The Volcano Letter



The Volcano Letter



Edited by Richard S. Fiske, Tom Simkin, and Elizabeth A. Nielsen

The Volcano Letter was published from 1925 to 1955 by the Hawaiian Volcano Observatory. It is here compiled and reprinted by the Smithsonian Institution on the occasion of the 75th anniversary of the observatory.

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The logo on the cover and title page of this volume first appeared in Number 436 of *The Volcano Letter*, June 1936, and was used frequently thereafter. A translation of the Latin phrase is: No More Abandoned or Buried Cities.

Preface

Most earth scientists today are familiar with the wide range of volcanological progress that has been made at the U.S. Geological Survey's Hawaiian Volcano Observatory during the past 30 years. Less is known, however, about the important work done there from 1925 through 1955. Some of this information can be found in the journal articles, books, and other publications of the time, but much of it resides in the 530 consecutive issues of *The Volcano Letter*, a quasi-formal publication issued regularly by the Observatory during that 31-year period. In addition, *The Volcano Letter* included reports from the Lassen Volcano Observatory (California) from its founding in 1926 to 1933. On the occasion of the Diamond Jubilee of the Hawaiian Volcano Observatory,[1] we are happy to make the wide range of information contained in this previously hard-to-find publication available for the first time in a single, fully indexed volume.

A look at most early issues of *The Volcano Letter* will reveal why we at the Smithsonian Institution were particularly interested in making this series more readily available to today's volcanological community. In an effort to make *The Volcano Letter* more appealing to the vast non-Hawaiian audience, the original editors made a point of including reports and notes describing the activity of volcanoes from around the world. Through the years, therefore, the readers of *The Volcano Letter* were treated to accounts of volcanic activity from Chile to Kamchatka, from Indonesia to Iceland. Also sprinkled liberally throughout were notes and comments on many other aspects of volcanism such as geothermal energy, volcano hazards, geysers, and calderas. In some ways, the collected *Volcano Letter* serves as a unique source of information on global volcanism and related topics from 1925 through 1955. Considering the Smithsonian's long interest in regular reporting of global volcanism--first through the Center for Short-Lived Phenomena (from 1968 to 1975) and then through the Scientific Event Alert Network (SEAN) (from 1975 to the present)--it is appropriate that we now make available to the international community the vast amount of volcanological information that is contained in *The Volcano Letter*.

This reprinted volume of *The Volcano Letter* was produced by a photo-offset process from a complete set of original issues provided by J. P. Lockwood. The photo-offset process has resulted in some degradation of the halftone illustrations, but we believe that the important features of the illustrations can nevertheless still be seen. After some editorial debate, we decided to include the many pages that repeat the standard maps, logo, or staff listings. Instead of publishing blank pages when there was insufficient material to fill the entire format of a particular issue, the original editors elected to repeat the various "filler" items. We retain them here to permit all multi-page issues to start on righthand pages. We therefore present *The Volcano Letter* in its entirety, including these superfluous illustrations. A single, comprehensive index for the entire collection of 530 issues of *The Volcano Letter* can be found at the end of this volume. The signature of the late Gordon A. Macdonald appears on the first page of several issues because the set of *The Volcano Letter* that we used to prepare this volume originally came from the personal library of Professor Macdonald. The handwritten number added to the upper right-hand corner of each page designates the Number of the respective issue.

Introduction

In today's jargon, *The Volcano Letter* would doubtless be regarded as "gray literature". It was published informally, with no copyright restrictions, at the Hawaiian Volcano Observatory from 1925 through 1955. As far as we know, contributed articles and notes were not subjected to peer review.

Through the years, the masthead carried the names of a succession of supporting organizations: the Hawaiian Volcano Research Association, the U.S. Geological Survey (USGS), the National Park Service, and the University of Hawaii. The mailing list evolved through time; some fraction of each printing went to a small group of libraries on an exchange basis. Other copies went to geology professors at various colleges and universities. Most copies of *The Volcano Letter*, however, were sent as a form of benefit to members of the Hawaiian Volcano Research Association. This association was founded in 1911 by the first Director of the Hawaiian Volcano Observatory, Dr. Thomas A. Jaggar, Jr., and a group of wealthy, influential, and intensely interested civic leaders from what was then the Territory of Hawaii.[2] Some of these individuals were descendents of missionaries who came to Hawaii in the early-19th century, and their names (Castle, Cooke, Judd, Thurston, etc.) constituted a social, economic, and political "Who's Who" of early-20th century Hawaii. This group provided generous financial support to the fledgling Observatory for a variety of research activities during at least the next 25 years.

In late 1924, just months after the administration of the Observatory was first taken over by the USGS, the Association decided to broaden its membership. At least part of this decision rested on the simple fact that more members meant more financial support for the Observatory. Membership in the Hawaiian Volcano Research Association cost $5.00 in 1925 (equivalent to at least $30.00 in 1987 dollars), which provided a very real incentive to offer membership to the vast potential audience residing throughout the United States and elsewhere around the Pacific basin. For each 100 new members of the Association, the 1987 equivalent of more than $3000 was made available to advance the cause of Hawaiian volcanology.

Thomas Jaggar, Director of the Observatory for its first 28 years, took on this new task with obvious gusto. He personally ensured that each issue of *The Volcano Letter* contained new and engaging items. First and foremost, each issue contained a brief report on the status of the volcanoes in Hawaii. Unfortunately for the readers of *The Volcano Letter* (and for Jaggar as well, we are sure), eruptive activity declined during the mid- and late- 1920s, so there was very little to report in most of the weekly mailings. Nevertheless, week after week, Jaggar and his staff engaged their readers with descriptions of rock avalanches into Halemaumau, changes in ground tilt and steam emission, and the shifting patterns of local seismicity. On the few occasions when Kilauea erupted, as it did briefly during each of the years from 1927 to 1934, *The Volcano Letter* provided vivid descriptions of the activity--in some cases, the only known printed descriptions of this activity other than contemporary newspaper articles. Some issues of *The Volcano Letter* contained retrospective accounts of previous activity in Hawaii, such as the 1823 and 1924 eruptions of Kilauea, the great 1868 earthquake, and the accompanying 1868 eruptions of Mauna Loa and Kilauea. Also included were many other notes describing a wide range of topics related to the earth sciences in Hawaii.

The Volcano Letter dramatically changed its format and emphasis several times during its 31-year life. The first 262 issues, which appeared from January 1, 1925, to January 2, 1930, were one-page weeklies, billed at the top of each page as a "news leaflet." There were no illustrations during those early years, so the appeal of *The Volcano Letter* depended solely on the content and style of the written word. With Number 263, dated January 9, 1930, *The Volcano Letter* expanded to a 4-page format, replete with photographs, maps, and line drawings. This expansion in size and format was made possible by the simultaneous demise of the *Bulletin* of the Hawaiian Volcano Observatory, a companion weekly publication of the Observatory devoted predominately to the details of Kilauea and Mauna Loa activity.[3] As this activity, especially Kilauea's, declined during the 1920s, there was insufficient new

information to sustain publication of the Bulletin. The decision was therefore made to merge its budget and staff with that of *The Volcano Letter*.

This new and expanded format lasted for more than three years, but the effects of the Great Depression were felt eventually, even in far-off Hawaii. In Number 385, dated May 12, 1932, the readership was tersely informed that, because of a 57 percent cut in the Geological Survey's budget for volcanological studies (from $35,000 to $15,000 in one swift blow!), *The Volcano Letter* would henceforth be a monthly publication. In fact, not only did it appear less frequently, but it also shrank to the austere 1-page format that had characterized *The Volcano Letter* during the 1920s. The going was obviously very rough during the next 3 years, but in the summer of 1935 publication responsibilities shifted from the USGS to the National Park Service. This administrative change, in addition to the vigorous and well-publicized eruption of Mauna Loa in November of that year, apparently had some beneficial effects. *The Volcano Letter* again expanded to an 8-page publication, complete with photographs, maps, and drawings such as those that had enlivened it during its heyday in the early 1930s. In late 1938, however, as the retirement of Thomas Jaggar approached, the production rate was further reduced. From that point on *The Volcano Letter* was issued only quarterly until publication ceased in late 1955.

In addition to the large body of information about volcanoes and related phemonena in Hawaii and around the world, the tone and overall content of *The Volcano Letter* tells us, in more subtle ways, something about the personalities and scientific philosophies of the 3 men who directed the Observatory from 1925 to 1955. Thomas A. Jaggar, Jr., a former professor and chairman of the Department of Geology at the Massachusetts Institute of Technology, first visited Hawaii in 1909 and delivered lectures to civic groups on volcanoes and the need for their continuous observation.[4] In early 1912 he arrived at Kilauea to assume the directorship of the newly-established Hawaiian Volcano Observatory. Jaggar was a spellbinding public speaker and a man of enormous energy. He combined evangelical zeal (his father was a Boston cleric) with an intense interest in Hawaiian volcanoes to build the scientific programs of the Observatory and to increase its visibility worldwide. Toward this end, Jaggar used *The Volcano Letter* to spread the word about a wide array of volcanological topics, both to the scientific community and to the interested public. Revealing his professorial background and inclinations, numerous issues of *The Volcano Letter* during the 1920s and early 1930s went far beyond volcanology itself and carried articles describing broad earth science topics such as continental drift, the origin of the earth's crust, and the nature of mountain-building processes.

This frenetic pace, however, could not be maintained indefinitely, even by someone as energetic as Thomas Jaggar, and the years 1935 to 1938 show a gradual narrowing of editorial focus to Hawaii and its volcanoes. In 1939, the year before Jaggar retired, *The Volcano Letter* was devoted entirely to Hawaiian topics, and there was no mention whatsoever of other volcanoes around the world that were active at the time. Clearly, the phase in the life of *The Volcano Letter* that was so influenced by Jaggar's enthusiasm and expansiveness was drawing to a close. Jaggar retired in 1940 and moved to Honolulu; the directorship of the Hawaiian Volcano Observatory then passed to geophysicist Ruy Finch.

Finch, who first joined Jaggar's staff in 1919, and who directed the Lassen Peak Observatory (California) from 1926 to 1935, inherited the leadership of the Hawaiian Volcano Observatory at a time of lean budgets, diminished staff, and a rapidly escalating World War.[5] These elements could have forced the Observatory and *The Volcano Letter* into a period of profound decline or, worse yet, into extinction. Mauna Loa in effect saved the day by erupting from its summit in 1940 and again from its summit and northeast rift in 1942, sending a large lava flow that, at least for a short time, threatened the city of Hilo. Descriptions of these eruptions dominated many pages of *The Volcano Letter* during the early 1940s, and, in a very real sense, set the editorial tone for the rest of the decade. Thus, looking through the pages of *The Volcano Letter* for the eleven years that Ruy Finch headed the Observatory, from 1940 until early 1951, one can see an almost total dedication to the volcanoes of Hawaii. Concurrently, there was a shift toward more scholarly volcanological topics (e.g., the history of activity along rift zones, the origin of the Pahala ash, and a discussion of the annual tilt pattern at

Kilauea). Also noteworthy during this period was an attempt to give greater visibility to new volcano-monitoring instruments and techniques that were being developed at the Observatory. Readers of *The Volcano Letter* could thus learn about geomagnetic studies, radio transmission of seismic signals, and the development of a teleseism annunciator for use in anticipating the arrival of damaging tsunamis. Clearly, the 1940s must have seen a shift of the *The Volcano Letter* readership away from the interested public (the "volcano buffs" so effectively cultivated by Thomas Jaggar) and toward a new audience of geologists, geophysicists, hydrologists, and other professionals who needed to know more about Hawaii and its volcanoes. Renewed activity at Mauna Loa in 1949 and again in 1950 provided *The Volcano Letter* with new vitality during the final years of Ruy Finch's leadership, and readers were treated to well-illustrated accounts of both of these important eruptions.

The final episode in the life of *The Volcano Letter* began in February 1951 with the appointment of Gordon Macdonald as Director of the Hawaiian Volcano Observatory.[6] Macdonald first came to the islands in 1939 to undertake geological and hydrological investigations with Harold T. Stearns and joined the Observatory staff in 1948. The Macdonald years were enriched by the long-awaited awakening of Kilauea, which had been inactive since 1934. Kilauea erupted from its summit in 1952 and again in 1954, but the most important event of those years was the east rift eruption in 1955 that poured huge volumes of lava upon the farms, highways, and fern forests of the Puna District of the Big Island. Thanks to Macdonald and his staff, these events were vividly described in the pages of *The Volcano Letter*, as were descriptions of the damaging earthquakes in Kona (1951), the swarms of earthquakes beneath the south flank of Kilauea (1952), and a host of other volcano-related events.

What particularly distinguished *The Volcano Letter* during the Macdonald years, however, was not the reporting of the events on Hawaii. Rather, it was a return to the reporting of erupti ons at distant volcanoes, in much the same way that Thomas Jaggar did in the 1920s and 1930s. The very first issue of *The Volcano Letter* over which Macdonald had editorial control (No. 512, April-June 1952) contained a call for correspondents around the world to send in news of other volcanoes. Apparently this call was heeded, because every subsequent issue contained descriptions of eruptions at far-off volcanoes, such as Myojin Reef (Japan), Trident Volcano (Alaska), Stromboli (Italy), and Hibok-Hibok (Philippines). Many of these descriptions were placed in a regularly-appearing section entitled "Volcano Notes and News." Other accounts of global volcanism are contained in feature articles, some of which were authored by leading volcanologists of the day. It seems clear that Gordon Macdonald intended to strengthen the Observatory's role as a clearinghouse for information about the world's volcanoes, in addition to its already well-established role as observer and interpreter of the Hawaiian volcanoes. *The Volcano Letter* was one of the chief means of disseminating this newly-gathered information to the scientists of the world.

Disagreements were building, however, between Macdonald and his USGS supervisors on the Mainland. Macdonald's increased interest in the humanistic side of volcanology, his expanding public role, and his desire to enlarge the Observatory's involvement with distant volcanoes, came at a time when USGS management wanted the Observatory's mission to be the development of new, multi-disciplinary approaches focused almost exclusively on Hawaiian volcanoes. These supervisors felt that Macdonald was overpersonalizing the Observatory and isolating it in some ways from the mainstream of the Geological Survey's volcanology program. In addition, there was a growing feeling that Macdonald, whose only USGS experience had been in Hawaii, should gain familiarity with Mainland facilities and procedures.

The end, both of Gordon Macdonald's directorship and *The Volcano Letter* itself, came abruptly. On page 14, No. 529-530 (July-December 1955), it was announced that the USGS was transferring Macdonald to Denver, Colorado, where he was to begin research on volcanoes and volcanic rocks of the western United States.[7] That was the last page of the last Number of The Volcano Letter. An era had ended, and a new one was about to begin.

Notes

1. The Diamond Jubilee of the Hawaiian Volcano Observatory is commemorated by U.S. Geological Survey Professional Paper 1350, *Hawaiian Volcanism*, a two-volume reference that thoroughly documents the history of the Observatory as well as many of the studies that have emerged there in recent years.

2. A description of the founding of the Hawaiian Volcano Research Association is found in a speech delivered by Thomas A. Jaggar, Jr., to a meeting of the Association on Dec. 11, 1913 and published as a *Special Bulletin* of the Hawaiian Volcano Observatory (16 pp.) by the Hawaiian Gazette Co., Ltd. in 1913.

3. Jaggar compiled a condensed index to the Bulletin in his 1947 book *Origin and Development of Craters* (Geological Society of America Memoir 21, pp. 322-24).

4. Macdonald, G.A., 1953, "Memorial to Thomas Augustus Jaggar", *The Volcano Letter*, no. 519, p. 1-4.

5. Macdonald, G.A., 1958, "Memorial to Ruy Herbert Finch, 1958", *Bulletin Volcanologique*, v. 19, p. 221-29.

6. Lockwood, J.P., 1980, "Memorial to Gordon Macdonald", *Journal of Volcanology and Geothermal Research*, v. 7, p. 177-88.

7. Macdonald returned to Hawaii in 1958 as Professor at the University of Hawaii. His book *Volcanoes in the Sea*, with A. T. Abbott, (Univ. Hawaii Press, 1970, 441 pp., 2nd edition, 1983) provides comprehensive treatment of Hawaiian geology, and his highly regarded text *Volcanoes* (Prentice-Hall, 1972, 510 pp.) is richly illustrated with examples from Hawaii.

Acknowledgments

Jack Lockwood contributed to this volume in many ways, not least of which was loaning us a complete set of the original *Volcano Letter*. That set, which is one of the few known collections of all 530 original issues of *The Volcano Letter*, was photographically reproduced to prepare this volume. We much appreciate the comments on early drafts of our preface and introduction that were provided by Russ Apple, Bob and Barbara Decker, Jane Dixon, Jack Lockwood, Virginia Macdonald, Howard and Dorothy Powers, and Tom Wright. The Atherton Seidell Endowment Fund of the Smithsonian Institution provided the support necessary to reprint *The Volcano Letter*. In these times of limited funding for scholarly research and, more particularly, of increased emphasis on short-term scientific investigations, it is a pleasure to acknowledge the generosity and perspective of the late Atherton Seidell, who established an endowment at the Smithsonian Institution for reprinting hard-to-find scientific information. The ultimate acknowledgment, however, must go to the staff of the Hawaiian Volcano Observatory who worked hard through the years to gather this huge volume of volcanological information, and then went on to write all of it down when many other tasks, no doubt, competed for their time.

-- Richard S. Fiske
-- Tom Simkin
-- Elizabeth Nielsen

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NO. 1 January 1, 1925

KILAUEA REPORT

DECEMBER 31, 1924
Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in Charge

Other notices in the press than those mentioned last week indicate that the seismographs of the world are recording large earthquakes and Tokyo mentions a strong felt shock that did damage in Japan. Two slight records of distant earthquakes were made on the Kilauea seismograph December 27 at 1:01 a. m. and December 28 at 12:34 p. m. Thirty local shocks were registered, two of which were felt, respectively on the 25th and the 30th, both in the evening. Tilting was to the northeast, a direction favorable for rising lava, but no new sign of lava has appeared in the pit.

About half of the local earthquakes were of the prolonged type characteristic of Halemaumau avalanches, and such slides were observed or heard repeatedly during the week. They made no large dust clouds.

A notable change now seen at Halemaumau, and occasioned by the big avalanche of December 12, is the cessation of smoking of the north wall. This blue fume was in evidence all summer and autumn, coming from a solfataric patch in the upper wall. The avalanche in question stripped that wall, and left a surface whitened with sulphates, but if any fume remains it is now mixed with the steam at the base of the wall.

The avalanches of the past week have continued to strip the north wall and to pile up the debris below so as to cover with talus the bottom part of the big intrusive sill. A faint sulphur odor was detected at some of the cracks back of the NNW rim of Halemaumau. With the undermining of the rock slides these cracks have increased at the north, outlining freshly broken segments of the rim scores of feet back from the edge, and breaking the earth along new steamy cracks parallel to the rim in many places. At one of these big chasms the surface rock has all caved in revealing an inclined cavern below The hole is ten to fifteen feet across and plunges downward at an angle of thirty degrees, with a slope of caved debris on one side. The roof and sides are broken and so close to the pit rim, where avalanching is always going on, that the whole mass appears to be settling.

Some of the steam cracks near the rim at the west are continuous for long distances, with hot vapor rising in puffs.

During the gentle swaying earthquake of the evening of December 30 at 8:51 p. m. a pheasant was heard to squawk at the moment of the shock. In Japan slight forewarning of quakes has sometimes been given by pheasants.

CHILEAN VOLCANOES

There are some parts of the world of volcanology that yield very little published information and one of them is Chile. Dr. Karl Sapper of Strasbourg mentions 14 eruptions in 13 years between 1901 and 1913 (Summary of volcanic data, Beitraege zur Geophysik, 1915). The very names of these volcanoes are unknown to most of us. Huallatri and Isluga at the north vented light smoke and black smoke and fire in 1913, and these about 19 degrees S. lat. are as far south of the equator as Hawaii is north. Next come San Pedro and Antofalla which vomited smoke in 1901 and 1911. Moving south to 35° we find Cerro Azul and Descabezado making explosive eruptions in 1907 and 1913, the former a peak 10,500 feet high. Chillan in lat. 36° opened a new crater in 1906, and Llaima appears to be a formidable volcano that kept up action for five years from 1903 to 1908 with both explosions and lava. Maipo was active in 1905.

The Chilean district of about 40° S. near the port of Valdivia appears to be a lively volcanic neighborhood where Villarica was erupting and throwing stones from 1906 to 1908. In the same region Rininahue in April of 1907 built up a cone of lapilli and ash, and the dust fell at Valdivia. Calbuco and Huequi are a little farther south and were making explosive steam clouds and smoke clouds in 1906-07.

All this shows that while there was no activity reported between 1895 and 1900, there were two eruptions in 1901, one in 1903, one in 1905, five in 1906 when Valparaiso and San Francisco had their earthquakes, four in 1907 when Jamaica had its earthquake, two in 1908 when Messina had its earthquake, one in 1911 and two in 1913.

Sapper shows that this 1906-07 time produced the most volcanic eruptions in nineteen years both for the whole world and for the Pacific half of the earth. Out of 414 eruptions between 1895 and 1913 there were 25 in 1906 and 31 in 1907. There were eruptions on Mauna Loa, at Bogoslof in the Aleutian Islands, at James in the Galapagos, at Vesuvius, on Savaii in Samoa, Kartala of the Comoro Islands east of Africa (1904), Namlagira, a lava maker in east Africa, Cotopaxi, Sangay, and numerous volcanoes of the Molucca-Philippine-Japan series. It is remarkable that this was also a period of some of the world's greatest earthquakes, including a big one in India.

It thus appears that certain years in the world's history are seismo-volcanic centers in time, just as districts are similar centers in place. About 1883-86 was another such time center with Java, Japan and New Zealand producing titanic eruptions, and in America came the Charleston earthquake.

T. A. J.

PERRET'S GREAT MONOGRAPH ON VESUVIUS

Those in Hawaii who remember Mr. F. A. Perret's fine work here dwelling on the rim of Halemaumau pit in 1911, and his wonderful faculty for making good photographs under adverse conditions, will wish to see and study the splendid volume by him just published, with noble pictures of craters, cones, cauliflower clouds, lava flows and avalanches of dust and debris. (The Vesuvius Eruption of 1906, Carnegie Institution, Washington, D. C. quarto, 151 pp. $4).

Mr. Perret discusses the preliminaries of that great eruption, presents a narrative and an analysis of every detail of its progress illustrated photographically, then recites the after effects as observed on the ground through the repose period of seven years, and finally gives most interesting account of the revival after 1913. For comparison with Hawaii this memoir is invaluable. In his last part he describes his instruments, comparative data of the 1872 eruption, and Dr. Washington discusses the petrology of the lavas. Dr. Washington has done admirable work in editing the volume, so as to introduce the vast experience of the Geophysical Laboratory of Washington in technical and bibliographic matters.

It is interesting to note that Perret says the "average interval between eruptions for Vesuvius during the 19th century was less than ten years." For Kilauea-Mauna Loa the cycle also is about nine years long.

T. A. J.

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NO. 2 RELEASED WITHOUT COPYRIGHT RESTRICTION January 8, 1925

KILAUEA REPORT NO. 678

WEEK ENDING JANUARY 7, 1925
Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in Charge

Halemaumau, the active pit of Kilauea volcano, was left by the explosive eruptions of May, 1924 an enormous blank cauldron lined with broken rock. It is 1280 feet deep, oval in plan, and 3400 feet long. The lava returned to the bottom for a fortnight in July so as to make a rock floor. Avalanching from the walls has been the principal process of change in evidence since the first of August, when all flow of lava stopped. These slides have made the debris slopes grow. The walls are precipitous and unstable. The bottom yields much steam mixed with sulphur gas and hydrogen sulphide, but in fair weather all the walls are in plain view and no vapor rises above the pit rim. There are vaporing cracks moderately hot parallel to and near the rim.

During the past week avalanching decreased, but a pinnacle of poised rock at the south has fallen in . This was a conspicuous landmark, and all that is left is a slender spire surmounting a sheet of rock partially split from the face of the wall. Some of the steam-holes in the talus are dry, hence probably very hot, others are wet. The Observatory registered 22 local earthquakes and northeasterly tilt. Two noisy avalanches were heard the forenoon of January 3, and half the earthquakes recorded were of the avalanche type. At night no glow is discernible in the pit.

LOCATING EARTHQUAKES

An earthquake is a sudden bump or break or slip in a definite place within the crust of the earth. The jarring moves out from that place as waves in the rock. Some of the waves are like sound waves, some are like water waves and travel with different speeds. If a blast were fired in a lake, the sound under water would reach you before the surface waves from the explosion. So it is with an earthquake in solid sandstone or granite. And the delicate pendulum called a seismograph, scratching a straight line on paper all the time, with tick marks at the side from the minute hand of a clock, makes a wobbly mark the instant the quicker waves get to it, and a big zigzag mark some moments later when the surface waves arrive. In the case of big earthquakes the marks are registered even 7,000 miles away.

As the quick waves race in a straight line through the earth at a speed that is independent of the severity of the earthquake, and that speed is known by experiment; and the surface waves go more slowly, also at a known speed; it follows that the difference in time of arrival of the two, measured in minute tick marks on the paper will be the greater as the distance away is greater. This time-distance relation, or "duration of the preliminary tremor;" has been worked out for all distances and published in tables. It is not quite so simple as told here, for there are two kinds of preliminary wave, but that all appears in the tables. The velocity of the most rapid earthquake waves averages over 300 miles a minute and the slowest waves can travel entirely around the world in about three hours.

The distance unit in the Zeissig tables, commonly used at most seismographic observatories, is 10 kilometers (6¼ miles), but these tables are mainly designed for big earthquakes many hundreds of miles away. At this Observatory Omori's tables, published in the Bulletin of the Imperial Earthquake Investigation Committee of Japan, Vol. 9, No. 1, p. 39 have been found much more satisfactory than any other. Omori's values are given to fractions of a mile. His fractions seem justified as it is easily possible to distinguish differences in shakes whose origins are only two and three miles away. The distances of quakes up to 40 miles determined from Omori's tables are from one to six miles less than those given in the Zeissig table. That Omori's tables are better than the Zeissig table for very local earthquakes, near a volcano at least has, repeatedly been shown here by the nice agreement between computed and actual distances of many quakes whose origins are known, as for instance by newly formed cracks at the center of disturbance. R.H.F.

HAWAIIAN SEISMOGRAPHIC STATIONS

The Volcano Research Association maintains three outlying stations on the island of Hawaii for registration of earthquakes, besides the main laboratory of the Observatory at Kilauea. The latter is now operated by the United States Geological Survey; it passed from the Weather Bureau to the Survey July 1, 1924. The outer stations are equipped with instruments built here by Dr. A. Romberg. They are at Kealakekua in Kona, Observer R. V. Woods: Hilea in Kau, Observer Ella W. Stephens; and Hilo, Observer J. B. Albert. The magnifications of the instruments are 25X and 50X (Kona). The Kona instrument also records tilt. Hilea gets the most small shocks (next to Kilauea), Kona next and Hilo fewest. Kona and Kilauea have horizontal pendulums, the others normal pendulums of short period.

The Volcano Research Association is working cooperatively with the Survey through the Observatory. Since 1920 it has built up the seismograph stations, conducted boring experiments at Kilauea, equipped a chemical laboratory at the Observatory, maintained a research fellowship at the station for a year, sent an expedition to investigate the Tokyo earthquake, assisted printing and publications, built an iron archives andoffice building for the Observatory and apparatus and books: and finally, the present campaign of the Association, which has been in progress for over a year, has in view supporting and promoting publication of th scientific results of the fifteen years of work at Kilauea done by its employees and by the government.

T.A.J.

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NO. 3 RELEASED WITHOUT COPYRIGHT RESTRICTION January 15, 1925

KILAUEA REPORT NO. 679

WEEK ENDING JANUARY 14, 1925
Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in Charge

The past week has been a rainy one at Kilauea with 5:88 inches of rainfall January 6-9 inclusive along with strong northeasterly wind. This however occasioned no increase of avalanching at Halemaumau pit. Both the seismographs, which appear to record ordinary avalanches, and the daily observation visits have indicated that the motion of the rock slopes was much less than hitherto.

The number of local earthquakes registered during the week was thirteen. On successive weeks beginning with that ending December 3, the numbers per week were 19, 41, 50, 33, 30, 22, 13. The maximum of 50 was just at the solstice, when there was notable avalanching that stripped the northeast wall of the pit, and also one strongly felt earthquake.

During the rainy spell there were electrical storms and snow fell on Mauna Loa and Mauna Kea, covering the cones at the 10,000 foot level and above.

Visited after the rains on January 10, the bottom of Halemaumau was steaming vigorously and vapor rose even from cracks in the rocky wall all the way up to where they join the tangential steaming fissures on the rim. The increased volume of bottom steam made more visible the sulphurous fume that is mixed with it, giving the vapor bluish edges and leaving blue gas where the vapor dissipates above. From a northwest pocket of the bottom and from the south talus the densest volutes of steam go puffing upward. At the bottom pocket January 12 there appeared to be puffing.

A second visit at 6 p. m. the same day discovered no more such noises, nor were they heard on the following days. At dark no glow could be seen. The whitening of the walls on drying after rain was especially noticed above the hot intrusive bodies, as though these were still emitting acid gases.

THE INSIDE OF THE EARTH

The distance to the center is 3960 miles. The outer crust, it is commonly agreed, within a depth of 35 miles changes from granite to a heavier dark olivine rock. Below the crust lies a zone of these rocks 960 miles thick growing heavier. Then comes a shell of mixed rock and metal about 870 miles thick, the outer part silicates pocketed with nickel-iron alloy, the inner a metallic matrix containing scattered clusters of olivine crystals. The specific gravity of this shell (its weight compared with water) varies from 4 to 9 going inward. Ordinary lava averages about 3.

We have now gone down 1865 miles and arrived at a red hot stiff sea of metal. This is the central core, its substance like the nickel-iron meteorites, its diameter 4200 miles, its specific gravity 10. This it is that brings up the average density of the globe to 5.5.

All of this doctrine comes from up-to-date experiment, analysis, and computation by Williamson, Washington and Adams of the Geophysical Laboratory of the Carnegie Institution of Washington, Dr. A. L. Day, Director. (Journ. Wash. Acad. Sci. 1923, 413; 1924, 333, 435, and 459).

The arrangement in shells agrees with the analogy drawn from the metal and stone meteorites, with the weight, rigidity, and compressibility of materials required for the waves from big earthquakes to pass through the earth as they do; with the inertia of the earth in its rotation and tides, and with compression calculated as varying with depth. At the center of the earth the pressure is amout 22000 tons per square inch.

The earth is not conceived to be a big meteorite, but a planet of graded substance metallic to rocky from within outward. If torn to pieces the fragments would be meteorites of the iron, part-iron and stony sorts. A Greenland lava contains 31 per cent of metallic iron, showing that some pockets of the rock-iron mixture come within reach of volcanoes.

Chemically the nickel-iron at the center, by analogy with known meteorites, is free from oxygen and silicon, but contains sulphides, carbides and phosphides. In the next rock-iron zone, crystalline compounds of silicon, oxygen, iron and magnesium are formed in a mother liquor of metal. In the next zone outward this changes to basic silicate magma with only pockets of iron. Oxides like magnetite now appear also feldspars introducing aluminum and calcium, along with borides and nitrides. Lastly the thin outer crust brings in sodium in its lower part and potassium above, and finally free silica as quartz and free oxygen in the air.

The metals from inside outward are in the order of increasing affinity for silica and for oxygen and grade from electro-negative to electro-positive. Of the whole earth 99.60 percent consists, in order, of iron, oxygen, silicon magnesium, nickel, calcium and aluminum, with subordinate amounts of sulphur, sodium, chromium and potassium. These with hydrogen and cobalt are also the principal elements we know spectroscopically in the sun.

The amount of oxygen in the iron core is zero, in the crust it is 47 per cent. The iron in the core makes up 91 per cent, in the crust only 5 per cent. Has there been a progressive oxidation of an elemental sphere, and is volcanism the relic of that process?

The last paper by L. H. Adams calculates the temperatures in the upper 180 miles. Radio-activity, melting-points, viscosity and circulation from the days of an original molten surface play their parts. The magma crystalized from below upward, concentrating a residue of basalt 60 miles thick which crusted over. The crusts foundered and left a honeycomb with liquid layers of great size. The age of the earth since cooling began is placed at 1600 million years. Final concentration produced granite.

The increase of temperature downward in the upper crust is much more rapid than it is below. It comes out

at	12	miles	depth	500	degrees Cent.
"	32	"	"	1000	" "
"	79	"	"	1500	" "
"	135	"	"	2000	" "
"	183	"	"	2450	" "

which is less by 1000 degrees than the temperature of the carbon electric arc. T. A. J.

ERRATUM

A misprint in the sixth line from the end, last number of Volcano Letter, should read: The Volcano Research Association "built an iron archives and office building for the Observatory records, also an iron steam laboratory over the bore holes at Sulphur Bank, furnished the station with machinery and apparatus and books, and finally" entered on a campaign of publication.

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NO. 4 RELEASED WITHOUT COPYRIGHT RESTRICTION January 22, 1925

KILAUEA REPORT NO. 680

WEEK ENDING JANUARY 21, 1925
Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

During the week at the Hawaiian Volcano Observatory on the rim of Kilauea crater the weather has been mostly without rain after the heavy downpour of the afternoon of the 15th when there was thunder and lightning. The wind has been fresh from the northeast, the barometer normal, and thermometer minimum 48° F.

The number of local earthquakes registered per week jumped from 13 to 27. Of the 27 for the past week three were perceptible. Fourteen of the shocks occurred in one day, January 17, about a half of them being of the avalanche type. Some noisy avalanches occurred at Halemaumau during the week but no very big ones. One distant earthquake was recorded at 2:45 a. m. on both the Kona and Kilauea seismographs January 18th, the indicated distance of origin being 3600 miles. From the 16th the tilting of the ground at Kilauea was northerly.

The pit Halemaumau, though devoid of active lava, performed peculiarly on the eve of Saturday the 17th, the day of the many earthquakes. On Thursday there had been a few avalanches. On Friday they were more numerous, and at 7 p. m. a strong roar from the pit was heard at the Observatory. The pit had been visited between 5 and 6 p. m. and about every ten minutes more or less, there was noticed an echoing hiss ending with the rattle of sliding rocks, like the steady puffing that had been observed the week before.

Steam obscured the west debris slope whence the noises proceeded, but some angular scarps in the gravel heap of the bottom were noted. There were small rock falls from the wall that made a different sound. The seeming hiss would prolong itself into the clatter of a sliding ribbon of talus, and while the moving fragments were not seen, the loud grating noise was believed due to the caving in of the northwestern and northern talus, the fragments sliding into a crack that was opening beneath. Possibly the lava column was disturbed below and made some kind of an opening.

Some hissing was heard again January 18th, but believed due to wind. Nothing more was heard of it. The northern walls have developed more white stain and the eastern wall has caved in so as to destroy the flag station. New cracks have appeared in the dirt back of the east rim.

A MODERN SUMMARY OF EXISTING VOLCANOES

It is no small task (see Sapper, Volcanological Review, III, 65, 1917) to compile from existing documents the number, kinds, activities, distribution, output and periodicities of the known active volcanoes. And there are some in remote lands, or under ice, or under the sea, which are unknown. Moreover many volcanoes exist which appear fresh, but no one knows their records. Of 202 volcanoes and lava fields mapped in Chile and Argentina, only 30 have active records. Of 165 volcanoes in Japan, 58 are ranked as active. Sapper makes the total number of active volcanoes on earth 430, of which 80 are submarine, as reported from time to time by mariners. Sixty-four per cent are in the northern hemisphere and thirty-six per cent in the southern. More than half of the total number lie within 30 degrees of the equator.

The Indo-Atlantic half of the world has only 94 active volcanoes as against 336 for the Pacific half. And most of these Pacific vents for the earth's internal fire are around the margin of the ocean, for only fifteen are in the middle. About 2500 eruptions are known to all history as hitherto compiled, and more than 2000 of these were about the Pacific.

As to the kinds of activity exhibited, to get reliable data on lava flows as contrasted with explosions or mixed eruptions, it is necessary to take a group of modern dates. From 1895 to 1913, of 396 eruptions in the world, 284 were explosive, 83 were mixed lava and ash producers, and only 29 were purely lava flows. Of the explosive, 255 or 90 per cent were from the Pacific border region. The Indo-Atlantic half of the globe has explosive, mixed and lava types all three, while the central Pacific rarely has explosive eruptions pure and simple. Since the year 1500 the total output of lava is estimated by Sapper at 12 cubic miles, and of fragmental material such as rocks, sand and ash 72 cubic miles. Of these last, 86% came from the Pacific Hemisphere.

The greatest lava-producers in single eruptions were the volcanoes Leirhnukur, Laki and Eldgja in Iceland, Lanzarote in the Canary Isles Kliutschew in Kamtchatka, Savaii in Samoa, and Sakurajima in Japan. Mauna Loa is possibly in this first class. In the second class of lava-makers are Etna, Vesuvius, Hecla, Kilauea, Asama, Mont Pele', and two Philippine volcanoes, Camiguin del Sur and Mayon. Other lava producers little known but important are Namlagira in central Africa, Kartala off the east African coast and Piton de la Fournaise in the island of Reunion.

A striking fact about lava outflow since 1701 is that high latitudes have produced twelve times as much lava per unit of area as the equatorial belt, whereas the equatorial region has produced eleven times as much explosive material as the latitude of Iceland. And the Iceland-Kamtchatka latitudes have produced twice as much lava as ash. Iceland alone in the eighteenth century was responsible for more than a third of the world's lava flows of the last 225 years. T.A.J.

FREQUENCY OF HAWAIIAN EARTHQUAKES

During the year 1924, 5877 local earthquakes were registered on the seismographs of this Observatory. Of this number, 772 were perceptible shakes, the remainder being detectible only by delicate seismographs. This is the largest number recorded here in any one year since the establishment of the Observatory in 1912 and is much above the yearly average.

The greatest number recorded in any one month was 3961 in May. The least was 21 in January, 1924, when the pit was full of lava. The large number in May accompanied the explosions and the collapse of the floor of the fire pit. This year confirms previous observations that seismic frequency and intensity are higher when the pit is quiet than when molten lava is visible. R.H.F.

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NO. 5 **RELEASED WITHOUT COPYRIGHT RESTRICTION** January 29, 1925

KILAUEA REPORT NO. 681

WEEK ENDING JANUARY 28, 1925
Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

The weather of the week has been fair with variable winds and calms, and one rainy day on the 26th. There are two conspicuous features in Halemaumau pit during the present quiet solfataric spell following the eruption of May, 1924, which change with the weather. One is the efflorescence of white sulphates on the walls after dry sunny weather, increasing the more such weather is prolonged. The other feature is the visibility and apparent density of the vapor jets about the bottom, and of the larger vapor cloud which condenses above the whole pit. In rainy weather the dense vapor of the small jets at the bottom may fill the whole pit and merge with the cloud above that rolls away to leeward. In sunny or cloudy weather this big cloud may be wholly invisible or merely shreds of rapid-rising cumulus high above the pit, and the steam jets on the bottom appear thinner, less flocculent and more idle in their rising activity.

At the beginning of the week after a dry spell the walls were notably white and chalky with magnesium sulphate, especially above the two ends of the hot north sill. On the 26th after a rainy day it was remarkable how these big areas of white stain disappeared.

This whitening is different from the true solfataric action of the live vents about the bottom depositing sulphur and sulphates yellow, cream colored or greenish or even pink, with hot steam making dry patches in the midst of stones dark with moisture roundabout. There are three such deposits at the base of the southeastern wall, eight patches in the talus west, south and east, and two stained areas fuming in the floor. These places are very hot, but they also become inconspicuous in coloring after excessive rains.

The vast pit of Halemaumau shows only gradual changes. Small rock slides have occurred mostly at the north intrusive sill. The peculiar sliding noise reported last week has not recurred, but in morning sunlight on the 25th a depression was detected about 20 feet wide extending N-S across the W side of the floor. The mud drainage was toward this place indicating extreme lowness, and here is the west pocket with salts and hottest and densest steam jets. The peculiar slides may have been into this depression.

The seismographs have recorded 11 local earthquakes, one of these January 26 at 6:42 a. m. showing indicated origin 11 miles from the Observatory, probably to the southeast. Tilting of the ground has been to the south-southwest.

Temperature measurements at vapor cracks from rim of pit outward from Halemaumau gave 162° Fahr. at south rim, 167° west rim, 169° southeast rim, 187° at a purring vent 100 feet back of southwest rim, 189° at road terminus 2000 feet back southeast and 194° at old sulphurous cracks south of Kilauea crater at the contact of lava and gravel. This last place was also blowing. If we go still farther outward to the Sulphur Bank at Volcano House we get 204°. Thus cracks are deeper and hotter the farther we go from the volcanic center.

A VOLCANIC OUTBREAK THAT SHOOK THE GLOBE

World-shaking earthquakes are well known. Sudden release of stress occurs somewhere in the earth, and a big earthquake is registered on seismographs thousands of miles away. It is commonly thought volcanoes have little to do with it. Many big earthquakes happen under deep oceans for the centers can be located by the seismographs. Of lava outpourings under the deep sea we know nothing; they may very possibly occur.

Dr. Tams of the Hamburg earthquake station (Volcanological Review, 1924, 137) shows that Katmai volcano in Alaska, in June 1912 produced eleven earthquakes which were well registered at St. Petersburg. The actual swing of the ground at the Russian station was from a thousandth to six-tenths of a millimeter. The instrument magnifies the movement and makes it visible as a written zigzag line. The Katmai earthquakes were registered at other stations in Europe, America, Asia and Africa. During the first three days of the tremendous explosions that gave birth to the Valley of Ten Thousand Smokes, two of the shocks were registered at Cape Town 11,000 miles away. Their centers were not right at the volcano, but at places 60 or 90 miles to the west.

All the centers located were notably along belts parallel with the line of volcanoes and 50 to 100 miles away. There were also big shocks in the Mt. McKinley range at the end of the line, and in the deep Aleutian trough of the Pacific.

Many earthquakes were strongly felt in towns near the volcano about the time of the disaster June 6th, 1912. The eruptions continued all summer with loud noises and numerous earthquakes. Dr. Griggs (Nat. Geog. Soc. 1922) and his colleagues estimated that six cubic miles of ash were ejected.

Mt. Katmai lost two cubic miles of rock unaccounted for in the ejecta. A big crater and many cracks remained, two new adjacent craters appeared, and in one of them stood an obsidian dome of new lava 200 feet high and 800 feet across. A fill of hot sand with hundreds of fumaroles occupied a valley representing a zone of fractures crossing the Alaskan peninsula. It was thought that a large body of siliceous lava underlay the peninsula and the earthquakes and eruptions accompanied movements of the earth's crust wherein tension cracks opened. It is a matter of theory as to which was cause and which was effect.

The seismographs of Europe were calibrated by the Sakurajima earthquake of 1914. This in Japan destroyed houses and lives. Registered in St. Petersburg it swung the pendulum four-hundredths of a millimeter. From St. Petersburg Alaska is the same distance away as Japan. Therefore Katmai earthquakes swinging the St. Petersburg pendulum twice as far and fifteen times as far as did the Sakurajima shock, were twice as big and fifteen times as big. In this way the size as well as the location of earthquakes in the Alaskan wilderness, were better determined in a quiet cellar in Russia than they could be by any evidence available in the region where they occurred.

Big earthquakes near volcanoes are not unusual. The Sakurajima eruption was itself a trigger that turned loose the big shock in South Japan. Large earthquakes near Etna in Sicily at times of eruption have been recorded on the seismographs of Europe. And lastly, the big lava flows of Hawaii in 1868 were preceded by an earthquake of the globe-shaking variety which was felt 300 miles from the volcanoes.

T.A.J.

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NO. 6 RELEASED WITHOUT COPYRIGHT RESTRICTION FEBRUARY 5, 1925.

KILAUEA REPORT NO. 682

WEEK ENDING FEBRUARY 4, 1925

Issued by the Observatory, U. S. Geological Survey:

T. A. Jaggar, Official in charge

The crater pit Halemaumau of Kilauea volcano remains quiet so far as lava activity is concerned. After January 29th, however, there was some revival of avalanching from the walls of the big cauldron, which is 1280 feet deep. Along with this came tremors recorded on the seismograms at the Observatory 2.1 miles from the pit. The number of local tremblings was 34, but of these only eight had amplitude enough to be conspicuous on the record sheets, and but few of these seismic movements had the sudden beginnings of local earthquakes. They begin as small quick tremors sometimes a half-minute before they develop gradually an amplitude sufficient to be read without a magnifier. Their correlation with avalanching may be caused by settlement or uplift under the pit, or the avalanches may directly cause the tremors. On the evening January 30th a small earthquake was followed by the squawking of a pheasant and then by a roar from the pit.

Two very slight distant earthquakes were registered respectively at 7:19 a. m. January 30th and 10:48 a. m. February 2nd. Tilting of the ground has been away from the pit toward the east and north.

On January 29th fresh cracks in the ash southeast of Halemaumau showed that wall of the pit to be working. On the 31st fresh sulphur deposit was noticed at the bottom on the south side. There were dusty avalanches February 1st and three pronounced quakes on the following night were coincident with strong avalanche signs discovered the next morning at the southwest wall. Adjacent to the tunnel of the Kau Desert rift, in the wall of the pit, the whole upper part of the precipice was freshly broken away, and one of the signal flags was gone. On the bottom were fresh fragments, and clouds of dust had powdered all the solfataric deposits, obscuring them. The ash was newly cracked for 100 feet back all along the southwest side. All that region is heavily crevassed back from the rim.

February 3rd and 4th the slides decreased and the pit was quiet. With sunny weather the gravel fields of 1924 debris northeast and the southwest of Halemaumau appear white with efflorescence of salts.

VOLCANOLOGY IN JAVA

The most colossal explosive eruption in all histroy is believed to be the Tambora outbreak of 1815. This volcano is on the island of Sumbawa east of Java. As is so often the case, it was supposed to be extinct. It began to throw out ash in 1814, became violent April 5, 1815, reached its maximum April 10, and became quiet by July 15. The top of the cone was destroyed and lowered from a height of 13,000 to 9,000 feet. The crater pit left was four miles across and 425 feet deep. The current estimate for rocks and ash ejected is 36 cubic miles. Ten thousand people were killed by burial under ash, and drowning by engulfment in the sea-waves, and 37,000 by famine and disease. The crops of the neighboring islands were buried under two feet of ash, and the houses necessarily crushed. At the height of the eruption the whole mountain was covered with showers and blasts of glowing gravel and sand, but not lava flows. The coast was reported lowered 18 feet, and elsewhere harbors had shoaled.

The volcanoes of the Dutch East Indies have produced vastly more explosive matter than all the rest of the world. There are at least four hundred of them, of which 80 show activity, and about 36 have had explosive eruptions, which ravage fearfully the fertile lands of Java and Sumatra.

Excellent topographic maps and investigations by the Office of Mines of the Dutch government at Batavia have been made for many years, but a new Volcano Committee was organized in 1919 under the direction of Dr. Kemmerling, and now under Mr. Taverne. Six memoirs on volcanoes have been issued since 1918, with colored maps and photogravure illustrations. A new one in press exhibits volcano studies made from airplane by Mr. Taverne. (G. Kolff & Co., Weltevreden, Java. Vulkanologische Mededeelingen Nos. 1-7). The photography, press work and engraving (done in Amsterdam) are admirable. Some of the large-scale maps would be improved if ruled scale, and contour interval, were given, and all these books need index maps to locate the small maps.

The first memoir deals with Sumatran volcanoes, caldera lakes and hot springs. The second is on Kelut volcano, which took 5500 lives in 1919 by throwing out its crater lake. A tunnel is beiog driven to drain it. Merapi in Java forms the subject of the third; this volcano ejected incandescent blasts in 1920-21. In the fourth the Bromo-Smeru country is described, with its sand-sea in the Tengger. The fifth deals with the northeastern archipelago, Minahassa and the Sangi islands, where the crater lake and mud eruptions of Awuh are like Kelut. And the sixth, with airplane illustrations, describes the outbreak of Galunggung 1918, with lava in the form of an andesite dome.

T. A. J.

ENGINE-MADE EARTH SHAKINGS

A measure of the sensitivity of a delicate seismograph is shown by the fact that as soon as the Fairbanks-Morse oil engine of the Kilauea Volcano House electric-lighting plant was started in December 1921, the operation of the engine was recorded on the seismographs of the Observatory about 800 feet away. Variations in the engine-speed or changes in load as well as exact times of starting and stopping were duly recorded. The engine record on the seismograms was shown as about six very minute vibrations per second. This corresponds with the number of explosions of the engine per second. Originally the engine exhausted into a steam crack adjacent to the power house, and when the exhaust was directed into the air in November 1924 the engine ceased to be recorded on the seismograph.

R. H. F.

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NO. 7 RELEASED WITHOUT COPYRIGHT RESTRICTION February 12, 1925

KILAUEA REPORT NO. 683

WEEK ENDING FEBRUARY 11, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

Conditions remain tranquil at Halemaumau pit. In the seismological laboratory of the Observatory twenty-six local seismic movements have been registered, of which more than half were prolonged tremors such as usually accompany avalanches in Halemaumau. Ten of the earth movements occurred on February 9th. At 1:34 p. m. of the 8th a felt earthquake occurred, with so short a preliminary tremor that the center must have been within a mile of the Observatory. The tilting of the ground at Observatory has been very slight to the west.

The journal of events recorded shows nothing remarkable for the 9th except a brisk northeast wind that made dust clouds on the desert, kept the debris more or less in motion in the pit, and thereby perhaps occasioned some avalanches, as the wall material in places is nicely poised. About that time also the smell of spicy sulphur from the bright yellow patch at the foot of the east talus had become strong, and that solfatara had become particularly bright in coloring. There was more of the sulphur odor than of hydrogen sulphide.

February 6th was dry and avalanches had notched the wall NNE. On February 7th there were three noisy slides in the early afternoon. There was fresh debris left on the northeast talus, and sulphur crystals were bright colored at the steam patch at the base of that slope. On both the 8th and 9th strong odor of sulphur rose. Fresh movement of the cracks back of rim southeast was observed. There was continuous rattle of falling stones southwest on the 9th, and the wall at the SW rift showed signs of more stripping.

On the 11th there was breakage in the talus, like an incipient landslip under the big north sill. In the wall made by the sill itself two vertical cracks were seen. These gaped open a foot or more and extended up and down for from 50 to 100 feet. There were possibly some corresponding cracks in the lava floor. This region at the northeast end of the pit corresponds to the place newly notched by avalanching southwest, as though the rift belt were in motion.

ROOTS OF A SCOTTISH KILAUEA

An area eighteen miles square, seventeen authors and twenty-three years of work are the elements of a new publication of the British Geological Survey, J. S. Flett, Director (Mull, Sheet and Text 44, 1924, Stanford, London. 18s.). This is a model of condensed statement, and the colored geological map needs only intercalated profile structure-sections to make it perfect.

Central Mull, surrounded by fjords, with mountains 2000 feet high, is the relic of an ancient Kilauea lowered by ring faults and profoundly worn away. The original lava dome was several thousand feet above. The root of the volcano shows siliceous and basic intrusions in a young inner series of lavas, surrounded by older plateau basalts.

Three cycles of change are shown from a basaltic mother lava to later granitic intrusives, with gradations. Silica ranges from 45% to 70%. Olivine decreases from earlier to later lavas. Inside of an encircling zone of 15 miles diameter the olivine crystals show alteration by vapors. Enough gneisses and sedimentary rocks occur both as ledges and inclusions to suggest assimilation of these rocks in the magma. The Mull complex differs from Hawaii in its siliceous sediments and granitic intrusives.

The analogies with Hawaii are many. "Pillow" lavas, bulbous, with glassy shells, are mapped in thirty places in the Mull crater area, and are supposed to have flowed into a crater lake. They are like the glassy pahoehoe formed during torrential rainstorms in Hawaii. Very Hawaiian are the ring-fractures and dykes, suggesting the "wall-crack fills" of Halemaumau. The double crater, plateau lavas, explosion dykes, vent agglomerates and gabbro intrusions all have parallels in Hawaii. The dyke swarms trending in one direction suggest the rift trends that are so definite on Mauna Loa and Kilauea, often productive of fissure eruption in Hawaii just as in Iceland.

The cone sheets of Mull are hundreds of concentric dyke-like intrusions dipping funnel-wise toward the volcanic center. Upward pressure of magma at one point is believed to have produced the funnel fractures, but the Hawaiian sinks make such inward dipping fractures by inbreak when the lava column withdraws. The ring-dykes are vertical or outward dipping crescent bodies about the central vent. One of them is an almost complete fault ring of size and shape like Kilauea, filled as a dyke with augite rhyolite. Ring tendency appears also in border folds eight miles from the center. T.A.J.

MAGNETISM IN HAWAIIAN BASALT

The magnetic compass points due north at only a few places on the earth's surface. At other places it points either to the east or west of north by know amounts. This compass error, declination or variation as it is called, is not constant for any one place but is always slowly changing.

At the rim of Halemaumau, the pit in the crater of Kilauea volcano, the behavior of the compass needle is very erratic. At some places it may show 10° easterly declination, the approximate correction for the Hawaiian Islands, a short distance away a much greater declination, no declination at all, or even a westerly declination.

Some such variation in the compass needle is to be expected in a region whose rock contains as much iron as that of Hawaii. In certain localities the percentage of iron is higher than the average or an appreciable part of the iron is in the form of the magnetic oxide and there the compass needle is very unreliable as a direction finder. One such place was found in a kipuka (a small area of older lava or soil surrounded by new lava—an oasis in a lava flow) in the 1859 lava flow from Mauna Loa by E. G. Wingate while making topographic maps for the U. S. Geological Survey in 1923. In the kipuka the compass pointed 50° to the east of north. R.H.F.

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NO. 8 | RELEASED WITHOUT COPYRIGHT RESTRICTION | FEBRUARY 19, 1925

KILAUEA REPORT NO. 684

WEEK ENDING FEBRUARY 18, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

The conditions at Halemaumau pit remain as they have been, and the greater part of the local seismic movements registered at the observatory were of the tremor type associated with avalanches at the pit. Thirty seismic movements were registered, of local origin, of which twenty-three were of the tremor type without the marked phases characteristic of sudden local earthquakes. Of the sudden ones two were felt at Kilauea, one at 6:43 a. m. February 12, and another 11:52 p. m. February 17. The tilting of the ground was moderate to the SSW.

Events at Halemaumau have shown continued peeling of the pit walls. No further developments have been observed in the crack athwart the big sill in the northeast wall reported February 11. In the different lighting of a cloudy day, February 12, the upper part of this crack appeared to have a red filling but underneath it appeared as a dark crevice extending all the way down to the talus.

On February 14 in the forenoon it was discovered that the inner ledge with its loose blocks a few feet below the rim at the tourist station southeast had fallen in. There was no fresh cracking back of the rim but there had been such cracking the previous week, showing that that edge of the pit was in motion. The portion that had fallen was the thin edge of an upright slab which has been partially detached from the wall and hanging out into the pit ever since the May eruptions of 1924.

On the 15th a new upright crack appeared in the lower northwestern wall in one of the promontories or buttresses which are characteristic of the lower walls in several places. This crack bounded a semi-detached crag about 150 feet long up and down next to a depression occupied by the northwest talus slide. On the 17th this wall was working steadily and three avalanches were seen in the wall adjoining this crack. By the next day the promontory was stripped and the crack gone.

During the last three days with light southerly wind and in spite of dry weather the steam on the bottom of the pit has been voluminous and a new sulphur patch has appeared in the east talus.

COMPARATIVE VOLCANIC ACTIVITY

One method of measuring comparative volcanic activity of different Pacific regions is by the proportion of extinct volcanoes to the total number for each district. This is based on the theory that all volcanic districts are remnants of greater activity in the Tertiary age. The percentage of dead cones in a district is called the "index of decadence." The lower the index number, the higher the percentage of live vents, hence the higher the activity as compared with other places.

In Hawaii, counting only the five complete volcanoes uninjured by faulting or erosion, only one, Mauna Kea, is extinct. Index of decadence then is one-fifth or 20%.

Von Wolff (Vulkanismus, Vol. II, Enke, Stuttgart 1923) arrives at the following index numbers (the Hawaii number is ours):—

	Volcanoes	Extinct	Index Number
1. Sumatra	117	106	90
2. S. Japan	22	16	73
3. Fuji cross-zone	40	25	62
4. Kurile Is.	51	27	52
5. Tonga Is.	15	5	33
6. Hawaii Is.	5	1	20

The extinction becomes less and the activity greater as we get more and more into the ocean.

Comparing with this the number of historical "outbreaks," we get a different order (Schneider, Volcanic Phenomena, Borntraeger, Berlin 1911).

1. S. Japan	160	eruptions
2. Fuji Zone	101	"
3. Hawaii Is.	31	"
4. Sumatra	23	"
5. Kurile Is.	18	"
6. Tonga Is.	10	"

This list means in general that the oceanic volcanoes have fewer explosive collapses than the Pacific margin, and also that Japan has the most complete records. The 160 eruptions for south Japan concern only five active cones.

Both of these lists are unsatisfactory, as the perfection of records and comparative numbers are too various, and the definitions of "extinct" and "outbreak" are elastic. But they mark progress. T. A. J.

EROSION REVIVED BY ASH-FALL

An interesting effect of the dust from the explosions of Kilauea last May is still to be seen at the sand spit on the crater floor southeast of Halemaumau and at other places along the south rim of the crater. Formerly most of the rain that fell on this sand spit quickly sank into old ash beds. Now, owing to the somewhat impervious fine ash covering, a heavy shower develops rapidly flowing streams that cut into the old ash beds and in one place the road to the pit is eroded to a considerable extent. The increased run-off is still striking even nine months after the laying down of the dust. The first downpour, after considerable dust had been deposited and before much had been either washed or blown away, produced the most remarkable erosion effects.

R. H. F.

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NO. 9 RELEASED WITHOUT COPYRIGHT RESTRICTION February 26, 1925

KILAUEA REPORT NO. 685

WEEK ENDING FEBRUARY 25, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

There was less apparent avalanching in Halemaumau pit during this week than in the previous one, and much of the time during visits to the pit the big cauldron was quiet without any noise of sliding rocks. On a very dry day February 19 the steam jets at the base of the east talus were so thin that the vents amid the broken rocks could be plainly seen and it there appeared in three places that bright yellow sulphur crystals were being deposited. These solfataras had developed rapidly, for they were amid fallen bowlders of the December avalanches. The contrast between these deposits of pure sulphur and others pale greenish-yellow at the foot of the north and south taluses is striking. Probably the sulphur at the latter is mixed with sulphates, such as are very conspicuous in vertical streaks of yellow and white at the base of the southeast wall, and in sheets of waxy white salts at the steaming vents in the lava floor near the center of the pit.

After the recent avalanches the northwest wall was seen to be notched so as to make three jagged abutments. Frequent small slides at the north wall, the odor of hydrogen sulphide, and faint hissing from the bottom of the pit were reported on the morning of February 20. Another small slide at the pit was heard that afternoon, and about 8:45 p. m. three deep detonations were heard at the Observatory.

With the dry weather chalky salts have again appeared on the high walls. In three places on the bottom of the pit there are mud flats, two of them showing much white stain when dry. During this week vapor appeared more conspicuously toward the top of the several taluses and in the wall just above the talus than heretofore. The stripping of the southwest wall has so freshened the rift dyke above the 1920 tunnels as to show that it is double, with country-rock between the two members, and a dark red fill. This is quite different from what the same dyke becomes below the big tunnel. Here it is thick and whitish. On the 23rd distinct upright steaming cracks in the body of the north talus were observed, showing that the talus matter breaks as a cake. It is remarkable how the very hot steaming slopes south and west make no deposits, although close at hand others deposit sulphur and salts. The sulphur is confined to the edges of the lava that came into the bottom in July, 1924.

Seventeen local seismic movements were registered during the week, of which seven were without evidence of preliminary tremors. One about 10:18 a. m. February 18 was felt in Kohala, and a pronounced shock partially dismantlling the seismograph at 10:20 a. m. February 23 came from an origin indicated by the seismogram as 13 miles from the Observatory. A distant strong earthquake at 1:31 p. m. February 23 appeared to originate about 4250 miles from the station, but neither the time nor the distance accorded with the destructive shock reported from Seward, Alaska. Tilting was moderate to the NNW.

INTERNATIONAL VOLCANOLOGY

The first publication of the volcano research section of the International Geodetic and Geophysical Union has made its bow to the public. This quarterly bulletin was published in Naples, September, 1924, by the secretary-general, Professor A. Malladra, Director of the observatory on Vesuvius. (Bulletin volcanologique, Royal Vesuvian Observatory, Resina, Italy, 30 fr. per annum).

It is in French and Italian and deals with the meetings in Rome and Naples 1922, and the program of the Madrid conference 1924. The American committee was evidently active, and its personnel and recommendations reflect the recent Pan-Pacific Science conferences.

Plans are outlined for a Central Bureau of Volcanology, which has now been established at Naples; for subordinate branches, with international libraries, at the Hawaiian Volcano Observatory and at the Italian institute of Catania, Sicily; for international cooperation that will furnish information instantly by wire or post, through the Bureau or its branches, of new volcanic activity anywhere; for urging naval establishments and mariners to give information about marine or submarine volcanic happenings; and for the preparation by each nation of a topographic, historical and statistical catalogue and bibliography of its volcanoes.

On May 8, 1922, on motion of Professor A. Lacroix, President of Section, it was

Resolved:—"(1) That, by reason of the services rendered to date by the volcanologic observatories of Vesuvius and of Kilauea, facilities should be accorded them for continuation of their work, and an institute of the same kind should be established for the study of Etna and the Eolian Islands;"

"(2) That continuous observations of volcanic phenomena should be made at the island Re'union."

Other matters given attention were underground thermal gradients, volcano borings, utilization of volcanic energy; papers published are on the activity of Vesuvius and Etna, on a new cinder island off the coast of Cochin China, on the power plant of Prince Ginori Conti using natural steam in Tuscany, and on volcanic potash, alumina and silica obtainable in the United States and Itlay; and a notice on the work of the late honored Professor A. Ricco of Catania, student of Etna, the first president of the volcano research section. T. A. J.

THE VOLCANIC DEATH-TOLL

Since the year A. D. 1500, 98 eruptions of 57 volcanoes have destroyed 190,000 people. Of these 176,500 died on the Pacific half of the earth. Tambora near Java in 1815 accounted for more than 56,000 victims; next came Krakatoa in the Sunda Strait in 1883, killing 36,400 mostly by a flood. This was set up by the collapse of the island, and engulfment of the sea; outgoing tidal waves swamped the fishing villages on the neighboring coasts of Java and Sumatra. Mont Pe'le' in Martinique and Soufriere in St. Vincent in 1902 together accounted for some 30,000 lives by ejecting fiery blasts and showers of stones. Ten thousand deaths each are credited to the volcanoes Laki in Iceland in 1783, Kelut in Java 1586 and Unzen near Nagasaki in Japan 1792. To these seven eruptions four-fifths of the death toll have been paid. These figures have nothing to do with the terrible earthquakes and consequent fires of volcanic regions, such as Tokyo in 1923 and Messina in 1908. These two modern earthquakes destroyed more than twice as many lives as all the volcano outbreaks of history. (See Sapper's catalogue of eruptions, Strassburg Scientific Society, 1917). T. A. J.

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NO. 10 | RELEASED WITHOUT COPYRIGHT RESTRICTION | MARCH 5, 1925

KILAUEA REPORT NO. 686

WEEK ENDING MARCH 4, 1925

Issued by the Observatory, U. S. Geological Survey:

T. A. Jaggar, Official in charge

The week has been rather quiet with reference to avalanching in Halemaumau pit, and on some days a visitor to the pit heard no rocks sliding at all. At noon of March 2nd however during fresh squally northeast wind and very dry weather, the northeast corner of the pit started caving away.

The air in the pit became charged with dust so that the whole orifice was outlined by the swirling veils. Occasional small individual clouds of dust rose, but nothing that suggested a big avalanche. The whole northeast talus next day was covered with fresh red rock fragments. In the middle of the wall above, about the eastern horn of the large sill, a notch several hundred feet high had been left, revealing red ochreous rock and white or greenish brown vein matter. The notched place was fissured up and down for hundreds of feet, the fractures appearing to trend in the direction of Keanakakoi.

Nothing but small slides have occurred during visits to the pit. There are six sulphur-lined holes venting steam in the east talus where the latter overrides the lava floor, and there is also sulphur at the top of that talus. The hotter looking vents, giving up dense flocculent steam south and west, deposit no sulphur. Irregular red bodies of large size, above and surrounded by the big sill north and the large intrusive mass west appear as though they might have been crags in an ancient pit of which the sills formed the bottom. The middle of the north sill has an upward extension in section shaped like a mushroom, with fossil talus slopes on each side. Right and left the sill rises into horns behind these taluses, suggesting the vents that we have seen so often breaking out from the top of a debris slope.

It is difficult to say what starts the avalanche notches to working as on March 2 mentioned above. The steep northeast and southwest walls have breakage lines up and down that the other walls do not have, possibly traces of the Kau Desert shear zone. The northeast wall has avalanched more than any other. It may be that this zone moves seismically. There have been 17 local shocks during the past week, 12 of them without earthquake phases, and one at 7 a. m. February 28 felt here with indicated origin 2 miles away. Tilt was moderate to the northeast.

MORE COMPARISONS OF VOLCANO DISTRICTS

Taking Sapper's data and combining his small zones into districts with a view to getting 18 to 32 volcanoes in each district, we have the following:

Activity by number of volcanoes active for aggregate length of volcanic zone.

Total number active	District	One volcano active per length of
1. 25	Iceland	25 kilometers
2. 26	Central America	45 "
3. 25	Aleutian Is.	50 "
4. 19	Java	55 "
5. 18	New Zealand—Tonga	77 "
6. 24	Kamtchatka—Kurile	85 "
7. 25	Japan	100 "
8 41	South America	104 "
9. 18	Mediterranean	120 "
10. 26	Sumatra—Sunda Is.	127 "
11. 32	Philippines—Molucca	138 "
12. 18	Atlantic Ocean	192 "
13. 25	Melanesia	224 "
14. 30	North America	275 "

The central Pacific islands (Juan-Fernandez, Galapagos, Hawaii, Samoa and submarine eruptions) number 15 or 16 known vents and in indefinite number of unknown ones. They cannot be treated by length of belts.

To one knowing the places, the order of this table as showing decreasing volcanic activity is no more satisfactory than Von Wolff's table by "index of decadence." Both are based on unproved theoretical assumptions. This one assumes that the number still smoking in a given distance is an index of the activity of that area. But it overlooks the fact that two regions may have the same number of active volcanoes for the same distance or area, yet the activity of the whole district may be much greater in the one than in the other. (See Sapper. Volcanological Review, 1917). T. A. J.

EARTHQUAKE IN ST. LAWRENCE VALLEY

Press reports of this week tell of a disastrous earthquake February 28 in eastern Canada, centering about the St. Lawrence, with the loss of at least three lives, and "scores of homes damaged by earthquakes and fire, and one church collapsed." The Saguenay river was near the center. This is a deep canyon forming a northern tributary of the St. Lawrence, below the Thousand Islands, with Tadousac at its mouth. It is well known earthquake district, and so is the Labrador, farther to the east.

This recalls the earthquake of 1663 in the same district, of which Clarke, state geologist of New York, writes that "no like catastrophic upheaval of the earth has ever occurred here within the memory of man." "With a roar as of artillery the earth leapt up, houses tottered, walls were split, river banks were levelled, new lakes were seen, two mountains were overturned into the river and dammed it; forests were swallowed up leaving what looked like ploughed fields; chasms of wonderful depth exhaled a foul stench, and rivers resembled in color streams of milk or blood." So run the old Jesuit chronicles. T. A. J.

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NO. 11 RELEASED WITHOUT COPYRIGHT RESTRICTION March 12, 1925

KILAUEA REPORT NO. 687

WEEK ENDING MARCH 11, 1925
Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, Temporarily in Charge

The past weeks was rather quiet up to March 10th. On this day some of the most spectacular avalanches in several weeks occurred. One at 12:52 p. m. sent up cauliflower clouds that maintained a hard outline for some little distance above the rim of Halemaumau pit. There was another large avalanche at 5:09 p. m. that crashed to the bottom with a roar that was almost deafening to observers standing on the rim. The pit was more or less dusty all day from the many small avalanches.

At the same time as the increase of avalanching there was an increase in the number of earthquakes. During the past week 32 earthquakes were registered at the Observatory, 23 of which occurred between 10 p. m. of March 9 and 6 a. m. of March 11. Four of the earthquakes were of sufficient intensity to be perceptible. The one at 8:14 a. m., March 10, felt as a distinct vertical jolt, had an indicated distance of about 1 mile. Another at 1:06 a. m. March 11 with about the same indicated distance, dismantled the seismographs and awakened many people.

The tilt for the week as a whole was moderate to the east-northeast. Just preceding the increased earthquaking the tilt changed from moderate southeasterly to moderate northeasterly.

A heavy fall of snow on Mauna Kea and Mauna Loa that accompanied the general rainstorm of March 7 and 8, will help to increase the available water supply on the two mountains next summer.

Immediately following the rain storm a large portion of the walls of Halemaumau showed a deep red color, giving the walls almost a velvety appearance. The red color is probably due to rain water percolating through the rock and bringing some of the iron salts to the surface where they are oxidized to iron rust. The bright red color persisted for but a short time probably becoming obscured mainly by dust from avalanches.

EARTHQUAKES IN HAYTI

A welcome volume has just appeared on the geology of Hayti by geologists Woodring, Brown, and Burbank, who were loaned to the West Indian republic by the U. S. Geological Survey. Volcanic lavas poured out in basaltic floods from central vents when the land mass was greater than at present. This was in Jurasic time or earlier. Andesites and more silicious lavas came later. There is still younger basaltic series, with intrusive rocks, of age between Mesozoic and Tertiary. Then came later acid andesites and quartz diorites. All of this was amid marine and non-marine sediments with folding, metamorphism and faulting from Mesozoic times on, and present day features are many of them the products of late Tertiary crumpling.

This movement is still going on, earthquakes are frequent, and those that are felt generally in Hayti originate in the ocean troughs, more localized shocks are related to particular peninsulas, and the central mountains are mostly immune. This is like the situation in the Philippines and the continental island masses. The recent volcanic and sesismic geology are typically cordilleran and like Alaska and the Coast Ranges.

At the meteorological observatory in charge of Rev. J. Scherer, Port-au-Prince, is installed a pair of Bosch-Omori horizontal pendulum seismographs, magnification 40X, which is stated to be "useless for determining the direction and amplitude of local shocks." This machine ought to be ideal for local shocks, with suitable modification of speed of drum and damping such as a physicist-experimenter could easily devise. We suspect that the Bosch air damper is making trouble, and it should be replaced by two or three metal vanes in oil.

The attitude toward this instrument as quoted is typical of much amateur handling of seismographs, owing to unwillingness to experiment, and an unnecessary awe of the supposed constants of the pendulums.

There were seven disastrous earthquakes in Hayti between 1551 and 1908, none of them occurring in the central region. They usually were accompanied by flood waves. The chart shows from six to forty earthquakes recorded in different places between 1909 and 1922, of which from two to twelve at each locality represented general shocks of widespread importance. The northwest peninsula and the north side of the southern peninsula are the regions of highest seismicity. None of the recent shocks was accompanied by a sea wave.

Most of them have intensity II to IV (Rossi-Forel), but a few reach grade VI. A shock on January 15, 1922 cracked ferro-concrete houses. (Geology of Hayti, 1924, English and French editions, Department of Public Works, Port-au-Prince). T. A. J.

VISITORS AT THE OBSERVATORY

On March 10 and 11 the Observatory was fortunate in having as visitors the distinguished geologists of the Third Asiatic Expedition of the American Museum of Natural History, Dr. C. P. Berkey and Frederick K. Morris and the topographer, Major L. B. Roberts.

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NO. 12 | **RELEASED WITHOUT COPYRIGHT RESTRICTION** | MARCH 19, 1925

KILAUEA REPORT NO. 688

WEEK ENDING, MARCH 18, 1925

Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, Temporarily in Charge

After the avalanching and earthquakes reported last week Halemaumau became more quiet and during the past week only thirteen earthquakes were registered at the Observatory. None of the earthquakes were perceptible at Volcano House and seven of them were without phases.

Some of the cracks concentric to rim of pit where there has been movement recently are quite hot. One of them that crosses the trail to the pit shows but little steam ordinarily but if a lighted match is held near it great volumes of steam become apparent. Smoke from a burning object affords an opportunity for the moisture to condense and if held near a hot crack that is already steaming vigorously there will be a great increase in visible moisture.

On March 13 the steam from the bottom, which is always present, rose in hard outlines as though with a greater velocity or hotter than common. During rainstorms and on rainy days the pit is often so full of steam that the bottom can only be seen occasionally.

The sulphur stained area near the southeast border of Halemaumau floor that was obscured by recent avalanches is again visible.

Tilting during the week was moderate to the south-southwest.

PHILIPPINE EARTHQUAKES

Recent papers in the Bulletin of the Weather Bureau, Manila, by Father Maso, show that 52 destructive earthquakes, or about two per year, occurred in the Philippines during the first 22 years of this century The strongest originated in the Pacific and in the Celebes Sea Shocks from the land or the shallow seas were of small extent. The damage was mostly to old or badly preserved buildings. Old tile roofs were particularly dangerous. Places in recent alluvial soils suffered most.

Shocks became more numerous from west to east, or in the Pacific direction, where the relief due to profound deeps is most pronounced. Shocks occur in clusters, calm years alternating with disturbed periods, and infested places likewise shifting. Manila had bad earthquakes in 1863 and 1880. 320 people were killed in 1863, and only about 20 in 1880. Houses of mixed construction, masonary below and wood above, resisted the earthquakes well.

The Agusan Valley in eastern Mindano is the most active region seismically. The earthquakes are most felt in the level marshy central part of the valley where there are lakes and where subsidence occurred during earthquakes of 1893 and 1894. Just to the east lies the great Pacific trough. A big earthquake occurred in this valley, July 12, 1911. T. A. J.

VOLCANIC ACTIVITY BY OUTPUT

		Cubic Kilometers Lava	Cubic Kilometers Explosive
1.	Iceland	15.5	10.0
2.	Central Pacific	10 plus	1.0
3.	Kamtchatka-Kurile	6.0	1.2
4.	Mediterranean	5.1	4.0
5.	Atlantic	4.5	2.2
6.	Japan	3.00	6 2
7.	South America	1.2	9.0
8.	North America	1.0	1.2
9.	Central America	0.6	44.0
10.	Aleutian Is.	0.5	2.5
11.	Philippines-Molucca	0.4	5.8
12.	Melanesia	0.1	3.1
13.	Java	0.1	10.0
14.	Sumatra-Sunda Is.	0.1	172.0
15.	New Zealand-Tonga	0.01	3.1

This table, arranged by decreasing lava production as estimated from eruptions since the year 1500 A. D., and exhibiting for comparison the production of explosive material, shows that lava and explosive material are at opposite ends of the series. Iceland, the Mediterranean and Japan indicate that both may be ejected in large quantities from the same region. Volcanologically this table is satisfactory. The oceans and sub-arctic regions are the great lava producers, the continental borders and the tropics produce much explosion. It is remarkable that the Americas fall together the Atlantic with the Mediterranean, and the Pacific island chains at the explosive end of the series.

Yachtsmen fond of exploring may with the new hydrophones make great discoveries of immense volcanic domes, as large as Mauna Loa perhaps, on the bottom of the oceans. A mountain 8000 feet high stands on the sea-bottom between San Francisco and Honolulu. (Data above arranged from Sapper). T. A. J.

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NO. 13 RELEASED WITHOUT COPYRIGHT RESTRICTION MARCH 26, 1925

KILAUEA REPORT NO. 689

Week ending March 25, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in Charge

The equinox produced no crisis at the volcano. Seismically the past week was the quietest since last November, only eight earthquakes being recorded. An earthquake with an indicated distance of four miles at 5:34 p. m. on March 20 was strong enough to be perceptible. The other seven shakes were very small, three of them being without phases. A distant earthquake with poorly indicated distance of 3600 miles from Observatory occurred at 10:28 p. m. March 21. A report from another station points to a possible location near Kamtchatka.

Some avalanching took place at Halemaumau, the active pit of Kilauea volcano, on March 20 and 21. The majority of the earthquakes for the week occurred on those days. Since the last named date the pit has been rather quiet. A large piece of the eastern end of the northern intrusive body broke off on March 20 making a gray talus slope below. On March 25 the northeast and north wall were avalanching slightly.

Tilting during the week was slight to the east-southeast.

A SHARP TRANSITION FROM FOREST TO DESERT

An interesting but often unnoticed sight on the road to Halemaumau in Hawaii National Park is the sudden change from forest to desert. The northeastern slope of Kilauea is forested and most of the southwestern slope is a desert. The zone of transition is near the summit of the mountain. Instead of being a broad zone that commonly separates forested from desert lands here the zone is narrowed almost to a line. In traversing a distance of 1000 feet one leaves a forested area and enters an open desert.

The change is due almost entirely to difference in rainfall nad not to volcanic fume as is sometimes supposed. The soil in the desert, volcanic ash, is the same as that of the forest. In order for fume to cause the sharpness of the desert edge there should be considerable westerly wind, but west winds are very uncommon at Kilauea. Southwest winds are not uncommon during winter months and occasionally trees are partially defoliated by volcanic fume near Volcano House but rapid growth soon covers up such effects. Stunted growths of ferns, shrubs, and trees are to be found on the lee, or fumy, side of the fire pit, occasionally less than half a mile away. The transition from forest to desert continues as a line extending for several miles down the mountain side.

The rainfall is controlled by topography and constancy of wind direction. In the forested area the air of the northeast trade winds is forced up the mountain slope and cooled off to produce rain. On account of thus losing moisture, air on the lee slope of the mountain is drier that it is on the windward slope. As soon as the air starts down the mountain slope its temperature rises and not only does the rainfall diminish but even the clouds tend to evaporate. R. H. F.

ANNUAL MEETING OF THE ASSOCIATION

The Hawaiian Volcano Research Association at its meeting in Honolulu March 12 reelected its Board of Directors. The officers are L. A. Thurston, president; C. H. Atherton and W. F. Dillingham, vice-presidents; L. Tenney Peck, treasurer; directors are W. R. Castle, Arthur L. Dean, W. W. Thayer. L. W. de Vis-Norton, Young Building, Honolulu is secretary of the Association.

Reports were read by the treasurer and the secretary, and addresses made by the president and by the volcanologist of the Hawaiian Volcano Observatory, who acts as scientific director for the Association.

At present the division of effort between the Government, through the United States Geological Survey, and the Association is as follows. The Government pays salaries, keeps daily journal and seismograms, prepares and issues the routine reports, maintains the plant, the routine, and expeditions when needed, and provides for the larger publications in Washington. The Association is improving the outlying seismological stations and operating them, building up the library of the station, providing for publication of a popular book on volcanism, printing the local publications including the VOLCANO LETTER, and is ready to assist in securing the services of cooperative workers in the chemical laboratory and in the laboratory for steam experiments built over the bore holes at Sulphur Bank.

The address of the Volcanologist was entitled "'National standards of volcano and earthquake research" and will be printed in the March Bulletin of the Observatory. The staff of the Observatory has succeeded in bringing the printing of the monthly bulletins nearly up to date, they are published and distributed to November 1924 inclusive, and ready for the press to February 1925. The December number will contain a discussion of "Volume relations of the explosive eruption." T. A. J.

TIDAL OSCILLATIONS IN HALEMAUMAU

Dr. Ernest W. Brown, in charge of the Department of Mathematics at Yale University and well known for his astronomical work as computer of the complicated motions of the moon, has published an analysis of the lava tide measurements of Halemaumau made by the staff of the observatory in 1919. He concludes that there is enough evidence of tidal effect to warrant repeating the work by a different method for a longer period. (American Journ. Sci. February, 1925). T. A. J.

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NO. 14 RELEASED WITHOUT COPYRIGHT RESTRICTION APRIL 2, 1925

KILAUEA REPORT NO. 690

WEEK ENDING APRIL 1, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in Charge

Halemaumau pit remains tranquil, after a week of extremely rainy weather, and by the wetting of the walls the red color of lava layers is brought into prominence. The reddening is due to oxidation of the iron in the rock, and above the several intrusive bodies is far more conspicuous than elsewhere. The bank of yellow and white sulphates at the base of the southeast wall lost all its color after the rains. The alums and other soluble salts at the edge of Kilauea crater were also washed down. There must be a concentration of these soluble products underground.

In the pit there has been very little sliding of debris. Some new fallen fragments were observed on the northeast talus. A dry patch with sulphur stain on the high north wall, where the rock all around was wet with rain, appears to mark the site of the blue fume vent which disappeared during a November avalanche. The steep cavern in cracked ground north of Halemaumau has recently collapsed, and is now close to rim of pit, so much has the edge caved away.

An examination of Keanakakoi gulch March 28th revealed new erosion and a new debris fan on the Kilauea floor. The 1924 ash both increased the run-off by its impervious surface and furnished cutting material to the water. New white spots on the Kilauea Iki floor are rain-wash hollows filled with ash-mud.

Fourteen seisms were recorded during the week, seven of which were without phases, and five very small were on March 31. A local shock at 12:30 a. m. March 29 was perceptible and had indicated origin distance of about one mile. Tilt was slight to the ENE.

ERUPTION OF BOQUERON, 1917

The republic of Salvador on the southwest coast of Central America contains ten active volcanoes along a zone of volcanic upbuilding over fault fractures between the Pacific coastal plain and the Guatemalan plateau. The zone trends curving into Mexico and Nicaragua with convexity toward the ocean as in so many of the Pacific chains of volcanoes. At the south end of the line is Coseguina and near the north end Santa Maria, both volcanoes that have made gigantic explosive eruptions in the last century. Salvador in the middle of the curve has a group of lava-making volcanoes rising to heights of 6000 feet from a plateau 2000 feet above the sea.

West of the capital San Salvador rises the volcanic peak of the same name 6400 feet above sea level, and a little lower on the west is an active volcano whose crater "Boqueron" contains a lake of water 1300 feet in diameter and 1200 feet below edge of its pit. In the district are other crater lakes and volcanoes such as El Playon and Izalco. El Playon produced a lava flow 3 miles long in 1659. Fiercely destructive earthquakes have wrecked San Salvador city twelve times, usually with volcanic accompaniments.

Beginning June 6, 1917 the volcano Boqueron achieved the thirteenth catastrophe, splitting open its northwestern flank, throwing forth a stream of rough aa lava, flinging up ash and cinder with thunderous noise, and wrecking towns and coffee plantations with a succession of earthquakes that lasted a week.

At 6:55 p. m. June 6 came a terrific shock of 15 seconds duration, fifteen towns were wrecked including the capital, 100,000 people were left roofless, several hundred were killed and many were wounded. Streams were dammed and deflected, water supplies were cut off, bridges fell, refugees in the country found the public ways broken and blocked, and mountain sides slid down. The district of wreckage was twenty miles across. In its midst stood Boqueron.

At the first shock buildings went to pieces, at the second landslips broke loose, and at the third the flank of the volcano exploded. The new crater fissure opened just above the plantation Las Granadillas. Nine craterlets formed in a row five miles long, the lowest "El Tronador" or the "thunderer" giving vent to a lava flow. The lava was at first so liquid that some people were caught and killed by it. There were houses only fifty feet from the place of outbreak, and these along with several plantations in the track of the flow were destroyed. The flow reached a length of four miles.

Cinder and ash explosions accompanied the outbreak, and mud rains fell at the city to add to the sufferings of the homeless population. The volcanic gases were strong, and the acid ash rain on bare-headed wanderers was said to cause the hair to fall out. The coffee plants were defoliated for miles around. Nine plantations were partly or wholly demolished. In them the explosive material averaged six inches in depth, but in Las Salinas the ash was four feet deep. In its deeper fillings the lava was 160 feet deep.

The crater lake at Boqueron showed boiling and wave motion, there were steam jets, incaving sides to the big crater, and cracks back from the rim. In June there was an apparent rise of lake level. In July the lake had sunk away and evaporated, white cauliflower clouds came through a bottom fissure, and then a circular cinder cone was built up. (Friedlaender, Volcanological Review, 1918).

T. A. J.

VOLCANOLOGY IN SALVADOR

We have received from Senor Jorge Larde' an account of the volcano Izalco (Government publication, San Salvador 1922). An observatory with seismograph has been established. Izalco is almost continuously active, the Republic is a stable well-governed little country, and with seismic and volcanic events numerous throughout the land, Salvador is an ideal laboratory of volcanologic science for any benefactor or institution wishing a place wherein to establish continuous work. The writer visited Salvador in 1910 and found it most hospitable and attractive. T. A. J.

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NO. 15 RELEASED WITHOUT COPYRIGHT RESTRICTION APRIL 9, 1925

KILAUEA REPORT NO. 691

WEEK ENDING APRIL 8, 1925
Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, Temporarily in Charge

The volcano continues to be rather quiet. Avalanches have been rather infrequent since the middle of March. During the past week the few avalanches noted occurred mainly on March 6, 7, and 8. Considerable steam arises from cracks concentric to the rim of the great pit in Kilauea crater as well as from the floor of the pit itself. The odor of hydrogen sulphide has been very slight during the last few days.

Not only is the pit quiet as observed by the eye but also the seismographs at the Observatory two miles away show less activity than at any time since the middle of Novem ber 1924. Only eleven earthquakes were recorded during the week, none of them being perceptible at the Volcano House. The tilt was very slight to the south-southwest. This is the usual direction of tilt for this time of year but the amount is smaller than usual.

During the recent rain spell one could frequently be in the midst of light rain at the hotel and observe dust clouds about three miles away in the desert.

THE VOLCANOLOGICAL REVIEW

Articles from the "Volcanological Review" have been quoted in the LETTER. The Zeitschrift fur Vulcanologie is issued from Naples, with the title in German, Italian, English, and French and printed in Berlin (Dietrich Reimer Co., Berlin, SW. 48, Wilhelmstrasse 29, 20 marks per volume). Dr. I. Friedlander is the founder and financier of the magazine at his Volcanologic Institute in Naples. The type is large, the paper heavy, the plates in heliotype and color, the substance sound, cosmopolitan and scientific. Four to six numbers are issued per year and the authors are of all nations, writing texts in any of the four languages. Six extra monographs, in part subsidized by the Institute, have dealt with volcanic bombs, the north Moluccas, Vulcano in the Lipari Isles, the Nyassa volcano district of Africa, the Cape Verde islands and some volcanoes of Iceland.

The seven volumes from 1914 to 1924 contain, by American authors; a description of the Teneriffe eruption in 1909 by Perret; another by the same author on Sakurajima; a discussion of lava tunnels in Hawaii by Hobbs; recent eruptions of Poas in Costa Rica by Tristan; new islands at Sakurajima by Powers, and articles by him on intrusions at Kilauea, and on Yakedake in Japan; and the activity of Irazu in Costa Rica by Tristan.

Hawaii is abundantly noticed with many reviews of work done here, descriptions of its peculiar stalacities, bombs, and small products, its fault valleys, the spacing of its volcanoes, its gases, its blowing cones, and by a special article by Friedlander on the island Kaula.

There are articles on the volcanoes in Java, the Moluccas, New Guinea, Central and East Africa, Iceland, Mexico, Nicaragua, Japan, Guatamala with its pairs of twin volcanoes, Lower California, and Italy, as well as reviews and descriptions of old volcanic districts in many parts of the world.

Of philosophical interest are the studies of hydrostatic equilibrium at volcanoes by Friedlander; of temperature and pressure inside the globe by Klussman; of the rift valleys and seismicity of Africa and the Red Sea by J. W. Gregory and E. Kreubel; of the spacing of volcanoes by Friedlander; of the geography of volcano distribution by Sapper, Arldt, and Schneider, of the crustal mechanism of granite intrusion by Cloos; of volcanic activity by Hempel; of earthquake depth by Quervain; of volcanic fault valleys, like the Haleakala gaps, by Friedlander; of magmatic distillation processes by Niggli; of volcanism and mountain building by Schwinner; of volcanic fault-block mountains by Reck; of volcanic gases by Salvatore, Friedlander, and Allen (review by Sonder).

No single publication in the history of science has done so much to establish volcanology on a sound and common sense basis as Dr. Friedlander's splendid publications, and as he is well known in Hawaii for his travels here, his interest in Kona, and the explorations of himself and his brother on Mauna Loa and Kilauea, these volumes should have a place on many Hawaiian shelves. T. A. J.

VOLCANIC ASH CEMENT

If one takes a walk into the desert to the southwest of Halemaumau he can not fail to notice the hard cemented crust that covers the ash from Kilauea in many places. The natural cementing action of the 1790 ash has preserved footprints of that time so that not only do the outlines of the feet show but also the individual toes.

The use of volcanic ash in cements was well known by the ancient Greeks and Romans and many structures made with this material and slaked lime as cement are in good state of preservation today.

Experiments on the nature of the cementing action of the 1790 ash from Kilauea made by J. C. Riperton of the Federal Experiment Station in Honolulu indicated that it is due to the formation of collodial or gelatinous compounds of silicon and subsequent dehydration. It should be noted that such an action is one of the explanations for the setting of Portland cement. R. H. F.

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NO. 16 RELEASED WITHOUT COPYRIGHT RESTRICTION APRIL 16, 1925

KILAUEA REPORT NO. 692

WEEK ENDING APRIL 15, 1925
Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, Temporarily in Charge.

Seismically the past week was the most active in a month. Of the 15 earthquakes that were registered at the Observatory, five gave records distinct enough for the distance away of the shaking to be calculated. The one at 1:37 a. m. April 9 awakened many people at the Volcano House and vicinity and dismantled one of the seismographs. The three local earthquakes on April 11 were at indicated distances from Observatory of 13, 6, and 2 miles respectively. The recording of earthquakes of such distances so close together may be taken as an indication of movement along either the northeastern or southwestern rift from Kilauea. A slight earthquake that awakened a few people near the Volcano House at 5:38 a. m. April 15 had an indicated distance to origin of 19 miles. The distance away of a slight distant shake at 2:31 a. m. April 11 could not be determined.

The resultant tilting for the week was very slight to the north-northwest, though there was a moderate southeast tilting on the 10th following by a rapid recovery or northwesterly tilting on the 11th.

The volcano as a whole has been rather quiet, though avalanches from the walls of Halemaumau can be seen and heard nearly every day. Most movements appear to be at the north wall above the large gray intrusive body there. In some places the accumulation of avalanche material is sufficient to bury a large part of the intrusive body. A sulphur stained area near southeastern border of the pit floor has been extending itself toward the center of the pit on the black lava fill of July 1924.

The brisk winds on April 15 stirred up heavy dust clouds in the Kau Desert and small ones on the Kilauea crater floor.

SUBMARINE LAVA FLOWS

Several submarine eruptions have been reported from different places off the coast of the island of Hawaii and other ones, not observed, have been surmised.

The northeast and southwest rifts from Kilauea and the southwest rift from Mauna Loa are known to terminate under the ocean and as lava flows are known to issue as fissure eruptions all along these rifts from the summit of the mountains to the shore it is easily possible that some of them still take place under the water.

The frequent withdrawal of lava from Halemaumau, the active pit of Kilauea, has sometimes been explained by assuming a submarine drainage. This may or may not be true as a subterranean flow within the northeastern or southwestern rifts might easily account for all the liquid lava that disappears from view.

In 1868 there was a withdrawal of liquid lava from Halemaumau followed by a profound collapse. A small amount of lava appeared along the southwestern rift about 10 miles from the volcano, and the ground was fissured at least as far as the ocean near Pahala. There are nothing but very meagre reports of the possibility of the lava appearing on the ocean floor along the extension of southwestern rift in this year.

In 1877 good observations were obtained of a submarine eruption from Mauna Loa but not along the well known southwestern rift. This eruption was in Kealakekua Bay almost due west from the summit of Mauna Loa. On February 24, 1877, following activity at the summit by a few days, there were earthquakes near Kealakekua Bay that left a visible fissure on land. Red, green, and blue lights, amidst steam, appeared about one mile off shore. The boats that were rowed through the scene of action were frequently hit by rising pieces of lava. These lava fragments, very light and frothy, were generally red hot when they reached the surface of the water but quickly cooled and sank.

One of the strangest accounts of a submarine eruption here is given on pages 245-246 in Vol. 2, Fire Fountain of Hawaii, by C. F. Gordon Cumming This eruption is strange because reported from a place where such an eruption might not be expected, off the northeast coast of the Island of Hawaii. The 1880-81 lava flow from Mauna Loa that started on November 5, 1880 was in progress and the entire Island was shrouded in smoke. About November 19 while the schooner Pauahi lay to, apparently near Honokaa, "The sea seethed and boiled, clouds of steam and masses of pumice were thrown up as in a fountain and the display lasted about three minutes." A similar display astern of the schooner immediately followed.

Hitchcock in Hawaii and its Volcanoes mentions a submarine flow off Puna in 1884 and another off Hilo in 1906 but gives no detailed information nor authority.

Submarine contours indicate numerous flows off the east and south points of the Island of Hawaii. The northeastern rift from Kilauea and the southwestern rift from Mauna Loa enters the ocean near these points respectively.

In 1922 and 1923 there were subterranean drainage and collapses of Halemaumau with very small lava flows appearing in or near Makaopuhi crater about eight miles away. In 1924 there was a profound collapse of Halemaumau and indications of a subterranean, possibly submarine, drainage in the northeastern rift. R. H. F.

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NO. 17 RELEASED WITHOUT COPYRIGHT RESTRICTION APRIL 23, 1925

KILAUEA REPORT NO. 693

WEEK ENDING APRIL 22, 1925
Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, Temporarily in Charge.

There is but little change in visible conditions at the volcano. While avalanches occur nearly every day they are for the most part rather small and merely represent progress of the material in a steep wall toward a more stable angle of repose. None of the earthquakes during the past two weeks seem to have affected the walls of Halemaumau to any extent as there is no evidence of any appreciable movement along the cracks concentric to the rim.

The odor of hydrogen sulphide has been rather noticeable of late and occasionally one can detect the odor of free sulphur. When gases are emanating from a volcano during quiet spells hydrogen sulphide is usually conspicuous while with molten lava present sulphur dioxide is the most characteristic gas. Hydrogen sulphide is a combustible and explosive gas and sulphur dioxide is a burned gas.

Considerable sulphates in the form of white incrustations are to be seen on the walls of the pit as well as on the floor. The deposits on the floor area are for the most part, along three parallel steaming lines that trend northeast-southwest.

During rainy spells the pit is often so full of steam that one can scarcely see into the pit. The noise from a large avalanche at such a time is exceedingly wierd.

Seventeen earthquakes were recorded during the past week. The one at 8:52 p. m. April 20 which was felt locally had the appearance of a Mauna Loa shake. An earthquake that was generally felt at Volcano House at 12:29 p. m., April 16, had an indcated distance to origin of two miles from Observatory. Most of the other local earthquakes appeared to have their origins one to two miles away. A slight record of a distant earthquake was written on the Observatory seismographs about 5:30 a. m., April 19. Newspapers report a disturbance in Japan about this time.

Tilting during the week was moderate to the west-southwest.

THE ASH DEPOSITS AT KILAUEA VOLCANO

While excavating for a cesspool in the Observatory grounds on July 12, 1924, good evidence was obtained to prove that the ash surrounding Kilauea Volcano represents the deposits of several different explosive periods. While the deposit is frequently spoken of as "the 1790 ash," the majority of geologists who have worked around Kilauea assumed that it represents at least two or more distinctly separated explosive periods.

Hitchcock in "Hawaii and its Volcanoes," speaks of soil interbedded in the ash and calls the 1790 discharge comparatively mild. Dr. Sydney Powers (American Journal of Science, March, 1916) who was one of the first to make any extended study of the ash, found not only evidence of an appreciable time interval between the laying down of different layers (uncomformity) but also that the Keomoku lava flow from Mauna Loa, which occurred prior to 1790, overlies ash deposits. Prof. Sherzer (Science, April 20, 1923) thought that the ash deposits are the product of three explosive eruptions though it may well be that there were many more than this number.

At the base of Uwekahuna Bluff there is an ash bed (now nearly obscured by the lava flows of 1919) under nearly 500 feet of lava flows that must have been laid down long before the deposition of the oldest of the deposits that now compose the present surface.

An unconformity between a thin superficial layer and older deposits that can be traced up hill and down dale at the south side of Kilauea indicates that only a small fraction of the total ash beds represents the 1790 ash. When the 1924 explosion material on the crater floor shall have become buried by lava flows the only evidence left of the 1924 explosion will be a thin layer of ash outside the crater on the desert side and it will be difficult to find any separation between the 1790 and 1924 deposits.

The molds of several small trees or other vegetal growth were found in the excavation in a slightly eroded layer about two and a half feet below the present surface. Two feet or so below this layer other and larger holes were found that may well have had their origin in the decay of buried trees. In all about 15 well defined were strata noted. In several cases there were indications of deposits on old and weathered surfaces of previous ash layers. It should be noted that any explosive period may lay down several well defined strata.

As the tree molds were excavated in the rain belt and considering the natural cementing qualities of the ash as well as the fact that the thickness of each layer was quite constant it does not seem probable that much of the material was ever moved by wind after it was laid down. Owing to the flatness of the location and to the porosity of the ash the possibility of erosion and transportation by water to effect the burial of small trees or sticks may be dismissed. The only other explanation is that the vegetal growth was buried by ash during some explosion of an appreciably later date than the one represented by the layer in which the vegetation was growing. What the time interval between the deposition of these layers was is not known that it may well have been 65 or 130 years or more.

R.H.F.

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NO 18 **RELEASED WITHOUT COPYRIGHT RESTRICTION** APRIL 30, 1925

KILAUEA REPORT NO. 694

WEEK ENDING APRIL 29, 1925

Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, Temporarily in Charge.

Landslides were rather infrequent during the past week though very small rock falls could be heard every day. The place on the floor where the densest steam escapes at present is a little way up the south talus slope, to the left of the place where visitors usually stand. On dry days like April 24 and 25 great quantities of white salts that resemble a light fall of snow can be seen on the ash around pit rim. The spicy odor of free sulphur is now very noticeable.

Twenty-three earthquakes were registered on the seismographs during the week though none of them were felt locally. Of this number 19 occurred on April 24 and 25. Several of the shakes had the appearance of having had their origins along the northeastern rift of Mauna Loa.

Tilting during the week was moderate to the southwest.

FOUNDING A VOLCANO OBSERVATORY

The essential features of a volcano observatory are a volcano, an observer and the record made by the observer. For success there are needed two things more—enthusiasm in the observer and publication of his record. It is an error to suppose that the purchase and maintenance of expensive buildings and instruments are among first requirements. A physicist living continuously at Galapagos, or on Kamtchatka, or in the New Hebrides, and keeping a diary, is a potentioal observatory. Students of volcanism the world over want to see that diary. Essentials of the record are exact places, maps and photographs, correct times, and descriptions and measurements of all volcanic and seismic events describable or measureable.

It is this matter of measurement that leads the observer to equip himself with instruments. But the object is not the instrument, it is the measurement. Many measurements may be made with a foot-rule, a thermometer, and a watch. The good observer uses these tools all the time. A transit or plane-table is only an extention of the foot-rule, a seismograph an extention of observation with the watch. When an observer has to remain awake all night in order to record all the earthquakes, he bethinks him of automatic recorders.

There are over four hundred more or less active volcanoes in the world not being continuously observed. Twenty or more of these are splendid natural laboratories. Such volcanoes are Stromboli in the Lipari Isles, Izalco in Salvador, Villarica in Chile, Tanna in the New Hebrides, Akutan in the Alentian islands, Waimangu in New Zealand, Bromo in Java, Oshima in Japan, Lassen in the United States, Colima in Mexico. Continuity of action, hot gases, frequency of ground movements, representatives character and position—such are some of the qualities that make a given volcanic center attractive. It is not the highest or most famous volcanoes in a given belt that should be selected for steady work, but those that are practicable and reasonably free from danger. In many places there are hardships aplenty without seeking them in the scientific work.

One feature that is desirable is a settlement near at hand where reports may be published and mailed, where supplies may be obtained and where headquarters may be made in case the volcano district itself is wild.

Generally exploration is necessary in addition to routine cataloguing of events. A place like Salvador, for example, has a dozen volcanic centers, some of which occasionally break into activity, although Izalco is the most faithful of the outlets. A volcano observatory is always striving to see underground. Hence the observing of slight tilts, or changes of temperature, or tremors, and the employment of volunteer observers among planters, school teachers, ministers and government officials.

Any university or museum that can find a man willing to go to one of these countries and to live there and use his influence while there to promote volcanology and local seismology, will have taken the initial step in founding an observatory. Such a man is a missionary of science.

T. A. J.

THE 1823 LAVA FLOW FROM KILAUEA

A curious and rather unaccountable error has crept into the literature of Kilauea and onto the maps of the Islands of Hawaii. The westermost of the most recent lava flows from Kilauea that entered the sea or nearly reached it near Pahala is commonly spoken of as having occurred in 1868 though it really occurred in 1823. W. O. Clark, geologist at Pahala, called the attention of F. A. Danforth, topographer who was mapping in that region in 1920, to the fact that nowhere in existing literature could he find authority for dating the Keaiwa flow 1868. (See map of the U. S. Geological Survey, Pahala quadrangel). He also pointed out that the Rev. Wm. Ellis in his "Journal of the Tour Around Hawaii" definitely placed it in 1823, and that the Rev. Titus Coan's account did not make it 1868. Coan mentions small outbreaks of lava in 1868 about 11 miles southwest from Kilauea but says nothing about a large lava flow near the sea though he was specifically looking for lava outbreaks. In 1868 the inhabitants of Pahala saw glow from a lava flow to the northeast but no record is found of their observing a brilliant glow to the east, which they no doubt would have seen had the flow in question occurred in that year. The so-called 1823 lava flow does not reach the sea while Ellis describes the real 1823 flow as reaching the sea and destroying a canoe at Mahuka. Mr. Danforth pursued the subject farther and found an old cowboy who stated that the trial across the so-called 1868 flow was indentical with the present trail prior to 1868.

On the new topographic maps the real 1823 flow is called the "Keaiwa Lava Flow" and what was formerly called the 1823 flow, which is really prehistoric, is designated the "Kamooalii Lava Flow."

R. H. F.

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NO 19 RELEASED WITHOUT COPYRIGHT RESTRICTION MAY 7, 1925

KILAUEA REPORT NO. 695

WEEK ENDING MAY 6, 1925

Issued by the Observatory, U. S. Geological Survey:

R. H. Finch, Temporarily in Charge.

On May 6 there were some slight indications that Halemaumau, the great pit in Kilauea Crater, was a little hotter than during the past several weeks.

The heavy steam cloud rising from south talus noted in last weeks report has become less conspicuous. The lower part of a steam line in the southwest talus that extends all the way from the July 1924 lava fill to the top of the talus is steaming less than before as though the deposition of salts and action of steam on the rock had plugged up the steam vents in that vicinity. The walls and even the floors have been quite red. On May 5 the odor of hydrogen sulphide was quite noticeable after having been scarcely detectable for a few days. An avalanche of considerable size fell from the north wall during the night of May 4-5. The wall rock from where it fell appears to be very rotten.

Nine local earthquakes were recorded at the Observatory during the week. The one at 8:12 a. m. April 29 had an indicated distance to origin of three miles. Slight records of three distant earthquakes were recorded at the following times: May 3, 7:03 a. m. and 12:48 p. m.; May 4, 11:47 p. m..

Tilting was slight to the northeast. This indicates a slight tumescing in the top of the mountain. As rule during this time of year the top of the mountain is subsiding.

IZALCO VOLCANO

Attention has been called to Izalco as a place worthy of an observatory. It is representative of ten active volcanoes in Salvador and of a region producing destructive earthquakes. It is a cordilliran region of the same Pacific coastal zone with Seattle, San Francisco and Los Angeles, but with its volcanic gases more in evidence.

Izalco is much misconstrued in the stories about it. In an article published in 1923 appears the statement that in 150 years Mt. Izalco "has risen from the surface of a level plain that was devoted to stock farming, to a majestic height of more than 6,000 feet above sea level." In the same article appear two photographs of Boqueron activity in 1917, purporting to be Izalco. In 1917 Izalco was quiet. As to the stock farm story, Izalco as it is today was built up by lava flows and cinder on the southern slope of Santa Ana volcano, making a total accumulation of about a thousand feet. The writer quoted above failed to state that the growth started on a lava spur of the older mountain already 5,000 feet above the sea.

The year of first outbreak of the flank cone destined to become Izalco is commonly quoted as 1770, but Larde' corrects this. In 1524 there was a solftara there giving vent to a rill of boiling water. In 1576 this had disappeared. In 1636 there was a craterlet in action at the same place throwing up smoke and incandescent substances, but not yet an independent cone. Therefore as a matter of fact Izalco was born about the beginning of the 17th century.

The eruptions from 1636 on produced a confused mass of lavas and there was a culminating eruption in 1722. There was no very definite hill in 1753. Big eruptions in 1770 inaugurated more continuous activity and still more so in 1798, so that a true cone grew up that was worthy of a name distinct from Santa Ana, the mother volcano. By the end of the 18th century Izalco was in full blast as an independent lava factory.

We learn that the major activity of the 18th century began with eruptions in 1802, 1805, 1806, 1807, and 1825. In the last a river course was changed. There were bad earthquakes in 1830, 1831, 1860, 1861 and 1863. In 1840 there were three crater orifices, one of them quiet, one making dark blue fume, and an active one throwing up stones and black clouds. In 1854 there were explosions every five minutes and lava flows in motion. From 1856 to 1859 there was much extrusion and in 1859 there were earthquakes and an ash eruption. Churches and towns were damaged. From 1860 to 1865 there was repeated activity. Other eruptive times were 1867, 1868, 1869, 1870, 1873, 1874, 1875, 1879, 1880, 1882, 1883, 1885, 1887, 1889, 1890 (lava), 1891, 1894 (continual eruptions), 1895-97; at this time it was compared to Stromboli as the "Central American lighthouse." May, June and July of 1898 Izalco continued its extrusions, and an important eruption occurred in 1899-1900.

Inactivity lasted from March, 1900 to May 1902. Then came an outbreak, followed by lava flow in September. A crack opened from top to bottom of the cone. In 1904-05 there was activity. In 1907 this abated. New activity started 1912 and continued, there was a disastrous earthquake in 1915, and Izalco quieted again January 26, 1916. From October, 1920 to April 1921 there were new explosions, lava flows and hydrochloric acid gas. In 1922 there was only fume. (J. Larde, El Volcan de Izalco, 1923). T. A. J.

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NO. 20 RELEASED WITHOUT COPYRIGHT RESTRICTION MAY 14, 1925

KILAUEA REPORRT NO. 696

WEEK ENDING MAY 13, 1925

Issued by the Observatory, U. S. Geological Survey:

R. H. Finch, Temporarily in Charge.

The Volcano continues to be quiet. During the last few days, however, there was a slight increase in the number of avalanches. These avalanches, for the most part, were from the north wall. Portions of the gray intrusive body broke off though most of the avalanche material was from the rather rotten rock just above the intrusive body. Neither the odor of free sulphur nor hydrogen sulphide has been noticed for several days.

Fourteen earthquakes were registered by the Observatory seismographs, though none were perceptible at Volcano House. At the beginning of the week there was a slight northeast tilt. During the latter part of the week the direction of tilting changed to southwest with the result that the net tilt for the week was very slight to the south.

EXPERIMENTAL SEISMOGRAPH

Mr. H. O. Wood reports tests of five horizontal torsion pendulum seismographs and one vertical torsion instrument of the new type designed by Dr. Anderson at the Mount Wilson Observatory laboratory in Pasadena, California. (Report of Seismology Committee, Carnegie Institution, Bulletin Seismological Society, America, Sept, 1924.)

The seismometer consists of nothing more than a vertical "bow-string" bearing a tiny mirror. This is the pendulum, oscillating about the torsion axis of the string, and writing photographically with high magnification. Magnets damp the horizontal swing and a drop of oil in a sleeve damps against vibration.

Two initial instruments had free periods of 0.8 second and static magnification of 1200 times the displacement of the earth. Another was given a magnification of 2500. Damping used in these short period instruments was about one fifth of the amount required for the critical, or aperiodic, condition. The short period pendulums registered local earthquakes well also the first phases of distant quakes. The first phases were registered of aftershocks of the Tokyo earthquakes. Many regional California shocks show pre-phases even earlier than the normal first phase, owing to the extremely high magnifications employed and the adaptability by resonance of a critically damped pendulum of period as short as the earthquake vibration itself.

An improved short period torsion seismograph was made with convenient adjustments for levelling, damping and measuring periods, using a meter-focus concave mirror, a static magnification of over 4000, and a bright light source prevented from fogging in quiet times by a slotted disc. This brighter recording point of light prevented underexposure during earthquakes.

Also a long period torsion seismometer was operated and found satisfactory for distant earthquakes. The period was from 5 to 15 seconds, damping ranged from underdamping to overdamping, and magnification was 300. The instrument showed little disturbance from tilting or temperature. A major teleseism recorded in June 1924 showed clearly the long-period surface waves which had travelled a major arc of the earth's circumferance, and others that had traversed both the minor arc from the source to the station, and the complete circumference of the earth in addition.

Most of the local California earthquakes registered originated at distances 25 to 200 miles from the station. They were numerous. Microseisms were best registered on the long period machines and were small. Engine vibrations and blasts were recorded. A good test of the rate of transmission of earth waves was furnished by the detonation of 182 tons of dynamite 67 miles from the station in hard rock. The timing was checked, good records were written by the machines, and these records are easy to interpret on both the long and short period instruments.

A torsion-suspension vertical component seismograph with period of one-half second was operated successfully with critical magnetic damping. A long period instrument of this type is unstable. It is interesting to observe in all this work of Anderson and Wood that synchronizing of pendulum with earth period, through different instruments for different types and parts of earthquake motion is the key to success. T. A. J.

A NEW TYPE OF SEISMOGRAPH

Dr. Paul Kirkpatrick of the University of Hawaii has devised a novel type of seismograph. Instead of employing a pendulum bob as a steady mass from which to record the movements of earthquakes, the common practice, Dr. Kirkpatrick proposes to use a falling body as a steady point. The course of a falling body is not affected by any change in earth motion during the period of its fall. A continuous liquid jet is used instead of a series of individual falling bodies. The record is made by projecting the shadow of the falling jet onto photographic paper. With such a seismometer it should be quite easy to determine the absolute motion of the ground. With the ordinary pendulum seismograph such a determination, with precision, is difficult. Some of the practical applications of the seismograph, such as determination of the seismicity of a place and aproximation location of the seat of earthquakes, and recording the tilting of the ground from which the probable time and location of earthquakes may be foretold, can be made as well, however, with a pendulum instrument. (Nature, April 11, 1925, p. 530). R. H. F.

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NO. 21 RELEASED WITHOUT COPYRIGHT RESTRICTION MAY 21, 1925

KILAUUEA REPORT NO. 697

WEED ENDING MAY 20, 1925

Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, Temporarily in Charge.

Seismically the past week was the most active one in over a month. Forty earthquakes were registered at the Observatory. Of this number, however, half were of the type that accompanies avalanches.. A shake at 2:02 a. m. May 17 was slightly felt at Volcano House and plainly felt at Hilea. Its indicated distance from the Observatory was 18 miles. At 10:26 p. m., may 19 there was another shake with the same indicated distance. A distant earthquake was recorded at 7:13 p. m. of the 18th.

Along with the increase in number of avalanche type of earthquake there was an observed increase in the number of avalanches. For the most part the avalanches were from the north wall though small ones fell from all sides of the pit.

There was a slight northerly tilt during the first five days of the week and a moderate southerly tilt during the last two days. The net result for the week was a very slight north-northwesterly tilt.

LASSEN PEAK

The Carnegie institution of Washington has recently published a great work on the volcano activity and hot springs of Lassen Peak. The first part deals with the explosive eruption of Lassen Peak from May 1914 to August 1917. Part two deals with the Hot Springs of Lassen National Park. It is published under the joint authorship of Dr. A. L. Day and Dr. E. T. Allen.

Lassen has been active in recent historical time, probably less than 200 years ago, as have some other peaks in the same volcanic region, viz., Mount St. Helens and Mount Hood.

The eruptions were more or less continuous from the start on May 30, 1914 until May 22, 1915 when the largest explosions of the series occurred. Thereafter there was a decline in activity that practically ceased by August 1917. The exlosion cloud on May 22 reached a height of 25,000 feet above the mountain top. In 1917 as 1914 and 1915 may seemed to be a critical month.

On May 19 and May 22, 1915 there were horizontal blasts, similar to the one from Mount Pelee that destroyed St. Pierre in 1902. Nearly every tree in the valley through which the blasts went were either destroyed by the blasts or by a mud flow started by water from snow melted by the first blast.

In May 1915 there was an upheaval of the crater floor to a height of some 300 feet above the original floor-level. This to a great many people will recall the spine in the crater of Mount Pelee though the authors state on page 72 that Lassen had no happenings like the Pelee spine.

The authors assume an earthquake preceding the first explosion which by openeing a crack admitted water to magma below. A magma at a proper temperature and containing water and other volatile ingredients in cooling and crystallizing may produce a tremendous pressure of water vapor. That such a mechanism may produce a high pressure, is easy to follow, but, in the opinion of the reviewer, whether the earthquakes introduced water into the system with a consequent increase of pressure and resulting explosions or whether the earthquakes were the result of a growing strain within the mountain that ruptured the mountain top and finally produced the explosions, is a mooted question.

Part two is a valuable contribution to our knowledge of the temperature and chemical composition of waters in hot springs. It throws considerable light on the formation of ore deposits. Both parts are profusely illustrated and defintely related. They constitute one of the most complete accounts, descriptive and causative, of volcanic on record. R. H. F.

TROUGHS OFF CENTRAL AMERICA

Commander Heck reports (Bull. Seismological Society of America, Sept. 1924) two newly discovered deep troughs detected by sonic soundings. One from 18,000 to 21.000 feet deep lies roughly parallel to the Pacific coast of Guatemala about 90 miles off shore. It is more than 300 miles long with steep slopes on both the shoreward and oceanward sides, the latter over 6.000 feet high to an ocean bottom lying about 13,000 feet below sea level.

The second trough is a narrow one 40 miles from shore between Tehauntepec and Cape Corrientes along the Pacific coast of Mexico. It is 650 miles long and from 13,000 to 17.000 feet deep, with shallower depths on both sides. These deeps are of interest as lying opposite two volcanic districts on shore, the Guatemala-Salvador belt and the Mexican plateau. T. A. J.

UNCONFORMITY IN THE ASH DEPOSITS NEAR GLENWOOD

In a cut through yellow ash in the road near Glenwood, Hawaii a dark streak representing old soil may be seen a foot or two below the surface. In this old soil layer old tree ferns may be found. This shows an appreciable time interval between the laying down of the layer containing the soil and the one on top. R. H. F.

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NO. 22 RELEASED WITHOUT COPYRIGHT RESTRICTION MAY 28, 1925

KILAUEA REPORT NO. 698

WEEK ENDING, MAY 27, 1925
Issued by the Observatory, U. S. Geological Survey;
R. H. Finch, Temporarily in charge

The strongest earthquake that has been felt at Volcano House since the fore part of April occurred at 9:01 A. M. May 26. It was accompanied by a roar and dismantled one of the seismographs at the Observatory. At 8:47 p. m. of the same day there was a very small shake with the same apparent distance to origin, about 2 miles. Altogether 23 earthquakes were registered during the week. Of this number six were of the avalanche type of earthquakes.

Tilting was a little stronger than for several weeks and was moderate to the southwest.

The increase in the avalanching noted last week continued into the present week. For the most part the avalanches were small though several sent up dust clouds well above the rim of pit.

CALIFORNIA EARTH MOVEMENT

Dr. Arthur L. Day of the Geophysical Laboratory reports for the several organizations working on California earth movements in "Science," March 27, 1925. The object is to focus scientific measurements on the inside of mountain ranges and sea-bottom so as to localize, not only the sources of earthquakes, but the centers of mountain building and creep of surface ground. To this end the Carnegie institution, the California universities, the U. S. Geological Survey, the Navy, and the U. S. Coast and Geodetic Survey are cooperating. The Advisory Committee on Seismology is aided by both the Geophysical Laboratory of Washington and the shops and laboratories of the Mount Wilson Observatory at Pasadena.

The Committee was appointed in 1921. Lawson had concluuded from variation-of-latitude observations that the earth's crust near San Francisco had been drifting north a foot a year for 20 years. Lambert showed that probable errors were of the same order of magnitude as the assumptions indicating creep, so that Lawson's conclusion was not final. There are lateral displacements of 20 feet in places along the great fault that moved during the earthquake of 1906. A new base line for triangulation of the whole region was adopted recently in the Sierra Nevadas, and work for several years including 1925, supplemented by levelling, shows that a prior base line nearer San Francisco has itself moved southward some five feet. Another region to the south and some distance from the fault slip has moved north 24 feet.

Messrs. Noble and Kew have located new active faults in southern California. The Hydrographic Office of the Navy with sonic sounding apparatus, assisted by the Coast Survey, is developing new maps of the sea bottom off California. For determining local earthquakes, tremors, and tiltings J. A. Anderson and H. O. Wood have made new instruments in Pasadena, these are being tested, improved and manufactured, and seismographs on a new principle are actually working at magnifications of from 1200 to 4000. Other devices are being experimented with to solve the problem of uniform time service at separated stations. A number of California and Arizona stations have been selected for work on local motion. Eventually the Coast Survey hopes to standardize and improve registration of distant large earthquakes, at such stations as Hawaii, Alaska, Arizona, Washington, and Porto Rico. Dr. Day mentions in his report the interesting possibility of instrumental measurement continuously of deep-seated rock pressures underground, through some such instrument as a metal bulb containing a fluid connected by a tube with the surface, the bulb being cemented in a deep subterranean chamber.

If tilt and creep and changes of level can be precisely measured, Dr. Day thinks that in any given place known to be moving, the site of the next sudden release may be reasonably determined in advance. Prediction of the time of rupture is much more difficult. This whole California enterprise is of the utmost interest to seismologic science, and it is to be hoped that Hawaii may with her volcano facilities be able to add an item of cooperation. T. A. J.

THE SEISMOGRAPH IN OIL FIELDS

The difference in the records of the same or a similar seismograph in different locations in response to a constant disturbance is often very striking. With the magnification, period, and sensitivity of the instruments the same such differences must be due to differences in the soil or rocky layers underground.

Differences in underground characteristics at St. Mary's School in Hilo and at Hilea, Kau, both on the Island of Hawaii, were recently shown during the installation of very similar instruments with about the same magnification at the two places. The record from the Hilo instrument leads one to surmise that it is installed over a lava tube or over loose and broken pahoehoe slabs.

A recent application of the seismograph's ability to through light on underground structure is in locating places that are geologically favorable for the retention of oil. R. H. F.

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NO. 23 RELEASED WITHOUT COPYRIGHT RESTRICTION JUNE 4, 1925

KILAUEA REPORT NO. 699

WEEK ENDING JUNE 3, 1925

Issued by the Observatory, U. S. Geological Survey;
R. H. Finch, Temporarily in Charge

Kilauea volcano continues to be in a quiet state, save for avalanches from the walls of Halemaumau, the great pit in the floor of Kilauea.

The depth of the pit has remained unchanged since the slight filling by lava last July. The area of the hole, however, has been slowly increasing by avalanches from the rim. There have been avalanches from all the walls. The maximum recession of the rim amounts to 10-15 feet or more. The greatest movement in the cracks back of the rim has been at the south where the recession of the rim is the least.

The steam that escapes from the floor of the pit seems to be nearly pure now as only rarely can the odor of hydrogen sulphide or other gases be detected.

May 1925 has come and gone without any very unusual signs from the volcano and it will soon be a year since the last small explosion.

Only six earthquakes were recorded during the week. This is the smallest number recorded here in a like period since the latter part of November 1924. None of the earthquakes were strong enough to be felt at Volcano House and two of them were of the avalanche type. Small avalanches occur daily at the pit. Tilting was very slight to the northwest.

EARTHQUAKES AT KATMAI

A review of an article by Dr. Tams on the earthquakes that accompanied the Katmai eruption in Alaska in June 1912 appeared in No. 5 of the VOLCANO LETTER. A rather complete discussion of "Earth Movements Accompanying the Katmai Eruption" is given by Dr. C. N. Fenner in the February-March and April-May numbers of the Journal of Geology. Much has been published about the eruption and the resulting "Valley of Ten Thousand Smokes." Some of the facts about the eruption used by Dr. Fenner were obtained by G. C. Martin on a trip for the National Geographic Society, to the Katimai region in 1913, just after the eruption. The rest of the information was obtained on trips by Dr. Fenner in 1919 and 1923, several years after the outbreak.

Field observations near Katmai indicated a lack of violent earthquakes. A deep seated tectonic earthquake (earthquakes resulting from growth of the earth's crust, according to one definition) that was recorded on seismographs all over the world accompanied one of the larger explosions. Many of the earthquakes were felt over 500 miles away. The noise of one explosion was heard at Juneau, 745 miles from Katmai.

Most of the earth movements noted are in a valley between Mount Katmai and Mount Trident with some movement on the mountains themselves. Dr. Fenner is of the opinion that the fracturing of the valley followed by numerous fumaroles, making it a valley of "Ten Thousand Smokes," was due to the intrusion of a sill of hot lava.

Dr. Fenner has handled the information at his disposal in a masterly manner but the exact sequence of earthquakes and explosions must remain unknown. All the discussions of the Katmai eruption point to the need of continuous observations of such events.

Some stress is laid on the distinction between tectonic and volcanic earthquakes. Any definition of tectonic earthquakes will likely include many volcanic shakes as there is no sharp division between the two. "'Tectonic" earthquakes in a volcanic region or its immediate vicinity frequently appear to have a much shallower origin than others in a region more remote from a volcano. In volcanic regions hot and somewhat plastic rock must be nearer the surface than in non-volcanic regions. R. H. F.

PUBLICATIONS OF THE NATIONAL RESEARCH COUNCIL OF JAPAN

No student of any science can afford to be without the publications of the National Research Council of Japan. Of these publications those that are of especial interest to students of volcanology and seismology are, Japanese Journal of Astronomy and Geophysics and Japanese Journal of Geology and Geography. These publications made their appearance in 1922. In addition to original articles such as Relations Between Frequency of Earthquakes and Atmospheric Pressure, and the Japanese Earthquake of Sept. 1, 1923, several of the numbers contain abstracts of articles published in other journals such as Seismological Notes of the Imperial Earthquakes Investigation Committee and in journals written in Japanese. R. H. F.

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NO. 24 **RELEASED WITHOUT COPYRIGHT RESTRICTION** June 11, 1925

KILAUEA REPORT No. 700

WEEK ENDING JUNE 10, 1925

Issued by the Observatory, U. S. Geological Survey;
R. H. Finch, Temporarily in Charge

Seismically, and otherwise, the volcano continues to be quiet. Only eight local earthquakes were recorded during the past week. None of the earthquakes were perceptible at Volcano House. The number of local earthquakes is getting to be nearly comparable to the number commonly recorded when molten lava is visible.

Two distant earthquakes were recorded as follows: June 4, 1:47 AM., slight; June 9, 3:21 AM, slight. The latter had an indicated distance to origin of 4750 miles, *equal to the distance to the Philippines or Formosa.*

Avalanches have been slightly more numerous and dust clouds that rose well above the rim of pit were common. But very few disturbances have been recorded on the seismographs to correlate with the avalanches. Most of the avalanches fell from the north wall.

THE DISTRIBUTION OF VOLCANOES

The some 430 active volcanoes in the world are widely scattered. The form of activity that a volcano may take varies greatly, from the quiet extrusion of fumes to an explosion like that of Krakatoa in 1883 that sent up dust clouds to a height of 17 miles.

In general, active volcanic regions are also regions of high seismicity. Not all regions subject to frequent earthquakes, however, have active volcanoes as for instance the middle Mississippi Valley, eastern South Carolina and the southern Appalachians in the United States. Volcanic regions cover a limited portion of the earth's surface, but no place is entirely immune from earthquakes.

In volcanic regions one can not say definitely that a volcano is the cause of all the earthquakes nor that the activity of the volcano is due to earthquakes. It would appear that both can frequently be referred to a common origin. If this is true then the terms "tectonic" and "volcanic" as applied to earthquakes refer more to different grades than to different causes.

Volcanoes usually are located in well defined zones. Sometimes the zone is comparatively short as in the Hawaiian Archipelago; and sometimes very long as the border of the Pacific Ocean.

The Pacific border chain of active or recently active volcanoes is in recent geological formation and crustal movements are still taking place. This is more or less common to all volcanic regions. For the most part ocean deeps are close to the shore so that the difference in elevation between volcano peaks and adjacent deeps is startling. Hawaii furnishes an example of proximity of elevation and deep more striking even than that of the west coast of South America. From the summit of Mauna Kea to a deep about 50 miles to the northeast there is a continuous land slope of about 37,000 feet.

In South America, Central America and Mexico the volcano chain is quite complete. In the United States the Pacific belt finds but few active volcanoes though several, in addition to Lassen's Peak, have been active in recent historic time and others in recent geologic time. Canada furnishes a near approach to a gap in the chain before Alaska with its several volcanoes is reached. The chain is continued by the Aleutian Islands to Kamchatka and Japan. In going south from the Philippines the chain fans out to include a large part of the southwestern Pacific Ocean.

Undoubtedly several of the island volcanoes started in as submarine eruptions on the ocean floor and built up the island and mountain. Scattered reports indicate that submarine volcanoes are still at work endeavoring to form new islands.

The Atlantic Ocean, while not so well supplied with volcanoes as the Pacific, has several in Iceland, the Azores, Canaries, and Cape Verde islands. In the Lesser Antilles group of the West Indies and in the Mediterranean Sea there are several volcanoes. The Mediterranean belt is almost continuous eastward for some distance into Asia.

Volcanoes are found in all oceans. The Artic ocean has its Jan Mayen volcanic island while in the Antartic are the volcanoes Erebus and Terror on Ross Island. One of the most active of volcanoes is on the Island of Reunion in the Indian Ocean about 400 miles southeast of Madagascar. It has been in eruption about every five years for a great many years and has been reported to show a continuous lake of molten lava similar to the one for which Kilauea is famous.

At times one of the most continuous volcanic spectacles is to be found at Matavanu volcano on the island of Savaii, one of the Samoan group. Starting in August 1905 Matavanu sent forth a lava flow that poured into the ocean continuously for about five years. R. H. F.

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NO. 25 RELEASED WITHOUT COPYRIGHT RESTRICTION JUNE 18, 1925

KILAUEA REPORT NO. 701

WEEK ENDING JULY 17, 1925

Issued by the Observatory of the U. S. Geological Survey:
R. H. Finch, Temporarily in charge

The seismic lull that started during the latter part of May still continues. During the week ending during the forenoon of June 17 nine local earthquakes were recorded at the Observatory. None was perceptible at Volcano House and only one was large enough to enable one to determine the approximate distance away. This one occurred at 10:09 P. M., June 10 with an indicated distance of 20 miles. Four of the others probably occurred at about the same distance from the Observatory. Seven of the nine shakes occurred on June 10 and 11.

The direction of the tilt was to the northeast. As during the preceding week the amount of tilt was very slight.

There were numerous avalanches during the week though for the most part they were less spectacular than during the preceding week.

Tremendous dust clouds were raised in the Kau Desert by the brisk wind on June 15. The desert showed a marked wall of dust that was fully 500-600 feet above the ground.

AN OFT-REPEATED MISSTATEMENT

How often we hear the assertion that the crater of Haleakala is "the largest crater in the world!" There are, however, two mistakes in this proposition. In the first place, the depression at the summit of Haleakala is smaller than are various craters in other parts of the world. And in the second place, this depression is not a crater at all.

Publications of the tourist agencies give the area of Haleakala "crater" as 19 square miles, its extreme length as nearly 7½, its extreme width as less than 2½ miles, and its perimeter as 20 miles. Anakchiak Crater, discovered in 1922, on the Alaska Peninsula is six miles in diameter but little more is known about it. If it is of circular outline, its area would be 28 squire miles and its perimeter 18 miles. This crater exceeds Haleakala in area though it does not equal in perimeter the long, irregular rim of the Haleakala rift.

In Tanganyika Territory (formerly German East Africa) there is a plateau called the "Highland of the Great Craters." This region has not been thoroughly explored but enough is known to justify the name. The best known crater is "Ngorongoro," which is about 12 miles across and has an area of 110 square miles. The surrounding walls are in general 2,000 feet high but two parasitic volcanic cones rise about 2,000 feet above the rim. There are only three or four possible routes of descent into the crater and the floor forms a natural game preserve with some 50,000 head of wildebeest and 25,000 head of other game. A single small volcanic cone rises from the crater floor.

A crater, according to Webster's New International Dictionary, is "the basinlike or funnel-shaped opening which marks the vent of a volcano." Undoubtedly the main, central vent of Haleakala was formerly in the region occupied by the present magnificent depression, the sight of which well repays those who climb to its rim. But the present form of this depression seems to have been caused not by volcanic action but by collapse within the mountain. The fracture at the surface took the form of a stretched letter "Z," the middle bar of which runs east-west while the others run south from the east end of the middle bar and north from the west end. The gash or rift made in this way has widened out a great deal by avalanching of the walls, much as Halemaumau has widened out in the last year. The subterranean continuation of the fracture has served as a channel for the ascent of small amounts of volcanic matter which have built cinder cones within the rift basin. True craters are of circular or oval groundplan and not of the irregular shape found on Haleakala. True craters are due to the processes that go on in and around volcanic vents ,whereas the Haleakala depression is due to processes independent of volcanism.

H. S. PALMER.

EARTHQUAKES AT KILAUEA DURING TIMES OF EXPLOSION AND TIMES OF QUIET

To show the difference in the number of earthquakes by months when the volcano is explosive and when it is quiet, the quiet lava activity of the year 1920 is compared with 1924 in the following table. In 1924 up to the 20th of February there was a large lake of molten lava. The extraordinary large number of earthquakes during April, May and June 1924 accompanied the subsidence of Halemaumau and the explosive eruption. The number of earthquakes to date in 1925 is comparable to the last six months in 1924.

	Number of Earthquakes	
	1920	1924
January	7	21
February	10	36
March	20	78
April	5	358
May	11	3961
June	13	801
July	9	110
August	15	90
September	8	116
October	35	106
November	36	51
December	40	169

R. H. F.

SAMPLE COPY

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NO. 26 | RELEASED WITHOUT COPYRIGHT RESTRICTION | JUNE 25, 1925

KILAUEA REPORT NO. 702

WEEK ENDING JUNE 24, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

The general situation volcanically of Halemaumau pit at the end of the year following the great collapse of May-June 1924 is extremely peaceful. During the spring earthquakes and avalanches have declined in numbers except for a minor revival in the latter part of May. In June earthquakes and avalanches showed another revival at the solstice, which was remarkable in that the greatest slide seen here for many months came at noon on June 20th.

On June 18th there had been two slides, on the evening of the 19th another, one about 4 a. m. of the 20th and then began an undermining of the northwest wall with increasing slides from 9:30 to 11:30. At 11:40 a beautiful avalanche there sent a crescent of cauliflower cloud across the bottom with a roar. Then came the climax at 11:48 a. m. when the whole wall up to the top stripped off with a thunderous crash that could be heard miles away and the whole pit was filled with clouds of red dust for a half hour. Yellow sulphur stain that had been visible at the east side of the botttom became obscured by the dust-fall, and the seismograph at the Observatory registered vibration for two minutes.

The week has recorded 18 earthquake movements of local origin, of which 6 were of the avalanche type, and 5 indicated distance of source greater than the 2 miles between Halemaumau and the Observatory. None was felt. Tilt was slight SSW.

THE ENGULFMENT-COMBUSTION THEORY

The nearly complete oxidation of the hydrogen, sulphur and carbon gases of Hawaiian lava lakes, and the availability of abundant oxygen in earth and air as a heat-producing agent of combustion, have led us for many years to seek a logical combustion hypothesis of volcanism (Jaggar, Amer. Jour. Sci. Sept. 1917). Day, Shepherd and Allen have analyzed the gases and proved their extraordinary irregularity in composition and their oxidized condition when they reach the surface (Bull. Geol. Soc. Amer. 1913, 573: Bull. Hawaii. Volc. Obsy. July 1919, May 1920, May 1921, Aug. 1922). Jaggar and Finch have demonstrated that the explosive eruption of Kilauea was an incident of a low temperature engulfment process. The volume of rusty rocks engulfed was 253 times the volume of ejected matter; this should be known as the ejection-engulfment ratio 1/253. Every short cycle of slow lava rising ends with rapid collapse and engulfment. (Amer. Jour. Sci. Nov. 1924, Bull. Haw. Volc. Obsy. May Dec. 1924).

At the meeting in Washington, April 30, 1925, of the American Geophysical Union, Shepherd and Jaggar presented an engulfment-combustion hypothesis based on a conception of subterranean normal magma containing combustible gases in solution and iron mostly ferrous; while engulfment down vertical chasms was conceived as a normal process for introducing to the magma oxidized rock matter containing ferric oxide. This holds an excess of oxygen from the rusting of old lava exposed to the air and acids.

In the presence of hydrogen, for example, the ferric oxide would be reduced to ferrous and the hydrogen would be oxidized to water vapor with evoluttion of heat. Given a moderate amount of hydrogen in the new magma rising, and oft-repeated engulfment of rusty crater rock, enough heat would be supplied to keep lava volcanoes in activity without much fresh lava from great depths. By this hypothesis explosive steam eruptions become nothing more than accidents due to engulfment-plugging of craters over ground-water boilers below.

The two novel features confirmatory of this explanation are the ejection-engulfment ratio 1/253 measured for the first time at Kilauea in 1924, and the excessive amount of red oxide of iron there revealed in the wall-rock fragments. Seven billion cubic feet of this rip-rap were precipitated several thousand feet deep into the heart of the mountain. The new lava that reappeared in the pit July, 1924 had frothed its way up through the crevices of this oxidized breccia. It took up oxygen and was heated as it rose. Doubtless other oxygen was entrapped as air. The agglomerate is both a porous heat insulator and an oxygen supply for the burnable magmatic gases. If three percent of the breccia were ferric oxide reduced back to ferrous iron, enough heat would be suplied to raise seventy million cubic feet of the debris from air temperature 20°C. to the temperature of liquid lava 1200° C.

This theory accounts for the excess of water vapor in lava, for the oxidized condition of the other gases, for the rapid passage of gas up the lava column, for the channels and tunnels of the lava lake bottoms. The half-melted breccia is lifted or lowered as a whole by the gas-charged melt in its honey-comb, and this explains the "bench magma" with its puzzling crags, islands and floors. Convection through the crevices produces the varying currents of the lava lakes. The upper portion of the breccia is renewed by every crateral subsidence; this makes a concentration mechanism for the less volatile gases such as sulphur, and the sulphur acids in turn powerfully oxidize the crater rocks.

The world-wide history of volcanoes agrees with the hypothesis. Enormous engulfments went unmeasured at Krakatoa and Sumbawa. Downfaulting since Tertiary time is the rule around the Pacific. Downfaulting is the age-long process at volcanic craters everywhere. Subsided crater floors are dominant on the moon. Downfaulting is what may be expected above subterranean chasms that open laterally and engulf large masses of their wall rock. Collapsing of crater regions with or without explosion has volumetrically been the biggest volcanic process of post-Tertiary time. Engulfment on a gigantic scale appears to have occurred along the Cordilleran intrusive belts. Agglomerate necks, plugs, domes and dykes are common. Hydrogen throughout the solar system is the dominant volcanic gas and the current theory of the earth's interior shows an evolution that has produced oxides, including water, increasing from within outward, and metallic iron increasing inward.

T. A. J,

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NO. 27 **RELEASED WITHOUT COPYRIGHT RESTRICTION** July 2, 1925

KILAUEA REPORT NO. 703

WEEK ENDING JULY 1, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

Halemaumau the fire pit of Kilauea remains dormant, the conspicuous changes of the week being increases in the amount of vapor directly caused by heavy rainfalls, after a dry spell when the steam jets on the bottom were only slightly visible.

On June 25th in the forenoon there was fresh debris on the northeast talus, a little sliding was heard at the northwest, and the most vapor was at the west pocket of the bottom. The flat wall slope at the bottom of east side of pit had now lost all its staining with salts. On the 27th there was a little sliding west. The west and north taluses were wet with steam, the east and south ones emitted dry vapor, sulphur being most conspicuous ENE. June 29 in dry weather two sulphur patches SW and in the center showed increase of yellow and creamy crystals, without any vapor at the places in question. The next day after a rainy night the bottom was transformed to a field emitting hundreds of tails of vapor. There were some slides N and NE. Today there is less vapor and the sulphur patches are whitish.

Seventeen local earthquakes were registered, 5 of them of the avalanche type, and 2 were felt, namely at 5:56 a. m. June 25 with origin distance 14 miles, and at 10:42 p. m. June 26 with origin distance about 2 miles.

The beginning of the disastrous earthquake in Montana June 27th was registered here at 3:09 p. m. (6:30 p. m. Montana time.) The Santa Barbara disaster recorded its beginning here at 4:20 a. m. June 29th, (6:50 a. m. California time) the initial wave taking about 6 minutes to reach Hawaii.

Tilting of the ground during the week has been slight to the NNE, compounded of NE tilt during the first two days and thereafter very slight SW.

HAWAII FROM THE AIR

Through the courtesy of Major General E. M. Lewis, Commander of the Hawaiian Department, Messrs. J. B. Stone and R. H. Finch of the U. S. Geological Survey were permitted to make airplane trips over Puna District, Island of Hawaii, on June 27. The planes were piloted by First Lieutenants James D. Givens and Glenn C. Salisbury.

The primary object of the flights was to determine whether any lava reached the surface along the northeastern rift of Kilauea where underground movement was strongly suspected in 1924. No 1924 lava was found, though dead trees along some of the steaming cracks in the rift zone indicate an increase in that form of activity. A similar indicated increase of steaming had been previously noted at Aloi crater farther west.

While flying to and from the Parker Ranch landing field at Waimea good observations were obtained of the entire eastern half of Mauna Kea. It was noted that three stream channels extend well above the timber line nearly to the summit of this mountain. These stream channels will eventually control most of the drainage of the upper reaches of Mauna Kea. Observations of several cones point to the need of detailed investigation. One cone is partially surrounded by a black deposit whose nature could not be determined. It was also determined that the several points of interest on Mauna Kea can fairly easily be reached from existing trails.

Good views were obtained of the northeastern slope of Mauna Loa. Most of the lava flows from this slope come from a well defined rift zone. It was noted that this zone, as far as lava flows from it are concerned, stops and forms a definite shoulder on the mountain about 15 miles from the summit.

The views of Kilauea and its lines of cones, craters, and cracks extending to the northeast and southwest were of great interest.

More inspection can be accomplished in a two hour geological reconnaissance from the air, over the territory traversed, than in two weeks on foot. R. H. F.

SEVERE MONTANA AND CALIFORNIA EARTHQUAKES

The copper region of Montana and the volcanic district of the Yellowstone were shaken destructively by earthquakes beginning about 6:40 p. m. June 27 and continuing the next day. Three Forks reported 41 shocks in 30 hours. $500,000 damage was estimated in Gallatin County and the town Manhattan. Two railways were blocked by slides. Three persons were reported injured, none killed. There were ground cracks and canyon landslips at Livingston, the hotel wall was cracked at Great Falls, avalanches occurred near Lombard, and serious shocks were reported from Billings, Butte, Missoula, Helena, White Sulphur and Anaconda, as well as the Yellowstone Park.

Just thirty-six hours later at 6:44 a. m. June 29, Santa Barbara was bumped upward and then wrenched in all directions by a sudden shock accompanied by noise that seemed like a subterranean explosion. The business district was wrecked, Arlington Hotel was a complete loss, State Street was buckled and cracked, two fires started but were extinguished, water mains and reservoir burst and made a flood, 13 people were killed and 30 injured, damage was estimated at $15,000,000, the lighthouse collapsed, and electric light, power and gas were cut off. Shocks continued. Weather was calm and sultry. Four shocks in the early morning and forenoon of the 30th occurred, one severe. T. A. J.

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NO. 28 RELEASED WITHOUT COPYRIGHT RESTRICTION July 9, 1925

KILAUEA REPORT NO. 704

WEEK ENDING JULY 8, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

Changes in Halemaumau are small. There were small rock slides SW July 3, very little W and NW July 4, hardly any July 5 during time of observation, some N and NW July 7 and fresh debris shown NE, and July 8 there had been a strong avalanche leaving a scar, debris and dust from the NE wall, probably coinciding with the earthquake of 6:45 a. m. There are white stains on the pit wall, a vapor column shows at night and during humid weather, and there is always hot steam on the bottom.

The week registered 12 local earth movements. Perceptible earthquakes occurred July 4 at 7:55 p. m.; distance 22 miles, felt in Hilo; July 6 1:47 p. m. distance 11 miles, EW component dismantled instrument; July 8 6:45 a. m. distance about 11 miles. A distant earthquake at 3:51 a. m. July 7 did not appear to coincide with the disaster reported from Nagoya for that morning, for by Japan time the shock registered here would have been late at night (about 11:30 p. m.). Tilt for the week was very slight to SW.

EARTHQUAKE-PROOF BUILDINGS

More than three hundred books on earthquake-proof construction are on file with the Building Committee of the Seismological Society of America (B. Willis, Bull. Seis. Soc. Amer. Dec. 1924, 256). Good workmanship and materials are of first importance, and are rare. Structures should resist a lateral stress equal 30 pounds per square foot. They should have unity and a natural period of vibration different from that of a strong earthquake. Earthquake periods are from 1 to 2 seconds. The best buildings are rigid and low with a half-second period or less. When the earth and structure synchronize the strain is terrific. Houses of brick or reinforced concrete up to eight stories may be stiffened to swing as natural pendulums with a period of a half second or less. Sky-scrapers have a period of two seconds or more; this was the natural swing of the ground in the Tokyo earthquake. If the vibration is shorter than that of the earthquake, the strain is on the basement; if longer the great stress is two-thirds of the height above ground.

Lack of unity causes the frame to knock the partitions and walls down, or the whole house to knock the chimney down, or the faced lower walls to knock the upper unfaced walls down. If the rectangular cells of a steel frame are distorted to become rhomboids, it stands to reason that a hollow tile partition will "stand about as much chance as a Sevres teacup under a steam hammer." If frames are flexible, then the contents of the frame must be made movable. The stress to be met is a horizontal jerk. If frames are rigid on a unit basement slab, and the walls as strong as the unrights and the horizontal beams, and all tied together, then your house floats on the moving ground like a ship. The ideal earthquake-proof house should stand still, while the ground jerks back and forth under it, like a ship cradled on two sets of rollers.. Stiffness may be greatly increased by diagonal sheathing of wood, metal lath, or steel struts in ferro-concrete panelling.

A well built house is a man's best insurance. The "fallen building" clause should be permanently removed from all insurance policies. There is no wisdom in taking earthquake insurance just after an earthquake, but it should be carried all the time on the principle of life insurance. Our towns are mortal. Let us make them immortal.

There were sixteen large steel-frame buildings in Tokyo of which ten were severely damaged. The undamaged ones used ferro-concrete wall construction which stiffened and braced them, and they suffered no damage whatsoever (Hadley, Bull. Seis. Soc. Amer. March, 1924, 6). In the others everything vertical that was supported by the frames was damaged.

Reinforced concrete performed splendidly. In the city 78 percent of 592 ferro-concrete structures were undamaged, and only 1.3 percent entirely collapsed. In the outside district 75 percent were undamaged and 7 percent collapsed. The remainder in both cases were more or less damaged.

Brick buildings with heavy exterior and division walls well tied together escaped without damage in some cases. The damage was much greater on soft soil than hard. Of 49 brick buildings on hard soil 6 percent entirely collapsed, about 50 percent were ruined, 32 percent were slightly damaged and 12 percent were uninjured. Of 436 on soft soil 10 percent entirely collapsed, 44 percent were ruined, 27 percent were slightly damaged and 19 percent escaped.

T. A. J.

NOTE ON VOLCANIC ORIGIN OF EARTHQUAKES

H. H. Turner (Report Brit. A. A. S. 1913, 65) studied correlation of volcanic eruptions and earthquakes for the period 1790-1900 with reference to times of increasing and decreasing volcanicity and seismicity and found 39 percent of correspondence between the two. He wrote "earthquakes and eruptions are affected by the same cause." This was a quantitative numerical calculation made after the method of an astronomer. Milne has published a world map of elliptical areas enclosing the regions of major earthquakes: the ellipses all enclose volcanic districts.

Volcanism includes underground intrusive action as well as surface craters; and this action may extend 100 miles down. In view of this it is extraordinary how persistent is the tradition among geologists to the effect that "volcanic earthquakes" are trivial, superficial, and limited in extent. Volcanologists generally tend to concur in the views of Oldham, Joly, Heilprin, Branca and others to the effect that great earthquakes may be occasioned by magmatic shifts beneath the earth crust, and even the great fault movements may be effects rather than causes.

T. A. J.

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NO. 29 RELEASED WITHOUT COPYRIGHT RESTRICTION JULY 16, 1925

KILAUEA REPORT NO. 705

WEEK ENDING JULY 15, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

There has been a change during the week in the direction of increased numbers of local earthquakes, avalanches on the west wall of the greater crater of Kilauea, some earthquakes felt that appear to center about Mauna Loa, and a little avalanching in Halemaumau pit. This appears to imply augmented seismic motion in the whole volcanic system, and the northerly tilt at the Observatory, if significant, would imply upward pressure in the underground lava.

July 10 avalanches at the pit made dust clouds at 8 and 11 a. m., and at 2:15 p. m. At 2:30 p. m. a small slide fell from the west niche. A yellow patch was observed east of the dyke in the north wall. July 13 at 4 p. m., a small slide occurred on the northeast wall, there was a little working of the northern walls the next day, and July 15 at 8:05 a. m. there was a considerable northeast avalanche which stripped part of the intrusive sill and left fresh debris and red dust on the northern side of the bottom.

At 8 a. m., and in the afternoon of July 14, slides fell from the high part of the Uwekahuna wall west of Kilauea, and July 15, at 7:20 a. m. and 9:00 a. m., fresh scars were made at the south end of that cliff by avalanches, both at the same place, as though the southwestern rift system were working. Nothing seismic was noticed simultaneously.

In Halemaumau a crack across the floor suggested swelling, but it was not certainly new. There was some blue fume and sulphur smell from this place July 15.

Twenty-seven earthquakes of local origin were registered, of which 3 were of the avalanche type. The earthquake of 6:45 a. m. July 8 was felt all over Hawaii. Two recorded quakes of the evening of July 9 were felt at Pahala. At 4:25 p. m. of the 12th an earthquake was felt here vertically moving accompanied by rumble. A shock registered 3:23 a. m. July 14 indicated an origin 27 miles away and was felt at Pahala, strongly suggesting movement under Mauna Loa.

THE WAR AGAINST CATASTROPHE

The publication of a thoughtful quarterly for the study of calamities ("Materiaux pour l'etude des calamite's," Geographical Society of Geneva under the International Red Cross, $1.25 per year, No. 1 Promenade du Pin, Geneva, Switzerland) was begun with the April-June number of 1924, written in French and English mostly, and has now finished its first year.

The topics considered are earthquakes, eruptions, landslides, floods, tornadoes, droughts, faminies, conflagrations, locusts, epidemics and tidal waves. The motive for the journal is the compilation of a world disaster map by the Red Cross, to assist in the mobilization of relief forces, and the publication is designed to draw together world organizations in reports on frequency, alleviation, preparation, education, defense, mapping, legislation and research.

Each number contains original memoirs, correspondence and reviews. Leading articles to date have dealt with landslides in Italy by Amalgia, the locust problem by Vayssiere, earthquakes and volcanoes by de Launay and Brun, tropical cyclones by Visher, earthquake-proof construction by van de Putte, the Kalahari irrigation project for Africa by Schwarz, tidal waves by Vallaux.

On the practical side of the war against volcanic eruptions Brun recommends geophysical studies at observatories of volcanic gases, magnetism, earth movements, sounds, ground temperatures, and full administrative powers in the matter of forewarnings. Precautions should be enforced and the populace trained in what to expect, in routes of retreat by land and sea, in requisitioning of shipping, in avoidance of beaches on account of probable tidal waves, and in organization of picked men as leaders. Houses with high pitched roofs to throw off the ashes are best in regions of explosive eruption even to distances ten miles or more away from the craters.

De Launay believes strongly in a "pyrosphere" or region of intrusive magma inside the crust of the earth intimately akin to both earthquake and volcanic phenomena. He points out that rise of temperature with depth varies enormously in different places in a proportion even as high as 1 to 10 for the same depth. The most ancient and solid lands are cooler than the younger and thinner parts of the crust. Near Lake Superior it is necessary to dig 124 meters to get a rise of temperature of 1° Cent.; in Tuscany the rate is 10 meters to a degree. The rate in Canada and New England is 124 m.; Bohemia, of Carboniferous age, 60 m.; the Paris basin of flat Teritary strata, 30.; Colorado, a region of extinct Teritary volcanism, 16 m.; and active volcanic centers of the present day, 10 meters or less. What is the temperature under the floor of the deep oceans?

It appears to the reviewer that this magazine of the Geneva Society is a most valuable educator and every Red Cross member should subscribe to it. In science there are two approaches to the earth-mapping problem for earthquake research where everybody may help; one is the distribution broadcast of simple seismoscopes for recording very small shocks so that everyone may become interested. The second is the taking of exact temperatures in hundreds of shallow holes in millions of places in the rock, wherever engineers and quarrymen drill, the world over. The Red Cross is an international organization capable of collecting such data. Both of these are parts of a propaganda for educating the public, and getting returns from the public. It is through such public interest that thousands of rain gauges and thermometers assist our Weather Bureau. It is through the compilation of such data that we may map the local shakiness and heat of the earth.

T.A. J.

