



HAWAIIAN VOLCANO OBSERVATORY
1969 QUARTERLY ADMINISTRATIVE REPORTS
INTRODUCTORY NOTE BY THOMAS L. WRIGHT AND JENNIFER S. NAKATA

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SUMMARY 53
JANUARY, FEBRUARY, AND MARCH 1969
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SUMMARY 54
APRIL, MAY, AND JUNE 1969
BY ROBERT Y. KOYANAGI, MARIE S. ONOUE, AND ELLIOT T. ENDO

SUMMARY 55
JULY, AUGUST, AND SEPTEMBER 1969
BY ROBERT Y. KOYANAGI, AKIRA YAMAMOTO, AND PATRICIA STEVENSON

SUMMARY 56
OCTOBER, NOVEMBER, AND DECEMBER 1969
BY ARNOLD T. OKAMURA, MARIE S. ONOUE, AND WILLIE T. KINOSHITA

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U.S. GEOLOGICAL SURVEY

U.S. Department of the Interior
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U.S. Geological Survey
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INTRODUCTORY NOTE

The Hawaiian Volcano Observatory Summaries have been published in the current format since 1956. The Quarterly Summaries (1956 through 1973) and the Annual Summaries (1974 through 1985) were originally published as Administrative Reports. These reports have been compiled and published as U.S. Geological Survey Open-File Reports. The quarterly reports have been combined and published as one annual summary. All the summaries from 1956 to the present are now available as .pdf files at <http://www.usgs.gov/pubprod>.

The earthquake summary data are presented as a listing of origin time, depth, magnitude, and other location parameters. Network instrumentation, field station sites, and location algorithms are described. Tilt and other deformation data are included until Summary 77, January to December 1977. From 1978, the seismic and deformation data are published separately, due to differing schedules of data reduction.

There are eight quarters—from the fourth quarter of 1959 to the third quarter of 1961—that were never published. Two of these (4th quarter 1959, 1st quarter 1960) have now been published, using handwritten notes of Jerry Eaton (HVO seismologist at the time) and his colleagues. The seismic records for the remaining six summaries went back to California in 1961 with Jerry Eaton. Other responsibilities intervened, and the seismic summaries were never prepared.

Chronology

The following Kīlauea eruption chronology covers the two recent reports and the six missing quarters:

Location	Beginning Date	Ending Date	Comment
Kīlauea Iki crater (Kīlauea's summit)	11/14/1959	12/20/1959	19 eruptive episodes
Kapoho (lower east rift zone)	1/13/1960	2/18/1960	4 eruption stages
Halemaumau (Kīlauea's summit)	2/24/1961	2/24/1961	Intermittent activity during uninterrupted inflation following the 1960 eruption
Halemaumau (Kīlauea's summit)	3/22/1961	3/25/1961	Same as above.
Halemaumau (Kīlauea's summit)	7/10/1961	7/17/1961	Same as above.
Heiheiahulu (middle east rift zone)	9/22/1961	9/25/1961	First historical east rift eruption at this location

The 1959-1960 eruptions were among two of the most spectacular Kīlauea eruptions. The HVO staff was kept busy with acquisition of unusually high quantities of instrumental data and observations of the two sequences, which were separated by less than one month. Even with a year's interval before the beginning of the summit-east rift sequence in 1961, the staff never caught up, and the seismic records were set aside for later study.

A total of 1,672 earthquakes—1,106 for 1960 and 566 for 1961—are part of HVO's cataloged database. The annual listings have been appended to the 1st Quarter Report of 1960 and to the 4th Quarter Report for 1961. The number of earthquakes is probably low, biased toward the larger magnitudes. The entire HVO catalog, including 1960 and 1961, is accessible from the ANSS CATALOG SEARCH site at <http://www.ncedc.org/anss/catalog-search>.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HAWAIIAN VOLCANO OBSERVATORY

SUMMARY 53

January, February, and March 1969

By Robert Y. Koyanagi, Steven A. Takeguchi
and Willie T. Kinoshita^{*/}

Issued September 1970

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CONTENTS

	Page
Summary of activities -----	1
Tilting of the ground around Kilauea caldera -----	4
Seismic summary -----	7

Illustrations

Figure 1. Map of the island of Hawaii showing seismograph stations and localities mentioned in the text -----	2
2. Tilting of the ground around Kilauea caldera between December 2, 1968 and February 5, 1969 -----	6

