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No. 1

CONTENTS

HALEMAUMAU

By R. M. Wilson

VOLCANIC CONDITIONS IN JANUARY

Activity of Halemaumau

JOURNAL, JANUARY, 1928

Illustrations

SEISMOMETRIC RECORD

Local Earthquakes and Tremors

Harmonic Tremor

Microseismic Motion

Tilting of the Ground

MAP AND STATION DATA

HALEMAUMAU

Lava activity in Halemaumau during 1927 was limited to the minor eruption of July. During the first few hours on July 7 lava gushed out copiously, but action diminished rapidly, and the succeeding 10 days showed but a mild trickle of lava from a covered cone. The several periods of increased avalanching during the year furnished some interesting action. The pit was otherwise very quiet.

The Bulletin for June, 1924, gives for past years dimensions of the oval pit as follows:

1912—1,225 by 1,530 feet
1921—1,535 by 1,210 feet
1922—1,980 by 1,520 feet
1924—3,410 by 2,910 feet

The figures are now approximately 3,420 by 2,980 feet. The 1922 dimensions were held practically unchanged until the explosive eruption of 1924, which

activity nearly doubled the dimensions of the pit, as the figures show. Since that time avalanching has been considerable, but parts of the rim do not often fall in, and when they do they are usually small blocks; so that in the last three and a half years the size of the pit has enlarged only slightly. The avalanches and slides have noticeably increased the size of the taluses, however. The longer diameter of the pit is an approximate continuation of the 1920 rift line, about northeast-southwest in direction.

Lava flowed into the pit in July, 1924, after the explosive eruption, the action lasting about 10 days, and formed a flat lava floor. This floor remained until covered by the flow of 1927 lava. These two minor eruptions, almost precisely three years apart, were very similar in duration and behavior, and no other active lava was in the pit during the interval of time between them.

Avalanching after 1924 caused the taluses to grow and to overlap the lava floor, and demolished and covered the 1924 source cone. The 1927 lava then filled in about 70 feet deep over the old floor, covering the toes of the taluses all around the bottom of the pit and making a fresh new floor. Since then the slides and avalanches have in turn been covering the edges of this new floor with debris as the toes of the taluses continue to advance. The west edge of the northwest bay now alone remains clear of debris.

The lava floor is at an elevation of 2,480 feet above sea level, and the summit elevations of the southwest and middle source cones are 2,643 and 2,530 feet, respectively. The floor and cones are surrounded by the talus slopes on all sides, which slant upward at an angle of about 30° (58% grade) to the steeper rock walls of the pit. Of these taluses, the greatest is the one at the southwest side of the pit, with the elevation of its top at 3,214 feet. The rock walls all around the pit ascend abruptly, their tops forming the sharp and definite rim with the comparatively flat floor of the main Kilauea Crater. To persons standing on the rim looking down into the pit, these walls seem perpendicular or even overhanging in places. Since the pit acquired its present form, there has been no descent made into it, though in former years, when lava was but a couple of hundred feet below the rim, persons easily descended by the intermediate benches to the lava lake level. Small and localized overhanging places exist where isolated jutting slabs occur, but in general the walls do not attain a slope greater than about 80° from the horizontal. The average slope from rim to talus of the west wall is but 53° (see Figure 1). The elevation of the rim averages about 3,650 feet above sea level.

The new lava floor, with its cones and spatter which extend a little up the southwest talus, had in July an area of about 30 acres. By the end of 1927 slides had diminished the exposed area of new lava to about 25 acres. The horizontal projections of the talus slopes cover 81 acres in all, of which 22 acres are for the great southwest talus. The area of the horizontal projection of the walls is also 81 acres, though of course the actual face area is much greater. Thus the total horizontal area of the open pit is 187 acres.

The walls, between rim and talus, being for the most part freshly peeled, reveal interesting detail. The layer-like structure, showing successive lava flows, is worth studying. The two open mouths of the 1920 rift tunnels on the southwest side of the pit, one above the other, show how the lava drained from the pit in 1920 to form the flow in the Kau Desert. The great intrusive mass, low down along the east-northeast wall, with its exposed face showing columnar structure, was glowing hot after the 1924 eruption.

It is interesting to note that during the last year avalanches have most frequently occurred over the ends of this intrusive mass. It seems possible that this great monolithic layer, with the rest of the east-northeast wall which it carries above it, may undergo independently slight relative movements in which the other walls of the pit do not partake. Thus there would be moving contacts between this wall and the ones adjacent, just over the ends of the canoe shaped intrusive mass. This may account for the greater frequency of avalanching at those points. Figure 2 shows how the niche in the north-northeast cor-

ner of the pit has perhaps been caused by a moving fault in the plane of the exposed face of the intrusive mass.

VOLCANIC CONDITIONS IN JANUARY

Activity of Halemaumau

There were numerous slides of varying sizes during the first days of the month, particularly on the west side of the pit. These reached a climax in the early morning of January 11, when there was a great landslide of the northwest wall and talus. A description of the result of this mechanism follows. It is interesting because an eruption was at first thought to have occurred.

The "false eruption" of January 11 seems to have been the result of avalanching material loading down the crust of a still liquid pocket of lava remaining from the eruption of last July. The lava lake formed at that time was both deep and fluid. With a thick crust formed over it as a blanket, there was so little loss of heat that some of the lava remained molten.

Avalanches during the first part of the month were frequent and large, and apparently the northwest talus gathered material until the whole body of the talus was overweighted and unstable on its underlying rock slope. The seismographs show a number of small avalanche tremors just after midnight on the 11th, culminating in a large one at 12:26 a. m. It is probable that at this time an avalanche fell on the overburdened northwest talus and caused it as a whole to slump down and out onto the lava floor, forming a distinct mound of material full on top of the northwest bay of the old lake, and decreasing the exposed lava floor by about five acres. This weight crushed down the crust of the pool, and squeezed out some of the stagnant liquid lava still remaining there. Cracks and crushed areas of the floor are visible to illustrate how this occurred. The lava was not gas charged, there was no fountaining, no harmonic tremor occurred on the Observatory seismographs, all action ceased as soon as the load of debris had settled into place. These facts all substantiate the idea that no new lava or first hand volcanic activity was involved.

JOURNAL, JANUARY, 1928

January 1. Much avalanche tremor recorded and occasional big avalanches were seen today. One this morning strongly recorded on seismographs. Does the tremor make the avalanche or the avalanche the tremor?

The pit shows at 6 p. m. fresh dry debris on all the taluses, and slides are tumbling from time to time. The walls are drying off. It is very noticeable how the two upright zones at each end of the NE. sill are solfataric, decomposed, and red-stained. These appear surely to be old wall-cracks, and the sill marks the bottom profile of an old pit.

January 2. Avalanches were heard last night and this morning, and dust was seen over the pit off and on all day. Now, at 3:30 p. m., the walls are dry, slides and single rocks are falling, and there is much trickling of slides at the north. There is white stain around the central cone. The NW. talus overlaps the lava floor of 1927 clear out to the breakdown around the edge of the lava pool.

The east wall of the pit overhangs. There is much starting of single rocks from high walls in various places. In bright light of a beautiful sunny day there is only a little steam in the usual places, and none of the cracks in the lava floor appear new or unusual. There are fresh cracks in wet earth back from the rim south and east.

January 3. No changes were noted at 5:30 p. m. A few small slides occurred, mostly N., NW., and S.

January 4. There is an almost continuous uneasy sliding of small rocks from the west, northwest, and north walls. These will start by a big rock giving away high up; the whole wall then "smokes" with rising dust. Some of these slides were next south of the west boss, some next south of NW. talus, and some at west end of big sill.

The July floor is overlapped with debris all around. The S. wall is wet because it does not get the winter sun. Steaming is very slight. The niche at the top of NW. talus is buried by the building up of the top of the talus cone.

The only conspicuous sulphur now is in the northernmost cone of the floor.

January 7. An examination was made about 3 p. m. of the ground west of the pit, above the area of frequent avalanching. At the WNW. station new cracks for 50 feet back from the rim have opened since the Christmas rain-storm. Fern and grass sods are freshly broken, and large deep cracks three feet or more wide give up hot steam.

The WNW. and NW. stations are in place, but the SSW. and SW. stations are not there. The west wall looks very unstable. The lava bottom still has its border toes and natural edge at the base of the SW. talus, but nowhere else.

There are numerous small slides.

January 9. Big slides from the NW. corner of pit occurred at 1 p. m. Six large avalanches were counted at that point between 12 and 1:30 p. m.

By means of spirit leveling the bench mark SE. appears to have sunk 0.4 foot in relation to "Spit" bench mark.

Measurements showed that the east rim cracks are still widening, most of the motion being where they run into the pit.

January 10. From 4:30 to 5 p. m. there was a series of heavy avalanches at the northwest and some sliding on all sides of the pit. The WNW. wall was clearly undermined and falling just under the heavy steam and opening cracks described January 7. Wet new fallen fragments lay under a wet place in the high wall. There are fresh dry fragments on the SSW. talus, and much new material on the N., and NE. taluses. Avalanches were heard and dust seen all day.

January 11. Just before 12:30 a. m. red glow from liquid lava appeared over Halemaumau. Preceding this was the prolonged roar of a monstrous avalanche, which made a big tremor on the seismograms, timed at 12:26 a. m.

When the pit was reached about 1 a. m., there were three glowing areas on the July lava floor of 1927; a long curved western band, a small central pudding, and a smaller fiery pot at the site of the north fountain. It was evident that new lava had spouted up, and moreover there was in the moonlight a light-colored area over the whole northwest floor to the south central cone and beyond, the dust stain from the big avalanche mentioned.

There had been some sort of bright incandescing at the beginning, making a moderate rosy glow over the pit, but this entirely disappeared in 20 minutes. At 1 a. m. the glowing areas were the usual filigree of cooling flows, with a hint of blue flame at the northern cone vent, but without observed motion. The wet spot in the wall was extended up to the top as the scar of the recent avalanche. There was steam on the face of the wall next to the north. There was no hissing or fountaining anywhere. Sliding continued from all sides, particularly northwest.

The forenoon from 9 a. m. on was spent in walking around the pit by south and west, for the purpose of close examination. The main new flow was semi-pahoehoe or "sharkskin" lava in a crescent around the south side of the northwest pool of July, 1927. It lay just outside of the sunken crust of that circular pool, which had been surrounded by a raised bank separated by cracks from the subsided inner portion. The new lava had come up these cracks in three places, the flows merging outside of the bank in the crescent described. The crescent was about 500 feet long. At its northeast end, near the center



Figure 1. West wall of Halemauau. Photo Wilson.



Figure 2. North-northeast corner of Halemaumau showing the niche above the northwest end of northeast sill.
Photo Wilson.

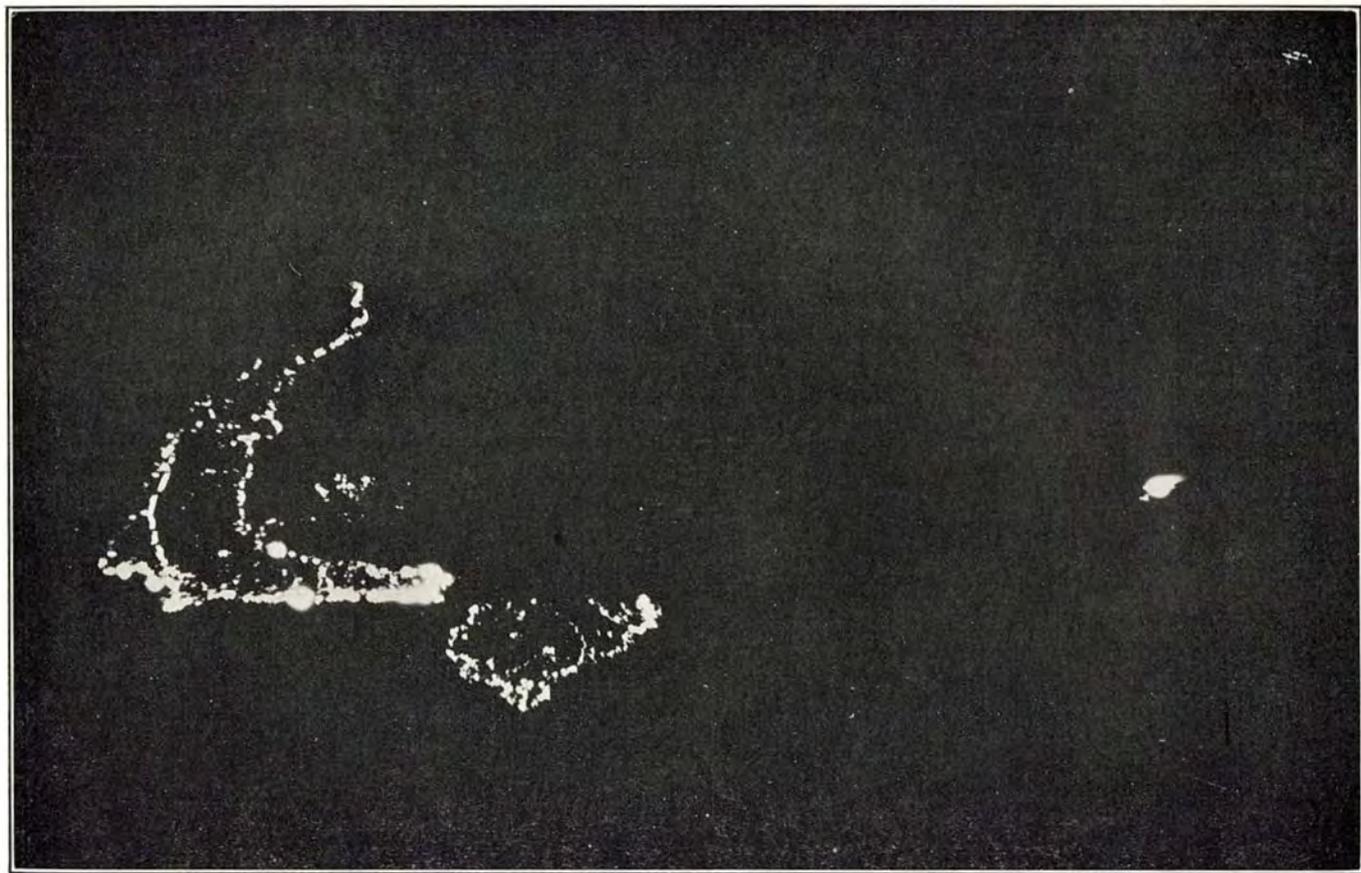


Figure 3. Night view of incandescent lava at 2:30 a.m. January 11. Compare with Figure 4. Photo Wilson.



Figure 4. The newly squeezed out lava as it appeared at 8:15 a. m. January 11. Photo Wilson.

of the pit, was a small ragged lava patch which had flowed from a similar source eastward. (See Fig. 4.)

All of this appeared to have been occasioned by the landslip of the northwest talus conoid. This landslip had ridden over and weighted down the whole of the northwest crusted pool of July, breaking up the crust, as shown about the edges, and apparently discovering live lava below which was squeezed up and out from the border cracks. Apparently this "lava floor," seemingly dead since last July, was really a stagnant crusted lava puddle still liquid below in its 70 feet, more or less, of depth.

The northwest floor area was all covered with lobate heaps of red rock fragments and bowlders, the lobes convex to the southeast. The northwest talus was completely stripped, revealing a rock slope at a flat angle below. The landslip of the talus cone (as on November 28, 1924), had been precipitated by an immense avalanche from the edge of the pit NNW., carrying away the NNW. flag and making a new deep notch in the pit edge where the opening cracks had predicted collapse.

The north cone vent seen glowing had merely sent up a little trickle of black lava, stimulated by the same landslide pressure on the crust as at the other places. All of this history checked with the observed facts of the last week, to the effect that subsidence, southwest tilt, opening of rim cracks, and many slides, pointed to a collapse rather than a rising. The collapse revealed and squeezed up a little remnant lava. There was no harmonic tremor and no hissing was heard, both of these being characters of gas-charged lava when it is vigorously tumescing and ready to make fountains.

During the day the slides seemed to subside. No incandescence could be seen in daylight.

January 12. On this day there was a strong NE. wind, making thick dust on the S. crater floor and Kau Desert. Thin dust filled the pit.

January 14. Nothing new at the pit at 3 p. m. The walls are wet, and the avalanches have stopped as though it were the instability of the west pool and NW. talus that occasioned all the uneasiness of January 1 and thereabouts.

January 18. There were no slides at 11:45 a. m. At 1:10 p. m. some dust arose from a slide at the NW. corner.

The weather was bright, with strong NE. wind.

January 24. At 5 p. m. Nothing new could be detected in the bottom of Halemaumau at 5 p. m. There was a little dust rising from the NW. corner about noon.

January 26. At 1 p. m. dust from a slide north was observed.

January 28. There was little sliding today, but no changes were noted during a visit to the pit at 3:15 p. m. The walls were dry, the weather fair, and sulphur spots still showed E. and SE.

SEISMOMETRIC RECORD

There were 149 local earthquakes recorded on the Observatory seismographs during the month ended at midnight January 31, 1928. These and other phenomena are listed below. The time used is Hawaiian Standard (time meridian is 157° 30' W.), which is 10 hours and 30 minutes slower than Greenwich Time.

The greater number of the very feeble local shocks counted in the list make such minute records that the character of the disturbance is not always apparent. Some are true earthquakes; others are perhaps the parts of greater amplitude of a continuous or protracted tremor, which at other times may be too feeble to record; some seem to be records of vibrations set up by avalanches in the pit of Halemaumau.

Abbreviations used above are as follows: vf, very feeble; f, feeble; s, slight; m, moderate; d, instruments dismantled; fl, felt locally; Δ , indicated distance in miles; *, continuous tremor.

Local Earthquakes

January

1	12:13 a.m. vf.	8	1:08 a.m. vf.	19	12:51 a.m. vf. Δ 24.
	2:20 a.m. vf.		9:25 a.m. vf.		10:40 a.m. vf.
	6:07 a.m. vf.		1:32 p.m. vf.	20	5:15 p.m. vf.
	8:04 a.m. vf.		6:03 p.m. vf.	21	11:58 a.m. vf.
	8:22 a.m. vf.		6:41 p.m. vf.		2:58 p.m. vf.
	8:32 a.m. vf.		10:34 p.m. vf.	22	11:52 a.m. vf.
	9:58 a.m. vf.		10:50 p.m. vf.		12:01 p.m. vf.
	12:51 p.m. vf.		10:58 p.m. vf.		2:08 p.m. vf.
	2:40 p.m. vf.	9	2:01 a.m. vf.		6:55 p.m. vf.
	5:02 p.m. vf.		2:59 a.m. vf.	23	2:23 a.m. vf.
2	1:40 p.m. vf.		5:37 a.m. vf.		6:43 a.m. vf.
	2:30 p.m. vf.		8:59 a.m. vf.		3:08 p.m. vf.
	2:32 p.m. vf.		12:57 p.m. vf.	24	8:23 a.m. vf.
	3:36 p.m. vf.		1:01 p.m. vf.		9:15 a.m. vf.
	9:07 p.m. vf.		1:09 p.m. vf.		10:06 a.m. vf.
3	9:22 a.m. vf.		1:46 p.m. vf.		11:12 a.m. vf.
	3:35 p.m. vf.		2:41 p.m. vf.		5:12-5:46 p.m. vf. *
	3:50 p.m. vf.		3:32 p.m. vf.	25	1:12 a.m. vf.
	6:11 p.m. vf.		4:59 p.m. vf.		5:42 a.m. vf.
4	12:01 a.m. vf.	10	3:21 a.m. vf.		5:44 a.m. vf.
	12:02 a.m. vf.		4:33 a.m. vf.		9:11 a.m. vf.
	12:45 a.m. vf.		6:28 a.m. vf.		2:59 p.m. vf.
	2:01 a.m. vf.		6:41 a.m. vf.		6:58 p.m. vf.
	4:34 a.m. vf.		2:58 p.m. vf.		7:03 p.m. vf.
	5:52 a.m. vf.		3:28 p.m. vf.		7:05 p.m. vf.
	9:12 a.m. vf.		5:00 p.m. vf.		7:06 p.m. vf.
	12:22 p.m. vf.		6:33 p.m. vf.		7:08 p.m. vf.
	1:07 p.m. m, Δ 21, fl.		10:43 p.m. vf.		7:20 p.m. vf.
5	3:21 a.m. vf.		11:42 p.m. vf.		11:31 p.m. vf.
	8:43 a.m. vf.	11	12:19 a.m. vf.	26	12:33 a.m. vf.
	2:52 p.m. vf.		12:20 a.m. vf.		4:59 a.m. vf.
	7:00 p.m. vf.		12:23 a.m. vf.		9:33 a.m. vf.
	7:01 p.m. vf.		12:24 a.m. vf.		9:48 a.m. vf.
6	6:02 a.m. vf.		12:26 a.m. vf.		10:13 a.m. vf.
	7:16 a.m. vf.		9:30 a.m. vf.		5:40 p.m. vf.
	8:45 a.m. vf.		12:02 p.m. vf.		5:56 p.m. vf.
	9:30 a.m. vf.		12:03 p.m. vf.	27	12:23 p.m. vf.
	12:54 p.m. vf.		12:08 p.m. vf.		4:56 p.m. vf.
	3:37 p.m. vf.	12	4:38 a.m. vf.		5:07 p.m. vf.
	3:42-3:44 p.m. vf. *		5:18 a.m. vf.		10:05 p.m. vf.
7	5:27 a.m. vf.		5:19 a.m. vf.	28	6:10 a.m. vf.
	5:37 a.m. vf.		6:51 a.m. vf.		9:14 a.m. vf.
	6:47 a.m. vf.		8:22 a.m. vf. Δ 16.		9:18 a.m. vf.
	6:51 a.m. vf.	13	8:38 a.m. vf.		11:14 a.m. vf.
	9:41 a.m. vf.	14	3:12 a.m. vf.	29	4:15 p.m. vf.
	9:44 a.m. vf.		3:17 a.m. vf. Δ 12.	30	12:17 p.m. vf.
	9:46 a.m. vf.	15	11:35 a.m. vf.	31	6:39 a.m. vf.
	10:56 a.m. vf.	16	2:39 p.m. vf.		5:25 p.m. vf.
	6:12 p.m. vf.	18	4:41 a.m. vf.		7:06 p.m. vf.
	7:51 p.m. vf.		12:51 p.m. vf.		

Harmonic Tremor

This type of movement was not recorded during the month.

Microseismic Motion

Microseismic motion was strong from January 4 to 8 and on the 14th. Amplitude was normal during the rest of the month.

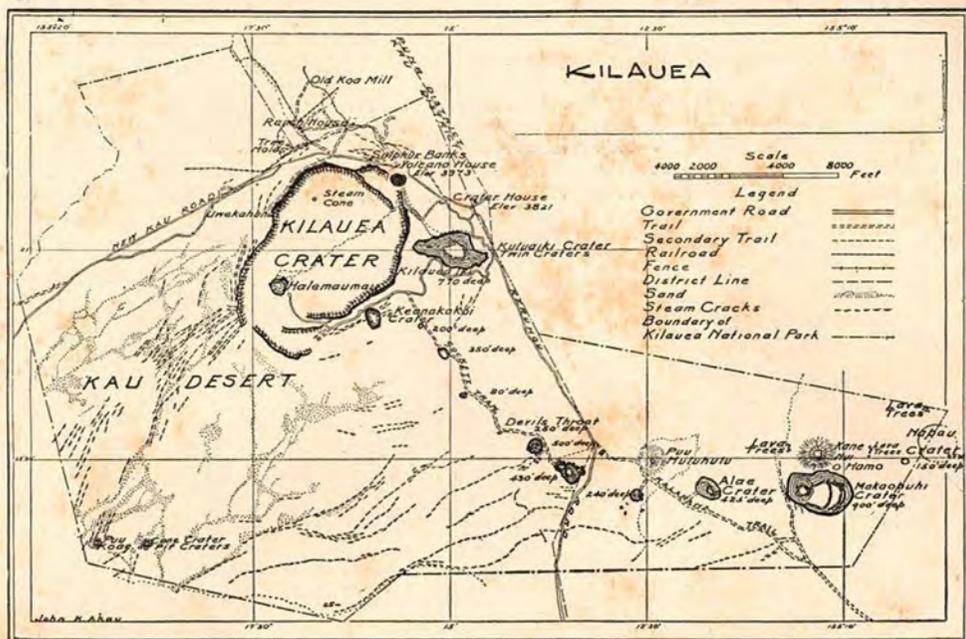
Tilting of the Ground

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

December 28-January 3.....	2.2	seconds	SW.
January 4-10.....	1.2	"	SW.
" 11-17.....	0.4	second	ENE.
" 18-24.....	0.5	"	NNW.
" 25-31.....	0.3	"	N.

T. A. JAGGAR,

Volcanologist.



Black spot shows location of Observatory.

All exchanges, gifts to library, news notes about Pacific volcanic and seismic events, and correspondence should be addressed HAWAIIAN VOLCANO OBSERVATORY, Volcano House, Hawaii.

The Observatory is operated by the U. S. Geological Survey, and its work is supplemented by the Hawaiian Volcano Research Association. The main station is on the northeast rim of Kilauea Crater. Subordinate seismograph stations are operated by the Research Association under the direction of the volcanologist in Kona and Hilo.

The Kilauea station operates horizontal pendulums of the Bosch-Omori type and receives time by wireless from the Honolulu Naval Station. Observatory Lat. $19^{\circ} 25' 54.3''$ N.; Long. $155^{\circ} 15' 39.6''$ W.; Elevation cellar 1214.6 meters (3985 feet). The Hilo and Kona stations operate horizontal pendulums. Their seismograms are sent to the Observatory.

The Hawaiian Volcano Research Association founded the Observatory in 1911, transferring the plant to the Government in 1919, but continuing cooperation in experimental work by furnishing funds and apparatus and workers as needed by the Government Volcanologist. It is a corporation under the laws of Hawaii, governed by a board of directors, and financed by the subscriptions of its members and patrons. Its aims are identical with those of the Observatory, namely, (1) To keep record of Hawaiian volcanism, (2) To attract volcanologic specialists to Hawaii, and (3) To promote worldwide knowledge of volcanoes and earthquakes and the foundation of more volcano observatories.

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CONTENTS

AN OBSERVATORY FOR THE STUDY OF LASSEN PEAK

By R. H. Finch

VOLCANIC CONDITIONS IN FEBRUARY

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Illustrations

SEISMOMETRIC RECORD

Local Earthquakes and Tremors

Teleseism

Harmonic Tremor

Microseismic Motion

Tilting of the Ground

MAP AND STATION DATA

AN OBSERVATORY FOR THE STUDY OF LASSEN PEAK

By R. H. FINCH

In accordance with the policy of the recently established Section of Volcanology in the Geologic Branch of the United States Geological Survey, to extend the work of the Hawaiian Volcano Observatory to California and Alaska, steps were taken in 1926 by Dr. T. A. Jaggar, chief of the new section, leading to the establishment of an observatory for the continuous study of Lassen Peak.

The new observatory is located at Mineral, California, at an elevation of 4,935 feet on the southwest slope of the Lassen edifice. (See sketch map, Figure 5). The present site of the observatory was obtained through the United States Forest Service. The observatory building consists of a small

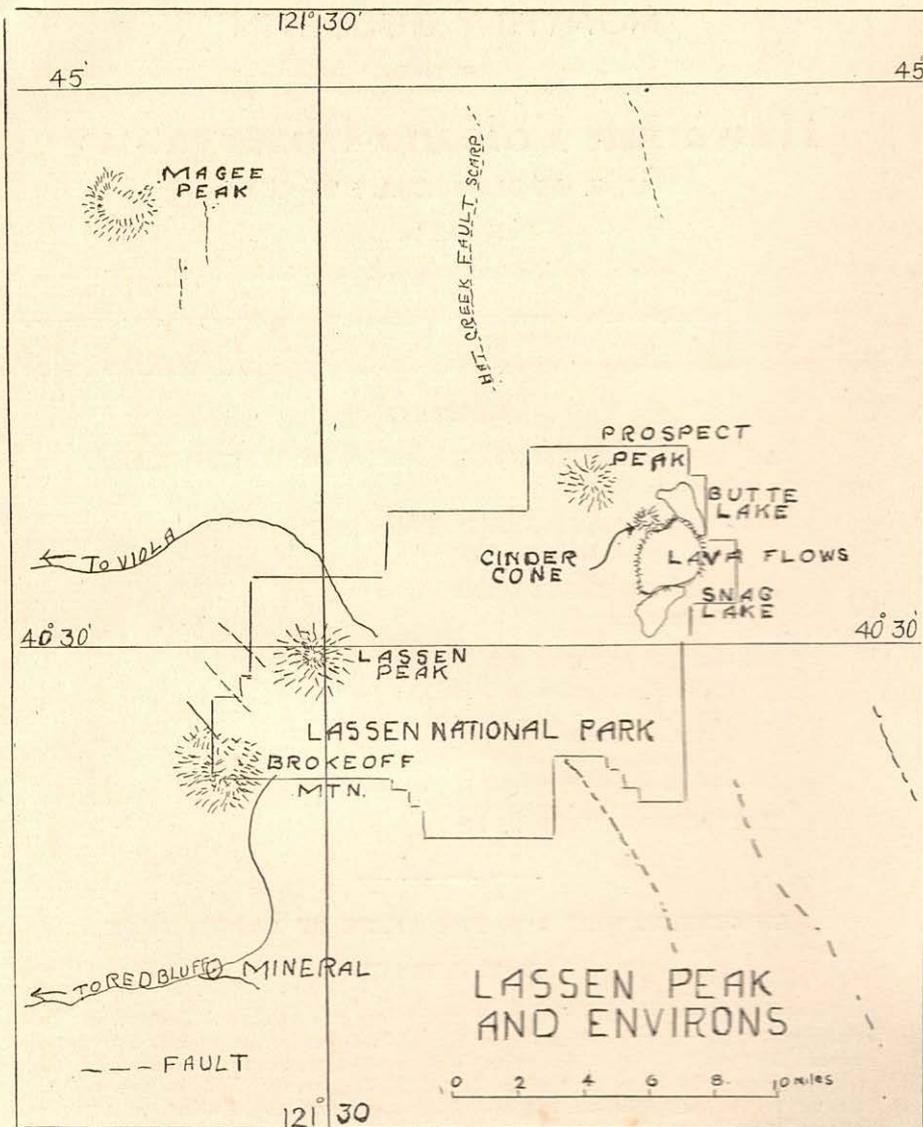


Figure 5.

office over a 10 by 10 foot concrete cellar, in which the seismographs are housed. Adjacent to the building are the rain gauge and instrument shelter for obtaining meteorological records.

The writer arrived at Mineral on September 15, 1926, and immediately started operations for the construction of the seismograph cellar, the office building, and the seismographs. The piers for the support of the seismograph pendulums extend downward into highly compacted glacial drift material two feet below the cellar floor.

The two-component seismograph of the Bosch-Omori type was built at Mineral. The pendulums, mounted to record north-south and east-west motion of the ground, are suspended from reinforced concrete posts that are 10 inches square. Each steady mass, weighing about 225 pounds, consists of nine lead weights held in a cast iron container. To facilitate the handling of the heavy masses by one man, each weight is bored to take a large screw eye. The magnification of the boom is 5, and of the writing lever, 40, making the total static magnification 200. The recording is done on smoked paper traveling 30 mm. per minute. The electromagnet timing device is controlled by a Howard pendulum clock. An auxiliary stylus to furnish a reference point from which tilt can be measured is attached to the plate supporting the drum and lever system. The pendulums were suspended on November 19, 1926, with a free period of seven seconds, and continuous operation started on December 1, 1926. More details of the construction of the instruments can be found in Volcano Letter No. 115, March 10, 1927.

