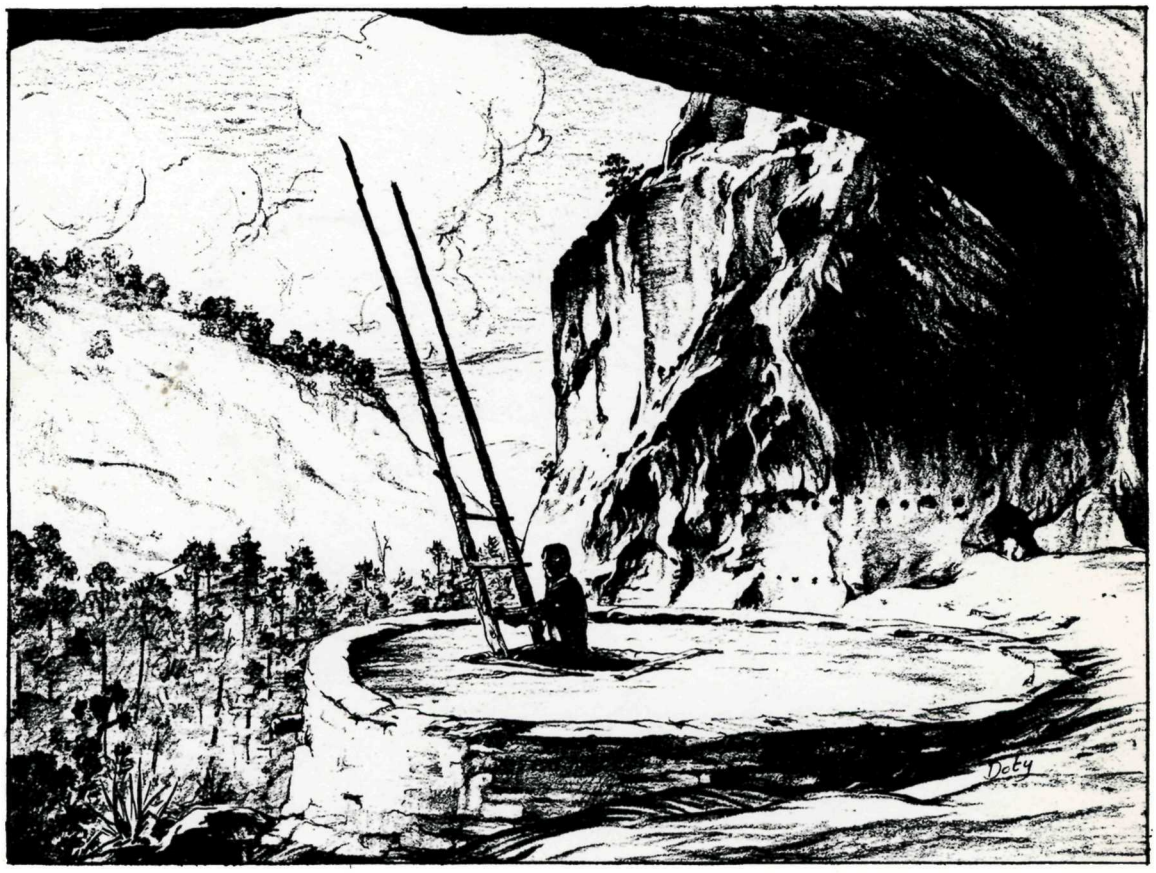
REGION III
QUARTERLY



NATIONAL PARK SERVICE

VOL 2 NO 2 APRIL 1940

THE COVER

Ceremonial Cave, Bandelier National Monument, near Santa Fe, New Mexico.

C O N T E N T S

Hillory A. Tolson — Regional Director

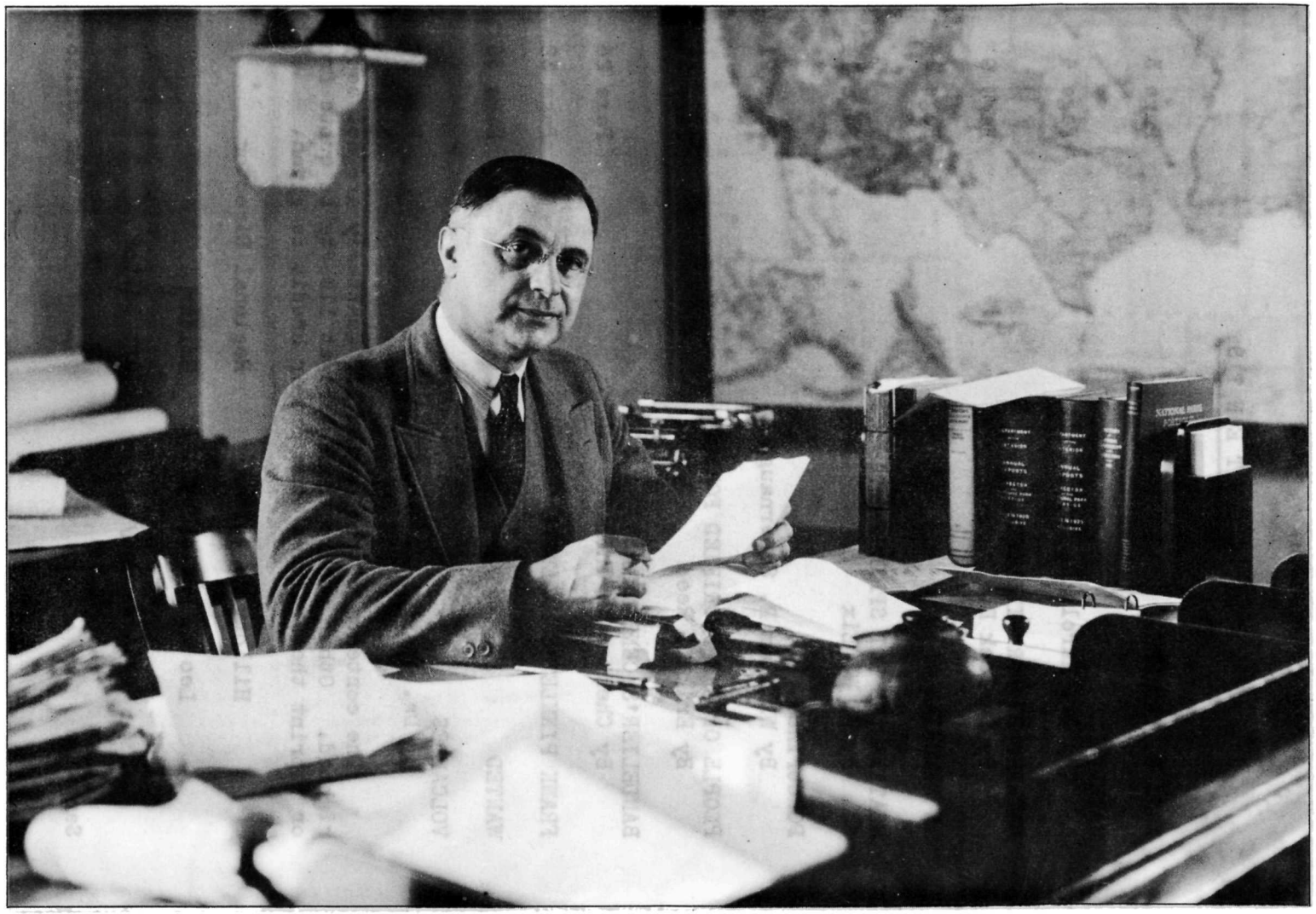
Leo A. McClatchy — Editor

Cecil J. Doty — Art Editor

Santa Fe, New Mexico.

R E G I O N III

ARIZONA - ARKANSAS - NEW MEXICO - OKLAHOMA
TEXAS - UTAH - AND SOUTHERN PARTS
OF COLORADO AND NEVADA



ARNO B. CAMMERER
DIRECTOR

ARNO B. CAMMERER

When Stephen T. Mather, first Director of the National Park Service, was seeking an Assistant Director, in 1919, the obvious field of his search seemingly should have been among experienced park executives. He had propounded the idea, however, that parks and art are very closely related - that identifying and preserving park areas is in itself a high art. So he went to the National Commission of Fine Arts and chose that organization's Assistant Secretary, Arno B. Cammerer. That the choice was a wise one has been attested many times, including the 1938 award of the Pugsley Gold Medal to Mr. Cammerer for distinguished work in park development.

Mr. Cammerer rose from Assistant Director to Associate Director, and in August, 1933, he became Director. National Park Service activities have expanded tremendously under his direction. He has succeeded in maintaining national park standards by successfully resisting frequent efforts to include areas in the National Park System that cannot qualify for national park status. The national park idea, he has repeatedly pointed out, is the most effective implement for conservation of areas and objects of great intrinsic value to the nation.

"The park concept," he has said, "provides a new form of land use, humanly satisfying, economically justifiable, and with far-reaching social implications. Inherent in it is a new recognition of human values and a more intelligent method of commercial exploitation. As such, it is a progressive step in land utilization and must take its place along with the other great land-use techniques such as forestry, agriculture, and mining."

Mr. Cammerer was born on July 31, 1883, at Arapahoe, Nebraska. He attended elementary and preparatory schools in Harvard, Illinois, and was graduated from Georgetown University in 1911 with the degrees of L.L.B. and M.P.L. He entered the Government service in 1904 as an expert bookkeeper in the Treasury Department, remaining there in various capacities until 1910, when he became Assistant Secretary of the National Commission of Fine Arts, where he remained until 1919. While with the Fine Arts Commission, he acted as secretary of other commissions, including the Lincoln Memorial, the Public Building, and the Rock Creek and Potomac Parkway Commissions. He is Executive Officer and Vice-Chairman of the National Capital Park and Planning Commission, and a member of the District of Columbia Zoning Commission, the Washington-Lincoln Memorial-Gettysburg Memorial Boulevard Commission, the National Park Trust Fund Board, the Fredericksburg and Spotsylvania County Battlefields Memorial National Military Park Commission, and the Petersburg National Military Park Commission.

In 1936 Director Cammerer was awarded the honorary degree of Doctor of Laws by Syracuse University.

WATERFALLS

By Dr. Harold C. Bryant,
Public Works Consultant.
(Formerly Supervisor of Research and Information).

Even if you haven't visited Niagara Falls on your honeymoon, somewhere you have seen water dropping over a precipice small or large, felt the spray on your face, and heard the endless roar. A boyhood memory of mine is of a trip to Eaton's Canyon, above Pasadena, California, to the Fall, perhaps fifty feet high. Even with later views of the great among waterfalls, memory of this lesser one holds a vivid place in my mind, for my childish question was why the water did not stop falling instead of furnishing a continuous roar.

The older the stream of water, the less spectacular are its waterfalls, for waterfalls and rapids belong to youthful streams. Most often a waterfall develops in streams that have not yet acquired a graded slope, but some appear as a result of some outside force causing an interruption. A lava flow or a landslide, a glacial moraine, an uplift or a fault line may produce proper topography for a waterfall. The first, or normal type, is formed by variation in the hardness of rocks into which the stream is cutting; in other words, unequal erosion. And of course a waterfall accentuates inequality by successfully increasing the rate of erosion below the fall. Falls due to vertical beds of hard rock seldom change their position, but those having horizontal beds, or beds dipping slightly upstream, slowly retreat upstream and become lower. The Niagara River flows over horizontal beds of hard limestone, superimposed on weak beds of shale. At the base of the falls the soft beds are cut away, allowing great blocks of hard limestone to break off. The fall has continuously moved upstream seven miles in about 20,000 years.

Shattered rock, between masses of resistant lava, helped the Zambesi River in Africa dig out a 400-foot canyon at right angles to the river valley, and produce the famous Victoria Falls. Sometimes the sapping process of a great glacier makes canyon walls perpendicular, and side streams may drop over great cliffs to a glacial-cut canyon below. Such is the explanation of Yosemite Falls, in Yosemite National Park, California. The Takakaw Falls, in the Yoho Valley of British Columbia, carry a glacial stream into an ice-carved canyon. Nor must we forget the series of waterfalls to which the name of cascade is given. Water flowing over an inclined bed is known as a rapid. Sound and speed begin with a rapid increase in the cascade, and meet the maximum in a clean fall from an overhang.

There is great inspiration appeal to the person viewing a waterfall. The whiteness of the water, the rockets, the contour of the lip, stir the senses of sight; the movement of cooled air, the spray on the face, bring tactual sensations; the damp odor of running water pleases

the nostrils, and the ear may catch the whole gamut of water music from the soprano of the tiny fall to the basso profundo of a great cataract.

The National Park System is blessed with a fair share of the continent's greatest waterfalls, in addition to the innumerable beautiful falls that are found wherever mountainous regions abound in running water. There is Mount Rainier, in Washington, with its array of beautifully named falls: Narada, Christina, Spray, Comet, Ethania and Fairy Falls to the south and west; and its Stafford, Sydney, and Silver Falls, in the Ohanapecosh section. Visible to every main entrance visitor is Shuskin Falls, near Paradise Valley. In practically all these, water is supplied from melting glaciers, and glaciated canyons form the setting.

Glacier National Park, Montana, is a land of falling water. Any trail to the high country leads along glacial streams which fall in steps from the melting face of some glacier. Numerous white cascading streams drop over precipitous heights to glacial valleys below. The head of avalanche Creek, above Avalanche Lake, furnishes a spectacular array of such streams. One trail is termed Many Falls Trail because it leads by so many waterfalls. A noted fall in the Bowman Lake country bears the name of Hole-in-the-Wall Fall. Another freak fall below Two Medicine Lake is properly termed Trick Falls, for when the stream carries plenty of water it forms a normal waterfall, but when the stream is low, water rushes out of a hole in the rock wall below the lip of the falls.

A trip to Chasm Fall in Rocky Mountain National Park, Colorado, is rewarding of effort. The Great Smoky Mountain National Park, in Tennessee and North Carolina, comprising the most massive mountain uplift in the East, and with heavy rainfall, naturally has plenty of running water with accompanying waterfalls. The most noted is Rainbow Fall. Shenandoah National Park, Virginia, has less spectacular streams and waterfalls but they are of sufficient beauty to stimulate visitors to take the trails. Devil's Postpile National Monument, California, possesses a fall of note. The whole northfork of the San Joaquin River plunges over a natural lava dam to form Rainbow Fall, spectacular because of the large volume of water. Glacier Bay National Monument, in Alaska, contains plenty of yet unnamed falls, such as accompany glacial conditions.

