PREFACE

The Volcano Letter was an informal publication issued at irregular intervals by the Hawaiian Volcano Observatory (HVO) during the years 1925 to 1955. Individual issues contain information on volcanic activity, volcano research, and volcano monitoring in Hawaii. Information on volcanic activity at other locations is also occasionally included.

To increase accessibility of this resource, previously only available in print format, this compilation was scanned from the highest quality Volcano Letter originals in the HVO archives. Optical Character Recognition (OCR) was run on the entire file. In addition, the file size was reduced by making it compatible with only Adobe Reader v. 8 and later. The scanning was done by Jim Kauahikaua and the quality control and posting was done by Katie Mulliken, both current staff at the Hawaiian Volcano Observatory.

Originals of the first three Volcano Letters could not be found so copies plus the Title Page and Index for 1925 have been extracted from an excellent scan of Volcano Letters for 1925 to 1929 available in Books.Google.com

The Volcano Letter was published by HVO through multiple changes in administration, including the Hawaiian Volcano Research Association (1925-1932), the U.S. Geological Survey (1932-1935), the Department of the Interior (1935-1938), and the University of Hawai‘i (1938-1955). Issues 1–262 were published weekly from January 1, 1925, to January 2, 1930, and consisted of a single page of text. Issues 263–384, also published weekly, from January 9, 1930–May 5, 1932, were generally longer—four-pages—and provided more detail on volcanic activity, including photographs, maps, and plots. Weekly issues 385–387, published May 12–26, 1932, were a single page of text due to budget reductions brought on by the Great Depression. Budget restrictions reduced the publishing frequency to monthly for issues 388–428, covering the period of June 1932 to October 1935; these issues were generally shorter, 1–2 pages, and sometimes featured figures. From November 1935 to July 1938, issues 429–461 remained monthly but increased in length (generally eight pages) and featured figures frequently. Issues 462–530, published over the period of August 1938–December 1955, varied in length from 2–15 pages, but were published quarterly, rather than monthly.

Six of the letters are misnumbered:
Jan. 21, 1926 number is 55 though it should 56
July 29, 1926 number is 82 though it should be 83
Feb. 16, 1928 number is 161 though it should be 164
May 31, 1928 number is 197 though it should be 179
Nov. 29, 1928 number is 204 though it should be 205

For background information on the Hawaiian Volcano Observatory: https://pubs.usgs.gov/gip/135/

The Volcano Letter publications are also available in print:

Fiske, R.S., Simkin, T., and Nielsen, E.A., eds.,1987, The Volcano Letter, No. 1-530. See https://www.si.edu/object/siris_sil_328087

April 2023

THE VOLCANO LETTER

No. 463 Department of the Interior National Park Service January-March, 1939

Edward G. Wingate Superintendent
Hawaii National Park

Hawaiian Volcano Observatory
T. A. Jaggar Volcanologist

HAWAIIAN VOLCANO RESEARCH ASSOCIATION
in cooperation with
UNIVERSITY OF HAWAII

The **Hawaiian Volcano Research Association** was founded in 1911 for record of volcanoes in the Hawaiian Islands and around the Pacific Ocean. Its equipment at Kilauea Volcano, Hawaii Island, is leased and operated by the United States Government, Department of the Interior, National Park Service.

The **University of Hawaii** cooperates in maintaining a research laboratory at Hawaii National Park. The **Association** and the **University** maintain outside seismograph stations and supplement the work of the government with research associates, instrumental plants and special investigations.

The **Volcano Letter,** a quarterly record of the Hawaiian volcano laboratories, is issued by authority of the Department of the Interior and supplied to a restricted membership and exchange list of the above establishments.

Hawaiian Volcano Observatory Report for January-March 1939

VOLCANOLOGY

January 1939

Until the last week, the month of January was locally quiet at the Hawaiian volcanoes. A feeble earthquake was sharply felt January 15, and there was a notable increase of spasmodic tremors during the last fortnight of the month. These originated under Mauna Loa and Hualalai. Distant destructive earthquakes of large size from Chile and the Solomon Islands were registered January 24 and January 29.

A moderate slide December 30, 1938 from about 300 feet below the north rim of Halemaumau occurred 10:07 a.m. On January 14 rock slides from the east and northwest walls occurred about 1:40 p.m. Slides became more numerous from the western walls of Halemaumau on January 25, ten being counted between 9:55 a.m. and 11:53 a.m.

On the morning of January 17 with nearly calm air much fume hung over Halemaumau originating mostly at the southeast solfatara at the edge of the floor.

Opening of the measured cracks around Halemaumau rim increased somewhat during the month along with the seismicity and the slides. For the week ending January 1, cracks across Chain-of-Craters road near Devil's Throat closed 2.0 mm. The next change noted there was opening of these cracks 1.5 mm. as measured January 20, and again by a like amount January 27. (See map Volcano Letter 462.)

The following are the local data for January:

Week Ending	Halemaumau Slides	Halemaumau Crack Openings	Seismic Disturbances
January 1	1	0.5 mm.	14
" 8	0	1.5 mm.	32
" 15	1	3.0 mm.	16
" 22	0	3.0 mm.	60
" 29	10	3.0 mm.	45

February 1939

The general conditions in Halemaumau pit as observed February 22 showed a small hole on the southeastern floor of the pit to be steaming near a long white stained crack. Fume above this eastern wall crack had lately been conspicuous. Stain was evident on the 1932 cone southwest, and along the canoe sill at the base of the northeast wall. Margin of the floor was sulphurous in several places. Slides had made a new scar on the south wall February 6 and February 16, and that wall kept scaling off during the last half of the month. The break made a wide white scrape up the entire height of the wall, on the east side of the upright southwestern rift cavern.

Kilauea was quiet the first week of February in contrast to volcanic disturbances in Central America and South America and a reported eruption of Asama in Japan February 3. The second week produced heavy rainfall February 9-10 resulting in clouds of vapor over Halemaumau.

A noisy rock slide fell from the southeast wall of Halemaumau 11:55 a.m. February 6. Rock slides increased during the third week and were noted February 16 at northeast rim 9:25 a.m.; February 17 north wall 7:55 a.m. and west wall 8:53 a.m.; February 18 northeast and north rims 11:00 a.m.; February 19 west wall 10:01 a.m. and northeast rim 10:08 a.m. This was the period when fresh scars and dust streaks were produced on the southeast wall. Two rock slides at the north wall occurred February 21, 9:18 a.m. and 12:10 p.m.

Measurements February 11 showed the new road cracks in the vicinity of Devil's Throat to have opened 2.0 mm., one near Hiiaka pit closed 0.5 mm., and the cracks beyond Pauahi pit were stationary. On February 17 the cracks near Devil's Throat had closed 1.0 mm.; one near Hiiaka closed 0.5 mm.; and one beyond Pauahi closed 0.5 mm. The excessive opening of Halemaumau rim cracks during the week ending February

26 was accompanied by openings of cracks near Devil's Throat 0.5 mm.; Hiiaka 0.5 mm.; and a large crack at Pauahi 1.0 mm.

The following are the local data for February:

Week Ending	Halemaumau Slides	Halemaumau Crack Openings	Seismic Disturbances
February 5	0	0.0 mm.	17
" 12	1	1.0 mm.	32
" 19	6	5.0 mm.	27
" 26	2	8.5 mm.	15

March 1939

The most distinctive event of March 1939 was excessive rainfall at the beginning of the month. This produced clouds of vapor from the floor of Halemaumau. Precipitation exceeded 19 inches in Hilo in one day, March 2, at Kilauea Crater the rain gauge registered 11.02 inches, and for the week ending March 5, 17.54 inches. The flood was disastrous in Hilo, and the level of water in Olaa Mill well rose three feet above the flood level of 1938 so as to require removal of machinery.

Sharp tilting of the Observatory ground westward March 2 may have been caused by the loading of floor of Kilauea Crater with rain. This was followed by remarkable increase of rim crack openings at Halemaumau for the week ending March 12. Fifteen of twenty-eight crack locations showed opening, one closed, resulting in aggregate opening 17.5 mm. The greater part of this value was contributed by cracks east and southeast. Increased rate of opening of the rim cracks about spring equinox has been noted each year since 1933, generally with accompaniment of rock slides. The strong opening of cracks continued for the remainder of the month.

Observations at Makaopuhi pit March 21, in the Chain-of-Craters, showed that sulphur deposition and fuming are in progress at a hot spot halfway up the crater wall, and a small rock slide was observed at the north rim. On March 29 vapor was observed rising from the talus on the east side of Alealea Crater probably stimulated by deeper penetration of the recent rain.

The cracks near Devil's Throat had opened 2.0 mm. March 3 and 1.5 mm. March 10. The cracks near Hiiaka pit and Pauahi pit had opened 0.5 mm. March 10. Inspection March 21 indicated that new cracks across the road are developing near Devil's Throat, a small portion of the southwest rim of this pit has recently fallen, cracks to the northwest have increased and humps in the road pavement are growing higher near Pauahi and near the Ainahou road. Temperature measurement at the hot area in ohia forest near Kokoolau Crater showed no change and there is no encroachment of solfataric action on the surrounding forest.

Rock slides in Halemaumau were observed at northeast wall March 3, 10:15 a.m. and 10:28 a.m. Two small slides from the north wall occurred at 10:20 and 10:30 a.m. March 6. Slides increased March 27 and were observed 11:51 a.m., northwest wall; March 30, 7:36 a.m., northeast wall and 11:07 a.m. northwest wall; March 31, 8:58 a.m. northeast wall; April 1, northeast rim 11:50 a.m. and 1:30 p.m.

The following are the local data for March:

Week Ending	Halemaumau Slides	Halemaumau Crack Openings	Seismic Disturbances
March 5	2	4.5 mm.	13
" 12	2	17.5 mm.	17
" 19	0	13.5 mm.	32
" 26	0	10.0 mm	24
April 2	6	13.5 mm.	28

T. A. J.

SEISMOLOGICAL DATA

Earthquakes

	Minutes of Tremor	Very Feeble	Feeble	Slight	Distant*	Weekly† Seismicity
Jan. 8	28	4	0	0	0	9.00
" 15	12	3	1	0	0	5.50
" 22	55	4	0	1	1	17.75
" 29	80	1	0	0	2	20.50
Feb. 5	15	2	0	0	1	4.75
" 12	28	4	0	0	1	9.00
" 19	32	4	1	0	0	11.00
" 26	11	4	0	0	0	4.75
Mar. 5	11	2	0	0	0	3.75
" 12	16	1	0	0	0	4.50
" 19	24	5	2	1	0	12.50
" 26	18	4	2	0	1	8.50
Apr. 2	23	5	0	0	0	8.25

* Including teleseisms or earthquakes over 5000 km. from Kilauea.
† For local seismicity definition see Volcano Letter 371.

Epicenters of the following local disturbances were determined by means of seismograms from the stations operated by the Hawaiian Volcano Observatory on the Island of Hawaii. Kilauea earthquakes were located by means of the main seismograph station at the observatory and the two subsidiary stations at Uwekahuna and the SE rim of Halemaumau respectively. The more distant shocks were located with the aid of seismograms from Hilo and Kealakekua. The disturbances began at the time indicated and whenever possible, a determination of depth of focus has been made.

January 2, 8:45 am, very feeble, 8.0 miles deep off seacoast 5.0 miles south of Ahua Point. 19° 11.0′ N; 155° 12.7′ W.

January 4, 8:40 am, very feeble, 2.5 miles deep, Kanaokuaiki Pali about 1.5 miles east of Puu Ohale. 19° 21.2′ N; 155° 15.4′ W.

January 7, 5:15 am, very feeble, 7.0 miles deep NE rift of Mauna Loa. 19° 31.5′ N; 155° 33.0′ W.

January 10, 9:41 pm, very feeble, 2.6 miles deep near Hiiaka and Pauahi Craters. 19° 21.3′ N; 155° 13.9′ W.

January 13, 12:01 am, very feeble, 18.0 miles deep in vicinity of Puu Kulua, Mauna Loa NE rift. 19° 34.0′ N; 155° 26.3′ W.

January 14, 10:46 am, very feeble, 1.2 miles deep, 0.7 mile SW of Ahua Kamokukolau. 19° 22.7′ N; 155° 16.7′ W.

January 15, 3:30 pm, feeble, of shallow origin in Kilauea Crater near Halemaumau. 19° 24.5′ N; 155° 16.3′ W. Reported felt by many persons in Hawaii National Park residential area and by a few in Hilo.

January 16, 1:10 am, very feeble, about 13.0 miles deep in Mauna Loa NE rift, in the vicinity of Puu Ulaula. 19° 33.0′ N; 155° 27.0′ W.

January 17, 4:35 pm, very feeble, about 6.0 miles deep under area about 3.0 miles SE of Puu Ulaula, Mauna Loa NE rift. 19° 31.7′ N; 155° 25.8′ W.

January 17, 8:19 pm, very feeble, 13.0 miles deep in Kilauea SW rift about 9.0 miles from Halemaumau. 19° 20.6′ N; 155° 24.5′ W.

January 19, 2:58 pm, slight, 16.0 miles deep under Hualalai. 19° 41.6′ N; 155° 52.0′ W. Reported strongly felt by many persons in Kona and Kohala districts and slightly by some in Hilo and Kau districts.

January 25, 11:42 am, very feeble, probably originated in Chain-of-Craters SE of Kilauea Crater.

February 2, 9:56 pm, very feeble, originated in Mauna Loa NE rift near Summit Crater. 19° 30.0′ N; 155° 32.0′ W.

February 5, 1:57 pm, very feeble, probably originated about 5.0 miles W by N of Pahala. (3.0 miles NW of Kula mountain.)

February 9, 7:45 am, very feeble, 0.9 mile deep at Chain-of-Craters near Pauahi and Hiiaka Craters.

February 10, 9:56 am, very feeble, 3.3 miles deep in same general area as preceding quake. 19° 21.3′ N; 155° 13.9′ W.

February 10, 3:46 pm, very feeble, 10.0 miles deep in Mauna Loa NE rift near Puu Ulaula. 19° 33.0′ N; 155° 27.0′ W.

February 13, 7:17 pm, very feeble, probably originated in area between Devil's Throat and Ahua Kamokukolau.

February 16, 9:26 am, very feeble, probably originated under NE edge of Kilauea Crater floor.

February 17, 6:05 am, very feeble, 25.0 miles deep, 8.0 miles E of Kulani cone. 19° 34.3′ N; 155° 13.3′ W. Reported felt in Hilo.

February 17, 6:36 pm, feeble, 4.0 miles deep under N rim of Kilauea Iki. 19° 25.8′ N; 155° 14.7′ W.

February 18, 4:36 pm, very feeble, probably located in Chain-of-Craters near Kokoolau.

February 21, 2:26 pm, very feeble, 2.7 miles deep in area N of Kilauea Iki. 19° 25.8′ N; 155° 14.5′ W.

February 23, 12:52 pm, very feeble, 5.0 miles deep in Hilina fault system 3.0 miles S of Makaopuhi. 19° 19.2′ N; 155° 11.0′ W.

February 26, 7:53 am, very feeble, originated under N portion of Halemaumau.

February 26, 6:11 pm, very feeble, probably originated in Kohala area about 4.0 miles N of Kawaihae. 20° 5′ N; 155° 50.0′ W.

March 4, 3:18 am, very feeble, originated in NE portion of Kilauea Crater.

March 5, 1:11 am, very feeble, 15.0 miles deep in Mauna Loa NE rift, 7.0 miles NW of Kulani Cone. 19° 35.4′ N; 155° 21.6′ W.

March 8, 10:33 am, very feeble, 22.0 miles deep in Mauna Loa NE rift near Pukauahi Cone. 19° 33.0′ N; 155° 31.2′ W.

March 13, 9:28 pm, very feeble, 10.0 miles deep under E slope of Mauna Loa, 2.5 miles SE of Mauna Loa seismograph. 19° 27.5′ N; 155° 21.2′ W.

March 14, 6:08 am, very feeble, 2.0 miles deep near Kipuka Puaulu. 19° 26.8′ N; 155° 18.7′ W.

March 14, 9:54 am, slight, 2.3 miles under Halemaumau, Kilauea Crater. 19° 24.6′ N; 155° 17.2′ W.

March 14, 10:56 am, feeble, probably originated in area between Makaopuhi Crater and Hilina Pali.

March 14, 12:10 pm, feeble, of shallow origin in area about 0.8 mile W of Devil's Throat. 19° 22.7′ N; 155° 14.9′ W.

March 20, 12:13 am, very feeble, probably originated in Hilina Pali area about 6.00 miles SE of Makaopuhi.

March 21, 8:47 am, very feeble, of shallow origin in area immediately E of Kilauea Iki. 19° 24.7′ N; 155° 13.6′ W.

March 22, 5:46 am, 40.0 miles deep Mauna Loa NE rift, 8 miles from Summit Crater. 19° 33.0′ N; 155° 30.0′ W.

March 22, 10:57 pm, feeble, 10.0 miles deep Mauna Loa NE rift, 13.0 miles from Hilo. 19° 38.0′ N; 155° 16.0′ W. Reported generally felt in Hilo.

March 24, 8:59 pm, very feeble, 9.0 miles deep in Kau desert area about 2.0 miles S of Puu Ohale. 19° 20.7′ N; 155° 15.0′ W.

March 25, 11:02 pm, very feeble, probably originated in Chain-of-Craters between Devil's Throat and Puhimau Crater.

March 28, 5:36 am, very feeble, 20.0 miles deep, Mauna Loa NE rift near Puu Kulua. 19° 35.2′ N; 155° 26.0′ W.

