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January 11, 1919.

The subsidence of the Halemaumau lava column reported last week, compensated by extensive flooding from cones at the base of the northeast and southwest walls, has in general continued during the week ending Jan. 10, but the liquid flooding has increased in volume so that the local upbuilding, confined last week to the two margins mentioned, has extended to the regions adjacent to the eastern and northern pools. The measurements indicate that positive subsidence continued to January 6 inclusive, during the next two days there was definite rising and thereafter the average surface level of the column remained stationary, though the building by liquid flows was voluminous. This condition appears to be that of slowly subsiding bench magma compensated by layers or veneers of lava flow.

The measurements of the week were as follows:

Jan. 3, depression of lake 87 feet, of crag summit 52 feet.

Jan. 5, depression of lake 90 feet, of crag summit 53 feet.

Jan. 11, depression of lake 61 feet, of crag summit 47 feet.

For the two days Jan. 3-5 the lake thus subsided 3 feet, or 1.5 feet per day, and the crag 1 foot, or .5 foot per day. For the six days Jan. 5-11 the lake rose 29 feet, or 4.9 feet per day, and the crag 6 feet, or 1 foot per day. Other measurements showed that the summit of the northeast slag heap and the edge of the southwest pond pit were both lower on Jan. 11 than on Jan. 4.

On Saturday, Jan. 4, 1919, at 11:15 a. m. the pit was smoky, there had been general subsidence since the previous day and the main and southeast lakes were both surging cauldrons with the liquid depressed 15 feet within their respective wells. The southwest heap against the wall of Halemaumau was built up high by overflow, and cascades from it had poured into the southwest pond pit. The central pot was glowing. The north lake was throwing up flings of heavy melt. Great volumes of smoke rose from the west cone, the central pot, the central crag, the west ends of the main and north lakes, the southeast pond, cracks east of the main lake, and from the east cone. More rocks had fallen from the cliff to the south and north edges of the floor.

On Jan. 5 at 3:30 p. m. the pit continued smoky and the lakes low. The floor under the southeast wall appeared lower but the slag heaps northeast and southwest remained high. There was considerable increase of collapse about the lakes. Streaming in the north lake was northward and in the main lake southward. A large cavern extended from the latter westward toward the central pond pot and that pot was glowing and fuming. An inactive pit, oval in outline, had developed by collapse in the summit of the northeast heap. The main and southeast ponds stood 20 feet below their rims and the north lake 12 feet.

On Jan. 6 this low and smoky condition continued and at 5 p. m. the fume rising from the pit was excessively dense. About 5 a. m. the nert morning, Jan. 7, however, there was very strong flaring seen above the main lake and the roar of the fountains could be heard at the Observatory two miles away in calm air. At 11 a. m. the fume had thinned remarkably and both inspection and measurement showed that a sudden rise was in progress, taking effect most vehemently in the liquid

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lava of the lakes and cones. The lakes had risen close to brimming, the main lake had recently overflowed, there were seven or eight large fountaining spots and the southeast pond was enlarged, the liquid standing within three feet of a newly built up rampart rim. The main and north lakes also showed new spatter ramparts three to five feet high. In curious contrast to these the southwest and west ponds remained in deeper pits, their liquid surfaces fountaining beneath cliffs 10 or 15 feet high. The heap at the base of the southwest wall had completely revived its activity, showed a hot flat top of recent cracking and foundering, the crust surfaces crackling and snapping, while fresh glowing lobes with collapsed crusts extended from the heap northward. Down its eastern slope a powerful flow poured rapidly and cascaded into the west pond pit. The north lake was fountaining continuously against the south side of its center and elsewhere was covered with skin. The tendency of its streaming was northward. In the main lake the streaming was eastward in a curve toward heavy bombardment at the northeast grotto and occasional central fountains broke into action. In the southeast pond the bombardment was against the west shore and in the southwest pond against the north shore. The northeast heap remained inactive. Dense smoke clouds still rose from the north side of the central crag and there was much smoke about the southwest pond.

On Wednesday, Jan. 8, 1919, at 6 p. m. the revival of liquid lava flooding continued and the northeast heap was again in action, with its summit pit obliterated, and the northeast cone spouting and flowing. Toes were pushing out at the eastern end of the heap. The main and north lakes were brimming full and fountaining, with occasional slight sinking spells. The southeast pond, squarish in outline and about 40 feet in diameter, was full close to the edge. On the north side of the main lake a rifted grotto dome was being violently bombarded, the streaming surface skins of the lake moving toward the grotto from the west end. The north lake occasionally flung up very high strings of melt at eastern and southern grottoes. The pot in the center of the pit was glowing and splashing, the east cone was hissing and there were large fields of fresh crusted glowing lava in the eastern, southern, western and central areas, the product of spectacular flows of the previous night. No special activity was noticed in the southwest or west ponds. The western slope of the northeast heap had not been flooded by the revival. The fume from the pit as seen from a distance diminished so greatly as to be at times almost imperceptible.

During the next two days, Jan. 9 and 10, the northeast heap produced more narrow trickle flows without any increase of height. There was overflow from the eastern and northern pools and the western heap continued to put out flows. All of this tended to even up the level of the central depression so as to lessen the relief of the two slag heaps. The end of the week finds the general surface still surrounded by cliffs over 60 feet high except northeast and southwest.

The seismographs of the Whitney Laboratory for the week ending at 8 p. m., Jan. 10, 1919, have registered no teleseisms. Local earthquakes were registered as follows: 9:15 p. m. Jan. 5, perceptible; feeble shocks 9:03 p. m. Jan. 8, and about 9:45 a. m. and 6:07 p. m. Jan. 9. Microseismic motion dwindled from moderate to small amplitude during the week. Microtremor of the rhythmic type was ordinary Jan. 3-6, strongly increased in the night of Jan. 6-7, remained strong with some decrease night of Jan. 7-8, showed very rapid vibrations superposed on the rhythmic ones in the morning of Jan. 8 and occasionally thereafter, and decreased slightly Jan. 9-10. Tilting was

to the west and south until the evening of Jan. 6, suddenly strong east and north on that night, this northeast tilt was continued Jan. 7-8, and after Jan. 8 the median line of the clinograph remained stationary, with diurnal fluctuations as usual. These diurnal movements of tilting appear to be southeast-northwest, and very definitely with the daily temperature range out-of-doors, but the longer term tiltings northeast-southwest accord with the lava rise and fall and depart from the longer term thermograph showings.

January 18, 1919.

The end of the week Jan. 10-17, 1919, shows a very pronounced rise of lava in progress with every prospect of overflow of the rim of the pit within a short time if the present flooding continues. (Note: Since this was written, at 8:30 a. m. Jan. 19, the lava overflowed the southwestern lip of Halemaumau.) This movement differs from the January risings of 1917 and 1918 in that the hard lava crags have disappeared, buried under layer on layer of liquid inner flows and the volume of upwelling liquid lava continually increases so that the floor of Halemaumau has become a gleaming slag heap with fountains on its crest which change position from day to day. At present the summit of the heap is toward the southwest and the recent floodings have come from three principal western vents, in locations almost identical with the feeding conduits of 1916 and 1917. The floor in general is now only 30 feet down and locally only 15 feet and easily accessible.

The confirmation of expectations based on a working theory of relationship between Mauna Loa and Kilauea which the writer has from time to time expressed and published, is very striking. The lava column is believed to be a stiff subterranean body, squeezed upward by terrestrial stresses through the ages, and charged with heating gases which effervesce and react most violently when the upward squeeze is relieved. Such effervescence generates liquid lava. The vents of Mauna Loa and Kilauea are believed to alternate in their action, 1903-07 producing Mauna Loa flow, 1908-12 intense Kilauea activity, 1914-16 Mauna Loa flow and now 1917-19 Kilauea overflow. Each eruption begins with the rise of the stiffer internal lava column and culminates with release of pressure and effervescence of liquid lava. Halemaumau in 1911 had craggy islands, in 1912 many hundreds of boiling fountains, so now in 1917-18 it had an upper surface of rocky crags, in 1919 it is developing great floods of liquid, and this year stands midway in the nine year interval between the 1914 outbreak of Mauna Loa and the next expectable Mauna Loa eruption.

The measurements of the week have been as follows:

Depression Below Southeast Section

	Main Lake.....	N. Lake.....	S.W. Pond.....	Central Crag.....	S.W. Edge Floor.....	N.W. Edge Floor.....	
Jan. 11 ..	61	57	49	47	44	59	ft.
Jan. 16 ..	34	38	30	29	20	47	ft.

These figures show that the main lake has risen 27 feet in five days, or 5.4 feet per day, and the central crag 18 feet, or 3.6 feet per day. The spurt of most rapid rising was after Jan. 15.

On Saturday, Jan. 11, at 4:30 p. m. the flooding of the entire floor continued, the northwest portion remaining relatively low. The northeast cone showed a flaming and hissing vent in the top of a steep sided pyramid five feet high which surmounted a heap of radial flows of snaky and lumpy character. The pit formerly at the top of the heap had disappeared. The western heap showed increased height and was covered everywhere with glowing flows not conspicuously in motion. The flows had encroached upon the base of the central crag so that the latter was becoming a small inconspicuous object.

The main lake streamed continuously westward within a rim three feet high, above which huge spatter heaps made a lumpy rampart. A heavy sheet flow with slightly festooned surface had recently poured southward from the lake. The grotto and fountaining activity were moderate. The southeast pond had become a raised cone, with a large irregular cauldron full of liquid lava

boiling visibly and all around were fresh glowing flows. The east cone was a small hissing filagree heap. The southwest and west ponds had now become pits and showed no special activity. The central pot glowed through cracks on its western rim and west of it live flows were in motion. The north lake threw up continuous fountains rather noiselessly against its southern and eastern banks and its ramparts were low, showing signs of extensive overflow northward. Smooth glowing flow surfaces extended along the base of the wall under the north station. The general situation revealed recurrence of strong lava flooding, but measurement made the northeast heap and the edge of the southwest pond lower than a week before.

On Monday, Jan. 13, in the evening, the spouting of the western wall cone and the line of its glowing flows could be plainly seen from the Observatory. In the daytime the southwest edge of the floor was discernible with field glasses. After midnight, with a western moon, the trail of thin Mokuaweoweo fume could be seen extending northeastward from the summit of Mauna Loa.

On Jan. 14 at noon the western wall vent was ejecting a steady spouting fountain and the building up of the heap on either side of it had become the most conspicuous feature of the pit. The northeast accumulation no longer appeared heaped up, the flows there were now irregular and lumpy and two large cones had formed. Fresh falls of wall rock near them indicated distinct subsidence of the northeast floor. The east cone, as before, was a hissing filagree heap, the southeast pond was surrounded by dull glowing cones and much Pele's hair, the main lake rim was five feet high, exhibited five grotto domes with large and vigorous fountains and northward streaming. The north lake was splashing and the southwest pond had built a high spire above its eastern rim. The west pond was indistinct in the midst of flows of the southwest heap. The central pot had become an indistinct cone, the crag was still more submerged and the smoke had increased, but remained thin above the pit as a whole.

At 8 p. m. on Jan. 15 a cone west of the north lake was spurting in high jets plainly visible from the Observatory, flows in motion could be seen at the north end of the west heap, and the splashing of the lake grottoes was also visible from a distance. The west wall cone had crusted over but the flows continued.

On Jan. 16 at 4:30 p. m. it was evident that a new fill had built a horseshoe shaped heap west, south and east, following the floor margin, with distinct fall-off to lower ground at the ends of the horseshoe northeast and northwest. At 4:45 p. m. very voluminous overflow poured from the east end of the main lake, followed by a hot welling-up and overflowing of the southeast pond, both torrents pouring to the foot of the east wall and pooling as far as the east shelter northward. Here the pool formed a flat platform and its edge sloped downward to a much lower surface at least 10 or 15 feet below, the former northeast cone being obliterated at about the place of falling off. Before the southeast pond overflowed, the ground southeast of it was seen to be greatly fissured and gaping cracks had opened along the wall. All of these were filled by the overflow.

The north lake showed a fresh glowing overflow across its northern lip. The west wall cone started a fresh flow which poured northward down the steepest face of the western heap. The cone itself was quiet, the flood pouring from a bright zigzag edge of crust. It was interesting to observe that this cone stood just where the former western wall ponds and cones had developed repeatedly, a short distance to the south of the west station.

New cones had formed, one just under the south cone heap on the Halemaumau edge and two on the floor southwest of the north lake, one of these a steep spire built by the spurting of the previous night. The west pond cone was a glowing heap, hissing and occasionally spurting. The central cone contained a large pot flaming. The east cone was flaming and spouting through the liquid lava around it. The southwest pond was crusted and mostly level with its banks, the large cone south of it glowing. The northern cones puffed somewhat.

The north and main lakes showed high grotto domes with quiet fountains puffing and spraying within them, showing high gas pressure without rumbling. At night the fountains were plainly visible from the Observatory.

The central crag summit peaks now protruded only about four or five feet above the general level of the flows. The slope of the floor was strongly northeastward from the high southwest heapings to the center of the pit and from there the grade was toward the northwest, the lowest portion of the floor lying at the base of the northwest wall. The smoke on this day was strongly variable, being thin in the morning, thicker at noon and thin again at 5 p. m.

On Friday, Jan. 17, 1919, there was revival of strong flooding from a perpetual fountain at the west pond vent about noon, plainly visible from the Observatory. This source became a standing fountain 20 feet wide backed by a crust on the south, the flood spreading from it fan-wise and then settling into a rapid river of melt pouring northward to make a fill in the northwestern part of the floor. Another flow from 2 to 4 p. m. was observed pouring steadily from the west wall cone, part flowing to the north and part to the south, the cone region itself being crusted over. The flow lava appeared under the west station as a north flowing stream and under the south station as a pool. Floor east and southwest and possibly in the center of the pit had slumped considerably. The northeast cone had resumed activity, filling the north-northeast depression and making again a northeastern heap.

The southwest pond was obscured by crust but it was marked by a high puffing and glowing cone. The main lake about five feet down its pit was surrounded by a raised rampart with high domes northeast, southwest and east, the southwestern one being closed on the lake side but open and glowing with a slit-like aperture on top. The north lake had a similar five-foot rim and raised rampart, a glowing cavernous grotto dome stood on its north bank, a group of large domes had been built east of it, while off to the southwest of the north lake and away from it on the floor stood two or three domes, one of them a spire.

At the central pond locality stood an irregular cone. The central crag remnant remained as before. At the eastern edge of the great flow there was much upending of glowing crusts. North of the west cone occasional increases in the flow pressure would burst the crust and make outflows through the cracks.

The seismographs have shown much microtremor during the intense flowing, the tilt has been first east, then west, then east again, and there have been a few small local earthquake movements, to be reported more fully later.

January 25, 1919.

During the week ending Friday, Jan. 24, 1919, it has become evident that the midwinter rise of lava in Halemaumau is to be powerful and to produce overflowing, this being the third time within a twelve-month that the liquid floods have crossed the rim of the pit. This time it is to the southwest, whereas before it was to the southeast and north. The three overflow localities have been opposite the three persistent lakes and at the places where there were open gateways for so many months between the three great crag masses.

During the past week there has been resumption of tumescence of the bench magma or central floor of the pit followed by excessive building up of the western lava heap until the latter surmounts the old rim for a quarter of the circumference and is sending sluggish flows out to the Kilauea floor as well as eastward and northward into the pit proper. The building up of the northeast and southwest heaps by overflow veneers has amounted to about as much vertically as the swelling of the bench magma beneath, so that the northeast and southwest heaps have gained elevation twice as much as the rest of the floor.

The measurements of the week expressed as depression in feet below the southeast station, except where otherwise indicated, have been as follows:

HALEMAUMAU FILLING WITH LIQUID LAVA

—Photos. Jaggar

December 13, 1918. The last of the triangle of crag masses before complete submergence.

Dec. 25, 1918. The flat-topped northeast lava heap within the pit, replacing the former "wall-valley fill."

Dec. 25, 1918. From east brink of Halemaumau; lake and submerged crag.

The evidence of central tumescence and wall crack subsidence was now strong, dense smoke rising from the cracked floor southeast, and greenish yellow sublimates lining large cracks in the center of the pit and around the main lake. The crusts of fresh flows at the base of the southeast wall had drawn away and downward, leaving on the wall the black scar of their higher position.

During the night Jan. 19-20 the pit was much less luminous and flows were inconspicuous. At 6 p. m. on Jan. 20 a new spiracle was hissing at the southeast wall cone locality and slow flows pushed out at the southwest overflow, the front being now horizontally 300 feet from the rim of the pit. The surface of the western heap stood five feet above the rim and the pool on top showed collapsed crusts and glowing edges. Lifting was in progress and high pressure was shown everywhere. The lakes were full; ten fountains splashed around the margins of the north lake and three large ones in the main lake. The northeast heap was again building up, its surface swelling and putting out marginal flows. There was great heat and pressure in the eastern cones and the cracks were opening wider.

On Tuesday, Jan. 21, at 6 p. m. the same processes continued, cherry red glow showed in the floor cracks and all the cones were flaming chimneys. There was much whitish stain beside the cracks. Immense dome grottoes had been built beside the lakes which stood four feet below their margins. The southwest overflow had become more extensive and leaf-shaped in plan, the lava being of the elephant toe variety, with lobes two to three feet thick, consisting of hollow shells which collapse on top. This characteristic made the flows on the slopes of the heap slump and leave glowing caverns. The summit of the heap cracked up and revealed a pool for a few minutes.

The northeast heap had risen so rapidly that the fill of 1918 was largely overflowed and after 6 p. m. this flood was cascading into the hot caverns under the northeast outer wall, making a most spectacular display as the melt poured from under its crust and found its way in tumbling rivulets among the debris of the 1918 pits and caves. During the night these depressions were entirely filled.

The east cone had become a splashing pot over an enlarged well beneath. The southeast pond cup depression had become a remarkable circular basin 30 feet across and 12 feet deep with the cone on its western edge. It appeared to be a sagging crust over something withdrawing below.

The general uplift had now brought the lakes and their fountains into plain view from the Observatory, the glow at night was strong and the fumes thin and even the banners of flame above the cones could be seen in the distance with field glasses and in calm weather the blowing of the cones was quite audible.

On Jan. 22 at 11 a. m. there was new welling up of lava in the southeast wall crack, increased swelling and cracking, a new spire cone at the edge of the floor south-southeast, the eastern cones were large and flaming, and even the central crag remnant appeared relatively higher, as though lifted above the floor around it. The northeast heap was higher and extended northward and the live pool on its summit streamed westward. The southwest pond was open and fountaining on the west side of its cone. The lakes were high and a cone west of the north lake had become large. The main lake was streaming eastward.

In the late afternoon the east cone burst open so as to split along a vertical east-west rift and a standing fountain gushed out on each side of the rift continuously and during the evening the flow spread into a wide pool. The lakes were brimming and streaming east and northeast. A flow poured west from under a crust in the northern part of the pit. The north cone was spouting, all the cones were flaming, there was high pressure at the southeast pond cone and the eastern flood finally spread southward and sent torrents into the eastern wall cracks which were filled from both sides. Driblet flows were making out from the northeast heap and occasional fountains were seen on the west heap but no flows.

On the following night the west heap started flowing and building again, and

at 9 a. m. a flow was pouring from it toward the center of the pit. At 11 a. m., Jan. 23, the west side of the heap was visited and live streams were there travelling in several lobes, some of them reaching a speed of ten feet per minute. A meandering rivulet six feet wide poured down the upper part of the heap to feed them. Within the pit a stream ten feet wide was pouring down the north slope of the heap. All of these flows have been pouring for weeks toward the northwest wall valley, which in spite of this continues to remain the lowest part of the pit.

In contrast to the west heap activity the pit elsewhere appeared as though sinking, the lakes six to eight feet down their cups, the crusts of recent flows slumping. The northeast heap, however, was high and making driblet flows and the cones were flaming and hissing. The southwest pond appeared to have developed a small pit in the flank of the western heap.

At 5 p. m. the overflow had stopped, trickle flows moved on the northeast heap, the lakes were low but rose somewhat an hour later, and the streaming in the main lake was east and west from the center. The crusts of the previous day's flows had collapsed and the east cone was quiet, but the southeast pond cone was puffing and flaming. On walking out to the edge of the lake across the new flows, the writer found these crusts much more substantial than the hollow shells of the western overflows. This seems to indicate that the fresh rising lava of the western conduit is much more frothy and charged with gas than the lava of the eastern lakes and sinkholes. At 11 p. m. the west heap was flowing and the lakes high.

On Friday, Jan. 24, 1919, in the morning the middle region had settled, the west heap was higher and making flows north of the summit. Fresh additions had increased the thickness but not the length of the southwest overflow. The northeast heap was making driblet flows. The lakes were rather low. This condition continued into the afternoon but during the night there was revival of rising, flows from the western heap, and immense fountains splashed above the lakes and some spatter ramparts collapsed.

Tilt to the east and strong microtremor have continued and earthquake movements have been slight as instrumentally recorded, though one pronounced felt earthquake is reported from Kohala.

February 1, 1919.

The last week in January of 1919, and indeed the whole of January, have produced movements of the Halemaumau lava column much like January of 1918, except for the absence of crags this year. The past week has been notable as bringing to a close the January rise, and inaugurating a moderate subsidence which still continues. The main effects so far have consisted in withdrawal of the liquid lava more than 20 feet and a sympathetic slumping of the lake margins so as to enlarge the pools, revealing as usual larger chambers just below the surface than the actual lake areas indicated. Furthermore the southwest lava heap, source of the recent overflows has sunk more than other portions of the pit floor. This checks with other evidence to the effect that the present sinking spell is a reaction from the recent high gas pressure and generation of liquid lava, the region of the liquid lava source exhibiting the reaction most strongly. The central floor of Halemaumau has gone down but slightly, and the glowing northeast heap has even at times risen a little. The excessive hissing gas pressure so pronounced last week has ceased, and coordinate with the diminution of pressure has been the great increase of visible sulphur smoke, condensing over the subterranean voids left by the retiring liquid.

Measurements of the week expressed as depression in feet below the rim of the pit at the southeast station have been as follows:

	Main Lake....	Central Floor....	N.E. Heap	S.W. Heap		
Jan. 25....	22	16	6	14	above	rim
Jan. 29....	38	23	7	1	"	"

The lake thus sank 16 feet in four

days, averaging four feet per day; the southwest heap 13 feet, averaging 3.25 feet per day; the central floor seven feet, averaging 1.7 feet per day; the northeast heap one foot, averaging 0.25 foot per day. The movement of subsidence began on January 25, actual overflow continuing until the previous night.

At 5 a. m. Saturday, Jan. 25, 1919, brilliant lava flows visible from Volcano House were pouring down the east and north slopes of the southwestern heap and the lakes were brimming within their spatter ramparts and fountaining tumultously. After 8 a. m. the northern stream continued to pour from a standing fountain at the top of the heap but the lakes were lower. At 9:20 a. m. the puffing of the gas cones was plainly audible at the road terminus near the pit. The south and east wall cones and the southeast pond cone were blowing noisily. The southwest pond cone had become a high spur of the western lava heap. The central and north corner were stained with solfataric deposits. The large crusted sag basin on the east side of the southeast pond cone suggested approaching collapse, and large crevasses had opened on all sides of this depression. A strongly hissing vent had formed in the floor just east of the main lake, on the line between the lake and the east cone and burning gases played through the glowing cracks. Fume had considerably increased in the south central part of the floor.

The lake margins were about four feet high, fountaining was sluggish and streaming in the main lake was eastward. An overhanging half dome seven feet high had been built above the southwest grotto of the lake and all the ramparts were mossy with Pele's hair.

Under the east station a broad flow was pushing toward the southeast from the slope of the northeast heap. This flow piled itself up close against the front of the east shelter at the floor level of the shelter. The overflows from the southwest heap now crossed the edge of Halemaumau along a greatly widened stretch and close to the old west station. This heap was greatly increased in bulk and live overflows were pushing southwestward from it outside of Halemaumau in three places, the middle flow 15 feet wide, moving slowly and covered with heavily festooned skin. Near the top of the heap trickle flows were pushing down the north slope.

The floor of Halemaumau was lifted at the small heap at the south wall cone and thence all the way to the north lake, the uplifted region being cracked and stained and covered with Pele's hair. The lift by both tumescense and overflow had now so raised everything inside the pit that to the observer standing on the southeast margin large portions of the south, southwest and northeast cliffs were cut off from view and the lakes were hidden by their ramparts, now nearly level with the eye. The two horns of the central crag remnant still stood five or six feet above the floor level.

At 6 p. m. two flows were pouring down the northeast slope of the western heap and during the evening the lakes rose for a last display of heavy fountaining and the southwestern overflows extended themselves.

On Jan. 26 at 3 p. m. the hissing had mostly ceased, smoke had increased and the lake margins were six feet high. The southeast pond had opened to become a small well and its cone had collapsed. No flows were in motion. The last spurt of flowing had caused the northeast heap flows to overtop the uppermost northeastern shelf of March, 1918, and had extended the southwestern overflows to a distance 600 feet outside of the former southwest rim of the pit. The broad leaf-shaped areas there of fresh lobes measured 500 feet from side to side and the summit of the west heap now stood well above the post at the west station and was therefore higher than the highest part of the Halemaumau rim. The cones were all smoky and the east cone was nearly submerged under the fresh flows.

On Monday, Jan. 27, the fume showed great increase in density, rising in heavy volutes from the eastern, southern and northern floors. The live fountains could no longer be seen from the Observatory, the lakes being down. There was no special change in the general floor level.

On Jan. 28 in the morning the last trace of built up ramparts around the

southeast pond had collapsed and the pond was greatly enlarged to a pool 50 feet long in the east-west direction, occupying the site of the former cone but extended so that the cup depression had become the east end of the new inner pit. The liquid stood some 20 feet below the general floor level and was mostly crusted over except for a splashing opening at the west end where a tunnel appeared to lead toward the southwest grotto of the main lake.

The main lake was surrounded by 20-foot cliffs, sluggish fountaining grottoes were hung with stalactites northeast and southwest of it, and bedded walls were mostly vertical or slightly overhanging, much Pele's hair clung to them and the surface of the pool was stagnant. The north lake was similar, its surface about 15 feet down. The large beehive cone on the floor west of the north lake had developed an open window one foot in diameter on its east side which led into a large glowing cupola with lava splashing below. The west arm cone and south wall cone were smoking but showed glow at night. The west heap remained high with a glowing cavern on top. The east cone was now a lok glowing lump. The central crag was enveloped in smoke and could not be seen. The central and southwest pond cones remained as before and there was no change in the overflow southwest. The northeast heap had slumped in places, showing glowing caverns with stalactite drip, and across its surface lines of arched crust were left in relief over tubes below whence the liquid had apparently drained downward. It was easy to walk across the floor in all directions and examine all details.

On Jan. 29 at 11 a. m. the lakes were depressed 25 feet within their inner pits and everything was stagnant and smoky. Especially dense volumes of smoke rose from the floor between the southeast pond and the south wall cone. Measurements indicated that the northeast heap had slightly risen but the western heap had settled. The large southwest grotto half dome on the edge of the main lake had fallen in and the rampart elsewhere was fast collapsing. Fountaining activity was mod- the streaming was towards the northeast grotto. There was no marked gas pressure at the cones. The floor showed increased staining along lines of cracks. The north cone was still bright and glowing. At night the glow above the lakes and cones was conspicuous, including a cone on the summit of the western heap.

At 6 p. m. on Thursday, Jan. 30, the main lake was found greatly enlarged by collapse of all its ramparts except the northeastern one and by further collapse eastward undermined by a tunnel extending toward the east cone. This lake was now 250 feet long by 100 feet wide. Its fountaining activity had increased, streaming was various, there were sharp alternations between rising and sinking spells and the glow at night was brighter. The walls of the inner pit were 30 feet high and well marked tunnels were revealed at the east and west ends of the lake, some 25 feet below the floor level. There was also suggestion of tunnels northeast and southwest. The tunnel leading eastward was circular and 10 feet in diameter.

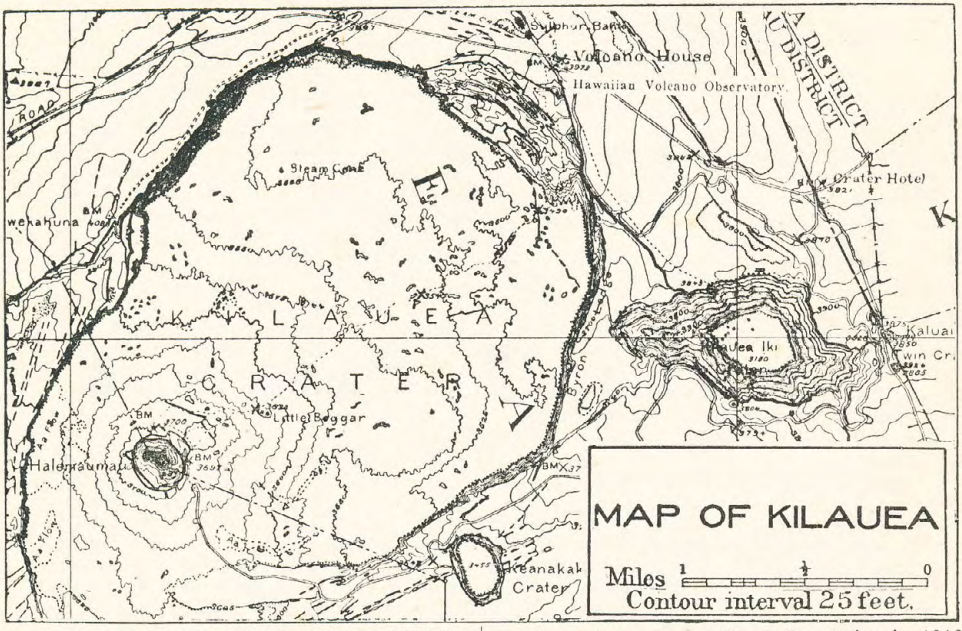
The north cone was becoming eaten through by the gases within so that a bright filagree patch had developed on its west side. The northeast heap glowed through many cracks, there was a large flaming and glowing area around the east cone, the southeast wall cone glowed brightly and there was some fire at the south wall cone. Chimneys sent up flames at the central and western cones. The revelation of tunnels leading into the lakes about 25 feet below the floor level, at the end of the recent period of building up by overflow, is of great interest compared with the observations of 1917 which showed persistent tunnels and wells in the bottom and walls of the lake basins at depths from 25 to 45 feet.

On Friday, Jan. 31, conditions continued to be sluggish, slow sinking continued, the flaring of the chimneys decreased slightly and smoke was dense.

In the Whitney Laboratory the seismographs have registered a few local earthquakes and a near shock on the afternoon of Jan. 28 which was felt in crate, there was much crusting over and Honolulu. Microseismic motion has been ordinary, microtremor has been strong and the ground tilt has been so slight as to keep the clinograph pen nearly stationary, aside from diurnal fluctuation.

Very respectfully,

T. A. JAGGAR, JR.,
Director.



HAWAIIAN VOLCANO RESEARCH ASSOCIATION.

This society is a voluntary one, made up of subscribers to scientific work which is being executed by Dr. T. A. Jaggar, Director of the Hawaiian Volcano Observatory, Volcano House, P. O., Hawaii. **All scientific exchanges should be sent to this address.**

In 1918 there were about 150 subscribers in Hawaii and elsewhere, firms and individuals. A group of firms and persons in Hilo built the main observatory building in the spring of 1912. The work was founded by the Massachusetts Institute of Technology. Publications to date have been weekly bulletins since the summer of 1911 now reprinted in Honolulu in monthly form. There are also special reports, printed from time to time.

The monthly bulletin is sent to regular annual subscribers to the work of the Association. L. A. Thurston is president of the Board of Directors of the Association, and L. T. Peck is treasurer. New subscribers who are interested in volcanoes will be welcomed in the Association. The Association aims: (1) To record volcanic activity and earthquakes in Hawaii; (2) to attract scientific men hither for special studies; (3) to promote the establishment of volcano observatories all over the world. The annual dues of regular members are $5; patrons of the Association subscribe larger amounts.

WHITNEY LABORATORY OF SEISMOLOGY.

The Whitney Laboratory of Seismology, named after an endowment fund for geophysical research held by the Massachusetts Institute of Technology, in memory of Caroline and Edward Whitney of Boston, 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 solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	1000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the acceleration, or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol a, or max. a, is given in the conventional unit, the milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

U. S. DEPARTMENT OF AGRICULTURE
WEATHER BUREAU
CHARLES F. MARVIN, CHIEF

MONTHLY BULLETIN

OF THE

Hawaiian Volcano Observatory

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February 8, 1819.

Again the history of 1919 is repeating that of 1918 in seasonal mechanism of the Halemaumau lava pit, and the first week of February shows complete recovery from the preceding subsidence and the liquid lava building up rapidly above the former wall crack vents northeast and south. The lakes have recovered their brimming and overflowing condition but the southwestern border heap, which in January produced overflows outside of Halemaumau, has not yet revived at its summit. The south heap, however, overflowed the rim of the pit on Friday, February 7, and in the course of three successive impulses of overflow during the day poured 400 feet down the outer southeast slope of the Halemaumau eminence so as unfortunately to damage a small portion of the newly built trail leading from the road terminus to the pit. This trail has been graded and marked with stones and whitewash by special appropriation of the Board of Supervisors of the County, the work being barely completed when this new overflow came. This flow is in the midst of the area similarly flooded in February-March, 1918, and the cone at its source is close beside the similar "South Cone" of last year.

Measurements of the week expressed in feet below or above the southeast station have been as follows:

Main lake, Jan. 29, 38 below; central floor, 23 below; N. E. heap, 7 below; S. W. heap, 1 above. Main lake, Feb. 7, 14 below; central floor, 15 below; N. E. heap, 3 above; S. W. heap, 4 above.

The figures indicate that in nine days the lake rose 24 feet, or 2.7 feet per day; the northeast heap built itself up 10 feet, or 1.1 feet per day. Both of these were recovery by rise of liquid, the lake at a rate three-quarters as fast as the previous subsidence, and the northeast heap four times as fast. The evidence for movement of the floor in places not overflowed is furnished by the central floor at the central cone locality which rose 8 feet in nine days, or .9 feet per day, and the southwest heap which at its summit rose 3 feet, or .3 feet per day. The evidence from these two points alone is inadequate, but it would appear that the bench magma rose but little during the week and it is probable that the main lava column subsided somewhat, especially across the northwest half of the pit, compensating the effervescence of its substance in the numerous flowing vents on the other side of the circle. It should be noted that the southwest heap after recovery was still 10 feet below its maximum of Jan. 25 and the central floor had just recovered its level of that date. The repeated heavy floods which poured into the northwestern region during the week still failed to fill it or reduce the grade from the north lake in that direction, evidence favoring the view that the underpinning was subsiding. This may have been compensated by some mass uplift under the main lake and eastern vents, but there were no fixed objects there, like the former crags, to serve as bench marks for measurement.

With a view to interpretation of the probable movement of the deep lava column at such a time as this it is interesting to make comparison with the week of November 22, 1918, which ended the subsidence of November 14. On November 17-18 the liquid lava rose 19 feet and the bench magma, represented by the central crag, sank 14 feet. This was a culmination of subsi-

dence when gas was released from confinement and induced effervescence. The present period appears to be in general a culmination of rising, with similarly a stagnation crisis in the internal pressures of the lava column and consequent release of gas inducing effervescence. It may well be true that an overflow like the one in January, abstracting many hundreds of tons weight from the top of the lava column, brings about effervescence of gas somewhat as in the case of the overflow of a geyser pool. In the geyser release of pressure lowers boiling points and explosive ebullition follows; in the lava column release of pressure lowers saturation points of gas dissolved in glass and effervescence follows. In both cases a foam forms at the expense of the fluid beneath. The excessive liquid lava of the past two months is such a foam and its rising and overflowing is not necessarily a measure of what the stiffer substance below is doing.

With this in mind it is curious to note that the clinograph, which has consistently shown eastward tilt with rising bench magma as measured by the crags, and westward tilt with sinking magma, has during the past fortnight, shown stationary or slightly eastward tilt during the spell of sinking liquid last week, and pronounced westward tilt during the time of strongly rising liquid this week. The last glimpse of the central crag was on February 1, and thereafter it disappeared, although no flows were definitely seen to drown it. In February, 1918, at the time when liquid lava welled up the 1894 depression northeast in excessive volumes, and the crater floor otherwise showed little change, there was a similar aberrant westward tilt, as though effervescence were in fact a mark of deep subsidence, not indicated at once in movements of the crater floor. Whatever the cause, it is a striking fact that the February high level of both years brings the only marked discordances between the apparent rising of lava and eastward tilt. The explanation of the discordance by lag is not tenable in the writer's judgment. Remembering the November case, when the real movement of the lava column was still downward as measured by the crags, though crags and liquid moved in opposite directions, and the tilt was to the west, agreeing rather with the crags than with the liquid, the suggestion is strong that the rise and fall of the liquid lava is not necessarily an index of the rise and fall of the lava column.

On Saturday, February 1, 1919, at 4 p. m., the lakes stood higher relative to the floor and the fumes were thinner. There was no puffing, the northeast heap and east cone glowed through cracks encrusted with salts, and the north floor cone was flaming. The main lake had 15-foot walls and was crusted over, with border fountains east and west. The southeast pond had overflowed its east end and the wall west of it was 12 feet high. A fountain bubbled up steadily on its west side and there was fountaining bombardment against its north wall. The north lake was also crusted over with 10-foot walls and border fountains northwest.

At 8 p. m. the night view showed at a distance marked increase in number of fiery areas. There were glow spots at the lakes, the central, western and northern cones and the west heap, and the spray of the main and north lakes was flung above the edge of their pits.

On February 2 at 6 p. m. the lakes were brimming and building ramparts. The north lake had overflowed extensively across the northwestern part of the floor, making a wide pool against the wall in process of cracking and foundering. The main lake was streaming eastward and bombarding its east rampart. The southeast pond overflowed eastward sluggishly with interruptions due to the bursting of its crust by gas generation of a fountain and temporary subsidence of one or two feet, followed by recovery. The southwest pond was fountaining. The south wall cone was building up by fountain splash and the east cone had become a patch of flaming and spray-

ing cracks over a large chamber below filled with fountaining lava. Gas pressure was renewed, the north cone was flaming from glowing orifices on its west side, there was some hissing and the central and west pond cones were flaming chimneys. One of the flings of spray on the east bank of the main lake burned with a yellow flame for a few seconds as though it were a splash of kerosene.

On February 3 at 10 a. m. the lakes were overflowing so that by noon the floor was covered with fresh lava east and north from the main lake, northwest from the north lake and south a short distance from the southwest pond. The south wall cone had become a much higher ring shaped pot belching bubbles through a heavy melt, the individual bursts lifting the whole cone surrounding the pot. Next to it was a second cone hissing through a live spiracle and this relation continued throughout the week, the hissing gas vent being maintained apparently as an essential valve mechanism of the overflowing pot. The cones were about two feet below the rim of the pit and 20 feet away from and inside of the rim. A flow was pouring at noon eastward and northward from this pot along the base of the wall a few feet under the southeast station and other fresh flows had been ejected from this vent along the wall crack toward the south station. Here there was tumescence of the floor away from the wall dragging open and depressing the marginal lava.

The lakes were again contracting in area by the building inward of grotto ramparts with spatter domes over six feet high. There were four or five fountains in each of the large lakes and at least one in the southwest pond. The crag remnant had disappeared. The northeastern and southwestern heaps remained quiet.

On Tuesday, February 4, there was pronounced rising of the lakes in the morning and at 6 p. m. At 9 p. m. the lakes were depressed three feet within their cups and rose somewhat during the next two hours. The southeast pond, at first almost indistinguishable under a crust flush with the floor, finally burst its crust and revealed a circular basin 30 feet in diameter, first flames and then fountains appearing, this being followed by subsidence of the pond leaving red hot banks five feet high with stalactite drip and tumbled glowing marginal crusts overhanging in places. Thereafter the pond recovered slowly. The main lake, although only a short distance away and apparently connected with the pond, for there is a flaming vent between the two, did not partake of these movements at all. Similarly the north lake had a sinking spell quite independent of the main lake. All the lakes and lava vents are at different levels held up by differential gas pressure. The west pond is higher than the southwest pond, the latter higher than the southeast pond, the southeast pond higher than the main lake and the north lake lowest of all. The northeast heap and the south cone produce flows at still different levels.

The northeast heap had completely revived and a puddle of lava on top 10 feet in diameter was fountaining continuously and feeding flows which pushed down the western slope of the heap. The whole structure was higher. The south wall cone was flaming, the southwest and west ponds showed occasional fountains, the east cone was piled up, hissing noisily and showing sharp spears of burning gas, and flames played above the central cone. There was a period of very strong fountaining at a high level after midnight but the next morning the lakes were lower and the pit somewhat smokier. It should be said that with the revival the fume had greatly diminished.

On February 5 towards noon the lakes rose and the main lake overflowed. The northeast heap had developed a large cone on its summit. At 8 p. m. the pit was dull, but the summit crusts of the northeast heap were cracking up and sinking, showing a pool within.

On Thursday, February 6, from 1 to 4 p. m., the lakes were about the same. Streaming in the main lake was eastward and its west and northeast grot-

toes were curtained with stalactites. The southeast pond was somewhat lower, showing a glowing edge, and the south wall cone had recently produced heavy flows which had poured all the way to the east station. The cone at the east summit of the northeast heap had broken down on its northwestern side so as to leave an open oven over a pot eight feet in diameter covered with a heavy skin which inflated periodically like a balloon, and this was followed by a burst of gas and sputter lava from the oven opening. The whole heap elsewhere was heavily crusted with an elongate flat top extending 300 feet northwest from the oven and sloping away in all directions. The summit was now well above the level of the east shelter. At 6 p. m. there was strong fountaining and a high level with much flaming from the chimneys.

On Friday, February 7, 1919, there was another high level at 8:30 a. m. and a broad flow from the south wall cone spread across the rim of the pit and 20 feet back from the rim on the east side of the south cone of 1918 and sent its main volume northeastward just inside the rim as before. At 11 a. m. this flow had crusted over and the lakes were lower but a live flow was pouring from the west pond toward the center of the pit. At 3 p. m. the south overflow revived and pushed forward 20 feet farther back from the rim and then developed two flows just inside the rim, moving east and west, the western one cascading steeply into the wall crack under the old south cone and flowing thence to a point under the south station. The source was now 5 feet above the level of the rim of Halemaumau, an open oven towards the southeast with a hissing and flaming spiracle cone beside it. At 8 p. m. the overflows were renewed, poured in a narrow tongue 400 feet down the slope across the new trail and otherwise sent voluminous floods across the floor inside the pit, temporarily drowning the southeast pond. The end of this flow penetrated the interior of the stone shelter on the east side of the pit. Probably at the same time the north lake and main lake overflowed. The pit was a very brilliant spectacle while these night flows were in progress. The blowing cone beside the south pot burst open and fountained violently, making an exceptional display of fireworks.

During the day the northeast heap was quiet and its summit cone closed but in the evening it broke open, piled higher and drowned the former northeast station under lava and extended the heap towards the north and west.

On this day the north lake was surrounded by six symmetrical half-domes and curtained grottoes. The west pond cone on the high slope of the west heap was a fountaining pot but the summit of the heap had greatly collapsed and showed no activity. The southeast pond was crusted over and the southwest pond had built three or four spatter domes. The central and north cones had diminished in brightness of incandescence. The east cone continued to puff as a large area of glowing cracks over a concealed chamber where lava could be heard pounding.

For the week ending at 8 p. m., Feb. 7, 1919, the instruments of the Whitney Laboratory of Seismology have registered local earthquakes as follows: Feb. 1, 3:14 a. m. and 6:29 a. m.; Feb. 2, 12:47 a. m., felt; Feb. 4, 4:23 a. m., slight; Feb. 5, 3:07 a. m. and 8:24 p. m., both slight. A teleseism was registered at 1:29 p. m. Jan. 31, 1919, not reported last week. This shock showed almost no effect on the east-west instrument, and pronounced long waves only on the north-south and optical instruments, suggesting an origin either north or south of the station. The distance was not indicated.

Microseismic motion has been moderately strong north-south and slight east-west, with some temporary increase on Feb. 3 and Feb. 6. The harmonic microtremor was strong Feb. 1, Feb. 3 and Feb. 7 and strongish at other times; the spasmodic tremor of quicker period was strongest Feb. 1 and 2 and decreased thereafter with some revival Feb. 5, the maxima notably occurring on the days of local earthquakes.

The clinograph showed a turning point from slight east tilt Feb. 1 to west tilt; the seismographs showed change from north tilt to south. The westerly tilt was strong, decreasing from Feb. 2 to Feb. 6, the meridional

component of the seismographs showing increasing south tilt to Feb. 4, with decrease Feb. 5 and stationary condition Feb. 6-7. On Feb. 7 the clinograph also showed stationary tendency.

Feb. 15, 1919.

During the week ending Feb. 14, 1919, the lakes have somewhat subsided within their cups, the floor has been stationary as a whole, and the northeast heap has built itself up until it stands 27 feet above the east station and has poured forth bulky overflows completely surrounding the eastern stone shelter and burying the bench mark of the United States Geological Survey which was set in a small masonry table near the back corner of the shelter.

These flows from the northeast heap pushed eastward across the rim of Halemaumau and 150 feet beyond so as to endanger the wooden hut belonging to the Observatory. The hut was accordingly removed and rebuilt on safer ground 200 yards farther north. This is the fourth time that the little wooden building has been moved. The first building was erected by Mr. Perret in 1911 on the east rim of the pit adjacent to and north of the stone shelter and its site was identical with that of the bench mark just buried up. Owing to molestation by vandals the hut was moved in 1912 to a point back of the north rim. This place proved fumy from the hot cracks and half of the building was transferred in 1916 to the position back from the east rim. In 1918 the part left at the north was torn down and rebuilt in the Observatory grounds and its former site was invaded by lava spatter with much burning of debris when the eruptive cones formed Nov. 1, 1918. February, 1919, compels another moving because of lava flow. It would be impossible to place a station anywhere near the pit margin which would be immune, unless it were built as a steel tower.

It is perhaps not generally realized that during the last year the lava column has through liquid flooding overtopped the rim of Halemaumau on eleven separate occasions and at nine different places. Six of these are considerable overflows extending more than 100 feet away from the pit and the others were driblet overflows which did not travel far. The southeast flows of Feb.-Mar., 1918, were the most extensive, those of Nov., 1918, to the north cone next in actual length and the flows of Jan.-Feb., 1919, now in progress, tend to fill some of the gaps east, south and southwest between the two earlier localities. August of 1918 produced driblet overflowing of the rim north and southwest, but no extensive flows. If the present overflowing continues as last year until the equinox and beyond, there is ample time for extensive flows yet to come.

The measurements from the rim at the southeast station have been as follows:

Main lake, Feb. 7, 14 feet below rim; Northeast heap, three feet above rim. Main lake, Feb. 14, 25 feet below rim; Northeast heap, 16 feet above rim.

In seven days the lake sank 11 feet, or 1.6 feet per day, while the northeast heap built itself up 13 feet, or 1.9 feet per day. Other points were in general stationary.

On Saturday, Feb. 8, 1919, at noon there was no further flowing from the south cone, the floor showed increased smoke in the south central region and the lakes stood about six feet below their banks and appeared rising. The east cone was hissing. The cone on the summit of the northeast heap had become a sharp horn in profile as seen from the northeast, this structure forming the protruding cover of an oven facing north within which a circular crusted pool heaved sluggishly. From this vent extensive new flows had piled up northward and westward.

The floods from the south cone on the previous night had poured voluminously northward and southward within the pit as well as outside of it to the southeast where it had crossed the trail. The flow northward had crossed the southeast pond and evidently had cascaded into it. This had been joined by other flows from the main lake and the lava penetrated a few feet into the interior of the east shelter. The flow southward had surrounded the south station and just west of the station a stream 30 feet wide crossed the edge of the pit and flowed 200 feet beyond to the south.

Extensive fresh floods had resulted from the overbrimming of the north lake so that its rampart was all changed and the whole northwestern region covered with fresh lava. This lake was even now brimming and appeared ready to overflow again. Later about 9 p. m. more extensive flows here took place.

On February 9 there was no special activity in the morning but in the late afternoon the summit pot of the northeast heap erupted violently and changed the direction of its flows from northward to southeastward. This at once threatened the east shelter and the government bench mark. All through the evening this pot ejected a standing fountain which made a brilliant display and showed at a distance as irregular flashing. The lakes also were luminous.

At noon Monday, Feb. 10, the lakes showed inner cliffs about six feet high, the south cone was quiet and the east cone had enlarged and opened a fountaining pot in its center. At 9 a. m. the northeast heap had still maintained its standing fountain, but this had now dwindled to a sluggish fountaining pot, while trickle flows pushed ahead and piled up here and there on the slopes of the heap. The new flows had made much progress southward across the floor of the pit and a heavy block of them had pushed 100 feet eastward on the north side of the stone shelter so as to cross the old trail and head straight towards the Observatory hut 200 feet away. This flow had hardened in light brittle shells with shredded edges and some tendency to aa structure and was quite different from the masssive lumpy lava of the earlier flows from the same source.

The southwest pond had built up its spatter domes. The south oven and blowing cone were quiet. The southeast pond had 6-foot walls and a somewhat inflated crust, and a whitened spatter dome stood on the north margin of its circular pit. No such rampart elsewhere surrounded this pit as encompassed the other two lakes. The rampart around the main lake was very heavy and covered with Pele's hair and the main fountaining activity was at a double grotto northeast of the lake under a large spatter dome. Here there were great accumulations of stalactites and the gas-blistered skin on the lake surface was incessantly drawn into the grotto fountains. The grotto at the west end of the lake was a symmetrical arch with a curtain of drip across the opening which was later seen to fall. A hissing spiracle had formed above a vent midway between the southeast pond and the main lake. The north cone had become inconspicuous. The north lake had enlarged and become circular.

At 4 p. m. the action at the northeast heap had increased and flows were pouring from the summit southward. This summit now stood fully 20 feet above the floor of the east shelter, and at the east station the whole north rim of the pit was now cut off from view.

At night the view from Volcano House showed nine fiery areas at Halemaumau, making the distant view of the pit appear like the lights of a town.

On Tuesday, Feb. 11, at 9 a. m. the northeast cone was found sharp-pointed on top of the heap with secondary frozen pools or platforms adjoining it on the east which had been sources for the eastern overflows. The northern flows had stopped. The eastern flows had pushed 50 feet farther and driblet lava was in motion. A fresh lobe of the flow had piled up five feet high, almost completely filling the interior of the east shelter, and another lobe during the day surrounded the government bench mark. The lakes remained low except the north lake, which had occasional brimming spells with high fountaining. The southeast pond was generally crusted over but occasionally rose somewhat. In the afternoon the northeast cone hissed and the flows increased in vigor. Lava could be heard fountaining in the east cone pot. In the night all the fire holes were bright.

On the morning of Feb. 13 the pit was dull, there was much solfataric staining and Pele's hair and no flows were seen in motion in the forenoon. There was glow at the south, northeast, west and north cones. The main lake and southeast pond were depressed 15 feet within their shafts, the north lake ten. The grottoes were curtained and sluggish.

At the east cone one could stand on the rim and look into the open pot four

feet in diameter where the lava was splashing some 15 feet below, and under the southern lip of the orifice a bright orange interior chamber was revealed, hung with delicately sculptured fiery stalactites shaped like long bunches of grapes. The entire interior including the liquid below was maintained at an even glow and at night a banner of blue-green flame fluttered above the orifice showing the presence of combustible gas. The fume to leeward was pale blue and transparent and acridly irrespirable with the acids of sulphur.

The northeast and south cones maintained hissing spiracles alongside the crusted lava pots which had been the flow sources. The flows following the sudden revival of the northeast heap of Feb. 8-9 had been brittle and papery, the later ones of Feb. 12 were heavy and bulbous.

In the afternoon there was increased hissing and at 4:04 p. m. the northeast cone, after spasmodic liftings of a lid of broken crust with some spurting of lava from within the gas cone, suddenly burst and collapsed. Instantly a large volume of very liquid lava domed up in artesian fashion, flooded the top of the heap, and then cascaded south in a rapid river of melt which progressed 100 feet in four minutes; the stream was 40 feet wide. The standing fountain was 10 feet high and 20 feet wide and explosive bursts shot up 20 feet. There was no noise worth mention, and the hissing stopped. The source quickly settled down into a rhythmically gushing spring with small bursts every five seconds emerging from a gash perhaps eighteen inches wide. The source torrent had an orange red pudding-like surface but the flow below quickly stagnated and spread sidewise, the crusts becoming rather brittle and papery, with heavier toes of the ball type emerging later. This flow continued all night, and the fountain bursts at the source dwindled after midnight. The flows were at first south, later east, mostly piling up on the previous flows. The phenomena of this outbreak were like the uncorking of champagne, and the sudden fountain was clearly a geyser effect due to release of gas pressure. This fountain, flowing for many hours, stood 40 feet above the level of the main lake of lava only 360 feet away southwest of it.

The next day, Friday, Feb. 14, 1919, the new flows were found completely surrounding the east shelter and the U. S. bench mark was buried. Slow moving toes were pushing ahead at the fronts. The east front was no farther advanced, but more spread out and piled up, but the south front had curved around the shelter, buried more of the old trail, advanced toward the east cone, and nearly reached the east station monument. The flows were now high bulbous masses of very solid pahoehoe. The cone on top of the heap was hissing slightly but not open.

There was little change in the lakes, spray could be seen in the west grotto of the main lake through an orifice above the curtain across the grotto entrance. The west cone appeared increasing in height and in the evening a revived pot on top of the west heap was fuming and flaring.

In the Whitney Laboratory of Seismology there were registered small local earthquakes at 3:44 p. m. Feb. 10, and at 12:35 a. m. and 8:08 a. m. Feb. 14. Microseismic motion and microtremor both increased to strong Feb. 10, otherwise their vibrations were moderate. The movements of tilting indicated were mostly slight or stationary, but there was strong continuous east tilt from about 2 p. m. Feb. 9 to 8 a. m. Feb. 10, and short spasms of unusually sharp east tilt on the evening of Feb. 10 and about 4 p. m. Feb. 13. The tilting was slightly west Feb. 13-14, with tendency to turn eastward on Feb. 14. The meridional component was strong north Feb. 9-10, slightly north Feb. 14, and on other days slightly southward.

Feb. 22, 1919.

During the week ending Friday, Feb. 21, 1919, the northeast cone continued its spasms of occasional overflow for a few days and then became quiet. The top of the lava column as represented by the floor and lakes has been essentially stationary, the lakes sinking and rising through a few feet. New openings filled with live lava have appeared at a pot adjacent to the central cone and in a collapsed depression at the summit of the west heap. There has

been marked increase of solfataric staining extending even to the older rim south and southeast outside of the pit proper. No measurements are here recorded, as the changes of level are very small.

It may be well in this place to describe briefly the present appearance of Halemaumau, so unlike the familiar "pit" of aforetime, and also totally different from the craggy hill of last year's high levels. As one looks down upon Halemaumau from the high west bluff of Kilauea the pit rim is practically obliterated and there appears in its place a flat smoking area with three lava heaps of slight relief and three inconspicuous small circular cups containing the liquid lakes. Close inspection with a field glass shows a semicircle of low rim remaining on the northwest side, but southwest, southeast and northeast the rim is replaced by an irregular surface of humpy pahoehoe. As a whole this smoking surface is the summit of the broad flat inner cone making the bottom of the greater crater. If the "floor" of Halemaumau were now to sink bodily, preserving its integrity, the circular margin would slice in two vertically each of the three heaps southwest, southeast and northeast, carrying down the inner halves and leaving the outer halves as eminences in the new rim of the pit. Above the low cliff of the north rim there is such an eminence today, consisting of the group of cones built by the spouting lava of the extensive overflows of November, 1918. The general arrangement of the present Halemaumau floor was determined in December, 1918, that mechanism persisting ever since, viz: A semicircle of lava heaping southeast and a semicircle of never completed filling northwest. The three places of high heaping and overflow of the pit are just where there were low benches between the high crags in 1916-17; and where the crags were there are now sags between the heaps, the greatest sag of all being at the northwest where stood the great crag masses of 1917.

On Saturday, Feb. 15, at 4 p. m., the pit was dull with much smoke and no marked gas pressure and no flows in motion. The southeast and main lakes were depressed 10 feet within their cups and the north lake 20 feet. This made the latter about 17 feet lower than the main lake. The main lake was hence higher than on the previous day and the north lake lower. In the interior of the east cone the lava was surging about 12 feet down and the only departure from uniform incandescence inside was the splash on the walls which at the moment of fling was a little brighter yellow. There was glow in the west and south cones which after dark appeared as incandescent spots. At night the glow above the north and main lakes was bright, above the southeast and southwest ponds dim, and pale flame fluttered over the east cone.

On Feb. 16 about 5:30 p. m. the northeast cone, which had developed two lumpy summits, erupted again with moderate fountaining and put out more flows which piled up inside the east shelter and spread to the east, south and southwest, extending the front to the base of the east cone. After dark the northeast cone became quiet, the lakes were low and the glow dull.

Daily measurements during this period directed to numerous floor points gave evidence of a condition extraordinarily stationary, as though the top of the lava column were rigidly locked to the old rim by the new overlaps. There was none of the sensitive rising and falling of a few feet which was so characteristic of the movements of the former craggy floor.

On Monday, Feb. 17, about 5 p. m., the lakes were a little higher, the eastern ones about eight feet below their rims and the north lake 15 feet. The activity was unchanged and much smoke rose from the floor south and southwest and some smoke around the north lake. A flow trickled sluggishly on the southwest flank of the northeast heap and the northernmost of several irregular lumpy cones on the summit of the heap was hissing mildly. The north rampart of the main lake and much of the northeast grotto dome had broken down. Flames were abundant and large and appeared at the following places: A rampart pot on the west side of the north lake, the west, east and south cones, a spiracle vent between the main and southeast ponds, and filagree heaps southeast of the north lake and east of the main lake.

January 19, 1919. Margin of Halemaumau southwest overflowed, looking towards west station. (Photo Jaggar.)

February 13, 1919, 11 a. m. Incandescent interior of cavern hung with stalactites, east cone, Halemaumau floor. (Photo Jaggar.)

On Feb. 18 about 6:30 a. m. the lakes were high so that their fountains were visible at a distance. Shortly after 8 a. m. the northeast heap again burst its northernmost summit cone and started a spouting flood which deluged the slope northeastward, many bright yellow flashes of flame bursting through the red melt some distance below the summit. At 9 a. m. the flows were pushing northward and northeastward on the heap and sluggish flowing continued all day.

About 3 p. m. the summit cone of the heap had reformed and was hissing and lifting a lid of crust. Instead of bursting out through the summit, however, the pressure was relieved by an outbreak on the northeast flank of the heap and the flow overran the higher edge of Halemaumau close to the north side of the rounded pressure mound, which since 1894 has been a conspicuous eminence on the northeastern outer rim of Halemaumau. This flow poured in a tongue about 30 feet long around the mound eastward, and another tongue 50 feet long pushed northward.

This overflow filled and permanently obliterated a depressed and sheltered niche in the rim which had been used by the writer as the northeast trig station and which in December, 1916, was the station occupied by Mr. Lionel Walden when the sketches were made for the famous diorama of Halemaumau.

At 7 p. m. there were twelve flaming cones and four lakes. The northeast heap was quiet, the north lake dull and relatively low, the main lake about nine feet down, streaming eastward and bombarding its northeast grotto. Around it there were flaming vents in the rampart, on the east, north and west, the western one a high chimney pot through the top of the west grotto dome.

A pot had opened at the central cone locality and was splashing and flaming. The west cone was flaming and the southwest pond glowed dimly. Flames rose at the spiracle locality between the southeast pond and the main lake, there were high gas pressure and flames in the fi'agree cone on the north brink of the southeast pond and the liquid in the east cone pot was somewhat higher. The south cone flared brightly and everything indicated much flaming of gases under pressure.

On Feb. 19 the pit was smoky, there was no special change and in the evening six main glowing areas in the view as seen from a distance represented the four lakes, the west heap and the south cone.

On Thursday, Feb. 20, in the morning, the north lake was low, the main lake relatively high and the lava in the east cone appeared lower, considerably extending the grotto cavern under the cone. The main lake was thickly crusted and apparently rising. There was no gas pressure at the northeast cone, no flows were in motion and there was much smoke.

On Friday, Feb. 21, 1919, at 11 a. m., the lava of the east cone and main lake was 15 feet below the rims and the north lake was low, fountaining noisily. The interior of the east cone had diminished in brightness. Smoke rose densely from the southeastern half of the floor surface, this being notably the region occupied by the three heaps which have given vent to the recent overflows. There was great increase of solfataric staining about the smoking areas and this extended over the rim southeast and south, where disagreeable fumes of sulphurous acid rose through cracks adjacent to the southeast station and there was much deposit of yellow and white sublimates, sulphur, alum and gypsum, at this place and also near the old south cone east of the south station. The edge of the inner floor of Halemaumau just south of the southeast station appeared slightly swollen but the measurements indicated no marked changes of floor level elsewhere.

Exploration of the summit of the west heap revealed the fact that it had caved in on top and the revived pot observed glowing on the night of Feb. 14 was found in the midst of a pool area in the depression, the pool being an oval 50 feet long southeast northwest, and the pot a cau'dron seven feet long near the southern end of the pool, containing liquid lava one foot down sluggishly bubbling. The west cone was a high sulphur-stained glowing pyramid on the northeastern slope of the west heap and the southwest pond, also on

the slope, was marked by rounded rampart heaps a little farther to the south.

In the evening the main lake was higher, a very large banner of flame played through the opening on top of the west grotto dome and in all seven cones were flaming and five ponds made luminous the fume above. The new west heap pond is included among these. The northeast cone was dark.

During the week ending at 8 p. m. Friday, Feb. 21, 1919, the seismographs of the Whitney Laboratory registered pronounced local earthquakes at 2:59 p. m. Feb. 15 and 6:40 a. m. Feb. 20. Microseisms and microtremors have both been moderate, the latter decreasing somewhat. Movements of tilting have been slight and variable—Feb. 15-16 to the northeast, Feb. 17 to the southwest, Feb. 18 stationary, Feb. 19-20 to the southwest, and Feb. 21 to the northeast.

March 1, 1919.

The last week in February of 1919 was strikingly repeated at the lava pit the performance of 1918, exhibiting revival of strong tumescence of the semi-solid lava around the lakes and eastern cones, and along with this mass swelling, eruptions of liquid lava making spectacular standing fountains, have, as expected for this season before the equinox, greatly extended the overflows from Halemaumau to the east, southeast and south. The lakes as well as the three lava heaps have taken part in overflowing and the swelling of the bench magma under and around the lake cups is pronounced, so that all the lakes now stand as ring-shaped basins elevated above the old rim level of the pit. There are now six lakes, the west cone having collapsed to an open pond. A conspicuous result of the renewed swelling is the mashing upward and outward of the Halemaumau pit rim southwest, south and east, so as to make a pressure ridge from 8 to 15 feet high with an elephant's-back curve on the side away from the pit. The width of the uplifted portion of the rim varies from 10 to 20 feet and for nearly a third of the circumference of Halemaumau this movement has destroyed and made unrecognizable the old rim. Similar rim crushing took place in February and October of 1918 on the southwest and north rims.

As the eruptions of the week have destroyed the three most used surveying stations, measurement for the time being is at a standstill. As the lakes have been high, at times overflowing and practically level with the adjacent floors, the net rise at the eastern surfaces has been from 10 to 15 feet and there has been overflow construction of a few feet at the northeast, south and southwest heaps. The placing of new flag stations and fresh triangulation of the altered topography is now in progress.

On Saturday, Feb. 22, 1919, at 4 p. m., it was evident that a strong rise of the liquid lava of the lakes had started. Where on the previous day the main lake and east pot lava had been 15 feet down, these places now showed the liquid only two feet below the marginal ramparts and in the southeast pond the crust was only one foot below the rim. Everything indicated increased gas pressure, marked by the steady, quiet, spraying type of fountaining. At the southeast pond the only fountain was inside of the curtained glowing cone on its north brink, elsewhere the liquid was coated with crust; the spray spurted out through the apertures of the cone. In the main lake there was steady streaming to the north and northeast grottoes, where the fountains noiselessly flung up strings of melt, the flaming gases blew incandescent spray of glass droplets across the surface skins, and these in turn were ceaselessly ballooning with gas rising from below. The ramparts were again being built up with spatter. The north lake was depressed three feet below its rim, quite circular, covered with a carpet of crust swollen in the center which was surrounded by a zone of quiet, high-flung fountaining under all the ramparts. Occasionally the gas accumulation burst the crust and started cracking and foundering of blocks and central fountaining.

The pot recently opened in the center of the floor of the pit had built a five-foot cone, which was noisily puffing through glowing apertures. The west and south cones were glowing, the east cone pot was filled with a crusted pud-

ding which left two flaming openings on the south side, at the south cone smoke was very dense and much free sulphur vapor deposited yellow crystals back from the rim of the pit around the southeast station.

At 9 p. m. Feb. 23 the lake margins were four feet high, the cones were flaming, the activity as before, and in general the only marked change was a slight lowering of the liquid relative to its banks. At the northeast grotto of the main lake the spurts were quite rhythmic at one-second intervals, the spray was flung up from 30 to 40 feet, and outward horizontally over the crust of the lake it was hurled from 75 to 100 feet. There were occasional flings of heavy melt which slopped back on the lake surface. The streaming was towards the active corner. Occasionally the crust, about three inches thick, would break up and founder, this being as usual followed by slight subsidence due to loss of gas, whereby a red hot margin was revealed all around the lake which gained a width of about a foot before recovery set in.

On Monday, Feb. 24, no unusual activity was observed, the fume was rather dense and swelling of the bench magma southeast began to be apparent. At 10 p. m. the north lake was brimming in its basin and fountaining high, and after midnight all the lakes were high, the west heap was spurting and the central cone flaring at intervals.

Tuesday, Feb. 25, proved to be a day of sudden crisis. Measurements at 9:30 a. m. showed mass uplift of the southeast floor, northeast heap, southwest floor and at the lake ramparts and there was doubtless marked uplift in the smoky region around the south cone. The central cone had changed its shape and a new straight flow had poured from it across the floor of the pit northwestward. The lakes, observed at 10 a. m., 1 p. m. and 4 p. m., were high and brimming all day.

At 10 a. m. the southeast concrete platform used as a trig station was practically horizontal, but surrounded by cracks hot with sulphurous fumes recently developed there. During the day very rapid acceleration in tumescence of the bench magma pushed the rim of the pit up 10 feet, swelling the southeastern half of the pit floor, tilting back the concrete station at an angle of 20 degrees away from the center of the pit and keeping the relation of the inner floor to the relief of the rim about as it had been before. Just north of the southeast station the floor had stood eight feet below the rim, whereas at the station it was only two feet down; after the upheaval these relations were the same, but the pressure ridge upheaved opposite the higher rim escarpment was 12 feet high and 15 feet wide with reference to the region back of it, whereas at the station it was only about eight feet high and ten feet wide. In other words, the biggest part of the ridge of rim rock squeezed up came opposite the place where the rim had been highest above the floor. All of the rim rock involved in this pressure ridge at this place for a length of 200 feet was the overflow lava of 1918. The ridge, however, extended around the rim to the southwest, there involving the older rim made of 1894 flows.

At 4:45 p. m. the two south cones, which for some time past have been quiet and smoky, suddenly erupted a flood of liquid lava which poured westward and southward, crossing the rim of the pit as before at the south station and in the direction of the southeast trail. This outbreak was followed almost immediately by a similar flood through the orifice of the east cone, which poured straight eastward across the rim of the pit on the south side of the east station, partially submerging that station. At 5:30 p. m. there were two dome-shaped standing fountains side by side at the south cone locality, each six feet high and ten feet wide, fed from below under strong pressure like an artesian well and the pooled lava around the cones was feeding rapid hot liquid flows which cascaded southeastward and westward. The flows followed the new trail towards the road terminus for two-thirds of the way down the slope, destroying at least half of the trail and pushing twice as far as the former flow from this vent. By 5:50 p. m. the standing fountains changed to spurting vents and the flows rapidly came to rest.

The east cone also maintained a standing fountain and at 5:30 p. m. the flow had reached the former site of the Observatory hut and was advancing six

feet per minute. Where the flow crossed the rim it was about 30 feet wide. This source also quieted down shortly after the other, or about 6 p. m.

During this spasm of flow the lakes were high and fountaining violently and continuously around their margins. During the night the north lake overflowed northwestward and in the evening 17 glowing points could be counted in the distant view of Halemaumau.

It is worthy of note that the sudden overflow with strong tumescence of 1918 occurred Feb. 23, whereas this year it was Feb. 25. Such intense swelling, accompanied by humping of the rim of the pit and immediately preceding in each case a spasm of strong flowing, occurred in February and November of 1918.

On Wednesday, Feb. 26, at 6:30 p. m., the fume was considerably reduced, all the vents were alive and the glow at night had increased, the pressure ridge had increased in height and the south cone was built up and spurting. The old south cone of 1918 was now entirely buried and also much of the ridge extending south from it. The east cone was flaming and the fountains of the main lake bombarded with unusual violence a long stretch of the north bank of the lake. The north lake was similarly active and the northeast heap showed summit incandescence.

On Feb. 27 the north lake was especially high, the fume was rather dense, the west heap pond had built up an inner cone and other activity continued as before.

At 2 p. m., Friday, Feb. 28, 1919, it was evident that the swelling of the bench magma included the region around the north lake and the entire southeastern half of the pit. The humped rim extended from the southwest side of the pit all around the southern margin as far as a point opposite the east cone. The continued swelling had warped the new flows of Feb. 25, broken the south cone in two and lifted its inner half so as to reveal glowing layers and in several places the inner floor layers by uplift had parted from the humped rim and so were revealed as the upheaved edge in cross section of the inner lava cylinder. The fresh flood south had extended some 600 feet beyond the south station and the southeast flows had moved a like distance but were wider and more forked. The east cone flow was about 300 feet long and had passed a short distance beyond the old hut site.

The 1918 rim was now buried under overflow from the southeast station to a point beyond the south station and from a place 30 feet south of the east station to a point 50 feet north of the northeast station. The fresh flow material south-southeast was itself mashed up to form part of the pressure rim eight to ten feet high. The south station was entirely buried, the southeast station platform borne high on the flank of the pressure rim at an angle of 40 degrees and fractured, and the east station had frozen cascades enveloping it. The highest part of the pressure rim, 100 feet north of the southeast station, stood 15 feet above the general level outside of the pit and from here it sloped down to the floor level opposite the east cone.

Looking at the Halemaumau surface from the high ground northeast of the pit, the pressure rim was seen to be a puffed up lip hemming in the uplifted floor which extended westward from it as a high flat surface with the cones, lava heaps and lake ramparts standing upon it at still higher levels. The uplift around the lakes had diminished the relative relief of the lava heaps.

The lakes were depressed about five feet within their cups, the north lake rather less than the others, moderate fountaining was in progress and dense smoke rose from the southern half of the floor. The west cone had collapsed to an open pit 50 feet in diameter, with lava splashing a short distance below the rim. The west heap pond had built up a broad cone 10 feet high, which was hissing in spasms from glowing orifices. A harsh puffing of gas was heard occasionally from one of the domes of the north lake. Short flows had recently poured out on the eastern side of the summit of the northeast heap. The northwestern floor had continued to subside and draw away from the wall of the pit; it showed marginal slumped crusts and cliff rocks which had tumbled on its surface. That

tumescence was still in progress southeast was shown by incessant tumbling of fragments in the fissures of the pressure rim.

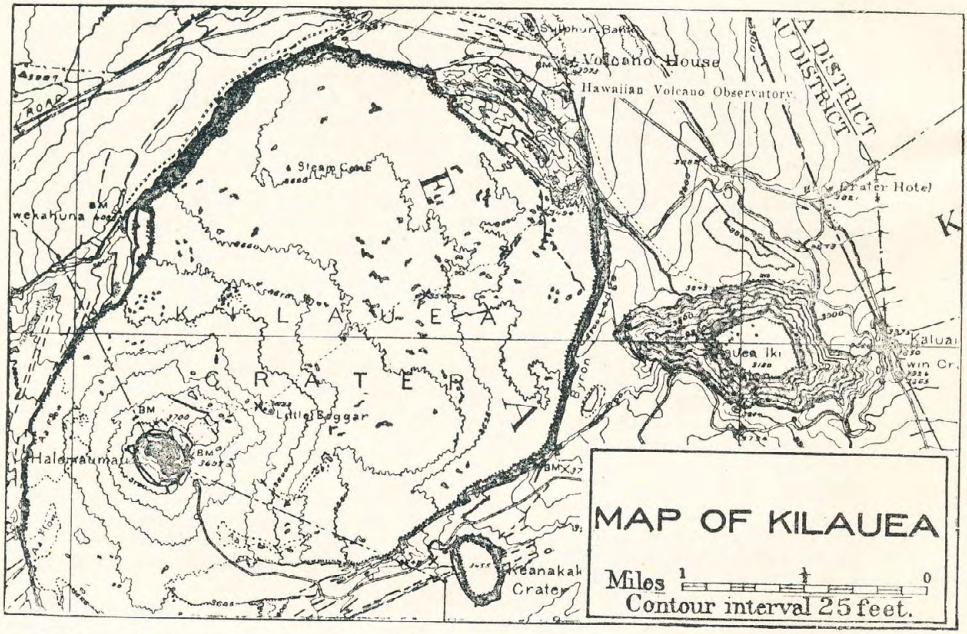
In the Whitney Laboratory of Seismology steady tilt to the east has accompanied the period of tumescence, microtremor has been strong and there have been notable local earthquakes which will be reported later. The strongest of these, at 9:24 p. m. Feb. 25, happened in the evening of the day of paroxysmal swelling and overflow, was very strongly felt and resulted in a fixed tilt of the ground to the north and east, as shown by all the instruments.

Very respectfully,
T. A. JAGGAR, JR.,
Volcanologist.

ERRATA.—January Bulletin, Vol. VII, No. 1. Page 3, for "Section," line 18, read "Station."

Page 6, line 1: The words "above rim" app'y only to "S. W. Heap, January 25."

Page 8, table bottom of page: The words "above rim" apply only to "S. W. Heap."



HAWAIIAN VOLCANO OBSERVATORY.

This issue of the Monthly Bulletin of the Hawaiian Volcano Observatory is the first under the authority and supervision of the U. S. Weather Bureau. In this connection, the valuable co-operation of the Hawaiian Volcano Research Association is acknowledged with gratitude.

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 solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	1000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the acceleration, or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol a, or max. a, is given in the conventional unit, the milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

U. S. DEPARTMENT OF AGRICULTURE
WEATHER BUREAU
CHARLES F. MARVIN, CHIEF

MONTHLY BULLETIN
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Hawaiian Volcano Observatory

VOL. VII. HONOLULU, HAWAII, MARCH, 1919 No. 3

March 8, 1919.

The changes in Halemaumau during the week ending March 7, 1919, have been occasioned by liquid overflows of the lakes and driblet flows eastward from the northeast heap. The tumescence of the floor has ceased. The cone on top of the northeast heap has developed into a steeple twelve feet high, which is a very conspicuous landmark crowning the summit of the new heapings. The longest overflow of 1919 poured south for a quarter of a mile on the afternoon of March 4.

Measurements week by week beginning Feb. 14 yield the following data showing the marked increase of rising as the equinox approaches. As the former southeast station has been destroyed measurements are now referred to the government bench mark on a concrete table back of the north rim of the pit. This mark stands 3700 feet above sea level and 11 feet below the southeast station used in recent surveys.

Feb. 14, main lake 14 feet below mark, summit cone N. E. heap 27 feet above mark.

Feb. 22, main lake 5 feet above mark, summit N. E. cone 30 feet above mark.

Feb. 28, main lake 18 feet above mark, summit N. E. cone 30 feet above mark.

March 7, main lake 37 feet above mark, summit N. E. tower 55 feet above mark.

These figures show that in eight days —February 14-22—the lake rose 19 feet, or 2.4 feet per day, and the northeast cone rose 3 feet, or .4 feet per day. In six days—February 22-28—the lake rose 13 feet, or 2.2 feet per day and the northeast cone was stationary. In seven days—February 28-March 7—the lake rose 19 feet, or 2.7 feet per day and the northeast cone rose 25 feet, or 3.6 feet per day.