Earthquakes Recorded

During the first year of the observatory, the seismographs recorded 305 earthquakes. Large records were obtained of the Alaskan earthquake of October 24, 1927, and the one off the southern California coast on November 4, 1927. With the exception of these two, and four shakes that originated near Eureka, California, all of the above number apparently originated in the Lassen edifice. The greatest number of shakes in one month was 134 in March, 1927, while only one was registered in September. The computed distance to origin of the local shocks varied from 2 to 33 km. The latter distance equals that of known or suspected faults in the neighborhood of upper Hat Creek. The most frequent distance computed was 15 km. The distance to several northwest-southeast trending faults between Lassen Peak and Brokoff Mountain is about 15 km. The majority of the felt shakes and some of the unfelt ones were accompanied by loud roars, seemingly out of all proportion to the intensity of the earthquakes.

Tilting

Shortly after recording was started, it was found that there was considerable overlapping of lines on account of temperature changes, especially on the east-west component. When the tilt* curves for the first year were plotted, they showed a westerly tilt from March to November, and an easterly tilt from November to March; a northerly tilt from January to August, and southerly tilt from August to January. The north-south tilt curve closely follows that of seasonal temperature, while the east-west component, which is greatly affected by diurnal temperature changes, shows but little correspondence with seasonal effect. There appears to be an accumulation of west-southwest tilt over and above the seasonal effect. Either a sinking of the ground to the southwest of the station or a rising to the northeast could account for such an accumulation of tilt. As the center of present day volcanic activity is to the northeast, it is assumed that the accumulation is due to a rising of the ground in that direction.

* Jaggar, T. A., Seismometric Investigation of the Hawaiian Lava Column, Bull. Seis. Soc. Amer. Dec., 1920, p. 201.

Field Trips

There are several fresh looking lava flows in the vicinity of Lassen Peak in addition to the one at Cinder Cone and the incipient flow of 1915 through the western notch of Lassen Peak. Striking examples of young flows can be found to the northwest of Prospect Peak and to the southeast of Magee Peak. The recent lavas at Cinder Cone have been considered as two flows of different dates, but study of the flows seen indicated that the supposed younger flow might itself be really two flows. Nothing was found to refute the contention of Harkness* that there was a lava flow at Cinder Cone during the winter of 1850-51, though certainly Dr. Harkness was mistaken in assuming that all the recent volcanics at Cinder Cone were a product of that time. Mr. A. E. Jones, who was an assistant at the Lassen Volcano Observatory during the summer of 1927, made a preliminary determination of the age of the flows by means of their magnetic properties, and placed the youngest flow about 1832 and the next youngest about 1795 (Volcano Letter No. 162, February 2, 1928). No observations by this method have as yet been made on the oldest flow, which is buried by volcanic sand. Perhaps more data and better equipment will bring about a closer agreement with the historical evidence presented by Dr. Harkness for the age of the last flow.

Fairly well authenticated rumors of activity at Glass Mountain, a peak about 70 miles north of Lassen, during January and February, 1910, were unearthed. A small explosion and numerous earthquakes were reported.

VOLCANIC CONDITIONS IN FEBRUARY

Activity of Halemaumau

Volcanic activity at Kilauea was confined to a few spectacular avalanches, some of them sending up great clouds of dust. The largest was at 8:57 a. m. February 20, judging by the tremendous dust cloud from it which was visible for many miles. Its resemblance to smoke started rumors of an eruption. The red dust gave a pinkish appearance to the crater floor. The seismographs recorded numerous avalanche tremors.

JOURNAL, FEBRUARY, 1928

February 8. At 3 p. m. light dust rose NE. At 5 p. m. a rock was heard to fall N., but otherwise all quiet at Halemaumau. There was very little steam, but the wet steaming places are very conspicuous on the talus slopes. Some fresh scars were seen NE., E., and N.

The crack at the SE. trail crossing has widened.

February 13. At 11:30 a. m. Halemaumau pit presents the quiet appearance prevalent the last few weeks. New fine material on the taluses denote light slides NE., N., NW., and SW. Avalanche dust at the E. was reported observed at 9:30 a. m. yesterday.

Crack measurements show pronounced widening from the 14-ton boulder to the pit rim.

February 17. Light avalanche dust clouds were seen NE. at 8:30 a. m., and NW. at 10:15 a. m.

February 18. Avalanche dust clouds were seen at intervals all the morning, and one large cloud rose N. at 1:30 p. m. and another about 3 p. m.

February 19. The pit was visited about noon with the expectation of avalanching. None was observed all day, however. The day was cloudy, and an electrical storm occurred over Pahala and the lower Kau Desert. Perhaps the lack of sun has affected the avalanching.

* Harkness, H. A., Proc. Calif. Acad. Sci. Nov. 2, 1874.

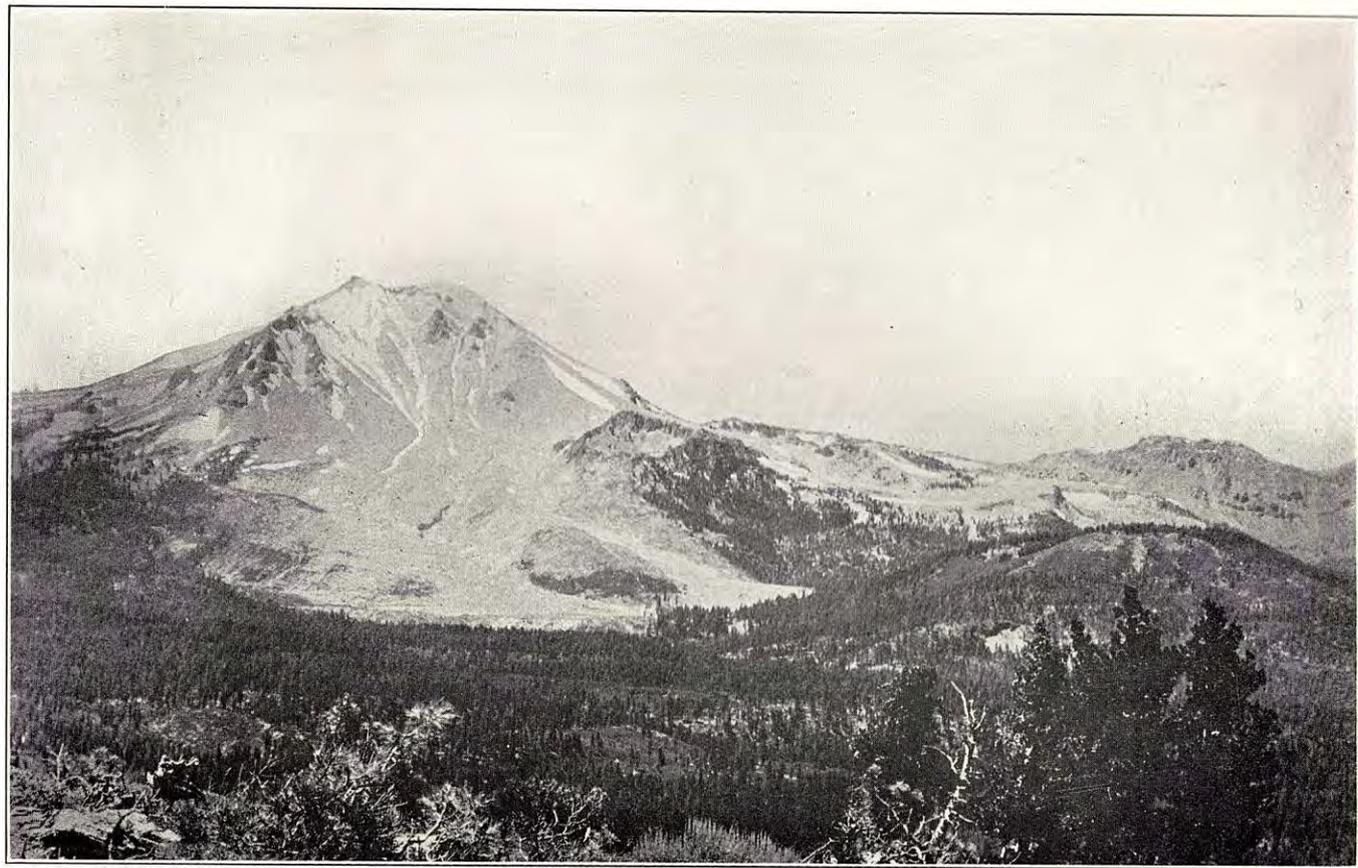


Figure 6. August 10, 1927. Lassen Peak, California, showing devastated area.



Figure 7. August 26, 1927. Hot spring temperature measurement at Bumpass Hell by Lassen Volcano Observatory. Pool is black because of pyrite scum.



Figure 8. Butte Lake, Lassen National Park, showing lava mounds erupted in the early part of the last century.

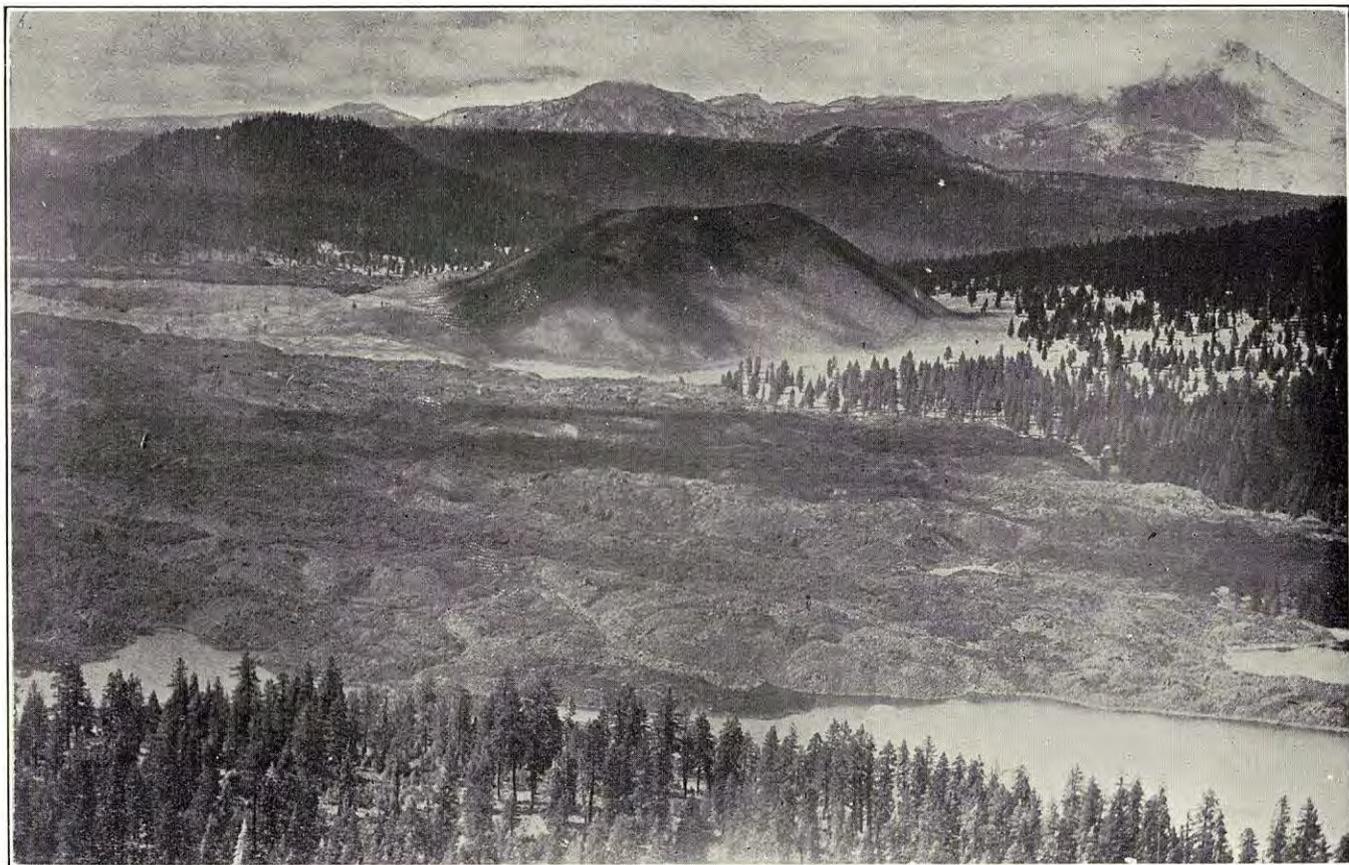


Figure 9. Aerial view of Lassen cinder cone from the northeast. Photo Army Air Service.

February 20. A few tremendous avalanches occurred in the early forenoon, and smaller ones throughout the day. Numerous tremors on the seismograms may mean big slides during the night. One big avalanche at 8 a. m. raised dust at the north pit corner that hung in the air at least 20 minutes. Another followed at 8:30. At 8:57 a. m. was the largest, apparently in three parts coming at five-minute intervals. It made a high, thick cloud of dust that was visible in Hilo, 30 miles away, starting rumors of an eruption there, as the dust resembled smoke. Dust fell thickly in the pit and on the crater floor north of the pit.

February 22. A big roar of an avalanche was heard at 3 a. m. At 8:30 a. m. there were slides NE.

The places that the big recent avalanches have carried away are the N. and NE. corners up to the top, and especially the west end of the big sill and the rock adjacent to it. The taluses below these two places are fresh.

There is little motion today. The east and southeast sulphur spots are yellow. The flat surface that made a bench of the west end of the NE. sill is no longer there.

February 25. At 2 p. m. there was no motion seen in the walls and nothing new observed.

February 26. Photographs were taken of the pit interior at noon. There was a slide at 1:40 p. m. in the north corner, and the NW. and N. niches were working. The N. floor is still covered with red dust.

February 27. Avalanche dust was seen NE. at 8:20 a. m.

February 29. At 3:15 p. m. the sulphur was a little brighter colored at the east. Dust is occasionally seen from small slides.

SEISMOMETRIC RECORD

There were 165 local earthquakes and one teleseism recorded on the Observatory seismographs during the month ended at midnight February 29, 1928. These and other phenomena are listed below. The time used is Hawaiian Standard (time meridian is 157° 30' W.), which is 10 hours and 30 minutes slower than Greenwich Time.

The tremor recorded at 8:57 a. m. on the 20th represents the effect on the Observatory seismograph of a very large avalanche. The slide caused so much dust that it was seen from Hilo and started a rumor there that the pit was again in eruption. On February 26 at 7:16 a. m., a moderate shock occurred apparently distinctly local to the volcano. It was felt by nearly everyone in the locality, and its first movement dismantled both components of the seismograph. A few minutes later when the instruments were again put in operation, it was found that the recording pen of the north-south component came to rest at a different part of the drum than that which it had occupied before the shock. This seemed to indicate that accompanying the shock there was a very considerable and sudden tilt toward the south.

The greater number of the very feeble local shocks counted in the list make such minute records that the character of the disturbance is not always apparent. Some are true earthquakes; others are perhaps the parts of greater amplitude of a continuous or protracted tremor, which at other times may be too feeble to record; some seem to be records of vibrations set up by avalanches in the pit of Halemaumau.

Abbreviations used below are as follows: vf, very feeble; f, feeble; s, slight; m, moderate; d, instruments dismantled; fl, felt locally; Δ , indicated distance in miles; *, continuous tremor:

Local Earthquakes

February

1	12:44 a.m. vf.	7:54 p.m. vf.	20	2:13 a.m. vf.
	5:27 a.m. vf.	8:15 p.m. vf.		2:22 a.m. vf.
	7:59 a.m. vf.	12	12:38 a.m. vf.	4:18 a.m. vf.
	12:17 p.m. vf.		12:54 a.m. vf.	4:32 a.m. vf.
	2:29 p.m. vf.		2:28 a.m. vf.	5:15 a.m. vf.
	2:30 p.m. vf.		3:09 a.m. vf.	5:56 a.m. vf.
	2:45 p.m. vf.		4:27 a.m. vf.	6:25 a.m. vf.
	3:25 p.m. vf. Δ 8.		5:35 a.m. vf.	6:47 a.m. vf.
	10:04 p.m. vf.		8:08 a.m. vf.	7:28 a.m. vf.
2	1:48 a.m. vf.		10:45 a.m. vf.	7:40 a.m. vf.
3	12:07 a.m. vf.		4:45 p.m. vf.	8:49 a.m. vf.
	2:58 a.m. vf.	13	2:10 a.m. vf.	8:52 a.m. vf.
	4:18 a.m. f. Δ 2.		5:00 a.m. vf.	8:54 a.m. vf.
	4:41 a.m. vf.		5:02 a.m. vf.	8:55 a.m. vf.
	11:31 p.m. vf.		7:57 a.m. vf.	8:57 a.m. vf.
4	8:05 a.m. vf.		10:08 a.m. vf.	10:05 a.m. vf.
	9:09 a.m. vf.		3:24 p.m. vf.	1:43 p.m. vf.
	2:43 p.m. vf.		4:31 p.m. vf.	5:54 p.m. vf.
5	6:58 a.m. vf.		5:45 p.m. vf.	21
6	2:03 a.m. vf.		5:58 p.m. vf.	7:26 a.m. vf.
	2:24 a.m. f. Δ 25.	14	12:30 a.m. vf.	10:20 a.m. vf.
7	1:29 p.m. vf.		5:45 a.m. vf.	10:21 a.m. vf.
8	3:21 a.m. vf.		4:18 p.m. vf.	5:31 p.m. vf.
	8:04 a.m. vf.		10:18 p.m. vf.	22
	9:39 a.m. vf.		4:38 a.m. vf.	3:05 a.m. vf.
	10:33 a.m. vf.	15	6:18 a.m. vf.	9:57 a.m. vf. Δ 40.
	10:35 a.m. vf.		8:54 a.m. vf.	12:56 p.m. vf.
	12:01 p.m. vf.		9:05 a.m. vf.	3:53 p.m. vf.
	12:16 p.m. vf.		12:06 p.m. vf.	10:50 p.m. vf. Δ 11.
	12:21 p.m. vf.		6:15 p.m. vf.	24
	1:19 p.m. vf.		6:57 p.m. vf.	9:12-9:15 a.m. vf. *
	1:32 p.m. vf.		8:17 p.m. vf.	10:45 a.m. vf.
9	7:10 a.m. vf.		9:46 p.m. vf.	1:04 p.m. vf.
	12:55 p.m. vf.		10:57 p.m. vf.	1:05 p.m. vf.
	6:33 p.m. vf.		11:40 p.m. vf.	3:04 p.m. vf.
	11:56 p.m. vf.	16	12:02 a.m. vf.	3:35 p.m. vf.
11	5:23 a.m. vf.		3:46 a.m. vf.	3:42 p.m. vf.
	7:14 a.m. vf.		4:00 a.m. vf.	6:48 p.m. vf.
	7:35 a.m. vf.		4:02 a.m. vf.	25
	8:20 a.m. vf.		4:42 a.m. vf.	7:16 a.m. vf.
	8:27 a.m. vf.		8:26 p.m. vf.	2:52 p.m. vf.
	9:23 a.m. vf.	17	6:10 a.m. vf.	26
	10:06 a.m. f. Δ 28.		10:34 a.m. vf.	1:41 a.m. s, fl.
	10:17-10:21 a.m. vf. *		4:23 p.m. vf.	7:11 a.m. vf.
	10:27 a.m. vf.		8:27 p.m. vf.	7:13 a.m. vf.
	10:28 a.m. vf.	18	7:58 a.m. vf.	7:16 a.m. m, fl, d, Δ 1.
	10:31 a.m. vf.		11:26 a.m. vf.	5:42 p.m. vf.
	10:45 a.m. vf.		2:17 p.m. vf.	6:07 p.m. vf. Δ 12.
	10:56 a.m. vf.	19	2:48 p.m. vf.	27
	1:03 p.m. vf.		9:27 a.m. vf.	12:33 a.m. vf.
	1:30 p.m. vf.		9:30 a.m. vf.	2:23 a.m. vf.
	2:55 p.m. vf.		9:58 a.m. vf.	4:38 a.m. vf.
	4:32 p.m. vf.		7:04 p.m. vf.	8:22 a.m. vf.
	4:35 p.m. vf.		7:05 p.m. vf.	9:10 a.m. vf.
	4:50 p.m. vf.		7:07 p.m. vf.	12:52 p.m. vf.
				28
				12:54 p.m. vf.
				2:08 p.m. vf.
				29
				3:24 p.m. vf.
				3:32 p.m. vf.
				7:27 p.m. vf.
				7:29 p.m. vf.

Teleseism

February 21

S or L 9:42 a.m. Very feeble record.

Harmonic Tremor

This type of movement was not recorded during the month.

Microseismic Motion

Microseisms were normal throughout the month.

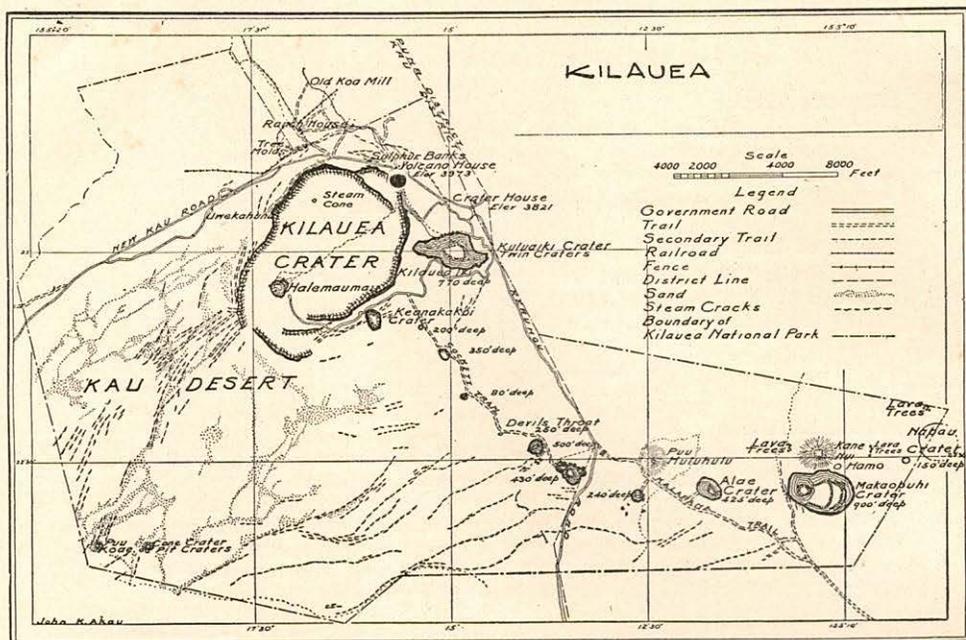
Tilting of the Ground

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

February	1-7.....	1.3 seconds	WSW.
“	8-14.....	0.7 second	SW.
“	15-21.....	1.4 seconds	SSW.
“	22-28.....	1.5 “	SSW.*
“	29-March 6.....	0.9 second	SSW.

* All of the southerly part of the tilt during this week and part of the south tilt during the week following was apparently caused at one time, 7:16 a. m. on February 26 at the time of a moderate local earthquake. The amount of south tilt at that particular time was apparently 2.3 seconds. The figures given above are the result of scaling from a smoothed curve made up by plotting overlapping seven-day means. This single lurch of tilt therefore affects the figures for both weeks due to this averaging process.

T. A. JAGGAR,
Volcanologist.



Black spot shows location of Observatory.

All exchanges, gifts to library, news notes about Pacific volcanic and seismic events, and correspondence should be addressed HAWAIIAN VOLCANO OBSERVATORY, Volcano House, Hawaii.

The Observatory is operated by the U. S. Geological Survey, and its work is supplemented by the Hawaiian Volcano Research Association. The main station is on the northeast rim of Kilauea Crater. Subordinate seismograph stations are operated by the Research Association under the direction of the volcanologist in Kona and Hilo.

The Kilauea station operates horizontal pendulums of the Bosch-Omori type and receives time by wireless from the Honolulu Naval Station. Observatory Lat. $19^{\circ} 25' 54.3''$ N.; Long. $155^{\circ} 15' 39.6''$ W.; Elevation cellar 1214.6 meters (3985 feet). The Hilo and Kona stations operate horizontal pendulums. Their seismograms are sent to the Observatory.

The Hawaiian Volcano Research Association founded the Observatory in 1911, transferring the plant to the Government in 1919, but continuing cooperation in experimental work by furnishing funds and apparatus and workers as needed by the Government Volcanologist. It is a corporation under the laws of Hawaii, governed by a board of directors, and financed by the subscriptions of its members and patrons. Its aims are identical with those of the Observatory, namely, (1) To keep record of Hawaiian volcanism, (2) To attract volcanologic specialists to Hawaii, and (3) To promote worldwide knowledge of volcanoes and earthquakes and the foundation of more volcano observatories.

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CONTENTS

A YEAR OF TIDE GAUGE OPERATION

By R. M. Wilson

VOLCANIC CONDITIONS IN MARCH

Activity of Halemaumau

JOURNAL, MARCH, 1928

Illustrations

SEISMOMETRIC RECORD

Local Earthquakes and Tremors

Teleseisms

Harmonic Tremor

Microseismic Motion

Tilting of the Ground

MAP AND STATION DATA

A YEAR OF TIDE GAUGE OPERATION

The installation a year ago of the tide gauge at Hilo, Hawaii, was described in the Monthly Bulletin for June, 1927. The cost of the installation and the observer's salary for this first year were paid by the U. S. Coast and Geodetic Survey. The gauge is situated near the outer end of Pier 1; its latitude is $19^{\circ} 43.8' N.$, and its longitude is $155^{\circ} 04.4' W.$ A small space is partitioned off just inside the northernmost door of the warehouse for the instrument, and a hole cut through the concrete floor of the wharf allows direct descent for the wire to the float. The float is protected from wave action by a chamber made of corrugated galvanized iron pipe. A direct reading tide staff is placed in the open water at the north end of the pier. Daily comparative readings are made on this staff to calibrate the marigram curve of the recording gauge. The instrument has been run through the year with very few interruptions; the worst difficulty was the occasional breaking of the float wire. The gauge was

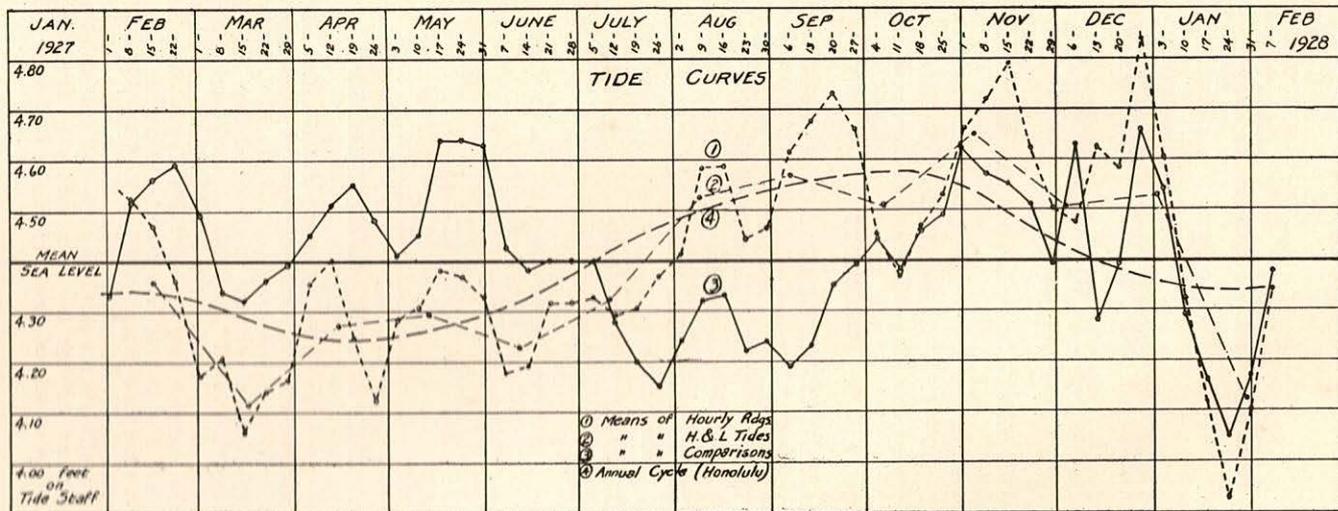


Figure 10.

in charge of Mr. B. F. Rush until August 31, from which time on Mr. M. F. Lacerdo has acted as observer.

A tide gauge must be operated more than a single year before precise results may be computed from its records. Some results of a preliminary nature may now be discussed, however. The regular tabulations of the Coast and Geodetic Survey provide for the listing of hourly heights of water. The standard forms contain these figures for seven days on each page. The first curve here shown (Figure 10, Curve 1) has been constructed by plotting the means of the 168 readings for each of these successive seven-day periods, each point plotted being shown on the middle day of its interval. These readings are actually scaled from the marigram curve, but in this diagram as in the tabulations themselves the values given refer to heights above the zero of the tide staff as if direct water readings had been taken there. The usual tabulations are also made of heights of all high and low tides. It is customary to obtain mean sea level from the mean of all these high and low waters taken together. The form for the tabulation of these heights provides for taking their averages in 29-day groups, so that each average may represent approximately a whole lunar month. The second curve in the accompanying diagram shows these averages represented as staff readings, each plotted upon the middle day of its 29-day interval. The averaging of the hourly heights and of the high and low tides both tend to give mean sea level. The second curve is therefore little more than a smoothing of the first, due to the taking of averages over longer intervals so that the shorter period fluctuations within a lunar month are ironed out.

In addition to these regular tabulations the Hilo marigrams have been compared with those from the Honolulu station day by day. By superimposing one marigram upon the other and adjusting them so that the tide curves coincide as nearly as possible in elevation, a difference of elevation is established between the two marigram datum lines. This can be easily transformed to a difference of elevation between the staff zeros at the two stations. The comparison is therefore essentially a determination of the difference of elevation at the two stations by continuous simultaneous sea level readings. The apparently fluctuating difference so secured is presumed free from those parts of the seasonal sea level changes which affect both stations in the same manner and amount. Changes in value of this difference should therefore indicate either local differential ocean level conditions, or actual relative changes of ground elevation between the two stations. The third curve plotted in the diagram is derived from the mean differences for successive seven-day groups. These successive means are applied to the well established elevation of the Honolulu tide staff zero to obtain the elevation of the Hilo staff zero, the curve showing where the resultant mean sea level readings on the Hilo staff would occur.

The fourth curve shows the average annual sea level cycle at Honolulu, secured by plotting the separate means for each of the 12 calendar months over a period of 18 years. These figures are from the Honolulu tide gauge records, from 1892 to 1909, inclusive, kindly furnished by Mr. Walter E. Wall, Surveyor of the Territory of Hawaii. The average annual cycle at Hilo is probably in general somewhat similar to this one for Honolulu, but there is not sufficient data in hand at present to determine it.

Mean Sea Level

The first result to be considered from the running of the gauge is the determination of datum, mean sea level. This will be more precisely determined as more years are added to the run of the gauge. Future figures to be computed by the Coast and Geodetic Survey with due corrections applied must be waited for as final. Preliminary approximations may be had at present, however, by three different methods, namely, by averaging for the whole year each of the three sets of data used in constructing the first three curves in the diagram. Thus the mean of the year's hourly readings would appear at 4.404 feet on the tide staff. The mean of all of the year's high and low waters would

be at 4.385 feet. The mean of the year's Honolulu-Hilo staff zero differences applied to the Honolulu established elevation would indicate that mean sea level should appear at 4.404 of the Hilo staff. The exact agreement of the first and third is accidental; the three are in fair agreement and their mean may arbitrarily be taken for the present as the tide staff reading corresponding to mean sea level. The datum line in the diagram has been drawn at this value, 4.398 feet.

By spirit leveling the tide staff zero is found to be 12.364 feet below U. S. Coast and Geodetic Survey bench mark No. F-2. The result of this year's run of the tide gauge therefore makes the elevation for this bench mark 7.966 feet above mean sea level. The bench mark is one established by Lieutenant Simmons in the precise level line which runs from Hilo to the summit of Mauna Loa. He assumed as a datum for his preliminary field elevations that defined by the 1911 value for a bench mark in Hilo. These 1911 values for Hilo bench marks were based upon the running of a recording tide gauge by the Corps of Engineers of the U. S. Army from June 1, 1911, to May 31, 1912. The elevation of the bench mark F-2 deduced through Simmons' line from the old mark is 8.280 feet, a difference of 0.314 feet with the present tide gauge determination. This discrepancy is probably due to the fact that neither in 1911-1912 nor in 1927 was a single year's running of the gauge enough to establish datum accurately.

