HOT SPRING ACTIVITY IN THE GEYSER BASINS OF THE FIREHOLE RIVER FOR THE 1959 SEASON

GEORGE D. MARLER

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Introduction

During the 1959 season hot spring activity in the Firehole geyser basins underwent far greater alteration as a result of the Hebgen Lake Earthquake than during any comparable period since discovery. Data are indicative that these alterations are more pronounced and far reaching in character than all combined changes during the 89 years since discovery. Some of the changes have already been tabulated in a paper prepared for the U. S. Geological Survey. This report will go into greater detail on many of the thermal units, and discuss changes in unnamed springs which the earlier report did not cover.

Prior to August 18 the general pattern of hot-spring activity was essentially the same as during the 1958 season. However, most of the major geysers during the 1959 pre-earthquake period showed a slight decline in average eruption frequency over that of 1958. Only two of the better known and popular geysers played on shorter intervals during the first part of 1959. The following table shows average eruption frequency for some geysers and number of eruptions for others.

Table 1

	Average, 1958	Average, 1959
Daisy	117 minutes	138 minutes
Riverside	7 hr. 2 min.	7 hr. 27 min.
Castle	14 hr. 33 min.	15 hr. 53 min.
Old Faithful	62.8 minutes	61.8 minutes
Grand	8 hr. 32 min.	9 hr. 2 min.
Great Fountain	12 hr. 24 min.	12 hr. 46 min.
Splendid	15 eruptions	18 eruptions
Fountain	52 "	1 "
Morning	54 "	14 "
Clepsydra (Wild phase)	54 "	9 "

Summer temperatures taken during 1958 indicate that the average temperature was .5° F. warmer than for the 1959 summer period prior to the earthquake. This is not indicative of a general decline in manifestations of thermal energy that theorists speculate is the inevitable picture. That is, that the hot springs are slowly and irrevocably cooling. In all probability it merely represents a fluctuation stage. Waxing then waning of thermal intensity has been the history of the hot springs since observations were first made. During the period these observations have been underway the evidence does not support the thesis of either a progressive or an overall decline in hydrothermal manifestations.

Table 2

Geyser activity was observed in the following hot springs between May 1 and August 18, 1959:

UPPER BASIN

Geyser Hill

1. Anemone Geyser
2. Plume Geyser
3. Beehive Geyser
4. *Depression Geyser
5. Lion Geyser
6. Little Cub Geyser
7. Solitary Geyser
8. Sponge Geyser
9. Pump Geyser
10. Vault Geyser
11. Giantess Geyser

Old Faithful Group

1. Old Faithful Geyser

Lone Star Area

1. Lone Star Geyser

Myriad Group

1. White Geyser

Black Sand Basin

1. Spouter Geyser
2. Cliff Geyser

Daisy Group

1. Daisy Geyser
2. Rocket Geyser
3. Splendid Geyser
4. Daisy's Thief Geyser
5. *Bank Geyser
6. Brilliant Pool

Castle & Sawmill Groups

1. Castle Geyser
2. *Tilt Geyser
3. Sprinkler Geyser
4. Sawmill Geyser
5. Spasmodic Geyser
6. Tardy Geyser
7. Bulger Geyser
8. Spanker Geyser

Grand Group

1. Grand Geyser
2. Turban Geyser
3. Vent Geyser
4. Rift Geyser
5. W. Triplet Geyser

Giant Group

1. Bijou Geyser
2. Oblong Geyser

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* Denotes springs unnamed until the time of the plane-table mapping of the Emergency Interpretive Earthquake Study.

Grotto Group

1. Grotto Geyser
2. Rocket Geyser
3. Spa Geyser
4. Grotto Fountain Geyser
5. *Culvert Geyser
6. *Grotto #2
7. *Grotto #3
8. Riverside Geyser

Morning Glory Group

1. Fan Geyser
2. Mortar Geyser

Cascade Group

1. Artemisia Geyser
2. Atomizer Geyser

Biscuit Basin

1. Cauliflower Geyser
2. Sapphire Pool
3. Jewel Geyser
4. Shell Geyser
5. Black Pearl Geyser

MIDWAY BASIN

1. Catfish Geyser
2. Flood Geyser

LOWER BASIN

Great Fountain Area

1. Great Fountain Geyser
2. White Dome Geyser
3. *Gemini Geysers

Pink Cone Group

1. Pink Cone Geyser
2. Bead Geyser
3. Narcissus Geyser

Firehole Lake

1. Steady Geyser

Fountain Group

1. Fountain Geyser
2. Morning Geyser
3. Clepsydra Geyser
4. Jet Geyser
5. Spasm Geyser
6. Jelly Spring
7. *Twig Geyser

Hotel Group

1. Kidney Geyser

Separated Lower Basin Springs

1. Snort Geyser
2. Morning Mist Geyser
3. Mound Geyser

Unnamed hot springs that were observed erupting prior to August 18 during the 1959 season are located as follows:

Lone Star Area . . . 3	Biscuit Basin . . . 2	Fountain Group . . . 2
Geyser Hill. 12	Midway Basin. . . . 2	Kaleidoscope Group . 5
Castle Group 1	Great Fountain Area 4	River Group. 2
Sawmill Group. . . . 3	White Dome Area . . 4	Fairy Meadows. . . . 4
Cascade Group. . . . 2	Pink Cone Group . . 3	Rabbit Creek 2
Round Spring Group . 1		Grotto Group 3

Table 3

Following the earthquake, and throughout the remainder of the year, geyser activity was observed in the following named hot springs:

UPPER BASIN

Giantess Group

1. Cascade Geyser
2. *Little Squirt Geyser
3. *Silver Spring
4. Anemone Geyser
5. *Surge Geyser
6. *Roof Geyser
7. Beehive Geyser
8. Plume Geyser
9. *Depression Geyser
10. Arrowhead Spring
11. Lion Geyser
12. Little Cub Geyser
13. Goggle Spring
14. North Goggle Spring
15. Ear Spring
16. Beach Spring
17. *Aurum Geyser
18. Sponge Geyser
19. Vault Geyser
20. Giantess Geyser
21. Infant Geyser
22. *Cone Geyser
23. Solitary Geyser

Myriad Group

1. Three Sisters North Vent
2. Middle Vent
3. South Vent
4. *Little Brother Geyser
5. *Trail Geyser
6. *West Trail Geyser
7. *Bell Spring
8. *Roung Geyser
9. *Abuse Spring
10 White Geyser

Black Sand Basin

1. Spouter Geyser
2. *Cucumber Spring
3. Cliff Geyser
4. Sunset Lake
5. Green Spring
6. Black Sand Pool

Daisy Group

1. Daisy Geyser
2. Splendid Geyser
3. Rocket Geyser
4. *Radiator Geyser
5. *Bank Geyser
6. White Geyser

Old Faithful Group

1. Old Faithful Geyser
2. Chinaman Spring
3. E. Chinaman Spring

Lone Star Group

1. Lone Star Geyser

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* Denotes springs unnames until the time of the plane-table mapping of the Emergency Interpretive Earthquake Study.

Castle & Sawmill Groups

1. Castle Geyser
2. *Tilt Geyser
3. Deleted Teakettle
4. Sawmill Geyser
5. *Penta Geyser
6. Spasmodic Geyser
7. Tardy Geyser
8. Bulger Geyser
9. *Oval Spring
10. Liberty Pool
11. Sprinkler Geyser
12. *Spatter Geyser
13. Churn Geyser
14. Spanker Geyser
15. Terra Cotta Spring
16. *Frog Spring

Grand Group

1. Grand Geyser
2. Turban Geyser
3. Vent Geyser
4. Rift Geyser
5. W. Triplet Geyser
6. Economic Geyser
7. *E. Economic Geyser
8. Wave Spring

Orange Spring Group

1. Orange Spring

Round Spring Group

1. W. Round Spring

Giant Group

1. Bijou Geyser
2. Oblong Geyser

Grotto Group

1. Grotto Geyser
2. Rocket Geyser
3. Spa Geyser
4. Grotto Fountain Geyser
5. *Grotto #2 Geyser
6. *Grotto #3 Geyser
7. *Culvert Geyser
8. Riverside Geyser

Morning Glory Group

1. Cyclops Spring
2. Sentinel Geyser
3. *Green Star Spring

Cascade Group

1. Artemisia Geyser
2. Atomizer Geyser
3. Calthos Spring
4. *Hillside Geyser
5. *Baby Daisy Geyser
6. *Pulcher Spring

Biscuit Basin

1. Cauliflower Geyser
2. Sapphire Pool
3. Jewel Geyser
4. Avoca Spring
5. E. Mustard Spring
6. W. Mustard Spring
7. Black Pearl Geyser
9. *Spicule Spring
10. *West Spring
11. Shell Geyser

Midway Basin

1. Catfish Geyser
2. Flood Geyser
3. Tromp Spring

LOWER BASIN

Great Fountain Area

1. Great Fountain Geyser
2. Surprise Pool
3. Diamond Spring
4. White Dome Geyser
5. *Gemini Geysers

Pink Cone Group

1. Pink Cone Geyser
2. Bead Geyser
3. *Shelf Spring
4. Narcissus Geyser
5. *Box Spring

Firehole Lake Area

1. Steady Geyser
2. Black Warrior Spring
3. *Artesia Spring
4. Sulfosel Spring

Fountain Group

1. Fountain Geyser
2. Morning Geyser
3. Clepsydra Geyser
4. Jet Geyser
5. Spasm Geyser
6. Jelly Spring
7. *Twig Geyser
8. Bellefontain Geyser
9. *Sub Geyser
10. Gore Spring
11. Cone Spring
12. Leather Pool
13. Silex Spring
14. Celestine Pool

Kaleidoscope Group

1. *Earthquake Geyser
2. Deleted Surprise Spring

Hotel Group

1. Thud Geyser
2. Fungoid Spring
3. Stirrup Spring
4. Gourd Spring
5. Cliff Spring
6. Kidney Geyser
7. Oak Leaf Spring
8. Lone Spring

Quagmire Group

1. Snort Spring

River Group

1. Mound Geyser
2. Fortress Geyser
3. Bath Spring

Separated Lower Basin Springs

1. Morning Mist Geyser
2. Spray Geyser
3. Ojo Caliente Spring
4. Boulder Spring
5. Rosette Geyser

Unnamed hot springs that erupted between August 17 & December 31, 1959:

1. Pipeline Group . . 6
2. Geyser Hill. . . . 7
3. Myriad Group . . .17
4. Black Sand Basin . 5
5. Daisy Group. . . . 1
6. Castle Group . . . 2
7. Grand Group. . . . 7
8. Round Sp. Group. . 3
9. Grotto Group . . . 1
10. Morning Glory Gp . 2
11. Cascade Group. . .21
12. Biscuit Basin. . .23
13. Midway Basin . . .12
14. Great Fountain . .16
15. Pink Cone Group. . 3
16. Firehole Lake . . .9
17. Fountain Group. . .7
18. Kaleidoscope Gp.. 27
19. Quagmire Group. . 2
20. Morning Mist Gp . 3
21. Fairy Meadows . . 11
22. River Group . . . 2
23. Lone Star Group . 3

UPPER BASIN

Geyser Hill

During the early part of 1959 thirteen springs on Geyser Hill had shown eruptive activity. Following the earthquake this number increased to twenty-nine, with the great majority showing changes in eruption behavior.

Anemone Geyser: For several seasons the average eruption interval has been 10 minutes, this being about 10 minutes less than its record prior to 1950. This geyser consists of three vents, all in a direct line, a few feet apart. A chain action has been the typical pattern of performance. The central vent would initiate the eruption, its water draining into the north vent. Following a few seconds of activity, discharge would shift to the south vent. Following the quake the north vent was seldom observed in eruption. Most of the energy would seem to have shifted to the south vent, which has been in eruption most of the time.

Plume Geyser: Prior to August 18 the Plume erupted about every 65 to 75 minutes. For several days after the quake, activity was infrequently observed. It was noticed that water was flowing into Plume's crater from a steadily erupting spring which started playing the night of the 17th. Diversion of this flow resulted in a marked response in Plume. The earthquake had greatly stimulated its activity, the average period being 44 minutes.

Beehive Geyser: Between May 1 and August 18, 28 eruptions were checked for the Beehive. It is highly probable that it played immediately following the quake. From then until November, its frequency was about the same as during the earlier part of the season. During November and December there was an increase in function. There were periods when there would be several consecutive daily eruptions.

Lion Geyser: Since 1950 the Lion's active phases have been less frequent than formerly. Following the quake no activity was observed for several weeks. From November and for the remainder of the year, it underwent marked rejuvenation, going into an active phase about every second or third day. The Little Cub did not show any increase in function following the quake, however most of its eruptions were of the major type.

Lioness & Big Cub Geysers: These geysers have been inactive for several years. The quake resulted in an increase in temperature and rise in water level, but by the end of the year no eruptions had occurred. On a number of occasions activity seemed imminent. There would be surging, with momentary overflow, but not of sufficient degree to trigger an eruption.

Giantess Geyser: Preceding the quake Giantess erupted on two different dates, in March and again in May. Both of these eruptions were of the steam-phase type, lasting for less than a day.

In conjunction with numerous other springs the Giantess was induced by the initial earthquake jarrings to start erupting. This eruption was

the intermittent-water type, and lasted for over 100 hours. The longest eruption on record previously was 38 hours.*

Due to the fact that a prolonged water-phase type eruption has a marked effect upon most of the springs on Geyser Hill it could not be determined for certain to what degree the changes in these springs were due to the unusual activity of Giantess and to what degree they were quake induced. Of the geysers which respond to an eruption of Giantess, the changes in Sponge and Infant were much more aggravated than following any previous Giantess eruption. Instead of a few inches of ebb in Sponge the water dropped 8 feet below the rim of the crater, and instead of erupting about every minute, it was dormant for several weeks. Activity in Infant Geyser had always stopped following cessation of play of Giantess, but Infant continued to erupt periodically for the remainder of the season, the water being below overflow level most of the time.