On Saturday, March 1, 1919, about 6 p. m., the main lake overflowed, the flood streaming eastward past the east cone and extending to the steam cracks southeast of the former site of the wooden hut. At 9 p. m. the northeast heap erupted, producing flows which poured eastward and northwestward. A branch of the latter flow extended north in the direction of the postal crack and surrounded the arched half-dome which was formerly a conspicuous eminence bounding Halemaumau on the northeast. On this day the west heap sent a flow down its northwest slope inside the pit and the south cone area developed five spiracles of different shapes. These were scattered along the wall crack between the uplifted southeast station and the south cone of recent eruptions.

On March 2 the fume was thinner, and at 5 p. m. the southeast pond was depressed five feet within its cup and covered with a blistered crust, the only fountaining being inside the curtained cone at the north margin of the pond. The main lake stood three feet below its rampart, there was the usual activity in its northeast grotto, and the surface of the lake was covered with heavy folding crusts which tended to balloon upward over rising gas, and occasional fountains would pulse under the crust, agitating it without breaking through. The north lake was nearly full to the brim with activity in several marginal grottoes. The cones elsewhere showed the usual glow and

flames, the northeast cone was alive and large reddish yellow flames played through the openings of the east cone.

At 7:15 p. m. the northeast cone burst open and ejected a standing fountain for half an hour, sending out two swift flows, the longer one westward and the shorter to the east. After 7:45 the eruption dwindled.

On Monday, March 3, trickle flows were moving on the northeast heap and the summit cone had developed a high, broad tower-like structure with an open shaft where the lava was splashing and throwing up jets. Fresh flow could be seen on the northwest slope of the western heap, there were flames at the south and east cones, the swelling movement was decreasing and the pit at night was brilliant with fifteen glowing points.

Extensive forest fires had developed along a line several miles in length on the east flank of Mauna Loa, spreading rapidly in three days, owing to the lack of rain. The flames at night appeared much yellower and less red than the glow at Halemaumau, and the smoke in daylight was similar to the volcanic fume but slightly browner.

On Tuesday, March 4, 1919, the northeast cone had built up a sharp spire standing 12 feet above its base, and as this surmounted the lava heap it was the highest and most conspicuous object in Halemaumau. The view of the entire pit filling from the top of the only remaining cliff, which bounds the pit on the northwest side, showed the lakes approximately on a level with the eye, the northeast tower some 20 feet higher, and the several domes and cones rising above the flat summit of the filling within the southeastern half of the circle, while from the main lake down into the foreground at the base of the northwest cliff sweeping flows sloped downward past and around the north lake which stood as a ring-wall eminence a little to one side. The whole arrangement preserved the tendency to southeastward heaping, which began in December, when the fill was over a hundred feet down, the main difference being that this inner heap had now risen until it was above the edge of the pit.

From 6 to 7 p. m. the south cone surmounting the lifted floor at the pressure rim was spasmodically hissing and had developed a peculiar shape, hooded on top and turning an open glowing face of fiery orifices which looked southwestward. The west pond had again closed over and was surmounted by a filagree cone. The southwest pond had built two domes, and east of it a banner of flame shot upward through a crevice. The central cone was a filagree heap and the south and northeast cones were both glowing. The main lake had recently enlarged by the collapse of the west dome grotto, and in both the main and north lakes the liquid lava was splashing at about the level of the ramparts.

The pressure rim around the south and southwest edges of the pit had continued to rise so that it was now 15 feet high in places and its extension on the east-southeast side was nearly 20 feet high. On climbing to the top of the south pressure rim the uplifted inner floor of pahoehoe flows was found level with the top, an expanse of rolling and warped pahoehoe sloping away towards the center of the pit.

The east cone was flaming and the southeast pond very quiet. The northeast heap was putting out trickling toes of live lava so that the old northeast half-dome was nearly buried under them. This trickle construction was extending the heap northeastward.

At 4:30 p. m. the cone at the west heap pond erupted vigorously, making a standing fountain of very liquid lava which gave vent to the longest flow of the year to date. By 6 p. m. this flow had reached its limit, 1300 feet, to the south, a very straight stream from 50 to 100 feet wide. A second flow from the same source poured down the northwest slope of the heap. The source cone after 6 p. m. was a large open well with raised sides spurting irregularly.

On this day the fume was thinner, and in the evening there were ten incandescent points and four fuming lakes visible, the two western ponds being again converted into glowing cones.

On March 5, at 11:30 a. m., the lake margins were about five feet high, there was eastward streaming in the main lake and a spatter dome was building at its east end. Flows which appeared fresh had poured across the north rampart of the north lake and thence into the northwest wall valley,

but the floor under the cliff remained low and the cliff high. The northeast cone was hissing and driblet flows from it were still in motion on the northeast side of the heap. In the evening these flows increased their vigor and during the night greatly extended the pile of driblet flows on the east side of the northeast heap, reaching out to the steam crack east of Halemaumau and covering the entire area which surrounded the former site of the Observatory hut.

On March 6, at 12:30 p. m., all tumescence appeared to have ceased, driblet flows were in motion in the vicinity of the remnant of the northeast half-dome, only the extreme summit of which remained visible. The lakes were three to four feet below their margins and the west heap pond was fountaining on the south side of the cone there. The top of the eastern stone shelter was found to be still intact at about the level of the lava heaps around it.

On Friday, March 7, 1919, there was a strong revival of rising and overflowing of liquid lava which was general throughout all the vents, excepting the south cone. Strong flows began about 8 a. m., all the lakes were high and a cascade poured across the eastern rampart of the main lake, sending a flow a few hundred feet to the east. The northeast cone tower ejected umbrella-shaped gushes through an orifice in its extreme summit. This tower was now an extraordinary steeple rising some 15 feet above its base. Driblet flows pushed out from the southeastern flank of the northeast heap. A flow poured northward from the central cone around the west side of the north lake, the cone developing into an open pot brimming with lava surging and splashing. The southwest pond overflowed southward for a short distance and built a high marginal dome. At noon the cones were hissing, the main lake brimming full and fountaining violently along its north bank and the west heap cone was an open oven ejecting lava with much fountaining, which produced a short flow southwestward. The west arm pond locality of former days was occupied by a cone hissing noisily, and the largest dome of the southwest pond was south of this and only a short distance away. The north lake was only one foot below its overflow level and its fountaining was vigorous. After this spasm of overflow there was a period of reaction, and in the evening the lakes and cones were unusually dull.

For the fortnight ending at 9 p. m. Friday, March 7, 1919, the seismographs of the Whitney Laboratory have registered the following local earthquakes: Feb. 22, 7:19 p. m., slight; Feb. 25, 9:25 p. m., strongly felt, registered for seven minutes; Feb. 26, 6:08 a. m. and 11:03 p. m., both slight; Feb. 27, 3:25 a. m., slight; March 1, 5:44 a. m., moderate; March 4, 4:54 a. m., slight; March 5, 1:33 a. m., slight; March 7, 7:08 p. m. and 7:26 p. m., both pronounced; 8:42 p. m., small.

Teleseisms, or distant earthquakes, were registered beginning 5:44 p. m. March 3 and 2:02 a. m. March 4, both of these yielding no evidence of distance and appearing much alike in energy and quality.

Microseismic movement has as usual been dominant in the north-south azimuth, moderate in amplitude Feb. 22-24, slight Feb. 25-27, stronger Feb. 28-March 5, slight March 6-7. The rhythmic microtremor has continued strong most of the time with some decrease Feb. 25 and Mar. 2-3. The spasmodic microtremor or supposed volcanic vibration has fluctuated, with strongish spasms Feb. 25-27 and March 4-5.

The tilting of the ground has also fluctuated through a small range as follows: Slightly west and south Feb. 22-24, stronger east and north Feb. 25-26, stationary Feb. 27-March 1, slight west and south March 2-3, pronounced north and east March 4-6, moderate south and west March 7.

March 15, 1919.

Continued overflow south and east from the lava heaps of Halemaumau has been the distinguishing feature of the week ending Friday, March 14, 1919. A renewal of fountaining at the wall crack south-southeast on March 11 was preceded, just as on February 25, by a swelling upward of the floor, and this was followed by a reaction during the three days following, whereby some of the ponds increased in size owing to subsidence below and collapse of the

banks. These first breakdowns probably herald a large subsidence which will follow the equinox. A conspicuous feature of the northeast flow heapings which has developed during the week is the swelling up of a dozen domes or tumuli in the midst of the thickening piles of lava. It will be remembered that this happened also in March of last year in the southeastern flows toward the close of the flow period. The cause of the phenomenon appears to be increased resistance to flow as the crust thickens and the front becomes more remote, so that the advancing and expanding fluid in the ducts can find outlet most easily by swelling the roof above it.

The measurements have indicated that the southeast margin of the lava column as represented by its hardened surface rose by tumescence from two to three feet betwen March 9 and March 11 and the north lake region subsided somewhat after March 12. The lakes have fluctuated from ten to fifteen feet within their cups but the rising of the liquid lava has been expended in flows from both the lakes and the cones. The flow eastward from the northeast heap on the evening of March 12 is believed to be the longest yet poured out in 1919, measured from its tip to the former rim of Halemaumau.

On Saturday, March 8, 1919, at 9 a.m., the fume from the pit was somewhat dense and the lakes were not visible from the Observatory. During the previous night the glow had been rather dull except at 1 a. m., when the main and north lakes were fountaining at a high level. At noon the lava in the north lake was about two feet below the rampart. At 7:30 p. m. there was another high level with brilliant fountaining, followed later by subsidence. No glow was observed in the northeast cone. During the night the southwest pond exhibited brilliant activity and the large spatter dome on its margin collapsed.

On March 9 at 10 a. m. the southwest pond was high and building a new spatter dome. The north lake appeared to be overflowing, the central cone was glowing on its north side and the fume from the pit was moderately thin. About noon no flows were found in motion on the northeast heap. This heap, its summit region 40 feet above the old rim of Halemaumau, now overlapped the edge of the pit with pilings of irregular lumpy character extending several hundred feet to the east of the old east shelter.

From 4 to 6 p. m. trickle flows were pushing eastward from the flanks of the heap in several places and a remarkable development of large swollen domes had appeared in the eastern part of the heap between the east shelter and the east outlying steam crack. One of these just east of the buried stone shelter was an oval tumulus 50 feet long and 10 feet high.

The main lake at this time was four feet below its rampart with an open tunnel grotto at the west end showing glowing and dripping interior walls, while at the northeast and southeast corners there were grottoes where perpetual surges threw out a fiery surf which curved back, flinging its spray over the crust of the lake.

There were hissing and flaming vents at the south, northeast, west, east and central cones and the cone on top of the west heap was seven feet high with glowing holes in its summit that were flaming. The west pond was found to be an open circular pit 50 feet in diameter with crusted lava depressed four feet below the rim, the surface ballooning with the gas rising from below and occasionally breaking to fling up a fountain of melt. The flaming west cone stood on the east side of the pond. The central cone was now an irregular heap three feet high. East of it an open crack 12 inches wide and six feet deep showed the interior glow of the bench magma to be a dark cherry red. The north lake was only one foot below the overflow level and its surface streaming was in the direction of the northern active grottoes. Occasionally both the north and main lakes would break up and subside, showing bright edges one to two feet deep.

West of the site of the former south station the pressure rim was now fully 18 feet high in places and frozen lava cascades from the region of the southwest pond marked the places across it where that pond had recently overflowed in considerable volume.

On March 10 the only rising activity observed was shown by continued trickle flows from the northeast heap.

At 3 p. m. the gas pressure at the south wall crack spiracles was less noisy than before, the lakes stood six to seven feet below their banks, the grotto activity was unchanged and on the east side of the northeast tower there were orifices half way up where flaming gases rushed out through very small holes and built vitreous spiracles of the melted drip bubbling out with the gas. The large tumulus east of the stone shelter was giving vent to stiff lava through several cracks and this had produced a new oval patch of thick bulbous outline about the same size as the dome and south of it. The dome was clearly full of this pressing pasty lava, and its escape was both upward and sidewise through cracks. Through such a heap as this one the lava is connected by a system of tubes with the pool inside the heap, the summit cone acting as a gas vent, while the melt, partially relieved of gas, seeks outlet under pressure at the extremities of the several ducts. The swollen tumuli in the eastern extension of the heap were now some of them 15 to 20 feet high; there were about ten of them in all and live lava was trickling in several places. In the evening there was a spurt of flowing from this heap.

It was evident on this day that the southeast floor had begun to swell again and the region around the southeast pond was greatly stained with sulphur.

On Tuesday, March 11, 1919, there was repeated a day of crisis similar to February 25, just two weeks before, but with effects less strong. During the previous night a new cone four feet high was formed at the south-southeast wall crack which had poured snaky driblet cascades down the outer face of the pressure rim. The increased tumescence and yellow stain in this vicinity was pronounced. At noon the new cone was spouting from a glowing cavern on its west side, the east cone was hissing harshly and the northeast cone mildly, and flows were pushing out from the higher slopes of the northeast heap. Fresh flows of this type had again invaded the remnant of the east shelter so that all of the old stone wall was covered except the south end.

At 3 p. m. the main lake margin was six feet high, its surface was crusted and its activity was sluggish. The north lake margin was three feet high and the activity consisted of ballooning skins and bombardment along the northwest shore of the pond.

The gas pressure during the early afternoon was mild but later it was increased, and at 5:15 p. m. this took effect as effervescence and outflow of liquid lava. The north lake overflowed its north bank, the flow pouring to the wall of the pit. The northeast heap broke out in many places, building extensions to the east and north. The cones hissed noisily and the main and western lakes were fountaining in lively fashion.

The new south-southeast cone burst open and produced a standing fountain while the south cone near it spurted southward through its orifices and sent out sheets of flame. The fountaining cone developed a cascade which tumbled as a rivulet down the steep face of the cone and the pressure ridge below, making a very liquid pool which forked and spread as a thin syrup in two main streams some 300 feet to the southeast. The cascade was about five feet wide and 18 feet high. This flow solidified in smooth glassy toes, cooling through mottled purple shades and showing none of the vesicular lace work which covers the pasty bulbous toes of the northeast heap. This suggested that the long tumultuous cascade had caused unusually complete discharge of gas from the melt.

On March 12 the region adjacent to the north lake appeared slightly lower as though there had been compensatory subsidence under the north lake overflows coordinate with the tumescence southeast. In the evening at 9 p. m. a long flow had pushed out from the extreme tip of the eastward extension of the northeast heap and travelled to a point a third of a mile or more from the pit. At 9:30 p. m. a sudden flare from the southwest pond suggested collapse. The main and north lakes were fountaining high above their ramparts, the cones were puffing noisily, the pit as a whole was very brilliant and it was during this period that the southeast pond, hitherto an inconspicuous circular pit about 50 feet across, became by collapse of its banks a much larger lake.

On Thursday, March 13, it was evident that the southeast pond cone had fallen in and the central cone had col-

lapsed to an open pot. A circuit of the pit between 4 and 7 p. m. revealed great change at the southeast pond which had become practically a large arm of the main lake, separated from the latter by only a small partition five feet thick. This southeast arm was nearly as large as the main lake, fully 150 feet long in a northwest-southeast direction and adjoined the main lake at the latter's southeast corner. The region which had collapsed followed the line of a former crack where flames were playing and spiracles were building. The streaming in the southeast pond was swift in the direction of the partition or northwestward, while in the main lake the grotto fountaining was very bright and the streaming was to the east. Both lakes stood about six feet below their banks.

The cones were hissing and flaming as usual, the west pond showed ballooning skins about five feet down and a large filagree cone above its east bank. Large yellowish and reddish flames played above this cone and another vent at the southwest pond. The north lake was bright, there were live flows on the northeast heap, one glow hole appeared low down on the south side of the northeast tower and the east cone was hissing and flaming.

On Friday, March 14, 1919, the pit had been rather dull during the night, trickle flows continued at the northeast heap and fountains were occasionally visible above the lake ramparts. In the afternoon there was pronounced subsidence, the lakes being reported over 15 feet below their banks, but after midnight they again rose to brimming levels.

In the Whitney Laboratory of Seismology the week has been seismically quiet so far as earthquakes are concerned. Microtremor has continued strong, microseisms became very strong during a period of calms and light southwesterly winds, and the tilting of the ground was eastward March 7-11, strongly westward March 12 and moderately westward March 13-14.

Gas collections with vacuum tubes have been made at several of the live vents of the crater during the week.

March 22, 1919.

The week preceding the vernal equinox of 1919 has shown the lava column of Halemaumau to stand at a constant high level so far as its crusted surface was concerned, while overflows continued from lakes and cones. The gas pressure, marked by hissing cones and spraying grottoes, has continued high, the northeast heap has remained the principal source of voluminous flowing, and the eastern lakes have exhibited a tendency to lowering within their cups. The fume has thinned.

Measurements referred to the north Government Bench Mark (3700 feet above sea level) were as follows:

March 7, main lake 37 feet above mark, N. E. tower 55 feet above mark.

March 18, main lake 35 feet above mark, N. E. tower 65 feet above mark.

The lake thus subsided two feet in eleven days, averaging 0.18 feet per day, while the northeast tower rose 10 feet, averaging 0.9 feet per day.

On Saturday, March 15, 1919, the fume was dense towards the west and southwest, new flows were pushing southward from the northeast heap and a new short fork had branched out from the easternmost flow of the heap on its north side at about the locality of the steam cracks east of Halemaumau.

At 6 p. m. the south-southeast cone was throwing up bright banners of flame with high gas pressure, the main lake and southeast pond stood six feet below their banks, the partition between them was still in place and all around the edge of the southeast pond a ballooned up crust marking a higher level had been left, now broken-in, leaving hollow shells. The pond was quiet except for a spraying fountain under its north bank.

On March 16 at noon a circuit of the pit east and north revealed a new flow from the northeast heap pushing southward along the east side of the high eastern pressure rim. The northeast tower had developed an open cavern at its base on the east side and this was hung with stalactites, while for 50 feet from it all over the top of the heap there were accumulations of recent glassy lava which appeared to have been splashed and spattered explosively from this cavern as a source. This glassy material was spread in a thin sheet with a smooth surface and ap-

peared to have been excessively liquid when it was thrown out. There had been heavy rains during the days immediately preceding this discovery and the occurrence closely resembled a similar explosive outburst of very liquid melt which happened in this vicinity a year ago, also during heavy downpours of rain. It is possible that localized heating of rain water causes superficial steam pressure in lava chambers and so brings about an explosive eruption of the melt which is confined within the heap.

The north lake was found brimming nearly level with the lower gaps in its rim, its crust pulsing with gas inflation and fountains playing around its margins.

At noon the west and southwest ponds were brimming level with their ridges and the west pond finally welled over, both its northern and southern lips, the southern flow pushing south-southwest as an overflow outside of the pit boundaries, while the northern one spread as a sheet over 200 feet wide, pouring down the slope into the northwestern depressed part of Halemaumau. There was fountaining in the pond and high flings of melt were thrown up by the southwest pond. The west heap cone stood high and was hissing. The south cones were hissing and flaming and the other activities of the pit remained as before. As compared with the north lake the main lake stood low relative to its bank, though at all times the absolute level of the north lake basin was much lower than that of the main lake basin.

At some time later in the day the north lake overflowed and produced another flow of glassy appearance which poured toward the northwest and joined with the west pond flow. Neither of these flows reached the wall of the pit.

On Monday, March 17, in the afternoon the south and south-southeast cones were hissing noisily and the eastern lakes were low with walls ten feet high. At the north base of the east cone a driblet flow was pushing out from cracks in the ground, the gas pressure at its source lifting a lid of crust three feet square and at least six inches thick, the gas rushing out with a hissing noise at each lift of the lid which rose an inch or two at every spasm.

Live flows were in motion on the northeast heap. The summit of the heap showed two mouths, each three feet in diameter, emitting pasty flows and lifting lids of crust in the midst of circular puddings three to five feet high and 20 feet across a short distance southeast of the high tower. At the southern base of the tower spiracles were being built by gas which rushed out with strong hissing noises. The cavern under the tower contained very large stalactites covered with fresh spatter. Near the southeastern foot of the northeast heap deep caverns had been revealed by collapse, glowing inside and as much as 10 feet deep vertically. On the south slope of the northeast heap some typical aa lava appeared among the pahoehoe flows and there were very rough aa surfaces on the under side of the thin glassy shells covering the explosion area on top.

Across the central part of the floor deep cracks extended from the west end of the main lake to the north cone which is situated just south of the north lake. These cracks were two to three feet wide in places and locally showed no glow even for depths of 15 feet. The west pond surface stood two feet below its border, the skin ballooning with gas and the current streaming to a western grotto. The cone east of this pond was smaller than before and rather inactive and the pond itself had contracted so that it was not more than 20 feet across. The west heap cone was hissing and building spiracles and the central cone was hissing from large glowing orifices on its east flank. The north lake showed a margin two feet high and its activity in fountaining grottoes was around the northern semi-circle of its pit, the southern semicircle being apparently the source of rising lava. The streaming was thus northward and northeastward and the border fountains flung up stringy melt, making much new construction at large domes along the north bank.

On Tuesday, March 18, at 2 p. m., it was apparent that the pressure rim was becoming pushed back farther with a horizontal thrust and the inner floor of the pit is distinctly arched as a flat dome from the former site of the east station to that of the south station. The

uplifted concrete platform of the southeast station was more broken and fallen apart owing to the tilting back. At the top of this slope the south-southeast cone had become an open dome with a glowing window two feet in diameter facing southeast and leading to the interior cupola, where the lava stood so high as to splash out through the window. A group of driblet spires and heaps stood near this cone and the older cone further south was blowing but with decreased violence. The east cone also was flaming under pressure but the area of the lifting lid of the previous day was quiet.

The southeast pond stood four feet below its rim and had risen to the brimming level within forty-eight hours as shown by an edge of crust still clinging to the margins and on the main lake side bridging the extension of the pond in that direction. The live part of the pond was circular, with overhang and active grottoes north and east, and a crust was cracking and foundering at 2:30 p. m.

The main lake appeared higher than before, standing five feet below its rampart with deep fiery grottoes northeast, southeast and west. There was much staining, smoking and cracking of the floor for 20 feet east of it. The north lake stood close to its margin and rose to brimming at 3:30 p. m. The west heap cone had built new gas spiracles on its western profile.

The northeast heap continued to show pasty bubbling lava at two craters three feet in diameter south of the high tower. Adjacent to the northeast tower on its south side was a blowing gas mouth flaming through a flap of incandescent skin and emitting a snake-like trickle of glassy lava. The mouth was three inches in diameter and the skin 18 inches long. A row of spiracles had been built near by and 50 feet away to the northeast there was a hot cavern made by a collapsed crust. At 4 p. m. the northeast heap gained pressure and broke into flows, the largest one pouring down its west flank.

At 6 p. m. strong rising occurred so that in the course of an hour the north lake overflowed northward, there were brilliant fountains at the southeast pond, the south-southeast cone increased its spitting of lava spray and flowing increased along the course of the northeast heap and at the eastern front of its flows.

On March 19 between 10 a. m. and noon the splashing window of the south-southeast cone closed to a puffing mouth. The other cones were flaming as before; the main lake, four feet down, showed the usual grotto fountains and eastward streaming with some bubble fountaining. The southeast pond had renewed its northern spatter dome and was splashing there. The west pond was overflowing in a steady stream northwestward as before. The north lake was still high, with northward streaming and grotto fountains. The fresh flow from it did not reach the north wall of the pit. The cone south of it had overflowed the surrounding floor. A new driblet cone six feet high had built beside the northeast tower on its south side and this cone was alive but the two craters farther south had solidified. Flows were in motion on the south and east flanks of the heap.

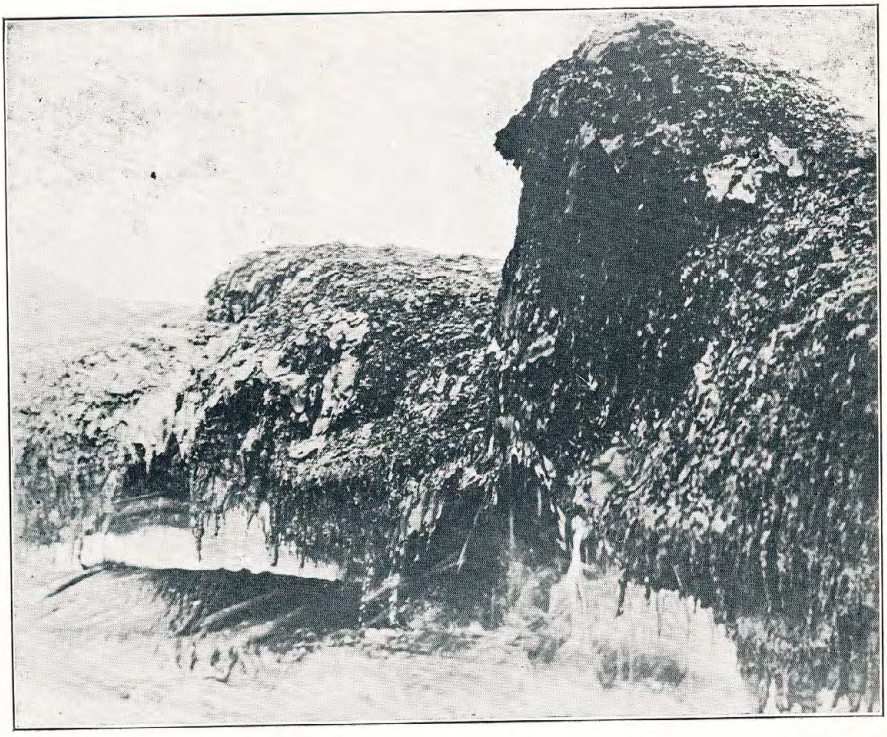
On Thursday, March 20, from 4 to 6 p. m., the high gas pressure with hissing and flaming from the cones continued, and the southeast floor showed cracks more numerous and increased in width.

The northeast heap flows were making out extensively southward so as to reach the base of the east cone and the shore of the main lake and to push past the pressure ridge outside of the Halemaumau margin 100 feet or more toward the roadway. This heap now extended over a third of a mile to the east-northeast over the Kilauea floor and many tongues projected southward from the extension.

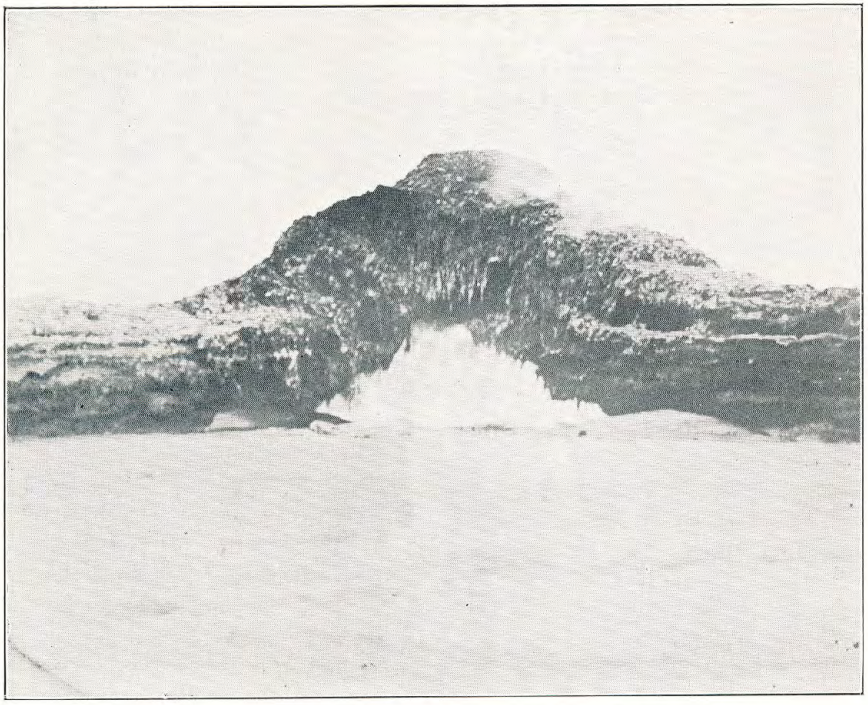
Relative to its banks the main lake was low, with walls about 12 feet high. The rampart dome on its north side had cracked open and showed cherry red glow within. A sheet of flame shot up from cracks extending west of the lake. The north lake stood only three feet below its banks, its surface was covered with heavy crusts which occasionally broke up and its streaming continued northward to active grottoes on that side. The west pond was quiet and the southwest pond fountaining.

On the upper flanks of the northeast heap there were fresh flows and the spiracle cone south of the tower had built up a chair-like structure. An

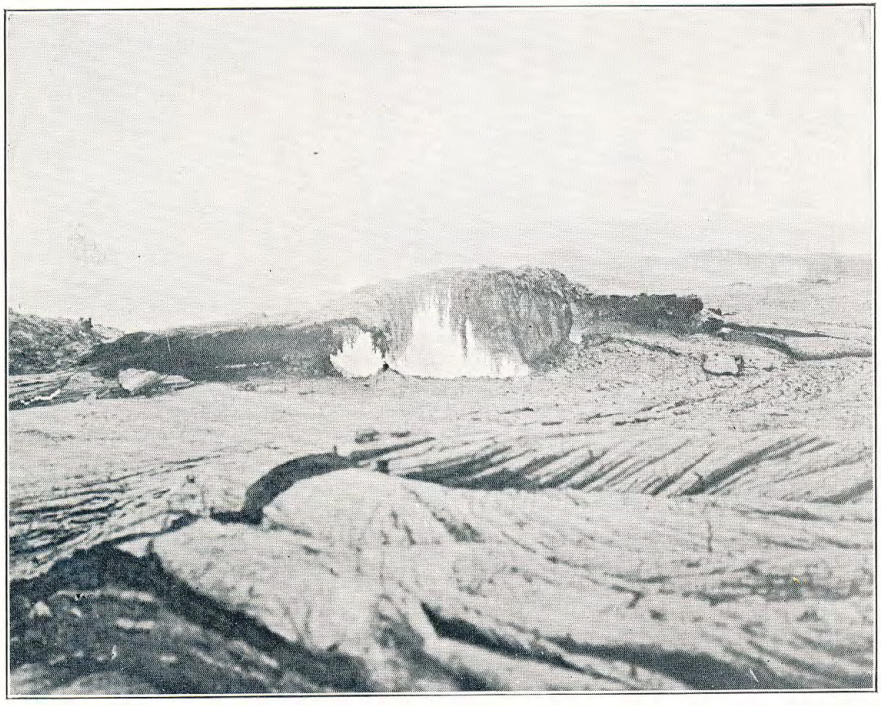
Feb. 6, 1919. Northeast grotto of main lake, fountaining.



Feb. 6, 1919. Northeast grotto; near view.



Feb. 6, 1919. The great west grotto dome, main lake.



Feb. 7, 1919. Grotto over receding flow lava, south cone; the flow source.
—Photos Jaggar.

orifice a few feet farther east was hissing and building driblet mouths, and very smooth lava, with excessively fine grained vesiculation, flowed out sluggishly in snaky toes.

On Friday, March 21, 1919, at 6 p. m., the high gas pressure continued and small vents north of the south-southeast cone were making driblet flows. The east pressure ridge was in motion with rocks falling from both its east and west sides. A small flow on the lower southeastern flank of the northeast heap exhibited a texture entirely different from the other flows, its surface solidifying into rough steely gray ropes and the crusts at the front breaking and upending so that the paste beneath was seen to solidify in typical aa lumps which fell forward as rough clinkers. The flowing lava appeared smooth but black granular chunks could be seen developing within it.

The lakes were somewhat higher than on the previous day, the eastern ones with six-foot walls, and the east cone was ejecting lava driblets as well as flaming. There were heavy crusts on the main lake, tumultuous cracking and foundering occurred with bubble fountains, and the melt appeared somewhat more granular and pasty than at other times. The northeast heap flows had poured over the east bank of the main lake into the lake for a length of 20 feet of shore. The lake appeared to have increased in size, probably by collapse of the northern and western ramparts. The west lake was fountaining above its margins. Fume from the pit was thin, the glow was very bright in the evening and in the calm air the noise from the blowing vents could be heard over two miles away.

In the Whitney Laboratory of Seismology for the fortnight ending at 8 p. m. March 21, 1919, one teleseism was registered, beginning 5:38 p. m. March 8., without phases giving indication of distance. Local earthquakes were registered at 6:34 p. m. March 8, 4:45 p. m. March 9, and a very slight shock 12:29 a. m. March 14. Microseismic motion was relatively slight March 8-13, increasing to strong March 14-17, and thereafter was moderate March 18-21. The rhythmic microtremor has continued moderately strong with some increase on each of the dates March 8, 14 and 19. The spasmodic short-period tremor has been slight except for spasms on March 9 and 12. Tilting of the ground was slightly but continuously east and north March 8-11, strongly west and south, with rapid decrease, March 12-14, slightly east and north March 15-18, stationary March 19-20, and pronounced to the west and south March 21.

March 29, 1919.

The week following the equinox at Halemaumau has produced the expected subsidence with enlargement of all lakes and lowering of liquid lava levels to depths from 15 to 20 feet within the inner pits. The main lake which on March 20 had sunk to a depression of 12 feet within its cup, was 18 feet down on March 23, and 20 feet down on March 24 and thereafter. The first sign of enlargement of the ponds by collapse had occurred at the southeast pond during the reaction from sudden rising on March 12. On March 22 the central cone collapsed to a pond, and by March 26 all the lakes had enlarged and the west heap cone became transformed into a pond. The southeast driblet cones became an open pot March 27. By the end of the week the main lake and central pond had merged into one lake by breakdown of the subterranean channel between them and similarly the southwest and west ponds occupied a single cup. The high gas pressure and lava flows have come to an end and the fume has greatly increased.

Measurements referred to the north bench mark (3700 feet above sea level) were as follows:

March 18, main lake 35 feet above mark, N. E. tower 65 feet above mark.

March 27, main lake 23 feet above mark, N. E. tower 60 feet above mark.

In nine days the lake thus subsided 12 feet, averaging 1.3 feet per day, and the summit of the tower subsided five feet, averaging 0.6 feet per day. The floor level at the margin of the main lake was essentially unchanged, showing that the bench magma has not yet moved down bodily, and this is further evidenced by the seismicity which has continued normal without marked earthquakes.

On Saturday, March 22, 1919, the north lake could be seen fountaining

above its margin in the morning. From 3 to 5 p.m. the southern cones were found still puffing but with diminished glow. The northeast heap continued to put out flows and to build driblet mouths at the summit. The flows later in the evening pushed eastward in considerable volume. No change was observed in the eastern lakes which continued to have margins about six feet high. The north lake as before was only three feet below its rim and from the north cone just south of it the chasm line leading to the main lake gaped wider open and was very hot in places. Another large crack was yawning open across the center of the floor from the main lake northwestward. The central cone had broken down, leaving an open pond 30 feet in diameter with a fountain pounding against its west shore. The west and southwest ponds had built up large spatter domes, but no new flows had poured out from them to the south or southwest. The west heap cone had become a large square topped structure like a hut about 10 feet high and 12 feet broad, with a glowing orifice near the top facing northwest. A new driblet spire three feet high and several smaller spiracles had been built near it. The northwest floor remained low and unchanged. Fume from the pit in general continued thin.

March 23 showed marked increase of smoke and lakes generally lower, with sharp fluctuations of the liquid lava up and down during the day.

At 8 p. m. the main and southeast lakes were surrounded by 18-foot cliffs and the north lake by a 12-foot margin. The lakes were crusted over, with fountaining only in the grottoes. During a rising spell from 8 to 9 p. m. extraordinary high gas pressure developed in the main lake which threw out from the northeast grotto a glassy spray at an angle of 30 degrees for a distance of fully 150 feet. The lifted crust impeded fountaining by blocking the top of the arch of the grotto and so the gas escaping from beneath the crust produced prolonged blowing against the top of the grotto chamber. The central pond was dull, the west pond bright and the southwest pond showed a glow heap. The west cone was puffing loudly but the southern cones had changed their action to quiet blowing and much flaming. The spiracles at the margin of the pit southeast had become large flaming cracks and the gas pressure was strong at the east cone and at driblet mouths which were blowing glass noisily at the south base of the northeast tower. The hissing noise had there increased and there was spurting of lava from a craterlet at the south end of the line of summit vents on the northeast heap. Flows were in motion at several places on the south side of the heap. About 9 p. m. this south flank near the summit broke open and developed two flows which originated at broken crusts about a foot square. Standing springs of lava developed at these holes, giving off sulphurous gas and sending streams of liquid pahoehoe with wrinkled skin down the slopes for a half hour or more. Bulbous flow lava from the heap had pushed out and swollen up over all the region north and east of the main lake.

Cracking had increased in the central part of the floor and continuous cracks of apparently deep origin cut through the flows of the northeast heap in the region east of the north lake. East of the main lake also there were glowing cracks behind the rampart, and the rampart elsewhere had fallen in in several places so as to enlarge the lake.

On Monday, March 24, the lakes were low, with considerable rising and falling, fumes were dense, some flows continued to push out from the northeast heap, and occasionally the fountains spurted above the level of the lake margins.

On Tuesday, March 25, there were flames at the east and southeast cones, but less incandescence, the west heap cone continued bright, the southwest pond occasionally flared brightly and visible fountaining in the larger lakes as seen from a distance had lessened, but occasionally the lava flings could be seen at the north lake. There was increase of breaking down of lake margins; fumes remained dense.

A marked change at this period was the gradual swelling up of more dome tumuli on the southern flank of the northeast heap along with occasional sluggish outflow. This became so marked that the new hillocks cut off from view of the Observatory the main lake and the east cone.

On Wednesday, March 26, at 2 p. m., the swelling of domes on the northeast heap had increased and there were fresh glowing flows on the summit and along three streams extending down the slope towards the west and north, the northern one 600 feet long. The inner cliff around the main lake was 20 feet high in places and the lake basin had a new V-shaped extension eastward, produced by caving. The lake was covered with heavy crust, three border grottoes were fountaining, the northeastern one sometimes throwing its spray above the rim. The cracks extending northwest and north from the main lake were 2 feet across in places, and locally these chasms were 25 feet deep without much heat evident. The central pool was perhaps 20 feet down and rumbling. The north lake was enlarged fifty per cent by breaking away of its banks southward to the north cone, and its former circular curvature was preserved only on the north side. Its northeast corner also had broken in. The lake surface was 10 feet down and a live tube was revealed about the lava level on the north side leading to a curtained grotto under a dome a few feet farther west. The tube was hung with stalactites. A half of the north cone still remained on the south brink of the pit occupied by this lake. A few feet farther south a large low sulphurous cone, bright yellow, marked the line of the crevasses. Sulphur stain had also developed in the south cone region. The blowing noise at the cones had greatly diminished, though there was some puffing from the east cone and an open pot north of the south-southeast cone emitted a large flame and the rumble of a fountaining pool could be heard below. The glow in the south-southeast cone had diminished. In the cracked ground east and south smoke had greatly increased. In the evening the brightest lights were from flames at the southeast pot and at the north grotto of the north lake, but all the ponds flared brightly on the fume cloud above.

On March 27 at 1 p. m. it was evident that the gas pressure had greatly diminished. The orifice of the southeast pot was about three by six feet in diameter, with an unstable bridge of crust across the middle, dividing a sheet of flame which rose from the wider chamber inside. This chamber, 15 feet in diameter and 20 feet deep, was incandescent, a bright orange color, and dripping with lava that splashed up from below from a narrow well at the bottom. The pot made a hollow rumble due to fountaining below and combustion above. There was much cracking and staining around the orifice.

The main lake had extended itself through to the central pond so that the combination created an inner pit over 600 feet long. The southeast pond remained separate, and was again a circular pit separated from the main lake by an isthmus 50 feet wide, where stood the abandoned shallow channel along which the southeast pond had enlarged on March 12. Both the main lake and southeast pond were depressed 20 feet within their cups.

The pressure rim around the south side of Halemaumau appeared to have slumped somewhat. The region between it and the southwest pond was covered with pahoehoe having this friable shells of crust. The southwest pond had joined its pit to that of the west pond during the general breakdown; both ponds were enlarged, but a low partition separated them only a foot or two above the lava level, which stood 15 feet below the margin of this inner pit. In the wall on the east side of each pond there was revealed the smooth cylindrical shaft opening beneath the marginal domes which had recently been the flaming and glowing indexes of the sites fo these ponds.

The west heap cone had wholly subsided into the pond beneath it, and the marginal cliff around this pond was 18 feet high. About noon a lava stream had been pouring across a terrace from a tunnel in the wall of this pond pit so as to pour downward at a flat angle into the pond. A spatter heap lay beside this half-solidified rivulet in the southern part of the bottom area, no doubt marking the site of the former cone.

The lava of the north lake was 12 feet down and fountaining only around the north margin, the rest being covered with crust. The northeast heap had ceased flowing, Halemaumau was moderately fumy, and the glow at night had become very spectacular with occasional brilliant flaring from individual ponds.

On Friday, March 28, at noon, the interior of the southeast pot had become dark, the bridge across the orifice had fallen in, and the rumble of fountaining could still be heard below. The eastern lakes were about the same, but the east floor appeared to be sagging. A shoreline mark above the lava of the main lake confirmed this, being 2 feet above the lake at the west end and sloping down to the lake level at the east. The northeast dome grotto, surmounting, above a 20-foot wall, a long and deep fountaining grotto below, appeared much shattered and ready to cave in. The streaming in the lake was northward and eastward from the edges of quiet crust, which wholly covered the western half. The north lake appeared little changed, but the yellow sulphur heap south of it was partly broken down and the chasms beyond appeared larger and more smoky all the way to the main lake.

At the northern base of the east cone there was an open hole 2 feet in diameter lined with stalactites, and other flaming orifices occupied the flanks of the cone which appeared ready to collapse. It was shattered and stained and covered with much Pele's hair, the individual strands being thickened with solfataric incrustations. Through the window the liquid lava could be seen splashing 15 feet below.

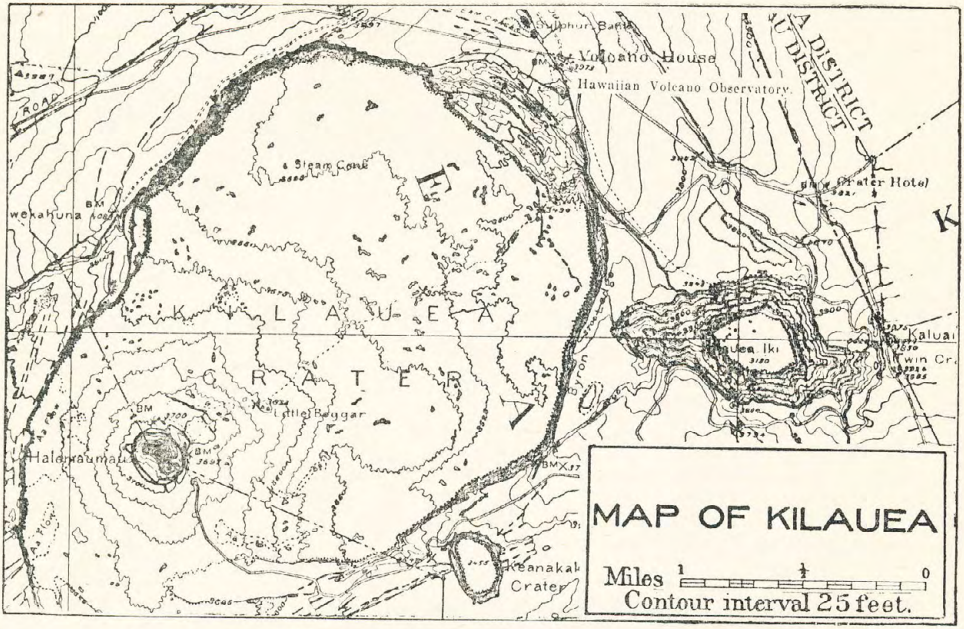
The northeast heap had developed an extraordinary explosive roar from an orifice near its summit. At irregular intervals of from five to twenty minutes a loud deep puffing noise was heard, made by gas rushing through orifices in the tower and also through a small broken-down flow-channel which led by a horizontal duct into the west side of the closed crater heaps. During the greater puffs at long intervals this tube would eject a roaring blast of gas and flame which on one occasion was prolonged for several minutes so as to bring the smooth dark interior walls of the tube to a state of incandescence. This tube was two feet high and eight inches across, and the explosive rush of gas was so strong that small rock fragments were blown out in showers.

This episode was really a miniature explosive eruption in the history of the building activity and the decline of the northeast heap, and as such is of great interest in that the explosive phenomenon did not appear until a large gas chamber had formed within the heap owing to the recession of the liquid lava.

The seismographs of the Whitney Laboratory for the week ending at 8 p. m., March 28, have registered seven small local earthquakes as follows: March 22, 12:30 a. m. and 3:52 a. m.; March 24, 1:49 a. m. and 3:45 a. m.; March 25, 3:24 p. m., very slight; March 26, 9:52 p. m., very slight; March 28, 1:40 p. m. The microseismic motion has decreased from moderately strong to slight. The harmonic microtremor, which was also moderately strong until March 25, decreased markedly thereafter. The spasmodic tremor was slight until March 25, but showed a number of spasms March 26-28. The tilting of the ground was strong to the east and north March 22-24, decreasing March 25-26, and March 27-28 became very strong to the south and slightly westward.

Very respectfully,

T. A. JAGGAR, JR.,
Volcanologist.



HAWAIIAN VOLCANO OBSERVATORY.

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 solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous 1000.0		2500.0
XI.	Catastrophic 2500.0		5000.0
XII.	Great catastrophe 5000.0		10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the acceleration, or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol *a*, or max. *a*, is given in the conventional unit, the milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

U. S. DEPARTMENT OF AGRICULTURE
WEATHER BUREAU
CHARLES F. MARVIN, CHIEF

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HAWAIIAN VOLCANO OBSERVATORY, April 5, 1919.—The subsidence of the lava at the end of March did not prove so profound a movement as in 1918. The lowest level was reached April 1 with the eastern lakes over 30 feet below their rims, the north lake 25 feet and the west heap pond only 10 feet beneath the surrounding lava surface. The tower and general floor level of the live lava column sagged somewhat in the course of the subsidence, averaging perhaps 10 feet, but as a whole the floor was much more rigid than in the days when it was covered with crags. The liquid lava started rising rapidly on April 2 at a rate three to four times faster than its previous subsidence, taking effect first in the western ponds and the north lake, and thereafter extending to the northeast heap and the eastern lakes. General heating of the bench magma with white staining of the cracks and some upward swelling took place, and then strong lava flows.

The net effect for the week of the subsidence followed by rising is to leave the upper surfaces of both lake magma and bench magma nearly where they were before or slightly higher. The measurements, referred to the north bnch mark (3700 feet above sea level), were as follows:

March 27—Lake 23 feet above mark, NE. tower 60 feet above mark.

April 3—Lake 24 feet above mark, NE. tower 63 feet above mark.

The north lake during the same week rose about 10 feet relative to its rim.

For the entire interval of seven days the figures indicate that the main lake rose 1 foot, or .14 foot per day; the north lake rose 10 feet, or 1.4 feet per day; and the northeast tower rose 3 feet, or 0.4 foot per day. What actually happened was that the main lake sank 15 feet March 27 to April 1, or 3 feet per day, and rose 16 feet April 1 to April 3 (8 feet per day). The north lake sank 13 feet March 27 to April 1, or 2.6 feet per day, and rose 23 feet April 1 to April 3 (11.5 feet per day). At its lowest, April 1, the main lake was 8 feet above the bench mark.

On Saturday, March 29, from 2:30 to 4:30 p. m. the eastern pool of the main lake was crusted, the northeast grotto was active, and streaming was west and south in the central pool, hence reversed since the previous day. The marginal cliff around the lake was 18 feet high, heavily hung with Pele's hair and lava drip. The southeast pond cliff was 20 feet high, and here also the streaming was reversed, with bombardment against a spatter heap on the south bank. The west heap pit was shallower, with puffed-up crusts over a stagnant pond which showed a grotto overhanging quiet liquid lava at the northwest end and gas hissing from glowing cracks at the southeast margin. The pit containing the southwest and west ponds appeared enlarged, the partition between the ponds remained, and the southwest pond was quiet and heavily crusted. Not so with the west pond, however, which streamed rapidly eastward to violent marginal grottoes. The source of the current was a sluice-like channel 5 feet wide and 20 feet long at the west side, which lay on the partition floor between the two ponds, with lava rushing out from a well-spring under the cliff. This was just

opposite the cavern corner of the west heap pond, which stood at a higher level, 8 feet below the floor, while the sluice was 16 feet down. The stream may have come through the tube. A spell of 4 feet of sinking reversed the torrent and reduced it to bubblings, and the lava of the pond poured into the channel, but in five or six minutes there was recovery, rising at the spring and the rush of the sluiceway was resumed. The southwest pond took no part in this rise and fall of the west pond. Its only activity was a little bubbling at the southern margin of its crust. The north lake was noisy and the smoke on this day was denser.

The blowing vent of the northeast heap glowed and faintly puffed. The cracks in the heap still glowed. The southeast pot was more broken in, showed a coffee brown drip glaze inside, and a small window below led to a fountaining chamber 25 feet down. The south-southeast cone glowed, flamed and rumbled. The breaking away of the south cone revealed an inner shell chamber and wonderfully colored stalactite lumps.

On March 30 the lakes were lower and very bright, flames were bright at the southern and central cones, and the floor remained stationary.

On Monday, March 31, at 2:30 p. m., the west heap pond had begun construction of a low hissing glow cone, the west and southwest ponds were 25 feet down, the former streaming east and the latter south. The well source was no longer a distinct channel, but merely a point of current departure, under the southwest bank of the west pond. The central floor of the pit was much shattered and the central pool of the main lake had become a gorge 40 feet deep with lava streaming west, but the east pool cliff was only 25 feet high. Glow and flame appeared at a crack in the floor north of the central pool, where a remnant of the central cone, broken in two, clung to the verge. The southeast pond had become a pit 35 feet deep to the lava level, with a spatter bank receiving bombardment at the southwest side and a tunnel leading northeast towards the east cone. The north lake had walls 25 feet high, the liquid streamed northward, and there was some fountaining south.

The northeast heap had ceased blowing. The southern cones emitted very heavy smoke. The window in the bottom of the southeast pot cavity opened into a large bright-orange colored chamber beneath, where lava surged. Dense smoke rose also from the east cone region, which showed a sulphur-stained cracked zone of 20-foot radius. The glow over the lakes was bright at night, a brilliant flame rose from the central vent, but the southeast cone glow was dim. On April 1 the lava was lower, both floor and lakes, smoke was dense, and there was a break formed in the middle of the east pressure rim.

On April 2, at 4:30 p. m., the main lake was higher, 20 feet down at the east end, and there had been more breaking back of the bank into the smoking cracked ground east. The north lake was much higher and its margin deformed, so that the liquid was 4 feet down on the north and 15 feet down on the southeast. There was a bulge in the ground between the two parts and the lake had enlarged by breaking back into the high ground of the footslopes of the northeast heap. There was much appearance of swelling in several parts of the floor of Halemaumau, accompanied by hot whitened cracks. The south end of the north lake had caved away as far as the yellow sulphur cone.

There were now five distinct inner pits: north, main, southeast, southwest, and west; the southwest one holding two ponds. The southeast old rim of Halemaumau was a pressure ridge with the lava floor overhanging it, and the northwest old rim was still a cliff 40 feet high. Northeast and southwest were great lava heapings, overlapping and burying the old rim completely, crowned by the northeast driblet tower in the one case and by the southwestern pits in the other.

On April 3 at 3:30 p. m. high gas pressure was again in evidence. The west heap pond had built a dome flush with the rim of its pit, the west and southwest ponds were only 12 feet down, and the north lake was brimming level with its north and west banks and had built two immense spatter domes on the west. The east and south cliffs of this lake were 8 feet high. The main lake was 15 feet down

and enlarged both northward and eastward.

The south cones were hissing and the northeast heap puffed from the vent south of the main tower. The southeast cone, which had collapsed to an open funnel on April 1, was now closed in the funnel but showed open mouths on each side leading to high lava pounding inside. At night the north lake was brimming and the northeast tower started an eruption of umbrella splashes of melt with a loud metallic clang and a gobbling explosion noise heard two miles away. This built up a second tower the duplicate of the first on its south side, so that the striking profile, for many weeks past a landmark, was changed to a wide double-peaked turret. In the early morning hours the spouting was from a cone on the high northwest slope of the heap

On Friday, April 4, inspection at 2:30 p. m. showed that this eruption had produced two glassy smooth flows, the double tower standing above their sources, 15 feet high. A short flow had pushed north-northeast from the summit, and a long ribbon flow had poured all the way from the cone northwest of the tower to the northwest wall valley on the north side of the north lake. There was a new vent open near the south cone, and the east cone vents were flinging out black glass and dense smoke rose from the ground west of this cone.

The southeast pond was surrounded by an inner annular bench 10 feet down and the pond surface was three feet lower, streaming north with a fountain under the northeast bank. The main lake was also about 13 feet down, streaming against its north bank and showing an inner bench of recent higher level. The north lake was splashing over at its north end, the west domes were covered with Pele's hair, and deep glowing cracks had opened northeast of the lake. There was no change in the northwest wall valley. The west heap cone was becoming a large ring, and the west pond, 10 feet down, was streaming east to a closed grotto with an open pot on top. A stream mark across the isthmus from the southwest pond to the west pond indicated that a flood had passed across during the high level of the previous night. The southwest pond, as usual, was quiet and crusted over.

In the Whitney Laboratory of Seismology there were a few local earthquake shocks recorded, microseismic motion was moderate, and microtremor somewhat increasing from low values, but the striking seismic feature was the tilt, which changed about April 1 from southwest to northeast.

HAWAIIAN VOLCANO OBSERVATORY, Apr. 12, 1919.—During the week ending Friday, April 11, 1919, the Halemaumau lava column has risen slightly, but the elevation of the surface has proceeded rather by local building and filling than by lifting. There has been bench magma uplift of a few feet also, and moderate rising of the liquid lakes within their cups. The conspicuous change of the week is occasioned by the extensive flows from the northeast heap on its northwest slope inside the old pit limits, these flows spreading and swelling gradually as heavy bulbous pahoehoe in the region between the north wall of Halemaumau and the north lake. This slope has repeated the constructional activity formerly so conspicuous on the east side of the northeast heap, the high tower marking as before the center of the highest upbuilding and the greatest output of flows.

On Saturday, April 5, the crater was quiet and unchanged in the early morning, but during the forenoon the liquid lava rose to the level of the inner terraces 10 feet down in the eastern lakes. The north lake fountains were splashing over the ramparts in the afternoon, and at 9 p. m. a flow was pouring northward from a standing spring of lava on the north flank of the northeast heap. The north lake overflowed its north margin, its flows merging with those of the northeast heap. The west pond lava splashed high above its east rampart. The east cone was sputtering, the south cone flaming, the northeast tower dark, and the glow bright above the lakes.

On April 6 at 10:30 a. m. there was fresh flow lava visible across the north-northeast rim of the north lake and the west pond had built up a dome above its eastern margin. Smoke was dense

at the east and south cones. The lava in the north lake was close to the rim level. A new spur of the northeast heap was building around the vent on the north flank. At 6 p. m. the north lake was brimming level with its rampart and the west pond fountaining above its margin. At 8:15 p. m. the newer southern spire of the northeast tower broke into spurting action, opening a window through its east wall and throwing out jets accompanied by muffled explosions, audible at the Observatory 2.2 miles away in a straight line. Two flows were in motion on the flank of the northeast heap in the region northeast of the north lake.

On April 7 at 4 p. m. the lakes were slightly lower, the southeast pond, a circular pool, stood 4 feet below the terrace, which was 10 feet below the cup rim. On the northeast side of the pond a spatter dome was built. The main lake stood 15 feet below the rim of its pit, crusted and with border fountains in its eastern pool, while the liquid in the channel leading to the central pool streamed westward. The north lake showed tendency to become circular again and was building up its northern and western embankment, now 3 feet above the pool, while the south and east margins, cut into the northeast heap, stood 8 feet high. The lake was covered with stagnant crust and there was marginal fountaining. The west ponds were little changed, their surfaces about 12 feet below the surrounding floor; the southwest pond was crusted, the west pond flung up heavy melt, the west heap pond was a crust with a ring-cone south of the center, and no fresh flows had poured out on the southwestern slopes of the west heap. About 6 p. m. the north lake was brimming full.

The south-southeast cone was now an open, but not fiery, pot. A hissing spiracle stood out on the inner wall of the southeast pot. Cracks in the southeast high floor had widened. The northeast tower had an added shoulder, giving it irregular form on the south face, and a new puddle of glassy lava had solidified on top of the northeast heap. On the northwestern flank of the heap a live vent was spouting and flowing and lifting a lid in spasms. From it a stream two feet wide and several hundred feet long meandered sluggishly northward. This northwestern extension of the northeast heap was now a big feature, reaching along the wall valley nearly to a point under the northwest station, the flows piling up and swelling into domes, and occupying the whole space between the north lake and the north cliff margin of Halemaumau. This width was maintained away up the flank of the heap in the direction of the northeast tower, and fresh toes of live lava even now were making out to the west of the tower.

On Tuesday, April 8, from 4 to 5 p. m., it was evident by measurement that this period represents stationary condition in the main as regards the floor. The liquid lava showed some rising and falling. A circuit of Halemaumau by way of the southern and western rims showed the west heap ring-cone to be hissing and glowing; the west pond had filagree glow heaps under its eastern cliff, rising above an inner terrace 10 feet down which encircled the pond some three feet lower. The crust over the southwest pond, which was quite inactive, stood higher than the west pond liquid level. On crossing the floor by way of the north side of the western pond group, a bright flame hole lined with stalactites, about two feet across, was found in the floor north of the central pool of the main lake. A smoking area farther west seemed to mark a tunnel line leading to the western ponds. The main lake was now some 450 feet long, a canyon-like trench 20 feet deep, 60 feet wide and 200 feet long on the west constituting the channel and central pool depressed in the higher part of the arched floor of Halemaumau, while at the east end the pool was more open, of dimensions 250 by 120 feet, and the bank only 12 feet high. This east pool showed inflated crust, border fountains, and heavy bombardment under its northwest bank, but no surface streaming. There had been more breaking back of the east end of the lake to make a terraced cove in the direction of the dense smoke which rose from the cracked region between the lake and the east cone. The east cone was noisy. There was much smoke also around the southern cones.

The northeast tower gave vent to occasional puffs of gas but the flow vents were quiet. A crack extending across the floor from the central channel of the main lake to the north lake was an open crevasse but not especially hot or fuming.

On April 9 the pit was quiet and smoky in the morning. In the afternoon the fume was thinner. At 6 p. m. the north lake was brimming high and the northeast cove of the main lake threw spray above its ramparts. At 8 p. m. fountains above the pond rim were visible also at the west pond. The northwestern footslopes of the northeast heap had now developed, by swelling from below, many dome tumuli with cracked summits.

On Thursday, April 10, at 5:30 p. m., the lakes were high, but the northeast tower and all the vents of the northeast heap had ceased to show gas pressure by hissing. The east cone was puffing and flaming from numerous orifices in its north horns. The main lake was only 10 feet down, with active border grottoes. The north lake was bombarding its banks south and west, while on the north side it was building up the rampart rapidly by high flings of lava. In the evening all the open lakes showed fountain splash above their rims, the north lake being especially vigorous in its rampart building.

On April 11 at noon there was some hissing at the southern cones and much cracking and white staining, with heat rising, east of the north lake and north of the main lake. There was snapping of the ground heard in the same regions. A large hot crevasse was discovered parallel to and a few feet farther east than the known crack leading from the main lake to the north lake. The main lake was streaming westward, 10 feet down, with grottoes northwest, north and southeast, occasional large explosive central fountains, and some bubble fountaining during sinking spells. The high level of the north lake continued and big spatter domes five feet high encased the grottoes on the north and northwest sides. A fountain was splashing against the west bank and there was some bubble fountaining out from under a terrace at the south end. There was much ballooning of skins into great blisters 10 or 15 feet across, like inflated blankets, which migrated with the current from the central part of the lake to the north. The same phenomenon was observed in the main lake. Fume from the pit was this day thinner.

A curious patch of incandescent broken lava, about two feet square, had kept its heat right on the surface of the summit floor of the northeast heap for several days, without any blowing, solfataric stain or visible flame. There was no odor. The place had exactly the appearance of a bed of hot charcoal, of cherry red heat, abruptly bounded by shells of non-incandescent lava of the same sort. The only explanation which occurred to the writer was that a slow seepage of burning gas was oxidizing the rock above some gas cavity below, not revealed on the surface.

In the Whitney Laboratory of Seismology for the fortnight ending at 8 p. m. April 11, 1919, there were registered local earthquake shocks, mostly very slight, as follows: March 29, 3:31 a. m.; March 30, 2:48 a. m.; March 31, 4:39 p. m.; April 5, 12:32 p. m. (moderate); April 7, 6:19 a. m. (felt); April 8, 4:53 a. m. and April 10, 2:11 a. m. The harmonic microtremor increased from slight values to strong about April 3 and has remained moderately strong since. The spasmodic type of tremor became strong April 7 and excessively strong April 9, vibrating the ground from 1 to 4 p. m. on that day with extraordinary continuity. On April 10 and 11 spasms of vibration continued. Microseismic movement has been ordinary with slight increase April 4 to 6 and April 9 to 10. Movement of tilting was to the south and west March 29-30, north and east March 31-April 4, south and west April 5-7, stationary April 8-9, north and east April 10-11.

HAWAIIAN VOLCANO OBSERVATORY, April 19, 1919.—During the week ending Friday, April 18, 1919, a new spasm of mass swelling of the entire hard upper surface of the lava column set in, which culminated as in February and March in a strong overflow which broke through the south

pressure rim and produced the longest and most liquid flow of 1919 to date. This flow followed the same course as the flow of February 23, 1918, again covering the trail and reaching the road terminus. The three long flows of this year, extending each about one-half mile from the center of Halemaumau, lie south, southeast, and east, and were produced respectively on March 4, April 17, and March 12. Owing to the eccentric position southeastward of the axis of uplift, the extensive flows which have poured in the other direction, i. e., toward the northwest, have been confined within the old pit wall.

Approximate measurements, referred to the north bench mark (3700 feet above sea level) were as follows:

April 3, central floor 39 feet above mark, lake 24 feet above mark, northeast tower 63 feet above mark.

April 17, central floor 64 feet above mark, lake 34 feet above mark, northeast tower 60 feet above mark.

In the course of fourteen days the central floor rose 25 feet, averaging 1.8 feet per day; the main lake 10 feet, or 0.7 feet per day; and the northeast tower has subsided three feet or 0.2 feet per day.

On Saturday, April 12, the lakes in the morning were moderately high and a puddle flow covering a small area poured out from the east cone on its north side. Large spatter domes had formed in a ring around the north lake and a similar dome on the edge of the west pond had enlarged. Fume from the east and south wall crack areas was much thinner. At 8 p. m. all the lakes were high and spurting, including the southwest pond; the east cone glowed brightly and a strong swelling in the bench magma lifted the central region and caused the north lake to overflow on its northwest side. The lifting movement caused rocks to tumble from the southeast pressure ridge.

At 5 p. m. on April 13 the lifted concrete platform of the southeast station on the pressure ridge was found tilting at a higher angle, and the ridge thereabouts was 25 feet high. The wall crack between the south and south-southwest cones was flaming and the southeast pot had become a yawning chasm. A new spatter heap on the east side of the east cone showed boiling lava through the cracks and glowing cracks extended up the west face of the northeast tower. The wall enclosing the main lake was six feet high at the east end and higher farther west. The streaming was westward and from 5 to 7 p. m. the liquid subsided about three feet, with vigorous fountaining and heavy skins inflating and discharging flames. That the enclosing cliffs about the lake were lifting relative to the melt was shown by a terrace level at the east end, a high tilted scarp on the south and a broad flaming crack back from the northern verge. The region between the main and north lakes showed yawning cracks, some of them incandescent. The recent surface glow and whitening in many places were symptoms precursory of the uplift.

The north lake lava stood within a foot of its north and northwest margins but the central uplift had raised the southern margins of the lake 10 feet above the liquid. Fresh heavy flows had crossed the northwestern lip. The streaming was northward, there were flaming closed grotto domes and occasionally heavy crusts would crack and founder. The west and southwest ponds glowed brightly and later in the evening the fountains were very bright in the east cove of the main lake and around the north lake.

On Monday, April 14, the strong tumescence continued, the fume was thinner and the lakes remained high. From 6 to 7 p. m. rocks were falling from the pressure ridge, the outer face of which was nearly vertical in places, and the masonry of the southeast station had fallen in ruins. The east cone and south wall-crack were flaming as before. The east cone had been uplifted with the rising bench magma and the surface from here to the southeast pond curved up in a steep dome slope. The partition between the southeast pond and the main lake was gone, leaving an open canyon and a continuous single T-shaped lake. Streaming was mostly northward to where fountains bombarded the north bank. The bench magma was rising faster than the liquid, making the cliffs around the lake from 15 to 25 feet high.

Gas pressure continued in the northwest tower. The noise of the rising bench magma under foot was a continuous series of snapping, creaking and crunching sounds to which was added from time to time the crash of blocks falling in crevasses. The sounds were incessant and awesome in their suggestion of resistless power. The lakes during the night made bright red glare on the fume cloud.

On April 15 the mass rising continued, extending to the southwestern region and the lakes remained about as before.

At 10:15 a. m. on April 16 the floor had become a distinctly arched dome as a whole, with the center about the region of the central pool. Even the new flows of the north side of the northeast heap were arched up. The pressure rim now extended from the southeast so as to bend inward in plan through the east cone and from here northward the edge of the uplift passed under the center of the northeast heap, fracturing the summit cones and lifting the western flows of the heap to horizontality. The new fill north was so pinched by the uplift as again to tip back the old north rim of Halemaumau. The buried southwest margin of the old pit was again revealing itself as a pressure ridge so that practically the entire circle of floor was outlined by either pressure ridge or remnant cliff.

An interesting development due to fracture and collapse at the northern rim cones of November, 1918, was the revelation in the cavernous interior of these cones, only five months old, of abundant grapevine stalactites with stalagmites beneath, some of the former over 20 inches long. The shell of this cavern was only a foot thick in places and it was an incandescent gas chamber at the time of the November flows. There was no traces of water drip, and gas melting was the only possible process whereby these stalactites could have originated.

The central axis of uplift of the domed floor of Halemaumau formed craggy cliffs on both sides of the central pool of the main lake and these were now on a level with the summit of the northeast tower some 60 feet above the north bench mark of the old rim. Instead of individual craggy scarps as in former years, the whole arched floor was now one mighty tumor, as high as the former crags, with the lakes as gashes in its crest.

The south wall crack was flaming and hissing and yawning open at the cones. A chasm extended straight toward this crack, and at right angles to it, from the southeast pond. The latter was quiet, about 10 feet below its southeastern rim, but where it extended as a gorge to join the main lake the bounding cliffs were 30 feet high. The main lake streamed eastward to a spatter dome at its east end. The east cone had a splashing pot on top, the north lake was six feet down on its north side, 15 feet on the south and was quiet with curtained grottoes. The whole cup of this lake had been upheaved and tilted northward and smoking chasms extended from it towards the main lake. The west heap pond had filled up and overflowed and a trickle flow was pouring from a small splashing cone. The other two western ponds were fountaining vigorously with 5-foot margins and somewhat constricted cups. Gas vents built driblet spiracles in the southwestern wall crack region.

On Thursday, April 17, at 11 a. m., the whole region southeast of Halemaumau was found flooded with a broad lava flow of multiple forks, consisting of gleaming silvery liquid lava which hardened as very smooth dense pahoehoe. This flow had started about midnight, breaking out along a vertical chasm in the pressure rim just east of the south cone. The lips of the chasm were now plastered with spatter lava and Pele's hair, and 15 feet above the flow beneath an open window three feet in diameter revealed an incandescent vertical lava chute or sluiceway where the liquid fell rapidly and continuously through a pipe of its own making. The window was dripping with the liquid melt. The pooled lava beneath, covered with a thick shell, could be crossed in a distance of 100 yards, but the flow in the vicinity of the road terminus was 300 yards wide. The liquid was pouring through tubes to the many fronts which were building smooth, snaky toes, distributing itself widely and spreading in the course of

the day over the entire trail region and as far as the front of the flow of February 23, 1918.

The pressure rim east was now 30 feet high and swelling still continued. The margin of the new uplift was increased in height at the west and south pressure rim, rocks were falling occasionally, and seen from the northwest remnant of border cliff, the central floor had become a dome above the level of one's head. The whole eastern semicircle of what had been the former rim of Halemaumau was cut off from view even as far north as the old north station, by the rising of the great swollen fill. The top of the northeast tower remained visible, and in the flank of the dome could be seen against the skyline only a little of the rim of the west pond pit and the chasm and spatter heaps occupied by the north lake. The west and north stations were both tilted away from the center of Halemaumau, the north bench mark platform 8.5 degrees from the horizontal. As this involved uplift as well as horizontal disturbance, the value of the bench mark as a levelling station is destroyed. There was no evident differential lift of the floor at the base of the northwest wall. The pressure rim effect at the north station is extended in a crushed and fractured zone up the flank of the northeast heap.

The north lake was extending its cup in a crooked crevasse headed in the direction of the main lake. Its surface streaming was north and northwest, there was some central turbulence, and the marginal cliff was eight feet high northwest and 25 feet high southeast. An inner 3-foot spatter level marked the fluctuations of the previous 24 hours. The northern border heaps were still in place and the fountains splashed below them.

The northeast heap had a hissing, glowing east-west crack through the middle of the tower and many other deep hot cracks, especially on the side of the main lake. On this side one walked uphill towards the center of Halemaumau. The latter had a 12-foot cliff at its east end, but the central floor level was 25 to 30 feet above the lake. The streaming was westward and from the southeast pond channel northward, and numerous central and travelling fountains developed from time to time. There was no evidence from the currents that the lake melt was feeding the south chasm outflow. The tunnel extending from the main lake to the east cone had now by crushing produced a pressure ridge, in contrast to the gaping effects seen along the northwest-southeast crevasses (north lake and southeast pond extensions). This was prolonged into the main outer pressure rim by way of the east cone. The cone had built a driblet slope on its northeast side 15 feet high, an open pot was splashing out lava on top, and the whole structure, with its outer base below the lake level, looked as though it might easily produce a new outflow by breaking open.

In general the fume was thinner, the glow at night brighter, the lakes hotter and more turbulent on the surface. The new outflow differed from previous ones of like rapid extension, in its smooth, hard silvery surfaces and thinly liquid habit. Like the flow of March 11 in texture, it also was fed, like that flow, by a rapid cascade capable of freeing it from gas.

On Friday, April 18, there were important changes in the extension of the swelling northwestward so as to tip and break up still further the basin of the north lake and extend it by collapse along the fissure line southwestward. The fountains splashed high at this lake and in the east cove of the main lake. The crumbling broke down some of the spatter heaps standing on top of the north lake border cliffs.

The appearance of Halemaumau as seen from the Observatory is now that of a smooth curved floor 1200 feet across, rising from the northwest rim of the former pit to a height about 50 feet above the general level of the former rim. This body falls off abruptly as an escarpment 40 feet high on the southeast at the pressure rim. The movement here has been bodily eastward, as known landmarks on the pressure rim, like the southern cones, have moved east in profile during the last few weeks. Along with this has gone the mashing up of the pressure rim, made of slabs of the rim flows, with an angular rotation from horizon-

Feb. 3, 1919. South rim of Halemaumau and live flow pouring from south cone in wall-crack. From south-east station. This margin was thrust up as the great pressure rim Feb. 25 and later.

Feb. 8, 1919. Same view five days later; the overflow which destroyed the trail. [Photos Jaggar.)

tal to vertical and beyond, so that the top of the rim is no longer defined, consisting of the old edge of the pit facing west and raised en masse, but is the rounded swollen lava floor, and is not a ridge but a scarp facing east. The upper part of the cliff so formed is the cross-section of the inner lava layers lifted clear, and the pressure rim is a tumble of talus.

In the Whitney Seismological Laboratory for the week ending at 8 p. m. Friday, April 18, 1919, there were registered six trivial local earth shocks and three distant earthquakes. The local quakes were at 7:20 p. m. April 13; 5:29 and 10:31 a. m. April 14; 5:57 and 7:19 a. m. April 17; and 7:10 a. m. April 18. The first teleseism at 12:50 a. m., H. S. T., April 17, gave evidence that the distance of its origin was about 2640 kilometers from this station, which would correspond probably to a source on the bottom of the Pacific ocean. This distance is not quite as far as the Phoenix Islands. The second teleseism was also on the 17th at 10:35 a. m. and indicated a source at 5585 kilometers, the distance of Mexico, Kamtchatka or the New Hebrides. The third teleseism at 10:51 a. m. April 18, registered pronounced long waves, but the preliminary tremor which would give evidence of distance was absent in the record.

Microseismic motion increased from slight to moderate about April 15. Both the harmonic and spasmodic types of microtremor decreased during the week from strong to slight. Movements of tilting have been remarkably slight in view of the strong swelling and overflowing at the crater, but this agrees with the February-March record as discussed in this Bulletin February 8. The general tendency of the tilt has been slight to the east and south.

HAWAIIAN VOLCANO OBSERVATORY, April 26, 1919.—The week ending April 25, 1919, at Kilauea volcano, after the long southeastward flow of the previous week, has been distinguished by intense renewed swelling of the lava floor towards the north, followed by an extraordinarily long and enduring flow, given vent, not from the pit, but from a fuming crack north-northeast of the pit approximately 790 feet from the north station. This crack has long been known as the "Postal Rift," because of its high temperature (over 300 deg. C.), making it a favorite place where travellers scorch postal cards. It marks the site of the old rim of Halemaumau prior to overflow in 1894. The long flow began Sunday morning, April 20, and at the end of the week is still progressing with front over 1.5 miles from the center of Ha.emaumau. The course of the flow lies north-northeast, passing on the west side of the well known steam cone which stands out on the floor of Kilauea crater towards the north. This breaking out of a flow back from the north rim recalls the similar flows of November, 1918, from sources nearer the pit.

The extension of tumescence to the old rim of Halemaumau west and north has tilted the west station 4.5 degrees to the southwest and the north bench mark platform 8.5 degrees to the north. The latter has been lifted bodily approximately eight feet, making its new elevation 3708 feet approximately above sea level. Measurements for the week with this mark as datum were as follows:

April 17, central floor 64 feet, main lake 34 feet, northeast tower 60 feet—above mark.

April 26, central floor 73 feet, main lake 38 feet, northeast tower 54 feet—above mark.

Allowing for the lift of datum mark and of the northwest station from which the angular measurements were made, the central floor rose 17 feet in nine days, averaging 1.9 feet per day; the main lake rose 12 feet, averaging 1.3 feet per day; and the northeast tower rose two feet, averaging 0.2 feet per day. Practically for the last three weeks the northeast tower has been stationary.

Approximate measurements of the progress of the front of the Postal Rift flow were as follows, the source of the flow being 1400 feet from the center of Halemaumau:

April 20, 3 p. m., front 0.4 miles from center of Halemaumau.

April 21, 10 a. m., front 0.5 miles from center of Halemaumau.

April 22, 11 a. m., front 0.6 miles from center of Halemaumau.

April 23, 10 a. m., front 0.9 miles from center of Halemaumau.

April 24, 11 a. m., front 1.2 miles from center of Halemaumau.

April 25, 12 m., front 1.4 miles from center of Halemaumau.

On Saturday, April 19, 1919, at 6 p. m., there was still glow in the southeast flow, the south wall crack was flaming and hissing and the east cone was flaming on top and splashing within. The northeast tower had cooled considerably and was quiet.