Tables

Table 1. Tilt coordinates at Uwekahuna vault -----	4
2. Tilt coordinates and changes at bases around Kilauea caldera -----	5
3. Number of earthquakes and minutes of tremor recorded on seismographs around Kilauea caldera -----	8
4. Local earthquakes recorded by seismographs of the U.S. Geological Survey -----	12
5. U.S. Geological Survey seismograph stations in Hawaii -----	24
6. U.S. Geological Survey tiltmeter stations in Hawaii -----	26

Summary of activities

Kilauea erupted from about 3 miles of fissure in the upper east rift starting a little before 10 a.m. on February 22, 1969. A swarm of short tremor bursts and small earthquakes started at 06:27. By nine o'clock the tremor was constant, though earthquakes had diminished, and lava appeared about 09:50. The first crack extended from the northeast rim of Alae nearly to the base of Kane Nui o Hamo and produced two flows that rapidly moved south across the Chain of Craters road. Within the next two hours, the erupting fissure extended eastward across the north flank of Kane Nui o Hamo, and westward across the western mezzanine of Alae, across the Chain of Craters road and to a point south of the west edge of Alae. Fountains from Alae mezzanine are forming a new lava lake in Alae that has filled the eastern pit by late afternoon of February 23rd. A sluggish aa flow from the eastern fissure is moving down the new highway, and reached more than a mile and a half by Sunday afternoon. The eruption continued until 17:15, February 24, and subsequently, the last fountain activity in Alae Crater subsided. In the afternoon of February 25, the fissure between Alae and Kane Nui o Hamo reopened, and started a second phase of eruption. Fountains nearly 200 feet high fed a flow, which once again, cascaded lava into Alae Crater. Activity finally ended on the morning of February 28.

The summit tilt network was run periodically this quarter to keep track of the inflation in the summit area. Two areas at the summit continue to inflate following the October 1968 eruption; one area northeast of Halemaumau that began inflating as the October eruption ended and a new area just west of Outlet vault that began inflating near the first part of this quarter.

Leveling completed on February 4, 1969, shows that the summit uplifted about 0.2 foot since November. The area near Makaopuhi seismometer also uplifted about 0.2 in the same time interval. Near the earliest August 1968 eruption vents, however, a subsidence of about 0.12 foot occurred during the same time interval.

It appears that, in the summit area, the inflation has not yet recovered its level of July 1968 before the 2 Upper East Rift eruptions. The line lengths as measured by the Geodimeter are still shorter than their July 1968 lengths and benchmark altitudes are still apparently about 0.1 foot lower than their July levels.

A third hole was drilled in Makaopuhi lava lake to the 'island' of crust to which our tramway cable is attached. Core was obtained from a section of the island root and the melt below. The crust-melt interface was displaced downwards to about 58 feet beneath the island. Most of the core is dense, very fine grained basalt, presumably the normal melt of the lake intruded into and quenched by the cooler island root. More vesicular core represents recrystallized and partially melted crust from the root. The sequence is similar to that reported last year from Kilauea Iki lava lake. Drilling extended 8 feet into the melt (66 feet) and ended when the molten lava moved into the core barrel before the drilling string could be completely lowered in order to attempt to drill deeper. We recovered the five-foot sample of glassy core, which proved to have lost most of its crystals during flow, a phenomenon also observed to have occurred in earlier samples collected by 'flow-in'.

The drilling rig was successfully removed from the crater by helicopter on February 11, 1969. We plan tentatively to re-drill Makaopuhi no later than the summer of 1971 and perhaps earlier as the volcano permits.

Tilting of the Ground Around Kilauea Caldera

Tilting of the ground around the summit of Kilauea is monitored daily by a short-base water-tube tiltmeter in Uwekahuna Vault, and at irregular intervals it is measured on a regional scale by means of a network of field tilt-bases and a portable water-tube tiltmeter. The attitude of the ground surface at each tilt-base is reported in terms of north-south and east-west tilt coordinates. Both coordinates at each station were arbitrarily set equal to 500 when measurements at that station were begun. Increasing tilt coordinates correspond to northward and eastward tilting of the earth's surface; that is, to a relative subsidence toward the north and east. A one-unit change in coordinate corresponds to a tilting of 1 micro-radian (1 mm per km) in the direction indicated.

