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ALEUTIAN VOLCANIC ERUPTIONS, DECEMBER, 1922

The following account of eruptions in Alaska at Christmas time was forwarded through the chief of the U. S. Weather Bureau from the observer at Juneau, Alaska, Mr. M. B. Summers, quoting a report by Captain O. A. Johansen of the S. S. Star, the monthly mail boat that plies between Seward and Unalaska. On February 8, 1923, the captain wrote as follows:

"We sighted the flame out of Pavlof Volcano as darkness set in on the evening of December 24, shortly after leaving False Pass, enroute to Seward. As we neared Belkofski the flame was standing perpendicularly to a height of perhaps 2,000 feet, it being a perfectly calm evening. It lighted up the village and presented a wonderful sight, especially in view of the fact that the time was Christmas eve.

"After we left Belkofski, a light northwest breeze set in and then the ashes began to fall, and by the time we reached Unga they were quite thick, the vessel being covered at daybreak of the 25th. The fall of ash diminished somewhat after leaving Sand Point, but became heavier at Perryville and continued until Chignik was reached. Later we learned that an old volcano back of Chignik had been working, also, although it had been silent for a generation or two.

"Mount Shishaldin, on Unimak Island, was also in eruption and deposited considerable ash, according to information we received at False Pass on our January voyage."

The only earthquake shock reported by cooperative observers near the date of the eruption was one at Kodiak, 380 miles northeast, at 2:00 p. m., December 23. It was of intensity 2, of the Rossi-Forel scale, and lasted 30 seconds.

Low barometric pressure prevailed over the Alaska Peninsula on December 22, 23, and 24, the reading in the Pavlof region being about 28.70 inches during the 12 hours ending at 8 a. m. of the 23rd. By 8 p. m. of that date it had risen to 29.03 inches, and by 8 p. m. of the 24th to 29.50 inches.

VOLCANIC CONDITIONS IN JANUARY

Activity of Halemaumau.

The new year inaugurated a marked change from rising to sinking in the lava of Halemaumau. There were fifty-five small earthquake shocks registered on the Observatory instruments January 1, some of them felt hereabouts, and this meant that the lava was lowering and the mountain trembling by collapse. On December 31, the southern lava lake had been falling and showing pasty aa on its banks. There was loud hissing of gas and flows were still trickling on the floor of the pit.

On New Year's day the southern half of the floor caved in and left a basin surrounded by a black ledge 40 feet high. Rough red aa lava oozed from the walls and on the northeast made a stream flowing into the depression from ground which had recently been flooded with pahoehoe. The source well southeast became a sink hole with both aa and pahoehoe lava pouring into it. Everything indicated that the substance just beneath the smooth pahoehoe was potentially a material which on cooling turned into rough clinker.

During the first week in January the whole floor continued to sink in funnel shape, making concentric glowing cracks that revealed rough paste between craggy blocks. The floor blocks around the north lake tipped inward, retaining their smooth upper surfaces. The glow decreased and the rate of lowering lessened rapidly. The bottom area was left about 650 feet below rim of pit, and a smoke-hole was left at the southeast source well. Some avalanches took away parts of the northwest rim of the pit. Very little fume developed so that the whole chaotic tumble of broken fresh lava was plainly visible.

During the early morning hours of January 8 new pahoehoe lava began to flow into the bottom of the pit, bringing the subsidence to an end. This poured from the same southwestern vent as in December, and at first two snorting fiery cones were formed, sending out snaky rivulets of molten lava that flooded the red clinkery depressions. Some lava was visible also in the southeast smoke-hole. For three days the floods spread out in leafy patterns, until the liquid had found its way to the old northern lake bed, where an aa flow had been the last matter in motion during the subsidence period.

Next this lake funnel began to fill up and the southeast well ceased smoking and in its turn started to build splashing pots and beehive cones. These overflowed and sent a torrent 20 feet wide into the north depression until the wide flat lake there overflowed the hollow and merged with the southern fill; a single fountain started spouting in the lake, the rest of it being covered with silvery crust. This lake by the middle of the month was less than 600 feet below rim of pit and fluctuated in height. The cones were highly spectacular, lifting lids over boiling pots, puffing and flaming angrily, and making noisy thuds that reverberated from the pit walls.

A strong earthquake shock about 2:30 a. m. January 14, in the midst of a southerly storm, was generally felt on Hawaii, shaking down stone walls and doing some slight damage at Hilea.

During the third week the rising continued intermittently, with one quiet spell. The bottom funnel so filled that the two depressions north and south were obliterated and all the new lava formed a single big floor 25 to 50 feet below the December shelf. The latter was 486 feet and the new floor 520 feet below rim of pit.

The cones had built themselves up ten or fifteen feet and exhibited hissing and splashing vents whence ribbons of live flowing lava could be traced, covered with glistening crusted surfaces and skins that wrinkled in loose festoons. The flows formed three leaf-shaped areas resting on a darker floor beneath. Remnants of the crags and reddish scoria left by the New Year subsidence still protruded around the edges and were piled up stepwise below the black ledge northeast. This ledge stood much higher above the new floor on that side than elsewhere, the floor itself being more built up on the west side of the pit. The upper surface of the black ledge was a wide platform along this western talus region, whereas the ledge elsewhere was little more than a plastered veneer. There was much rain and steam at this time and during heavy showers at night, sudden breakings up of the lava would produce a brilliant glare.

At the end of the month the inflowing lava from the source vents travelled through tunnels and appeared on the floor as trickling flows. The loudly hissing cone at the southwest was most conspicuous. The floor level was being slowly but constantly raised. The southeast vent gave out fume, but at night it was always glowing and like the southwest cone it frequently ejected splashes of lava. At night the center of pit was dark most of the time, whereas the marginal wall-crack fill showed glow through its cracked crusts. On the more recent flows and fills there were brilliant breakings up of crust occasionally.

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January 1. At 9 a. m. the floor which had been about 466 feet beneath the rim, was found to have collapsed across its southern half, so as to leave a black ledge about 35 feet high. Aa lava was tumbling into the depression from the under part of the new ledge. An aa stream was pouring into the depression from the tumble of northeast floor debris. This region had been the scene of rapid flooding for several days. The remains of the southeast lake were pouring as a pahoehoe stream into the southeast well now converted into a sink-hole, and some aa trickled into this hole also. Where the southwest well had been noisy gas explosions were occasionally heard.

The old northwest lake still remained high, though its banks were falling in; it stood higher than the remnant southeast pool.

January 2. The area of collapsed floor had extended itself from the southern part of the pit in a half-circle along the wall-valley east, north and northwest. This half encircled the area around the northwest lake which seemed to be sinking with but little cracking. Elsewhere glowing cracks were visible. Later in the day the floor around the northwest lake collapsed and small aa flows from the eastern tumble moved toward the central depression. The sinking from this time until January 6 averaged about 24 feet per day.

January 3. At 4 p. m. the tumble of broken floor matter, due to subsidence, had resolved itself into concentric broken blocks or crags with smooth pahoehoe surfaces and rough partly glowing aa lava in the interstices. A bench was left around the edge of the funnelling depression, and this shelf was widest where it had lapped over the buried western talus. It was very narrow on the northeast side of pit. On the west side big craggy blocks were parting from the bench and subsiding.

The deepest hole was at the southeast well where smoke rose and bright glow was visible in a crack. The lowest part of the funnel appeared

to be about the site of the former northwest lake and this was over 500 feet below rim. Here an aa pool had formed, fed by the sluggish stream from the east, exhibiting rough festoons on its surface. At the head of this flow there was a rough cone glowing and spitting. Occasionally masses of rock fell from the inner crag blocks. Glow was visible in nine places where rough incandescent paste showed in cracks amid the tumble. There was but little fume.

January 6. Imperfect measurements on this day indicated that the bottom of the funnel was over 600 feet below rim. There was fresh avalanche debris at the base of the northern walls and a northwestern surveying station had fallen in. The southeast smoke-hole showed no glow in daylight and the aa incandescence was no longer visible. Slight falls of rock occurred and there was some fresh debris at the base of the eastern wall. The northeastern aa flow was motionless, and its source was a broken-down bank on the northeast exhibiting a thin shell of pahoehoe crust broken asunder in patches concentric to the pit and revealing aa throughout the crevices. There was bright red iron oxide on the old wall northeast where the fresh black ledge had broken away. The northern depression had become a distinct funnel surrounded by pahoehoe surfaces tilted inward. The fume at southwest rift chasm was very thin.

January 8. No glow on the fume cloud over Halemaumau had been visible since January 3, but at 3 a. m. January 8 glow again appeared. At 10:30 a. m. the cause of this was seen to be a revival of the southwest floor cone opposite the talus of the Kau Desert rift and its southwestern chasm or niche. Two vents had opened just inside the black ledge at the margin of the collapsed area.

These vents were hissing, puffing, snorting, flaming and lifting lids of solidified lava. Pahoehoe flows trickled away from them in two belts northward and eastward. These flows were cascading toward the bottommost part of the tumbled southern depression. The southeast smoke-hole had also developed a glowing pahoehoe cone on its bottom. An avalanche talus had formed on the south side of pit. The northern part of the bottom area was unchanged.

January 9. At 4 p. m. several pahoehoe surfaces had formed over pools in the lower portions of the collapsed funnel. Crusts on the pools were seen cracking and foundering. There were numerous small live toes around edges of pools, indicating that the latter were supplied through tunnels leading from the southwest cones. The larger cone was coughing loudly and ejecting lava to the adjacent floor and the smaller one was hissing.

The new floods of the bottom had a leaf-like pattern and the aa flow of the northern depression was drowned under them. The southeast vent was fuming less than before.

January 11. At 3 p. m. the northern lake had become a large pahoehoe surface with a small fountain at its southern margin where flows were feeding it. These flows came from the southwest cones, now two beehive domes, the one nearest the black ledge thudding, snorting and lifting a lid. The other had a glowing and flaming crack across its top. The flows from these cones had spread over the southern half of the bottom area, filling depressions there, which were overflowed so that steep streams swept into the northern depression. Some of the flows were running in glowing ribbons, others were crusted over and flowing in tunnels. All these appeared to end at the north lake. The southeast vent was glowing but had not as yet produced any flows. The smoke there had disappeared and the pit was almost wholly clear.

January 12. At 3:30 p. m. it was evident that the bottom was rapidly filling. The pit had been bright the previous night. The southeast vent had developed a splashing cone pot and strong flows that supplemented the

work of the southwestern cones. The latter were still hissing and flaming and their flows ran to the north lake in tunnels. From the southeast cone on the other hand, a bright flow 15 feet wide ran in the open to the north lake. This lake and the southern fill were now almost at a common level. They were crusted except for one fountain as before.

January 14. A pronounced earthquake was felt at 2:30 a. m., and in the afternoon the north and south fills of the Halemaumau bottom were found to have merged into one, shaped in plan like a squid, the flows from southeast and southwest cones forming the tentacles.

January 16. At 10 a. m. the pit, visited after a southerly storm, exhibited a large crusted lake 524 feet below rim, covering both the north and south depressions. There were feeding flows from the southwest and southeast cones. The lake showed fresh moving lava all around its edges, and a patch of cracking and foundering crust was seen to extend itself in concentric rings from the center. One smoking crust near center of pit, not engulfed by the breaking-up action, appeared to be the top of the crag remnant.

Southeast cone had become a large structure, with open and splashing pot on top, and a flow from it to the northeast side of lake. Southwest cone was now a single heap with hissing glow-hole and a steep snaky flow from it down to the lake. Debris at the base of eastern walls probably represented avalanches started by the earthquake.

January 18. At 2 p. m. it was evident that there had been a quiet spell leaving the recent pool a dead floor. Over this a new flood now poured from three southwestern cones. These were hissing steadily and sometimes puffing. Several spots in center of pit were smoking. Southeast cone was 15 feet high with a glowing pot on top. The new round lake was sending out tongues into broken ground at its edges. The floor appeared to be built highest at the west.

January 21. At 11 a. m. southeast and southwest cones were giving vent to silvery pahoehoe flows, the southwest in greater volume so that the floor there stood higher with reference to the December shelf. Of the three southwestern cones one was hissing, one puffing and thudding, and the third inactive. The southeast cone was a large oven, open towards the north, with heavy viscous lava flung out as in a grotto, and the pool at the entrance continuous with a flat flow that covered the east and south sides of the floor. The southwestern flows were pushing in various directions over the western side of the bottom, making a pattern of wide bands with loose festoons. An avalanche fell from the north wall. Remnants of the aa tumble of the first of the year still protruded around edge of bottom, and a wide belt of it made an uphill slope to the black ledge northeast. This ledge was nearly continuous all around and on the west its upper platform was 30 to 50 feet wide.

The bottom at this time was not properly a lake. A slight bank effect showed towards the north, but the floor pattern was made up of three leaf-shaped flow puddles, one on the southeast, a big one across the center with its stem at the southwest vents, and a subsidiary branch from the same source following the base of the west ledge.

January 22. At 4 p. m. the southeast cone was found less active and the southwest cones had built up the region around them and gave rise to most of the flows.

January 24. At 4 p. m. the processes were as before, the floor gradually filling. The western black ledge appeared 20 feet high and the northeastern one 50 feet high. The southeast cone appeared bright but not visibly productive of flows. The western flows were gushing at their front. A northern avalanche was seen.

January 25. At 8 p. m. center of pit was black without glowing cracks, there was moderate hissing southwest and one area of moving lava was seen towards the north and a few small toes elsewhere.

January 27. At 5 p. m. there was dense fume from southeast vent and loud hissing southwest. Several small trickling flows were seen and the eastern fill appeared to be fed from the north.

January 28. At 3 p. m. the pit was quiet and the vents smoking. There was some splashing in the southeast cone and coughing at the southwest cone every four seconds or so. Two small trickling flows moved at the north side of the new fill.

January 30. At 10 a. m. all the vents were quiet and no live lava was visible. Fume rose from the southeast vent and from the ground north of southwest cone. There was still a remnant of the broken ground of January 1, not covered by new lava, at the northeast side of the bottom area.

January 31. At night there was glow on the fume above southeast side of pit.

LAVA MEASUREMENTS

Measurements of depression of the mobile lava column, made with transit, referred to northeast station on rim of Halemaumau pit (3716 feet above sea-level), for the month ending January 31, 1923, including floors of bench magma and liquid level of lake magma, were as follows:

| Date | Time | Southwest Cone | Northwest Floor | South Bottom | North Bottom | West Ledge |
|----------------|----------|----------------|-----------------|--------------|--------------|------------|
| Dec. 22, 1922, | 11 a. m. | 494 ft. | ----- | ----- | ----- | ----- |
| Jan. 2, 1923, | 9 a. m. | ----- | 466 ft. | ----- | ----- | ----- |
| Jan. 6, 1923, | noon | ----- | ----- | 643 ft. | 616 ft. | ----- |
| Jan. 18, 1923, | 2 p. m. | ----- | ----- | 524 ft. | 524 ft. | 486 ft. |

Progressive changes accompanying and following the strong subsidence of the first of the year were as follows:

December 22-January 2, the floor in 11 days had risen at least 28 feet and the maximum upbuilding may have been 50 feet.

Survey of January 6 was defective, but there was subsidence of about 150 feet around January 3.

Taking mean depression of January 6 at 630 feet, the filling to January 18, 12 days, was 106 feet, averaging 8.8 feet per day. A western ledge left from the December high level stood 38 feet above the bottom of January 18.

The filling activities of January ended on the 28th and the floor was built up (as shown by a survey made later), between January 18 and 28, 10 days, with 27 feet of fill, averaging 2.7 feet per day.

Monthly changes of bottommost part of pit floor from July 1922 were as follows:

| | | |
|--------------|----------------------|-----------|
| July 1922 | Lava inflow | + 70 feet |
| August | Slight slumping | - 29 " |
| September | Lava inflow | +100 " |
| October | Lava inflow | + 65 " |
| November | Uplift and inflow | + 73 " |
| December | Uplift and inflow | + 73 " |
| January 1923 | Sinking and recovery | - 31 " |

SEISMOMETRIC RECORD

During the month ending midnight January 31, 1923, one hundred and forty-eight local earthquakes and two teleseisms were registered at the observatory. These and other earth movements are exhibited below. Dis-



Figure 1.—Halemaumau January 1, 1923, collapsed bottom in southern part of pit from southwest side.—Photo. Finch.

tance of origin when indicated by the instrumental record is stated in English miles. Time is Hawaiian Standard of meridian 157° 30' W, 10 h. 30 m. slower than Greenwich.

Local Earthquakes.

| | | |
|----------------|-------------|-------------------------------------|
| January 1..... | 12:06 a. m. | Slight. |
| | 12:11 a. m. | Very feeble. |
| | 12:12 a. m. | " " |
| | 12:13 a. m. | Slight. |
| | 12:15 a. m. | Very feeble. |
| | 12:17 a. m. | " " |
| | 12:20 a. m. | Moderate, E-W component dismantled. |
| | 12:36 a. m. | Feeble. |
| | 12:57 a. m. | " |
| | 1:20 a. m. | Slight. |
| | 1:25 a. m. | Moderate. |
| | 1:28 a. m. | Slight. |
| | 1:34 a. m. | Feeble. |
| | 1:37 a. m. | Slight. |
| | 1:46 a. m. | " |
| | 2:11 a. m. | Feeble. |
| | 2:15 a. m. | " |
| | 2:40 a. m. | Slight. |
| | 2:45 a. m. | " |
| | 2:54 a. m. | " |
| | 2:57 a. m. | Feeble. |
| | 2:59 a. m. | Slight. |
| | 3:05 a. m. | Moderate. N-S dismantled. |
| | 3:57 a. m. | Slight. |
| | 4:00 a. m. | Feeble. |
| | 4:06 a. m. | " |
| | 4:09 a. m. | Slight. |
| | 4:10 a. m. | " |
| | 4:19 a. m. | " |
| | 4:20 a. m. | Feeble. |
| | 4:22 a. m. | " |
| | 4:23 a. m. | " |
| | 4:28 a. m. | " |
| | 4:34 a. m. | " |
| | 5:00 a. m. | Slight. |
| | 5:53 a. m. | " |
| | 6:05 a. m. | " |
| | 8:25 a. m. | Feeble. |
| | 11:24 a. m. | Slight. |
| | 11:26 a. m. | Feeble. |
| | 11:38 a. m. | Slight. |
| | 12:00 m. | " |
| | 12:40 p. m. | Feeble. |
| | 2:40 p. m. | Moderate, dismantled instruments. |
| | 4:44 p. m. | Slight. |
| | 4:50 p. m. | Feeble. |
| | 5:02 p. m. | Very feeble. |
| | 5:35 p. m. | Slight, distance 4 miles. |
| | 5:36 p. m. | Very feeble. |
| | 6:10 p. m. | " " |
| | 6:51 p. m. | " " |
| | 6:56 p. m. | " " |
| | 6:57 p. m. | " " |
| | 7:27 p. m. | " " |

| | | |
|----------------|-------------|----------------------------|
| | 7:50 p. m. | Very feeble. |
| | 8:55 p. m. | Slight, distance 4 miles. |
| | 9:18 p. m. | Very feeble. |
| | 10:10 p. m. | " " |
| | 10:15 p. m. | " " |
| | 10:20 p. m. | " " |
| | 11:15 p. m. | " " |
| January 2..... | 12:17 a. m. | " " |
| | 12:18 a. m. | " " |
| | 12:20 a. m. | Feeble. |
| | 1:16 a. m. | Very feeble. |
| | 1:48 a. m. | Feeble. |
| | 3:45 a. m. | Very feeble. |
| | 4:18 a. m. | " " |
| | 6:18 a. m. | " " |
| | 6:48 a. m. | " " |
| | 6:49 a. m. | Moderate, E.-W dismantled. |
| | 7:08 a. m. | Very feeble. |
| | 7:10 a. m. | Slight. |
| | 7:12 a. m. | " |
| | 7:28 a. m. | Feeble. |
| | 7:30 a. m. | Slight. |
| | 7:31 a. m. | Feeble. |
| | 7:44 a. m. | Very feeble. |
| | 7:50 a. m. | " " |
| | 7:51 a. m. | Slight. |
| | 7:58 a. m. | " |
| | 8:01 a. m. | Very feeble. |
| | 8:06 a. m. | " " |
| | 8:10 a. m. | " " |
| | 8:16 a. m. | " " |
| | 8:20 a. m. | Slight. |
| | 8:24 a. m. | Very feeble. |
| | 9:10 a. m. | Feeble. |
| | 9:21 a. m. | Very feeble. |
| | 9:36 a. m. | Slight, distance 4 miles. |
| | 9:38 a. m. | Very feeble. |
| | 12:19 p. m. | " " |
| | 1:20 p. m. | Slight, distance 5½ miles. |
| | 3:04 p. m. | Very feeble. |
| | 3:45 p. m. | " " |
| | 4:30 p. m. | " " |
| | 7:10 p. m. | " " |
| January 3..... | 12:47 a. m. | Feeble. |
| | 12:57 a. m. | Slight, distance 2 miles. |
| | 4:09 a. m. | Very feeble. |
| | 4:16 a. m. | Feeble. |
| | 4:16 a. m. | Feeble. |
| | 4:24 a. m. | Very feeble. |
| | 4:26 a. m. | Feeble. |
| | 4:27 a. m. | Slight. |
| | 4:30 a. m. | Very feeble. |
| | 4:33 a. m. | Feeble. |
| | 4:40 a. m. | Very feeble. |
| | 5:11 a. m. | Slight, distance 9 miles. |
| | 5:17 a. m. | Very feeble. |
| | 5:21 a. m. | " " |
| | 5:51 a. m. | " " |
| | 6:24 a. m. | Slight. |

| | | | |
|---------|-------------|---|---|
| | 6:40 a. m. | Very feeble. | |
| | 9:34 a. m. | " " | |
| | 9:38 a. m. | " " | |
| | 9:43 a. m. | Slight, felt locally, distance 2 miles. | |
| | 9:55 a. m. | Very feeble. | |
| | 10:21 a. m. | " " | |
| | 11:56 a. m. | " " | |
| | 12:39 p. m. | " " | |
| | 2:30 p. m. | " " | |
| | 4:22 p. m. | " " | |
| | 5:06 p. m. | " " | |
| | 5:14 p. m. | " " | |
| | 5:34 p. m. | " " | |
| January | 4..... | 5:42 p. m. | " " |
| | 5..... | 4:35 a. m. | " " |
| | 6..... | 10:55 a. m. | " " felt in Hilea. |
| | 8..... | 2:28 a. m. | " " |
| | 10..... | 4:07 p. m. | " " |
| | | 4:08 p. m. | " " |
| | 13..... | 2:14 p. m. | Slight. |
| | 14..... | 2:28 a. m. | Strong, felt in Oahu and all over Hawaii. |
| | | 3:16 a. m. | Very feeble. |
| | | 4:08 a. m. | Slight, distance 4 miles. |
| | | 9:14 a. m. | Very feeble. |
| | | 10:02 a. m. | " " |
| | 15..... | 1:05 p. m. | " " |
| | 17..... | 4:07 p. m. | " " |
| | 18..... | 2:01 p. m. | Feeble, distance 18 miles. |
| | 21..... | 11:15 p. m. | Feeble. |
| | 22..... | 1:02 a. m. | Very feeble. |
| | 24..... | 2:29 a. m. | Moderate, distance 24 miles. |
| | | 9:25 a. m. | Very feeble. |
| | 25..... | 2:43 a. m. | Feeble. |
| | 28..... | 4:25 a. m. | Slight. |
| | 31..... | 1:55 a. m. | Very feeble. |
| | | 4:57 a. m. | " " |

Teleseisms.

| | | | |
|---------|---------|-------------|---------------------------------|
| January | 2..... | 12:25 p. m. | Slight. |
| | 21..... | 10:45 p. m. | Moderate, off the Oregon coast. |

Spasmodic Microtremor.

This type of tremor was slight throughout the month.

Harmonic Microtremor.

This type of tremor was extremely slight throughout the month.

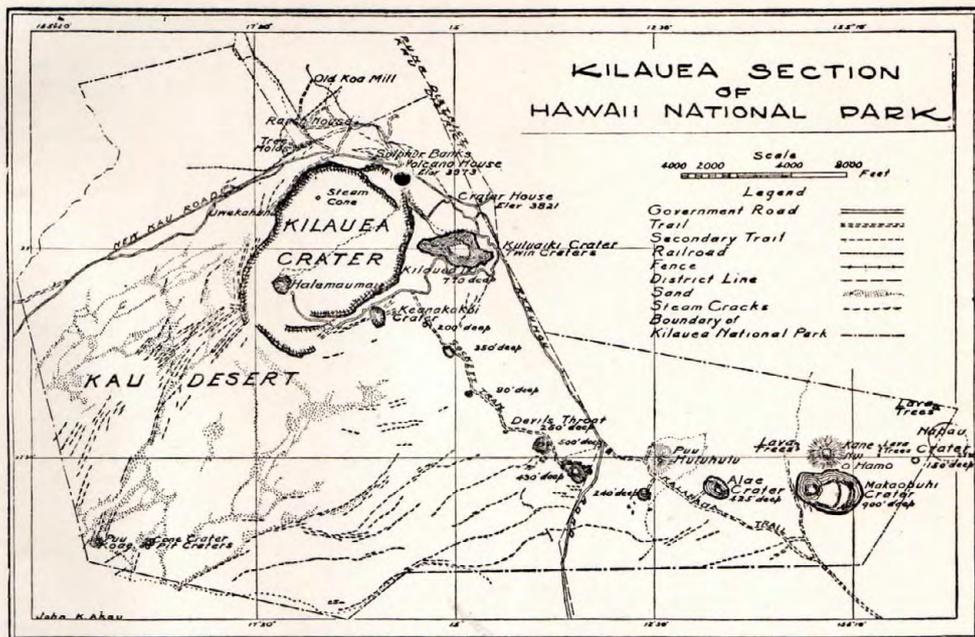
Microseismic Motion.

The amplitude of microseisms was moderate on 13th, 14th and 15th and slight during the rest of the month.

Tilting of the Ground.

| | | | |
|--------------|------------|-------------|--------|
| Dec. 31-Jan. | 6..... | 1.9 seconds | NE. |
| | 7-13..... | 0.1 second | N. |
| | 14-20..... | 1.3 seconds | SSW. |
| | 21-27..... | 4.7 | " SSW. |
| Jan. 28-Feb. | 3..... | 1.3 | " SSE. |

T. A. JAGGAR,
Volcanologist.



Black spot shows location of Observatory.

All exchanges should be addressed to

HAWAIIAN VOLCANO OBSERVATORY,

Volcano House P. O., Hawaii.

The Observatory is equipped with the following seismometric instruments rebuilt at the station in 1918 for the special needs of volcano research: two Bosch-Omori pendulums, high-speed registration of local earthquakes; one optically recording seismograph for distant earthquakes; one clinograph registering E-W tilting of the ground. A vertical component seismograph was in December, 1918, set up in experimental operation. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by wireless signal from the Pearl Harbor Naval Station. The chronometer is loaned by the University of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time. Observatory Lat. 19° 25' 54.2" N.; Long. 155° 15' 39.2" W.; Elevation 1214.6 meters (3985 feet).

HAWAII NATIONAL PARK.

This park was created by act of Congress August 1, 1916, and includes three famous volcanoes—Kilauea and Mauna Loa on Hawaii and Haleakala on Maui. Frequent passenger steamers ply between these islands and Honolulu.

Haleakala Section—Haleakala, "house built by the sun," a peak more than 10,000 feet high, carries an immense fissure-like crater 8 miles long and 3 miles wide, with walls 2000 feet high. Here, as well as on Mauna Loa and Manna Kea, grows the Silver Sword (*Argyroxiphium*). Thirteen volcanic cones lie wholly within the crater, some rising nearly to the height of the summit. The scene at sunrise is marvelously beautiful.

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There are trails on the Kona side, and also from the southwest, but the usual and best route is with saddle mules from the Kilauea section to Puu Ula-ula (9800 feet), a ride of six hours. Here there is a fully equipped cottage with stables and water supply. From this point on the second day a four-hour ride takes the visitor to the summit crater, where there is water. A right of way within the park connects Kilauea with Mauna Loa, where eventually a road will be constructed. The views are glorious and the chasms, cones and contorted lavas indescribably chaotic.

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The Kilauea Park and the inner pit itself are both reached directly by automobile from Hilo, the second city of the Territory of Hawaii, and there are excellent hotel accommodations. The distance from Hilo is 30 miles. Within the park there are 15 miles of roads and about 20 miles of trails. As shown on the map, there are a dozen ancient pits within the area of the park, as well as cones, caverns and hot solfataras and a strange desert where lava flows have poured out of cracks as recently as 1920.

The live pit of Halemauau is easily accessible and not dangerous. Frequently one can walk to the actual edge of the splashing, fountaining lava lakes, the lava column rising and falling from year to year so that its most distinctive character is ceaseless change. At night the spectacle is full of marvelous color, and the region is a paradise for artists, photographers and naturalists.

The several sections are under the control of the National Park Service of the Department of the Interior. The United States Weather Bureau maintains the Hawaiian Volcano Observatory which stands on the brink of the greater crater within the Kilauea Park.

U. S. DEPARTMENT OF AGRICULTURE
Weather Bureau
CHARLES F. MARVIN, Chief

MONTHLY BULLETIN
OF THE
HAWAIIAN VOLCANO OBSERVATORY

VOL. XI

HONOLULU, HAWAII, FEBRUARY, 1923

No. 2

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GENERAL MAP, KILAUEA SECTION, HAWAII NATIONAL PARK

EARTHQUAKE WAVE IN HAWAII

The illustrations show destruction wrought at Hilo, Hawaii by a tidal wave at 12:30 p. m. February 3. The seismograph stations at the Observatory and at Kealakekua in West Hawaii both gave warning of the probability of this wave about four hours in advance. Inspection of the instruments at 8 a. m. showed that a large earthquake had occurred about 16 h. 02 m. Greenwich Mean Time or 5:32 a. m. Hawaiian Time. The seismic center was believed to be under the ocean off the Aleutian islands, the water waves reaching northwestern Oahu at 12:02 p. m. and Hilo about 12:30 p. m. The waves were first noticed as a recession of the waters, followed by a series of movements back and forth for many hours, as shown by the tide gauge at Honolulu. The major wave at Hilo was reported to be the third noticed visually, and the waters rose over twenty feet in places, wrecking sampans and railway bridge in Wailoa River and killing one man. Elsewhere frame houses were demolished and displaced, embankments were washed away and damage was done to boats and wharves. There was serious damage also at Kahului on the east coast of Maui.

VOLCANIC CONDITIONS IN FEBRUARY

Activity of Halemaumau.

At the beginning of the month the activity of the fire pit decreased. The southwest cone which had been the main source of January flows on the floor, was very dull and gave vent to only an occasional hiss of escaping gas. The lava in the southeast well lowered though it was still visible some distance down. Smoke at the southwest cone decreased but increased in the rift chasm on that side of the pit.

By the second week of February Halemaumau was quiet and avalanches made new debris piles resting on the north and south sides of the floor. One of these fell suddenly about February 9, blocking the southeast well, shutting off both flames and smoke, and making a wide halo of dust on the floor. By the next day, however, the fire had reasserted itself and the lava in the funnel had engulfed the rocks blocking it. Dense whitish fume poured out of the hole over flaring flames beneath, indicating much gas pressure in the melt a short distance down. This smoke rose fitfully in billows above rim of pit, making a notable increase in fume as seen from a distance.

The bottom of pit was now about 550 feet below rim and the only glow was at the two cone vents and in the southwest chasm.

The third week produced a renewal of fitful lava activity with outpourings of molten matter from the southwestern cones beginning at noon February 17. The southeastern smoke funnel had increased in brightness so as to make some glow over the pit at night. The smoke at this vent decreased as the glow augmented and the bubbling lava inside made noises of rumbling and splashing. The glow became visible by daylight and occasional lava spurts were ejected.

In the forenoon of the 17th this smoke-hole lost its glow as though the southwestern vents had robbed it of its lava. It was glowing however in the evening. The southwestern flows covered much of the southern floor area with an incandescent mantle of partly crusted spreading slag, through the midst of which a river of bright molten stuff made two cascades and terminated in three fiery tongues. The largest of these when seen at night was progressing northward across floor of pit, shaped like a tree, with the stream for its trunk and the delta of spreading frontal toes making the branches and foliage.

Towards the end of February Halemaumau was in vigorous eruption pouring up floods of molten lava across its bottom, 490 feet below the verge. The rate of inflow increased so that the bottom rose about five feet per day. There was a quiet spell about the 19th, but after the 20th the floods waxed stronger, the pit became brighter at night, and both the southwestern and southeastern wells sent out flows simultaneously, whereas before they had been alternating in their outpourings. By the 25th the whole bottom area was filled to within four feet of the December ledge. Rivers of lava swept from south to north, penetrating among boulder slopes, and making a brilliant flare on steam clouds produced by heavy rain. A sharp earthquake was felt February 23.

The December ledge 486 feet down began to disappear under the fiery flood February 26, and an oval lake became defined around one of the fountain vents. The southwestern well began building up a broad plateau dome with its spouting lava, showing streams coursing down its outer slope.

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Feburay 1. Halemaumau was inactive except for an occasional hiss from a southwestern vent.

February 3. At 2 p. m. there was no activity but a glow was visible far down the southeast vent. Smoke issued from this vent and from the talus near southwest cone.

February 6. At 10 a. m. conditions were unaltered and hissing had entirely ceased.

February 7. At 5:30 p. m. the glow in southeast vent was found brighter so that it illumined the cloud after nightfall. From the northwest wall a large avalanche had fallen, the debris burying part of the January black ledge.

February 9. At 4 p. m. and thereafter occasional rockfalls were observed and one small avalanche towards the south. A large avalanche had recently fallen into the throat of the southeast vent, covering it with a dry whitish and salmon colored talus; the source of the fall was from the lower wall. A dust halo in front of the heap extended in an arc halfway across the floor. There was now no glow and but little smoke over this vent. The southwest floor cones were glowing through cracks and at night there were still a few spots of glow amid the boulders of southwest chasm. The floor was still 20 feet below the western ledge of January and on the north a large red talus overlapped this bench.

February 10. At 4 p. m. the southeast pot was found to have opened again as a dark hole four feet in diameter with some glow below and white fume rising through it. The debris had probably been engulfed. This fume greatly increased the smokiness of the pit, rising in billows above it as seen from a distance. An earthquake was felt the previous night.

February 11 to 15. Slight noise developed at southeast vent, the glow above pit was very slight, and the fume thinned somewhat.

February 16. At 2 p. m. the southeast vent was smoking and glowing and occasional rumble was heard. Lava could be heard splashing inside and on one occasion a slight jet of incandescent melt was seen.

February 17. About noon southwest cones started flowing. Prior to this the southeast vent had ceased to show visible glow. The flows were trickling pahoehoe and the vents puffed and spurted.

At 8:30 p. m. the flows had extended from two flaming orifices over the southern third of the floor with trickles eastward and northward. A pudding of glowing lava had been formed with three frontal flows northward from its east side. Along the surface of the pudding flowing lava broke out in cascades from west to east. There were glow and smoke at the southeast funnel. The southwest chasm still had on its bottom several glowing areas like hot coals, and these in daylight were yellow spots, in the talus and the cracked wall.

February 18. At 2 p. m. no flowing was perceptible and no glow was detected in southeast hole, but smoke still rose there. There was an inactive glow-hole on top of southwest cone. A small fall of rocks was heard. The flows had advanced very slightly since the previous evening.

February 19. In the forenoon there were audible puffs of gas and occasional spurts of lava at southwest cone and slight glow was visible in southeast cone. In the evening fountaining lava could be seen at the vents and the flows were glowing through cracks. In the southeast vent at 11 p. m. lava spray was sometimes thrown up to a height of 40 feet.

February 20. At noon the vents were glowing as before. At 9 p. m. lava overflowed the southeast vent and spread northward, the source making nearly continuous low massive fountains which developed into explosive ones sending spray 25 feet high. The southwest cone was glowing and hissing. The new flows within five hours had covered about one-fifth of the floor area on the east side of the pit.

February 21. At 6 p. m. the flows had covered a quarter of the floor and the southeast vent had become a fountaining grotto open towards the northwest. Toes were making out from the skirts of flows and the surface broke up by swelling action so that the crack-and-founder process spread over a third of the live area from the vent outward, while overflows pushed into the south talus and over the floor immediately west. The southwest cone flamed conspicuously and the pit had increased in brightness.

February 22. During this day the southwest cones broke into action making flows that joined the eastern live area so that two-thirds of the floor was covered with new lava. The southeast vent became crusted over.

February 23. Another earthquake was felt and about four-fifths of the floor became covered with live lava, the western edge remaining uncovered. Both vents were active, the southeast vent dominant, and the glow at night was brighter.

At 2 p. m. there were several glowing toes, small cracking and foundering areas, low massive fountains against a spatter bank at southeast vent, and lava splashing from southwest cone. The flows moved under a shell of crust, but in the evening open flows were reported at the southwest cones.

February 25. At 2:30 p. m. a southwesterly rain storm was in progress. The whole floor was now covered with smooth pahoehoe to within four feet of the January shelf, and this meant that new heapings were from 450 to 490 feet below rim in different places, being piled up most around the vents. The more vigorous flows were from the southwest cones, but the southeast vent was a splashing grotto with circular pool in front of it. The western flows poured northward in broad bands.

February 26. At 4:30 p. m. there were flowing areas over most of the western half of the pit and the northwestern part of the January ledge was covered. There were two glowing vents at the southwest cones and a lake with defined borders covered the southeast third of the floor. The crust over the whole of this lake was seen to break up and founder.

February 27. At 2:30 p. m. the pooled western flows covered the west ledge, there was a round lake in front of the southeast grotto, and along the northeast margin of floor the January ledge stood three feet high. A southwest cone had been built up into a large structure with a hole on top showing fountaining inside. A rapid narrow torrent of melt poured northward from this cone. Falls of rock occurred at the north wall over the deepest fill of the new pool. The southeast lake made a raised plateau where flows spilled over the margins. The west lake was not defined, being a flowing and spreading puddle.

February 28. At 9 p. m. the southeast lake was overflowing toward the north in three places. There were three flows in motion along north wall of pit from the southwestern source. Ordinarily lava was splashing at the southeast grotto, but all fountaining in that lake ceased during a spell of cracking and foundering of crust. At the western flood there was slow cracking and foundering, and the southwest cone kept up its splashing.

SEISMOMETRIC RECORD

During the month ending midnight February 28, 1923, twenty-two local earthquakes and seven teleseisms were registered at the Observatory. These and other earth movements are exhibited below. Distance of origin when indicated by the instrumental record is stated in English miles. Time is Hawaiian Standard of meridian $157^{\circ} 30' W$, 10 h. 30° slower than Greenwich.