March 29, 9:47 am, very feeble, of Kilauea Crater origin.

March 30, 9:35 pm, very feeble, originated in NE portion of Kilauea Crater.

Continuous Tremor

Thirty-seven minutes beginning at 8:30 am, January 27. Eleven minutes beginning at 2:02 am, February 18.

Teleseisms

January 18, 11:53 pm, H.S.T., beginning of unidentified portion.

January 24, 5h 15m 41s pm, H.S.T., "P" waves began to register. Shock originated in Chile and was of very destructive nature resulting in estimated loss of over 20,000 human lives, distance from Kilauea 6,435 miles.

January 29, 3h 57m 57s pm, H.S.T., "P" waves began to register. Shock originated in Solomon Islands. Distance from Kilauea 3,800 miles.

February 2, 7h 05m 37s pm, H.S.T., "P" waves began to register. Distance from Kilauea, 3,795 miles.

February 7, 8:26 pm, unidentified portion began recording. No reports have been received concerning this quake either by press or from other stations.

February 24, 4:01 am, unidentified portion.

Microseismic Motion

Microseismic motion of the ground at the Observatory was moderate January 15-21 inclusive and January 29, 30, and 31. It was strong the remainder of the month.

For February it was light on the 20th, 21st, and 25th; moderate on the 12th, 22nd-24th, 26th-28th, and strong the remainder of the month.

During March it was strong 3-5, 17-19, and moderate the remaining dates. All dates inclusive.

H. H. W.

Tilting of the Ground

The following tables show tilt by weeks as recorded by the observatory seismograph and the one at Halemaumau; the algebraic sum toward or away from the pit.

At the Observatory the total accumulated tilt for the year ending January 29, 1939 was 1.15" S and 5.93" W.

For the year ending February 26, it was 1.00" S. and 1.73" W.

For the year ending April 2, it was 3.08" S and 4.85" W.

Table of Tilt

Week Ending	Observatory	Halemaumau West Station
Jan. 8	0.43" S 54° E	3.22" S 64° E
" 15	0.55" S 11° E	3.52" S 42° W
" 22	0.91" S 19° W	4.77" N 15° W
" 29	0.97" S 35° W	2.62" N 30° E
Feb. 5	2.00" S 28° W	2.92" N 85° W
" 12	0.77" S 12° W	1.49" S 60° W
" 19	0.25" N 16° W	1.49" N
" 26	0.00" 0	1.64" N 25° W
Mar. 5	1.81" N 26° W	2.89" N 20° E
" 12	0.62" S 29° W	2.59" S 60° W
" 19	3.20" S 43° W	3.61" S 34° W
" 26	1.30" S 51° W	1.49" N 39° W
Apr. 2	1.03" S 30° W	1.49" N 61° W

Week Ending	Halemaumau Southeast Station	Halemaumau Resultant
Jan. 8	2.53" N 85° W	4.30" toward
" 15	1.65" N 70° W	1.23" from
" 22	2.95" S 35° W	1.56" from
" 29	4.54" S 34° E	1.98" toward
Feb. 5	1.13" N 44° E	2.67" from
" 12	4.28" N 59° W	2.55" toward
" 19	2.56" N 87° W	1.62" toward
" 26	2.49" N 25° W	1.81" toward
Mar. 5	4.05" N 37° W	5.08" toward
" 12	3.30" N 15° W	0.70" toward
" 19	1.07" N 31° W	2.17" toward
" 26	4.21" N 81° W	2.03" toward
Apr. 2	1.20" S 9° W	2.00" from

H. H. W.

Crater Angles

Measurement of horizontal angles across Kilauea Crater from the Observatory January 21, indicated closing of both the Halemaumau and the crater values compared with similar measurements of December 29. The Halemaumau angle between the pit seismograph and the NW pit BM closed 0.50". The crater angle between the SE crater rim station and Uwekahuna closed 1.58".

Angle values determined on February 15, indicated opening across Halemaumau and closing across the crater. Between January 21 and February 15, the Halemaumau value increased 0.83", and the crater value decreased 1.15".

During March two determinations were made of the angles. These were March 13 and 30. On the first of these two runs, the Halemaumau angle closed 2.25" and the crater angle closed 0.25". Between March 13 and March 30 the Halemaumau angle again decreased (0.59") and the crater angle opened by an amount of 2.24". Total change for the month, Halemaumau angle closed 2.84" and the crater angle opened 2.00".

During the first three months of 1939 the Halemaumau angle has decreased 2.51" and crater angle has decreased 0.84".

These changes agree favorably with current tilt toward Halemaumau.

H. H. W.

Levelling at Kilauea

Since January 1, 1939 two sets of levels have been run over the usual circuit on the floor of Kilauea Crater between the Spit BM on the SE crater rim and the NW Pit BM. The line of levels follows the S-SW-W, rims of Halemaumau.

These determinations were made January 30 and March 21. In both cases the NW Pit showed relative lowering with reference to Spit BM. On the first run, this value amounted to 14.0 millimeters and on the second run, a similar value of 15.0 millimeters. These determinations are in accord with both tilt and horizontal angle determinations.

Since the lava inflow at Halemaumau in September, 1934 the NW Pit BM has showed a total relative lowering with respect to the Spit BM of 0.429 meters or 1.41 feet.

H. H. W.

Chain of Craters, Crack Openings*

At 6:00 am, May 28, 1938 a series of earthquakes of various intensities began to register on the seismographs of the Hawaiian Volcano Observatory. Many were strongly felt in the National Park Headquarters area. Within the ensuing 24-hour period well over 100 earthquakes were recorded as well as several hours of continuous tremor in the early stages of the disturbance. Accompanying this seismic activity were visible ground movements along pre-existing cracks in the Chain-of-Craters between Pauahi and Aloi, roughly four miles SE of Kilauea Crater. Definite evidence of these movements was produced by shattering of the hard surface of the Chain-of-Craters road at approximately 11 different localities. Slides occurred in Pauahi. The largest crack developed near Pauahi where a large section of the roadway was destroyed by caving. A few days later seismic conditions had returned to normal.

On the morning of August 8 at 2:14 o'clock, a similar crisis began. More earthquakes were recorded in the following 24 hours than had occurred in the corresponding period in May. Over 200 earthquakes occurred on August 8 alone. This time there were a number of shocks from Kilauea Crater, several from Hilina Pali and others at various points along the Chain-of-Craters but mostly concentrated near Kokoolau and Devil's Throat. Again visible evidence of the general area of disturbance was indicated by cracks across the Chain-of-Craters road; three groups near Devil's Throat and one near Hiiaka (SW rim). The cracks between Pauahi and Hiiaka showed no appreciable changes.

On August 10 seven representative cracks were chosen for measurement and numbered successively from the large crack (hump) near Devil's Throat to the last large crack near Aloi.

The list is as follows:

No. 101—At the "hump" about 1000 feet W of Devil's Throat.

No. 102—At W side of junction of Chain-of-Craters road with the Hilina Pali road.

No. 103—Near S rim of Hiiaka.

No. 104—Large crack near S rim of Pauahi.

No. 105—About 1000 feet SE of the Chain-of-Craters road and Ainahou Ranch road junction.

No. 106—About 50 feet SE of No. 105.

No. 107—About 750 feet W of W rim of Aloi Crater.

Table of crack measurements on Chain-of-Craters road. (Values in centimeters except No. 104 which is in feet, inches and sixteenths.)

Date	101	102	103	104	105	106	107
August 10	402.05	62.85	101.60	17'8- 8/16"	87.00	88.45	41.00
September 2	402.65	63.90	101.45	17'8-12/16"	87.10	88.60	40.90
October 7	402.80	64.00	101.40	17'8-14/16"	87.15	88.65	40.75
November 4	402.95	64.10	101.40	17'8-15/16"	87.20	88.65	40.65
December 2	403.00	64.10	101.45	17'9.0"	87.15	88.65	40.60
January 6	403.30	64.20	101.45	17'9.0"	87.05	88.65	40.50
February 3	403.45	64.25	101.45	17'9.0"	87.05	88.65	40.45
March 3	403.65	64.30	101.40	17'9- 1/16"	87.10	88.65	40.40
March 31	403.70	64.40	101.35	17'9- 1/16"	87.15	88.65	40.40
Total change in mm.	+16.5	+15.5	—2.5	+10.0	+1.5	+2.0	—6.0
	plus (+)=open			minus (—)=close			

The indications from the above figures are that the greatest amount of movement has been and continues near Devil's Throat with next highest rates of change at Pauahi and Alai respectively.

These measurements are to be continued and will be reported regularly.

H. H. W.

* See Volcano Letter 462, August-December 1938 for map and description.

THE VOLCANO LETTER

No. 464 Department of the Interior National Park Service April-June, 1939

Edward G. Wingate Superintendent
Hawaii National Park

Hawaiian Volcano Observatory
T. A. Jaggar Volcanologist

HAWAIIAN VOLCANO RESEARCH ASSOCIATION
in cooperation with
UNIVERSITY OF HAWAII

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TIME CONTROL FOR SEISMOGRAPHS OPERATED BY THE HAWAIIAN VOLCANO OBSERVATORY

HUGH H. WAESCHE, Asst. Geologist

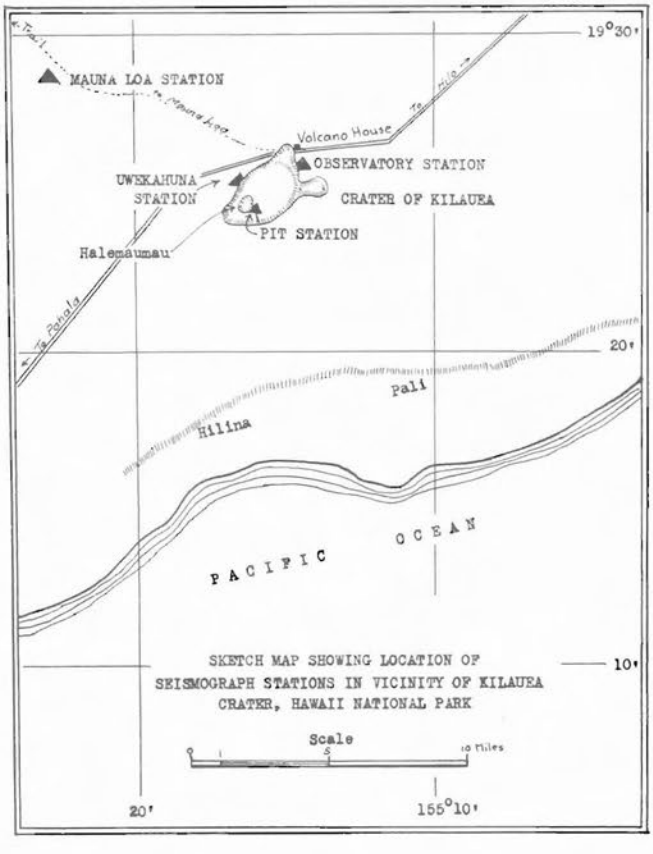
A major problem concerning the operation of any group of seismograph stations is the time control. This is important for widely separated stations but becomes of increasing value for studying travel times between stations separated by distances from one mile to several hundred miles where time errors of tenths of seconds may produce relatively large error in determining earthquake focii.

At Kilauea, seismographs are located at the Observatory, NE rim, Uwekahuna, NW rim and at the SE rim of Halemaumau (see map). At the Observatory there are three instruments, the Bosch-Omori, a vertical component and a low magnification instrument of special design. The entire group has always had a common time control, originating from a pendulum clock (Howard) equipped with electrical contacts for closing the circuit on the fifty-ninth second and breaking on the sixtieth second of every minute and closing for ten seconds during the first minute of each hour. Proper correction of clock is maintained by comparison with radio time signals from NPM and NPG daily at 4:30 pm, H.S.T.

The writing pens are lifted off the smoked drums by a solenoid supported in front of and slightly above each needle. This system has been the most satisfactory method found for indicating the time on the smoked paper. It is true that occasionally important phases are missed in an earthquake but this occurs far more rarely than might be suspected and indicates the time in a reliable manner. The Bosch-Omori low magnification and Uwekahuna recording drums have minutes 50 millimeters in length; all the other records have minute lengths of 30 millimeters.

Individual time clocks were installed at Halemaumau and Uwekahuna as well as in the outlying stations at Hilo and Kealakekua. A station using the same system was installed on Mauna Loa in October, 1938. The latter is located about 10.0 miles NW of the Observatory. None of these stations had radio sets for time corrections and were unattended except for daily visits to change the recording drums.

In 1931 Mr. A. E. Jones began studies of travel times in

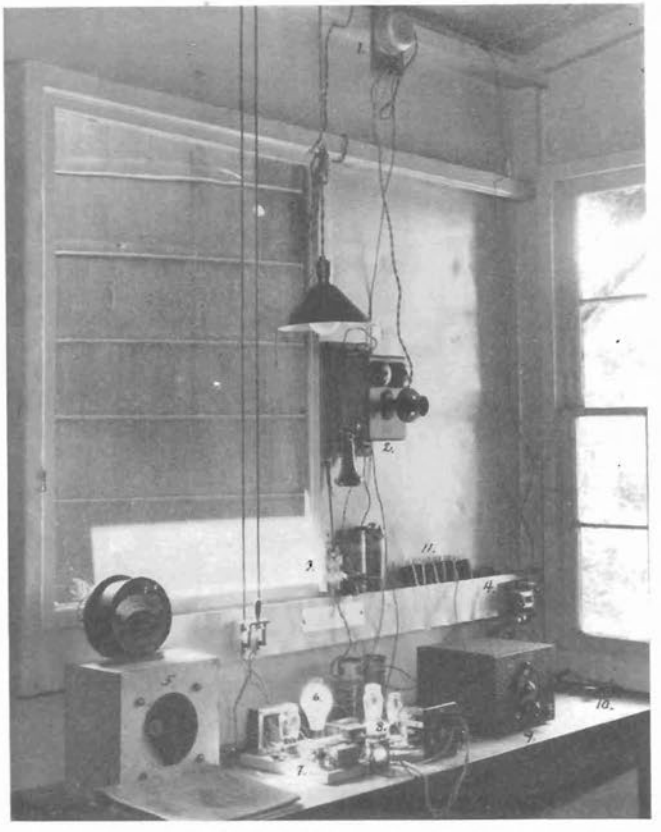


the Hawaiian Islands. Before this, travel times developed by Omori for local shocks in Japan had been used. Mr. Jones found that the Omori travel times did not agree with the seismic facts in Hawaii so immediately set to work developing a set of travel times for the Island. He succeeded in doing this very ingeniously as described in his paper "Hawaiian Travel Times", published in the Bulletin of the Seismological Society of America in January, 1935. During these studies, time comparisons between the Pit and Uwekahuna clocks were made with the clock at the Observatory using a stop watch carried between stations daily. Time corrections at Hilo and Kona were made by listening to the time tone and then as nearly as possible synchronizing this by manual operation of a key which transmitted a signal over the mutual telephone lines to those stations. Lags and other errors of the personal equation as well as unreliability of time clocks in the outlying stations made the system only partially successful and by 1937 all attempts at time control have been given up other than for S-P determinations based on the known speed and dimensions of the recording drum and at the Observatory where close watch could be kept on clocks and radio.

As more earthquakes were recorded, however, there came the conviction that good, reliable time control with all the stations exactly correlated with the clock at the Observatory was a necessity. There was still considerable doubt as to the speed of the compressional and transverse waves from various parts of the Island and earthquakes with good preliminaries at all stations still did not give satisfactory solutions when locations were attempted. Consequently, various plans were considered, varying from radio control from the central station to direct wire connections. Little was done because of the expense of the necessary equipment.

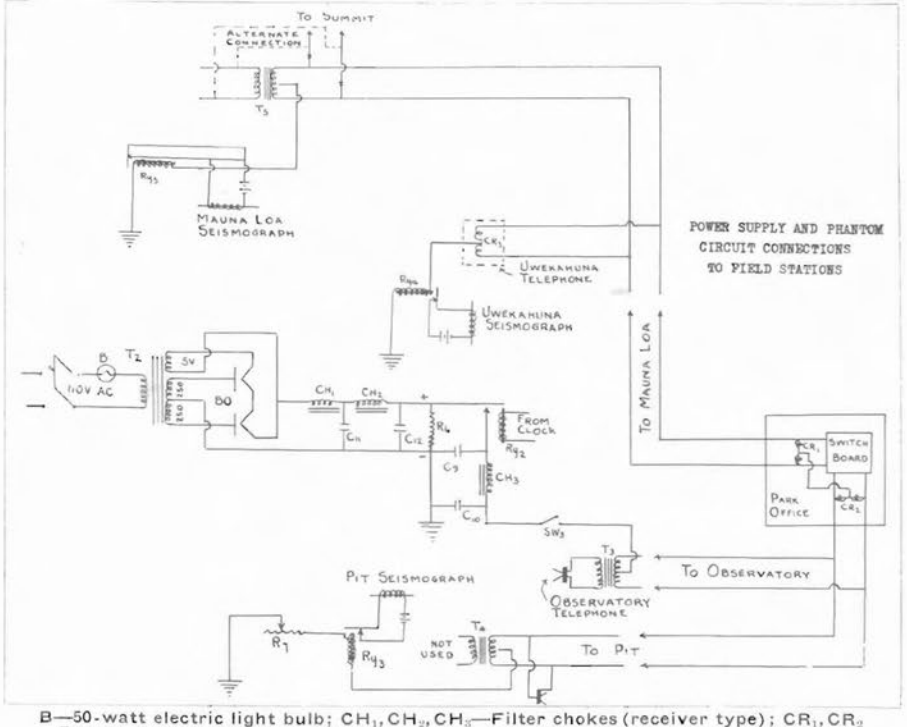
The first step was made in December, 1936, when a sensitive relay and vacuum tube amplifier to operate it were added to the regular short wave receiver then in service. About the same time a rectifier was added to the set, thus utilizing the Hilo power, 110 volts A.C. Previously batteries had been used but had proved expensive. The radio-operated sensitive relay closed the same circuit operated by the time clock and thus indicated the position of true time with reference to the nearest minute. Every day time was checked at 4:30 pm, by an operator tuning the set to the 12,885 kc frequency of NPG or NPM. This was highly successful and probably gave a time correction at the Observatory well under 0.5 sec. for all the instruments operated in that building.