Mean sea level may be slightly too high or too low for a whole year or more, so that datum cannot be considered determined from a single year's observations. This may easily be seen from the following table in which yearly means of sea level are given in feet above (plus) or below (minus) the adopted datum. These figures result from the 1892-1909 records of the Honolulu gauge, already mentioned.

1892 — .131	1898 — .152	1904 + .004
1893 — .156	1899 — .310	1905 — .189
1894 — .242	1900 — .163	1906 — .065
1895 — .312	1901 + .173	1907 — .053
1896 — .152	1902 — .149	1908 — .095
1897 — .031	1903 — .244	1909 — .355

A datum founded on the 1901 observations alone would therefore differ by 0.528 foot from one based on the 1909 records. This is the extreme range for the 18 years, but is parallel to the case above considered; 1911-12 compared to 1927.

On the other hand, the discrepancy developed at Hilo during the last 15 years, 0.314 foot, may in part represent actual subsidence of the Hilo shore line during that time. Continuous Honolulu-Hilo comparisons should in time solve the problem as to what parts of these discrepancies developed year by year are actual local shore line elevations or depressions, and what parts are merely long period changes in ocean elevation.

The mean range of tide secured by subtracting the mean height of all low waters from the mean height of all high waters during the year is 1.650 feet. The maximum range between the highest high water noted and the lowest low water during the year is 4.3 feet.

Referring again to the curves in the diagram, the fluctuations of the first two show roughly the monthly, seasonal, and annual changes in sea level which are expected at all tide stations. These changes are caused by changing factors in the luni-solar attraction, by conditions of wind, barometric pressure, local shore-line configuration, and other effects.

Contemplation of the risings and fallings of the third curve invites us to wander into the realm of speculation. Values for this curve were obtained so as to eliminate as much as possible the effect of general changes of sea level. If sea level behaves the same at both stations, Honolulu and Hilo, and if no relative change of ground elevation occurs between these two stations, this

curve should then be a straight line without variations. But this third curve follows in a remarkable manner the curve of hourly height means. This would tend to show that these parallel fluctuations manifest alike in both curves are the result of local conditions affecting Hilo and not Honolulu. The explanation may be that Honolulu is on the lee side of its island, Oahu, while Hilo is on the windward side of Hawaii. The prevailing trade wind would therefore be expected to cause greater water level irregularities at Hilo than at Honolulu.

This third curve has some interesting individual features, however. During the first part of the year it runs consistently above the hourly heights curve, but early in July it breaks abruptly and runs below. Is it mere coincidence that at this particular time an eruption of lava occurred in the pit of Halemaumau? Risings and fallings of the Hawaiian lava column are known to cause tiltings and changes of elevation of the upper slopes of the island, due probably to changes of pressure within the mountain itself. Is Hilo within the range of these effects? Another individual feature of the third curve is the sharp upward peak during the first part of December. Is it again mere coincidence that at this time there occurred at Kilauea a particularly remarkable swarm of spasmodic earth tremors? Again, during the last of December, 1927, and the first of January, 1928, not only does the third curve show a remarkable decline in value, but the other two curves do also. Abnormal sea level conditions of course existed at this time due to reactions from the heavy southwest storm which began on December 25, yet perhaps a third correlation is shown by the tilt at the Observatory. A remarkable surge of tilt toward the south, surely representing some volcanic condition, was recorded during the last 10 days of December and continued in a rapid movement towards the southwest during the first week of January. Thus three major features of the year's seismic and volcanic activity at Halemaumau exhibit correlations, at least in time, with three definite features of this third tidal curve. Whether there is actual connection between these phenomena which may indicate that the elevation of Hilo is in some way affected by tumescence or operation of the volcanic mechanism remains to be shown by future observation.

Tidal Waves

During the year records of two tidal waves were observed, resulting from earthquakes which were well recorded on the seismographs of the Hawaiian Volcano Observatory. The first of these seismic sea waves followed the earthquake of November 4, 1927, which occurred off the coast of California. This earthquake was felt in Santa Maria, California, and was also felt at sea by the American S. S. "Socony" which was at the time in latitude $34^{\circ} 54' 30''$ north, longitude $121^{\circ} 01' 00''$ west. The second tidal wave resulted from the earthquake of December 28, 1927, in the Kamchatka region.

The two curves here given (Figures 15 and 16) are reproduced from tracings of the Hilo marigrams. A tracing of the Honolulu marigram is also shown for the sea wave of December 28. Although the November 4 tidal wave was apparently stronger at Hilo than the one of December 28, the former was not definitely recorded on the Honolulu tide gauge. The reason for this is perhaps the direction from which the disturbance came, since the tidal wave of November 4 would have to pass around the Island of Oahu to reach Honolulu, whereas that of December 28 had a more direct approach.

The following table of approximate results is here submitted to show the times of arrival of the earthquakes and sea waves, and the computed velocities of the latter.

SEISMIC SEA WAVES AT HILO, 1927

(Hawaiian Standard Time)

	November 4	December 28
Arrival of Preliminary Earthquake Wave.....	3:27:45 a.m.	7:59:12 a.m.
Arrival of Second Earthquake Wave.....	3:33:28 a.m.	8:06:23 a.m.
Computed Distance to Epicenter.....	3,925 km.	5,530 km.
Approximate Bearing of Epicenter.....	N. 50° E.	N. 22° W.
Computed Time at Origin of Shock.....	3:20:32 a.m.	7:50:10 a.m.
Time of Arrival of Sea Wave.....	8:33 a.m.	3:40 p.m.
Sea Wave Velocity from Origin.....	210 meters per sec.	196 meters per sec.
Or.....	7.8 miles per min.	7.3 miles per min.

These figures are based upon the seismic data obtained at the Hawaiian Volcano Observatory alone. Tentative epicenters for the two earthquakes concerned have been furnished by the U. S. Coast and Geodetic Survey as follows: November 4, at latitude 33.2° north, longitude 122° west; December 28, latitude 55° north, longitude 160° east. These positions result from a preliminary combination of records from a number of different stations, but still do not represent the final determinations of epicenters. When the positions of the epicenters of these shocks are finally determined, better distances may be computed from them to the position of the Hilo tide gauge, which will result in more accurate velocities than are given in the table above. Since this table is at best only approximate, the fact has been ignored that the Volcano Observatory, the point of reception of the earthquake waves, and Hilo, the point of reception of the sea waves, are 24 miles apart.

The destructive tidal wave which occurred in Hawaii on February 3, 1923, and several other sea waves in the past that have come to the notice of this Observatory, are reviewed by Mr. R. H. Finch in an article written for "Proceedings of the Second Pan-Pacific Science Congress," Sydney, Australia, 1923, and published also in the "Monthly Weather Review," March, 1924, p. 147. These are, briefly: September 7, 1918, origin Kamchatka, computed sea wave velocity 215 meters per second; April 9, 1919, from southwest, computed velocity 126 meters per second to Honolulu, and 158 meters per second to San Francisco; November 11, 1922, origin near Chile, 201 meters per second; February 3, 1923, origin off Aleutian Islands, computed velocity 201 meters per second.

Still other figures on seismic sea wave velocities may be had from "Journal of the College of Science, Imperial University of Tokyo," Japan, Volume XXIV, 1908. Some observed velocities taken from this publication are: December 23, 1854, origin Japan, to San Francisco, 186 meters per second; to San Diego, 198 meters per second. Two South American earthquakes in 1868 and 1877 give velocities to Japan of 185 and 183 meters per second. The great tidal waves originating at Krakatoa on August 28, 1883, are also discussed.

The same publication deals thoroughly with the secondary water oscillations, or seiches, within various bays in Japan. A distant disturbance, sending sea waves which arrive at a bay or harbor, in ordinary cases sets up within the bay oscillations of the same period as the natural period of the bay itself. As may be seen from the accompanying reproductions of the marigram curves, the effect of these two tidal waves of November 4 and December 28 at Hilo was simply to exaggerate the natural secondary oscillations of the bay. These water oscillations have a period at Hilo of about 25 minutes. It should be expected, therefore, that the effect in Hilo Bay of a tidal wave arriving from a distant source would be to cause the water to fall and rise every 25 minutes, the amplitude of these fallings and risings depending upon the size and intensity of the sea wave causing them. In both the curves here reproduced the water is shown to have first receded. Mr. Finch states that in the case of the 1923 tidal wave also, the first motion of the disturbance noted was a recession of the waters.



Figure 11. July 8, 1927. Boiling lake near Drakesbad, California. Photo Finch.

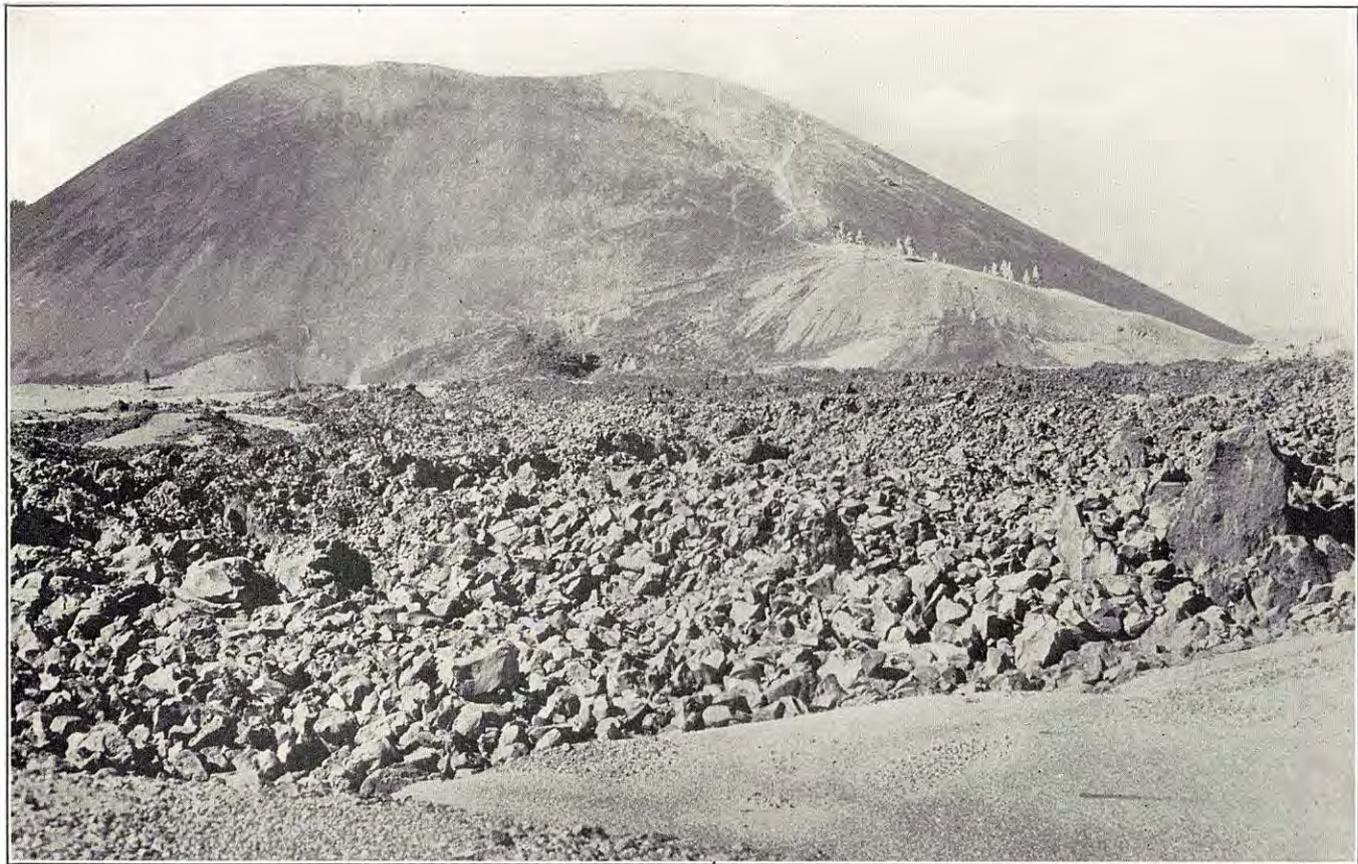


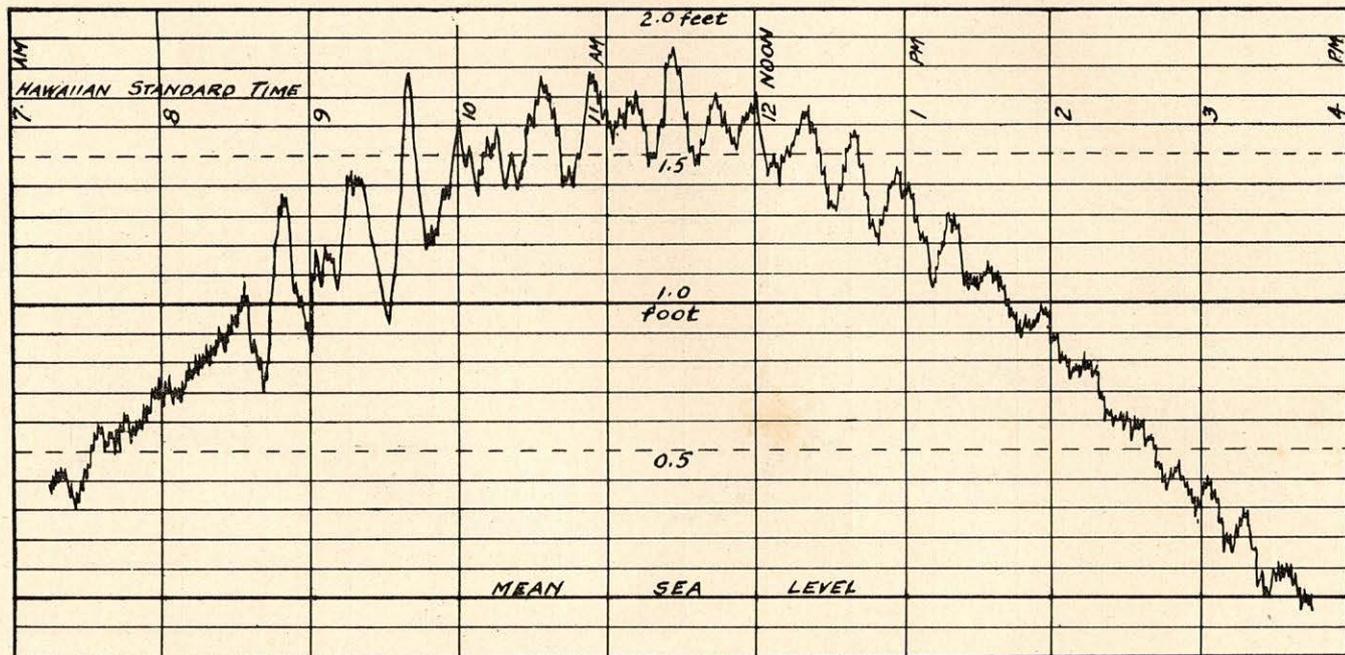
Figure 12. August 10, 1927. Lassen cinder cone from southeast. Photo Finch.



Figure 13. August 27, 1927. Lassen Peak from Mount Diller at the southwest;
showing 1915 lava in the western notch.

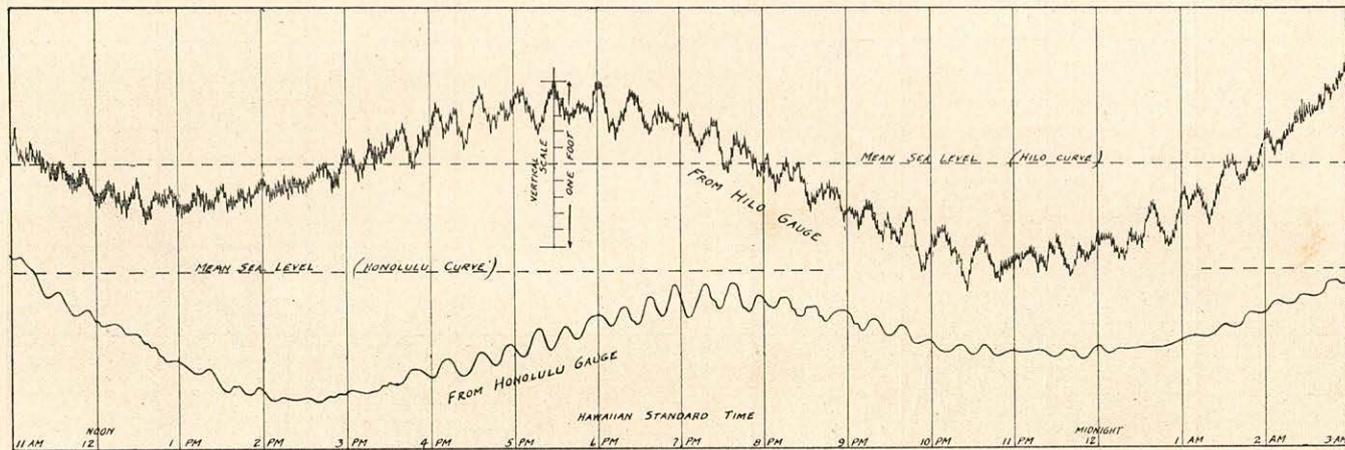


Figure 14. Aerial view of cinder cone. Photo Army Air Service.



TIDAL WAVE, NOVEMBER 4 1927
HILO, HAWAII.

Figure 15.



TIDAL WAVE, DECEMBER 28 1927

Figure 16.

The wide range of values in the observed velocity of seismic sea waves is due to the fact that these velocities depend upon the depth of oceans traversed. Continued observation will give data with which velocities may be more and more accurately estimated in advance, so that the times of arrival of these sea waves can be more surely foretold from the arrival of the seismic waves.

VOLCANIC CONDITIONS IN MARCH

Activity of Halemaumau

Slides continued from the Halemaumau walls, probably the largest of which was one at the northeast corner at 1:50 p. m., March 13, making a prolonged roar and a dust cloud that hid the pit from view for many minutes. The sulphur spot on the southeast talus became obliterated by falling debris.

The avalanching is slowly enlarging the inner crater. Working of the walls undermines the rims, and every time the rim material gives way the enlargement is noticeable. This process is conspicuous at the 14-ton boulder. This great block, blown out in the 1924 eruption, is now within a dozen feet of the rim and will eventually fall in. It was formerly several feet back, but the rim is gradually approaching it.

JOURNAL, MARCH, 1928

March 4. The pit when visited from 3 to 3:20 p. m. was quiet save for a slide in the lower NE. corner at 3:10, and noise of rocks dropped by people standing on the north rim.

March 6. Thin dust from a slide was seen drifting away from the north corner at 11:25 a. m., and again at noon.

March 7. No changes were observed in the pit. Rocks were trickling on the north wall, and a small slide at the south occurred at 12:20 p. m.

March 10. Several slides today; one northeast at 11:30 a. m., another at 3 p. m., and during a visit 4:25 to 5 p. m. several slides were seen NE. and NW., sometimes occurring simultaneously, filling the pit with diffused dust.

March 13. There were avalanches during the forenoon, concentrating at the NE. corner. At 1:50 p. m. a long avalanche roar was heard from the Observatory, making a dust cloud that hid the pit from view, and thinning out during the course of more than a half hour. At 3 p. m. more dust was seen.

March 14. In the morning thin dust was occasionally observed, and a new scar showed high up on the SE. wall.

March 18. At 4:15 p. m. no slides were occurring and all was quiet. The south cone was steaming more than the center one. Much new debris has fallen on the SE. floor area, and the SE. sulphur patch is obliterated by slides. Large scars showed on the NE. wall, and the NNE. wall was streaked from stripping. The rim near the 14-ton boulder has receded considerably.

March 21. Halemaumau was very quiet at 9:45 a. m., with no slides and little steaming. The pit was very dry, with no rain all the week.

March 24. The pit was quiet. A few stones were heard NW., NE., and SW. between 9 and 9:30 a. m., the latter fall making dust. Steaming was as usual. The east rim cracks were measured.

March 28. There was a slight increase of steaming in Halemaumau due to recent light rains. One floor vent, on the site of the twin fountains of last July, emits very dense, flocculent vapor.

A small slide was heard north at 8:40 a. m., and dust was observed there from the Observatory at 2 p. m.

SEISMOMETRIC RECORD

There were 64 local earthquakes and four teleseisms recorded on the Observatory seismographs during the month ended at midnight March 31, 1928.

These and other phenomena are listed below. The time used is Hawaiian Standard (time meridian is 157° 30' W.), which is 10 hours and 30 minutes slower than Greenwich Time.

The greatest number of the very feeble local shocks counted in the list make such minute records that the character of the disturbance is not always apparent. Some are true earthquakes; others are perhaps the parts of greater amplitude of a continuous or protracted tremor, which at other times may be too feeble to record; some seem to be records of vibrations set up by avalanches in the pit of Halemaumau.

Abbreviations used below are as follows: vf, very feeble; f, feeble; s, slight; m, moderate; d, instruments dismantled; fl, felt locally; Δ , indicated distance in miles; *, continuous tremor:

Local Earthquakes

March	March	March
1 3:04-3:14 p.m. vf. *	13 1:53 p.m. vf.	21 5:39 a.m. vf.
9:26 p.m. vf.	3:04 p.m. vf.	1:44 p.m. vf.
2 12:08 a.m. vf.	14 4:18 a.m. vf.	3:05 p.m. vf.
4:10-4:23 p.m. vf. *	11:30 a.m. vf.	3:08 p.m. vf.
5 5:26 a.m. vf.	15 2:08 a.m. vf.	22 2:23 a.m. vf.
9:55 a.m. vf.	8:00 a.m. vf.	11:42 a.m. vf.
1:07 p.m. vf.	2:59 p.m. vf.	1:02 p.m. vf.
6 4:45 p.m. vf.	11:38 p.m. vf.	3:28 p.m. vf.
7 7:46 a.m. vf.	16 1:44 a.m. vf.	23 4:02 a.m. vf.
4:57 p.m. vf.	17 3:30 a.m. vf.	24 5:50 p.m. vf.
8 7:38 p.m. vf.	18 12:17 a.m. vf.	26 12:48 a.m. vf.
8:23 p.m. vf.	10:54 a.m. vf.	27 10:10 a.m. vf.
9 3:08 p.m. vf.	12:41 p.m. vf.	1:55 p.m. vf.
10 8:13 a.m. vf.	1:35 p.m. vf.	28 5:38 p.m. vf. Δ 11.
11:45 a.m. vf.	19 10:17 a.m. vf.	29 9:56 a.m. vf.
10:46 p.m. vf.	11:45 a.m. vf.	10:06-10:18 a.m. vf. *
11:29 p.m. vf.	12:55 p.m. vf.	11:58 p.m. vf.
11 1:57 a.m. vf. Δ 23.	1:10 p.m. vf.	30 3:12 p.m. vf.
10:17 a.m. vf.	10:49 p.m. vf.	31 5:35 p.m. vf.
12 12:12 a.m. vf. Δ 9.	10:50 p.m. vf.	9:29-9:32 p.m. vf. *
2:16 a.m. vf.	10:56 p.m. vf.	9:34 p.m. vf.
	20 10:26 a.m. vf.	

Teleseisms

March 13		
?	8:12 a.m.	Very feeble record.
March 15		
eP	6:40:27 p.m.	
S	6:47:59 p.m.	Distance 3,685 miles.
L	6:56:03 p.m.	
March 21		
eP	5:56:50 p.m.	
S	6:04:39 p.m.	Distance 3,875 miles.
L	6:14 p.m.	
March 28		
iP	6:45:38 p.m.	Feeble record.

Harmonic Tremor

This type of movement was not recorded during the month.

Microseismic Motion

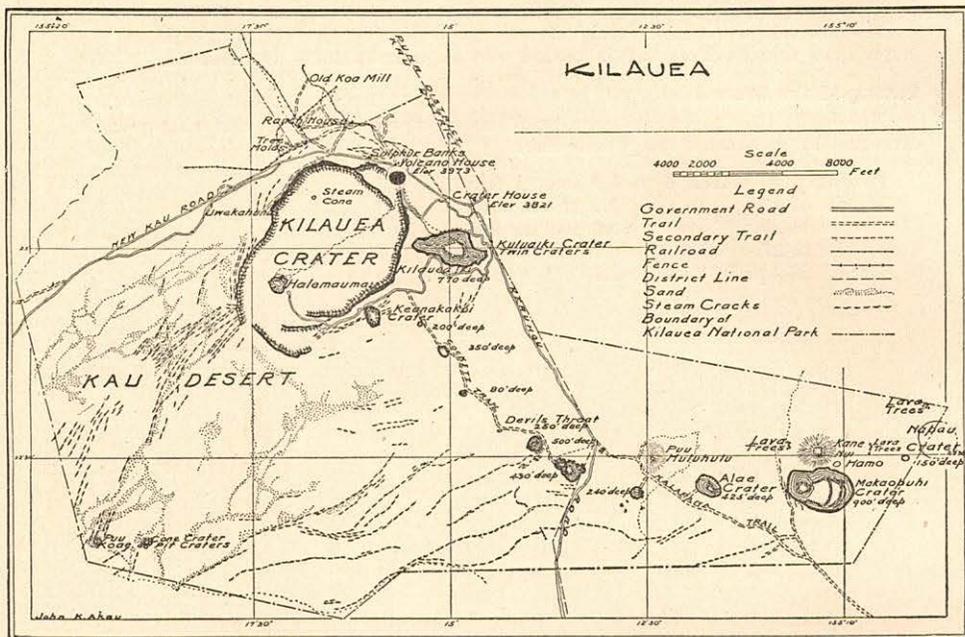
Microseisms were moderately strong from the 23d to the 25th, and on the latter date seemed irregular in period and angular in form as recorded.

Tilting of the Ground

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

February 29-March 6	0.9 second SSW.
March 7-13	1.2 seconds NE.
“ 14-20	0.6 second SW.
“ 21-27	0.1 “ N.
“ 28-April 3	0.8 “ E.

R. M. WILSON,
Topographic Engineer.



Black spot shows location of Observatory.

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Hawaiian Volcano Observatory
(U. S. GEOLOGICAL SURVEY)

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VOL. XVI

HONOLULU, HAWAII, APRIL, 1928

No. 4

CONTENTS

THE OHIKI

By R. M. Wilson

VOLCANIC CONDITIONS IN APRIL

Activity of Halemaumau

JOURNAL, APRIL, 1928

Illustrations

SEISMOMETRIC RECORD

Local Earthquakes and Tremors

Harmonic Tremor

Microseismic Motion

Tilting of the Ground

MAP AND STATION DATA

THE OHIKI

For the purpose of experimenting with a vehicle capable of going both on land and water, the Ohiki (sand crab) was constructed in the shops of the Hawaiian Volcano Observatory during November and December, 1927. Having in view explorations in Alaska with a similar amphibious boat, to be built by the Powell Mobile-Boat Works in Chicago, it was desired to operate such a vehicle under varying conditions in order to ascertain what performance might be expected of it. It will have practical value in Hawaii as a means for studying shore line lava formations and for making shallow soundings over the submarine portions of lava flows.

A Ford chassis with Ruckstell axle mounted inside a 16-foot wooden skiff, with outside paddle-wheels mounted on the ends of the axle, constitutes the boat part of the amphibian. This boat is mounted on a regular Ford front axle forward and a Smith "Formatruck" axle aft. The rear wheels, on the Smith axle, are chain driven from the Ford-Ruckstell axle. The wheel-base is 17 feet, and the axles have been retained standard gauge. At first, the length

over all was 21½ feet and the beam measurement of the boat was 5 feet 4 inches. Preliminary tests made at Ninole in Kau on December 21 indicated the advisability of certain revisions such as raising the freeboard to make the boat more seaworthy, and the addition of an outboard motor for greater speed and power when in use as a boat. The Ford motor, used through the Ruckstell axle, and geared still lower by means of the chain drive to the "Formatruck" axle, gave sufficient power to pull the vehicle up very steep pitches and to operate at the speed of an ordinary truck along the highways.

With the improvements suggested by the preliminary trials at Ninole, such as the addition of a five horsepower Johnson outboard motor, building the freeboard higher, building a box transom at the stern of the boat to increase buoyancy, and enlarging the area of the paddles of the paddle-wheels, the Ohiki was taken for further trial to Hilo on January 17. The weight of the machine thus enlarged was 3,800 pounds, and its dimensions had become 22 feet long, with a maximum width of 7 feet at the paddle boxes. Twenty miles an hour over the highways on land was easily accomplished. In the water, with the Ford motor turning the paddles and the Johnson outboard motor running, a speed of 4 miles an hour was attained. Steering in the water is accomplished by the disk front wheels, which act as rudders. Thus the same steering gear serves alike on land or water. Other tests were made at Hilo to determine the most efficient engine speeds and to try out the capacity of the machine for landing on beaches of various sorts. It was found possible to climb out of the water over stony beaches having rather steep grades, and sand beaches were easily negotiated so long as they were hard enough to support the rear wheels.

During February the machine was taken around the island, partly by land and partly by water. The trip began on February 8 by going overland to Kona, where a number of days were spent navigating as a boat up and down the Kona coast and in landing on and taking off from the various beaches there. The Ohiki was then taken by sea north and northeast along the coast to Kawaihae, thence by land back through Hamakua and Hilo to the starting point at the Observatory, completing the journey on February 21. The distance covered was 208 miles on land and 58 miles by sea, with many experimental landings and launchings. In landing and launching it was sometimes difficult to get over the stretch of soft, dry sand usually lying between the wet and hard part of a beach and the nearest road. To pass these places it was found necessary to use planking or other material to secure traction for the machine. The use of the cellular metal matting, such as is sometimes used on the door steps of large buildings, and which can be made in strips of any length, was found to serve the purpose admirably as an aid in traversing sand. The heavier grade of this matting was not bent by the weight imposed upon it by the wheels of the machine, and did not allow the wheels to sink into the sand. The strips of matting could be rolled up and were not too heavy or bulky to carry along and use when necessity arose. This idea, together with other experiences gained by the use of the Ohiki, will be of great value when applied to the navigation of the Powell boat Honukai (sea turtle) in the Alaskan explorations.

VOLCANIC CONDITIONS IN APRIL

Activity of Halemaumau

Slides continued to occur from the Halemaumau walls at various times, and on April 7 there were avalanches making roars loud enough to be audible at the Observatory and strong enough to make seismograph records.

Near the close of the month yellow stain gave evidence that the southeast sulphur patch was again forming after having been buried under debris since the middle of March.

There was no other notable activity.

JOURNAL, APRIL, 1928

April 4. The SW. wall has been avalanching, as shown by its dusty surface from top to bottom. Looks like rim blocks had been tumbling in. Stones fell there at 9 a. m. The SSW. talus is covering the south cone gradually. There is very little steam.

Small scars indicate that slides have occurred NE. and E.

April 6. At 8:55 a. m. the south and center cones were steaming profusely, and other vents were also quite active. The SW. wall is still a bit uneasy—one fall of rocks heard.

April 7. At 7:07 a. m. there was a prolonged roar of an avalanche, followed by a dense cloud of dust. Seven minutes later there was another roar and more dust. The first avalanche made a very definite seismograph record. Other avalanches occurred during the day.

April 8. Slides occurred NE. at noon, and at 3:15 p. m. slides were heard N., NW., and SW.

The center cone looks as though it had collapsed.

April 28. The pit was quiet except for one slide heard at the north corner.

April 11. At 8:50 a. m. falling rocks indicated that the walls were restless N., NW., and SW., and new debris could be seen on the respective taluses. Thin gray dust was observed NW. at 11:25 a. m.

April 13. At 10 a. m. the pit was quiet and dry. A few stones stirred occasionally on the N. wall, where there is a scar in the center. There was very little steam, the largest fumarole being at the center of the SW. talus. Dusty slides were observed in the N. corner, on NE. sill.

April 16. The wind was too strong to hear sounds in Halemaumau. At the south station the ground showed signs of fresh cracking.

April 18. The pit was quiet at 10 a. m., with both cones steaming. No sulphur spots were to be seen, although there was yellow stain at the edge of the east talus. New black boulders were lying on the south talus.