Vault and Teakettle are situated on the same platform of sinter with the Giantess. They show immediate response to an eruption of Giantess by ebbing 24 to 30 inches. Vault, an active geyser, becomes dormant for several days following an eruption of Giantess. When it resumes activity it goes into an active phase about 2 times weekly.

Following the earthquake-induced eruption of Giantess, Teakettle ebbed about 6 feet, and stayed at low level for the remainder of the season. Vault remained dormant until the latter part of October. From then until the end of the year it played with unprecedented frequency, being in an active phase most of the time. When in an active phase the eruptions occur about hourly, lasting nearly 4 minutes.

Arrowhead Spring: This spring was named by the author several years ago as a result of retrieving an Indian Arrowhead during the course of removing tourist-introduced debris. Perhaps the early aborigines were no less wont to throw objects into the hot springs than modern-day visitors.

Prior to the big event on the 17th, Arrowhead was never known to erupt. Its crater, which had been partially cleaned many times, was again practically filled with rocks from count ess hands. The new eruptive activity lifted and deposited many of these rocks outside the crater, cleaning it much more effectively than previously had been possible by means of tools. The eruptions were in the form of heavy surges, lasting but a few seconds. With waning discharge, periodic activity continued for the remainder of the year.

Cascade Geyser: The last reference I can find to any activity of Cascade is in the 1903 Haynes Guide. The 1910 Guide states that "it has been inactive for a number of years." If this geyser became inactive following the 1903 season, it remained dormant until the earthquake. One of the

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* Park Ranger Riley McClelland spent the 1959-60 winter at Old Faithful observing the hot springs. He reported an eruption of Giantess on February 19. According to Riley the eruption was a comparatively "tame one."

first sights to greet me on the morning of August 18 was an eruption of this geyser. From then until September 15 it played with considerable frequency and regularity. The intervals of checked eruptions varied between 14 and 30 minutes. The heights of the eruptions were from 20 to 30 feet, the duration being not more than one minute, usually less. Its manner of function corresponded very closely with earlier guide-book descriptions.

By September 8, Cascade's crater was beginning to fill and overflow preceding an eruption. The initial muddy water was also becoming relatively clear. This was perhaps a prelude to complete cessation of activity.

Little Squirt Geyser: This small but interesting geyser is located about 50 feet southeast of Anemone. It was named in reference to its squirtgun-like action. Some seasons it has been active, others dormant. It was rejuvenated into activity by the quake and squirted constantly for the rest of the year.

So far as could be determined Pump Geyser, a constant spouter, Pendant and Beach Springs were the only units on Geyser Hill that did not show any direct evidence of having been affected by the quake or the unusual activity of Giantess. If they did respond, which they might well have done immediately following the quake, the evidence was not recognized by later observation. Beyond showing an increase in temperature, and murkiness in Doublet Pool, they did not show any marked changes resulting from the shocks. The little geyser Aurum, located 45 feet southeast of Beach Spring, was stimulated into an active cycle.

Some of the most pronounced earthquake changes on Geyser Hill occurred in the central area, ringed by Anemone, Plume, Beehive, Arrowhead, Sponge and the Giantess Group. Practically all of the springs in this area erupted the night of the quake, three of them breaking through the sinter for the first time. Of the new ones, the one nearest Arrowhead has been called Blowout Spring. Following an unprecedented eruption of Dragon Spring its water stayed at a 3 foot ebb for the remainder of the season. Fifty feet west of Dragon a spring with a bridge over the crater began erupting on 4 to 5 minute intervals following the quake. It is named Roof Geyser. Its activity persisted. Three springs located between Plume and Giantess, with no record of previous activity, started steady eruptive discharge following the quake. Steady play continued for the remainder of the year. In this area a previously quiescent spring became eruptive on 5 minute intervals. Because of surging-type activity it is called Surge Geyser.

At the southwest base of the Giantess mound several fumaroles developed over an area about 20 feet square. This activity, like the above, persisted. It might be a prelude to the development of a new hot spring or springs.

What had been a large, cold pond prior to the earthquake, upon which I have seen mallards in winter, became hot following the quake. Its water ebbed about one foot revealing an old hot spring crater. It is located about 100 feet east of Infant Geyser.

The highest cone on Geyser Hill is located directly south of the above pond, and southeast of Infant. Butterfly Spring, now dry, was located at the base of this cone. Following the quake the cone's water became murky, but it was not until November 4 that it erupted. The eruption was jet-like in character, the bursts being from 25 to 30 feet in height. Following a short period of activity the water dropped about 10 feet in the crater. For the remainder of the year there was periodic boiling and surging.

This new geyser was named Cone Geyser. While it was new so far as known Park history is concerned, the cone's fluted flanks present indubitable evidence that it erupted in the solitudes of Yellowstone long before white man's advent.

Myriad Group

This group was named Three-Crater Group by the 1878 Hayden Survey. "It is named from the principal spring or geyser of the collection, and might well be called the mud group, for it contains about all the mud and turbid springs of the upper basin." In 1890 the Hague party changed the name Three-Crater Springs to Three Sisters, and designated the group as Myriad. Myriad is more descriptive as a name.

The Myriad Group as a whole would seem to be lacking the water once available to it, with the result the Ph value shifted toward the acid side. As a consequence numerous small aperatures developed in the old sinter sheet, giving the appearance of myriad springs, especially on a cold and humid morning. Many of the springs, as Hayden indicated, range from murkiness to mud.

Three Sisters Springs: On a crescent-like fringe of the Myriad Group most of the springs are clear, but generally lacking in discharge, the water being from 1 to 3 feet below the crater rims. The Three Sisters are the most noted exception. During the known history of the area the Three Sisters have been characterized by a greater amount of geyser activity than any of the other springs in the group.

During the pre-earthquake period of 1959 none of the several vents in Three Sisters showed any eruptive proclivities. Following the quake the water began to ebb in the three main craters. This ebb continued slowly for the remainder of the year. In October the two southernmost craters became eruptive for the first known time in their histories. After a short period of activity the eruptive energy shifted to one of the vents in the north crater and to a small crater, named Little Brother, located on the eastern edge of the north bowl. Both of these vents continued to erupt with considerable regularity for the remainder of the year.

Many clear, non-flowing springs are located to the south of the Three Sisters. Practically all of these springs erupted following the quake. There is no historical or physical evidence of any previous eruptive activity. One of the springs, now called Trail Geyser, erupted frequently to a height of about 50 feet for several weeks following August 17. Toward the end of the year its eruptions became infrequent.

Forty feet west of Trail Geyser a spring about 10 feet in diameter erupted simultaneously with Trail, indicating quite direct underground connections. It is called West Trail Geyser. One hundred feet to the south of these geysers a large bell-shaped spring, now named Bell Spring, had frequent sub-aerial eruptions for the remainder of the season.

Myriad Geyser: During the 1953 season for the first known time in the Park's history this spring demonstrated geyser potential. It was active one or more times daily that season. It closely resembled Daisy, but was a more powerful geyser. Conditions about the crater indicate eruption cycles comparable to the 1953 one, at some much earlier period. Since the 1953 season there has been no further geyser activity. Despite continuous and vigorous boiling, the earthquake did not trigger an eruption.

Three springs lying near Myriad, and to the east, erupted the night of the quake. These springs have previously erupted, but on infrequent occasions. There was no eruptive activity during the 1959 pre-earthquake period. One of these springs has been used for many years by concessioners as a source of hot water. Because of the misuse and spoliation it has suffered it has been called Abuse Spring. Following three different eruptions I observed strewn about the crater bricks, bottles, cans, staves, lead pipes and numerous other extraneous objects that were ejected during the eruption.

White Geyser: During most seasons this geyser is active. It plays from 12 to 15 feet high about every 15 to 20 minutes. It was inactive during 1959 until the quake, which initiated a new eruptive cycle. Activity persisted for the rest of the year.

On the eastern side of the Myriad Group, in the direction of Old Faithful, several new mud springs developed following the earthquake. Most were small. However, one of considerable size developed. It continued to grow and enlarge a concealed cavern for the rest of the year. The cavern was revealed only by echoing mud splashes which could be heard but not seen. It is called Pint Cistern. It is cistern or bottle shaped, with only the growing neck protruding from the ground.

Black Sand Basin

Spouter Geyser: Prior to the earthquake the principal 1959 geyser activity in Black Sand Basin was that of Spouter Geyser. Over the years it has maintained a near set-type activity. Its spouting is near constant. One or two quiet-phase periods, when the crater empties, characterizes it each day.

Neither its type of function or frequency were noticeably affected by the jarrings. However, the splashing did seem more vigorous. This observation was no doubt valid as there was a tempersture rise of 3 degrees. For the first two days its water was quite murky but it rapidly cleared.

A large cucumber-shaped spring is located on the creek bank directly below Spouter. Its shape, as well as its color, suggested the name Cucumber. Its limpid, greenish appearing water was very turbid on the morning of the 18th. It was several days before the green color returned. In the east end of Cucumber Spring's crater a small vent was spouting on the 18th for the first observed time. This activity continued without respite for the rest of the year.

Green Spring: This spring is a true geyser. It has been in a dormant cycle the past few seasons, but erupted the night of the quake. There was no further activity throughout the remainder of the year. During dormant cycles the discharge is uniform and steady.

Emerald Pool: During the past few seasons Emerald Pool's temperature has been slowly dropping, resulting in a darker and less attractive green color. The morning following the quake it was murky and 3 degrees hotter. It took several days to clear.

Sunset Lake: The most interesting effect of the earthquake in Black Sand Basin was an eruption of Sunset Lake. This eruption, like so many, must have occurred immediately following the initial jarrings. The previously sunset-colored water was muddy, but in a few days it changed to a beautiful turquoise blue. By the end of September the original coloration was largely restored. The colored algae in the drainage channel leading into Iron Creek were scalded by the eruption. Rainbow Pool, located a few feet south of Sunset Lake, was murky and in a state of ebb on the morning of the 18th. By the end of the week its water had largely cleared, but it stayed about 6 inches below overflow stage for the rest of the year. Prior to the earthquake Rainbow flowed copiously and was beautifully hued.

Handkerchief Pool, which is connected underground with Rainbow, was affected by the quake in the same manner as Rainbow.

Whistle Geyser: Beginning with the 1958 season the temperature of Whistle dropped from 199 to 143 degrees. This apparently resulted from the water rising in the crater to the overflow stage. This spring had never previously overflowed during the period it has been under my observation. Following the quake its temperature was 145 degrees and the water was murky for several days. There was no eruptive activity.

Cliff Geyser: Cliff has been cyclic throughout its known history. Some of its dormant cycles would seem to have been relatively long. During 1959, prior to August 18, 2 eruptions are known to have occurred. Due to the length of the active phase, 6 to 8 hours, these 2 eruptions no doubt represent its total 1959 pre-earthquake activity. As a result of the quake Cliff became far more active than during any previous eruption cycle. For the first six weeks it was active most of the time, but the eruptions had decreased to 2 or 3 per week by the end of the year.

Black Sand Pool: This pool is located midway between Black Sand Basin and the Daisy Group. Its water is deep blue in color, the temperature being near constant, at about the boiling point. Its discharge likewise has been uniform during the years I have observed it.

The earthquake resulted in a 3 degree rise in temperature. This was sufficient to give the pool geyser characteristics. Every 5 minutes steam detonations at depth could be heard and felt. This was followed by boiling and flow, then ebbing.

Daisy Group

This small, but important group of hot springs underwent profound changes as a result of the earthquake. The thermal energy, which during the early part of 1959 had been shifting back and forth between Daisy Geyser and Brilliant Pool and Splendid Geyser, not only shifted to the east, in the direction of Daisy, but it resulted in a number of new springs and fumaroles developing on the east side.

Daisy Geyser: Except for periods when the thermal energy had shifted to Brilliant Pool and Splendid, the Daisy played with a fair degree of regularity prior to August 18. From May 1 to August 18, 145 eruption intervals were checked. The average time was 138 minutes. The average time given is only for the periods when the thermal energy was expressed by the Daisy. It is dormant when the energy shifts to Brilliant and Splendid. This dormancy will sometimes last for a week or more. The minimum length interval for the 145 intervals was 86 minutes, the maximum 200 minutes.

On the morning of August 18 the water in all the springs connected subterraneously with Daisy, and in the Daisy as well, was in a state of ebb comparable to that which follows an eruption of Splendid. Examination revealed that Splendid had erupted apparently at the time of the quake. Before the day had progressed very far it was evident that in spite of an ebbed condition in all springs, Daisy was periodically erupting. With the Splendid inactive, this was something entirely without precedent. The Daisy had never been observed to erupt independently of the Splendid except when its crater was full and overflowing. During the early history of the Park, Daisy would occasionally erupt in concert with the Splendid. At such time the water would be down in Daisy's crater, but with the dormant cycle of Splendid, Daisy had always overflowed before playing.

Not only was the Daisy erupting when the water was about 6 inches below overflow, it was playing on shorter intervals than before the quake, the average time being about 90 minutes. This average continued to shorten for the next few weeks. During the first week in September, by means of an automatic recording device, constructed by Park Ranger Naturalist William Germeraad, obtained of most of Daisy's eruptions. These data are as follows:

Date	Intervals checked	Average	Minimum	Maximum
September 1	7	74.3 min.	69 min.	85 min.
" 3	14	60.9 "	55 "	67 "
" 4	15	61.6 "	45 "	71 "
" 5	30	47.0 "	28 "	61 "
" 6	23	47.8 "	37 "	55 "

For those who are acquainted with Daisy's past performance the above figures are quite startling. A day's average of 47 minutes and an interval as short as 28 minutes would seem to border on the miraculous.