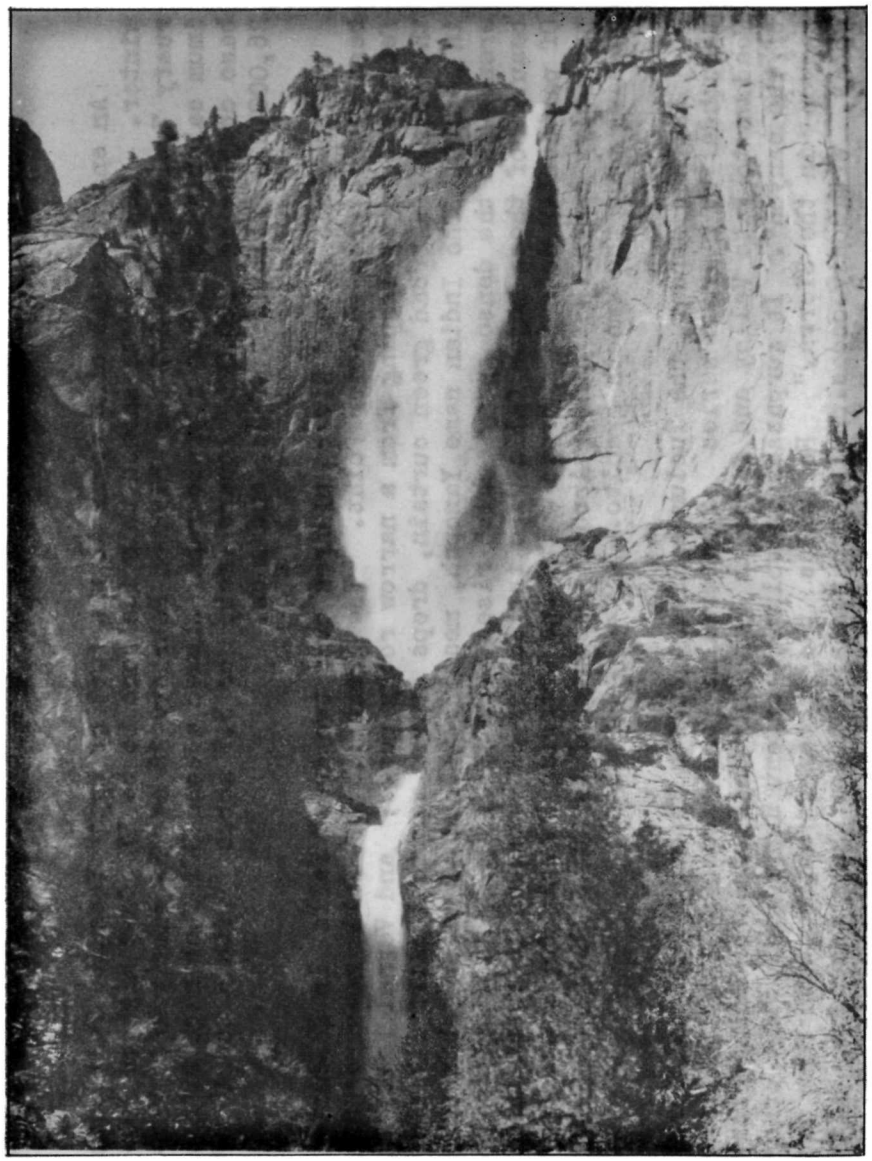
Yellowstone National Park, Wyoming, possesses two falls on the Yellowstone River that are spectacular because of size and location at the head of the colorful Grand Canyon of the Yellowstone. The artist and photographer have marked these falls, twice the height of Niagara, as furnishing a scene of superlative beauty. A trail leads to the foot of the Lower Falls so that the visitor may see the spectacle from observation points along the rim of the canyon, or more intimately from the winding trail to the bottom. Nor must the Beehler Basin country be forgotten with its Cave Falls and other smaller ones.

The park with just the proper topography to present waterfalls is Yosemite. Here we find several superlatives. On the way in we pass Cascade Fall, and at the gateway to the valley, we see Bridalveil Fall, 620 feet in height, a perfect type falling over a vertical precipice. Because the water and the spray of the latter are wafted back and forth by a breeze, the Indians called it Pohono, the "Fall of the puffing winds." Late in summer this fall often turns to spray entirely and is wafted up as well as sideways. Early in spring we may catch glimpses of Ribbon Fall, to the left of great El Capitan, which is highest of all if we do not demand a clear drop, 1,612 feet. To the right, up the valley, is Silver Strand, more familiarly known as Widow's Tears, which has a drop of 1,170 feet. Then from a notch on the north, Yosemite Falls, highest of its kind in the world, looms into view.

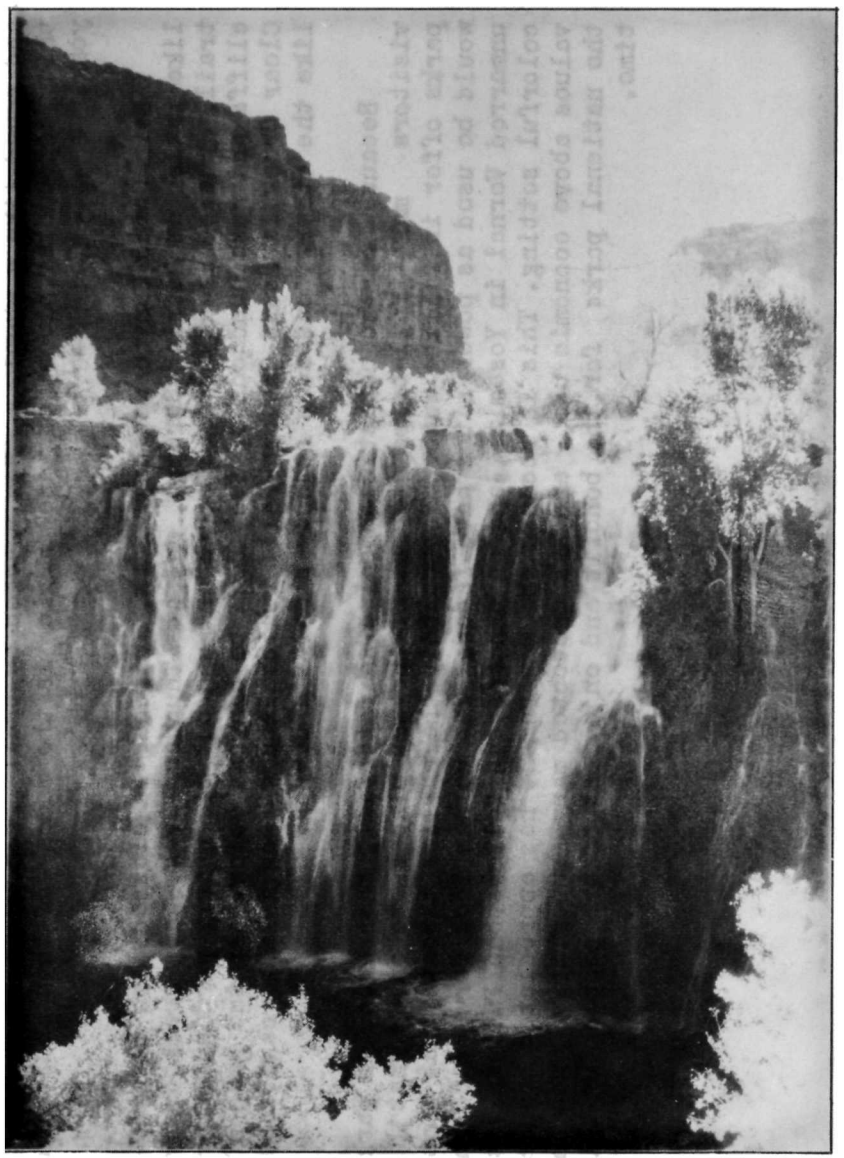
Mr. Francois Matthes of the U. S. Geological Survey, has gathered statistics of all the great waterfalls of the world and has concluded that Yosemite Falls surpasses all others in height and splendor. Even though formed by only a tributary of the Merced River, they constitute the most spectacular feature of the valley proper. Composed of a great upper fall, an intermediate chain of cascades, and a smaller lower fall, the combined height is 2,565 feet. The Upper Fall, with its drop of 1,430 feet, 1,360 of which is a clear leap, constitutes what is believed to be the highest free leaping waterfall in existence. Most waterfalls of great height in other countries for which superlative claims have been made, either prove to contain cascades, or the measurements have been exaggerated.

Mr. Matthes, in his "Geologic History of the Yosemite Valley", (U.S. Prof. Paper 160, P. 20-21) lists numerous great waterfalls of the world, including Takakaw in the Yoho Valley of British Columbia (1,346 feet with partly free leap of 900 feet); Akaka of Hawaii; Basaseachic of Mexico; Tequendamas on the Bogota River, Columbia; Kaietur of British Guiana (822 feet of the 400-foot-wide Potaro River); Staubbach of Switzerland, the Voring Fos (1,150 feet), and Vettis Fos (853 feet), of Norway; Gavarnie of the French Pyrenees (two leaps of 958 and 427 feet); Kalambo of Southern Africa (1,200 feet); the Gersoppa (830 feet) on the Sharavati River of South India; Wooloomumbi of New South Wales; and the Stirling, Bowen and Sutherland (1,904 feet divided into sections of 815, 751, and 338 feet) of New Zealand; but gives Yosemite Falls the lead as a leaping fall, and also as a chain of falls 2,565 feet in height. Mr. Reynold Carlson in "Which is the World's Highest Waterfall?" (Yosemite Nature Notes, 14, pp. 1-8) also confirms this view. Because Yosemite Falls often disappears entirely in late summer, many have advocated a storage reservoir to keep it running. The California State Legislature once passed a resolution urging this artificiality which, of course, the National Park Service opposes.

As second in height in the United States, Tuculala Fall in the Hetch Hetchy Valley of Yosemite National Park, is cited with its total estimated height of 1,000 feet and its clear fall of 600 feet. Multnomah Fall, in the gorge of the Columbia, in Oregon, makes an essentially unbroken descent of 700 feet.



YOSEMITE, WORLD'S HIGHEST FREE LEAPING FALLS



NAVAJO FALLS, GRAND CANYON

An enormous ice cone forms at the foot of Upper Yosemite Fall each winter. Measurements showed this ice cone to be 173 feet high on February 7, 1936, and 247 feet high on February 28 of the same year. Maximum calculation from a photograph showed a cone 322 feet high with a base comprising 160,000 square feet, or 3.7 acres, with a total of 25,000,000 cubic feet of ice and snow.

The whole Merced River plunges over two great falls in Yosemite, best viewed from Glacier Point. The great Nevada Fall measures 594 feet, the water issuing from a narrow rocky gorge; and Vernal Fall, in the form of a broad green curtain, drops over a vertical cliff 317 feet in height. The Indian name Yanopah, meaning "cloud of water", has reference to the dense spray which rises from its foot. Adding to the beauty of these major falls are the series of cascades between them. Of particular note is a broad white one entering Emerald Pool, and very properly named the Silver Apron, because of the thin sheet of water rushing over the smooth granite.

Another stream, the Tuolumne River, within Yosemite National Park, descends by a great series of waterfalls and cascades from Tuolumne Meadows to Pate Valley and forms, as John Muir said, the "crowning glory of the canyon". It surpasses in volume, extent and variety "any other canyon in the Sierra." For miles the stream is white with foam and spray, with only occasional green pools. Below White Cascades, California, and Le Conte Falls, we find the unequaled spectacle of Waterwheel Falls, a series of great fountain-like jets of white foaming water, thrown fifteen to thirty feet in the air by holes in the steep granite bed of the stream, which give the appearance of turning round and round like a wheel. Now reached by trail from Tuolumne Meadows, this astounding piece of water magic is the mecca of thousands each year.

Even Grand Canyon National Park, Arizona, is blessed with cascade-like falls at Roaring Springs and at Thunder River, now reached by trail, where great streams of water gush out of nearly perpendicular cliffs and rush hundreds of feet down to canyons below. At the head of Clear Creek is found Cheyava Fall, which issues from a large cave, and like the others, cascades steeply down to a canyon.

Because of the esthetic appeal of a waterfall, thousands of park visitors make trail-trips to out-of-the-way places to enjoy what the parks offer in falling water. Fortunately the earlier threats that some would be used as power sites have faded, and we can look forward to an unmarred Vernal in Yosemite, and an unharnessed Yellowstone Fall in its colorful setting. This is because the government has appreciated scenic values above economic use, and has protected many superlative ones in the national parks for the benefit and enjoyment of the people for all time.

WATERHOLES FOR WILDLIFE

By Carlock E. Johnson,
Park Ranger,
Carlsbad Caverns National Park.

"Say Ranger, what do you raise in this country besides dust and cactus?" This question was asked of me one day by a visitor in one of our Southwestern national parks. I explained to him that this country had many cattle and sheep ranches, as well as a huge annual crop of cotton. The conversation finally drifted to wildlife in the region. When I mentioned that we had Mountain sheep, deer, and even a few elk in the park, he was considerably surprised, and even a little dubious.

"If those animals live in this country, they sure must walk a long ways in trying to rustle a square meal," he said.

That evening I counted twenty-eight mule deer on a six-mile drive through the park. As I rode along, I thought of the gentleman from Michigan and wished that he could be with me. If those deer couldn't speak for themselves, then he was beyond conviction.

There is much wildlife in our Southwestern national parks and monuments. The wildlife report book in the office is full of reports on deer, coyote, fox, ring-tailed cat, quail, squirrels, song birds, and badger. Many other parks include antelope, elk, bear, and small game among their wildlife census. All of this leads to the subject of game management and its subsequent problems.

In this region one of the most important factors governing wildlife distribution is water. In an area which has an annual rainfall of from ten to twenty inches each year, there is certain to be a scarcity of permanent streams and springs. Man may pipe his water from the mountains. He may sink wells to supply water for his stock. But the wildlife must be dependent upon frequent favors of nature, which are often unreliable. Such rains as do fall here usually are heavy and of short duration, resulting in a heavy surface run-off from the surrounding hills. These rains are often followed by several weeks of hot and dry weather. If some means were available for conserving this surface run-off, it would be a valuable asset to assist in relieving the drain upon the permanent springs in the area. In the case of browsing or grazing animals, the distance which they may forage is directly controlled by the available water supply. The amount of water needed by an animal is in turn governed by factors such as exercise, temperature, and type of food consumed.