April 21. At 9:20 a. m. a streak from a slide at the south corner extending from midwall to bottom of talus was seen. There was nothing new at the cracks by the south station.

A small slide occurred in the north corner at 10 a. m.

White salts are prominent SW. where slides occurred a few weeks ago.

April 23. A dusty path of slides from the west rim was observed. White rocks lie on S. and SSW. taluses. The red N. wall is becoming salt coated.

April 25. There was a noisy slide from low down on the south wall at 8:50 a. m., followed shortly by another. They came from a fractured ledge midway the wall. Rocks rolled on other walls.

April 28. The pit was quiet except for one slide heard at the north corner at 10:30 a. m. White-coated debris indicates that the north wall has had several slides.

The SE. sulphur patch, long buried, is beginning to show definite signs of returning.

SEISMOMETRIC RECORD

There were 72 local earthquakes recorded on the Observatory seismographs during the month ended at midnight April 30, 1928. These and other phenomena are listed below. The time used is Hawaiian Standard (time meridian is 157° 30' W.), which is 10 hours and 30 minutes slower than Greenwich Time.

The greater number of the very feeble local shocks counted in the list make such minute records that the character of the disturbance is not always apparent. Some are true earthquakes; others are perhaps the parts of greater amplitude of a continuous or protracted tremor, which at other times may be too feeble to record; some seem to be records of vibrations set up by avalanches in the pit of Halemaumau.

Abbreviations used below are as follows: vf, very feeble; f, feeble; s, slight; m, moderate; d, instruments dismantled; fl, felt locally; Δ , indicated distance in miles; *, continuous tremor.

Local Earthquakes

April

1	4:41 a.m. vf.	12:29 p.m. vf.	11:15 a.m. vf.
	8:50 a.m. vf.	2:51 p.m. vf.	11:11 p.m. vf.
	10:25 p.m. vf.	4:05 p.m. vf.	21 1:55 a.m. vf.
2	2:04 a.m. vf.	4:38 p.m. vf.	22 5:06 p.m. vf. Δ 25.
	2:31 a.m. vf.	4:41 p.m. vf.	5:18 p.m. vf.
	3:31 a.m. vf.	4:46 p.m. vf.	23 2:24 p.m. vf.
	3:39 a.m. vf.	8 12:25 p.m. vf.	7:14 p.m. vf.
	4:18 a.m. vf.	1:26 p.m. vf.	24 1:41 p.m. vf.
	10:16 a.m. vf.	9 10:36 a.m. vf.	4:18 p.m. vf.
	10:21 a.m. vf.	8:28 p.m. vf.	4:19 p.m. vf.
3	12:01 a.m. vf.	11 5:59 a.m. vf.	10:58 p.m. vf.
	4:15 p.m. vf.	1:57 p.m. vf.	25 5:40 p.m. vf.
4	8:39 a.m. vf.	12 9:28 a.m. vf.	26 10:29 p.m. vf.
	9:18 a.m. vf.	14 5:48 a.m. vf.	27 12:28 a.m. vf.
	4:02 p.m. vf.	11:06 p.m. vf.	1:41 p.m. vf.
5	2:12 a.m. vf.	15 2:28 a.m. vf.	3:56 p.m. vf.
	8:39 a.m. vf.	10:08 a.m. vf.	5:16 p.m. f. Δ 53.
	9:50 a.m. vf.	11:52 a.m. vf.	28 9:48 a.m. vf. Δ 15.
6	1:27 a.m. vf.	2:36 p.m. vf.	10:26 a.m. vf.
	3:19 p.m. vf.	16 1:43 a.m. s. fl. Δ 5.	10:54 a.m. vf.
7	3:12 a.m. vf.	17 2:35 a.m. vf.	12:15 p.m. vf.
	6:19 a.m. vf.	12:42 p.m. vf.	29 12:12 p.m. vf.
	7:07-7:09 a.m. vf. *	18 11:53 p.m. vf.	5:29 p.m. vf.
	7:13 a.m. f. Δ 25.	20 7:40 a.m. vf.	8:36 p.m. vf. Δ 20.

Harmonic Tremor

This type of movement was not recorded during the month.

Microseismic Motion

Microseisms were slightly stronger than normal on April 6, and somewhat weaker than normal on the 26th and 27th.

Tilting of the Ground

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

March 28-April 3.....	0.8 second	E.
April 4-10.....	1.3 seconds	SW.
“ 11-17.....	0.6 second	ENE.
“ 18-24.....	0.6 “	NW.
“ 25-May 1.....	0.7 “	SSW.

R. M. WILSON,
Topographic Engineer.



Figure 17. December 21, 1927. First trial of the Ohiki. Photo Wilson.



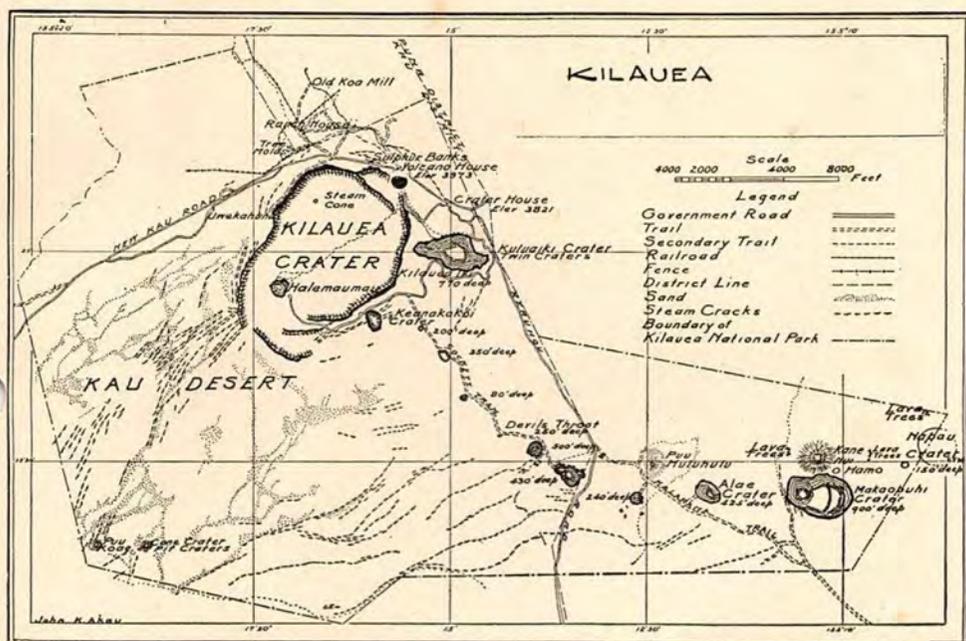
Figure 18. February 8, 1928. The Ohiki leaving the Observatory for Kona. Mr. L. A. Thurston beside Dr. T. A. Jaggar, who is driving. Photo Wilson.



Figure 19. February 11, 1928. The beach at Hookena where the Ohiki made its first launching in Kona District. Note old lava cascade on face of cliff at right. Photo Wilson.



Figure 20. April 15, 1928. Looking northeast across Makaopuhi Crater from the end of the Chain of Craters Road. Photo Wilson.



Black spot shows location of Observatory.

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CONTENTS

VOLCANIC CONDITIONS IN MAY

Activity of Halemaumau

JOURNAL, MAY, 1928

Illustrations

SEISMOMETRIC RECORD

Local Earthquakes and Tremors

Teleseisms

Harmonic Tremor

Microseismic Motion

Tilting of the Ground

MAP AND STATION DATA

VOLCANIC CONDITIONS IN MAY

Activity of Halemaumau

There were a few slides and a little stripping of the walls as a consequence during the month. A circuit of the pit showed considerable change in rim contour in recent weeks, particularly noticeable at the north-northeast rim. Measurements of the east rim cracks failed to show any decided movement of the rim blocks. A survey of locations of active steam vents was made on May 7, as noted in the Journal.

Visitors to the volcano included a few thousand sailors from United States battle squadrons.

JOURNAL, MAY, 1928

May 2. SE. sulphur patch not distinguishable today. A new scar at center of N. wall. White salts there before are now gone.

After two wet days steam has increased, particularly at a wet patch on the NNW. wall. A few rocks fell at N. corner at 8:45 a. m.

May 5. Very windy. N. wall has had slides. Wet spot NNW. still persists. Dust seen N. and NW. at 9:50 a. m.

May 6. At 4:20 a. m. there was an avalanche N.

May 7. Measured east rim cracks at 9 a. m. The pit was quiet. Steam seen at S. and center cones and at N. cone vent. Twin cone vent reported steaming yesterday. Present steaming places are: Below edge E. rim; back of N., NW., and W. rims; middle NNW. wall; middle and S. top of SW. talus; middle NNE. talus; three places on SE. talus; below E. end of NE. sill; two floor fumaroles at foot of N. talus; both wall edges of NW. talus.

A few minute rock trickles were heard at intervals.

May 9. Dark red surface of N. wall indicates peeling. All the former white salts gone. Slow trickle of rocks there at 9:30 a. m. Cones were steaming.

Note that big SW. talus is the only one which has not changed in the past year or more. The edge of July lava floor here is the only place not overlapped by debris.

May 11. At 6:13 p. m. an avalanche N. made a seismographic registration.

May 12. Stones trickled W. at 8:50 a. m.

The pit is dark from rains—SW. wind yesterday. Steam vents all a trifle more active.

A streak of gray debris on red N. talus must be the avalanche of 6:13 p. m. yesterday.

Avalanche dust N. was seen at 11:50 a. m.

May 14. At 12:15 p. m. there was a slide at the west corner. W. wall is dusty. Not much steam. Heard rocks N. and SW.

May 15. At 3 p. m. there was avalanche dust over the NW. corner.

May 16. New debris tops NW. talus. Stones heard NW. and W. at 8:30 a. m. Steaming places on taluses and walls are conspicuous.

May 19. 10-10:20 a. m. Pit is quiet and no sounds heard. Yellow stain is discernible at site of SE. sulphur spot. Alee, guide, reports slide S. corner two days ago.

Hundreds of sailors from U. S. Navy visiting Halemaumau.

May 21. Circuit of pit made 9:45-11 a. m. Odor of spicy sulphur N. Much change noted in rim contour. Slide from upper N. corner at 10:55 a. m.

SE. sulphur stain is growing.

May 22. Thin dust seen in the pit from Observatory at 9:05 a. m. Strong wind blowing. At 11:35 there was a large slide from NE. corner. More avalanching occurred about 1 p. m. from the north.

May 23. Slides reported S. making noise and dust yesterday about 9 a. m. Slide SW. now at 8:40 a. m. Rocks fell 9:10 a. m. NW. Dust from slide NW. seen 11:15 a. m. Several avalanches N. or NW. during the afternoon.

Cracks were measured, but little difference found over measurements of May 7.

May 25. Due to very strong NE. wind the south Kilauea floor is very dusty, and desert is so thick with dust clouds that the whole horizon is hidden.

May 26. Rainy and windy, but at 11:30 a. m. no sliding noted. N. wall streaked from center down, and talus has new red dirt.

Slides at S. corner have again obliterated SE. sulphur spot.

May 28. At 9:15 a. m. Halemaumau was quiet. S. cone steams.

May 30. Quiet and sunny at 9 a. m. Very little steam; most conspicuous at center of SW. talus.

Rumor of extraordinary crack widening at 14-ton boulder proved erroneous.

SEISMOMETRIC RECORD

There were 98 local earthquakes and three teleseisms recorded on the Observatory seismographs during the month ended at midnight May 31, 1928. These and other phenomena are listed below. The time used is Hawaiian Standard

(time meridian is 157° 30' W.), which is 10 hours and 30 minutes slower than Greenwich Time.

The greater number of the very feeble local shocks counted in the list make such minute records that the character of the disturbance is not always apparent. Some are true earthquakes; others are perhaps the parts of greater amplitude of a continuous or protracted tremor, which at other times may be too feeble to record; some seem to be records of vibrations set up by avalanches in the pit of Halemaumau.

Abbreviations used below are as follows: vf, very feeble; f, feeble; s, slight; m, moderate; d, instruments dismantled; fl, felt locally; Δ, indicated distance in miles; *, continuous tremor:

Local Earthquakes

May

1	1:10 a.m. vf.	7	9:54 a.m. vf.	14	2:16 p.m. vf.
	2:42 a.m. vf. Δ11.		1:16 p.m. vf.		3:18 p.m. vf.
	9:43 a.m. vf.		3:20-3:22 p.m. vf. *	15	12:21 a.m. vf.
	1:10 p.m. vf.		8:25 p.m. vf.		9:26 a.m. vf.
	3:10 p.m. vf.	8	1:36 a.m. vf.		3:42 p.m. vf.
2	3:57 a.m. vf. Δ5.		2:00 a.m. vf.		3:49 p.m. vf.
	5:49 a.m. vf.		7:56 a.m. vf.	16	6:45 a.m. vf.
	9:39 a.m. vf. Δ26.	9	5:17 a.m. vf.		3:50 p.m. vf.
	2:45-2:49 p.m. vf. *		11:16 a.m. vf.	17	10:48 a.m. vf.
	2:58 p.m. vf.		2:05 p.m. vf.		9:40 p.m. vf.
3	3:48 a.m. vf.		2:19 p.m. vf.	18	2:19 a.m. vf.
	8:26 a.m. vf.		2:42 p.m. vf.		9:47 a.m. vf.
	8:35 a.m. vf.		3:40 p.m. vf.		4:17 p.m. vf.
	10:57 a.m. vf.		10:07 p.m. vf.		5:00 p.m. vf.
	11:13 a.m. vf.	10	12:27 p.m. vf.		7:43 p.m. f. Δ14.
	11:14 a.m. vf.		3:29 p.m. vf.	19	2:21 p.m. vf.
4	5:15 a.m. vf.		6:13 p.m. vf.	20	4:23 p.m. vf.
	10:30 a.m. vf.	11	7:08 a.m. vf.		10:59 p.m. vf.
	10:31 a.m. vf.		10:28 a.m. vf.	22	9:05 a.m. vf.
	10:32 a.m. vf.		11:15 a.m. vf.		8:15 p.m. vf.
	3:22 p.m. vf.		8:38 p.m. vf.	23	4:48 p.m. vf.
	3:44 p.m. vf.	12	1:45 a.m. vf.	24	3:55 p.m. vf.
	9:48 p.m. vf.		5:41 a.m. vf.		8:31 p.m. vf.
5	6:19 a.m. vf.		4:05-4:09 p.m. vf. *	25	8:34 a.m. vf.
	9:00 a.m. vf.	13	1:07 a.m. vf.	26	4:04 a.m. vf.
	2:48 p.m. vf.		11:03 a.m. vf.		7:32 a.m. vf.
	4:41 p.m. f. Δ19.		12:07 p.m. vf.		4:33 p.m. vf.
	4:55 p.m. vf.		12:15 p.m. vf.	27	12:44 a.m. vf.
	9:26 p.m. vf.		8:03 p.m. vf.		1:23 a.m. vf.
6	4:13 a.m. vf.	14	12:32 a.m. vf.		1:26 p.m. vf.
	4:18 a.m. vf. Δ12.		4:24 a.m. vf.	29	5:56 a.m. vf.
	9:51 a.m. vf.		11:12 a.m. vf.	30	11:54 a.m. vf.
	2:55 p.m. vf. Δ11.		2:01 p.m. vf.		

Teleseisms

May 7

iP 6:24:39 p.m. Feeble record.

S ? 6:31:28 p.m.

May 14

iP 11:57:01 a.m.

S 12:07:18 p.m. Distance 5,580 miles.

LE 12:22 p.m.

May 26

S ? 11:37:55 p.m. Feeble record.

L ? 11:46:29 p.m.

Harmonic Tremor

This type of movement was absent throughout the month.

Microseismic Motion

Microseisms were slight on May 9, becoming stronger to somewhat more than normal amplitude on the 13th, diminishing again to normal by the 16th. On the 25th between 8 and 10:30 a. m. small vibrations due to heavy wind were present.

Tilting of the Ground

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

April 25-May 1.....	0.7	second	SSW.
May 2-8.....	0.6	“	S.
“ 9-15.....	1.0	“	SW.
“ 16-22.....	0.3	“	WSW.
“ 23-29.....	0.3	“	W.
“ 30-June 5.....	0.7	“	SW.

R. M. WILSON,
Topographic Engineer.



Figure 21. February 20, 1928. Coating of dust from avalanches settled on north part of Halemaumau floor. Photo Wilson.



Figure 22. June 6, 1928. Looking west across floor of Makaopuhi Crater. Showing source cones and flow of 1922 on the talus slope. Photo Wilson.



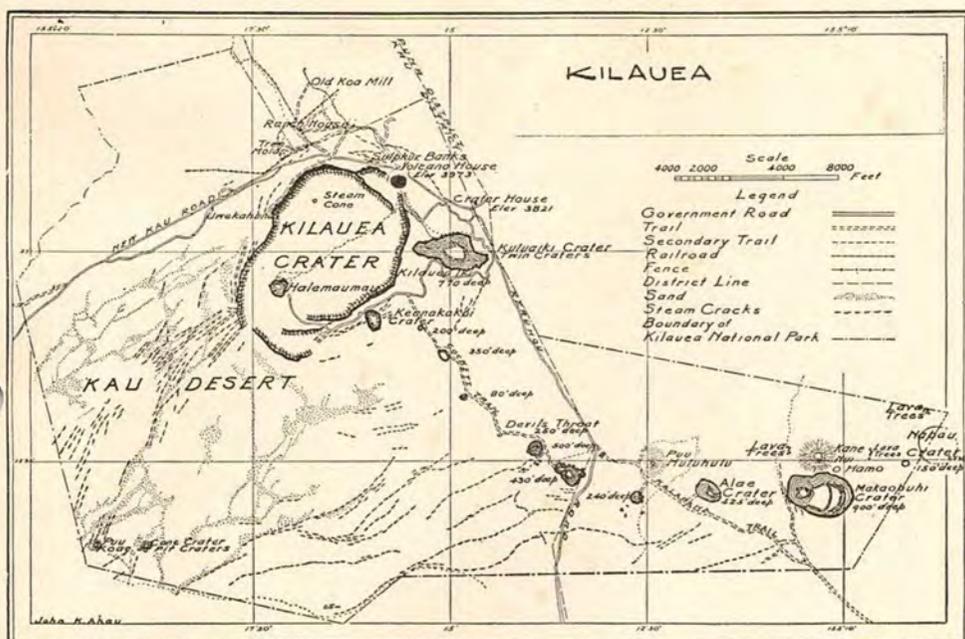
Figure 23. February 20, 1928. Telephoto view of middle cone and January lava. Photo Wilson.



Figure 24. June 6, 1928. Makaopuhi Crater, showing edge of aa lava floor at lower left, and the boulders at the foot of west talus. Photo Wilson.



Figure 25. December 21, 1927. First water test of the Ohiki in the lagoon at Ninole. Photo Hodges.



Black spot shows location of Observatory.

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VOL. XVI

HONOLULU, HAWAII, JUNE, 1928

No. 6

CONTENTS

THE SEISMIC SEA WAVE AT HILO, JUNE 17

By R. M. Wilson

VOLCANIC CONDITIONS IN JUNE

Activity of Halemaumau

JOURNAL OF JUNE, 1928

Illustrations

SEISMOMETRIC RECORD

Local Earthquakes and Tremors

Teleseisms

Harmonic Tremor

Microseismic Motion

Tilting of the Ground

MAP AND STATION DATA

THE SEISMIC SEA WAVE AT HILO

By R. M. Wilson

Early in the morning of June 17 there occurred at Hilo a mild tidal wave due to the Mexican earthquake of June 16, 1928. This went unnoticed at Hilo, perhaps because of the time of its occurrence, between 1 and 2 a. m.

The epicenter of the earthquake was in the Acapulco Deep of the Pacific Ocean, about 125 miles south of the coast of the Mexican State of Oaxaca. The coast towns in this region suffered considerable damage; press reports refer to destruction by tidal wave at Chacahua, and at Puerta Angel water waves are mentioned as coming in from the sea which "rushed inland 50 yards."

On March 22, 1928, a similar earthquake occurred in almost the same place. The March earthquake, however, produced no sea wave that could be discovered on the Hilo tide gauge records. The fact that only one of these two earthquakes produced a sea wave is perhaps to be explained by their relative intensities. The seismograph records of the two shocks as made at the Hawaiian Volcano Observatory were somewhat similar in character, but the trace amplitude of the June 16 earthquake was greater.

The seismic sea wave here discussed was recorded feebly at Honolulu, but its beginning on the records of the gauge there could not be definitely identified. The water wave from Mexico had to pass around the Island of Oahu to reach Honolulu, and the Honolulu harbor is more fully protected than the Hilo harbor, which facts probably account for the feebleness of the Honolulu record.

Fig. 26 is a tracing of the marigram made by the recording tide gauge at Hilo covering the first parts of the tidal disturbance. The curve shows the arrival of the sea wave on June 17 at 1:18 a. m., developing into a series of sharp risings and fallings through a maximum range of 1.32 feet. The period of the first cycle was about 22 minutes, conforming approximately to the period of the natural water oscillation of Hilo Bay. The maximum oscillations of the water had a period of about 15 minutes. The duration of the disturbance was remarkable, as the marigram curve shows evidence of disturbed water level for over 24 hours. There seem to be definite recurrences of the disturbance, perhaps due to reflections of the original tidal wave from other coasts or to after-shocks at the origin of the earthquake. The most important of these recurrences began at 6:08 a. m., having a period of 18 minutes and a range of rise and fall of 0.7 foot. Fainter recurrences seem to have occurred at 7 p. m., 7:45 p. m., and on June 18 at 12:35 a. m. and 6:10 a. m.

The first table given below shows the results of computing the sea wave velocity from data recorded at the Hawaiian Volcano Observatory, which were immediately available from the seismograms:

SEISMIC SEA WAVE AT HILO JUNE 17

(Hawaiian Standard Time)

Arrival of preliminary earthquake wave.....	June 16, 4:59:08 p. m.
Arrival of secondary earthquake wave.....	June 16, 5:06:59 p. m.
Computed distance to epicenter.....	6,300 km., or 3,915 statute miles
Time at origin.....	June 16, 4:49:19 p. m.
Time of arrival of sea wave.....	June 17, 1:18 a. m.
Travel time of sea wave.....	8 hours, 29 minutes
Sea wave velocity from origin.....	206 meters per second
Or	7.7 miles per minute

Somewhat better figures result from the use of the coordinates of the epicenter and the time of the earthquake at its origin as computed by the Jesuit Seismological Association from records of a number of different observatories. Figures in the following table are based upon the preliminary position and time of the shock as furnished by that Association:

Origin at	14.5° N. Lat., 96.8° W. Long.
Distance from origin to Hilo.....	6,210 km., or 3,860 statute miles
Bearing of epicenter from Hilo.....	N. 86° E.
Time of origin.....	June 16, 4:49:05 p. m.
Travel time of sea wave.....	8 hours, 29 minutes
Sea wave velocity	203 meters per second
Or	7.6 miles per minute

During the year 1927 there were recorded two seismic sea waves at Hilo which were discussed in this Bulletin for March, 1928 (Vol. XVI, No. 3). The disturbance described above was of greater amplitude than either of the waves of 1927.

VOLCANIC CONDITIONS IN JUNE

Activity of Halemaumau

The volcano remained inactive throughout the month, although during the solstice conditions were closely watched for any indication of changes. There was slight working of the walls.

On June 6, 1928, Messrs. Clark, Russ and Wilson went to the bottom of Makaopuhi Crater. Notes on this and former trips will be found in Volcanic Letter Nos. 47 and 181: see figures 22 and 24, this Bulletin, May, 1928.

JOURNAL, JUNE, 1928

June 1. The SE. sulphur patch has reappeared. Quiet and sunny day. Very little steam.

June 2. Dust cloud from an avalanche rose at 11:30 a. m. Other dust clouds observed during the afternoon.

June 3. Streaks from slides N. and E. seen. New red debris covers the N. talus.

Rainy day. Red wall colors are conspicuous. The SE. sulphur area is again buried.

June 5. Slides NW. at noon, and NE. at 3:45 p. m.

June 6. No changes to be seen in the pit. Tropic birds heard chirping loudly somewhere in upper E. wall. Very slight odor of free sulphur noticed SE. Avalanche dust seen at 11:30 a. m.

June 9. A strong NE. wind stirs up dust clouds in the desert. A small slide occurred low down on S. wall at 10 a. m. Almost no steaming following a long, dry spell.

June 11. Nothing new to be seen at 10 a. m. Numerous rusty spots on floor, similar to those on Mauna Iki, indicate hot areas. There was one light-trickle of rocks S. Steaming is extremely slight.

June 13. All quiet at 9:40 a. m. Only a little steam—NW., NNE., S., and SW. taluses, and S. cone.

June 16. Halemaumau was never more quiet. One or two very light slips of rocks heard. Both cones and usual talus vents steam thinly.

A few new sulphur crystals have formed in the 1923 crack south of the Chain of Craters Road.

June 17. Avalanche dust NE. seen at 12:30 p. m., and again at 3 p. m.

June 18. Green-yellow stain is plain at floor edge of SE. talus, with a little steam. The solfatara on E. talus edge does not change.

Cracks were measured. A very slight widening has taken place at the 14-ton boulder.

June 20. At 8:50 a. m. a slide on the W. wall made noise and dust. The N. wall has peeled pinkish. A very high wind makes observations difficult.

June 23. No changes noted, except slight peeling of the N. wall.

June 25. Nothing new. A little slide occurred NE. at 9:30. At 9:45 there was a slide of rocks on the SE. talus.

Greenish stain over SW. tunnels appears new.

June 27. The N. and NE. walls and taluses are dark from recent rains. Steam vents are all slightly more active.

SEISMOMETRIC RECORD

There were 102 local earthquakes and four teleseisms recorded on the Observatory seismographs during the month ended at midnight June 30, 1928. These and other phenomena are listed below. The time used is Hawaiian Standard (time meridian is 157° 30' W.), which is 10 hours and 30 minutes slower than Greenwich Time.

The greater number of the very feeble local shocks counted in the list make such minute records that the character of the disturbance is not always apparent. Some are true earthquakes; others are perhaps the parts of greater amplitude of a continuous or protracted tremor, which at other times may be too feeble to record; some seem to be records of vibrations set up by avalanches in the pit of Halemaumau.

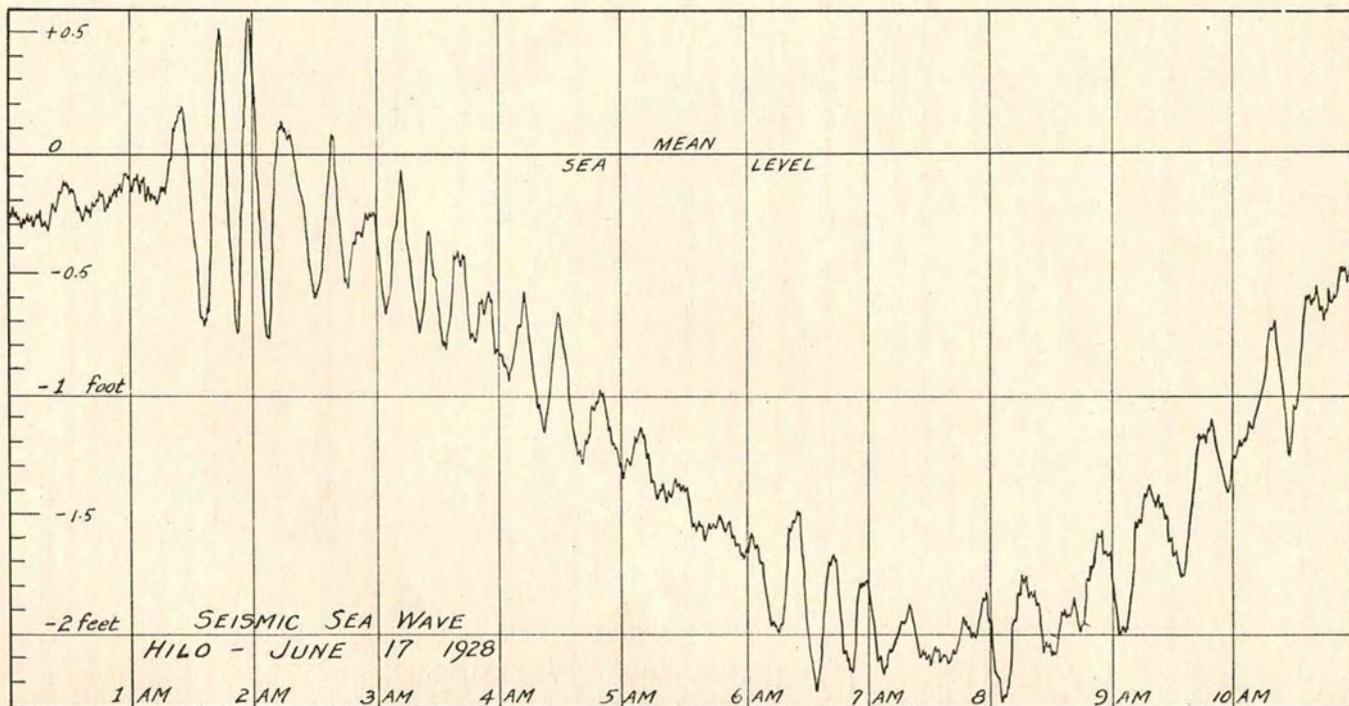


Figure 26. Tide gauge record of seismic sea wave, Hilo, Hawaii, June 17, 1928.

Abbreviations used below are as follows: vf, very feeble; f, feeble; s, slight; m, moderate; d, instruments dismantled; fl, felt locally; Δ , indicated distance in miles; *, continuous tremor.

June	June	June
1 12:22 a.m. vf.	13 5:58 a.m. vf.	20 12:34 p.m. vf.
2:20 p.m. vf.	10:20 a.m. vf.	21 4:27 a.m. vf.
3:20 p.m. vf.	7:42 p.m. vf.	6:47-6:49 a.m. vf. *
5:59 p.m. vf.	14 4:58 a.m. vf.	3:18 p.m. vf.
2 6:32 a.m. vf. Δ 9.	7:56 a.m. vf.	22 9:15 a.m. vf.
11:01 a.m. vf.	9:10 a.m. vf.	9:25 p.m. vf.
2:04 p.m. vf.	9:52 a.m. vf.	25 12:49 a.m. vf.
3 9:54 a.m. vf.	11:34 a.m. vf.	2:12 p.m. vf.
11:03 p.m. vf.	12:22-12:24 p.m. vf. *	3:57 p.m. vf.
11:50 a.m. vf.	12:28 p.m. vf.	5:47 p.m. vf.
5 7:53-7:59 a.m. vf. *	12:35 p.m. vf.	26 10:11 a.m. vf.
8:03-8:07 a.m. vf. *	8:00 p.m. vf.	2:45 p.m. vf.
6 3:27 a.m. vf.	9:01 p.m. vf.	6:37 p.m. vf.
12:26-12:30 p.m. vf. *	15 2:55 a.m. vf.	27 5:37 a.m. vf.
12:31 p.m. vf.	4:07 a.m. vf.	28 12:07 a.m. vf.
7 1:31 a.m. vf.	4:17 a.m. vf.	12:27 p.m. vf.
5:03 a.m. vf.	4:29 a.m. vf.	1:47 p.m. vf.
5:04 a.m. vf.	8:47 a.m. vf.	1:56 p.m. vf.
4:24 p.m. vf.	9:04 a.m. vf.	7:21 p.m. vf.
4:28 p.m. vf.	2:44 p.m. vf.	11:14 p.m. vf.
6:29 p.m. vf.	6:45 p.m. vf.	29 1:04 a.m. vf.
8 9:53 a.m. vf.	16 12:48 p.m. vf.	12:57 p.m. vf.
9:56 a.m. vf.	8:19 p.m. vf.	6:30 p.m. vf.
10:09 a.m. vf.	18 1:19 a.m. vf.	30 12:20 a.m. vf.
12:43 p.m. vf.	8:57 a.m. vf.	4:06 a.m. vf.
9 9:03 a.m. vf.	10:46 a.m. vf.	4:31 a.m. vf.
10 12:05 p.m. vf.	11:40 p.m. vf.	5:48 a.m. vf.
5:36 p.m. vf.	19 12:58 a.m. vf.	9:06 a.m. vf.
7:21 p.m. vf.	6:44 a.m. vf.	10:59 a.m. vf.
11 3:53 a.m. vf.	11:10 a.m. vf.	10:01 p.m. vf.
1:36 p.m. vf.	7:38 p.m. vf.	10:30 p.m. vf.
9:37 p.m. vf.	20 4:43 a.m. vf.	11:55 p.m. vf.
12 1:38 a.m. vf.	5:43 a.m. vf.	
11:52 a.m. vf.	9:07 a.m. vf.	
7:56 p.m. vf.	11:36 a.m. vf.	