The main lake was greatly enlarged in a north-south direction along its east bank, its enclosing walls were from 15 to 25 feet high and the streaming was outward from the south arm (formerly the southeast pond). There was the usual grotto fountaining. The north lake was found surrounded by unmistakable signs of rapid extension northward of the floor swelling so conspicuous on the southeast during the previous week. As one stood on the brink of the lifted north lake cup the view all the way to the Postal Rift revealed a downward slope past and involving the north rim of Halemaumau and the driblet cones of 1894. The north lake was itself so affected by this lift that it was enlarging itself rapidly by collapse of its southeast and northwest sides. The high southeast wall crumbled into the lake in spectacular avalanches and a tumbled crevasse made a yawning chasm in the wall in the direction of the main lake. A cavern under the west bank of the lake ejected a rapid torrent of glowing melt from the direction of the western ponds and the avalanches made much tumult of boiling. The northwestern bank was a subsided flat of fractured rock submerged beneath the lava like a beach. At the northeast end of this lake two of the large spatter domes remained intact 15 feet above the lake level. There were cracks in the swollen floor with hot air rising. A crisis of northward swelling was in progress, lifting and tilting the zone of the Halemaumau rim all the way back to the old rim line of 1891.

At some time near noon on April 20 the liquid lava welled up in a standing fountain through the cracks of the Postal Rift north of Halemaumau and west of the small solfataric crater known as Pele's Kitchen. The place was within a few feet of those hottest cracks visited by tourists. There was not the slightest seismic disturbance and even the volcanic tremors were remarkably slight at this time. The lava was in great volume, of slight viscosity and flowed rapidly in rippling cascades towards the north so that by 2:30 p. m. the front was 900 feet from its source. There was at 3:41 p. m. a small local earthquake shock (instrumental, not felt). The source of this flow was visited at 7 p. m. and two small cones were found built above a crack on the north side of the densest fume of the Postal Rift. From these the stream poured steadily in the direction of Perret's Cone, widening out in shape like a laurel leaf and consisting of ordinary pahoehoe. The fountaining and spurting at the vent were moderate and commonplace.

No immediate effect at the Halemaumau lakes suggested drainage by this flow. On the contrary, the lakes were distinctly higher with pronounced gas pressure, but the tumescence of the bench magma was less. The activity of the main lake was unchanged. The north lake walls were 10 to 20 feet high, more defined on the northwest side, the caving in had ceased and the liquid had risen to drown and check the torrent from the southwest cavern. The cavern was filled up. The wall around the southeast side of the north lake had become straight and smooth.

About 10:30 p. m. the lakes rose to their levels and an overflow poured from the east end of the main lake past the east cone on its north side to the region of the old automobile terminus, some 500 feet east of Halemaumau.

About 6 p. m. on April 21 the east cone overflowed and sent a torrent eastward 600 feet overriding the lake flow of the previous night. At 9 p. m. the front of this flow was stagnant. The main lake was streaming mostly westward, with 10 to 20-foot cliffs bombarded at the lake level by violent fountains east and northeast. About every half hour the lake level suffered sudden subsidence of three to four feet with break-up of crusts and very large turbulent central fountains.

The north lake was also pulsating with rising and sinking spells and was building new curtained grottoes at its

northeast end. Many cracks in the floor of Halemaumau showed incandescent bench magma beneath.

The Postal Rift flow continued its progress and had sent two narrow branches to the west in the direction of Uwekahuna. Already this flow was much the longest of the 1918-19 series.

On Tuesday, April 22, the Postal Rift source developed strong fountaining at noon so that the progress of the fronts of the flow was more rapid, the main front showing at night a shape like a glowing hand creeping in the direction of Perret''s Cone.

At 5:30 p. m. there was hissing at the south cone and the main lake showed a large continuous fountain in the southeastern part while the streaming was mostly westward and northward. The sinking spells happened suddenly at intervals of from 20 to 40 minutes, followed by quick recovery in the course of 10 minutes or less. At the beginning of the sinking spells there were very intense explosive outbursts against the wall and from under the crust margin. These outbursts began on the north and extended themselves eastward. The north lake was brimming level with its rim and rather quiet. The bench magma continued to rise but the rapid swelling had ceased. The lake fountains at night were visible from the Observatory and some high jets were seen at the west pond.

On April 23 the crater was quiet, the floor lava stationary and the lake shores caved in in places. The Postal Rift flow continued its progress with front now a mile from the center of Halemaumau and glow at the front of the upper western fork as well as at the main front near Perret's Cone. The north lake was fountaining above its rim at 7:30 p. m. and there was a very high level after midnight.

Exploration of the Postal Rift flow in the early afternoon of Thursday, April 24, showed that it consisted of moderately smooth pahoehoe lava extending beyond and west of Perret's Cone. As a whole the flow is a ribbon from 100 to 300 feet wide, spreading continuously by slowly oozing toes which are fed through tubes in the crusted upper portions of the flow. The source was still merely a small cone three feet high with hissing and flaming cracks in its summit. All the upper part of the flow was frozen solid on the surface. Active moving toes were found at 3 p. m. on the western side of the frontal lobe.

From 5 to 6 p. m. the north lake was found brimming full and dribbling over with two large high flung fountains playing continuously next to the spatter domes at the north end. The remainder of the pond was crusted over and the ravine in the direction of the main lake had widened.

The main lake was still undergoing sinking spells with northward streaming, bombardment of the north shore, and cliffs 10 feet high on the east and 30 feet high in the center. Large balloons of skin formed during the rising spells when inflation was dominant. At the west end of the central pool a chasm three to five feet wide had opened clear down to the pool level so as to connect the main lake through to the west pond. Two similar chasms less wide and not open to the liquid lava level extended from the north lake towards the main lake.

The floor was crossed on the north side of the main lake and these chasms were found to be still narrow enough to step across. The west pond was found to be circular with wall 10 to 12 feet high on the side of the chasm leading to the main lake, but on the opposite or western side the liquid stood level with the rim owing to the fact that the cup of the pond was tipped away from the center of the pit just as in the case of the north lake. A short distance farther west the west pond cone was hot and fuming and the southwest pond was in the midst of fume farther south. There were as yet no fresh flows from the western ponds.

The dome swelling of the Halemaumau floor had now lifted the floor slightly on the northwest side so as to reduce the height of the cliff there and the ends of this cliff north-northeast and west southwest had become pressure rims so that the remnant of the old border cliff now included not more than two-fifths of the former circumference of the pit. The west station platform showed increased deformation. All tumbling of rocks at the south pressure rim, however, had now ceased and the lava column was stationary.

The sluiceway which had been the source of the flow of April 17 was now covered with a few snaky driblet trickles of solidified lava from above where there was a hissing vent. In the wall crack chasm left by the southeast pot, large masses of bright colored stalactites were revealed. The east cone continued to show flaming vents over lava surging within.

On April 25 from 2 to 3 p. m. the cliffs over the main lake were found to be somewhat higher, a 3-foot spatter margin appeared above the level of the liquid lava and the streaming was at first north and west, but this was reversed to north and east when an immense central fountain developed and migrated eastward to expend itself at the lake shore. The pulsations of rising and falling continued. The cliffs were from 15 to 30 feet high.

The north lake showed walls four feet high on the northwest side and a block of that wall was seen to collapse. There was much cracking and foundering, the usual northern border fountaining and in both the north and main lakes the ballooning of crusts was conspicuous.

Some trace of the eastern pressure rim could now be followed all the way from the southeast wall crack to the northeast tower along a line of crunched up flows, ridges and cracks marking the course of the Halemaumau pit margin beneath. Hissing continued at the south, east and northeast cones.

The Postal Rift flow was still pushing ahead and the line of active toes was bright at night as were also the glow spots at the source of the flow and at the east cone. The flow was spreading its frontal lobes eastward so as greatly to widen in a sort of a puddle the whole frontal strip. At noon the front was 1.4 miles from the center of Halemaumau and this proved to be nearly the limit of its progress.

The seismographs of the Whitney Laboratory have registered traces of two teleseisms during the week ending at 8 p. m. Friday, April 25, 1919. These were at 4:44 p. m. April 21 and 8:57 p. m. April 22, H. S. T. The evidence of distance is not clearly shown. Local earthquakes were registered at 3:41 p. m. April 20; 3:02 p. m. and 11:44 p. m. April 21, both very slight; and 10:54 a. m. April 25. Microseismic motion decreased to very slight, harmonic microtremor remained slight and the spasmodic tremor has continued abundantly in evidence with prolonged spells of several hours when it was strong.

The tilting of the ground became strong to the east and north April 19-20, reacting moderately west and south April 21-22. April 23-24 exhibited stationary tendency and April 25 there was slight tilt east and north.

HAWAIIAN VOLCANO OBSERVATORY, May 3, 1919.—During the week ending Friday, May 2, 1919, there was a short-lived sinking spell from April 25 to April 28, both the crater floor and liquid lakes taking part in the depression, and the long Postal Rift flow coming to rest. Beginning April 29, however, strong rising and overflowing were resumed, the net effect for the week being a slight rise of crater levels and voluminous new flows. The Postal Rift flow has continued to lengthen and also to spread sidewise in many places along its whole length. Its front is in the extreme north corner of Kilauea floor, against the northern end of the Uwekahuna wall, and approximately 1.6 miles from the center of Halemaumau.

The measurements of the week, above the north Halemaumau bench mark (approximately 3708 feet above sea-level) are as follows:

April 26, central floor 73 feet, main lake, 38 feet, N.E. tower 60 feet.

April 28, central floor 67 feet, main lake 27 feet, N.E. tower 60 feet.

May 2, central floor 74 feet, main lake 44 feet, N.E. tower 60 feet.

The floor thus subsided six feet in two days, or three feet per day, and the main lake 12 feet, or six feet per day. Thereafter the floor rose seven feet in four days, or 1.8 feet per day, and the lake rose 17 feet, or 4.2 feet per day. The northeast tower remained stationary. Measurements across Halemaumau from southeast to northwest show that the maximum of floor movement was adjacent to the central pool of the main lake.

On Saturday, April 26, 1919, at noon the main lake appeared lower relative to its bounding cliffs which were 15 feet high at the east end, 35 feet high

on the north and 25 feet high on the south. Streaming was westward from the east end and northward from the south arm. Much of the lower spatter rim around the lake had fallen away.

The north lake was also lower and showed a wall seven feet high on the northwest side and a spatter rim of similar height under the higher bluff of the southern side of the lake. The wall at the northeast end supporting remnants of the rampart was 12 feet high and showed fresh breaks. At the southwest end this lake showed an open cavern extending under the wall.

The west and southwest ponds had both overflowed since the high level of April 24, making flows which extended 200 to 300 feet westward and southwestward across the pressure rim. These flows probably poured out in the night of April 24. The ponds were now depressed within their cups.

There was continued the gas blowing at the south and east cones and at the cone source of the "Postal Rift" flow. This flow kept pushing forward until it was nearly half way from Perret's Cone to the north wall of Kilauea, and in the evening an arm was pushing eastward on the south side of Perret's Cone.

On April 27 the front of the Postal Rift flow ceased motion and became dark, but the source continued its flaming. A pot in the south wall crack contained fountaining lava which flared on the fume cloud above. The northeast side of the north lake caved in, demolishing the rampart remnant there. The east cone continued to be a bright beacon light and the flare over the lakes was brilliant. The dome swelling of the floor of Halemaumau appeared to have lifted more towards the south and west than towards the northeast, so that the northeast sector appeared relatively depressed, bounded by the east cone pressure ridge and south cliffs of the main lake on the one side, and by the west wall of the north lake crevasse on the other.

On Monday, April 28, fume had increased slightly, the bench magma was stationary and there was some increased caving in of the banks of the lakes. The front of the Postal Rift flow remained inactive. At noon the lakes were very low, the main lake depressed 25 to 40 feet and the north lake 15 to 30 feet, with the old rampart all fallen in and the surface covered with very heavy crust. In the north lake the only fountaining was at the north corner. In the central pool of the main lake there was also a heavy crust and the streaming in the east pool was eastward with moderate border fountaining and a central fountain opposite the east cone tunnel. The high bench magma surface adjacent to the south arm was found broken up with chasms, an especially large one extending southward and narrowing from the south arm pool towards the south wall crack. This pool was crusted over and oval in form, connected with the main lake by a narrow channel. A small fountaining pond 10 feet across and 15 feet below the upper ground occupied the wall chasm near the south cone. The east cone was flaming and rumbling through vents on its west side. There was some swelling and cracking in the long southeast flow. The bench magma was snapping, indicating renewed movement, and some rocks were sliding at the pressure ridges.

During this day there was pronounced rising of the lakes and at night fountains splashed above the bank levels and the east cone flamed brightly. The Postal Rift cone made an incandescent spot which became very bright after midnight, but no glowing lava appeared at the front of the flow.

On Tuesday, April 29, there was no lift observed in the floor and no unusual activity of the lakes. At 7 p. m. an outburst of liquid lava in the middle of the frontal puddle of the Postal Rift flow in the north corner of Kileaua crater developed a standing spring with lava spreading in lobes. At 8:30 p. m. there were two such springs feeding the revived front of the flow.

On April 30 at 4:30 p. m. Halemaumau was found with generally revived flows to the southwest, north and southwest. A fresh flow of silvery lava with dense texture had pooled under a new sluiceway vent which had opened in the face of the south pressure rim a few feet farther east than the vent of April 17. This lava had sent trickling snaky toes around the upper trail monument. The wall crack

pond above was boiling and fuming. The cone at the Postal Rift had increased in size and was puffing like a freight engine. The frontal pool of the flow from this cone was now midway between the north wall of Kilauea and Perret's Cone and vents in the middle of this pool opened from time to time and kept the lava working out so as to enlarge the front in different directions. The renewed trickling was now again continuous. The third region of renewed flowing was from the west ponds. The west and southwest ponds were now united in a horseshoe shaped depression at the end of the chasm leading from the main lake. This depression was indented in the southwestern flank of the dome of uplifted floor lava and in the opening of the horseshoe was the third vent (formerly the west heap pond), now a pool 20 feet across with two border spatter heaps and fountains flinging up lava which was level with the brink of the pond. Off to the southwest a broad flow had swept from these ponds as a source down the outside slope away from Halemaumau in a sheet forking into separate arms which had poured southwest out on the Kilauea floor fully a half mile from the center of Halemaumau. The end of the flow had pooled and widened on flatter ground in the direction of the 1868 cracks. Flowing had been in progress here for two days, some of the flows being freshly incandescent, others a little cooler.

The east cone was flaming and rumbling. The main lake cliffs were 12 feet high on the east and 30 feet high on the north, and the streaming was westward and northward, with fountaining under the north bank. The north lake showed a six-foot cliff on the north and 20-foot cliff on the south; streaming was northward to a line of bombarding fountains under the straight northwestern bank of the lake. These fountains occupied seven niche grottoes in a row. There were two other fountaining grottoes at the southeast bank of this lake. The north lake was now diamond shaped, its long axis trending north-northeast and south-southwest, and the northeast wall had slumped down to the lake level making an inclined surface. The south ravine leading to the main lake had enlarged and a pulpit pinnacle stood out at its entrance.

The floor continued to rise moderately. The northeast tower was smoking at its western base with mildly sulphurous fume and whitened cracks in the rock as though a slow roasting process were going on.

The tilt of the northern and western rim rock of Halemaumau was measured at 4:20 p. m. on this day with Brunton clinometer at the north bench mark and the west station platforms. The north platform surface dipped 9 deg. 5 ft. in the direction N. 10 deg. E. The west platform dipped 4 deg. 35 ft. in the direction W. S. W. There thus appears to be an arching of the north rim over the conduit leading to the Postal Rift flow as well as a pushing up of the ground away from the center of Halemaumau.

On May 1 the southwestern overflow continued and the Postal Rift flow surrounded islands of old lava, spreading so as to approach the base of the northern part of the Uwekahuna wall. In the evening there were very strong pulsations of rising and falling in the lakes and some rock fell from the walls of the main lake during sinking spells. At night the lakes were brimming level with their banks and fountaining high.

On Friday, May 2, at 3:30 p. m. there were flaming and spitting holes in the southeast chasm at the top of the pressure ridge; the main lake, five feet below its east bank, streamed westward and northward, and the north lake was covered with heavy inflated crust and building spatter domes southeast and east. The north lake was within two feet of its north brink. It had built an inner margin which was overflowed during tumultuous breaking up spells. The western ponds had made fresh flows 200 feet long in numerous lobes during the day by way of the cone pot at their gateway. The cone was built higher and splashing inside and the larger pond brimming level with its banks and fountaining. The chasm leading to the main lake here was somewhat choked below.

At 4:30 p. m. the east cone burst open and sent a double cascade down its north slope, one torrent six feet wide and the other two feet wide, unit-

ing below into a flow which poured eastward 200 feet and spread out. The flowing ceased quite suddenly about 5:30 p. m. and the last gushes at the head of the flow were very stiff and pasty. The head of the flow solidified completely within 10 minutes so that the writer was able to cross it. This shows the enormously rapid heat radiation and solidification of such lava, and its dependence on gas supply to keep it mobile.

The main lake showed high level throughout this flowing spell and its streaming was straight away from the tunnel leading to the E cone.

In the Whitney Laboratory the seismometric instruments have registered one slight local earthquake and three teleseismic during the week ending at 8 p. m. May 2, 1919. There have also been strong spasms of tremor amounting to very small local shocks. The local quake was at 3:06 p. m. April 27. The initial movements of the teleseisms were at 8:50 p. m. April 29, 3:54 p. m. May 1, and 2:34 p. m. May 2.

The distant earthquake of April 29 was a powerful one under the Pacific several thousand kilometers away, and tidal waves were noticed the next morning at Punaluu and Hilo. I am indebted to Mr. Jas. B. Mann, an engineer in the employ of the Bishop Estate, for the following: "The morning of April 30 the water receded in Punaluu Bay first at 7:30 a. m., until almost the whole bay was dry. It came back gradually but went out rapidly again about 9 a. m. and 10:30 a. m."

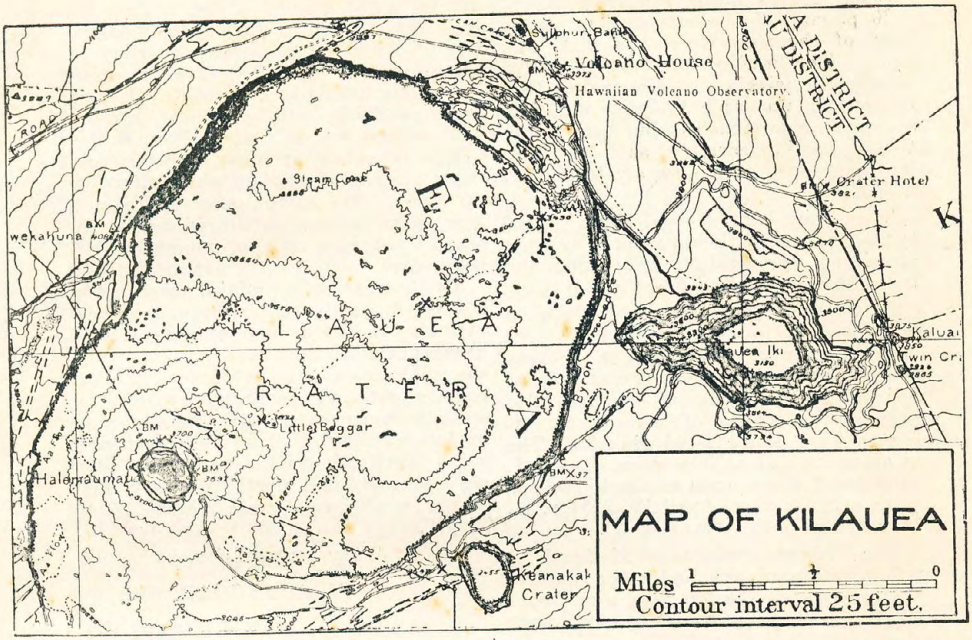
The teleseism of May 1 showed obscure phases, giving no clear data for distance. The earthquake of May 2 was very plainly registered and indicated a distance of approximately 6100 kilometers.

The spasmodic microtremor was strong, especially in daytime, April 26 and May 1 and 2, developing spells of great agitation of the ground. The slower harmonic microtremor has become slight and inconspicuous. Microseismic movement has been slight to moderate. The tilting was west and south April 26, stationary April 27-28, strong east and north April 29, and steady west and south April 30 to May 2.

Very respectfully,

T. A. JAGGAR, JR.,

Volcanologist.



HAWAIIAN VOLCANO OBSERVATORY.

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 solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	1000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the accelerations or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol a, or max. a, is given in the conventional unit of milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expresed in milligals by multiplying each of the numbers by 100.

U. S. DEPARTMENT OF AGRICULTURE
WEATHER BUREAU
CHARLES F. MARVIN, CHIEF

MONTHLY BULLETIN
OF THE
Hawaiian Volcano Observatory

VOL. VII. HONOLULU, HAWAII, MAY, 1919 No. 5

HAWAIIAN VOLCANO OBSERVATORY, May 10, 1919.—During the week ending Friday, May 9, 1919, the lift of the central floor of Halemaumau has continued at a slightly decreasing rate and the lakes have maintained high levels, building up their banks, and overflowing in the case of the western pond. The flow at the Postal Rift has widened out east and west from the source region so that the extremities of its two lateral arms are 0.7 mile apart, the one lying close to the base of the Uwekahuna wall south of the summit tripod, the other in the depression west of the Little Beggar with its front pushing parallel to the Volcano House trail. The whole flow, in shape like a bird with outstretched wings, now covers a considerable percentage of the northern half of Kilauea floor, the tail spreading on both sides of Perret's Cone and the head lying at the Postal Rift. The flow still continues to push forward energetically at its new lateral fronts, with occasional movements in its medial zone, and the source cone continues as a flaming beacon with occasional spouting spells. The backflow from these gushings has so plugged up the solfataric area of hot cracks that the voluminous fume from these cracks has greatly diminished.

As the north bench mark has continued to rise and tilt until it is now more than 10 feet above its original position, the measurements will hereafter be referred to the 3700-foot contour (original level of bench mark and of former rim of Halemaumau) and not to local marks near the crater. The following are approximate elevations above this contour:

May 2, central floor 82 ft., main lake 52 ft., N. E. tower 68 ft.

May 9, central floor 88 ft., main lake 53 ft., N. E. tower 68 ft.

The point of central floor here measured was on the south side of main lake; the northwest sector rose still more, about 10 feet during the week, making the maximum lift average 1.4 feet in the seven days. The movement, however, was not continuous, but in spurts. The rise of central floor at point measured was 6 feet, or 0.9 feet per day; of the main lake 1 foot, or 0.14 feet per day; and the northeast tower was stationary.

On Saturday, May 3, the lakes were high and brimming in their basins and the roaring of the Postal Rift source could be heard at the Observatory, the air being calm. The flow from this source was increasingly active, widening in many places, and seven moving streams were counted at one time, one of these the highest western fork, south of Uwekahuna. There were cascades over the wall of the depression containing the Pulpit Rock north of Pele's Kitchen, and an eastern arm of the flow started filling that depression. The extreme front of the main flow was moving toward the north end of the Uwekahuna wall.

On May 4 the lakes remained high, the fountains of the north lake being almost continuously visible at the Observatory. The floor of Halemaumau was rising. The reflected light from the lakes on the fume cloud at night made a brilliant display. There was dense smoke from cracks on the north side of the main lake, but elsewhere fume was thin. The Postal Rift flow

made strong progress, showing a line of lights, like a city at night, across Kilauea floor from source to front, and the roar of its gas continued.

On May 5 the lakes continued high and measurement revealed a strong lift of the bench magma taking effect most around the southwest lake. Angular measurement showed also that the west and north concrete platforms had lifted farther since April 27. The Postal Rift flow was cascading into the broken ground of the Pulpit Rock depression northeast from the source and the front of the flow was against the northern base of the Uwekahuna wall. Perret's Cone was now surrounded by the flow as an island, along with some other old surface west of the cone.

At 3 p. m. the southeast wall chasm was hissing and glowing in one small hole. The uplifted crest of the arched Halemaumau floor was now 70 feet above the upper trail monument where the former southeast station had been and fully 40 feet of wall surmounted by yawning crevasses confronted the visitor approaching the so-called fire-pit—no longer a pit, but a domical hill, pitted in its crest with the fiery lakes, now occupying three chasms radiating from the center of the dome in clover-leaf pattern. The main lake, the eastern and largest of these, is forked to the south by its union with the southeast pond, so as to give to the clover a four-leaf aspect. The visitor follows the wall around to the east and climbs upward to the brink of the main lake by a pass between the east end of the wall and the heap of lava flows around the northeast tower. Here the east cone is passed, on the left, hissing and glowing, standing on the dome-slope, with the elephant-back surface arching up beyond it southward. The east bank of the lake is 6 feet above the liquid lava, which extends away into the heart of the dome for 800 feet as a canyon 40 feet deep, with the south arm another gorge forking off to the left. The traveller now walks over piles of lava between the northeast tower and the lake following around the dome slope and comes to the north lake. This is again high on the flank of the dome, with its north brink low and its south margin a high cliff on the side of the ravine leading into the heart of the dome—where a crack joins through to the central canyon of the main lake. This crack is the stem of the north clover leaf. Looking out from this north lake towards the familiar 1894 driblet cones on what was once the north edge of Halemaumau pit, we look downhill, see these cones all tipped backward to the north, and beyond them, with the steaming hot cracks no longer steaming, we find the postal Rift area a field of fresh black glistening live flows, extending away off to the north end of Kilauea crater under the Military Camp, and flooding out right and left towards the Volcano House trail and towards the high western bluff. Continuing the tramp around Halemaumau to the west side, a bit of the old wall is here preserved about 30 feet high until we pass the west niche of 1894. Inside the wall there is an upslope of flows 100 feet high to the smooth skyline profile of the great dome, and from here practically no lakes are visible. We are on the northwest slope of the dome, between the north and southwest lakes, and this is the widest unbroken sector. The southwest lake, usually shrouded in fume, is much like the north lake, but differs in that a wide chasm leads through to the central pool, and a slope of overflows, outside of Halemaumau, extends away on the southwest floor of Kilauea for half a mile. Going on around back to his starting place, the explorer picks up the wall once more, and realizes that he has to do with a great lava plug, lifted unsymmetrically above the former pit, making a wall on this southern side and a wall-valley on the northwest.

Examination on this day of the region on top of the south wall showed the pond in the wall-crack to be 50 feet long, 8 feet below the upper ground, crusted over, and with hissing gas spiracles in the crust. The ground on top thereabouts was smoking and dangerously crevassed. One looked down, forty feet below to the base of the wall here bounding abruptly the dome of uplift, and saw extending away to the southeast for a half-mile the expanse of flows which had poured

over this lip and through this wall repeatedly since February of 1918. And across it all is the trail from the automobile terminus.

The main lake was streaming westward and northward. Its north bank glowed and flamed to the top and dense smoke rose from cracks above. The north lake was crusted over, two border fountains were in action, and the spatter dome on the southeast side was enlarged. The old north station was lifted more and a pressure slope of uplift extended from it towards the northeast tower, with the fresh flows from the tower lifted and broken. Similar pressure effects were seen at the west niche, where the old semi-circular ledge of 1894 was found crushed and broken.

The Postal Rift cone was covered with eight or ten gnarled spiracles hissing loudly. The cascades of this flow were pouring over the western wall of the horseshoe cliff enclosing the Pulpit Rock depression, the cascades crusted but the pool below a glistening pahoehoe flowing forward in many live toes.

The southwest lake cone (former west heap cone) was found still giving vent unremittingly to flows pushing along the southern side of the southwest heap of overflows.

May 6 proved a day of revival of gas-and-liquid flooding following the strong preceding tumescence. Shortly after midnight the Postal Rift cone burst open just as in its first spurt, and all day it sent out a surface torrent over its former flows, as well as through tubes to the fronts. The new surface floods were mostly east and west. The Pulpit Rock became surrounded with new lava and the old horseshoe tended to fill up. At 8 p. m. the cone source was still spouting. The backflow drowned out most of the Postal area smoke. The renewed cone was 5 feet high sending a 5-foot stream northward; this lava, very liquid, welled up about three feet at the orifice and swept away in its channel maintaining several standing waves. The surface flows moved west, northwest, north and northeast with fronts from 100 to 800 feet from the source, and the lower end of the original long flow pushed eastward. In the evening the freshly glowing melt made three marked arms east, north and west near the source and two, east and west, at the front near Perret's Cone .

All the while the lakes remained high. At 11 a. m. they were slightly down, the north lake, crusted but fountaining in five border grottoes, had built an inner spatter margin standing 4 feet above the melt, and some high heaps east and southeast of this lake gave evidence of a high level of the previous night when the Postal flow revived. The main lake at 11 a. m. was streaming swiftly northward and a central fountain in the east cove was the goal of local streaming from both east and west. The northeast tower smoke had become slight.

On Wednesday, May 7, at 6 p. m., the southeast wall chasm was cracked and glowing and the south chasm pond was puffing through a flaming gas cone, whence driblet streams had trickled down the outer wall of uplift. The southwest lake was noisy and bright with occasional fountaining. Short fresh flows from the southwest cone had extended the lava heap to the old west station and moved along the inside of the old wall of Halemaumau so as to override the south side of the west niche. The wall bounding the east side of the southwest lake was more lifted, the cone source was building a new lava heap, and the west station appeared still more tilted. The north lake was tending to become round again through building in of its margin which stood 7 feet above it on the north. A central fountain played at the west end of the pond, with crust ballooning near it, and two northwestern grottoes were active. From the ravine south of the north lake to within 25 feet of the central pool of the main lake a chasm 10 feet wide and 40 feet deep extended; the bottom of the chasm was covered with broken rock some 15 feet above the level of the north lake. The cliffs around the central pool were 40 feet high. The main lake stood 15 to 20 feet above the north lake. The central pool was fountaining violently against the base of its southern wall. Heavy smoke rose from

the knob of cliff over the north side of the narrows between the east and central pools, as though undermining were there in progress which would eventually join through to the north lake chasm. Under this smoke a very brilliant cracked and flaming cliff surface high up the wall above the main lake suggested a closed in or curtained shaft. The main lake was comparatively high, its bank about 10 feet high at the east end, and the streaming, out from both the east cove and south arm, was swiftly westward.

The Postal Rift cone was quiet but flaming; all of the upper part of the flow was glowing and a main torrent poured from a low vent in the west lobe supplying an elongate pool parallel to and near the Uwekahuna wall south of the trig station. The glow at the Perret Cone front had ceased for a time. The east arm during the next twenty-four hours forked around the broken ground east of Pulpit Rock depression and bent north in the sag west of Little Beggar cone.

On May 8 the bench magma rising became slower, the lakes remained high. The long front flow of the Postal Rift outpouring had apparently become stiff and forced outlets east and west above, where there were two fountaining cones in a medial line besides the source cone. These seemed to be over the medial tube below, suggesting the gas cupolas along the upper course of the Thurston tube. At 11 p. m. the source cone burst and spouted lava and made a short surface flow.

On Friday, May 9, the central smoke was denser, the lakes continued high, with central and western fountains in the north lake. The Postal Rift flow continued spreading, showing a live torrent in the upper west arm in the afternoon, and in the evening two live areas revived in the Perret Cone front. From 6 to 7 p. m. all the upper part of the flow was alive as well, especially in the medial zone and cascading eastward to the east front. Beacon flames continued to burn steadily at the Postal cone and the east cone, and there was bright luminosity over the lakes and the south wall crack.

In the Whitney Laboratory of Seismology for the week ending at 8 p. m. May 9, 1919, the seismographs have registered the following local earthquakes: May 3, 8:35 a. m. (felt); May 5, 12:39 p. m.; May 6, 3:19 a. m.; May 7, 4:21 p. m. The following teleseisms have been registered, the times being initial motion: May 6, 9:34 a. m. and 7:11 p. m. The first of these was from a source about 5600 kilometers distant. Faint teleseisms were registered at 11:58 a. m. May 7 and 8:58 a. m. May 8. Microseismic movement and harmonic tremor have both been feeble during the week but spasmodic tremors have been moderate to strong. The tilting of the ground became strong to the east and north May 4-6, reacted to west and south May 7-8 and became stationary May 9.

HAWAIIAN VOLCANO OBSERVATORY, May 17, 1919.—The week preceding and incuding Friday, May 16, 1919, produced towards its close another spell of subsidence of liquid lava accompanied by inbreak of the bench magma and enlargement of the lakes. Until May 13, however, the high levels had continued and throughout even the subsidence days the Postal Rift flow has pushed ahead without cessation. The most marked topographic charges of the week have consisted in enlargement northward of the main lake, collapse and lowering of the broken ground between the main and north lakes and extension in all directions of the Postal Rift flow along with development of swollen domes in the several frontal regions of that flow.

This swelling up of tumuli, mostly 15 to 20 feet across and 5 to 10 feet high, always begins after a pahoehoe flow has progressed some distance from its source, and the swelling first is noticed in the frontal part of the flow. An individual dome forms in the course of a day or two. Usually such a dome gives vent to the lava within through the cracks. The lava welling out is generally the same as all the rest, but sometimes is very pasty and solidifies as heavy lumps with rough "shark skin" surface and even with formation of aa. This last is a rare phenomenon, observed, however, in three different flows since February of 1918. The apparent explanation of the

dome swelling is that the crust and margins of the flow lobe have solidified, the lava inside has become pasty, and a revival of pressure after temporary stagnation finds swelling the path of least resistance. The forces inducing the pressure are threfold, namely gas effervescence at the source, weight of heavy fields of crust, and hydrostatic pressure in the fluid melt.

The measurements of the week expressed as approximate height of the several surfaces above the 3700-foot contour, are as follows:

May 9, central floor S. W. 88 feet, central floor N. E. 83 feet, main lake 53 feet.

May 16, central floor S. W. 87 feet, central floor N. E. 67 feet, main lake 37 feet.

These figures show the remarkable slump in the northeast summit sector of the floor along with subsidence of the main lake. The rest of the floor west and south remains a high dome as before. In seven days the central floor southwest subsided one foot but this happened May 14-16, averaging 0.5 feet per day on those two days; the central floor northeast sank 16 feet, also showing more rapid subsidence May 14-16, and averaging for the seven days 2.3 feet per day; the lake sank the same amount, namely 16 feet. The rate of sinking was really much faster, for the turning point was reached May 13, after which date the rate of subsidence for lake and northeast sector of bench for four days averaged 4 feet per day. The northeast tower continues stationary.

On Saturday, May 10, at 9 a. m., the south wall crack was hissing and flaming, the west cone was hissing and the southwest lake showed border fountains against its north and south shores. The southwestern overflowing had ceased, there was a large grotto dome in the south corner of the southwest lake. This lake had formed from the union of the former southwest and west ponds, was brimming level with its banks on the western side, but lay in the shadow of a 20-foot cliff where the great Halemaumau dome rose toward the east.

The writer climbed to the summit of this dome and stood on top of the cliff overlooking the junction of the main lake and the south arm. This cliff appeared fully 45 feet high where it overhung the central pool and from this high vantage point, looking down into the gashes occupied by the lakes, one gained the impression of being on uplifted crags, quite similar to those of 1917 and 1918. They also had surfaces sloping away from the center, and cliffs overhanging the lakes, differing only from the present situation in the lack of continuity in their outlooking slopes. The breaking up of this continuous dome surface which is going on this week so as to leave the tips of the sectors at different levels, promises to convert them into crags wholly analogous to those of former years.

The streaming in the main lake was northward and eastward. The bank at the east cove was 5 feet high. Two chasms prolonged the south arm southward, the eastern one 4 feet wide. A marginal terrace in the south arm stood 5 feet above the lake level.

The north lake was covered with crust, and spatter grottoes were building up at the southwest corner of this lake as well as on other sides. The east cone had become quieter and yellow sulphur stain had formed on the surfaces south of it. The Postal Rift cone was puffing and the flow from it progressed steadily with live toes at its three fronts northwest, north and northeast. All night long a spectacular cascade at the northeast front poured from the ponded region of the Pulpit Rock depression over the broken ground farther northeast so as to make an extensive pool in the region east of Little Beggar cone. Late at night the source cone renewed its spouting.

On May 11 the fume from the high ground north of the main lake was very dense and the central peak overhanging the east pool there collapsed. Measurements showed stationary bench magma, the lakes continued high and the Postal Rift flow continued to send out live tongues in many places so that at night the flow resembled a bed of hot coals. At midnight a new cone broke into action 20 feet northeast of the original source cone.

On May 12 at 4:30 p. m. the east

cone was noisy with gas rushing through a new summit hole. The lakes were about as before. The hot smoking ground north of the main lake was whitened by the solfataric vapors and greatly crevassed. The Postal Rift cone was covered with hissing gas spiracles and the new cone beside it was a steep spatter heap four feet high built over the heavily crusted streamway which led in the direction of the eastern lobe of the flow. For several hundred feet around these source cones the surface was smooth and the crusts several feet thick, the upper pattern giving indication of long sweeping lines of flow in the three directions of the three main arms of the flow. It is a singular characteristic of these lava flats at the source of flows that they become thicker and stronger and more heavily roofed above the lava continuously pouring through the tunnels below than any other part of the area covered by the outflow. The capacity which this Postal Rift flow shows for throwing out wings laterally is interesting evidence of the way in which the Hawaiian dome mountains like Mauna Loa and Kilauea have been built; the building is not only radial but also concentric in zones.

The Postal Rift flow had now obliterated the western wall of the Pulpit Rock depression, the Pulpit Rock itself rose only a few feet above the fill surrounding it and the lava had made an extensive flow away beyond and below this ground in the direction of Volcano House. There were also several new elongate arms of the flow trending northward from the western wing.

It was now evident that this high level of May, 1919, must be considered the equivalent of the similar high May level of 1917 and the high levels of February-March, August, and November of 1918. But the present culmination has produced much the greatest effusion of liquid lava, inducing what appears to be an equilibrium or stationary condition in the main lava column satisfied by the steady outpouring.

On May 13 the lakes continued high, dense fume rose from the region north of the main lake, the great flow continued and in the night the source cone resumed its spouting.

On May 14 at noon the south wall cones were quiet, the east cone was still less active and the main lake, about 8 feet down at the east end, was streaming to the north and east. The other lakes remained as before and the fuming had increased north of the east pool.

The Postal Rift flow was active at the west and north fronts. The source cones were partially drowned by the new lava of the previous night and this lava had very thick crusts. The cones were hissing and flaming as usual. Live lava was in motion against the base of the Uwekahuna wall northwest of Halemaumau, domes were swelling up near the front, the middle region was hot over tubes below and the east arm was stagnant.

On May 15 the dense smoke north of the main lake had disappeared and the broken ground had collapsed into the lake making a new deep northeast cove. Smoke had disappeared also from the west corner of the north lake and from the Postal crack region. In the evening the lakes were low and dull and the lights from the east and Postal Rift cones dim. The upper parts of the flow were dark but there were many live places in the west and north arms.

About 4 a. m. May 16 the Postal Rift source had started spouting again and this continued into the forenoon. It was evident that the sector of raised Halemaumau floor north of the main lake was sinking and the general surface was slightly lower.

At 6 p. m. the east cone was found with one small flaming orifice, part of the pressure ridge east of it had collapsed to a cup and the main lake was 20 feet down at the east end while the walls to the south and west remained 50 feet high, but the north walls were only 30 feet high, owing to the localized subsidence of the bench. There was great enlargement northward of the northeast cove and big rifts had formed extending westward from the end of the cove to the north lake chasm and beyond. The streaming in the main lake continued northward and eastward, there was a cavernous quiet grotto hung with stalactites at the east cove and some border bombardment in the north-

east cove. The north lake had lowered but its north rim was still 10 feet high. This lake had enlarged by collapse of its spatter margins. There were very thick crusts and the lava was pasty and spattering over the crust through blowholes; the grottoes were dull.

The Postal Rift cone was puffing and flaming and the lava about it was cracked and glowing. Flows were moving at the base of Uwekahuna and the main spreading of the flow was east and west from the intermediate region south of Perret's Cone. There was much increase of white vapor in the tilted ground near the north bench mark.

The seismographs of the Whitney Laboratory for the week ending at 8 p. m., May 16, 1919, have registered the following local earthquakes, mostly feeble: 6:24 a. m. May 10; 5:26 a. m. and 12:26 p. m. May 11; 6:43 a. m., 10:45 a. m. and 3:09 p. m. May 13; 10:05 a. m. May 16. Microseismic movement has decreased from slight to very slight. Harmonic microtremor has continued slight. The spasmodic microtremor developed many strong spasms May 12-14 and continues moderate to strong; the motion is stronger east-west than north-south and stronger daytime than night. Tilting of the ground remained stationary May 10, was strong to the east and north May 11-13, and stationary with westward tendency May 14-16.

HAWAIIAN VOLCANO OBSERVATORY, May 24, 1919.—During the week ending Friday, May 23, 1919, a sluggish subsidence of the surface of the lava column amounting to about a half foot per day has been in progress, if one measures subsidence by the altitude of the hard surfaces and liquid lakes over the area which was formerly Halemaumau pit. Through all this, however, the Postal Rift flow has sent a ceaseless torrent through tubes to its northern fronts extending itself generally over the entire northern quarter of Kilauea crater, piling up along the base of Uwekahuna wall and finally obliterating the vapor vent known as Perret's Cone. A notable local subsidence of a block of the Halemaumau dome, similar to the northeastern one of last week, took place May 20-21 on the south side of the central pool, an immense cube of bench magma sinking 20 feet and causing tumult in the adjacent lake by the slumping into the lake of debris, which as usual lay as normal talus slopes, at flat angles of rest, the foundations lying on the lake bottom.

The meaurements indicate the following approximate elevations above the 3700 foot contour:

May 16, central floor S. 80 feet, central floor S. W. 87 feet, central floor N. E. 67 feet, main lake 37 feet.

May 23, central floor S. 68 feet, central floor S. W. 84 feet, central floor N. E. 62 feet, main lake 33 feet.

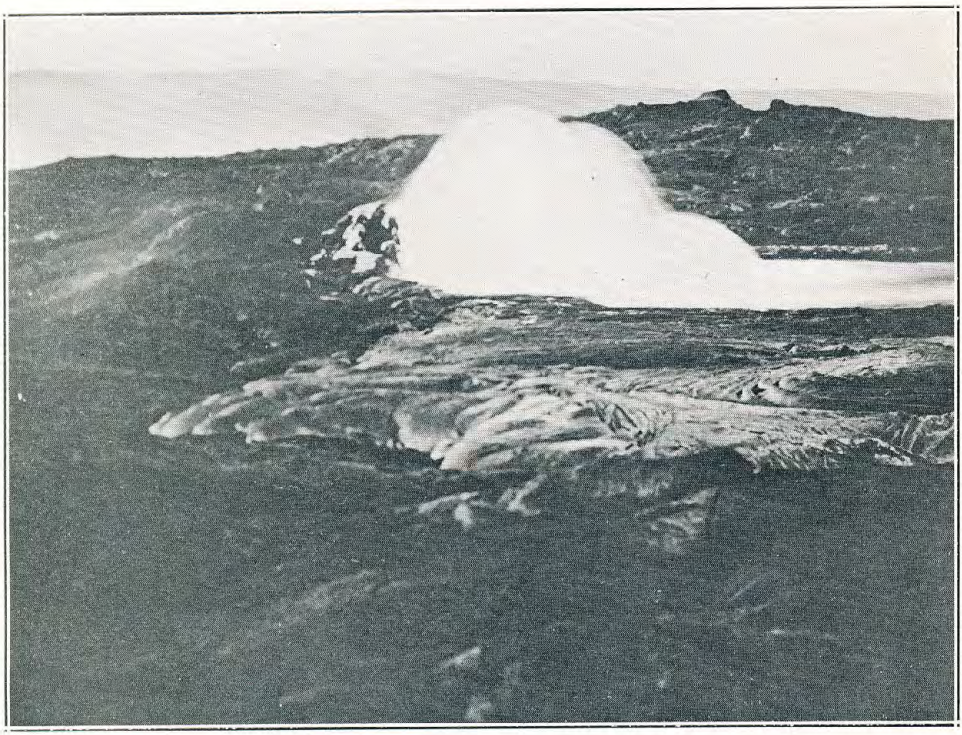
Thus the floor block south of the main lake sank in seven days 20 feet, or 2.9 feet per day; the crest of the Halemaumau dome southwest of the center sank 3 feet, or 0.4 feet per day; the northeast floor block sank 5 feet, or 0.7 feet per day; and the lake sank 4 feet, or 0.6 feet per day.

On Saturday, May 17, the middle part of the Postal Rift flow was spreading out in hooked and forked lobes and the front east of Perret's Cone had increased in size and changed in pattern. The upper wings of the flow had become stagnant.

The broken region north of the main lake continued to subside and increased smoke there suggested further undermining. The fountains of the north lake were high enough to show above the rim, there was some light from the south wall crack and the east cone beacon had become dim.

From 3 to 4 p. m. on May 18 no hissing could be heard at the south wall crack but lava was pounding and puffing within the east cone cupola. The walls of the main lake stood 20, 30 and 50 feet above it and the streaming was swift eastward and northeastward out of the southern and western arms. No further subsidence was noticeable in the ground north of the central pool and the fume there was not dense. On the south wall of the north lake there was a high splash mark 20 feet above the liquid believed attributable to an avalanche which had been seen at 10 a. m. to produce a puff of brown dust. The encompassing wall of the north

Feb. 21, 1919. Southeast rim station, Halemaumau, before uplift.



Feb. 25, 1919. Standing fountain spring of lava at East Cone, the day of sudden uplift.

March 6, 1919. Southeast station after mashing up rim, which began suddenly Feb. 25.

April 17, 1919. Northeast tower and its snaky lava flows. —*Photo. Jaggar.*

ceased. The southwest lake was also lower with walls 30 to 40 feet high and the west pond, also lower, showed fallen banks at its southern corners. Both ponds were crusted over. The Postal Rift source showed two fiery places, fume was moderate and at night the lakes were dull.

The next day there was little change. On Friday, May 23, the bench magma was slightly lower and fume had become dense again in the region of central crevasses. The northern part of the Postal Rift flow was pushing forward rapidly. At 10 a. m. it was observed that the south pressure wall had been gradually breaking up of late into numerous pinnacles. The east cone was no longer noisy but had a flaming hole on top. The main lake had been about 4 feet higher as shown by a border terrace, and this terrace in the middle of the lake had formed an isthmus clear across from north to south so as once more to separate off the central pool as a distinct pond. The streaming had notably changed, the east and northeast region being stagnant while the current out of the south arm bent westward to the isthmus. The north lake also had a low marginal terrace. In the evening a window was found to have opened in the roof of the tube leading from the Postal Rift cone so that one could look into the glowing chamber where the lava, 12 feet below, was pouring steadily northward to feed the moving fronts of the flow.

During the week ending at 8 p. m. May 23 two small local earthquakes have been registered on the instruments of the Whitney Laboratory. These occurred at 12:45 a. m. May 18 and 4:53 p. m. May 23. Distant earthquakes showing no phases sufficient to identify distance were registered at 7:07 p. m. May 19 and 1:41 a. m. May 22. Spasmodic microtremor increased during the week so that it was very strong, amounting to swarms of very small earthquake shocks May 23. Harmonic microtremor has been slight with some spasmodic increase May 21-23. Microseismic motion was very slight until May 20 when it increased somewhat and then became slight again May 22-23. The tilting of the ground continued to the west and south May 17-19, was stationary May 20, slightly east and north May 21-22, and was stationary May 23.

HAWAIIAN VOLCANO OBSERVATORY, May 31, 1919.—During the week ending Friday, May 30, 1919, the continued slight subsidence of the lava column accords with what is to be expected just before solstice. This subsidence is taking the form of collapses of bench magma in numerous places, and cones have been replaced by pits owing to such breaking down over voids below. Smoke also has greatly increased over such voids beneath the crevasses in the center of the Halemaumau dome. The Postal Rift flow on the floor of Kilauea crater has continued to spread and push forward but with somewhat diminished volume.

Measurements for the week show that the liquid lava of the lakes has been stationary and the sinking of the dome sectors has been various, amounting only to a few feet. The approximate levels above the 3700 foot contour were as follows:

May 23, central floor S. 60 feet, central floor S. W. 84 feet, central floor N. E. 62 feet, main lake 33 feet.

May 30. central floor S. 54 feet, central floor S. W. 80 feet, central floor N. E. 60 feet, main lake 35 feet.

The southern block has thus subsided 6 feet in seven days, averaging 0.9 feet per day; the northeastern block 4 feet, or 0.6 feet per day; the southwestern block 2 feet, or 0.3 feet per day. The lake has risen 2 feet, or 0.3 feet per day.

On Saturday, May 24, at 8 a. m., no trace could be seen of Perret's Cone and the Postal Rift flow continued strong pushing out of toes at its northern fronts. The Halemaumau dome still stood high, its summit only slightly below the profile of the far rim of Kilauea crater as seen from the Observatory, but smoke had increased at the hot cracks north of the main lake.

From 6 to 7 p. m. the east cone was flaming and the main lake stood higher relative to its shores so that its level was nearly flush with the isthmus dividing the east pool from the central pool. There was strong northward current

out of the south arm. The north lake, on the other hand, was low, showing 20-foot walls on its north and east sides. It was covered with crust which cracked and sank now and then, and a somewhat rhythmic explosive fountain burst out every two minutes from under the edge of the lake crust under the southern chasm ravine. Some northward streaming was evident in the northern part of the lake. At night this lake showed tendency to dark spells.

On the north side of the Postal Rift cone, a few feet away from the cone proper, two windows in the floor about 2 feet across each led to the tunnel beneath which was discharging continuously the flow lava northward. The northern window was clogged with glowing matter, but the other revealed brilliantly incandescent cavernous space where about 12 feet down the orange colored melt flowed northward in a majestic torrent. By looking obliquely toward the region under the cone one could see a streaming fountain feeding this flow. In the other direction the river poured northwestward in a tube and blue fume rose through cracks in the floor of hardened flow lava above. This was the wellspring which ceaselessly fed the ever pushing fronts a mile and a half away and the opening of the upper half of the tube was evidence of some decline in the volume of lava furnished.

On May 23 about 3 p. m. the isthmus shutting off the central pond was seen to be growing wider and there were live grottoes on the southeast side of the isthmus and at the northeast cove. The east pool showed central fountaining but the central pond was quiet. The north lake had a cracking crust and was increasingly dark at night, the main lake was mostly bright and the southwest lake had brightly active spells. The Postal Rift showed the same flowing in the source tube and at the fronts.

On May 26 slight continued subsidence was indicated. Smoke was increasing. The flow continued vigorous and there were bright flames at the east cone and at the Postal Rift cone.

On Tuesday, May 27, at noon the cliffs about the main lake were 20 feet high on the east, 30 feet high on the north, 25 feet on the south and 50 feet southeast and west. There were the same western and northeastern grottoes, the central pond was stagnant and more shut off, and dense fume rose from the central chasms. There appeared to be a line of breaking extending eastward from the northeast cove to the northeast tower and at the west base of the tower smoking was renewed. At 1 p. m. this place caved in and sent up a brown avalanche cloud.

The north lake showed a 15-foot wall on the north and a 40-foot wall on the south. Amid the stagnant cracking crusts there were lines of bubbling lava and a grotto cave was open on the southwest side.

The isthmus between the southwest lake and the west pond showed increased subsidence and fracture. The floor of the isthmus stood 3 feet above the lakes, whereas the wall on the southwest side of the pond stood 15 feet high and the walls bounding the lake stood 25 to 40 feet above the liquid, except at the isthmus. The lake was turbulent and smoky in its northern part and crusted toward the south. The pond had a broken tumble of rocks on its northwest side and at the opposite end a pulpit rock stood out between it and the lake.

The south wall crack was still alive, emitting pungent fume and glowing at night.

At the Postal Rift source a close inspection of the interior chamber showed it to be a large cupola under the cone where lava spouted up in gushes in two places, the one 10 feet farther east than the other. These fountains were about 15 feet below the orifices in the top of the cone. The western fountain may have fed a western tube. The eastern one fed the northern torrent which flowed north-northeast about four miles an hour, the surface of the current 12 feet below the general floor bounded on the east by a vertical wall under the window and on the west by another wall which could be seen with difficulty 15 feet to the west—making the tube 15 feet wide. Flame and sulphurous acid fume rose through the orifices and 20 feet from the cone to leeward (south-

west) there was bright yellow sulphur being deposited in an oval patch 20 feet long. Similar patches of sulphur stain have recently developed to the leeward of the southwest pond and of the east cone and all of these patches smell of free sulphur. Apparently the pressure of the wind on the gas chambers underground carries the unconsumed sulphur through cracks and pores to crystallize at these places, whereas at the live vents it burns and the combustion product is sulphurous acid gas.

Exploration of the flow to the west showed that the lava was piled against the Uwekahuna cliff face for several hundred feet of length from the ash locality northward. Near the front there were high driblet heaps and swollen domes.

On May 28 at 3 p. m. the lakes were unchanged and the east cone flaming through filagree orifices in its summit. The collapse of the smoking ground under the northeast tower had produced a pit 30 feet in diameter containing a stagnant crusted lava pool in the cavity 15 feet beneath the base of the tower. There was some glow at the edge of the pool and a little gas hissing. The inner rock of the northeast heap revealed in the wall of the pit was red with abundant iron oxides. The smoking had ceased at this locality.

At the Postal Rift source the speed of current was estimated at six miles per hour in the tube. The northern part of the flow was exploded and driblet lava was found pushing through cracks in the top of a swollen ridge. The position of the first front of the flow west of the Perret Cone locality was found occupied by an elongate flat-topped swollen area. Much of the lava recently squeezed out is blue gray, heavy and smooth, rarely showing aa patches and frequently having bulbous blisters of brown glass on the surface, two or three inches in diameter. The flow has spread over all the northern part of Kilauea crater clear to the talus west of Volcano House.

On May 29 the east cone was found to have collapsed to a pit full of broken reddish rocks and the gas flames there were extinguished. The north lake was now mostly dark and crusted. The Postal Rift source region broke open in a new collapse of the main tube 200 yards northwest of the source cone.

On Friday, May 30, at 11:30 a. m., both the source cone and the new pit were emitting flame and blue fume. Exploration of the nw pit discovered the fact that the roof of the tunnel had broken in for a length of 30 feet and a width of 15 feet, revealing a lava torrent tumbling over a slope into a broad portion of the tube beyond where it flowed away into cavernous brilliant glowing depths. The part exposed to the air showed wrinkled skins. The source tunnel showed increased rapidity of flowing. It seems likely that the loss of gas from the lava as it flows through these open smoking ducts may account for the dense blue glassy lava solidifying at the frontal outlets.

The main lake was very slightly higher and the partition separating it from the central pond stood 4 feet above the liquid. Streaming was outward from the south arm and inward to the northeast cove. Fume rose densely in two columns at the northeast cove crevasse and at the north lake chasm. A new cavern of collapse with very hot air inside was revealed in the southwest summit knob of the northeast heap. The entire southern half of the northeast tower had fallen into the pit beneath choking the lava pool there so that no further activity was in evidence.

The north lake was higher, only 8 feet down on its north side, and a new spatter border had been built. A glowing vent at the lake edge south broke out more or less periodically about once in two or three minutes with a roar of rushing gas and a little lava sputter. This was a closedin grotto,for the lake crust outside would heave and break during the spasms.

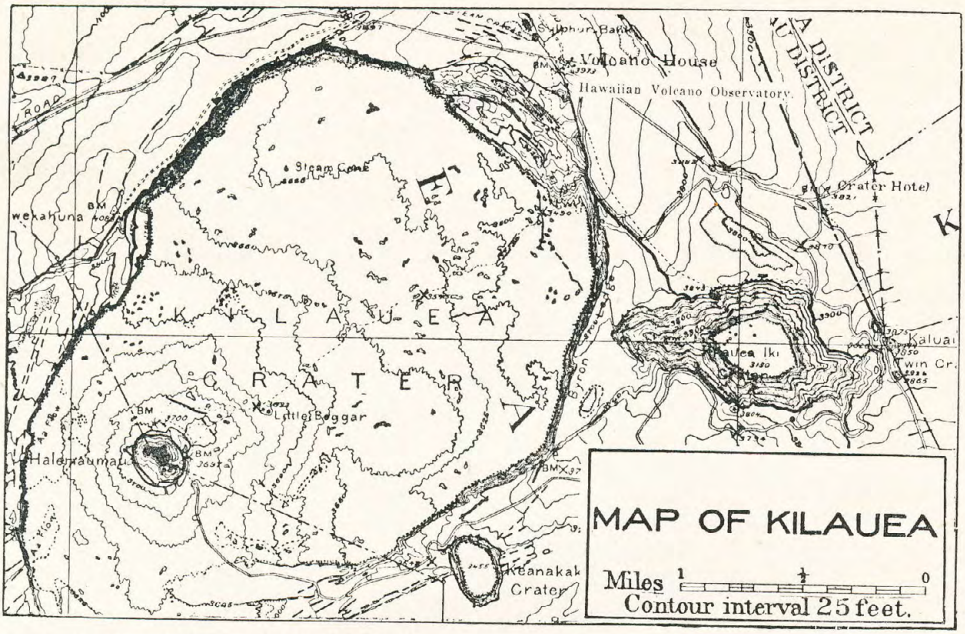
The Postal Rift flow continued to glow brilliantly at night and to spread continuously and build up by many outbreaks in the middle portions. Sometimes these could be seen in daylight. The general subsidence evidenced by collapse of voids at the cones appears at the end of the week to be followed by some recovery of the liquid lava.

In the Whitney Laboratory of Seismology for the week ending Friday,

May 30, 1919, the following local earthquakes have been registered, mostly very trivial: 11:58 p. m. May 24; 9:18 a. m. May 26; 6:44 a. m. and 4.03 p. m. May 27; and 5:15 p. m. May 30. The faint trace of a teleseism was registered at 10:04 a. m. May 26 H. S. T. Spasmodic microtremor has been very strong to strong all through the week. Harmonic tremor of slower period has been moderate to slight, with a tendency to spasmodic occurrence. A remarkable spasm of slow tremor was registered about 10 to 10:20 a. m. May 28. Microseismic motion has been slight, always more in evidence north-south than east-west, which is the invariable rule here, and on May 28 there was very slight short-lived increase in amplitude. The tilting of the ground was slight to the east and north May 24, to the west and south May 25, to the west and north May 26, nearly stationary May 27-29, and strong to the west and south May 30.

Very respectfully,

T. A. JAGGAR, JR.,
Volcanologist.



HAWAIIAN VOLCANO OBSERVATORY.

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 solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	10000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the accelerations or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol a, or max. a, is given in the conventional unit of milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ. per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

U. S. DEPARTMENT OF AGRICULTURE
WEATHER BUREAU
CHARLES F. MARVIN, CHIEF

MONTHLY BULLETIN
OF THE
Hawaiian Volcano Observatory

VOL. VII. HONOLULU, HAWAII, JUNE, 1919 No. 6

June 7, 1919.

The subsidence has continued at a moderate but increasing rate during the week ending June 6, 1919. The Postal Rift flow has continued its progress, spreading voluminously under the north wall of Kilauea crater and beginning to progress from that region eastward towards the trail under Volcano House. There have been no conspicuous developments at Halemaumau, the central smoke has increased, the bench magma has slumped in places, and the lakes have been notably quiet, crusted over, and dark at night.

The measurements of approximate levels above the 3700-foot contour were as follows:

May 30—Central floor S., 54 feet; central floor SW., 80 feet; central floor NE., 60 feet; main lake, 35 feet.

June 6—Central floor S., 50 feet; central floor SW., 76 feet; central floor NE., 55 feet; main lake, 32 feet.

These figures indicate a general subsidence of about 4 feet in seven days, or 0.6 foot per day. The rate of subsidence of the bench magma has been like that of the preceding week. The liquid lava has tended to hold itself stationary, the difference shown being within the diurnal range.

On Saturday, May 31, there was much smoke and the Halemaumau dome was essentially stationary.

On June 1 at 11 a. m. exploration of the south wall-crack revealed numerous and extensive crevasses in that vicinity and the site of the former pond in the wall-crack was a jumble of crusts with live lava somewhere below which could be heard pounding beneath a pile of fuming sulphur-stained rocks. Under the spiracles at the top of the pressure wall which here bounds the Halemaumau lava column, was a partly collapsed cupola chamber. These spiracles stand at the top of the slope down which the last southeastern trickle flows poured.

The southwest wind permitted exploration of the summit of the Halemaumau dome from that side. Looking down at the main lake and central pool from the south central cliff, there was seen a depression containing the lakes, with three arms respectively northeast, west and south. The western gorge containing the central pool was floored with the isthmus separating that pond from the remainder of the main lake, and the central pond was a small circular puddle tending at the moment to overflow the isthmus. Rising of the liquid lava was in progress. The walls of this central gorge were 40 to 45 feet high on the south and 30 feet high on the north. Looking down on the south arm another gorge was seen with a narrow entrance and wider interior cup containing what was formerly the southeast pond. This arm is bounded on the west by an immense block of cliff rock which in slipping down has separated off from the dome surface beyond along a chasm trending northwest-southeast, 10 feet wide and 30 feet deep. This block stands 20 feet above the lake, while across the way the southeast crag makes a bluff 40 feet high. Turning now and looking at the larger lake consisting of the east pool and the northeast cove, we see a smoking bluff on the left 35 feet high, a low margin only 10 feet high toward the east, and the aforementioned southeast crag on the right. The liquid lava of this pool was high and

crusted over, but later it broke up and showed northeastward streaming. The south arm was covered with crust. There was some spatter fountaining on the north side of the central pool. A striking feature of the summit plateau, whence these observations were made, was the accumulation of iron oxide at the edges of the hot cracks in the rock, bright orange red in color, while all around the ground was covered with a mat of Pele's hair.

The southwest lake and west pond were unusually high, the latter tending to overflow the isthmus separating it from the lake. The lake was quiet, but later developed a fountain in its southeast corner. Attached to the cliff margin of the lake southwest were several spatter-drip columns 6 feet high, made each by persistent flings at one point from fixed spraying fountains which had played against the wall like water from a hose. The effect was quite like frozen cascades.

The north lake was high and quiet, with wall 6 feet high on its north side and some general cracking and foundering which spread across the lake and left a quiet crust. The rhythmic vent under the south chasm continued to blow occasionally.

The lava in the source tunnel of the Postal Rift flow was running about 10 miles per hour and the open channel farther west still showed the cascading torrent pouring from the cavern above to the deeper tube beneath with shell-like crusts of peculiar pattern arched across the torrent in places.

On June 2 in the afternoon the lakes were somewhat lower. The main lake stood four feet below the platform separating it from the central pond; it was mostly crusted over, but there were occasional border outbursts of gas east and a sluggish grotto persisted under the sunken southwest cliff. The southwest lake was lower, with some central fountaining breaking the crusts, and there was no special change in the north lake. Very heavy smoke rose from the central chasms, which glowed brightly at night.

The Postal Rift flow was now bright enough at night to illumine the north walls of Kilauea crater and to make luminous the vapor and clouds towering above. The luminosity of the flow itself came from scattered brilliant points where the liquid lava was welling up.

The whole northern area of the flow appeared like a glowing pool, and in daytime this had a bluish tarnish different in luster from the early days of the flow. Both the tunnel openings of the source region made glow and flames visible at night. The crusted north lake at night was now notably dark, and there was no longer any fire at the east and south cones.

On June 3 there was continued slight localized sinking of the bench magma, and the lakes were still lower, the main lake wall at the east end standing 15 feet high. The central smoke was growing denser, and both Halemaumau and the Postal Rift flow were dull at night.

On Thursday, June 5, the subsidence had continued and both smoke and glow were increasing at the high crevasses in the center of Halemaumau. The east cone had slumped bodily about 10 feet, while preserving its form, the ground all around showing slope inward to a cup-like hollow. For hours during the afternoon the main lake had remained heavily crusted with curtained grottoes and its streaming concealed by the crust.

Examination of the glow locality where the dense smoke was emitted from the high ground north of the main lake revealed a tumble of crevassed rock like a bed of glowing coals, with flames playing through the interstices. This area was 20 feet in diameter, and its temperature had gradually been raised by gas seepage and oxidation over some void forming below. Dense sulphur fume and water vapor rose from the hot area, and the place appeared ready to cave in and produce a lava pot.

The north lake was crusted over except for a small liquid area under the south chasm ravine, where the rhythmic fountain broke out occasionally, and the liquid appeared to be flowing in from the south and over the crust of the lake. The occasional fountain bursts here made sudden flares at night visible from a distance as reflected from the fume cloud above.

At the Postal Rift source tube the flowing stream appeared a little higher and slower than before, and the cascade locality farther northwest was crusted

across the open part, but below and beyond the broad cavern showed a steady stream pouring northward from under the crusted cascade. The front of the flow continued its spreading out and filling against the north wall of Kilauea crater so that the contact with the wall was now nearly a mile long from the northern part of the Uwekahuna bluff following around the north margin of Kilauea crater to a point under the wooded fault blocks southwest of Volcano House.

On the morning of June 6 the measurements showed marked subsidence of the central and southeastern parts of the Halemaumau dome, and the central fume column was denser. At 3 p. m. more slumping of the cup around the east cone was apparent, and the high ground south of the south arm appeared lower. There was a new tumble of rock from the cliff north of the central gorge to the isthmus floor below. The main lake had resumed its streaming from the south arm to the northeast grotto, and its level relative to the cliffs was unchanged. The north lake showed little change, there was periodic blowing from the south grotto, the north bank was 8 feet high, and a patch of crust adjacent to the west bank was in process of breaking up. At night Halemaumau showed bright activity at the east pool, south arm and southwest lake, there were flames at the central smoke patch and at the two tube vents of the Postal Rift source, and the flow showed much activity at its front which was spreading eastward in the direction of the cliff trail leading down from Volcano House.

The seismographs of the Whitney Laboratory for the week ending June 6, 1919, have registered local earthquakes as follows: Slight shocks May 31 at 1:49 a. m. and 5:16 p. m.; a very pronounced shock of large amplitude at 4:14 p. m. June 2, not felt here, but felt strongly in the district of Kau to the south; slight shocks 1:38 a. m. June 3, 10:15 p. m. June 5, and 4:50 p. m. June 6. The spasmodic microtremor was moderate May 31 to June 1, but became very strong on June 2 and remained so throughout the week, with some decrease on June 5. There were about 50 spasms of trembling June 2 to 4 inclusive. The harmonic type of tremor slightly increased June 2 to 3, and has remained somewhat stronger than before. Microseismic movement, which has been slight of late, increased a very little June 1 and 2, but became very slight after June 4, having hardly any more development in the north-south component than in the east-west, a condition very unusual here. The tilting of the ground continued strong to the south and west until June 2, when it changed and became strong to the north and moderately so to the east until June 6. It then turned again to the west and south.

June 14, 1919.

The continuation of subsidence of the Halemaumau lava column reported last week led on June 7 to the formation of a lava cascade whereby the liquid of the main lake poured over a submerged ledge into a fiery pot at the base of the northeastern marginal cliff of the lake. This phenomenon accompanying subsidence has happened frequently before, and appears to be occasioned by the faster sinking of the vesicular melt at the sinkholes of the convectional circulation. That it is a part of the normal circulation phenomena, and not an outflow, is demonstrated by the unaltered level of the lake, which remains relatively constant even when such a draining cascade continues for many days. The cascade in question has persistently poured into the gulf as a violent torrent now for a week, yet the lake feeding it has at times risen in relation to its own banks.

The other phenomena of Halemaumau have remained as before, the subsidence of the bench magma has proceeded with slight increase of rate, and the Postal Rift flow still pushes forward with somewhat diminished vigor.

The measurements indicate the following approximate levels above the 3700-foot contour:

June 6—Central floor S., 50 feet; central floor SW., 76 feet; central floor NE., 55 feet; main lake, 32 feet.

June 14—Central floor S., 40 feet; central floor SW., 70 feet; central floor NE., 50 feet; main lake, 25 feet.

These figures indicate that in eight days the south cliff block sank the most, 10 feet in all, averaging 1.2 feet per day; the central floors of the Halemau-

mau dome sank 6 feet, or .8 foot per day; while the main lake subsided 7 feet, or .9 foot per day.

On Saturday, June 7, 1919, in the morning the fume from the lava column appeared thinner, and it was evident that there had been some breaking back along the crevasse extending west from the northeast cove of the main lake. Measurements indicated local irregularity of movement. The Postal Rift flow was making long arms eastward from the northern part of the flow.

At noon the explanation of the change at the northeast cove was revealed when the lava pit was visited, and the main lake was found streaming rapidly from south to north as a torrent which ended in a violent cascade into a hole. This pot, 20 feet wide, lay at the north end of the northeast cove, where the grotto had been, leading into the smoking crevasse traceable on the surface above. The downpour made a roar which could be heard some distance back from the verge of the lake. Inside the cavity the liquid could be seen churning and piling up about 10 feet below the lake level. The surface streaming of the lake took its rise at the east cove, the south arm and at the isthmus in the central pool direction. For a spell the streaming changed so as to divide in the middle of the east pool and pour in part southward into the south arm.

No changes were observed at the summit smoke holes, and the north lake appeared rising, with an occasional explosion at the rhythmic fountain locality on the south side of the lake. Most of the time, night and day, this lake lay quiet under a heavy crust. The Postal Rift source tube was found unchanged at both openings, the lava current in the tube moving more slowly than before.

At 8:30 p. m. the lake cascade was found still pouring without cessation. At times the churning pool at the foot of the fall sank lower so as to make the cascade more rapid. There was no lowering of the level of the lake, the bank at the east end remained 15 feet high, and the grotto on the southwest side of the lake had built up a half dome of spatter indicating rising rather than lowering with reference to the confining cliffs of the lake cup. The embayment in the western isthmus appeared somewhat deeper than before. Blue flames played from under the marginal crusts of the lake at the east end. There was some fountaining activity in the central pond and southwest lake. Occasional movements of loose rock in the east pressure ridge gave evidence of the slow subsidence of the bench magma. A row of flames played above the source cone of the Postal Rift flow.

On June 8 the cascade continued and conditions remained as before. June 9 at 12:30 p. m. the edge of the fall was 15 feet long and curved in plan, with its concavity down stream, or toward the wall pot, and the curve ended in an angle at its west end. The fall was steeper than before and fully 20 feet high, and the boiling torrent inside the receiving pot bent westward in the cavern, where it disappeared. This direction corresponds with the large crevasse above. There were stalactites in the wall pot.

The harder substance of the lava column continued to subside slightly over the whole Halemaumau dome. The channel across the entrance to the south arm was now very narrow, and the streaming outward across the lake was from under the crust which covered this channel and the southern pool. There was a fresh tumble of rocks on the isthmus west of the east pool, which had fallen from the cliff to the south. Spatter dome grottoes stood at the shore of the pool both southwest and southeast.

At noon on June 10 the crusts of the main lake were found generally breaking up and the level of the lake somewhat higher than before. The form of the ledge over which the cascade poured had changed so that its curvature in plan was now convex down stream as though the bottom had built or swelled in that direction. This curve was the opposite of what it was the previous day. The liquid of the cascade was higher relative to the roof of the cavern into which it poured, and splashes were building an accumulation of solidified lava on the roof as well as out from the right bank of the cascade. The interior churning level was 15 feet down.

The smoke from the summit crevasses had lessened and the glow heap at the base of the smoke was much less luminous. The north lake at night resumed

some of its former activity. There was slight hissing of sulphur gas in the broken east cone, and the interior cupola was hung with scores of dark reddish brown rough stalactites in close ranges, showing some feathery accumulations of iron oxides. The stalactites were from one to three inches in diameter with small globular surface accretions, from six inches to three feet long, and separated by only two to three inches, the closely packed stalks hanging side by side and filling the greater part of the cupola. This was the later development of the same interior shown glowing, in illustration of February Bulletin.

The southwest lake was found much lowered, with walls 20 to 40 feet high, a curtained grotto on the north side, and quiet crust. The small western pond was also low and crusted.

On June 11 the bench magma continued to subside so that a pronounced depression with steep slopes and open crevasses had formed around the east cone and for some distance to the north. A similar depression had by now formed west of the northeast tower. The Postal Rift flow was diminishing in volume of output and brightness of the fronts. Smoke was dense from the central chasms and the cascade continued in action.

On Thursday, June 12, the Halemaumau dome appeared lower, the fume was dense, and there was considerable heat and fume from the pit at the base of the northeast tower.

At 9 p. m. the east cone hollow, which it is necessary to cross in approaching the main lake, was found decidedly lower. The main lake was streaming brightly and rapidly toward the northeast cascade and the latter was found to have clogged its own passage with the accumulations built out from the roof and the east bank. The fall was thus largely concealed inside the curtained cavern. Marked increase of rapidity of inrush was noted at times, indicating a fluctuating level in the lower chamber whither the fall plunged. It is evident that a slight rise of this lower level to the point of complete filling of the cavern, would restore normal conditions of lake streaming and fountaining, without any change in the form of the subterranean chambers.

The north lake had curtained and upbuilding spatter grottoes on the north and northeast sides, and was mostly crusted over, with some border fountaining. The Postal Rift source vents were flaming and the lava seen pouring through the tube as revealed in the roof window was lower and more sluggish than of late. The second opening in the tube farther northwest, where the visitor could look downward obliquely and see the stream of melt pouring onward in the bright depths of the cavern, revealed distinct lowering of the surface of the melted river leaving the visible cavern roof higher. This place was now a singular structure, a true "subway entrance"; begun as a caved-in roof, with the lava revealed cascading over the debris, this was now frozen solid as a new roof; looking down the frozen cascade there remained a steeply inclined wide cavern where the molten flood could be seen emerging from beneath the crusted part. The hot gas rushing out of this cavern rose as blue fume, and on this night the writer deliberately entered this fume and breathed it. He was surprised to find it quite tolerable and largely air, with much less sulphurous acid than in the gas from the source cone.

In the Whitney Laboratory of Seismology the following local earthquakes have been registered: 4:49 a. m. June 8, slight; 10:53 a. m. June 9, pronounced; 2:06 a. m. June 11 and 7:23 p. m. June 12, both slight. A weakly recorded teleseism was registered, beginning 3:03 a. m., H. S. T., June 11. The spasmodic microtremor has continued very strong, occurring as sudden spasms, as spells several minutes long, and as prolonged vibrations lasting an hour or more. The harmonic type of slower microtremor has continued moderate to slight. Microseismic motion has been very slight. The tilting of the ground in the east-west azimuth has been various and slight; in the north-south azimuth it has been strong to the south, with rapid recovery to the north on two days, June 9 and June 12.

June 21, 1919.

During the week ending Friday, June 21, 1919, the Halemaumau lava floor has continued to subside at about the same rate as before, but the liquid lakes

have shown tendency to stationary condition and some slight rising. Along with this change there has been diminution in volume of the heavy fume volutes from the central chasms, and the lava cascade of the northeast cove has from time to time ceased pouring as the liquid in the receiving funnel rose to the level of the discharging lake. The first cessation of the cascade was observed June 18, eleven days after it had commenced. The Postal Rift flow has continued spreading along the base of the extreme northern cliffs bounding Kilauea crater and the stream pouring through the source tube has been always visible, but its volume and speed have dwindled.

The measurements indicate the following approximate levels above the 3700-foot contour:

June 14—Central floor S., 40 feet; central floor SW., 70 feet; central floor NE., 50 feet; main lake, 25 feet.

June 20—Central floor S., 30 feet; central floor SW., 64 feet; central floor NE., 47 feet; main lake, 28 feet.

It thus appears that in six days the south cliff block again subsided 10 feet, averaging 1.7 feet per day; the central floors of the Halemaumau dome sank about 5 feet, or 0.9 foot per day; while the main lake rose slightly—3 feet, or 0.5 foot per day.

On Saturday, June 14, at noon the south wall crack region was found more craggy and tumbled and the slumped cup deeper around the east cone. There was much heat and some fume at the northeast tower. Fume was very dense at the summit cracks and abundant at the south wall crack and Postal Rift. A large sulphur patch had recently developed between the Postal Rift and Halemaumau, apparently above the passage connecting Halemaumau with the great flow. The latter continued flowing sluggishly. The subsidence of bench magma was evidenced by occasional rock falls observed at the main lake, the east ridge and the northeast tower.

The main lake was streaming rapidly from the closed south arm channel and had built a spatter margin recently to within 5 feet of the east verge, but at the moment the lake was there 15 feet down. The bench southwest was also only 15 feet above the lake, showing further subsidence. The southwest grotto was inactive. The cascade at the northeast cove had built a middle accumulation dividing the fall into two torrents northeast and northwest which poured into holes in the wall. The north lake was heavily crusted, occasional outbursts occurred at the southern grotto. There was northward streaming along the north border of the lake, the grottoes there were sluggish, and the liquid level appeared lower by about 5 feet.