For the remainder of the year Daisy continued to erupt on much shorter intervals than prior to August 18. The length of the interval seemed dependent upon how far the water would rise in the crater. A fluctuating condition existed. On some days the eruptions would consistently start when the water was down 12 inches. Other days the ebb would be more or less. Occasionally the crater would fill. At such times the intervals would be about 90 minutes. The degree of ebb determined the length of the interval. The greater the ebb the shorter the interval and vice versa. From October through the rest of the year the average interval was near one hour. It varied between 45 and 90 minutes.

During those periods when the eruption would start with the water several inches below overflow the duration of the play was consistently about one minute longer than when the crater was near full or overflowing. With the shorter intervals and more prolonged activity the force of the eruption seemed greater. This seemed to present a rather paradoxical situation.

Following an eruption of Daisy the water would drop in its crater and the craters of Splendid, Brilliant and Comet to about the same degree as was formerly characteristic following the first eruption of Splendid.

Comet Geyser: Until August 18 the Comet played during 1959 as in previous seasons. Boiling in its crater was constant. At about 4 minute intervals the water would surge up about 4 feet above the crater rim.

An eruption of Daisy had very little effect on Comet. Periodic surging would continue during or immediately following Daisy's activity, with not more than one or two inches of ebb in Comet. An eruption of Splendid would not only bring cessation to Comet's activity, but the water would ebb from a foot to several feet, depending upon the number of times Splendid played during the series.

Following the quake all intermittent activity in Comet ceased. The surging was constant irrespective of Daisy's activity. An eruption of Daisy, however, would lower the water about a foot in Comet.

Splendid Geyser: During the past few years Splendid has shown a greater amount of activity during winter and early spring than in summer. From May 1 to August 18, 1959, 18 eruptions were recorded as against 15 during the same period in 1958. When the Splendid would go into an active phase there were usually 2 or 3 eruptions in the series. The intervals would vary from 1 to 3 hours. In May 1959 there were 4 during the active phase. In 1958 and early 1959 Splendid was more active than during any previous season since 1952.

An eruption of Splendid at the time, or immediately following the earthquake was the last time it played during 1959. The cause of this

dormancy apparently resulted from the surficial expression of the thermal energy shifting away from Splendid in the direction of Daisy and beyond.

From August 18 to the end of the year the water stayed from 6 inches to 2 feet below the rim of Splendid's crater. This resulted in an increase in surging as well as temperature over what characterized it prior to the jarrings. At times, especially following an eruption of Daisy, there would be incipient eruptions of Splendid when the water would rocket up from 15 to 20 feet.

It is highly probable that Daisy and Splendid played in concert following the quake. If so, this is the first known time it has happened since the 1890's.

Brilliant Pool: During the past few seasons whenever the thermal energy shifted from Daisy to Splendid it would also shift to Brilliant Pool, resulting in overflow. Until this overflow ceased the Splendid would not erupt. Sometimes the overflow would persist for a week or more. Following an eruption of Daisy the water in Brilliant Pool always ebbed about 12 inches. Following an eruption of Splendid it would ebb from 4 to 8 feet, depending on the number of times Splendid played. After an eruption of Splendid the temperature would increase from 10 to 12 degrees in Brilliant. This frequency resulted in Brilliant Pool becoming a geyser. The geyser activity would usually follow the second or third eruption of Splendid. It was characterized by a number of angular jets, reaching out about 20 feet beyond the crater.

On the memorable morning of August 18 when I first observed the Daisy I noted that the water in Brilliant Pool was down about 4 feet, suggesting that Splendid had just erupted. The situation was due to conditions as above described for Daisy. From then to the end of the year the water in Brilliant Pool was in a state of ebb. Instead of the crater filling, as it had formerly done before an eruption of Daisy, the water would still be about a foot below the crater rim when Daisy would erupt, ebbing another 3 feet by the end of Daisy's activity. The degree the water would rise in Brilliant Pool prior to an eruption of Daisy was governed by the level of the water in Daisy at the time of an eruption. Following the quake no geyser activity was observed in Brilliant, but it was boiling most of the time. When the water would be down 3 to 4 feet in the crater the temperature would be 202 or 203 degrees. When the crater is full the temperature is about 194 degrees.

Bonita Pool: Prior to the time the road was built practically over the top of Daisy and Bonita, Bonita served as an indicator for an eruption of Daisy. In recent years Bonita has shown little response to Daisy's eruptions, the water being below overflow except on rare occasions. During the 1937 and 1938 seasons Bonita frequently erupted. Between 1951 and the summer of 1959 its temperature had dropped from 140 to 104 degrees. Following the quake there was little change in Bonita's temperature, but the water ebbed several inches.

One of the marked and interesting changes in the Daisy Group resulting from the quake was the development of a number of fumaroles and small springs in the parking area and on the shoulder to the east of Daisy. From scores of points water began bubbling from the ground. Existing springs, all of them small, became more active. The one nearest Daisy, a narrow rift in the sinter, which had boiled and gurgled constantly before the quake, sounding very much like a boiling radiator, became periodically eruptive. It has been named Radiator Geyser. It showed connections with Daisy by occasionally playing to a height of 9 to 10 feet immediately following an eruption of Daisy. In 1951 and 1952 it always boiled over following an eruption of Splendid. The very active geyser on the side of the shoulder or bank 100 feet east of Radiator is Bank Geyser. Its eruptions occur about every 45 seconds to a minute.

Castle Group

The springs discussed in the Castle Group will also include the ones in Sawmill, a sub-group.

Castle Geyser: Between May 1, and the earthquake, 1958 steam-phase eruption intervals were determined for the Castle. The average interval between eruptions was 15 hours and 53 minutes. The minimum interval was 13 hours, the maximum 18 hrs. and 28 min.

Like most of the geysers, Castle played less frequently during the 1959 pre-earthquake period than during the 1958 season. Its 1958 average was 14 hrs. and 33 min. It was more difficult to predict its 1959 eruptions, especially during the early part of the season. There was but one 4 minute eruption. These 4 minute eruptions, minus the steam phase, always result in short intervals.

The Castle, like most of the geysers, has shown great irregularity during its known history. For a number of years the eruptions would approach regularity; during other similar length periods activity would seldom be observed. During recent years it has played with unusual frequency and regularity.

Following the earthquake it soon became evident that a new source of thermal energy had been made available to the Castle. During August 18 and 19 three daytime steam-phase eruptions were observed. Such activity was entirely without precedent. Eruptions occurring about every 4 hours seemed utterly fantastic. During these two days there was one interval of 3 hours and 55 minutes! In spite of the very short intervals there was no apparent change in the type or forcefulness of the activity. The water phase lasted about 15 minutes, the steam phase continuing for more than double that time.

During the first few days following the quake the Castle was manifesting about 4 times as much eruptive energy as in the pre-quake period. By September the intervals had increased to approximately 6 hours. The average time continued to increase slowly for the remainder of the season.

Between November 3 and 17, 37 eruption intervals were mechanically checked. The shortest interval was 7 hours 38 minutes; the longest, 10 hours and 23 minutes; the average, 9 hours and 3 minutes.

It has not yet been determined whether the earthquake made available to Castle latent thermal energy, or the great increase in function resulted from a shift to it of thermal energy from other springs. It is not unlikely that at least part of Castle's new energy was at the expense of Crested Pool and possibly Grand Geyser which became dormant after an earthquake stimulated eruption. During recent seasons the Grand and Castle have shown sympathetic responses in function that seemed a bit more than coincidental. Crested Pool is located on the same mound with Castle. Prior to the quake its temperature was 200 degrees, with a 15 gallons per minute steady discharge. Following the quake its water had ebbed 12 inches and the temperature had dropped to 155 degrees.

In spite of the great increase of activity in Castle, Tortoise Shell Spring, situated right at Castle's base, did not show any alteration in temperature and function from either Castle's unusual activity or the earthquake. This was also true of the little geyser, now called Tilt that sprayed on the walk between Castle and Crested Pool.

Sprinkler, located on the river bank at the base of Crested Pool's mound, rose 4 degrees in temperature and was observed erupting more frequently following the quake. Detailed data has not yet been obtained for this geyser. Across the river from Sprinkler, and on the side of the high sinter bank, a new geyser began erupting after the 17th. Prior to the quake there was no discharge from this spring. Neither is there any record of geyser activity. There was periodic activity in it for the rest of the year.

The quake induced deleted Teakettle to erupt. For the remainder of the year there was steady discharge from it which had not been true prior to the 18th. Prior to the quake the water in nearby South Scalloped Spring was below overflow. Following the 17th it discharged about 5 gallons per minute for the rest of the season with a temperature increase of 4 degrees. The water in Scalloped Spring showed about the same increase in temperature, but stayed below overflow. Terra Cotta Springs, located across the river from the above springs, rejuvenated from dormancy and began an active cycle.

Sawmill Geyser: Before the earthquake the activity in Sawmill was essentially the same as during 1958. The eruptions occurred about every 2 to 3 hours, lasting about 1 hour. For the first two days following the 17th it seemed to play constantly. Whenever I was in a position where I might observe it, it was erupting. Following this initial surge of activity it again became periodic, the intervals varying between about 1 and 3 hours.

On two different dates the sawmill was dormant. On both of these days a geyser 100 feet northeast of Sawmill played constantly all day long. It plays from 5 small orifices to a height of about 20 feet. It is named

Penta Geyser. During its history it has been cyclic, active some seasons and dormant others. That the Sawmill might figure in some of its cyclic function is indicated by the above observation. A few feet north of Penta Geyser a large open pool, Oval Spring, erupted following the quake. There is no record of previous activity. The water ebbed about 6 inches in Spasmodic Geyser, with a 4 degree rise in temperature and increased vigor of boiling. This condition persisted.

Liberty Pool: Prior to the earthquake this spring had maintained a near constant 133 degree temperature. Its crater was lined with masses of brown algae which would occasionally sluff off and, island-like, float on the surface. During the night of August 17 eruptive energy was communicated to it, resulting in a heavy discharge of water. There was no further activity, but a 40 degree increase in temperature was maintained for the rest of the season.

One of the remarkable changes in springs near Liberty was the eruptive activity in 3 comparatively cold springs lying a short distance to the east. One had been named Frog Spring. In summer frogs could always be observed there. All three springs were filled with algae and aquatic plants. During the night of the quake the Frog Spring erupted. One month later its temperature was still 196 degrees, this being almost 140 degrees hotter than before the quake. A large non-flowing spring just south of Frog erupted violently the night of the 17th.

Grand Group

Grand Geyser: During 1959 the average eruption interval for the Grand was 30 minutes longer than in 1958. Prior to August 18, 242 eruption intervals were checked. The average time was 9 hours and 2 minutes. The maximum and minimum length intervals came near the same date. The maximum interval, 11 hours, was on July 24; the minimum, 6 hours and 7 minutes, was on July 26. The great majority of the eruptions were between the 8 and 9 hour range. This high degree of regularity made possible relative accuracy in prediction of the time of an eruption, enabling thousands of park visitors to see and enjoy this magnificant geyser.

Early on the morning of August 18 the Turban and Vent were observed playing simultaneously. This, in connection with the empty crater of the Grand, made it certain that it had erupted a few hours earlier. Following this eruption it became dormant for the rest of the year.

Before August 18 the temperature of the Grand after recovery from an eruption, and during the quiet phase preceding an eruption, was approximately 176 degrees most of the time. This temperature dropped to 165 degrees. This drop was sufficient to render the Grand inactive. Following the eruption the night of the 17th the crater filled as formerly and continued to flow periodically, with a slight increase in discharge, for the remainder of the season. By October brown algae were beginning to grow in the crater.

This dormancy of the Grand, while directly the result of the earthquake, is not without precedent. In 1888 it was inactive all summer. When it rejuvenated is not known. In late May 1942 when I first visited the Grand, long filaments of algae were adhering to its crater, with the water appearing very stagnant. It was evident it had not erupted for many months. An induced eruption initiated an eruption cycle which persisted until August 18, 1959.

While the causes of the two earlier dormant periods did not result from an earthquake, there is a reasonable degree of probability that the present inactivity might have resulted from a shift of the thermal energy from Grand to other hot spring units. This is what happened before.

If the quake did not disturb the nature of underground plumbing there is a high degree of probability that the Grand will become a functional unit again.* The great increase in thermal energy of springs near, and aligned with Grand, was very suggestive of the cause of its dormancy. Intensity of activity abated in these springs as the season progressed. With this declining activity there was a gradual increase in Grand's temperature. By December 15, it had increased to 173 degrees. Barring underground structural changes the Grand will again enthrall future park visitors.

Turban Geyser: There is a marked sympathetic relationship between the Grand and Turban Geysers. Like the Grand, the Turban became dormant following an earthquake induced eruption. Its temperature, while about 20 degrees hotter than Grand's, dropped approximately the same amount, 10 degrees.

In spite of quiescence the Turban continued for several weeks to show the same ebb and flow characteristics as it had done prior to the big incident. The ebb and flow periods, with a sympathetic response of Grand, came with the same frequency as had Turban's pre-earthquake eruptions. However, at the time of Turban's flow periods there was no boiling or overflow.

By late September Turban was having feeble eruptions on about 17 minute intervals, indicating increasing temperature. These eruptions, with greatly diminished overflow into Grand and Vent, continued for the rest of the season.