About one year after the relay was installed, the 10,000-ohm coil winding burned out. A new 5,000-ohm coil was wound and operation resumed with little change in the sensitivity of the relay. In attempting to make some mechanical changes in the relay during April of this year, the coil was injured beyond repair. Rather than rewind the relay and take chances on its burning out again, a new relay was constructed, using two 1,250-ohm telephone ringer coils in series. This relay proved sensitive enough (closes on about 0.5 milliamps) and has the added

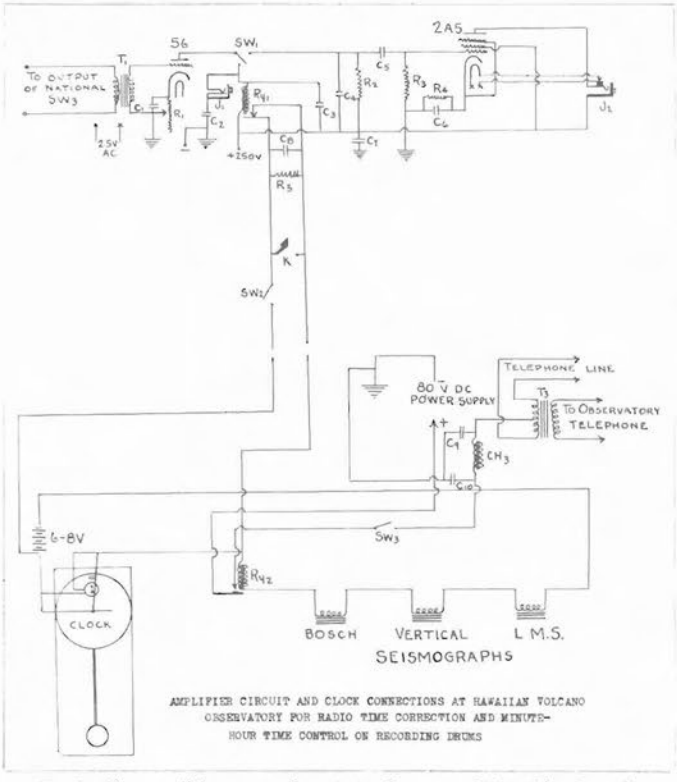


TIME CONTROL STATION AT THE HAWAIIAN VOLCANO OBSERVATORY

1. Observatory repeating coil; 2. Test telephone set; 3. Anne-mometer switch; 4. Sensitive time relay connected to radio receiver; 5. Loud speaker; 6. 50-watt ballast bulb in series with power transformer; 7. Power unit and rectifier for operation of time control system; 8. Power and amplifier unit for radio receiver; 9. National SW3 radio receiver; 10. Key for manual control of circuits; 11. Wave band coils for radio receiver.



B—50-watt electric light bulb; CH_1, CH_2, CH_3—Filter chokes (receiver type); CR_1, CR_2—Double sets of 800-Ohm telephone ringer coil; CR_3—Ringer coil on Uwekahuna telephone; T_2—Power transformer 250-250 secondary and 5 V for rectifier; T_3, T_4, T_5—Repeating coils; Ry_2—Relay of low resistance in Observatory circuit; Ry_3, Ry_4, Ry_5—1250-Ohm relays at seismograph stations; SW_3—Single pole, single throw switch for cutting off phantom circuit; $C_9, C_{10}, C_{11}, C_{12}$—8 mfd filter condensers; R_6—50,000-Ohm bleeder resistor; R_7—5000-Ohm wire wound variable impedence (not found necessary).



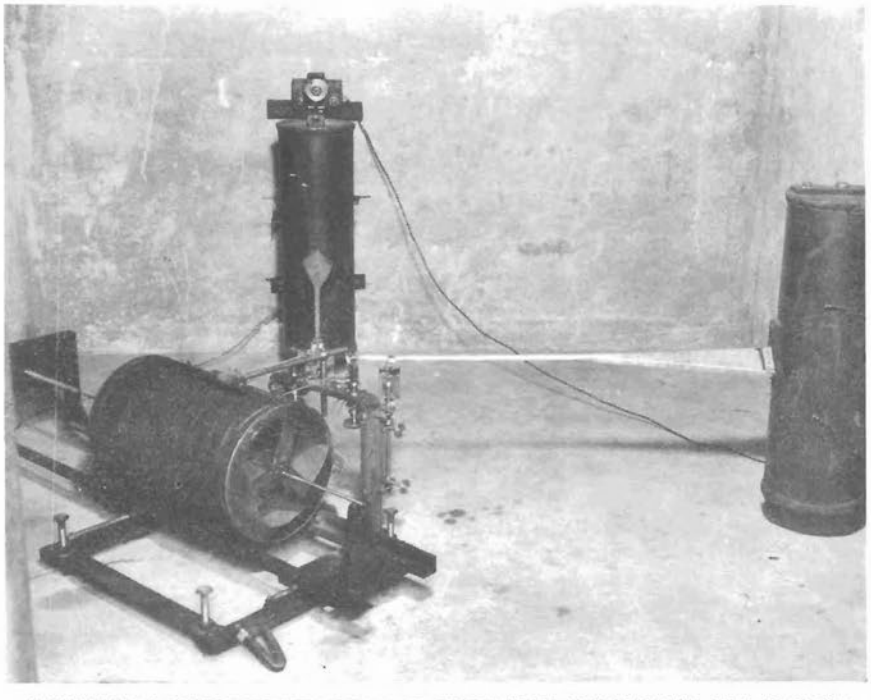
AMPLIFIER CIRCUIT AND CLOCK CONNECTIONS AT HAWAIIAN VOLCANO OBSERVATORY FOR RADIO TIME CORRECTION AND MINUTE-HOUR TIME CONTROL ON RECORDING DRUMS

T—Audio-amplifier, coupling transformer; SW_1—Single pole double throw toggle switch; J_1, J_2—Jacks for connecting speaker; C_1—4 mfd; C_2—0.2 mfd; C_3—0.1 mfd; C_4—0.002 mfd; C_5—0.1 mfd; C_6—10 mfd; C_7—0.25 mfd, relay sparking filter; C_8—0.5 mfd; R_1—50,000-Ohm potentiometer DC component control; R_2—30,000-Ohm 1 watt carbon; R_3—75,000-Ohm 1 watt carbon; R_4—300-Ohm 2 watt carbon; R_5—500-Ohm 1 watt carbon relay sparking filter; Ry_1—Home-made relay 2500-Ohm; K—Key for manual operation; SW_2—Single pole single throw switch to disconnect amplifier from clock; SW_3—Single pole single throw switch to disconnect power from telephone line; C_9, C_{10}—8 mfd electrolytic filter condenser; Ry_2—Relay operated by clock circuit, closes time circuit to other stations; T_3—Repeating coil.

advantage of having readily replaceable coils of which there always are some in stock as the Hawaii National Park keeps a supply for replacement purposes in their telephones.

The U. S. National Park Service, for purposes of protection and convenience, operates its own telephones and necessary lines in the Park. There is a small exchange at Park Headquarters through which are connected three trunk lines, all of which are metallic, that is, two wire and ungrounded. One line is connected to the Observatory and also serves the southern part of the Park, including Halemaumau. A second line serves the Park employee, residential area and the third line serves Uwekahuna Museum, the Hotel, Military Camp and the Mauna Loa line extending to the summit. For some time these lines had been thought of as potential connecting links between the seismograph stations with direct time control from the Observatory clock. A plan was evolved using center tapped resistors across the line, one at the Observatory and one at the Pit seismograph station. This would produce a phantom circuit on the metallic line with a ground return. A relay was to be activated by the clock simultaneously with the Observatory seismographs. The contact circuit of the relay would then be made to send a direct current of sufficient voltage over the phantom circuit to operate a relay at the Pit station. Theoretically this circuit would not interfere with the telephone circuits as the current on the metallic line would be balanced and moving in the same direction over the lines. Before trying this arrangement Mr. L. W. Branch, local manager of the Mutual Telephone Company, was consulted. His opinion was that such a circuit would be effective but recommended the use of standard telephone repeating coils instead.

In December two of the repeating coils were purchased from the telephone company. One of these was placed in the Observatory and the other was placed at the Pit and connected as indicated in the accompanying diagram. Ninety volts of "B" battery were the source of power. The trial was successful in that the time was transmitted and synchronized with the Observatory. However, it was discovered that each time the circuit was closed or opened, an unbearably strong popping noise was heard on all phones on that line or others connected through the switch-board. A filter circuit consisting of the conventional 8 mfd condenser—filter choke and 8 mfd of condenser inserted in the phantom alleviated the situation so that the phones were usable; but this did not completely clear up the situation. The lines were undoubtedly either unbalanced or one wire was grounded. Furthermore, the batteries soon become exhausted. As batteries were short-lived and therefore impractical a power pact similar to those used regularly on radios was constructed. This was connected to the regular 110-volt A.C. power. The transformer was that from an old radio receiver and an 80 rectifier tube was used. A 50-watt electric light bulb was hooked in series with the primary of the transformer as an indicating device and safety precaution in case any of the circuits should become shorted. The flash of this bulb every minute showed that the circuit was operating and continuous bright glow of the bulb showed that something was wrong with the circuit. When the high voltage power was idling and only the filament current for the rectifier



MAUNA LOA SEISMOGRAPH STATION SHOWING LARGE DRUM FOR 48-HOUR CONTINUOUS OPERATION. N-S COMPONENT TO RIGHT; E-W TO LEFT.

tube was being drawn, only a dull red glow showed from the bulb in the darkness.

For about three months the test circuit operated consistently but the disturbance to the phones, though not bad, continued. Finally the relay at the Pit stopped. Current tests showed that the line drew 150 milliamperes. It was evident that at least one line was shorted. A careful check showed that the short was at a place near the Pit station, where insulation had been worn from a wire running through a portion of the line which had been put in a pipe below ground. Correction of this fault cleared the telephones of all noise and the relay responded vigorously. The trial circuit was then a complete success and the Pit station was considered permanently time-coupled to the Observatory.

The problem was now to add the Mauna Loa and Uwekahuna stations to the circuit. This could be done by putting repeating coils at the switch-board terminals of the Observatory-Pit line and the Mauna Loa line. A repeating coil with one side of the transformer burned out was available in the Park. Cost of more transformers made them impractical. The burned out transformer was placed at the Pit and the good side used. The transformer from there was transferred to the Mauna Loa station. To offset the lack of repeating coils at the switchboard two sets of two 800-ohm ringer coils were used. One set was connected across the Mauna Loa line and the other set across the Observatory line. The two coils in each set were connected in series. This connecting wire was equivalent to a center tap so a jumper was connected from the link on one pair of coils to the link on the other. This made a phantom circuit path for the time signal whether the two lines were directly connected through the switchboard or not. Effective resistance across the metallic line was that of two telephones at 1,600 ohms each, but offered only a total of 800 ohms in the timing circuit. The relays at the Pit and on Mauna Loa had 150-ohm coils. They were replaced by 1,250-ohm telephone ringer coils. This made them much more sensitive and reduced current consumption materially and even allowed for considerable current loss through line leakage in wet weather or from other causes.

A third relay patterned after the one at the Pit was installed at Uwekahuna. No more repeating coils were available so the phantom circuit was tapped from the connecting link between the two ringer coils on the regular Uwekahuna telephone. This was found to be a satisfactory arrangement with the relays responding consistently and without interfering in any way with the telephone service.

With the telephone lines clear all three relays in the circuit operating and a 50-watt bulb in series with the power transformer primary, the current drawn is 60 milliamperes at about 80 volts.

The results have been very gratifying. The only interruption was caused by an accidental short on the line to Mauna Loa by linemen placing a grounded cable against a guy wire which in turn was bent across a service line. When this short was in existence, the Mauna Loa and Uwekahuna relays responded only when the switchboard was connected through from 4:00 pm to 8:00 am, daily. A few days before the short was discovered, all the relays were out of operation. Since this trouble was cleared up the circuit has performed perfectly.

No careful studies have been made of the results on the seismograms yet, but preliminary observations indicate that the arrangement is extremely worthwhile and gives direct time correlation for the entire circuit. Extra work involved in making time corrections has been eliminated and the uncertainty of S-P values has been corrected.

The remaining problem now is to obtain accurate time correlation for the Hilo and Kona stations. Specially designed semi-automatic radios have been requested and it is hoped they will be available in the near future. There will be much value and satisfaction to a completely coordinated set of seismograph stations. When this is accomplished accurate travel times for the area may be determined and possibly more knowledge obtained of the underground structure in Hawaii.

Hawaiian Volcano Observatory Report for April-June 1939

VOLCANOLOGY

April 1939

The Volcanic Observatory recorded a cold and rainy April, with low seismicity and some Halemaumau slides. A rock slide from the northwest wall of Halemaumau occurred at 9:50 a.m. April 5 and several unusually large newly fallen boulders were seen at the foot of the northeast talus at 10:00 a.m. April 7. On April 16 a slide from the southwest rim at 9:32 a.m. continued for about five minutes. It left a mark on the Pit wall and produced tremor at the Halemaumau seismograph. Marks on the Pit walls indicated other slides.

Crack measurements at the twenty-eight marked localities around Halemaumau showed decline from the measurements of March during the first week of April, there was increase of opening the second week, and thereafter the crack movement notably declined and for the whole month there was strong decrease of crack-opening.

Mauna Loa was visited by the northeast trail April 20, and no visible changes in the conditions of that volcano were observed.

Of the sixty-six shocks and tremors registered on the seismographs for April, fifteen were located by seismometric method, and of these eleven were under Kilauea mountain, three were Mauna Loa and one was Hualalai.

The following are the local data for April:

Week Ending	Halemaumau Slides	Halemaumau Crack Openings	Seismic Disturbances
April 9	2	6.0 mm.	19
" 16	1	10.5 mm.	16
" 23	0	3.0 mm.	18
" 30	0	2.5 mm.	13

May 1939

The month of May appears to have been strongly seismic and volcanic all over the world with press reports of a destructive earthquake in Japan and of increase of volcanic activity in Alaska, Costa Rica, Italy and Java. Hawaii showed steady increase of numbers of earthquakes reaching a peak of seismic activity May 31 with three strongish shocks near Hilina Pali and Kilauea. Exceptionally strong tides with high waves altered the black sand beach at Kaimu May 19 and 20, measured cracks near Chain-of-Craters road both opened and closed, relative height of the road humps on this road increased, and slides occurred at Makaopuhi, Devil's Throat and Hilina Pali.

Rock slides occurred in Halemaumau at northwest rim 8:47 a.m. and 9:02 a.m. May 3. At 12:47 p.m. May 11 a slide fell from the northwest wall. The strongish earthquake of 10:27 a.m. May 15 was accompanied by slides from the northern and western walls 10:28 a.m. and 10:29 a.m. Sliding at northwest wall occurred 11:23 a.m. May 15. Along

with earthquakes approximately fifteen slides occurred in Halemaumau as follows:

May 23, southwest wall, 2:14 and 2.31 p.m. ;
24, northeast and northwest rims 1:11 p.m. and north rim 2:30 and 5:50 p.m.;
26, north wall, 8:17, 8:20, 8:40 a.m. and 4:29 p.m.;
27, northwest rim, 2:20 and 2:40 p.m.;
28, northern rim, 8:38, 8:59, 10:15 and 11:05 a.m.

At Makaopuhi Crater a scar indicating fresh slide from the north rim was seen on May 5, and the Devil's Throat continues to fracture and break away along the west and north rims. Several slides from the cliffs in the Hilina Pali region occurred about 2:05 p.m. May 18.

Of one hundred eighty-four seismic disturbances twenty-three indicated place of origin. Of these, six were from Kilauea, six from Hilina Pali and six from Mauna Loa. One each was from Hualalai and Chain-of-Craters. One was near Honolulu, one west of Maui and one from Mountain View.

The following are the local data for May:

Week Ending	Halemaumau Slides	Halemaumau Crack Openings	Seismic Disturbances
May 7	2	7.5 mm.	12
" 14	1	3.5 mm.	38
" 21	3	13.0 mm.	39
" 28	15	8.5 mm.	95

June 1939

After the second week of June the seismic activity dwindled. The maximum of the different types of activity, including seismic frequency, was the second week of June, but the greatest intensity of quaking had been at the end of May. A strongish shock occurred June 12 and another June 19, both fairly deep under Kilauea; a peculiar shock June 24 was like a blast, of shallow origin under the northeast rim of Kilauea crater. Of late, Veniaminof has been active on the Alaskan peninsula, Poas and Irazu volcanoes in Costa Rica, Vesuvius excited some press report, and so did Krakatoa. Eleven distant earthquakes have been registered from New Caledonia, northeastern Asia, Solomon Islands, Lower California, Aleutian Islands, Tonga Islands, and a near shock about ninety miles from us.