On June 16 at 5 p. m. the general subsidence continued and there was increased fume and revived glow at the east cone. The main lake was lower, the double cascade poured into the bank as before, and its interior cavern was now obscured by crusts and curtains. The lake level stood 18 feet below the lowest part of the eastern bank and 4 feet below the central isthmus. Fume was dense from the bank bordering the cascade on the east and also from the summit crevasses.

The north and southwest lakes were both lower relative to the walls bounding them on the sides away from the center of Halemaumau, and less so with regard to their bounding walls towards the center. This arrangement appeared to indicate that a central block of the Halemaumau dome was subsiding with the lakes. Further evidence of this was shown at the south wall crack, where the line of pinnacles of the pressure ridge was beginning to form an infacing escarpment. All around Halemaumau the line of breakage bounding the sinking central block could be discerned extending from the south wall crack to the west pond, thence past the central crevasses to the north lake, and from there, by way of hot crevasses and much slumping, past the northeast tower to the east cone.

The northern wall of the north lake now stood 20 feet above the liquid, which was covered with heavy crusts that occasionally broke up. The west pond was now a deeply sunken well with 30-foot walls; the isthmus between it and the southwest lake made a 10-foot wall above the pond. A glowing cavern under the bank on the north side showed a current streaming into the pond. The pond stood much higher than the southwest lake. The southwest lake was both enlarged and very low,

the walls of its pit standing 50 feet high on the west side and 60 feet high on the east. A glowing cavern hung with stalactites was revealed by the subsidence, at the southeast end of this lake, and in the northern part of the lake there was streaming towards the cavern leading in the direction of the main lake. A cavernous cove had some fountaining activity towards the northwest. Wide and deep crevasses extended from the southwest side of the lake towards the south wall crack.

The Postal Rift tube showed flow more sluggish than before, and the stream in the tube was lower. At night the flow from this source was bright in isolated spots at the base of the north wall of Kilauea.

On Tuesday, June 17, at 3 p. m. the east cone area was more sunken, and through the remnants of the cone a flaming and rumbling pot had developed.

The east bank of the main lake had caved in and the hot streaming to the cascade, with heavy smoke above, continued as before. The north lake was crusted over, the northern border fountains were making much Pele's hair, and one fountaining blow-hole was kept open through the heavy crust east of the center of the lake.

The source tube of the Postal Rift flow as revealed through its two openings contained a lava stream much lower and moving more slowly than before. Inside the northwestern opening the flowing lava far inside the cavern to the north could be seen with difficulty and at a lower level than before.

During the night June 17-18 the bright illumination above the northeast cascade ceased. Fume was denser on the morning of June 18 from the cascade locality, but during the day the fume diminished both there and at the summit smoke chasms.

A visit to the lakes at 5 p. m. revealed general rising activity in all the pools and a revival of the south wall crack pond. This pond was now a high boiling puddle 10 feet in diameter. The east cone pot had enlarged, lava was splashing within and occasional spray was thrown out.

The main lake was about 5 feet higher, and the cascade had stopped. It was replaced by a sluggishly bubbling border pot at the northeast cove. The middle part of the lake was crusted over, but border fountains were constructing spatter banks on the north and south sides of the west cove, at the east cove, and against the east-northeast bank. The characteristic northeastward streaming towards the cascade locality may have been in action under the crust, but it was not shown.

The north lake had rhythmic explosions at the south border pot, the lake had risen about 5 feet, and numerous spraying fountains around the north and east shores gave evidence of increased gas pressure.

The southwest lake and west pond were both 5 or 6 feet higher. A heavy mass of rock was seen to fall into the west pond from its south bank, leaving glowing walls. Large dome fountains burst at short intervals against the northeastern bank of the southwest lake.

The stream in the Postal Rift source tube was slightly higher and more rapid, and in the evening there were some luminous outbreaks of the flow far to the north. Fume on this day had increased at the northeast tower but was less at the central chasms. A small tunnel in the debris of these chasms led downward at a high angle to the north, showing glow in its bottom.

On June 19 the fume had greatly diminished, but mass subsidence continued. The northeast cove cascade was again in action, and the main lake showed spells of subsidence and recovery. The south arm had become an enlarged circular pond, the channel leading to the east pool being crusted. Recent risings had extended the lava floor at the lake level through the broad chasm where the southern cliff block had broken away. The upper edge of this block was now only about 6 feet above the main lake.

In the evening the cascade again ceased action, showing that the liquid lava was rising in pulsations in the subterranean voids to which the cascade poured, and the diminished fume confirms this.

On Friday, June 20, about 10 a. m. the cascade again began to develop during a spell of subsidence in the receiving pot. The lake prior to this time was crusted, with spraying border fountains building spatter banks, and there

was similar activity in the north lake. Fume on this day was notably thin. During the later morning hours and again in the afternoon there were some avalanches sending up puffs of dust near the cascade locality of the northeast cove.

In the Whitney Laboratory of Seismology for the week ending Friday, June 20, 1919, registration of two slight local earthquakes is reported as follows: June 16, 3:10 a. m.; June 18, 12:53 p. m. The spasmodic type of microtremor has continued very strong with fluctuations in intensity, always stronger east-west than north-south, and strongest during the morning hours. Harmonic microtremor increased from slight to strong beginning June 18, decreasing June 20. Microseismic motion has continued very slight. Tilting of the ground has fluctuated as before, the tilt being north and east June 14-15, south and west June 16-17, north and east June 18-19, and strongly south and west on June 20.

June 28, 1919.

The June solstice of 1919 proved to be a time of pronounced change in the Halemaumau lava column. During the week ending Friday, June 27, the topography of the edge of the former pit northeast, east, south and southwest has again asserted itself as an infacing escarpment circular in plan. The mechanism bringing this about was a sharp subsidence between June 20 and June 23 of the prism of hard lava surrounding the lakes, accelerating the more gradual gentle subsidence of the last few weeks. What was before a general sagging of the surface of the Halemaumau dome, now takes definite outline as a sinking cylinder. As frequently happens in such cases, the crisis of release of pressure which lowered the bench magma also set free increased volume of gas so as to make the liquid lakes froth up to relatively higher levels within their cups. The crisis therefore has been accompanied by new gas pressure and spatter building at the border fountains, and by the renewed development of wall-crack ponds. The cascade of the northeast cove has gone out of action, but the Postal Rift flow continues to spread. The total subsidence for the week has been nearly compensated by the relative rising of the liquid, so that it is not yet evident which process is to dominate.

The measurements show that the net downward movement of bench magma for the week was not greater than during the previous weeks. On June 26, as compared with the measurements of June 20, the cliff block south of the main lake had subsided 6 feet, averaging 1 foot per day; the southwestern floor, 4 feet, or 0.7 foot per day; the north central floor block, 10 feet, or 1.7 feet per day; while the main lake remained comparatively stationary or subsided only slightly relative to fixed bench marks. Relative to its encompassing bank, the lake distinctly rose. A new triangulation and determination of levels is in progress, and the actual heights of the several lakes, in relation to sea-level, will shortly be determined.

On Saturday, June 21, at 10 a. m. the main and north lakes were high with marginal fountains building up the banks, and the southwest lake was quiet with eastward streaming. In the main lake the major constructional activity was along the south and west banks, and the streaming was northeast. The west pond stood at a level slightly higher than the southwest lake. The flow lava in the Postal Rift tube moved slowly. At 10 p. m. there was intense central fountaining in the main lake, the fountains tending to migrate towards the north.

On June 22 there was increased smoke from the south wall-crack, the northeast cove, the central chasms and at the Postal Rift. The inner circle of benches around the main lake was sinking strongly. The Postal Rift flow continued to progress sluggishly.

On June 23 conspicuous changes were evident. The sinking of the central block bounded by the northeast tower, the north and southwest lakes, and the south wall crack, had proceeded with such increased rapidity as to develop an escarpment over 15 feet high facing inward toward the center of the pit. This escarpment had now become a definite cliff under the northeast tower, also at a point a few feet east of the east cone, and along the south pressure ridge. This movement had defined anew the edge of the Halemaumau pit, leav-

1. May 6, 1919. Halemaumau a dome; southeast pressure ridge; main lake hollow to the right; former east shelter under flows in foreground.

2. May 6, 1919. Postal Rift overflowing through cracks. Halemaumau on the left. Arrow shows cone source of the great flow.

—Photos Jaggar.

ing the long pressure rim crescent and the northeast tower outside of the pit. The northeast tower wall-crack had begun again to fume and glow, a puddle of lava had formed in the hollow beside the east cone, and glow and dense fume had again developed at the south wall-crack

The westward facing cliff at the east cone now made it necessary to make a detour to the north in order to reach the main lake. Inspection 5:30 to 7 p. m. showed that the relief of cliffs around the main lake cup was not greatly changed; the lowest part of the east bank stood 15 feet above the lake, the southeast crag was 30 feet high, the northern cliff was about 25 feet high, and the western cliffs stood 40 feet over the central pool. The sunken south cliff block stood only about 8 feet above the lake.

The dominant streaming of the lake was westward, and active spatter grottoes were building on all sides. The cascade locality of the northeast cove was represented by flaming orifices puffing noisily in a spatter bench. This cove was extended 20 feet farther north by collapse, the extension being floored by tumbled debris and hardened lava. During a temporary sinking spell there was swift streaming northward under the bank and much bubble fountaining at the cascade locality.

The smoke holes of the summit of the north central region were found to have greatly diminished fume, and glow could be seen in two of them. The northernmost of these was a shaft 10 feet in diameter inclined northward at a high angle and narrowing below; 30 feet down this became a tube curved both in plan and elevation and ending at the bottom in an opening 6 feet in diameter, where lava boiled under overhanging stalactites. This liquid appeared to be about the level of the north lake, and the surging currents moved first to the south and then to the north. This deep tube was a revelation of the subterranean honeycomb of passages which connect the different lakes.

At the north lake a large flaming curtained grotto dome had been built on the north side, the usual rhythmic outbreaks took place every two or three minutes at the south corner, and there were abundant spraying border fountains building spatter benches.

In the glowing interior of the Postal Rift source cone many slender stalactites had formed of both the worm and straight types, and these hung motionless and brilliantly incandescent, added to by slow accretion of fused material from the walls, and not by splash from below. The standing fountain or cascade feeding the flow could be seen through the window of the cone about 15 feet below the surface of the ground pouring from the south toward the north. Through the window in the roof of the tube 20 feet farther north the slow steady flow continued with drawn-out bubbles bursting the surface. At night the flow under the northern Kilauea cliffs was brighter than before, and the Halemaumau lakes also made a more brilliant illumination.

On Thursday, June 24, at 6 p. m. the lakes were distinctly higher relative to their margins and exhibited high gas pressure and numerous rapidly constructing spatter half-domes and crescent niches. The south arm appeared a few feet higher than the main lake, its surface streaming was southward, and a spraying fountain was building a crescent of spatter at its south end. The central pond was sluggish and the main lake rose during an hour so that the height of all its border cliffs was lower than before by about 5 feet. The streaming was to the northeast. During the high level the western grottoes became quiet and choked with crusted lava.

The inclined shaft of the central smoke hole showed a diminished window at the bottom only 3 feet across, revealing the live lava beneath. The north lake was streaming northward and had a violent spraying fountain on its west side and several others along its north shore. Relative to its border cliffs, this lake also was 5 feet higher than on the previous day.

The sinking of the central bench magma had now brought all of the cliffs around the depression containing the two western lakes to about a common level some 25 feet above the liquid lava. The western pond was only slightly above the southwest lake level. It showed sluggish fountaining, and a small extension of its pit had opened

southward by collapse. The block of ground west of this pond remained high, indicating that it would hold up as the rim of the new Halemaumau pit, continuous with the semicircular escarpment to the south.

This escarpment was now a cliff 10 feet high surmounted by broken pinnacles, the down-faulted block which created it moving on the south wall-crack as a fault plane and carrying down all the broken ground next to the north so as to close the gaping cracks there. Very large chasms concentric with the Halemaumau circle were found just back of the northeast tower and back of the station on the northwest rim of Halemaumau. This last crack was an interesting feature extending in a curve from the northwest station to the cone vents of the November flow of 1918 next to the north stone corral. This crack was the only sign of motion in the northwestern region, though measurement showed gentle subsidence of the floor west of the north lake. From this crack to the Postal Rift source a series of solfataric stained areas marked the course of the subterranean passage leading to the Postal Rift flow. These places emitted much pure sulphur vapor and were brightly colored with yellow and white coatings of sulphur, alum and sulphates.

On Wednesday, June 25, the sinking of the Halemaumau dome had reached the point where the cliff bounding the west side of the southwest lake depression had again come into view as one looked across Halemaumau from the Observatory. There was increasing smoke, but not in such concentrated masses as were present during the previous week.

On June 26 at 11:30 a. m. the south escarpment was more jagged in profile from irregular caving in, and the extension of this new rim of the pit to the east stood in such relief that the visitor could see the live lava of the main lake from the new eastern verge while yet 100 feet back from the actual edge of the lake. The lake was streaming eastward and a large elongate spatter half-dome was in violent action at the southwest shore. Here the sunken south cliff block now had the edge of its upper surface submerged under new lava. The cliffs around the lake looked lower.

The northeast tower, so long a prominent landmark, had fallen into the pit beneath it and this pit contained a new circular pool of lava at the base of the northeast heap escarpment, now a vertical cliff 15 feet high. The tower had been at the top of this cliff, another development of the wall-crack like the south escarpment. The new pool here was 50 feet in diameter and overflowing in fan-shaped outpourings of heavy bulbous pahoehoe which had spread 150 feet toward the northwest. At noon this pond was highly inflated, but the crust suddenly gave way, releasing gas with a prolonged hiss which made an overpowering odor of sulphurous acid to leeward. Much bubbling ensued, and the pond sank 15 feet during the next twenty minutes, leaving a bright glowing margin. Then the liquid recovered and crusted over and small trickle flows pushed through the new crust. A cavernous tube had been revealed by the deflation of this pond in the direction of its recent overflow.

The north lake remained as before. The lava in the Postal Rift source tube was low and flowing very slowly, estimated at half a mile per hour. The flow at night still made occasional breaks in the crust of its northern fields, where the melt would well up and spread out to fill hollows.

On June 27 from 3 to 5 p. m. the general situation indicated continued subsidence of bench magma and rising of liquid lava, and the fume was thinner. The east cone sag appeared still lower with a 20-foot cliff east of it. The lava pool of the south wall crack had revived, making at the foot of the south escarpment an elliptical pond 60 feet long fountaining at its west end. The main lake continued high, with activity as before, the cliffs about the east pool standing 20 feet high and about the central pond 30 to 40 feet high. The lowest sag of the east bank stood 12 feet above the lake. The northeast wall-crack pond was again high and fluctuating in level. The north lake had built large spatter domes on its west, north and east sides, the older banks standing 15 feet above the lake on the north and 30 feet on the south. The summit smoke hole had again open-

ed its wide pot of fountaining lava 30 feet down, and the liquid showed northward drift of currents and occasional sudden increase of speed.

The southwest lake and west pond appeared somewhat lower with walls over 30 feet high in places, and western walls higher than eastern. The west pond was crusted over with extensions to the north and to the south, the southern one making a puffing roar of gas through the tumbled debris. The southwest lake was fountaining violently against its east bank and streaming eastward.

The registration of the seismographs in the Whitney Laboratory recorded slight local earthquakes at 8:26 p. m. June 21; 6:56 p. m. June 23, and a pronounced shock felt in Hilo at 7:37 p. m. June 26. Spasmodic microtremor continued strong during the week, and the harmonic type of tremor was moderately strong. Microseismic motion has continued very slight. The tilting of the ground became excessively strong to the north, June 22, and moderate to the east. Thereafter it recovered to the west and south, becoming strong to the west June 25; stationary tendency ensued.

July 5, 1919.

During the week ending July 4, 1919, it has become apparent that the subsidence of the Halemaumau lava column is to continue and the lakes have gone down rapidly. The central prism of bench magma and the main lake which it encloses have sunk at about the same rate as before, but the outlying lakes west and north have subsided twice as fast. The rate of lowering of the central block has decreased to stationary July 5. The Postal Rift flow has at length come to rest and the supply of liquid lava at the source tube has given out. Smoke has again increased at Halemaumau. The newly developed escarpment bounding the pit has increased in length and height, but the inner dome of bench magma and the marginal cliffs of the lakes are still in view from the Observatory.

The measurements from the Observatory on July 4 have shown depression of the various parts of the Halemaumau surface since June 26 as follows: South ridge, 2 feet; southwest cliff, 3 feet; northeast heap cliff, 1.5 feet; ground east of north lake, 2 feet; ground north of north lake, 4 feet; crags southeast of main lake, 12 feet; block north of main lake, 9 feet; block west of main lake, 13 feet; ground northwest of west lake depression, stationary. The main lake in the same interval has sunk 12 feet, the north and southwest lakes each 24 feet.

These figures indicate that the marginal ground has broken down slowly, about 2.5 feet in eight days, averaging 0.3 foot per day; the central prism around the main lake has averaged 11.3 feet in eight days, or 1.4 feet per day; while the main lake has gone down 1.5 feet per day and the north and southwest lakes 3 feet per day.

On Saturday, June 28, at 4 p. m. the main lake was slightly lower, with marginal fountains and no predominating current. The south arm pond was nearly on a level with the main lake and exhibited a single fountain at its south end. The east cone was glowing and puffing at the bottom of the funnel-shaped depression around it. The lava pool in the south wall crack was quiet, and heavy fumes were arising there and increasing in volume.

The northeast pond had increased the size of its overflow and was covered with heavy crust. The lava appeared to be rising and falling periodically, and a blast of gas through the crust was followed by a slackening of the overflow.

On June 29 from 4 to 5 p. m. the subsidence of bench magma continued and the main lake stood high relative to its banks, with strong border fountains on the west, bright lines and moving skins in the middle, and streaming first east and then west. The northeast pond was at first high, but later it broke up and developed much fume strong with sulphurous acid. The north lake showed slumping of the northern bank of its pit, the usual border grottoes were active, and at 5:30 p. m. two of these on the north and west sides caved in. The Postal Rift flow cone showed a low and sluggish stream, with more than a foot of the west wall of the tube visible above the liquid as seen through the roof window. There was glow at the base of the east cone.

On Monday, June 30, the main lake remained relatively high and covered

with crust at 10 a. m., and the north lake showed increased breaking down of its northern and eastern banks. New wall-cracks had developed between the northeast pond and the north station, and there were new cracks near the northwest station. The northeast pond rose between 10 a. m. and 12:40 p. m. The well of lava at the central summit crevasse showed liquid unusually high and boiling.

The western lakes were crusted except for a violent fountain at the east corner of the southwest lake. The block of ground east of this lake had subsided and the margins of the lake showed evidence of slumping. The pit extending the west pond southward was larger, and much water vapor rose through cracks near the western end of the south pressure ridge.

The inner bank of this ridge had caved in, leaving a vertical wall over the south pool, the surface of which lay 10 feet below the general floor level. There was increased breaking down of the southwest wall of the south arm pond.

On July 1 at 10 a. m. the south pressure ridge appeared about as high above the inner flat as above the outer flows, and much smoke rose from the cracks there and from the east cone pit. There was some fresh driblet lava in this pit. The main lake stood very high relative to its banks, there was much border construction around it, and its surface stood only about 10 feet beneath the east bank. During the morning this lake rose slightly. In the west cove of this lake there was increased indentation into the isthmus leading toward the central pond, and a vigorous fountain was in action there. Like the central pond, the south arm pond was now separated by an isthmus from the main lake.

The central well was full of smoke and the bottom was not visible. The northeast pond had a circular opening in its crust about 7 feet in diameter, where sluggish glowing melt could be seen 5 feet below under the overhang. The north lake appeared as much lower (about 5 feet) than before, as the main lake appeared higher. The crevasses along the east side of the north lake had widened and let down the block on the lake side about 7 feet so as to create a new cliff margin. There was similar slumping, of more gradual slope, around the entire north margin, the crest of which stood 20 feet above the liquid lava. This lake was streaming northward to the usual border fountains. The Postal Rift flow continued in motion, and outbreaks of small streams were pushing through the surface of the flow in the north corner of Kilauea crater. Clouds of white vapor arose from the surface of the flow during rain.

On July 2 at 4 p. m. the main lake showed steady streaming from its southeast corner westward, and its border grottoes were inactive. There was some enlargement at the northeast cove. During the next hour the lake subsided 2 feet. The spatter shelf of the recent high level stood 4 feet below the east bank. The north lake appeared lower, and some breaking away of the west wall and lowering was seen during the afternoon. The western lakes also showed collapsing walls, especially northwest of the southwest lake and at the north pit of the west pond. The southwest lake was mostly crusted, but a swift current rushed toward the active grotto at the corner chasm leading to the main lake. The marginal shelf stood 5 feet above the liquid. The west pond occasionally broke up and bubbled and its level was higher than that of the southwest lake; there was a small bubbling pot in its southern corner. The northeast pond on this day appeared wholly inactive, but the cracks extending northward from the northeast heap were widened and extended to the 1894 spatter cones near the north station. The south wall crack pond was still alive, and an isolated pinnacle which had been a conspicuous landmark on the pressure ridge above it had collapsed.

On Friday, July 4, from 3 to 4 p. m. it was evident that the northern and western lakes were sinking, though the main lake showed little change relative to its banks. The southern cliff facing inward from the pressure ridge was now 30 feet high in places, with a jagged irregular crest, and the inner block next adjacent formed a sloping surface, merging with talus. So gradual had been the downward movement of the central part of the Halemaumau dome, that several flags supported by

piles of stones still remained erect amid the sunken cliff blocks.

The main lake was streaming westward, and there was strong fountaining in its west cove. An open pot in the east cone was flaming above lava that could be heard rumbling within. There was a glowing pot in the middle of the crust of the northeast pond as before, but the lava inside was fully 15 feet down and smoke there had greatly increased.

The old rim of the pit was now defined by subsidence and crevassing, or by remnant rim, around its entire periphery. The north lake appeared very low, its southern cliff stood 50 feet above it, the east cliff was 30 feet high and the northern broken slope varied from 20 to 30 feet in height. There were four cavernous border grottoes and occasionally prolonged central fountains which tended to migrate slowly eastward and draw surface currents in their direction. There was no longer any rhythmic fountain at the south corner of the lake.

The roof window in the Postal Rift tube was nearly dark, but dull red glow, wholly without motion, could be seen in the hardened flow which made the bottom of the tube. The chamber under the source cone was somewhat brighter than this, but without flowing lava. A last small festooned flow glowed red-hot at the site of the former fountain, and there were many cooled stalactites in wormy and other forms. A new collapsed roof area of the tube left an open pit a few feet farther north, and here again the floor showed a narrow longitudinal ridge made by a hardened flow. The ceiling of the cavern was hung with abundant worm stalactites. The other opening farther northwest showed faint cherry red glow far within. The flow at its northern fronts no longer showed any glow at night.

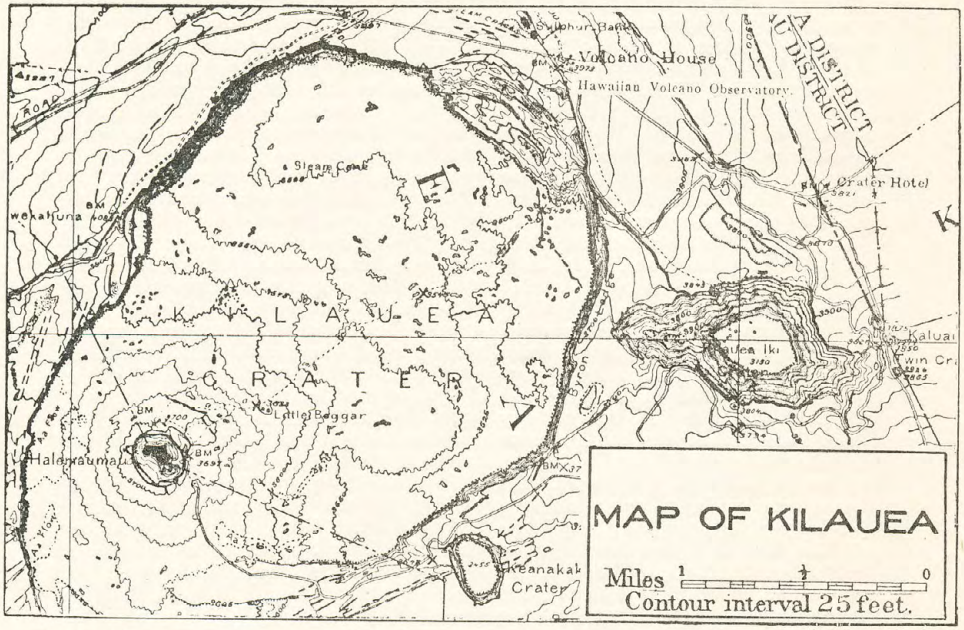
The southwest lake depression was now much deeper, with walls 40 to 50 feet high, and the inner spatter rim stood 8 feet above the lake. There were violent central fountains near the north side of the lake. The west pond, at a level slightly higher, was covered with skin and cascading continuously over a fall about 3 feet high eastward into a bubbling pot which appeared to be connected by a tunnel with the southwest lake. The pot was at about the level of the latter lake. The wall bounding the west pond on the west was 50 feet high, and this promised to be continuous, with the escarpment of the pressure ridge farther south bounding the Halemaumau pit. The extensions of the west pond along the wall crack north and south were enlarged as tumbled pits full of broken rock.

The general situation appeared to indicate pronounced subsidence, with the bench magma and liquid lava alternating in spells of sinking. The liquid lava was at the moment draining downward through the north and west lakes in a spasm of retirement following upon the cessation of the Postal Rift flow. As usual in such cases, the central cylindrical body of bench magma had moved down faster than the border ring of benches, which tended to cling to the walls of the old outlying funnel.

In the Whitney Laboratory of Seismology for the week ending at 8 p. m., July 4, 1919, three local earthquakes and one distant earthquake have been registered. The local shocks were at 2:31 p. m., June 30; 8:29 p. m., July 2; and 2:35 p. m., July 3. The teleseism occurred at 1 p. m., H. S. T., June 30, and the preliminary phase of the record was well marked, giving evidence of distance of origin 7300 kilometers, equivalent to the distance from this station of Nicaragua, South Japan or New Guinea. Spasmodic microtremors have been less strong than of late, the harmonic tremor has been moderately strong, and microseismic motion has dwindled almost to the zero point—a condition very unusual here. The tilting of the ground has continued to fluctuate through a narrow range, north and east June 28-29, south and west June 30-July 1, north and slightly east July 2-3, and nearly stationary July 4.

Very respectfully,
T. A. JAGGAR, JR.,
Volcanologist.

ERRATUM.—On page 54, April Bulletin, lines 16 and 18 from the top right column, for "ft." read "min."



HAWAIIAN VOLCANO OBSERVATORY.

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 solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	10000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the accelerations or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol a, or max. a, is given in the conventional unit of milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ. per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

U. S. DEPARTMENT OF AGRICULTURE
WEATHER BUREAU
CHARLES F. MARVIN, CHIEF

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NOTE:—Appended to this number of the Bulletin is an article by Dr. E. S. Shepherd, of the Geophysical Laboratory of the Carnegie Institution of Washington, on "The Composition of the Gases of Kilauea." The Geophysical Laboratory has honored us by permitting first publication of these important analyses in these pages, and it is believed that these are the first complete quantitative analyses ever made of gas collected directly from the flaming vesicles of live lava.

T. A. JAGGAR, Jr.

July 12, 1919.

The movement of the Halemaumau lava column for the week ending July 11, 1919, has been a continuance of subsidence at greatly diminished speed and some recovery so far as the liquid lakes are concerned. There has been nothing new in the nature of the activity. At the source opening of the recent Postal Rift flow all is now dark, and there has been much collapsing there, revealing hot caverns.

The measurements of the week directed to the visible ridges of bench magma and marginal portions of Halemaumau pit as seen from the Observatory were as follows: South ridge down 2 feet; northeast heap and west cliff stationary; ground east of north lake down 1 foot; ground north and west of main lake down 4 feet; ground north of west pond down 4 feet; and ground southwest of southwest lake down 4 feet.

These measurements show that the marginal ground has been nearly stationary, with a maximum movement in the south ridge of 2 feet in eight days, averaging 0.25 foot per day. On the other hand, the central prism of hardened lava around the central and southern group of lakes has moved down 4 feet, or 0.50 foot per day: a rate about one-third as fast as that of the previous week. The depression of the lakes within their cups indicates that they have lowered less rapidly than their surroundings, for the end of the week shows them distinctly higher relative to their adjacent banks.

The writer is indebted to Messrs. Sumner Roberts and Charles Thorndike, co-operative observers, for the following new data concerning the levels of Halemaumau features. It will be remembered that the old government bench mark on the north rim of the pit, before it was lifted and tilted in April, 1919, stood 3700 feet above sea level.

The new elevations are:

Southern wall of Halemaumau—New elevation, 3733 feet.

South-southeast wall of Halemaumau—New elevation, 3746 feet; old elevation of November, 1918, 3711 feet.

East wall of Halemaumau—New elevation, 3727 feet; old elevation of November, 1918, 3700 feet.

Northeast wall of Halemaumau—New elevation, 3733 feet.

West wall of Halemaumau—New elevation, 3728 feet; old elevation of November, 1918, 3727 feet.

Northwest wall of Halemaumau—New elevation, 3729 feet; old elevation of November, 1918, 3732 feet.

North wall of Halemaumau—New elevation, 3718 feet; old elevation of November, 1918, 3700 feet.

The lakes on July 12 stood as follows:

Main lake—22 feet below 3700-foot contour, 49 feet below east rim flag.

North lake—32 feet below 3700-foot contour, 50 feet below north rim flag.

SW.. lake—20 feet below 3700-foot contour, 53 feet below SW. rim.

W. pond—About 18 feet below 3700-foot contour, 46 feet below west station (concrete platform).

The inner cliffs relative to the several lakes stood as follows on July 12: Cliff south of north lake, 48 feet high; cliff southeast of main lake, 31 feet high; cliff north of central pond, 26 feet high; cliff east of southwest lake, 25 feet high.

These figures reveal remarkable changes which check with recent events whereby general rising of the lava column in 1918 and 1919 made its upward thrust and overflooding dominantly toward the southeast. In 1917 the highest walls of the pit were northwest and west. Now the highest walls are south and southeast and the lowest walls are north and west, and the west station is the only one of the older bench marks which is preserved at nearly its former altitude. The north flag at present, on top of the cone which was the source of the November flows of 1918, and almost directly over the site of the old stone shelter hut, stands 18 feet above the ground level of 1917 at that point, although it is now the lowest of the rim stations.

The carefully-measured lake elevations check with recent observations which have indicated all through the spring of 1919 a tendency for the southern lakes to be highest, the main lake at an intermediate level and the north lake much lower. Coordinate with this has been the tendency for actual overflow heaping in the pit to go southeast of the center and marginal subsidence to be at a maximum northwest. It will be observed that this sinking along the northwest wall-crack has now taken effect even outside of Halemaumau with downward faulting along newly-opened rifts back of the northwest station. Accordingly, the elevation of the northwest station by the new measurements is revealed to be 3 feet lower than it was in 1918.

The intense doming of the south central part of Halemaumau in February, 1919, followed by the great Postal Rift flow 800 feet north of the pit, and this latter in the direction of marginal subsidence during the doming period, accords perfectly with the supposition that the region to the north was flexed downward to the breaking point as a reaction from the flexing upward of the Halemaumau dome. The break so opened must have gaped downward in the region under the Postal Rift and so admitted the live lava from a lenticular extension of the tumescent magma underground. The Postal Rift was a natural place for such breaking, for this was the old wall of the pit of 1893, where the subterranean contacts were vertical.

On July 6 at 11 a. m. the eastern Halemaumau cliff margin stood so high above the depressed surfaces of the pit floor that the southern and western crag blocks bounding the main and southwest lakes appeared well below the eye of the visitor. The east cone at the foot of this cliff was now buried under a slope of talus, and its vent was a new glowing chimney in the slide-rock a few feet farther south. The main lake was streaming westward. The north lake showed occasional strong central fountains, a glowing and flaming high filagree of curtained lava had formed against the west wall of the lake basin, there were the usual four or five border fountains, and the depression of the lake appeared unchanged.

The source orifices of the Postal Rift were now nearly dark, but some hissing was heard in the vent under the source cone. The western tube leading from the source cone, and a few hundred feet away, had caved in, showing abundant worm stalactites. Some solfataric fume producing much white staining in the new lava rose east of the source cone where the older solfataras of the Postal Rift lay buried.

On July 7 at 6 p. m. the fume at Halemaumau was rather dense, and occasional slight adjustments whereby rocks fell in the wall-crack indicated subsidence. In addition to the flaming chimney there was a glowing puddle of lava at the east cone locality. The main lake streamed westward to spatter grottoes, the roofs of which collapsed into the lake. In the north lake large central fountains developed at in-

tervals as the crust became inflated, and this was always followed by collapse and marginal subsidence. Flames were always abundant in border grottoes and through the crust. Streaming was southward at the south corner of the lake, but usually northward elsewhere.

On Tuesday, July 8, about 9 p. m. the apparent lake levels remained as before, there were strong central fountains, and in the north lake much gradual cracking of crusts was noticed with slow development, along extended zigzag lines of incandescence. The outbreak of central fountains in the north lake was observed first toward the northwest, migrating northward, and later towards the east, migrating eastward, the fountains expending themselves under the bank. Flaming curtained grottoes were observed in both the north and main lakes. The northeast cove of the main lake and much of the lake south of there remained continuously crusted. Streaming was from the southeast cove of the lake westward to large grottoes southwest and west, which had built heavy overhanging spatter shelves which were twice seen to cave in. The isthmus of crust leading to the south arm stood high and was covered with Pele's hair. There was some tendency to rapid flow under the bank northwest of the main lake, and there was similar rapid shoreward flow on the west side of the north lake.

The northeast and south wall-crack pools still showed the reflection of incandescence below on the fume cloud above. As seen from a distance the Postal Rift flow was no longer glowing, but glow could be found on close approach. While the liquid lakes showed no changes in relative levels, sinking continued in the north central part of the pit and some movement was noticed in the east wall-crack.

On July 9 there was continued slight subsidence in the center of Halemaumau, the smoke was rather dense and the glow moderate, and the measurements indicated an approach toward stationary condition.

At 11 a. m., July 10, the main lake appeared rather higher, with marginal fountains under shelves along the side cliffs and a slight current westward. The northeast wall-crack pond was smoky and the north lake quiet, with fresh rock slides above its north bank. The western lakes were very quiet and heavy fume rose from the west pond. The southwestern wall-crack was enlarged and very hot. The central pond was small and nearly hidden by an overhanging shelf of lava crust.

At 3 p. m. the new east wall of Halemaumau at the east cone locality was estimated to be 35 feet high, and the live chimney beneath was rumbling. One now looked from the east brink of the pit across the entire upper surface of the Halemaumau dome to the basin of the southwest lake. The north lake appeared lowered in its basin and its streaming was away from the east bank towards a new curtained grotto on the northwest side.

An examination of the northwest station on the outer rim of Halemaumau revealed the fact that the large crevasse there had developed, trending in a curve through the two sulphur patches to the Postal Rift cone. The crack departed from the edge of the pit in a tangent merging with the inner wall-crack about the west niche. The fault-block on the side toward Halemaumau had sunk from two to three feet, leaving a new wall of that height. Just behind the northwest station the crack formed a tumbled crevasse 10 feet wide, which extended narrowing toward the southwest, joining with the cracks just west of the west station.

The west pond was found to be a crusted oval about 50 feet below the western cliff, with two small pots showing the liquid lava about 4 feet below the crust. The southwest lake was fountaining in its western cove and showed westward streaming. Exploration of the flat south of it revealed nothing but a continuous plateau occupying the southwestern quadrant of Halemaumau, and the southern wall-crack pond was found to be merely a deep smoky chasm where invisible lava could be heard rumbling far below. The south arm of the main lake visited from this side showed a circular pool of glowing lava in heavy crust, the latter covered with a mat of Pele's hair. There was no notable change in conditions on July 11.

In the Whitney Laboratory the seis-

mographic instruments have registered local earthquakes for the week ending at 8 p. m. Friday, July 11, 1919, as follows: Slight shocks at 9:51 p. m., July 5, and 2:20 a. m., July 7; a pronounced shock at 5:24 p. m., July 11. Teleseisms were registered (H. S. T.) at 8:49 p. m., July 5, probable distance of origin 6520 kilometers; 11:01 a. m., July 8, probable distance of origin 7215 kilometers; and two others, without evidence of distance, at 9:14 a. m. and 4:13 p. m. on July 9. Spasmodic microtremors increased from slight to very strong between July 5 and July 8-9, and thereafter decreased to slight on July 11. Harmonic microtremor was moderately strong throughout the week, decreasing at the end. Microseisms were very feeble. Motion of tilting was nearly stationary until July 8, when it was pronounced to the east and north, reacting to the west and south July 9-10; on July 11 the inclination was again east and north.

July 19, 1919.

The rising tendency in the lakes exhibited last week has now communicated itself to parts of the bench magma, and while the general situation in Halemaumau appears stagnant, the measurements indicate slight rising, especially at the west pond vent, which has long been a conduit source of feeding lava for the pit. Along with this rising the lakes have been notably quiet, dull, and crusted, the central and southern part of the pit has continued smoky, and changes have been slight.

Mr. Roberts made measurements during the forenoon of July 19; the several lakes, below the 3700-foot contour, were as follows, as compared with previous week:

July 13—Main lake, 22 feet; N. lake, 32; SW. lake, 20; W. pond, 18.

July 19—Main lake, 20 feet; N. lake, 33; SW. lake, 18; W. pond, 10 approximately.

The cliff south of north lake had gone down 2 feet (elevation 3713).

The cliff southeast of main lake had risen 1 foot (elevation 3711).

The cliff north of central pond had gone down 4 feet (elevation 3701).

The cliff east of southwest lake had risen 2 feet (elevation 3707).

These figures indicate slight rising south and slight sinking north. The main and southwest lakes in seven days have risen 2 feet, averaging 0.3 foot per day; the west pond has risen about 8 feet, or 1.1 feet per day; the north lake has sunk 1 foot, or 0.14 foot per day. The block south of the north lake has sunk 0.4 foot per day, but the southeast and west central blocks of bench magma have risen respectively 0.14 and 0.3 foot per day, like the adjacent lakes.

On Saturday, July 12, the fume from the northeast wall-crack, recently a pond, nearly obscured the view of the main lake from the east rim of Halemaumau. There was slight hissing from the east talus pot. The main lake seemed high with slight westward current and small grotto fountains. The north lake was low, with fountains in the west corner. The west lakes were high and very quiet, without evident current. The lava shelf around the west pond had increased so that the liquid was hardly visible, but it could be seen streaming from west to east. The cracking of the ground near the west station, especially in the newer lava of the interior of Halemaumau, had increased so as to extend from the west pond depression to the northwest station obliquely across the west niche of 1894.

On July 13 at 11 p. m. the north lake was very quiet and the main lake exhibited strong southwest streaming with bright lines and thin skins. The fountaining activity was at the southwest grottoes. There were heavy fumes from the eastern wall vents, and the odor of sulphuretted hydrogen was perceptible. The southwest lake made a faint glow.

On July 14 at 3 p. m. the north lake was higher, with curtained grottoes and glow-holes in wall northwest and west. The north grotto had collapsed and was buried under talus. There were occasional central fountains. The southwest lake was high and quiet, and the west pond was inactive. The main lake was so high as to slightly overflow the isthmus leading to the central pond. The Postal Rift source cone had caved in on top and some fresh splash material had spattered out around the orifice, but the interior was now all dark.

There was hardly any change on July 16 at 4 p. m. The cove extending west

from the main lake had broken away on the south side, and the lake was quiet and crusted. The north lake had some very large central fountains, and its crust was cracking and foundering. The levels of the lakes showed nothing new, fume as a whole was rather dense, the southwest lake was bright at night, but the other lakes were dull. The Postal Rift flow was reported still glowing in places along the front.

On July 17 in the afternoon and evening the north lake was bright and active with much bubble fountaining. On July 18 at 10 a. m. a new cone was building on the west bank of the north lake, but the lake was rather quiet, with three small border fountains west, northwest and north. The southwest lake was completely crusted over, with gas hissing from under the crust at the northeast corner. On the north side of the gorge between the southwest lake and west pond, a large pulpit rock had separated off from the higher ground and tended to fall southward. The west pond had a small open circular pool, fountaining on its north side. Near the north side of the west pond depression a glow heap of tumbled rocks was flaming. The central pond was now a crusted circular pudding of hardened lava without visible pool.

In the Whitney Laboratory of Seismology for the week ending at 8 p. m. Friday, July 18, 1919, only one local earthquake was registered, July 13, 12:48 a. m. Teleseisms without clear indication of distance were registered beginning 3:38 a. m., July 14; 8 a. m., July 16, and 3:28 a. m., July 18, Hawaiian Standard Time. Spasmodic microtremor, always stronger daytime than night, was moderate to strong, and the harmonic type of microtremor slight to moderate. Microseismic motion increased slightly July 12 to 16, and then became very slight again. Tilting of the ground was strong to the north July 12, 15 and 17, with stationary condition in the intervals, and the east-west component of tilt has been gradual inclination to the west.

July 26, 1919.

During the week ending July 25, 1919, the lava column has risen sharply, carrying up both the foaming lakes and the semi-solid bench magma. This movement has had the same characters as previous risings have shown, and the principal thrust against the marginal wall of Halemaumau has been to the south and east. There has been no revival of the Postal Rift flow.

On July 19 and 20 preparations were made for beginning lava tide measurements from a tent at the north lake on July 21, with Messrs. Jaggar, Roberts, Thorndike and O. Emerson as workers. This investigation was launched July 21 to 25, and the men worked in shifts, taking observations with transit every twenty minutes night and day. It is hoped to continue these observations for a month, and the results will be compiled later. Suffice it to say at this time that the occurrence of the strong and continued rising from the first days of the work has given unexpectedly pronounced changes of angle in the measurements made, the whole surface of the lava column doming up quietly and continuously. Throughout it all, to the instrument men camped directly on the bench magma, there have come no shocks of earthquake and the entire movement has proceeded as a pasty flow. There have been creakings and snappings in the outer old wall rock of the south ridge against which the swelling lava is exerting pressure.

Measurements during the week show that from July 19 to July 25, six days, the southeast rim ridge was stationary and the northeast heap rose 2 feet. The south block of inner crags rose 4 feet, the southeast crag 11 feet, the block north of the main lake 17 feet, and the block west of the main lake 12 feet. The ground east of the north lake rose about 6 feet. The sharp rising first appeared July 21, but became very strong only after July 22. By July 23 it became apparent that a great movement was in progress.

During July 19 and 20 no marked changes were noted in Halemaumau, which continued smoky and by measurement stationary. The sinking had ceased.

On Monday, July 21, fume from the northeast wall-crack was thinner, and a strong rise of both bench magma and liquid lava of the lakes was beginning. Some sliding rocks were heard. With the coming up of the liquid, spatter ramparts were forming, with much

blowing and spraying of fountains and some flaming. The main lake was streaming eastward with fountains east, northeast and southeast. The south arm of this lake and the central pond were fountaining. There was a puffing vent in the bottom of the east cone depression showing bright glow. An inner bench was building at the cove in the northwest corner of the north lake, and surface streaming was east and northwest. The southwest lake was bright, and pounding against its south shore, but the only activity in the west pond depression was the forming of a driblet cone.

At 2:45 p. m., after a series of very heavy rain showers followed by crustings of the north lake and spells of cracking and foundering, there came a violent spell of this kind, when the whole lake sank suddenly 4 feet, with hundreds of turbulent fountains developing, which expended themselves against the north bank of the lake. Otherwise on this afternoon there was the usual alternation of crusting and breaking up. At about 7 p. m. this lake overflowed the inner bench on its southwest side.

Throughout July 21 and 22 the lakes were building ramparts and contracting in area. At 10:45 a. m. on July 22 the north lake overflowed its rampart, these overflows continuing until past noon. Large gas balloons were blown in the skin of this lake, and frequent falls of rock from its southeast wall took place. Strong rising of both the bench magma and the lakes continued, the latter evidenced in the evening by a cascade of lava pouring across the crust from the south arm to the main lake.

On July 23 the fume at Halemaumau was distinctly thinner. The rising of the bench magma had now become very pronounced, amounting locally to 3 or 4 feet per day. All the lakes were building spatter cones and forming pronounced inner benches. Occasionally very large central fountains would break out and migrate to the banks, and flames were abundant at the border cones. The north lake continued to have spells of overflowing and building up its rim, alternating with marked cracking and foundering and sinking of the liquid one to two feet. There were about seven border fountains. In the southwest lake streaming was to the south corner activity, and the cone in the west pond depression was blowing.

On July 24 the fume was still thinner. The southeast crag was now in full view again from the Observatory. On the margin of the main lake large spatter domes had been built east, southeast and northeast, the east one being opposite the east cone depression. The north lake in occasional spells, as at 4 a. m., overflowed its benches so as to fill its cup all the way to the walls on all sides. Overflows of rim with large gas balloons forming, were common at other times. At times of breaking up, prior to the development of central fountains and strong cracking and foundering, the crisis would begin with hissing gas flames in serrate lines through straight cracks of crust followed by fountainings at the same spot which developed into immense areas of doming and flinging turbulence. Then would come general brilliant cracking and foundering all over the lake, with multitudes of bubble fountains, and there would be a sinking spell followed by a quick crusting and recovery. A heavy fall of cliff rock at southeast corner of north lake at 8:56 p. m. produced one of these break-ups.

All during the hours between midnight and daylight on Friday, July 25, there were high spraying fountains from border grottoes in all the lakes, but by early morning the north lake was quiet and crusted, with occasional spells of general cracking and foundering. The east cone had become a driblet spire, sputtering and blowing glass through a small orifice. The streaming in the main lake was toward the east. There was creaking in the southeast ridge and rocks were rolling down its outer slopes. From the Observatory the telescope shows that this ridge is being pushed back to the east.

August 2, 1919.

During the week ending Friday, August 1, 1919, the strong rising of both lake and bench magma in Halemaumau has continued at a rate reaching a maximum of about 4 feet per day in the uplift of the southeast crag. The lakes have mostly kept pace with the rising dome of stiff lava, though individually the lakes have risen at different rates.

The uplift has culminated as before in flows both north and south, repeating the events of the rising movements of the spring. The northern flow broke out through a vent in the Postal Rift area slightly south of the former cone source and continues to flow sluggishly a few hundred feet to the north on the east and west sides of the old crater known as Pele's Kitchen. The south flow on July 31 broke through the wall of the southern pressure ridge and made headway about 100 yards in two arms.

Measurements of the week have shown that in six days, from July 25 to 31, the southeast and east pressure rims rose 5 feet, this being the maximum movement due to mashing up of the outer rim wall of Halemaumau. The inner column of bench magma on that side of Halemaumau exhibited maximum rising of 23 feet at the southeast crag. The central cliff blocks bounding the main lake on the north and west rose 17 feet, and the ground on the northern slope of the dome east and west of the north lake rose 10 feet. The lakes have in general risen about 15 feet, the north lake thereby gaining on the adjacent ground, whereas the main lake has lagged behind its confining walls so as to seem more sunken within them. The southwest lake, the source well, has about kept pace with the rising of the bench magma.

The continuous measurement of the lava tide from a tent on the east brink of the north lake pit has been maintained unremittingly and exhibits striking fluctuations in level of both bench magma and lake magma without any perceptible quaking of the ground and few angular changes which are other than gradual.

On the morning of Saturday, July 26, the main lake had overflowed its east bank and the driblet spire at the east cone formed a pipe 6 feet high with a rectangular hook at its summit. About 7 p. m. the main lake again overflowed strongly into the east cone depression. The fountains of both the main and north lakes were in plain view from Volcano House. The north lake fluctuated in level with a tendency to overflow its banks from time to time. Its spatter margin had built out an inner floor on the east, north and west sides where the lake overflowed owing to the northward tilt of its cup. The cliff on the south side kept scaling off and the lake margin against this cliff tended to recede or remain stationary owing to the general northward tipping. The inner bench stood about 8 feet below the east rim of the cup occupied by the lake and about 5 feet below the northwest sag leading to the northern wall valley.

The southwest lake was found in the evening to be L-shaped, with arms extending southeast and northeast, and, like the other lakes, it had built up a flood bench on all sides, the flooding filling the west pond depression with a sheet of new lava. There was no open vent at the west pond. The chasm leading from the southwest lake to the main lake had opened into a canyon. The wall-crack pond on the inner side of the south ridge was flinging lava spatter over the ridge. This ridge was creaking and rising so as to loosen rocks on its southern slopes, and similar avalanches rolled down the south wall of the north lake.

On July 27 the general rising continued, but the crunching noises in the south ridge had lessened. The east cone depression was all filled up, and a small circular pond there was fountaining in a grotto on its west side. At the main lake the lift of bench magma was so much faster than that of the liquid that in the afternoon there was an inner wall 4 feet high around the lake surmounted by the inner flood bench. The south arm remained shut off from the lake, marginal fountaining was on the east side, and streaming was eastward. Streaming was eastward also in the central pond with grotto fountains at the east end of the pond.

The north lake was now nearly level with the northwestern gap, and from time to time it overflowed its widening flood bench, its actual rim tending to contract and form a circle.

The whole upper surface of the Halemaumau floor had now risen as an arch or dome, and on this day the measurements registered a curious local depression of the central blocks of the dome. From the central crevasses the fume was quite dense, but it had now almost disappeared from the northeast wall-crack. New cracks revealing glow beneath were opening northward from

the north lake, but the great crack in the ground outside of Halemaumau, extending northeastward from the northwest station, was closing up, indicating a movement of uplift extending beyond the north rim flag.

In this region Professor A. Romberg had for four days been experimenting with a seismograph in a cavern, and he reported crunching noises and falling rocks in the cave July 26-27. The seismometer at the same time revealed excessive tilts, sometimes sudden, to the north; that is, away from the Halemaumau center.

At 10:28 p. m. a geyser-like rush of lava erupted through cracks about 200 feet south of the Postal Rift source cone of the April flow, and the standing fountain kept playing for some hours and developed a new flow which poured down the east side of Pele's Kitchen. This flow was a somewhat broken pahoehoe and pooled over a large area between Pele's Kitchen and the 1894 driblet cones. By the next morning the vent was a mere spatter area showing a hissing crack, heaving slabs and a gas spiracle. All that was noticed at the north lake observation camp when the lava geyser broke out was a short-lived sinking of the lake not apparently different from many other such sinkings.

On July 28 the wall around the main lake was 5 feet high and the signal flags of the south pressure ridge had fallen over owing to the continued upheaval. Inspection of the several lakes in the evening showed that the southwest lake was streaming towards a southern grotto and occasionally flung up spray above its northern wall. The cliffs surrounding the main and southwest lake-basins were about 25 feet high in general, the highest crags being those southeast and west of the main lake depression. The new north flow showed active streams pouring through the saddle east of Pele's Kitchen but no visible activity at its source. At 7:34 p. m. the crust of the main lake broke up and the whole lake streamed rapidly, with two feet or more of sinking, towards the east. There was a large dome grotto on the southeast side of this lake and other active marginal places were southwest, northwest and northeast, with occasional brilliant spraying display east. A similar cracking of the crust and streaming occurred again at 8 p. m., but no simultaneous break-ups were observed in the north lake.

From the summit of the southeast crag the south arm was seen to be a large pool streaming vigorously southward and with a stalactite grotto at southwest corner. In the high partition between the south-arm pond and the main lake was a bubbling spring of lava which appeared to well up there and pour southward towards the pond. The rampart around the pond was a 4-foot wall of the same character as that around the main lake. During the night there was much quiet crusting of the north lake and no such frequent breaking up as before.

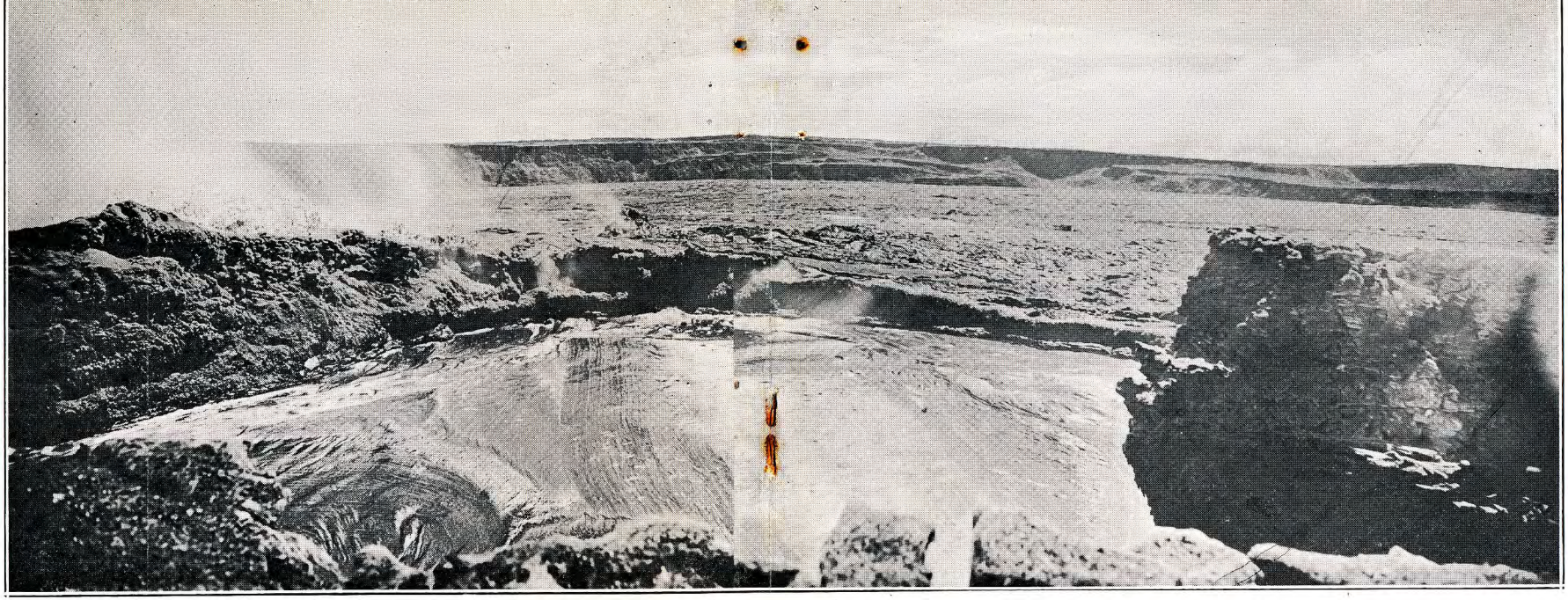
On July 29 the north lake was mostly below its rampart until 5 a. m. Later in the day it built two very large spatter domes on its west side, and at 3 p. m., after two hours of heavy crusting, it broke up and sent driblet flows over the north rampart for a distance of about 15 feet. This lake has no spatter bench on the south cliff side owing to being tilted in its cup northward and so doing its overflowing and bench-building on the north.

The central region of Halemaumau had shown a rise in the previous twenty-four hours of 12 or 15 feet, and the northeast ridge of bench magma between the main lake and the northeast heap has risen so as to cut off the view of the tents at east side of north lake from the automobile approach above the east pond. The south ridge had also risen greatly, forming a new outer talus.

In the east cone depression there was a small circular crusted pond from which some hissing could be heard. From the Observatory at night glowing toes could be seen in the north flow on the floor of Kilauea, and bright fountains were seen in the north lake.

The process of swelling in the dome of bench magma in Halemaumau continued on July 30, with the south ridge, the southeast cliff and the west central walls the highest points of the dome. By evening the rising of the west wall profile of the north lake had nearly shut off the west station from view of the tent. Continued creaking and tum-

538-a
(VL330)



May 10, 1919. From summit of Halemaumau Dome, looking NE. across main lava lake.

444 (VL241)

May 6, 1919. The rush of lava from Postal Rift cone.

May 9, 1919. Telephoto of Halemaumau dome from Uwekahuna. Postal Rift flows in foreground.

bling of rocks were heard in the south ridge.

The north lake had a nearly circular rampart, with about twelve evenly-spaced grotto domes. These grottoes and some central fountaining could be plainly seen in the daytime from the Observatory. At noon this lake overflowed slightly and again at night strongly.

In the evening the main lake rampart wall was 8 to 10 feet high, with dome grottoes 12 to 15 feet above the lake. The west cove was deeper than before, but the crust partition between this lake and the central pond persisted. A castellate group of crags had parted from the west wall of the northeast cove, and a chasm had opened, extending northwest from this cove. There were wide gorges between the main lake and the other two lakes, all these central crevasses yawning open from uplift. At night there was a strong overflow over the east rampart of the main lake.

The flow on the north floor of Kilauea was moving at its front down the slope east of Pele's Kitchen, with nothing but strong hissing at its source.

At 6:30 a. m., July 31, the main lake was higher, with rampart from 5 to 8 feet high and a stream of liquid lava pouring across the isthmus into the south arm. The north lake had filled high the depression behind its rampart, so that the new surface was only 10 feet below the ground on which stands the tent.

At 11 a. m. lava was flowing through the south ridge at the wall-pond locality, forming a tube down the outside of the wall and pooling at its base. The flow then spread out in two lobes, each 100 yards long, one headed due south on the east side of the tunnel ridge of 1918, and the other west along the base of pressure ridge. It consisted of smooth pahoehoe like other flows characterized by a cascade at their sources.

On the floor of the west pond there was a barrel-shaped driblet cone spouting and lifting a lid on its north side while sending out a sluggish flow of lava. The southwest pond was now elongate, low and rather quiet. The north lake at this time was also very sluggish in action, changing from its previous heavy crusting with sudden bursting and sinking spells to balloon skins and more or less open soft surface, with bubbling and sinking at intervals. This means that the accumulation and release depends, not on surface crust, but on the upper viscous layer at all times subject to thickening by radiation cooling and gas expansion.

The south pressure ridge was in motion all day. At 6 p. m. large boulders were seen to roll down its outer slope in two places. It is conspicuous that the east-northeast rim of Halemau mau, just north of the east pond, is pushing up into a new pressure ridge, with rounded profile on its outer side. The lava surface inside was rising strongly and evidently lifting the east wall-opnd bodily, though the latter was raised also by numerous overflows of the main lake. The general effect of the uplift in Halemaumau is to close the crevasses outside of its rim limits and open them in the central region.

At 6 a. m. on Friday, August 1, 1919, no motion was observed at the south ridge. The east-northeast pressure ridge and the lava surface about the east pond were markedly higher. The south floor was now so greatly domed up that the inside of the south wall could not be seen from the northeast edge of Halemaumau. The view of the main lake from this same position was now cut off by its high rampart wall. The castle crags on the west side of the northeast cove of this lake had collapsed.

There had been no revival of the flow through the south wall, but the north flow continued to push out toes at its front.

The north lake overflowed on the older ground near the tent 30 feet from its bank and extensive flows on its northwest inner bench threatened to go through the gap and out into northwest wall-valley. The inner floor or ring platform of this lake is wide east, north and northwest, while along the base of the uplifting south cliff there is only a broken shelled-off spatter scar 3 feet high; and the rampart is increasing so much in height that the view of the liquid from the tent is likely to be entirely cut off.

All the lakes have been making a brilliant display at night. There is now fume rising from the central region and some west and south.

Very respectfully,

T. A. JAGGAR, JR.,

Volcanologist.

THE COMPOSITION OF THE GASES OF KILAUEA

BY E. S. SHEPHERD

The search for the sources of energy back of volcanic phenomena requires not only a continuous observation of the physical activities of the volcano, but also an examination of the matter thrown out from the crater. This matter consists essentially of the mineral portion (lava) and the gases.

Of the various lavas and their forms we have already fairly complete information. This is not the case with the gaseous matter.

The gaseous emanations have necessarily attracted much attention, but, from the extreme difficulty encountered in the attempt to collect them, no really satisfactory data have been obtained thus far. Of the three attempts at such collection made by the Geophysical Laboratory expeditions, only that of 1917 resulted in satisfactory samples for quantitative study. The 1912 collection was most valuable from a qualitative standpoint especially as regards the minor constituents of the gases evolved. But it did not allow a quantitative determination of the most important constituent, namely, water vapor. On the other hand, the 1917 collection, while made under less favorable conditions, develops several important facts. In this place it will suffice to state that, in 1917, vacuum tubes with soft glass plugs at one end were wired to bamboo rods and the fusible end inserted into promising flame holes as the lava crusts swept along the edge of the lake.

There are several objections to this sort of gas but it was the only one available at the time.

THE ANALYTICAL RESULTS.

The methods of analysis of such complex mixtures as one obtains from volcanoes are not altogether satisfactory. Certain constituents such as SO_2, SO_3, Cl_2 and F_2 are not easily separated where, as is too often the case, the vacuum tube does not seal perfectly, or by subsequent cracking of a tip allows the tube to fill with air before it can be properly sealed. This unfortunate condition too often results in a tube which will for analytical purposes contain ninety or more per cent of air. The volcano gas has then to be determined with this large amount of foreign gas hindering the analysis. Nevertheless, an apparatus has been developed which allows reasonably accurate determinations under such unfavorable conditions.

The analyses which follow were made with the above-mentioned apparatus, whose complete description must wait for a future publication. We would merely note that H_2O and S_2 are determined gravimetrically. SO_2 can, under our conditions, be regarded as not sharply separated, but of the correct order of magnitude. CH_4 is not tabulated; working with the best samples yet available it is not present in the fixed gases in quantities greater than 0.2% if present at all. This means that when the water is also included in the computation the amount of hydrocarbons is negligible.

In Table I are given the analyses of 10 tubes collected from the passing flames on the lake surface. In Table II is given the analysis of one of the samples obtained by Prof. Jaggar in 1918-1919. The remaining tubes of this series will be analyzed at an early date and should be the most important collection of gas yet made from any volcano. Previous collectors have necessarily been satisfied with *any* gas. This series of Prof. Jaggar's is made as opportunity offered and along certain definite lines of study. I include the analysis of No. 17 merely for comparison with the 1917 collection which was made from the lake surface.

TABLE I.

GASES COLLECTED FROM KILAUEA, 1917.

VOLUME PERCENTS AT 1200° C.

Tube	CO_2	CO	H_2	N_2	A	SO_2	S_2	Cl_2	H_2O
1*	2.65	1.04	4.22	23.22	udt	0.16	0.70	udt	67.99
2*	17.95	0.36	1.35	37.84	udt	3.51	0.49	udt	38.48
3	33.48	1.42	1.56	12.88	0.45	29.83	1.79	0.17	17.97
4	11.12	3.92	1.42	....	0.51	....	8.61	0.02	77.50
5	9.54	1.12	1.53	10.47	....	9.90	2.72	....	64.71
6	1.97	0.82	0.21	3.50	0.07	0.95	2.70	....	89.77
7	17.25	0.62	0.76	5.88	0.18	9.75	1.07	0.25	64.18
8	15.27	0.45	0.70	0.87	0.14	6.98	0.49	....	75.08
9	8.32	0.82	1.82	8.92	0.29	16.80	2.48	1.01	59.97
10	1.54	0.43	0.37	2.44	0.39	....	3.56	1.34	89.93

* Tubes 1 and 2 were analyzed before the calcium tube was added to the apparatus, so that the rare gases were not determined. Chlorine was not determined in these tubes (udt). Other blanks in the table mean that the gas was not present in determinable amounts.

TABLE II.

Tube No. 17 collected by Dr. T. A. Jaggar, Jr., March 17, 1919.

(Note:—Tip inserted in soft bursting bubble through crust of west pond.)

VOLUME PERCENTS AT 1200° C.

B is computed, neglecting water and sulfur, for comparison with the 1912 collection.

C is the analysis of Tube 16 of the 1912 collection.

Comparison of B and C shows that the source of gas in 1912 was as reliable as can be hoped for. The relative deficiency in SO_2 in C is probably due to conditions of collection and storage.

	A	Comparison of Fixed Gases	
		B	C
CO_2	11.61%	57.0%	75.77%
CO	0.37	1.8	2.31
H_2	0.58	2.8	4.44
N_2	1.29	6.4	8.22
A	0.04	0.2	0.15
SO_2	6.48	31.8	8.09
Cl_2	0.05	...	...
S_2	0.24	...	...
H_2O	79.31	...	...
F_2	trace	...	...

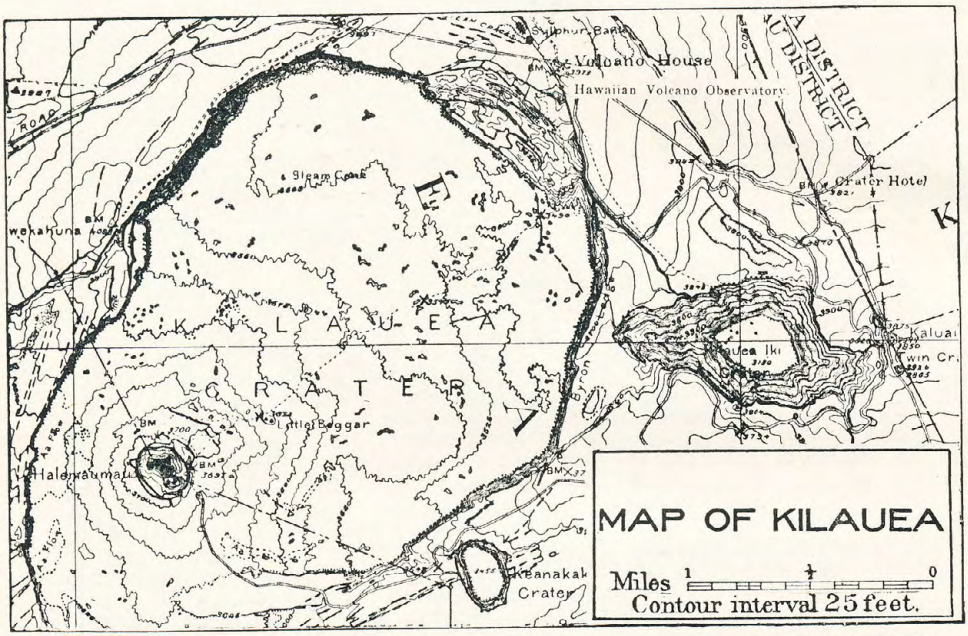
Examination of these tables raises more questions than it answers. The composition of the gas collected in 1917 varies greatly. Certain relations are apparent. Thus: Co is usually present in less quantity than H_2. Next to H_2O, CO_2 is the chief constituent. N_2 is usually a minor constituent and often the rare gases (computed as argon) are no more than would be required on the assumption that the nitrogen came in as air. The chlorine content is surprisingly low. On the other hand, tube 4 shows over seven per cent of sulfur, which agrees with the observation that at times fountains break which set free violet brown fumes which look like sulfur vapor.

It is clear that in most cases the gas as it reaches the surface of the lake is almost completely burned. Similarly the gas in Table II retains but very little combustible gas, although Prof. Jaggar says in his notes he regarded the sample to be as nearly perfect as one could hope to obtain.

The amount of water in all samples is surprisingly high and it is always present. Either we must allow some validity to the thesis that sea-water diffuses through the earth's crust and reappears in the volcanoes—a thesis which we have rejected for reasons stated in an earlier publication[1]—or we must agree with Jaggar's thesis that the combustible gases are burned at and below the lake's surface by air carried down by sinking crusts, air sucked down by fountaining, and oxygen diffusing into the lava as it rises in the conduits. These analyses indicate that perhaps all three of the processes postulated by Jaggar are active. Trapped air would call for a great deal more nitrogen than is present in the gases thus far collected. But this objection does not apply to oxidation along the conduits nor at the lake surface. I am at present inclined to accept the surface combustion as an important factor in the maintenance of the lake's heat supply. On the other hand, the great variations in composition of all samples collected lend support to Day's thesis that a part of the energy may be derived from the shifting gaseous equilibria due to lack of equilibrium among the gases rising in the magma, and undoubtedly the analysis of Prof. Jaggar's 1918-1919 collection as well as future systematically - taken samples will give us for the first time the data needed to establish definitely the relative importance of these various suspected sources of volcano energy. It seems to me that the further collection of gases along the lines which Prof. Jaggar is now pursuing is one of the most promising investigations now before students of volcanology.

Geophysical Laboratory,
Carnegie Institution of Washington,
Washington, D. C.,
July, 1919.

[1] Day and Shepherd, Water and Volcanic Activity. Bull. Geol. Soc. Am. 24, 605. 1913.



HAWAIIAN VOLCANO OBSERVATORY.

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 solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	10000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the accelerations or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol α, or max. α, is given in the conventional unit of milligal. The milligal is a measure of acceleration, such that 1 milligal $=$ 1/100 mm. per sec. per sec. $=10\ \mu$. per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

U. S. DEPARTMENT OF AGRICULTURE
WEATHER BUREAU
CHARLES F. MARVIN, CHIEF

MONTHLY BULLETIN

OF THE

Hawaiian Volcano Observatory

VOL. VII. HONOLULU, HAWAII, AUGUST, 1919 No. 8

August 9, 1919.

During the week ending Friday, August 8, 1919, the strong rising of the Halemaumau lava column has continued so that the lifted dome of bench magma presents much the same appearance as it had in the spring. Again the old rim at the north station has been lifted strongly week ending Friday, August 8, 1919, the strong rising of the Halemaumau lava column has continued so that the lifted dome of bench magma presents much the same appearance as it had in the spring. Again the old rim at the north station has been lifted strongly so as to tilt back the north concrete platform and the west station has also been tilted. The new north flow from the Postal Rift area has continued to progress slowly on both sides of Pele's Kitchen so that its western front is about one half-mile from the source. Other flows have continued to pour over the south pressure ridge from a cone at the south wall-crack so that a new field of glistening glassy lava has spread in many lobes over the upper part of the trail leading from the road terminus. The southwest lake has also flowed across the outer borders of Halemaumau and also into the northwest wall-valley. A conspicuous change of the week has been the merging together of the four central pools, namely the southwest lake, central pond, main lake and south arm, so as to make one elongate trench containing liquid lava streaming rapidly from west to east.

Rising and overflow have necessitated removal and replacing of the tents where the transit observations are in progress, but this has been done without serious interruption of the work of incessant measurement of the lava tide night and day. Readings every twenty minutes have now been continued nearly three weeks. On August 3 Mr. R. H. Finch arrived from Washington to become first assistant at this station, and with his aid five men are now available for the shifting watches at the pit.

The measurements of the week have shown a lift of the south and east pressure rims of 5 feet in eight days, July 31 to August 8. In the same period the north station has been lifted 6 feet, the west station 1 foot and the northeast marginal ground appears to have been stationary. The interior central blocks of the Halemaumau dome consisting of live lava rose 13 feet at the southeast crag, 12 feet in the central region and 9 feet at the ground west of the north lake. The north lake liquid rose approximately 10 feet with much building up of its marginal bench. The main lake rose only about 6 feet and the end of the week found it lower relative to its inner bench by about the same amount. The bench had thus lifted twice as much as the lake.

On Saturday, August 2, 1919, after a stagnant spell in the early morning the north lake rose and overflowed its ramparts in the forenoon. In the afternoon it lowered again. In the evening two fountaining grottoes of this lake were in full view of the Observatory. At the east pond locality on this day a glowing cone was hissing and the surrounding surface had been lifted nearly level with the east rim of Halemaumau. From here the east margin of the main lake was now a serrate craggy mass above the observer, shutting off the

lake from view. Inside its cup the lake preserved a level 6 to 8 feet below the inner wall, the south arm was continuous with the east pool, and the streaming poured from the direction of the central pond across to the east bank and in a curve through the narrows into the south arm. By measurement the central cliffs showed pronounced rising. The fume was in moderate volume. The new Postal Rift flow was hissing at the source vent and its flowing increased at the front making several glowing lobes.

At 9 a. m. on August 3 the central pool was continuous with the main lake and the streaming was swift around the bend into the south arm to a large grotto 20 feet high at the southern end of this arm. Between the central pool and the southwest lake there was still a partially closed crevasse with lava streaming eastward through openings below. In the central cracked ground between the main and north lakes the deep shaft or pot, seen glowing there previously, was now puffing with live lava below and new spray covered the orifice. A new small flow of lava had poured from the east cone and the western lakes had overflowed towards the southwest and into the northwest wall-valley.

The Postal Rift flow was swelling rapidly in a wide slag heap for several hundred feet around its source vent, the latter was glowing and hissing and toes were pushing northward at the fronts of the flow both east and west of Pele's Kitchen. In the evening on the west side of the Pele's Kitchen cone a spraying gas spiracle formed at the margin of the swollen area and gave vent to a live lobe of the flow. At about this time the old north rim of Halemaumau was lifting rapidly, as though the filling of a subterranean passage leading to the flow were also swelling. Under this stress the fissure extending northeast from the northwest station closed and its walls were compressed locally into pressure ridges. Another such pressure ridge made an arched and broken dome at the northeast base of the high ground south of the north lake.

On Monday, August 4, the east cone had been re-established well above the east rim of Halemaumau and the uplifting movement had created a new pressure ridge along the eastnortheast rim. The north lake had built up a high rampart so that in the afternoon it was necessary to move the transit station to higher ground on the north side of the north lake.

The joining through of southwest and main lakes was now so nearly complete that the surface of the lake at the east pool had changed its habit completely, and there was now a majestic river-like torrent pouring out from the central narrows with radiating bright lines on its surface, dividing into two currents which swept respectively into the northeast cove and the south arm. This arrangement shaped the lake into an elongate pool such as was repeatedly formed in 1914, 1915, 1916 and 1917 with a source pond at the west end and a fan-shaped group of sink-holes at the east, these being fountaining grottoes east, northeast and south. The cliffs around the main lake, which had built up its spatter-margin, were now rather low, from 10 to 20 feet high, the southeast and west crags being somewhat higher.

There was strong upward lift in the night of August 4-5 followed by overflows from the north lake. The rapid flow eastward of the main lake continued, the east bench standing 5 feet above the lake and the grotto heaping still higher. The south pressure ridge was in motion, its outer face very steep, its summit over 40 feet high, and the pressure had thrust known peaks of its summit outward as well as upward with reference to the center of Halemaumau. The ridge showed two concentric walls, one within the other as seen from the south. In four days the lift of these walls had completely destroyed the frozen lava cascade which poured over the wall July 31.

About 9 a. m. August 4 the north lake overflowed voluminously on all sides and sent streams into the northwest wall-valley. In the evening at 5:30 p. m. it was evident that another lava cascade had poured down the outer side of the south pressure ridge from the south wall-crack pond which stood at a high level just inside the pressure ridge, surmounted by a spout-

ing cone which could be seen at the top of the saddle where the flow poured over. Exploration around Halemaumau to the south and west discovered a new flow which had hardened with folded fragile crusts and had poured from the west pond flat about August 3 simultaneously with the flow which on the other side of the west pond vent had poured into the northwest wall-valley. Into the northwest wall-valley other flows had coursed down the inner slope of Halemaumau from the northwest corner of the north lake.

Inspection of the southwest lake from its northern margin showed that this pool had now merged completely with the central and east pools to make one long lake through the middle of the Halemaumau dome from west to east. In the southwest pool the rampart on the west side showed distinct downward inclination from south to north. The south side of the pool was crusted over and formed the source of the rapid streaming which rushed through the narrows eastward. The narrows in question had been the crevasse separating the southwest and central pools. Here there were standing rapids and the crevasse had become a gorge leading to the central pond and beyond could be seen a current less swift sweeping from the central pond to the east pool. Another rapid current streamed from the main lake through the narrows into the south arm where a very large grotto dome received the final downrush of the circulation. The recent sudden change of habit in the activity of the main lake (east pool) from spells of crusting to continuous bright-line streaming was coincident with the yawning open and breaking down of the chasm which admitted the flood from the southwest lake.

During the night, August 5-6, the north flow cone was puffing and at the fronts the lava progressed mainly over the upper part of the former Postal Rift flow on the west side of Pele's Kitchen. During this night also the north lake had increasing high spasms of rising which culminated in strong overflows early the next morning.