Prior to the quake the Vent Geyser had never been known to perform except when induced by an eruption of the Grand. This relationship was further emphasized by complete dormancy of Vent along with the Grand.

Rift and West Triplet Geyser: Near dormancy of the Triplets during the past few seasons has been an important factor in the marked increase of Grand's eruptions. Only West Triplet has shown any eruptive activity,

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* The first eruption of the Grand following the quake-induced activity was on February 19. Park Ranger McClelland reported that from then until April 1 there were four additional eruptions.

and most of this occurred at the time of an eruption of Grand. After the quake and for the remainder of the year, West Triplet was dormant. However, it would have occasional overflow periods when the water would well out quietly.

Rift Geyser on infrequent occasions has been observed erupting independently of the Grand. The great majority of Rift's eruptions, however, came in the form of a chain action. Approximately 45 minutes after the start of an eruption of Grand, Rift would erupt.

The quake did not bring about complete cessation of Rift's activity. Between August 18 and the end of the year it was observed erupting on four different occasions.

Economic Geyser: The following statement is found in the 1926 Haynes Guide: "The Economic has not been observed in action for a season or more, and may have become extinct." Whether the dormancy resulted from a shift of the thermal energy to other springs, or from underground changes arresting the flow of the energy was never determined.

From about the middle 1920's no further eruptive activity was observed in Economic until May 19, 1957. On this date Park Ranger Jim McKown reported seeing 3 eruptions, each about 8 feet high. On June 1, 1957, when I first viewed Economics crater that season, it was full of brown algae. There was no surficial evidence of recent eruptive activity. No further eruptions were reported until the morning of August 18, 1959.

One of the big surprises on the above morning was to see this long-dormant geyser erupting. More surprising still were the eruptions of a spring at the base of the hill a few feet east of Economic. A search of available records does not reveal evidence of any previous geyser activity in this unnamed spring.

Activity of Economic and East Economic, as it has been called, presents certain evidence of underground connections. Both manifested a high degree of sympathetic response. In both geysers practically all the water of the eruptions flow back into the craters, hence the name Economic.

For the first three weeks following August 17, both geysers were very active. During the first few days when Economic was in an eruption phase activity would occur about every 5 minutes. By the end of three weeks some of the intervals were from 15 to 20 minutes. Most of Economics eruptions were from 5 to 8 feet in height, with an occasional one reaching about 30 feet.

The back vent did not erupt as frequently as Economic. As closely as could be determined the intervals were from 3 to 5 hours. East Economic, however, was a more powerful geyser. The column of water was much more voluminous, the average height being about 35 feet. If this spring has ever had a previous eruption cycle of comparable magnitude it would have been a long while ago. Current activity scalded and killed some large lodgepoles growing near the crater.

After the middle of September activity in both geysers became infrequent. After September 21 no further activity was observed. The water in both craters cooled rather rapidly, and by the end of the year both craters were lined with brown algae.

Following cessation of play in the above geysers a spring 250 feet to the north, located between Wave Spring and Beauty Pool, became eruptive. It played about 6 feet high, several eruptions occurring during the day. The eruptions issued from a fissure in the sinter, resulting in this new performer being called Crack Geyser. Activity persisted in it for the remainder of the year.

Beauty & Chromatic Pools: Beauty and Chromatic are connected subterraneously. There is a direct exchange of function between them. Water will flow for a few months from one with the other ebbed below overflow. This situation will then be reversed. At the time of the earthquake Beauty was overflowing, and continued to do so for the rest of the year. Its post-earthquake overflow, however, was almost doubled. The temperature increase was 4 degrees. About the only effect noticeable in Chromatic was additional ebbing.

During the night of the quake a few of the small springs in the flat between Economic, Beauty, and Calida erupted, with no further activity being observed. Calida Pool did not erupt, but its temperature rose 9 degrees, and its water was murky for the rest of the season, with increased flow. The milky colored spring, 50 feet west of Calida, was named Milk Cauldron. Following the quake its temperature rose 6 degrees. This, plus a 20 inch ebb in the crater, resulted in more vigorous boiling. Other than murky water, which rapidly cleared, the Witches Cauldron showed no change in either temperature or discharge. Lime Kiln Spring, just west of Witches Cauldron, was the only spring in the Grand Group that did not show some change attributable to the earthquake.

Orange and Round Spring Groups

Both these groups are small. The geysers are few and all small. Prior to the quake no geyser activity had been observed in the Orange Group. Orange Spring (cyclic) began erupting following the quake. This activity continued periodically for the rest of the year.

In the Round Spring Group both Pear and West Round Springs erupted the night of the quake. The eruption of West Round appeared to have been very violent. There was no further activity, and none had ever been recorded previously.

Giant Group

Though small, the Giant Group contains a number of important geysers, most of which are located on the same sinter platform with Giant Geyser. In this group the Oblong was the only geyser that showed marked effects resulting from the quake.

Giant Geyser: Since 1955 the Giant has been in a dormant cycle. During the early part of 1959 there was increased sloshing in the crater over what was observed in 1958. This was suggestive of a pending eruptive cycle.

Unlike most of the geysers the earthquake did not stimulate an eruption of the Giant. For several days following August 17 there was promise of an eruption. For the first time since 1955 sloshing was forceful enough in the crater for water to splash over the back of the cone. During this increased animation the indicator vents in front of Giant never became activated, which activity is a prelude to an eruption of Giant.

For several days there was increased splashing in Mastiff Geyser, with more forceful activity of Bijou. The Catfish never rejuvenated. It would seem that too much of the thermal energy along the fissure, of which the Giant Group is a member, was diverted to Oblong and the Grotto Group. With their greatly increased activity, animation in Giant and adjacent springs slowly subsided.

Purple Pools: These Pools lie across the river from the Giant, with which they have underground connections. Of the 3 Purple Pools only the south one was overflowing prior to the quake. It would seem to have been affected to a higher degree than the other two. All were murky following the quake, but in South Purple Pool the temperature rose 37 degrees and there was cessation of overflow.

Oblong Geyser: During the pre-quake period of 1959 the eruptions of Oblong occurred with about that same frequency, every 6 to 8 hours, which has been characteristic for the past few seasons.

On the morning of the 18th the water in Oblong's crater was murky. By the 19th it had cleared. The rapid clearing might in part have been due to the increase in eruptive frequency. The intervals prior to August 18 had varied from about 6 to 8 hours. The quake just about doubled its manifestations of thermal energy.

During the first few days following the quake, due to a lack of opportunity to make observations, very few of Oblongs intervals were checked. The shortest interval determined was on August 26. It was 2 hours and 14 minutes. There evidently was no marked increase in the length of the eruption intervals in the early period following the quake. During the last week in September 47 intervals were mechanically checked. The minimum interval was 2 hours and 29 minutes, the maximum, 5 hours and 24 minutes. The average eruption interval was 3 hours and 31 minutes. For the remainder of the year it continued to play on essentially the same frequency.

This great increase in eruptive frequency was not balanced by any decrease either in the duration of activity or the volume of discharge for individual eruptions. The duration of the eruptions was the same and they were equally forceful. The increase in the discharge of thermal energy was actual and real, and to the degree that was manifested by the increase in eruption frequency.

Grotto Group

Grotto Geyser: In 1959, as during 1958, the Grotto was active about half of the time. During the latter part of 1958 the duration of the active phase increased from 1½ to 3 hours to nearer 8 hours. The quiet phase was also near 8 hours in length. This pattern of play carried over into the pre-quake period of 1959. Following August 17 the duration of the active phase showed considerable increase over that of the quiet phase. Due to the duration of the activity, and the limited opportunity for checking, it was difficult to determine accurately how long most of the eruptions lasted. It is certain that the great majority lasted for more than 24 hours. One active phase was determined that lasted for 43 hours. The quiet phase seemed to vary between about 8 to 12 hours. Considering the fact that the Grotto while in eruption discharges about 470 gallons per minute, the great increase of the active over the quiet phase is revealing of the extent of the increase in thermal energy. The volume of discharge per minute was essentially the same before the quake as after.

Grotto Fountain, or Surprise Geyser: During the pre-earthquake period in 1959 the same pattern of play was characteristic as during the latter part of the 1958 season. Instead of the majority of Grotto's eruptions being initiated by Grotto Fountain, most of them would be triggered by the small geyser lying 20 feet to the south. This relationship was not greatly changed by the August incident. After August 17 Grotto Fountain played with about the same frequency as before. The same was true of Spa Geyser.

Riverside Geyser: From May 1 to August 18, 235 eruption intervals were determined. The shortest interval, 6 hours and 23 minutes, was on July 23; the longest, 8 hours and 4 minutes, was on July 4. The average interval was 7 hours and 27 minutes. The season's average was 25 minutes longer than during 1958. The time of the overflow preceding an eruption varied from 104 to 145 minutes.

During the first 10 days following the quake Riverside's average was 5 hours and 45 minutes. This was a shortening of the interval by 1 hour and 48 minutes. By the end of September the great majority of the intervals were over 6 hours. Between September 1 and December 11, 70 eruption intervals were checked. The average time was 6 hours and 28 minutes. During the last 3 months of the year Riverside showed great regularity, not varying more than 10 minutes from this average.

One of the small springs in the Riverside parking area erupted the night of the quake. Water in all of them ebbed. They stayed in an ebbed state for the rest of the year.

Chain Lake Group

This group is a part of the Grotto Group. It contains several large and interesting springs.

Link Geyser: In late June 1958 the thermal energy shifted from Link to the Bottomless Pit, the largest spring of the Chain Lakes. Link's temperature showed decline during the rest of the season, dropping from 202 to 182 degrees. By May 1, 1959, its temperature had further dropped to 157 degrees. There was no overflow. Following the quake there was no rejuvenation of eruptive activity, but the temperature increased to 163 degrees and for the rest of the season there were 34 gallons per minute of steady overflow.

Bottomless Pit: Between June 1958 and the summer of 1959 the temperature of this springs rose from 140 to 195 degrees. This was explicable by a comparable drop in temperature of Link, known to be connected subterraneously.

Following the quake the Pit's temperature increased to 198 degrees, and there was evidence of surging. The water was very turbid for several days. Later it changed to turquoise color. It did not entirely clear during the rest of the year.

Several springs are located directly south of Bottomless Pit, between it and the road. When the present road was located one of these springs was buried, its water being diverted by a culvert to the side of the road. In recent years it has developed steady geyser activity and has been named Culvert Geyser. Following the quake its temperature rose 2 degrees. There was noticeable increase in the vigor of the boiling.

A square shaped spring is located about 25 feet southwest of Culvert Geyser. It is about 18 feet square, and has been named Square Spring. Infrequently it has shown geyser activity, but no eruptions have been observed for several years. The night of August 17 there was a quake-induced eruption. For the remainder of the season there was no further evidence of geyser activity.

The remaining springs in the Chain Lakes, which are connected both at the surface and underground, became murky following the quake. The water ebbed in all craters and there was an increase in temperature. There was no overflow from these springs, either before or after August 17. The two springs on the northern end of the chain have on infrequent occasions erupted.

Morning Glory Group

Morning Glory Pool: During all of its known history this spring has maintained a near set volume of overflow. Its temperature also has been relatively constant, the range of fluctuation, except at the time of two known eruptions, being not more than 10 degrees. Its pre-quake temperature for both 1958 and 1959 was 163 degrees. On the morning of the 18th the water had ebbed about 1 inch. This was sufficient to stop all overflow. The water was slightly murky and the temperature was 165 degrees.

For the next 10 days the ebbing continued slowly until it was a minus 6 inches. The temperature had increased to 169 degrees. During September

and most of October the water level fluctuated between a minus 2 and minus 6 inches. During the latter part of the year the ebb stayed at a level of near 6 inches.

Though the temperature rose 6 degrees in Morning Glory there was less discharge of thermal energy than before the quake. This was due to a complete lack of overflow following August 17. As yet no clues have presented themselves which might account for the loss of this energy.

About 100 feet north of Morning Glory there are two large craters of comparable size. Both have been empty during their known history. It is possible that the nearby Firehole in incising its bed into the geyserite tapped arteries leading to these springs. Following the quake near boiling water rose about one foot in the bottom of the crater closest to Morning Glory.

East Sentinel Geyser: This geyser erupted the night of the 17th, no geyser activity having been observed earlier in 1959. Following the quake-induced eruption no further major activity took place. However, the 2 degree increase in temperature was sufficient to result in more vigorous boiling. West Sentinel did not erupt, but steady boiling was at an increased tempo.

Some large springs at the bottom of the embankment south of West Sentinel became more active following the quake. One took on a brick color. Another, on a smaller scale, showed flashing jets of water comparable to the Dragon's Mouth. It was named Serpent's Tongue. Three springs 200 feet north of this group erupted the night of the quake.

Fan & Mortar Geysers: During recent years both these geysers have been dormant more seasons than they have been active. They are connected underground and when in eruption play simultaneously from many separate vents. Over the years vandals have made a large contribution toward destroying these geysers.

On June 21 and 29, Fan and Mortar had major eruptions. No further activity was noted. They did not erupt the night of the quake and there was no activity during the rest of the year. Following the quake both showed increases in temperature. Increased boiling in Fan was very noticeable for the first few weeks, but it was not sufficient to trigger an eruption.

Cyclops Spring: This large spring is located on the extreme northern end of the old Wylie campground. It and two adjacent springs were used as depositories for much of the refuse of the camp. One large spring was completely filled with tin cans, bottles and related articles from the mess.

The temperature of Cyclops has been near boiling for many years. It has maintained steady and copious overflow. There is no record of its ever having erupted. Being somewhat isolated it was not observed for several days after the quake. When it was, physical evidence was indicative

there had been one or more tremendous surges from it. Plant growth on the south embankment had been scalded several feet away and above the crater. Heavy wash was in evidence in all directions.