Rock slides at Halemaumau were reported June 7, north wall, 12:53 p.m.; June 8, northern walls, 12:53 p.m.; and from northwest wall on June 9; June 14 a slide wth large boulders from high up west wall 3:25 p.m. Dust clouds indicated slides at northwest wall June 12, 1:36 p.m.; June 16, 2:12 and 2:13 p.m. A slide from northwest wall was reported June 26 11:15 a.m.

That the working of the fault benches southeast of Kilauea is a distributed movement was shown by discovery June 12 of a fresh landslip on Pali Lele O Kalihipaa four miles south of the center of Kilauea.

Of a total of three hundred thirty-seven local seismic disturbances in June, thirty-one had their centers located, of which twenty-two were under Kilauea, five along Chain-of-Craters, three at Hilina Pali and one between Kilauea and Hilo. It is remarkable that Mauna Loa and Hualalai were not heard from. There was some seismic activity near Maui.

The following are the local data for June.

Week Ending	Halemaumau Slides	Halemaumau Crack Openings	Seismic Disturbances
June 4	0	8.5 mm.	36
" 11	3	10.5 mm.	124
" 18	8	4.5 mm.	88
" 25	0	4.0 mm.	58
July 2	1	5.5 mm.	31

T. A. J.

SEISMOLOGICAL AND GEODETIC DATA

Earthquakes

Date	Minutes of Tremor	Very Feeble	Feeble	Slight	Moderate	Distant*	Weekly Seismicity†
April 9	16	3	0	0	0	1	5.50
" 16	11	3	0	2	0	0	8.25
" 23	15	3	0	0	0	3	5.25
" 30	10	3	0	0	0	1	4.00
May 7	11	1	0	0	0	1	3.25
" 14	35	2	0	1	0	1	11.75
" 21	34	4	0	0	1	0	14.50
" 28	85	7	0	1	2	0	33.75
June 4	28	5	0	1	2	1	17.50
" 11	102	21	1	0	0	2	37.00
" 18	72	12	1	2	1	0	33.00
" 25	49	6	0	2	1	0	23.25
July 2	30	0	0	0	1	0	11.50

* Including teleseisms or earthquakes over 5000 km from Kilauea.
† For local seismicity definition see Volcano Letter 371.

Epicenters of the following local disturbances were determined by means of seismograms from the stations operated by the Hawaiian Volcano Observatory on the island of Hawaii. Kilauea earthquakes were located by means of the main seismograph station at the Observatory and the two subsidiary stations at Uwekahuna and the SE rim of Halemaumau respectively. The more distant shocks were located with the aid of seismograms from Hilo and Kealakekua. The disturbances began at the time indicated and, whenever possible, a determination of depth of focus has been made.

April 4, 9:03 pm, very feeble, probably originated near center of Kilauea Crater.

April 5, 3:04 am, very feeble, 3.0 miles deep, Kilauea near W rim of Halemaumau (SW rift). 19° 24.6'N; 155° 17.8' W.

April 6, 9:09 pm, very feeble, Mauna Loa NE rift near Puu Ulaula.

April 12, 4:18 am, slight, 18.0 miles deep NE slope of Kilauea about midway between the crater and Glenwood. 19° 27.0' N; 155° 14.0' W. Reported felt in Hilo, Olaa and Hawaii National Park.

April 13, 2:53 pm, very feeble, probably originated in Twin Craters area E rim of Kilauea Crater.

April 15, 9:48 pm, slight, felt by many persons in Hawaii National Park. Located 1.3 miles deep in Kilauea Crater, NE rim of Halemaumau. 19° 25.0' N; 155° 16.9' W.

April 16, 6:14 pm, very feeble, probably originated in Hilina fault system S of Makaopuhi Crater.

April 16, 10.57 pm, very feeble, probably of shallow origin near center of Kilauea Crater.

April 17, 1:08 pm, very feeble, of Kilauea Crater origin, near center.

A shock was reported felt in Hilo at 10:24 pm, April 17. This corresponded with the registration time of a tremor at the Observatory. It apparently originated 13.0 miles from Hilo in the NE rift of Mauna Loa.

April 20, 6:42 am, very feeble, Kilauea Crater near NE rim of Halemaumau.

April 20, 8:49 am, very feeble, NE portion of Kilauea Crater.

April 24, 2.51 pm, very feeble, Kilauea SW rift about 18.0 miles from Kilauea near sea.

April 25, 2:21 am, very feeble, 22.0 miles deep under Hualalai area. 19° 41.5' N; 155° 46.0' W.

April 29, 9:57 pm, very feeble, Mauna Loa NE rift, 5.0 miles deep and 5.0 miles NE of the summit crater. 19° 31.6' N; 155° 26.0' W.

May 1, 5:15 pm, very feeble, originated under Halemaumau.

May 8, 7:03 am., slight, probably originated in Hilina fault system about 20.0 miles deep and 4.0 miles S of Makaopuhi Crater.

May 11, 7:51 am, very feeble, probably originated 7.0 miles under Kilauea Crater.

May 13, a tremor at the Observatory recording at 3.32 pm corresponded with time of an earthquake reported felt in Honolulu.

May 14, 5:37 am, very feeble, of Kilauea Crater or Chain-of-Craters origin.

May 15, 10:28 am, moderate to strong, strongly felt over entire Island of Hawaii with exception of Kohala district. Probably most strongly felt in Hilo where there was slight damage to some masonry structures and plaster work. Also quite strongly felt in Hawaii National Park. Located 10.0 miles deep, 2.5 miles E of Makaopuhi Crater. 19° 22.0' N; 155° 08.0' W.

May 18, 8:48 pm, very feeble, 10.0 miles deep in Hilina Pali area, 4.0 miles S of Makaopuhi. 19° 19.0' N; 155° 9.0' W.

May 20, 2:05 am, very feeble, Kilauea Crater near NE rim of Halemaumau.

May 20, 10:18 am, very feeble, probable origin, Hilina fault system about 4.0 miles S of Puu Huluhulu.

May 23, 2:14 pm, moderate to strong, felt over entire Island of Hawaii and registered on University of Hawaii seismograph at 2h 16m 03s pm. All instruments at the Observatory except the strong motion seismograph were dismantled. Subsidiary stations at Hilo, Kona on Mauna Loa and around Kilauea Crater likewise were dismantled. Source of origin was apparently 7.5 miles NW of Kilauea Crater from a depth of 12.0 miles. 19° 28.5' N; 155° 22.0' W.

May 24, 12:59 pm, moderate to strong. Similar to quake of preceding day in that it was felt throughout Island of Hawaii and dismantled all seismographs except strong motion instrument at the Observatory. Registered at Unversity of Hawaii, Honolulu, "S" wave at 01h 00m 29s pm. Location 15.0 miles deep, 2.5 miles SE of Observatory, E rim of Kilauea Crater. 19° 25.0' N; 155° 14.0' W.

May 24, 1:09 pm, slight, probably same epicenter as preceding but possibly 5.0 miles deeper.

May 25, 3:39 am, very feeble, probably originated in Hilina fault system.

May 25, 8:54 am, very feeble, probable epicenter same as moderate shock of May 23, 2:14 pm.

May 26, 10:40 pm, very feeble, probable origin, Hualalai.

May 27, 4:29 pm, very feeble, probable origin, about 5.0 miles from Summit Crater, Mauna Loa, NE rift, about 8.0 miles deep.

May 28, 3:48 am, very feeble, probable origin, about 15.0 miles under Mauna Loa Summit Crater.

May 28, 6:34 am, very feeble, probable origin, Mauna Loa SW rift, 15.0 miles under area near 1907 source cones.

May 29, 7:15 pm, very feeble, registered on Honolulu seismograph "P" wave at 07h 15m 09s pm. Reported widely felt on Oahu and on Maui. Located 20-30 miles deep, 90.0 miles S of Lanai, 19° 30' N; 156° 50' W.

May 29, 11:45 pm, very feeble, probable origin, Chain-of-Craters near Devil's Throat.

May 31, 3:10 pm, moderate to strong, 11.0 miles deep in Hilina fault system, 8.0 miles S of Kilauea iki. Dismantled seismographs at Observatory and Pit but no others. 19° 18.5' N; 155° 14.5' W. This shock was peculiar in that there were no reports of it being felt. Members of the Observatory staff were conscious that earthquake was taking place through a special electric signal system, yet experienced no sensation of earth motion.

May 31, 8:38 pm, slight, felt in Hilo and Hawaii National Park, 12.0 miles deep, Mauna Loa NE rift, 13.0 miles SW of Hilo. 19° 37.5' N; 155° 15.5' W.

May 31, 8:51 pm, moderate to strong, reported felt throughout Kau and Hilo districts as well as other parts of Island of Hawaii but was particularly strong in Hawaii National Park and moderately so in Hilo. Location of source of origin, 11.0 miles deep, area 4.0 miles W of Mountain View. 19° 34.0' N; 155° 10.5' W.

June 2, 11:38 am, very feeble; Hilina fault system near SW rift was probable origin.

June 5, 2:06 am, very feeble, probable origin, under Kapoho area about 7.0 miles E of Pahoa, E extremity of Island.

June 5, 7:01 pm, very feeble, probably originated under sea floor off SE coast of Hawaii near Kalapana.

June 6, 4:07 pm, very feeble, 4.0 miles deep in Kilauea SW rift at Crater Junction. 19° 24.1' N; 155° 18.0' W.

June 7, 1:34 pm, very feeble, origin similar to that of moderate quake of 3:10 pm, May 31.

June 7, 10:47 pm, very feeble, NE portion of Kilauea Crater.

June 8, 10:45 pm, very feeble, 1.1 miles deep, 1.0 mile W of Puhimau Crater. 19° 23.6' N; 155° 15.9' W.

June 9, 2:25 am, very feeble, 3.0 miles deep, 0.5 mile NW of Pit seismograph station, Kilauea Crater. 19° 24.8' N; 155° 17.1' W.

June 9, 9:29 am, very feeble, probably of relatively deep origin, Hilina Fault system, 10.0 miles SE of Observatory.

June 9, 2:06 pm, very feeble, of shallow origin, cracks 0.7 mile N of Puu Ohale. 19° 21.9' N; 155° 16.7' W.

June 10, 5.41 am, very feeble, 1.1 miles deep, E rim of Kilauea Crater in vicinity of Kilauea iki. 19° 25.0' N; 155° 15.6' W. Felt slightly by a few persons in Hawaii National Park.

June 10, 10:10 am, very feeble, about 3.0 miles deep, 1.0 mile SW of Kamokukolau. 19° 22.5' N; 155° 16.9' W.

June 10, 8:51 am, feeble, 3.0 miles deep, about 0.5 mile W of Ahua Kamokukolau. 19° 23.0' N; 155° 16.6' W.

June 11, 11:18 am, very feeble, probable origin deep under Hilina fault system about 8.0 miles S of Observatory.

June 11, 10:45 pm, very feeble, 2.5 miles deep, about 2.1 miles W of center of Halemaumau. 19° 24.6' N; 155° 19.0' W.

June 12, 1:11 am, moderate to strong, 13.0 miles deep in Kau Desert area near Koae and Puu Ohale. Felt generally on the Island of Hawaii but apparently with greatest intensity in Hilo and Hawaii National Park areas. Dismantled Observatory, Pit and Mauna Loa seismographs.

June 12, 5.47 pm, feeble, 3.7 miles deep, 2.0 miles W of Pit seismograph under SW rim, Kilauea Crater. 19° 24.4' N; 155° 18.5' W.

June 12, 6:26 pm, very feeble, of shallow origin (0.5 mile ±), approximately 0.5 mile N of Uwekahuna. 19° 26.0' N; 155° 17.4' W.

June 13, 10:47 pm, very feeble, probably originated near SE rim of Kilauea Crater.

June 14, 1:04 am, slight, approximately 2.0 miles deep, Kilauea Crater between SE rim of Halemaumau and SE rim of Crater. 19° 24.5' N; 155° 17.8' W.

June 14, 2:06 am, very feeble, probably originated near SE rim of Kilauea Crater.

June 14, 6:27 am, very feeble, 2.3 miles deep, Kilauea SW rift near Cone Peak. 19° 23.7′ N; 155° 18.5′ W.

June 14, 10:02 am, slight, 2.1 miles deep, S rim of Kilauea Crater, 1.3 miles SE of Center of Halemaumau. 19° 23.6′ N; 155° 16.5′ W.

June 15, 3:18 pm, very feeble, 15.0 miles deep, S rim area of Kilauea Crater. 19° 23.5′ N; 155° 15.5′ W.

June 15, 5:46 pm, very feeble, probably originated near Kilauea iki.

June 16, 11:35 am, very feeble, Kilauea Crater origin near Halemaumau.

June 18, 5:12 pm, very feeble, of shallow origin near NE portion of Halemaumau.

June 19, 4:49 am, moderate, 15.0 miles deep in area E of Kilauea Crater approximately 2.0 miles SE of Observatory. 19° 25.3′ N; 155° 15.0′ W. Felt in Hilo and Hawaii National Park, where many persons were awakened. Dismantled E-W component of Bosch seismograph at Observatory and both components at Pit.

June 20, 4:10 am, very feeble, of shallow origin, Kilauea Crater near SE portion of Halemaumau.

June 20, 3:01 pm, slight, 13.0 miles deep, Puna rift near Makaopuhi. 19° 22.0′ N; 155° 10.0′ W.

June 24, 2:04 pm, slight, Bosch seismogram at Observatory indicated no S-P phase interval but began abruptly with "M" phase. In immediate vicinity of this station (Hawaii National Park headquarters) the shock was reported felt as a sudden vibration similar to that produced by nearby blasting. Many persons thought it actually was a heavy blast. On this evidence it was assumed the quake originated in the faulted area NE rim of Kilauea Crater. Examination of the Pit and Uwekahuna seismograms confirmed this assumption and the point of origin was so placed and considered of shallow origin. 19° 25.8′ N; 155° 16.6′ W.

July 1, 12:20 am, moderate, 11.0 miles deep, Chain-of-Craters near Puu Huluhulu and Alealea Crater. 19° 23.0′ N; 155° 11.5′ W. Reported felt by many persons in Hilo, where a large number were awakened. In Hawaii National Park the shock was reported felt as a prolonged and persistent swaying motion lasting 15 ± seconds. Here, too, a number of persons were awakened. E-W component of Bosch seismograph was dismantled as was the same component at Halemaumau.

Teleseisms

April 5, "P" waves began recording at 6h 21m 58s am, 3,755 miles from Kilauea. Reports from the Jesuit Seismological Association place the origin in the vicinity of New Caledonia. 27° S; 167° E.

April 17, unidentified portion at 8h 16m 33s pm.

April 20, "eP" at 6h 08m 17s pm, distance 3,630 miles. Jesuit Seismological Association reports 500 km deep, NE Asia. 48.6° N; 138° E.

April 21, "eP?" at 9h 42m 35s am, no distance determined and no reports from other localities received.

April 29, "eP" at 4h 34m 49s pm, distance 3,730 miles. Reports from U. S. C. and G. S. give origin as 11° S; 158° E. Solomon Islands.

May 2, "eS?", 3h 01m 26s am, U. S. C. and G. S. report—off coast of Lower California as place of origin. 29.5° N; 113.8° W.

May 9, "ePr?" at 9h 21m 27.0s pm, U. S. C. and G. S. location given as Aleutian Islands. 41° N; 179° W.

June 1, "iP" at 5h 15m 10s pm, no distance, no reports.

June 8, "eP" at 10h 24m 31s am, U. S. C. and G. S. reported location between Samoa and Tongas. 15° S; 173° W.

June 11, "eP?" at 5h 01m 13s ± am, no distance, no location reported.

On June 16, at 4:20 am, a tremor registered on the Observatory seismograph having the appearance of a near shock. Kona seismograms indicated a distance of 66 miles; the Mauna Loa seismograph indicated a distance of 93.0 miles.

Microseismic Motion

April

Light—10, 11, 13, 14, and 25.
Moderate—9, 12, 15, 16, 19, 21-24, 26-28.
Strong—3-8, 17, 18, 20, 29, 30.

May

Light—2, 6, 7, 19, 20.
Moderate—3-5, 8-13, 16-18, 21-31.
Strong—1, 14, 15.

June

Light—2-9, 13-16, 18, 21-30 inclusive.
Moderate—1, 10, 11, 12, 17, 19, 20.
Strong—None.

Time used throughout is Hawaiian Standard, 10h 30m slower than G. C. T.

Tilting of the Ground

The following tables show tilt by weeks recorded by the Observatory seismograph, NE rim of Kilauea Crater and at Halemaumau the algebraic sum toward or away from the Pit as indicated by tilt stations on the W and SE rims respectively.

At the Observatory the total accumulated tilt for the year ending April 30, was 4.0″ S and 5.35″ W.

For the year ending May 28, it was 3.92″ S and 4.75″ W.

For the year ending July 2, it was 3.75″ S and 2.6″ W.