About 4 a. m. on August 6 these overflows of the north lake flooded the rampart shelf and thence drained into the northwest wall valley. The spasm of rising was general and about 5 a. m. the cone in the saddle of the south pressure ridge sent a double cascade down the outer face of the ridge and this lava spread out in glistening masses of glassy lava which solidified as dense rock and covered the upper part of the new heap of such flows which radiated from this cascade locality out in the direction of the road terminus. Cascading here was repeated at 6:30 p. m.

At 3:30 p. m. August 6 the north lake again overflowed voluminously after building up its ramparts with large dome grottoes; during the afternoon it remained high with brilliant fountaining. The swelling of the bench magma had now arched the northern part of the Halemaumau dome so as greatly to lift the ground west and north of the north lake. Once more also the ground outside of the limits of the Halemaumaumau pit area was in process of strong upheaval on the west and north so that the masonry stations and signal flags were again being lifted and tilted away from the Halemaumau center. This was creating a new narrow pressure ridge at the west station and a wide zone of upheaval in the region beyond the north bench-mark.

On the morning of August 7 the tumescence culminated in extensive overflows of the north lake to the northwest and to the east, so that it was necessary to remove the small sleeping tent at the transit station to a safer place farther north. The eastern overflow extended 200 feet from the lake in a northeasterly direction to the point where the Halemaumau dome falls off in a very steep marginal slope. The uplifted bench magma here rose as an arcuate bend in the crust of the lava column, but did not exert crushing pressure outside. Farther to the south at the northeast wall pond locality a distinct pressure rim in the outside rock was developed and this became a high wall all around the southeast, south and southwest sides of Halemaumau. The materials of this wall now consisted of the semi-solid lava column as the highest tumbled wall inside marking the edges in many places of a pla-

teau extending inward as the surface of the Halemaumau dome.

The main lake was now depressed within its cup, its east bank rising steeply into ragged crags, and a continuous crasm was developing from its northeast cove in the direction of the north lake.

On Friday, August 8, this tendency of the main lake had increased and the inner bench was 15 feet high on the south side of the lake. All around the liquid lava this rampart bench showed horizontal bedding and stood as a wall above the lake as much as 20 feet high in places on the southeastern and eastern sides and 10 feet high on the north side. The north lake at 1 p. m. was brimming level with its banks, during the afternoon it fluctuated in height and from 5 to 6 p. m. strong avalanches southeast of the lake rapidly developed the new gulch leading towards the northeast cove of the main lake.

The glassy lava of the south ridge flow had spread in many lobes covering the upper part of the trail from the road terminus and these flows on this day were hot and making progress. In the evening there was a strong spurt of flowing at this locality. The new northern flow of the Postal Rift locality was extending itself eastward.

August 16, 1919.

The high pressure under the Halemaumau lava column causing it to rise bodily and produce voluminous floods of liquid lava has continued during the second week in August. The rate of rising of the crater floors or bench magma has been slower than during the previous week, but the flooding of liquid lava has increased. One short spell of sinking, involving the craggy matter and causing the collapse of the southeast crag, took place on August 13, the Halemaumau dome sinking about a foot, and the uptilted southeast crag block breaking down into an island so as to lower its summit 14 feet. The flow from the Postal Rift has continued its progress and the north and southwest lakes have repeatedly overflowed. The south wall-crack has also continued its cascades.

Measurement has shown lift of the southern pressure ridge 1 to 2 feet and the old west and north rim stations of Halemaumau have risen 4 feet. The transit tent on the north brink of the north lake was lifted 8 feet in seven days August 8 to 15. The central blocks of the Halemaumau dome rose 6 to 9 feet in different places. The outer lakes gained somewhat on the rising bench magma so as to overflow and build up ramparts, and the main lake gained about 6 feet on its rising shores, though it was still some 9 feet beneath its rampart wall on August 15.

On Saturday, August 9, in the hours before daylight the lakes were very bright and the grotto domes of the north lake could be seen from Volcano House brilliantly fountaining. The Postal Rift flow was bright with greatest advance in its western lobe and there was glow in the southern flows. Collapse, making rock slides, developed a pronounced gulch in the middle of the wall bounding the north lake on the southeast, this being the crevasse over a subterranean tunnel connecting the main and north lakes.

At 6 a. m. the north lake was quiet and high. There had been a general breaking down of the rampart domes around the lake, only the northwestern and western ones remaining. The main lake streamed from bright lines under banks 10 to 15 feet high to an active eastern grotto. The east cone, glowing and fuming, stood over a wide crevasse in the upswollen slope leading from the east rim of Halemaumau as a steep upgrade to the verge of the lifted lake. The east pond was gone, there was left only the cone. Halemaumau was again a high hill where one looked down steep slopes towards the hut on the east and the field of Postal Rift flows towards the north. This latter field was now greatly swollen and its edge had extended itself several hundred feet to the east. In the evening the north lake was low, the rising movement lessened, and just before midnight the entire rampart block bounding the liquid lava on the southwest slowly collapsed and sank beneath the lake. At the same time the level bubble of the transit on the north side of the lake showed a sudden tilt of the ground southward. The lake remained very low for the remainder of the night, the north flow was quiet and slight earthquakes were felt at the sleeping tent.

On August 10 at 6 a. m. the southeast chasm had again increased through rock sliding and the north lake was rising slightly. At 6:30 a. m. a very exceptional condition was found in the main lake in that the current was streaming westward through the narrows leading to the southwest pool, showing that the grade of the surface was reversed, accompanied by withdrawal of lava through the western source tubes. Hitherto the eastward flow had made rapids. The fume was slightly increased. During the day, however, there was recovery and at 6 p. m. the main lake was again streaming eastward.

On August 11 there was strong revival of the new Postal Rift vent about 3 p. m. and a fountaining gush of flowing took place there. In the evening the cone was spurting high jets which fell on the surface of a new flow heap that covered the former flow for several hundred feet from the cone center. In Halemaumau occasional slips of rock were heard, the north lake was low, and there was some rising toward midnight.

On August 12 the main lake continued to stream eastward. There were fresh driblet trickles of lava through the saddle in the south pressure ridge. It was now becoming evident that the lift of the bench magma had widened the central gulches and hot cracks on the north side of the north lake, these latter marking a new mound distinct from the central Halemaumau dome and extended into farther uplift of the northern Halemaumau rim. The government bench mark there tilted northward a little over ten degrees. The northeastern pressure ridge had increased in height and steepness and the slope from the east cone up to the edge of the main lake was growing steeper. The walls east and south of the main lake cup were about 20 feet high. The block of ground between the two gulches extending south from the north lake appeared to be stationary and flat topped. About noon there was overflow from the southwest lake.

At 4:30 p. m. there was a sudden pronounced general rise of lake magma which resulted in a remarkably voluminous torrent falling as a triple cascade from the south ridge and in overflow of the north lake which sent streams over the edge of the north lake basin eastward and into the northwest wall-valley. The southern flow differed from its predecessors in the appearance and consolidation of the lava, as it tended to form broken pahoehoe slabs rather than round glistening glassy toes. As the cascades fell over the wall, the glowing melt was mottled with black blotches and fell in crumbly and stringy curtains showing a cavernous background through their interstices. The flood started with a standing fountain at the wall-crack cone and flowed for nearly an hour.

The Postal Rift cone was now about 8 feet high with gas spiracles on its crest which were hissing, and the lava inside was pushing out as toes at the fronts of the flow. This flow had now extended to the southwest as well as to the northeast, and in the new direction had broken down the roof of the cavern formerly called Pele's Reception Room and had invaded the subterranean chamber. This was the cave recently in use as a chamber for seismograph experiments.

In the forenoon of August 13 the Postal Rift cone was puffing and the new swollen flow surrounded it. The south flows were quiet. The main lake was streaming eastward. The north lake rose to a high level at about 8:30 a. m. and thereafter subsided.

Some very striking results of mass uplift were now in evidence. What had been a crack extending from the northeast cove of the main lake to the southeast wall of the north lake was now a continuous gulch from 30 to 50 feet wide, floored with tumbled rock, and the central crevasse farther west had also widened. This opening of cracks did not stop at the north lake but crossed the bottom of the lake and reappeared as huge chasms extend-lake to the north wall of Halemaumau. One of these chasms was 20 feet wide, narrowing northward. Other such chasm gulches had yawned open east and south of the main lake as result of the swelling up of the Halemaumau dome, each chasm beginning as a glowing crack penetrating deeply into the crust of the bench magma. The fact that these

cracks cross the lakes, and in places develop into lakes, such as the main lake channel, seems additional proof that the lake basins are shallow openings. The change in elevation of the transit shelter produced marked changes in angle of view; the old crater to the north known as Pele's Kitchen, a few days before entirely cut off from view by the slag heap of the new flow, was now again in full view so much had the shelter been lifted. On the other hand, the view of the shelter itself from the northwest station as a triangulation point had become cut off by the swelling of the ground west of the shelter.

At 5:30 p. m. the north lake rose to slightly overflowing and then sank deeply during the night, leaving the inner wall of its rampart 15 feet high. Dense puffing fume rose from the chasm gulch southeast of the north lake and rock slides there told of the undermining beneath. At midnight the Postal Rift cone was spurting with a live flow all around it. There were small earthquake shocks during the night.

About 1 o'clock in the early morning of August 14 a rift broke open in a north-south direction on the east side of the southeast crag block, this being a continuation southward of the chasm last mentioned. As a result the whole tilted summit area of the crag was carried down to a horizontal position and the block became an island mass 25 feet high, squarish in profile, standing midway between the south arm pond and the main lake, with a channel on each side of it. The movement was fairly rapid and created much disturbance in the adjacent lakes and some small earthquake shocks felt in the immediate vicinity. One of these shocks was felt at the Observatory. The sinking of the southeast crag quite changed the profile of Halemaumau as seen from Volcano House. The channels on both sides of the new island quickly crusted over so as to shut off the south arm pond from the main lake. After daylight the main lake was found with current pouring rapidly eastward through the central channel like a river, the bounding cliffs 15 to 30 feet high, and in the east pool the current spread out like a fan, carrying surface skins to the northeast cove and the southeast shore, while a large dome grotto was developing on the southwest shore. Standing on the east brink of the lake the observer could look southward through the new gap and see on the south side of the south arm pond the immense dome grotto there, 20 feet high and 40 feet broad. The north lake was now recovering and near its rampart level, and the Postal Rift cone was puffing through a high spire of its own construction.

At 6 p. m. the north lake was dribbing over its rim and a fresh flow from the Postal Rift source was pushing out to the east and also to the southwest. About noon a sharp earthquake had been recorded at Hilo. On this day the measurement had shown the first pronounced reaction from rising of the bench magma, marked by subsidence of the summit region of the Halemaumau dome by something more than a foot. Toward midnight the north lake again sank low and the southern ramparts fell in. The rising and falling spells were more frequent than at the end of July and the lake surface was more continuously broken up.

On Friday, August 15, the main lake ramparts stood from 6 to 12 feet above the liquid, a long grotto dome had formed on the southwest side and the floodings of the channel on the west side of the southeast island had almost completely drowned the sunken crag there of the June subsidence. The north lake had risen to a high level at 4 a. m.; at noon, however, it was rather low and the puffing of the Postal Rift cone was slight. This cone now occupied a hollow in the midst of an extensive swollen area, the whole flow around it being intensely inflated both locally and in general.

During the afternoon the humped ground north of the north lake and also the central Halemaumau dome were both swelling measurably, and this tumescence culminated at 6 p. m. in a rapid rise whereby the north lake overflowed quickly and voluminously in long streams eastward and northeastward. The eastern torrent went down the slope to the 1894 bench region and beyond, and lasted about a half hour. The main lake at the same time was very full and gigantic spraying foun-

tains played beneath its eastern rampart at a level only about 6 feet below the bank. The east cone, which had recently built a new heap of gas spiracles alongside of the former cone, had now become entirely quiet. The cone in the south wall saddle was hissing and flaming and in the evening this vent erupted and sent a long flow southward and westward keeping for some distance parallel with the pressure ridge. The swollen Postal Rift area at this time was nearly dark.

The accumulating evidence from many occasions such as were illustrated on this day, indicates that each pronounced spell of localized overflowing is preceded by rapid localized swelling of the bench magma near the point where the overflow is to take place.

August 23, 1919.

During the week ending August 23, 1919, there was a pronounced lowering of the upper surface of the Halemaumau dome and of the lava lakes, simultaneous with the most voluminous flow which has yet poured out on the floor of the greater crater during the present Kilauea activity. This flow spouted from the Postal Rift vents, making new cones slightly to the west of the earlier outlets, and the flood swept in a few hours to the southwest wall of Kilauea and made an extensive pool at the foot of the southern part of Uwekahuna bluff. The new outbreak started on the afternoon of August 16 and has spread its outpourings ever since, with marked fresh gushings every evening. The sinking effects at Halemaumau were mostly between August 16 and August 20. Thereafter in the bench magma a stationary condition of adjustment to the flowing was reached, followed by recovery of the lava in the lakes.

The measurements have shown the following changes of level in seven days from August 15 to August 22: south pressure ridge down about 1.5 feet; central cliff blocks around main lake down 6 to 10 feet; east margin of main lake down about 2 feet; ground around north lake down 1 foot. The lakes lowered 30 to 40 feet August 16-17, remained low two days more, and began strong recovery August 20 so that on August 22 the north lake was again fountaining visibly above its rampart as seen from Volcano House.

At noon on August 18, the twenty-eight days of continuous measurement of tidal movement in the lava column, from a transit station at the north lake, was concluded. The writer takes this opportunity to express his appreciation, on behalf of the Observatory, of the devoted attention to duty of the volunteer and staff workers who took turns night and day in completing this task.

On Saturday, August 16, 1919, after a night of high lakes and strong flowing from the south wall-cone, the Postal Rift cone area was found intensely inflated and swollen into dome tumuli, and there was much heat from all the flow areas. The bench magma was in rapid upward movement, rocks were tumbling from the south pressure ridge almost continuously, the central crevasses and those in the northern mound were yawning open and causing rocks to fall in, and it was becoming evident at the tents near the north lake that the ground was tilting perceptibly to the east and northeast. The inclination showed in the tent poles, and the sleeping cots were so inclined that they had to be blocked up to make them level. As illustrating the nature of bench magma, red hot only a few feet down, it should be said that the tent poles of the transit shelter repeatedly caught fire during this camping venture, and had to be extinguished with water from the canteens. The cracks at the front entrance to the shelter were at all times hot enough to boil water in a few minutes.

The main lake at 6 a. m. was streaming to the east and south. The huge dome grotto in the south arm pond was again active. The wall rampart of the north lake was 6 feet high. The eastern flow from the north lake of the previous evening was about 600 feet long and now solid. The Postal cone was hissing and the bench magma rising.

About 3 p. m. a sudden outburst of spouting lava took place within the southwestern extension of the recent Postal Rift flow area, forming two new cone vents, probably over newly opened deep cracks of the underlying Postal Rift fissure system. This place was

about 100 yards west of the cone source hitherto active, which in turn had broken out only a short distance southeast of the cone source of the April-May flows. The whole group of Postal Rift source cones thus lay within the strongly fuming solfataric area of whitened crevasses which for many years past have been called the "Postal Cracks." This entire area is now buried, excepting the hill with summit crater known as Pele's Kitchen. A big flood of lava rushed westward from the new vents, and immediately drained the inflated slag-heap surrounding the cone of earlier formation, causing the dome tumuli to collapse and reveal cavernous glowing interiors and broken shells. The new flow made rapid streams and delta lobes all the way to the southwest wall of Kilauea immediately west of Halemaumau and all night the lava was pooling there. The spectacular surface stream continued all night and appeared in its first rush to be much the most rapid and voluminous Kilauea flow yet produced in the 1918-19 series.

Immediately after this outbreak the north lake sank rapidly until its walls beneath the overflow bench were 30 feet high. There were many tumbles from the ramparts and at the two gulches on the south side of the lake. The main lake also lowered, its streaming still going east and northeast, and an open arch leading to the south arm pond appeared under the isthmus on the east side of the southeast island.

On August 17 at 2 p. m. the lakes remained low but showed some tendency to recovery and some spectacular fountaining. In the very early morning hours an immense block of the southeast rampart fell into the north lake making a high and brilliant puff of dust and gas. Eastward streaming continued in the main lake, and in the north lake a tube was revealed under the south chasm with liquid lava streaming out from it, like a brook, into the lake. There was continuous bubbling in front of the gulch southeast of the north lake, and the surface of the lake showed bright-line pattern and no hard crusting.

The bench magma dome had lowered along with the lakes so that the greater sinking of the central part of Halemaumau was revealed in both the main and north lakes by the greater lowering of those portions of the rampart bench which lay nearest to the central region. Thus in the main lake the east bench was high and the north benches much lower, while in the north lake the north bench was high and the rampart scar along the south wall of the lake was low with a distinct tilt between these two points.

All day the new flow was flooding northwestward from Halemaumau and about 5 p. m. there was intense revival of the flow sending streams westward on top of the solidified portion. These streams as seen in plan, looking down on them from Uwekahuna bluff, showed tendency to form a pattern like a pair of lobster claws, the main stream spreading out like a delta in arms which tended to recurve and meet. Each minor fork showed the same tendency as though forking around an obstacle and meeting on the other side.

At 6 a. m. on August 18 the main lake appeared very low with eastern rampart wall over 30 feet high and the cliff blocks north and south of the lake appeared to have slumped. The streaming was still eastward with fountaining activity east and southwest. The angles of view showed clearly that the central part of the Halemaumau dome had lowered. The rampart walls of the north lake were 15 to 30 feet high and at 5:45 a. m. strong avalanches were tumbling on the west side, removing the rampart and leaving a raw cliff of bedded flows. The stream pouring out of the cavern just west of the south gulch appeared to come from the direction of the southwest lake. At the summit crevasses the fume was still thin. During the forenoon there was some rising in the north lake but the main lake, at 3 p. m., was still very low. The north flow vent had become a hissing cone and the flow from it was crusted over during the day but at 8 p. m. a new and brilliant incandescent flow was streaming over the surface westward.

On this day at 11:40 a. m. the last watch in the series of transit measurements at the north lake was concluded, and the twenty-eight days of continuous observation, with readings every twenty

June 7, 1919. The lava cascade at the northeast cave, 9 p. m.

June 9, 1919. Cascade at the northeast cove, 12 noon; daylight view—Photos Jaggar.

minutes, was brought to a close and the camp dismantled.

On Tuesday, August 19, at 3 p. m., the measurements showed continued lowering of the bench magma. A circuit of Halemaumau starting by the east and north sides showed few changes. The main lake was streaming eastward with a rampart wall 40 feet high at the east end. The north lake stood twenty feet below its rampart edge and its activity was sluggish. The southwest lake was draining in a rushing cascade through the narrows to the central pool and the block of ground formerly high which lay south of the narrows had been tilted westward so that its western edge stood only a few feet above the southwest lake level. The rampart bench of the lake was mostly 15 to 20 feet above the liquid and the lake had enlarged considerably in the southern bay. The west pond flat was smoking. The northern flow cone was hissing and its flow crusted over in the afternoon, but at 6 p. m. voluminous spouting was resumed and a bright surface stream ensued.

Examination of the old edge of Halemaumau at the west station showed that a new narrow pressure rim had been mashed up there during the last upheaval, very similar to the northeastern pressure rim. This extended the horseshoe ridge, the middle of which lay to the south so as to encompass three-quarters of Halemaumau, while the northern quarter had been more gradually upheaved back to the place where the Postal Rift flows had welled up.

On August 20 the sinking of the bench magma continued but slightly and in the afternoon the lakes were rising strongly and the flow from the Postal Rift was gushing westward. The large grotto of the south arm pond was again active. The fume continued thin. In the evening the lakes were bright and the northern flow glowed extensively without any special bright streams.

At 6 p. m. on August 21 the source cone of the north flow contained a fountaining pot making a new pool by overflowing around it and adding to the large flow which extended west. The lakes were all higher and in the southwest and main lakes the current flowing eastward was slower. The large dome grotto of the south arm pond continued its fountaining and there were new overflows of the crust in the two channels connecting the main lake and the south pond. In the north lake the crust broke up and sank at intervals At its northwest corner there was a flaming crevasse and the remnant of spatter bench from the former high level now showed a tilt northward from the south corner of the lake indicating renewed rising of the bench magma in the center of Halemaumau. The bubbling and outward streaming, opposite the submerged southeast and south tunnels under the north lake could no longer be seen and occasionally a large fountain broke out and migrated to the bank in the northeastern part of the lake.

On August 22 the bench magma was slightly higher and from 6 to 8 p m. the northern flow was again gushing and streaming from the source cones, the lakes were all very bright and the north lake fountains were high and showed brilliantly above the rampart. The general situation indicated a recovery of the lake magma adjusted to the outflow at the new northern cones.

August 30, 1919.

During the week ending August 29, 1919, the only striking change at the Halemaumau center of activity of Kilauea volcano has been the cessation of intense fountaining at the source vents of the flow pouring from the Postal Rift region, and the transfer of such gushing to points farther west, the main stream feeding the front of the flow now travelling in an underground tube. This has been the usual history of such flows, the source region encrusting itself and forming a plateau covered with a heavy carapace from under the edge of which the moving fluid emerges.

The measurements for the six days August 22 to 28 have indicated that the lava column was essentially stationary. The main and north lakes were lower relative to their banks by about 3 feet on August 28 than on August 22 and the northern half of the bench magma showed elevation of something over one foot at the end of the interval as though the clogging effect of the restraint of the north flow by its in-

crustations were felt in the subterranean passages leading from Halemaumau. Otherwise there was no pronounced movement within the Halemaumau pit limits and the fluctuations of the lakes were small, the lake magma being in adjustment to the gas release of the Postal Rift overflows.

On Saturday, August 23, at 9:45 a. m. there were new spatter margins around the main lake, the liquid was level with them and spatter construction was in progress east and south. Streaming was eastward with bright lines between patches of skin. Occasionally strong fountaining would break out at the southeast bank releasing gas and lowering the lake. Considerable peninsulas of crust were built out into the meandering channel leading from the southwest lake so as to partly bridge the central pond region. The east bank of the main lake was 15 feet high and the cliffs about the lake were mostly 15 to 20 feet high. The highest cliff was towards the southwest, possibly 30 feet high. The lake was brimming hotly against the isthmus plains separating it from the south arm pond and in the latter the large dome grotto had somewhat changed its form, become partially submerged, and exhibited fountaining behind a curtained front. The activity of the lake indicated high gas pressure. A small crusted lava pond had formed in the tumbled debris of the northeast cove where a gulch floored with a jumble of rocks extended through to the north lake.

The adjustments of mass uplift of the lava column and upheaval of the northeast pressure ridge had now flattened the slope from the lake edge to the east cone, and at the same time the east bank of the lake now lay in full view of the hut and flow slope outside of Halemaumau to the northeast. This meant a restoration of the high dome of May 30, when a similar view of the whole northern floor of Kilauea crater was to be had from this point.

The north lake lay 8 to 10 feet below its rampart and was building spatter rims on the south, east and northwest. The Postal Rift cone was spurting from a small orifice and the flow heap near it was putting out live lava toes. The southwest lake was streaming slowly eastward through the narrows and had spells of breaking up and violent spraying fountains, when slight sinking occurred. This lake was very high, with a new flood plain around it which had buried the western scarp of the tilted plateau lying between this lake and the main lake. The rim cliff of Halemaumau bounding the southwest lake depression on its west side stood only 7 feet above the lake. The west pond flat showed no cone or other vent.

Examination of the south half of the Halemaumau dome surface discovered a large flat featureless area between the southwest lake and the serrate southern pressure ridge. From the south arm embayment of the main lake two large gulches had developed in place of the former crevasses, extending to the south ridge on either side of the wall-crack cone which now occupied the site of the former wall pond. This cone stood at the top of a low part of the ridge, the saddle where the cascades had poured down to build the southern flow heap. The cone consisted of four lumpy knobs each about 4 feet high with a pot in the middle where there was internal hissing and fuming and no visible live lava.

All along the inner side of the south pressure ridge the dome surface was a plateau, in places level with the top of the ridge, which could everywhere be easily reached by a climb of 10 or 15 feet, whereas the outer slope was over 40 feet high. The south arm pond was found to be circular and mostly crusted over, with occasional spells of breaking up and sinking.

The indications on this day showed strong gas pressure, high liquid lava, and some rising of bench magma. In the evening from 6 to 9 p. m. another very long and bright surface flow poured to the west from the Postal Rift. This August flow as a whole covered the floor of Kilauea crater northwest of Halemaumau out to the base of the Uwekahuna wall with deep filling for over a half mile along that wall; every evening for a week past there had been surface spurts adding layers to this flow, each spurt showing in plan the river and delta pattern. The whole area around the source cones had become an extensive plateau falling off to

irregular ground with dome tumuli on the southwest, west and northwest. This evening was the last which showed violent surface flooding. The Postal Rift flow of April had shown the same characteristics, surface flooding at first, and flowing in tunnels thereafter.

On August 24 at 6 p. m. the bench magma was found stationary, the main lake high with eastward streaming and there was fountaining under the east bank and at the southwest grotto. The east bank stood about 12 feet above the liquid. The north lake stood about 8 feet below its bank and there were occasional breakings up of the surface accompanied with bubble fountaining. The most active border fountains were at the east end and there were flaming curtained grottoes at the northwest end. The Postal Rift flow area was flaming, puffing and making toes, but there was no strong surface flooding. In general the lava column appeared to be adjusting itself to the flowing conditions at the new vent so as to hold itself stationary.

On August 25 the bench magma continued stationary and the Postal Rift flow continued to push westward without any specially bright streams. The fountains of both the main and north lakes could be seen splashing above the ramparts.

On Tuesday, August 26, at about 2:04 a. m. a local earthquake occurred, strongly felt in Hilo and in Kona and seismometrically registered at the Observatory. There was no special change at Halemaumau in the evening. Here and there brilliantly gushing vents broke out in the flow at points half way between the source cones and the west wall of Kilauea and the most conspicuous new arm of the flow lay on its northern side.

On August 27 the fume at Halemaumau was somewhat denser, the lava dome remained stationary and the flow had a spasm of renewal at 10 p. m. with gushing in its western and northern lobes.

On August 28, at 10 a. m., measurement indicated slight rising of the central and northern parts of Halemaumau but there was very little change in the main features of the pit. The main lake had constructed an inner bench which stood about 5 feet above the liquid, the older margin standing 12 feet above the lake at the east end. The streaming was sluggish eastward. The south arm pond was brightly active at times. The north lake showed a rampart edge about 9 feet high, the fountaining was moderate and ballooning skins formed on the surface. The southwest lake lay under an overhanging bench 10 feet high on the west pond side and here there was a tunnel beneath, out of which the lava flowed slowly from the direction of the west pond. The streaming in this lake was sluggish, partly southward and partly towards the main lake channel. The southern current ended at a fountaining grotto in the south arm of the lake.

The cones at the northern flow source were hissing and making gas spiracles and the top of the lava plateau west of the cones showed sweeping flat stream lines evidently over tunnels beneath which headed toward the west and northwest. There was some hissing through the heavy crusts over these tunnels, and here and there were hot semi-solidified puddles where new lava had welled up through cracks. In the evening a new northern lobe of the flow was glowing.

On Friday, August 29, there was no change in general situation, the lakes remained bright and the flow streams were far to the west, lighting up the Kilauea cliffs.

In the Whitney Laboratory of Seismology for the six weeks ending at 8 p. m., Friday, August 29, the registration of seismic events has been as follows:

For the week ending July 25 there were three local earthquakes respectively at 7:03 p. m. July 19 (slight); 6:30 p. m. July 20 (double shock); and 5:43 p. m. July 22. A slight teleseism was registered at 8:50 a. m. July 25. Spasmodic microtremor was slight, increasing somewhat July 21 to 23. The harmonic microtremor was also much less marked than before but became strongish July 22. Microseismic motion was very slight. Tilting of the ground was moderate to the west and south except on July 22 when it was to the east and north.

For the week ending August 1 there were five small local shocks as follows:

7:39 p. m. July 28; 11:05 p. m. July 29; 5:57 a. m. July 30; 8:06 p. m. July 31; 7:42 a. m. August 1. Spasmodic and harmonic microtremor were both moderate to slight, microseismic motion very slight. Tilting was to the north until July 29 with fluctuation in the east-west azimuth; July 30 to August 1 the tilting was slight and fluctuating.

For the week ending August 8 there were four local shocks as follows: 10:36 and 10:43 a. m. August 3; 7:53 a. m. and 3:43 p. m. (pronounced) August 4. Microtremor of both kinds was slight except August 6 and 8 when there were a few quick-period spasms. Microseismic motion continued very slight. Tilting continued to fluctuate through small angles, the tendency being mostly west and south with slight recoveries in the opposite directions August 3 and 5.

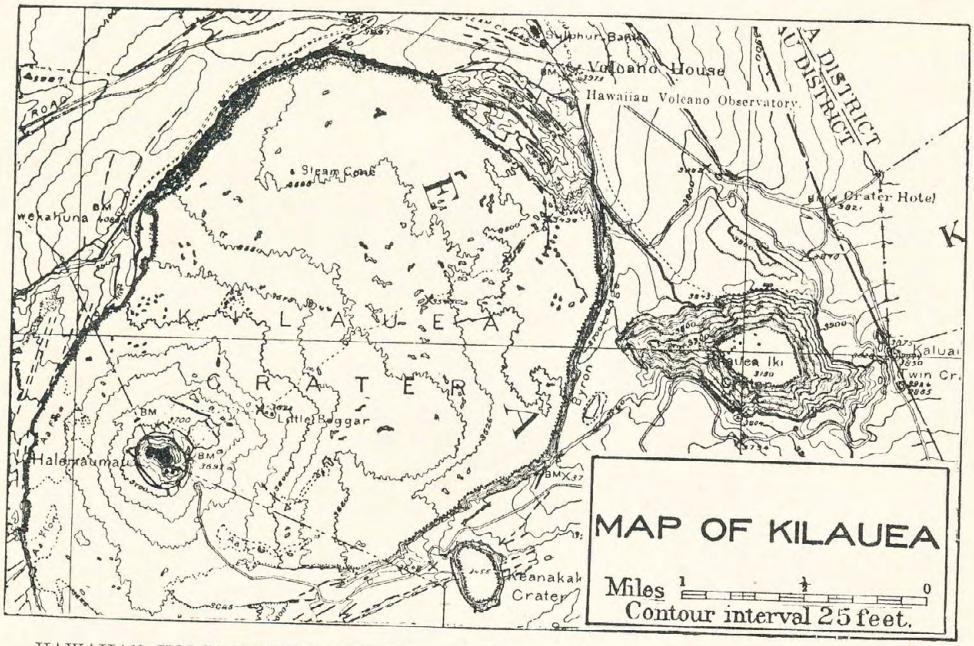
For the week ending August 15 there were six local shocks as follows: 9:33 p. m. (slight) August 12; 12:56 a. m. and 1:02 a. m. (both moderate) and 11:36 p. m. (double shock, slight) August 13; 11:37 a. m. (moderate) August 14; 2:12 a. m. (slight) August 15. Spasmodic microtremor tended to be very slight but there were strong spasms August 11, 14, and 15. Harmonic microtremor was slight to moderate. Microseismic motion increased from very slight to moderate in the course of the week. Tilting was strong to the south and west August 9, strongly east and north August 10-11 and nearly stationary thereafter.

For the week ending August 22 there was one slight local shock August 18 at 10:55 a. m. and a moderate distant earthquake was registered at 6:30 a. m. Spasmodic microtremor showed occasional strong spasms and the harmonic tremor was slight to moderate. Microseismic motion changed from moderate to very slight. Tilting was strongly east and north August 16-18 and strongly west and south after August 19.

For the week ending August 29 there was one moderate local shock at 2:04 a. m. August 26. Weak teleseisms occurred at 6:57 and 7:22 p. m. August 23, 2:23 a. m. August 24 and 7:50 p. m. August 28. Spasmodic microtremor became strong August 24 to 26 and showed strong spasms throughout the week. Harmonic microtremor also became strong after August 25. Microseismic motion was slight. Tilting showed mostly northward and eastward tendency, especially August 24.

Very respectfully,

T. A. JAGGAR, JR.,
Volcanologist.



HAWAIIAN VOLCANO OBSERVATORY.

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 solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	10000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the accelerations or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol α, or max. α, is given in the conventional unit of milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ. per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

U. S. DEPARTMENT OF AGRICULTURE
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CHARLES F. MARVIN, CHIEF

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September 6, 1919.

Observations of the week ending Friday, September 5, 1919, at the inner center of lava activity of Kilauea volcano show a lowering of the lava dome over Halemaumau by a small amount, a nearly stationary condition of the liquid lava of the lakes, and continued flowing of the stream pouring out on the floor of Kilauea crater from the Postal Rift. The appearance of the lakes and crags has changed but little, smoke has slightly increased, and the glowing portions of the flow in visible motion have been altogether along the base of the western wall of Kilauea, where elongate streams have pushed northward under the Uwekahuna summit.

Measurements for the eight days August 28 to September 5 have shown that the lake margins and crag blocks of bench magma of the central region have subsided about 3 feet, the high ground north of the north lake about 4 feet, and the island remnant of the southeast crag about 8 feet. The region of Halemaumau margin west and north which was recently uplifted has sunk about 1 foot, but the east and south sides have been stationary. The lakes at the end of the week appeared, with reference to their containing basins, about 3 feet higher than at the beginning of the interval, which would mean that they are stationary as referred to fixed bench marks.

On Saturday, August 30, the bench magma was slightly lower. At 2 p. m. no changes were noticeable at the south wall cone. There was some increased sulphur fume at the east cone. The main lake continued its eastward streaming and its surface appeared low, with 30-foot rampart on the east and 12-foot inner rampart south. The north lake also appeared low with rampart wall 15 feet high and some strong fountaining near the northeast bank. Both the main and north lakes were covered with soft skins in patches, separated by bright lines. The southwest lake was high relative to its ramparts at 3 p. m., the confining walls being 6 feet high, and there was sluggish streaming eastward through the narrows leading to main lake.

The Postal Rift flow cone was hissing, and a slow flow had welled up through the top of the lava heap near the cones and south of them. A heavy shower made dense masses of vapor rise from the flow area, much denser in the western part where the surface heat was greater. The cross-section of the whole flow consists of a flat plateau near the cones, a much swollen irregular slope next to the west, and a flat pooled area under the Kilauea cliffs farther west, with flows making out at the edges. The ancient ash section at the base of the Uwekahuna wall was now nearly covered up by the new fill. In the evening there was increase of flowing both at the source cones and farther west. In the north lake there was notably more yellow and less red in the fountain glow than in the main lake.

On August 31 at 3 p. m. fountains were vigorous in the main and north lakes, some of those in the north lake being 12 to 15 feet high and very large. Currents were slight except in the

south arm pond, where there was streaming through a tunnel from the main lake, the current carrying crust fragments on its surface and exhibiting bubble fountains playing continuously, each about a foot high. The north lake stood 20 feet below its north bank. Fumes were abundant. The general situation was stationary, and the Postal Rift flow made bright streams in the evening both near the source cone and in a long lobe moving northward at the base of Uwekahuna bluff.

On September 1 stationary conditions continued and at 11 a. m. the main lake was 25 feet below its eastern bank and about 8 feet below its inner rampart, this being the level of the flats separating the lake from the south pond. Streaming was eastward through the channel leading from southwest lake, there were bright lines and ballooning skins, and large fountains broke out occasionally near the east bank. There was no specially marked border fountaining. Subsidence by gas release occurred after a spell of fountaining.

The upper rampart bank of the north lake was the level of recent overflow. The plane of this bank was now tilted relative to the lake level from southeast to northwest, the eastern bank being 15 feet high and the northwestern bank 8 feet high at the most. The cliff on the southeast side appeared as though it were arched higher than the rest. The activity was marked by alternate spells of central fountaining and quiet crusting. All the time four or five border fountains along the northern shore suggested considerable gas pressure. During a central outbreak four or five large fountains were seen in action at once, producing marginal subsidence of about 2 feet and revealing a tunnel under the bank at the south gulch. There was some tendency to ballooning skins and traces of streaming toward the north and northeast.

The Postal Rift flow cones were hissing and stained with solfataric deposits, and sulphur patches had developed southeast of them. The flow was making slender arms northward along the base of Uwekahuna.

Examination of the April flow cone and tunnel showed that the lower stretches of collapsed tunnel northwest and west were now obliterated by the new flow. There remained one upper opening, no longer very hot, into which the wind was blowing toward the source cone, and dense white water vapor arose from the cone. At the cone vent of July 27, farther east, there was a large collapsed dome area with much hot air rising, but no glow or gas pressure. The new flow surfaces between these two earlier cone sources were becoming stained with fume action from the Postal Rift cracks beneath.

On September 2 there were no changes and the pushing fronts of the flow made bright reflections on the extreme southwestern wall of Kilauea as well as under Uwekahuna.

On September 3 at 4 p. m., after heavy rains, there was increase of water vapor and summit fume from the Halemaumau dome. At the south wall cone lava could be heard bubbling beneath. The grotto dome at the south arm pond was found still large, and the pond lay 10 feet below the bank, with fluid surface and not much fountaining. A new smoke-hole had developed at the east-northeast pressure ridge. At the main lake the east wall was 40 feet high and the inner bench 10 feet high on the norh side and 20 feet high on the south side. The lake was crusted over, but streaming under the bank could be seen at the southeast and northeast corners. The north lake appeared higher, with numerous fountains along its north bank and a large central fountain near the northeast shore. The banks were from 10 to 20 feet high. The southwest lake had marginal benches 10 to 30 feet high and appeared rather low. Like the main lake, it was crusted over. There was a bridge of crust across the channel leading to the central pond, and under this appeared a cavern 10 feet high hung with stalactites. The Postal Rift flow cone hissed loudly from one orifice only, and in the evening the flow was vigorous towards the northwest and north. The general situation indicated some sinking, and slackening in the flow.

This was confirmed by the measurements of September 4, which indicated slow lowering of the bench magma, and

smoke had increased at the central gulches. There was no notable change on Friday, September 5, but the flow remained bright when it was seen in evening light, and continued to spread northward in two or more narrow streams moving parallel to each other until they had passed the base of the cliff immediately under the Uwekahuna summit signal post.

In the Whitney Laboratory of Seismology during the week ending at 8 p. m., September 5, there was one local earthquake shock slightly felt here at 11:44 p. m., August 31. A slight teleseism occurred at 2:17 p. m., August 30, and another with more pronounced phases at 6:58 a. m., August 31, indicating a strong earthquake at a distance about 4085 kilometers from the station. Spasmodic microtremor alternated from moderate to strong during the week, and the harmonic tremor from slight to moderate. Microseismic motion slightly increased, but remained weak. The tilting of the ground was south and west until August 31, when it changed to north and east and remained so, the north-south component showing throughout the week more tilting than the east-west.

September 13, 1919.

During the week ending Friday, September 12, 1919, the motion of the lava column in Halemaumau crater has continued to be a slow subsidence of the bench magma compensated at the end of the week by slight rising of the lakes relative to their banks. The only notable change of activity was an increase of subsidence of the liquid lava relative to the containing basins, September 10 and 11, whereby there was established an inrush from both the north and main lakes to a sinkhole under the smoking central gulches. At the main lake this phenomenon resembled the initial stages of the cascade, which during a period of subsidence was so conspicuous a feature in June last. Smoke during the week has been on the increase at Halemaumau. The Postal Rift flow has continued its progress under Uwekahuna, the source cone hissing continuously, and bright yellow sulphur patches developing at the source region.

Measurements for the seven days September 5 to 12 have indicated a stationary condition of the south pressure ridge, a lowering of the west rim about two feet, of the north rim flag one foot, and of the new flow plateau surrounding the live flow cones two to three feet. All of these subsided points are places upheaved or upbuilded by the movement which inaugurated the flow, so that their lowering implies a waning of that force. Within the interior of Halemaumau the crag blocks around the lakes have sunk from three to five feet in the center and about two feet in the outlying floors south, east and north. Until September 11 the lakes also sank even more than the crags, but on September 12 they had recovered about five feet.

On Saturday, September 6, at 11 a. m., the main lake showed a quiet surface, eastward streaming and apparently rising activity. There was much smoke from the marginal benches and the central gulches. At the wall crack east-northeast there was new development of smoke acrid with sulphur. The north lake was high relative to its marginal cliffs and its newer inner rampart was being overflowed at the northwest corner of the lake. The lake surface was inflated, and there were several border fountains. The Postal Rift cone was hissing, there was much sulphur in the vicinity, and under Uwekahuna bluff the flow continued its progress.

From 3 to 5 p. m., September 7, there was slight lowering by measurement and little apparent change. The smoke was dense at the central gulches. The main lake was streaming eastward without much fountaining and some activity at its southwest grotto. The north lake had been comparatively high, building grotto domes at its northwest corner; it was now mostly quiet, with some fountaining towards the east. The Postal Rift flow cone showed one small hissing spiracle, and the flow in the tunnel beneath continued to pour westward. The southwest lake appeared rather low, its surface streaming sweeping toward the tunnel that leads to the central channel. Against the south side of this tunnel a rhythmic fountain burst occasionally. At the west pond locality a few yards west of the south-

west lake there was a tumbled depression yielding much smoke. There was also smoke at the south cone wall-crack of the pressure ridge.

On September 8 at 2:30 p. m. the main lake showed much disturbance of its surface currents. Streaming was now westward from the south pond tunnel at the southeast corner of the lake in a curved zone leading to the southwest grotto. Another current took its rise at the central canyon and swept in a curve toward the northeast and against the middle of the north bank of the lake. The northeast cove was stagnant. There had been some recent undermining by fall of banks in the central channel so that an unstable crag was protruding and overhanging the channel on its south side. The lake appeared rather low, with inner benches 15 feet high, and the confining wall of older rampart 30 feet high at the east end. The north lake was crusted over except for the usual fountain near the northeast bank. The eastern wall overhung the lake and was 15 feet high. Spatter domes had been built at the northwest corner. Portions of the heavy crust were heaving under gas pressure, lines of flame were hissing through cracks, and a break-up was imminent.

On Tuesday and Wednesday, September 9 and 10, there was at first little change, fume increased, and the flow continued its progress along the base of both the southwest and west walls of Kilauea. On September 10 the subsidence of the lakes increased, the overhanging crag south of the central channel fell, and numerous falls were reported in the evening.

On September 11 at 10:30 a. m. this sinking spell had re-established a marked inrush to two tunnels at the northeast corner of the main lake. This resembled the June cascade, but if a cascade existed, it was hidden. All that could be seen was a steady current which affected the whole lake, increasing at the northeast cove to a torrent moving about 10 miles per hour into holes in the bank without fountaining. The lake was covered with skins and bright lines. Blowing noises could be heard from the south arm pond. The rampart walls confining the main lake were 30 to 40 feet high on the east, 15 feet high on the south and 10 feet high under the north cliff. The south island cliff stood 40 feet above the lake; the south, southeast and northeast cliffs 50 feet, and the cliff west of the central pool 60 feet.

The north lake also was streaming steadily toward a central sinkhole in the region of the same gulch that received the main lake inrush. Where this gulch abutted on the north lake there was a steady streaming southward under the bank without fountaining. Otherwise the north lake exhibited three active border grottoes along its northwest shore, the surface currents migrating towards them. There was a quiet tunnel under the south gulch. East and northeast the lake was crusted. The east bank was about 18 feet high, the north bank 15 feet and the northwest rampart only 4 feet high. The south cliffs, through which the two gulches were trenched, stood 50 feet above the lake.

The Postal Rift flow cone continued its hissing, the flow moving at the fronts a mile or so from Halemaumau both to the northwest and southwest, and three sulphur patches had developed near the source cones.

On Friday, September 12, at 6:30 p. m., after considerable rain, the new smoke hole at the east-northeast wall crack was bubbling noisily with a deep, thudding sound and emitting much smoke with sulphur odor but no glow. In the afternoon during a lull in the rains, great quantities of water vapor were seen rising over the whole area covered by the 1919 flows, with greatest volume above the live western lobes of the present time. In the morning there had been a calm spell, when the vapor rose from the Halemaumau dome, dense below, thinning to a narrow stem, and bulging out above in a flower-like form, both the lower and upper parts appearing to be water vapor.

At both main and north lakes the inrushing torrents had stopped. Both appeared about five feet higher. The main lake was mostly covered with quiet ballooning skin, but there was a bright area streaming eastward, in a curve from the central channel to the southwest grotto. The central pool was crusted over. There was fountaining in the south arm pond.

In the debris of the northeast cove gulch two open pots were flaming and rumbling. The north lake had six border fountains northwest and north, large northeast occasional fountains, and the crusts were cracking and foundering. The southwest lake was occasionally very bright.

For the week ending at 8 p. m., Friday, September 12, 1919, no earthquakes have been registered in the Whitney Laboratory of Seismology. Spasmodic microtremor has diminished during the week from moderately strong to slight. The harmonic microtremor has been mostly slight. Microseismic motion has been very slight. Tilting of the ground was to the west and north September 6, nearly stationary September 7 to 9, south and west September 10 to 11, and southeast September 12.

September 20, 1919.

The principal seismo-volcanic event of importance at Kilauea volcano during the week ending September 19, 1919, was a strong earthquake which occurred at 5:20 p. m. on September 14. This was a prolonged twisting movement felt generally throughout the Island of Hawaii and slightly felt on Maui and Oahu. The maximum damage yet reported appears to have been in the Kau section, where chimneys fell and walls cracked, making the intensity approximately No. 8 of the Rossi-Forel scale. At Hilo also, objects were thrown down and much glass broken. At Kilauea crater there was strong swaying of hanging objects and a slow cumulative twisting movement which stopped a clock having torsional pendulum escapement. Rock slides were started, notably strong at the north wall of Kilauea Iki. A fairly complete record was written by the seismographs, and as in the case of some former local earthquakes registered here, the movement of the ground continued for over an hour in slow-period swayings strongly suggesting a teleseism. A similar effect was registered by Dr. Romberg in Honolulu. That the earthquake was of deep origin was indicated by the swarm of felt after-shocks which continued, gradually decreasing, for twenty-two hours at Hilea. A second strong local shock was registered at the Observatory in the very early morning of September 18 (3:37 a. m.).

The occurrence of these earthquakes with maximum effect between Kilauea and Mauna Loa and just before the equinox points toward the probability of an equinoxial volcanic crisis. Nothing, however, has occurred at Halemaumau which as yet gives evidence of what the change is to be. There was some increased gushing of the Postal Rift flow and simultaneous temporary sinking of the lava lakes during the evening of September 14.

The measurements of vertical movement of the upper surface of the Halemaumau lava column during the seven days ending September 19 indicated a slight subsidence September 12 to 15 and slight rising thereafter, the net result being a lowering of the central bench magma blocks adjacent to the lakes by one or two feet and a stationary condition elsewhere. The lake lava remained essentially stationary except for the usual daily fluctuations. The volume of flowing at the Postal Rift increased.

On Saturday, September 13, there was nothing new at Halemaumau. The bench magma was slightly falling, fume was pronounced from vents in the center, east, west, and south, and there was much vapor at the flow sources. A very smooth pool in the flow area between Halemaumau and Uwekahuna appeared to be a place of stagnant liquid lava with cracking and foundering crusts.

After the earthquake of September 14, observations of Halemaumau from 9:30 to 10 p. m. showed all the lava lakes falling rapidly, leaving a bright red margin over 10 feet deep. This was followed by landslips and caving in of lake ramparts. There was much rush of gas in the gulch north of the northeast cove of the main lake. The Postal Rift flow showed new gas pressure and new live lobes.

On September 15 from 4 to 5 p. m. the lakes appeared higher than on the previous day and the fumes rose densely from numerous vents. New cracks had developed at the south wall crack cone, and a new live vent was hissing and flaming there several feet west of the former center of activity. Two other live wall-crack vents had developed at the east cone and in the east-northeast pressure ridge, with rumbling and splashing lava beneath the surface and much flame and smoke. Smoke was is-

suing from several vents along the base of the northeast ridge.

The main lake was streaming sluggishly eastward with quiet wrinkled crust. The south pond grotto was more active, and a current flowed southward from the tunnel leading from the main lake. Dense fume rose at the northeast cove, and the east marginal cliff was 24 feet high. There were signs of slumping around the north lake margins, and along the north and northwest side the bank in several places was only 4 feet high. There were two persistent fountains in this lake.

The source cones of the Postal Rift flow were noisy and smoky, and at night the flow showed several bright patches under Uwekahuna.

On September 16 at 3 p. m. there was less fume from Halemaumau, but the lakes appeared four or five feet lower relative to their banks. The east wall of the main lake was 28 feet high, and the north lake stood 9 feet below its northwest bank. There was smoke from several vents along the south wall-crack. The east cone and the east-northeast wall-crack vent were both alive with much rumbling, hissing, flaming and fuming, and the lava could be heard splashing below. The main lake was streaming rapidly eastward, and there was molten lava in the bottom of the northeast cove extension. Central fountains formed in the lake and migrated to the east bank. The south pond was crusted over and quiet. In the north lake there were two continuous fountains. One of the source cones of the Postal Rift flow continued actively hissing and flaming, and this was extended along a red-hot crack south of the cone.

At 4 p. m. on September 17 the lakes appeared higher and the fumes moderate. The lava boiling beneath the east cone occasionally threw out spatter driblets, and the east-northeast vent was rumbling and fuming. The south pond was quiet except for some hissing of gas along the base of its north bank. The eastward streaming in the main lake was sluggish and one fountain was seen in the channel leading from the central pool. The east bank of the lake was about 20 feet high. There were four fountains in the north lake, which stood 4 feet below its northwest bank. The southwest lake was crusted over and quiet. The activity of the Postal Rift cone was accompanied by considerable noise and smoke, and the flow continued spreading to the west.

On September 18 at 4 p. m. the main lake was about 25 feet below its east rampart, grottoes were active south of the central channel and in the south arm pond, and the eastward streaming was barely perceptible. The east cone continued its flaming and rumbling, but the east-northeast vent was less active. The ground between the east cone and the south arm pond was in motion. The north lake crust appeared higher on the south side than on the north, and four grottoes were active along the northern banks. The crack extending southeast from the Postal Rift cone was hissing loudly.

On September 19 at 2 p. m. the lakes were higher, the fume moderate, and the eastern cones as before. Only one fountain was seen in the main lake, which stood 20 feet below the east rampart. Large fountains were playing in the south pond. The north lake was so high that its lava had overflowed the northwestern bank and drowned two spatter grottoes seen there the day before. Two fountains were in action in the center of the lake and three along the banks. The gas pressure at the Postal Rift cones was increasing, as were also the flows under Uwekahuna.

In the Whitney Laboratory of Seismology a very strong local earthquake was registered at 5:19 p. m., September 14, followed by two after-shocks within an hour. The optical instrument indicated swayings of the ground for over an hour. After-shocks felt in Hilea, and recorded by Miss Zalida de la Nux, were as follows:

September 14, 5:35 p. m., light, lasting 2 seconds.

September 14, 5:45 p. m., medium, lasting 3 seconds.

September 14, 5:55 p. m., medium, lasting two seconds.

September 14, 6:28 p. m., heavy, lasting 3 seconds.

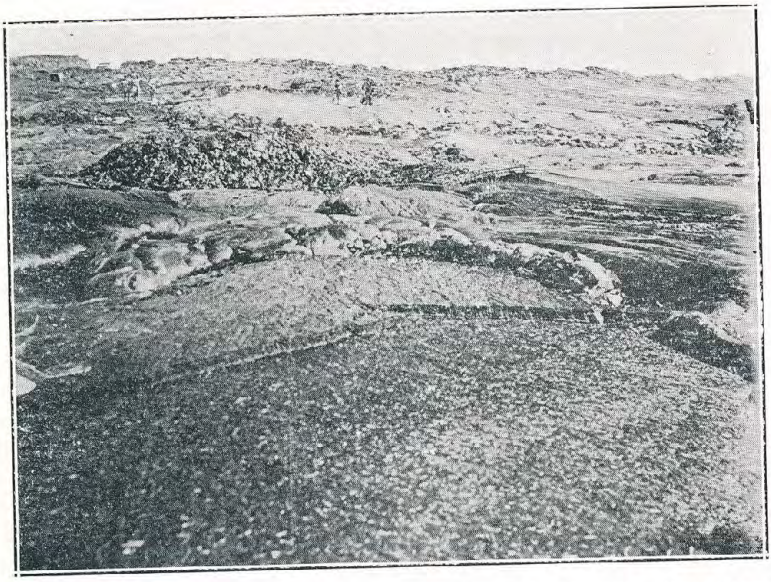
September 14, 6:43 p. m., light.

September 14, 6:45 p. m., light.

September 14, 6:58 p. m., light.

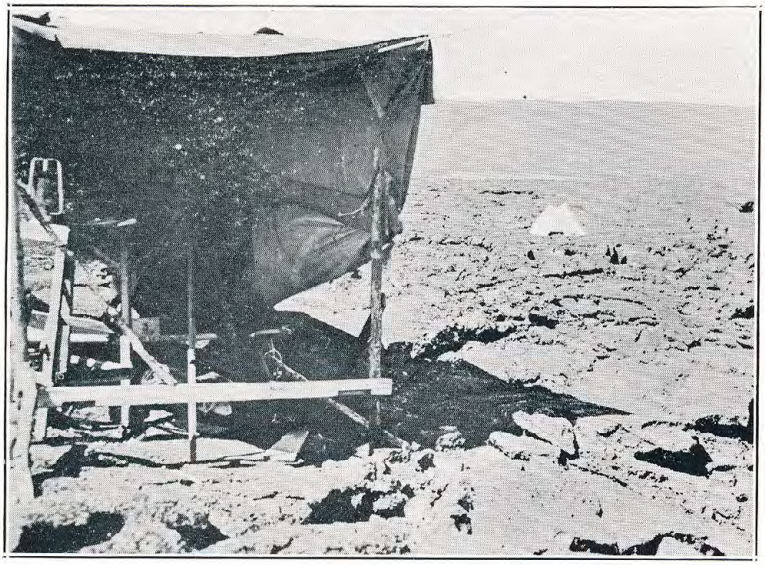
September 14, 7:05 p. m., light.

September 14, 7:07 p. m., medium, lasting 1 second.

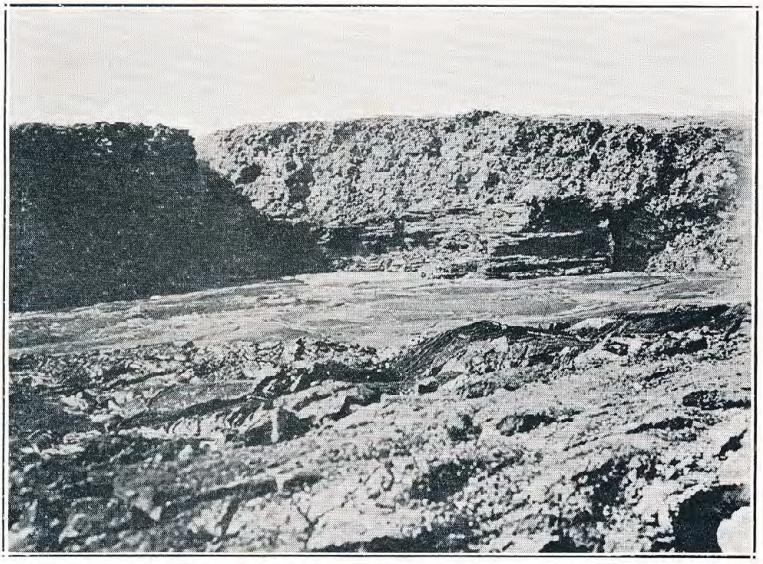


August 17, 1919. Lava gushing from new Postal Rift vents (liquid lava on the right). —Photos Jaggar.

August 17, 1919. New flood of lava, looking west; tilted bench-mark in foreground.



August 17, 1919. Transit shelter and sleeping tent used in lava-tide measurements for one month.



August 18, 1919. The North Lake in front of transit shelter.

September 14, 8:08 p. m., light.
September 14, 8:23 p. m., light.
September 14, 9:31 p. m., light.
September 14, 9:39 p. m., light.
September 14, 10:03 p. m., light.
Other light shocks during the night.
September 15, 4:27 a. m., light.
September 15, 6:49 a. m., medium, lasting 2 seconds.
September 15, 11:06 a. m., light.
September 15, 3:13 p. m., light.

At 3:37 a. m., September 18, there was another strong local shock and two others in the course of thirty seconds. A distant earthquake was registered at 2:35 a. m., September 13, of apparently very remote origin. The spasmodic microtremor showed tendency to few and strongish spasms at the beginning and towards the end of the week, and was only slightly in evidence September 16 and 17. The harmonic tremor, at all times slight, increased a little after September 15. Microseismic motion increased somewhat until September 17 and decreased thereafter. The tilting of the ground had southwesterly tendency until September 14; at the time of the earthquake there was an apparent shift of the pendulums, indicating strong north and east tilt, which continued September 15 and 16, and thereafter the ground remained stationary.

September 27, 1919.

An outbreak of Mauna Loa about three miles south-southwest of the southernmost pit of Mokuaweoweo at 6 p. m., September 26, revealed the meaning of the equinoxial volcanic crisis mentioned in the Bulletin a week ago. The strong earthquakes of September 14 and 18, the sudden short-lived subsidence of the Halemaumau lakes on September 14, the increase of flowing at the Postal Rift, and the strong northeast tilt of September 14-16 were now accounted for. Probably a deep rending open of the Mauna Loa rift system occurred during the earthquakes and the rising wedge of gas-charged melt attained a first explosive release of its gases September 26.

The main characteristic of the activity of the Kilauea lava column during the week has been a greatly augmented volume of flowing in the flow pouring from the Postal Rift source cones northward along the base of the Uwekahuna bluff. At one time this increase was sufficient to revive the incandescence of the flow all the way from the source cones to the front, and also to produce surface spouting from a new oven opened on top of the flow a few hundred feet west of the source vents. It must be remembered that such increase of flowing is the only measure of rising available at a time when the pit is full to the brim as at present. The activity of the week, therefore, would have been recorded as intense rising if the liquid lava had been confined within a deep pit as in former years. On the day of actual Mauna Loa outbreak there was irregular disturbance in Halemaumau, reversed streaming in the main lake, with strong fountaining and sinking bench magma, all of this having begun about September 23.

The measurements of the week indicated that the blocks of bench magma between the lakes rose about 2 feet between September 19 and September 22, and thereafter subsided from 3 to 6 feet September 23-26. The subsidence was greater in the central region and less toward the old Halemaumau border. Along with this subsidence increased smokiness occurred, westward streaming and some tumbling of talus blocks.

At 11 a. m., Saturday, September 20, all the lakes appeared higher and the fumes were thinner. Lava was bubbling noisily beneath the east cone, the splashes rising nearly to the orifice. The second rumbling vent farther north was quieter and emitted very little smoke. The liquid of the main lake stood 15 feet below the lower part of the eastern ledge and some 5 feet higher than on the previous day. The streaming was eastward, and two large fountains were in action. In the south pond there were no fountains, and the currents there were various.

The north lake was high, overflowing the gentle slope back of its northwest rampart. Six border fountains were in action along the northwest, west and southwest margins. At the Postal Rift source a new cone had formed, and the flow was spreading both eastward and southward.

On September 21 at 6 p. m. inspection of the south pressure ridge showed no marked change during the last week. The flaming and bubbling orifice of the east cone was a crack south of the cone

proper. The wall-crack vent east-northeast was much stained and fuming. The main lake was quiet and crusted. There was glow in the southern grotto of the south arm pond, and a flaming chimney occupied the edge of the cliff west of the pond. The north lake showed cracking and foundering crusts, some small border fountains and occasional migratory central fountains in the northeastern region which moved toward the northeast bank. There was no change in the general height of the lake, its marginal cliff standing 10 to 15 feet above the liquid at the east and about 5 feet at the west.

Comparison of the Postal Rift cones with their appearance a week previous indicated greatly increased blowing and flaming, as new flaring cracks had opened on both the north and south sides of the northernmost of the two active cones. The flow from these cones was now very extensive and was alive along the base of the Uwekahuna bluff from a point nearly west of Halemaumau to a point midway between Uwekahuna and the north corner of Kilauea crater. An eastern arm of the flow was making out in the direction of the Volcano House trail.

The southwest lake and west pond pot were both brightly incandescent, the lake showing tendency to crust over and to rise at the time of visit. The west pot was flaming brightly. The southwest lake appeared higher than it was the week before.

On September 22, at 11 a. m., a circuit of the pit by the south and west sides revealed an active grotto in the southeast corner of the southwest lake, southward streaming in the south cove of the lake, and a level somewhat lower than on the previous day. The north lake was dull, crusted over and unchanged. The main lake was streaming slowly eastward from the central channel without much fountaining. Dense smoke rose from the summit crevasses between the main and north lakes, and the lava in the east cone vent was still pounding vigorously.

Northwest of Halemaumau, and midway between the north station and the west wall of Kilauea, live tongues of lava were found breaking out from the crust of the great flow by way of a cone formed there. A short distance south of this cone one of the tubes in the flow was found broken down, revealing in the interior cavity live gas spiracles and glow in the cracks.

At 8 p. m. the main lake was dull and there was some streaming through the central channel eastward from the southwest lake. The south wall-crack chasm at the top of the pressure ridge was glowing and fuming. Streaming in the south arm pond was southward, and the surface of the pond rose and fell at intervals, while from time to time strong fountaining and flaming would increase under and adjacent to the large south grotto dome. The lakes were sufficiently high to make the north lake fountains visible from the Observatory.

On September 24 at 12:15 p. m. a southeasterly wind made the usual approaches to the lakes very fumy. The south arm pond was lower streaming against its northwest bank, where there was violent fountaining and rumbling. There was also some fountaining in its south grotto dome. The main lake was streaming outward from its southeast corner and thence westward to a line of continuous border fountains under the southwest bank. Here there was noisy rumbling. This westward streaming in these two pools accompanied a lowering of the lake whereby the wall at the east end was 28 feet high, and the southern overflow bench 10 feet high. In the northeast cove there was some streaming under the bank. On account of the changed wind, the north lake could not be seen from its east brink because of excessive fume, but noisy rumbling fountains could be heard. The east cone vent was lower and less bright.

The Postal Rift flows were pushing far to the north along the base of the Uwekahuna wall with marked increase in the rate of lengthening northward, and the whole stretch of the flow from head to foot glowed brilliantly.

On September 25 at 3:30 p. m. there was much smoke from the border cracks and central crevasses of Halemaumau. The surface of the cliff blocks in the central region had lowered from 1 to 3 feet. The lakes appeared relatively high, especially the north lake and south arm pond. Streaming in the main lake was from the central channel to the southeast corner, and the strong fountaining along the southwest bank continued. The

east bank was about 22 feet high. The south arm pond was crusted over, but a fountain was puffing from under the crust of the south grotto dome. The north lake was crusted over except for some fountaining at the northeast border, the east bank 8 feet high, and the northwest bank 2 feet high.

The main Postal Rift source cone appeared enlarged with a glowing slot in its summit. The flow seen in plan, looking down upon it from the northern end of Uwekahuna bluff, was extremely brilliant for its entire length. The flow lay against the base of the bluff on its west side, but on its east side it was sending out some ten tongues, beginning at the Postal Rift region and repeating these tongues all the way to the north end of Kilauea crater. The southern part of this great lava pudding, near the source cones, appeared just as bright as the extreme northern front. The whole mass glowed through hundreds of cracks, and live toes were pushing out all the way from the source region to the frontal lobes. In this respect the present activity of this flow differed from that of the later stages of the April flow and appeared to have a marked renewal of gas pressure to feed it.

From 7:30 to 10 p. m. on Friday, September 26, very dense fume was rising at the summit crevasses of Halemaumau. The main lake was streaming west from its east bank, the latter about 20 feet high, there were six vigorous border fountains, and the south bank of the lake was only 6 feet high. The northeast cove exhibited a flaming and fountaining pot at the entrance to the northeast gulch. Fountaining was strong in the south pond. The east cone was rumbling and hissing, and there was evidence of subsidence in the adjacent blocks. Some rocks were heard falling on the northeast ridge. The east-northeast vent at the south end of this ridge was making dense acrid fume.

The north lake appeared higher relative to its banks as though the benches had slumped, and a large east-west crevasse north of the lake had opened until it was 10 feet wide. The east rampart bench was broken and showed motion. This bank stood 8 feet above the lake; the cliff south of the north lake was 45 feet high. The fountains could be plainly seen from Volcano House, and the lake stood only 3 feet below its northwest bank.

At the Postal Rift source region, the southern cone had broken in on its south side so as to make a window revealing the bright yellow glowing interior of the cupola beneath where the lava boiled up to feed the flow. The liquid lay about 15 feet below and was streaming into tubes toward the southwest and northwest. Out of the window rose a banner of flame. There were other flaming cracks and hissing mouths at the northern cone. At 10 p. m. a cone midway between Halemaumau and the west wall of Kilauea burst open and made a very brilliant display of surface flowing, this flood pouring out toward Uwekahuna. All night long the flowing was strong and extended along the base of the bluff all the way to the north wall of Kilauea.

In the early evening of this day, September 26, a thin mantle of clouds, with clear sunset sky above, lay over Mauna Loa as seen from the Observatory. On the left the new moon was sinking in the western sky. Enough of the outline of the mountain could be seen to locate the summit. At 5:50 p. m. an explosion cloud from the upper part of the southern Mauna Loa rift punctured this veil and sent up the familiar "cauliflower" puffs or volutes of a volcanic eruption. This vapor against the light of the setting sun had chocolate-colored edges of smoky aspect, in marked contrast to the normal clouds, while the lower rising billows had a terracotta color, due either to transmitted sunlight or the luminosity of the eruption beneath. The point of explosion was practically due west of the Observatory, corresponding to the group of large cones which lies about three and a half miles southwest of the center of Mokuaweoweo. By 6:15 p. m. it was evident that there were two distinct columns side by side and perhaps a mile or so apart, just as there had been in the similar high outbreak of the morning of May 19, 1916. The culminating height of the explosion was reached at 6:30 p. m., when the top of the jet was estimated to stand 7000 feet above its base. Up to this time the northern column had seemed the stronger of the two, rising higher than the southern. Their color was now a bright orange red.

At 6:40 p. m. the sky was nearly dark except for the sinking moon on the left, and the fume stood in two pink columns, the southern one now the stronger. The explosion was now waning, and a thin ring halo of extraneous vapor encircled the two volcanic jets extending farther to the south than to the north. The jets were still boiling up in "cauliflowers," while the evening clouds on the mountain beneath had increased and obscured the mountain profile. There was evidently little wind at the scene of the eruption, the columns rising nearly vertical, and only a light air drawing out the halo toward the south, giving the whole outline something of a mushroom effect. At 7 p. m. the pile of vapor had ordinary cumulus form, lighted a pale rose color by the gushing lava foam which was flowing at the vent under the explosion clouds.

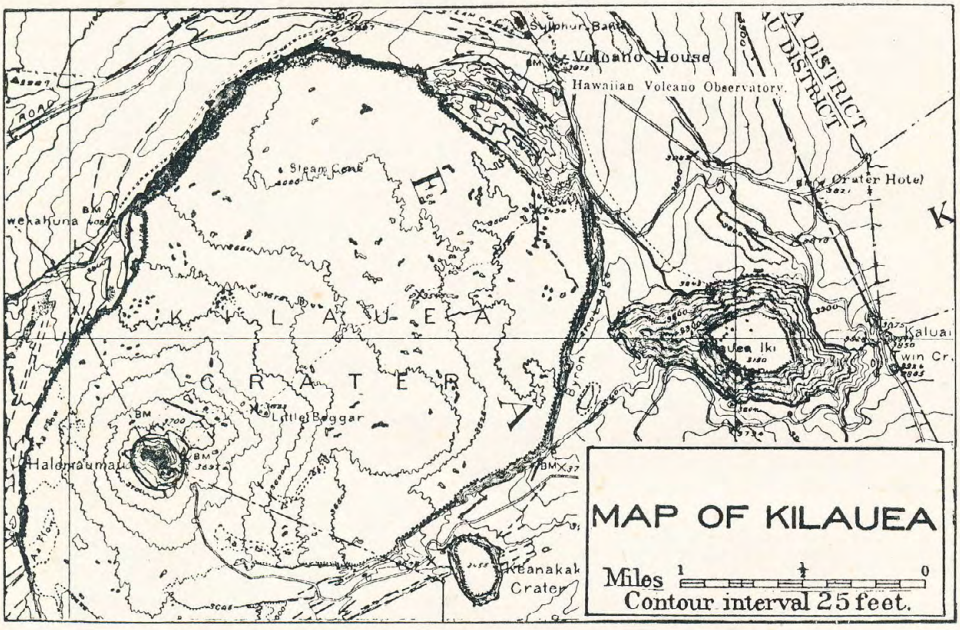
The presence of the lava was unquestionable, as the glow of the eruption was bright until midnight, and an investigation five days later by the writer revealed the presence of fresh small flows around these orifices.

At 10 p. m. the mountain was clear and only one fume jet could be seen, this apparently the upper or northern one of the two previously in action. Below this and south of it there was considerable diffuse glow, probably from the short frothy flows then spreading about the vent, the fume rising from a fountaining orifice. The glow diminished after midnight, and at 3 a. m. was no longer visible. This first eruption was very short-lived, for no fume was visible next day and in later investigations no glow was again seen at this vent.

The only local earthquakes registered in the Whitney Laboratory for the week ending at 8 p. m., September 26, 1919, occurred on September 26, the day of the Mauna Loa outbreak. These were slight, occurring at 2:20 and 2:34 p. m., and five very slight shocks at other times. The spasmodic type of microtremor was feeble except for a few strong spasms September 22 to 23 and several strong spasms September 26. The harmonic slower microtremor was slight to moderate. Microseismic motion continued very weak. The tilting of the ground was to the east September 20, west September 21, increasingly strong to the south September 22 to 24, changing to north and east September 25-26.

Very respectfully,

T. A. JAGGAR, JR.,
Volcanologist.



HAWAIIAN VOLCANO OBSERVATORY.

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 solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	1000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the accelerations or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol a, or max. a, is given in the conventional unit of milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ. per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

U. S. DEPARTMENT OF AGRICULTURE
WEATHER BUREAU
CHARLES F. MARVIN, CHIEF

MONTHLY BULLETIN
OF THE
Hawaiian Volcano Observatory

VOL. VII. HONOLULU, HAWAII, OCTOBER, 1919 No. 10

October 4, 1919.

The week ending October 3, 1919, was characterized on Hawaii by a further outbreak of Mauna Loa with extensive lava flow from a source on the west side of the high Kahuku lands of the District of Kau and about 11 miles south-southwest of the point of outbreak of September 26. The new eruption was first seen from the Observatory location about 1:45 a. m. September 29. The source is a rift line trending S. 35° W., about half a mile to the west of the line of the 1916 rift, five miles above or north of the main 1916 source cone, and at an elevation approximately 7700 feet above sea level. As this was on the Kona flank of the mountain, a steep forested slope, the lava flood quickly descended and in twenty-four hours reached the sea along a curved path, first southwest, then west-southwest, 14 miles long. It crossed the Kona highway, twelve miles from the source, at 9:30 p. m. on the day of the outbreak, September 29, and reached the sea in the early morning hours September 30. The lands traversed are Kahuku, Kipahoehoe and Alika and the point of entry into the ocean lies two miles north of the landing at Hoopuloa village. The rate of travel of the flow from source to road measured as a smooth curve on the map was 0.6 mile per hour; the measured rate in the steep forest lands above the road about 6 p. m. September 29, according to R. McWayne, was one mile per hour. This eruption and its flowing torrent has continued throughout the week. The source fountains were reached and photographed by the writer October 1.

The changes observed at Halemaumau during this week amounted chiefly to continued subsidence of bench magma and lava lakes and some slackening of the Postal Rift flow in Kilauea crater. There was increase of fume and slight sliding of rocks, but otherwise the changes were small, gas pressure continued strong and the fountaining and streaming activities as usual. There was nothing unusual yet registered in local seismic movement.

I. Activity of Kilauea Volcano.

The measured change for the eight days ending October 4 was a subsidence of the Halemaumau rim ridges amounting to 2 feet east and south and 5 feet at the north and west stations. The inner bench magma blocks subsided over 7 feet, the greatest movement amounting to 9 feet in the region east and northeast of the main lake. The lava lakes sank about 10 feet in the seven days September 27 to October 3 inclusive.

On September 27 and 28 the lava lakes continued high, with the north lake fountains visible from the Observatory and the Postal Rift flow remained brightly glowing with high pressure behind it. The bench magma was sinkng about 2 feet per day, the rate decreasing after September 28.

At 3:30 p. m. September 29 there was increased cracking and slumping at the east cone locality, so that the small driblet heaps had sunk on the inner side of the wall crack out of sight of the trail which at the east follows the outer margin of Halemaumau. There

was one glowing crack where gushing sounds could be heard from below. Rock movement was audible in the northeast pressure ridge. Dense fume rose from the solfataric area over the wall crack near the southern end of this ridge and there was much fuming also from the central crevasses.

The main lake stood high relative to its banks, the inner bench standing about 4 feet above the liquid. The cliff blocks back of this bench seemed much lower. There were five fountaining grottoes and the streaming was toward the southeast from under a crust at the central channel and from the northeast cove.

The banks of the north lake stood 5 feet above the liquid, which was streaming toward the east. There were four grottoes built up along the lake margin and much fresh spatter on the north bank. The eastern bank had lowered so as to slope toward the lake. At the eastern corner where the cliff descends to the lake level there was a blowing and flaming chimney built among old floor slabs. At 6 p. m. glow and flame could be seen in the source cone of the Postal Rift flow.

At 2:45 p. m. September 30 the main lake was streaming eastward and the north lake mostly crusted over, with two border fountains. The large grotto dome of the south arm pond showed fountaining and the east cone vent continued its flaming with bubbling noises below. The Postal Rift flow showed live toes at its front, but its vigor of flowing had decreased.

At 4 p. m. October 1 the main lake was higher with its confining rampart in places only two feet high. There was one large foutain on the east bank, the rest of the surface being quiet and crusted. The south pond was very smoky.

The north lake was also high with its northwestern bank only three feet above the liquid. A large grotto had been built on the northeast side and two others were active along the west bank. The surface currents of the lake trended northeast. Fresh cracking was in evidence about three feet from the lake margin for a length of 40 feet. There was much down-sucking along the eastern edge of the lake. The east cone locality showed increased slumping inside of the Halemaumau rim and the internal bubbling and flaming continued. The Postal Rift flow continued its progress.

At 1:30 a. m. October 2 the north lake fountains were visible from Volcano House and the Postal Rift flow glowed moderately. In the afternoon at 3:30 the east cone cracks were found flaming and rumbling as before and the inner ground north and south of this point was depressed much more than before, so that a deep wall valley was developing under the northeast ridge escarpment. Rocks were heard moving here. In general increased cracking was noticed in bench magma surfaces.

The main lake was lower with banks 7 feet high and rapid streaming from the northeast cove to the southeast bank where there was vigorous and noisy fountaining. Streaming was eastward from the central channel.

Smoke was dense from the east-northeast wall crack and the south wall crack. The north lake showed banks 11 feet high and there were six splashing grottoes around the margin, one of them under the south gulch. Rampart walls 10 feet high were revealed above the liquid lava at the mouths of the two gulches. The eastern chimney was dead. The north bank showed increased depression. Heavy crusts formed over the central parts of the lake, broken up occasionally by central fountains which migrated to whatever grotto was nearest. The Postal Rift flow showed glowing extensions in three localities.

II. Activity of Mauna Loa.

At 1:45 a. m. Monday, September 29, a moderate red glow appeared over the southern rift line of Mauna Loa at a point approximately S. 73° W. from the Observatory. Fume rose above the locality in moderate volume. There was no seismic disturbance. Both fume and glow spread to the south from the point first illumined. It was evident that the outbreak was some 5 or 6 miles north of the 1916 vent in Kahuku and near the 8000-foot level as drawn on the Government Survey map of Hawaii.

The writer by telephone at once notified Kapapala, Naalehu, Kaalualu, Kahuku and Honomalino of the coming lava flow. Mr. E. Edwards at Kaalua-

lu near the south point of Hawaii on the shoreline could see the glow and located it as well to the north of Puu o Keokeo, the flow progressing southward.