Cascade Group

Great changes occurred in this group the night of the 17th. Seventeen springs with no record of geyser activity erupted, with nine additional ones having played. Geysers that are cyclic, and were dormant prior to the quake, were stimulated into active cycles which lasted for the rest of the year.

Artemisia Geyser: Despite numerous changes in the Cascade Group, three of its important springs, Artemisia, Atomizer and Iron, showed no immediate or after effects of the quake. The water in Artemisia's large crater on the morning of the 18th was the same limpid blue as on the 17th. For the remainder of the year its eruptions came with the same frequency, every 20 to 30 hours, as preceding the quake. The same observation is true for the Atomizer Geyser. It is not impossible that both geysers could have been stimulated into an eruption with the initial jarrings, as was so generally the case with hundreds of springs. In the case of Artemisia and Atomizer, if they did erupt at the time of the quake, due to the nature of their surface structures, physical evidence would be wanting by the morning of the 18th.

Gem Pool: During all of Gem Pool's known history it has maintained a steady overflow of about 85 gallons per minute with a temperature of about 188 degrees. Due to its depth, temperature and limpid water it has been one of the loveliest of the blue colored springs, hence the name, Gem Pool.

On the morning of the 18th the water had ebbed about 6 inches below overflow and was very murky. By the morning of the 19th it was again overflowing, but it took several days for the water to clear. In late November the water again ebbed and remained below overflow for the rest of the season.

Calthos Spring: During the night of the 17th this spring erupted. There is no record of any previous geyser activity. Conditions about its large mound, however, are indicative of geyser activity at a time prior to the discovery of the Park. Gem's ebbed condition was the direct result of the eruption of Calthos. Before the quake it had been demonstrated that these springs have rather direct underground connections. Gem's ebbed condition in November was again preceded by an eruption of Calthos. Gem stayed ebbed for the year due to the shift of the thermal energy to Calthos, resulting in frequent boiling and water standing at a higher level in its crater.

Sprite Spring: Prior to the quake there was no overflow from this spring. Its temperature was 164 degrees. The morning following the quake found its previously clear water of almost a mud consistency, and overflowing. Its temperature had risen to 181 degrees. Its water never completely cleared for the rest of the year.

On the hillside directly above Gem and Sprite there is a large crater of some earlier existing hot spring. Prior to the quake it was empty. Within the crater, near one of the upper shoulders, bears were able to enlarge a lateral cavern in the geyserite sufficiently to make it suitable for hibernation. Two bears hibernated there the winter of 1958 and 1959. At least one bear is hibernating there during the current winter.

Their steam heated apartment was almost ruined. The quake resulted in near-boiling water filling the bottom of the crater. The bears have a good trail to the opening of the cavern, but it is now perched over a rather precarious situation. Bear Den has been suggested as a name for this spring.

Two large springs are located at the northwestern base of the large mound of Calthos. Both are situated within a much older crater whose walls rise about three feet above the existing springs. Prior to the quake the spring nearest Calthos was of a beautiful deep-blue color. It was named Pulcher, the Latin for beautiful. Thin shelves of geyserite extended out over the crater. Water in the other spring was much cooler, supporting an algae growth.

On the morning of the 18th these springs had disappeared. The large crater where they were located had filled with murky water and was overflowing heavily to the northwest, having scoured a channel through grass and around pine roots. After a few weeks the overflow stopped, but the water level stayed near the top of the old crater.

On both the west and northwest side of Pulcher Spring several springs erupted the night of the quake. Two of them were geysers that had been in dormant cycles.

Hillside Geyser: This geyser is about 300 feet southwest of Pulcher. It is located on the side of the hill or high sinter bank of the Firehole River. It consists of two vents separated by a constriction. During most seasons there is periodic boiling and discharge, the water surging up about 3 feet. During the 1952 season the eruptions were of greater magnitude than during any other recorded period. They were about 20 to 30 feet in height.

The earthquake stimulated Hillside Geyser into a major eruption cycle. During the periods checks were made of the length of the eruption intervals they varied from 20 to 66 minutes. The average interval was 26 minutes. During the eruption, which lasts from about 3 to 5 minutes, a heavy flow of water cascades into the Firehole. The heights of the eruptions, as well as the durations, were variable, being between 15 and 30 feet. Activity persisted for the rest of the year. Its location makes it difficult to view to best advantage.

On the south bank of the Firehole, across the river from Hillside Geyser, 11 springs are known to have erupted the night of the quake. Five of them were periodically eruptive for the remainder of the year.

Cauliflower Group

Baby Daisy Geyser: Prior to the post-earthquake period of 1959 there is only one season when this geyser is reported to have been active--1952. During this season several previously quiescent springs became eruptive. In its manner of function the one named Baby Daisy was a near replica of Daisy. The water played out at the same angle, to a height of about 30 feet. Prior to 1952 there could have been no activity in this geyser for many years. Lodgepole pines, about 50 years old, were killed by the ejected hot water. Following the 1952 season no further activity of this geyser was observed until the morning of August 18, 1959.

For the rest of the year Baby Daisy erupted on essentially the same pattern as in 1952. The eruptions lasted from 2 to 2½ minutes. The height was about 30 feet and the intervals varied between 60 and 96 minutes. During 1952 the intervals varied from 90 to 120 minutes.

Biscuit Basin Geyser, a major geyser 200 feet northwest of Baby Daisy, which was very active in 1952, was not stimulated by the earthquake to erupt. The same was true of 5 other small geysers near Biscuit Basin Geyser that were active during 1952.

Cauliflower Geyser: This spring is a true geyser. Its eruptions consist of a sudden surge or boiling roll of the water. The duration varies from 1½ to 3 minutes. All intervals I have checked have varied between 50 and 60 minutes. After the quake this same pattern of activity continued. However, for about 3 days following the quake the water was murky,

The only observed effect of the quake on nearby Mirror Pool was murky water that rapidly cleared. During the years it has maintained a near constant volume of discharge, being about 22 gallons per minute.

In Cauliflower's drainage channel leading to the west, 100 feet from Cauliflower, a new geyser developed the night of the 17th. For the rest of the year it played about every 5 minutes to a height of 5 to 6 feet. Several new fumaroles developed in the grove of trees farther west.

Five of the small springs on the east side of the Firehole, and in the Cauliflower Group, erupted the night of the quake. The one on the north side of the road was periodically eruptive from 2 vents for the rest of the season. This geyser is cyclic. Prior to the quake it had been dormant for several seasons.

Sapphire Group

This group of springs seems to have been affected to a greater degree than any other area in the Upper Basin. None of its springs escaped alteration in behavior. New springs and fumaroles developed. There was more evidence of surface fracturing than in other parts of the Upper Basin. Near the south bank of Black Opal and Wall Springs a large crack appeared. It was over 150 feet long and partially encircled Wall Spring. Until Sapphire began scouring the formations, filling a portion of this crack with sediments, its water drained into it.

Black Opal Spring & Wall Pool

Black Opal presents indubitable evidence of having come into being explosively. Large blocks of cemented aluvial sediments are strewn about its crater. Some are found over a hundred yards from the crater indicating the force of the explosion. This event happened prior to the discovery of the Park.

Some seasons Black Opal will have a series of eruptions. The eruption consists of a momentary, huge surge which sends thousands of gallons of boiling water into the Firehole. During 1959, prior to August 18, Black Opal was characterized by dark opalescent coloration. There was no eruptive activity. A continuous thumping sound could be heard. These sounds did not seem to come from any great depth. The most important effect the earthquake seemed to have on this spring was to destroy its lovely color. The water was very murky at first and did not completely clear during the remaining part of the year.

A constriction of cemented gravel separates Black Opal from Wall Pool. On the morning of the 18th a fracture extended through the length of the gravel. Wall Pool's water which had formerly flowed over this dike and into Black Opal had ebbed about 10 inches.

Prior to the quake Wall Pool did not seem to have a source of water of its own. Its water was quite cool and was replenished by part of the overflow from Sapphire. Following the quake, springs developed in the northwest end of the big crater resulting in a higher temperature for the pool.

What final effect Sapphire's new activity is going to have on Wall Pool cannot be determined as yet. One of Sapphire's main drainage channels leading into it. Great quantities of sediments are building a big delta.

Sapphire Pool: Of the blue springs in Yellowstone Park that are crystaline clear, Sapphire without doubt is the loveliest. During the quiet phase its water scintillates with all the beauty and brilliance of the Oriental sapphire.

While named a "pool", it is a true geyser. During all of its known history it has had a minor but very spectacular type of an eruption, the activity occurring about every 17 to 20 minutes.

During early 1959 Sapphire continued to play on essentially the same pattern as has been its habit in recent seasons. A vandal, soap-induced eruption on June 14, 1955, resulted in some alteration in the nature of the active phase, which alteration had persisted up to the time of the earthquake.

On the morning of August 18, Sapphire was in a state of violent boiling. Its murky water was jetting up about 8 feet. It soon became evident that all periodic activity had ceased. The boiling was constant. It had

developed into a steady geyser. Sometime during the night of August 21, there was a major eruption, comparable in size to the 1955 eruption. By the morning of the 22nd the crater had again filled and was boiling steadily and in the same manner as prior to the night eruption of the 21st.

The steady geyser activity continued until September 5. On this date it was evident that a spectacular change had taken place. At approximately two hour intervals Sapphire was having major eruptions.

The eruptions would come suddenly and explosively. Following an eruption the water would ebb from 4 to 6 feet in the crater. With constant boiling and surging it would steadily rise. Upon reaching the base of the biscuits the water would suddenly well, overflowing the crater. Within seconds the explosion would lift a huge mass of rocketing jets of water to heights which seemed to vary from 100 to 125 feet. Occasionally there would be a burst fully 150 feet in height.

The eruptions were spectacular, not only due to their height, but from their lateral extension and the tremendous volume of water discharged during the initial burst. Many of the eruptions would be wider than they were high.

Following the initial burst, which was estimated to discharge in the neighborhood of 50 tons of water, there would be anywhere from 1 to 5 later bursts, about 5 minutes apart. Had it not been for the magnitude of the initial burst some of the later ones could have been viewed with fuller appreciation because of their own merit. Between the initial explosion and the second one, a series of deep seated steam explosions resulted in marked jarrings of the formations about Sapphire's crater.

The eruptive activity on near 2 hour intervals continued through September 13. From the 14th through the 28th it again lapsed back into steady geyser function. On the morning of the 29th it was again periodically erupting on a major scale. Major activity persisted for the rest of the year.

Following the September 29 rejuvenation Sapphire erupted for several days in a manner similar to the earlier pattern. Its eruptions then started coming with greater frequency, the intervals being between about 30 and 90 minutes. Occasionally there would be a near two hour interval.

With shortened intervals the eruptions decreased in magnitude. Instead of the crater filling before an eruption, it would occur when the water was anywhere from a foot to 3 feet below the crater rim. The higher the water in the crater, the more forceful and voluminous would be the explosion. Once in a while the crater would fill, resulting in an eruption of great magnitude. This type of activity persisted for the rest of the year.*

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* The Sapphire continued its major eruptive activity until January 15. Park Ranger McClelland reported that from then until January 30 there was but one known major eruption. Its activity was characterized by continuous boiling. On the night of January 30 a very powerful eruption tore out large blocks of the biscuit-like geyserite on the west side. Between February 1 and April 1 Sapphire had active and dormant periods. In March the active periods were in excess of the dormant ones.

Whether it was a coincidence, or the prime cause, it was following a heavy tremor the night of September 4 that Sapphire began major eruption activity. There was a similar tremor the night of the 13th. From then until a big tremor the night of the 28th it reverted to constant surging. On the morning of the 29th Sapphire was again in an active cycle. There were a number of tremors of similar magnitude following the one of the 28th, but they produced no noticeable effects.

The great wall of water that rolled in all directions from Sapphire at the time of the eruption, and down the slopes to the Firehole, resulted in tremendous erosion. After a few weeks of activity the formations about Sapphire looked as if a bulldozer had been at work. The laminated geyserite in a wide area about the crater was degraded several inches. Tons of sinter washed into the Firehole River, making large deltas. The delta that formed in the channel of the Firehole south of Sapphire completely blocked all flow of the stream.

Jewel Geyser: During the years Jewel has adhered to a near set type of function. The eruptions occurred at approximately 5 to 6 minute intervals, and were characterized by 3 or 4 separate bursts, the maximum height being near 25 feet. On the morning of the 18th, like nearby Sapphire, Jewel was ejecting murky water and was in a state of constant activity.

By September 1 the steady activity was becoming periodic, the quiet phase lasting for about 1 minute, the active for about the same duration. The length of the interval increased until by the 18th it was averaging about 6 minutes. With the increase in length of interval the number of separate bursts during an eruption also increased, the number being from 4 to 6. This type of function continued for the rest of the year.

Shell Geyser: Apart from initial murky water, the most noticeable effect of the quake on Shell was a 4 degree increase in temperature. Most of the water of an eruption flowed back into the crater.

A tract of ground, about an acre in extent, and lying near and south of Shell showed marked effects from the quake. Prior there had been but small, waterless potholes of earlier existing hot springs in this area. The ground had cooled sufficiently for the encroachment of Lodgepole pines. On the morning of the 18th many of these former potholes were full of boiling water. Some had erupted. Tree roots extended through the craters. New fumaroles were showing along a series of cracks.

Silver Globe and Avoca Springs: During the known period these springs have had steady overflow, the volume small, being not more than 3 gallons per minute for either spring. Of the two, Avoca was hotter, its central vent was in a state of constant boil.