Location of and essential data on each tiltmeter station are listed in table 6, which is published only in the first quarter issue each year.

Table 1.--Tilt coordinates at Uwekahuna, January,
February, and March, 1969

Date (1969)	N-S	E-W	Date (1969)	N-S	E-W
Jan. 5	527	412	Mar. 2	516	436
12	526	412	9	520	429
19	529	409	16	524	425
26	529	405	23	526	422
Feb. 2	532	406	30	530	417
9	533	408			
16	534	408			
23	527	424			

Table 2.--Tilt coordinates and changes at basis around Kilauea calders. (See fig. 2)

Tilt base	Date (1969)	Tilt N-S	Coordinates E-W	Rate (10^{-6} rad/mo) and direction of tilting since last reading	Date of last reading (1968)
Uwekahuna (U on fig. 2)	6 Feb	580.9	381.6	13.3 N38.2°W	3 Dec
Tree Molds (TM)	6 Feb	472.1	504.6	5.2 N4.5°W	3 Dec
Sand Spit (SS)	4 Feb	875.0	698.4	4.0 N18.0°W	27 Nov
Keamoku (Kea).	6 Feb	531.9	431.1	9.6 N60.8°W	2 Dec
Ahua Kamokukolau (Kam).	7 Feb	466.3	542.1	11.9 S20.8°E	27 Nov
Kipuka Nene (KN)					
Hilina Pali (HP)					
Kapapala Ranch (Kap).					
Mehena (M)	5 Feb	575.3	577.9	2.7 N11.1°E	2 Dec