An Observatory pack train of eight animals with supplies for a week had been previously prepared and was set in motion at 7 a. m. on the way to the source by the Kapapala-Kahuku trail. The party consisted of Messrs. Jaggar and Finch from the Observatory, John and Wale Kama, packers, from Keauhou Ranch, and across the Kapapala lands Mr. Julian Monsarrat kindly furnished the services of Kalua, as guide.

The itinerary was as follows: Left Kapapala bull pen near Halfway House 9:45 a. m.; arrived Ainapo 11 a. m.; Kahuku-Kapapala gate 3 p. m.; camped in Kahuku meadows back of Pahala 4:30 p. m. at 7000 feet above sea level. Continued with pack train September 30, 8 a. m.; camped 12 noon at forest edge inland from Hilea at a point seven or eight miles eastward from the rift line. October 1 left camp at 7 a. m.; tethered riding animals 10:30 a. m.; walked across lava flows to summit of high red hill a half mile east of source fountains, arriving at this hill at 1 p. m. In afternoon explored fountaining pit and flows and spent night in bivouac 700 feet east of fountaining pit. October 2 at 4:30 a. m. started back, arriving in camp 11:15 a. m. Broke camp 8:30 a. m. October 3, arrived Observatory 5 p. m.

From the second camp ground at 6 p. m. September 30, after heavy rain, gigantic cauliflower clouds of fume were seen over the rift osurce to the west. The highest puff was at the north end of the line of jets, direction N. 80° W., vertical angle to top of cloud 11 degrees 30 minutes. The southernmost jet lay S. 85° W. This line of clouds probably followed the course of the flow down the Kona slope. At 7 p. m. the high puff was over, but there was a bright arc of lighted fume billows with a dark zone beneath, the two vapor columns at the ends of the arc being the source of fountains on the right and the jet of steam from the foot of the flow at the shoreline on the left. The maximum distance of the high puff could not have been more than eight miles away, making the height of the column 1.6 miles.

At 8 a. m. on the morning of October 1 from the upland could be seen the two explosion vents of September 26 about 10 miles away to the north. These were gashes in the bright red oxidized rock cutting through two large cones south side. There were lines of white vapor and fresh short black lava flows, and the two cones lay perhaps a mile apart. When examined later, after nightfall, on this day these upper vents showed no glow.

The horses were left at a high flow of brown block lava and the walk to the source fountains was across some ten alternations of aa and pahoehoe. Here could be seen the line of rift cones from Puu o Keokeo northward, some forty cones visible at one time. Right ahead was a large red cone with the smoke of the eruption beyond. When this cone was climbed the source of the outbreak was revealed in panorama, consisting of a line of cones, a true fissure eruption, along a crack parallel to all the others of this rift belt, about half a mile to the west across a plain of fractured lava. Here great fountains were spouting continuously along the fissure for a thousand feet like a wall of red flames, and in detail they were seen to be made of incandescent, light, crumbly material, yellow when it shot up, and red when it came down. The noise was a roar like surf on the rocks, and was occasioned by gas rushing through a lava pool filling the rift, churning it to a foam, and flinging up the foamy matter to solidify as it fell. The bearing of the fountaining pool from the red cone was S. 80° W., and of Puu o Keokeo from the red cone S 14° W. The estimated distance of Puu o Keokeo was between four and five miles.

Northward from the large fountaining pool the fuming vents followed a rift line about one mile long, the smoking patches and driblet heaps becoming progressively smaller northward. Leveling from the summit of the red cone, which was estimated to be 175 feet high, the continuous fountains appeared to throw their denser spray jets 150 feet above the general level of the ground outside of the heapings. Individual rocket jets went higher. A very noisy

cone a few feet to the north of the fountaining pool was sending up such rocket jets with angry rumbling and blowing noises amounting at times to explosive detonations.

At 3 p. m. we left the red cone and proceeded across much faulted ground to the immediate base of the rampart built by the fountains. From the east side this appeared to be a linear structure hemming in the eastern margin of the great lava lake at the southern end of the active part of the rift. At 4 p. m. we climbed over fresh flows to the southern ridge of rift construction,, now accessible, though there were small flaming cones along the crack occasionally emitting sluggish pahoehoe lava. This crack extended about two miles to the south, to judge by four vapor vents seen in that direction. The new lava floods did not there extend so far, but to the west the whole country was covered with glowing and flowing lava fields. The ridge where we stood was 50 feet above the old ground level, and 50 yards north of us stood the highest peak of the rampart wall, a singular structure when seen end on. It stood up as a narrow slab or shell confining the mighty fountains, and its height above the outside ground was about 100 feet. Next to it the fountain jets sprayed up continuously half again as high, the glowing soft fragments eternally poundng down upon the rampart, plastering it with the new matter or rolling noisily down the outer slope, gilded with a mottled fiery pattern. This eastern wall pinnacle fell off to a much lower rampart on the south, where the spatter construction was less continuous. Through the southwestern wall the lake had found an outlet, and here in a gorge 40 feet wide rushed the main lava flow like the sluiceway of a dam. This flow, only 100 feet west of us, made a fiery river with current estimated eighteen miles per hour and sweeping along a nearly straight course for 300 yards to the south, where it bent to a course about S 75° W. and appeared to plunge over a fall into a brightly glowing abyss beyond. The stream appeared shallow with many standing waves and bright grottoes along its banks. It brimmed level with these banks and occasionally overflowed them. Another stream flowing slowly lay parallel to the first one and west of it. The fume from the rift vents was oppressive and had the usual foundry smell with some sulphur in addition.

The western side of this lake of live lava was obscured by fume, but from what could be seen of the fountaining belt was not less than 100 feet wide, and this belt stood over the rift zone on the eastern side of the lake. This lake of foam could not have been less than from 200 to 300 feet wide toward the west, and some 600 feet long in a north-northeast direction. The writer obtained one glimpse of the lake surface by climbing the rampart at the northeast end where the summit was only 40 feet high and the fountaining less violent than at the south. The heat was intolerable, but by choosing a moment when the falling of fragments was at a minimum, it was possible to scramble to the edge, look in, and then beat a quick retreat. A definite lake surface of heaving, foamy lava lay about 20 feet below the edge, and the rampart curved off to the west, indicating the presence of a lower confining bench or shore in that direction of the same general quality as the spatter wall on the east. Probably the pit was somewhat of horseshoe shape with openings to the west.

Next north from the fountaining lake, following the rift line, there was a group of flaming and spraying cones containing eleven live vents and the distinctive type of activity here was violent explosion and much spilling over and rocketing. A large orifice in a cone near the south end of this group was named the "growler" because of its spasmodic awakenings when it became very noisy, some of its explosions involving distinct combustion of gas like the exhaust of a petrol engine. The noise of the main lake was compounded of rumbling due to the rush of gas through melt and a steady surf sound due to fragments falling back in a shower. The "growler" and its neighboring vents added irregular detonations and crashes to the continuous roar, so that the total was much like the noise heard when an observer looks down upon a factory city from surrounding heights. There was a distinct suggestion of traffic and me-

tallic clangor in the hubbub, but it was not overpoweringly loud. The "growler" threw small glowing fragments to great heights, and these went up in a spray, sometimes inclined from the vertical and falling outside of the cone whence they came. The noise at rare intervals became a deep heavy booming. The group of cones here under consideration will be referred to as the middle zone lying between the main lake south, and a line of small but active vents next to the north terminated at their north end by a small cone destined to grow enormously in the course of the next three weeks. In order to simplify description, this will be referred to as the north crater, and the main lake south of the middle zone as the Alika crater, for it was at this lake that the Alika flow took its rise.

In order to show the rapid changes which were taking place at the source rift, the following notes indicate the times during this eventful night when new features developed:

7:30 p. m. During a second visit to south ridge, the flow near its cascade source seen to overflow its east bank and made a fork spreading eastward, which was short-lived.

8:00 p. m. In main lake, from a point 600 feet east, vertical angle to top of highest flung visible fragments 18°, making maximum height at this time 200 feet. Change in color of fragments from yellow (1100° C) where flung up to cherry red (800° C) in falling. Size of fragments up to maximum diameter of 4 feet, some of which dropped in showers on outside of rampart. Material basaltic pumice.

8:15 p. m. South end of main lake rampart caved in. This rampart was 100 feet high at the south, 75 feet high in the middle and 40 feet high at its north end. The "growler" vent of middle zone became more noisy and started fountaining in addition to spraying.

Flames from the end vents were seen at night to be colored bluish green to violet. Over the great fountains were banners of nearly colorless transparent flame, 200 to 300 feet higher than the fountains, surmounted by salmon colored condensing fume. A flutter of yellow-red marked these flames, and there was much bright green where the yellow reflections on fume streamers blended with the blue flame of burning gas.

The heat was sufficient to make for comfort 600 to 700 feet away, temperature of the outside night air 45° to 50° F. The light illumined the whole landscape a half-mile away.

8:30 p. m. Heavy boomings, apparently from northern part of main lake.

9:00 p. m. All three zones along the rift were in violent activity, about one hundred fountain jets in the south lake, eleven vents spraying and spilling over their flanks in the middle cones, and the north zone flaming and fuming as far as the north cone, which now began to flood its flanks in a continuous golden sheet; from its middle a lava geyser spouted up.

The middle zone now began an increase of fountaining, making overflow floods in a bright-line pattern of black and gold, and a brilliant pahoehoe flow started down the east slope from the overwash and moved southward along a depression at the immediate base of the main lake rampart.

9:30 p. m. This flow was now a strong current of lava following the general south slope of the old ground east of the rift line. A veering wind to the northwest brought pungent gas which made the eyes smart, and the great column of fume-cloud, many hundred feet high, topped by immense cumulus billows, came overhead so that a fall of light pumice lapilli showered about our bivouac.

10 to 11 p. m. The new flow moving south progressed a quarter mile or more, bushes were burning at its front, and the middle cones feeding it, including the "growler," were golden with continuous overflow. The bed of pumice lapilli between us and the main lake rampart was now buried under the new flow and it was no longer possible to reach the southern ridge for views of the Alika flow on the western side.

11:00 p. m. The "growler" was now no longer noisy. More of the gas distressing to eyes settled about us, apparently from the new flow. This gas had the foundry smell,, and seemed very heavy. A gas haze hovered low over the eastern landscape, and the upper fume column was bent over in an arch to the southwest, above the first uprush, suggesting a gas like carbon dioxide. The gas was quite irrespirable, when encountered near a vent. A white butterfly killed by the gas was found in a bed of pumice. No sulphur odor was detectable in this particular gas.

12 Midnight. About this time it became evident that the increased activity of the middle cones making the new flow had depleted the southern fountains, for their height was less and the deep rumble from them was slighter. From time to time the southern lake had revivals of great intensity, but as a whole it was less active.

The new south-moving flow on the east side kept going all night and its foot disappeared in the distance, bending apparently to the southwest, the direction of the land called Papa. It later appeared that this flow spread slightly east and moved no great distance. All of the flows near the source rift were a rough pumiceous pahoehoe on the surface, with aa efflorescence in places; the development of nearly continuous aa or clinkery surfaces took place within a mile from the source.

The great gas effervescence was what distinguished this eruption from the ordinary phenomena of Kilauea, with gases different in odor and probably rich in carbon. The fountaining in its continuity and extent suggested Halemaumau in the summer of 1912 when there were hundreds of violent and very hot fountains playing at once. But the fluid there was stringy glass, making much Pele's hair, whereas the Mauna Loa fluid is a granular glass, making crumbly fragments of pumice from the instant the fountains form, suggesting a disintegration in the air and an even more rapid cooling effect than is present at Halemaumau. The luminosity and heat effects are much the same, but the Halemaumau grottoes and cupolas of confined viscous lava appear to the eye hotter than the Mauna Loa vents. The rapid cooling of the Mauna Loa pumiceous lava makes the fountains scarlet in daytime, whereas a bright orange is the rule at Kilauea for the grottoes and central fountains. There was no great quantity or mat of filamentous glass or Pele's hair found near the Mauna Loa vents, though pumice lapilli had short needles of such material attached.

The color effects at sundown at the rift source on Mauna Loa were gorgeous beyond description. Over the scarlet fountains rose the sheets of red and green flame topped with lilac fume, against a murky green or blue-gray background. Above rose the great buff-colored volutes of cloud, with individual billows coffee-colored or brown. All of this was backed by an outer sky of deepest cobalt blue, with normal distant horizon clouds of pearly gray.

At 4 a. m. on Thursday, October 2, 1919, the invisible gas became intolerable to both eyes and throat and we left our bivouac and moved to the east about one-third mile where the air was normal. There had been some collapse of the eastern rampart of the lake, making its profile serrate, but this was quickly repaired by backfall and splashings. When we left at daybreak the fountains were unchanged, the east flow was sluggishly pouring southward and its source cone appeared eroded down somewhat by the incessant spilling over on all sides which was still in progress. The north cone had also contributed to this flow, so that both the middle and northern zones of the rift zone were overflowing down their east flank, the floods united in a stream which moved south parallel to and beside the rift ridge; the stream had two or three marginal lobes which forked off from the main flow and trickled a few yards to the southeast.

We arrived at the place where the riding animals were tethered at 8 a. m. after three and a half hours walk, rode southeast over pahoehoe lava to the timber, and covered the way back to camp northward by the trail, arriving

11:15 a. m. Out of five days spent at this forest edge two were rainy, suggesting that this is a climatal line, with desert beyond to the west at the flow source.

The Lava Flow to the Sea. The source vents opened about midnight, September 28-29, and the flows spread to the southwest, the first rush quickly reaching the steep slope of Mauna Loa in a direction S. 60° W. and curving thence eastward to S. 78° W. through the lands of Kahuku, Kipahoehoe and Alika. At 6 p. m., September 28, the flow was reported three miles east of the main highway in Alika, at 9:30 p. m. it crossed and destroyed the road as a stream of aa some hundred yards wide in Alika, and at 4:30 a. m., September 30, the stream plunged into the sea at the Alika shore over an older flow of the same sort. This shore consists of a narrow platform of lava flows about a half mile wide, fronted with a twenty- to forty-foot cliff over the ocean, and backed by a steep bluff rounding upward into the forest lands of the mountain. The road crossing was twelve miles and the sea contact fourteen miles from the source rift following approximately the course of the flow. The stream continued to flow as a lava river for ten days.

Many persons visited the flow by sea and on land. There was a succession of short-period shallow tidal waves ranging from 3 to 14 feet in height during the flow into the sea, with maximum nearest to the flow delta, and on the third day of the period. The water was hottest north and south of the delta. Noises were heard underwater of seething and of tapping concussions. The uprush of steam where the lava made contact with the sea carried up rock fragments and sand and built a black sand cone. The lava "rafts" or blocks of bench magma which rolled down the live channel, were seen to bob up, make surface steam, and float out some distance from the shore without sinking at first, as though buoyed by the hot gas inflating them. Lightnings were seen in the steam column. There was much muddying of the water and fish were killed in considerable number.

The writer is indebted to Mrs. Jaggar for data as follows, from her observations at the points where the lava was flowing across the road and into the sea September 30 and October 1, while he was at the source. Where the flow had first crossed was 200 feet north of a lumber camp in the forest. This lava was on September 30 at 10 a. m. black aa on the surface, but glow and flames were seen all over the flow. One lobe was moving slowly down the slope 200 feet back of the houses with a rolling motion. The roadway followed the contour of the mountain toward the north, with the sea 1600 feet below on the west down a steep slope, and the hillside above whence the flow was pouring was all forested with high ohia growth. The lobe in question pushed very slowly to a pile of cordwood and set it afire.

On looking north across about 500 feet of black clinkery surface, the party could see a foaming torrent of liquid lava making a noise like running water, with speed varying at different times and in different places, estimated five to ten miles per hour. Great raft blocks of lava, red hot or black, or red below and black above, rode along with the current either smoothly or rolling over as though striking on the bottom. Sometimes these blocks broke up, either quietly or with some spraying. There were dull distant explosions heard and small nearby ones. Later at 5 p. m. these explosions were small and infrequent. An island of unconsumed trees comprising five or six acres of ground was standing on the uphill slope 100 yards from the south bank of the lava field and there some cattle were imprisoned, quietly browsing. On the ocean side a great column of vapor thousands of feet high rose from the shore, spreading above into a broad cloud. As the day advanced this made a great arch of cloud to the east, joining with the cloud from the source vents, and at intervals great drops of water fell. Two houses and a considerable quantity of the drug awa-root were said to have been burned.

Inspection of the foot of the flow at the seashore three miles north of Hoopuloa village was accomplished by riding and walking through heavy rain showers across the old lava shelf until a wall 15 feet high of glowing aa lava

blocked progress. Going around a corner of this on the ocean side, with only a shelf 12 feet wide to stand on and a cliff below abutting on deep water boiling hot, all that could be seen was the fall of blocks of incandescent lava tumbling into the sea, where the water boiled and the steam vapor was so dense as to fog the view. The water was bubbling and dead fish of many colors floated in it. For 50 or more feet out to sea from the base of the great column of vapor which was rising opposite the lava channel somewhere beyond, the water was dotted with small jets and sometimes a swirling "steam spout" or tornado effect, a foot of two in diameter, would rise from the water a few feet away from the main steam column and join the cloud above.

Sometimes a shower of small rock fragments each two or three inches in diameter would be jetted up from a place in the water close to shore, each projectile followed by a tail of vapor, to heights 15 or 20 feet above the sea.

On returning to the flow at the road at 5 p. m., it was noticed at nightfall that the flowing lava channel had a dark zone down the middle shading off to bright red at the banks. The trees at the upper edge of the forested island broke into flames, causing the imprisoned cattle to bellow in distress.

Next day, October 1, at 12:30 p. m., the channel stream was lower and only half as wide as before. It had been about 250 feet wide and its width now was 125 feet. The island was smaller, as many trees had been overwhelmed and the marginal trees were singed. The lava field was generally less hot and its total width across the road about 1000 feet. The odors were mostly the foundry smell, but coal gas was perceptible at the edges of the flow; probably from charred vegetation. There was noticeable dizziness and shortness of breath in those who stood on the edge of the lava field for any length of time. The rafts were frequently much larger than those of the day before. The whole countryside in the evening was bright with the reflected light from the arch of cloud above. The lobe back of the houses had advanced a few feet but appeared stationary.

October 10, 1919.

The high gas pressure of the Hawaiian lava column during the week ending October 10, 1919, kept Mauna Loa in intense activity of fountaining and flowing at the Kahuku rift source, while the response at Kilauea was a continued slight subsidence of the crags in Halemaumau, the lakes tending also to sink somewhat with recovery toward the end of the week. The Alika flow from Mauna Loa ceased moving on October 10, the source vents shifting the discharge northward so as to flood new ground. The Postal Rift flow in Kilauea crater increased in volume and speed.

Observatory expeditions were made to the Alika flow October 6, and to the source rift October 8 to 11, both in charge of the writer, the last having in view the collection of gas from Mauna Loa, samples of which were obtained with vacuum tubes.

Local seismic movements in unusual number began to be registered by the instruments of the Whitney Laboratory at the Kilauea Observatory on October 5 and thereafter. Fourteen shocks were recorded in six days, as well as numerour strong spasms of micro-termor. All but two of the shocks were feeble.

I. Activity of Kilauea Volcano.

The measurements for the six days October 4 to 10 indicated continued lowering of the general level of the Halemaumau lava column but at a decreased rate. The central blocks of bench magma subsided 2 to 3 feet, and the marginal stations 1 foot or less. Until October 9 the lakes sank 4 to 5 feet, showing recovery October 10.

An examination of Halemaumau on Saturday, October 4, after the writer returned from his first Kahuku expedition, showed that there had been border slumping of the bench magma along the old wall-crack line south, southeast, east and north, there was some collapse of the central region apparent, and the eastern and northern lakes appeared rather high relative to their banks, but the southwest lake and west pond were low. The Postal Rift flow continued its outpouring with some slackening of vigor, filling the ground under the north end of Uwekahuna bluff, the

gas making a great increase of yellow sulphur deposit around the source cones 100 yards north of Halemaumau.

In the region of Halemaumau proper there had been slipping of stones on the south pressure ridge and on the inner face of the northeast ridge. From the east cone locality, both to the north and to the south, the wall valley had developed extensively so that the steep infacing escarpment of the northeast ridge stood 30 feet above the smoky depression.

The south pond now was crusted over, its southern dome gotto being large with a flaming chimney on the face towards the pond. There was some breaking up along its northern margin. The main lake showed sluggish eastward streaming, and there were continuous fountains in the southeastern and northeastern parts and a steady current poured under the bank northward at the end of the northeast cove at a rate of about 4 miles per hour, suggesting the former cascade at this place. New spatter ramparts had been built around the lake. The crag block on the north side of the lake was becoming isolated like the south island, and this and the other cliffs of bench magma surrounding the lake stood from 20 to 30 feet high.

Bubbling noises were still audible under the east cone and disagreeable sulphurous fume arose there and from the wall crack farther north.

The north lake showed two or three border fountains, and while the southern wall still remained 30 to 40 feet high, the block between the two central gulches had slumped considerably. The old rampart remnant above the lake on its west side was tilted southward toward the center of Halemaumau. There was some flaming chimney action above the live grottoes. The lake stood only from 3 to 8 feet below the northern banks as the ground north and east had lowered.

The west pond was again an open pit of liquid lava, 30 feet in diameter, exhibiting surface streaming toward its southwest bank. A platform separated it from the southwest lake and the latter stood lower than the pond and 12 feet below the platform. The surface of the lake showed bright lines with streaming action towards its southeast and northeast coves. The rhythmic fountain of the latter cove had revived, exploding in large liquid domes at intervals of a minute or more against the bank on the south side of the tunnel leading to the central pond.

The two live source cones of the Postal Rift flow both had open flaming windows and a third group of cones all covered with sulphur had been formed a few paces to the south. Through the window in the middle cone the lava could still be seen boiling up and rushing westward about 15 feet below the orifice. The odor of sulphur vapor was strong. At night the lakes were very bright and the Postal Rift flow broke out and produced surface streams at several places in the northern part of Kilauea crater.

On October 5 and 6 the bench magma was stationary and the north lake fountains were high enough to be plainly visible from the Observatory. The Postal Rift flow continued its progress.

On October 7 at 5 p. m. two gas vents were spurting in the south pond and there was cracking and foundering in the main lake with slight eastward streaming. The lake stood 25 feet below the bench at the northeast cove. There was increased sinking of the bench magma adjacent to the main and north lakes on the east, and much fume rose from the inface of the northeast ridge. The north lake was quiet. The lava in the interior of the Postal Rift source cones was somewhat lower than before.

On Wednesday, October 8, at 3 p. m. the lakes appeared lower and the fumes denser. In the southwest lake a central fountain was playing and the streaming was towards the east and southeast. In the main and north lakes there were active and numerous border fountains, and again the eastward current of the main lake ended in a pronounced inrush under the bank at the northeast cove. The Postal Rift cones and the cracks adjacent covered upwelling lava as active as usual.

On October 9 at 1:30 p. m. the lakes were lower still, the fume was moderate and the lava under the source cone window of the Postal Rift flow was slightly higher. Two gas vents were flaming in the bank of the south pond, and a crevasse south of the pond was

open to depths lower than the pond surface. In the main lake the east streaming continued, with numerous border fountains, and the bench at the northeast cove stood 30 feet above the lake. Two gas vents in the gulch extending back from the northeast cove and 20 feet from the lake edge were hissing loudly and spurting lava slightly. About 1:40 p. m. the north lake was seen to have a sinking spell to a level about 8 feet below the northern bank. It had been up to the level of the bank during the day and had slightly overflowed on the northwest.

On October 10 at 1 p. m. the lakes were higher, the northeast cove bench standing 25 feet above the main lake. The south pond and main lake were much as before. A current poured into a tunnel at the northeast cove and there was much noise from the gas vents in the adjacent gulch. Portions of the main lake were crusted over. The north lake was brimming level with its banks and had again overflowed its northwestern rampart, this being partly due apparently to subsidence of the bench magma. The east cone and the northeast wall crack were rumbling. Again the flow lava under the Postal Rift source cones appeared higher.

II. Activity of Mauna Loa Volcano.

On the afternoon of October 4 light southerly breezes produced general haziness, occasioned by the Kahuku eruption, the fume column of which could be seen dimly, and at 4 p. m. the sun appeared bright red. On succeeding days calm weather with some thunder and diffuse lightning was accompanied by much smokiness obscuring the view of Mauna Loa. The smoky atmosphere extended all the way to Honolulu, where it was said to fog the view of well known nearby landmarks. On October 9 the light from Mauna Loa was very bright at 8 p. m. and thereafter.

Progress of the Alika Flow. The writer visited the Alika flow at the road crossing on October 6 at 1 p. m. The flow on October 2 had made two additional short arms through the forest on the Kona or northern side, both of these crossing the road there and extending the damage already done. This made the actual length of roadway destroyed over 2000 feet. There had been tendency for the lava channel to narrow itself within definite banks, which were now about 40 feet apart, and this channel lay on the north side of the forested island, about which the flow had forked. From time to time overflows of the channel were still occurring, which added layers to the fields of rough aa on both sides of the channel and ocasionally these overflows came very suddenly and stampeded the bystanders. There were still occasional puffs from the ocean, but the continuous column of steam there had ceased.

The three features of the molten torrent which was rushing through the gorge at the time of the writer's visit, which were most impressive, were the noiselessness of the movement, the standing waves, and the rising and falling mechanism. It was now possible to walk out on the aa and stand on the river's brink. The stream was bright red, with darker blotches of rafted material, large and small, in the middle zone, and brighter incandescence along the banks. The uphill slope of the steepest part of the channel was here about 8 degrees and good-sized blocks of bowlders occasionally rode over the crest above and came down the middle of the torrent, riding easily, but sometimes surging from side to side and rolling over as though striking on the bottom. The largest blocks seen on this day were 10 to 12 feet in diameter. All along the course of the stream were standing waves such as one sees above a rapid or waterfall in a river where the irregularities of the bottom take effect in throwing the torrent into undulations. The effect in the lava stream was as though the bottom were everywhere at shallow depth, and perhaps itself shifting down hill at a slower rate than the liquid film on top. The distance from crest to crest of these standing rapids varied from 50 to 150 feet, and the crests themselves shifted somewhat and new undulations formed as the rafts came along and introduced irregularities interrupting continuity of flow.

The noise could hardly be heard at all until one stood on the hot brink of

the channel. There it was a slight swishing sound, which occasionally took on a deeper note at times when the lava was rising. It should be explained that the stream came over the brow of a hill above, down a steep glen to the flat shoulder of the mountain occupied by the road, then bent off in two straight stretches of slight grade, and disappeared below toward the sea over the brow of another slight rise. The channel was a canyon with the rushing lava generally 10 or 15 feet below the bank and in places much deeper.

The mechanism of rising, at the times when the deep rumble was heard, appears to be extended the whole length of the visible stream. The lava started to rise in the channel and in a few minutes it was brimming level with the banks, as though the whole mass inflated at once. There was no wall of added liquid advancing from above, nor was there any obvious damming and pooling to make the fluid back up from below. It simply rose with a rumble and it was an even chance as to whether it would overflow somewhere or not. As a matter of fact, on this occasion it did overflow at a point on the skyline down stream where there was a short tunnel in the streamway bridged over by previous accumulations. One of the party crossed this bridge to the northern side of the flow and returned without mishap across the still glowing aa lumps of the short-lived overflow. There was much disagreeable gas with the carbon iron smell.

The melt showed a granular texture. Rows of trees, fallen but not burned, lay on the edge of the lava fields adjacent to the forest. Much of the verdure was bleached but not completely burned. Here and there the aa lava showed smooth continuous surfaces, and the stranded raft blocks were frequently rolled into ball form and exhibited layers of material which they had accumulated from the bottom of the river by rolling over and over.

After seeing the marked differentiation between the liquid lava in the channel and the evident semi-solid matter of the channel bottom and sides, this being the material of the rafts and of the still glowing lava fields covering hundreds of acres on both sides of the channel proper, the writer surmised that there were here present two kinds of magma, just as in Halemaumau. There we have the sharply differentiated lake magma and bench magma. The one flows rapidly and keeps molten through the heat of its contained gases; the other becomes half congealed, but remains mobile, owing to the porous crust which acts as a heat insulator. The islands which have appeared in the Halemaumau lakes as upraised pieces of the bottom differ from the rafts in the Mauna Loa flows only in that the one is very slow and the other is rapid; the one is produced by slowly shifting weights of crust in a pit, the other by rapidly shifting torrents rolling up and rending the substance of bottom and banks. The explanation of the dominant aa in the Mauna Loa flow is a different matter, difficult of elucidation, dependent on complex gas expansions and perhaps also peculiar oxidations of the iron in the melt.

Second Expedition to Source Rift. The itinerary of the second Observatory expedition to the Mauna Loa source rift was as follows; the route following the trail through the Kahuku Ranch from the south. Left Observatory at Volcano House P. O. October 8, 1919, 5:10 a. m., in automobile; arrive Kahuku Ranch gate 7:30 a. m.; left gate with pack train 9 a. m.; camped at forest edge approximately 7 miles southeast of flow source 3 p. m.; October 9, left camp 9 a. m., tied horses 11:30 a. m. at aa flow; started on foot 12:45 p. m., crossed lava flows westward, arriving rift source 5:45 p. m., making bivouac for the night; returning October 10, left bivouac 7:20 a. m., arrive horses 12:20 p. m.; leave the aa flow locality 1:15 p. m., arrive camp 4 p. m.; October 11, break camp 9:30 a. m., arrive Kahuku gate 2:45 p. m.; arrive Observatory by automobile 6 p. m.

The party on this occasion consisted of Mr. and Mrs. T. A. Jaggar, Dr. and Mrs. J. R. Judd, and the guides, Charles Meinecke and George Campbell. There were four pack animals and six riding horses in the train. The motive for the trip was to collect gas with vacuum tubes, to make reconnaissance of the Kahuku route, and to obtain new data on the progress of the eruption. It was hoped that by camping farther south than in the first expedi-

tion a way over smooth lava might be found for riding animals leading closer to the source rift; this effort failed, and the walking was even longer than on the first occasion, October 1. Otherwise the method of approach was much the same, crossing the upland on foot from the east. The camp ground, at elevation approximately 6000 feet, was near a good spring in a meadow to the southwest of the old aa flow called Pohaku Pohina, and near the forest reservation boundary. This was reached by the Kahuku-Kapapala trail, skirting the eastern lobes of the 1916 flow through koa forest, much of which was burned, and crossing three stretches of old aa flows beyond by a wellmarked trail.

On the afternoon of October 8 occasional distant rumbles of the fountain vents could be heard. In evening the lighted fume column was magnificent and later in the night the glow illumined a rippled cirrus. The wind was easterly and light and the weather good.

Riding northward October 9 we quickly left the timber, passing one fine speciment of silver-sword, standing about four feet high, and noting a pair of Hawaiian wild geese which seemed very tame. We followed the eastern margin of a rough brown aa flow which stood as a wall from 10 to 20 feet high, and finally penetrated a bay of this flow, tying the animals there. After making a flag station on top, we pushed on foot across this and other flows toward the source fume which lay on the left of the distant Red Cone of the first expedition; the course was west-northwest. A wide stretch of smooth lava was found which should have been reached in the first place with the horses, an old Hawaiian trail with many ancient rock shelters crossing this pahoehoe. This smooth ground appeared to extend to the timber southeast. The walking beyond was difficult as a fog of rain came on at 2:15 p. m. and we steered by compass N. 75° W. across aa and shell pahoehoe which broke in under foot. The light wind was southeast and the fountains were not noisy enough to be heard at this time. Fortunately the clouds rose and the Red Cone appeared ahead with the scarlet gashes of the old rift zone cones east of it. The fountaining was quite inaudible even to the eastern foot of this cone ridge, as this happened to be a quiet spell. The fresh red cindery aa of the last stretch was the most difficult walking of all, then came the crossing of the lava channels, one of them 20 feet deep and 50 feet wide, with steep sides. We passed around the north side of the Red Cone and sighted fountains at 5 p. m. A crevasse was crossed, 3 to 5 feet wide, deeply riven in solid rock; this and other irregular cracks in broken ground making the rift zone which extended up Mauna Loa and was here a mile wide on the east side of the 1919 vents.

We moved in close to the fountains, which were spouting along the whole line of cones much as on October 1, and at 5:45 p. m. made a first bivouac at the wall of broken rocks 700 feet from the active vents of the middle group which in the vicinity of the "growler" of October 1-2 were now strongly fountaining, but not at first overflowing on the eastern side. The activity of the week had built up and changed the outline of the several cones and ramparts. The eastern side of the Alika crater was now 150 feet high and the fountains inside shot up irregularly 50 to 100 feet above the rampart, less continuously than on October 1, and more on the north side, where the outer wall was now 40 feet high with a large flaming hole at its base outside and another in the small cone a few feet farther north, these pots being 3 to 5 feet in diameter.

The cauldrons of the middle zone showed increasing energy during the evening, throwing up geyser jets of pumiceous fountaining 200 to 300 feet high, and sometimes subsiding to growling and exploding activities which made deep thudding detonations. A northern high pot of this group was full of lava overflowing its lip sluggishly to the northwest, and also to the east, with bursts of flame through the crust on top. The largest pool here also started overflowing in spurts to the east and southeast, much as on October 1. These overflows at first were overfloodings of the rampart, which became sufficiently incessant to keep a puddle idly pushing its edge southward on the east side of the rift ridge, while the whole fountain-

with double swirling and spurting as though the heat had started a small tornado which caught up the surface fluid. One branch current near the south edge of the fiery swamp escaped in a more definite channel and joined the Alika stream, the effect being like the distributaries and "cut-offs" of a flooded river delta. The granulated surface of the Alika river appeared aa, but all the visible hardened lava near the source crater, so far as could be determined by the bright light of the volcanic fires, appeared to be pahoehoe. At this time, from 7 to 8 p. m. October 9, there was not the slightest sign of any diminution of the Alika flow. In fact, on this afternoon at the road crossing twelve miles below, there were overflows of the borders of the Alika channel which caused visitors to run for their lives.

The flow to the south, toward Honomalino, which we had watched forming the previous week, by overflow of the east flank of the middle zone or "growler" group of cones, was now solidified and cool over most of its course and buried under deep beds of cinder along the base of the main lake rampart. Here a glowing crack was found where the cinder which filled it was red hot—a useful camp fire for making tea and drying clothing. The outer edge on the east of this flow belt was higher than the depression at the base of the rampart, as though the former flow had somewhat drained out the middle part of its channel.

This fact determined the course of a new flow of the same character, which developed rapid progress by 11:30 p. m. The fountaining and overflow at the middle group of cones by this time had vastly increased, and the noise had changed from a mild roar like the surf on a rocky coast, to a loud thunderous pounding, with much deep rumbling along with splashing sounds. The fountains of the middle cone were now beating down and wearing away their own ramparts and extensive golden floods poured over in a steady torrent, making surges in the crater pool which piled forward to the east and south and pushed the new flow in an ever-increasing river southward along the sag at the base of Alika cone rampart. Here the flow bent eastward and sent a front 100 yards wide out into an old aa channel which was there, and thence the flow pushed towards the south-southwest and disappeared into the distance, burning bushes and making side lobes, and in general moving on the east side of and parallel to the night flow of October 1-2. The new flow continued all night.

The middle fountains increased in violence and height until the whole series of vents there became one gigantic line of geysers with maximum jets estimated 500 feet high at about 4 a. m. October 10. At the same time the former main lake, or Alika Crater, went entirely out of action so far as could be seen, though the Alika channel continued its stream.

With reference to the location of the summit of the Alika crater-cone, considered as about the middle of the 1919 rift, I am indebted to Mr. J. W. Waldron for aneroid readings made this same night on a cone one-half mile south of our location. This cone at summit his aneroid made 7700 feet, the same instrument giving 6750 at summit Puu o Keokeo on same date; true elevation Puu o Keokeo is 6870.2 by the government survey, making aneroid correction +320 feet. This would make summit of Waldron's hill 8020 feet, corrected reading. This hill could not have been over 100 feet higher than the summit of the Alika cone of 1919, which in turn was 150 feet above the general old ground level. Deducting 250 feet from 8020 gives 7770 feet as ground level at Alika Cone. The constructed summit of the Alika Cone would thus be at elevation 7920 above sea-level. The distance of the Alika Cone from Puu o Keokeo can only be approximated by angles read with transit from the Kilauea observatory on the smoke of the eruption, and by estimates made by eye. Estimates based on time of walking, in such ground, are wholly unreliable. Until Government surveys are made, the position may be provisionally stated to be five miles N. 10° E. from Puu o Keokeo.

Before midnight the flow on the east side began to burst through its western edge and send tongues in the direction of our bivouac. The line of fountains extended for a length of 400 feet through all the cones and pots of the middle zone, the southernmost of these

making a torrential downpour which accumulated below in high rhythmic surges of the pond that overran the crater edge and so fed the flow; no single channel was formed. The surges filled the saddle and certainly overflowed westward also. The long rampart of the Alika Cone now stood dark and quiet against a background of fume, but there was glow beyond from the western flows. The flow on the east side moved steadily but not rapidly, and its surface bubbled, flames shot through the bubbles, it showed foundering crusts, its borders made toes of pahoehoe, and its motion was most rapid where the flow bent eastward in a kind of cascade. The new side lobes were spreading from south to north on the east side and our bivouac was hemmed in between a very rough aa channel of old blocks and the widening flow. We retreated across the aa to higher ground 200 yards farther east, and finished the night there.

On the north side of the active cones one of the vents was overflowing both west and east, and the eastern trickle here moved northward, making the accumulated pool of lava on the east side of the spilling vents a source of flowing both northward and southward. This north flow dwindled later, but the main fountaining continued strongly all night. The quality of the fountaining was frothy, just as before, the falling materials light, the shredding of the upjets very marked, and the concentrated force in a smaller area made the intensity much greater than on October 1, and the fountain jets were higher. Four-hundred-foot jets were common. In the early evening explosive rocket jets from one of the vents threw out some blocks which were like heavy aa and as much as nine inches across, but this was exceptional. No earthquakes were felt but the deep explosions of the "growler" in the early evening made concussions. The fume glow was red, the fountains in daylight were bright scarlet; at night they appeared yellow at the base and red in the trajectories and the fume above was salmon-colored. The flames were variously red, copper green and bluish.

About 9 p. m., in order to collect gas, I took vacuum tubes of 300 cubic centimeters capacity, and on attempting to reach the live flames of the northern cones found it necessary to cross to leeward of fresh flows making gas and heat which were both insupportable. The gas was quite different from the smoke of the south rampart, which had been suffocating in volume but still somewhat tolerable with the aid of a wet cloth over the nostrils. The northern gases were not visible; they had no odor except the foundry smell, but they corroded the eye tissues and gripped the lungs so as instantaneously to stop all breathing. A wet cloth produced no improvement whatever, and there was no possibility of crossing this gas belt and surviving, unless with an oxygen helmet. Accordingly I went to windward of the vents making this gas, thinly steaming hot cracks in live flows about 100 feet east of the north rift zone. The cracks had a temperature estimated 300° C. Two tubes of gas were successfully collected, breaking the tips at a depth of one foot within the crack, getting the sharp hiss reaction of the vacuum, and sealing with paraffined rubber caps, and later by fusing the glass. The insuck drew in rock powder as well as gas, and water immediately condensed on the interior of the tubes when they cooled. The samples should serve to indicate the general quality of the Mauna Loa gas, characterized by the carbonaceous foundry smell and producing the peculiar asphyxiating and enervating effects which have been described.

It was evident that we had chanced to witness an important crisis when the Alika Cone stopped functioning, for the Alika flow stopped the next morning, October 10, as reported by the guards at the road-crossing.

In the very early morning hours of this date there was some low fume drifting from the northwest which was disagreeable. At daylight the middle zone fountains and their flows continued and the Alika Cone remained dead. The great fume column above the fountains rose high in still air, drifting in a cirrus band showing flat wavy ridges far to the east overhead. There was a continuous shower of pumice during much of the night, before and after daybreak, some of the fragments one inch in diameter, light

greenish gray in color. These lapilli fell two miles east of the source, frequently with drawn-out threads of Pele's hair attached, and this material must have fallen for scores of miles to the west during ordinary daytime trade-winds. We had good weather on the return and during most of the trip. The concentrated fountains of the middle zone were both noisier and higher than the distributed fountains of the previous day, for we could see them five miles across country high above the Red Cone, and could hear them far down in the Kahuku ranch lands, when we returned to the ranch gate on October 11.

Seismometric Records.

The instruments of the Whitney Laboratory, at the Observatory near Kilauea crater, registered seismic movements as follows for the fortnight September 27 to October 10, 1919.

For the week ending at 8 p. m., Friday, October 3, there were local earthquakes at 10:04 a. m. (feeble), September 27 and 4:35 a. m., September 30 (slight but well defined). A slight distant earthquake was registered 11:23 p. m. October 2. Spasmodic microtremor was mostly slight except for a few strong spasms September 27 and October 1. Harmonic microtremor was moderate to strong. Microseismic motion was slight. Tilting was notably stationary, with some north tendency September 29 and 30.

For the week ending at 8 p. m., Friday, October 10, local earthquakes were registered 7:48 a. m. October 5 (moderately strong); 4:13 a. m. October 6 (slight); October 7, 3:40 a. m., 5:36 a. m. (feeble), 1:46 p. m. (slight), 5.40 p. m. and 5:44 p. m. (both feeble); October 9, 4:25 a. m. (slight), 6:40 a. m., 10:26 a. m. (moderate), 12:30 p. m. (slight), and two other slight disturbances; October 10, 2:20 p. m. (feeble). A teleseism was registered at 2:45 p. m., October 9. Spasmodic microtremor increased from slight, to slight with occasional strong spasms after October 6. Harmonic microtremor was moderate and microseismic motion slight. Tilting was irregular and stronger than before.

October 18, 1919.

The combined activity of Mauna Loa and Kilauea together in pouring forth lava appears to have reached a culmination during the week ending October 17, though the fluid rush of lava to the ocean on Mauna Loa by the Alika channel stopped on October 10. Thereafter the fountaining of the source vents shifted northward in the Mauna Loa rift and the north crater of the series became the dominant one, with five or six other vents of the middle and northern zones rivalling it, the outpourings spreading across the upland to the west and invading the forests of Papa, Kaapuna and Opihihale, threatening more damage to cattle lands. Ultimately the flow of this later group which went farthest was in Kaapuna, and this stopped four miles east of the Kona highroad. The fountaining continued strong, with some jets rising over 400 feet occasionally. Several parties have visited the source region.

The situation in South Kona created by this uncertain condition of the lava menace above, was critically dangerous for the inhabitants, and made sharply evident the need for good topographic maps. The government contour maps on large scale are finished in some of the islands, but not in Hawaii, and should be completed at the earliest possible date. The sequence of eruptions on Mauna Loa 1914, 1916, and 1919 points to a period of unusually strong activity, especially as Kilauea keeps up high pressure and increasing overflow. Such sequences on former occasions have led to great crises of lava flow and earthquake, and the warning in the present instance should not be disregarded. In view of the menace to plantations, harbors, ranch lands, and settlements, and the presence of a National Park in the midst, it would seem that the least which can be done is to provide adequate and accurate maps of the land. There were no such maps for *any* of the land invaded by the eruptions of 1914, 1916, and 1919, and this Bulletin has set forth that fact on each occasion.

In Kilauea crater during the week ending October 17, there was continued increase of overflowing of the northern floor, compensated somewhat by continued slight sinking of the Halemau-

mau bench lava, the floods originating, as for months past, from vents of the Postal Rift area a few hundred feet north of the area of Halemaumau proper, and travelling through tunnels of their own incrustations to emerge as upwellings and outskirt tricklings two or three miles away, following the western and northern wall valley of the greater crater. The lava lakes of Halemaumau have changed but little, showing an adjustment to the flowing mechanism. Halemaumau has been making much smoke, and much fume rises from the Postal Rift region.

The seismic activity which began last week to be pronounced and in accord with the development of the Mauna Loa eruption, culminated on October 14 in a total of eighteen shocks in one day, registered seismographically at Kilauea Volcano. Thereafter the frequency of local shocks declined, but there were still from seven to fourteen quakes per day, mostly slight, though occasional earthquakes of wide amplitude demonstrated an increase of seismic intensity, the seismograms giving evidence of distance of earthquake centers accordant with the general distance of the Kahuku rift. No strong earthquakes have been reported from the base of Mauna Loa since the September shocks; four shocks were recorded as felt at Hilea between October 11 and 17, lasting each from one to three seconds, of intensity from No. 2 to No. 4 of Rossi-Forel scale, and of gradual development.

I. Activity of Kilauea Volcano.

Measurements of the week at the Observatory have shown at Halemaumau subsidence of the south and northeast pressure ridges by about one foot and a stationary condition at the west and north rim stations. The interior bench magma blocks adjacent to the lava lakes have subsided 4 feet on the west and south, 3 feet in the middle region, and 1 foot on the north. The ridge of fresh lava over the Postal Rift source region outside of Halemaumau and at the origin of the flow showed a lift of about one foot.

Saturday, October 11, at 11 a. m., the fume from Halemaumau was moderate and the lakes lower than on the previous day. Rocks were falling along the wall crack of the northeast ridge. The south pond was quiet, the main lake 30 feet below its bounding northeast wall, streaming was to the east, and three grottoes were in fountaining activity toward the south and southeast. In the north lake two grottoes were fountaining along the southwest border, the liquid 4 feet below the bank in general. The Postal Rift source cones continued their usual activity of subterranean fountaining and flowing, under flaming and fuming openings.

After nightfall the fountains of the north lake were visible from the Observatory, the flow on the Kilauea crater floor continued bright, and its filling under the north part of the Uwekahuna bluff had nearly submerged the locality of gypsum crystals, a white-stained patch at the base of the cliff which had long been a familiar landmark. Tongues of the newer flowing had made out eastward across the April flow area.

October 12 at 4 p. m. there was little change at Halemaumau. The main lake was high with eastward streaming, the east cone wall-cracks were noisy, the northeast wall valley appeared lower, and the north lake was one foot below its bank, showing border fountains, one central fountain during a sinking spell, and with it the usual bright edge revealed. A flaming dome had been built at the northeast corner of the north lake. The windows in the Postal Rift source cones were on the north side of the northern cone and the south side of the southern cone, the northern one revealing the fountains boiling up in the chamber below, the southern one the lava river flowing off in its tunnel to the west. There was much sulphur stain all about these cone vents. The fume from Halemaumau was not dense.

October 13 showed little change in Halemaumau, but in the evening the great flood under Uwekahuna was much increased in general brilliancy, as though swollen and incandescent all over, and especially bright under the north corner of Kilauea crater. Fountains in the north lake were still visible in the distance.

On October 14 in the evening Halemaumau was less luminous and the

Postal Rift flow was much less vigorous in its movement and brightness than on the previous evening.

On October 15 at 11 a. m. there was evidence of slight increase of subsidence of bench magma blocks, this movement by very gradual stages having been in progress since September 25. The gas pressure, however, remained high and the flowing strong.

The east cone crevasses were now wide and impassable, and the rumbling and flaming along them had shifted a few feet northward. In the south pressure ridge there was no notable change. The south arm pond was bright at night.

The main lake had four vigorous fountains around its east pool; the surface was hot and covered with thin skins moving rapidly eastward. A new cove had been built by collapse in the cliff of the east bank, the floor, however, covered with rampart and overflow material. The south island appeared lower relative to the lake. The inner bench around the lake stood 4 feet above the liquid, and back of that the cliff blocks stood 15 to 25 feet high.

The north lake was within two feet of overflow along its northwest bank and its crusted surface was slowly cracking and foundering. The dome on the northeast bank was sulphur-stained and had lost its flaming gas pressure. The marginal bench around the north lake had slumped considerably towards the east and north, showing a distinct downward bend between the southeast portion still standing high, and the bank on the east side. Back of the northern marginal bench the floor block occupied by the transit shelter in August now stood about 12 feet high.

The southwest lake had narrowed somewhat, the liquid standing 8 feet below the western margin and the cliff blocks standing from 15 to 30 feet above that. Streaming was toward the south and east and there was a grotto at the north border. The general outline of the pond was unchanged, an L-shape with the two arms pointing northeast and southeast. The west pond, depressed in the bench on the angle side of this L, was crusted over and smoking, showing two small inactive pots.

Under the Postal Rift source vents the fountaining and flowing liquid was 15 feet below the orifices, and the cone at the northern window appeared smaller, while a new spatter heap had formed by lava splashing out towards the north. The bright yellow and white accumulations of salts were increasing. Both the lava lakes and flow were brighter in the evening, and the latter more in motion than on the previous night.

On October 16 at 6 p. m. there were heavy fumes at Halemaumau. The south pond was covered with crust slowly heaving, and a glowing gas vent hissed at the south bank. The main lake was mostly crusted, with some eastward current showing, border fountains, and inpouring to a tunnel at the northeast cove The north lake appeared sinking, stood 7 feet below its bank and showed border fountains. A banner of flame 8 feet high played over one of the Postal Rift orifices. The rumbling and hissing at the east cone cracks were loud. The flow after dark showed glowing puddles over its surface and moderately rapid progress.

On Friday, October 17, at 10 a. m., the fume was rather dense, no motion could be detected in the slopes of the pressure ridges, and the liquid lava showed high gas pressure and rising. The south pond was now a circular pool with heaving crust, and a strong hissing and flaming gas vent open in the face of the large south grotto dome. At the south wall-crack cone locality there was an open break which was steaming with the inner half of the cone broken down and lowered. In the main lake the liquid stood 4 feet below the inner rampart, streaming was to the east and a spatter dome was building on the southeast. The east cone crevasses continued glowing, flaming and rumbling. Here and farther around to the south the ring of bench magma inside of the wall crack had sunk from 10 to 15 feet during the last three weeks.

The north lake was again high, standing 3 feet below its east rampart, and the northeast dome was again flaming and blowing through cracks above a large active grotto inside. There were other border fountains, the center of the lake was covered with skin, and the gas pressure was strong.

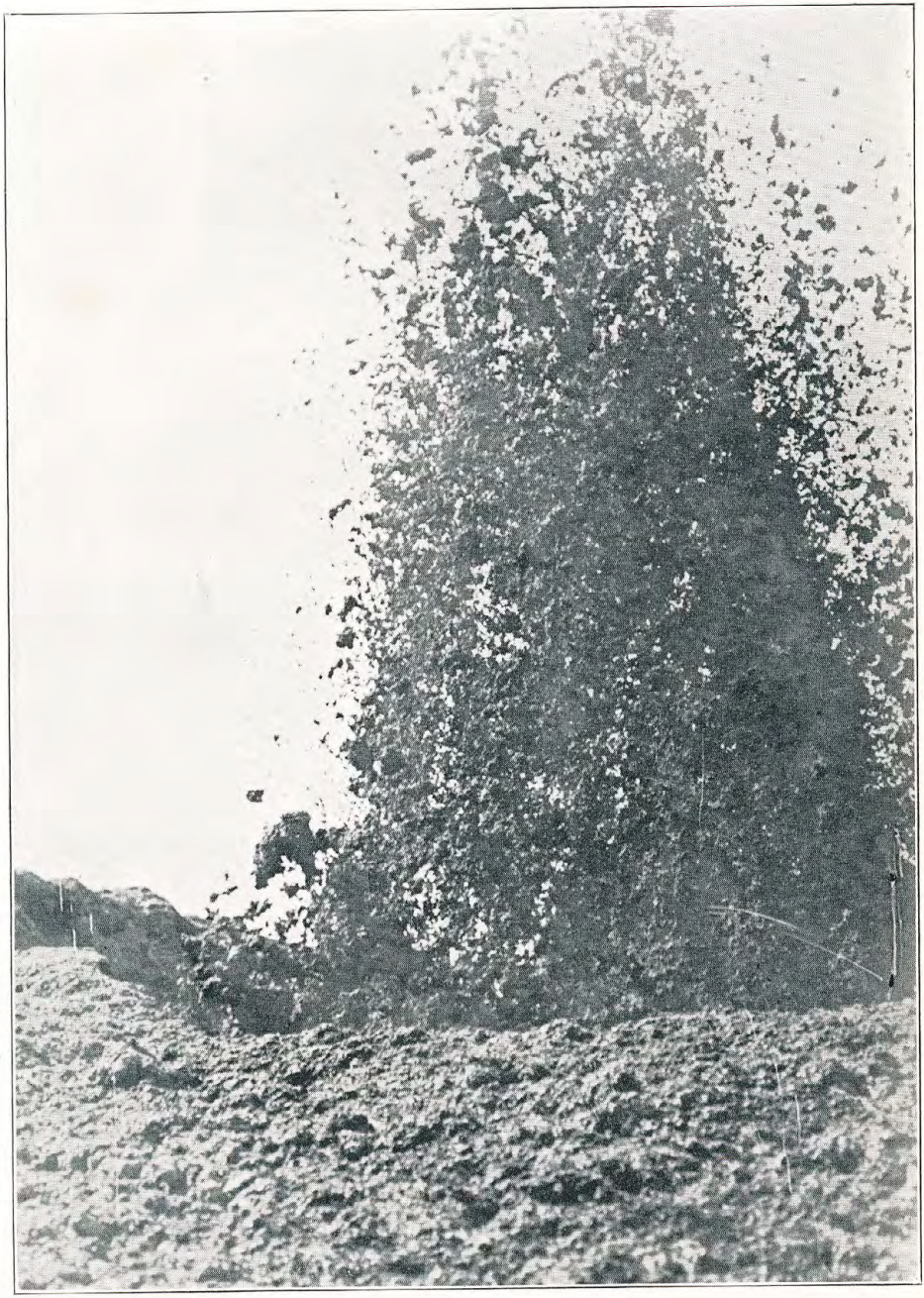
The southwest lake had recently overflowed its western bench and was streaming toward a grotto at the tun-

422 (VL 285)

Mauna Loa Rift-Source from the East. Oct. 1, 1919.

Alika Lava Flow, looking upstrea m—road crossing. Oct. 6, 1919.

579 (VL 348)



Lava Fountain 50 feet away. North Crater. Oct. 25, 1919.—Photos, Jaggar.

nel leading to the central pond. The west pond was a small round pot, with a violently hissing gas jet under the wall west of it. Both lakes and flow were high and bright in the evening.

II. Activity of Mauna Loa Volcano.

On the night of October 11 the light from the Kahuku fountains was bright. On October 12 Mauna Loa was smoky. On the night October 13-14 the smokiness cleared up and in the very early morning the fume column and source glow over Kahuku were as bright and sharply defined as at any time during the eruption.

At 7 p. m. on the evening of October 15 a clearing after rain with easterly wind revealed the Mauna Loa fume column extraordinarily bright, with a band of diffuse light on the left of it as seen from the Observatory, equivalent to a length of at least 3 or 4 miles southward from the fountain source. There was an occasional puff of vapor in this bright zone, quite removed from the fume column over the fountains. Waiohinu and Kaalualu also reported seeing this bright glow and new fume seemingly south of the fountain locality. Hilo, owing to the atmospheric conditions, reflection from high clouds and very clear air, saw very brilliant glow, and much excitement resulted.

Telephone advices stated that cattlemen from Honomalino reported continued upland pooling of a wide flow to the north of the Alika flow. There was extreme nervousness in South Kona at this time, owing to uncertainty concerning the exact direction of slopes and guiding ridges, as no accurate topographic map of the details of this country was available.

It is probable that the extreme brilliancy on this night was occasioned not only by atmospheric clearness, but by an actual culmination of intensity in fountaining and flowing, October 14-15 being the time of very pronounced seismic maximum for the whole eruptive period, as registered by the instruments of the Observatory.

October 16 produced excessive noisiness at the source region and a flow spreading in the direction of Papa and invading the timber. This occasioned great uneasiness at Honomalino ranch, causing the manager's family to move from the ranch house to a dwelling on the roadway. This flow, however, shortly came to a stop. A party which visited the source reported five fountaining vents.

On October 17 Honomalino ranch reported two branch flows, with fronts just below the timber line, to be moving very slowly, in the region between Papa and the Alika flow. The noise had greatly diminished but the flow was bright.

Some earthquakes of wide amplitude registered at the time by the seismographs, were not felt at Honomalino, and none of four strong ones registered October 16 to 18 was reported at Hilea. The distance of earthquake centers indicated by the seismograms was from 27 to 32 miles; the horizontal distance from the Observatory to the Kahuku rift fountains is approximately 32 miles, and to the upper explosion vents of September 26, twenty-four miles.

On October 17 T. C. White of Kona went to the source rift by the Kaapuna trail, making the journey in six hours of horseback and forty minutes of walking. Six fountaining vents were in action and maximum height of fountains was estimated at 300 feet. The dominant crater was the north cone, the bowl estimated 200 feet in diameter. Four live flows were found, two towards Opihihale, one towards Kaapuna, and one towards Papa. Streams of lava poured rapidly from the source vents, but the velocity was described as soon dying out when these streams mingled with the slowly-moving lava fields farther west, which were described as spreading out over the country. The Kaapuna flow at this time was 8.5 miles from the road, the Opihihale flows 13 miles from the road, and the Papa flow had its front only 3 or 4 miles southwest of the source rift. The fronts of the Opihihale flows were by aneroid 350 feet, and the Kaapuna front 1300 feet below the elevation at the source cones. The progress of the live Kaapuna flow was estimated at less than a quarter mile per hour.

III. Seismometric Record.

During the week ending at 8 p. m. Friday, October 17, 1919, the instru-

ments of the Whitney Observatory have registered local earthquakes as follows:

Oct. 11, 1:00 a. m.—very feeble.
1:50 a. m.—very feeble.
2:15 a. m.—very feeble.
5:35 p. m.—very feeble.
6:06 p. m.—slight.
Hilea reported an additional slight shock at 7:45 p. m.

Oct. 12, 10:25 a. m.—feeble.
10:40 a. m.—very feeble.
10:50 a. m.—slight.
11:48 p. m.—very feeble.

Oct. 13, 11:25 a. m.—feeble.
3:30 p. m.—very feeble.
4:00 p. m.—slight.
6:15 p. m.—slight.
6:30 p. m.—slight.
6:48 p. m.—feeble.
9:30 p. m.—feeble.
Hilea reported an additional moderate shock 7:15 a. m.

Oct. 14, 12:15 a. m.—slight.
4:20 a. m.—feeble.
4:25 a. m.—feeble.
6:48 a. m.—very feeble.
6:52 a. m.—moderately strong
9:20 a. m.—feeble.
11:24 a. m.—very feeble.
1:40 p. m.—feeble.
1:50 p. m.—feeble.
1:52 p. m.—slight.
2:10 p. m.—feeble.
4:47 p. m.—feeble.
11:03 p. m.—very feeble.
11:06 p. m.—slight.
And three other small disturbances.
Hilea reported an additional moderate shock at midnight.

Oct. 15, 8:28 a. m.—moderately strong (felt).
10:20 a. m.—slight.
11:10 a. m.—feeble.
1:35 p. m.—very feeble.
3:40 p. m.—slight.
7:01 p. m.—very feeble.
8:40 p. m.—very feeble.

Oct. 16, 4:15 a. m.—very feeble.
5:25 a. m.—very feeble.
7:20 a. m.—feeble.
7:30 a. m.—feeble.
7:40 a. m.—feeble.
9:00 a. m.—strong.
9:05 a. m.—slight.
11:17 a. m.—very feeble.
2:50 p. m.—very feeble.
3:35 p. m.—slight.
5:30 p. m.—very feeble.
6:40 p. m.—very feeble.
8:20 p. m.—moderately strong.
8:25 p. m.—very feeble.

Oct. 17, 8:18 a. m.—very feeble.
5:40 a. m.—slight.
8:05 a. m.—feeble.
8:35 a. m.—slight.
8:30 p. m.—feeble.
8:35 p. m.—feeble.
11:25 p. m.—moderately strong.
And three other small disturbances.
Hilea reported an additional weak shock at 9:03 p. m.

A very weak teleseism was registered at 1:35 a. m., October 11. Spasmodic microtremor throughout the week was moderate to strong. Harmonic tremor decreased during the week from strong to slight. Microseismic motion was slight. The ground tilted strongly to the east and north October 11 to 14, recovering slightly thereafter.

October 25, 1919.

During the week ending Friday, October 24, 1919, the measureable changes of the Halemaumau lava column were various, with a rising on October 18 and a sinking after October 22, both of the movements being small. In general the nature of the activity at Kilauea was quite unchanged and the flow pouring across the greater crater to the north and filling there against the wall continued unabated. On Mauna Loa the activity of the middle and northern craters of the rift continued to produce floods of lava pouring over the high land of western Kahuku and upper Kaapuna, the flow in the latter district reaching to within 4 miles of the Kona highway. The seismic record showed a decline in numbers of shocks registered daily, though individual local earthquakes had greater intensity than before.

I. Activity of Kilauea Volcano.

Measurements for the seven days ending October 24 showed a rise of the southern and eastern pressure ridges by about two feet on October 18 and a settlement of like amount thereafter. There was slight rising also of the

Halemaumau rim rock northeast and west, but the north station appeared stationary.

The inner crags of bench magma rose from 2 to 3 feet in the center of Halemaumau October 18, and sank 4 feet after October 22. This movement of subsidence was stronger than the preceding rise and affected the marginal bench magma as well as the central blocks. A similar movement of rise and fall was detected in the Postal Rift flow ridge north of Halemaumau.

On Saturday, October 18, there was pronounced rising of the lava column as indicated above, and this was responded to by the lakes and by the Postal Rift flow. The lakes in the evening were fountaining vigorously and the north lake could be plainly seen from the Observatory. So strongly was the gas pressure increased at the flow sources that a bright surface flow broke out in the slope of the new lava heap northeast of Halemaumau and streamed toward the Uwekahuna wall. Everywhere in the northern stretches of the flow there was increase of bright surface oozing, indicating a marked spurt in the flowing of liquid lava following upon the spasm of uplift of bench magma.

On October 19 there was reaction from the rising spell of the day before, shown by increased smoke, stationary bench magma, and a more sluggish condition in the flow. The lakes were fountaining very brilliantly in the evening.

On October 20 at 3 p. m. the main lake was streaming eastward from the central channel in a riverlike band covered with festooning skins, and at the northeast cove heavy crusts lay like elephant hide over the melt beneath. The inner bench around the lake stood 3 feet high and showed fresh construction all around. The cliff at the northeast corner stood 15 feet above the lake.

The south pond had built a grotto dome on its northwest side where the fountaining activity was strong, as also at the large south grotto dome. In both places stalactite curtains had formed across the ovens where the domes face the pond. The pond stood one foot below the marginal bench most of the time, but during a sinking spell it went two feet lower and developed central fountains.

The gulch extending out to the lake shore from the east cone region appeared more sunken, and the live cracks at the east cone and farther north were flaming, rumbling and smoking excessively. In the north lake a large continuous central fountain was in action, and four large border fountains; there was a flaming cone on the north side; fresh spatter ramparts gave evidence of the recent high level of October 18, as did also fresh overflows across the north and northwest ramparts. The central crevasses in the high ground south of the lake were fuming densely.

The openings at the Postal Rift source cones continued their bright flaming, the northern one over noisy fountains in the chamber beneath, which appeared higher and nearer the surface than before. The southern orifice showed steady streaming towards the southwest. Outside of the northern window, on the ground there were clusters of bright yellow sulphur needles on strands of Pele's hair and small spatter fragments, and sulphur patches had greatly increased all around the source region, emitting much sulphur odor. One strongly fuming sulphur patch lay a few yards south of the original source cones. In the evening the Postal Rift flow was moderately bright and the north lake was high.

On October 22 at 3:30 p. m., the lakes continued high, the fume moderate, the two grottoes of the south pond were in action and all of the eastward currrent of the main lake appeared to bend northward into the northeast cove. The north lake was crusted over and quiet, 3 feet below its banks, and the source cones of the flow continued their activity.

On October 23 at 1 p. m. the fume was denser and the lakes were lower, the sinking being marked just after noon. In the southwest lake there were four border fountains. Rocks were falling on the inface of the south ridge, giving evidence of subsidence of the floor beneath. Three vents were rumbling in the eastern ridge cracks. Three fountaining grottoes were active in the main lakes and the north lake stood about 7 feet below its banks. The south

wall-crack cone was visited and found quietly fuming.

On October 24 at 1 p. m. it was evident that the lakes had risen and subsided again within the twenty-four hours, for there had been overflow from the main lake around both sides of the south island. That some subsidence was now in progress was shown by falling rocks at the northeast ridge. There were three border fountains in the main lake and four in the north lake. The postal Rift flow continued its progress vigorously.

II. Activity of Mauna Loa Volcano.

On the evening of October 17 Honomalino reported that three tongues at the margin of the upland flow area had penetrated the upper timber between Papa and Alika, some 8 miles from the road. The roaring noise from the fountains had diminished but the light continued very bright. The flows observed were reported moving very slowly.

On October 19 about 1 p. m. the glow over Mauna Looa was seen very dimly from the Observatory and at daylight the fume column stood as usual over the brow of the mountain. From the steamer off the south point of Hawaii the rift region was seen to be marked by a bright glare over the fountains in the early morning hours.

On October 20 South Kona reported an extensive advance of the Kaapuna flow in the valuable cattle land of the On Tai ranch, invading the trail by which the White party had made the ascent. Two other lobes of the upland flow area were said to be in the higher forests of Opihihale. There appeared to be no marked diminution of fountaining activity at the rift source, according to the reports of several parties which climbed the mountain both from the Kona and Kahuku sides. It was evident from the reports, however, that the activity was confined to the northern parts of the rift.

Visitors to the rift from the northwest side during the evening of October 23 noticed a marked increase of activity with revival of the fountains of the middle zone, beginning about 11 p. m. Extensive creeping flows were moving westward and northward across the upland, with a front in the upper Opihihale land close to the Kahuku boundary. The writer visited the rift source from the Kona side, beginning October 24, his account appearing in the Bulletin of October 25-November 1.

III. Seismometric Record.

During the week ending at 8 p. m., Friday, October 24, 1919, the seismographs of the Whitney Laboratory registered local earthquake shocks as follows:

Oct. 18, 9:10 a. m.—very feeble.
1:14 p. m.—moderately strong.
3:20 p. m.—very feeble.
3:25 p. m.—very feeble.
4:15 p. m.—very feeble.
11:30 p. m.—very feeble.
And two other small disturbances.

Oct. 19, 3:50 a. m.—slight.
6:45 a. m.—feeble.
7:05 a. m.—feeble.
7:10 a. m.—slight.
12:10 p. m.—moderately strong.
2:35 p. m.—very feeble.
4:00 p. m.—very feeble.
8:00 p. m.—very feeble.
8:35 p. m.—very feeble.
And two other small disturbances.

Oct. 20, 3:55 a. m.—very feeble.
9:55 a. m.—very feeble.
11:30 a. m.—very feeble.
11:45 a. m.—feeble.
2:45 p. m.—feeble.
3:05 p. m.—feeble.
4:20 p. m.—very feeble.

Oct. 21 12:30 a. m.—very feeble.
1:02 a. m.—feeble.
1:25 a. m.—very feeble.
3:15 a. m.—very feeble.
9:20 a. m.—feeble.
9:50 a. m.—very feeble.
11:00 a. m.—slight.
12:23 p. m.—moderately strong.
2:45 p. m.—very feeble.
9:30 p. m.—very feeble.
Hilea reported an additional weak shock at 6:45 p. m.

Oct. 22 1:10 a. m.—feeble.
3:02 a. m.—very feeble.
3:15 a. m.—very feeble.
3:25 a. m.—feeble.
6:50 a. m.—very feeble.
11:07 a. m.—feeble.
12:40 p. m.—strong.

2:08 p. m.—very strong (felt).
7:00 p. m.—very feeble.
11:24 p. m.—feeble.
Oct. 23, 12:20 a.m.—moderately strong.
4:35 p.m.—moderately strong.
And one other small disturbance.
Oct. 24. 6:05 a. m.—feeble.
6:15 a. m.—feeble.
12:30 p. m.—slight.
1:12 p. m.—very slight.
3:35 p. m.—very feeble.
3:40 p. m.—very feeble.

Spasmodic microtremor was characterized by strong spasms throughout the week. Harmonic tremor was moderate. Microseismic motion was slight. Tilting of the ground in the east-west azimuth was to the east, becoming excessively strong October 22; the north-south component fluctuated, but was northerly during the excessive eastward movement.

November 1, 1919.

During the week ending Friday, October 31, 1919, Halemaumau continued to exhibit fluctuating lava lakes and stationary bench magma with strong flowing from the Postal Rift vent, unremittingly filling the northern part of Kilauea crater with wide sheets of glowing lava. The only new feature of the fortnight at Kilauea was the tendency to pulsation up and down of the lake lava from levels of overflow of benches to depression 10 or 12 feet below benches, all within the course of single days.

The eruption on Mauna Loa continued its progress, in general diminishing, but with some increase October 25 and 26, marked by revival of the rift vents of the middle zone and by increased frequency of earthquakes registered at the Kilauea station. The only effect of this was to add some volume to the plateau, floods on the west side of the source rift, these fields of lava tending to stagnate at the western brow of the upland, where the steep forested slope above South Kona begins, and to keep widening northward on the ground nearer to the source. This mechanism accorded with the tendency at the rift to clog at the south end and develop activity northward; and it accorded also with the tendency of the flows from the beginning of the eruption to be most voluminous and elongate at first through Alika westward to the sea, and then to make progressively shorter westward arms from sources progressively northward from the Alika source-cone, so that the map of the flow-covered area presents a step-like shortening of flows from Alika through Kipahoehoe, Kaapuna and Opihihale.

Thanks to the generosity of Dr. J. R. Judd and Mr. John Guild, who equipped the expedition, the writer was able to make a third trip to the source rift from the Kona side, camping there October 24 to 27, and this time remaining continuously at the actual base of the northern fountaining cone, and securing surveys, photographs and specimens.

I. Activity of Kilauea Volcano.

Measurements at the Observatory for the seven days ending October 31, 1919, showed small and variable movements by less than a foot of both the bench magma blocks and rim stations of Halemaumau. The liquid lakes fluctuated strongly from day to day, the net effect at the end of the week being a rise of about 5 feet. The Postal Rift flow showed increase of volume, as measured by numbers of glowing puddles and toes, rate of outward spreading in area and height of the lava in the source tunnels.

On Saturday, October 25, at 1 p. m., the Halemaumau fume was moderate and the lakes higher and fluctuating rapidly. Streaming in the main lake was toward the northeast cove and there were three small border fountains. Small landslides were in motion at the northeast ridge. The north lake was only two feet below its northern and northwestern banks, and on the northwest side there had been subsidence of the bench blocks. The southwest lake was quiet and crusted over.

On October 27 at 1 p. m., there was much rumbling and flaming in the eastern wall cracks and the strong fluctuation of the lakes was marked and movements sometimes of 4 to 5 feet vertically, both up and down, occurred within an hour. The north lake was now 4 feet below its banks. There was strong activity at the Postal Rift source cones.

At 1 p. m. October 28, the fume was thicker and there had been rock tumbles on the inface of the southeast pressure ridge. The central channel region between the southwest and main lakes showed evidence of subsidence. Smoke had increased from the wall-crack along the northeast ridge at several places other than the rumbling vents east and east-northeast. The lakes did not yet show subsidence, the eastward streaming and border fountains of the main lake remaned as before, and the banks of the north lake were only 2 feet high and contained four fountaining grottoes.

At 1 p. m. on October 29, however, the lakes also exhibited unusually low levels and were mostly quiet, the north lake standing 13 feet below its bank. The south arm pond appeared smaller and was crusted. The current in the main lake was into the northeast cove and there was only one border fountain. The three eastern and northeastern wall-crack vents were rumbling loudly, and the flow source maintained its ceaseless tunnel drainage.

On October 30 there was recovery from the low stage of the preceding day, and on October 31 at 5 p. m., the lakes were all up again and the adjustment of Halemaumau pit levels to the unending flow from the postal rift was resumed as for weeks past. The flow on the Kilauea floor was voluminous, with bright surface streams and spreading edges. There was glow in the south wall-crack of Halemaumau. The south pond was very brilliant with live fountains and a flaming chimney west of it. The main lake was high, with grottoes in its southwest and eastern banks, eastward streaming, and no change in the height of the benches and cliffs around it. The eastern wall-cracks noisily bubbled and flamed as before and hot sulphurous fume was rising athwart the trail across the northeast ridge, making the trail impassable; some bubbling noise was audible here. Fume in general was dense and abundant and had recently increased in the sulphurous region around the Postal Rift source vents and the covered tunnels extending northwest from there. The north lake stood 3 feet below its northern and eastern ramparts and these were newly veneered with spatter. There were live grottoes east, northeast and north, the latter with flaming holes in its roof, and the streaming was toward the northeast bank. No special change was noticeable in the gulch crevasses extending through the sunken and broken high ground south of the north lake. The boiling and streaming lava seen through the open windows of the Postal Rift cones stood somewhat higher than before, the greater depth of the stream producing much slower flow, estimated about 5 miles per hour. Possibly also other tunnels were carrying off the drainage.

II. Activity of Mauna Loa Volcano.

The third Observatory expedition, the equipment and transportation being furnished through the kind interest of Dr. Judd and Mr. Guild on behalf of the Hawaiian Volcano Research Association, was organized with a view to making record of the progress of events at the source rift by approaching from the Kona side, a route which experience had shown must be much more direct and easy from the inhabited shore belt than the Kapapala and Kahuku routes, which the writer had followed in the first two trips. Furthermore, the great anxiety of the South Kona ranchers continued, unrelieved by any complete information as to what was going on above. A visit to Kona, moreover, was desirable in order to secure records of the happenings there and for study of the Alika flow and its delta.

The itinerary was as follows: Sailed from Honuapo 11:30 a. m. October 22, inspected Alika flow from the sea 4 p. m., arrived Napoopoo 7 p. m. October 23 visited Alika flow from Kona side and made photographs. October 24 left Kona road at Kaohe at 7 a. m. horseback, with two pack animals, guided by James On Tai, Frank Coelho and McKinley Kaupu. Arrived 10:30 a. m. On Tai mountain house in Kaohe, elevation 5000 feet; left mountain house 12:30 p. m.; arrived ridge west of active crater 3:50 p. m. Here sent back animals and on foot reached camp northwest side of north fountaining cone 4:30 p. m., Jaggar and On Tai remaining in camp here until October 27. October 27 broke camp 9:45 a. m.,

arrived horses 10:30 a. m., arrived mountain house 1 p. m., arrived Kona road 4 p. m. October 28 chartered sampan from Robert Leslie, towing canoe, and in company with Captain R. V. Woods made landing at delta of Alika flow for collections, notes and photographs from explosion cone there; Napoopoo to Alika delta two and a half hours by sampan. Returned by steamer from Napoopoo October 29, arriving Honuapo and Observatory October 30.

The delta or ocean end of the Alika flow, as seen from the sea, fans out on a platform of older flows of the same sort with cliff faces above the water 15 or 20 feet high on the south side of the place where the Alika lava enters the sea, and 40 feet high farther north. The channel of the new flow extends up the bluff back of this platform at a high angle, and the aa on each side of the channel is there a narrow ribbon. Other flow channels of ancient date followed nearly the same course and are seen scarring the face of the mountain as black vertical bands extending upward into the forest zone and widening at the base of the steep elephant's-back slope into leaf deltas at the shore. The new flow is merely one more veneer 10 to 15 feet thick on top of the platform beneath and spreading out in plan into a lobate front about one mile wide. Most of this front is heavy aa which crept forward and in many places crumbled, rather than flowed, over the precipice into the water, making a visible talus beneath when the water was shallow enough. Only in the middle where the channel was, did the flow actually run liquid into the ocean, and this channel is marked by a gorge 25 feet deep and 20 feet wide just above the cone at the ocean contact. This cone, at the lower terminus of the channel was built by the steam explosions resulting from the incandescent torrent rushing into water, a crater being there formed, surrounded by a heap of black sand. This horseshoe heap was 75 feet high above sea-level, and the front of it had broken down on the ocean side, revealing a section of bedded sands over a rock wall beneath. The crater was not preserved, as the last hot flows of the channel had crept down into it after the sand eruption was finished, making a fill of aa with no definite channel extending to sea-level. On either side of the sand cone similar thin last flows had crept out over the sand, these being only 3 or 4 feet thick. These differed from the earlier flows in having no sand coating on top of them. It was evident by this arrangement that the last push of the flow at the sea end was a slow-moving aa which crept across the explosion products of the former swift stream, buried up their crater and reached the water at too low a temperature to make any explosions.