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NO. 30 RELEASED WITHOUT COPYRIGHT RESTRICTION JULY 23, 1925

KILAUEA REPORT NO. 706

WEEK ENDING JULY 22, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

The increase in numbers of local earthquakes instrumentally registered continues, the numbers for each of the three weeks of July to date being 12, 27 and 34.

Of the 34 shocks of the past week at least ten were of the type characteristic of avalanches at Halemaumau, and the dust of numerous avalanches has been seen. Some of these avalanches, especially two near midnight July 18-19, were big and carried away the northeast rim of the pit where a new trig station flag had been erected the day before. These falls of wall-rock left the bottom covered with much red dust. A remarkable slide observed the afternoon of July 17 started at a brick-red patch in the middle of the northeastern wall and made a rose-colored cauliflower cloud and a purplish red streak on the wall.

Three local earthquakes perceptible here were at 11:57 p. m. July 16; 8:52 a. m. July 18, and this one was accompanied by rumbling noise; and 8:46 p. m. July 19. Tilting of the ground for the week was very slight to the west.

There has not been much of interest at Halemaumau pit. Small dusty slides were seen by anyone remaining a half-hour or more. At 6:15 p. m. July 16 a northeastern slide was heard at the observatory and the dust-cloud seen. One was seen on the 17th from the southeast wall, which is unusual. Sulphur stain on the bottom was increasing the 18th but the avalanches covered the stain with dust. That afternoon a remarkable fumy cloud was seen over Mauna Loa about 5:45 p. m.

A sharp earthquake producing panic about San Francisco bay (R. F. grade 7) is reported for 11:31 a. m. California time July 19. It was not registered on the Kilauea seismograph.

THE SEA-BOTTOM

The earthquake of October, 1873 west of Greece produced a cliff on the sea-floor where the depth was 2000 feet instead of 1400 feet, the former sounding. A violent earthquake near Crete in 1878 broke the submarine cable in two places and made the bottom so irregular as to make necessary the laying of the new cable in another place. The cable from Zante to Crete was broken by an earthquake in 1886 and at the break soundings revealed an increased depth of 1300 feet. There are cliffs on the Mediterranean bottom 3000 to 5000 feet high. (Scott's Geology, p. 47).

With new precipices forming from time to time several hundred feet high in the depths of the sea, it is certain that the bedrock is accessible, and in many places on the floor of the deep oceans the mud may be thin. Fragments of the bedrock have not been collected.

Seventy-two percent of the bedrock of the earth's surface is thus unexplored. If we add some twenty percent of unexplored territory in the Antarctic, the Asiatic mountains and deserts, about the Arctic circle and the South American and African jungles, it is evident that we know little as yet about the globe and its rocks.

The topography and geology of the sea-floor is the biggest item of ignorance. If it is worth spending millions to study the sea-bottom until at least we know what the rock is. The echo-measurement machine for sounding the oceans is now engaging the attention of the nations. With it hundreds of accurate soundings can be made where one was made with the sounding wire. Soundings can be made while the ships are travelling. An electric buzzer or an explosive detonation makes the sound under water, electrical devices determine with great accuracy the time of discharge and the time of the arrival of the echo, and the difference of these times gives the distance of the bottom. The U. S. Naval Research Laboratory through Dr. H. C. Hayes is working out a new instrumental equipment that will both register and record the depth automatically. The U. S. Coast and Geodetic Survey through Commander N. H. Heck has developed a method of accurate loacting of a survey ship by sound ranging to the shore for distances of fifty to a hundred miles. (Jour. Franklin Inst. March 1924).

This type of sounding will quickly produce topographic maps of the hills and deeps on the sea-bottom, but what about the rock specimens? Dredging and tubular sounding irons have secured mud specimens for a few feet of depth into ooze bottoms. Thirty nautical miles east of Hilo, Hawaii, the ocean depth is 18,000 feet. Such depths may be followed for thousands of miles beyond. What is the bedrock? The two possibilities of invention for collecting specimens of the deep sea rock are blasting and boring. They would require long cables and devices operated electrically through them. A mine set off on the bottom followed up by a drag-net might be the simplest solution.

Boring with a rotary diamond drill from an enclosed motor on the sea-bottom set to drive say thirty feet of rods automatically and bite off the core, would be the most elegant device. The frame would have to be heavy and self-adjusting on the bottom. The ship supplying current and holding the cable would have to hold itself fairly stationary or else detach a float. The motor would have to operate at the great pressures of the bottom water. When is the exploration of the unknown seven tenths of the earth to begin? T. A. J.

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NO. 31 RELEASED WITHOUT COPYRIGHT RESTRICTION JULY 30, 1925

KILAUEA REPORT NO. 707
WEEK ENDING JULY 29, 1925
Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

Halemaumau continues quiet so far as exhibiting live lava is concerned, but seismically it is uneasy, sulphur gases testify to lava below, and exceedingly hot vapor rises in places through the bottom gravel.

Near the road terminus July 24 a new hair line crack crossing the hardened mud of the road and for a short distance on each side along the steam cracks following the southeast margin of Kilauea crater was observed. This showed motion in the floor of the greater crater along cracks parallel to the pit rim but 2000 feet back.

Heavy dust clouds were observed in the Kau desert this day and the next. The northeast trade wind is thereby greatly rearranging the ash and sand of 1924.

There were numerous avalanches July 25, one at the pinnacles east of the south station at 10 a. m. July 27 and at 10:15 a. m. one northeast. During the night preceding July 29 after heavy rain there was a fall of rock from the northeast wall leaving a straight-sided upright band of fresh dry rock in the wall and a new dump of debris at the base. On the opposite side of the pit falling rock was heard at the rift caverns at 9 a. m. July 29.

The seismic frequency diminished from 34 movements the previous week to 27 this week. Fourteen of these were like avalanche jarrings. There were perceptible earthquakes at 8:57 p. m. July 23 and at 2:42 a. m. July 27, the latter indicating origin distance 19 miles. The seismograms showed what appeared to be harmonic tremor the forenoon of July 25 and the morning of July 29: this is a type of motion ordinarily characteristic of active lava at Halemaumau. Tilt for the week was slight SSW, varying from moderate NE to moderate SW.

The summit crater of Mauna Loa was visited July 24 and found to be fuming in two principal places as usual. No remarkable change there was observed.

SURVEY OF THE MOON

The nearest of the heavenly bodies is still incompletely surveyed by modern telescopes. The 100-inch reflector on Mount Wilson reveals thousands of topographic objects on the moon's face hitherto unrecorded (Saunder, Mem. Roy. Astron. Soc. LX, 1-81, 1911-15), and makes possible photographic mapping stereoscopically that will reveal the relief even of the bright lines, hitherto believed to be flat.

A complete survey should contemplate securing two sets of excellent photographs with the big telescope for the two extreme positions of latitude libration, each set covering every hour of the lunar month of approximately 28 days. Once an hour would give a sufficient number of shadow changes on the lunar ridges to measure small items of relief. Roughly this would amount to 672 photographs for extreme north libration, and 672 for south libration, furnishing 672 stereoscopic pairs, or 1344 photographs in all. Comparatively few extra pictures would cover the stereoscopic possibilities of the diurnal and longitude librations.

It would take years to complete this atlas, but in the meantime the photographs taken could be worked up into contour maps as separate atlas sheets, using adjustment or "restitution" cameras, as in aerial topographic mapping, for converting the pictures of the inclined portions of the lunar surface to a suitable uniform projection, and referring the contours to an arbitrary baselevel spheroid. Such an atlas would exhibit everything measurable in the moon on a large scale in terms of measured dimensions. Then and only then could we compare scientifically the craters and other topographic features of the earth with the volcanic relief of the moon, making due allowance for the difference of gravity on the two spheroids, so as to arrive at quantitative conclusions. This result is of first importance for geology. T. A. J.

NEW SAN FRANCISCO EARTHQUAKE

The earthquake shocks of January and February in the eastern United States and Canada gave promise of a seismical year in North America. Numerous subsequent shocks in the eastern states, and in Montana and southern California, partially fulfilled the promise. It continues to be verified. If press report is correct, the latest demonstration is from the northern Coast Range of California. A strong earthquake occurred at 11:31 a. m. by California time, on Sunday forenoon July 19.

The brief telegram announces that what damage there is is not reported (doubtless owing to the usual suppression of earthquake news). The shock was so sharply felt in San Francisco, Oakland and San Jose as to cause church congregations to run into the street. General panic of this type denotes an earthquake of Grade VII of the Rossi-Forel scale, wherein I is very feeble and X very disastrous.

San Jose is 250 miles from the reported center, hence the shock was more widespread than the local but disastrous Santa Barbara quake of June 29. The center of the new shock is said to be 200 miles northwest of San Francisco. This would be either in the ocean floor at the north end of the great rift of 1906, or on land near Cape Mendocino. Along these mountains are boiling springs, steam used for power, quicksilver mines, and very hot ground testifying to subterranean volcanic energy. T.A.J.

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NO. 32 **RELEASED WITHOUT COPYRIGHT RESTRICTION** August 6, 1925

KILAUEA REPORT NO. 708

WEEK ENDING AUGUST 5, 1925
Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

Nothing has occurred of new activity at Halemaumau. Even avalanching is reduced to a minimum. There is some new red debris on the northeast talus. There have been very high winds, dry days and wet days but none of these has produced avalanching.

August 1 and 2 there were destructive sea waves due to high northeast winds, and microseisms became large. For the week there were 24 local earthquake movements, none felt. An earthquake felt on Oahu 9:18 p. m. July 29 was not recorded here. A shock at 8:11 a. m. July 30 indicated origin distance 13 miles and most of the local disturbances appeared to originate farther away than Halemaumau. Tilt was moderate to the NNW. Seasonal northerly tilt is usual in late summer and autumn.

UTILIZING VOLCANIC STEAM

The Larderello electric plant using natural steam (World Power Conference, July 1924, Wembley, address by Prince Ginori Conti; also in "Chimie et Industrie" 1923) is in a region of Liassic, Eocene and Miocene limestones, slates and serpentines. Eight districts of steam blow-holes occur, natural water is scarce, the elevation is 600 to 1600 feet, and the active area covers 100 square miles of hilly country in Tuscany near Volterra and Florence. Borax works have been using the vapors for chemical processes since 1818. The emanations contain besides mineral salts from 94 to 96 percent by weight of steam, and the gases remaining contain percentages by volume of carbon dioxide 92, hydrogen sulphide 2, methane 1.78, hydrogen 2.45, and small amounts of oxygen, nitrogen, argon and helium. Borings yield steam at temperatures varying from 100 to 190 degrees C., and ordinarily pressures of 1 or 2 atmospheres in excess of that of the air.

Ginori Conti applied a jet of this steam to a rotary motor in 1903. He next used a small reciprocating engine connected to a dynamo. Then bore-holes of 12 to 20 inches diameter were drilled and higher temperatures were obtained and a variety of pressures. The temperature was found constant for a given output of steam, but the steam was superheated for an unknown cause and could not be treated as saturated and its pressure measured by its temperature In 1905 a strong well gave 4000 kg. of steam per hour at slightly above atmospheric pressure when fully opened. A 15 h. p. engine was started in 1905 and has been working steadily for 15 years. In 1915 a 250kw. unit with turbo-alternator was started, using aluminum wires and circuit-breakers on account of the corrosion induced by the fumes on copper. This turbine received an effective pressure of 0.5 atm. at 3000 rev. generating a three phase current at 4000 volts and 50 periods frequency. Power was conveyed as far as Volterra In 1916 three units of 2500kw each were installed . The turbines have jet condensers. The natural steam at 120° C. is led through 22 evaporators in which pure water is heated to 110° C. in aluminum tubes, this water being the condensate of natural steam from huge cooling towers. By drilling new wells over 120,000 kg. of steam per hour from wells was supplied. The effective pressure at the turbines is only a quarter atmosphere or about 4 pounds per square inch.

The wells are driven by both percussion and rotary drills. Iron casings are used diminishing the diameter two or three stages to each well. The depths vary from 200 to 600 feet. Steam increases as a well deepens. A headpiece over the well diverts the steam laterally while the working rods pass through an opening at the top. It takes two to six months to complete a well. Sometimes in wet ground little steam comes until a piston is put down and raised suddenly; this starts a geyser of mud and stones followed by steam, which then takes control. The steam output is measured by fitting conical gauge openings on the well, below which a mercury manometer reads the pressure appropriate to the opening: the volume is then calculated by the Saint Vainant formula. By using different openings a diagram is drawn giving the outputs at different pressures.

Since 1923 the evaporators have been abandoned, the natural steam is cleared of its gases by physical condensation and revaporizing, and so is led directly to the turbines. Three such depurators furnished 60,000 kg. of steam per hour with only 0.5 per cent of gas. Some new wells are furnishing 35,000 and 60,000 kg. each per hour. Experiments are successfully progressing with a turbine exhausting into the air, thus doing away with the condenser plant. The net result of the Larderello experiments is that the consumption of natural steam at 2 atm. effective pressure is 40 kg. per kilowatt hour. The plant is now connected with two high tension lines at 38,000 volts for current distribution in Tuscany, running in parallel with several large hydraulic plants.

In view of the great quantities of rocks red with ferric oxide in the Larderello region, and the presence in the dry gases of oxygen along with 6 per cent of hydrogen and its combustible compounds, it appears to the reviewer that the superheat may well be due to slow oxidation of gas with reduction of mineral oxides. T. A. J.

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NO. 33 RELEASED WITHOUT COPYRIGHT RESTRICTION AUGUST 13, 1925

KILAUEA REPORT NO. 709

WEEK ENDING AUGUST 12, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

Halemaumau, the fire-pit of Kilauea volcano, has reached another extra quiet spell as shown by few avalanches and few earthquakes or tremors for the week. There were 11 local seismic movements of which five appeared to be of the avalanche type. Most of the others were very small and from origins apparently, as determined from their preliminary tremors, more distant than Halemaumau. The pit itself shows sulphur increasing about eastern and southern edges of the bottom, and during an inspection of two hours the forenoon of August 9 small avalanches averaged every fifteen minutes from different parts of the walls.

On that morning there had been a big slide making a dust cloud seen at a distance. This had fallen from the middle of the large gabbroid sill in the northeast wall. Falls at that place had created a new notch in the wall and a new talus conoid below.

Tilting of the ground for the week at the Observatory was moderate to the SSE.

There is nothing to imply "extinction" in present conditions. Extra quiet spells preceded a fortnight by extra quaky ones have come every two months since the beginning of 1925. There have been no big inward tilts to indicate subsidence of the internal lava since it was present in the pit in July 1924.

VOIDS IN LAVA FLOWS

In a typical shelly pahoehoe lava flow quite an appreciable percentage of the total bulk of the flow is represented by voids. A water stream channel developed through such lava has great bottom irregularities as well as numerous voids in its banks.

The large volume of the bottom irregularities and voids in the sides of the channels is often strikingly shown by the behavior of freshets in small streams. The road between Mountain View and Glenwood, Island of Hawaii, crosses the same stream several times within a little over a half mile. Sometimes after a heavy shower in the upper reaches of the stream there is a lapse of nearly an hour between the time of the stream becoming bank full at the upper bridge and the beginning of the flood at a lower bridge about a half mile away. The water is flooding underground before it appears overground. Seepage is probably only a minor factor in controlling such retardations in flood stages. R. H. F.

ENGULFMENT AT CRATER LAKE, OREGON

In view of the remarkable evidence of engulfment as the dominant process at the explosive eruption of Kilauea in May, 1924 (Bull. Hawn. Volc. Obsy. Dec. 1924) wherein the ejeeted matter was less than one percent of the matter engulfed, Diller's conclusions concerning the origin of the vast crater at Crater Lake National Park, Oregon are interesting. (Jour. Geol. April-May 1923, 226).

The great depression containing the lake is completely encircled by a rim cliff 2000 feet high, the lake is 2000 feet deep, and the outfacing slopes are gentle. The whole constitutes Mount Mazama built up of lavas and ejecta, andesite first, folowed by dacite and dacite pumice. The latest dacite flows outside the crater are not covered by material blown out and flows just inside the rim of the crater as it stands came from a notch produced by the collapse that engulfed the central portion of the volcano.

As the Crater Lake basin with the water removed is five miles in diameter and four thousand feet deep, and this is only one of many volcanoes in the northwestern United States, it would appear that engulfment may be a big process is post-Tertiary volcanism. T. A. J.

ILLINOIS-WISCONSIN EARTHQUAKE OF 1909

The supposition that the central United States is safe against earthquakes was rudely shaken May 26, 1909. Michigan and the great lakes are places seismically quiet according to de Montessus, but at 8:38 a. m. five hundred thousand square miles were shaken from Missouri to Michigan and from Minnesota to Indiana. Buildings were lightly damaged, chimneys fell, furniture was overthrown, dishes were broken, there was much panic. There were three centers and the duration varied from four seconds to a minute. There were rumbling and swishing noises.

Sidewalks were seen to heave and a bridge to sway. People had difficulty in keeping their feet. Glass was shattered. Instruments and machines were put out of commission. Gas pipes were disjointed in Chicago. Fires were started in Aurora and Chicago. Grain bins broke and lost their contents. Italian laborers fell on their knees and prayed. Chicago feared a tidal wave from the lake. Telephone girls left the switch-boards. The top floors of the high office buildings swayed much more than the bottom. (Udden, Pop. Sci. Mon. Aug. 1910). T. A. J.

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NO. 34 RELEASED WITHOUT COPYRIGHT RESTRICTION August 20, 1925

KILAUEA REPORT NO. 710

WEEK ENDING AUGUST 19, 1925

Issued by the Observatory, U. S. Geological Survey:

T. A. Jaggar, Official in charge

Halemaumau remains passive. On August 13 the niche over the northwest talus appeared to be without its former overhang that had made it a kind of a cavern, and the talus below showed fresh debris, showing that the overhang had been falling away. On the 16th and 17th the pit was very quiet, the former being rainy with steam showing in the bottom, the latter dry with hardly any steam. From the northeast side of the pit, the upper rift tunnel in the southwest wall appeared more filled with debris in its bottom part than formerly.

August 18 there were fresh white sulphates at a steaming patch in the middle of the bottom and a sulphur smell was perceptible at the southeast edge of the pit. There has been very little of this odor lately, and the hydrogen sulphide odor, which a year ago was strong even miles away to leeward, is no longer noticed.

August 19 at 2:30 p. m. some light sliding at the northwest wall of the pit was noticed twice during a quarter hour of observation. There had been some recent fresh stripping up and down the west wall. There was fresh white stain on the northeast and southwest walls due to drying after recent rains.

At the Observatory 10 earthquakes of local origin were registered during the week, but for five days from the 10th to the 14th there were not any. One appeared to be an avalanche tremor and all the others were small and unfelt. The net tilt of the ground for the week was zero.

A moderate distant earthquake was recorded at 1:46 a. m. August 19, the seismogram indicating an origin distant about 3000 miles—equal to the distance from Hawaii of Kamtchatka or northern Mexico.

NEW ZEALAND VOLCANO OBSERVATORY

Thanks to the excellent work of Hon. G. M. Thomson and Dr. J. Allan Thomson, it is reported that the Minister for the Interior has approved the proposal of a committee of the New Zealand Institute for establishment in the North Island of a volcano observatory.

As a beginning a suitable man is to be appointed for two years as volcano observer, stationed in the Taupo district, equipped with a motor car, and prepared to make as continuous observations as possible, having in view the selection of a site for a permanent observatory. The publication of regular reports from the New Zealand volcanoes will be welcome to volcanologists. T. A. J.

BATHYSEISMS

Dr. R. D. Oldham, who from 1879 to 1903 studied earthquakes as a member of the Geological Survey of India, in lectures at the Royal Institution January-February, 1923 (Nature, March 31, 1924, 432) reaches the conclusion that great earthquakes may result from rapidly produced strain. They are commonly thought to result from gradual accumulation of strain, which acts from below in opposite directions on some part of the solidified outer shell of rock, so that the shell gives way by faulting or "elastic rebound," and the rupturing motion on the fault-fissure is the earthquake nucleus or center. In such a case the maximum quaking should be at the rupture, the rupture should be parallel to the line of strain, and the strain should be demonstrably slow.

Oldham points out that the maximum quaking is often not at any one rupture or at any visible rupture at all; in the great Indian earthquake of 1897 and the California earthquake of 1906 there were several centers of intense shallow shaking over hundreds of miles, with isoseismal lines close together, and outside of these there are widely separated isoseismal lines for the lesser intensities of shaking. The Charleston earthquake showed no definite faults at all. The fault displacements in the Cutch earthquake of 1819 and in the California earthquake of 1906 reached twenty to thirty-five feet up-and-down or horizontally, but away from the fault plane die out within six miles.

The argument is that the multiple centers are themselves the result of a big movement more profound called a bathyseism; that their close set isoseismals are the results of their own shallow movements; that complicated scattered movements simultaneously over a wide area with outlying centers are incomprehensible results of slow growing strain, but are easily understood if the development of deep strain over a wide area is rapid. L. Pilgrim in 1913 concluded that the origin of the California earthquake lay at a depth of 100 miles, and H. H. Turner concludes on analytical evidence from seismograms that many teleseisms originate from 50 to 300 miles below the surface of the earth. As at these depths the material is weak and plastic, the original motion is not conceived to be fracture, but a volume-density change due to some process of deep-seated volcanism.

The Tokyo and Santa Barbara earthquakes agree with the conception of deep strain. Tokyo showed two distinct displacements; widespread slight shore uplift of one to seven feet due to a deep cause, and a dropped fault-block, locally down six hundred feet in the bay. Santa Barbara lay between measured bench marks that in fifty years have moved respectively 24 feet north and 10 feet south; no north-south fault has been reported on the surface, but the bench-mark creep appears to indicate growing strain, remote from the 1906 movement. Oldham's ideas are in good agreement with many earthquakes where the shock is evenly felt over wide areas. T. A. J.

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NO. 35 RELEASED WITHOUT COPYRIGHT RESTRICTION AUGUST 27, 1925

KILAUEA REPORT NO. 711

WEEK ENDING AUGUST 26, 1925
Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

Halemaumau has never been quieter. On August 21 the pit was dry and still. On August 22 the only observable change was that a sulphur spot on the bottom appeared brighter yellow. On August 25 after rain the walls were deep red and vapor rose even above the rim.

The seismographs during the week registered 15 earthquakes. One at 11:32 a. m. August 19 was felt in Hilo and Kohala and the seismogram indicated origin 41 miles away. With the same indicated distance came a smaller quake the same day at 3:49 p. m. The other shocks of the week were small and four of them were of the avalanche type accompanying slides in Halemaumau.

Tilting was very slight to the north. At 4:05 a. m. August 21 a meteor was observed at Kilauea, Kohala and Kona.

INCREASED EARTHQUAKE INSURANCE

A New Haven insurance firm states that many firms in the eastern United States are taking out earthquake insurance. This is confirmed by the Spectator, an insurance journal of New York, the Underwriter's Report of San Francisco, and the National Underwriter. The Edison Electric Illuminating Co. of Boston has insured for $45,000,000; the Equitable Building of New York is insured against earthquake for $2,000,000 on a basis of 25 percent coinsurance, and against tornado for $4,000,000 on 50 percent coinsurance. This means that if the total amount of such insurance at time of disaster on the property is less respectively than 25 or 50 percent of cash value by any or all companies insuring, the underwriters of these particular policies shall be liable for those proportions of the actual loss which two million dollars and four million dollars respectively bear to the said 25 percent and 50 percent of total value.

Large buildings in Providence and Philadelphia have been insured up to 90 percent of their value. The New Haven firm above mentioned offers a rate of 40c per $1000 for one year, or $1 per thousand for 3 years on dwellings and fireproof buildings in the East. Revised California and Montana earthquake insurance rates range from 21c to 40c a year on $1000 according to the class of risk and coinsurance percentage, the latter being mandatory with a minimum of 70 percent.

From the Santa Barbara earthquake the estimated total loss given by the insurance journals is under seven million dollars, and the insurance losses under two millions. The amount of insurance written by Los Angeles offices within four days after the Santa Barbara catastrophe was thirty millions, placed all over southern California on all classes of buildings, and all records for earthquake insurance were broken in San Francisco the second week in July when the Assocated Oil Co. purchased thirty-seven million dollars protection for its containers, pipe lines and tanks and their content. The underwriters are described as fairly swamped with earthquake business, which is very complicated in its requirements and necessarily imperfectly understood and badly scheduled. Some companies are declining to write earthquake or raising their rates, maintaining that for such a catastrophe hazard a large reserve should be built up. Usually all companies demand that fire insurance be purchased in at least equal amount with earthquake protection.

The Los Angeles Board of Education has applied for $20,000,000 earthquake insurance on sixty brick school buildings. The San Francisco board of supervisors has passed a resolution calling for a study of Santa Barbara and revision of building regulations. Buildings insured against earthquake are the Woolworth in New York $5,000,000, Kearns in Salt Lake City $360,000, dwellings, offices, warehouses and factories in New Orleans, Boston, Baltimore, Portland, Seattle and cities in New Jersey and in Canada. Many of the smaller buildings have been insured in New York and Brooklyn. The Schuster stores in Milwaukee have been insured for $5,630,000. The companies write a regular earthquake policy covering both seismic danger and the fire that may follow earthquake. They are unhesitatingly accepting more earthquake insurance in Santa Barbara than ever before. T. A. J.

RAPIDITY OF EARTHQUAKE VIBRATIONS

It has long been noted that the period of vibrations of earthquake waves increases somewhat with increase of distance. For some very distant earthquakes the period of the waves in the principal portion of the record on seismographs may be as high as 70 seconds, or less than one vibration per minute. With very local schocks—distance to origin two or three miles—the period is very rapid. Often vibrations at the rate of 200 per minute are recorded. When the distance increases to 10-20 miles the common period of earthquake waves is 0.5 second or 120 vibrations per minute. Periods of 0.6 to 0.8 second or more are commonly observed with earthquakes when the indicated distance to origin is from 30-50 miles. An experienced observer in a suitable building by merely experiencing a perceptible shake can often get some idea of its distance to origin. The long period waves of distant earthquakes do no damage to buildings and are not perceptible to human beings. They can only be detected by seismographs. R.H.F.

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NO. 36 RELEASED WITHOUT COPYRIGHT RESTRICTION September 3, 1925

KILAUEA REPORT NO. 712

WEEK ENDING SEPTEMBER 2, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

The only remarkable change of the week has been a very notable development of spasmodic tremors increasing about September 1, as registered on the seismographs. The pit of Halemaumau has shown no phenomena accordant with the tremors.

August 27 steam was heavy on the taluses after much rain. Blue fume mingled with the steam along the east edge of the floor. August 29 there was fresh debris on the northern slopes. An upward directed cavernous hole was developing above the northwest talus in the wall. Otherwise the pit has been very stable, except for little falls of single stones from the walls.

There were 27 local earthquakes and 36 spasmodic tremors, none of them felt here. A shock at 9:03 p. m. August 28 had an indicated distance to source of 43 miles and was plainly felt in Kealakekua. One at 2:42 p. m. August 29 had distance indicated as 25 miles. Tilting for the week was slight to the northeast and this is the time of year when tilt usually changes radically from southwesterly to northeasterly.

WHAT HOT SPRINGS INDICATE

In a recent symposium on hot springs (Jour. Geol. 1924) physicists and geologists mostly of the Geological Survey and the Geophysical Laboratory described warm springs of Virginia, boiling springs of the west, and scorching fumaroles of Alaska. These are "outpourings of heat energy at the earth's surface," regarded as continuous series. Chemical reaction and radio-activity prove inadequate to explain the high temperatures. Forced flow from a depth of greater pressure may explain part of the slight heating of such warm springs as those in the southern states and Haiti. Heat effects might also be produced by a forced flow of steam from the water excluded from cystallizing lava or magma underground.

From study of rate of increase of temperature downward the Yellowstone boiling waters are calculated to rise from depths of from 3400 to 8000 feet, the water being rain-water that reaches unusual depths. Iceland, Lassen Park, and the Sonoma county boiling waters of California are believed to be more than half rain-water. Geologists differ as to how much magmatic water is mixed with surface water.

Sosman summarizes the discussion by saying that the thirteen authors agree that the source of hot-spring heat is in hot magma under the crust of the earth. These authors represent the southeastern United States, Haiti, Arkansas, California, Greece, Italy, Iceland, Nevada, Utah, Idaho, Katmai in Alaska, and the Yellowstone as places of hot-spring investigation.

The question is left open as to how the volcanic heat is localized and applied. There is no obvious direct connection between volcanic lavas and hot springs, but the heat underground at shallow depths is greater in regions of recent lavas or active intrusives. The increase of temperature downward in flowing wells ranging in depth from 50 to 1600 feet varies from 3 to forty-eight feet per degree Fahrenheit; in mines and non-flowing wells from 20 to 60 feet per degree. The average for flowing wells is about 30 feet, and in mines and still wells about 40 feet per degree. Two hundred and eleven places in the western United States are included.

There is evidently much hot ground in the regions of ore deposits, recent lavas and hot springs, including under "lavas" recent intrusive igneous rocks. Heat of acid formation and of rock oxidation is found by Day and Allen to yield only two percent of the temperature of boiling springs. There seems to the reviewer to be room in the discussion for oxidation of hydrogen and reduction of rock oxides as a prevalent deep intrusive heating process in the outer crust of the earth wherever engulfment and assimilation may be in progress. And oxidized hydrogen is water. T. A. J.

WEST INDIAN EARTHQUAKES

Centers of the many destructive earthquakes recorded in the West Indies are grouped along two east-west lines north and south of very deep ocean troughs south of Cuba and north of Porto Rico. (Taber, Bull. Seis. Soc. Amer. Dec. 1922.) These reach depths of 3500 and 4600 fathoms. The earthquake belts coincide with faults at the edges of the troughs. Haiti suffers most. Sometimes successive earthquakes are on the same fault. There are exceptions to the oft-cited rule that the steepest slopes are the most seismic. High relief does not agree with places of most earthquakes. Permanent changes of shore elevation at time of quakes are rare. Such changes have however occurred gradually within fifty years.

Continued deepening of the troughs accompanies the quaking. Neither tension nor compression agrees particularly with the observed facts. Loading with sediments is not considerable. Big sea-waves have been abundant, usually with withdrawal of water preceding rise, indicating sudden downward displacement of ocean bottom. Disastrous quakes rarely repeat at the same places, hence those places along the belts "near which severe earthquakes have not originated during historic time are to be regarded as most dangerous." As the towns are built on water-logged alluvial soil, and the Antillean masonry is bad construction, the selection of sites and architecture (excepting the modern Kingston) is dangerous both for waves and earthquakes. T. A. J.

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NO. 37 RELEASED WITHOUT COPYRIGHT RESTRICTION September 10, 1925

KILAUEA REPORT NO. 713

WEEK ENDING SEPTEMBER 9, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

There has been no change in Halemaumau pit. Very slight falls of rock from the walls have been heard every time the pit has been visited, and on one occasion there appeared to be more sulphurous steam of bluish color at the south talus than usual. A little fresh debris is discernible on the southern taluses.

Forty-four earthquakes and tremors of local origin were registered. Quakes plainly felt in Pahala happened at 8:24 p. m. and 10:40 p. m. September 2. An earthquake felt here at 3:34 p. m. September 5 had origin distance indicated as 39 miles. A slight record of distant earthquake was registered at 6:21 a. m. September 5. Tilt was slight to the west.

RADIOACTIVITY, GEOLOGY AND VOLCANOES

Professor Joly of Dublin accounts for the systematic recurrence of great geologic revolutions accompanied by mountain-building, volcanism and extinction of floras and faunas, by a series of cycles thirty million years long each, occasioned by storage and release of radioactive heat. (Halley Lecture, Oxford University Press, 1925, "The influence of radioactivity on the surface history of the earth," J. Joly. See Nature, May 5, 1923, June 7, 1924 and May 30, 1925). This conception accords well with the volcanologist's experience of short term tides and cycles, and with the evident condition of the earth today volcanically as degenerate compared with Tertiary time.

There is first a lowering of the continents under shallow seas and deep sediments. Then the sediments rise crushed and wrinkled and are worn into mountains. There is outbreak of floods of lava, generally along western coasts. The land attains its former elevation and a long time of comparative quiet ensues with life prospering. Figuring the age of the sedimentary rocks we know from the radioactive degeneration of thorium lead, Joly makes the four or five world revolutions of geology thirty million years apart.

The continents float upon yielding basalt below. The crust is 24 miles deep and the basalt 200 miles. The cooled non-liquid basalt heats itself to liquidity in 25 million years. It becomes lighter on heating, so that the continents sink slightly while the supporting liquid expands and ruptures them. The ubiquitous radioactive elements do the heating. Volumes of lava pour out. The volume increase of the lava substratum is over six per-cent, enough to increase the surface area of the globe 650,000 square miles.

Tidal effects appear in this sea of lava underground. The continental crust lags behind as the earth rotates and the eastward pressure of the substratum crushes and crumples the deeper portions of the continental blocks filled with sediments, especially on their western sides. These crushed troughs are to become the mountains. The continents drifting relatively west leave the lava on the east under the sea-bottom close to the surface, quicker circulation in the liquid lava causes it to cool and crystallize losing its heat to the oceans, so that the hot eruptive period draws to a close.

With the cooling comes greater density to the basalt and the continents rise by floating higher through a period of some five million years, and volcanic activity wanes. The sea-bottom lava shrinks and lowers. This is the sort of time we are living through now. The early Tertiary age was the last time of revolution. The crushed sediments of the former shallow land-locked seas are heaved higher than the rest of the continents because their roots go lower in the floating, just as a deeper ice-berg lifts a higher peak. The weather and streams erode them into mountain ranges.

It is true that all mountain ranges do not trend north and south like the Cordilleras. But in the cases of the Himalaya and the Pyrenees, for example, the rupturing Eurasian continental blocks had merely to execute slight turning movements to distort the mountain axes. The inter-revolutionary periods are full of small revolutions through graded cycles leading to the big ones. Summarizing, radioactivity furnishes the heat that periodically takes effect by liquefying the outer part of the earth, and the rest of the energy is furnished by the rotation of the earth when the crust becomes mobilized. The globe is enormous and heavy, the crust is trivial and light, and the surface velocity is 1000 miles an hour. T. A. J.

MAXIMUM HEIGHT OF EXPLOSION CLOUDS FROM KILAUEA IN MAY 1924

Owing to the closeness of the Observatory to the seat of the explosions good estimates of the maximum heights of the clouds could not be made. The cloud columns would lean in various directions so that their true distances from the Observatory were not known and one could not measure the angle to their summits and accurately compute their heights. The estimates of the height of one of the tallest clouds noted at the Observatory accordingly varied between 15,000 and 30,000 feet above sea level. The tops of the clouds of the three most violent explosions of the series could not be seen from the Observatory because of general cloudiness.

Good views of several explosion clouds were obtained from Waimea. Waimea is about 50 miles from Kilauea and 2700 feet above sea level. The clouds were observed just to the right of a line to the summit of Mauna Kea from Waimea and appeared to be about 2000 feet higher than the summit. As the summit of Mauna Kea is about 20 miles from Waimea and 13,825 feet above sea level, it would seem that the cloud heights may have been 33,000 feet above sea level. Allowing for possible errors in estimates and some spreading out of the cloud tops, it would appear that the maximum height reached by the explosion clouds was about 30,000 feet. R. H. F.

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NO. 38 **RELEASED WITHOUT COPYRIGHT RESTRICTION** September 17, 1925

KILAUEA REPORT NO. 714

WEEK ENDING SEPTEMBER 16, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

Nothing new happened at Halemaumau pit until the evening of September 11 when about 11 p. m. the roar of an avalanche of rock was heard in the still night air, the noise proceeding from the pit and quite audible at the Observatory and Volcano House two miles away in an air line. Somewhat later the same night there was another avalanche.

From 10:30 to 11:30 the next forenoon the northeast wall was seen to be working, two slides occurred in a half-hour, and at 1:45 p. m. came a larger slide that sent up a considerable dust cloud from the same place. The weather at this time and for most of the week was hot and sultry, the maximum temperature reaching 82° F. September 14. On that day there were slight slides, but a loose slab that appeared ready to fall at northeast edge of the pit was still in place. A dust cloud rose at 12:50 p. m. September 15. The pit thereafter was tranquil and very dry, the only notable steam patch being at the west pocket. The many avalanches of the year have produced vertical striations on the walls.

Sixteen seismic movements were registered, of which eight were of the avalanche type notably on September 12. Tilting was moderate SSW. None of the earthquakes was perceptible.

EARTHQUAKES IN THE UNITED STATES 1915-23

During the nine full years, 1915-1923, that the U. S. Weather Bureau collected and published in the Monthly Weather Review the earthquake statistics for the mainland of the United States, 955 separate earthquakes distinct enough to be perceptible were reported. This makes the yearly average over 100. Forty-two states and the District of Columbia reported earthquakes. The average number of states reporting one or more earthquakes each year was 19. If the records for 1924 and the first two months of 1925 were included all states excepting Delaware, Florida, and Louisiana would have earthquake reports. An earthquake on October 16, 1916 was undoubtedly perceptible in Florida also, as it was reported from a place in Georgia almost on the Georgia-Florida line.

The number of earthquakes felt in each state is shown in the following table:

State	No. of shakes 1915-23 incl.	State	No. of shakes 1915-23 incl.
Alabama	8	Nebraska	1
Arizona	20	Nevada	36
Arkansas	12	New Hampshire	2
California	594	New Jersey	2
Colorado	19	New Mexico	4
District of Columbia	1	New York	10
Georgia	2	N. Carolina	5
Idaho	15	N. Dakota	1
Illinois	29	Oklahoma	1
Indiana	7	Oregon	17
Iowa	2	Pennsylvania	2
Kansas	3	S. Carolina	17
Kentucky	16	S. Dakota	6
Maine	7	Tennessee	28
Maryland	1	Texas	2
Massachusetts	3	Utah	36
Michigan	4	Vermont	1
Minnesota	2	Virginia	6
Montana	5	Washington	37
Mississippi	4	W. Virginia	1
Missouri	20	Wisconsin	3
		Wyoming	13

As several of the earthquakes were felt in more than one state they were counted more than once so that the sum of the numbers in the above table exceeds the actual number of separate earthquakes. Over half of the earthquakes were reported from California but this is not surprising when one considers the great extent of the state and the fact that it is the most active region, seismically, in the United States.

The most active regions seismically in the eastern United States are along the middle part of the Mississippi River—southern Illinois, western Kentucky and Tennessee, northeastern Arkansas, and southeastern Missouri—and the southern Appalachians. Some of the earthquakes experienced in these regions caused minor damage; though the areas affected were nearly as great as the area affected by the San Francisco earthquake of 1906. This indicates that the actual breaks that cause the earthquakes are, as a rule, at a greater depth below the earth's surface in the eastern part of the United States than in the western part.

During the first part of the nine-year period under discussion several earthquakes were experienced yearly at or near Charleston, South Carolina but during the latter part of the period the frequency of earthquakes at that place seems to have diminished.

The strongest earthquake during the nine-year period occurred in Nevada on October 2, 1915. It was the strongest earthquake that has occurred in the United States since the San Francisco earthquake and was recorded on seismographs all over the world. Cracks 22 miles long were opened in the earth's surface, but little damage was done, however, as the break occurred in a sparsely settled country.

R. H. F.

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NO 39 **RELEASED WITHOUT COPYRIGHT RESTRICTION** September 24, 1925

KILAUEA REPORT NO. 715

WEEK ENDING SEPTEMBER 23, 1925

Issued by the Observatory, U. S. Geological Survey:

T. A. Jaggar, Official in charge

Nothing has happened as yet to indicate any equinox effect at Halemaumau pit. There has been some stripping of the north wall by avalanches. On the 19th there was a new notch adjacent to and west of the north sill; the debris below was red. On the 23rd there was new dry debris on this same north talus but it was white, and had come from the horn of the sill itself, which consists of a whitish rock.

Not much has been seen of these avalanches. About 1 a. m. of September 22 the roar of an avalanche was heard. That the walls are still unstable was proved on September 22, when some men throwing bowlders over the northwest rim succeeded in starting a slide sufficiently great to make a small dust cloud above the pit. The pit most of the time is quiet. Bluish vapor has been noticed at the base of the wall itself SSW. After rain increased steam returned to the bottom.

Nine earthquakes of local origin were registered on the seismographs. One of these was felt in Hilo at 9.53 a. m. September 17; the seismogram indicated distance to origin from the Observatory at Kilauea of 12 miles. Only one of the registered seisms appeared to be of the avalanche type. Tilt was moderate to the ESE.

COSTA RICAN VOLCANIC DISASTERS

There were many earthquakes, eruptions and floods in the mountainous and volcanic lands of Costa Rica from the seventeenth century on, but reliable records only begin about 1840. From that time some ten to twenty earthquakes per year were sufficiently destructive to be recorded. From 1888, when there was a severe shock in central and western Costa Rica, the Alajuela disaster, a seismologic station was established in the capital San Jose', and from thirty to eighty local earthquakes per year were registered, many very short, only from four to sixteen seconds duration.

Cartago, the second city, and near the continental divide, has suffered terribly from earthquakes in 1822, 1841 and 1910. April 10, 1821, a shock damaged the parochial church, and a year later, May 7, 1822, the whole of central Costa Rica was devastated by a major earthquake, aggravated by the rainy season that deluged the refugees in their straw, plank or skin huts. In 1827 a church at Nicoya on the Pacific coast was ruined. September 27, 1841, Cartago was destroyed anew by a violent quake. The population numbered 17,000, and a third of them were trapped in the ruins and many lost their lives. The center of the city containing 600 large and beautiful buildings including many churches was a total wreck, and 4205 houses were more or less demolished. Shocks continued for twenty-one months, keeping the inhabitants in light shacks exposed to the weather. This was the worst Costa Rican seismic disaster in the 19th century. The year 1851 produced a serious earthquake at San Jose', which is a few miles west of Cartago in the same mountainous central region.

The terrific Cartago earthquake of 1910, on May 4th, demonstrated the obscure but intimate relationships between volcanoes and these shocks. Cartago is at the foot of Irazu volcano and San Jose' near the base of Poas, another active cone with a geyser-like lake of boiling water in its crater. In 1910 Poas became explosive on January 25th and threw much ash over the country and pumice bombs on the borders of its crater. In southern Costa Rica there had occurred a strong shock January 10th. On April 13th there were two midnight shocks of great intensity near San Jose', damaging several towns, and felt from Nicaragua to Panama; the aftershocks were numerous and kept many persons in camp outside of their houses. On May 4th at 6:50 p. m. a tremendous jolt from the east came after an afternoon of many shocks and made of Cartago a heap of rubble, destroying the Carnegie Peace Court, the churches, dwellings, public buildings, and shops. There were killed 272 persons and hundreds were wounded.

Irazu volcano in 1910 showed cracks about its crater, but no activity until 1917 when it broke into explosive eruption damaging the agricultural lands with ash. March 4, 1924, violent earthquakes shook the western half of Costa Rica, again two shocks an hour apart, seriously injuring San Jose', several other towns, the roadways by landslip debris, the western railway and a large country district.

It is worthy of note that in 1891 Cartago was smashed by another type of disaster, a sudden torrential river flood caused by a cloudburst. This started a landslide that dammed a stream, which finally burst the barrier. (Materiaux pour l'e'tude des calamites, April-June 1925, Tristan, p. 62; Viquez, p. 91 See also Jaggar and Spofford, Jour. Assoc. Eng'g Socs., February 1911, Boston).

T. A. J.

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NO. 40 **RELEASED WITHOUT COPYRIGHT RESTRICTION** September 30, 1925

KILAUEA REPORT NO. 716

WEEK ENDING SEPTEMBER 30, 1925

Issued by the Observatory, U. S. Geological Survey:

R. H. Finch, temporarily in charge

This week marks the end of 14 months during which the volcano has been quiet. Several avalanches, some of which were loud enough to be heard at Volcano House and sent up dust clouds, occurred during the week.

On September 30 there were several bright red patches on the walls of Halemaumau showing that light rains may produce redness in restricted areas. Heavy rains cause a general reddening of the walls.

Ten earthquakes were registered on the Observatory seismographs. None was perceptible at Volcano House. Excepting three that were of the avalanche type the majority appeared to have had origins at distances considerable in excess of two miles from the Observatory. Tilting was slight to the west.

PRESENT CONSTITUTION OF THE EARTH

Sir Horace Lamb, president of the British Association for the advancement of Science, made a notable address on this subject at the recent Southampton meeting. (Science, Sept. 11, 1925 and Nature, Aug. 29, 1925). "The primary aim of science is to explore the facts of nature, to ascertain their mutual relations, and to arrange them into a consistent and intelligible scheme."

Irregularities in the intensity of gravity have been found to exist over wide areas, proving that in mountainous regions the observed value of gravity, i. e. the weight of the earth crust, is abnormally low, whilst on oceanic islands and about the sea it is abnormally large. The accepted explanation is that the stratum of rock above an imaginary level surface sixty miles down is approximately uniform, in the sense that equal areas of the surface in question bear equal weights. The mountain elevations are held up by the inferior density of the underlying matter, whilst the oceanic hollows are made up for by increased density beneath. The matter in the interior of the earth, below the stratum of "isostatic balance," is in a state of pressure uniform in all directions. The material of the stratum itself is strong enogh to withstand the shearing forces due to the weight of continents and the lack of lateral support at the oceanic depressions.

A rough picture of the material of the inside of the earth makes the central core of about the density of iron, surrounded by an envelope of rock. This satisfies the requirements of gravity distribution, the ascertained velocities of seismic waves from big earthquakes at different depths and the permissible elasticity of the globe.

Lord Kelvin's attempt to limit the age of the earth by loss of heat was upset by the discovery of generation of heat in the processes of radioactive change of elements everywhere present in the rocks. A stratum some ten miles in thickness would provide all the heat wanted for the present known increase of temperature downward. The time elapsed since the consolidation of the earth, estimated by a comparison of the amount of uranium and of the lead associated with it by radioactive degeneration, must be between a thousand million and ten thousand million years.

As to rigidity, the earth itself has a tide occasioned by the deforming action of the sun and moon. The horizontal force of these bodies must slightly deflect the apparent vertical of a pendulum. If the earth were perfectly unyielding, the pendulum would have a calculable displacement. If its observed displacement were less than the calculation, it would mean that the earth itself yielded to that extent. Michelson used two canals E.-W. and N.-S. as pendulums, each 500 feet long, and measured optically their microscopic tides, with a range of movement of the order of a hundredth of a millimeter. The observations magnified exhibit all the features of a tide-gauge record, but the observed tides were only seven tenths as great as those calculated for the canals on an assumed rigid earth. Both E.-W. and N.-S. were alike. The three tenths unaccounted for were taken up by the tides passing through the solid rock. This would amount to a rise and fall of about a rigid, like steel, but not perfectly rigid. The elasticity of foot each half-day. The material of the earth is highly the earth as shown by the wave velocities of compressional and distortional waves from earthquakes, and the ratio of the two, appears to be much like that of ordinary metals and glass. The compressional travel 4½ miles per second and the distortional or transverse waves 2½ miles per second in the outer rocks; thirteen hundred miles down and beyond they travel much faster, 8 and 4 miles per second respectively.

There is an interesting discrepancy between the thermal and tidal arguments about the earth's interior. The thermal argument suggests a plastic condition for the interior. The perfect elasticity shown by the tidal arguments and the earthquake waves indicates great resistance to shearing or flow. Some substances are plastic only to long continued stress. Dr. Lamb suggests that the interior matter of the globe may be plastic under the steady application of centrifugal force, but rigid under such short period forces as the tides or the earthquake waves. T.A.J.

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NO. 41 RELEASED WITHOUT COPYRIGHT RESTRICTION October 8, 1925

KILAUEA REPORT NO. 717

WEEK ENDING OCTOBER 7, 1925

Issued by the Observatory, U. S. Geological Survey:

R. H. Finch, temporarily in charge

After the spell of moderate avalanching noted during the middle and last of September Halemaumau is again rather quiet. Small rock falls, however, can nearly always be heard. On calm days the wierd multiple echoes produced by such falls make it seem as though many landslides were in motion.

Several of the steaming vents on the floor of Halemaumau pit and on the avalanche slopes appear dry as though the visible vapor escaping were live steam. The rapid ascensional rate of some of the steam columns that appear above the rim of pit on damp days also indicates a rather high temperature. The borders of other vents appearing wet leads one to believe that the vapor escaping from them is not excessively hot.

Nineteen local earthquakes, all too small to be perceptible at Volcano House, were registered on the Observatory seismographs. Four of the tremors were of the avalanche type.

Faint records of two distant earthquakes were written at 5:30 p. m. October 3, and 5:58 p. m. October 4.

There was considerable fluctutation in tilt during the week with the net result being slight to the southeast.

Mr. J. B. Stone, geologist of the Bishop Museum, who spent a week on the summit of Mauna Loa with the topographers of the U. S. Geological Survey, now mapping that mountain, reports the usual amount of fume in Mokuaweoweo the summit crater. The odor of sulphur dioxide is quite perceptible at the several fuming vents.

TILTING OF THE GROUND AT HAWAIIAN VOLCANO OBSERVATORY

By tilt is meant a change in the angle of inclination between a portion of the earth's surface and the horizontal. If an entire mountain edifice domes upward symmetrically with a maximum uplift at its central area and decreasing amounts with increase of distance from the center, then at the central area there will be a vertical uplift. Any other surface within the area affected by the swelling will have its angle of inclination with the horizontal changed. There would be a tilt away from the center. Similarly if the mountain subsided there would be a tilt toward the center.

Tilt may be measured by noting the changes in the position of rest of a pendulum. A horizontal pendulum, such as is commonly used for seismographs, may be made more sensitive to tilt than an ordinary pendulum like those in clocks.

Tilt records are affected by temperature changes, probably both by temperature changes in the ground and in the instrument itself. There is a diurnal tilt that closely follows the dirunal temperature change and a seasonal tilt that closely follows the seasonal temperature change. The cylcic seasonal tilt at Kilauea, though large, is small compared with the accumulated tilt for several years.

An attempt was made to find some correlation between tilt and rainfall but no striking results were found. This is surprising as Kilauea is situated at the edge of the rain belt with heavy rains to the northeast and very light rains to the southwest.

Sometimes the area to the northeast of Kilauea will receive in one day a rainfall load of nearly 1,000,000 tons per square mile while the area to the southwest may have but little or no rain.

A very rapid tilt means a rapid bending of the rocky layers that compose the Kilauea mountain edifice. A large and rapid bending of rocky layers is apt to cause breaks with the resultant earthquakes. There seems to be a positive connection between tilt and earthquakes.

At Kilauea there is a connection between tilt and volcanic activity. From 1913 to 1919-1920 there was a gradual rise of the mean lava level of 600 feet. During the same time there was a gradual swelling of the mountain top as shown by the northeast tilt on the Observatory seismographs. This tilt was checked by level lines run in from sea level. They showed that at the Observatory, 2 miles or more from the place of suspected maximum increase of elevation, there had been an increase in elevation of over a foot between 1912 and 1921. At some places nearer Halemaumau the increase in elevation was greater.

From 1919-1920 until the disappearance of lava in 1924 there was a gradual sinking of the lava column. During the same time there was slight accumulation of southwest tilt showing that the mountain was sinking. Coincidental with the rapid sinking of the lava column in the spring of 1924 there was a rapid southwest tilt. The accumulation of southwesterly tilt during the three years ending with 1924 amounted to about one minute and 32 seconds of arc. In September 1925 A. L. Burdick, Hilo engineer, kindly ran a level line between the Observatory and two points near Halemaumau. The levelling showed that one point had sunk nine feet and the other five feet with respect to the Observatory. The Observatory itself undoubtedly sank several inches.

This is but an outline of a more complete discussion to be published elsewhere. R.H.F.

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No. 42 | RELEASED WITHOUT COPYRIGHT RESTRICTION | October 15, 1925

KILEAUEA REPORT NO. 718

WEEK ENDING OCTOBER 14, 1925

Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, Temporarily in charge.

Eleven earthquakes were registered during the week. None was perceptible at the Observatory. A month has elapsed since a perceptible earthquake has occurred at Volcano House.

Avalanches have been rather infrequent during the past week, though small rock falls were occasionally noticed. After the heavy rain of October 13 the walls of Halemaumau were colored a brilliant red excepting for some thick dense layers and instrusive bodies which remained gray.

Tilting was slight to the south-southwest.

Microseismic motion that increased on October 12 indicates the possible presence of a storm at sea near Hawaii. Microseisms became more noticeable on the 13th and continue on the 14th. The only other effects of such a storm noted were southwest winds, thunderstorms, and heavy rainfall.

THIRTY YEARS OF EARTHQUAKES

A summary study of all earthquakes felt in Italy for thirty years following 1891, compiled at the government office, shows that the time of day between 2 and 4 a. m. has the most shocks, while the fewest are from 6 to 8 p. m. There are somewhat more earthquakes in summer than in winter, about 20 per cent more. (Cavasino, Boll. Soc. Sism. Ital. XXV, 49, 1925).

There is great difference between night and day, about twice as many earthquakes being reported at night. This is commonly attributed to fallacy, dependent on more being felt in the quiet hours. To test this, Cavasino listed only strong earthquakes of Grade V of the Mercalli scale or stronger, as these would surely be generally felt either night or day. This special list showed that 1194 shocks of this magnitude came at night as compared with 890 in daytime during the thirty years, making 34 per cent more at night.

He asks, what is the reason? And why is the maximum in the summer and from 2 to 4 in the morning? Cavasino suggests barometric pressure of the atmosphere as a possible control. A millimeter of pressure change on a square kilometer of the earth equals 13.6 million kilograms, sufficient to tilt the adjacent land 0.29 seconds.

Such change gradually applied could have little systematic effect on tectonic earthquakes dependent on accumulating pressure or tension. But for volcanic magma underground the effect might be regular in releasing gas tension. Low barometric pressure would favor such expansion of magma and the pressure of the confined paste on its chamber walls would produce earthquake by repeated rhythmical stresses. The barometer is lowest and the atmosphere presses least at four a. m. for the day and in the summer among the seasons, thus agreeing with the theory. But there is a disagreement; there is a daytime minimum of atmospheric pressure at 4 p. m. without any corresponding earthquake maximum.

An investigation of rainfall by districts in relation to earthquake frequency discovered no correspondences.

The districts of Italy, listed in the order of intensity or violence of their earthquakes, and then in the order of frequency of all earthquakes, showed about the same order of quakiness by both methods. Those places having the most shocks have also the strongest. Sardinia is remarkable in being without earthquakes. In the order of increasing numbers of shocks next came Basilica, Liguria, Lombardy and Piedmont, places of weak seismicity. Next are Lazio, Emilia, Puglia, and Venice, moderate shakiness. Lastly and strongly seismic are in order of increase Campagna, Abruzzo, the March, Tuscany, Calabria, Umbria and Sicily.

In all Italy in thirty years the number of shocks was 13,531 or 451 earthquakes per year felt. Many of these were aftershocks due to the adjustment of local disruptions produced with big earthquakes. Eliminating the aftershocks from the list there are still high frequencies for the years of big earthquakes; such are 1905 (the Calabrian disaster), 1909 (Messina), and 1915 (Avezzano). Apparently some deep-seated process affected all Italy in those years.

Apart from aftershocks, there is an earthquake every two days in Italy, and a disastrous one about every two weeks destroying either property or life. And Italians have done much for practical seismology; may they carry on the work until every dweller in the land feels that his house is safe. T.A.J.

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NO. 43 RELEASED WITHOUT COPYRIGHT RESTRICTION October 22, 1925

KILAUEA REPORT NO. 719

WEEK ENDING OCTOBER 21, 1925
Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge.

There are no changes to report in Halemaumau pit. Small slides occur from time to time. The floor vapor continues to rise at several places, increasing after rainfall. On October 15 with southwest wind the vapor condensed about 400 feet below rim and made dense clouds at rim level at 2 p. m. when the weather was foggy. On October 17 small rock falls were heard, and dust from such a fall was seen about 2 p. m. October 21.

For the week seven local seisms were registered, of which four were of the avalanche type and none was perceptible. Tilting of the ground was moderate to the NNE. Microseisms were stronger than common during the forepart of the week.

THE DALY GLACIER ON MAUNA KEA

Evidences of ancient glaciers on the top of Mauna Kea in the form chiefly of stony moraines and ice-scratched ledges and bowlders have been observed since 1909. At that time they were described by R. A. Daly (Am. Jour. Sci. 1910, 279; Science Conspectus, 1911, 120; Proc. Am. Acad. Arts. and Sci. 1915, 158). The writer October 13, 15 and 19 explored the scenes of the Daly glacier and in addition to the other evidences of glacial action discovered large outwash plains from the glacial drainage on the SSW flank of Mauna Kea at elevations about 6600 feet. By the Daly glacier is meant the ice cap that covered the summit flat south of the summit cones. The summit flat ends with a distinct shoulder that edges the plateau, where the slope below increases to thirty degrees or more. The shoulder is at about the 10,500-foot level. Apparently the glacier overhung this shoulder and its drainage swept down 4000 feet to the plain below.

As other moraines are described on the northern parts of the summit area, the ice cap must have been seven or eight miles across. The Daly glacier was over three miles long, now represented by mutton-back ledges elongated to the SSW, scored heavily in grooves and polishings, the rock a smooth trachydolerite whitened by the weather and more or less covered by erratic bowlders. The bowlders are sub-angular, rounded and scratched. The mounds of morainic material make big whitish piles heaped along the mountain shoulder. The ledges are curiously broken up and plucked, as though by the freezing and thawing of snow ice of modern days. There are drainage gorges amid the moraines. The whitish glaciated area is in marked contrast to the red aa lava spurs and red cinder cones which bound it. As to the relation in age between these volcanic eruptions and the glacier, the upper part of the latter appeared to leave debris that was younger than the summit cones of the mountain, but some lower lava cones appeared partially to bury the glacial deposits. This is a matter that requires geologic mapping.

The plain of gravel, rounded bowlders and alluvium below is ten miles long in a WNW direction from Kalaieha, the sheep station, and at a slightly lower level is another series of flood plains about four miles long. The width of the upper plain is four or five miles. It is wonderfully flat, covered with winding stream channels of only a few feet depression, revealing in their banks an upper two or three feet of yellow or buff alluvium, over coarse gravel and stones below. The plain is covered with bunchy grass and scattered mamane trees. The streams appear to converge upward at a big diagonal gorge that led down from the glacier, and west of this are other gorges trenching the pyramid-like face of the mountain below the moraines. Some of the plain areas are bordered by terraces that suggest lake shores, consisting of old aa flows reshaped and partially buried by flood or lake action. The plains are so flat as to remind one of playas. The stones of the flood plain are identical with those of the glacier, and with nothing else.

The big wash plain where it butts against the steep face of the mountain makes a sharper angle in profile than the upper shoulder makes with the summit plateau. This summit plateau is far from flat and is interrupted by immense cones that appear 800 to 1000 feet high or more. These cones threw out bombs of viscous lava in almond shapes and of all sizes, they have cup craters, and aa lava flows emerge from them. The summit lake is at about the head of the Daly glacier. Towards the sheep station there appears to be a zone of cones suggesting the trend of a rift line. T.A.J.

ACTIVITY OF SANTORIN

H. S. Washington of the Geophysical Laboratory of the Carnegie Institution sends word from Greece that the well known volcano Santorin, near the island Thera of the Grecian Archipelago, is again in eruption. The new cone is back of an older one called Mikra Kaimeni, formed in 1573, and within the central group of island cones that recent eruptions have formed, this all being in the middle of a circular oceanic lagoon surrounded by an annular older island. With Professor Ktenas of Athens Dr. Washington is watching the eruption; on September 14 a high Strombolian cloud of steam was rising accompanied by continuous loud roaring and many blocks were ejected without much lava flow being visible.

On September 18 a definite cone had formed which these observers call Fouque' Kaimeni after the distinguished French savant who has monographed Santorin. They approached the cone September 17, but showers of red hot lava blocks prevented them from getting very near. The spectacle was magnificent. T.A.J.

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NO 44. RELEASED WITHOUT COPYRIGHT RESTRICTION October 29, 1925

KILAUEA REPORT NO. 720

WEEK ENDING OCTOBER 28, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge.

The large inner pit of Kilauea crater, Halemaumau, left 3500 by 3000 feet in plan and 1300 feet deep by the activities of 1924, remains inactive with reference to lava activity, but very hot in parts of its bottom and in its convectional emission of gas or vapor. There is little odor. The evidence of heat was striking on the late afternoon of October 26, after a thunder storm with torrential rain, when the vapor jets from all over the Kilauea floor were drawn inward toward a huge cumulus over the pit which billowed up to an immense height. Steam spouts or whirls have been common with the cessation of the trade-wind. With light south wind the gas from the pit nucleates the vapor jets north of it.

Slides have been small. For 15 minutes the morning of October 24 no single pebble fell. There are notable dry hot streaks in otherwise wet talus south and northwest where steam rises. The north and northeast walls have peeled the most showing fresh breaks and cavernous recesses.

The seismographs have registered 10 tremors of which six were pronouncedly of avalanche type and none was perceptible. Tilting was moderate SSE.

A WORLD CAMPAIGN OF EARTHQUAKE SAFETY

"If the seismologic control of the world were put in the hands of some superman with scientific knowledge and authoritative powers it is possible to imagine the way in which he would organize his forces and carry out his task. First of all he would not rest content with the scientific resources in his possession, but would provide for continuous investigation in order to re-examine constantly the knowledge already acquired and to add new information. He woud fit up well-equipped and competently manned centres for investigation. These institutions he would place in strategic positions throughout the world in such a way as to bring the widest variety of earth movements under constant scrutiny. He would further see to it that the staffs of these research centres were in constant communication so that duplication of effort would be avoided and the results secured in one place put quickly at the disposal of workers in all the other institutions. In this way he would organize geonomic research as a world activity, constantly recruiting his groups of investigators and producing steadily new knowledge about the nature and variety of tilts, level changes, tremors, quakings and wave movements, and especially the safe living of mankind with the cataclysms which afflict it."

With only a few words changed (hygienic to seismologic, etc.)' the above is the first paragraph of "International Public Health" by Dr. Vincent, President of the Rockefeller Foundation, in Caldwell and Slosson's "Science remaking the World." What is being done in public health may be done in LOCAL seismology, but this means the creation of just such an organization as the Rockefeller Institute of Medical Research to unite the world in defense against the earthquake "epidemics." All the succeeding measures advocated by Dr. Vincent apply equally to earth study: an administrative world preparedness and construction organization, a centralization of seismic statistics, a positive campaign of house to house education and of training experts. Avoidance of earthquake disaster does not mean stopping the earthquake, but as Mr. John R. Freeman has well said, "seventy-five per cent of the great losses of life and property in the earthquakes of the past could have been prevented by better building, and all within present economic means" (Earthquake Insurance, Manufacturers Mutual Fire Insurance Co., Providence).

It is one of the tasks of the Hawaiian Volcano Research Association to encourage LOCAL study of earth process about the Pacific Ocean. Taking the final paragraph reviewing the success of public health propaganda in Dr. Vincent's article, seismologic science is seen to be backward in comparison; "In the last half-century the scientific resources of modern medicine have been enormously enriched. The causes of a great number of devastating diseases have been discovered; the methods of controlling them have been worked out; medical education has been put upon a higher level; a beginning has been made in the training of expert sanitarians and an entire hygienic personnel. Organization of health administration has been greatly increased in efficiency. The death rates in all the leading countries of the world have fallen in a most gratifying fashion. Beginnings have been made in the education of the public, etc."

To paraphrase this, the scientific resources of modern LOCAL seismology have not been experimentally enriched; the causes of LOCAL earth movements have not been discovered; the methods of LOCAL earthquake-proof placing and construction have not been worked out; seismologic education is not in the school geographies, and except for a few men such as the late honored Professor J. B. Woodworth of Harvard there are few professors of the subject in the universities, and those not reaching the LOCAL, experimental and engineering sides of the subject; no beginning has been made in the training of expert seismic engineers and architects and a seismician personnel. Organization of LOCAL seismologic administration and statistics is still backward. The seismic death and destruction rate in all the earthquake countries of the world is increasing alarmingly without sufficient insurance control of congestion and conflagration, and hardly any beginning has been made in the education of the public.

In view of the colossal destructions of life and capital of the last quarter century this comparison is pregnant with possibilities for reform. The insurance companies are the logical agents to bring about the reform, for the situation affects every department of their business. T.A.J.

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NO. 45 RELEASED WITHOUT COPYRIGHT RESTRICTION November 5, 1925

KILAUEA REPORT NO. 721

WEEK ENDING NOVEMBER 4, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge.

On Saturday, October 31 there were rocks in motion falling from the north and west walls of the Kilauea pit Halemaumau. The north corner showed fresh red debris and dust on the slopes. The recently developed talus cone against the northeast intrusive sill lies below a niche in the wall that has scaled off so as to be bounded on the east by the rift dyke of 1919. On November 3 there were occasional slippings of wall rock SW, NW, and NE. These slides were very small. The steam rising at the west pocket of the bottom is livelier than elsewhere.

Thirteen seisms were registered, mostly little shocks, four were avalanche tremors. A local earthquake at 4:52 p. m. October 28 had indicated origin 8 miles southeast of the Observatory and was of the perceptible class. Tilt was moderate NNE.

TELLING THE AGE OF OLD LAVA FLOWS

It is impossible in Hawaii to guess at the relative ages of lava flows by the vegetation or any such landmark, because the different rainfalls in short distances produce strong differences in apparent weathering and plant growth.

Nature (Oct. 3, 1925, 515) cites M. R. Chevallier who worked on the lava flows of Etna and showed it to be possible "to determine the magnetic declination at the time the lava solidified by observing the direction in which it is now magnetized" (Annales de Physique, July-August 1925). The magnetic declination or compass variation from the true north slowly changes through the centuries at any one place, so that a given year has a characteristic declination.

Chevallier took the average direction of polarity of several pieces of lava from a flow just as they lay, and therefrom obtained a satisfactory agreement with the declination of the year 1911 for the 1911 flow; and with the declination of 1669 for the 1669 flow. This appears to mean that a majority of the crystals of magnetite oriented themselves to the earth's magnetism before the flow congealed. When the declination values so obtained from specimens of earlier lava flows of known dates were plotted, the curve obtained continued the known declination curve of the Etna region symmetrically backward, passing zero declination about 1630, through 18 degrees east about 1440, and through zero again toward westerly variation about 1240. The time intervals from zero to zero are nearly equal and the extremes of declination east and west are the same. These results appear worthy of laboratory experiment on slags containing magnetic minerals. T.A.J.

BUILDING FOR EARTHQUAKE SAFETY

The natural period of vibration of the Claus Spreckels building in San Francisco is 2.3 seconds, about twice that of the ground in a destructive earthquakes. In 1906 the walls were most damaged about the 13th floor, two thirds of the height up. The buildings in Santa Barbara on the other hand had short vibration periods less than that of the ground, and their frames and walls suffered most in the lower stories (Dewell, Building against earthquake shock, The Commonwealth, Sept. 1, 1925, published by the Commonwealth Club of San Francisco).

Block construction is inherently unsatisfactory against earthquake. Dewell lists earthquake-proof construction in order of excellence: first, structural steel frame and reinforced concrete walls; second, ferro-concrete buildings of small height; third, structural steel and brick walls; fourth, reinforced concrete frame and brick walls; fifth and weakest terra cotta buildings without structural frame. All these are fire-proof.

On solid elastic ground the wooden house properly founded and braced suffers only broken chimneys and cracked plaster. But it can be greatly improved. We pile one story on another without continuous members. We could make wooden buildings immune to earthquake if we used the "balloon" framing, with vertical studding continuous, with diagonal bracing continuous cut and nailed into the studs, with floor-joist ends spiked into the studs; and with heavy metal lath instead of chicken-wire in the plaster, this metal reinforcement properly tied at the joints, in plaster thickened using good Portland cement; such construction might increase the cost ten per cent and be opposed by the craftsmen, but it would give the owner of a residence a feeling of real security.

Since 1906 San Francisco has been "letting down the bars." Wind pressure resistance has been reduced from 30 pounds to 15 pounds, and this is earthquake resistance also. Office buildings that resisted the 1906 shock were designed for a floor load of 75 pounds per square foot. Today they are designed for 40 pounds. "Recently the ordinance has again been revised to allow an increase in the permissible unit stresses for structural steel of 12½ per cent, saving one eighth the steel formerly required." Buildings are very much weaker, reinforced concrete is of poor quality, schools are of hodge-podge construction, low cost apartment houses and hotels are being built with light ferro-concrete frame and timber interiors, and another earthquake of the severity of that of 1906 will throw down stores, schools, churches, offices, hotels and apartments. Mr. Dewell concludes that the California public needs to be warned. The warning should be taken to heart away beyond California. T.A.J.

SAMPLE COPY

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NO. 46 RELEASED WITHOUT COPYRIGHT RESTRICTION November 12, 1925

KILAUEA REPORT NO. 722

WEEK ENDING NOVEMBER 11, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge.

There is nothing new to report of volcanic or other activity in the Hawaiian volcanoes. They are dormant. Halemaumau pit sent up dust clouds due to avalanches at 9:20 and 10:26 a. m. November 5th from the north side. Fresh red and gray debris was left on the northern slopes.

Twelve local earthquakes were registered, two of them avalanche tremors, and one at 10:44 p. m. November 5 indicated an origin distant 13 miles probably to the NW. This was felt at Volcano House and in Hilo. The long waves of a strong distant earthquake were registered at 3:35 a. m. November 10. Tilt for the week was slight to SE.

A BUSINESS APPRAISAL OF EARTHQUAKE DANGERS

The following paragraphs are from "Earthquake Insurance," a forty-one page pamphlet issued by the Manufacturers Mutual Fire Insurance Co. and five associated companies with headquarters at Providence, Rhode Island, offering "a new service of earthquake coverage for the peace of mind of those already insured in this company who realize that a destructive earthquake can happen in New England or the Mid-west, with as little warning as at Charleston, S. C.,, in 1886."

"Seldom or never has destructive violence extended farther than over spots in a narrow tract, rarely so extensive as 10 miles wide by 50 miles long."

"There is an immunity from tornado and windstorm and lightning loss in the Pacific coast localities, that will go far toward offsetting additional earthquake hazard."

"It is hoped to develop recommendations for obtaining maximum resistance to earthquake shocks, somewhat as heretofore our engineers have developed many aids to fire-resisting construction."

"After a period of activity the internal stress becomes relieved, and there is a long period of quiet."

"The cause of earthquakes is now well established as being a slight slip of a great mass of bedrock, of many cubic miles in quantity."

"Earthquake damage comes nearly always from the elastic oscillation extending out several miles on either side of the deeply buried rift."

"Greatest damage is nearly always found near the border line, between original hard ground and soft marshy ground or 'made land'."

"Earthquakes of greater or lesser intensity somewhere in the world are occurring almost daily." This is an understatement; the average is of the order of 2000 shocks per year on recorded ground, and more than 80 per cent of the world's surface is uninhabited and unknown.

"It was not until about 25 years ago that the modern science of earthquakes, or seismology, was fairly started."

T.A.J.

AMERICAN EARTHQUAKES IN 1924

An earthquake sheet published by the Safe-Cabinet Co. of Marietta, Ohio, makes a serious statement of the congestion-earthquake-tornado-fire menace, which is reliable:

"Two of the greatest fires in history have occurred in the last twenty years as a direct result of earthquakes, those of San Francisco and Tokyo."

"Modern civilization is responsible for the grouping of great numbers of people in one community. It is also responsible for the vast number of fires grouped into these communities for cooking, heating and industrial purposes." It might have added transportation, for every motor-car is burning gasoline.

"The following table, compiled by F. A. Tondorf S. J., chief seismologist of Georgetown University, covers the earthquake record of the U. S. for 1924.

Winchester, Va,	Jan. 1	Salinas, Cal.,	May 26
Greenville, S. C.,	Jan. 1	Walla Walla, Wash.,	May 27
Florence, Alabama,	Jan. 1	Santa Rosa, Cal.,	July 6
Orderville, Utah,	Jan. 1	Brawley, Cal., (2),	July 17
Los Angeles, Cal,	Jan. 2	Eureka, California,	July 17
Salinas, California,	Jan. 4	Brawley, California,	July 18
Stanfield, Oregon,	Jan. 5	Yellowstone, Wyo,	July 20
Walla Walla, Wash,	Jan. 6	Yorba Linda, Cal.,	Aug. 26
Milton, Oregon,	Jan. 6	Santa Rosa, Cal,	Sept. 1
Eureka, California,	Jan. 9	Eureka, California,	Sept. 7
Yellowstone, Wy.,	Jan. 11	Summerville, S. C.,	Sept. 26
Santa Clara, Cal.,	Feb. 9	St. Johnsbury, Vt.,	Sept. 30
Seattle, Washington,	Feb. 10	Calexico, California,	Oct. 2
Calexico, Cal.,	Feb. 13	Calexico, California,	Oct. 3
Summerville, S. C.,	Feb. 14	Julian, California,	Oct. 7
Cairo, Illinois,	March 2	Columbia, S. C.,	Oct. 20
San Francisco, Cal.,	Mar. 3	Landover, S. C.,	Oct. 30
Spreckels, Cal.,	March 9	Los Gatos, Cal.,	Nov. 12
Spreckels, Cal.,	April 2	Salinas, Caliornia,	Nov. 13
Paducah, Kentucky,	April 2	Geneva, Idaho,	Nov. 24
Clarksville, Tenn.,	April 3	Montpelier, Idaho,	No. 25
Monterey, Cal.,	April 3	So. Pass City, Wy.,	Nov. 25
Yosemite, Cal.,	April 4	Roanoke, Va.,	Dec. 25
Kalispell, Montana,	April 9	Salinas, Caliornia,	Dec. 27
Hayward, Cal.,	April 11	Hayward, Cal.,	Dec. 28
San Jose, Cal.,	April 22	Salinas, California,	Dec. 29
Seattle, Wash.,	April 25	Santa Barbara, Cal.,	Dec. 30
Calexico, Cal.,	May 23	Rapid City, S. D.,	Dec. 30

T.A.J.

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NO. 47 RELEASED WITHOUT COPYRIGHT RESTRICTION November 19, 1925

KILAUEA REPORT NO. 723
WEEK ENDING NOVEMBER 18, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge.

Volcanic activity remains dormant in Hawaii, but other parts of the world appear to be having large earthquakes. Three such distant earthquakes were recorded on Observatory seismographs. The one beginning at 1:34 a. m. November 16 had an indicated distance of 3200 miles, equivalent to that of Kamtchatka or Mexico.

The only changes in Halemaumau pit have been peelings of the wall at the north, at the west end of the gray sill in red ancient lavas, dumping red and gray debris on the slope below. This has cut away the shelf that formerly was topped by a high talus over the west horn of the sill. There was odor of hydrogen sulphide at the northeast rim November 17.

Eight local seisms were registered, none perceptible. One on the 13th at 5:30 a. m. appeared to originate 16 miles away by seismogram measurements. Tilting of the ground was slight to the NNE.

INTERIOR OF MAKAOPUHI CRATER

On November 16, 1925, a party from the Observatory, (Stone and Finch) visited the pit crater of Makaopuhi eight miles southeast of Kilauea. The descent into the lower pit was made with little difficulty. It is apparent that at some former time the western wall of the crater closed around what is now the eastern "mezzanine floor." The collapse which formed the present western pit exposed a section through the older floor. At the surface are four pahoehoe flows with an aggregate thickness of perhaps 20 feet underlain by a massive lava fill at least 100 feet thick. Beneath the fill is a layer of red cindery material marking the old floor. The upper part of this fill has developed a very regular, vertical, prismatic jointing; the lower portion also has prismatic jointing but dipping west as if it were normal to the former crater wall. High up on the massive rock of the exposed lava fill is a patch of bright blue-green, which has given the name "Makaopuhi" ("eel's eye") to the pit. More of the green coating was found on the enormous talus blocks in the bottom of the pit and has been determined to be the basic copper sulphate, brochantite.

The flow of 1922, which issued from a straight northeast trending fissure in the western wall, covered the bottom of the pit with a jagged layer of mostly aa. Steam issues from a number of cracks and there are sulphur patches on the talus against the western walls. Several small dikes were seen low down in the southwest wall. Approximately the lower quarter of the 900-foot wall is concealed by talus, but in the remaining section no ash beds were visible. J. B. Stone.

MONOGRAPH ON TOKYO EARTHQUAKE

The Imperial Earthquake Investigation Committee of Japan has issued three volumes of its reports in Japanese on the earthquake of September 1, 1923. (Sinsai Yobo Tyosakwai Hokoku, 100A, 100B, 100E, Tokyo 1925. Professor A. Imamura, Secretary of the Committee, Imperial University, Tokyo, has already issued in English a preliminary note in Seismological Notes No. 6.)

Imamura contributes the leading article on seismology of the earthquake followed by a second statistical and mathematical discussion by Saemontaro Nakamura of the Meteorological office. These are followed by special studies of phenomena observed in different prefectures, damage to wooden buildings compared in different places by Matuzawa, aftershocks in Tokyo and Oshima by Yasuda and Seizi Nakamura, relative intensities in different places by Nasu, personal experience near Kamakura by Abe, and list of casualties

The second volume deals with geology, physical geography, land changes in elevation and triangulation, and tidal waves. Kato and Yamasaki are the leading geological authors. Seizi Nakamura presents a survey of Oshima volcano. Imamura discusses the coast line changes of the Boshu peninsula and the mud flow of the Nebukawa. The maps and charts are intensely interesting showing the changed profiles, the places where cables were broken, the numerous epicenters, the progressive changes in railway levels in all directions from Tokyo and Yokohama, the depression area in the middle of Sagami bay and the raised areas opposite the peninsulas. Faulting appears to have been complex, and of the tilted block type so characteristic of the old volcanic mountains of the Connecticut valley.

The third volume deals with an exhaustive engineering, physical and economic research on the conflagration. This ought to be translated piecemeal by insurance bureaus and engineering societies until it is well known in the American business world. Photographs are reproduced showing the terrifying heaps of tens of thousands of corpses in the Honjo yard. The succession of maps showing the fire nuclei anl the successive stages of merging conflagration, and other maps showing scores of tornadoes that developed, are most instructive. Professor Seizi Nakamura of the Physics department of the Imperial University organized students into a fire investigation corps immediately after the disaster, and his chartings form the bulkiest parts of this exhaustive work. Some of the diagrams in these volumes have English titles, a practice to be commended if such invaluable monographs are not to be issued in the English series. We hope however that the whole of it is to appear in English; it is needed by economists, geologists, actuaries and engineers. T.A.J.

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NO. 48 RELEASED WITHOUT COPYRIGHT RESTRICTION November 26, 1925

KILAUEA REPORT NO. 724

WEEK ENDING NOVEMBER 25, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge.

At Halemaumau, the lava pit of Kilauea, nothing new has developed. During a period of two hours on the forenoon of the 21st three slight slides from the walls in different places were heard. The next day dust was seen occasionally. On the 24th in the forenoon nothing but slight trickle of gravel was noticed, but in the afternoon a dust cloud rose from the pit. Today the 25th after noon the weather was damp and clouds hung low, there was abundant vapor in and about the pit, one slide and two or three light falls of stones were seen in a quarter-hour from the northern walls, and dense steam at the south talus was hot and unusually blue with sulphur gas.

Eleven seisms were recorded for the week, six of which were of the avalanche type. All were too small to be perceptible. Tilting of the ground was slight to the SSW.

ISOSTASY

This Greek word means the balanced stand between the land and sea-bottom parts of the earth crust. A condition of such balance is proved by gravity measurements. The continents are light and the sea-bottom rocks are heavy Sandberg has added the notion that the loss of heat and importation of heat at different crustal blocks may effectively change gravity relations, so that an area of mountain erosion may go down beneath the sea, and one of basin accumulation of sediment under the ocean may emerge and become eroded. ("Isostasie, and the causal unity of mountain-building and volcanism," in German, by C. G. S. Sandberg, Gebr. Borntraeger, Berlin, 1924.)

The fact that such revolutions of sea and land have happened has been one of the stumbling-blocks to theory. The surface of the earth was at one time molten. It was not uniform, so that some blocks solidified first. As solid rock is heavier than its molten gassy magma it tends to sink. In the primitive paste stresses were set up between the thicker blocks that sank lowest and the later ones. There was thus a primitive topography, the lowest and thickest blocks being the ocean basins. Then came water condensation and erosion, the high lands being worn down and lightened over the paste below, the depressions being filled and weighted. The lowest and thickest blocks were thus made still thicker, and the highest and thinnest still thinner. Gravitative isostasy keeps a floating balance, and the weighted blocks sink lower and the eroded blocks rise. But geological history shows that periodically basins full of thick sediments have swollen, wrinkled, thickened and lightened, so as to rise into mountain ranges.

Here comes in thermal isostasy. The balance between heat acquired at the bottom of the crust blocks, and heat lost at the surface determines that in the erosion area the bottom of the crust is cooling. In the sea-bottom, blanketing with muds, the bottom of the crust is heating. Under the erosion area, the bottom of the crust is thickening. Under the other, its bottom is melting. Also the heated mantle of water-charged sediment expands through both rock and steam distension, increases in bulk and decreases in density. This expansion folds the strata and along with the isostatic adjustment set in motion, it lifts the area of sedimentation above the sea. The erosion area near base-level is wearing more and more slowly anyway, and the material worn off makes less and less addition to the basin. The strongly developing thermal activity is all that is needed to upset the balance. The thickened and heavier crust under what was the eroded area sinks, and the melted off and lightened crust under the basin rises. All of this imagines a definite crust and a definite pasty substratum, without attempting to define the viscosity. By "bottom of the crust" is meant the contact side of a crust block with the hot paste beneath.

Sandberg believes that active volcanism and folding of strata are both products of this heating up of sediments in basins, with the water of sedimentation furnishing physical and chemical reactions quantitatively sufficient, according to the depth of burial. He conducts experiments in the distension and folding of a sheet of asphalt, subjected to hydrostatic pressure and release. We follow him so far as volcanism applies to mountain-folded regions, but we believe there is more primitive volcanism still active in the oceanic basins, connected with the substratum itself. Sandberg illustrates mechanism whereby big overturned folds may pile up, with igneous matter at their cores. He calls this "regenerated" or "vitalized" magma. He believes that both mountain-building and volcanism would wane or disappear or become only periodic in a world losing its air and water. This he thinks happened to the moon, and he thinks the great craters on the moon themselves prove that it once had air and water. T.A.J.

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NO. 49 RELEASED WITHOUT COPYRIGHT RESTRICTION December 3, 1925

KILAUEA REPORT NO 725
WEEK ENDING DECEMBER 2, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge.

There has been nothing whatever of volcanic activity in the Hawaiian pits for the week, other than vapor and sulphur fume as usual Halemaumau at Kilauea continues to sleep The pits to the east such as Aloi, Alealea and Makaopuhi, and the field of 1923 lava west of the latter, give up steam and some sulphur. The 1920 fissures in Mauna Iki in the Kau Desert are hot enough to light wood Fissures in and near Mokuaweoweo, the summit crater of Mauna Loa, are hot and sulphurous. Tremors local to the crater regions indicate that something below stirs. No great tilt of the ground inward since the lava was in Halemaumau in July, 1924, but rather at present a tilt outward or away from the center, indicate that the underground lava is either stagnant or rising. A poised slab of the rim of pit was found to have fallen November 28th.

For the week ending this morning 14 earthquake movements were registered, all small and imperceptible, with three of the avalanche type. Coincidental with a cool spell beginning the 26th there was marked NE tilt. The net tilt for the week was strong NNE. Seasonal tilt in this direction is expectable in the winter.

INTERNATIONAL VOLCANO REPORTS

The second and third volumes of the Bulletin of the Section of Volcanology of the International Geodetic and Geophysical Union, covering the last quarter of 1924 and the first two quarters of 1925, are published. (Prof. A. Malladra. Royal Vesuvian Observatory, Resina, Naples, Italy, 30 francs a year).

The office of publication of this quarterly has now been definitely established at the University of Naples. The second volume promised that a full account of volcanology at the Madrid meeting of the Union would appear in the next volume, but it did not appear. This was in October, 1924, and the report of the general meetings has appeared, published in Toulouse, 1925, with hardly any mention of volcanology.

The articles in the second and third Bulletins are very interesting. In the second, Matsuyama reports very briefly on gravity measurement with Eotvos balance across Sakurajima and Unzen in Japan. He finds changing density, apparently across country. At Unzen these changes are not radial to the volcano, but in parallel belts NE-SW. At Sakurajima the gravity changes corresponded somewhat to the subsided areas of the eruption of 1914. He makes the extraordinary statement that the area of subsidence there, proved by precise levelling, has recovered its former level.

In the third Bulletin H. Tanakadate reviews the activity of 18 Japanese volcanoes from 1914 to 1924. Of eight recognized volcanic belts in Japan all but two have had activity in the decade that ended with the Tokyo earthquake. In the five belts of volcanoes that converge on central Japan, ten volcanoes erupted, Tarumai, Komagatake, Kattadake, Asama, Yakedake, Hakone (tremor spasm), Oshima, Bayonnaise Rock, Smith Rock, and Minami-Iwozima. In the numbers of volcanic events tabulated the maxima were in 1914, 1919 and 1923. Apart from earthquake there were 17 and 15 events in 1919 and 1923. The activities extend all the way from the Kurile Islands to the Loo Choo group.

Another paper in this volume is by A. Lacroix on the island Reunion near Madagascar. The active lava crater is at the southeastern end of the island, a U-shaped amphitheatre sloping to the sea, with numerous inner craters always different as seen by a succession of travellers. The activities are very frequent, and mostly quiet lava flows. There have been one or two explosive eruptions, very exceptional, just as at Kilauea. The flows are both aa and pahoehoe, aa being called "gratons" or scratchers To show how frequent are the lava flows, fourteen different years exhibiting some activity are cited for the twentieth century. Most of the flows are from fissures and the top crater is a pit from 700 to a thousand feet wide and variously filled up or evacuated. All the "cow-dung" splashes of lava, bombs, Pele's hair and glassy types of basalt with iridescence are like Hawaii. T.A.J.

SUBMARINE LANDSCAPE OFF HAWAII

Hawaii is very wonderfully situated for scientific experiments with the sea-bottom. Could one look east from Hilo and drain away the ocean, a vast flattish territory would be seen 18,000 feet below and only thirty nautical miles away, with perhaps some big volcanic domes here and there like Hualalai In the foreground would be a ragged mountain slope with remnant beach lines. The observer would be far up an enormous mountain range, bigger than the Himalaya, and he would have nose-bleed and nausea, for he would be up towards the top of the sea of breatheable air. The atmosphere would have filled up the space of the lost ocean. We could no longer live in Hilo, unless we developed the wonderful lung capacity of some of the tribes of the Andes.

We want to sound by echoes and discover those lost volcanoes We want to bore into that great plain and get cores of the rock. Is there oil, iron, copper, sulphur, manganese, radium or selenium in vast quantities there? No man knows. No one has ever prospected the ledges of the deep sea, 72 per cent of the earth's face. If we lay a delicate magnetic instrument on the bottom, electrically connected with Hilo by cable, and thoroughly sealed, is the magnetism extraordinary? If we swing a gravity pendulum in a closed case on the bottom, is the rock enormously heavy? Pendulum work many years ago suggested that the matter under the Hamakua shore is twice as heavy as the stuff under Mauna Kea. Does it not get heavier as we go out under the sea? If with our cable attachments we operate a very delicate seismograph in a vacuum on that bottom land, so that the slightest tremblings or tilts of that wonderful country are written as autographs in the Hilo laboratory, day and night all the year around: will not this be exploration to make the north pole look tame?

Why go to remote lands when the greatest discoveries in the history of science and invention are within the reach of engineering experiment, a sampan sail of thirty knots from Hawaii? (Address Hilo Rotary Club November 11). T.A.J.

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NO. 50 RELEASED WITHOUT COPYRIGHT RESTRICTION December 10, 1925

KILAUEA REPORT NO. 726
WEEK ENDING DECEMBER 9, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge.

The past week has exhibited a marked revival of felt local earthquakes, such as has not been registered here for some months, but as yet nothing has occurred of volcanic activity on either Kilauea or Mauna Loa. There was considerable avalanching in Halemaumau before the earthquake spell began.

In a quarter-hour from 9:45 to 10 a. m. December 3 four slides fell from the western and northern walls of Halemaumau. The wind was light SSE The walls were wet and steaming in several places though there had been no rain. The slides were small but started suddenly from high up the walls and made trails of rocks and dust, especially about the southwest rift outcrop. The walls were much more in motion than at any time recently. There were trickle cascades of sand in motion on the west wall. Soon after noon the next day big clouds of dust rose from the pit and the seismogram at 2:31 p. m. showed a long earthquake movement coinciding with an extra big avalanche.

On the 5th there was a large scar in the west wall, cascades of black sand were continuous four fifths of the way up the wall, and there was fresh red debris below and dust clear across the bottom obliterating the sulphur stains.

Two strongly felt shocks occurred about 9:30 a. m. and 12:45 p. m. each dismantling both of the seismographic instruments. The first set off a small slide at the pit, but in the afternoon the pit was very still and sleepy. On the 7th at 2 p. m. there were again sand cascades on the west wall and slides occurred several times during the day. An earthquake at 10:16 p. m. December 8 was prolonged but gentle and a lighter shock occurred at 11:48 p. m.; both of these were felt at Hilo. The indicated distance was 9 miles SE of the Observatory.

Eighteen earthquakes were recorded during the week of which one was of the avalanche type and four were perceptible. The two of December 6 appeared to have origins very near, only two miles away. A strong NNW tilt accompanied the quakes of that day and the tilting of the week was moderate NW. A dog showed alarm and pheasants squawked during the first earthquake of the evening of December 8.

TIDAL WAVES

The disastrous sea-waves that go by this name are of various origins, and they do their damage on shelving shores. The most common are occasioned by big earthquakes on the bottom of the ocean. Some are occasioned by volcanic disturbances of the sea-floor. Others are due to typhoon storms with greatly depressed barometer such as occur in the Bay of Bengal. (Materiaux pour l'etude des Calamites, No. 4, Geneva, Jan.-March, 1925, Les Raz de Maree, by C. Vallaux, p. 333).

The waves are distributed rather markedly about the Pacific and the Mediterranean belts, including the tropical East Indies and the Caribbean. The Atlantic coasts are remarkably free from tidal waves, excepting the Cape of Good Hope and Ascension Island. An active zone of submarine eruptions between Africa and South America does not, however, make tidal waves on those coasts.

Peru and Chile have suffered much from tidal waves. These are accompanied usually by earthquakes that are felt. The people pay little attention to this, but look for the "negative wave," that is, the retirement of the sea as a first sign. But frequently the first movement is a positive wave or rising water, usually smaller than the succeeding negative one. On the 28th October, 1746, a terrible earthquake that destroyed Lima in the interior, also made a terrific wave on the coast, as did the Lisbon earthquake of 1755. The Lima wave finished the destruction of Callao already begun by the earthquake. The sea retired slowly and returned with a roar. It swept everything before it There were twenty three ships in port mostly crushed and sunk, but the largest were carried beyond the walls of the city, four vessels, and left in the fields. The sea swung back and forth several times. Of 4900 inhabitants, only 200 escaped. Great quantities of sand and pebbles was swept over the ruins from the wash of landslips made in the harbor islands by the earthquakes and subsequently transported by the waves.

Darwin described the tidal wave at Valdivia in 1835, again following a severe earthquake, as producing a quiet rapid rise and rapid fall. During aftershocks there were curious and complicated currents in the harbor. At the port of Concepcion, which city was damaged by the earthquake, great flocks of sea-birds were seen flying inland. Thirty minutes after the earthquake the sea retired so far as to strand ships in 7 fathoms of water. All the reefs came into view. Then the return wave poured in thirty feet above high tide. Two others followed, some minutes apart, and progressively bigger. Then for several days there were small oscillations. There were said to be eruptions out to sea.

At Arica in 1868 there was an earthquake about 5 a. m. August 13th and twenty minutes afterwards there came inward a wave two or three meters high. Then the sea went out for a mile and the inhabitants fled to the heights. An enormous wave returned more than 17 meters above high tide line and carried two ships a mile into the interior of the country. Several oscillations a quarter of an hour apart followed. This wave did damage even on the New Zealand coast across the ocean.

The two most murderous waves of this sort were the Krakatoa wave of 1883 near the Strait of Sunda on the Java shore, and the Kamaishi wave on the east coast of Japan in 1896. They drowned respectively 30,000 and 32,000 people. The Krakatoa waves appeared to be due directly to the gigantic engulfment of the island that went with the volcanic eruption, an affair of three huge explosions in two days. The waves bombarded the adjacent coasts of the strait, the largest 22 meters above tide, and a succession of them kept going about a half-hour apart. They flattened out in a very short distance, for they were not large at Batavia, just a short distance away.

The Kamaishi wave was a positive inundation of from 6 to 15 meters, the earthquake occurring far out to sea. It was not felt. The fishermen at sea in their boats knew nothing of the tragedy until they returned to their homes to find the flat shore devastated. T.A.J.

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NO. 51 RELEASED WITHOUT COPYRIGHT RESTRICTION December 17, 1925

KILAUEA REPORT NO. 727

WEEK ENDING DECEMBER 16, 1925

Issued by the Observatory, U. S. Geological Survey:

T. A. Jaggar, Official in charge.

The spasm of seismic intensity registered last week has this week died away. No activity has yet appeared in Kilauea or Mauna Loa.

Visits to the pit in dry weather have discovered much wetness of the walls with steam. Steam crack belts in and outside the pit notably accord with the southwest rift direction. Small stones fall most of the time from the north wall. Avalanche dust arose December 13 at noon. There is some sulphur odor and sulphur spots are reappearing on the bottom through the avalanche dust of a week ago. Steam is increasing at the southwest wall.

Twelve very feeble earthquakes were registered, lessening in amplitude and frequency. Microseismic motion increased about the 15th. Most of the quakes were mere tremors.

PREDICTION OF TIDAL WAVES

In the discussion quoted last week from Vallaux, (Materiaux p. calamite's No. 4), some interesting data are given about the Fosse de l'Hirondelle, a supposed submerged volcanic crater northwest of Saint Miguel in the Azores. This and other submarine volcanoes are believed to be the source of some dangerous tidal waves known as tide rips which occur on the coasts of Cornwall and Brittany. At places where the depths shallow rapidly near shore, a succession of sudden, brief, big waves develop without any relation to the weather or earthquakes. These change by interference into big swells that break on the shore, sweep everything and frequently drown people, and retire equally quickly. A family of five were drowned in this way near Land's End in 1870.

Vallaux remarks that there is no hope of predicting tidal waves successfully or of learning anything from experiment. In view of the very successful experiments on harbor reactions in Japan and of valuable forecasts from seismograms in Hawaii seven or eight hours in advance, we do not feel so pessimistic about it. (Prediction of tidal waves, by R. H. Finch, Monthly Weather Review, Washington, March, 1924, p. 147). Even with regard to long range forecasting of submarine earthquakes, there are seasonal effects which Perret has pointed out, (Science, August 28, 1908, p. 277). Vallaux thinks typhoon tidal waves are entirely hopeless, yet Father Algue' in the Philippines has repeatedly demonstrated that typhoons are entirely predictable, their courses are charted in great detail, and the waves that result are quite calculable by experience. T.A.J.

METAMORPHISM DUE TO MAGMA

Sandberg has introduced the word "magmamorphosis" into geology (Geodynamische Probleme, II, Tektonik und Metamorphose, Borntraeger, Berlin, 1924), meaning all kinds of heat and pressure recrystallization, in sedimentary rocks which have subsided and been buried to depths where the contained water was heated by magma or underground lava. This theory is in line with Sandberg's conception of a volcanic substratum everywhere under the earth's crust. (See Volcano Letter No. 48).

The remarkable accordance of the direction of strike of gneisses and schists with the margins of granite bodies, the interpretation of hornblende schists and serpentines as altered sediments rather than eruptives, the analysis of "regional metamorphism," heat metamorphism and "dynamo metamorphism," the obvious chemical relations of "contact metamorphism"—these being the different forms of recrystallization of deeply buried sedimentary rocks—all these phenomena are a part of the genesis of folded mountains, and the fundamental cause is the "activating" of magma.

All folded mountains must contain magmatic cores if we go deep enough. Magmamorphosis is the interaction of such magma with the sediments. This produces effects in both minerals and structure. The operation of magmamorphosis is strictly limited to geosynclines—that is, to troughs which have deepened while receiving erosion products from adjacent land until the sedimentary mantle itself reached the bottom region of the earth's crust. Here thermal isostasy asserts itself by rock expansion, water expansion and intrusion of substratum matter. The magmamorphism introduces an episode which itself conditions the production of mountain folds. Beyond the range of gas and hydrothermal action there may still be enormous compressions and folds due to the gliding of masses of sediments, from higher to lower positions on the flank of the swelling geosyncline. T.A.J.

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NO. 52 RELEASED WITHOUT COPYRIGHT RESTRICTION December 24, 1925

KILAUEA REPORT NO. 728

WEEK ENDING DECEMBER 23, 1925

Issued by the Observatory, U. S. Geological Survey:

R. H. Finch, temporarily in charge.

The walls of Halemaumau are again very red. The red is more extensive than has been observed for a long time and even several of the talus slopes are very brightly colored. Steam from the numerous vents in the pit has been abundant. Rock falls, especially from the northwest wall, are frequent.

Six earthquakes were recorded during the week. The one at 3:37 p m. December 19 was felt locally and at Olaa. Its indicated distance to origin, 9 miles, is the same as that of the shakes of December 8. Tilting was moderate to the southeast.

Coincidental with the beginning of the Kona wind there was a marked increase in the amplitude of the microseisms as registered by all the seismographs on the island.

THE SOUTHWEST RIFT OF MAUNA LOA

An Observatory party recently returned from spending several days on the southwest slope of Mauna Loa with E. G. Wingate, topographer of the U S. Geological Survey, who is now engaged in mapping that portion of the mountain. The Wingate camp is in a lava tube at an elevation of 9940 feet on an ancient Hawaiian trail. The trail roughly follows the 9900 foot contour and shows evidence of having been extensively used in former times.

Mauna Loa is certainly a mountain of contrasts. Starting up from sea level on the Kona or western side of the mountain one first encounters a hot arid belt. With further increase in elevation one traverses in succession a belt of moderate rainfall with a heavy vegetal growth, one of heavy rainfall with a tropical jungle, then moderate rainfall with open forests and one reaches the timber line which is limited by both cold and moisture at about 8,000 feet. The mountain is quite arid beyond the 8,000 foot level though there seems to be a slight increase of precipitation beyond the 10,000 foot contour over that of the 8,000 to 10,000 foot belt. An ohia tree (metrosideros polymorpha) over one foot in diameter was noted at an elevation of 8200 feet and smaller ones of the same variety can be found several hundred feet higher.

Leading southwest from Mokuaweoweo, the central crater of Mauna Loa, is a great belt of fissures from which have poured numerous lava flows both recently and long ago. This rift belt has a slight southerly curving tendency which is especially noticeable about 20 miles from Mokuaweoweo. Its total length is about 35 miles and in many place it is over two miles wide. The counterpart of this rift on the northeast slope of Mauna Loa seems to terminate about 15 miles from Mokuaweoweo.

Activity, marked by vari-colored cinder cones, lava spattered cracks, and long arms of aa (clinkery) or pahoehoe (smooth) lava flows, has taken place from numerous vents along nearly the entire length of the rift. While many of the lava flows reached the sea the majority issued from vents between the 3,000 and 13,000 foot contours.

The sequence of events in the 1919 flow from Mauna Loa is rather typical of the lava flows from the southwest rift. Acompanied by earthquakes the southwest rift zone became active and the ground began to crack open. On September 26 lava broke out at an elevation of about 11,000 feet. This outbreak, which lasted but a few hours was accompanied by fiery fountains and produced a very frothy lava flow. The cracking appeared to progress down the mountain and on September 29, the main lava flow broke out 11 or 12 miles from the upper site at an elevation of 7,700 feet. A stream of molten lava reached the sea, 14 miles away, in about 24 hours and continued to pour into the ocean for 10 days. Thereafter the volume of the output diminished and activity was confined to shorter flows around the source region. The fire fountains occasionally were as much as 400 feet high and built up a cone 250 feet above the former ground level All activity appeared to cease during the first week in November.

The rift belt may be reached at several places from both the northwest and southeast side without encountering much aa lava. By leaving the timber line at a point above the Komakawai water hole in Kona and travelling almost due east one reach the site of the preliminary outbreaks without having to traverse over 1000 feet of aa lava. In recent years there have been several preliminary outbreaks all the way from the 11,000 foot elevation to the summit crater. Between the 11,000 and 12,000 feet elevations the rift is marked by brilliant sulphur deposits and hot steaming cracks, and is covered by fresh pahoehoe lava

The thin covering of new lava at the upper vents appears to rest on very old lava In fact all the lava flows on the southwest half or Mauna Loa may be put into two classes —recent (within the last 100 to 150 years, say) and old. There is no uniform gradation between the youngest and oldest lavas.

Exploration of the summit of the mountain and along the rift line as low as 12,000 feet (lower when the mountain is covered with snow) is greatly facilitated by the fact that many of the cracks contain snow, ice, and water. Some are so deep and narrow that a line is necessary to lower a container to the water pocket.

The sunset effects over clouds produced by both land and sea breeze and tarde wind currents is truly wonderful. It is similar and perhaps less majestic than the view from the proposed Mauna Loa road terminus on the rim of Mokuaweoweo. R.H.F.

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NO. 53 RELEASED WITHOUT COPYRIGHT RESTRICTION December 31, 1925

KILAUEA REPORT NO. 729

WEEK ENDING DECEMBER 30, 1925

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge.

No renewal of activity nor of seismic action heralding activity has appeared after the December solstice at the Halemaumau lava pit of Kilauea volcano. Everything remains placid at the end of the year. At 11 a. m. on December 27th no rock falls were heard during a visit to the pit, and steam was abundant especially from the southwest half of the bottom region and walls. On the 29th a few small dust puffs rising from the cauldron during the day gave evidence of slides. Today, the 30th, dust in small amounts rises frequently, steam is conspicuous along the south rim of the pit and from the southwest half of the interior, and at the edge in the forenoon sulphurous odors were noticed, possibly hydrogen sulphide. On the northeastern wall above the great intrusive sill a coating of white sulphates has recently blossomed out on the face of the rock.

For the week ending December 30 nine local earthquake movements were registered on the Observatory seismographs, all too feeble to be perceptible. Tilting of the ground was slight towards the west.

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COMPOSITION OF HAWAIIAN LAVAS

In a recent copy of the Extension Letter of the University of Hawaii attention was called to the fact that contrary to common opinion most vegetables raised in Hawaii contain as much iron as vegetables raised on the mainland. When one considers that the lavas of Hawaii contain from 5 to 15 per cent of iron and that some soils show even a higher percentage, it is to be expected that Hawaiian vegetables should not be deficient in iron.

Not only are there appreciable percentages of iron in Hawaiian lavas but a great variety of other minerals is also found. The following table shows an analysis by oxides of lava dipped from a molten lava lake at Kilauea. Its composition is quite typical of most of the recent flows from Kilauea and Mauna Loa.

Silicon	49.74	per cent
Aluminium	12.36	"
Iron	11.72	"
Magnesium	8.83	"
Calcium	10.88	"
Sodium	2.45	"
Potassium	0.55	"
Titanium	2.49	"
Phosphorus	0.41	"
Manganese	0.14	"

In addition to the above a great variety of other substances are found in varying amounts. Among the more common of these substances are sulphur, copper, selenium, chlorine, nickel, chromium, strontium, barium, vanadium, and molybdenum.

Besides the commonly observed olivine, an iron-magnesium-silicate, which sometimes constitutes 60 per cent or more of some lavas, a great variety of other crystals are found. Among the other crystals augite, magnetite, hematite and feldspars are common.

Frothy pahoehoe lava may well be termed an iron-stained glass. Hawaiian lavas are classified as basaltic though some specimens have been found that approach the acid types of lava, and quartz is not uncommon on Oahu.

R.H.F.

:x:

EARTHQUAKE INSURANCE RATES

It is interesting to observe that insurance specialists have called in engineers and geologists to secure revision of earthquake rates, increasing the charges in all cases except on wooden dwellings. National Underwriter, November 19, 1925, p. 10). Immediately after the Santa Barbara and Montana earthquakes the schedule adopted was short and regardless of territory. Then the only consideration was nature of buildings, in three classes. Now there are six classes of building risks, and four specified districts.

The buildings in the order from least dangerous to more dangerous are (1) wooden dwellings, (2) first class stores, (3) limited size wooden houses, (4) second rate brick and concrete, (5) factory and frame constructions of masonry and some wood, (6) soft masonry, dams, reservoirs, bridges, etc.; each of these six classes being scheduled at greater length than is shown here.

The districts for the Pacific Board of Underwriters are (1) Alaska and Nevada, lowest rate, (2) Interior counties California, next higher, (3) coast counties and Montana, and (4) Imperial, Riverside and San Bernardino, highest rate for the six classes, namely 15 cents for Class 1 buildings, and $1.40 for Class 6, per thousand dollars of insurance. For district (1) the rates of these two classes are 7 cents and 65 cents. Contents of buildings and co-insurance and rents are also scheduled.

This rapid evolution of earthquake insurance shows how little is really known of the risk, what a gamble there is in the words "Alaska, Nevada, dams, bridges," and what a splendid field of research is here for the future of science and humanity.

T.A.J.

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No. 556 RELEASED WITHOUT COPYRIGHT RESTRICTION January 21, 1926

KILAUEA REPORT NO. 732

WEEK ENDING JANUARY 20, 1926

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

On January 14 the northeast wall or Halemaumau had been working sufficiently to open new cracks in the soil ENE back from the pit rim. The N corner was making noisy avalanches. On the 16th the pit was dry and quiet. On the 18th the big sill NE and N had been peeling as shown by gray talus below.

In the very early morning hours January 19 the roars from avalanches were heard and light southwesterly wind brought the dust to the Observatory in droplets of mud rain. By daylight the east floor of Kilauea was seen to be coated with red dust. In the forenoon the northern walls were working strongly, and at 9:45 a. m. a spectacular avalanche at the north corner of the pit made a salmon-colored cauliflower cloud. There was fresh gray talus NE and red N.

Seventeen earthquakes were registered. One at 12:33 p. m. January 16 indicated origin-distance 14 miles and was plainly felt in Hilo. Thirteen of the shocks were on the 18th and 19th, when avalanches were numerous at Halemaumau. Tilting was moderate SW; seasonal change from NE to SW is expected about this time of year.

THE EARTH'S MAGNETISM

There are several reasons whereby volcanology is interested in terrestrial magnetism. At Kilauea in 1913 J. W. Green of the U. S. Coast and Geodetic Survey determined differences of declination of 16 degrees near the fire-pit, and of over 5 degrees about the greater crater. All kinds of basaltic lava fragments deflect the needle, even the Pele's hair. In 1902 when the volcanoes Pelee and Soufriere exploded violently in the Caribbee Islands, a horizontal disturbance was noted at many magnetic stations about the world starting at almost the minute of the St. Pierre destruction and lasting thereafter for several hours.

The conception of the earth as a great magnet with its poles near to its axis of rotation was long considered untenable. It was supposed the heat of the earth's interior would demagnetize it. (See D. L. Hazard, The Earth's Magnetism, Special Publication 117, 1925, U. S. Coast and Geodetic Survey). In view of current beliefs, however, in a ferruginous lava substratum and a terrestrial core of nickel-iron, and recent investigations suggesting that these materials under high pressure may have magnetic properties even though hot, magneticians are again turning to the earth-magnet idea.

What is earth magnetism, what causes it, and what causes it to change? Cathode rays, the electronic theory of matter, the constitution of the sun and the earth are all being studied in this connection. When it was thought that the hot globe could not be a permanent magnet, a mathematical analysis was made to see whether our magnetic field might be due to electric currents flowing around the earth, making the sphere an electro-magnet. Such an analysis by Bauer in 1922 showed that 94% of the field is internal, with 3% external and 3% representing a non-potential system. His results indicated that the intensity of magnetization of the earth had decreased during the last 80 years at a rate irreconcilable with the age of the earth and the present intensity of its magnetism, unless we suppose that there have also been periods of increasing intensity. This is interesting in comparison with Joly's idea of increasing evolution of the latent heat of radioactivity at long intervals. (See VOLCANO LETTER, nos. 3, 37 and 40, 1925.)

The laws governing the mutual attraction and repulsion of moving positive and negative electrons probably cause the phenomena of gravitation, and there is a growing belief that gravitation and terrestrial magnetism are probably to be traced to a common origin. As volcanism on the earth and sun is intimately associated with the physics of hydrogen, and electronic motion has a similar association, it would appear that volcanism, gravitation and magnetism may be cousins.

The variations of earth magnetism take the form of magnetic storms, diurnal variation and secular variation. Magnetic storms are irregular disturbances of short duration. They occur almost simultaneously all over the earth. Like auroras they coincide with large sunspots, but the coincidence by averages is better than that by individual cases. Magnetic storms may be due to streams of electrified particles shot out from the sun. Hale at Mount Wilson has shown that the sun has a magnetic field, and that pairs of sunspots have opposed polarity, with remarkable reversals of polarity in the two hemispheres every 11 years.

The daily variation of magetism is a function of the position of the sun above the horizon for any place, and so is independent of absolute time. The extremes occur in daytime. There is a slight effect during a solar eclipse. It is supposed a solar electrical emanation by way of the upper atmosphere affects electric currents flowing about the earth.

The secular change of terrestrial magnetism does not agree with the notion that a systematic change in the magnetic axis of the earth causes it. The periodic change every 11 years in numbers of sunspots, is paralleled by an 11-year period in the secular magnetic change. Bauer and Abbott are working toward a relation between magnetism changes and the variations in the sun's heat. Here again thermal controls, as in volcanism, may be closely related to magnetism. All three types of magnetic change in the earth appear to be related to the sun. This has given new interest to the study of atmospheric electricity and earth currents.

T.A.J.

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No. 57 **RELEASED WITHOUT COPYRIGHT RESTRICTION** January 28, 1926

KILAUEA REPORT NO. 733

WEEK ENDING JANUARY 27, 1926
Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

As the end of January approaches nothing new has yet been inaugurated for 1926 in the way of Hawaiian volcanic activity. Seismic motion is sufficiently in evidence, with tilting of the ground and high temperatures at some places, to indicate to the observers that Kilauea and Mauna Loa are just as active as ever underground. The quiet spell that followed upon the explosive eruption of 1924 has not yet endured for any unusual length of time. The excessively hot spots where a stick may be lighted at the surface of the ground, on the summit of Mauna Iki in the Kau desert, where lava was flowing in 1920, show some sign of growing hotter. Sticks may now be lighted at two different areas. The well drilled in the Kilauea floor 80 feet deep in July, 1922, shows a temperature today, 67 degrees Centigrade, only 2° cooler than when it was drilled, and adjacent steaming cracks at 57° are 2° hotter than they were then. There is no sign of cooling or diminution of sulphur deposit at the Sulphur Bank near hotel.

Halemaumau the lava pit has been dusty with small slides from the steep north wall, but avalanches have not been so big as during the previous week. On January 23 the bottom was dusty but sulphur-stained spots on the east floor were not obscured at all. The talus slopes were red with fresh debris at the north, and with broken gray fragments of the big sill at the east. All along the wall that overlies this large intrusive sill the steepest overhang is maintained, and motion of sliding and breaking away of the edge of the pit has been stronger and more continuous there for a year than anywhere else. This dense white ledge was red hot after the 1924 eruption, and it seems as though its peeling and undermining of the wall above must be connected with its heat.

At the Observatory during the week 15 local seismic movements were registered, all small, and a few were of the type that accompanies avalanches at the pit. Tilt was slight to the SW.

A large distant earthquake was registered at 2:16 p. m. January 24, the vibrations continuing for over an hour. The distance indicated by the preliminary tremor on the gram is 3600 miles, equal to that of the ocean off Central America or Japan, or of the western Kurile Islands, the Bonin Islands or the Guam region. A tidal wave from it would have reached Hawaii about 10 p. m.

FOREWARNING OF TIDAL WAVES IN HAWAII

A terrific earthquake happened somewhere at a quarter past two in the afternoon of January 24 by Hawaiian time. It was well registered by the Kona and Kilauea seismographs of the Hawaiian Volcano Observatory. Its long slow waves exhibited on the seismogram sheets were preceded by preliminary quicker vibrations lasting 7 minutes, 25 seconds, indicating a distance of transit of the waves of compression through the earth of 5800 kilometers or 3600 miles; the origin might have been in the deeps of the Pacific off Salvador or off Japan, in which cases a water wave of 20 minutes period and over 100 miles amplitude might have been sent across the ocean. (See R. H. Finch, On the Prediction of Tidal Waves, Monthly Weather Review, March 1924, p. 147.) The time taken by the first rock vibrations to travel from the source to Hawaii was 9 minutes and 19 seconds.

The time of transit of a sea wave for approximately this distance, is dependent not only on the distance, but also on the mean depth of the ocean between the locality where the bottom of the ocean is suddenly displaced, and the coast which the wave reaches. The observed velocities of the water waves range from 3 to 8 miles per minute. From observed and computed velocities, Finch has determined in Hawaii, that the transit time of the seismic rock waves making the first preliminary seismograph vibrations, is very nearly equal in minutes and seconds to the hours and minutes taken by the water waves. Thus on the morning of February 3, 1923, a big earthquake somewhere in the north Pacific estimated 2200 miles away from Hawaii, at 5:32 a. m., made seismograph record at Kilauea 5:39 a. m., seven minutes after the shock occurred, and the water wave reached Hilo in Hawaii about 12:30 p. m., seven hours after the shock occurred. This same wave reached Honolulu's island, Oahu, thirty minutes before it reached Hilo; the distance is 225 miles northwest. The Hawaiian islands are thus a valuable gauge for the progress and direction of seismic sea waves, particularly as these waves travel all the way from Alaska to Australia, or from Chile to Japan.

Many more tidal waves may occur than are reported, when they are so small that only tide-gauges register them. The times of such tide-gauge registrations deserve more attention by seismologists than they have had, for they would yield valuable lists of transit times for water waves at different distances and through waters of different depths. These lists could be compared directly with earthquake centers, times and distances, as computed by seismograph publications.

Finch cites an earthquake in the Kamtchatka region September 7, 1918, distance 3200 miles, water wave 8 miles per minute, doing some damage in Hilo. Another southwest of Hawaii in shallower waters, the water wave reaching Honolulu at 4.7 miles per minute and San Francisco at 5.9 miles per minute. The Chilean earthquake sea-wave of November 11, 1922, travelled to Hilo at 7.5 miles per minute and registered on the seismograph early enough for a prediction of its coming over nine hours in advance. A Kamtchatkan earthquake 3200 miles away April 13, 1923, registered here at 5:17 a. m. and made a small tidal wave at Hilo at 12:40 p. m. In general the very dangerous tidal waves would be due to very big earthquakes a few hundred miles away, the water wave arriving on a shelving shore in from 3 to 6 hours, and the rock vibration arriving in from 3 to 6 minutes, thus giving several hours warning.

T.A.J.

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THE VOLCANO LETTER

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No. 58 **RELEASED WITHOUT COPYRIGHT RESTRICTION** February 4, 1926

KILAUEA REPORT NO. 734
WEEK ENDING FEBRUARY 3, 1926
Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

There has been no change during the week to indicate any new activity in Kilauea or Mauna Loa craters. The pit Halemaumau gave up a dust cloud due to avalanche about noon January 28. At 1:45 p. m. slides were moving down a vertical notch grooving most of the height of the east wall athwart the end of the big north intrusive sill. This filled the air with dust along the bottom region of the east wall. The pit was dry. Nothing new was observed January 30 and February 1, no glow in the evening could be detected anywhere inside the pit, but the northeast talus was observed to be growing high and sharp-pointed. The interior surfaces were quite dusty February 3. About noon this day a rock slide fell from the west wall of the larger Kilauea crater.

Nine earthquakes were recorded during the week, one of these at 8.18 a. m. January 28 being in the perceptible class. Tilting was slight NNE. The weather was the coldest for the winter so far, and drought continues.

DAY'S THEORY OF PRESENT-DAY VOLCANISM

After quoting the evidence from Kilauea and Lassen, Dr. A. L. Day reaches the conclusion (Some Causes of Volcanic Activity, Journal Franklin Institute, August 1925) "that volcanoes are local and superficial developments representing (geologically) the last stages in crystallization in a mass of magma below, of which little remains fluid, and this in small (as geologic dimensions go) pockets, which are quite variable in gas content, pressure and conditions of chemical equilibrium." "The outstanding factor in determining the character of modern volcanism is the gas content of the crystallizing magma. If this be mainly of steam released in a closed chamber, as at Lassen Peak, then only steam explosions are to be expected as the surface manifestation of the crystallization of the magma below; if to the steam are added such chemically active gases as chlorine, sulphur, hydrogen and the hydrocarbons, then chemical reaction between these will be a sufficient cause of higher temperatures and lava flows of the character well known at Vesuvius, Stromboli or Kilauea."

The supporting evidence for this theory cited is:—The temperatures in Kilauea lava lake are very variable; the viscosity of the material in the lava basin is diversified; gases maintain fluidity remarkably and more gas brings more heat: the gases are variable and not in equilibrium; surface temperatures are hotter than those below; the Lassen eruptions on the other hand showed little red heat; they produced merely great explosions of water vapor; the Kilauea pit after the 1924 explosive eruption showed red hot crystalline bodies and possible lateral vents; on other occasions it has shown lava flowing from different levels. All this is summed up as proving that "the heterogeneous character of the gases collected, the temperature conditions within the lava basin, the appearance of the crater when free of all its liquid lava, and the dynamic relations within the lava body when present in the crater, all point to many sources rather than to a single source both of gases and of magma." Day thinks that the great Tertiary floods of lava of Africa, India and North America may have been from a crustal substratum, but that modern volcanoes have no such source. T.A.J.

THE ERUPTION OF SANTORIN

The activity of this volcano in the Grecian archipelago cited in the VOLCANO LETTER of October 22, 1925, has continued (H. S. Washington, Jour. Wash. Acad. Sci. Jan. 4, 1926) and is likely to last for a year or more. The general quality of its stiff aa lava flows and explosions recalls Sakurajima. The active central islands are in the midst of an oceanic lagoon about seven by five miles in diameter, partly enclosed by the inhabited islands Thera and Therasia; the lagoon is probably an ancient engulfment crater. The present eruption was started by small earthquakes in July, 1925 and during the first nine days of August an islet was built up in a strait between Mikra and Nea Kaimeni. By vulcanian explosions and hypersthene andesite flows this filled the strait and united these island conelets. The water was heated to nearly boiling, and 69 degrees C. was measured.

The lava piled up several meters and on October 27 the eastern flow was still moving into the lagoon. Another flow was moving on the land. Steam and sulphuretted hydrogen were given off. The lagoon water was colored orange with iron hydroxide. The new hill formed, Fouque' Kaimeni, was 75 meters high and 120 meters in diameter. It was a fissured incandescent dome continually changing with violent explosions making cauliflower clouds and throwing showers of rocks. Elsewhere there were hissing steam jets and 'coronet' jets from encircling incandescent crevices. Bluish, yellow and red flames played over the lava dome. T.A.J.

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No. 59 **RELEASED WITHOUT COPYRIGHT RESTRICTION** February 11, 1926

KILAUEA REPORT NO. 735

WEEK ENDING FEBRUARY 10, 1926
Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

There has been some avalanching in Halemaumau during the week, seismic activity has been feeble at Kilauea, but an earthquake was felt in Honolulu and on Maui about 11:28 a. m. February 7.

On February 4 conditions in the pit were quiet. February 6th there was fresh talus NE, new cracks were found in the soil WNW of the pit, and small slides occurred SW and NE after 3:30 p. m. Light southerly wind caused the gas from the pit to nucleate and make visible the northerly steam jets on the Kilauea floor. This nucleation effect was noted at 5:30 p. m. February 7 in the western floor jets of the pit itself, which at first appeared feeble, then changed to densely flocculent steam tails without any apparent cause. Dust does not nucleate the steam, as shown February 10 when a northeast gale filled the pit with dust. Feburay 8th the northeast wall was dropping rock in bunches every few minutes and making red cauliflowers. The gale of the 10th, which blew down a chimney at Volcano House, did not seem to start avalanches.

Six earthquakes were registered, including a tremor simultaneous with the Honolulu earthquake, apparently a coincidence merely. Tilt was strong SSW.

DALY'S THEORY OF VOLCANISM

It would be hard to imagine any more completely different explanation for the same phenomena than is R. A. Daly's doctrine of the cause of volcanic action, as compared with the crystallization-pocket theory of A. L. Day cited last week. (Daly, R. A. Relation of mountain building to igneous action, Proc. Amer. Phil. Soc. LXIV, 2, 1925, pp. 283-307). Daly is geologist at Harvard, Day is physicist and director of the Geophysical Laboratory at Washington.

Daly makes the fundamental cause of volcanic action a rising of molten rock from the interior. Fluxing gases from such an injection are responsible for the long lives of ordinary volcanoes. Effervescence of the gas-charged slag is one of the conditions for lava outflow. Gas pressure is one of the causes for the initial rise of this material. But it is not the main cause.

The main cause is the weight of the crystalline crust of the earth, which from time to time breaks so that the continental blocks slip or glide sideways, underlain by a thick shell of hot basaltic glass, which is rigid but weak. This hot basalt, released of pressure, rises into tension cracks that open when the broken continents slide toward lower basins of sedimentation (oceans).

The migration of crust blocks of continental dimensions, over a substratum of lava-glass which is easily strained by prolonged pressure in one direction, is the Wegener "drift theory" of the origin of continents and compression of mountain chains. The existing continents broke away from an Asia-Europe center, migrating toward the Pacific both westward and eastward. The crust is some 40 miles thick. The substratum is "slippery." The continental movements have been like great landslides, leaving widening tension cracks behind, which are now the Arctic, Atlantic and Indian oceans. These have shore-lines peculiar to such origin. The Americas and the Australia-Asia blocks migrated towards the Pacific center, "folding and rafting together" the strata downstream, and so crumpled up and finally lifted the mountain ranges of the Cordillera, the Andes and eastern Asia and Australia.

The granite intrusions of the mountains are accounted for by Daly as follows. At the front of the advancing continents huge crust fragments sank in the lava substratum. There they were melted and produced solutions more siliceous than the original basic glass. New gases from limestones were introduced into the melts so formed. These account for the concentration of alkaline lavas and intrusions. This deeply assimilated matter was injected into or through the crumpled mountain sediments as granites, diorities, rhyolites and andesites.

This explanation is said to accord with the tidal-disruption theory of earth origin, which demands a primitive molten stage for the globe, and a thin crust. Proofs for the basaltic under-layer are the computed deep temperatures, too high for crystallization (See Volcano Letter No. 3, January 15, 1925). Isostatic balance implies plasticity in the substance beneath the crust (See Volcano Letter No. 48). The sinking of sedimentary basins, and their great squeezing together and shortening long before they are lifted and eroded into mountains, are facts that appear to agree with the idea that a substratum makes room for them and that something advances to crush them. The tension cracking and sinking of large areas of the crust of the earth over which basaltic floods of lava have poured out, and the repeated upgushing of black "trap rocks" as dykes in all geologic ages, are evidences of a basaltic underpinning capable of effusion when the crust breaks up above it. Such broken and flooded areas are the great rift of Africa, the Deccan of India, the Columbia basin of Idaho and Oregon, and the Bushveld of the Transvaal.

Earthquake wave caculations show sudden changes in substance, of layers of the globe 35 and 75 miles beneath central Europe. The rock is believed to change from siliceous to something heavy like basalt 35 miles down. Such a change is estimated to be only 15 miles down under the Atlantic, and is absent under the Pacific. T.A.J.

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No. 60 RELEASED WITHOUT COPYRIGHT RESTRICTION February 18, 1926

KILAUEA REPORT NO 736

WEEK ENDING FEBRUARY 17, 1926

Issued by the Observatory, U. S. Geological Survey:

T. A. Jaggar, Official in charge

There is nothing to say about the Hawaiian volcanoes for the past week to the effect that they have changed in any perceptible or measurable way. They are dormant. In Halemaumau there is moderate quantity of bottom vapor, little stones fall occasionally from the walls, no dust over the pit has indicated internal slides, and the only fresh debris on the talus is on the northeast side where there were slips last week. The vapor jets are less condensed in dry weather, and in such weather a greenish yellow sulphate patch may be seen on the lava floor.

Six local seisms were registered, very small, two of them being of the avalanche type. Long waves of a distant earthquake, of small amplitude, were recorded at 5:00 p. m. February 14. Tilting of the ground during the fore part of the week was to the NE, later to the SW, the net result being slight ESE.

HOBBS' THEORY OF VOLCANISM

Professor W H Hobbs of the University of Michigan bases his idea of volcanic action on a conception of pockets of melted sedimentary rocks. (Earth Evolution, Macmillan, 1921.) He believes in giving up the notions of permanence of oceans, of nebular origin for the earth, of intrusive rocks being connected with a substratum, of earthquakes having an epicenter, of subterranean flow and outthrust from Asia of mountain-forming pressure, of isostasy, and of tensional stress anywhere. Compression is the rule. Strata of stiff limestone arched up over shale by compression, the rocks being restrained from melting only by pressure, relieve the pressure on the hot shale so that it melts. Laccoliths are formed by this mechanism, and according to Hobbs have no feeding dykes below.

Proofs of the hypothesis are adduced as follows: The planetesimal theory is right and calls for no molten planet. On the basis of Gutenberg's 1914 conclusions from earthquake wave velocities, the center of the earth is like the stone-iron meteorites, next outward comes a layer of heavier nickel-iron, then meteoric stone of density 3.6, and outside is a thin rind of sediments and igneous rock. The fusing point is elevated with increase of pressure. Mountain forming sediments are under great pressure and very hot. Local release of pressure will fuse them. The interior of the earth is proved rigid by physical experiments, hence cannot be molten. Water greatly lowers fusion point and sediments contain water. In pegmatites all gradations exist between water solution and rock melt. According to Hobbs less than five per cent of the igneous rocks are as heavy as the lightest of the meteorites (he appears to take no account of the possible distribution of basalt under the bottom of the sea). And finally, the average composition of shale is like the average composition of the igneous rocks.

This last argument is developed at great length, and groups of slaty sediments are said to constitute petrographic provinces just as igneous rocks do. No argument is brought forward, however, to show that any gradations are anywhere found between unmelted and melted shales in the hollows of folds.

It is granted that normal faulting means extension of earth surface area, apparently, but Professor Hobbs thinks the overwhelming proof of shortening of the surface everywhere is that rails, pipes, bridges and masonry always buckle in earthquakes and never stretch. The reviewer has before him a photograph of a curved water-pipe in Hawaii subjected to the Puna earthquakes of 1924, which was pulled out to a straighter curve, and can recall other cases of tension in earthquakes. The fallacy of the Hobbs position appears to lie in the much greater difficulty of proving tension, whereas buckling is easy and obvious. Hobbs states that in those lenticular intrusions called laccoliths, "the supposed conduit feeders have never in a single case been discovered." This is simply an error. (Laccoliths of the Black Hills, by T. A. Jaggar, 21st Annual, U. S. Geological Survey.)

Other evidences cited for the shale-melting origin of lava are that the gases in sediments are like those in volcanoes, that the limited range in chemical composition of magma is accounted for, and that this composition is systematically different in block-faulted regions from folded regions. Professor Hobbs believes that geologists have over-estimated the span of geological time because the science grew up around the Atlantic where processes are slow. T.A.J.

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No 61 RELEASED WITHOUT COPYRIGHT RESTRICTION February 25, 1926

KILAUEA REPORT NO. 737

WEEK ENDING FEBRUARY 24, 1926

Issued by the Observatory, U. S. Geological Survey:

T. A. Jaggar, Official in charge

In Halemaumau pit everything remains quiet. About the 19th sliding made fresh debris NE. During a half-hour February 22nd one slide occurred on the NW wall in the afternoon, and one NE in forenoon of February 23 while it was raining. The rain greatly augmented the steam jets in pit.

Eleven tremors occurred, six of them February 18 and 19 of avalanche type. A shake 7:39 a. m. February 21 was felt, though very small, as a single bump with a cracking noise, followed by rumble. The slip that caused it appeared to be close to the Observatory. Tilting for the week was moderate NE.

TILT AND CHANGES OF ELEVATION, KILAUEA

In VOLCANO LETTER No. 41, 1925, it was shown that there was a marked subsidence of the top of Kilauea mountain accompanying strong southwest tilt at the Observatory from 1921 to 1924 inclusive. Referred to the bench mark in front of the Volcano House one point near Halemaumau, the great pit in Kilauea crater, about two miles away, sank five feet and another nine feet. These amounts must be corrected for whatever movement took place at Volcano House.

In June 1925 R. W. Hendry, engineer, Department of Public Works, Territory of Hawaii, ran a level line to the Volcano House bench mark from a point about six miles down the mountain toward Hilo, in Puna district. Mr Hendry found that the bench mark where the Crater Hotel formerly stood, one and one-fourth miles from Volcano House, was relatively down 3.32 feet and the one at Volcano House down 3 97 feet. The ground at Volcano House sank 0.65 foot more than at Crater Hotel site. Some such difference is to be expected as the Volcano House bench mark is about one-half mile nearer Halemaumau, the place where maximum sinking is suspected, than the one at Crater Hotel. The actual sinking of the two places near Halemaumau is, therefore, about 9 and 13 feet respectively, relative to Hendry's datum mark, itself up the mountain about 24 miles from Hilo. A new level line has not yet been run all the way to sea-level. R.H.F.

BOWIE ON VOLCANISM AND ISOSTASY

The leading American expositor of the doctrine of isostasy, W. Bowie, considers volcanism superficial. (Geology from the isostatic viewpoint, Scientific Monthly, January 1926; Journal Franklin Institute, August 1924 and other papers). Dr. Bowie is chief geodesist of the U. S. Coast and Geodetic Survey. He writes "mountains are not formed where the crust is weakest, but where conditions are favorable to the expansion of crustal matter. Volcanoes are due to local causes," citing Day and the Geophysical Laboratory. "Active volcanoes seem to be only in areas of recent uplift or where uplift is still taking place. Volcanoes probably are mere incidents to the processes involved in the decrease in density and increase of volume of crustal material."

"It is probable that earthquakes are phenomena caused by local processes. Earthquakes probably are incidents to the up-movement of materials when mountains and islands are formed, to subsequent erosion, and to the sinking of the earth's crust as sediments accumulate. They are exceedingly rare in areas not subjected to the above three processes.

There are at least two statements here that geologists may take exception to. The greatest floods of lava in the world have been in regions of tension and down-break, and present-day volcanoes, since Tertiary time, are mostly breaking down and lowering. This is true of the Bay of Naples, Hawaii and most of the island volcanoes. On the other hand, where lava volcanism is in process of extinction through stages of explosive eruption, as in the Andes, elevation has occurred. This does not agree with the notion that **active** volcanoes are characterized by uplift. Moreover earthquake centers are abundant along the great deeps of the oceans, some of them extremely remote from land derived sediments This does not agree with the statement that they are rare in regions not subjected to either erosion or sedimentation.

To Dr. Bowie the dominant crust movements are vertical. Horizontal pressures are mere lateral components of up and down stresses. The "crust" is about 60 miles thick, and below this depth the earth's material acts as though it were plastic. The dominant control of the movements today is lightening by erosion and weighting by sedimentation. The reason why a sedimentary basin sinks for a long time before the heat from below expands and raises it, is that sediments are poor conductors and there is a long lag in the heating; in the same fashion there is lag in the cooling of eroded areas, but when it is achieved the sub-crustal material that has flowed in is dense and aids contraction in bringing about final subsidence. This is much like Sandberg's view (Volcano Letter No. 48).

"The earth's crust rises under erosion areas and sinks under the sedimentary areas." Therefore the crust is very weak in yielding to long-continued pressure due to weight. It seems to the reviewer that Bowie over-accents sedimentation, and disregards the great differences in weight of quartzose continental intrusions, and iron-charged oceanic lavas and their probable enormous volume. We know nothing of the amount of sluggish volcanism going on on the ocean floor to keep it heavy and low. We do know that quartz is the commonest mineral of the continents, and that both are light and stand high. As by Bowie's own showing the deficiency or excess of mass in theoretical earth columns is far below the surface at sea-level, it would seem possible that intrusive and extrusive processes may lighten or weight the crust much more profoundly than the movement of sediments. T.A.J.

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No. 62 RELEASED WITHOUT COPYRIGHT RESTRICTION March 4, 1926

KILAUEA REPORT No. 738

WEEK ENDING MARCH 3, 1926

Issued by the Observatory, U. S. Geological Survey:

T. A. Jaggar, Official in charge

The only volcanic event of note during the week was an earthquake that appears to have centered under Mauna Loa. At Halemaumau February 25, at 5 p. m., there was some rock sliding at the west. On March 1 at 3 p. m. there was an avalanche from the SW wall and the steam vents at the base of the south wall appeared to be yellowing with sulphur increasingly.

Ten local earthquakes were registered. One at 8:20 p. m. February 24 was accompanied by a deep booming noise and felt here, origin very near station. At 6:41 a. m. February 28 an earthquake generally felt on the island dismantled seismographs at Observatory and Kona and was perceptible more than 10 seconds at Kilauea. The shaking dislodged rock at Kapapala ranch which broke a water-pipe there and was the strongest felt there in two years.

Tilting of the ground at the Observatory was slight to the SSE.

J. C. Beam, topographic engineer at the station, has started surveys for a net of bore-hole locations on Kilauea floor, wherewith to determine the isothermal lines of surface temperature of the rock in the crater region by means of shallow drilling, and thermometer measurements.

THE GAS VENTS OF THE KATMAI ERUPTION

In 1919 Allen and Zies of the Geophysical Laboratory studied the fumaroles at Katmai Volcano, Alaskan peninsula. (See Volcano Letter, No. 5; Technical Papers, National Geographic Society, No. 2, 1923, A chemical study of the fumaroles of the Katmai region by E. T. Allen and E. G. Zies). These gas craters at very high temperatures were mostly in the "sand-flow" of the eruption of 1912, and the following conclusions were reached:—

The vents are along deep fissures, with secondary characteristics, and temperature-pressure features partly unaccountable.

Temperatures range up to 650°C. The borders of the area are cooler.

Fumarolic activity is declining. Steam is about 99 per cent by volume of the gases, the remainder are hydrochloric acid, carbon dioxide, hydrogen sulphide, nitrogen, hydrofluoric acid and methane, with minor amounts of oxygen, carbon monoxide, argon and ammonia. Hydrogen was not determined apart from the sulphide. Sulphur dioxide was not detected. Fluorine as hydrofluoric acid occurs in amounts comparable with hydrogen sulphide and nitrogen, a quantity unheard of elsewhere.

The argon and nitrogen are largely atmospheric and the water largely from surface sources, as the fumaroles below the surface appear to be accessible to surface air and steam.

The water appears to have been vaporized and heated before it entered the fumaroles.

The heat is not from oxidation by atmospheric oxygen.

No combustible gases burn at the surface, and decrease of temperature downward in some places is due to hot lateral gas vents higher up.

Except for the soluble gases, no relation between temperature and gas composition was observed, and the Deville-Fouque' generalizations of a world-wide order of gas change with declining eruptivity, do not hold. T.A.J.

THE GEYSERS, CALIFORNIA

Steam for power is being drilled for at "the Geysers" in Sonoma County. The hot areas extend along the side of a narrow canyon, repeated at intervals for six miles. No lava or igneous products are visible, and like the Larderello power area in Italy (Volcano Letter No. 32) serpentines are present, along with sandstones, schists and shales. At the Geysers drilling reaches sandstone at less than 100 feet depth. Close to the surface the temperature is 100 degrees Centigrade. "As cracks are cut by the drill the steam flow increases and the temperature rises rapidly 25° C. or more per 100 feet in the upper strata, and measurements show that water could not penetrate to any considerable depth without being vaporized." (E. T. Allen, Jour. Wash. Acad. Sci. p. 74, Feb. 4, 1926. Further evidence of the nature of Hot Springs.)

Small hot springs are frequent, often of high mineral concentration. Their maximum temperature reaches the boiling point for the elevation 98° C. The acid springs contain sulphates of amonium and magnesium, the alkaline ones carbonate, bicarbonate and sulphate. "The evidence shows that the volatile matter is derived from volcanic gases which are escaping from springs and fumaroles," the non-volatile matter coming from serpentine and other metamorphic rocks. Oxidation is shallow as shown by fresh pyrite in the drillings; the surface water cannot penetrate deeply.

Allen accounts for the phenomena "on the assumption that superheated steam and other volcanic gases are ascending from a hot batholith" or body of intrusive magma "through a deep crack in the overlying strata; that the steam is heating surface water by condensation, and the gases hydrogen sulphide and carbon dioxide through logical chemical changes are decomposing the superficial rocks." T.A.J.

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No. 63 RELEASED WITHOUT COPYRIGHT RESTRICTION March 11, 1926

KILAUEA REPORT NO. 739

WEEK ENDING MARCH 10, 1926

Issued by the Observatory, U. S. Geological Survey:

T. A. Jaggar, Official in charge

On March 4 there was some revival of avalanching from the walls of Halemaumau. Off and on all day dust clouds were rising from the northeast side, with maximum about noon. The northern talus and walls were covered with red dust. The slides were occasionally from the west. In a steam jet at the base of the south wall sulphur stain is conspicuous. Slides continued the next two days and then diminished. The southwest and west wall showed stripping, as well as the northeast. Now the pit is quiet and dry.

Thirteen earthquakes were registered, of which two were of the avalanche type, and all were very feeble. A shock at 1:25 a. m. March 8 had distance of origin indicated at 11 miles. A few waves of a distant earthquake were recorded 11:13 p. m. March 3. Tilt for the week was very slight SW.

COMPRESSIONAL HEAT IN VOLCANIC BLASTS

An original conception of the cause of the burns to victims and shredding of tree stumps in such volcanic blasts downhill as those of Mount Pelee and Taal Volcano is presented by G. N. Cole and supported in discussion by C F. Brooks. (Monthly Weather Review, Oct. 1918, p. 453).

The question is asked, "Do the hot crater gases actually sweep down the mountain as a withering blast effective for miles around? If not, the hot blast must be the result of compression on the front of the explosive wave. The fact of pressure disruption of trees, buildings and bodies indicate a pressure wave of sufficient magnitude to produce the observed heating and wind effects." Cole explains the hot blast as the passage of a tremendous compressional wave travelling at a speed exceeding the velocity of sound (335 meters per second). Brooks supposes kinetic energy moving the gas forward at a velocity exceeding the molecular velocity of air, 510 meters per second. If the second zone of air did not move while the first zone, a half kilometer thick, was driven into it, the initial temperature being 80 degrees Fahrenheit, the temperature would be raised to 621 degrees F. Even if 85 per cent of the second zone of air gave way, the temperature would still rise high enough to burn people.

Cole's analysis is as follows. The compression is called adiabatic because there is little time for dissipation of heat. The gas is compressed by three actions: (1) The crater lava is in the condition of water in an exploding boiler. The ejecta of the volacno are conceived as possibly being entirely vaporized and on condensation becoming the sand and grit that covers the landscape. This makes the first wedge to crush the air into compression. (2) The heat of this matter expands the surrounding air, compressing the air of the second zone. (3) Combustion of some of the gases may cause further heating adding to the secondary compression. This all gives rise to destruction as complete in the outer zones of action, as if done by a tornado. Both rise and fall of pressures suddenly are believed to produce phenomena observed. Trees denuded of bark, with fibre cut and shredded, ,are believed accounted for by "some such action as that which pops corn or puffs rice when the pressure is removed after heating." The sudden rise in pressure "must be indescribably worse on the ear drums than going through an air lock in caisson work. Lung and heart action must be stifled." Mr. Cole thinks that the only hope of protection in such countries is to have steel volcano cellars with stability, heat insulation, and pressure insulation.

The reviewer visited St. Pierre at the time of the Pelee eruption, and he has seen similar effects at Sakurajima, Bandaisan, and at St. Vincent. There may be compressional heat in volcanic blasts, but there is so much other heat not mentioned by Mr. Cole, as well as attrition and obvious asphyxiation by dust, and so little evidence of pressure, that the pressure argument seems to prove too much. Mr. Cole says that "if the pressure comes on it will heat the air of a cavern a hundred feet underground." Yet people in cellars, in steamer cabins, a sailor who wrapped himself in a tarpaulin, and Cibaris the convict cited by Mr. Cole, survived with comparatively flimsy protection. It is not a fact that at St. Pierre there was "pressure disruption" of trees, buildings and bodies. The trees were shredded by a sand blast, with the pebbles left sticking in the wood. Boiler plate was left punctured by bowlders, with the rocks left sticking in the holes. One end of St. Pierre was buried under 40 feet of gravel and dust. The heat of a burning city disembowelled bodies. There was no mystery about the deaths, to the medical officers; at the end of the town near the volcano the rock dust was incandescent and falling by tons. People and houses were burned. At the far end of the town the dust was scalding hot in a steam emulsion. Thin clothing was spared while flesh was burned. The awful cases of bronchitis in the wounded were due to nothing but hot dust. The population of St. Pierre died chiefly from instantaneous pneumonia The dust was not volatilized lava, but plain ground up rock. A mighty jungle was burned away by hot sand.

The most puzzling feature of these volcanic blasts is that they move downward and in one direction only, with dynamic effects uni-directional. Their heat is contained in ordinary volcanic ash. T.A.J.

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KILAUEA REPORT NO. 740

WEEK ENDING MARCH 17, 1926

Issued by the Observatory, U. S. Geological Survey:

T. A. Jaggar, Official in charge

The week past has shown marked increase of local earthquakes and tremors. Halemaumau when visited was dry and quiet from March 11 to 13. About 10 a. m. March 14 an avalanche sent up a considerable reddish dust cloud. On the afternoon of March 15 some rocks were slipping on the west wall. Along the trace of the southwest rift dykes up and down the wall of the pit there was a dust trail clear to the top of the wall. This was interpreted to be an avalanche track: there were two such vertical markings.

Twenty-five earthquake movements were registered for the week, four of which were of the avalanche type. A felt shock at 11:51 a. m. March 14, felt also at Hilo, appeared to originate on the northeast rift of Mauna Loa, like the quake of February 28. A tremor was slightly felt about 4 a m. March 11. A shake distinctly felt at Kapapala 3:23 a m March 14 was only very slightly registered at Observatory. Tilt was moderate to WSW.

EXPLORING THE EARTH FOR MAGNETISM

The earth is a big but not very powerful spherical magnet, with both its actual poles near the earth's center. The magnetic poles are the outcrops at the surface of this interior axis. The magnetic poles move, the compass direction varies with time, and there are magnetic storms which vary somehow with sunspots. Not only does the compass vary in its nearness to pointing north, but it varies in the force with which it swings, and in another force which it exerts downward toward those interior poles. Of course the compass is only an indicator of a terrestrial force affecting the particles of balanced iron in the needle. Much of navigation is dependent on the forces that pull this needle. There are earth-air electric currents passing from the air into the earth and vice-versa, apparently associated with the general circulation of the atmosphere, in places downward with downward positive electricity, elsewhere upward for streams of both positive electricity and of the air motion.

There has just been published the fifth of the most complete series of volumes on magnetism exploration ever produced by science. (Carnegie Institution, Ocean Magnetic and Electric Observations 1915-1921. Ault, Mauchly, Peters, Bauer and Fleming, Washington, January 1926, 430 quarto pages).

This volume describes the magnetic results obtained from cruises IV, V and VI of the non-magnetic ship Carnegie, 1915 to 1921; logs of the voyages and auxiliary observations on ice-bergs, sea temperatures and meteorology; atmospheric-electric results; and special reports on the Hudson Bay expedition, navigation of air-craft by astronomical methods, the compass-variometer, sun-spot variations in relation to atmospheric electricity, and studies of atmospheric electricity with reference to potential gradient, ionization, conductivity, current density, radio-activity and penetrating radiations.

The two vessels in this service, the Galilee and Carnegie, in nine cruises between 1905 and 1921, have spent 2668 ocean days, covering 316,536 nautical miles, making 3316 observations of magnetic declination, 2147 of inclination, and 2147 of horizontal intensity. To show the improvement in skill and instruments, the Galilee cruises between 1905 and 1908 averaged 1.8 days between observations for declination; the Carnegie averaged 0.7 day. Hence the advantage of the ship constructed without iron in its composition. The Galilee averaged 196 miles between stations for declination; the Carnegie 84 miles. The Galilee made a total of 325 observations for declination; the Carnegie, in twice as many voyages made almost ten times as many such observations.

A map of all the work on land and sea from 1905 on shows extraordinary achievement; the continents dotted with magnetic stations, the oceans zigzagged by cruises from 60° south latitude to 80° north. All of this was planned by one man, Dr. L. A. Bauer, who has directed magnetism for the Carnegie Institution from the beginning. In 1906 he wrote, "However great this task of a general magnetic survey of the earth may appear, I have now had sufficient experience to know that with good system and management, and ample funds, the work can be completed in a period of about fifteen years."

The volume before us appears to justify this forecast. So far as the discovery of the magnetic constants for all latitudes and longitudes used by mariners are concerned, the tables of figures in these volumes will correct most of the charts. Many of the charts have been wrong in their compass variations by one or more degrees. The yearly changes known as secular variation now have a basis for new reckonings in many places where before there were no data at all. This secular change is what future voyages will measure.

In reading the logs of this three hundred and seventeen thousand miles of cruising in some of the stormiest water in the world in two small sailing vessels, one is impressed with the romance of achievement in modern science. No shipwreck, no savages, no scurvy, almost no adventure. No long narratives of heroism. Continuous observations every hour with delicate instruments rain or shine away to the south of the roaring forties and away to the north of fifty-three. Computations made en route and reduced results sent home from every port, quickly corrected, and supplied to the nautical bureaus of the world. The whole world studied with one object in view, magnetism. This is the sort of thing we would like to see done for the rock bottoms of the oceans of the world, and for volcanism.

T.A.J.

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No.65 RELEASED WITHOUT COPYRIGHT RESTRICTION March 25, 1926

KILAUEA REPORT NO. 741

WEEK ENDING MARCH 24, 1926
Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

Though the number of local earthquakes was not large, the position and intensity of some near shocks during the past week has been interesting. Nothing new in volcanic activity has happened. The increased frequency of local shocks last week and the widely felt Hawaiian earthquake of March 19 point to correspondence, with equinox, of seismic activity.

A steaming hole in the wall of Halemaumau just west of the south talus has been growing increasingly yellow with sulphur. Hot steaming cracks at the east edge of Kilauea crater next to the gravel bank have recently produced a marked increase of alum, sulphur and probably other salts which cover the surface of the lava at the contact with the underlying gravel.

An examination of the southwest edge of Halemaumau showed that the two upright white streaks there were probably produced by the avalanche of March 14, for the top of the rift notch had caved away, and also a place a few feet farther west. The material which had fallen was largely the white floury ash of 1924, there one to two feet thick at the surface, and this in falling had made a white streak on the wall below. No fresh breaks in the soil along the edge cracks were noticed farther back.

After this the only motion observed in the pit was some tinkling of stones heard falling March 22 and dust seen rising from a small slide March 24. Some fresh whitish debris was left on the northeast talus.

Twelve earthquakes were registered during the week, three of which were perceptible. A large earthquake centering some eighty miles away from the observatory was plainly felt here as a prolonged gentle swaying at 10:33 p. m. March 19. A small but perceptible aftershock from the same origin occurred at 7:27 a. m. March 20. Both of these made good records on the seismographs of Kona, Hilea and Hilo as well as at Kilauea, and from the indicated distance to origin from the three stations it appears that the disturbance was on the ocean floor 26 miles north of Honokaa, or 25 miles northeast of Kohala. At the Observatory both instruments were dismantled by the larger shock, which was felt at Honolulu, strongly felt at Kohala and Honomu, and less strongly felt in Hilo. It produced a weak rocking in Kona. Tilt was slight WSW. A small jolt occurred March 21 11:38 a. m.

THE QUERVAIN-PICCARD SEISMOGRAPH

The two professors named, in Zurich, have built a three-component seismograph with pendulum weighing twenty-one tons. By "three-component" is meant registration of up-down, east-west and north-south motion, and in this instrument all three are registered from the motion of the same suspended body. (Iberica, Madrid, No. 522, Nov. 15, 1924, Fr. M. M. S. Navarro, Meeting of the Seismologic Section, Second Assembly of the International Geodetic and Geophysical Union).

A most interesting cut is shown in this article, representing a portable seismograph made by the same investigators. It is described as designed for the registration of local earthquakes. Its plan is the same as the 21-ton instrument. The photograph shows an upright skeleton cylindrical frame on three projecting feet with levelling screws. Within the frame apparently hangs the normal pendulum and three pens write on clock-driven smoked paper. From the electrical devices indicated, apparently the damping is magnetic. Upright spiral springs appear inside the frame, suggesting that the vertical component is in some way identified with the same mass that writes the two rectangular horizontal motions. The whole instrument appears to be about three feet high and quite compact. T.A.J.

GAS WELL PIT

Dr. Sidney Powers, chief geologist of the Amerada Petroleum Corporation of Tulsa, Oklahoma calls attention to an extraordinary photograph of the pit left by a gas well blow-out. In appearance it is precisely like the Hawaiian pit-craters, subcircular, with vertical walls and internal talus and clinging rim pinnacles. The picture is published in the Oil Weekly of February 26, 1926, p. 23, and the pit appears in a wide flat terraced country, with a few trees. The walls show horizontal bedding. The caption states that this is a big gas well that blew out at White Point, South Texas. The crater developed a "vortex" in the center in which the derrick and machinery sank to unknown depths. It is said now to contain boiling water and burning gas. Perhaps there is here a lesson to be learned for volcanology, showing that pit craters are easily produced by engulfment, when deflation of something below, through loss of gas, decreases bulk locally, and a superficial pit is the result. T.A.J.

NEW SEISMOLOGICAL QUARTERLY

Referring to critical study of tide-gauge registration recommended in the Volcano Letter No. 57, Dr. William Bowie writes that for more than a year the U. S. Coast and Geodetic Survey has been examining the tidal records and every seismic sea-wave is studied with reference to the earthquake record for the same occasion. This will be a feature of a forthcoming quarterly seismological report of the bureau, the first number of which will cover January-March 1925. "Science Service" of the National Research Council so cooperates with telegraphic reports as to locate epicenters immediately. Thus Dr. Bowie has located the big earthquake of January 24 as in the Solomon Islands (Volcano Letter January 28). T.A.J.