On the morning of the 18th the craters of both springs were empty. Silver Globe's stayed empty for the rest of the year. A few days following the quake Avoca's north vent turned into a steam vent. At about 1 minute intervals there would be a momentary roar of rushing steam.

In mid-October water began rising in Avoca's south crater. The rise of water apparently smothered the steam, as mostly water droplets would be ejected at the time of the former steam periods. For the remainder of the season water never did rise higher than 10 inches in the bottom of the south crater.

During the night of the 17th a large spring about 100 feet north of Avoca had a voluminous eruption. Its shores were heavily washed and numerous new drainage channels extended away from the spring. There is no evidence of any previous eruption. Being the westernmost spring in the group, it has been named West Spring. Spicule Spring, about 30 feet east of West Spring, ebbed about 26 inches following the quake and stayed at this level for the rest of the year.

Mustard Springs: Both East and West Mustard were affected in a marked way. Prior to the quake the temperature of West Mustard was 163 degrees, East was 157. The bowls of both springs were lined with yellow algae, hence the name Mustard.

On the morning of the 18th water had dropped about 30 inches in both craters, and for the remainder of the year they were constant spouters. The temperature in both springs had risen to 200 degrees. /steam vents/ Twenty-five feet south of East Mustard a patch of what had been merely warm ground showed a series of fractures following the quake. Fumaroles were issuing from many points. They increased in intensity during the rest of the year. The decomposed nature of the ground is suggestive that a new spring might develop.

Black Pearl Geyser: Activity in this small geyser is cyclic. During 1959, prior to the quake, it had been dormant. On the morning of the 18th the water had ebbed about 12 inches. For the rest of the season, like nearby Mustard Springs, it was a constant spouter.

Four springs lying north of Black Pearl erupted the night of the quake. Three continued periodic activity for the remainder of the year. The spring farthest to the north, it is the northernmost spring in the Upper Basin, is named North Geyser. Over the years it has shown cyclic activity. The quake initiated an eruptive cycle. It was active every 9 to 12 minutes, the height of the eruptions was about 12 feet.

MIDWAY BASIN

Flood Group

Flood Geyser: Its crater was empty on the morning of the 18th, indicating eruptive activity. No further activity was observed until mid-October. From then until the end of the year there were several eruptions each day, its activity being essentially the same as before the quake.

Just across the river from Flood is an unnamed geyser, whose size and style of eruption are very similar to that of Flood. Following the quake I did not observe any eruptive activity during the remainder of the season.

The very large unnamed spring lying north of flood was very murky on the morning of the 18th. Its water had ebbed about 15 inches, staying at about this level for the rest of the year.

Catfish Geyser: An eruption of this geyser closely resembles the pre-earthquake activity of Sapphire. It was murky following the quake, but its eruptive pattern did not appear to be altered.

Most of the springs in the Flood Group are small. Thirteen erupted the night of the quake. On the following morning 25 of them were murky.

Rabbit Creek Area: The Rabbit Creek drainage forms a part of the Midway Basin. Most of its springs are somewhat isolated and infrequently visited. Lack of visitation is in part due to numerous grizzlies that range in this area because of an inadvertently placed dump. One of the largest hot springs in the park is located at the head of Rabbit Creek. The loveliest reddish-colored springs in Yellowstone are in this same area. The geysers are few and small. Only two seemed to have been stimulated by the earthquake, but 107 of the springs were murky.

Excelsior Group

Excelsior Geyser: Due to its size this spring was formerly called Hell's Half Acre. Water over its large surface is in a constant state of boil. The boiling is in the form of numerous islands, suggesting gas leakage from many points in the bottom of the crater. It has by far the most voluminous discharge of any hot spring in the park, being between 60 and 70 gallons of boiling water per second. This flow is constant.

On the morning of the 18th the previously deep blue colored water had the color of mud. The copious discharge seemed to result in rapid clearing. By the end of the first week the water was practically back to its original coloration.

Murky water was the only apparent effect upon Excelsior. The volume of the flow did not show any alteration. It would seem a bit of a perversity that the earthquake did not stimulate eruptive activity of this geyser, as it did so many others.

Turquoise Pool: So far as available records go, this beautiful pool had shown no change in character until the night of the quake. There is no evidence that it had a source of water of its own. The crater was kept full by overflow from Grand Prismatic. During cold periods in winter it would freeze over.

The jarrings apparently opened up the sediment clogged pipe in the bottom of the pool, permitting the water to drain out. On the morning of the 18th it had ebbed 8 feet. It stayed at this low ebb for several weeks, following which there was a slow rise. After a rise of about 36 inches the water stayed near this level for the rest of the year. There would be alternate ebb and flow from this level. Following the quake the temperature rose from 54 to 132 degrees, indicating a possible new source of hot water. By the end of the year the water had cooled sufficiently for ice to form in sub-zero weather.

Opal Pool: For the past two seasons there has been no overflow from this spring. It has been known to have had two eruptive cycles. Its water became murky following the quake, rising about 2 feet in the crater. The temperature increased from 160 to 182 degrees.

Grand Prismatic Spring: During all of its history this spring has been one of the gem spots in Yellowstone Park. Despite the fact that a trapper, Osborne Russell, in 1839, observed the hot springs from Lone Star down the river and through the Lower Basin, Grand Prismatic was the only one that impressed him sufficiently that he left a description: "We traveled down the stream northwest about 12 miles, passing on our route large numbers of hot springs. At length we came to a boiling lake about 300 feet in diameter, forming nearly a complete circle as we approached on the south side. The steam which rose from it was of three distinct colors. Whether it was something peculiar in the state of the atmosphere or whether it was some chemical properties contained in the water which produced this phenomenon, I am unable to say, and shall leave the explanation to some scientific tourist who may have the curiosity to visit this place at some future period." The colored steam and the prismatic coloration that impressed this early trapper enthrall thousands of park visitors who yearly visit Midway Basin.

Not only does Grand Prismatic have a greater surface area than any other hot spring in the park, it is the only one whose water flows over the entire rim of the bowl more or less evenly in all directions. The volume of overflow would seem to have had insignificant changes, if any, during its known history.

Following the earthquake the water ebbed below overflow. During the morning of the 18th, overflow, in slightly decreased volume compared to the day before, began. After a few days it became evident that this spring had been slightly tilted to the east. No water was overflowing the western rim, but as you approached the eastern side the volume of flow increased.

Indigo Spring: This spring was named from its deep blue coloration. It has always been characterized by a steady overflow. Following the quake it was murky, and had ebbed about a foot. By the end of the year it had not recovered from the ebb.

LOWER BASIN

The immediate effects of the earthquake were more in evidence and pronounced in some sections of the Lower Geyser Basin than in the basins farther up the Firehole. This was especially true in the Firehole Lake area and in the Fountain and Kaleidoscope Groups.

Great Fountain & White Creek Areas

Broken Egg Spring: This interestingly shaped spring has maintained a light, but steady overflow over the years. Following the quake it ebbed 15 inches. The temperature rose from 152 to 187 degrees and the water was murky. There was little or no change in this state for the rest of the season.

Firehole Pool: This spring is one of but few in the Lower Basin that escaped functional change. Both before and after the earthquake the overflow was 40 gallons per minute and the temperature 196 degrees. However, for the first few days its water was murky.

Surprise Pool: During most of this springs' known history its water has been superheated. There are times, however, when it drops below boiling.

Surprise Pool, among many others in the Upper and Lower Basins, showed a delayed reaction to the earthquake. The only immediate effect that was noticeable was murky water. By early September the temperature had increased from 200 to 202 degrees. In mid-October it became eruptive. The temperature was 204 degrees.

The eruptions were minor in character. At no time did I see the water dome up more than 2 feet. It was typical geyser function, however, indicating that this spring possesses true geyser potential.

Most of the springs on the east side of the road, in the flat immediately above Surprise Pool, erupted the night of the quake. Five of them showed eruptive activity for the first observed time. The only named spring, Diamond, is on the southeast side of the flat. It erupted the night of the 17th, but no further activity was noted.

In a grove of Lodgepoles across White Creek from the flat there was a type of volcanic activity the night of the quake. From two empty craters, where hot spring activity appeared to be extinct, steam explosions would seem to have ejected more solid than liquid matter. A great array of fragmental pieces of sinter surrounded the craters, indicating the force of the explosions.

For the first few days after the 17th the water in White Creek was very murky, indicating that the great majority of the springs along its course had become turbid.

Great Fountain Geyser: From May 1 to August 18, 157 eruption intervals were checked. The longest interval was 17 hours and 10 minutes, the shortest, 9 hours and 42 minutes. The average time was 12 hours and 46

minutes. The cause or causes of the great fluctuation in the length of the intervals has not been determined as yet.

Since the 1957 season Great Fountain's average time showed an average of about one half hour each season. During 1958 and 1959 the activity was more erratic than for several preceding seasons. Erratic activity makes the eruptions more difficult to predict.

For the first few days following the earthquake it was impossible to stay in the vicinity of Great Fountain long enough to determine how it might have been affected. It was apparent that it had undergone a marked change in eruption behavior. The first determined interval was on August 22. It was 3 hours and 40 minutes! Nothing even closely comparable to this had ever been checked before. During succeeding days all of the eruption intervals showed that Great Fountain was playing with unprecedented frequency. During the first two weeks 6 hours and 41 minutes was the longest interval noted.

From September 18 to 20 inclusive, by means of Germeraad's eruption recorder, eleven successive intervals were checked. The shortest interval was 3 hours and 10 minutes, the longest, 9 hours and 3 minutes, the average being 5 hours and 46 minutes.

During succeeding weeks occasional checks were made that were indicative there was a progressive, but slow increase in average eruption time. By December, from limited data, the average time was near 7½ hours. The longest interval checked was on November 30, and was 9 hours and 15 minutes. This was but 12 minutes longer than an automatically recorded eruption on September 18.

The marked shortening of the eruption interval was not the only effect of the earthquake on Great Fountain. Many of its pre-eruption symptoms underwent alteration. Since observation first began on Great Fountain it had been its habit following each eruption for the water to drop about 4 feet in the crater. The water would then slowly rise, taking from three to four hours for the crater to fill. Following an erupting there would be a violen boiling, which would gradually subside as the water rose in the crater. The rise of the water resulted in a slow drop in temperature. By the time the crater filled to near overflow the boiling completely subsided over the main portion of the crater. The water would still be superheated, ranging between 200 and 202 degrees. This resulted in frequent bubbling on the edges where the water contacted the crater walls.

Following the near-filling of the crater there would be rhythmic ebb and flow periods, the intervals being about 40 to 45 minutes. The rise and drop of the water amounted to a differential of about 6 inches. At the time of maximum rise the water would not quite flow over the crater rim, except when approaching an eruption phase.

The time of the beginning of overflow has served as a most useful monitor in predicting the time of an eruption. During most of the time I have

observed Great Fountain the beginning of overflow was anywhere from about 80 to 90 minutes preceding an eruption. When the water once started overflowing the rhythmic ebb and flow periods ceased, the water would continue to overflow, in ever increasing volume, right up to the eruption. The last 4 years, instead of the overflow continuing after it once started, there would be one and sometimes two ebb periods, each of about 40 minutes duration, before the continuous overflow which always precedes an eruption. During this change in pre-eruption pattern, which perhaps is cyclic, the overflow periods have preceded the eruptions by about 75 to 85 minutes.

Following the earthquake the crater would refill within 60 to 90 minutes following an eruption. Instead of the water being relatively placid at this time it was in a constant state of ebullition. The former ebb and flow periods were wanting. Instead the surface level would fluctuate about one inch, and on two occasions the overflow preceding an eruption was observed to start within about 10 minutes following the filling of the crater. During an observation made on September 12 the overflow preceding an eruption showed wide variation, the minimum and maximum range observed being 33 to 68 minutes.

During the post-earthquake period the duration of the eruption phase shortened. In this respect Great Fountain was different from the major geysers in the Upper Basin whose eruption intervals were shortened. Instead of lasting for about 60 minutes, the duration of checked eruptions was from 38 to 58 minutes.

During the active phase, as prior to the quake, there would be 4 main periods of activity, each lasting from 6 to 9 minutes. During the initial period of activity there would be a larger proportion of big bursts than was characteristic before the quake.

The small spring in Great Fountain's drainage channel that used to steadily boil until the overflow stopped it, ceased all activity after August 17. The water in it and nearby springs stayed at an 18 inch ebb.

White Dome Geyser: This geyser's intervals have varied rather widely over the years. The extremes noted have been 12 and 141 minutes. Whether it is playing on long or short intervals, the pattern of activity will be consistent. Some days all of the eruption intervals will be near 15 minutes. On other days they will be over an hour, or any figure between minimum and maximum range. The cause of this interesting fluctuation in pattern of length of interval has not as yet been determined.

No activity of White Dome was reported the first few days following the quake. Markers placed at the cone indicated that it was dormant. By September 1, it was having occasional eruptions. Observations made on September 12 showed that the intervals were erratic in length, varying between 25 and 118 minutes. Before the end of the season White Dome seemed to be back on its pre-earthquake pattern of play.

Pink Cone Group

This is a rather small group of hot springs, containing a number of small, but interesting geysers. Until recent years observational data on functional behavior is largely absent. All springs in the group showed marked effects from the earthquake.

Bead Geyser: Of the geysers playing 10 or more feet in height, Bead has shown a higher degree of regularity than any geyser that has come under my observation. During at least the three seasons preceding the quake, none of the observed intervals varied by more than one half a minute. Most would be an even 33 minutes. Occasionally there would be one of 33½ minutes. The duration of the eruptions was 2½ minutes.