The sand cone protruded as a horseshoe-shaped ridge opening towards the sea, with steeper slope of 37 degrees on the crater side and a curved outer slope of 21 to 25 degrees away from the explosion center. The ring of upper rim had a diameter of 150 feet, highest on the south and half buried under flows at the north. The material was a black and rather fine lava sand, with hard crusted surface and smooth sweeping grooved lines following the slopes, which appeared to be the result of continuous even sliding of the coarser materials of the sand shower. This pattern was quite different from the rill markings due to water wash. There were a few scattered small lava fragments on the surface of the sand. Everywhere the sand was coated with a thin film of crystalline white salt, common sea salt, to judge by the taste, and this made the cone white as seen at a distance.

On the south side of the cone where large bowlders were mantled over with sand, there were open holes with hot vapor rising from below smelling of muriatic acid. On the borders of such orifices there were zones of solfataric incrustation, dove-colored, brown, cream, orange and yellow from within outward, ending in the pure white of the general surface. Probably these coatings were iron and lime chlorides. There was much more sandfall to the south than to the north, and the cone was higher on the south side, facts which showed that the prevailing wind had been from the north during the eruption.

The channel just above the cone was a gorge in very rough and heavy aa lava, through the cracks of which

bright red heat could be seen below and adjacent to these hot cracks were deposits of salts colored bright green and aquamarine. The bright green salts tasted like old brass and suggested copper. Much of the lava showed continuous rough surfaces like shark skin, with a flowering up through the cracks of rosettes or lumps of frothy hard aa. The specimens were much heavier than the rock of the flow 2000 feet higher up the mountain, just as that in turn was much heavier than the lava near the source rifts.

On the side of Hoopuloa south of the flow the vegetation was all scorched and brown for more than a mile, in contrast to the green tropical verdure beyond. A continuous sea cliff of old rock 20 feet high was here surmounted by new sand-coated lava 10 feet high. On the northern side the higher cliffs of old rock were also surmounted by thin flows which had tumbled over into the sea and built up talus slopes beneath. The southern cliffs showed no such talus, as though the water there were deeper. At the north end of the northern cliffs one of the flow lobes had poured down a gradual slope into the sea.

Inspection of the Alika flow at the highway as approached from the Kona side, showed two tongues of the flow across the road on that side, with short stretches of roadway between. Many fallen trees lined the side of the main flow. All was now stationary and there was little fume or odor, but here and there trunks of trees were still burning. What had been the channel gorge was now 20 to 30 feet wide, full of rough aa blocks, bearing no resemblance to the smooth stream lines and standing rapids of the lava when it was in motion. In this respect aa differs utterly from pahoehoe, the latter preserving when cold every detail of its appearance while hot. The aa shrivels and tumbles into lumps of every conceivable shape and size and leaves nothing but a scoriaceous chaotic field as record of its streaming. There were tree moulds in the aa, tubular spaces which had encased burning logs. Remains of the "rafts," the large blocks of bottom lava rolled forward by the streams, could be seen here and there on the surface of the lava field as immense half-buried bowlders showing signs of being built in concentric layers.

The recent history of the rift crater on October 23, so far as it could be interpreted from rumors in Kona, was to the effect that all flows approaching the road had stopped. A party which visited the source rifts October 21 had seen one high narrow fountain in the north cone and a flow in the upland running toward the southwest. A party which spent the night October 23 at the source reported only the north cone active in the evening of that day, but just before midnight the middle craters broke out noisily and were still in action when they left. They also saw strong flowing and spreading aa on the upland west of the source craters. Honomalino on October 23 reported loud noises like rumbling or cannonading, and while no live flows were any longer in motion in the upper Papa lands, smoke and glow could be seen in the upper forest farther north towards Kona and the wind carried burnt koa leaves from that direction which fell at Honomalino. The glows over the source region as seen from Kona were moderate reflection on high cirrus in the evening October 22, very bright flaring in the early morning hours October 23, and a very dull dark red glow on low clouds in the early morning of October 24.

The route up the mountain on the Kaohe land proved to be a well marked steep jungle trail over ancient aa lava, through ohia, fern, ieie, wild taro and finally koa in the high lands. The trail is straight and very direct. This slope has heavy rainfall and the trail is muddy. In the koa here the making of dugout canoes is still an industry and we saw several logs in process of canoe-making. The rough-hewn canoe is dragged with horses all the way down to sea-level.

After leaving the upper ranch house the trail follows fence lines until it emerges from the forest into bushy country. Twenty minutes after leaving this house (12:50 p. m.) we could hear the rumble of the source fountains. We left the timber at 1:05 p. m. and saw the fume cloud ahead. At 1:40 p. m. we reached a high wall of aa known as the Kukuiopae flow,and crossed this by a beaten trail. On the opposite side of

this flow we turned more to the east from a previous course southeast and followed old pahoehoe for two hours. Here we soon found ourselves travelling parallel to the front of a broad field of fresh fuming aa lava south of us, with glimpses of sluggish incandescent streams back from the front, one of these showing a cascade in a crook of the stream with black islets protruding through the falling melt. At 2:45 p. m. the fiery jets above the crater could be seen ahead and at 3:15 we reached a big crack with old but fresh-looking black glassy pahoehoe lava lining it and splashed out on both sides. This was the beginning of the rift belt on its western side, and from here on these cracks, often with cones and pits along their course, were common, the lines always trending in a general northeasterly direction toward the summit of Mauna Loa.

At 3:50 we dismounted at a ridge consisting of a long line of such cone accumulations with deep pits and impassable gulfs, and proceeded on foot, working our way across this rift and across aa fields beyond. A walk of forty minutes brought us to another line of cones which extended miles northward as a curious serrate profile. We camped near these cones and northwest of the active crater. Here we were at the edge of the live lava field of 1919, and 300 yards in front of us was the great northern cone with its fountains spurting 400 feet into the air and making the usual surf-like rumble. The northerly winds kept the fume entirely away from this side of the rift, and our camp was on moderately high ground a few hundred feet east of this last line of old rift cones and north of the hot lava fields around the base of the active cone. As we faced this cone we could see the middle crater beyond throwing up lazy flings of heavy lava, and still farther away and slightly to the right, the summits of the Alika cone could be barely discerned above the heaped-up flows which filled the whole area on the west side of the source rift. The camp ground was due north from this Alika cone, and northwest of the north cone. On our left (east) the rift line northward from the north cone exhibited no activity and little fume and consisted of only a few small conelets and sulphurous holes a foot or two in diameter. Farther east in the distance stood the familiar red hill, whence we had approached the scene in our expeditions of October 1 and 9.

In the evening there were spells of great increase in the intensity of the north crater explosions, the roar increasing and the jets spurting up 450 feet or more. The crater was an open horseshoe with a lava cascade 15 feet wide pouring from the opening northward, the lava immediately turning west and making a second fall before settling down into rather straight westward flow through a well defined channel. The highest part of the cone was its south side at the toe of the horseshoe where the summit was estimated to be 200 feet high above the general level of the old plateau land. The lava channel extended miles away to the west, a gorge within other lava spread out as hot fields on each side, these fields being themselves in motion and incandescent beneath the surface. The thickness of the lava fields may have been 40 or 50 feet above the old ground level close to the cones, thinning out to 4 or 5 feet at the edges of the field. So far as could be judged from inspection at a distance, the whole country to the west is covered with fresh lava for a width of several miles in a north-south direction. The lava field at the immediate base of the cones was rough pahoehoe with aa patches, and live aa toes occasionally pushed out from the edges of the field. Within a half-mile of the cones going west the lava became mostly aa, and beyond that it was all aa except for certain stretches where the stream channel had overflowed and made small patches of pahoehoe. The lava in the channel rose and fell from time to time, and was seen overflowing and building out a new lobe of the lava field about one mile west of the cone source at 5 p. m. At this time a great spurt of high fountaining was going on and the lava pond at the base of the fountains could be seen surging forward in its bowl and temporarily increasing the width of the outlet cascade. Later there was a reaction when the stream level lowered and a definite canyon was revealed all along the channel with

walls 10 to 15 feet high. Far to the west the lava channel made other cascades which at night made a very brilliant glare on the fume above. In that direction a loud detonation was heard during the evening, like a distant blast of dynamite. This was probably an explosion of gas in old caverns adjacent to the hot flow.

On this first night (October 24) the fume column rose into a great cumulus above, the wind was at first light from the northwest and later very light from the east. The only odors of volcanic gas which were noticed happened during this last spell of east drift, when the fume from the northern extension of the 1919 rift was wafted to the camp ground. This smelled of free sulphur and was not disagreeable. There were occasional light falls of small pumice pebbles at this time. The atmospheric conditions were evidently moist and favored the development of high rain clouds above the hot lava fields, for on subsequent nights with cold northeast wind and brilliant starlight in dry air, there was no high cloud whatever over the craters, and the fume rose as thin brown smoke, which blew off to leeward without any moisture development above.

On the morning of October 25 an excursion was made around to the east side of the rift line in order to compare conditions with what had been observed in the earlier stages of the eruption. The rift line is a distinct single crack trending south-southwest and the big cone craters are developments due to lava and gas rising through this crack since September 29. This development began with the southern or Alika cone and in the course of a month has deserted that end and built up the northern cone a half-mile away. This half-mile along the crack is the line which delimits the area of big fountains; north and south from this area the crack goes on for more than a mile in each direction and is marked by small cones which were formed at the beginning of the eruption before the big vents had opened to their full size. When these latter had quarried out holes apportionate to the explosive energy of the great gas fountains, the small vents sealed themselves, leaving lines of small conelets and driblet lava solidified on each side of the crack. In going around the north side of the north crater it was necessary to cross this crack, which one might have expected to be incandescent and full of noxious gases. Strange to say it was nothing of the kind, but merely a line of small holes one or two feet in diameter, with smooth black glassy pahoehoe on the sides, red stalactites inside, and some warm air rising and smelling faintly of sulphur.

Following the edge of the lava field to the east side of the north cone, some oozing toes of red hot aa were making out in places and then came deep beds of pumice fragments from an inch to a foot in diameter. The whole east side of the line of cones was covered deeply with this material over flows below. These east flows, which had been running when seen on previous visits, trending off to the south towards Honomalino, were now entirely dead. The line of cones was now a high ridge rising in places 200 feet above the surrounding country, banked up by flows and pumice for nearly half this height, the three main eminences of the ridge being big horseshoe cones north, south and in the middle, the southern one dead, the other two alive, and the northern one roaring, fountaining and flowing continuously. There were other smaller cones as features of the ridge. The lake of lava in the middle crater would fling up a fountain above its rampart now and then, and the horseshoe of this crater, which had opened southward so as to spill both east and west, was now sealed on the east side and its opening was to the west, not visible from the eastern slopes. The great north cone seen from the east side showed slopes 45 degrees above on the south profile, and about 27 degrees on the north profile, with a spur making out on this gentler slope to confine the torrent which was pouring northward. Over the high summit lip the fountains would fling their red crumbly fragments which poured down in an endless avalanche of fire on the steep outer slope. The wind on this hot surface set up small tornadoes lasting several minutes, moving along the slope, and picking up the light pumice in violent noisy whirls. The fountains

of the inner bowl, made by gas rushing continuously up through the lava lake, consisted of an endless succession of big jets, ever changing their direction and angle, and not necessarily vertical. The wind also affected them, making the heaviest avalanching of falling fragments on the side away from the wind, which was blowing from the north. There were two main noises, the deep rumble of the gas and the surf-like noise of falling, most of this last coming from the enormous showers inside the crater itself. The avalanches outside made distinct individual crashes. South of this cone in the saddle between it and the middle crater, there was a smaller cone emitting dense smoke.

Taking advantage of the long low spur on the north side, I climbed that slope in order to get an instantaneous photograph of the fountain by as close an approach as possible. It was necessary to clamber up through pumice knee deep and excessively hot. On the other side of the spur, which was the east end of the enclosing horseshoe ridge, lay the fountaining basin with its gigantic waves surging forward to the cascade outlet, and from under the back wall of this cup rose the geyser of fiery fragments 200 feet above the level of the top of the spur, the pieces bright red hot and very porous, from six inches to four feet in diameter. It was evident from occasional fragments on the ground still glowing, and from the incessant change of direction of the jets, that the nozzle might at any moment be turned in my direction, so that it required quick work to get to the summit of the spur, point and snap the camera, and get away without being bombarded. The sensation of incessantly looking up at that towering curve of rising and falling bombs, and calculating its angle, with the heat almost insupportable and the noise deafening, was an experience not soon to be forgotten. I succeeded, however, in getting to the edge of the inner declivity and taking a look down into the basin as I pointed the lens and discharged the shutter. It all had to be done in much less time than it takes to tell it, for a very few seconds of that heat would have ruined the camera. The far wall of the basin made a reflector for the heat, so that but for the wind at my back, it is doubtful whether I could have reached the edge at all. The interior of the basin was like a titanic open chalice of fiery liquor foaming in scarlet surges, these being impelled continuously forward by the geyser jets behind, the flood lifted by the jets losing its liquid aspect almost instantly, the expanding gas within the jet giving it the apearance of very loosely knitted worsted. The frothing surges were quite as liquid in appearance as any beaten foam and the mass bubbled and seethed, quickly quieting down to form black skins where the pond cascaded through the sluiceway leading to the flow channel. The nearest falling fragments at the moment of taking the picture were apparently 50 feet away.

Continuing southward past the middle crater, it became of interest to get a glimpse once more of the interior of the southern crater, whence had poured out the Alika flow prior to October 10. On October 9 I had looked into this crater and seen the liquid 15 feet below the rim. Crossing to the eastern flow channel without difficulty—it contained blocks of rough pahoehoe—I found the northern summit of the cone only 20 feet above the lava level outside, so much had that level been raised by piling flows. On climbing up, this summit was found to be the eastern lip of a large inactive crater 1000 feet in diameter and 300 feet deep. The opposite or western wall was much lower and the country beyond was all covered with fresh lava. A break in the southwest wall showed the channel of the Alika flow, the course of which could be traced in the distance. No flowing lava was to be seen. The bottom of the crater was smooth pahoehoe plastered over large balls which resembled the "raft" balls of the Alika flow. The southeastern and southern inner walls were high and nearly vertical. The edge on which I stood was traversed with cracks emitting scalding hot vapor. As this cone had been built up 150 feet at its southeastern rampart, the outer slope now being partially buried under outer accumulations, the inner depression now over 100 feet deeper must represent collapse, on the rift line, due to the eruption.

It was evident from the deep accum-

ulations of pumice, the avalanches from the north fountains, and from disagreeable gas which in the late morning was troublesome on the east side of the rift line, just as it had been on that side during former visits, that the wind at this season is here frequently a Kona sea breeze, or else a draught from the north rather than from the east. This is due no doubt to the fact that the 1919 crack is well over on the western side of the rift zone of this district, placing it really on the Kona side of the mountain so far as climate is concerned.

At 12:30 p. m. the "growler," one of the vents of the middle crater, started noisy detonations, followed by high spraying jets of lava and a gushing fountain which drained off to the west from the southwestern spur of the middle cone. This noisy display continued until 4:30 p. m., and there were recurrences later, the flow and new geysers from the middle crater continuing in action all night and longer. The fountain of the north crater gradually became less high as the other waxed in strength. The outflow from the north crater continued to fluctuate, the cascade widening occasionally as the pool above brimmed over its lip, but the black crusts carried over the cascade increased in number. The view at 6 p. m. from the high cone west of camp, which commanded a view over the top of the live lava fields, revealed a cascade sweeping down from the new fountains of the middle zone and making a new fiery river which extended a short distance westward parallel to and south of the main flow from the north crater. Another spurting and gushing vent had developed between the north and middle cones, low down on the west side, also feeding the lava fields to the west.

In the morning, October 26, the "growler" vent was quiet and both the craters were less vigorous than before. At 12 noon the middle vent became noisy again and made sounds like the rattle of musketry or at other times like a heavy locomotive. In the evening both the craters were flowing as on the previous night, but the north crater was obviously dwindling, the cascade outlet now only 10 feet wide, and once the inner wall of the crater was seen to cave in, leaving a bright red scar. Many of the north crater jets now barely overtopped the high south rim.

On this day exploration was directed to the west, and the north edge of the extensive lava fields was followed about four miles. The channel of running lava lay parallel to this edge, often less than 100 feet back, and carrying a stream which here and there spilled over to feed the north lobes of the field. The channel stream lost speed rapidly from east to west, moving 15 miles per hour near the source, 10 miles per hour at a conspicuous bend two miles west of the source, and 3 miles per hour at a point four miles west. The channel where first visited was about 25 feet wide and had walls standing 10 or 15 feet above the liquid. The stream made a mild rippling sound like running water. Farther west at the great bend it was only 15 feet wide, and had here dwindled since first seen in the distance on October 24. This place was a crook in the gorge where large rafts frequently jammed and were seen to block the current completely for a few seconds. Then the liquid portion would percolate through the cracks and disintegrate the rafts and the masses gave way suddenly, making a flood, which poured on through two forking channels below. The raft bowlders were red hot and cheesy, and were carried along and rolled over and over at varying speeds. The ground through which the main channel was grooved was very irregular, falling off in step-like terraces of craggy tumbled aa towards the north edge of the lava field, so that many details of flow could be seen from this front of the field, by standing on knolls of the older pahoehoe. The distributive forks of the channel were frequently brimming full of slow-moving liquid, dotted with granular black lumps marking the beginnings of solidification. At the front of the lava field lobes these forks either directly fed the movement of the front, or that front was creeping by a push from below, the rates being estimated at 200 feet per hour for the first case, or 2 feet per hour for the second.

There was a second parallel lava channel about a half mile back of the first one, more to the south, and its stream also moved west and fed the lava field. Behind it farther south

could be seen a fantastic wall of very rough aa pinnacles, estimated 75 feet high above the general level of the country. This southern channel was believed to be the one fed by the middle crater, and on this night that channel could be traced as a line of light from the source cone some distance westward, passing on the south side of two conspicuous ancient cones which stood as landmarks in the midst of the lava field a mile or so southwest of our camp ground. The main channel from the north crater, in its westward extension, passed to the north of these old cones.

At noon we stood on the edge of the steeper forested ground falling off to the western sea-shore, and four miles from the source cones. On our right was bushy upland merging downhill into koa forest. On our left was the lava field, its front trending east and west, a rugged tumble of aa 8 feet high, hot and occasionally crumbling forward and setting fire to bushes. Steam rose from old cavernous spaces along its front. Just 30 feet back from its front, there could be seen, by climbing a hillock or a tree, the sullen noiseless red river covered with rafts and black chunks, moving three miles per hour and spilling over its banks in places, and always spilling northward, sideways and in one direction. It was as though the river bed slid downhill sideways on the lava field of its own making. What was really happening, if one could have mapped the whole area, was a migration northward of the lava deposits of the distributing lava river system, just as a water river migrates sideways on its own delta. Somewhere downstream there was possibly forest burning, for at 10:15 a. m. we had seen soft clouds rising rapidly over hot air toward the west-southwest, and at night there was brighter glow in that direction.

Small explosions were heard in caverns; bushes burst into flame; a branch flow was found coming right out of the cracks in the ground, where a lobe had found access to an old tunnel; another poured into an old pit; numerous ancient cairns and stone shelters built by the natives here showed earthquike tumble, though similar artificial structures near our camp close to the source rift exhibited no such effects; much coal gas was perceptible due to the burning vegetation, but the flow gas was merely sulphurous and even the source fume not different from Kilauea. This was remarkable, for on October 9 the gases had been different, and often quite irrespirable. There was still much of the foundry smell. At many places the channels were visibly spilling over into new ground, always aa lava, and sometimes toes made out from under the older fields. A hot air whirlwind was seen in a patch of ohelo bushes, with rotation counter-clockwise, lasting several minutes. On returning to the great bend at 1:15 p. m. the channel flow was supplemented by new cascades pouring over the terrace, as though the liquid channel were pooled beyond.

In the evening, after return to camp, we found that the gushing of the middle crater had built out its western spur so as to cut off our view of its cascade, but its flow channel beneath on the flat was plainly seen, extending farther than the night before, and about a half-mile south of the north crater channel and parallel to it, corresponding to the second stream we had seen from farther west. These streams appeared to feed the same flow area, reaching down into the upper Opihihale forests. The lava field near camp was making many new toes, always creeping westward and northward. The whole western flow area was doing this, spilling and shifting its channels across a wide bushy upland of slight grade, and as long as this upland was available there was little danger for the lands below. No glow whatever could be seen in the extreme south where the Alika and Papa flows had been, and everything indicated that the south end of the rift was dead.

On this evening (October 26) the cones were more smoky and the fountains of both craters less high. The next morning (October 27) the activity was notably weakened. The cascade from the north crater was 10 feet wide and covered with black skins. Small flows were still glowing and moving. After leaving camp and starting back for Kona we noticed the flow spreading as on the previous day in the Kahuku upland and the Opihihale forest, but

no smoke was visible to the southwest.

From Kona on October 28 and 29 the source glow was not conspicuous. At 4:30 a. m. October 30, when rounding the south point of Hawaii, from the S. S. Kilauea the writer saw a single fume jet lighted from the fountain at the rift, and a dull glow west of it from the lava fields.

III. Seismometric Record.

During the week ending at 8 p. m. Friday, October 31, 1919, the seismographs of the Whitney Laboratory registered local earthquake shocks as follows:

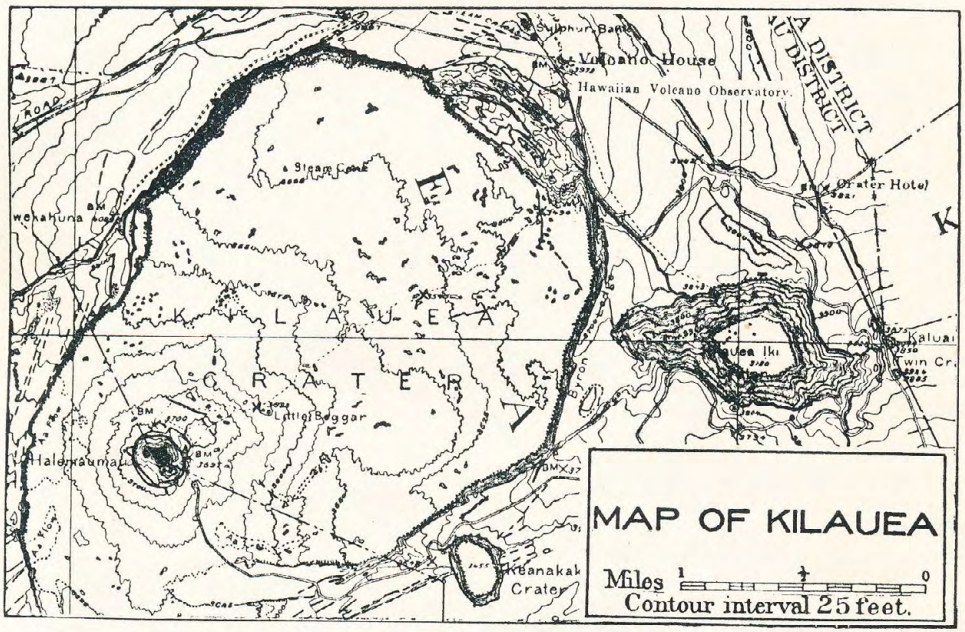
Oct. 25	7:03	a. m.—very feeble.
	9:48	a. m.—very feeble.
	9:57	a. m.—very feeble.
	1:20	p. m.—feeble.
	4:30	p. m.—light.
	8:00	p. m.—light.
Oct. 26	3:40	a. m.—very feeble.
	4:05	a. m.—feeble.
	4:18	a. m.—light (felt at Hilea)
	7:15	a. m.—light.
	9:58	a. m.—light.
	10:47	a. m.—very feeble.
	10:49	a. m.—light.
	12.48	a. m.—light.
	1:30	p. m.—very feeble.
	3:17	p. m.—feeble.
	6:00	p. m.—feeble.
	7:02	p. m.—light.
	8:10	p. m.—light.
	8:43	p. m.—light.
Oct. 27	1:30	a. m.—slight.
	5:17	a. m.—moderately strong.
	9:08	a. m.—very feeble.
Oct. 28	4:25	a. m.—feeble.
	2:07	p. m.—very feeble.
	3:25	p. m.—very light.
	6:35	p. m.—feeble.
	11:10	p. m.—light.
Oct. 29	5:00	a. m.—moderately strong (felt in Kona).
	6:45	a. m.—light.
	1:17	p. m.—light.
	1:19	p. m.—light.
	2:20	p. m.—very feeble.
	7:39	p. m.—light.
	7:43	p. m—light.
Oct. 30	3:45	p. m.—light.
	4:10	p. m.—feeble.
Oct. 31	4:10	a. m.—feeble.
	5:12	a. m.—moderately strong.

In view of the strong revival of earthquake frequency October 26, when the writer was in camp at the foot of the active north cone on Mauna Loa, it is remarkable that he felt no earthquakes during his stay of three nights at that camp.

Spasmodic and harmonic microtremor were mostly moderate during the week in question. Microseismic motion was slight. Tilting was north and somewhat east October 25-27, east October 28-29, west and south October 30-31.

Very respectfully,

T. A. JAGGAR, JR.,
Volcanologist.



HAWAIIAN VOLCANO OBSERVATORY.

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 solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	10000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the accelerations or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol α, or max. α, is given in the conventional unit of milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ. per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

U. S. DEPARTMENT OF AGRICULTURE
WEATHER BUREAU
CHARLES F. MARVIN, CHIEF

MONTHLY BULLETIN

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Hawaiian Volcano Observatory

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November 8, 1919.

During the week ending Friday, November 7, 1919, the effusive activity of Kilauea increased. So far as can be told by the evidence of distant glow and declining seismic motion, the Mauna Loa eruption appears to be drawing to a close. No glow has been seen there since November 5, but the cumulus billows over the Kahuku heated area continue to show. No more flows have penetrated the forests of South Kona.

Activity of Kilauea Volcano.

Measurements of the rise and fall of the crags and rim stations at Halemaumau indicate that the south and east old rims are stationary, but that the north and west stations have each risen about 1 foot. This rise was coincident with an upward swelling of the ridge formed at the source region of the Postal Rift flow of about 2 feet between November 3 and November 7. In the same interval the flow made a spurt of progress forward with rapid filling about the base of the northern cliffs of Kilauea crater, which represents a large volume of new lava poured out. The inner blocks of bench magma at Halemaumau generally rose about one foot and this movement was pronounced between November 5 and November 6, and was accompanied by strong rising of the lakes, amounting to at least 5 feet.

Recently the conditions at Halemaumau have indicated a continuance of the adjustment between the height of bench magma and lake magma which has been the characteristic of the place for many weeks past. This adjustment is dependent upon the continuous flowing of the Postal Rift stream, which since August has fluctuated but little. Consequently measurements directed to the summits of the crags around the lakes—really tabular blocks of floor—have shown an almost stationary condition, in marked contrast to the incessant fluctuation in height which was recorded before the overflows began. The rise and fall of the lava column at present, therefore, should be measured by the changing volume of outflow, a very difficult measurement to make as the flow is through tunnels and the front is a group of pools and fingering lobes. Moreover, as has been pointed out before, it is not known to what extent a real rise of the deep lava column is measured by the frothing mechanism of outflowing liquid lava charged with gas. Incidentally the Mauna Loa eruption has given further evidence of a very high gas pressure in the whole system, so that all that can be said quantitatively about the present height of the Hawaiian lava column is that it is rising and overflowing strongly.

On Saturday, November 1, 1919, at 11 a. m. the principal activity in the north lake was border fountaining against the northeast bank. Around the Postal Rift source cones there was much sulphur deposited and at the north end of Kilauea crater the flow was sending out arms rapidly in the direction of the Volcano House trail.

The topography of this flow was now divided into three parts: the source region was a closed-in heap of lava making a new ridge extending from the

western part of the old Postal Rift district northeast toward Uwekahuna bluff; the pooling region was a great field of semicrusted glowing lava filling the whole north end of Kilauea crater, north of the line joining the base of the Volcano House trail with Uwekahuna trig station; the flowing region was the eastern edge of this pool, which from time to time made new lobes tending to move eastward and encircle the Halemaumau dome, the longest lobes being near the base of the Kilauea bluffs.

The source region heap is traversed by several main tubes or tunnels all leading from a single lava chamber which can be seen through the windows, open flaming orifices, of the group of source cones. Here the lava wells up below with violent fountaining all the time, and from this chamber the tubes radiate. The chamber is under the summit of the heap; it began as a spouting crack which covered itself with lava crust, and is probably by now in the nature of a small pit housed in by its own accumulations. Each tube is created through the evolution of a surface lava channel, which begins as a flood, narrows to a river, then builds in its banks with overhang until the surface crusts across, and finally the stream under this crust becomes adjusted to its enclosing shell with a cross-section much like a railroad tunnel. The marks of the original streamways on the surface are obliterated by subsequent surface flows and this thickens the roofs over the tubes. It should be understood that all of this refers only to the characteristic smooth, or pahoehoe, lava of Kilauea, the rough aa of the Mauna Loa flows behaving differently.

The pooling region of this Postal Rift flow appears at night from Uwekahuna bluff like a lighted town. The surface is dotted with incandescent points wherever active flowing is in progress, and when these are examined by nearer approach they are found to be toes of slowly-moving pahoehoe, small surface streams with festooned middle zone and lobate front, or cracks swelling open from the pressure of lava beneath so that domes are formed whence lava oozes out or gas driblet cones are built up. The latter sometimes spurt and make small explosions, building spires several feet high. Along the base of the Uwekahuna bluff the flow has now filled to depths of from 10 to 20 feet, so that the ancient ash section south of Uwekahuna summit at the base of the bluff is entirely covered up, and also the locality farther north, formerly white with gypsum crystals. The flowing region differs from the trickling lava of the pooling region only in that it spreads out over new ground, whereas the other wells up through its own crust.

On November 2 there was in the evening very strong rising of the lakes so that the main lake overflowed into the south arm pond on both sides of the south island, and the latter was seen slowly to subside. The pit was extremely brilliant. A portion of the roof of one of the main tubes of the Postal Rift flow caved in 300 yards west of the source cones, making a brilliant source of light for illumining the fumes above. The surface flows showed long stems and fingering delta fronts and the flow was particularly brilliant along the base of the cliffs in front of Volcano House.

On November 3 Halemaumau continued to have high lakes and bright fountains. Much fume had developed both from Halemaumau proper and over the source tubes of the Postal Rift flow. The latter continued its vigorous spreading and brilliant surface outpourings, one long tongue with fingering front making out in the direction of the Volcano House trail so that its extremity was east of the line joining the Observatory with the center of Halemaumau. This tongue moved parallel with the northeast cliffs of Kilauea and a few hundred feet away from them.

On November 4 at 11 a. m. the south island, which had been a tabular crag separating the south arm from the main lake, was found to have sunk out of sight, buried under new crust made by overflow of the lake. There was left a flat peninsula jutting out from the southwest shore of the main lake and standing two feet above the lake. Around the southeast end of this peninsula was an open channel which restored the south pond as an arm of the main lake. There were active

grottoes in the south arm and northwest and west of the main lake, one of these being curtained. The central pond was still shut off by an isthmus of crust from the main lake. The streaming was northeast and southeast.

The east cone cracks were flaming and rumbling. The north lake stood 10 feet below its rampart and a group of perpetual fountains was in action under the gulch southeast of it. Ballooning skins tended to form here. There was fountaining on the northeast side of the lake and a curtained grotto with long stalactites had formed on the north bank.

The fume on this day was somewhat thinner. The sulphur patch south of the source cones of the Postal flow had developed incandescence and driblet lava, in the form of a ball about a foot in diameter, covered with small hissing gas mouths. Seen through the window of the south cone at the Postal Rift source the flow appeared rapid, perhaps 11 miles per hour. The new pit 300 yards farther northwest was visited and an orifice 10 feet in diameter was revealed in the side wall of the subterranean tube showing the flow inside of bright orange color, 15 feet wide, streaming north about 7 miles per hour.. The pool region of the flow continued brilliant and the eastern arm made progress.

On November 5 everything at Halemaumau continued brilliant with the flows showing marked increase of volume. There were two bright openings now in the tunnel roof northwest of the Postal Rift source. The fountains of the north lake were now continuously visible from the Observatory.

On November 6 the fume over Halemaumau appeared slightly less dense. At 5 p. m. there was an active gas vent at the edge of the south arm, the east cone cracks rumbled noisily, the main lake had eight border fountains and the north lake was nearly brimming and showed five border fountains. The gulch extending from the northeast cove to the north lake had been increasing in size by collapse and slight subsidence was indicated near the northeast edge of the north lake. Hot cracks were extending themselves east of this lake. The new driblet ball of the sulphur patch was increasing in size and hissing loudly, this noise being heard at times at the Observatory.

On Friday, November 7, at 10 a. m. the lakes were found extraordinarily high. The southwest lake had encroached upon the crag east of it and had freshly overflowed its ramparts and into the west pond depression. The streaming in the southwest lake was westward to grottoes southwest and west, an unusual condition. A partition continued to divide this lake from the central pond. The cliffs around the lake were 5 to 15 feet high. Occasional sinking spells lowered the lake surface from one to three feet.

The west pond was covered with piled circular upwellings of lava crusted over, and gas spiracles on top of this heap were flaming and hissing loudly at intervals.

The north lake was high and recently had overflowed its ramparts. The lava was pounding in the northeast grotto. A column of dense fume rose from the central crevasses. The main lake was very high, streaming to the east, its inner bench freshly built up, encroaching on the cliff blocks. Of these the northern one appeared to be tipped down on the lake side. The central pond appeared unusually high and through the gorge one could see to the southwest lake. The south arm had been overflowing into the depression southeast of it and the large grotto dome which has been a landmark on its bank for many weeks was found half-buried under fresh bench accumulations. On the south side this bench was built across a chasm 3 feet wide, this crack extending well below lake level.

The east cone cracks continued their bubbling noises and everything indicated a strong rising movement. At the south sulphur patch of the Postal Rift source the new driblet cone had grown until it was 4 feet high and its hissing and flaming continued. In the source cone cupola the lava boiled high and flowed rapidly. The northeastern tunnel from this center could be traced on the surface by hot stained cracks and thin blue fume. The pit already described west of the source was found supplemented by another break south of it with an opening facing west, showing the whole lava torrent 15 feet wide

flowing rapidly northward under an overhanging shell of cavern roof standing 10 feet above the liquid. Still farther to the northwest nearer Uwekahuna another break had formed in the roof of the tube 6 feet in diameter, revealing a perilously thin shell only 8 inches thick. This led to a part of the tunnel which was 25 feet high and 20 feet wide with the lava river pouring through it in a meandering curve at a rate estimated about 5 miles per hour. These breaks in the roof of the tube probably mean a lowering of the stream level inside, but this may be occasioned quite as much by a fresh outlet from the pooled area to the north as by any diminution in supply from Halemaumau. Surface indications of fume and stain appear to indicate that there is another tunnel leading directly north from the source cones.

Activity of Mauna Loa Volcano.

The fume column and glow over the Kahuku rift of Mauna Loa continued as strong as ever apparently, up to Monday, November 3, inclusive. On the night of November 4-5 the fume column could be seen, but the glow was slight. Thereafter for two days the weather was rainy. On the morning of November 8 a large cumulus cloud could be seen. Smokiness is reported from Kona, but not any glowing radiance.

Seismometric Record.

In the Whitney Laboratory of Seismology for the week ending at 8 p. m. Friday, November 7, 1919, four local earthquakes have been registered as follows: 5:35 a. m. November 1 (very feeble); 7:50 p. m. November 1 (light); 7:56 a. m. November 3 (feeble); 5:03 p. m. November 6 (very feeble). This is a marked decrease from the earthquake frequency of mid-October when the Mauna Loa eruption was at its height. Spasmodic and harmonic microtremor have both been moderate to slight and microseismic motion slight to very slight. Movements were pronounced to the north and slightly east November 3, with recovery to the south and west during the remainder of the week.

November 15, 1919.

The week ending November 14, 1919, has apparently brought an end to all visible evidence of the Mauna Loa eruption, and the Kilauea center of volcanic activity has so increased its floods across the floor of the greater crater as to overflow the main trail leading from Volcano House to Halemaumau. This arm moved eastward from the pool in the north part of the crater, the flow thus executing an encircling movement following the Kilauea walls. The bench magma of Halemaumau has been nearly stationary, and the lake magma sank somewhat, this movement being accompanied by a swarm of ten feeble earthquakes November 11 to 13.

I. Activity of Kilauea Volcano.

Measurements have shown the Halemaumau rim to be stationary on the east and north and lowered about one foot on the south and west during the seven days ending November 14. The inner floor blocks have been stationary west and south, and lowered one to two feet in the central region. The lakes sank five or six feet beginning November 11. The ridge at the Postal Rift source has continued to rise about one foot.

On Saturday, November 8, the high levels continued and the flow remained voluminous. In the afternoon the pooled area in the northern part of Kilauea crater was putting out very rapidly a long glowing tongue of glassy bluish pahoehoe towards the Volcano House trail, and this arm advanced all the evening in the direction of the bridge where the trail crosses the 1889 crevasse. At 10 p. m. a fall of rocks was heard, perhaps at some crack in vaded by the flow. After midnight in the early morning hours of November 9, a noisy blowing cone formed on a swollen tumulus of the flow under Uwekahuna Bluff, and for hours this was belching and making gobbling noises and explosions, so as to build two spires of driblet lava.

November 9 at daylight the flow was seen to have crossed the trail about 100 feet south of the crevasse bridge,

and at 9 a. m. the flow was over 100 feet east of the trail. In general this tongue was a long narrow arm some 50 feet wide from the pooled area eastward. The arm was inspected and photographed at 3 p. m. It was flowing all around the edges, a sheet two to three feet thick of glassy heavy pahoehoe with bluish iridescent surface, rather rough, and making large transparent glass blisters in places. There was strong foundry smell and no such sulphurous odor as characterizes the flow nearer the source. In places the liquid was cascading into deep cracks, the walls of which would shift and tumble and snap, and some remote sounds were heard which resembled underground explosions in old caverns.

At Halemaumau at 5 p. m. the fume was moderate, the lakes high, and a brisk flow of lava poured under the tunnel windows of the Postal Source. The crack extending from the north tunnel window was covered with spatter lava.

The north lake was three feet below its bank, streaming towards the northeast grotto, and active gas vents were numerous through the ramparts. The main lake had numerous border grottoes, the current being to the east, with one sluggish branch toward the northeast cove and a very swift branch through the strait leading into the south pond. There was some falling of rocks on the inface of the northeast ridge with loud rumbling in the wall-cracks at the middle of the ridge and at the east cone.

At 11:30 a. m., November 11, all the lakes were notably low but the fume appeared slightly thinner than usual. Rumble in the east cone and the northeast ridge cracks was less loud, both groups of openings giving heat, fume and stain. The main lake stood eight feet below its inner bench, the latter overhanging at the end of the peninsula which protrudes between the main lake and the south pond. The surface of the lake was hot with thin skins, the current streaming out from a glowing tunnel under the floor which separates the central pond from the lake. In the larger pool of the lake the current divided to north and south. The northeast cove had increased in length northward by breaking back into the depression there. The bench at the east cove had slumped greatly, leaving wide crevasses north of it.

The north lake stood five feet below its bench, with general fountaining and not much streaming. A pit had formed in the bench east of the north lake rampart and fuming whitened cracks extended back from the lake in this direction. Looking south at the profile of the cliffs on the south side of the north lake they show a dome curve bending up sharply from east to west, but falling off suddenly to a lower level at the region of the central gulches. The southwest lake stood five feet below its inner bench and both this lake and the west pond heap were very smoky.

The long crack extending northward from the northwest station was again opening, as in June, to a chasm three feet wide in places. The driblet spire south of the Postal Rift source cones continued its hissing and there was extensive fuming all about and much deposition of white salts. The various openings of the flow tunnel showed the rapid lava stream as before, with slight increase of enclosing crusts.

The pool area of the flow in the north part of Kilauea crater on November 10 and 11 was slightly diminished in brightness but its extension past the Volcano House trail continued to make progress in numerous lobes towards Byron's and Waldron's Ledges. This flow had crossed and filled up portions of the 1889 chasm. A second arm of the flow was making out eastward from the pooled area at a point farther south than the arm which crosses the trail.

On November 12 at 8 p. m. the north lake was very high, with all its fountains in full view of the Observatory, and the flow was brilliant, with its arms pushing eastward rapidly. In the night times of both early morning and late evening the cone on the floor tumulus under Uwekahuna Bluff was streaming brightly and occasionally spouting, and showed growth in size.

On the morning of November 13 the lakes continued low, there was much smoke and the flow continued to progress. There were no marked changes on Friday, November 14.

II. Activity of Mauna Loa Volcano.

On the morning of November 8 a large cumulus rain cloud of ordinary form stood over the hot Kahuku source region above the south slope of Mauna Loa. No glow had been seen for two nights previously from Kona, Kaalualu or from the Observatory. South Kona reported no more flows advancing in the forests. On the afternoon of this day the sun shining through a western cloud veil was whitish and not red, in marked contrast to the blood-red effects observed when the Mauna Loa fume was rising.

At 6 p. m., November 9, there was cumulus over Kahuku and a smoking place was observed farther up the mountain slope, but not so high as the vent of September 26. There was no glow after nightfall, though the cloud could still be seen. In the very early morning of November 10 the mountain slope was perfectly clear and no glow whatever was discernible.

On the morning of November 11 there was a well developed cumulus cloud over Kahuku which showed some tendency to mushroom form, but there was little evidence of any smokiness. On November 12 and 13 even the rain cloud over the hot area ceased to form, the mountain profile was perfectly clear and not a trace of glow or localized cloud development was thereafter seen.

III. Seismometric Record.

Local earthquakes of intensities respectively 4, 5 and 1 Rossi-Forel, and lasting 10, 15 and 3 seconds, were reported at Hilea in the southern part of the Island of Hawaii at 9 a. m. November 11, 12 noon November 13, and 3:30 a. m. November 14.

In the Whitney Laboratory of Seismology local earthquakes were registered as follows for the week ending at 8 p. m. November 14, 1919: November 11, 8:42 a. m., slight; November 12, 9:17 a. m., 9:27 a. m., 9:32 a. m., 9:53 a. m., 10:40 a. m., 12 m., and 6:44 p. m., all feeble; November 13, 11:52 a. m., slight, 3:49 p. m., feeble. Spasmodic microtremor was moderate with increase in numbers of spasms during the earthquake swarm of November 11-13. Harmonic microtremor was slight throughout the week and microseismic motion also slight except for some increase November 8. Tilting was strongly to the east and north until November 14, when it recovered slightly to the south and west.

November 21, 1919.

During the week ending November 21, 1919, the gas pressure at Kilauea crater, taking effect in increased volume of outflow, has augmented so that on November 20 the flood not only surcharged the cones and tunnels of the Postal Rift area, but caused the lakes of Halemaumau to rise and overflow suddenly. This increase of outflow at Kilauea immediately follows the cessation of outflow on Mauna Loa, and in contrast to the collapse of 1916, the present situation seems rather to augur a growing pressure. This pressure reached a high value at Kilauea in August-September, a culmination disrupting Mauna Loa in September-October, and now a Kilauea revival following upon the clogging of the Mauna Loa vent. If Kilauea keeps up its voluminous discharge without any collapse as in 1916, the implication would appear to be that the eruptive period of the whole Mauna Loa-Kilauea system which began in 1914, has not yet reached its climax. It is too soon, at present, however, to assert that a strong collapse may not still be in preparation, the condition of Mauna Loa being somewhat doubtful, and the effervescence of Kilauea ambiguous with reference to the movements of the deeper lava column.

Just as in the case of previous weeks, the measurements of the Halemaumau floor crags have indicated slight subsidence, in spite of the voluminous rising and overflowing of the lake magma. The marginal ridges, east and south, were slightly up by less than a foot during the seven days ending November 21, and down by about one foot at the west and north stations and at the ridge above the tunnel feeding the Postal Rift flow. The bench magma subsided about one foot in the region between the main and north lakes. The lakes showed spurts of rising during the early part of the week and on November 20 rose and overflowed so as

to make a net rise of not less than 15 feet at the time of maximum flooding.

On Saturday, November 15, at 4 p. m., there was much dense vapor from recent rainfall, but the Halemaumau fume was moderate. In the main lake the streaming was eastward, with branches into the northeast cove and south pond; there were two border fountains and an active gas vent in the south pond grotto. The north lake stood eight feet below its bank and had two border fountains and one central fountain. The wall-crack fissure of the northeast ridge continued to open and cause rocks to fall and there was slumping still in the region between the main and north lakes.

Eighty feet west of the Postal Rift source cones a new collapse over the flow tunnel showed the torrent in motion only four feet below the surface rock. At the front of the main flow near Byron's Ledge the lobes had spread backward to the west so as to cross the Volcano House trail for a second time, and small trees were burning at the foot of the cliff trail. Small underground explosions could be heard from time to time where the flow gases mixed with air in caverns.

At 11 p. m. on November 16 the cracks at the east cone were rumbling, there was slumping about the central crevasses, the central cliff block between the main and north lakes was lower, but the lakes were relatively high. The main lake had recently overflowed its banks northeast, east and south and the central pond floor west of the main lake showed fresh layers of overflow. The streaming continued eastward with very symmetrical currents diverging north and south in smooth curves at the northeast cove and at the south pond.

The southwest lake stood four feet below its west bank; its surface was crusted and the west pond was smoky. The north lake had overflowed its northwest cove extensively. There were new spatter heaps at the east border of the main lake and at the north and east borders of the north lake. The general situation indicated lower central bench magma and higher lakes.

In the Postal Rift source cones the flow lava had risen, partially sealing the orifice of the northern window and leaving a hissing flame vent. In the southern window the surface of the flow was only 10 feet down and rushing rapidly. In the new pit next to the east the torrent poured from under a crust and through the cavern beyond in a westerly direction at a rate estimated 12 miles an hour. The next two openings farther to the northwest were unchanged, but a short distance beyond disclosed a new pit leading down into the lava tunnel. This pit was 12 feet in diameter and revealed the subterranean river 20 feet wide, with a shore cavity on its north bank full of tumbled stones, all heated cherry red. The fifth opening, where the underground channel bends under Uwekahuna, remained unchanged, a thin shell above an incandescent tunnel 20 feet deep, with a broad stream moving slowly and majestically around an abrupt U-curve to flow off to the north on its underground way.

A visit to the cones on the northwest side of Kilauea crater, reached by walking over the surface of the live flow, discovered them to be a number of high swollen domes with driblet spires built by the lava oozing through summit cracks. There were no more tunnel openings in this direction, and apart from puddled moving lava in various places, the flow had crusts three or four feet thick and was extremely substantial in spite of the riverways below. The highest of the domes stood some 10 feet above the general level and was covered with spatter droplets of wormy basaltic glass, indicating the viscous character of the lava ejected on the night of November 8 and later. The normal pahoehoe of all this part of the flow, down the middle fields of the northern pooled area, showed no unusual texture and the live liquid puddles were common glistening flow lava without the bluish iridescent or sharkskin texture. The gas rising from the tubes below had dominantly the odor of sulphur. All of this was in marked contrast to the blue lava of the foot of the flow at the Volcano House trail with its foundry smell.

On November 17 and 18 the lakes were very high, so that the north lake fountains were almost continuously in view from the Observatory. Kilauea crater was never so brilliant at night within the memories of the last twenty-five years. The five bright pits leading down to the big source tunnel were

rather evenly spaced to the right of Halemaumau as seen from the Observatory, each with a flaming orifice lighting fumes above, a miniature of the pits occupied by the lakes, which crowned the eminence to the left. All the foreground was a brilliant filagree of fire with ever-changing lines and streams of orange light, covering hundreds of acres across the whole northern third of the crater floor between Uwekahuna and Byron's Ledge. The flow had by now flooded the bridge on the trail and partially filled the 1889 crevasse.

On November 19 at 11 a. m. the fumes were moderate and the lakes rising. The inner benches of the eastern lakes were four to six feet high, and the rapid eastward streaming poured in swift currents into the south pond and northeast cove, where there were fountains. A break in the crust at the northeast cove showed a rapid current under the bank. The north lake stood seven feet below its rampart and was quiet except for two border grottoes. Rocks fell occasionally at the northeast ridge.

The new southern Postal Rift cone had built itself up during a spouting period at 5:30 p. m. November 18 so that it was now a large black structure seven feet high, with small flows which had poured from it into the depression east of it. A truncated cone had been built up at the first break in the flow tube, and in this cone a sluggish current could be seen joining with rapid currents which poured on each side so that all cascaded into a single tube at a lower level. The other orifices of the tunnel showed the usual volume of flowing lava.

On November 20 at 11 a. m. Halemaumau was found flooded with fresh overflows from the lakes. These flows had reached their maximum during the early morning, and were now swollen, hot and crusted over. The south pond had overflowed the entire depression of the southeast wall-valley between the south pressure ridge and the southeast crag. The main lake had overflowed the eastern wall-valley. The north lake had overflowed both to the east and to the northwest. The former overflow filled the whole northeast wall-valley, destroying much of the new trail and filling to a height above the top of trail monuments four feet high. This fill lies at a slightly lower level than the wall-valley fill made by the main lake, which had spilled over and cascaded into the northeast valley fill. On the northwest side the overflow of the north lake had filled the wall-valley under the northwest station so as to reach in places the top of the Halemaumau wall and the floor level of the west niche. The southwest lake and west pond did not overflow but the central pond had risen and overflooded the central channels, widening them and drowning the base of the cliffs.

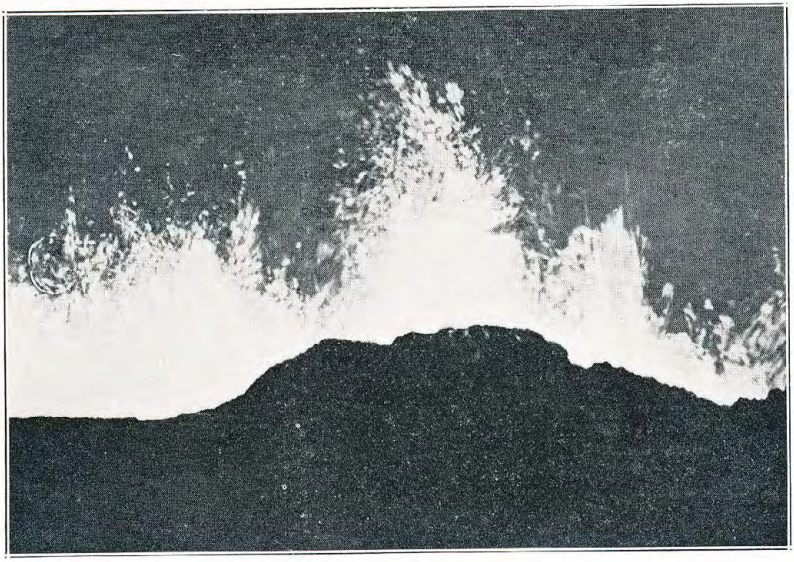
The main lake stood very high with new spatter domes, eastward streaming and extensive new floors built far into the gulch at the northeast cove and across the peninsula separating the lake from the south pond. The cliffs around the lake were now only from 10 to 15 feet high The lava of the new wall-valley fills was pahoehoe with heavy shells which tend to collapse on cooling.

The north lake was now fountaining against a circle of new spatter domes, the new overflows standing level with the lake margins, but not visibly moving. The southwest lake had built up large spatter domes and the west pond cone was hissing. There were bubbling noises in the south wall crack cone and similar noises continued in the east and northeast wall-crack vents.

Inspection of the cliff over Kilauea crater at the northern part of Byron's Ledge showed that the bushes had burned up to the top of the cliff and the lava was still spreading over all that part of Kilauea floor. New embayments between spurs were forming where the cliff trail descends to the floor. Surface floods broke out during the evening all over the flow, and again the north lake fountains were seen at night splashing high over their ramparts. The new Postal Rift cone was also spurting.

At 10 a. m. Friday, November 21, the lakes stood two or three feet below their banks and were rather quiet, and the wall-valley fills had slumped on cooling. The west pond had a hissing vent on its southwest side and a round sulphur-stained cone in the middle. The southwest lake from time to time developed noisy bubble fountain activity. The main lake and south pond were little changed. The wall-crack of the northeast ridge was rumbling and smoking strongly, the east cone cracks

Sept. 30, 1919. Kahuku Flow source looking west at night, 8 miles away. —Photo, Jaggar.



Oct. 1, 1919. Source fountains of Alika Flow, at night. Photo, Jaggar.

Oct. 1, 1919. Alika Flow pouring into ocean. Photo by courtesy of Rev. A. S. Baker.

Oct. 28, 1919. Foot of Alika Flow, sand cone in foreground. Photo, Jaggar.

making somewhat less noise. The north lake was surrounded with four or five immense spatter domes and remained very quiet at the time of visit. About 2 p. m., however, the north lake again overflowed with much development of marginal fountaining.

The tunnel break immediately west of the Postal Rift source cones showed a very rapid and voluminous torrent 17 feet wide and moving over 15 miles an hour. The wall-crack on the northeast side of Halemaumau showed large open chasms from recent movement, breaking across the August overflows of the north lake.

In the Whitney Laboratory for the week ending at 8 p. m. November 21, 1919, there were registered local earthquakes as follows: November 14, 11:32 p. m. (well defined); November 15, 9:30 p. m. (felt); November 16, 12:45 a. m. (very feeble), 4:05 a. m. (feeble), 5:42 p. m. (very feeble); November 18, 5:42 p. m. (very feeble). A teleseism was registered November 20 at 3:46 a. m. Spasmodic microtremors were variable throughout the week and harmonic tremors slight, increasing somewhat after November 20. Microseismic motion was slight. Tilting was strong to the south November 15, to the north and east November 16-19, and moderate to the west and south November 20-21.

November 29, 1919.

During the week ending Friday, November 28, 1919, the expected reaction at Kilauea volcano has come, from the gas and lava release of the combined Mauna Loa and Kilauea eruptions. Just as on June 5, 1916, after the Mauna Loa flow of that year, so on November 28, 1919, an even more sudden quiet drop of the Kilauea lava column took place, amounting to at least 600 feet in a single morning. As before, the subsidence was accompanied by almost continuous light local quaking of the ground, limited to the immediate vicinity of the crater. Within an hour after the disturbance started, the whole ancient pit of Halemaumau was revealed to a depth of over 400 feet, the topography of lakes and crags was largely buried under encircling talus, and a single new lake of liquid lava had started to reform in the middle of the cup. The Postal Rift flow had continued its outpouring through the source wells up to the moment of the crisis, when it on the instant ceased to flow and the tunnels were left glowing but void. There resulted in the great pooled flow of the northern part of Kilauea crater reactions of collapse and fountaining due to the withdrawal of gas pressure. The liquid lava in the bottom of Halemaumau recovered very rapidly and by November 29 was forming a large lake.

This event, culminating a sequence of explosive outbreak and flowing on Mauna Loa, with all the details analogous to the events of the combined Mauna Loa-Kilauea activities of 1914 and of 1916, appears conclusively to demonstrate a sympathy of action between the two volcanoes and proves that they are connected by underground conduits. The sequence from 1914 on has shown increase of interval, increased volume of outflow, increased height of vents, increased rapidity of the subsidence reaction, increased rapidity of the recovery, and decreased intensity of seismic crises.

All available information indicates that the Mauna Loa eruption is over. Reports from cattlemen who visited the source cones in Kahuku show that smoke was still rising there on November 19, but no moving lava was seen.

Measurements for the week indicate that for the six days, November 21-27, the marginal stations of Halemaumau were stationary on the south and west and sank about one foot on the north and northeast. The bench magma or floor lava adjacent to the three lakes subsided about one foot. The ridge adjoining the Postal Rift source cones stood stationary. The lakes remained 6 to 10 feet below their banks. At 2 a. m. November 28 the lava column, including both lake magma and bench magma, sank very suddenly, so that measurements at noon from the edge of the restored pit made the depression of the liquid surface 591 feet below the northeast rim of the pit, this having been the northeast ridge before the subsidence. The rim station was 3727 feet, and the liquid lava surface 3136 feet above sea level. The dimensions of the lava lake at the bottom of the

pit were 120 x 120 x 160 feet, and the shape roughly triangular.

On Saturday, November 22, at 4 p. m., the lakes were low and appeared sinking, and the fume was rather dense. Streaming was eastward in the main lake and much fume rose at the northeast cove. The northeast ridge wall-crack was rumbling. The north lake stood 10 feet below its rampart and had two active grottoes under its north bank. The collapsed tunnel near the Postal Rift source cones contained two torrents, pouring one on each side of the black driblet cone that had formed over the edge of the hole, these coming together in the cavern beyond. In the second orifice, farther northwest, the level of the tunnel stream had lowered.

At the west pond site a gas vent was hissing, and in the southwest lake the streaming was slow towards two very large grottoes in its southeast cove. The south wall-crack cone was again glowing, fuming and rumbling.

About 4 p. m., November 23, a cloud was seen over the Kahuku rift source on Mauna Loa, which showed very hard edges and resembled the fume clouds of the eruptive period.

On this same afternoon at 5 p. m. there was a new development of marked subsidence in the south pond of Halemaumau, which suggested the beginning of a crisis. The pond had sunk 10 feet lower than the main lake, and through the channel from the main lake to the pond a cascade was falling continuously with a roar, converting the pond into a whirlpool. The channel was 20 feet wide and dark skins from the main lake were continuously carried down over the fall. The lake was slightly lower than before, exhibiting grotto caverns at the central channel and at the northeast cove. The streaming was outward from the former and inward at the latter.

The north lake stood about eight feet below its bank and was making much noisy fountaining. There was high gas pressure at the Postal Rift flow source, with much hissing and flames rising through cracks in the ground near the cones. The surface of the torrent in the tunnel opening appeared somewhat granular, like aa. The new black cone south of the Postal Rift source cones was flaming through many holes and had increased the size of its outflow area.

In the evening Halemaumau was unusually bright, owing to the brilliancy of the cascade locality, and the Postal Rift flow was also very brilliant. After midnight the south pond rose and put a stop to the cascading, and fountains could then be seen at the rampart levels at both the south pond and the north lake.

On November 24 the Postal Rift flow was unabated, the north lake fountains remained high, and while the cascade and whirlpool were not resumed in the daytime, the bright illumination of the south pond about 10 p. m. suggested a temporary renewal, which stopped later in the night. The hissing at the new north cone could be heard at the Observatory. The third tunnel opening of the Postal Rift stream had broken wider open and showed a stretch of surface flow with standing waves. The main flow surface was brightest toward the northeast, under Byron's Ledge, the pooled area of the north corner of Kilauea tending to grow darker. Extensive arms of the flow had by now developed over the middle area between Halemaumau and the Observatory.

At 11 a. m., November 26, the south pond was found with its bank five feet above the liquid and so built in that the large south grotto dome stood back from the edge of the pond, with an open glowing pot in its summit. The main lake sent a rapid stream through the channel into the south pond, and was otherwise streaming eastward without much fountaining. Evidence of motion in the bench magma was shown by a fallen block of rock on the fresh flow lava of the southeast wall-valley. The north lake stood six feet below its bank, where a very large wide spatter dome had been built on the east side. The lake was quiet, with tendency to ballooning of its crust, and a flaming grotto dome stood on its bank. The interior of the Postal Rift source cone showed high lava, streaming rapidly. The first tunnel orifice exhibited bubbles in the surface of the flowing lava, but no granulation, and a speed of about six miles per hour. The second and third openings contained a sluggish stream of dark-red color, with its banks

considerably built in from the sides. The two pits of the fourth opening contained rapid streams similar to opening No. 1; a curtain of accumulation hung from the roof down to the flow surface, the latter adding to it by splashing. The new black cone south of the source vents was now 15 feet high, hissing and flaming and with new flows around it.

The Postal Rift flow, in the northern part of Kilauea crater, together with all the outflows of Halemaumau on other sides, make a covering occupying nearly a quarter of the greater crater. This flow continues to grow in area, and on this evening new fingering flows were piling on top of those already accumulated at the base of Byron's Ledge, so that a new pool was making there and widening in the direction of Halemaumau.

Up to midnight, November 27, there was nothing notably new about the condition of Halemaumau. The main lake was streaming rapidly into the south pond and northeast cove, the north lake was six to eight feet below its banks, the Postal Rift source was pouring out its torrent as before, and the northern flow area was very bright, puddling and spreading as usual.

At 1:42 a. m., November 28, earthquakes began to be registered seismometrically, and about 2 a. m. five or six pronounced quakes were felt in the course of five minutes. In all some seventy-five felt shocks occurred between 1:58 and 4 a. m. Over two hundred shocks were instrumentally registered, the half-hour following the onset being practically a continuous jarring of the ground.

With the first observed trembling, Halemaumau as seen from the Observatory became very bright in the south pond region. At 2:05 a. m. the writer was watching the cliff profile, about 40 feet high, which as seen in the distance was sharply outlined as a crag on the south side of the north lake. Hundreds of visitors have climbed the rounded slope leading to this cliff in order to view the lake from above. In less than a minute this cliff flattened out and disappeared beneath the edge of a new pit created by general subsidence, the entire Halemaumau inner dome diasppeared, and there was left a straight edge with only the south pressure ridge and the Postal Rift cones remaining as breaks in the smooth profile. It was now certain that the whole lava column was sinking quietly and very rapidly, and the five openings of the Postal Rift tunnel on the right lost brilliancy and became dull as the flow ceased within them. A few minutes after the crags sank, dense avalanche clouds of dust went up from the pit and a continuous roaring noise could be heard, partly from Uwekahuna Bluff, where sliding was started by the earthquakes.

The pooled flow in the north part of Kilauea crater grew brighter, and within an hour small ponds had been formed by collapse in western and central parts of the surface, the liquid in these ponds fountaining and spraying to considerable heights, when the steady pressure, which had been applied by the source tunnels, was withdrawn. This process continued into the forenoon, when a standing fountain was seen welling up in a small oval pond between the Observatory and Halemaumau.

Arriving at Halemaumau 3:15 a. m., the writer could hear continuous sliding of avalanches in the pit. There was no visible change in the south pressure ridge, and the trail monuments built of loose stones had not been shaken down by earthquake. The light from the lava was greatly diminished. From the platform at the east end of the pressure ridge, it appeared that the whole filling of the old circular pit of Halemaumau had gone down over 400 feet in an hour and fifteen minutes; probably the greater part of this happened in the first half-hour, for the pit was already more or less adjusted and heavy avalanches were rare. The walls were nearly vertical, the pit 1200 feet in diameter, big talus cones with glowing edges could be seen far below, and a small partly crusted lava lake was bubbling at its edge and spurting through a crust crack in the middle. The upper edge of the pit was cracked and overhanging in places, but falls from the edge were very rare and none were seen. On the rock wall inside, a layer of cracked glowing matter formed a veneer which frequently scaled off on the surface so that from the opening so form-

ed powdery avalanches of glowing matter poured out. There was some gas puffing from vents in the floor.

The pit was extended northward through the collapsing of all the region between the northwest station and the 1894 cones, including the new large black cone. The Postal Rift source cones remained a short distance north of the new edge. This edge did not here descend to any great depth, but there was left a niche or shelf extending in irregular terraces down for perhaps 100 feet, to where the old pit margin was defined beneath as an upright cylinder. These terraces could be seen, one below the other, with ragged edges standing out in profile against the fume below.

The tunnel opening near the Postal Rift source cones was glowing brilliantly, but entirely empty. There was no hissing or flaming in the cones and the cupola beneath was glowing and empty. The stream bed of the tunnel showed a shoreline bench only 4 feet above it, indicating that the torrent had been only five or six feet deep.

Occasional heavy avalanches in the pit sent up brown dust clouds, but the continuous roar was due to the trickling slides from the glowing veneer, and to slips on the slide rock slopes below. There were some glowing cracks in the north wall, low down.

When seen by daylight at 10:30 a. m., the lava column was already in nearly complete adjustment; the pit was dusty but not very smoky, and a small triangular lake stood 591 feet below the northeast rim and lay in the northeastern corner of the floor against the talus. The floor elsewhere consisted of large surfaces of cracked bench magma, which had been lowered bodily from the Halemaumau dome above. Some traces could be made out of the original topography, and the remnant pool appeared to be the north lake. The talus slopes extended as much as a quarter of the way up the pit wall in places.

A most remarkable and interesting feature revealed by the sudden subsidence was the veneer of glowing matter moulded against the walls of the pit, and more or less striated vertically. This in daylight was a dusty brown, and had shelled off completely in places, revealing its thickness of from two to five feet. This was the wall-crack fill or dyke which had surrounded the inner hard lava column, standing between the bench magma and the old wall, and probably liquid up to the time of the subsidence. It will be remembered that the wall-crack, or contact surface between the bench magma and the confining pit, has been the source of overflows, the site of cones and flaming vents, and the place of development of "wall valleys" during subsidences, all of these actions being prominent since 1917. How deep the wall-crack extended has been problematical, dependent on the thickness vertically of the semi-solid lava which we call the bench magma. The revelation of this veneer to depths of over 500 feet, its inner surface the mould of an inner hard substance which confined it, demonstrates that the bench magma extended to that depth at least. It may well be that the lubricating action of the wall-crack filled with lake magma, accounts for the extraordinary quietness and quickness of the rapid descent of the column on this occasion.

The lake was crusted, with occasional cracking and foundering, two or three sluggish fountains broke through the crust, and some driblet cascades were pouring into the lake from a fissure heap on its west side. Farther west there was a puffing cone, with glowing orifices whence trickle flows had spread across an old bench magma surface coated with Pele's hair. These flows gave evidence of renewed or continued gas pressure, making lake magma.

A remarkable feature of both the east and west walls of the pit, at points exactly opposite each other, was a pair of open cracks extending straight up and down and trending northeast and southwest. These appeared to be the continuation of the same crack across the pit, a deep vertical break through the Kilauea inner cone, wherein Halemaumau is the crater. The crack opened downward and petered out upward, showing for some 400 feet above the bottom of the pit as a fissure one to two feet open. A new development of fume southwest of Halemaumau came from a fissure in line with this one, and apparently its continuation a few hundred feet outside of the pit rim.

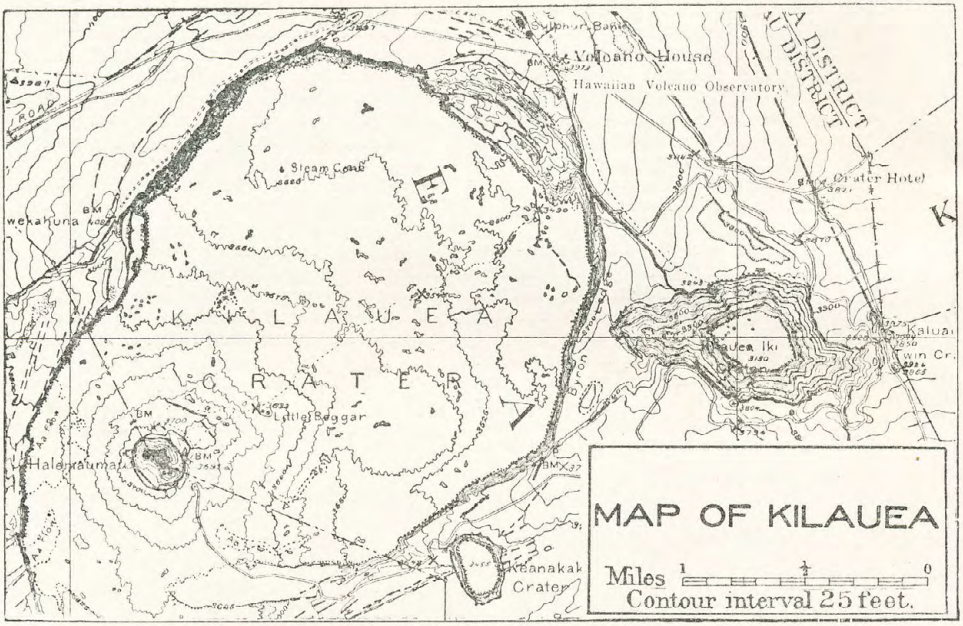
Vapor rose densely from the ring of 1893 cracks around Halemaumau. There was much reddish grit from the avalanche clouds, which fell about the edges of the pit both in the early morning hours and in the daytime. There was some fume from the west side of the new northern shelf. The Postal Rift flow continued to make blue fume and remained bright in the evening of this day, especially near the extreme front under Bryon's Ledge. The earthquake swarming quite ceased after daylight, thereby affording additional evidence that the subsidence was completed in a few hours.

During the week ending at 8 p. m., Friday, November 28, 1919, the seismographs of the Whitney Laboratory registered local earthquakes as follows: November 22, 2:37 a. m., very feeble; November 23, 10:35 a. m., very feeble; November 25, 9:58 p. m., a near shock with origin about 110 miles away, reported strongly felt in Maui; November 26, 3:20 a. m., slight, and 3:16 p. m., feeble; November 27, 3:42 a. m., feeble (felt in Hilea). On November 28 earthquakes were registered almost continuously from 1:42 a. m. to 4:11 a. m., some seventy-five of these being perceptible between 1:58 and 4 a. m., the total number of shocks amounting to over two hundred. The heaviest and most continuous trembling was between 1:58 and 2:30 a. m., the time of the major subsidence in Halemaumau. Other earthquakes November 28, all feeble, were as follows: 8:58 a. m., 9:02 a. m., 12:45 p. m., 6:57 p. m., and 8:39 p. m.

Spasmodic microtremor during the week was slight to moderate, and harmonic tremor moderate to slight. Microseismic motion continued slight. Tilting of the ground was slight to the northwest November 22, to the southeast November 23-26, and excessive eastward and northward November 28.

Very respectfully,

T. A. JAGGAR, JR.,
Volcanologist.



HAWAIIAN VOLCANO OBSERVATORY.

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 solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	10000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the accelerations or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol a, or max. a, is given in the conventional unit of milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ. per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

U. S. DEPARTMENT OF AGRICULTURE
WEATHER BUREAU
CHARLES F. MARVIN, CHIEF

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December 6, 1919.

During the week ending Friday, December 5, 1919, the recovery of the lava column in Halemaumau pit has continued with great rapidity, developing in a few days features the equivalent of which it took weeks to produce in 1916. The liquid lava on the first day after the subsidence increased to a large lake, on the second day cascades were pouring into the lake from springs of lava which welled up behind the talus, then the ring of bench magma under the border talus rose bodily and tipped toward the lake, the gaping wall-crack so formed engulfed the talus, and finally by the end of the week long curved ponds of boiling lava developed in the encircling crack, rose to levels 100 feet or more above the central lake and cascaded inward over the ring crags so as to increase the volume of the lake.

The revelation of this encircling solid rock under what had at first appeared to be high talus cones shows that the topography of bench magma was more completely preserved during the great subsidence than appeared at the time. What had been the arched surface of flat dome shape encircling the three lakes, became after the subsidence a surface of basin shape, its edges masked by debris and a single lake in the middle. The angle of slope of the sides of this basin appears to have been increased by the weighting effect of the inflow that enlarged the lake. The semi-solid matter beneath appears to have been squeezed outward and upward, reaching the wall-crack region of less pressure and so by release of gas generating liquid magma. This is a reversal of the process so often seen in 1918 and 1919, whereby the wall-valley fill weighted the margins and pushed up the center.

Measurements on Tuesday, December 2, at 10:15 a.m., were made just after a spell of pronounced uplift of the bottom area whereby the ring of older bench had been raised as well as the lake, the bench more than the lake. There was also an inner bench or lake shore line which marked by its height above the liquid the extent to which the older basin had been lifted in excess of the rise of the lake. The depression of the lake below the northeast rim of the pit was now 446 feet, the inner bench 413 feet and the outer bench or talus 378 feet, all of these measurements being directed at the northwestern corner of the lake basin, where two days before there had been a trickling spring of lava pouring into the lake from the top of the talus. The solidified materials of this cascade were broken by the uplift. The height of the inner bench, which gave the lake the appearance of having fallen, really indicated that the annular margin of old floor had risen 33 feet in excess of the rise of the lake. The lake itself as compared with the measurements of November 28 had risen 145 feet in four days, making the average rise 36¼ feet per day. The liquid lava in the wall-crack ponds stood at levels 50 or 60 feet higher than the central lake, so that if this were compared with the liquid level of November 28 the rate of rising would be 50 feet per day. As the

ring of bench magma had risen more than the lake, and confined the liquid of the wall-crack, and this last had been flowing voluminously into the lake at nearly lake level on November 30, it is a fair statement of the whole rising movement to say that the lava column rose 200 feet in four days, this including the lake, its confining basin and the liquid welling up the wall-crack. The rim bench mark to which the above depression figures are referred stands 3727 feet above sea level.

A plat of the upper rim of the pit determined it to be oval in form with diameters 1200 feet east-west and 1485 feet north-south. The extra 285 feet of the north-south axis is mostly made up of the northern inner shelf, the lowest terrace of which stands 85 feet below the northeastern rim of Halemaumau. The rest of the pit and the deeper portion containing the live lava column, is nearly cylindrical with walls that slope inward but slightly, so that the ring of talus, floor crags and lake has diameters of something over 1100 feet.

On Saturday, November 29, at about 4 p.m., the interior of Halemaumau was almost entirely free from fume, but the vapor from the outlying cracks was dense, especially to the southwest. The inner walls still showed the wonderful veneer of solidified wall-crack material, which gave the pit a very clean-cut upright circular appearance like the inside of a bucket. This was identical with the old shaft of 1916, but the upper rim of the pit, added to by 1918-19 overflows, showed marked changes. Among these changes are the dark colored beds of southwest overflow about 20 feet thick; the fill of the west niche formed in February, 1918; the new north shelf and a section of flows back of it; the northeast heap of 1919 built above the fill of 1918 to a depth of 40 or 50 feet with the old red scar of the 1894 bench showing in section below; and lastly the jagged profile of the south pressure ridge still standing high above the general level of the rim of the pit. Breaks in the west wall at lower levels showed at least two clean-cut unconformable bedding lines marking ancient Halemaumau rims. The only source of fume inside the pit was a stained patch at the top of the western talus.

The lake had risen to become a large pentagonal pool some 600 feet in diameter and estimated over 50 feet higher than the little pond of the previous day. The pool was quietly rising, its shores directly against the loose stones and hard rock of the talus ring without any spatter rampart or border grottoes, and its surface was covered with black skins through which four or five central fountains were breaking almost continuously. There was some bright-line pattern and occasionally the crust would crack and the blocks founder. A cracked surface of the old floor still bounded the lake on its south side.

A fragment of the east rim of the pit, which had been poised and tottering the previous day, had now fallen. A few trivial avalanches were seen. Apart from these the only noise in the pit was from the fountains. At night the pit was brighter than before. In the tumble of the northern benches no trace could be seen of the old features such as the 1894 cones and the masonry bench mark.

The Postal Rift source cone was more broken in and a large dark chamber was revealed below; a well still retaining red heat could be seen through the adjacent tunnel opening, but the tunnel itself was dark in the first three openings to the northwest. The fourth group of openings showed brilliant red heat inside and the fallen bowlders were still cherry red just as when the lava was flowing. The fifth opening was brilliantly yellow with incandescence, and the empty stream channel was six feet deep, making the height of tunnel 26 feet. The hot gas which emerged from the opening was breatheable and seemed to be merely air. The retention of heat in such large chambers having access to air suggests continued oxidation of the iron in the rock.

At night the glow spots of the Postal Rift flow were fewer and confined largely to the area under Byron's Ledge, where the lava was still spurting through openings. This revival of fountaining in a lava field cut off from a source of supply suggests gas reaction with atmospheric oxygen.

At the base of Uwekahuna Bluff in several places large and small bowlders were seen resting on the fresh lava of the Postal Rift flow, this debris having been dislodged from the bluff during the earthquakes of the early morning of November 28.

At noon on November 30 a visit to the fuming crack southwest of Halemaumau determined it to be a vertical fissure extending out radially from the pit about 300 feet from the edge and trending in the direction of the 1868 cracks. The rising smoke was dense, blue and sulphurous along some 200 feet of the fissure line, the rock of the 1919 flows was stained and the crack had a very high temperature. It was about six inches wide cutting across all the flows indiscriminately. This was much the most densely smoking vent anywhere about Halemaumau. It corresponds in position and trend with the crack in the opposite walls of the interior of Halemaumau, but the latter emits no smoke.