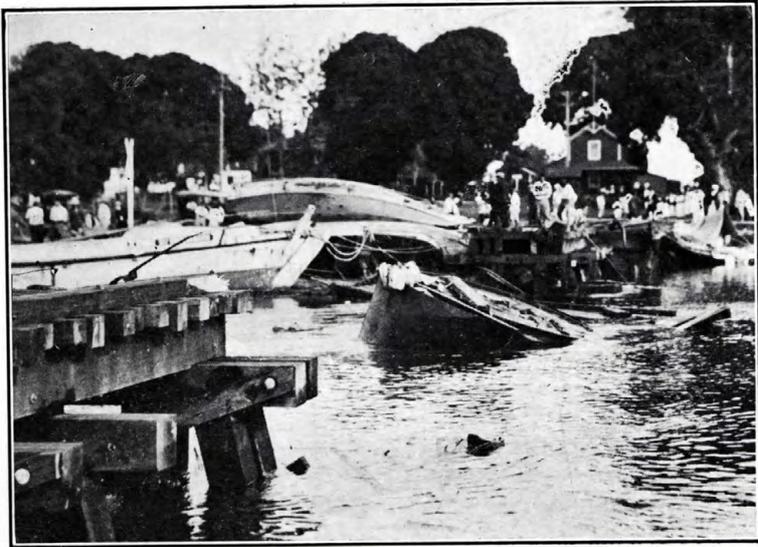


Figure 2.—February 3, 1923, Hilo, Hawaii, wreckage in Wailoa River where sampans were hurled by tidal wave against railway bridge and both were wrecked. A man in one of the boats was killed.



Figure 3.—Railroad embankment washed by tidal wave between Hilo and Kuhio wharf February 3, 1923.—Photcs. Morihiro.

Local Earthquakes.

| | | |
|-------------|-------------|---|
| Feb. 3..... | 9:46 a. m. | Very feeble. |
| 7..... | 12:45 p. m. | " " |
| | 3:06 p. m. | " " |
| 9..... | 3:30 p. m. | " " |
| | 8:41 p. m. | Moderate, dismantled instruments, felt all over Island of Hawaii. |
| 12..... | 7:50 a. m. | Very feeble. |
| 14..... | 12:11 a. m. | " " |
| | 4:32 p. m. | Feeble, distance 5 miles. |
| 16..... | 8:31 a. m. | Feeble, distance 14 miles. |
| 18..... | 12:22 a. m. | Very feeble. |
| | 8:37 a. m. | " " |
| 20..... | 6:06 p. m. | " " |
| 23..... | 8:54 a. m. | Feeble, distance 2 miles. |
| | 12:05 p. m. | Moderate, E-W dismantled, distance 2 miles. |
| 24..... | 8:53 p. m. | Very feeble. |
| 26..... | 3:30 a. m. | " " |
| | 8:40 p. m. | Feeble, distance 23 miles felt in Kohala and Honomu. |
| | 11:33 p. m. | Feeble, distance 23 miles. |
| 27..... | 5:36 p. m. | Very feeble. |
| | 6:54 p. m. | " " |
| | 7:05 p. m. | " " |
| | 7:06 p. m. | " " |

Teleseisms.

| | | |
|-------------|-------------|--|
| Feb. 1..... | 3:50 p. m. | Slight. |
| | 8:30 p. m. | Moderate, distance 2900 miles. |
| 3..... | 5:39 a. m. | Strong, distance 2200 miles, caused tidal waves in Hawaii. |
| | 8:00 a. m. | Slight. |
| 18..... | 12:35 p. m. | " |
| 23..... | 9:14 p. m. | " |
| 28..... | 10:11 p. m. | " |

Spasmodic Microtremor.

This type of tremor was moderate on the 12th, 13th and 18th and slight during the rest of the month.

Harmonic Microtremor.

This type of tremor was extremely slight throughout the month.

Microseismic Motion.

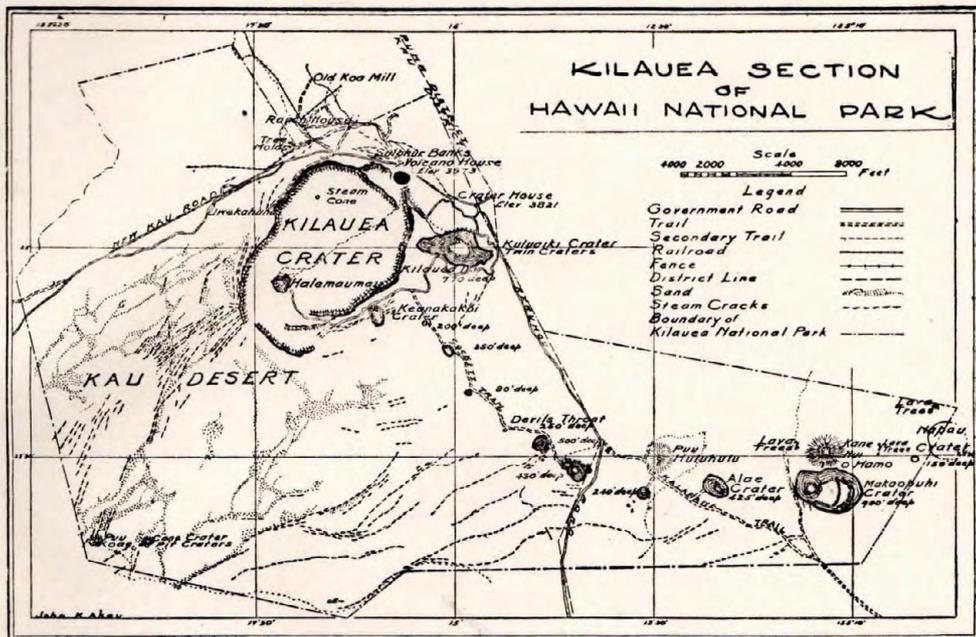
The amplitude of microseisms was moderate on the 1st and 2nd and slight from the 3rd on.

Tilting of the Ground.

By weeks this movement was as follows, expressed as angular change and direction of motion of the plumb line.

| | | |
|----------------|-------------|--------|
| Feb. 4-10..... | 2.8 seconds | SSW. |
| 11-17..... | 1.2 | " SW. |
| 18-24..... | 3.8 | " S. |
| 25-Mar. 3..... | 4.0 | " SSW. |

T. A. JAGGAR,
Volcanologist.



Black spot shows location of Observatory.

All exchanges should be addressed to
HAWAIIAN VOLCANO OBSERVATORY,
Volcano House P. O., Hawaii.

The Observatory is equipped with the following seismometric instruments rebuilt at the station in 1918 for the special needs of volcano research: two Bosch-Omori pendulums, high-speed registration of local earthquakes; one optically recording seismograph for distant earthquakes; one clinograph registering E-W tilting of the ground. A vertical component seismograph was in December, 1918, set up in experimental operation. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by wireless signal from the Pearl Harbor Naval Station. The chronometer is loaned by the University of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time. Observatory Lat. 19° 25' 54.2" N.; Long. 155° 15' 39.2" W.; Elevation 1214.6 meters (3985 feet).

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GENERAL MAP, KILAUEA SECTION, HAWAII NATIONAL PARK

VOLCANIC CONDITIONS IN MARCH

Activity of Halemaumau.

From the beginning of March the southwestern active slag-heap spread out across the pit until the fountains on top of the flat-topped pile stood fifty feet above the base of its slope at the opposite side of the pit. Cascades poured from the southwestern pool on top of this heap into the southeast lake and from that lake again toward the northern depressed region. Ridges were pressed up in front of these accumulations, showing dull red aa lava in the cracks. The December black ledge about eleven feet high still persisted on the northeast, the floor beneath it standing 497 feet below rim of pit, whereas the fountains on the opposite side of the bottom area on top of the heap were only 442 feet down. The slag-heap built up 50 feet in a week. The heat on rim of pit was intense and rocks fell from the cliff occasionally.

The fountaining varied and rose to gigantic proportions at 4 p. m. March 7. After a spell of quiet bubbling the southeast lake suddenly spilled over on all sides and developed a fountain gusher 80 feet high and 30 feet across which gradually achieved its maximum in the course of a minute like a geyser of fire. Then it rapidly died down and thereafter for an hour both lakes were crusted and dormant.

The second week of March exhibited rapid rising of the floor with its live two lakes and two areas of fountaining in the lakes over the source wells. The lakes had built up slag heaps, but now the floor margins were

filling six feet per day and the lake regions building up only five feet per day. The higher southwest lake was 400 feet down and the lowest marginal area 50 feet lower. The widening total floor area as the lava filled the crater funnel was now 1300 feet in diameter, and approximately 170,000 cubic yards of lava filling entered the pit each day.

The scene was bright at night and there were usually big streams flowing from one or both of the lakes. The latter had developed definite banks. Aa lava from the crevasses in the northern floor flowed out in short streams of stiff paste with clinkery sides and scored surfaces. Falls of rock were common. An island of craggy aspect appeared in the southwest lake, standing four feet above the liquid.

The southeastern lake gradually built up its borders until it was higher than the southwestern. Periods of quiet alternated with periods of rapid overflow. About equinox the rise averaged seven feet per day and the southeast pool was less than 350 feet below rim of pit. The plateau surrounding this pool stood about 30 feet higher than the rest of the floor. There were overflows several times a day and other streams made progress through tunnels emerging as small glowing trickles in many places. Six or seven fountains were sometimes in action. At the end of March there was some decrease in rate of rising.

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March 2. At noon the heat on rim of pit was strong from cracking and foundering areas both in the midst of the fresh western flood and in the southeast lake. The southwest cone was a single large pot surrounded by a rampart five feet high. There were fountains inside and outside the rampart. Over the southeastern vent there were three of four fountains along the margin of the lake. This southeastern lake had a definite edge or bank, but the western pool was making border flows, one of which poured into the southeast lake. The northeast corner of the floor was unchanged, standing three feet below the January ledge. The whole of the western flood was fresh lava overlying an older recent surface. On the south floor a sulphurous spot was smoking but the pit as a whole was making thin hot fume in no way obstructive to seeing.

March 3. At 3 p. m. the southwest fountaining cone was 442 feet below rim and 55 feet higher than northeast edge of floor. The bottom was very hot and building up rapidly with lava floods. The western talus heaps were becoming low by encroachment of the lava that was now doing its major construction around the southwest cone. This was no longer a cone, but rather an open fountain, and a remnant of the cone was seen to founder in the melt. There was a continuous crackling sound of crusts in motion, and everywhere there were advancing overflows and breaking crusts where the western and southeast pools fed new lava to the bottom. Both these pools were at the top of slag heaps, the western one the higher, and their weight was crushing out the floor beneath them into a pressure ridge or spur at the northeast. A continuous cascade poured into the southeast lake, and a stream from this lake moved north towards the pressure ridge. Aa lava was visible in the chasms of the pressure ridge, and there were other chasms along the east border of the southeast lake. Rocks fell from the north wall.

March 4. At 9 p. m. there were no fountains in southeast lake, but continuous fountaining was in action at the southwest vent. Lava flows emerged from tunnels and flowed along the northern walls. Another in center of pit was moving eastward. Lava overflowed the north bank of southeast lake for a short time after a breaking-up of crust in that lake.

March 5. At 9 p. m. fountains were flinging up the melt at the southwest vent and sending broad sheet-streams northward. There were small fountains at the southeast vent and a flow streamed northward from the edge of southeast lake. The whole northeast region was full of glowing lava submerging the January ledge.

A large flood developed, flowing eastward from the western slag heap and cascading into the southeast lake. In its turn this lake overflowed. At other times small streams poured down the flank of the western heap, many flames were observed and there was much cracking and foundering. The light from the pit was so bright that the glowing cracks of the southwest chasm could be detected in only one place.

March 7. The lava was now rising five to six feet per day and the southwest fountain was only 423 feet below rim. At 3 p. m. the southeast lake showed banks three feet high west and south, small bubble fountains over its well, and the liquid brimming level with the northeast bank. Soon after this the southwest plateau pool overflowed voluminously towards east and northwest with fountaining over the source well.

About 4 p. m. the southeast fountain became enormous in a series of gushes until it stood 80 feet high like the fountains on Mauna Loa. It held these jets at this height for about two minutes, flooding the southeast lake with a great access of lava so that the lake overflowed on all sides.

This spasm of gushing was followed by a very quiet period when both lakes appeared dead and the southwest pool sank two feet below its banks revealing a flat island two feet high in its western part.

At the base of the north wall of pit the floor margin had subsided and two aa flows lay along the wall-valley exhibiting rough surfaces with even stream-lines that appeared to have debouched from the northeast pressure ridge.

Examination of rim of pit indicated, by measurement and location of a new surveying station, that the whole north-northwest edge had caved back 20 feet during the big avalanches of February 7.

March 8. At 2 p. m. the southwest lake was quiet except for small patches of breaking crust and the fountain at source well. The same was true of the southeast lake. No flowing lava was visible. The northern subsidence area and aa flows showed no glow.

March 10. At 3 p. m. it was evident that rising had been resumed, the southeast lake showed cracking and sinking crusts and had glowing overflow floods around it, even to the west, showing that it had gained on the southwest source. The western heap showed fresh overflows down steepish slopes around its southern margin, and other floods to the north and west were making glowing toes at the talus there, which was greatly encroached upon. The bank was two feet high around southern half of southwest pool, and the small island was tilted up. The well fountains in both pools now stood out from the banks. There were several fallen rock fragments.

March 11. At 4 p. m. the southwest lake was overflowing on three sides and the island was nearly submerged.

March 13. At 11 a. m. southwest lake was heavily crusted with banks seven feet high and discontinuous fountaining action at source well. The southeast lake on the other hand had vigorous multiple fountaining and overflow in a rapid stream which followed east wall of pit around to the north where tongues were pouring down into the depressed wall-valley. The floor appeared to have subsided at north end of the western lake so that the lake rim was lower there relative to the liquid. There were now three

islands about eight feet high in this lake. Both lakes appeared to be at about the same level. At night the pit was dull.

March 14. At 11 a. m. the western lake was nearly brimming full but heavily crusted, and the southeast lake was now depressed six feet within its banks. A small stream from a recent overflow to the northeast was cascading back into the lake at its eastern bank. The southeast fountain was vigorous.

March 16. At 11 a. m. the southwest lake was low and crusted, its surface 10 to 15 feet below banks to the south of the islands and 7 to 10 feet at the north. Part of the southeastern bank had fallen in and the outlying floor around the lake was cracked especially towards center of pit. The southwestern well was active and small flows from it poured over the collapsed shell of the lake.

The southeast lake was smaller than before and overflowing sluggishly in eight places. There was smoke from a vent near north wall of pit.

March 17. At 11 a. m. a small intermittent fountain was active at southwest vent, and the collapsed southwest lake was being flooded by an overflow from the other lake. The southeastern fountain was playing continuously and this eastern lake sent other floods to the east and north.

March 18. At 3 p. m. the southeast lake was still overflowing slowly, but now towards the south and northwest, and the southwest lake area was still depressed within its bank, its fountain spouting continuously.

March 19. At 4 p. m. the southern half of the southwest lake was overflowing into the northern half of its basin and there were vigorous dome fountains at the southeast and southwest vents. The eastern side of the floor was now higher than the western, but the southeast lake was slightly depressed within its banks. During the evening there was a rapid flooding of the western region.

March 20. At 3 p. m. the eastern lake was overflowing east and west, both source fountains were playing, and the western lake was overflowing toward the north.

March 21. At 4 p. m. continuous dome fountains were in action both southeast and southwest, both lakes were covered with crust and overflowing, the eastern pool to the east and the western one to the north.

March 23. At 11 a. m. the southwestern fountain was small but continuous, while the southeast lake maintained a large dome fountain. This lake overflowed rapidly westward, one branch of the flow passing under the crust of the southwest lake, and two other branches spreading on southwest floor of pit. In several places over northern half of floor there were small trickling flows.

March 24. At noon the southeast lake was seen to surmount a slag heap higher than the rest of the floor. This lake was overflowing towards the east with its usual source-well fountain and occasional other fountains. There were numerous small flows on the northern half of the floor and also a smoking cracked area colored yellow. The southwestern fountain was in action as usual.

March 27. At 9:30 a. m. the southeast lake was 353 feet below rim, and 36 feet above northern edge of floor. A big avalanche fell from western wall at 10:15 a. m. and other small falls of rock occurred.

At 10:30 a. m. the southeast lake overflowed through gaps in its border rampart to the north and west, and these flows increased during an hour filling a sag along the northern and northeastern edge of the floor. Previously a small spurting vent had emitted a flow from the northern edge of a sagging depression northwest of center of pit, and this flow fed an

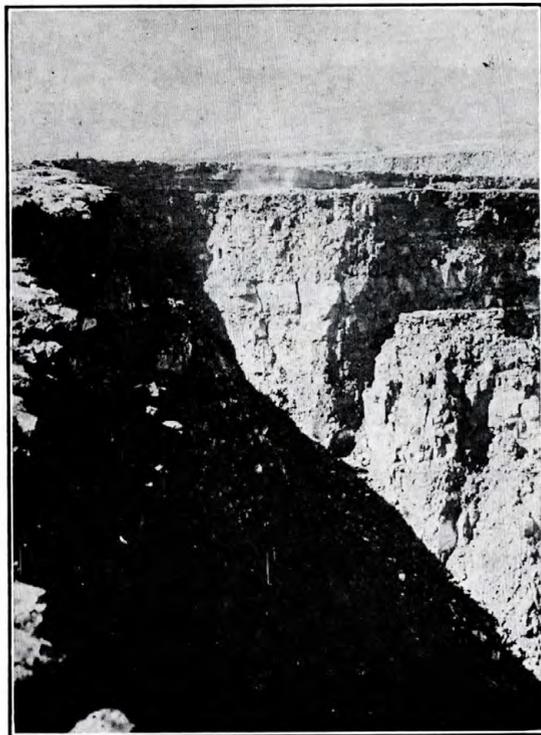


Figure 4.—January 8, 1923, southwest chasm and inner pinnacles of Halemaumau from south side of pit, showing lowered west bench and buttness still lower.



Figure 5.—Halemaumau January 8, 1923, from south rim of pit looking towards northwest talus and the December ledge below.—Photos. Jaggar.

elongate fountaining wall-pool filling northwest margin of floor. The two lakes had banks four feet high around their margins and the fountaining was stronger in the southeast lake which was obviously higher than the southwestern one. The outer slope of its plateau to the north and west was covered with fresh festooned flow material. The flow pattern indicated that the southwest lake stood higher than the southwest floor margin.

March 28. All the debris slopes of the summer of 1922 were now buried under new lava except remnants at the north, northwest and southwest. On this date flows were active and travelling fountains along lines of conflicting surface currents were reported for the first time during the present rising spell.

March 29. At 9:45 a. m. the southeast lake was seen overflowing to the north by way of a channel covered with crust and through a tunnel under the rampart which stood six feet high above lake level where the liquid escaped. This border rampart was only two feet high at the south end of the lake. Fifty feet of glowing flow was exposed to the point where it poured under the crusted fill of the northeastern wall-valley. The sag northwest of center was now filled with a live pool fed from the northwest vent, and the wall-pool in that direction had become inactive. The pool filling the sag was trickling around the edges. There were the usual fountains over the two wells.

At 10 a. m. five explosive fountains of the "travelling" variety developed in the northern part of the southeast lake. All the crust broke up and the slabs migrated to the line of fountains. The fountains in turn migrated to the northeast bank, and other fountains developed elsewhere under banks of lake while the lake surface lowered about two feet. The travelling fountains were evidently exaggerated forms of the "crack-and-founder" bubblings that spring up between slabs during a general break-up. The source well fountain continued undisturbed throughout the course of the phenomenon. Much strong sulphur dioxide was emitted by the travelling fountains. In the late forenoon the northeast overflow became completely crusted over.

March 30. At 4 p. m. the southeast lake was overflowing through the northern tunnel as before and there were two small overflows, from the southeast lake westward. The southwest lake had one small fountain at its northeast edge in addition to the usual source fountain, and this lake overflowed into the northwest pool.

LAVA MEASUREMENTS

Measurements of depression of the mobile lava column, made with transit, referred to northeast station on rim of Halemaumau pit (3716 feet above sea-level), for the month ending March 31, 1923, including floors of bench magma and liquid level of lake magma, were as follows:

| Date | Time | Lava Pool | Northwest Floor | Southwest Fountain | Southeast Fountain |
|----------------------------|----------|-----------------|------------------|--------------------|--------------------|
| Jan. 18, 1923 | 2 p. m. | 524 feet | ..... | ..... | ..... |
| Jan. 28 (Measured March 3) |  | ..... | 497 feet | ..... | ..... |
| March 3 | 3 p. m. | ..... | ..... | 442 feet | ..... |
| March 7 | 3 p. m. | ..... | 474 feet | 423 feet | 444 feet |
| March 20 | 3 p. m. | ..... | ..... | 394 feet | 363 feet |
| | | East edge floor | North edge floor | | |
| March 27 | 10 a. m. | 354 feet | 389 feet | 369 feet | 353 feet |

The depression of northeast edge of floor measured March 3 represents the filling that ended January 28. The building up of the southwest vent was interrupted from January 28 to February 17. Thereafter in 14 days to March 3 the southwest region built itself up 55 feet, averaging 3.9 feet per day, on the assumption that the floor of January was horizontal.

The changes thereafter in March were:

| | | | | |
|---------------------|-------------------------|----------|-------------------|--------|
| Mar. 3-7, 4 days, | southwest heap rose | 19 feet, | averaging per day | 4.7 ft |
| | northeast floor | " 23 " | " " " | 5.7 " |
| Mar. 7-20, 13 days, | southwest pool | " 29 " | " " " | 2.2 " |
| | southeast heap built up | 81 " | " " " | 6.2 " |
| Mar. 20-27, 7 days | southwest fountain rose | 25 " | " " " | 3.6 " |
| | southeast | " " 10 " | " " " | 1.4 " |

In 20 days from March 7 to 27 the northeast floor rose 85 feet, averaging per day 4.2 feet.

Monthly changes of bottommost part of pit floor from July, 1922, were as follows:

| | | |
|-----------|----------------------|-----------|
| July | Lava inflow | + 70 feet |
| August | Slight slumping | - 29 " |
| September | Lava inflow | +100 " |
| October | Lava inflow | + 65 " |
| November | Uplift and inflow | + 73 " |
| December | Uplift and inflow | + 73 " |
| January | Sinking and recovery | - 31 " |
| February | Bottom stationary | + 0 " |
| March | Uplift and inflow | +125 " |

SEISMOMETRIC RECORD

During the month ending midnight March 31, 1923, thirty-four local earthquakes and three teleseisms were registered at the Observatory. These and other earth movements are exhibited below. Distance of origin when indicated by the instrumental record is stated in English miles. Time is Hawaiian Standard of meridian 157° 30' W, 10 h. 30 m. slower than Greenwich.

Local Earthquakes.

| | | |
|--------------|-------------|--|
| March 3..... | 11:46 p. m. | Moderate, distance 12 miles, felt in Hilo. |
| 4..... | 1:07 a. m. | Very feeble. |
| 5..... | 12:52 p. m. | " " |
| | 3:21 p. m. | " " |
| | 3:58 p. m. | Feeble, distance 17 miles. |
| 6..... | 12:38 p. m. | Very feeble. |
| | 9:38 p. m. | " " |
| 7..... | 6:33 p. m. | " " |
| | 6:39 p. m. | " " |
| 8..... | 6:00 a. m. | Feeble. |
| 10..... | 8:47 p. m. | Feeble, distance 4 miles. |
| | 10:01 p. m. | Very feeble, distance 4 miles. |
| 11..... | 1:12 a. m. | Very feeble. |
| | 4:14 a. m. | " " |
| 12..... | 9:27 p. m. | Slight, distance 4 miles. |
| 16..... | 3:09 a. m. | Slight, distance 3 miles. |
| | 11:18 a. m. | Very feeble. |
| | 4:20 p. m. | " " |
| 17..... | 9:50 a. m. | " " |
| 19..... | 2:19 a. m. | " " |
| | 7:15 p. m. | " " |

| | | |
|---------|-------------|----------------------------|
| 20..... | 1:34 a. m. | Very feeble. |
| 21..... | 3:33 a. m. | " " |
| | 11:40 a. m. | " " |
| | 12:21 p. m. | " " |
| | 2:46 p. m. | " " |
| 22..... | 12:02 a. m. | " " |
| | 8:13 p. m. | " " |
| | 11:36 p. m. | " " |
| 23..... | 3:18 a. m. | Feeble, distance 8 miles. |
| | 6:55 p. m. | Very feeble. |
| 25..... | 4:33 p. m. | " " |
| 26..... | 5:07 a. m. | Very feeble, felt in Kona. |
| 29..... | 4:10 a. m. | Very feeble. |
| 30..... | 2:30 p. m. | " " |

Teleseisms.

| | | |
|--------------|-------------|---------|
| March 2..... | 12:41 a. m. | Slight. |
| 3..... | 7:40 p. m. | " |
| 24..... | 2:39 a. m. | " |

Spasmodic Microtremor.

This type of tremor was moderate on the 8th and 22nd and slight on other days.

Harmonic Microtremor.

This type of tremor was extremely slight from the 1st to 17th and slight from 18th on.

Microseismic Motion.

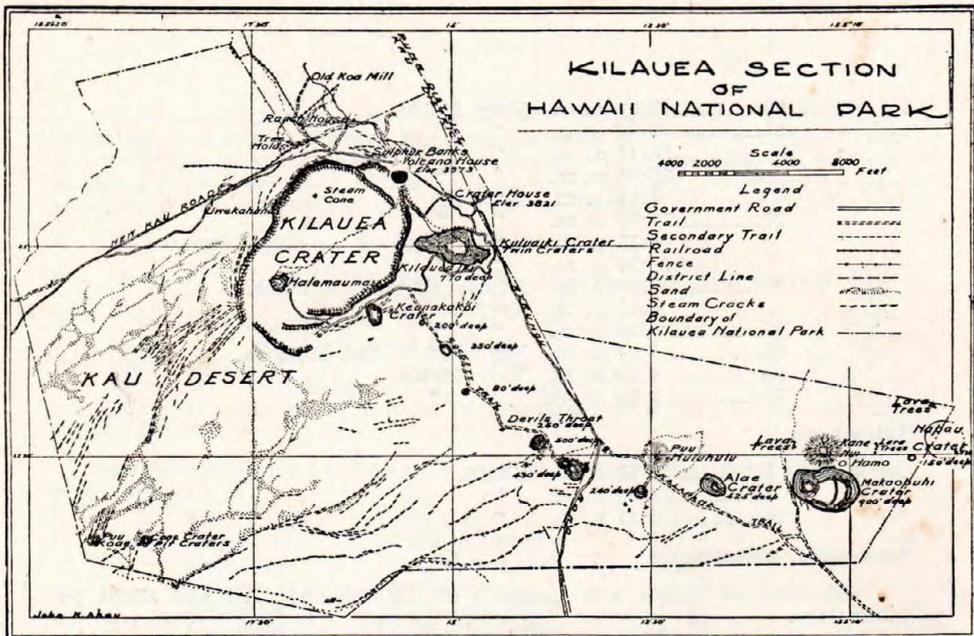
The amplitude of microseisms was moderate on 27th and 28th and slight on other days.

Tilting of the Ground.

By weeks this movement was as follows, expressed as angular change and direction of motion of the plumb line:

| | | |
|-----------------|-------------|------|
| March 4-10..... | 3.8 seconds | NE. |
| 11-17..... | 4.5 | SSW. |
| 18-24..... | 1.6 | WNW. |
| 25-31..... | 2.1 | NNE. |

T. A. JAGGAR,
Volcanologist.



Black spot shows location of Observatory.

All exchanges should be addressed to

HAWAIIAN VOLCANO OBSERVATORY,

Volcano House P. O., Hawaii.

The Observatory is equipped with the following seismometric instruments rebuilt at the station in 1918 for the special needs of volcano research: two Bosch-Omori pendulums, high-speed registration of local earthquakes; one optically recording seismograph for distant earthquakes; one clinograph registering E-W tilting of the ground. A vertical component seismograph was in December, 1918, set up in experimental operation. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by wireless signal from the Pearl Harbor Naval Station. The chronometer is loaned by the University of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time. Observatory Lat. 19° 25' 54.2" N.; Long. 155° 15' 39.2" W.; Elevation 1214.6 meters (3985 feet).

HAWAII NATIONAL PARK.

This park was created by act of Congress August 1, 1916, and includes three famous volcanoes—Kilauea and Mauna Loa on Hawaii and Haleakala on Maui. Frequent passenger steamers ply between these islands and Honolulu.

Haleakala Section—Haleakala, "house built by the sun," a peak more than 10,000 feet high, carries an immense fissure-like crater 8 miles long and 3 miles wide, with walls 2000 feet high. Here, as well as on Mauna Loa and Mauna Kea, grows the Silver Sword (*Argyroxiphium*). Thirteen volcanic cones lie wholly within the crater, some rising nearly to the height of the summit. The scene at sunrise is marvelously beautiful.

Wailuku is the point of departure, automobiles taking the traveler to Olinda, a summer residence settlement 4043 feet high. After 2 hours drive to this point, saddle horses are taken to the summit, a ride of 3½ hours. Here is a fine concrete rest house, built by the citizens of Maui, and fully equipped with iron beds, blankets, stoves and cooking utensils.

Mauna Loa Section—Mauna Loa, a vast dome 13,675 feet high, reached through forests of Hawaiian mahogany (koa) and tree fern, then up bril-

liantly colored lava slopes, has a summit crater 3 miles long by 1½ miles wide, with walls 700 feet high, and when in action fountains of fire froth are here jetted 500 feet into the air. Every five or ten years splendid spectacles of lava eruption are staged on the mountain, sometimes from the lower flanks.

There are trails on the Kona side, and also from the southwest, but the usual and best route is with saddle mules from the Kilauea section to Puu Ula-ula (9800 feet), a ride of six hours. Here there is a fully equipped cottage with stables and water supply. From this point on the second day a four-hour ride takes the visitor to the summit crater, where there is water. A right of way within the park connects Kilauea with Mauna Loa, where eventually a road will be constructed. The views are glorious and the chasms, cones and contorted lavas indescribably chaotic.

Kilauea Section—The lakes of foaming fiery lava within the crater of Kilauea form the most spectacular exhibit in the Hawaii National Park, if not in the world. The pit of fire, Halemaumau, is inside of the main crater, at the apex of a broad, flat, inner cone. Kilauea is a dome volcano 4000 feet high, overriden by the lava slopes of Mauna Loa on the west, so that it seems but a spur of the greater, and perhaps younger, slag-heap mountain.

The Kilauea Park and the inner pit itself are both reached directly by automobile from Hilo, the second city of the Territory of Hawaii, and there are excellent hotel accommodations. The distance from Hilo is 30 miles. Within the park there are 15 miles of roads and about 20 miles of trails. As shown on the map, there are a dozen ancient pits within the area of the park, as well as cones, caverns and hot solfataras and a strange desert where lava flows have poured out of cracks as recently as 1920.

The live pit of Halemaumau is easily accessible and not dangerous. Frequently one can walk to the actual edge of the splashing, fountaining lava lakes, the lava column rising and falling from year to year so that its most distinctive character is ceaseless change. At night the spectacle is full of marvelous color, and the region is a paradise for artists, photographers and naturalists.

The several sections are under the control of the National Park Service of the Department of the Interior. The United States Weather Bureau maintains the Hawaiian Volcano Observatory, which stands on the brink of the greater crater within the Kilauea Park.

U. S. DEPARTMENT OF AGRICULTURE
Weather Bureau

CHARLES F. MARVIN, Chief

MONTHLY BULLETIN

OF THE

HAWAIIAN VOLCANO OBSERVATORY

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No. 4

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GENERAL MAP, KILAUEA SECTION, HAWAII NATIONAL PARK

VOLCANIC CONDITIONS IN APRIL

Activity of Halemaumau.

On April 1 there was a vigorous and spectacular flow of lava in the pit that covered the entire floor, an area of about 28 acres, with a fiery flood. Within a few hours some 200,000 cubic yards of molten lava poured forth. The floor of the pit was now level, where before it had been higher towards the southeast. The place of maximum output of lava now changed from the southeast source well to the southwest well. Intermittent fountains of the travelling type appeared from time to time in both the lava pools. Over the two source vents there was continuous fountaining action dominant at the southwest well.

During the first ten days of the month there were lava displays of great brilliancy. The flooding of April 1 which for some hours had converted the whole bottom into one vast pool 1400 feet in diameter and about 308 feet down, was succeeded that night by a reactionary drainage accompanied by swarms of earthquakes. This left a black ledge from ten to fifteen feet high all around the floor and the two separate lakes were restored to view along with their fountaining vents.

There next occurred a succession of risings whereby the two wells alternated in supplying new floods. Sometimes eighteen fountains were in

action at once. Cascades poured from the western lake over the floor and into the eastern pool, and then the process was reversed.

Finally the eastern and older vent became dominant with its lake higher than the rest. A torrent poured from it continuously to the west pool, and the floor north of it swelled up and cracked, while the wall depression northeast became accentuated through subsidence of its bottom while lava welled up from below and made a new border pool. The eastern lake showed a raised bank as though its cup had been lifting. The western lake had become a long pool ever widening as the torrent filled its basin, and a small island of craggy matter had appeared in its midst.

The stream between the lakes built a bridge of crust over itself and showed variations in rapidity of flow. It exhibited bubblings of scintillating appearance. The middle region about April 9 was 314 feet down showing that the floor had risen more than four feet per day.

By the middle of April the live floor was only 290 feet below rim of pit and one or more flowing rivers of melt were nearly always in view. The southeast lake remained higher than the rest and overflows of its banks were daily occurrences. The northern banks of the western lake stood about ten feet above the liquid lava. What had been islands joined together to form a peninsula. One peak stood about twelve feet above the lake. A shallow lava pool at the base of the wall bounding the pit formed a half circle around the northwestern and northeastern sides. In both the lakes fountains occasionally broke out flinging up molten spray 35 feet in the air and migrating towards the banks. There was now bright glow at night especially when the crust broke up, and this happened frequently so as to reveal several acres of glowing lava.

During the third week the lava rose three feet per day until its level was 268 feet below rim of pit. The lifting was accomplished partly by an actual swelling up and cracking of the hard floor, and partly by flooding due to liquid lava rising through the two source wells. Over these wells lay groups of bubbling fountains. Around each well there was a lake, and a third lake occupied a depression in the northern floor fed by tunnels leading from the wells.

Great floods of overflow from the lakes swept along the western and northern sides of the floor bounded by a curved rampart concentric with the pit. Outside of this rampart, there was a downward slope built up by overflow, and extending to the base of the precipitous wall of the pit.

It was as though the lake system tended always to keep itself at the top of a circular heap; whenever continuous overflowing was in progress. The scene was very brilliant, craggy shorelines and peninsulas were developing, and the spells of "break-up" made marvellous firework display.

Rising continued vigorous until April 25, when an important crisis occurred like that of April 1. This was a sudden upward gushing of increased volume of lava beginning in the early morning hours. At 7 a. m. the whole vast floor was covered with a flat pool of liquid lava showing many bubbling fountains, and all the crags and ramparts were drowned.

About 8 a. m. the flood sank back and during the next few days there was a slight lowering of the liquid, the old crags and lake shores again coming into view.

The net result of this spurt was a rising, for the liquid lava continued to pour into the lakes and to flood the floors. The inner area was surrounded by a narrow black ledge from 15 to 20 feet high representing the higher flood level of the 25th. At its highest this flood had been 235 feet below rim of pit. The action remained as before with vigorous fountaining and one lake higher than the others.

JOURNAL, APRIL, 1923

April 1. A rapid overflow that appeared to have come from the southwest vent occurred sometime during the morning. The entire floor of pit was nearly level and covered with hot lava that had a very thin crust. A little of the south end of the southeast lake was still visible. Cracking and foundering took place slowly at many places. There was vigorous fountaining at the southwest vent and occasional fountaining at southeast.

April 2. At ten a. m. the lava was down 8-10 feet as shown by black ledge around edge of pit. The southeast lake area was again well outlined, but the southwest lake was not visible. There were small fountains at the two vents.

At 3 p. m. there was vigorous fountaining at the southeast vent with strong overflow of the southeast lake toward the southwest and small overflow to the north. The fountain continued small at the southwest vent.

Seventeen earthquakes were recorded between 9 p. m. of the 1st and 9:48 a. m. of the 2nd.

April 3. At 11 a. m. the southeast lake was depressed within its banks from 5-8 feet. There was vigorous fountaining at southwest vent—three or four dome fountains being in action at all times—and only small fountains at the southeast vent. Lava flows were pouring over the northeast floor from the southwest lake by way of the north side of pit. By 11:30 a. m. two cascades were pouring into the southeast lake. At 8 p. m. the southeast lake was overflowing to the southwest, and there were eighteen fountains in action.

April 4. The overflow from southeast lake into southwest pool was still going on at 11 a. m. There were trickling flows due to the above overflow on the north floor. Whichever of the two source vents that had the most fountaining was the locus of principal upwelling of lava. Three or four dome fountains were in action at the southeast vent and small fountains at the southwest vent. The eastern floor had subsided a few feet.

April 5. On April 1st the flood level of lava appeared to have reached about 308 feet below rim. The floor now appeared 15 feet below black ledge of April 1st on the northeast, 10 feet below it northwest, and 5 or 6 feet below it southeast, this last being a 2 foot ledge and a slope of inward dipping floors.

The southeast lake was the highest and from it there was a steep cascade chute to the west pool in a northwesterly direction. The southeast lake had a three-foot bank and was fountaining vigorously and continually at source well, and making migratory fountains that moved to the bank by cracking and foundering in west portion of lake. Chute showed gas bubbling 50 feet from southeast lake.

The west pool was fountaining idly in one or two places and had a permanent scar and feeble fountaining at its source well. The pool was merely a fill without rim, but with a small crag or island in it. The rest of the floor was flat, slumped pahoehoe except for a little aa in northeast floor.

The cascade has been rushing for two days like a fixed circulation. The north talus is covered while the northwest persists.

April 7. At 3 p. m. both the southeast and southwest wells were making several bubble fountains, the southeast ones being larger. A stream poured steadily as before from southeast pool to west pool. The latter was still

about 10 feet below black ledge of April 1st. The floor north of southeast pool had swelled up and cracked and a similar development of height in bench magma showed in ground southwest of southeast pool and in a peninsula making out into west pool from south side of cascade stream.

A new wall pool was developing between the high ground of north central part of floor and northeast wall of pit. The source of this lava appeared to be from the wall crack below it. It was sluggish, scoracious pahoehoe without gas pressure. It may have percolated through the crevasse of the domed floor. The wall-pool appeared to lie in a depression lower than before for the black ledge of April 1st was 20 feet above it.

The edge of southeast pool on wall side appeared to have been built up by overflow toward the wall. The cascade stream had built an arch over itself in the middle part of its course. Cracking and foundering was seen to start in north corner of west pool and spread slowly clear across pool and around the peninsula to and beyond the southwest wall fountains. It reached the mouth of cascade stream, where the stream plunged under crust, broke up the older black festooned surface there, and a new festooned surface formed. During the cracking and foundering there were overflow gushes around edges of west pool on west side. For the most part the southeast pool gas pressure was in adjustment to the outlet, but some slight cracking and foundering occurred. There were slight rock falls.

April 8. At 9 p. m. the cascade stream was covered with arch of crust over its lower half. Its speed varied from time to time. The west pool was crusted and the southeast pool dull, but with fountaining at source well as before. There were fresh border overflows from southeast pool to the south, from west pool to the west and northwest, and from northeast wall-pool to the northwest. The west lake cracked and foundered gradually during an hour, starting at mouth of cascade. There were spectacular color bands during the crack-up, from bubbling golden with scintillating effect to copper bronzy on cooling.

A different type of cracking was observed on the north part of southeast lake. It was started by a large fountain and spread as the fountain lowered the level of pool. Coincidental with the lowering the outlet stream became sluggish.

April 11. About 3 p. m. the southeast lake began a strong overflow to the east and south, filling space between it and the wall and thence pouring west into west lake. This flow continued and the pit was very bright at night.