Following the quake Bead began playing on near hourly intervals. They varied between 60 and 63 minutes. With the longer intervals there was a marked increase in the length of the active phase. It increased from the 2½ minutes to about 11 minutes.

After about 6 weeks of this pattern of activity the eruptions began coming on greatly shortened intervals, occurring almost 4 times as frequently. They varied between 15 and 16 minutes. The duration shortened to the previous 2½ minutes. For the rest of the year it continued on this pattern, manifesting about 2 times the thermal energy it did before the quake.

A large superheated spring is located about 12 feet southwest of Bead Geyser. Like Doublet and Skeleton Pools, it has thin ledges of geyserite extending out from the crater rim. Because of these ledges it has been named Shelf Spring. Prior to August 18, Shelf's constant level had resulted in steady overflow. There is no record of eruptive activity.

The evidence imdicates that the quake stimulated Shelf Spring into eruptive activity which lasted for about one week. The eruptions occurred at intervals of about 4 hours and were characterized by two or three heavy surges, reaching a height of from 10 to 12 feet. The water in the crater stayed murky for several days following the eruptive period. During the clearing there would be periodic overflow. By the end of the year the overflow was steady.

Pink Cone Geyser: Observations of Pink Cone's frequency and duration of activity are very scanty. Early records are entirely wanting. Observations in recent years are indicative that the eruptions occurred 2 to 3 times weekly, lasting from 90 to 120 minutes. During the active phase the water would play forcefully for several minutes, to a height of about 15 feet. This activity would slowly subside in vigor to be followed by periods of recurring forceful play.

Pink Cone experienced great animation as a result of the earthquake. For the first 10 days it erupted almost constantly. During September the quiet and active phases were about equal in length, varying between 40 and 55 minutes. By the end of the year the intervals increased from about

1 to 3 hours. With increase in length of interval there was increase in the length of the active phase.

Near Pink Cone and Bead 6 springs erupted the night of the quake. No previous eruptive activity is of record in two of them. Four of these 6 springs continued to erupt periodically during the rest of the year.

Firehole Lake Area

Beginning with the 1958 season there was a noticeable waning of activity in this area. The constant jetting from Steady Geyser's eastern vent would have occasional pauses. The pauses increased in length with the progress of the season. Water in a spring in the southwest end of Firehole Lake's crater ceased flowing, resulting in a noticeable decline of discharge from Firehole Lake. This same condition was characteristic in 1959 during the pre-earthquake period. Steady Geyser's action was more feeble than in 1958.

The earthquake resulted in many times the amount of surface fracturing in the Firehold Lake area than occurred in any other sinter area in the geyser basins. Numerous surface cracks traversed the whole of the area. These cracks were crisscrossing, with no evident pattern. In large measure they resulted from a slumping of the geyserite. In some parts the slumping amounted to as much as a foot. There was weak fumarolic action in some of the cracks. Measurements of the cracks 3 months after the quake showed that if they were in one straight line the distance would be 9072 feet, or approximately one and three-fourths miles. This measurement did not include numerous cracks that crossed, or extended into the craters of the lakes.

Twelve springs erupted the night of the quake. There is no record of any previous eruptive activity in 10 of them. Most of the springs that erupted were north of Black Warrior Spring, and in an area where the ground had slumped several inches. It looked as if the compression of the surface structure could have, in squirt-gun fashion, ejected the water.

Firehole Lake: This large spring derived its name from the flame-like ascent of gas bubbles from two points in the lake. These bubbles resulted from the steady evolution of carbon dioxide, and had the appearance of a flickering blue flame. The springs supplying the gas also furnished most of the water for the lake.

On the morning of the 18th Firehole Lake was very murky and all flow had stopped. It soon became apparent that the ebbed condition at the outlet was not due to a general lowering of the lake, as the ebb was balanced by a corresponding rise on the side next to the hill. Slumping of the ground had tilted Firehole Lake.

The tilting had resulted in overflow to the northwest, in the direction of Sulfosel Spring. At first this overflow was in the nature of a seep, but the volume gradually increased as the season advanced. With the advance of the season the lake level gradually rose, eventually resulting in a trickle through the old channel.

During the first few weeks following the quake the near absence of discharge from the lake apparently resulted from the escape of the water through cracks that had formed on the floor of the crater. On the shoulder of the lake next to the hill the fracturing was very extensive. Breaks, with much slumping of the ground, encircled the northeastern end.

A number of hot spring vents are found on the shoulder bordering the gulch of Firehole Lake. Some of these vents are periodically active. All were dormant prior to the quake, but on the morning of the 18th one was steadily erupting to a height of about 3 feet. This spring was thought by some to be Young Hopeful Geyser. Young Hopeful is located farther to the west. The erupting spring was apparently unnamed. After a month of steady eruption its state became one of steady, heavy overflow. A crack on the gulch side of the lake resulted in the development of several new fumaroles.

Steady Geyser: This geyser has two vents. One is at the top of the mound, the other is on the west side, the side bordering a small lake. It was named in 1871 by the Hayden Survey. The vent named the Steady, "from the constant action of the column," was apparently not the vent that has been known as the Steady during the last 50 or more years. In describing this geyser, Hayden states: "It is close to the edge of the small lake which is just east of the main Hot Lake. The water is projected with rather a steady force in an oblique direction* from the side of an irregular mass of deposit that forms a mound a couple of feet in height."

The Steady Geyser of the current period, referred to above, has not projected its water in an "oblique direction," but vertically. The water has played from the vent on top of the mound and not on the "side of an irregular mass of deposit that forms the mound." Since the naming of this geyser by the Hayden Party it would seem that the steady action has shifted from the side to the top vent. This observation adds interest to a change which was in progress during the 1958 season.

During the recent period (its length cannot be determined) the top vent, as stated, has been the Steady Geyser. The vent on the side of the mound, at the edge of the small lake that played in an "oblique direction," has had true geyser status. Its periodicity has never been determined. Of the two vents, the periodic one played the highest, the eruptions being between 25 and 30 feet.

During the 1958 season Steady (the top vent) would have occasional pauses. As the season advanced these pauses increased in length. In May 1959 it was observed the height of the column had subsided from near 10 to about 2 feet. The action was periodic while the side vent was ejecting water steadily to a height of 3 or 4 feet. This condition continued until the earthquake, after which the top vent became dormant with the lake-side vent a steady geyser. This condition persisted for the rest of the year.

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* The italics are the authors.

During the recent period of steady activity of the side vent the water is not ejected as high as when the eruptions were periodic. It is of interest that an exchange of function was in progress prior to the earthquake, a shift apparently being made back to the 1871 condition.

Severe fracturing of the mound by the quake might result in new changes. Two large cracks, caused by the quake, crossed near the central portion of Steady's cone. These cracks might have been a factor in the complete cessation of discharge of the top vent. Numerous cracks formed in the vicinity of Steady. In places the surrounding geyserite had slumped. In others it had emerged, giving a wavy effect.

Black Warrior Spring: There is some confusion as to the location of this spring. It has been located differently by a number of writers. A few years ago a sign by the large spring 100 feet east of Steady bore the name Black Warrior Spring. This spring will be described in the present instance.

Prior to the earthquake its temperature was near boiling and there was a steady overflow. There is no record of eruptive activity, or physical evidence about the crater that there had been any. The Black Warrior Geyser described in 1901 by Olin Wheeler was in all probability Bead Geyser.

On the night of the 17th there was a quake induced eruption of Black Warrior. There was physical evidence about the crater that a large volume of water had been discharged. Following the eruption the water never regained overflow status during the rest of the year. Its temperature dropped from 195 to 177 degrees.

Considerable fracturing occurred about the crater. A large fissure on the east side had an escarpment of about 1 foot.

Sulfosel Spring: This spring is located at the base of the hill north of Black Warrior. Physical evidence indicates that for many years it has been a steadily flowing spring. Like a number of unnamed vents nearby, it erupted following the quake. By November, water was again flowing from Sulfosel.

Hot Lake: Over the years this lake would seem to have been maintained by the other springs in the Firehole Lake area. There is no evidence of an independent source of water. Its outlet is the beginning of Tangled Creek.

On the morning of the 18th the water had ebbed about 1 inch on the side of Hot Lake nearest to Steady Geyser. What appeared to be a drop in water level was due to an emergence of the geyserite along this shore. From this side a number of cracks in the sinter entered the lake.

While most of the springs flowing into Hot Lake showed a definite decline in discharge following the quake, the outlet into Tangled Creek carried fully as much water as before the 18th. Water would seem to have been entering the lake through newly formed fissures.

Zomar Spring: This spring is found on the hillside south of Hot Lake. Like other springs in this area it has been characterized by steady overflow. The quake had no apparent effect on the discharge, but the water became very murky, not entirely clearing by the end of the year.

Fountain Group

All of the springs in this important group underwent marked changes due to the earthquake. From August 17 to the end of the month the most spectacular changes in the Firehole geyser basins were in the Fountain area. During all of the 18th three of its major geysers played in concert. Such activity was without precedent. New mud springs evolved and many formerly quiescent springs became eruptive.

Fountain Geyser: During the 1959 pre-earthquake period the Fountain was less active than during any season since its rejuvenation in 1946, Since the 1946 season whenever Morning Geyser erupted, from one to two chain actions of Fountain would follow. Despite 14 eruptions of Morning before August 18, it was only following one that Fountain responded. Its temperature was 4 degrees cooler than during 1958. Yellow algae growing on the sides of the crater had changed the color of the water from a blue to a green cast.

The first part of the night of August 17 the moon was shining. Barry Watson, a ranger naturalist stationed at Old Faithful, chose the road next to the Fountain as a parking place for him and his companion. Soon after parking the earthquake occurred. It was his observation that almost simultaneously with the initial jarring, Fountain, Morning, and Clepsydra began concerted action. How long the activity continued in Fountain is not known. At 7 a.m. on the 18th its night activity had ceased. Morning and Clepsydra were still erupting. Before 8 a.m. Fountain began erupting again. This activity, with the simultaneous activity of Morning and Clepsydra, continued for the rest of the day. By the morning of the 19th Fountain had ceased playing. This big splurge was its last eruption of the season. Frequent convection (premonitory signs of a pending eruption) occurred, but unlike pre-earthquake conditions, no eruption resulted.

Morning Geyser: From May 1 to August 18, 1959, the Morning erupted 14 times. During this same period in 1958 there were 35 eruptions. Most of the 1959 inactivity occurred in May and June, there being but 3 eruptions during the two month period. Its activity in July and early August was comparable to that for the same period in 1958.

To those familiar with the history of Morning, Fountain and Clepsydra, their concerted action on the morning of August 18, and throughout the day, was truly fascinating. It was almost bewildering. The question was frequently asked, "Where is all the energy coming from?"

While the action of Fountain and Clepsydra was continuous throughout all of the 18th, the Morning would have pauses of 2 to 6 minutes in duration, with the active phase lasting from 45 to 50 minutes. During the 19th and 20th the length of the eruptions was still the same as on the

18th, but the intervals had increased from 12 to 30 minutes. From the 21st through the 25th there was a gradual shortening of the active phase and increase in length of the quiet phase. On the 24th Morning was playing about half of the time. On the 25th the intervals were from 40 to 60 minutes, the eruptions lasting from 10 to 18 minutes. From then until activity ceased on September 1 the eruptions were brief, from 3 to 5 minutes, with the quiet phase lasting from 60 to 73 minutes.

From the 18th through the 25th the eruptions of Morning were comparable in magnitude to those preceding the disturbance. However, when the duration of the active phase was reduced to 3 to 5 minutes, the surges became feeble, being not more than 10 feet in height.

Following the above 2 weeks of unprecedented activity the Morning lapsed into dormancy for the rest of the year. The water level in both Fountain and Morning stayed at pre-earthquake level, with the same volume of steady overflow of Morning. It and Fountain's inactivity in large measure would seem to have resulted from the continuous dissipation of energy by Clepsydra. Until activity ceases in this geyser it is doubtful if the other closely associated big geysers will erupt.

Clepsydra Geyser: The three eruptions of Morning that occurred during May and June 1959 were not followed by a wild-phase eruption of Clepsydra. Since Morning began an eruption cycle in 1946 this lack of response of Clepsydra is not known to have happened before. The typical chain action did follow all eruptions of Morning during July and to the time of the quake.

The earthquake resulted in a much higher degree of activity in Clepsydra than any geyser of near comparable size in any of the Firehole basins. The wild-phase activity that started at the moment of the quake was unceasing throughout the remainder of 1959. At the time of this writing it is still in progress.

During the first three days Clepsydra's action seemed to increase in force. This was particularly true of the steam vent. By this time the water in the other 3 vents had been reduced largely to steam. The roar of rushing steam was intimidating. After about 2 days of violent steam activity from all vents there was an ever increasing admixture of water. This finally resulted in the steam vent becoming a water spouter, the same as the other three. This had not happened since the rejuvenation of the wild-phase type eruption in 1946.

During the latter part of 1959 there would be times when momentary pauses of play of water from the steam vent would occur. Almost immediately the full force of the eruption would be resumed. The other 3 vents were observed at no time to wayne in the forcefulness of water ejection.

Gore Spring: During all of its known history this spring, located at the base of the hill below Clepsydra, has maintained a steady overflow. The reddish-colored algae in the wide drainage channels were responsible for

the Hayden Party giving it the name Gore. At the time, however, the algae were mistaken for ferric oxide.

An eruption following the quake completely destroyed the algae. The water had ebbed in the crater about 3 feet and was violently boiling. After 10 days of low ebb the water began a slow rise. As the water level rose the boiling diminished. By November the spring, as well as a new growth of algae, has resumed the pre-earthquake coloration.