Experiments made with deer in the Southwest have shown that where air-dry foods are consumed in the Spring and Fall, the average animal requires one and one-half quarts of water for each 100 pounds of live weight each day. In cases where succulent vegetation is being consumed,

this amount of required water is considerably reduced. They also require at least 2.2 pounds of air-dry feed each day for every 100 pounds of live weight. This is the minimum required to maintain weight and vigor.

Lack of accessible water results in a heavy concentration of animals within the vicinity of the available water holes. When this happens, the area soon becomes over grazed with a consequent depletion of the more palatable grasses and shrubs. Yet a few miles away, there may be many acres of excellent forage, which is not being used because there is no water within a traveling radius. Development of a water hole in this area would tend to decrease the population of the over-grazed portion and at the same time would increase the carrying capacity of the total area. It would be possible in many cases to double the wildlife in areas with less damage to the range itself, by a judicious location of these water supplies.

National parks serve as wildlife sanctuaries for several reasons: (1) To give the public a chance to observe this wildlife in its natural habitat. (Many a small boy's eyes have grown as large as saucers while he watched a huge Grizzly bear shambling through the woods!) (2) To preserve species and prevent extinction of these birds and animals, such as the Trumpeter Swan, Bison, Mountain Sheep and Grizzly Bear. (3) To form a nucleus for breeding stock where the wildlife may propagate without interference by man. These offspring in many cases will in turn gradually migrate from the parks and monuments to the surrounding areas, thus furnishing a continuous supply of game for the sportsmen of that area. It is, therefore, to his advantage to observe the boundaries of these wildlife refuges. Such cooperation is usually gladly given by sportsmen's organizations.

There are several methods of improving and constructing waterholes. In the case of permanent springs, the water is there. The main problem is to conserve it and obtain the maximum benefit from it. Enlarging the basin of the spring is practical, but in many cases should be discouraged, especially on occasions where blasting would be necessary to enlarge the pool. Disturbance of the water channels by blasting often results in diverting the water back into subterranean passages and causes a subsequent drying up of the spring. Placing a covering over the springs and piping the overflow to a prepared pool is one means of solving the problem. This prevents trampling of the banks and allows the water source to remain pure and free from trash and other defilement. The basins may be of several types. Earthen receptacles made by scooping out shallow pools are the most economical. The chief disadvantage is that considerable water will be lost by soil absorption. This may be partially overcome by laying a concrete flooring in the bottom, or by covering the basin area with a layer of powdered clay or silt mixed with gravel and puddling it. Concrete basins are much more expensive and often will not blend into natural surroundings. Small dams may be erected

in the small gullies or canyons, which would serve as storage reservoirs for the overflow, in case excavated basins were not desired. In this way, it is possible to receive the maximum benefits from this meager supply of permanent water. This alone will not solve the problem. There must be some other source of water. Springs and streams are far apart in most of this region. If a plan could be devised to retain some of this lost rainfall, the problem would be partially solved. One of the most practical solutions appears in the form of earthen or stone and earth dams. Dams of the suggested type would conserve a great deal of this water if they were judiciously placed in the canyons and small ravines. Earthen dams are the most simple, economical and practicable type to construct. They may be constructed with materials found near at hand. The only appreciable cost will be that of the labor. CCC projects may be the answer to this. Clay, or clay loam, is an excellent material, if it contains enough gravel to prevent shrinking and cracking when it becomes dry. This may be eliminated by mixing gravel in the clay at the time the dam is made. These dams should be placed in carefully selected sites. There will be some water lost by seepage, evaporation and overflow. Every effort should be made to keep this at a minimum. Any advantages of natural topography should be utilized whenever possible. The water which is retained by the barriers will not form a permanent supply. It will, however, in many cases last several weeks. This will enable the animals to forage these areas for a portion of the year, where in previous times they were unable to do so. As a result, the population in the vicinity of the permanent springs will be decreased and spread more evenly over the entire range, and the carrying capacity is increased proportionately.

When planting is advisable, the following sources of browse for deer may help in deciding the species to use: The three live oaks, (Quercus oblongifolia, Q. Emoryi, and Q. arizonica) Mulberry, (Morus microphylla) and both of the hackberries (Celtis pallida, C. reticulata) are very good forage. Aspen (Populus tremuloides) serves very well. Among the shrubs, Mountain mahogany and both Eriogonum (wrightii) and Hydrangea (Fendlera rupicola) are commonly used. The Eriogonum is especially important as a source of food for large game animals in Arizona. During the succulent stage, portulacas, morning glory (Ipomea, spp.), plantains, pigweeds (Amaranthus spp.) and filaree are very excellent sources of feed. Filaree is especially suited as a winter feed. Mistletoe (Phoradendron macrophyllum) is a good year long feed. These may all be used to advantage to increase the palatability of the range. The whole basis of this plan is to increase the amount of wildlife which the park or monument is capable of supporting, without subsequent damage to the sources of food supply. There is no assumption that nature balance will be destroyed.

FRANK PINKLEY

IN MEMORIAM

Superintendent Frank Pinkley suddenly passed away as the result of a heart attack in his Southwestern National Monuments headquarters in Casa Grande National Monument, Arizona, on February 14. Death occurred almost immediately after he had concluded the opening address in a three-day meeting he had called of the custodians who worked under his supervision in maintaining and operating twenty-seven national monuments in Arizona, Colorado, New Mexico, and Utah. He had said, in opening the meeting for which he had been planning for several years: "This is one of the red letter days in my life."

"The Boss", as he was known to his many intimates throughout the Southwest, was 58 years' of age. He had been in the service of the Federal Government for more than 35 years, originally in 1901, as Custodian of the Casa Grande Ruins when that area was administered by the General Land Office. Those were the days when he lived out in the open desert in a tent, carried a six-shooter, and rode to town in a buckboard wagon for his supplies. He interrupted his Government career to serve one term in the Arizona Legislature and later to operate an Indian trading post. When the National Park Service was organized in 1917, with jurisdiction over historic and scientific areas, Mr. Pinkley was appointed Superintendent of the Southwestern National Monuments. He developed that organization into one of the most efficient of federal agencies.

He was an authority on the history of the Southwest and possessed a wide and sympathetic knowledge and understanding of the Indians. He pioneered in the development of many services for visitors to the monument areas and worked out practical and interesting plans for museums and exhibits. He was widely known for his writing, particularly his "Ruminations" contained in the monthly report distributed by his organization. To most of those who know him, he was more than an individual-he was something of an institution.

Funeral services for Mr. Pinkley were held near the ruins in Casa Grande National Monument, and he was buried in the nearby town of Florence. Surviving him are his mother, Mrs. Nancy Graham Pinkley, of Casa Grande; a daughter, Miss Nancy Pinkley, of Tucson; and a son, Addison Pinkley, a student at the University of Arizona.

HEATING THE HOT SPRINGS

By H. W. Lix,
Acting Park Naturalist,
Hot Springs National Park.

Practically every visitor who comes to Hot Springs National Park, Arkansas, is curious about the origin and mechanics of the hot springs. Until several centuries ago, supernatural agencies were credited with responsibility for such phenomena as large streams of hot water gushing out of the earth. Evil monsters were a favorite explanation of incomprehensible occurrences in nature. Later, the water of springs, and expecially of hot springs, was believed by many to be forced up by the winds produced by immense subterranean fires. Misconceptions of volcanoes gave credence to this idea of fires beneath the earth's surface. Today, with the development of geology, we know that hot springs may have one or a combination of various sources of heat. By interpreting the nature and relationships of rocks and their fossil and mineral contents, in the light of what is happening on the earth's surface today, geologists have gradually pieced together a remarkable geological history of the earth that extends back immense ages of time. An explanation of the hot springs logically begins with a summary of the geological history of this region, including the processes that eventually produced our present topographical features.

Hot Springs National Park is in the Ouachita (Wash-i-taw) Mountains of the Interior Highlands. This mountain system extends from Little Rock, for about 220 miles westward into Oklahoma. The average width is about 50 miles. The novaculite uplift portion of the Ouachita Mountains is divided into a series of seven mountain ranges and four wide flat intermontane basins in which flow the larger streams. One of these ranges, known as the Zigzag Mountains, contains Hot Springs National Park. Adjacent to the park on the southwest, and extending into it in the valley between West Mountain and Hot Springs Mountain, is the Mazarn Basin.

All of the rocks of the Ouachita Mountains, with the exception of several igneous intrusives of moderate extent, are of marine sedimentary formations. They were deposited as sediments of the floor of a sea during the Paleozoic era of geologic time. During most of the Paleozoic era, this present mountainous region was submerged by the waters of the Ouachita Embayment which was a westward-extending arm of the Appalachian geosyncline, an ancient sea located roughly between Louisiana and New Hampshire. To the south of this gradually sinking Ouachita Embayment area of western Louisiana, Texas, and southern Arkansas and Oklahoma, lay the land of lofty mountains known as Llanoris. The eroding rocks of northern Llanoris were carried northward by rivers and streams into the Ouachita Embayment and deposited there as gravel, sand, mud, and chemical precipitates. Throughout the hundreds of millions of years believed to have passed during the Paleozoic era, these sediments continued to accumulate until they reached the remarkable thickness of over 30,000 feet. This deposition all occurred in comparatively shallow water, accompanied by a gradual corresponding sinking of the ocean floor.

In late Pennsylvanian time there came a period of mountain-making. Compressive forces from the ocean to the south and southeast were applied against the thick sediments and raised their surface above sea-level. In this elevation, the rocks were compressed so severely that they now occupy but one-half their original surface area. A width of 100 miles or more was reduced to the present average 50-mile width of the Ouachita Mountains. This compression produced a series of folds, or anticlines and synclines. Where they were unable to withstand the strain produced by the enormous pressure, the rocks fractured, and often adjacent masses moved up and down, respectively, along the break, or fault plane.

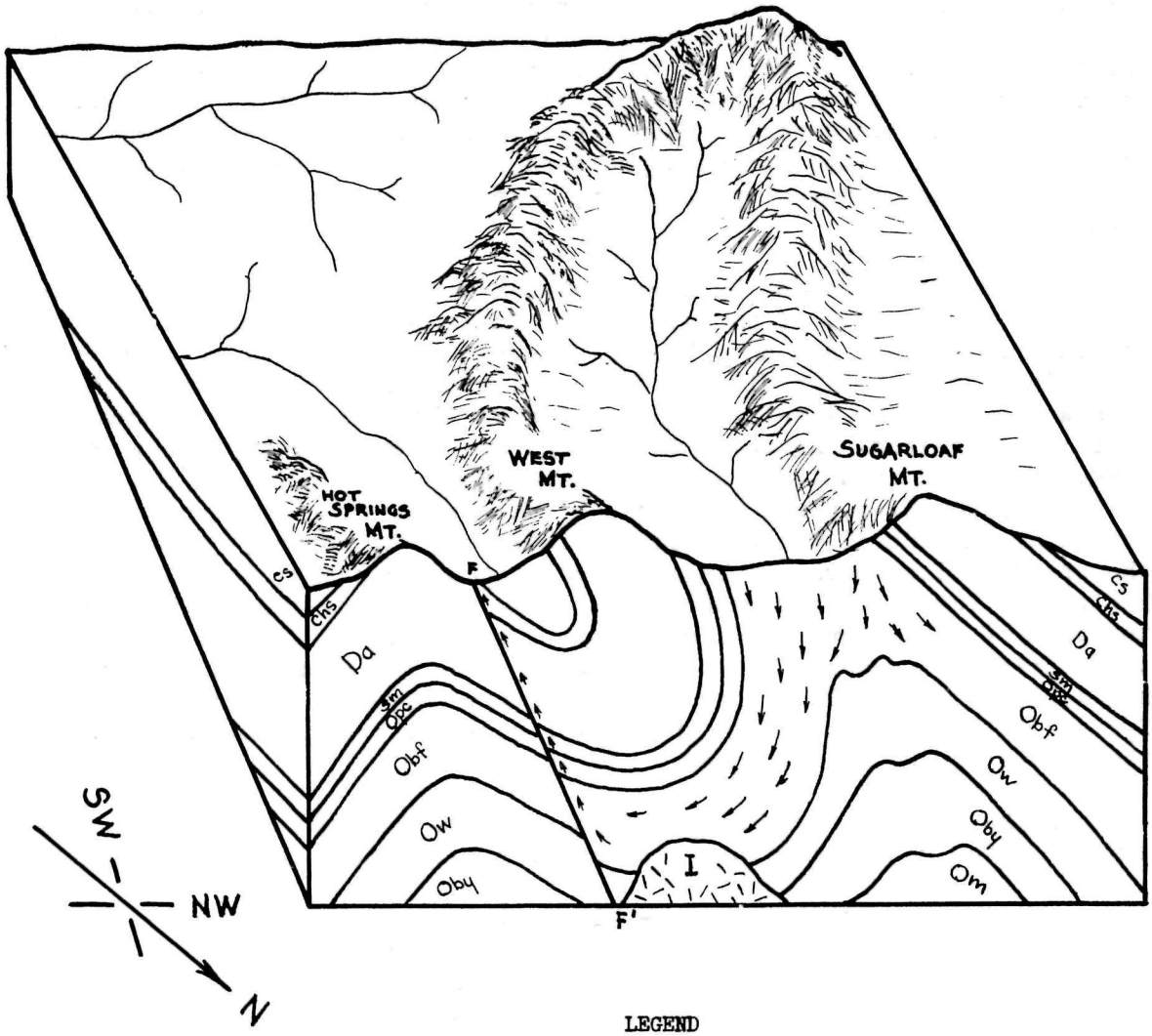
The rocks of the Hot Springs district have remained above sea-level during most or all of the time since their emergency near the end of the Paleozoic era, and have been subjected to subaerial erosion from that time. This erosion did not proceed steadily. At least twice, this area was reduced to low-lying land of such low relief that erosion practically ceased. Areas at this stage are known as peneplains. There always followed an uplift, which resumed the erosion process. The first of these peneplains, now evidenced by the higher mountain crests, occurred at the end of the Jurassic period; and the second, evidenced by the present intermountane basins, developed in early Tertiary time. Horizontal layers of sediments beneath an inland sea were lifted many thousands of feet above sea-level, compressed and folded into one- half their original space. The lofty ridges were cut down until they are now valleys. This is a part of the history of the hot springs of Hot Springs National Park. With this brief geologic background, the springs themselves can be discussed more easily.