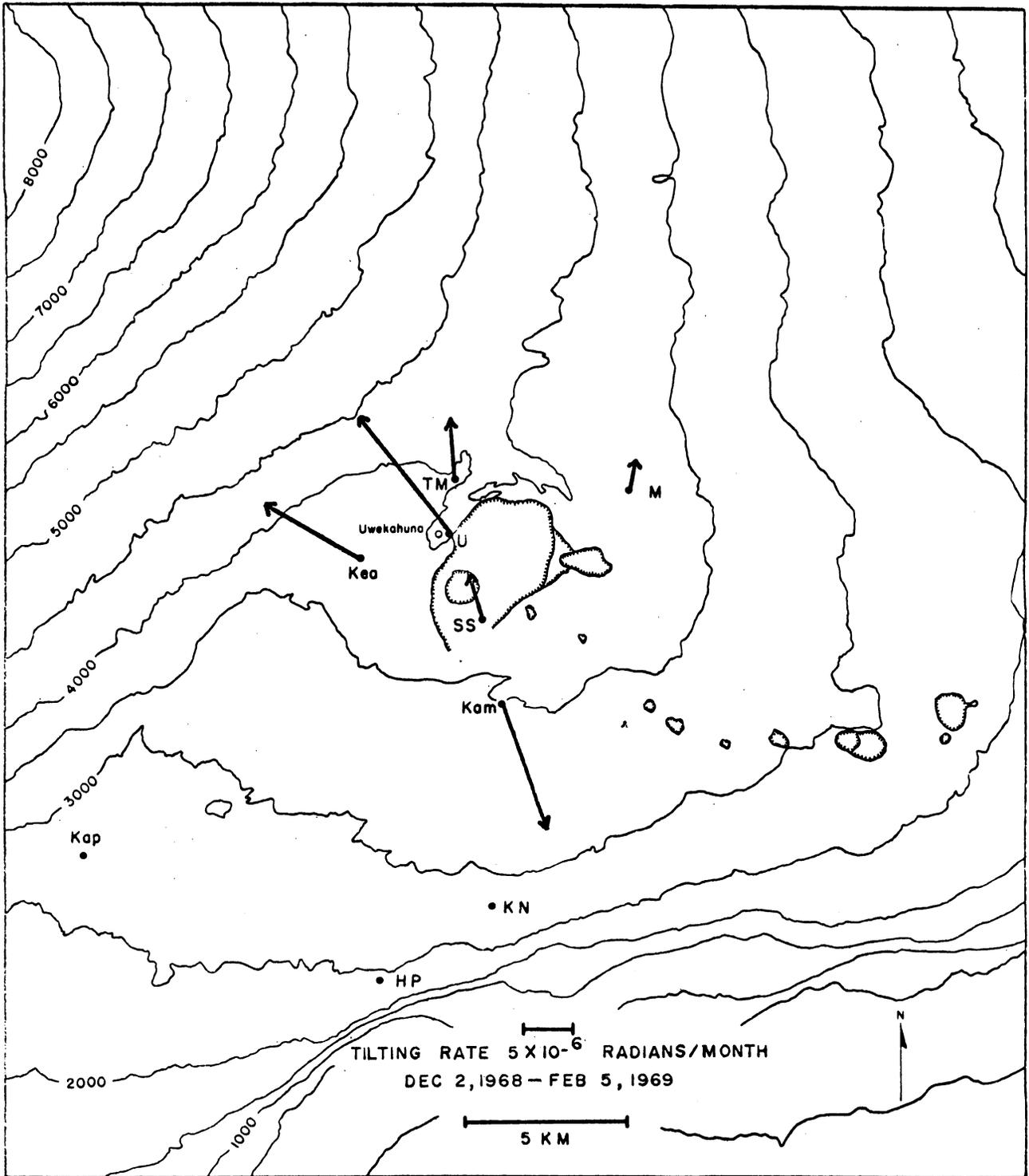


Figure 2.--Tilting of the ground around Kilauea Caldera between December 2, 1968, and February 5, 1969. The vector depicting tilting at a given tilt base points in the direction of maximum relative subsidence and has a length proportional to the rate of tilting during the measurement interval. Closed circles represent field tilt bases; open circles, short-base water-tube tiltmeters. See table 2 for explanation of abbreviations.

Seismic summary

Events recorded by the U.S. Geological Survey seismograph network in Hawaii fall into two categories: Local earthquakes and tremor originating in the region of the Hawaiian Islands (usually within 100 km of at least one seismograph), and distant earthquakes originating more than 3,000 km from Hawaii. As an index of seismic activity at Hawaiian volcanoes, daily counts of earthquakes and minutes of tremor recorded by seismographs in Hawaii are listed in table 3. The earthquakes are separated in groups on the basis of region of origin as determined by analysis of records obtained daily at the observatory (U, M, Mx, A, D, N, WP, MP, Kx, O). Earthquakes of magnitude 2.0 or greater are generally sufficiently well recorded to be located with greater precision; they are listed individually in table 4.

Location of and essential data on each seismograph station are listed in table 5 in the first-quarter issue each year.

Acknowledgments

Several people or agencies reported "felt" earthquakes during the first quarter, 1969. Their assistance is gratefully acknowledged.

Table 3.--Number of earthquakes and minutes of tremor recorded on seismographs around Kilauea Caldera

Tremor is separated into three categories: deep, intermediate, and shallow, on the basis of relative amplitudes on seismographs in the summit region. Unless otherwise stated, tremor is presumed to be associated with movement of magma within the central complex of Kilauea.

Earthquake categories are: Kilauea summit, 30 km, earthquakes from a source about 30 km beneath the Kilauea summit region; long-period, earthquakes characterized by low-frequency waves that originate about 5 km beneath Kilauea summit; and shallow earthquakes in the Kilauea Caldera region; shallow earthquakes along the SW. rift zone of Kilauea and the adjacent portion of the Kaoiki fault system; earthquakes along the eastern half of Kilauea's east rift zone--detected largely on the Pahoa seismograph; earthquakes from the upper east rift zone and the adjacent fault systems of Kilauea's south flank; and earthquakes from other regions: west Hawaii, Mauna Kea, etc.

Date (1969)	Tremor (m = minutes h = hours)			Earthquakes							
	Deep	Inter- mediate	Shallow	Kilauea Summit			SW rift and Kaoiki	Eastern east rift	Upper east rift	Koaie	Other
				30KM	Long Period	Shallow					
January 1	3	104	43	2	27	3	1
2	.	.	.	1	.	97	9	.	18	1	
3	92	8	.	28	4	
4	63	5	.	29	4	
5	120	.	.	29	4	
6	.	5m	.	1	.	290	6	.	22	2	
7	139	16	1	43	.	
8	.	.	.	1	.	89	9	.	23	3	
9	122	6	.	26	8	
10	.	.	.	3	.	87	11	.	31	3	
11	.	.	.	2	44	122	16	.	37	.	
12	.	.	.	2	36	73	5	.	30	5	2
13	.	.	.	3	5	89	18	.	25	2	1
14	.	6m	.	2	.	76	9	.	26	1	1