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No. 66 RELEASED WITHOUT COPYRIGHT RESTRICTION April 1, 1926

KILAUEA REPORT NO. 742

WEEK ENDING MARCH 31, 1926

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

There is practically nothing new to record of volcanic activity in Hawaii. Halemaumau and Mokuaweoweo are dormant. The weather has been calm to southerly at Kilauea, with rain, and northerly at Hilo with fresh wind and dry weather. Halemaumau has shown much steam and the big sill northeast has caved away a little, but there have been no avalanches noticed.

Ten local earthquakes were recorded on Observatory seismographs. One at 12:34 a. m. March 29 dismantled one seismograph, and the distance to origin indicated was about 19 miles. A distant earthquake apparently 3560 miles away occurred March 27 at 12:30 a. m. Tilting for the week was slight to the SW.

Work has been begun on the Kilauea floor, with compressor and hammer drill, in making small holes at surveyed stations 1000 feet apart, to serve as permanent places for measurement of the temperatures of the bedrock.

THE WHITE ISLAND VOLCANO

In the Bay of Plenty on the northeast side of New Zealand's north island, there is an active volcano islet which strongly resembles Bogoslof of the Aleutians. This is known as "White Island" and in September of 1914 it was the scene of a frightful disaster when all the operatives of a company mining sulphur were swept away by an eruption. All that was seen from the adjacent shores of the bay was the ejection of steam clouds, but the crater lagoon appears to have been blown out after the fashion of a gigantic geyser and to have overwhelmed the camp.

The Auckland Weekly News of January 7, 1926, brings word that after some years of idleness the sulphur camp has been reestablished, not on the sand flat separating the open crater from the sea, but on the opposite side of the island more than a mile from the crater and where on the southwest side of the volcano the principal area of vegetation has developed, groves of pohutukawa (metrosideros). The crater rim a thousand feet above the camp, which is on the windward side of the island, forms a barrier between the workers and the poisonous solfataras always steaming violently on the crater side. The new camp is described as peaceful and delightful, with imported poultry, pigs and sheep, numerous buiildngs and huts, a fresh water supply from a natural spring which is said to contain an excess of iodine, abundant firewood, a receiving and transmitting wireless plant and a track communicating with the sulphur works at the mouth of the crater on the other side of the island. A motor boat and three row boats are kept on hand and there is a telephone between the camp and the workings. A medical officer is stationed at the plant. There is good fishing. A rookery of boobies is close at hand.

Just over the divide every vestige of life has been destroyed by the poisonous fumes of hydrochloric acid and sulphur which rise with roaring steam jets from a main blow hole in the center of the crater floor and from lesser vents about the talus slopes.

Dr. J. Allan Thomson, director of the Dominion Museum, sends an article from "The Dominion" of Wellington, February 18, stating that the side fumeroles have from time to time been blocked by avalanches, this seeming to increase the force of the central blow-hole. About the end of January the central vent gave out "unusual volumes of superheated sulphur, the fumes carrying with them dense clouds of red oxide dust. On calm days the cloud reached measured heights varying from eight to ten thousand feet."

"Finally on the night of February 3, 1926, a fault apparently developed at the base of a 200-foot cliff on the western side of the main blow-hole, and some hundreds of yards of the cliff collapsed. The pressure of gas and steam blew forth a mass of sulphurous mud covering an area of ten acres three inches deep." A new vent broke through the disturbed earth fifty feet above the crater floor. For forty-eight hours the air was full of dust-charged steam. The main blow-hole was giving off overpowering fumes. Between it and the new vent the crater saucer was covered with massive volcanic bowlders smothered under fresh mud. When visited the place showed that a new gas vent had created the landslide, with activity very similar to the central blow-hole, sending up sulphur fume with a roar and, owing to the intense heat, not condensing its steam until the vapor reached a height of fifty or sixty feet. The steam rose to the top of the crater walls, where it was caught by the wind and blown away in clouds.

The new vent did not produce the same "nerve-wracking noise" as the central blow-hole, but it had lessened the force of the latter. "The formation of the new vent's cone is not yet permanent. Occasionally a minor landslide above the vent is blown into the air by the tremendous force, and the dust thus formed is scattered broadcast over the crater floor." The writer of the article states that the two blow-holes of the White Island crater constitute the greatest thermal activities of their kind in the world. He is of the opinion that the new eruption, by adding to the safety-valve openings "obviously has rendered the crater even safer than previously."

We would venture to caution our friends in New Zealand against putting too much confidence in this safety-valve theory. White Island has all the characteristics of a dangerous volcano like Bogoslof or like Krakatoa. The collapse above described, accompanied by red cauliflower clouds thousands of feet high, and the opening of a new wall-crack vent, means engulfment. If engulfment continues it may mean the retirement of lava lying below, at the end of a pressure cycle. If our diagnosis of what happened at Kilauea in the spring of 1924 is correct, such retirement of deep lava may take several months, and be followed by sudden collapse of the crater bottom. This we believe accounts for the considerable delay of the Krakatoa, Kilauea and Pelee eruptions after the first symptoms. Tarawera in New Zealand was a clear case of engulfment. Engulfment opens voids which fill with water, and steam explosion follows. In the event of a true explosive eruption, which can throw eight-ton bowlders three miles, a camp like that of the sulphur workers on White Island would be exposed to the first barrage.

T.A.J.

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No. 67 RELEASED WITHOUT COPYRIGHT RESTRICTION April 8, 1926

KILAUEA REPORT NO. 743

WEEK ENDING APRIL 7, 1926

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

On rainy afternoons during the past week there has been much fume and vapor at the vents in the lower walls and bottom debris of Halemaumau. Sulphur odor is occasionally perceptible. At a vent in the south wall increasing yellow coatings indicate sulphur depositing, and at the south talus there is dense blue fume of sulphur gases mixed with the steam. This blue fume is seen also near the center of the pit and at the east edge of the bottom. On April 4 new debris had fallen on the northeast talus, and a new wall scar was in evidence up and down the NNW wall. Rocks were sliding a little at the NW and NE. Such slides must have been slightly bigger about noon April 5 for dust in small amounts rose over the pit. On that afternoon the large northeast sill was steaming at a place near its east end where the rock has recently fallen away and left fresh gray surfaces.

Twenty-three local earthquakes were recorded by the Observatory seismographs during the week, all too small to be noticed. Tilting was slight to the SW.

UNITED STATES SEISMOLOGICAL REPORT

Under the title "Seismological Report" for January, February, March, 1925, by Frank Neumann, mathematician, Division of Terrestrial Magnetism and Seismology, U. S. Coast and Geodetic Survey, there has just been printed the first number of the new quarterly which marks the transfer of seismological investigations in the United States from the Weather Bureau to the Coast Survey. Formerly this matter was printed in the Monthly Weather Review. A special report will be issued to cover the six months ended December 31, 1924, during which time the Weather Bureau ceased publication. Commander N. H. Heck is chief of the Division of Terrestrial Magnetism, now made to include seismology.

The new report is in octavo form, forty-eight pages, and includes all seismological investigation in the United States, the regions under its jurisdiction, and adjacent regions. The statistical data include tables of felt earthquakes, instrumental records and a summary of current earthquakes. A special canvass was made for intensity information concerning the regions affected by the Quebec earthquake of March 1 (February 28, local time) and the Alaska earthquake of February 23. The Quebec earthquake is here considered only in relation to places in the United States. The instrumental reports use the Klotz symbols and all reports are reduced to Greenwich time.

The summary of earthquakes for the three months in lands under the jurisdiction of the United States shows only eleven days without reported shocks and many days with two to seven earthquakes. The well established locations of shocks include forty in the Philippines, twelve foreign, eleven in California, ten in Canada, and nine in Alaska. The local shocks of Hawaii are not here included, but the Bulletin of the Hawaiian Volcano Observatory is referred to. Ninety-seven earthquakes were well located, sixty-seven had positions doubtful, thirty-seven were in unknown locations, and twenty-nine were aftershocks of the Alaska and Quebec earthqaukes, making two hundred and thirty shocks in all.

The principal earthquakes were in New England on January 7, a submarine shock January 18, an earthquake February 23 centering seventy miles north of Valdez on the south coast of Alaska, the Quebec earthquake near the St. Lawrence river, and a disastrous shock March 16 in China which destroyed 5000 lives about the city of Tali in Yunnan.

The list of observatories cited in the summary includes nine in the United States, five in Canada, one in Panama, one in Guam, two in Hawaii, one in the Philippines, and one in Alaska.

Mention is made of the work of the Coast Survey in precise triangulation in California which has determined extraordinary changes in horizontal position of old stations amounting to as much as 24 feet northward near Gaviota in the Santa Barbara district. A new baseline is to be measured in that district with a view to finding out how much of this movement is an actual geographic change and how much may be ascribed to residual errors in the triangulation. A preliminary report on "Earth Movements in California" has appeared as Special Publication No. 106, U. S. Coast and Geodetic Survey. Precise leveling has been run across southern California comparing the data of 1906 and 1924. In seven kilometers distance between Santa Ana and Barstow a change of elevation of 54 millimeters was found, and between Orange and Barstow, a distance of 214 kilometers, the change was 63 millimeters.

These reports may be expected to grow in size and value, and represent the first appropriations specifically made by Congress for collecting seismological information from all parts of the United States. The Coast Survey needs the cooperation of the public. "The humblest citizen can often furnish information as valuable in its field as the technical report of the seismologist with elaborate instrumental equipment." Progress depends on cooperation. All people who keep records of felt earthquakes should send their lists to the U. S. Coast and Geodetic Survey, Washington, D. C. People in remote places are especially fortunate in situation for furnishing valuable data. Firms having organization of representatives in many places could enormously help the work by securing blank forms from the Survey and having them sent in systematically whenever an earthquake is felt. T.A.J.

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No. 68 **RELEASED WITHOUT COPYRIGHT RESTRICTION** April 15, 1926

KILAUEA REPORT NO. 744

WEEK ENDING APRIL 14, 1926

Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, Temporarily in Charge

A very diffuse blue fume was observed with the steam escaping from one of the many vents inside Halemaumau during the fore part of the week. Accompanying the numerous earthquakes attendant on the outbreak of Mauna Loa there was an increase of avalanching from the walls of Halemaumau. During the forenoon of April 10 two large slides from the wall near where the southwest rift of Kilauea enters Halemaumau were observed. Possibly this rift was in motion.

On April 11 Halemaumau was full of steam most of the afternoon and a faint odor of hydrogen sulphide was noticeable at the south rim. An occasional glimpse into the pit showed abundant floor vapor. On April 12 following the rain of April 11 the walls of Halemaumau were found to be quite red. Steam was escaping in continuous jets from a line of vents in middle of southwest talus slope. Recent movement in cracks back from the rim of Halemaumau were noticed on April 13. During the afternoon diffuse blue fume appeared to be mixed with the steam escaping from a vent in sulphur stained area on south floor of Halemaumau.

376 earthquakes were recorded during the week, 363 of which occurred during the four days following outbreak of Mauna Loa. The majority of the shakes appear to have had their origin along the extension of the southwest rift of Mauna Loa into the lower Kau country, though some appeared to originate under Mokuaweoweo the summit crater of Mauna Loa and along the northeastern rift. The net tilting for the week was very slight to the ENE. On April 13 there was a noticeable spurt of northeast tilt. A northeasterly tilt which means an increase of internal pressure of Kilauea coupled with the known sympathy of action between Kilauea and Mauna Loa indicates that Halemaumau should be watched closely.

THE APRIL 10, 1926 OUTBREAK OF MAUNA LOA

Shortly after 3:00 a. m. April 10, 1926, Mauna Loa became active after having been quiet since November, 1919. The rising fume columns illuminated by fire fountains and lava flows below cast a pinkish glare all over the island of Hawaii. Large print could be read at the Observatory 24 miles away.

The Observatory is greatly indebted to E. G. Wingate, Topographic Engineer, U. S. Geological Survey, for a very complete report of the outbreak. Mr. Wingate, who was camped a few miles from the summit of the mountain at an elevation of 11,400 feet, went immediately to the scene of action. By nightfall he had made copious notes on the activity and very accurately mapped the lava flows, the location of fountains, and active fissures.

Lava spattered from a crack over three miles long and from several places short lived flows started. The highest flow issued from near the edge of Pohaku Hanalei crater—the southern part of Mokuaweoweo. The lava both streamed down the mountain side for about one mile and cascaded over the crater rim. The southeastern half of Pohaku Hanalei crater was covered with the new lava.

Owing to lava flows along its edge observations were not made at the first of the two outer craters about a half a mile below Pohaku Hanalei. At the second of the outer craters about a half a mile below the first there was a wonderful sight. A line of fountains marked the main rift crack which cuts through this crater.

Lava was cascading into the crater from the upper edge and at the lower side there were two lava streams one running into a tunnel and the other over the surface. These two streams with others lower down fed the main lava flows which went down the mountain with branches leading toward both the Kau and Kona sides for a distance of about four miles or more. The lowest vent was at an elevation of about 12,000 feet or above the site of the preliminary outbreaks in 1916 and 1919. One branch of the flow went by the sulphur bank area which appears as a conspicuous scar when viewed from above the timber line far down the southwestern rift zone. (For a description of this rift zone, see Volcano Letter No. 52, Dec. 24, 1925).

Shortly before 8:00 a. m., as viewed from the Observatory, activity at the source vents had nearly ceased. By 8:30 a. m. the large fume cloud that was drifting to the northeast had disappeared.

There was no "swarm" of earthquakes preceding the outbreak, though they have been coming in "swarms" since. The warning quakes which were widely felt over the eastern half of the island of Hawaii occurred at 1:50 a. m. and 2:04 a. m. or about an hour before the appearance of the lava. Before the occurrence of these shakes, however, at 1:36 a. m. "harmonic tremor," a motion that is recorded on the Observatory seismographs only when there is molten lava at either Kilauea or Mauna Loa, was recorded. This type of tremor became very noticeable after the 2:04 a. m. shake and continued so for that day.

Prior to the outbreak Mauna Loa had been watched with considerable interest for three reasons: 1, there was an indication of increase of internal pressure of the volcano system as shown by a slight accumulation of easterly tilt from 1925 to 1926; 2, quite a large number of earthquakes had been occurring on Mauna Loa during the past several months; and 3, Mauna Loa had been quiet for nearly 6½ years which is rather longer than the average interval between periods of activity.

The outbreak followed one of the driest years ever noted on the summit of Mauna Loa. There was scarcely any snowfall during the preceding winter. For the last seven months the entire island of Hawaii has been unusually dry.

R.H.F.

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No. 69 RELEASED WITHOUT COPYRIGHT RESTRICTION April 22, 1926

KILAUEA REPORT NO. 745

WEEK ENDING APRIL 21, 1926

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

During the Mauna Loa eruption there has been no increase of steam or avalanche activity noted at Halemaumau. Hydrogen sulphide was smelled there on the 17th. The sulphurous steam at south talus appeared a little hotter and more flocculent.

Numbers of local earthquakes per twelve-hour interval beginning the morning of April 14 were 32, 24, 51, 32, 37, 29, 29, 16, 12, 8, 12, 8, 18, 2, the last being the night of April 20-21. The total is 310. Tilting was moderate SE with unusual daily fluctuation. Intensity of earthquakes increased as numbers diminished. Three of the quakes of the 20th were of Halemaumau origin.

PROGRESS 1926 MAUNA LOA ERUPTION

The writer explored the summit region from camp of E. G. Wingate April 11-14. The new break on the southwest rift is tangent to the two upper small pits on their east sides, and cuts across the third pit. Flows of silvery light weight pahoehoe extend from these fissures several miles south, and others have cascaded into the pits. The upper cracks are hot and vaporing in places but no longer flowing. An unusually sharp earthquake felt on the mountain the evening April 13, along with others, showed that the rift was working. Three cups on the rift east of the divide cones at about 8000 feet elevation were seen April 13 smoking with dense yellow fume, (looking down the southwest rift). April 14 about 8:30 a. m. a big brown fume column arose at that place and then others higher up the rift zone. The lava flows had started on the rift approximately 15 miles from the center of the summit crater, and five miles above Puu o Keokeo as one follows the curved rift line. At night there was red glow there and smoke all along the rift to the summit.

These observations and subsequent ones by R. H. Finch and W. O. Clark the night of April 19 in the source region above Naalehu show that the main new crack of this outbreak is several miles long and on the eastern side of the rift belt divide. In spite of this the floods of lava made their longest flow on the western side to the ocean.

April 15 observation from south of Waiohinu in evening showed the glowing front of an eastern flow in Pele o iki Kipuka high up the mountain above the Waiohinu homesteads. Beyond could be seen the lurid glare and fume column of the source fountains, and vivid glow in a long belt to the west over a flow going towards South Kona. There the cowboys of upper Papaa ranches reported the Kona branch flow as four miles from the belt road near Honomalino and progressing.

April 16 an observatory party reached the new Pele o iki eastern flow but were unable to cross it. It was aa. In the forenoon news came that the Honomalino flow was close to the road; two columns of fume showing great increase of volume and heat convection appeared over the source region. We arrived at Kaanaana's house at Honomalino 10:30 a. m. where the smoke of the burning forest at the front of the flow was visible just above. At 12:22 p. m the aa flow there crashed through the guava bushes into a causeway of the road creeping as a red hot landslide of tumbling "snow-ball" block-lava 500 to 600 feet wide. Immense accretion balls or bowlders covered the surface and tumbled forward at the front. Advance across road at 1:10 p. m. was 6 to 8 feet per minute. This place was three miles above the Hoopuloa wharf and south of the Hoopuloa road. The Kaanaana house was crushed and burned.

We descended the trail to Honomalino beach, Milolii, and Hoopuloa.

April 17 at 3:30 a. m. the front overtopped the bluff back of Hoopuloa; at 9 a. m. it reached the lava flat some thousand feet back of village; the interior liquid was rolling over the front by friction with the ground, shoving forward the top layer of blocks, and maintaining a red hot talus at the lower ends of each lobe. The mass was delta shaped, 25 to 50 feet high and increased in width from 1000 to 1500 feet. Its average forward creep was 2.7 feet per minute. The middle of stream on bluff slope broke into cascades every 3 or 4 hours that night.

April 18 the front reached Hoopuloa at 4 a. m., burned houses about 5 a. m., reached sea 6:30 a. m. and in next two hours buried the town and the harbor. Clouds of steam peppered with black sand shot up, small pebbles rose in wavy trajectories, the vapor was sour with muriatic acid, and the noises were hissings and later thudding explosions and prolonged roars of escaping steam. Fish were killed by thousands.

At the road crossing a sluggish orange colored aa river pulsated within hardened lava fields. The Waiohinu flow stopped. Upper ranch buildings of Honomalino were destroyed, by branch flows. Army aviators photographed the district from the air.

April 19 about 9 a. m. the road flow stopped. Finch and Clark reported fountains at about 7600 feet elevation, activity on rift miles long, immense smoking columns and loud roar from one of them, large fountaining areas and a rived from them passing to the north of Puu o Keokeo over to the Kona side. The line of activity appeared to be 5 or 6 miles long. New cones and fountains were 50 to 100 feet high. The line is well to the east of the 1919 line.

T.A.J.

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No. 70 **RELEASED WITHOUT COPYRIGHT RESTRICTION** April 29, 1926

KILAUEA REPORT NO. 746

WEEK ENDING APRIL 28, 1926

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

Halemaumau continues quiet after having been inactive for one year and nine months. Today the pit floor and walls were dry and dusty with but little steam escaping.

The Mauna Loa outbreak produced no visible effects in Halemaumau save that caused by the earthquakes. There was an increase in avalanching and some of the blocks around the rim of pit were jostled so that small new cracks appeared. Some such effect is to be expected when one considers the rather unstable 1200 foot walls being jarred by earthquakes the largest of which was strong enough to overturn some objects.

During the week 46 earthquakes were recorded, 32 of which occurred on April 21 and 22. The shake at 4:32 a. m. April 22 was one of the strongest of the series and was widely felt over the island of Hawaii. The seismographs both at Hilo and Volcano were dismantled. A shake at 11:05 p. m. April 22 had an indicated distance to origin of 12 miles, equal to the distance of northeastern rift of Mauna Loa from Observatory.

The net result of tilting for the week was slight to the south-southeast.

DECLINE OF MAUNA LOA ERUPTION

The 1926 outbreaks on Mauna Loa began one year and nine months since lava activity was last seen in the Kilauea-Mauna Loa system. This is not a long interval and it is clear that the explosive eruption of Kilauea 1924 in no way interrupted the normal successsion of lava effusions. The new outburst was accompanied by a sharp change of tilt at Kilauea observatory from westerly to easterly, and a moderate change from southerly to northerly, beginning about April 11, a day after the summit outbreak. The change was from tilt towards the active center to tilt away from it. Along with this came 70 to 90 earthquakes per day, then in the second week 15 to 50, and the numbers per 24-hour day midnight to midnight beginning April 21 have been 17, 17, 6, 4, 2, 1, 1. This decline suggests a finish within three weeks of the beginning; whereas the Alika period of 1919 lasted seven weeks. But more observation of the source region is needed before this conclusion is established for 1926.

From Kilauea, glow was seen over the Kahuku lava source region April 25, also the fume cloud, and faint fume was visible April 27 and later. Fume jets had apparently developed down the rift immediately after the summit outbreaks of the 10th, gradually increasing and concentrating at about the 8000-foot level on the 13th, when the stage was set for the lava flows from the lower levels. The absence of glow at the Kilauea distance 35 miles away does not prove that small fountaining has ceased.

April 21 the cattlemen of Honomalino Ranch reported a second flow alongside of the one that had destroyed Hoopuloa moving not faster than a mile a day, and near the 1916 flow in the forest 2 to 3 miles above the belt road, in Honomalino. This stopped there, and on the 23rd they reported another branch 5 to 6 miles above the road moving 2 feet per minute, in flat country. Valuable upland paddocks in the Koa forest were destroyed.

The writer went to the flow source at about elevation 7400 feet, 3 miles north of Puu o Keokeo, and spent the night April 22-23 there on an old red cone, against the north foot of which lay the flowing streams. These streams flowed to Honomalino from a fissure line dotted with nine active cones. These made the most active part of a line of sixteen new cones visible, the lower three making pahoehoe slag-heaps of the Kilauea type, the upper ones making clouds of smoke so as to hide any others that lay farther up the rift. The nine middle vents bounded the east end of the Hoopuloa source belt of fresh lava, here a half-mile wide and trending WSW. Most of this was aa, but through the southern part of it swept a gorgeous meandering river of fiery melt with rapids, and risings and fallings, and floating rafts, and overflows, all within well defined banks. This stream took its rise at the northern cones of the spectacular nine, where the hills piled up, and a spray fountain rose and fell in brilliant orange incandescence, and brooks of molten basalt fed the torrent with lava springs. With very brilliant reflection on the cloud above, the river of fire wandered off three miles across the plateau in a shimmer of western mirage and disappeared over the shoulder of the mountain towards Kona. No glow was seen in the direction of the earlier Kahuku flow towards Waiohinu. A lower cone of the nine was an open cup vomiting sluggish aa, and this went out of action during the night. The other vents were flaming or spitting or fuming fierily, and showed by the cooled field of lava from them and by their built-up flanks that they were dying remnants of what had been fountaining and flooding during the first days of eruption.

The report of a visiting party showed that the source region was still fountaining and golwing April 26th. On that day the Observatory party visited the northern sides of the Hoopuloa flow at the sea-shore and at the road, and found the former steaming feebly and the latter flaming in spots where vegetation was burning beneath. Otherwise the flow was cool and easily walked over. There is ammonia among the gases distilled. The abundant large concretionary balls of lava and the worn, lumpy aa fragments make this flow different from the rusty arborescent aa of 1919. The 1926 stream-flow was more viscous and less hot.

By analogy with former eruptions, if the Kahuku source stops action, Halemaumau may have its bottom disturbed from below, and it will be watched with interest. On the other hand the slag-heap pahoehoe in Kahuku, working sluggishly, might develop flows. T.A.J.

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No. 71 RELEASED WITHOUT COPYRIGHT RESTRICTION May 6, 1926

KILAUEA REPORT NO. 747

WEEK ENDING, MAY 5, 1926

Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, Temporarily in Charge

Though there has been a decline in the number of earthquakes there has been a noticeable increase in the avalanching at Halemaumau. Many avalanches may be observed every day. Nearly all are small however. On May 3 avalanching was nearly continuous from 2:40 to 3:00 p. m. On May 5 with a high humidity there was but little steam escaping from the Halemaumau floor. The most conspicuous steam vent was near the sulphur stained area at the south side. From some places on the rim it appeared that some blue fume was mixed with the steam while at other places the apparent fume was not visible.

Eight very small earthquakes were recorded during the week. Tilting was moderate to the northeast.

THE EARTHQUAKES ACCOMPANYING THE MAUNA LOA ERUPTION OF 1926

From the time of the beginning of the preliminary outbreak of Mauna Loa during the early morning of April 10, to April 28 when shaking had practically ceased 647 earthquakes were recorded on the Observatory seismographs.

The daily distribution of the total number of earthquakes and of the number of shakes perceptible at Observatory are shown in the following table:

Day	Number of shakes	Number of perceptible shakes
April 10	75	4
11	35	1
12	81	5
13	83	8
14	60	9
15	86	13
16	61	17
17	53	7
18	26	10
19	20	4
20	23	2
21	17	1
22	12	4
23	6	0
24	4	0
25	2	0
26	1	0
27	1	0
28	1	0
29	0	0

Of the 85 shakes that were perceptible 24 dismantled the Observatory seismographs. The strongest shakes of the series were at 4:30 a. m. April 18 and 4:32 a. m. April 22. The latter dismantled the seismographs at Hilea, Hilo, and Kealakekua (See Letter No. 2, Jan. 8, 1925), and was strong enough to overturn some unstable objects though no real damage was done. A press dispatch from a Colorado seismograph station on April 10 stated that a distant earthquake was recorded whose origin was probably on Mauna Loa. The same disturbance was recorded as a distant earthquake on the several seismographs in Hawaii.

The 1926 outbreak more closely resembles that of 1916 in regard to the number of earthquakes and the time between the upper preliminary outbreak and the lower one from which the main flow issued than the 1919 one. In 1916 about 632 earthquakes accompanied the eruption or about the same number as in 1926, while in 1919 there were but 185 earthquakes. During an eruption in Mokuaweoweo in 1914 with no flow outside there were but 60 earthquakes. The time interval between the upper and lower outbreaks in 1916 was nearly three days, in 1919 about 2¼ days, and in 1926 nearly four days.

The two large earthquakes that occurred just prior to the first appearance of molten lava apparently occurred along the entire length of the southwestern rift as small tidal waves were reported from Hilo a short time afterwards and by the middle of the day of April 10 thin smoke was already issuing from a crack along the rift at an elevation of about 8,000 feet or at a distance of about 10 miles from the center of the upper outbreak.

The distance to origin as computed from the four seismograph stations located the majority of the earthquakes as occurring near Mokuaweoweo and along the upper end of the southwestern rift. There was no striking change of distance to correspond to a progressive cracking down the mountain side which has been noted at times of other outbreaks both on Mauna Loa and Kilauea.

It is interesting to note that discrepancies in the indicated distance to origin of many of the earthquakes as determined from different seismograph stations could be explained by assuming that the great faults of Mauna Loa are inclined toward the east or have an easterly dip.

R.H.F.

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No. 72 RELEASED WITHOUT COPYRIGHT RESTRICTION May 13, 1926

KILAUEA REPORT NO. 748
WEEK ENDING MAY 12, 1926

Issued by the Observatory, U S. Geological Survey:
T. A. Jaggar, Official in charge

The change from a very quiet pit at Halemaumau through April, with the exception ot the tenth, the day of the summit outbreak of Mauna Loa, to numerous wall slides beginning May 1, is the only happening of the past fortnight to suggest any sympathy between Kilauea and Mauna Loa. Kilauea motion began when Mauna Loa stopped. During the past week rock falls and avalanches have continued, and steam on the pit bottom has been thin. The northwest rim is shattered so that slides are easily started. On the tenth slides were timed, occurring at 4:30 p. m., 4:41, 4:47, 4:50, and 5:00. They were mostly from the NE and NW walls. After heavy rain this morning there is nearly continuous slipping of rocks there. Steam has ceased to be conspicuous at base of northwest talus; it is sulphurous in the center and at the south.

Thirteen very small local seisms were recorded. A small record of distant earthquake occurred 4:39 a. m. May 12. Ground tilt for the week was moderate SW.

END OF MAUNA LOA ERUPTION

At noon of April 28 T. C. White and Charles Ka of Kona reached the source cones of the Honomalino flows from the northwest by way of Kaohe and Kaapuna in South Kona. They went around the north side of the larger Alika source-cone of 1919, where they could see the whole belt of 1926 heapings along the 1926 crack a half-mile east of them. A mile up the rift were fresh openings fuming with strong sulphur gas, bordered with warm pahoehoe lava in short flows, and coated with bright yellow sulphur needles. Far up the mountain along the crack two steaming places were visible. Opposite and below the Alika vents was a string of new spatter cones for a mile and more. The upper sulphur place was at elevation 7750 feet by aneroid; a high cone in the lower series of 1926 openings gave 7280 feet. From here a small active cone was seen next south along the rift, feeding with lava a small lake a few hundred feet across. The feeding stream was about ten feet wide flowing about five miles an hour. The lake lay in the rift to the south of the feeding cone, and intermittently a big fountain of lava spouted in the southern end of the lake, the action resembling Kilauea lakes. There was no outflow towards Kona seen, and the exceedingly brilliant display which we had seen on the 23rd had greatly dwindled. White's lake appears to have been identical with the big fountain vent, at the source of our lava river. He made the direction of the 1926 rift N. 30 E. changing to approach N.-S. at its southerly end.

In the morning April 30 Honomalino ranch reported dense smoke over the source region. A Kona party of visitors to the upland the next day saw nothing glowing. On May 3 the writer rode up from Kona to the Umi Caverns next the Alika source, and camped there three nights, going by the Kaapuna trail through the On Tai Ranch, and exploring somewhat thoroughly the upper 1926 rift from the new sulphur deposits to the fountain location. All flowing lava activity had stopped, and very hot gas rose from some of the vents, which was spicy sulphur at the upper cracks and sulphur dioxide, making blue smoke, at the lower ones. It was now possible to walk right down the line of new cones, of which there were thirty below the 8000-foot level. Sixteen of these are below the big-fountain location, ending at the slag-heaps west of the 1916 cones, two miles above Puu o Keokeo. There are eight in the zone of maximum output opposite the Alika source. Above this there is a gap of a half-mile with only cracks and sulphur stain. There next occurs a group of small cones and puddled lavas, pahoehoe, and up the mountain farther the new crack occupies a valley amid old hills. The fissure has here vomited pahoehoe cascades, and the openings are coated with beautiful crystals of prismatic sulphur for several hundred feet; this marks the rift brilliantly as seen from a distance, and pale blue fume arises. This whole belt of thirty vents is about four miles long, and lies between elevations 7050 and 8000 feet. The position of the cracked zone is very near that of the 1916 rift, as though extending the latter up the mountain. The 1926 lavas in fact override those of 1916.

The belt of maximum outflow 1926, aboout elevation 7400 feet, has left a half mile of big spatter heaps of frothy pumice forty to fifty feet high in a line trending S25°W, with four or five channels on each side of the ridge leading off at right angles to unite in river beds. These made the Kahuku and Honomalino flows. On the west side the flows bent southward parallel to the spatter ridge and then united to a westerly course. On the east side they pitched down the slope in several separate rivers, and perhaps it was this separation that kept them from making any single big flow. There are large fields of new pahoehoe on both sides; the aa develops after the lava has flowed a quarter mile or more. The fountain lake is now a tumbled smoky channel full of big slabs and semi-aa rubble. This channel meanders in big sweeping curves away towards Kona. An ancient cone is split asunder where the new spatter heaps go through. and the heather bushes show charred stumps. Everything indicates that the rift opened from above downward, and the airplane photographs show that the rift developed southward between the 17th and 19th April. This developed the second Honomalino flow to the south of the Hoopuloa flow.

Looking up Mauna Loa one could see gleaming fields of new lava and two steaming areas along the rift high up. The last puffing effervescence of fume at the lower rift was seen at 9 a. m. May 4. T.A.J.

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No. 73 RELEASED WITHOUT COPYRIGHT RESTRICTION May 20, 1926

KILAUEA REPORT NO. 749

WEEK ENDING MAY 19, 1926

Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, temporarily in charge.

The frequent avalanching noted in last week's report has ceased. Steam from a vent near south wall and from southwest talus continues abundant. Despite the dry weather several points on the different walls appear quite damp.

Eleven earthquakes were recorded during the week. One at 1:34 a. m., May 14, was plainly felt at Waiohinu and at other points in Kau. Tilting for the week was moderate to the SW.

VOLCANOES AND AIR TEMPERATURES

In the immediate vicinity of volcanoes, fumaroles, and hot springs it is quite common to find air temperatures higher than in places more remote from the vents. Volcanoes exert a warming effect.

The amount of heat given off by Halemaumau when there is a large lake of molten lava present is rather startling. In January and Febraury, 1924, there were times when the heat escape from Halemaumau was equal to the heat produced by the complete combustion of one and a half tons of coal per second. Most of the heat quickly escapes to space but when smoke and steam clouds are present the warming effect may be noticeable for considerable distances from the vent on the windward as well as on the leeward side.

The escape of smoke, steam or water vapor and air even at moderate temperatures from fumaroles, hot springs and hot cracks tends to increase the temperature over small areas. The heating ffect of steam and warm air escaping from the many cracks in the vicinity of the Observatory is the main reason why with a heavy frost only 1500 feet away where there are no steam cracks the lowest temperature at the Observatory may be only 43° Fahr. It is possible to sleep without blankets along steam cracks at an elevation of 13,000 feet on Mauna Loa while only a few feet away freezing temperatures would be encountered.

All lava flows, of course, tend to raise the temperature in their immediate vicinity as long as they remain hot. A lava flow through a forest even after it has cooled off tends to slightly increase the average temperature by reducing evaporation. The rain quickly percolates through the lava and drains away underground and with no vegetation there is but little evaporation.

There is another and much more profound effect of volcanoes on temperatures that is just the opposite from the above--a cooling effect. The lowering of the temperature is often very widespread and in many cases the entire world is affected. The cooling effect of volcanoes is produced by violent explosions hurling great quantities of fine dust into the upper atmosphere where it may persist for several years and shut out incoming solar radiation.

One of the earliest recorded volcanic eruptions believed to have had some effects on world temperatures was that of Vesuvius in A. D. 79. Another eruption of Vesuvius in 1631 that sent up a dust cloud to a height of 30 miles was followed by cool weather in 1632 and 1633. The average of world temperatures makes the year 1785 one of the coldest on record. This cold year as well 1784 and 1786 is attributed to a violent explosion of Asama in Japan in 1783 aided by activity of Skaptar Jokull in Iceland durin gthe same year and of Vesuvius in 1785. Following the great explosion of Tomboro near Java in 1815 the whole world was remarkably cool in 1816. 1816 was frequently called "The year without a summer."

Explosions in more recent years have also produced cooling effects. The Krakatoa explosions in 1883 which sent up a dust cloud to a height of 17 miles was followed by world wide lowering of temperatures in 1884 and 1885. This dust cloud produced visible sky effects for three years. Katmai's explosions in 1912 produced a cooling effect especially noticeable in the northern hemisphere. An extensive volcanic eruption in the Chilean-Argentine Andes in December 1921 not only affected the southern hemisphere but produced noticeable results in the northern hemisphere.

Volcanic explosions may be of tremendous economic importance not only because of resulting rigorous winters in the temperate zones as in 1783-84-85, but also by the lowered temperatures greatly diminishing crop yields as in 1816.

Observed cooling effects have been such as to lower the average world temperature three degrees Fahr or more. If violent explosions from several different volcanoes should nearly coincide in time the effect might be very profound. Volcanic dust has been advanced as one of the causes of the ice ages. It is interesting to note that a lowering of the average temperature over Mauna Kea by but a few degrees would be sufficient to produce glacier conditions on that mountain. Many places now well populated might become glaciated by a lowering of the mean annual temperature only a few degrees for several years.

R.H.F.

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No. 74 RELEASED WITHOUT COPYRIGHT RESTRICTION May 27, 1926

KILAUEA REPORT NO. 750

WEEK ENDING MAY 25, 1926

Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, temporarily in charge.

Halemaumau continues quiet. Small rock falls are heard occasionally. On May 22 the steam vent at the south edge of the pit floor which usually omits more steam than any of the other vents was scarcely noticeable while the vents in the southwest talus and in the north floor were steaming as usual. This indicates that there is a variation in the amount of steam that escapes from the different vents. There is, of course, a large apparent variation due to variations in atmospheric conditions.

Considerable interest was taken in large white clouds that hung over Mauna Loa during the afternoon of May 24. This type of cloud may be seen quite frequently. It is primarily due to the heating of the mountain slopes during a clear non-windy day. Occasionally such clouds may be seen over Mauna Kea. The many steam vents on Mauna Loa naturally aid in the formation of such clouds.

Seven local earthquakes all too small to be perceptible at Volcano House were recorded on Observatory seismographs. This is the smallest weekly total since February.

There was a strong north-northeast tilt during the week.

BULK DISPLACEMENT DUE TO TILTING

In Volcano Letters No. 41, October 8, 1925 and No. 61, February 25, 1926, short discussions of tilting and the resulting changes of level at Kilauea volcano may be found. The exact amount of subsidence is not yet definitely known nor are the limits in distance from Halemaumau to which the subsidence may be detected by precise levelling. Determined values, however, indicate that detectable sinkings may be found 20 miles or more from Halemaumau. Preliminary values which will probably have to be increased when more determinations are made indicate that the subsidence of Kilauea during 1921-1924 inclusive ranged from 13-14 feet at Halemaumau to a tenth of a foot or more 20 miles to the northeast.

Tiltings to produce elevation changes of the above amounts and to such distance from a volcano center are not unknown. The subsidence accompanying the Sakurajima eruption in 1914 amounted to nearly nine feet at the mountain and was still large enough to be measurable over 30 miles away. At Kilauea there was a swelling up of the mountain from 1913 to the beginning of 1921 whose value probably nearly equaled that of the subsidence from 1921 to 1924. Mauna Loa appears to give surface manifestations of changes of internal pressure by tiltings of its great dome but there are no quantitative data at hand for this mountain. Shoreline elevations and subsidences have been noted at many places on the earth's surface. Elevation changes take place in regions without active volcanoes as well as in active volcano regions.

In a region like Kilauea volcano computation of the volume involved in changes of elevation is difficult unless a very elaborate net of levels are run. The value of the elevation change may jump suddenly when a zone of cracks in the earth's surface is crossed while on either side the values may change systematically. Two wide crack zones lead away from Halemaumau, one leading to the southwest and the other to the northeast.

By using the preliminary data determined for a northeasterly direction and assuming a symmetrical subsidence about Halemaumau as a center it may be shown that the volume of land withdrawn by subsidence during 1921-1924 amounted to 20,000,000,000 cu. ft. This is nearly three times the amount engulfed during the collapse of Halemaumau in 1924. If there was no compensation by elevation at other places on the Island of Hawaii it would mean that the volume of the island above sea level was decreased by the above number of cubic feet. The estimated volume displacement at Sakurajima in 1914 is about one-fourth of the above. Owing to the average porosity of the rock involved it is probable that the weight of the 20,000,000,000 cu- ft. was not much over one and one-quarter billion tons.

At times of solar eclipses the moon frequently shows an apparent error of as much as four seconds of time in her computed schedule. Dr. E. W. Brown of Yale University in discussing causes for the apparent erratic behaviour of the moon suggests that the earth my be at fault. He computed that shrinking and tumescing of the earth to the extent of a few feet in a comparative short period of years would be sufficient cause to account for the apparent failure of the moon to travel by schedule. In the foregoing discussion tumescing and subsiding have been shown to take place over small areas and it would seem to be easily possible for some such movement to take place over large areas. R.H.F.

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No. 75 **RELEASED WITHOUT COPYRIGHT RESTRICTION** June 3, 1926

KILAUEA REPORT NO. 751

WEEK ENDING JUNE 2, 1926

Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, temporarily in charge.

In all its recorded history Halemaumau was never more quiet than it is at present. There has been a noticeable decrease in the steaming from the vent on the south floor of Halemaumau and a slight increase at the north. Avalanching still takes places though not very frequently. Aside from anything due to the recent activity of Mauna Loa that mountain for months has been emitting more actual smoke than has Kilauea.

Six earthquakes were recorded during the week. One at 7:10 p. m. May 31 was perceptible and had an indicated distance to origin of 22 miles. Tilting was slight to the southwest.

ANCIENT VOLCANOES

In the earliest known geological ages volcanism or other forms of igneous action was very general. From these early times on there appears to have been fluctuations in volcanic activity. There were periods of great volcanic activity all over the world followed by periods of quiet. During the relative quiet periods, however, it is probable that many volcanoes showed activity. It is probable that there will be periodic fluctuations in activity in the future.

There are but few places in the world where one would have to travel far to see effects of ancient volcanism. Were there no active volcanoes in the world today one could get good impressions of how lava flows behaved and of the formation of volcanic cones by studying ancient volcanic regions.

Not conspicuous to everyone but obvious to all when the formations are pointed out is the fact that at one time there was a volcano near the site of New York city. In Auvergne—south-central France—there are many cones produced by volcanic activity thousands of years ago. These cones, as a rule, are in well defined zones showing that they were located over active fissure belts. They are among the best preserved forms of ancient volcanic activity to be found anywhere. A photograph showing several of these cones, excepting for the vegetation, looks very much like a photograph on some of the higher parts along one of the great rifts of Mauna Loa.

In Great Britain there are many remains of ancient volcanism. The subject is so extensive that Sir Archibald Geikie in writing on the subject, "Ancient Volcanoes of Great Britain," found it necessary to fill two large volumes in order to make the discussion at all comprehensive.

Pisolitic ash similar to that produced at Kilauea in 1790 and to some extent in 1924 may be found in certain strata in western Germany. This shows that explosive volcanic eruptions took place in Germany. This type of ash is produced by rain drops falling through dust laden atmosphere collecting so much dust that they fall as mud pellets. Owing to natural cementing qualities of the ash they more or less retain their round shape. There is some justification in calling pisolites, "fossil rain drops."

Probably the largest lava flow of old geologic times that may be traced quite clearly took place in India. It is known as the Deccan Trap and is still exposed over an area of 200,000 square miles. The original area was probably much greater. Its thickness varies from 4,000 to 6,000 feet.

More recent than the Deccan flows were the ones in Oregon, Washington, and Idaho which extended over an area of about 200,000 square miles. The accumulation in thickness of these flows vary from a few feet to over 2,000 feet.

Still earlier than the Deccan flows there was a flooding over a vast area in the Lake Superior region. This flow took place so long ago that its evidence is not striking. It is remarkable in having produced fills as much as 15,000 feet in thickness.

In prehistoric times but very recent there was activity in the southern part of Califorina and Arizona. Beautiful volcanic cones nearly as fresh as though they were formed but yesterday may be seen. In northern California, western Oregon and Washington it appears that there was a gradual decline of volcanic activity to present day conditions.

In the San Jose valley in New Mexico there is a very fresh looking pahoehoe lava flow. There is an Indian legend handed down for several generations of a river of fire in this valley. This legend would make the flow one of comparatively recent times. The freshness of the lava adds to the plausibility of the legend.

In recent times the most active producers of lava have been the volcanoes of Iceland. In 1783 from one volcano system, Laki, lava poured forth to the extent of 420 cubic miles.

R.H.F.

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Sent free to libraries and to members. Dues of Association $5 per annum. Members receive in addition the Illustrated Monthly Bulletin of the Hawaiian Volcano Observatory. Anyone may join the Association and thereby support Pacific volcano research. The society has also patrons—individuals, firms and institutions.

No. 76 **RELEASED WITHOUT COPYRIGHT RESTRICTION** June 10, 1926

KILAUEA REPORT NO. 752

WEEK ENDING JUNE 9, 1926

Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, temporarily in charge.

During the week 11 local earthquakes were recorded on the Observatory seismographs. On June 4 at 1:53 a. m. one of the shakes was slightly felt in Hilo. Another shake at 9:35 a. m. June 9 was rather widely felt over the island of Hawaii. It was strong enough to shake objects off shelves at Kapapala and dismantled the seismographs at Volcano Observatory. The indicated distance to origin from Volcano House was 16 miles southwest. A slight record of a distant shake was written at 9:35 a. m. June 5. Tilting for the week was moderate to the south-southwest.

Halemaumau continues quiet with but few avalanches. Following the recent rains the walls are quite red.

Snow was observed on Mauna Kea during the afternoon of the 7th but none was visible on Mauna Loa.

MUD VOLCANOES

A rather comprehensive definition of volcanoes has been given about as follows: It is an orifice in the crust of the earth commonly terminating in depression or crater whose sides mark the summit of a mountain or hill. From the crater are ejected—sometimes continuously, sometimes with long intervals of quiscence—hot water, steam, gases, dust, gravel, broken stone. or molten lava. The ejection of the different kinds of materials depends upon the condition of the volcano and its age. According to the above definition lava flows, explosions, steam and gas vents, geysers, mud volcanoes, and some hot springs are but surface manifestations of more deep seated volcanic processes.

The Italians have given names to several types of decadent volcanic activity. The name solfatara is applied to vents emitting chiefly steam and sulphurous vapors. Examples are found in many active volcano regions. Soffioni is a term used to designate volcanic vents which emit steam, hydrogen sulphide and carbon dioxide. These may occur in regions of recent volcanic activity but away from present day active regions. Mofetta is a name given to volcanic discharge consisting chiefly of carbon dioxide. Examples of the latter are rather widespread, and some are quite well known such as Death Gulch in Yellowstone Park and Valley of Death in Java. In the Valley of Death not only may the bones of birds and beasts be found but also the bones of men.

The conditions necessary for the formation of a mud volcano depends largely upon the nature of the ground through which hot water and steam escapes. If the ground is of unconsolidated material like clay or tufa mud volcanoes may result and build up cones varying in height from a few feet to 500 feet or more.

Frequently, as at the Vesuvian eruption of A. D. 79, large explosive eruptions are accompanied by mud flows. Such mud streams result from heavy rains occurring at the time of the explosion mixing with the ejected dust in the air or on the ground or in both places and are not the product of true mud volcanoes.

Mud volcanoes often discharge streams of mud frequently exhibit fountaining when the vents are surrounded by a mud lake. In the northern part of Lower California near the California border rather spectacular fountaining may frequently be seen. Cheduba and other small islands in the northeastern part of the Bay of Bengal near the Burma coast contain a chain of mud volcanoes. In this chain in 1906 a new island of mud was thrown up that had an area above the water line of 600,000 sq. ft. A mud volcano, Gorela, near Kertch in Crimea with a cone 264 feet high has sent forth several streams of mud. The volume of one of these flows was estimated to have a volume of over 22,000,000 cu. ft.

Mud volcanoes are commonly located in extinct volcano regions (extinct, meaning not producing molten lava nor ash) or over rather queit fissures in active regions. The "paint pots" in Yellowstone National Park are mud volcanoes in a region where volcanism has been extinct for thousands of years. Mud volcanoes are found on Mount Etna an active volcano region. Tikitere, a valley in New Zealand, containing many mud volcanoes is near active volcanoes.

That mud volcanoes may afford an interesting sight may be gleamed from the following description of mud volcanoes of the north of Iceland: "From the plain of mud vast clouds of steam rise into the air, while a low drumming sound proceeds from many sources. Vents are numerous but there are especially 12 large one in which the slime is boiling. In some the mud is as thick as molasses while in others it is smiply ink-black water. The thundering and throbbing of these boilers, the thud of hot waves striking banks, the scream of escaping steam at the edge of a blue-slime pond produce a horrible effect. In some places the mud is boiling furiously in others bells of black ooze rise and explode into scalding sprinklings. The whole is a frenzied roaring pool of slush. R.H.F.

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No. 77 **RELEASED WITHOUT COPYRIGHT RESTRICTION** June 17, 1926

KILAUEA REPORT NO. 753

WEEK ENDING JUNE 16, 1926

Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, temporarily in charge.

At daylight the morning of May 11 and for over an hour thereafter Halemaumau was a spectacular sight. The pit was full of steam and from the rim a continuous, rather dense, steam cloud extended upward to a height of about 1500 feet. With no other cloud around and the entire column well illuminated by the sun it looked as though Halemaumau were in eruption.

The vent at the south edge of the pit floor is again emitting much more steam than any other vent inside the pit. Avalanching is rather in frequent though small rock falls at least can nearly always be heard.

During the week 10 earthquakes were recorded. All were too small to be perceptible at Observatory.

The net result of tilting was slight to the northwest. This is the usual direction of tilting for this time of the year. Tilting so far this year has been greater than during 1925. The direction of tilting during the first half of the year is normally to the south. During 1925 the accumulation of southerly tilting amounted to 7.5 seconds of arc and in 1926 it amounted to 12.6 seconds. The westerly tilt now going on will probably continue for two more months but already the 1926 westerly tilt exceeds the total of 1925 by over one second.

BORINGS IN KILAUEA CRATER

Some progress is being made in the boring on the floor of Kilauea crater. (See Volcano Letter No. 66, April 1, 1926.) One hole was drilled through rock that at the surface showed only ordinary temperatures though only 75 or so feet away there were steam cracks. After reaching a depth of about a foot a temperature of 194° Fahr was encountered. This temperature was constant for about four feet and is a few degrees higher than the natural steam vents in the neighborhood. Upon going deeper a lower temperature was encountered. At a depth of 10 feet the temperature was 172° Fahr or 20° less than at one foot below the surface. When the temperature of the hole was again measured a few days later it was found that the bottom of the hole had become slightly hotter. The amount of steam escaping from the hole when it is uncapped is very slight and the velocity of escape is low.

R.H.F.

ACTIVITY ON ISLAND OF REUNION

A. Lacroix recently reported to the Paris Academy of Sciences that a lava flow from the volcano Piton de la Fournaise, Reunion, started on December 30, 1925. The volcano is apparently in a period of active output as there was another flow in September 1924. This volcano resembles Kilauea in being classified as continuously active. It has been mentioned in Volcano Letters No. 4 January 22, 1925 and No. 24 June 11, 1925. The active cone rises to a height of 8600 feet above sea level. Glow can be seen over the mountain nearly every night. Frequently the flows that pour down the side of the mountain are of pahoehoe nature and develop lava tubes in which lava stalactites may be found.

R.H.F.

JAPAN'S LATEST VOLCANIC ERUPTION

Tokachi-dake and its companion peak Mount Iwo became active suddenly on May 24 after having been quiet for a long period. Mount Tokachi is the next to the highest peak on the island of Yezo. It rises to a height of 6541 feet above sea level.

The outbreak was heralded by preliminary rumblings so that many people in especially dangerous areas escaped. It was fortunate for those who were forced to flee and for rescue work that the outbreak occurred in the day time. A railroad train that was entering the dangerous district was turned back just in time to escape its being overwhelmed. Both lava flows and explosions accompanied the eruption. The roar from the explosions were reported audible 20 miles away. One river was damned by a lava flow and another by explosion debris. The water impounded in these damns later on broke loose and caused floods in the valleys below. The worst flood was caused by the rupture of a mountain lake which let loose a flood that rushed forward as a wall of water 30 feet high. The outbreak quickly diminished in vigor though ashes and smoke were intermittently emitted for some time after.

It is thought that about 400 lives were lost; lava flows, floods, and explosions each taking a share. Newspaper reports, from which most of the above facts were taken, state that 144 bodies were recovered within two days.

R.H.F.

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No. 78 **RELEASED WITHOUT COPYRIGHT RESTRICTION** June 24, 1926

KILAUEA REPORT NO. 754

WEEK ENDING JUNE 23, 1926

Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, temporarily in charge.

Halemaumau continues to be very quiet. Large avalanches have been rather infrequent though rock falls continue. Judging from the numerous cracks and shattered rock at many places on the rim, Halemaumau walls are still quite unstable. With the increased day temperatures during the past week the amount of visible steam escaping from the vents in the pit has lessened. A sulphur stained patch on the south-southwest wall is becoming more conspicuous.

20 earthquakes were recorded during the week. This is the largest weekly total since the eruption of Mauna Loa ceased. Only two of the shakes were perceptible at Observatory. One of these, at 4:56 p. m., June 19 with an idicated distance to origin of two miles, was preceded by a rumble. The other, at 12:46 p. m., June 22, had an indicated distance to origin of 15 miles.

Daily tilt values were small, the net result for the week being slight to the north-northeast.

VOLCANIC FLAMES

Where the recent lava flow from Mauna Loa crossed the road at Honomalino, banners of flames issued from numerous vents on each side of the flow. The flame jets varied in height from a few inches to over six feet. They were pale blue in color and at night brilliantly illuminated the approach to the flow. Through a pocket spectroscope the flames showed only the lines that are characteristic of sodium. Some of the vents from which the flames issued were 50 feet or more from the edge of the flow. The distance of the flames from the flow and the fact that they continued for hours led some people to conclude that they were of true volcanic origin arising from gases issuing from the lava. Speculations of the lava burrowing its way underground were even heard. The flow here went through a forest and, of course, the flames were of burning gases produced by distillation of vegetal matter underground. The ground is very porous and the amount of vegetal matter in it is very large. The flow crossed the road at a fill where the amount of underground vegetal matter was much more than normal. When the flames began they often issued as explosive puffs, but after a large part of the air in the underground cavities was expelled an explosive mixture was no longer formed and they issued as nearly continuous banners.

Farther up the mountain where the flames did not continue so long there were often true explosions. Occasionally small trees were blown bodily into the air and larger ones uprooted. The explosions were frequently large enough to be heard 3-4 miles away. Flames were seen to follow many of the explosions. Alongside the flow in higher and drier country near the timber line, fires ran underground as much as 300 feet from the edge of the flow and small explosions were noted at that distance.

In a flow from Kilauea in 1919 over pahoehoe lava with scanty vegetal covering, gases accumulated in small caverns and when exploded would blow the roofs of the caverns to pieces.

Along all lava flows in a region where there is any vegetation there is a distinct odor of burning hydrocarbons produced by destructive distillation of vegetal matter in addtion to the usual odor of burning wood. The odor of burning hydrocarbons near the source of the 1916 lava flow from Mauna Loa led to the conclusion that hydrocarbons in considerable quantities were a natural exhalation of Mauna Loa. Such a conclusion is probably not true as there is considerable vegetation along the southwest rift of Mauna Loa as high as 8,500 feet, or several miles above the 1916 source. The source of the main flows from Mauna Loa in 1919 and 1926 were in the same region as that of 1916 and the peculiar hydrocarbon odor was noticed in these years also. At the upper outbreak in 1926 in the neighborhood of 13,000 feet where there is no vegetation, the odor was lacking.

Flames of strictly volcanic nature have been observed on numerous occasions and at many different volcanoes. At Kilauea the flames are usually of a bluish tint, though occasionally they are of a yellowish color and often play over a vent for hours at a time. Intermittent jets of flame frequently issue from cracks in the crust on a molten lava lake. Great banners of flame a hundred feet or more in height, indistinctly seen on account of fume, have been noted accompanying Mauna Loa fountains.

Gases collected over true volcanic flames are chiefly water vapor, together with sulphur dioxide, carbon dioxide and lesser quantities of other constituents. This indicates that hydrogen may be the chief source of volcanic flames.

R.H.F.

Correction: The date "May 11" in Kilauea Report of Volcano Letter No. 77, should be "June 11."

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No. 79 RELEASED WITHOUT COPYRIGHT RESTRICTION July 1, 1926

KILAUEA REPORT NO. 755

WEEK ENDING JUNE 30, 1926
Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, temporarily in charge.

Halemaumau shows no signs of activity. The most conspicuous steaming vent in the pit is at the northwest. Faint sulphurous odors may be distinguished on the rim.

The number of earthquakes recorded during the week was 16. Four of the earthquakes were slightly perceptible at Observatory. Two that occurred at 9:20 p. m., June 23 and at 11:18 a. m., June 27 respectively, caused pheasants to squawk and had indicated distances to origin of one mile. The strongest shake of the week occurred at 3:27 a. m. June 30 and had an indicated distance of 14 miles.

A distant earthquake was recorded at 4:08 a. m. June 29 with an indicated distance of 4750 miles. A shake was reported from near Singapore about this time.

Tilting for the week was moderate to the East-northeast.

SUBMARINE VOLCANOES

It is not uncommon for sea captains to report passing through seas of pumice or turbulent waters, the result of submarine volcanoes. When one considers the number of land volcanoes and the fact that three fourths of the earth's surface is covered with water it is easy to imagine a rather large number of volcanic vents on the ocean floor.

Before a great many of the present day active volcanoes developed in height so that their throats remained permanently above water they would have been classified as submarine volcanoes. Many known extinct volcanoes passed through the submarine stage. Both Vesuvius and Etna as well as Stromboli started from the floor of the Mediterranean.

Numerous islands in the Pacific ocean are of volcanic origin. Others that are classified as coral islands may be rally volcanic with a coral cap. Islands might be covered with a coral growth either if their summits never quite reached to sea level before the volcano became extinct or if they were once higher and were eroded to below sea level. The great depth of the ocean around many of the coral atolls in the Pacific ocean points to a volcanic foundation.

The elevation of entire islands or parts of them may have been greatly reduced by subsidence. Penguin Bank west of Molokai in the Hawaiian group may have been much higher once and its elevation reduced more by subsidence as a whole than by erosion. The outline of the Bank is marked by submerged cliffs where the depth of the water abruptly changes from an average of 240 feet to an average of 1320 feet. Magnetic observations as well as topography indicates that the base of the coral atoll of Funafuti in the Ellice group is of volcanic origin. A boring in this island to a depth of 1114 feet, however, failed to reach the igneous base. The island may have been sinking coincidental with the coral growth.

The Hawaiian Island group have been elevated from a depth of 15,000 to 18,000 feet below sea level, unless we assume the rather untenable theory that the group is but a remnant of a large land mass now submerged. The volume of land of the Hawaiian Islands above water is but a small percentage of the great volume below sea level. This volume relation is true of the majority of volcanic islands because there is a great ocean deep adjacent to nearly all volcanic regions.

Occasionally at the present time new islands are born. Some live for but a short time while others make permanent additions to the land mass above sea level. An effect of the short-lived volcanic island may be the production of a shoal where once there was deep water. Graham Island was born in the Mediterranean about 30 miles southwest of Sicily in July 1831. The birth was heralded by a column of water 800 feet in diameter and 60 feet high quite suddenly appearing at a place where the Mediterranean was 600 feet deep. The water column was shortly followed by steam clouds and presently an island of pumiceous material appeared. It quickly reached a height of 200 feet with a circumstance of three miles. Within six months the island had quite disappeared though the top of its submerged remnant is but 9 or 10 feet below sea level. In 1891 there was a submarine eruption in this same general region but no island appeared. Near Bogosloff volcano in the Bering Sea an island, New Bogosloff, appeared in 1883. It appears to be a permanent addition to the land in Bering Sea. Near the Azores a short-lived volcanic island was formed in 1811. A submerged volcano near Saint Miguel in the Azores appears to be active occasionally. Several temporary islands have been reported in the Pacific. Some that persisted for a few years and were several times observed were placed on maps but later on utterly disappeared. R.H.F.

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No. 80 RELEASED WITHOUT COPYRIGHT RESTRICTION July 8, 1926

KILAUEA REPORT NO. 756

WEEK ENDING JULY 7, 1926

Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, temporarily in charge.

During the past week there has been a revival of avalanching from the walls of Halemaumau. Frequently the avalanches are large enough to send dust clouds well above the pit rim. Most of the slides have been from the north wall, usually from near the top of the wall. The echoes of the roar produced by the largest avalanches produce wierd noises.

During the recent dry spell the deposit of white salts, sulphates, have been quite conspicuous around Halemaumau pit especially on the southwest side.

The strong wind that blew on July 5 stirred up great dust clouds in the desert to the southwest of the volcano. Whirlwinds in the dust clouds greatly increased the dark appearance of the cloud. Small clouds were stirred up in the middle and southwest parts of Kilauea crater. The north end of the crater where the total dust fall of the explosions in 1924 amounted to only an inch or two is now quite free from dust. Owing to the trade winds there has been a quite constant progressive movement of the dust toward the southwest. Though it has been over two years since the explosions the appearance of the desert on July 5 closely resembled its appearance following many of the explosions.

The 12 earthquakes recorded during the week were all too small to be perceptible at Observatory. About half of them appeared to be of Mauna Loa origin.

Tilting for the week was moderate to the north-northeast. The greatest amount of the tilt occurred on the 5th and 6th of July.

THE RATE OF DISSEMINATION OF VOLCANIC DUST

The eruption of Krakatoa in 1883 not only caused widespread dust clouds in the lower atmosphere but also sent great quantities of dust into the upper atmosphere well above the level of the highest clouds. Dust was collected over 1100 miles from the vent and the dust that reached the upper atmosphere spread all over the world. Such a dust cloud in the upper atmosphere throws light on the air currents in that region. Other great explosions have occurred but few have been so widely observed. From known air currents over equatorial regions it is to be expected that the dust would spread around the world over the equator quicker than over places nearer the poles.

Professor Stentzel of Hamburg has collected data on the rate of travel of these high dust clouds and estimates the average speed of propagation to be from 85 to 125 miles per day. The actual velocity is, of course, much greater as the dust does not travel out in straight lines to all places from the explosive vent but pursues greatly curved paths before it appears over most stations.

A newspaper account reviewing Professor Stentzel's work states that the dust from the Mauna Loa outbreak on April 14, 1926 may be expected over Europe some time in July. As no dust cloud was produced by Mauna Loa this year such an expectation will not be fulfilled. R.H.F.

THE IMMANUEL FRIEDLANDER VOLCANO INSTITUTION

A discussion of The Volcanological Review and notes on some of the articles published in it were given in Volcano Letter No. 15, April 9, 1925. This review is the official organ of the Volcano Institution of Immanuel Friedlander. The institution is organized under Swiss laws and is now located at Zurich. Its work is encouraged in Italy, Swizerland, Germany, and elsewhere. The chief concern of the institution is the observatory building at Naples. Active in addition to Dr. Friedlander, the director of the institution, there is an assistant editor for the Volcanological Review, a chemist, a petrographer, a seismologist, and others. The institution is very much like the Hawaiian Volcano Research Association in its scope and supports scientific publications, trips for making scientific investigations, compilation of material, and loans instruments. R.H.F.

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No. 81 RELEASED WITHOUT COPYRIGHT RESTRICTION July 15, 1926

KILAUEA REPORT NO. 757

WEEK ENDING JULY 14, 1926

Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, temporarily in charge.

The avalanching from the walls of Halemaumau reported last week has continued during this week. Most of the avalanching is still from the north wall. On several days the avalanches, both large and small, were so frequent that when the pit was not filled with dust it was quite hazy. The scars on the walls from which avalanches broke loose are much brighter than the rest of the walls and often show considerable deposits of salts. The sulphur stained patches in southern part of the pit have been greatly dimmed by dust from avalanches. The amount of steam escaping from the pit floor does not seem to vary greatly. The steam vents may be roughly grouped into three lines that cross the bottom of Halemaumau from north to south.

Despite the large number of avalanches the number of earthquakes has not greatly increased. Of the 18 shakes recorded during the week four appeared to be of the type that accompany avalanches. The only earthquakes large enough to be at all perceptible during the week occurred at 8:15 a. m. July 12. It, apparently, caused a rather large avalanche as a dust cloud that rose well above pit rim was observed shortly after the earthquake.

Tilting for the week was slight to the south-southeast.

In answer to the question, "Is Kilauea dead?" it can be said that not only is there no evidence pointing to the fact that Kilauea is a dead volcano but also there is evidence that it is still active internally. When lava is present in the pit there is often a variation in the internal pressure of the volcano system that causes the top of the visible lava column to vary in height from 600 feet below the rim up to the rim level. An internal and unseen variation in the height of the lava column may also be possible. Records at the observatory show that the internal pressure of the Kilauea-Mauna Loa volcano system has been increasing since June 18, 1926. The increase of pressure is manifested by a swelling of Kilauea mountain that is recorded as a northeast tilt at the Observatory. There is a normal westerly tilt closely following the seasonal temperature curve from the last of winter until August. When the seasonal temperature starts to decrease in August the direction of tilting normally changes from west to east. This year not only has the westerly tilting been arrested nearly two months prior to the normal time but there has been an accumulation of easterly tilt since June 18. The 1926 tilt curve is closely parallel to the 1924 tilt curve that preceded the return of lava to Halemaumau in July of that year.

THE RETENTION OF HEAT IN LAVA FLOWS

Two and a half months after the 1926 lava flow from Mauna Loa crossed the road at Honomalino it is still quite hot. At some places even the rocks that are well exposed, as at the edges of the flow, are so hot that they hiss when water is thrown on them. Where the flow entered the sea the water is still warm. In some of the small protected arms of the sea the water is so hot that it is unbearable to the touch.

Some cracks in the Mauna Iki lava flow that poured onto the Kau desert from Kilauea in 1920 are still hot enough to ignite a stick of wood. It seems probable that a part of the heat found in lava flows long after the time of issue may be due to chemical action. R.H.F.

THE KEAIWA FLOW OF 1823, HAWAII

In Volcano Letter No. 18, April 30, 1925, attention was called to the fact that since 1920 the Keaiwa lava flow to the southwest of Kilauea which had been assumed to be of the 1868 has been correctly called an 1823 flow.

This flow is the subject of a paper by J. B. Stone in the *American Journal of Science* for May 1926. The flow, of typical olivine basalt, poured out along the southern half of a fissure 11 miles long. It flowed out so rapidly that a canoe was burned at Mahuku. One of the most interesting features of this flow is the "ball-lava" which may be seen at a few places in the upper portion of the walls of the crack from which the flow issued. It is assumed that the lava balls were formed by cool fragments of lava falling into the crack where molten lava was surging and after growing by acquiring coatings of molten lava during the churning action were hurled out as smooth rounded balls. Two small explosions with possibly some smaller ones marked the closing stage of the flow.

An excellent description of this flow, among other things, is contained in a paper on the above subject by H. T. Stearns in the Journal of Geology, for May-June 1926. In the abstract by Stearns he states that there is evidence that the usual fire fountains of Hawaii did not play during the eruption. Spatter that is found at the edge of the flow shows that there were rather tall fountains accompanying the eruption. Excepting for the fact that this spatter is not pumiceous the action along this crack in 1823 must have been quite similar to the preliminary Mauna Loa eruptions near the summit in 1916, 1919, and 1926. R.H.F.

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NO 82 RELEASED WITHOUT COPYRIGHT RESTRICTION July 22, 1926

KILAUEA REPORT NO. 758

WEEK ENDINIG JULY 21, 1926

Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, temporarily in charge.

There has been a considerable dimunition in the number of avalanches from the walls of Halemaumau that became especially frequent about the first of July, and continued for over two weeks. Rock falls and small avalanches may be seen and heard neraly every day however. There was a large slide from the southwest wall though the north wall still appears to be more unstable than the others.

Following moderate rains the walls of Halemaumau were quite red on July 19. The red color makes ats appearance as a series of horizontal parallel bands separated by layers of quite dense gray strata whose color changes but little. These pleasing color contrasts give Halemaumau a very striking appearance.

It has now been two years since the lava returned to Halemaumau, after an absence of about three months, to stay for only 12 days and therefore nearly two years that there has been no lava in the pit. Halemaumau was without lava duruing a large part of the thirteen year period from 1894 to 1907. During most of this period considerable smoke issued from the pit, while in the last two years there has been but very little smoking and at present practically no smoke escapes.

There has been practically no change in the location of steam vents during the past several months though the place of maximum steaming is at the northwest instead of at the south as formerly.

Earthquakes continue to be quite frequent. Twenty-two were recorded during the week. All were too small to be perceptible at Volcano House. Several appeared to have indicated distances equal to that of Mauna Loa.

Tilting for the week was slight to the north northwest. There was a strong spurt of north-northeast tilt on July 20.

LAVA TUBES

One of the most interesting and picturesque of volcanic formations are lava tubes or tunnels. Nearly every pahoehoe lava flow produces tubes, large or small.

The most common type of tube is produced by a crust forming over a lava river that initially flowed over the surface of the ground laterally confined by banks of its own making. After the crust is formed over the river the lava continues to flow underneath much as a water river does when it freezes over. When the activity ceases, the lava drains away, leaving an empty tube.

There is another type of tube that is not so frequently observed. This type is formed by lava pouring through a crack or fissure often several hundred feet below the surface. The presence of such tubes in subterranean lava flows can usually only be surmised. In the southwest wall of Halemaumau, 275 feet below the rim this type of tube is exposed. Initially this tube was but a narrow crack into which lava started pouring in 1919. A tube of considerable dimensions and over six miles long was quickly developed. The "Devil's Throat" and some similar holes, 250 to 300 feet deep in the Kau Desert southwest of Halemaumau are but breakdowns in the roofs of such tubes.

Lava rivers follow the topography just as water streams do but in several respects they are just the reverse of water rivers. The greatest volume of lava is at the source. The discharge is often through small tubes that spread out like the delta of a river. Lava tubes have been observed to be nearly horizontal, steeply inclined, and even practically vertical. The later occur where lava cascades over a cliff.

The picturesqueness of lava tubes is often increased by stalactitis and stalagmites. Two widely different types of stalactites are often present. The more common type is composed of lava and is formed by the melting action of burning gas that escapes from the lava river as it flows through the tube. In some places the roof of a tube may be quite thickly covered with these stalactites. The length of the stalactites vary from an inch or less to over three feet. Lava stalactites three feet in length with an average diameter of only half an inch have been found. Probably a large portion of the drip from stalactites fall into the lava river below but where the drip falls onto a ledge above the lava level stalagmites may be found. The stalagmite formation often resembles a bunch of petrified grapes.

The other type of stalactite occasionally found in tubes is composed of sulphates. They are formed after the tube has started to cool off but when it is still quite hot by rain water percolating through the roof of the tube and dissolving the sulphates that have been formed in the material of the roof. They often show a variety of colors and make a tube quite beautiful. Being, for the most part, quite soluble they quickly disappear when the tube cools off.

Lava tubes are found at many places in both recent and ancient lava flows. There is a lava tube on Mt. Shasta, Calif., with a roof 60 to 80 feet high. One can not travel any distance on either Kilauea or Mauna Loa without encountering lava tubes.

R.H.F.

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No. 83 RELEASED WITHOUT COPYRIGHT RESTRICTION July 29, 1926

KILAUEA REPORT No. 759

WEEK ENDING JULY 28, 1926

Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, temporarily in charge.

While there has been no surface manifestation of unusual activity at either Kilauea or Mauna Loa during the past two weeks, the Kilauea-Mauna Loa volcano system is passing through a crisis as real, from the Observatory standpoint, as though molten lava had been present. The northeast tilt that started on June 18 appears to have stopped and during the past week there was a slight northwest tilt. With the change in the direction of tilting there has been an increase in earthquake frequency. Thirty-three separate, small earthquakes were recorded. In addition to the thirty-three shakes there was a nearly continuous tremor from 9:30 a. m. to 1:30 p. m. July 22. A similar tremor was noticed for four hours during the afternoon of July 26.

During the last two or three days there has been a slight increase in avalanching from the walls of Halemaumau. All walls appear to be in motion though the greatest number of avalanches appear to have fallen from the west wall.

The fume column that can usually be seen over Mauna Loa in late clear afternoons was especially conspicuous in the afternoon of July 28. It rose as a rather narrow column at least two or three thousand feet above the outline of the mountain.

SEISMIC EFFECTS OF A SOLAR ECLIPSE

The solar eclipse of July 9, 1926, was not annular at the Hawaiian Volcano Observatory but the maximum obscuration of the sun was roughly estimated to be above 80 per cent. Such an interruption of radiant energy with its consequent lowering of ground temperatures, might well be expected to cause measurable tilts of the earth's surface. The relation between tilts and ordinary daily and seasonal temperature variations has already been mentioned in Volcano Letter No. 41, Oct. 8, 1925.

In an attempt to detect such eclipse effects the seismograms written at the Observatory during the week including the day of the eclipse were subjected to a thorough examination, and an especially sensitive optical tilt-recording instrument was put into operation for the occasion.

After some study the optical records were put aside as being too much influenced by known and suppositious accidental disturbances. From the seismograms however a good tilt curve was deduced, extending over an interval of six days. Any special tilt changes so large as one second of arc would have been unmistakable on this curve, and it is most probable that magnitudes half so great would have been correctly identified. Nothing of the kind appeared, however, which could be associated with the eclipse. One can say, then, that if eclipse tilts existed they must have been of the order of a small fraction of a second of arc.

No earthquakes were detected which could be changed in any way to the eclipse. P. H. Kirkpatrick.

ARE MAUNA LOA AND MAUNA KEA HOLLOW MOUNTAINS

Occasionally one hears the statement that Mauna Loa and Mauna Kea are essentially hollow mountains. This idea arises from the fact that when gravity observations were taken years ago on the two mountains it was found that the actual attractions of the mountains masses were less than the computed amounts based on their bulks and average specific gravits of the rock of which they are composed.

One explanation of this seeming hollow condition that has been offered is that subterranean tunnels abound in the two mountains. While such tunnels might be a contributing factor to hollowness it is probably relatively unimportant. An important factor contributing to the deficiency in the mass of the mountains is the natural voids in the lava flows of which they are largely composed. The voids in an aa lava flow may be over 35 to 40 per cent. The voids in pahoehoe flows while commonly less than in aa may still be quite high especially when the imperfect contact of one flow on another is considered. The presence of intrusive bodies of high specific gravity would tend to decrease the effects of the voids.

The crushing strength of the lava is so high that one would not expect to find the percentage of voids very greatly reduced until a depth in excess of 5,000 or 6,000 feet is reached. This becomes evident when one sees a layer of very friable pumice around Kilauea supporting compacted ash beds that in places are six feet or so in thickness. R.H.F.

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No. 84 **RELEASED WITHOUT COPYRIGHT RESTRICTION** August 6, 1926

KILAUEA REPORT NO. 760

WEEK ENDING AUGUST 4, 1926

Issued by the Observatory, U. S. Geological Survey:
R. H. Finch, temporarily in charge.

Earth shakings continue to be quite frequent, 34 being recorded on the Observatory seismographs during the current week. Only one of the shakes was perceptible at Observatory. It occurred at 11:02 a. m. August 3 and had an indicated distance to origin of 10 miles. This earthquake was the first perceptible one at Volcano House since the last of June. None of the 102 earthquakes recorded during July was perceptible. Usually six or seven per cent of the total number of earthquakes recorded are perceptible.

On July 30, at 2:33 p. m., there was a large avalanche from one of the walls of Halemaumau. It was the largest avalanche that has been observed for some time and sent a dust cloud well above the crater rim. Despite the large number of earthquakes avalanches have not been frequent and Halemaumau is again very quiet.

The lull in tilting noted last week continues. The net result for the week was a very slight tilt to the east-southeast.

AN EASTERN MEDITERRANEAN EARTHQUAKE

An earthquake occurred in the eastern Mediterranean Sea on June 26, 1926, that was of world shaking proportions. Three world shaking earthquakes, quite widely separated, occurred within a short time. In addition to the eastern Mediterranean shake there was a quite destructive earthquake on or near the island of Sumatra on June 27 and one in the China Sea on June 29.

The Mediterranean shake appears to have been especially severe near the island of Crete. The area over which the disturbance was perceptible was rather widespread. Minor damages were reported from Egypt, houses collapsed and at least one person was killed on the island of Rhodes, and alarm and panic was caused as far west as Malta. Ceilings were shaken down in the Archeological Museum at Candia, Crete, and considerable damage was done to valuable collections.

It is interesting to note that this shake had its origin in an active volcano region. The principal manifestation of volcanic activity in this region is Santorin. Mention of Santorin, which became active in August 1925, was made in Volcano Letter No. 43, October 22, 1925. The exact location of the fault where the earthquake occurred is not yet known but it may well pass under Santorin for, according to press dispatches, an outburst of Santorin coincided in time with the occurrence of the principal earthquake shock. Crete is but 50 or 60 miles from Santorin and the island of Rhodes but little farther.

It has been said, even by students of earthquakes, that there is but little connection between strong, widely felt earthquakes and volcanoes; that all volcanic earthquakes are small. The last statement undoubtedly does apply to the majority of volcanic earthquakes but certainly not to all of them. There are many examples of strong world shaking earthquakes accompanying volcanic eruptions, among such is the 1868 earthquake that accompanied an outbreak of Mauna Loa and the earthquakes accompanying the Katmai eruption in 1912. The June 26, 1926 shake may be another example. R.H.F.

HUALALAI

Hualalai is principally known to the majority of people who know anything at all about this mountain as the source of a very spectacular lava flow in 1801. According to O. H. Emerson who recently returned from spending a few days on this mountain there is much of interest to be seen near the summit. It is covered with cones of various types, some like those of Mauna Kea or Haleakala and some like those to be found on Mauna Loa. Cones composed of mixed lava and volcanic ash may also be found. Pit craters like those on the northeast rift of Kilauea are not uncommon. Evidence of small explosions is given by angular blocks of dense material and by layers of ash overlain by more recent lava. One gains the impression that there is a great range of age between the different formations on the summit of Hualalai. R.H.F.

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No. 85 RELEASED WITHOUT COPYRIGHT RESTRICTION August 12, 1926

KILAUEA REPORT NO. 761

WEEK ENDING AUGUST 11, 1926

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

The numerous earthquakes that marked the last three weeks still continue. During the current week 50 earthquakes were recorded. In addition to this number there were spells of very small tremors that lasted for several minutes. The only earthquake that was strong enough to be perceptible occurred at 8:24 a. m. August 6.

Tilting for the week was slight to the north-northwest.

Small avalanches are frequent from the walls of Halemaumau. The walls at the north and west appear to be the most active. The odor of hydrogen sulphide can frequently be detected at south rim of pit. A crack about 250 feet back from the south rim showed signs of recent movement on August 10.

SECTION OF VOLCANOLOGY, U. S. GEOLOGICAL SURVEY

There was established on July 1, 1926, a Section of Volcanology in the Geologic Branch of the Survey. Mr. W. C. Mendenhall is Chief Geologist directing the activities of the Geologic Branch in Washington. Mr. T. A. Jaggar at the Hawaiian Volcano Observatory is Volcanologist in charge of the new Section. The Section of Volcanology is empowered by act of Congress to operate volcanologic surveys, measurements and observatories in Hawaii, including subordinate stations elsewhere, and to provide and maintain laboratories and quarters for the work, and to print reports.

This establishes a government service for continuous observation of volcanic action in the United States and its dependencies, with headquarters on Kilauea volcano. In immediate effect it enlarges the scope of the Hawaiian observatory so as to create experiment stations to study volcanism in California and Alaska, these making their reports to the Hawaiian headquarters for publication and comparison. Hitherto the Hawaiian station has been the only permanent American volcano observatory.

Lassen National Park, where was staged in 1914-15 an eruption in the northern California mountains at Mount Lassen, and where there were other eruptions from 100 to 250 years ago, has been selected for the second. This second volcano observatory will be in charge of Mr. R. H. Finch, Associate Volcanologist, who has been first assistant at the Kilauea station since 1919. His task is to establish an earthquake laboratory modelled on the one in Hawaii, equip it with seismographs, man it winter and summer, and make studies also of slow movements of the mountain, of weather controls, and of underground temperatures as shown by the springs and gas vents.

The seismographic laboratory at the Hawaiian station is placed in charge of Mr. Ronald M. Wilson, topographic and geodetic engineer. Mr. Wilson becomes geodesist and mathematician to the Section of Volcanology, as aide to Mr. Jaggar in physical investigations, and will specialize in tilt measurements and change of ground levels in relation to tide-water, and in horizontal movement determined by precise triangulation. Of late years work in Japan, California and Hawaii has proved that these slow movements are of enormous importance in relation to earthquakes and volcanoes, and that they have forecasting value.

Another officer in charge of the clerical and disbursing work of the Section of Volcanology is Mr. Richmond B. Hodges, stationed at the Hawaiian laboratories. Mr. Hodges has served through the grades of junior and assistant clerk in the Washington office of the U. S. Geological Survey. He will have charge of the records, files and accounts at the Hawaiian observatory, and of part of the drafting and editing.

Mr. Jaggar has made reconnaissance of the Lassen district in 1925 and 1926. The Topographic Branch of the U. S. Geological Survey, Colonel C. H. Birdseye in charge, is now at work making a topographic administrative map of the Lassen Park and surrounding country of the National Forests. This map will be of great importance to the volcanologists. Furthermore a monograph on the recent eruption of Lassen, by Doctors Day and Allen of the Geophysical Laboratory, excellently prepares the field for permanent studies of volcanic energy there.

For the present the program of publication of the Section of Volcanology is to issue weekly reports of earth shakings, tilts, temperatures, and other volcanic phenomena observed at all stations occupied. These are given the local press in the vicinity of each observatory, and are collected every week in the Volcano Letter for wider distribution. In the Monthly Bulletin of the Hawaiian Volcano Observatory will be published the fuller illustrated reports from each station, in this as in other things the Hawaiian laboratory becoming the mother station.

The third observatory of volcanic action planned is naturally in that wonderful region almost unknown, the Aleutian mountains and islands of Alaska. That land will be reconnoitred for the purpose in 1927, and among the many volcanoes there belonging to the United States, one will be selected for laboratory study winter and summer. Financial aid to supplement the small work that the government funds can do will be essential to any thorough research in that country. T.A.J.

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No. 86 **RELEASED WITHOUT COPYRIGHT RESTRICTION** August 19, 1926

KILAUEA REPORT NO. 762

WEEK ENDING AUGUST 18, 1926

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

Changes at Halemaumau pit have been slight. Six places at the bottom of the talus slopes, one of them in the rock wall itself, have developed yellow sulphur stain. These places are all east, south and southwest from the bottom area, and are distinct from the places of maximum steaming. The steaming is higher on the debris slopes, and the vapor at present is not dense.

Action is confined to small slides of rock from the walls. A wait on the rim of a half-hour is usually rewarded by the sight or sound of two or three small avalanches. Usually a bunch of debris from the middle of the cliff parts suddenly from its place, without evidence of what starts it. The northern walls are the favorite places. The dust of a slide rose above the rim about noon August 17.

Twenty-six earthquakes were registered for the week, all too small to be perceptible; a weekly total much less than that of the three preceding weeks. Tilting was slight NNE.

HORIZONTAL GROUND MOVEMENT IN CALIFORNIA

An interesting report by William Bowie was published in 1924 (Special Publication No. 106, U. S. Coast and Geodetic Survey, Earth Movements in California) describing results of precise triangulation in 1922 and 1923 by re-occupation of old stations in the sections Sierra Nevada to San Francisco, San Francisco to Santa Barbara, and Santa Barbara to San Diego. The immediate vicinity of Santa Barbara itself was left to be done in 1924. The Santa Barbara earthquake occurred June 29, 1925. The published report covers the southern belt from Ventura to the base line in the mountains southeast of Riverside, and the northern belt from Gaviota just west of Santa Barbara to the vicinity of the Lick Observatory. This northern belt is referred to the base line Mount Lola—Round Top in the Sierras.

As the discussion of the author of the report was written in 1924, it does not cover the Santa Barbara earthquake and was unbiased by knowledge of that earthquake. The results of the resurvey show that in the forty years following 1880 (about), the stations of the Coast Range from Monterey to Santa Barbara moved northward respectively, taking them in order southward, 4, 7, 11, 15, 20, 22, and 24 feet, the last being Gaviota station. The results for the southern belt beginning to the southeast of Los Angeles, show that the stations progressively westward from Santiago to Ventura County, after about 1890, moved southwestward and southward 1, 2, 2, 4, 5, 6, and 7 feet, the last being Chaffee station, just east of Santa Barbara, with its motion almost exactly in the opposite direction from that of Gaviota. The changes in geographic position indicated by the resurveys are based on assumptions that the base-lines in the distant mountains stood still.

It seems to the reviewer that the various writers who have described the Santa Barbara earthquake have been unduly prejudiced by the presence of east-west faults in that region, and that they have neglected this astounding trigonometric forecast of the disaster in Dr. Bowie's survey. Professor A. C. Lawson, when he heard of the 24-foot movement at Gaviota at the meeting of the American Geophysical Union in Washington about May 1, 1924, rose and asserted that this meant a coming earthquake. A year later the earthquake came.

What was the stress acting on the under-earth at Santa Barbara in the spring of 1925? Chaffee, 22 miles to the east, had migrated south; Gaviota, 28 miles to the west, had migrated enormously north. The earth crust under Santa Barbara was strained to the breaking point, and the whole mosaic of mountain blocks suddenly yielded, with jarring, on June 29. It was not necessary that any north-south fault should show. Twenty fault-blocks may have twisted a little, a deep slab may have snapped, or deep magma may have been released intrusively.

It would appear that this work of the Coast Survey has brought earthquake forecasting into the range of quantitative measurement. T.A.J.

THE FORMATION OF AA AND PAHOEHOE LAVA

The question of how aa or clinkery lava is formed occupies considerable space in scientific literature. Nearly all of the discussions have been largely of a philosophical nature and but limited portions have been based on chemical analysis, close observations in the field, or on experiments.

A paper on "The Formation of Aa and Pahoehoe" by O. H Emerson, American Journal of Science, Vol. 12, Aug. 1926, gives a discussion of the artificial formation of aa lava. In an effort to produce aa artificially Mr. Emerson melted some powdered pahoehoe in a crucible and stirred it constantly while it was slowly cooling. While the interior remained fluid for several minutes a pahoehoe skin quickly formed on the surface. When the solidified mass was broken open it was found that the interior was essentially crystalline and that the hole formed by the stirring was lined with typical aa arborescence. Repetition of the experiment gave the same result- In one case pulverized aa was used and there was no essential difference in the result. Crystallization taking place while the flow is in motion seems to be a real factor in the production of aa. The question of the limiting conditions of temperature, gas content, and degree of crystallization in controlling types of lava flows needs more investigation.

Mr. Emerson omitted part of the history of his experiments. The method was suggested by the undersigned to see if the natural mechanical stirring in a flow was a factor in the production of aa. A first test at Hawaiian Volcano Observatory gave only pahoehoe lava because the lack of sufficient heat made it impossible to stir the melt. R.H.F.

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No. 87 RELEASED WITHOUT COPYRIGHT RESTRICTION August 26, 1926

KILAUEA REPORT NO. 763

WEEK ENDING AUGUST 25, 1926

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

Changes have been very slight at Halemaumau pit of Kilauea volcano during the past week. The very heavy rain of the 20th and 21st, amounting to 8.42 inches at Kilauea Observatory, washed away much of the sulphur stain at the solfataras in the bottom, and deepened the red of the walls.

Again the seismograph shows great numbers of very feeble tremors. The total number for the week was 58. A feeble shock at 2:19 a. m. August 24 had origin at distance indicated as 18 miles. Tremors were frequent the forenoon of the 20th. Tilt was light NNW. A weak teleseism at 7:22 p. m. August 24 had distance to center indicated as 3600 miles.

LAVA DOME AT SANTA MARIA 1922-25

Santa Maria volcano in western Guatemala, after an interval of twenty years, has followed its explosive and engulfment eruption of 1902, with a lava-plug eruption of three years' duration beginning June 29, 1922. (K Sapper, Zeitschrift fur Vulkanologie, 1926, Vol. IX, pp. 156-200, 14 plates. Die vulkanische Tatigkeit in Mittel-Amerika im 20. Jahrhundert. I Teil).

The 1902 outburst left a great hole in the southwest flank of the mountain at about 6500 feet elevation. This engulfment crater was left 3300 feet across and 800 feet deep to the geyser like lake of boiling water spouting and making sulphurous fumes until after 1906. Thereafter the volcano became quiet.

In 1922 at the end of June the same crater sent up cauliflower clouds of dust and made rumblings and small localized earthquakes and electric storms. Mr. G. Hurter of Quetzaltenango on August 13th photographed the new rounded dome of aa lava which had risen from a fissure in the bottom debris of the crater, and already had reached a height 300 feet above its lower lip. There was much growing of the heap during four months, with rumblings, fume jets, crashing of debris down slopes, and sulphurous coatings. There was glow at night illumining dust jets that were mistaken for flames. Explosive eruptions making light ash falls were frequent. October brought temporary decline.

This Cumulo-dome was of the same type as the Pelee heap of 1903, that of Bogoslof of 1907, that of Tarumai in 1909, and similar to that of Kilauea in 1888. The Lassen plug of 1915 appears to have been much the same. These domes have all the features of stiff lava flows, forced by the topography to pile upward instead of streaming downhill. When the Hoopuloa flow on Mauna Loa in April, 1926 accumulated at the shore below a steep slope above, it formed a circular heap with spiny top and red hot slide slopes closely resembling the photographs from Santa Maria.

The Hurter photographs present a series of eighteen taken on successive dates for three years, wonderful pictures showing the growth of this Santa Maria lava hill, all from the same viewpoint. These are the plates in Dr. Sapper's monograph. In 1923 the flow took a fresh spurt enlarging the dome, which preserved a finely serrate profile. It had made a great growth by May. At the beginning of 1923 it was 800 feet high and 3300 feet across. It swelled further and overlapped the old crater edge. It became craggy, square-topped and massive, always fuming and glowing, in 1924. On June 1, 1924 a spine 200 feet above the top of the heap had pushed itself up through a chasm in the crest. This was quite like the Pelee tower or the Bogoslof fin. The growth stopped in 1925, leaving the new structure 1600 feet high above its base and 4000 feet across. Its top was now a wide cluster of castles, turrets, spires, domes and buttresses, surrounded by sweeping talus slopes. T.A.J.

VOLCANIC HISTORY OF OREGON

A remarkably interesting and beautifully illustrated book entitled "Mount Multnomah, ancient ancestor of the Three Sisters, by Edwin T. Hodge," has been published by the University of Oregon, Eugene, Oregon (Aug. 1, 1925). This book is for the use of geologists, mountain climbers and nature lovers, is illustrated by superb photographs and excellent block diagrams and maps, discusses the history of the Cascade Plateau, the climate, flora and fauna of the volcanoes called "the Three Sisters," and is a model of good scientific book-making, condensation, colorful writing and clear explanation. I have never seen block perspectives of landscape used to better purpose in association with photographs of the landscapes themselves.

Professor Hodge concludes that a 15,000-foot volcano once lay over the site of the Three Sisters, built above the post-Eocene Cascade fault that extends north and south along what is now the "break" between the Cascade Plateau and the rugged gorges to the west. In Oregon eighteen volcanoes lie along this fault today. In "Multnomah" a Mauna Loa of basalt was built up in Miocene time. Thereafter it collapsed or blew up or both, and enormous engulfment occurred. A circular fault eight miles in diameter bordered the sink. Streams cut back into the sink, but in Middle Pliocene two sister volcanoes were built up within it. Then more volcanoes arose, followed by glaciation. The Oregon block sank again after the Ice Age, and revivified the volcanism, which continues to the present day. T.A.J.

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No. 88 RELEASED WITHOUT COPYRIGHT RESTRICTION September 2, 1926

KILAUEA REPORT NO. 764

WEEK ENDING SEPTEMBER 1, 1926

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

Small avalanches have continued in Halemaumau pit and are notably conspicuous at present at northeast wall. These slides have undermined so as to reveal fresh rock for several hundred feet below the rim, and the ground above is heavily cracked and threatens to wreck the northeast trig station in the near future. During temporary visits about four avalanches are seen in a half hour and many falls of small stones. Some of these were observed this morning, September 1, also from the western wall, and there also the dirt is freshly cracked along fissures back from the rim of the pit. A dyke of light-colored rock was observed in the middle portion of the northeast wall. At the foot of this wall the talus heap has been growing higher during several months past, and now tends to rival the southwest heap in height. These two are just opposite each other, which suggests that the major caving away is along a line trending toward Kilauea Iki.

Recent rains have increased the volume of visible steam in the bottom of the pit, and the fuming patch at the base of the south talus appears very hot and sulphurous. Another at the base of the east talus is making yellow sulphur.

Unusually large numbers of very small local earthquakes have been registered on the seismograph. The total number counted for the week was 107. Tremors in addition to the measured movements were frequent on August 27, 28, and 29, particularly during the forenoon of the 27th. At 2:21 p. m. August 31 a faint teleseism was registered without distinct phases. The tilt for the week was slight to the SSW.

The increase in tremors may possibly forecast new activity in either Mauna Loa or Kilauea. There was a remarkable cloud over Mauna Loa at 6 p. m. August 30 that suggested volcanic fume. Some of the local earthquakes appear on the seismograms like avalanche tremors from Kilauea, others seem to indicate a Mauna Loa distance of origin.

PHOTOGRAPHIC RECORD OF LASSEN VOLCANO

In May of 1914, when Lassen Volcano, on the borderland between the Sierra Nevada and Cascade Ranges, broke into eruption, the newspapers were incredulous. It was known that at the Cinder Cone, in the eastern part of what is now Lassen National Park, there had been a lava flow some 250 years ago. Nothing is known of what then happened at Lassen Peak, a big volcano of the same class as Mount Shasta, with a shallow crater depression and pool of water in its top. It has been the custom to connect Lassen Peak with the Cinder Cone and its lava flow, but the two are 12 miles apart and there is no obvious relation between them.

In 1914, the old crater depression in the top of Lassen Peak began to eject dust and steam through small caved-in depressions of the summit. These depressions engulfed the rock of their margins until they had united into a single crater hole apparently at the junction point of several cracks in the mountain mass. The forester's Lookout House became gradually destroyed by falling stones in a sucession of explosions which increased in vigor and in numbers. The eruptions occurred every few days and rarely lasted more than 20 minutes. In the two years 1914 and 1915 the month of May appears to have been the critical one for Lassen, for the first outbreak was May 30, 1914, and the maximum explosion was on May 22, 1915.

Mr. B. F. Loomis, proprietor of the hotel at Viola, is an energetic photographer who has compiled a "Pictorial History of Lassen Volcano" (published by Anderson Valley News Press, Anderson, Cal., 1926). This book is not only a useful guide to Lassen National Park, but contains a critical review, illustrated by many photographs of the activity of 1914-15. Mr. Loomis cites the opinions of Messrs. Diller, Day, Allen, and Holway in their published statements about the Lassen eruption, and reaches some conclusions of his own, backed up by photographic evidence, that are of interest.

The chief of these is to the effect that the eruption of May 19, 1915, produced merely a flood of water and ash which devastated the northeastern creeks without throwing down trees. With this eruption there was no down-rushing blast of steam capable of melting snow to cause the flood. The much bigger eruption of May 22, on the other hand, produced a down-rushing steam blast which is photographically shown to have overturned trees and cut a V-shaped swath through the forest to the northeast for four or five miles. The action in both cases was quite like that of the volcano Pelee in Martinique, which also began with a flood and ended with a blast.

Loomis believes that both Lassen eruptions gave vent to liquid water from the mountain itself, followed by steam, and his pictures of mud torrents from the very summit appear to bear out his belief. The photographs also suggest very strongly that the plug of lava breccia which rose to fill the new crater, overflowed the west lip in a definite aa lava flow, which according to him was seen flowing and glowing. T.A.J.

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No. 89 RELEASED WITHOUT COPYRIGHT RESTRICTION September 9, 1926

KILAUEA REPORT No. 765

WEEK ENDING SEPTEMBER 8, 1926

Issued by the Observatory, U S. Geological Survey:
T. A. Jaggar, Official in charge

Few changes have taken place in the pit of Kilauea Volcano during the past week. Occasional small rock slides and avalanches occur at intervals, causing thin dust to rise from the pit. Dust from these slides was observed several times during the day on September 6. Dust from a slide was observed a few minutes before 8 a. m on the 7th, at which time a spasmodic tremor was recorded by the seismographs, suggesting correlation between the two occurences.

The seismographs record 81 tremors for the week, for the most part very feeble. One exception was a local feeble earthquake at 5:38 p. m. September 1, which was perceptible to many people at the Volcano House and others in the vicinity. During the afternoon and evening of September 2 the very feeble tremors were most frequent, 27 being recorded during that time, being a third of the number recorded for the entire week. Of these, several exhibited phases indicating the distance to their origin to be about 35 miles. In contrast to this period of time with many tremors, it is of interest to note that during the 24 hours from 8 a. m. September 7, to 8 a m. September 8, only one very feeble tremor is recorded. The records show two faint teleseisms, having phases so indistinct as to prohibit the calculation of the distance to their origins, one at 5:17 a. m. September 4, and the other at 2:03 a. m. September 7.

A slight tilt to the north has accumulated during the week. R.M W.

BORING AT CALIFORNIA GEYSERS

An article in the Oil Weekly (February 2, 1926) describes drilling for steam at the "Geysers," Sonoma County. California. A number of wells have been opened with a view to harnessing steam power to furnish electricity. J. D. Grant drilled two wells with churn rig and cable tools in something over two years. The rock is sandstone and hard serpentine. The Geysers Development Company are using a rotary drill with hydraulic feed, which permits putting extra pressure on the Hughes cone bit. A system of valves to protect the workmen and control the wind is used. Mud is pumped through the drill rod and returns through a special valve. The serpentine cap rock is said to be from 200 to 400 feet thick.

The temperature of the hole reached a dull red heat, 998 degrees Fahrenheit. Seven wells were drilled with Hughes bit to some 500 feet each in less than two months to each well, and the cone bits stood this temperature. In one well, four sets of hardened steel cones were dulled in drilling 277 feet of 9¾-inch hole in hard rock. At a depth of 451 feet such a steam pressure was encountered that the uprush of rocks, mud, and steam at the casing head wrecked the timbers.

To deal with these forces, casing is cemented from top to bottom; in the latest wells the upper casing is 15 inches in diameter, and the lower 10 inches. Steam pressure increases with the depth. The well cited above developed 67 pounds pressure at 228 feet, 169 pounds at 416 feet, and another well developed 240 pounds at 486 feet. A runway is built from the upper derrick off to the hillside, to save the derrick man in case of a steam blowout. T.A.J.

TOKYO SHORELINE ELEVATION

The Kwanto District around Tokyo and Yokohama not only had blocks of the bottom of Sagami Bay dropped and elevated hundreds of feet, at the time of the 1923 earthquake, but the land tilted This tilt was from southeast to northwest, with a depression in the interior country, and elevation of some two meters at the peninsulas. These two peninsulas, moreover, at the entrance to Tokyo Bay, have moved horizontally towards the southwest four (Boshu) and two (Miura) meters. The coasts had been sinking a half meter or so in the half century preceding the disaster. (On the Recurrence of Destructive Earthquakes in Southeast Japan during 2,000 years, A. Imamura, Proc Imp. Acad. Jap. 1926, Vol. 2, No. 6).

The tide gauges showed gradual lowering of the shore for 38 years, and sudden elevation at time of earthquake They also show nine-year and eighteen-year periodic oscillations of several centimeters.

Professor Imamura has traced old shorelines suddenly uplifted during earlier big earthquakes at Misaki on the Miura peninsula. These earthquakes occurred A. D. 33, 818, 1703, and 1923. The different benches have been allocated to their proper earthquake date by relative erosion of the standard holes in the cliff of the boring shell *Lithophaga nasuta* The shell works at sea-level. The cliff has been etched back since elevation at the rate six millimeters in 220 years. The shell holes make sea-level belts which are identifiable . History records great earthquakes that check with the shell-hole-erosion data.

On this basis the bench of the 1703 earthquake was elevated 5 5 meters at the tip of Boshu peninsula, and that of the year 818 A. D., 4.7 meters—both of these more than double the uplift of 1923. T.A.J.

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No. 90 RELEASED WITHOUT COPYRIGHT RESTRICTION September 16, 1926

KILAUEA REPORT No. 766

WEEK ENDING SEPTEMBER 15, 1926

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

Halemaumau pit at Kilauea Volcano is always different from the other pits, such as Kilauea Iki and the Chain of Craters, in that the walls are sliding and the rim enlarging. The avalanches eating away the northeast rim, as noted September 1, have accomplished their threat of destroying the northeast flag station. This monument was installed last April, and was found to have gone on September 12. It was probably carried away by the morning slide of the 7th.

On September 12 slides were frequent. Today they were not observed during a half-hour. There is fresh, red dust on the slopes, and a new bowlder on the floor has left a gray trail. The south talus solfatara makes blue fume in hot puffs. In many places the rock wall of the pit steams on the inner faces.

Seventy-three earthquakes were registered in the seven days prior to the morning of September 15. The frequency and intensity of instrumental earthquakes has increased since September 8. On that day there were four; on September 14 there were 17, of which three were almost big enough to be felt. Additional spells of volcanic tremor appeared on September 14 and 15. Tilt for the week was slight SSE.

NEW ZEALAND VOLCANIC ACTIVITY

Recent files of the New Zealand Herald (Auckland) beginning in April, 1926, report earthquakes and volcanic activities along the Taupo belt of the North Island from Ngauruhoe Volcano to White Island Volcano in the Bay of Plenty.

A local earthquake was felt at Christchurch March 31. April 8 there was comment on submarine disturbance near White Island causing disappearance of the fish. A cutter in 1886, during the great Tarawera eruption, in the same waters, ran into muddied sea, floating weed, and dead and dying fish. Near Mercury Bay there are hot water springs. Ngauruhoe opened a new vent with explosion and detonations April 16. The shores of the Bay of Plenty felt a sharp earthquake April 18, time said to be 10:45 p. m. at White Island. All of this was simultaneous with the outbreak of Mauna Loa in Hawaii.

From Waimarino April 24 enormous clouds of black dust along with bowlders were seen rising from Ngauruhoe for two hours. Detonations and severe vibrations were reported from other places, and brilliant glow at the crater in the evening. Campers near the mountain described shots like cannon, the noise of stones falling, rumblings, and one tremendous report after daybreak April 25 which sent up black smoke 1,500 feet. One message described "tongues of flame."

April 12 (after the activity of Mauna Loa in Hawaii had begun) earthquakes were reported from Fiji and the Marshall Islands. About May 1 the rumblings from Ngauruhoe were heard in the Gisborne district. The Tongariro National Park reported vibrations and volumes of explosion clouds from Ngauruhoe May 12. May 15 the activity increased, with loud reports, glow, and red-hot bowlders. At 7:45 p. m. a wide streak of fire extended down the mountainside. Bowlders rolling down the slopes prevented approach.

The maximum paroxysms were evidently at this time. From the railway to the west, May 17, "great gusts of light burst up from the crater." The fume column was estimated 6,000 feet in height, and was seen from Wanganui 60 miles away. Taupo reported frequent "shots" from the crater, jets of black smoke 2,000 feet high, with concussion that rattled windows, earth tremors, and "flame" visible from there.

A photographer reported May 18 a great roar, prolonged shaking, and a tremendous shot: the lips of the crater were a vivid red with flame, while bowlders of 10 to 20 tons crashed red-hot down all sides of the mountain with regular monotony. These were discernible in daytime five miles away. The snow of Tongariro was buried under the ash of Ngauruhoe. A sharp earthquake occurred May 20. Two notices of this period describe "a stream of lava through a hole in the lip of the crater," probably glowing slides of debris.

May 28 the volcano was sending white steam straight up, and was quieter. May 31 glow was still seen. June 1 a sharp earthquake was felt at Gisborne, and at the Bay of Plenty. Another occurred in the South Island June 6.

June 5 an ascent of Ngauruhoe was made; varicolored fume rose, first white, then black; there was a notch in the north lip, the crater appeared 600 feet deep, and down below what appeared to be "dark-red and blue flame" rose in glimpses 40 to 50 feet above the surface of "molten lava." The former crater floor was covered with sand and split by huge fissures which suggested coming engulfment. There was roaring noise.

July 2 a sharp local earthquake was felt at Taupo and a succession of shocks occurred July 5 in the north end of the South Island. July 8 White Island appeared to make unusual clouds of steam. July 30 a tremor was felt at Taupo and both Ngauruhoe and Tongariro showed symptoms of increased "activity" of steaming.

Such is what can be made out of press notices. It is to be hoped that the volcano observer of the Government will soon be sending us official reports; clearly there has been abundant work for a New Zealand volcanologist during the past six months. T.A.J.

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No. 91 RELEASED WITHOUT COPYRIGHT RESTRICTION September 23, 1926

KILAUEA REPORT No. 767

WEEK ENDING SEPTEMBER 22, 1926

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

On September 19 the only developments of the last week noticed at Halemaumau pit were stains of yellow sulphur and white alum on the rock slope at foot of southeast wall. On September 21 fresh gray rock fragments lay at foot of northeast wall. A line of sulphur stain at base of east talus has increased. Rock slides have not been seen lately.

Forty-four local earthquakes were registered for the week, and tilt was moderate to the NE. A distant earthquakequake was well registered at 7:38 a. m., September 16. Its preliminary phase indicated distance of origin 3,630 miles and direction southwesterly, suggesting New Caledonia. Its time of occurrence at the origin by this should have been Greenwich civil time 17 h. 59 m. 08 s. Science Service and the U. S. Coast and Geodetic Survey from records of seven stations made the origin west of the New Hebrides and the time 17 h. 59 m. G. C. T. Another weak teleseism occurred September 17, 12:59 p. m.

EARTHQUAKE IN ENGLAND

Just as the United States in 1925 was stirred by earthquake peril, so now England is in the throes of a paroxysm. The Channel Islands started the excitement August 1, with a shock in Jersey about 2 p. m. which wrecked chimney stacks and broke gas pipes. This was felt on the coasts of England and France. There were rumbling noises and rocking at Jersey that lasted several seconds, throwing over wall cases of merchandise and bringing down ceiling plaster and pictures. The vicinity of the Channel Isles is a recognized seismic center.

On August 15, 1926, a shock in the Hereford district of England, to the east of Wales, shook some 40,000 square miles of the most densely populated parts of England. Davison reviewed the happening in the Birmingham Post August 20. A similar but more extensive earthquake had shaken Birmingham and centered near Hereford in December, 1896, with 98,000 square miles as the area shaken, including the Isle of Man and Southeastern Ireland.

The 1926 shock produced great alarm but little damage. Chimneys fell between Ludlow and Hereford. This was the principal epicenter, and a radius of 150 miles from there probably includes all places of felt quaking. The 1896 quake and earlier ones in the same district had two centers, near Hereford and Ross, respectively, the double earthquake in each case producing maxima almost simultaneously in the two places, but stronger sometimes at the Ross center, sometimes at the Hereford. Hereford is said to be a place of faulting.

Morrell in the "Graphic" suggests that Hereford and South Wales are not far from volcanic matter below. Fifty miles to the south is Bath, where "the water constantly wells up from those superheated depths at a temperature of 120 degrees Fahrenheit. A volume of some 180,000 galloons of warm water is thus literally erupted daily, and this process has been going on for ages." Judd pointed out that this "is a slight manifestation of volcanic activity." Thirty miles west of Hereford are sulphurous wells in old volcanic rocks.

Oldham (Nature, August 28, 1926), on the basis of a formula dependent on area of felt shock, maximum intensity, and meaning of the word "perceptible," estimates the depth of origin at 30 miles; but he makes the diameter of the region of felt shock less than Davison, so that the depth may be nearer 40 miles. He makes the maximum violence number six of Mercalli's scale (Rossi-Forel seven).

The greatest of the English earthquakes was probably the Colchester shock at the east coast. 50 miles northeast of London, April 22, 1884, with twin centers near Rowhedge and Peldon, where most of the houses were damaged. Houses in 24 towns to the number of 1,213, including 31 churches, required repair. The maximum intensity was Rossi-Forel 9. The damage was greatest in low river grounds.

The area shaken was more than 100,000 square miles, and the shock was felt in France and Belgium. Sounds were heard 198 miles from the center. At London and Cambridge the intensity was R-F 6. T.A.J.

NATURAL HORSEPOWER

The horsepower in industry of the United States is 190 million ,of which 111 million is coal-produced, 67 million petroleum, and 12.3 million falling water. Great Britian uses 45 million horsepower, Germany 41.5 million, France 17.8 million, and Canada 10 million. (Compressed Air Magazine, September 1926.)

The total world horsepower resource in falling water is about 450 million, of which only 30 million is used. There is thus in sight enough water power to replace all present-day fuel when the latter is exhausted. This is without counting volcanic steam power and future development of direct solar energy and the tides. T.A.J.

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No. 92 RELEASED WITHOUT COPYRIGHT RESTRICTION September 30, 1926

KILAUEA REPORT No. 768

WEEK ENDING SEPTEMBER 29, 1926

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in charge

The period leading up to the equinox showed a notable growth in numbers of small local earthquakes and tremors at Kilauea, but no volcanic activity has yet appeared. Beginning with the week-end August 18, the weekly numbers of shocks at the Observatory recorded by seismographs were sucessively 26, 58, 107, 81, 73, 44; and this week the number is 27. Such a curve of waxing and waning frequency has some volcanic meaning, and the weeks of large numbers showed many small avalanches at Halemaumau, which however seemed to be effects rather than causes of the shakings.

The past week has produced no slides that have been seen and no marked changes at the pit.

Besides the 27 earthquakes, microtremors were a little stronger than usual the first part of the week. There were other very minute volcanic tremors on the 22nd and the 23rd. The tilt was slight to the NNE, and during the past two weeks about two seconds of angular tilt to the east has accumulated. This is the third pronounced bend in the tilt curve away from westerly in the past six months. The first accompanied the Mauna Loa eruption. The second occurred about the June solstice. And the present one is the usual seasonal eastward tilt of the autumn.

CONCLUSIONS CONCERNING VESUVIUS

Reviewing observation of Vesuvius for twenty years as recorded in Perret's monograph (The Vesuvius Eruption of 1906; Study of a Volcanic Cycle. Frank A. Perret. Publication 339, Carnegie Institution of Washington, 151 pages, 25 plates, 1924), Dr. A. L. Day cites conclusions drawn from Vesuvius by the volcano workers of the Geophysical Laboratory. (Annual Report Director Geophysical Laboratory, 1925, Carnegie Institution Year-Book).

The pre-eruption period was 1903-06, the great paroxysm April 1906, the repose period 1906-1913, and the new eruptive period 1913-1921. Fumaroles were formed during the repose period, and the enlarged crater was gradually filled in by break-down of the walls, and after 1913 by effusion of lavas on the pit floor. The post-1913 period constitutes the beginning of a new cycle that will lead to another paroxysm.

"It is of interest to note that although lava flows developed during the eruption, the most intense activity appeared to center in the discharge of the volatile components, carried in solution in the magma in enormous quantity; and in particular with increasing concentration as greater depths within the lava column became exposed by the release of overlying pressure. It is pointed out that some, perhaps a considerable portion, of this tremendous volume of volatile material may have come from the sea nearby, and it is intimated that the gradual filling up of the crater between one extravasation and the next represents reactions in which infiltrating sea-water plays a major part, though what manner of connection exists between the sea and the volcano hearth is still unknown."

"Some years ago it was demonstrated by Johnston and his associates in the Geophysical Laboratory, that capillary forces could not properly be invoked to account for accessions of water into regions containing fluid magma; but no such limitation prevents the circulation, in appropriate channels, of (gaseous) water above its critical temperature or indeed of liquid water through supercapillary openings, such as may very well be supposed to exist near a center of explosive activity."

"It was observed further that other volatile ingredients of a chemically active kind, such as chlorine, fluorine and sulphur, were conspicuously in evidence in the preliminary stages of the eruption, but as the period of maximum intensity approached, there appears to be no evidence of any of them in quantities sufficient to affect the sense of smell. The great outpouring of volatile matter at the height of the eruption appears therefore to be water vapor, as it has also been shown to be at Lassen Peak."

Two facts emerge in this analysis, of great interest to those who studied the explosive eruption of Kilauea in 1924. One is that underground water is unreservedly appealed to as the source of volatile matter in the explosive phase of the eruption of 1906 at Vesuvius. The other is that the lava gases of the earlier phases are admittedly different, strong chemical acids. The pre-eruption period of lava flows and a full terminal crater occurred in the three years preceding the Kilauea eruption just as at Vesuvius. The forceful agent in the Kilauea explosions was pure steam, quite different from the acid gas of the great lava lake of only three months before. All of this parallels Vesuvius. But Vesuvius differed from Kilauea in that it mingled a luminous liquid-lava phase with explosion at first. Then came the paroxysmal emission of gas like Kilauea May 17-18). Then the Vesuvian "dark, ash phase" corresponding to the avalanching and earthquake maxima of Kilauea May 21 and 24.

It appears to the reviewer that this phase was a tremendous engulfment of crater rock at Vesuvius just as at Kilauea. T.A.J.

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No. 93 RELEASED WITHOUT COPYRIGHT RESTRICTION October 7, 1926

KILAUEA REPORT No. 769

WEEK ENDING OCTOBER 6, 1926

Issued by the Observatory, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

During the past week there has been no appreciable change in the pit of Halemaumau. There have been no slides or avalanches noted, nor any change in the amount of vapor. The total number of earthquakes for the week is only 25, showing that the number of earthquakes is still diminishing. The week's earthquakes have all been very feeble, of the local spasmodic tremor type, with the exception of a feeble trace of a teleseism which occurred at about 8:45 a. m. Hawaiian time on October 3. The fact that earthquakes have been so few and feeble is probably connected with the lack of slides and avalanches. Tilt has been very slight during the week, to the NNE, but of insufficient amount to continue the eastward trend of the tilt curve that has been exhibited during the last two weeks.

THE TIDAL WAVE ON PALMERSTON ISLAND

The Sheffield "Telegraph" (Great Britain) of August 10, 1920, tells of a tidal wave on Palmerston Island, about 300 miles northwest of Raratonga, probably on May 12, 1926. Only one life was lost, but all the buildings excepting the church were swept away, and the population, about 100 in number, were left without homes and property, and with ony very scant means of sustenance. Hand-caught fish, and cocoanuts enabled them to live till relief came.

The "Telegraph" says: "The destitute condition of the inhabitants was revealed only when Sir Maui Pomare, the New Zealand Minister of Health and a Maori, on the New Zealand government steamer Hinemoa, touched there on an inspection tour. Supplies were landed and a relief ship ordered immediately from Raratonga."

The coming of tidal waves has many times been heralded by the more speedily propagated earthquake waves recorded on seismographs. Nature has thus arranged to send a message of warning, that only requires interpretation to make it possible, by preparation, to minimize the damage done by a tidal wave. The interpretation and preparation require time, and the message would hardly have been of assistance to the people on Palmerston Island without wireless. But it is conceivable that such a seismic message might still have been put to use, in suggesting to the outside world that these people were in trouble, and so have shortened their period of privation.

EARTHQJUAKE WAVES

In the Proceedings of the Imperial Academy (Japan March, 1926), A. Imamura shows that in some cases a long wave motion may preceed or travel along with the usual "P" wave in the propagation of seismic disturbances. In this paper Mr. Imamura indicates the difficulty encountered in separating on the seismograms the effect of slow motions horizontally to and fro and of tilting back and forth without horizontal motion. The trace of some of these early long waves strongly suggested the curve resulting on the seismogram when the instrument was known to have undergone sudden tilt. Mr. Imamura therefore analyzed these waves from the tilt point of view, and states that the results of his investigation appear to favor the idea of explaining them in this manner. Whether these waves of tilting are propagated in that particular form from the origin, or locally induced by the regular "P" wave, is left as an open question R.M.W.

PRECISE LEVELS ON MAUNA LOA

Lieutenant Simmons, of the U. S. Coast and Geodetic Survey, is this week begining work on the line of precise levels to be run from Hilo, via the Volcano of Kilauea, to the summit of Mauna Loa. This line of levels, in addition to making a determination of the elevation of the summit of Mauna Loa, will also provide means of establishing bench marks upon which later leveling may be done. to secure evidences of possible changes of elevation. This work should yield very interesting results when considered in connection with the tilting of the ground as recorded by the seismographs at the Hawaiian Volcano Observatory. R.M.W.

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No. 94 RELEASED WITHOUT COPYRIGHT RESTRICTION October 14, 1926

KILAUEA REPORT No. 770

WEEK ENDING OCTOBER 13, 1926

Issued by the Observatory, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

At the pit of Halemaumau there has been no activity of note during the past week, with the exception of an occasional avalanche, of which the most striking was one noted at about 9 a. m. on October 12 by a number of people at the Volcano House. The number of earthquakes for the week is only 12, being a very considerable decrease from the number of last week. This continual decrease in the number of earthquakes per week has been continuing for the past two months. There were three days this week upon which no earthquakes were recorded during the 24 hours, October 7, 11, and 12. Of the 12 earthquakes recorded there were two worthy of note. One local shock which occurred at 5:41 p. m. on October 9 was almost intense enough to be felt and lasted for nearly two minutes. The other quake is a teleseism of which the "P" wave began at 8:45:04 a. m. October 13, Hawaiian standard time. The indicated distance is 2,370 miles. Owing to the weakness of the initial motion of the "P" wave, it is difficult to estimate the direction. The entire disturbance as recorded on the seismographs lasted over an hour before the waves completely faded out.

Microseisms during the first part of the week were somewhat stronger than usual. The accumulated tilt has been only very slightly towards the west.

EARTHQUAKES AND EARTH ROTATION

In the "Transactions of the Astronomical Observatory of Yale University," Volume 3, Part VI, Dr. E. W. Brown has set forth his investigation of the constancy of the earth's rate of rotation. This is especially interesting from the point of view of Seismology and Volcanology in that the cause of these changes in rate of rotation is ascribed to geophysical changes within the earth itself. To change the rotational momentum of the earth, some gain or loss of either its mass or its impounded kinetic energy of rotation must take place. Its rotational kinetic energy is drained slightly by tidal friction. This effect is well understood and has been corrected for in the investigation. But apparently there still remain unexplained changes in the rate of rotation, in addition to the retardation explainable by tidal friction. Rate of rotation, mass and distribution of mass (moment of inertia) are factors making up rotational momentum. It is therefore possible to alter the rate of rotation, and yet retain rotational momentum and mass unchanged, by altering the distribution of the mass. Thus if the earth expands, its mass is distributed on the whole somewhat farther from the axis of rotation, its moment of inertia is greater, and therefore its rate of rotation may be slower, without loss or gain of mass or energy. An example of this effect may be had by swinging a weight on a string in a complete circle, allowing the string to wind up on the finger—the shortening of the radius will speed up rotation without the input of any more energy.

Dr. Brown suggests periodic expansion and contraction of the earth, in amount between five inches and twelve feet change of mean radius, as an explanation of the apparent fluctuations in rate of the earth's rotation. These fluctuations in rate are detected astronomically in the discrepancies developed between the computed and observed places of the moon and sun. That is, using time as derived from orbital motions and the gravitational theory the earth appears to run ahead or behind its mean rate of rotation by a slight amount, so that in the course of years a few seconds may be gained, then lost, and gained again.

If this is to be explained by the shrinking and expanding of the earth, one might expect to find evidences of it here beneath our feet. Dr. Brown reasons that this amount of change would by no means be enough, in itself, to stretch or shrink the crust of the earth to the point of fracture. But these periodic strains in the crust of the earth may be enough to liberate or shake loose greater strains accumulated almost to the breaking point through other causes—isostatic compensation for example. The investigation shows, in fact, that there is apparently a rough correlation between frequency of earthquakes and change of rate of rotation. Astronomy has, therefore, brought a direct challenge into the realm of geophysics.

R.M.W.

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No. 95 RELEASED WITHOUT COPYRIGHT RESTRICTION October 21, 1926

KILAUEA REPORT No. 771

WEEK ENDING OCTOBER 20, 1926

Issued by the Observatory, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

During the past week there have been no notable changes at the pit of Halemaumau. The seismographs show very few earthquakes, there being only 12 very feeble ones recorded for the week. On the 14th and 15th microseisms were somewhat stronger than usual, and on the 16th there were very faint evidences of occasional spasmodic tremors which have not been included in the count above. There has been moderate tilt towards the east accumulating during the week.

Last week, just as the Volcano Letter was being prepared, a strong teleseism was received which was described at that time. The records from the seismographs at Hilo, Kealakekua, and Hilea, which have since been received, also recorded this earthquake.

A letter from Mr. R. H. Finch, who is in charge of establishing the Geological Survey volcano observatory at Mount Lassen, California, has just been received. Mr. Finch states that the excavation for the seismograph cellar is well under way and he expects to have the seismographs in operation by the end of this month.

Lieutenant L. G. Simmons of the Coast and Geodetic Survey is now camped at the Rest House at an elevation of about 10,000 feet on Mauna Loa. He is endeavoring to complete the upper end of the precise level line before the coming of winter weather. This level line, as stated in a previous Volcano Letter, is to be run between sea level and the summit of Mauna Loa. The work is being done with the high degree of accuracy usual in precise levels, being run independently in both directions with a standard prism level, and level rods having the graduations on invar metal. The U. S. Coast and Geodetic Survey is also planning this winter to make observations for gravity at the summit of Mauna Loa and also to establish a standard tide gauge at Hilo. These precise geodetic surveys will be of invaluable assistance in learning more of the activities within Mauna Loa.

The University World Cruise, a floating college comprising a full faculty and students to the number of about 570 persons, visited the volcano on the 18th. On the 19th the Los Angeles Chamber of Commerce visited the volcano with 107 persons in its party. These two days, therefore, brought a flood of visitors, many of whom were much interested in seismology and volcanology.

EARTHQUAKES DUE TO COLLAPSE

An extract from the Johannesburg "Star" (Transvaal) tells of the establishment 16 years ago of a seismograph at the Union Observatory in that city. This instrument was established to study the earthquakes felt in the vicinity of extensive mines at that place, to determine whether the quakes were of natural origin or were caused by settling and collapse due to mining excavations. In the early days, before the ground had been honeycombed by mining operations, no earthquakes had been noticeable, but in 1905 earthquakes began to occur with increasing frequency. In 14 years, following the establishment of the seismograph in 1910, there were recorded 5,427 local shocks of which about one-seventh were classed as strong. These earthquakes tend to occur in series or batches, being most frequent in the dry season, perhaps due to lack of the binding effect of moisture in soil and rock. The fact is noted that the greater number of these earthquakes, and those having the greatest intensity, occurred during the early morning hours.

Realizing that these earthquakes were probably caused by the settling of the workings of the mines, more care was exercised in timbering and in refilling abandoned tunnels with waste material, to guard against collapse. A response to this care has been shown in the diminishing number of local earthquakes registered on the seismograph.

If earthquakes can be caused by artificial excavation, may it not be that some of our ordinary earthquakes are caused by the collapse of internal voids in the earth, such as might be left by retiring magma?

This idea is perhaps supported by evidence furnished in both of the recent eruptions on Hawaii; the explosive eruption of Kilauea on May 11, 1924, and the lava flow on Mauna Loa on April 10, 1926. In both of these cases it was during the waning phases of the eruptions that the maximum number and violence of earthquakes occurred. This may mean that the subsiding pressure or retiring magma, allowing the upper layers of the earth's crust to settle back, has caused earthquakes due to this readjustment.

R.M.W.

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No. 96 **RELEASED WITHOUT COPYRIGHT RESTRICTION** October 28, 1926

KILAUEA REPORT No. 772

WEEK ENDING OCTOBER 27, 1926

Issued by the Observatory, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

A few slides and avalanches in the pit of Halemaumau represent all the activity noted during the week. There have been 15 local earthquakes, all very feeble, and three teleseisms. On October 23 there were a few very minute spasmodic tremors that have not been included in the above count of earthquakes.

Two of the teleseisms were recorded on the 22nd and occurred almost precisely an hour apart, their maxima coming at 2:21 a. m. and 3:21 a. m., respectively, Honolulu time. These earthquakes, according to Associated Press report from San Francisco, were sharply felt in San Francisco at 4:35 and 5:36 a. m., Pacific Standard Time, which, allowing for the time difference, would be 15 minutes before they were recorded here. A peculiar circumstance is that two local earthquakes occurred almost exactly an hour apart, the first one following 16 minutes after the first teleseism, and the second local shock following the second teleseism by the same amount of time. This is perhaps no more than an interesting coincidence.

The third teleseism was on the 25th, the preliminary wave arriving at 5:26 p. m. and the main wave at 5:46 p. m., Honolulu time. The estimated distance to the origin of this earthquake is 4,440 miles. A United Press report states that this earthquake was recorded at Ewa, near Honolulu, at about 5:55 p. m., Honolulu time, the distance indicated by the record at that observatory being 4,590 miles. The accumulated tilt during the week is slightly to the SW.

AN ACHIEVEMENT

In "Science," the issue of October 1, 1926, the resolutions adopted by the American Geophysical Union are of considerable interest. That resolution concerning the determination of the value of gravity at sea is of especial interest from the point of view of seismology. It almost seems that Dr. F. A. Vening Meinesz, of the Dutch Geodetic Commission, has accomplished the impossible.

To accurately determine the value of the attraction due to gravity is a delicate operation even on land. A pendulum, swinging in a partial vacuum, is timed very carefully. The value of the attraction due to gravity is computed from the time taken for a complete swing of the pendulum, by the usual formula of phsics. But in order to attain the great accuracy necessary to discover the minute variations in gravity, there are many precautions and corrections to be applied. Rigidity of support for the pendulum, elevation above sea level, and accurate time are matters of prime importance which on land can be satisfactorily attended to. But at sea complications are introduced that seem almost insurmountable. There can be no rigid support for the pendulum—a ship at sea must always have motion that will disturb the natural swing of the pendulum. The elevation of the instrument at sea, due to tide and wave, is difficult to determine. In fact, all the complexity that attends the determination on land is many times multiplied in a determination at sea.

Dr. Meinesz conducts his observations in very cramped space in a submarine, which in itself is an accomplishment. He uses a submarine in order to get into the comparatively quiet water below that agitated by wave action. Instead of swinging one pendulum only, as in land observations, Dr. Meinesz swings three, in planes making 120° with one another. These furnish sufficient data so that the effect of the motion of the submarine can be computed and eliminated.

In the face of all the difficulties presented, the accuracy attained is comparable to that resulting from land observations. Most certainly this is an achievement of high order.

Seas and oceans cover nearly three-fourths of the earth's total area. Land gravity stations can only cover a limited part of the earth, and this method will enable studies of gravity to be made systematically over the whole earth. Dr. Meinesz hints that certain areas may show values of gravity that are not in accord with completed isostatic compensation, which would probably have a definite bearing on seismic activity.

Dr. Meinesz visited the Volcano of Kilauea about a month ago, and was very generous in telling many of his interesting experiences.

R.M.W.

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No. 97 RELEASED WITHOUT COPYRIGHT RESTRICTION November 5, 1926

KILAUEA REPORT NO. 773

WEEK ENDING NOVEMBER 3, 1926

Issued by the Observatory, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

A couple of large avalanches were noted on Saturday and Sunday in the pit of Halemaumau. There have been no other notable changes or activity at the pit. Eight local earthquakes and two teleseisms occurred during the week. The local earthquakes were all very feeble, with the exception of that which came at 12:16 a. m. on October 31. This shock, apparently about 14 miles from the observatory and probably on the rift line of Mauna Loa, was of sufficient intensity so that one of the seismographs was partly dismantled. There have been no reports of its having been felt, probably due to the time of its occurrence, although its maximum acceleration indicates that it should have been perceptible.

One teleseism, which occurred at 9:20 a. m. on the 30th, was rather feeble, and no estimation as to distance and direction could be made. The other teleseism, at 3:27 p. m. on the 31st, had a maximum amplitude of 0.61 millimeters actual movement of the ground. This produced on the seismogram a record about six inches wide. In spite of the apparent size and intensity of this earthquake, no preliminary wave could be distinguished, probably being obscured by microseisms. The seismograph operated by Captain R. D. Woods in Kealakekua, Hawaii, also recorded this earthquake. A telephone message from him was the first news of the quake at the observatory, as the seismographs had not been inspected during the afternoon.

Tilt has been accumulating slightly to the east during the week.

USE OF VOLCANIC ENERGY

Manifestations of such liberal amounts of energy as occur in volcanoes, earthquakes and geysers, naturally lead to thoughts of harnessing and making use of this energy. The tides have been to a certain extent made use of in generating power, and large projects of further developments are in view. Volcanic energy is more difficult to harness, but has been successfully done.

Prince Piero Ginori-Conti, President of the Italian Society of General and Industrial Chemistry, tells (New York "Times," September 15) of using volcanic steam in the region of Vesuvius. The steam escaping from the ground is under low pressure—about 30 pounds per square inch at best, and it has been successfully utilized even when the effective pressure is as low as five pounds per square inch. It was at first an experiment. In 1903 a small engine was run at Larderello by steam escaping from a natural vent. Since that time wells have been drilled tapping larger supplies under better pressure, so that in 1914 a plant of three turbo-alternators was running with a net power output of 2,500 kilowatts.

The wells drilled are 16 inches in diameter, and vary in depth from 180 feet to 750 feet, ordinarily by using a rotary drill. In the Larderello district the steam brings with it various gases that have commercial value, as carbon dioxide, helium, and argon. Also sulphurous gas is separated from the steam before it reaches the engines.

Geysers have also been tapped, and made to deliver power. Prince Ginori-Conti says that there are in our western states geysers that are comparable to the ones that have been utilized in Italy.

In order to find natural volcano steam under pressure it is probably essential to have the surface strata sufficiently impervious to confine the steam. In the vicinity of the Volcano of Kilauea the structure of the upper layers, at least, is not only composed of a rather porous lava, but is also broken by many earthquake cracks. Thus steam that is formed underground has so many natural vents that it has practically no effective pressure when it reaches the surface. But there is aparently an inexhaustible supply, and pressure might be found by deeper drilling.

Apparently hopeful ambition is not lacking in the matter of harnessing the volcano noted in an extract from the "Madras Mail" of September 9, 1926, though in this case it seems to be to muzzling, rather than utilizing, the volcano's output. The extract is as follows:

"Farmers living near the Masaya volcano, in Nicaragua, who have clung to their homesteads in spite of damage frequently done to their crops by poisonous gases given off by the mountain, have apparently decided to muzzle their enemy.

"According to the latest report they have employed a group of German engineers, who propose to build a cap over the crater, and by the injection of certain chemicals, to neutralize the gases, which, if necessary, will be allowed to escape through a safety valve." R.M.W.

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NO. 98 RELEASED WITHOUT COPYRIGHT RESTRICTION November 12

KILAUEA REPORT NO. 774

WEEK ENDING NOVEMBER 10, 1926

Issued by the Observatory, U. S. Geological Survey:

R. M. Wilson, Temporarily in Charge

Conditions at the pit of Halemaumau remain unchanged. The steaming at the southwest talus continues, and there are still occasional avalanches.

During the week there have been eleven local earthquakes, all very feeble, and one teleseism, which occurred at 9:45 p. m. Hawaiian Standard Time on November 4. This was apparently a minor earthquake with indicated distance of 2,160 miles. During the week microseisms have been unusually strong. Accumulated tilt has been slightly to the east.

PRECISE LEVELS ON MAUNA LOA

Lieutenant L. G. Simmons, of the U. S. Coast and Geodetic Survey, now has the Mauna Loa level line completed about halfway from the summit of the mountain to the Volcano House. The difference of elevation between the summit and the Volcano House is a little less than 10,000 feet, and the distance is approximately 30 miles. In running spirit levels, level sights only are taken, and rods of 10 or 12 feet in length are used, therefore for each time the instrument is set up, only about nine feet in elevation can be gained, as an average. To make a single measurement of this difference of elevation thus requires, roughly, 1,100 "set-ups" of the instrument. But as this work is being double run—that is, each part is run in both directions—it is actually being run twice, as a check. Lieutenant Simmons will therefore have to set up, level, and read his instrument about 2,200 times to complete this section of the work. One hundred "set-ups" are considered a very fair day's work.

So far, during the progress of the work, the weather has been favorable. Rain is not so frequent on the higher part of Mauna Loa, and wind has not bothered excessively.

The party camped at the Rest House, beside Red Hill, for a while, at about 10,000 feet elevation, and then moved to the "Hotel de Jaggar" not far from the summit and at the northeast end of the Crater of Mokuaweoweo, where they stayed about 10 days. This camp is no more than a lava tube, which affords meager shelter if one is inclined to get down on hands and knees and crawl for it. A caved-in portion of the tube is the front door, which, covered with a sheet of canvas, also served as kitchen and commissary. Water in the crevices of the lava supplied the camp, though it was necessary each morning to break through an inch of fresh ice. It is a surprising fact that mice were found at this camp, easily 5,000 feet above the highest outpost of vegetation.

The party is now camped below the Rest House, at an elevation of about 6,500 feet, in comparative comfort below timber line.

THE SEISMOGRAPH STATION AT KEALAKEKUA

The Hawaiian Volcano Observatory is located on the east flank of Mauna Loa. On the west flank, in Kealakekua, is the branch station operated by Captain R. V. Woods, consisting of a single horizontal pendulum mounted in a N—S plane, being thus most sensitive to E—W motion. This instrument is of simple construction, yet during the few years of its operation has been very successful in detecting both local shocks and teleseisms. Many earthquakes have been recorded both on this instrument and on the instruments at the Hawaiian Volcano Observatory. Comparison of the records is especially interesting on account of the fact that the line between the two stations passes practically through the middle of the great mass of Mauna Loa. The two stations are also almost equidistant from the center of this volcano, and are therefore strategically placed as observation posts to study the interior workings of the mountain. Comparative study has heretofore been somewhat hampered by the difficulty of accurate time comparison. For a long time the clocks at the observatory have been corrected by the radio time signals, but at Kealakekua dependence was placed upon time secured by telephone, sometimes more than a minute in error. A radio set for receiving time signals has just been installed at the Kealakekua station. A key placed beside the radio set is connected into the station clock circuit, so that at the instant the time signal is received the key is depressed, thus recording it on the current seismogram along with the minute marks made by the station clock. To obtain the clock correction it is therefore necessary to simply measure on the seismogram the time interval between the radio time and the clock time. It is believed that time can thus be secured to within half a second or better. This will make possible the comparison of the time of arrival of shocks at the two stations with a fair degree of accuracy. R. M. W.

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No. 99 RELEASED WITHOUT COPYRIGHT RESTRICTION November 18, 1926

KILAUEA REPORT No. 775

WEEK ENDING NOVEMBER 17, 1926

Issued by the Observatory, U. S. Geological Survey:

R. M. Wilson, Temporarily in Charge

The pit of Halemaumau is still confining its apparent activity to occasional small avalanches, and continued steaming at various points on the floor of the pit and through the talus slopes. Conditions remain practically unchanged.

Rumors and reports have occasionally been heard of a glow, or smoke, being seen on Mauna Loa. Lieutenant Simmons, camped near the summit, has seen no sign of activity, nor have the seismographs indicated any unusual activity. The 1926 flow is probably still warm enough to convert into steam any rain that falls upon it, thus perhaps giving rise to rumors of smoke on Mauna Loa. The same thing happens in the pit of Halemaumau—during and after a rain the steaming is much more pronounced.

There have been but eight very feeble local earthquakes recorded this week, and no teleseisms. On the 14th of November microseisms were exceptionally strong, perhaps due to the high wind that prevailed upon that day. Tilt accumulated during the week has been moderate to the N.E., coming mostly on the 14th.

THE FIELD OF THE SEISMOGRAPH

The seismograph, as its name implies, was primarily designed to study earthquakes. That is of course its major application, but its other practical usefulness is sometimes not realized. Practically all modern knowledge of the mechanics of earthquakes and the propogation of earthquake waves has come from data furnished by the seismograph in its various forms. It is now being used not only for general study, but for obtaining information upon certain definite points of commercial and industrial interest.

In the Volcano Letter of October 21, mention was made of the use of a seismograph installed to detect local and artificial shocks due to mining operations.

Oil companies have been making successful use of seismographs to help locate oil formations. This is done by setting off charges of explosive, thus causing an artificial earthquake of which the time and place may be accurately determined. The record made on a seismograph at some distance away is then studied. The earth waves originating with the explosion are reflected back from the underground strata, and careful timing yields data from which the depth of these strata may sometimes be computed.

An instrument, operating upon the same principle as a seismograph, has been used mounted upon a railroad car, recording during the car's progress the sway caused by unevenness of roadbed.

In engineering, seismographs are adapted for use in studying the nature and amount of vibration in structures. Mounted on bridges or buildings, deflections and sway due to passage of vehicles, to variation of loading, and to wind pressure might be recorded, if these motions are of sudden or periodic nature. Slight tipping, such as might occur due to unequal settlement of foundations, would also be recorded. The effect of earthquakes on tall buildings might so be studied.

Many may be written on the use of seismographs as an aid in detecting danger to structures due to earthquakes. In the April-June, 1926, issue of the "Materiaux pour l'Etude des Calamites" (Societe de Geographie de Geneve) Dr. G. Agamennone, Directeur de l'Observatoire royal de geophysique de Rocca di Papa, writes on the menace of dams built for hydroelectric developments. There have been several calamities due to the failure of such dams, resulting in loss of life and damaged property in the flooded areas. Dr. Agamennone suggests various reasons for such failures—unusually heavy rains, poor design, undermining due to leaks under the foundations, and so on. He states that earthquakes may easily cause such failures in various ways. An earthquake may not cause an immediate failure, but may so crack the structure as to allow water to seep through and complete the destruction. Dr. Agamennone suggests that since the success of a project depends upon the care with which it is planned, that a study of the seismic conditions might well be made at a site chosen for a dam. Engineers consider rainfall, geologic structure, and many other things, but sometimes neglect seismic activity as a factor in determining the design of the dam. Frequency and intensity of local shocks should be considered, both through historical information and by setting up seismographs at the chosen site. When the dam is built, as a measure of protection seismographs should be installed at the dam.

Dr. Agamennone suggests that laws should be passed enforcing this precaution, as it would be but a small amount of insurance invested towards the safety of those living below the dam. Such instruments might give early warning of earthquakes of sufficient magnitude to endanger the dam. If mounted on the dam itself they would give warning by recording any undue vibration, settling or "giving" of the structure. Certainly these instruments would be excellent sentinels to report the coming of danger, and might easily minimize the loss of life, through warning, that would probably result should the dam fail. Sometimes legal suits result from such a failure. Seismograph records would be important evidence in ascertaining cause and blame. R.M.W.

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No. 100 RELEASED WITHOUT COPYRIGHT RESTRICTION November 26, 1926

KILAUEA REPORT No. 776

WEEK ENDING NOVEMBER 24, 1926

Issued by the Observatory, U. S. Geological Survey:

R. M. Wilson, Temporarily in Charge

At the pit of Halemaumau continued steaming has increased the yellow sulphur deposits at various places, and dust from avalanches has begun to settle on the black lava portion of the floor to such an extent as to be noticeable, causing the floor to be of a dusty, reddish tint, rather than the shiny black of the fresh lava. On November 22, at 1:20 p. m., a very considerable avalanche was noted, the dust continuing to rise in heavy clouds from the pit for five or ten minutes. An inspection of the seismogram shows a very slight tremor at that time, probably caused by this avalanche. This slide appears to have been a sloughing-off of the lower part of the wall on the north side of the pit.

There have been eighteen local earthquakes this week. All of these were much too feeble to be felt, but two of them were large enough to show definite preliminary phases indicating the distance of each to be about 28 miles. On November 20, during the middle of the day, a few very minute spasmodic tremors were noted, which have not been included in the above count. For the past several weeks the frequency of earthquakes has been very low. The number this week marks a very considerable increase. It is perhaps possible that the low ebb of seismic activity is at an end and that more frequent earthquakes may be expected.

Tilt during the week has accumulated slightly to the northwest. Tilt accumulated since the middle of September is about seven and one-half seconds of arc towards the east, and about five seconds of arc towards the north.

OCTOBER TELESEISMS

During the month of October there were seven teleseisms recorded at the Hawaiian Volcano Observatory. These were noted briefly in the current Volcano Letters. Information from other stations, not available at the time these Letters were published, has since been received. This makes possible the comparison of the various data from other parts of the world with the data recorded here.

In Volcano Letter No. 93 of October 7 a teleseism is mentioned as having been recorded at 8:45 a. m. Hawaiian Standard Time on October 3. This corresponds to 19:15 Greenwich Time. The trace of this earthquake was a feeble one and the disturbance noted at the time was probably not the preliminary wave as was then supposed. The preliminary wave probably arrived at 19:50 Greenwich Time. This earthquake apparently caused some doubt at other stations as to the position of the epicenter, and no conclusion seems to have been reached concerning it. A very uncertain estimate of the distance from this station is 5,670 miles.

On October 13, as noted in Volcano Letter No. 94, an earthquake was recorded, beginning at 8:45:04 a. m., corresponding to Greenwich Time 19:15:04. An estimate of 2,370 miles was made for the distance to the epicenter of this earthquake. From other stations come reports of three earthquakes on that day, all in the same region, near the Aleutian Islands, the one recorded here being the third. Its epicenter as computed by the central station of the Jesuit Seismological Association, St. Louis, is 51 degrees north latitude and 178 degrees west longitude. This checks with the distance from this station as estimated above. The first earthquake of this day was also recorded on the seismograph at this station, but was so faint as to have been overlooked at the time. The preliminary wave of this first earthquake was recorded at about 6:10 Greenwich Time.

The earthquakes felt in San Francisco on the 22nd of October, noted in Volcano Letter No. 96, attracted considerable notice from the press. The preliminary bulletin of the central station of the Jesuit Seismological Association makes no computation of the position of the epicenter except to say that these two shocks were apparently at approximately the same place and about 640 miles from the station at Tucson, Arizona. These earthquakes perhaps occurred two or three hundred miles off the south-central portion of the coast of California.

Another earthquake was also mentioned in Volcano Letter No. 96, recorded on the 25th day of October at 5:26 p. m., Honolulu Time, corresponding to 3:56 October 26 Greenwich Time. This earthquake apparently took place about five or six hundred miles south of the southwest end of Japan.

The earthquake which was recorded here at 9:20 a. m., Honolulu Time, on the 30th, occurred at 19:41:28 Greenwich Time, near the Queen Charlotte Islands, British Columbia, Canada. The latitude and longitude of the epicenter as given by the U. S. Coast and Geodetic Survey from combined data is 53 degrees north and 129 degrees west.

The earthquake which was recorded here at 3:27 p. m. on the 31st, Hawaiian Time, is reported as having occurred at 1:39:10 Greenwich Time on November 1 in latitude 50 degrees north, longitude 130 degrees west. This is only two or three hundred miles south of the earthquake just described above on the 30th. R.M.W.

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No. 101 RELEASED WITHOUT COPYRIGHT RESTRICTION December 2, 1926

KILAUEA REPORT No. 777

WEEK ENDING DECEMBER 1, 1926

Issued by the Observatory, U. S. Geological Survey:

R. M. Wilson, Temporarily in Charge

The pit of Halemaumau is still quiet. The steaming continues and has made a yellow deposit of sulphur at one point on the southeast talus. A new deposit of sulphur has also appeared near the foot of the northwest talus. Avalanches are infrequent.

The total number of earthquakes for the week has been nine, of which four occurred on the afternoon of the 29th of November. All of these were very feeble with the exception of one which came at 4:09 p. m. on the 29th. This was strong enough to be felt by a few persons in the vicinity, being a local shock with a maximum acceleration of about 8.0 millimeters per second per second. During the afternoon of the 29th there are evidences of occasional very slight spasmodic tremors, in addtion to the earthqaukes noted above.

Tilt has been accumulating during the week slightly towards the southwest.

SEISMOLOGY AND GEODESY

Seismology is intimately involved with many other branches of science, geodesy being one of the most important. Geodesy, dealing as it does with measurements over large areas of the earth's surface, is available as a means of discovering movements of the earth's crust due to seismic and tectonic forces. Trinagulation is used to measure the horizontal surface displacement resulting from earthquakes; precise levels to discover change in slope, or tilt, and differences in elevation due to vertical displacement. Tide gauges may record sudden or gradual elevation or depression of a shore line. Astronomical latitude and longitude observations may show change of position of great areas of the earth's surface, as in the theory of the "Drift of Continents."

Surveys of the earth's surface in general have been made to determine dimensions of areas for various civil uses, without thought that these areas may be measureably changing. The ever-increased accuracy with which geodetic surveys are being made is developing the fact that our apparently solid earth is actually undergoing surface movements that may be directly measured. Geology easily shows that the earth's surface has many times been made over. But geology deals in such vast periods of time to accomplish these changes, that an individual, in the few years given him in which to observe, must observe very closely to see the changes actually progress.

Successive surveys over the same area will always show discrepancies, even if no actual change in the area exists, as curveys and measurements can never be exact. Thus two surveys will differ, due simply to errors and inaccuracies in measurement which cannot be reduced to zero, even by the most careful work. The actual ground movements are usually small, and it is therefore difficult as a rule to separate, in the discrepancies developed by two successive surveys, the amounts that are due to measurement errors and to actual movement or change of dimensions of the measured area. If the probable errors of measurement are known, through knowledge of the methods employed, and if the discrepancies developed are considerably in excess of such probable errors, then it may be said that very likely actual movement exists.

Triangulation, by the U. S. Coast and Geodetic Survey, has successfully shown earth movement over large areas in California (U. S. Coast and Geodetic Survey Special Publication No. 106, "Earth Movements in California"), and a very comprehensive compilation of old triangulations has been made by R. H. Tucker in the September, 1926, issue of the Bulletin of the Seismological Society of America, wherein is shown the definite measurement of the relative displacement accumulated along the San Andreas fault between 1885 and 1907.

Spirit levels in Japan, re-run after the eruptions of Sakurajima and Usu, showed cases where relative differences of elevation had changed many feet in the regions around these volcanoes. Levels run in 1912 around the Volcano of Kilauea showed the presence of tilt, and more elaborate running in 1920 and 1921 apparently confirmed the idea that the elevations at this volcano are changeable, causing slight tilting or altering of grade in the slopes of the mountain.

Observations are now in progress to simultaneously establish accurate astronomic latitude and longitude stations in various parts of the world. In future years these stations may be again occupied, thus perhaps making a direct measurement of changes in latitude and longitude of a given point on the earth's surface due to its horizontal movement under the impluse of isostatic adjustment, faulting or other causes.

Therefore, in many ways are the surface motions of the earth being watched. Geology shows the results of past changes. Many of the earthquakes studied in seismology are the indication of present changes in progress—they are in fact the creaking and groaning and cracking of the earth's crust under the forces that are remodelling it Such surveys as are here mentioned may help in the future to show where, and in what amount, this remodelling is taking place. R.M.W.

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No. 102 RELEASED WITHOUT COPYRIGHT RESTRICTION December 9, 1926

KILAUEA REPORT No. 778

WEEK ENDING DECEMBER 8, 1926

Issued by the Observatory, U. S. Geological Survey:

T. A. Jaggar, Official in Charge

During the past week Halemaumau pit has developed no volcanic activity and the Mauna Loa-Kilauea system continues quiet, though some earthquakes slightly perceptible have occurred. The earthquake reported last week, of 4:09 p. m. November 29, gave evidence on the seismographs of Kona, Hilea and the Observatory of an inward tilt towards the Mauna Loa center at these stations, exhibited as a sudden swing of the pendulums, causing off-set of the seismogram lines, from which there was no recovery afterward. This sudden tilt accorded with the accumulated southwest tilt at the observatory. This would all seem to indicate that the Mauna Loa rift belt, after the eruption of April, 1926, is still subsiding.

Halemaumau has on the south talus a bright yellow sulphur patch about 25 feet in diameter, with blackened stones in its midst. This was formerly a superheated, whitish, dry area in the midst of steam-wetted talus. Prolonged dry weather has developed six other paler sulphurous patches. During 20 minutes today rocks fell twice at the NNE wall. Sixteen steam jets occur about the bottom of the pit.

Only six earthquakes for the week were registered. One of these at 1:29 a. m. December 2 was of intensity sufficient to be perceptible, and the seismogram indicated an origin 10 miles away in the line of direction N 68° W. Tilt for the week was slight to the east.

SCIENCE CONGRESS IN TOKYO

The Third Pan-Pacific Science Congress opened in the great hall of the Imperial University of Tokyo on October 30 and closed its session November 11. More than 200 delegates from overseas were present and some 400 delegates from Japan. The Congress was organized with extraordinary efficiency under the able leadership of Dr. Sakurai, and the foreign delegates were entertained lavishly by the Imperial Government and by distinguished citizens of the Empire. Excursions were provided, before the Congress opened, to the Ainu villages of Hokkaido (the northern island of Japan), to the Cretaceous and Tertiary deposits of that island, and to Tarumai volcano, which staged a small explosive eruption just at the time of the Congressional visit. Other excursions prior to Congress were to Nikko and Hakone, and these beautiful mountain districts were in the full glory of autumnal foliage. Numerous short excursions occupied the week-end of November 6 and 7, and after the Congress there were long excursions to central Japan, the Inland Sea, and the mines, hot springs, and volcanoes of Kyushu. All of this travel was furnished to the overseas delegates at the expense of the Imperial Government, and was even extended to Korea for those delegates who were headed toward China.

The countries represented in the Congress were Japan, the United States, Australia, Canada, China, France, Great Britain, Hawaii, Hongkong, Holland, the Dutch East Indies, New Zealand, Papua, the Philippines, the Strait Settlements and Federated Malay States, Russia, Sweden, Peru and Chile.

More than 400 papers were presented in English, the official language, and geophysical sciences were represented by a large number of delegates. Oceanography was accented, and the geological sciences had more representatives than any other group. Japan exhibited instruments and methods, bearing on seismology and earthquake-proof construction, greatly in advance of former practice. At Kyoto there are seismographs with magnification of 50,000, electrical transmission of the motion, and vacuum-tube amplification for registration. Remarkable new accelerographs and vertical-component instruments are under test in the University of Sendai and at the Imperial University of Tokyo. Dr. Imamura has new horizontal pendulums, designed for registering great earthquakes by reducing the amplitude instead of magnifying it, and others of extraordinarily long period by means of special adjusting screws and great height to the supporting columns.

The discussions of the Congress developed the need for more extensive translation of scientific works written in obscure languages. Resolutions were passed on motion of those interested in volcanology and local seismology, recommending (1) more published notes at short intervals, (2) more cooperation by radio, (3) more interchange of research workers, and (4) translation of far-eastern scientific books through such interchange.

It was provided that the Congress of 1929 shall be held in Java. T.A.J.