In the immediate vicinity of Hot Springs National Park, the following seven rock formations, with their respective ages, are found:

Stanley shale - Mississippian
Hot Springs sandstone - Mississippian
Arkansas Novaculite - Devonian
Missouri mountain shale - Silurian
Polk Creek shale - Silurian
Bigfork chert - Ordovician
Womble shale - Ordovician

The relative positions of these formations and their pertinent structure are shown in the accompanying diagram. This drawing includes the hypothetical hot igneous intrusive and is adapted for illustrating the theory outlined below.

It is believed by probably the majority of geologists that the highly fractured Bigfork Chert formation is the aquifer upon which rain water falls and flows between the collecting area and the spring outlets. The Womble shale below, and the Polk Creek shale above, retain the water within the chert formation. Analysis of the hot spring water would indicate that the water is at least chiefly meteoric (rain)- in origin. The minerals in solution, with possibly one exception, are those which would be expected in rain water that has flowed through



LEGEND

I - Hot igneous rock.
FF'- Fault.
→ - Water.

Cs - Stanley shale.
Chs- Hot Springs sandstone.
Da - Arkansas novaculite.
Sm - Missouri Mountain shale.
Opc- Polk Creek shale.
Obf- Bigfork chert.
Ow - Womble shale.
Oby- Blakely sandstone.
Om - Mazarn shale.

rocks of the kind that occur in the spring area. Furthermore, the geologic structures required by the meteoric theory seem to be present.

From the collecting area, the water flows southeastward in the Bigfork formation beneath the lowest part of the trough of the fold (syncline) which lies below West Mountain. The water is then forced upward by hydrostatic pressure along the western part of the upturned fold (anticline) which makes up Hot Springs Mountain. The springs emerge from the base of the Stanley shale and the top of the Hot Springs sandstone. This requires the water to pass through the Polk Creek shale, Missouri Mountain shale, Arkansas Novaculite, and most of the Hot Springs sandstone. The logical assumption is that this transfer is accomplished along a crack, or fault, at the site of the springs. Indications are favorable for the existence of this fault.

The abnormally high temperature of the spring water is its most unusual characteristic. To account for the source of heat, we must rely on hypotheses because of a lack of any definite diagnostic criteria. The generally accepted belief today seems to be that the spring water, somewhere in its underground course, passes near a hot igneous intrusive that has not been exposed at the earth's surface. Possibly the water is heated chiefly by rising hot vapors emanating from this cooling mass of igneous rock. This possibility is supported by the trace of boron which has been found in the water. Steam would be a principal constituent of these vapors and in condensing would add to the meteoric water of the springs. Some geologists attribute all or most of the water to this juvenile source. It may be that the water merely approaches near enough to the buried igneous mass to heat the water by conduction and convection.

There are several areas of exposed igneous rock and numerous dikes in the vicinity of Hot Springs National Park. These are supposedly related to the larger intrusives. This igneous rock material is believed to have been intruded into the sedimentary formations near the end of the Lower Cretaceous epoch. Presumably any heat of such ancient igneous activity would have been dissipated before now. Consequently, it is not maintained that the exposed igneous masses represent a part of the identical magmetic body which supposedly heats the spring waters. Probably the chief objection to this theory explaining the origin of the springs is the apparent inadequacy of the collecting basin to supply the large volume of water which the springs produce. The fact that part of the collecting area has an elevation lower than that of some of the springs has also been used as evidence against this theory. However, it has not been shown that an adequate supply of water at sufficient elevation does not exist.

It has been suggested that subterranean chemical activity produces the heat, but this is not borne out by analysis of the water. It would be expected to find unusually large amounts of mineral matter, or minerals different from those ordinarily extracted from the containing rocks by solution in water. Radioactivity has also been repeatedly suggested as a source of heat. There has been no definite evidence to substantiate this hypothesis. The amount of radioactivity of the water is not very large, and there is no correlation between the temperatures

and amounts of radioactivity found in the different springs. Compression of rocks during periods of intense stress, such as obtains during periods of mountain-making, produces heat, but any such connection between the hot springs and the orogeny of this region is too remote.

The temperature of the earth increases with depth. Assuming an average thermal gradient of 1° Fahrenheit for every 65 foot descent, and assuming a mean atmospheric temperature of 60° Fahrenheit, the line of flow of water would have to descend almost 5,400 feet, or over a mile. Allowing for a certain amount of cooling in ascending, this depth would be increased considerably. This hypothesis is generally mentioned merely as a possibility.

The group of hot springs which are extensively used for bathing, is the chief feature of Hot Springs National Park that attracted more than 175,000 visitors last year. The hot waters are generally believed to possess curative properties for the treatment of various diseases. Approximately 750,000 baths are administered annually by the bathhouses licensed to use the hot springs water. There are forty-seven known springs, including two hot wells. The total flow of hot water is approximately 1,200,000 gallons per day. The temperature varies from about 112,5 degrees to 148 degrees Fahrenheit, with an average of about 143 degrees. Generally classed as "mineral springs", the hot springs produce remarkably pure water. The amount of mineral matter in solution varies with individual springs from 231 parts per million to 310 parts per million, with an average of about 280 parts per million. The following, in parts per million, is an analysis of a typical sample of the hot water:

Silica (SiO_2)	45
Iron (Fe)	.05
Manganese (Mn)	.26
Calcium (Ca)	46
Magnesium (Mg)	5.8
Sodium (Na)	5.1
Potassium (K)	1.6
Bicarbonate (HCO_3)	165
Sulphate (SO_4)	9.1
Chlorine (Cl)	2.1
Fluoride (F)	0
Nitrate (NO_3)	0
Total dissolved solids	280.0

Gases in cubic centimeters per liter at 0 C. and 760 millimeters pressure: Nitrogen (N), 8.8; oxygen (O), 3.8; free carbon dioxide (CO_2), 6.9; hydrogen sulphide (H_2S), none. Radioactivite, 0.45 millimicrocurie per liter.

The forms of combination of the most abundant constituents are calcium carbonate ($CaCO_3$) and silica (SiO_2). Considerable thicknesses of these minerals, making up the rock known as tufa, were deposited around the vents of the springs. The hot water has also been found to contain measurable amounts of the radioactive gas known as radon. The

amount of this gas varies considerably between different springs. This radioactivity varies from fiftytwo one-thousandths of a millimicrocurie per liter to nine and one-tenth millimicrocuries per liter, with an average of forty-six hundredths of a millimicrocurie per liter. Some of the tufa was found to contain a small amount of radium. The effect of this radioactivity from a medical standpoint has not been determined.

Hot Springs National Park consists of approximately 1,000 acres of steep mountain ridges attaining an elevation of 1,200 feet above sea-level, and narrow V-shaped valleys having an elevation of 600 feet above sea-level. The springs are in an area of about twenty acres at the base of one of these ridges known as Hot Springs Mountain. The geology has been studied in detail by various geologists. Further clarifying data could possibly be derived from deep drilling and a study of the rainfall in the collecting areas, and of the course of underground water movement in the relevant rock formations.

This discussion has been an interpretation of various references published on the subject. The following bibliography will indicate the sources of the general information for this paper:

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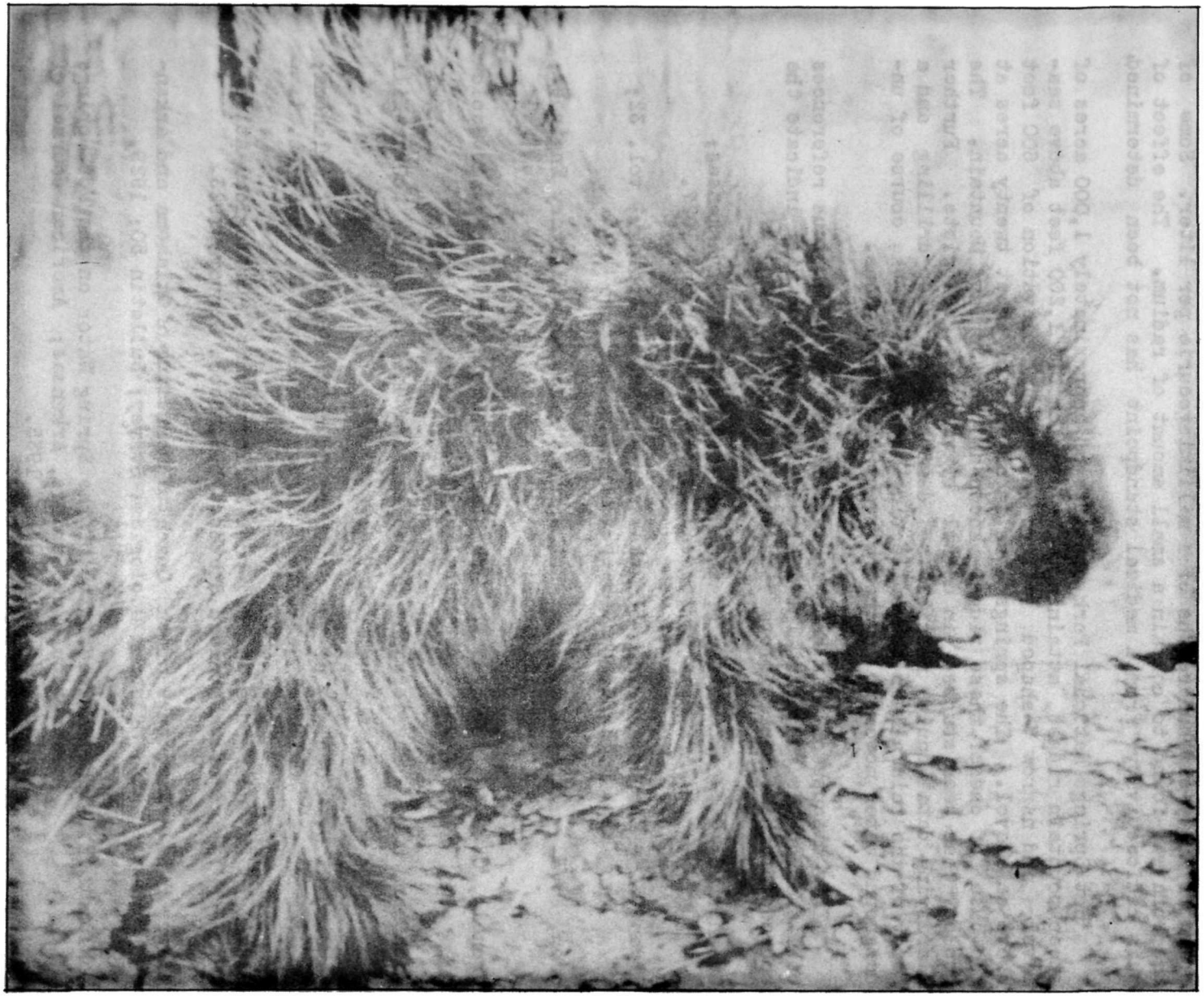


NOBODY LOVES HIM

PORCUPINES

By William R. Supernaugh,
Custodian,
Organ Pipe Cactus National Monument.

The porcupine is found in nearly all the forested areas of the United States, and is probably seen by more people than is any other animal, with the exception of the small rodents. In spite of this, he probably has been studied less than other creatures. In some areas porcupines are protected by law, while in other sections people have been encouraged to kill them on sight. No other animal is so well equipped by nature for defense against his animal enemies, and he has a sublime trust in that protection. The entire upper part of the body is covered by quills, nearly as thick as the hair. The quills range from one-quarter of an inch to two inches in length; they are very sharp at the end and are covered behind the points with hundreds of tiny barbs. These barbs make the quills difficult to extract and when broken off, they will work their way entirely through the flesh. Stories told about the porcupine "throwing his quills" are not true. This fiction results from a person being struck by Porky's tail, which is switched with lightning-like suddenness -- and woe to anything in its way.

Due to his natural protection, the porcupine's mental qualities have not been developed. He is perhaps the dullest of all wild animals. When attacked he will not run, but will just lie flat with his nose between his front feet, trusting in the quills to do the rest -- and this is usually plenty. The only animals that have solved the problem of safe attack are the fisher and the fox. These will dive under the porcupine to slash at his unprotected abdomen. Although the porcupine is primarily a vegetarian, he will go to almost any extreme and face any danger to get salt. Many an inexperienced camper has found this out to his sorrow, in discovering that his saddle or tool handles had been gnawed during the night. On one occasion when I was camping near timberline, a porcupine walked across my bed. That was the one time that I thought there were elephants in the high country, for you can imagine a lot of things when awakened from a sound sleep by about fifty pounds of porcupine.

The porcupine has come in for much criticism because during heavy winters he is forced into the trees, and at times girdles them to the extent of killing them. In open seasons he will eat almost any sort of vegetable matter but the main diet in winter is bark. It may be that now and then he will kill a tree of commercial value, but it has been my observation that he will seek the small, heavier growth in the forests. In Canada the government protects porcupines. In some districts of this country an unwritten law protects them, so that people lost in the woods may obtain food. A porcupine can be killed with a stick, but he doesn't provide a very palatable dish.

Recently a resident down here said he had found a porcupine on the edge of Ajo. This was over 100 miles from the known range, but he had photographs to prove it, so my problem now is to find out whether there are porcupines native to this area, or if that one just wandered down here to pose for a few pictures.

PEOPLE OF THE PETRIFIED FOREST

By Erik K. Reed,
Regional Archaeologist.

The rather desolate, but very fascinating, area now constituting Petrified Forest National Monument, located on both sides of U.S. Highway 66, just east of Holbrook, Arizona, was occupied by prehistoric peoples over a period of almost 1,000 years, though already long deserted when first seen by white men. Prehistoric Pueblo Indians, probably ancestors of the modern Zuni, lived in and around the Petrified Forest from an early period, probably before A.D. 500, to about A.D. 1400. These dates, and continuancy of occupation between them, are not established by direct tree-ring dates from archaeological sites in the Petrified Forest, but by an equally dependable method: the occurrence of varieties of prehistoric pottery whose time-span is known, from tree-ring dates, in other areas of northeastern Arizona.