Changes evident were the flooding of April 1st ledge all along west side of pit. The black ledge along north and northeast persisted with same height as before—10-15 feet. The north central region was cracked and raised as though pulled toward the southeast which is the highest part of the floor. The southeast lake dominated everything and recent flows from it had filled the northeast wall valley. The southern part of west lake appeared more active than the slightly sagged northern part.

The bubbling fountains at southwest and southeast vents showed increased gas pressure and number of fountains. Craggy bits of shore line appeared just south of southwest fountains. The crag peninsula was more pronounced.

April 12. At 5 p. m. there was vigorous fountaining activity at both southeast and southwest vents and there were three fountains near the wall south of southwest fountain. A hissing vent that showed several glowing

spots was located near southwest bank of southeast lake about where the persistent streaming of a few days ago was located. A sloping crust from southwest talus indicated that the fill due to the flooding of April 11 had subsided 8-10 feet.

April 13. There was vigorous fountaining activity at southeast vent at 3 p. m. while the activity at southwest vent was periodic at about one minute intervals. There were six islands in west part of pit. The single island in center of pool was tilted with a slope toward the north. The crust cracked and foundered in northeast pool and along northwest wall. The bank along south and west side of southwest pool was 8-9 feet high, and no bank at the north side. The southeast lake was flush with its banks.

At 8 p. m. numerous flame jets of about one second duration were noticed in cracks from time to time over all the lakes.

April 14. The fountaining activity at both southeast and southwest vents continued. Near the center of the pool on the west side there was a small continuous fountain that was building up a small spatter cone. Traveling fountains were frequent in the southeast lake. The streaming to the west from about the location of the open channel between southeast and southwest lakes of a few days ago continued.

April 15. The southwest lake was a few feet higher than on the 14th, though surrounded by well defined banks. There was continuous fountaining at southeast and southwest vents. A small trickling flow was observed at north side of pit. The southeast lake was crusted and bank full with an overflow pouring toward the east from a point near the wall.

April 16. Activity at the southeast and southwest vents was unchanged. The south end of southwest lake was bank full, while the north end, which was separated from the south by an island, was depressed within its bank 6-10 feet. The bank on the west side appeared to be due to tumescence as it sloped toward the outer wall of pit. A wall pool with one continuous fountain appeared to be developing near north end of southwest lake. The southeast lake was overflowing into south end of southwest lake. The northeast wall pool was crusted.

April 19. The floor of pit was constantly enlarging and rising on the wall contact. A slight slump of 3 feet around edges was noticed but none of this black ledge appeared to be that of April 1st. Crags were very pronounced on south side of southwest pool, and other marked high ground lay around the north pool and west of southeast pool. Fountains played over source wells southwest and southeast. No trace of tunnel cascade was visible between southeast and north pools. The north pool was more pronounced in outline. There were wall-valley fills all around west, north, and northeast sides of floor. The rise of floor area by these fills was very marked at contact with the west inner benches which were partly submerged. The northwest talus was buried.

April 21. The situation at 11 a. m. was like that on April 19th, except that a new flood was pouring over west lip of southwest lake and filling a new wall valley, its front cracking and foundering and advancing eastward on north side of floor area. The edge of floor was higher and west bench still more submerged. There were whitened smoking cracks in northeast part of floor. The peninsula crag was 18 feet high and higher than southwest crag. There were some small fountains in west wall-valley flood and the usual triple or quadruple dome fountains in both southeast and southwest lakes.

April 22. The north and southwest pools cracked and foundered at 3 p. m. Two or three dome fountains played over each source well. Short festooned streams overflowed a rampart along side the great west flow pool at many places. There were similar rampart overflows in south side of southeast lake. The west bench and southwest talus were being increasingly encroached upon. The crags and crevassed ground was higher. The lake areas were probably 20 feet above much of the wall valley depression. The bench magma containing the lakes had thus risen with the lake. The whole lake and swollen area tended to make high ground, arched in a flat dome relative to the wall crack that remained low. The lake borders were 1-6 feet high; crags 20-40 feet high. Much small fountaining accompanied cracking and foundering in many places. A majestic stream poured west out of southwest lake.

April 24. At 9 a. m. conditions were much the same as on April 22nd. There were fresh overflows to the south and east from southeast pool. The three pools occupied high ground. The peninsula crag appeared to have changed its axis from east-west to northeast-southwest. A recent flow had poured between the two southwest crags. Numerous crevasses had developed into small crags to the north of north pool. The wall crack region in general, was low. The north lake was crusted. There was streaming directly across southwest lake and cracking and foundering in southeast lake.

April 25. At 11 a. m. an important crisis like April 1st was going on. It began in early morning. At 7 a. m. there was yellow fume and at 8 a. m. the national park men saw the beginning of a subsidence. There had been a complete filling of the whole floor above the highest crag level, making a new black ledge all around, and leaving fresh crusts on top of the crags. The west bench was entirely submerged. The new ledge is 15 feet high generally, a little higher northeast, and only half as high southeast where there is a sloping bank next to the southeast pool. The subsidence left four crags of which two were southwest, one was the peninsula, and one was the east bank of the north pool. There was a promontory of new lava at west bench locality. The black ledge, as usual, showed aa where the wall of subsidence was left, and the lower slope of crags showed aa. There was no change in the general pattern of floor due to the subsidence. A big stream poured west along the south wall of pit from south corner of southeast lake. Fountains occurred as usual at southeast lake and occasional ones at southwest lake. A big stream showed its outline northwest from southwest fountain like yesterday. A northeast high region was appearing. The southeast lake was an oval with slabby rampart developing. Hissing noises were abundant and cracking and foundering was in progress. There was no fume whatever except from southwest chasm talus. Flats emerged at edge of floor northwest and west of north pool. A new flat wall valley fill extended in a zone clear around south side of floor, and the stream from southeast lake lay as a festooned band between it and the southwest crags. Noises of cracking and clanking crusts were heard. The black ledge had fallen away at a few places on north side of pit. The new black ledge had encroached on the foot of the square west pinnacle and the only taluses left were those north and south of this pinnacle. The black ledge was approximately 235 feet and lakes 250 feet below rim.

April 26. Heavy rains were in progress that began at 4:30 p. m. of the 25th. During the ensuing 36 hours the total fall was over 14 inches. Water falls were observed at Uwekahuna Bluff and elsewhere along north wall of crater. There was a large pool of water at Sulphur Bank flat. Big steam clouds rose from Halemaumau.

Glimpses of the bottom of Halemaumau were obtained from the south and the floor was lower than on the 25th. The crags were 30-40 feet high.



Fig. 6, April 4, 1923, from southwest rim showing southeast pool overflowing to the west. Photo. Finch.

The ground west and north of north pool was crevassed. Large streams flowed from southeast and southwest pools south and west along wall valley. Columns of steam arose from the flat ground. The fountaining was as usual and the general pattern was unchanged.

April 27. At 11 a. m. the details were observed to be the same as on the 26th, but more plainly visible. The northwest black ledge was 20 feet high, and the southeast, 5 feet. The southeast lake was highest. Torrents poured from it to south wall valley and between the two southwest crags from southwest lake to south wall valley. These flows united into a big stream that moved north along west side of floor. An overflow to the west from southwest pool joined this stream. Large crevasses were forming west and north of north pool. The floor north of southeast lake was high. Fountains at southeast and southwest source wells played as usual.

A new tumble in southwest chasm wall of pit was wet and dripping. The pale yellow glow patches there had mostly disappeared.

The general situation in Halemaumau appeared to be: lava rising southwest and southeast wells, with the southeast well dominant; same pattern of lakes and bench magma as before subsidence.

A large convection cumulus was observed over Mauna Iki.

April 28. At 10 a. m. both lakes were brim full and the southwest lake started to overflow. The big south and west fill was high and flush with the southwest lake. A beehive cone had formed at the end of one of the crevasses west of north pool. The north and southwest pools were joined and the peninsula crag was an island 15 feet high. The large southwest crag was about 30 feet high. The crevassed crags northwest of north pool appeared about 30 feet above the pool. The central floor was covered with yellow stains. Lava was flowing in a tunnel from the southeast lake to the north pool as evidenced by a bright line streaming across north pool in a northwesterly direction from the tunnel, and also by smoking cracks over the tunnel. There was the usual fountaining at the source wells. A big stream flowed through the southwest crag gap and across southwest wall valley pool causing cracking and foundering at its front.

The southeast lake was about 240 feet down; the southwest, west and north pools, 245 feet, down; north and northeast wall valley, about 255 feet down.

April 29. At 4 p. m. the general arrangement was unchanged, with a rise of the liquid going on. The southeast lake overflows were within 1 foot of the black ledge, and the west overflow pool within five feet of it. The ledge was still 20 feet high at the north and northwest. A torrent poured from southwest lake between the two southwest crags and kept the whole west pool alive. Bright lines in the north pool showed continued northwest streaming from the smoking tunnel between southeast and north pools. The southeast pool had built up its edge and overflowed east, south and west to the southwest pool. North and northeast wall valley remained unchanged. The north pool had spread northwestward into the craggy region. The surface circulation was southeast lake to north pool, north pool to southwest lake, southwest pool south through gap southwest and north the whole length of west side of floor. The west pool had a rampart bounding it at the north which was slightly overflowing toward the much lower north wall valley.

The southeast lake was fountaining in convulsions every four or five minutes, during which periods the fountaining patch over source well became a mass of bubble fountains and three or four dome fountains. The

crust broke concentrically out to the far side of pool, while the melt rushed centripetally to the fountaining. As the fountains diminished, they traveled to the southeast bank. The succession of fountaining convulsions and inflowings brought the overflows from the southeast lake to a stop. The inflowing to a fountaining center is certainly the same phenomenon as what takes the form of cascading into a funnel of subsidence in extreme times. The convergence of the streaming and the multiple fountaining is quite like the funnel action, and the concentric breaking and inflowing of crust blocks show a distinct slope of surface centripetal to the source well. Probably these convulsions brought to a close a spell of overflow when the pressure restrained gas and the gas expansion was relieved by the flooding. The reaction released gas fountaining with decreasing pressure, these released deeper gas down the well and the void left by the gas ejected caused the inrush from all sides. Action and reaction of this sort set up the rhythmic convulsions. "Old Faithful" fountains are another form of the same balance of gas in a well.

April 30. At 5 p. m. rapid flooding was in progress with entire floor of pit nearly level. Small bubble fountains and occasionally a large fountain were observed at each of the two source wells. The lava streamed slowly in all directions from southwest vent. There were five fountains in a row along west border of north end of southwest lake. Vigorous fountaining was continuous at northeast wall. Fountains of short duration played from time to time at one place or another all over the floor. Much blue fume escaped wherever there was fountaining. The black ledge of April 25th stood from 1-2 feet above the flood.

LAVA MEASUREMENTS

Measurements of depression of the mobile lava column, made with transit, referred to northeast station on rim of Halemaumau pit (3716 feet above sea-level), for the month ending April 30, 1923, including floors of bench magma and liquid level of large magma, were as follows:

| Date | Time | Southeast Lake | Southwest Lake | North Floor |
|-----------|-------------|----------------|----------------|-------------|
| March 27, | 10:00 a. m. | 353 feet | 369 feet | 389 feet |
| April 5, | 11:00 a. m. | 314 " | | |
| April 11, | 2:30 p. m. | 297 " | 304 " | 298 " |
| April 21, | 11:00 a. m. | 268 " | 268 " | 265 " |

Progressive changes for the southeast lake were as follows:

| | | | |
|-------------------|---------|--------------------|----------------------------|
| March 27-April 5, | 9 days, | lake rose 39 feet, | averaging per day 4.3 feet |
| April 5-11 | 6 " | " " 17 " | " " 2.8 " |
| April 11-21 | 10 " | " " 29 " | " " 2.9 " |

Changes for the southwest lake were:

| | | | |
|--------------------|----------|--------------------|----------------------------|
| March 27-April 11, | 15 days, | lake rose 65 feet, | averaging per day 4.3 feet |
| April 11-21 | 10 " | " " 36 " | " " 3.6 " |

Changes for the north floor were:

| | | | |
|--------------------|----------|---------------------|----------------------------|
| March 27-April 11, | 15 days, | floor rose 91 feet, | averaging per day 6.1 feet |
| April 11-21 | 10 " | " " 33 " | " " 3.3 " |

Monthly changes of bottommost part of pit floor from July 1922 were as follows:

| | | |
|-----------|----------------------|-----------|
| July | Lava inflow | + 70 feet |
| August | Slight slumping | " " |
| September | Lava inflow | + 100 " |
| October | Lava inflow | + 65 " |
| November | Inflow and uplift | + 73 " |
| December | Inflow and uplift | + 73 " |
| January | Sinking and recovery | + 31 " |
| February | Stationary | 0 " |
| March | Uplift and inflow | +125 " |
| April | Uplift and inflow | +143 " |

SEISMOMETRIC RECORD

During the month ending midnight April 30, 1923, sixty-four local earthquakes and one teleseism were registered at the Observatory. These and other earth movements are exhibited below. Distance of origin when indicated by the instrumental record is stated in English miles. Time is Hawaiian Standard of meridian 157° 30' W., 10 h. 30 m. slower than Greenwich.

Local Earthquakes.

| | | |
|--------------|-------------|---|
| April 1..... | 10:45 a. m. | Slight, NW-SE, distance 23 miles |
| | 1:54 p. m. | Very feeble. |
| | 9:51 p. m. | Slight, distance 3 miles, felt locally. |
| | 10:10 p. m. | Very feeble. |
| | 10:32 p. m. | Slight, distance 3 miles, felt locally. |
| | 11:13 p. m. | Very feeble. |
| | 11:25 p. m. | " " |
| | 11:52 p. m. | " " |
| 2..... | 12:05 a. m. | " " |
| | 2:56 a. m. | Slight, distance 3 miles. |
| | 3:04 a. m. | Very feeble. |
| | 5:17 a. m. | " " |
| | 7:17 a. m. | " " |
| | 7:27 a. m. | " " |
| | 7:47 a. m. | Feeble, distance 3 miles |
| | 7:52 a. m. | Very feeble. |
| | 9:29 a. m. | " " |
| | 9:41 a. m. | " " |
| | 9:48 a. m. | " " |
| 3..... | 6:18 p.m. | Feeble, distance 3 miles. |
| | 10:11 p. m. | Very feeble. |
| | 11:15 p. m. | " " |
| 4..... | 2:17 a. m. | " " |
| | 9:06 p. m. | " " |
| 5..... | 11:02 p. m. | " " |
| 6..... | 12:49 a. m. | " " |
| | 3:05 a. m. | " " |
| | 2:22 p. m. | " " |
| | 3:57 p. m. | " " |
| | 11:28 p. m. | " " |
| 7..... | 9:46 p. m. | " " |
| | 10:51 p. m. | " " |
| 8..... | 4:19 a. m. | " " |
| | 2:02 p. m. | " " |
| | 10:47 p. m. | " " |

| | | | |
|---------|-------------|--------------|---|
| 9..... | 3:27 a. m. | Very feeble. | |
| | 9:28 a. m. | " | " |
| 10..... | 3:10 p. m. | " | " |
| 11..... | 12:03 a. m. | " | " |
| | 6:10 a. m. | " | " |
| 12..... | 4:11 a. m. | " | " |
| | 7:19 a. m. | " | " |
| | 9:30 p. m. | " | " |
| 13..... | 4:31 a. m. | " | " |
| | 4:41 p. m. | " | " |
| | 10:49 p. m. | " | " |
| 14..... | 11:39 a. m. | " | " |
| | 8:36 p. m. | " | " |
| 15..... | 8:34 a. m. | " | " |
| | 2:08 p. m. | " | " |
| | 3:03 p. m. | " | " |
| | 7:51 p. m. | " | " |
| 16..... | 10:22 p. m. | " | " |
| | 11:52 p. m. | " | " |
| 19..... | 12:51 a. m. | " | " |
| | 7:11 a. m. | " | " |
| 20..... | 11:57 p. m. | " | " |
| 22..... | 8:24 a. m. | " | " |
| | 1:54 p. m. | " | " |
| 24..... | 10:02 p. m. | " | " |
| 27..... | 9:02 a. m. | " | " |
| | 11:14 a. m. | " | " |
| 28..... | 8:45 p. m. | " | " |
| 30..... | 10:37 a. m. | " | " |
| | 11:07 p. m. | " | " |

Teleseism.

April 13.....5:17 a. m. Moderate, produced tidal wave Hilo 12:40 p. m.

Spasmodic Microtremor.

This type of tremor was slight throughout the month.

Harmonic Microtremor.

This type of tremor was slight throughout the month, occurring in spells several times a day.

Microseismic Motion.

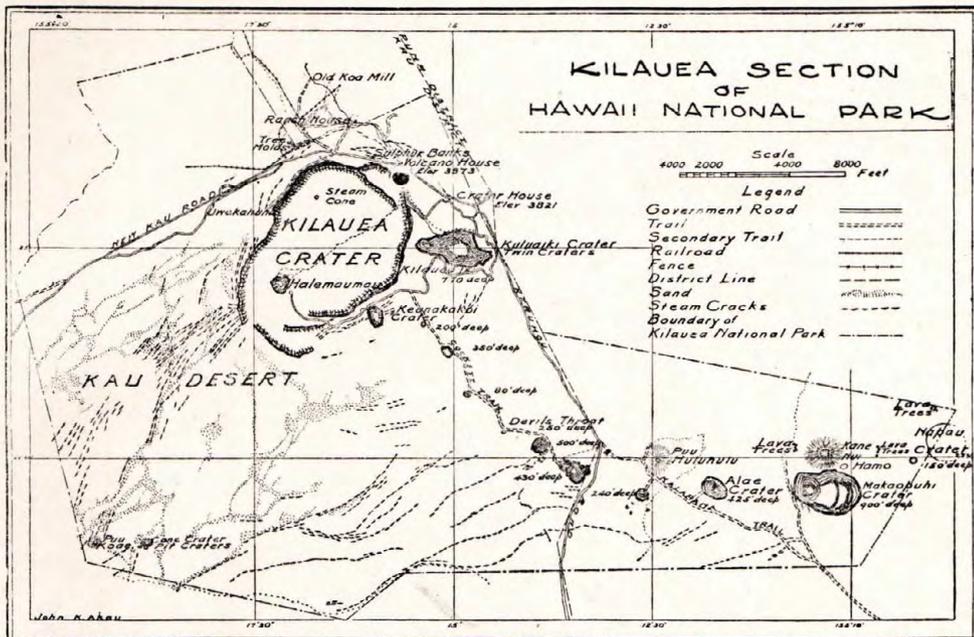
The amplitude of microseisms was moderate on the 25th and slight for the rest of the month.

Tilting of the Ground.

By weeks this movement was as follows, expressed as angular change and direction of motion of the plumb line:

| | | | |
|-------|------------|-------------|------|
| April | 1- 7..... | 3.2 seconds | SW. |
| | 8-14..... | 1.9 | NE. |
| | 15-21..... | 1.5 | SW. |
| | 22-28..... | 2.1 | SSE. |

T. A. JAGGAR,
Volcanologist.



Black spot shows location of Observatory.

All exchanges should be addressed to

HAWAIIAN VOLCANO OBSERVATORY,

Volcano House P. O., Hawaii.

The Observatory is equipped with the following seismometric instruments rebuilt at the station in 1918 for the special needs of volcano research: two Bosch-Omori pendulums, high-speed registration of local earthquakes; one optically recording seismograph for distant earthquakes; one clinograph registering E-W tilting of the ground. A vertical component seismograph was in December, 1918, set up in experimental operation. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by wireless signal from the Pearl Harbor Naval Station. The chronometer is loaned by the University of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time. Observatory Lat. 19° 25' 54.2" N.; Long. 155° 15' 39.2" W.; Elevation 1214.6 meters (3985 feet).

HAWAII NATIONAL PARK.

This park was created by act of Congress August 1, 1916, and includes three famous volcanoes—Kilauea and Mauna Loa on Hawaii and Haleakala on Maui. Frequent passenger steamers ply between these islands and Honolulu.

Haleakala Section—Haleakala, "house built by the sun," a peak more than 10,000 feet high, carries an immense fissure-like crater 8 miles long and 3 miles wide, with walls 2000 feet high. Here, as well as on Mauna Loa and Mauna Kea, grows the Silver Sword (*Argyroxiphium*). Thirteen volcanic cones lie within the crater, some rising nearly to the height of the summit. The scene at sunrise is marvellously beautiful.

Wailuku is the point of departure, automobiles taking the traveler to Olinda, a summer residence settlement 4043 feet high. After 2 hours drive to this point, saddle horses are taken to the summit, a ride of 3½ hours. Here is a fine concrete rest house, built by the citizens of Maui, and fully equipped with iron beds, blankets, stoves and cooking utensils.

Mauna Loa Section—Mauna Loa, a vast dome 13,675 feet high, reached through forests of Hawaiian mahogany (koa) and tree fern, then up bril-

liantly colored lava slopes, has a summit crater 3 miles long by 1½ miles wide, with walls 700 feet high, and when in action fountains of fire froth are here jettied 500 feet into the air. Every five or ten years splendid spectacles of lava eruption are staged on the mountain, sometimes from the lower flanks.

There are trails on the Kona side, and also from the southwest, but the usual and best route is with saddle mules from the Kilauea section to Puu Ula-ula (9800 feet), a ride of six hours. Here there is a fully equipped cottage with stables and water supply. From this point on the second day a four-hour ride takes the visitor to the summit crater, where there is water. A right of way within the park connects Kilauea with Mauna Loa, where eventually a road will be constructed. The views are glorious and the chasms, cones and contorted lavas indescribably chaotic.

Kilauea Section—The lakes of foaming fiery lava within the crater of Kilauea form the most spectacular exhibit in the Hawaii National Park, if not in the world. The pit of fire, Halemauouma, is inside of the main crater, at the apex of a broad, flat, inner cone. Kilauea is a dome volcano 4000 feet high, overriden by the lava slopes of Mauna Loa on the west so that it seems but a spur of the greater, and perhaps younger, slag-heap mountain.

The Kilauea Park and the inner pit itself are both reached directly by automobile from Hilo, the second city of the Territory of Hawaii, and there are excellent hotel accommodations. The distance from Hilo is 30 miles. Within the park there are 15 miles of roads and about 20 miles of trails. As shown on the map, there are a dozen ancient pits within the area of the park, as well as cones, caverns and hot solfataras and a strange desert where lava flows have poured out of cracks as recently as 1920.

The live pit of Halemauouma is easily accessible and not dangerous. Frequently one can walk to the actual edge of the splashing, fountaining lava lakes, the lava column rising and falling from year to year so that its most distinctive character is ceaseless change. At night the spectacle is full of marvelous color, and the region is a paradise for artists, photographers and naturalists.

The several sections are under the control of the National Park Service of the Department of the Interior. The United States Weather Bureau maintains the Hawaiian Volcano Observatory, which stands on the brink of the greater crater within the Kilauea Park.

U. S. DEPARTMENT OF AGRICULTURE
Weather Bureau
CHARLES F. MARVIN, Chief
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GENERAL MAP, KILAUEA SECTION, HAWAII NATIONAL PARK

VOLCANIC CONDITIONS IN MAY

Activity of Halemaumau.

At the beginning of May the great field of lava in the bottom of the Kilauea fire-pit was increasingly growing in size and height by means of spectacular floods that rose through the two main source wells. There were big gushings of this kind April 25, April 30 and May 5. They were increasing in volume and the highest fill of May 5 was only 200 feet below rim of pit.

During these floods the whole vast cauldron became one sheet of liquid 1600 feet across, drowning all the crags and lake shores. The fountains at such times increased in number until from twenty-five to thirty separate outbursts might be counted in action at one time. The heat on rim of pit was insupportable without a shield for the face.

After each flood which lasted for a day or so, there was a settling back of the liquid fifteen or twenty feet, leaving a black ledge all around and exhibiting again the drowned landscape of lake shores, five craggy islands and cracked irregular high ground between the lakes. A flowing river developed, taking its rise in a lake over the southwest source well, and

following the edge of the floor in a semi-circular course to a stagnant pool at the opposite side of the pit.

This river was always in motion during the first week in May, the source standing high and the receiving pool always low, as though the latter were a sink-hole which never filled. There appeared to be an endless rotary circulation. At times there were spectacular cascades from one pool to another as the lake cups chanced to be more or less lifted, each with reference to its neighbor.

By the middle of May the floods of glowing lava in the bottom of Halemauau increased in spectacular quality and in the frequency of their gushing. Every few days there had been sudden wellings up of the liquid lava through one or other of the two source wells, the pit became brilliant and noisy with numerous fountaining patches and then the visitor would have before him a sea of boiling lava intolerably hot, making suffocating fumes and fed from beneath the lake through a well whence bright lines radiated in all directions. The two known wells under the lake alternated in supplying these risings.

After the first week of the month the intervals between these brilliant displays became shorter than before. The greatest performance, on May 12, rivalled in brilliancy and awe-inspiring beauty the display of March 1921. Thereafter the floods remained high, the center of dispersion changed from the eastern to the western source well and a new southwestern well made its appearance near the wall of the pit.

On May 12 the higher eastern lake became an overflowing slagheap, with five tremendous cascades radiating from it, craggy spurs dividing one of the falls, and sometimes breaking away and rolling, as incandescent boulders, into the deep pool below. In that western lake, whirlpools were to be seen. This flood filled all the hollows and drowned the heap at its source so that by the next morning the cascades had disappeared. The great fiery lake had not been so enormous since 1894.

The activity of the third week recalled to mind for oldtimers the wonderful displays of December 1911, when the pit contained one continuous lake from wall to wall. The separate lakes had now completely disappeared through the drowning of their shorelines and a general merging into one. One island remained and even that was sometimes covered.

Until May 20 the liquid lava was rising five feet per day and its surface reached a level only 148 feet below the rim where visitors stand. Since the previous July the lava had risen over 700 feet.

The pulsations of rising and falling every few days had given place to such fluctuations every hour or so. There was now one obvious source well bubbling, on the southeast side, and surface streamings radiated from that upwelling, intensely hot, and making a golden pattern of indescribable brilliancy and beauty. Skins would form and tear and reform along zigzag lines of fire, and the blistering gasses would bulge them up, burst forth in flame and end in a tail of pale blue smoke. Lines of big fountains migrated to the walls, expending themselves in spatter and engulfment. These fountains changed their locations and number; during a rising spell the only bubbling might be at the source well; during subsidence however more than forty puffing tumultuous jets of melt were sometimes counted.

After May 20 the lake lowered ten feet leaving at its edge rounded lumpy ledges of dark glassy lava covered with black spatter, and against the island a continuous fountain was building a grotto. At its highest the

lake was 1700 feet long and over 1400 feet wide. All the debris slopes were submerged except at the southwest rift chasm and below the neighboring pinnacles where a small remnant of talus remained to recall the avalanching of May 1922. The fountains were sending up milky blue fume which was hot and suffocating on the leeward side of the pit.

At the end of May the liquid lava was holding its own as a lake showing liquid surface from wall to wall. It had lowered about fifteen feet and recovered half as much leaving the black ledge about seven feet high around the margin. The island protruded through the liquid southwest, standing from one to four feet high on different days. The southeast source well kept up a hot gassy bubbling, and the melt went streaming away from this center dragging out the skins that buckled, blistered and wrinkled. There were always thirty or forty bubblings in action over the well and heat was intense on the rim above, near the road terminus.

On the opposite side of the pit large fountains broke forth irregularly in lines or patches or expended themselves against the walls of the pit. They sent up spray and built lumpy spatter benches. They were occasioned by the gas confined under the skin of the lake, this gas being held in the melt until it rent the crust by its accumulated pressure and so by its release created a place of less pressure where more gas escaped from solution.

The number of large fountains counted at different times varied from three to fifteen, and the illumination over the pit at night was greatest when the fountains were numerous. The colors on the fume clouds varied from greenish yellow to rose.

Under the fountain bombardment the island changed its shape, and the direction of streaming from the source well also changed on different days. A small avalanche fell at the southwest chasm about May 25.

JOURNAL, MAY, 1923

May 1. At 10 a. m. the liquid lava extended from wall to wall with a slight black ledge all around just above the lava level. The higher southwest crag was just beginning to show as a flat island. There were eleven groups of fountains with the majority in the northwest part of pit. The fountains of southwest and southeast wells were notably inconspicuous. The west talus was almost completely covered by the black ledge of this rise. The outline of the west bench below reappeared rapidly as the liquid subsided. This subsidence was rapid during the morning so that by noon the black ledge and southwest crag were 10 feet high and lake outlines appeared. There was continuous bubble fountaining at southeast well, east side of north pool and in northwest region. The southwest well developed feeble fountaining. The banks around margins caved in and revealed cavernous chasms and red hot aa in a few places. The whole performance repeated the happenings of April 1st and 25th, but the interval between such spurts seems to be decreasing, and the volume of inflow increasing. The fume over the pit was excessively thin, but the noxious sulphur gas was stronger than before owing to the increased fountaining. Twenty-four fountains were counted at one time and the whole appearance of pit was like the end of December 1911. The heat was felt very strongly on the rim. The fume at southwest chasm was very slight.

May 2. At 10 a. m. the general conditions were the same as on May 1, but recovering. The black ledge was 15 feet high southwest and 5 feet high northeast. This means that the rising was dominantly southwest and it

was probably true that the April 25 black ledge persisted on the topmost edge northeast and southeast. At the southwest and west the new ledge certainly overtopped the April 25 ledge.

The inner landscape showed the three crags of the southwest and north pools fountaining equal at southeast and southwest wells, big craggy benches along base of wall southeast, a crag near northwest wall, and wall valleys streams from southwest and southeast sources that met at north side of pit. The southwest pool was slightly higher than the southeast. Cracking and foundering of crust was general. The north flats stood slightly above the pools. The crags and cracked ground that before lay north and northwest of north pool were entirely submerged by the general burial of the recent rise. The new northwest crag near wall of pit was entirely different, corresponding to the border flats of the previous floor.

It looked as though steady filling equally from both wells was being resumed. There was considerable cracking and foundering.

May 3. At 10 a. m. the general situation was the same. A small spouting cone west of north pool had appeared.

A new feature was the relative heights of black ledges. The southwest ledge was losing in height and northeast ledge was now highest, whereas yesterday the southwest ledge was the highest. It was apparent that the two lake cups were building up, the southwest one probably the more. Their overflows were drowning the base of black ledge. The southwest ledge was 8 feet high. On the other hand the wall crack pool northeast was filling, yet its surface was lower, i. e. its bottom was lowering faster than it filled. The isostatic adjustment appeared to be in full swing, the source wells rising and the weighted cooling regions sinking. The northeast ledge was 20 feet high. Another change was the stream northeast from southeast lake, which was a steep bubbling cascade, instead of a broad river. The stream from southwest lake was much as before, its ultimate destination being the northeast wall pool where it produced cracking and foundering. This process was frequent everywhere. There was some tendency for the flooding to drown the west and southeast shelves. The elevation of southeast and southwest lakes was much the same.

May 4. At 10 a. m. there were four fountaining areas, namely, southeast and northwest sides of southeast lake, at southwest well, and at northwest shelf. There was a little blue smoke from crags and shore lines. There was a new crag heap, oval and slabby, between southeast and southwest lakes. There were four crag heaps at the southwest and two at center between north and southwest pools. The large center crag was much bigger and showed a northwesterly tilt. A spurting cone was located between west river and north pool. The west river was a broad festooned stream that terminated in the northeast shore of pool. The stream from the southeast lake to this pool was crusted over. There was much cracking and foundering in the northeast pool.

The lakes were bright the evening of the 3rd and the floors showed flooding had covered the shelves and the sides of the crags. The shelves stood in about the same relief as the central floor. The flooding had built up the southwest region, but the crags were in greater relief than ever. The lake shore lines were low slabby ramparts. There were migratory fountains along northwest shore of southeast lake, and short overflows of lake banks. The southeast and southwest lakes were of the same height. The black ledge seemed lowest along southwestern taluses and highest northeast. A high bank was developing north of north pool. Much the biggest live feature was the great western river flowing from the southwest

lake in an arc greater than a semi-circle around to the crusted northeast wall pool, but never filling it. Apparently the southwest cup and crags were lifting most and extravasating most liquid. The central floor was lifting, the southeast lake was holding its own, but was slightly lower than southwest region, and the northeast pool had gained on it. The flood to the northeast however kept 20 feet below the highest marks of the northeast black ledge, as though there were steady compensation between southwest vent and northeast destination, whereby the former lifted and the latter sank. It looked as though the southeast lake was getting to be a sink hole pool. The fountaining there was of the multiple bubble type with in-sucking action, and two border fountains along west and north banks of lake. The fountaining over southwest well was steadier with three or four large dome fountains in a non-streaming puddle. The difference was marked. If the southeast lake was a sink hole then a stationery convection was accomplished. The northwest shelf fountaining was sporadic, there being four fountains at 10 a. m., and none at 11:30. Noises were caused by the puffing and splashing of the fountains and the steady crunching of skin on the great river. The great river recalled the 1919 flow in Kilauea crater, but the motion and incandescence of this river were more continuous.

May 5. At 9 a. m. there were seven fountaining patches. The banks of north and southwest pools and of river at west and north had all become higher relative to liquid, whereas the southeast pool remained up to rampart and overflowed a little east and south. There were dome fountains at southeast and southwest wells. The highest points on the floor were probably the two larger crag islands. The new spouting vent west of north pool had become a small well fountain with a stream from it to north pool. The banks around the western lake and river system—really all one lake with four islands—was higher at pit center and lowered to south and west edges of the liquid. The central crag island and north lake shores were 2-10 feet high, whereas the three south crags had platforms 3 feet high, and the edge of pool and river south and west was 1 foot high. There was a definite edge of differential movement between liquid and bank, whereas at southeast lake the border was a slab rampart and the cup proper practically brimming. There was cracking and foundering with bubble fountaining in many places. There was puffing from the well fountains and crunching noises from the western river. There was a large smoke patch on the north floor. This goes hand in hand with the movement of bench magma uplift. Relative height of black ledge to floor appeared the same as on the 4th, but the central bench magma was probably higher. Fresh festooned dribble flows around pool margin east of southeast lake, south and west of western lake system, prove centrifugal slope. Small fountaining groups developed here and there, sometimes at banks but did not build spatter grottoes. Throughout this period this contrasted with 1917.

There was rising and sinking in the western lake. The lava was ordinary pahoehoe of dull luster and the river was covered with skins, pulling apart along bright lines forming polyhedra, this changing gradually along northeast to stagnant crust. The lakes were crusted and now and then cracked up. The floors were flat with slabby pressure ridges and frozen festoons. The general appearance recalled December 1918 without the grottoes.

At 5 p. m. the floor of Halemaumau was one smooth flood. The only break was the even top of the higher southwest crag. It had just emerged from the flood. All the older black ledge was submerged except a few sections on northeast wall. There were no signs of the lake or stream margins. Sometimes there were more than twenty fountaining patches in the pit with dome fountains at southeast and southwest source wells. The streaming of

the western river could be detected and it ended in a surf-like splash against the northeast wall. The subsidence that revealed the top of south west crag continued slowly and revealed a large flat island northwest of it and two small ones in the center of the pit. Sometimes the southeast source well would completely crust over and be followed by great domes of red lava that broke through the crust. By 7 p. m. the only streaming was that of two opposing currents which met at the location of central lake and formed a line of fountains 30 or 40 feet long. At 10 p. m. the subsidence had continued so that the west lakes had 2 foot banks, and the crags were 8 to 10 feet high. There was inward streaming to the southwest well where there was a single fountain. A stream from the southeast lake poured across the flat and cascaded into the southwest lake. The cascade was 2 feet high and 8 feet long. Twenty-two fountains were counted and some flame observed. Border fountains in the southeast lake were building spatter niches. Glow could be seen in the black ledge.

May 6. There was a new black ledge 10-15 feet high. Some red hot aa caved in from the north ledge. The central crag had migrated 15-20 feet to the north. There was new crevassed ground north of north pool. There was a northwest fountaining well in a canal that connected north pool to west river. The southeast pool was still cascading into southwest pool with a 4 foot drop, each of two cascades being 10-15 feet wide. The southeast pool was bank full and overflowing to the south. The other pools were depressed within their banks 2-4 feet. The same general outline prevailed as on the morning of the 5th. There was a new small crag island in the northeast wall pool. The west river had a bright line at liquid origin and a smooth crusted course. Fountains were playing over the southeast and southwest source wells as usual and a second group in the southeast pool. Some fume arose from the floors.

May 7. During the afternoon and evening another strong rise was reported that drowned the crags, and was accompanied by many fountains.

May 8. At 9 p. m. the lava lakes were dull. Fountains played at the southeast and southwest wells. Hissing flames issued from cracks in crust of southeast lake. There were also flaming spots along western black ledge and at northwest canal vent. The south crag was high and the banks of lake were 3 or 4 feet high in places. The black ledge was 10 feet high at the west and 20 feet high at the north. The western river was as usual.

During a cracking of crust near the southeast fountain group, the fountains showed a yellow flame with puffs of smoke that persisted for a few minutes. There was no apparent possibility of wood fragments. The flames were of the spume variety.

May 9. At 9 A. M. there were about fourteen fountains mostly confined to the southeast and southwest sources. The north banks of north and southeast pools were 6 feet high and the south crag was about 20 feet high. The black ledge was a sloping bank at the southeast, a steeper bank southwest and a 6 foot ledge at the north and northeast. The central crag was only a small slabby patch about 1 foot above liquid with another small patch north of it. Blue smoke issued from the north pool region. There was much cracking and foundering. There was no crag in the northeast wall pool. The broad river west, north and northeast was as usual. The flats west of north pool were 4 feet high. The southeast pool was overflowing at its south end, while it was depressed within its banks 2-3 feet at the north. Rising was in progress.

At 9 A. M. the rise continued with a welling up at southwest source. There were 22 or 23 individual fountains. The fountains were like December 1910, December 1911, and July 1912. There was some glow from the black ledge as though subsidence was in progress. The southeast source was very quiet with only occasional small fountains, and the southeast lake was crusted. During an intense upwelling at the southwest source the action was accomplished by zigzag radial bright lines and centrifugal streaming that formed a marvelous pattern. Swarms of bubble fountains waxed and waned at the center. The top of the south crag, west talus, and the border ledge were gradually submerged. Readjustments of the debris and puffs of blue smoke were seen at the southwest chasm. The scorching hot cracks back of southwest rim were heard cracking and snapping and there were many deep rumbles and small earth tremors. No noises were noticed elsewhere on rim of pit. Violent explosive fountains broke out at the east, northeast, northwest, and southwest and tended to form lines of conflicting inrush of skins and travel fountains radial to the center. Each explosive group gave off clouds of dark fume, made noisy rumblings, and shot spray 40-50 feet into the air. The western river nearly went out of action and the turbulent fountaining replaced the eastern wall bombardment. Two places that seemed to be notable centers of explosive fountaining were the southeast lake and northwest side of pit. The northwest side formed most striking linear fountaining radial to the center of upwelling. This fountaining sent up notable clouds of greenish, reddish, and occasionally brownish fumes. A veil of fume 1000 feet or more high over the pit was capped by a small cumulus cloud the border of which was adorned by pendant streamers.

The seismographs showed some very small earthquakes, and the harmonic tremor was notably weak considering the violence of the fountaining. There was strong southwest tilt.