VOLCANO EXHIBIT PROJECT

The Hawaiian Volcano Research Association has now provided for an exhibition room to be built adjacent to the volcano observatory at Kilauea. For many years travelers who have visited the pit and the active lava flows have come to the observatory keenly interested to ask questions about volcanology. The new establishment is designed to meet this demand with what may be called a "live museum," that is, a place for short lectures, demonstration of maps and charts, projection of motion pictures and lantern slides and an exhibition seismograph. Plans for the building have been drawn, a curator will be appointed to care for this work, and the exhibit will be opened during the first half of 1927. T.A.J.

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No. 103 RELEASED WITHOUT COPYRIGHT RESTRICTION December 16, 1926

KILAUEA REPORT No. 779

WEEK ENDING DECEMBER 15, 1926

Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in Charge

No new activity has appeared in the volcanoes Kilauea and Mauna Loa. A visit during the past week to Mauna Iki shows that the rusty spots in the top of that hill are hotter than ever. A stick thrust in a crack ignited instantly at one of these spots. Halemaumau, the lava pit of Kilauea, exhibits still further increase in the sulphur stain of the south talus. A new patch of yellow has developed at the margin of that talus, while the large yellow patch in its midst still shows strong solfataric activity. There is very little avalanching.

Fourteen earthquakes have been registered on the seismographs, all small and local except one. This last was a faintly recorded teleseism reaching a maximum at 10:25 p. m. December 9. The U. S. Coast and Geodetic Survey reports the time of occurence at the source 8 h. 37 m. 59 s. Greenwich Time December 10, and the place on the bottom of the ocean about 1,000 kilometers west of Cape Mendocino, California, at 41° N. Lat. and 136° W. Long. Tilt for the week at the Observatory was very slight to the east.

LASSEN REPORT NO. 2

The first note from Lassen Volcano Observatory in California was printed in the VOLCANO LETTER of October 21. Mr. R. H. Finch, Associate Volcanologist, now reports that the seismograph pendulums have been operating about a month (November 24), are still in process of adjustment, and have shown no earthquakes. Mid-November produced heavy rains at Mineral, where the volcano station is located. For several days the rainfall was three or four inches per day, and high winds blew down the big yellow pine trees with crashes like the rumble of earthquakes. The road to Mineral was blocked by fallen trees. Snow developed in the latter part of the storm.

"A man who has been cattle-ranching in the Lassen countrty for twenty1five years, told of hearing distinct rumbling from the volcano about 18 years ago. (The eruption was in 1915). The water that went down Hat and Lost creeks during the mud flows of 1914-15 was still warm 18 miles down their valleys. The Lassen edifice has certainly been getting a soaking this month."

"November 29. Winter conditions here are quite primitive. I am all by myself with the nearest neighbor about a mile away. All water has to be carried. Fortunately there is a brook about 500 feet away. So far there has been practically nothing recorded on the seismographs. They are not yet in final shape. The road to Susanville is still open, while some of the Sierra roads farther south are closed on account of heavy snow."

The Lassen Station at present consists of an office and seismograph cellar at Mineral near the Lassen Park headquarters, and a cottage for the volcanologist has been kindly supplied by the U. S. Forest Service. The seismograph cellar was started September 20 and finished October 5. The office building was finished October 19. The seismographs are of the horizontal pendulum type, built on the spot, but the time-piece is an excellent Howard seconds pendulum clock, electrically fitted. T.A.J.

EARTHQUAKE OF SEPTEMBER 16

In the Volcano Letter of September 23 we reported a big earthquake west of the New Hebrides, Greenwich time 17h. 59m., September 16, and another about five hours later. The center was located by the U. S. Coast and Geodetic Survey.

The Sydney Morning Herald of 28 September reports that the ship Mataram on that day (September 17 in Australia), was docked at Yandina, Solomon Islands. The shock was felt all over those islands, and much furniture was knocked about on the ship. On Tulagi the earthquake was very severe. Twelve distinct shocks were felt during the day, the most powerful about noon and five p. m. local time. The wharf was damaged at Makambo, and natives were panic-stricken at Viduna, a cattle ranch, where the principal shock lasted about one minute.

T.A.J.

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No. 104 RELEASED WITHOUT COPYRIGHT RESTRICTION December 23, 1926

KILAUEA REPORT No. 780

WEEK ENDING DECEMBER 22, 1926

Issued by the Observatory, U. S. Geological Survey:

T. A. Jaggar, Official in Charge

The past week has been excessively rainy at Kilauea, and the only changes noted at Halemaumau pit were wetting of the walls, consequent washing-away of some of the soluble salts stained with sulphur at the solfataric areas, and a little sliding from the northern walls of the pit. As usual, the rain has increased the volume of visible vapor at the steam jets.

Sixteen very feeble local earthquakes have been registered. One at 8 p. m. December 18 indicated distance of origin as 12 miles. A prolonged tremor at 11:15 a. m. December 15, of very slight amplitude, may have been occasioned by an avalanche in the pit. No tilt was accumulated during the week.

ELASTIC-REBOUND THEORY OF EARTHQUAKES

The California earthquake of 1906 was characterized by a long, vertical rift extending northwest and southeast for several hundred miles through California. The crack passes San Francisco on the west and lies just within the coast line north of the Golden Gate, until it disappears beneath the waters of the Pacific off Cape Mendocino. The earthquake is believed to have been caused by accumulated strain on opposite sides of this crack, whereby the land to the east was moving southward, and that to the west of the crack was moving nortward, the two motions opposing each other on the rift line and demanding relief there in the course of time. When the earthquake occurred there was sudden, violent motion northwestward of the land west of the crack, and similar motion southeastward of the land east of the crack. The country on the crack itself was torn and shattered, trails, roads and fences crossing the rift zone were offset, and sod was torn athwart hills and fields and bottom lands that chanced to lie in the rift zone. The maximum was near Point Reyes, north of San Francisco, and consisted of horizontal offset of more than 20 feet. The vertical displacement on opposite sides of the gashed ground was small, only a foot or two, and the horizontal movement became progressively less along the fault zone for scores of miles to the southward. The severity of shaking was in general greatest along the rift itself, and died out away from the rift, although there were some parallel belts to the eastward which behaved like independent centers of seismic activity.

This earthquake has been reviewed, along with other great shocks, in an interesting illustrated volume entitled "Our Mobile Earth," by R. A. Daly (Scribner, 1926). In explanation of the great earthquakes of the world Professor Daly accepts Reid's theory of elastic rebound. The growing strain was resisted by the strong crust. At last at a certain moment in the year 1906, the forces reached the elastic limit of the crust. The crust broke at a point. With the speed of sound in rock, that is, at the rate of over three miles a second, this incipient fracture spread along the line of the San Andreas rift. In a minute or two of time the long fault was formed. The crust was relieved of strain which had long been growing. The crust bounded back towards its original position, and that so suddenly as to jar the whole State of California and, in fact, the whole earth. Proofs cited to confirm this theory of elastic rebound are that the belt of destruction was elongated parallel to the rift, the isoseismals or lines of equal shaking were elongated symetrically around the rift, and the shock was greatest along the rift. Eleven other great earthquakes are mentioned having faults from 12 to 190 miles long associated with them, and these faults suffered displacement both vertically and horizontally of from three to 47 feet.

A second confirmation of the theory is found in the fact that broad belts of country alongside the fault trace are permanently displaced, up and down or horizontally, at the time of the earthquake. In California this was tested by a net of triangulation stations which should have indicated a lengthening of lines where the country expanded and a shortening of lines where the country has been dilated before, and suddenly contracted at the time of the earthquake. Just such effects were discovered between triangulation stations which had been established in the 19th century, and were reoccupied after the earthquake. Moreover, the permanent displacements were approximately parallel to the fault zone, with total shifts reaching more than 15 feet and the average displacement nearly twice as much on the west as on the east with reference to a distant base line.

A fourth test of the elastic rebound theory depends on the location of the depth of the point of fracture. The principal shock is supposedly due to a sudden snapping apart of two fracture surfaces at some distance underground. Various instrumental methods have been devised for determining how deep is this point of origin, which is called the focus of the earthquake. "In general the most trustworthy determinations give depths no greater than 25 miles; their weighted average is not far from half that." This agrees with the notion that the earth's crust is only 25 to 50 miles thick and that within that thickness the fractures occur which produce big earthquakes.

The four tests proposed by Dr. Daly seem then to agree with the elastic rebound theory. They are (1) that the shock is greatest along the fault, (2) that wide areas are displaced next the fault, (3) that the land measurably contracts and expands, and (4) that the depth of focus is consistent with the notion of sudden fracturing of the crust deep underground.

With reference to volcanoes Daly concludes that they are best explained on the supposition that such deep fractures allow gas-charged lava to rise, and very often, therefore, earthquakes and volcanoes are associated. Daly considers that both quake and volcano are effects of a common cause, the sudden fracture of a strained crust. He writes: "In all this we are dealing with earthquakes of the kind that causes great destruction. The much feebler shocks, caused by volcanic explosions or by sudden injections of liquid lava into the crust, belong in a quite different category—the class of true volcanic earthquakes."

This definition of volcanic earthquakes appears dubious to the reviewer. At Kilauea neither injection nor explosion produces earthquake. Volcanic earthquakes in Hawaii are due to slipping on fault planes. These slips are of all intensities from tiny to very large. It would seem that the shift of underground magma under change of surface loading may be quite as competent to produce a big earthquake as elastic rebound. T.A.J.

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No. 105 RELEASED WITHOUT COPYRIGHT RESTRICTION December 30, 1926

KILAUEA REPORT No. 781
WEEK ENDING DECEMBER 29, 1926
Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in Charge

Nothing new except the dribble of small rock falls from the walls, has been noticed at Halemaumau, the lava pit of Kilauea. Kilauea and Mauna Loa remain inactive.

The total number of earthquakes recorded for the week is 17. These were all very feeble with the exception of one which occurred at 9:26 p. m. on December 25. This earthquake was a perceptible one, and evidently shook a large section of the island, having been felt in Hilo and Waiohinu. This earthquake was recorded on the Hilo seismograph as being 46 miles from that place. It was distant 25 miles from the Volcano Observatory, probably near the summit of Mauna Loa. A few hours after this earthquake, on the 26th, between 3:57 and 4:20 a. m., the seismographs show a very feeble, but almost continuous tremor.

Tilt accumulated during the week has been moderate to the north-northeast.

THE MYSTERY OF MAUNA LOA

The terrific earthquakes and tidal wave of 1868, with landslip in Kau, lava flow in Kahuku, and collapse of the whole crater of Kilauea, seems very remote to us of the peaceful present.

On the Hilo side, we have only to quote from letters of 1881:

"Six months glided on, and still the fiery streams continued to grind on their seaward way, burning the forest through which they passed, filling up ravines, and making for themselves a vast level highway, and in places huge tunnels, through which the liquid lava flowed. It became evident that, should the awful streams unite, there would soon remain no trace of Hilo or its harbor."

"All Hilo may be said to have visited the flow during the last few days (July 6, 1881). Men, women and children, some on foot and some on horseback, have made the pilgrimage. Many in Hilo have been packing, so as to be ready to make a sudden start."

"It is almost impossible now to say when the flow will reach the sea; but all things considered, the probability is that it will take the Kukuau gulch. It is now not over one and three-quarters miles from the sea. Probably, before you hear from us again, all the lower part of the town will be destroyed."

"The lava is now only two and one-half miles from Volcano Street, and it is very liquid. It has, some part of the time, run at the rate of half a mile a day."

"Large parties of fifty to one hundred visit it daily, and some go up early in the morning and return, and again go up in the afternoon. Mr. Kennedy and Mr. Richardson are alarmed for the mills, and they have begun to pack and remove their valuable articles. Our town is greatly moved, and some have suspended all other business to watch the fires. The puffs of smoke and steam along the channel appear like the smoke of steamers descending a river. The main body of the fire is moving slowly down upon us in sufficient breadth to sweep our whole town, while the small stream is like advanced pickets on a skirmish line. Probably a few days hence we shall see its triumphant entrance into our town, about half a mile east of Church Street. It will be a grand spectacle, though full of terror."

Finally August 14th, Mrs. Luther Severance wrote:

"I know you are longing to hear about our lava flow. You will thank the Lord, as we do, that it has ceased action. It had advanced to within a mile from the beach, having travelled fully forty miles from the summit of Mauna Loa."

"We hardly can think or talk of anything else. This fiery flood, whose steady advance we have watched since last November,—that is, for nine long months—has occupied all our thoughts, and for the last two months we have spent much of our time near this terrible, fascinating monster: night and day have called us to its side." (Fire Fountains, by Lady Gordon Cumming, Blackwood, 1883.)

These human documents of forty-five years ago have very human meaning for those of us who watched the flow of 1926 invade and crush, to pulp and cinder, the village of Hoopuloa. The machinery of Mauna Loa is more than a mystery: it is an inaccessible mystery. It extends down through 18,000 feet of sea water. Skilled physicists are at this moment weighing it at a camp on the summit: is the central rock lighter than the shoreline rock? The Kilauea fountains are heavier than the Mauna Loa fountains. Cracks, mysterious cracks, extend toward Hilo and toward Kau. Where is the liquid lava now? Why do the groups of eruptions time themselves to a systematic interval? Why did the eruptions shift from the Hilo side to the southwest side; 1843, 1852, 1855, 1859, and 1881 were at the north. Now they are all at the south—1907, 1916, 1919, 1926.

The Government last year honored Hawaii by making Kilauea headquarters for widespread work in volcanology. A private corporation, the Hawaiian Volcano Research Association, has recognized the honor by financing most generously a new exhibition and lecture system for tourists at Kilauea National Park.

The Territory of Hawaii now has its chance to recognize what the Federal Government has done by building an emergency 7-foot trail up Mauna Loa in Alika. This trail, passable for low gear truck, is needed for protection of the ranches, for a scientific observatory, and to let travellers see the source fountains in that marvellou Kahuku country.

There was a summit eruption in Mauna Loa in 1903 and 1914, and damaging flows poured into the cattle lands in 1907, 1916, 1919 and 1926. There was a flow on the Hilo side in 1899. The intervals were 4, 4, 7, 2, 3, 7 years. Will the next eruption be in 1928, 1929 or 1930? Two, three or four years? Is the south side shaking now? Are the cracks growing cooler or hotter? Is the ground bending down or up?

The Alika flow did one good thing. It came against the Koa Camp road, and opened a way, only five miles long, to extend that as a 7-foot trail to the summit of the Kahuku ridge, 7,500 feet above sea-level. With that trail we will keep an observatory on the most active part of Mauna Loa. With that trail everybody can see the 400-foot fountains. With that trail we can warn the cowboys. With a telephone at the Kahuku observatory we can keep the public informed. An emergency trail need only cost about $25,000. We are going before the Territorial Legislature asking for this trail.

Mauna Loa is mysterious like the Antarctic continent. Every trail, however rough, into Mauna Loa, helps to lift the curtain and explain a mystery T.A.J.

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No. 106 RELEASED WITHOUT COPYRIGHT RESTRICTION January 6, 1927

KILAUEA REPORT No. 782

WEEK ENDING JANUARY 5, 1927
Issued by the Observatory, U. S. Geological Survey:
T. A. Jaggar, Official in Charge

At Halemaumau on December 29, at 3 p. m., there were dribbling falls of rock at the northwest wall and the southwest rift caverns. New red sand on the talus slopes showed that this had been going on for some time. The rock falls continued throughout the week, and January 5 showed a new notch at the northeast rim and new debris below. The bright-yellow sulphur at the south talus was not washed away by the heavy rains of the new year. It is noticeable that the blue sulphurous fume does not show at this place as it did formerly.

Sixteen local earthquakes were registered during the week, all very feeble. Owing to northeast wind, microseisms were large after January 2. West tilt increased slightly the first part of the week, but January 3 and 4 nearly four seconds of east tilt suddenly set in, making the net tilt moderately eastward for the week.

THE INTENSITY OF GRAVITY

Lieutenants Brown and Bainbridge of the U. S. Coast and Geodetic Survey have just completed "swinging a pendulum" at Kilauea and Mauna Loa. This is to determine the differences of the force of gravity at those places. Older determinations were made near Mauna Kea, and another station is to be made at Hilo.

Gravity is the resultant of the earth's attraction and the centrifugal force of its rotation. These forces change with height and distance from the equator. The same object, at sea-level, weighs one two-hundredth less at the equator than at the poles, and one two-thousandth less for each mile of elevation. If a spring balance could be made reliably sensitive to measure the tiny changes, these differences of weight of the same mass, and so the gravity variations, might be directly measured. At present, however, more delicate methods are needed.

The time of a complete swing of a pendulum (period) is dependent on its length and the force of gravity. If we measure the period and length, the force of gravity for the place of swinging becomes known. To determine the absolute force of gravity in dynes (force necessary to move a gram weight one second with the velocity of one centimeter per second) at a standard location, a double-ended pendulum is used. Adjustments that produce the same period of swing when hung from either end give precise measure of length. Counting the beats gives the other requirement, period.

Determinations of absolute gravity are made carefully at a few base stations. The force is 980.112 dynes at Washington, D. C. Field observations are made by a comparative method. The length of the field pendulum is determined by swinging and timing it at a base station of known gravity. The field pendulum is thenceforth regarded as retaining the same length, with due regard to temperature variation. A dummy pendulum exactly like the one swung, with a thermometer bulb inside its bob, is kept inside the apparatus and the thermometer is always read and temperature is recorded. From time to time the field pendulums are recalibrated at the base station.

The comparative method thus necessitates the use of only a single suspension instead of a double-ended pendulum, and the other end is a lens-shaped bob as big as a large watch. The pendulum is about a quarter meter (nine and seven-eighths inches) long with a period of a half-second. Two or more pendulums are used alternately and the results averaged. They are made of invar metal, a nickel-steel alloy that hardly expands at all with heat. An agate plane in a stirrup at the upper end of the pendulum bears upon an agate knife-edge support. An air-tight metal box holds the pendulum, which swings in a partial vacuum, having a pressure of 60 mm. of mercury, registered by means of a manometer. The box has glass windows and levers for starting the swing, and is exhausted by a hand pump. The pendulum is started through an arc of only two or three degrees, yet it will keep swinging twelve hours. Even the rigid support sways a litle; an interferometer measures this swaying, and a proper correction for the period of the pendulum is computed. The pendulums are most carefully handled, as corrosion, dirt, or deformation would so alter the distribution of mass as to change their mathematical lengths.

With corrections made for amplitude of swing, vacuum pressure, temperature, and flexure of supports, the major measurements consist of swinging the pendulums through six twelve-hour intervals. Accurate time for the beginning and ending of these intervals is necessary,and may be secured by telegraph or radio, or from star observations.

An electric light flashes through a slit. A chronometer controls the flash of light every two seconds. Only when the pendulum passes the vertical a small attached mirror reflects back the light to the observer's eye. By direct observation and noting standard time, a comparison of coincident flashes is made between pendulum and chronometer. The beats of the chronometer and the wireless time-signals are recorded on a chronograph. Thus the swings of the pendulum for a few minutes, at the beginning and ending of the twelve-hour interval, are compared with standard time to within a few hundredths of a second, and this gives the number of swings. In the meantime the pendulum beats out its twelve hours unobserved.

This interval, divided by the number of swings, gives the period of the pendulum. A mathematical formula gives the force. The allowable probable error is .004 dyne. The period determination must be within one millionth second. Radio time signals are amplified and recorded on the chronograph. In Hawaii they are received from Washington, D. C., by short-wave wireless. All of this physical apparatus was set up on the top of Mauna Loa, for a week in winter, in a cavern covered by a tent.

The gravity determinations measure the earth's radius, and so determine its shape. They are used in studying isostasy, and in measuring local densities of the earth's crust. The latter use will show, here on Hawaii, what are the interior densities of our volcanoes, Kilauea, Mauna Loa and Mauna Kea. R.M.W.

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No. 107 RELEASED WITHOUT COPYRIGHT RESTRICTION January 13, 1927

KILAUEA REPORT No. 783

WEEK ENDING JANUARY 12, 1927

Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

There is nothing new to report concerning the conditions of Kilauea and Mauna Loa volcanoes. Both are dormant, Kilauea with a vast pit 3,000 feet across, inactive since August 1, 1924; Mauna Loa with a summit crater and hot rift athwart it, inactive since May 1, 1926.

For the week at Kilauea 14 very feeble tremblings were registered seismographically. Tilt has been moderate westward, about four seconds. Microseisms, after high easterly winds, were still strong January 6, but have diminished to normal.

REPORT No. 3
LASSEN VOLCANO OBSERVATORY

Mineral, California, December 29, 1926
R. H. Finch, Associate Volcanologist

About the middle of December there were press reports stating that Lassen Peak was in an eruptive stage. The reports were quite certainly based on peculiar cloud formations. On December 18 and 19 a trip was made to the National Park boundary and good views of the peak were obtained. There were no signs of unusual activity. The only clouds seen were of the cirrus type high above the level of the peak. Updrafts produced snow clouds that shot up to a height of 300 to 400 feet above Lassen Peak and adjacent peaks. Such clouds when viewed at some distance, especially by transmitted light, might easily be mistaken for small eruption clouds. The updrafts were observed to start as much as a mile below the summits. The seismographs showed nothing unusual at this time.

On December 28 the seismographs of Lassen Volcano Observatory registered their first "swarm" of earthquakes, 22 quakes being recorded on that day. The strongest shake occurred at 6:12 p. m. It was preceded by a rumble and dismantled the E-W component of the seismograph. The only other one that was perceptible occurred about an hour earlier. The majority of the earthquakes preceded the strongest one. The indicated direction was northeast at Mineral, which is southwest of Lassen Peak.

MAUNA LOA TRAIL

On January 3, 1927, Mr. Allen Burdick, Engineer of the Department of Public Works, Territory of Hawaii, accompanied by Dr. T. A. Jaggar, examined the region above the Koa Camp in Alika with a view to a trail survey. It was found that there are two possible routes from the Koa Camp to the source of the Alika flow, the one leading through the forest and old pahoehoe, between the Alika and the 1919 flows. The other route leads directly over the Alika flow, straight towards its source. The objective for the proposed seven-foot trail is the camp ground at the Umi altar, a few hundred feet north of the largest Alika source cone. There is a third possible route following the contour of the mountain about the 5,100-foot level along the trail that passes the Kaapuna Ranch house. This would lead to the north side of all the branches of the Alika flow, whence a way could be followed due east up the pahoehoe, to the top region.

It is believed that the proposed trail would serve five purposes: (1) It would assist the Board of Agriculture and Forestry in reaching the South Kona Forest Reservations with automobile trucks; (2) it would assist the County of Hawaii in time of danger from lava flow in protection and for warning given to the forest rangers and the cattle ranchers; (3) it would enable the Geological Survey to keep a seismograph station on Mauna Loa, equipped with telephones, near the sources of all the lava flows of the twentieth century; (4) it would assist the ranchers of the western slope of Mauna Loa; and (5) it would make more accessible to travelers the mountaineering and camping on Mauna Loa at all times and especially in times of splendid eruption.

Mr. Burdick is at work on an estimate for this emergency trail, and it is hoped that an act providing for its construction will be introduced for consideration of the Hawaiian Territorial Legislature through the Commissioner of Public Lands. T.A.J.

GEODETIC MEASUREMENTS ON HAWAII

To the Island of Hawaii for precise measurement by levelling came Lieutenant L. G. Simmons of the U. S. Coast and Geodetic Survey October 4, 1926. His work started from Hilo on the Hilo-Kilauea road October 4 to 14. From October 15 to November 17, with the assistance of packers and animals from Keauhou Ranch, he ran levels from Volcano House to the highest summit of Mauna Loa by way of the National Park trail and Puu Ulaula. Bench marks were placed about two miles apart. About December 18 the upper part of the Hilo-Kilauea road was levelled, completing the entire stretch from Hilo to the Mauna Loa summit. Preliminary computation indicates that the old Hawaiian survey of W. D. Alexander, which determined the height of Mauna Loa by vertical angles, differs by only about two feet from the result of precise levelling.

Lieutenants Brown and Bainbridge arrived December 15, and swung gravity pendulums at the Hawaiian Volcano Observatory, Kilauea Crater rim, December 17 to 23. By preliminary computation, not reduced to sea-level, the value of gravity at Kilauea is 978.667 dynes. These observers camped at the north lip of Mokuaweoweo, the crater of Mauna Loa, December 28 to January 7, and obtained preliminary value of gravity, not reduced to sea-level, for the Mauna Loa summit region 979.091 dynes. January 10 they began gravity observations at Hilo.

They will install at Hilo a standard recording tide gauge, to be used under the supervision of R. M. Wilson, geodetic engineer at Hawaiian Volcano Observatory, in determining a datum for the new precise levels. The gauge will also detect tidal waves. It will be operated under the U. S. Coast and Geodetic Survey by Brother J. B. Albert, Hilo seismograph observer. All this new geodetic work has been made possible by cooperation between the Coast Survey and the Geological Survey.

R.M.W.

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No. 108 RELEASED WITHOUT COPYRIGHT RESTRICTION January 20, 1927

KILAUEA REPORT No. 784

WEEK ENDING JANUARY 19, 1927

Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

There are three things happening in Halemaumau pit of Kilauea Volcano that show increase during the past week. There is a movement registering earthquakes on the seismographs: there is marked increase of avalanches in the pit; and there are yellow sulphrous patches on the debris slopes which are increasing in area. The combination means disturbance both chemical and physical, and lava eruption may follow, but the effects are not yet unusual enough to justify a forecast.

On January 13 dust from a small slide rose at 1:40 p. m. There were many small slides the next day. On the 15th dust hung over the pit after 11 a. m., and at 11:43 a. m. avalanche roar was audible at the Observatory. Small avalanches continued, dwindling in afternoon. The pit was left with northern walls scarred, and at 4 p. m. northern, western and southern walls were uneasily scaling off. Fresh debris lay on the talus slopes. The seismographs did not respond to avalanching this forenoon, but local quakes were registered the previous day, this afternoon and the day following. About 3 p. m. January 16 came a small earthquake, a big avalanche roar and a cloud of gray dust. Again the pit walls were steadily working, and a mass of red debris had fallen on the north slope. Spicy sulphur was smelled at the south rim, and the yellow solfatara below had increased in area. The slipping of rocks in the pit from the walls continued on the 18th, particularly near the Kau Desert rift tunnel.

During the week the seismographs recorded 29 local earthquakes, all very feeble. On the 13th, 14th and 15th the seismographs showed the greatest activity as on these three days most of the earthquakes for the week occurred. These three days as noted above were also the most active days for slides in the pit. One of the earthquakes, larger than the others but still not large enough to be perceptible, occurred at 5:07 p. m. on the 14th and lasted over two minutes. No avalanche was observed coincident with this quake, although it was somewhat larger than the shock above noted at 3 p. m. on January 16. There was, however, red avalanche debris produced at about this time.

Tilt accumulated during the week has been very slight to the east.

THREE PRESS REPORTS

Confirmation, denial, or explanation of the following, from those who have been there, is invited by the **Volcano Letter:**

(1) At Ballybunicn, on the west coast of Ireland, the Atlantic rollers, making great fissures by breaking down the cliffs, finally reached masses of iron pyrite and alum. Rapid oxidation took place by contact of water with these, which produced a heat fierce enough to set the whole cliff on fire. For weeks the rocks burned like a volcano, and great clouds of smoke and vapor rose high in the air.

(2) A dispatch from Dutch Harbor of December 31, 1926, states that Mount Makushin, on Unalaska in the Aleutian Islands, erupted the evening of December 30 with "fountains of fire and masses of vapor," making a spectacular display. A slight earthquake accompanied the eruption and there was fear for the safety of Makushin village.

(3) The boiling springs of Iceland are piped underground and used, not only to heat the houses, but to warm and water greenhouses and gardens. The warm water hastens the growth of flowers, vegetables, and fruits. "Near the largest geyser at Reykjavic a large greenhouse has been built." Iceland can compete with the Channel Islands in growing early potatoes, vegetables, and flowers.

We did not know the Icelandic geysers were at Reykjavic, no added facts have been seen about the Makushin eruption, and we would like to know the date and details of the Ireland story. T.A.J.

FIGHTING IN LASSEN AA

A remarkable story of the Modoc Indians is told in a popular book on Lassen National Park (The Kingship of Mount Lassen, by Mrs. F. H. Colburn; Nemo Publishing Company, 628 Mills Building, San Francisco). These Indians lived in a lava country. Captain Jack, a young Modoc chief, secreted in a lava cavern which still has a bad name, made headquarters in an inaccessible ridge of aa, flanked by deep ravines, fissures and masses of bowlders. Here with one hundred and fifty followers he conducted depredations against the whites.

Lieutenant Colonel Wheaton fought 52 Indian braves with 400 U. S. troopers January 17, 1873. He reported to the War Department that "the bowlders ranged in size from a matchbox to a church. Captain Jack's stronghold was in the center of miles of rocks, fissures, caves, crevices, gorges and ravines—some fully 100 feet deep. In my twenty-three years of service, mostly fighting Indians, I have near before encountered an enemy, civilized or savage, occupying a position of such natural strength as the Modoc stronghold. Nor have I ever seen troops engage a better armed or more skillful foe."

The fight lasted from 8 a. m. to 10:30 p. m. when the troops retreated to their camp 15 miles away. They had fought all day without seeing an Indian! Little puffs of smoke through a hole in the lava was all they had to guide their attack. Added to the difficulties was a fog so dense that the parties could not communicate. It was bitter cold. Because of the incredibly rough lava surfaces the soldiers were obliged to advance crawling on their hands and knees. It was utterly impossible to recover the dead, and they had great difficulty in removing the wounded. The attack was a complete failure.

This Lassen book contains very beautiful photographic illustrations of the volcano's eruptions and boiling springs, a life of Peter Lassen, descriptions of the country and its pioneers, and a map of the Park. Its pretensions are rather literary and poetic than geological. T.A.J.

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No. 109 RELEASED WITHOUT COPYRIGHT RESTRICTION January 27, 1927

KILAUEA REPORT No. 785

WEEK ENDING JANUARY 26, 1927

Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

The avalanching activity at Halemaumau pit reported last week did not continue. At 6 p. m. January 20 there were a few falls of stones northeast and west, some dust had been seen over the pit during the day, fresh debris lay on the northern taluses, and at 6 p. m. rocks were heard falling in the pit.

The afternoon of January 22 a few isolated rocks fell from the walls, and during a circuit of the pit it was noticed that the eastern sulphur stain is about 100 feet above the floor, and the southern larger one is at least 200 feet up the talus. No fresh cracking of the soil near the pit edge was anywhere observed. On January 26 very heavy rains had not washed away the bright yellow crystals of the south talus, though the other sulphurous spots were paler than before.

During the week 25 earthquakes were registered, mostly very feeble. On January 24 at 6:49 a. m. a shock was strongly felt in Kona, and registered at the Kilauea Observatory feebly, indicating a distance of 44 miles by its preliminary tremor, which is almost the distance to Kealakekua, Kona. At 6:54 a. m. January 25 a slight earthquake was felt at Volcano House, with maximum acceleration E-W.

A distant earthquake was registered January 23, beginning 2:45 p. m., and showing phases that indicated distance to origin 3,585 miles. Greenwich time at origin (0) should have been 1 h., 05 m., 46 s., January 24. Tilt was slight to the SE.

PROGRESS OF SANTORIN ERUPTION

Professor C. A. Ktenas of Athens describes the growth of the new lava dome surmounted by an ejection cone in the Grecian Archipelago. (Bulletin Volcanologique, Nos. 7 and 8, 1926, pp. 3-64, Naples. See also Volcano Letter Nos. 43 and 58.) His account extends to January, 1926, and the eruption had begun August 11, 1925, with the piling up of dacitic andesite lava in a sea-water channel among ancient lava cones. Santorin Volcano is in a crater lagoon enclosed by the crescent islands of Thera. August 23 a dome 73 meters high had formed, and afterwards kept about this height. Temperatures from 700° to 900° C. were measured in luminous cracks. Explosions through the dome went hand in hand with lava-flow extensions. The explosive products were of contemporaneous lava, and the gas rushes made cauliflower clouds charged with sand, pebbles and bombs.

The lava flows spread through and filled up two water channels, progressing 700 and 1,000 meters by January, 1926. The lavas expanded under a glassy carapace, and showed increase of inclination toward their fronts. The water was 10 to 50 meters deep, and the lava flows thickened to 25 to 30 meters above it. The water was heated to 65 degrees C. The lava front domed up.

The lava is glassy with plagioclase, angite and hypersthene crystals, and subordiante titano-magnetite and olivine. The composition is excessively siliceous, without quartz; silica 65%, alumina 16, iron 5, alkalies 7, and lime exceeds magnesia.

Yellowish and bluish flames were abundant on the dome, and spectroscopically showed hydrogen, sodium, chlorine and no helium. The salts showed lime, magnesium, chlorine, sulphuric acid and ammonia dominant. The fumarole gases showed dominant sulphurous acid, hydrogen, and carbon dioxide, at temperatures from 65° to 380° C. Water vapor was abundant, as shown by many explosive jets of white steam, but the gases from the lava proper showed signs of dryness. Litmus paper gave no acid reaction until it was wetted. The ashes that fell showed no acid effects until they were wetted by rain. Some of the fumaroles were anyhdrous, and some were humid. Flames during principal eruptions were several meters high. Sea salt was not deposited by the fumaroles. Sulphuretted hydrogen was notably inconspicuous, but was detected in the sea-water reactions.

The lavas were not properly aa, but formed stiff carapaces that cracked and dragged showing transverse crevasses like glacial seracs. The whole islet of the active volcano in the middle of the Thera lagoon is increased and unified on its eastern side. The lava dome developed cinder cone slopes about the central vent as the eruptions went on, the whole being called a "conodome." The explosive phenomena have increased during the development of Santorin since 1707.

The explosive activity of the period, very strong at first, reached a maximum the first half of September, and declined thereafter. There were paroxysmal explosions occasionally, and spells of waxing and waning moderate effervescence. A very interesting observation, by measurement with a micrometer scale in a field glass, records that the central portion of the dome, during a series of expulsions of gas, would rise visibly three or four meters continuously and rapidly; after the explosion this area, 50 meters across, would sink back. This oscillation repeated itself six to ten times an hour. The net result was continual change in the form of the dome. T.A.J.

CHLORINE AND VOLCANISM

Attention is called by Dr. Sidney Powers, of Tulsa, Oklahoma, to the fact that Malladra, Volcanologist of Vesuvius, and Ponte of Etna, both consider increase of chlorine in the solfataric cracks at the craters a sign of coming eruption.

The collections of gas from live Hawaiian lavas have never shown such excess of chlorine as the Italian volcanoes. Shepherd says (Bull, Hawn. Volc. Obsy. May, 1921, p. 88) "Chlorine occurs, but in relatively small amount." His analyses generally show only a few hundredths of a percent, and chlorides are rare among Kilauea salts. Muriatic acid, very conspicuous in odor and effects where the Hawaiian lava flows enter salt seawater, is comparatively unknown at the source vents. T.A.J.

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No. 110 RELEASED WITHOUT COPYRIGHT RESTRICTION February 3, 1927

KILAUEA REPORT No. 786

WEEK ENDING FEBRUARY 2, 1927

Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

An inspection of Halemaumau pit of Kilauea Volcano between 3 and 4 p. m. January 28, revealed nothing new in the condition of the bottom. There was a marked jet of steam arising from a bowlder in the midst of a dry, hot patch that extends up and down the moist middle region of the southwest talus. No slides of any size occurred at this time.

On February 1, avalanching from the northern walls of the pit was noticed, somewhat like that of a fortnight before. In the middle of the afternoon, dust from slides arose from the pit, and at 5:45 p. m. singularly white dust rose in a thin cloud from the whole pit gradually, beginning at the northeast corner. This left the air over the orifice of the pit suffused with dust for 30 minutes or more. The next day, February 2, dust rose from the north corner of Halemaumau about 7:30 a. m.

Fifteen very feeble local earthquakes, and one teleseism, have been registered during the week. Two of these indicated distances to origin of 22 and 37 miles. The preliminary wave of the distant earthquake arrived at 7 h., 36 m., 10 s., a. m., February 1. There was practically no accumulated tilt.

LASSEN REPORT No. 4

Mineral, California, January 14, 1927
R. H. Finch, Associate Volcanologist

L. W. Collins, Superintendent of Lassen National Park, and R. H. Finch, made a round trip to the summit of Lassen Peak during the three days January 11, 12, and 13. The first day was taken up in reaching camp by Supan's Hot Spring region and on the 12th the trip from camp to summit and back was made. The depth of the snow averaged between five and six feet. The places where horses are usually tied in summer ascents, about 1,400 feet below the summit, was reached at 11 a. m. Here snowshoes were left behind both because of the steepness of the slope and of the fact that it was covered with ice. About one and one-half hours were taken up in the ascent, while the descent was made in 20 minutes. Some idea of the windy conditions at the summit was obtained far down the slope by observations of swirling clouds of snow that were almost continuously blowing out from the peak. On the southeast slope, where the ascent was made, the air was still and the sunshine almost too warm. Gloves which had become wet from the explorers' going on all fours during the ascent, were almost instantly frozen in the arctic blast that greeted them as they peered over the summit. The frozen gloves were thawed out, but not dried, while lunch was eaten over a steam crack in the crater. Shortly after the start to climb out of the creater, gloves were again frozen, and at the foot of the icy slope it was found that fingers were frosted and a frosted toe was brought home as souvenir. Camp was reached shortly after nightfall.

Before starting home on the morning of January 13, the temperature of the upper Supan's Spring was taken. At a vent where the steam was escaping with a loud hiss the temperature was found to be 194° F., or about 9° F. hotter than the highest temperature reported from this spring by Doctors Day and Allen in 1923.

A perceptible earthquake that was accompanied by a loud rumble was recorded on the Observatory seismographs at 6:20 p. m. January 13.

SEASHORE OBSERVATORIES

England, the United States, and Canada are begining a definite scientific measurement of the shoreline as a sensitive marker of geophysical changes. There was a tremendous Galveston flood in 1900 from the piling-up of hurricane waters by a 100-mile gale, producing a rise of 15 feet. Galveston is now protected by a massive seawall 17 feet high. To June 30, 1925, the American Government had spent $15,000,000 in an effort to deepen and maintain the waterways leading from the ocean to eight principal cities in the region extending from Beaufort, N. C., to Jacksonville, Fla. During the 20 years 1900 to 1919, hurricanes on the coast of the Gulf of Mexico have destroyed 7,225 lives and property amounting to $105,000,000. Now comes the tragedy of Miami, Fla., more appalling than that of Galveston, and "one of the most striking examples of the helplessness of man against the unbridled elements" (R. S. Patton, "The Toll of the Waves," World To-Day, London, December 1926). Enormous sums have been spent on the levees of the lower Mississippi, which in time of flood at New Orleans hold the water so precariously that the flood patrol piles sand bags at weak places, and the water rises to within two inches of the top of the sand bags. Mr. Guy Gest, of New York, points out that an earthquake at such a moment of the kind that devasted the Mississippi valley in 1812, would wreck the whole levee system.

Mr. Patton, a British coastal survey expert, states that there are virtually no quantitative data regarding the forces which attack our beaches from the engineering standpoint. People flock annually in increasing numbers to beach resorts in search of rest and refreshment, and the beaches have become important national assets to meet the efflux of population from the over-congested cities. This is an incident to the more comfortable standards of living attained within the past few years. The coast of England between Bridlington and Spurn, a distance of 36 miles, has receded 2¼ yards annually, amounting to 3 acres lost per year. At this rate the coast, here about 40 feet high, has lost a mile since the Norman Conquest. Mr. Patton states that it is possible for engineering science to minimize or prevent this detrimental course of events, but the way to attack it is not yet clear. He cites the State of New Jersey, which has assumed jurisdiction over the entire problem and is providing for a study of basic principles of shore erosion.

The Coast Survey has just installed a tide gauge at Hilo, and nowhere is there more interest than in Hawaii in the relation of shore erosion to the rising and falling of the land. T.A.J.

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No. 111 RELEASED WITHOUT COPYRIGHT RESTRICTION February 10, 1927

KILAUEA REPORT No. 787

WEEK ENDING FEBURAY 9, 1927

Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

On February 3 small avalanches were indicated by dust rising from Halemaumau. This continued the next day, ond on the fifth, at 4 p. m., a considerable slide from the N.E. wall of the pit was seen to start under the stimulus of stones dropped by visitors. The talus below showed much fresh material. The sulphur patch at the south is spreading among the fragments. The wall and slides above this are blackened. At 5:20 p. m. a noisy natural slide fell at the N.E. wall. The steam cracks S.W. and W. of the pit are purring as though water were below, and this is true also of Sulphur Bank flat.

Only eight local earthquakes were registered for the week, none perceptible. A feeble one at 11:26 p. m. February 2 showed origin distance 45 miles. An unusual quiet interval of 60 hours, without even a tremor, occurred after 5:52 p. m. February 6, and is now in progress. Tilt for the week was slight south-southwest.

COMPRESSIONAL HEAT IN VOLCANIC BLASTS

Referring to **Volcano Letter** No. 63, March 11, 1926, I do not think there is "a tremendous compressional wave travelling at an immense speed." There is movement of air ahead of ejecta, rather than great compression. The main compression is probably at the start of the explosion, in the crater. By the time the ejecta reach the rim, the air is moving freely in front of the ejecta. The crater acts like the gun barrel. Such, at least, was my impression watching numerous explosions of Vesuvius. This I took to be proven by the height to which the material rose compared to the initial velocity. Had there been heavy compression, the air cushion formed would soon have terminated their ascent.

I happened to see a factory of high explosives blow up, one day, near Ottawa. I was looking at it at the time, from a distance of about 200 yards, across an open field. It was a thick-walled stone building. The whole building rose bodily, comparatively slowly, then the walls bulged out, and then the roof began to rise, and the whole thing flew into fragments travelling with great velocity. Judging by what I had seen at Vesuvius, I thought their velocity would take the rocks to a height of 1,500 feet, but I judged that not a single one reached 500 feet, though some travelled a long distance laterally. I expected heavy air blast, either from or toward the explosion. I felt none, though plate glass windows in Ottawa, three miles or more away, were broken outwards.

At the start of the explosion, there was evidently some compression, which held the light roof on to the walls—and burst the solid masonry walls before the roof went. The comparatively slow speed at first was due only partly to the time taken for complete oxidation of the explosive, but mainly I think to the retardation by the air before it began to move ahead of the material of the factory.

Similarly a large, hot-air balloon when released jumps up about 20 feet, hesitates an instant, and then shoots up like an arrow. The air compressed in front of it stops it, and then travels ahead of it.

In the Frank Landslide (Great Landslide at Frank, Alberta, by R. G. McConnell and R. W. Brock; Pt. VIII, Annual Repoort 1903, Department of the Interior, Dominion of Canada), the main peak of Turtle Mountain for a width of half a mile broke away, and fell into the valley 3,000 feet below to the N.E. Here then was heavy air compression. But it was not felt by anyone in the town on the north edge of the slide, nor could I find any trace of an air blast there. It was, however, felt by miners in the gangway of the local mine. The mouth of the tunnel was aboout 200 yards within the buried area south of the north edge of the slide. South of the edge of the slide, for half a mile down the valley, there were evidences of the air blast. The trees near the edge of the slide were overturned, and farther away were stripped of branches, and still farther, of twigs. There was great air compression, but not enough heat generated to have any observable effect upon the most delicate plants. There were no men for several miles down the valley to the S.E. I did not find any birds or field animals killed or injured by the blast. So it cannot have been very hot.

The above supports the view of T. A. J. that the destruction of volcanic blasts is due to volcanic material and volcanic heat, and not to pressure as suggested by Cole and Brooks. R. W. Brock.

MORE ABOUT SHORELINE OBSERVATORIES

The Hawaiian in'erest in the shore is deeply involved with the study of volcanoes. Our land is going up and down remarkably, as proved by tilt pendulums and levels. The rising goes with rising lava and the sinking with falling lava. The thing called "mean sealevel" is the only datum to refer to. If the island of Hawaii rises differently from the island of Maui, nothing will prove it unless both islands maintain tide gauges all the time, and unless "mean sealevel" is the same for both islands.

Professor Douglas Johnson (Columbia Univeristy, New York City), Chairman for Shoreline Investigations of the U. S. National Research Council (Science, January 7, 1927), has published remarkable pictures of the stages of receding shoreline at Cape Breton ("The New England-Acandian Shoreline"), and notes that the Canadian Hydrographic Office is undertaking in New Brunswick a comparison of mean sea-level with a large embayment which receives great quantities of fresh water. The tidal range is over 20 feet, and the study involves tide gauge records and the running of lines of levels. Similar studies are being made at New York City and at Eastport, Maine. Graduate students from Columbia University have also been studying the evolution of special shorelines along the Atlantic Coast.

Dr. Johnson asks the support of everyone interested in beach property and in the burdens which coast erosion throws upon the taxpayer. His committee wishes information on changes in shoreline cutting, on engineering works, on artificial beaches, and on photographing shoreline changes. T.A.J.

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No. 112 RELEASED WITHOUT COPYRIGHT RESTRICTION February 17, 1927

KILAUEA REPORT No. 788

WEEK ENDING FEBRUARY 16, 1927

Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

In Halemaumau pit on February 12 there was a new scar in the middle of the northeast wall where an avalanche has fallen. In midafternoon Febraury 14, strong, red, dust clouds rose from pit, and when Halemaumau was visited at 6 p. m., a prolonged, small avalanche was tumbling at the north corner of the pit, making a roar and sending up red dust. This slide took several fresh starts from about midway up the wall. The northern taluses were covered with fresh, red debris, and big slides had evidently fallen, for the dust extended across the bottom of the pit. On February 16, with strong south wind, nothing new was noted at the pit, but pinkish dust from the desert filled the air above Kilauea Crater.

One distant and 12 local earthquakes were registered during the week, the teleseism occurring about 3:30 p. m. February 15. Microseisms, which were strong the first part of the week, diminished in spite of the strengthening of the southwest wind. The wind squalls affected the seismogram February 16 beteewn 5:15 and 7:30 a. m., as a short-period, jerky, irreguiar vibration, the microseisms remaining normal. Tilt for the week was very slight WNW.

SUPPOSED NEW VOLCANO

Those who have studied Mexican volcanology recall the case of Jorullo Volcano, famous for having grown up under the eyes of men. A newspaper report (Minneapolis Tribune, December 26, 1926) states that in Chiapas, in southern Mexico, there is a new hill called Mount San Cristobalito. Subterranean rumblings are heard, and a "sulphurous waterfall" of curative powers has increased. German engineers are said to have pronounced the hill as a rapidly developing volcano, which began as an insignificant mound of earth about eight years ago. The statement is that "persons ascending the top of the mound are almost suffocated by the intense heat; and no one knows when the terrific subterranean pressure will blast its way through to the open air." T.A.J.

ERUPTION OF MERAPI

A wireless from the volcano service of Java states that Merapi Volcano, in middle Sumatra, has been in eruption, throwing out ash since February 5. T.A.J.

REVIEW OF HAWAIIAN EARTHQUAKES 1926

The total number of seismic disturbances registered on the seismographs during the year 1926 is 1,801. The number includes 23 teleseisms, of which eight were decipherable as to distance.

The remaining local earthquakes and tremors, individually counted, number 1,778. These may be classified by their strength, or by their kind. The greater number of them were very feeble, 90% being so classified. There were 4% of them feeble, 4% slight, and 2% moderate. The number reported as felt was 101, or 5.7% of the total.

The period of the Mauna Loa eruption, April 10 to 24, is responsible for about a third of the total, and the numbers are given day by day in Volcano Letter No. 71, as a review of the earthquakes during the eruption. The smaller disturbances are of different kinds: those caused by actual earthquakes, those accompanying avalanches in Halemaumau, and those caused by a waxing of harmonic tremor. The large count during the Mauna Loa eruption is in part due to the kind last mentioned. At times of lava flow there is a characteristic and continuous very short-period tremor registered on the seismographs. This type of tremor waxes and wanes, and many of its times of increased amplitude were counted as individual disturbances. It is interesting to note that the large number that came in April in excess of the usual average, were quite definitely confined within the period of flow from Mauna Loa, the beginning and ending of excess numbers being rather abrupt.

The number recorded for 1925 was 922 (see review of earthquakes in Volcano Letter No. 54), so that if the April excess, caused by the Mauna Loa flow, were subtracted from the 1926 total, the two years would be nearly the same.

Following is a table showing the number of local disturbances for each month:

January	54
February	32
March	68
April	761
May	43
June	56
July	101
August	254
September	240
October	62
November	46
December	61

R.M.W.

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No. 113 RELEASED WITHOUT COPYRIGHT RESTRICTION February 24, 1927

KILAUEA REPORT No. 789

WEEK ENDING FEBRUARY 23, 1927

Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

There has been no significant change in the lava pit of Kilauea during the past week. There have been the usual small slides from the walls, and the sulphur spots near the bottom of the pit on the debris slopes continue to grow, indicating that lava gas is emerging.

Seismically, the week has been extraordinarily quiet, only eight local shocks being recorded on the seismographs at Kilauea. Six of these occurred on the 21st and the 22nd, and one of those on the last date indicated by the length of its preliminary tremor a distance of origin 12 miles from the Observatory. Tilting of the ground for the week was moderate to the SSW.

EARTHQUAKE AT MORRINSVILLE, NEW ZEALAND

Disastrous earthquakes in the north-central part of the North Island of New Zealand centered about the town of Morrinsville, beginning Friday, November 12, 1926. They occurred intermittently all that day, and by the evening everyone was living out of doors. The old residents described the earthquakes as the worst they have ever known. Fire was prevented, and only one person was injured.

There was first felt a small shock at 9:01 a. m. November 12. Another came five minutes later, and another at 10:16 a. m. The big shock arrived at 10:21 a. m., without noise, swaying buildings violently, followed by a resounding thud and by numerous convulsive tremors.

Chimneys fell on the iron roofs, crockery and glassware crashed to the floors, whole shelves of goods fell in the shops, and people made a rush for the streets. The damage was particularly severe in the drug shops and liquor stores, some plate-glass windows were smashed, cracks appeared in several concrete buildings, and the top part of a granite obelisk was displaced several inches. About half the chimneys broke at about the roof level and fell.

Morrinsville lies between Hamilton and Tauranga, about 30 miles northwest of the Rotorua volcanic district. At Piako, two miles east of Morrinsville, a tank was displaced from its stand. The earthquakes were remarkably local, for in the Waikato district around Hamilton, only 18 miles west of Morrinsville, they did not cause any alarm or do any damage.

For the remainder of November 12, earthquakes continued, and according to the New Zealand "Herald" of December 23, 1926, Mr. L. I. Grange, the New Zealand Volcanologist, determined that 41 shocks occurred during the next few days. The disastrous shock was of intensity No. 8 of the Rossi-Forel scale. He believed the shocks to be of shallow origin, caused by movement of a fault on the east side of the Pakaroa Range. The Te Aroha hot springs, 12 miles northeast of Morrinsville, were unaffected by the earthquakes. One of the smaller shocks at 6:45 p. m. was described as coming without warning as a heavy, double thud, which violently shook the house, caused the windows to rattle, knocked over one or two articles on shelves, and started the people moving toward the street. Cambridge, Hamilton, and Morrinsville felt occasional small shocks during the month following the Morrinsville earthquake.

Mount Ngauruhoe, in the southern part of the New Zealand volcanic belt, was sending up steam and black smoke December 21, and on the evening of December 29 detonations were heard from the crater, followed the next morning at 4:15 by an immense volume of smoke which shot thousands of feet into the air. (New Zealand "Herald," Auckland, November 13 and December 22 and 31.)

T.A.J.

EARTHQUAKE STATISTICS

According to Professor Tondorf, of the Seismological Laboratory of Georgetown University, the frequency of earthquakes in the world was computed in 1900 by Montessus de Ballore. Aftter a close analysis of earthquake records then available, 131,292 in number, he placed the annual average earthquake occurrence at 3,830, equivalent to an earth shock every two hours and 37 minutes.

In 1904, Dr. August Sieberg, of the University of Jena, questioned the estimate as too low. A recalculation made by him in 1923 lifted the annual average frequency to 9,000, or about one every hour. Five thousand of these he indicated as being felt by human beings somewhere on earth. Violent or world-shaking earthquakes occur about every three and one-half days, either on the continents or on the ocean's bottom. Violent ones on land average one every five days.

California is visited by a shock on an average of 81 times annually. The liability of one of these shocks being heavy is about eight-tenths of one per cent. (Associated Press report January 1, 1927.)

Statistics of this kind are useful in order to stimulate thought, but the difference between the totals arrived at by Ballore in 1900 and Sieberg in 1923 is rather due to increased knowledge of the earth through human experience in the 23 years, than to any greater accuracy in the methods of Dr. Sieberg. This means that 9,000 earthquakes per annum is no nearer to the facts than 3,830 earthquakes. Neither figure means anything until we define the word "earthquake." In the Hawaiian Observatory alone we registered 5,877 local Hawaiian earthquakes in 1924, of which 3,961 were recorded during the explosive eruption in May. This is the record of only one of the 430 active volcanoes of the world. What about the bottom of the oceans, with reference to local shocks, not recorded as "world-shaking?" The ocean bottoms cover seven tenths of the earth. Clearly, then, an analysis of such few earthquakes as are recorded, is not an analysis of the terrestrial earthquakes that really occur. T.A.J.

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No. 114 RELEASED WITHOUT COPYRIGHT RESTRICTION March 3, 1927

KILAUEA REPORT No. 790

WEEK ENDING MARCH 2, 1927

Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

The changes at Halemaumau pit observed on March 1 were a fresh reddening of the whole northwest wall of the pit where a large shell of the wall had fallen. The debris slopes below were seen to be covered with reddish rocks and dust, and the dusting of the bottom of the pit extended clear across to the south taluses. Most of this had been accompanied by small slides from the decomposed rock of the northwest wall. But there had been at least one big avalanche, which had carried away the greater part of a pronounced bench at the west end of the big intrusive sill which forms the lower part of the northeastern wall. The dusting of the bottom of the pit was further evidence of a big avalanche, and the middle talus of the northeast wall showed more fresh debris. The yellowing of the southern solfataras continued to be conspicuous.

The intense oxidation of the northwestern wall beneath the former surface is remarkable, and it was here that there was excessive heat, along with blue sulphurous fume, in 1923 and earlier.

Fourteen very feeble local earthquakes were registered for the week. Ten of these came on the first two days of the weekly period, February 23 and 24. In the last issue of the Volcano Letter it was noted that a large part of last week's shocks came February 21 and 22. Thus 75% of the shocks for the fortnight occurred within a four-day spell of comparatively greater seismic activity. Three of the earthquakes of that time had indicated distances of about 13 miles, which corresponds to either the northeast rift of Mauna Loa or portions of the northeast rift of Kilauea that were active in 1923 and 1924.

Tilt during the week was moderate ENE. On February 21 the direction of tilt began to change from southwesterly to southeasterly, and by the 23rd it was nearly due east; thus a definite change in direction of tilt coincided with the time of frequent shocks.

The seismological station of the U. S. Coast and Geodetic Survey at the University of Hawaii, Honolulu, Mr. Harold McComb in charge, reports that seismometric measurements of six stations of the United States and Canada locate the distant earthquake of February 15 (noted in Volcano Letter No. 112) as 48° N. Lat. and 153° E. Long., the time at that locality being 1h., 35 m., 22 s., a. m. (G. M. T.) on February 16. The distance from Honolulu was 3,230 miles, and the epicenter is in the Kurile Islands.

EARTHQUAKE IN SCOTLAND

In view of what was said about Britain being stirred in 1926 by recognition of the earthquake peril (Volcano Letter September 23, 1926), the four columns in the Aberdeen "Evening Express" of January 24, 1927, are interesting. They announce that at 5:20 that morning the whole of the north of Scotland and much of southern Norway were shaken by an alarming earthquake, which reached intensity No. 6 (Rossi-Forel scale) in Aberdeen (Nature, February 5, 1927). The British seismographs indicate an origin outside of Scotland in the Norwegian direction. Never before has a North Sea earthquake been felt over so wide an area in Gerat Britain. The area disturbed extended all along the eastern coast of Scotland from the Orkneys to Berwick, and was probably felt in Northumberland. At the northeast end of the great Scottish rift near Moray Firth, an earlier shock the previous evening occurred at 11:05 o'clock.

The shock lasted from five to 30 seconds, and in Aberdeen people were awakened by a loud rumbling noise, doors and crockery rattled and bells were set ringing, and in some places furniture was moved. Ornaments fell from mantlepieces and shelves; doors were slammed; beds pitched up and down, and many persons were greatly alarmed; in some places plaster fell from ceilings.

The press reports from Norway state that the time was 6:20 a. m. by Norwegian Time, which is an hour earlier than Greenwich Time, and that in some towns masses of masonary crashed to the ground and other houses were cracked. People rushed panic-stricken from their homes, but there were no deaths. Three principal shocks were counted, felt from Notodden to Stavanger. The shocks were followed in Norway by terrifying rumblings which sounded like subterranean thunder. All of this indicates greater violence in Norway than in Scotland. T.A.J.

LOWER CALIFORNIA EARTHQUAKE

A violent earthquake at Calexico, on the California-Mexico boundary, occurred about 18 minutes after the midnight that ushered in the New Year (California Time.) Damage was reported at $2,000,000 throughout the entire Imperial Valley, martial law was declared on the Mexican side, and to prevent looting a special police patrol was organized on the California side of the border, with orders to shoot to kill. Many persons were cut and briused, subterranean rumblings were heard almost constantly, 50 or more shocks followed the disastrous one, and during New Years Day these diminished in intensity. At the first shock the mud houses of the Mexicans crumbled to dust, and the merry-makers of the cafes and casinos celebrating the New Year were terrified and poured into the streets. The shocks were felt from Anaheim, Calif., 150 miles north of Calexico, to Yuma, in Arizona. Damage by breakage of the water mains, followed by fire, was heavy in Mexicali. Yuma reported a succession of shocks, terminating at 6:10 a. m. The ocean at Ensenada, on the Pacific coast of Mexico, 50 miles south of the border, was thrown into extraordinary heavy swells, which prevented the launching of small boats. T.A.J.

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No. 115 RELEASED WITHOUT COPYRIGHT RESTRICTION March 10, 1927

KILAUEA REPORT No. 791

WEEK ENDING MARCH 9, 1927

Section of Volcanology, U. S Geological Survey:
T. A. Jaggar, Volcanologist in Charge

The week has been very rainy, with northeast wind, and this moisture increased the volume of visible vapor in Halemaumau. Slides have continued. One considerable avalanche was seen about 11 a. m. March 6, and another one fell with a roar at 1:50 p. m. March 9. Both of these were at the northwest wall.

Five local earthquakes and one distant one were registered during the week. The local ones were very feeble. The preliminary wave of the teleseism, here faintly recorded, arrived about 11:09 p. m. March 6, and the disturbance continued weakly for three-quarters of an hour. Allowing for the difference in time, this was probably the disastrous earthquake in central Japan reported as "Monday night" (March 7).

Tilt for the week has accumulated slightly to the south.

LASSEN OBSERVATORY SEISMOGRAPH

Two horizontal pendulum seismographs recording on a single drum by the smoked-paper method were built along with the cellar to receive them, by R. H. Finch between his arrival at Mineral, September 15, and November. The dimensions of the cellar are 10 by 10 feet, and an office room was constructed above it. The general plan of the instruments follows the lines of the Omori seismographs as they have been modified by Hawaiian experience. The time-piece is an excellent Howard pendulum clock, with seconds pendulum and eight-day movement. The upright posts, 10 by 10 inches square, rise 27 inches above piers which are 18 inches high and two feet square. The heavy masses weigh 225 pounds, consisting of cast-iron containers holding nine lead weights, each bored to take a screw-eye for convenience in handling by one man. A mental rod passes horizontally through the middle of the heavy mass and protrudes 52 inches from the center of the latter, greatly reduced in size at the outer end. The larger portion next to the post is bent slightly, and fits a niche in the face of the post, where it is held by a cardan hinge consisting of a very short piece of fine steel wire, in slots. The upper support is a piano wire with the usual adjustments at the top of the post. The sytem is damped by sheet-aluminum vanes attached to the arm, moving edge-wise in a tank of oil, supported by a removable stand in front of the pier. This permits instant lowering of the oil tank for tests of free swing of the pendulum.

The magnification of the boom is 5, and of the writing lever, 40, making the total static magnification 200. The drum is built on a steel spindle threaded with ¼-inch worm, the ends being made of 3/16-inch three-ply wood, and the cylindrical surface of pasteboard. Light-weight glassine paper is used, each seismogram being 12½ by 38 inches in size. The writing pens are of magnetized steel, lifted to make a gap in the record every minute by an electromagnet, and the pivots of the tubular aluminum writing levers and of the pen-points are made of clock and watch balance staffs. The speed of the drum is 30 millimeters to the minute, and the transmission of motion from the pendulum arm to the writing levers is by means of light metal T-bars, with points resting in sockets in the arm and the lever, respectively. A marker pen attached to the plate supporting the drum and lever system, writes a line for a few minutes once a day on the side of the smoked paper, to be used as a datum line for measurement of wandering of the pendulums under tilting of the ground. The free period of the pendulums is seven seconds.

All of this material, with the exception of the time piece, was gathered together and erected by the Associate Volcanologist, and the driving clocks for the drum were obtained from the Seth Thomas Company, having two-barrel drive and a rotation rate of the spindle of about 15 minutes, which is slowed down with the appropriate gear. The uniformity of rotation given to the drum by these clocks with a speeded balance wheel, is remarkable, and no trace whatever of jerking movement due to the ticking escapement appears in the seismograms. Hitherto, although Mineral is on the actual slope of the Lassen volcanic mass, the seismometric registration has not shown tilt and has been free from tremors of the non-earthquake type. A few tremors have been recorded that have not been identified. R.H.F.

HAWAIIAN OBSERVATORY NOTES

Since the Section of Volcanology was established (Volcano Letter August 12, 1926) the work of the central station in Hawaii has been directed to adaptation of the plant and personnel for its enlarged scope, and to systematizing of its local Hawaii work in the three branches; namely, geodetic, temperature, and seismometric measurements.

The buildings have been repaired and improved, and a new machine-shop was started in operation March 1, 1927, with F. Y. Boyrie as instrument maker. The shop contains lathe, drill presses, power hack-saw, and circular-saw table, and hereafter saving of time and money will be accomplished by machine work done on the spot.

Ground was broken for the new exhibit and lecture building of the Hawaiian Volcano Research Association February 22, and the concrete floors of the new buildings have been laid. The site selected is the actual summit of Kilauea Mountain, on top of Uwekahuna Bluff, where the view of Kilauea Crater, the Kau Desert, Mauna Loa, and Mauna Kea is magnificent. The main building will be of iron and concrete, with stone corner posts and stone benches along the outside. In front a large terrace is being built, inclosed by rough stone wall and containing stone benches. The showroom will contain an alcove exhibiting through glass a modern set of seismographic instruments in operation, as well as other instruments, and on the floor will be glass cases containing the best of the cabinet specimens collected by the Observatory. There will also be wall cases and special exhibits, roller maps illustrating Pacific geograhy, photographic prints and transparencies, and projection apparatus.

The plan of operation so far as can be foreseen is that at a certain hour in daytime the tourist groups will be received and given a short talk on the open terrace concerning the geology of the crater. They will be shown the collections, and their questions will be answered with the aid of the maps and diagrams; then a projection lecture will close the proceedings. Later there will be a National Park naturalist with office hours to meet those who are interested in the walks and rides and natural features of this volcanic park. T.A.J.

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No. 116 RELEASED WITHOUT COPYRIGHT RESTRICTION March 17, 1927

KILAUEA REPORT No. 792

WEEK ENDING MARCH 16, 1927
Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

Rainy weather has continued through much of the past week at Kilauea Volcano. Dust from slides has not been noticed at Halemaumau pit.

The total number of local earthquakes registered at the Observatory during the week was 14, all very feeble. There are also four records of blasts that were noted and timed. Tremors due to blast are of the same character as the usual spasdomic tremor; they wax to a maximum amplitude about the middle of the disturbance, and then diminish to zero, the whole lasting about 15 seconds. The source is on the Hilo road, about a mile away, where the contractor is using dynamite, approximately ESE from the Observatory, and 15 feet lower.

Probably several of the jarrings counted as earthquakes are also due to this cause, but it is not possible to tell which ones. One definite feeble earthquake had phases sufficiently distinct to indicate an origin 20 miles away. This shock was recorded at 8:50 p. m. March 12, and was also registered on the seimograph operated by Captain R. V. Woods, in Kealakekua, on the other side of Mauna Loa.

The Kona seismograph also made a feeble record of the Japanese earthquake of March 7, noted in last week's Volcano Letter.

Practically no tilt accumulated for the week, as the slight SW tilt of the beginning of the week was compensated in the opposite direction later.

THE ALEUTIAN ISLANDS

The region in Alaska which contains the largest number of volcanoes extends in a continuous curved belt from the Aleutian Range of mountains west of Cook Inlet, through the Alaska Peninsula and the Aleutian Islands, to Attu, the westernmost possession of the United States, where there are warm springs. Volcanoes that have an active record lie along a broad arc 1,500 miles long. There are at least 40 of them, ranging in height from mere islets to Redoubt Volcano, 10,200 feet high. Many of the volcanoes ore symetrically-shaped snow-covered cones, with glaciers on their flanks. All along the belt there are hot springs, and in some places sulphur springs (Mineral Springs of Alaska, by Waring, Water-Supply Paper 418, 1917, U. S. Geological Survey).

The Section of Volcanology is authorized to establish one or more volcano observatories on the Aleutian belt. The greatest recent eruption in Alaska was at Katmai Volacno, opposite Kodiak Island, in 1912. This gave vent to tremendous explosions ejecting bowlders, sand, and dust, and also a very siliceous, stiff, soda rhyolite lava, with about 77.5 per cent silica. This magma is chemically at the opposite extreme from the basic olivine basalt of Kilauea, with 48 per cent silica.

The writer criused from Unimak Pass to Atka in 1907, and learned from traders that lumps of pure native copper had been found on the shore of Copper Island, belonging to the Russians, west of Attu. On Attu is a small village of Aleuts. On Agattu there are high peaks, and all of the islands west of Buldir are believed to be pre-Tertiary rocks.

Following the chain east from here, the southern half of the island belt, comprising the larger land areas in the middle of the chain, consists of ancient igneous rocks, without active volcanoes. The northern half, on the other hand, with the dividing line sometimes in a single island and sometimes separating different islands, consists of shapely, recent, volcanic cones, many of them fuming and some the sites of eruptions during the last 50 years.

Buldir is an eroded volcanic cone, with sunken rocks to the south, where islands are said to have existed prior to eruptions that destroyed them more than a century ago. Kiska has a fuming volcano 4,050 feet high at its north end, it contains a good harbor, and its southern half is geologically different, and said to contain "mineral." Chugul and Little Sitkin are said to be fuming volcanoes, the former containing iron. Amchitka is nonvolcanic, and has good cattle feed. Semisopochnoi is covered with volcanoes, but does not smoke.

We now come to a group of large islands strongly volcanic on their north sides. Gareloi is always fuming. A smoking volcano occupies the north end of Tanaga. The north end of Kanga was very active in 1904. Great Sitkin was reported fuming in 1904, and Kasatochi is said to be the top of a volcano with a big crater lake; about 1899 the lake disappeared, and steam was rising. Copper is reported from near Salt Island on Atka, and sulphur amid the volcanoes in the north of Atka. The writer camped there in 1907, and found a boiling spring, and saw fresh volcanic cinder on snow fields.

Seguam broke into eruption for a week in December, 1891, and this was followed by a terrific eruption in the spring of 1892, making detonations heard at the native village on Atka, 75 miles away, and exhibiting two jets of cauliflower clouds. Mount Cleveland, 8,156 feet high, in the Islands of Four Mountains, was active in 1893.

This brings us to Bogoslof, Makushin, Akutan, Shishaldin, and Pavlof, well known volcanoes with an active record.

The Section of Volcanology of the American Geophysical Union (Bull. Nat. Research Council, November, 1926) conducted a symposium on scientific cooperation in the Aleutian Islands in Washington, April 29, 1926, wherein the need was urged for a permanent cooperative observatory in the large central islands, dealing with volcanology, climate, charting, the sea bottom, geology, seismology, magnetism, and atmospheric electricity. As a beginning, we shall establish a seismograph station at Kodiak in the summer of 1927, and make exploration of the eastern Aleutians. T.A.J.

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No. 117 RELEASED WITHOUT COPYRIGHT RESTRICTION March 24, 1927

KILAUEA REPORT No. 793

WEEK ENDING MARCH 23, 1927
Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

The week of the equinox has been marked in the Hawaiian Islands by an exceptionally far-flung earthquake and by some slides in Halemaumau pit. The slides in question were not wholly due to the greater earthquake, as they had been observed the day before.

On March 19 there were numerous slides at Halemaumau in the afternoon which sent up dust. At 10 a. m. of March 20 the pit was visited with a view to discovering what were the effects of the strongly felt earthquake that had shaken all the eastern islands in the early morning. There were evidences that large slides had fallen at the northeast corner of the pit, and big boulders lay on the lava floor which has displaced a very large boulder known as a landmark there previously. There were also freshly fallen accumulations of debris on the northwest talus, characterized by white salts deposited upon their surfaces. At 4 p. m. March 22 some slides were in motion at the middle of the large northeast sill.

The local earthquakes for the week registered at the Observatory were 16 in number, all very feeble with one exception, the moderate shock that occurred just before 5 a. m. on March 20.

The beginning of this shock was recorded at the Hawaiian Volcano Observatory abruptly at 4:52:00 a. m. Hawaiian Standard Time. The instruments show no preliminary phase, the motion breaking abruptly into a strong movement of about 10 millimeters per second per second acceleration. This continued for about 10 seconds, and then became stronger, dismantling the instruments, so that the maximum acceleration and the subsequent details of the shock were not recorded. The shock was perhaps the strongest and most widely felt that has occurred for a year. Reports from other islands indicate that it was felt with about the same intensity throughout the group. Its beginning was recorded in Honolulu by the seismological station of the Coast and Geodetic Survey at the University of Hawaii, at 4:51:07, reaching its maximum there as 4:51:50. That station also reports a second shock at 5:59 a. m. The extent of damage in Hilo was limited to a few broken dishes and small articles thrown from shelves in various localities.

The fact of its abrupt beginning, without preliminary phases, at any of the places where it was recorded in the islands, makes localization of the epicenter a difficult problem. It is worthy of note that Washington, D. C., reports an earthquake 4,800 miles away for the same morning, but the time is not given.

On the Island of Hawaii, the shock was recorded at the Volcano Observatory, at Kealakekua, and at Hilo. An interesting coincidence is the fact that on March 19, 1926, at 10:33 p. m., almost exactly the same date a year ago, a heavy shock occurred with almost the same characteristics. This time of year is very close to the vernal equinox.

There were several severe electric storms during the night of March 22-23, apparently centering near Hilo.

Tilt for the week has accumulated slightly to the SE.

LASSEN REPORT No. 5

Mineral, California, March 2, 1927
R. H. Finch, Associate Volcanologist

Lassen Peak Volcano again showed signs of uneasiness on March 1, 1927, after having been relatively quiet since December 28, 1926. About seven o'clock in the morning of March 1, six earthquakes followed one another in rapid succession. Two of this number were plainly perceptible, the others were detected only by means of the seismograph. At 2:26 p. m. of the same day there came another and larger shock. It was preceded by a loud rumble, and was strong enough to cause buildings to creak. It is interesting to note that "swarms" of earthquakes have been occurring at intervals of about two months.

ADRIATIC EARTHQUAKE

A severe local earthquake was described in the British press of about February 16, 1927, as occurring along the shore of the Adriatic in Jugo-Slavia, and affecting the provinces of Dalmatia, Bosnia, and Herzegovina. Near Serajevo, famous for the murder of the archduke that precipitated the world war, there were big landslides. Chimneys fell, even in Belgrade. The center is said to have been under sea, huge waves were reported on the Dalmatian coast, and ships were said to encounter gigantic seas, even in the Mediterranean off southern Italy, but the correlation of these events with the earthquake may be erroneous.

The reports stated that 19 earthquakes occurred, the first on February 14 at 4:40 a. m. by the local time, and the others during the following 20 minutes. There was said to be subterranean rumbling, and also thunder and lightning out of a clear sky. There appears to have been engulfment in some places, attributed to the underground drainage in a limestone country known to be honeycombed by solution cavities, and much subsidence due to this cause is said to have gone on in the past. The last serious subsidence was at the time of the Laibach Earthquake of 1895. The worst damage of the present earthquake is said to be in Stolac, 35 miles south of Mostar, the capitol of Herzegovina, and cracks formed in the ground.

A later report from Belgrade (Daily Telegraph, London, February 21) states that three persons were killed, 15 injured, and the damage was about $175,000. This took the form of collapsed houses, a tobacco factory destroyed, a fallen railway bridge, damage to famous historical buildings ruined from flood waves, and the crashing down of sculpture and frescoes. T.A.J.

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No. 118 RELEASED WITHOUT COPYRIGHT RESTRICTION March 31, 1927

KILAUEA REPORT No. 794

WEEK ENDING MARCH 30, 1927
Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

The week in the vicinity of the Volcano Observatory has been rainy, with light southerly winds, some thunder showers and increased snow is seen on Mauna Kea. At Halemaumau pit some small slides have occurred, chiefly from the north wall, where the rock is oxidized to a bright red color. The red debris has changed the appearance of the slope below.

After the heavy rains, the steam from vents in the lava floor and the talus has increased the visible volume of vapor clouds, and the three sulphurous patches at the south talus are growing in size. The two lateral ones have hitherto been very small, but they are now becoming large yellow patches like the big middle solfatara at that talus. It is extraordinary that the bluish fume mixed with steam that formerly was conspicuous at this middle vent, has there entirely disappeared, as though the sulphur were now deposited by a gas without the blue fume characteristic. Blue fume is seen, however, at the lower sulphur patch next the north edge of this talus. In addition to these places, white vapor rises abundantly at the center of the floor and from the southwest and northwest taluses.

There is much steam at the southwest rim cracks on the edge of the pit, and along the south wall inside the pit. An extraordinary change has happened at the southeast rim cracks of Halemaumau crossed by the tourist trail about 70 feet back of the rim. With wind in the southeast, these cracks were first observed to be free from steam March 26 and 27. They had been measured January 24, 1925, and had a temperature of 169° F., and were producing much visible vapor until recently. They have frequently been observed to yield so much steam as to be disagreeable where the trail crosses them. Now, however, the visitor may thrust his hand into the cracks, and almost no vapor is visible. Vegetation, such as lichens, mosses, grasses, and ferns, is taking hold in abundance about the openings of these cracks.

Twenty-two local earthquakes of very feeble intensity were registered at the Observatory during the week. There were two periods during the week of almost continuous tremor, apparently very much like the harmonic tremor that is the usual accompaniment to lava outbreaks. At 1:27 p. m. March 26 a very feeble tremor began, waxing gradually to a maximum at 1:37 p. m., waning, and waxing again to a second larger maximum at 1:41 p. m., and finally waning to the point where it no longer recorded itself on the seismogram at 1:48 p. m., making about 20 minutes of continuous tremor. The two maxima noted were counted as two earthquakes of the total for the week. On March 28 continuous tremor was again evident, beginning at 9:01 a. m., and continuing until 9:10, starting again at 9:16 and waxing to a maximum at 9:20 a. m., and waning to an end at 9:41 a. m.

Microseisms were rather strong on March 29.

Tilt has accumulated during the week moderately to the SSW.

LASSEN REPORT No. 6

Mineral, California, March 15, 1927
R. H. Finch, Associate Volcanologist

From March 10 to 14, 1927, the most remarkable series of local earthquakes was recorded since the establishment of the Lassen Observatory. The seismographs were dismantled three times. The strongest earthquakes were on March 10 and 11, though the majority of the entire 52 shakes were perceptible. Lyonsville, 12 miles to the southwest, also reported the strongest of the quakes. As seems to be a characteristic of Lassen earthquakes, all shakes both large and small were accompanied by loud rumbles. After the occurrence of such a series of earthquakes, it would seem indiscreet to say that Lassen Peak is dead.

CAUSE OF LASSEN MUD FLOWS

During the eruption of Lassen Peak in 1915, there were strong horizontal blasts on May 22 that denuded a section of the northeast slope of the mountain and produced remarkable mud flows down Lost and Hat Creek valleys.

It has been maintained by some that mud flowed over the lip of the crater, by others that hot water came out of the crater, and by still others that the water was derived from condensed steam and from snow melted by the steam and hot ashes. In looking over the Peak last January (Volcano Letter No. 110), it seemed to the undersigned that the source of the water may well have been due entirely to melting snow, that hot water from the crater was rather improbable, and that condensed steam, if any, played only a minor part. Snow usually accumulates on the slope in question until in March, while in the middle of January the depth of the snow—five to six feet—was sufficient to furnish water enough to account for the floods. The snow in the upper half of the comparatively narrow belt four miles long, if melted suddenly as must have been the case in 1915, could have produced steep flood waves of about the proportion of those that swept down Lost and Hat creeks. Gravel and boulders must have aided the finer particles in melting the snow and in raising the temperature of the water well above the melting point of ice. A very large boulder was still hot several days after the floods.

If the direction of the horizontal blast on May 22 was only slightly different from that of the one on May 19, as was the case, there would have been enough snow in its path to account for the minor flood that accompanied it, and the condensed steam factor may have been trivial.

R.H.F.

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No. 119 RELEASED WITHOUT COPYRIGHT RESTRICTION April 7, 1927

KILAUEA REPORT No. 795

WEEK ENDING APRIL 6, 1927
Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

Halemaumau pit at Kilauea Volacno has been visited several times during the past week, but nothing has occurred to indicate any marked change in the magma that underlies the volcano. There are usually small slides of loose rock from the walls of the pit if the visitor waits a half hour or more, but large slides have not been seen, and the sulphurous spots on the debris slopes have remained about as before. In rainy weather these solfataras give off much steam, and in dry weather the steam diminishes, but always there is some vapor at the sulphur patches. At the crack back of the southeast edge of the pit, there has been no return of steam where the trail crosses, and the winds have continued southerly. It will be of interest to observe what happens there when the northeast trade winds are resumed.

The seismographs at the Kilauea Observatory have registered a total of 16 local earthquakes, all very feeble. The only possible exception was one of these at 8:44 a. m. April 1, which appeared to be part of the faint record of a distant earthquake. Tilt for the week was moderate to the SW.

AMERICAN GEOLOGISTS

Professor E. H. Sellards, of the University of Texas, has compiled on a map the geographic distribution by states of geologists in the United States. He has presented on the same map the approximate number of papers on geological topics published in the two years 1921-1922, relating wholly or in part to each state. This figure, along with the figure showing the number of geologists, indicates to what extent the published work of the geologists concerns their own states. The list indicates all professional geologists who have worked at the science at least three years after their graduation, and at specialties that include geology, paleontology, mineralogy, petrography, engineering geology, and physiography Presumably geophysicists are distributed among several of these branches.

There are listed 1,744 geologists, and these produced in two years 1,072 scientific papers. Although the district of Columbia contains 114 geologists, only four papers were published concerning that district. On the other hand, California contains 180 geologists, who published 89 papers; and Texas 220 geologists, who published 75 papers, in each case about the state in question. New York has 171 geologists, but only 38 papers were published about New York geology. The activities of the geologists of New York and Washington, D. C., are largely in regions distant from the place where they reside.

The total number of papers for 1921-22 concerning state geology is 1,072, and of these 243 relate to the oil and copper states—Oklahoma, Texas, New Mexico, California, and Arizona. It is remarkable that of 1,744 geologists, 503, or more than one-fourth, live in Oklahoma, Texas, and New Mexico. This shows an astonishing development of geologic activity centering around oil in the last 30 years. The geologists most prolific of publications concerning their own states are in Utah, Nevada, and Oregon. In Utah eight geologists produced 32 papers, in Nevada three geologists produced 24, and in Oregon seven geologists produced 31.

Figures of this kind are very stimulating, and they mark the overwhelming domination of economic geology and especially oil geology which has grown up in connection with the vast industry of drilling and producing petroleum in the southwestern states. T.A.J.

THE TANGO EARTHQUAKE

A very severe and disastrous earthquake occurred on the west side of the Lake Biwa depression that crosses central Japan, on Monday, March 7, 1927. The principal damage was in Mineyama and vicinity, on the northwestern coast of Japan, the destruction being confined largely to fishing villages.

The Home Office on March 10 reported 2,458 dead, 4,107 injured, some 60,000 people homeless, and 88 missing. About 6,000 houses were destroyed by fire or collapse, and some 2,000 more were damaged. Airplanes were used for inspection and investigation, as railways were broken, roads were blocked, and the country at the time was suffering from floods. The misery was accentuated by snow and cold, there were numerous cracks, rumblings continued after the first earthquakes, and a flood-wave from the sea was said to have damaged Yamada and other villages. A terrific gale swept the region on March 11, adding to the misery by demolishing refugee shelters.

The earthquake was felt strongly in Kyoto, Osaka, and Kobe, but no very serious damage was done on the Pacific side of Japan. The details of the seismological data have not yet been reported outside of Japan. T.A.J.

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No. 120 RELEASED WITHOUT COPYRIGHT RESTRICTION April 14, 1927

KILAUEA REPORT No. 796

WEEK ENDING APRIL 13, 1927

Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

Halemaumau continues to show little change, but the red dust made by avalanches on the north talus has increased. On April 10 some slides were heard falling in the forenoon from the northeast wall of the pit, and at 5:15 p. m. a larger avalanche sent up a distinct dust cloud that rose above the rim of the pit and was simultaneous with a short-lived avalanche tremor registered on the seismographs at the Observatory. Heavy rain has washed away part of the sulphur and salts that were so conspicuous on the south and east debris slopes.

For the week 17 feeble local earthquakes were registered. One beginning at 9:02 p. m. April 7 continued feebly for about six minutes. Another at 2:09 p. m. April 8 had an indicated distance of origin 14 miles away. Tilt for the week was very slight to the east.

LASSEN REPORT No. 7

Mineral, California, March 30, 1927

R. H. Finch, Associate Volcanologist

Mr| Finch made a reconnaissance of the volcanic steam district of Sonoma, Napa, and Lake counties in California March 20-30. Volcanic cones are numerous in this district, and some are well preserved. A crater was found just above the petrified forest near Calistoga, which is very well preserved and shows a cone in the middle and a distinct Somma rim. The rainfall in this region is variable, so that age determinations on the basis of erosion changes affecting topography are apt to be misleading unless precipitation is considered. Thus the crater above mentioned appeared much younger than anything on Mount St. Helena. Near the petrified forest there are some interesting caves, either excavated by cliff-dwelling Indians, or else formed by erosion of softer material along an ancient lake shore that once occupied the valley.

THE UNDER SIDE OF THE EARTH'S CRUST

Seismology and the physical study of the elastic constants of rocks are making discoveries by a combination of experiments in the laboratory and measurements with the seismograph. The Geophysical Laboratory has published evidence that the earth consists almost entirely of ultra-basic rock, largely olivine, except for a thin crust and for a metallic core (Volcano Letter No. 3, January 15, 1925).

Adams and Gibson (Proc. Nat. Acad. Sci. Vol. 12, No. 5, pp. 275-283, May, 1926) have attacked the problem of what the material is under the crust of the earth. They believed it to be olivine rock or peridotite, Daly believed it to be basalt (Volcano Letter No. 59, February 11, 1926). They took specimens of granular olivine rock (dunite) from North Carolina, and basaltic glass from Kilauea, and cut a polished cylinder from each, and subjected these to pressures of from two to twelve thousand atmospheres immersed in a liquid. The changes of volume in the two substances under different pressures were determined with precision. Given the compressibility and the density, it is possible to calculate the velocity with which the preliminary and the secondary earthquake waves will be propagated through these substances.

Now in the earth itself the velocities of these two types of wave motion, the first compressional, and the second distortional, are known for various depths below the surface from seismologic data. Hence a comparison of these velocities with those calculated from the elastic constants of different rocks provides a key for elucidating problems of the earth's interior. From the seismologic data the velocity of the compressional waves increases slowly to a depth of 60 km., and at this level it changes suddenly from about 5.9 kilometers per second to 8.0 kilometers per second. The velocity in rock increases with increasing basicity and density. The pressure at 60 kilometers of depth is about 17,000 atmospheres.

Applying the formulae to the compressibility results for the granular olivine and the Kilauea basaltic glass, respectively, the investigators found that at that depth the velocity in the olivine rock for the compressional waves would be 8.4 km./sec., and for the basaltic glass the Kilauea rock would transmit these earthquake waves at 6.9 km./sec.

It is evident from this that the material at depths greater than 60 km. is heavier and more basic than gabbro, and approaches olivine in composition. With due allowance for the effects of high temperature which would probably decrease the velocity a little, the authors estimate that the material below the crust of the earth at 60 km. of depth should consist of a peridotite largely olivine, but containing some less basic silicate like hypersthene. The authors believe that measurements of the compressibility of rocks at high temperatures would enable one to make a precise estimate of the composition of the earth's crust.

The results show that the glassy, basaltic substratum under the crust of the earth, which Daly has characterized as "slippery", cannot exist there if the seismograph data are correct, and "whatever basaltic material there may be within the earth is probably confined to a comparatively thin zone." T.A.J.

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No. 121 RELEASED WITHOUT COPYRIGHT RESTRICTION April 21, 1927

KILAUEA REPORT No. 797

WEEK ENDING APRIL 20, 1927

Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

The week at Halemaumau pit has produced no important changes. At 11 a. m. April 20 the taluses showed fresh debris N, WNW, and SSW, and the sulphur patches of the eastern inner slopes showed dimming of their brilliant color through the washing of recent rains. The upper walls were dark red in color, owing to wetness. The large sulphur patch at the S talus was still bright yellow with a dark area in its center.

There has been for many weeks past a lump of red rock at the core of the west boss, an irregular dense rock mass underlain by intrusive gabbro in the middle of the western wall of the pit. This lump protruded; now it has totally fallen away, and it was evident from small slides observed three times on this morning that motion there was still in progress. The slides were very small, so that the dust from them was detected with difficulty, though the noise could be heard plainly. At 11:16 a. m. a small slide occurred NNE.

Steam appeared at the usual places in the pit, and although light NE wind was blowing, the steam cracks back of the SE station had failed to develop any return of their heat and vapor. It is evident that the cessation of steaming there, first noted about March 30, is not connceted with the direction of the wind and is more or less permanent. They are vaporing about 50 yards south of the trail, but this is quite invisible at the trail crossing, and the air rising from the cracks is barely warm.

Fourteen very feeble local earthquakes have been registered for the week at the Observatory. Tilt was slight SSW.

OPENING OF THE UWEKAHUNA OBSERVATORY

During the visit to Kilauea of the Pan-Pacific Conference on Education and Recreation recently held in Honolulu, Dr. Hubert Work, U. S. Secretary of the Interior, at 9 a. m. April 19 opened to the public the new Uwekahuna Observatory and Exhibition Room of the Hawaiian Volcano Research Association (See Volcano Letter No. 115).

Dr. Jaggar made a short address, mentioning the fact that for 11 years past it has been the hope of the workers at the Hawaiian Volcano Observatory (Bull. Hawn. Vol. Obs. Vol. 4, No. 4, 1916) that some sort of a trailside museum might be provided for which would make it possible to explain to travelers in an appropriate setting the fascinating mechanism of volcanoes, and at the same time show them pictures of recent activities and maps or diagrams illustrating the relation of the Hawaiian volcanoes to the surface features of the globe. Thanks to the liberality of Congress in creating the Volcanology Section of the Geological Survey in 1926, the Research Association supplied money for the building of a small exhibit hall equipped with electric current and projection apparatus. This is now finished, and some of the best of the collections of the Observatory have been placed in display cases, the whole room being faced with large plate-glass windows that command a magnificent view southward of the whole Kau Desert and Halemaumau pit. As the buildings and equipment furnished by the Hawaiian Volcano Research Association are all part of the plant of the Observatory, Dr. Jaggar took occasion to convey the new establishment to the use of the Department of the Interior through the two branches here presented, the National Park Service and the Geological Survey.

Secretary Work accepted the offering on behalf of the Department of the Interior, and short speeches were made also by Honorable Stephen T. Mather, Director of the National Park Service, and by Honorable Wallace R. Farrington, Governor of Hawaii.

The new buildings are of iron, with rough stone corner posts, the smaller one housing the water tank, preparation room, and power plant, the larger one standing on the highest rim of Kilauea Crater, with a terrace in front designed to display the view that on bright mornings extends all the way from Mauna Kea and Mauna Loa around past the south point of the island in panorama, and thence eastward, including all the cones and landmarks of the Kau Desert, to Halemaumau, spread out at the feet of the observer as an enormous chasm less than a mile away. Beyond it and around is seen all the detail of Kilauea Crater and the pits Keanakakoi and Kilauea Iki, while in the distance to the east lies Puu Huluhulu, that marks the site of the new Chain of Craters Road, which Secretary Work dedicated the same morning.

It is hoped eventually to install on the terrace a large Zeiss binocular telescope, and projection apparatus for lantern slides and motion pictures has already arrived, and in a short time will be installed and in operation.

T.A.J.

HILLS CREEPING IN QUEENSLAND

From Nambour in Queensland comes the report (The Argus, Melbourne, Australia, January 28, 1927) that an unusual and serious catastrophe occurred about January 26, 1927, near Perwillowan. Whole farms have moved, fissures have opened, and small earthquakes have occurred. This is a hilly country near the sea, and one farm is described as having moved a portion of its lands bodily across a road onto the territory of another farm, so as to lose part of its acreage. In one place a washout is described nine feet deep, in another place the slip of a block country 700 feet long by 60 feet deep, with a forward motion of over 600 feet, carrying banana plants on its surface. Elsewhere there is a chasm 12 feet deep and three feet long.

At Robinson's farm the roadway is reported entirely gone for a mile of length, creaking noises are heard, the hillside at the back has moved to within a few feet of the house, and the house has tilted.

At another residence on the morning of January 26, there was a landslip carrying with it trees, boulders, and earth. Culverts have been carried away or shifted. The loss in property is severe, and some families have moved into Nambour.

T.A.J.

EARTHQUAKE IN CHILE

On April 13, 1927, the press reports 50 injured and 16 dead over 1,000 miles of Chilean coast near Santiago and Valparaiso.

T.A.J.

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No. 122 RELEASED WITHOUT COPYRIGHT RESTRICTION April 28, 1927

KILAUEA REPORT No. 798

WEEK ENDING APRIL 27, 1927
Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

Halemaumau, the inner crater of Kilauea Volcano, continues to evidence little change. There is no avalanching, though during a circuit of the pit on April 23 it was noticed that there are several places ready to fall whenever there is sufficient seismic disturbance. The intrusive mass at the west boss, mentioned in last week's report, has fallen away a little more, and several rock falls were heard on three visits to the pit during the past week. One of these, on April 27, 8:45 a. m., made echoes lasting for a few seconds.

White salts are seen on the walls, the sulphur patches on the talus slopes and floor remain about the same, and steam continues at the usual places. On April 25 it was noticed that the cracks near the tourist trail crossing, mentioned in Volcano Letter Nos. 118, 119, and 121, are again steaming, though very moderately.

During the week the total number of earthquakes recorded has been 19, all of them very feeble. More than half of this number occurred on the 23rd and 24th, culminating in a shock in the early morning of the 25th somewhat stronger than the rest, which had an indicated distance of 12 miles. Tilt has accumulated moderately ENE.

It has so frequently happened that either Mauna Loa or Kilauea has erupted soon after Dr. Jaggar's departure from the station, it has become almost a superstition that his leaving should be a signal for an eruption to occur. Two days after his recent departure for Alaska rumor was rampant on Hawaii that an eruption was in progress without, however, the slightest foundation in fact.

THE OCEAN

Since three-fourths of the area of the earth is covered by water, such studies as geology, topography, geodesy, volcanology, seismology, and other investigations dealing with the composition, shape, and mechanics of the earth's crust, are most easily persued over the area limited to the remaining quarter, or land area. These water-covered areas are attracting increased attention, however, through modern methods of sounding, and through evidences supplied by seismology and allied sciences.

In "La Science Moderne" (Montreal, Feb. 1927) Professor J. Thoulet writes concerning volcanic and seismic disturbances beneath the oceans. He describes the ocean depths as places of almost perfect rest. The motion of the waves and tides are for the most part surface movements and do not affect the depths, and disturbances due to diffusion must be slight, and ordinarily convection currents due to either solar or earth temperatures cannot very much disturb the deep ocean waters.

On land, geologic formations show evidences of the crust having been many times revised and made over, volcanoes are seen building new surface, and rivers are seen removing old surface. Geodesy is now a science of sufficient precision to detect progress of slow warpings and bendings. Changes must also be taking place beneath the seas, and may in time made available for study.

Volcanoes, under water, are undoubtedly producing lava flows. Lava erupting in air tends to be light and frothy due to gas expansion. But under water at great depths the pressure is so great, and cooling is so fast, that in all probability the gases are never released, and the lava is compact and dense. Thus there would be no gas bubbling to the surface, there would be no light pumice-like material ejected to float to the surface, nor any other surface indication of such an eruption, unless it might be a local heating of the water detectable at the surface—though diffusion would make this improbable.

The presence of such flows may perhaps be detected, while still fresh and unmasked by sedimentation, by sounding for character of surface. Volcanic cones and topographic shapes might become apparent with depth soundings in sufficient detail.

The U. S. Coast and Geodetic Survey has developed a sonic sounding device, utilizing a transmitted sound and a timed echo, wherewith depth measurements are possible with ease at the rate of one or more a minute, without checking the ship's speed. The sounding lead requires half an hour or more in moderately deep water, with the ship's position held. Thus it seems that here a new field of investigation is opening, through the possibility of greatly increased detail in sounding.

Earthquakes in the ocean floor are easily detected, through seismology, and their locality closely determined. But the nature of the movement producing them can only be guessed at. On land the movement along a fault can at least be measured at the surface.

Risings and fallings of the ocean's floor, of a gradual sort, defy detection, though the sudden change in depth of Sagami Bay, Japan, in 1923, was made available for study through detailed soundings in existence before the change, compared with soundings made afterwards. On land such risings and fallings of the earth's surface are made apparent through stream erosion, and if rapid, through precise leveling.

The ocean itself gives some indications of earth changes. Suboceanic earthquakes may produce tidal waves. Mean sea level, as a reference datum, has inscribed itself in geologic time as shore lines, now elevated for inspection and proof of rising of the crust. Rapid rising or falling of shore lines may be detected and measured by tide gauges, as was done at Sagami Bay.

R.M.W.

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No. 123 RELEASED WITHOUT COPYRIGHT RESTRICTION May 5, 1927

KILAUEA REPORT No. 799

WEEK ENDING MAY 4, 1927

Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

Halemaumau shows no suggestion of lava activity, but slides from the walls have increased. These are taking place mostly from the northeast side, and at 10 a. m. on April 30 dust from an avalanche was seen to rise from the north corner and drift away. Later that day there were more slides, accompanied by much dust. On a visit to the pit on May 2 a large scar was seen at the north, beginning just above the west horn of the big sill and extending all the way down to the talus slope, which was coated with new debris. The wall at the other end of the sill is similarly freshly broken away, and a new boulder lies at the foot of the NNE talus. During a circuit of the pit on May 3 rocks were heard falling almost continuously from the north and northeast walls.

For the past week there have been 18 local earthquakes, all very feeble with one exception. On April 30, at 2:33 p. m., a shock occurred that was felt by a few people, both at the volcano and in Hilo. It may be classed as "slight," its maximum acceleration being about 11.0 mm. sec. per sec. The indicated distance to origin from Kilauea is about 40 miles, and from Hilo, 34 miles. It was followed by several very feeble after-shocks, one of which was of four minutes duration.

During the first part of the week tilt accumulated moderately to the south, which was recovered by northerly tilt, so that the net for the week is practically zero. The change from south to north tilting closely agrees in time with the time of the earthquake above described.

EARTHQUAKE INTENSITY

So many factors enter into the determination of the intensity of an earthquake that it is difficult to secure a scale by which the wide variety of different kinds and sizes of earthquakes may be definitely graded. The motion of an earthquake is very complicated and involved, any given point of the earth's surface traces a path which, if reproduced, would very much resemble a bad tangle in an unwound spool of thread. It is a complicated elastic vibration. The motion defies mathematical analysis. Seismographs record it ordinarily in three parts representing the three dimensions of space; for example, north-south, east-west, and up-down are the usual three components. Each of these components represents the motion back and forth in its particular direction only. In order, therefore, to unravel the actual complete motion, all three of these components must be combined, instant for instant; an undertaking of considerable complexity.

As a given point traces its tangled path, every time its motion is changed in direction or velocity, it is spoken of as being accelerated; the acceleration being ever changing in amount and direction, and its intensity being measured by the suddenness in the change of velocity or direction that it produces in the motion of the point in question. The maximum acceleration attained is the index of the power and severity of the earthquake. We feel no motion until the earth's crust is shaken or accelerated beneath us. The acceleration of an earthquake is rapidly and repeatedly reversed in its direction, producing a swaying or vibrating motion back and forth. A great acceleration means a strong starting and stopping, and re-starting and stopping again in reverse direction, of the ground beneath our feet; a harsh shaking that we feel and that tests the strength of our structures. The range of such a motion may be small—a few hundredths of an inch perhaps—but if the shaking is rapid it is nevertheless evidence of strong acceleration. If, however, the same range of motion is only accomplished through a longer period of time; say a complete cycle of motion requires fifteen or twenty seconds, as in an earthquake the origin of which is at a great distance from the observer; then the acceleration is weak and the earthquake is not felt by the observer, though the shock may be severe at its origin. Thus the intensity of an earthquake, its acceleration, its perceptibility and resulting damage, is dependent not only upon the range of motion, but also upon the rapidity with which the ground is shaken back and forth through this range. No one of the three components alone will, as a rule, show the amount of the whole acceleration; therefore, in order to compute by rigorous mathematics the value of the maximum value so as to grade the earthquake, it would be necessary to compute instant for instant throughout the disturbance the value of the varying acceleration as found from a combination of the three components, and so find where the maximum occurred. That would be an impracticable and tedious problem. Ordinarily the approximate time of maximum acceleration will be apparent in the records. The approximate maximum acceleration may then be computed for that portion of the earthquake. The same earthquake results in different action in different localities, due to distance from the origin and to the varying elastic properties of the earth's surface at different places. An earthquake is ordinarily graded, however, by its intensity at or over its origin, or where it is most severe.

Thus it is seen that it is difficult to accurately scale an earthquake, even with good records of it, and also a seismograph is not always located near the origin. The instrumental and mathematical measure of the acceleration is hardly more satisfactory as a measure of the intensity of an earthquake than is the simpler method of feeling and noting its effect on objects around us. Thus the natural scales are still in customary use. Of these natural scales the common ones are the Rossi-Forel, the Cancani, the Mercalli, and others, in general similar. These scales may be found in any textbook on seismology, but for convenience a copy of one of them will be included in next week's "Volcano Letter." R.M.W.

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No. 124 RELEASED WITHOUT COPYRIGHT RESTRICTION May 12, 1927

KILAUEA REPORT No. 800

WEEK ENDING MAY 11, 1927

Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

The activity at Kilauea is still confined to avalanching, which has diminished toward the close of the week. Small rock falls continue intermittently. Several falls were noted on May 5 and 7. On May 9 the wind was too strong to hear clearly sounds in the pit. Rain accompanied the wind, and from the dry places in the pit the hot areas could be detected. May 11 the pit was very quiet, and but a few rock falls were heard during a two-hour observation, the largest slide being one from the SSE wall, which is ordinarily very stable.

During the week ending May 11 there were 36 very feeble local earthquakes recorded. This is an increase in number over that for any weekly period since the middle of September, 1926. At that time there was a marked decrease in number, as noted in Volcano Letter No. 92. Since then the weekly average has been 15 local earthquakes, and the number per week has clung close to the average, the maximum and minimum during this time being 29 and 6, respectively. Thus the increase this week is worthy of note. One of these shocks, while still very feeble, yet plainly indicated a distance of 36 miles. On May 8 there were five cases in which the earthquakes appeared to come in pairs, the interval between the first and second tremor being in all cases close to 50 seconds. In the count for the total for the week, each pair has been counted as one. Avalanches during the first part of the week were more frequent than usual, and it may be that the second tremor in the pairs above noted are the result of avalanches precipitated by the first, and real, earthquake.

Tilt has been feeble during the week, accumulating only very slightly to the NE.

THE ROSSI-FOREL SCALE (1883)

Grades of Earthquake Intensity.

No. 1, recorded by a single seismograph, or by some seismographs of the same pattern, but not by several seismographs of different kinds; the shock felt by an experienced observer. No. 2, recorded by seismographs of different kinds; felt by a small number of persons at rest. No. 3, felt by several persons at rest; strong enough for the duration or direction to be appreciable. No. 4, felt by several persons in motion; disturbance of moveable objects, doors, windows, creaking of floors. No. 5, felt generally by everyone; disturbance of furniture and beds; ringing of some bells. No. 6, general awakening of those asleep; general ringing of bells; oscillation of chandeliers, stopping of clocks; visible disturbance of trees and shrubs; some startled persons leave their dwellings. No. 7, overthrow of moveable objects, fall of plaster, ringing of church-bells, general panic, without damage to buildings. No. 8, Fall of chimneys, cracks in the walls of buildings. No. 9, partial or total distruction of some buildings. No. 10, greater distasters, ruins, disturbance of strata, fissures in the earth's crust, rock-falls from mountains.

No. 1 grade above described is too strong in which to class the great numbers of non-perceptible tremors recorded on the seismographs at the Hawaiian Volcano Observatory, where the grading used is as follows: Very feeble, acceleration 2.5 mm. per sec, per sec., totally instrumental. Feeble, acceleration 5.0, mostly instrumental. Slight, acceleration 10, slightly perceptible. Moderate, acceleration 25, generally felt. Strongish, acceleration 50, strongly felt. Strong, acceleration 100, alarming. These terms are as used in the Volcano Letter. Dutton evaluates the Rossi-Forel grades (excepting the tenth) in terms of acceleration as follows: No. 1, 20 mm. per sec. per sec.; No. 2, 40; No. 3, 60; No. 4, 80; No. 5, 110; No. 6, 150; No. 7, 300; No. 8, 500; and No. 9, 1,200 mm. per sec. per sec. Comparisons may be made through equal values of acceleration. It is seen that "very feebly," feeble," and "slight" come below the lowest Rossi-Forel grade. Some uncertainty is introduced, as "slight" includes shocks that may be perceptible, in spite of the fact that Rossi-Forel No. 1 is intended for the lowest perceptible grade. R.M.W.

TIME

At the Hawaiian Volcano Observatory, the controlling timepiece is a Howard seconds-pendulum clock. Its correction is frequently determined by radio, and it runs in a room in which the temperature range is small. A chronometer is used in daily comparison. During the months of December, 1926, January and February, 1927, its rate was remarkably constant at -0.08 second per day. Near March 8 its rate changed to -0.66 second per day, and since then it has run at -1.71 second per day. These changes in rate are most likely due to disturbances of the clock when winding, by earthquakes, or any other of many possible causes. An interesting speculation, however, suggested by the timing of the pendulum in the gravity apparatus used here last December by the U. S. Coast and Geodetic Survey (Volcano Letter No. 106) is the possibility that the pendulum of this clock may be sensibly indicating changes in the value of gravity. Other geodetic dimensions here at Kilauea are changing—elevations through a range of about two feet, and horizontal positions as much as five feet—amounts measureable during a few months' time. Gravity would change very slightly due to the known changes in elevation, and it might also be changed by the movement or intrusion of magma in the edifice of the volcano. The value of gravity determined here in December was 978.667 dynes—not corrected for elevation, topography, etc. This value would need to change but .013 dyne and .024 dyne to produce the two changes in clock rate mentioned above.

In making the series of clock corrections observed, 82 during the period of time since the first of December, 1926, the radio signals sent out from Pearl Harbor, Hawaii, were used. It was at first thought that the clock rate fluctuated badly, but it soon became apparent that the chronometer showed precisely the same fluctuations, if the radio signals were taken as correct. It seemed inconceivable that both clock and chronometer should execute the same fluctuations, and it so became evident that the time signals themselves were in error by varying small amounts over and above the published correction. The mean rate over a long period would be practically free of these errors.

R.M.W.

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No. 125 RELEASED WITHOUT COPYRIGHT RESTRICTION May 19, 1927

KILAUEA REPORT No. 801

WEEK ENDING MAY 18, 1927
Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

Halemaumau shows little change over last week, except for a nitch which has formed in the upper part of the north sill, near its west end. Small rock falls from the walls continue, and steam issues quietly from the usual places on the walls, taluses, and floor.

During the week ending May 18, there were recorded 13 local earthquakes, all very feeble with the exception of one at 7:01 a. m., which was feeble, with an acceleration of 9 mm. per sec. per sec., its indicated distance being 17 miles. It was felt by only one or two persons in this vicinity. On the same day a perceptible earthquake was reported in Kealakekua, which was recorded here as a very feeble shock at 9:01 p. m., with an indicated distance of 31 miles.

Tilt has accumulated very slightly to the west.

KILAUEAN ASHES

It has sometimes been asserted that the term "volcanic ash" is a misnomer, since it implies the false idea of a residue from combustion, and that its usage should be discontinued. Such a suggestion receives additional support from the fact that the term ash has been so widely employed and in such different senses that it has ceased to have any accurate connotation. The term, however, has come to stay in geological literature, and has its value as a general field name for all loose pyroclastic material smaller in size than a pea. When such material is compacted, it is usually described as tuff. The palagonite-tuffs of Diamond Head and of Punchbowl, on Oahu, are typical compacted ashes.

A tuff composed essentially of glass fragments is spoken of as a vitric tuff. Such a tuff results from the violent comminution of frothy lava, and is especially characteristic of viscous acid lavas, such as rhyolites. The more liquid basaltic lavas of Kilauea usually give rise to thread-lace scoriae (limu) on explosion, the vesicles being retained within delicate walls. Occasionally, however, even the liquid Kilauean basalt has been so quickly chilled and triturated as to give rise to vitric tuff, composed of angular and crescentic chips of glass. The olive-green and yellowish tuff of the 1790 eruption which rests upon pahoehoe lavas along the 1868 cracks west of Halemaumau, consists locally of over 95 per cent of glass dust, probably derived from the shattering of thread-lace scoriae. In places the upper surface of this glassy deposit is curiously channelled by sharp U-shaped valleys, occupied by the coarser ejecta of later eruptions.

When crystals predominate over glass in a tuff, the term crystal tuff is employed; when rock fragments predominate over both glassy and crystal fragments, the term lithic tuff is used. Among the later products of the 1790 explosive eruptions, lithic and crystal tuffs alternate irregularly. Much of the dark gray ash in the road cuts near Keanakakoi is almost devoid of glass, being composed of chips of olivine, augite, felspar, and magnetite.

The ejecta of the 1924 eruption are almost wholly made up of pieces of previously consolidated rocks; the ash is thus essentially lithic. Certain specimens collected from the present surface of the old "aviation field," southeast of Halemaumau, are, however, chiefly composed of glass dust, with subsidiary amounts of crystal and basalt chips. The presence of glass in the 1924 ash is more likely to be due to the trituration of old, glassy basalts than to the explosion of fresh lava froth, since bombs appear to be absent from the ejecta.

Pyroclastic materials varying in size between that of a pea and that of a walnut are classed as lapilli. Coarser materials, if composed either wholly or in part of fresh magma on eruption, are included under the term bombs; if composed of previously formed rocks, as in the 1924 ejecta, they are described as ejected blocks, pebbles, and cobbles, according to their size.

Compared with the explosive ejecta of acid volcanoes, those of basaltic character are normally of very limited distribution and of more irregular thickness. For example, the palagonite-tuffs from the craters on Oahu are notably restricted in extent, and the 1790 ash of Kilauea varies rapidly in thickness over small areas. By contrast, an acid, rhyolitic ash-band averaging only a foot in thickness has been traced for over 200 miles along the Pelly River, Yukon, and an ancient Palaeozoic acid tuff is believed to occur at intervals over an area stretching from Kentucky and Tennessee in the east to Missouri in the west, and from just south of Lake Erie to near the shores of the Gulf of Mexico.

Howell Williams.

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No. 126 RELEASED WITHOUT COPYRIGHT RESTRICTION May 26, 1927

KILAUEA REPORT No. 802

WEEK ENDING MAY 25, 1927
Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

Halemaumau continues to show little change. Rocks can be heard falling nearly every time the pit is visited, and occassionally slides of varying sizes are witnessed. A rather large one occurred at the southwest rift tunnel about 9:30 a. m. May 23. The sulphur spots seem to be increasing low down on the southwest talus and on the lava floor of the pit.

There are recorded on the seismographs at this station 11 very feeble local earthquakes for the week ending May 25. On May 22 there is record of a teleseism with a vaguely indicated distance of 6,340 miles. The preliminary wave of this earthquake came at 15 minutes and 33 seconds past noon Hawaiian Standard Time, and the following phases lasted nearly an hour before the record died out completely. This earthquake was also feebly recorded on the seismograph at Kealakekua.

Tilt has accumulated only very slightly to the west.

A SIMPLE SEISMOMETER

The overthrow of columns by earthquakes long ago suggested the design of a seismometer composed of bars standing on end as a means of detecting earth shocks. Bars having very narrow bases would overturn more easily than those upon a wider footing. Bars hinged at the bottom, or resting on a knife edge, and leaning back against a rest, ladder-fashion, would be thrown over away from the support the more easily if held nearly vertical. For these types of seismometers West's formula has been used in computing the horizontal acceleration of the ground required to effect the overthrow, given the dimensions of the column. This formula is based upon an assumption that the acceleration is constant for a long enough time to allow the column to become overbalanced beyond recovery.

In "Science" of April 15, 1927, Professor Paul Kirkpatrick of the University of Hawaii has deduced a formula for the acceleration necessary to overthrow a column or bar of given dimensions, which takes into consideration the fact that the acceleration of an earthquake is not constant, even for very short periods of time, but is oscillatory. The formula contains several variables; the distance of the center of mass above the horizontal axis of rotation, the radius of gyration of the bar about that axis, the angle that the bar is allowed to lean back from its vertical against the support, the period of the oscillatory acceleration (assumed simple harmonic). From these, the value of the acceleration that will just suffice to overthrow the bar is computed. This formula suggested the design of a simple seismometer, which has been tried out on an oscillating table in the laboratory. Bars of varying form tested by accelerations of varying period and amplitude have proven the formula by experiment. Professor Kirkpatrick plans to bring the device to Kilauea to study its action in recording the local earthquakes in the vicinity of the volcano. He promises a more complete description as his experiments progress. R.M.W.

A DEFECT IN HORIZONTAL PENDULUMS

Kyoji Suyehiro, in the March, 1927, issue of the "Proceedings of the Imperial Academy," Japan, indicates that there may be an effect, hitherto ignored, that would cause the records of horizontal pendulum seismographs to be inaccurate representations of the true earth movements. Seismographs of this sort are arranged to swing about an axis that is nearly vertical. There are usually two pendulums, to record the two horizontal components of earth movement, hanging in vertial planes at right angles to each other. Thus the axis of a pendulum intended to record north-south motion is inclined slightly away from the vertical in an east or west direction in order that the pendulum will come to rest in a position at right angles to the direction whose component it is intended to record. This angle of inclination of the axis from the vertical is called the angle "I", and is assumed in most discussions to be constant, once the seismograph is set up and kept in adjustment. If this angle is changed, the period of the pendulum is changed, and if the angle is diminished to zero, the pendulum becomes unstable. A pendulum of this sort is usually regarded as being affected only by that component of the earthquake motion which is at right angles to the plane of its angle "I", which is duly recorded. If tilt is present to affect the value of "I", obviously the period of the pendulum would be changed, and if tilt were sufficient to make "I" zero, the pendulum would be unstable and would record meaningless wanderings instead of real earth motion. While tilt would hardly attain values large enough to accomplish this effect, it is shown in Mr. Suyehiro's paper that the component of the earthquake acceleration in the plane of the angle "I", supposedly without effect, may change the inclination of the effective axis of the pendulum, and so temporarily change the effective value of "I", even to the point of making it zero. Thus the pendulum would be rendered unstable, and its records might show swings of large amplitude without real earth movements to warrant them. R.M.W.

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No. 127 RELEASED WITHOUT COPYRIGHT RESTRICTION June 2, 1927.

KILAUEA REPORT No. 803

WEEK ENDING JUNE 1, 1927
Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

Kilauea Volcano continues dormant, the only activity being rock falls and small avalanches from the walls of Halemaumau pit and steaming at the usual places in the pit and on the floor of the crater. On May 30 about 11:30 a. m. dust from a big slide was seen to rise on the north side of the pit and hang over it about five minutes. During a visit to the pit on the 31st new debris was noticed on the northwest talus, reaching nearly to the lava floor, and the wall above was very dusty. At 11:53 a. m. slides were heard both northwest and south. On June 1 new debris was seen on the east, north, and south-southwest talus slopes, and the wall below the west boss appeared to be more broken away.

There have been 13 very feeble local earthquakes recorded during the week ending June 1. Tilt has accumulated very slightly to the north.

The teleseism reported last week, which occurred on May 22, originated in latitude 35 degrees north, longitude 92 degrees east, at 22 h., 32 m., 48 s., Greenwich Civil Time, according to a determination made by the U. S. Coast and Geodetic Survey.

PHOTOGRAPHIC RECONNAISSANCE

The use of photographic surveying is increasing rapidly, especially under conditions that limit the time for field operations. Methods have been developed to use pictures taken from airplanes for map making, that allow tremendous areas to be covered in a short time. A recent undertaking, and one of the largest, is the U. S. Naval expedition to southeastern Alaska. This is well described in the "Scientific American" of May, 1927. Many parts of this area are very inaccessible, and mapping by ordinary ground methods is slow and arduous in the extreme. The shore lines are precipitous, and the waters rough, so that to run a ground survey along them is a serious problem. The Navy airplanes have been able to fly over and photograph, from an altitude of 10,000 feet, more territory in a day that a survey party on foot could cover in many weeks. The airplane photographs exhibit shore lines excellently, but are not so well adapted to determine land elevations and topographic shapes, especially in a country blanketed with timber. In general, aerophotography must be supplemented by a certain amount of ground work before a complete topographic map can be secured. But until such ground work can be done, the photographs furnish an excellent and useful reconnaissance map of the area.

Southeastern Alaska is not an area of volcanoes, but this work will undoubtedly be extended to other regions where its usefulness to volcanology will be more direct. Recent topographic work on the Alaskan Peninsula has brought to light volcanic craters hitherto practically unknown that would not have escaped notice in an aerophotographic survey. When the work is expanded to cover the Peninsula and the Aleutian Islands, the photographs will unquestionably yield a great deal information to those interested in volcanoes.

In a smaller way airplane photography will probably come into greater usefulness in the vicinity of active volcanoes. Already Mr. R. H. Finch has made use of airplane flights in connection with volcanologic reconnaissance both in Hawaii and in California. Photographs of Mauna Loa from the air would show perhaps more graphically than topographic maps the outlines of the more recent lava flows. In case of eruption, an airplane view of the mountain would tell much more surely and speedily the trend and progress of a lava flow than would a slow trip up the rough and forested slopes on foot. The Forest Service makes use of aeroplanes to reconnoiter forest fires, so in the same way may volcanology watch the fires of a volcano.

R.M.W.

A PRESS FANTASY

The Mauna Loa flow of April, 1926, was described in the Volcano Letter at the time. It was a spectacular cascade of lava, but was no larger than most of Mauna Loa's flows. The ribbon of new lava, from its source two-thirds of the way up Mauna Loa's 13,650 feet of elevation, down to the sea, averaged not more than a half mile in width. It covered country already rather barren, and destroyed a half mile of county roads and some twelve houses at the beach.

The "Cape Argus" (April 2, 1927), Cape Town, South Africa, excites in your imagination this terrible calamity:

"Towering 1,300 feet above the blue waters of the Pacific, Mauna Loa was covered with lush green forests and waving fern trees, with dancing streams and picturesque dwellings until the eruption of last April, when, without any warning, a sea of boiling lava eddied and surged down the mountain slopes, melting the rocks, whose grandeur of outline had been one of Mauna Loa's most arresting charms, and reducing them to a shapeless mass; destroying the bridges and transforming the forest into charred and stunted remnants.

"From the snow-capped summit great jets of black liquid spouted, the air was filled with the hissing of steam, the churning of molten lava, the fumes of sulphur, the exploding of noxious gases, and no longer did one wonder why long-dead Hawaiians called Mauna Loa the 'House of Eternal Fire'."

R.M.W.

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No. 128 RELEASED WITHOUT COPYRIGHT RESTRICTION June 9, 1927

KILAUEA REPORT No. 804

WEEK ENDING JUNE 8, 1927

Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

On the morning of June 2 a dense cloud of steam, due to falling moisture, was rising from the north side of Halemaumau pit. On June 4 the walls of the pit were seen to be colored dark red from the recent rains. No rocks were heard falling during this visit. The sulphur patch at the southeast bank appeared on June 6 to be a little brighter. A visit to the pit on June 8 discloses the fact that there has been an increase of rock falls. Both the north and the south walls are very dusty. Several rock trickles were heard from the north side, and a little dust was seen rising there.

During the week ending June 8 there have been only five local earthquakes recorded. In addition to these, on June 2 there is record of a faint teleseism, probably about 5,500 miles distant. The prefiminary wave arrived at 8 h., 53 m., 53 s. p. m., Hawaiian Standard Time, the secondary wave arriving approximately 9 minutes and 45 seconds later.

Early in the morning of June 8 several people in the vicinity of the volcano were awakened by a noise resembling the falling of a heavy weight or the striking of a heavy mass with a hammer. The effect seems to have been more a concussion than an earth shake. It is reported that this noise was also heard in Hilo. All observers have agreed as to the time close to 1:30 a. m. On the seismograph there is a very feeble tremor recorded at 1:29 a. m., but so small as to be certainly imperceptible as an earthquake. It resembles very much the records made by blasting a few miles from the Observatory. The night watchman at the hotel reports having seen a bright glow in the sky two or three minutes before he heard the noise. Indications are that this disturbance is not volcanic or seismic, having the appearance rather of an explosion of powder. But that such an explosion should occur at that time of night and be strong enough to awaken people at widely separated places is unusual. Diligent inquiry has not yet disclosed the cause of the disturbance.

SURVEYS AROUND KILAUEA

In 1920 a number of points in the vicinity of Kilauea were selected and permanently marked on the ground. These marks were then tied in both by spirit levels and triangulation, making a net covering about 24 square miles surrounding the volcano. The object is to repeat the surveys at intervals in the future to determine possible ground surface movements. Some of the points so tied in were points established by older surveys, and comparisons made it at once apparent that actual changes had taken place. Since 1920 there have been several surveys made for various purposes touching some of these points, and further movements have been disclosed. The leveling done by the Bureau of Public Roads and by the County of Hawaii in connection with new road work has yielded differences of elevation that are not the same as those secured by the 1920 work. In March and April, 1926, the Kilauea net was releveled, confirming the changes found by the road surveys. The elevation of the Volacno House bench-mark above the old Hilo datum was accurately determined by the modern precise methods of the Coast. and Geodetic Survey in November and December, 1926, with results differing from the 1920 values, just as the 1920 values differed from the original 1912 level line. In May, 1926, a partial re-triangulation of the Kilauea net was made, and in December, 1926, the points were again triangulated, this time completely, the same accuracy being secured as in 1920. Another complete re-leveling of the Kilauea net is just now nearing completion, using a precise level and rods with graduations upon invar metal strips.

In studying the differences developed by successive surveys, the first question that arises is of course the accuracy of the surveys. Upon the answer to this question depends the decision as to whether the differences developed represent actual ground movements. The levelings in the vicinity of Kilauea have circuit closures averaging only about two tenths of a foot, yet successive surveys may yield relative elevations differing several feet. In the triangulation, accuracy represented by an average triangle closure of close to three seconds has been secured, yet some angles in the net of 1926 differ by several minutes from the corresponding angles of 1920. Clearly, these differences are too large to be ascribed to inaccuracies of surveying.

Results of these surveys are being computed, and work is being done towards the making of a systematic intercomparison of them all, with an attempt to correlate the changes with changes of tilt, and eruptive stages of the volcano. R.M.W.

ALEUTIAN STATION NOTES

Dr. Jaggar sends word from Alaska, telling of his arrival in Kodiak on May 12. It is his intention to spend the season making a reconnaissance of the volcanology and seismicity of the Alaskan Peninsula and the Aleutian Islands. He expects to establish one or two seismological stations, the one already temporarily decided upon being at Kodiak. The seismographs for this station were constructed in the shop of the Hawaiian Volcano Observatory, and others are now being made for a possible second station in Alaska. The instruments in Kodiak will probably be set up in the cellar of a building of the Agricultural Experiment Station, a settled structure about 10 years old, whose foundations are close to bedrock. This will have advantage over a new building in that the instruments will not require so long a time to adjust themselves to the settlement in new foundations. The location of the station in Kodiak may be temporary or permanent, as may be found advisable by further investigation of seismic conditions. The object is to go over the country more thoroughly before final selection is made for the location of a permanent station.

On May 17 Dr. Jaggar was expecting to make a trip around the Peninsula to Nushagak, probably returning to Kodiak about June 1. R.M.W.

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No. 129 RELEASED WITHOUT COPYRIGHT RESTRICTION June 16, 1927

KILAUEA REPORT No. 805

WEEK ENDING JUNE 15, 1927

Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

Few changes have taken place in the great pit Halemaumau. Coatings of white salts have increased on the wall east of the lower southwest rift tunnel and down the north edge of the southwest talus. The hole formerly at the top of the northwest talus no longer exists, because the wall has broken away around where it was. Its outline, however, is still discernible on account of the difference in the color of the dirt there. New debris on the north talus indicates that recent slides have occurred from the wall above. By far the greater number of slides in the pit take place at this point. For some time this north wall has been kept red by peeling. Steaming in the pit is about as usual, increasing and decreasing according to the rainfall.

At 1 p. m. on June 10 dust from a slide at the northeast corner of the pit was observed.

The seismograph records for the week ending June 15 show 11 very feeble local earthquakes. During the afternoon of June 14 there were numerous traces of minute spasmodic tremor—so feeble that they have not been included in the count as earthquakes. Microseisms have been unusually feeble during the week. Tilt has accumulated moderately to the southwest.

LATITUDE VARIATIONS

In Volcano Letter No. 94 (October 14, 1926) a brief review was made of Professor E. W. Brown's evidence of fluctuations in the rate of rotation of the earth. There has since appeared in "Nature" (February 5, 1927) another paper by Professor Brown essentially the same as the first, but condensed. The question is attracting widespread interest, as several reviews and criticisms have appeared.

Mr. Walter D. Lambert has published in the Journal of the Washington Academy of Sciences a discussion of the possible correlation between the fluctuations in rate, and the variation of latitude of which he has made a study for the U. S. Coast and Geodetic Survey. Attention is here called to the fact that if the expansion and contraction of the earth is not uniform over its entire surface, so that the alteration is not symmetrical with respect to the axis of rotation, then the axis of rotation will seek a new position through the mass of the earth. The precise positions of the poles and the equator will therefore change, on account of this adjustment to the unbalanced moments of inertia resulting from the lopsided expansion or contraction. Latitudes are based upon the position of the poles and equator; such a change will affect the precise latitude of a given point on the earth's surface. The positions of the poles do change slightly, through explainable causes. But after the explainable causes have been computed and accounted for, there still remains a slight polar motion without apparent reason. Mr. Lambert shows that these remaining motions may thus be conveniently explained, if the expansion and contraction is not uniform or symmetrical with respect to the earth's axis. He states that there is indication of a correlation between latitude variations and changes in rate of earth rotation. He has made calculations, showing that the earth changes required to produce the unexplained latitude variations would be of the same order of magnitude as those required to produce the observed changes in rate of the earth rotation. Lopsided changes may, therefore, explain both of these effects.

The objection to the idea of non-uniform expansion or contraction is taken on the basis of sea-level. If expansion or contraction affects a part, only, of the earth's mass, the resulting elevation or depression of the earth's surface over that part should become immediately apparent through the change of its relation to sea-level.

There are, however, evidences of elevation or depression of certain sections with respect to sea-level. Geology speaks of elevated shore lines, or of drowned valleys. In Alaska, not long ago, a sudden elevation of shore line took place. This was probably an index of the elevation of a considerable area of the earth's surface. Such an elevation might represent no disturbance to isostatic compensation, yet through the increase of distance from the earth's axis, would represent a change of moment of inertia.

Here at Kilauea, it has been estimated that during the collapse that followed the 1924 explosive eruption, many times more material was engulfed than was ejected. Also, elevations have been lowered in the vicinity of the volcano. This has already been noted in the Volcano Letter (No. 74, May 27, 1926). The volume of material here locally involved is doubtless of too small an order of magnitude to produce the effects in question. But it may be that this engulfment is the result of a more general contraction, the volcano acting as a sensitive point for its registration.

A suggestion attributed to Professor J. W. Evans is that the variable amount of volume in the polar ice caps may affect the total moment of inertia of the earth. The volumes of these ice caps change through long periods of years. As they melt to their smaller volumes, water is added to the oceans, raising their level, and tending to transfer mass from the poles towards the equator, thus increasing the earth's moment of inertia, and so to change its rate of rotation. This would be a "lopsided" effect, since ocean and land areas are not symmetrically arranged on the earth's surface, and only the ocean masses would be changed. Therefore, Mr. Lambert points out, latitude variations would probably result, along with the change in rate of rotation. R.M.W.

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No. 130 RELEASED WITHOUT COPYRIGHT RESTRICTION June 23, 1927

KILAUEA REPORT No. 806

WEEK ENDING JUNE 22, 1927

Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

Several changes have taken place at the lava pit, but nothing by which to predict an eruption. The solfataras are a little brighter on the floor and southwest talus; white salts are forming on the north wall; a new scar is on the south wall about a hundred feet below the rim, produced by a slide; the northern walls of the pit have avalanched considerably; and the ground at the east rim has moved inward slightly, as evidenced by a widening of the surface cracks. Probably most of the slides from the north walls took place on June 21, as dust clouds were seen rising about 9:30 a. m. There is some movement of the walls at the southwest rift tunnels, as slides were seen there on June 22 about 9 a. m.

Due to the strong northeast wind on June 17, great clouds of dust, resembling smoke, covered the Kau Desert south of Kilauea Crater.

The seismographs have recorded 15 very feeble local earthquakes during the week ending June 22. There is also a feeble trace of a teleseism at 8:40 p. m., Hawaiian Standard Time, on June 16. One of the local earthquakes (7:11 a. m. June 19) was of sufficient intensity to record indications of its distance, probably 11 miles. Microseismic motion is still very weak.

Moderate north tilt has accumulated during the week.

SOME POINTS CONCERNING 1927 OBSERVATIONS AT KILAUEA

Avalanches in the pit of Halemaumau have seemed to be more frequent in the afternoon than in the forenoon. If large enough, they undoubtedly make small records on the seismographs; and earthquakes may cause avalanches, if rock is ready to fall in reponse to a slight impulse. There is, therefore, a loose correlation between the two, especially during these quiet times when there are no larger disturbances present to mask the effect.

This suggested that the small local earthquakes recorded by the seismographs might be more frequent during some particular part of the day. Local earthquakes during the last eight months (October 1, 1926, to May 31, 1927) have been counted according to the hour of the day in which they occurred. The percetnages of the total for each of the 24 hours of the day are as follows: A. M.; 2.3, 3.3, 2.3, 3.1, 1.7, 3.5, 4.2, 2.8, 2.7, 3.8, 3.5, 8.1; P. M.; 5.6, 7.6, 6.0, 6.1, 5.8, 5.6, 4.4, 3.6, 4.2, 2.7, 3.5, 3.6. Thus it is seen that the early morning hours are the most quiet, with a slight increase in number during the forenoon. At 11 a. m. is an abrupt increase, and the following afternoon hours contain large percentages, decreasing towards evening. This irregular distribution is perhaps not due to seismic causes. Most of the disturbances counted are very feeble, and some of them may not be true earthquakes. Avalanches in Halemaumau apparently occur more frequently in the afternoons due to temperature and drying effects of the sun on the walls of the pit. During some of these eight months road construction has been in progress within a few miles of the Observatory, involving the blasting of rock. Some of the blasts are known to have caused records on the seismographs. The contractors usually tried to set off their "shots" just before noon in order that the workmen could be off work for lunch. These blasts are very likely the cause of the large percentage in the hour between 11 and 12 a. m., and others may also have added to the number of records made during the afternoon hours. Records made by avalanches in the pit also are added more to the afternoon numbers.

It seems possible that the true earthquakes may be evenly distributed throughout the twenty-four hours, and that the surpluses shown by these percentages for the afternoon hours are the result of non-seismic disturbances. This question should be considered in making use of the numbers of earthquakes given in the Kilauea Report. In times of more frequent earthquakes, and when no blasting is in progress, the proportion of non-seismic records would be so small as to be negligible.

Tilt, as given in the Kilauea Report, taken one week at a time, seems to have little significance. But at times when lava is in the pit, east tilt is observed to have correlation with the height of lava. During the 1926 eruption of Mauna Loa, tilt exhibited a rapid surge towards the east and southeast; a movement distinctly apart from its regular annual accumulation to the southwest and back. The source of the Mauna Loa flow was 24 miles from the Observatory. It seems certain that tilt changes are produced by volcanic activity within the mountains of Kilauea and Mauna Loa, even if evidences of that activity are not otherwise apparent at the surface. A review of this movement over the last six months is of interest. A surge of tilt towards the east during the last few days of February is a feature, and somewhat resembles the movement accompanying the Mauna Loa eruption. A rapid change towards the southwest beginning March 21 and ending abruptly on May 5, probably has some significance. It is interesting to note that the latter movement began practically at the time of the moderate earthquake that was perceptible throughout the Hawaiian group; a coincidence only, perhaps. Since May 5 tilt has been particularly sluggish, and the normal northeast accumulation seems to have begun. Values throughout the whole six months period are considerably more to the northeast than contemporary values of 1926, as if Kilauea were trying to gain back the east and northeast tilt lost during the 1924 explosive eruption.

The first three months (February, March and April) of records of the tide gauge installed at Hilo, mentioned in previous Volcano Letters, have been subjected to a preliminary analysis and comparison with the Honolulu records. It is the aim to detect possible seismic sea waves, and after a long period of time to detect possible shore line elevation or depression, but so far there has been no evidence of either. The records near March 20 were carefully inspected to see if the earthquake of that date had any effect, but there was none noted. R.M.W.

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No. 131 RELEASED WITHOUT COPYRIGHT RESTRICTION June 30, 1927

KILAUEA REPORT No. 807

WEEK ENDING JUNE 29, 1927

Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

The working of the walls of Halemaumau pit has continued this week, though not so actively as last week. Several small slides have occurred, and one large slide was seen at the southwest at 3 p. m. on June 26. Red dirt lies thickly on the north debris slope and at the foot of the northern and western walls. Steaming is very moderate at all the vents.

A circuit of the pit was made on June 25. At this time it was noted that the cracks back of the north and northeast rims seem to have the greater movement. One of the larger northeast cracks is very hot, but not steaming. The freshness of some of the smaller cracks give the ground a very unstable appearance. The top of a prominent pinnacle which overhung the northeast rim has slid off. This must have occurred on June 21, when there were some large avalanches on that side.

There have been only nine very feeble local earthquakes recorded during the week ending June 29. Of these, four were on June 24, and on the 23rd, 27th, and 28th there were none. Tilt has accumulated moderately NNE, apparently continuing its normal annual course.

CYCLICAL VOLCANIC ACTIVITY

Among the questions now most frequently asked by visitors at Kilauea are: "Is the volcano dead?" and "When will the next eruption be?" The Volcano of Kilauea is not dead. The second question is not so easily disposed of, as the principles involved in trying to answer it are most complicated and intricate. To be able to predict earthquakes and volcanic eruptions has long been the aim of seismology and volcanology (see "Predicting Earthquakes," by T. A. Jaggar, in Scribner's Magazine, Octoebr, 1924). The lines of reasoning that have seemed most often to hit the mark are, first, to learn through local history the habits of the area in question, and second, to observe and correlate current symptoms and phenomena. The earth's forces slowly accumulate stresses that are deep beneath the surface, of which the indications are difficult to observe. Periodicity is a good hand-hold for prediction, particularly in dealing with volcanic eruptions.

The "Second Report of the Hawaiian Volcano Observatory." by Harry O. Wood, published in 1917 by the Massachusetts Institute of Technology, sets forth in considerable detail the "Cyclical Variations in Eruption at Kilauea." Here the habits and history of activity of the volcano have been systematically studied. A great number of natural phenomena have definite periods; cycles of similar action repeated again and again. Most familiar to us are day and night, summer and winter, high and low tides. Volcanic activity is probably the result of a combination of causes, many of which are of periodic nature. Tides are caused in the waters of the ocean by the gravitational attraction of the sun and moon. In the earth's stiff crust stresses are set up to resist these deforming attractions, in spite of which a slight tide also exists in the solid earth. These earth stresses and tides doubtless affect volcanic action, and have seasons of greater intensity just as the ocean has spring tides. If the action of a volcano depended upon only one such simple periodic cause, it would perhaps erupt with perfect regularity. But there are probably many causes, some orderly and periodic and some irregular, few of them well understood, and it is the combined result of them all that is reflected in volcanic action. Cycles of gas pressure accumulation and release, of chemical reaction, and of geyser-like action in slow subterranean flow of viscous magma; slow changes due to isostatic adjustment; accidental effects as choking of vents, or draining off of lava through newly formed earthquake cracks; these are some other suggested causes. Periodic effects combined, in general, yield a periodic resultant with a cycle long in time, as only occasionally will the individual effects work together in harmony. Thus if observations are studied over a considerable length of time, and periodicity is discovered, periods of equal time may be projected into the future as a basis for forecasting.

Tidal effects, semi-monthly and semi-annual in period, are to be expected, and appear to have been recognized in observation. Thus Mr. Wood suggests that early summer and winter are times favorable to eruption, while early spring and fall induce quiet. An effect having a seven-year period seems to exist, perhaps being correlated with latitude variations (see Volcano Letter No. 129, June 16, 1927). The combined resultant of these and other periodic effects has been estimated to have a cycle 130 years long; a result derived by independent investigators, and apparently justified by observation.

The history of Kilauea reveals other quiet periods like the present one. Old residents here remember the relatively dormant period between 1894 and 1907, when people were asking then, just as they are now, "Is the volcano dead?" Could they have then foreseen the high lava activity of 1920, and the explosions of 1924, the question would have seemed ridiculous. The present quiet phase is but part of the cycle of the volcano; history repeating itself. As time goes on, a longer recorded history will be available for the study of periodicity; the symptoms of accumulative and accidental effects will become better understood; causes will be recognized, and forecasting will rest on a firmer foundation. R.M.W.

ALEUTIAN STATION NOTES

From Alaska, Dr. Jaggar reports favorable weather and convenient transportation. The cooperation of other Government Departments, and of individuals, is making a success of his reconnaissance (see Volcano Letter No. 128, June 9, 1927). His trip is covering the Aleutian Islands and the Alaskan Peninsula as thoroughly as may be in the time at his disposal, both by land and water. The Coast Guard cutter takes him to Attu and to the Pribilof Islands, arrangements have been made to go to the far west Aleutian Islands. He will go around Pavlof Bay by power boat, and expects to explore Pavlof Volcano. He has been into Bristol Bay and back to False Pass. It is expected that a second seismograph will be installed at Unalaska. R.M.W.

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No. 132 RELEASED WITHOUT COPYRIGHT RESTRICTION July 7, 1927

KILAUEA REPORT No. 808

ENDING JULY 6, 1927

Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

New lava began to flow into the pit just before 1 a. m. on the morning of July 7. The Kilauea Report, as follows, had been prepared but had not been sent to press. It applies to the last week, and is here presented as a preface to the events of July 7:

Avalanchings have continued this week at Halemaumau, particularly at the northeast, where cave-ins have formed a large bay. Dust from slides can very frequently be seen there. The northeast talus has much new debris. Many slides are also occurring at the southwest rift tunnels. Several wide, gray streaks on the south-southwest talus, three of them reaching to the foot, mark the courses of tumbling bowlders. The north wall of the pit has fresh scars. A pinnacle and several overhanging blocks at the north-northeast are about ready to fall.

The cracks developing parallel to the east and northeast rims of the pit of Halemaumau, first mentioned in Volcano Letter No. 130 of June 23, have continued to widen steadily. These cracks in which movement has been noted vary in distance from the edge of the pit, few of them being back more than 50 feet. There is about 1,500 feet of ground along the rim that has shown motion in this manner. Avalanching has been considerable during the past months at the northeast rim of the pit, and it seems as if the ground that has been gradually falling away there has been acting as a keynote to the horizontal arch of the pit walls. The gradual disintegration of this keynote has thus allowed this long section to slump inward slightly. The widening of these cracks suggests the probability of increasing avalanching on the east and southeast sides of the pit, which have heretofore been more stable than the other sides. This is the part of the rim most frequented by visitors, and it has been thought advisable to warn them to cross these fresh cracks with caution. Measurements are being made to determine the rate of motion.

During the week ending July 6, the seismographs have recorded 10 very feeble local earthquakes. In addition to these, on July 3 at 12:15 a. m. Hawaiian Standard Time, there is a very faint trace of a teleseism. No phases are distinct enough to indicate the distance.

Microseismic motion has been somewhat more feeble than normal. Tilt has accumulated slightly towards the east.

The foregoing report was prepared on July 6. Early in the morning on July 7 the night watchman at the Volcano House saw a glow at the pit, and awakened the people at the hotel. Mr. James K. Tsuchiya spread the news through the neighborhood. The lava probably came into the pit shortly before 1 a. m. People who were awake at midnight have reported nothing unusual. There was no disturbance to awaken people, and the fountaining in the pit probably began gradually. The seismographs show two very feeble local earthquakes at 11:12 and 11:46 p. m. July 6, which in no way differ from the many recorded during the last months. Harmonic tremor commenced rather definitely at 12:32 a. m. July 7, and probably marks the beginning of release of lava, though perhaps at the very beginning it was coming up through cracks or loose talus, so that glow was not immediately visible. The night watchman was inside the hotel until nearly one o'clock, when he was due to make his regular inspection of the premises. He saw a rather faint glow, which brightened rapidly as he watched it, and he then notified the manager of the hotel. By a few minutes after one, there were many witnesses, and the first cars reached the pit at about 1:40 a. m.

There are four fountains of lava, nearly in the line of the 1920 rift; that is, along the NE and SW diameter of the pit. The one to the southwest is a short distance up the talus slope, just beneath the 1920 rift tunnels. From it a river of lava is running down the talus to the lake forming on the floor of the pit. The second fountain is near the base of the big SW talus, and from it two short lava rivers are flowing down. The third fountain, smaller than the others, is near the edge of the lake, and at the bottom of the same SW talus. The fourth fountain is on the other side of the pit, near the bottom of the NE talus, and its source is below the level of the lake. The three larger fountains are spouting lava over 100 feet into the air, and all are rapidly building spatter cones. The level of the lake, now of irregular shape, is about 1,500 feet long and 900 feet wide. It is slowly rising, as the fountains feed it. The surface is rather placid, being broken by the usual red cracks between the slowly moving blocks of the cooler crust. Around the rim of the pit, new "Pele's hair" can already be found, and a small amount of light, forthy spatter has been brought up by wind and deposited near the edges of the pit.

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No. 133 RELEASED WITHOUT COPYRIGHT RESTRICTION July 14, 1927

KILAUEA REPORT No. 809

WEEK ENDING JULY 13, 1927
Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

Lava is still flowing into the pit, though perhaps with diminishing activity. The flowing from the southwest cone is gradually filling the lake through channels that are crusted over and invisible. The flow shows glowing cracks, and occasional red toes of liquid lava are thrust out. At night the crack patterns are most interesting. There has been only a little glow from the pit during the latter part of the week.

The seismographs have recorded 20 earthquakes during the week. One of these, at 3:21 a. m. July 7, a little over two hours after the outbreak of lava in the pit, was moderate; all the others were very feeble. The moderate shock had an indicated distance of 35 miles. It was reported as felt in many parts of the Island of Hawaii. A perceptible earthquake was reported in Kona at 20 minutes after midnight, July 7. A preliminary trace of harmonic tremor occurred at 10:55 p. m. July 6, and lasted 17 minutes. Harmonic tremor definitely began at 12:32 a. m. July 7, and the lava broke out a few minutes later. At 1:25 a. m. July 8 the harmonic tremor faded out, though there were a few recurrences for a few minutes at a time during the rest of that day. It has not been strong enough to show anything but very feeble traces since the 8th. Tilt has been slight to the NNW.

NEW LAVA IN HALEMAUMAU

The coming of lava into the pit of Halemaumau occurred just in time so that the beginning of the flow was described in the last number of the Volcano Letter. The lava spouted into the pit very vigorously during the first few hours, but began to show diminishing energy during the day, and the small fountain ceased action about 5 p. m. July 7. The lake formed on the bottom of the pit rose to an elevation of 2,480 feet above mean sea level, the old floor level being at 2,392 feet. The lava in the lake was quite fluid, as the waves induced by the convulsions of the northeast fountain could be seen to cross to the opposite side of the lake. During the early morning hours of July 8 two more fountains ceased action, and the molten lava of the lake partly drained out, perhaps flowing down the vent of the northeast fountain when the active lava retired at that place. When daylight came, it was seen that the cooled surface of the lake had collapsed about 10 feet, leaving a shore line bench around the edges. A sector of spatter on this bench and adjacent talus indicated about where the northeast fountain had been. Two little cones mark the site of the short-lived small fountain, and a larger spatter cone, whose summit elevation is 2,520 feet, marks the position of the fountain at the base of the southwest talus. These cones are above the lake, so that the collapse did not disturb their formations as it did in the case of the northeast vent. The remaining action was confined to the southwest fountain, which had built around itself a spatter cone about 40 feet high above the talus upon which it is built, and its summit elevation was then 2,602 feet. Down the side of this cone, from a low edge of the hole in its summit, lava was pouring in a large, steady stream. The lava was building a steep delta down to the edge of the collapsed lake, and was beginning to flow out on top of the depressed lake surface.

The more quiet phase thus begun on the morning of the 8th has continued since. Lava has been flowing uninterruptedly from the cone, but it has been becoming less and less spectacular. The spatter from the fountain encased within the cone has built the cone higher, and it has capped itself over. The lava stream gushing forth from the base of the cone has gradually built itself a roof. Occasional interesting action is seen when this stream becomes clogged and the lava breaks out and flows on the surface for a while; or when the cap of the cone collapses or is blown off, and a glimpse is obtained of the energetically boiling lava within. The lava from the cone forms a miniature pahoehoe flow which is gradually covering the surface of the collapsed lake. The front of this flow has progressed slowly, by uneven spurts, so that by July 13 it has reached the site of the dead northeast fountain, and has covered most of the surface of the collapsed lake; the northwest bay being still uncovered. The southeast shore line bench of the lake has been covered by the flow, as the flow is higher here near its source. The flow has not yet reached the elevation of the bench at the east and north sides of the lake, though the collapsed part of the lake is covered on these sides.

Action so far is of a minor sort only, when compared to the usual lava displays of Halemaumau in past years. The new lava in the bottom of the pit, including lake, cones and delta, covers an area of but 30 acres. This outbreak is much the same as that which occurred in 1924, about two months after the explosive eruption. At that time lava came into the pit on July 19, spurting from a source on the southwest talus. Lava continued to flow, but with diminishing vigor, till July 29, when it ceased, and there has been no active lava in the pit until the present outbreak. The present active cone is not far from the position of that of 1924.

The very energetic manner in which the lava first appeared a week ago perhaps represents the effervescence due to the sudden release of pressure upon breaking through into the pit. The steady persistence in the activity of the one remaining cone is an encouraging sign for continued activity, though action does not seem as strong on the 13th as during the preceeding days of the week.

R.M.W.

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No. 134 RELEASED WITHOUT COPYRIGHT RESTRICTION July 21, 1927

KILAUEA REPORT No. 809

WEEK ENDING JULY 20, 1927
Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

The flow of lava into the pit of Halemaumau has been diminishing during the week. The volume of new lava poured into the pit on July 7, the first 24 hours of the outbreak, represents about half of the total accumulated to date. The flowing from the southwest cone has been continuous, though fluctuating in amount, until July 19. The top of the cone has in general remained open towards the southwest, parts of its walls or roof being blown off from time to time. On July 19 the flow ceased during part of the day, though lava flowed from the cone at 3 p. m. and during the evening at about 9 p. m. Inspection of the pit on the morning of July 20 showed no lava flowing; no active lava was visible down the throat of the cone, and only a very thin trace of blue fume was issuing from its mouth.

The number of earthquakes recorded during the week ending July 20 is 18. These were all local and very feeble. Harmonic tremor does not show on this week's seismograms. In addition to the above local earthquakes, a feeble teleseism is recorded; its long wave beginning at about 1:34 p. m. July 14. Tilt has accumulated moderately towards the northwest.

SOME ALEUTIAN VOLCANOES

In a wireless message from Dutch Harbor, Alaska, Dr. Jaggar tells of a most interesting fortnight spent in the western Aleutian Islands. He went with the Coast Guard Cutter to Attu, and returned to Dutch Harbor July 8, having seen some 20 big volcanoes on the trip. He is high in his praise of the region as a field for volcanological study. Gareoli, an island-volcano over 5,000 feet in height, is a cone from which yellowish steam is issuing. Tanaga, a wonderful composite cone covered with cinder, is the eastern neighbor of Gareoli. Semisopochnoi, to the west of Gareoli, is shown on the chart as having "burning volcanoes." The present report speaks of sedimentary rocks, such as sandstones and conglomerates, in abundant occcurrence on the south side of this Aleutian belt, which are perhaps comparable with the rocks found near Unga.

Bogoslof Volcano is of especial interest. The island, which is the top of the volcano, has changed its formation many times. Passing ships have reported from time to time the appearance of new summits, or the disappearance of old ones, and an occasional eruption has been witnessed from a distance. Sidney Powers, in the "Geographical Review" September, 1916, gives a brief sketch of the history of the volcano. He gives the date of the first formation of the island as 1768. Another island developed nearby in 1796, and still another in 1883. These were at first separate islands, the last mentioned being a precipitous plug pushed up from a volcanic orifice to a height of 800 feet above sea level. These islands changed in form during the years up to 1906, when another plug, 2,000 feet in diameter and 400 feet in height above the ocean, was pushed up into the group. A few months later this was partially blown away, and still another plug rose by its side, being in turn partly destroyed by an explosion in 1907.

In the Technology Review, Vol. X, No. 1, is the "Journal of the Technology Expedition to the Aleutian Islands, 1907," of which expedition Dr. Jaggar was himself in charge. Bogoslof was visited in August, 1907, and the Journal has a number of photographs of the steaming summits, which at that time had become joined together by volcanic additions and by sand and gravel bars into a single island. Sketch maps show the development of the island as reported by various observers up to that time.

Activity since 1907 has been only casually observed by passing ships or by distant witnesses on the nearer neighboring islands, Unalaska and Umnak. Dr. Jaggar's recent visit has shown him the result of the many active phases since 1907. He reports a new steaming lava dome, 1,200 feet in diameter and 200 feet high, which is surrounded by a salt lagoon, in which the water is warmed to 75° Fahr. Around the lagoon is a complete ring of gravel and sand, which forms the connecting link between the summits that were separted by open channels prior to 1906. New Bogoslof or Grewingk Island, the northern peak that appeared in 1883, he reports much changed in form since 1907. Old Bogoslof, the peak of 1796, is now surrounded by a high bank of gravel. The island is tenanted by great numbers of sea-lions, a count up to 400 having been made. Murres and other nesting birds are present by the million. The latest phase of volcanic activity probably began about July, 1926, and increased thereafter with occasional explosions which were seen from distant villages on the neighboring islands. This recent activity was probably very similar to the eruption of 1906. There is no continuous accurate record being made of these phenomena.

This is all but a sample of the area of volcanic and seismic activity that the region has to offer. Katmai and the Valley of Ten Thousand Smokes, Pavlof Volcano and many others are available for study and research. Dr. Jaggar suggests that Dutch Harbor, on Unalaska Island, is an ideal place for a Government scientific research station, not only for the study of volcanology and seismology but also geology, biology and botany. For these investigations, and for coast, geodetic and topographic surveys, such a station would be an admirable base for the whole Aleutian belt. R.M.W.

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No. 135 RELEASED WITHOUT COPYRIGHT RESTRICTION July 28, 1927

KILAUEA REPORT No. 810

WEEK ENDING JULY 27, 1927

Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

There has been no renewal of flowing lava in Halemaumau pit. Glow and fumes are absent from the southwest cone, but at night there is still some glow to be seen in the cracks of the pit floor. Steam vents in the pit are quite active, particularly on the south and northwest taluses.

There is considerable working of the walls of Halemaumau, most of this being on the northeast side. The ground back of the north-northeast and northeast rims is breaking up, forming many small new cracks as well as widening the old ones. Debris falling from this side of the pit has covered a very large section of the new floor and partly filled the depression between the north-northeast and northeast taluses. Frequent avalanching has occurred. On July 21 at 9:10 a. m. a cauliflower dust cloud rose from the pit, hanging over it for about five minutes. At 2 p. m. July 22 there was dust from slides at the west boss, and stones could be heard falling there. On July 24 dust hung over the pit in varying quantities all day, and there was almost constant avalanching from the north-northeast wall. The two bowlders on the north-northeast talus, which have served as landmarks, have disappeared under new debris.

This spurt of avalanching, together with the widening of old cracks and the opening of new ones around the rim of the pit, is similar to the action noted in Volcano Letter 130, on June 21 and 22, which was at that time considered due to natural disintegration of the walls. There was then a very slight increase in the frequency of earthquakes, of which two gave indicated distances of 11 and 25 miles. About 16 days later lava came into the pit, and it seemed that in some way the presence or release of active lava stabilized the walls, so that instead of the increased avalanching expected from the development of the cracks, there was in fact a decrease of avalanching. An avalanche was reported on July 18 in Makaopuhi Crater. On the 19th lava ceased to flow into Halemaumau. Now, on the 23rd to the 25th comes another spurt of avalanching and development of cracks at the rim, which is in turn about 16 days after the outbreak of lava. This time the avalanching is accompanied by a swarm of earthquakes, two of them feeble and three slight, definitely drawing attention to the presence of volcanic forces. Whether the possible changes in conditions at the pit will be towards increase or decrease remains to be seen.