The earliest known occupants of the Petrified Forest lived in small, scattered villages of circular pit-houses or slab houses -dwellings consisting of shallow excavations in the ground, lined with stone slabs and covered over with more or less dome-shaped walls and roofs of poles, brush, and mud. Later they lived in numerous small settlements of rectangular rooms on the surface built of rough masonry. In the last phases of occupation, these little scattered villages were replaced by a few relatively large towns, such as the one to be seen beside the ranger station south of the bridge over the Puerco River. This site, known as the Puerco Ruin, consisted of small oblong rooms arranged in a hollow square about 230 by 180 feet, around a plaza, approximately 185 by 130 feet. This village was probably two-storied, and could have comfortably housed over 100 families. The Puerco ruin was occupied from the sixth or seventh century into the fourteenth century, judging by the types of pottery found in it. There are three other sites occupied in the fourteenth century within Petrified Forest National Monument, but the Puerco ruin is the only one which was occupied continuously from "Basketmaker III" times (the sixth and seventh centuries) into early "Pueblo IV" (the fourteenth century). Two of the other, smaller, late sites within the monument were not established until the twelfth or early thirteenth century, as was also the very large late site at Wallace Tank just outside the monument's eastern boundary. The fourth late site seems not to have been founded until the middle or late thirteenth century.

The seventy-odd other sites within Petrified Forest National Monument were established and abandoned at various times between A.D. 500 and A.D. 1250. They fall into three main groups on the basis of time-periods as distinguished by pottery-types: sites occupied during "Basketmaker III" times and abandoned about or before A.D. 700; sites occupied in "Pueblo II" and abandoned about or before A.D. 1100; and sites occupied during early and middle "Pueblo III" and abandoned by A.D. 1250. Many of the "Pueblo II" and "Pueblo III" stone villages were built

over the remains of "Basketmaker III" slab-houses; and many sites yield both "Pueblo II" and "Pueblo III" potsherds, evidently having been more or less continuously occupied from the tenth century to the late twelfth or early thirteenth. There were thirty-four "Basketmaker III" pit-house villages, almost certainly not all occupied at the same time, in the Petrified Forest. Exactly half of these sites were permanently abandoned before or in the eighth century and never reoccupied, so that there are seventeen pure sites of this period. In the tenth and eleventh centuries, there were twenty-eight "Pueblo II" settlements, of which twelve were built over "Basketmaker III" sites, and sixteen were at locations not occupied by earlier groups. Eighteen "Pueblo II" sites did not continue into the twelfth century, but thirty-one new villages were founded during "Pueblo III", five of these being located on top of "Basketmaker III" sites. Ten of the "Pueblo II" sites had continued into the twelfth century, giving a total of forty-one "Pueblo III" sites. As had been mentioned above, only four of these settlements lasted into the fourteenth century. Probably only a small number of villages were occupied at any one time. Almost half of the "Pueblo III" sites and more than half of the "Pueblo II" sites were very small, seemingly temporary settlements -- a few houses or shelters, probably occupied only during the farming season. There may have been only about ten permanent pueblos occupied at any one time during these periods.

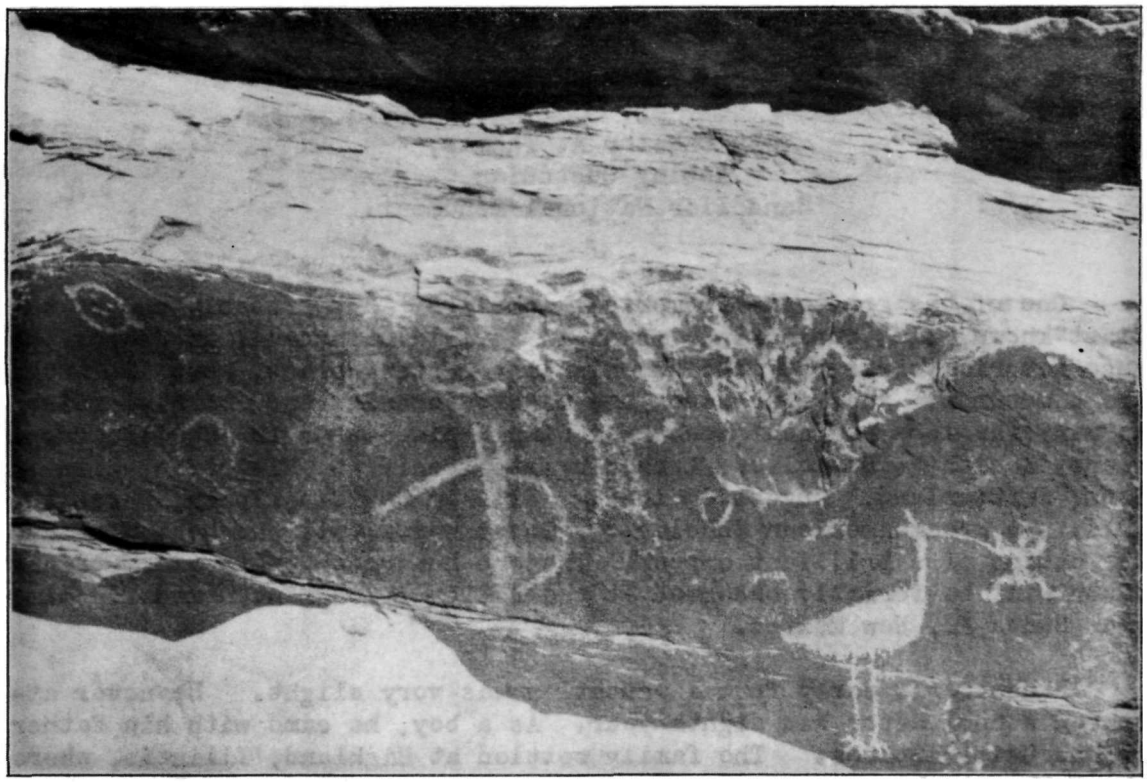
The "Pueblo I" period has hitherto not been mentioned in this discussion. This is because "Pueblo I", ordinarily coming in the time from 700 to 900, does not seem to be a distinct period in the Petrified Forest area. "Pueblo I" black-on-white pottery occurs sparsely, in only ten sites, so far as known -- all of them primarily "Pueblo II" sites except two which are Basketmaker-type sites evidently not abandoned until after 700. Virtual depopulation of the area for 200 years seems surprising; possibly, trade with peoples to the northwest and northeast, for the black-on-white pottery by which these sites are classified according to period, decreased sharply during these two centuries. There is also the possibility in connection with the second suggestion, of relative immobility of population, or, in other words, that these sites at which Pueblo I black-on-white potsherds have been found were continuously occupied by small groups during the period in question. It is believed that all, or virtually all, of the black-on-white wares (and also, after 1100, certain other varieties of pottery) were received by the people of the Petrified Forest through trade. The local ceramic production seems to have been exclusively or primarily brownware, plain brown, red slippered, and smudged, developing into black-on-red, and brown corrugated types. This group of brown pottery is similar to brown and red pottery found primarily further south, in the forested mountain country of the Mogollon Rim. This ceramic complex, with accompanying traits, has been designated the "Mogollon Culture"; and the people of the Petrified Forest, or at least their pottery, would thus seem to be originally of Mogollon affiliation. The black-on-red and corrugated types developed because of influence from the Pueblo area proper to the north and northeast. Pueblo influence may have included actual immigration of peoples; in the "Basketmaker III" sites, the gray Pueblo pottery approximates in quantity the brown Mogollon pottery. Pottery,

of the types mentioned, was made by these prehistoric Indians during the nine or ten centuries of occupation of the area, steadily improving in quality, with changes in techniques and styles. Stone and bone implements were made and used; cultivation of corn, pumpkins, and beans, was practiced, supplemented by hunting of wild game and gathering of wild plants. The prehistory of the Petrified Forest follows closely that of the northern Southwest as a whole, in general outlines and in many details, aside from the southward affiliation of the pottery.

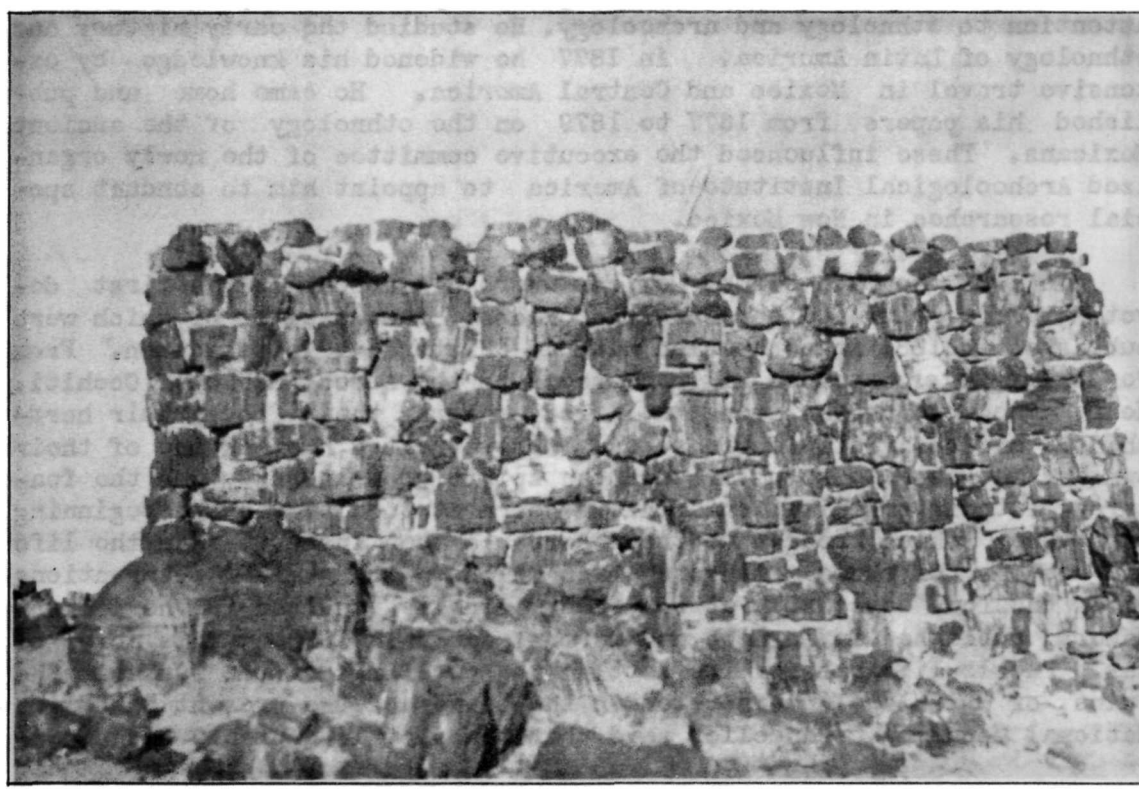
Three features of Petrified Forest archaeology, however, are of unusual interest. First, and least unusual, is the relatively dense prehistoric occupation of a now desolate area by a farming people who had no well-drilling rigs. The explanation of this phenomenon here, as in many other areas of the Southwest, is not a great climatic change, but rather the fullest utilization by the skillful and practical Pueblos of the springs along the low escarpments framing the area, which dried up or decreased because of very minor climatic changes. It is not unlikely that Pueblo Indians could have supported themselves in the area, in small numbers, during most of the time since final abandonment in the early fifteenth century. This abandonment may have been due to Apache inroads, as much as to drought or arroyo-cutting. This idea is supported by the fact that most of the few fourteenth-century sites are in naturally defensible locations; the one late site within the monument not so situated is a small one, probably a seasonally occupied farming village. The great decrease between 1250 and 1300, however, probably was due to the great drought of 1276-1299.

The second interesting feature is the occurrence on the low cliffs of brown sandstone around the northwest margin of the Petrified Forest proper, south of the Puerco River, of an unusually extensive series of petroglyphs, geometric and naturalistic designs cut into the rock by these prehistoric Pueblo Indians. Among the most striking of these rock-engravings is a very realistic picture of a heron eating a frog (formerly described as a "stork bringing a baby"). There are a number of petroglyphs on the low cliffs beside the Puerco ruin, and presumably they were made by the inhabitants of that town. One of these is a very fine reproduction of a geometric design such as is frequently used in decoration of textiles. Petroglyphs and pictographs can seldom be "interpreted", and often they have no "story" to tell. In many cases they are probably the clan symbols of passersby.

The third feature of interest is the utilization of the petrified (silicified, agatized) wood as material for house-building and for arrowpoints. Arrowpoints made from agate chips from petrified logs are found occasionally in various archaeological sites in northeastern Arizona, and probably they come from the Petrified Forest. In a few instances, stone houses in the southern portion of the present national monument were built of chunks of silicified wood. One of these, Agate House, was partially rebuilt in 1934.



PETROGLYPHS



AGATE HOUSE

BANDELIER'S CENTENNIAL

By Chester A. Thomas,
Acting Custodian,
Bandelier National Monument.

One of the greatest of American scholars, and probably one of the least known, lies buried in a crypt in Seville Cathedral, in Spain. No huge memorial marks the site of his last resting place, but his works are a monument that overshadow the massive bronzes and marbles raised to many far less eminent men. A simple plaque on the Seville Crypt reads: "Adolph F. Bandelier, Archeologist, Archivist, Historian, Born in Born, Switzerland, August 6, 1840. Died in Seville, Spain, March 18, 1914. A great American Scholar." These words tell the beginning and the ending of a brilliant career. The one-hundredth anniversary of his birth will be formally observed at the national monument named for him, near Santa Fe, New Mexico.

Bandelier's early formal education was very slight. He never attended school after his eighth year. As a boy, he came with his father to the United States. The family settled at Highland, Illinois, where the father took up banking. In 1856, young Adolph went to Bern, where he studied geology under Professor Studer of Bern University. The young man who returned to Illinois joined his father in banking and mining enterprises, but soon found that the humdrum of business in a small midwestern town was not to his liking. Always a student, he turned his attention to ethnology and archeology. He studied the early history and ethnology of Latin America. In 1877 he widened his knowledge by extensive travel in Mexico and Central America. He came home and published his papers from 1877 to 1879 on the ethnology of the ancient Mexicans. These influenced the executive committee of the newly organized Archeological Institute of America to appoint him to conduct special researches in New Mexico.

In 1882 he came to New Mexico where his attention was first devoted to the ruins of the Pueblo of Pecos, the results of which were published in 1881 in connection with an "Historical Introduction." From Pecos, Bandelier extended his researches to the Keres Pueblo of Cochiti. He remained two months among the Keres, sharing their food, their hardships, and their simple pleasures. They treated him as one of their own and he was able to understand the spirit of fraternity and the features of their organization. This sojourn at Cochiti was the beginning of several which brought to the observer a keen insight into the life and customs of these villagers, and which, with similar observations among the Tewa especially at San Juan, finally resulted in The Delight Makers, published in English and German, early in 1890. This novel of early Pueblo life has for its setting the dwellings of the Tyuonyi, the ruins of which are incorporated in the bounds of the present Bandelier National Monument. Bandelier said that the plot is entirely his own,

but his characters are real Indians. He knew the Keres and gained their confidence. He believed that only by presenting ethnologic studies in the guise of fiction, would his writings be read by laymen.