May 10. At 11 A.M. the lave was down, the lakes and banks restored, and the western river as before except for the source, which was a standing fountain near the southwest wall. The southwest well had ordinary bubble fountains and slight outward streaming. The maximum fountaining was in the northeast wall pool where the river flowed vigorously. The black ledge at the west and the southwest chasm left by the high level was about 40 feet above river; elsewhere the black ledge was about 30 feet high. The bench between southeast lake and wall as well as west bench showed down faulted glowing aa steps, veneered over with pahoehoe. South crag was about 15 feet high. Five other slabby crags were located around central lake and in west river. There was no trace of the central crag. The southwest and north central pools formed one central lake. Forty-three small fountains were counted. The glow pattern near the southwest gusher was similar to the one of the evening of the 9th. There was a small lava spring in the extreme southwest that caused crusted streaming from north to southwest gusher. There were black spatter marks along the northeast wall above the black ledge. There was a little blue fume from the aa banks and southwest chasm. The pit was dull at night.

May 11. During the midday there were about ten fountains and the pit showed the same general features as on the 10th. Both the southwest wells were fountaining mildly, the new one not so steadily as on the 10th. Spatter niches were forming around the north and west edges of southeast lake. This appeared to indicate a stationery lake. The main supply of the western river was from the new southwest well which was also the source of rapid streaming to the central lake. There was some fume, most of which rose from the southwest chasm.

There was a new fall of rock at the west buttress. As there was no crag west of the south crag and a crag in the western river, it looked as though the western river crag had drifted northward like a shifting mud flat. A crag had reappeared in the central lake.

May 12. At 9 A. M. the southwest lake had 4 foot banks and there were no banks around southeast lake. There were fifteen fountains in action, and the general conditions and level were the same as on May 11. There were three islands in the west river, two being formed, perhaps, by the fresh current from the southwest well carrying blocks and sediment out as clots of accumulation. The old western island was higher and tipped northward and separated central lake from western river. The two new islands were north of the old one. The open spatter niches of the southeast lake had become small curtained grottoes. There was some cracking and foundering.

During the evening it became evident from the brightness of the pit that a change had occurred. Alex. Lancaster reported the southeast lake overflowing and making a cascade at 3 P. M. This overflow probably began about noon..

A roar could be heard on approaching the rim. The southeast lake was overflowing its heap in five principle cascades, two to northeast wall pool and three to central lake. The difference of level of southeast lake and the other pools was 20-25 feet. The biggest cascade was to the south end of central lake, and made a rotary current around south crag. (See illustrations). The southwest well fountains were almost imperceptible and the northwest canal fountain was spitting. The new southwest source was not in evidence. The western river was quietly moving along west and north wall to the north and east. The black ledge was 30-40 feet high except opposite the southeast lake where it was only 6-10 feet high.

The great feature was the southeast lake with its upwelling source and big cascades. There were about fifty bubble fountains over the source. The big western cascade was 100 feet wide with crags protruding through it. One of these crags was seen to split, break off, showing incandescent interior, and roll into the lake below. The south crag appeared 20 feet high and the banks of central lake 10 or more feet high. The other cascades were rivers with curving golden courses above and steep chutes below. Around the southeast pool there was a banked flood, not cascading, which during three hours migrated out over the north floor, and was continuously piled up and crusted against southeast wall of pit. There were many small flames where the skins burst. During three hours there was no certain appearance of filling up except the spread of the southeast lake pudding or puddle.

This display rivaled in beauty that of March 1921.

May 13. At 9 a. m. the lake filled the whole pit and was higher than the former black ledge. The flood radiated from the southeast well where there were bubble fountains. There were no crags or banks and no visible fume, but much SO₂. There were no outlying fountains, and a steady roar of crusts.

During the evening there were fifteen fountaining patches. The southwest well fountains were hardly recognizable and there was upwelling at southeast well with small bubbling. The main streams from the source went north and west. For a while there were big fountains in a northwest line. Many fountains played along the north wall. The new southwest well could not be seen. The black ledge was 5 feet high at first and later on was practically submerged, though the flat beaches of bench magma south-



Fig. 7. May 12, 1923. From south rim of pit looking down on western cascade.

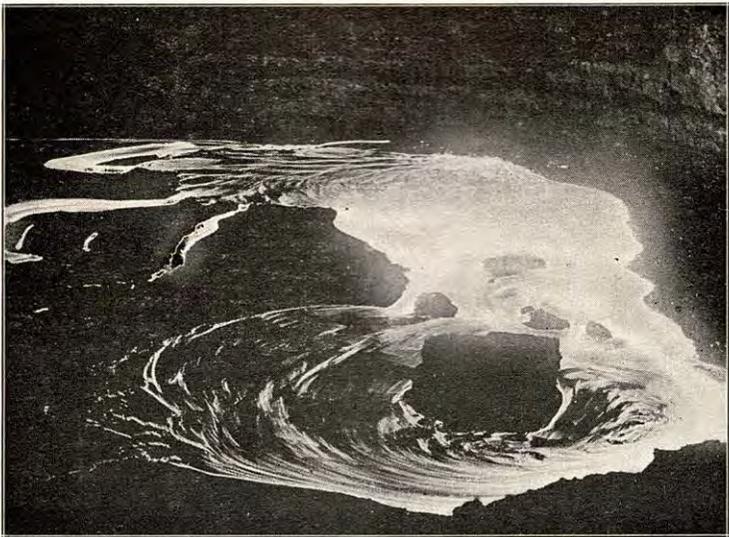


Fig. 8. May 12, 1923. From southwest rim showing southeast pool and cascades. Photos. Jaggar.

east, northwest and southwest remained. After a time all fountaining except at the source stopped. Still crust marked the south crag locality.

The lake was the largest it had been since 1894. There were no signs of subsidence. The streaming pattern recalled the cascades to the north and west of the evening of the 12th.

May 14. During the morning the lake was high and 3 feet below the highest black ledge which was of the same height as May 10th. The source had changed to southwest pool and new southwest wall vent, from which there was northward streaming. The southeast source was almost unmarked save for some little bubble fountains. The flats southeast, northwest and southwest were 2 feet above lake and the south crags 1 foot above lake. The fountaining was mild at southwest pool, and there were two or three strong fountains at new southwest vent. The heat was intense and there was only thin blue fume.

May 15. In the forenoon there were three islands and the southwest was the source with but little change from the 14th. During the evening there was some subsidence and the pit was very bright with more than forty fountains.

May 16. During the afternoon the heat was intense and pale blue transparent fume was being emitted. There were from one to six large fountains in the west region and many bubble fountains near the southeast well which was the source of strong rising. The liquid was flush with the last black ledge and slightly above it at places. The streaming from the southeast was very rapid and in a wide sector. The south crag summit was an island of piled skins and there was some stagnant piled crusts in the north central region. The biggest streaming was to the southwest, west and north from the southeast source. The western fountaining patches were tumultuous and changing. A curve of wrinkled skin that bounded the southeast fountaining area probably indicated a shelf nearly at lake level. The bubble fountaining at the source wells was of the "swan" quality like the February 1921 migratory fountains.

During all this time of heat and gas the high cumulus over the crater only appeared in the evening and not invariably then. When there are considerable clouds in the sky, however, they are nearly always accented by a large cumulus over the pit.

May 17. During the forenoon the pit appeared much the same as on the 16th, except that there was less fountaining. During one fifteen minute interval there were no fountains. At other times there were four. The streaming was radial from the southeast.

May 18. The pool was higher at 9 a. m. and the few remnants of the black ledge were submerged. The liquid was against the walls, except for shelves at lake level, southwest, northwest, northeast and southeast. There was inward streaming toward the bubble fountain patch at the southeast. The southwest vents were not marked by fountains. There were three or four large, sometimes migratory and linear, fountaining patches toward the west. The streaming was irregular. A steady grating of crusts caused by the piling up of slab ramparts on all sides was heard. Smoke was emitted when the fountains bombarded the banks. The slab heaps, like the northwest niche ramparts of 1894 were piled on the black ledge. The largest of the three islands with slabs of crust was the south crag which had spatter heaps on its west side. One of the other two islands was near the southwest source locality, and the third in the north floor.

May 19. The recent border bombardment of fountains had made high spatter zones above the black ledge in places. At 4 p. m. this was very marked on the west side of the pit opposite the southeast source well which was functioning as a center of rising and dispersion. The liquid lava was higher than before, and the border shelves and islands were submerged. The bubbling source area was notably extended and there was much blistering of the skin. There were three or four fountaining patches at the west which migrated and bombarded the wall. There was abundant fume over the puffing fountain and the pit was very bright at night.

Northeast tilt was in progress and the harmonic tremor was increasing.

May 20. The lava was higher and against the wall inside of southwest chasm back of the pinnacles. At 11 a. m. there were ten to fourteen fountaining patches, besides the bubbling at southeast source. Coincidental with the fountaining the pool sank to three feet below ledge, and the south island emerged. The fountains were of the blowing and traveling type. The southwest source wells were not marked by fountaining. The heat was intense. In the course of 30 minutes the number of the fountaining patches decreased and the lava simultaneously rose for some time; the only large fountaining continuing was the bombardment of the west wall.

The fume notably increased about 4 p. m. probably indicating another subsidence spell. At 10 p. m. the number of fountains suddenly increased, twenty-nine being counted. The pit was very bright.

May 21. At 10 a. m. the lava was down 10 feet, with reference to the black ledge. There were increased spatter marks on the walls, 30 feet over the black ledge, notably at the north. The south island was 8 feet high. Upwelling continued at the southeast source. A line of fountains in the southwest radial to center has a general trend in their migrations toward the southwest chasm. The streaming was outward from the bubble fountains of the southeast. The number of fountains varied from five to ten and the changeable currents increased with sinking and decreased with rising. This meant short term rising and falling spells of an hour or less. The fountains developed against the north wall. There were rounded spatter ledges along upper course of black ledge in layers at two or three levels. There was considerable bluish fume over the border fountains and thinner fume over the central fountains. To the leeward of the pit fume was acrid.

May 22. The pool was a little lower—12-15 feet below top of black ledge. At 4 p. m. the lava was upwelling at southeast vent. The line of radial fountains at the southwest was much the same as on the 21st. Fountains were bombarding the wall at northwest and north. Occasionally a central fountain migrated to the northwest wall, and another bombarded the south island which was about 10 feet high. The pit was less bright at night.

May 23. During the evening the lake was a little higher—black ledge about 6 feet high. The line of fountains southwest had ceased. There were three big bombardment patches along the northwest and north walls with grottoes, stalacites and flame banners. The spray was thrown 50 feet high. An occasional small dome fountain played at the southwest well. The island was 3 or 4 feet high. When the fountains decreased the lava rose steadily. Flames were observed at cracks in the crust and the fumes were very active.

May 24. At 9 a. m. the lava was slightly lower, the black ledge being 10 feet high and the flat slabby south island 3 feet high. There were five

fountaining patches, three of which were against the wall and a line of travel fountain moving to west wall.

May 25. At 9 a. m. there was a notable change at the southeast source. The streaming was straight out from the east bank with about thirty bubble fountains over the well in the track of the stream. The southwest line of fountains was again in evidence. The south island was bigger and about 5 feet high. The black ledge was 15-18 feet high. A large central fountain and a small border fountain developed in the western part of the pit. The crusts migrated to the north and west banks of lake, but pulled out from the south and east banks. The heat was less intense than before. There was a bright line around the margin due to subsidence. Big, rounded, overhanging spatter ledges marked the west, north and northeast. A steamy vapor different from that from the fountains rose from cracks in the black ledge in the southeast.

A very slow subsidence seemed to be in progress. There were no longer any marked border shelves of the black ledge, though in places thick spatter banks stood out 10-15 feet from the wall. Marginal grotto fountaining began at the northeast, north and west about 9:40 a. m. A change in the crust block action to bright line streaming by slow engulfment of the wide blocks was noticed. Query? Is not the bright line streaming always a current slowly making and engulfing slabs? These surfaces show bright line on down-stream side and overlap upstream. At 10 a. m. there were fifteen fountaining patches. The pit was bright during the evening of the 25th with a greenish yellow light.

May 26. The pit was very much the same. At 9 a. m. there were six fountains in the southwest and two against the west wall. Large bubble fountains marked the southeast. Wrinkled skins north of center indicated movements there. The south island had broken down on its western side where a fountaining grotto was in action, and the longer axis was north-south. Broken rock on the new lava in the southwest chasm marked an avalanche from the west fault bench. The lava was about 15 feet below the highest level of the black ledge. The pit was bright at night.

May 27. At 9 a. m. the conditions were much the same as on the 26th, and only two fountains were in action. The lava was only 8 feet below the black ledge and the south island was but 1 foot high. From the southeast bubbling source a stream poured to the northeast. Evidently the streaming changes greatly. There had been no intervening high level over the black ledge since the 26th.

May 28. At 9 a. m. the general conditions were much the same as on the 27th with nine fountains in action. There was a line of fountains from the southwest well westward. The island was a little higher, about 3 feet above the lake, and the black ledge 10 feet high. There was northward streaming from the southeast bubble fountain area. The pit was very bright at night.

May 30. At 11 a. m. there was rapid streaming outward from the south wall and five border fountaining patches along the northwest wall. The southwest line of fountains was again in action, and small bubble fountains at the southeast source. Over the rest of the lake there were small bubble fountains. The south island appeared to be 4 or 5 feet above the liquid and the lake was about the same distance below overflow platform in southwest chasm.

May 31. At 5 p. m. the pit was a little lower than on the 30th. The south island and black ledge appeared to be 5 or 6 feet above the liquid. There were three border fountains along the west wall and no center fountaining. The streaming to the northeast from the south wall was conspicuous.

LAVA MEASUREMENTS

Measurements of depression of the mobile lava column, made with transit, referred to northeast station on rim of Halemaumau pit (3716 feet above sea-level), for the month ending May 31, 1923, including floors of bench magma and liquid level of lake magma, were as follows:

| Date | Time | Southeast lake | Southwest lake | South crag | Black ledge (mean) |
|-----------|-------------|----------------------|----------------|------------------|--------------------|
| April 21, | 11:00 a. m. | 268 feet | 268 feet | ..... | 265 ft. (N. floor) |
| May 1, | 10:00 a. m. | 234 " | 233 " | 222 ft. | 217 " |
| May 9, | 10:00 a. m. | 206 " | 208 " | 185 " | 206 " |
| May 10, | 10:00 a. m. | 211 " | 210 " | 194 " | 173 " |
| May 14, | 10:00 a. m. | ..... | 184 " | ..... | 178 " |
| May 18, | 10:00 a. m. | 164 feet (mean lake) | | 156 ft. (island) | |
| May 20, | ..... | 148 " | " " | ..... | ..... |

A comparison of the floor of April 21 and the high level of the night preceding May 1 shows a rise in ten days of 48 feet averaging 4.8 feet per day.

The progressive measured changes were as follows:

| | | | |
|-----------------|----------|-----------------------------------|---------------------------|
| April 21-May 1, | 10 days, | southeast lake rose 34 ft., | averaging per day 3.4 ft. |
| | | southwest " " 35 " | " " " 3.5 " |
| May 1-9, | 8 days, | southeast " " 28 " | " " " 3.5 " |
| | | southwest " " 25 " | " " " 3.1 " |
| | | south crag " 37 " | " " " 4.6 " |
| | | black ledge " 11 " | " " " 1.4 " |
| May 9-10, | 1 day, | southeast lake lowered 5 feet. | |
| | | southwest " " 2 " | |
| | | south crag " 9 " | |
| | | black ledge was built up 33 feet. | |
| May 10-18, | 8 days, | mean lake rose 46 feet, | averaging per day 5.8 ft. |
| | | south island rose 28 feet, | " " " 3.5 " |
| | | black ledge " 9 " | " " " 1.1 " |
| May 18-20, | 2 days, | lake rose 16 " | " " " 8.0 " |
| | | black ledge built up 16 feet | " " " 8.0 " |

Monthly changes of bottommost part of pit floor from July 1922 were as follows:

| | | |
|-----------|----------------------|-----------|
| July | Lava inflow | + 70 feet |
| August | Slight slumping | - 29 " |
| September | Lava inflow | +100 " |
| October | Lava inflow | + 65 " |
| November | Inflow and uplift | + 73 " |
| December | Inflow and uplift | + 73 " |
| January | Sinking and recovery | + 31 " |
| February | Stationary | 0 " |
| March | Uplift and inflow | +125 " |
| April | Uplift and inflow | +143 " |
| May | Rising and sinking | + 60 " |

SEISMOMETRIC RECORD

During the month ending midnight May 31, 1923, twenty-one local earthquakes and three teleseisms were registered at the Observatory. These and other earth movements are exhibited below. Distance of origin when indicated by the instrumental record is stated in English miles. Time is Hawaiian Standard of meridian 157° 30' W., 10 h. 30 m. slower than Greenwich.

Local Earthquakes.

| | | |
|------------|-------------|-----------------------------------|
| May 1..... | 1:56 a. m. | Very feeble. |
| 2..... | 5:48 a. m. | Feeble. |
| 4..... | 7:07 a. m. | " " |
| 6..... | 10:30 a. m. | Very feeble. |
| 9..... | 8:31 a. m. | Feeble. |
| | 8:39 p. m. | Very feeble. |
| 10..... | 5:15 p. m. | " " |
| 15..... | 6:59 p. m. | " " |
| 17..... | 9:50 p. m. | " " |
| 18..... | 9:38 p. m. | " " |
| 19..... | 12:13 p. m. | " " |
| 20..... | 2:25 p. m. | " " |
| 22..... | 7:50 p. m. | " " |
| 23..... | 11:50 a. m. | " " |
| 25..... | 2:43 a. m. | " " |
| 27..... | 6:17 p. m. | " " |
| 28..... | 1:48 a. m. | " " |
| | 1:23 p. m. | " " |
| 30..... | 12:06 p. m. | Slight, SE-NW, distance 18 miles. |
| | 12:07 p. m. | " " |
| | 12:10 p. m. | Very feeble. |

Teleseisms.

| | | |
|------------|-------------|--------------------------------|
| May 4..... | 6:04 a. m. | Moderate, distance 2600 miles. |
| 5..... | 4:48 a. m. | Feeble. |
| 23..... | 12:16 p. m. | Slight, distance 2625 miles. |

Spasmodic Microtremor.

This type of tremor was slight throughout the month.

Harmonic Microtremor.

This type of tremor was slight until May 24th, with the exception of a strong spell about 6:40 a. m. May 4th. Beginning May 24th, the tremor increased to moderate.

Microseismic Motion.

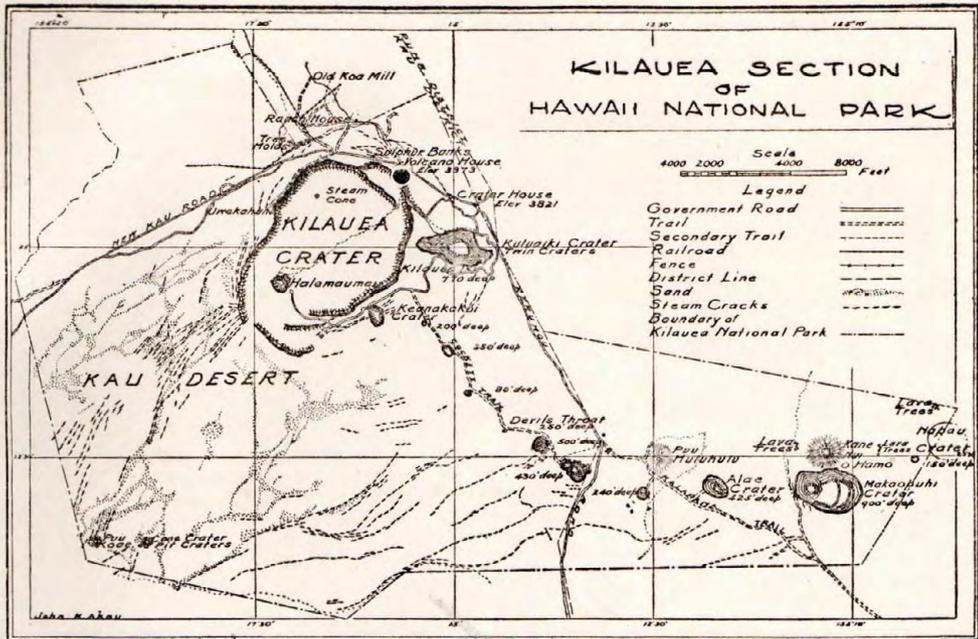
The amplitude of microseisms was slight throughout the month.

Tilting of the Ground.

By weeks this movement was as follows, expressed as angular change and direction of motion of the plumb line:

| | | | |
|-----------------------|-----|---------|------|
| April 29 - May 5..... | 0.2 | seconds | NNE. |
| May 6 - 12..... | 3.2 | " | WSW. |
| 13 - 19..... | 1.9 | " | NE. |
| 20 - 26..... | 3.5 | " | NNE. |
| 27 - June 2..... | 3.7 | " | N. |

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All exchanges should be addressed to
HAWAIIAN VOLCANO OBSERVATORY,
 Volcano House P. O., Hawaii.

The Observatory is equipped with the following seismometric instruments rebuilt at the station in 1918 for the special needs of volcano research: two Bosch-Omori pendulums, high-speed registration of local earthquakes; one optically recording seismograph for distant earthquakes; one clinograph registering E-W tilting of the ground. A vertical component seismograph was in December, 1918, set up in experimental operation. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by wireless signal from the Pearl Harbor Naval Station. The chronometer is loaned by the University of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time. Observatory Lat. 19° 25' 54.2" N.; Long. 155° 15' 39.2" W.; Elevation 1214.6 meters (3985 feet).

HAWAII NATIONAL PARK.

This park was created by act of Congress August 1, 1916, and includes three famous volcanoes—Kilauea and Mauna Loa on Hawaii and Haleakala on Maui. Frequent passenger steamers ply between these islands and Honolulu.

Haleakala Section—Haleakala, "house built by the sun," a peak more than 10,000 feet high, carries an immense fissure-like crater 8 miles long and 3 miles wide, with walls 2000 feet high. Here, as well as on Mauna Loa and Mauna Kea, grows the Silver Sword (*Argyroxiphium*). Thirteen volcanic cones lie wholly within the crater, some rising nearly to the height of the summit. The scene at sunrise is marvelously beautiful.

Wailuku is the point of departure, automobiles taking the traveler to Olinda, a summer residence settlement 4043 feet high. After 2 hours drive to this point, saddle horses are taken to the summit, a ride of 3½ hours. Here is a fine concrete rest house, built by the citizens of Maui, and fully equipped with iron beds, blankets, stoves and cooking utensils.

Mauna Loa Section—Mauna Loa, a vast dome 13,675 feet high, reached through forests of Hawaiian mahogany (koa) and tree fern, then up bril-

liantly colored lava slopes, has a summit crater 3 miles long by 1½ miles wide, with walls 700 feet high, and when in action fountains of fire froth are here jetted 500 feet into the air. Every five or ten years splendid spectacles of lava eruption are staged on the mountain, sometimes from the lower flanks.

There are trails on the Kona side, and also from the southwest, but the usual and best route is with saddle mules from the Kilauea section to Puu Ulua (9800 feet), a ride of six hours. Here there is a fully equipped cottage with stables and water supply. From this point on the second day a four-hour ride takes the visitor to the summit crater, where there is water. A right of way within the park connects Kilauea with Mauna Loa, where eventually a road will be constructed. The views are glorious and the chasms, cones and contorted lavas indescribably chaotic.

Kilauea Section—The lakes of foaming fiery lava within the crater of Kilauea form the most spectacular exhibit in the Hawaii National Park, if not in the world. The pit of fire, Halemaumau, is inside of the main crater, at the apex of a broad, flat, inner cone. Kilauea is a dome volcano 4000 feet high, overridden by the lava slopes of Mauna Loa on the west, so that it seems but a spur of the greater, and perhaps younger, slag-heap mountain.

The Kilauea Park and the inner pit itself are both reached directly by automobile from Hilo, the second city of the Territory of Hawaii, and there are excellent hotel accommodations. The distance from Hilo is 30 miles. Within the park there are 15 miles of roads and about 20 miles of trails. As shown on the map, there are a dozen ancient pits within the area of the park, as well as cones, caverns and hot solfataras and a strange desert where lava flows have poured out of cracks as recently as 1920.

The live pit of Halemaumau is easily accessible and not dangerous. Frequently one can walk to the actual edge of the splashing, fountaining lava lakes, the lava column rising and falling from year to year so that its most distinctive character is ceaseless change. At night the spectacle is full of marvelous color, and the region is a paradise for artists, photographers and naturalists.

The several sections are under the control of the National Park Service of the Department of the Interior. The United States Weather Bureau maintains the Hawaiian Volcano Observatory which stands on the brink of the greater crater within the Kilauea Park.

U. S. DEPARTMENT OF AGRICULTURE
Weather Bureau
CHARLES F. MARVIN, Chief
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GENERAL MAP, KILAUEA SECTION, HAWAII NATIONAL PARK

VOLCANIC CONDITIONS IN JUNE

Activity of Halemaumau.

The movement of lava in Halemaumau fire pit at the end of May appeared to be subsidence, for the great molten lake had reached its highest level 148 feet below the rim on May 20, and temporary lowerings after that time went 10, 18, and finally 40 feet below the ledge or shelf left by the highest rise.

In the forenoon of June 4 the lake was about 194 feet below rim of pit. For some days the level had remained constant at about 165 feet of depression, and there were fluctuations of rising. The lava pool was enormous, tumultuous puffing and flaming fountains chased each other across the incandescent surface, hot bubbleings were seen over the upwelling lava foam, and everything was in plain view with very little smoke. There was one island in the lake, a small rocky eminence that changed height from day to day and was sometimes bombarded by fiery surf.

Border fountains formed against the wall of the pit in elongate patches and sometimes built overhanging curtains and stalactites. The number of fountaining patches was decreasing, so that apart from the small bubbling

the total number ranged from two to eight. Strong currents were seen rushing in the direction of the big fountains, where several patches would migrate together forming lines and swarms of bubblelings that sent up brown fume turning milky above, and at night flame puffs were visible over the fountains, and there was much vehement blowing and spraying. From the source well bubblelings on the southeast side, a current carried wrinkled skins across the center of pit, and on either side there was a zone of streaming against the wall, where the surface crusts were crushed. Bright zigzag lines of melt were revealed everywhere as the skins tore asunder.

During the first half of June the great lava lake held its level about 40 feet below the top of the inner black ledge and there were small fluctuations with more tendency to fall than to rise. The fountaining distinctly decreased to only four or five patches, and sometimes there were no fountains at all except the hot bubblelings over the source well southeast. Hence the pit was darker at night.

Against the southern wall a large grotto formed surmounted with a black arch of spatter accumulation, but this broke down within 24 hours. Curious burning froth was seen one night, when a fountain against the wall would throw up spatter lumps that flamed yellow, and the flames continued their burning for a minute or more. This happened repeatedly, showing that some unusual combustible gas was present in the lava spume.

After the middle of the month the lake stood about 170 feet down with one or two big blowing fountains. The zigzag bubbleling lines tended to radiate outward from the southeast corner of the pit. These lines were where the molten stuff welled up between crusts broken and torn apart by surface currents. On the opposite western side of the pit the gas confined by the viscous surface lava burst through the lake explosively so as to produce spectacular flaming jets and spurts and doming gushes. Brown fume shot up above the flames, glassy spray fell back on adjacent crust, and the finer spray spun the glassy cobweb known as "Pele's Hair." Often the fountains formed in lines, where the upper crusts, heavier than the foam below tended to rush inward and sink, thus setting up surface currents toward the fountains from opposite directions.

It was now recognized by visitors who have been familiar with Kilauea for seventy years past that the lava lake in Halemaumau of June 1923 was the biggest continuous sheet of molten matter they had ever seen. This lake had been produced by the union of separated pools, for in May the wells perforating the red hot substance under these pools had started a series of gushings so that the separating isthmuses and hard lava floors were overflowed, one or two islands were left, and finally these also were drowned. The lake was nearly 1900 feet long by 1450 feet wide.

By analogy with June 1912 and some other occasions a change was looked for about June 22 the time of solstice. Before that the lake had lowered slightly, but now it began to rise and to increase the number and vehemence of its fountains, reaching a level less than 140 feet below rim of pit. Always the main upward gushing was at the southeastern source where in May there had been a circular pond.

Here there was hot bubbleling and the bright zigzag lines streamed slowly outward between blistering and flaming scum patches, the skin moving out across center of pit and drawing away to right and left where the crust became darker and broke along fewer and straighter lines. Towards the margin the big fountains asserted themselves, breaking and engulfing this crust, making jets and puffs of violet flame and brown fume and dashing

violently against the walls. To leeward of the pit the invisible fume from the fountains was noxious and suffocating.

At the end of June the lava lake was 128 feet below rim and a stationary condition was reached. Large grotto domes were built more than 25 feet high. Slab ramparts were piled up on one side resulting from incessant sliding of crusts from lake to shore as the lake rose and the currents moved shoreward. The chief current was a great open spiral from southeast source to the west, north, and east, superposed upon a steady streaming outward radially from the source region.

As stationary conditions were reached, there came a time of border spalshing over the rampart, overflows poured into the southwest chasm behind the buttresses and pinnacles there, and then the big grottoes were built. Central fountains appeared, migrating to the west wall. A bench wider than before formed near the eastern source region.

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June 1. At 5 p. m. the lava lake was lower than on the previous day, the island standing 12 feet above the liquid. There was very slow streaming northward from the southeastern wall. One fountain was playing in the northern region and from four to seven fountains formed from time to time towards the west. There were three border fountains along the west wall, one of these in a grotto behind a curtain of stalactites.

June 2. At 2 p. m. the black ledge appeared fifteen feet high and the dark splashings from the fountains extended up the cliff for from fifteen to twenty feet higher in places. The island was fifteen feet high and rather lumpy and small. Five or six fountaining patches were in action in the southwestern region and against the west wall. There was the usuals southeastern bubbling and outward streaming, and a current towards the northeast bank was noticeable. There was fume from the southeast bank and over the fountains. In the southwest chasm avalanche debris lying on the floor appeared just as it had been the previous week.

June 3. Conditions were much as before and at 9:20 a. m. a study of the fountain developments was started and carried for two hours. The black ledge appeared 20 feet high, there was outward streaming from the southeast bubbling region, a swarm of fountains played against southwest wall of pit and a fountaining patch lay against the west wall. The island was twenty feet high. A bright edge around margin of lake showed temporary subsidence.

Numbers of Fountains changed as follows:

| | | |
|------------|---|------------|
| 9:20 a. m. | 8 | fountains. |
| 9:25 | 2 | " |
| 9:35 | 4 | " |
| 9:40 | 5 | " |
| 9:43 | 5 | " |
| 9:47 | 9 | " |
| 9:53 | 4 | " |
| 10:05 | 8 | " |
| 10:12 | 5 | " |
| 10:15 | 3 | " |
| 10:20 | 2 | " |
| 10:26 | 3 | " |
| 10:30 | 4 | " |
| 10:35 | 2 | " |

| | | |
|-------------|---|------------|
| 10:42 a. m. | 5 | fountains. |
| 10:45 " | 4 | " |
| 10:47 " | 5 | " |
| 10:50 " | 3 | " |
| 10:55 " | 4 | " |
| 11:00 " | 5 | " |
| 11:02 " | 3 | " |
| 11:05 " | 2 | " |
| 11:07 " | 3 | " |

This progress represents counts of actual fountaining patches apart from small bubbings. What actually happened was as follows:

At 9:25 a. m. streaming was straight away from all the western walls, lake was rising and two wall fountains bombarded west and southwest banks.

At 9:35 a. m. the wall fountains continued and two new fountaining patches developed northwest and southwest of the island which lay in the south central part of the lake. These new fountains became tumultuous and fummy.

At 9:40 a. m. a fountaining patch northwest of the island, about where the southwestern well lies under the lake, migrated southward and all the southwestern fountains united in a big display near the wall of the pit. New fountains developed southeast and northwest of the island.

At 9:43 a. m. the southwestern fountains all merged against wall of pit accompanied by hundreds of bubbings on a large scale.

At 9:47 a. m. a new group of five fountains developed in southwestern part of pit somewhat to the west of the well locality, forming a line trending southwest, the fountains being progressively bigger from northeast to southwest. In 5 minutes these settled into a large tumultuous fountaining patch migrating to join the southwestern wall fountains. Two new patches formed along south wall of pit. A total of nine fountains decreased to four by merging.

At 9:53 a. m. a new fountain in the southwestern region was increasing in size and

At 10:05 a. m. this fountain had developed a line of fountains with brown fume, flames and much blowing; this line moved to the western wall and a new fountaining patch developed 200 feet behind it and migrated in the same direction. The direction of migration of both of these was entirely different from that of the fountains at 9:40. Two fountains appeared against the southeast wall.

At 10:12 a. m. a big fountaining patch developed south of the island and others were moving toward southwest wall. The repeated evolution of fountains about the southwest well locality suggested that lava was rising there as well as at the southeast well. The north and northeast walls remained free from any big fountains, but the crusts kept creeping against those walls and piling slabs against the banks.

At 10:15 a. m. there was general multiple fountaining against southwest wall and one fountain against west wall. At this time the streaming from east to west on the surface of the lake, was met by a conflicting current from west to east that arose in the southwest source region. The streaming was radial and outward from that region. A strong current moved northward on the west side of pit and the stream outward from the southeast source was bent northward.

At 10:20 a. m. the southwest wall fountains ceased activity and a new fountain developed west of the southwest well.

At 10:26 a. m. the new fountain had developed into two big fountaining patches migrating towards the southwest chasm, while a constant fountain played against the west wall.

At 10:30 a. m. the two southwestern fountains merged and a new one formed at the southwestern center and migrated after them. From the island region there was a rapid rush of currents in the direction of the big fountaining patch.

At 10:35 a. m. the big patch expended itself against the wall just north of the southwest chasm, and a new patch started at the southwestern center. All this time the black ledge remained about fifteen feet high and no marked rising or falling of the lake occurred.

At 10:42 a. m. there were four fountains in an east-west line southwest of center of pit, and one fountain against west wall.

At 10:45 a. m. there was a big fountaining patch against south wall and the southwestern fountains had merged. In this counting of fountains small bubblings which happened here and there on the lake and at the border are not counted.

At 10:47 a. m. there were five fountains and

At 10:50 a. m. a southern patch migrated west along the wall and the southwestern fountains migrated to the wall and merged together.

At 10:55 a. m. there were four fountains, increasing

At 11:00 a. m. to five and

At 11:02 a. m. four of these merged with much tumult against southwest wall. The backflow from the southwestern region towards the southeast well had now ceased.

At 11:05 a. m. there were two fountains and

At 11:07 a. m. a third developed in the usual place.

June 4. At 9:30 a. m. lake was lower with bright edge around margins indicating subsidence, and the black ledge of May 20 was forty feet high. The island had subsided with the lake and was only two feet above it. A continuous big fountain was in action on the western side of the island, and a tumultuous swarm of fountains was shifting position in southwest corner of pit. A temporary fountain formed against west wall and from two to five fountaining patches in all were counted. The southeastern bubbling and outward streaming remained as before and the tendency to develop lines of southwestern fountains continued. The island remnant was covered with slabs on the upstream or eastern side, and with spatter on the downstream side. The island looked as though its overturn had been due to pressure from the east and the fountain on the downstream side of the island appeared to owe its presence to release of pressure occasioned by the eddy. The current past the island was increased in velocity by the suction around the southwestern fountains. At 9:50 a. m. the island fountain ceased action and a backward current developed in an easterly direction.

June 5. At 9:30 a. m. the lake was 176 feet below rim of pit and the black ledge was 30 feet high in places. The island was about four feet high. Streaming was swifter than before, there was great variability in the fountaining, from one to eight fountains being counted, including border fountains against north, west, and south walls. Travelling fountains sometimes started at the southeast source region. The fountain at the island was inconstant. A zone of thin wrinkled skins moved across center of pit while on either side there were angular blocks of crust bordered by bright lines. In places the black ledge had caved away extensively.

During the previous night there had been alternations in brightness from brilliant to very dull at the pit. Now the cause of this was seen to lie in fluctuation of fountaining. One travelling fountain was observed to migrate fully 1200 feet from the southeast source to the southwest line of fountains; these in turn migrated to the bank at the southwest chasm. Immense turbulent fountains suddenly broke out in the northeast central area and migrated toward the north wall. One central fountain was seen to die away sluggishly in the northern region.

At 9 p. m. about nine fountains were in action especially around edge of lake. The island was small and low. Many blobs of bright flaming spume were thrown up by the fountains against wall of pit. The slop would lodge on the bank and burn with a yellow flame for from one to two minutes, like a piece of waste soaked in oil. Other flames were observed over border fountain of violet color. The burning blobs were seen repeatedly. Fountaining was very variable being sometimes reduced to only one patch and the only light over the pit at such times was from the southeast source bubbling. At this source there were black nodal skins with a dispersion pattern of bright lines radiating from the nodes.

June 6. At 3 p. m. the island was small and about two feet high. Number of fountains varied from two to five and bright blue fume rose above them. Wall of pit was scarlet with iron oxides where the black ledge had fallen away.

June 7. At 11:30 a. m. the number of fountains varied from none to four. A black current from the southwest region was observed, meeting the outward streaming from southeast source. East of center of pit there was a nodal patch of crust toward which currents converged from all sides. A debris slope of red rock lay in the lake southeast where the black ledge had caved in. There was some excessively turbulent fountaining against south wall of pit, with inrush of currents, many hot bubbleings and five or six large fountains. This fountaining lowered the lake in its vicinity so that the island, which had been a mere crust flush with the lake was left standing two feet high.

June 8. At 9:30 a. m. the black ledge appeared at least 45 feet high in places and the lake was lower than before. Four fountains were in action, two of them at arched grottoes southwest and west. The island had disappeared. The southwestern grotto was a splendid semi-circular arch of rounded spatter 25 feet high with a continuous big fountain inside and steady inward rush as though there were a cascade below with the liquid pouring down a sinkhole. The location of this grotto corresponded with the southwest wall vent, just east of the pinnacles. The border grottoes kept up steady action when all the central fountains died out. Small central fountains were seen to play about the southwest well locality. The black ledge had fallen away still more, and everything indicated subsidence.

June 9. At 8:30 a. m. there were from one to three fountains and the large southwest grotto arch had fallen in. Lake was lower leaving the black ledge more than fifty feet high and more fallen away than before, revealing reddened walls behind it. Some new debris had fallen on the southwest chasm floor, probably the product of three small earthquakes recorded on the previous day. Because of the few fountains there was notably little fume over pit.

June 10. At 11 a. m. there was no evident change in level of lake. There were one or two border fountains and the positions of fountains had somewhat changed. The southeastern black ledge avalanche debris on top,



Fig. 9. June 30, 1923. Halemaumau one vast lake, from the northeast. Photo. Jaggar.

and also the northwestern. Both of these parts of the black ledge protruded from the wall. There was the usual outward streaming towards center of pit from southeast side of lake. At night the pit appeared darker than usual, with only one or two fountains in action.

June 11. On this day the activity of the lava pool was sluggish.

June 13. At 8 p. m. there was slow streaming radially in all directions from a crust on the surface of the lake that lay over the southeast source vent. One fountain was playing in the southwest central part of the lake and two border fountaining patches bombarded the northeast and northwest walls.

June 14. At 4 p. m. the lava appeared to be rising slightly. One fountain was seen to play for a short time in the southwestern region and one border fountaining patch washed the base of the northwest wall. The streaming was toward the southeastern source from the region of the northeast border of the lake, and away from that source toward the west.