Halemaumau on this day was more smoky, the lake was about 40 feet higher and the wall-crack vents back of the talus were bubbling with liquid lava which cascaded into the lake across the talus on the eastern, western and southern sides of the pit. One of the western vents was spurting noisily. The old bench and slopes of slide rock were much encroached upon by the lake so that none was left on the east; on the west they were low, and the higher embankments north and south were mostly solid rock remnants with some talus on top.

The upright fracture seen cutting across the lower pit walls is of great interest on the eastern wall, in that it cracks across the wall-crack veneer, an open chasm one to three feet wide; if this veneer solidified after the early morning of November 28, then this crack across it opened still later. Its mate appearing on the southwest wall cuts across ancient bedded rocks.

The lake now showed a narrow beginning of rampart shoreline, implying the formation of a thin shell of bench magma under its bottom and sides. There were two main fountaining areas in the lake, each with two or three dome fountains of the sluggish type, the fountain sending up a blue smoke ring as it burst, and recalling the "Old Faithful" of 1911. The fountaining areas were in the north central and southwest central parts of the lake, and the crusts tended to crack in rings around the fountains. These crusts were heavier than before. The wall-crack lava of the east side accumulated in a considerable pool which drained into the lake by way of a wide cascade. The avalanches on this day were mostly under the south pressure ridge, the bowlders sometimes reaching the lake and breaking up its border crusts.

The sunken shelf at the north edge of Halemaumau lies between the cracks which formerly extended northward from the 1894 cones and from the northwest station. Before the collapse the north edge of Halemaumau was much broken up, undermined and inflated by sulphurous gases during the development of the Postal Rift flow. It seems probable that this undermining was developed by lava seepage through these two cracks, and when the drop came the whole region collapsed. Much smell of sulphur vapor still rose from the Postal Rift source region, but no glow could now be seen in the tunnel well. Luminous spots in the Postal Rift flow were now few, but the fluid was still oozing out in one place under Byron's Ledge. Blue fume rose from the flow in many places, and in some rare vents there was a puffing red fume.

On December 1 at 3:30 p.m. the fume had increased at Halemaumau and the ring of bench magma around the lake had risen about 8 feet, giving the lake the appearance of subsidence within its basin. Four fountains were playing continuously. Some light fume was issuing from a new crack northeast of Halemaumau and dense smoke rose from the southwest fissure and from several places in the old Postal Rift circle. The fourth and fifth openings of the Postal Rift flow tunnel appeared as hot as ever, the rock was red hot within two inches of the surface at the edge of a large opening and the bottom of the deep tunnel was plastic and of bright yellow incandescence. There were still numerous glow cracks in the flow covering the northern part

of Kilauea crater, but no moving toes were seen.

A prolonged light earthquake in the early morning hours of December 2 was perhaps occasioned by the stress of sudden rising of the lava column. On visiting Halemaumau at 10 a.m. it was found that the encircling ring of old floor under the talus and around the lake had risen bodily and tilted inward toward the center, breaking up the solidified wall-crack cascades, opening the wall-crack until it had become a gulch and causing the talus to slump into this gulch on all sides. There was thus created an annular knife-edge ridge standing out from the wall, and on the northeast side a pool of hot liquid lava occupied the gulch and showed continuous bubble fountaining. The lake margin inside of the ring had retired from its uptilted shores leaving a sloping terrace scarred with black shore lines; this scar was 15 feet high on the northeast side and 4 feet high southwest, indicating that the uplift of the cup involved tilting from northeast to southwest. There was further evidence of this in a triangular shoal on the northeast side of the lake sloping southwestward at a flat angle, making a beach of uplifted lake bottom, with one of the fountains at its margin puffing as though building a cone. This fountain, and the persistence of the other fountaining localities, gave evidence thus of spring holes in a shallow bottom under the fountaining localities. There were still two principal fountaining areas, quiet crusts over the lake and occasionally cracking and foundering of the crusts which revealed the hot melt beneath.

There was increased smoke in the pit from talus openings north and south. Nightfall revealed glow in the northwest wall crack from lava still bubbling beneath the cascade debris. Small avalanches continued, especially southwest, the side of downward tilt of the floor.

The line of openings in the Postal Rift tunnel northwest of Halemaumau was wholly dark at the first three localities, red hot at No. 4, and at the deep pit No. 5 there was orange heat but darker than before, the rocks near the orifice being purple to cherry red. Small stones thrown in encountered a hard bottom at the stream channel and took from ten to fifteen minutes to heat up to incandescence. There was a roaring noise as of rushing air through the tunnel or its orifice, but no appearance of windy outrush was seen. It seemed possible that this noise was due to some reaction in the rock. Where the linings of the tunnel had cooled off and could be seen in daylight, the glaze was dark red with oxidation of the contained iron.

At 6 p.m. the lake was rising and had encroached upon the shoal at its border. The fountains were small, flinging a viscous melt, and the northeast wall-crack had two ponds with hundreds of small fountains making a pattern recalling the activity of 1912. Disagreeable sulphurous fume rose from these fountains at the eastern edge of the pit.

After a southwesterly storm the floor of Kilauea at 9:30 p.m. on December 4 presented dense masses of vapor and there were still scattered glowing openings in the Postal Rift flow. Halemaumau was much brighter and from its eastern edge the ring ridge could be seen to be much higher and moved inward so as to increase the width of the gulch between it and the wall. Elongate wall-crack ponds had again formed on the northeast and west, the former greatly enlarged and still boiling violently and continuously. The mottled pattern of the bubble fountaining here was what produced the bright glow from the pit, the breaking skins continuously streaming north and south from a middle dark zone. At the two ends the pond was crusted, with some spitting of small vents towards the south. At the base of the south wall of the pit the debris was sliding into a smoke hole, making small avalanches and sending up gritty dust. Some Pele's hair from the fountains fell outside of the pit.

The western wall-crack pond had two or three small fountains and was otherwise quiet. The main lake had five fountaining centers, was generally crusted and the eastern fountain was building a low cone. The spray shot up 20 or 30 feet. There was again a flat of lifted floor east of the lake.

Occasional small avalanches fell from various parts of the pit wall.

At 11 a.m. December 5 the pit was smoky, but the eastern wall-crack pond could be seen some 600 feet long and over 50 feet wide, continuously boiling and streaming northward. There were fountaining vents in the crust of the pond at its south end and farther south in the wall-crack there was noisy puffing with inward slipping talus undermined by lava below.

The main lake crust was heavier than before with three sluggish fountaining vents breaking it, the eastern one throwing up umbrella flings of melt.

The northern part of the western wall-crack pond was wide and quietly fountaining, but at its southern end this pool overflowed inward across the knife-edge ridge and sent a cascade down to the lake. The cascade was 25 feet wide and other vents in the slope below made a line of fountaining springs which flooded the western crust of the lake and made there a fresh field of pahoehoe. The large cascade fell 50 feet to the spring line, and there was about 50 feet more of drop from here to the lake surface, making the difference of level between the wall-crack pond and the lake about 100 feet.

The wall gulch on the north side was now 200 feet wide at the level of the ring ridge bordering it and the top of this ridge now stood up as a jagged crag all around the central lake. It was evident that the present rise was taking effect by lifting the margins of the old sunken floor instead of the middle, as though the weight of the lake had caused displacement outward of the plastic matter below. The intense effervescence in the wall-crack to heights greater than the lake appeared to show that marginal pressure release had converted the under paste into liquid, by release of gas from solution, and consequent heating.

The southwest fume crack showed no change. Some of the northwest edge of Halemaumau appeared to have fallen away. The debris of the inner slope of the south pressure ridge had mostly fallen, making that ridge a nearly vertical wall on the inside with an outer slope of debris.

In the Whitney Laboratory of Seismology for the week ending at midnight Friday, December 5, 1919, local earthquakes were registered as follows: November 29, 3:49 a.m.; November 30, 10:30 p.m., moderate; December 1, 3:28 a.m., slight; 9:26 a.m., very feeble; December 2, 5:36 a.m., felt; December 3, 10:23 p.m., very feeble; December 4, 2:02 a.m., light. Spasmodic tremor was weak to moderate during the week with pronounced wind effects December 4 and 5. The harmonic microtremor became excessively slight during the week. Microseismic motion was very slight, increasing a little December 4 and 5. Motion of tilting was strong to the south and moderate to the west in the early part of the week, changing on December 2 to strong east and moderate south.

On December 1, after some weeks of experimentation, a seismograph was started in operation in Hilo for the measurement of local earthquakes coordinate with the work of the Whitney Laboratory. This installation is the work of the Hawaiian Volcano Research Association, the first of a series of instruments to be placed in the hands of volunteer observers on the Island of Hawaii. The seismograph was designed by Dr. Romberg in cooperation with the writer, who has set up and modified the Hilo instrument as experiment required. Major W. V. Allen, United States Customs Collector of Hilo, has kindly consented to operate the instrument and mail the seismograms to the Observatory.

The vault used is of heavy concrete with double walls reinforced with steel, each nine inches thick and with a four-inch air space between. The roof is an arch of solid concrete fifteen inches thick. The inside space measures 14 feet 6 inches by 10 feet 8 inches, floored with concrete resting on the beach sand on land very slightly above tide water in what is known as the Ponohawai district on the north side of Kamehameha Avenue between Waiakea and Hilo town.

The use of this vault was contributed by the Hilo Mercantile Company. To this firm we are indebted for co-

operation in the establishment of the seismograph, and also to the following Hilo firms and organizations who have done work on the building gratuitously through their interest in the Hawaiian Volcano Research Association: Hilo Electric Light Company, Hawaii Publicity Commission, Charles H. Will. Volcano Garage, Hawaii Consolidated Railway Company, American Factors, Ltd., and the county engineer representing the Department of Public Works.

To the last named officer we are in debted for the exact determination of the meridian, and the horizontal pendulum is set up in the meridian for registration of east-west vibration. On this site there is some artificial disturbance due to railway trains and heavy trucks, but the registration of such movement is quite distinct in character from that of earthquakes. The preliminary tests of the instrument have satisfactorily registered earthquake, tilt and micro seisms, and have demonstrated that no trace of the harmonic and spasmodic microtremor, so common at Kilauea, is observed at Hilo. This seems to indicate that these tremors are distinctive of the crater region. The microseisms are stronger than at the volcano. The Maui earthquake of November 25 was registered, showing that the ground is satisfactory.

December 13, 1919.

The week ending Friday, December 12, 1919, at Kilauea Volcano has demonstrated that the rising movement of the lava of Halemaumau now in progress is the most rapid which has occurred since the Observatory was founded in 1911. The central lake area for the fourteen days following the great collapse of November 28 has risen 444 feet, averaging 31.7 feet per day. The uplift moreover up to the middle of the past week has involved the heavy prism of seemingly solid lava which we call bench magma, that filled the pit from wall to wall and had on its surface the former topography.

The movement has proceeded by alternations of spurts between the lake magma and the bench magma. For the first two days after the collapse of November 28 the lake basin filled up rapidly. For the next three days the heavy ring crag became defined and the lake was distributed into the wall-cracks and replaced by uplifted shoals. This was followed for two days more by vigorous rising of the liquid in the wall-cracks and cascading inward to fill up the basin. Beginning on December 6 for three days there was again an uplifting movement developing a great circular craggy ridge with its summit over a hundred feet above the liquid level. Then came, from December 9 to 12, a most extraordinary upwelling of violently boiling liquid, flooding the pit from wall to wall and half drowning the crag ridge so as to convert it into an island.

This last upheaval with liquid rising 40 feet per day in the upper and larger part of Halemaumau pit is a flood incomparably greater than anything heretofore seen by the writer at Kilauea. The boiling mechanism is like that of the spurts of December, 1911, and July, 1912, with thousands of fountains and intense radiation of heat. Nineteen hundred and twelve was as a whole a year of declining lava level, so that this analogy suggests that the present spasm will be short-lived and that it marks the beginning of a period of subsidence for the next two years.

The pit as a spectacle at the present time, wholly free from fume, with an enormous lake containing a great craggy island crescent, the summit of the latter only 75 feet down and the fiery turbulence made infinitely various by the rushing currents and the bombarding of ramparts, is quite comparable in magnificence to any of the phenomena of the Mauna Loa eruption.

Measurements on Tuesday, December 9, at 10 a.m., from the northeast rim station, the elevation of which is 3727 feet above sea level, determined the depression of the several features below this station to be as follows: Shore of ring pool north 267 feet; north crag peak 154 feet; central lake 270 feet; west wall-crack cones 253 feet; south wall-crack fountain 200 feet. The outside diameter of the ring pool north and south was 1000 feet and east and west 1050 feet. The width of the ring pool ribbon on the north was 100 feet and on the east 70 feet. The diameter

of the central floor east-west was 760 feet.

Measurement from the same station December 12 at 10 a.m. made the depression of the north pool 147 feet and of the north crag peak 75 feet.

These measurements show that in seven days, from December 2 to December 9, the ring pool rose 129 feet, averaging 18.4 feet per day; the central lake 176 feet, averaging 25.1 feet per day; and the north crag 216 feet, averaging 31.0 feet per day. In three days, from December 9 to December 12, the lakes, now at a common level, rose 120 feet, averaging 40 feet per day, and the north crag 79 feet, averaging 29.7 feet per day.

On Saturday, December 6, at 4:30 p.m., Halemaumau contained much fume rising from the debris in the wall-cracks. A comprehensive view obtained from the south pressure-ridge showed the large lake basin of the center with a live pool on its west side, a ring ridge around it with highest summits north and south and a gulch between this ridge and the wall of the pit filled with an elongate boiling pond on the east, with rock debris north and south and with live lava cones on the west.

The changes which had occurred since the previous day were chiefly those occasioned by strong uplift of the floor on the east side. This had opened wider the eastern wall-crack pond, which had risen and was still covered with multiple fountains in its middle and northern parts, crusted over on the south and streaming northward with occasional bombardment of the walls east and west, such occasions causing a lessening of the general bubbling. The gorge occupied by this pond was extended into really profound gulches on the north and south sides of the pit.

The movement of uplift had pivoted about the contact of the floor block with the west wall so that the wall-crack on the west was narrow with spurting lava through the two cone vents. The cascade of the previous day had ceased and its frozen remnants were crushed. It had flooded the western side of the crusted central lake basin, and the new movement of eastern uplift had again followed the lead of the heavy weighting of the western floor. What was left of the central lake had moved to the west side of its basin and the whole eastern half was a cracked beach slope. At the cascade locality, the cone on top was hissing and at its base in the lake there was a sputtering fountain. The area of the lake had dwindled, probably along with the increase of the east wall pond. Three sluggish spasmodic and explosive fountains occasionally broke through the heavy crust, the northern one making a noisy report followed by a splash of falling melt. Some avalanches fell at the north end of the east pond where the liquid lava was undermining the wall-crack. The whole floor had risen even at its lowest western part.

December 7 produced much lengthening of the wall-crack pond. At 11 a.m. December 8 fume was still dense in the crater, especially at its south end. The wall-crack pond was now a crescent extended from the east to the north and south sides of the pit and the central lake had become a dark floor with two cones on its north side, one bubbling almost continuously and the other exploding at intervals with reports like a pistol shot. The streaming in the wall-crack pond was from centers north, south and east, with conflicting currents and violent bubbling at the meeting points northeast and southeast. In the south wall crack there were three isolated pools. The pit at night steadily increased in brightness and the fume column rising in calm air was very brilliantly illumined by the areas of bubble fountaining beneath.

On December 9 in the forenoon, the wall-crack pool was extended in a broad ribbon around the north side of the pit and was fed from a fountain spring in the talus on the south side which stood at a much higher level than the rest of the pool. The annular ridge on the north was now lifted into a high peaked crag. The bubble fountaining was violent in the north pool as well as at the east, and rampart benches were building with crescent niches at places of continuous bombardment. Two pronounced capes or points had thus been built on the

inner margin of the eastern part of the pool. The western wall-crack now contained sputtering cones all along the base of the wall, including some in a depressed ravine northwest. The central lake was now a raised floor forming the bottom of the dish surrounded by the ring or crescent of crags, and this floor was now higher than the level of the wall-crack lake. The live part of the floor was a field of overlapping pahoehoe flows fed by a sluggish fountain south of the center, which broke the crust occasionally, while at the north fountain locality a cone had formed, which belched noisily at intervals, making a patter of falling fragments after each explosion. There was another cone at the southwest corner of the floor at the cascade site.

Much smoke still rose along the west wall-crack and from parts of the southern ring crag. The currents of the annular lake moved east and west from a bridge of skin at the north, and met from north and south in the eastern pool making hundreds of bubble fountains and some travelling fountains, recalling the turbulence of 1912. The general situation indicated steady rising, with transfer of the liquid from center to periphery, and encroachment by this marginal lake upon the wall-crack talus. Meanwhile the central cylinder of bench magma was lifting so as to bow its edges inward and convert them into high crags. The maximum of this lift at the north produced a peak.

On December 10 at 11 a.m. a visit to the outside fume crack southwest found it excessively hot and the fume now was thin and blue instead of the dense masses of vapor seen a week ago. No glow could be detected there. In Halemaumau the ring pool had extended itself to the southwest, where there was now a large pool of lava cascading to a lower quiet crusted puddle. At the base of the west wall the spurting cones were surrounded by crusted pools, the northern openings making fountains in grotto ovens. The north arm of the crescent lake was larger, with fountains bombarding its south bank, and this was continuous around to the east and south as a long ribbon lake from 10 to 50 feet wide, with violent bubble fountaining in several places. The continued uplift of the ring crag-mass, with its culminating summit at the north, had produced a low pass at the east as though the rise north and south were breaking the dish in two. The pool within the dish was now flooding through a continuous fountain in the center which made a spread of radial flows. The blowing cone also was larger, throwing up gushes of melt. The heat from the pit had increased, the fume from the fountains was strong with sulphur, much Pele's hair was strewn about at the north, and small avalanches continued, jostled loose by the lava movements. The southern ridge of the crag mass was now straight-topped, mostly bowlders and less than half as high as the northern summit, the eastern ridge being still lower.

On Thursday, December 11, at 10 a.m., after a night of exceedingly brilliant glow at the pit, the lake was found to have welled up at an unprecedented rate north, south and west, so as to bring central and marginal pools all into one and convert the crag-mass into a crescent island with its horns pointed west. Along the foot of the west wall was a line of twelve standing fountains with some cone remnants confining them, the ring pools were boiling and the central region was a quiet flooded field covered with large areas of fresh skin which showed surface patterns like watered silk. The marginal currents diverged from the three source wells north, south and west, and converged to intermediate shifting places, where thousands of fountains, large and small, boiled up, or bombarded the walls, or built ramparts against the island. The speed of streaming was variable, but mostly swift. The avalanches were mostly at the southeast corner of the pit. The only dark skins which formed in the ring lake were at the source wells. The most violent fountains were at the east.

In the evening everything was higher and a large dome fountain bursting about eight times to a minute broke the skin of the central pool where the explosive cone had been. There was violent multiple fountaining in the ring

channel southwest and in the north pool the rising lava made a pattern of golden rosettes which united in currents rushing toward the island bank. Against this bank on the north-northeast side lay a semicircle of dark skin from which streaming radiated. A torrent poured from the western cones along the wall to the north pool. Intense multiple fountaining continued at the east, and on the western side of the north pool. The heat and illumination were stronger than ever and the pit remained clear of visible fume all day.

At 10 a.m. on December 12 the concentrated intensity of the fountaining activity reached a maximum. The convection currents of the liquid lava now tended to rise along the wall of the pit, rush across the marginal lake from the wall to the island and against the island to go down in swirls and explosions of fountaining. This mechanism was strongest on the northern and southeastern sides. The heat was terrific and the uprush of gas from the pit generated troublesome whirlwinds on the edge, with showers of grit and gravel. The lake had gained on the crag mass, making the latter narrower and the former wider. The central pool, fed from the west, showed quiet cracking and foundering with one dome-fountain, almost exactly in the center, which exploded every two or three seconds. The western quarter of the ring was a line of upwelling fountains in a row, but everywhere else in the outer ring lake the fountaining was furiously tumultuous with thousands of great dome bursts of the same order of magnitude as at Halemaumau in July, 1912. The fume had slightly increased, from sources at the places of bombardment along the ring ridge. At the eastern gap in this ridge the splashing had broken through and built a spatter platform across the island There were some narrow zones of crust, especially north and southeast, at the outer border of the ring lake where the centripetal currents departed from the wall. These crusts were evenly striated in the direction of the currents. The avalanches were mostly from the south wall, strong ones being recorded, one at 9:30 a.m. and two about 12:10 p.m. The weather was calm and the roar of the fountains in the forenoon could be heard at the Observatory nearly three miles away.

A striking feature of this period of intense localized heat at the pit was the development of high cumulus clouds above the hot convection column, which showed a brown fringe beneath and a zone of transparent bluish gas between the bottom of the cloud and the edge of the pit. At sundown there was no cumulus and the fume extended far away to leeward as a thin veil hanging in flat strata. In the cool of the evening shreds of water vapor condensed irregularly in the fume cloud and a bank of fog poured over Uwekahuna Bluff like a waterfall, marking the indraught of cooler air around the margins of the hot uprush at the pit. In the evening the pit was more brilliant than at any time since 1912.

During this week the Postal Rift flow area has continued to show four or five glowing cracks as seen from the Observatory. At the source tunnel all glow has disappeared, and much hot air still rises from the openings, which have collapsed to some extent.

White localized cumulus clouds were noticed over the Kahuku source region of the recent Mauna Loa eruption in the night of December 5–6 and in the forenoons of December 10 and 11.

In the Whitney Laboratory for the week ending at midnight Friday, December 12, 1919, there have been a few very feeble local earthquakes as follows: December 9, 6:29 p.m. and 11:28 p.m.; December 10, 12:45 p.m.; December 12, 12:02 p.m. and 10:07 p.m. Spasmodic microtremors have increased from a few weak spasms per day on December 6 to several strong spasms on December 12. The harmonic microtremor has increased from almost none to slight. Microseismic motion has been moderate, and distinctly stronger than anything recorded for many weeks past. Tilting of the ground was westward and southward about December 7 and 8 and northward and eastward about December 12.

December 20, 1919.

During the week ending Friday, December 19, 1919, Kilauea has continued its remarkable performance of swift

rising in Halemaumau followed by sudden outbreak of foamy thin-shelled flows through a long radial crack on the floor of Kilauea crater southwest. This action has happened twice during the week, the first outflow occasioning sudden subsidence in the pit, followed by a swarm of earthquakes, the origins of which appear from the seismograms to be nine or more miles away. The newly opened rift is continued outside of Kilauea crater for a mile and a half in the Kau desert along the line of the so-called 1868 cracks, where new hot vapor is rising and the chasms have yawned open profoundly. The activity of the liquid lava in Halemaumau continues to be marked by stormy fountaining in a lake which fills the pit from side to side, and the ring-shaped island enclosing the central lake has slowly become more and more submerged. The fountaining is still confined to an outer annular channel which has increased in width as the liquid rose in the funnel-shaped pit and gained volume at the expense of the island. The highest level was reached December 15, when the lake was in places only 20 feet below the Halemaumau rim and very near the 3700-foot contour. At present the lava appears to be rising and falling in pulsations, overflowing when it passes the level of the open southwest rift, and giving off immense quantities of gas, heat and light.

The approximate fluctuations of level of the lake at the north pool, and of the island at its northern summit for the week ending December 19 are shown in the following table, from estimates checked by transit on north-northeast rim December 16:

Dec. 12, 10:00 a. m., lake 147 feet below rim; crag 75 feet below rim. Dec. 13, 11:30 a. m., lake 90 feet below rim; crag 25 feet below rim. Dec. 14, 3:00 p. m., lake 50 feet below rim; crag 5 feet above rim. Dec. 15, 11:00 a. m., lake 35 feet below rim; crag 50 feet above rim. Dec. 15, 6:30 p. m., lake 135 feet below rim; crag 50 feet below rim. Dec. 16, 11:00 a. m., lake 148 feet below rim; crag 71 feet below rim. Dec. 17, 11:00 a. m., lake 80 feet below rim; crag 40 feet below rim. Dec. 18, 12 noon, lake 70 feet below rim; crag 40 feet below rim. Dec. 19. 6:00 p. m., lake 50 feet below rim; crag 25 feet below rim.

The figures show that during the three days December 12–15 the lake rose 112 feet or 37.5 feet per day, and the crag rose 125 feet or 41.3 feet per day; then came outflow and subsidence, from 11:25 a.m. December 15 to the same hour the next day, the lake sinking 113 feet and the crag 121 feet in one day; the recovery for three days December 16–19 lifted the lake level 98 feet, or 33 feet per day, and the crag only about half as much, 46 feet, average 15.3 feet per day; another outflow resulted.

On Saturday, December 13, at 11:30 a.m., the rise continued and at noon the crag peak was in view above the edge of Halemaumau as seen from the Observatory. The crag was coming up more than a foot per hour very steadily, but this movement was accelerated at times so as to lift the shores of the island more than the lake; in general both island and lake were keeping pace, but not uniformly. The fountains were larger, building ramparts on the outer shores of the ring-island, but the lake contact with the wall of the pit showed quiet and continuous overlap of liquid on rock with no sinking spells. The island rose most on the east and north sides so as to keep the outer ring-channel from joining across the east gap with the central basin, but on the west side the two were blended. The currents there rushed together from north and south and poured out into the basin lake. Elsewhere the marginal streaming was mostly inward from the wall against the island, except for some remnant of the north and south currents coming together on the east. The multiple fountaining had lessened. The central lake was quiet, skinned over, with some cracking and foundering of crusts. The level of the liquid lava now reached the lower edge of the north shelf of November 28. There were still occasional slides southwest. The pit at night was extremely brilliant.

At 3 p.m. December 14, the crag was well above the rim of the pit and the multiple fountaining of the ring-pool was again furious and incessant, mak-

ing a loud roar like a cataract, audible three miles away (Crater Hotel). The streaming was mostly centripetal and the lake less than 50 feet down. Sulphurous acid gas was the dominant odor. The lake was gaining on the island and had reached the upper north shelf of November 28. The ring-pool boiled up in hundreds of large dome fountains. Very swift currents on the west side of the pit poured from north and south around the island crags and swept inward to the central basin, sometimes making whirlpools there on the north side. In the evening the whole body of the north crag, and the fountains north, east and west were in view from the Observatory. These fountains hurled spatter lumps of dense black glass over the top of the west cliff of Halemaumau, then 60 feet high, and small spray went much higher. The ramparts were 10 or 15 feet high, built at the lake edge on the west end of the north crag, and the southwest side of the island was buried under rampart lava. The noise at the road terminus was like the roar of the surf. An occasional dome fountain burst in the central pool region. Some smoke rose from stony patches of the island where bombardment was strong. The southwest crack outside of Halemaumau was yawning open and making thin blue fume which was very hot. Avalanches were slight. The light and heat radiation at the edge of Halemaumau were now excessive.

Monday, December 15, proved to be a day of crisis. The whole crag could be seen from the Observatory, and the fountains boiled tumultuously only 20 feet below parts of the pit rim, the rising and the roaring implying a frothing up of gas and lava analogous to a Mauna Loa eruption.

At 10:30 a.m. the streaming was southward on the west side of the ring-lake, inward to the island on the south, eas tand north sides and somewhat southward on the northeast side. The ribbon of this channel was now much wider, and the island lay like an atoll in the pit, enclosing a quiet lagoon open to the west, where occasionally enormous dome fountains broke the surface crusts in the north central region. The rampart lumps of spatter were built high against the island, and the heat at the actual rim cliffs of Halemaumau was insupportable.

Examination of the southwest crack at 10:50 a.m. discovered there a bulged puddle of incandescent crusted lava 50 feet in diameter, which had welled up the crack near the smoke hole some 600 feet from the Halemaumau edge. The ground was swelling and groaning, fragments were falling in the crevasses, and small quakes could be felt underfoot and shook down loose rocks from the south pressure ridge of Halemaumau. At 11:15 I crossed the cracked zone, sulphurous hot fume was rising, and the 1919 lava of this region was freshly fissured with breaks from three to eighteen inches in diameter. Noisy intumescence was so clearly in progress that I prepared to watch for and photograph the outbreak of liquid lava which was sure to follow.

At 11:25 a.m. a puff of dust and fume shot up near the southwest edge of Kilauea crater, in the line of this rift, and under the outcrop, in the Kilauea wall, of the 1868 fissures. Instantly and quietly the ground opened, for a length of four-tenths mile, and some two hundred small fountains of very liquid lava burst out along the crack and the melt bubbled and spread right and left. This outburst was below the shoulder of ground where the first flow puddle had been observed, and down the outer slope of the Halemaumau heap some quarter mile from southwest edge of the pit. The flow-source was a single crack, curved somewhat in plan, and this crack extended to and united with the 1868 cracks, for the latter now began to show motion and avalanching on the Kilauea outer cliff. The flow spread out until it was a mile wide in the southwest Kilauea wall-valley. Molten lava could be seen flowing in the upper part of the fissure system some 15 feet below the surface, showing that the flow was fed from the lake, and that the vertical crack in the inner Halemaumau wall was really continuous with this one. Within an hour the lake had drained down to the flow-level and the flow stopped, showing in this case every appearance of hydrostatic connection. Moreover the lake went much lower and the flow became

a sheet of collapsed shells, as though it had drained back through the rift when the "head" was reversed. In the afternoon, after 2 p.m., a swarm of earthquakes recorded seismometrically, indicated a sharp readjustment in the volcanic fissure system.

At the moment of the flow outbreak, both the lake and crag-mass in Halemaumau went down steadily and slowly, the center lagoon nearly keeping its level against the island, but going down a little the faster. A marginal black ledge was left against the wall of the pit all around, two or three feet wide, making a shell of that thickness with horizontal corrugations on its face marking shore levels, the upper ones one to two feet apart. These ones three to four feet apart. These shore marks gave evidence of the rhythmic jerks, with slowly increasing interval, wherewith the downward movement proceeded.

After the first ten minutes (11:35 a.m.) the column had sunk 5 feet; after 45 minutes 25 feet; after 245 minutes (3:30 p.m.) 90 feet; after 425 minutes (6:30 p.m.) 105 feet; and thereafter very little more, possibly 10 feet in 15 hours, to judge by measurements next day.

From 4 to 6 p.m. an examination of the 1868 fissures southwest of Kilauea revealed the fact that they were steaming, something unheard of for many years past, and the ground there, coated with gravel beds crusted with calcareous cement, was well suited to show the new cracking. The freshly opened zone was about a quarter mile wide and a mile and a half long, extending from the edge of Kilauea to a point 1000 feet southeast of the Cone Peak trig. station. The larger chasms had yawned open and engulfed their dirt fills; some creaking and tumbling could be heard within them. One of them was now 80 feet deep and 5 feet wide, leading down to a narrower space going to black depths. The vapor was steamy, of acid sulphurous smell, with temperature over 100 degrees F. Five conspicuous steam vents were aligned across the desert, one at the south end of the opened zone, four nearer to Kilauea in a group. The smaller fractures were of all sizes down to small fresh break lines in the dirt, and the zone petered out in a group of these minute breaks at the south end of the region indicated. Probably these chasms had opened slowly for several days, along with the opening of the smoke-hole crack near Halemaumau, but the steam was not seen before this day.

The activity of Halemaumau did not change its character. At 3:30 p.m. the lake stood 90 feet below the rim, there was the same stormy fountaining and streaming, and the even narrow black ledge all around was an impressive reminder of the recent higher level. There was no avalanching, the walls being in nice adjustment from the earlier subsidence and recovery. The island maintained its height relative to the liquid. At 6:30 p.m., however, the bench magma was sinking faster than the liquid, so that floods from the ring-pool, seeming to arise at a dark crust on the southeast border, swept around the island and across its lower parts east and south into the central lagoon. Two currents met in lines of bubbling at the west. Besides the southeast locality, there were points of departure of currents right and left at the wall margin of the north and southwest corners of the ring-pool, and these streamings were accompanied by the usual intense multiple fountaining and island bombardment which had been the distinctive feature of the last three weeks. Only once a fountain was seen in the lagoon.

At Lee's pit in the southwest part of Kilauea crater, the edge was found newly broken in from the quaking of the afternoon. Small quakes were felt about 4:10 p.m. and at 4:18 p.m. an avalanche fell from the southern part of Uwekahuna Bluff — doubtless an earthquake slide. Blue fume and flame arose from the crack where the fountains had been, white vapor rose from the next higher part of the rift towards Halemaumau, and dense whitish-brown vapor from the smoke-hole still higher a few yards from the lava pit. The flow was glowing but collapsed, friable shelly lava, and had not extended beyond what was seen at noon.

At 11 a.m. December 16 the lake was

148 feet down and the crag summit was 77 feet high above the lake. Dense fume rose from the southwest smoke-hole, twelve jets of blue fume from the source-crack, and five jets of white vapor from the desert beyond.

The liquid of the lake had encroached on the southern half of the island. Streaming in the ring-pool was away from the wall on the north, southeast and southwest, intense multiple fountaining there continued, and an occasional dome-fountain broke in the north central part of the lagoon. The trace of the southwest rift-crack, up the inner wall of Halemaumau, was seen to stand open, a vertical chasm, cutting the fresh black ledge veneer, and about one foot wide. This implied its maintenance as an open crack under the lake and presumably full of liquid in the outer country up to the lake level.

The north shelf or niche of the Halemaumau rim, where vacated by the recent fill of the high level, was covered with rough black aa lava with only a few patches or crusts of pahoehoe. A little of the black ledge around the pit had scaled off. The lake appeared as though rising, it could be seen from Uwekahuna at 4:30 p.m., and at night the pit was brilliant as before.

The rising of the liquid was verified next day, for at 11:30 a.m. the lake had risen over 60 feet in twenty-four hours. The fountains were bigger and even more tumultuous, like the July demonstration of 1912 and more of them, and the foci of radial outward streaming from the wall margins of the lake were north-northeast, southeast and southwest. There was more overflowing of the south half of the island, still in progress, all except a small remnant of crag and bowlders. The north crag was surrounded by new wide fresh platforms, and appeared to be rising more than the south end of the atoll-shaped island of which it is a part. A swift torrent was again pouring south around the west end of the northern crag, making violent conflict of currents at the west with high fountains. Other such conflicts happened south and east. Large periodic dome fountains broke the skin of the central lagoon every one to two minutes, and there was a fountaining grotto built at the southwest side of this lagoon. The black ledge had scaled off more and one avalanche was seen.

From Uwekahuna at 8 p.m. both the fountains and the summit of crag were in view above the edge of the pit, which was gorgeous in its brilliancy, lighting up all the cliffs of Kilauea. No glow was seen in the southwest flow or the fuming desert cracks. The rumble of the pit was loudly audible. The Postal Rift flow, remnant from November, still shows four glowing cones, two in the north central part of Kilauea and two under Uwekahuna.

At 7:40 p.m. a detonating meteorite or bolide passed over the island, probably from northeast to southwest, making a streak of light, an explosion, and a concussion, perceived over all the eastern parts of Hawaii and from the sea to the north.

At noon December 18 the island in Halemaumau was more submerged, the lake about 70 feet down, and thousands of points of ebullition north-northeast, south and southwest made tumultuous coarse fountaining, the streaming moving out from dark skins at the wall border, north, southeast and southwest. The ring channel was wide south and north, and narrow on the west, where there were some spatter lumps marking the border of the lagoon dish. Southwest the border was marked by two large spatter lumps, one of them a grotto. The central lake had been increasing in size at the expense of the southern half of the island; the latter, however, still showed a patch of crag bowlders southeast, the island rising on the east side. The ring lake was flowing into the lagoon across its rampart west-northwest, west, southwest, south-southwest and south. The north central dome fountain in the lagoon exploded at long intervals.

The southwest crack was smoking moderately near Halemaumau and a little visible fume rose from the crack in the lower flat where the fountains had been. The crack elsewhere was yielding very hot air. It had opened one to two feet across the upper fresh lava puddle, where the rift zone was about 60 feet wide with numerous cracks and some sulphur staining. The

lower crack in the flow area was lined with brownish stalactitic lava, and isolated outliers of the fissure had bubbles of lava over small vents below.

On December 19 there was enough rising in the lake to reach again the level of this outflow crack, an earthquake was felt at 6:50 a.m., and about 4:45 p.m. liquid lava again fountained up in the midst of the southwest flat and revived the flow there. This again appeared to be hydrostatic with reference to the pit. At 5:30 p.m. the flow extended right and left along the base of the Kilauea wall for three-quarters of a mile and was spreading. One large geyser of lava stood about seven feet high in the middle of the source crack, and three or four spurting cones lay along the crack on the Halemaumau side of this fountain and about 325 yards from the pit. The upper smoke hole was making thin fume and the crack above the flow was crossed without difficulty. The flowing continued steadily and the lake in Halemaumau did not go down.

The lake was about 50 feet below the rim, and the southwest crack in the inner wall was from 12 to 18 inches open. The island was more submerged southwest, south and west, the north crag standing about 35 feet above the liquid and 15 feet below the rim of the pit. The central lagoon showed a bright pattern of lines between blocks of skin, and was bordered by a broad platform on the north, part of the rampart accumulation which was burying the craggy portions of the island. The peripheral streaming was from the southwest and north, with centripetal bombardment against the island at the north and east. The noise of the endless fountaining was like a waterfall, and was audible far away. The fume continued thin and the glare brilliant.

The new situation appeared to be an adjustment of the outflow crack to the rising lake, with the rising slightly in excess of the outflow, and the mechanism tending to consume the bench magma beneath so as to lower the island relative to the liquid or frothy lava. The first outbreak of this rift December 15, with the level of liquid in the pit much above the level of outflow, and a long fissure system breaking open, produced a sudden pressure release accompanied by a reaction of subsidence. The second outbreak made no rupture and found the fissures ready and open, filled with lava which rose quietly to the level of outflow. This sequence is quite parallel in a small way to what happens in a Mauna Loa eruption.

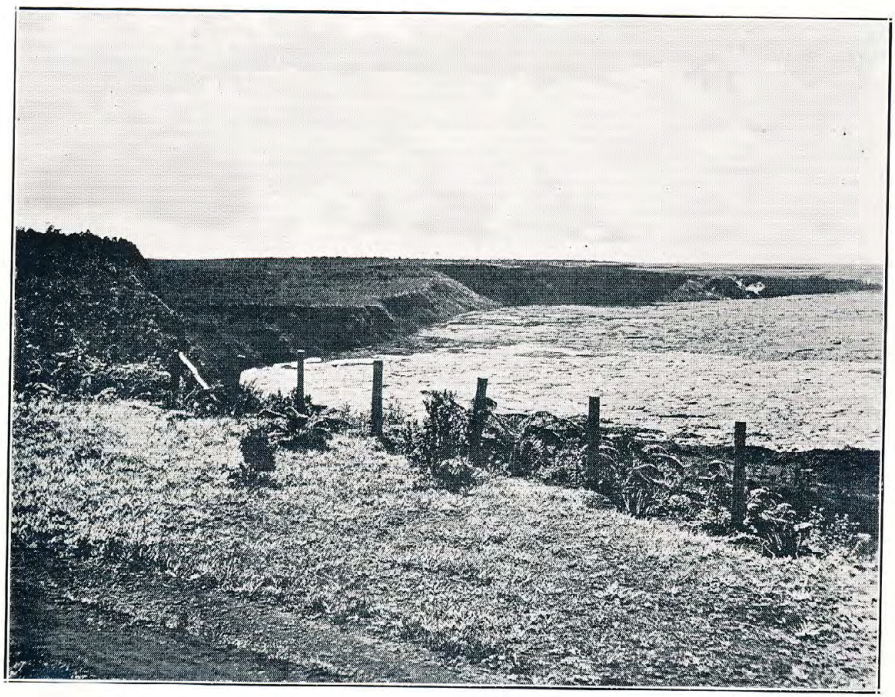
In the Whitney Laboratory of Seismology for the week ending at midnight Friday, December 19, 1919, the following local earthquakes have been registered:

Dec.	13,	7:50	a.m. very feeble
	15,	10:56	a.m. feeble, and four tremors
		1:30	p.m. feeble
		1:33	" very slight
		1:35	" feeble
		1:36	" slight
		1:37	" very feeble
		1:38	" very feeble
		1:39	" slight
		1:41	" very feeble
		1:42	" moder'ly strong
		1:45	" very slight
		1:48	" very slight
		1:49	" feeble
		1:51	" very feeble
		1:52	" feeble
		1:53	" slight
		1:57	" feeble
		2:00	" slight
		2:01	" very feeble
		2:04	" feeble
		2:07	" feeble
		2:17	" very slight
		2:37	" feeble
		3:05	" feeble
		3:13	" slight
		3:17	" very feeble
		3:32	" slight
		3:40	" slight
		3:41	" slight
		3:49	" very slight
		3:50	" very slight
		3:52	" feeble
		3:55	" very slight
		3:58	" very slight
		3:59	" very slight
		4:01	" feeble
		4:02	" very feeble
		4:03	" slight
		4:04	" moder'ly strong
		4:06	" very feeble
		4:07	" very feeble
		4:09	" slight

November 28, 1919. Halemaumau pit reopened, looking southwest.

November 30. Lake in Halemaumau and ring crag under talus, looking SE.

November 30, 1919. Southwest rift in Kilauea floor, looking from Halemaumau toward 1868 cracks.



November 30, 1919. Frontal portion Postal Rift flow from Observatory, looking S.
—Photos, Jaggar.

4:11	"	very feeble
4:13	"	very feeble
4:16	"	slight
4:20	"	moder'ly strong
4:22	"	feeble
4:26	"	feeble
4:28	"	feeble
4:29	"	slight
4:30	"	2 feeble quakes
4:31	"	very slight
4:32	"	slight
4:36	"	feeble
4:38	"	slight
4:40	"	feeble
4:43	"	feeble
4:48	"	feeble
4:50	"	very slight
4:52	"	feeble
4:55	"	very feeble
5:05	"	very feeble
5:08	"	very feeble
5:09	"	feeble
5:14	"	very slight
5:15	"	slight
5:17	"	very feeble
5:33	"	very slight
5:45	"	feeble
5:50	"	slight
5:51	"	very feeble
6:07	"	feeble
6:23	"	very feeble
6:30	"	very slight
6:39	"	feeble
7:17	"	very feeble
10:02	"	slight

In all eighty-one earthquakes, eighteen of which were perceptible.

Dec. 16, 7:40 a.m. very feeble
19, 6:50 " felt

Spasmodic microtremor increased to strong December 15 and was moderate thereafter. Harmonic tremor and microseismic motion increased from slight to moderate during the week. Tilting was slightly north December 13, nearly stationary December 14-16 and then moderately west and south.

December 27, 1919.

During the week ending Friday, December 26, 1919, the Hawaiian lava column has passed through another crisis which was reached in Halemaumau exactly on the solstice, December 22. At that time the lava in the pit again gained a high level following the two spurts of rising at rates exceeding 30 feet per day described in last week's Bulletin. At the same time the rifts which had been opening in the Kau desert five miles southwest of Kilauea crater gave vent to flowing pahoehoe lava. These flows have increased throughout the week and their reaction on the pit has steadily lowered the lava lake and crag at a rate exceeding 25 feet per day, leaving the lake depressed 150 feet at the end of the week.

The rending open of the rift system southwest from Kilauea, following upon the similar outbreak of the southwest flank of Mauna Loa, recalls the events of 1823 and 1868. In those years also lava flowed from the Kau desert, and the line of the present rifting lies between the two former eruptions. In both 1868 and 1823 the Kilauea lakes were very large, and appear to have lowered greatly during the outflow. The 1823 flow originated six miles to the southwest. In 18[illegible] both Mauna Loa and Kilauea erupted from fissures far down the southern flanks, the Kilauea outflow thirteen miles southwest of Kilauea crater. That eruption produced lava which welled out of a crack quietly without building up a source cone, and something similar appears to be the character of the 1919 outflow.

Measurements of the week have recorded in Halemaumau pit the following depressions of the lake and north crag, respectively, beneath the northeast stone monument on the edge of the pit, which stands at elevation 3727 feet above sea level:

Dec. 19, 6 p. m. lake 50 feet below rim; crag 25 feet below rim. Dec. 20, 11:00 a. m., lake 40 feet below rim; crag 20 feet below rim. Dec. 21, 11:00 a. m., lake 35 feet below rim; crag 10 feet below rim. Dec. 22, 11:00 a. m., lake 30 feet below rim; crag 0 feet below rim. Dec. 23, 11:00 a. m., lake 40 feet below rim; crag 5 feet below rim. Dec. 24, 10:00 a. m., lake 75 feet below rim; crag 45 feet below rim. Dec. 25, 11:00 a. m.. lake 110 feet below rim; crag 70 feet below rim. Dec. 26, 12:00 noon, 150 feet below rim; crag 100 feet below rim.

The movement of the lava column indicated by these figures was as follows: From December 19 to 22, three days, the bench magma rose 25 feet,

or 8.3 feet per day, and the lake magma 20 feet, or 6.7 feet per day; from December 22 to 26, four days, the bench magma subsided 100 feet, or 25 feet per day, and the lake magma 120 feet, or 30 feet per day. The north crag summit is the highest point of the island in the lake and on December 21 the lake had so gained on the island that this summit stood only 20 feet above the liquid; after the subsidence, the liquid had gone down so much faster than the island that the summit stood 50 feet above the lake.

On Saturday, December 20, conditions in Halemaumau were little changed, but rising continued so that in the afternoon the crag summit came into view above the edge of the pit as seen from the Observatory. The violent boiling and streaming continued stormily in the outer ring lake surrounding a horseshoe-shaped island and the inner lagoon encircled by the island was covered with polygonal areas of skin separated from each other by bright lines. The large fountain which had burst out through the rift in the southwest part of the Kilauea floor on the previous day was now building up a broad flat-topped slag heap surmounted by an active pool. This heap lay against the southwest wall of Kilauea crater and extended from Lee's pit to the south end of Uwekahuna wall. The spreading lava at the western edges of the heap could be seen from the Observatory above the right hand profile of Halemaumau.

At 11 a.m. December 21 rising activity continued, the lake standing only 35 feet below the rim of the pit and the outer slag heap to the southwest exhibiting several standing fountains on its summit which spurted 5 or 6 feet above the surrounding pool. The southwest crevasse nearer to Halemaumau at the smoke hole stood open from 3 to 4 feet and contained live hissing lava spiracles. The multiple fountaining in the pit made a great roar, sent up much gas and radiated intense heat, and the liquid had so gained on the island that the southern side of the latter was now completely covered with rampart splashings.

The writer could see smoke in the Kau desert to the southwest beyond the first line of vapor jets. Accordingly the whole line of the rift was explored and lava was discovered overwelling the lip of the crack five miles from Kilauea and three-quarters mile west of Puu Koae.

Starting at the southwest edge of Kilauea crater, an open network of gaping fissures was found, the largest of these being a chasm 15 feet wide broken through rock below and volcanic ash above, the sand continuously slipping on the inner slopes, giving evidence of motion in progress. Vapor rose from a few of the smaller cracks, in some places smelling strongly of sulphurous acid. A second group of conspicuous cracks was found midway between the edge of Kilauea and Cone Peak. Here dense white vapor was puffing up, and down a crack 4 feet wide fluid lava could be seen 50 feet below. This was sluggish pahoehoe welling up in heavy snake-like folds, throwing out incandescent toes and making a crackling noise by reason of the heating and snapping of the adjacent rock. No visible vapor whatever arose where the lava was seen. The dense vapor always came from small cracks adjacent to the lava fillings.

A second zone of steaming cracks was found on the western side of Cone Peak and continuing thence down the mountain to the southwest. This made the active zone about a quarter mile wide and the breaking of the ground was irregular; small fractures across sand and gravel flats being frequently oblique and transverse to the general trend of the rift system. The main steaming cracks on the east and west sides of Cone Peak were usually from one to two feet wide and very continuous. In the southern hill of the Cone Peak ridge a new crack under the slope had broken down and engulfed the pumice of the cone, making a small pit about 10 feet in diameter.

The western of the two main cracks, about four and a half miles down the mountain, showed live lava inside at considerable depths, and on following the crack a half mile farther this lava rose to the surface level. It made a fill in the crack of heavy black pahoehoe, with hissing gas vents breaking through it which yielded flames and

built up small spires or roundish heaving puddles. An occasional deep detonation suggested that the expanding lava was heaving open the crack. About four miles from Kilauea the lava overflowed the crack in two small puddles 30 to 50 feet in diameter which were spread out on surfaces of sand and old pahoehoe. These pools were oozing out in incandescent toes at their margins and along the fissure a line of about fifteen spitting and spurting driblet cones crossed the puddles and extended for some distance on either side. One of these was a narrow erect spire about 4 feet high. Below these flows this crack narrowed and became inconspicuous. There were vapor jets at intervals along the live line but not where the lava was most lively.

From this region for another half mile down the mountain the lava activity was offset to the eastern crack beginning a half mile west of Puu Koae and extending for a half mile farther southwest. Bluish brown fume rose densely from this area, smelling of steam and sulphurous acid, as at the old Postal Rift of Halemaumau. This crack was full of lava all along the line with spires, spiracles and heaving pudding vents, the activity appearing to have slowed down from something greater a day or two previous. The place appeared stagnating while the western crack took up the action. The eastern crack was a chasm from 2 to 4 feet wide, showing much spatter from the cones within it and some sulphurous stain. The cones were hissing and flaming but not at the moment spurting, and some of them were spires 3 to 4 feet high inside the chasm with their tops altogether below the surface of the ground. Other vents were small curled driblet spiracles where the gas escaped through a hole in a fold of heavy pahoehoe which filled the rift. Many of these were level with the surface but none of the lava actually welled over the lip of the crack. At the lower end of the half-mile stretch the crack petered out.

The line of this rift system trends throughout the upper part of its course from Halemaumau through Cone Peak in the direction of Hilea and accords perfectly with the so-called 1868 cracks shown on the maps. These cracks constitute a rift belt which in places is more than four miles wide, extending from Kilauea crater to the ocean, with curvature to the east in the southern part of the belt. A dozen cones and numerous pits and deep chasms mark the course of the rift area, and in Kilauea crater itself the chasms outcrop in the face of the southern wall. Uwekahuna cliff is itself a fault face of the system and numerous cracks and fault blocks on the gravel flats near Keanakakoi lie in the rift belt. Northeast of Kilauea there is no definite evidence of any such belt. The great fractures to the southwest are ancient features and the incidents of 1868 form but a trivial part of their history.

The lava in Halemaumau on December 22 reached a maximum of fury in its boiling, the top of the crag was level with the rim and the lake about 30 feet down. The heat was so great that numerous whirlwinds were started carrying up fragments of lava and making much commotion. The fountaining pool of the southwest slag-heap continued active and the flows down the flanks of the heap reached Lee's pit so as to make a single ropy cascade across the overhanging rim of the pit which solidified, leaving a vertical column from the rim to the floor 15 feet high and one to two feet in diameter.

On this day a visit was made to the desert flow area by way of the road leading from Volcano House to Pahala. We left the road at the water tank nine miles from Volcano House and walked east across the rough aa flow for half an hour and then for one hour on smooth pahoehoe ground. This brought us to the flow at the rift west of Puu Koae. The gas pressure had ceased and the lava was not flowing. The puddles had increased in size, the largest now being 400 feet in diameter. Expansion had continued in the crack, breaking open cones and flows already solidified. In several places the surface breaking of the ground along the crack was guided by tree roots which had penetrated older fissures.

No change was observed at the smoking crack nearer to Puu Koae, but along this line two miles farther down the mountain there were new steaming fissures. The cracks were here in

motion, with sand falling at the edges, occasionally deep thudding noises could be heard and several vents gave off thick white sulphurous vapor. The lava was here rising deep underground but had not yet reached the surface. The crack was extending itself in a direction which would carry it to the west of the Kamakaia hills (1823 flow) and somewhat to the east of the 1868 source vents.

At 11 a.m. December 23 Halemaumau showed the beginnings of subsidence. The ring pool was boiling evenly with inward streaming. The island stood in higher relief above the lake, its complete outline being restored at the south about 10 feet above lake level, while the north crag stood 35 feet high. Three fountains had resumed action in the central lagoon. The maximum level which had been reached the day previous was marked by a spatter margin all around the pit standing 8 feet above the lake, this being inside of the black ledge of December 15 the top of which stood 10 or 12 feet higher. It was evident that the liquid was sinking faster than the island. A broken wall 8 feet high encircled the inner lagoon. A single fountain was still in action on top of the southwest slag heap, with a cone built around it. This slag-heap was now three-fourths of a mile long and 25 feet high, built against the southwest wall of Kilauea and sloping thence rather steeply to lower ground.

Before daylight on Wednesday, December 24, travellers on the Pahala road could see flowing lava in the Kau desert. A distant view from the Uwekahuna summit at 9 a.m. revealed the gleaming surface of a flow about eight miles from Kilauea where the yawning cracks and sulphurous vapor had been seen at the lowest point reached two days before.

The lake in Halemaumau was now 75 feet down and the island stood in high relief with a large dome grotto developed on the southwest side of the inner lagoon. The crag summit was far below the rim of the pit and no longer visible from the Observatory. All fountaining had ceased at the southwest heap, and the summit pool had collapsed to a smoking pit.

At 10:30 a.m. an expedition to the desert was made by way of the Pahala road to the Kapapala bull-pen, whence the trip on foot eastward crossed smooth country so that the lower end of the new lava flow was reached in thirty minutes. This flow was found to consist of three sheets of pahoehoe lava moving steadily and slowly along the top of the rift, with rift fountains playing in a line down the middle. The total flowing area was about one and a half miles long and one-eighth mile wide at the broadest part near the lower end. This wide area was essentially a flat-topped slag-heap with slow streaming down the middle in the direction of the rift, its borders spilling over more to the west than to the east. In places the lava invaded trees and bushes which flared up, and there were some detonations of exploding gas in old caverns. The three separate sheets referred to were separated along the course of the rift by short uncovered stretches where the crack might be crossed, with live flows above and below. In the separate pools the rift line was marked by either a row of fountains or by spitting cones standing in the midst of the flow area. The lava as in the upper locality seen December 21 was chiefly porous pahoehoe with rough surface. In detail aa lava appeared locally between the pahoehoe shells.

Following the fissure below the flow, we found a place where the ground was groaning and heaving, making small earthquakes and yielding sulphurous vapor from many cracks. Sitting quietly on this ground one could feel slight shocks and hear the rock underground snapping and creaking, while pebbles and sand fell in the crevices. A mile farther down the rift there was timbered country with large sand dunes. Here the live crack was found cutting through deep banks of sand and through rock below, where incandescent lava 40 feet down was slowly welling up and making crackling noises.

It was now evident that the flow was progressing by a splitting forward of the rift and a subterranean draining of Halemaumau, each upwelling being more voluminous than the next

preceding, and the individual outflows decreasing in viscosity as they gained volume.

On December 25 at 11 a.m. the lava lake in Halemaumau was about 110 feet below the rim and the crag peak could be barely seen from Uwekahuna Bluff. The fume from the pit had increased and dense vapor rose from the southwest heap.

Renewed exploration of the Kau desert flow on this day was made from the old Halfway House site fourteen miles from Volcano House on the Pahala road. Going east from here we crossed wide pahoehoe flats, one aa flow, and chasm depressions made by sunken blocks between crevasses on either side. The first of these, five miles above the beginning of the 1868 flow, has heaps of black pahoehoe lava surmounting the crack as an upper and outlying outflow of 1868. There are several wide open cracks which are very deep. Some of these appear within a mile of the road going eastward. A walk of 1 hour 50 minutes brought us to the summit trig. station of the southern Kamakaia cone. This cone is of pumice with a high lava heap beneath, and around it are the extensive flows of 1823. The view showed four localities symmetrically spaced from Kilauea for nine miles down the rift line, where fume rose. The upper of these was a quarter mile from the Kilauea edge, the second four miles, the third six miles and the lower one in the forested sand dunes nine miles from the crater. At this last locality could be seen a new flow burning the forest and making rapid progress from the source crack where on the previous day live lava had been seen in the depths.

On visiting this flow we found the rift above the upper end breaking across deep sand deposits, which occasionally slipped in, and some rumbling could be heard below. Above this crack several driblet cones had formed and these led to a wide flat flow surface 4 or 5 feet high from which streams made out laterally and on top of which there was slow streaming in a south-southwest direction and some fountaining directly over the rift line. The fronts of the live lobes were mobile pahoehoe sheets one to two feet thick, much thinner than the heaped up flows of the next higher zone of activity seen on the previous day.

There was marked increase of sharp explosions in old cavernous spaces near the live fronts, and as all of this flow was in open woodland with much burning of vegetation, it seemed probable that carbon monoxide and air were responsible for the detonations. The odor of coal gas and of burnt organic matter was more noticeable than the odor of sulphur. This flow was a half mile long and from a few yards to one-eighth mile wide. Many trees were standing in the midst of the flow and here and there they were burning and falling. The only aa noticed was on the crests of some of the driblet cones and efflorescences in cracks of pahoehoe. The live crack below this flow could be traced for only a hundred yards with some white vapor rising and no perceptible motion. A second steaming crack was found at the eastern base of the old aa flow a half mile west of this locality.

At noon Friday, December 26, the lake was lower in Halemaumau and the island stood high above it. A large dome grotto had formed against the island on the southwest side of the inner lagoon and in the middle of the latter three fountains were in action. The outer ring lake showed very intense multiple fountaining on all sides in large domes and the streaming was away from stagnant skins at localities southwest, southeast and north. The southeastern part of the island was now an uplifted flat sloping inward. The spatter rampart built against the north side of the north crag was more than half as high as the crag, and no such uplifted rampart appeared on the outer face of the island east and south. The shore of the inner lagoon showed a broken-down slope about 4 feet high. On the outer wall of the pit all around the horizontal spatter lines marking shores progressively deserted by the sinking liquid were one to two feet apart and rather closer together below than above. This black ledge makes a shell one to three feet thick. The heat and light from the stormy fountaining were intense and the visi-

days, December 26–29, prior to the outbreak of the aa flow in the desert, the lake went down 62 feet, or 20.7 feet per day, while the crag subsided 54 feet or 18 feet per day. For the next three days, however, December 29 to January 1, the lake subsided only 32 feet, or 10.7 feet per day, while the crag sank 50 feet, or 16.7 feet per day. The relief of the crag above the lake was therefore as follows:

December	26,	50 feet
	27,	51 "
	29,	58 "
January	1,	40 "

On Saturday, December 27, at 3 p.m. the lava column of Halemaumau continued its equable subsidence, the lake receding faster than the island. The outer ramparts of the island had slumped, giving it steep walls, and cracks parallel to the walls showed tendency to further slumping. The fountaining was somewhat less intense. The evenly terraced spatter lines, marking the successive stands of the liquid against the outer wall of the pit, constituted an impressive and unbroken index of the subsidence. The fume was thin in the pit, a little rising from the island, but much vapor rose from the southwest heap in the outer crater.

In the Kau desert the flows of the middle zone six miles from Kilauea had now become specially active and were piling up an elongate terraced slag-heap along the rift for a length of two miles. This heap could be seen at night looking southward from Uwekahuna Bluff and appeared like a broad bed of coals in the midst of the open country. The glow and rumble from Halemaumau pit were now notably less, though both were still strong.

December 28 at 10 a.m. another visit was made to the lava heaps in the desert. There were now three localities where live flows had been seen and photographed, but only the two lower ones had developed imposing piles of lava. These are respectively six and nine miles from Kilauea. Both are flat-topped elongate slag-heaps with profiles not unlike the profile of Mauna Loa in miniature. Building up to heights of from 30 to 50 feet these structures, thousands of feet long, have become prominent landmarks, even rising above the tree tops as seen across the desert from the west. The upper of the two was first visited and this stands in open desert country with old pahoehoe flats on either side. At the lower end there had been no flowing forward beyond the point reached December 24, but what had then been three sheets of lava along the rift was now a series of six terraces, the one overlapping the other, following the general slope, standing over the rift line, and each surmounted by a fountaining pool which was perfectly flat, more or less crusted and occasionally spilled over its edge. By this process the terraces were increasing in height, each of them at this time from 25 to 30 feet above the general level of the country on either hand. Sluggish pahoehoe streams trickled down the outer slopes. It was possible to climb one of these slopes at an inactive area, but there was nothing on top of the heap except heavy flat crusts and a line of small fountains marking the trend of the crack beneath. Each terrace was about a third of a mile long and from one-eighth to one-quarter mile wide, the whole series making a tabular ridge extending two miles down the mountain beginning at six miles from Kilauea. There was a small patch of aa lava on the west side of the second terrace, counting from above. This entire ridge lay over the western of the two marked cracks which have been conspicuous in the present eruption. A half mile below the lower end of this ridge some small flows have welled up from the same crack.

The lower flow heap in the midst of the forested sand dunes is on the next crack to the east and so out of line with the upper ridge by about one-eighth mile. The flat summit of this heap shows numerous fountains about 40 feet above the general level of the country and on this day the flows were pushing into the forest sluggishly from the lower end of the heap. The trend of the rift cracks under both heaps is the same, S. 50° W. There was some trickling outflow on the east side of the lower heap which was burning the forest, but very little smoke or fume

ble smoke mostly from the island. The transparent fume which rises from the fountains condenses in the upper atmosphere to a reddish stratus somewhat opalescent, and this volcanic smoke is transported great distances and has been reported recently from Kona, Kohala and Honolulu.

The crack in the southwest wall of the pit was no longer open, but covered with spatter drip and showing glow spots in places. The lower northern shelf of Halemaumau, which at the end of November was covered with tumbled debris, had by overflow become a flat platform of smooth lava about 50 feet below the rim of the pit and below it the inner slope was sculptured by drip-marked horizontal terraces.

Inspection of the desert outflows on December 26 showed little progress in the lower flow area and the crack below the flow was very small and not steaming. In this lava field the fountains were vigorous and the heap piling up with tendency to outflow spreading west. The upper flow in the open country was piling up and flowing strongly. The rift under this flow as extended down hill lay a quarter mile west of the rift under the flow in the sand dunes, and from this western rift west of the sand dunes a new small flow had welled up and the ground was in motion there. Along this line some fume could be seen farther down the mountain. Cavern explosions had diminished.

During the week ending Friday, December 26, 1919, local earthquakes registered in the Whitney Laboratory have been few and very feeble, as follows: December 22, 10:30 p.m. and 11 p.m.; December 23, 4:18 a.m.; December 25, 1:25 a.m. No earthquakes whatever were felt at Hilea in southern Hawaii. This is a matter of some interest, as in 1868 some persons believed that the Kau desert rift system extended beyond Kilauea mountain in the Hilea direction. The swarm of earthquakes December 15 and others accompanying the opening of the Kau desert rift have been wholly limited to Kilauea mountain.

Spasmodic microtremor has been slight with some increase December 22--23. Harmonic tremor has been moderate. Microseismic motion was moderate to slight. Tilting became strong to the east and north December 23 and was otherwise not pronounced.

January 3, 1920.

During the week ending Friday, January 2, 1920, the lava column of Kilauea volcano again passed a critical point, the rift in the desert giving vent to a long and vigorous aa flow. This outbreak came from the midst of the upper of the two pahoehoe slag-heaps which breached itself on its eastern side and sent out a voluminous flood that travelled two miles per day. This flood was pahoehoe above but quickly changed to aa in its lower reaches and formed a straight river of lava which bent off to the south-southwest and poured down the depression immediately to the west of the Kamakaia cones. This flow in volume and steadfast progress has become comparable to the recent Alika flow on Mauna Loa and at the present time has progressed more than five miles from its source. Halemaumau has continued to show subsidence at a decreasing rate, the drainage of the lake magma becoming strikingly less when the outflows in the desert changed from pahoehoe to aa.

Measurements of depression of the lake and north crag of the island, below the northeast monument on the rim of the pit as datum (3727 feet above sea level) have been as follows. Where not otherwise indicated the lake measurements have been directed to the ring pool at north base of the north crag:

Dec. 26, 12 noon, lake 150 feet below rim; crag 100 feet below rim. Dec. 27, 2:40 p. m., lake 171 feet below rim; crag 120 feet below rim. Dec. 29, 3:00 p. m., lake 212 feet below rim; crag 154 feet below rim. Jan. 1, 11:30 a. m., lake 244 feet below rim (at north pool); crag 204 feet below rim. Jan. 1, 11.30 a. m., lake 255 feet below rim (at S. W. side lagoon).

The diameter of the lake January 1 was 1115 feet from east to west.

These figures show that for the three

rose from the live lava. Neither the upper nor the lower heaps were making any definite flow down the mountain, and the splitting open of the rift system had ceased.

At 3 p.m. December 29 inspection of Halemauman showed that the rate of lowering was less. The island stood high above the lake and the north rampart under the craggy summit of the island was seen to be breaking down with avalanches. An islet in the north pool under this rampart showed that other blocks had slipped down. There were two fountaining areas in the central lagoon near its middle and others near the western border of the lagoon where the streaming was outward toward the fountaining ring pool. The maximum boiling in this pool was along the base of the eastern wall of the pit. Other conditions remained as before.

This day was a time of crisis in the Kau desert rift, but in the forenoon the only marked change was some increase in the number of aa patches on the east flank of the upper part of the six-mile ridge. The summit of the heap was fountaining strongly, as was also the lower nine-mile heap. At some time in the afternoon of this day the upper heap broke open on its eastern side and gave vent to the great flow.

On the morning of December 30 I entered the desert from the roadway one mile below the old Halfway House site, exploring the country below the lava heaps and finding no new outbreaks. I then went up the west side of the lower heap and found that the flows in front of that heap had lengthened it until it was a mile and a half long and had completely buried the new rift at the lower end. The tabular summit at the upper end was now 60 feet high with three or four fountains playing on top in a stagnant pool that overflowed the flanks with sluggish pahoehoe streams that pushed into the sand dunes and occasionally ignited trees.

From a high dune at the north end of this heap I discovered the new aa flow a quarter mile to the east. It was a glowing river of melt extending up the country about two miles, where it bent to the west, and it evidently took its rise in the upper part of the long terraced ridge of new lava. On close examination this flow was found to be a lava band 100 yards wide, its margin a wall of rough incandescent aa 5 feet high and its middle portions creeping along about four feet to the minute. Large bowlders of accumulation lay on its surface, the edges were glowing and crumbling like cheese and the fragments which fell from the crumbling made a tinkle of hard rock. The newest of these fragments while still hot was yet intensely oxidized. Slabs of pahoehoe were scattered over the surface of the flow and the reason for this appeared when on following the flow towards its source, I found that the middle portion became increasingly pahoehoe, until at the upper half mile of the flow the material all congealed in the smooth and festooned fashion without a trace of aa.

The front of the flow lay in a fault chasm made by a sunken block 100 feet wide between two lateral rifts. The channel was about 30 feet deep with trees growing in it. The flow had increased its speed as it entered this constricted area so that it was moving approximately one-fifth mile per hour. The mass moved like a stiff glowing mud full of bowlders which would flow around the trees while they still remained upright and set them on fire. The tree trunks thus weakened finally gave way and were slowly pushed over, the tops set ablazing and finally completely engulfed by the resistless tide of molten rock. An ohia tree 35 feet high and one foot in diameter was thus swallowed up in about two minutes. The flow appeared to be making headway of about two miles per day.

Following the flow up to its source, the middle stream of pahoehoe was found travelling two to three miles per hour, and at the source itself the river, now wholly pahoehoe, moved at least eight miles per hour. Where the stream emerged from the lava heap, the eastern side of the second terrace had slumped and broken down into a ravine about 75 yards wide with walls 25 feet high. The liquid lava came from a vent in the wall as a cascade at the head of this ravine and formed rapids below over tumbled debris where

a large angular fragment of the breached ridge stood as an island about 20 feet in diameter. The river was extremely liquid and from 60 to 70 feet wide within margins of its own overflow somewhat raised above the surrounding country. The whole belt of flow was 100 yards wide. Fountains could no longer be seen on top of the lava terraces of the source ridge. The breached portion of the ridge was just where the slow small aa flows in the midst of pahoehoe had been seen December 28 and December 29.

A word of explanation is necessary in speaking of live lava as **flowing pahoehoe** or **flowing aa.** The words pahoehoe and aa are commonly used of already solidified products. The difference between the two types when in motion is this: pahoehoe lava forms glistening skins which stretch and wrinkle, the lava beneath shows vesicles being drawn out, and the process of solidification leaves a highly glassy lustrous surface with rounded or ropy or serpent-like forms. As flowing lava is always congealing on the surface and at the sides, the nature of the congelation seen defines the nature of the flowing. Aa lava while in motion forms no skins on its surface and is characterized by a granular look which resembles a bed of hot anthracite coal flowing. This granular paste keeps rolling up lumpy balls of its bottom material, and these make slow moving rafts and islands. Around the edges or fronts of such a flow the glowing paste moves with an incessant cheesy crumbling and breaking. The part which is actually glowing is usually a thin layer, which rides over tumbled fragments of very rough shapes, and carries on its back other fragments of all shapes and sizes, highly scoriaceous, rusty and without any glassy surface at all. There is no bubbling or visible vesicularity to an aa front, though the rock contains irregular gas blebs when it is cold. When, as in the case of this flow, we get a transition from pahoehoe to aa in the process of flowing, the wrinkling skins and crusts of the pahoehoe phase pass down the middle of the flow and the edges start effloresceing in the cheesy aa fashion.

On December 31 Haiemaumau continued its slow subsidence with the same strong boiling and intense emission of gas. Fume continued thin from the pit but dense vapor was increasing from the southwest heap and much vapor rose from the cracks near Cone Peak.

The Kau desert flow was visited by a new approach leaving the Pahala road four miles from Volcano House and heading toward Puu Koae. The upper lava crack localities of the rift were fuming slightly and flowing not at all. The head of the flow source heap was found to be a series of inactive lava pilings. The top of this heap was found to be a hard plateau pression a fine view was obtained of the flow as it poured out from its basin. This proved to be a rugged amphitheatre across the bottom of which, from west to east, flowed the lava river swiftly and silently with ripples and rapids. The river was 100 feet wide in places, flush with a bank of its own overflooding, and this sloped away on either side so as to leave the stream raised about 12 feet above the general level of the country. The whole accumulation, banks and river, thus created a lower ridge 100 yards wide with the river advancing along its middle. The source of the stream was a round opening 10 feet in diameter with a driblet rim up which the lava welled continuously in a low standing fountain rising only about three feet. This torrent bent at once into a cascade feeding the river below. The surface of the lava so emerging was full of coarse drawn-out vesicles. It made no noise and showed no gas spurting. There were a few small bubble fountains in the upper part of the river.

Keeping on the eastern side, the flow was followed about five miles to its foot. On climbing to the edge of the river in the upper part of its course, the molten stream was found brimming level with its confining margin, the surface currents progressing at different rates in separate bands lengthwise with here and there an island emerging through the surface as though the stream were very shallow.

The front of the flow lay opposite to and west of the lower Kamakaia

hill. Here it was wholly aa, with a sluggish granular river showing in places, and forking about ledges which made islands in the flow. The extreme front was at the moment pouring into a chasm and setting fire to trees. The rafted blocks which made islands in the aa could be seen to move with an excessively slow creeping motion. They were evidently a part of the stiff bottom material of the stream, itself moving much more slowly than the surface river.

Fountains were still playing on top of the lower lava heap, the summit plateau of which now stood about 80 feet above the general level. A small spatter cone about three feet high stood on top of the crusted pool. At the southern end of the upper slag-heap terrace a small aa flow was oozing out and glowing.

At 9 p.m. from Uwekahuna the flow and its source heap in the distance across the desert were spectacular, the light of the source-well being reflected from the fume above while the trickle flows, the summit fountains of the southern heap and the long bright line of the flow itself made a luminous and unusual picture.

At 11:30 a.m. January 1, 1920, the lava lake in Halemaumau showed by the large spatter accumulations on the wall that its subsidence had become slow. Two flat upright slabs on the north side of the north crag had broken down into the ring pool, making islets with channels about four feet wide between them and the crag. A similar islet half filled the southeast channel and the northwest channel had greatly narrowed. The effervescence was strongest on the east, west and south. Streaming was northward on both sides of the pit, the currents meeting towards the northeast. The south and southwest channels appeared to be dividing up into fountaining pockets. Much smoke rose from the north crag. The lake had subsided sufficiently to leave a vertical wall under the north shelf and there was marked transition from the terraced spatter lines above, to the heavy border accumulations of the lake below which recorded the change from rapid to slow sinking.

On January 2 it was evident that fume from the pit was increasing and very dense vapor arose from three places along the crack in the southwest slag-heap.

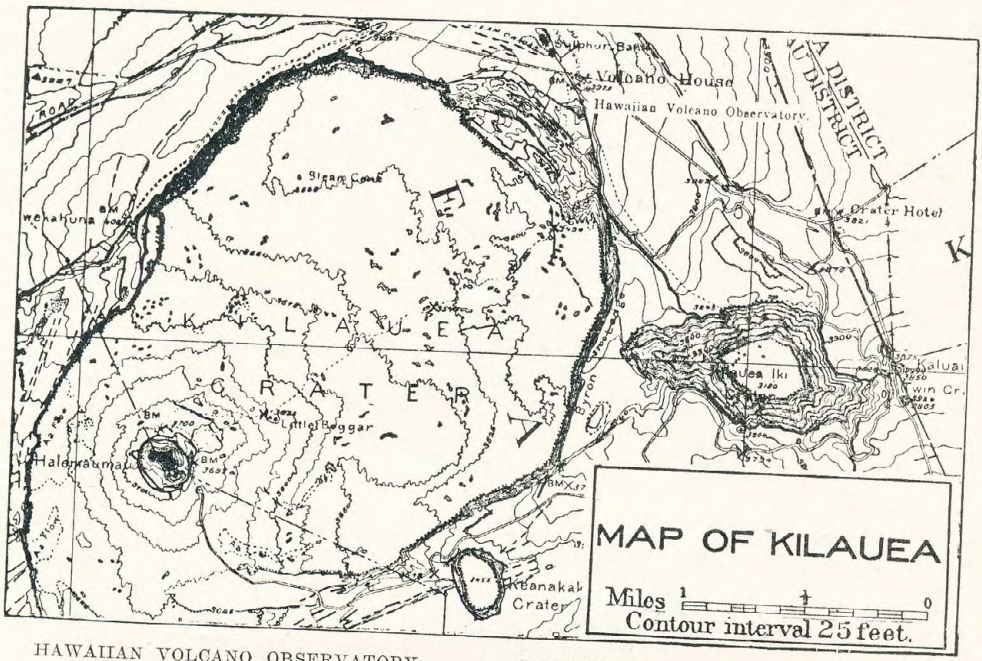
On this day exploration was directed to the region below the flow in the desert by way of the old trail from the Kapapala Ranch gate across the 1868 flow. The topography slopes off more steeply towards the sea in this region, some 1300 feet above sea level. The foot of the live flow was estimated to be about 2200 feet above sea level in the vicinity of Puu Kouele and now advancing less than a half mile a day. A long smooth pahoehoe surface leads downward along a depression between the 1823 aa flow on the east and the 1868 rift escarpment on the west, and it seems probable that this will be the natural route for the new flow if it continues.

Investigation of the lower lava heap in the sand dunes revealed the fact that fountaining there had ceased. I climbed on top of the heap and found it smoking and very hot, with a summit crust about two feet thick. Some sluggish pahoehoe flows were still making out into the forest on the east side. The view from the summit showed the long aa flow as bright and vigorous as ever and following the same course as before. A second small flow was said to be making out towards the west from the upper lava heap. Glowing lava in motion could be seen near the front of the main flow near Puu Kouele and occasionally the smoke of burning forest broke out in that vicinity.

In the Whitney Laboratory of Seismology for the week ending at midnight January 2, 1920, only one very feeble local earthquake has been registered, at 1:25 a.m. on December 30, 1919. Spasmodic microtremor has been slight with a little increase December 31-January 1. Harmonic tremor was moderate and microseismic motion slight. Movement of tilting was pronounced to the east and north until December 30, when it became stationary, and on January 2 a strong reverse movement to south and west set in.

Very respectfully,

T. A. JAGGAR, JR.,
Volcanologist.



HAWAIIAN VOLCANO OBSERVATORY.

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 solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	1000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the accelerations or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol a, or max. a, is given in the conventional unit of milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ. per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.