Bandelier temporarily suspended his New Mexico investigations to join in the researches of the Lorillard expeditions to Mexico and Central America, under Desire Charnay. Charnay had already disbanded and returned to France, but Bandelier proceeded to Cholula where he spent four months studying the famous pyramid and the customs and beliefs of the native inhabitants. In March of the following year he was again among the Pueblos. He continued his studies along the same general lines from 1883 to the winter of 1886, meanwhile making Santa Fe his home in order to be in more immediate touch with the field of his observations. During these years he penetrated almost every corner of New Mexico, southern Arizona, Sonora, and Chihuahua; explored the country even farther southward in Mexico, visiting and describing hundreds of ruins, and surveying and mapping as he went. So hazardous were his journeys that many times he was reported missing, supposedly dead at the hands of the hostiles or of starvation or of exposure. During one of his journeys he was afflicted with smallpox in the two-foot snows of the Manzanos. In 1882 he had a narrow escape from death in a midwinter blizzard in the desert of eastern New Mexico, where two companions perished. His own hardihood enabled him to reach safety after journeying 93 miles on horseback and 35 miles afoot through deep snow.

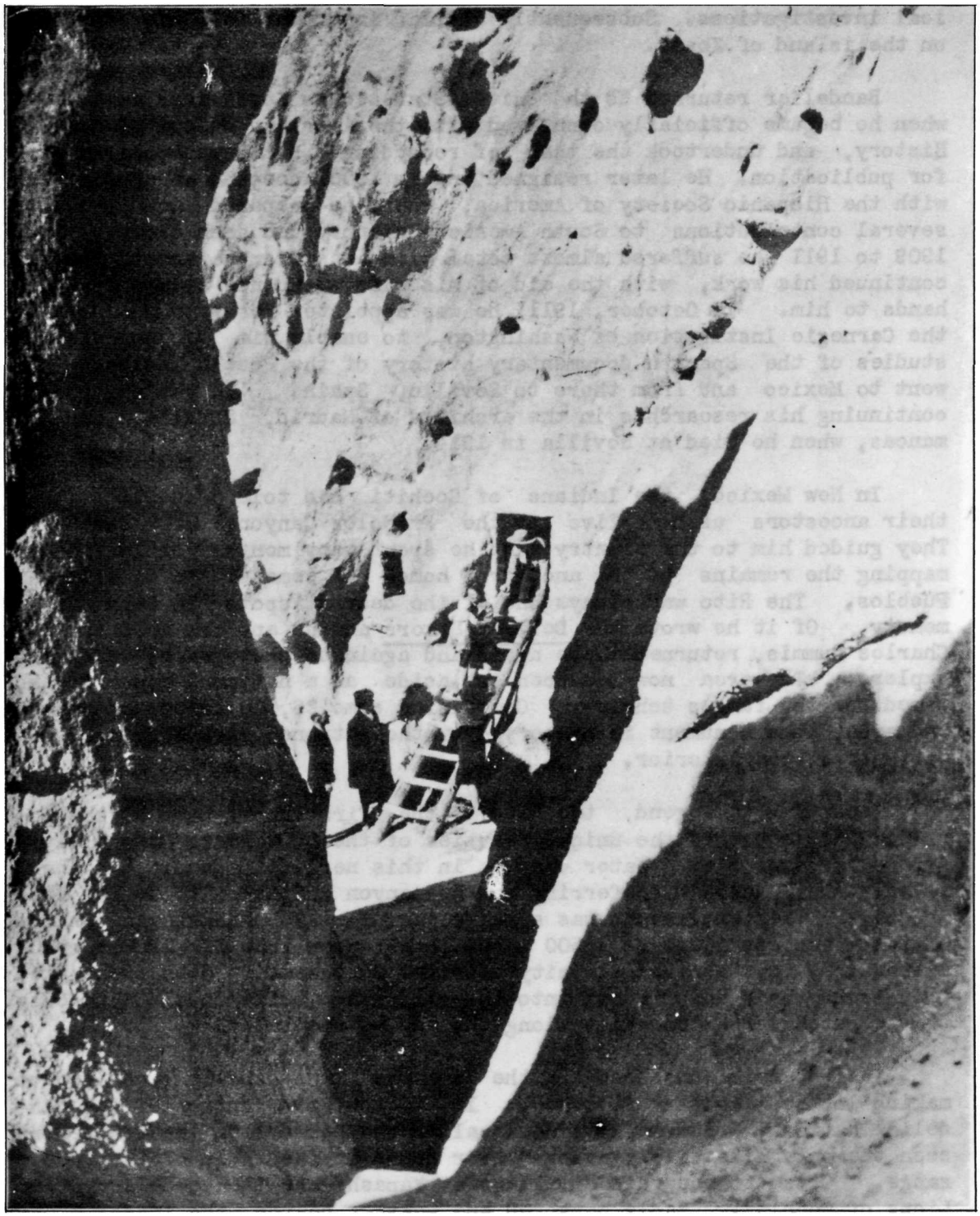
His friend and companion, Dr. Charles F. Lummis, says of their journeys together: "Thousands of miles of wilderness and desert we trudged side by side--camped, starved, shivered, learned and were glad together. Our joint pursuits in comfort at our homes (in Santa Fe and Isleta, respectively) will always be memorable to me; but never so wonderful as that companioning in the hardships of what was, in our day, the really difficult fringe of the Southwest. There was not a decent road. We had no endowment, no vehicles. Bandelier was once loaned a horse; and after riding two miles, led it the rest of the thirty. So we went always by foot; my big camera and glass plates in the knapsack on my back, the heavy tripod under my arm; his aneroid, surveying instruments, and satchel of the almost microscopic notes which he kept fully and precisely every night by the campfire (even when I had to crouch over him and the precious paper with my water proof focusing cloth) somehow bestowed about him. Up and down pathless cliffs,through tangled canyons, fording icy streams and ankle deep sands, we traveled; no blankets, overcoats, or other shelter; and the only commissary a few cakes of sweet chocolate, and a small sack of parched popcorn meal. Our lodging was the cold ground. When we could find a cave, a tree, or anything to temper the wind or keep off part of the rain, all-right. If not, the open....He was in no way an athlete--nor even muscular. I was both--and not very long before had completed my 3,500-mile 'Tramp Across the Continent.' But I never had to slow down for him. Sometimes it was necessary to use laughing force to detain him at dark where we had water and a leaning cliff, instead of stumbling on through the trackless night to an unknown 'somewheres.'"

No small part of his ambition was to upset the popular theories respecting the history, archeology, and ethnology of the Southwest. To this end he destroyed the fanciful notions regarding the Aztec origin of various Pueblo ruins, the Montezuma myth among the Pueblos, the age of the city of Santa Fe, the mystery of Quivira and of the Gran Quivira, the locations of the Seven Cities of Cibola, the routes of various early Spanish explorers, and many other fallacious beliefs. He was the first to offer scientific evidence, based on his broad scholarship and remarkable ability in the utilization of source material, to settle the varied problems concerning the condition and range of the Pueblo and other tribes before and after the beginning of the Spanish period.

From time to time Bandelier prepared various accounts of the progress of his investigations in the Southwest, which were incorporated chiefly in the annual reports of the Archeological Institute, although several valuable papers appeared in various periodicals. He contributed brief articles to the Century Cyclopedia of Names and to the Catholic Encyclopedia. His most noted work is the "Final Report of Investigations among the Indians of the Southwestern United States, carried on mainly in the Years From 1880 to 1885." Part I of this work was issued by the Archeological Institute in 1890, and Part II in 1892. Of equal importance, from the historical point of view, is his "Contributions to the History of the Southwestern Portion of the United States", published also by the Archeological Institute in 1890, partly at the expense of Mrs. Mary Hemenway.

In 1886 the Hemenway Southwestern Archeological Expedition was organized under the patronage of the late Mrs. Mary Hemenway, of Boston, and under the directorship of Cushing. Bandelier was selected as its historiographer. During the next three years he applied himself to a study of the Spanish archives relating to the Southwest, not only in Santa Fe, but in Mexico City and elsewhere. On the termination of the Hemenway Expedition in July, 1889, Bandelier's collection of copies of documents, together with a few originals, comprising in all about 350 titles, was deposited in the Peabody Museum of Harvard University. In 1886-88 he prepared, in French, an elaborate manuscript history of 1400 pages, illustrated with 400 watercolor sketches, of the colonization and the missions of Sonora, Chihuahua, New Mexico, and Arizona, to the year 1800. This great work now reposes in the Vatican.

In July, 1892, Bandelier went to Peru to engage in archeological and historical researches under the patronage of the late Henry Villard. These were prosecuted under Mr. Villard's patronage until April, 1894, when the important collections which had been gathered were given to the American Museum of Natural History, and the investigations were continued by and for that institution. Bandelier's field of operations now shifted to Bolivia. He visited the ruins of Tiahuanaco, where many valuable collections were obtained and the structural details of the ruins were studied and platted. Returning to La Paz, he explored the slopes of Illimani, where, at an altitude of 13,000 feet, other valuable collections were gathered from the ruins and burial



HOMES OF PREHISTORIC CLIFF-DWELLERS

cists. In December of the same year, he visited the island of Titicaca, where three and a half months were spent in archeological and ethnological investigations. Subsequently similar important work was conducted on the island of Koati.

Bandelier returned to the United States from South America in 1903 when he became officially connected with the American Museum of Natural History, and undertook the task of recording his South American work for publication. He later resigned and in 1906 accepted an appointment with the Hispanic Society of America, where he prepared and published several contributions to South American history and archeology. From 1909 to 1911 he suffered almost total blindness from cataract, but he continued his work, with the aid of his wife, who now became eyes and hands to him. In October, 1911, he was appointed research associate in the Carnegie Institution of Washington, to enable him to complete his studies of the Spanish documentary history of the Pueblo Indians. He went to Mexico and from there to Seville, Spain. He was engaged in continuing his researches in the archives of Madrid, Sevilla, and Simancas, when he died at Sevilla in 1914.

In New Mexico, the Indians of Cochiti had told Bandelier that their ancestors used to live in the Frijoles Canyon, near Santa Fe. They guided him to the country and he spent many months exploring and mapping the remains of the ancestral homes of some of the present day Pueblos. The Rito was always one of the dearest spots in Bandelier's memory. Of it he wrote the Delight Makers and he and his good friend, Charles Lummis, returned there again and again to photograph, study and explore. The area now has been set aside as a national monument and named for the famous scholar. Comprising some 26,000 acres of canyon and mesa, the monument is preserved by the National Park Service, Department of the Interior.

According to legend, the Rito is the first known home of the Cochiti. It is one of the unique beauties of the Southwest. Lummis says, "There are scores of greater canyons in this neglected land; but there is only one Tyuonyi" (referring to the canyon of the Rito de los Frijoles). The settlement was a large one for the prehistoric United States - perhaps 1,000 to 1,500 people, a figure that likely was never exceeded by any aboriginal "city" of the Southwest. With stone axes they hewed their inner rooms into the cliffs and built little pueblos that stretch serpentine-like along the top of the talus.

Ancient work in stone in the Southwest was usually confined to making little images or fetiches. In the southern portion of the Bandelier National Monument, on a mesa called the Potrero de las Vacas, are seen the only life-size carvings ever found in the whole of the Pueblo range. Close to the ruined village of Yapashi are the so-called Stone Lions of Cochiti. Badly battered and weather beaten, the images today are far from artistic in appearance. Enclosed in a fence of slabs of tuff set on edge, the shrine resembles in shape a great tadpole. The lions are a shrine of the hunting society of Cochiti today and they

figure prominently in Zuni mythology. Not far away is the "Cueva Pintada", or Painted Cave, a natural cavern whose walls are covered with the crude attempts at art of an ancient people.

For some years the policy of the government had been to reserve Bandelier National Monument entirely as a wilderness area and not to encourage travel and development. In time the area became so well known through the medium of magazine articles, books, and scientific publications that public demand for access could no longer be ignored. The lower end of Frijoles Canyon was chosen for modest development. A road, trails, campgrounds, water and sewer system, museum, small hotel, and administration buildings were built by the Civilian Conservation Corps. Fully 90 per cent of the monument is still primitive country through which no roads will be built. Weeks on end can be spent in the solitude of natural areas without meeting a "white man."

Last year 11,000 people visited the monument to see the famous ruins of a prehistoric culture, and to gain rest and inspiration from the climate and scenery. The greatest concentration of population in olden times was in the Canyon of El Rito de los Frijoles (little river of the beans). A deep canyon or gorge cut by the stream rising high in the mountains is a veritable oasis in the dry country of New Mexico. Groves of cottonwoods, alders and box elder grow along the stream-banks, their light green contrasting with the somber green of the pine and juniper-covered slopes. Salmon pink cliffs on both sides lend a more than usual amount of color. Here on the south exposure of the canyon and on the valley floor, drought-stricken and harried people, forced to desert their homes in the Mesa Verde, Chaco Canyon, and Little Colorado regions in the 13th century, found a haven. They brought their Pueblo culture, and the resulting blend led to a culture peculiar to the Rio Grande area. For centuries the pioneer Indian farmers lived in the Rito, built villages, honeycombed the cliffs with artificial caves, and tilled the soil in the valley and on the uplands. After several hundred years, drought, flood, famine, savage foes, disease, or depletion of the soil forced them again to seek new homes. This time they turned to the broad valley of the Rio Grande where some of their kinsmen were already living. Descendants of people who once inhabited the Rito, today live close by, till the soil, dance to persuade the rain clouds to come, and hold colorful pageants. They no longer need the protection of the cliffs; their pueblos are compactly built on the flats close to the fields.

Bandelier National Monument is so located that the traveler may "catch archeology alive." The ranger archeologists provided by the National Park Service accompany groups of visitors to the ancient villages and interpret the ways of the "old people." A short drive from the headquarters takes the explorer to an occupied pueblo where he may see life today much as it was lived centuries ago.

FRANK PINKLEY'S FAREWELL.