June 15. At 10 p. m. the liquid appeared about 25 feet below the top of the black ledge. The streaming was westward from the eastern side of the lake, and there were some stationary crusts surrounded by bright lines whence these streamings seemed to depart centrifugally. There was bubbling along the bright lines, and small blisters in these crusts were seen to emit flames. There were only one or two fountaining patches, sometimes southwest of center of pit, sometimes at the northeast wall, and sometimes at the south wall. The gas pressure seemed less than it had been a week before.

June 16. At 9:30 a. m. the fountaining was weak and there was very little source bubbling southeast. The lake surface as a whole was higher than the previous week, the black ledge appearing over 20 feet high.

At 3 p. m. there was notably little activity when the pit was first inspected, but the fountains increased, developing some violence and spraying action, notably southwest of center and along western border. In the evening the pit was rather dark showing decrease of fountaining activity until there were almost no fountains.

June 18. At 9:20 a. m. the lava level was slightly higher with the black ledge exhibiting only 15 feet of height above the lake in places. There was a line of fountains westward from the southwest central region one of them large and tumultuous. From the southeast margin of the lake there was steady outward streaming with small bubbling. The rest of the lake was covered with skin and crust, in patches, separated by bright lines, the crusts migrating to the banks where they were broken up and the blocks sank. There was blue fume over the fountains and some whiter fume rose from the southeast ledge.

June 19. At 10 a. m. there was hot streaming towards the southwest region where from three to five fountains were in action. The black ledge near the southwest chasm had slumped and a heavy mass of debris had fallen on the floor inside the chasm niche. Elsewhere the black ledge appeared to stand from 12 to 16 feet high. At the southwest chasm the ledge stood only 10 feet above the lake as though the pinnacles, the floor of chasm, and the ledge had all faulted downward together. Along the lake northeast there were piles of broken crust. The skin on surface of lake showed the "watered silk" pattern and there were small border fountains southwest.

June 20. At 8:30 a. m. there was no apparent change of level and a line of four big fountains extended west from the southwestern center. A shoreline bordered by a narrow ledge a foot or so high had formed along the eastern and southeastern border of the lake. There was bright-line

streaming from standing skins in the southeastern part of the lake and the usual outward streaming poured from the east bank. A small border fountain was active on the south shore. Five fountains were the maximum number counted at one time. The skin was thin and the heat radiation strong.

June 21. At 9 a. m. the crust was thicker and the heat radiation less. The lake was higher, so that the black ledge appeared 10 feet high north-east, 6 feet high south, and one foot high west-southwest. Seven fountains were in line southwest of center and an active grotto had formed against southwest wall of pit east of the pinnacles. The line of fountains migrated to form a concentration of bubbling against the southwest bank where they died away. Then there was a rising spell and the lake became flush with the top of the western ledge. After about five minutes a small fountain broke into action in the southwestern region and this started a line of travelling fountains which developed three violent patches throwing up puffs of brown sulphur gas and flame which condensed to blue fume above. This action lasted for fifteen minutes. At the southeast source there was a tendency to form five or six radial carpets of crust in long bands of skin marked with longitudinal lines in the directions of the outward streaming currents.

During the rising spell thick crust areas were seen to be arched by gas pressure, and these would break along straight cracks. The lake was notably rising in coincidence with the solstice. New sets of travelling fountains started about every twelve minutes; these would relieve pressure and cause temporary subsidence of the surface. The southeastern source bubblings were notably larger than on the previous day. There was continuous noise of crunching crusts. The transparent gas from the fountains to leeward of pit was insupportable.

June 22. At 9:30 a. m. the lake was one foot below the southwest chasm floor and the black ledge elsewhere averaged only 5 feet of height above the lake. On the northeast side a new bench of piled slabs had formed under the black ledge. Fountains southwest increased in number from three to twelve, and large fountains developed bombarding the wall to the north. For an hour from seven to thirteen fountains were in action and this loss of gas lowered the lake level three feet.

On the previous evening eleven fountains had been counted and the pit was brighter. Now there was increase of southeastern bubbling, of speed of current, of heat and of thinness of skins, all accompanying the marked rising spell which occurred just at the solstice.

A small border shelf had formed all around the lake, its width from three to twenty feet, widest opposite the southeastern source bubbling, and built up in places from one to four feet above lake level. It was wide and low at the southeast; narrow and lumpy with spatter south, southwest, west and northwest; wider and covered with piled slabs north, northeast and east-northeast. There was a general set to the current in a clockwise spiral from the southeast source with the heaping of slabs at the end of the current along the northeast shore. It seemed probable from appearances that the southwest wells were feeding the lake as well as the southeast source. The process of heaping slabs on the northeast bank was a sign of rising lava. Each slab shoved out on the shore from the crust over the lake made the heap higher than before, and it was necessary for the lake to rise higher before a new slab could be shoved on top of the last layer of slabs.

At 11:30 a. m. the old black ledge of May 20th was about four feet above the lake toward the south and west; northeast however the slab rampart was piled up almost level with the black ledge.

At 8 p. m. there were from seven to eleven fountains including increasing numbers of border fountains west and north. The pit was bright.

June 23. From a distance increased blue fume of fountains over the northwestern part of the pit was noticeable. Harmonic vibration was increasing at the observatory seismographs.

At 8 p. m. the lava lake appeared higher, the southern bench was being built up by overspatter and the northeastern slab rampart was overflowed. There were ten or more fountains and the southeastern source region appeared to have higher gas pressure. There were small bubblings in the center of the lake, a line of big wall fountains made banners of flame northeast, and other wall fountains changed position in the western region. Occasional central fountains formed in single patches which migrated to the wall. The streaming that radiated outward from the southeast source showed radial bright lines in an inner circle which were very jagged; outside of this there was a darker area of polyhedral crusts bordered by straighter lines. Over the region of the southwest well an occasional small fountain would form, but not any lines of big fountains.

There was very marked change on this evening in the habit of fountaining. There was change from central fountaining to wall fountaining in general. There was the development of big fountains northeast where the slab piling had been, and this had been dominant all day as shown by the blue fume at that place.

June 24. From 3 to 4 p. m. it was found that the lake had built a rampart of slabs athwart the opening between the two eastern buttresses at the entrance to the southwest chasm. This rampart stood at least five feet above the southwest chasm floor, and there was hardly any of the old black ledge to be seen. The lake appeared to be about 140 feet below rim of pit.

At intervals the fountaining mechanism was similar to that of previous night, but the large north grotto was dead and a line of big wall fountains developed northwest. Around the edge of the lake southwest and north there was much small bubbling and long spells occurred without big fountains. Possibly a flow was pouring into the southwest chasm. There were folds of skin piled on the eastern ledges at the edge of the lake and spatter ledges had formed on the north and northwest.

Between 3 and 3:30 p. m. from one to seven big fountains were seen, mostly along western border. At 3:40 p. m. four patches of wall fountaining developed at the northwest which merged with great violence and showed shoots of red flame and brown fume amid tumultuous sprayings. This fume curdled above to blue smoke. In another patch of fountains seen in the shadow against west wall of pit the flame banners were violet in color. Repeatedly large purple flame were seen and were noted as unusual.

June 26. At 3 p. m. the lava was still rising and crust ramparts were built up around the lake from four to five feet high. There were two central fountains and two large northern border patches of fountaining.

June 27. At 4 p. m. the lake was overflowing its rampart along the southern shore. In other places the rampart was built up five or six feet above the ledge. There was a northern border fountain and another along the rampart at the entrance to southwest chasm.

June 29. At 5:30 p. m. pit was quiet with rising tendency still in evidence. Some lava had recently poured over the embankment to the southwest chasm floor. There were four border fountaining patches west and northwest and no central fountains.

June 30. Measurement at 11 a. m. made the lake 128 feet below rim. The lava was now nearly stationary, building spatter and slab ramparts, and

oven grottoes. About seven high ovens had been formed along the west and northwest shore, with their activity shifting. From four to six fountain-patches were counted, some of them central ones. There was the usual outward streaming from the southwest source. A broad shoreline bench had formed there, crescent-shaped in plan. There were other wide benches at the southwest chasm and along the northeastern and northern shores. The old western buttress or pinnacle now stood only about twenty feet above the lake. Some of the grotto ovens were twenty feet high, but the general height of the spatter ledge was about four feet above the lake. There had been overflowing into the southwest chasm, but the rising in general had been slow. The noises were of splashing and crunching. An occasional fountain formed over the southwest source. The slab ramparts were still mostly towards the north and east. The pit was clear, with fume chiefly over the active fountains.

LAVA MEASUREMENTS

Measurements of depression of the mobile lava column, made with transit, referred to northeast station on rim of Halemaumau pit (3716 feet above sea-level), for the month ending June 30, 1923, including floors of bench magma and liquid level of lake magma, were as follows:

| Date | Time | Mean Lake | Lake Southeast | Lake West |
|----------|-------------|-----------|----------------|-----------|
| May 20, | ..... | 148 feet | ..... | ..... |
| June 5, | 9:30 a. m. | 178 " | 176 feet | 180 feet |
| June 19, | 10:00 a. m. | 166 " | 164 " | 167 " |
| June 30, | 11:00 a. m. | 129 " | 130 " | 128 " |

Progressive changes in mean lake level were as follows:

| | | | |
|----------------|----------|--------------------|-----------------------------|
| May 20-June 5, | 16 days, | lake sank 30 feet, | averaging per day 1.9 feet. |
| June 5-19, | 14 days, | lake rose 12 " | " " " " 0.8 " |
| June 19-30, | 11 days, | lake rose 37 " | " " " " 3.3 " |

Monthly changes of bottommost part of pit floor for one year from July 1922 were as follows:

| | | |
|-----------|----------------------|-----------|
| July | Lava inflow | + 70 feet |
| August | Slight slumping | - 29 " |
| September | Lava inflow | +100 " |
| October | Lava inflow | + 65 " |
| November | Inflow and uplift | + 73 " |
| December | Inflow and uplift | + 73 " |
| January | Sinking and recovery | + 31 " |
| February | Stationary | 0 " |
| March | Uplift and inflow | +125 " |
| April | Uplift and inflow | +143 " |
| May | Rising and sinking | + 60 " |
| June | Sinking and recovery | + 40 " |

SEISMOMETRIC RECORD

During the month ending midnight June, 30, 1923, thirty-two local earthquakes and five teleseisms were registered at the Observatory. These and other earth movements are exhibited below. Distance of origin when indicated by the instrumental record is stated in English miles. Time is Hawaiian Standard of meridian 157° 30' W, 10 h. 30 m. slower than Greenwich.

Local Earthquakes.

| | | |
|-------------|-------------|---------------------------------|
| June 3..... | 9:30 p.m. | Very feeble. |
| 5..... | 7:48 p. m. | " " |
| | 11:46 p. m. | " " |
| 6..... | 6:29 a. m. | " " |
| 8..... | 1:49 a. m. | Slight, distance about 2 miles. |
| | 1:55 p. m. | Very feeble. |
| | 4:13 p. m. | " " |
| 9..... | 1:40 p. m. | " " |
| | 11:35 p. m. | " " |
| 10..... | 9:59 p. m. | " " |
| 11..... | 10:13 a. m. | " " |
| | 4:03 p. m. | " " |
| 12..... | 9:24 a. m. | " " |
| 13..... | 4:41 a. m. | " " |
| | 9:00 a. m. | " " |
| | 5:59 p. m. | " " |
| | 6:01 p. m. | " " |
| 14..... | 6:30 p. m. | " " |
| | 7:14 p. m. | " " |
| | 8:06 p. m. | " " |
| | 11:40 p. m. | " " |
| 16..... | 2:50 a. m. | " " |
| 17..... | 3:35 a. m. | " " |
| 19..... | 4:51 p. m. | " " |
| 20..... | 1:43 a. m. | " " |
| | 2:11 p. m. | " " |
| | 2:16 p. m. | " " |
| | 9:21 p. m. | " " |
| 21..... | 2:52 p. m. | " " |
| 23..... | 7:06 a. m. | " " |
| 27..... | 11:16 a. m. | " " |
| 30..... | 1:04 a. m. | " " |

Teleselsms.

| | | |
|-------------|-------------|------------------------|
| June 1..... | 7:05 a. m. | Slight. |
| | 10:02 a. m. | " " |
| 17..... | 10:20 p. m. | " distance 2500 miles. |
| 19..... | 1:00 p. m. | " " |
| 21..... | 8:49 p. m. | " " |

Spasmodic Microtremor.

This type of tremor was slight throughout the month.

Harmonic Microtremor.

This type of tremor decreased from moderate the first week of the month to slight June 6 and 7, very slight June 8 to 20 increasing to moderate June 23 to 27, and becoming slight thereafter.

Microseismic Motion.

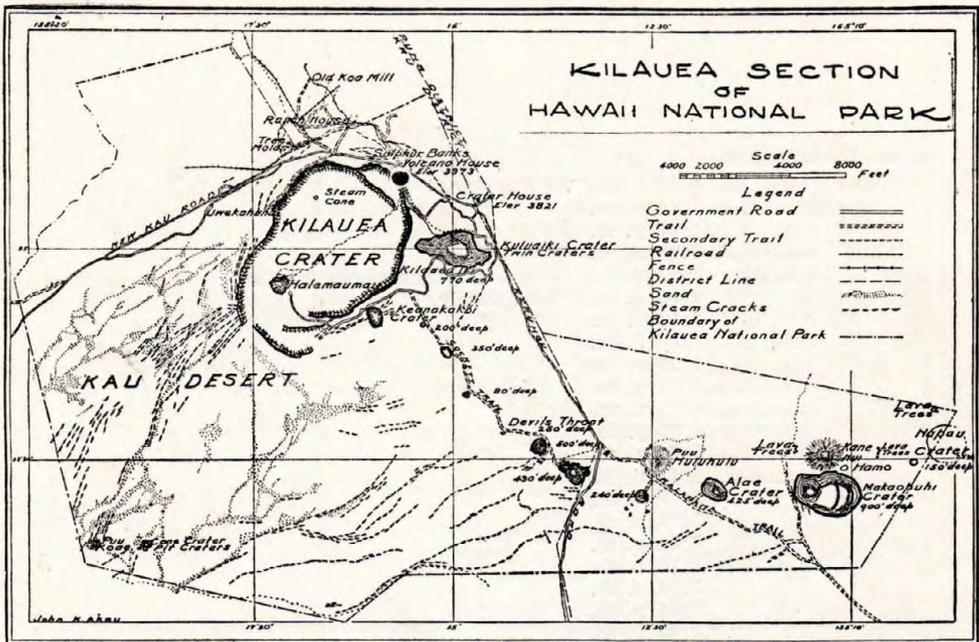
The amplitude of microseisms was slight throughout the month.

Tilting of the Ground.

By weeks this movement was as follows, expressed as angular change and direction of motion of the plumb line:

| | |
|----------------|----------------|
| June 3- 9..... | 3.6 seconds N. |
| 10-16..... | 1.4 " E. |
| 17-23..... | 1.1 " NNW. |
| 24-30..... | 1.1 " SW. |

T. A. JAGGAR,
Volcanologist.



Black spot shows location of Observatory.

All exchanges should be addressed to

HAWAIIAN VOLCANO OBSERVATORY,

Volcano House P. O., Hawaii.

The Observatory is equipped with the following seismometric instruments rebuilt at the station in 1918 for the special needs of volcano research: two Bosch-Omori pendulums, high-speed registration of local earthquakes; one optically recording seismograph for distant earthquakes; one clinograph registering E-W tilting of the ground. A vertical component seismograph was in December, 1918, set up in experimental operation. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by wireless signal from the Pearl Harbor Naval Station. The chronometer is loaned by the University of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time. Observatory Lat. 19° 25' 54.2" N.; Long. 155° 15' 39.2" W.; Elevation 1214.6 meters (3985 feet).

HAWAII NATIONAL PARK.

This park was created by act of Congress August 1, 1916, and includes three famous volcanoes—Kilauea and Mauna Loa on Hawaii and Haleakala on Maui. Frequent passenger steamers ply between these islands and Honolulu.

Haleakala Section—Haleakala, "house built by the sun," a peak more than 10,000 feet high, carries an immense fissure-like crater 8 miles long and 3 miles wide, with walls 2000 feet high. Here, as well as on Mauna Loa and Mauna Kea, grows the Silver Sword (Argyroxiphium). Thirteen volcanic cones lie wholly within the crater, some rising nearly to the height of the summit. The scene at sunrise is marvelously beautiful.

Wailuku is the point of departure, automobiles taking the traveler to Olinda, a summer residence settlement 4043 feet high. After 2 hours drive to this point, saddle horses are taken to the summit, a ride of 3½ hours. Here is a fine concrete rest house, built by the citizens of Maui, and fully equipped with iron beds, blankets, stoves and dining utensils.

Mauna Loa Section—Mauna Loa, a vast dome 18,675 feet high, reached through forests of Hawaiian mahogany (koa) and tree fern, then up bril-

liantly colored lava slopes, has a summit crater 3 miles long by 1½ miles wide, with walls 700 feet high, and when in action fountains of fire froth are here jettied 500 feet into the air. Every five or ten years splendid spectacles of lava eruption are staged on the mountain, sometimes from the lower flanks.

There are trails on the Kona side, and also from the southwest, but the usual and best route is with saddle mules from the Kilauea section to Puu Ula-ula (9800 feet), a ride of six hours. Here there is a fully equipped cottage with stables and water supply. From this point on the second day a four-hour ride takes the visitor to the summit crater, where there is water. A right of way within the park connects Kilauea with Mauna Loa, where eventually a road will be constructed. The views are glorious and the chasms, cones and contorted lavas indescribably chaotic.

Kilauea Section—The lakes of foaming fiery lava within the crater of Kilauea form the most spectacular exhibit in the Hawaii National Park, if not in the world. The pit of fire, Halemauama, is inside of the main crater, at the apex of a broad, flat, inner cone. Kilauea is a dome volcano 4000 feet high, overridden by the lava slopes of Mauna Loa on the west, so that it seems but a spur of the greater, and perhaps younger, slag-heap mountain.

The Kilauea Park and the inner pit itself are both reached directly by automobile from Hilo, the second city of the Territory of Hawaii, and there are excellent hotel accommodations. The distance from Hilo is 30 miles. Within the park there are 15 miles of roads and about 20 miles of trails. As shown on the map, there are a dozen ancient pits within the area of the park, as well as cones, caverns and hot solfataras and a strange desert where lava flows have poured out of cracks as recently as 1920.

The live pit of Halemauama is easily accessible and not dangerous. Frequently one can walk to the actual edge of the splashing, fountaining lava lakes, the lava column rising and falling from year to year so that its most distinctive character is ceaseless change. At night the spectacle is full of marvelous color, and the region is a paradise for artists, photographers and naturalists.

The several sections are under the control of the National Park Service of the Department of the Interior. The United States Weather Bureau maintains the Hawaiian Volcano Observatory, which stands on the brink of the greater crater within the Kilauea Park.

U. S. DEPARTMENT OF AGRICULTURE
Weather Bureau
CHARLES F. MARVIN, Chief
MONTHLY BULLETIN
OF THE
HAWAIIAN VOLCANO OBSERVATORY

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VOLCANIC CONDITIONS IN JULY

Activity of Halemaumau.

At the beginning of July there was a slight sinking back of the liquid lava lake in Halemaumau pit from the level 128 feet below rim which had been recorded June 30. Sometimes nine large fountain patches were in action at once and those at the lake margin were building arches of spatter over glowing grottoes, some of the half-domes so formed being more than 25 feet high. The border black ledge became ten feet high in places, and temporarily a submerged southern island appeared as a stationary patch of clustered crusts.

On July 4 there was recovery of the lake to a level only 127 feet below the rim of pit and the island disappeared by July 6. This was the maximum height attained during the recent rise. The pit was now occupied by a vast lake of restless molten lava some forty-five acres in extent. On July 7 the lake was falling and by the 9th it was 150 feet down, and the streaming which had been outward from the southeastern source well for many weeks, on this day reversed its direction.

The second week of the month produced a temporary rising spell and the maximum number of fountains increased from about four July 10 to twelve July 16. The liquid lava welled up at the southern sources and streamed westward and northward, and big gushes of gas, spray and flame would burst out in the lake in the region away from the source wells against the northern and western banks. Arched grottoes on the margins tended to form, break down and reform according as the level remained stationary, lowered or rose. There were spells when southwestern source wells were dominant and the currents were northerly, and other more common spells when the hot southeastern bubbling well controlled the situation. Skins over the lake were thin and blistered, the bright lines were numerous and radiated from the southeast source, fountains were noisy and violent in lines moving northwest and southwest and on July 16 a small avalanche was seen.

During the third week the lake remained stationary, heat increased and the number of fountains increased so that sometimes twenty might be counted at one time. The lake rose seven feet and sank about an equal amount. A slight fluctuation of about six feet means a volume change of some 800,000 cubic feet. One or more glowing grottoes continued in action and the brilliant pattern of bright lines seen at night was intensely spectacular.

On July 26 a pronounced subsidence of nearly 20 feet took place until the lake was 166 feet below rim. Then the benches started collapsing and sinking continued for a few days. This made no great difference in the appearance of the pit except that the black ledge around the margin was revealed to a height of 50 feet or more above the liquid lava. The fountains continued to explode with much violent spraying and flaming in from four to nine patches.

In the early part of the last week of the month there was diminution in the number of fountains from eighteen to eight. On July 25 large grottoes were forming and the border bench was growing, and in one place a regular rhythmic fountain had developed. The pit was now very bright at night and the fume was thin.

Throughout July as in June there was a single large lake filling the whole pit. The level of the lake fluctuated slightly with a downward net movement for the month.

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July 3. At 9 a. m. there were three to nine fountains of varying intensity chiefly under south, southwest, west, and northwest banks, though migratory central ones appeared in the southwestern part of the lake.

The island in the southern part of the lake had risen several feet since the day before, and was still covered with broken crusts. The fume was thin, mainly from the fountains and grottoes, which was quite blue in contrast with the small amount of white fume from the southeastern bench and the island.

The lava was welling up in the southeast source, which was marked by thin skins with some bubbling and much heat, and radial streaming. Along the north bank there was some breaking up and sinking of crusts. In the north and northwest parts of the lake, away from the bank there were thick crusts with hardly any streaming. As a whole, the lake seemed quieter, with thicker crusts than the day before. Sounds were mainly the splash of fountains, with some hissing along the northeast margin.

July 4. At 9 a. m. the fountain activity was still along the west edge, though it had moved north since the day before. There was also occasional fountaining under the northeast bank. The number of fountains varied from three to nine. Those of the southwest part of the lake were decidedly weaker than previously. The direction of streaming was about the same as before, but a trifle faster. The fume continued thin. Crusts were thin, and the heat was strong, almost unbearable at the transit stations on the east and north edges of the pit.

The lake threatened to overflow the northeast bench in several places at 9 a. m., but sank later in the morning. The island was still rising, and was larger than before.

July 5. The fountains were moderately active, with four to five border patches and up to two central ones. The patches along the west bank were further south than on the 4th. The fume from the island was thicker than before, but that from the lake continued thin. The source of streaming had moved further south, and a moderately strong current flowed along the margin northward. The crusts were thin, with moderate to strong heat radiation. There was no material change in the appearance of the benches and ramparts.

July 6. The fume from the lake was thicker, mostly from the fountains, with a little from the crack between the southeast wall and the bench. The fountains were variable, and at times strong. There were up to seven central fountains in the southern part of the lake. The island had vanished. The crusts were thicker, and the heat radiation less strong than on July 5, otherwise conditions were similar.

July 7. At 10:30 there had been marked sinking of the lake, with collapse of benches on the west and southwest sides. A small avalanche took place on the west side. There was one constant border fountain on the west side, and a few occasional central ones in the southern part of the lake. The main sources of fume were the west fountains and the southeast bench, but many minor sources gave the lake a hazy appearance. As a whole the fume was thicker than before. The main streaming was due west from the southeast source. The crusts were moderately thick, and the heat radiation moderate.

July 8. At 3 p. m. the lake had fallen further, and there had been some collapse of benches all around it. The fume was thicker. The fountaining had shifted to the center of the lake, where there were six active fountains. The only marginal patch was a weak one near the southwest chasm. The main current from the southeast source was going south parallel with the edge.

July 9. At 10 a. m. the height of the lake had not changed since the day before.

There were no active marginal fountains, but three central ones in the southern part of the lake with a few weaker ones in the northern part. The whole southwest, west, and northwest portions of the lake were crusted over and inactive, with hardly any fume. The southeast source of streaming had moved a little further north, and the main streaming was slowly toward the south. Thickness of crusts and heat radiation were moderate. The southern group of fountains were giving off considerable fume of a bluish color, while the sources along the northeast, east, and southeast wall were giving off yellowish blue fume.

July 10. At 8:30 a. m., there had been no apparent change in the height of the lake, or in the conditions of the benches and ramparts. The fountains

were migratory, starting in the center they moved up to the north bank and promptly died there. Their number varied up to four, some of which were moderately strong.

The streaming was rather sluggish with breaking up of crusts. The crusts seemed thinner, and heat radiation stronger than for the past few days. The fume from the margin was thinner, but from the fountains it was moderately thick at times.

July 11. At 9:30 a. m. there was no noticeable change in benches. There was one stationary central fountain in the northern part of the lake, and by it other fountains would start and drift to the northwest bank. The fume from the margin was decidedly thinner. Most of the fume came from the fountains. The crusts on the lake were medium stiff, and the heat radiation moderate. The source of streaming under the southeast bank was bubbling, with thin skins. From there the strongest current was toward the northwest fountains. Strong local currents along the northeast bank broke up the crusts and piled them up as slab ramparts. The sounds were from the splash of fountains, with some hissing along the northeast edge.

July 13. There were from two to nine fountains, of which one near the north bank was strong and constant, while there were occasional strong ones in the southwest portion of the lake, and along the southwest margin. Heat was moderate and fume thin. There were quite strong currents from the southeast source toward the north, with breaking up of crusts against the northeast and north banks.

July 14. From 10 to 11 a. m. there were seven to ten fountains, with lines of travelling fountains from the center to the northwest, and five or more border fountains along the west margin, one of which had a smooth grotto of spatter. The streaming started from a ragged edge of crust on the south side of the lake and flowed across the bubbling southeast source, travelling northward. The southwest source showed small bubbling fountains and occasional larger bursts. The grotto building showed stationary conditions with a 5 foot ledge on the southwest, a 15 foot one on the southeast, and a 25 foot one on the north.

July 15. At 5 p. m. the lake appeared 5 to 10 feet higher. The streaming originated part of the time from a border skin under the south wall, and at other times from a nodal skin southeast of the center. Over the southeast source there was blistering and bubbling. There were ten to twelve fountains, some forming perpetual lines tending northwest. Other lines migrated in groups of three or four from the southwest source to the southwest chasm. Border fountains were few. The stronger fountains sent up high spray with violet flames. The lake surface was higher and hotter, with thin skins.

July 16. At 10:30 a. m. the fountains were active, there being from one to three under the southwest rampart and seven central ones in the west part of the lake. There was one particularly active group about 100 yards from NNW station. The fume was thin considering the activity of the fountains. A small amount still came from the bench under the auto stand. There was active streaming from the southeast source toward the north with overthrusting and jamming of slabs against the north bank. There was also a strong drift west in the western half of the lake. Along south-west and west margin the fountains built up grottoes, otherwise the benches were not appreciably changed.

The crusts along the northeast and southeast edges of the lake were thin, with strong heat radiation, and in the central and western portions, the crusts were thicker.

July 17. At 10 a. m. the fountains continued active, with one to three border patches and five to seven central ones; the former being near the southwest chasm and most of the central ones in the northern part of the lake. Crusts were fairly thin, and the skins in the eastern part of the lake were blistered. Heat radiation was strong. The speed and direction of streaming was little changed from the day before.

The piling up of slabs against the north and east ramparts continued. No change in the benches and ramparts were noted and the fume continued thin.

July 18. At 9 a. m. the fountains were still active. One marginal one near the southwest chasm had built up a large grotto. There were also four more in the northern part. Except for the new grotto there was no visible change in the ramparts. There was moderate streaming from the southeast source along the north margin, with sluggish jamming of crusts against the bank, and more moderate toward the west bank. The heat radiation was strong, with thin crusts. Those along the east bank were wrinkled. The fountains were noisy, and there was a hissing under the east bank.

July 19. At 9 a. m. the height of the lake was practically unchanged. Intermittent marginal fountains, up to four, were building spatter ramparts along the southwest, west, and northwest margins. The active group of central fountains in the north part of the lake continued as before. Other fountains were in the southwest and northeast portions of the lake, totalling about ten central fountains.

Fairly rapid radial drift continued away from the southeast source, with many local currents, especially in the neighborhood of the fountains. The piling of slabs against the northeast and north banks continued as usual. The fume was thin, mostly from the fountains and southeast bench, though a little oozed up through the crust near the north fountains.

July 20. At 9:30 there were only two groups of fountains, both in the northwest part of the lake, totalling from three to six large fountains, and a very few small ones. The nature of the streaming and appearance of the crusts and fume were very similar to that of the day before.

July 21. At 10 a. m. the fountains in the north part of the lake were small and weak, though still constant. In the southwest they were variable, up to four large ones. A strong current flowed from the southeast source toward the southwest fountains, and a more moderate one along the northeast bench, where the crushing of slabs against the bank continued slowly. The lake had been overflowing the bench under the auto parking place. There appeared to have been some collapse of benches in spite of the rising lava. The fume from the southeast bench was thinner and whiter than before.

July 22. The fountaining was somewhat variable. As many as eighteen were going at once. All but four were central. There had been marked building of grottoes along the west and southwest margins. The lake appeared to have fallen several feet since the day before. The streaming was away from the southeast source, with strong currents toward the fountains and along the northeast bank, where the crushing of slabs against the bank continued. The crusts were thin, and the lake hot. The fume was thin considering the number of fountains.

July 23. At 10 a. m. the fountains were rather constant, up to eighteen, most of which were rather small, and in the west central part of the lake six marginal ones were rapidly building up grottoes. The fume was a trifle thicker, and the lake a little lower than the day previous, otherwise conditions were the same.

July 24. At 8:30 a. m. the height of the lake was about the same as the day before. Some of the grottoes along the west margin had collapsed; otherwise the benches were unchanged. The number of fountains was much reduced, and they were in two groups, one near the north edge consisting of three or four rather weak ones; the other group consisted of four much stronger ones in the southwestern part of the lake, and one marginal one near the southwest chasm. The fume was thin, most of it coming from the southwest fountains and southeast bench. The streaming away from the southeast source was slow, and the jamming of slabs against the northeast bank was sluggish.

July 25. At 10 a. m. there were three large and constant marginal fountains building grottoes under the west bank, and two to three large central ones in the southern part of the lake. The north group had practically stopped, but a new fountain had appeared in the northeast part of the lake, and was spurting spasmodically about every two seconds. Outside of the growth of grottoes and spatter ramparts, there was no material change in the benches. The streaming from the southeast source along the south bank to the fountains was strong, while along the northeast margin it was sluggish. The fume continued thin, coming mostly from the southeast bench and the fountains. The thickness of crusts and heat radiation were also moderate.

July 26. At 9:30 a. m., there had been marked sinking of the lake, with some collapse of benches on all sides. The fountains continued active, though variable, up to six large ones in the southwest part of the lake. Six small but constant ones continued in the north part of the lake. The spasmodic fountain in the northeast was a little bigger and stronger than on the day before. There was a fairly strong current from the southeast source toward the southwest fountains, and a sluggish current along the northeast bank; otherwise no streaming was noticeable. The crusts seemed thicker, and the heat radiation milder than the day before. Along the northeast bank the breaking up and sinking of crusts continued. The fume was thin, though thicker from the southeast bench.

July 27. At 10 a. m. the height of the lake was about the same as the day before. There had been some local, though no general collapse of benches. Avalanches took place at 9:56, 10:03, 10:45 a. m. Occasionally as many as six migratory fountains were observed in southwestern part of the lake. The north fountains were constant, though weakly active. The spasmodic fountain in the northeast was smaller and the spasms less frequent. There was a sluggish drift from the southeast source along the north margin, with local currents toward the bank. The fume continued thin, and thickness of crusts and heat radiation was the same as before.

July 28. At 9 a. m. the height of the lake was practically unchanged. Fresh reddish-brown scars indicated further collapse of benches, but nothing general. The main fountains were in the southwest part of the lake, three to five large ones, which migrated slowly to the bank. The lone spasmodic fountain in the northeast was more active than the day before. The streaming from the southeast source was very sluggish. The fume was thin, and the thickness of crusts and heat radiation moderate. The sounds were the splash of fountains, and a roar like distant surf from the northeast bench.

July 29. At 10 a. m. there had been considerable further collapse of benches, notably along the east side, and there a new delta-shaped bench a foot or so above the lake level had been formed. The fountains were active, about six near the southwest grotto, all of which were central and somewhat migratory. There were also four moderately active ones in the northeast part of the lake, and the spasmodic fountain in the northeast was



Fig. 10, July 27, 1923. Looking towards southwest chasm showing black ledge of July 4. Photo Emerson.

more active and had become double, the two parts being ten yards apart. There was strong streaming from the southeast source toward southwest fountains, and more moderate along the northeast bank, where the slow driving of crusts against the bank, with overthrusting of slabs, continued. The fume was thin, mostly from the southwest fountains and southeast bench. The heat radiation was moderately strong.

July 30. The height of the lake was not much changed. The fountaining mostly in southwestern part of the lake was variable, up to four marginal and five central fountains. The spasmodic fountains in the northeast were still active. The currents were generally sluggish. The fumes from the southwest fountains and southeast bench were thicker, but these were practically the only sources of fume. There was no material change in the benches. The new bench under east wall seemed to be partly covered with aa. A mass of black crusts had collected along the east margin, undisturbed by the thin crusted current from the southeast source.

July 31. At 4 p. m. the pit appeared stagnant, with slow streaming. At the most, there were four or five fountains, the principle ones in the southwest region being continuous or slightly migratory. The north half of the lake was heavily crusted. The southeast source was hot and bubbling as usual. The black ledge appeared fifty or sixty feet high on the north, and the lake about 170 feet below the rim. In the north central region there were isolated fountains. At night the pit was moderately bright.

LAVA MEASUREMENTS

Measurements of the depression of the mobile lava column, made with a transit, referred to the northeast station on the rim of Halemaumau pit (3,716 feet above sea level, for the month ending July 31, 1923, were as follows:

| Date | Time | Lake Southeast | Lake West |
|---------|-------------|----------------|-----------|
| July 2 | 8:45 a. m. | 132 | 139 |
| July 3 | 9:00 a. m. | 132 | 134 |
| July 4 | 9:00 a. m. | 127 | 128 |
| July 6 | 10:00 a. m. | 129 | 130 |
| July 7 | 10:00 a. m. | 136 | 136 |
| July 9 | 10:00 a. m. | 149 | 150 |
| July 10 | 8:30 a. m. | 147 | 156 |
| July 11 | 9:30 a. m. | 147 | — |
| July 13 | 10:00 a. m. | 145 | 147 |
| July 16 | 10:30 a. m. | 146 | 146 |
| July 17 | 9:30 a. m. | 146 | 146 |
| July 18 | 9:15 a. m. | 146 | 144 |
| July 21 | 10:00 a. m. | 140 | 142 |
| July 23 | 10:00 a. m. | 147 | 146 |
| July 25 | 9:15 a. m. | 145 | 149 |
| July 26 | 9:30 a. m. | 160 | 164 |
| July 27 | 9:15 a. m. | 162 | 166 |
| July 29 | 10:00 a. m. | 165 | 168 |

SEISMOMETRIC RECORD

During the month ending midnight July 31, 1923, forty-six local earthquakes and ten teleseisms were registered at the Observatory. These and other earth movements are exhibited below. Time is Hawaiian standard, 10 h. 30 m. slower than Greenwich.

Local Earthquakes.

| | | |
|--------|-------------|---|
| July 2 | 4:20 a. m. | Very feeble. |
| 3 | 5:37 a. m. | " " |
| 7 | 12:07 a. m. | " " |
| | 1:39 p. m. | " " |
| | 11:09 p. m. | " " |
| 10 | 9:21 p. m. | " " |
| | 9:22 p. m. | " " |
| 11 | 1:10 p. m. | Slight, distance 2 miles, NE-SW. |
| 16 | 6:55 a. m. | Very feeble. |
| 18 | 5:30 a. m. | " " |
| 19 | 1:00 a. m. | " " |
| | 3:52 p. m. | " " |
| 20 | 2:30 a. m. | " " |
| 21 | 1:22 a. m. | " " |
| | 12:10 p. m. | " " |
| | 2:36 p. m. | " " |
| | 2:41 p. m. | " " |
| 23 | 6:06 a. m. | Slight, distance 2 miles, NW-SE. |
| | 8:52 a. m. | Very feeble, continuous for 2½ minutes. |
| | 2:28 p. m. | Very feeble. |
| | 6:57 p. m. | " " |
| 24 | 9:08 a. m. | " " |
| | 9:30 a. m. | " " |
| | 8:29 p. m. | " " |
| | 8:50 p. m. | " " |
| 25 | 7:55 a. m. | " " |
| | 12:07 p. m. | " " |
| | 4:42 p. m. | " " |
| | 5:02 a. m. | " " |
| | 5:45 p. m. | " " |
| | 6:45 p. m. | " " |
| | 6:57 p. m. | " " |
| | 9:33 p. m. | " " |
| 26 | 7:55 a. m. | " " |
| | 7:56 a. m. | " " |
| 27 | 1:28 a. m. | " " |
| | 12:15 p. m. | " " |
| | 7:50 p. m. | " " |
| 28 | 1:45 a. m. | " " |
| | 2:02 p. m. | " " |
| | 7:12 p. m. | " " |
| | 7:13 p. m. | " " |
| | 11:03 p. m. | " " |
| 29 | 10:41 a. m. | " " |
| 31 | 9:37 a. m. | " " |
| | 10:04 a. m. | " " |

Teleseisms.

| | | |
|--------|-------------|---------|
| July 4 | 2:09 a. m. | Slight. |
| | 2:37 a. m. | " |
| 11 | 10:00 p. m. | " |
| 13 | 1:51 a. m. | " |
| 16 | 3:22 a. m. | " |
| 21 | 3:56 a. m. | " |
| 22 | 9:14 p. m. | " |
| | 10:45 p. m. | " |
| 25 | 9:18 p. m. | " |
| | 11:44 p. m. | " |

distance 2,600 miles.
Southern California.

Spasmodic Microtremor.

This type of tremor was slight throughout the month.

Harmonic Microtremor.

This type of tremor was moderate on the 5th and 6th, and slight on other days.

Microseismic Motion.

The amplitude of microseisms was slight throughout the month.