During the week a total of 21 earthquakes have been recorded. On July 24 at 6:05 a. m. there was a slight shock that may have been felt. The next day, at 2:07 a. m. and at 6:13 a. m., there were slight shocks that were felt at the volcano and in Hilo, and possibly elsewhere. On the same day also, a feeble shock occurred at 11:56 a. m. On the 26th another feeble earthquake occurred at 1:29 a. m. All others in the above total were very feeble. Three of the stronger shocks had indicated distance of 25 miles. Tilt has accumulated very slightly to the west.

COAST RANGES FROM THE AIR

Through the courtesy of Major General J. L. Hines, Commander of the Ninth Corps Area, U. S. Army, San Francisco, California, the undersigned was permitted to make an airplane trip over the Coast Range mountains between San Francisco and Clear Lake during the forenoon of April 4, 1927. The plane was very successfully piloted by First Lieutenant H. A. Moore. The course taken was to Calistoga and thence just to the east of Mount St. Helena and north to the southeastern part of Clear Lake, Mount Konocti, with a fairly distinct crater remnant in its southern peak, was passed, and the return to San Francisco was made about 18 miles west of the outgoing course.

Deep erosion valleys that trend the same as the mountain ranges, that is, northwest-southeast, showed up very distinctly. Layers of rock that showed up as systematic bands were noted on the east slope of Mount Konocti. From the varying extent of the erosion it appeared that there was considerable difference in age between the different mountains. Most of the mountain ranges appeared to have steeper slopes on their western sides than on their eastern sides, as though they had been formed by some mighty force shoving at the country from the east.

The airplane method of making a reconnaissance in this country is especially time-saving, as on foot one encounters dense underbrush of live oak, manzanita, and poison oak.

R. H. Finch.

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No. 136 RELEASED WITHOUT COPYRIGHT RESTRICTION August 4, 1927

KILAUEA REPORT No. 811

WEEK ENDING AUGUST 3, 1927

Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

Avalanches continue to be rather frequent at Halemaumau, some of them making considerable noise and dust. Slides are occurring on all sides of the pit, though the largest seem to come from the north walls. Steam vents are moderately active, the one on the northwest talus being very flocculent.

A circuit of the pit was made on August 3. A close view of the northeast wall, from the north side, reveals many loose blocks in the vicinity of the northeast dike.

During the week ending August 3, there have been 18 local earthquakes recorded. Of these, there were four that were perceptible, all the others being very feeble. The perceptible shocks were recorded at 11:31 a. m. July 29, 2:14 a. m. on the 31st, 8:40 p. m. August 1, and at 9:42 a. m. on the 3rd. The first three were of the barely perceptible sort, having indicated distances of 39, 16 and 15 miles, respectively.

The fourth earthquake, on August 3, was the heaviest registered or felt at the Volcano for some time. Both seismographs were dismantled, and the disturbance was felt by nearly everyone. Windows were rattled slightly, and a moderate avalanche which occurred at the time was probably precipitated by the shock. Captain R. V. Woods reports that his seismograph in Kealakekua, Kona, was also dismantled, and the earthquake was pronounced there the strongest for some time. It was strongly felt in Hilo, causing considerable excitement and a small amount of damage due to merchandise being thrown from shelves in a store. The seismograph at the Brother's School was dismantled, first indicating a distance of 34 miles from Hilo to the origin of the earthquake. The indicated distance from the Volcano was 16 miles. These distances are misleading if the origin of the shock was a general slip along the main Hawaiian rift. Other reports have not yet had time to come in, but it was undoubtedly felt throughout the Island of Hawaii, and probably on the other islands also. This earthquake seems upon preliminary inspection to have characteristics similar to that which occurred on March 20, 1927, and is perhaps stronger than that one. In both cases the seimographs failed to record the maximum intensity, as the early movements of the shocks dismantled the instruments. One of the seismometers that is being developed by Professor Kirkpatrick (see Volcano Letter No. 126 of May 26, 1927) indicates maximum acceleration in the E-W component of between 50 and 90 mm. sec. per sec.; degree of perception also suggests intensity No. 3 on the Rossi-Forel scale.

Since July 24, beginning as noted in the last issue of the Volcano Letter, there have been nine shocks of sufficient intensity to be perceptible. This is a very distinct and sudden increase in earthquakes of this type. Most of them have been felt all over the island. This latest shock is perhaps but one of the series, being featured by greater intensity.

There has been no sign of return of lava. Both Mauna Loa and Kilauea are being closely watched for symptoms that may be correlated with this increase of seismic action.

Tilt has accumulated moderately to the NW.

HOT SPRINGS IN THE COAST RANGES NORTH OF SAN FRANCISCO

A considerable portion of Napa, Sonoma, and Lake counties, north of San Francisco Bay in California, is covered with lava of comparatively recent geologic age. The lava caps most of the Coast Range mountains which traverse this region. At many places hot springs and geysers are to be found. The geysers, for the most part, are not natural in that their vents were formed by drilling through the material that confines the steam and hot water.

To ascertain whether there is any appreciable variation in the temperatures of the hot springs, it is a part of the work of the Lassen Volcano Observatory to make systematic measurements of their temperatures. The temperatures of nearly all springs in California were measured several years ago, and appear in Water-Supply Paper 338, Springs of California, by G. A. Waring, U. S. Geological Survey. There is thus a basis for comparison already established.

The temperatures of a majority of the hot springs in the above mentioned region were measured in March, 1927. It was found that some of the springs were hotter and others colder in 1927 than when they were measured by Mr. Waring in 1908.

Varying rainfall and weather conditions affect the temperature of many of the springs. In order to accurately detect slight variations in temperature the measurements should be taken at about the same time each year.

R. H. Finch

THE CHINESE EARTHQUAKE

The death toll, at first exaggerated, of the Kansu Province earthquake has recently been before the public eye in the papers. It has taken over two months for the details to get out to civilization. Seismologists the world over knew of the occurrence of the earthquake, and knew its position, within a few hours after it happened (see Volcano Letter No. 127, June 2, 1927). R.M.W.

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No. 137 RELEASED WITHOUT COPYRIGHT RESTRICTION August 11, 1927

KILAUEA REPORT NO. 812
WEEK ENDING AUGUST 10, 1927

Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

The pit of Halemaumau is now comparatively quiet, conditions being apparently much the same as during the months before the July activity. Avalanching has been quite frequent, and new scars can be seen on nearly all sides of the pit. Cave-ins have so undermined the northeast wall that more or less continuous avalanchingg can be expected there for some time. On August 7 an observer on Uwekahuna Bluff saw blocks dropping from the usually stable southeast wall.

During a circuit of the pit on August 9 strong odor of sulphur dioxide was noticed at the north rim. This odor has been noticed at this point many times before, but not so strongly. The bowlder marking the north rim station has fallen in.

The new lava floor is stained white at the foot of the southwest talus. Steam vents in the pit do not seem to change in any way.

Fourteen very feeble local earthquakes have been recorded during the week ending August 10. In addition to these local shocks, there is a feeble record of a distant earthquake at an estimated distance of 4,250 miles; the arrival of the preliminary wave recorded at 3:17 a. m. Hawaiian time, August 9. Two very faint traces, probably teleseisms, are recorded at 11:43 a. m. on the 5th, and at 1:45 a. m. on the 10th.

Tilt accumulated slightly towards the south during the first part of the week, but the motion then reversed, so that the net accumulation for the week is practically zero.

MIGRATION OF EARTHQUAKE REGIONS

The systematic progression of the epicenters of successive major earthquakes in a definite direction in the same zone has been many times observed. Along the whole length of a given fault or rift zone in the earth's crust stresses may slowly accumulate, finally producing fracture at some weak point. Such an earthquake releives the stress at that particular point, only to add stress at adjacent localities each way along the line of weakness. The next fracturing stress will so accumulate in one of these adjacent regions, making the progression along the fault. Thus the Kansu Province earthquake of May 22 is found to be in about the same latitude, but some 250 miles to the west of the similar great Chinese earthquake of Dec. 16, 1920. The westerly progression checks with the known east and west direction of the main faults.

A more general analysis suggesting the migration of whole seismic zones is briefly set forth in the paper "On a Long Period Fluctuation in Latitude of the Macroseismic Zone of the Earth" by Torahiko Terada and Naomi Miyabe (Proceedings of the Imperial Academy, Japan, May 1927). Earthquakes in certain regions have been divided into groups of fifty years each, and the mean latitude for the shocks of each group computed. Graphs of these means for the past several hundred years have been plotted for the following regions: (1) Eurasia; (2) North and Central America together with the West Indies; (3) South America; (4) China, by itself; (5) Japan. For comparison, there have also been plotted on the same time scale a curve representing tree growth and the curve representing the fluctuations in the rate of rotation of the earth as given by Prof. E. J. Brown (Volcano Letters No. 94, Oct. 14, 1926, and No. 129, June 16, 1927). Graphs (1), (2) and (4) are in remarkable agreement, showing most clearly a diminishing north latitude from about 1725 to 1825, followed by increasing north latitude to the present time. Graph (3) seems to exhibit correlation if decrease of north latitude is accepted equivalent to increase of south latitude, suggesting migration of the same direction in the two hemispheres. The curves representing tree growth and earth rotation also show remarkable correlation, as if the long period fluctuations in earth's atmosphere rate of earth rotation and position of earthquake zones may all be inter-related in some manner. Perhaps latitude variation and the long period of variation in volcanic activity may also be involved with the same suggested relation. The migration of the earthquake zones in Japan is represented by two graphs, giving the fluctuations in both latitude and longitude. The latitude graph does not show direct correlation with the others mentioned above, but a suggested explanation is given. R.M.W.

A MUSEUM FOR LASSEN NATIONAL PARK

A museum to make better known the natural history of Lassen National Park was opened with a formal dedication ceremony on July 4, 1927. It is located near the northwestern entrance to the Park. The museum was erected by Mr. and Mrs. B. F. Loomis as a memorial to their daughter Mae and they plan to turn it over to the National Park Service as soon as the boundary of the Lassen National Park is extended to include the area in which the museum is located. The most striking part of the exhibit is the pictoral history of Lassen Peak. There are pictures showing the condition of the peak prior to the outbreak in 1914, numerous ones showing the progress of the eruption, and others showing Lassen as it is today. There is a good display of the different kinds of lava to be found in the park and the mounted wild life exhibit is quite complete. R. H. Finch.

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No. 138 RELEASED WITHOUT COPYRIGHT RESTRICTION August 18, 1927

KILAUEA REPORT No. 812
WEEK ENDING AUGUST 17, 1927

Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

Halemaumau pit has evidently settled down for a quiet period, following the spell of avalanching of several days ago. Four visits to the pit during the week fail to reveal any striking changes. There are a few new scars on the north and northeast walls, and the northeast talus overlaps the new floor a little more. Several bowlders have also rolled out onto the floor. Small slides can frequently be heard, but seldom can they be seen unless they make dust. The white stain on the lava floor has increased, some of it being slightly tinged with yellow. Steaming is very moderate.

During the week ending August 17 the seismographs have recorded but seven earthquakes, all local and very feeble. Tilt has accumulated slightly NNW.

WHAT IS EARTHQUAKE INTENSITY

The Rossi-Forel scale for grading earthquakes according to their intensities (see Volcano Letter No. 124 of May 12, 1927) illustrates the century-old practice among seismologists of making and using such classifications. The practice has been supported by some investigators and decried by others, but that it is generally accepted is shown by the fact that more than 27 such scales, all different, based upon seismographic measurements, arbitrary mechanical effects or personal emotions, have been constructed and used.

This confusion of scales would have been avoided if the makers had had any definite agreement or perhaps more definite ideas as to what they were attempting to grade. "Intensity," as applied to earthquakes, at first appeared to be a term without precise meaning, but the later scale-makers all agree that it is the destructive mechanical effect, rather than the degree of ensuing panic, which properly characterizes the intensity of an earthquake. But how is the destructive power of an earthquake to be stated numerically? Holden, in 1888, on the authority of Milne and other workers in Japan, introduced the idea that a destructive intensity scale was the same as a scale of maximum accelerations. The argument for this view was partly theoretical and partly the result of some approximately successful Japanese experiments. Accordingly Holden devised an absolute or dynamical scale, in which each degree meant an earthquake having a certain, stated, maximum acceleration.

Since Holden's work, scales similarly based upon maximum acceleration have been brought out by Omori, Cancani, Wood, Milne, McAdie, and perhaps others, but no one offered a conclusive demonstration that maximum acceleration and destructiveness really do go hand in hand. This is an important postulate and would seem to deserve investigation. As it is, the scales furnish us with many different answers to the question of what acceleration will be required, say, to knock down a given fence. One feels that there would not be so many if it had first been more critically asked whether or not there is any one unique acceleration which is necessary and sufficient to accomplish this destruction. The present writer believes that there is not, but that the acceleration required all depends upon the circumstances of its application; that is, upon the period and amplitude of the disturbance which brings it.

For example, let us consult some of the scales to learn what maximum acceleration will suffice to destroy an average frame house. Omori puts it at 4,000 millimeters per second per second; Wood gives from 1,200 to 3,000; Holden 1,200, as nearly as can be interpreted; while Cancani apparently considers 500 to 1,000 as sufficient. Nothing is said about periods or amplitudes. Now with these figures in mind take a C tuning fork, vibrating 512 times a second, and apply its stem to a door panel or a wooden table top. The wood is thrown into vibrations which can readily be felt with the fingers. With a little trouble the amplitude of vibration can be measured. It may be one one-thousandth of an inch or more, but to be on the safe side we shall here assume that it is only one tenth of this amount. Putting this into millimeters, and applying a formula well known to physicists, we obtain as the maximum acceleration of the wood particles 26,400 millimeters per second per second, or more than six times the highest estimate above for the destruction of wooden structures. It may be noted that the door or table survives the experiment unharmed.

This extreme case shows that the intensity-acceleration proportionality is certainly not of general applicability. A big accereation with a small period is harmless. Apparently the period should be given seperate consideration in the establishment of the true meaning of intensity. It would perhaps be more nearly correct to define intensity as a quantity proportional to the product (maximum acceleration) x (period). It is easily shown that this is the same thing as putting intensity proportional to the ratio of amplitude to period. This tentative suggestion, with any others covering this same question, await a test which can only come by systematic observation of the destructive effects of a large variety of accurately measured earthquakes.

Paul Kirkpatrick.

HAWAII TERRITORIAL FAIR EXHIBIT

At the Territorial Fair, which opens in Honolulu on August 29, there will be an exhibit of photographs and lava specimens from the vicinity of Kilauea Volcano. The Hawaii National Park will exhibit jointly with the Hawaiian Volcano Observatory. The Observatory will show a seismograph which was constructed in its own shop, and there will be a short moving picture shown of the 1926 Mauna Loa flow. In order to furnish information to those not already acquainted with the history and work of the Observatory, the Volcano Letter for next week will deal briefly with these subjects. A number of extra copies will be printed and furnished for free distribution to those interested at the Fair.

R.M.W.

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No. 139 RELEASED WITHOUT COPYRIGHT RESTRICTION August 25, 1927

KILAUEA REPORT No. 813
WEEK ENDING AUGUST 24, 1927
Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

Kilauea Volcano continues dormant, and very few changes are to be noted in the lava pit, Halemaumau. During a walk around the pit on August 18 a faint odor of sulphur dioxide was noticed at the fourteen-ton bowlder on the east rim and also at the north rim, and a few rock falls were heard. On August 23 the only changes appeared to be an increase of the white salt coatings on the north and northeast walls and of the white and yellow stains on the lava floor. A crack at the southeast rim seemed to have been in motion. Steaming was very slight. On August 24 there was increase of steaming due to the wet weather.

During the week ending August 24 there have been 26 local earthquakes recorded, all very feeble except one which was registered at 9:22 p. m. August 23. This was feeble and hardly strong enough to be perceptible. Its indicated distance from the Observatory is 25 miles. On August 17 a swarm of very feeble tremors was recorded, and a similar swarm came on August 20. Faint traces of tremor, occasionally visible between the counted earthquakes, suggests that each swarm represents a continuous though very feeble disturbance, perhaps similar to harmonic tremor. Very slight south tilt has accumulated during the week.

THE HAWAIIAN VOLCANO OBSERVATORY

The Hawaiian Volcano Research Association was founded in 1911 by business men of Honolulu as an organization to promote volcanological research, and to establish the Observatory at Kilauea. Professor T. A. Jaggar of the Massachusetts Institute of Technology was secured to take charge of the work; and additional funds towards the support of the project were also furnished through the Institute. The seismograph cellar and the main laboratory building were constructed in February, 1912, and detailed routine records of activity have been kept ever since. The station was transferred to the United States Government in 1919, and was operated under the Weather Bureau until 1924, when through governmental reorganization it was changed over to the Geological Survey under the Department of the Interior. The Research Association has continued its full collaboration throughout these different transfers. The Hawaiian Volcano Observatory, therefore, now represents this combination of interests. Professor Jaggar has remained in charge since the beginning; he is now Chief of the Volcanology Section of the Geological Survey, and a director of the Research Association. In the former capacity he is also in charge of volcanologic stations in California and Alaska. Under his direction the Observatory operates subordinate seismological stations at other places on the Island of Hawaii.

Kilauea Volcano is an excellent subject for volcanological study. It is an active volcano, yet being ordinarily non-explosive, it is relatively safe and may be studied at close range; it is accessible; its activities are confined to a region conveniently within the scope of a single station; Mauna Loa, also active, is close by and furnishes additional phenomena for study; there are great numbers of local earthquakes as clues to its moods; it is in the middle of the wide circle of earthquake zones defined by the shores of the Pacific Ocean; it is American territory.

The aims of the Observatory are: To keep detailed records of Hawaiian volcanism; to attract to Hawaii volcanologic specialists and scientists interested in allied subjects; to make available elsewhere the knowledge gained in Hawaii concerning volcanoes and earthquakes. The work of the Observatory is under the general heading of Geology. The mountain's structure, its features and faults, its interior mechanism, statistics of its eruptive habits, details of its individual lava flows and eruptions, the character of its ejected material—these are all main lines of investigation under the general heading. Various branches of science are used as tools for observation. Seismology is most important, as the local earthquakes and tremors are in fact the heart-beats of the volcano, and tilt is its respiration. Chemistry gives the analysis of lavas and gases, and is a key to some of the reactions within the volcano and to the behavior of lava at the surface. Astronomy, through the tidal effects of lunar position, helps in the study of the periodicity of eruptive phases. Geodesy provides methods for measuring the stretching, warping and bulging or collapse of the ground surface near the volcano, and also checks the tilt; gravity measurements indicate interior densities. Meteorology suggests correlations such as weather and barometric pressure with volcanic activity. Hydrography and topography show the shape of the volcano, and the former includes knowledge of tides and fluctuations in mean sea level. Engineering is represented by the boring of wells and holes in the crater floor, for the study of sub-surface strata and temperatures. Photography, microscopy, radio, all do their part.

The cooperation of the U. S. Coast and Geodetic Survey has been very valuable in furnishing precise levels from Hilo to Mauna Loa, in making gravity determinations at Hilo, Kilauea and on Mauna Loa, and in establishing a tide gauge at Hilo. The regular operations of that Survey, and of other organizations and individuals, give much data useful to the Observatory along the lines suggested above.

Results of the study of special problems, tabulations of routine observations and discussions concerning them, are printed in the regular publications and reports of the Observatory, or appear as articles in the scientific periodicals and bulletins. The Hawaiian Volcano Research Association has recently financed the erection of a Lecture and Exhibit Hall. Lava specimens, photographs and charts are exhibited here, and illustrated lectures are given by the Hawaii National Park and the Observatory in cooperation so that visitors may be as fully informed on the points of local interest as is possible in their sometimes too brief stay.

Kilauea and Mauna Loa are active volcanoes. Its history shows that Kilauea is visibly active during the greater part of its time. Most of the lines of investigation outlined above are important even though molten lava or other spectacular surface activity is absent. The volcanoes are at present quiet, and no "fire" is visible, so that visitors now seeing them for the first time are led to the conclusion that the preponderance of pictures of activity is deceptive. Photography is obviously most extensively used during the spectacular phases. The present quiet period seems long, but it is only a short phase when counted in terms of the active age of these volcanoes.

R.M.W.

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No. 140 RELEASED WITHOUT COPYRIGHT RESTRICTION September 1, 1927

KILAUEA REPORT No. 814

WEEK ENDING AUGUST 31, 1927

Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

Very few changes have taken place in Halemaumau pit. Conditions remain practically the same, except for occasional rock falls and avalanches. At 2:30 p. m. August 28 gray debris lay on the northern taluses, and at 3:10 p. m. a large avalanche dust cloud rose from the northeast corner of the pit. Two other slides just previous were noted by observers on Uwekahuna Bluff. At 11:50 a. m. August 29 avalanche dust clouds rose from the north, northeast, and east sides of the pit, and hung over it for several minutes. On August 30 at 9:35 a. m. a large, gray streak from a slide was seen to extend all the way from the west rim to the pit floor, and the northern walls were freshly peeled in several places. Rather continuous slides were occurring at the lower northeast corner of the pit. A section of a ledge southeast has fallen. A visit to the northeast rim August 31 shows the ground to be very loose there.

During the week ending August 31 the seismographs recorded 17 local earthquakes. One of these, at 8:10 a. m. August 28, was feeble and apparently not more than two miles from the Observatory. There are no reports of its having been felt. The other 16 shocks were all very feeble. There has been no accumulation of tilt during the week.

A REVIEW

The Bulletin of the National Research Council, Number 61, reporting the transactions of the American Geophysical Union at the meeting of April, 1927, contains a number of papers of very considerable interest. Already these papers are but brief abstracts, so that this still more brief review can hardly aspire to be more than a mere list of the subjects introduced. This Bulletin also contains the report of the delegates of the American Geophysical Union who went to the Third Pan-Pacific Science Congress at Tokyo in October, 1926.

The papers presented are grouped under general headings. Meteorology is represented by a "Symposium on Some Factors of Climatic Control," and by a number of papers on particular features. Terrestrial Magnetism and Electricity are discussed, and so is Oceanography. Volcanology, Seismology and Geodesy are of particular interest to this Observatory, and some of the features brought up by the papers under these headings are here outlined.

Under Volcanology comes a discussion of the investigation of hot springs by the Geophysical Laboratory. Phenomena in California, in Lassen Park and at the Geysers; in the Katmai region in Alaska; in the Yellowstone National Park; are compared as to range of seasonal temperature and as to materials brought to the surface with the water and steam. These considerations open the way for deductions on subterranean formations and conditions. Another paper points out the part played by gases in the phenomena of volcanism, commenting on the hypotheses of gas-heating and gas-fluxing, and refers to conditions at Kilauea. The presence of metals in various deposits placed by volcanic steam is touched upon. A discussion of conditions on the Moon is given, particularly the low value of lunar gravity and the lack of atmosphere, and the effect of these conditions upon the probable method of formation of the Moon's craters.

Reports of the work being done and the progress made in seismology by various organizations occupies considerable space. Improvement of instruments and the substitution of more modern seismographs for those of older design, the establishment of new stations, cooperation in centralizing the data, and early publication of results and summaries of earthquake information, seem to be the main lines of progress. The investigation of shifts and motions of the Earth's crust in relation to earthquakes is shown to be important, as through such measurements it may be possible to keep watch over dangerous fault zones. There are discussions of the travel of seismic waves through the Earth's surface layers, and concerning new phases observed in teleseismic registration.

The papers relating to Geodesy are numerous. Mention is made of triangulation by the Geodetic Survey of Canada at two places where the object is to discover and study earth movements in connection with seismic disturbances. The statement is made that "The geodesist has proved the theory of isostasy to be a scientific fact . . . . " The earthquakes of the St. Lawrence River Valley are supposed to be due to the recovery, by isostatic adjustment, of the area relieved of the weight of ice of the glacial period. A brief description is given of the methods, accuracy and preliminary results of the World Longitude-Net operations. In this work automatically recorded time signals and refined star transit observations were used simultaneously at stations scattered all over the world; the many different longitude differences to be harmoniously adjusted. The probable errors of these individual longitude differences, expressed in time, are given as amounting to only a few thousandths of a second. An interesting feature is brought out in the description of an adjustment made in the North American level net. The whole net was adjusted without the introduction of conditions for ties to sea-level. The result seems to indicate that according to spirit-leveling, mean sea-level is about a foot higher at Portland, Maine, than at St. Augustine, Florida; and nearly a foot higher at Seattle, Washington, than at San Pedro, California. The first order triangulation covering the western half of the United States has been re-adjusted, and one paper tells briefly of the loop closures; the mean of all the closures being about one part in 450,000, representing an error of about 14 inches per 100 miles.

In many of these abstracts reference is made to publications wherein these subjects are dealt with more in detail, and there are frequent references to forthcoming publications along the same lines which will soon be available. At this April meeting a resolution was adopted to find a way to have translated into English the many and valuable publications in Japanese that represent the current investigations in seismology in Japan. It is to be hoped that this may be done. R.M.W.

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No. 141 RELEASED WITHOUT COPYRIGHT RESTRICTION September 8, 1927

KILAUEA REPORT No. 815
WEEK ENDING SEPTEMBER 7, 1927
Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

There has been considerable working of the walls of Halemaumau during the past week. One very large avalanche occurred on the northeast side at 2:20 p. m. September 1. On September 2 two large scars were seen where the northeast wall had peeled, and from 9:30 to 10 a. m. small slides were almost continuous on that side. At 3:45 p. m. the pit was full of dust from slides. A large avalanche dust cloud was reported to have been seen about 6:45 a. m. September 4. On the 5th new debris lay thickly on the north-northeast, northeast, and south taluses. Steaming activity varies little.

On September 2 the crack at the southeast tourist station had widened very perceptibly, and there were several small new cracks nearby. The following day several crack measurements were taken, and the large southeast crack was found to have widened more than half a foot since July 11. Another crack had widened nearly as much in the same period of time. While other cracks in the vicinity had opened, their movements were not as great. On September 5 the small new cracks were more pronounced.

Six very feeble earthquakes occurred during the week. In addition to these there was a swarm of very feeble tremors on September 1. Minute tremors came also on the 2nd, 3rd, 4th, and 5th. Accumulation of tilt during the week has been negligible.

JAPANESE SEISMOLOGICAL INVESTIGATIONS

More than any other nation, perhaps, Japan is vitally interested in earthquakes. The high activity of its seismic zones, bringing heavy earthquakes into densely populated regions, makes earthquake knowledge actually a life and death matter. It is the business of the Japanese seismologists to examine in detail the circumstances and meaning of every shock, to delineate the active faults, to detect where the accumulating forces and stresses may next produce fracture with resulting damage to life and property. On March 7, 1927, an earthquake occurred in Tango Province, Japan. It was recorded on the seismographs of observatories in many places, and the press reported it rightly as disastrous. In the "Proceedings of the Imperial Academy," 3 (1927), No. 4, Japan, is an abstract of the seismological investigation of this earthquake by A. Imamura and Nobuji Nasu. There were two faults produced at right angles to each other, the vertical and horizontal displacement along each one being measured at the surface. Changed elevations along the sea coast were also noted. These are not unusual movements and changes to be produced by an earthquake. One feature that seems particularly interesting is the reported apparent temporary lowering of sea level, two or three feet in amount, which took place two hours and a half before the earthquake. In the analysis of the shock, the authors explain this to be a temporary elevation of the ground, caused by the up-tilting of a block of the earth's crust under accumulating stress. This stress was then expended in producing the fracture, generating the earthquake and allowing this area to resume its former position without the permanent displacement exhibited at other places. Three portable seismographs were set up at the corners of a triangle covering the epicentral region. These instruments began recording only four or five days after the earthquake, and the after-shocks that were still occurring were carefully analyzed. It was thus possible to estimate the boundaries of the disturbed block and to suggest the sort of mechanism involved.

A few months ago Mr. Imamura published a description of a horizontal pendulum seismograph which could be adjusted to a free period as long as three and a half minutes. In a more recent paper in the "Proceedings" (3, 1927, No. 5), with the title, "On the Observations of Slow Earthquake Motions," he describes certain earthquakes as recorded on this instrument. The very slow natural period of the instrument has apparently made it sensitive to long period motions that have heretofore escaped notice in teleseismic registration. There are several records reproduced in the paper, plainly showing waves having periods in the various cases between 53 and 220 seconds, ordinarily with an amplitude of from 0.3 to 0.6 mm. These long period waves may be thought to be a result of the very long period of the horizontal pendulum making the records. It is hard to believe that this is so, however, when the period of the waves is not the same as the period of the pendulum. Mr. Imamura, in fact, discards one well-marked wave which has a period about the same as the pendulum, suspecting that it may have been caused by instrumental resonance. He then turned his attention to the records of ordinary seismographs for the same earthquakes, and found in several cases that the ordinary instruments showed traces of these long waves when attention was called to them by the records of the special instrument. This would seem to make it certain that the long waves so recorded are not fictitious phenomena resulting from the peculiarities of the instrument itself, but are in fact representations of real earth movement. R.M.W.

THE UWEKAHUNA SEISMOGRAPH

When the Uwekahuna Observatory was built, provision was made for setting up an exhibition seismograph. A small alcove at one side of the main room contains a pier which is founded upon solid rock and which does not in any way touch the foundations of the building. This space has so far not been utilized as the seismograph has not been ready. This instrument is one of modern Japanese make that was ordered by Dr. Jaggar when he was in Japan with the Third Pan-Pacific Science Congress last October. Delivery has been slow as Dr. Jaggar requested the makers to substitute cardan hinge supports for the heavy masses in place of the cup and pivot supports used in the stock instruments of this type. The seismograph has arrived in Honolulu, and will be set up at Uwekahuna in the very near future. It will be run continuously, and its records will be filed at the Observatory. It is expected that a study of these records will yield interesting information as to the seismic conditions at that place, which is much nearer to the pit than is the present seismograph station. R.M.W.

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No. 142 RELEASED WITHOUT COPYRIGHT RESTRICTION September 15, 1927

KILAUEA REPORT No. 816

WEEK ENDING SEPTEMBER 14, 1927

Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

The avalanching activity at Halemaumau has continued with increased vigor. Probably the largest avalanche was one that occurred at 9 a. m. September 9 from about the center of the wall just west of the Kau rift tunnels, leaving a scar several hundred square feet in area. The many tons of debris dislodged have partly buried the southwest cone. This section of the wall is usually quiet, and avalanching there may be considered significant inasmuch as it may mean that the northeast-southwest rift line was in motion.

Many new scars made by slides are to be seen all over the northeast, north, and northwest walls. Some very large slides have come from the northwest wall which, until recently, has been very quiet. A rather loud avalanche was reported to have occurred from the north wall about 9:30 p. m. September 12; also continuous small slides on that side. On the afternoon of the 13th several noisy slides from the north wall were seen from the Uwekahuna Observatory.

A circuit of the pit made on September 12 disclosed a few changes. An immense bowlder that hung under the northeast rim has fallen, and nearby is a slim pinnacle which appears ready to topple over. Dirt has been dislodged by the widening of a crack through the north-northeast fault cliff.

During the week ending September 14 there have been 19 very feeble local earthquakes recorded on the seismographs. Tilt has accumulated moderately to the NNE.

THE HILO SEISMOGRAPH STATION

The Hawaiian Volcano Observatory has for several years operated subordinate seismological stations on the Island of Hawaii. They have been found very useful in locating the epicenters of near earthquakes. The instruments at the Observatory usually give the distance to the origin of an earthquake, but only in exceptional instances can reliable direction be derived from the records. Thus the actual position is difficult to definitely determine from the records of a single station. But with other stations recording distances to the same shock, it is possible to quite accurately plot the position of the origin. The value of the data supplied by these outlying stations certainly warrants the making of any improvements possible in them.

About the first of this year a well equipped machine shop was added to the facilities of the Observatory. Among other things this has made possible the construction of better seismographs for these subordinate stations. A reasonably simple design was adopted for a two-component type, and already three sets have been made, and a fourth is partly constructed. The first of these three is the one installed by Professor Jaggar this summer in Kodiak, Alaska; the second is being held for a probable second station in Alaska; the third has just been installed in Hilo, Hawaii. One of these instruments was placed on exhibit at the recent Territorial Fair in Honolulu. In these instruments the heavy mass is a 27 inch long section of 8 inch iron pipe, with end plates welded top and bottom, and filled with sand, weighing approximately 225 pounds. The mass is slung as a horizontal pendulum by means of short piano-wire links at the top and bottom. These links on the base side are fastened into an upright bar which is in turn supported by a plate arranged to be bolted to the wall. The bar can be adjusted to secure the proper inclination of the support axis. The center of gravity of the upright heavy mass is out 8 inches in front of the axis of support. To the front of the heavy mass is bolted a tubular aluminum boom 41 inches long with wire guys to stiffen it, and with a fine pivot at the outer end. The recording mechanism consists of an aluminum drum about 11 inches in diameter and 12½ inches long, to carry smoked paper. The drum is rotated by an escapment clock, which gives the paper a speed of 30 mm. per minute. Both components of the seismograph record on the same drum. The writing point is a fine steel needle in jewelled bearings that rests upon the smoked paper with its own weight only, and is fastened to the long arm of a magnifying lever. The short arm of the lever is coupled to the pivot at the end of the heavy mass boom by a light aluminum bar with jewelled bearings. The pendulums will first be tried with a free period of seven seconds. The magnification is 160. Oil damping is employed to steady the heavy masses. These instruments are intended to be hung on the wall, so that the only pier necessary is the one to support the recording mechanism.

The single component instrument that has been in operation for six years at the Brothers' School in Hilo has been replaced by one of these two-component instruments just described. Brother Albert will continue in charge of this station. A completely new housing has been made in the back corner of the school grounds, far from the disturbances of street traffic and school activity. This new seismograph cellar is reinforced concrete of monolithic constrution, walls and roof being five inches thick. The inside dimensions are eight by nine feet, and the floor is about seven feet below the outside ground surface. The walls are set on solid rock, as is also the pier in the middle of the room which carries the recording mechanism. The building is turned so that its 9 foot length is in a northeast-southwest direction. A flight of narrow stairs, partly outside and partly inside, leads down through a low door into the cellar. The instruments are hung in the corners of the room; the east-west component pendulum in the south corner, and the north-south component in the west corner. The axes of the instruments are therefore at 45 degrees with the walls of the building. A ventilator is arranged to carry off the smoke from the smoking lamp. The temperature of the room seems to vary through a daily range of only about five degrees Fahrenheit. Notes as to the behavior of this new installation will appear in future issues of the Volcano Letter. R.M.W.

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No. 143 RELEASED WITHOUT COPYRIGHT RESTRICTION September 22, 1927

KILAUEA REPORT No. 817
WEEK ENDING SEPTEMBER 21, 1927
Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

Numerous slides have occurred from nearly all sides of Halemaumau pit. Most of them have been from the north and northeast walls, though the northwest wall has also been very active. Crack measurements taken on September 17 showed that there has been a general increase in the width of all cracks on the east side and that the southeast ledge was fast separating from the main rim, having moved about eight inches in a week. The observer could see the dirt settling into the southeast crack and hear the rocks adjusting themselves to the movement. At 1:30 p. m. September 19 the ledge fell with a roar resembling an explosion, tearing away a great strip of the rim. A disturbance recorded by the seismographs about this time may have been caused by this avalanche. This and several other avalanches were seen and heard from the Uwekahuna Observatory.

The walls of the pit are very dark and reddish from the recent rains. Steaming is moderate at all vents.

There have been 28 very feeble local earthquakes recorded on the seismographs during the week ending September 21. One of these was an extended disturbance of small amplitude covering more than four minutes of time, which occurred at 5 p. m. on the 14th.

During the week no material tilt accumulated up to the 17th. On this day a definite spurt to the south-southeast began, lasting for two days, making the net accumulation for the week moderately south-southeast. On these same two days the records show the presence of an unusual amount of short-period tilting, causing the seismogram lines to crowd and overlap.

LOCAL SEISMIC PERIODICITY

A few weeks ago a rough analysis was made to determine whether the very feeble local earthquakes recorded at the Hawaiian Volcano Observatory inclined to a greater frequency at any particular time of day. The afternoon hours seemed to contain the greater percentages, as was stated in a previous issue of the Volcano Letter.

During the last ten months these feeble disturbances have seemed to come in waves of increasing and decreasing frequency, the time interval from crest to crest of increased frequency being about two weeks. So another preliminary analysis has been made to determine whether these recurring waves show real periodicity. It is a question whether the investigation should be based merely on the number of shocks, or whether intensity should also be considered. One heavy shock probably releases as much accumulated stress as would several smaller ones. No attempt has been made therefore, in this rough review, to make a quantitative computation of the energy displayed by the various disturbances. Instead, the crests of seismic activity have been selected merely by inspection of the records to find at what times activity is most apparent.

The short period of time covered by the inspection, and the crudeness of the method used in reducing the records, prohibit a definite and final statement of results. It seems apparent however, that there is a true periodicity present, and there seems to be a correlation with the phases of the moon, as would be expected if luni-solar gravitational attraction is considered as a factor. The maxima of this periodic local seismic activity seem to come when the moon is at first or last quarter, and the times of lesser activity when the moon is either new or full. July 7, 1927, when new lava came into the pit of Halemaumau, seems to be timed as one of these crests of activity. The evidence of periodicity seems more pronounced since the July eruption, and the last noted crest of seismic activity occurred about September 16.

R.M.W.

HORIZONTAL GROUND MOVEMENTS

An interesting development in the recent work of the Observatory is the detection of horizontal earth movements in the vicinity of Halemaumau. Marked points located in 1920 have been re-surveyed during the last year. Progress of the work has been mentioned from time to time in the Volcano Letter. Preliminary computations have just been completed, and comparison made between the 1920 and the 1926 results. It has become apparent that motions of considerable magnitude have taken place during this six-year interval of time. The points surrounding the pit have converged, agreeing with the general collapsing of the region around the pit that has already been detected by the re-running of spirit-level lines. The horizontal movements of the ground, within a zone of two miles radius about the pit, do not in all cases converge radially towards the center of the pit. This would be expected if the collapse were centralized at the pit. Instead the movements seem to indicate that the collapse was more probably along an elongated belt, perhaps determined by a fault line. The points within this zone show movements of from two to five feet. There are two points near the pit, less than a mile apart, that have approached each other, one moving three feet and the other five feet, so that the distance between them has become eight feet less than before. The line between these two points forms one side of a triangle that was used in the triangulation. In the triangle, the angle opposite this side has changed more than two minutes of arc. Since in both the 1920 and the 1926 surveys an accuracy represented by an average triangle closure of three seconds was attained, it is evident that real motion has taken place. This line is the one that joints the marked point at Uwekahuna and the one near Little Beggar, and the angle is that measured at the mark at the Observatory between these two points. If motion of the same sort continues, or if the movement reverses, it is evident that a re-measurement of the angle at the Observatory will detect it. If the approaching together of these two points represents a collapse of the area around Halemaumau, as seems to be the case, then variations in the angle spanning them should immediately indicate further collapse or recovery. In other words, fluctuations in this angle should be an important clue in detecting changes of volcanic phase in Halemaumau.

R.M.W.

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No. 144 RELEASED WITHOUT COPYRIGHT RESTRICTION September 29, 1927

KILAUEA REPORT No. 818

WEEK ENDING SEPTEMBER 28, 1927

Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

Avalanching at Halemaumau has continued to be frequent. There has been so much sliding since the July lava activity that the new floor of the pit is now well overlapped with debris on all sides. The slides have occurred mostly from the northern walls, eating away the rim to such extent that the pit is constantly enlarging itself in the direction of Volcano House.

At 5:20 p. m. September 21 the prolonged roar of an avalanche was heard from the Observatory, but the weather was so foggy that no dust could be seen. The next day new scars were seen on the south, east, northeast, north, and northwest walls, and a coating of new debris lay on the north-northeast talus. A section of the east rim has collapsed. On September 24 more new debris was seen on the northern taluses.

On September 26 the pit was quiet and steaming was very slight. The character of the weather has a great deal to do with the amount of steaming. On September 28 a light rain was falling, and there was a considerable increase in the volume of steam escaping. The wet weather also has its effect on the colors of the walls, so that on this day there were very pleasing contrasts of deep red and light and dark gray colorings. A large scar near the top of the north wall may have been made at 1:10 p. m. September 26 when dust was observed. There were also fresh scars on the northeast wall.

Twelve local earthquakes have been recorded during the week ending September 28. These were all very feeble, excepting two which occurred at 3:03 p. m. and 4:11 p. m. on the 27th. The first of these was feeble, its origin apparently about 28 miles from the Observatory. The second was slight, its origin being about 14 miles away. There have been no reports yet received that these shocks were generally felt, though the latter was noticed by a few persons in Hilo. Microseisms were slightly stronger than usual on the 26th and 27th. Tilt has accumulated moderately to the NNE.

LASSEN REPORT No. 11

Mineral, California, September 7, 1927

R. H. Finch, Associate Volcanologist

A description of two lava flows from Cinder Cone, about 10 miles northeast of Lassen Peak, was made by J. S. Diller as far back as 1891. Diller stated that the youngest of the flows occurred in the 19th century something like 50 years previous to his writing. There are indications that there were at least three flows, and Diller's conjecture that the youngest occurred about 100 years ago is probably correct. The age of the oldest of the flows is not known, although it may be about 300 years. One of the older flows crossed a lake, making two new ones—Butte Lake and Snag Lake. The latter takes its name from the many snags still standing in the water, though snags are also found in Butte Lake. The bed of the old lake that shows in many places well above the level of the present lakes indicates that the ground in the vicinity of Cinder Cone was first upheaved and later sank. The weight of the lava flows, in places over 100 feet thick, might well be the cause of a sinking.

The last flow covers but little new ground, lying almost entirely on preceding flows. Both weathering and tree growth point to the fact that there were at least three flows and that the youngest might possibly have occurred within the memory of some people still living. A preliminary investigation by Mr. A. E. Jones, who worked as seismologist at Lasse Volcano Observatory during the summer of 1927, by means of the magnetic properties of the flows ("Telling the Age of Old Lava Flows," Volcano Letter No. 45, November 5, 1925), places the youngest flow about 1832, and the next youngest about 1795.

R. H. Finch

EARTHQUAKES AS CATASTROPHIES

A short review of the notable catastrophies that occurred in the world from September 1, 1924, to August 31, 1926, appears in "The World's Health" (Paris, July, 1927). M. Raoul Montandon, the editor-in-chief of "Materiaux Pour l'Etude des Calamites," in this review distributes according to time, and according to place, 551 disasters that have afflicted mankind in this two year period. In kind, they are represented as follows: Earthquakes, 66; volcanic eruptions, 4; avalanches and landslides, 9; floods, 197; cyclones, hurricanes, typhoons, 148; droughts, 23; tidal waves, 8; fires, 48; famines, 17; plagues of locusts, 31. Their distribution is given as: Africa, 35; North America, 75; Central America, 19; South America, 38; Asia, 97; Europe, 249; Oceania, 38. Summer is apparently the most hazardous season.

These figures are based upon reports published in the press, and Journalism is prone to inaccuracy in stating damage to life and property. It is therefore difficult to draw a fine line in selecting the happenings that are of sufficient magnitude to be classed as catastrophies. Yet in the case of the earthquakes, the figures above agree remarkably well with the statement of Montessus de Ballore that of the 30,000 earthquakes which may occur in a year, 31 will be to some extent destructive.

In dealing with a summation of calamities of such varied kind, it will be difficult to make correlations as to general cause, though it is suggested that solar activity and sun spot years may have something to do with some of them. There is of course one factor that must be considered in connection with all catastrophies; that is, the density of population. A tremendous earthquake, an extensive flood or a violent hurricane can only be counted as a catastrophy when man and the works of man are present to suffer destruction. This factor probably accounts for the large percentage of catastrophies that these figures give to Europe.

R.M.W.

Professor Jaggar has completed his season of volcanologic reconnaissance in Alaska. He made a short visit to the Lassen Volcano Observatory in California, and is now in Washington. It is probable that he will arrive in Honolulu on October 18.

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No. 145 RELEASED WITHOUT COPYRIGHT RESTRICTION October 6, 1927

KILAUEA REPORT No. 819

WEEK ENDING OCTOBER 5, 1927

Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

Halemaumau pit has taken on a somewhat new phase in regard to the restlessness of the walls. The heavy avalanching so prevalent during the period of the equinox has practically ceased, and now there are only numerous small slides. These are rather continuous, often so small as to be barely perceptible. They seem to be occurring from nearly all sides of the pit, but are concentrated mostly southeast and northwest. The fine material thus deposited on the northwest talus has made a wide streak its full length. Slides at the top of the northeast talus have eaten a hole into the wall similar to that just above the northwest talus.

Few other changes have taken place in the pit. The white and yellow stains on the floor increase in the vicinity of the southwest cone. Steam escapes from the smaller cone in irregular puffs, and all vents are moderately active.

During the week ending October 5 the seismographs have recorded 22 very feeble local earthquakes. On September 30 there was a period of continuous harmonic tremor, beginning feebly at 9:30 p. m. and increasing in strength until about 10:40 p. m., when it began to fade out, disappearing from the records at 10:50 p. m. This type of disturbance is of especial interest, as in the past it has been closely associated with the presence of active lava. There are, however, no other symptoms of renewed activity. It is interesting to note that this spell of harmonic tremor, with the small group of very feeble spasmodic tremors that closely preceeded it, represents another crest of seismic activity that comes just two weeks after the last crest noted, confirming the idea of periodicity (see Volcano Letter No. 143, September 22, 1927).

The two earthquakes on September 7, mentioned in last week's Kilauea Report, were also well recorded on the seismographs in Kona and Hilo. The plotting of distances has shown that the second one originated not far from Ainapo, on the southeast slope of Mauna Loa.

Tilt for the week has accumulated very slightly to the east.

VOLCANOES AND SUBMARINE EARTHQUAKES

Disturbances of the surface of the ocean, attributed to volcanic or seismic causes, have been noted at various times. In the "Bulletin Volcanologique" (Italy, 1926, Nos. 9 and 10) is given a series of reports of such occurrences, and other instances are noted in the Seismological Report Supplement for 1924, published by the U. S. Coast and Geodetic Survey. These phenomena are observed and recorded by ship's officers or other persons aboard vessels at sea. Some of the descriptions are very meager, merely mentioning that shocks were felt, or that the surface of the ocean was disturbed. It seems doubtful that the vibrations of an earthquake, which are elastic vibrations in a solid body, could be propogated through sea water and reach a vessel as a perceptible shock or tremor unless the water were shallow or the disturbance great. It is easier to understand that a submarine eruption should disturb the surface of the sea, causing it to heave or seethe, and perhaps bring up sediment from the bottom. In two of these reports the heaving, seething and discoloring of the ocean's surface is described, but in neither one is the feeling of shock or tremor mentioned. Those reports mentioning perceptible shocks say nothing of the water surface, or say that nothing unusual was observed.

It is difficult, save in one or two doubtful cases, to correlate these disturbances with earthquakes as recorded upon seismographs at the time. A volcanic eruption might well be a slow outpouring of lava, producing convection currents with resulting disturbances at the surface, yet which would not send out seismic waves of sufficient intensity to be recorded at any great distance. On the other hand, a tectonic earthquake violent enough to be felt as a shock through any great depth of sea water should certainly send out seismic vibrations (along the earth's solid crust) over distances great enough to record on many of the world's seismographs.

When the ocean surface shows disturbances, as seething or sediment, water temperatures should yield interesting information. In the few cases here reviewed no such temperatures were recorded. R.M.W.

AN ELECTRICAL ACCELEROMETER

Juichi Obata (Proceedings of the Physico-Mathematical Society of Japan, May, 1927) describes an electrically recording accelerometer. Minute earth tremors can be detected with this instrument, as the magnification can be made great. A simple pendulum is held about 10 degrees out of vertical by a prop bearing against a thin metal diaphragm. Horizontal acceleration of the apparatus in the plane of the pendulum and prop will cause the prop to bear more or less heavily against the diaphragm which is used as one element of an electrical condenser. The second element is so placed that any variation of the pressure of the prop will vary the distance between the elements, and so vary the capacity of the condenser. The condenser is connected up electrically as part of an oscillating circuit containing an ordinary radio vacuum tube. Changes in the capacity of the condenser induce changes in the grid potential of the tube, thereby altering the plate current and causing a galvanometer to register.

The dispalcement of the diaphragm necessary to register on the galvanometer is so slight that relative motion within the apparatus may be neglected and the readings may therefore be regarded as representations of true acceleration. The sensitivity of the arrangement in this simple form is stated to be such that one millimeter galvanometer deflection is produced by an acceleration of 0.4 cm. per sec. per sec. Greater magnification may be secured by the use of additional tubes to amplify the electrical impulses issuing from the first tube, just as in a radio receiving circuit. R.M.W.

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No. 146 RELEASED WITHOUT COPYRIGHT RESTRICTION October 13, 1927

KILAUEA REPORT No. 820

WEEK ENDING OCTOBER 12, 1927

Section of Volcanology, U. S. Geological Survey:

R. M. Wilson, Temporarily in Charge

Conditions at the volcano are much the same as last week, with numerous small slides from the walls of Halemaumau pit and only an occasional avalanche. These slides are mostly from the northwest side, where they can be heard nearly continuously, and much fine material lies at the foot of all the walls.

Yellow stains are quite pronounced on the smallest of the cones active on July 7, and in spots on the south and east taluses. A bright yellow area of sulphur crystals lies at the foot of the south talus. Higher up this talus is streaked with wet steaming places.

There were 23 very feeble local earthquakes recorded on the seismographs during the week ending October 12. One of these, at 10:25 a. m. October 5, was recorded just at the time of a large avalanche in the pit, and is probably a record of the vibrations caused by the falling rocks. Microseismic motion has been normal. Moderate tilt towards the NNW has accumulated during the week.

ISOSTASY AND GRAVITY

If the earth were so simply constructed as to have no irregularities of surface or composition; if it were a perfect mathematical body, then many present scientific problems would not be crying for solution. It might then be a true spheroid of revolution, all its surface at a single elevation, and, at any particular point on its surface, its radius, its curvature, the value of gravity, would all be easily computed by simple formulae dependent upon latitude. Such is not the earth upon which we live. Science does use, however, as a basis for many calculations, an imaginary mathematical spheroid, chosen of such dimensions that it represents as nearly as possible our actual earth in shape.

Mean sea level represents the nearest natural approximation to the spheroid. Imagine perfectly calm oceans, and think of their surfaces as continued even under the land areas at the same natural level that the water would assume if it had free passage there. This smooth and continuous sheet of water surface would be the geoid, and is the surface of zero elevation. The geoid is the slightly irregular figure of which the spheroid is the idealized mean. At all points on the geoid the plumb line hangs exactly perpendicular to its surface. The plumb line is deflected from the true vertical by certain local conditions. Thus at one side of a high mountain range, a plumb bob would be subject to greater horizontal components of gravitational attraction toward the high country than toward the lower country on the other side. This implies that the geoid surface would slope up toward the high country, relative to the spheroid. In general the geoid surface would thus be above the spheroid for land areas, and would be below the spheroid for ocean areas. Dr. William Bowie gives the result of a computation along 700 miles of a parallel of latitude, one end over land and the other over water, taking account of land elevation, ocean depth, and isostasy. It appears in this particular case that the geoid should be some 60 feet below the spheroid at the water end of the line, and 15 feet above at the land end.

Isostasy, briefly, tells us that in general the earth's crust considered for a thickness of some 60 miles, is of the same weight per surface area, everywhere. While high elevations like mountain regions imply thicker crust, the thickness is compensated by lesser density. It is thought that this crust rests upon a layer in the earth's structure that is, through heat and the tremendous pressure upon it, maintained in a state of high viscosity. This layer must be elastic, as it transmits earthquake waves, but because of its viscosity it slowly flows as a very thick fluid under the great pressures put upon it. If a mountain range could be lifted from one place, and set down in another, it would press down the crust of the earth under its new position, forcing out from underneath some of this viscous layer, which would flow beneath the area relieved of the mountain's weight, lifting this place and again restoring balance. Mountain ranges are not moved outright, yet through long ages great amounts of material are shifted from place to place on the earth's surface through stream erosion and deposition. This accommodation of the crust and its supporting layer to such shifts of weight is called isostatic compensation. The crust, being brittle, yields by successive fractures to these deforming forces, causing earthquakes.

On a perfect earth, such as that suggested above, the value of gravity would be easy to compute for any chosen point, once fundamental values were determined. Observed values would agree with computed values everywhere. Such simplicity is not attainable on the real earth. Thus when a value of gravity is observed (see Volcano Letter No. 106, January 6, 1927), there must be many corrections applied; for the elevation of the station, for local topography, for general irregularities of the earth's surface distant even to the antipodes, and for crustal density as suggested by isostasy. An observed value, so corrected for all known variations of the real earth from the perfect one, should agree with a value computed for the corresponding point on the perfect earth. A discrepancy represents, probably, the omission of some unknown factor in applying the corrections to the observed value. Such discrepancies are called the anomalies of gravity. Dr. Bowie indicates that the correction for the elevation of a gravity station should not be the elevation above mean sea level, or the geoid, but should be taken as the elevation above the true spheroid (see American Journal of Science, September, 1927). The corrections show isostasy and gravity to be in harmony.

A very real usefulness of gravity observations comes through the study of these anomalies. For, if a corrected observation gives a value too great, so that the anomaly is positive, it is an indication of a geologic formation of unusually great density not far beneath the surface, or of unusually small density if the anomaly is negative. In Japan, earthquake regions are so investigated to search for hidden faults and dykes, or to detect shifts or intrusions of magma beneath a volcano. R.M.W.

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No. 147 RELEASED WITHOUT COPYRIGHT RESTRICTION October 20, 1927

KILAUEA REPORT No. 821

WEEK ENDING OCTOBER 19, 1927

Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

Recent visits to Halemaumau show the pit to be quiet. Slides are not so numerous as last week, and steaming changes little. At 10:20 a. m. October 17 there was a small slide at the north corner which made dust, and about 3:30 p. m. October 19, slides occurred at the south corner making a bright red scar visible from the Uwekahuna Observatory. There is fresh yellow sulphur at the base of the southeast talus.

Crack measurements along the east rim of the pit show little movement, but on October 19 small new cracks were seen in the dirt back of the south station.

The seismographs have recorded 18 very feeble local earthquakes during the week ending October 19. A perceptible shock occurred in Kona, local to that place, at 6:01 p. m. on October 16. Tilt has accumulated slightly to the NNW.

ERUPTION OF MAGEIK IN ALASKA

The Seattle "News-Tribune" carries an Associated Press dispatch of the date September 30 stating that Mageik Volcano of the Katmai group erupted explosively "late in August" (1927). The authority quoted is Captain Harry W. Crosby, President of the Crosby Fisheries, who spent the summer aboard his schooner-cannery "Salmon King" in the northeast arm of Uganik Bay on the northwest side of Kodiak Island. Mageik and Martin were two volcanoes seen by Dr. Jaggar to be steaming, looking northwest from Shelikof Strait on May 18, 1927. Both took part in the great Katmai eruptions of 1912. Mageik is forty nautical miles from the middle of Shelikof Strait, and sixty miles from the Crosby anchorage in Uganik Bay.

Thousands of tons of pumice stone and ashes were reported by Crosby as showered over an area 50 miles square. The article quotes him:

"We were about 50 miles off the Alaskan Peninsula in clear weather, when suddenly we noticed a gigantic puff at the top of Mageik. Soon the air was filled with volcano ash, and it began to rain pumice stone. After the explosion, the volcano smoked like a factory chimney. A short distance from the ship we found large quantities of pumice stone, some pieces as big as your first, floating on the ocean.

"We scooped up a bushel or more of the stones and brought them to Seattle. For five days the eruption continued, and the mountain was still smoking when we left for Seattle.

"Each morning while we were off the Alaskan Peninsula, the decks and rigging of the ship would be covered with the fine powdered volcanic ash, some of it so white that it resembled snow. The first duty of the crew in the mornings would be to sweep the decks clear and to dust off the rigging.

"The eruption followed a period of unusual weather, a great calm with scarcely a breath of air, and a depressing atmosphere. The air was full of white volcanic ash for a week, and thousands of tons of pumice stone fell around us."

No dates or ship's positions appear in this article, but apparently the vessel did not sail until five days after the major explosion. Captain Crosby is a reliable commercial man, navigator and fisherman of many years' experience in Alaskan waters. T.A.J.

ALEUTIAN VOLCANOLOGY

The foregoing account illustrates how much is needed a reliable scientific station for collecting and verifying reports of activity from the forty-five potentially eruptible volcanoes of the Aleutian volcano chain, extending from Mount Spurr to Buldir. When Dr. Jaggar was at Naknek May 24, 1927, the teacher there, who had been to the Valley of Ten Thousand Smokes, reported that a trapper in January, 1927, had seen an ash eruption from one of the Katmai hills, and that two trappers were missing who had gone into that region. This is in the same district as Mageik.

Here, then, are two accounts, both incomplete as to hours and dates and places, suggesting that ash and pumice eruptions are being renewed in January and August, 1927, for the Katmai volcanic system.

Bogoslof was found in lava eruptivity when Dr. Jaggar on the "Unalga" visited and made landing on the islet July 6, 1927. This was in the technical sense that a pile of steaming hot lava was slowly heaving itself from the submerged crater above the sea-water. The salt lagoon surrounding the lava heap was warm. Fresh bombs and bomb-pits lay about. The records of mariners for a year past told of explosions in July, August, September, and November, 1926, at Bogoslof.

After this visit came a telegram from Captain Cochrane, commander of the Bering Sea Patrol, dated July 27, saying, "One of Akutan whalers reports Bogoslof active on July 26." The word "active" here certainly means another explosion. Where was the whaler; how far away; what direction was the wind; what was the hour; what happened? Such are the details needed by science.

Now we get Mageik exploding a month later. Fortunately a small sidelight is thrown on this volcanic action of the Katmai group by the new seismograph at Kodiak village. While it was being installed, July 30, at 7:10 a. m. Kodiak Time (ten hours slower than Greenwich), a local earthquake was sharply felt. At 5:52 a. m. August 11 a slight east-west swaying shock was felt and was registered by the seismograph so as to indicate an origin distance of 35 nautical miles; duration of registered motion three and one-half minutes.

Coinciding with "late August" of the reported Mageik eruption, the Kodiak seismogram of 7:18 a. m. August 28 exhibits a feeble local earthquake with preliminary phase indicating a distance of 30 nautical miles; duration of motion about one minute.

Summing up, we have (1) Bogoslof piling lava July 6 and exploding July 26: (2) Earthquakes at Kodiak originating 30 to 40 miles away at intervals of 12 and 16 days after July 30: (3) Explosion of Mageik the end of August and first days of September. Kodiak is 93 nautical miles from Mageik and about 35 miles from Shelikof Strait, where there is probably a northeast-southwest fault. T.A.J.

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No. 148 RELEASED WITHOUT COPYRIGHT RESTRICTION October 27, 1927

KILAUEA REPORT No. 822

WEEK ENDING OCTOBER 26, 1927

Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

There are evidences in the Halemaumau walls of slides west and northwest during the past week, and some dust has been seen rising once or twice. In general, however, the pit has been very dry, quiet and free from steam.

During the week ending October 26 there were 20 local earthquakes recorded, and one teleseism. All the local shocks were very feeble, with the exception of one which was feeble, yet perhaps of sufficient strength to have been felt, though no reports have been heard of it. This one took place at 6:20 a. m. October 24, possibly through trigger action, superimposed upon the diminishing waves of the teleseism.

Tilt has accumulated moderately to the ENE during the week.

RECORD OF ALASKAN EARTHQUAKE

The preliminary phase of the distant earthquake recorded at the Kilauea Observatory has a feebly registered beginning at 5 h., 37 m., 48 s. a. m. October 24, and confusion at the beginning suggests that there were two individual shocks at the origin, separted by a few minutes of time. The distance to the origin, doubtfully indicated, is 2,800 miles, and the time of the shock at that place approximately 5 h, 30 m. a. m. A report from Petersburg, Alaska, states that an earthquake occurred there at 6:51 a. m., which appears to check closely with the computed time and distance above, and broke windows at that place.

The long wave phase here was large, lasting more than an hour and a half. The records indicated a heavy shock, which if under the ocean would have caused a tidal wave. Warning was therefore issued, but no tidal wave occurred, as the epicenter was not under the ocean.

This earthquake was well recorded on the newly established seismograph in Hilo, and also on the instrument on the other side of the island in Kona. These three instruments agree in showing a waxing and waning in amplitude of the long wave phase, periodic in nature, approximately two and a half minutes in cycle; the effect persisting through several cycles. This perhaps has meaning if the shock was a double one, as it suggests interference between two wave trains of slightly differing periods, starting from the two separate shocks. R.M.W.

THE ULTRA-BASIC MAGMAS

A generalization of far reaching importance to volcanology is made by N. L. Bowen (American Journal of Science, August, 1927) to the effect that the porphyritic crystals in a basaltic lava, calcic feldspar and olivine, are virtually foreign to the liquid magma in which they occur, considered as a liquid melt. That is to say, all approach to ultra-basic chemical composition in porphyritic lavas, glassy rocks and fine grained dyke or sill rocks, resides in the effect of these phenocrysts on the analysis. The lavas of glass or fine-grained uniform crystalline material without phenocrysts, equivalent to the groundmass of the porphyries, never "remotely approach ultra-basic compositions."

The larger or more crowded the phenocrysts the more the approach to such extreme rocks as peridotites or anorthosites. When the crowding reaches the stage of a completely crystalline gabbro extremes of basicity may be attained never approached by effusives. Here the porphyritic and gabbroid rocks of Mull, for instance (see Volcano Letter No. 7, February 12, 1925), show feldspar phenocrysts four-fifths anorthite feldspar. Normal basaltic feldspar is only fifty per cent anorthite. Likewise normal basaltic olivine reaches only ten per cent of the rock. When an extreme type from Juan Fernandez analyzes 53 per cent normative olivine, it proves to be crowded with great porphyritic crystals of olivine, in a matrix of plagioclase and augite.

Bowen concludes that "the process of accumulation of crystals is not supplemented by significant re-solution of the accumulated crystals." He believes that ultra-basic liquids do not exist, corresponding in composition with the coarse granular or porphyritic rocks. Liquidity ceased with the crystallizing out of the porphyritic or coarse granular basic plagioclase and olivine. These represent chemical excesses incompatible with flowing liquids. "As the amount of accumulated crystals increases the mass becomes less capable of being poured out as a lava and to some extent of forming minor intrusives, and the extreme types occur only as a major intrusion." Only some pocket or part of a major intrusion can be the locus of accumulation of basic plagioclase crystals or olivine crystals.

Speaking of the feldspar, the following is Bowen's conception of how crystal accumulation starts and how it feeds the flow of porphyries. A rock that is "always porphyritic in its finer crystallizations" has no liquids corresponding to it in bulk composition. No matter how rapidly chilled and solidified, some of the feldspar remains as porphyritic crystals. These never were in solution in the matrix liquid that forms the groundmass. They were once in solution in some large mass of liquid of another composition, where they crystallized out and accumulated, presumably by a movement of crystals under the action of gravity either upward or downward. "No doubt other crystals were separating at the same time, but their motion differed either in magnitude or in direction."

"If the mass thus enriched in accumulated crystals is injected into surrounding rocks, or is poured out," it gives a basalt with porphyritic crystals. "If on the other hand it cools where it had its origin, or is moved elsewhere as a large mass, the continued outgrowth of crystal boundaries gives a gabbro" with porphyritic tendency lost or obscured.

The meaning of this for Hawaiian lava flows which show large porphyritic white feldspar crystals or green olivines, is that these minerals are lifted in a current of normal basaltic liquid from a region of partial crystallization deep underground. And that when the Kilauea lava lakes or the Mauna Loa fountains are fluid and splashing, if we could strain the molten glass through a metal screen, we would capture these crystals completely formed and probably not forming at all at the moment of capture. Both Kilauea and Vesuvius show included large lumps of granular crystalline olivine. These must be pieces of completed segregations of the excess basic matter of the deep major intrusion. All of this entirely agrees with the presence of crystalline olivine gabbro and porphyry so abundantly shown at the bottom of Halemaumau after the collapse of 1924. T.A.J.

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No. 149 RELEASED WITHOUT COPYRIGHT RESTRICTION November 3, 1927

KILAUEA REPORT No. 823

WEEK ENDING NOVEMBER 2, 1927
Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

Changes in Halemaumau have been slight. On October 29 in the early afternoon the pit was dry and sunny, and the rain of the previous night had not increased the visible steam. There were slight steam jets in the upper parts of the northern, western, and southern talus slopes. The north floor cone steamed a little and showed increase of yellow stain. The middle cone showed only once a slight vaporing. Some feeble rock sliding was heard towards the north. On October 31 dust from numerous northern avalanches was observed at the pit morning and afternoon. In rainy weather, which brings out the rock colors, at 2 p. m. November 2, the pit wall was very brilliant with red oxides in contrast to the blue black of the new lava floor. The central and northern cones were giving off vapor, and the vapor on the debris slopes was condensing. Some sliding was heard at the southwest. The walls show more iron oxide color at the bottom than at the top, and more of this red dust on the lower western wall than on the eastern.

The number of earthquakes registered on the seismographs at the Observatory during the week ending November 2, is 9. Seven of these were very feeble. One which occurred at 2:38 a. m. October 28 was recorded as feeble here, but was stronger in Kona, being felt there as an 8-second tremble with a rumbling noise. It was recorded on the Kealakekua seismograph, and also on the Hilo instruments, the combined records showing that the origin of the shock was about four miles east of Kailua, Kona, on the southwest slope of Hualalai. Another earthquake was 19 miles from the Observatory. Tilt during the week has accumulated slightly towards the SW.

CRATERS MADE BY METEORITES

A remarkable report from Russia ("Science" Oct. 14, 1927, p. 352) states that the Soviet Academy of Sciences "has discovered the resting place of a large meteorite, estimated to weigh nearly half a million tons, which fell in a remote district of Yenesei Province, Siberia, in the summer of 1908. The site of the fall occupies over a mile in diameter in almost inaccessible terrain in a marshy forest. The meteorite fell in pieces, so that the ground is pitted with deep funnels from 50 to 100 feet in diameter. The forest for over fifteen miles around the place was completely leveled and the fallen tree trunks scorched. The fall, nineteen years ago, was registered on the seismographs at Irkutsk, 900 miles away, and in the towns of Kirensk and Ilimsk, about 250 miles distant. T.A.J.

SILENT ZONES AROUND EXPLOSIONS

It has been known for many years that great volcanic eruptions are sometimes heard several hundred miles away, when at places near at hand almost nothing is heard. Dr. Omori mapped these phenomena as recorded at various distances from Asama Volcano, and discovered that there are zones of audibility and zones of silence at different distances. Experiments are now to be made in England by firing big guns and broadcasting the sound by radio ("Science" July 15, 1927, p. xiv). People at all distances who are equipped with radio receiving sets may hear the guns by radio and then several minutes later hear the actual sounds as they arrive through the air. Dr. Whipple, of the Kew Observatory, reports that at a place 80 miles from the guns he has heard the sounds about 11 minutes after the firing. He says that it is agreed that such long-range sound records are produced by a layer of the atmosphere some 25 miles or more above the earth's surface, where the temperature is relatively high, and the sound waves are refracted down to earth again. The so-called Heaviside layer is known to reflect radio waves from the upper atmosphere, and this sound effect may depend on something similar. Through such a layer a sound inaudible 20 miles away might by reflection and refraction be heard at a distance of a hundred miles. During the Pelee eruptions in Martinique of 1902, it was positively proved that explosions from the volcano unheard at Fort de France, 12 miles away, were heard at Barbadoes, 150 miles away directly to windward.

T.A.J.

A VIBRATION MICROPHONE

"Science" reports (July 15, 1927, p. xiv) that the Type H inertia microphone of the Bell Telephone Research Laboratories has been modified so as to record selectively minute vibrations of the walls of a safe, while refusing to pick up sound waves or such noises as are made by a heavy truck rumbling by the building. It is said that when this instrument is placed in a bank vault, it is unaffected by subway trains rumbling by, but is instantly affected by anything which touches the safe itself, however slight. The instrument is said to be small and compact, several may be placed at strategic points liable to burglarious contacts, and the slightest local disturbance summons the police.

It may be inquired whether this instrument would not be of great value in local seismometry so as to transmit, say from small drilled wells in the rock, the times of first vibration of earthquake at different places to a central station. T.A.J.

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No. 150 **RELEASED WITHOUT COPYRIGHT RESTRICTION** November 10, 1927

KILAUEA REPORT No. 824

WEEK ENDING NOVEMBER 9, 1927

Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

There has been little in the behavior of Halemaumau pit to justify the excessive spasmodic trembling of the seismographs. On November 5 in clear, dry weather, the pit was quiet with only small patches of visible vapor Slight sulphur stain has developed at a wet steam vent 200 feet up the south talus. In the afternoon there were slight slippings of debris at the south and north walls. On the 7th at 1:15 p. m. a considerable avalanche fell at the northeast. At the same place another sent up dust about 8:30 a. m. the 8th, the dust hanging over the pit for a quarter hour. Today, the 9th, there is new debris on the NE, N and SSW slides, and some dust has arisen at the north.

During the week the Observatory seismographs have recorded 68 very feeble local earthquakes, and one moderate distant earthquake. The number of local shocks is a definite increase over the general average for the past months. The numbers increased during the first days of the week, reaching a climax in frequency on the afternoon and early evening of November 5, this swarm then coming to a surprisingly abrupt halt at 9:40 p. m. On the 6th there was none recorded. The 7th and 8th together produced but six shocks, suggesting a return to the same general average as before.

The teleseism occurred in the early morning of November 4. The preliminary was recorded at 3:28 a. m., the ensuing phases suggesting a distance of 2,400 miles. The other instruments on this island, at Hilo and Kealakekua, also have good records of the shock. Before news of the earthquake was issued, a report came from Hilo that at 9 a. m. there was observed at the end of the breakwater a slight unusual rise and fall of water level. This may perhaps have been a small tidal wave resulting from the shock, though the tide gauge records have not yet been inspected. Press reports indicate that the shock was strongly felt in California, and that trains were delayed for an hour or so north of Santa Barbara

Tilt during the week has accumulated very slightly to the south.

ISOSTASY, EARTHQUAKES AND VOLCANOES

Referring to Omori's view that earthquake centers are not deeper than 27 kilometers below the surface of the earth, William Bowie writes (Isostasy in Geophysics and Geology, Journal of the Washington Academy of Sciences, March 4, 1927):

"The four major causes of earthquakes would seem to be (1) the breaking of crustal material caused by the weight of sediments, (2) the breaking of rock as the crustal material is pushed up under the area of erosion to restore the isostatic balance, (3) the breaking of the rocks as the result of the expansion of the crustal material under an area which had previously undergone heavy sedimentation, and (4) the breaking of rock caused by the contraction of crustal material under an area which had previously undergone erosion during an extended time.

"According to the Pratt theory of isostasy, the overflow of lava from a fissure or from a volcano is probably caused by an expansion of the crustal material below. No extra mass has been added to the prism of the crust involved. It is merely a case of fluid material from some depth within the crust being raised to the surface, increasing the volume of the prism and decreasing the density. Whatever processes cause the uplift of a mountain system undoubtedly cause the volcano and the lava overflow.

"It would seem that the earth is gradually losing heat as the result of erosion and sedimentation. As the eroded material is carried away, the prism of the crust beneath is forced up to restore the equilibrium. Erosion may have occurred to the extent of five or ten miles before an uplifted area is baseleveled. In such a case every element of the crust beneath would have been raised to a position approximately equal to that distance and would have been brought to a region having a much lower temperature than that of the region from which it came. Eventually there would be a loss of heat at the surface, and the material of the prism would be cooled down by 100° to 300° C., depending on how far the crustal material had been pushed up. That heat lost would not be compensated by heat gained in other places. The areas of heavy erosion later become synclinoria into which sediments are deposited. The sediments accentuate the synclinoria, resulting in a pushing down of crustal material into hotter regions. Eventually this material takes on the temperature of its new position, expands to form mountain systems or plateaus, and again loses heat at the surface. What maintains the heat of the earth no one knows. There have been many theories, including the one now advocated by many, that the disintegration of radioactive materials replaces heat in sufficient amounts to cause the surface of the earth to remain at a practically constant temperature. Be this as it may, we cannot escape the conclusion that the raising up of crustal material under areas of erosion brings hotter material to the surface with a consequent loss of heat.

"It is rather difficult to see how a volcano could come into being out in the middle of an ocean, but, in general, volcanoes are merely a part of a region that is higher than the surrounding bottoms of the ocean. The Hawaiian Islands, for instance, occupy a long stretch extending for some 1,200 kilometers, while the average width of the pedestal on which the islands rest is of the order of magnitude of 140 kilometers. There must have been light crustal material where the islands now are at the beginning of the sedimentary age, and the uplifts and subsidences of the Hawaiian area have been the result of erosion, sedimentation, and to a certain extent of the accumulation of rock from coral growth. It is very difficult to explain a chain of islands out in an ocean without assuming under it crustal material which has been lighter than normal density from the beginning of the sedimentary age."

The recent determinations of gravity on the Island of Hawaii by Major Bowie's associates have shown positive anomalies or excess densities everywhere on the island, anomalies growing greater at the summit of Kilauea than at shoreline, and still greater at the summits of Mauna Kea and Mauna Loa. Dr. Bowie points out that there is an outstanding average positive anomaly over the sea bottoms as shown by reductions of Dr. Meinesz's pendulum work in a submarine. The Island of Hawaii, then, shows gravity conditions similar to those of the great ocean bottoms. This does not quite agree with the above assumption of "crustal material lighter than normal density." It may be, however, that the Hawaiian ridge began with the piling up of light siliceous lavas, and is now subsiding with heavy gabbros crystallizing in its core. T.A.J.

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No. 151 RELEASED WITHOUT COPYRIGHT RESTRICTION November 17, 1927

KILAUEA REPORT No. 825

WEEK ENDING NOVEMBER 16, 1927
Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

The "blue black" of the new lava floor of Halemaumau, described on November 2, was obliterated under tan-colored dust about November 10. In the night between November 10 and 11 numerous earthquakes were registered, and at 2:40 p. m. of the last date rocks were sliding from the south wall, which was streaked with dust, and the lava floor of the pit was thickly coated with it, especially at the south. The northeast corner showed a new scar. A crack had widened at the east rim. At 2:50 a somewhat continuous slipping of stones occurred at the south, at 3:10 bowlders tumbled the full length of the south talus, and 10 minutes later there was more active sliding of fine and coarse material at the south. Much gray dust arose. The middle and north cone vents were steaming, and the southwest cone steamed in puffs.

At 11 a. m. November 13 the pit was quiet, but the floor dust was very thick under the southwest rift tunnels. A few stones were in motion at the south. The sulphur patches east were still yellow and not dust-covered. At 9:40 p. m. a noisy avalanche was heard, followed by a smaller one.

Today, the 16th, there was a little sliding south and northwest, but the conspicuous feature was the cracking of rim ground for fifty feet back at the south, with hanging edge blocks and freshly broken soil.

Evidences of increased local seismic activity continue. There have been 62 local earthquakes recorded during the week ending November 16, and one feeble teleseism. The local earthquakes were all very feeble with the exception of the one which was felt in Hilo at 6:10 a. m. on the 11th. This one was slight in Hilo, and even weaker at the volcano, being barely above the very feeble class at the latter place. It appears to have originated beneath the east flank of Mauna Loa. The shocks included in the above count show character in that they tend to come in swarms, and many are of the small spasmodic tremor type. One such swarm, five tremors within ten minutes, culminated in the earthquake just described. Another more marked swarm, between 1 a. m. and 1:50 a. m. November 16, includes 21 separate very- feeble earth quakes. The distant earthquake is too feebly recorded to indicate the epicentral distance; the preliminary phase apparently began at 10:07 p. m. on the 24th. Microseismic motion increased in strength during the 15th, and was still strong on the morning of the 16th. Tilt during the week has accumulated moderately to the northeast.

FALCON ISLAND

Press reports in England describe new heaping-up of the volcano Falcon Island in the Tonga group, about 30 kilometers north of Honga Hapai. The British warship "Laburnam" on October 8 describes the volcano erupting every 20 minutes, and forming an island 1,730 yards long N-S and 1,430 yards E-W. The crater is said to be 305 feet above sea level. The eruptions each last about one minute and consist of "columns of steam and lava." The sides have a gradual slope.

Falcon is like Bogoslof in its record of rising and being washed away repeatedly. It was a shoal in 1867, smoking 10 years later, erupting 11-13 October, 1885 along a northeast line two miles long, with great ejections of cinder and ash. The island formed was 150 to 300 feet high and over two miles long. In 1889 it had a cliff 150 feet high, in 1892 it was only 27 feet high, and in 1894 it was a mile and one-half long 20 to 50 feet high, and very hot in places, with a lake in the center four to five feet deep. In 1898 and 1900 it was only a shoal, and it was reported to have disappeared in 1913 (J. A. Thomson, N. Z. Journ. Sci. & Tech., Dec. 1926). T.A.J.

VIENNA EARTHQUAKE

The press reports a strong shock in Vienna at 8:49 p. m. October 8, upsetting old houses, stopping clocks, breaking chimneys, cutting off telephone and telegraph communication, stopping tramways, and starting panic in the theaters. An oil fire was started in a suburb. Village houses were damaged in lower Austria, and the people camped in the open.

An earthquake in a large city like Vienna always leads to thoughts of New York, and the following is of interest in this connection ("Gas Logic," published by the Consolidated Gas Company, New York, October, 1927, page 13):

"The nearest Manhattan ever came to the source of an earthquake was the tremor which shook Long Branch, New Jersey, on June 1, 1927. But it was the Charleston, South Carolina, quake of 1886 that destroyed New York's equilibrium. The upper west side of the Island was greatly affected ,especially in Harlem, where entire blocks of buildings shook to such an extent that mortar dropped from the brick walls, furniture rocked, and pictures fell from the walls." T.A.J.

THE ALASKA EARTHQUAKE OF OCTOBER 24, 1927

Seattle newspapers report that this earthquake was severe in Juneau and Sitka, with north and south movement at Juneau lasting 30 seconds and followed by three lesser shocks. Sitka reports two heavy shocks at 6:59 a. m. and five minutes later, respectively. The Sitka seismograph pens were flung to the southeast. Windows were broken at Petersburg. Telegraph cables were broken near Wrangell and between Juneau and Skagway. The epicenter is located on land in the basin of the Alsek River, about 100 kilometers east of Yakutat (Jesuit Seismological Association, Preliminary Bulletins). The various northwestern American seismographs were dismantled, and seismometrically the earthquake was very big. The two shocks check with interference phenomena shown by our record at Kilauea (Volcano Letter No. 148). Apparently heavy fault movements occurred from the Fairweather Range southeastward, and our expectation of a tidal wave would have been abundantly verified if the disturbance had been under the ocean a few miles to the west. T.A.J.

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No. 152 RELEASED WITHOUT COPYRIGHT RESTRICTION November 24, 1927

KILAUEA REPORT No. 826

WEEK ENDING NOVEMBER 23, 1927

Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

Halemaumau remains dormant and the spell of excessive seismicity has waned, probably following the fortnightly law (see Volcano Letter No. 143, September 22, 1927). Some noise has been heard and avalanche dust has been seen over the pit, but mostly it has been quiet.

On November 19 at 4:15 p. m. rocks were heard falling once or twice at the north, and fresh brown debris lay on the northeast talus. Recent rains had washed into puddles some of the floor dust which had discolored the lava. Much dust was seen blowing away in clouds at this time, for several days, at the west rim of Kilauea Crater, owing to strong northeast wind.

Today, the 23rd, a little steam is rising at the hole in the middle floor cone, and the northeast talus has fresh dark red fragments from a wall scar of the same color above. It is noteworthy that the cracks of 1924 at the road terminus now steam hardly at all.

The seismographs at the Observatory have recorded 33 very feeble local earthquakes and one teleseism during the week. On the 17th, at 5:02 a. m., and again at 5:50 a. m., there occurred prolonged tremors, lasting about 5 minutes in each case. At 3:55 p. m. on the 18th, and at 12:11 p. m. on the 19th, there were other similar tremors of several minutes duration. These seem to suggest disturbances due to avalanches rather than harmonic tremor. The distant earthquake was very feebly recorded, its long wave phase beginning at about 8:45 p. m. November 18. No estimation as to distance could be made. Microseismic motion was strong on the 16th and 17th, but diminished to normal amplitude during the following days. Tilt has accumulated moderately to the NNE during the week.

GASES OF MT. PELE'E IN MARTINIQUE

Thorough chemical analysis of five specimens (Gases of the Mt. Pele'e Lavas of 1902, by E. S. Shepherd and H. E Merwin, Journal of Geology, February-March 1927) representing the old and new lava of Mt. Pele'e for the great eruption of 1902, which destroyed St. Pierre, reveals remarkable uniformity of siliceous hypersthene andesite, with free silica in the form of tridymite in the groundmass. The analyses show almost no change of composition as between the old peak and the fresh lava of 1902. The glassy forms of the rock contain more gas than the crystalline ones. Silica averages 63 per cent, and the normative quartz 21 per cent. It was found that the determination of water from rock powder gave excessive values as compared with melting chips in vacuo. The powder takes up water.

The total volatile constituents amount usually to from 5 to 7 Cc. per Gm. of rock, one exceptional glassy shell of a bread-crust bomb giving 26 Cc. per Gm. Water vapor averages about 80 per cent of the total gas volume at 1,200° C., and carbon dioxide 9 per cent. Chlorine is 0.6 per cent, fluorine 2 per cent by volume, large because of its small atomic weight, though amounting to only 0.005 per cent of the weight of the rock. Sulphur and carbon monoxide are about 1 per cent each, and hydrogen about 0.3 per cent. Hydrogen is notably more abundant in the glassy specimens. Water is at a maximum in the glassy shell of the bomb (96 per cent). At 1,000° C. each cubic meter of issuing lava has 50 cubic meters of gas, or a minimum partial pressure of 50 atmospheres. Even the pumice contains nearly 7 Cc. of gas to the Gm., showing that it had not yet parted with all its volatile constituents.

The excessive gas in the shell of the bread-crust bomb reverses Lacroix's explanation for the cracked crust. He thought the shell cooled suddenly, expelled its gases, and so produced shrinkage cracks. Shepherd and Merwin explain the bread-crust as having cooled before vesiculation gets under way, so as to imprison the gases. The more slowly cooling interior allows vesicles to go on forming with a swelling which cracks the shell. This gas evolution in large blocks may continue for days and reduce them to piles of detritus. Crystallization throughout the mass may liberate heat and so maintain the vesiculation temperature. Such a rock would be instable if suddenly erupted into a region of low pressure.

"The conditions under which bread-crusting can occur are very limited. Possibly a temperature change of 100° or less determines whether a bomb shall develop a bread-crust surface, or completely expand to pumice."

The fluid mobility of a glass is much greater when it contains gases, and gas-charged glass will flow at about 900° C, whereas the hardened threads left after frothing require 1,250° C. to melt them.

"It will be noted that the relationships between temperature, viscosity, volatile content, and gas pressure in relation to the magma, are complex. Increased concentration of volatiles implies a reduction in viscosity accompanied by an increased pressure if the temperature remains constant. Increase of temperature implies rise in pressure and decreased viscosity, and vice versa. A crystallizing rock, by concentrating volatiles in the mother-liquor, raises the pressure and lowers the viscosity, with, however, two opposing forces: the increase in viscosity due to lowering temperature and in some cases increased silica content of the mother-liquor." The increase of silica increases viscosity unless the glass is at the same time enriched in gases.

The authors explain the down-rushing ash clouds of Pele'e as having at least 70 cubic meters of gas at a pressure of 50 atmospheres at 1,200° C. for each cubic meter of lava. The gas was chiefly steam. The heavy rumbling explosions accompanied a forceful ejection laterally of a momentarily glowing mass of lava from the wall-crack where the lava dome made contact with rock substratum. This emulsion "was possessed of ample energy to keep it well stirred and prevent its coming to rest until the gas evolution had quieted down by cooling." The internal partial pressures of the volatiles in the glass are estimated at over 100 atmospheres where they lifted the heavy spine that rose continuously in the Pele'e dome.

"For its explosive impetus each eruption depended upon the available mobile vesiculated lava and carried with it material less vesiculated which supplied energy gradually to the cloud after it detached itself from the peak." This shows the importance of preliminary vesiculation to produce the phenomena of eruption. T. A. J.

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No. 153 RELEASED WITHOUT COPYRIGHT RESTRICTION December 1, 1927

KILAUEA REPORT No. 827

WEEK ENDING NOVEMBER 30, 1927

Section of Volcanology, U. S. Geological Survey:

T. A. Jaggar, Volcanologist in Charge

Halemaumau pit remains quiet. Visits to the pit November 27 and 30 in the forenoons showed that rain produces visible vapor from the rock walls in places and great increase of visibility of floor vapor. There have been little slides making dust from time to time, chiefly from the northern walls.

During the week the seismographs recorded 20 very feeble local earthquakes.

Tilt during the first part of the week accumulated moderately to the SSE, but partly recovered this motion on the 28th and 29th, so that the net accumulation for the week is only slightly to the SSE.

KODIAK STATION REPORT

October 31, 1927

The first shocks recorded on the seismograph installed in Kodiak, Alaska, last summer, were mentioned in Volcano Letter No. 147, October 20, 1927. The instrument was started August 8, and there were four earthquakes recorded during the remainder of the month. In September, there was but one very feeble shock recorded. Microseismic motion is usually slight, but occasionally increases in intensity over a period of one or two days. Thus September 2, 17 and 23 were days which show records of strong microseismic motion, perhaps caused by wind or stormy weather.

October was a more active month. There were 11 local earthquakes recorded, and an excellent record was obtained of the big earthquake which occurred in southeastern Alaska on the 24th. The local shocks were perhaps too small to be perceptible, though the ones which came at 1 a. m. on the 23rd and at 11:50 p. m. on the 31st may have been felt. These earthquakes appear to have taken place 28 miles and 22 miles, respectively, from Kodiak. Some of the others showed distances of 30, 37, and 101 miles to the epicenter. During the month there were three periods of increased microseismic motion, perhaps caused by stormy weather. These came on October 9, 14 and 27.

The earthquake of October 24 recorded its preliminary wave at 6:01:44 a. m. Kodiak time (16:01:44 Greenwich Civil Time). The secondary wave came at 6:03:12, the long wave began at about 6:03:41, and the maximum motion was at 6:07:30. The resulting indicated distance is 510 miles from Kodiak to the epicenter, which is in good agreement with the scaled distance to the origin as now known. The indicated time at origin of the shock is 5:59:56, which also is in very good agreement with the time determined by the various other observatories. Details of this earthquake have been mentioned in Volcano Letters Nos. 148 and 151. R.M.W.

LASSEN REPORT No. 12

Mineral, California, November 18, 1927

R. H. Finch, Associate Volcanologist

A wireless set for time service was installed in June at the Lassen Station, through the good offices of Charles A. Huff of San Francisco. During the summer months many tourists visited the observatory. Mr. Finch worked on construction of a portable seismograph for installation eventually near Lassen Peak. The National Park road to the peak is advancing rapidly. Messrs. C. A. Anderson and Howell Williams, graduate students in geology from the University of California, were among the visitors to the laboratory, and Mr. Williams spent three weeks at work in the district, studying the petrography and mapping Chaos Crags and Chaos Jumbles near Viola. Mr. Austin E. Jones on July 9 became temporary assistant and seismological observer, remaining until the end of August .

During July and August explorations were made and photographs taken by Messrs. Finch and Jones at Lassen summit, Brokeoff Mountain, Magee and Prospect Peaks. Notes were made on faults and fresh-looking lava flows, having in view the mapping of several of the latter. It looks as though there had been one or more lava flows per century in the Lassen country for many hundred years past. Measurements were made of temperatures of hot springs at Supans, Bumpass Hell, Morgan's, and in the Upper Warner valley. Mr. Jones made preliminary tests of the age of the Cinder Cone lava flows by magnetic methods (see Volcano Letter No. 144, September 29, 1927).

It is planned to equip the observatory at Mineral with a new two-component Hawaiian seismograph uniform in mechanism and constants with the instruments at Hilo and Kodiak, and to make the present Lassen seismograph, built by Mr. Finch, an exhibition instrument in the Loomis Memorial Museum at Manzanita Lake.

Among the activities of the Lassen Volcano Observatory is weather recording, a matter of considerable importance in relation to hot spring work, seismology, and on account of the excessive snow falls of winter. The U. S. Weather Bureau has kindly furnished the equipment of a regular cooperative observing station; maximum and minimum thermometers, and a rain gauge. The road between Mineral and Red Bluff was kept open in 1926-27, excepting for two weeks in February. The inner roads were blocked with snow between mid-January and April 25, sometimes five feet deep. This winter marked the opening of Mineral as a place for winter sports, the Sunday afternoons showing 50 or 60 cars parked by the store, whither people from the valley came for snowshoeing, sledding, tobogganing, etc.

The Lassen seismographs gave very large records of the Alaskan earthquake of October 24, 1927, as well as the one off the coast of California on November 4. The needles of each component went clear off the sheet during the two earthquakes. The Omori tables seem to work for California earthquakes as the distance indicated from the Mineral seismographs agreed with the records from Berkeley and Santa Clara. The depth of the California shake appears greater than the average for this region.

On October 20, 1927, three sharp local shocks occurred. The first was the strongest and made windows rattle and buildings creak within a range of 15 miles from the peak. All shakes were preceded and accompanied by rumbles. These shakes occurred distinctly before fall rains had set in. The earthquakes mentioned in first Lassen report occurred on October 13, 1926, after there had been some heavy rains, only a few days before the shaking. There is a saying current here that with a wet fall there are many earthquakes and with a dry fall but few. The saying may be founded more on fancy than on fact.

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No. 154 RELEASED WITHOUT COPYRIGHT RESTRICTION December 8, 1927

KILAUEA REPORT No. 828

WEEK ENDING DECEMBER 7, 1927

Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

Two visits to Halemaumau show little change over last week. No avalanches have been noted, and only a few slides have occurred. One small slide was observed at 11:40 a. m. December 6 at the lower part of the northeast wall. The north wall has a few new scars. At 10 a. m. December 7 the pit was quiet, wet from the recent rains, and full of color. Steam vents were very active, particularly at the center cone.

The week ending December 7 is of considerable seismological interest. The instruments recorded 98 local earthquakes during the week, of which two were slight but perceptible, the rest being very feeble. This unusually large number is due to a series of small shocks of the spasmodic tremor type, beginning at 5:58 a. m. on December 3, increasing in numbers on that day to a maximum frequency at about 6:30 p. m. At this time they were occurring at fairly regular intervals, on an average of six minutes apart. They then became less frequent, but the series persisted during all of the next day, coming to an end at 2:27 a. m., December 5. These spasmodic tremors were on the whole very similar to one another in character, intensity and individual duration, though toward the end of the series their intensity was somewhat diminished. The total number of tremors counted in the series was 76, of which 47 came on December 3. This is the greatest number for any one day since the tremendous numbers which occurred during the Mauna Loa eruption in April, 1926. Treated as earthquakes, some of them displayed a preliminary phase from which distance could be estimated. From the average of these it would appear that the disturbance was about 18 miles from the Observatory. Phenomena of this type are distinctly of volcanic origin. Careful attention was therefore paid to Mauna Loa and Kilauea, for other possible symptoms of outbreak. No other signs of activity were observed, however. The fact that harmonic tremor, which comes hand in hand with eruption of lava, was totally absent from the records, served to diminish the idea of immediate activity. The suggested crisis is apapparently past, as the instruments are now recording nothing unusual. The occurrence of such phenomena, however, is sure evidence of volcanic life within the mountains of Mauna Loa and Kilauea, which in time may be expected to display itself at the surface.

The two earthquakes that were of slight intensity, and were perceptible, came at 10:09 a. m. December 1, and 7:37 a. m. December 6. The first of these was reported felt both in Hilo and at the volcano. It was well recorded on the seismographs at these places, and a very feeble record was made on the instrument in Kona. These records combine to indicate that the origin was near the Puna rift line ,about 12 miles east of the volcano. The second slight shock was apparently local to the volcano, as the motion broke abruptly into maximum amplitude, without appreciable preliminary phase. It was felt by a number of persons in this vicinity, and was accompanied by a rumbling noise. It was followed four minutes later by a very feeble after-shock.

Microseismic motion has been normal during the week, and tilt has accumulated moderately to the NNW.

HILO STATION REPORT

A description of the Hilo seismographic installation appears in Volcano Letter No. 142, September 15, 1927. The instruments are of the same type as those installed at Kodiak, Alaska. The more important recordings of the Hilo station have been mentioned from time to time in the Volcano Letter, when they have had a bearing on the data obtained at the Hawaiian Volcano Observatory. The Hilo station is about 23 miles in air line distance from the Observatory, so that in general the stronger local shocks are recorded at both stations. This is a convenient arrangement, since by plotting indicated distances it is possible to determine the point of origin of many of the local earthquakes. The plotted distance from the Kona station aids in such determinations. This is a well known method, and has been used for a number of years here. The new installation at Hilo is somewhat more sensitive than the old instrument, making possible the plotting of more of the feeble shocks.

During the month of October, 1927, there were recorded at Hilo 13 local shocks and one teleseism. The recording of the distant earthquake (October 24) has already been described in Volcano Letter No. 148, October 27, 1927. None of the local earthquakes was reported as perceptible there ,and they were with one possible exception of the very feeble class. Of the 13, nine were recorded at the Observatory also. There was strong microseismic motion on the 17th and 18th.

The November records show 12 local earthquakes, 10 being very feeble. The other two were slight, but were perceptible in Hilo, and occurred at 6:12 a. m. November 11, and at 9:13 p. m. on the 21st. There were nine of the 12 recorded also at the Observatory. In addition to the local earthquakes, there were three teleseisms recorded, one at 3:35 a. m. November 4, which has already been mentioned, another very feeble trace is shown at about 9 p. m. on the 17th, and the third was a slight but definite record of long waves at 8:48 a. m. on November 18.

The Hilo records are exceptioanlly free from such bothersome disturbances as diurnal tilt, traffic movements, or pen displacements due to room or instrument temperature changes. The massive construction of the concrete walls and roof of the seismograph cellar, combined with the fact that the structure is set deep into the ground and is in a location shaded by trees, is perhaps responsible for the small temperature range within the instrument room. The situation is distant from any highway, and local external disturbances are infrequent.

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No. 155 RELEASED WITHOUT COPYRIGHT RESTRICTION December 15, 1927

KILAUEA REPORT No. 829

WEEK ENDING DECEMBER 14, 1927

Section of Volcanology, U. S. Geological Survey:

T. A. Jaggar, Volcanologist in Charge

At Halemaumau on December 10, at 2 p. m., one small slide of rock was heard. A slide was heard from Uwekahuna December 13 at 3:55 p. m. Today, December 14, about noon small rockfalls occurred every 5 or 10 minutes at the northeast, north and south walls. The air was perfectly still, and no other noise, such as hissing, was heard. Recent avalanches have scarred the walls all the way to the upper edge NW, NE and SW. The heavy rains now wet the entire north sill, which was formerly so hot that it resisted soaking. There are, however, large dry patches at the top of its east end, in the wall above that point, and on the north side of the west boss.

The total number of earthquakes registered on the seismographs at the Observatory during the week ending December 14 was 21. These were all very feeble at this place. One at 4:13 a. m. on the 10th had an indicated distance of 37 miles, and was reported as perceptible in Hilo.

LASSEN REPORT No. 13

Mineral, California, November 25, 1927

R. H. Finch, Associate Volcanologist

Between 9 and 11 p. m. November 24, nine local earthquakes were recorded on the Mineral seismographs. Three were perceptiple. The perceptible quakes and some of the unfelt ones were accompanied by deep rumbling noises. The occurrences of single earthquakes seem to be well distributed throughout the year, while the earthquake "swarms" appear to be confined to the winter months. It will be interesting to watch in the coming years to see if this relation continues.

CENTRAL OREGON VENTS

Dr. E. T. Hodge, investigating fossil forests in the volcanic strata of central Oregon (New York "Times," October 2, 1927), doubts the evidence reported in the nineteenth century by Russell that the lava welled from fissures, and says that "with the exception of one place in the eastern John Day country, he has not found any of the postulated fissures." Instead of this, the lava welled from craters, and in some instances the flow virtually buried these craters, erosion removing further evidence. He pointed to the many craters in the Deschutes country as proof of the crater theory. T.A.J.

ERUPTION OF SOLFATARA

The report in the newspapers (Seismological Despatches, Georgetown University) dated at Pozzuoli, Italy, August 1, 1927, is extraordinary if true. It states "in sympathy with Vesuvius, the volcano known as the Solfatara today resumed violent activity for the first time recorded since the year 1198. It hurled skyward from the center of its semi-extinct crater quantities of blazing hot, but dry, sand." T.A.J.

THE PALESTINE EARTHQUAKE

A very serious earthquake in the Holy Land occurred just at the time when Kilauea was last in action. The "Richmond River Express" of September 16 (Richmond, Australia), cites a letter giving details. The writer, Mrs. Drayton, had been having her house newly decorated; "we had just finished putting up a bed, when there was a most terrific noise like hundreds of tube trains approaching at once. The house commenced to rock, and I was thrown over against the wall—gazing upwards. Saw the ceiling at an angle of about 45 degrees. The plaster began to fall. We bolted for the children, fled from the house, and stood in the road.

"When we eventually crept gingerly back again we discovered that we had not one whole wall or ceiling, and all our six weeks decoration had gone for nothing in 10 seconds—less than 24 hours after the work had been completed. It was a very upsetting experience. I am quite certain that I had never before felt real fear—air raids in London and submarines left me cold compared to this. The casualties are 200-odd killed and 385 seriously injured, and about 100 minor injuries in Palestine. Then 68 killed in Trans-Jordania, and about 500 injured.

"Nablus suffered very heavily. Government House, on the Mount of Olives, was damaged to the extent of £50,000. Lord Plumer was on leave, and if he had been here would probably have been killed.

"We had another less severe shock on the following Sunday, the 17th, and several minor tremors. Although the loss of life was not very severe in Jerusalem, the damage to property was considerable, the houses of three senior British officials fell down and others have been condemned. In the Bennetts' house, on the opposite corner to ours, the cistern burst and the place was flooded, they being away on leave." T.A.J.

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No. 156 RELEASED WITHOUT COPYRIGHT RESTRICTION December 22, 1927

KILAUEA REPORT No. 830

WEEK ENDING DECEMBER 21, 1927

Section of Volcanology, U. S. Geological Survey:

T. A. Jaggar, Volcanologist in Charge

At Halemaumau pit December 12 at 2 p. m. there was nothing new in evidence, no slides were heard and the slopes appeared undisturbed after excessive recent rain.

During the week there were 37 local earthquakes recorded on the Observatory seismographs. All of these were very feeble with the exception of one which occurred at 3:37 p. m. on the 18th. This one was feeble, but was felt locally; the origin of the shock was apparently within two miles of the Observatory. Two earthquakes were felt in Hilo on the 15th, one at 2:07 a. m., the second and stronger one being at 6:01 p. m. Distances indicate that these shocks originated on the northeast rift of Mauna Loa.

Tilt has accumulated during the week moderately toward the NE.

A WHEELED BOAT FOR VOLCANO EXPLORATION

Aleutian Island explorations in 1907 led the writer to wish for a wheeled boat that would beach itself. The father to the wish was the experience in a schooner of nearly landing at Vsevidof Volcano, finding no anchorage, and being forced to go to sea. In 1927 he tried a low-geared small motor car with balloon tires on tundra and beach of the Alaskan Peninsula. Traveling was practicable, but inlets, rivers, and rocky stretches were obstacles. Again the beach boat became desirable, a boat motor-car that would launch itself, and resume land travel along favorable beaches. The beaches in many volcano lands are nearly continuous, and the shore line is a natural highway. Where storms and fogs are frequent, life at a shore camp, with gasoline power, electric lights, electric or gasoline heating, and tent extension of the vehicle, is more flexible than in a boat cabin restricted to safe anchorages, which are few and far between.

Numerous patents have been obtained for amphibious boats, and the Mobile-boat of Powell in Chicago is to be tried out next summer in Alaska. This is a Ford truck chassis with steel boat body and twin screws. At the observatory shop at Kilauea, we have converted the Alaskan motor car of 1927 into a car-skiff for experiments in traveling along the shores of Hawaii and camping on the beaches. The principles of the new beach boat differ from that of Powell: a 16-foot flat-bottomed skiff by Kneass of San Francisco has a Ruckstell-Ford car chassis of 1926 mounted on oak timbers inside, and a Smith "Formatruck" chain drive rear axle has been adapted to support a stern extension of the skiff on double springs, using the Ford wheels. The Ford front axle and steering-gear are adapted to the bow of the boat. We thus get a substantial lorrie with a skiff body.

For the water drive, the counter-shaft holding the front chain sprocket of the driving mechanism carries two light steel paddle wheels 24 inches in diameter expected to be about one-third immersed. These paddles are removed and carried inboard during land traverses. The balloon-tired land wheels will be largely submerged when the boat is in the water, the rear ones continuing to revolve. The land wheels necessarily cut down the speed in water, but act somewhat as low ballast, and the disc surfaces oppose lateral leeway. The disc front wheels act as rudders in the water with the same steering wheel as on land. By jacking up the boat in shallow water, removal of 10 bolts aft and five forward, sets free all the running gear, which may be left on the beach or stored inboard for a long water run at higher speed than otherwise.

Tests of the boat-car on land have been satisfactory, and the water test will be made in a few days. There remain the various adaptations to sounding, camping, cooking, protection against the weather, winch, stake, and cable contrivances for hauling the car over steep or rough land, and tests of caterpillar chain treads, mud hooks and the like for driving through soft ground. All of this work, under the Hawaiian Volcano Research Association, is in sequence upon a long series of experiments in driving over desert and lava whereby cross-country cars have been used for many years at the Observatory. Much of this work was necessitated by the requirements of drilling for temperature measurements. Heavy drill rigs of three different types have been hauled, and 34 bore-holes have been made, mostly on the lava floor of Kilauea Crater.

It is planned to do practical work in exploring the Kona coast with the beach-boat. There is great volcanologic interest in sounding and dredging at Hoopuloa and Alika where the recent Mauna Loa flows entered the sea, and it is reported that the U. S. Coast and Geodetic Survey is about to begin operation with the U. S. S. "Guide" mapping in detail the west Hawaii harbors. The best of these is Kealakekua, where in 1876 there was submarine eruption, and pumice was reported to float up hot. Dredging would be of interest here. Echo and wire sounding admit of important experimental work in volcanology, with a view bottom such as the Alika flow, what is the character and density of the underwater rock, and how can it be diagnosed by sounding apparatus as different from the sea-bottom round about? If by noise, or feel, or sampling such a flow can be outlined, an important scientific advance can be made. For where are there other such submarine lava flows? They may be found off the Puna and Kau coasts. There have been many occasions when the sudden drainage of lava from Halemaumau pit led to suspicion of submarine quiet flow. Here is where it behooves volcanology to join hands with oceanography.

The first Kona expedition will be directed to exploring and collecting the Hualalai and Mauna Loa lavas of North Kona where the many flows have entered the sea. For this country now the Geological Survey has admirable topographic maps, and there are numerous beaches here and there to serve as landing places for making camps. The 1859 flow built out much new land and its lower fields have never been explored geologically. T.A.J.

The "Palestine Earthquake" described last week occurred July 11, 1927, at 1:10 p. m. Greenwich time (3:10 p. m. Palestine).

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No. 157 RELEASED WITHOUT COPYRIGHT RESTRICTION December 29, 1927

KILAUEA REPORT NO. 831

WEEK ENDING DECEMBER 28, 1927

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

After a week of excessive rainfall, wherein Halemaumau pit has been continuously full of vapor, the scene from the edge today, December 28, at 3:15 p. m., was of a faintly visible cauldron with hundreds of vapor jets on the bottom blown from the west, and many others on the walls. Avalanches were almost continuous, several moderately strong ones occurring within a 15-minute stay. They were mostly from the northern walls, but occasionally rocks fell at the south. The bottom did not appear changed in configuration, and the rock sliding was probably due to undermining occasioned by the excessive washing-out of the finer material.

During December to date rainfall has amounted to 42 inches at the Observatory, and the daily rainfall, beginning December 21, was 1.85, 3.00, 0.95, 2.00, 7.80, 4.50, and 7.45 inches. This was one of the heavy winter "Kona" storms from the southwest.

The Observatory seismographs have recorded 30 local earthquakes during the week. These were all very feeble with the exception of one, classed as feeble, which occurred at 8:57 a. m. December 21; its origin was about 14 miles from the Observatory. It has not been reported as perceptible. In addition to these local shocks, there was a period of definite though very feeble continuous tremor, beginning at 1:38 p.m. December 21 and lasting 25 minutes. A teleseism was recorded on the 28th, the preliminary wave beginning at 7:59:12 a. m. Other phases indicate the distance to the origin to be 3,440 miles. The time at origin, in Greenwich Civil Time, resulting from this data, would be December 28, 18:20:10.

Microseismic motion showed increase on the 25th, reaching its maximum amplitude on the 27th, although on that day the wind had moderated locally. Tilt has shown a strong spurt toward the SSE, the accumulation for the week being approximately 3.0 seconds of arc in that direction.

MUD RAIN DROPS FROM BRISBANE

Richards and Bryan describe (Proc. Roy. Soc. Queensland XXXIX No. 5, 1927, 54-60, 2 plates) lithified tuff or ancient volcanic ash containing "mud balls." The Brisbane turf is Upper Triassic, unconformable above schist. The base of the section is an agglomerate with schist and rhyolite fragments. The tuff is well known about the city of Brisbane, but the pisolites are found only at Castra, 12 miles away. Portions of the tuff are believed to be water-laid, for it is underlain by fresh water lacustrine sediments and grades above into shales. The pisolitic ash described and figured is in all respects exactly like the modern hardened mud raindrops that accompany such explosive eruptions as those of Kilauea in 1790 and 1924, or Vesuvius in 1906. It is of great interest to find it in ancient fossilized form in hard rock.

The Brisbane pellets are compared with marbles or beads. The largest are 25-30 mm. diameter, and these are abnormal. (Compare Bull. Haw'n Volc. Obs'y June, 1921, Fig. 21 and p. 102.) The balls occur scattered in the lower and middle portion of the Castra section, crowding certain layers. (Compare 1790 ash with [illegible] nts, Kilauea, Bull. Haw'n Volc. Obs'y, July, 1921, Fig. 22 and p. 114.) Most of the Brisbane spheroids were 6-9 mm. diameter, some are flattened and egg-shaped, internally they are concentric layered, the skin is often discolored and harder than the rest, and the grain is finer than the matrix tuff. (Compare "Kilauea pisolites," Fig. 2, F. A. Perret, "Some Kilauean Ejectamenta," Amer. Jour. Sci. Art. LII, June, 1913, p. 612.)

The authors find parallels to the Australian mud-balls in the ejecta of Taal Volcano, 1911, and the mud-drops of Pelee in Martinique, 1902. These comparisons are entirely justified, and it may be said that all "cauliflower cloud" eruptions of recent observation have produced mud rains when the atmospheric condensation accompanied dense floury ash accumulation in the rain clouds. The condition for preserving layers of pisolites is when stiff mud-drops fall in light dry dust beds of previous eruption, and it is possible that the baking the dust has been subjected to, accounts for its cement-like quality in rapid hardening. The pisolitic ash of 1790 at Kilauea, where the footprints were hardened, was a mud when the footprints were made, and its upper surface crusted to preserve the footprints like a weak cement.

The presence of pisolites is a sure proof of direct subaerial ash fall, and each layer usually means a separate mud-rain shower. Such mud rains may occur many miles away from the volcano. T.A.J.

HEAT BY LAVA CIRCULATION

After discussing gas-heating and gas-fluxing, which he believes to be reasonable, but perhaps unnecessary, Shepherd (Section of Volcanology, 1927, Bull. Nat. Res. Counc. No. 61, p. 262, Washington, D. C.) suggests that these hypotheses were invented to explain an undrained lava lake, a closed system. If we assume the Kilauea lava lake to be a bubbling spring with many subterranean outlets, not from one magma chamber, but from numerous roots, he believes that the required heat could easily be supplied by "the rise of a few cubic meters of lava per second with only a two-hundred degree drop in temperature." The basaltic roots go to considerable depths, the acid volcanoes taking their origin among the more superficial roots.

In this connection a quotation from Tempest Anderson (Volcano Matavanu in Savaii, Quart. Jour. Geol. Soc. LXVI, 1910, London, p. 637) is relevant: "Matavanu is certainly a (lava) river. Kilauea may be a river, but is more probably a boiling pot. Does the lava of Kilauea at the times when the lake empties itslf periodically, say once in five years, also discharge itself into the sea?" T.A.J.

ERRATUM

In Volcano Letter No. 156, fifth paragraph of the article, fifth sentence should read: "Echo and wire sounding admit of important experimental work in volcanology, with a view to identifying a lava-flow bottom. Taking a known basalt bottom such as the Alika flow," etc.

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No. 158 RELEASED WITHOUT COPYRIGHT RESTRICTION January 5, 1928

KILAUEA REPORT No. 832

WEEK ENDING JANUARY 4, 1928

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

The week following the storm of the solstice season has been characterized at Halemaumau pit by many avalanches, tremors, and strong WSW tilting. Recorded avalanches were at 8:15 and 10 a. m. December 29, 10:02 a. m. December 31, and just after 9 p. m. January 2 and preceded by felt jarring. Dust rising over the pit was repeatedly seen, and several people reported avalanche roaring.

Measurements about 3 p. m. December 29, at 15 places along large cracks close to the east edge of the pit, showed that the cracks had widened two to four inches during December. All the talus slopes show fresh debris, and the falls of rock are particularly conspicuous along two vertical solfataric zones at the east and west ends of the big northeast sill. These appear to be ancient wall cracks where the pit wall shows a U-shaped cross-section of an ancient pit. The lava floor shows no changes other than fresh overlapping of extending talus debris, notably at the northwest.

There were 84 earthquakes registered during the week. One at 9:56 p. m on December 30 was feeble; it has not been reported as felt. All the others were very feeble. On January 1 at 8:04 a. m. a tremor almost large enough to be classed as feeble was recorded, and at the same time a heavy avalanche was noted in the pit. Another heavy avalanche followed a few minutes later, but its recorded tremor was not nearly so pronounced.

Microseisms continue moderately strong.

NEW ZEALAND-TONGA VOLCANOES

A suboceanic ridge connects New Zealand and Tonga, and east of this is a narrow, almost linear, trough in the ocean bottom over 4,000 fathoms deep in two places (Volcanoes of the New Zealand-Tonga Volcanic Zone, by J. Allan Thomson, New Zealand Journal of Science and Technology, December, 1926, p. 354-371). West of the Kermadec Islands the submerged region descends gradually to depths of over 2,000 fathoms. The Tongan Plateau bears the inhabited islands of Tonga on its eastern higher side, composed of submarine tuffs and coral limestone. On its westward lower side there are small volcanic islets and submarine volcanoes. Similarly in New Zealand there are sedimentary rocks in the northeastern part of the country forming a raised mountain axis, while in a relatively depressed belt, next to the west, lie the volcanoes. In the Kermadecs the volcanoes lie close to the edge of the ocean trough, but there are granite fragments in the tuffs there of continental origin.

The volcanoes from Ruapehu in New Zealand to Fanua Lai in Tonga lie in a northeastward-trending straight line parallel to the ocean deep east of them. Farther north the lines of both plateau and trough swing to the northwest toward the discontinuous platforms which support the Ellice, Gilbert, and Marshall groups of islands. The active volcano line also bends, ending with Niuafou.

Andesitic lavas and ashes dominate throughout the entire chain of old and new volcanoes, only the Kermadec Islands and Niuafou showing basalt in addition. This andesitic composition and the linear arrangement make the whole system one volcanic group.

To the east of this group all the Pacific islands consist only of basalts and their derivatives characteristic of the Pacific basin proper, while to the westward, as the active volcanoes are mainly andesitic, the New Zealand-Tonga line is believed to be marginal to the Pacific, particularly as many of the islands are partly composed of continental plutonic, and sedimentary rocks.

"There are at present two competing theories as to the origin of andesitic magmas. Daly, who believes that a universal layer of basaltic composition everywhere underlies other rocks, considers that andesite is best regarded as a direct derivative of common basalt by the removal through sinking of the heavier constituents in a column of slowly cooling liquid basalt. Hobbs, on the other hand, considers that andesites are formed by the simple melting of shales under up-folding arcs of the crust owing to the relief of pressure caused by the arching." After pointing out some objections to both these theories, Thomson concludes: "Probably a combination of Hobb's theory with Daly's theory of a universal underlying layer of basalt comes nearer the truth. Under the up-rising arcs there is a melting both of shales and other continental rocks and of basalt and an admixture, resulting in an andesitic magma. Within the Pacific basin proper, where the basalt layer forms the surface of the crust, a remelting forms only a basalt magma, from which trachytes and alkaline rocks are formed in small amounts by differentiation."

Dr. Thomson's paper is in the main a record of eruptions of this whole line of active volcanoes Forty explosive outbreaks are recorded since the beginning of the 19th century, the only records of lava flows being those of Ngauruhoe of 1869 and 1881, both of which are disputed. However, all the larger cones show lava flows in section. "Either flows are relatively so infrequent that nearly a century can pass without one, or there has been latterly a change in the mode of eruption by which the lava has become more explosive." This all sounds very much like the eruptive history of Lassen Volcano and the Aleutian and Japanese cones ,and as the list of Tongan outbreaks is admittedly incomplete, it is probable here as elsewhere that many of the lava flows are from the lowest vents and consequently submarine.

This accents the importance of what has become increasingly evident at the Hawaiian Volcano Observatory, namely, to devise geophysical methods for studying movements of magma underground. This means investigation of tilt, tremor, magnetism,gravity, horizontal and vertical shift of benchmarks, and changes of solfataric chemistry. A combination of these processes, rapidly at times of explosive crisis, and slowly at other times, is what must form the basis for diagnostic measurement in volcanology. Intrusion is the greatest volcanologic process; it is in action today, and this fact is insufficiently realized by geologists. There is no field more hopeful for development of precise methods along these lines than the volcanic districts of New Zealand, where a new volcanologic service has been inaugurated. T.A.J.

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No. 159 **RELEASED WITHOUT COPYRIGHT RESTRICTION** January 12, 1928

KILAUEA REPORT No. 833

WEEK ENDING JANUARY 11, 1928

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

This week has ended with a small gush of lava in the bottom of Halemaumau, but it is very doubtful whether this is anything more than a squeezing-up by pressure of remnant liquid lava from the July eruption of 1927.

The week has been fine, ending with strong northeast wind. At the end of last week there was almost continuous uneasy sliding of small rocks from the west, northwest, and north walls of Halemaumau. This is usually started by a big rock falling from high up the wall. The July floor has been greatly overlapped with debris, especially under the northwest talus cone, the top of which has been incessantly added to so as to bury the niche formerly seen there.

A traverse of the south and west edges of the pit the afternoon of January 7 showed that the flag at the west-northwest rim was in a precarious position, and new cracks were giving up hot steam for 50 feet back of this flag. So fresh were the cracks that fern and grass sods watered by the recent rains were torn asunder, and some of the fissures were more than three feet wide. Numerous small slides were falling under this place.

On January 9 new measurements along the cracks back of the east rim showed progressive widening of the principal crack northward to a maximum of five inches increase of width over the measurements of December 29. Leveling across Kilauea Crater floor from the south gravel ridge to the vicinity of the pit revealed a lowering in eight months of the Halemaumau rim region of 0.4 foot. Six notable slides occurred just after noon.

On January 10 avalanches increased all day at the northwest, and from 4:30 to 5 p. m. big slides indicated that the WNW wall was undermined and in process of falling. A large wet scar in the high wall lay over wet new-fallen fragments below. There was some sliding on all sides of the pit, as though the bottom plug were lowering under the debris slopes.

At 12:26 a. m. January 11 there was a prolonged avalanche roar heard, and then a moderate rosy glow appeared over Halemaumau. When the pit was reached about 1 a. m. there were three glowing areas of fresh incandescent lava on the floor, a long curved western band, a small central pudding, and a smaller fiery pot at the site of the north floor cone of July, 1927.

It was evident that new lava had spouted up, but in addition a light-colored landslide area covered the whole northwest floor. The rosy glow above the pit as seen from a distance had entirely disappeared in 20 minutes; the new lava was no longer bright, but consisted of a filigree of cooling flows with a suggestion of blue flame at the northern cone. There was little observed motion, no hissing or fountaining anywhere, but sliding continued from all sides, particularly northwest. The high, dark, avalanche scar in the WNW wall was now extended up to the top, and steam was seen on the face of the wall next to the north.

A circuit of the pit during the forenoon showed that the main new flow was not visibly incandescent by daylight, and consisted of black "sharkskin" lava in a crescent around the south side of the northwest pool of 1927. It lay just outside of the sunken crust of that circular pool, which had been surrounded by a raised bank separted by cracks from the subsided inner shell. The new lava had come up these cracks in three places, the flows merging outside of the bank to make the crescent, which was about 500 feet long. At its northeast end, near the center of the pit, was a small, ragged, lava patch, which had flowed from another crack eastward.

All of this appeared to have been occasioned by the landslip of the northwest debris slope. The tumble of rocks had ridden over and weighted down the whole of the crusted pool, breaking up the crust, as shown about the edges, and apparently squeezing up live lava from below, which emerged at the border cracks. Apparently this "lava floor," seemingly dead since last July, was really a stagnant lava puddle, still liquid below. It had been about 70 feet deep.

The northwest floor area was all covered with lobate heaps of red bowlders, the lobes convexed to the southeast. The northwest talus was completely stripped, revealing a rock slope lying at a flat angle. An immense avalanche from the edge of the pit had carried away the WNW flag, made a new notch in the pit edge just where the opening cracks had predicted collapse, and the crash had precipitated the landslide at the bottom.

The fire pot at the north cone had merely sent out a little trickle of black lava, stimulated by the same landslide pressure on the crust as at the other places. During the day the slides seemed to subside.

All this history pointed to a collapse rather than a rising, as shown by the slides and inward tilt of the past week. The load of tumbled rock revealed and squeezed up a little remnant lava. There was no harmonic tremor and no hissing was heard, both of these being characters of gas-charged lava when it is vigorously tumescing and ready to make fountains.

There were 58 local earthquakes recorded during the week. All were very feeble with the exception of one, at 1:07 p. m. January 4, which was a moderate shock felt in Hilo, South Kau, and other places, as well as locally. The distance to its origin from the Observatory is indicated as 21 miles. A number of the very feeble local tremors occurred coincidently with avalanches in the pit. For many avalanches the time was not noted. It is probable that if more avalanche times had been noted, there would have been a greater number of the recorded tremors matched with coincident avalanches. During the night of January 10-11 a very heavy avalanche occurred, probably at 12:26 a. m., if the tremor recorded on the seismographs at that time can be regarded as the resultant disturbance. This tremor was more strongly recorded on the Uwekahuna seismograph than at the Observatory, which is to be expected; the distances of the two stations from the pit being 0.9 and 2.2 miles, respectively. The tremor as recorded at the Observatory was almost strong enough to be graded above the very feeble class, being nearly large enough to be perceptible. It was preceded by four more feeble preliminary tremors, the first of which was recorded at 12:19 a. m.

Microseisms were slightly stronger than usual during the middle part of the weekly period. Tilt accumulated moderately toward the WSW during the week.

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No. 160 RELEASED WITHOUT COPYRIGHT RESTRICTION January 19, 1928

KILAUEA REPORT No. 834

WEEK ENDING JANUARY 18, 1928

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Succeeding events confirm the belief that the lava gush of January 11 was only a squeeze by landslip on remnant liquid lava under crust. There has been no more flowing, and all the seismic, avalanche and tilt disturbances of the first of the year have ceased. There is nothing new at Halemaumau.

The number of earthquakes recorded on the Observatory seismographs during the week is only 15. They were all very feeble. Of this number, nine came on the first two days, leaving only six for the rest of the week. Microseisms were moderately strong on the 13th and 14th. Slight east tilt has accumulated during the week.

LAVA AND ASH OF KILAUEA

In 1925 Dr. John B. Stone, Bishop Museum Fellow of Yale University, made a geological investigation of the rock materials and structural relations of Kilauea Volcano, which he presented as his dissertation for the doctorate. (Products and Structure of Kilauea, Bishop Museum Bulletin 33, Honolulu, 1926; 59 pp., 2 pl., 7 fig., and bibliography.) This essay is an admirable introduction to the discussion of the difficult interpretation of field facts concerning the relation of Kilauea to Mauna Loa. Dr. Stone examines without prejudice the specimens he collected himself, giving full credit to all earlier workers. He makes use of block diagrams to exhibit the structure and topography of Kilauea Crater and Kilauea mountain. He gives special attention to the boundary line between Kilauea flows and Mauna Loa flows, and concludes that a volcano in the general vicinity of Mauna Loa was older than Kilauea. On the basis of the evidence presented, this conclusion appears to the reviewer to be still in doubt, as it seems to him not unlikely that the ancestral volcano under the Mauna Loa-Kilauea complex was a ridge connecting the present Kilauea sink with the Waiohinu district by way of Wood Valley and Mohokea, all of these places being engulfment remnants of ancient craters.

Stone makes the following wise comment: "It is generally assumed in discussions of Hawaii that the island has been built by the five recognized volcanoes, but this is by no means certain. An old land mass underlies Kilauea and at least part of Mauna Loa. That this land was built by the present Mauna Loa is quite possible. but not proven. The evidence of extensive faulting along the southern coast and probably also along the northern side of Kohala suggests that there may have been older volcanic centers of which nothing is known, now sunk beneath the ocean or buried by the later volcanoes." It seems to the reviewer that Wood Valley and Mohokea are physiographically much too important as probable old volcanic centers to justify the statement that "nothing is known" about them.

The petrography of Kilauea indicates that all specimens are basalts, with labradorite basalts most abundant and containing only one per cent of olivine. There are some olivine basalts, and from the deeper mountain gabbroid explosion blocks have been thrown up which are picrite basalts containing 15 to 40 per cent of olivine. The minerals are olivine, pale brownish augite, rare hypersthene, calcic plagioclase feldspar, magnetite, ilmenite, and brown glass containing apatite. Cristobalite was found in vesicles of some of the coarser rocks. Sulphur and sulphates have been formed by fumarolic action. The textures of the rocks range from intersertal to diabasic when they are crystalized, porphyritic crystals are olivine, feldspar, and pyroxene, and the tops of the flows have a black, glassy ground mass.

Typical feldspar basalts of Kilauea Crater contain weight percentages of minerals as follows: Olivine, 1; augite, 54; labradorite, 31; iron ores, 13; glass, 1; and the specific gravity is about 3. Dikes are rare, and when found have chemical composition like the flows. Gabbroid intrusions are common in the bottom walls of the innermost craters, showing percentage compositions as follows: Olivine, 40; augite, 31; laboradorite, 37; iron ores, 2; apatite, 0.3; and specific gravity, 3.

The ash beds make up less than five per cent of the section of ancient lavas exposed on the fault cliffs near the sea southeast of Kilauea. There are interbedded with the lavas five layers, 15 to 20 feet thick, of reddish yellow stratified ash here, which are quite fresh. On top of these older lavas and underneath the veneer of recent flows which have cascaded over the Kilauea slopes, there is a bed from 20 to 60 feet thick of alternating yellow and gray ash containing lapilli. This occurs at the top of the pre-Kilauea series in the big fault cliffs, and is correlated by Stone with the so-called "yellow ash," from 28 to 95 feet thick, in the Pahala and Kapapala districts. Stone states that the yellow ash of Kapapala contains bands of lapilli and is pisolitic. He classifies as a single stratum marking an episode in the geological history of the country the red and yellow clays of Glenwood and the Bird Park, the beds of the southeast fault cliffs, and the ocher soils of Pahala.

There are ash beds at the base of the Uwekahuna cliff west of Kilauea Crater, and others forming the surface soils around Kilauea. These last range in thickness from one to 30 feet, and contours drawn by the reviewer on Dr. Stone's map of thicknesses show that the surface ash is at its maximum just south of the crater and is distributed northeast and southwest from there in belts of decreasing thickness.

The thread-lace scoria, or basaltic pumice, which lies at the base of these ash beds, ranges in thickness from one to 18 inches, the thickest exposures adjoining the north side of Kilauea Crater. The contours indicate a symmetrical development around this part of the crater with widest belts at the north, as though a south wind were blowing when lava fountains in the northern part of the crater ejected this material.

Four intervals between ash eruptions are indicated by fossil sod layers in the beds above the thread-lace scoria, and Stone considers only the coarse upper layer to be the product of the eruption of 1790. The ash beds contain mineral and glass fragments, sometimes the one and sometimes the other being dominant. The 1924 ash consists almost entirely of mineral fragments. T.A.J.

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No. 161 RELEASED WITHOUT COPYRIGHT RESTRICTION January 26, 1928

KILAUEA REPORT No. 835

WEEK ENDING JANUARY 25, 1928

Sectior of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Nothing has happened during the week to change Halemaumau pit. A little dust from slides was seen rising January 24. The seismographs at the Observatory recorded 25 very feeble local earthquakes. On the 24th, beginning intermittently at 5:12 p. m. and becoming continuous at 5:18 p. m., there was a very feeble protracted tremor, very much resembling harmonic tremor in appearance on the record. It waxed and waned, so that there were five distinct times of maximum amplitude, which have been included in the above count for the weekly total. The greatest of these maxima occurred at 5:37 p. m., and the tremor itself continued until 5:46 p. m. before the last trace died out.

Microseisms have been normal during the week, and tilt has accumulated very slightly toward the ENE.

LASSEN REPORT No. 14

Mineral, California, January 15, 1928

R. H. Finch, Associate Volcanologist

There have been several reports recently concerning activity of Glass Mountain, a peak about 7,850 feet high and about 75 miles north of Lassen Peak, in the Modoc lava beds. Rather new lava flows are to be found nearly all the way between Glass Mountain and Lassen Peak. Forest Service officials report about half an acre of land covered with pumice which is very hot. By digging but a little way into the pumice, much higher temperatures can be reached. Near this pumice bed there is a deep fissure from which steam issues.

According to George W. Courtright, a rancher and trapper residing about 12 miles east of Glass Mountain, the heat of the mountain has been known for years. The local Indians, ever since the country was settled, have been known to say, "Glass Mountain no good place." Mr. Courtright reports that numerous earthquakes occurred in January and February, 1910, and that during the shaking flames were observed over the mountain. In the spring of the same year he reports finding "blue mud" on vegetation on the mountain slope. Earthquakes originating in the mountain and accompanied by rattling noises have been noted by Forest Service officials for at least 15 years. Similar noises and shakes have been observed by Mr. Courtright for a much longer period. Near the northern end of the lava beds to the north of the mountain, a fissure about one-half mile long opened up during a very pronounced shake in 1910.

The writer and Mr. George L. Collins of the National Park Service endeavored to make temperature measurements and to take photographs on the mountain January 13, 1928, but were driven back by a heavy snow storm. It is planned to conduct further explorations in the spring.

VOLCANO-GLACIER FLOODS

The effect of volcanic heating on glaciers in Iceland is of great interest in comparison with what may happen on the glacier-covered volcanoes of Alaska. This melting was supposed to happen on the snow-covered Lassen Volcano of California. It may even have happened some thousands of years ago in Hawaii, when glaciers lay on top of Mauna Loa and Mauna Kea. This may account for some Hawaiian tuff deposits. The heat of the eruption melts the snow and ice masses, and the warmed water melts out gorges in the glaciers, increases in volume, and mixes with volcanic and glacial debris so as to make collossal torrents carrying icebergs out over the lowlands. These glacial floods are common in Iceland, where they are known as "Jokulhlaup" or glacier rushes. (Vulkankunde, by Karl Sapper, with petrographical introduction by A. Bergeat; 32 text figures, 30 plates, and 4 colored maps; 1927, Engelhorn, Stuttgart.)

At Katla, Iceland, in 1918, several openings trending SW-NE, about 1,000 meters above sea level, went into action along this crater which had become buried under ice since 1823, when it was last active. At 2 o'clock in the afternoon of October 12, 1918, after a swarm of weak earthquakes, steam clouds shot up, and for three nights thereafter these were full of electric fireworks. Human electrical operations, such as telegraph and telephone, were interupted. There was much rumbling, and heavy ash-fall occurred and shrouded much of the land in darkness. This continued off and on for 20 days, with maxima about the 10th and 21st day. In a radius of one kilometer 698,220,000 cubic meters of ash fell.

The warm water streams from the melting of ice reached a depth of from 60 to 70 meters, and the masses of sand and mud which the glacier rush carried with it were so extensive as to build out the coast line.

The first glacier rush happened an hour and a half after the eruption began, and flooded a sandy waste at the foot of Katla. Spectators saw the flood, overhung by steam and dust clouds, laden with gigantic icebergs, rushing down a valley, and in a short time the sea nearby was covered with large and small bergs. At 5:30 that afternoon, a new glacier rush started in farther to the east, and continued most of the night, as shown by the roaring of the waters and the crashing and rumbling of colliding icebergs. This torrent spread out over a flat area of about 125 square kilometers, carrying thousands of ice slabs, the larger ones becoming stranded on the sandy waste. At one place the torrent rushed against a cliff 60 meters high, so that ice fragments and water shot into the air like a gigantic surf on a sea shore. By the next morning most of the flood was finished, but there were several smaller out-breaks on later dates. Farming lands were damaged, and many animals were killed. A visit to the crater after the eruption revealed heaped-up ash and great clefts 500 to 800 meters long, 40 meters wide, and 25 meters deep. Two great gorges had been eroded out of the glaciers by the floods.

This review will be continued. T.A.J.

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No. 162 RELEASED WITHOUT COPYRIGHT RESTRICTION February 2, 1928

KILAUEA REPORT No. 836

WEEK ENDING FEBRUARY 1, 1928

Sectior of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

There has been nothing new observed at Halemaumau pit. The week has been stormy with northeasterly wind and rain. A little sliding from the walls was observed January 28, and sulphur is reappearing at the bottom of the talus E and SE. Today there is increased avalanching on the north walls of the pit. Thirty very feeble local earthquakes have been registered at Kilauea for the week. Microseisms have been normal.

LASSEN REPORT No. 15

Mineral, California, January 16, 1928

R .H. Finch, Associate Volcanologist

On December 21, 1927, the temperatures of Morgan's main hot springs varied but slightly from previous measurements of October. Some of the smaller springs near Mill Creek channel show increase of temperature and decrease of outflow. In one of these in October, some larvae of presumably a large fly were living in water at a temperature of 168 degrees F. In December there were still more larvae, and the temperature was 195 degrees F. On each occasion the larvae appeared very much alive.

At 8 a. m. December 30, R. H. Finch and O. H. Emerson left Mineral to try for an ascent of Lassen Peak. The cabin at Supan's solfatara was reached at 2 p. m. While the snow was not as deep as last year at a corresponding date, snowshoes were needed all the way. At Supan's (the 'Sulphur Works"), the snow was about four feet deep as compared with about six feet last year. All small streams showed less volume than a year ago. Owing to high wind and dense steam clouds, a satisfactory temperature reading of the largest steam vent at Supan's was not obtained, but indications were that it was as hot as when measured in October, 1927 (240° F.). Owing to heavy snow storm, no attempt was made to complete the ascent, and Mineral was reached on the return December 31 at 2 p. m.

AGE OF LASSEN CINDER CONE LAVAS

By AUSTIN E. JONES

The following preliminary notes on rough field application of the Chevallier method (Volcano Letter No. 45; Nature, October 3, 1925, p. 515) to Lassen lavas are of interest. The method assumes the magnetic declination of the outcrop to preserve the declination of the year of solidification. Mr. Finch writes that Mr. Austin E. Jones, assistant at the Lassen station, and he had found evidence of a source fissure in this flow marked by a NW-SE line of cones. Mr. Jones writes:

"August 30, 1927, I made rough experiments with a Forest Service surveying compass by Keuffel and Esser. (Lat. 40° 32′ N., Long. 121° 15′ W. Magnetic declination 19° E.). Loose lava blocks showed magnetic declinations varying up to 20° from the earth's field here. A traverse was run, checked by backsighting, to a large reddish outcrop on the east side of the lava beds between Butte Lake and Snag Lake. The magnetic field of this outcrop was found to have a declination of 14° 9′ east of north. This was close to a small red cinder cone on this edge of the lava beds.

"Traversing across the beds, a black rock was found giving declination 16° 7′ east of north. This had smooth surfaces and was part of a fissure eruption frozen in place. The ridge had precipitous sides 20 to 40 feet high, was 50 feet thick, and indicated a former fissure for more than 100 yards.

"Assuming equivalence to Redding, California, the nearest magnetic station, and extrapolating for the declinations at ten-year intervals 1810 to 1920 (Smithsonian Physical Tables), the older rock cooled between 1794 and 1797. Interpolating for the newer rock, it cooled in 1832. The probable error is within 10 years.

"If the lava underlying the Cinder Cone ash were examined, it should prove much older than either of the other two flows, and should help date Cinder Cone itself."

ALASKAN NOTES

Associated Press notices of December 7, 1927 (Seismological Dispatches of Georgetown University) say that many square miles of land are rising in upper Cook Inlet. Small boats here have gone aground in waters formerly deeper, and places formerly covered by several feet of water at low tide are now only reached by the highest tide, which has a range of 34 feet at Anchorage. (The same thing has been observed in eastern Japan.)

A notice of December 8 states that two volcanoes on Unimak had been smoking for ten days, after a season of unusual activity in the Aleutians. The smoke and vapor is stated to be "in comparatively small quantities."

Lake Kenai, 20 miles northwest of Seward, is reported to have been severely shaken by three earthquakes December 9. Cabins swayed, but no damage was done. Juneau experienced a rattling earthquake for 30 seconds at 10:02 a. m. December 31. T.A.J.

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No. 163 RELEASED WITHOUT COPYRIGHT RESTRICTION February 9, 1928

KILAUEA REPORT No. 837

WEEK ENDING FEBRUARY 8, 1928

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Halemaumau pit remains the same, no noticeable changes having occurred since the "activity" of January 11. There are occasional slides from the walls, sometimes large enough to send a little dust above the rim, but no large avalanches have been observed. A visit at 5 p. m. February 8 showed a few wall scars north, northeast, and east. There was very little steaming, but the wet steaming areas on the taluses were very conspicuous. The crack at the southeast trail, about 75 feet back from the rim, has widened.

Twenty-five earthquakes were counted on the seismograph records, of which 21 were very feeble and four were feeble. One of the later group, at 2:24 a. m. February 6, had an indicated distance to origin of 20 miles.

VOLCANO LORE

A very important book on geographical volcanology has just been published by Professor Karl Sapper, in charge of the Department of Geography at the University of Wurzburg. (Vulkankunde, von Karl Sapper, with petrographical introduction by A. Bergeat; 32 text leaves, 30 plates, and 4 colored maps; 1927, Engelhorn, Stuttgart.) Dr. Sapper is well known for his extensive studies of the statistics of eruptions and the distribution of volcanoes on the earth, and he has made extended journeys, especially among volcanoes of Central America and Iceland. This book is a readable text on the geographical distribution, significance, and forms of volcanoes on the one hand, and on the mechanism of volcanic eruption in its relation to mineralogy, physics, and chemistry on the other. No attempt is made to expound the mathematical aspects of the subject in relation to geophysical processes, but a very complete chapter on the history of volcanologic investigations is presented from the time of Aristotle to the days of such modern theorists as Daly and Joly.

The petrographical introduction by Dr. Bergeat presents current notions concerning the minerals in volcanic rocks, the classification of such rocks, and the distinction between the intrusives and the effusives. This chapter hardly goes beyond 19th century petrography.

Chapter II, on the gas-content of magma, is very modern, and contains a full discussion of the recent work on collection and analysis of gases and the studies of lava temperature which have been made by American investigators, especially in Hawaii, California, and Alaska.

Chapter III deals with the meaning of "magma" and a discussion of basaltic substratum in its relation to such conceptions of the motion of the crust of the earth as have been expounded by Daly, Wegener, and von Wolff. With reference to von Wolff's book on "Vulkanismus," Dr. Sapper expressly states that he does not attempt to double on the geophysical data set forth in von Wolff's book, but wishes rather to supplement it with a text which is expressly geographical.

The fourth chapter, on the "Nature of Volcanic Activity," is illustrated by descriptions and pictures of the wonderful eruptions of Santa Maria Volcano in Guatemala, which have come under the direct observation of the author, and also such recent happenings as the eruption of San Orin in 1926, the explosive eruption of Kilauea in 1924, and the remarkable Icelandic eruption of Katla in 1918. This chapter is necessarily one of the most important in the book, 90 pages long, and deals with the forewarnings and accompaniments of what are called eruptions, and then discusses these phenomena under the headings "Subaerial Eruptions, Sublacustrine, and Submarine Eruptions; and finally pure effusive outbreaks, which are treated somewhat more completely than other phases of the subjects because of the fact that they are less well known than explosive eruptions.

The history of Masaya is traced from the sixteenth century on, this Nicaraguan volcano having exhibited a lava lake, lava flows, gas outbursts, and many moderate explosive eruptions with ejection of ash, sand, lapilli, and scoria. Some of these were disastrous.

Sapper next describes Kilauea, treating in order the visit of Ellis in 1823, Daly's work in 1909, the work of Brun, in 1910, who obtained the impression of a continuous lava stream or spring passing under the pit, only a part of which was revealed by the opening. It should be said that Tempest Anderson, in 1909, had a similar notion about both Halemaumau and the volcano on Savaii, and it is interesting to note that Shepherd's recent suggestion of heat by lava circulation (Volcano Letter No. 157, December 29, 1927) contains the elements of a similar conception. Perret's work is given much attention by Sapper, who has evidently studied exhaustively his description of observations made in the summer of 1911, which were the beginning of what has since developed into the Hawaiian Volcano Observatory. Sapper points out that whereas W. L. Green considered the lava process a hydrostatic one, Daly added the conception of gas frothing to establish a convectional circulation, and then Perret added the notion of a continuous gas combustion, which has been carried still farther by Jaggar.

The next purely effusive volcano to be discussed is Matavanu, on Savaii, in the Samoan group, which developed a lava lake and sent a flood of basalt over several villages into the ocean for six years—1905 to 1911. The condition in successive years is reviewed largely from the data published by German observers, making the most complete condensed statement of the succession of events in that remarkable Samoan eruption which has yet appeared.

This review of Dr. Sapper's book, the first article of which appeared under "Volcano-Glacier Floods" in Volcano Letter No. 161, January 26, 1928, will be concluded next week. T.A.J.

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No. 164 **RELEASED WITHOUT COPYRIGHT RESTRICTION.** February 16, 1928

KILAUEA REPORT No. 838

WEEK ENDING FEBRUARY 15, 1928

Sectior of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Conditions at Halemaumau show no change over last week. A slide from the east wall at 9:30 a. m. February 12 was reported. A visit at 11:30 a. m. on the 13th showed new fine material at the bottoms of the NE, N, NW, and SW walls. Measurements show pronuonced widening of the east rim crack from the 14-ton bowlder to the edge of the pit.

The number of earthquakes recorded on the Observatory seismographs during the week ending February 15 shows a very considerable increase over the numbers for the last few weekly periods. The records show 61 local earthquakes, all very feeble with one exception. The earthquake recorded at 10:06 a. m. on February 11 is graded as feeble, and may have been perceptible to some people in the vicinity of the volcano. The indicated distance to the origin of this shock is 28 miles. It has been reported as felt in Hilo. A few minutes after this earthquake there was a prolonged tremor lasting about four minutes. Aside from the fact that this perceptible earthquake and prolonged tremor occurred on the 11th, this day also had more than its share of the very feeble earthquakes, 16 being recorded during the 24 hours.

Microseismic motion was somewhat stronger than usual on the 9th and 10th. There has been practically no accumulation of tilt during the week.

VOLCANO LORE

(Conclusion)

It is pointed out that lava volcanoes occasionally produce intense explosive phenomena, and in this connection the explosive eruption of Kilauea in 1924 is carefully reviewed. Masaya is quoted as having behaved like Kilauea in ejecting pumice and breadcrust bombs at the end of a lava flow period.

The classification of eruption types is considered, as for instance in the four categories of Lacroix; namely, the Hawaiian, Strombolian, Vulkanian, and Pele types. The Hawaiian type has great fluidity of magma, seldom exhibits explosive paroxysms, and characteristically produces glassy black slags and fibrous spun glass. The Strombolian type exhibits basaltic magma, more viscous, resisting the explosion of gas, so as to make heavy explosions common, with ejection of magma bombs. The Vulkanian type has very stiff magma, which becomes fully solidified between explosions, so that when an explosion occurs cauliflower clouds are the rule, with ejection of angular stones and breadcrust bombs. In the Pele type, glowing clouds of dust are ejected explosively, with extreme restriction in the orifices, viscosity of the underground magma is at a maximum, and down-rushing torrents of debris are common.

Finally, the subject of phreatic or water-made explosions is treated, and in this connection there is cited an explosion that took place in the lava fields of Matavanu in May, 1908. A great opening was made in the lava field of 50 meters diameter, great quantities of mud were thrown out a hundred feet into the air. At first it was thought that a new crater had formed. The place was in the midst of the former town Saleaula, where there had been a stream of water. Similar explosions have been described in Mexico, in the Aegean Sea, and elswhere.

The aftermath of volcanic activity is next considered, as shown in the activity of solfataras, geysers, mud streams, gas craters, and the like. Next comes the genetic morphology of the volcanic edifices, and the destruction of the same through atmospheric erosion, chemical action, the work of the winds, and other processes.

The geography of active volcanoes is Dr. Sapper's specialty, and this book presents more fully than any of its predecessors the facts known concerning the distribution of volcanoes, the amount of materials ejected, the frequency of eruptions, and the geographical significance of these facts with reference to the activities of men and in relation to the other geophysical processes of the crust of the earth. There follows a condensed list of active volcanoes, and their several histories are treated by means of formulae, such as were instituted first by de Ballore. This treatment promises much for volcanologic science as it makes possible the condensation of a vast amount of information in a single letter. Thus Kilauea is described for the year 1822 "a^2", which means lava flows of greatest magnitude exceeding two cubic kilometers in bulk. So the letter "b" stands for ejection of ash, sand, lapilli, and scoria; "c" stands for ejection of deep magma, and "d" for explosive ash eruptions involving chiefly surface material.

The review of volcanology at the end of the book is eclectic, and covers with the same thoroughness and brevity that appears in all the other chapters the progress of volcano theory during the growth of civilization, and ends with the statement: "The most important goal for the future of volcanology is to obtain new collections of fact and make them available, for only by such procedure can a substantial basis be made for more satisfactory theories than have hitherto been evoked." T.A.J.

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No. 165 RELEASED WITHOUT COPYRIGHT RESTRICTION February 23, 1928

KILAUEA REPORT No. 839

WEEK ENDING FEBRUARY 22, 1928

Sectior of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

It has been a week of avalanching at Halemaumau pit, with the accompanying tremors recorded on seismographs. On February 17 at 8:30 a. m. and at 10:15 a. m. light avalanche dust clouds were seen NE and NW respectively. All the forenoon of the 18th the north wall was working, and dust clouds went up at intervals. At 1:30 p. m. there was a big dust cloud at the north, but when the pit was visited all was peaceful both that afternoon and the next day.

February 20 at 8 a. m. a large dust cloud rose at the north corner of the pit and hung in the air for 20 minutes. Other avalanche clouds followed, and a climax of sliding sent up such a cauliflower that the column of dust rose several thousand feet and was visible from Hilo, starting rumors of an eruption. Between 9:30 and 11 a. m. only minor avalanches occurred N and NW, and there were others in the afternoon. The pit floor was covered with red dust on its north side, and the big cloud had stained the outside Kilauea floor there also. On February 22 the roar of an avalanche was heard about 3 a. m., small slides were seen NE at 8:30 a. m., and on visiting the pit at 2 p. m. I found little motion. The bench at the west end of the big north sill is gone, and there is a break in the wall west of there. The northeast corner had been sliding, as shown by fresh avalanche debris.

During the past week there have been recorded on the Observatory seismographs 52 very feeble local earthquakes and one very feeble teleseism. The avalanching at the pit is probably responsible for many of the small tremors recorded on the seismographs. Avalanching began during the early hours of the 20th, apparently working to a climax at 8:57 a. m., when an avalanche occurred that made a definite record on the instruments. At 3:05 a. m. February 22 there was heard a roar of an avalanche, and a corresponding tremor appears on the seismogram.

The teleseism was very feebly recorded, a phase that may be the beginning of either the secondary or long wave is shown at 9:42 a. m. February 21. No estimate of distance could be made.

An earthquake reported felt in Hilo at 6:55 p. m. Febraury 15, is represented only by a very feeble tremor shown on the Observatory seismogram.

Tilt during the week has accumulated modrately towards the SSW.

EXPLORATION OF WEST COAST OF HAWAII

The wheeled boat "Ohiki," described in Volcano Letter No. 156 December 22, 1927, traveled 30 miles to the beach at Ninole lagoon December 21, and successfully propelled itself in the water and landed itself on two beaches. It went forward and backward as required, taking up motor-car propulsion when the wheels touched bottom. The freeboard was raised, the paddle-wheels enlarged, an extension of the boat aft and water fenders were built, a winch and cable were mounted in the bow, and tests on Hilo beaches were made with increasing success January 17 and 20, and Febraury 4. A large outboard motor was added to the paddle-wheel propulsion, and a speed in water of four miles per hour was attained. The machine weighs 3,800 pounds, and is 22 feet long, with 5 feet beam, and overall width of 7 feet at the paddle boxes.

Thus equipped, an expedition was conducted to the west coast of Hawaii. The scientific party consisted of L. A. Thurston, President of the Hawaiian Volcano Research Association; T. A. Jaggar, R. M. Wilson, and T. Dranga, the personnel varying during the fortnight. The machine in the guise of an automobile truck left Kilauea Observatory February 8, the party of six camped at Waiohinu Homesteads that night, proceeded overland to Hookena, remaining there one day making beach and sea tests. We then went overland to Keauhou February 11, and camped there four nights, making sea trips south to Kaawaloa and Napoopoo, and north to Kailua, returning in each case overland. The boat was run with outboard propeller alone, paddles alone, and both together, and landings were made on rocks, pebble beaches, and sand.

Crew and load were reduced to four men, Thurston, Jaggar, Dranga, and Tahara, and a minimum of equipment, extra washboards were built amidships, and a voyage off the wild shoreline of northwest Hawaii was undertaken from Kailua to Kawaihae, a distance of about 40 miles. Camps on beaches were made at Makalawena, Kiholo, and Puako, and landings on other beaches at Kukio and Kalahuipuaa. Kawaihae was reached without accident at 11:30 a. m. February 19, the boat again became a truck for the steep hill road of 2,600 feet rise to Waimea, where the night was spent; and the next afternoon a land journey of 69 miles brought the party to Hilo via Hamakua and eastern Hawaii. February 21 completed the circuit of the island to Kilauea, making the whole journey by amphibian 208 miles by land and 58 miles by sea. Boat, engines, and running gear were all strong and in running order. The runs overland all made elevations of from 1,000 to 3,900 feet.

Geological features of interest observed on this journey were the lava cascades of Hookena, what appear to be fault cliffs at Hookena, Kaawaloa, and Keauhou, the 1801 flow north of Kaupulehu, mostly aa at its sea-front, the 1859 flow at Kiholo, where it is black pahoehoe of very fresh aspect, and the Kaniku flow in South Kohala, mostly aa lava equally new in appearance but of unknown date. At Puako are brown soils more than 10 feet deep, which appear to be freshet deposits, and a flat of this material heavily forested with algeroba extends more than three miles southwest of Puako, suggesting the yellow tuffs, of southern Kau, the glacial outwash of Mauna Kea near Humuula, and the North Kohala soils. The thickness of such deposits, remote from the volcanoes, more and more appears to suggest a glacial outwash origin rather than ashfall. (See Bull. Hawn. Volc. Obs'y October, 1925, p. 76.) T.A.J.

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No. 166 RELEASED WITHOUT COPYRIGHT RESTRICTION March 1, 1928

KILAUEA REPORT No. 840

WEEK ENDING FEBRUARY 29, 1928

Sectior of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

The notable avalanching described last week at Halemaumau pit came to an end, and during the current week very little has occurred in Kilauea Crater with the exception of a seismic flurry of felt earthquakes on February 26.

A visit to the pit at 2 p. m. February 25 revealed no motion of sliding from the walls, nothing new in the bottom, and more yellowish green sulphur stain near the base of the talus slopes east and southeast at spots which have exhibited such solfataric action for a long time past.

On February 26, after the two felt earthquakes of the night and morning hours hereinafter recorded, along with the southerly tilt which might have presaged subsidence in Kilauea, there was no conspicuous rock sliding to justify such a conclusion. Only one small fall of rocks that made dust occurred between 11:30 a. m. and 1:15 p. m. At 1:40 p. m. there was a slide at the north corner of the pit, and the niches in the wall northwest and north were working a little. On February 29 in the afternoon there was no change in the pit, but the eastern sulphur patches, after a spell of dry weather, appeared a little brighter colored.

There were 29 local earthquakes recorded by the Observatory seismographs during the week. Two of these were perceptible; the others were all very feeble. The two perceptible shocks occurred during the morning hours of February 26, the first one at 1:41 a. m. is classed as slight, and the second one, which came at 7:16 a. m., is classified as of moderate intensity. The first awakened a number of people from sleep, and is reported by some as accompanied by an earth noise. The second was of greater intensity than the first, and was felt as a single jolt by nearly everyone in the vicinity of the volcano, even though some were on their feet and walking at the time. A single bursting noise came with it. This second shock in its first movement dismantled both seismographs, so that after the first movement nothing was recorded till the last small dying out tremors, which show on the record after the instruments were set to rights three minutes later. When the pen was again set on paper, there was a definite tilt of about two seconds of arc disclosed, probably representing an actual tipping of the ground remaining from the disturbance of which the earthquake was the indication. The preliminary movement of both of these shocks was toward the southwest, in the direction of Halemaumau, and owing to the total lack of preliminary phases, both shocks were apparently strictly local.