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Table 3.--Number of earthquakes and minutes of tremor recorded on seismographs around Kilauea Caldera--Continued

Date (1969)	Tremor (m = minutes h = hours)			Earthquakes							
	Deep	Inter- mediate	Shallow	Kilauea Summit			SW rift and Kaoiki	Eastern east rift	Upper east rift	Koae	Other
				30KM	Long Period	Shallow					
February 22	.	.	.	.	.	--	--	2	--	.	1
23	.	.	24h	.	9	29	9	.	--	.	3
24	60m	.	24h	5	.	19	5	.	--	5	1
25	.	.	24h	7	15	31	10	.	--	3	
26	6h	.	24h	3	.	28	8	1	--	3	
27	2h	.	24h	6	.	30	5	1	--	.	
28	.	.	.	2	495	38	12	3	--	.	1
<p>On Feb. 22, lava erupted for a few days between Alae Crater and Kane Nui o Hamo on the east rift zone. The Makaopuhi seismograph line was cut by the lava flow (-- = station out of order).</p>											
March 1	1	.	.	1	.	42	13	2	--	2	1
2	17	.	.	5	10	33	11	.	40	.	
3	.	.	.	7	1	49	6	.	24	1	
4	.	.	.	6	7	50	6	2	17	4	1
5	.	.	.	3	11	71	10	.	--	2	
6	.	.	.	3	4	57	11	1	60	1	1
7	.	.	.	4	2	73	11	1	60	.	
8	.	.	.	2	.	88	10	2	30	1	
9	.	.	.	3	2	72	8	.	45	2	1
10	26	.	.	4	2	73	14	.	60	.	
11	.	.	.	1	4	83	11	1	35	1	1
12	.	.	.	5	2	86	12	.	30	.	
13	.	.	.	3	.	92	10	1	26	3	1
14	.	.	.	2	.	111	9	.	40	2	
15	3	.	.	6	2	110	12	1	78	6	1

March

16	.	.	.	2	1	111	16	.	41	.	2
17	.	.	.	4	.	110	8	2	33	1	1
18	30	.	.	3	.	107	19	.	45	.	1
19	.	.	.	2	.	86	11	.	45	3	
20	.	.	45	1	.	98	9	.	200	2	
21	.	.	.	1	.	54	8	2	55	2	
22	.	.	.	1	.	79	12	1	49	1	
23	.	7	.	.	.	90	22	1	51	2	1
24	8	.	.	2	1	109	10	1	55	1	2
25	.	.	.	1	3	195	7	.	70	3	
26	.	.	.	3	2	125	7	.	50	.	
27	.	25	.	1	.	143	5	.	63	.	
28	.	.	.	1	5	194	16	.	45	2	1
29	.	.	.	1	.	107	16	1	35	.	1
30	.	.	.	1	.	147	17	1	61	2	1
31	.	.	.	4	.	375	9	.	57	6	

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey

January, February, March 1969

Entries for a given quake are: Date, origin time (Hawaiian Standard Time), magnitude, depth, epicenter, and felt report. All earthquakes of magnitude 2.5 and larger, as well as many favorably located smaller ones, occurring on or near the island of Hawaii are included in the list.

Date	Time <u>h</u> <u>m</u> <u>s</u>	Magni- tude	Depth (km)	Epicenter			Felt Report
				Lat. N.	Long. W.	Description	
January 1	02-47-27.8	4.2	13	20°06'	157°52'	150 km SE of Kipapa, Oahu	
3	01-53-57.9	2.4	9	19°24.1'	155°28.3'	13 km NW of Desert seismometer	
5	17-25-00.2	3.6	10	19°19.8'	155°13.2'	7 km SW of Makaopuhi seismometer	Kilauea Summit Area
5	18-31-26.7	3.0	10	19°18.8'	155°13.3'	8 km SW of Makaopuhi seismometer	Kilauea Summit Area
7	07-59-05.4	2.0	10	19°19.8'	155°13.0'	7 km SW of Makaopuhi seismometer	
8	14-00-41.0	2.8	8	19°24.2'	155°26.3'	9 km NW of Desert seismometer	
9	17-25-12.3	2.5	25	19°24.0'	155°18.8'	2 km SW of Kilauea Caldera	
10	22-38-52.2	2.0	9	19°22.0'	155°02.5'	7 km NW of Kalapana	
12	07-22-17.5	2.3	13	19°39.5'	155°26.4'	14 km SE of Pohakuloa	