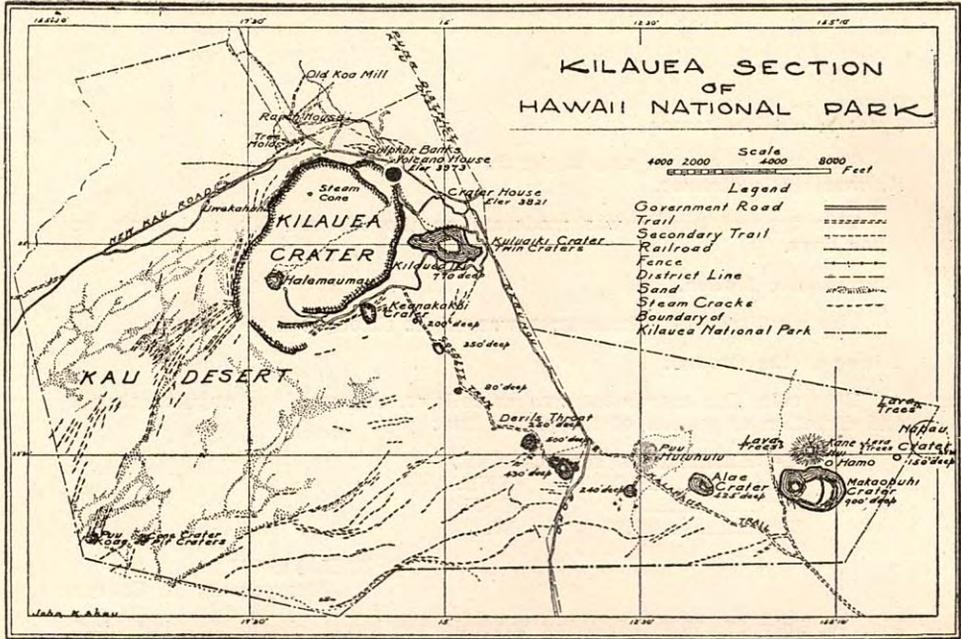
Tilting of the Ground.

By weeks this movement was as follows, expressed as angular change and direction of motion of the plumb line:

| | | | |
|----------------|-----|---------|------|
| July 1- 7..... | 4.0 | seconds | NNE. |
| 8-14..... | 0.2 | " | NNE. |
| 15-21..... | 2.7 | " | ENE. |
| 22-28..... | 1.8 | " | W. |

R. H. FINCH,
Temporarily in Charge.

Fig. 10, July 27, 1923. Looking towards southwest chasm showing black ledge of July 4. Photo Emerson.



Black spot shows location of Observatory.

All exchanges should be addressed to
HAWAIIAN VOLCANO OBSERVATORY,
 Volcano House P. O., Hawaii.

The Observatory is equipped with the following seismometric instruments rebuilt at the station in 1918 for the special needs of volcano research: two Bosch-Omori pendulums, high-speed registration of local earthquakes; one optically recording seismograph for distant earthquakes; one clinograph registering E-W tilting of the ground. A vertical component seismograph was in December, 1918, set up in experimental operation. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by wireless signal from the Pearl Harbor Naval Station. The chronometer is loaned by the University of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time. Observatory Lat. 19° 25' 54.2" N.; Long. 155° 15' 39.2" W.; Elevation 1214.6 meters (3985 feet).

HAWAII NATIONAL PARK.

This park was created by act of Congress August 1, 1916, and includes three famous volcanoes—Kilauea and Mauna Loa on Hawaii and Haleakala on Maui. Frequent passenger steamers ply between these islands and Honolulu.

Haleakala Section—Haleakala, "house built by the sun," a peak more than 10,000 feet high, carries an immense fissure-like crater 8 miles long and 3 miles wide, with walls 2000 feet high. Here, as well as on Mauna Loa and Mauna Kea, grows the Silver Sword (*Argyroxiphium*). Thirteen volcanic cones lie wholly within the crater, some rising nearly to the height of the summit. The scene at sunrise is marvelously beautiful.

Wailuku is the point of departure, automobiles taking the traveler to Olinda, a summer residence settlement 4043 feet high. After 2 hours drive to this point, saddle horses are taken to the summit, a ride of 3½ hours. Here is a fine concrete rest house, built by the citizens of Maui, and fully equipped with iron beds, blankets, stoves and dining utensils.

Mauna Loa Section—Mauna Loa, a vast dome 18,675 feet high, reached through forests of Hawaiian mahogany (koa) and trees fern, then up bril-

liantly colored lava slopes, has a summit crater 3 miles long by 1½ miles wide, with walls 700 feet high, and when in action fountains of fire froth are here jetted 500 feet into the air. Every five or ten years splendid spectacles of lava eruption are staged on the mountain, sometimes from the lower flanks.

There are trails on the Kona side, and also from the southwest, but the usual and best route is with saddle mules from the Kilauea section to Puu Ula-ula (9800 feet), a ride of six hours. Here there is a fully equipped cottage with stables and water supply. From this point on the second day a four-hour ride takes the visitor to the summit crater, where there is water. A right of way within the park connects Kilauea with Mauna Loa, where eventually a road will be constructed. The views are glorious and the chasms, cones and contorted lavas indescribably chaotic.

Kilauea Section—The lakes of foaming fiery lava within the crater of Kilauea form the most spectacular exhibit in the Hawaii National Park, if not in the world. The pit of fire, Halemauau, is inside of the main crater, at the apex of a broad, flat, inner cone. Kilauea is a dome volcano 4000 feet high, overridden by the lava slopes of Mauna Loa on the west, so that it seems but a spur of the greater, and perhaps younger, slag-heap mountain.

The Kilauea Park and the inner pit itself are both reached directly by automobile from Hilo, the second city of the Territory of Hawaii, and there are excellent hotel accommodations. The distance from Hilo is 30 miles. Within the park there are 15 miles of roads and about 20 miles of trails. As shown on the map, there are a dozen ancient pits within the area of the park, as well as cones, caverns and hot solfataras and a strange desert where lava flows have poured out of cracks as recently as 1920.

The live pit of Halemauau is easily accessible and not dangerous. Frequently one can walk to the actual edge of the splashing, fountaining lava lakes, the lava column rising and falling from year to year so that its most distinctive character is ceaseless change. At night the spectacle is full of marvelous color, and the region is a paradise for artists, photographers and naturalists.

The several sections are under the control of the National Park Service of the Department of the Interior. The United States Weather Bureau maintains the Hawaiian Volcano Observatory, which stands on the brink of the greater crater within the Kilauea Park.

U. S. DEPARTMENT OF AGRICULTURE

Weather Bureau

CHARLES F. MARVIN, Chief

MONTHLY BULLETIN

OF THE

HAWAIIAN VOLCANO OBSERVATORY

VOL. XI

HONOLULU, HAWAII, AUGUST, 1923

No. 8

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EXPLORATION OF SOUTHWESTERN RIFT OF MAUNA LOA

A party consisting of O. H. Emerson and the writer from the Observatory, with C. W. and M. L. Carlsmith as aides, guided by William Kama, left the Ontai ranch mountain house in South Kona, 5,400 feet above sea level, at 6:40 a. m. August 5. The ridge west of the Alika flow source was reached at 11 a. m. and the guide and pack animal sent back. New, 1919, cracks marked by sulphur stains were observed above Alika source cone for over half a mile. Camp was made the first night near a conspicuous red cone 8,500 feet above sea level. August 6th, the party left camp at 5:30 a. m., barometer reading 22.10 inches. The way until about 10,000 feet elevation was reached was for the most part over very old lava. A rift line marked by greatly weathered spatter was found at places between 9,000 and 11,000 feet. Along the rift line from about 11,000 feet to the Mokuaweoweo rim there were comparatively new cracks with very light pahoehoe spatter and flow adjacent. These flows looked very new and probably all date from 1916, 1919, or some other of the recent flows. Some idea of the rapidity with which the lava had gushed forth is shown by frozen lava 20-30 feet up on the sides of some cinder cones. There were no signs of broken blocks from a preliminary explosion.

All the cinder cones appeared to be older than the 1916 or 1919 outbreaks and there was no fresh pumice. Between 10,500 feet and 12,000 feet, hot steaming cracks with sulphur deposits were common. Many of the cracks held monoclinic sulphur crystals. A hot sulphur coated cinder cone was found at what appears to have been the location of the conspicuous red scar observed at about 11,000 feet from near the Alika source in 1919.

The new crack runs through both of the small crater near south crater of Mokuaweoweo. Both of these craters as well as rim of south crater were steaming and marked by fresh black pahoehoe lava. The night was spent at the lower of the two outer craters and by crawling into steam cracks the party managed to keep warm despite freezing temperature outside. Considerable snow was found in cracks around the craters.

A flat stretch of land was found between 8,500 feet and 9,500 feet. Several miles were covered during which the barometer reading was nearly constant. What appeared to be a somewhat disguised fault scarp that crossed the southwestern rift line at about a right angle was observed above the Mohokea region.

Aside from the flows of known date all the lava along the southwestern rift appears to be very old and lends weight to the contention that prior to the coming of the missionaries Mauna Loa, as far as southwest flank is concerned, had been quiet for a long time.

VOLCANIC CONDITIONS IN AUGUST

Activity of Halemaumau.

At the beginning of the month the lava in Halemaumau was 175 feet down and by the 5th the depression was 210 feet. Thereafter there was but little change in the level until the 23rd when a marked subsidence began. By the 24th the rate of fall had greatly increased and numerous earthquakes occurred. The origin of many of the earthquakes was in the Puna region between Puu Huluhulu and and Makaopuhi where the lava broke out on August 25th. On the 28th no molten lava was to be seen and the floor was about 560 feet down. Avalanches were frequent, repeating on a much smaller scale the dust clouds of 1922. During the remainder of the month there was no molten lava and the few glowing patches decreased both in number and brightness.

Activity by Makaopuhi.

The earthquakes had opened up a new set of cracks between Alae and Makaopuhi crater. The NE end of the crack is unknown, most of them terminating along the rift belt over which the Puna craters are located. The SW continuation of the cracks crosses the Kalapana trail over a zone nearly a mile wide parallel to and a little above the 1922 cracks. The lava that issued to cover a few acres to a very shallow depth is very frothy. Vigorous fountains played along the crack and often hurled large pieces of molten lava into the tops of nearby trees. Many trees not reached by lava were apparently shaken down during the earthquakes. Sometime previous to the outbreak the steam cracks west of Makaopuhi were reported to have become hotter and several months after the 1923 outbreak they were found to be much hotter than in 1922 and previous. Fumes emitted rendered exploration of the outbreak difficult until several days after the lava ceased to flow. Trees and ferns were killed for a distance of several hundred feet to the leeward.

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August 1. At 5 p. m. the streaming was more lively and the lake appeared lower than on July 31. There was strong puffing, spraying and flaming of fountains. There was bubbling in thirty or more spots. The lower ledge was 10 feet high in southeast. There was outward streaming from a crust along whole east bank of lake. Some of the turbulent foun-

tains expended themselves on the bank. The southwest fountains were continuous, but always changing number and pattern. From four to nine fountains were counted here and three or four other quieter dome fountains in north central region.

In the evening there were occasions when the pit was dull and no fountain fume in evidence. Later in the night the pit was bright and fume jets reappeared.

August 2. At 1:30 p. m. a red avalanche cloud arose from the north side of pit.

The lake was lower and still falling at 3 p. m. There were four to twelve fountains in action. The southwest fountains were small. The streaming from the southeast was from the bank itself. The skins were rather thin.

At 7 p. m. the appearance of the lake was peculiar with a suggestion of aa texture in glowing dots. The lava was falling and appeared to be about 190 feet down. A bright glowing or perhaps flame hole was observed in face of black ledge west-southwest. As many as twenty-two fountains were in the west half of the pit at times. The heat was strong.

August 3. At 3 p. m. the skins were thin and the lake very hot. Twenty-two earthquakes occurred during the day, ceasing toward evening. The lake was lower, about 200 feet down. The number of fountains had increased and were mostly in groups west of center and southwest wall. The streaming from the bank at southeast continued. There was much blistered skin on the lake. There was some indication of a pronounced sinking movement with perhaps increases about noon or shortly thereafter.

August 4. The lake was reported to be falling slowly. The fume was very thin.

August 5. The lake was much lower and the upper black ledge had fallen away in several places. There were six to eight fountains, one patch north of center, being somewhat rhythmic. There was outward streaming from the lake edge south-southeast, but inward streaming to the eastern wall.

August 9. During the afternoon there were from five to seven central fountains in western part of lake. The streaming was slow and northward. Much of the black ledge had scaled off, though still intact near southwest chasm.

August 10. At 9 a. m. the fountains varied in number and intensity. Bubbling at southeast source was very slight. Streaming was sluggish. The southeast source of streaming appeared to have moved further north and away from the bank.

August 11. Occasionally ten fountains were counted, some of which were strong. All were in the northwest part of the lake. The conditions at 11 a. m. were much the same as on the 10th.

August 12. At 11 a. m. the lake level was much the same as on the 11th. There were from two to six fountains in the western part of the lake. The crusts were thin, heat radiation moderately strong. The southeast source was quiet and fumes thin.

August 13. During the forenoon the fountains varied in number and intensity from hardly any to half a dozen large ones. All were in the southwestern part of the lake. There was slight bubbling at the southeast source.

At 5:30 p. m. there were from seven to ten fountains, and the lake appeared to be lowering.

August 14. At 10 a. m. the height of the lake was but little changed, about 220 feet down. Occasionally eight fountains were in action, mostly in the south and southwest. The southeast source was bubbling slightly.

The fume was thin, almost all of it coming from southeast fountains and southeast bench.

August 15. At 9 a. m. the lake appeared to be about 3 feet higher than on the 14th. Four strong central fountains were in action. The streaming was scarcely perceptible. At 10 a. m. a bright edge appeared around the lake.

August 16. At 9 a. m. the lake appeared to be about 2 feet lower than on the 15th. The number of fountains varied from three to ten, most of them being in the southwest and west parts of lake. The bubbling at the southeast source had increased slightly. The crusts were thin, heat radiation moderately strong, and the fume very thin.

August 17. At 8 a. m. the height of the lake was unchanged. All the fountains were in the western part of the lake and varied in number from zero to eight. There was sluggish streaming from the east. There was bubbling at the southeast source.

August 18. At 3 p. m. the height of the lake was unchanged. There were six strong fountains in the southwest part of the lake. Some sluggish streaming was perceptible.

August 19. The height of the lake was unchanged. The number of fountains varied from zero to ten, most of them being near margin in the west and north sides. The crust was thicker than for some days previously, and heat radiation was mild. The fume was thin.

August 20. During the forenoon the lake appeared much the same as on the 19th. Occasionally seven fountains were in action.

August 21. At 9 a. m. the lake had risen perceptibly since the 20th, though the general conditions were much the same. The fume had increased.

August 22. At 9 a. m. the lake had subsided about 5 feet as shown by a black ledge. The fountains had increased in number and were more active.

August 23. At 9 a. m. occasionally as many as six strong fountains were in action at once. The southeast source was crusted and quiet. Subsidence was indicated by a bright edge around the lake.

August 24. At 9 a. m. the lake was decidedly lower. The fountains were quieter and smaller than on the 23rd. The lake was generally sluggish. The fume was moderate. Occasional rock falls were heard.

During the afternoon the lava was lower, about 250 feet down, and about ten fountains were in action. There was a sluggish stream from the southeast source. Much Pele's hair was flying. Earthquakes were numerous from about noon on.

August 25. When observed during the forenoon the fall was still in progress. Two active fountain groups were in action, one under NNE bank, another in south center. The southeast source was quiet. Crusts were medium thick and broke up frequently, part of the breaking being due to avalanches.

At 3 p. m. the lake had fallen about 50 feet since morning and twelve islands of various sizes had appeared. About twenty fountains, mostly small, were in action. The fume had increased.

At 9 p. m. the lake was marked by bright line patterns. A lava stream moved out from the island under southeast wall. No fountains were in action, but a crack in the northeast floor occasionally shot spray to a height of about 100 feet, accompanied by a report like a high-powered rifle. Glow from the pit was slight.

August 26. At 10 a. m. the bottom of the pit was full of enormous cracks, jagged and tilted blocks. Scarcely any fire was visible except at



Fig. 11, Aug. 31, 1923. Looking toward east wall of Halemau mau from the southwest.



Fig. 12, Aug. 27, 1923. Fume from lava flow near Makaopuhi, from Puu Hululu. Alae crater in foreground and Kane Nui o Hamao at the left.

southeast source, where lava was streaming out of a crack. Later on this streaming stopped. Apparently there was a large mass of aa on the southeast side of the floor.

Some chauffeurs claim to have seen smoke toward Puna in the morning. No smoke could be seen from Uwekahuna at 1:30 p. m.

At 4 p. m. no material changes since morning were noted at Halemaumau.

August 27. A trip was made to the lava flow that had broken out just to the west of Makaopuhi, presumably on August 25. Puu Huluhulu was climbed at 10 a. m. and white fume was noticed above the region west of Makaopuhi. Seeing into the Puna country was good and no activity was visible. No flowing lava was visible at the recent outbreak, though a great quantity of fume was still rising. The outbreak locality was marked by many small new cracks. Some small new cracks were also observed near the east end of Alae crater.

Alec Lancaster reported that he saw smoke by Makaopuhi at 10:30 a. m. August 25th, while on the hill near the Devil's Throat.

August 28. At 10 a. m. Halemaumau was a tumbled mass of broken blocks about 560 feet down. The black ledge was largely intact, northwest, west, and southwest. The mass of matter was rather level, as seen from the west, like the Asama bottom of 1909. There was much aa among the fragments. The fume from the pit as a whole was thicker than before the subsidence, but the seeing was good.

At night about thirty glowing places were visible in the bottom between the crags, some of which were bright and probably flaming. Heavy avalanches were heard from the north ledge.

Lava Flow by Makaopuhi. A closer investigation showed a development of north-south crack west of Makaopuhi, in a region about 500 feet wide by 2,000 feet long. Some of the cracks on the edge of the belt emitted no gas, but toward the center of the belt the fume increased. Dense white fume rose from one major vent which could not be explored on account of acid gases. The new lava was a patch some two acres in extent at north end of the belt. The fumes were steaming and biting, probably containing considerable SO₃. Some sulphur was deposited around live solfataras, in the lava patch. The lava was mainly a shelly pahoehoe with some aa. There was much spatter and filaments on vegetation and on the ground, in the lava field. There were round holes and small cones along the cracks. The smoke was brown in transmitted light and more blueish and sulphury at north end of live area than at south end. Some of the old deep cracks showed renewed motion. There was no sign of lava at the south end of the new crack belt. There was no evidence of new activity at Makaopuhi. The usual steam cracks on the west edge, at top of inner talus north and lava of 1922 were much the same as in the last of May of that year. It should be noted that Mrs. James Judd in July reported extra hot cracks west of Makaopuhi.

August 29. The condition of the pit was unchanged. No fire was visible in the daytime. Avalanches fell occasionally.

August 30. The pit was much the same during the forenoon. One avalanche sent up a large dust cloud. The pit greatly resembled that of January 1923. There was a notable long slope of bench magma fragments over the big western talus of 1922, which did not slow but determined the grade.

An investigation of the Kau Desert rift of 1920 showed no new fume or other activity.

August 31. At 10 a. m. conditions at the pit were unchanged. There were occasional avalanches, one at 10:25 a. m. made the earth shake slightly at the pit.

LAVA MEASUREMENTS

Measurements of the depression of the mobile lava column below north-east rim of Halemaumau (3716 feet above sea level) for the month ended August 31, 1923, were as follows:

| Day | Time | Mean lake level |
|-----------|----------|--|
| August 5, | 10 a. m. | 210 ft. |
| " 9, | 3 p. m. | 216 " |
| " 11, | 10 a. m. | 221 " |
| " 13, | 9 a. m. | 223 " |
| " 15, | 9 a. m. | 220 " |
| " 20, | 9 a. m. | 211 " |
| " 21, | 9 a. m. | 208 " |
| " 22, | 9 a. m. | 214 " |
| " 23, | 9 a. m. | 206 " |
| " 24, | 9 a. m. | 220 " |
| " 25, | 9 a. m. | 342 " |
| " 26, | 10 a. m. | 553 " |
| " 29, | 9 a. m. | 564 " Rock at bottom of pit, no molten lava. |
| " 30, | 10 a. m. | 565 " " " " " " " " " " |

SEISMOMETRIC RECORD

During the month ended midnight August 31, 1923, one hundred and eighty-nine local earthquakes and two teleseisms were registered at the Observatory. These and other earth movements are exhibited below. Time is Hawaiian standard, 10 h. 30 m. slower than Greenwich.

Local Earthquakes. Abbreviations have meanings as follows: Vf-very feeble; f-feeble; s-slight; m-moderate; d-instruments dismantled; fl-felt locally; ✧-indicated distance in miles.

| Aug. | Aug. | Aug. |
|---------------------|--------------------------|---------------------|
| 1..... 3:51 a. s. | 11:45 p. vf. | 3:31 p. s.✧3 |
| 8:48 a. vf. | 4..... 12:40 a. vf. | 3:54 p. vf. |
| 2..... 12:24 p. vf. | 8:17 a. vf. | 4:23 p. vf. |
| 3:02 p. vf. | 10:09 a. vf. | 4:27 p. vf. |
| 10:48 p. vf. | 11:50 a. m.d.fl. | 4:46 p. vf. |
| 3..... 1:05 a. vf. | 12:00 a. m.fl. | 5:43 p. s.✧3 |
| 1:48 a. vf. | 12:25 p. vf. | 6:05 p. f. |
| 7:41 a. vf. | 12:52 p. m.d.fl. | 6:34 p. f. |
| 10:03 a. vf. | 2:05 p. vf. | 6:41 p. vf. |
| 10:05 a. vf. | 4:43 p. vf. | 6:42 p. vf. |
| 10:10 a. vf. | 8:07 p. vf. | 6:48 p. f. |
| 10:16 a. vf. | 10:16 p. s.✧4 | 7:00 p. vf. |
| 10:17 a. vf. | 5..... 1:09 a. vf. | 7:18 p. s.✧4 |
| 10:21 a. vf. | 3:28 a. vf. | 9:01 p. f. |
| 10:31 a. vf. | 5:35 a. vf. | 9:04 p. f. |
| 10:42 a. vf. | 9:47 a. vf. | 9:30 p. vf. |
| 10:47 a. vf. | 3:20 p. s.SE-NW.✧1 | 9:39 p. vf. |
| 10:53 a. vf. | 3:54 p. vf. | 9:42 p. vf. |
| 11:01 a. vf. | 6:10 p. vf. | 9:54 p. s.✧4 |
| 11:07 a. vf. | 6..... 5:00 a. s.✧4 | 10:01 p. vf. |
| 11:10 a. vf. | 7:03 a. vf. | 25..... 7:04 a. vf. |
| 11:14 a. vf. | 11:23 a. f. | 7:05 a. vf. |
| 11:20 a. vf. | 8..... 2:05 p. vf. | 7:06 a. s. |
| 11:22 a. vf. | 11..... 6:01 p. vf. | 7:17 a. s. |
| 11:25 a. vf. | 12..... 12:42 a. vf. | 11:45 a. vf. |
| 11:29 a. vf. | 13..... 11:33 a. vf. | 12:15 p. f. |
| 11:30 a. vf. | 15..... 4:53 a. f. | 12:17 p. s. |
| 11:33 a. f. | 9:00 p. f. | 1:16 p. s. |

| Aug. | Aug. | Aug. |
|-------------------|-----------------------|----------------------|
|11:34 a. s. | 16..... 6:27 p. vf. | 1:20 p. s. |
|11:35 a. vf. | 18..... 8:55 a. vf. | 2:20 p. vf. |
|11:40 a. vf. | 24.....11:35 a. vf. | 3:03 p. f. |
|11:47 a. vf. |12:30 p. vf. | 4:12 p. f. |
|11:54 a. vf. |12:40 p. vf. | 4:30 p. s. |
|11:57 a. vf. |12:52 p. f. | 5:28 p. vf. |
|11:59 a. vf. |12:59 p. s.↗2 | 6:22 p. f. |
|12:02 p. vf. | 1:08 p. vf. | 7:07 p. vf. |
|12:03 p. vf. | 1:12 p. vf. | 7:52 p. vf. |
|12:04 p. vf. | 1:13 p. vf. |10:08 p. vf. |
|12:14 p. vf. | 1:14 p. vf. |10:34 p. vf. |
|12:20 p. vf. | 1:15 p. vf. |10:38 p. f. |
|12:48 p. vf. | 1:16 p. vf. | 26..... 1:07 a. f. |
|12:50 p. vf. | 1:17 p. vf. | 1:14 a. f. |
| 1:06 p. vf. | 1:19 p. vf. | 1:54 a. vf. |
| 1:08 p. f. | 1:20 p. vf. | 1:58 a. vf. |
| 1:09 p. vf. | 1:24 p. vf. | 1:59 a. vf. |
| 1:12 p. vf. | 1:37 p. s. | 2:59 a. vf. |
| 1:23 p. vf. | 1:39 p. vf. | 3:01 a. vf. |
| 2:00 p. vf. | 1:40 p. s. | 3:44 a. f. |
| 2:02 p. vf. | 1:41 p. f. | 4:05 a. vf. |
| 2:07 p. vf. | 2:02 p. vf. | 4:07 a. f. |
| 2:14 p. vf. | 2:05 p. vf. | 4:18 a. vf. |
| 2:50 p. vf. | 2:07 p. vf. | 4:22 a. vf. |
| 2:51 p. f. | 2:11 p. vf. | 7:18 a. vf. |
| 2:52 p. vf. | 2:35 p. s. | 7:44 a. vf. |
| 2:54 p. vf. | 2:37 p. s. | 9:10 a. vf. |
| 2:54 p. s. | 2:38 p. f. |12:10 p. vf. |
| 3:04 p. vf. | 2:41 p. m.EW.d. | 1:57 p. f. |
| 3:06 p. f. | 3:02 p. f. | 2:11 p. vf. |
| 3:44 p. s. | 3:04 p. f. | 2:21 p. vf. |
| 3:47 p. vf. | 3:08 p. vf. | 8:24 p. vf. |
| 3:53 p. s. | 3:09 p. vf. | 8:25 p. s. |
| 7:19 p. f. | 3:10 p. vf. | 31..... 1:56 a. f.↗2 |
| 8:13 p. vf. | 3:27 p. s. | |

Teleseisms.

Aug. 28..... 1:06 p. m. Slight.
 31..... 4:38 p. m. Strong. 4175 miles Japan.

Spasmodic Microtremor.

This type of tremor was slight throughout the north.

Harmonic Microtremor.

This type of tremor was moderate on 25, 26, and 27th and slight on other days.

Microseismic Motion.

The amplitude of microseisms was moderate on the 18th and 19th and slight on other days.

Tilting of the Ground.

By weeks this movement was as follows, expressed as angular change and direction of motion of the plumb-line:

| | | | |
|----------------------|-----|---------|------|
| July 29—Aug. 4..... | 1.9 | seconds | NNW. |
| August 5-11 | 0.3 | " | SSE. |
| " 12-18 | 0.4 | " | N. |
| " 19-25 | 1.5 | " | ESE. |
| Aug. 26—Sept. 1..... | 2.9 | " | NW. |

R. H. FINCH,
 Temporarily in Charge.

U. S. DEPARTMENT OF AGRICULTURE
Weather Bureau
CHARLES F. MARVIN, Chief
MONTHLY BULLETIN
OF THE
HAWAIIAN VOLCANO OBSERVATORY

VOL. XI

HONOLULU, HAWAII, SEPTEMBER, 1923

No. 9

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GENERAL MAP, KILAUEA SECTION, HAWAII NATIONAL PARK

Activity of Halemaumau.

There was no molten lava in Halemaumau from August 27th until the evening of September 4th when a flow broke out near the southeast wall of the pit. The depth of the pit which at beginning of month was about 565 feet steadily decreased mainly by accumulation of lava flows until at end of month the molten lava was a little less than 400 feet down. On September 6th another source of upwelling lava appeared in southwest center of pit. A third source well manifested itself on September 11 at a place in south side of pit which had been fuming for several days. The southeast and south sources were at about the same location of the two main source wells of the spring and summer of 1922. On September 19 a source fountain appeared in the north side of pit. Two well defined pools were apparent by September 23, one being fed by the southeast source and the other by the south and southwest sources. On the 27th a poorly defined pool was observed near the north source cone. The three pools and the same general arrangement continued at the end of the month. The rise on the whole was quite continuous though there were slight fluctuations. There was considerable fountaining, especially at times of the slight subsidences.

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September 2. At 4 p. m. the pit was quiet, with thin fume from three of four cracks in the bottom. On the west side of the pit there were at least four benches of bench magma corresponding with the submerged talus of 1922.

September 3. The southern fume crack had stopped, but the northern one was pouring out a dense white column, making the pit hazy. Occasional rock falls took place, with one big avalanche at 2:30 p. m.

Puu Huluhulu was visited at 11 a. m. and from there the fume of the Makaopuhi outbreak was observed to have greatly dwindled. There were three puffing places, of which the middle one was pouring out most of the white vapor. There was blue gas over all three.

September 4. During the day the fume was reported to have become denser. At 9:30 p. m. a dull intermittent glow was observed over the pit from the Observatory. During the night the glow was said to have become more constant, though not perceptibly brighter.

September 5. At 10 a. m. there was a moderately strong spasmodic fountain at the southeast source, overflowing into the pit. The stream was then some 75 yards long by 30 wide. The south, west, and north fumaroles were pouring out dense white fumes, making the pit so hazy that transit measurements were impossible.

At 5 p. m. the stream had gone 250 yards. The fume was still dense, but had no odor of sulphur dioxide. The cracks near the southwest chasm that had been quite cool during the subsidence, were now much hotter.

September 6. At 10 a. m. the flow had progressed somewhat further, but was going very sluggishly. The southeast fountain was much weaker than the day before, but was still noisy. The fume was coming from the same sources as the day previous, but was somewhat thinner. At 5 p. m. a new lava stream broke out from a crack in the southwest center of the pit, the lava pouring out quietly.

September 7. At 9 a. m. the fume was dense, with the south fumarole in particular pouring out thick clouds. The flowing from the southeast source had increased, with a double spasmodic fountain. The pool was heavily crusted, but in several places the lava was pouring in steady streams from under the crusts. The small flow of the previous afternoon was dead and cold. At 4 p. m. the fume was notably thinner, the north fumarole having practically stopped. The lava was scarcely flowing at all.

September 8. From 10 a. m. to noon the pool was crusted, with the lava flowing from underneath the crusts in several places, and with moderate speed. There was no fountaining at the source. The fume was thinner even than the previous afternoon. Frequent avalanches took place, some of which were large.

September 9. At 10:30 a. m. the pool was crusted, with the lava flowing quietly from under the crusts. No fountaining. The pit was smoky. At 9 p. m. there was more activity, a small fountain at times playing in the southeast well, with streaming toward it. A small flow of lava oozed out of a crack in the southwest center of the pit, near where the flow of September 6 had taken place. There was a strong hissing cone near the new flow.

September 10. At 10 a. m. the lava was not flowing actively, and there were only a few live toes. The crack near southwest center was hissing strongly. Most of the fume was coming from the southwest source.

September 11. Between 10 and 12 a. m. the lava was flowing from the southeast well somewhat more rapidly than before. The south fumarole was now the source of a small flow, and was giving off but little fume. The area covered by the fresh lava was about one-sixth of the floor of the pit. The hissing from the southwest continued. The fume in the pit was thin.

September 12. The flow from the south source was much more rapid, tumbling into the main pool over a twenty foot cascade. The southwest crack which had been so noisy was now discharging a small flow, and making much less noise. The southeast source was a miniature lake, some 45 to 60 feet, crusted most of the time, but occasionally the crusts broke up with strong fountaining, rapid streaming and subsidence. The southeast well was building itself up as a dome considerably higher than the main pool which it fed.

September 13. Fed by the various sources, the pool had risen considerably. The south source was crusted, and no fire was visible there, though it was puffing somewhat noisily. The southeast source was behaving as it was on the day before. The fume was thin.

September 14. The south source puffed noisily, and the southwest source was fuming, though no lava flowed. The southeast source was pouring out a vigorous stream from under crusts. The total area covered by fresh lava was now about one half of the floor of the pit. The crusts on the main pool were breaking up more actively than before. The fume was still thin.

September 15. Flowing from the south source had been resumed, and the hissing continued. The southwest source was still fuming, but showing much heat in cracks. A voluminous flow from the southeast source was interrupted occasionally by sharp subsidences with vigorous fountains lasting two or three minutes. The southeast source was continuing to build itself up as a dome. The pool had risen and extended itself almost to the south source. Late in the afternoon a strong puffing place developed near the southeast source, which at times exploded with a deep roar.

September 16. The southeast source was behaving as it was on the day before, and continuing to pour out rapid flows. The south source was also pouring out lava, and was being buried by the rising lake. The southwest source was building itself up as a tall chimney, fuming and showing much heat through cracks. During the afternoon the puffing and exploding near the southeast source was resumed. The action suggested a gas channel getting choked with pasty lava. The fume continued thin.

September 17. The main pool had risen markedly, and had built ramparts around itself so that there was low ground under NNE station that was 25 feet below the level of the lake. On account of the ramparts the southeast source was no longer feeding the lake, but was flooding the low ground outside of it. The south and southeast sources were pouring out abundant streams. The southwest cone had split on the east side, and from it gushed a stream of orange yellow lava like water of an artesian well. Nearly two-thirds of the floor of the pit was covered with fresh lava, and the heat radiation was strong. Many places among the slabs were giving off small clouds of fume, and when the southeast well broke up with powerful fountaining, much bluish fume escaped.

September 18. The lake had risen markedly, and all three sources were active. There was a very fast flow from the southeast source to the low area under NNE station. The lake was rising faster than the southeast dome could build itself up, and the latter was being engulfed. The fume continued thin. Occasionally the southeast source broke up with vigorous fountaining.

September 19. A new source fountain had broken out under north station, and was flooding the surrounding bench. The southwest cone was active with bubbling lava, but the south and southeast sources appeared quiet. The southeast dome was wholly submerged by the rising lake. The breaking up of crusts was active, and the heat radiation strong. The fume was generally thin, the main source being the southwest cone.

September 20. The lake was rising and expanding, and now covered about eight-tenths of the floor of the pit. All four sources were active, the north and south ones as fountains in the lake, and the southeast and southwest ones as cones belching out lava. There was much flowing lava, and the heat radiation was strong. The ramparts were not wholly broken down, so that there was much relief in the lava covered area. Near the southeast source there were a number of islands which looked like mud islands eroded by running water. The fume was thin.

September 21. From 2 to 4 p. m. the lake had risen to cover the entire floor, with the exception of half a dozen islands. All four sources tended to build themselves up as cones, the tendency being least with the south source. There was but little noise, and the fountaining generally was weak.

September 22. At noon the lake was rising, and all the sources were building cones. The fountains were small, and there was but little hissing. The fume was very thin.

September 23. The tendency for the pit to form two pools was very apparent in the afternoon. The southeast source pool was about 250 to 300 feet long and 200 wide. The main pool was in the southwestern part of the pit, including the south and southwest, but not the north sources. It occupied between a quarter and a third of the floor of the pit. Both pools were building ramparts around themselves, which they were almost continuously overflowing, flooding the lower portions of the floor. The southeast pool occasionally broke up with active fountaining and strong streaming with subsidence. No streaming was visible in the main pool except near the breaks in the ramparts through which it was pouring. The southwest cone was broken down on one side, and a vigorous fountain played there. The south cone had vanished and a weak fountain marked its former site. The north cone was inactive except for hissing. The fume was very thin.

September 24. The southeast source was crusted and quiet, and sunk in its cup. The north source was also inactive, and the south one weakly active. The southwest fountain was very constant and active, with some streaming away from it. The main pool was about 750 feet long by 350 feet wide, and somewhat more walled in than on the day before. A rapid and voluminous stream was pouring from it to the northeast, bright red as it fell over the rampart. The skins on the main pool were medium thick, though thin and blistered in the vicinity of the southwest fountain. The fume was thin, and the heat radiation strong.

September 25. At 11 a. m. the pools were crusted, and with only moderate fountains at the north, south, and southwest sources. A new fountain had appeared in the northeast part of the main pool, almost in the geometrical center of the floor. A cone in the southeast source region at times belched lava. Both pools were full to the brim, but not overflowing appreciably. The fume was very thin.

September 26. Early in the day the southeast source pool was moderately active, but late in the afternoon it sank about 15 feet. Occasionally there was a breaking up and sinking of the crusts over it. The chief activity was at the other three sources, which poured out much lava, though the southwest source was less active than on the day before. The north source was intermittently active. The building of the ramparts continued through the day.



Fig. 13, Sept. 20, 1923. Looking towards south and southwest source cones from southeast rim of Halemaumau. Photo Emerson.

September 27. From 11 a. m. to noon the southwest source fountain was constant and vigorous. The south source fountain had only occasional feeble outbreaks of short duration. The southeast pool was shaped like an oyster shell, crusted, sunken, and wholly inactive. The north cone was hissing, but not showing much live lava. The small pool between it and the north wall exhibited breaking up and sinking of crusts. It had never been very active before, and had only weakly developed ramparts. The pool appeared to be about 350 feet in diameter. At 10:50 a. m. the main pool broke up with active fountaining and rapid streaming to the southeast corner. It had a slight subsidence, but soon recovered and overflowed the southwest embankment. An area of old flat pahoehoe in the northeast part of the pit had broken, forming ridges of pahoehoe slabs and aa, resembling sections of the floor of Mokuaweowoe. The fume continued extremely thin, with a number of minor sources. There were some white solfataric deposits near cracks in the eastern part of the floor.

September 28. The main pool had sunk slightly. The southwest fountain was constant and active, with occasional weaker ones, usually in the south cove of the main pool, accompanied by rapid streaming and subsidence. The southeast pool was quiet and crusted, but a cone east of it was hissing strongly and emitting small amounts of lava. The north cone had become a moderately active grotto. The north pool was crusted and brimful. The fume was slightly denser than the day before.

September 29. From 10:30 a. m. to noon the main pool was crusted, with constant fountaining on a small scale at the south grotto and occasionally elsewhere. The southwest fountain was inactive. The southeast pool was full, and the cone next to it was pouring out a small flow. Two strong streams came from the north cone, one flowing east, and the other west. The limits of the north pool, if such existed, were extremely vague. The fume was extremely thin, the main source being the southeast cone. At 4 p. m. the main pool had risen, and was overflowing the southeast bank with vigor. The southwest fountain was very strongly active, throwing large gobs of lava to a height of 30 to 40 feet. The southeast pool was active for a short time with a breaking up of crusts. The north cone was pouring out less lava than during the morning.

September 30. At 2:30 p. m. the main pool was overflowing the south and southwest bench somewhat sluggishly. It had built up high ramparts along the east side. The southwest fountain was active, but the south grotto scarcely so. The southeast cone was hissing and pouring out a small flow, and the north cone was quiet. At 3:20 there was a breaking up of crusts on the west bay of the main pool.

LAVA MEASUREMENTS

Measurements of the depression of the mobile lava column below the northeast station on rim of Halemaumau (3716 feet above sea level) for the month ended September 30, 1923, were as follows:

Highest lake level

| | |
|------------------|----------|
| September 8..... | 516 feet |
| “ 11..... | 476 “ |
| “ 16..... | 457 “ |
| “ 21..... | 448 “ |
| “ 22..... | 440 “ |
| “ 24..... | 419 “ |
| “ 28..... | 404 “ |
| “ 29..... | 398 “ |

SEISMOMETRIC RECORD

During the month ended midnight September 30, 1923, thirty-five local earthquakes and one teleseism were registered at the Observatory. These and other earth movements are exhibited below. Time is Hawaiian standard, 10 h. 30 m. slower than Greenwich.