Microseisms were somewhat stronger than normal on the 26th. Accumulated tilt during the week is strong toward the south, being due almost entirely to the sudden occurrence of south tilt during the second perceptible shock, as noted above.

LASSEN REPORT No. 16

Mineral, California, February 8, 1928

R. H. Finch, Associate Volcanologist

On Saturday, January 21, 1928, a rather sharp earthquake shock was plainly felt at Mineral. Within a few minutes two more smaller shocks occurred. All appear to be Lassen earthquakes. Sixteen inches of snow fell January 22-23, making it necessary to plow out the road.

In the library of the California Academy of Science an account of the last lava flow at Cinder Cone, Lassen Park, dates the flow during the winter of 1850-51. Other notes say January, 1851. According to the field evidence, there is nothing to refute the date 1850-51.

Newspapers have reported a new geyser at Calistoga. Examination showed in a new drilling, when the steam-producing depth of adjacent wells was reached, a temperature of 230° F. was measured. Before drilling was resumed, the well blew off and steam rushed up around the casing and eroded a crater before the well was cooled off with cold water so that the casing could be cemented in. Now the well is capped, and the steam supply is used in one of the bath establishments. The old, much advertised geyser well has been drilled deeper, and now it spouts about every minute instead of every four minutes.

On February 8 at 7:55 a. m. at Mineral there was a perceptible earthquake accompanied by loud roaring.

EAST INDIAN VOLCANO BULLETIN

A new monthly publication in English, the Bulletin of the Netherlands East Indies Volcanological Survey, was begun in November, 1927. It will be sent to those interested by the Survey in question, Bandoeng, Java.

There 58 volcanoes in the East Indies which have been in eruption since 1600 A. D., and 45 others in fumarolic activity. Sixteen volcanoes have erupted in Java. Observatories are in operation on seven Javanese volcanoes. The research carried on concerns seismologic, meteorologic, temperature, and chemical measurement, and depth soundings in crater lakes. Each Bulletin reviews the volcanic phenomena of the month, lists publications, and No. 2 contains an interesting table and map summarizing all the volcanic activity of the East Indies. T.A.J.

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No. 167 RELEASED WITHOUT COPYRIGHT RESTRICTION March 8, 1928

KILAUEA REPORT No. 841

WEEK ENDING MARCH 7, 1928

Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

On March 4 at 3:10 p. m. there was a slide in the lower northeast corner of Halemaumau. On March 6 at 11:25 a. m. and again at noon thin dust from slides rose from the north corner. On March 7 at noon the pit was without change, rocks dribbled occasionally from the north wall, and a slide at 12:20 p. m. fell at the south.

The Observatory seismographs have recorded only nine very feeble local earthquakes during the week ending March 7. In addition to these there were two pronounced spells of continuous tremors, 3:04 to 3:14 p. m. on March 1, and 4:10 to 4:23 p. m. on March 2.

Microseisms have been slight. Tilt during the week shows only a slight accumulation towards the SW.

NEW KRAKATOA ERUPTION

Just after the December solstice Krakatoa, in the Straits of Sunda, between Java and Sumatra, broke into activity. Krakatoa is the volcano which in 1883 started activity in May and reached one of the greatest explosive climaxes in history in August, blowing away the side of the island, and making a flood wave in the sea which drowned some 35,000 people on the neighboring shores of the strait.

A Reuter dispatch of January 5, 1928, states that Dr. Stehn, head of the Java volcanological service, had led an expedition to Krakatoa and reported the active crater to be under water, ejecting columns of water, steam, lava, and ashes 250 to 650 feet high. The activity on that date had greatly increased within the preceding 24 hours. A press dispatch of January 26 stated that an eruptive outburst occurred that afternoon, that the volcano was almost submerged in the sea, and that its activity had been increasing during the preceding few weeks. A message of January 28 stated that the eruption had been violent in recent days, but was apparently dying out, with submarine rumblings still persisting, and only the exhalation of fumes and gas for the preceding 12 hours.

Details reported in the Paris "Times" of January 24 are that the refugees from the southwestern coast of Java were coming into Batavia, that the government had sent a naval vessel for rescue and investigation, and that an enormous column of steam and fire was rising 200 to 300 yards above the top of the crater. Terrifying rumblings were heard under Sunda Strait on all sides of the Krakatoa island-ring. Natives were said to be standing in terrified awe, assembled in groups along the coast of Java and Sumatra, panic had caused the inhabitants of Coneet Bantam in southern Sumatra to flee into the high regions inland, the men venturing back to the coast only during daylight, and local insurance companies have increased their rates for volcanic insurance.

On January 25 it was reported that the government was broadcasting warnings to the population and that the main crater had been building itself up to the surface of the sea for the past five days.

"For the past five days 300 eruptions a day have taken place between 8 o'clock in the morning and noon. A tenth of these are more than 300 meters high. The highest column of burning ashes on January 21 reached 1,200 meters into the air."

Then follows an obscure statement to the effect that if the three active craters became closed, or if the crater became built up above the ocean, an explosive disaster might occur. T.A.J.

LONDON EARTHQUAKES

A curious note in the "Evening News" of London, England, March 9, 1927 ("When London Quakes," by Mary Morrissey), states that an earthquake occurred in London in April, 1580, which knocked pieces off St. Paul's Cathedral, set the church bells ringing, caused people to rush out of the theaters and taverns, and led Queen Elizabeth to order a special prayer against earthquakes to be used nightly by every household.

In 1692 an earthquake in London filled the streets with terrified crowds. On February 8, 1750, there was a sharp shock, accompanied by a roar, thought to be the blowing-up of powder mills. Just a month later another earthquake broke crockery, caused bells to ring, made the dogs howl, and fish were said to jump clean out of the water.

Then as now quackery in seismological forecasting was rampant, and a weak-minded soldier foretold a third and worse earthquake to occur the night of April 5. On the evening of that day there was a fashionable exodus, the roads out of London were thronged with vehicles, some contenting themselves with spending the night in their coaches in Hyde Park, with cards and candles to pass the time, while others went "to an inn 10 miles out of town," says Horace Walpole sarcastically, "where they are to play brag until 4 o'clock in the morniing and then come back, I suppose, to look for the bones of their husbands and families under the rubbish."

But the earthquake never came, and the soldier was shut up in a mad-house. T.A.J.

AN EARTHQUAKE IN PARLIAMENT

A curious interlude in the New Zealand Parliament (N. Z. Herald, 12th October, 1927) occasioned by an earthquake, occurred October 12, 1927, when a seismic spell began, leading to a violent shock October 15 at New Plymouth and a number of shocks November 8 and 9 in northern New Zealand. At an evening session of the Parliament at Wellington, a sharp earthquake shook the building, produced a buzz of murmuring that almost drowned the voice of the Member speaking, and caused an immediate evacuation of the galleries. Later a debate was just starting when the electric lights failed. Pending the arrival of candles there were vain attempts to relieve the gloom with song. With candles business was resumed, then the lights flashed on again. Members had hardly settled down to business, however, when the lights failed a second time, and the leader of the opposition suggested adjournment. Discussion of this was arrested when the lights once again appeared with their usual brilliance. T.A.J.

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No. 168 RELEASED WITHOUT COPYRIGHT RESTRICTION March 15, 1928

KILAUEA REPORT No. 842

WEEK ENDING MARCH 14, 1928

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

On March 10 at 11:30 a. m., dust arose from slides at Halemaumau on the northeast corner of the pit. At 3 p. m., and again between 4:25 and 5 p. m., several slides occurred, those during the last period being observed at the edge of the pit. The falls of rock were from places halfway up the cliff on the northeastern and northwestern walls, sometimes occurring simultaneously at two distinct places, and obscuring the pit with thin dust clouds.

On March 13 there were avalanches during the forenoon which sent up dust clouds chiefly at the northeast corner of the pit, and about 1:50 p. m. a prolonged roar of an avalanche was heard at the Observatory, a thick cloud of dust rose at the northeast so as to cut off the view of the pit, and this gradually thinned and disappeared in the course of a half-hour. At 3 p. m. there was more dust from the same place.

On March 14 thin dust clouds rose occasionally from the pit, and a new scar was observed from Uwekahuna Bluff on the southeast wall of Halemaumau not far below the upper edge of the pit.

The seismographs at the Observatory recorded 17 very feeble earthquakes during the week ending March 14. There were two that had the indicated distances 23 and 9 miles. On March 13 the big avalanche in the pit caused a decided tremor to be recorded at 1:53 p. m.

Moderate NE. tilt has accumulated during the week.

WORK OF THE SECTION OF VOLCANOLOGY 1927

In 1926 various phenomena in Halemaumau indicated the probability of the return of quiet lava through the bottom talus, and this happened July 7, 1927. The end of 1927 showed no reaction of subsidence, and hence it was expected that at decreasing intervals lava would return. That eruptible lava was close to the bottom of the pit was verified January 11, 1928, when a landslip forced liquid melt to come up through cracks.

The routine of the Hawaiian staff involved new features as follows: Compiling of Lassen and Kodiak reports, measuring seismograms from Kodiak, study of tide gauge records, supervision of a machine shop, and increased precision in measurement of horizontal and vertical movements at Kilauea Crater. The staff operated the Uwekahuna Museum until December, when it was turned over to the National Park Service. Field work has included exploration of Mauna Loa trails, continuation of drilling for temperature measurement, tests of a special motor boat for shore exploration, establishment of the Kodiak Station, and exploration of the Aleutian Islands.

Additions to the plant in Hawaii were a new seismograph and its cellar in Hilo, motor car radio receiving sets for time signals, and various machines. The Uwekahuna Observatory and Museum was finished in April and opened to the public, and this establishment forms an addition to the scientific equipment in that a high-class Japanese three-component seismograph has been added to the recording mechanism of the Observatory at a point nearer to the pit than ever before.

Collaboration in Hawaii has been largely through the Research Association, as will be detailed next week. The Alaskan Branch of the Geological Survey has cataloged and stored the collection of Aleutian specimens, and has furnished valuable cooperation in Alaskan volcanology. The topographic maps of Hawaii, now nearly finished by Captain Burkland's topographers, are invaluable as a basis for extending geologic and volcanologic surveys. The Bishop Museum has published an excellent bulletin on the geology of Kilauea by Dr. Stone. The National Park Service has given every assistance, and is now relieving the Observatory of labor and expense in operating for the public service the Uwekahuna Museum. The Coast Survey is doing work closely linked to volcanology in precise triangulation, leveling, magnetism, gravity measurement, hydrography, and computations of theoretical isostasy. The Observatory has furnished the Coast Survey with an Hawaiian seismograph for use at Sitka, Alaska. The National Geographic Society has authorized Dr. Jaggar to explore the Pavlof Volcano group on the Alaskan Peninsula in 1928, and will finance the expedition. The motor boat amphibian, subject of construction experiments and field tests in Hawaii under the Research Association, is a collaborative effort coordinate with the National Geographic project. The Coast Guard furnished invaluable service in transporting the Volcanologist to Attu Island and back to King Cove, and in offering every facility for exploration and for developing a collaborative Government project for Dutch Harbor. The United States Army, through Major General E. M. Lewis, in command of the Hawaiian Department, has assisted the Observatory with the loan of important equipment, and both the Army and Navy have taken great interest in the possibilities of assisting volcanology with airplanes.

It is hoped that in the future several scientific bureaus of the Government will make a united effort, from Dutch Harbor as a base, to map the Aleutian Islands, explore their natural resources, and conduct geophysical work in that land of abundant earthquakes, remarkable weather phenomena, unusual tides, and superb transitions in geological process.

Outstanding events of the year, in addition to the volcanic activity above noticed, were the opening of the Uwekahuna Observatory by the Honorable Hubert Work, Secretary of the Interior, on April 19; and the exhibition by the Observatory with the assistance of the Hilo Chamber of Commerce of a working seismograph, motion pictures, and photographs of active eruptions, at the Hawaiian Territorial Fair in Honolulu in September.

Associate Volcanologist R. H. Finch discovered spells of seismic activity at Lassen Park, explored the steam district northwest of Calistoga, measured temperatures of hot vents, mapped recent lava flows and faults, and investigated earth movements at Supan's Springs by installing a line of stakes at the sulphur bank there. The Kodiak seismograph station has been operated efficiently by Mrs. E. M. Floyd. An eruption of Mageik Volcano, in the Katmai group, occurred in August, and a heavy Alaskan earthquake in October.

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No. 169 RELEASED WITHOUT COPYRIGHT RESTRICTION ~~No. 168~~ Mar. 23, 1928

KILAUEA REPORT No. 843

WEEK ENDING MARCH 21, 1928

Section of Volcanology, U. S. Geological Survey:

R. M. Wilson, Temporarily in Charge

Two visits to Halemaumau this week disclose no important changes. Exceedingly dry weather has been prevalent, and there has been a minimum of slides in the pit. At 4:15 p. m. March 18 a few stones were heard falling, and the south cone was steaming freely. Considerable debris had fallen on the east floor from slides of the preceding week. The southeast sulphur spot was entirely obliterated, and the east sulphur spot was dimmed. Large new scars showed on the face of the northeast wall, and there were streaks made by slides north-northeast. The rim has receded very noticeably at the 14-ton bowlder. During 15 minutes just before 10 a. m. today not a sound was heard, and steaming was very slight at all vents. The whole pit interior appeared very dry, dusty, and peaceful.

During the week ending March 21 there were 20 very feeble local earthquakes and one teleseism recorded on the instruments of the Observatory.

The record of the teleseism showed fairly definite phases, the preliminary being at 6:40:26 p. m. on March 15, the secondary coming at 6:47:59 p. m., and the long wave beginning at 6:56:03 p. m. The beginning of the preliminary wave was of the gradually emergent type, so that the distance indicated by these times of arrival, 3,685 miles, is probably slightly too small. This earthquake was also well recorded on the seismograph in Hilo. At this station the preliminary wave showed a more definite beginning, and the somewhat greater indicated distance of 3,720 miles is probably more nearly correct.

The accumulation of tilt during the week has been slight toward the SW.

WORK OF THE RESEARCH ASSOCIATION 1927

In the course of 1927, the Hawaiian Volcano Research Association has accomplished through the Hawaiian Volcano Observatory the following:

(1) Construction and opening of the Uwekahuna Observatory and Museum, now serving the public through the National Park Service.

(2) Establishment, manning, and maintenance of the useful instrument shop.

(3) Manufacture and output of three seismographs, two now in operation at Kodiak and Hilo, and one shipped to the U. S. Coast and Geodetic Survey for use at Sitka, Alaska.

(4) Continuation of boring experiments on the floor of Kilauea Crater, so that in all 34 holes for measurement of temperature have been drilled.

(5) Continuation of seismometric recording at Hilo and at Kealakekua in West Hawaii, and establishment of a new station, equipped with a three-component instrument of Japanese manufacture, at the Uwekahuna Observatory on the high bluff west of Kilauea Crater.

(6) Continuation of publication of the Monthly Bulletin of the Observatory and of the Volcano Letter.

(7) Building and testing a wheeled boat.

The Uwekahuna Observatory is a success, and travelers find in the motion pictures, the exhibits, the explanations, and the splendid view a compensation for what is missing when the lava pit is inactive.

For the winter of 1927-28 the drilling apparatus is laid up, and the work connected with temperature measurements on the holes and points located and on the cracks adjacent to the 132 surveyed stations of the Kilauea floor.

The seismological registration done by the stations under the Research Association is incessantly improving as to quality of instruments and time service, and it will not be long before all stations have instruments of the same quality as those at the Observatory.

Under the Research Association, F. Y. Boyrie has worked continuously from March 1 to December 31 as machinist in the shop equipped here by the Association. He has constructed seismographs, repaired instruments, set up the electric plant for projection apparatus at the Uwekahuna Observatory, installed all the machinery in the shop itself, kept the drilling apparatus in order, and assisted by F. F. Fischer and S. Oda, has built the wheeled-boat. Professor Paul Kirkpatrick was employed by the Association from July 1 to August 14 to act as lecturer, in cooperation with the National Park Service, at the Uwekahuna Observatory, and to carry on seismological research. He devised special projection for the motion pictures at the Territorial Fair, and had charge of the Observatory's exhibit at the Fair. Captain R. V. Woods and J. B. Albert continued to do good work as seismograph operators in Kealakekua and Hilo, respectively. The station at Hilea, under A. D. Williams, was temporarily discontinued on May 15 until such time as a better istrument is available.

The Hawaiian Volcano Research Association has added to the plant complete tool equipment of a power machine shop, including gasoline engine, automatic hack-saw, large and small machine drills, a machine grinder, a circular-saw table, and a forge. A large lathe was obtained and added to our shop. New parts for this lathe were obtained through the Government in October, and this tool, supplementing the small Barnes lathe and the still smaller jeweler's lathe already on hand in the Observatory, equips the establishment with turning tools sufficient for all present need. T.A.J.

STATION NOTES

On March 15 Dr. T. A. Jaggar left this station, beginning his trip to Washingtoon, D. C. In Washington on April 5 he will deliver a lecture before the National Geographic Society, and will then start for Alaska as leader of the National Geographic Pavlof Volcano Expedition.

Mr. F. Y. Boyrie terminated his services as machinist for the Observatory on March 15. In his place Mr. Tai On Au has been engaged to continue the construction of other units of the Hawaiian type seismograph and to carry on the miscellaneous machine work of the station. Mr. Au is a resident of Hilo, and comes to the Observatory after three years training in the machine shop of the Smith-Hugh Vocational Training School. R.M.W.

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No. 170 RELEASED WITHOUT COPYRIGHT RESTRICTION March 29, 1928

KILAUEA REPORT No. 844

WEEK ENDING MARCH 28, 1928

Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

Conditions at Halemaumau remain practically the same as last week, except a slight increase of steaming due to recent light rains. There were three floor vents emitting steam this morning, two of which mark the sites of two of the lava fountains of last July. The vent of the small twin fountain, at the center of the pit floor, had the densest vapor. There has been no avalanching and very little sliding. Two or three small slides were observed March 24 and 28.

Crack measurements taken on the 24th show varying differences over measurements of February 13 of from seven-eighths of an inch to three and three-quarters inches. Four of the original 15 marked measuring points along the east rim have become unavailable through caving or becoming too wide to be reached.

During the week ending March 28 the Observatory seismographs have recorded 12 very feeble local earthquakes and one teleseism. The teleseism is recorded on March 21, its preliminary wave beginning at 5:56:50 p. m., the secondary wave at 6:04:39 p. m., and the long wave at about 6:14 p. m. The indicated distance is 3,875 miles. A notice from Lieutenant J. H. Peters, in charge of the field station of the U. S. Coast and Geodetic Survey in Honolulu, gives as the preliminary determination of the epicenter Lat. 28° N., Long. 96° W. By the same authority, the teleseism mentioned in the Kilauea Report last week, which occurred on March 15, was in Lat. 23° S. and Long. 170° E. These preliminary notices are obtained from the records of different observatories, assembled and computed through the cooperation of Science Service, the Jesuit Seismological Association, and the U. S. Coast and Geodetic Survey.

Tilt has accumulated only very slightly to the south during the week.

REVIEW OF HAWAIIAN EARTHQUAKES OF 1927

The total number of seismic disturbances recorded on the seismographs of the Hawaiian Volcano Observatory during the year 1927 is 1,168. This number includes 19 teleseisms, of which seven were decipherable as to distance.

The remaining local earthquakes number 1,149. These grouped by their intensity are as follows: 1,121 were very feeble, 16 were feeble, 9 were slight, and 3 were moderate. All of the slight and moderate shocks and five of the feeble shocks were reported as perceptible, being 17 in all for the number of earthquakes felt here during the year.

The following table gives the number per month of the local shocks for 1925, 1926, and 1927. The numbers for 1925 and 1926 have been included here for the sake of comparison, and were copied directly from Volcano Letters Nos. 54 and 112, respectively, in which the earthquakes for these years were reviewed.

Month	1925	1926	1927
January	94	54	85
February	94	32	46
March	79	68	63
April	70	761	68
May	83	43	82
June	51	56	45
July	109	101	72
August	94	254	75
September	102	240	103
October	50	62	76
November	48	46	191
December	48	61	243

The number in April, 1926, is swelled due to the shocks accompanying the eruption of Mauna Loa. The very feeble earthquakes here counted are probably not all true earthquakes. Many of the records are too faint to distinguish the character of the shocks. While most of them are real earthquakes, some are caused by avalanches in the pit, some are the waxing to maximum amplitudes of a more continuous tremor of the harmonic type which may be present, but for the most part may be too feeble to record, some are volcanic spasmodic tremors, and a few during February and March, 1927, were probably caused by blasting in the vicinity.

There are certain features of interest that stand out during the year 1927. The regular recurrence of times of increased local seismic activity cannot be set aside as accidental. These crests of activity come at intervals of about two weeks, near the times of the first and last quarter phases of the moon. This feature has been mentioned in Volcano Letter No. 143, September 22, 1927. The records for October, November, and December continued to show the same effect.

On March 20 the heaviest earthquake of the year duplicated the one of March 19, 1926. It is a coincidence perhaps that these two big earthquakes should fall almost on the same day of the two years, though the proximity of the equinox may have been the inspiration in each case. The outbreak of lava in July was oddly enough almost wholly unaccompanied by seismic activity. There was one perceptible earthquake just after the appearance of lava differing in no way from other shocks that occurred during the year. The only definite seismic accompaniment was the presence of harmonic tremor during the first day of the eruption of lava.

A group of seven perceptible earthquakes, with two more almost strong enough to be felt, occurred in the period between July 24 and August 3. This is a large share of the heavier shocks for the year, and their grouping within these few days undoubtedly has some significance. On December 3 and 4 there occurred an extraordinary series of spasmodic tremors clearly volcanic in origin. In this series there were about 75 individual tremors which have all been counted in the total number of earthquakes for the month, swelling that total considerably above its normal amount. R.M.W.

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No. 171 RELEASED WITHOUT COPYRIGHT RESTRICTION April 5, 1928

KILAUEA REPORT No. 845

WEEK ENDING APRIL 4, 1928
Section of Volcanology, U. S. Geological Survey:
R. M. Wilson, Temporarily in Charge

Scars on the Halemaumau walls indicate that slides have occurred at various places. The largest of these is at the southwest, and extends the full height of the wall. Appearances seem to indicate that great rim blocks have tumbled down the face of the wall, gathering material to such extent as partly to bury the southwest cone. Just as the cone of July, 1924, was buried by debris of the southwest talus, it now appears that the big cone of July, 1927, is to share the same fate.

During the week ending April 4 the Observatory seismographs have registered 20 very feeble local earthquakes and one teleseism. Two of the local earthquakes were of the protracted tremor type, one beginning at 10:26 a. m. on the 29th being 12 minutes long, and the other beginning at 9:29 p. m. on the 31st being three minutes long. One earthquake at 5:38 p. m. on the 28th was registered here as very feeble, but was perceptible in Hilo. The teleseism is very faintly recorded, the preliminary wave beginning at 6:45:38 p. m. without other distinguishable phases.

Tilt has accumulated during the week moderately toward the ENE.

EARTH MOVEMENTS IN JAPAN

The great Kwanto earthquake of September 1, 1923, is well known as a classic among the great earthquakes of the present age. Accurate surveys existing before its occurrence have fortunately made possible the discovery and study of earth movements of a most surprising magnitude resulting from it. In 1925 a report published by the Imperial Earthquake Investigation Committee showed that the floor of Sagami Bay had suffered serious deformations. Depressions of the bottom of the bay amounting to as much as 400 meters, and elevations as great as 250 meters, were shown to have occurred. In a very general way the depressions and elevations exist in alternate parallel belts as if caused by a wrinkling of the original surface.

There has recently been published (Proceedings of the Imperial Academy, Tokyo, February, 1928, Vol. IV, No. 2) three papers of considerable interest dealing with additional information on the effects of this great earthquake. The elevations and depressions above mentioned seemed so great and out of reason that a careful study was made of the data used in obtaining them. Possible errors in making the soundings were discussed, and while it is admitted that some of the values showing extreme change may be improbable, yet for the most part the differences originally obtained seem unassailable.

By re-triangulation a study has been made of the horizontal movements in connection with this earthquake. An analysis has been made to show where the greatest horizontal stresses existed in the earth's crust. This analysis tends to show that the maximum horizontal compressional stress accumulated some distance to the northeast of Sagami Bay; yet the maximum effects appear to have occurred in the bay itself.

The suggestion is made that the land areas are more rigid than the area of the earth's crust underlying Sagami Bay. Thus under the horizontal pressure shown by the triangulation, it is perhaps possible that the entire land block in the region of the greatest stress moved forward, the force expending itself in crumpling the more plastic crust under the bay. This idea is supported by the fact that no visible faults were made on the land area, indicating that whatever motion in which the land block took part, it moved as a whole. The relatively small horizontal displacements shown by the triangulation may have easily occasioned the much larger vertical displacements in the wrinkling of the bottom of the bay. This may be easily illustrated by noting the height to which a piece of paper will buckle up from a flat surface if its ends are forced only slightly nearer to each other.

It therefore seems that the area beneath Sagami Bay is a weak spot in the earth's crust which was compressed and deformed by the earth stresses accumulated in the more rigid surrounding regions.

There are also two other papers in the same publication dealing with certain interesting cases of land elevation and depression due to other earthquakes, detected by re-running spirit level lines. A tabulation is given showing the results of re-leveling over or near the epicenters of eight different earthquakes where changes of elevation were clearly shown. The Kwanto earthquake above discussed produced changes of elevation on land amounting to as much as two meters, which is the greatest amount shown in the list.

Much of this re-leveling over old lines was done several years after the original leveling was completed. The results may be questioned, therefore, in that the changes disclosed may not all be due to the single greatest earthquake occurring in that interval of time. Slow tiltings are known to exist, and the changes may be due in part to these slow motions instead of to the one earthquake suspected. There is one interesting case quoted, however, wherein the vertical changes discovered can be definitely attributed to a given earthquake. The running of a spirit level line was in progress when a sharp local earthquake occurred back on part of the line only three months completed. The portion of the line passing over the epicenter was immediately re-run. It was discovered that over the epicenter the earth's crust had bulged up an amount of over 2 cm. in a distance of only 4 km.

That motions of the ground are not all sudden and accompanied by earthquakes is shown by the last paper, dealing with a spirit level line run over older work after an interval of 35 years. In the region covered during this period of time there were no major local earthquakes. The line crossed several land blocks surrounded by known fault lines, and it was found that the blocks had suffered a general depression. In each case the west side of the block had fallen more than the east side. In one block the west side was depressed 9.4 cm., while the east side showed a depression of only 3.8 cm. In the adjoining block the west side was down 9.6 cm., while the east side had been elevated 0.4 cm. These two land blocks are being independently tilted towards the west.

The study of such earthmovements gives information that is valuable in the prediction of earthquakes. For the most part the cases above are movements that took place at the time of occurrence of earthquakes. But if slow movements can be detected, and their mechanics correctly interpreted, it may be possible with increased knowledge along these lines to tell where earth stresses are accumulating, and to so predict an earthquake before the actual fracture takes place. Work is being done along these lines in California and Japan, so that in the future it may be possible to detect the development of potential earthquakes. R.M.W.

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No. 172 **RELEASED WITHOUT COPYRIGHT RESTRICTION** April 12, 1928

KILAUEA REPORT No. 846

WEEK ENDING APRIL 11, 1928

Section of Volcanology, U. S. Geological Survey:

R. M. Wilson, Temporarily in Charge

Halemaumau on April 6 at 9 a. m. was comparatively quiet, although the southwest wall was still dusty from slides of the preceding week, and the south and center cones and other vapor vents were steaming profusely. On April 7 the pit began a spell of active avalanching, when at 7:07 a. m. a very prolonged roar of falling debris was heard by occupants of cottages in the vicinity of the Observatory. Reference to the seismogram showed that this avalanche set up strong tremors lasting two minutes. About five minutes later a thin cloud of dust arose and rolled along the crater floor and up the north ledge. At 7:14 a. m. there was another avalanche roar, and thick dust ascended. Other large slides followed from time to time, also evidenced by rising dust clouds. The slides appeared to come from the north and northwest walls.

On April 8 there were slides NE. at noon, and at 3:15 p. m. the southwest wall was still dust-coated. Rock falls were heard N., NW., and SW. On April 10 thin white dust was seen at intervals over the north corner of the pit. On April 11 the pit was free of steam and quiet, except for a dustless slide of rocks in the north corner at 8:50 a. m., a few invisible falls of stones from different walls, and a slide at 11:25 a. m. at the NW. New debris lay on the NW. talus.

A visit on April 1 to Mauna Iki, the Kau Desert flow of 1920 from Kilauea, showed that there are still several spots hot enough to ignite dry sticks.

The number of local earthquakes recorded during the week ending April 11 was 24. All of these were very feeble with the exception of one at 7:13 a. m. on April 7. This one was still a feeble shock, but larger than the others and almost strong enough to be perceptible. It followed by six minutes the heavy avalanche above described, and more rocks were heard to fall at about the time of the shock.

The acumulation of tilt during the week was moderate toward the WSW.

On April 2 Messrs. G. E. Josephson and W. E. Bonsey, of the faculty of Kamehameha Schools, Honolulu, walked to the Rest House on Mauna Loa, the following day going to the Crater of Mokuaweoweo and returning to Kilauea. This trip to the top and back within two days is somewhat of an accomplishment. They reported steaming in the southwest end of the crater, with a suggestion of yellow sulphur stain and fume. Conditions in Mokuaweoweo, however, are probably normal.

SUN SPOTS AND VOLCANIC ACTIVITY

Various correlations have been attempted between recurrences of volcanic activity and other phases of earth condition. In Volcano Letters No. 94, Octoper 14, 1926; and 129, June 16, 1927, it was suggested that there is a definite connection between fluctuations in the rate of rotation of the earth and latitude variations with changes of volcanic activity. The effect of lunar phases and solar season has been many times discussed. These causes have their effects on volcanic and seismic activity through possible stresses set up in the earth's crust due to earth tides or to slight periodic expansion and contraction of the earth as a whole.

In "Technology Review" of January, 1928, Dr. Charles G. Abbot gives an interesting description of his experiences and general results in the study of the sun. The sun's control of the earth is manifest in several ways, and it may easily have a periodic effect on volcanic activity through its radiations as well as through its gravitational attraction. Of particular interest is the 11-year cycle in the waxing and waning of sun-spot numbers. Perhaps there is a correlation between this sun-spot cycle and the 11-year cycle of volcanic activity that has been suggested as existing at Kilauea. The volcanic cycle still needs some years of observation before the fact of its existence is made certain and its phase and period fully determined. Yet a rough histrocial review detects years of high activity about 1896, 1908, and 1919. High sunspot years came about 1918 and will again be due about 1929.

The variation of solar radiation also shows a shorter cycle of a little over 25 months in period, which probably produces response in conditions on the earth. These changes in solar condition have already been found to affect climate and weather, and their study is proving useful to meteorology. Volcanology may perhaps also derive benefit from the investigation of these changes in the sun's radiation .

Such far reaching problems as earth rotation, latitude variation, earth tides, sun-spot variations, isostatic adjustment of erosion, long-period climatic changes of the earth's atmosphere, and periodic phases of volcanic activity, are delicately inter-related, so that the study of each involves consideration of the others.

NOTICE TO NON-SUBSCRIBERS

The Volcano Letter mailing list is being revised to effect as much economy in mailing as possible. We are very glad to send the Volcano Letter free to libraries of educational institutions, professors of geology, etc., but we suspect that there are recipients of this publication that may no longer be interested in it. We shall be deeply appreciative if those no longer desiring it will please send notice to the Hawaiian Volcano Obseravtory, Volcano House, Hawaii.

TITLE PAGE AND INDEX

Those who have saved their copies of the Volcano Letter for binding will be interested to know that the Hawaiian Volcano Observatory is preparing three annual title pages and indexes of the articles appearing in the issues of 1925, 1926, and 1927. These will be printed and mailed in the near future.

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No. 173 RELEASED WITHOUT COPYRIGHT RESTRICTION April 19, 1928

KILAUEA REPORT No. 847

WEEK ENDING APRIL 18, 1928

Section of Volcanology, U. S. Geological Survey:

R. M. Wilson, Temporarily in Charge

The volcano continues inactive and without phases to indicate the possibility of reappearance of live lava in the near future. Visits to Halemaumau were made on the mornings of April 13, 16, and 18. On the 13th the pit was quiet and dry, and there was very little steam. Stones were heard rolling occasionally on the north wall, and there were one or two small dusty slides atop the west end of the northeast sill. The most noticeable fumarole was at the center of the southwest talus. On the 16th the wind was too strong to hear sounds within the pit. There were indications of ground cracking in the vicinity of the south station. On the 18th no changes were noted, except a quantity of dark-colored bowlders scattered down the south talus. The two 1927 cones were steaming. The yellow stain at the base of the east talus seemed deeper, but the south and southeast sulphur spots have not yet reappeared.

During the week ending April 18 the Observatory seismographs registered 11 local earthquakes. All were very feeble with the exception of one which occurred at 1:43 a. m. on April 16. This one was slight, but was felt by many people in the vicinity of the volcano. Its origin is shown to be five miles from the Observatory, the direction suggested being SE.

Slight ENE. tilt has accumulated during the week.

THE CHAIN CRATERS ROAD

The Hawaii National Park on April 15 opened its new road along the chain of craters southeast and east of Kilauea. Work on this road was commenced in April, 1927, and its cost as now given to the public is $158,083. It starts from the Volcano House-Halemaumau road at a point one-half mile east of the Summer Camp, and follows in general the route of the old Cocktail Trail, crosses the old Keauhou Road, and continues on through the general region traversed by the Kalapana Trail, ending at the southwest side of Makaopuhi Crater. Its length is 6.95 miles. It is throughout a first-class, modern, gravel surfaced, automobile highway.

The craters from which the road takes its name are in a sweeping curve along the Puna Rift line, and give evidence of both ancient and recent volcanic activity along that crack in the mountain structure. Out-pourings from this same rift line where it curves still farther east and northeast beyond Makaopuhi, have built the ridge of Puna, marked by its line of cones. The Puna ridge probably continues even beyond the easternmost point of the island, though it there disappears into the sea. The road may some day be continued down into Puna to make another most interesting route between Hilo and the volcano.

Starting at the point of departure from the older Volcano House-Halemaumau road, the new road passes at 0.5 mile, 1.0 mile, and 1.6 miles the three craters Lua Manu, Puhimau, and Kokoolau. At 2.3 miles is the Devil's Throat, and at 2.4 miles the cinder cone. Two more craters, Heake and Pauahi, are next passed, the first at 2.7 miles, and the highway follows the rim of the second between 3.4 and 3.6 miles from the beginning of the road. At 3.8 miles the old Keauhou road is crossed, and then comes Aloi Crater at 4.6, where is the steaming area and the road's nearest approach to Puu Huluhulu. Between 5.5 and 5.7 miles the road follows the edge of Alealea Crater. At 6.0 miles is the entrance south to the very interesting 1923 miniature lava flow. The end of the road is reached at Makaopuhi Crater, 6.95 miles.

Justice cannot be done in describing these points of interest in so small a space; a brief review must suffice. The craters are members of the same family which includes the Crater of Kilauea, Kilauea Iki, and Keanakakoi. They are the stand-pipes where in times past the lava rose and fell as it was forced into or allowed to drain from the great crack called the Puna Rift. The benches and mezzanine floors in some of the craters represent lava lake levels that were maintained long enough for the lava beneath parts of them to harden. Those parts of a cooling lake where lava still remained soft enough to drain away when the release of pressure came, would then collapse, leaving these benches high and dry.

The Devil's Throat is like the Pit Craters in the Kau Desert. These deep well-like holes are the cavings-in of the roofs of lava tubes or chambers, weakened by heat or earthquake cracks; the falling debris perhaps being removed by the flow or heat of lava beneath to make room for more and still more caving-in till finally the very top surface falls in. Near the Devil's Throat is an interesting cinder cone, of which the inner construction has been exposed by the cutting for the road. The road throughout its length exposes by its cuttings interesting shallow sections showing the thickness and composition of the region's surface layers.

The steaming area at Aloi Crater gives evidence of rock beneath the surface still hot enough to turn back as steam the ground water that comes in contact with it. In the steaming area is an interesting ridge of hard, dense, bluish rock very different from the usual vesicular and frothy types of lava.

Of special interest are the miniature lava flows of 1922 and 1923. The little flows in Makaopuhi Crater of May 28, 1922, and on the brink of Napau Crater which oozed out the next day, are the clues that indicated how the lava was draining from Halemaumau during its great collapse of that month. Halemaumau refilled its lava reservoir during the next 15 months, but again movement along the Puna Rift occurred, as evidenced by earthquakes, opening the way for the lava to drain again from the pit during August, 1923. In this case the clue was the small flow of August 25, 1923, just south of the new road, at the 6.0 miles point. Here can be seen how lava issued from a long crack in the ground, spattering up into the trees and flowing down through the forest for a few hundred feet, making interesting tree moulds. Halemaumau partly recovered from this second collapse, then in April of 1924 came the earthquakes and subsidence in Puna, at the lower part of the rift line, followed by the great explosive collapse of Halemaumau in May. This time no lava appeared along the rift, but evidence seemed ample without it that once more the same crack was responsible for the wasting of Kilauea's fire.

Thus the Puna Rift is easily seen to be an important part of the volcano. The new road now makes it more accessible for study, so increasing the knowledge of the volcano as well as making available to the pubilc a region of great interest and scenic beauty. R.M.W.

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No. 174 RELEASED WITHOUT COPYRIGHT RESTRICTION April 26, 1928

KILAUEA REPORT No. 848

WEEK ENDING APRIL 25, 1928

Section of Volcanology, U. S. Geological Survey:

R. M. Wilson, Temporarily in Charge

Halemaumau is quiet, and there has been very little working of the walls and little change in steaming. The coatings of white salts have increased on the north and southwest walls. Two noisy slides from the ledge at the middle of the south wall were observed at 8:50 a. m. April 25, and the quantity of debris on the talus below indicated that there has been other slides. There is no new surface cracking about the south rim.

The east rim cracks were measured on April 21, but little difference was found over the measurements of March 24.

The Observatory seismographs have recorded 12 very feeble local earthquakes for the week ended April 25. Tilt has accumulated slightly WNW. during the same period.

ECHO SOUNDING

In Volcano Letter No. 122 of April 28, 1927, mention was made of sonic or echo sounding for ocean depths. The U. S. Coast and Geodetic Survey S. S. Guide has for the past few weeks been operating along the Kona coast of the Island of Hawaii, making standard charts in the region of Kealakekua and Kailua bays. The writer was given opportunity to go aboard and witness the sounding operations, seeing the fathometer in operation.

This device is simple in principle and most efficient in operation. The hydrophone, a part of the apparatus, is placed in contact with the water on the ship's bottom. This is a metal diaphragm, which is caused to vibrate by means of a powerful electro-magnet, like a giant telephone receiver. The sound thus transmitted to the water travels to the ocean's bottom, and is reflected back again as an echo. This faint echo is then received by a microphone and is electrically amplified by vacuum tubes to such strength that it will operate a magnetic relay. The speed of sound in sea water is known. The timing of the sound's journey from the ship to the ocean's bottom and return is therefore a measure of the depth. The whole operation is made automatic. A disk revolving behind a fixed scale carries upon it a contact device and a neon tube. When the neon tube passes the zero point of the fixed scale, contact is made causing the hydrophone to start the sound waves on their downward journey through the water. The return echo is signaled by the operation of the relay, which causes the flash of a spark through the neon tube; but during the journey of the sound to the ocean's bottom and return, the neon tube on its revolving disk has traveled along the scale from the zero point where operations were started, so that the flash of the spark occurs at a distance from the zero point of the scale corresponding to the time elapsed. The flash of the spark is instantaneous, but due to the persistence of the image in the retina of the eye, it appears to remain stationery for a fraction of a second at some part of the scale where its position may be read. The scale is graduated to read directly to fathoms, so that one needs but to glance at the instrument, noting where the spark flashes occur on the dial scale, to be immediately informed of the depth of water beneath the ship.

The work of the vessel includes the taking of other data of all sorts. Direct wire soundings are frequently made with a lead which brings back samples of the bottom. Water samples are taken from near the bottom at the same time. Thermometers are lowered which record temperatures.

In order that the positions of the soundings may be plotted upon a chart, the ship's position is known at will by three-point locations read upon shore objects, when the work is within sight of land, as is usually the case. The position of the ship is thus determined for each sounding made. The frequency with which these soundings are made and plotted is dependent upon the distance out from shore, the regularity of the bottom, or the importance of the area being covered and the amount of detail desired in the chart. In contrast to the older method of lead and line soundings, the use of which demands that the ship be nearly stopped each time a sounding is taken, this sonic method allows soundings to be taken at any speed the ship may be making. In chart making the only reason for diminishing speed is to allow the observers time to record the depth and position data. In the shoal water near land where the ship cannot be taken, small motor boats are used, with ordinary lead and line, to fill in the shore details of hydrography. Topographic parties on shore add other information for the chart.

The interest of volcanology in this work can be understood when it is realized that the volcano is not all above sea level. One too easily thinks of the base of this island volcano as being at sea level. As a matter of fact its base is where its slopes first start upwards from the great general plains of the sea bottom. The average sea bottom of the Pacific about Hawaii is easily as much below the sea surface level as the summit of Mauna Loa is above it. Thus in height the whole lower half of our volcano is under water and not available to direct observation. On the slopes of Mauna Loa that are above sea level, which we are able to study directly, we find many points of interest to volcanology. There are lava flows, cones and volcanic vents, rift lines, and fault scarps. These features obviously must exist on those parts of the mountain's slopes covered by sea water, though perhaps in changed form. This speedier and easier method of taking soundings that has been developed in the last few years should teach us much about these inaccessible lower slopes of the mountain. It may be that further developments in echo sounding will enable those operating the apparatus to tell by the quality of the returned echo what the character of the sea bottom is. We may thus be led to discover and be enabled to chart submarine areas freshly covered by lava. Increased detail of shape of the ocean's bottom discovered by greater numbers of soundings will perhaps disclose cones or volcanic topography of other sorts. In last week's Volcano Letter mention was made of the possibility that the great Puna rift extends on to the northeast after it dips into the water. The few scattered soudings taken for the older charts confirm this idea, showing a ridge extending on down the submerged flank of the island. Detailed soundings here might easily show interesting features which would reveal the history of this ridge.

R.M.W.

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No. 175 RELEASED WITHOUT COPYRIGHT RESTRICTION May 3, 1928

KILAUEA REPORT No. 849

WEEK ENDING MAY 2, 1928

Section of Volcanology, U. S. Geological Survey:

R. M. Wilson, Temporarily in Charge

Halemaumau remains unchanged except that steaming has increased in the pit due to the rains of the past two days. Most conspicuous is a wet steaming area on the north-northwest wall.

There were evidences on April 28 and May 2 that the north wall had had slides. Dust from a slide at the north corner was observed at 11:30 a. m. on the latter date. For some time there has been a slight accumulation of yellow stain at the site of the southeast sulphur patch, which has long been buried under debris, and on April 28 this stain was so plainly perceptible that it was thought that sulphur crystals were forming. Today, however, no yellow stain or crystals were to be seen.

The Observatory seismographs have recorded 20 earthquakes during the week. All of these were very feeble with the possible exception of one at 5:01 p. m. April 27. This one, while still feeble, might perhaps have been felt. Several of the others were large enough to show themselves plainly as true earthquakes rather than as small and distinctly local spasdomic tremors.

Tilt accumulated slightly to the south during the week.

THE THREE-YEAR CRUISE OF THE "CARNEGIE"

On May 1 the yacht "Carnegie" was scheduled to start upon its seventh cruise. This vessel of the Carnegie Institution of Washington is in charge of Captain J. P. Ault, and during the next three years is to engage in investigations of terrestrial magnetism and electricity, marine, biology, meteorology, and oceanography.

Work in magnetic observations at sea was first begun systematically by Halley in 1698. Other observations were made casually by various ships until in 1905 the "Galilee" was started out specifically for magnetic observations. The "Galilee" had iron in its hull that was found to be disturbing to the observations, but it was used until 1909, when the present vessel, the "Carnegie," was completed. The "Carnegie" started its first cruise in August of 1909, and has now traveled about 290,000 miles. This seventh cruise, which is starting, will add about 110,000 miles to its record. The proposed route for the present cruise is to start with a circuit in the North Atlantic Ocean, after which the vessel will go through the Panama Canal to the South pacific, then into the North Pacific, and will be near Hawaii about August, 1929. The route then goes through the South Pacific, and eastward once and a half around the world in the south latitudes, then up through the Atlantic and back to Washington, reaching the starting point about July, 1931. (See Journal of the Washington Academy of Sciences, Vol. 18, No. 5; or Scientific Monthly, February, 1928.)

With the experience furnished by the "Galilee," the "Carnegie" was built with as little iron and steel in its construction as possible. It is a two-masted sailing ship with an auxiliary engine of 100 horsepower capable of driving it without sail at the rate of six knots. The engine is constructed for the most part of non-magnetic metals, only a few essential parts being of steel. There is practically no other iron or steel on board. The vessel's anchors are of bronze, with manila cables. There are seven men on the scientific staff, and 17 in the crew.

The study of terrestrial magnetism has been and still is the major aim of the vessel's journeys. Observations for compass declination or deviation are systematically made ,and the secular or annual variation is determined for the different parts of the oceans. Seasonal and daily changes are also observed. From this information accurate isogonic charts are made enabling navigators to correct for compass errors. It is interesting to note that here again the eleven-year cycle of sun-spot activity has an effect. It has been found that there are changes in terrestrial magnetism that correspond to these changes in solar radiation.

On this cruise the vessel will undertake new work, the study of terrestrial electricity. This includes the measurement of atmospheric charges and potential, and leads to better understanding of conditions affecting radio transmission and of the Heaviside layer. Marine microbiology and chemistry will be studied, and other branches of marine life will be observed. Tow nets have provided for the collection of samples of ocean living organisms, and a laboratory on the ship provides the means for analysing or preserving the samples brought in. Another new laboratory has been added to accommodate the radio apparatus and the electrical depth sounding equipment. Marine meteorology is given attention. At sea, meterological observations and investigations of terrestrial magnetism and electricity are free from the many disturbing influences that exist on land.

Oceanography receives its share of study. Deep sea soundings are made, deep and shallow water temperatures are observed, bottom samples are collected, by a line run out to depths as great as 20,000 feet. In order that the line may go straight down and not be slanted in the water by the ship's motion, the vessel is stopped every other afternoon, or about every 150 or 200 miles, for the purpose of making these observations. The vessel is equipped with echo sounding appartus, as described in last week's Volcano Letter. Captain Ault remarks that the topographic features of the bed of the ocean must be as interesting to the geodesist and seismologist as are the features on dry land.

Results of some of the observations will be computed on the vessel and transmitted for publication when various ports are touched. The information is disseminated to all nations, and for this reason the vessel is a welcome visitor to ports all over the world. R.M.W.

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No. 176 RELEASED WITHOUT COPYRIGHT RESTRICTION May 10, 1928

KILAUEA REPORT No. 850

WEEK ENDING MAY 9, 1928

Section of Volcanology, U. S. Geological Survey:

R. M. Wilson, Temporarily in Charge

A few changes have taken place in Halemaumau. The wet steaming area of the north-northwest wall has become less conspicuous. The coating of white salts on the north wall has entirely peeled away. Dust was seen there on May 5 and 6, and stones were heard rolling at that side on other visits.

A survey of locations of various steam vents was made on May 7. They are as follows: Back of N., NW., and W. rims; below edge of E. rim; middle of NNW, wall; both side edges of NW. talus; center and south top of SW. talus; three places on SE. talus; below east end of NE. sill; middle of NNE. talus; two floor fumaroles at foot of N. talus; the south and center cones.

The southwest talus, by far the greatest debris slope in the pit, has some interesting phases. Slides rarely occur from the wall above it, and it is the only talus that has not overlapped the lava floor formed last July. This indicates that the talus has remained stationary and without change for about a year. For some time, however, a crack just below the upper edge and parallel to the wall has been developing, and may mean that the talus as a whole is slipping, perhaps to slide down onto the lava floor as did the northwest talus, which by this mechanism caused the squeezing up of liquid lava in Halemaumau on January 11 last.

During the week ending May 9 there have been recorded on the Observatory seismographs 35 earthquakes. One of these was a very feeble teleseism of which the preliminary phase began at 6:24:39 p. m. May 7. The record was so feeble that other phases could not be distinguished, and no estimate of distance could be made. Of the local earthquakes all were very feeble with the exception of one at 4:41 p. m. on May 5. While this shock was still feeble it may have been strong enough to be perceptible. The distance to its origin is indicated as 19 miles from the Observatory. On May 2, at 2:45 p. m., there was a protracted tremor which lasted for four minutes apparently of volcanic origin.

It was stated last week that there had been several earthquakes somewhat larger than the usual run of very feeble tremors. Most of them were not large enough to rise above the "very feeble" class, but were strong enough to indicate distance. This series of earthquakes has continued through this week also, so that the fortnight shows a very definite feature of seismic activity. An attempt to determine the epicenters of some of these earthquakes has shown them to have been rather scattered and without indication that any particular locality is responsible for the disturbances.

Tilt has accumulated during the week slightly to the south.

EARTHQUAKE BELTS

There is published in the "Scientific American" for April, 1928, a decidedly interesting and easily understood article on the world distribution of earthquakes. This article is by Professor Bailey Willis, and therefore carries with it the weight that can be expected from an authority on the subject.

The necessity for earthquake-proof building is emphasized. Here again is pointed out the fact that very few parts of the earth are absolutely free from earthquakes. The limited areas that we consider as liable to earthquakes are merely those in which earthquakes are relatively frequent. Those which are usually considered free from earthquakes are the spots on the earth where earthquakes are less frequent, but where shocks are by no means impossible.

The risk of earthquake damage increases as density of population increases. A great earthquake may occur under the ocean and pass completely unnoticed by mankind, except by seismographic records: yet a smaller earthquake taking place at a great center of population sometimes brings with it tremendous damage.

Professor Willis calls attention to the fact that buildings may be made more earthquake-proof at very little additional original cost. Great buildings are erected with careful consideration paid to the various forces that may affect them. Their design is calculated to make them strong against wind pressures, to enable them to carry loads of snow, and to make them proof against the disintegrating effect of weather. Much attention is paid toward making them fireproof. But in many places earthquakes happen so seldom that risk of damage from that cause is ignored completely, and in the design of buildings no features are included to guard against the earthquakes which the place must some time expect.

The article gives a table headed "Annual Frequency of Earthquakes in the More Seismic Regions." Some readers here in Hawaii have noticed and commented on the fact that Hawaii is omitted from this table. There are here great numbers of volcanic earthquakes, particularly on the Island of Hawaii. These are for the most part the accompaniment of movements in the mechanism of the volcanoes. They are not deep-seated nor far-reaching in their effects. The type of earthquake with which Professor Willis deals is the more far-reaching tectonic kind. Tectonic earthquakes are slippings in the earth's crust when it yields suddenly to stresses which have accumulated through ages, and do not necessarily occur in volcanic regions only. Such shocks are so heavy and deep-seated, involving the sudden shifting of such large volumes of the earth's crust, that they are recorded sometimes by seismograph stations throughout the world. Here in Hawaii our seismographs frequently record such distant earthquakes, which we call teleseisms. But it is very seldom that we transmit answers to these messages from distant parts of the earth. Tectonic earthquakes of sufficient depth and power to be recorded away from Hawaii seldom occur here. Practically all of our earthquakes are so purely local that they pass unnoticed by seismographs in other parts of the world.

R. M. W.

NOTES

A radio message from Dr. Jaggar, at Squaw Harbor, Alaska, has just been received. He states that he has arrived there safely with his outfit, and that the tests of his new amphibian automobile-boat have proved satisfactory. When Dr. Jaggar was in Washington, the National Geographic Society, under whose auspices this expedition is being made, saw the necessity of and made appropriations for a topographer to accompany the party. With tests completed, the expedition will start in actual work of reconnaissance within a week.

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No. 177 RELEASED WITHOUT COPYRIGHT RESTRICTION May 17, 1928

KILAUEA REPORT No. 851

WEEK ENDING MAY 16, 1928

Section of Volcanology, U. S. Geological Survey:

R. M. Wilson, Temporarily in Charge

The north and northwest walls of Halemaumau have been sliding, and several clouds of dust, made by avalanches, were seen rising from time to time. One from the north wall at 6:13 p. m. May 11 made vibrations which were recorded by the seismographs. There have been no changes in the pit except the difference in the amount of steaming under varying weather conditions.

During the week ended May 16 the seismographs at the Hawaiian Volcano Observatory recorded 32 very feeble local earthquakes. A teleseism was also recorded, the preliminary wave arriving at 11:57:01 a. m. on May 14; the secondary showing itself 10 minutes and 16 seconds later. The estimated distance to the epicenter is 5,580 miles.

Microseismic motion, which has been unusually feeble for some weeks past, increased to moderate amplitude during this week. Tilt has accumulated slightly WSW.

THE CRUST OF THE EARTH

Man's burrowings into the crust of the earth by means of shafts and tunnels barely scratch its surface when the depths so reached are considered in terms of the dimensions of the crust itself. Information as to composition, consistency, and temperature at greater depths must be obtained by indirect observation. In 1914 Michelson conducted experiments to measure the periodic tiltings of the earth's surface which he translated into earth tides. These tides, similar to ocean tides but of smaller amplitude, resulting from the attractions of the sun and moon, gave a measure of the rigidity of the earth by showing how much the earth's structure yields to these deforming forces. His experiments showed that the earth is a whole is somewhat more rigid than solid steel.

Geology, by the study of strata that have been laid bare by ages of crust folding, up-thrust and erosion, by analyses of volcanic ejecta and extrusives, has arrived at certain conceptions of the construction of the earth's crust. Seismology has yielded up most important evidences since the path and rate of travel of earthquake waves are dependent upon the density and elasticity encountered along their routes. These earthquake wave paths penetrate most parts of the earth, and serve to probe its inner condition. Thus it has been found that at a depth of some 50 or 60 km. there is a level of change of condition; earthquake waves are reflected from this level of discontinuity, or if they penetrate it are found to travel at much greater speeds below it than in the upper levels. Geophysicists have been making tests of the compressibilities of various rocks. Isostasy gives data as to the relative distribution of density with depth.

Geologists, seismologists, isostasists, experimental geophysicists, each have their particular ideas of exactly what is beneath us in the earth's crust, based on their individual lines of observation. How do successive layers vary in composition, density, temperature, conditions of rigidity and elasticity? Professor Reginald A. Daly, in an article published in the American Journal of Science, February, 1928 has assembled these various data and ideas with the aim of producing harmony among them.

Professor Daly shows that while the paths and velocities of earthquake waves are dependent upon conditions of density and elasticity, yet it is dangerous with information at present available to assume that the rocks which we believe to have those conditions of density and elasticity are thereby identified as those actually traversed. The preliminary earthquake waves travel at speeds of from 5.4 to 6.0 km. per second in the upper layers of the earth's crust, and the secondary waves travel from 3.2 to 3.5 km. per second; but below the layer of discontinuity the preliminary waves attain a speed of about 7.9 km. per second.

To try to determine what particular rocks these earthquake wave speeds represent, geophysicists have made compressibility tests of various constituents of the earth's crust. Specimens have been subjected to careful measurement under great pressures. But these samples are generally tested at our ordinary living temperature, and are tested in small pieces only. Daly's article points out that the results of these tests for a given material may not accurately apply to the higher temperatures and greater bulks of the same material at the depths in question. Also it is known that constants of rigidity and elasticity of many materials are not the same for great stresses as they are for small stresses, nor are they the same for stresses applied and released quickly as they are for stresses held through long periods of time. The vibrations of an earthquake wave are rapid, and their stresses are slight. In response to these vibrations perhaps different constants of rigidity and elasticity apply than those secured in making the tests or in computing from the static conditions of great pressure within the earth's crust. It therefore seems doubtful that it is yet possible to take the constants derived by timing earthquake waves to identify any particular rock or mineral.

Taken without these reservations ,the compressibility tests seem to preclude the possibility of a basaltic layer underlying the earth's crust. The idea of its presence there, however, is desirable to geologists and isostasists. The article here reviewed suggests that if basalt could be tested under the conditions existing at that great depth, that it might be found to have constants which would make it the proper medium to carry earthquake waves at their observed speeds.

R. M. W.

SAMPLE COPY

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THE VOLCANO LETTER

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No. 178 RELEASED WITHOUT COPYRIGHT RESTRICTION May 24, 1928

KILAUEA REPORT No. 852

WEEK ENDING MAY 23, 1928

Section of Volcanology, U. S. Geological Survey:

R. M. Wilson, Temporarily in Charge

On May 19 yellow stain was strongly noticed at the site of the southeast sulphur patch, and on May 21 the area of stain, as seen from the opposite side of the pit, appeared to have increased. Apparently sulphur crystals are again forming at this place.

A circuit of the pit on the 21st showed considerable change in the rim contour due to avalanches. On May 22 several slides occurred, one from the south corner about 9 a. m. making considerable noise. Dust was seen rising from the north and northeast corners during the day.

The east rim cracks were measured on May 23, but very little difference was found over the measurements of May 7 .

The seismographs at the Observatory recorded 13 local earthquakes during the week ended May 23. One at 7:43 p. m. May 18 was feeble, but may have been perceptible; all the others were very feeble.

Microseismic motion diminished during the week to an amplitude somewhat less than normal. Tilt accumulated slightly to the SSW.

The teleseism of May 14 mentioned in last week's report is given a tentative origin in Lat. 8 degrees S., Long. 80 degrees W. (north coast of Peru). This position results from a preliminary combination of reports from several stations, assembled and computed by the U. S. Coast and Geodetic Survey, the Jesuit Seismological Association, and Science Service in cooperation.

Thousands of sailors from United States battle squadrons now in Hawaiian waters are visiting the volcano.

ANCIENT PHILIPPINE EARTHQUAKES

A recently published catalog of historic earthquakes in the Philippine Islands (Seismologiacl Bulletin of the Weather Bureau, Manila, for 1926) gives 32 pages of very interesting descriptions of some of the greater ancient earthquakes and volcanic eruptions there. The time included is from 1585, when the first shock was recorded after the discovery of the Philippine Islands, to 1865 when the establishment of a government bureau began the more systematic collection of data. The descriptions of earthquakes are for the most part from writings of the priests, and frequently mention the damage to churches and parish houses. More damage occurred to such buildings because of their masonry construction than to the native buildings of loosely built wood, bamboo, and thatch.

It is suggested in the preface that the seismicity was probably about the same then as now; the number of earthquakes chronicled being then about as great as the numbers noted in recent years.

The descriptions are very graphic and interesting, and are set forth as the personal experiences of the various authors. About all the different effects that earthquakes produce are mentioned. Landslides and mud flows, shaken and broken buildings, earth cracks large enough to engulf human beings, changed river courses, ejections of mud, sand and water, darkness caused by dust of destroyed buildings or by clouds of volcanic ash, general destruction of towns, subsidence and flooding of land by sea water, tidal waves, and many other things are mentioned in the descriptions.

Many references are made to improved building construction with the aim to minimize the amount of earthquake damage. One writer says: "In spite of all these (experiences) the vanity and forgetfulness of men left them unconvinced that high houses are more subject to a great ruin. After the said earthquakes numerous houses were again built in the city, most of them of cut stone, as if all had forgotten the former disasters. Against all good architectural rules, walls fourteen to twenty meters high and less than a meter thick with a foundation about two meters deep were raised. Moreover these high and thin constructions had not any buttress as support or reinforcement; the mortar was of very poor quality made of little and weak lime and sand carelessly applied by unscrupulous Chinese, but yet our citizens pretended to have lasting buildings." Can it be said that even now in modern times with all this experience available to us that enough consideration is given to earthquake-proof building construction? Their experiences in those earlier years led finally to the building of wooden columns into masonry walls to prevent the falling-in of roofs should the masonry be shaken down. They also took such precautions as adding buttresses to building design, and building thicker walls and wider foundations. There is occasional note that damage was greater near a river than distant from it, perhaps having to do with the known increase of earthquake effects on buildings situated upon beds of alluvium.

The terror and grief among the people during these great earthquakes, and the ensuing pestilences and famines, are listed among the most serious effects of the shocks. Thus was Manila visited by disaster in the great earthquake of November 30, 1645: "The horrifying spectacle of that night was made more terrible by the distracted and precipitous wandering of the people through the darkness, blackened by the dense cloud of dust covering the city, the yells of the terrified multitude and the cries for help of the victims crushed and buried in the ruins."

The question of "earthquake weather" is mentioned by one writer as follows: "On the date of the main earthquake the weather was calm, the sky cloudy and dull, the air hot and heavy with puffs of wind and drizzling at intervals." These are indications, that author remarks, of impending earthquakes. There seems to be persistent belief throughout history that so-called "earthquake weather" exists as a forerunner of great seismic disturbances. This question is still open for science either to prove or disprove.

R. M. W.

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No. ~~197~~ 179 RELEASED WITHOUT COPYRIGHT RESTRICTION May 31, 1928

KILAUEA REPORT No. 853

WEEK ENDING MAY 30, 1928

Section of Volcanology, U. S. Geological Survey:

R. M. Wilson, Temporarily in Charge

Halemaumau continues quiet. A few small slides have occurred. On May 26 the north wall was streaked from slides. The southwest sulphur patch has again been obliterated by fallen debris.

Rumors of recent widening of cracks at the 14-ton bowlder proved false, although this place presents a dangerous appearance.

An extraordinarily strong northeast wind on May 25 made dense dust clouds on the south Kilauea floor and over the Kau Desert.

Eleven very feeble local earthquakes were recorded on the Observatory seismographs during the week ending May 30. There was also a very feeble record of a teleseism on May 26, of which the secondary and long waves are doubtfully identified at 11:37:50 and 11:46:24 p. m.

During the first part of the week there was a sharp spurt of tilt toward the NE., with an equally definite recovery, so that the net tilt accumulated for the week is but very slight toward the N.

GEODETIC WORK ON THE NORTHWEST HAWAIIAN ISLANDS

The U. S. Coast and Geodetic Survey S. S. "Guide," after completing the work of charting on the Kona coast of the Island of Hawaii (Volcano Letter No. 174, April 26, 1928), proceeded to the northwest islands of the Hawaiian group. The work there is the beginning of an extended program of latitude and longitude observations, determinations of gravity, measurements of magnetic declination and intensity, charting and topographic mapping. These small islands have needed such observations in order that they may be accurately charted. Their positions have heretofore been located for the most part by sextant observations only.

The geological aspect of these islands has been considered by Professor Harold S. Palmer in Bulletin 35 of the Bishop Museum. They are uninhabited, and have been given but little attention in the way of scientific investigations and surveys. It is believed that these are the older islands of the Hawaiian group and that they were at one time high volcanic cones, now reduced by erosion to projecting fragments and shoals.

The "Guide" has just completed the first trip of three weeks to Nihoa and Necker islands and to French Frigates Shoal. On Nihoa an astronomic station was occupied, where latitude, longitude, and azimuth were determined. Observations were also made for gravity and for magnetic declination. A topographic map of the island was made on the scale of 1:2,500. Some difficulty due to heavy seas attended the first attempt to go ashore on the island. The boat carrying the scientific party with instruments and supplies was capsized during the landing, but the instruments were for the most part recovered and there were no casualties.

Observations were to have been made on Necker Island, but rough weather made landing there impracticable. The ship therefore proceeded to French Frigates Shoal, where on East Island the same observations were made as on Nihoa. Triangulation was also started, and more complete magnetic observations were made at this place.

The ship returned to Honolulu for supplies and fuel, and has just started on a second trip to these islands. Another attempt will be made to occupy Necker to make there the same observations that have been completed at Nihoa and French Frigates Shoal, and to continue the triangulation work at the latter place.

The program contemplates continuing these observations on through the islands to the northwest as far as Ocean Island, if conditions permit, perhaps representing several seasons' work. For the longitude and gravity observations radio time signals are received direct from the Arlington station near Washington, D. C. Lieutenants Brown, Bainbridge, and Simmons, who did geodetic work on the Island of Hawaii about a year and a half ago, are the observers in this present work. R.M.W.

THE BALKAN EARTHQUAKES

The destructive earthquakes which occurred last month in Bulgaria and Greece filled the columns of the press at the time with descriptions of death and destruction. A series of pictures appeared in the "Illustrated London News" of May 5, 1928, giving very graphic evidence of the damage which the earthquakes accomplished.

Reports from the scientific investigations by seismologists and geologists as to just what occurred will be some time getting into print, due to the time that the necessary observations must take. A short preliminary discussion by Dr. Charles Davison of this group of earthquakes and their aftershocks has already appeared in "Nature" of May 5. That there will be many points of interest to scientists is evident from the number of observed geological effects mentioned in the press. The migration of focus during the series of earthquakes has attracted attention. The great area disturbed in the Bulgarian earthquakes and the lesser area disturbed by the Grecian shocks has already suggested that the former had a greater depth of focus. Changes of land elevation, tidal waves, the opening of great cracks in the earth, altered volume of flow in mineral springs with changes in the temperature of the water, are all things which will supply a wealth of material for scientific study. There is mention made of electrical displays noted before the occurrence of the first shock, suggesting forewarning phenomena, though science still doubts the existence of such effects. Mention is also made of investigations immediately started to discover the effects upon buildings, thus to learn more about details of design which will minimize damage by future earthquakes.

The scientific discussion of such calamities must be made the most of to increase knowledge toward lessening the loss of life and property in the future. R.M.W.

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No. 180 RELEASED WITHOUT COPYRIGHT RESTRICTION June 7, 1928

KILAUEA REPORT No. 854

WEEK ENDING JUNE 9, 1928

Section of Volcanology, U. S. Geological Survey:

R. M. Wilson, Temporarily in Charge

Practically no changes have taken place at Halemaumau in the past week. On June 2 and 5 there were avalanches, dust from one of them at 1:45 p. m. on the former date rising in a peculiar compact cloud. The odor of free sulphur was noticed very slightly at the southeast rim at 11:30 a. m. June 6.

During the week there were 14 very feeble local tremors recorded on the Observatory seismographs. One of these, an earthquake slightly larger than the others, exhibited phases indicating a distance of nine miles to its origin. On June 5 there were two periods of continuous tremor, the first one beginning at 7:53 a. m. and lasting six minutes, and the second one beginning at 8:03 a. m. and lasting four minutes. These two spells of tremor perhaps represent the same disturbance, as they were separated by only a four-minute quiet interval.

During the first part of the week microseisms were somewhat more feeble than normal. On June 2 and 3 there seemed to be evidences of a vibration of longer period than the normal microseisms. Their period was about 7.2 seconds, and they could be detected in the records at intervals during the greater part of these two days. Microseismic motion again became normal by the end of the week.

Tilt has accumulated slightly to the southwest.

AERIAL PHOTOGRAPHS

In the current issue of "The Military Engineer" there is another article describing the campaign of aerial photography in southeastern Alaska. This project was described some time ago in the "Scientific American," and was mentioned in Volcano Letter No. 127, June 2, 1927. The recent article gives reproductions of some of the excellent photographs secured and briefly describes the field program and the subsequent compilation of the pictures into maps. Some of the country covered is so inaccessible to people on foot that it has not been thoroughly explored, and some lakes that were heretofore unknown were discovered in the photographs. Much valuable information was thus obtained in the matter of possible power sites and water supplies. Sets of these photographs are on file in the Geological Survey offices in Washington and in the office of the Forest Service at Juneau, Alaska.

During the 1926 outbreak of Mauna Loa in Hawaii, aerial photographs were for the first time used here to record progress of lava flows. The value of their use in this connection cannot be over estimated, both for the collection of scientific data and as a safety measure for the protection of human lives and property. At times of Mauna Loa eruptions, with the consequent lava flows down the slopes of the mountain, automobiles carrying sightseers in great numbers have crowded in to the flanks of the flow from both directions on the belt road running around the island. The traffic congestion resulting has usually been considerable, although during the last outbreak police organization kept everything well in hand. But with such congestion on this road there is grave danger that a lava flow coming down from above may split and isolate some of these sight-seers in a dangerous predicament. Some of the regions on the mountain slopes above the road are almost impenetrable, and it is difficult in the extreme for men on horseback or on foot to keep close watch on all the developments of the flow that might prove dangerous to those below. Periodic flights of an airplane over the flow, with the photographs that might be taken on such flights, would easily show the development of any dangerous aspects of the outbreak. A series of such pictures would constitute a most valuable scientific record of the flow. R.M.W.

THE FAILURE OF THE SAINT FRANCIS DAM

There has just been issued the report of the commission appointed by the Governor of California to investigate the failure of the Saint Francis dam, which occurred shortly after midnight on March 13, 1928. Defective foundations is the cause given for the collapse of the structure. Part of its length was built on a geologic formation which appears like solid rock when dry, but was found to lose much of its strength when water-soaked.

The body of the dam crossed a geologic fault which has been termed "dead." Motion along this fault line might easily have caused the failure of the dam. Careful investigation showed no sign of movement, however, and the nearest seismographs showed no earthquakes anywhere near the time of the calamity. In Volcano Letter No. 99, November 18, 1926, an article by Dr. G. Agamennone is reviewed in which he laid emphasis upon the necessity of an installation of seismographic instruments as a safety measure at all large dams. Stresses to the point of failure in these great dams probably do not accumulate suddenly. The softening of the foundation may have allowed this dam to settle or yield a little, perhaps with slight internal fractures, even some days before it actually collapsed. A seismograph installed upon the dam might have detected these slight preliminary motions, recording them either as tremors or as slight tiltings.

The failure of the dam in this case is not ascribed to actual earthquakes, but the use of seismographic instruments might nevertheless have given warning of the coming collapse, possibly several days in advance. The cost of installation of these instruments would seem to be a very slight amount to pay for the possibility of detecting the danger of such a calamity. R.M.W.

ERRATUM

The number of the preceding issue of "The Volcano Letter" was transposed. The correct number is 179, not 197. Recipients are urged to make the correction on their copies to avoid confusion in filing.

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No. 181 RELEASED WITHOUT COPYRIGHT RESTRICTION June 14, 1928

KILAUEA REPORT No. 854

WEEK ENDING JUNE 13, 1928

Section of Volcanology, U. S. Geological Survey:

R. M. Wilson, Temporarily in Charge

The volcano is quiet. There have been a few light slides, mostly from the south wall, but none has been noticed that was large enough to cause clouds of dust to rise. The weather is extremely dry, resulting in diminished steaming activity. There are no phases apparent which may indicate a change in volcanic conditions, but with the approach of the summer solstice close watch must be kept for anything that may be significant.

Twenty-three very feeble volcanic tremors were registered at the Observatory. One of these lasted for four minutes beginning 12:26 p. m. June 6. Microseismic motion is slight. Tilt accumulated slightly to the WSW.

MAKAOPUHI CRATER

The new Chain Craters Road in the Kilauea Section of Hawaii National Park, which at present ends at Makaopuhi Crater, has brought this interesting piece of scenery more under public observation than before. In Volcano Letter No. 47, November 19, 1925, there are notes of a visit to the bottom of this crater by Dr. John B. Stone, and Mr. R. H. Finch of the Observatory. Dr. Stone remarks that the eastern part of the crater was originally inclosed by a complete oval wall, the western part of which was destroyed when the collapse making the western pit occurred. This exposed a section down through the lava fill of the original eastern crater, which now forms a mezzanine floor to the western pit. The small spot of green salt part way up on the cliff on the east side of the deeper pit, and other small spots of the same salt appearing on bowlders in the talus slide below, Dr. Stone identifies as the basic copper sulphate, brochantite. The green spot upon the wall of the crater has been called the "eel's eye," whence comes the Hawaiian name of the crater, Makaopuhi.

On June 6, 1928, another trip was made to the bottom of the crater by Messrs. W. O. Clark, G. W. Russ, R. M. Wilson, and others. Some additional interesting features were noted. The ridge-like block above the north end of the cliff of the mezzanine floor appears to be part of the original northwest wall of the crater, which at some time has tilted forward and down. This is shown by the fact that the strata exposed in the surface of this block are tilted down at a considerable angle, while those in the undisturbed wall are nearly horizontal. The steep gully filled with talus just to the west of this tilted block is the crack formed when the block separated from the main wall. This apparently occurred some time during the life of the crater before the formation of the western pit.

The present bottom of the crater is a fill of ordinary aa lava which flowed down the western talus from the fissure vent of 1922. Looking down at this floor from the lookout point on the southwest rim of the crater, the lava appears smoother than it really is when one attempts to walk across it. From the same rim viewpoint the larger rocks which form the talus slopes do not appear to be as large as 8 to 10 feet in diameter, as is actually the case.

Below the lookout point, and low down on the southwest talus of the deeper pit of the crater, is a sulphur patch very similar to those seen in the pit of Halemaumau.

This double crater is slightly over 5 000 feet long east and west, and about 3,200 feet wide north and south. The rim elevation opposite the end of the road is slightly over 2,900 feet above sea level, and the bottom of the deep pit is a little less than 2,100. The mezzanine floor is about 2,500 feet in elevation. R.M.W.

EXPLOSIVE ERUPTION OF TOKATI-DAKE

In the "Bulletin Volcanologique" Nos. 13-14, 1927, is given a description by Hidezo Tanakadate of the explosive eruption phases of Tokati-Dake beginning December, 1925. The first explosions seemed to differ in character from those which followed nearly a year later. The first phases showed no sign of new lava in the ejectamenta, and it is suggested that the explosions were caused by water heated in the upper strata of the plug of the volcano by the gradual rising of the lava column some distance below. That these eruptions were rather shallow in origin is also attested by the fact that the tremors and earthquakes which they inspired were not severe nor recorded at any great distance.

The second phase which occurred after several months of quiet brought to the surface lava bombs and fragments at such high temperature that a nearby wooden cottage took fire from the bombardment. The description suggests that these explosions of the second phase originated deeper in the throat of the volcano and were perhaps caused not only by the conversion of ground water into steam at high pressure, but perhaps also by the liberation of actual volcanic and explosive gases. R.M.W.

JAPAN'S LATEST EARTHQUAKE

Deep down in the Pacific Ocean east of Japan was the center of a severe earthquake recorded by seismographs throughout the world on Sunday, May 27. The epicenter was 39° north latitude and 149° east longitude, according to computations of the U. S. Coast and Geodetic Survey after a study of records from seismograph observatories in Samoa, the Philippines, Canada, and the United States. This is in the Tuscarora Deep, which is north of a ridge along the bottom of the Pacific Ocean extending northward from Tokio. Seismologists recognize this region as one of the world's great earthquake belts. (Daily Science News Bulletin, May 28, 1928.) R.B.H.

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No. 182 RELEASED WITHOUT COPYRIGHT RESTRICTION June 21, 1928

KILAUEA REPORT No. 856

WEEK ENDING JUNE 20, 1928

Hawaiian Volcano Observatory, U. S. Geological Survey

R. B. Hodges, Temporarily in Charge

There is nothing new at Halemaumau. A few slides have occured, but for the most part the pit is very quiet. A spot of yellow-green sulphur stain is plainly visible at the lower edge of the southeast talus. The solfatara on the east talus remains the same. Steaming has not increased. The weather remains fair, but the velocity of the northeast trade winds has increased considerably.

The east rim cracks, measured on June 18, show an extremely slight increase of width in the neighborhood of the 14-ton bowlder.

Thirty-two very feeble local earthquakes were recorded. In addition is the record of a distant shock beginning at 4:58:55 p. m. June 16 and continuing for about 2 hours and 20 minutes. The distance to origin appears to be 3,914 miles. This is very probably the earthquake at Oaxaca and Mexico City, mentioned in news dispatches.

There is steady tilting, in moderate amount, to the WSW, which is unusual at this time of the year.

PISOLITES

Pisolites, or mud rain drops, are commonly found in areas that have experienced ash fall, yet there has been comparatively little attention directed to them. Probably the earliest public mention of them was made by Dr. Edward Otis Hovey, following the explosions of Mont Pele in 1902. A few geologists have given them some attention, and recently they have been studied by Dr. J. Allen Berry, of Napier, New Zealand.

The mud balls are extremely hard and formed in layers, which give the term "pisolite." They vary somewhat in size, the largest being comparable to a marble or a large pea. A simple explanation as to how they are formed is given by Finch, in Volcano Letter No. 75, June 3, 1926, who states: "This type of ash is produced by rain drops falling through dust-laden atmosphere and collecting so much dust that they fall as mud pellets. Owing to the natural cementing qualities of the ash, they more or less retain their round shape.". Jaggar, in Volcano Letter No. 157, December 29, 1927, adds: "The condition for preserving layers of pisolites is when stiff mud-drops fall in light dry dust beds of previous eruption, and it is possible that the baking the dust has been subjected to accounts for its cement-like quality in rapid hardening." Dr. Berry, in the "New Zealand Herald," Auckland, March 24, 1928, likens their formation to hailstones, as follows: "In the formation of hailstones it is well known that the laminated structure they present is due to ascending currents of air causing the hailstone to be surrounded by alternate layers of ice and snow, due to its being carried up into layers of the atmosphere having varying degrees of temperature. In the same manner, these masses of mud were carried up into a layer of pumice dust, where there was not much water vapor, resulting in a dense lamination. As the result of increased weight, or a diminution in the velocity of the ascending currents, and these ascending currents are quite common, they fell back into the layer of pumice dust containing a large quantity of water vapor, and a less dense lamination resulted. This process of ascent and descent repeated several times would result in the formation of what is called chalazoidites, from the Greek words meaning 'stone resembling hail'."

Continuing to quote from the "Herald:" "Dr. Berry has shown from staining and X-ray methods that these laminations are characteristic of these bodies; in fact they are very similar to the layers of an onion. Although these pumice bodies, or chalazoidites, must in New Zealand have a widespread distribution, no geologist has previously directed attention to them. It is also remarkable that although they are probably a concomitant of every great volcanic eruption in any part of the world where dust with large quantities of water vapor is being ejected, the references to their occurrence in the literature are remarkably few.

"Dr. Berry has recently discovered that chalazoidites fell during the eruption of Vesuvius which overwhelmed Pompeii in 79 A. D., and that they were similar to specimens which have been found in Napier and Taupo."

Large quantities of pisolites are found on the lee slopes of Kilauea, obviously a product of the great eruption of 1790. They formed to a certain extent in the explosions of 1924. Other places where this type of ash is known to occur, other than those mentioned, are Brisbane, western Germany, Japan, and the Philippines. Doubtless it exists also in Alaska and other volcanic regions. It may occur many miles from a volcano. In the case of Napier it is 80 or 90 miles from the probable origin.

R.B.H.

NOTES

R. M. Wilson is temporarily absent from headquarters in order to install a new seismograph at the Kona station. A description of the installation will appear in the next issue of the Volcano Letter.

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No. 183 .RELEASED WITHOUT COPYRIGHT RESTRICTION June 28, 1928

KILAUEA REPORT No. 856

WEEK ENDING JUNE 27, 1928

Hawaiian Volcano Observatory, U. S. Geological Survey

R. M. Wilson, Temporarily in Charge

No changes have been detected at the pit. There are only infrequent slides and a slight increase of steaming following recent rains.

There were 18 very feeble local earthquakes recorded on the Observatory seismographs during the week ending June 27. Two teleseisms were also recorded, both on the 21st. The preliminary motion of the first one arrived at 12:18:27 a. m., and the indicated distance to its origin is 3,120 miles. The beginning of the preliminary wave of the second teleseism was recorded at 6:05:07 a. m., with 2,900 miles as the indicated distance. Both of these records were feeble, but the phases were fairly distinct.

Accumulation of tilt during the week was slight toward the east.

THE PAVLOF VOLCANO EXPEDITION

A brief radio message from Dr. T. A. Jaggar dated May 15 gave his address as King Cove, Alaska. Some additional news has now come from him in a letter of the same date written from his camp at Squaw Harbor. The expedition arrived at that place on May 9, camp was established, and the equipment tried out.

The "Honukai of Hilo" is the amphibious boat in use by the party, and was built for the expedition by the Powell Mobile-Boat Corporation, Chicago, Illinois. The name "Honukai" comes from the Hawaiian for "sea turtle." Photographs of the vehicle have appeared occasionally in the daily press during the last few weeks. It is in principle similar to the "Ohiki," described in Volcano Letters Nos. 156 and 165. The "Honukai" is a metal boat built upon a truck chassis for land travel, and is propelled in the water by twin screws as an ordinary motor boat. The amphibian was tested in Puget Sound before it was shipped to Alaska. Dr. Jaggar speaks highly of its behavior during the test and during the first days of work in establishing camp in Alaska. He states that it is tight and dry, its canopy top furnishing good protection from the weather. It is sufficiently seaworthy to navigate easily in moderately rough weather when white caps and ground swells are running. It can be "navigated" right up out of the water over the stony beaches and tundra directly to the camp site or elsewhere, and promises to be very useful and practical. Its power and speed in the water is augmented when necessary by the use of a Johnson outboard motor.

A sloop with a 5 h. p. motor has been hired locally as an auxiliary in water transportation. Two pack mules, towed upon a scow from base to base, are used when the party wishes to make expeditions inland into the mountains beyond the range of the "Honukai."

At the time of writing, it was planned to start work at Canoe Bay, at the head of Pavlof Bay, about May 18. The expedition is under the auspices of the National Geographic Society. The scientific data collected, the maps and photographs obtained, and the experiences of the party, we hope will appear in the National Geographic Magazine soon after the season is ended. R.M.W.

KONA SEISMOGRAPH STATION

The Monthly Bulletin and the Volcano Letter of the Hawaiian Volcano Observatory have from time to time mentioned the records of the seismograph that has been operated in Kealakekua since March 4, 1922. This single-component instrument has furnished data of great value. The usefulness of the station can be understood from the fact that it is directly on the other side of Mauna Loa from the Observatory, and is therefore in a strategic position to supplement the records of the Observatory in the study of that active volcano. The air line distance between the two stations is 43.6 miles, affording an excellent base from which to triangulate the epicenters of Mauna Loa earthquakes.

One of the new Hawaiian type two-component instruments has just been installed in place of the older and smaller seismograph that has so well demonstrated the value of seismic observations on the west side of the island. The new instrument is the same type as the one installed last summer in Hilo, except that the magnification is slightly reduced. The same concrete pier that was used for the old instrument is being used, with a few alterations, for the new installation. It is founded on solid pahoehoe lava, and is well protected from temperature changes in an insturment room built in a sheltered basement. Captain R. V. Woods remains in charge of the station. Operation of the new instrument was begun on June 22.

Surveys show the station to be at latitude 19° 31′ 18″ N. and longitude 155° 55′ 20″ W. Its elevation is about 470 meters above sea level. Using these coordinates, computations show this position to be 70.2 km. N. 81° 30′ W. of the Hawaiian Volcano Observatory. The summit of Mauna Loa lies almost exactly midway, in line, between these two stations.

The instrument has inertia masses of about 70 kilograms, and records on smoked paper. The static magnification is 120. Both N-S and E-W components have been adjusted to a free period of 6 seconds, and are oil damped to a 3:1 ratio. The recording drum is driven by an escapement clock mechanism, giving the paper a speed of 30 millimeters per minute. Time used is Hawaiian Standard, 10 h. 30 m. slower than Greenwich. The time clock is corrected by radio signals from U. S. Naval Radio Station NPM at Pearl Harbor. R.M.W.

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No. 184 **RELEASED WITHOUT COPYRIGHT RESTRICTION** July 5, 1928

KILAUEA REPORT No. 857

WEEK ENDING JULY 4, 1928

Hawaiian Volcano Observatory, U. S. Geological Survey

R. M. Wilson, Temporarily in Charge

Observations at Halemaumau fail to show any indication of changes in volcanic phases. Falls of rocks occur at infrequent intervals, but few of them are large enough to cause dust clouds. Wet weather has deepened the colorings in the wall stratification.

The Observatory seismographs have recorded 24 very feeble local earthquakes during the week ending July 4. One teleseism was also recorded on June 29, with its preliminary phase beginning at 12:28:15 p. m. The record was very feeble, so that all the phases as read from the record are doubtful. The indicated distance is therefore doubtful also, but is apparently 3,400 miles.

Tilt has accumulated slightly to the north-northeast during the week.

ACTION OF IRREGULAR IMPULSES UPON SEISMOGRAPHS

The general theory of seismographs is based upon the assumption that earthquake motion is simple harmonic. This is natural since the motion is an elastic vibration, but it is in fact the resultant of many simple vibrations in different directions and of many different periods. The actual net result is, therefore, a very complicated motion which defies mathematical analysis. In applying such formulas as are deduced by considering the earth's motion to be simple harmonic, it is to a certain extent unknown what errors are introduced due to this complication of motion that actually exists. The records made by seismographs cannot be expected to represent true earth displacements, motion for motion. The indicated accelerations probably roughly represent ground accelerations in order of magnitude only, except perhaps for very slow and simple movements and vibrations.

Some welcome investigation seems to have been undertaken by T. Terada and U. Nakaya to determine the effect of a series of irregular impulses upon an oscillating mechanism. In Volume IV, No. 5, of the Proceedings of the Imperial Academy (Japan) is a brief abstract describing the experiments made by these investigators. An oscillating system somewhat similar to an ordinary seismograph with its recording apparatus was arranged to be acted upon by streams of shot, so that impacts would result irregularly from opposing directions. The records made by these irregular impulses were then studied.

There are many factors entering into the action of a seismograph as ordinarily installed for the study of earthquakes. First there is the natural period of the seismograph itself; and the damping and friction attendant upon its mechanism. These are the usual instrumental constants determined by computation and experiment. Some individual parts of the seismograph, such as the recording levers or the wire suspensions of the heavy mass, perhaps have natural periods of their own which through the action of resonance may have a marked effect upon the action of the instrument under certain conditions. The foundation of the instrument may also have a natural period, and the very ground upon which the station is built may respond more easily to vibrations of certain frequency. Thus even if the earthquake motion were simple harmonic, its recorded result after passing through these various parts of the installation might easily yield a record of considerable complexity. And since actually the earthquake motion is itself complicated, its relation to the resultant motions of the recording pen is entirely too involved to be subject to exact analysis.

The records secured by the experiments here described show a remarkable resemblance in character to the usual seismographic records of real earthquakes and microseisms. In these experiments it is possible to govern the average frequency and intensity of the impulses given to the mechanism. A comparison of actual earthquake records with the records artificially obtained should show to what intensity and frequency of impulse the actual earthquake may correspond. The character of the earthquake may so perhaps be determined without the necessity of the long train of mathematical reasoning that must fall short of true results at the best.

The authors promise a more detailed description of the experiment, with discussions, to appear in Volume V of the Bulletin of the Earthquake Research Institute of the Tokyo Imperial University. R.M.W.

GENERAL DIMENSIONS OF HALEMAUMAU

The approximate center of the pit of Halemaumau is in latitude 19° 24′ 34″ north, and longitude 155° 17′ 10″ west. In its present condition it is almost circular in shape, though the northeast-southwest diameter is slightly greater. Its diameters are 3,420 by 3,980 feet. The perimeter is 1.96 miles. The depth of the lowest part of the floor below the average rim elevation is 1,170 feet. The summit of the southwest cone is 160 feet above the lowest part of the floor. The debris slopes or taluses repose at an angle of about 30° from the horizontal, which is about a 58% grade. The steeper walls stand at about 80° from the horizontal; while the average slope of the northwest wall is about 53° from the rim to its lowest toe. The area of exposed lava floor and the cones with their spatter is now about 19 acres. The horizontally projected area of all the taluses is 87 acres, and the area of the horizontal projection of all the walls is 81 acres; the slope areas are of course much greater. This makes the total area of the pit 187 acres. The southeast station at the "Halemaumau sign," which is the point from which the pit is most often viewed, is about south 30° east from the center of the pit, and the elevation of the bronze mark there is 3,651 feet above mean sea level. R.M.W.

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No. 185 RELEASED WITHOUT COPYRIGHT RESTRICTION July 12, 1928

KILAUEA REPORT No. 859

WEEK ENDING JULY 11, 1928

Hawaiian Volcano Observatory, U. S. Geological Survey

R. M. Wilson, Temporarily in Charge

Halemaumau is still very quiet, and there is nothing to indicate that any changes are about to take place. Activity of the walls is so slight as to be practically negligible. The only variation in conditions occurs when there is increased steaming in wet weather and a corresponding decrease in dry weather. Reddening of parts of the walls also occurs during rains.

Twelve very feeble local earthquakes and one faint teleseism are shown on the Observatory seismograms for the week ending July 11. The record of the teleseism, July 9, is too faint to show phases, and therefore distance to origin cannot be computed. The first sign of the preliminary phase is shown at 11:02:50 a. m.

Tilt has accumulated moderately toward the WNW.

CONTINENTAL DRIFT

The "Theory of Continental Drift," a symposium recently published by the American Association of Petroleum Geologists, Tulsa, Oklahoma, assembles the modern conceptions regarding the earth's outer layers, and digests them to brief outlines and discussions for application in this particular question. Dr. van der Gracht gives as introduction an outline of Wegener's theory of continental drift, setting forth the major evidences in its favor. Following this are comments by such authorities as Bailey Willis, Rollin T. Chamberlin, John Joly, G. A. F. Molengraaff, J. W. Gregory, Alfred Wegener, Charles Schuchert, Chester R. Longwell, Frank Bursley Taylor, William Bowie, David White, Joseph T. Singewald, Jr., and Edward W. Berry. Dr. van der Gracht then adds a few paragraphs in reply to these comments which are for the most part not in favor of the theory. Many modern ideas over a wide range of subjects have been brought forward as weapons with which either to support or to attack the theory. The discussions are of great interest not only to one who is concerned alone with the study of continental drift, but also to anyone interested in geology or geophysics in general.

Dr. van der Gracht added very materially to the strength of Wegener's theory by utilizing the calculations of Joly. These calculations tend to show that by radioactive disintegration enough heat is generated in 31 km. of depth of the earth's crust to about equal the amount of heat which that thickness of crust is capable of transmitting to the surface. This means that such a thickness of crust is a perfect blanket, and any heat generated below cannot escape through it. Joly suggests that the effect of this condition is the slow accumulation of heat, particularly under the continents, until the under part of the crust is brought to melting point. More and more of the earths under crust is fused until some escape for this heat is provided. Van der Gracht believes that this melted layer allows the continents an easy base upon which to slide and that the tidal effects of luni-solar attraction in such a liquid layer may produce the tangential power to effect the motion.

As evidences that this has happened, it is shown that the Atlantic coast lines of the Americas would approximately fit against the Atlantic coast lines of Europe and Africa. Other apparent parallelisms of coast lines would suggest that at one time there was only one great continent and one ocean, and that the continent was rifted and torn apart by these forces, the present continents being the separated fragments of the original one. The mountain ranges parallel to coasts are taken to be the crumpling of advancing edges of the continental masses as they meet with resistance in front of them. The theory attempts to plot climatic zones as defined by fossils, which existed in the geologic past about a different polar axis than the present one. These zones now seem to occur in separated arcs, but plotted on the re-assembled original continent become more perfectly arranged as true earth belts.

In a note by Wegener himself sent to be included in this symposium, it is suggested that a definite test of the theory will come from periodic remeasurements of geographic longitudes at various places. There is cited the case of the apparent change of relative longitude between Greenland and northern Europe amounting to as much as 1,190 meters in the interval of time between 1870 and 1907. Unfortunately this comparison depends upon longitudes obtained by lunar observations, which are subject to considerable error. The more recently determined longitudes by radio time signals throughout the world will establish a very definite base upon which continental movements may be checked.

Arguments against the theory are many. The most common one appears to be the doubt that there are available horizontal forces sufficient to accomplish these great results, even though great lengths of time are given these forces in which to act. It is suggested that the apparent agreement of coast lines supposedly left by the separation of continents once adjacent, is as conveniently explained as accidental. This is borne out by rock analyses taken from corresponding parts of these separated coast lines which should have been, according to the theory, at one time very close together. These analyses, made by Washington, fail to check as would be expected if the coast lines had once actually fitted together. The theory postulates that the continents are floating masses supported by a yielding layer, a condition somewhat similar to that called for by isostasy. The crust underlying the Pacific Ocean is supposed to yield slowly to the advancing continents, its action in yielding being considered more as a viscous yielding than one of crushing and fracturing. Yet it is pointed out that tectonic earthquakes occur under the Pacific, which would not be the case if the crust there could yield as a viscous layer.

The theory is based on considerable thought and the assembling of a great deal of data. Many vexing geologic problems might be solved by its acceptance. But the general opinion of those making comment upon it, however, is that the theory is not yet sufficiently well founded to accept.

R.M.W.

ERRATUM

In the "General Dimensions of Halemaumau," as given in last week's Volcano Letter, the pit diameters should be 3,420 by 2,980 feet. The latter was given too great by 1,000 feet through a typographical error.

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No. 186 | RELEASED WITHOUT COPYRIGHT RESTRICTION | July 19, 1928

KILAUEA REPORT No. 860

WEEK ENDING JULY 18, 1928

Hawaiian Volcano Observatory, U. S. Geological Survey

R. M. Wilson, Temporarily in Charge

Conditions have not changed at Halemaumau. Rockfalls are infrequent, and steaming is slight.

The seismographs of the Volcano Observatory have recorded but seven earthquakes during the week ending July 18. This is the smallest number for any week since June, 1927.

Tilt has accumulated slightly toward the east.

LASSEN REPORT No. 17

R. H. Finch, Associate Volcanologist

U. S. Forest Service Ranger W. J. Brokenshire and other Forest Service officials found a considerable quantity of lava in the top of a fir snag when it was felled during a forest fire in the latter part of May, 1928. The find was made on Sugarloaf Mountain near some fresh looking lava flows that are just to the east of Magee Peak. The lava specimens are covered with sulphate deposits, and some pieces contain charcoal. The snag, which appeared to have been dead for many years, was about 30 inches in diameter. A volcanic explosion may be offered as a possible explanation for the location of the lava specimens.

THE PAVLOF VOLCANO EXPEDITION

In Volcano Letter No. 183, June 28, 1928, there were notes on the progress of the Pavlof Volcano Expedition of the National Geographic Society, based upon letters from Dr. Jaggar dated May 15 in Alaska. At that time the party was organized in camp, and work was just beginning.

Another letter dated June 13 has just been received telling of the exploration accomplished up to that time. The amphibious autoboat "Honukai" is proving itself most practical and useful. Its weight is about the same as the "Ohiki," but it is more protected against weather and does not leak. The experiments with the "Ohiki" of the Hawaiian Volcano Research Association (see Volcano Letters Nos. 156 and 165) here in Hawaii furnished experience which has proved of the utmost value in handling the "Honukai" in Alaska. The woven steel mats first used with the "Ohiki" are being used with the "Honukai" frequently and with great profit. These mats when placed under the wheels of the vehicle allow it to be taken over soft sand and muddy places without difficulty. The "Honukai" is doing full duty both on land and water in hauling freight and passengers, firewood and camp material, in trolling for fish, and in bringing down from the foothills such game as is shot; Dr. Jaggar speaks of using five bullets to kill a 10-foot bear. As a boat it is not particularly fast, but has been found very seaworthy in heavy seas and in strong currents and tide rips, and has been found able to land successfully through fairly heavy surf. On land it is taken along the beaches and over the tundra quite easily. It makes excellent sleeping quarters for two men whether on land or on sea.

Mr. C. P. McKinley, the topographer furnished by the Geological Survey, had mapped 600 square miles of the mountain country on a scale of 1:180,000. He has used the mules to make topographic side trips up into the mountains. The rest of the party have been collecting and pressing plants and sea weeds, and at the time the letter was written had already taken about 150 excellent photographs.

Dr. Jaggar states that the geology of the region is very interesting. Some fossil leaves and shells have been found. A mountain north of Canoe Bay which is 4,300 feet in elevation has been identified as a new volcano. It has a large crater and a lake in its summit and Dr. Jaggar proposes to name it Dana Volcano.

The weather had so far been good, and on some days the temperature reached almost 70° in the sun. At that time of writing, the expedition was preparing to start on a somewhat pretentious overland trip with the "Honukai" across the foothill country on the east part of the Pavlof Bay-Bering Sea isthmus. The object was to get into a chain of lakes on the Bering Sea side.

It was expected that wild flowers would soon be out in great profusion. Specimens will be collected, and many color photographs will be taken. Already 1,500 feet of motion picture film have been taken and shipped out.

R. M. W.

LAVA SLICKENSIDES

In the New Zealand Journal of Science and Technology, Vol. X, No. 1, May, 1928, is a brief description of an igneous dyke recently exposed in a quarry at Aukland. The faces of the dyke show striations, which were apparently formed when the mass was still soft, and was being forced up into the volcanic debris and scoria in which it was found. The writer suggests that had striated blocks from such a dyke been found in a talus deposit, or in less obviously associated surroundings, they might easily have been taken to be of glacial origin.

R. M. W.

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No. 187 RELEASED WITHOUT COPYRIGHT RESTRICTION July 26, 1928.

KILAUEA REPORT No. 861

WEEK ENDING JULY 25, 1928

Hawaiian Volcano Observatory, U. S. Geological Survey

R. M. Wilson, Temporarily in Charge

An avalanche from the northeast wall of Halemaumau occurred on July 20 at 4 p. m. Dust resulting was seen above the pit rim about five minutes later. On July 21 two dusty scars showed on the northeast wall, and a heap of new debris lay at the foot of the wall between the northeast and north-northeast taluses. The north wall is quite red from wetting. No other changes have been observed.

One feeble and 15 very feeble local earthquakes were registered during the week. The feeble shock occurred July 21 at 1:05 p. m., and had an indicated distance to origin of 15 miles. There was also the faint record of a distant earthquake beginning at 8:47:36 a m. July 18.

There was a slight accumulation of SSW. tilt.

Microseismic motion was slight throughout the week.

THE ISOTHERMAL SURFACES OF THE EARTH'S CRUST

In the American Journal of Science of June, 1928, is a discussion of isogeothermal surfaces by Van Ostrand. This represents a more general attack on the problem inspired by the various local investigations at different places for oil bearing formations. Mr. Van Ostrand applies formulas for conductivity of heat through earth crust materials, and works out the thermal gardients that would result if the earth had cooled to its present condition by conduction and radiation from an original state of high and uniform heat. The result of this mathematics is a set of perfectly regular isothermal surfaces. But actually these surfaces are irregular, conforming to local conditions of structure, conductivity, moisture content, and geologic formation. The oceans carry off heat from the underlying crust by convection, and therefore the isothermal surfaces in low latitudes are depressed under the oceans. It is supposed, however, that these isothermal surfaces are in general smooth and without abrupt variations.

In the discussion an important place is not given to the possible heat generated by radioactive decomposition, as suggested by Joly (see Volcano Letter No. 185).

The general problem when modified by the effects of surface configurations such as mountains, valleys, or oceans, by known details of geologic structure, and by known mean surface temperatures, will give the expected variation of temperature with depth Thus when abnormal temperature conditions are encountered, they may in many cases be used as indications of local irregularities of some sort in the earth's crust. It is found that the salt domes of oil bearing areas are associated with elevation of these isothermal surfaces and this principle is taken advantage of as an aid in determining the extent and shape of such formations.

This line of investigation would probably have application in the vicinity of a volcano to determine at least where the most recently active parts of the structure might be. It is known that heat flows slowly through rock, and it is probable that the intrusion of magma into a region could not be detected by changes of temperature at any great distance except after the passage of a considerable period of time. This assumes, however, that the layers blanketing such an intrusion are not cracked or punctured in any place to allow convection.

The temperature borings undertaken in the vicinity of Kilauea by the Hawaiian Volcano Observatory represent a still more localized application of the problem. Here the different strata have been laid down in very recent times at high temperatures. The entire floor of the crater is broken up by many cracks which furnish means of escape of heat from the lower layers by convection as well as by conduction. Since here the temperatures involved are great and the distances small, a great precision of temperature measurement is not so essential as in the case of the more thoroughly adjusted areas existing in older regions. Isothermal surfaces determined in the lava fill of Kilauea Crater should indicate by their shape the position of those parts most recently deposited, and should show where cracks are allowing heat to escape by convection.

R. M. W.

GEOPHYSICAL PROSPECTING

The use of specially designed seismographs in prospecting for oil bearing formations has been discussed occasionally in preceding issues of the Volcano Letter. The development of geophysical methods toward the particular end of commercial prospecting is receiving considerable attention, as may be judged by an article in the New Zealand Journal of Science and Technology for May, 1928, by Donald C. Barton. The use of the Eotvos balance is given the most important place among the methods he mentions. The seismic method comes next. There follow the methods using tests of the earth's crust for electrical conductivity, and for magnetic properties.

These methods of prospecting are considered sufficiently important to oil companies so that the expenditures in our southern oil producing states is estimated to be $400,000 a month on geophysical investigations alone. Other countries have been using the same methods in a lesser degree. The discovery of several oil fields and the mapping of others has come about through the use of these investigations.

The demand for their use has been greatest in the field of oil prospecting. There is no reason, however, why these methods, which are now so well developed, may not be used in prospecting for ores or other resources hidden beneath the earth's surface. Their application has already been used in Japan to account for certain details of seismic and volcanic mechanism. There is possibility that with more development it may yet be possible through their use to discover more definitely and more in detail the structure and mechanism of a volcano.

R. M. W

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No. 188 RELEASED WITHOUT COPYRIGHT RESTRICTION August 2, 1928

KILAUEA REPORT No. 862

WEEK ENDING AUGUST 1, 1928

Hawaiian Volcano Observatory, U. S. Geological Survey

R. M. Wilson, Temporarily in Charge

Wet weather at Kilauea Volcano on July 26 and 27 increased considerably the activity of steam jets in Halemaumau and on the outer crater floor. There have been a few slides from the pit walls caused by visitors rolling bowlders over the edge, but no natural ones of any size. Slight fresh cracking of the ground has occurred about the south rim station. Dusty slides at the south corner were noticed on July 19.

Several patches of buff colored ash of 1924 are still noticeable in depressions on the crater floor.

Measurements of the east rim cracks on July 30 showed a few minor differences.

The seismographs recorded 28 very feeble local earthquakes during the week.

Tilt has accumulated moderately NNE.

Recent surveys around the pit show that there have been four major cave-ins from the rim during the past 12 months. One strip about 400 feet long just to the northwest of the 1920 rift tunnels has fallen in. Directly over the northwest talus a strip about 700 feet long and containing nearly an acre has fallen in since the surveys of last year. The falling in of this part of the rim very likely represents the avalanche which caused the squeezing up of liquid lava on January 11, 1928. Another piece is gone from the north-northeast rim, just over the north end of the intrusive mass; probably the accumulative result of the minor avalanching that has been going on there so frequently during the past year. A long narrow strip having an area of about 0.7 acre has also fallen in from the east-northeast rim.

THE CALDERA PROBLEM

Several theories have been advanced to explain why many volcanoes are encircled by outer craters of which the diameters are great if compared to the apparently localized centers of activity. These calderas, sometimes with extended flat bottoms, are usually supposed to have been caused by volcanic explosion or by subsidence and collapse. Thus a volcano may build itself up as a perfect, sharp cone, with only a small summit crater, until an explosion causes its top to be blown off, thereby creating a summit crater of greatly enlarged proportions. This summit crater may then gradually fill, resulting in a large caldera with only localized activity within it. Again a volcano may proceed to build itself as a perfect cone until such time as the lava column retires and allows the summit portions to collapse inward upon the descending lava. This again would result in an enlarged summit caldera.

A new idea has recently been advanced by Sandberg, Koninklijke Akademie van Wetenschappen te Amsterdam, who believes that neither of the above ideas is the true one. He suggests that the explosion theory would not necessarily leave the inner walls so nearly perpendicular and so nearly circular in shape, as is the usual case. He believes that the large volumes represented by some of these calderas could not have collapsed into a comparatively restricted volcanic throat. The new theory is that these large calderas, which are usually circular and have steep inner walls, actually represent the tops of former great volcanic throats extending in undiminished size down into the volcano. Thus these "cone pipes" measured by the diameter of the outer caldera would suggest older volcanic activity on a greatly enlarged scale. As volcanic activity decreases, the volcanic throat diminishes in diameter until the remaining activity occupies a comparatively restricted area within a greater encircling caldera. As so many volcanoes now show smaller cones and throats within greater encircling calderas, it is taken as evidence that volcanism has diminished by that ratio within rather recent geologic time.

At Kilauea Sandberg describes the larger crater, which is approximately oval in shape and 3 by 2 miles in length and width, as being the top of the original "cone pipe" of Kilauea Mountain. The walls of Kilauea Crater, would, according to this idea, continue almost vertically downward nearly to the bottom of the mountain structure. Later activity having diminished, this large pipe has filled, and the activity has become centralized at Halemaumau, which now represents in turn the size of the reduced volcanic throat in which the lava column rises.

The explosive eruption of 1924 was a comparatively small one of its kind, as is testified by the much thicker beds of older explosive ejactamenta underlying its debris. During this eruption, the explosions which threw material from the pit, the avalanches from walls rendered unstable upon the retirement of the lava, and the material engulfed which followed the lava as it retired, enlarged the pit to double its former diameter. Geodetic measurements have shown that at this time the central parts of the floor of Kilauea Crater surrounding the pit settled by as much as nine feet in places with respect to the surrounding country. Thus even this small eruption did a great deal toward working the walls of the pit back and forming a larger caldera. Had the processes of this eruption been continued through longer time and in greater violence, the entire floor of Kilauea might have been eaten away and either engulfed or thrown out as ejected material. Had the processes continued still farther, the walls of Kilauea Crater itself might have been eaten back from their present position. The present position of the walls of the crater probably represent the limit of action of such a destructive phase in the history of the volcano. Evidences of this exist in the number of down-faulted blocks around the rim, which seem very suggestive of the method of development and enlargement of the great crater. These down-faulted blocks would have no place in the large volcanic pipe theory suggested by Sandberg.

R.M.W.

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No. 189 RELEASED WITHOUT COPYRIGHT RESTRICTION August 9, 1928

KILAUEA REPORT No. 863

WEEK ENDING AUGUST 8, 1928

Hawaiian Volcano Observatory, U. S. Geological Survey

R. M. Wilson, Temporarily in Charge

There has been slightly increased avalanche activity at Halemaumau during the past week. The slides occur mostly at the north end of the northeast sill. No other noteworthy changes have been observed.

Twelve local earthquakes and one distant shock were registered on the seismographs. One of the local earthquakes, classed as feeble, occurred at 7:50 p. m. August 7, and was felt by a few persons in the volcano district. The teleseism recorded very faintly, the preliminary wave beginning at 8:06:24 a. m. August 4.

Tilt was moderate to the SW.

POWER FROM NATURAL STEAM

The development of power from natural steam issuing from the ground has been for some time a fact in Italy (Volcano Letters 32 and 97). Development of natural power of this sort has now been made in California at The Geysers. A brief description is given in the July 7, 1928, issue of "Nature" by Allen and Day of the Geophysical Laboratory of Washington. Experiments were started there about six years ago in a small way, until outside capital became interested, making possible a more complete development of the power at hand. The area which shows signs of abnormal surface temperature is a narrow strip about 25 miles long, but the more intense thermic activity is limited to a smaller area only about six miles long and one-quarter mile wide. Wells have been sunk to various depths from 400 to 650 feet by allowing cold water to flow into the well while the drilling operations were in progress. This cold water condensed the steam and so reduced the steam pressure, allowing the operations to proceed without undue difficulty. The steam pressure made available in five new wells varies from 95 pounds to 276 pounds per square inch, and issues in such volume as to make available for power an average per well of about 1,000 kilowatts. The wells are rather close together, the distance between them varying from 50 to 175 feet, yet apparently there is no lessening in steam pressure of any of these wells due to the discharge of steam from the others. The original two wells which were drilled before the advent of outside capital were utilized to operate the electric lighting plant for the inn and cottages located nearby. Plans have been made for the commercial use of the increased power available from the newer and larger wells.

It is pointed out that in all probability this steam comes directly from underlying masses of hot magma. The steam is superheated to such high temperatures that the idea of its coming from an underground water reservoir does not seem reasonable. Additional evidence is the fact that the gases brought up with the steam are those that would be expected to issue from hot magma. These are particularly carbon dioxide, hydrogen sulphide, nitrogen, and argon, and traces of other gases. Thus these indications seem to point to hot magma as the origin of the virgin steam, rather than to the mere heating of infiltrated surface water by hot strata. It is noted that here again heat at the surface in the form of natural steam or hot springs is probably an indication of the presence of a deep fault. R.M.W.

PREDICTION OF EARTHQUAKES

The daily press is prone to give considerable space to those who desire to predict calamities. The predictions of Professor Raffaele Bendandi, of Faenza, Italy, have been given considerable publicity. It is the habit of this forecaster to make frequent and rather vague predictions as to coming earthquakes, tornadoes, and tidal waves. Earthquakes occur in considerable frequence on our world, which may yet pass unnoticed except by seismologists, unless they happen to occur in some thickly populated area where damage to humanity results. It is safe to prophesy a great earthquake at almost any time one may wish, and then afterward to point to a selected earthquake which may appear to justify the prophecy, if one is not too particular as to precise time and locality. The prophecies of Professor Bendandi have been subjected to analysis by Mr. James Young, of Toronto, Canada, who has found that no more of these prophecies have been properly fulfilled than would be expected from the laws of chance, merely. He points out that many of the earthquakes selected by Bendandi as justifications of his prophecies, while they may occur within a few days of the time set, often fail by whole continents to agree with the prophesied locality. It is also pointed out that several of the greatest and most disastrous earthquakes were not predicted at all. Thus it would seem that Professor Bendandi may make his prophecies merely at random, afterwards making use of a far fetched chance method to justify them.

Earthquake prediction by conventional scientific methods is by no means impossible. The tiltings, changes of level, and horizontal creeps of the earth's crust discoverable by geodetic measurements are apparently proved to be forewarnings of earthquakes by a number of actual observed cases in Japan and California. These movements probably represent elastic crust yielding before earthquake fracture occurs. RM.W.

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No. 190 RELEASED WITHOUT COPYRIGHT RESTRICTION August 17, 1928

KILAUEA REPORT No. 864

WEEK ENDING AUGUST 15. 1928

Hawaiian Volcano Observatory, U. S. Geological Survey

R. M. Wilson, Temporarily in Charge

Halemaumau presents an extremely quiet and peaceful appearance, and there is absence of any indication of volcanic activity in the near future. Slides were noted at 2:40 p. m. August 9, 3:15 p. m. August 11, and 9:15 a. m. August 15. Steaming is extremely slight in the pit.

Fourteen very feeble local earthquakes were registered on the seismographs at the Observatory. It is interesting to note that nine of these occurred on August 8, and that one shock was a three-minute tremor coming just after noon. Beginning at 9:51:21 p. m. August 11 is a brief disturbance, presumably a faint trace of a teleseism.

Microseismic motion is considerably below normal.

The net accumulation of tilt for the week is strong to the NNE.

SOUTH AMERICAN EARTHQUAKES

The following extract from "Harper's Weekly" of December 5, 1868, indicates that inhabitants of the Pacific Coast region of South America must always have lived in fear of disastrous earthquakes.

"The Spaniards in South America were not without early intimation of the insecurity of the soil. Lima was founded in 1535, under the high-sounding title of Ciudad de los Reyes, or City of the Kings, since altered to its present name. In 1582 Lima had its first recorded attack of earthquake. The centre of the shock, however, was lower down along the coast, in the neighborhood of Arequipa, founded by Pizarro some twelve months after the establishment of Lima. Arequipa was laid in ruins then as now; but Lima escaped with a warning. Lima's turn, however, was not long in coming. Four years afterward it was laid prostrate; and so great was the catastrophe, even in that land of catastrophes, that the anniversary of that destruction is solemnly commemorated to the present time, on the day of the Visitation of Elizabeth. Lima had its third attack in 1609. In November, 1630, there was another earthquake; but so many of the citizens contrived to escape that they, then and there instituted the Festival of Nuestra Senora del Melagro, which is celebrated annually to this day.

"Thenceforth, earthquake and city may be truly said to have entered into contest for possession of the soil. Earthquake returned to the charge in 1655 with such violence that, for the first time, the citizens camped for several days in the country districts around. When they returned they found no stone standing on another; nevertheless the city rose again. After this there was no earthquake for some twenty years. Again, ten years later, in 1687, at four o'clock in the morning, houses and public edifices came tumbling down without the least previous intimation, the inhabitants, as usual, rushing into the squares and open spaces. The miserable consolation, however, of looking on in safety was this time denied them. At six in the morning the earthquake repeated its attack with renewed vigor, and the sea, retiring and rising in a wall of inky waters—as it did in the great earthquake of this year (1868)—dashed back with overwhelming force over the land. Callao, which had arisen as the port of Lima, a few miles from it, was entirely destroyed, and most of the inhabitants were carried away by the receding waters. The local records, preserved to us by Don Antonio de Ulloa, captain of his most Christian majesty's navy, mention this as the most disastrous visitation to that date. December, 1690, September, 1697, July, 1699, February, 1716, January, 1725, December, 1732, were all earthquake months in Lima. In 1734 and 1745 there were more earthquakes. On the 28th of October, 1746, at half past ten at night, the first shock was felt of another earthquake, and within the space of three minutes all the buildings in the city, great and small, public and private, were heaps of ruins, burying with them those inhabitants who had not been quick enough in escaping to the squares. Then succeeded a moment's calm, as when the heavy ordnance has opened the battle, and the lighter, but more numerous, musketry prepares to follow. Soon it began again, and the houseless, homeless inhabitants counted two hundred distinct shocks within the following twenty-four hours. These shocks continued until the February of the following year, and were computed at four hundred and fifty in all. On this occasion the port of Callao sank quite down below the level of the sea. Nothing was left standing save a piece of wall belonging to the fort of Santa Cruz, on which twenty-two persons contrived to save themselves. Of the twenty-three ships then in port, nineteen were wholly sunk, and the remaining four carried a considerable distance inland. Of the four thousand inhabitants which the port of Callao then numbered, only two hundred survived. In Lima thirteen hundred dead bodies were excavated from the ruins, exclusive of great numbers of maimed, who afterward died of their hurts. Commander Wilkes, of the United States exploring expedition of 1849, was able in that year to define the site of the old port of Callao beneath the sea." R.B.H.

THE HAWAIIAN SEISMOGRAPH

Another set of instruments, of the type developed and manufactured in the laboratories of the Hawaiian Volcano Observatory, is being tested prior to shipment for installation at Dutch Harbor, Alaska. This is the sixth set of instruments of the series built at the Observatory. The other five sets are distributed as follows: Hilo and Kealakekua, Hawaii, stations operated by the Hawaiian Volcano Research Association; Kodiak, Alaska, station, and Lassen Volcano Observatory, Mineral, California, operated under the Section of Volcanology, U. S. Geological Survey; and U. S. Coast and Geodetic Survey, Washington, D. C., for test before installation at Sitka, Alaska. A description of the instruments appears in Volcano Letter No. 142. R.B.H.

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No. 191 RELEASED WITHOUT COPYRIGHT RESTRICTION August 23, 1928

KILAUEA REPORT No. 865

WEEK ENDING AUGUST 22, 1928

Hawaiian Volcano Observatory, U. S. Geological Survey

R. M. Wilson, Temporarily in Charge

At 9:50 a. m. August 18 the north wall of Halemaumau was working very slightly. Two falls of rocks were heard in 10 minutes from that side, and another from the northeast corner. The north wall and talus gave the appearance of having had numerous small slides. During the "Pageant to Pele," presented to a large audience at the side of the pit from 9 to 11 p. m., there was nearly constant avalanching, filling the air with dust, and at times drowning the exercises. By daylight August 19 could be seen heavy coatings of red dust on the floor and walls of Halemaumau and on the south Kilauea floor. The avalanching continued at irregular intervals, coming from blocks tumbling from the north rim, and gathering debris along their course. Examinations show that widely cracked areas formerly back of the north rim have gone in, and that there are numerous fresh cracks of varying sizes. Many of the new cracks are emitting steam, and several of those that are dry are allowing the escape of heat. At the present time there is still some sliding from the north rim.

The Observatory seismographs have recorded nine local tremors during the week ending August 22. These were all very feeble with the exception of one which occurred at 10:47 p. m. August 18. This one is classed as feeble, and was apparently caused by an unusually large avalanche in the pit of Halemaumau. Tremors of this magnitude can very seldom be ascribed to avalanches, yet the evidence points to the fact that this one is the result, and not the cause of an avalanche. The amplitude increases gradually to the maximum, and fades out again gradually; there are no phases to be recognized, as would be the case in a true earthquake. The record of the same disturbance from the Uwekahuna seismograph is 25% greater in amplitude, in spite of the fact that the magnification of that instrument is less than the corresponding factor for the instruments at the Volcano Observatory. This is easily explained in the case of an avalanche tremor by the fact that the Uwekahuna instruments are but 0.7 mile from the pit, while those at the Volcano Observatory are 2.6 miles away. This tremor was the climax of a series of five avalanche tremors, of which the first was at 9:41 p. m. Thus the Observatory seismographs bear witness to exceptionally heavy avalanching during the evening of the 18th, when there were present at the edge of the pit well over a thousand spectators who had come there to see the entertainment furnished by the program of the Cook Sesquicentennial.

Microseisms throughout the week have been normal. Slight tilt has accumulated toward the northeast.

THE PAVLOF VOLCANO EXPEDITION

A letter from Dr. Jaggar dated July 11 gives us additional notes of the progress being made by the National Geographic Pavlof Volcano Expedition, of which he is the Director. The letter was written in camp at the north end of Pavlof Bay, just east of Pavlof Volcano. The party had just completed a trip into the interior of the Peninsla, where two comps were made on the northeast base of the volcano. From these camps a nine-day side trip was made to the region north of the mountain, where an interesting bit of volcanic topography was found similar in nature to the Chaos Jungle at Viola on Mount Lassen, California. A view into the crater of Pavlof was had, and two inner cones were seen. In the crater there was also visible an old lava flow and considerable steam from a number of solfataras. No hot springs were found, but mineral springs were discovered on two occasions.

The topographic section of the expedition had mapped 2,000 square miles of country. The expedition had taken 225 photographs and a considerable number of color plates. Wild flowers are there in abundance, and specimens of the different kinds have been collected and pressed. Dr. Jaggar says that fossils have been found and that the geology of the region is very interesting. The geologic details, however, must wait for a more thorough investigation by some geologist in the future who will be able to base his work upon the present reconnaissance and the topographic maps being made by the party.

The weather has been bad, especially from the point of view of the topographic party, who need clear weather for long distance photography and plane table operations. There have been hundreds of caribou seen, and 25 to 30 bears. The expedition has had no difficulty in keeping its larder stocked with meat, fish, and clams at all times. Salmon have been caught with a small seine operated by the "Honukai."

The "Honukai" is still holding its place as one of the most useful units in the expedition's transportation. It traverses the beaches with ease, and can go over the greater part of the dry tundra country. Swampy tundra and "niggerheads" have at times caused it to turn back, however. The use of the steel mats in soft places, as suggested by the experience with the "Ohiki" in Hawaii, has proved valuable in the extreme.

At the time of writing, the expedition was planning to go westward to Volcano Bay as the last lap of the season's explorations.

A radio message has just been received from Dr. Jaggar stating that the work was completed and the expedition was starting back home from Alaska on August 16.

R.M.W.

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No 192 RELEASED WITHOUT COPYRIGHT RESTRICTION August 30, 1928

KILAUEA REPORT No. 866

WEEK ENDING AUGUST 29, 1928

Hawaiian Volcano Observatory, U. S. Geological Survey

R. M. Wilson, Temporarily in Charge

There was rather active avalanching from the north wall of Halemaumau on August 24. Since that time the wall has continued to be restless, with numerous falls of rocks and an occasional dusty slide. The south wall has had a few slides recently, as shown by streaks in the heavy dust coating of the south talus. The whole pit interior is still thickly coated with dust from the avalanches of August 28.

There have been eight very feeble local earthquakes and one teleseism recorded on the Observatory seismographs during the week. The record of the teleseism was feeble; the arrival of the preliminary phase is shown at 11:23:00 a. m. on August 24. Subsequent phases suggest a distance of 2,800 miles to the origin.

Microseisms have been more feeble than normal. Tilt has accumulated moderately toward the NW.

THE ISOSTASY OF HAWAII

An article of exceptional interest to the Hawaiian Volcano Observatory has appeared in the American Journal of Science of August, 1928, by Roy W. Goranson. The primary object of the investigation outlined was to discover the density of the island mass of Hawaii. The method of attack, through the use of gravity observations, has also developed some interesting conceptions as to the state of isostatic adjustment of the island.

The first part of the paper outlines briefly the method of computing theoretical gravity. Correction for isostatic adjustment is given considerable space, and it is shown that lack of knowledge of the true distribution of mass in the earth's crust leads to a rather wide range of possible values in arriving at this correction. Isostasy is accepted as a fact, but its precise mechanism is not fully determined. Geology and seismology may eventually yield data which will determine how the variations of density are distributed in the isostatically adjusted earth crust. Another problem of isostasy which has a direct bearing on the calculation here discussed is the strength of the earth's crust. How large may an uncompensated topographic mass be and still be upheld by this crust?

The large values, all positive, of the local anomalies of gravity have led this investigator to believe that the island of Hawaii is for the most part not compensated. That is to say, the island mass is present as an isostatically unbalanced load upon the earth's crust, its excess of matter causing the large values in the observed gravity.

To put this in figures, the island is resting on the ocean floor with a pressure amounting to 9,700 pounds per square inch over an area of about 19,000 square miles. If this great mass is not isostatically compensated, it is being supported simply by the strength of the earth's crust which forms the ocean floor. It is suggested that this load is just about the greatest that can be so supported. Isostatic adjustment is probably attained only with the passage of geologic time, so that it is conceivable that this island has been volcanically built at such a rate as to be still largely uncompensated. He believes that the island of Hawaii is even now gradually accomplishing its adjustment by gradual sinking and downfaulting. This might easily account for the downfaulting areas around the coast of the island as in Puna, Kona, and perhaps Hamakua and northeast Kohala

Again to express this in figures. it is suggested that if the island as it now stands is not at all compensated, and if the earth's crust beneath it has no strength it would be expected that the island as a whole would settle downwards 11,000 feet to accomplish total isostatic adjustment. This would leave the tops of Mauna Kea and Mauna Loa projecting above the ocean as small islands with summit elevations of only about 2,800 and 2,600 feet above sea level. This of course represents the extreme case. Presumably isostatic adjustment is already partly accomplished, and it is known that the earth's crust has considerable strength, so that perhaps a sinking of only 8,200 feet should be taken as an estimate.

It is suggested that this mechanism explains the general progressive diminishing elevation of the islands of the Hawaiian group towards the northwest which may once have been as high as Hawaii. These islands perhaps increase in age toward the northwest; they have had more time to settle and to more completely accomplish their isostatic adjustments. This may also be an explanation of the gradual sinking of basaltic ledges in the ocean with the coral growths on their tops having to grow higher and higher to maintain their position at the ocean surface.

The object of the calculation was primarily to discover the density of the bulk of the island. H. S. Washington is quoted as giving a density of 2.96 for the average value of Hawaiian rock material. As it lies in place the apparent density of the rock would be considerably less, perhaps as little as 2.0, due to its vesicularity and loose bedding. From the evidence furnished by gravity stations on the side and top of Mauna Kea, Goranson calculates 2.12 as the density of the upper part of the cone of Mauna Kea. Similarly, the upper portion of Mauna Loa, lying above 4,000 feet of elevation, is given a density of 2.52, resulting from the use of gravity determinations at Kilauea and at Mauna Loa summit. For the whole island cone from its base on the ocean floor to the summit he gives an average density of 2.69. Thus it is apparent that the densities at higher elevations are smaller. This would be expected due to the compacting by pressure of the lower layers and the probable intrusion of dykes of denser material in the lower structure. Summing up, the density of the mountains of Hawaii is given as lying between 2.40 and 2.63, the probability favoring the lower value. R.M.W.

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No. 193 RELEASED WITHOUT COPYRIGHT RESTRICTION September 6, 1928

KILAUEA REPORT No. 867

WEEK ENDING SEPTEMBER 5, 1928

Hawaiian Volcano Observatory, U. S. Geological Survey

R. M. Wilson, Temporarily in Charge

Avalanching from the north wall of Halemaumau is not so active; only a very few small slides now occur. Dusty slides were rather frequent on August 30 and 31. New cracks back of the north rim appear to have widened slightly. The odor of chlorine gas was noticed in that area during a circuit of the pit on August 31. There are scattered new coatings of white salts on the north wall.

There have been recorded only seven local tremors during the week. One at 11:04 p. m. on August 30 was classed as feeble, but was reported perceptible to a few people in the vicinity. All the others were very feeble.

Microseismic motion has been more feeble than normal during the past weeks, but increased slightly in amplitude on September 4. Tilt has accumulated slightly toward the NE.

TILT

Ground movements are becoming increasingly important as indications of forces acting beneath the earth's surface. Pressures set up by volcanic action or by the stresses accumulating in the earth's crust which tend towards earthquake conditions may be thus sometimes detected at the surface. Triangulation for measurement of horizontal displacements has yielded interesting data in a number of places, notably in the areas of the major faults in California, and in Japan in the region shaken by the great Kwanto earthquake of 1923. Leveling has shown vertical displacements largely resulting from earthquakes, in cases too numerous to mention. Triangulation and leveling are expensive operations, and cannot be used as a means of keeping continuous watch over ground movement. The accumulated movements during a period of months or years may be discovered by retriangulation or releveling over an area, but the day by day development of movement cannot be watched by these methods.

Tilt, or tipping of the ground surface, must obviously occur in a region where change of relative elevation takes place. Occurrence of tilt may therefore be taken as an indication of ground movement involving changes of elevation. It is possible to make continuous record of tilt. Omori, some 20 years ago, started the recording of tilt in Japan with a pair of long period horizontal pendulums. In fact, most horizontal pendulum seismographs are competent to record it with greater or lesser degrees of accuracy, according to their design. A clinograph designed by M. Ishimoto is a small bi-filar horizontal pendulum, optically recording, which has been used to some extent in Japan specifically for measuring tilt. Temperatures of ground and instrument affect all such arrangements to a certain degree. The most precise tilt measurements so far made perhaps resulted from the experiments of Michelson and Gale; these observations were so accurate as to detect tiltings due to the earth tide, for which purpose they were made.

Continuously recorded tilt as observed at the Hawaiian Volcano Observatory has been most valuable in the study of the volcanic phases of Kilauea (see Volcano Letter No. 41, October 8. 1925). Tilt as considered in Japan in connection with great earthquakes is briefly outlined by Imamura and Haeno in "Proceedings of the Imperial Academy," Tokyo, IV, 1928, No. 4. Here it seems possible that continuously recorded tilt may be the key to the foretelling of earthquakes. Stations near or in an area wherein ground stresses are accumulating would be expected to record the bending and elastic yielding of the rock crust caused by such stresses before their release in fracture and earthquake. It would not be difficult to maintain a considerable number of tilt stations scattered over a suspected region.

A number of cases in Japan are cited where abnormal tilt actually occurred and was recorded before an earthquake. The Kwanto earthquake of 1923, with its many and great upheavals of the earth's surface, would doubtless have been very rich in data of this sort had there been more stations to record the tilt. As it was, a slow shoreline subsidence was noted preceding the earthquake which must have meant the presence of very considerable tilts. Seismographs in Tokyo actually did record some of these precursory tilts. From July 30 to August 17, 1923, a definite surge of abnormal tilt was noticed, and then after an intermission of two weeks a very sharp surge of tilt in the same direction began and continued for eight hours, at which time the earthquake occurred. There are no less than nine other cases where abnormal tilts of from 7 to 30 seconds were observed as preliminaries to major earthquakes. The earthquakes followed the recording of these tilts after a period of from four days to two weeks.

The Advisory Committee in Seismology of the Seismological Society of America emphasizes the importance of tilt by making it one of the four subjects important for future attention.

With instruments of the horizontal pendulum type, and perhaps with others when they may be designed, the changes of air and ground temperature at the station cause trouble in recording tilt. Most records show cyclical variations, diurnal and annual, which are in all probability not caused by the volcanic or seismic tilt which it is desired to study. It is sometimes difficult to separate from the composite motion recorded the components which are due to these particular movements. Most types of tilt recording instruments are not provided with methods for absolute check whereby the accumulative instrumental errors may be eliminated. Thus an instrument may gradually settle on its foundation, and so record false tilt. It cannot be known whether this is true tilt unless it is determined that the ground upon which the instrument stands has partaken of the same amount of motion. This is a function of precise leveling in connection with tilt; that is, to analyze the apparently accumulated tilt. By leveling, or other outside observations, it may be possible to see whether the accumulation shown by the instrument over a long period of time is an actual accumulation of tilt or merely an accumulation of errors and instrumental change.

R.M.W.

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No. 194 RELEASED WITHOUT COPYRIGHT RESTRICTION September 13, 1928

KILAUEA REPORT No. 868

WEEK ENDING SEPTEMBER 12, 1928

Hawaiian Volcano Observatory, U. S. Geological Survey

R. M. Wilson, Temporarily in Charge

Halemaumau has been quiet during the past week. A few slides have occurred, but no notable changes have been observed. Crack measurements on September 10 show a few minor differences.

There have been 24 local earthquakes and one teleseism recorded on the Observatory seismographs during the week. One of the local shocks, at 2:27 p. m. on September 11, is classed as feeble, but was felt by a number of people in the vicinity. The distance to its origin is 14 miles from the Observatory. All the other local shocks were very feeble. The teleseism, also on September 11, made only a feeble record, and the phases could not be definitely distinguished. The beginning of either the secondary or the long wave is shown at 2:20:06 a. m. Hawaiian standard time.

An earthquake reported felt in Kona at 8:30 p. m. on September 4, whose origin was indicated on the seismograph there as being seven miles from Kealakekua, was recorded at the Hawaii Volcano Observatory as a very feeble tremor.

Microseismic motion was slightly stronger during the first part of the week; and tilt has accumulated moderately toward the SW.

MICROSEISMIC MOTION

Microseisms are found to exist at practically all seismological stations, and it is presumed that all parts of the earth's surface are subject to these slight but continuous vibrations. They probably act differently in different localities, and have their origin in various causes. In general these oscillations have periods of from 2 to 10 seconds, and amplitudes of motion of from 0.02 mm. to 0.5 mm. They are usually continuously present, but wax and wane in amplitude. It is sometimes difficult to read from seismograms the weak preliminary motions of a true earthquake when microseisms are thus being continually recorded, as they frequently mask the earthquake motion which it is desired to observe.

Considerable study has been given to microseismic motion to determine its nature and cause, but a direct and satisfactory explanation has not yet been reached. An enlightening investigation by Takeo Matsuzawa is described in Volume II, Part 5, of the Journal of the Faculty of Science, Imperial University of Tokyo. This investigator in studying the types and causes of microseisms at Tokyo remarks that his results must of necessity be influenced by the particular locality. Studies carried on at other places would presumably develop individual microseismic characteristics. His suggestion is that each small part of the earth's crust composes a local oscillating system, having in each place its own characteristics as to natural period and ease of oscillation. Such a system, depending upon local topographic shape, density, material, geologic structure, etc., would naturally be very complex, and would probably respond to a number of different natural periods, together with their harmonics. Microseisms at stations only a few kilometers apart have different characteristics, while those recorded at stations close together usually appear to be somewhat similar in period and amplitude.

At Tokyo Omori found three particular types of microseisms, perhaps resulting from the more outstanding natural periods of vibration of the particular locality. For the first of these types Matsuzawa gives periods of from 2 to 3 seconds, with normal range of motion of about 0.02 mm.; the second type has a normal period of 4 seconds, and range of motion of 0.05 mm.; and the third has somewhat irregular periods ranging between 6 and 9 seconds, and sometimes attains a range of motion amounting to 0.5 mm.

As to the agencies inspiring these vibrations, those suggested are changes of atmospheric pressure, changes of temperature, wind, ocean wave action on nearby coasts, ocean tides, precipitation. This investigator considers change of atmospheric pressure the chief cause of microseismic motion at Tokyo. Wind produces certain effects due to the shaking of the buildings which shelter the instruments, but apparently affects true michroseismic motion only to a limited degree.

The correlation between changes of barometric pressure and the amplitude of microseismic motion seems well established at Tokyo. Many cases are cited wherein the general presence of barometric depressions due to cyclones has produced definite increase of amplitude of microseisms. Conditions of barometric pressure less violent than those accompanying cyclones, such as the presence of steep pressure gradients merely, have been also shown to swell the microseisms. Studies of these correlations have progressed so far that the character of response of microseismic motion has been found to depend upon the character and location of the atmospheric disturbance. Thus it is stated that apparently at Tokyo the more rapid microseismic motions are inspired by atmospheric disturbances in the northeast part of Japan, while the slower motions are inspired by disturbances to the southwest. It has also been noticed that where a marked barometric depression travels from west to east, there is a time lag in the climax of microseismic motion produced thereby amounting to three or four hours after the nearest approach of the depression. On the other hand, if the depression is traveling from east to west, the maximum microseismic motion appears to occur coincidentally with the nearest approach of the disturbance. This perhaps has something to do with a difference of effect of the barometric depression on land areas and on water areas. In general, the coming of a time of increased microseismic motion is heralded by the development of the quicker motions first, while the waning phases are marked more by the predominence of the slower motion.

Whether or not atmospheric pressures produce microseisms through a direct mechanical compressing or flexing of the earth's crust is not definitely known, but is suggested as what may possibly happen. Thus perhaps the pressures and impulses applied to the earth's structure are causing it continually to vibrate and to ring like a great bell.

The discussion suggests that if it is true that each particular locality has its own natural periods of vibration, that very probably the recording of earthquakes is affected thereby. Thus a natural period of a locality would tend to control the period of the earthquake as transmitted and recorded. It would seem that the care taken to design seismographs which will not impose their proper periods upon their records is somewhat lost if the natural period of the locality, which cannot be controlled, is to impose its effect on the recorded results anyway. R.M.W.

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No. 195 RELEASED WITHOUT COPYRIGHT RESTRICTION September 20, 1928

KILAUEA REPORT No. 869

WEEK ENDING SEPTEMBER 19, 1928
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

Heavy coatings of white salts formed on the fresh surfaces of the north wall during the week. Today, however, they have disappeared after a night of rain. The thick layer of dust on the Halemaumau floor is finally being washed away, and yellow-stained areas are again showing. Steam vents are all mildly active.

There were 20 very feeble local earthquakes recorded at the Observatory during the week. Microseismic motion was normal, and tilt accumulated slightly towards the N.

PROJECT FOR ALEUTIAN GEOGRAPHIC OBSERVATORY

By T. A. Jaggar

The writer on September 7, 1928, addressed the Seattle Chamber of Commerce on a proposed Aleutian Geographic Observatory to be established at Dutch Harbor, Alaska. This project is formulated in extension of a report on a possible Alaskan volcano observatory, revising somewhat and broadening the project. (Volcano Letter Nos. 116, 128, 134 and 147.)

Experience shows that mapping should be the main aim, and that all sciences should be represented. The founding of the Hawaii observatory by the sugar and other industries through the Volcano Research Association, with government collaboration, suggests that the fish, fur, and shipping industries might do something effective for southwest Alaska.

Modern exploration and discovery is extended by each new invention. Montana and Arizona have been "discovered" to be garden spots through irrigation and agricultural machines. The "Carnegie" is mapping all the oceans with echo sounding and new electrical instruments (Volcano Letter No. 175, May 3, 1928).

The advent of the salmon canneries, of Diesel engines in 60-foot boats of 2,000 miles fuel radius, of radio communication, and of some new maps, have greatly improved the Alaskan field for the explorer.

It is proposed that the observatory be at Dutch Harbor as a fixed home for land and sea mapping and for measuring geophysical, biological, and chemical processes along the arc of the Alaskan peninsula and the Aleutian Islands. The station will work in concert with eight scientific bureaus of the government, seven civil offices, and two outside institutions. It is called geographic, because it will study that part of the earth in relation to man.

It will measure and secure data all the year around concerning the weather, tides, currents, magnetism, earthquakes, volcanic activity, crust upheaval, animals, plants, fish, natives, and commercial needs.

For the summer half of the year, the observatory will maintain expeditions to collect land and marine organisms, minerals, rocks, and human antiquities; to map the lands, the geology, the depths of the sea, the air currents, temperatures and pressures, and such earth activities as magnetism, tremor, tilting, and changes of mean sea level. The snowy craters of the big volcanoes will be explored and photographed with the aid of alpinists and aviators.

It is a land of ancient inhabitants who linked America with Asia; it contains the greatest craters on earth; it exhibits volcanic activities that should throw light on the origin of the earth and the origin of ores; on the mainland there are known occurrences of gold, silver, lead, copper, zinc, sulphur, petroleum, and coal, and the numerous big western islands have not even been prospected.

It is a grassy country without trees. Sheep, reindeer, and cattle are grown there, but ranching is a new industry. There is much fur produced, largely foxes, mink, and land otter. The Aleutian land is one of the great breeding grounds for the study of migratory birds.

There has come recently a demand for scientific study of the Aleutian lands from numerous scientific institutions and conventions, so that the matter is being pressed by the National Research Council of the United States. The writer has reconnoitered the field by three expeditions devoted primarily to volcanology.

The proposal is to place four workers at the main station winter and summer, equipped with a powerful Diesel yacht and small boats, also laboratories, shop, quarters, dock, and photographic dark room. The station will keep in radio communication with its yacht and with existing stations. It will provide a base and a boat for the Coast Survey and the Geological Survey in mapping the coasts and interiors. It will publish weekly and quarterly reports.

The substations will work from April to September, and each summer will produce a new substation, for intensive geophysical measurements, photographing, and collections, on a volcano for instance, setting up a seismograph and weather instruments, and keeping a journal. The summer staff will be eight persons, and the substation will report to the main station. The substation camp will be left for future use. Specialists in all sciences will be imported from outside institutions for work at the substations.

The observatory vessel will carry the observers, the pack horses, and the camp equipment to the substation site, and the base camp may be moved by boat as often as necessary, when the substation work is in the nature of an exploring expedition. It will probably be advantageous for the first established substations to work in conjunction with map-making expeditions.

It is useless to establish such an institution without adequate funds. The following is the estimated cost of equipment and operation:

EQUIPMENT		ANNUAL UPKEEP	
Boats	$25,000	Salaries	$22,200
Houses	12 000	Station Upkeep	6,000
Horses	400	Boat Upkeep	4,200
Apparatus	1,000	Food Supplies	3,500
Contingent	8,600	Travel & Freight	3,000
		Contingent (Incl. publications)	11,100
	$50,000		$50,000

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No. 196 RELEASED WITHOUT COPYRIGHT RESTRICTION September 27, 1928

KILAUEA REPORT No. 870

WEEK ENDING SEPTEMBER 26, 1928

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

There have been no changes in Halemaumau. The bottom region is remarkably dry and free from steam.

During the week 27 local earthquakes and one teleseism were recorded on the Observatory seismographs. One of these local shocks, at 10:02 a. m. September 20, although feeble was yet possibly strong enough to have been perceptible. All the others were very feeble. The teleseism made a weak record from which the distance could not be estimated. The beginning of either the secondary or the long wave is shown at 9:21:54 p. m. on September 21.

Microseismic motion was normal throughout the week, and the accumulation of tilt was moderate towards the NNE.

THE 1928 OUTBREAK OF KRAKATOA

The volcano Krakatoa in the Sunda Strait between Java and Sumatra consisted of an old engulfment crater in the sea prior to August, 1883. The crater rim protruded above the water as the islands Verlaten, Lang, and Krakatau. The latter was the largest, five miles long, consisting of three cones, the basaltic Rakata the largest, 2,623 feet high, the other two smaller and andesitic named Danan and Perboewatan. These two last occupied the extension of Krakatoa island from the region of the ancient andesitic crater rim, on which Rakata was built, northwestward to the site of the ancient crater center.

The colossal eruption of 1883 followed two centuries of quiet. Danan and Perboewatan became explosively active in May, and on August 28th, 1883, one of the most enormous volcanic explosions ever recorded occurred. These two cones were engulfed completely, leaving water 900 feet deep, columns of ash and pumice went miles into the air, and the engulfment wave drowned 36,417 people in the low coastal villages of western Java and southern Sumatra. Rakata was left with a sector of its cone gone, and a great bluff reaching to sea level like the northeast side of Molokai.

Krakatoa since then has been quiet. A new submarine eruption about the center of the triangle made by the three remaining islands began December 29, 1927. Fishermen reported columns of smoke rising from the sea sixty feet or more, with bombs that glowed at night. Gas bubbles had been seen here earlier in 1927.

Early in January, 1928, feeble eruptions every half-minute or minute culminated in a repose interval of 5 to 8 minutes every quarter hour, and this was followed each time by unusually heavy explosions. The water would rise in a dome. Out of this a black mass of ashes and bombs, clinging together, emerged in tree-like forms. The sea in contact with the incandescence boiled, surrounding the ash column with a wreath of steam. When the ash reached its greatest height, the black color disappeared in rocket trails of white steam and gases. A few bombs floated for awhile buoyed by gas. A white central steam column remained, encircled by the wreath at its base. The relapse of the water dome made a wave, and the ring of falling matter made other waves, felt at some distance as a swell. Sometimes the eruptive material was ejected obliquely in several directions. There appeared to be six crater orifices below sea level. The photographs taken are very striking, showing the central column like a lily, and the basal wreath like a flower pot.

The sea water was made turbid by the ash. Water temperature was 103° F. 1,600 feet away, the normal water being 84° F. The glow of the ejected bombs could be seen at night. The width of the eruption center on the water was 2,000 feet in a WNW.-ESE. direction. The sea had been about 600 feet deep where the eruption occurred.

A temporary observatory, with seismograph and radio sending apparatus, was set up on Lang Island. Others on military motor trucks were maintained on the mainland to receive warnings for the populace. There were tremblings and rumblings. The first eruptions were only 200 feet high. After January 13 glowing masses were thrown up occasionally 4,000 feet. Regular observations were inaugurated night and day. After January 26 the activity dwindled. On that date the new crater rim appeared above sea level and reached in a few days a height of 10 feet and a length of 570 feet, consisting of loosely piled cinder. The waves quickly washed this away. On February 4 only three eruptions occurred and 11 rumblings were heard. The next day one eruption and two rumbles. Nothing but seismographic shakes and gas bubbles with sulphuretted hydrogen occurred after that date in February.

In March a thorough survey was made. A depth of 113 feet of water was sounded at the new crater. The bottom temperature was 97° F. There is a cone on the bottom at the wall-crack region of the submarine engulfment pit of 1883, steepest toward the deeper pit-center. There was a small eruptive revival the end of March, and another the last half of April. Some sulphurous gas bubblings in the sea several miles apart were found in Sunda Strait spread over 500 square yards, off Tjarita, and have been noticed by fishermen for some years. (Bull. Neth. East Ind. Volc. Surv. 1927-28 and Overdruk Leidsche Geologische Mededeel., 1928, pp. 325-329: articles by Ch. E. Stehn and J. H. F. Umbgrove.) T.A.J.

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No. 197 RELEASED WITHOUT COPYRIGHT RESTRICTION October 4, 1928

KILAUEA REPORT No. 871
WEEK ENDING OCTOBER 3, 1928
T. A. Jaggar, Volcanologist in Charge

Halemaumau has been particularly quiet throughout the week. During the first part of the week the pit was dusty from previous avalanching, and steam vents were only slightly active; but with the southerly rainstorm of October 1 the pit walls and floor were washed clean of the dust coatings, and steaming was very noticeably increased, particularly at the fountain vents of July, 1927. Qcassional small rock falls are difficult to locate because of the lack of dust to mark them.

The Observatory seismographs have recorded 18 very feeble local earthquakes during the week. Microseismic motion was normal at the beginning and end of the week, but was more feeble than normal on September 29 and 30. Tilt accumulated very slightly towards the east.

THE HALEMAUMAU SEISMOGRAPH

The seismograph installed at Uwekahuna, the west wall summit of Kilauea Crater, in December, 1927, has in general recorded the same earthquakes shown on the records of the instruments at the Volcano Observatory. As would be expected from its magnification, most of the Uwekahuna earthquake traces are smaller in amplitude. But a few which apparently originate at the pit of Halemaumau are shown larger on that instrument, perhaps due to the fact it is nearer to the pit than are the Observatory instruments. To carry the idea thus suggested still farther, a seismograph has recently been installed close to the edge of the pit. It is expected that this will record tremors due to avalanches that are too feeble to be recorded on the more distant seismographs at Uwekahuna and at the Volcano Observatory. By comparison it should then be possible to discover definitely which of the tremors recorded at the Observatory are caused by avalanches.

Spirit leveling near the pit has made it apparent that the tilting motions there are large. It is perhaps these tilting movements and the corresponding change in inclination of the pit walls that are the cause of periodic spells of avalanching that have been evident during the past years. This tilting measured close to the vent of the volcano may prove to be a more sensitive key to the movements of the lava column, just as the tilts at the Volcano Observatory are known to be correlated when the lava level is visible within the pit and the tiltings are correspondingly stronger. This new seismograph is in a position to pick up the first feeble indications of returning activity.

The installation is distant 1,900 feet radially from the center of Halemaumau in direction S. 34° 05′ E., and is back 450 feet from the edge of the pit along the same radius extended. This places it a little north of the trail from the automobile parking place to "Halemaumau sign," and it is about 300 feet from the shelter hut. The elevation is approximately 3,635 feet above mean sea level. A shallow depression was dug in soft pahoehoe lava till a more stable layer was reached, upon which was founded a pier for the recording drum and a column for the support of the pendulum. The pendulum axis is approximately parellel to the pit edge to make it sensitive to shocks and tilt from the direction of the pit. The shelter hut is 4 by 5½ feet, inside dimensions, and is about 4½ feet from floor to roof in the highest part. Its walls are of one-inch boards, with tar paper both inside and out, and with rocks and gravel piled against the outside up to the eaves. The roof is double, with a four-inch space packed with sawdust. It is further protected from rain and sunshine by a corrugated iron roof with a ventilated air space beneath it. The floor is of gravel and asphaltum so sealed as to prevent steam from rising inside the chamber from the floor, as this area of the crater is porous with small steam ducts rising through it almost everywhere. The building was constructed during the first two weeks of September, and the instrument was first set up on September 12. Operation was experimental for several days, the useful run beginning on the 18th.

The seismograph used is the one removed from the Kona station when the larger Hawaiian type seismograph was installed there this summer. This instrument has been overhauled and somewhat revised. It is a single component horizontal pendulum, with suspension similar to the Bosch-Omori. The boom axis hangs from the column to the drum in a direction S. 78° 45′ W. The inertia mass is 30 kg., and static magnification is 70. It is at present adjusted to a period of nearly seven seconds, and the damping ratio is 2.6. Sensitivity to tilt is 2.5 seconds of arc for one centimeter displacement of the null point of the writing pen. Recording is on smoked paper, which moves about 23.5 mm. per minute. The instrument will run nearly 60 hours without attention. Before it was installed at the pit its constants of magnification and sensitiveness were tested on the oscillating table at the Hawaiian Volcano Observatory.

The records so far accumulated do not cover a long enough period of time so that deductions may be made from them. The useful run of the instrument began on the 18th, but was interrupted during the first few days by lack of proper adjustments. From that date up to and including October 1, there were 13 very feeble tremors recorded. It seems so far that this new instrument is recording an entirely different group of very feeble tremors than those recorded at the Hawaiian Volcano Observatory. None of the 13 recorded is identified as recorded at the Obeservatory. There has not yet occurred a heavy enough shock to be recorded on both instruments.

Large tilting movements close to the pit are to be expected, and the seismograph is apparently to bear out that expectation. From September 28 to October 2 there was recorded no less than 10 seconds of arc tilt away from the pit. This is perhaps not due entirely to volcanic causes, however, as the instrument may not yet be fully settled on its foundation. On October 1, beginning at 3:54 p. m. and ending at 6:45 p. m., there was an apparent surge of tilt, which accounted for more than half the amount above noted; but this interval of time represents very closely the time and duration of a very heavy shower of rain. In this instance the pen movement was probably caused by wind, temperature, or other effects of the shower, rather than by actual ground tilting, though there was evident no tendency for the pen to return to its former position after the effects of the shower had ceased.

R.M.W.

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No. 198 RELEASED WITHOUT COPYRIGHT RESTRICTION October 11, 1928

KILAUEA REPORT No. 872

WEEK ENDING OCTOBER 10, 1928

T. A. Jaggar, Volcanologist in Charge

The past week has developed no changes at Halemaumau. Fresh wall surfaces are conspicuous north and southeast, but no slides of magnitude have been observed.

On October 6, during a visit to Mauna Iki, the lava cone of 1920 six miles southwest of Kilauea, temperature measurements taken at the second hot area with a 550° C. thermometer, showed a temperature at the first vent of 260° C., and at the second vent 275° C. (527°F.). At the latter place a stick caught fire.

The Observatory seismographs have recorded 16 very feeble local earthquakes during the week, and one teleseism. The teleseism was on October 8, with its preliminary phase recorded at 4:40:47 p. m. The indicated distance to its origin is 3,815 miles, suggesting another earthquake off the Pacific coast of Mexico to add to the series that has been taking place there during the past year.

Microseismic motion was strong during the first part of the week, but diminished to normal during the last part. Tilt accumulated moderately toward the NNE.

EQUATORIAL BELT HAS THE MOST EARTHQUAKES

A remarkably interesting statistical investigation of violent earthquakes has been made by Charles Maurain showing gradual diminution in frequency from the equator to about 50 degrees of latitude, and very rapid diminution thence to the poles. ("On the Distribution of Earthquakes by Latitude," Comptes Rendues del l'Académie des Science, Paris, Vol. 184, 1927, p. 612; Matériaux pour l'"Etude des Calamités, Geneva, April-June, 1928, p. 90.)