Table of Tilt

Week Ending	Observatory	Halemaumau West Station
April 9	1.61″ S 83° W	1.85″ N 5° E
" 16	0.93″ N 72° E	3.73″ N 87° W
" 23	0.25″ N 83° E	1.49″ S
" 30	0.47″ S 60° W	2.53″ W
May 7	0.45″ N 22° E	6.11″ N 69° W
" 14	2.19″ S 61° W	7.09″ S 79° W
" 21	0.92″ N 73° E	11.62″ S 64° W
" 28	0.31″ N 25° E	15.44″ N 41° W
June 4	0.43″ N 19° E	3.37″ S 85° W
" 11	0.48″ N 36° E	3.99″ W
" 18	0.17″ N 45° E	11.18″ N 72° W
" 25	0.88″ N 11° E	4.41″ S 50° E
July 2	0.42″ N 21° E	11.62″ N 48° W

Week Ending	Halemaumau Southeast Station	Halemaumau Resultant
April 9	6.48″ N 63° W	5.97″ toward
" 16	15.91″ W	5.82″ toward
" 23	15.31″ W	9.09″ toward
" 30	6.12″ N 41° W	3.63″ toward
May 9	4.99″ N	1.62″ from
" 14	5.67″ N 21° E	3.93″ from
" 21	12.15″ N 40° E	7.96″ from
" 28	16.20″ N 86° W	1.59″ toward
June 4	16.85″ S 74° E	17.04″ from
" 11	8.42″ N 37° W	4.41″ toward
" 18	1.72″ S 41° W	10.46″ from
" 25	2.75″ N 11° W	4.75″ toward
July 2	6.45″ S 89° W	8.38″ from

Crater Angles

Measurement of horizontal angles across Kilauea Crater from the Observatory, April 15, indicated closing of both the Halemaumau and the Crater values compared with similar measurements of March 30. The Halemaumau angles between the Pit seismograph and the NW Pit BM closed 0.91". The crater angle between the SE crater rim station and Uwekahuna closed 1.16".

During May two determinations were made of the same angles. These were May 6 and 26. On May 6 the Halemaumau angle had opened 1.59" and the Crater angle had closed 1.17". Between May 6 and 26 the Halemaumau angle closed 0.34" and the Crater angle opened 0.75". Total change for the month, Halemaumau angle opened 1.25" and the Crater angle closed 0.42".

Angle values determined June 17 indicated closing of the Halemaumau and closing of the Crater angle. Halemaumau value decreased 3.33". Crater value decreased 0.38".

Total change at Halemaumau, March 30 to June 17, 2.99", closing; across Crater 1.16" closing.

Chain-of-Craters Road Cracks

Date	101	102	103	104	105	106	107
April 28	403.70	64.40	101.35	17'19/8	87.15	88.60	40.35
June 2	404.00	64.40	101.45	X	87.20	88.60	39.75
June 30	404.35	64.50	101.45	X	87.25	88.75	39.70
Total change in mm.	+ 6.5	+ 1.0	+ 1.0	——	+ 1.0	+ 1.5	—6.5

Plus (+) = open. Minus (—) = close.

In 104, near Pauahi was temporarily discontinued. Large size makes it difficult to measure but determinations will be resumed in near future.

There was no change between March 30 of last report and April 28 of this report.

It is obvious that these cracks were greatly accelerated in their openings during the month of May, when seismic activity likewise increased. Cracks around Halemaumau showed relatively large increase in same period. This demonstrates the probability that the cracks around Halemaumau, although greatly activated by gravity, are also moved by volcanic changes, i.e., seismic changes.

H. H. W.

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EXPEDITION TO LAVA-BOMBING SITE

T. A. JAGGAR

This expedition to the north slope of Mauna Loa was conducted by the volcanologist of Hawaii National Park in cooperation with the Territorial Department of Forestry and Agriculture. The scientific members of the party were T. A. Jaggar, L. W. Bryan and H. H. Waesche. Cordial assistance came from Parker Ranch through Joseph Ignacio, who prepared trail and camp ground at 7,000 feet elevation on the north slope of Mauna Loa. The objects were to photograph the exact spots where bombs fell to deflect the 1935 lava flow, to delimit the flow area, to note the bomb effects, to map some older flows and to start a campaign to study more closely Mauna Loa on its danger slope above Hilo.

Fig. 1—Bomb crater with upstanding edges and pahoehoe ring and torrent of released lava; Target 2, elevation 8,200 feet. Arrow shows crater. Photo by Jaggar.

Camp was made August 30, 1939; the Bryan party studied the middle of the flow September 1 and the source region at 8,900 feet September 2. The Jaggar party joined them, and mapped and photographed the bomb craters September 3 and 6, taking color and monochromatic pictures. On September 5 a study was made of the 1899 flow about 8,000 feet, and on September 7-8 a heavy black aa flow in contact with the 1935 flow on its east side was found to be very fresh and to check perfectly in age and position with the western 1880 flow, **never hitherto mapped,** but described succinctly by Coan, Baker and Hitchcock as sweeping from Puka Uahi twelve miles towards Mauna Kea the first week of November 1880. This becomes of very great importance in studying the source of the 1935 Humuula flow that was bombed, for the 1935 outburst was between this relatively recent flow and the 1843 flow and was guided by the depression between them. The contact between the aa lavas of this 1880 branch and 1935 was found, 1935 red and free from vegetation, 1880 black with some lichens and with large concretionary "snow-ball" boulders on its surface (Figure 8).

The exploration of the bomb craters was started by Forester Bryan and carried forward by Dr. Jaggar, Mr. Waesche and Ranger Jess, so that most of the twenty demolition bombs dropped by the army squadrons were accounted for in the mile of lava-source cracks and tunnels between Target A and Target B. (See Volcano Letter 442.) Fragments of shrapnel, rusty red, were found in profusion; several of the "pointer" bombs of black powder and sand were discovered; one large "dud" bomb was found with end torn off and several hundred pounds of TNT exposed (Figure 3); and pieces of casing, vanes, covers and detonator tubes were picked up (Figure 6). The pointer bomb casings contained Hilo beach sand. The TNT was lighted and burned, first piecemeal, then as a whole with a newspaper fuse, while the party retreated down the mountain. After twenty-five minutes of flame and black smoke, the remains of the explosive were detonated by the fire perhaps reaching the war-head mechanism, and a quarry blast ended the perform-

Fig. 2—Bomb crater in old lava; near Target 1, elevation 8,800 feet. Photo by Stearns.

ance. The place was revisited and photographed by Mr. Jess, who found a 3-foot depression, and fragments 100 feet away.

About sixteen of the bomb-holes were identified, one a perfect oval one hundred feet long by forty feet wide, crowned by a ring of upturned fragments of the rim, the interior a pit forty feet deep to a lava tunnel below. Liquid lava had splashed up and out in great sheets and gushes of molten glass. Seventy-five per cent of the holes found had exposed liquid lava. Four holes were off the stream line and in pairs, making bomb craters of broken rock (Figure 2), circular soucers twenty feet across and six feet deep.

In one case melted glass clung to shell fragments. In another a winged bomb had plunged through a thin crust, possibly into liquid lava (Figure 4), and was intact, its nose exposed protruding down into a tunnel below. Great blobs of glassy lava lay on the surface of pahoehoe silvery tongues, where explosions had flung them high. Rivers of liquid lava had escaped from some of the deep tunnel punctures, where the explosion had opened the tube. Other places had halos fifty or sixty feet wide, platforms of black glass, around an immense circular hole, where the bomb had released an artesian well of lava. The edge of the hole was scalloped like a tiara (Figure 4). The upper Target A was thickly strewn with pieces of rusty steel, from a quarter-inch to ten inches across, thin and thick, terribly jagged shrapnel torn from the big 600-pound shells like so much pasteboard.

The source region one mile below its upper limit had been studied by Jaggar and Waesche on foot in March 1936. They had found the lower bomb-craters, recognized the slabs and upwellings, but had not found any iron fragments. The actual source at Target A is a channel twenty feet across bordered by a bank of froth lava, meandering slightly, and lined

Fig. 3—Demolition bomb fragments with protruding TNT; near Target 1. Photo by Waesche.

Fig. 4—Pointer bomb of black powder near Tarket 1 with nose in cavern beneath; and Forester L. W. Bryan. Photo by Jaggar.

by a glassy pahoehoe floor, with windows revealing frozen streams and tunnel beneath. This channel begins abruptly at a ten-foot inclined shaft and transverse cracks. Up the mountain is a hill or flow-front of pasty-mixed lava of non-identifiable age. Down the mountain the torrent flowed in the channel, sometimes on the surface, sometimes deep in a tube. Mostly the margins are silver pahoehoe, but aa patches occur. Farther down a gush of pahoehoe begins and spreads in a fan. This is repeated five times in three miles. Underneath all this is a flow of aa. Down at Humuula the pahoehoe gushes unite at a river bending into a lake. They bend around the front of two large feather-shaped deltas of the aa of mid-December, 1935.

A striking feature of the bombed area was the existence upstream from some bomb-holes (Figure 5), of tunnel-openings where pudgy, pasty, stiff semi-aa lava welled up as a heap or pudding. The smashing of the tunnel had cooled the oncoming liquid so that it dammed itself. This confirmed the theory that the bombing solidified the tunnel lava back into the heart of the mountain. With twelve river hits out of sixteen, and liquid flung up hundreds of feet, there can be no question whatever that the bombing stopped the flow. The tunnels farther down the hillslope from the artificial damming were full of liquid which poured on for a week. But the bombardment of the river targets had cooled, dammed, solidified and freed from gas an enormous volume of slag, which froze where it lay, and the

very smallness of the natural vents proves how large was the artificial effect of this human achievement. The whole flow was in a single pipe, and the collective bomb craters were much bigger than that pipe. The pipe was a natural sewer tunnel twenty to forty feet underground and ten to fifteen feet across. A single one of sixteen bomb punctures was eighty feet across and forty feet deep to the roofed-over flow. No slag-stream full of gas could take such a bombardment, flinging up its substance, with several tons of high explosive, distributed along a mile of stream-way, and fail to thicken and solidify.

The source stream of the Humuula flow when active, at elevation 8,900 feet, glowed and steamed in a line of vents that were pahoehoe where the lava emerged, and this heap was visited by Ranger G. E. Olson, Philips and Ignacio November 25, 1935, as is shown by the photograph, Figure 7. An air photograph by Dod at the same period shows that the line of vapors ended abruptly against older dark lava uphill. This was the lower glow-spot, Figure 5, Volcano Letter 429, and the upper limit of bombed stream, Volcano Letter 442 frontispiece. The conclusion is that this channel and tunnel was a crack in the mountain that vomited out the Humuula flow of 1935, and that the dark lava uphill is part of the cold 1880 torrent. The line of vapors and glows ended against this older lava, and the crack beneath emerged downhill from it but did not break it.

The event was on December 27, 1935, when the front of the lava flow was pushing toward Hilo a mile a day, twelve miles from the city, and fifteen miles downhill from this source tunnel. The United States Army Air Corps all day long bombed the two targets of the source tunnel from the air. The next day the front slowed down, and five days later it stopped.

This camping trip of a week shows that the scientists can live in the high lava of Mauna Loa in comfort, that the danger

Fig. 5.—Pasty lava plug welled up, as result of bomb damming, in main stream tunnel; Mauna Kea in distance; Target 1. Photo by Jaggar.

Fig. 6—Miscellaneous fragments of bombs and vanes collected. Photo by Cunningham.

slope above Hilo can be critically studied with new markers and air photographs, and with the proposed barriers for deflection of the most rapid flows that may rush to the sea near Hilo, we can eventually, if supported with men and trails and additional upper Mauna Loa lands in the Park, make the inhabitants of this fair land take pride in their defense against volcanoes.

Hawaiian Volcano Observatory Report for July-September 1939

VOLCANOLOGY

July 1939

Halemaumau had few rock slides, but the month showed uneasy working of fault blocks on Chain of Craters, and at Hilina Cliff south of Kilauea fresh avalanche scars were found July 13. A strongish shock July 14 originated there five miles underground. Three slides on Hilina Cliff July 25 occurred about 4:20 p.m. A slide from the northwest wall of Halemaumau July 30, 11:30 a.m., made a cloud of dust.

The cracks parallel to Halemaumau rim, of which 28 are measured weekly, showed aggregate closing for the first and third weeks of July, a condition not recorded since October, 1938. It is of interest that Chain of Craters measured fault cracks, four miles southeast, also closed for these weeks.

Sulphur fume was reported July 7 on Mauna Loa trail as an odor one mile below 1935 cone. Fuming in Halemaumau bottom has decreased, but was observed at the stain southeast the second week, and on July 28.

Messrs. Bullard, Schulz and others camped at Mokauweoweo rest house, summit of Mauna Loa, July 20-21. Abundant fumes were found on the crater floor, heat was rising from the summit part of 1935 rift northeast, and sulphur was being deposited in cavities on southwest flank of 1935 cone at 11,000 feet.

The numbers of local and distant seismic disturbances recently, by months, have been:

	Local	Distant
April	66	5
May	184	3
June	337	3
July	203	3
August	287	2
September	101	1

The swarm of June-July is evident, but the July disturbances were mostly tremors. Sixteen Kilauea shocks and five from Mauna Loa were located for July, two of the latter 35 miles deep. A distant earthquake of July 6, 3,550 miles away, was reported as 550 km. deep between Fiji and Tonga.

Of the 203 shocks and tremors of local origin registered on the seismographs for July, 21 were located by seismometric method, and, of these, 10 were under Kilauea crater, 5 were under Mauna Loa, 3 under Kilauea rifts, and 3 at the Hilina Cliffs.

The following are the local data for July:

Week Ending	Halemaumau Slides	Halemaumau Crack Openings	Seismic Disturbances
July 9	0	3.0 mm. closed	40
" 16	0	7.5 mm. opened	56
" 23	0	2.0 mm. closed	70
" 30	1	3.5 mm. opened	37

August 1939

The month at Kilauea crater exhibited some movement in the Hilina-Chain of Craters fault blocks which border the Kilauea rift on the southeast. (See map Volcano Letter 462.) A roadside crack at the edge of Aloi pit opened 2 feet in an hour of the early afternoon August 2, and extended 20 feet in depth. The motion did not continue.

The next event was a swarm of earthquakes about August 17, several of them felt, centering at the Hilina Pali fault system, including greatly increased frequency of very feeble movements and tremors.

A remarkable feature of this period, enduring for two weeks, was cumulative closing instead of opening, of the 27 concentric rim cracks around Halemaumau edge which are measured once a week. On the week ended August 18, of the rim cracks 19 closed, 8 were unchanged, and none opened, with aggregate closing of 15 millimeters. Along Chain of Craters, also, the measured cracks showed temporary closing of 8.5 millimeters. As these measurements were made the day after the Hilina disturbances, and the following week showed restorative opening of cracks, it appears that the fault movements caused this unusual compression normal to the fault planes, and both Halemaumau and the Chain of Craters took the squeeze, as both are on the major Kilauea rift.

Of two distant earthquakes both in New Hebrides region, 3,270 and 3,500 miles away, August 11 and 17, the second coincided in date with the moderate local earthquakes, preceding them by about six hours.

Slides in August were observed as follows:

August 2, 10:20 a.m., at north wall of Pauahi Pit;
" 2, 10:00 a.m., west wall Halemaumau, small;
" 6, Kilauea Iki scars north wall;
" 15, north wall Halemaumau, 11:19 a.m.;
" 17, scars in Pauahi crater.
" 20, north wall Halemaumau, 3:17 p.m.;
" 27, dust streaks north and west walls Halemaumau.

Of the 287 local shocks and tremors counted on the seismograms for August, 20 were located, and of these 7 were from Hilina Cliffs, 6 from Kilauea crater, 3 from Mauna Loa, 1 each from Kilauea southwest rift, Kona, Kohala and Hualalai.

The following are the local data for August:

Week Ending	Halemaumau Slides	Halemaumau Crack Openings	Seismic Disturbances
August 6	1	2.5 mm. opened	57
" 13	0	1.5 mm. closed	50
" 20	2	15.0 mm. closed	86
" 27	0	11.0 mm. opened	52
Sept. 3	0	5.0 mm. opened	42

September 1939

For six weeks following August 20 the decline in local earthquake frequency, and in numbers of tremors that determine technical seismicity, was steady and progressive. There were some feeble earthquakes felt that preceded equinox. Nothing volcanic was remarkable. An earthquake near Kamchatka under Bering Sea occurred September 8, 2,800 miles from Kilauea station.

Slides in September were observed as follows:

September 8, 12:40 and 12:59 p.m., northwest wall Halemaumau;
" 29, 10:33 a.m., north rim Halemaumau;
" 29, fresh fall of debris in road crack Pauahi Pit.

There was gradual movement detectable along the fractured rim of Devil's Throat, and humps in the road increased slightly between Hiiaka and Aloi pits. Blue fume is notably less at Halemaumau. Gas collections were made by Dr. Ballard of the University of Hawaii in Mokuaweoweo September 14. The three members of the expedition felt a sharp earthquake on the Mauna Loa crater floor at 10:07 a.m. of that date. This registered as a tremor at Kilauea seismographs.

Fig. 7—Pahoehoe steaming heap with glow-hole in foreground, November 25, 1935, at 8,900 feet elevation, Humuula. Photo by Olson.

Of the 101 local shocks and tremors recorded in September, 16 were located, and of these 6 were from Kilauea crater, 4 from Mauna Loa, 3 from Kilauea rifts, 2 from Hualalai, and 1 from Hilina Cliff region.

The following are the local data for September:

Week Ending	Halemaumau Slides	Halemaumau Crack Openings	Seismic Disturbances
September 10	2	2.0 mm. opened	39
" 17	0	1.5 mm. opened	28
" 24	0	3.0 mm. opened	19
October 1	1	2.0 mm. opened	15

T. A. J.

Fig. 8—Concretion balls on supposed 1880 lava. Photo by Jaggar.