Local Earthquakes.

| | | |
|--------------|-------------|-----------------------------------|
| Sept. 1..... | 4:03 a. m. | Very feeble. |
| | 7:33 p. m. | " " |
| 3..... | 5:26 a. m. | " " |
| | 2:20 p. m. | " " |
| 8..... | 5:33 a. m. | " " |
| | 5:13 p. m. | " " |
| 9..... | 9:23 p. m. | " " |
| 12..... | 7:17 p. m. | " " |
| 14..... | 10:25 a. m. | " " |
| | 5:17 p. m. | Slight, distance 14 miles, SW-NE. |
| 16..... | 11:21 a. m. | Very feeble. |
| | 12:30 p. m. | " " |
| | 6:25 p. m. | " " |
| | 11:44 p. m. | " " |
| 17..... | 9:31 p. m. | " " |
| | 11:45 p. m. | " " |
| 20..... | 5:11 a. m. | " " |
| 21..... | 1:53 a. m. | " " |
| | 11:37 p. m. | " " |
| 22..... | 12:33 a. m. | " " |
| | 3:36 a. m. | " " |
| | 2:37 p. m. | " " |
| 23..... | 11:39 a. m. | " " |
| | 11:40 a. m. | " " |
| 24..... | 12:32 a. m. | " " |
| 25..... | 12:44 p. m. | " " |
| | 10:34 p. m. | Feeble. |
| 26..... | 1:48 p. m. | Very feeble. |
| | 1:49 p. m. | " " |
| 27..... | 1:00 p. m. | " " |
| 29..... | 1:06 a. m. | Feeble. |
| | 10:00 a. m. | " " |
| | 5:29 p. m. | Very feeble |
| | 5:31 p. m. | " " |
| | 8:14 p. m. | " " |

Teleseism.

September 1.....4:40 p. m. Slight.

Spasmodic Microtremor.

This type of tremor was slight throughout the month.

Harmonic Microtremor.

This type of tremor was very slight throughout the month.

Microseismic Motion.

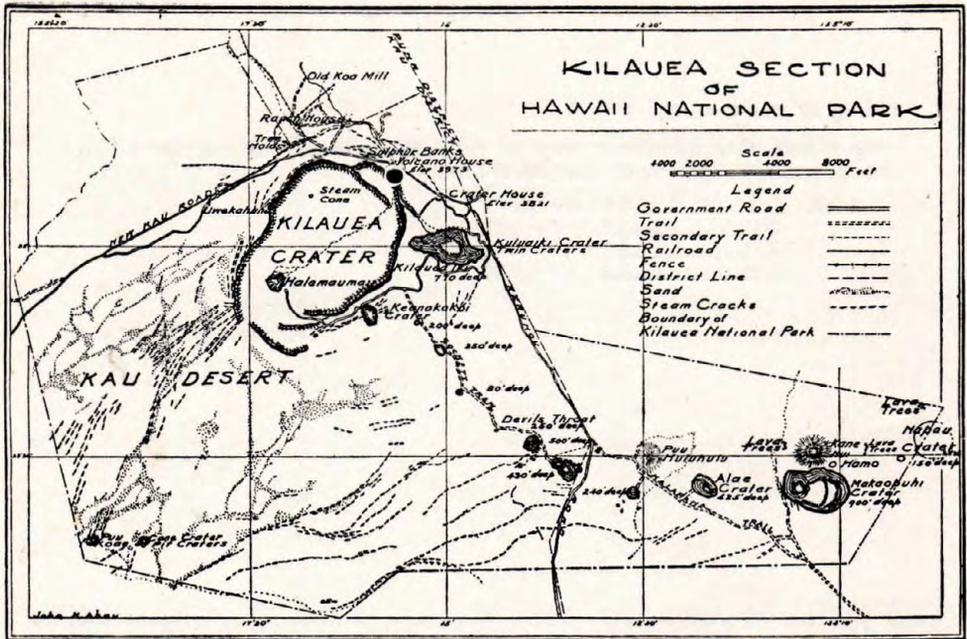
The amplitude of microseisms was moderate on the 12th, 17th and 30th and slight on other days.

Tilting of the Ground.

By weeks this movement was as follows, expressed as angular change and direction of motion of the plumb-line:

| | | | |
|-----------------|-----|---------|------|
| Sept. 2- 8..... | 0.4 | seconds | W. |
| 9-15..... | 1.3 | " | ENE. |
| 16-22..... | 0.7 | " | SE. |
| 23-29..... | 1.9 | " | N. |

R. H. FINCH,
Temporarily in Charge.



Black spot shows location of Observatory.

All exchanges should be addressed to

HAWAIIAN VOLCANO OBSERVATORY,

Volcano House P. O., Hawaii.

The Observatory is equipped with the following seismometric instruments rebuilt at the station in 1918 for the special needs of volcano research: two Bosch-Omori pendulums, high-speed registration of local earthquakes; one optically recording seismograph for distant earthquakes; one clinograph registering E-W tilting of the ground. A vertical component seismograph was in December, 1918, set up in experimental operation. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by wireless signal from the Pearl Harbor Naval Station. The chronometer is loaned by the University of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time. Observatory Lat. 19° 25' 54.2" N.; Long. 155° 15' 39.2" W.; Elevation 1214.6 meters (3985 feet).

HAWAII NATIONAL PARK.

This park was created by act of Congress August 1, 1916, and includes three famous volcanoes—Kilauea and Mauna Loa on Hawaii and Haleakala on Maui. Frequent passenger steamers ply between these islands and Honolulu.

Haleakala Section—Haleakala, "house built by the sun," a peak more than 10,000 feet high, carries an immense fissure-like crater 8 miles long and 3 miles wide, with walls 2000 feet high. Here, as well as on Mauna Loa and Mauna Kea, grows the Silver Sword (*Argyroxiphium*). Thirteen volcanic cones lie wholly within the crater, some rising nearly to the height of the summit. The scene at sunrise is marvelously beautiful.

Wailuku is the point of departure, automobiles taking the traveler to Olinda, a summer residence settlement 4043 feet high. After 2 hours drive to this point, saddle horses are taken to the summit, a ride of 3½ hours. Here is a fine concrete rest house, built by the citizens of Maui, and fully equipped with iron beds, blankets, stoves and dining utensils.

Mauna Loa Section—Mauna Loa, a vast dome 13,675 feet high, reached through forests of Hawaiian mahogany (koa) and tree fern, then up bril-

liantly colored lava slopes, has a summit crater 3 miles long by 1½ miles wide, with walls 700 feet high, and when in action fountains of fire froth are here jettied 500 feet into the air. Every five or ten years splendid spectacles of lava eruption are staged on the mountain, sometimes from the lower flanks.

There are trails on the Kona side, and also from the southwest, but the usual and best route is with saddle mules from the Kilauea section to Puu Ula-ula (9800 feet), a ride of six hours. Here there is a fully equipped cottage with stables and water supply. From this point on the second day a four-hour ride takes the visitor to the summit crater, where there is water. A right of way within the park connects Kilauea with Mauna Loa, where eventually a road will be constructed. The views are glorious and the chasms, cones and contorted lavas indescribably chaotic.

Kilauea Section—The lakes of foaming fiery lava within the crater of Kilauea form the most spectacular exhibit in the Hawaii National Park, if not in the world. The pit of fire, Halemauau, is inside of the main crater, at the apex of a broad, flat, inner cone. Kilauea is a dome volcano 4000 feet high, overridden by the lava slopes of Mauna Loa on the west, so that it seems but a spur of the greater, and perhaps younger, slag-heap mountain.

The Kilauea Park and the inner pit itself are both reached directly by automobile from Hilo, the second city of the Territory of Hawaii, and there are excellent hotel accommodations. The distance from Hilo is 30 miles. Within the park there are 15 miles of roads and about 20 miles of trails. As shown on the map, there are a dozen ancient pits within the area of the park, as well as cones, caverns and hot solfataras and a strange desert where lava flows have poured out of cracks as recently as 1920.

The live pit of Halemauau is easily accessible and not dangerous. Frequently one can walk to the actual edge of the splashing, fountaining lava lakes, the lava column rising and falling from year to year so that its most distinctive character is ceaseless change. At night the spectacle is full of marvelous color, and the region is a paradise for artists, photographers and naturalists.

The several sections are under the control of the National Park Service of the Department of the Interior. The United States Weather Bureau maintains the Hawaiian Volcano Observatory, which stands on the brink of the greater crater within the Kilauea Park.

U. S. DEPARTMENT OF AGRICULTURE
Weather Bureau
CHARLES F. MARVIN, Chief

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GENERAL MAP, KILAUEA SECTION, HAWAII NATIONAL PARK

VOLCANIC CONDITIONS IN OCTOBER

The general arrangements of pools and source wells in Halemaumau was much the same in October as in the latter part of September. The main pool was at southwest edge of pit and was fed by the south and southwest source wells. The source well of the southeast pool was at the southeast end. The north pool appeared to have but one source well. Occasionally following rapid rising the outlines of these pools were quite vague. On October 16th when the pools were depressed within their cups three islands appeared in the main, or southwest pool. A cone persisted at the southeast source while the other sources were marked by nearly continuous fountaining in the surrounding lava pools. The fountaining was mostly at the sources though occasionally strong fountaining occurred at various places in the different pools. The depression of the lava at the beginning of the month was 388 feet below rim and during October as a whole the lava rose quite uniformly averaging 2.5 feet per day. Slight sinkings were noted on the 10th, 16th, 19th, 20th, and 30th.

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October 1. At 11 a. m. the main pool was pouring out a rapid stream to the northeast. The southwest fountain was vigorous, and the south grotto moderately active. Breaking up of crusts was frequent. The ramparts around the pool were well defined, and in some places fully 10 feet high. The southeast and north pools were crusted and quiet, the former sunk in its cup, and the latter full. The north pool measured about 300 by 200 feet. The fume continued extremely thin.

October 2. At 11 a. m. the main pool was slightly sunk in its cup, but soon rose and overflowed the bench in five places. The southwest fountain was constant and vigorous, and the south grotto weakly active, although it had been building up a high cone. There were occasionally other fountains, which were sometimes strong. The southeast pool was quiet, but a cone just east of it had poured out a considerable flow to the north, and had built itself up 10 to 15 feet. It was now fuming slightly. The north pool was much more indefinite in shape than on the day before, and looked as though it might extend several hundred feet to the west. The north cone was moderately active.

October 3. At 11 a. m. the main pool was somewhat sunk in its cup. The southwest fountain was quiet most of the time, but the south grotto was more active than before, and was the source of streaming. At times there were as many as five fountains in the main pool, several of which were very vigorous. The north cone was markedly more active, and was the source of streaming in the north pool. In it were several areas covered with broken slabs which looked like islands, some of which were fuming. The southeast cone was fully 20 feet high, and was more active than it had been for some time. The southeast pool was full, and showed more activity in fountaining and breaking up of crusts. The fume was thicker than it had been, but was still thin. The heat radiation was strong.

October 4. At 11 a. m. the pools were full, and the main one overflowing in five places. The margins were vague, with the exception of the east rampart of the main pool. The southwest fountain was quiet, but the south and north grottoes were very active and constant, and were sources of streaming. The southeast cone was quiet. At times both the main and north pools broke up with rapid streaming and very powerful fountaining. The fume was slightly thicker. The heat radiation was strong.

October 5. At 8:30 a. m. the various pools appeared to be uniting, the main pool was overflowing into the southeast one, and a large section of the rampart near the south grotto had collapsed, making it an island. The south grotto was constant and powerfully active, throwing large gobs of lava 20 to 30 feet, and smaller particles fully 50 feet high. The southwest and southeast fountains were quiet, and the north grotto was much less active than it had been. The fume was thin, and the heat radiation strong.

October 6. At 3 p. m. the pools were sunk in their cups, quiet and crusted. The subsidence had been recent, as the lava was slowly streaming into the main pool from a low area to the northeast, which it had just been flooding. Then the main pool started to rise, with breaking up of crusts near the south grotto and very powerful fountaining and streaming away from the fountains. Soon after the fountains died down to moderate activity. The north pool was clearly revealed, being some 300 feet long by 200 wide. The southeast pool was somewhat enlarged, and nearly round.

October 7. At 11 a. m. the north and main pools were full, and the edge of the latter was ill defined along the south and east sides. It appeared to be enlarging greatly to the southward. The southeast pool was also enlarging by the faulting and sinking of blocks around the rim. The south and southwest fountains were active, and the north grotto somewhat feebly so. At times there were as many as seven fountains in the main pool. The southeast pool was generally quiet, with occasional breaking up of crusts. There were two main sources of fume, both in the bench near the east end of the main pool, but as a whole the fume was very thin. The heat radiation was moderately strong.

October 8. At 11:30 a. m. the north pool was full, but the southeast and main pools were sunk in their cups. The fountaining was weak, the north and southeast cones were merely puffing, and south and southwest fountains moderately active. Occasional other fountains accompanied break-

ing up of crusts. The south and west benches of the main pool were only about 4 feet high, while the north and east ones were fully 10 feet, indicating tilting of the floor of the pit. Some large cracks were forming in the bench at the east end of the main pool. The main pool had extended itself 100 to 150 feet to the southeast. Several places along the rampart at the east end of the main pool were giving off dense white fume, making the pit hazier than it had been since the rise had gotten well under way. There was but little exposed lava, and the heat radiation was mild.

October 9. At 9 a. m. the main pool had flooded the bench, and appeared to extend to the main wall of the pit. There was a distinct rampart extending across the floor over which the lava poured in four strong streams. The southeast pool was joined to the main one, and as a separate unit ceased to exist. The north pool was also flooding the surrounding bench. There was constant and powerful fountaining over the south well, and at times as many as seven short lived fountains elsewhere. The north and southeast cones were moderately active and pouring out some lava. At times the north pool broke up with strong fountaining, rapid streaming, and subsidence. The fume was much thinner than it had been on the day before. The crusts were thin, and the heat radiation almost unbearable.

October 10. The main and southeast pools were still joined, but sunk in their cups, and much smaller than they appeared the day before, and were surrounded by a rim of crags ranging up to 10 feet in height. The fountaining generally was much weaker than on the day before, though all four source fountains were active. The crusts were thicker, and the heat radiation mild. The fume was very thin.

October 11. At 2 p. m. the main pool was surrounded by crags ranging up to fifteen feet in height, and the southeast gulf had become a sinking region, with a steady and at times rapid stream flowing into it. However, the southeast cone was pouring out a small flow onto the bench east of the gulf, which at times cascaded into the main pool. The fountaining was moderate, with all four source fountains somewhat active. The north cone was hissing strongly, and the north pool was full, with indefinite limits. The large sunken area east of the north pool appeared cold. The west wall of the southeast gulf was made of aa, which glowed like a coal fire at 2 p. m. but later cooled off. The fume continued thin.

October 12. At noon the situation was much like that of the day before, except that a ledge had risen, severing the southeast pool from the main pool. Both southeast and main pools were sunk in their cups, though the north pool was overflowing. The benches appeared to have risen somewhat. The north cone was very noisy; the southeast one was still pouring out a small flow that was cascading into the southeast pool. The fountains in the main pool were somewhat weak. During the afternoon the pit became more active, and the glow during the evening was brilliant.

October 13. At 10 a. m. the pools had risen, and drowned almost the entire bench. A few islands remained in the west part of the pit, and some in the east part. At only two places was there rapid streaming, one at the west end of the main pool, where an undrowned wall constricted the current, and the other on the edge of the north pool, where the lava from the main pool was pouring into it. The fountaining was variable, up to eight fountains, some of which were at times powerful. There were two constant fountains over the southeast source, the south grotto was active, and the north one feebly so. No activity was visible at the southwest well. The fume was thin, coming from an island. The crusts were thin, and the heat strong.

October 14. At 10 a. m. the main pool had taken on definite limits, and occupied the entire east half of the pit, the southeast pool, and the sunken area to the northeast. It extended to the main wall in several places, but usually there was a margin of bench up to 75 feet wide. The fountaining

was at times powerful, the strongest one appearing intermittently in the western end of the main pool. Constant and moderately powerful fountains played over the four source wells. The north pool was full, with indefinite limits. The fume was thin, but contained more sulphur dioxide than it had for a long time, so that it was at times unpleasantly strong.

October 15. At 10 a. m. the appearance of the two pools was similar to that of the day before. The main pool was some what more sunk in its cup. There was no fountaining over the south and southeast wells, but there were many fountains elsewhere, up to about 20, varying greatly in strength, and emitting much sulphur dioxide.

October 16. At 9 a. m. both pools were sunk in their cups, and three islands were appearing in the center of the main pool, the largest of which was 75 yards long, and stood about 15 feet above the lake. The north and southeast source fountains were quiet, the south one at times weakly active, and the southwest constant and moderately active. No streaming was visible. The heat radiation was moderately strong, and the fume extremely thin.

October 17. At 10 a. m. both pools were sunk, particularly the north one, and the main pool was much shrunken in size by the rising of the previously drowned bench. What had been the main island the day before was now joined to the east side, and the topography was similar to that of October 12. The west side of the bench forming the new peninsula was identical with what it had been before the submergence. A new island had appeared in the main bay of the main pool, and during the afternoon another one appeared southwest of it. The fountaining was very weak. The fume continued thin, and a little came from the newly risen bench, just as it had before the submergence.

October 18. Both pools had risen considerably in their cups, but the main pool was further reduced in size by the withdrawal of the lava from the northeast sunken area and the southeast pool. The northeast area was either cold or heavily crusted, and appeared just as it did before being submerged. The bench around the pools was much cracked in several places, indicating differential uplift. The islands which had appeared in the main pool the day before had risen and greatly increased in size. The southwest source fountain was constant and moderately active, while the north and south ones were feebly so. A new cone had formed over the southeast source, and was pouring out a small flow. The fume continued very thin.

October 19. Both pools were flooding the bench between them, and the northeast sunken area. There was constant and active fountaining over the north, south, and southeast wells, the one over the north well being the strongest. The one over the south well was a multiple fountain, made up of many small ones close together. The north well was the source of a rapid current, but there was no perceptible streaming from the other sources. At times strong fountaining occurred elsewhere, with rapid streaming and slight subsidence. The crusts over the pools were thin, and the heat radiation strong.

October 20. At 11:30 a. m. both pools were sunk in their cups, the main one having sunk the more. The general topography was the same as that of October 17, but the north pool was somewhat changed, and many minor features altered. The fountaining was weak, only the north, southeast and south source fountains being active at all. No streaming was visible. There were occasional breaking up and sinking of crusts. The heat radiation was moderate, and the fume very thin.

October 21. At 2:30 p. m. the main pool was further shrunk. The fountaining was generally feeble, though for a few minutes the south fountain was strongly active, with rapid streaming away from it. Except for those few minutes, there was no visible streaming. There were four distinct islands in the main pool. The northeast sunken area was cold, and the thin veneer of pahoehoe was much cracked, showing aa below. Between

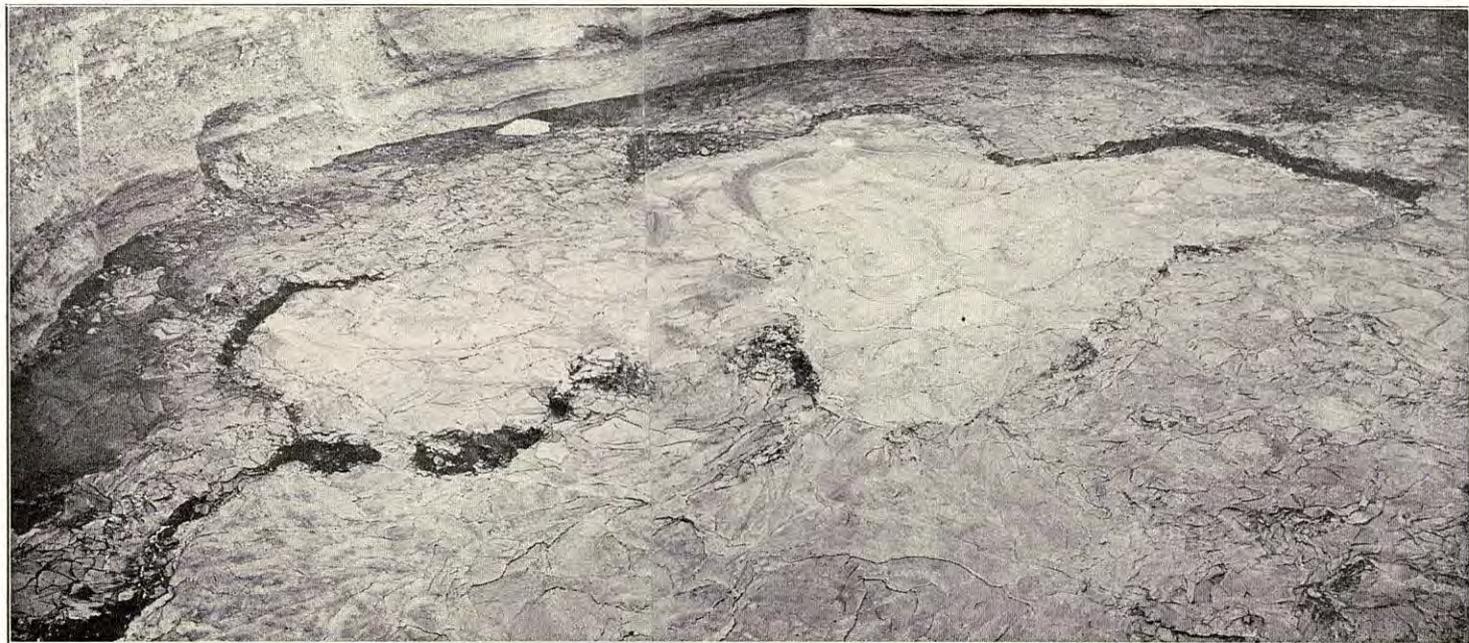


Fig. 14, Oct. 10, 1923. Halemaumau from the northeast rim, showing main and southeast pools. Photo Emerson.

the southeast and main pools there was a particularly rough section. The crusts on the pools were moderately thick, and the heat radiation mild. Occasionally the crusts broke up. The fume was thin.

October 22. At 10 a. m. the pit was little changed. The north and southeast fountains were occasionally weakly active. There were several small fountains over the south source, constant and moderately active. There was a sluggish flow from the southeast cone, showing a few bright toes. No streaming was visible in the main pool. The southwest island was connected to the bank by a low bench which the pool was sluggishly flooding. The northeast sunken area is being separated from the main pool by a rising block of bench, which stood about four feet above the northeast area, and a little higher above the lava. The crusts on the pools were thick, and there was little fire visible. The heat radiation was scarcely perceptible. The fume was thin.

October 23. At 11 a. m. the flowing from the southeast source was somewhat more active than it had been during the previous few days. The south, southwest, and north fountains were active, at times moderately strong. The size of the main pool was being further reduced by the formation of an inner bench, and its shape was becoming very irregular. The north pool which was sunk in its cup, started to rise, with vigorous fountaining at the north grotto, and it overflowed the bench to a small extent. The fume was medium, and coming from two sources, one at the east end of the main pool, and the other at the east end of the north pool. The crusts on the north pool were thin, and the heat radiation strong.

October 24. At 12 noon the appearance of the pools was similar to that of the day before, with the inner bench of the main pool becoming more pronounced. The north, southeast, and south source fountains were moderately active. The southeast source was pouring out increasingly large volumes of lava. The southeast pool was taking on definite shape, and was nearly as large as the north pool. The bench around the main pool was rising differentially, and the north and east crags were nearly as high above the lava as the island.

October 25. Between 11 a. m. and noon the southeast pool was pouring out by far the largest flow that it had poured out since the middle of September, and the cone beside it was belching out lava actively. The north and south fountains were constant, and at times the south fountain was moderately strongly active. The north and main pools occasionally had break ups of crust and the heat radiation was moderate. There was no streaming in the main pool, and the growth of the inner bench continued. The bench around the pools was rising, and the cracks in the east part becoming larger. The fume was thin, and came from the bench at the east end of the main pool.

October 26. At 11 a. m. all three pools were sunk in their cups, and a new island had appeared in the eastern part of the main pool, otherwise there was little change. The tilting of the shore line of the main pool had continued, so that a slight rise would cause an overflow to the southwest, while the crags along the north and east side stood 15 to 25 feet above the lake. The fountaining was generally weak to moderate, only the north, southeast, and south fountains being active. About noon the south fountain became powerfully active, with streaming away from it. The fume was moderate, coming almost wholly from cracks in the bench, and was free from sulphur dioxide.

October 27. All three pools were full and overflowing the bench vigorously; the main pool to the southwest, and southeast one to the northwest, and the north pool to the south. Occasionally the north and main pools broke up with short bursts of fountaining and subsidence, followed by rapid recovery and resumed overflow. The north pool had built high ramparts, chiefly on the north side, so that it stood on a steep and very pronounced hill. The southeast fountain had built up a high chimney whose

roof had collapsed. There was vigorous fountaining at the north and south sources, and a weak one at the southwest. The southeast chimney occasionally belched strongly. At times of subsidence there were two groups of fountains in the north pool, one at the east end, and the other at the west. During the afternoon a torrent of lava poured over the north wall of the north pool, and flowing under the rim of the main pit, poured into the sunken area east of the main pool and filled up a large part of it.

October 28. All three pools were slightly sunk in their cups at 11 a. m. The fountaining at the north and south sources was constant and moderate. Occasionally the crusts on the main pool broke up with rapid streaming and many small fountains. The fume was moderate, coming from various places in the bench. At 11:30 there was a large avalanche in the southwest chasm.

October 29. At 2 p. m. all three pools were slightly sunk in their cups and crusted moderately. The north and southeast cones were moderately active, and six small fountains played over the south source. The southwest fountain was weakly active, with slow streaming away from it. Occasionally the crusts broke up. The fume was moderate and came from cracks in the bench. There was further tilting of the shore line of the main pool to the southwest.

October 30. The pit was visited in the evening by Mr. Durning, who reported it quiet. The glow as seen from the Observatory was slight.

October 31. All three pools were crusted and sunken in their cups. The fountaining was weak, only the north, south, and southwest fountains being active at all. There was no perceptible streaming. A new island was appearing in the main pool between the east peninsula and the north crag. The fume was moderate, coming wholly from the bench. The heat radiation was scarcely perceptible.

LAVA MEASUREMENTS

Measurements of the depression of the mobile lava column below the northeast rim station of Halemaumau, for the month ended October 31, 1923, were as follows:

| | North pool | Main pool |
|----------------|------------|-----------|
| October 1..... | 396 feet | 388 feet |
| 2..... | 391 | 386 |
| 3..... | 380 | 381 |
| 4..... | 372 | 370 |
| 7..... | 368 | 366 |
| 8..... | 365 | 365 |
| 9..... | 355 | 354 |
| 10..... | 357 | 364 |
| 11..... | 348 | 356 |
| 13..... | 347 | 340 |
| 14..... | 337 | 338 |
| 15..... | 330 | 335 |
| 17..... | 346 | 338 |
| 18..... | 344 | 326 |
| 19..... | 320 | ..... |
| 20..... | 330 | 342 |
| 21..... | 329 | 336 |
| 23..... | 325 | 328 |
| 24..... | 315 | 325 |
| 25..... | 313 | 322 |
| 26..... | 310 | 320 |
| 27..... | 299 | 312 |
| 28..... | ..... | 308 |
| 29..... | 304 | 308 |
| 31..... | 307 | 313 |

SEISMOMETRIC RECORD

During the month ended midnight October 31, 1923, twenty-seven local earthquakes and one teleseism were registered at the Observatory. These and other earth movements are exhibited below. Time is Hawaiian Standard, 10 h. 30 m. slower than Greenwich.

Local Earthquakes.

| | | |
|----------------|-------------|----------------------------------|
| October 1..... | 12:09 a. m. | Very feeble. |
| 2..... | 2:45 a. m. | " " |
| 4..... | 2:35 p. m. | Feeble. |
| 5..... | 8:20 p. m. | Very feeble. |
| 6..... | 11:27 p. m. | " " |
| 8..... | 4:36 a. m. | " " |
| | 1:46 p. m. | " " |
| | 10:45 p. m. | " " |
| 9..... | 10:09 a. m. | " " |
| 10..... | 3:37 p. m. | " " |
| 11..... | 8:01 p. m. | " " |
| 12..... | 9:44 p. m. | Feeble. |
| 15..... | 7:53 p. m. | Very feeble. |
| 16..... | 11:56 a. m. | " " |
| 18..... | 4:41 p. m. | " " |
| 20..... | 10:23 a. m. | " " |
| | 8:22 p. m. | " " |
| 21..... | 6:48 a. m. | Feeble, distance 2 miles. |
| 23..... | 10:48 a. m. | Very feeble. |
| | 12:40 p. m. | " " |
| 25..... | 8:30 a. m. | " " |
| | 9:50 a. m. | " " |
| | 1:45 p. m. | Feeble. |
| | 10:42 p. m. | Very feeble. |
| 27..... | 2:50 a. m. | " " |
| | 2:04 p. m. | " " |
| | 6:31 p. m. | Slight, distance 6 miles, SE-NW. |

Teleseism.

October 6..... 5:45 p. m. Slight.

Spasmodic Microtremor.

This type of tremor was slight throughout the month.

Harmonic Microtremor.

This type of tremor was very slight throughout the month.

Microseismic Motion.

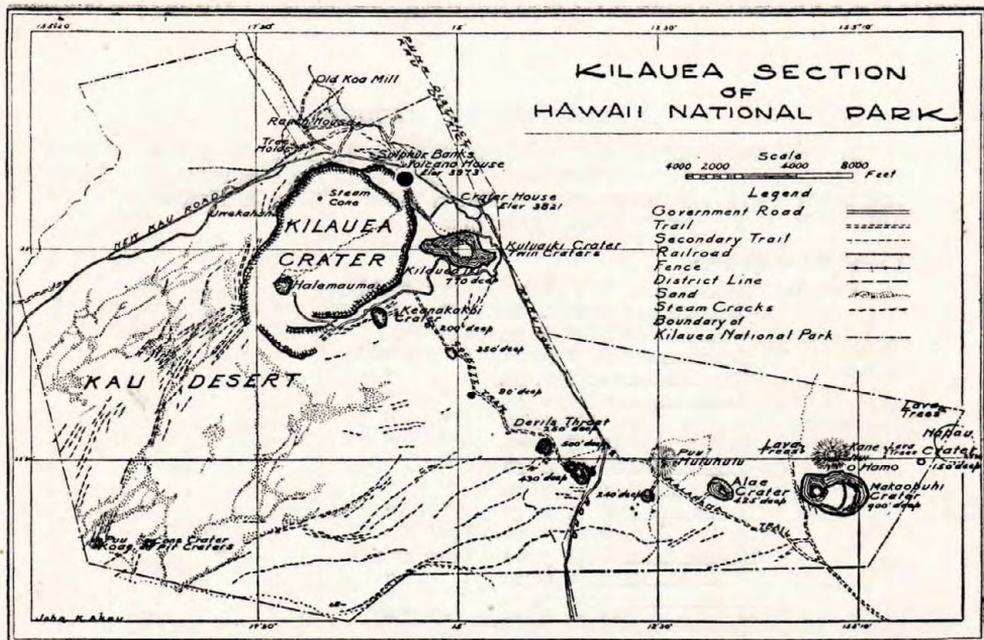
The amplitude of microseisms was moderate on the 1st, 2nd, 3rd, 12th, 14th, and 28th and slight on other days.

Tilting of the Ground.

By weeks this movement was as follows, expressed as angular change and direction of motion of the plumb line.

| | | |
|----------------------|-------------|--------|
| Sept. 30-Oct. 6..... | 0.8 second | NNE. |
| 7-13..... | 1.6 seconds | SSE. |
| 14-20..... | 4.0 | " N. |
| 21-27..... | 1.1 | " ENE. |
| 28 - Nov. 3..... | 1.7 | " N. |

R. H. FINCH,
Temporarily in Charge.



Black spot shows location of Observatory.

All exchanges should be addressed to

HAWAIIAN VOLCANO OBSERVATORY,

Volcano House P. O., Hawaii.

The Observatory is equipped with the following seismometric instruments rebuilt at the station in 1918 for the special needs of volcano research: two Bosch-Omori pendulums, high-speed registration of local earthquakes; one optically recording seismograph for distant earthquakes; one clinograph registering E-W tilting of the ground. A vertical component seismograph was in December, 1918, set up in experimental operation. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by wireless signal from the Pearl Harbor Naval Station. The chronometer is loaned by the University of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time. Observatory Lat. 19° 25' 54.2" N.; Long. 155° 15' 39.2" W.; Elevation 1214.6 meters (3985 feet).

HAWAII NATIONAL PARK.

This park was created by act of Congress August 1, 1916, and includes three famous volcanoes—Kilauea and Mauna Loa on Hawaii and Haleakala on Maui. Frequent passenger steamers ply between these islands and Honolulu.

Haleakala Section—Haleakala, "house built by the sun," a peak more than 10,000 feet high, carries an immense fissure-like crater 8 miles long and 3 miles wide, with walls 2000 feet high. Here, as well as on Mauna Loa and Mauna Kea, grows the Silver Sword (*Argyroxiphium*). Thirteen volcanic cones lie wholly within the crater, some rising nearly to the height of the summit. The scene at sunrise is marvelously beautiful.

Waialuku is the point of departure, automobiles taking the traveler to Olinda, a summer residence settlement 4043 feet high. After 2 hours drive to this point, saddle horses are taken to the summit, a ride of 3½ hours. Here is a fine concrete rest house, built by the citizens of Maui, and fully equipped with iron beds, blankets, stoves and dining utensils.

Mauna Loa Section—Mauna Loa, a vast dome 18,675 feet high, reached through a forest of Hawaiian mahogany (koa) and trees, then up bril-

liantly colored lava slopes, has a summit crater 3 miles long by 1½ miles wide, with walls 700 feet high, and when in action fountains of fire froth are here jettied 500 feet into the air. Every five or ten years splendid spectacles of lava eruption are staged on the mountain, sometimes from the lower flanks.

There are trails on the Kona side, and also from the southwest, but the usual and best route is with saddle mules from the Kilauea section to Pun Ula-ula (9800 feet), a ride of six hours. Here there is a fully equipped cottage with stables and water supply. From this point on the second day a four-hour ride takes the visitor to the summit crater, where there is water. A right of way within the park connects Kilauea with Mauna Loa, where eventually a road will be constructed. The views are glorious and the chasms, cones and contorted lavas indescribably chaotic.

Kilauea Section—The lakes of foaming fiery lava within the crater of Kilauea form the most spectacular exhibit in the Hawaii National Park, if not in the world. The pit of fire, Halemaumau, is inside of the main crater, at the apex of a broad, flat, inner cone. Kilauea is a dome volcano 4000 feet high, overridden by the lava slopes of Mauna Loa on the west, so that it seems but a spur of the greater, and perhaps younger, slag-heap mountain.

The Kilauea Park and the inner pit itself are both reached directly by automobile from Hilo, the second city of the Territory of Hawaii, and there are excellent hotel accommodations. The distance from Hilo is 30 miles. Within the park there are 15 miles of roads and about 20 miles of trails. As shown on the map, there are a dozen ancient pits within the area of the park, as well as cones, caverns and hot solfataras and a strange desert where lava flows have poured out of cracks as recently as 1920.

The live pit of Halemaumau is easily accessible and not dangerous. Frequently one can walk to the actual edge of the splashing, fountaining lava lakes, the lava column rising and falling from year to year so that its most distinctive character is ceaseless change. At night the spectacle is full of marvelous color, and the region is a paradise for artists, photographers and naturalists.

The several sections are under the control of the National Park Service of the Department of the Interior. The United States Weather Bureau maintains the Hawaiian Volcano Observatory, which stands on the brink of the greater crater within the Kilauea Park.

U. S. DEPARTMENT OF AGRICULTURE

Weather Bureau

CHARLES F. MARVIN, Chief

MONTHLY BULLETIN

OF THE

HAWAIIAN VOLCANO OBSERVATORY

VOL. XI

HONOLULU, HAWAII, NOVEMBER, 1923

No. 11

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GENERAL MAP, KILAUEA SECTION, HAWAII NATIONAL PARK

VOLCANIC CONDITIONS IN NOVEMBER

The quite uniform rise that marked October continued through November. At the beginning of the month the depression of the lava was 320 feet and on November 30th the lava stood 260 feet below the rim, making the average daily rise 2 feet. There were slight falls, however, on the 3rd, 4th, 5th, 8th and 21st.

The pool around the southeast source built up a platform so that on the 12th it was 30 feet higher than the adjacent main pool. During the building up process the pool greatly diminished in size. Further decrease in size left nothing but a cone that by the 13th was fully 50 feet high.

The island that had been in the main pool for several weeks after considerable shifting of position moved nearly to the southeast bank during Nov. 24-25. A second island appeared in the main pool on the 10th but disappeared on the 12th. On the 13th it reappeared and soon thereafter became joined to the main island.

Fountaining during the month, excepting during times of breaking up of crusts, was almost wholly confined to the source wells.

JOURNAL, NOVEMBER, 1923

November 1. Between 2 and 3 p. m. all pools were sunk in their cups, and crusted. The moderate to weak fountain over the south source well was the only one that was active at all. A new island was appearing in the northern part of the main pool, and some seemed to be developing in the

north pool, but these latter were indefinite. The fume was medium dense, and came from various sources, all of which were in the bench.

November 2. Between 2 and 3 p. m. the north and southeast fountains were vigorously active, with their respective pools overflowing the bench heavily. The lava from the north pool appeared to be more fluid, and was being poured out in greater volume. The main pool was full, but not overflowing to any extent. The south fountain was moderately active, and the southwest one was quiet. Occasional bursts of fountaining occurred outside the three source wells, accompanied by rapid streaming and temporary subsidence. These temporary fountains emitted much bluish sulphurous fume, which the source fountains did not do, and when they occurred, the source fountains became noticeably weaker. The lava from the north and southeast pools were forming shallow lakes in depressions in the bench, and the lakes formed by the north pool frequently showed breaking up of crusts, which would indicate that that phenomenon was caused by the gas held in the lava, and not wholly by gas bubbling up from below. The lava from the southeast source was more viscous and appeared to be much less gas charged, and there was much less foundering of crusts on the lake fed by it.

November 3. At 11 a. m. the north and southeast pools were sunk in their cups and almost wholly inactive. The south and southwest fountains were moderately active, and the crusts on the main pool frequently broke up, with slight subsidence. The south fountain was distinctly spasmodic in its behavior, the spasms lasting only a few seconds, and crusts formed between spasms. A few islands were visible at the east end of the north pool. The fume was extremely thin. At 3:30 p. m. there was a large avalanche from the west wall, preceded by many rock falls. This was the first large avalanche for several weeks. There were occasional rock falls elsewhere.

November 4. At noon all four source fountains were mildly active, and the crusts on the pools were moderately thick. The island in the main pool was tilting very decidedly to the southwest. The fume continued thin.

November 5. The fountaining was weak, with the south and southwest fountains constant and moderately active, and the north and southeast ones usually quiet. The crusts on the southeast pool were thick, but those on the north and main pools were thinner. The crusts on the main pool broke up moderately frequently, but usually there was no streaming visible. The island in the main pool had tilted further to the southwest, and a large part of the top had fallen off. The fume was thin.

November 6. At 2 p. m. the southeast pool was overflowing slightly, but the other two were somewhat sunk in their cups. The southeast cone was very noisy, and the other three source fountains were moderately active. The north and main pools were crusted and quiet, with no streaming visible. At 2:15 the southeast pool broke up with moderate fountaining. The fume was moderate, and came mainly from the bench at the east end of the main pool.