Teleseisms

June 16

eP 4:59:08 p.m.
 S 5:06:59 "
 ? 5:13:03 "
 L? 5:15:25 "

Distance 3,915 miles. This earthquake caused a tidal wave at Hilo, which has been described in the foregoing pages of this Bulletin.

June 21

iP 12:18:27 a.m.
 S 12:25:04 "
 L 12:29:11 "

Distance 3,120 miles.

June 21

iP 6:05:07 a.m.
 S 6:11:23 "
 SR? 6:14:41 "
 L 6:16:41 "

Distance 2,900 miles.

June 29
eP 12:28:15 p.m. Distance 3,400 miles.
S 12:35:25 "
? 12:39:25 "
? 12:41:25 "

Harmonic Tremor

This type of movement was absent throughout the month.

Microseismic Motion

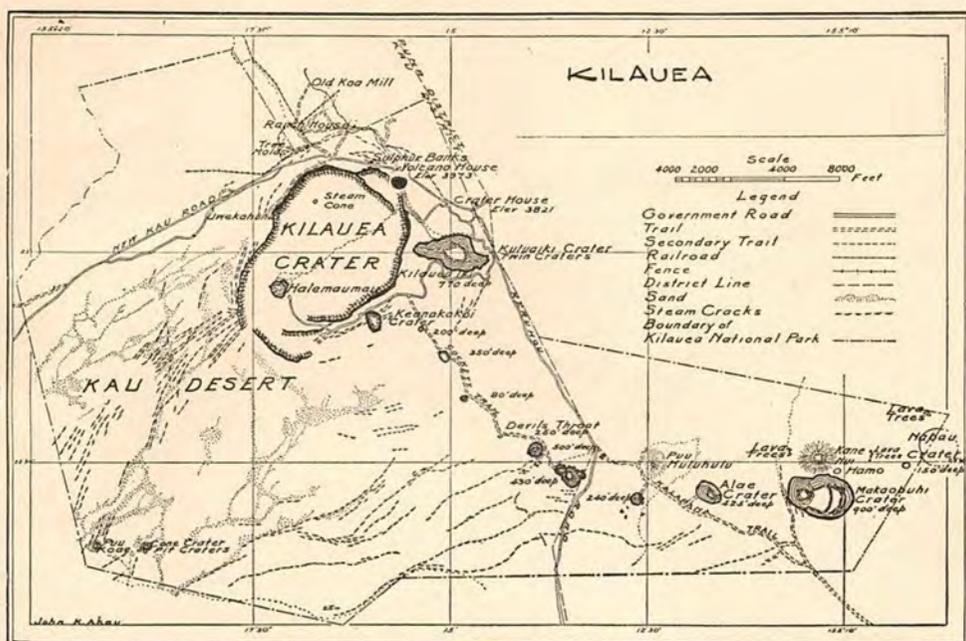
Microseisms were slightly stronger than normal on the 14th and 15th, and normal for the balance of the month.

Tilting of the Ground

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

May 30-June 5	0.7	second	SW.
June 6-12	0.2	"	NE.
" 13-19	0.4	"	WSW.
" 20-26	0.2	"	E.
" 27-July 3	0.3	"	NE.

R. M. WILSON,
Topographic Engineer.



Black spot shows location of Observatory.

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JOURNAL OF JULY, 1928

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Tilting of the Ground

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DIMENSIONS OF HALEMAUMAU

By R. M. Wilson

The approximate center of the pit of Halemaumau is in Latitude $19^{\circ} 24' 34''$ North, and Longitude $155^{\circ} 17' 10''$ West. (Fig. 27.) In its present condition it is almost circular in shape, though the northeast-southwest diameter is slightly greater. Its diameters are 3,420 by 2,980 feet. The perimeter is 1.96 miles. The depth of the lowest part of the floor below the average rim elevation is 1,170 feet. The summit of the southwest cone is 160 feet above the lowest part of the floor. The debris slopes or taluses repose at an angle of about 30° from the horizontal, which is about a 58% grade. The steeper walls stand at about 80° from the horizontal; while the average slope of the northwest wall is about 53° from the rim to its lowest toe. (Fig. 28.) The area of exposed lava floor and the cones with their spatter is now about 19 acres. The hori-

zontally projected area of all the taluses is 87 acres, and the area of the horizontal projection of all the walls is 81 acres; the slope surface areas are of course much greater. This makes the total area of the pit 187 acres. The southeast station (Fig. 29) at the "Halemaumau sign," which is the point from which the pit is most often viewed, is about south 30° east from the center of the pit, and the elevation of the bronze mark there is 3,651 feet above the mean sea level.

VOLCANIC CONDITIONS IN JULY

Activity of Halemaumau

There was no lava activity in Halemaumau throughout the month. The usual wall slides occurred. Liquid lava last appeared in the pit one year ago this month. Crack measurements along the east rim showed no decisive changes. Due to wet weather there was an increase of steaming activity on July 26 and 27.

JOURNAL, JULY, 1928

July 1. No sounds in pit, and no changes. Rains have deepened wall colorings. Time is 4:30 p.m., and late afternoon light causes poor visibility, but a scar on N. wall looks fresh.

July 4. Fresh appearing slide streak shows on N. wall of Makaopuhi Crater.

July 7. At 10 a. m. there was considerable steam rising from Halemaumau following a night and morning of rain.

July 9. New gray debris lies between NNE. and NE. taluses.

July 11. No conspicuous changes. N. wall is very red, and one bright scar shows. Talus is also red. A reddish scar shows on lower edge of NE. sill between N. and NNE. taluses.

July 16. 9:15-10:40 a.m. Taking photographs of Halemaumau interior and walls, and making transit surveys. Quiet all the time, with only one or two rockfalls; one at the SE. center wall, where there is a large fresh scar.

July 18. The pit is quiet. Not much white salts, except two areas on S. wall. There is also a lack of steaming. One fall of rocks heard SW. about 9:30 a. m.

July 19. Avalanches from S. corner making dust were noted at 7 and 7:21 a. m.

July 20. An avalanche NE. made dust at 4 p. m.

July 21. No decisive changes. Two dusty scars on NE. wall.

July 25. 9:25-9:45 a. m. High wind, and no sounds distinguishable. N. wall is quite red from wetting.

July 26. Steam jets quite active all over Kilauea Crater floor on this cloudy afternoon.

July 27. At 9 a. m. steam was very dense from Halemaumau in heavy mist.

July 30. Measured cracks SE. rim at 10 a. m. Some slight differences found. Point No. 14 has an unusual amount of steam.

Pit shows no changes. Wind is too strong to hear sounds, if any.

July 31. Avalanche dust NW. rose at 3:05 p. m. Men standing on pit rim are probably dropping rocks.

SEISMOMETRIC RECORD

There were 69 local earthquakes and two teleseisms recorded on the Observatory seismographs during the month ended at midnight July 31, 1928. These and other phenomena are listed below. The time used is Hawaiian Standard (time meridian is 157° 30' W.), which is 10 hours and 30 minutes slower than Greenwich Time.

The greater number of the very feeble local shocks counted in the list make such minute records that the character of the disturbance is not always ap-

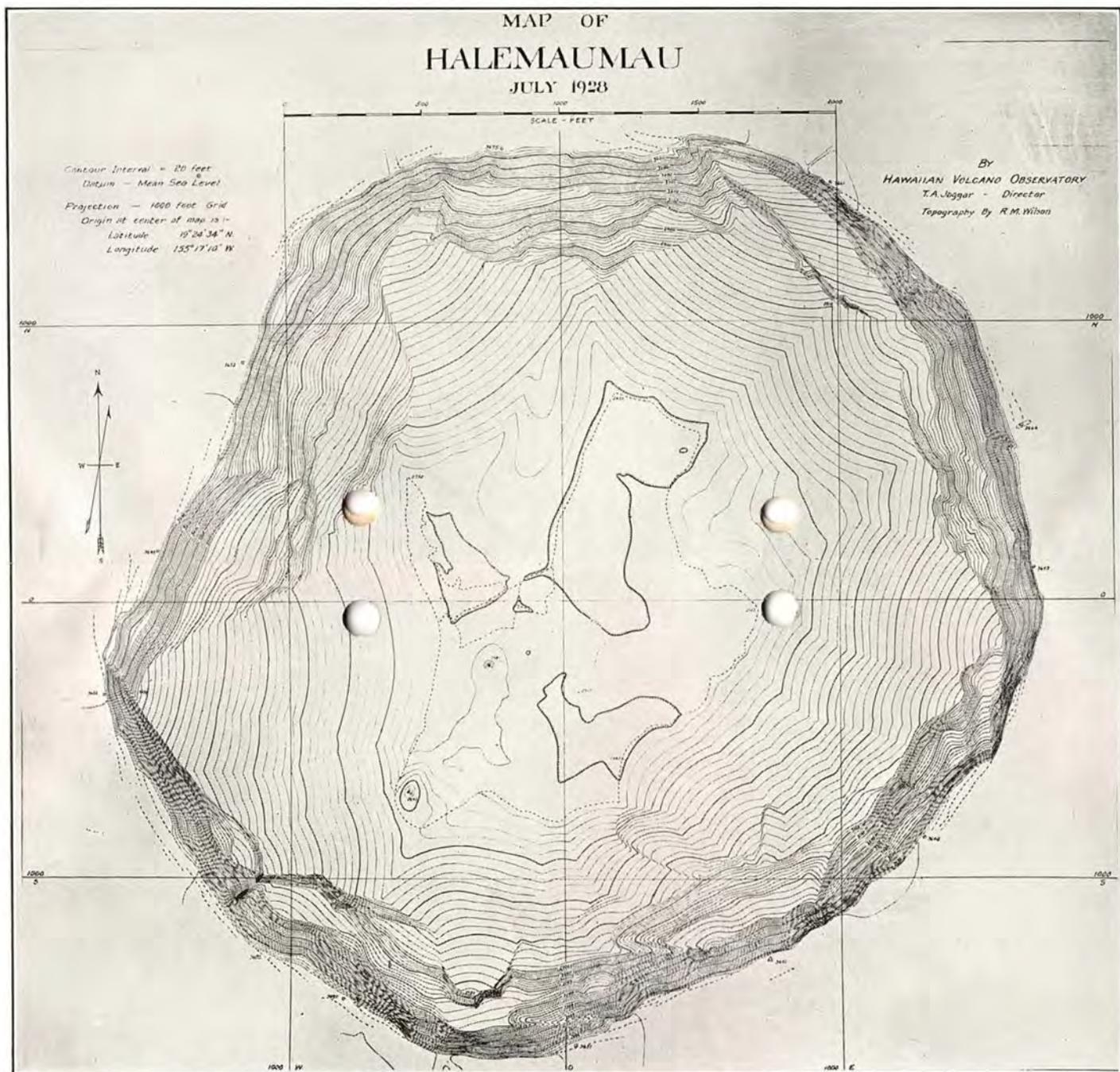


FIGURE 27. Map of July, 1928, by R. M. Wilson. Compare the accompanying photographs. Twenty-foot contours. Figure 28 is from a point on the rim W. 805 feet, S. 1,422 feet from intersection of O-lines in center of pit. Figure 29 is from a point on rim W. 201 feet, N. 1,620 feet.



FIGURE 28. Looking NE. in Halemauau; the great canoe sill. July 21, 1928. Volcano House in center distance. Kau Desert fault fractures on the right. Photo Wilson.



FIGURE 29. Looking SSE. from NNW. side of Halemaumau, July 21, 1928. Showing 1927 cone and lava floor. The 1920 tunnel and dykes on the right. Photo Wilson.

parent. Some are true earthquakes; others are perhaps the parts of greater amplitude of a continuous or protracted tremor, which at other times may be too feeble to record; some seem to be records of vibrations set up by avalanches in the pit of Halemaumau.

Abbreviations used below are as follows: vf, very feeble; f, feeble; s, slight; m, moderate; d, instruments dismantled; fl, felt locally; Δ , indicated distance in miles; *, continuous tremor.

Local Earthquakes

July		July		July	
1	2:14 p.m. vf.	15	12:23 p.m. vf.	26	8:24 a.m. vf.
2	2:52 a.m. vf.	18	4:32 a.m. vf.		10:13 a.m. vf.
3	6:26 a.m. vf.	19	6:16 a.m. vf.		12:08 p.m. vf.
	6:28 a.m. vf.		8:46 a.m. vf.		5:08 p.m. vf.
	12:28 p.m. vf.	21	1:05 p.m. f. Δ 15.	27	6:40 a.m. vf.
	8:48 p.m. vf.	22	5:21 a.m. vf.		10:01 a.m. vf.
4	1:08 p.m. vf.		12:19 p.m. vf.		11:06 a.m. vf.
5	4:14 p.m. vf.		1:01 p.m. vf.		12:42 p.m. vf.
	6:21 p.m. vf.		2:03 p.m. vf.		3:32 p.m. vf.
6	11:08 a.m. vf.		6:52 p.m. vf.		8:20 p.m. vf.
7	12:08 a.m. vf.	23	1:50 p.m. vf.		9:03 p.m. vf.
	1:18 a.m. vf.		7:38 p.m. vf.	28	6:51 a.m. vf.
8	10:22 p.m. vf.		8:47 p.m. vf.		8:37 a.m. vf.
	10:32 p.m. vf.	24	9:23 a.m. vf.		11:41 p.m. vf.
9	2:32 p.m. vf.		11:24 a.m. vf.	29	9:20 a.m. vf.
10	12:53 p.m. vf.		4:43 p.m. vf.		9:45 a.m. vf.
	3:29 p.m. vf.		4:47 p.m. vf.		12:30 p.m. vf.
11	3:35 a.m. vf.	25	5:51 a.m. vf.		6:46 p.m. vf.
	8:21 a.m. vf.		8:23 a.m. vf.		7:03 p.m. vf.
	1:08 p.m. vf.		8:54 a.m. vf.		7:44 p.m. vf.
12	3:02 p.m. vf.		11:01 a.m. vf.		8:27 p.m. vf.
14	9:35 a.m. vf.		1:42 p.m. vf.		11:00 p.m. vf.
	9:36 p.m. vf.			30	9:41 a.m. vf.
					11:11 a.m. vf. Δ 1

Teleseisms

July 9		
eP	11:02:48 a.m.	Very faint record.
July 18		
P	8:47:20 a.m.	Very feeble record.

Harmonic Tremor

This type of movement was absent throughout the month.

Microseismic Motion

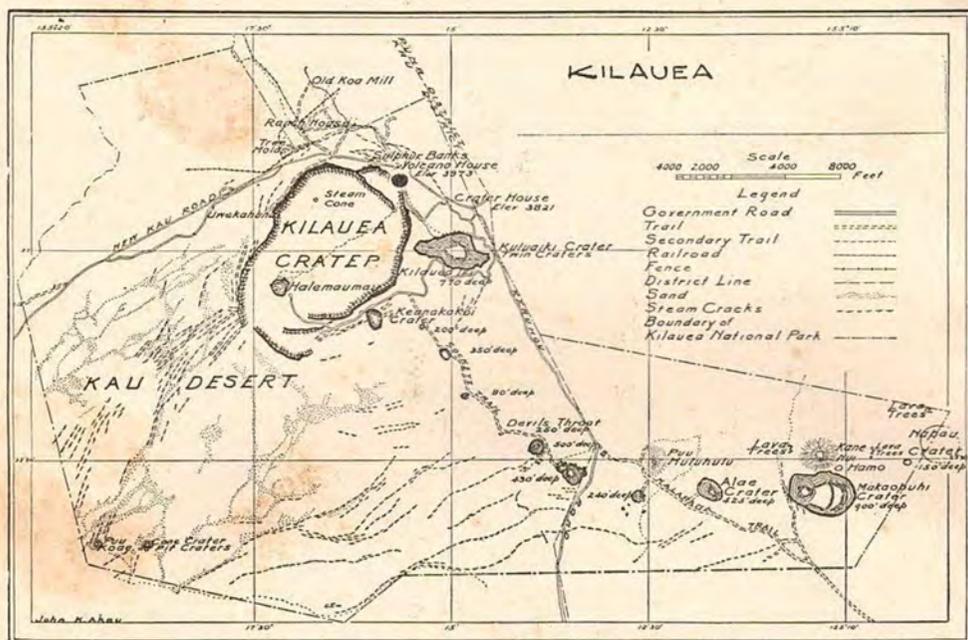
Microseisms were normal throughout the month.

Tilting of the Ground

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

June 27-July 3	0.3	second	NE.
July 4-10	0.3	"	NNW.
" 11-17	0.4	"	SE.
" 18-24	0.5	"	SW.
" 25-31	0.9	"	NNE.

R. M. WILSON,
Topographic Engineer.



Black spot shows location of Observatory.

All exchanges, gifts to library, news notes about Pacific volcanic and seismic events, and correspondence should be addressed HAWAIIAN VOLCANO OBSERVATORY, Hawaii National Park, Hawaii.

The Observatory is operated by the U. S. Geological Survey, and its work is supplemented by the Hawaiian Volcano Research Association. The main station is on the northeast rim of Kilauea Crater. Subordinate seismograph stations are operated by the Research Association under the direction of the volcanologist in Kona and Hilo.

The Kilauea station operates horizontal pendulums of the Bosch-Omori type and receives time by wireless from the Honolulu Naval Station. Observatory Lat. $19^{\circ} 25' 54.3''$ N.; Long. $155^{\circ} 15' 39.6''$ W.; Elevation cellar 1214.6 meters (3985 feet). The Hilo and Kona stations operate horizontal pendulums. Their seismograms are sent to the Observatory.

The Hawaiian Volcano Research Association founded the Observatory in 1911, transferring the plant to the Government in 1919, but continuing cooperation in experimental work by furnishing funds and apparatus and workers as needed by the Government Volcanologist. It is a corporation under the laws of Hawaii, governed by a board of directors, and financed by the subscriptions of its members and patrons. Its aims are identical with those of the Observatory, namely, (1) To keep record of Hawaiian volcanism, (2) To attract volcanologic specialists to Hawaii, and (3) To promote worldwide knowledge of volcanoes and earthquakes and the foundation of more volcano observatories.

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CONTENTS

TEST OF HAWAIIAN TYPE SEISMOGRAPH

By R. M. Wilson

VOLCANIC CONDITIONS IN AUGUST

Activity of Halemaumau

JOURNAL OF AUGUST, 1928

Illustrations

SEISMOMETRIC RECORD

Local Earthquakes and Tremors

Teleseisms

Harmonic Tremor

Microseismic Motion

Tilting of the Ground

MAP AND STATION DATA

TEST OF HAWAIIAN TYPE SEISMOGRAPH

By R. M. Wilson

Data herein considered resulted from a test of one of the seismographs designed and constructed at the Hawaiian Volcano Observatory. The instruments that have been constructed to date have been placed as follows: Kodiak, Alaska, August, 1927. Hilo, Hawaii, September, 1927. To U. S. Coast and Geodetic Survey, December, 1927, for test in its laboratory at Cheltenham, Md. The fourth was established in Kealakekua, Hawaii, in June, 1928, and is the particular instrument which was subjected to the test herein described. The fifth was sent in July, 1928, to Lassen Volcano Observatory, Mineral, California. A sixth instrument was shipped in August to Dutch Harbor, Alaska. These instruments are the same in general design, though some small details have been changed from time to time.

The test undertaken was not complete, inasmuch as the instrument was adjusted throughout the test to the same period and the same value of damp-

ing ratio. The trial was made on a specially constructed oscillating table. Motions delivered to the instrument were varied between amplitudes of 0.171 mm. and 0.0103 mm., at periods from about 0.3 second to a little over 10 seconds. A more complete test would involve a wider range of amplitudes and periods in the motion of the table, applied to the instrument adjusted to various values of natural period and damping. But it was desired in this test to discover how the instrument would behave under conditions of adjustment similar to those planned for its use. Thus the pendulum period and damping ratio were taken at the approximate values selected for future normal operation. The artificial earthquakes applied by the oscillating table were primarily intended to imitate local shocks; the range of motion implied by teleseisms being not so important in the present consideration.

The seismograph itself has been briefly described already in this publication (Vol. XV, No. 11, Nov., 1927). It is ordinarily of two components, but in this test one component only was used. The 70-kilogram inertia masses are 27-inch lengths of eight-inch pipe filled with sand, suspended with their axes upright. Suspension is by means of short piano wire links, which have a clear length for flexure of about one-half inch. The inertia masses operate as horizontal pendulums. The mathematical length from the hinge line, or axis of rotation, to the center of oscillation is 25.7 cm. This value was determined both by computation from the dimensions of the parts, and by noting the change of period with changes of the angle of inclination of the axis of rotation. The length from the axis to the pivot at the end of the boom is 126.2 cm. The short and long arms of the pen lever are 0.839 cm. and 22.24 cm. These figures give a computed static magnification of 130. The pen lever is of tubular aluminum, counterbalanced so that the center of gravity is at its pivot staff. The connecting link between the boom and the short arm of the lever is $1\frac{1}{2}$ inches long, carrying inverted cups at each end which fit over the up-pointing pivots on the boom and lever. The recording stylus is a fine steel needle partly counterbalanced on its axis so that only part of its weight rests by gravity on the smoked paper. Oil damping is used, the vanes which dip in the oil being fastened near the outer end of the boom. Both components, when both are used, record on the same drum, which is 30.5 cm. wide and 28.7 cm. in diameter. The paper speed is 30 mm. per minute, and the instrument will run 24 hours without attention.

The oscillating table used for the test is of massive concrete, weighing about 800 pounds, mounted upon two long steel rollers $1\frac{7}{16}$ inches in diameter (see Fig. 30). It carries both the pendulum and the recording mechanism of the seismograph (Fig. 31). Accelerations applied were small enough so that the exciting forces could be applied through these rollers without slipping. Levers were attached to the rollers and were operated by a link connection to an adjustable crank held in the chuck of a nearby lathe. Amplitude of motion was governed by varying the radius of the crank, and the desired range of period was obtained by changing the lathe speed. Amplitude of motion of the table was computed from the motion observed at the lathe by applying the reducing factor of the lever and roller system.

The running of machinery in the shop caused slight vibration, which would not likely be present in an ordinary seismograph cellar. It appears occasionally on the test seismograms as an almost microscopic rapid tremor. Its effect in the tests was probably to reduce by jarring the solid friction present in the instrument. The shop machinery was not running when the decay curves were made, from which the amount of solid friction was computed. A test was made to see how much tilt was present as an accompaniment of the sidewise motion of the table; that is, to see how pure was the motion of the table. This was done with the seismograph set up and recording; the table was displaced first to one side, and then to the other, and the position of the recording pen was noted after it had come to rest in each position. The range of pen movement due to tilt was thus found to be 16 mm., for a range of table dis-

placement of more than 4 times the greatest range of harmonic oscillations used in the tests. The direction of this tilting was such as to reduce the recorded amplitudes of the harmonic oscillations. But tilting acts slowly, and this source of error would not affect the results obtained in the short-period tests. In the tests using longer periods this correction might perhaps be applied, though in preparing the results herein given it has been thought slight enough to neglect.

The instrument was set up, adjusted approximately to the desired natural period, and was allowed to write decay curves first as damped in the tests and then with oil damping removed, all with the table held stationary. The analysis of these curves to determine solid friction, viscous damping, and period was then undertaken. The period to which the instrument was adjusted throughout the tests was 7.6 seconds (T_0 in Figure 32). Solid friction was apparently rather large and somewhat irregular in its action. In the decay curves made without the oil damping the value of 'r', denoting the amount of solid friction, is 3.4 mm.; yet after being disturbed the pen always returned quickly to within much closer proximity of its null point than that value for friction would imply. After applying the oil damping and allowing for solid friction as above, the damping ratio due to the oil as computed from the damped decay curves is 1.8. Even with friction thus allowed for, the ratio seemed to vary from 1.5 for the larger amplitudes to 2.8 for the smaller ones. Counting friction and oil damping together as total damping effect, the value for the larger amplitudes was about 2, while for the smaller amplitudes 5 seemed the more proper value. The irregular action of the solid friction, and the changing amounts of power available to overcome it as amplitudes changed, is probably the cause of the uncertainties that appear in computing this damping ratio.

Reproductions of parts of the test seismograms are given in Figs. 33 and 34. A complete table of the individual tests is not given, although the separate result of each is plotted on the magnification diagram (Fig. 32). An abridged table, however, is given for the individual tests which appear in Figs. 33 and 34, so that the conditions under which these tests were made can be considered in connection with the resulting record. The six columns of the table have the following meanings: Test number, table amplitude, trace amplitude, period, apparent magnification, maximum acceleration of the harmonic motion of table. The tests numbered 67 to 69, inclusive, were made with the maximum amplitude of the series, the periods being purposely taken near the proper period of the seismograph in order to study the effect of resonance.

Test No.	a mm.	A mm.	T	M	Max. Accel. mm. sec. sec.
9	0.099	12.2	2.51	123	0.622
10	0.099	11.5	1.43	116	1.91
11	0.099	13.5	3.86	136	0.266
16	0.062	8.3	0.50	134	9.80
29	0.062	2.1	8.88	34	0.031
30	0.062	3.5	8.01	57	0.038
31	0.062	3.0	8.65	48	0.033
33	0.062	2.0	10.15	32	0.024
66	0.171	12.0	10.16	70	0.065
67	0.171	23.5	8.50	137	0.093
68	0.171	38.0	6.71	222	0.150
69	0.171	39.0	6.10	228	0.181

To show the variation of magnification with period, points have been plotted for each of the individual tests in Fig. 32. An averaged curve joining these points would be the practical approach toward the theoretical magnification curve given by Wiechert and others. The simple theoretical formula is a function of static magnification, damping ratio, and ratio of impressed period to the proper period of the instrument. In its simple and usable form, it does

not take account of the always uncertain solid friction. The apparent effect of solid friction present in these tests seems to make separate magnification curves with different amplitudes. This is presumably because the smaller amplitudes imply, for the same period, smaller accelerations, so that a greater proportion of the smaller forces available must be used in overcoming the constant solid friction in the small amplitude motions than in those of large amplitudes. This applies particularly to the motions of longer period, where the accelerations are slight anyway. For the short periods, where there are usually ample forces available to overcome friction, the magnification is apparently the same regardless of amplitude, as in the theoretical formula. The magnification curves here shown have been drawn through two sets of points only; the sets representing the two larger amplitudes used in the tests. The results from the tests using smaller amplitudes are somewhat uncertain on account of the difficulty in making the fine measurements accurately, but it will be noticed in general that the smaller the amplitude the smaller is the magnification for any given period.

Another departure of these curves in Fig. 32 from the theoretical magnification curve is the sharp upward trend when the period is diminished to less than one second. This is probably a result of the design of the instrument. With short periods, accelerations become great. The forces transmitted through the boom and connecting link to the pen lever increase in proportion to these accelerations. The connecting link with its inverted conical cups is not capable of transmitting large forces, and is thrown off, or partly thrown off, when these forces become too large. The upward trend, therefore, probably represents that point where the connecting link begins to leave its seat upon the pivots with increase of acceleration. The weight and moment of inertia of the pen arm taken in conjunction with the forces which can be transmitted through the connecting link thus limit the accelerations which the instrument can record. This improper increase of magnification due to the unseating of the connecting link does not get serious until periods are reduced to less than one-half second. The pen arm then begins to slap back and forth out of control, and the connecting link is thrown off. The few tests made at periods shorter than one-half second were obtained by weighting the connecting link so that it could not so easily be dislodged.

It would appear from the parts of these curves which represent periods between 1 and 4 seconds, within which range they must most nearly conform with the theoretical curve, that the static magnification should be about 113. This value is smaller than the value computed from the dimensions of the instrument. The loss of magnification may perhaps be due to absorption of motion in the wire links which suspend the heavy masses. These wire links may very easily yield slightly in a direction perpendicular to their lengths, and so prevent all of the impressed motion from reaching the pendulum itself. More particularly would this be expected for short periods when the forces which must be transmitted by these wires are correspondingly great.

VOLCANIC CONDITIONS IN AUGUST

Activity of Halemaumau

There was no visible lava activity during August, but slides were somewhat prevalent during the last half of the month. Few slides occurred during the first half.

On the evening of August 18, there were numerous big avalanches on the north wall, culminating in a landslide at 10:47 p. m. that made a perceptible tremor at the automobile parking space 3,000 feet away, and recorded strongly on the seismographs at Uwekahuna Observatory and the main observatory (see Volcano Letter No. 191, August 23, 1928). On this evening there was a large crowd at the edge of the pit to view a pageant presented in conjunction with

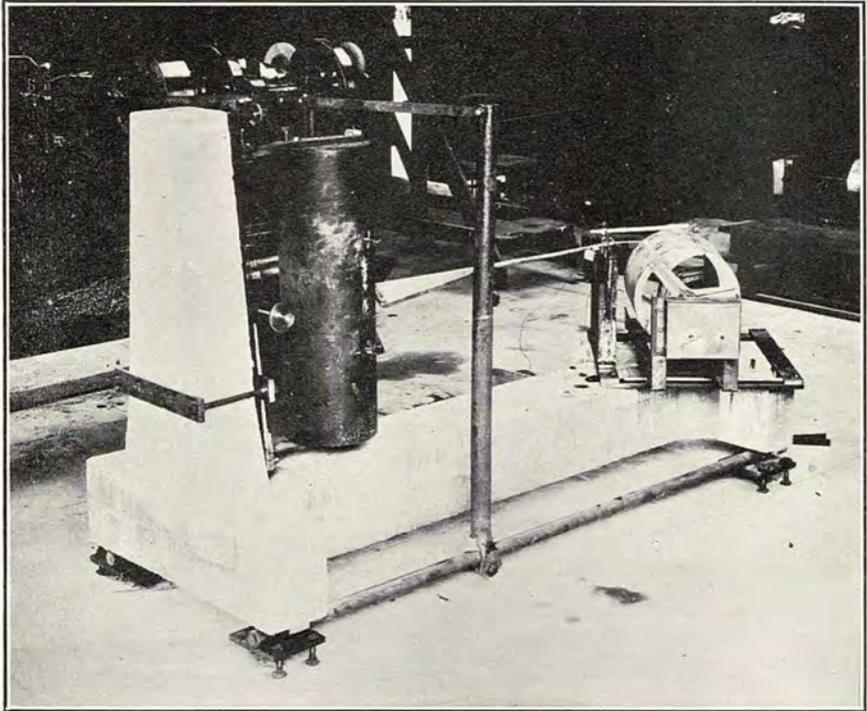


FIGURE 30. Oscillating table, with seismograph mounted upon it. In the background is the lathe chuck that oscillates it.