The investigation is based on seismograph records locating big distant earthquakes made by stations all over the globe during the first two decades of this century. The most modern group concerns 542 shocks reported by the International Seismological Summary between 1914 and 1920, and secondly 1,009 earthquakes listed by John Milne between 1903 and 1910. These 1,551 great earthquakes are distributed as follows among zones of 10 degrees of latitude from the equator northward or southward; and the third column takes account of the surface area of these different latitude belts:

Latitude (Northward or Southward)	Nos. of Earthquakes	Nos. of Earthquakes Per 10,000,000 Square Kilometers
0°–10°	450	50.8
10°–20°	329	38.3
20°–30°	244	30.4
30°–40°	258	35.4
40°–50°	152	24.1
50°–60°	87	17.1
60°–70°	21	5.6
70°–80°	9	3.9
80–°90°	1	1.3

This list shows strikingly that large earthquakes have greatest frequency in the equatorial belt, and are remarkably few in number near the poles. An examination of the 542 more modern records (1914-1920) indicates that the earthquakes are distributed almost equally between the north and south hemispheres (273 north of the equator, 264 south of the equator), and five actually equatorial. The statistics of the first decade show a larger number in the northern hemisphere than in the southern. Of the whole 1,551 shocks for both decades, 927 are at the north and 624 at the south.

It seems likely to the reviewer that the greater number of northern earthquakes registered in Milne's time was due to the scarcity of instruments in the southern hemisphere, a defect which was later remedied.

Maurain concludes that the distribution of mass in the crust of the earth may be sufficiently uneven with reference to the equilibrium between centrifugal force and terrestrial gravity to produce tensions greatest at the equator, and diminishing from the equator to the poles, Other investigators have shown that the strongest seismicity is in regions where geological movements such as *volcanism and mountain building* are most rapid. If we combine these two things, centrifugal stress and geological activity, the greatest sensitiveness would be in the equatorial belt, and this would account for the increasing earthquake frequency in that direction.

With reference to the influence of volcanism on the distribution of big earthquakes, it is interesting to compare Maurain's results with the tables of volcanic outbreaks between 1801 and 1914 compiled by Sapper (Zeitschr. Vulk., Aug. 1917, p. 130; also Volcano Letter No. 4, Jan. 22, 1925):

Latitude (Both North and South)	Nos. of Eruptions	Nos. of Eruptions Per 10,000,000 Square Kilometers
0°–10°	944	107.0
10°–20°	826	96.5
20°–30°	238	29.6
30°–40°	437	60.0
40°–50°	157	24.9
50°–60°	101	19.7
60°–70°	47	12.4
70°–80°	115	49.5
80°–90°	0	——

T.A.J.

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No. 199 RELEASED WITHOUT COPYRIGHT RESTRICTION October 18, 1928

KILAUEA REPORT No. 873

WEEK ENDING OCTOBER 17, 1928

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

There has been an increase of avalanching at Halemaumau. Probably the greatest slide was on October 11, when a dense cloud of dust rose out of the pit about 4:15 p. m. An avalanche of large size occurred also on October 13 at 3 p. m. from the north wall. It was followed a few minutes later by a smaller slide from the south wall. The north wall has had numerous slides for two months past.

On October 15 at noon much steam was rising from Halemaumau following several hours of rain.

There have been 16 local earthquakes recorded at the Observatory during the week. Two of these were feeble, but were a little larger than the others, which were all very feeble. The first of the two larger shocks was caused by a big avalanche in the pit at 4:07 p. m. on the 11th. The second shock at 4:11 a. m., October 12, apparently originated a few miles south of Kilauea, and was felt by a number of persons at Kilauea and in Hilo. This earthquake was recorded on the seismographs at the Observatory, at Uwekahuna, at Halemaumau, in Hilo, and in Kona. The indicated distances from these stations, in the order given, were 11, 15, 11, 29, and 49 miles.

On the 14th, at 10:30 p. m., there is recorded a very faint disturbance that is probably the long wave of a teleseism.

Microseismic motion was slightly stronger than normal during the first part of the week. Tilt accumulated moderately toward the east.

POSSIBLE 1851 LAVA FLOW AT LASSEN CINDER CONE

The evidence of two flows from Cinder Cone, the small recent volcano 10 miles northeast of Lassen Peak in California, is very clear. The older flow is covered with volcanic sand, and the newer flow overlies the sand. The locations of trees that existed before the sand eruption are still plainly marked by depressions in the sand.

There are several small cinder cones to the southeast of the main one. Where the lava flow is crossed along the line of these small cones, it quickly appears to an observer that the so-called younger flow might itself really be two flows.

The writer knew that Doctors Day and Allen had dated the last flow over 250 years ago, and during his own trip, made to take photographs, the evidence of the presence of three flows came as a complete surprise.

Later Mr. A. E. Jones, who worked as seismologist at Lassen Volcano Observatory during the summers of 1927 and 1928, provisionally dated the last two flows as of 1795 and 1832 approximately, with a probable error of 10 years more or less, measuring magnetic declination of fixed ledges. This is on the theory that the declination constant of the ledge preserves record of the earth's regional magnetic field at the time the lava congealed. (Volcano Letter Nos. 45, 144, and 162.)

The magnetic work thus suggested a possible lava flow eruption in the middle of the nineteenth century. Dr. H. A. Harkness, for whom is named Mount Harkness in the southeastern part of Lassen Volcanic National Park, wrote an account of activity at Cinder Cone (Cal. Acad. Sci. Proc. Nov. 2, 1874) said to have occurred during the winter 1850-51. Dr. Harkness made the mistake of attributing all the lavas and ejecta of Cinder Cone to 1850-51, a contention that can easily be shown to be in error. His evidence was unacceptable to Dr. Diller and to Drs. Day and Allen, and by them was dismissed. Diller however (Lassen Peak Folio 15, U. S. Geol. Survey), writing in 1894, states that the second or effusive eruption was much later than the first, "but certainly more than 50 years ago, and was of such a character as not to attract attention."

I read the account by Dr. Harkness at the library of the California Academy of Science in January, 1928. The following statements are taken from his article:

Lights were observed apparently by different observers to the east of Lassen "Butte" from time to time from 1850 to 1854. The Indians of that country were hostile, so no attempt was made to ascertain the source of the light.

Dr. Wozencraft from above Red Bluff observed a great fire to the eastward of Lassen during the winter of 1850-51 which continued for many nights without change of position. He dismissed the Indian camp-fire theory. Dr. J. B. Trask at Rich Bar on the north fork of the Feather River, to the southeast of Lassen, also saw light for many nights.

Mr. Charles Gibbs with a party of miners saw the same lights and reported them as due to a volcanic eruption. Miners arriving at a hotel near Georgetown, El Dorado County, during the summer of 1851, reported passing an active volcano and hot rock, their location of which agrees exactly with that of Cinder Cone.

The same miners gave a description of Boiling Lake and the geyser near Drakesbad, features of the present Lassen district, and their description would apply at the present day were the activity at those places a little greater than at present. R.H.F.

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No. 200 **RELEASED WITHOUT COPYRIGHT RESTRICTION** October 25, 1928

KILAUEA REPORT No. 874

WEEK ENDING OCTOBER 24, 1928
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

At Halemaumau avalanches were noted at 9:35, 9:40, and 9:45 a. m. October 18, so that dust was rising rather steadily at the north rim at 10 a. m. On October 20 at 11:20 a. m., thin dust filled the pit, and this recurred in the afternoon. At 2 p. m. fresh debris was observed on the SW., S., and SE. bottom slopes. The pit was very dry, only slight vapor appearing at the center cone and the SE. and S. taluses. At 9 a. m. today fresh rocks were seen on the north talus, and the noise of falling material was heard at the west.

During the week ending October 24 there were 20 local earthquakes recorded on the seismographs of the Volcano Observatory. Two of these, at 10:41 a. m. on the 21st and at 9:56 a. m. on the 22nd, while feeble, may have been felt. The distances to the origins of these shocks were 13 and 12 miles, respectively. All the other earthquakes recorded were very feeble.

Microseismic motion was normal during the week. Tilt accumulated moderately toward the north.

RECENT ACTIVITIES IN NEW ZEALAND

We are indebted to Mr. Birch of the New Zealand Herald, published at Auckland, for clippings noticing a number of earthquakes in the spring and summer of 1928.

Opotiki, on the shore of the Bay of Plenty opposite White Island Volcano, reports earthquakes as follows: A slight shock January 16 at 1:18 p. m., a sharp shock February 5 at 1:30 p. m, a sharp tremor February 16 at 3:30 a. m., another February 19 at 3:30 p. m., a short and very snappy shock on June 20 at 1:10 p. m., another more severe at 5:50 a. m. July 11; and at Waihi, on the west side of the Bay of Plenty, an earthquake at 6:10 a. m. August 13 seemed to travel in a north and south line, sufficiently pronounced to awaken many persons. All of these shocks are of interest as occurring in the northern part of the belt of active volcanoes, and close to White Island, reported as showing some activity in June.

Other earthquakes have been felt in various parts of the North Island, and at least two in the South Island. Mercer, south of Auckland, felt a slight shock at 6:55 a. m. February 17. March 7 produced a really severe earthquake in the city of New Plymouth at 6:50 a. m. This seemed to come from the slopes of the great volcano Mount Egmont, 8,260 feet high, immediately adjacent to New Plymouth on the south, and the damage was greatest in the southeastern quarter of the borough.

Chimneys went down in all parts of the town, and the shocks were said to be the most severe felt there for many years, lasting about 30 seconds, working up to a climax, and then dying away. The damage was estimated at many hundreds of pounds. Shops suffered severely, goods being shaken off of shelves and falling in show windows. In one grocer's shop everything on the eastern wall fell, resulting in many broken bottles, but the other walls were not damaged, and generally the drug stores appear to have escaped. In one shop a plateglass window was cracked. There was a landslip on the Frankley road which barely missed a passing motor truck. The villages at the northeast base of Mount Egmont all experienced the earthquake, but were not severely damaged.

The capital, Wellington, felt a slight earthquake at 7:27 a. m. March 16, and another at 5:15 a. m. July 31.

On June 12 the volcanic belt at its southern end, between Lake Taupo and the Rangitikei River, was shaken. Taihape reported tremors preceded by heavy rumbling which lasted for several seconds about 5:30 a. m. Presumably the same earthquake reported as about 6 o'clock was felt in the Rangitikei district accompanied by a rumbling sound which made a rapid crescendo and then diminished. The north end of Lake Taupo reported an earthquake at 9:25 a. m., with vibration from east to west. This was not noticed at the south end of the lake.

On the evening of July 17 Raetihi, southwest of the Ngauruhoe group of volcanoes, felt two shocks, the first reported severe and accompanied by a loud rumbling noise and lasting about 30 seconds. The second tremor was mild, only a few seconds long, and occurred only 10 minutes after the first shock.

For the South Island Oamaru on the southeast coast reported a series of severe shocks in the Ben Avon district for the fortnight preceding February 7 which had set rocks tumbling down the hillsides and terrified both the cattle and the inhabitants. The convulsion was confined to a limited area. Greymouth, near the state collieries on the northwest coast of the South Island, felt slight tremors shortly before 9:15 a. m. March 25, and these were followed by a greater shock progressing apparently from northwest to southeast. T.A.J.

On March 3 Ngauruhoe began to rumble after smoking and steaming all day, and at 6 p. m. threw up rocks to a height of 500 feet. One rock dropped outside the crater and rolled down the slope, and glow was seen over the summit at night. The rumbling resembled thunder. At 10 a. m. March 4 the thundering began along with ejection of great clouds of white and blue vapor, and lasted five minutes. Heavy sulphur fumes rolled down the slopes of the cone. Twenty minutes later, and again at 10:30 a. m., loud explosions occurred, accompanied by jarring which shook the mountain huts at Whakapapa, and the smoke column rose 2,000 feet while showers of rock rolled down the northern slope, where dust arose as the material slid. Far away at Opotiki a severe earthquake occurred this day at 3:30 a. m., preceded by a prolonged rumble. A thick column of black smoke was rising at 5:50 p. m. March 9, reaching a height of about 8,000 feet, and spreading to drop a shower of ash over Tongariro Volcano to the west. Glow was seen over the crater March 9 and March 10.

The White Island activity was said to have begun in June with excessive steam as seen from Opotiki which died away during the following week. It was believed some sort of an eruption occurred during the night June 24-25, for the next day the volume of steam from the blowhole was enormous, rising to a height of 2,000 feet in clear frosty air, and stretching away in a long white cloud for a mile. The local radio station reported hearing nothing from the sulphur workers on the island.

As no news since June is presumably good news, it may well be that all of this excessive steaming seen from Opotiki did not really amount to an eruption. T.A.J.

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No. 201 RELEASED WITHOUT COPYRIGHT RESTRICTION November 1, 1928

KILAUEA REPORT No. 875

WEEK ENDING OCTOBER 31, 1928

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Kilauea Volcano continues to remain in repose. A few slight avalanches from the northeast and east walls of Halemaumau were noticed. They caused dust clouds during the forenoons of October 30 and 31. Dense steam was rising from the fire pit following rains on the latter day.

The number of local earthquakes recorded on the Observatory seismographs during the week is 15. They were all very feeble.

Microseismic motion became somewhat stronger than normal toward the end of the week.

Tilt accumulated only very slightly to the south.

POISONOUS GASES IN JAVA

Beginning in the autumn of 1927 the East Indian Volcanological Survey has produced in English, a monthly bulletin of volcanic activities. The excellent volcano service of the Dutch East Indies has erected observatories on the volcanoes Semeroe, Tangkoeban Prahoe, Papandajan, Merapi, Keloet, Lamongan, Idjen, and Karmodjang. Most of these have permanent observers, five of them have seismographs, five report thermometric measurements of gases or hot springs, two report chemical tests, and six make meteorological measurements. In two of the volcanoes crater lakes are sounded occasionally, and 10 other active volcanoes are visited from two to four times a year. (Bull. Neth. East Ind. Volc. Surv. Nos. 1 to 11, Nov. 1927 to Sept. 1928, Bandoeng, Java).

The word kawah means crater, and Tangkoeban Prahoe, in west central Java, has seven vents. In three of these craters after August, 1927, increased solfataric action produced the suffocating gases carbonic acid and hydrogen sulphide. Throughout 1927 the locality known as "Death Valley, outside of the Ratoe vent of this volcano, had its gases sampled by means of the Bunte burette. At the same time the temperature was taken, and such weather conditions recorded as might influence the gas measurement, such as air temperature, humidity, pressure, cloudiness, and wind. Carbonic acid in August varied from 36 to 69 per cent, in September from 46 to 78 per cent; hydrogen sulphide, in August, between 7 and 16 per cent, and in September between 4 and 15 per cent.

In Papandajan, of southwestern Java, the hottest place is the Kawah Mas, where a self-recording electrical thermometer automatically registers the temperature every 12 minutes. The maximum reading was 372° C. September, 1927, and the highest temperature during that year was 420° C.

Here also suffocating gases are abundant in the Roeslan Valley, named after a native observer who was suffocated there December 18, 1925.

In October, 1927, "Death Valley" gave from 59 to 75 per cent carbonic acid, and 10 to 12 per cent hydrogen sulphide. Observed at a place where at the end of June 1923, three high school boys had met with sudden death caused by asphyxiating gas, the measurements showed a decline of the percentages, especially in the case of carbonic acid. On September 13 the sum total of both gases had been 35 per cent, whereas on October 29 it was 18 per cent.

At Papandajan, in the Kawah Mas, maximum temperatures were higher in October, and minimum temperatures lower, than in the preceding month. The highest temperature recorded was 379°.C. In Roeslan Valley carbonic acid varied from 20 to 42 per cent, hydrogen sulphide from 7 to 12 per cent. The crater Nangklak No. 4 gave carbonic acid 4 to 33 per cent, hydrogen sulphide 2 to 11 per cent.

In December, 1927, cold carbonic acid gas was coming out at Death Valley, and a spring showed sulphur in suspension. In Roeslan Valley hydrogen sulphide varied between 10 and 20 per cent. carbonic acid between 41 and 51 per cent. At another crater of Papandajan, Nangklak No. 4, hydrogen sulphide varied from 10 to 12 per cent, and carbonic acid from 43 to 68 per cent.

In January, 1928, Roeslan Valley on Papandajan gave hydrogen sulphide 16 to 17 per cent, carbonic acid 47 to 49 per cent. Nangklak No. 4 gave hydrogen sulphide 6 to 9 per cent,carbonic acid 43 to 49 per cent.

Papandajan in February, 1928, showed higher temperatures, and along the banks of a small brook traversing the volcanic crater hydrogen sulphide developed in a new place near an old camp, so that a native who passed the place swooned.

In March Tangkoeban Prahoe increased its gas pressure, and in a ravine between two of the craters suffocating gas appeared in such high concentration that one of the dogs of the observatory was choked. The carbon dioxide there was found to be 75 cm. deep, by the capacity of the gas to extinguish a flame.

In April Bromo Volcano in eastern Java was reported as having been active since the middle of March when the eruption had begun with loud explosions, the ejection of big stones, and ash clouds of reddish color. A light ash fall continued, and a sulphurous smell was perceived some miles away. At Papandajan in May a blow-hole in the Baroe Crater threw up black sulphurous mud, staining the whole region round about. In central Java a sudden eruption occurred near Batoer, a well known tobacco producing center. Strong earthquakes occurred May 4-13, and then an explosion amidst the tobacco fields, where three vents opened, a dull noise occurred, and the material thrown up was saturated with water and flowed south in three hot mud streams, while the stones ejected destroyed a large part of the hamlet Timbang. One man was killed by a falling stone, there were new cracks in the ground the crops and vegetation were destroyed. and highly concentrated suffocating gases came forth.

In July these gases were investigated, and carbon dioxide was found escaping from fissures under high pressure along the road from Batoer to Dieng. The gases streamed down drainage ditches, forming a layer 20 cm. deep, which would extinguish a candle flame 60 meters away from the vent. On June 13 a light wind blowing up the grade depened the gas until it was 16 cm. deep (5 feet ,and so was dangerous. The gas layer became visible by condensation, and produced giddiness, high pulse, and heavy pressure at the back of the head. Birds were killed, and the lush bamboo vegetation, as well as fields of tobacco, withered from exposure to the gas. T.A.J.

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No. 202 RELEASED WITHOUT COPYRIGHT RESTRICTION November 8, 1928

KILAUEA REPORT No. 876

WEEK ENDING NOVEMBER 7, 1928

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

In Halemaumau pit at noon of October 31 a slide was reported, and beginning at 9 p. m. of November 1, a series of heavy avalanches occurred repeatedly for about two hours. In the still night air these were distinctly heard at Volcano House. An especially heavy slide at 10:30 p. m. was registered on the several seismographs. Dust from avalanches at the northern wall of the pit was seen at 8:30 a. m. November 2, and at 4 p. m. November 5 thin dust from slides rose above the pit in a veil.

Examination of the walls at 3:30 p. m. November 3 indicated that the avalanches had fallen mostly at the north and northeast corners of Halemaumau, making red debris on the two talus cones at the ends of the large intrusive sill.

For the week ending at 8 a. m. November 7 the Observatory seismographs have registered 17 very feeble earthquakes. A tremor at 2:37 a. m. November 1 has the gradual development to a maximum, followed by similar gradual decline, which is characteristic of avalanche tremors. Throughout the week microseismic motion was strong, but is now decreasing.

Tilt accumulated moderately to the north.

ERUPTIONS OF ETNA

Press reports indicate that the volcano Etna in Sicily is giving vent to a lava flow. The last lateral eruption was in June-July. 1923. Since that time activity has been confined according to last reports to jets of vapor and dust from the summit crater. (1926 Bulletin Volcanologique, Nos. 9-10, Etna From August 1923 to the end of 1925, By G. Ponte.)

The activity of Etna, according to Perret, has been marked by eruptions during the past 300 years at intervals averaging about six years, making some 17 eruptions per century. It is a volcano in many ways resembling Mauna Loa. In the surrounding country have occurred some of the most disastrous earthquakes of history, notably at Messina, and the volcano itself has occasioned serious loss of life.

The observatory stands about 1,000 feet below the summit, where there is a central crater, but just as in the case of Mauna Loa, the serious eruptions of modern times do not occur at this crater but rend open the flank of the mountain. The observatory was originally designed for astronomical observations, but is now assigned to the Volcanologic Institute of Catania University.

A small eruption occurred on the 29th of April, 1908, which lasted only 12 hours, following upon a repose period of 16 years. Such a long sleep required greater relief than this, and therefore the succeeding months were considered a time of anxiety. This was justified by the terrible earthquake at Messina on December 28. After the earthquake both Etna and Stromboli diminished in activity, as though the earthquake had relieved a subterranean strain. Finally, however, March 23, 1910, a greater eruption occurred, and still another in September of 1911. The lava of 1910 flowed at the speed of 11 miles per hour from a vent which threw up spatter to a height of about 150 feet. Mr. Perret obtained a photograph of a remarkable smoke ring which floated upward over 5,000 feet and expanded until it was about a quarter mile in diameter. The lava of Etna is basaltic, containing from 44 to 49 per cent of silica. From a chimney at the vent Perret observed banners of flame due to burning gas rising 10 or 15 feet. Rafts were observed floating down the lava stream, the latter was from 6 to 12 feet in depth, and as the big masses on top of the stream were carried along at about four miles an hour they gave the impression of big barges floating past. The color of the hotter parts of the flow at night was a golden yellow, estimated to have a temperature of about 1,200°C. Lava tunnels were found, through which the stream poured, and the lower portion of the flow was typical aa lava.

Mr. Perret makes the point that tunnels very commonly form along the line of the fracture or fissure through which the lava flow pours, and the lava tunnel left exposed extended from crater to crater along the rift, and was revealed only after the slope of the mountain slumped away near the lowest crater at the end of the eruption. The entrance to the tunnel was a perfect arch 12 feet high, and in the interior it was 25 feet high in places. All this closely resembles the lava tunnels of Kilauea and Mauna Loa, where the flows are smooth and slaggy near the source vents in the portions of their courses where the tunnels are formed, but farther down the mountain the lava turns to clinker. It will be remembered that the tunnel now exposed in the southwest wall of Halemaumau is a true rift tunnel, through which poured the lava flow of Mauna Iki in 1920. (The Eruption of Etna in 1910, by F. A. Perret, Science Conspectus, Massachusetts Intitute of Technology, Vol. I, No. 3, Feb. 1911.) T.A.J.

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No. 203 RELEASED WITHOUT COPYRIGHT RESTRICTION November 15, 1928

KILAUEA REPORT No. 877

WEEK ENDING NOVEMBER 14, 1928

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Conditions at Halemaumau do not change materially. Rains of the past few days have not soaked the pit to any great extent. The areas of steaming are conspicuous through being wet, in contrast to surrounding dry areas. The south and central cones steam thinly, and other vents are more or less flocculent.

The week has been particularly quiet seismically, only three very feeble local earthquakes having been registered. Microseisms appear normal, despite a strong, steady northeast wind.

Tilt is strong to the northeast.

HORIZONTAL MOTION IN JAPANESE EARTHQUAKES

The work of the United States Coast and Geodetic Survey in reoccupying triangulation stations in California after the great earthquake of 1906 showed that horizontal motion had shifted large blocks of country. The triangulation stations east of the fault had moved south; those on the west had moved north. This agreed with observed displacement of fences, trails, and roads, which were offset over 20 feet north of the Golden Gate.

The same method has now been applied to Japan. In the case of the Tango earthquake (Volcano Letter No. 119, April 7, 1927), the Gomura fault exhibited dislocation on the ground of as much as eight feet. The fault trends NW-SE, and the country round about contains bench marks placed during trigonometric surveys made between 1884 and 1888. These stations were retriangulated in June and August, 1927, some months after the earthquake. It was found that the stations east of the fault line had moved north several feet, while those to the west had moved south.

A geometric method was devised for platting on a diagram the amount of displacement of those bench marks lying nearest to the fault plane on both sides of the rift, and then projecting on the line representing the fault the amount of the several displacements so as to obtain a figure representing the total offset along the fault trace. Just as in California, the basis for displacement of any station was a base-line connecting two distant monuments that lay outside the area affected by the fault.

The results indicated that the total offset shown by triangulation is about 2.4 meters, while the maximum movement measured directly was 2.7 meters. In general the amount of shift of the triangulation stations is the greater, the nearer the station lies to the rift.

It next became of interest to apply this triangulation method to the great Kwanto earthquake, which produced the terrible Tokyo-Yokohama conflagration of 1923 (see Volcano Letter No. 171, April 5, 1928). The actual fault in this case trends NW-SE in the middle of Sagami Bay, where, it will be remembered, there was actual deepening of the soundings by from 400 to 600 feet along the zone of fault blocks which subsided at the time of the earthquake. As this fault plane had no marked extension on land, and yet the bay is surrounded by lands containing trig stations, it is clear that in order to find out the horizontal displacement on the rift, the triangulation method is the only one available.

The whole Tokyo area has been retriangulated, and the stations lying in the Misaki and Boso peninsulas nearest to the rift on the east side, all show strong displacement to the south. On the other hand the bench marks on Oshima Island and the Izu Peninsula, west of the rift, show still greater displacement northward. The base line used lies 90 miles to the north between Teruisiyama and Tukubasan.

Using the same graphical method as before, platting the line of the fault, and the line at right angles thereto on which are laid off the several distances of the trig stations from the fault trace, and then projecting on the fault trace the displacements north of the western stations and the displacements south of the eastern stations, it is found that the net offset or shift horizontally along the rift amounts to eight meters, or over 26 feet.

This triangulation was all carried out by the Military Land Survey Department. An extraordinary feature of the map exhibiting all the displacements around Sagami Bay, which represent the changes between the surveys of 1884-1899, and the post-earthquake surveys of 1924-1925, is that the land stations appear to have shifted somewhat uniformly in a circular arc around the west, north, and east sides of the submarine earthquake center. That is to say, Sagami Bay is an indentation in the southeastern coast of Japan, and the land southwest of it has moved north, the land northwest of it has moved northeast, the land north of it has moved east, and the land northeast of it has moved southeast. Here again, as in the Tango earthquake, the maximum displacements are at those stations nearest to the rift, and the amount of displacement diminishes quite consitently in proportion to the distance from the Sagami Bay center. The map gives one the impression that the land has executed this rotation around Sagami Bay almost as though it were plastic. (A. Imamura and F. Kishinouye, On the Horizontal Shift of the Dislocations Accompanying the Recent Destructive Earthquakes in the Kwanto District and in Tango Province, Proc. Imp. Acad. Japan, IV, 1928, No. 3.) T.A.J.

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No. 204 RELEASED WITHOUT COPYRIGHT RESTRICTION November 22, 1928

KILAUEA REPORT No. 878

WEEK ENDING NOVEMBER 21, 1928

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Volcanic conditions at Kilauea have not changed. There is very little working of the walls, and earthquakes are very infrequent, only eight very feeble shocks having been registered during the past seven days. Tilt accumulation is moderately northwest.

THE ERUPTION OF ETNA

The volcano Etna occupies an oval tract 30 miles long in a north-south direction, and 23 miles wide, on the north-eastern coast of Sicily. The city Catania is at the southern edge of the mountain, and was destroyed by earthquake in 1169 and invaded by lava in 1669. A railroad connecting Catania with Messina follows the coast line east of Etna. Taormina lies northeast of the mountain, and Messina is 35 miles farther to the northeast on the strait that separates Sicily from the mainland of Italy. Etna is 10,758 feet high, and its height was reported to have decreased 112 feet between 1861 and 1900. The circumference of the mountain is about 91 miles, and its area about 460 square miles. The summit is truncated, and an inner cone rises from the summit plateau containing the large crater. East of this is the Valle del Bove, a vast desert gulf three miles wide, bounded on three sides by cliffs 2,000 to 4,000 feet high, and constituting apparently a collapsed area much like the crater of Haleakala.

Numerous lava flows have poured out in the Valle del Bove, and others have come from the flanks of the mountain on other sides, forming minor craterlets below the base of the large central cone. Historic eruptions of Etna are reported as far back as 693 B. C.

The lower belt of vegetation to about 3,000 feet of elevation is the zone of cultivation, where vegetables are grown, and in the drier upland vines and olives flourish. The slopes are densely populated, having 930 inhabitants per square mile below elevation 2,600 feet, and more than 3,000 inhabitants per square mile in the southeastern sector. The highest zone is wooded up to elevation 6,800 feet. For much of the year the summit region is covered with snow.

The present eruption began about November 1, and from press reports we learn that four streams of lava started about elevation 3,000 feet on the east flank. This appears to mean north of the lava flows of 1811 and 1852, near the north rim of the Valle del Bove. Mild earthquakes preceded the eruption, and one flow appeared to be headed in the direction of Sant Alfio and Giarre which is east of the mountain, on the railroad. On November 4 Pontanazzo, with a population of 2,000, was threatened, 22 farm houses on its outskirts had been engulfed, and officials were causing evacuation of the danger zone.

It now became apparent that the flows were moving more to the north, road traffic was disrupted, and on November 5 the large town Mascali was being deserted.

November 8 the eruption was said to be spreading destruction comparable to that of the great flows of 1169, several hamlets had been destroyed, the flow was widening as it reached lower levels, and hundreds of persons were reported homeless. At this time three men who had returned to their homes to rescue household goods, and had decided to sleep there overnight, were said to have been surrounded by lava flows so that fellow townsmen looked on helplessly as the molten slag engulfed the victims.

On November 9 Mascali was invaded, although the three principal streams seemed to be diminishing in volume. The central stream had advanced several miles, and two other flows had gone less than a mile. By November 11 the largest flow was said to be moving toward the shore at the rate of 15 feet an hour, with a front two miles wide and 16 feet high. Twelve thousand persons were homeless and being cared for in schools, churches, and railway stations. Villages, cultivated fields, and orchards had been destroyed, and the government was preparing to provide measures of relief. The railroad was overwhelmed by the flow, trees were blazing, the torrent was following the valleys, and factories and mills were being dismantled. A roaring noise was heard, the usual explosions occurred about the front of the lava, where coal gas from burnt vegetation was mixed with air in caverns, and out of the cracks came forth the odor of hydro-carbons.

By the 13th the speed of the flow had greatly decreased. Relief funds were appropriated by the Mussolini cabinet. The Italian press estimated damage to agricultural lands at three million dollars, and to habitations, roads, railways, bridges, and engineering works, 15 million dollars. Only 50 out of 800 houses are left standing in Mascali, and 100 houses are reported destroyed in Serrageano. Other places mentioned as suffering are Annunziata and Carraba. Earth rumblings were heard as far as Messina and the explosions from the lava caverns are reported as hurling up flakes of stone, just as they do about the front of Mauna Loa flows when the lava enters a forest. The last report from Rome (November 12) states that 4,000 acres have been laid waste, 700 houses destroyed, and 5,000 persons made homeless. It is worthy of note that this eastern region has hitherto been mostly free from lava flows of historic dates, so that the mountain is merely fulfilling the law of symmetrical cone-building. T.A.J.

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No. 205 RELEASED WITHOUT COPYRIGHT RESTRICTION November 29, 1928

KILAUEA REPORT No. 878

WEEK ENDING NOVEMBER 28, 1928

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Dense steam was rising from Halemaumau on the afternoon of November 22 due to falling moisture. On November 24 at noon there were no changes whatever in the pit that could correlate in any way with numerous earthquakes registered in the early morning. A slide from the northeast wall made dust at 8:20 a. m. November 26. Nothing new was seen today.

Earthquakes increased materially during the week, a total of 36 having been registered. Twenty of these were recorded between 5:17 and 5:43 a. m. November 24, and five of this number were of sufficient intensity to be felt locally. Two shocks, slightly larger than the others, had phases indicating distances to origins of 0.4 mile and 1.3 miles from the Observatory.

Tilt for the week accumulated SSW. As most of this took place on November 24 and 25, the earthquakes seem indicative of a partial collapse of the center floor, possibly due to subsidence of the lava column.

CRATERS OF THE MOON NATIONAL MONUMENT

The large basaltic areas of the Snake and Columbia rivers have long been considered flows that emerged from obscure fissures. Gradually the fracture lines that constitute the vents are coming to light. One of these is the rift zone trending NW.-SE. lying Southeast of the White Knob Mountains in Idaho, which has been set aside as the Craters of the Moon National Monument, including about 80 square miles south of Arco, Idaho. The reservation is about 23 miles long by 8 miles wide, and stands between 5,000 and 6,000 feet above sea level in a semi-arid district. A roadway penetrates the northwestern end of the Monument, and the whole district is in every way similar to the Kau Desert southwest of Kilauea or the Puu o Keokeo desert of the southwestern rift of Mauna Loa.

There are both aa and pahoehoe lava flows, many horseshoe-shaped cinder cones made by fire fontains at the sources of the flows, numerous lava caverns in the pahoehoe, which become natural bridges were these are partially broken down, and a large number of tree moulds and lava trees. There are also ice caves and water holes, all of which owe their existence to ground ice. (H. T. Stearns, Bull. Idaho Bureau of Mines and Geol. No. 13, July, 1928, Moscow, Idaho.)

There are yawning crater pits. and many spatter cones, and the floods of lava for six miles against the southern spur of the White Knob Mountains filled the valleys as if they were bays, and left the spurs like projecting headlands in a black sea. These mountains are of granitic rocks, and when in recent geological time the great rift opened on their slope, and thick jagged lava flows poured to the south and east, there were left small and large fragments of granite that broke off from the roof of the lava reservoir and floated upward in the molten lava during the eruption. Obsidian occurs among these older eruptions, and this was quarried by the Indians to make arrow heads.

A second series of eruptions broke out making many of the large cinder cones in the middle of the Monument area. The third and last eruptive epoch gave vent to barren black lavas which form the latest veneer over much of the area, these flows in many places surrounding the earlier cones. Altogether about 35 cones and vents and 30 different lava flows are found in the Monument. Everything indicates that the actiivty was accompanied by quiet fountaining of vesicular lava, with much foaming and great quantities of gas, but without explosive eruption such as would spread volcanic dust for hundreds of miles. The bombs are of the spindle, ribbon, and bread-crust types associated with the ejection of clots of liquid lava.

The rock is basaltic, with 51% of silica, 14% alumnia, 15% iron oxides, 6.5% lime, 2% magesia, and 6% alkalies.

Pahoehoe flows cover about half the area, often with blue glassy crusts and billowy, ropy surfaces, these flows being filled with caverns. The caverns invariably occur in pahoehoe and not in aa. The aa flows. just as in Hawaii, are in many cases produced where pahoehoe changes to clinker some distance away from its source, but the aa never changes back into pahoehoe. Some of the aa lava flows are 25 to 100 feet thick, and have moved several miles out on the plain.

The cones of the Craters of the Moon area are large cinder heaps about 450 feet high, or lines of smaller spatter cones about 50 feet high and 100 feet in diameter, or lava domes rising 30 to 50 feet above the surrounding country, and sometimes surmounted by tiny spatter heaps less than 10 feet high. These lava domes are compared with Mauna Iki, which was formed in 1920 at Kilauea.

The tree moulds vary from a few inches to three feet in diameter, and are sometimes 10 to 20 feet deep. Sometimes the liquid lava flowed into the checks or shrinkage cracks in the charred surface of a log, forming a checker pattern, easily mistaken for bark impressions. Lava trees rising one to five feet above the general surface occur where part f the lava flow has drained away, leaving the mouded trunk in relief.

The abundant water holes are due to the freezing period, which at this elevation in Idaho covers about seven months in the year. This is much like the summit regions of Mauna Loa and Mauna Kea. The caves and cinder heaps act as heat insulators, and in one place called Ice Cave a heap of ice and snow 20 feet thick is found even in summer. Fifteen perennial water holes are listed. The temperature of the water rarely exceeds 34° F.

Stearns concludes from the evidence of pine trees and other vegetation growing on the flows that the youngest cones in the area are over 400 years old. The charred wood seen in many places was set on fire artificially or by lightning, and was not fired by hot lavas. There is some very fresh pahoehoe lava which may be little more than 250 years old, and there are obscure Indian traditions of fire seen in the region. All of this resembles similar evidence concerning the Lassen country, and indicates the possibility of other eruptions yet to come near the Craters of the Moon National Monument. In detail the photographs of stalactites, shore-line marks of lava in caverns, festoons, pits, and the rift landscape in Mr. Stearns' report are extraordinarily like Hawaii. T.A.J.

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No. 206 **RELEASED WITHOUT COPYRIGHT RESTRICTION** December 6, 1928

KILAUEA REPORT No. 880

WEEK ENDING DECEMBER 5, 1928

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

There are no changes at Halemaumau. Some large slides occurred on the forenoon of December 3. At 10:55 a. m. there was a big avalanche at the north, with a column of dust spreading NW.-SE. rising from the pit. The debris fell from the north rim, in the region of the active avalanching of last August. The north wall is thickly coated with white salts, and much white material covers the north talus.

A section of the southeast rim near the tourist outlook has caved away. It is still very unstable, and further slides will occur there until all the loosened area goes.

Crack measurements along the east rim show practically no changes in nearly three months.

The count of earthquakes for the week is but three very feeble local shocks. One of these at 6:17 p. m. December 3 had an indicated distance to origin of 9.3 miles.

Tilt accumulated moderately to the NE.

WHITE ISLAND VOLCANO

It will be recalled that White Island, in the Bay of Plenty, near the north island of New Zealand, is an active volcano which has a sulphurous crater nearly at sea level, surrounded by fuming cliffs, and separated by only a bar from the ocean. On the back-slope of the cone, away from the crater, dwell the operatives of a sulphur-mining company, equipped with a launch, wireless, and a tramway to the workings at the crater. In the second decade of this century (1914) a former group of sulphur workers, who lived on the lowland between the crater and the beach, were all exterminated by an evisceration of the crater which no one survived to describe. The wreckage suggested an explosive eruption and a flood.

In Volcano Letter No. 200 of October 25, 1928, we described White Island activity in June, 1928, seen as excessive steam from Opotiki on the neighboring coast.

On September 1, 1928, a new eruption of White Island occurred. This "was accompanied by a phenomenon in the form of a sulphurous dust cloud," believed similar to the one experienced some days earlier by the steamer "Emlynian" in the Netherlands East Indies, about 30 miles north of Flores and 200 miles east of Java. It appears that this dust cloud in both cases coated the decks of ships. In White Island it swept south, across Crater Bay, where the company's launch, the Whaakari, was moored, and dusted it without arousing the men sleeping on board. (New Zealand Herald, September 13, 1928.) It should be pointed out that the "Emlynian" was close to the volcano Rokatinda, which has just had a disastrous eruption.

The men in the camp, which is removed from the active area of White Island, were unaware that anything unusual had taken place during the night. The telegram to the head office of White Island Products, Ltd., Auckland, from the island, was as follows:

"A minor eruption occurred in the active crater area about 1 a. m. on Saturday, September 1. Series of new vents formed from two to four chains from the main blow-hole in the direction of 'Lot's Wife'."

"The whole of the upper crater area is covered eight to 24 inches deep with very fine blue-gray dust. Stones and bowlders up to two and three hundredweight were scattered in a radius of about 200 yards around the activity. We have not yet been able to make a full inspection, but from the edge of the activity it appears that the force has subsided, although steam is blowing over an area of about half an acre. The chief trouble is that we are completely cut off from the sulphur suppiles, as the road is impassable."

Professor J. A. Bartrum, geologist of Auckland University College, considered that the main interest of the White Island activity lay in whether the activity was caused by avalanching from the crater walls at the back of the main blow-hole, believed to have caused the 1914 eruption, or whether there was some other cause. Mr. Welsh, the general manager of the company, stated that slips had not caused the recent eruption. Professor Bartrum thought that " in that case the occurrance is certainly a little disconcerting, and the tendency to any special activity needs watching.

We previously reported earthquakes about the Bay of Plenty in January, February, March, June, July, and August. A sharp earthquake was felt at Opotiki shortly before 1 p. m. September 12, and Rotorua reported several shocks after 1:30 a. m. on October 2. They terminated at 3:15 a. m. with the heaviest shock experienced here for many years. All the geysers at Whakarewarewa were very active in the early morning. At Tauranga, again on the Bay of Plenty, a sharp earthquake shock was felt at 5:17 a. m. November 6, and the tremor was felt at Te Puke. All of these jarrings, throughout the year, around the bay in which White Island is situated, make that volcano an interesting object, especially as it has had two reported outbreaks, one just at the June solstice, the other just before the September equinox. (See Volcano Letter No. 66, April 1, 1926.) T.A.J.

ERRATUM

The previous issue of the Volcano Letter should be numbered 205, instead of 204.

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No. 207 RELEASED WITHOUT COPYRIGHT RESTRICTION December 13, 1928

KILAUEA REPORT No. 881

WEEK ENDING DECEMBER 12, 1928

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

There is nothing new to report about Halemaumau pit of Kilauea Volcano. There has been little avalanching, and the visible vapor from the cones on the bottom and from the vents about the border talus varies with the weather. After excessive rain such as has fallen during the last twenty hours vapor fills the pit, but there is equally great increase of vapor from the cracks of the floor and rim of the greater crater.

Sixteen very feeble local earthquakes were registered during the week ending at 8 a. m. December 12, including two continuous tremors each of about 2½ minutes duration, both on December 11, beginning respectively at 10:31 a. m. and 11:19 a. m. Tilt for the week was slight to the NE. Microseisms were normal.

THE ROKATINDA ERUPTION

A newspaper report of August 9 stated that the eruption of Rokatinda killed a thousand people, injured 600 with flying rocks, and in addition six villages were wiped out by eruptions and earthquakes, and a large section of the seaboard had been submerged and recurrent waves of enormous size had caused the sinking of nine vessels.

The exact facts of this eruption have now been investigated by the volcanologists of the Netherlands East Indies and it appears that 226 people were killed, of whom 128 perished by flood waves caused by landslides at two places on the southeast and south coasts of the island. Four villages were covered with ash and pumice, and two others were partly destroyed.

The volcano Rokatinda is on the southern flank of the circular island Paloeweh which lies north of Flores in the eastern part of the Javanese Archipelago. The eruption occurred in the night August 4-5. It was preceded by local tremors which increased in intensity from July 25 on. Many of the inhabitants of the southern villages near the crater fled to the northern part of the island. The greatest destruction was between 10 p. m. and midnight. Great masses of new material in the form of pumice and ash were thrown out, and of old material in the shape of lava blocks. The new craters were enlarged by subsequent explosions. The red hot stones could be seen far away from the north coast of Flores. As this is the dry season the grass and trees were fired by the incandescent material so that the southern half of the island was ablaze.

Three new craters were formed, some 500 meters apart, one 400 meters in diameter. During the violent eruptions of the first few days ash and pumice to a depth of from one to two meters accumulated at a distance of one kilometer from the craters. Large blocks fell 1.5 kilometer away from the center. These blocks were as big as a man's head and made large impact cavities in the ground. Pumice fell all over the island. Ash, carried by the prevailing wind covered the southwestern part of the island with a thick mantle of light gray dust. On August 5 and 6 this ash fell on Bali and on East Java.

On August 8 only white clouds of steam were issuing from these pits. In the large southern crater a plug had appeared consisting of coarse loose porous light gray block lava containing many inclusions. After this conditions were tranquil, the crater could be approached without danger, one of the smaller craters threw off some ash, another went out of action at the end of August, and on September 9 a new craterlet was formed throwing out stones in the immediate vicinity of the vent and fine ash that fell all over the island.

This new eruption ceased September 25 and thereafter only white steam clouds were emitted. The three earlier craters had thrown out light gray ash, whereas the later crater ejected dark gray ash and angular blocks of old material.

A beach on the southeast shore of the island disappeared, and a steep bluff was formed by sinking of the seacoast on the south shore. Fumeroles and solfataras are found on several parts of the island about lava flows, old domes and fissures, and some of these as well as the elevated fringing reef around the island, indicate that the island is subject to fracturing by uplift. There is no previous historical record of eruption on Paloeweh.

It is of interest to note that Krakatoa was still showing recurrent volcanic activity at its submarine vent in between the three islands, as seen from the observation post and seismograph station which was established in January to keep track of the eruptions. August 25 there were 19 explosions, three upwellings and ten tremors. August 27 tremors were recorded. August 28 there were 21 explosions and tremors were increasing day by day. August 31 produced 15 explosions, seven upwellings and 12 tremors. (Bull. Neth. East Ind. Volc. Surv. No. 12, Oct. 1928.) T.A.J.

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No. 208 RELEASED WITHOUT COPYRIGHT RESTRICTION December 20, 1928

KILAUEA REPORT No. 882

WEEK ENDING DECEMBER 19, 1928

Section of Volcanology, U. S. Geological Survey

E. M. Buckingham, Temoprarily in Charge

No new phases have been discovered at Halemaumau. Conditions remain unchanged. Ocassional rockfalls are heard. Fresh wall scars north and northeast were observed today.

Only five very feeble local earthquakes were registered during the week. Microseisms were very slight. Tilt accumulated very slightly to the SW.

WORLD EARTHQUAKES

The literature of seismology is hopelessly dry. It consists of long lists of figures. Moreover the figures are technical and the headings of columns quite incomprehensible to the layman. There is great value however to the lists of figures for the interested experimenter, who possesses a delicate pendulum swinging free in a quiet basement room, which has suddenly begun to swing in long sweeping strokes at a certain hour of a definite date, and has then written an autograph lasting over three hours. It is unfortunate that the fascination of building and using seismographs has not taken hold of amateurs the way the construction of telescopes has done. If we had more amateur seismologists the science of the earth would progress faster. We believe the dryness alluded to above could be remedied, and that hundreds of persons might be led to take an interest in recording earthquakes and reporting on their findings, if some of the many organizations for popularizing science would start a campaign for popularizing seismology. This would be particularly welcome in such earthquake lands as California, Japan, India, Italy, New Zealand and western South America, and a comparatively simple instrument might be placed in the hands of hundreds of persons who are interested in local earthquakes by reason of their habitat.

Two documents have come to hand recently, issued by the British Association for the Advancement of Science. One is the 33rd report of the Committee on Seismological Investigations, of which the astronomer, Professor H. H. Turner, is chairman. The other is a catalogue of earthquake as registered by seismological observatories all over the world for seven years between 1918 and 1924.

The notes show that earthquakes are apt to recur at the same epicenter. In one case the same epicenter has done duty for thirty-four earthquakes. Most earthquakes are believed by measurement to originate at approximately the same depth below the earth's surface. By this is meant big shocks. Most seismologists believe this depth to be about thirty miles down. According to Professor Turner there is evidence that a certain number of earthquakes are above the normal depth in their origin, while still stronger evidence shows that some earthquakes are touched off from very deep foci, and so shake a very large area of the surface of the globe.

In the Committee report we learn that there is not a single day during the whole seven years on which no earthquake was recorded, though there are many days on which shocks were recorded at one or two observatories only.

The monthly counts of epicenters show that twenty-nine large earthquakes occur somewhere in the world most months, and that September for this group of seven years has more earthquakes than any other month. The figure for September is fifty-one, even leaving out the exceptional year 1923 when came the Tokyo disaster with its many aftershocks in September. To judge by the table of averages shown, there are more in spring than in winter, more in summer than in spring, more in September than in summer months, and then a gradual decline to a low level in frequency in January.

There is an interesting note on vertical component seismographs. It is well known that the elasticity of a suspension spring is liable to changes when temperature varies. With the Galitzin vertical pendulum a change of 1° C. in the temperature of the apparatus is sufficient to put the instrument out of action.

At Strasbourg a spring made of elinvar, an alloy with a low-temperature coefficient for elasticity, has been in use for some time. Such a spring tested at Kew Observatory is found to yield continually under the load, but the effect of ordinary temperature change is almost eliminated.

The work of the International Seismological Summary published by the British Committee every quarter is a very useful and valuable adjunct to every earthquake station. It must be very laborious to compile. The seven-year catalogue is a digest of this summary, and is intended to reach geologists and geographers, so as to interest them in using the statistics of latitude and longtitude and numbers of earthquakes, in connection with their field knowledge. We believe that this catalogue would be still more popular if it could have two columns added to the tables; one to express the general locality of the epicenter in a geographical name; and another to express the probable intensity or "size" of the earthquake in terms of its seismographic range. It is true that the number of stations represented is somewhat a measure of extent but it would seem that an obvious aftershock ought to be labelled as different from a world-shaker. T.A.J.

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No. 209 **RELEASED WITHOUT COPYRIGHT RESTRICTION** December 26, 1928

KILAUEA REPORT No. 883

WEEK ENDING DECEMBER 26, 1928

Section of Volcanology, U. S. Geological Survey

E. M. Buckingham, Temoprarily in Charge

There has been a slight increase in the working of the Halemaumau walls. It is believed that this is due to possible fluctuations of the Kilauea floor as indicated by tilt measurements.

On December 20 considerable steam was escaping from the south cone and a vent on the SSE. talus. On December 23 an avalanche from the NNE. wall was observed at 3 p. m. On December 26 there was evidence of avalanching from the north and east walls, and dust from two slides was seen. Several falls of rocks were heard.

There were six very feeble local earthquakes registered during the week. In addition were two perceptible shocks having epicenters from 10 to 12 miles southeast of the Obseravtory. The first, at 8:43 p. m. December 24, was accompanied by a tilt at the Observatory of seven seconds to the north. The second shock occurred at 10:13 p. m. December 25. Tilt for the week accumulated slightly northeast.

Measurements made at the Halemaumau seismograph station on December 19 and 26 indicate a tilt of 10 seconds away from the pit during this interval. Tilt has been slowly accumulating in this direction since the early part of November.

EXPECTED HAWAIIAN ERUPTION

In 1912 the writer wrote that Mauna Loa should become active before 1915; it broke out in 1914. In 1917 he wrote that a great crisis in Hawaiian volcanism should come around 1920; both Mauna Loa and Kilauea had flank outflows within the twelve month preceding July 1, 1920, and a great explosive crisis came in 1924. In 1923 he wrote that the nine year cycle following 1913 would probably be unusually long and representative of one of the long term intervals such as 1868 and 1790 had illustrated; the 1924 engulfment accompanied by shore collapse at Kapoho was a close parallel to 1868. All of these tests of reasoning with reference to forecast are merely based on observation and experience, coupled with a logical deduction from the records of the nineteenth century.

Experience has shown that in Japan, Italy, Hawaii and the Caribbee Islands, one hundred and thirty years or some such figure is a common interval between either big eruptions or big earthquakes near eruptive centers, or both. On the other hand Vesuvius and Kilauea both exhibit a minor interval of from nine to ten years, and the larger volcanoes Etna and Mauna Loa tend to average their outbreaks at intervals of one half this period, or about four and one half years. Mere charting of the facts for the last thirty years has shown a distinct tendency in the pit-lava of Kilauea to rise when Mauna Loa breaks out, and to sink when Mauna Loa stops action. These things are not invariably observed, for the simple reason that the Kilauea lava column is not always visible.

It is not permissible to say that Kilauea and Vesuvius shall break out every nine years, or Mauna Loa and Etna every four and a half years. A volcano is not a clock. The interval theory is based on averages, and the averages are based on certain laws of nature such as those that determine the space intervals of ripple marks in the sands of the sea or the time intervals of waves when they break rythmically on the beach. The lava under a volcano has been pressing upward for ages through a crack of a certain size. It has blocked or impeded that crack with its own heap of lava and so has forced itself to adopt a rhythm or interval like the puffs from a steam engine. If it has several vents, these divide responsibility for the interval, and if one vent is low and close to the water table, while the other is high and far above the ground water of the island, the probability of explosion is greater for the lower vent. This is because a sudden drop in the lower vent may place the lava column below the water table and so develop a steam chamber. This is the situation of Kilauea as compared with Mauna Loa.

The whole great edifice or volcanic system is itself involved in responsibilities to large masses of lava underground which it perhaps shares with other active or half extinct volcanic systems along the same rift or crack, and these responses may demand certain major eruptions or major dormancies at very long intervals of time, when the whole crust of the earth for that part of the world is disturbed to an unusual extent. It is like the intake and outgo of a large corporation, itself made up of the accounts of smaller stores. One must know all the books or the accounts will not balance. So when we argue about the expectancy of eruption at Kilauea, we must take account not only of average small intervals and average great intervals but also of the volume of output of lava in relation to the intervals as compared with the volume expected by analogy with average eruptions in the past.

As compared with the outpourings of 1852, 1855, 1859, and 1868 the lava output of the island of Hawaii in the last eighteen years has been very small, unless there has been an enormous unseen lava flow under the ocean. Yet there are many features of the flows of 1914, 1916, 1919 and 1926 from Mauna Loa, and the intervening effusions about the crater of Kilauea, that closely resemble the double cycle that followed 1850. We have platted a curve of the combined activities of Mauna Loa and Kilauea, which shows a pronounced low level about December of 1913 and December of 1924, and a remarkable high level about December 1919. The lava of Kilauea rose rapidly after 1913 with arresting depressions after each Mauna Loa flow. After 1924 the lava has risen slightly in the bottom of Halemaumau pit and Mauna Loa flowed vigorously in 1926. If the curve of rising now continues comparably to what happened after 1913, it is logical to expect activity from either Kilauea or Mauna Loa in 1929. T.A.J.

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No. 210 **RELEASED WITHOUT COPYRIGHT RESTRICTION** January 3, 1929

KILAUEA REPORT No. 884

WEEK ENDING JANUARY 2, 1929

Section of Volcanology, U. S. Geological Survey

E. M. Buckingham, Temporarily in Charge

The week has been very quiet at Kilauea, with only two very feeble earthquakes and very little change at Halemaumau. The tilts noted last week have dropped back to nearly the values shown prior to those accumulated at the time of the two perceptible earthquakes of December 24 and 25.

VOLCANIC ACTIVITY NEAR TONGA

From the Apia observatory, Dr. Andrew Thomson Director, came news under date September 24, 1928, that Falcon island, the newly formed volcano fifty miles to the nortwest of Nukualofa in the Tongan islands, continues to give off steam with an occasional expulsion of a mass of cinders and ash. Its activity had diminished during the previous six months.

Dr. Thomson writes, "There is a rather striking difference between the Tonga and Samoa volcanoes, in the materials ejected. In all recent eruptions in Tonga, ashes, cinders and scoria have been thrown up, while in Savaii lava only has been ejected. The volcano Maugaloa in Savaii, which threw out such enormous quantities of lava from the Matavanu vent during 1907-11, has become dormant. The steam column, which used to issue from a vent, became smaller in size, then came only at irregular intervals and it is now several years since it has been seen at the Government residency about five miles away."

The same observatory reports a probable new submarine eruption about 120 miles farther to the northwest indicated by fields of floating pumice first observed by the S.S. Carisso, October 3, 1928, about 240 miles east of Suva, Fiji. (Science, p. XIV, Nov. 9, 1928.) During that night patches of pumice ,each covering several miles, were seen along a course 70 miles to the southwest of the first patch. The S.S. Veronica sighted a patch a mile wide 30 miles farther to the west October 7, over water more than 1200 feet deep, and a very large field of pumice was found farther to the east many miles in length in an N-S direction and about a half mile wide.

The pumice first seen was at 17° 25′ south latitude, 176° 09′ west longtitude. If the vent is on the bottom of the sea near this place, it is an area in deep water of great seismic activity where ten violent earthquakes occurred between 1913 and 1920 and one of the epicenters lies about 75 miles north of where the pumice was seen. There are two principal earthquake centers, and it is a remarkable fact that all of this seismic and volcanic activity is on the line between the active volcano island Niuafou and the Tonga volcanoes further to the south. Niuafou is about 100 miles north of the region in question.

The activity of Falcon Island is well described in the December, 1928, National Geographic Magazine (Hoffmeister and Ladd, Falcon the Pacific's Newest Island, p. 757). These authors landed on the revived island in May 1928, discovering strong hydrogen sulphide fumes, no red glow at night, a roundish island with crater close to the shore on the southeast or windward side, and the greater part of the heap built to leeward of pumice, cinder, lava fragments, bombs and ash to a height of 365 feet. The island is about two and a half miles across in an east-west direction, clouds of steam and sulphur fume rise from the crater, the surface is rill marked and washed into gullies, and steep cliffs have already been cut by the sea along the windward side of the island.

The present eruptive period of Falcon Island began with its most violent eruption on record in October 1927, and minor eruptions from time to time have added to the heap since. It is an old volcanic shoal first reported in 1865 and occasionally active since.

The north shoreline consisted of coarse black cinders and pumice banked at 70°, and the ground was made up of fine ash mixed with sharp fragments of cinder, pumice and lava, with only trench-like gullies to break the uniform curve of the ridges. The profile of the island shown in a photograph exhibits a distinct wave cut platform at the east The bottom of the crater is elliptical, covered with a boiling lake, some parts of which boil incessantly, while other places bulge upward periodically, when black sediment is brought up from below. The water varies in color from milky green to yellowish white. The lake is surrounded with ash and sulphur flats, dotted with steam jets, and the steep walls of the crater are vertically fluted, with steam vents rising from the depressions which have deposited sulphur and other substances coloring the gullies yellow, orange or white in contrast with the drab ridges.

There is a younger crater with steep sides, and an outer crescent ridge, with a gulch between the two that has drained into the lake to form a low delta built out into the lake from its eastern side. The crater wall is largely fine ash and scoria but there are numerous volcanic bombs and blocks. The bombs are spindle shaped, were thrown out in a liquid condition, are often exceedingly porous, in other cases they show concentric structure. Some of the blocks are three feet in diameter, made of agglomerate or of either dense or porous lava. The vent noises are of sputtering and whistling, the lake waters have a vile taste, and sulphur dioxide appears to have been dominant, as the eyes smarted and breathing through cloth gave relief.

T.A.J.

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No. 211 **RELEASED WITHOUT COPYRIGHT RESTRICTION** January 10, 1929

KILAUEA REPORT No. 885

WEEK ENDING JANUARY 9, 1929

Section of Volcanology, U. S. Geological Survey

E. M. Buckingham, Temporarily in Charge

Beginning January 5 there was a marked increase in avalanching in Halemaumau pit, all from the south, and southeast walls. Since that date avalanching has been practically continuous, and a large part of the south rim has disappeared. Half the lava floor of the pit is buried under debris from a big avalanche occurring at 7:40 a. m. January 7 and carrying away the south station. The area around the tourist stand is badly shattered and has settled noticeably, rendering the bench mark at the edge of the pit valueless. Crack measurements in the vicinity show a widening of 0.8 foot in one of the cracks between December 4 and January 7, with an additional widening of 0.3 indicated by a measurement on January 8.

The avalanching is progressive and appeared to originate about one-third of the way down from the southest rim, undermining the top and lossening the lower sections by impact, and spreading progressively from south to southeast.

The seismographs at the Observatory recorded 16 very feeble earthquakes, 12 of them occurring during the interval from January 5 to 6:30 a. m. January 6. Beginning at noon of January 5 the instruments recorded a very faint continuous tremor which lasted, with varying amplitude, throughout the remainder of the week. Many of the counted earthquakes are hardly more than pronounced increases in the amplitude of this tremor.

MORE ABOUT ETNA

The eruption of Etna is said by Professor Ponte, Director of the Etna Observatory, to be much bigger than those of 1910, 1911 and 1923 (London Times. Nov. 12). The eruption started November 1 and on the 6th the velocity of the lava increased and the stream was only 200 yards from the Circum-Etna Railway at 9 a.m. The volume of lava had been increased suddenly by three arms which had been flowing separately uniting as they approached the hamlets before Mascali, and this produced accelerated movement. At one place the flow formed a huge cascade. An iron bridge began to sink at the approach of the lava, and was simply fused when the lava reached it. The spectacle is described as ominous and terrifying. Trees suddenly take fire and flare up, and orchards disappear in flames. The people in the villages continually formed processions and carried religious banners, pictures and even statutes before them while praying fervently. The preceding night big explosions were heard, with loud subterranean rumblings (Daily Telegraph, London, Nov. 7).

On November 7 Mascali, a town of 7000 inhabitants, had been destroyed, and The Illustrated London News of November 17 carries remarkable pictures showing the lumpy aa lava in the midst of this masonry town with the dome of a large church still standing. A message of this date said, "the main body of the parish church, its belfry and the new War Memorial, the last three structures standing collapsed at three o'clock this afternoon and the village is now entirely obliterated." The pictures give a vivid idea of what a Mauna Loa lava flow would do if it were to invade the newer masonry structures of Hilo such as the business blocks and the Federal Building.

Vehicles of many kinds were brought in to carry away the inhabitants. The correspondent writes "during the night the lava stream steadily advanced, obliterating house after house, and this morning (7th) when I tried to approach the town, the heat prevented me from getting within 300 yards of the last group of houses, which were already surrounded by a burning mass."

"The town hall was one of the last buildings to remain standing. For some time as the lava rose all around it the walls offered stubborn resistence. Suddenly, however, they collapsed and mingled with the mass of melted rocks."

"Several secondary craters opened on the 2nd and 3rd and on the 4th they formed one vast crevice on the side of Monte Frumento, from which poured out huge volumes of lava."

Along the eastern railway there was dense fume for more than a mile making breathing very difficult. The lava near Mascali was moving about five feet per minute but it was certain to reach the railway. The breaking of an aqueduct by the lava caused serious inconvenience and destruction of road bridges interrupted traffic. An attempt to divert the main lava stream and open an artificial outlet to the sea to prevent the destruction of important towns was being planned (London Telegraph, Nov. 8).

By the end of November 7 the flow had gone 300 feet beyond Mascali. It had now cooled sufficiently for a hard, dark crust to form on its surface. It therefor no longer presented the appearance of a river of fire, but looked rather like an enormous pile of coal. It was twenty-five feet high where it entered Mascali. Cracks appeared in the flow, revealing its fiery interior and as it advanced it made a horrible crunching noise. At night, by contrast with the surrounding darkness, it resumed its fiery aspect. The stream now stretched about ten miles from its crater. (London Daily Mail, Nov. 8).

On the 8th digging and mining new channels to lead the lava away from the large town Giarre were occupying the attention of the authorities. The most tragic scene at Mascali was the engulfment of an aged couple who had fallen asleep after nights of anxious vigil At three o'clock in the afternoon, when the lava had surrounded them, they were suddenly seen on their roof imploring help. A crowd of spectators 500 yards away were terrified and realized that help was impossible. Then the walls fell in and the unfortunate couple disappeared.

After the little church had crumbled in, the campanile or bell tower stood. It was observed to lean first in one direction and then in another and suddenly the bells rang out. The crowd was deeply affected and many of the old folk fell on their knees and prayed. The bells were still heard long after dark, and at eight o'clock the tower fell and the bells rang no more. (London Telegraph, Nov. 8).

On the ninth a huge cascade of fiery liquid rock was pouring uninterruptedly into the valley of Bove, where a lake of lava had been formed three-quarters of a mile wide, feeding the torrents that descended to the lowlands. On the 11th the railway bridge at Mascali was destroyed and the railway was obliterated. This finished the second railroad interrupting all traffic at the east end of Sicily. (London Telegraph, Nov. 10 and 12.) T.A.J.

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No. 212 **RELEASED WITHOUT COPYRIGHT RESTRICTION** January 17, 1929

KILAUEA REPORT No. 886

WEEK ENDING JANUARY 16, 1929

Section of Volcanology, U. S. Geological Survey

E. M. Buckingham, Temporarily in Charge

The avalanching which began last week reached a climax at noon of January 10, when a section of the southeast rim about 100 feet long fell into the pit, carrying away the 19th hole golf tee. Since that time there have been only occasional small slides, although another section of the southeast rim appears to be slowly loosening.

The continuous tremor which began at noon of the 5th died out in the afternoon of the 9th. During the week there were recorded eight very feeble local earthquakes and one teleseism, which occurred on January 12 from 1:42 to 2:14 p. m. The strongest of the local shocks was coincident with the landslide at Halemaumau on Janury 10.

MAKING ARTIFICIAL EARTHQUAKES

The Hawaiian type seismograph (described in Bull. Hawn. Vol. Obsy. vol. XV, No. 11, Nov. 1927) has been mentioned in the Volcano Letter as an instrument designed especially for local earthquakes from experience at the Hawaiian Volcano Observatory. Six pairs of pendulums of this design have been built in the Kilauea shops and set up at Hilo and Kealakekua, Hawaii, at Kodiak, Alaska, and Cheltenham, Maryland, at Mineral, California and Dutch Harbor, Alaska. The last is still in process of being installed. A seventh instrument is now set up in the Observatory shop, and is being subjected to tests with experimental earthquakes.

The readers of the Volcano Letter may be interested to know how that can be done. The late Professor Omori of Japan made a shaking table on wheels actuated by a connecting rod from the driving wheel of a steam engine. With this he set up various brick, stone and cement columns clamped to the top of the table, and then subjected the machine to rhythmical jerks or accelerations applied by the engine. By increasing the period and amplitude of these jerks to the critical value that led to the overturning or fracture of the columns, he learned much about the strength of masonry suitable for an earthquake land. Similar experiments were conducted in the engineering laboratory of the Massachusetts Institute of Technology about 1911 under the guidance of Professor C. M. Spofford and others.

The problem before us in the Hawaiian laboratory is different, in that it is desired to imitate feeble earthquakes such as frequently affect seismographs in a volcanic land, and to provide devices on the oscillating table for setting up such a seismograph with its full recording mechanism. In the summer of 1928 Mr. R. M. Wilson designed and built such an oscillating table, having the property of reducing the amplitude of motion of the machinery to which it was attached to microscopic proportions, while retaining with scientific accuracy a constant reduction ratio. This ratio is approximately 1/29, so that when the motor moves back and forth 1/10 of an inch, the shaking table moves 1/290 of an inch. Earthquakes of this small amplitude in actual motion of the ground are very common at Kilauea, and produce on the Observatory seismograph an autograph about a half inch in range of back and forth motion of the writing pen on the smoked paper.

The tool used for giving harmonic motion to the table is the chuck of a machine lathe holding an adjustable crank to which is attached a connecting rod that may be set at any desired distance from the lathe center. The other end of the connecting rod operates two upright levers attached to long steel rollers that bear the weight of the table. The table is a T-shaped body of massive concrete weighing about 800 pounds with a post of concerte rising at one end to hold the pendulum of the seimograph. At the other end is a platform to hold the clockwork and recording drum. The crank radius in the lathe chuck can be easily changed to give the required amplitude to the table, and the desired period of oscillation is obtained by changing the lathe speed, which may be governed through a wide range of motions with the belt pulleys, the speed gears, and the throttle of the power plant.

The Hawaiian seismograph is a horizontal pendulum with mass weighing 80 pounds, hinged above and below with short links of piano wire, operated usually with a free period of about seven seconds, and damped with light aluminum vanes dipping in oil near the outer end of the boom. The lever magnification is about 130 times and the time is marked on the smoked paper by a lift of the pen tips once a minute electro-magnetically. The paper speed is 1¼ inches per minute.

An account of the first tests of the Hawaiian seismograph with artificial earthquakes will appear in the August Bulletin of the Observatory (Vol. XVI, No. 8). These tests were made by Mr. Wilson with a view to checking the theoretical magnification with the observed magnification for various amplitudes and periods of forced vibration communicated harmonically to the oscillating table. The result was a magnification curve of great interest showing that oscillations representing periods between one and four seconds most nearly conformed to the theoretical curve, and indicated a magnification about 113, instead of 130 as computed from the lever system.

The effects of solid friction in relation to viscous damping and to the energy of the impressed motion were conspicuous, as usual with smoked-paper seismographs. The elimination of friction in instruments with pivoted levers entirely omitted is now being tested with interesting results. T.A.J.

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No. 213 RELEASED WITHOUT COPYRIGHT RESTRICTION January 24, 1929

KILAUEA REPORT No. 887

WEEK ENDING JANUARY 23, 1929

Section of Volcanology, U. S. Geological Survey

E. M. Buckingham, Temporarily in Charge

There have been noticeable changes at Halemaumau during the week. A small area of the south wall, at about the point where the recent sliding originated, has been emitting a moderate but constant volume of steam since the sliding began, and may furnish the key to the cause of the sudden failure of that section of the rim.

There were 21 local earthquakes recorded during the week. Only one, occurring at 6:02 p. m. of the 20th, was strong enough to be perceptible. Its indicated distance was 19.5 miles from the Observatory. At several times during the week a very feeble continous tremor was noted. Microseisms increased noticeably toward the end of the week.

MUD VOLCANOES

A combination of natural gas and muddy water rising through cracks in formations where hydrocarbons are abundant may produce fields of mud and clay, with little cones and craters which simulate volcanoes in form. Otherwise they are not volcanoes at all. These mud and gas cones occur in many parts of the world, especially in the vicinty of petroleum-bearing strata.

A recent dispatch from Australia states that at Lake Victoria, nine miles from Paynesville, a small island was thrown up last January so as to stand about 3 feet above the surface of the lake. This was nearly washed away, but in the summer some 2000 cubic yards of slimy black clay was brought up by a combustable gas so as to make a new island at the same place 60 feet long and 30 feet wide. This stood about 4 feet above the water and contained much fibrous material resembling decomposed vegetable matter. The lake here was 12 feet deep. Gas rose through two big cracks in the island. Gas bubbles have risen through the lake in the past.

Burma is a land of mud volcanoes and the rising gas is sometimes very hot. An extraordinary report of the 29th of July, 1926, stated that at 2:10 a. m. a large flame was seen rising several hundred feet high, burning for about fifteen minutes, and then jetting up again ten minutes later. This was in Kyaukpyu township. It proved to be a mud eruption a half mile north of the village of Kin which built a considerable hill and buried many acres of cultivated land. Many young plants were distroyed by the heat. A similar eruption had occurred here forty-eight years earlier, preceded by rumbling, when a large volume of fire and smoke came forth and fine debris fell miles away from the center. There was excessive heat and leaves were scroched.

The Minbu district of Burma, 300 miles north of Rangoon on the right bank of the Irrawaddy river, is an area of blue and green Miocene clays and soft sandtones. These contain traces of oil. From small holes in the ground mud oozes out along with inflammable gases. Mud is cold and smells of petroleum. Gradually a small cone is formed with a crater. The biggest crater is six feet across. The bubbling of thick viscous mud inside is incessant and one after another bubbles two feet or more in diameter form and burst so as to splash the mud round about. Occasionally there are subterranean gurglings which alarm visitors. There are many such mud cones in different stages of development over a few acres of land near Minbu. The mud is salt. (Indian newspapers, 1926.)

In central Java 50 miles northeast of Solo there is an elevated mud plain two miles in circumference, in the center of which salt mud is thrown up to a height of from 10 to 15 feet in the form of globes which burst and emit white smoke. Two bubbles observed rose and burst seven or eight times to the minute. Some times these vents throw up two or three tons of mud. The fumes smell like gunpowder. When the bubbles burst, they throw the mud out from the center and there is a loud noise as it falls on the surrounding surface. The ground is all a quagmire round the active vents.

The smaller bubbles heave and swell, and when they burst the mud falls in concentric circles, the intervals between explosions being from a half minute to two minutes. In other places the mud is rocketted up to a height of 20 or 30 feet accompanied by vapor. This mud was too stiff to be blown into bubbles. The mud was all cold at the surface, but it is said to be warm underground. In this immediate vicinity there are salt lakes and bubbling pools with cold water of offensive smell and bitter, salt and sour taste. Here there is a mud cone and crater with bubbling mud inside. This mud is very liquid and when it rises there are rumbling noises. At several large springs in the vicinity there is gas effervescence with strong odors of hydrocarbons. The ground is hot and the boiling can be heard 30 yards away. (The Family Magazine, 1843.)

Near Turbaco, a few miles from the north coast of Colombia, there are lowland thickets on a rectangular plain where the soil is dark brown clay and there are open areas of mud volcanoes separated from one another by irregular clumps of sedges. Here there are fifty or sixty active craters in conelets two to four feet high. The craters are from one to five feet across filled with cold creamy liquid mud continously bubbling and sometimes overflowing the lip and running down the sides of the cone to harden in the hot sun. The gases are hydrocarbons with more or less carburetted and sulphuretted hydrogen and nitrogen. (The Scientific Monthly, July 1928, p. 42.)

T.A.J.

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No. 214 RELEASED WITHOUT COPYRIGHT RESTRICTION January 31, 1929

KILAUEA REPORT No. 888

WEEK ENDING JANUARY 30, 1929

Section of Volcanology, U. S. Geological Survey

E. M. Buckingham, Temporarily in Charge

There were no changes at Halemaumau during the week.

The seismographs at the Observatory recorded 10 very feeble earthquakes. Continuous tremor was still present at times, but became much fainter and died out about noon of the 28th.

Microseisms were unusually large in the early part of the week, but became normal on the 25th.

POSTSEISMIC BLOCK MOVEMENTS IN THE TANGO DISTRICT

An article in the November "Proceedings of the Imperial Academy" (Tokyo) by Chuji Tsuboi on the postseismic block movements in the Tango earthquake district presents data which may shed considerable light on the completeness of the isostatic adjustment of the earth's crust. Immediately after the Tango earthquake of March 7, 1927, the Japanese government began a network of precise levels, to be repeated periodically, to determine what earth movements, if any, were taking place in the final adjustment after the earthquake. Three surveys have been made on April 12 to June 16, 1927; June 1 to July 31, 1927; and March 3 to April 20, 1928.

While the discrepancies between these surveys are of the order of millimeters, their peculiar grouping indicates that they are actual earth movements and not instrumental errors. The movements were plotted against a projection of the lengths of the level lines and connected by a series of straight lines. A study was then made of the known fault lines of the region, and it was found that in every case discontinuities in the plotted points fell across known faults, showing that each block or group of blocks moved as a unit with an upheaval, subsidence, or tilting which was constant throughout that block.

The changes between the second and third runnings were not all of the same sense as between the first and second, showing that in some cases the forces causing movements actually reversed themselves, relative to each other if not absolutely.

The average distance across blocks is the neighborhood of four kilometers. While this cannot be taken as the width of the maximum area which will remain isostatically uncompensated, it does give an indication of the extent to which adjustment proceeds once the rigidity of the crust has been destroyed by a major earthquake. An interesting check on this deduction is seen in the system of parallel fault scraps in the neighborhood of Kilauea, which in one place reach a frequency of four faults of relatively large displacement in a distance of about two miles.

A vertical displacement on a land area of 40 feet in one movement is exceedingly rare, even with an earthquake of the first magnitude. It would therefore seem, if complete adjustment attains after each major shock, that a topographic feature of any size cannot remain uncompensated, and that isostatic compensation must be very complete indeed. E.M.B.

INTERNATIONAL CONGRESS OF OCEANOGRAPHY MARINE HYDROGRAPHY AND CONTINENTAL HYDROLOGY AT SEVILLE

Notice has been received of a meeting of the International Congress of Oceanography, Marine Hydrography and Continental Hydrology to be held at Seville, Spain, May 1-6, 1929. The subjects for discussion are:

Section of Oceanography and Marine Hydrology.

1. Relations between the vitality and the oxygen of the seas.
2. Study of the straits as means of communication between the seas.
3. Modern methods for the determination of the relief of the sea-bottom.
4. Aereous currents in the equatorial regions of the oceans.
5. Relations between oceanography and navigation of the air.
6. Cooperation in an international map of the scale of 1/1,000,000 and consideration of the suitability to complete same by a map dividing the oceanic and continental regions, including in the latter the continental plain.
7. Relation between the currents and emigration of fishes.
8. Influence of the arctic ice on the climate.
9. Methods for the determination of the density of sea-water.

Section of Continental Hydrology.

1. Solid stock.
2. Formation of bancs and deltas.
3. Methods for precise measurements of the hydraulic yield of turbines.
4. Investigations with reduced models and their laws of analogy.
5. Subterranean waters.

Persons interested should address the Secretary of the Organizing Committee, Instituto Espanol de Oceanografia, Calle de Alcala, 31, Madrid. E.M.B.

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No. 215 RELEASED WITHOUT COPYRIGHT RESTRICTION February 7, 1929

KILAUEA REPORT No. 889

WEEK ENDING FEBRUARY 6, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

Examination of Halemaumau February 2 showed the rim gone to a depth apparently 15 feet more or less south and southeast, carrying away such landmarks as the old burned boards of the 1918 outhouse and the pinnacles just inside the rim, as well as the south station. The bronze datum bench mark southeast is on cracked dangerous ground at the extreme edge of the pit. A new tourist platform for viewing the pit has been built at the east rim. The south talus was struck by the great avalanches and set in motion as a landslide so as to cover the whole south half of the lava floor. This is much like what happened just a year ago, January 11, 1928. At that time, however, liquid lava was pressed up.

There is a little steam high on the south and southwest taluses, and from the cavity in the central lava cone. Some minor wall cracks are steaming, and the SSE. rim cracks steam vigorously and show fresh soil breaks 40 feet or more back from the rim. Rocks were sliding a little on the lower south wall. February 3 and 4 a little dust rose from slides at the north corner of the pit, and gravel was heard slipping at the south. On February 5 the strongly felt earthquake of 2:25 a. m. appeared to produce little effect at the pit.

Nine very feeble earthquakes were registered at the Observatory during the week, and in addition one strongly felt earthquake (intensity IV Rossi-Forel scale) occurred at 2:25 a. m. February 5 so as to awaken sleepers generally. This shock was felt strongly also at Hilo and Kohala, appeared to be local at Kilauea seismographically, and hence may represent a deep earthquake under the east side of the island

Tilt for the week was moderate ENE. All the seismographs showed an apparent easterly tilt at Kilauea during the earthquake. This suggests that if subterranean lava was concerned with the earthquake at all, the lava movement was one of rising. Microseisms for the week were ordinary.

THE BALI ERUPTION 1926

On the ilsand of Bali, next east of Java, there is a volcanic rift line trending northwest and southeast carrying two larger volcanoes, Batoer on the northwest and Agoeng on the southeast. The latter is believed extinct, but Batoer has had lava flows in 1849, 1888, 1904, 1905, and twice in 1921. In August, 1926, a new and extensive lava flood destroyed the village Batoer with its Brahman temple.

Dr. C. E. Stehn, in charge of the Volcanologic Service of the Netherlands East Indies, has produced an interesting memoir on this eruption, with 67 pages of text, 47 photographs, 10 map plates and 14 text figures (Vulk. en Seismol. Mededeelingen No. 9, 1928, Bandoeng, Java.) There is an abstract in English, and the plates have both Dutch and English legends. Contour maps on large and small scales are presented, showing fissure eruptions, details of cones, craters, and flows, and lava tunnels which are all like Hawaii in topographic arrangement, but there is ash ejected with the lava outflow, and this is uncommon in Hawaii. The lava is an olivine-bearing pyroxene-andesite, or basalt, carrying about 52% of silica, and therefore is somewhat more acid and refractory than the Hawaiian basalt.

The upper part of Mount Batoer is an oval sink, larger than the Kilauea crater, with NW.-SE. axis 8½ miles long, and the other dimension 6 miles. Inside this there is a second cauldron 4 1/3 miles across, merging into a crescent-shaped crater lake at the southeast end of the greater caldera. This lake is 200 to 260 feet deep.

On the floor of the inner crater stands a mixed cone rising 2,000 feet above its base and 5,600 feet above sea level. This is some 1,300 feet below the highest rim cone, Mount Abang, at the southeast end of the outermost ring wall. The greater ring crater is closed with its drainage inward to the lake, and in this respect differs from Asosan, in Japan, which it somewhat resembles. The inner volcano, here as at Aso, is the scene of activity, and the historic lava flows have been filling the southern half of the inner wall valley from 1849 to the present.

Batoer is the name of the inner volcano, which has two summits, several groups of craters, and fracture lines mostly radial, which are followed by the crater cones and pits. There are some fractures which are concentric, and one that crosses the flank of Batoer. The summit pits of Batoer are 160 and 650 feet deep, and gave vent to lava flows in 1905.

Twenty-two groups of parasitic cones and craters have been found, partly built of ash and partly of lava scoriae, either loose packed or sintered together.

The eruption of 1926 began in the night of August 2, was preceded by earthquakes, and opened a long radial fissure at the southwestern base of the inner volcano Batoer. Hot slag was thrown up, and lava flowed southwestward. The following night the fracture opened to a length of 4,200 feet northeastward in the direction of the peak. The lava flow divided into two streams flowing north and south when the confining wall of the inner sink was reached, and the southern branch overwhelmed the village completely by August 27.

The progress of the eruption greatly resembled a flank eruption of Mauna Loa. At first there were 20 spurting jets along a continuous crack. After August 10 three groups of active mouths became segregated, containing 8 to 10 craterlets each. These built up in the course of the month so as to make the highest cones of ash at the northeast or highest group of vents. The middle group produced blocks, bombs, and cinder, and built cones of intermediate height. The lower openings of both groups produced lava flow with a temperature from 1,100 to 1 200° C. Lava fountains were observed. Gases escaping at the border of the lava field as late as May, 1927, still had temperatures up to 575° C. The lowermost group of vents was some 1,600 feet down the rift from the others, and during the eruption it would fling up large blobs of glowing lava from 30 to 60 feet into the air.

The uppermost lava flow was a foamy pahoehoe near the vent. The lower one was a scoriaceous aa, and both streams flowed together as a rough clinkery lava in the lower parts of the flows. Large rafts of plastered clinker 20 feet high and 40 to 50 feet across were observed on the surface of the flow transported 1¼ miles. In its upper course the lava flowed 20 feet a minute on a slope of five degrees; farther down on a horizontal floor 1.8 miles from the source the lava field was 26 feet thick and progressed 130 feet in 24 hours (Aubust 9-11). August 28 a velocity of 39 feet per hour was measured two miles from the source. Approximately 741 million cubic feet of lava was produced, the outflow ending September 21.

This memoir is of great interest in showing true lava eruptivity in the East Indies. T.A.J.

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No. 216 **RELEASED WITHOUT COPYRIGHT RESTRICTION** February 14, 1929

KILAUEA REPORT No. 890

WEEK ENDING FEBRUARY 13, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

The lava pit of Kilauea has exhibited no conspicuous change during the past week. Occasionally rocks have been heard to fall from the walls, and the rainy weather has produced more visible vapor than is seen during dry weather.

Seven very feeble earthquakes have been registered on the seismographs at the Kilauea Observatory, and one short period of spasmodic tremor occurred on February 9 about 12:52 p. m. Two local earthquakes on February 8, at 11:17 a. m. and 6:48 p. m. both indicated an origin approximately 18 miles from the station. This origin is probably in the direction of Mauna Loa, as these earthquakes were similarly registered in Kona. The strongly felt earthquake of February 5 appears to have originated under the southern part of Kilauea Mountain, as shown by measurement of the seismograms of Hilo, Kona and Kilauea.

Tilt for the week was moderate to the SSE. at Kilauea. Microseismic motion was slight.

NGAURUHOE ERUPTION OF MARCH 1928

Ngauruhoe is a steep-sided symmetrical cone rising 7,515 feet above sea level, in the national park near the southern end of the volcanic belt that traverses the north island of New Zealand. The 1928 eruption is the eleventh recorded outbreak since 1839. The known eruptions have ejected blocks of augite hypersthene andesite. A dark colored aa lava flow found at the foot of the mountain is reported to have been poured out in 1869 (Eruption of Ngauruhoe, March, 1928, by L. I. Grange, N. Z. Jour. Sci. and Tech., Vol. X, No. 3, Oct. 1928, page 143).

On the morning of March 4, 1928, the volcano rumbled, and there were two vertical shots from the crater with an interval of half an hour between them. Blocks of lava were ejected and rolled down the side of the mountain, and black clouds of ash were blown toward the south. The rumbling and belching continued in the afternoon, and two more shots occurred in the evening. At 6 a. m. March 5 a big shot was accompanied by earthquakes that shook the Whakapapa huts, about six miles away. Twice that day the volcano roared, and for the rest of the week the mountain was clouded over. On March 11 Mr. Grange, the Government Volcanologist of New Zealand, at the foot of the mountain could sometimes hear the roar of gas vents. The crater was reached March 12 and found to be a flat-floored depression surrounded by steep walls, and partitioned into east and west divisions, with a small shallow crater occupying a part of the rim at the north. The main crater is more than 200 feet deep and about 650 feet in diameter, the inner walls exposing beds of scoria and lava flows. There were three small vents on the bottom, the central one being active, and small steam vents occured in several places in all the craters and some sulphur was being deposited.

The active vent was a conelet about 70 feet in diameter where red-hot lava could be seen below a surface covering of stones that had fallen back during the eruptions. It resembled a quiescent blacksmith's fire. The lava appeared viscous, to judge from the sharp edges, smooth faces, and open contractive cracks of the hot, fresh blocks. Blue smoke was escaping with a tremendous roar,and at times there were bursts of gas darkened by ash. Sometimes the roar would cease for several seconds. The first of the gas jets was inclined west, but after 20 minutes the inclination shifted to the southwest. Red-hot fragments of lava were thrown up 50 feet. Once there was a sharp, loud explosion, throwing blocks above the rim of the main crater, into which they all fell back. In the afternoon black cauliflower clouds rose several times from the crater, and at night a red glow was reflected from the fumes. It appears that on February 21, 1928, the lava surface was about 80 feet below the rim of the vent, and descriptions of the crater floor by observers at other quiescent times indicate that the active vent has changed position. T.A.J.

VOLCANIC TREMOR AT VESUVIUS

The annual of the Vesuvian Observatory for 1925 contains an analysis of the seismograms registered during paroxysmal explosions in the crater for 24 hours November 30-December 1, 1923. (G. Imbo, Annali, del R. Osservatorio Vesuviano, Vol. II, 1925, page 149.)

Harmonic continuous vibrations and more rapid spasmodic occasional ones are distinguished at Vesuvius, just as at Kilauea. There are also longer period wave movements, and very feeble local earthquakes usually not stronger than Grade II of the Cancani scale.

The active date in question followed about three months of moderate activity. The Vesuvian crater was floored over with an active conelet on the high bottom. At 4 p .m. November 30 a lava flow poured from the west base of the conelet to the north wall of the crater, and the conelet produced nearly continuous explosions accompanied by projection of lava shreds. Scoriae were thrown up over 300 feet. By 4 p. m. of the next day a million cubic meters of lava had been produced, it ceased flowing, and the vent activity became normal.

The Vesuvian Observatory maintains a vertical component seismograph with heavy mass weighing 200 kilograms, period 2.11 seconds, and lever magnification 170. Horizontal tremor is indicated by an Agamemnone instrument.

About 724 explosions were registered in 24 hours, and the frequency exhibits three decreasing maxima and three decreasing minima. The microtremor waxed in somewhat similar pulsations to a high maximum, and then declined.

Professor Imbo on February 5, 1926, carried an accurate timepiece to the crater and compared the time of explosion with the seismograph records for 10 explosions. The mean time of propagation was 5.9 seconds for a distance of 2,670 meters, showing a superficial velocity of 450 meters per second. Probably the distance from the deep explosion was less than this over a more horizontal course. It was estimated that the depth of the explosion source was 312 meters, reducing the angle of the line from source to observatory to 4.8°; the angle from conelet to observatory is 11.2°. T.A.J.

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No. 217 RELEASED WITHOUT COPYRIGHT RESTRICTION February 21, 1929

KILAUEA REPORT No. 891

WEEK ENDING FEBRUARY 20, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Until midnight of Tuesday, February 19, nothing whatever was noticed in Halemaumau pit at Kilauea Volcano to make certain the immediate approach of a new lava eruption. There was merely the expectation as reported in Volcano Letter No. 209 of December 26, 1928. The past week has been quiet at the pit, a survey party noted that the steam rising from the northwestern floor was a little bluish the forenoon of February 19, and a few rocks fell from the northern walls.

About 12:30 a. m. February 20 frothy fountaining lava gushed up a new crack athwart the 1927-28 lava bottom of Halemaumau, at the base of the northwest talus.

The seismographs exhibited 17 very feeble earthquakes for the week at the Observatory. One at 10:08 p. m. February 13 gave distance to origin 24 miles. Fourteen of the shocks were just before the lava outbreak, between 10:47 p. m. February 19 and 12:28 a. m. February 20. Continuous volcanic tremor began 12:46 a. m. on the 20th. Microseisms for the week were slight. Tilt for the week was moderately strong to the NNE. The pit seismograph showed a first tremor at 10:27 p. m. the 19th, accompanied by tilt away from the pit (SE.); other tremors followed each with a tilt, and continuous tremor began at 12:44 a. m.

HALEMAUMAU OUTBREAK FEBRUARY 20

In view of the forecast of December 26 (Volcano Letter No. 209) it was satisfactory to find molten lava gushing up the peripheral wall-crack of the bottom of Halemaumau northwest just after the midnight preceding February 20. This inaugurated a new eruptive spell quite like those of July 19, 1924 at 1 p m., July 7, 1927, at 1 a. m., and 12:26 a. m. January 11, 1928: but the new eruption appears more vigorous and voluminous than any of those. All four followed either midnight or midday, as though a solar influence might be present. In none of the four was a witness actually present at the first gush of gas. The 1924 eruption lasted 12 days; 1927, 13 days; 1928, 1 day.

The watchman at Volcano House and some others saw glow over Halemaumau about 12:30 a. m. The volcanic tremor on the seismograms became continuous, after some scattered trembling spells before and after midnight, at about 12:45. Strong tilt away from the pit in trembling spasms was registered at the pit seismograph 1,900 feet southeast from the center of Halemaumau. These spasms finally became continuous trembling of the ground.

A rift broke open through the lava floor and base of the talus slides, 1,370 feet long, trending N. 63° E., about 270 feet out from the northwestern edge of the floor proper. By analogy with 1927 what happened was the rush of blue sulphurous gas, carrying with it increasingly incandescent basaltic foam, until spray fountains of melt were jetting up from 100 to 300 feet all along the crack. The eruption was of Mauna Loa type. Only thin fume arose. In the first hour and a half a lava lake was formed covering all the floor except the central cone summit to a depth near 30 feet. The average rise of the lake for 11 hours was more than 5 feet per hour.

At 2 a. m. there was a group of big fountains at the north with one great jet like an upturned hose shooting 225 feet into the air; this was reduced to 100 feet by 12 noon. Next southwest came a smaller fountain building a cone. Next was a long nearly straight line of violently boiling fountains across the west side of the lake roaring like a surf for a length of 1,000 feet. The great north fountain, just under where the avalanches have been numerous for years, and about where the old Postal Card fissure was 10 years ago, is the source of a wide lava stream out into the lake.

Around the line of perpetual fountains, which played up 50 to 100 feet, at the west, the lake quickly filled in to submerge their vent fissure. These fountains were thus out in the lake with the lake surging about them making a concentric elliptical pattern in the crusts. These crusts streamed in toward the fountain line and foundered. The rest of the lake cracked in radial bright lines toward the east. Glowing lava toes pushed from under the skirt of skin around the lake edges, and the talus shores steamed a little.

The lake at noon February 20 was 1 500 feet long and 1,000 feet wide, and shaped like a properly oriented map of Australia. The old central cone at first made a crescent island with horns turned south, but was submerged by 10 a. m. By 4:30 a. m. the lake touched the rock wall northwest. The high south-southwest cone of 1927 stood 83 feet above the lake at noon February 20.

There was a little avalanching at the east in the early morning, but this was exceptional. The tremor, and the reverberation of the rumbling fountains increased as the day wore on, and as the heavy viscous lake tended to restrain the gas of the rising foam. By evening the line of fountains made thudding detonations and reddish yellow flames rose as the huge gas bubbles burst in quick succession through the boiling western part of the lake.

By 5 a. m. the northern fountains were building cones and ovens, with glowing grottoes inside, and cascades of glowing slag poured down from the higher ones. Thin blue fume, brown in transmitted light, rose from the big pit, and reflected the light of the slag pool below so as to rival the moonlight. The steady roar could be heard at Volcano House. Gray or salmon colored moisture clouds billowed up rapidly hundreds of feet above the fume veil: these were made of atmospheric humidity drawn in by convection.

Needles of lava glass and wisps of Pele's hair, along with pellets of pumice, fell to leeward and in the Kau desert. Rampart shores of the lake were forming southwest and southeast during the day. Small fountains in the lake itself became more numerous as the vent fountains diminished. At first the spray banks to leeward of the north fountains were of greenish brown pumice, later of black glass. In daylight the lava lake surface acquired a leaden color with a blocky pattern. T.A.J.

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No. 218 RELEASED WITHOUT COPYRIGHT RESTRICTION February 28, 1929

KILAUEA REPORT No. 892

WEEK ENDING FEBRUARY 27, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

In Halemaumau pit of Kilauea Volcano a new eruption of gas charged lava, which began near 12:45 a. m. February 20, and continued its fountaining throughout that day and the first half of the next, went out of action about 1:15 p. m. February 21 so far as fountains are concerned. Since that time a heavily crusted lake, with glow cracks seen at night, has remained in the bottom of the pit, and all around it stands a rampart approximately 8 feet high above the lake sufrace This implies that the lava lake subsided by shrinkage and loss of gas about 8 feet below its highest stand, and this subsidence was mostly accomplished during the 24 hours following noon of February 21. The average diameter of the new lava fill is approximately 1,600 feet, and its average depth about 64 feet. These figures give 128,680,000 cubit feet (3,640,000 cubic meters) of new lava.

The report of the watchman who saw the first evidences of the eruption from the northeast rim of Kilauea Crater, 2 miles away, was to the effect that a dark cloud arose, then a white steamy cloud, and then the glow of spouting lava. The fountaining rift in the bottom of the pit for the first 12 hours was described in Volcano Letter No. 217. The heat of the big lake on February 20 made whirlwinds at the south edge of the pit which carried needles of lava glass and small lapilli. A long rampart was building at the lake edge toward the west, and a smaller one appeared at the southeast. During the next day this rampart formed all around the lake.

At 7 p. m. February 20 the big north fountain had built a high spatter wall and oven, the lake was in contact with the northwest wall of Halemaumau, and a line of grottoes had appeared under the west rampart.

The rumbling thud of the long line of fountains west and the big geyser of slag at the north had become deep and heavy, with occasional detonations. Along with this all the seismographs showed stronger volcanic tremor, which had increased since the morning. The pattern of bright lines was concentrically elliptical around the belt of western fountains, and zigzag radial lines extended E., SE., and S. The spray from the north fountain was sometimes 100 feet high.

On February 21 after an earthquake felt about 3:33 a. m., the lava was sinking, and avalanches were sliding at the north about 10 a. m.; the west fountains, beginning at 10:30 a. m., dwindled to small spurting at the east end of their crack, and the big north jet lessened. This last had built an "armchair" grotto. At 11:30 a. m. the west fountains went out of action, seismometric tremor decreased, and about this time the lake was receding. At noon there was no trace of the line of western fountains, and it was evident that the active north fountain had built its niche by lowering and causing its cone to cave in. The second northwest conelet of the 20th was gone. The coarse blocky crust pattern showed no trace of the radial lines. In a few places the crust cracked, and glowing melt welled up. The border rampart was complete, 7 feet above the lake, with an overflow margin outside. At 1:10 p. m. the north fountain stopped, and at 1:13 p. m. a slide occurred NE.

At 8:30 p. m. a long oval glow area was defined at the west, and a glowing cove at the east, with sluggish lava welling up along the outlines. The rest of the lake had a dull cherry red pattern like a bed of coals. There was the grinding noise of foundering crusts. A northwestern slide occurred at 8:50 p. m. During the night the dark red glow on the clouds decreased. Another earthquake was felt at 12 midnight.

The forenoon of the 22nd showed brown fume hanging under the rain clouds far to the SW., but the pit appeared clear. After this the lake changed little, avalanche debris rested on the new pumice bank at the north and on the eastern talus, and glow cracks were still visible at night. On the evening of the 23rd the hot air rising above the new lava made a rain cumulus with long tails leading down to the pit. On the 24th fifteen spots were counted on the lake crust where the last lava trickles had welled up. After rain, steam had increased at the top and bottom of the south talus and at the N. edge of the new lava. Small slides at the north were heard the forenoon of the 25th, and yellow stains at the north fountain locality were seen on the 26th.

The seismographs at the Observatory registered 5 very feeble and 3 slight local earthquakes for the week, and one weak teleseism at 10:50 p. m. February 25. The felt earthquakes of February 21 at 3:33 a. m. and 2:00 p. m. indicated origins 13 miles away, and the earthquake felt at 4:51 p. m. February 24 showed distance 14 miles. Both the last named were felt at Pahala, and the first two were felt in Hilo. Volcanic tremor began 12:46 a. m. February 20 and ended 11:30 a. m. February 21. At the pit seismograph it continued until about 1:00 p. m. Tilt at the Observatory was strong SSW. Microseismic motion increased at the end of the week.

The Halemaumau seismograph, recording only NW.-SE. tilt (to and away from rim), registered 11 seconds angle of tilt to the SE. between 9:15 a. m. February 19 and 12:45 a. m. (time of outbreak) February 20. Five seconds of this accompanied small earthquakes between 10:06 p. m. the 19th and 12:35 a. m. the 20th. The rim region then tilted back to the NW. 6 seconds between 12:35 a. m. the 20th and 2:23 p. m. the 22nd; tipping was strongest between 8 a. m. and 1 p. m. the 21st. At that time there was thus a net gain of 5 seconds (11 minus 6) tilt away from the pit.

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No. 219 RELEASED WITHOUT COPYRIGHT RESTRICTION March 7, 1929

KILAUEA REPORT No. 893

WEEK ENDING MARCH 6, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

The lava activity that was observed in Halemaumau pit Febraury 20 has entirely ceased, and there remains the frozen lava lake with virtually no motion of any kind. The incandenscent pasty lava undoubtedly exists under the crust, but the shell on the lake has become too thick to show any further glow or gas action. On March 1 at 11 a. m. fresh debris lay on the eastern taluses, and there was also slight change in the northern and southern slopes. A slide was heard at the southwest. Sulphur stain was increasing near the north spatter cone, and a new patch had appeared at the south edge of the lava floor, which was steaming. At the west a crack in the floor was seen, and the south side of the lava area appeared to be settling more than elsewhere. White stain suggests fumarole action on a large red rock in the gravel near the bottom at the east. White stains are increasing on the lava crust. Columnar fluting is conspicuous at the southern end of the east sill, where also there is steam from the wall.

On March 2 the strong earthquake at 10:24 a. m. dislodged a small slide at the east wall of the pit. At 11 a. m. March 3 a little sliding was heard, there was a line of steaming up and down the top of the south talus, and fresh avalanche debris had increased at the east.

In the forenoon March 4 slides were common N. and NE., and about noon visitors throwing rocks at the edge NNE. started a slide that made a red scar in the wall, put numerous white rocks on the talus below, and made a cloud of dust. March 5 there were small rock falls N. and SE.

The seismographs registered only 6 local earthquakes for the week, 4 very feeble, 1 feeble at 10:19 a. m. March 2, and 1 slight and locally felt 10:24 a. m. March 2 of intensity III R. F. The last two indicated a distance from the Observatory of 17 miles, probably in the Kapapala direction, making the center somewhere between Kilauea and Mauna Loa. Tilt for the week was moderate to the north, and microseisms were normal.

MOUNT SHASTA MUD FLOWS

During the summers of 1924 and 1926 there were floods from Mud Creek, which drains the Konwakiton Glacier on the south slope of Mount Shasta. Owing to the depth of the mud deposited by the floods, trees were killed over hundreds of acres, roads buried, and railway traffic interrupted, while the drainage system into which Mud Creek flows was contaminated by mud for over 75 miles.

The floods were due to the rapid melting of the Konwakiton Glacier. The glacier rests on a thick deposit of unconsolidated volcanic ash. Mud Creek always carries a great amount of this ash. Light snowfalls of the winters preceding the mud flows allowed the summer sun to cause more rapid melting of the glacier than is common. The floods in Mud Creek were the result.

Some press reports, written by correspondents a considerable distance from Mount Shasta, attribute the rapid melting of the glacier to an increase in the volcanic heat of the mountain. Nothing has been found to support such a contention. The hot springs on the summit of Mount Shasta are steaming much the same as they have been for years. The highest temperature found at these springs on June 18, 1928, was 180° F., or a little below the boiling point for an elevation of 14,000 feet. R.H.F.

EARTHQUAKES ON ISLAND OF HAWAII 1928

The total number of seismic disturbances registered by the seismographs of the Hawaiian Volcano Observatory during the year 1928 is 1,053. Of these 1,034 were local earthquakes and tremor swarms.

Of the local earthquakes, the grouping by intensity is as follows: 1,004 were very feeble and so registered only by instruments; 25 were feeble, making a clean-cut earthquake seismogram, and felt by some persons; 3 were slight, making strong seismograms, and generally felt, except by persons in motion; 2 were moderate and strongly perceptible. The latter were January 4 and February 26.

The total of local shocks compares as follows with the three previous years: 1925, 922; 1926, 1,778; 1927, 1,149; 1928, 1,034. The average then is about a thousand per year at present, as 1926 was the exceptional year of the Mauna Loa outbreak, when there were 761 shocks in April alone.

The number of teleseisms for 1928 is 20, of which 4 are near the March equinox, 8 before and near the June solstice, and 8 near the September equinox.

An interesting feature was the notable increase of tremor swarms, lasting each from 2 to 34 minutes. They were conspicuous in January, March, June, and December, and were identified with pit avalanches in the late summer and autumn. T.A.J.

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No. 220 RELEASED WITHOUT COPYRIGHT RESTRICTION March 14, 1929

KILAUEA REPORT No. 894

WEEK ENDING MARCH 13, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Halemaumau continues quiet. On March 8 there was some sliding of rock from the north wall and also March 12. but in less amount. On March 13 at 11 a. m. fresh red debris was observed on the east talus from a newly stripped portion of the wall two-thirds of the way down, above the big sill. A few stones were heard slipping twice during a visit of a half hour. Some stones from slides had rolled out over the new lava southeast.

The weather being sunny, no vapor was detectable rising anywhere from the new lava floor, not even from the stained area at the south edge. From the slide rocks outside the southeast edge of the floor, and from a wet spot at the top of the south talus, vapor was rising. There was also steam and moist ground at the lower ledges southeast, whereas most of the talus slopes appeared dry. Hot vapor rose from fissures inside the south wall of the pit, near the top.

Four very feeble local earthquakes were registered at the Observatory during the week. A large distant earthquake began about 3h. 11m. 22s. p. m. March 6, and the long waves threw the writing pens off the drum. The indicated distance was 3,650 km., corresponding to the north side of the Aleutian Deep south of Amukta Pass. This origin was confirmed by radio report from Alaska. Small seismic sea waves were registered as following this earthquake in Hilo Harbor at the tide gauge between 7:45 and 10 p. m. March 6.

Tilt for the week was slight SSW and microseismic motion was very slight.

SEISMIC SEA WAVE MARCH 6

The large, distant earthquake registered at the Hawaiian Volcano Observatory as beginning 3 h 11 m. 22 s. p. m. March 6, Hawaiian Standard Time (G.M.T. 1 h. 41 m. 22 s. March 7) exhibited on the seismogram very clear preliminary tremors lasting 5 minutes and 26 seconds and a well marked beginning of secondary waves, which merged without distinction into such large long waves that the writing pens of the seismographs at Kilauea and at Hilo swung off the smoked paper. These seismograms indicated an earthquake of great magnitude at a distance approximately 3,650 kilometers, or 2,270 statute miles from the Observatory. The seismogram showed signs of the return wave that had passed around the crust of the earth on the side of the globe remote from Hawaii about four hours after the start of the record. Calculation showed that the time of the actual shock at the epicenter was 6 m. 52 s. before the registration began; that is, the seismic waves through the rock under the bottom of the sea took a little less han 7 minutes to travel 2,270 miles.

This distance is slightly less than that of California from Hawaii, and the indication from the direction of first disturbance and from the excess of long wave motion in the north-south direction implied an earthquake origin lying probably either NNW or SSE from Hawaii. Toward the south this would be near the Marquesas Islands, and toward the north it would mean the well known earthquake region of the extremely deep trough (over 4.000 fathoms) that lies about 125 miles south of the Aleutian Islands. Everything indicated that one of the big Aleutian earthquakes was in progress.

In accordance with previous experience at this station (Volcano Letter No. 57, January 28, 1926) the big submarine earthquakes from Alaskan waters and also those still farther away from the sea bottom off Chile are liable to create flood waves in the ocean that may do some damage on the eastern side of the large Hawaiian Islands. The experience of February 3, 1923, had shown that a large earthquake south of the Alaskan Peninsula could make a disastrous tidal wave which arrived at Hilo about seven hours after the shock was registered at the Kilauea seismographs. Accordingly, in the present instance a tidal wave warning was sent to the harbor masters at Hilo on Hawaii, and Kahului on Maui, and through the Naval Radio to the Commandant at Pearl Harbor in Honolulu. It seemed probable that the water wave would reach Hawaii about 10 p. m., by analogy with the transit time of the sea wave of 1923.

The speed of travel of such waves is comparable to that of the wave represented by the normal daily tide, and this speed has nothing to do with the violence of the resulting shore waves, which are compounded with the natural period of the local harbor or basin, and usually keep swinging back and forth for hours at intervals of 15 or 20 minutes. The speed of the free wave in the open ocean is for the Atlantic tides about 500 miles per hour, and for an earthquake wave in the Pacific 300 miles per hour, more or less.

On March 6 the event proved that a great earthquake had occurred at the north edge of the Aleutian Deep approximately 100 miles south of Amukta Island, as reported by Japanese steamers in that vicinity, which felt the sharp bump of the quake. Also Dutch Harbor reported severe shaking. The surging waters began to swing in and out of Hilo Bay about 7:45 p. m., as recorded on the tide gauge at Pier 1 back of the breakwater, with a range of motion of something over a foot and an interval of about 15 minutes between crests. In the Wailoa River at the head of Hilo Bay the harbor master reported 16 inches between high and low level swings. I watched these swings as follows:

8:20 p. m.,	current	inward
8:27 p. m.,	"	outward
8:31 p. m.,	"	inward
8:34 p. m.,	"	outward
8:38 p. m.,	"	inward

With higher tide the surges were watched between 9 and 11 p. m., and the intervals grew longer. The S. S. Haleakala at Pier 2 broke stern lines as result of the surging motion. The maximum was between 8 and 9 p. m., and about 10 p. m. the surges dwindled. It was evident that the speed of propagation of the water movement must have been over 400 miles per hour.

The correspondence of location of earthquake, and of sea wave as registered on the tide gauge, with published expectation in accordance with seismogram data, was completely satisfactory. The time of transit of sea wave appears to be less than that of 1923 Its resultant surges in Hilo Harbor were much lower than in 1923, when disastrous wave action reached heights about 15 feet above normal. As the earthquake of 1929 appears to have been equally intense, and the position only a few hundred miles farther west, it seems likely that local surging must depend on wave resonance with the stage of the tide, and the effects of winds and waves over the ocean intervening between the earthquake origin and the port. T.A.J.

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No. 221 RELEASED WITHOUT COPYRIGHT RESTRICTION March 21, 1929

KILAUEA REPORT No. 895

WEEK ENDING MARCH 20, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

No volcanic changes have been observed at Kilauea or Mauna Loa indicating anything unusual. Some rapid tilting, accompanied by tremor, at three seismograph stations in and around Kilauea Crater has interested the observers because of its resemblance to similar movements incident to the eruption of February 20. This interest is reinforced by prolonged tremor spasms at the Observatory March 15, 17, 18, 19, and 20, two of these accompanied by east tilt.

On March 15 at Halemaumau a small slide was heard about 9 a. m. toward the north, and the falls of rock during the forenoon were very slight. The next morning, March 16, there was very little steam in the pit, and only a few slides. March 18 at 9 a. m. there was a very little sliding at the northwest. Yellow sulphur has appeared in cracks at the stained whitish spots along the north and south edges of the new lava. The downfaulted bench around the edge of the subsided lava lake is in steps. A little steam shows sometimes quite suddenly at the north sulphur spot as though nucleated by invisible gas blown over the place from a nearby orifice. There is vapor high on the west and south taluses, on the lower east talus, and at the top of the talus NNE. On March 19 just before 6 p. m. red and gray dust rose from avalanches in Halemaumau.

Seventeen very feeble earthquakes were registered at the Observatory, of which one at 9:05 a. m. March 13 indicated origin distance two miles away, and another, 11:14 a. m. March 19, origin distance 11 miles. The tremor spasms above mentioned are not included with these earthquakes. Tilt for the week was strongish WSW., several of the shocks of March 17 until 4:14 p. m. exhibiting westerly tilt simultaneous with the tremor. Microseismic motion was normal.

HAWAIIAN VOLCANO RESEARCH ASSOCIATION 1928

The work of the Association is divided between general furtherance of the progress of the Hawaiian Volcano Observatory and the specific tasks of maintaining seismograph stations and issuing publications. The Board of Directors are L. A. Thurston, W. F. Dillingham, F. C. Atherton, L. T. Peck, W. W. Thayer, W. R. Castle, A. L. Dean. The Honolulu office is 1031 Fort street, L. W. de Vis-Norton, secretary. The Association is incorporated, and has about 180 patrons and members, and a mailing list of about 600 institutions, libraries, and individuals.

The division of work between the United States Geological Survey and the Association at the Kilauea observatory is broadly on the line between salaries and equipment: the permanent salaries are Governmental. Outside of the observatory, the Research Association employs the seismograph observers in Hawaii, and occasionally other persons on Research Fellowships.

The Observatory was founded by the Research Association in 1912, and has gradually acquired increasing Government aid. The collaboration may be compared with the demands of manufacturing associations on the Bureau of Standards. The Association has supplied shops, instruments, laboratories, expeditions, researches, books, specialists, vehicles, and machines, that have made possible path-breaking investigations which could not have been attacked under Government alone, owing to the restrictions that control Government funds.

The work of the Association in 1927-28 in seismology illustrates perfectly its influence and results. The Association built the Uwekahuna Observatory, for use as a trailside museum by the National Park Service; equipped it with a seismograph for both exhibition and research, and placed the best collections on exhibition. This accomplished three distinct advances: it provided a new seismograph and observation station in a new place; it gave the public a museum and relieved the Observatory of exposition duties; it provided the National Park with motion picture hall and apparatus for exhibiting to travelers volcano activities of other times. Government staffs immediately assumed operation expense.

The Association at the same time equipped and manned a machine shop for making seismographs. Seven instruments have now been built in that shop, new ones are installed in Kona and Hilo, many other tools and machines have been built, and the machinist is now a Government employee. The old seismograph released from Kona was rebuilt and installed in a small roofed cellar near the Kilauea pit: this instrument showed remarkably instructive tilt and tremor in the Halemaumau eruption of February 20, 1929.

In the summer of 1928 the seismologist built an oscillating table for mounting and testing seismographs by imparting to them artificial earthquakes. The "Ohiki," wheeled boat built by the Research Association and tested in a longshore trip on Hawaii, was the experimental basis of a successful season with an amphibian in Alaska.

The published work of the Association in 1928 concerns volcano notes from many lands, the weekly reports from Kilauea, Lassen Observatory notes from California, reviews of volcanologic books, popular statements of the technical work in progress on local shocks, tilt, microseismic motion, distant earthquakes, tidal waves, temperatures of borings, work of the several seismograph stations, notes on explorations, new methods and cooperative work of other bureaus, some National Park enterprises, addresses and articles on borings, Coast Survey work, gravity measurements, and on tide gauge measurements and station installation.

The improved registration of earthquakes by the Association seismographs was never better demonstrated than during the last three months, when the local earthquakes that preceded and followed the February eruption were well recorded at five stations, and all five also made record exhibiting data that bear on distance of origin, direction, and intensity, for the great Aleutian earthquake of March 6, 1929. To the radio equipment installed at Kilauea and in Kona the Observatory owes increasingly accurate time service, the time signals being sent out from Washington, D. C., and from naval stations in California and Hawaii.

T.A.J.

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No. 222 RELEASED WITHOUT COPYRIGHT RESTRICTION March 28, 1929

KILAUEA REPORT No. 896

WEEK ENDING MARCH 27, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Avalanche dust rose from the northeast side of Halemaumau at 3:10 p. m. March 20. In the forenoon of March 23 what appeared to be a fresh scar on the north wall of the pit was observed, and a very few small slides occurred. About midday March 25 the pit was quiet, except that a slide occurred at the north end of the large northeastern sill about 1 p. m.

At 8:40 a. m. March 27 the pit was very quiet, no stones fell, there was steam back of the upper edge E., N., NW., and W. outside of the pit, but the floor was not steaming. There was the usual vapor from the taluses. About 11 a. m. some dust rose from the pit.

At the Observatory 20 very feeble earthquakes occurred, and tremor in irregular recurring spasms, also very feeble, as follows: March 28, 8 to 10 a. m., 8:50 to 10:45 p. m.; March 21, 6:30 to 8 a. m., and irregularly in the afternoon; March 23, irregularly 10:12 a. m. and 3:25 p. m.; March 24, irregularly 6 to 7 a. m.; March 25, 9:34 to 9:37 p. m.; March 26, 8 of the earthquakes above mentioned, between 3:19 p. m. and 4:50 p. m., may be expansions of tremor too feeble to register continuously.

Microseisms were normal, diminishing during the week. Tilting of the ground was slight to the south.

VOLCANOES IN CHILE

The following notes from a letter received from Mr. John B. Stone are of great interest as they are written by a geologist who worked five months on the geology of Kilauea Volcano in 1925 (Bulletin 33, B. P. Bishop Museum, Honolulu, 1926).

"I have recently returned from a vacation trip to Chile" (Mr. Stone is engaged in mining geology in Peru) "during which I went as far south as the island of Chiloé. One of the objects of my trip was to get some information on the volcanoes in that region.

"In Santiago the director of the seismological service stated that the volcanoes in north Chile are not active, but that those in the region between Santiago and Chiloé are active intermittently. There are others farther to the south, but the country is almost uninhabited and little is known about them. Among the volcanoes are Llaima, near the town of Temuco; Villarica and Pueyhue, near Osorno; and Osorno Volcano, Calbuco, and Tronador, near Puerto Varas on Lake Llanquihue. These volcanoes are on the west side of the central valley of Chile (which is beautiful farming country), and are easily accessible from the excellent railway running south from Santiago to Puerto Montt."

A short time before the first of December, 1927, there were earthquakes along the coast of Chile, and at the same time several volcanoes of the southern Andes were active.

The volcano Llaima began erupting violently about November 29, 1927. Enormous flashes and a great quantity of smoke, lava, and cinders came out of the crater. Llaima is some 65 kilometers from Temuco, and it is not more than 3,000 meters high. It has two craters, and is covered with snow all the year round. It lies in latitude 38 degrees 44 minutes. The volcano had a violent eruption in 1864, and flashes of fire have frequently been seen in its craters. There are said to be 34 volcanoes between the latitudes of 24 degrees and 42 degrees.

"I went south from Valparaiso by sea, and on arriving in Puerto Montt on January 6, 1929, found that the volcano Calbuco was in eruption. The air was full of light ash, but only steam was issuing from the volcano at noon of that day. I went in an automobile to Puerto Varas, but was unable to get closer to the volcano than six or eight miles. According to the people there the eruption began about 1 a. m. January 6, 1929, and the outbreak was accompanied by a slight earthquake. The volcano then threw out ash until about 6 a. m., and there was another smaller earthquake about 4 a. m. For the rest of the day there was a fine steam plume from the peak, and once or twice I thought I saw small, dark puffs that could have been ash. Faint steam or smoke was rising over a large area of the woods at the foot of the volcano. I thought it might be caused by the fall of hot ash. but there were reports of a lava flow. On January 7, 1929, I saw the volcano from a different angle, and there appeared to be two steam jets. The only press report of the eruption that I saw was much exaggerated.

"It would be possible for an observer with headquarters at Puerto Varas, or possibly at Osorno town, to keep half a dozen volcanoes under fairly close observation. The eruption that I saw is probably typical, consisting of a short ash ejection, possibly accompanied by lava flows. The country is far more accessible than Alaska, and except for the heavy winter rains is a most agreeable place to live in. Puerto Varas, I judge, is only about 200 feet above sea level, and Calbuco volcano would appear about 5 000 feet high" (1,738 meters or 5,700 feet, according to Sapper). "I think that an expedition less expensive than those to Alaska could get important results in two or three months. December-January is the best season.

"At the Braden Copper Mine at Sewell, I found that the Talca earthquake of about December, 1928, had lasted one minute and a half and had destroyed the tailings dam at the mill, thereby causing a rush of mud that killed 43 people. A new Chilean law has established a Department of Public Works, which has as one of its chief duties the supervision of buildings to make them more nearly earthquake-proof." T.A.J.

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No. 223 RELEASED WITHOUT COPYRIGHT RESTRICTION April 4, 1929

KILAUEA REPORT No. 897

WEEK ENDING APRIL 3, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

During a half hour at Halemaumau pit about 2:30 p. m. March 29 no slides were heard. Fresh debris was observed on the north and northeast talus slopes, and scars were visible half way up the wall above both places. A ranger reported that the northeastern slide occurred about 2:30 p. m. March 27.

Measurement of cracks near the tourist outlook on the eastern rim of Halemaumau indicated that little or no change had occurred since January 18. At the former tourist outlook, farther south, where so much avalanching occurred in January, a rim crack was found to have widened 0.13 foot.

On March 30 at 8:30 a. m. a small slide removed rock from the eastern rim, and another was reported the next morning farther south. At 10 a. m. March 31 everything was quiet at the pit, and nothing new was observed. At 3:45 p. m. that day an avalanche sent up dust above the rim level.

Sixteen very feeble earthquakes were registered on the Kilauea seismographs, and irregular tremor occurred at intervals throughout the week, but very feebly. Tilt was moderate to the SSE., and microseismic motion was slight.

EARTHQUAKE INTENSITY SCALES

The attempt to define the size of an earthquake has led to making scales of earthquake severity. Where a large country is involved these scales have been based on popular reports. For scientific comparison with other places the size of the earthquake at any place ought to be expressed by a number. Just as four pounds of sugar ought to be four times as big as one pound, so a number four earthquake should be four times as big as number one. Herein lies the difficulty.

The Rossi-Forel intensity scale in common use is numbered 1 to 10, the numbers are defined by such expressions as "recorded only by seismographs," "cracking of plaster," "fall of chimneys," and by such adjectives as instrumental, moderate, and disastrous. The trouble with such a scale is that a nervous, sensitive person not used to earthquakes considers a feeble shock "stong." On the other hand, the average psychology of many people is a vaulabe criterion of intensity. The five grades (1) not felt, (2) felt by people at rest, (3) felt by everyone, (4) causing general fright, (5) causing consternation and panic, are definite.

The scientific basis of intensity, from a pendulum swinging in oil and scribing the length and time of its swings, or better, the length and time of the maximum swings of the earth while the pendulum stands relatively still, is called an "acceleration" or jerk. It is measured in rate of change of motion, millimeters per second change of motion per second (mm./sec.^{2}). The mathematical expression for this involves the square of the velocity of the earth particle divided by the amplitude of its motion. The changes of motion involve changes of direction as well as of speed. But for measurement it suffices to consider earthquake vibration a simple to and fro swinging. The seismograph pendulum assists this conception, for each instrument translates the earthquake motion into harmonic vibration in one direction only.

The Cancani intensity scale is based on a range of accelerations for each of 12 grades. The first 3 grades, from 1 to 10 mm., are instrumental only, and grade 12 would make a terrible catastrophe, reaching the acceleration due to gravity, 9,810 mm. per sec.^{2} Each grade doubles the value of the next preceding grade, expressed thus in millimeters (2½, 5, 10, etc.).

The Rossi-Forel scale, when reduced to accelerations, has values in terms of grade I as unity.

Grade	I, barely felt	equals	1
"	II, felt by few	"	2
"	III, felt by several	"	3
"	IV, feebly felt generally	"	4
"	V, felt by everyone	"	5.5
"	VI, alarm	"	7.5
"	VII, panic	"	15
"	VIII. damage	"	25
"	IX, destruction	"	60
"	X, catastrophe	"	125

It is thus arithmetically good from 1 to 4, and thereafter is an ascending curve. Grade I Rossi-Forel equals Grade IV Cancani.

The following are the grades of the Mercalli scale, abridged to show human effects:

I, INSTRUMENTAL, not felt.
II, VERY SLIGHT, felt by very few.
III, SLIGHT, felt by several.
IV, MODERATE, felt by many, no alarm.
V, RATHER STRONG, felt generally, some alarm.
VI, STRONG. felt by nearly everyone, many with fright.
VII, VERY STRONG, flight from houses, some damage.
VIII, RUINOUS, great terror, some wounded, much damage.
IX, DISASTROUS, a few lives lost, general ruin.
X, VERY DISASTROUS, great loss of life and utter ruin.

In the writer's tests, and Professor Mercalli among Italian peasants evidently had similar experience, ignorant persons in city or country can understand a human scale. They usually distort or exaggerate physical effects on masonry, water, trees, chimneys, etc., because they have no training in measured or judicial statement. T.A.J.

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No. 224 **RELEASED WITHOUT COPYRIGHT RESTRICTION** April 11, 1929

KILAUEA REPORT No. 898

WEEK ENDING APRIL 10, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Halemaumau, the inner pit of Kilauea Crater, has been almost motionless during the past week, and the new floor of black lava which was poured out February 20, 1929, appears almost as fresh as the day it solidified. In the forenoon of April 3 vapor rose over the whole pit after light rain. At 10:30 a. m. April 6 a small slide occurred at the north wall. At 8:05 a. m. April 9 light dust arose at the northeast side of the pit. On this day white salts were noticeable on the walls and talus blocks after two dry days following rain. The next morning, when there was a little drizzle wetting the stones, much of the whiteness disappeared.

The seismographs registered five very feeble local earthquakes during the week. One at 10:13 p. m. April 3 had indicated distance 11 miles from Observatory. The spasms of tremor were not observed after April 6. Tilt was slight to the south. and microseismic motion was normal.

THE ORIGIN OF LASSEN MUD FLOWS

By R. H. Finch

The cause of the mud flow from Lassen Peak on May 19, 1915, has been disputed. Drs. Day and Allen in their book, "The Volcanic Activity and Hot Springs of Lassen Peak," attribute the flow to melting of snow by a hot blast of gas, a deposit of hot volcanic ash, and hot rain. Loomis in his book, "A Pictorial History of Lassen Volcano," contends that hot water came out of Lassen Crater.

It is hard to believe that hot water came out of the crater, and Day has shown that the mud flow started some distance below the crater rim. The hot water theory may be dismissed. The writer agrees with Loomis that there is not sufficient evidence to indicate the occurrence of a hot blast or any considerable explosion just prior to the mud flow of May 19. There was only one flood on this date, excepting the possibility of a small one below the western flow, while the known explosions on May 22 produced several small mud flows. If there was no explosion and no hot blast, then there would not have been any hot ash deposit nor warm rain. Even if there had been an explosion, any rain accompanying it would probably have been but little warmer than any other rain—certainly not hot. It is also doubtful under the conditions existing on Lassen Peak at that time whether a rainstorm, unless of very unusual intensity, could cause a flood of the magnitude observed.

The flood originated in an embayment on the northeast slope of Lassen Peak that was uniformly covered by snow with a depth of several feet over most of the area. Now it is known that a few feet of snow of uniform covering can absorb several inches of rainfall so that the rain produces but little immediate run-off. If there had been bare spots in the snow field, then water could have run under the snow in considerable quantities and, in a place as steep as the Lassen slope, started avalanches. A hot blast, unless long continued, or a slight deposit of hot volcanic ash would produce much the same effects as a rain—a melting of superficial layers of snow and an absorption of the water by lower layers. A hot blast or a hot ash fall on a steep slope not uniformly covered with snow could, as in the case of rain, start streams under the snow and also cause avalanches.

It would seem, then that the Day and Allen theory as to the cause of the Lassen mud flow on May 19 may also be questioned.

An examination of enlargements of the photographs taken by Mr. Loomis immediately after the mud flow on May 19, and of the material transported by the mud flow, indicates that a large volume of hot lava poured through the eastern notch of the crater. There is much new lava that was carried in fragments down the flood. This flow was not only much more voluminous than the one through the western notch, but as would be expected, it was probably, as a whole, more molten. The lava flow could easily have melted the snow down to the ground and sent a stream of warm water under the snow lower down the slope. An avalanche mixed with hot rock could easily have been started in this way and produced a flood of the magnitude observed.

Minor mud flows did accompany the explosions on May 22. There was a horizontal component of this explosion that was parallel with the course of the upper part of the mud flow on May 19. The area affected by this blast was much wider than the area devastated by the mud flow of May 19 and accordingly encountered snow banks with exposed edges. Considerable hot ash was also thrown out by this eruption. The largest mud flow that accompanied this explosion followed the course of the one on May 19. At places where there was still uniform snow covering, the mud flows occasioned by hot ash and perhaps mud rains of this explosion for the most part stayed on top of the snow.

TITLE PAGE AND INDEX

The Title Page and Index for 1928 is now published and has been mailed to the regular list. It will be sent to anyone desiring it.

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No. 225 RELEASED WITHOUT COPYRIGHT RESTRICTION April 18, 1929

KILAUEA REPORT No. 899

WEEK ENDING APRIL 17, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

At Halemaumau on April 11 at 3 p. m. bluish vapor was noticed rising through the talus at the east edge of the new lava floor and staining the rocks yellow. At a sulphurous patch on the north edge of the new lava, yellow vapor was observed in a jet, by one of the park rangers. Fresh red debris was observed on the north talus slope. At 3:07 p. m. a small slide occurred at the south, and some very feeble sliding of sand occurred there almost continuously.

On April 13 at 10:15 a. m. a red scar was noticed above the east end of the big sill on the eastern wall, and fresh debris lay on the talus below. The pit was visited about 9 a. m. April 15, 16, and 17, but nothing new was observed and the walls were quiet.

At Kilauea Observatory nine very feeble local earthquakes were registered during the week. One at 4:48 p. m. April 13 was felt in Hilo and indicated a distance of 11 miles from the Observatory for its origin. Another at 12:17 p. m. April 14 was weaker, and indicated a distance of eight miles. Tilt was slight to the north, and microseismic motion was normal.

SECTION OF VOLCANOLOGY 1928

The Section of Volcanology of the United States Geological Survey makes headquarters at the Hawaiian Volcano Observatory on the northeast brink of Kilauea Crater. Its work in Hawaii is greatly assisted by the Hawaiian Volcano Research Association (see Volcano Letter No. 221). It maintains in addition the Lassen Volcano Observatory at Mineral, Californfnia, has placed a seismograph in the Loomis Museum at Viola, California, and another at Kodiak, Alaska. Service of the Kodiak instrument had to be discontinued temporarily after the closing, in August, 1928, of the Agricultural Experiment Station, where the seismograph was operated. Another seismograph with its time clock and other appurtenances has been deposited at Dutch Harbor in the Aleutian Islands. This station will be started and the Kodiak station revived in 1929.

The report of the Volcanologist for 1928 stated that "it is logical to expect activity from either Kilauea or Mauna Loa in 1929." This has been verified by the outbreak of Kilauea February 20, 1929. The new cycle of lava activity in Hawaii has proceeded with lava in Halemaumau pit in 1924, 1927, 1928, and 1929, and lava from Mauna Loa in 1926. The cycle should be half finished by January of 1930, and so approaching its maximum of lava gas pressure at that time, equivalent to that of 1919 for the last cycle.

The routine in Hawaii in 1928 consisted of mapping changes in Halemaumau, operating seismographs at the pit, Uwekahuna, the Observatory, Kona, and Hilo, measuring crater rim fissures and temperature of bore-holes, keeping track of Mauna Loa, studying the seismograms and also those of Kodiak, publishing Volcano Letter and preparing Monthly Bulletin, experimental work with new seismographs and the oscillating table, building seismographs, keeping up the office work and records, operating tide gauge and maintaining time service by radio. The routine in Lassen National Park is similar in seismological work, but includes measurements of hot springs, of marked landslip areas, and of magnetism in lava flows, and geological mapping.

The personnel in Hawaii included T. A. Jaggar, volcanologist; R. M. Wilson and E. M. Buckingham, engineers; R. B. Hodges, clerk; F. Y. Boyrie and Tai On Au, machinists; and H. Yasunaka, janitor. The Kona station was operated by R. V. Woods, the Hilo station by J. B. Albert and the Kodiak station by Mrs. E. M. Floyd. The tide gauge was operated by M. F. Lacerdo. Additional employees were S. Oda, J. H. Tahara, and Aiu Ahoi. The Lassen station was in Charge of R. H. Finch, associate volcanologist; assisted by A. E. Jones and C. A. Anderson, who made special investigations. Mr. Howel Williams also worked on Lassen geology. Mr. B. F. Loomis built a very substantial concrete and stone seismograph exhibition building next the museum at Manzanita Lake, where was installed the Finch seismograph, that had been replaced at Mineral by the Hawaiian type of instruments.

The Pavlof Expedition of the National Geographic Society under T. A. Jaggar materially advanced the exploration of Aleutian volcanoes. This has been given further impetus by the Federal Relations Committee of the National Research Council, which has formed a group of federal representatives of government scientific bureaus interested in the Aleutian Islands, to formulate a project for collaborative study of that region.

The shop of the Hawaiian Volcano Observatory has now produced eight pairs of seismographs, the wheeled boat "Ohiki," the oscillating table, special drilling apparatus whereby 34 bore-holes are now available as temperature stations, and machines for various physical experiments. T.A.J.

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No 226 **RELEASED WITHOUT COPYRIGHT RESTRICTION** April 25, 1929

KILAUEA REPORT No. 900

WEEK ENDING APRIL 24, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

At Halemaumau at 2:40 p. m. April 17 thin clouds of avalanche dust were arising over the pit. A more concentrated cloud rose at the north side, and the field glass showed that men were standing at the NNE. rim, probably dropping rocks and so starting the slides. At 3:15 p. m. both the dust and the visitors were still present. On the 19th at 2:30 p. m. the cleft above the north talus was seen to be somewhat enlarged, and a fresh scar was identified west of it. Apparently a thin layer of surface debris from a comparatively large area of the wall had caused the slides of the 17th. On this day there were occasional falls of single rocks from the northern wall, and at 2:35 p. m. dust from a slide appeared in the cleft above the NNW. talus. At 10 a. m. April 22 the pit was quiet, dry, and sunny, and exhibited no change. At 9:30 a. m. April 24 artificial slides on the north side of the pit were occasioned by men dropping rocks. At 1:10 p. m. thick, reddish dust arose at the north.

The seismographs registered eight local earthquakes, or tremors, all excessively feeble except one on April 20 at 10:21 p. m., which was very feeble but indicated distance of origin about 16 miles from the Observatory.

Tilt was pronounced to the SSW. Microseismic motion was slight.

A NEEDED SHOCK RECORDER

Seismoscopes that show whether a local earthquake has occurred were invented centuries ago. Seismographs which write earthquake autographs with pencil, ink, a scraping pen on smoked paper, or a light beam on photographic paper are mostly the product of the last century.

It was an effort of the staff of the Kilauea Observatory from 1911 to make a simple local earthquake instrument. But it proved difficult. It is easy to place a marble on top of a pillar: an earthquake rolls it off. It is easy to set up a pencil on its end on a glass plate: an earthquake rocks it or topples it over. Both require watching or they tell little about the time duration, and size of the shock. And if they are found upset, a spider or a cockroach might have done it. If they require a strongly felt earthquake to upset them, what use are they? If they are too sensitive to tell how large a big earthquake is, again what use are they?

In short, the effort to record time, duration, and size appeared to require a masonry cellar at constant temperature, timekeeping like that of an astronomer, clockwork of the finest, observers directed by physicists, and five or six seismographs of different sensitiveness to be ready for big earthquakes, medium earthquakes, and little earthquakes. The Tokyo laboratory has 15 or 20 working instruments.

The object is to secure cheapness and attractiveness, in order to get records of local motion from many places and to interest many people. This is what, for meteorology, makes the thermometer and the rain gauge so useful. There is an enormous moral and ethical inertia, and even resistance, to be overcome, in order to make the discovery of the distribution of small local earth motions interesting to the man on the street. Recently the presidential addresses of the Seismological Society of America, the work of several associates of the Hawaiian Volcano Observatory, an appeal from the president of a leading insurance company, and a letter from the Scientific American, have set the writer to experimenting, and the Jaggar Shock Recorder is the result.

The problem boiled itself down to the question, "What have we really got from our outlying seismograph stations, after running them for 10 years." We have a list of earthquakes, identifying the same ones at four different places, showing others strangely limited to single places, showing how long the jarring lasted at each place, and how great was the amplitude or back-and-forth motion of the levers. The timekeeping was not accurate beyond that of central telephone stations appealed to by the seismograph operators. The amplitudes were comparable only to such extent as the pendulums were built alike, tuned alike, and set up in like directions. Artificial jarrings were possible, from locomotives and trucks and school children. Directions of maximum motion, where a pair of pendulums is used, are of doubtful value; the reason is that each instrument place is likely to have its own swaying habit in all earthquakes, strongest always either east-west or north-south; every hillside is a pendulum. And finally, the magnification is so great in these instruments that strong shocks merely dismantle them.

Determination of distance of origin by study of the preliminary tremor is the one thing for which distributed good seismographs are important. This, however, requires expensive instruments, wireless timekeeping at each place, paid observers, and continuous attention by a central observatory. And even then, many shocks occur without good preliminary tremors, and the distance determination of centers tells nothing of how deep underground were the bumping, or gaping, or scraping fault surfaces that made the shock.

The seismologist says, "I wish I had sure knowledge of the measured size of that shock at plantations and ranches all around Mauna Loa." Then he could check up his theoretical place of origin by knowing where the shock was strongest. For this he needs a shock recorder, easy as a thermometer to read, working night and day, kept by the planter and the rancher. The need for this has grown, rather than lessened for we have recorded an astonishing number of little earthquakes felt all over the island of Hawaii.

The instrument that I have been working in the Kilauea station is made of a lead cylinder, hinged with two hacksaw blades, and writing on the face of an alarm clock. It produces an eight-inch paper disc with a line written round it like a gramophone record. The operation is no trouble at all. The paper is smoked, runs a week, and is then dipped in dilute shellac. Any quiet corner away from machinery receives the box, about three feet long, which is screwed down It is sensitive so as to show our feeblest instrumental Kilauea earthquakes. The time is recorded by a dial printed on the paper. The cost will be about $25. When interesting earthquakes occur, any number of copies of the disc seismogram may be printed on blue paper like any engineer's drawing. In this way, if purchasers of a shock recorder care to send us their record discs, we can send them blue prints to keep of any earthquakes that interest them.

We shall be glad to correspond with any prospective purchaser of one of these instruments. T.A.J.

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No. 227 **RELEASED WITHOUT COPYRIGHT RESTRICTION** May 2, 1929

KILAUEA REPORT No. 901

WEEK ENDING MAY 1, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Halemaumau pit has been remarkably quiet during the past week with slight slides from the walls observed between 9 and 10 a. m. April 25 and about 11 a. m. May 1. These were quite possibly occasioned artificially.

Eight very feeble local earthquakes were registered at the Observatory. On the 24th of April there was very faint tremor at intervals.

Tilt for the week accumulated slightly WSW. Microseisms were normal.

GEOGRAPHICAL SHIFT OF EARTHQUAKES

Professors Terada and Miyabe (A Long Period Fluctuation in Latitude of the Seismic Activity on the Earth, Bull. Earthq. Res. Inst, Tokyo Imperial Univ., March, 1929, Vol. VI, pp. 333-343) have investigated how big earthquakes have shifted from south to north and back again in the course of five centuries on both sides of the equator.

The inquiry was suggested by successions of disasters in Japan lying on a line progressively farther north. Then it was found that in the 19th century maximum of average frequency of Eurasian earthquakes lay about latitude 35° N., whereas in the 20th century they cluster about latitude 40° N.

This led to platting mean frequency of severe world earthquakes by latitude belts. It was found that:

(1) A southing of latitude in the 16th century in Japan and Eurasia equalled a northing in the southern hemisphere for South America.

(2) A northing in Eurasia about 1600 equalled a southing in South America.

(3) A southing about 1700 in Eurasia equalled a northing in South America early in the 18th century.

(4) A northing about 1800 in Eurasia equalled a southing early in the 19th century in South America.

(5) Approaching 1900, Eurasian earthquakes moved south and South American earthquakes moved north, both starting to change direction in the 20th century.

The listing of Central American earthquakes showed some correspondence of latitude fluctuation with South America, and North American earthquakes exhibited a curve somewhat resembling the rest of the northern hemisphere. China and Japan were platted separately, and were found to have in common an east-west component of shift as well as a meridional one. In both, the successive displacements of earthquake activity are in the direction SW-NE. This corresponds in general with the axes of the great deep, the island arcs, the inner seas, and the continental structure of eastern China. For either hemisphere there is suspected from all the curves a period of about 200 years between like phases of the fluctuation. It should be remembered that these are curves of fluctuation of latitude for earthquakes where 1,000 or more casualties are reported. The curves have no bearing on general relative frequencies for latitude belts, where the epicenters are determined instrumentally (see Volcano Letter No. 198).

Seeking a cause for the northing and southing of earthquake frequency periods, the authors compare the deviation of the moon's longtitude from 1640 to 1925 with the earthquake curves (see Volcano Letter Nos. 94 and 129). De Sitter and Brown have suggested that the changes in the length of day are due to actual change in the earth's radius, and so to change of its moment of inertia. The maximum moment of inertia was near 1786 and the minimum 1897. The earthquake frequency reached higher latitudes about 1800, and moved toward the equator about 1900.

Terada and Miyabe find it easier to conceive increase and decrease in the equatorial protuberance and the polar flattening, than to assume expansion and shrinkage of the whole earth. The greatest shearing stress would be in the middle latitudes and so express itself in seismic activity. The simultaneous poleward and equatorward shifts of seismic frequency in the two hemispheres suggest that in some way the change in ellipticity of the globe shifts the earthquake latitudes.

There was an acute change in the length of day observed in 1918, believed by De Sitter as possibly explained by a general shrinkage of the earth's radius. Moreover, he considers the curve of the centuries as consisting of a succession of straight lines, changing suddenly. T.A.J.

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No. 228 **RELEASED WITHOUT COPYRIGHT RESTRICTION** May 9, 1929

KILAUEA REPORT No. 902

WEEK ENDING MAY 8, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Halemaumau has remained very quiet throughout the past week, with practically no changes. Only one slide was observed, occurring from the north wall at 9 a. m. today. The debris fell from near the top of the wall to its lowest point of contact with the north talus.

On May 6 fresh red scars were noticed north.

There has been a slight increase of white stain at the foot of the south talus, and some increase in the yellow stain at the west end of the spatter formed by the big fountains of February 20-21, 1929.

Four very feeble local earthquakes were registered at the Observatory. One of these was strong enough to rattle a window of one of the nearby cottages.

There was a slight accumulation of tilt to the southeast. Microseismic motion was slight.

MECHANISM OF TOKYO EARTHQUAKE

The disaster of 1923 contained as main facts:

(1) Great earthquake at Sagami Bay September 1, 1923.
(2) Coast uplifted 1 to 2 m., Oshima volcano island stood still.
(3) Bottom of bay subsided between 1912 and 1923 up to 210 m.
(4) An earthquake sea-wave flooded the coast.
(5) Region around Bay suffered clockwise horizontal displacement of vortical aspect between 1884 and 1924 as shown by triangulation.

The subordinate facts were:

(1) Land subsided and beaches retreated for 20 years before the earthquake; amount of subsidence 10 cm.
(2) The shoreline has been upheaved in ancient times.
(3) Westerly tilt was measured of 1.7 seconds July 30 to August 17, 1923.
(4) Four small faults and one big crack system were formed.
(5) The isoseismals were radial, irregular and extended to the NW.
(6) The direction of earthquake motion was somewhat vortical.
(7) Submarine cables were snapped.
(8) Deep sea fish floated dead.
(9) Landslips were common west and northwest.
(10) Mineral Springs, lakes, and wells changed.
(11) Aftershocks occurred in several zones.
(12) Decrement of aftershocks was irregular.
(13) Epicenter determinations of the great shock were conflicting, and indicated a "seismic domain."
(14) Distribution of the initial motion, somewhat doubtful, made the center probably on land due north of Sagami Bay.

The theories to account for the disturbance were as follows:

(1) Upthrust, suggested by T. Kato.
(2) Block movement, suggested by N. Yamasaki.
(3) Submarine fault, suggested by A. Imamura.
(4) Subterranean fault, suggested by S. Nakamura.
(5) T-shaped fissure, suggested by T. Shida.
(6) Plutonic intrusion, suggested by T. Ogawa.
(7) Linear rebound, suggested by M. Matsuyama.
(8) Horizontal folding, suggested by T. Terada.
(9) Vortical action, suggested by K. Suda and S. Fujihara.
(10) Magmatic action, suggested by H. Nagaoka.

S. Fujihara and T. Takayama now present somewhat fully in English the conception of a vortical shear. (On the Mechanism of the Great Sagami Bay Earthquake on September 1, 1923; Bull. Earthq. Res. Inst, Tokyo, March, 1929, Vol. VI, pp. 149-176). A vertical surface of discontinuity is believed to extend along the Japan coast with southwesterly motion on the Pacific side and northeasterly motion on the land side. A rotational motion of crustal blocks is believed to have taken place about Oshima as a center. The volcanoes have been notably rigid when other formations shifted. Oshima resisted the shear and a horseshoe distribution of stress has accumulated about Sagami Bay. This stress was last released in 1853-54. Discontinuous yielding occurred again September 1, 1923, There was a sudden warping of the horseshoe, which the authors illustrate by a model consisting of a circular rubber plate laid horizontally. An eccentric clamped vertical axis corresponds to Oshima. A tangential horizontal pull southward on the east side of the disc wrinkles it appropriately and rotates all points on the surface as the triangulation bench marks found to be moved.

The great subsidence of the bottom of the bay is believed to have been a warping for 11 years past, accelerated at the time of the earthquake. Rotation clockwise accompanied by convergence was computed for the bay, and a rotation in opposite sense for a region next to the northeast, accompanied by divergence. The primary epicenter lay in between. T.A.J.

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No. 229 RELEASED WITHOUT COPYRIGHT RESTRICTION May 16, 1929

KILAUEA REPORT No. 903

WEEK ENDING MAY 15, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Halemaumau pit, the inner vent of Kilauea Crater, has remained quiet. Between 9:30 and 10 a. m. May 15 there was only one vigorous steaming area, namely at the top of the south talus. The north wall appears more freshly stripped than the others, but no slides have been observed during the week.

The upright cracks parallel to the eastern rim of the pit, and back from the edge, were measured May 15, and the 11 marked stations along the fissures showed very slight widening since March 29, 1929, the greatest movement amounting to 0.11 foot. This was at station No. 14, near where the opening crack extends tangentially into the pit wall.

Seven local earthquakes have been registered for the week, of which six were very feeble. One at 5:54 a. m. May 12 indicated an origin very close to the Observatory and was felt, the intensity being No. 3 Rossi-Forel. Microseisms for the week were slight, and tilt moderate to the northeast.

MECHANISM OF EARTHQUAKES

"A great earthquake is accompanied by topographic changes; such changes have been particularly remarkable in the three last great earthquakes that have happened in Japan. The study of these shakings has led to the conclusion that the change in the surface of the land is not such as would result in seismic rays radiating out in all directions."

"We may now consider proven the existence of blocks and block movements, using the evidence of measurements made by means of precise leveling. These measurements have demonstrated that the motions of these earth blocks are so independent that there exists little correlation between them, and there is deduced the existence of a malleable layer under the groups of blocks."

"The fact that the atmospheric pressure gradient plays an important part in the incidence of an earthquake, suggests the existence of a mobile stratum within which viscous matter is present, easily displaced under the action of differences of barometric pressure."

"Studies of the properties of magma, such as the phenomena of differentiation, the rapidity of magmatic intrusion, etc., permits us to consider the origin of seismic waves as result of shock provoked by sudden change in the kinetic moment of an intrusive."

"In the case of a feeble earthquake, there will be only the shock induced by the intrusion itself. But in the case of a big cataclysm there may be formed actual fractures in the terrestrial crust, resulting from the enormity of the disturbance."

"We have, in fact, many aftershocks following a great earthquake, which may be explained as injections of magma in the fissures formed by the first big disturbance. The topographic changes of level or of horizontal position are then accounted for as resulting from movements tending to readjust the isostatic equilibrium of the block."

"Seismic wave motion tends in fact to die out in passing a fault plane, whether that fault were the direct result of seismic happenings or other tectonic cause. The anomaly exists in the fact that seismic intensity diminishes when elastic waves pass athwart a fault plane standing perpendicular to the directions of propagation."

"In introducing magma as a cause, we can more easily explain other facts that accompany earthquake." (On the mechanism of production of seismic waves, by Misiho Ishimoto, in Japanese, abstract in French, Bulletin of the Earthquake Research Institute, Tokyo Imperial University, March, 1929, Vol. VI, pp. 127-147.)

The author discusses the relation of dykes, faults, and existing igneous outflows to earthquake rifts, presents maps and a diagram exhibiting the relations of dyke intrusion to time, specific heat, conductivity, density, thickness, distance, and temperature, and quotes Barrell (Professional Paper No. 57, U. S. Geol. Surv. 1907, pp. 157-159), to the effect that "the extension of dyke intrusions resembles volcanic eruptions in that both take place in an intermittent and paroxysmal manner."

It would appear from the facts of volcano research that lava outflow, magmatic intrusion, and swarming of earthquakes may all correlatively take place in an intermittent manner, which is cyclical and not at all paroxysmal. Paroxysm is nothing more than occasional acceleration. T.A.J.

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No. 230 RELEASED WITHOUT COPYRIGHT RESTRICTION May 23, 1929

KILAUEA REPORT No. 904

WEEK ENDING MAY 22, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

The past week at Kilauea and Mauna Loa has exhibited suggestion of movement on the flow rifts of the latter mountain. Kilauea has been notably quiet.

At Halemaumau about sundown May 15 a ringing noise of snapping was heard in the new lava bottom like deep cracking due to cooling as the sun's rays left the surface. On May 17 about 4 p. m. a slide occurred at the east rim. On the 19th a little dust rose at the north corner of the pit about 9 a. m., and a very small fall of rock was heard during a visit at 2:30 p. m. May 20-21 it was noticed that the wall gulches above the north and northwest taluses are deepening toward each other, as though a slab of that wall might some day fall. Some stones now lie on the east side of the 1929 floor.

About 6 p. m. May 15 a smoky film of cloud was observed above the normal rain cloud that lay over Mauna Loa. At 8 p. m. May 17 Honomalino Ranch reported Mauna Loa to be smoky. The Puu o Keokeo district, about the 8,000-foot level of the southwest rift of Mauna Loa, was examined by ranchmen, and nothing new could be found on the mountain. The sulphur patch of 1926 was fuming slightly. Mauna Loa was absolutely clear in brilliant sunlight this morning, May 22.

Only three local earthquakes, all very feeble, have been registered, but two of these indicated a distance of origin appropriate to the south end of Mauna Loa; namely, 9 a. m. May 19, distance 34 miles, and 1:45 a. m. May 20, distance 28 miles. It may be added that two small earthquakes registered last week were: 6:16 a. m. May 14, felt at Honomalino, distance from Observatory 38 miles; and 12:05 a. m. May 15, distance 31 miles.

Tilt for the week was strong WSW., and microseismic motion was slight.

ACTIVITY OF KRAKATOA IN 1928-29

Krakatoa, in Sunda Strait between Java and Sumatra, was in new activity between December and April, 1927-28, as previously reported (Volcano Letter Nos. 167, March 8, and 196, September 27, 1928). The outbreak of 1928 was in the ocean between the three islands that had been left by the gigantic eruption of 1883, and a cone was built up on the sea bottom which was piled above sea level occasionally in 1928, and then washed by the waves. The third phase of activity was in April.

This third phase was characterized by a series of little eruptions lasting until May 15. From 6 a. m. May 14 till 8 a. m. May 15 a total of 7164 jets occurred, and 14 of these reached a height of 100-400 meters. Dr. Stehn reports that on May 1 after 7 p. m. strong glare was seen above the crater in the ocean accompanied by steam, which he attributed to the flowing of lava over the rim of the submarine crater. Flames were also seen above the vent of orange-yellow color, making the surface of the sea look as if it were ablaze. The flames rose about 10 meters and were suspected as being due to hydrogen.

The fourth phase of activity lasted from May 18 to May 27. An ash eruption rose 500 meters. Each period of activity was preceded by volcanic tremors registered on the island seismograph. The directions of motion of the seismic components suggested an inclined vent underground and some slow displacement of the position of maximum action.

June 1 and 2 there were slight eruptions. The submerged crater rim lay from 5 to 10 meters below sea level. The fifth phase of activity began July 6 and ended July 13, with small eruptions reaching a maximum height of 250 meters. Soundings indicated a lowering of the submerged cone. Explosions and tremors were renewed at the end of August and early in September. In October Krakatoa was quiet except for bubblings of gas and tremors recorded by the seismograph. Many audible explosion noises were heard in November, and seismic activity was renewed. The noises are described as peals, reports, and rumblings. The shaking was strong enough to cause noteworthy avalanches from the summit of Rakata Peak. Small eruptions occurred in December, one on the 20th throwing up ashes and bombs 80 meters with glow and rumblings.

Except for tremors, Krakatoa was quiet at the beginning of January, 1929. The seventh phase of activity began on January 12 with steaming above the eruption point and bombs of old pumice material floating about as long as they remained hot and charged with gas. Activity slightly increased, reaching a maximum January 20-21, when 8817 separate jets were counted within 24 hours, the maximum height being 1100 meters. On that day the crater rim was built up above the sea as a loose pile of bombs and blocks. Only a strong surf marked the spot the next day. Then the activity decreased somewhat, but after January 25 the eruptions increased and created a new island called "Anak Krakatau," meaning child of Krakatoa. Enormous masses of solid material were thrown out from two or three crater openings, eruption columns reached 1,200 meters in height with a width of 500 meters, and the photographs presented show a crescent-shaped island with magnificent explosive jets of dark material radiating upward surrounded by a wreath of white steam at sea level.

The greatest number of separate jets was counted February 3-4, amounting to 11,791 spurts within a period of 24 hours. On Febraury 9 the new island was 21 meters high, and on Febuary 18, 38 meters. Electric discharges were sometimes observed in the eruption columns. The building up of the island wall around the crater cut off the view of minor eruptions from the station on Lang Island, as did the dust cloud when the wind was unfavorable. Pauses in activity increased from February 4 to Febraury 18, when the seventh phase of explosion ended. The island was examined from an airplane, the horns of the crescent pointed WSW., and the length was about 250 meters. (Bulletin Netherlands East Indian Volcanologic Survey No. 17, March, 1929, and preceding numbers.)

T.A.J.

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No. 231 RELEASED WITHOUT COPYRIGHT RESTRICTION May 30, 1929

KILAUEA REPORT No. 905

WEEK ENDING MAY 29, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Halemaumau has remained quiet during the past week, and nothing more has been heard from Mauna Loa. The afternoon of May 24 showed a few rocks on the new floor at the southeast and some appearance of fresh debris of large size at the top of the north talus, with appropriate fresh red scars in the wall above. A small slide at 12:05 p. m. May 27 and another at 1:35 p. m. sent up dust at the north corner of the pit.