SEISMOLOGICAL AND GEODETIC DATA

Earthquakes

Week Ending	Minutes of Tremor	Very Feeble	Feeble	Slight	Moderate	Distant*	Weekly Seismicity†
July 9....	34	4	1	1	0	1	13.50
" 16....	48	7	0	0	1	0	19.50
" 23....	66	4	0	0	0	2	18.50
" 30....	33	4	0	0	0	0	10.25
August 6....	50	6	1	0	0	0	17.00
" 13....	46	2	2	0	0	1	14.50
" 20....	66	16	1	1	2	1	35.50
" 27....	50	2	0	0	0	0	13.50
September 3....	36	5	1	0	0	0	12.50
" 10....	35	3	1	0	0	1	11.25
" 17....	22	4	2	0	0	0	9.50
" 24....	16	3	0	0	0	0	5.50
October 1....	13	2	0	0	0	0	4.25

* Including teleseisms or earthquakes over 5,000 km from Kilauea.
† For local seismicity definition see Volcano Letter 371.

Epicenters of the following local disturbances were determined by means of seismograms from the station operated by the Hawaiian Volcano Observatory on the island of Hawaii. Kilauea earthquakes were located by means of the seismograph station at the Observatory and the two subsidiary stations at Uwekahuna and the SE rim of Halemaumau respectively. The more distant shocks were located with the aid of seismograms from Hilo and Kealakekua. The disturbances began at the time indicated and, whenever possible, a determination of depth of focus has been made.

July 5, 12:20 am, slight, 12.0 miles deep in Hilina Pali area 2.5 miles S of Makaopulii 19° 20.2' N., 155° 10.2' W. Felt slightly in Hilo and by a few persons in Hawaii National Park.

July 7, 5:46 pm, very feeble, probably originated in SE rim area of Kilauea Crater.

July 7, 7:23 pm, very feeble, probably originated in SE rim area of Kilauea Crater.

July 7, 8:04 pm, feeble, probably originated in E rim area of Kilauea Crater.

July 8, 3:32 pm, very feeble, probably originated Kilauea SE rift near Kalapana.

July 11, 5:51 pm, very feeble, of Kilauea Crater origin.

July 12, 11:30 pm, very feeble, of Kilauea Crater origin.

July 14, 3:51 am, moderate to strong, 5.0 miles deep, Hilina fault system about 5.0 miles SE of Makaopuhi. 19° 19.5' N; 155° 07.0' W. All instruments at the Observatory were dismantled with the exception of the strong motion seismograph. The quake was generally felt on the island with the greatest internicity centered in the Kau-Puna area. Most sleepers were awakened in Hawaii National Park and in Hilo. Reported unusually strong at Pahoa.

July 15, 9:46 pm, very feeble, of shallow origin in Kilauea Crater E of Halemaumau.

July 16, 7:14 am, very feeble, about 35.0 miles deep, Mauna Loa NE rift, 13.0 miles NE of Summit Crater. 19° 33.5' N; 155° 25.5' W.

July 16, 3:57 pm, very feeble, probable origin Hilina Fault system about 3.5 miles S of Makaopuhi Crater.

July 19, 11:38 am, very feeble, 1.5 miles deep, Chain of Craters, near Puhimau. 19° 23.6' N; 155° 14.9' W.

July 19, 10:15 pm, very feeble, 1.4 miles deep, 1.3 miles W of Hiiaka Crater. 19° 22.6' N; 155° 15.1' W.

July 21, 9:04 pm, very feeble, Mauna Loa NE rift about 12 miles SW of Hilo.

July 25, 11:00 am, very feeble, originated about 1.7 miles NW of Volcano Observatory, 4.2 miles deep. 19° 26.9' N; 155° 16.3' W.

July 25, 11:45 am, very feeble, 35.0 miles deep, Mauna Loa NE rift, 16.0 miles NE of Summit Crater.

July 27, 2:02 am, very feeble, 23.0 miles deep on W slope of Mauna Loa, 14.0 miles W by S of Mauna Loa Summit Crater. 19° 26.0' N; 155° 48.0' W.

July 28, 5:12 pm, very feeble, probably originated in Kilauea Crater 1.3 miles SW of Observatory.

July 31, 8:58 am, very feeble, of shallow origin Mauna Loa NE rift 16 miles from Summit Crater.

July 31, 8:18 pm, very feeble, probably originated in Kilauea Crater near Halemaumau.

July 31, 8:21 pm, very feeble, of shallow origin, Kilauea Crater rim area near Kilauea Iki. 19° 25.1' N; 155° 15.3' W. Reported felt by few persons in Hawaii National Park and dismantled NS component of Pit seismograph.

August 4, 3:16 pm, very feeble, of shallow origin near S rim of Keanakakoi Crater. 19° 24.1' N; 155° 16.0' W.

August 4, 11:56 pm, very feeble, 2.2 miles deep, 4.0 miles NW of the Observatory. 19° 28.5' N; 155° 18.8' W.

August 5, 1:46 pm, very feeble, 8.0 miles deep, 5.0 miles SW of Kailua. 19° 31.0' N; 156° 02.0' W. Reported felt at Holualoa and Hookena.

August 6, 5:09 pm, very feeble, origin was 40.0 miles under Hualalai. 19° 41.5' N; 155° 35' W.

August 7, 7:19 am, very feeble, probably originated under N rim area of Kilauea Crater.

August 8, 4:32 am, feeble, originated in Hilina Fault system, 3.0 miles N of Apua Point, 6.0 miles deep. 19° 18.0' N; 155° 11.5' W. Reported felt in Hilo.

August 8, 6:50 am, feeble, 10.0 miles deep in Hilina Fault system 4.0 miles S of Makaopuhi. 19° 19.0' N; 155° 10.0' W. Reported felt in Hilo.

August 11, 6:39 pm, very feeble, probably originated in Kilauea SW rift near sea coast.

August 15, 2:52 pm, very feeble, probably originated in Mauna Loa NE rift.

August 16, 10:29 am, very feeble, originated in area between Makaopuhi and Hilina Fault.

August 16, 2:20 pm, very feeble, originated near Uwekahuna, NW rim, Kilauea Crater. 19° 25.5' N; 155° 17.6' W.

August 16, 2:40 pm, very feeble, Mauna Loa NE rift about 5.0 miles SW of Puu Ulaula.

August 17, 5:57 am, moderate, 8.0 miles deep in Hilina Fault system, 4.5 miles SE of Makaopuhi. 19° 19.5' N; 155° 06.5' W. Unusual in that it was not reported felt.

August 17, 6:18 am, moderate, 4.0 miles deep in Hilina Fault system, 4.0 miles ESE of Makaopuhi. 19° 21.5' N; 155° 07.0' W. Not reported felt.

August 17, 6:58 am, very feeble, probably in Hilina Fault system, about 15.0 miles deep and N of Keahou Point.

August 17, 11:51 pm, slight, probably of shallow origin in Hilina Fault system 3.5 miles S of Puu Ohale.

August 18, 9:03 pm, very feeble, probably originated under NE portion of Mauna Loa Summit Crater.

August 20, 10:01 am, very feeble, 12.0 miles deep, 3.0 miles W of Kulani Cone near NE rift of Mauna Loa. 19° 31.7' N; 155° 21.0' W.

August 27, 4:19 pm, very feeble, NE rim area of Kilauea Crater.

August 28, 6:21 pm, very feeble, probably originated in Kohala district.

September 3, 6:17 am, very feeble, Mauna Loa Summit Crater origin.

September 3, 6:54 am, very feeble, of shallow origin in Chain of Craters near Kokoolau and Devil's Throat. 19° 23.0' N.; 155° 14.7' W.

September 3, 8:10 pm, feeble, 7.0 miles deep, Mauna Loa NE rift, 3.0 miles SE of Puu Ulaula. 19° 30.0' N; 155° 26.0' W. Reported felt at Kilauea Military Camp accompanied by mild roaring noise.

September 4, 12:28 am, very feeble, 5.0 miles deep, Mauna Loa NE rift near Pukauahi Crater. 19° 31.5' N; 155° 31.0' W.

September 7, 1:32 am, feeble, 15.0 miles deep, Hualalai Volcano. 19° 41.0' N; 155° 51.0' W. Reported strongly felt at Puu Waawaa.

September 7, 10:46 am, very feeble, 4.0 miles deep under Waldron Ledge, NE rim Kilauea Crater. 19° 24.4' N; 155° 15.4' W.

September 8, 1:39 pm, very feeble, NE portion of Kilauea Crater.

September 13, 6:49 am, feeble, 9.0 miles deep Kilauea SW rift, 6.0 miles from the Observatory. 19° 24.0' N; 155° 20.0' W.

September 13, 4:20 pm, feeble, 13.0 miles deep Hilina Pali about 4.0 miles N of Apua Point. 19° 18.0' N; 155° 10.0' W.

September 14, 10:07 am, a tremor, reported felt on Mauna Loa.

September 14, 12:10 pm, very feeble, probably originated from relatively great depth under Hualalai.

September 15, 6:13 pm, very feeble, NW rim of Kilauea Crater, 0.6 mile N of Uwekahuna. 19° 25.9' N; 155° 17.5' W.

September 17, 3:33 am, very feeble, of shallow depth, Kilauea Crater near Halemaumau.

September 20, 10:41 am, very feeble, about 2.5 miles deep in Kilauea Crater near Halemaumau.

September 27, 11:24 am, very feeble, Kilauea SW rift.

September 28, 9:11 am, very feeble, probably from SW portion of Kilauea Crater.

Teleseisms

July 6, "P" waves began recording at 12h 18m 54.0s pm. This was reported by the Jesuit Seismological Society as a deep earthquake (550 km) which originated in the area between the Fiji and Tonga groups of the S. Pacific. 24° S; 18° W. Distance from Kilauea approximately 3,550 miles.

July 17, unidentified portion at 5h 11m 36s pm. No reports received.

July 23, 5h 03m am, unidentified portion.

August 11, "P" waves, 3h 46m 11s pm, J. S. A. location in vicinity of New Hebrides 13° S; 169° E. Distance from Kilauea, 3,270 miles.

August 17, surface (L) waves at 12:10 am, U. S. C. and G. S. location 18° S; 168° E in New Hebrides area. Distance from Kilauea, 3,500 miles.

September 8, 1h 42m 19s am, "P" waves began. U. S. C. and G. S. location near Kamchatka in Bering Sea. 51° N; 175° E. 2,800 miles from Kilauea.

Microseismic Motion

July

Light—5, 7-9, 18-21, 24-29, 31.
Moderate—3, 4, 6, 10-12, 15, 17, 22, 23, 30.
Strong—13, 14, 16.

August

Light—3-6, 8-10, 12-15, 19, 21-31.
Moderate—1, 2, 7, 11, 16-18.
Strong—20.

September

Light—1-3, 5-12, 18, 27-29.
Moderate—4, 13-17, 20, 23, 24, 26, 30.
Strong—19, 21, 22, 25.
Time used throughout is Hawaiian Standard, 10h 30m slower than G. C. T.

Tilting of the Ground

The following tables show tilt by weeks as recorded by the Observatory seismograph, NE rim of Kilauea Crater and at Halemaumau the algebraic sum toward or away from the Pit as indicated by tilt stations on the W and SE rims respectively.

At the Observatory the total accumulated tilt for the year ending July 30, was 2.05" S and 4.0" W.

For the year ending August 27, it was 1.53" S and 3.43" W.

For the year ending October 1, it was 1.24" S and 3.20" W.

Table of Tilt

Week Ending	Observatory	Halemaumau West Station
July 9	0.50" N 20° E	6.97" S 26° W
" 16	0.97" N 26° E	3.13" S 23° W
" 23	0.66" N 21° W	2.98" N 79° W
" 30	1.05" N 20° W	5.72" N 60° W
August 6	0.88" N 51° W	5.63" N 66° W
" 13	2.05" N 63° E	6.82" N 9° E
" 20	0.27" N 89° E	3.03" N 80° W
" 27	0.48" N 33° E	2.15" N 69° W
Sept. 3	1.00" N 10° E	4.65" N 80° W
" 10	1.34" N 50° E	1.58" S 60° W
" 17	0.35" N 42° E	1.97" S 27° E
" 24	0.30" S 3° W	0.00
October 1	0.50" N 86° E	2.68" N 30° W

Week Ending	Halemaumau Southeast Station	Halemaumau Resultant
July 9	4.92" N 79° E	7.15" from
" 16	3.34" N 31° W	1.91" toward
" 23	4.86" N 17° W	1.71" toward
" 30	7.71" N 44° E	3.62" from
August 6	2.43" N 69° W	4.31" from
" 13	3.63" N 39° W	5.36" toward
" 20	11.99" N 50° W	8.83" toward
" 27	0.78" N 66° E	2.10" from
Sept. 3	3.11" N 38° E	3.66" from
" 10	10.37" S 81° W	3.52" toward
" 17	10.89" S 69° W	3.66" toward
" 24	8.29" S 44° W	1.45" from
October 1	12.02" N 75° W	8.20" toward

Crater Angles

Measurement of horizontal angles across Kilauea Crater from the Observatory were made twice during the month of July. On July 7, these measurements indicated opening of 0.58" for the Halemaumau value and closing of 0.61" for the Crater value compared with similar measurements of June 17. Between July 7 and July 29, the Halemaumau value showed closing of 2.73" and the Crater value showed opening of 1.58". Total, June 17 to July 29: Pit closed 2.25" and Crater opened 0.97". The Halemaumau value is measured between the seismograph station on the SE rim and the NW Pit bench mark. The Crater value is measured between a station on the SE rim of Kilauea Crater and the Uwekahuna station.

Angle values August 17, indicated opening of the Halemaumau value of 4.42" and closing of the Crater angle of 2.75".

Two measurements were made during September. On September 12, the Halemaumau angle had closed 0.17" and the Crater angle had closed 0.25". Between September 12 and September 27, Halemaumau value closed 2.41" and Crater value opened 2.41". Total change August 17 to September 27, Halemaumau closed 2.58" and the Crater opened 2.16".

Total change at Halemaumau, June 17 to September 27: Halemaumau closed 0.41" and the Crater opened 0.38".

Spirit Levelling around Halemaumau

Between August 25 and 30, a line of levels on Kilauea Crater floor was run for a complete circuit around Halemaumau. Comparison with a similar run made March 20-21, 1939 shows that the NW Pit BM had lowered since that period 4.4 centimeters relative to the Spit B. M.

Chain of Craters Road Cracks

Date	101	102	103	104	105	106	107
July 28	404.40 cm.	64.45	101.45	17'19⅛"	87.30	88.70	39.60
Sept. 1	404.45	64.50	101.55	17'19⅛"	87.35	88.80	39.55
Sept. 29	404.65	64.55	101.55	17'19⅛"	87.30	88.75	39.65
Total change in mm. since June 30..	+3.0 mm.	+0.5	+1.0		+0.5		

Plus (+) = open. Minus (—) = close.

New cracks developed in the side of the road nearest Aloi Crater and on its S rim. One crack was parallel to the road and the other was across the road surface. Measurement of these two cracks was started August 2, 1939. They were designated 108 and 109 respectively. On September 29 No. 108 had opened from 102.55 cm to 102.70 cm, a total of 1.5 millimeters. No. 109 remained unchanged at 97.70 cm.

H. H. W.

HAWAIIAN VOLCANO RESEARCH ASSOCIATION
in cooperation with
UNIVERSITY OF HAWAII

The **Hawaiian Volcano Research Association** was founded in 1911 for record of volcanoes in the Hawaiian Islands and around the Pacific Ocean. Its equipment at Kilauea Volcano, Hawaii Island, is leased and operated by the United States Government, Department of the Interior, National Park Service.

The **University of Hawaii** cooperates in maintaining a research laboratory at Hawaii National Park. The **Association** and the **University** maintain outside seismograph stations and supplement the work of the government with research associates, instrumental plants and special investigations.