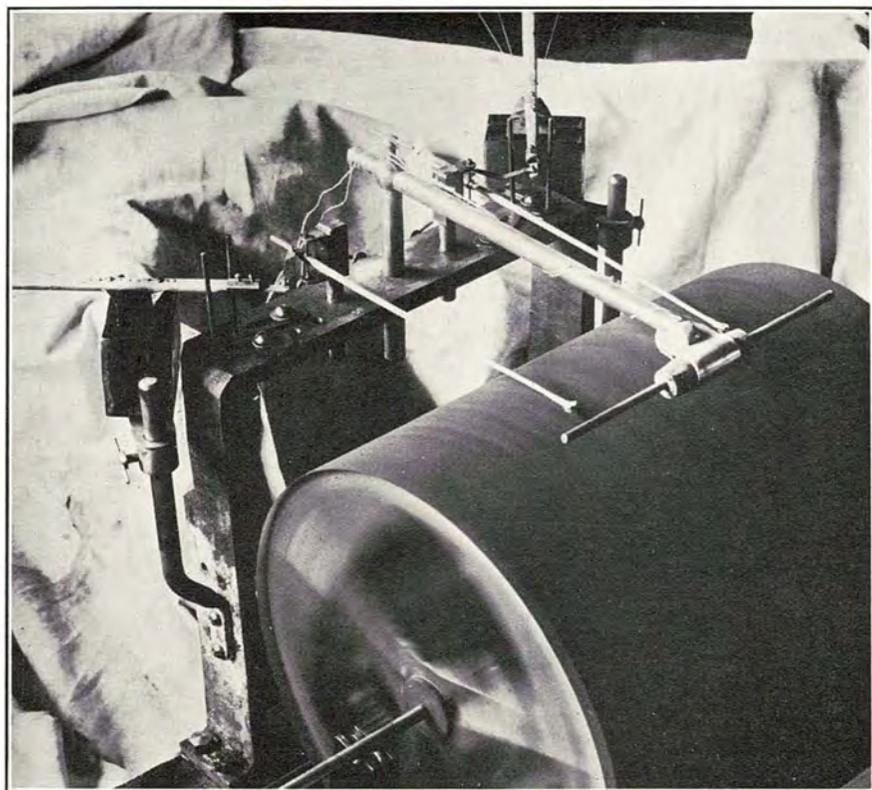


FIGURE 31. Recording system of seismograph.

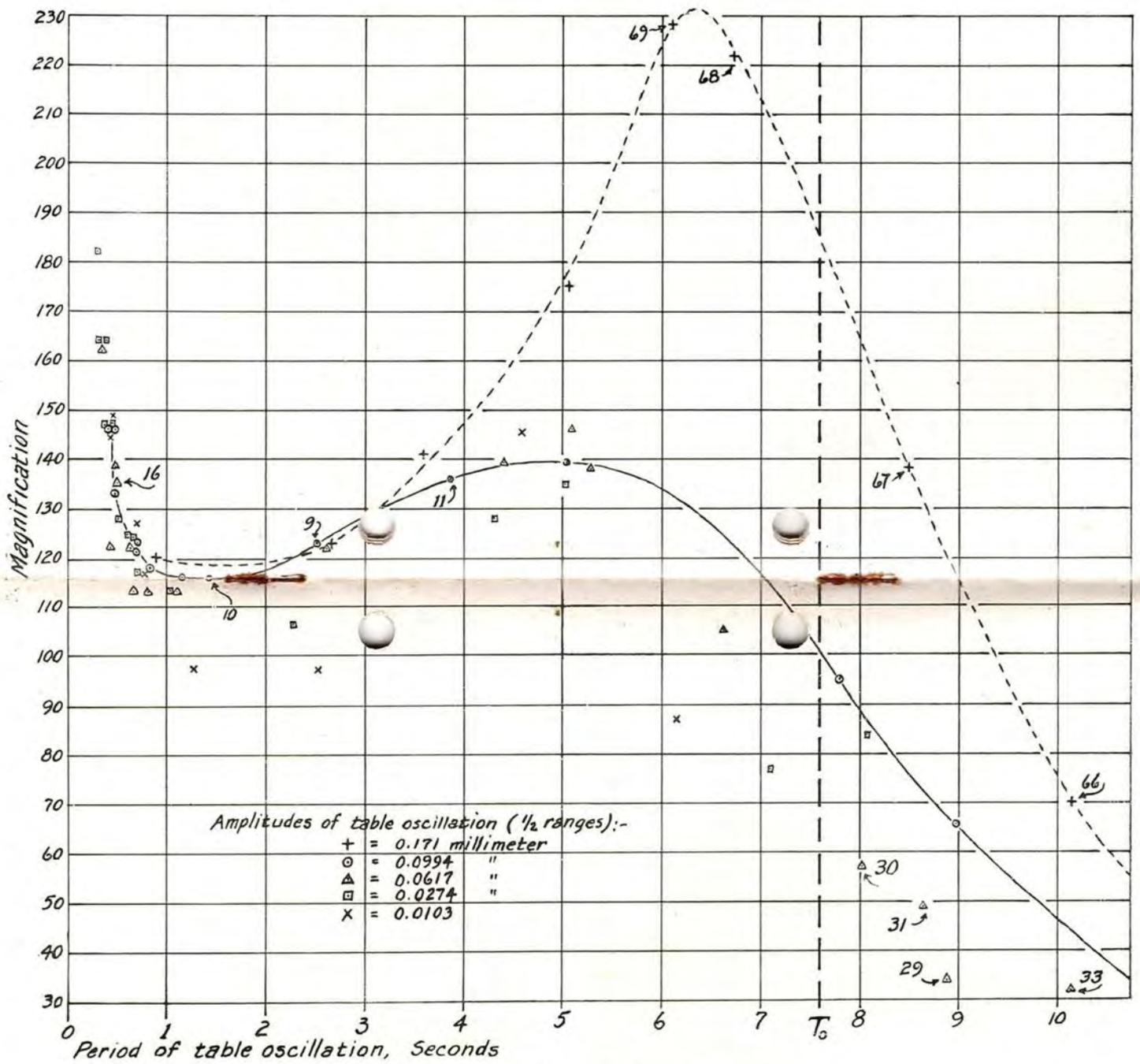


FIGURE 32. Magnification diagram.

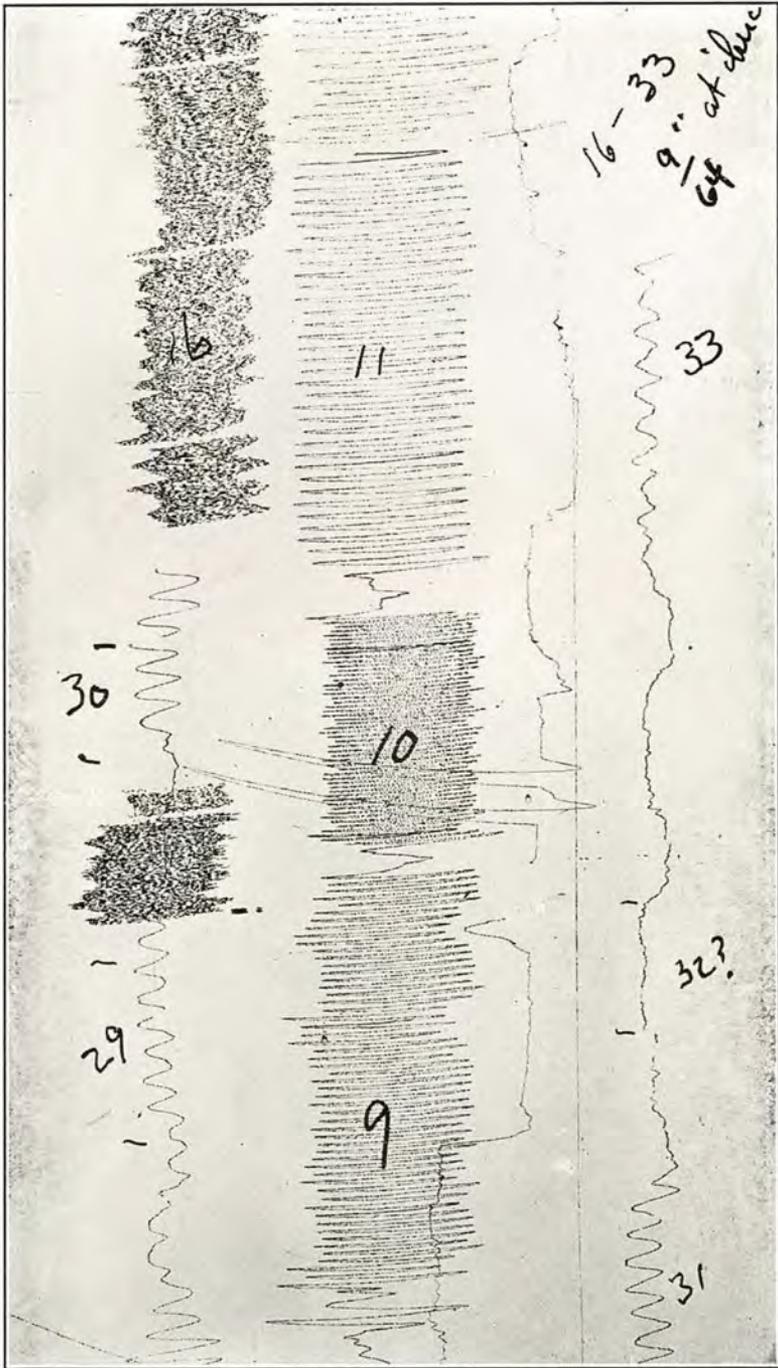


FIGURE 33. Reproduction of part of test seismogram, with test numbers.

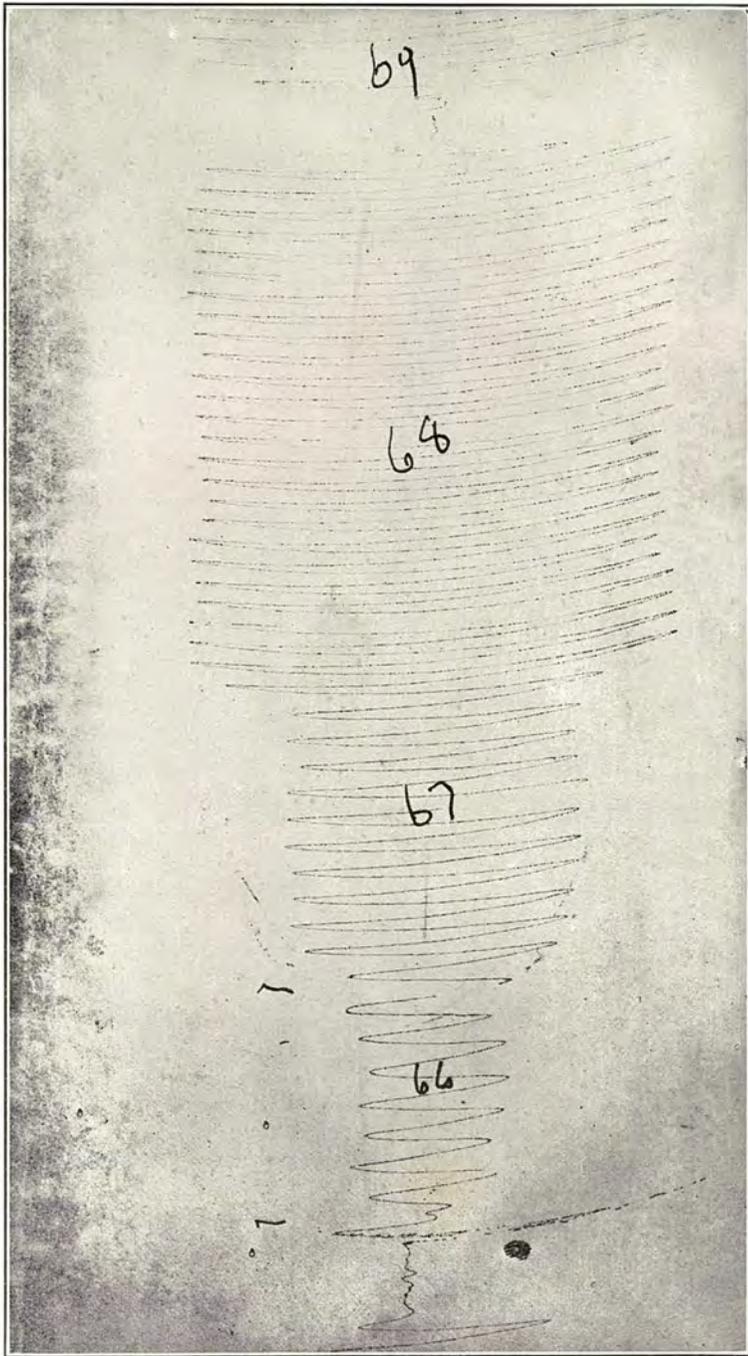


FIGURE 34. Reproduction of part of test seismogram, with test numbers.

the Cook Sesquicentennial. The rumbling avalanches and dust filled air made weird accompaniment to the exercises.

Large slides occurred nearly every day for the rest of the month. An examination of the area of active avalanching showed that the cracked ground formerly back of the north rim had all gone in and that small new cracks were numerous for several feet back. Much heat and steam were escaping from these cracks. The whole pit interior was thickly coated with dust from the slides, and so was much of the Kilauea floor in the vicinity.

The cause of this avalanching is not known, but it is suspected that the slides succeeded a fall of the invisible lava column after the summer solstice. There were similar spells of avalanching in July, 1927, following the cessation of lava activity in the pit, and in January, 1928, when a heavy landslide from the northwest wall squeezed up remnant liquid lava by crustal pressure.

JOURNAL, AUGUST, 1928

August 1. No changes, except N. wall has fresh surfacings. No sounds except one or two faint noises of stones sliding (9:30 a. m.). Saw fresh cracks by S. station.

There are still numerous patches of the buff colored 1924 ash on the S. crater floor.

August 4. At 10 a. m. a very few light slides heard occasionally. No noteworthy changes, however.

August 5. No changes seen.

August 6. Nothing new seen at 9:40 a. m. At 12:30 p. m. there was dust NE. from an avalanche.

August 8. One or two slides occurred at N. corner at 10 a. m. At 10:15 there was a noisy avalanche N. making dust. At 2:44:30 p. m. an avalanche on the NE. wall caused dust to hang in the air for three minutes.

August 9. Much dust N. at 2:40 p. m.

August 11. New debris lies atop S. talus. Almost no steam activity in Halemaumau. Thin dust at N. corner at 3:15 p. m.

August 13. All still at 9:50 a. m.; no changes. Buried boards of a destroyed structure still in place at SE. rim.

August 15. A small slide fell from NE. rim at 9:15 a. m. No changes noted. Thin dust rose N. at 1:40 p. m.

August 18. At 9:50 a. m. a few rocks fell N. That wall and talus have the appearance of having had many small slides. Just now a light fall of stones NE. Two large boulders lay balanced on north end of the big sill, close together. Remarkable that they stay in such a precarious position.

The pageant to Pele presented by the side of Halemaumau in connection with the Cook Sesquicentennial, from 9:30 to 11 p. m., was accompanied by almost constant avalanching from the north wall.

August 19. At 8:50 a. m. there was a big cloud of avalanche dust. Report of others occurring about 6:30. At 9:20 a. m. dust was continuous. Air very dusty at pit at 12 noon. N. wall working steadily, and is coated gray (usually red) from high slides.

Walked to NNE. rim. The gray debris is from N. rim. Red debris slides down niche at end of sill. Appears as though the ledge N. is the origin of all present activity. Dust everywhere.

August 20. At 8 a. m. red dust rose N. and drifted E.

Park Ranger at pit at 10 a. m., reports perceptible avalanche tremor occurring at 10:29:42 a. m. Noted fresh surface cracks 75 feet from N. rim. Another sizable avalanche occurred at 11:10:45 a. m., and small slides were almost constant.

August 21. All quiet at 9:50 a. m. One small slide N.

On N. side of pit all of cracked area has gone in except a small section, which appears ready to fall. Many new cracks. Some emitting steam; others

are not steaming, but the rocks are very hot—first noticed heat through canvas shoes.

August 23. At 3:40 p. m. salmon colored dust was rising N. rather steadily. Dust from slides also noticed this morning.

August 24. At 10:15 a. m. there was a very large, red dust cloud from N. wall. At 11 a. m., at the pit, slides N. were more or less constant. At 12:10 p. m. there was more avalanche dust. Dust at intervals during the afternoon showed that N. wall was quite restless.

August 29. From 9:00 to 9:15 a. m. the pit was quiet, but very dusty. One or two slides were heard on N. wall. Streak of a boulder was seen down S. talus. Hardly any steam; most conspicuous SSE.

A little gray dust N. was seen yesterday morning from the Observatory.

August 30. 1:10 p. m. Thin dust fills NW. half of pit. Some also seen this morning. Thin dust NW. seen at various times all the afternoon.

August 31. Pit quiet at 9:45 a. m. Much new debris streaks the N. talus. One slide N. at 10:15 a. m. making gray dust just as seen yesterday. Noticed chlorine odor NNE. N. rim cracks may have widened but am not sure. They are very fresh looking. Slide N. at 11:07 a. m.; at 11:12 another.

Dust from an avalanche seen at 4:20 p. m., and also one previously. Dust seen also at 5:45 p. m.

SEISMOMETRIC RECORD

There were 46 local earthquakes and two teleseisms recorded on the Observatory seismographs during the month ended at midnight August 31, 1928. These and other phenomena are listed below. The time used is Hawaiian Standard (time meridian is 157° 30' W.), which is 10 hours and 30 minutes slower than Greenwich Time.

The greater number of the very feeble local shocks counted in the list make such minute records that the character of the disturbance is not always apparent. Some are true earthquakes; others are perhaps the parts of greater amplitude of a continuous or protracted tremor, which at other times may be too feeble to record; some seem to be records of vibrations set up by avalanches in the pit of Halemaumau.

Abbreviations used below are as follows: vf, very feeble; f, feeble; s, slight; m, moderate; d, instruments dismantled; fl, felt locally; Δ, indicated distance in miles; *, continuous tremor.

Local Earthquakes

August	August	August
2 9:16 p.m. vf.	8 12:05-12:07 p.m. vf. *	18 10:32 p.m. vf.
3 8:10 a.m. vf.	12:35 p.m. vf.	10:47 p.m. f.
3:47 p.m. vf.	1:56 p.m. vf.	21 1:10 p.m. vf.
4 2:14 p.m. vf.	2:27 p.m. vf.	22 5:21 a.m. vf.
3:40 p.m. vf.	3:17 p.m. vf.	4:04 p.m. vf.
5:25 p.m. vf.	4:02 p.m. vf.	24 2:40 a.m. vf.
5 1:11 a.m. vf.	9 12:13 a.m. vf.	10:10 a.m. vf.
6:06 a.m. vf.	10 2:40 a.m. vf.	3:54 p.m. vf.
6 1:36 a.m. vf.	11 12:51 p.m. vf.	25 11:07 a.m. vf.
7 10:30 a.m. vf.	1:33 p.m. vf.	26 1:04 p.m. vf.
11:24 a.m. vf.	12 12:22 p.m. vf.	28 1:51 p.m. vf.
7:50 p.m. f. fl. Δ 16	17 10:55 a.m. vf.	3:07 p.m. vf.
8 9:17 a.m. vf.	4:40 p.m. vf.	30 11:04 p.m. f. Δ 14.
10:50 a.m. vf.	18 9:41 p.m. vf.	31 12:26 a.m. vf.
10:59 a.m. vf.	10:30 p.m. vf.	9:04 p.m. vf.
	10:31 p.m. vf.	

Teleseisms

August 4
iP 8:05:42 a.m. Very feeble record.

August 24
eP 11:23:00 a.m. Distance 2,800 miles.
S? 11:29:13 "
S? 11:30:25 "
L 11:34:20 "

Harmonic Tremor

This type of movement was absent throughout the month.

Microseismic Motion

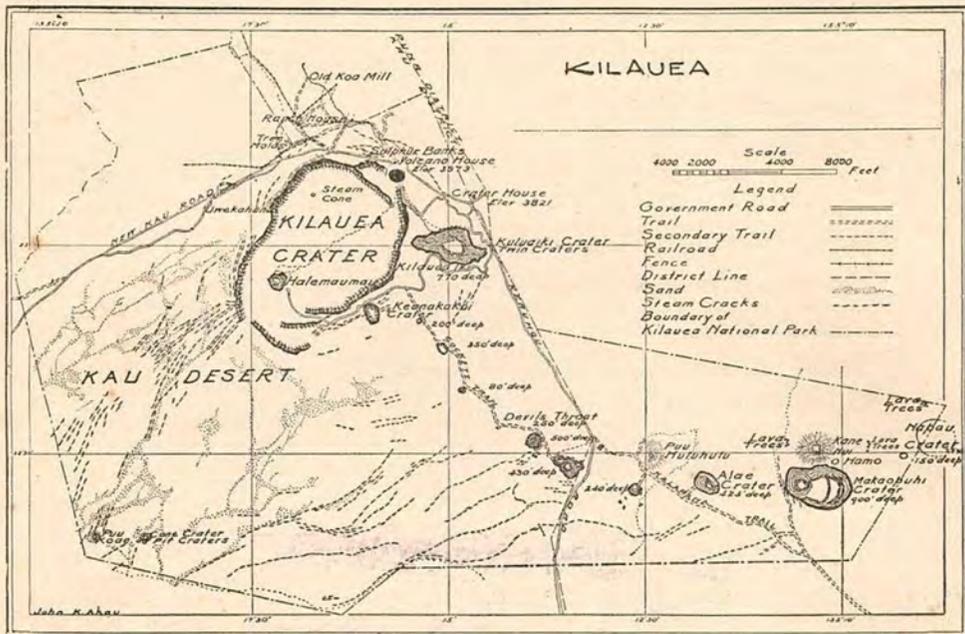
Microseisms were normal throughout the month.

Tilting of the Ground

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

August	1-7	0.2	second	NW.
"	8-14	0.4	"	N.
"	15-21	0.0		
"	22-28	0.9	"	NW.
"	29-Sept. 4	0.3	"	E.

R. M. WILSON,
Topographic Engineer.



Black spot shows location of Observatory.

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HONOLULU, HAWAII, SEPTEMBER, 1928

No. 9

CONTENTS

MAGNETISM OF CINDER CONE LAVA FLOWS,
LASSEN VOLCANIC NATIONAL PARK,

By Austin E. Jones, Assistant at Lassen
and Alaskan stations.

VOLCANIC CONDITIONS IN SEPTEMBER

Activity of Halemaumau

JOURNAL OF SEPTEMBER, 1928

Illustrations

SEISMOMETRIC RECORD

Local Earthquakes and Tremors
Teleseisms
Harmonic Tremor
Microseismic Motion
Tilting of the Ground

MAP AND STATION DATA

MAGNETISM OF CINDER CONE LAVA FLOWS,
LASSEN VOLCANIC NATIONAL PARK

By Austin E. Jones

In 1927, while assisting R. H. Finch at Lassen Volcano and vicinity, in California, the writer made a trip into the Cinder Cone lava beds with the object of applying Chevallier's magnetic method to them so as to determine their age. The trip was a success in that the compass showed differences of magnetic declination in the various flows. As the trip was a three-day back-packing affair no really accurate work was accomplished, beyond showing that actual magnetic differences exist, and that the flows might be very roughly dated from the findings.

The argument is that lava in solidifying retains the magnetic orientation of its iron oxides. M. Chevallier (*Annales de Physique*, July-August, 1925), describes his method of making a study of the magnetic declination of Sicily from about the year 1,000 A. D. to the present. He used the dated historical lava flows in the Mt. Etna region and found consistent difference of magnetic declination of the rock in place. He also found that the declination of the compass had varied from 18° west through true north to 18° east for different dates, and back again (Fig. 37).

Magnetic observations taken over a period of years anywhere on the earth show a slow continuous change of the compass needle. Chevallier's observations are valuable in that they show that this change is periodic, repeating itself in about 720 years (Fig. 37).

Such observations have been kept in London for 300 years and agree with Chevallier's observations in being periodic in character and taking about the same number of centuries for a complete change. The differences are:

1. The total change in declination is greater for London, being 35° for a partial period, while the Mt. Etna total change is 36°.

2. The London curve does not have zero degrees as its axis of symmetry, while the Mt. Etna curve does.

3. The peaks and valleys of the two curves do not agree in the decades.

Redding, California, is the nearest magnetic station of the Coast Survey to Lassen National Park. The most accurate mathematical analysis of the Redding, California, curve gives a maximum declination of about N. 21° E., while a less accurate one gives a maximum of about N. 27° E., both having an axis of symmetry about N. 15.5° E. and both crossing this within reasonable limits of 1810 A. D. The formula is:

$$\text{Declination to E.} = 15.6 + 11.57 \sin \left(\frac{\text{date} - 1810}{2} \right)$$

If declination values are found in this region which are greater than N. 27° E. or less than N. 4° E., this curve would not apply. Since the greatest declination was less than N. 24° E., the solid lines sketched in as approximate curves will give values as close as it is possible to give them at present (Figs. 37 and 38).

The numbers one to seven (used in Figs. 35 to 38 and in the table) represent the locations of the tests made, one being on the top flow and seven being the lowest flow.

The short curve for Cinder Cone is plotted from data published by the U. S. Coast and Geodetic Survey and is accurate. From the data furnished by location one in the table we find that it corresponds to the date of 1846. This date is of considerable interest as Dr. Harkness published in the California Academy of Sciences proceedings in 1874 a note stating that there was activity at Cinder Cone in 1851.

The method of taking the data is as follows: A location is chosen which seems least under the influence of the other flows. A line, whose true bearing is known, either from sun or north star observations, is marked. Along this line at intervals the compass is read giving the declination of the underlying lava. The reason for a number of readings at short intervals of five or six feet is that an average of readings should compensate for both the local attraction of small magnetic pockets and for errors caused by shifted blocks of lava. The declination values of locations one to seven were found by such a method and the averages are tabulated, with the number of readings from which the average was determined, and whether the readings were made by the transit compass or the Brunton pocket compass.

In locating the year corresponding to the declination the top flow was taken first (Fig. 37). One is located just before 1850. The only other values it could have (Fig. 38) are 1440, 1100, 715, or 390 A. D. These latter dates are ruled out, for this flow is so fresh that no trees grow on it.

Locating the declination value of position two in Figure 38 we find its age corresponds to 1800 A. D. This difference in declination may be real or caused by errors or by the influence of nearby lava flows whose declination is less than N. 15° E. The same may be said of numbers four and five. In this manner the different flows are located as closely as is possible on the variation curve of Figure 38, considering their geologic position in Figure 36. The following is a tabulation of these values:

**TABLE OF DECLINATION VALUES OBSERVED ON CINDER CONE
LAVA FLOWS**

Map Location	Number of Observations	Declination	Corresponding Date	Remarks
1	4t 13e	N. 16.7 E.	1846	Youngest flow, fresh black surface.
2	8t	N. 15.0 E.	1800	May be same as above.
3	5t	N. 22.5 E.	1350	Insufficient data, probably more than one flow.
4	14t	N. 18.8 E.	1130	Sand covered flow.
5	10e	N. 17.9 E.	1120	Probably same as above.
6	10t	N. 21.6 E.	650	Next to bottom flow.
7	8t	N. 23.8 E.	600 500	Bottom flow.

t=transit; e=Brunton compass.

VOLCANIC CONDITIONS IN SEPTEMBER

Activity of Halemaumau

There were slight changes in wall and bottom conditions during the month. An accumulation of white salt coatings was noticed on September 15. These were washed away by rains of the next few days. The heavy dust coatings on the walls and floor, caused by the avalanches of August 18, were partly washed away. Rim crack measurements showed no noteworthy changes.

The single component seismograph formerly at Kealakekua, on the west side of the island, was installed on the Kilauea crater floor in order to study seismic conditions near Halemaumau as compared with registrations at the main observatory on the northeast rim of Kilauea, and at the Uwekahuna Observatory, on the northwest rim.

JOURNAL, SEPTEMBER, 1928

September 5. New debris shows on N. talus in contrast to dust coatings elsewhere. A small rockfall N. just now (9:25 a.m.). Scattered new salt coatings on N. wall. No other changes.

Preparations begun on this day for installation of the old Kona seismograph on the crater floor about 450 feet back from the SE. rim of Halemaumau.

September 6. Avalanche dust seen NW. at 8:30 a.m.

September 10. Measured E. cracks at 10:15 a.m.

N. wall quiet. Red surface is clear of dust and salts, probably washed by recent rains. NNE. wall has prominent rills not heretofore noticed; appear to be effect of recent erosion.

One small slide broke from niche just over sill and above N. talus peak at 10:48 a.m.

September 12. 10:10 a. m. Light rain and moderate NE. wind. No changes seen. Rainbow across pit bottom.

September 13. Dust rose from N. corner of pit at 4:30 p. m.

September 15. There are fresh coatings of white salts on the pit walls, the most prominent being on the reddish N. wall. N. talus is speckled with new white and red debris.

Yellow stained areas of pit floor are again showing, as dust coatings become washed away.

September 17. At 9:45 a. m. all was very quiet and still at Halemaumau. N. wall still has very conspicuous coatings of white salts.

Heard peculiar whirring sound accompanying a very light fall SW. at 9:55 a.m. Must be echoing of a slide inside tunnels. A light fall of stones N. at 10:05 a.m.

An avalanche at 12:45 p. m. made considerable roar. (From Halemaumau seismograph station.)

September 19. A light steady rain at Halemaumau, and steam vents are all mildly active. White salts of N. wall have gone. Dry cracks on the pit floor must be very hot. Red and gray wall colorings are very conspicuous.

September 26. No changes noted at 10:30 a.m., and conditions all very quiet.

SEISMOMETRIC RECORD

There were 88 local earthquakes and two teleseisms recorded on the Observatory seismographs during the month ended at midnight September 30, 1928. These and other phenomena are listed below. The time used is Hawaiian Standard (time meridian is 157° 30' W.), which is 10 hours and 30 minutes slower than Greenwich Time.

The greater number of the very feeble local shocks counted in the list make such minute records that the character of the disturbance is not always apparent. Some are true earthquakes; others are perhaps the parts of greater amplitude of a continuous or protracted tremor, which at other times may be too feeble to record; some seem to be records of vibrations set up by avalanches in the pit of Halemaumau.

Abbreviations used below are as follows: vf, very feeble; f, feeble; s, slight; m, moderate; d, instruments dismantled; fl, felt locally; Δ, indicated distance in miles; *, continuous tremors.

Local Earthquakes

September	September	September
1 5:55 a.m. vf.	14 8:55 a.m. vf.	23 12:34 p.m. vf.
4 8:57 a.m. vf.	9:08 a.m. vf.	5:34 p.m. vf.
11:21 a.m. vf.	9:46 a.m. vf.	24 6:31 a.m. vf.
8:31 p.m. vf. Δ 22.	9:48 a.m. vf.	10:06 a.m. vf.
5 12:01 p.m. vf.	10:14 a.m. vf.	12:47 p.m. vf.
6 1:01 p.m. vf.	10:41 a.m. vf.	1:41 p.m. vf.
8:58 p.m. vf.	1:42 p.m. vf.	25 2:15 a.m. vf.
7 1:33 p.m. vf.	1:44 p.m. vf.	10:00 a.m. vf.
1:54 p.m. vf.	15 5:53 a.m. vf.	10:06 a.m. vf.
3:30 p.m. vf.	12:56 p.m. vf.	10:10 a.m. vf.
8 7:15 a.m. vf.	16 3:31 a.m. vf.	10:11 a.m. vf.
2:13 p.m. vf.	12:46 p.m. vf.	10:59 a.m. vf.
11:58 p.m. vf. Δ 22.	12:47 p.m. vf.	12:17 p.m. vf.
9 3:53 a.m. vf.	4:23 p.m. vf.	1:35 p.m. vf.
6:06 a.m. vf.	6:10 p.m. vf.	26 5:41 a.m. vf.
1:13 p.m. vf.	7:11 p.m. vf.	10:19 a.m. vf.
3:16 p.m. vf.	17 1:19 a.m. vf.	10:51 a.m. vf.
10 11:16 a.m. vf.	6:22 a.m. vf.	12:52 p.m. vf.
1:34 p.m. vf.	19 3:53 p.m. vf.	1:10 p.m. vf.
1:49 p.m. vf.	20 9:11 a.m. vf.	1:58 p.m. vf.
3:22 p.m. vf.	9:15 a.m. vf.	27 12:44 p.m. vf.
5:03 p.m. vf.	9:36 a.m. vf.	2:33 p.m. vf.
7:45 p.m. vf.	10:02 a.m. f. Δ 25.	28 10:40 p.m. vf.
11 2:48 a.m. vf.	11:58 a.m. vf.	29 2:43 p.m. vf.
3:06 a.m. vf.	12:36 p.m. vf.	7:28 p.m. vf.
9:22 a.m. vf.	21 11:31 a.m. vf.	9:06 p.m. vf.
9:55 a.m. vf.	2:09 p.m. vf.	
7:27 p.m. f. Δ 14.	22 2:32 a.m. vf.	30 12:25 p.m. vf.
13 9:50 p.m. vf.	5:39 a.m. vf.	2:33 p.m. vf.
9:52 p.m. vf.	10:59 p.m. vf.	