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey

January, February, March 1969

Date	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	<u>h</u>	<u>m</u>	<u>s</u>			Lat. N.	Long. W.	Description	
January 12	11	06	47.2	2.3	0	19°27.2'	155°48.2'	14 km SE of Kealakekua	
13	18	30	08.9	2.0	3	19°19.8'	155°47.8'	12 km SE of Hookena	
14	17	21	24.5	2.3	8	19°26.0'	155°28.1'	11 km SW of Mauna Loa seismometer	
14	17	35	22.3	2.1	8	19°51.9'	155°31.9'	8 km NW of Mauna Kea summit	
14	21	37	06.0	3.8	8	19°47.7'	155°30.9'	6 km SW of Mauna Kea summit	Kamuela, Pepeekeo, Kealakekua, Hilo
16	00	02	07.5	2.3	9	19°21.3'	155°03.8'	9 km NW of Kalapana	
16	07	48	41.6	2.0	9	19°24.0'	155°25.3'	8 km NW of Desert seismometer	
16	10	50	15.5	2.5	40	19°13.2'	155°21.0'	14 km NE of Pahala	
17	12	41	59.6	2.3	9	19°20.2'	155°11.9'	5 km SW of Makaopuhi seismometer	
20	05	55	26.0	3.2	8	19°22.3'	155°29.9'	12 km NW of Desert seismometer	Pahala

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey

January, February, March 1969

Date	Time	Magni- tude	Depth (km)	Epicenter			Felt Report
	<u>h</u> <u>m</u> <u>s</u>			Lat. N.	Long. W.	Description	
January 21	23-22-41.6	2.5	10	19°19.7'	155°12.7'	6 km SW of Makaopuhi seismometer	
21	23-29-51.8	2.1	10	19°18.0'	155°12.8'	5 km NW of Apua Point	
22	05-15-32.7	2.6	0	19°32.7'	155°48.2'	13 km NE of Kealakekua	
23	05-30-14.1	2.2	9	19°20.8'	155°08.1'	4 km SE of Makaopuhi seismometer	
23	18-20-48.6	2.7	8	19°24.8'	155°26.0'	10 km NW of Desert seismometer	Pahala
23	21-04-39.0	2.7	55	19°26.5'	154°59.2'	7 km SW of Pahoa	
24	01-48-36.7	2.4	8	19°26.1'	154°53.2'	5 km SW of Pohoiki	
24	14-06-20.5	2.6	3	19°22.3'	155°47.0'	13 km ESE of Hookena	
24	16-58-27.0	2.9	30	19°23.3'	155°18.6'	3 km SW of Kilauea Caldera	Kilauea Summit Area, Pahala
25	09-07-36.2	2.0	9	19°19.5'	155°08.6'	5 km SE of Makaopuhi seismometer	
25	19-18-02.9	2.0	9	19°20.8'	155°08.0'	5 km SE of Makaopuhi seismometer	

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey

January, February, March 1969

Date	Time	Magni- tude	Depth (km)	Epicenter			Felt Report
	<u>h</u> <u>m</u> <u>s</u>			Lat. N.	Long. W.	Description	
January 25	23-16-53.9	2.0	9	19°19.9'	155°11.3'	4 km SW of Makaopuhi seismometer	Pahala, Hilo
26	08-41-20.9	2.2	9	19°19.3'	155°13.2'	7 km SW of Makaopuhi seismometer	
26	12-58-32.0	2.6	29	19°22.1'	155°17.3'	3 km SW of Ahua seismo- meter	
27	06-03-30.5	2.8	8	19°52.1'	155°34.2'	9 km NE of Waikii	
28	07-34-37.1	3.2	8	19°24.0'	155°24.9'	8 km NW of Desert seismometer	
28	10-44-19.1	2.0	13	20°52'	155°05'	95 km NE of Honokaa	
28	11-22-26.4	2.5	9	19°21.0'	155°07.7'	5 km SE of Makaopuhi seismometer	
29	05-34-36.3	2.5	8	19°24.5'	155°53.2'	3 km NE of Hookena	
30	02-26-43.6	2.0	11	19°20.4'	155°08.7'	4 km SE of Makaopuhi seismometer	
30	06-07-01.7	2.2	10	19°22.2'	155°04.0'	11 km E of Makaopuhi seismometer	
31	02-05-48.3	2.4	30	19°45.8'	154°59.0'	12 km NE of Hilo	