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THE VOLCANO LETTER

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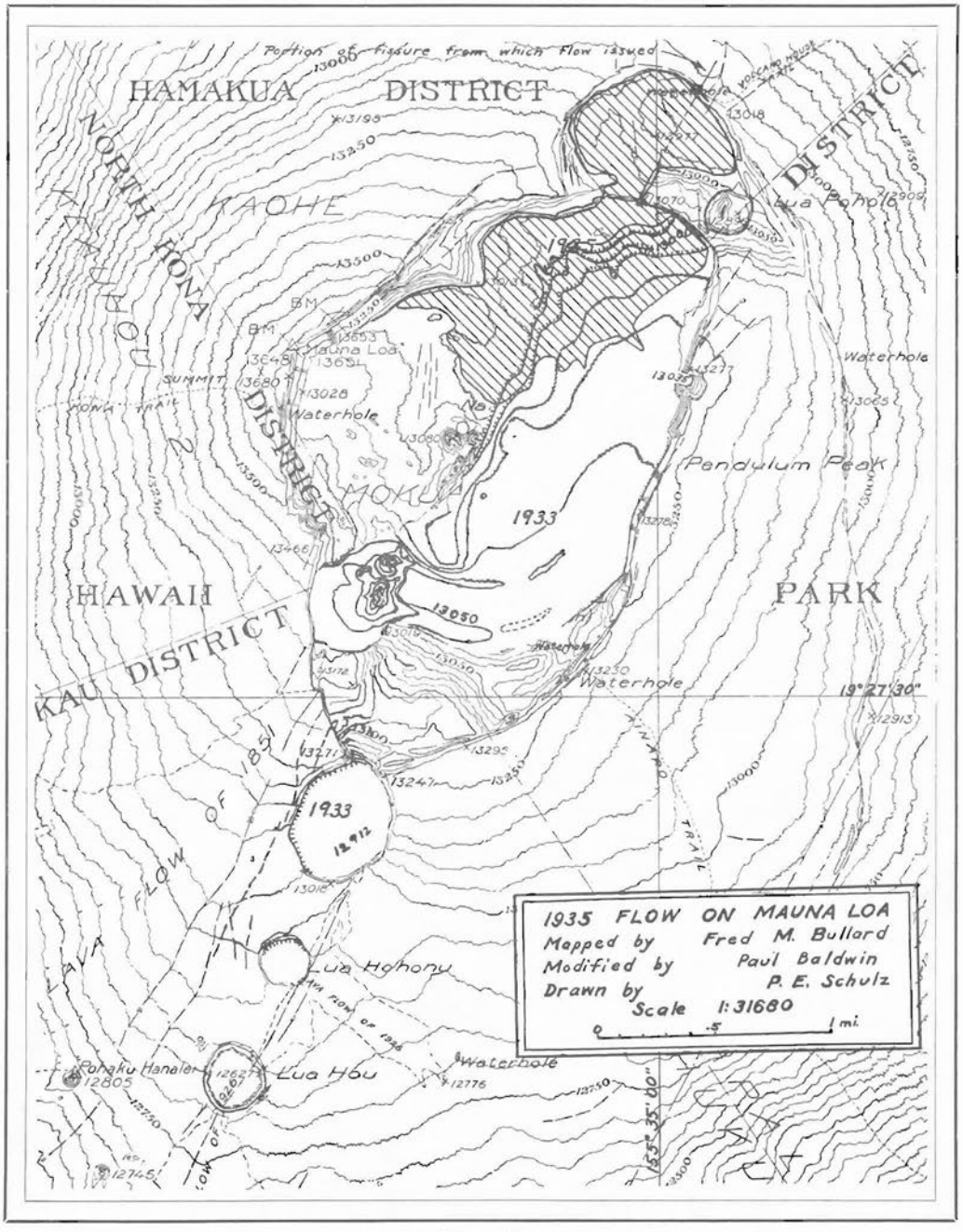

Figure 1

1935 LAVA IN MOKUAWEOWEO CRATER

By HUGH H. WAESCHE, Assistant Geologist

In the evening of November 21, 1935 about 6:30 p.m., Hawaiian Time, Mauna Loa began on eruption which was to lost well over six weeks and which was to exhibit oll phases of activity common to Mauna Loa eruptions. The major portion of the activity was a spectoculor outflow with large streams of lavo descending the north slope of the mountain into the saddle between Mauna Loa and Mauno Kea.

Just what occurred in the eorly hours of the eruption is vague. It was a cloudy evening and the activity was not visible from the Observatory until about 10:00 p.m. At that time a minimum of 8 fountains were playing olong the northeast slope af the mountain from the summit crater to a point about five miles along the rift. Apparently the NE rift had cracked open over this distance. By 2:00 a.m. oll of the upper fountoins had diminished slightly and the octivity was concentrating at the two lowest fountains near the 12,000 foot elevation. At approximotely 6:00 a.m., Lt. Carl Truesdole of the United States Army Air Corps flew over the Crater of Mokuaweoweo and reported some activity there still in progress. By 10:00 a.m. when the writer flew over the area af activity with Lt. Campbell all activity in the Summit Crater had ceased. The two fountains at 12,000 feet continued for approximately ten days. The remainder of the time, lava issued from what appeared to be a rift hidden by old lava flows on the north flank of the mountain. At most the crater activity lasted hardly more than twelve hours.

Later when National Park rangers went to the summit af Mauna Loa, they found thot the fissure indicated on the map (near top) had opened within 100 feet of the rest house and that lava had poured into the crater and down the northeast slope in great quantities from it. The lava was a brownish-black, frothy type of pahoehoe indicating that it had probably been highly charged with gases. The Volcano House Trail was covered and eliminated for about three-quarters of a mile. (For photographs see Volcano Letter No. 445, March 1937.) It is possible that the fissure extended southwest toward the center of Mokuaweoeo in the general direction of the 1903 and 1914 cones but was covered by lava pouring into the main crater from the higher elevation bay to the northeast.

Fig. 2—Dr. Jaggar on an exploration of a Mauna Loa rift. Pit in 1881 pahoehoe dome northwest of Puu Ulaula. (October 4)

The attention of olmost everyone had been concentroted on the flows resulting from this eruption so consequently the croter hod received little attention. In 1934 Mr. A. E. Jones had made a detailed map showing the extent of the 1933 crater flow.* Dr. Jaggar has described that eruption. Mr. E. G. Wingate had mapped the 1926 flow. It was desirable that the series be completed, therefore on July 18, 1939, Dr. Fred M. Bullard, professor of geology at the University of Texas ond temporarily employed by the National Park Service ot the Volcano Observatory, made the trip to the summit. Using a United States Geological Survey preliminory sheet of the area as a base, he mode a Brunton Compass survey of the crater inflow which is indicated by the hatched area toward top of map. The work was done July 19, 20, and 21. Mr. Paul Baldwin, temporary National Park ranger, repeated the work of Dr. Bullard obout three weeks later. His map was identical to Bullard's with the addition of the tongues and other slight modification of the southeast edge of the flow.

Apparently the 1935 lava covered a sizeable portion of the 1933 flow as indicated by the dotted boundaries of the latter flow as mapped by Jones.

The 1935 flow is little more than a veneer over pre-existing flows and has changed the contour of the crater little. It may attain a thickness of 5 feet in a few spots particularly where it adjoins the 1933 flow which in some places is aa in character.

* The Volcano Letter No. 309, September 1936.

Hawaiian Volcano Observatory Report for October-December, 1939

VOLCANOLOGY

October 1939

October had no special volcanic events. For the first week seismic activity increased and northeast tilting of the ground at the observatory was marked but normal for this time of year. The second week this tilt increased as well as the number of earthquakes; one of these was sharply felt on the floor of Mokuaweoweo, the summit crater of Mauna Loa, at 2:27 p.m. October 11, and on the same day at 3:42 p.m. a shock resembling a powder blast was felt at Kilauea. On the 15th a rock slide at 10:32 a.m. sent a dust cloud up the north wall of Halemaumau. The third week held a similar seismicity and thin fume rose from the southeast marginal crack of Halemaumau floor; the northwest solfatara had dimmed in color and ceased to fume. During the last week things quieted down and the measured rim crocks which changed closed instead of opening, just as in July-August.

Distant earthquakes were registered October 3 and October 16, the last located near the New Hebrides. The local shocks were distributed between Mauna Loa and Kilauea with the last most abundant, and one shock of October 19 was from Hualalai or beyond that mountain.

Exploration of NE Rift of Mauna Loa

Dr. Jaggar, with Mrs. Jaggar and Ranger Jess, camped at Puu Ulaula, 10,000 feet elevation, northeast rest house of Mauna Loa October 2-5, to identify lava flows with those seen in Humuula trip of September, (Volcano Letter No. 465) to collect specimens for spectrograph tests, and to take photographs in Kodachrome and monochrome. Some of the latter are reproduced here. (Figures 2, 3, 4, 5, 6, 7.)

Puu Ulaula is old shell pahoehoe and cinder (Figure 5) with other old cones northeast of it, over the rift line here trending ENE and bifurcating to the NE. Southeast from the hills lying a mile WSW, extends the Kapapala aa flow of November 1880, entirely distinct from the pahoehoe black flow and cones (Figures 3, 6, 7) of 1881 which originate above and to the west of Puu Ulaula and trend NE, dominated by the large square-topped black cone of 1881 at elevation 9,617 feet lying a mile and a half NE of the Rest House, (from summit of which photographs 6 and 7 were taken). The aa lava of 1880 is distinct from the later 1881 source basalt: the former has a red porridge-like surface (Figure 4), its pahoehoe being bronzy and frequently frothed on the surface to coarse brassy pumice.

The 1899 lava is black pahoehoe all around the cone Puka Uahi and overriding the 1880 flows. Just northeast under the 1880 floods are the red and bright-colored cones of 1855 with surfaces of fine-grained brassy pumice a half inch thick. The black, smooth torrent of 1899 flowed off to the north from Puka Uahi, and was explored far to the north in September trip. On the engraved Humuula sheet U.S.G.S. the northeast Hilo flow is misnamed 1880 and the southeast Kapapala flow is misnamed 1881: these names should be exchanged. To all appearances it is possible to ride on the 1899 pahoehoe to Humuula by the routes explored in September.

The black floods of the 1881 Hilo-flow NW of Puu Ulaula are like the Kilauea floor lavas, and extraordinarily like the smooth piles of Mauna Iki in Kau Desert. Figure 2 shows the rim and cavernous overhang of a circular pit 60 feet across, with tumble of debris of collapse, that was in 1881 a lava lake on top of a pahoehoe dome. This was a source-heap over a crack of the NE Mauna Loa rift belt, a half-mile WNW from Puu Ulaula rest house. In the background of the photograph is one of the older cones of possibly 1855 cinder. The general view up the rift belt from the top of the 1881 black cone (elevation 9,617 feet) includes this slag heap near the skyline (Figure 6). The floods of pahoehoe from it fill the picture. The near line of conelets curving to the right, is the 1880-81 rupture. This pahoehoe is the later phase of 1881 that pressed forward in tunnels seven months to Hilo. Among the distant cones on the right is Puka Uahi (11,068 feet). In the early months of the 1880-81, floods of lava that pushed towards Mauna Kea from the Puka Uahi region, and towards the Hilo slope, were all stirred to become aa in the lower lands and some of these came from the Black Cone line of vents. The plexus of cones around Puka Uahi were sources of 1855, 1880, 1881 and 1899.

Before leaving the 1881 Black Cone, let us look at a photograph from its summit to the northeast, Figure 7. This is towards Puu Oo ranch lands, in the extreme distance across the sag of the upper Wailuku drainage above Hilo. In the foreground the open gash of the rift is bordered by pumice cones and aa lava. On the left appears the 1881 pahoehoe which sweeps to the right across the distant lands.

Outside the extreme right of the picture is the source of the aa of 1852 which gushed from a vent only 8,500 feet above the sea, but as always, with pahoehoe at its source and down its middle stream for three miles. Its flowing was short lived, so it never sent its vitreous lava to Hilo by the tunnel method. If its rushing torrent of liquid aa, 13 miles long between elevations 8,300 feet and 3,300 feet, had not been preceded by the emission of great volumes higher up the mountain twice, respectively 6 months, and 3 days, before the lowest Hilo outburst, this 1852 flow would have been in Hilo harbor in a week. The duration of the Hilo flow including decadence was 17 days, February 20 to March 8, the front stopping 12 miles from Hilo shore. As in all the outflows there was an extension of the crack up to the summit, this gushed from summit downwards with tremendous power February 17-18 for forty hours, and these upper 1852 floods are quite unidentified on the landscape of today.

The extension of the mapped crack from its cone at 8,420 feet elevation, takes us past the south side of Puu Ulaula, where a flood of black lava with phenocrysts of feldspar makes a sharkskin type of pahoehoe. This is overlapped by the 1880 Kapapala flow and is shown on the right in Figure 4. It may be part of the upper floods of 1852. A line of conelets heads almost due east from Puu Ulaula to Kulua and Puu Kipu, showing how cracks radiate from Puu Ulaula, as an important subsidiary dome on the ENE rift.

The map of all these features is Humuula Sheet, 1930, County of Hawaii, United States Geological Survey. Any later eruption may bury the lava of any former one. The concretion-ball aa lava supposed 1880 (Figure 8, Volcano Letter 465) discovered in September at elevation 7,000 feet, 4½ miles SSW from Humuula sheep station, came from near Puka Uahi, and its source pahoehoe is obscure in that vicinity until some petrogenic distinction, chemical or mineralogic, is discovered characteristic of date or age. Progressively later date means stage of internal alteration of magma. Age means stage of external weathering. In order to map thoroughly all these flows and recount their histories, specimens for comparison are being collected.

Microscopical petrography is not enough when a single flow may differ more in samples from source to front than two flow specimens of separated ages differ from each other. For this

Fig. 3—Cascades of 1881 pahoehoe along line of cones, north of Puu Ulaula. (October 4)

reason it is proposed to submit samples of known different years to arc vaporization in spectrograph for possible qualitative or quantitative differences in elements, and also to test for hydration and some other analytic distinctions, that may be characteristic of year of emission, apart from chemical or crystal differences exhibited within a single eruption. If discovered, this would mean secular magmatic change throughout a century, and identity of year could be estoblished for two flows reaching different fronts, if both had the same characteristic of a specific date.

The color pictures that were taken of the interior brilliant ochre glazes of 1855 ond 1935 vents showed brick red, bronzy green, orange and coffee-colored surfaces within cracks and pits. Similor colors mark the pumices. Here ore gas-fluxing phenomena. Vent basalt can be gas-melted to recrystallization and reglazing like ihe glazing of pottery. The recrystollization within Hawoiian basalt stalactities, by gas melting, of augite and feldspor shelled over by hematite and magnetite, as described by Edword Dana ("Characteristics of Volcanoes," J. D. Dona, p. 339. The quotation from Brigham of water origin is totally erroneous.) shows that cavern linings remelted by gas heat demonstrate the power of gas fluxing to recrystallize the lava's own substance in a gas-filled chamber. The small droplets on the stalactites and glozes show they were very liquid. The small bubbles on the pumiceaus skin of gassy source lavas again shaw intense liquidity; these by their rainbow tints produce the brass color mentioned.

Geologists do not realize that gas-reactions approoching 1500° C., in enarmaus volumes of suddenly released carbon gases and hydrogen, make the high-energy phase of the dike-rupture colled "o volcanic outbreak". This foaming incandescence and its gas, freed in confinement (pits and caverns), ore melting agents. The gas-tight shell over a flowing lava stream can increase the temperature af that stream, by confining its reacting gases; and those gases can glaze and recrystallize the under-surface of the shell. If such a gas-melt were re-digested by rising lava, we would have a feldspar-augite-iron oxide concentrate assimilated by normal basalt.

Now imagine the inbreak (irruption) of an intrusion in a foreign rock doing the same thing, and gas-fluxing that rock. The rock might be highly siliceous or calcareous. The deep chamber of rupture would be gas-tight and confine the vesiculate foam, but the rise of temperature would be greot ond the melting assimilation by bosalt would proceed to whatever ondesitic crystallinity the final gas-free magma achieved. Just as in the beautiful aggregates of feldspar crystals synthesized in Mauna Loa glozes and stalactites, totally different in grouping, and somewhat in chemical composition, from the lava, so where gas-fluxing melts to dripping a quartzite or shale, it is eosy for anyone who has seen in Hawaii glowing caverns, red hot fuming and Mauna Loa fountains, to envisage the evolution of hybrid magmas from pre-existing solid phases when attacked by olivine-basalt glass in process of gas effervescence. There is a field for experiment in solution of gases in such glass, pressure release from solution, and in gas-fluxing various rocks to a glaze.

Fig. 4—The 1880 flow near source, aa in foreground, on Kapapala side of rift, south of Puu Ulaula, looking north. (October 5)

The following are the local data for October:

Week Ending	Halemaumau Slides	Halemaumau Crack Openings	Seismic Disturbances
October 8	0	3.0 mm. opened	22
" 15	1	2.0 mm. opened	33
" 22	0	2.5 mm. opened	44
" 29	0	6.5 mm. closed	19

Fig. 5—Summit of Puu Ulaula, showing flag, wind gauge, and azimuth plate. (October 5)

November 1939

The month of November was notable for steady decline of the seismic index. The first week showed a slight increase over the end of the preceding month in seismic activity of both Mauna Loa and Kilauea. Fresh rocks on the floor of Makaopuhi Crater indicated there had been small slides from the southwest wall. There was a return to the opening of Halemaumau rim cracks, whereas the previous week had been extraordinary in that none had opened. Tilting of the ground at the Observatory was away from the crater. A slight shock November 3 and a feeble one November 4 were of Kilauea origin but not reported felt.

The second week produced a moderate rock slide sending up dust at the north

Fig. 6—Looking up rift from 1881 Black Cone; Puu Ulaula on left skyline.

wall of Halemaumau 10:22 a.m. November 10. There was one feeble earthquake under Kilauea Volcano and felt there. Tilting of the ground at the Observatory was away from the crater.

The third week recorded one rock slide Halemaumau north rim 10:20 a.m., November 14. Earthquakes were very feeble. The rim cracks resumed excessive closing. Tilting of the ground continued NNE.

The fourth week showed excessive microseismic activity along with a storm at sea causing waves to wash over Hilo breakwater. Seismic activity was locally very small though earthquakes were reported all over the world. Observatory tilt was still away from the crater.

The following are the local data for November:

Week Ending	Halemaumau Slides	Halemaumau Crack Openings	Seismic Disturbances
November 5	0	8.0 mm. opened	25
" 12	1	4.0 mm. opened	21
" 19	1	1.5 mm. closed	19
" 26	0	2.0 mm. opened	13

December 1939

The month of December was seismically quiet and, in accordance with the habit of the last five years, the solstice week about December 21 was particularly peaceful. This is the more remarkable in that during the active years of the last two cycles December has been the eruption month. Seismic activity increased at the beginning of the month and Observatory tilt changed to the crater direction. The second week fume was noted in Halemaumau probably from the solfatara along SE edge of floor. On December 8 at 10:35 a.m. rocks were heard falling at Halemaumau wall NW. Distances of earthquakes indicated Hualalai, Mauna Loa and Kilauea. Tilting was resumed away from Kilauea Crater. The third week produced a moderate slide at 2:55 p.m. December 12 making noise and sending out dust at Halemaumau NW wall and two other slides from the rim N and NE occurred at 3:25 and 3:29 p.m. A very feeble earthquake under Halemaumau completely dismantled the seismograph there, was felt at Uwekahuna but registered as very feeble. Observatory tilt was towards the crater.