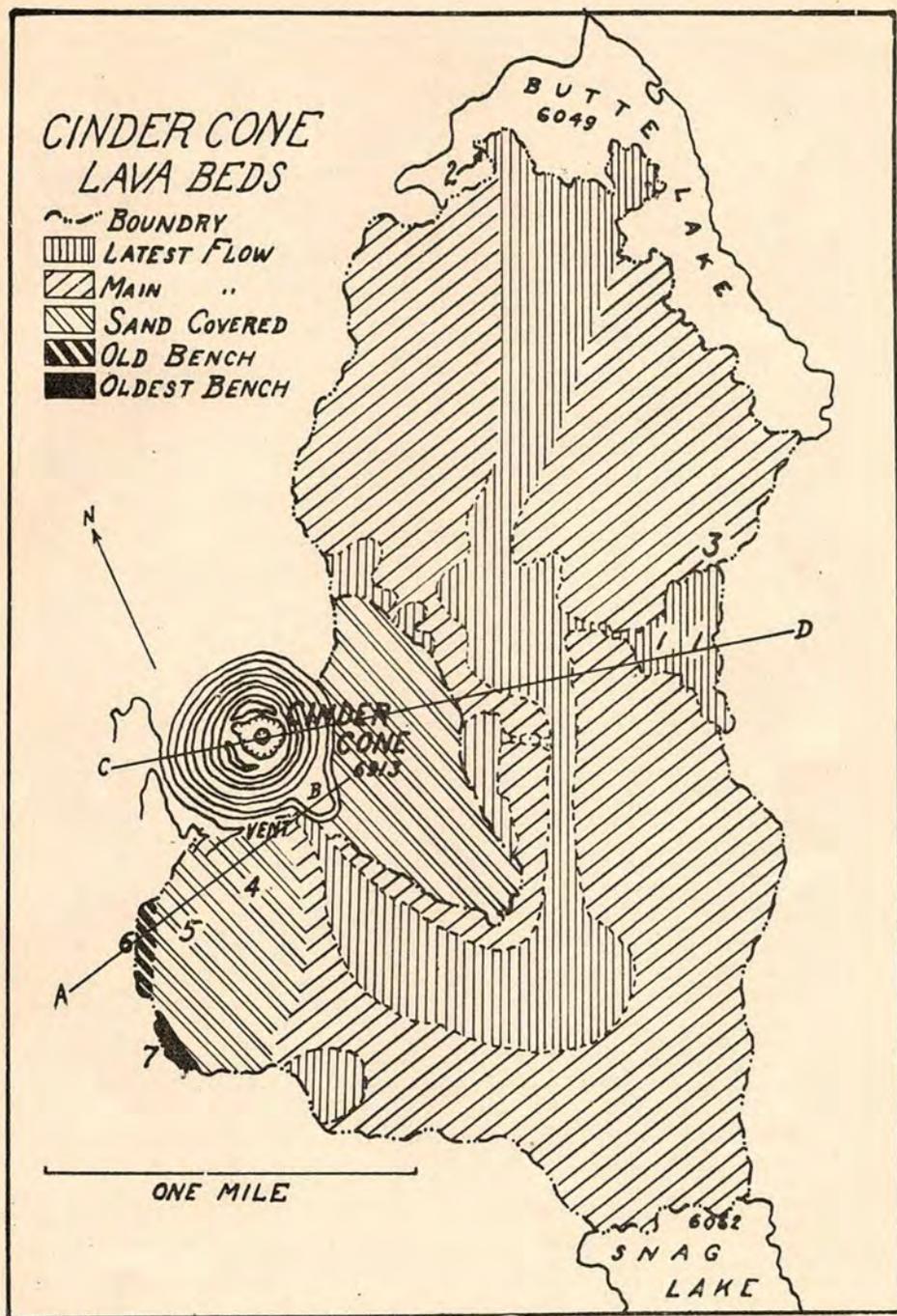
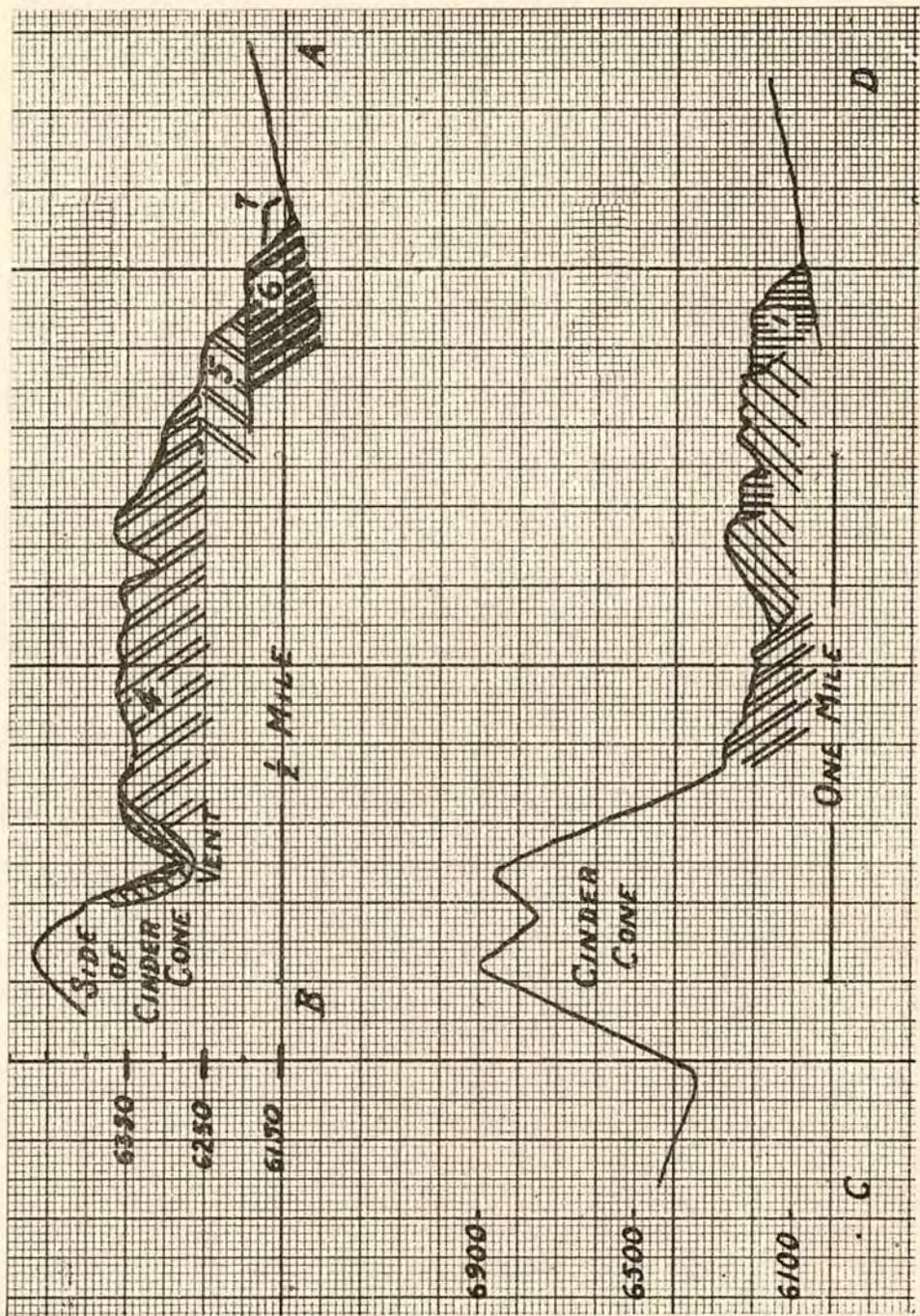


FIGURE 35. Cinder Cone lava beds, Lassen Volcanic National Park, California.



URE. 36. Cross section of Lassen Cinder Co

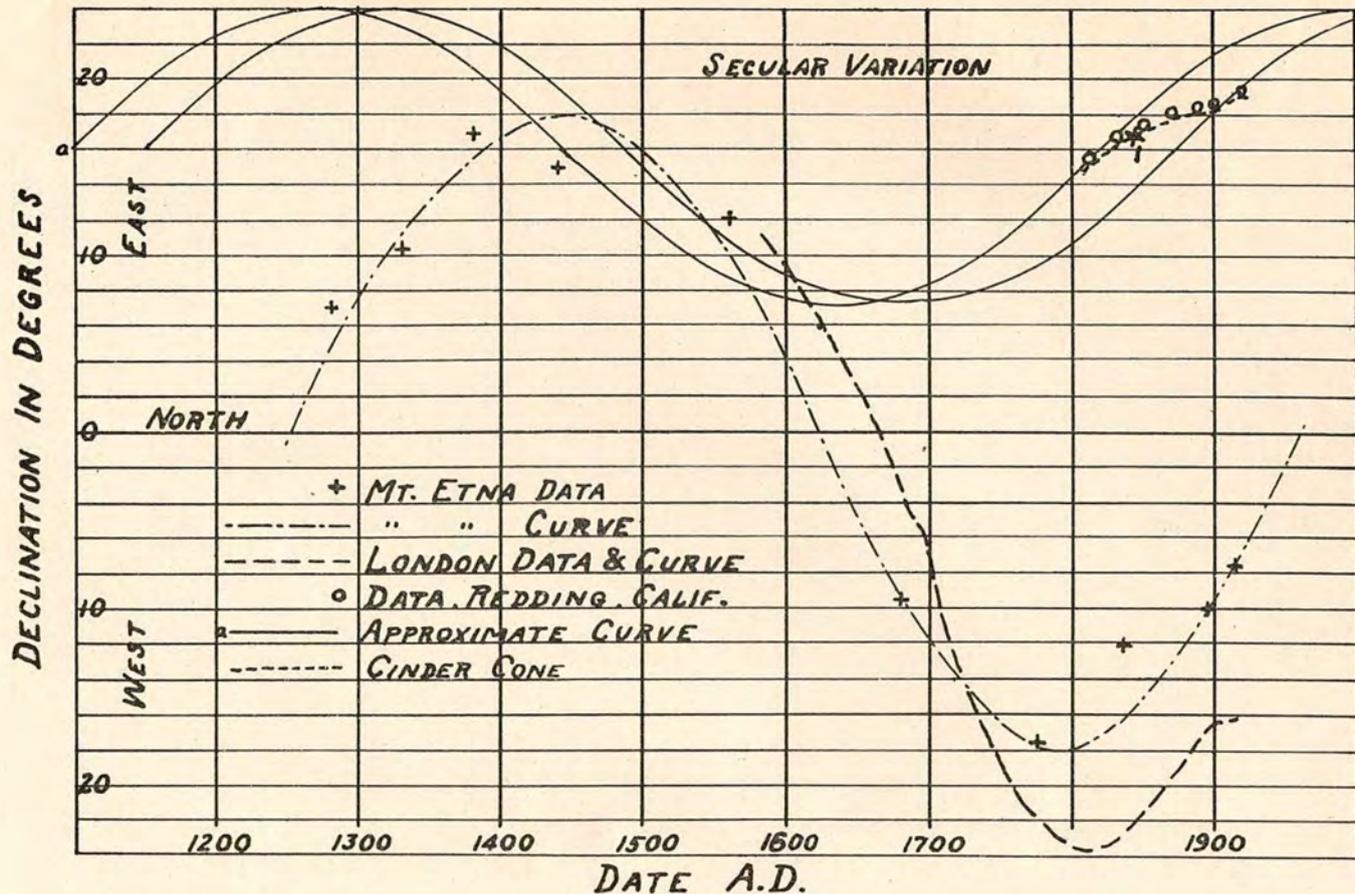


FIGURE 37. Secular Variation of Magnetic Declination in Sicily, England and California. (Solid lines are two different approximations for Redding, California.)

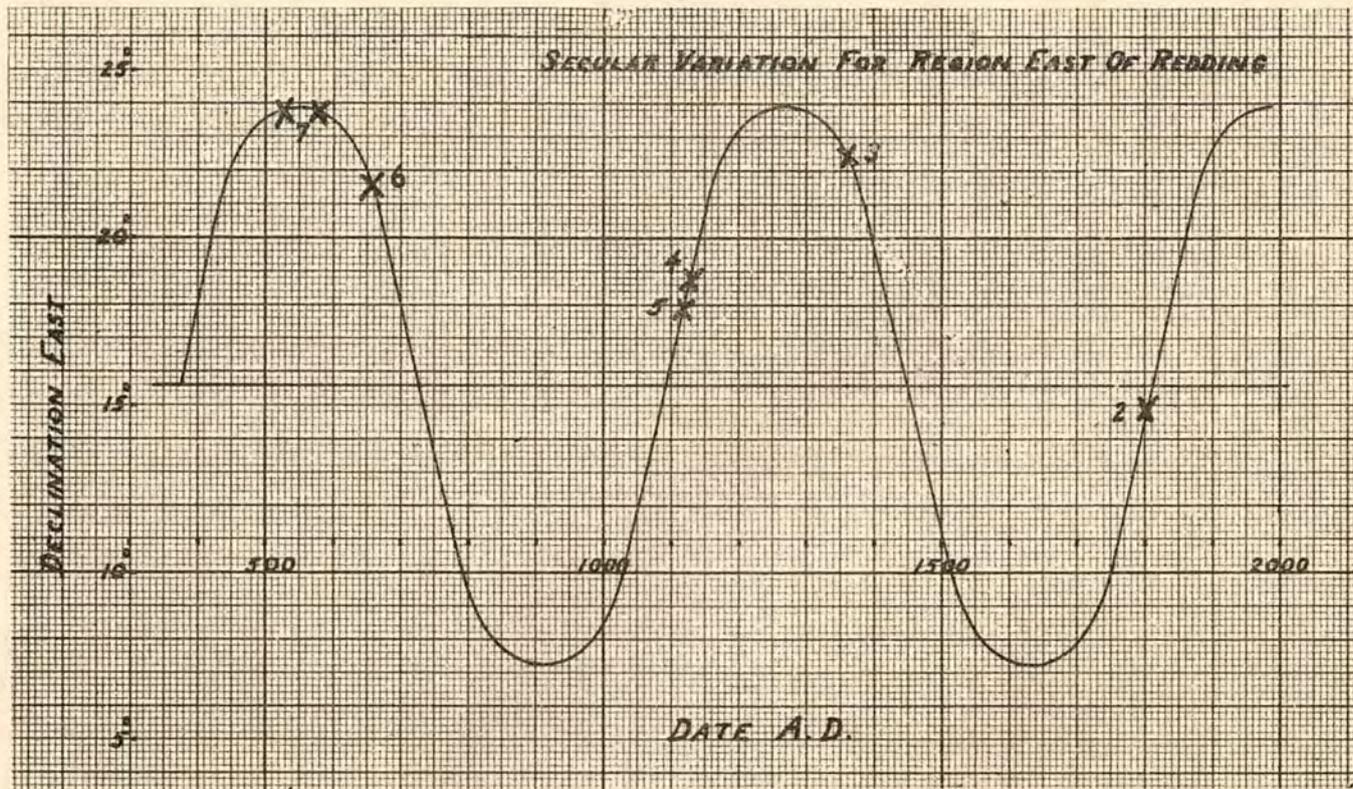


FIGURE 38. Secular variation for region east of Redding, California, (numbers refer to progressively older lava flows Figure 36).

Teleseisms

September 11

S or L 2:20:06 a.m. Very feeble record.

September 21

P 9:17:53 p.m.
S 9:21:56 " Distance 3,150 miles.
L 9:24:46 "

Harmonic Tremor

This type of movement was absent throughout the month.

Microseismic Motion

Microseisms were stronger than normal on the 4th and 5th; unusually feeble on the 29th and 30th. They were normal for other parts of the month.

Tilting of the Ground

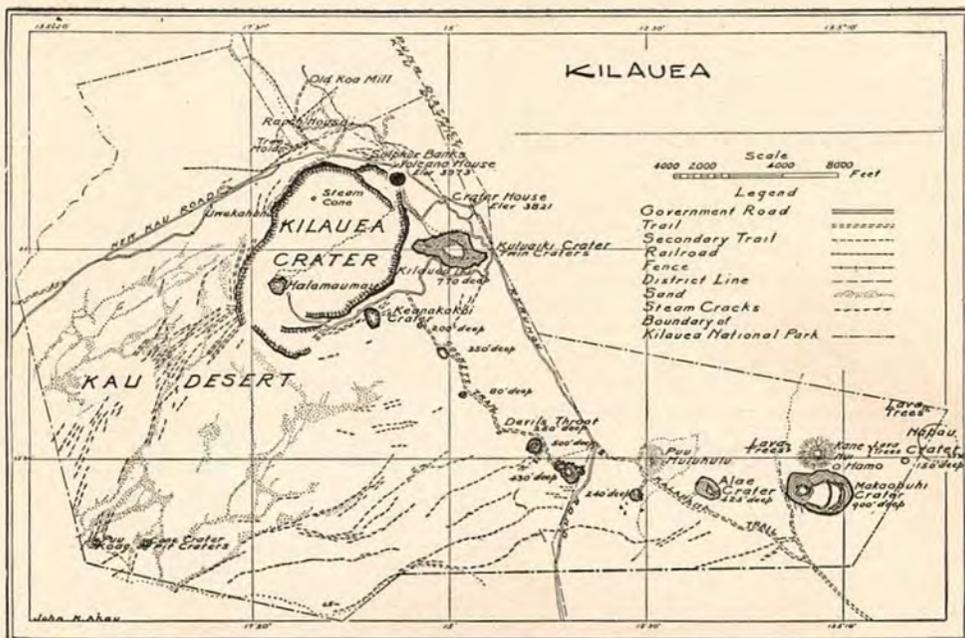
By weeks this movement was as follows, expressed as angular change and direction of motion of the plumb line:

August 29-September 4	0.3	second	E.
September 5-11	1.5	"	SW.
" 12-18	0.9	"	N.
" 19-25	0.6	"	SSE.
" 26-October 1	0.9	"	ENE.

The very feeble earthquake noted in the above list at 8:31 p. m. on September 4 was a perceptible shock in Kona on the west side of the island.

The seismographs at the Hawaiian Volcano Observatory, upon which the above listed earthquakes are being recorded, were overhauled on September 8. The period was left unchanged, but the damping ratio was reduced from aperiodicity to about 10:1. New magnifying levers and writing styluses of the same dimensions as the old ones were installed, and the guy wires of the booms were tightened. As a result, the sensitivity of the instruments has been increased so that teleseisms are more plainly recorded. A very rapid continuous tremor has been brought out, which is probably due to the engine of an electric light plant distant about 200 yards from the Observatory. The new pens also show numerous very small short-period tremors of short duration, probably due to local non-seismic causes, as they appear only during daytime hours.

R. M. WILSON,
Topographic Engineer.



Black spot shows location of Observatory.

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CONTENTS

THE ALEUTIAN GEOGRAPHIC OBSERVATORY

By T. A. Jaggard

VOLCANIC CONDITIONS IN OCTOBER

Activity of Halemaumau and General Notes

JOURNAL OCTOBER, 1928

Illustrations

SEISMOMETRIC RECORD

Local Earthquakes and Tremors

Teleseism

Harmonic Tremor

Microseismic Motion

Tilting of the Ground

MAP AND STATION DATA

THE ALEUTIAN GEOGRAPHIC OBSERVATORY

By T. A. Jaggard

Address endorsed by Seattle Chamber of Commerce, September, 1928

The Modern Meaning of Exploration

The ancient mariners, Captain Cook and Bering and Magellan, made discovery in geography that roughly mapped the world. Some Arctic explorers have complained, "There is nothing left to discover." Such an attitude means misapprehension of the word "discovery."

Manhattan Island and the Hudson River were "discovered" (uncovered, brought out of darkness) perhaps by Hendrik Hudson, but both have been explored in detail a thousand times since.

New York has had "uncovered" its potencies as a harbor, a center of transportation, a commercial mart, an airplane base, a goal of inland waterways, and

a strategic nucleus in war, until it has accumulated men and women to the point of suffocation.

The discovery of the world has only barely begun. Millions of square miles of mountains, rivers, plains and deserts have never been trodden by civilized men. Untold millions of square miles of the sea bottom, about 72 per cent of the surface of the earth, have never yielded a sounding or a rock specimen.

Each new invention, like the airplane, the modern oil well, or the Diesel engine, makes possible explorations never dreamed of before. Our great wheat and beef belts have been discovered by means of the railroad, the automobile, the wire fence, the experiment station and the machine harvester.

The State of Arizona, supposed to be a desert, has been "discovered" in the last 25 years to be one of the garden spots of the earth. The one-time cowboy State of Montana has "discovered" itself to be an agricultural land of wheat and sugar.

Thoroughness is the characteristic of modern science. "Unexplored" is a purely relative term. "Prospecting" has generally been done by haphazard grubbing.

Contrast is great between the writer's experience in cruising through the Aleutian Islands in a sailing schooner in 1907, on an expedition from the Massachusetts Institute of Technology, and a similar trip he made for the United States Geological Survey in 1927.

The advent of salmon canneries, of the Diesel engine for 60-foot boats, and of radio communication, have facilitated exploration immeasurably. On both journeys he was seeking experience of the great Aleutian volcanos.

Volcano observation is a logical central interest for geographic work in the Aleutian chain. The volcanoes are everywhere landmarks, are centers of thronging life on sea and land, and are connected with the profoundest problems of geology, ore deposits, climate, coal and oil. They are topographic features of first importance to the map maker, whether he be charting the sea bottom or sketching the topography of the islands.

Geophysics, or earth physics, is a group of rather new sciences, dealing with changes measurable in earth, air and water; land, atmosphere and sea.

Geophysics differs entirely from geology. Geology is the science of dead rocks, fossils and soils, and how they came to be where they are. Geophysics is the science of how much energy, force, motion is passing through the rocks, the air, or the sea. By the measurements of geophysics we can estimate what forces made the rocks what they are.

Some of the geophysical sciences are seismology, volcanology, fluviology (rivers), glaciology (glaciers), limnology (shorelines), oceanology, meteorology, terrestrial gravity and magnetism, and eodesy (earth measurement).

There are still other sciences growing up dealing with measurement of the movements of soils, lakes, uplift of mountains, and loose materials in the desert.

In like manner there is a live science of geochemistry, which treats of the chemical activities of land, water, and air. This again means not merely analysis of rocks and water, but the changes which are going on chemically and may be measured with instruments.

For all things are changing, second to second, hour to hour. It is this element of physical or chemical change which demands measurement stations fixed at one carefully chosen place.

Proposed Aleutian Geographic Observatory

The foregoing will show what advantages would be possessed by a natural history observatory in the Aleutian Islands as a fixed home for mapping and exploring the processes of some hundred thousand square miles of unknown American lands and sea bottoms, where today the charts are derived from old Russian maps made a hundred years ago.

This observatory will investigate mysteries of the stormy lands, often shrouded in fog, where there are at least 60 unknown harbors, 40 unknown volcanoes, and resources in mineral, fish and fur and opportunities for navigation and travel.

In cooperation with the observatory, scientific vessels will explore 5,000 miles of American shore line where few vessels have ever touched, home of swan and ptarmigan, seal and sea lion, sea otter and brown bear, cod and halibut and herring, of great eagles that prey on the young of red, white and blue foxes, and of a race of men, the Aleuts, whose origin is still a mystery.

The Aleutian Arc

It is a land which trends in a nearly perfect circular arc on the face of the globe for 1,600 miles, with Bering Sea and the Pacific on opposite sides, shallowest and deepest of oceans.

Here there are unmapped ocean currents and tides, creating an extraordinary climate only imperfectly known, with tide rips and fogs and gales of wind, along shores which are rising and falling through the centuries under volcanic forces.

Knowledge of these is essential in order to predict the weather for the benefit of mariners going from America to Asia.

Proposed Work and Collaboration

The new observatory will work in concert with some eight scientific bureaus of the government, seven civil offices, and two outside institutions, with a view to gathering information all the year around concerning the weather, tides, currents, magnetism, earthquakes, volcanic activity, crust upheaval, animals, plants, natives, and commercial needs.

For the summer half of the year, the observatory will help maintain expeditions to collect animals, fish and other marine organisms, plants, birds, minerals, rocks and human antiquities, and to map the lands, the geology, the depths of the sea, the air currents, and such earth activities as tremors, tiltings and changes of mean sea level.

It will explore and photograph, with the help of alpine ascents and airplanes, the great glaciers and snow fields of the volcanoes and their craters, which extend all the way from the upper end of the Alaskan Peninsula to the inland Buldir.

The Scientific Opportunity and Advantages

Here probably lies the key to the very ancient inhabitants of the linking islands that connected America with Asia. Here some of the islands are more than 50 miles long, known to contain mummies and implements and ancient burial places, and on many parts of their surfaces no man has ever set foot.

On the Peninsula are the greatest volcanic craters on earth, and along the chain are unknown deposits, hot and cold, of sulphur and sulphides, and solfataric patches of activity, making all sorts of chemical incrustations never collected or analyzed. Complete studies of these serve to throw light on the origins of ores.

Along the line of this great arc today there are gold, silver, lead, copper, zinc, sulphur, petroleum and coal, known on the Peninsula, but never even prospected in the western islands.

Here there are plants and insects and birds, seaweeds and sea animals, related to Kamchatka on the west and Alaska on the east. The distribution of these is as yet unmapped.

There are no trees, though the climate is mild and trees are abundant at both ends of the line. Grasses and flowering plants grow profusely, and already a sheep industry has been started.

Living Permanently With Nature

A geographic observatory differs from a natural history museum in this, that its object, instead of being to store and exhibit native implements, birds, lavas, and glacial boulders, is rather to live permanently with the natives and birds and volcanoes and glaciers, to watch and measure their movements, and to map and chart all changes. And it is profoundly interested in the trappers, fishermen, miners and farmers, and in fostering their progress.

Earth Observatory Not a New Idea

The terrestrial observatory, while newer in origin than the astronomical observatory or the weather stations, is not a novel, untried experiment.

Volcano and earthquake observatories, observatories of magnetism, of electric currents in earth and air, of the tides, special stations for the observation of the sun's heat, of coral growth, of glacier movement and of desert plants, are in existence as different forms of geographic observatories. And agriculture has maintained observatories or experiment stations for many years. In a sense all the great research laboratories of the industrial corporations are observatories, for, in every direction, they are compelled to experiment on the effects of time and change, wind and weather and soil, on metal, or wire, or piping or rails, exposed to the vicissitudes of a hundred different climates.

Demand for Aleutian Knowledge

A demand for studies of the Aleutian land has come from naturalists of a great international science congress held in Australia in 1923. Other expressions of the need for Aleutian research have come in various forms from the National Research Council of the United States, from the Geological Survey, from the Weather Bureau, the Carnegie Institution, the Coast Survey, and the National Geographic Society, to say nothing of the crying need for new charts voiced by all navigators in those waters.

For years the Director of the United States Coast and Geodetic Survey has pressed for an appropriation wherewith to make a permanent government station at Dutch Harbor.

New charts of the Aleutian hydrography are greatly needed, the present ones being small scale Russian surveys of nearly a century ago, with many harbors wholly unexplored and outlines wrong.

The Aleutian Geographic Observatory will aim to create a scientific meeting ground, and will work the year around in this difficult country. It will aim to help surveyors, chemists, physicists, and naturalists to make charts, collections, surveys, experiments, researches, and voyages, until the Aleutian Islands have been explored and their resources have been made known.

And beyond this, there are many years of work for the staff of the observatory itself. They will measure what geological changes are taking place on one of the most lively corners of the globe.

Continuity of Volcanic Events

To take an example of only one science, that dealing with the measurement of volcanoes, there has not been a year for the last half century when, at some point of this great arc of mountains, there was not some sort of outburst from a crater. And knowledge of this helps solve the earthquake problem in California and Japan.

Everybody is familiar with the vagaries of Bogoslof, the recurrent reports of fire on Pavlof, and the tremendous world-encircling dust explosions of Katmai. And mariners know well the glow and steam over Shishaldin, and the black smoke often vomited from Akutan Volcano, both of these close to Unimak Pass, where the steamers sail through the islands on their way to Nome.

The geographic observatory will be located near such volcanoes. Its little ship will be ready with Diesel power, on call by radio, to send men with cameras and instruments post haste, when news of an eruption arrives.

On the nearest volcano it will be keeping a log book of measurements of little earthquakes made with a delicate pendulum, of temperatures at hot springs and gas vents, of temperatures of special borings equipped with self-recording instruments, of tiltings of the crust of the earth and consequent changes of elevation. And it will make a photographic record from year to year of craters, dust clouds and lava flow, and all other changing features of an active volcanic mountain. And it will record all the great earthquakes of the Aleutian seabottom.

Main Stations, Substations and Expeditions

The writer has spent three years in exploring Aleutian mountains, and 18 years in operating a volcano observatory in Hawaii. He believes the activities of this Alaskan country can be adequately provided for by a main experiment station, placed at Dutch Harbor, to be occupied by a staff of four workers winter and summer.

This station, with instruments, will observe, record, and publish data of volcanoes, earthquakes, tides, winds, rainfall, temperature, barometric pressure, sunshine and clouds. It will be equipped with a powerful motor yacht and small boats. It will have laboratory, quarters, shop, dock, and dark room, and will keep under observation Bogoslof and Akutan volcanoes.

It will keep in radio communication with existing stations on the Aleutian arc for scientific information. And it will keep in touch by radio with its own vessel when visiting subordinate stations and expeditions.

The biggest task of the Aleutian observatory for the next 10 years will be to provide a home, a base, and a boat for the Coast Survey and the Geological Survey, in mapping the Bering Sea side of the Alaskan Peninsula and the portions of the Pacific Coast not yet mapped, and all the coasts of the islands farther west.

This mapping of the depth of the sea bottoms, and of the dangers to navigation, and of mountains, rivers, water powers, harbors, lakes, plains, and beaches, is the first requirement of all sciences. Maps are what make the islands accessible to ships, and provide base plans for the erection of settlements, and for showing distribution of rocks, plants, earthquakes or weather data.

The substations of the Aleutian Observatory will be designed for work the six months from April to September, when some one place each year will be selected for special observations in geophysics or other sciences. The places immediately contemplated are volcano stations at Akutan, Shishaldin, Pavlof and Katmai.

Three of the Dutch Harbor staff, assisted by imported workers, will move to a substation for intensive summer work on the volcano in question, making collections, setting up a seismograph and weather instruments, photographing the crater, and keeping a journal of minor activities.

With them may be placed an alpine climber, a geological mapper, a zoologist or botanist, for work in climbing to and photographing snowy craters, and investigation of the rocks and of biological features.

It is proposed to put up a substantial camp at each substation on its first occupation, the camp to be left for future use. In this way the scenes of coming eruptions will be photographed and will become familiar to the staff.

When a major eruption of Akutan Volcano for instance, takes place, there will be a place of observation ready. The staff will thus gradually secure data about the places strategically important for volcanologic work.

The assistant who remains in charge of the main observatory will keep up the instrumental record and keep in radio communication with the substation at such times as the substation is visited by the observatory vessel with its

radio operator. It may well be advantageous for the map-making expeditions of the first few years to work in conjunction with the first established sub-stations.

The expeditions of the Aleutian Observatory will use the large motor boat to make hydrographic and topographic surveys and geologic reconnaissances. Here also, when feasible, specialists in other sciences will be taken along.

The vessel will carry horses to act as pack animals and these will be taken to the base selected for survey, so that instruments and camp equipment may be carried inland from the base camps. The base camp at a harbor may be moved by boat as often as necessary, and at these base camps the hydrographers will work with smaller boats, making surveys of the coast.

As the boat will carry wireless, reports from the field parties will go to the central station.

It must not be supposed that the visiting workers in outside sciences will greatly add to the expense of operation. There are always applications from specialists, when such expeditions are contemplated, and these men come from institutions willing to stand the expense. All that the permanent station has to do is to provide room for such workers.