Superintendent Frank Pinkley suffered a heart attack and died almost immediately after concluding the following splendid talk at a conference of Southwestern National Monuments Custodians, in Casa Grande, Arizona, on February 14:

I think you will all understand that this is one of the red letter days in my life. It was in December, 1901, that I started down the lonesome trail which has finally led to today and this room and these (60) co-workers. Until 1916, the Casa Grande was a lone post. Then came the formation of the National Park Service, and, while it was still a lone post as we speak of them today, at least I could feel that I was part of an organization and that there were other men elsewhere with whom I was working along the same lines and handling somewhat similar problems.

The gradual expansion of the early 20's brought George L. Boundey to work by my side, and several additional monuments for us to worry about. Then came the hectic 30's with their financial floods and their sudden expansion. We grew by leaps and bounds, always undermanned and praying for more help; always getting more work before we got more men to do it; always thinking that in another six months or another year we would work our way out to where we could begin to look around us and take things easier. That time has not yet come.

Always there has been before me the mirage or the dream of all the Southwestern Monuments personnel getting together and sitting down where we could talk over our problems and try to find how to do our work in the best possible way. That time is now here and with it comes a great responsibility on your shoulders and on mine. If this meeting should end with no great amount of good done; if we should go home with no more information or esprit than we had when we came together; if we cannot build in the next three days a better team spirit; then I must sit down and write the Chief that my plans and dreams of the last 20 years are shattered; that we have wasted several hundred dollars of our funds in coming together and that our whole theory of the Southwestern Monuments' administration has been wrong through all these years.

The idea behind our organization has been that twenty-seven individual areas, each struggling along in its own individual way, each using its own plan, each meeting its own problems as they arise; can be welded into one compact group where every man will have benefit of the experience of every other man to start with when a problem arises and the same mistake need not be made twenty-seven different times. We also have a very definite theory that national parks and national monuments are different types of areas, and, because of this difference, require a

different type of handling which can better be done by a man and a group of men specialized in monument needs. If these basic propositions be true, then there has existed for many years a need that we who deal exclusively with monuments should get together and go over our common problem, working out the best methods of dealing with the various angles and phases of our work.

The present moment is the culmination of long years of absolute belief in and hope for just such a meeting as we have now opened. We want to make it clear at the start that this meeting is not called for the same purpose, nor will it operate the same as the superintendents' conference which meets from year to year. The name, "school of instruction", was given with some forethought, and represents the purpose of the meeting. You are here to learn.

We have long hoped that some day we could have a handbook for custodians. We plan some day to get out a book which will become the textbook by which a new custodian can become thoroughly familiar with all the details of his position whether or not he may have had a "breaking in" period at headquarters. This dream, as you know, has never been realized. We have simply never been able to find the time to do it. For lack of such a handbook, many things are being done in the field which should not be done, and a lot of things are being left undone which by all means should be done. We want to talk over with you in the next few days a few of these things. As proof that we do not contemplate a one-sided conversation you will note that we have, in our tentative program, left liberal time for your questions and arguments, and we want you to utilize this time to the full.

I need hardly tell you that we want no "yes" men in this meeting and that you need pull no punches; and knowing you as I do I am not much afraid of any of you on either score. I am just telling you this so you will feel at home and be your usual selves in the arguments.

My personal greeting goes to the park service wives who are present, and I am sincerely glad to see you here. No one knows better than I that the wife is a large half of a firm, both members of which are working for the interest of the government. One of the most interesting features of my work as I sit here at headquarters is watching the play and interplay of the man and wife and the job at some of these field stations. It gives me pleasure to welcome you wives here and to tell you that I open these meetings to you, not as a superficial courtesy, but because I want you to attend any or all of them as a right which you have well earned by the excellent service you have donated to us in your field work.

You are to feel free to come and go as you please. I well know that many of you will not be interested in bookkeeping and purchase procedure and may want to skip those parts of the meetings. None of you

is under any order, or even any moral pressure to stay, and the moment the proceedings get too dry for you, feel free to walk out. Many of these talks, however, you will find intensely interesting and I especially wish that you would feel free to enter into the discussions which follow the talks. You women will see these things from a slightly different angle from the men, and for that reason your viewpoint is very important to me. Aside from this official side of your visit, we want also to welcome you into our homes here at headquarters. Please feel at all times free to use them when you want to read or lie down, or just rest and relax, or to hold little meetings of your own. We want you to feel really at home.

To the men I might say that we want this to be a working meeting. Our three days together will be all too short for the things we want to say and we have provided a full program. I will be a little tough on you and may grow tiresome at times, but we hope you will be able to look back on these days and consider the work a job well done. I am well aware that half the good you will get from this trip will be the pleasant contacts you will make in the odd hours before, between, and after the official sessions when you will be able to find out what fine fellows we have in the Southwestern Monuments. I am depending on these contacts to broaden your knowledge of our work and give you an understanding of the multiplicity of our problems. You will find that the problem which you thought was yours alone is shared by half a dozen other men, and they will have solved some of the things which may be bothering you and can offer you short cuts which may not have occurred to you. It is my opinion that the hotel lobby sessions and the little group sessions which gather here and there during one of these meetings will contribute nearly a third of the good which will result from our getting together.

To our own headquarters office force this will be a great opportunity. Here you will have a chance to meet in the flesh the many men and women with whose names you have so long been familiar. Hereafter, as you handle the 7,000 pieces of mail which flow across your desks each month, these names will have a significance which you have not heretofore been able to give them. And you from the field will hereafter be able to direct your blasphemy at some real individual, whom you can materialize in your mind's eye, instead of the unsatisfactory blast you have heretofore had to send toward those so-and-so nitwits down there in the headquarters office. We want as many of the office force as it is possible to spare to attend these meetings. I realize that the mail and telegrams must be kept moving, at least after a fashion, and that the office jam cannot be allowed to accumulate beyond a certain critical point but I wish Parke would see that you are with us as much as possible and of course you will be in attendance at the night sessions.

We would like for the visitors from the field to have a chance to look through the offices, and some short recess may be taken for that

purpose if and when we can squeeze it in. I would like you to realize how much work these boys are doing. Most of you have been through the ruins and the museum. Al will arrange a special trip for those of you who wish to go, or you may, if you wish, join a standard trip and thus see how Al and the boys handle their visitors. Arrangements will also be made to take the ladies on either the standard or special trips as they may desire.

In closing, let me speak for a moment of those who are not here. It was impossible to withdraw all our forces from the field and we have left a skeleton force to keep things running. We will miss these men and women as they will miss being with us. Some of the wives could not come because of sickness or household duties which forbade the journey. I hope you will, in their case, understand that the girls we have here are a typical cross section of our organization and that the others, who could not attend, are just as nice.

There are others who are not here. Hosteen John and George Boundey are examples of those who have fought a good fight and are now wishing us well from the sidelines of retirement. They were with us when the going was tough and helped to put us where we are today. Let us not forget them. And there are yet others, like Jack and Hilding, who have gone "Over the Divide" but who did yeoman work while they were with us in a time when things were not as easy as the present, who must be included in our thoughts along with all those here present when we say, "Our Outfit."

To my great glee, one of the very correct and formal writers of the Service once hauled me hither and yon over his bed of coals for using that term, but to me it is a very natural expression and rather covers our case. We speak not alone of our men in uniform; not only of our men and women here present; not only of our forces not living; but of all these and the areas under our charge with all that we have therein, the twenty-seven finest national monuments in the United States, when we say, "Our Outfit." No other term suits me quite so well and no other is so all-inclusive. It is ours to make or ruin. Some of our mistakes may hurt not only ourselves but may go on down through the years hurting those who come after us. Let us try hard to make ourselves worthy of these obligations which have been placed upon us. May we leave this meeting three days hence with a bigger and broader comprehension of our work and a fixed determination to do it better this year than it has ever been done before.

WANTED!

Wanted, an unlimited number of men and women! Besides the time-tested qualities of honesty, dependability, common sense, and willingness to work, they must have a variety of others. Being mentally alert, physically fit, and personally neat, and having the skills to do their respective jobs efficiently, they must have an attitude of mind which will tend to bring out the best in themselves and in others.

By "attitude of mind" is meant that combination of qualities, which, hard to achieve, is essential for the best interest of the State, society, the organization, and self. There must be loyalty - loyalty not only to superiors, equals, and subordinates but to the cause for which the individual is working. There must be a willingness to follow orders; however, in following orders, the individual is to be expected to use his own judgment to push the program forward or where it will save the time, energy, and money of others.

Working for a greater cause than mere self, the individual must subordinate self to that cause through cooperation with others. Coordination of his work with that of others is essential if the cause for which all are working may be advanced.

Those willing to accept positions of greater responsibility and leadership must meet additional requirements. The leader will be known by his ability to inspire those who follow him. His courtesy and consideration to subordinates and his dependency upon them is just as important as his ability to please and serve his superior officers. As a leader he must have vision - vision which will enable him to look ahead of those around him. Such vision, if founded upon bases of practicability, will lead to ultimate success.

With ability to follow approved rules and regulations, he must be able to interpret them with tolerance and judgment where his fellow beings are concerned. At no time should the desire to follow rules and regulations to the letter mean the loss of ability to judge the individual instance with fairness, impartiality, and human consideration. The best judge, after all, is one who tempers justice to fit the circumstances of a case.

Other qualifications are desired. Besides being familiar with a specific job and the work of others, and the aims of the greater cause, it is necessary to know the problems of the present day world in order that they may be solved by those whom they affect - all of us.

VOLCANOES

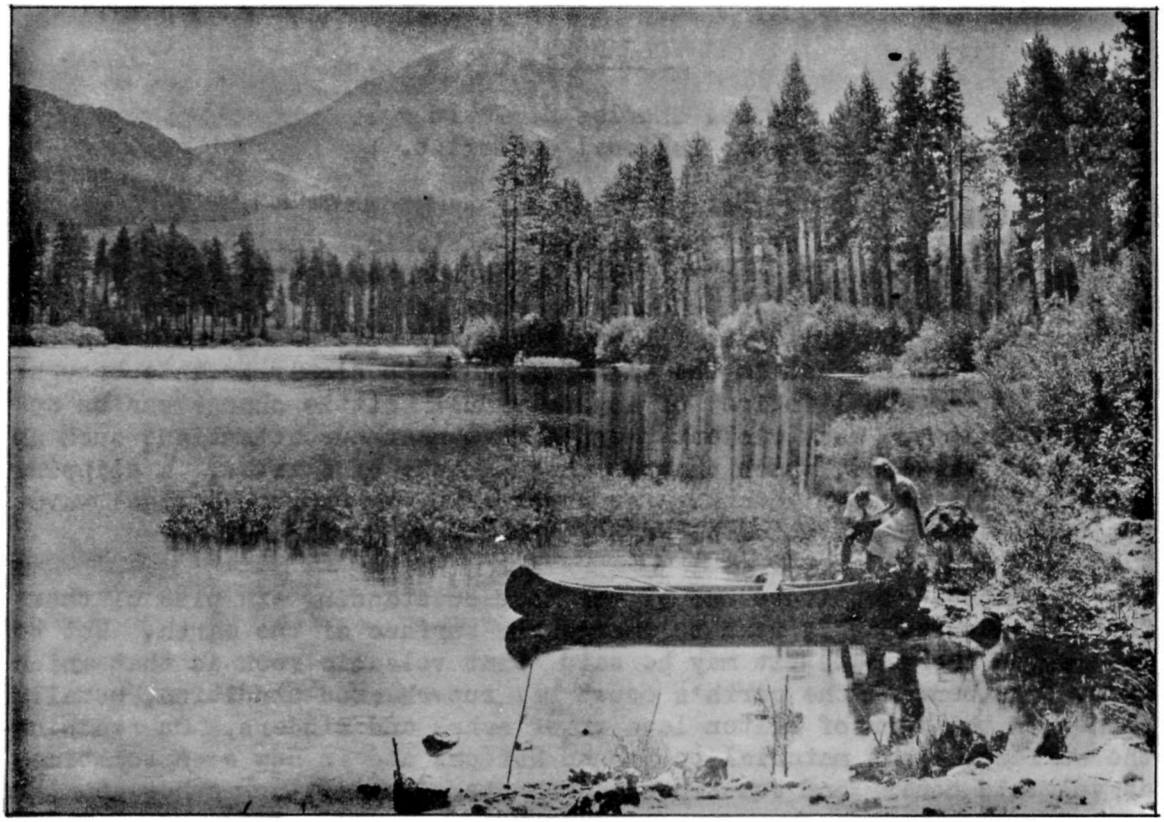
By Dr. Charles N. Gould,
Former Regional Geologist.

We are apt to think of our earth as a stable, finished, unchangeable body. But such is not the case. The surface of the earth is in a constant state of change. Mountains rise and fall; seas are scooped out, deepened, and are again filled; rocks and soil are washed down the slopes and come to rest in the valleys. But so slowly is this brought about that in the lifetime of an individual little change can be noticed. Only the most violent phenomena attract our attention, such as a destructive flood, which changes the channels of a river; a slipping along a fault line which causes an earthquake, and perhaps a tidal wave; a titantic explosion which blows off the top of a volcano.