The fourth week with earthquakes reported from Costa Rica, Manila, London, Kamchatka and the Celebes nothing happened at the Observatory except registration of some distant shocks and a feeble earthquake near noon December 23 indicating origin 15 miles deep under Mauna Loa northeast rift with epicenter eight miles from Mokuaweoweo. Sources at this locality command close attention because of the menace to Hilo. Observatory tilt was away from the crater. The end of the year produced outbreaks of disastrous earthquakes in Turkey. Some fume could be seen over Halemaumau on calm humid days, rim cracks closed and Observatory tilt was inward.

The following are the local data for December:

Week Ending	Halemaumau Slides	Halemaumau Crack Openings	Seismic Disturbances
December 3	0	3.5 mm. opened	26
" 10	1	0.5 mm. opened	18
" 17	3	0.5 mm. closed	33
" 24	0	5.5 mm. opened	18
" 31	0	0.5 mm. closed	20

Change of Annual Tilt

A significant change of importance is indicated by the following table showing in seconds the amount of tilt and its direction at the Observatory, NE rim of Kilauea Crater, for the year preceding the date indicated respectively in north-south azimuth and east-west azimuth at the seismographs.

January 29, 1939	S 1.15 seconds	W 5.93 seconds
February 26, 1939	S 1.0 "	W 1.73 "
April 2, 1939	S 3.08 "	W 4.85 "
April 30, 1939	S 4.0 "	W 5.35 "
May 28, 1939	S 3.92 "	W 4.75 "
July 2, 1939	S 3.75 "	W 2.60 "
July 30, 1939	S 2.05 "	W 4.00 "
August 27, 1939	S 1.53 "	W 3.43 "
October 1, 1939	S 1.24 "	W 3.20 "
October 29, 1939	S 1.15 "	W 1.48 "
December 3, 1939	N 2.20 "	W 1.56 "
December 31,1939	N 1.70 "	W 1.35 "

Fig. 7—From summit of 1881 Black Cone looking toward Puu Oo ranch lands.

This record of tilt south and west, or toward Kilauea Crater at the top of the NE wall of that crater, throughout the year 1939 as representative of the preceding twelvemonth for the end of each month, was also characteristic of many preceding years, checked by levels and readings of horizontal angles towards Kilauea and Halemaumau that have all agreed in indicating since the explosive eruption of 1924 that the general trend has been downward and inward. Individual Halemaumau eruptions have produced temporary tiltings away from the crater, but the annual record for repeated monthly summaries has appeared to imply that the ground around Halemaumau pit was continuing to lower as it did in 1924, but in less angular amount.

Beginning with the record of December 3, 1939 the north-south component suddenly shows a change from the preceding month of a total of 3.35 seconds from the record of October 29, and this substantial northerly tilt for the year preceding the date of record is retained on December 31 as nearly two seconds to the north or away from Halemaumau. When a record of this kind is a resultant of accumulated change for an entire year it is much more significant of a change of habit in underground workings of the volcano than the mere tilt from one month to the next. It should be remembered that the spring and summer of 1938 produced first a big earthquake in Maui and then a visible rupture along Chain-of-Craters, east rift of Kilauea in May, with renewal of movement there in August 1938 and some seismic sequences of the same disturbance in 1939. As the average interval for Kilauea outbreaks in this century was about a year and a half up to 1934, it appears that an eruption was omitted in 1936, and was about due in 1938. This Chain-of-Craters disturbance may have been the equivalent of that eruption, absorbed in subterranean intrusion, and representative of the return of lava from the seaward direction to the east, where there was submarine outflow in 1924. This submarine outflow as a fundamental disturber of the mountain, producing intense subsidence, may have continued that subsidence by sluggish flow until the backing up of the lava achieved the 1938 intrusion. Meantime the succession of gushes on the Halemaumau bottom may have been offshoots from Mauna Loa. If now the change in tilt at the Observatory means a resumption of swelling and elevation of Kilauea Crater, the lava that returns to Halemaumau about 1940 may have enduring characteristics more like the Kilauea activity of aforetime.—T.A.J.

SEISMOLOGICAL DATA

Earthquakes

Week Ending	Minutes of Tremor	Very Feeble	Feeble	Slight	Moderate	Distant*	Weekly Seismicity†
Oct. 8	19	3	0	0	0	1	6.25
" 15	27	3	3	0	0	0	11.25
" 22	39	5	0	0	0	1	12.25
" 29	17	2	0	0	0	0	5.25
Nov. 5	16	7	1	1	0	0	10.50
" 12	17	3	1	0	0	0	6.75
" 19	12	7	0	0	0	0	6.50
" 26	11	2	0	0	0	0	3.75
Dec. 3	22	4	0	0	0	0	8.00
" 10	11	7	0	0	0	0	6.25
" 17	30	3	0	0	0	1	9.00
" 24	12	4	2	0	0	2	6.00
" 31	19	1	0	0	0	1	5.25

* Including teleseisms or earthquakes over 5,000 km from Kilauea.
† For local seismicity definition see Volcano Letter 371.

Epicenters of the following local disturbances were determined by means of seismograms from the stations operated by the Hawaiian Volcano Observatory on the island of Hawaii. Kilauea earthquakes were located by means of the main seismograph station at the Observatory and the two subsidiary stations at Uwekahuna and the SE rim of Halemaumau respectively. The more distant shocks were located with the aid of seismograms from Hilo and Kealakekua. The disturbances began at the time indicated and whenever possible, a determination of depth of focus has been made.

October 3, 4:12 p.m., very feeble, probably originated Mauna Loa NE rift near summit crater.

October 5, 5:52 p.m., very feeble, probably originated in area south of Kilauea Crater near junction of Poli Lele o Kalinipaa and Pali Kalanaokuaiki.

October 8, 10:35 a.m., very feeble, originated in vicinity of NE rim of Kilauea Crater.

October 11, 1:11 a.m., feeble, probably originated in Hilina Fault system about 4.0 miles southeast of Makaopuhi.

October 11, 2:27 p.m., feeble, 8.0 miles deep, Mauna Loa NE rift about 3.0 miles SW of Puu Ulaula. 19° 30.5′ N; 155° 29.0′ W. Reported sharply felt at Mauna Loa resthouse.

October 11, 3:42 p.m., feeble, 0.8 mile deep, east portion of Kilauea Crater. 19° 24.7′ N; 155° 16.0′ W. Reported felt in Hawaii National Park.

October 14, 3:55 p.m., very feeble, originated near east central portion of Kilauea Crater.

October 15, 4:38 a.m., very feeble, originated 22.0 miles under Mauna Loa summit crater, 19° 28.5′ N; 155° 36.0′ W.

October 15, 11:03 a.m., very feeble, east central portian of Kilauea Crater.

October 16, 10:25 a.m., very feeble, of Kilauea Crater origin.

October 16, 1:35 p.m., very feeble, of Kilauea Crater origin.

October 17, 6:33 a.m., very feeble, probably originated in Chain-of-Craters near Puhimau.

October 19, 7:33 p.m., very feeble, under west slope of Hualalai, 5.0 miles NNW of Kailua, 19° 42.0′ N; 156° 01.0′ W.

October 26, 6:18 p.m., very feeble, probably originated in Mauna Loa NE rift about 10.0 miles SW of Hilo.

October 29, 12:02 a.m., very feeble, about 7.0 miles deep, Mauna Loa NE rift, 19° 35.5′ N; 155° 23.0′ W.

November 1, 2:38 p.m., very feeble, of shallow origin about 0.6 mile west of Kokoolau Crater, 19° 23.2′ N; 155° 16.0′ W.

November 3, 12:15 a.m., very feeble, probably originated in Hilina Fault system, near Laeapuki.

November 3, 3:38 p.m., slight, 3.0 miles deep in the vicinity of Cone Peak along Kilauea SW rift. 19° 23.5′ N; 155° 18.3′ W.

November 4, 3:07 a.m., feeble, probably of same origin as preceding shock.

November 4, 3:54 p.m., a tremor at the Observatory recorded on Mauna Loa as a feeble shock probably originating in the NE rift.

November 4, 10:58 p.m., very feeble, 25.0 miles deep under Mauna Loa 8.0 miles NW of Pahala. 19° 17.5′ N; 155° 34.0′ W. Reported felt in Pahala.

November 7, 5:34 a.m., very feeble, 2.7 miles deep, 1.4 miles east of Puu O Hale in Kalanaokuaiki Pali near junction with Pali Lele O Kalihipaa. 19° 21.4′ N; 155° 15.4′ W.

November 8, 11:23 p.m., very feeble, of shallow origin east central portion of Kilauea Crater. 19° 25.0′ N; 155° 16.0′ W.

November 10, 7:06 a.m., feeble, of shallow origin east rim of Kilauea Crater under SW portion of Kilauea Iki. 19° 25.0′ N; 155° 15.0′ W.

November 10, 11:06 a.m., very feeble, probably of same origin as preceding quake.

November 13, 1:02 a.m., very feeble, of Kilauea origin.

November 13, 1:59 p.m., very feeble, of shallow origin east central portion of Kilauea Crater.

November 14, 7:55 a.m., very feeble, from Mauna Loa NE rift about four miles from Summit Crater.

November 14, 9:56 a.m., very feeble, of Kilauea origin, probably Hilina Fault system south of Makaopuhi Crater.

November 19, 3:21 a.m., very feeble, of relatively shallow origin under Summit Crater of Mauna Loa.

November 19, 6:08 a.m., very feeble, of Mauna Loa NE rift near Summit Crater.

November 19, 7:23 a.m., very feeble, of shallow origin, SE rim of Halemaumau in Kilauea Crater.

November 20, 4:29 p.m., very feeble, 7.0 miles deep, Mauna Loa NE rift about 5.0 miles from Summit Crater. 19° 31.0′ N; 155° 31.5′ W.

November 24, 5:34 a.m., very feeble, from Hilina Fault Zone, 5.0 miles west of Kalapana.

November 27, 10:30 p.m., very feeble, of shallow origin, Kilauea Crater, 1.0 mile NE of Pit seismograph.

December 1, 12:35 p.m., very feeble, probably originated in Mauna Loa NE rift.

December 2, 8:48 a.m., very feeble, 0.8 mile deep, 1.0 mile SSE of Halemaumau. 19° 23.5′ N; 155° 16.6′ W.

December 3, 5:21 a.m., very feeble, 18.0 miles deep under Mauna Loa Summit Crater. 19° 31.0′ N; 155° 32.5′ W.

December 5, 6:29 a.m., very feeble, probably originated under ocean floor to SE of Island of Hawaii.

December 6, 10:56 p.m., very feeble, of shallow origin Mauna Loa NE rift 5.0 miles from center of Summit Crater.

December 8, 12:18 a.m., very feeble, probably originated under sea floor to SE of Island of Hawaii.

December 8, 3:49 a.m., very feeble, of shallow origin, NE rim of Mauna Loa Summit Crater. 19° 30.0′ N; 155° 34.3′ W.

December 8, 11:54 p.m., very feeble, from Chain-of-Craters near Devil's Throat.

December 10, 2:24 p.m., very feeble, of shallow origin 1.0 mile SE of Pit seismograph. 19° 23.8′ N; 155° 16.3′ W.

December 13, 1:56 a.m., very feeble, probably originated under sea floor about 23 miles west of Hualalai.

December 17, 2:48 p.m., very feeble, of shallow origin, south rim of Kilauea Crater, 1.0 mile south by east of Pit seismograph. 19° 23.5′ N; 155° 16.8′ W. Dismantled both components of Pit seismograph and reported felt in residential area of Hawaii National Park.

December 19, 1:11 p.m., very feeble, of shallow origin, Kilauea Crater.

December 21, 8:15 a.m., very feeble, about 20.0 miles deep and 12.0 miles south of Mauna Loa Summit Crater, 8.0 miles NW of Pahala. 19° 17.5′ N; 155° 34.0′ W.

December 22, 5:36 a.m., feeble, 9.0 miles deep, 8.0 miles SE of Summit Crater of Mauna Loa. 19° 24.4′ N; 155° 29.0′ W. Reported strongly felt at Kapapala Ranch House.

December 23, 12:06 p.m., feeble, 15.0 miles deep, Mauna Loa NE rift, 8.0 miles from Summit Crater. 19° 32.0′ N; 155° 29.0′ W.

December 23, 10:54 p.m., very feeble, 1.7 miles deep, 0.7 mile SE by south of Pit seismograph. 19° 23.8′ N; 155° 16.4′ W.

December 26, 8:50 p.m., very feeble, Kilauea SW rift near junction with Hilina Pali. 10.0 miles deep. 19° 15.5′ N; 155° 23.0′ W.

December 13, 8 minutes of continuous tremor began recording 6:02 a.m.

Teleseisms

October 3, 3h 18m 40.0s, a.m., "P" waves? Distance undetermined.

October 17, 8h 01m, p.m., located in New Hebrides area. Reported to have originated at a depth of 100 km. Distance from Kilauea, about 3,500 miles. Epicenter 16° S; 168° E, by U.S.C. and G.S.

December 16, 12h 25m 48s, a.m., "P" waves. Distance undetermined.

December 21, 10h 42m 55s, a.m., "P" waves. Distance from Kilauea approximately 5,505 miles, probably originated in Celebes.

December 21, 6h 25m 13s, p.m., "P" waves. Distance from Kilauea, approximately 4,625 miles. No reports received on location.

December 26, 2h 16m, p.m., surface waves. Distance undetermined; origin the disaster near Erzerum in Asiatic Turkey.

Microseismic Motion

October

Light—6, 8, 11, 14.
Moderate—1, 4, 5, 7, 9, 10, 12, 13, 15-20, 27.
Strong—2, 3, 21-26, 28-31.

November

Light—
Moderate—4-9, 20.
Strong—1-3, 10-19, 21-30.

December

Light—
Moderate—14, 20.
Strong—1-13, 15-19, 21-31.

Time used throughout is Hawaiian Standard, 10h 30m slower than Greenwich Time.

Tilting of the Ground

The following tables show tilt by weeks as recorded by the Observatory seismograph, NE rim of Kilauea Crater and at Halemaumau the algebraic sum toward or away from the Pit as indicated by tilt stations on the W and SE rims respectively.

At the Observatory the total accumulated tilt for the year ending October 29, was 1.15" S and 1.48" W.

December 3, 2:20" N and 1.56" W.

December 31, 1.70" N and 1.35" W.

Table of Tilt

Week Ending	Observatory	Halemaumau West Station
October 8	1.85" N 45° E	4.47" S 60° W
" 15	1.45" N 52° E	5.16" N 15° W
" 22	0.50" S 58° W	0.00 ——
" 29	0.77" N 79° E	2.98" W
November 5	1.43" N 35° E	3.81" N 53° W
" 12	0.56" N 30° E	4.41" N 74° W
" 19	0.74" N 11° E	0.00 ——
" 26	0.00 ——	0.00 ——
December 3	0.60" N 53° W	0.00 ——
" 10	0.27" W	3.13" S 55° W
" 17	0.27" S 6° E	5.99" S 30° E
" 24	0.21" N 67° E	4.47" N
" 31	1.17" S 48° W	0.00 ——

Week Ending	Halemaumou Southeast Station	Halemaumau Resultant
October 8	4.86" S 50° E	8.55" from
" 15	9.23" N 47° E	0.09" toward
" 22	4.96" N 67° E	0.97" from
" 29	15.10" N 83° W	6.90" toward
November 5	3.79" N 25° E	0.90" from
" 12	1.94" S 65° E	5.64" from
" 19	3.60" N 30° W	4.86" toward
" 26	14.45" S 30° E	4.25" from
December 3	0.00 ——	No change
" 10	4.76" N 30° W	1.86" toward
" 17	6.58" S 17° W	1.52" from
" 24	6.48" N 30° W	6.93" toward
" 31	6.48" S 30° E	6.48" from

Crater Angles

Measurements of horizontol angles across Kilauea Crater from the Observatory were made October 10 and 26, November 15 and December 7 and 19. On October 10 the measurements indicated opening of 1.16" for the Halemaumau value and opening of 0.92" for the Crater value, compared with similar measurements made on September 27. Between October 10 and October 26 the Halemaumau angle remained unchanged and the crater angle closed 2.08". Total, September 27 to October 26, Pit opened 1.16" and Crater closed 1.16". The Halemaumau volue is measured between the seismograph station on the SE rim and the NW Pit bench mark. The crater value is measured between a station on the SE rim of Kilauea Crater and the Uwekahuna Station.

Angles November 15 had changed by the Halemaumau value opening 0.59" and the Crater value opening 0.24" compared with October 26 determinations.

Two more angle determinations were made during December. On December 7, the Halemaumau angle had opened 0.16" and the Crater angle had opened 1.09" since November 15. Between December 7 and 19, the Pit angle closed 1.25" and the Crater angle remained unchanged. Total change November 15 to December 19; Halemaumau angle closed 1.09" and the Crater angle opened 1.09".

For the period September 27 to December 19, both ongles showed on increase. The Halemaumau value increased 0.66" and the Crater value increased 0.17".

Chain-of-Craters Road Cracks

Date	101	102	103	104	105	106	107
October 27	404.65	64.55	101.50	17'9⅛"	87.30	88.75	39.55
November 24	404.60	64.60	101.50	same	87.35	88.75	39.60
December 29	404.55	64.60	101.55	same	87.35	88.75	39.50
Total change in mm. since September 29	—1.0	+0.5	.....	.....	+0.5	.....	—1.5

The two cracks which opened at the road edge of Aloi Crater rim during August showed no changes in the past three months.

H. H. W.

HAWAIIAN VOLCANO RESEARCH ASSOCIATION
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UNIVERSITY OF HAWAII

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