Publications

It is important in such an establishment as is here envisaged that the results of work be given continuous publicity in dignified but popular form. Science makes no progress nowadays unless it has the backing of the public, and the public means business men who have now learned by many years of research at industrial laboratories that pure science is a paying proposition.

The Aleutian Observatory will publish, at its main station, a multigraphed weekly letter sent out to subscribers, to libraries, and to government and educational institutions, describing the events recorded and the experiments and researches in progress.

It will also publish at some suitable center in the United States, an illustrated quarterly magazine, describing more fully the expeditions, collections, researches, and measurements acquired by the members of the staff and visiting workers.

Probable Expense

The cost of equipment and operation of the Aleutian Geographic Observatory is figured approximately as follows:

Equipment	Annual Upkeep
Boats \$25,000	Salaries \$22,200
Houses 12,000	Station upkeep 6,000
Horses 400	Boat upkeep 4,200
Apparatus 4,000	Food supplies 3,500
Contingent 8,600	Travel and freight. 3,000
	Contingent 11,100
\$50,000	(incl. publications)
	\$50,000

Work Now in Progress

No suggestions are made here as to the possible auspices under which the Aleutian Geographic Observatory may be established. The idea of an Aleutian volcano observatory has been fostered by the United States Geological Survey since the Volcanologic Section of the Survey was organized in 1926. A first beginning of this work in Alaska was done in 1927 by establishing a seismograph at Kodiak.



Fig. 39. Captain Harbor: there are scores of harbors unknown on the Pacific side of the western Aleutians.
Photo Nat. Geog. Soc.



Fig. 40. Wild flowers, ferns, and berry bushes in the alders: the Aleutian flora of the Alaskan Peninsula at Volcano Bay. Photo Nat. Geog. Soc.



Fig. 41. Eggs of sea-gulls are prized as food by the Aleutian natives. Photo Nat. Geog. Soc.

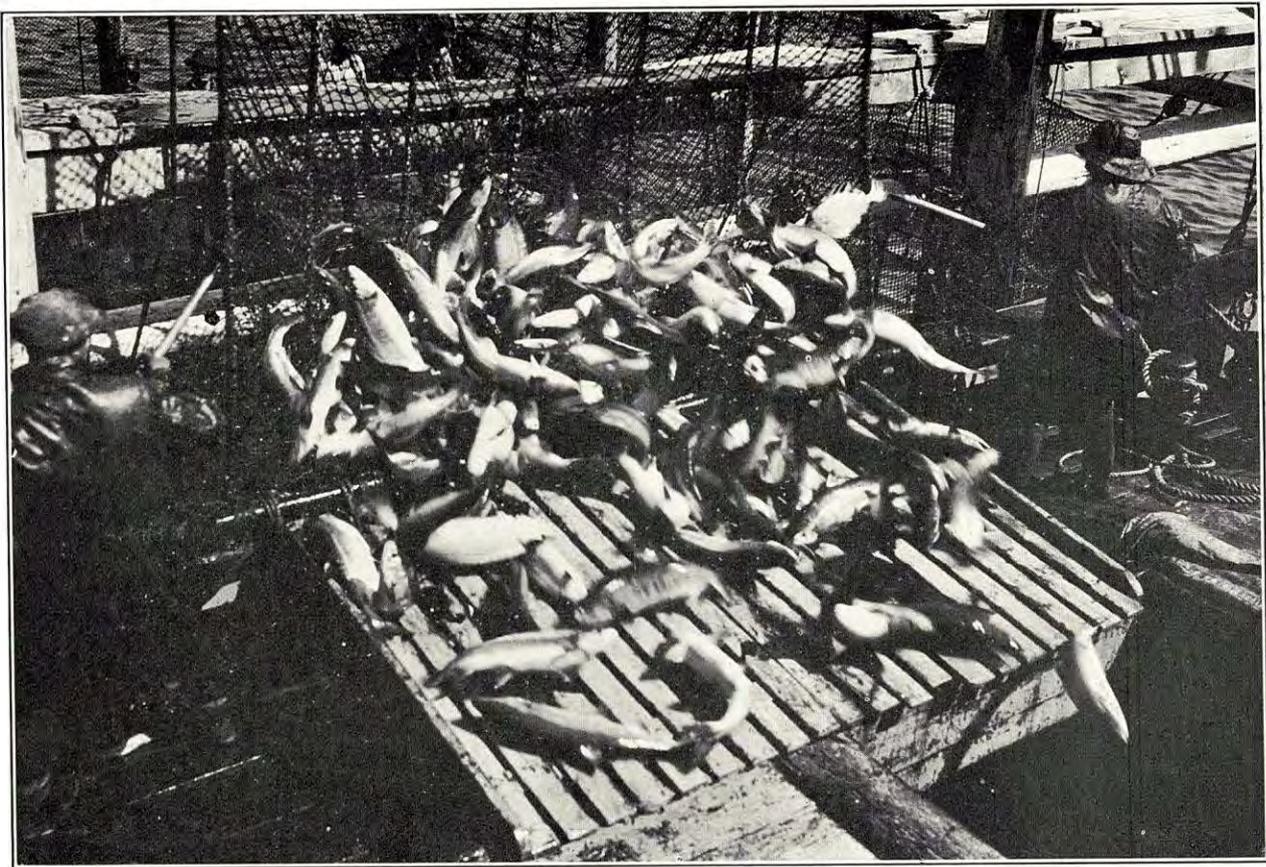


Fig. 42. Brailing salmon from a fish-trap on the Alaskan Peninsula: the wealth of the country is in the canneries. Photo Nat. Geog. Soc.



Fig. 43. Pavlof and Pavlof Sister, typical Aleutian volcanoes. Photo Nat. Geog. Soc.

The Bureau of Fisheries, the Biological, Geological and Coast Surveys have all done work in the Alaskan Peninsula; the National Park Service is interested in Mount McKinley National Park and in the Katmai National Monument; and the National Geographic Society, assisted by the Carnegie Institution, has done extensive work at Katmai and has begun a new series of expeditions. The Weather Bureau has numerous volunteer observers along the Aleutian belt. The Post Office Department, the Lighthouse and Coast Guard Services, the air services of the Army and Navy, the Bureaus of Education and Indian Affairs, and the Department of Agriculture are all variously interested in the mysteries of this region.

Such station might be established under private auspices. One good reason for this is that it is useless to establish such an institution without adequate funds. The main item of cost is salaries, and one cannot ask able scientists to make a tour the year around in such a wild country without paying them, so as to hold them in competition with the research laboratories of commerce. Also it is essential that they be given safety in transportation, and what little comfort in quarters and laboratories may be obtained in a disagreeable climate amid rough people and rough surroundings.

Both business and science have learned that if a work of this kind is to be done, it must be done well. And if it is to be done well, it must hire good men to do it. It cannot be done on a shoestring. I believe that the Aleutian Geographic Observatory, if properly financed and properly manned for 10 years, would produce publications having a wide circulation and exciting great popular interest in Alaska, by reason of the very boldness and originality of such an undertaking in a tempestuous, unknown land of hardy exploration.

And by furnishing good maps, it would promote in southwestern Alaska, along the lines of commerce, navigation, mining and agriculture, what the fisheries have only begun.

VOLCANIC CONDITIONS IN OCTOBER

Activity of Halemaumau and General Notes.

Activity at Halemaumau throughout October consisted practically exclusively of light avalanches. These were mostly during the last half of the month. There was slight increase or decrease in steaming from time to time occasioned for the most part by weather conditions. A hard rain on the second day of the month washed away much of what remained of the dust coatings from the big north avalanches of August.

Temperature measurements at one of the hot areas of Mauna Iki, a lava heap piled up during a flank outflow from Kilauea in 1920, showed considerable heat after an interval of eight years. Two vents had temperatures of 260° C. and 175° C., respectively, and a stick thrust into the second vent caught fire.

JOURNAL, OCTOBER, 1928

October 1. A bright sun, and light SW. wind. Pit very quiet, but looks dusty as from slides. SW. cone steams steadily but slight, and an occasional wisp comes from center cone. Midstreak of SW. talus steams steadily and stronger than seems usual for dry weather.

October 2. After hard S. rain, Halemaumau is washed clean of dust, so that two or three loud rock falls could not be accurately located by looking for disturbed dust. Walls are of brilliant red color, and floor is contrasty black. There is very noticeable steaming at the sites of all four July, 1927, fountain vents.

October 3. Pit quiet, though two small rock falls were heard, but not seen. Steaming still evident at the sites of the four lava vents; particularly flocculent at the small hole in the pit floor marking the site of the small twin fountain of July 7, 1927.

October 4. No slides in pit. Slightly increased steaming in south talus. No changes noticed. There is dust from August avalanches on the pit floor. The recent tremors shown by the pit seismograph may coincide with occasional avalanches. It is important to check this up.

October 6. At second hot area on Mauna Iki temperatures taken with 550° C. thermometer, with nitrogen inside: 1st vent, 260° C.; 2d vent, 275° C. (527° F.), where a stick caught fire.

This gray dust from Halemaumau NE. at 11:15 a. m.

October 7. At noon one or two falls of rock heard W. and NW. N. wall shows fresh peeling and salt coatings. N. talus has new debris.

From Uwekahuna Observatory saw bright fresh strip on SE. wall.

October 8. Nothing new seen at Halemaumau at 10:45 a. m. S. cone not steaming. Avalanche dust rose N. at 12:40 p. m.

October 11. Slides occurred on this day. At 8 a. m. dust from a NW. avalanche was seen from the Uwekahuna Observatory. This dust rose E. or SE. at 8:40 a. m. At 4:15 p. m. much was seen rising in E.

October 13. At 3 p. m. much gray dust rose, concentrated mostly NNE. A Park Ranger reports that the origin was N., followed a few minutes by a slide S.

October 15. At 11:30 a. m. much steam was rising after a night and a forenoon of rain.

October 18. Ranger reports avalanches 9:35, 9:40, 9:45 a. m. From H. V. O. at 10 a. m. dust rose N. rather steadily, once or twice in a straight column which would spread out.

October 20. Thin dust filled the pit at 11:20 a. m., also various times after noon. At 2 p. m. fresh debris lay on SW., S., and SE. inner slopes. The pit was very dry. The only vapor was at center cone and at SE. and S. taluses.

October 24. At 9 a. m. there was a fresh spot on N. talus and an invisible fall of rocks W. No steaming.

October 30. Thin dust rose E. at 10:35 a. m., in five minutes continuing more thickly, over NE. rim.

October 31. Thin dust rose NE. at 11:35 a. m. and spread out. At 2 p. m. dense steam was rising from Halemaumau after a forenoon of rain.

SEISMOMETRIC RECORD

There were 73 local earthquakes and one teleseism recorded on the seismographs at the Hawaiian Volcano Observatory during the month ended at midnight October 31, 1928. These and other phenomena are listed below. The time used is Hawaiian Standard (time meridian is 157° 30' W.), which is 10 hours and 30 minutes slower than Greenwich time.

The greater number of the very feeble local shocks counted in the list make such minute records that the character of the disturbance is not always apparent. Some are true earthquakes; others are perhaps the parts of greater amplitude of a continuous or protracted tremor, which at other times may be too feeble to record; some seem to be records of vibrations set up by avalanches in Halemaumau.

Abbreviations used below are as follows: vf, very feeble; f, feeble; s, slight; m, moderate; d, instruments dismantled; fl, felt locally; Δ, indicated distance in miles; *, continuous tremor.

Local Earthquakes

October		October		October	
1	5:03 a.m. vf	11	12:02 p.m. v.f.	22	6:43 a.m. vf.
	8:07 a.m. vf.		12:05 p.m. vf.		9:56 a.m. f. Δ 12
	11:49 a.m. vf.		2:07 p.m. vf.		10:46-10:50 a.m. vf. *
2	9:08 a.m. vf.		3:52 p.m. vf.		2:35 p.m. vf.
	11:39 a.m. vf.		4:07 p.m. f. Δ 28?		3:52 p.m. vf.
4	2:47 a.m. vf.	12	4:11 a.m. f. Δ 11?		5:07 p.m. vf.
	9:38 a.m. vf.		5:28 a.m. vf.		5:24 p.m. vf.
5	2:57 a.m. vf.	14	6:17 a.m. vf.		9:50 p.m. vf.
	3:13 a.m. vf.		7:07 a.m. vf.	24	6:29 a.m. vf.
	3:16 a.m. vf.	15	3:29 a.m. vf.		2:35 p.m. vf.
	4:00 p.m. vf.		3:44 p.m. vf.	25	5:27 p.m. vf.
	5:16 p.m. vf.		5:13 p.m. vf. Δ 14	26	11:57 a.m. vf.
	5:18 p.m. vf.	16	9:56 a.m. vf.		12:56 p.m. vf.
6	11:11 a.m. vf.	17	5:31 a.m. vf.		8:56 p.m. vf.
	12:59 p.m. vf.		5:38 a.m. vf.		11:15 p.m. vf.
7	10:30 a.m. vf.		1:49 p.m. vf.	27	2:42 p.m. vf.
	12:36 p.m. vf.	18	4:00 a.m. vf.		3:40 p.m. vf.
8	6:36 a.m. vf.		9:08 a.m. vf.		6:24 p.m. vf.
	8:23 a.m. vf.		11:21 a.m. vf.	28	2:55 a.m. vf.
9	2:28 p.m. vf.		3:05 p.m. vf.	30	12:41 p.m. vf.
10	6:35 a.m. vf.		5:01 p.m. vf.		1:31 p.m. vf.
	7:55 a.m. vf.		6:42 p.m. vf.	31	12:53 a.m. vf.
		19	4:35 p.m. vf.		12:55 a.m. vf.
			5:56 p.m. vf.		5:32 a.m. vf.
		21	10:41 a.m. f. Δ 13		6:54 p.m. vf.
			12:37 p.m. vf.		

Teleseism

October 14

? 10:30 p. m. Very faint.

Harmonic Tremor

No harmonic tremor was registered, except possibly the tremor from 10:46 to 10:50 a. m. October 22.

Microseismic Motion

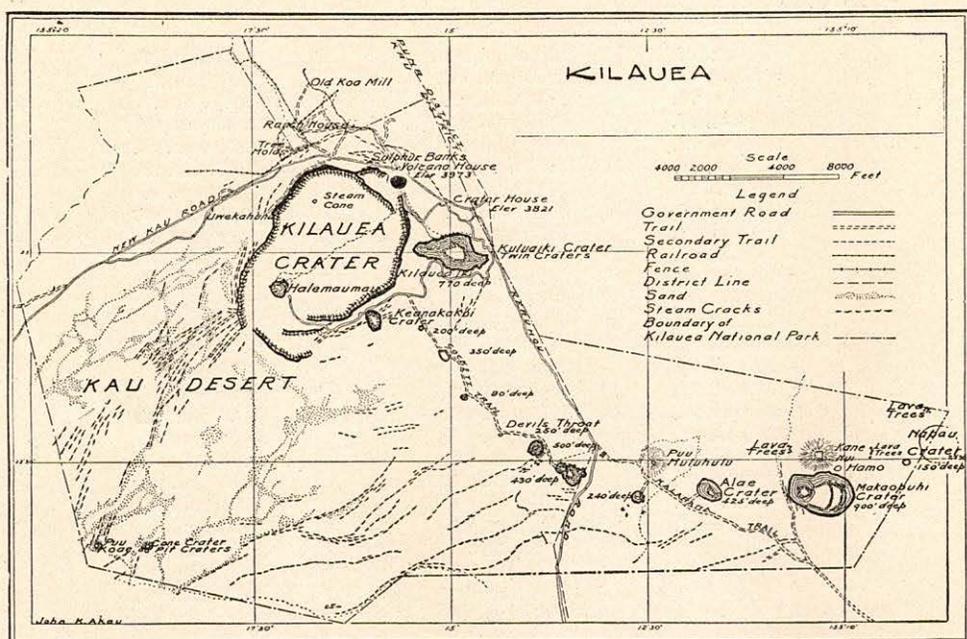
Microseisms were strong on the 3d, 9th, 12th, 30th, and 31st, and normal the remainder of the month.

Tilting of the Ground

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

September 26-October 2.....	0.8 second	E.
October 3-9.....	0.6 "	N.
October 10-16.....	1.0 "	ENE.
October 17-23.....	1.8 seconds	N.
October 24-30.....	2.8 "	S.
October 31-November 6.....	1.6 "	NNE.

T. A. JAGGAR,
Volcanologist.



Black spot shows location of Observatory.

All exchanges, gifts to library, news notes about Pacific volcanic and seismic events, and correspondence should be addressed HAWAIIAN VOLCANO OBSERVATORY, Hawaii National Park, Hawaii.

The Observatory is operated by the U. S. Geological Survey, and its work is supplemented by the Hawaiian Volcano Research Association. The main station is on the northeast rim of Kilauea Crater. Subordinate seismograph stations are operated by the Research Association under the direction of the volcanologist in Kona and Hilo.

The Kilauea station operates horizontal pendulums of the Bosch-Omori type and receives time by wireless from the Honolulu Naval Station. Observatory Lat. $19^{\circ} 25' 54.3''$ N.; Long. $155^{\circ} 15' 39.6''$ W.; elevation cellar 1214.6 meters (3985 feet). The Hilo and Kona stations operate horizontal pendulums. Their seismograms are sent to the Observatory.

The Hawaiian Volcano Research Association founded the Observatory in 1911, transferring the plant to the Government in 1919, but continuing cooperation in experimental work by furnishing funds and apparatus and workers as needed by the Government Volcanologist. It is a corporation under the laws of Hawaii, governed by a board of directors, and financed by the subscriptions of its members and patrons. Its aims are identical with those of the Observatory, namely, (1) To keep record of Hawaiian volcanism, (2) To attract volcanologic specialists to Hawaii, and (3) To promote worldwide knowledge of volcanoes and earthquakes and the foundation of more volcano observatories.

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CONTENTS

VOLCANIC CONDITIONS IN NOVEMBER

Activity of Halemaumau and General Notes

JOURNAL NOVEMBER, 1928

SEISMOMETRIC RECORD

Local Earthquakes and Tremors
Harmonic Tremor
Microseismic Motion
Tilting of the Ground

MAP AND STATION DATA

VOLCANIC CONDITIONS IN NOVEMBER

Activity of Halemaumau and General Notes

Early in the month there were numerous avalanches, most of these occurring during the night of November 1. One at 10:30 p. m. was louder than others and strong enough to record on the seismographs. These slides originated at the north rim of Halemaumau, and as the debris rolled down the face of the wall it carried along scattered loose fragments.

During the remainder of the month few changes occurred at the pit except variations in steaming according to weather conditions. The seismographs behaved peculiarly 5:17 to 5:43 a. m. November 24, registering 20 earthquakes in 26 minutes, several at the rate of two per minute. Five of the shocks were felt, and those with distinctive phases had indicated distances to origins close to the Observatory.

JOURNAL NOVEMBER, 1928

November 1. Numerous avalanches were heard at night from near the Observatory between 9 and 10 p. m. One big one was noted at 10:30 p. m.

November 2. Gray dust was observed from Uwekahuna at 8:30 a. m.

November 5. Thin dust, resembling a haze, filled the pit at 4 p. m.

November 8. Thin dust filled the whole pit at 3:25 p. m.

November 14. At 9:15 a. m. the pit was quiet. A strong northeast wind was blowing. The north wall has gray markings over the red area.

Steaming was not unusual despite rains of the past days. The southwest talus has the usual wet steam streaks, and the curved streak across its top is particularly prominent.

November 19. At 10 a. m. a fresh red scar showed on the northeast wall, and new debris below. Steaming was about the same.

November 20. All quiet at Halemaumau at 9:10 a. m. One light fall of rocks occurred north. Wind was south.

November 21. No changes were noted at the pit at 10 a. m. The southwest cone was steaming.

November 22. Dense steam rises from the pit, merging with low clouds. Steam jets are active over the whole Kilauea floor.

November 24. Four earthquakes in five minutes were felt out of a total of 18 registered in the early morning. At 11:45 a. m. the pit was remarkably quiet and dry, with no fresh falls in evidence and no trace of any effects of the earthquakes.

November 26. A slide northeast making dust was reported at 8:20 a. m.

November 28. No changes observed at 9:15 a. m. The center cone steams.

SEISMOMETRIC RECORD

There were 61 local earthquakes recorded by the seismographs at the Hawaiian Volcano Observatory during the month ended at midnight November 30, 1928. These and other phenomena are listed below. The time used is Hawaiian standard (time meridian is 157° 30' W.), which is 10 hours and 30 minutes slower than Greenwich time.

The greater number of the very feeble local shocks counted in the list make such minute records that the character of the disturbance is not always apparent. Some are true earthquakes; others are perhaps the parts of greater amplitude of a continuous or protracted tremor, which at other times may be too feeble to record; some seem to be records of vibrations set up by avalanches in Halemaumau.

Abbreviations used below are as follows: vf, very feeble; f, feeble; s, slight; m, moderate; d, instruments dismantled; fl, felt locally; Δ , indicated distance in miles; *, continuous tremor.

Local Earthquakes

November		November		November	
1	2:37 a.m. vf.	17	2:20 a.m. vf.	26	9:15 a.m. vf.
	10:30 p.m. vf.	20	12:11 p.m. vf.		1:15 p.m. vf.
2	12:59 a.m. vf.	21	2:23 p.m. vf.		10:13 p.m. vf.
	12:45 p.m. vf.		4:40 p.m. vf.	27	1:11 a.m. vf.
3	5:43 a.m. vf.	22	3:23 a.m. vf.		10:08 a.m. vf.
	4:32 p.m. vf.	23	8:15 a.m. vf.		11:49 a.m. vf.
	4:47 p.m. vf.		8:25 a.m. vf.		1:28 p.m. vf.
4	12:09 a.m. vf.		10:15 a.m. vf.	28	5:24 p.m. vf.
	10:06 a.m. vf.	24	5:17 a.m. vf.		6:05 a.m. vf.
	4:44 p.m. vf.		5:23 a.m. vf.		7:12 a.m. vf.
6	7:35 a.m. vf.		5:29 a.m. vf.		11:18 a.m. vf.
	9:27 a.m. vf.		(2)5:32 a.m. vf.		3:05 p.m. vf.
	9:53 a.m. vf.		(2)5:33 a.m. vf.		
	2:02 p.m. vf.		5:34 a.m. vf.		
	7:07 p.m. vf.		5:35 a.m. vf.		
7	5:32 a.m. vf.		5:36 a.m. f. Δ 1.3 fl.		
	5:43 a.m. vf.		(2)5:37 a.m. vf. fl.		
8	1:40 a.m. vf.		5:38 a.m. vf.		
	6:37 p.m. vf. Δ 2.6.		5:39 a.m. vf. fl.		
10	4:49 a.m. vf.		(2)5:40 a.m. vf. fl.		
15	12:41 p.m. vf.		5:41 a.m. vf.		
	1:11 p.m. vf.		(2)5:42 a.m. f. Δ 0.4 fl.		
	1:16 p.m. vf.		5:43 a.m. vf.		
	1:52 p.m. vf.				
	1:53 p.m. vf.				
	6:09 p.m. vf.				

Harmonic Tremor

This type of tremor was absent throughout the month.

Microseismic Motion

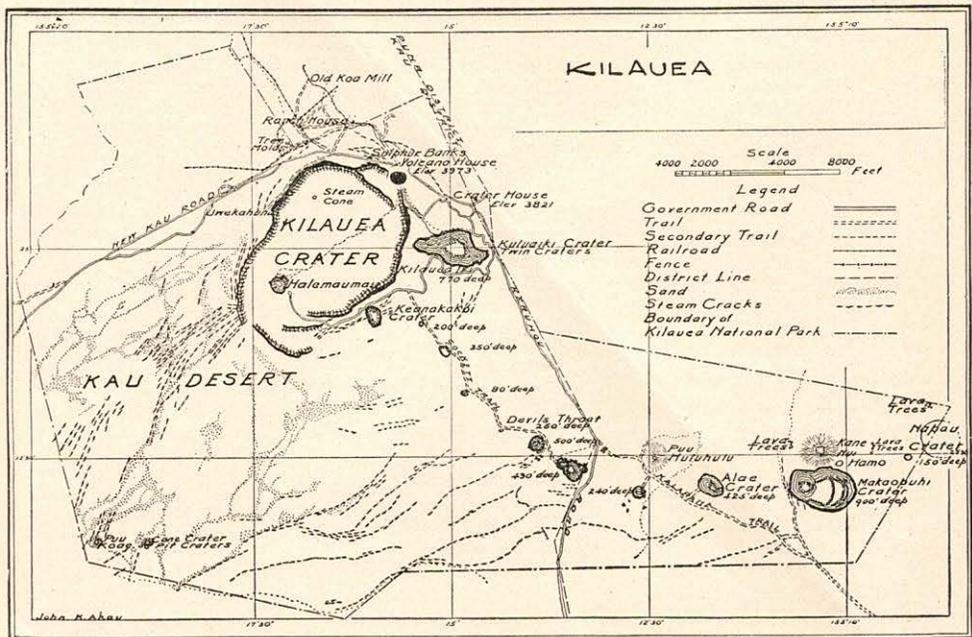
Microseisms were strong the first part of the month, diminishing somewhat on the 7th. They were normal following the 12th and until the 29th, when there was a slight increase.

Tilting of the Ground

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

October 31-November 6.....	1.6 seconds	NNE.
November 7-13	2.2	“ NNE.
“ 14-20	0.7	“ W.
“ 21-27	2.1	“ SSW.
“ 28-December 4.....	2.0	“ NNE.

T. A. JAGGAR,
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CONTENTS

VOLCANIC CONDITIONS IN DECEMBER

Activity of Halemaumau and General Notes

JOURNAL DECEMBER, 1928

SEISMOMETRIC RECORD

Local Earthquakes and Tremors

Harmonic Tremor

Microseismic Motion

Tilting of the Ground

MAP AND STATION DATA

VOLCANIC CONDITIONS IN DECEMBER

Activity of Halemaumau and General Notes

The fire pit remained inactive throughout the month and showed few indications of changes in volcanic conditions. The seismographs, however, showed some interesting features.

At the time of a perceptible earthquake December 24 at 8:43 p. m. there was a spurt of tilt to the north. With the Observatory located on the northeast crater rim, accumulation of tilt north and east of Halemaumau can be taken to mean rise of magma within the volcano edifice.

Slides in the pit were infrequent during the month. One large slide was noted December 3 at 10:55 a. m. The north wall was rather thickly coated with white salts early in the month.

JOURNAL DECEMBER, 1928

December 3. Much dust from slides north and northeast occurred from 10:30 to 11 a. m. At 10:55 a. m. there was a big avalanche at the north, with a spreading column of dust northwest-southeast rising from the pit.

December 4. The red north wall is heavily coated with white salts, but many white fragments are over the whole of the north talus. Much of the

new debris is lying between north and northwest taluses. The slides were from the north rim.

There is extraordinarily little steaming anywhere.

December 19. At 11:30 a. m., two fresh spots on the walls were noticed. One was just above the top of the north talus; one in the midwall above the north-northeast talus. A few rock falls were heard.

December 20. No changes were observed at 10:30 a. m. Much steam rose from the south-southeast talus and the south cone. The north wall was salt coated.

December 23. A dusty slide on north wall was observed at 3 p. m.

December 24. No changes noted at 10 a. m. Cones were steaming.

December 28. New steam cracks reported on northeast side of center cone, also a fresh avalanche scar on the north rim.

SEISMOMETRIC RECORD

There were 31 local earthquakes recorded by the seismographs at the Hawaiian Volcano Observatory during the month ended at midnight December 31, 1928. These and other phenomena are listed below. The time used is Hawaiian standard (time meridian is $157^{\circ} 30' W.$), which is 10 hours and 30 minutes slower than Greenwich time.

The greater number of the very feeble local shocks counted in the list make such minute records that the character of the disturbance is not always apparent. Some are true earthquakes; others are perhaps the parts of greater amplitude of a continuous or protracted tremor, which at other times may be too feeble to record; some seem to be records of vibrations set up by avalanches in Halemaumau.

On December 22 there were several seismic disturbances too faint to record as earthquakes.

Abbreviations used below are as follows: vf, very feeble; f, feeble; s, slight; m, moderate; d, instruments dismantled; fl, felt locally; Δ , indicated distance in miles; *, continuous tremor.

Local Earthquakes

December	December	December
3 6:17 p.m. vf. $\Delta 9.3$.	12:41 p.m. vf.	22 1:40 p.m. vf.
6 9:40 p.m. vf.	12:56 p.m. vf.	1:42 p.m. vf.
7 4:58 a.m. vf.	9:47 p.m. vf.	2:05 p.m. vf.
10:43 a.m. vf.	11 10:31-10:32 a.m. vf. *	23 1:41 a.m. vf.
11:13 a.m. vf.	11:19-11:22 a.m. vf. *	2:28 p.m. vf.
8 2:20 a.m. vf.	13 1:21 a.m. vf.	24 3:48 a.m. vf.
6:02 a.m. vf.	4:21 a.m. vf.	8:43 p.m. vf. $\Delta 10.9$ fl.
10:18 a.m. vf. $\Delta 10.9$.	16 12:00 noon vf.	25 10:13 p.m. vf. $\Delta 12$ fl.
1:26 p.m. vf.	17 8:05 a.m. vf.	30 5:47 p.m. vf.
2:35 p.m. vf.	3:33 p.m. vf.	
10 7:22 a.m. vf.		
12:14 p.m. vf.		

Teleseisms

None recorded.

Harmonic Tremor

Several very feeble seismic disturbances on December 22 too faint to record may have been parts of harmonic tremor. This may also be true of two short spells of continuous tremor on December 11.

Microseismic Motion

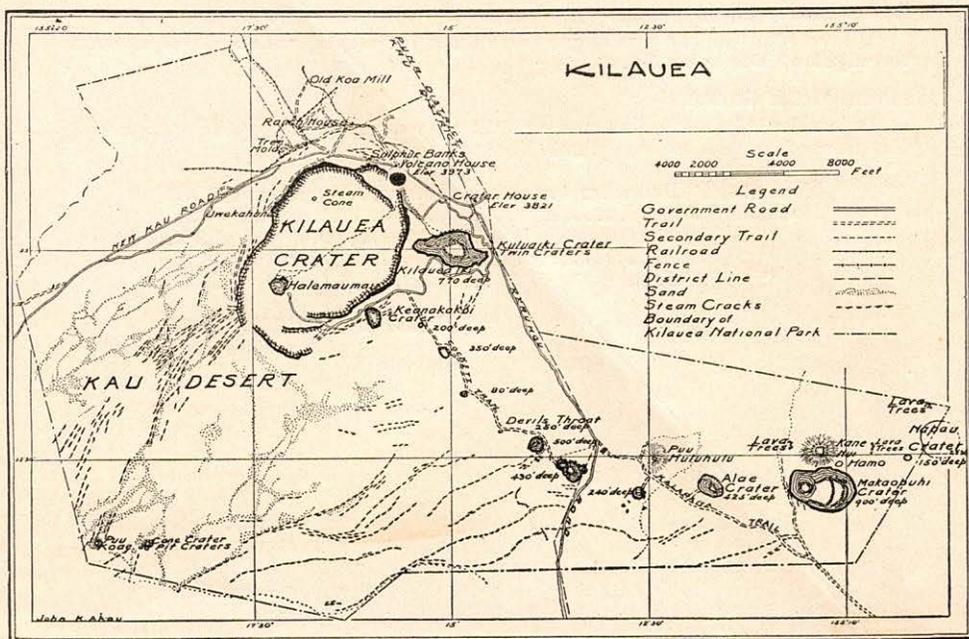
Microseismic motion was slight throughout the month, with a slight increase the night of December 5-6.

Tilting of the Ground

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

November 28-December 4	.....2.0	seconds	NEE.
December 5-11	.....0.5	second	NE.
“ 12-18	.....0.9	“	SSW.
“ 19-25	.....1.4	seconds	N.
“ 26-January 1, 1929	.....1.7	“	SSW.

EARL M. BUCKINGHAM,
Associate Engineer.



Black spot shows location of Observatory.

All exchanges, gifts to library, news notes about Pacific volcanic and seismic events, and correspondence should be addressed HAWAIIAN VOLCANO OBSERVATORY, Hawaii National Park, Hawaii.

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