Spasm Geyser: Most of Spasm's eruptions during the pre-earthquake period were of the major type, as during 1957 and 1958. Like other nearby geysers, it did not erupt as frequently in 1959. Following the quake its eruptions assumed a new violence, and were characterized by a marked steam phase which was entirely new. The water played from farther down in the crater, resulting in the water and steam jets coming at an angle. Prior, the water had been projected vertically. By September 1 all activity ceased.

Jelly Geyser: The Jelly has exhibited more than one type of an eruption. Most of its eruptions have been near a foot in height. Occasionally there would be activity from 4 to 5 feet in height. On rare occasions the eruptions would be near 10 feet. Only following such an eruption would the water noticeably ebb in the crater.

For several days following the quake it was erupting more than half of the time. All of the eruptions were major in character. Some of the bursts were near 15 feet in height. The activity was less frequent as the season progressed and there was some diminution in the violence of the play.

Jet Geyser: Over the years this geyser has played with a fair degree of consistency, though like all geysers that show definite subterraneous connections with other springs it has occasional erratic periods, even dormancy. During 1959, prior to the quake, its intervals were varying between about 5 and 8 minutes. Following August 17 the eruptions occurred every 2 to 3 minutes. The shift back and forth between the 2 and 3 minute intervals was gradual and quite uniform. By the middle of September the intervals had lengthened to 5 to 6 minutes, where they remained for the rest of the season.

Sub Geyser: This spring is located about 100 feet northwest of Morning, on the shoulder of the hill. On infrequent occasions it has been observed erupting. During most of its known history water has stood about 6 feet below the crater rim. The quake initiated eruptive activity which was continuous for the rest of the year. The eruptions were sub-aerial in character, hence the name. The splashing started about 5 feet below the crater rim, reaching about a foot above. Pre-earthquake data are indicative that Sub is connected underground with the other springs in the immediate Fountain Group.

Cone Spring: This spring is located midway between Morning and the Paint Pots. During the years I have observed it it has been dormant and below overflow stage most of the time. Following the quake it began minor activity from 2 vents, which was continuous for the rest of the year.

Bellefontaine Geyser: This geyser has been dormant during the period covered by my observations. An active cycle was stimulated by the quake. For the first few days it was active most of the time. Its intervals gradually lengthened, but periodic activity persisted for the rest of the year.

About 200 feet south of Bellefontaine a new crater was formed the night of the 17th. An explosion tore out a block of sinter about 5 feet square. No further activity was observed.

Leather Pool: Records of this pool are very scanty. It is highly probable that until the time of the quake no evident change took place since the discovery of the park. It was named Leather Pool in reference to the leathery appearance of the brown algae adhering to the crater walls. This situation characterized it until the night of August 17.

On the morning of the 18th the water was very murky and had ebbed about 4 inches. Previously there had been a light, but steady overflow. During the first few days the water ebbed slowly. When it dropped near 6 inches the pool had a series of eruptions. Some of the bursts were about 30 feet high. Practically all of the erupting water fell back into the crater. The pool stayed at an ebb of 4 to 6 inches for the rest of the year. The water never cleared.

Silex Spring: Prior to the quake there was steady overflow. The temperature was 190 degrees. During the years I have observed it there have been seasons of periodic boiling, other seasons when the water stood in the crater below overflow level.

On the morning of the 18th the water had ebbed about one foot. It was very murky and in a constant boil. As the ebbing progressed the boiling turned to surging, the water being very turbid. By the time the water had ebbed 3 feet the violence of the surging was suggestive of major eruption activity, but after several days of this function the water began to rise in the crater, resulting in diminished boiling. By September 15 the boiling has ceased, with a 15 gallon per minute overflow. This condition persisted for the rest of the year.

Celestine Pool: The beautiful coloration of this spring is responsible for its name. Over the years the overflow has maintained a comparatively steady discharge; its temperature near boiling.

Following the quake its water was murky, with about a 1 foot ebb in its crater. For the next few days the ebbing progressed until no water could be seen in the crater. From August 25 to September 2, Celestine was in an eruptive state. During the first few days the eruptions were all sub-aerial. The top of the eruption barely reached the surface. About 7 feet of the spout could be seen in the crater. By August 31 the top of the eruptions were becoming aerial, with the water rising in the crater.

The rise of the water in the crater was rapid. On September 1, the crater was full enough for light overflow, with the eruptions about 3 feet

in height. By September 4 the crater had filled to pre-earthquake overflow stage; there was light boiling and the water was practically clear. The clearing progressed rapidly and from September 15 on, Celestine looked very much as it had before the quake.

Fountain Paint Pots: Scanty records and a few early photographs are indicative of some shifting of activity in the crater of this spring. The major part of the action, however, has been predominately in the southern end. There has been seasonal fluctuation in the level of this spring. In winter and spring the level is about 1 foot higher than in autumn, at which season (paradoxically) the level begins to rise.

On the morning of the 18th the mud puffs appeared to be bubbling very much as they had the day before. With the great amount of eruptive activity in the immediate area, and the ebbed and ebbing condition of many springs, it was speculated that the paint pots would soon respond by showing ebb. Instead, by the 19th it was evident that the mud was beginning to rise. By evening of the 20th it had risen fully 12 inches. During the night the northern end became activated. On the morning of the 21st many new mud pots had formed. More interesting still, two mud pots had broken out about 30 feet to the north beyond the main crater. New fumaroles had formed in two places in the parking area, also in a warm spot of ground just across the road at the north end of the main mud crater. These last fumaroles soon developed into a mud pot. Water and steam were oozing out on the road side of the walk at the north end of the crater. The tops of three of the posts supporting the guard rail were hot from escaping steam.

After a few days of mud spouting from the new mud pots outside the main crater they changed to steam vents. Steam continued to roar from them for the rest of the year. The mudpot that developed from the fumaroles would alternately eject grey and then pink mud. The same was true of a pot coming out from under the rock wall on the north end of the crater.

From the 21st through the 23rd there was increased animation in the main crater. The blobs of mud were ejected over the guard rail and the walk, particularly on the north end.

After a few weeks of activity the fumaroles that had formed in the oil mat in the parking area subsided and finally cooled off. At first it was thought they would develop into new mud springs, as was the case with the fumaroles across the entrance roads on the north side.

The many new mud puffs that formed in the north end of the crater remained active for the rest of the year. By December the mud had become more fluid than it had been in September. More water was in evidence and it stood at a higher level.

One of the interesting observations in the Fountain Group was that despite excessive discharge of water from Morning, Clepsydra and a few of the smaller geysers, many of the springs that had ebbed following the

quake began to rise even while this excessive activity was in progress. Instead of depletion of the ground water it was being rapidly replenished from some unknown source. It would be interesting to know whether a part of it might have been magmatic.

Pithole Springs

This group lies in the flat near Tangled Creek, west of the Fountain Group. It is a small group with no named springs. Most springs are small. Only one shows heavy discharge.

On the morning of the 18th all springs in this group were murky. Five of them had erupted. The largest eruption was from a spring never before observed to be active. Apparently there was but one eruption.

Kaleidoscope Group

This group includes the Sprinkler Springs. It was examined on the morning of the 18th. As closely as could be determined every spring in this area had been affected by the quake. Some in a very marked way. Twenty-nine had erupted during the night of the 17th. No eruptive activity had been observed previously in 22 of them. Thirty-one springs were much more active than they had been the day before; seventy-two were murky.

Gentian Pool: Over the years Gentian Pool has been one of the most beautiful springs in the Park. Of the springs with an opalescent coloration it has had no peer. The thin ledges of geyserite that extend out from the crater rim are indicative of near constant level and overflow for a long time, possibly hundreds of years.

On the morning of the 18th Gentian was murky and the water had ebbed 18 inches. Until near the end of September the ebbing slowly progressed. After reaching an ebb of 41 inches a gradual rise began. By the end of the year the water was still 5 inches below overflow. Fortunately by December the brilliant gentian coloration had been largely restored.

Earthquake Geyser: This geyser is situated about 200 feet west of Gentian. It was the largest geyser that developed in the Lower Basin as a result of the earthquake. The first eruption no doubt came with the initial shock. The first I observed it was mid-morning of the 18th. To see a major geyser erupting from its location was most surprising. No eruption had been observed from this point before.

The geyser played from an old fissure running in a north-south direction. Prior to the quake not even boiling activity had been observed. About the fissure the ground had apparently been warm enough to be free of snow in winter. The numerous bison droppings strewn in the area surrounding the vent indicated these animals corralled here in winter.

During the first few days the eruptions occurred on about 4 hour intervals. They were near 11 minutes in duration. The water played from a number of closely spaced vents. A voluminous volume was discharged

from the main vent to a height of approximately 100 feet. The water column was 5 to 10 degrees from the vertical.

After 7 days the main eruptive activity ceased. This was apparently due to what had been a continued lowering of the water table. This resulted in frequent minor eruptions with an accompanying steam phase. During this stage a steam explosion tore out a new opening in the same rift, 20 feet to the north. This vent proved to be a large fumarole which stayed active the rest of the year. With the development of the fumarole minor activity ceased.

During the last week in December there were at least two major eruptions of Earthquake. By this time the water table had risen about 30 inches. Whether this new geyser will continue to function would seem to depend upon height of water table and steam supply.

During December a new geyser developed about 250 feet south of Gentian. It played frequently, but its periodicity was not determined. It played to a height of about 10 feet.

Kaleidoscope Geyser: The rejuvenation of this geyser during the winter of 1957-58 lasted until the following winter. It was dormant during the 1959 season. The earthquake did not rejuvenate it. However, the big spring connected underground with Kaleidoscope was stimulated into an active cycle.

There are several large springs surrounding Kaleidoscope. All were active following the quake, and continued to erupt periodically for the rest of the season. Evidence was suggestive there had been a tremendous burst from one of these springs the night of the 17th.

Hotel Group

There are but 11 springs in this group; all are small. On the morning of the 18th they were all murky, five had erupted during the previous night. In 1959, prior to the quake, Kidney Spring was the only one that had been eruptive. For the rest of the year 9 of the 11 springs were more active than they had been prior to August 18. Gourd Spring stayed murky.

River Group

The springs in this group showed less effect from the quake than any similarly sized group in the Lower Basin. Mound, Bath and Fortress erupted as a result of the jarrings, also a few of the small springs in Pocket Basin. An important effect from the quake was on Skeleton Pool and a large unnamed spring 100 feet west. Skeleton Pool was murky and its level had dropped 8 inches. The water in the large pool to the west had dropped about 3 feet and was murky. Neither spring filled during the remainder of the year.

Fairy Meadows

There are numerous hot springs in this infrequently visited area, but no important geysers. Many of the springs are large. A few are beautifully ornamented.

So far as could be determined all of the springs in the meadows proper were affected by the earthquake. Murkiness and a generally ebbed condition of the water were the most noted characteristics. Most of the springs that had ebbed (45) had been non-boiling prior to the 18th, and had been characterized by no overflow. There was increased activity in 16. Nine of the 11 springs that had erupted the night of the 17th had shown no prior eruptive activity. None of the springs about the base of south Twin Butte seem to have been affected by the quake, unless it was murkiness that could have cleared before they were checked.

Old Faithful: While this most famous of all geysers is in the Upper Basin, it is being discussed last because of its importance and uniqueness.

From May 1 to August 18, 1158 eruption intervals were checked. The time of the average eruption was 60.8 minutes. Since records have been kept there has been no season when Old Faithful played on as short an average. The shortest seasonal average prior to 1959 was during 1949 when the average was 62.3 minutes. Had the 1959 seasonal record been extended to the same date as the 1948 one, 1959 still stands as a record for Old Faithful.

During the day following the quake Old Faithful was performing in a manner that was suggestive of no adverse effects from the quake. However, its action was more erratic, alternating long and short intervals, indicating a possible increase in function. When the intervals of the 17th were compared with those of the 18th this proved to be the case, as the following table shows:

August 17		August 18	
Eruption time	Interval minutes	Eruption time	Interval minutes
6:26 a.m.		8:57 a.m.	
7:26 a.m.	60	9:50 a.m.	43
8:36 a.m.	70	11:00 a.m.	70
9:24 a.m.	48	11:47 a.m.	47
10:33 a.m.	69	1:03 p.m.	76
11:36 a.m.	63	1:49 p.m.	46
12:40 p.m.	64	2:58 p.m.	69
1:29 p.m.	49	3:27 p.m.	39
2:42 p.m.	73	5:02 p.m.	85
3:27 p.m.	45	5:40 p.m.	38
4:42 p.m.	75	6:56 p.m.	76
5:35 p.m.	53	7:26 p.m.	40
6:46 p.m.	71	8:42 p.m.	78
7:52 p.m.	66		
8:35 p.m.	43		
Average	60.6	Average	59.9

Old Faithful continued to be erratic for the rest of August, but there was a gradual increase in the average time. The 175 eruption intervals checked showed an average of 62.1 minutes for the last 14 days of the month. This average continued to increase for the rest of the year.

Broken down monthly, Old Faithful's 1959 record is as follows:

Month	No. of Determined Intervals	Longest Interval Minutes	Shortest Interval Minutes	Average
May	172	83	33	60.6
June	365	84	39	59.8
July	397	85	36	62.0
Aug. 1-17	224	85	37	61.9
Aug. 18-31	175	89	36	62.1
September	239	95	40	65.0
October	47	85	36	66.8
November	no check			
December	255	96	39	67.4

Ninety-six minutes is longest officially checked interval on record.*

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* By means of an automatic eruption recorder Park Ranger McClelland secured the following data on Old Faithful during the winter months - 1960:

Month	No. of Intervals	Maximum	Minimum	Average
January	607	98	35	66.67
February	607	93	39	66.51
March	437	90	39	65.73