November 7. The appearance of the pit was similar to that of the day before, but the north and main pools were higher in their cups. The crusts on the main pool occasionally broke up with rapid streaming and scores of small bubble fountains; the activity lasting two or three minutes. The southeast pool was overflowing with moderate energy, and was building up a dome considerably higher than the surrounding bench. Occasionally it broke up with vigorous fountaining and subsidence. There was constant and moderately strong fountaining over the south and southwest wells. The southeast cone occasionally hissed, and belched strongly, and the north fountain was constant but weakly active.

November 8. At 11 a. m. the pools were sunk in their cups, and moderately crusted. All four sources were constantly active; the south and south-

west moderately strongly, the north slightly so. The southeast cone was belching noisily at times, throwing spatter 20 to 30 feet high. The southeast pool was much shrunken in size, being only about 50 feet in diameter. There was no streaming visible in any of the pools, and only occasional partial break-ups with moderate fountaining and slight subsidence. The fume was thin.

November 9. Between 10 and 11 a. m. the southeast pool was overflowing strongly, and the north pool slightly. All four source fountains, except the south, were active, and occasionally there was fountaining elsewhere. The southeast pool had built itself up further, and had moved about 30 feet away from the southeast cone. At 10:55 it broke up with vigorous fountaining. The fume continued thin.

November 10. At 3 p. m. all pools were somewhat sunk in their cups, the main pool being sunk the least. The southeast pool was shrunk until it was only about 15x25 feet. The fountaining was weak with only the south and southwest fountains active at all. Occasionally the crusts on the main pool broke up. A new island was appearing in the main pool, just north of the old island. The fume was thin.

November 11. At 11 a. m. the pools were quiet and crusted, and depressed within their cups as they were on the day previous. The new island in the main pool had risen further. There were three small fountains over the southwest well, and one over the south. The north fountain was weakly active at times. Occasionally the south fountain threw gobs of lava to a height of 50 feet with a dull explosion. The southeast cone was only fuming slightly.

November 12. The north and southwest fountains were constant and moderately active, and the south fountain was behaving as it had on the 11th. The southeast cone was fuming and showing heat through cracks. The southeast pool was quiet most of the time, but at 10 a. m. it suddenly rose, discharged a lot of sulphurous gas, and then subsided, the whole activity lasting about 5 minutes. In the main pool there was slow streaming away from the southwest source fountain. The new island had vanished. The fume generally was moderately thin, and came wholly from the bench except, at rare occasions, some came from the southeast pool.

November 13. At 11 a. m. the north pool was slightly sunk in its cup, the main pool was full, and the southeast one was overflowing vigorously. The fountaining was moderate, with five small fountains over the southwest source, two over the south, and the north grotto was moderately active. The southeast cone was quiet. There was no general streaming visible in any of the pools, though local currents accompanied the foundering of crusts. The lava from the southeast pool appeared decidedly viscous, and that slag heap had built itself up materially since the day before. The island in the main pool, just north of the old island, had reappeared. The fume continued thin.

November 14. At noon the southeast slag heap was a cone fully 30 feet high, with slopes of 25 to 40 degrees. It was discharging some viscous lava from the top, and occasionally emitted much sulphurous fume, with fountaining. The old southeast cone, between it and the rim, occasionally ejected large gobs of lava with much vigor, making dull but loud reports. The main pool was full, and the north pool slightly sunk in its cup. The north, south, and southwest fountains were moderately active. No streaming was visible in any of the pools. The fume was thin.

November 15. At 1:30 p. m. the southeast pool had vanished, the top of the cone becoming sealed. The north pool was fuller than it had been for some time, with more active fountaining. The main pool was full, with active fountaining over the south and southwest wells. The fume was thin.

At 5:30 it was reported that the westernmost of the two southeast cones suddenly discharged gas furiously, and, it is said, threw spray to a height of over 200 feet. The activity lasted about five minutes.

November 16. At 11 a. m. the pools were crusted and slightly sunk in their cups. No streaming was visible. The north, south and southwest fountains were moderately active. The southeast cone was puffing a little.

November 17. At 4 p. m. there were fresh flows flowing from both of the southeast cones, the largest flow having followed the wall of the pit to the south. The more eastern cone was puffing and lifting a lid. In the main pool the south and southwest fountains were moderately active, and appeared to be bubbling through decidedly viscous lava. The northeast arm of the lake cracked up with effervescence. At times there was prolonged hissing toward the north.

November 18. At 3 p. m. the pools were slightly sunk in their cups and the easternmost of the southeast cones was pouring out a small flow of viscous lava. The north, south, and southwest fountains were moderately active, and there were occasional fountains elsewhere. The main island in the large pool was tilting decidedly to the south. The fume was much denser than it had been for some time.

November 19. At 11 a. m., following a sudden vigorous fountain at the northern of the two southeast cones, the western cone let off a tremendous gas blast that lasted for five minutes and might well have been heard two or three miles away. The northern cone became quieter simultaneously with the beginning of the blast. A similar performance was reported on the 15th. An opening about three feet in diameter was formed at the top of the cone. A little spatter accompanied the blast and one gob of lava went up fully 100 feet. At noon both pools were full, and the north one was overflowing somewhat strongly to the north. The fountaining was weak, with only the north, south and southeast fountains moderately active. No streaming was visible. The fume was much thinner than it had been the day before.

November 20. From 4 to 5 p. m. the fountaining was moderate, with from three to six active fountains, including the north, south and southwest source fountains. Occasionally there was foundering of crusts with subsidence, and many small bubble fountains. The main pool was being further reduced in size by the formation of an inner bench at the eastern end, and the island in it was tilting further to the south. A moderately large flow had taken place from the eastern one of the southeast cones, and had flowed under the east rim. Live toes were still visible. The fume was thin.

November 21. At 3 p. m. both pools were sunk 5 to 8 feet in their cups. The fountaining was weak, with the south and southwest fountains moderately active, and the north one feebly so. The eastern of the two southeast cones was puffing, and fuming slightly. The fume was thin, coming wholly from the bench. One solfatara at the east end of the north pool was making a yellow deposit.

November 22. From 4 to 5 p. m. both pools were slightly sunk in their cups. The fountaining was feeble, only the south fountain being constant and moderately active. A flow of viscous lava was in progress under the northeast wall of the pit, apparently oozing out of cracks in the bench parallel to the wall. The bench was rising, and large cracks were forming in it, particularly in the southwest part of the pit. In one of these cracks lava was visible.

November 23. Between 11 a. m. and noon both pools were full, and the flow under the northeast wall was still in progress. It cooled to a dull black, unlike other lava in the pit. The fountaining was moderate, with the south



Fig. 15, Nov. 28, 1923. Halemaumau from the northeast, showing island in main pool and the southeast cones. Photo Emerson.

fountain vigorous, and several small ones over the southwest well. The old southeast cone puffed noisily at times, and occasionally the newer cone, called Vesuvius, became active, though not nearly as strongly as it had on previous occasions. The cracks in the bench in the southwest appeared to be widening. The fume was thin.

November 24. At noon both pools were full, with the north and south fountains vigorous, but the southeast cones and the southwest fountain were quiet. The flow under the northeast wall appeared to be dead. A pronounced rampart was being built along the south side of the island in the main pool. The fume was moderately thin.

November 25. Between 11 a. m. and noon both pools were full, and showed signs of recent overflowing. From 11 to 11:40 "Vesuvius" poured out a moderate stream of lava, and then threw spray to a height of about 100 feet, and subsided. The flow under the northeast wall was apparently dead, but several times there was prolonged hissing from cracks there. The island in the main pool had moved south, almost closing the channel between it and the southeast bank of the pool. The south fountain was vigorously active, with decided streaming away from it, but the southwest and north ones were feeble. There were also various small fountains at the northeast end of the main pool. At 11 a. m. the southeast cone belched noisily, but later became quiet. The fume was thin, and came wholly from the bench. The solfatara action at the east end of the north pool continued.

November 26. From 2 to 3 p. m. both pools were slightly sunk in their cups, and a pronounced rampart was being built around the main pool. The tilting of the island to the south continued, so that practically the whole of the high part had fallen over. The south fountain was vigorous, and the southwest and north ones were weak. At 3 p. m. there was a small discharge of gas for about a minute from "Vesuvius," with simultaneous rapid streaming to the west end of the north pool.

November 27. From 11 a. m. to noon the south, southwest, and north fountains were moderately active, the south one being less vigorous than it had been. The pools were crusted, with no fire visible except at the three fountains, and foundering of crusts were infrequent. The ramparts around the main pool were a little higher than they had been before. A small flow was in progress in the southwestern part of the pit, apparently coming from cracks in the bench near the wall of the pit. The fume was thin, but smelt decidedly of sulfur dioxide.

November 28. From 10 to noon the main pool was slightly sunk in its cup, but the north pool was overflowing moderately. The south fountain was strongly active, the southwest one quiet, and the north one was active at times, occasionally strongly so. Occasionally the crusts on the main pool broke up with rapid streaming and many small fountains. The island had drifted further away from the southeast bank. The fume was thin, coming from the southeast cones and the east end of the main pool.

November 29. At 11 a. m. the south and southwest fountains were both active, but the north one was quiet. The southeast cones were puffing a little at times. The main pool was full, but the north one was sunk in its cup. The cracks in the bench, parallel to the southeast wall of the pit, had widened and split the old southeast cone. The fume was thin.

November 30. At 11:30 a. m. the north pool was slightly sunk in its cup, and the main pool was overflowing slowly on several sides. The south and southwest fountains were vigorous, and the north source was becoming a cone that was hissing strongly. Occasionally the crusts on both pools broke up with rapid streaming and many small fountains. The fume was somewhat heavier, with "Vesuvius" pouring out a dense cloud.

LAVA MEASUREMENTS

Measurements of the depression of the mobile lava column below the northeast rim station of Halemaumau, for the month ended November 30, 1923, were as follows:

| | North pool | Main pool |
|-----------------|------------|-----------|
| November 1..... | 313 feet | 320 feet |
| 2..... | 296 | 313 |
| 3..... | 316 | 306 |
| 4..... | 312 | 320 |
| 6..... | 315 | 319 |
| 7..... | 302 | 313 |
| 8..... | 303 | 318 |
| 9..... | 292 | 305 |
| 11..... | 299 | 302 |
| 13..... | 291 | 291 |
| 14..... | 286 | 287 |
| 18..... | 286 | 285 |
| 19..... | 279 | 280 |
| 21..... | 286 | 286 |
| 23..... | 275 | 280 |
| 25..... | 271 | 270 |
| 26..... | 267 | 263 |
| 27..... | 270 | 267 |
| 28..... | 256 | 266 |
| 29..... | 263 | 258 |
| 30..... | 257 | 260 |

SEISMOMETRIC RECORD

During the month ended midnight November 30, 1923, sixteen local earthquakes and two teleseisms were registered at the Observatory. These and other earth movements are exhibited below. Time is Hawaiian standard 10 h. 30 m. slower than Greenwich.

Local Earthquakes.

| | | |
|-----------------|-------------|----------------------------|
| November 1..... | 9:02 a. m. | Slight, NW-SE. |
| 2..... | 12:53 a. m. | Very feeble. |
| 3..... | 2:23 a. m. | Feeble. |
| | 3:36 p. m. | Very feeble. |
| 4..... | 10:56 p. m. | " " |
| 5..... | 5:35 a. m. | " " |
| 6..... | 1:18 a. m. | " " |
| 8..... | 8:41 a. m. | " " |
| 11..... | 6:16 a. m. | Slight, distance 2 miles. |
| 15..... | 10:40 a. m. | Slight, distance 22 miles. |
| 16..... | 4:16 p. m. | Feeble. |
| 19..... | 10:25 p. m. | Very feeble. |
| 23..... | 9:18 a. m. | " " |
| | 11:40 p. m. | " " |
| 24..... | 2:17 a. m. | " " |
| 25..... | 4:08 a. m. | " " |

Teleseism.

| | | |
|-----------------|-------------|-----------|
| November 2..... | 10:50 a. m. | Moderate. |
| 3..... | 2:00 p. m. | Slight. |

Spasmodic Microtremor.

This type of tremor was very slight throughout the month.

Harmonic Microtremor.

This type of tremor was very slight during the first two decades and slight during the last.

Microseismic Motion.

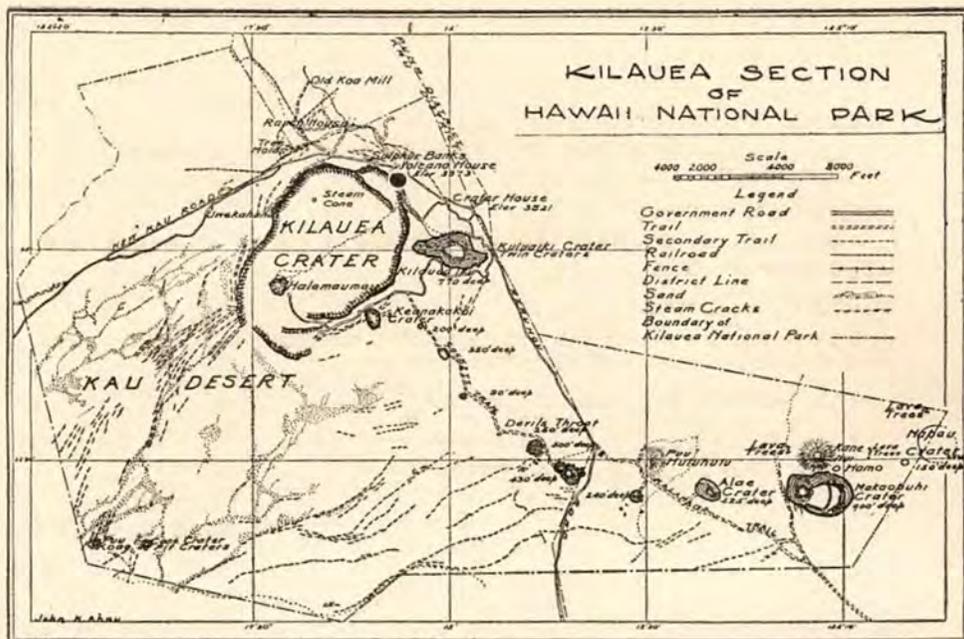
The amplitude of microseisms was moderate on the 4th, 5th and 6th and slight on other days.

Tilting of the Ground.

By weeks this movement was as follows, expressed as angular change and direction of motion of the plumb line.

| | |
|---------------------|------------------|
| November 4-10..... | 2.6 seconds NNW. |
| 11-17..... | 3.0 " S. |
| 18-24..... | 0.9 second NE. |
| Nov. 25-Dec. 1..... | 3.1 seconds NNE. |

R. H. FINCH,
Temporarily in Charge.



Black spot shows location of Observatory.

All exchanges should be addressed to

HAWAIIAN VOLCANO OBSERVATORY.

Volcano House P. O., Hawaii.

The Observatory is equipped with the following seismometric instruments rebuilt at the station in 1918 for the special needs of volcano research: two Bosch-Omori pendulums, high-speed registration of local earthquakes; one optically recording seismograph for distant earthquakes; one clinograph registering E-W tilting of the ground. A vertical component seismograph was in December, 1918, set up in experimental operation. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by wireless signal from the Pearl Harbor Naval Station. The chronometer is loaned by the University of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time. Observatory Lat. 19° 25' 54.2" N.; Long. 155° 15' 39.2" W.; Elevation 1214.6 meters (3985 feet).

HAWAII NATIONAL PARK.

This park was created by act of Congress August 1, 1916, and includes three famous volcanoes—Kilauea and Mauna Loa on Hawaii and Haleakala on Maui. Frequent passenger steamers ply between these islands and Honolulu.

Haleakala Section—Haleakala, "house built by the sun," a peak more than 10,000 feet high, carries an immense fissure-like crater 8 miles long and 3 miles wide, with walls 2000 feet high. Here, as well as on Mauna Loa and Mauna Kea, grows the Silver Sword (*Argyroxiphium*). Thirteen volcanic cones lie wholly within the crater, some rising nearly to the height of the summit. The scene at sunrise is marvelously beautiful.

Wailluku is the point of departure, automobiles taking the traveler to Olinda, a summer residence settlement 4043 feet high. After 2 hours drive to this point, saddle horses are taken to the summit, a ride of 3½ hours. Here is a fine concrete rest house, built by the citizens of Maui, and fully equipped with iron beds, blankets, stoves and camping utensils.

Mauna Loa Section—Mauna Loa, a vast dome 18,675 feet high, reached through forests of Hawaiian mahogany (koa) and trees, then up bril-

liantly colored lava slopes, has a summit crater 3 miles long by 1½ miles wide, with walls 700 feet high, and when in action fountains of fire froth are here jetted 500 feet into the air. Every five or ten years splendid spectacles of lava eruption are staged on the mountain, sometimes from the lower flanks.

There are trails on the Kona side, and also from the southwest, but the usual and best route is with saddle mules from the Kilauea section to Puu Ula-ula (9800 feet), a ride of six hours. Here there is a fully equipped cottage with stables and water supply. From this point on the second day a four-hour ride takes the visitor to the summit crater, where there is water. A right of way within the park connects Kilauea with Mauna Loa, where eventually a road will be constructed. The views are glorious and the chasms, cones and contorted lavas indescribably chaotic.

Kilauea Section—The lakes of foaming fiery lava within the crater of Kilauea form the most spectacular exhibit in the Hawaii National Park, if not in the world. The pit of fire, Halemauama, is inside of the main crater, at the apex of a broad, flat, inner cone. Kilauea is a dome volcano 4000 feet high, overriden by the lava slopes of Mauna Loa on the west, so that it seems but a spur of the greater, and perhaps younger, slag-heap mountain.

The Kilauea Park and the inner pit itself are both reached directly by automobile from Hilo, the second city of the Territory of Hawaii, and there are excellent hotel accommodations. The distance from Hilo is 30 miles. Within the park there are 15 miles of roads and about 20 miles of trails. As shown on the map, there are a dozen ancient pits within the area of the park, as well as cones, caverns and hot solfataras and a strange desert where lava flows have poured out of cracks as recently as 1920.

The live pit of Halemauama is easily accessible and not dangerous. Frequently one can walk to the actual edge of the splashing, fountaining lava lakes, the lava column rising and falling from year to year so that its most distinctive character is ceaseless change. At night the spectacle is full of marvelous color, and the region is a paradise for artists, photographers and naturalists.

The several sections are under the control of the National Park Service of the Department of the Interior. The United States Weather Bureau maintains the Hawaiian Volcano Observatory, which stands on the brink of the greater crater within the Kilauea Park.

U. S. DEPARTMENT OF AGRICULTURE
Weather Bureau
CHARLES F. MARVIN, Chief
MONTHLY BULLETIN
OF THE
HAWAIIAN VOLCANO OBSERVATORY

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HONOLULU, HAWAII, DECEMBER, 1923

No. 12

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GENERAL MAP, KILAUEA SECTION, HAWAII NATIONAL PARK

VOLCANIC CONDITIONS IN DECEMBER

Halemaumau was marked in December by numerous short period though large oscillations. The net gain for the month was 39 feet, only slightly over half of the amount of the rise on days of especially large fluctuations. The lake level on December 1 was 258 feet below rim and on December 31 it was 219 feet.

Following considerable flooding on the 3rd there was a very strong spurt on the 7th with a spectacular cascade into the north pool. These spectacular performances were repeated at weekly intervals for several weeks. On the 14th and 21st there were cascades into the north pool much the same as on the 7th only of greater magnitude. On the 27th the weekly period was continued with a rapid rise and very rapid fluctuations. During one half hour period over 10,000,000 cubic feet of lava was poured out. At the times of these floods over 40 acres were covered with molten lava that drowned all islands and individual lakes. The rapid subsidences followed tumultuous fountains, that would break out at various places. The source wells—sometimes sink holes—were the same as in November, the southeast cones, the south and southwest fountaining patches and the north pool. For a while another source pond was located near the wall at the southwest.

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December 1. At 11 a. m. the south and southwest fountains were active and the north one quiet most of the time. The southeast cones were fuming. The crusts on both pools foundered occasionally. Cracks in the bench

parallel to the wall of Halemaumau were widening extending northeastward. A small flow oozed out of cracks under southwest rim.

December 2. At 2 p. m. the main pool was full and the north pool decidedly sunk in its cup. The southeast cones were fuming and fountains played at the south and southwest sources. The crusts on both pools foundered occasionally with some fountaining in the center but mostly along margins. The island in the main pool had moved several yards to the northwest.

December 3. At 4 p. m. the pools were joined and almost the entire bench flooded. The inner southeast cone had broken down and from it the main source of the flood issued. There were about twenty fountaining patches. There were decided signs of subsidence at 5 p. m.

December 4. At 11 a. m. both pools were crusted and almost full. The south and southwest fountains were moderately active and the north fountain was active at times. The outer southeast cone was fuming slightly and the inner one was marked by a pool of lava. The island in the main pool had moved farther northwest and tilted to the southwest. The entire floor was covered with new lava.

December 5. At 2 p. m. all three pools were overflowing. The south, southwest and north fountains were active. At 3:30 p. m. the north pool broke up with vigorous fountaining and rapid streaming to the east end, the fountaining being more vigorous than seen for some weeks. The island in the main pool was being drowned and was tilting to the north.

December 6. At 10 a. m. the main pool was nearly bank full and the north southeast pools depressed about 8 feet in their cups. The south and southwest fountains were active. There was an intermittent fountain in the west part of main pool. The island in the main pool had moved farther north. The fume was thin.

December 7. During the forenoon the pools were crusted and slightly sunk in their cups. There were weak fountains at the south and southwest sources. The island in the main pool had continued its northerly migration. The southeast cones were fuming and quiet. At 8 p. m. all the pools were joined and the lava was streaming to the north pool which was a great sink hole into which the lava cascaded. The north pool was depressed ten feet below the rest of the lake. The south and southwest sources and the southeast cones were feeding the flood. For a time there was a 8 foot dome fountain over the inner southeast cone.

December 8. The lake showed no sign of falling. The main source was the south well and the southwest source was a secondary feeding well. A small stream was pouring into the inner southeast cone. The outer southeast cone was quiet and crusted. There was a powerful fountain under the north station, another in the west central part of the lake, and a third near the west end of southwest ledge of June, 1923. The heat radiation was very strong. The rise continued during the afternoon. The fountains were more vigorous and less numerous. Both southeast cones were sink wells.

December 9. At 1 p. m. the lava was down 40 feet or so and still falling slowly. The depression of the top of the southeast cone had not changed. The south fountain area was a sink hole with lava streaming to it from the north lake. The island by the southwest fountain was 4-5 feet high. There was no fountaining except at the south area. A slow cracking and foundering of crust extended over the entire pool. Some of the plaster left by the recent drop had already scaled off.

December 10. At 11 a. m. there were two separate pools apparently rising. Small fountains played at the south, southwest and north sources. The main pool was much enlarged, but with no definite outline. The island had moved northwest and apparently passed the southwest source. The southeast cones were on a high bench with a cliff about 6 feet high between them and the lava to the west and southwest. It appeared as though the central part of the bench had subsided. There was some aa on the sides of the southeast cones. Thin fume came from these cones.

December 11. At 9 a. m. both the main and north pools were overflowing slightly. A new pool some 30 feet in diameter had appeared in the southwestern part of the pit where one of the fountain groups had been playing on December 8. The island had moved farther west and apparently had become joined to the bank. There was a heavy avalanche under the south station at 8 p. m.

December 12. At 11 a. m. the north pool was sunk in its cup. There was fountaining at the south and southwest sources. The southwest pool was quiet. Sluggish streaming to the northeast was detectable in the south pool. The fume was very thin.

December 13. At 2 p. m. there was strong fountaining at the south source and weak fountaining at the southwest. There was rapid streaming to the northeast from the south source. The main pool was assuming a definite shape by down faulting of the surrounding bench.

December 14. At 2 p. m. the main pool was full and a flow poured into it from the higher northern pool. The southeast cones were quiet and fountains played at the south, west and north sources. The main pool was building a rampart between itself and the northeast sunken area.

At 8 p. m. there was practically a repetition of the display of December 7; the south and southeast wells were the main sources. The dome fountains from the southeast cones were 10-15 feet high. The streaming to the north pool was more rapid and for a time the cascading was from all sides. The cascade started at about 6:25 p. m. The north pool slowly filled up until it was within about 5 feet of the top, when it suddenly rose and the cascading stopped at 9:15 p. m.

December 15. During the night the lake had risen and covered the top of the avalanche under the south rim but subsequently sank about 20 feet. At 9:30 a. m. perhaps a slight rise was in progress. There were about thirty small fountains in all. Large aa patches covered the southeast talus and the base of the southeast cones.

December 16. There was fountaining at the south and southwest vents and occasionally fountaining in the north pool which was depressed within its banks 8-10 feet at 10 p. m. There was no streaming anywhere and only slight cracking and foundering of crusts in a dumbbell-shaped pool extending northeast and southwest with the handle in the middle of the pit.

December 17. At 4 p. m. the topography of the pit bottom was much like that preceding the flood of December 14. The whole bench appeared to have risen. The island in the main pool had tilted strongly to the north and a new island had appeared to the south of it. Small fountains played at the north, south and southwest sources. The southeast cones were quiet and fuming with solfatara incrustations.

December 18. At 2 p. m. the north and main pools had risen and were flooding the entire pit. The lava was about 225-230 feet below the rim. The north pool appeared to be the main feeding well. It was reported that the southeast cones had been very active at 11 a. m., but they were quiet

at 2 p. m. As many as twenty fountains were in action at one time, some of which were very powerful.

At 8 p. m. the lava had risen. The southeast cones were active and the north pool was a source of a rapid stream. There was slow streaming from the south source.

December 19. At 3 p. m. the north pool was overflowing into the main pool, at times in a stream over a hundred feet wide. Occasionally there was a broad, low dome fountain over the north source. Grottoes 15 feet high had been built up at the east end of the north pool. The south fountain was vigorous, but without apparent streaming to or away from it. The main pool occupied all the central part of the pit. The bench surrounding this lake was widest at the southeast cones. A steep sided island had appeared almost in the geometric center of the lake.

December 20. At 4 p. m. a strong overflow from the north pool joined a broad sluggish stream from the south source well and moved clear to the northeast bank of the eastern pool. A rampart 4-6 feet high and 15-20 feet from the wall marked the eastern border of the eastern pool. The southeast cones were higher and glowing and rumbling. Five to eight fountains were in action.

December 21. Similar to December 7 and 14 the lava was cascading into the north pool. At 7 p. m. the drop of the cascade was 20 feet or more. The main source of streaming was from the south well. The southeast cones were active with several small streams flowing from the outer one and one stream from the inner. The north pool slowly filled about 9 p. m. and a rapid rise followed, which drowned the inner southeast cone.

December 22. At 1 p. m. the lava was 25-30 feet lower than on the 21st, but again rising. The main source was at the south. The west bank of the north pool was broken down and a stream flowed through it to the west. There was a crag by the southwest bank of the north pool. The rise on December 21 reached a level of about 212 feet or nearly equal to that of the 7th.

December 23. At 1 p. m. the lava was lightly lower than on the 22nd, being about 240 feet below rim. Lava was flowing from the north pool which was 6-8 feet higher than the main pool. There were several small islands at the southwest. The one small fountain was at the south source well.

December 24. At 11 a. m. the lava lakes were quiet. The southeast cones were dead and sulphur stained. There was sluggish streaming north-eastward from the south source well where small fountains played.

December 25. At 1 p. m. the lava was 245-250 feet below rim,—a little lower than on the 24th. There was considerable cracking and foundering of the crusts all over the pool. Fountains played at the south source well and at the bank in north pool.

December 26. At 11 a. m. the lakes were much the same as on the 25th except that the north lake was higher and nearly bank-full. The streaming from the south source well was stronger and a rise was beginning. One puff was heard at the southeast cones.

December 27. At 11 a. m. the entire floor was covered with the moving flood. The inner southeast cone was buried and slabs of crust marked the top of the outer cone. Large turbulent fountains played over the north pool locality. By 11:30 a. m. the lava was sinking rapidly and the outer south-



Fig. 16, Dec. 21, 1923. Cascade into north pool at 7 p. m. Photo Finch.

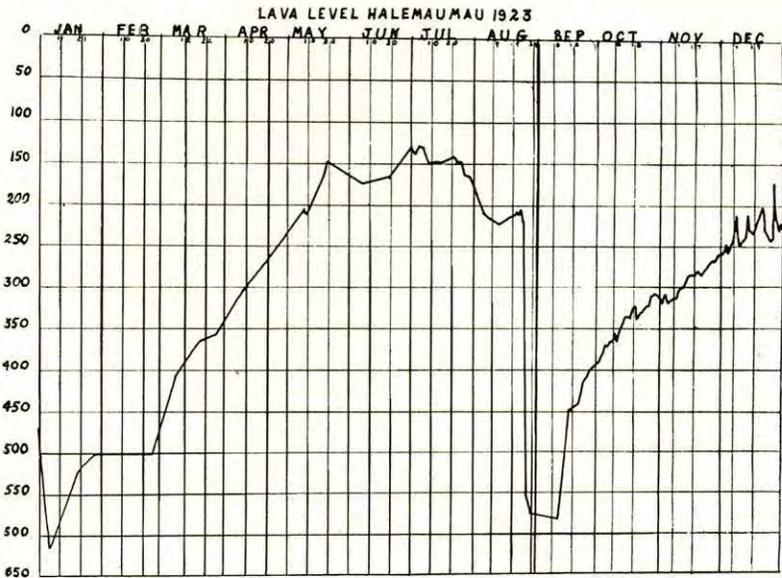


Fig. 17. Depression in feet of lava level below rim of Halemaumau during 1923. Plotted by Emerson.

east cone appeared as an island. The south source appeared to be the main feeder of the flood. The high level reached appeared to be about 185 feet below rim. There was continuous fountaining in two places near the southeast cone and bubble fountaining at the south source. Within half an hour after the fountaining in the north pool stopped the lava rose 4 feet or more to the top of the southeast cone island. The rise continued until a level of about 170 feet below rim was reached.

December 28. At 11 a. m. the lava was down so that the southwest island stood 8-12 feet above the liquid and the southeast cones on a platform 3-5 feet high. The north pool was 8-10 feet lower than the main pool. There was bubble fountaining at the south source and radial streaming from it. The lava was rising.

December 29. At 4 p. m. there were two islands in the southeast pool, two southwest of big southwest island and one elongated island with a tall pinnacle at its west end south of the southwest islands. The lava was 12-15 feet lower than on the 28th. A cascade with a drop of 5-6 feet poured to the southwest from the north pool.

December 30. The lakes were higher than on the 29th. The north pool was cascading in a broad stream to the southwest and in a very small stream to the southeast pool. There was one island in the southeast pool. Bubble fountaining marked the south source from which there was radial streaming. Much smoke issued from the inner southeast cone.

December 31. At 4 p. m. the lava was lower than on the 30th. The cascade to the southwest from the north pool was smaller than on the 30th. A sluggish stream coursed northeastward from the south source well. There were two islands in the southeast pool and six islands in the main pool.

LAVA MEASUREMENTS

Measurements of the depression of the mobile lava column below the northeast rim station of Halemaumau, for the month ended Dec. 31, 1923, were as follows:

| | North pool | Main pool |
|-----------------|------------|-----------|
| December 1..... | 261 feet | 258 feet |
| 4..... | 255 | 256 |
| 5..... | 236 | 252 |
| 6..... | 246 | 245 |
| 7..... | 246 | 243 |
| 8..... | ..... | 213 |
| 10..... | 248 | 250 |
| 12..... | 239 | 243 |
| 19..... | 218 | 226 |
| 21..... | ..... | 213 |
| 22..... | ..... | 236 |
| 27..... | ..... | 173 |
| 28..... | ..... | 223 |
| 31..... | ..... | 219 |

SEISMOMETRIC RECORD

During the month ended midnight December 31, 1923, sixteen local earthquakes were registered at the Observatory. These and other earth movements are exhibited below. Time is Hawaiian Standard, 10 h. 30 m. slower than Greenwich.

Local Earthquakes.

| | | |
|-----------------|-------------|---|
| December 1..... | 6:30 a. m. | Very feeble. |
| | 6:37 p. m. | " " |
| 3..... | 10:34 a. m. | " " |
| 4..... | 7:58 a. m. | " " |
| 7..... | 5:01 p. m. | " " |
| 9..... | 5:40 a. m. | " " |
| 11..... | 6:34 p. m. | " " |
| 14..... | 5:34 a. m. | Slight, distance 23 miles. Felt in Hilo Kona and Kau. |
| | 10:24 p. m. | Very feeble. |
| 15..... | 1:56 a. m. | Feeble, distance 4 miles. |
| 17..... | 12:22 a. m. | Very feeble. |
| | 11:42 p. m. | Slight, distance 2 miles. |
| 25..... | 4:14 p. m. | Very feeble. |
| | 6:46 p. m. | " " Felt Oahu, Molokai and Lanai. |
| 28..... | 4:37 p. m. | Moderate, instruments dismantled. Felt over East Hawaii, distance 27 miles. |
| 30..... | 6:11 a. m. | Very feeble. |

Spasmodic Microtremor.

This type of tremor was moderate on the 27th and slight on other days.

Harmonic Microtremor.

This type of tremor was moderate on the 21st and slight on other days.

Microseismic Motion.

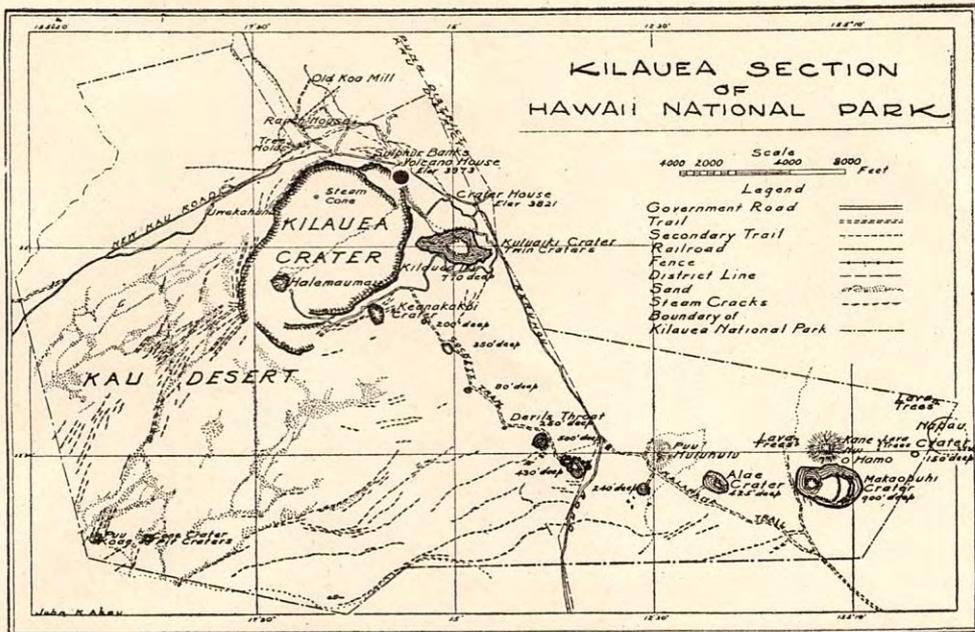
The amplitude of microseisms was moderate on the 11th, 12th, 13th, 16th, 17th, and 24th and slight on other days.

Tilting of the Ground.

By weeks this movement was as follows, expressed as angular change and direction of motion of the plumb line.

| | | |
|---------------------|-------------|------|
| December 2 - 8..... | 0.5 second | ENE. |
| 9 - 15..... | 1.6 seconds | NNE. |
| 16 - 22..... | 0.4 second | WNW. |
| 23 - 29..... | 2.9 seconds | WNW. |

R. H. FINCH,
Temporarily in Charge.



Black spot shows location of Observatory.

All exchanges should be addressed to
HAWAIIAN VOLCANO OBSERVATORY,
 Volcano House P. O., Hawaii.

The Observatory is equipped with the following seismometric instruments rebuilt at the station in 1918 for the special needs of volcano research: two Bosch-Omori pendulums, high-speed registration of local earthquakes; one optically recording seismograph for distant earthquakes; one clinograph registering E-W tilting of the ground. A vertical component seismograph was in December, 1918, set up in experimental operation. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by wireless signal from the Pearl Harbor Naval Station. The chronometer is loaned by the University of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time. Observatory Lat. 19° 25' 54.2" N.; Long. 155° 15' 39.2" W.; Elevation 1214.6 meters (3985 feet).

HAWAII NATIONAL PARK.

This park was created by act of Congress August 1, 1916, and includes three famous volcanoes—Kilauea and Mauna Loa on Hawaii and Haleakala on Maui. Frequent passenger steamers ply between these islands and Honolulu.

Haleakala Section—Haleakala, "house built by the sun," a peak more than 10,000 feet high, carries an immense fissure-like crater 8 miles long and 3 miles wide, with walls 2000 feet high. Here, as well as on Mauna Loa and Mauna Kea, grows the Silver Sword (*Argyroxiphium*). Thirteen volcanic cones lie wholly within the crater, some rising nearly to the height of the summit. The scene at sunrise is marvelously beautiful.

Wailuku is the point of departure, automobiles taking the traveler to Olinda, a summer residence settlement 4043 feet high. After 2 hours drive to this point, saddle horses are taken to the summit, a ride of 3½ hours. Here is a fine concrete rest house, built by the citizens of Maui, and fully equipped with iron beds, blankets, stoves and dining utensils.

Mauna Loa Section—Mauna Loa, a vast dome 18,675 feet high, reached through forests of Hawaiian mahogany (koa) and tree fern, then up bril-

liantly colored lava slopes, has a summit crater 3 miles long by 1½ miles wide, with walls 700 feet high, and when in action fountains of fire froth are here jettied 500 feet into the air. Every five or ten years splendid spectacles of lava eruption are staged on the mountain, sometimes from the lower flanks.

There are trails on the Kona side, and also from the southwest, but the usual and best route is with saddle mules from the Kilauea section to Puu Ula-ula (9800 feet), a ride of six hours. Here there is a fully equipped cottage with stables and water supply. From this point on the second day a four-hour ride takes the visitor to the summit crater, where there is water. A right of way within the park connects Kilauea with Mauna Loa, where eventually a road will be constructed. The views are glorious and the chasms, cones and contorted lavas indescribably chaotic.

Kilauea Section—The lakes of foaming fiery lava within the crater of Kilauea form the most spectacular exhibit in the Hawaii National Park, if not in the world. The pit of fire, Halemauaua, is inside of the main crater, at the apex of a broad, flat, inner cone. Kilauea is a dome volcano 4000 feet high, overridden by the lava slopes of Mauna Loa on the west, so that it seems but a spur of the greater, and perhaps younger, slag-heap mountain.

The Kilauea Park and the inner pit itself are both reached directly by automobile from Hilo, the second city of the Territory of Hawaii, and there are excellent hotel accommodations. The distance from Hilo is 30 miles. Within the park there are 15 miles of roads and about 20 miles of trails. As shown on the map, there are a dozen ancient pits within the area of the park, as well as cones, caverns and hot solfataras and a strange desert where lava flows have poured out of cracks as recently as 1920.

The live pit of Halemauaua is easily accessible and not dangerous. Frequently one can walk to the actual edge of the splashing, fountaining lava lakes, the lava column rising and falling from year to year so that its most distinctive character is ceaseless change. At night the spectacle is full of marvelous color, and the region is a paradise for artists, photographers and naturalists.

The several sections are under the control of the National Park Service of the Department of the Interior. The United States Weather Bureau maintains the Hawaiian Volcano Observatory, which stands on the brink of the greater crater within the Kilauea Park.