Seven very feeble local earthquakes were registered for the week, of which one at 4:07 a. m. May 28 was felt in Hilo and Papaikou, the seismogram at Kilauea indicating distance of origin 21 miles. A big distant earthquake beginning 12 h. 17 m. 34 s. p. m. Hawaiian Time May 26 gave evidence of origin about 6,800 kilometers from east Hawaii, or something over 4,200 English miles. As Honolulu recorded 6,500 kilometers, the possible location might have been anywhere in the belt extending north and south through Japan. Otherwise the distance would correspond to the ocean north of New Zealand or to Central America.

Tilt was moderate WNW., and microseismic motion slight for the week.

TEMPERATURES OF CRYSTALLIZING MINERALS

The older text books possessed little information about the temperatures of mineral formation, and so the loose generalizations of the 19th century imagined that basaltic lavas were cooler than deep-seated magma like granite, which was conceived to crystallize under enormous temperatures and pressures. The facts almost completely reverse this, and extensive laboratory work has thrown light on the temperature meaning of the mineral crystals found in the rocks. Besides the direct measurements of temperature of lava at craters, we now have many measurements of the melting temperatures of minerals, the inversion temperatures of minerals which change from one crystalline form to another, like quartz to tridymite, and to cristobalite, the melting temperatures of mineral mixtures, the temperature at which a mineral decomposes, and the effect on fusion or on chemical reaction of increased pressure in depth and of included gaseous mineralizers. (The Temperatures of Magmas, by E. S. Larsen, The American Mineralogist, Vol. XIV, pp. 81-94, 1929.)

Rocks crystallize from a liquid condition, or melt from a solid condition over a temperature interval which is greatly affected by the pressures involved and by the presence of steam or other gaseous ingredients which exist in the deep magma underground when the paste is congealing, but do not exist in the powdered rock of the open crucible heated in a furnace. Basalt melts through a temperature interval from 980° to 1,260° C., and granite 1,215° to 1,260°. Obsidian or rhyolite, the lava equivalent of granite, with much water in its composition melts easily until it loses its water, but thereafter it can be made liquid only at a much higher temperature. The two forms of quartz, the commonest mineral of granite, are stable up to 870°, above that to 1,470° silica becomes tridymite, and above that to 1,720° it becomes crystobalite. Quenched at any higher temperature silica takes the form of glass.

The apparent discrepancy between the higher melting range of the granitic magma as compared with basalt, and the much lower crystallizing range of temperatures which are evidenced by its minerals, can be explained as due to the gases in solution which are in the granitic magma, but are not in the rock when it is melted in a crucible. The slow cooling of a magma intermediate between rhyolite and basalt shows first the crystallization of lime-feldspar and dark minerals, leaving the remaining liquid richer in the material for quartz and orthoclase feldspar. There is finally left a liquid with a composition near that of pegmatitic granite. The original magma with the composition of basalt required a higher temperature to keep it liquid, and the granitic material was liquid at a lower temperature. The conclusion is that rhyolite or granite crystallize at the lowest temperature of the group. The magma in the throat of a volcano may be excessively hot owing to gas reactions and surface oxidation. When a mineral crystallizes from a solution, the temperature must be below the melting point of the mineral. But that does not tell how much below, as most of the rock minerals are in a condition of what is called "solid solution" and the crystallizing temperature differs with the composition. Most basaltic magmas remain almost completely liquid at a temperature below 870°.

The following is a summary of conclusions: (1) Rhyolitic magmas have lower temperatures than basaltic magmas. (2) Measurements of the basalt of Kilauea vary from 750° to over 1,200°, those at Vesuvius vary nearly as much. (3) The melting temperatures of minerals yield only maximum temperatures. Some biotite mica must form below 850°. (4) The inversion temperatures of silica show that some basalts and most rhyolites and quartz latites are nearly completely liquid at temperatures below 870° and probably all magmas crystallize above 570°. (5) Common hornblende inverts to basaltic hornblende at a rising temperature of 753°. Hence most hornblende rhyolites and quartz latites and many andesites containing common hornblende, crystallize below that temperature. (6) Since the inversion of quartz inclusions to tridymite or cristobalite is very rare, and this inversion takes place without a flux at an appreciable rate at 1,250°, very few magmas have so high a temperature. (7) The lack of fusion of most granitic and arkose inclusions indicates a temperature below 1,150° but mineralizers would permit fusion at much lower temperatures. (8) The results show that some basalts have temperatures below 870°, many are below 1,000°, very few are as high as 1,260°, and most are not far from 800° to 900°. (9) Rhyolite or granite magma has lower temperatures, in the range between 573° and 870°. Most of these rocks crystallize below 850°, the temperature of decomposition of biotite, and below 750°, the changing point of common hornblende, for they contain both these minerals. Hence most rhyolites or granites had temperatures between 600° and 700°.

T.A.J.

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No. 232 **RELEASED WITHOUT COPYRIGHT RESTRICTION** June 6, 1929

KILAUEA REPORT No. 906

WEEK ENDING JUNE 5, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

Examination of Halemaumau pit at 5:50 p. m. May 30 showed that the whole northwest talus was covered with new gray debris, this overlapped the lava floor of 1929, and the wall showed fresh breaks above this talus clear to the top. Sliding at the north corner had been observed the previous day. On June 3 at 8:45 a. m. a large dun colored dust cloud from an avalanche was seen to rise over the northwestern half of the pit.

Eight very feeble earthquakes were registered for the week, one of these coincident with the above mentioned avalanche cloud. Tilt was moderate NNE., and microseismic motion was slight.

OCEAN SALTS FROM VOLCANOES

Visitors to the sulphur bank near the hotel at Kilauea have been impressed with the heavy layers and beautiful crystals of sulphur, with steam at 96° C. puffing up and smelling of sulphur dioxide. In the summer 1922 Dr. E. T. Allen determined that the vapor from the bore-holes has the following composition by volume:

Steam	96.2
Fixed gases (nitrogen etc.)	3.7
Sulphur dioxide	.096
Sulphur vapor	.004
Hydrochloric acid	trace
	100.00 percent

In one or two years the big iron pipes that encase the bore-holes become lined with an inch or so of compacted crystals of pure sulphur over a thin layer of sulphide of iron, a black coating that is next to the metal. All of this, and the heavy banks of sulphur that cover the old ash deposits, are laid down from .004 per cent sulphur vapor in the steam. (Bull. Haw'n Volc. Obsy. Vol. X, No. 8.)

Dr. E. G. Zies determined at the Valley of Ten Thousand Smokes near Katmai, Alaska, that the fumaroles gave off 26 million liters of steam per second containing about 0.2 per cent of hydrochloric acid, hydrofluoric acid, and hydrogen sulphide. Figuring the volumes given off per year and reducing to weights, this amounts to 1,250,000 tons annually of hydrochloric acid gas, 200,000 tons of hydrofluoric acid gas, and 300,000 tons of hydrogen sulphide gas.

The temperatures of these gases in 1919, seven years after the eruption, exceeded 500° C., the incrustations lining the cracks showed how powerful had been the solvent action of the gases, indicating the power of such an agency to concentrate valuable ore deposits. At the Kilauea sulphur banks there is abundant pyrite, a product of the action of the fumarole gases on the lava.

The power and rapidity of this deposition, despite the tiny percentage of the ingredients in the steam, only appears when we consider the agregate quantity of even the least significant of the acid gases when continually discharged into the atmosphere at these rates. The average river contains insufficient chlorine to convert its sodium into salt; the ocean contains much more chlorine than sodium. One hundred million tons of hydrochloric acid is the annual requirement to account for the saltiness of the sea. In about 40 inches of world-wide rainfall this would amount to one-fifth of a millionth part of chlorine. Yet in ordinary chemical determinations one part in a million is considered insignificant. Hence we see what a large part can be played by volcanic steam which never ceases.

Of this 100 million tons of hydrochloric acid gas the Katmai area alone of the 450 active volcanoes of the world was contributing more than one per cent in 1919, and Kilauea, with its bare trace of chlorine, contributed about 30,000 tons. Many volcanic districts discharge acid gases. It appears that volcanoes, of which also there are many on the sea bottom mostly unknown, are quite competent to supply to the ocean the excess of chlorine needed for its salt.

The fluorine content of seawater is only one-twenty-fourth that of chlorine. The fluorine becomes locked up in the incrustations, and when it gets into the sea is absorbed into the bones and shells of marine animals, all of the phosphate beds of the vast ancient oceans showing a fluorine content of from 1.0 to 1.5 per cent. This element forms an insoluble compound with calcium, in contrast to chlorine which with sodium forms the highly soluble common salt. This disparity between the amounts of fluorine and chlorine in sea water, and the relatively large amounts of fluorine given off by volcanoes, disposes at once of the argument that volcanoes get their chlorine from the sea. Everything indicates that both these halogen gases are derived from the lava itself. (Annual Report Director Geophysical Laboratory, Year Book No. 27, 1928 Carnegie Institution, page 81.)

Sea water contains calcium carbonate as well as other salts. This is secreted from the water in the body of globigerina, a tiny organism ceaselessly dying and depositing billions of skeletons that make chalk on the ocean bottom. Locally the ocean floor is built up a foot per annum. Ten thousand years would shoal the ocean, but there have been millions of years, and the ocean is still deep.

The accumulation of heavy chalk or globigerina ooze is partly kept low by isostasy, the crust sinking and the continents rising. But this could not take care of millions of years of globigerina hailtsones. And what furnishes the lime to the salt water? Shifting shorelines and erosion of limestones on the land has furnished new lime to the rivers and the sea. But has the amount of rising limestone equalled the vast seabottom, which covers seven-tenths of the surface of the earth?

But though globigerina is everywhere in the upper waters, two-thirds of the seabottom has no chalk. What could account for chalk banks being absent? The chalky bottoms are where the ocean is not so deep. It was found that where the ocean is more than two and a half miles deep, where the pressure approaches three tons per square inch, sea water can readily dissolve the chalk skeletons. And so, with the circulation of the oceans the lime salts are brought back and secreted over again by the live organisms. (Liverpool Echo, January 26, 1929, citing J. Stanley Gardiner, professor of zoology, Cambridge.) T.A.J.

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No. 233 RELEASED WITHOUT COPYRIGHT RESTRICTION June 13, 1929

KILAUEA REPORT No. 907

WEEK ENDING JUNE 12, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

Halemaumau remains practically unchanged, with occasional slides from the walls. Debris from recent slides was noticed on the northwest talus June 5, at 2 p. m., with larger bowlders on the lava floor. A small slide was observed on the south wall at 9:30 a. m. June 8. The pit otherwise was very quiet. On June 9 nothing new was seen. There was a small rockfall north about 10 a. m. today. Very thin dust from a slide rose north at 2:15 p. m.

Twice as many earthquakes were recorded this week as for the preceding week; namely, 16 of very feeble intensity. The accumulation of tilt was slight to the northwest Microseismic motion was normal.

WEATHERING OF HAWAIIAN LAVA

Many people who visit Hawaii ask the question "How long does it take for these fresh lava flows to make soil?" The first of a series of papers on the chemistry of decomposition of basaltic lavas in Hawaii (The Composition of Lavas and Soils from Kauai, by N. E. A. Hinds, Am. Jour. Sci. April, 1929) has been published by Professor Hinds, including reviews of many analyses made by Kelley, McGeorge, and Thompson, Bulletin 40, Hawaii Agricultural Experiment Station.

On all the islands there are astonishing differences of rainfall and of climate, wet on the side of the trade winds, dry on the opposite side. On the dry sides lava remains unaltered, on the wet sides it breaks down rapidly.

The predominant lavas of Kauai, the western of the larger islands, are olivine basalts, composing 85 per cent of the dome visible above sealevel; next come augite andesites and olivine augite andesites, while subordinate in amount are the basic lavas largely augite and olivine and some rare nephelite and melilite basalts.

Olivine is very conspicuous in most of the rocks as large and numerous visible crystals. Hinds found these in approximately 92 per cent of 400 specimens. Most of the lava is of the blocky or aa type, the ratio of aa to pahoehoe (smooth lava) being about 3 to 1. The chemical composition of the Kauai lavas when fresh, (and the smaller island Niihau to the west is very similar,) is as follows: Silica 40-49 per cent, alumina 8-14, iron 11-14, magnesia 7-16 lime 9-12, alkalies 2-5, water 0.30-1.00, and titanium oxide 2-3.

Rainfall on windward Kauai varies from 50 to 100 inches along the eastern and northern coasts, and from 10 to 30 inches on the western coast which is 12 to 15 miles from the summit of the single volcano dome that makes up the island. This summit, slightly over 5,000 feet in height, is possibly the rainiest locality in the world, where for a seven-year period the extraordinary average of 473 inches per annum of precipitation was measured. The main average temperature yearly for elevations varying from 14 to 300 feet ranges from 68° to 79° F.

Most of the weathering is chemical. There is a little frost on the uplands, and the detritus is moved by streams, landslides, and ocean waves, but the mineralogical and chemical changes in the soil vary mostly with the climate of different sections of the island. There are no analyses as yet from the swampy region of the summit plateau. The soils and subsoils are in the main from decomposition in place of lavas and agglomerates, the latter from local vents where this material has been dumped about subsidiary cones on the weathered lavas. There are some alluvial soils at the mouths of rivers, and some coral detritus near the shores.

Throughout the Hawaiian islands rock alteration varies with the climate and the age of the domes. Younger domes are Haleakala, Mauna Kea, Hualalai, Mauna Loa, and Kilauea; older ones are Kauai, east and west Oahu, east and west Molokai, west Maui Kohala, Niihau, Lanai, and Kahoolawe. The last three have dry climates and are less dissected and better preserved than the wet islands. The stage of topographic evolution therefore is not a measure of age.

Some weathered lavas and their disintegrated products from Oahu yield the following:

	Lava (Per Cent)	Disintegrated Product
Silica	52	20
Alumina	11	38
Iron	10	18
Lime	10	0.33
Magnesia	6	0 20
Alkalies	3	0.50
Titanium ox.	4	4.7
Water	1	17

On Kauai bright brick-red soil is found in the dry regions, brown and dark red soil in the wet, the powdered and clayey decomposition material passing downward into brown, yellow, gray, or green rotten rock in marked contrast to the soils and subsoils, for the latter retain none of the original texture. In the lower zone are great numbers of concentrically weathered bowlders (onion structure), having spherical or ellipsoidal masses of relatively fresh rock at the core. Going down farther we come to relatively unaltered rocks, the depth of the weathered zone depending on the amount of rainfall.

An average of eight soil analyses from Kauai gives percentage of insoluble residue, mostly silica 39, alumina 17. iron 14, magnesia 3, lime 0.89, alklalies 0.42, titanium oxide 2.3, water 12, averaged from a range of from 4 to 19.

The mechanical analyses of a typical soil gave in percentage volatile matter 19, fine gravel 0.02, coarse 1.57, fine sand 5.48, silt 6.449, fine silt 33.40, clay 33.50. The content of water in soils and subsoils is about the same, an average of 26 soils and subsoils together giving 8.6 per cent, of eight subsoils alone 8.14, and of 26 soils alone 9.16. T.A.J.

NOTE: Address of Secretary, Hawaiian Volcano Research Association, is 300 James Campbell Building, Honolulu, T. H.

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No. 234 **RELEASED WITHOUT COPYRIGHT RESTRICTION** June 20, 1929

KILAUEA REPORT No. 908

WEEK ENDING JUNE 19, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

On June 13 at noon the north wall of Halemaumau was dusty with fresh red and gray scars and new material on the northwestern talus appearing fresh. There was other new red debris northeast, from the middle of the wall above. On June 18 the felt earthquake at 8:42 a. m. produced some sliding in the pit, but much stronger sliding was occasioned by the earthquake of 9:31 a. m. when much dust rose above the pit. Examination showed a gouge down the middle of the west wall where large fragments of rim rock had fallen so that broken debris lay on the lava floor below. At 11:40 a. m. rocks were heard and seen falling at the north, west, and south walls of the pit. On the west wall of Kilauea Crater north of Uwekahuna a fresh avalanche scar was produced by the large shock, with new talus below. A party near the Halfway House in the Kau Desert noted the earthquake of 9:31 as a shock accompanied by a rumble, and sufficiently strong to cause the trees to wave back and forth. At the Observatory the dominant effect was a slow east-west swaying with creaking of the building. The high magnification seismographs were dismantled.

It is worthy of note that this seismic disturbance occurs close to solstice, and that the press reports an eruption of Komagatake in the north island of Japan, and a disastrous earthquake in the southern district of New Zealand.

The seismographs registered for the week two distant earthquakes, two moderate local shocks, several very feeble local shocks, and one tremor lasting two minutes. The first of the two strongly felt Hawaiian shocks, at 8:42 a. m. June 18, indicated distance of origin 11 miles, and the second one, much stronger, at 9:31 a. m., 44 miles. The tremor following this lasted 10 minutes. The first distant earthquake was weakly recorded about 11:06 p. m. June 12. The second was more pronounced, beginning 12h. 28m. 46s. p. m. June 16. The indication of distance is 8,100 kilometers, and possibly this was the New Zealand shock.

Microseismic motion was light throughout the week. Tilt accumulated, moderate to the WSW.

ENGULFMENT AT KRAKATOA 1883

An important review of the history of the Krakatoa group of islands, bringing up to date the geology and the eruptive history, has just been published by the Volcanological Survey of the Netherlands East Indies as a special report for the Fourth Pacific Science Congress, Java, 1929 (The Geology and Volcanism of the Krakatau Group, by Dr. Ch. E. Stehn). The following is a summary of the constructive and destructive periods in the building of what is now a group of three islands at the corners of a triangle, with a new eruption in progress building a new islet in the sea between them (Volcano Letter No. 230).

I. Formation of a hypothetical ancient single volcano about 2,000 m. high of which the last lava streams and ejecta were hypersthene andesite with tridymite, and a microlithic devitrefied glass. The period involved the destruction of this volcano, leaving four remnant islands, with a sea basin in the center.

II Formation of an eccentric basaltic volcano covering the southern Rakata remnant. 800 meters high.

III. Submarine activity of two andesitic volcanoes, Danan and Perboewatan. Formation northward of an island, Krakatau proper, which joins up with the basaltic volcanic cone of Rakata. The same magma penetrates into the Rakata cone through a dyke fissure. Fresh activity in May, 1680.

IV. May 20, 1883, commencement of a new eruption which continued with short pauses, and became the gigantic famous eruption.

August 26-28. 1883, the greatest activity. Considerable increase in size of Rakata, Verlaten Eiland, and Lang Eiland from ejecta of andesitic magma, obsidian, pumice, and older rocks. Terminating with destruction of the volcanoes Perboewatan and Danan and half the basaltic cone of Rakata Peak. Formation of a basin 279 m. deep between the three islands left.

V. Severe abrasion by ocean waves especially on the west coasts, and extension of the low northern portion of Verlaten Eiland by the building of a spit.

VI. Submarine activity beginning June, 1927, and becoming an eruption December 29, 1927. Submarine cone of basaltic bombs, ashes, and old material appeared above the surface of the sea January 25, 1928, and later washed away. Submarine lava streams. The submarine crater rim appeared again January 28, 1929, forming new basaltic island "Anak Krakatau."

From May to August, 1883, smaller eruptions left their products close to the active craters and threw out much pumice. The paroxysm came on August 26 and thereafter. On August 27 Perboewatan subsided and a severe explosion followed, directing its discharge eastward. In no case were collapses preceded by explosions.

Fresh subsidences took place associated with tidal waves which formed bluffs. About six hours after the first subsidence August 27 came the gigantic collapse, followed by an explosion which piled unsorted pumice to thicknesses of 100 meters, strewed ash over 827,000 square kilometers, ejected ash clouds over 70 kilometers high, and made noises heard in Australia.

More subsidences and fractures occurred involving the basaltic Rakata Peak, and a second explosion that followed within an hour of the big one was believed to destroy Danan Volcano as shown by the sequence of the present strata. This disrupted the remainder of the big island and part of the sea bed, left a submarine ridge between the two explosion centers and deposited some shells and coral in the strata. More fractures followed and another engulfment of the northeastern part of Rakata and the south part of Lang Eiland, causing the last tidal wave.

Verbeek in 1885 prophesied "In any renewed activity of the volcano, islands will arise in the middle of the sea basin, just as formerly the craters Danan and Perboewatan formed in the sea within the old crater wall." This is just what is going on now.

In the light of what was observed showing engulfment the dominant process at Kilauea in 1924, Dr. Stehn's conclusion that collapse was the dominant process at Krakatoa in 1883 is of fundamental interest in volcanology.

T.A.J.

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No. 235 RELEASED WITHOUT COPYRIGHT RESTRICTION June 27, 1929

KILAUEA REPORT No. 909

WEEK ENDING JUNE 26, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

The week at Halemaumau has produced very few changes. On June 20 all was quiet. One or two rocks fell south at 3:45 p. m. There was nothing new in the bottom or on the walls. On June 24 with a stiff NE. breeze, dust was disturbed on the northeast and south walls. Light rock falls were heard south and southwest. A dusty slide occurred northeast at 11:55 a. m. At 5 p. m. more dust was observed thinly spread over the pit. Today at 2:45 p. m. was seen the scar of slides from midway the north-northeast wall, and a pile of new gray debris at the foot. The ground back of the southeast rim shows very slight signs of caving at the cracks which opened in January, as though further movement had occurred there.

Earthquakes registered by the seismographs at the Observatory included seven very feeble local shocks, one two-minute tremor beginning 12:16 a. m. June 22, and one moderate earth shock also on June 22 at three minutes past noon. This earthquake, which was felt locally, had an indicated distance to origin of nine miles.

Tilt for the week accumulated moderately NNW. Microseismic motion was very slight.

NEW INVESTIGATIONS

Section of Volcanology.

Changes of personnel at the Hawaiian Volcano Observatory have recently occurred, and new investigations are now beginning. Mr. R. M. Wilson rejoined the Topographic Branch of the Survey in California in November, 1928, and Mr. Earl M. Buckingham was temporarily appointed in his place as topographic engineer at the Observatory. Mr. Buckingham made a new map of Halemaumau after changes in the walls had been made by the avalanches of January, 1929, and a new lava floor had been created by the eruption of February 20. He also continued investigations which had been started by Mr. Wilson dealing with mean sea level at Hilo, and with tilting of the ground at the Observatory as determined with level-bubble. Mr. Buckingham also joins the Topographic Branch of the Survey in California on July 1, 1929. Mr. Howard A. Powers, instructor in petrography at Harvard University, has been appointed Junior Geologist on the Survey as chief assistant at the Hawaiian Volcano Observatory, beginning July 1, 1929. Mr. Powers will specialize on the study of minerals in the rocks of the Hawaiian Islands along with mapping of the geologic formations on the basis of the excellent topographic maps of Hawaii made by the Topographic Branch in cooperation with the Territory under Captain A. O. Burkland. These atlas sheets are now finished and in process of engraving for the whole of this island, and some geologic work has already been started by the Survey. This will now be carried forward, and the specimen collections of the Observatory will be subjected to microscopic and chemical examination. For the first time the Observatory will enter on the field of investigation of the older lavas of the island and their relation to the past history of the volcanoes.

For continuation of the seismologic work started in the Aleutian belt of Alaska, Mr. Austin E. Jones left Seattle on the Coast Guard cutter June 8, 1929, for Kodiak and Dutch Harbor, and in both those places he will establish seismograph recording. A new observer will be found for the seismograph at Kodiak, the service of which was discontinued in August, 1928, and the Hawaiian type seismograph now stored at Dutch Harbor will be set up in a cellar constructed for the purpose and operated in connection with the Naval Radio Station at that place. Mr. Jones is now at work building the cellar.

Hawaiian Volcano Research Association.

Professor Chester K. Wentworth of Washington University, St. Louis, has been appointed Research Fellow of the Association for the summer months of 1929, and is now at work investigating the volcanic tuffs, soils, wind-blown deposits, and other related loose materials on the island of Hawaii. His special topic is the origin of the yellow tuff so well known in the Kau district from Pahala to South Points. These tuffs are important in that district as marking a dividing line between older and newer series of lavas Mr. Wentworth will subject the specimens to microscopic investigation and also make comparisons in the field of the relationships of these deposits to the surrounding rocks in the different districts of Hawaii where they are found. It is hoped in this way to determine the meaning of an important dividing line in the volcanic stratigraphy of Hawaii.

Dr. John B Stone now with the Cerro de Pazco Copper Corporation in Oroya, Peru, has been appointed Research Fellow of the Association to make an exploration and report in Chile during the winter months of 1929-30. The investigation has in view a study of the volcanoes on the west side of the central valley of Chile with especial reference to the beautiful cone of Osorno and the recently active volcano Calbuco on Lake Llanquihue. Dr. Stone will make a volcanological reconnaissance of the region with the special object of securing photographs and specimens and of bringing the Hawaiian Volcano Observatory in closer touch with the volcanologic work of Chile. This country is little known, but is important because of its many earthquakes and numerous volcanic vents.

Dr. Stone and Professor Wentworth have both done geological work in Hawaii in the past. Dr. Stone investigated the products and structure of Kilauea during the summer and autumn of 1925 under a Bishop Museum fellowship awarded by Yale University (Bulletin 33, Bernice P. Bishop Museum, 1926.) Mr. Wentworth was Bishop Museum Fellow 1923-24 investigating the sediments of the Pacific islands and published studies of the geology of Lanai and the pyroclastic geology of Oahu (Bulletins 24 and 30, Bernice P. Bishop Museum, 1925 and 1926.) T.A.J.

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No. 236 RELEASED WITHOUT COPYRIGHT RESTRICTION July 4, 1929

KILAUEA REPORT No. 910

WEEK ENDING JULY 3, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

The Kilauea lava pit has remained quiet throughout the past week. At 9 a. m. June 29 a compact cloud of dust from an avalanche rose near the northeast rim. Because of its whiteness, the dust at first had the appearance of a cloud of steam. At 10 a. m. July 1 Halemaumau was so densely obscured in rain and fog that observations were impossible. All was quiet and no sounds were heard. A light dust cloud from a small slide was seen at 2:30 p. m. from near the Halemaumau seismograph station on the Kilauea floor.

Eight very feeble local earthquakes were registered on the Bosch-Omori seismographs at the Observatory. One of these, registered at 5:14 a. m. June 28, had an indicated distance to origin of 17.3 miles. In addition is the feeble record of a distant shock, beginning at 2:36:53 a. m. June 27.

Microseismic motion continued to be very slight, although a little stronger near the close of the week. Tilt accumulated slight to the WSW.

LASSEN REPORT No. 18

Lassen Volcano Observatory, Mineral, Calif.,

R. H. Finch in Charge

HOT SPRINGS OF THE COAST RANGES

The following table shows the result of hot springs measurements together with the Waring (G. A. Waring, Water-supply Paper 338, U. S. Geological Survey) data for comparison. (See Volcano Letter Nos. 120, 135, 136.)

Location	Temperature	1927	Waring Data
Calistoga:			
Throat of Plummer's Geyser	218(F.)	Mar. 22	
Pool at Plummer's Geyser	143	Highest of	
Pacheteaus, side of capped		natural vents,	
geyser	213.5		173
Well back of Calistoga Hotel	143		
Harbin Hot Springs:			
Entrance of bricked-in pool	119	Mar. 26	122
Anderson Hot Spring:			
(Practically abandoned as a resort.) Highest temperature found in a board-covered spring on east side of hot spring canyon	116	Mar. 26	146
Castle Springs:			
In storage tank a little way from intake	152	Mar. 26	164
Seigler Springs:			
Magnesia	61	Mar. 27	72
Arsenic	96		90
Hot Iron	106		100
Sulphur	106		
Near Sulphur	118		119
do	125		126
Howard Springs:			
Borax	91	Mar. 26	95
Iron sulphur	110		110
Magnesia	108		102
Iron soda	88		
Excelsior lithia	72		
Sulphur Bask:			
Pool in old shaft near road	106	Mar. 27	120
Highland Springs:			
(Appeared to be abandoned.)			
Magic Bath	78	Mar. 28	
Diana Spring	78		80
Skagg Springs:			
Upper	132	Mar. 28	120
Middle	120		122
Lower	128		135

The average rainfall for the area in which the above springs are located is 48 inches, though the amount varies greatly from year to year.

The most recent volcanic activity in this section of the Coast Ranges took place at the Sulphur Banks, to the east of Mt. Konocti. Becker thought it might have occurred within the last 1,000 years, and mentioned Indian tradition of activity at Sulphur Bank. Judging from erosion, Mt. Konocti may have had its last activity much more than 1,000 years ago. The remnant of a crater is still discernible, however, on the south peak of Mt. Konocti. In the hills to the east of the Sulphur Bank there is a fairly well preserved crater. As one goes south from Clear Lake there appears to be a progressive increase in the ages of the last lava flow that capped a good deal of the country. There is, however, a well preserved crater above the Petrified Forest to the west of Calistoga. Considerable volcanic ash is found in its vicinity that has been faulted since its deposition.

The rock mass of the Coast Ranges in this vicinity has been greatly faulted, folded, and crushed, with the main faults trending northwest-southeast, the direction of the main valleys. Folds in the rock appear to be better preserved in the region to the southwest of Clear Lake than farther south.

From the summit of St. Helena, Napa Valley might once have extended much farther north, and drainage from the north was interrupted by lava flows from a small cone to the southwest of Mt. St. Helena. There appears to have been another interruption a little farther north caused by lava flows or upheaval. Above the Palisade Mine there is well preserved evidence of a fissure eruption. Judging from the numerous faults and the recentness of the last activity, it is surprising that this section of the Coast Range has so few earthquakes.

R.H.F.

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No. 237 RELEASED WITHOUT COPYRIGHT RESTRICTION July 11, 1929

KILAUEA REPORT No. 911

WEEK ENDING JULY 10, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

No noteworthy changes have taken place at Halemaumau. On Sunday, July 7, avalanches occurred, one about 12:30 p. m. filling the entire interior of the pit with dust. There were other slides later in the afternoon.

Observations on July 8 showed that the top fourth of the north talus was covered with fresh material. The north wall appeared to be the only site of avalanching.

On July 10 thick steam was rising out of the fire pit during the forenoon after several hours of good rain. Prior to this there had been a long dry period at Kilauea. At 3 p. m. it was noted that there were many very active steam jets in the Halemaumau bottom, making an interesting sight as they projected straight upward. A southerly rainstorm was in progress.

During the week there were registered on the seismographs 28 very feeble local shocks, one feeble earthquake at 11:04 p. m. July 9 with an indicated distance to origin of 23 miles, and three teleseisms. This is the greatest number of earthquakes registered in one week since the week ending November 28, 1928, when 30 very feeble local shocks were recorded.

Two of the teleseisms occurred on July 5, one at 3:57 a. m. and the other just after 4:08 p. m. They were not well enough recorded to distinguish phases. The third teleseism began at 11:01:06 a. m. July 7. A preliminary determination of distance to epicenter is 7,480 kilometers from Kilauea.

Tilt for the week was moderately south-southwest. Microseismic motion was very slight.

LASSEN REPORT No. 19

Lassen Volcano Observatory, Mineral, California,
R. H. Finch in Charge

Lava Flows

There are several post-glacial lava flows in the vicinity of Lassen Peak in addition to the three at Cinder Cone and the small one that started through the western gap of Lassen Crater in 1915. There is a series of flows along a north-south line extending south from Tamarack Peak.

Another fresh-looking flow had its origin between the two Prospect peaks. Another flow originates near the northeastern corner of the park east of Cinder Cone. The above flows were not very fluid and consist of broken blocks. A typical basalt flow that was quite fluid extends for miles in Hat Creek valley just below the Hat Creek fault scarp. It contains a great many lava tubes. About 15 miles to the east-southeast of Mineral there is a flow that contains both aa and pahoehoe and formed lava tubes.

Lassen Peak

An ascent of Lassen Peak was made on August 5-6, 1927, supplies being carried on a pack animal. Camp was made inside the main crater about 30 feet below the western rim, above and to the west of the lake in the crater. Rock falls from different walls were frequent. By 7 p. m. ice was forming over the lake, though at the camp, about 50 feet above the lake, the lowest temperature during the night was 46° F., and on the crater rim the temperature was still higher. Steam cracks afforded an easy method of heating food. Lassen Peak may be thought of as being composed of three lobes.

When the doming pressure incident to the 1914-15 activity became sufficiently great, the north lobe cracked away slightly from the other two and opened an east-west crack that probably was very superficial. From the gaps that already existed in the crater wall, it seems that the cracking was along an old break. A massive layer with scars shows that material broke off from it both into the crater and down the outer slope. The layer was in the same plastic condition when it was deposited as was the incipient flow that went through the eastern and western gaps. The flow through the eastern gap was blown or slid on down the mountain side while that through the western gap is still in place.

The flows had probably just started when the explosion blew away the source material. Mud deposits in the Lost Creek Valley indicate that there have been one or more explosions and mud flows from Lassen within the last 500 years. The 500-year limit was obtained from the conditions of preservation of tree trunks buried in the mud flow and recently unearthed by stream erosion.

Dacite pumice in the ash material of the 1915 eruption was scattered over a wedge-shaped area extending from Bumpass Hell nearly to Chaos Crags and from the Peak itself for 12 miles to Butte Lake on the northeast. Just to the north of Hat Mountain, near the center of the area, the ground appears to have been covered with the pumice. Great quantities of this pumice are to be found on the summit of East Prospect Peak, the rock of which is basalt.

Glass Mountain

Following several newspaper accounts of Forest Service officials discovering activity at Glass Mountain, which lies about 70 miles north of Lassen, and after telephone conversation with a Forest Service supervisor familiar with that country, it seemed advisable to investigate the acitivity. Accompanied by G. L. Collins of the National Park Service, an attempt was made to photograph and take temperature measurements at the scene of activity, but we were forced to go back on account of heavy snow. Contact was made with G. L. Courtright, of Dry Lake, about 12 miles east-northeast of Glass Mountain, and from him was obtained an account of an explosion on Glass Mountain in 1910. (Volcano Letter No. 144, 1928.) From other people was obtained an account of a small lake that had formerly existed on the mountain. Mr. Courtright said that he is now unable to find this lake. An explosion under the lake could account for the mud reported on vegetation after the explosion, as well as for the disappearance of the lake. R.H.F.

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No. 238 **RELEASED WITHOUT COPYRIGHT RESTRICTION** July 18, 1929

KILAUEA REPORT No. 912

WEEK ENDING JULY 17, 1929

Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

There appear to have been no volcanic changes at Halemaumau throughout the past week. No slides have been noticed, nor are there signs indicating that stripping of the walls has occurred.

On July 13 a semicircle of moisture was noted at the top of the big west talus. This was like an arch just under the uppermost point of the talus which as a whole is shaped like an inverted V. The effect is as though a crescent-shaped crack marks a deep break in the talus cone. The crack emits some vapor, and there are steaming spots in the middle of the talus below. The south talus shows a linear up-and-down fissure steaming at its top.

A slight increase of steam at the center of the west talus was observed at 3 p. m. July 17.

A total of 18 local earthquakes was registered by the instruments at the Observatory during the week. Two of these were felt locally, one on July 10 at 1:27 p. m. and the other July 15 at 10:02 a. m. The felt shock of July 10 had an indicated distance to origin of 10 miles; that of July 15 had no distinguishable phases on account of being immediately preceded by the waning tremor of a very feeble earthquake. There was continuous tremor July 17 from 5:14 to 5:16 a. m.

Tilt accumulated moderately strong SSE. Microseismic motion was extremely slight.

LASSEN REPORT No. 20

Lassen Volcano Observatory, Mineral, California
R. H. Finch, In Charge

The following measurements refer to landslipping in progress at Supan's steam holes, Lassen National Park, and to temperatures at various hot springs. (Compare Day and Allen, 1925, Volcanic Activity of Lassen Peak, Carnegie Institution.)

The line of stakes across new cracks that was placed 50 feet apart in November, 1927, parallel with the valley containing the sulphur works was retaped on July 27, 1928. The following table shows that there was downhill slipping in the upper part of the 1,00-foot line that was practically compensated by over-riding lower down.

	Stake Intervals	New Measurement	Change
	0— 1	50.1 feet	+0.1
	0— 2	100.1 "	+0.1
	2— 3	51.4 "	+1.4
	3— 4	51.3 "	+1.3
	4— 5	50.0 "	0.0
	5— 6	49.4 "	—0.6
	6— 7	49.6 "	—0.4
	7— 8	49.8 "	—0.2
	8— 9	49.8 "	—0.2
	9—11	99.5 "	—0.5
(Note: †10 moved)	10—11	49.9 "	—0.1
	11—12	50.2 "	+0.2
	12—13	49.6 "	—0.4
	13—14	49.9 "	—0.1
	14—15	49.9 "	—0.1
	15—16	49.8 "	—0.2
	16—17	49.9 "	—0.1
	17—18	50.0 "	0.0
	18—19	50.0 "	0.0
	19—20	†20 moved	

The line was extended 300 feet and three lines run across the valley by transit: one at the upper end of the stake-line, one near the middle, and one at the lower end.

Temperatures of Hot Springs

Supan's.

The highest temperature found at the "Big Steamer" at Supan's solfatara on July 28, 1928 was 240°. The same vent on September 5, the driest part of the season, was but 235°. As the temperature of such hot springs varies inversely as the amount of water discharged, the slight cooling of the spring was contrary to what was expected.

Morgan Hot Springs, August 7, 1928.

No.		Fahr.	No.		Fahr.
1		177	12	muddy water	188
3	middle pool	185		mud	172
	lower "	196		clear water	195
			14		178
4	north "	190	17		201
	middle "	168	19		144
	south "	176	20		200
5		172	Between 12 and 14		
6		176	in black earth		160
7		196	23		192
8		156	24		198
9		106	Geyser		200

Live, wiggling larvae in mud algae at No. 3 with temperature of 120°. When temperature was 140° the larvae was dead.

Boiling Lake, August 11, 1928.

Water north end of lake	130 Fahr.
Mudpot north end of lake	198
Milky pool southwest edge of lake	192
Site of Cornpopper, south end of pool	204

(The ground at this site sank several feet since the fall of 1927.)

Devil's Kitchen.

Bluish-gray pool of water near northwest end	171 Fahr.
Deep pool just above one with stream flowing through it near upper end of "kitchen"	195
Splashing pool upper north side	169
Yellow pool northwest end	189
Pool in rock southwest edge	198
Small splashing vent southwest	199
Large splashing pool southwest	199

Bumpass Hell, September 5, 1928.

No. 8		194 Fahr.
9	mud pot	194
10	pool	174
11	steam vent	192
13	" "	194
14	east side	190
16		194
17		195
Several small vents depositing sulphur crystals		195

The highest temperature observed at Bumpass Hell in 1928 was considerably lower than the highest for 1927.

R.H.F.

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No. 239 **RELEASED WITHOUT COPYRIGHT RESTRICTION** July 25, 1929

KILAUEA REPORT No. 913

WEEK ENDING JULY 25, 1929

Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

A quiet flow of lava broke out in the bottom of Halemaumau about 6 a. m. today. The flow at first was from two fountains loudly splashing just above the lower edge of the big west talus. About 8 a. m., before the new lava had covered the floor formed last February, a crack opened athwart its center with much gasrushings, releasing a line of fountains in direction approximately northeast-southwest. The fountains are about 200 feet high.

The eruption is one of a series of minor, short-lived flows characteristic of this period of cyclical events at Kilauea. It can not be stated how long the flow will continue, though at the present time it is strong.

The last activity in Halemaumau occurred on February 20 and 21, 1929. It filled the bowl-shaped bottom of the pit with lava to a depth of about 60 feet, forming a floor a little less than 1,200 feet below the rim. Few changes occurred at the volcano since that time. No great avalanches took place that might denote a great subsidence of the lava column, and it was therefore thought that magma lay not far below the surface of the volcano edifice, and another eruption during 1929 was accordingly considered possible.

The usual harmonic tremor indicative of flowing lava is registering on the seismographs at the Observatory. This began to be somewhat steady at 6:46 a. m. Beginning at 8 p. m. July 24 there were spells of tremor fairly regularly every 16 seconds and lasting nearly an hour.

The earthquakes for the week ending July 24 at 8 p. m. total 19. These were all of very feeble intensity and not large enough to be felt. At numerous times throughout July 21 the seismographs registered short spells of microscopic tremor. The seismograph on the crater floor near Halemaumau did not record this tremor, however.

Tilt accumulated moderately NNE. Microseismic motion remains very slight.

VESUVIUS IN JUNE 1929

The following is quoted from Nature, June 15, 1929, showing that Vesuvius has recovered from its 1906 engulfment to the stage where it makes external lava flows:

"After the great paroxysmal eruption of Vesuvius in 1906 there followed seven years of obstruction and comparative repose. In 1913 the conduit became open and the normal type of external activity began. Since then the crater has been steadily filling from a succession of central conelets, and at intervals in recent years there have been minor crescendos of explosive and effusive activity. By far the greatest and most spectacular of these broke out in the early hours of June 3. The outburst began with tremendous explosions and the hurling into the air of masses of incandescent material. The central conelet split and collapsed. As it fell back into the crater lava welled out and occupied the northeastern quadrant of the crater. (This was the lowest lip left in 1906. T.A.J.) Professor Malladra announced on June 3 that he considered the eruption to be one of the periodic recrudescences of activity; that it was unlikely to last more than two or three days; and that a disastrous eruption of the culminating type—such as those of 1872 and 1906—was not yet to be expected.

"On the morning of June 4 it became clear that for a minor eruption the manifestations were more than usually violent. The interior of the crater now became a lake of effervescing lava some 500 yards in diameter. The lava overflowed into the Valle dell Inferno and escaped down the outer slopes into the valley of Cuppaccio and towards the little town of Terzigno, following the course of the 1834 lava stream. After a short interval of quiescence from 2:30 to 7:30 p. m. there was a sudden paroxysm of activity for three-quarters of an hour. Incandescent matter rose 1,500 feet above the crater and fell in glowing showers on the slopes of the volcano. Afterwards there were loud and frequent explosions, followed by an ash cloud that rose to still greater heights. From 11 p. m. on June 5 to 3 a. m. on June 6 there were further tremors and explosions, and columns of lava were thrown into the air to break into incandescent bombs. Since then there have been (at the moment of writing) no further reports of activity. The lava stream has extended five miles down the southeastern slopes, widening to a frontage of 900 yards, destroying 110 acres of cultivated land and wiping out three small hamlets. Although Terzigno was evacuated with the prompt aid of the military, the township itself has fortunately been spared, the lava having halted 300-400 yards from the houses. It is estimated by Professor Malladra that the volume of lava approaches half that emitted during the 1906 eruption." T.A.J.

THE NEW ZEALAND EARTHQUAKES OF JUNE 1929

On Hogben's map (Geography of New Zealand, p. 243, by P. Marshall, Christchurch, Whitcombe and Tombs) of larger New Zealand earthquakes, eight principal shocks appear in the middle belt between the north and south islands, only two in the northern region of active volcanoes, and four in the southern mountains and fjords. The Wellington earthquake of 1855 elevated the shoreline. Now comes a series of disastrous shocks in the north mountains of the south island, the region extending southwest from Nelson, with the worst damage at Murchison, which was virtually destroyed.

The new series began on June 17 in the Buller Gorge, but within three months there had been another serious earthquake with many landslides in the Otira Gorge. These are sites of two of the south island's famous roadways. The new crash occurred all along the route between Greymouth and Westport, on the west coast of the north end of the South Island, and the north coast at Nelson, seat of a college. The college, a large masonry building, was wrecked. The roads were split open in huge crevasses, landslides wrecked quarries, railways, and homesteads, some peole were killed and wounded, even frame houses were lurched and collapsed, communications were destroyed, roads disappeared, bridges collapsed, and railway tracks were warped, twisted, and destroyed. (Auckland Weekly News, June 26, 1929.) All the chimneys came down, telephone poles fell over, and trains were derailed. Valleys were blocked and lakes formed. People were thrown off their feet. The time of the major shock was about 10:25 a. m. local time June 17.

Riverview Observatory at Sydney calculated the epicenter 100 miles east of the South Island, but the Wellington seismograph station did not agree to this: field evidence indicated an epicenter in the mountains. Messrs. Ferrar and Grange of the Geological Survey of New Zealand are investigating the movement, which is believed to be a fault displacement. T.A.J.

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No. 240 **RELEASED WITHOUT COPYRIGHT RESTRICTION** August 1, 1929

KILAUEA REPORT No. 914

WEEK ENDING JULY 31, 1929

Section of Volcanology, U. S. Geological Survey
H. A. Powers, Temporarily in Charge

The lava activity reported last week as beginning about 6 a. m. July 25 continued until 7:42 p. m. July 28, when all fountaining ceased. The lake formed during the flow reached a maximum depth of 94 feet in the center of Halemaumau, and nearly buried the south cone of 1927 which was well up the talus slope prior to the eruptions of 1929.

Following the cessation of flow there was still some activity in the lake as the sluggish liquid continued to seek its level, but cooling of the crust was rapid. The crust settled, and the cracking noises of this process can still occasionally be heard. There is glow at night from numerous scattered points. No avalanching has followed the eruption.

Seventeen very feeble local earthquakes were registered by the instruments at the Observatory. In addition was the harmonic tremor accompanying the lava activity. This tremor was continuous after 6:32 a. m. July 25, although the fume was first noticed at about 6:10 a. m. The tremor waxed and waned at times, but grew stronger on July 27. Fountain action was also stronger. About 7 p. m. July 28 the tremor weakened and after 7:11 p. m. it was unsteady. It ended entirely at 7:42 p. m., when the fountains also went out of action.

There was moderate WNW. tilt during the two days preceding the eruption, slight SSE. tilt during the flow of lava and until July 29, and very slight WSW. tilt for the next two days. The net accumulation of tilt for the week was moderate to the south. Microseismic motion is still very slight.

HALEMAUMAU OUTBREAK JULY 25-28, 1929

Halemaumau has again been the scene of volcanic activity. The eruption began on the morning of July 25 and continued until the evening of July 28. It was one of a series of short-lived, quiet rises of magma which has characterized the present cycle of activity in Kilauea. The lava column attained a maximum height in the pit of 2,640 feet above sea level, a gain over the fill of February 20-21, this year, of 94 feet.

The first indication of the renewal of activity was a series of very small earthquakes a few minutes apart beginning at 4:35 a. m., each accompanied by a slight tilt to the east. The shocks and the tilt made only a slight record on the north-south component of the instrument. They were followed by spasmodic tremor, caused by fountain action, which became stronger and continuous after 6:30 a. m. and lasted so throughout the eruption.

The first observed activity was a cloud of smoke noticed by the machinist of the Observatory at 6:10 a. m. At 6:40 a. m. two fountains of lava were spurting from vents above the lower edge of the middle of the large western talus bank. A high column of blue smoke, pungent with the odor of sulphur dioxide, rose continuously from the fountains, and occasionally spurts of brown sulphur fumes were mixed with the smoke. By 7 a. m. a moisture cumulus had gathered over the pit.

The fountains strengthened rapidly so that by 7:20 a. m. they were throwing pumice and bombs at least 200 feet in the air, and two-thirds of the old floor was covered with new lava.

At 7:45 a. m. steady blasts, sounding like gas rushing through small orifices, were audible above the pounding of the lava fountains. These increased until, at 8 a. m., several small lava fountains, yielding brown fumes and apparently flaming, broke through cracks at the eastern edge of the old floor. Simultaneously, the western fountains lowered slightly, though their fuming increased. A little later the rapidly foundering old floor west of the new fountains was split by a large crack. By 10:20 a. m. it was covered by a lava lake, but its position was marked by a linear fountain, most active at its eastern end.

The filling continued steadily until, at 12:45 p. m., the old floor was nearly covered by a lake 25 feet deep over its lowest points. Fountaining continued with increasing vigor in the western and central areas, but the gas blasting had ceased. Blue smoke still issued from the fountains, but little brown fume was in evidence. About this time two phenomena became evident which, with the fountaining, characterized the remainder of the activity, namely, the cracking and foundering of the surface crust, and the pouring of cascades over ramparts built up near the margins of the lake.

The western fountains gradually strengthened at the expense of the central fountains until, at 6 p. m., 12 hours after the start of activity, spouting was confined to the western marginal fountains. These remained constant and strong (throwing material 300 feet high) until the morning of the fourth day, July 28. During this day the vigor showed periodic increase and decline. About 4:30 p. m. fountaining ceased entirely for 15 minutes, then increased suddenly to nearly the former vigor. Spouting continued with constant force until about 7 p. m., then gradually decreased until it stopped completely at 7:42 p. m.

The influx of lava continued constantly during the life of the fountains. The margins of the lake were extended during the rise by cascading over the marginal ramparts. Tilting of the bench lava beneath the lake, and convection currents in the lake influenced the advancing of the lake margins in such a manner that cascading and spreading was strong first on one side of the lake and then on the other.

During the first 24 hours the lava rose 44 feet above the level of the old floor. At the end of 48 hours the depth had increased to 77 feet, and on the morning of the fourth day, Sunday July 28, the pit had been filled 88 feet. The maximum elevation of the lake surface, reached July 28 after 85 hours of flowing, was 2,640 feet above sea level, 94 feet above the old floor.

The lake, shaped somewhat like an ivy leaf with the broad stem lying toward the southwest, has a maximum width of 1,700 feet and a length of 2,100 feet. Its area is approximately 50 acres.

Soon after the cessation of activity, withdrawal of the supply of molten lava and some shrinkage accompanying crystallization of the crust permitted the surface of the middle of the lake to settle. A survey of the pit made the next day shows that the existing floor has an elevation above sea level of 2,600 feet. This central floor is bounded by in-facing fault scarps from 20 to 30 feet high. The narrow lake margin, between these scarps and the walls of the pit, varies in elevation from 2,615 to 2,630 feet. From these data it has been estimated that approximately eight million tons of rock have been left in the bottom of Halemaumau by this eruption. H.A.P.

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No. 241 RELEASED WITHOUT COPYRIGHT RESTRICTION August 8, 1929

KILAUEA REPORT No. 915

WEEK ENDING AUGUST 7, 1929

Section of Volcanology, U. S. Geological Survey

H. A. Powers, Temporarily in Charge

There has been no renewal of volcanic activity at Kilauea. Appearances at the fire pit indicate that there will be several weeks of quietude before another flow of lava occurs. A few slides have fallen north and east, but otherwise Halemaumau remains unchanged.

Recent measurements of the east rim cracks show no significant changes over the measurements of May 15, the largest amount of movement being 0.135 foot.

A substantial increase in the number of earthquakes during the past week may mean slight subsidence of the invisible lava column. Twenty-seven very feeble local shocks were registered at the Observatory. In addition there was a two-minute period of microtremor 5:14-5:15 a. m. August 7; also two felt earthquakes, one at 10:43 p. m. August 5 and the other at 2:42 a. m. August 7. The distance to origin of the former can not be determined because the preliminary phase was destroyed by the minute mark; the latter shock originated about nine miles from the Observatory.

Microseismic motion was slight throughout the week except for a temporary feeble increase early August 2. The accumulation of tilt was slight to the NNE.

FOURTH PACIFIC SCIENCE CONGRESS

Mr. R. H. Finch, Associate Volcanologist in charge of Lassen Volcano Observatory in California, was delegated by the United States Geological Survey to attend the Fourth Pacific Science Congress as representing the Section of Volcanology of the Survey. In this journey he received assistance also from the Hawaiian Volcano Research Association as their delegate.

Mr. Finch reports that Dr. Maclawin of New Zealand represented the New Zealand Government so as to be able to give advice on extending the observations on New Zealand volcanoes. At a Japanese dinner in Singapore Mr. Finch met Dr. H. Tanakadate, volcanologist of Sendai University. The return trip from Java May 31 was on a Japanese freighter passing by Borneo and Celebes, and through the Sulu Archipelago and Sulu Sea. Most of the large islands of the Philippines was seen, as well as the southeast side of Luzon. A small fume cloud was observed over Mayon. Dr. Kozu from Sendai, and S. Kunitomi, seismologist of the Central Meteorological Observatory of Tokyo, were passengers. The program of papers at the Congress was serious and of sustained high quality. Mr. Finch feels that he benefitted much by his contacts at the Congress. He reports:

"The opening meeting of the Fourth Pacific Science Congress was held in Batavia, Java, on May 16, 1929. The Congress then moved to Bandoeng, Java, where in the delightful climate appropriate to an elevation of 2,000 feet the scientific sessions of the Congress were held from May 18 to May 24.

"The Congress was organized under the supervision of the General President, Dr. O. De Vries and Dr. H. J. Lam, General Secretary. About 250 foreign delegates were present, as well as a strong delegation from the Dutch East Indies. The delegates came from 24 different countries, with South American countries and Mexico not represented.

"One of the most interesting excursions prior to the opening of the Congress was to the volcano Krakatau. With the steamer 'Rumphius' provided by the Royal Packet Navigation Company (K.P.M.), excellent views were obtained of the three older islands of the Krakatau group. Landings were made on these islands, as well as on Anak Krakatau (Baby Krakatau), the island that was formed by explosions early in 1929. Exhibitions of native dances and native industries of the principal tribal groups of the Dutch East Indies were other outstanding features of the entertainment provided before the Congress opened. Both foot and airplane trips were made during the session of the Congress to Tangkoeban Prahoe volcano. After the Congress adjourned on May 25, there were excursions until June 4, many of which were to active volcanoes.

"For the most part papers were not presented before the Congress by the authors themselves. Papers on closely related topics were grouped and reviewed by one person. The time saved by this method was devoted to open discussion. Printed abstracts of most of the papers were available before they came up for review and discussion. The papers will be printed in full in the proceedings of the Congress.

"There were four sectional meetings under the head of volcanology. Many questions of interest to volcanologists were discussed in the sections of seismology and petrology. Of especial interest under seismology was the evidence offered on the occurrence of earthquakes with a focal depth of from 180-240 miles. The papers of Dr. Kozu on the influence of temperature upon the volume of granite and some lavas given under petrology proved of great interest to volcanologists.

"The invitation of Canada to hold the next Congress in Vancouver, B. C., in 1932, was accepted." R.H.F.

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No. 242 | RELEASED WITHOUT COPYRIGHT RESTRICTION | August 15, 1929

KILAUEA REPORT No. 916

WEEK ENDING AUGUST 14, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Dust from slides in Halemaumau was seen at various times during the forenoon of August 8, possibly caused by persons dropping rocks.

On August 11 it was noted that slumping since the July eruption leaves a terraced fault bank high along the west side where the deeper conduit was. The deeper withdrawal occurred there, and the deepest part of the slump appears to be at the northwest in the floor surface. There is little change of the east side of the bottom. Twenty or more hummocks are at the west. One of these is open and round like a tree mold, and stands up like a huge pipe 20 feet across. There are avalanche rocks on the steep down-faulted terrace at the edge of the floor under the northwest talus.

Blue smoke continues to come from the east rampart, and there is the usual steam from vents in the west and south taluses.

Earthquakes for the week number 28. None was felt, all being of very feeble intensity. Two of the shocks were of the continuous tremor type, one occurring 12:45 - 12:47 p. m. August 7 and the other 10:43 - 10:53 p. m. August 10.

Tilt accumulated slight to the NW. Microseismic motion was slight, with a little strengthening on August 10.

VOLCANIC LIGHT, HEAT AND POWER

In view of the possibility of warming the rooms of the hotel at Kilauea Volcano by natural steam with the aid of a hot water radiator system, it is of interest to learn what has been done in other places. At Kilauea the four bore-holes at Sulphur Bank close to the hotel yield constantly great quantities of steam at 96° C. If this were passed through a tubular boiler containing the water circulation for the hotel radiators, with the pipe properly insulated, every room might contain an adjustable heater filled with pure water from the tanks. There would thus be no waste of water. The slight corrosive effect of the acid steam would be met by building the boiler of a suitable resistant metal. The hot water system would be a great comfort to many guests in cold, rainy weather and by drying the building would act as a preservative against mildew.

Even in ancient times it was the dream of mankind to utilize volcanic heat. This does not mean harnessing the eruptions of volcanoes, but rather making use of the fumaroles and boiling springs generally found in volcanic districts. For many years the steam of fumaroles has been used in Iceland for the heating of schools and other public buildings. In Japan there is a village heated in winter with the aid of volcanic steam led into the buildings. Most of this is the steam of ground water brought to the boiling point through the agency of underground magma or of volcanic gases. The latter are dominantly hydrogen, carbon, chlorine, and sulphur, and their compounds through union with oxygen of the air.

Even farmers have made use of volcanic energy to assist them in agriculture. On the island Ischia, near Naples, the peasants make use of numerous fumaroles to warm their tomato plants and so make them sprout sooner. On the bottom of the extinct Agnano Crater a gardener found the volcanic heat useful in order to keep his vegetable crop producing all the year around by distributing his sowing and his harvesting in accordance with an irrigation system dependent on hot springs. Recently a company has been formed that makes use of volcanic steam for the warming of hot houses where useful plants are produced.

It is well known that in many places in Iceland, North America, the tropics, and New Zealand hot springs are used as laundries, and of course they have been used from time immemorial as baths beneficial in certain diseases.

Near Lardarello in Tuscany boric acid has been produced from scalding natural steam for more than a century. Prince Ginori Conti began there in 1904 to operate a small steam engine by curbing a natural steam vent. Further development of the steam power was hampered by the low pressure and temperature of the surface steam and the rapid eating away of the metal by the acid vapor.

In order to obtain higher pressures and temperatures, bore-holes were drilled which yielded a rush of steam at 190° C. and 14 atmospheres of pressure. There was finally obtained at Lardarello from several bore-holes 250,000 kgs. of steam per hour averaging two atmospheres of pressure and a temperature from 120° to 190° C.

In order to avoid the corrosion of expensive machinery, the high-pressure natural vapors were condensed under pressure, the fixed gases were assembled and conserved as by-products, and pure water was heated above the boiling point in a low pressure boiler so as to make steam, utilized by expanding it in low pressure turbines.

At Castel Nuovo a well 130 meters deep operates three turbo-generators of 2,000 kilowatts capacity. At present the plant yields some 12,000 kilowatts and no exhaustion of the resources of the ground has yet appeared.

In Java experiments at Kawah Kamodjang Crater with a bore-hole 128 meters deep yields a volume of steam at six atmospheres pressure estimated capable of producing 900 kw. At the Geysers in the St. Helena Range in California a great store of hot steam has been revealed by drilling, and this increases with depth. Borings for power have been made here discovering temperatures from 99° to 173° C. and pressures from 60 to 169 pounds. The wells vary in depth from 154 to 636 feet. Both temperature and pressure increases with depth. These wells also have been harnessed for power. The geological conditions indicate that the region overlies intrusive volcanic magma. (Volcanoes which heat Towns, by Dr. L. Steinberg, Weser Zeitung April 26, 1929, Bremen. Steam Wells at the Geysers, California, by E. T. Allen and A. L. Day, Carnegie Institution Publication No. 378, 1927.) T.A.J.

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No. 243 **RELEASED WITHOUT COPYRIGHT RESTRICTION** August 22, 1929

KILAUEA REPORT No. 917

WEEK ENDING AUGUST 21, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

A slide was reported at the north wall of Halemaumau about 3 p. m. August 16, and the next morning a fresh scar was observed there. Notably little visible steam appears about the new lava floor. A small crack at the east edge of the floor yields blue fume, and on August 17, at 9:45 a. m. the upper edge of the northern grotto niche at the west side of the floor began to yield blue smoke. This was very slight and diminished on succeeding days. The talus slopes make a little vapor visible on cool, moist days.

Nineteen very feeble earthquakes were registered at Kilauea and one feebly perceptible shock at 12:38 p. m. August 14. This had indicated distance to origin of 30 miles. Microseismic motion increased slightly during the nights of August 15-16 and August 19-20.

Tilt accumulated moderately NNE.

THE RISING LAVA IN HALEMAUMAU

The three short-lived eruptions which have occurred in the inner pit Halemaumau since 1925 have brought into the bottom of the pit a total of 8,692,000 cubic yards of solidified lava and have filled the bottom to a depth of 210 feet. Expressed in terms of the old Halemaumau which was overflowing in 1921, and was a much smaller shaft, this volume of lava would have meant in the old pit a rise of level of 350 feet.

Because of the fact that the dimensions of the pit have been increasing owing to the breakdown of the walls, and also because the bottom has been changing, it has been necessary from time to time to revise the topographic map of the actual pit crater. By keeping this map up to date it has been possible to compute with fair accuracy the actual amount of lava added during each eruptive period.

Before the outbreak of July 7, 1927, the bottom of Halemaumau stood at an elevation of 2,390 feet above sea level. It was 1,260 feet below the observation station on the southeast rim. During the 1927 eruption the level of the lava rose to an average elevation of 2,500 feet above sea level, and the total area of the new surface was 30 acres. After making proper allowance for the slope of the containing walls, the volume of new lava was computed to be 85,430,000 cubic feet.

Heavy avalanching during the months following, and other avalanches at the time when an internal landslip in the pit in January, 1928, was accompanied by an upward squeezing of red hot lava, produced burial of much of the 1927 lava floor beneath debris from the walls.

A new eruption of lava came February 20, 1929, pouring its floods over 19 acres of the 1927 lava that still remained unburied by debris. During the 36 hours of activity, a lava lake was formed which had an average depth when frozen of 45 feet, a surface area of 40.5 acres, and a total volume of 51,900,000 cubic feet. The new floor thus formed had an elevation of 2,546 feet above sea level and was 1,104 feet below the rim at the observation station.

The last eruption which began on July 25, 1929, and continued for 85 hours built up the floor of Halemauamu to a point 1,050 feet below the observation station. The total volume of this lava of July, 1929, in the new floor is 97,350,000 cubic feet and the surface area is 54 acres.

The figures given for the volume of each flow represent only the actual amount of lava which remained in the pit after activity had ceased. In each case a great deal of the frothy liquid material extruded during the eruption was either withdrawn from the lake when the lava column sank into the earth at the end of the active period, or else contracted by loss of gas. During the eruption of July, 1929, the inflated lava lake at the time of maximum activity before any recession contained a total volume of 126,850,000 cubic feet of molten lava.

A tabulation of these data facilitates comparison:

	Depth	Area	Volume
July, 1927	110 ft.	30 acres	85 430,000 cu. ft.
Feb., 1929	45 "	40.5 "	51,900,000 " "
July, 1929	55 "	54 "	97,350,000 " "

H.A.P.

THE NEW CYCLE IN HALEMAUMAU

The above figures computed by Dr. Powers exhibit the facts of a true rising of the lava column of Kilauea since the explosive eruption of 1924. After that engulfment the funnelling talus had its lowest point 1,330 feet below the observation station. The depression of the bottom was diminished by 70 feet with the lava filling of July, 1924, by 110 feet with that of 1927, by 45 feet with that of February, 1929, and by 55 feet with the eruption of July, 1929. As the talus of the bottom opens out funnelwise at an angle of 30 degrees, the areas have increased and in general the volumes have increased. The duration of eruption in the two outbreaks of 1929 was less than in the outbreaks of 1924 and 1927, while the volume of inpouring per day was much greater. The 1924 eruption lasted 10 days and the 1927 eruption 13 days, while the two outbreaks of 1929 each stopped suddenly at the end of a day and a half and three days and a half, respectively.

The fountaining at the beginning of all these eruptions was of the Mauna Loa type, throwing up basaltic pumice. The fountains of 1924 were estimated to be 150 feet high, those of 1927 125 feet high, those of February, 1929, 200 feet high, and those of the last day of the July eruption, 1929, reached maxima of 300 feet at times. The 1927 eruption was estimated to pour out 50 per cent of its volume during the first hour, and something similar was true in 1924. Both these eruptions built up cones at single vents, whereas the two 1929 eruptions opened fissures at the floor margins, and the largest fountains left only niches. This history seems to indicate that the intensity of gas action and the freedom of flowing has increased in 1929, and at the same time the interval between outbreaks has decreased.

A platted curve of the rate of rising now in progress, with an average fill of about 70 feet for each eruption, and a diminishing interval between eruptions, should make the next inflow of lava take place some time between now and November, 1929. This expectancy might be interfered with if Mauna Loa should erupt, but that would be an equally satisfactory demonstration that the Hawaiian lava column is alive.

T.A.J.

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No. 244 RELEASED WITHOUT COPYRIGHT RESTRICTION August 29, 1929

KILAUEA REPORT No. 918

WEEK ENDING AUGUST 28, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

The pit Halemaumau at Kilauea Volcano has shown no movements of interest during the past week. A round convection cloud hung over the pit during the night August 23-24, gradually vanishing with forming and reforming as the sun's heat dried the air about 8 a. m. On August 25 at 2 p. m. the weather was rainy and this developed steam at hot places in the wall of the pit above the northeast and southwest taluses and on the talus slopes. Blue vapor rose from the crack at the niche at the western edge of the floor where the northernmost source fountain had been in July, 1929.

Sixteen very feeble earthquakes were registered at Kilauea, including several spells of spasmodic tremor August 21, mostly during the noon hour and possibly occasioned artificially. One slight perceptible shock occurred at 1:45 a. m. August 28 with origin not more than four miles from the station according to the seismographic evidence.

Microseismic motion was slight, with some increase August 21-22. Tilt to August 24 accumulated moderately SSW. Tilt measurement was temporarily interrupted thereafter by repairs to the seismograph basement.

MEASURED DEFORMATION FROM TOKYO EARTHQUAKE

Tanakadate calls attention to the fact that regional deformation by uplift, sinking, or sidewise motion of the land has only been measured in relation to earthquakes within the last 40 years. (Geomorphology of the Kwanto Earthquake in Japan—in Italian—by H. Simotomai Tanakadate, R. Accad. delle Sci. Fis. e Mat. Napoli, December 3, 1927.) This has been done for the San Francisco earthquake 1906 and, for the Japanese Empire, in the cases of the earthquake of Nobi 1891, of Omati 1918, Kagi in Formosa 1906, and the recent Tango earthquake.

After the great Kwanto earthquake of September 1, 1923, the Naval Institute of Hydrography measured the bottom of Sagami Bay in comparison with soundings of 12 years before, and found enormous changes. A belt extending SSE. from the central part of the bay had lowered from 110 to 210 meters, and a horseshoe of the bottom enclosing this on the northwest had been lifted or shallowed to a maximum of 250 meters. The maximum subsidences were, in a pocket near the head of the bay of 300 meters, and in the channel leading to Tokyo Bay of 400 meters. The biggest belt of sea bottom elevation trends northwest along the northeastern half of the bay, and the biggest belt of sea bottom depression trends out to sea from the southern half of the bay, interrupted by a belt of 100 meters of elevation, between the active volcano island Oshima and the mainland northwest of it.

In other words the belts of elevation and depression are along northwest-southeast axes alternating, with the southern elevation axis lying along the active volcano line Oshima-Fuji. Although the entire northeastern belt of elevation exhibits such positive uplifts as 100, 180, 230, and 250 meters, which cannot possibly be accounted for by the filling of bottom depressions by submarine landslip, the immediately adjacent shorelines rose only one or two meters. The same may be said of the Idu Peninsula on the opposite side of the bay, immediately adjacent to the undersea ridge raised 100 meters and undersea depression from 100 to 300 meters; this shoreline moved hardly at all. The bottom of the bay appears to be sharply differentiated mechanically from the solid rocks of the shore.

The area of the sea bottom region lowered was 700 square kilometers and the bulk displaced 50 cubic kilometers. The area of the sea bottom region elevated was 240 square kilometers and the bulk displaced 20 cubic kilometers.

Coming now to the shoreline, it was mostly elevated somewhat, at the instant of the earthquake, from the head of Tokyo Bay to the mouth of Sagami Bay. A region back in the interior, extending northeastward from Fuji Volcano, was slightly depressed. The axis bounding these two belts is northeast and southwest, or about at right angles to the Sagami Bay axis. Precise levels run by the Military Institute of Geography immediately after the earthquake discovered elevations of one or two meters or less at the southern end of the Boso Peninsula east of Sagami Bay, and at the extreme head of the bay near Kodu. The maximum uplift was at Hemuro Mountain 21 kilometers north of Kodu amounting to 2.65 meters. This maximum land uplift was a localized hump clear inside the Fuji belt of depression. The subsidences in this last belt were small, of the order of tens of centimeters.

The relative horizontal movements of bench marks relocated by precise triangulation in 1924-25, compared with the geodetic net of 1884-89 from base lines measured in 1882 and in 1924, reached a maximum on the volcano Oshima, of 3.78 meter, in a direction N. 8° E. In general the displacement is at a maximum around Sagami Bay of the order of one or two meters, and is north on the west side of the bay, eastward to the north of the bay, and southeastward to the northeast of the bay. This encircling movement diminishes in the interior country. The displacement at Oshima island is toward the bay.

The country has been shown to be broken up into small fault blocks and the two peninsulas where the maximum shore movements occurred consist of lithified tuffs of Tertiary age excessively dislocated from that time to the present, and much of this dislocation extends into broken shore terraces directly related to Quaternary and recent earthquakes. Tanakadate shows that by investigation of the tide gauge at the Miura Peninsula, nearest to the earthquake center, the shore had been gradually sinking about 10 centimeters in the last 23 years. Before that, on the authority of researches by scientists, and of a careful investigation of 150 fishing villages, the evidence shows that prior to the earthquake of 1923 there had been gradual lowering of the shore, and encroachment of the sea, of the order of three feet in 65 years. This applies especially to the two peninsulas. The evidence goes to show that in just such measure as the subsidence prior to the earthquake had been greater, so much the higher was the elevation or springing up of the ground at the moment of the earthquake.

A great earthquake in the same region in 1703 produced elevation of the Boso Peninsula and lifted dry land areas unknown before, said to have been from one to four kilometers wide, at different places along the shore. Accordingly it seems likely that from Tertiary time to the present this has been a region of "hereditary earthquakes," like southern Italy, where magmatic invasion brings about elevation, eruptions, and earthquakes. T.A.J.

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No. 245 RELEASED WITHOUT COPYRIGHT RESTRICTION September 5, 1929

KILAUEA REPORT No. 919

WEEK ENDING SEPTEMBER 4, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

On August 29 dust rose from Halemaumau pit at 1:30 p. m. in two small clouds separated by an interval of about one minute. At 12:05 p. m. August 30 a large dust cloud rose from the east side of the interior of the pit with protuberances projecting upward, an indication that a strong avalanche had occurred. The pinkish dust hung visibly over the pit for many minutes. The effects of this were seen at 10 a. m. August 31 in that the north side of the new lava floor was dusted by the outward projections from a big avalanche that had fallen from the north wall, and that corner of the pit was still sliding. There were some large stones on the north side of the floor. Much fresh rock was in evidence on the northeast talus. Above the northern niche at the edge of the floor west, blue smoke appeared as though puffing. Small patches of milky stain lay on the edge of the floor south and north-northwest.

Fifteen very feeble earthquakes were registered. The day records of August 30 and September 3 were interrupted by repairs. Microseismic motion was slight.

MURCHISON EARTHQUAKE, NEW ZEALAND

At 10:17 a. m. June 17, 1929 New Zealand time (11h. 30m. faster than Greenwich) a disastrous earthquake struck middle New Zealand with maximum damage in the Buller Gorge of the mountainous district of the north end of the South Island.

The shock was severe in Wellington, dismantling the Milne-Shaw seismographs. Aftershocks on these instruments indicated epicenters in the northern part of South Island. Murchison suffered the most damage. Landslips in precipitous country destroyed four homesteads and killed fourteen people. Numerous chimneys and two clock-towers were broken, many walls cracked, one badly built two-story house partially collapsed after the second severe quake; on these data the preliminary statement of the Geological Survey Office makes the intensity at Murchison R. F. VIII.

There was a severe aftershock June 23. This and the main earthquake appeared to center on the White Creek fault-plane that crosses the Buller River 7 miles west of Murchison. It was possibly a twin-earthquake with second centrum on the Kongahu fault-plane off NW coast of South Island. Many aftershocks occurred, some perhaps on other fault-planes. Differential movement of about 14 feet displacement was found at the White Creek fault. In 1928 this fault had been mapped for seven miles, but it is not known whether the displacement since was sudden or gradual, nor whether movement has yet ceased.

At Whitecliffs on the west coast a strip of sea-bottom was uplifted 100 feet, forming a ridge 180 feet wide by 4000 feet long, apparently the west side of a small fault-block tilted. Tilting of the land at Kelburn is suspected.

Dr. E. Marsden, Minister for Scientific and Industrial Research, called a conference of scientists June 26 on earthquake investigation, seismograms are being registered at Wellington and Christchurch, a seismograph and sound-ranging instruments were set up at Murchison, having in view study of focal depth of aftershocks, and the Milne seismograph was set up at Westport to locate aftershocks, and check time-curves of the permanent instruments. Questionnaires were broadcasted and geological investigations are in progress. The air Defense Service will photograph the faults from airplanes. Soundings were made off the west coast, and repeat observations in levelling and triangulation are in progress. Bench marks have been placed and occupied on each side of the active White Creek fault, which appears to have allowed movements of earth blocks to take place since the earthquake.

On request of Dr. Marsden drawings and specifications of the Jaggar shock-recorder were sent to Wellington from the Hawaiian Volcano Observatory June 29 and he writes that two of these have been constructed. It is planned to have some of these shock-recorders distributed about the country, and to have an additional major station with three-component seismograph in the middle of the North Island. A full report of the earthquake will be published later. (Circular of N. Z. Geol. Surv. "Murchison Earthquake Investigations" by H. T. Ferrar, Acting Director, 31 July, 1929 (mimeographed.)

New Zealand has an exceptionally good field for path-breaking in the study of the relation of local earthquakes to instrusive magma. There are cold springs, warm springs, hot springs and boiling springs; active volcanoes, inactive volcanoes and ancient volcanoes, mountain folds, live faults, dykes and batholiths. There is much Tertiary and Recent mountain uplift. There is an axis of gradation of these things from Samoa to the South Island, from Hawaiian type volcanism to Norwegian type fjords.

No one knows what causes an earthquake. No one ever will know until local observers with local instruments and controlled experiments investigate local earthquakes in a strategic field. The doctrines of emergence angle, epicenters, distance, depth, nature of source, as nowadays applied to distant earthquakes, (and that means big earthquakes,) are not doing clinical work on local patients. The earthquake problem needs a Pasteur. Omori and the Italians were the pioneers. T.A.J.

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No. 246 RELEASED WITHOUT COPYRIGHT RESTRICTION September 12, 1929

KILAUEA REPORT No. 920
WEEK ENDING SEPTEMBER 11, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

The week at Halemaumau lava pit has produced nothing new. Occasional dust is seen from small slides, but these are often caused by visitors rolling stones. Two notches up the wall north and northwest are deepening by avalanche erosion, and the buttress between them is likely to fall in the future.

Near the 1919 desert chasm, a quarter mile southwest of the Kilauea rim, there are patches one or two feet long of Pele's hair and pumice droplets scattered about in the holes of the sand. These have accumulated to leeward from the February and July lava fountains of Halemaumau.

Only four very feeble local earthquakes are registered for the week at Kilauea. The day records of September 5 and September 10 were omitted, owing to repairs. Microseismic motion increased slightly September 6 to Septem- 9. Apparent tilt, imperfectly recorded, was moderate NE.

ALEUTIAN NOTES

Alaskan Volcanoes 1929.

Mr. Austin E. Jones, seismologist for the Section of Volcanology, has spent the summer at Dutch Harbor and Kodiak establishing seismograph stations. He reports that a party landed on Bogoslof Volcano July 27, 1929, and found it very quiet. This is in line with its behavior in 1928, when the heap of steaming lava, in the midst of the circular lagoon, which had been so active in 1926-27, was much cooler and showed less steam than in the previous year.

Akutan Volcano had been reported in strong activity in 1928, and this year on June 18 the lower slopes were lightly covered with ash. It was reported fuming again during July, 1929.

Mount Cleveland and a volcano to the west of it, in the region of the Islands of the Four Mountains, were smoking heavily in July. A mountain west of Kanatak on the Peninsula was reported fuming in March. In the Katmai group Mount Martin and Mageik have been seen steaming throughout the year. Shishaldin, the great volcano on Unimak Island, was "flaming high" on May 28, 1929, and glowing matter was overwelling the edge of the crater and rolling down the slopes. On June 17 Shishaldin was quiet though steam was visible when the crater was inspected with field glasses. It was fiery again June 23 and appeared to have opened three new craters low on the north side. On August 4 the summit steam was barely visible to the naked eye. In 1928 Shishaldin was smoking heavily in August.

The above note on the fuming of Mount Cleveland recalls the heavy earthquake just south of those islands at the edge of the Aleutian deep reported in the Volcano Letter No. 220. This occurred March 6, 1929.

Aleutian Seismograph Stations.

Mr. Jones started work in the middle of June, 1929, at Dutch Harbor digging a cellar and building a hut over it to house the seismograph in the reservation of the U. S. Naval Radio Station at Dutch Harbor, Unalaska Bay, on Amaknak Island, a mile to the north of Unalaska village. The instrument was making a test run on July 16 and thereafter. It is a pair of Hawaiian type horizontal pendulum recording E-W and N-S components on smoked paper. The magnification is X135 and the damping by vanes immersed in oil. The time control is a Howard master clock, and an electric connection makes it possible for the operator from the radio station to impress directly on the seismogram the time signal received daily from Mare Island, California. The location of the hut is lat. 53° 53′ 08″ N. and long. 166° 32′ 07″ W. The distance is about 400 feet SSE. from the radio station on the line of the hand railway leading to the station jetty. The excavation was carried to a depth of five and a half feet where rock was reached. The hut is a 10 by 10 foot shed projecting one and one-half-feet above ground at the back, with double sheathing and a double window, roofed with tar paper, and banked up with earth and sod.

The instrument pier is Y-shape so that the stem holds the drum and the two arms carry uprights at their ends, all of concrete, which support the pendulums. The concrete is reinforced with steel.

The station is operated by Mrs. McDonald, wife of the Chief Radioman, using 120th meridian time (Pacific Coast). Microseisms were very faint in July, and the instruments registered two small local shocks and an earthquake indicating epicenter about 90 miles distant, not felt.

Work was started on reestablishment of the Kodiak seismograph station, by Mr. Jones, early in August. The 1927-28 station has been in the basement of the dwelling house of the Agricultural Experiment Station on the hill back of Kodiak, now turned over to the Bureau of Fisheries. On August 10 the concrete dairy house of the station was turned over to the Geological Survey for use as a seismograph laboratory. This is sturdily built of concrete with walls in places 30 inches thick. The Bureau of Fisheries occupies the establishment only during the summer season, but a local operator has been secured for year-around recording with the two-component Hawaiian seismograph, identical in model with those at Dutch Harbor, Lassen Volcano Observatory, Kealakekua, and Hilo.

Mr. Jones is to be congratulated on his successful season in constructing these stations, much of which he did with his own hands, and the Section of Volcanology is grateful for the cordial assistance given by the officers and men of the Bering Sea Patrol, U. S. Coast Guard, and the Naval Radio Service, and by the officers of the Bureau of Fisheries at Kodiak. T.A.J.

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No. 247 RELEASED WITHOUT COPYRIGHT RESTRICTION September 19, 1929

KILAUEA REPORT NO. 921

WEEK ENDING SEPTEMBER 18, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

The inner pit at Kilauea remains quiet. There is a little steam on the southern talus slopes. Dust from avalanches was seen at 3:10 p. m. September 11 and 2:55 p. m. and 3 p. m. September 12. The slides of September 12 made a dense gray dust cloud of moderate size which hung over the northeast rim for a few minutes, and after the second slide the air within the pit was full of dust for many minutes. At 9 a. m. September 14 there was fresh debris on the north talus; and September 16 there was no change.

The seismographs have registered one feeble earthquake at 7:31 p. m. September 16, indicating origin distance five miles from the Observatory, and eight other very feeble disturbances. A teleseism of moderate amplitude was registered for about 50 minutes beginning 9:04 a. m. September 17. The long waves developed soon after the start and no preliminary waves were detected. Microseismic motion was slight, and tilt was imperfectly recorded with moderate WSW. trend.

ROCK BENEATH THE DEEP SEA

What is called the deep ocean includes depths of two or more miles. Professor Twenhofel, a leader in sedimentation studies, has made an important contribution in answer to the question, "How thick are the deposits under the deep sea?" (Magnitude of the Sediments under the Deep Sea, by W. H. Twenhofel, Bull. Geol. Soc. Amer. Vol. XL, pp. 385-402, June 30, 1929.)

The text books have asserted that the deposits in the very deep oceans are trivial, and recent theories, such as that of July, would lead one to expect basalt only a short distance below the red clay at depths of 18,000 feet of water. "The rates of deposition in the deep sea are unknown, and no methods seem to have been devised by which they may be measured." Sediments from rivers have been thought to remain near the lands where they originate, and it was always believed impossible to transport considerable thicknesses of land sediments out to the deep oceans.

Twenhofel corrects all this, with evidence to indicate the deep sea sediments may even exceed those of the shallow water, that the quantity of lime in the earlier deep sea sediments was small in comparison with the lime in those of later geologic ages. On the basis of the deposition of 20 tons of mineral matter per annum over each square mile of an ocean basin averaging, since the beginning of Devonian time, an area of 115,000,000 square miles, and according to current estimates of geologic time, he finds there has been deposited in the deep sea approximately 80,000,000 cubic miles of inorganic sediments.

During the same time there was deposited an unknown volume of lime carbonate, silica, and other substances, the precipitating agencies being surface organisms which have increased in effectiveness in later geologic ages.

Underneath these deep sea sediments there is buried an unknown and possibly large volume of shallow water and continental slope sediments, the total thickness of which is dependent on what length of time in the pre-Paleozoic represented shallow water conditions, for the areas that subsided in the Devonian and later, on the basis of Walther's conclusions.

It is suggested that the deep sea sediments of the early ages contain more insoluble and undecomposed materials, in contrast to the ages since the late Mesozoic, during which the organisms of the surface waters have deposited much lime over the lesser depths, and this lime is permanently removed from the continental masses.

The major factors in the problem are the length of geologic time, the dimensions of the deep ocean basins, and the fact that few deep sea sediments have ever really been destroyed, whereas the shallow water sediments have been repeatedly uplifted and partially destroyed, and with each uplift have contributed their constituents to the deep abysses of the sea.

Calcareous organisms are deposited all over the sea bottom, but the shells pass into solution at depths beyond 16,000 feet. The siliceous shells go into solution around 18,000 feet. Over the entire area of the deep sea there is a shower of inorganic material such as clay, silica, iron oxide, small particles of resistant minerals, manganese oxides, phosphatic matter, minerals of igneous rocks whose direct origin is uncertain, matter which clearly is of volcanic origin, and rare particles believed to come from meteorites. There is also some lime of inorganic precipitation.

The atmosphere transports fine materials for long distances, as shown by the vast loess deposits of the continents. Europe has received 266 tons per square mile per annum during 3,000 years; 850,000,000 tons of dust are carried 1,440 miles in the air of the Mississippi Valley each year. This material falls over the sea as over the land.

Flocculated particles are carried by the currents of the sea, and the muds of the Amazon are visible 300 miles from its mouth. No one knows how much volcanic matter comes up through the sea bottom or falls from the air.

Sea water contains 1,500 tons of solid matter per cubic mile. This is precipitated more rapidly in warm tropical waters. As the waters of the deep sea cover 115,000,000 square miles with average depth of two miles, they contain 234,000,000,000 tons of sediment in suspension, or more than 21 times the amount carried to the sea by streams.

The length of geologic time since the beginning of the Paleozoic may be estimated to be at least 567,000,000 years, and since the beginning of large deep oceans 300,000,000 years. At the rate of only one foot of sediment in 87,100 years there would be deposited since the Devonian about 4,000 feet, or 0.7 mile, of mineral matter from all sources over the present deep sea bottom.

Twenhofel concludes that the sediments on the continent above sea level are little more than half the calculated volume of the inorganic sediments in the deep sea deposits, and only about 28 per cent of the total volume of all deep sea sediments including limestones. These astonishing conclusions add new zest to the project of boring beneath the mud of the deep sea bottom, the last stronghold of nature unexplored by man, and constituting more than 70 per cent of the earth's surface.—T.A.J.

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No. 248 **RELEASED WITHOUT COPYRIGHT RESTRICTION** September 26, 1929

KILAUEA REPORT No. 922

WEEK ENDING SEPTEMBER 25, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

The week at Kilauea has been entirely lacking in visible volcanic activity. The lava pit Halemaumau has been quiet, and no changes have been noted. From time to time dust from avalanches has been observed, sometimes caused by earthquakes originating at distant points.

On September 19 at 11:50 a. m. a small cloud of dust rose NE. On September 21 at 2:30 p. m. a few stones were heard falling NE., and very slight smoke was noted at the north July grotto at intervals. On September 22 a new line of sulphur at the floor edge north of the grottoes was observed. Steam was slight on the west talus and normal on the south talus. At 6 p. m. dust from a slide was seen from the Volcano House.

On September 24 at 9 a. m. there was no change. New debris lay on the north talus. At 3 p. m. an avalanche occurred, sending up dust. At 4:15 p. m. and thereabouts there were other clouds from larger slides, the buff-colored dust probably originating on the red north wall of the pit. Today two new bright scars can be seen on the south wall from the Observatory.

An extraordinarily large number of seismic disturbances have occurred during the week, the total count being 221. This is an especially surprising number when contrasted with the total of nine shocks for the week preceding. The earthquakes appear to originate in North Kona District, on the west side of the island of Hawaii, but are felt all over the island, intensity decreasing with distance. Due to crowded and overlapping lines on the seismograms some shocks could not be counted.

The earthquakes appear to portend lava activity, but at the present time nothing has been observed to indicate flow. It may be significant that the shocks fall on the equinoxial period. Many of them are of the very feeble, or imperceptible, class; others are classed as feeble, slight, and moderate, and can usually be felt. Moderate shocks are generally strong enough to dismantle the seismograph pens.

The earthquake distances vary from 14 to 37 miles from the Observatory. Plotting these distances on a map of the island, in conjunction with distances shown by records of two other seismograph stations at Hilo and Kealakekua, the epicenters of the shocks appear to fall on points along lines extending both northwest and northeast of the summit of Mauna Loa. The apparent locations of a large number of the shocks are in the region lying between Mokuaweoweo and Hualalai.

Some of the shocks showed distances in miles as follows: 2, 14; 3, 17; 5, 18; 2, 20; 7, 23; 4, 25; 1, 26; 1, 28; 1, 30; 1, 32; 2, 37.

Frequently the distance phase of earthquakes is obliterated by long tremors obscuring the preliminary wave of the shocks. In such cases it is impossible to compute distance.

A few of the earthquakes of this series are tremors varying from two to 17 minutes in length, which occasionally wax in aplitude sufficient to become perceptible. Tilt for the week accumulated slight NNE.

SEISMIC CRISIS ON HAWAII

Numerous tremors beginning soon after noon September, 19, 1929, at Puu Waawaa Ranch, seven miles north of the summit of Hualalai Volcano, a mountain 8,269 feet high on the west side of the island of Hawaii, inaugurated a seismic crisis. This has gone on increasing to September 25, and implies new movement of the Hawaiian Lava column.

At Puu Waawaa there were more tremors September 20, becoming shock groups in continuing series on September 21. The spasms were at first separated by several hours, later they were lenghtened so that the intervals of quiet were only for an hour or two. Also the motion spread to the entire Kona District and perceptible earthquakes became numerous at equal distances from Hualalai to the north and northeast. The belt shaken most is about 35 miles from Hualalai as a center, and the region of the Kau, Puna and South Hilo districts has received the least shaking. The seismograps at Kilauea Volcano have shown increased disturbance both in intensity and frequency.

At Puu Waawaa on September 21 there were 13 shocks in 10 hours, on September 22 there were 79 seismic spells in 22 hours, and on September 23-24 there were 86 spells in 26 hours. This makes the number of disturbances per hour 1.3 for September 21, 3.6 for September 22, and 3.3 for September 23-24.

Huehue Ranch, eight miles northwest of the Hualalai summit, recorded 73 felt shocks in 34 hours, averaging 2.2 per hour. At the F. R. Greenwell residence, Honokahau, six miles WSW. from Hualalai summit, 444 shocks were felt in 73.5 hours, averaging 6.0 shocks per hour. Slight rumble through the ground seeming to come from the mountain was observed with some of the quakes at Huehue and and Honokahau. This was not heard at Puu Waawaa.

For intensity Honokahau registered 71 that were sharp, and Puu Waawaa about the same number, the intensity increasing between September 19 and September 25. As the number of sharp shocks increased, the perception of them over the island at great distances also increased. For frequency the Kealakekua seismograph gave a consistent record for five days beginning September 19-20 of 13, 21, 60, 92, and 280 disturbances per day. For distance of origin from the three seismograph stations Kilauea, Hilo, and Kealakekua, the records suggest the saddle between Hualalai and Mauna Loa volcanoes as an important epicenter, and other seismographs imply motion both northwest and northeast from the central crater of Mauna Loa. The local felt earthquakes all indicate motion on the northwest flank of Hualalai.

The writer examined the summit region of Hualalai September 22, found no fresh cracks, no signs of heat, and felt no earthquakes. The Hualalai and Mauna Loa profiles have been clear, and as yet have shown no fume.

Summarizing, the situation shows increasing tremor earthquakes of volcanic quality centering about the northwest region of Hualalai, accompanied by deeper earthquakes centering about the northern slopes of Mauna Loa and extending their perceptibility to the whole north half of Hawaii Island. Everything suggests that the Mauna Loa lava column, which has sent out its flows from the southwest rift of that mountain during the last 25 years, is now transferring its upward wedging in the direction of Hualalai. This is just what happened in 1801, ten years after the explosive eruption of Kilauea. The present time is five and a third years after the explosive eruption of 1924.

T.A.J.

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No. 249 RELEASED WITHOUT COPYRIGHT RESTRICTION October 3, 1929

KILAUEA REPORT No. 938

WEEK ENDING OCTOBER 2, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

Halemaumau continues to be very quiet and without lava activity. Numerous earthquakes during the week have probably been the cause of several slides.

A total of 244 shocks were counted on the seismograms. In addition to these were several spells of spasmodic tremor. Some of the tremor occasionally waxes into wide amplitude and earthquakes. Earthquakes registered were as folows by days: September 25, 63; 26, 61; 27, 27; 28, 27; 29, 29; 30, 15; October 1, 19, October 2, 3. September 25 and October 2 are incomplete days coming at the beginning and at the end of the period covered by this report. It should be stated that many more shocks are felt in West Hawaii, the apparent center of the present seismic disturbance, than are recorded at Kilauea.

Thirteen shocks give distance 23 miles, 10 distance 28 miles, 6 distance 30 miles, 7 distance 32 miles; others distances varying from 14 to 46 miles from the Observatory.

Microseismic motion was slight throughout the week. Tilt was strong ENE.

CONTINUED HAWAIIAN SEISMIC CRISIS

The development of swarms of earthquakes, as reported last week, on the west side of the island of Hawaii, has continued throughout a second week without the appearance of lava activity to date (noon October 1). The concentration of local shaking in frequency and intensity has remained about Hualalai volcano. In general until September 26 the frequency mounted to a maximum, and thereafter it systematically declined. The intensity of individual shocks has occasionally been extremely strong between September 25 and September 30, but no shock has exceeded grade IX R. F.

The strongest shock of the series to date appears to have been at 6:20 p. m. September 25, felt generally throughout the inhabited Hawaiian Islands. This inaugurated groups of heavy shocks which have occurred in west Hawaii 6:20 to 11:00 p. m. September 25, 10:00 to 12:00 p. m. September 27, 3:18 to 5:18 September 28, 5:00 to 6:00 a. m. and 10:00 to 11:00 p. m. September 29. Extremely severe shocks have occurred (other than 6:20 p. m. September 25) at 10:50 a. m. September 27, 7:08 a. m. and 3:18 p. m. September 28, and 11:55 a. m. September 30. All of these have added greatly to damage of tanks, masonry, stone fences, chimneys, roadways and weak buildings on slopes. There have been numerous other wrenching shocks in the North Kona district which would rank as very strong.

The Count of Earthquakes

As before, the two places which have received larger numbers of groups of felt shocks were Honokahau and Puuwaawaa. Thus for the twenty-four hours midnight to midnight September 24, Puuwaawaa counted 144 earthquakes, Kealakekua only 40. For September 25 Puuwaawaa 171, Kealakekua 30. Kealakekua is twenty miles south of Puuwaawaa. These were felt spasms or groups of shocks. For a twenty four hour period, September 24-25, about 210 shocks were registered at Kealakekua by an 80-times magnifying seismograph.

A shock recorder of magnifying power 25 was set up on a verandah at Puuwaawaa Ranch and for each twenty-four period beginning midnight September 26 registered individual quakes, small and great, in the following numbers:

September 26	599	shocks	
" 27	541	"	
" 28	400	"	(about)
" 29	334	"	
" 30	221	"	

The Kealakekua seismograph was injured by the earthquake of 6:20 p. m. September 25, but thanks to the prompt action of Captain R. V. Woods, was re established September 26. It showed some decline in frequency and amplitude of earthqaukes September 25 to 27, the decline in frequency becoming pronounced on September 27, but with it there came seven shocks of much larger amplitude September 27 to 28. The seimogram of September 30 to October 1 shows an increase of frequency to about 100 shocks.

Comparison With 1868 Crisis

The summary of the situation on October 1, 1929, is that a period of tremor began at Hualalai volcano in west Hawaii at noon September 19, produced a damaging shock of grade IX, six and one half days later, then produced decline in frequency and some increase in intensity of shock groups for five days more. The populace nearest to the mountain is sleeping in the open air, stone walls have been thrown down with notable fracturing away from the mountain, and the stronger shocks have been of the quality to displace furniture, throw down and overturn loose objects, move buildings, crack masonry and produce slides on steep slopes.

In the quality of growing gradually to a maximum from tremor to bumping shocks, and from bumping shocks to oscillations of longer period, this seismic crisis in Hawaii is quite unlike such earthquakes as those of San Francisco and Tokyo. These latter are called tectonic, and begin with a terrific earthquake, thereafter declining with aftershocks. Therefore it seems probable that the present Hawaiian series is volcanic, and marks the shift of magma underground from the Mauna Loa center toward the Hualalai center. We have a close parallel to this in the shift of magma from the northeast rift of Mauna Loa, to a new series of eruptions in the southwest rift, in the year 1868. There were no southwestern Mauna Loa eruptions recorded prior to 1868. In that year on March 9 came a hard earthquake in Kona, on March 27 the beginning of continuous quaking at the south end of Hawaii, on March 28 a very severe damaging shock of the same quality as the one of September 25, 1929, and thereafter an increase of very hard shocks along with many small ones, so that just as in the present year the earthquakes were felt farther and father away. On April 2 came a terrific shock of grade X producing a landslide near Pahala, destroying wooden houses as well as masonry ones, and leading four days later to a rapid outflow of lava, from the south end of Mauna Loa, that endured less than a week. Earthquakes gradually ceased, though there were still two or three a day, five months later.

In 1868 the shift of lava was from northeast to southwest. Now apparently the shift of lava is from southwest to northwest, if rising lava is making the earthquakes. That it should do so a few years after the explosive eruption of Kilauea of 1924, agrees perfectly with 1801, when Hualalai erupted after the 1790 explosions of Kilauea.

T.A.J.

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No. 250 RELEASED WITHOUT COPYRIGHT RESTRICTION October 10, 1929

KILAUEA REPORT No. 924

WEEK ENDING OCTOBER 9, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

No lava has appeared on the island of Hawaii. Halemaumau showed thin dust clouds from slides the forenoons of October 3 and October 5, and there were big slides in the pit and from the walls of Kilauea Crater at the time of the strong earthquake 9:22 p. m. October 5. There were more slides at the pit the forenoon of October 6 and examination of Halemaumau October 7 and 8 showed that falls from the rim had left streaks, the new lava floor is staned with dust from a big slide at the northwest, and a long strip of rim has fallen at the southeast. At that rim also cracks had widened. Small new talus cones were piled at the base of the western wall.

The Observatory seismographs registered 129 earthquakes for the week, and in addition there were spells of spasmodic tremor October 2, 4, 5, 8, and 9. The numbers of earthquakes for complete days midnight to midnight beginning October 3 and ending October 8 were 15, 18, 30, 19, 10, and 16. This shows a distinct frequency maximum on October 5, the day of the very strong earthquake, and does not support the notion that a decrease of frequency precedes violent shocks. This big earthquake began at 9:22 p. m. October 5. No preliminary waves were present to indicate distance of origin. The long slow waves moved the pendulums for an hour.

Seismometric evidence of distance of origin indicated two principal groups of centers, one from 24 to 28 miles from the Observatory, the other from 34 to 37 miles away. There were eight shocks for the shorter distance and seven for the longer. Other shocks indicated distances varying from 18 to 40 miles.

Microseismic motion was slight and tilt for the week was strong WNW. It is of interest to note that for the three weeks of the seismic crisis the tilts at the Observatory have all been northerly with increase of strength first easterly and now westerly. This suggests a swelling pressure under Kilauea.

THREE WEEKS OF HAWAIIAN EARTHQUAKES

The earthquakes that began in West Hawaii September 19 reached maximum of frequency the last week of September and have declined irregularly since that time both in frequency and in intensity.

The outstanding event of the first week of October was a very strong earthquake at 9:22 p. m. October 5, 1929, which was more disastrous than the one of September 25. There is good reason for believing also that it was more intense, as its effects in cracking roadfills and overthrowing embankments at the road spurs in North Kona introduced new phenomena. For the rest, the effects on buildings extended the damage for masonry and water tanks to Waiki and Waimea, while in Kona the long siege of shaking had weakened foundation posts, walls, and tanks with some 200 shocks recorded as sharp prior to October 5. Many of these had been very hard jolts, usually with maximum fling down the mountain slopes as shown by the collapse of hundreds of stone walls in a seaward direction.

Thanks to the Naval Air Service the writer inspected the districts of South Hilo, Puna, Kau, Kona, and South Kohala from an airplane at elevation 10,000 to 12,000 feet in the early morning hours of October 3, traveling approximately 160 miles from Hilo over Kilauea, across the south flank of Mauna Loa, and across the divide between Mauna Loa and Hualalai. The visibility was good, and all the upland of the three active volcanoes was revealed as showing not a trace of new outbreak. Other flights have since been made by the airmen, and the mountains have been clearly seen repeatedly including this date, October 9. Moreover the seismographs show no trace of continuous harmonic tremor, which is characteristic of fountaining lava.

The big shock of October 5 was reported by an observer in Hilo as no more severe than one of an earlier date. It seemed to last fully a minute, nothing in that house was overturned, no water was spilled from a glass three-quarters filled, and the cement basement was not cracked. Cement is reported cracked in the Federal Building.

In the concrete basement of the Observatory the writer perceived a long, gentle, swaying motion which dismantled the seismographs and subjected them to much strain: there was no jerking. Rocks were heard falling from the Kilauea cliffs and several fresh scars were seen on the high northwestern walls and elsewhere. One or two small cracks in the soil were reported.

In Kealakekua the motion was a heavy jerk, somewhat prolonged, and applied very suddenly. Vertical retaining walls broke on the downhill side of roads and of filled land, stone houses were cracked, tanks burst or were thrown off their foundations, and some weak structures collapsed. Furniture was moved and loose objects were thrown about.

Puuwaawaa Ranch received the brunt of the disturbance as usual, unbraced foundation posts went over, the masonry of the basement of the main house was partly thrown down, new avalanches fell in the gulches of Puuwaawaa Hill, bowlder fences were generally prostrated, and a chimney stump was broken for the second time. The effects suggest Grade IX Rossi-Forel for a radius of nine miles around Puuwaawaa Hill, and Grade VIII for a radius of 20 miles around a point northeast of that hill. Grade VII appears to include the Kohala sugar district and the region of Kealakekua Bay.

The count of felt earthquakes from October 1 to October 6 was 5 to 14 shocks per day at Kealakekua, 17 to 83 shocks per day at Holualoa, and 89 to 241 shocks per day as registered on the shock-recorder at Puuwaawaa. In each case there was decline in numbers during the week, with some revival for the day of the big shock October 5. Prior to the big shock there was a marked lull in frequency during the daylight hours. The seismographic registration gives the following numbers of shocks October 1 to 4 for different places: Hilo 38, 26, 13, 74; Kealakekua 155, 110, 96, 138; Puuwaawaa 241, 117, 97, 114. Each of these thus shows a revival before the big shock of October 5. The intensity relations, obtained by counting the numbers of strongish shocks, indicate a general correspondence between the curve of intensity and the curve of frequency; that is, there were maxima in numbers of strong shocks about September 24-25 and about October 5.

T.A.J.

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No. 251 RELEASED WITHOUT COPYRIGHT RESTRICTION October 17, 1929

KILAUEA REPORT NO. 925

WEEK ENDING OCTOBER 16, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in charge

Halemaumau the inner pit of Kilauea remains quiet and as yet no lava activity has appeared elsewhere, although the felt earthquakes in West Hawaii continue. October 9 the four jets of steam on the northeast rift of Mauna Loa at about 12,000 feet elevation were conspicuous owing to still air, but they have been there for many years without change.

Halemaumau has developed nothing new. The morning of October 10 there were many vapor jets owing to a night of rain. An avalanche fell at the north wall 1.23 p. m. October 11. This left a fresh scar above the northwest talus.

In general Halemaumau shows wet patches on the west talus and the three lava niches of the July fountains at the edge of the black lava floor at the foot of this talus. The south talus has a line of wet fissures with steam up and down its upper portion. The floor extends over the whole bottom area with only a few stones from slides overlapping it. It has a large area of white and yellow stain at its south edge and many cracks. The recent dust stain over the northwest side of the floor has been washed away.

The seismographs at Kilauea registered 97 shocks and tremor spasms, a decrease of 32 from the previous week. The average indicated distance of 39 shocks by Omori's formula is 44.3 miles. This is exactly the distance from the Observatory to Hualalai summit. The number per day October 9-15 was 15, 14, 10, 9, 9, 14, 23, thus showing marked revival October 15.

Microseismic motion for the week was strong. Tilt was slight NNW. The intensity of the earthquakes increased October 14-15 as well as the frequency.

THE EARTHQUAKE CRISIS

Hawaii has now had four weeks of unusual earthquakes centering about Hualalai volcano. There is no question about this epicenter. The local damage shows it, the perceptibility records show it, the instrumental frequency registration shows it, and the instrumental measures of distance show it at three stations Hilo, Kilauea and Kealakekua.

The seismograms of 39 local earthquakes during the past week at Kilauea Observatory, critically measured, indicated 20-30 miles for three shocks, 30-40 miles for 11 shocks, 40-50 miles for 13 shocks, and 50-60 miles for 13 others. The average distance measured is 44.3 miles, exactly the distance of the center of Hualalai mountain. The shocks fall into three principal groups, of distances 34-37 miles, 42-46 miles, and 51-60 miles respectively. These distances correspond to the east, middle and west parts of Hualalai ridge.

The history of the week ending midnight October 15 reports earthquakes in the Kona district diminishing in frequency and strength from October 9 to October 13, and increasing strongly October 14-15. There was a strong shock in Kona 11:35 p. m. October 14, and four strongish ones occurred on October 15 at 9:59 a. m., 1:04 p. m., 5:41 p. m., and 10:05 p. m. At the same time small shakings increased greatly.

At Kilauea the strong shock of 11:35 p. m. was registered as moderate and barely felt, dismantling one seismograph pen. The others registered with 3 to 4 centimeters of amplitude on the seismograms of about 120 times magnification. They would rank as slight earthquakes.

Hilo reported two shocks felt October 8 and 9 each, one each day October 10 and 11, and none October 12 to 14. The Kealakekua observer in Kona reported five October 7, three October 8, two October 9, eight October 10, six October 11, three October 12, and two October 13.

The Kealakekua seismograph showed

59	shocks	and	tremors	October	7-8
94	"	"	"	"	8-9
61	"	"	"	"	9-10
42	"	"	"	"	10-11
41	"	"	"	"	11-12
43	weaker ones			"	12-13
25	very weak			"	13-14

It is of interest to review the whole crisis from September 19 to the present time. The Kilauea Observatory seismographs jumped in their registration from only 9 shocks the week ending September 18, to 221, 244, 129, and 97 the four following weeks. The climax in frequency of local earthquakes was thus the week ending October 2, and the strongest shock of the series came at 9:22 p. m. October 5.

The number of shocks registered at Kilauea, and those of intensity corresponding to Kona earthquakes moderate, strong and very strong, were for the week ending

Sept.	18	Total	9	All	Small				
"	25	"	221	12	Moderate	2	Strong		
Oct.	2	"	244	18	"	12	"	1	Very Strong
"	9	"	129	9	"	3	"	1	" "
"	16	"	97	6	"	1	"		

The agreement between frequency and intensity of shakings is good, and the decline in both frequency and intensity during the last fortnight is so pronounced as shown by these figures, that the prospect is reassuring. However there is always a possibility of a very big earthquake when the lava breaks forth in a new place.

The concentration of seismicity at the north side of Hualalai volcano; the waxing of earthquakes in both size and number to a maximum about October fifth; and the persitency of seismic action still, although it seems to be lessening, all imply preparation for a volcanic outbreak as result of the intrusion of basaltic magma underground near the surface. The splitting jerks are now less, perhaps because the mountain fissures are more open, and the earth crust is in tension. Lava outbreak is expectable.

—T.A.J.

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No. 252 RELEASED WITHOUT COPYRIGHT RESTRICTION October 24, 1929

KILAUEA REPORT NO. 926

WEEK ENDING OCTOBER 23, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in charge

There has been no lava activity on Hawaii. Halemaumau pit remains quiet. Wet streaks have been noticed on the wall above the south talus, and higher there is steam at ancient cracks. Small avalanches tumble occasionally.

The seismographs at Kilauea registered 3 feeble earthquakes of the faintly perceptible class, 9 very feeble ones, and 41 prolonged tremors, very feeble, which were small earthquakes at their origin in Kona; total number 53 seismic disturbances as compared with 97 for the previous week. Microseisms were strong and tilt was very slight WNW.

The average distance of nine shocks computed seismometrically was 41 miles, corresponding to Hualalai. An earthquake was strongly felt in Kona about noon October 21. The observer there October 16-19 counted small shakes per day three, four, four, one, as felt. The Hualalai seismic crisis has declined.

VOLCANIC TUFF AND SUGAR CANE ON HAWAII

Studies of volcanic ash and tuff on the Island of Hawaii during the past summer show that the sugar industry is dependent partly on products of explosive vulcanism for its annual $1,250,000 crop. These materials, together with the slightly coarser agglomerate, either aa lava or of explosive origin, form the surface mantle where sugar is grown, and their weathering has apparently been essential to the production of a sufficiently deep and fertile soil on this Island.

On other islands of the Hawaiian group sugar cane grows on soils derived by the weathering of lava rocks, old enough so that a deep soil cover has been developed in those areas which have a moderate to heavy rainfall. The island of Hawaii, is mostly of such recent origin that in few of the areas where aa or pahoehoe lava forms the surface has a soil cover of value for sugar cane culture been produced. In the Kohala district, the sugar growing areas are underlain by agglomerate, made up of small fragments, and much more readily weathered than pahoehoe flow lava. Here the presence of detrital volcanic materials produced by explosive eruptions may be partly responsible for the soil in which cane is grown.

Very little is known as to the actual rates at which either lava or ash might weather under the varied conditions found in Hawaii. The rate of decay on the moist windward slopes, possibly may be ten or twenty times that on drier, leeward slopes. A considerable growth of trees and ferns may develop on lava flows in so short a time as 20 or 30 years under favorable moisture conditions. But the soil condition which will support such vegetation is still far short of that required for the growth and especially for the proper tillage of sugar cane. It may be doubted whether a soil sufficiently deep for commercial sugar production would develop from lava in a period shorter than a thousand years under the most favorable conditions found anywhere in the group.

On the other hand, the fine grained, powdery ash which has been produced at many different times by explosive eruptions on Hawaii, Oahu and other islands of the group has formed a mantle several feet thick over large areas in which weathering must have proceeded much more rapidly. Such material has from the beginning a constitution permitting plowing and cultivating and it seems likely that the finer grained phases of it may become sufficiently leached and modified to permit the growth of sugar cane in a few decades.

The soils of the Hamakua coast and Hilo districts as well as those of the Pahala district have been developed in this way, and the sharp southward limit to sugar growth which follows closely the course of the Wailuku River is the line along which the comparatively young Mauna Loa flows have covered the older ash from the Mauna Kea summit cones. The soils of the Olaa district are mainly derived from agglomerate, partly decomposed aa lava, similar to that of the Kohala region.

It thus appears that if a volcano must erupt and by spreading its product over the land, temporarily interrupt the growth of crops and other human activities, an explosive eruption is much to be preferred to lava. This is apparent if we attempt to compare the value of an acre of land freshly ash-covered with the value of an acre freshly lava-covered. If we take $200 as an average value for good sugar land and from the discussion above assume that perhaps 100 years may elapse before ash-covered land can attain this value through weathering we can easily compute the initial value of the ash-covered land. If the rate of appreciation is fixed at 6% per annum the initial value at the beginning of the hundred year holding would be $0.632 per acre.

Similarly if we assume that lava under favorable rainfall might attain an equally fertile and arable soil in 1000 years its initial value would be a very small fraction of one cent, and even at the end of the first 500 years an area of the size of the state of Texas would be worth only a cent from the sugar viewpoint.

All this is equivalent to saying that, whereas a fresh lava flow is about as worthless agriculturally as any terrane could be, a fresh ash-fall, even of great thickness, has a moderate but tangible worth. The good fortune of the Island of Hawaii is that its legacy was left largely in the form of volcanic tuff which in the twentieth century has attained its financial maturity in a crop worth a million and a quarter dollars. —C. K. Wentworth.

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NO. 253 RELEASED WITHOUT COPYRIGHT RESTRICTION October 31, 1929

KILAUEA REPORT NO. 927

WEEK ENDING OCTOBER 30, 1929

Section of Volcanology, U. S. Geological Survey:
T. A. Jaggar, Volcanologist in Charge

The week has produced no lava activity and the Kona earthquake crisis has continued. Halemaumau pit at Kilauea showed a few new slide rocks on the crater floor west the morning of October 26, but there has been no evident motion there except what the usual small earthquakes will account for.

Seismographs at Kilauea have registered 86 local disturbances divided among 56 tremors, 39 very feeble quakes, and one feeble earthquake at 4:04 p. m., October 29. The average distance for thirteen of the shocks measures 51 miles from the observatory seismometrically, corresponding to the west end of Hualalai volcano. The frequency is higher than the previous week.

Holualoa in North Kona reports numbers of felt shocks for the days beginning October 20 as follows: 6, 69, 5, 2, 8, 2, 1. The seismograph at Kealakekua gave a similar record with about 30 per cent more shocks shown instrumentally. Evidently the volcanic agency that started this seismic crisis is still at work, with marked revivals on such days as October 21 and 23. On these two days there were 41 and 31 disturbances respectively at the Kilauea instruments.

Microseismic motion at Kilauea declined during the week to normal, and tilt was slight NNE. Hilo reports two tremors felt October 18 and three October 21.

VOLCANIC MUD-FLOW IN JAVA

Prefessor B. G. Escher (L'Eboulement Préhistorique de Tasikmalaja et le Volcan Galounggoung, Leidsche Geologische Mededeelingen, Deel I, Aflevering 1, XI 1925, Blz. 8—21) reports on a quantitative study of the missing sector of the cone of Galounggoung volcano in Java, and its relation to the "Ten Thousand Hills of Tasikmalaja" nearby. There have been mapped a total of 3,648 of these hills or hillocks. Escher groups these into categories according to heights (0 to 10, 10 to 20, 20 to 30, 30 to 40, 40 to 50, 50 to 60, and 60 to 70 meters) and computes their total aggregate volume as 142,000,000 cubic meters.

The hillocks are composed of very fine material enclosing large blocks. Various exposures were studied where recent cuts had been made to get out the andesitic blocks for road materials.

The cone of Galounggoung is young and still smooth and nearly perfect except for a wedge-shaped valley sector on the southeast slope. A first glance at the topographic map suggests that this trench is a radial down-sunken block, narrow above and widening down the slope. Escher restored the original contours across the trench and by comparison with the actual contours prepared a map which shows by 100 meter layers the thickness which has been removed. Multiplying by the areas, he gets the total volume of the missing part of the cone as about 2,866,000,000 cubic meters, or about 20 times the 140,000,000 cubic meters of the hillocks.

The aggregate volume of hillocks is far too small to correspond directly to the missing part of the cone. One agency, though a minor one, is erosion that has carried part of the hillocks into the ocean.

A second probability is that the hillocks are only projections from a broad layer of similar rock and mud material. The underlying mixture forms a layer which is at least 20 meters thick at the center though it thins toward the margins of the area it covers. Escher holds that the underlying material and that of the hillocks are due to a single tremendous landslide or mud flow. Where the hillocks are highest is where the moving mass had its greatest energy. Within historic times mudflows caused by rains have produced similar deposits at the other volcanoes in Java. The thickness is difficult to compute. It could only be done where a capping of lava had protected and preserved the whole thickness, and such a capping is unfortunately lacking. It is clear that the volume of the hillocks is not the total volume of the landslide material for the underlying part must be added.

A third point to be considered in connection with the origin of the debris is the nature of the fluid which on its release caused the landslide. The two hypotheses which suggest themselves are that the liquid was lava and that it was water. Escher excludes lava for no lava is found in any of the cuts. It must have been water, which implies that the crater must have had an impervious lining capable of making a crater lake. The barrier must have consisted of alternating beds of lava and explosion material which were held in place by their great weight. Some very unusual condition must have arisen to allow it to be broken. Taverne has shown that the first eruptions of Galounggoung were from a central crater, and that later a new vent opened a little to the southeast which gnawed into the southeast wall of the first crater. A third vent was a little farther southeast and gnawed still more into the southeast wall of the original crater and finally thinned it to the breaking point.

When the crater wall had thinned sufficiently the crater lake broke through and caused an extremely violent and watery landslide. The hillocks represent the fixation of the last materials of the slide, clots that remained standing higher, the principal mass having slowed down because of increasing bottom friction as it spread out fanwise and lowered, and as it lost part of its water. The surficial parts continued their movement for the friction against the air was small.

The air pressure of the resulting landslide wind must have been tremendous and would undoubtedly have annihilated such a town as Tasikmalaja had there been one there at the time. Therefore one can confidently speak of the landslide as prehistoric for such an event would surely have been recorded had there been any written records.

It is not specifically so stated by the author, but the reviewer concludes that the volume of the hillocks plus the volume of the underlying layer of similar material may well be equal to the volume of the missing sector of the cone.

HAROLD S. PALMER

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No. 254 RELEASED WITHOUT COPYRIGHT RESTRICTION November 7, 1929

KILAUEA REPORT NO. 928

WEEK ENDING NOVEMBER 6, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

All has remained quiet in the volcanic districts of Hawaii during the past week. Small earthquakes have continued in the North Kona District with some slight revival about November 4, the shocks as usual being feebly felt in Hilo.

On Thursday, October 31, about 1:30 p. m., a considerable avalanche fell from above the northeast talus in Halemaumau crater. The wall continued to work during the afternoon and two more slides were reported about 3 p. m. These breaks in the wall left a scar noticed on November 2, and there was new dust on the northeast edge of the July lava floor. This was whitish pink and similar fresh material was seen on the east talus slope. A lump had been left in relief protruding from the red boss in the middle of the eastern wall.

On the morning of November 4, at 9:30 a. m., there had been more than two inches of rain and all walls of the pit were dark red with moisture while many small steam jets arose from cracks of the crater floor. The steam was specially conspicuous at the several sulphurous spots of the floor. A few rocks were heard falling on the north talus. At 10:15 a. m., November 6, dust rose from a slight slide at the north side of the pit.

The seismographs at Kilauea registered 57 local disturbances, of which 35 were tremors and 21 very feeble earthquakes. One earthquake slightly more intense ranked as feeble at 3:03 a. m. November 5. This and a preceding shock 12 minutes earlier indicated distances from Kilauea seismometrically of only 18 and 12 miles. They were felt in Hilo, and suggest jarrings local to the east side of the island. The distances for nine other shocks registered indicate origins 50 to 60 miles away, corresponding as heretofore in the recent seismic crisis, with the western or northern parts of Hualalai. Microseismic motion was slight, and tilt was slight to the south.

The Kealakekua observer reports many slight tremors and only three earthquakes in the preceptible class. Hilo reports four felt shocks for the week.

LASSEN REPORT NO. 21

TEST FOR ARSENIC AT MORGAN SPRINGS

There are rather persistent rumors that one or more of the individual vents at Morgan Hot Springs, about six miles south of Lassen Peak, are poisonous, because of the fact that cattle have died in this vicinity. The deposits at Morgan Springs contain silica and various sulphates as well as common salt. Because of the latter, they are commonly frequented by live stock. To keep stock away from the heavier deposits of salts, most of the larger springs have been fenced in.

During the latter part of the summer of 1929, the flow from many of the smaller springs was very low and some had ceased entirely. The quantity and temperature of the discharge from the larger springs were about normal. The incrustation of common salt, alum, and other material around the springs was heavier than usual, as might be expected during an unusually dry season.

The presence of arsenic in the springs has been offered as a possible explanation of the death of cattle in this vicinity. The Marsh test for arsenic of a number of samples of suspiciously colored water and incrustations from the springs failed to show any trace of arsenic.

Near the springs there is at least one poisonous plant which might account for the known death of cattle. An overdose of alum, epsom salts, and other material mixed with the deposits of common salt might result in the death of stock that used the springs for their source of salt.

CHAS. A. HUFF.

VOLCANOES OF FLORES

An admirable monograph on this subject has been published by Kemmerling accompanied by excellent photographs and maps (Vulk. en Seismol. Meded. No. 10, Vulkanen von Flores, by G. L. L. Kemmerling, Bandoeng, 1929, pp. 138, photos 54, plates 10). There are from 100 to 200 eruption points on the island, the young volcanic mountains making about one half its surface. The cones are arranged in rows either parallel or at right angles to the fold structure of the Tertiary rocks. Volcanism is older at the west. In the east, lines of young volcanic cones trend either E-W or N-S.

There are 14 active volcanoes, the records are scanty, and it appears that lava effusion is still important in the Indian Archipelago. Lava streams and lava plugs are common. Table mountains of loose ejecta have sometimes funnel-shaped explosion craters, which change to kettles with wide bottoms ascribed to a hardening of the central region, and cylindrical pits are rare. Lava slag heaps are very rare.

The volcano regions are comparatively uninhabited. There is indirect danger, however, of collapse near the sea causing huge tidal waves. The lavas are basaltic andesites with feldspars high in anorthite. The recent ejecta are basaltic and underlying gabbro or granodiorite is indicated by fragments.

T. A. G.

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No. 255 RELEASED WITHOUT COPYRIGHT RESTRICTION November 14, 1929

KILAUEA REPORT No. 929

WEEK ENDING NOVEMBER 13, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Volcanic quiet continues in Hawaii. Seismic activity, however, is still going on in the region of Hualalai Volcano. The frequency of local earthquakes there has averaged about the same as the previous week.

At 9:15 a. m. November 9 a few new rocks lay on the northwest edge of the floor of Halemaumau, and a pink streak up the wall above, as well as fresh purple dust below, indicated a recent slide. The dust on the northeast floor had washed away. A circuit of the pit November 10 at 3:30 p. m. showed that much steam rises from the middle and the top of the large west talus cone as well as up the middle of the south talus. This last line of steam jets curves eastward into the wall above. About 4 p. m. there were two small falls of rock at the west and northwest walls.

The seismographs at Kilauea registered 62 local disturbances for the week. Of these 32 were tremors, 28 were very feeble earthquakes, and there were two feeble shocks.

These last were felt generally in Hawaii; one was at 8:19 p. m. November 10, indicating a distance of 34 miles, the other at 8:17 p. m. November 11, distance 30 miles from the Observatory. Fourteen records gave an average distance of 44 miles from the Observatory as measured seismometrically, and this corresponds with the location of Haulalai summit.

Tilt for the week was moderate NNE., and microseismic motion was slight.

A VERTICAL MOTION SEISMOGRAPH

For some weeks we have been experimenting in the shop of the Volcano Observatory on a companion instrument for the horizontal pendulums, to register vertical motion of local earthquakes. For seventeen years, with the aid of two Japanese instruments, and with experimental machines optical and mechanical, this problem of measuring vertical motion has been studied here, but without any success in solving it. It is a very old problem in seismology. The vertical motion of an earthquake is smaller than the horizontal motion. To measure it we must secure a mass acting as an up-and-down pendulum, with exactly the same properties as the horizontal pendulums otherwise, in weight, damping, magnification and friction. Then if they register E-W and N-S motion, the new pendulum will register up-down motion, and we can calculate something of the vertical angle by which the earthquake waves emerge from the ground. This in turn furnishes data as to the depth of the local bumping or grating that is the cause of the quake.

The angle of emergence is a very important element of earth motion. Mallet at the Neapolitan earthquake measured it by the vertical angles of cracks across the corners of broken buildings. Dutton at the Charleston earthquake found buildings at the seismic center with the second storey fireplaces telescoped into the first storey chimney-piece. The thrust there was upward. By Mallet's theory the buildings more distant from the seismic center would be more vertically cracked, those nearer to the center would show cracks more nearly horizontal. Angle of emergence was of great practical importance in the earth waves that destroyed stone fences to the value of many tens of thousands of dollars in Kona recently. The walls were flung over in the direction away from the mountain in many cases, which was also the direction away from the seismic center. There is needed an instrument less crude than the breaking of masonry, for measuring this angle, and for measuring it during all the different phases of the progress of the earthquake.

The obvious answer of all machinists has been a spiral or flat spring with a weight on the end. Many vertical motion seismographs have been made this way. But unfortunately springs are also thermometers, so much so that in the Wiechert vertical instrument a temperature change of one tenth degree moves the writing pen three centimeters. This is compensated by a lever holding the spring supported by iron and zinc rods which expand on warming. To get a slow natural period in a helical spring seismograph, where the spring is counteracting gravitation, the usual method is to attach a horizontal rod to the support at a hinge-line, weight the end of the rod remote from the hinge, attach a spiral spring vertically to a support above the rod, and then attach the lower end of the spring to the rod so that the angle ULH (upper support, lower attachment and hinge) is so much less than 45 degrees that instability begins to set in. The weighted rod sways up and down on the spring, and at the lower part of its journey it tends to flop. When this is the adjustment, the natural period may be slowed to six or seven seconds. Meanwhile the stiffness of the spring, the weight to be carried, the size of the spring, and the frictionless quality of the hinge all play their parts.

What we need in Hawaii is a vertical moving pendulum with a mass equilvalent to 225 pounds, eight inches from the hinge line, a natural period of six seconds, a magnification at the pen of 120 times, complete correction against temperature change, against horizontal motion, and against tilt of the ground, and with recording mechanism, damping and friction identical with the Hawaiian type horizontal instruments. The experiments have been made with a small model, and then with a full size model wherein a variety of spring arrangements have been installed having in view temperature correction. Further progress will be reported from time to time. T.A.J.

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No. 256 RELEASED WITHOUT COPYRIGHT RESTRICTION November 21, 1929

KILAUEA REPORT NO. 930

WEEK ENDING NOVEMBER 20, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

There are no changes in the dormancy of Hawaiian volcanoes. Kona continues to feel about one earthquake a day, but the seismic activity has greatly declined.

Halemaumau has shown no changes except increase of steam due to heavy rain. Mauna Loa at 7 a. m. November 20 showed two remarkable convection clouds, each with pine-tree shape, a narrow stem with widened tabular top. One of these was over the summit crater, and the other over the steam-jet region of the northeast rift. Both were mere rain clouds induced by peculiar still atmospheric conditions, and both disappeared in the course of 20 minutes.

The seismograph at the Observatory registered 28 local disturbances and one distant earthquake. There were 16 very feeble shocks of which 5 indicated origin distance averaging 46 miles from the Observatory. The other local movements were tremors. The distant earthquake began at 7:39 a. m., November 15, recorded about 36 minutes, and showed imperfect phases. Microseismic motion was slight, increasing to strong at the time of the easterly wind storm November 17-18, and diminishing thereafter. Tilt for the week was slight SE.

EARTHQUAKES DUE TO MINE COLLAPSE

Earthquakes became numerous on the Witwatersrand mining district after 1907. (The Rand's earthquakes, by A. G. Boyden, South African Mining Review, December, 1928, p. 328.) Loss of life underground is occasioned by these disturbances, falls of rock trapping and crushing the miners, the collapse being the effect of the earth movement. The Rand syncline is unstable owing to many dykes and dislocations, the mine excavations constitute a belt of weakness many miles long and nearly a mile deep, and earthquakes have increased as this belt settled.

On the surface the major tremors have been alarming, but damage to property above ground has been slight. The following is the record of underground accidents:

Year	Local Tremors	Accidents	Killed	Wounded
1923		71	44	83
1924		79	45	76
1925	484	168	28	160
1926	528	137	34	143
1927	666	143	32	161
1928 (10 months)	558	130	22	168

The quakes are believed due partly to slipping on faults and dykes making frictional vibration, and partly to the reaction of a hammer-like blow of a large mass of falling rock for which this slipping is responsible. The collapse is taking effect in many ancient workings, and the jarring results in "rock-bursts" at the live workings, the yielding of pillars of ore left to support stopes. There are also "rock punches," when hard columns break through softer rock below them.

Committees appointed at three different times have grappled with the situation. Seismographs have been set up. The ore pillars have been replaced by timber and stone packs, designed to let the stopes close gradually. Another device was to fill the worked-out cavities with sand sent down fluid through pipes or bore-holes. This must be done on a large scale to lessen the big falls of "hanging wall." It seems the best procedure for preventing loss of life. An instrument is needed, delicate enough to detect increasing strain in the rock. The miners themselves hear and feel dangerous ground. T. A. J.

EARTH TILTING IN TOKYO

An Omori tiltometer compared with the registration of an Ishimoto clinograph (On the Tilting of the Earth Observed at Tokyo, by S. Haeno, Proc. Imp. Acad. IV, 1928, No. 4, p. 151) gave a daily and annual variation in approximate agreement with the corresponding variations of the earth's temperature at a depth of 10 cm. No agreement was found between tilting and precipitation nor between tilting and barometric pressure.

The daily variation exhibits a plumb-line swing counterclockwise ESE in the morning, WNW. in the forenoon and afternoon, and ESE again from about 4 p. m. to midnight. The plumb-line swings in a flattened elliptic curve with major axis 0.57 second N. 80°W.

The annual variation of tilt causes the plumb line to describe a clockwise swing N. 50° E. from July to February of 10 seconds, and SW. from February to July, with marked departures from regularity. The minor axis of the ellipse described (annual NW.-SE. variation) is 3 seconds. The abnormal movements may be connected with seismic phenomena. Agreement is close in direction and amount of annual tilting between Tokyo and Kilauea (Bull. Haw'n. Volc. Obs. Dec. 1927, fig. 48). T. A. J.

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No. 257 RELEASED WITHOUT COPYRIGHT RESTRICTION November 28, 1929

KILAUEA REPORT NO. 931

WEEK ENDING NOVEMBER 27, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

The week has been uneventful at the Hawaiian volcanoes and the seismic activity in North Kona has continued to decline, though the registered earthquakes continue to indicate a source near Hualalai Volcano.

Halemáumau showed no changes November 20 and the next day appeared unaffected by a small earthquake which occurred that evening. Rock falls were heard at the pit at 12:08 p. m. November 24 and 7:45 a. m. November 26. They were heard at the Observatory because of the southerly wind. A very heavy rainstorm from the southwest with repeated wind thunder, and lightning crises between November 23 and November 26 flooded the country and coated Mauna Loa and Mauna Kea with snow. Consequently much steam rose from Halemaumau November 25, and after more than seven inches of rain for the 24 hours preceding the forenoon of November 26, the road near Keanakakoi was washed out. The July floor of Halemaumau showed about 25 new vapor jets clustered in front of the cone made by the lava fountain at the west, there were many scattered steaming places on the floor, and the stained areas at the floor edge south and northwest were steaming conspicuously. The walls of the pit were also steaming. The rock falls made a fresh scar at the west.

The Observatory seismographs at Kilauea registered 32 local disturbances, of which two were feeble, 12 very feeble, and 18 tremors. The two feeble shocks were in the perceptible class, and one of these at 8:29 p. m. November 20 was strongly felt in Hilo and feebly felt near Kilauea. Its indicated distance to origin was 12 miles. The other shock at 6:59 a. m. November 24 was felt strongly in Kona and had indicated origin distance 40 miles. The average origin distance of five such Kona earthquakes for the week was 48 miles, corresponding as recently during other weeks, to Hualalai Volcano.

Tilt for the week was moderate ESE., and microseismic motion became strong November 22-25, declining thereafter.

THE TENGGER CALDERA

Many craters in different parts of the world have the character of a large cauldron miles across surrounded by cliff walls, floored with the products of several inner vents, and broken at one side by a radial valley leading down the mountain. The radical valley is not an essential, but is common. In Java and Bali there are four notable calderas of different sizes, Idjen of diameter 16 km., Batoer 14 km. (Volcano Letter No. 215), Tengger 8 km., and Roeang 2 km. Escher defines caldera as "A very large steep depression with a flat floor in the top of a volcano, the diameter of the upper rim being much larger than that of necks." by "necks" are meant the inner conduits up which lava rises, these being smaller units than the whole caldera.

The caldera conception may be very well illustrated by Mokuaweoweo and Kilauea in Hawaii, each over 5 km. across and containing inner pits or cones that lie over necks. The Kau Desert is somewhat like a radial valley leading from Kilauea Crater.

Calderas have been subjects of controversy in geology. The disputes concern the question whether the large orifice overlies a magma column of that large size, whether the large cauldron was produced gradually or by a single titanic eruption, whether it was made by the up-welling and sinking back of lava, whether it was made by a gigantic explosion, whether it could have been made by gradual down-faulting and this be related to a down-faulted sector that made the radial valley, or finally whether it was produced by a plexus of causes not always the same in different cases. The last seems most reasonable, and is the moderate viewpoint of Dr. Escher in discussing Tengger (Vesuvius, the Tengger Mountains, and the problem of Calderas, by B. G. Escher, Leidsche Geol. Meded. Deel. II, pp. 51-114, 1927, Royal Geological Museum of Leiden).

The Tengger is a large crater ring in eastern Java near the resort Tosari, and famous for the activity of the crater Bromo and the wonderful photographic views which have been made of the sand-sea, the great smoking volcano Smeroe, and the marvelous landscape of the huge caldera which surrounds Bromo.

Bromo is in the Tengger caldera along with four other smaller craters. Off to the northeast extends the Sapikerep Valley leading away from the caldera. The older explanation was that there was first a big double volcano which had an enormous eruption accompanied by engulfment and such lava flows out through the valley as to break down that side of the mountain. Then came deposits of loose materials and finally younger lava filling through small new vents inside the caldera.

Escher was greatly impressed by the scouring effect of the gas phase in the eruption of Vesuvius in 1906 which he calls an eruption of the Perret type. He draws analogy for explaining Tengger from the sequence of events in Vesuvius between 1906 and 1926. This sequence in Vesuvius was (1) a small high crater, (2) the big eruption and the large deep crater, (3) crumbling walls, (4) building up the inner floor, and (5) high crater floor, one principal inner cone, some smaller cones and some lava domes.

The history of Tengger was probably as follows: (1) a twin volcano 4,000 meters high with one strongly developed erosion valley, (2) a gas phase in the eastern of two craters scoured out a deep funnel, (3) a gas phase and collapse funnel in the western crater, (4) lava overflowed this western crater into the eastern one and later into the radial valley, (5) a repose period, valley erosion, and subsidence of the eastern crater lava, (6) minor activity in the five inner craters of which Bromo is the survivor.

Assisted by Kuenen the author carries out experiments in gas erosion of upright funnels through sand with a compressed-air blast to make cylindrical and other chimneys by gas erosion. The paper contains striking maps, photographs, and block diagrams showing stages in the crateral evolution T.A.J.

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No. 258 **RELEASED WITHOUT COPYRIGHT RESTRICTION** December 5, 1929

KILAUEA REPORT NO. 932

WEEK ENDING DECEMBER 4, 1929

Section of Volcanology, U. S. Geological Survey

H. A. Powers, Temporarily in Charge

Seismic conditions on the Island of Hawaii remain unchanged. Fewer earthquakes were recorded this week, but distances indicate sources in the North Kona District of west Hawaii.

Kilauea Volcano has had some increase of steam activity at the various vents in and about the outer crater and in Halemaumau pit, due to southerly rainstorms. Small rock falls from the walls occurred from time to time, but no large avalanches have been noted or reported. At 3:10 p. m., November 27, after heavy rain, there was only one spot with vigorous steam, the sulphur stain on the southeast floor of the pit. A fresh scar was noticed on the east wall, and a slide was heard in that region. On November 30 at 9:30 a. m. much steam was coming from cracks on the floor, thickest at the southwest stained area. On December 2, about 9:30 a. m., there was a small avalanche over the north talus, and steam was still noticeable at the southwest sulphur stain. At 11 a. m., December 4, more slides were heard from the north wall, one from the rim sliding down the niche at the north end of the big sill. This part of the pit shows by scars that it has more slides than other sections have. Little steam was to be seen. Cracks of the lava floor are stained brown, giving them clear outline.

Twenty-five seismic disturbances were counted on the seismograms of the Bosch-Omori instruments, classified as follows: 10 tremors, 13 very feeble earthquakes, and 2 feeble earthquakes. One of the feeble earthquakes, at 2:06 p. m., December 1, was reported felt in Kona; it had indicated distance to origin 42 miles. Seven earthquakes showing distance phases give an average distance of 46 miles from the Observatory, corresponding very closely to average distances of previous weeks.

Tilt for the week accumulated slightly to the southwest. Microseismic motion was slight.

THE MURCHISON EARTHQUAKE, NEW ZEALAND

On the 17th of June, 1929, the South Island, New Zealand, was shaken by an earthquake which had its center in the northern part of the island near Murchison. The intensity of the shock is reported as VIII on the Rossi-Forel scale, as chimneys were shaken down and masonry walls cracked through an area over a hundred miles in diameter (Geological Reconnaissance in the Murchison Earthquake Area, by H. T. Ferrar and L. I. Grange, New Zealand Journal of Science and Technology, Vol. XI, No. 3, 1929, pp. 185-191). After the initial shock which did the damage the "northwest corner of the South Island continued to creak like the deck of a ship for weeks" due to the gradual release of earth-stresses.

The authors review the New Zealand earthquakes of the past and point out that, in most cases, they were associated with movements on fault-planes which were known to geologists to be active faults. A reconnaissance of the area disturbed by the quake of June 17, however, showed that earth movement had occurred only along the White Creek and Kongahu fault-zones, both classed by geologists as dormant faults. Further, most New Zealand faults are concave toward the upthrow block, whereas the White Creek fault is convex toward its upthrow side.

Marked differences in the extent of damage in different localities within the disturbed area are cited and explained in general by the effect of geologic structure on the transmission of the earthquake waves. For instance, Blenheim seems to have been protected considerably by the Wairau fault-plane which passes between that town and the quake center on the White Creek fault.

The disturbance on the Kongahu fault upraised a considerable area of sea-floor in the vicinity of Whitecliffs. This area is to be studied in detail next summer. The movement on the White Creek fault has been studied by H. E. Fyfe and is reported in the same issue of the Journal (Movement on the White Creek Fault, New Zealand, pp. 192-197).

The White Creek fault is the eastern one of two almost parallel faults which bound a strip of Tertiary rocks, inset by the faults in granite country rock. The dip of the plane is nearly 90 degrees, and its trace is slightly concave to the west trending slightly east of north. It has been known as a dormant fault for several decades. The fault is located about seven and a half miles west of Murchison.

At its intersection with the fault-plane, the Murchison-West Coast road was offset vertically 14 feet 9 inches, the east side of the fault having risen relatively to the west side. There was no detectable horizontal movement. The trace of the fault was clearly marked by shattered ground and disturbed vegetation for a distance of at least three miles.

Data obtained by releveling part of the Nelson-West Coast railway show that the level of the country east of the fault-line has been changed for a distance of about nine miles from the fault. At the fault, the eastern block was found to have risen 14 feet 9 inches, the total throw of the fault. The maximum measured increase in elevation of the eastern surface was 16.08 feet, about 25 chains east of the fault.

A graph showing the nature of displacement along the White Creek fault is compared with the graph by Reid illustrating the displacement of the surface along the San Andreas fault after the 1906 earthquake. In the California quake, the movement was horizontal and the total displacement was divided between the two blocks so that each block moved relative to a fixed point in the fault-plane. The movement along the White Creek fault-plane was vertical and, according to the data at hand, the entire displacement is accounted for by the upthrow of the eastern block. The author postpones his discussion of the application of Reid's elastic-rebound theory until the whole White Creek area has been releveled and the absolute movement of both blocks determined. H. A. P.

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No. 259 | RELEASED WITHOUT COPYRIGHT RESTRICTION | December 12, 1929

KILAUEA REPORT No. 933

WEEK ENDING DECEMBER 11, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Everything remains quiet at the Hawaiian volcanoes. At Halemaumau pit a slide on the north side at 11:05 a. m., December 10 made a roaring noise and produced a small dust cloud. A bigger avalanche occurred at noon, December 11, making a loud roar and sending up dust which remained visible for 15 minutes.

Seventeen local earthquake disturbances were registered at the Observatory. Nine of these were tremors, 8 were very feeble earthquakes, and 5 of these indicated distances averaging 47 miles from Kilauea. The duration of the most prolonged of the tremor spasms was 2 minutes. Tilting of the ground accumulated moderately to the west, and microseismic motion was slight.

LASSEN REPORT No. 22

Lassen Volcano Observatory, Mineral, California

R. H. Finch, Associate Volcanologist

During the afternoon and evening of November 17, 1929, eleven earthquakes were registered on the seismographs at Mineral. Another shake occurred during the early morning of November 18. Two of the earthquakes were plainly perceptible. The one that occurred at 7 p. m., November 17 gave buildings a sharp jolt. The disturbances can undoubtedly be classed as Lassen shocks as the indicated distance to origin, 12 miles, is equal to the distance to Lassen Peak from Mineral.

NOTICE

Recipients of the Volcano Letter are requested to examine the address on the envelopes and to notify the Hawaiian Volcano Observatory of any changes desired.

MAYON VOLCANO

On July 1, 1928, Mayon, the "Fujiyama" of the Philippines, was in mild eruption, sending blocky incandescent lava flows from notches in the rim of the summit crater, and emitting dust-laden steam. Chlorine and sulphuric acid were found in the dust. The climax was reached about July 20, and in August the volcano reurned to its normal state, emitting steam vapors (Mayon Volcano and its Eruptions, by Leopoldo A. Faustino,, Phil. Jour. Sci. Vol. 40, No. 1, Sept. 1929, pp. 47, 24 illustrations). The lavas are andesitic basalts, with plagioclase, augite, hypersthene, magnetite, and hematite.

Mayon is in southeastern Luzon, 23 hours by rail from Manila. It is 2,421 meters high, and has had 28 eruptions in 114 years since a destructive eruption in 1814. There were two long quiet periods, 1814-27 and 1900 28. The normal condition is continuous mild activity. The most violent eruptions are followed by the longest periods of rest. The beautiful cone has never been destroyed, and the conduit has always been in the center. The losses of life have been by asphyxiation, dust blasts, overpowering incandescent slides, flood, and earthquake. The last two are secondary. The incandescent slides appear to be thrusts clear to the sea of unbalanced slopes attacked by radial aa flows above and bombardment of falling material. The lava flows follow the steep gulches and rise above them, forming ridges where trenches were before.

There were disastrous outbreaks in 1814 and 1897. The greater damage was the overwhelming of shore villages by a torrent of "fire, lava, and large hot stones." Two great disasters by flood and typhoon, in 1766 and 1875, were occasioned by heavy rainfall causing the unstable volcanic slopes to wash down to the sea as mud flow, with high mobility and great rapidity. Thousands perished and much property was destroyed. The path of the waters was an expanse of bowlders and sand, with pieces of wood, to mark the place where was once a thriving community.

The events in 1928, after 28 years of quiet, began with rumblings in January. June 16 the steam jets increased in volume and crater glow was seen. Dust "cauliflowers" began June 24. Incandescent flows overlipped the crater June 27. Army fliers June 29 circled the crater at 2,500 meters, and photographed the cauldron at 200 meters distance. They felt the heat strongly, inhaled sulphur, and estimated the crater diameter at 500 meters. It was circular, with vertical inner walls, a deposit of cindery material on the sides, and a pool of bubbling hot lava in the center. The rim is notched with a main chute or horseshoe opening on the eastern side Aluminum sulphate and sulphur are common in the crater during quiet times.

Fragments were shot into the air, reports were heard, lava poured out through the notches in the crater wall and followed the gullies, forming snakelike trickles radiating from the summit. The molten material crusted over and cracked, and the impact of falling glow-stones made fireworks.

At the end of June the lava streams lengthened, resembling red hot glaciers covered with moraines. Black clouds of dust-laden steam swept down the mountain. The explosions waxed and waned until July 20. Hollows filled with the molten material and the junction of two valleys assumed the appearance of a subordinate crater. July 16 volcanic materials were descending the northern slopes. There was periodicity of three to five hours in the spells of roaring, hissing, cracking, and tumbling noise. At the climax there was a spectacular evening display of bombs describing parabolic curves of fiery rocketing at the summit. A column of heavy dark clouds rose 8,000 meters above the summit, the top of the mountain was rose red, brilliant lightning flashed from dustcloud to dustcloud, and streams of lava flowed in all directions. Sometimes the column moved spirally. When the wind arose, "the volcano appeared like a gigantic locomotive puffing on a heavy grade." T. A. J.

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No. 260 **RELEASED WITHOUT COPYRIGHT RESTRICTION** December 19, 1929

KILAUEA REPORT NO. 934

WEEK ENDING DECEMBER 18, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

No lava activity has occurred, but stormy weather has produced much steam in Kilauea Crater. On December 12, at 1:19 p. m., a steady roar from Halemaumau pit was heard at the Observatory caused by an avalanche lasting several seconds, which finally sent up dust above the east rim which drifted toward the north. A prolonged very feeble earthquake movement registered on the seismographs coincided with the slide.

A southwest rainstorm December 16 flooded the country and condensed much vapor over Kilauea and Halemaumau. Violent wind wrecked the Observatory weather-vane at 10:05 a. m. At noon, December 18, the pit was quiet and in spite of rainy weather there was hardly any steam on the south talus. Fresh debris lay on the north and east talus cones.

The Observatory seismograph registered 13 local disturbances during the week, of which nine were very feeble earthquakes and four were tremors. Seismometric evidence for five shocks indicated an average distance of 48 miles for the location of the origin. This corresponds to North Kona as in other recent weeks, and earthquakes are still felt in that district.

Tilting of the ground at the Observatory was moderate SSW. Microseismic motion increased December 16, accompanied with wind tremor. With the change of wind to northeast December 17, the microseisms remained large and rythmical.

A large distant earthquake was registered December 17, beginning 12:37 a. m., the preliminary phase indicating distance of origin 4,300 km. (2,600 miles). This distance corresponds to the north end of the Tonga Deep, the west end of the Aleutian Deep, the cordilleran belt of the west coast of North America, or the west end of the Alaskan Peninsula. The Kodiak station reports fire and smoke from three volcanoes between Kodiak and Unalaska.

THE CENTER OF THE TOKYO EARTHQUAKE

Professor Imamura, Director of the Seismological Institute of Tokyo Imperial University, has just published a brief summary concerning the most recent information about the location of several centers for the great Kwanto earthquake of September 1, 1923 (On the multiple source of origin of the Great Kwanto Earthquake of 1923 and its relation to the fault system connected with the Earthquake, by A. Imamura, Proc. Imp. Acad., Oct. 1929, Vol. V, No. 8, p. 330).

It was found that the Tango earthquake of 1927 had a double source of origin. It may be that the Tokyo earthquake had a multiple series of epicenters. The seismic waves that caused such widespread destruction emerged from at least three different places, along a line NE-SW. beginning at the middle of Sagami Bay. Two of these points were in the bay and one in the mountains north of Fujiyama. The first break was from the middle of the bay, the second from the mountains three seconds later, and the third, 7.5 seconds still later, came from the head of the bay west of Kamakura. Everything that succeeded these early phases of the earth motion, if the process repeated itself, was masked by the exceptionally large earth movements that lasted for more than a minute.

The Seismological Institute at Tokyo stood broadside to the big NW-SE. trending faults, and so with several pairs of seismographs could interpret the direction of motion of the earliest phases.

Imamura has continued the work of the late Professor Yamasaki in mapping the fault systems surrounding the epicenters. These have been interpreted in connection with precise leveling and triangulation. There emerges from this mapping a series of east-west faults across the Bosyu Peninsula and the eastern part of Sagami Bay; a series of very big faults along the volcanic axis NW.-SE. extending from the bay to the mainland along the Oshima-Fujiyama belt; and a series of N.-S. faults tending to curve westward in the entrance to Tokyo Bay and in the region west of Yokohama. Fifteen faults and flexures have been worked out with lengths varying from 1 to 22 km. and vertical displacements varying from 0.3 meter to 20 meters. Some of these topographical changes accompanied the first earthquake and others were probably adjusted along with the big after-shocks.

The details of these movements are worked out in accordance with the strength of effects and sensations in different places, and with seismogram records in different places. A map is presented exhibiting the directions of initial motion as recorded on seismographs all over central Japan, and the facts seem accordant with two main epicenters, one in the bay and one on the mainland. The time-distance curves of the preliminary tremors also accord with the double origin.

Imamura concludes that shearing stresses tore asunder the bottom of the bay on a weak zone and then leapt to the Tanzawa Mountain to release a second violent rending of the earth's crust. This was succeeded by a still bigger collapse in the bottom of the bay, when the whole countryside was thrown into agitation. It will be seen that this analysis is totally different from Imamura's earlier theories which attributed the earthquake to tectonic movements under the Pacific off to the east. T. A. J.

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No. 261 RELEASED WITHOUT COPYRIGHT RESTRICTION December 26, 1929

KILAUEA REPORT NO. 935

WEEK ENDING DECEMBER 25, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Kilauea remains quiet. There are no avalanches. A white stain has appeared in a niche of the wall at the top of the northwest talus. On wet days fog has condensed over the pit and in it, but the steam on the talus slopes has diminished.

The Kilauea seismographs have registered 10 tremors and 3 local earthquakes, making 13 disturbances. Two of the local shocks indicate distances of 34 and 51 miles. These were felt in North Kona. Microseisms were slight, and tilting of the ground was stationary.

The distant large earthquake of December 17 is located by "Science Service" at the west end of the Aleutian Deep, near Attu.

A BIG ATLANTIC EARTHQUAKE

A powerful movement of the earth crust under the Atlantic Ocean along the steamer track between New York and Liverpool is unusual. Such an earthquake recalls the Charleston disaster of 1886. This is not a place of deep holes under the ocean like the earthquake centers off Japan and Chile.

The shock occurred about 3:40 p. m., eastern standard time, November 18, 1929, 180 miles south of the Newfoundland coast, off the edge of the continental shelf, and probably moved a large area of sea bottom. The bottom is fairly steep, and possibly submarine landslip accounted for the breaking of Atlantic cables in several places. The location of center was about lat. 44° N., long. 58° W.

The first reports told of very heavy shocks in Nova Scotia lasting for many minutes. Halifax was severely shaken. In Windsor chimneys were knocked down and dishes were broken. In St. John's, Newfoundland, the shock was only "half a minute" long, and not so strong, but the Burin Peninsula in south Newfoundland received a violent shaking. From Boston to Maine in the United States the phenomenon was described as "sharp earthquake shocks."

The big steamship "Olympic" was 300 miles from the center, and the captain felt the vessel suddenly quiver, as though she had lost a propeller blade, and this was followed by vibrations for two minutes. The ship was found to be uninjured.

Sea waves piled into the Newfoundland inlets along the west shore of Placentia Bay two and a haif hours after the earthquakes. Burin and La Maline bays were most damaged. At Burin whole families were trapped at their dinner tables as a wall of water 15 feet high swept inland. Boats and schooners were lifted from their moorings and dashed against the waterfront buildings and wharves. A mother, who was with her two children alone in her home, rushed to the door to learn the cause of the roar of waters. When she ran back to rescue the children, the wave broke over the house, drowned them all, and washed the wreckage out to sea.

Women and children were the greatest sufferers, as the men were away with the fishing fleets. Nine lives were lost at Burin, and 17 others at Lord's Cove and La Maline. In Long Harbor, at the head of a narrowing inlet, fishing booms and weirs were damaged and 75 yards of roadway were destroyed.

Twelve out of 22 telegraph cables in the epicentral earthquake area were fractured, and 10 of these cross the ocean. Two Western Union cables were severed at 90 fathoms depth off Nova Scotia, and a third at a depth of 900 fathoms. Thus the dislocation of the sea bottom was distributed. Davison reports (Nature, Nov. 30, 1929, p. 859) that such an earthquake occurred in 1884, breaking three cables along a straight line on the southeastern slope of the Newfoundland Bank, and that probably the present earthquake had a multiple origin.

Boston was 700 miles from the supposed center, and the U. S. Coast Survey (Science News, Science, Nov. 29, 1929, page X) estimates perceptible shaking over a million and a half square miles, and strong shaking over 200,000 square miles. This is a very large disturbed area, and yet not the slightest trace of this earthquake appeared on the Bosch-Omori seismograph of magnification x120 at Kilauea Volcano in Hawaii This distance is only 5,800 miles, and yet the Porto Rico earthquake at similar distance recorded clearly on these instruments.

It is 43 years since the last great earthquake (1886) on the Atlantic seaboard of the United States. That one, the Charleston cataclysm, was preceded a year and a half before (1884) by a disturbance breaking cables along a straight line off the Newfoundland Bank. In 1929 there is a new disturbance breaking 12 cables off the Newfoundland Bank.

We do not know what cycle controls the marginal movement of the North Atlantic basin around Bermuda as a center, but these west Atlantic earthquakes are so rare that seismological measurement should be made practical in the eastern United States during the next few years, with special attention to local frequency of small movements.

T. A. J.