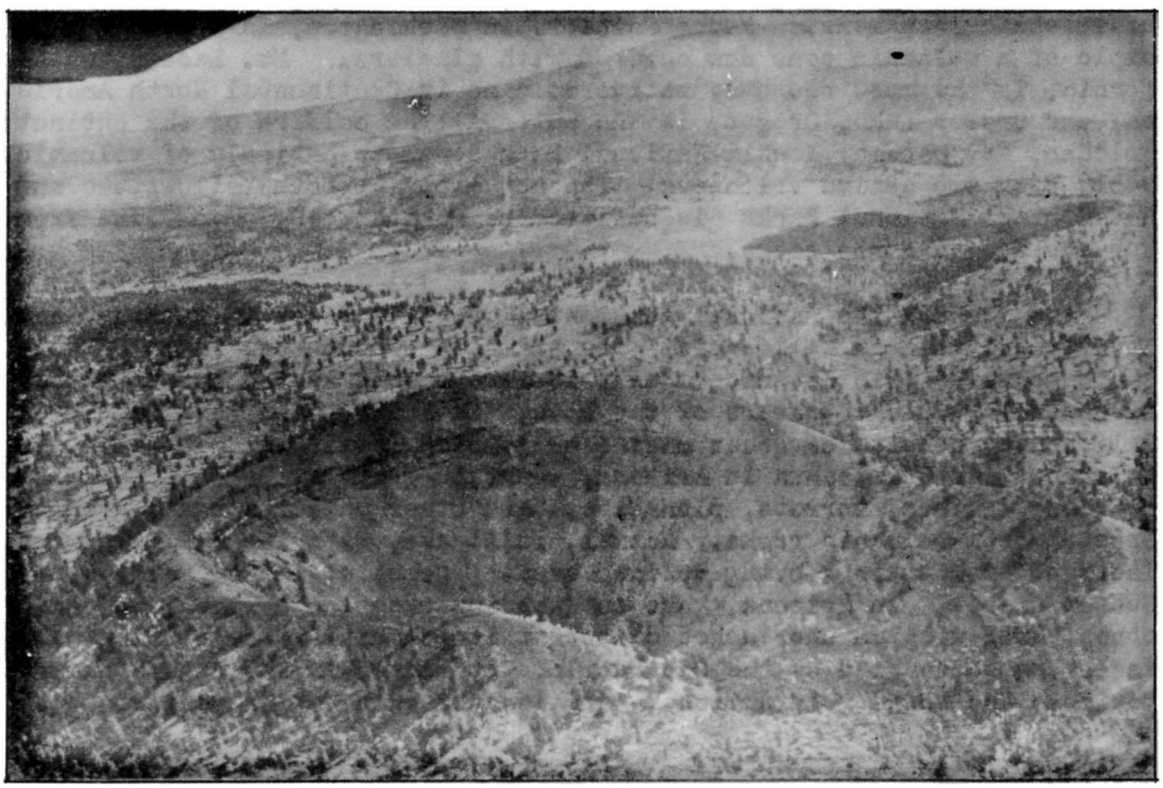
Volcanoes constitute one of the most outstanding examples of those forces that constantly tend to change the surface of the earth. Not to become too technical, it may be said that volcanic rock is that which comes from beneath the earth's crust in a superheated condition, usually either in the form of molten lava or of ashes and cinders. On reaching the surface, this material cools and hardens and is now seen sometimes as volcanic cones and sometimes as sheets of basalt or other similar rock.

In selecting areas of outstanding scientific interest, the National Park Service has not neglected volcanoes, lava flows, and other forms of volcanic phenomena. Mount Rainier, in Washington, is a perfect example of a volcanic cone now covered with glaciers. Mt. Lassen, California, is the most recently active volcano in Continental North America; and Crater Lake, Oregon, is the water-filled caldera of the extinct volcano, Mt. Mazama. Hawaii National Park consists entirely of volcanic rock, with two active volcanoes. The hot water at both Yellowstone and Hot Springs National Parks is believed to be heated by emanations from sub-surface volcanic rocks.

And so with the national monuments. Devil's Tower in Wyoming, and Devil's Postpile in California, are examples of unusual forms of volcanic rocks. (His Satanic Majesty is always well served in the matter of nomenclature.) Craters of the Moon, in Idaho, and Lava Beds, in California, consist of great masses of jumbled lava rock. Wheeler, in Colorado, and Chiricahua in Arizona, contain great numbers of pillars, needles, spires, turrets, pinnacles, and other unique forms carved by erosion from volcanic rocks. Katmai, in Alaska, with the Valley of Ten Thousand Smokes, is a dying volcano area. Capulin, in New Mexico, and Sunset Crater, in Arizona, are outstanding examples of young volcanic cones, each with an unbreached crater at its summit. The cliff dwellings, once occupied by the Old People, at Bandelier and Gila, in New Mexico; and Tonto, in Arizona, are located in caves in volcanic rock.



MT. LASSEN, CALIFORNIA



CRATER NEAR GRANTS, NEW MEXICO

Grand Canyon National Monument, Arizona, adjacent to Grand Canyon National Park, contains many examples of young cinder cones, from some of which lava poured out in such quantities that it once formed a dam across Grand Canyon. So recently did this volcanic activity occur that the river has not had time to completely clear its channel, as is evidenced by a series of rapids in the bottom of the canyon at the site of the old dam.

There are a number of areas in the Southwest containing volcanic rocks that from time to time have been considered for national monument status. Some of these may be of national monument calibre, in that the geological features are outstanding. The largest single area of volcanic rocks in New Mexico is in western Valencia County, some 100 miles southwest of Albuquerque, and half that distance southeast of Gallup. Its easiest approach is by way of Grants. The area is irregular in shape, but approximates 1,000 square miles, being 50 miles long and averaging 20 miles in width. It includes scores of volcanic cones and craters. From the Oso ridge fire tower, about 3 miles northwest of the Ice Caves, at an elevation of 9,500 feet, I counted thrity-two volcanic cones, to the south or southwest. Twelve of these appeared to be less than 15 miles distant. It is the accumulated material from these various craters that makes up the malpais rock that we see today.

Within this mass of volcanic rock there are a number of ice caves. One of these has been exploited and tourists may now enter by a wooden stairway. The cave is about 300 yards from a point at the edge of the malpais which may be reached by a car. A trail has been broken out, over which it is possible to walk with no great inconvenience. At the end of the trail one comes abruptly to a sink hole, or depression, in the lava, approximately 300 feet long, 100 feet wide, and 40 to 50 feet deep. The sides are precipitous, and the bottom of the cavity is filled with blocks of broken black basalt. At the northwest end of the sink-hole is a cave 50 feet below the bottom of the main channel, and at the bottom of this depression a cave extends back under the lava for perhaps 100 feet. Along the sides of the depression I counted seven layers of basalt and cinders in regular sequence, indicating a number of separate lava flows. The northwest wall of this lower depression is formed of solid ice. This ice wall is 10 to 12 feet high and 35 feet long. The top is covered with boulders dropped from the roof.

About 2 miles south of the ice cave there is a channel more than a mile in length, very similar to the one at the first cave visited. The width of this channel is about 100 feet and the depth 50 feet. The sides are precipitous. Two natural bridges span this channel, each about 100 feet wide. In each case the lava rock which forms the bridge is 10 to 15 feet thick. Ice is reported in caves at each end of this channel. Still further south may be found another series of channels and caves, many of which contain ice. No one seems to know how many caves there are in these lava beds, but the number will undoubtedly run into the scores, and possibly into the hundreds.

This lava bed is one of several places in the Southwest supposed to contain the noted Adams Diggings, which, as a popular legend, ranks with the Lost Dutchman's mine, in the Superstition Mountains. So persistent is the belief of vast treasures hidden somewhere among the lava beds that old prospectors still hunt for it. The only inhabitants of an area nearly as large as Rhode Island are wandering prospectors lured ever onward by the hope of hidden wealth. There is an occasional sheep herder, seeking grass for his flock.

The largest known extinct volcanic crater in the world is the Jemez Crater, about 40 miles northwest of Santa Fe. According to Dr. Clarence S. Ross, of the U. S. Geological Survey, this crater was formed by eruptions on a stupendous scale. It was simply blasted out of the older volcanic materials. It is 16 to 18 miles in diameter, over 50 miles in circumference, and 600 to 800 feet deep. The materials ejected were largely ashes and small rock fragments which were carried by the wind and deposited along the slope of the volcano. On compaction, this ashy material became tuff which today forms Pajarito Plateau, lying between Jemez Crater and the Rio Grande. Some fifty small streams heading along the outer slope of the crater have cut deep, steep-sided canyons in the soft tuff. The Old People built their homes in caves in the walls of these canyons. The cliff dwellings in Frijoles Canyon, in Bandelier National Monument; and those at Puye, nearby, are the most noted. On the mesas between the canyons there are hundreds, perhaps thousands, of ruins built by prehistoric people.

Of the Jemez Crater, Ross says: "This is much the largest crater known, being even larger than the great Ngorongora Crater of Africa." He also says: "The great crater is now drained by two streams which have breached the rim, but within the crater there has been little erosion. At one time the crater was a great lake." This lake must have had an area of approximately 150 square miles, or nearly eight times the area of the present Crater Lake, in Oregon. Within the crater there are numerous hot mineralized springs, some of which have at various times been utilized as health resorts. Geologists believe that, as in the case in Yellowstone, and in Hot Springs, Arkansas, this hot water is caused by hot subsurface volcanic rock.

The malpais near Carrizozo constitute one of the most noted lava flows in New Mexico. Tularosa Valley, or Basin, averages 30 miles wide and extends north for nearly 150 miles from near El Paso, Texas. On the east this valley is bounded by the Sacramento and Sierra Blanca Mountains, and on the west by a range variously known as Franklin, Organ, San Andreas, and Oscura. These mountains, which lie east and west of the basin, rise 2,000 to 4,000 feet above the valley floor. The White Sands National Monument, south of the center of Tularosa Basin, and 25 miles north of the monument is the south end of the malpais.

Students of biology find in the black rocks of the malpais, substantiation of the theory of protective coloration. The following par-

agraphs, from an article entitled, "In Black and White", by John Eric Hill, Assistant Curator of Mammals, American Museum of Natural History, are quoted with permission, from the March, 1939, issue of Natural History:

"In the Tularosa Valley, in southern New Mexico, there are two unusual environments situated close to each other, a black lava flow and an area of white sand dunes, each with mammals that blend with their respective backgrounds in color. The most interesting are black pocket mice and white ones, members of a southwestern American family, intermediate between the squirrels and the mice proper, having fur-lined cheek pouches and peculiar teeth.

"The lava bed or malpais is about 40 miles long by two to five miles wide. Most of this lava is probably not over a few thousand years old and very little weathered. The surface is unbelievably rough and broken up; there are piles of lava blocks, fissures, wells and dykes. The bubbling and swirling of molten lava is congealed, and reminds one of the inferno it was when it poured from the crater. Progress on such terrain is slow and often painful. Footing is insecure on the balancing blocks, and the jagged lava cuts and abrades leather boots in unbelievably short time.

"The crevices and cracks of the malpais form the only shelter of the mammals, for the material is hard as cast iron. In the crannies the windborne dust and weathered lava collect and offer soil for an abundant and varied flora.

"Peculiar animals of the lava beds are a blackish rock squirrel, black pocket mice, blackish big-eared mice and black wood rats. The malpais pocket mice belong to a rock-dwelling species, Perognathus intermedius. Normally this species is grayish brown, but the race from the black malpais is uniformly blackish, almost matching the malpais in color. The other dark mammals show a wide range of variability, from slightly darker than normal to almost black. All of the dark mammals have normally colored relatives in the mountain sides and on the rocky buttes which occur in the northern half of the valley."

One of the outstanding areas in the Southwest exemplifying volcanic activity is in northern Arizona, situated chiefly north of the main line of the Santa Fe Railroad and south of Grand Canyon. An area of approximately 1,500 square miles is covered with volcanic rock. During late geologic time this material was brought to the surface, chiefly in the form of molten lava, which on cooling formed the hard rock we see today. More than 200 volcanic cones, large and small, are known to exist in this area. The dominant feature is San Francisco Peak, the highest point in Arizona, the summit of which stands at an elevation of 12,611 feet above sea level and approximately 5,500 feet above the surrounding plain. Basalt is the most common volcanic rock in the area. Near the summit are evidences of glaciation, this being one of the southernmost glaciers of the great ice age in North America.

At Sunset Crater National Monument, it has been found possible to determine the date of the volcanic activity. At the time of the founding of this crater, the area was already occupied by prehistoric people and their homes were destroyed by the lava. By the tree-ring method it has been determined that the eruption occurred during the last quarter of the ninth century, A. D. It is believed that Sunset represents the most recent volcanic activity in the San Francisco area. Sunset Peak is but one of the peaks there. A number of others are higher, and in many ways equally spectacular. Sunset Crater is a perfect example of a volcanic cone. It rises to a height of approximately 1,000 feet above its base. At the summit is an unbreached crater 400 feet deep and a quarter of a mile in diameter. The sides of the cone are composed of fragments of black volcanic rock which even yet roll down the slope. The name "Sunset" is from the vari-colored rocks near the summit, where the color grades downward through different shades of yellow, orange, red and brown, into the black material on the lower slopes.

In many ways Sunset Crater reminds one of Capulin Peak, in Capulin Mountain National Monument. Both are typical cinder cones. Both are located in a region of intense volcanic activity. Both have craters at the top. The ejecta from both cones is quite similar. Sunset is the larger cone but Capulin, because of its isolated location, is perhaps more spectacular. Both mountains are very young geologically, and owe their perfect shapes to the fact that so short a period of time has elapsed since the cones were formed, that erosion has not had time to destroy the symmetry.

To summarize: Taken in connection with Grand Canyon, San Francisco peaks exemplify the greater part of the story of earth's history. In Grand Canyon the rocks of the first three chapters are shown. Rocks of the fourth chapter - the age of dinosaurs - are buried beneath the lava of the mountains. The volcanoes were formed during the fifth and last chapter of geologic time, the Cenozoic age. It should be remembered that this is the classic area selected fifty years ago by Dr. C. Hart Merriam to exemplify the life zones in North America. From the bottom of Grand Canyon to the top of San Francisco peaks, a difference in elevation of over 10,000 feet, one passes successively through the following life zones: Lower Sonoran, Upper Sonoran, Transition, Canadian, Hudsonian, and Arctic-Alpine.

1. Region III Headquarters
2. Bandelier National Monument
3. Chaco Canyon National Monument
4. El Morro National Monument
5. Gran Quivira National Monument
6. Carlsbad Caverns National Park
7. White Sands National Monument
8. Gila Cliff Dwellings National Monument
9. Chiricahua National Monument
10. Tumacacori National Monument
11. Saguaro National Monument
12. Casa Grande National Monument
13. Organ Pipe Cactus National Monument
14. Tonto National Monument
15. Petrified Forest National Monument
16. Montezuma Castle National Monument
17. Tuzigoot National Monument
18. Walnut Canyon National Monument
19. Sunset Crater National Monument
20. Wupatki National Monument
21. Grand Canyon National Park
22. Grand Canyon National Monument
23. Pipe Spring National Monument
24. Boulder Dam National Recreational Area
25. Lehman Caves National Monument
26. Zion National Park
27. Cedar Breaks National Monument
28. Bryce Canyon National Park
29. Timpanogos Cave National Monument
30. Capitol Reef National Monument
31. Rainbow Bridge National Monument
32. Navajo National Monument
33. Canyon de Chelly National Monument
34. Natural Bridges National Monument
35. Hovenweep National Monument
36. Yucca House National Monument
37. Mesa Verde National Park
38. Aztec Ruins National Monument
39. Arches National Monument
40. Colorado National Monument
41. Black Canyon of the Gunnison National Monument
42. Wheeler National Monument
43. Great Sand Dunes National Monument
44. Capulin Mountain National Monument
45. Platt National Park
46. Hot Springs National Park


DEPARTMENT OF THE INTERIOR