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey

January, February, March 1969

Date	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	<u>h</u>	<u>m</u>	<u>s</u>			Lat. N.	Long. W.	Description	
February 2	15	05	58.4	2.0	10	19°17.2'	155°12.7'	4 km NW of Apua Point	
3	01	15	47.3	2.9	13	19°37'	156°28'	60 km W of Kealakekua	
3	14	42	10.2	2.0	0	19°28.3'	155°49.0'	12 km SE of Kealakekua	
4	07	51	51.3	2.4	8	19°24.2'	155°26.0'	8 km NW of Desert seismometer	Pahala
4	21	15	23.1	2.5	13	18°35'	156°01'	50 km SW of Kalae Point	
5	14	14	46.4	2.1	9	19°20.3'	155°08.3'	4 km SE of Makaopuhi seismometer	
5	20	01	50.6	2.4	9	19°20.6'	155°14.7'	4 km SE of Ahua seismometer	
6	21	58	52.8	2.0	9	19°20.6'	155°11.5'	4 km SW of Makaopuhi seismometer	
6	23	33	51.1	3.5	45	19°12.3'	155°21.2'	13 km E of Pahala	Pahala, Kealakekua
7	05	59	36.6	3.5	30	19°21.3'	155°23.1'	2 km NE of Desert seismometer	Pahala, Mt. View, Kealakekua, Kilauea Summit Area

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey

January, February, March 1969

Date	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	<u>h</u>	<u>m</u>	<u>s</u>			Lat. N.	Long. W.	Description	
February 8	04	12	20.7	2.0	25	19°24.0'	155°15.2'	2 km SE of Kilauea Caldera	
8	06	28	45.5	2.0	10	19°20.7'	155°06.3'	7 km SE of Makaopuhi seismometer	
8	22	56	43.8	3.3	10	19°20.3'	155°09.0'	3 km SE of Makaopuhi seismometer	Hilo
9	16	24	42.2	4.1	10	19°20.2'	155°08.1'	5 km SE of Makaopuhi seismometer	Hilo, Mt. View, Kilauea Summit Area, Kealakikua, Honokaa, Pohakuloa, Kamuela
10	10	55	08.0	2.5	31	20°10'	156°22'	55 km WSW of Upolu Point	
10	21	29	59.3	2.1	10	19°20.0'	155°09.2'	3 km SE of Makaopuhi seismometer	
11	04	49	34.4	3.2	8	19°25.5'	156°02.5'	17 km SW of Kealakekua	
11	13	09	12.8	2.0	0	19°51.9'	155°26.9'	5 km NE of Mauna Kea Summit	

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey

January, February, March 1969

Date	Time <u>h</u> <u>m</u> <u>s</u>	Magni- tude	Depth (km)	Epicenter			Felt Report
				Lat. N.	Long. W.	Description	
February 11	13-42-02.6	2.0	0	19°52.3'	155°25.5'	7 km NE of Mauna Kea Summit	
12	01-34-18.5	2.1	3	19°53.3'	155°24.1'	11 km NE of Mauna Kea Summit	
13	03-05-01.9	2.1	20	19°26.2'	155°15.4'	1 km NE of Kilauea Caldera	
14	07-22-44.0	2.3	10	19°19.8'	155°12.0'	5 km SW of Makaopuhi seismometer	
14	16-03-52.4	2.0	8	19°49'	156°09'	13 km NW of Keahole Point	
14	18-26-39.8	2.2	3	19°34.0'	155°56.9'	6 km NW of Kealakekua	
14	20-48-31.7	2.4	10	19°20.3'	155°07.7'	5 km SE of Makaopuhi seismometer	Hilo
17	00-42-00.6	3.3	10	19°18.7'	155°13.1'	7 km NW of Apua Point	Kilauea Summit Area, Hilo, Pohakuloa, Pahala
17	00-59-19.2	2.2	10	19°18.5'	155°13.5'	7 km NW of Apua Point	
20	02-16-07.4	2.4	10	19°19.2'	155°13.2'	7 km SW of Makaopuhi seismometer	

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey

January, February, March 1969

Date	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	<u>h</u>	<u>m</u>	<u>s</u>			Lat. N.	Long. W.	Description	
February 22	12	24	23.5	3.5	13	19°30'	156°20'	44 km W of Kealakekua	
22	14	37	12.3	2.0	5	19°22.1'	155°12.3'	4 km W of Makaopuhi seismometer	
22	14	54	10.7	2.0	7	19°21.9'	155°13.0'	5 km E of Ahua seismometer	
22	16	27	19.0	2.4	30	19°27.2'	155°12.3'	10 km NE of Uwekahuna seismometer	
23	14	55	05.0	3.2	8	19°31.5'	155°37.4'	6 km NW of Mokuaweoweo Caldera	
23	14	56	26.3	2.5	8	19°32.2'	155°36.8'	7 km NW of Mokuaweoweo Caldera	
23	15	48	23.4	2.4	7	19°31.2'	155°36.6'	4 km NW of Mokuaweoweo Caldera	
24	18	35	11.7	2.5	8	19°10.3'	155°38.5'	14 km NW of Naalehu	
26	00	28	08.0	2.0	10	19°19.7'	155°02.0'	7 km SW of Kalapana	
26	12	12	49.7	2.6	25	19°22.1'	155°18.7'	4 km SW of Kilauea Caldera	Pahala
26	12	52	23.0	2.0	8	19°15.2'	155°25.8'	8 km NE of Pahala	

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey

January, February, March 1969

Date	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	<u>h</u>	<u>m</u>	<u>s</u>			Lat. N.	Long. W.	Description	
February 28	07	33	35.0	3.7	32	19°18.8'	155°24.7'	4 km SW of Desert seismometer	Pahala, Mt. View, Hilo, Kealahou
28	17	40	41.9	3.7	8	19°25.5'	155°26.2'	10 km SW of Mauna Loa seismometer	Pahala
28	19	03	07.0	2.0	0	19°31.2'	155°43.0'	21 km E of Kealahou	
March 1	07	09	18.5	2.5	8	20°00'	155°21'	5 km SE of Paauilo	
1	08	45	36.4	2.2	8	19°23.7'	155°25.9'	7 km NW of Desert seismometer	
2	12	56	55.9	3.0	8	19°24.2'	155°25.8'	9 km NW of Desert seismometer	
4	10	27	19.9	2.1	8	19°22.8'	155°25.0'	5 km NW of Desert seismometer	
4	18	16	10.3	3.6	35	18°59.5'	155°29.3'	13 km SE of Naalehu	Pahala
4	18	30	14.3	2.3	30	19°20.2'	155°19.4'	7 km E of Desert seismometer	Pahala
6	01	50	42.7	2.2	30	19°21.9'	155°20.3'	8 km SW of Uwekahuna seismometer	

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey

January, February, March 1969

Date	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	<u>h</u>	<u>m</u>	<u>s</u>			Lat. N.	Long. W.	Description	
March	6	04-54-26.4	2.4	13	20°44'	155°06'	14 km ESE of Haleakala, Maui		
	8	05-25-51.2	2.5	9	19°19.8'	155°07.2'	6 km SE of Makaopuhi seismometer		
	9	03-08-06.1	2.4	9	19°18.9'	155°06.8'	8 km SE of Makaopuhi seismometer		
	9	16-08-38.0	2.2	8	19°32.7'	155°39.3'	10 km NW of Mokuaweoweo Caldera		
	10	20-15-05.2	2.2	30	19°22.9'	155°16.8'	2 km S of Kilauea Caldera		
	11	00-36-55.4	2.1	9	19°17.0'	155°11.6'	3 km N of Apua Point		
	11	03-35-07.6	3.5	27	19°23.5'	155°16.9'	1 km S of Kilauea Caldera	Pahala, Kilauea Summit Area, Naalehu, Pohakuloa	
	11	04-48-47.5	2.2	9	19°18.2'	155°12.0'	5 km N of Apua Point		
	11	10-10-13.2	3.7	8	19°13.2'	155°27.9'	3 km NE of Pahala	Kealakekua, Pahala, Kilauea Summit Area	

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey

January, February, March 1969

Date	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	<u>h</u>	<u>m</u>	<u>s</u>			Lat. N.	Long. W.	Description	
March	11	17-54-51.1	2.1	35	19°26.0'	155°31.2'	8 km SE of Mokuaweoweo Caldera		
	13	00-21-32.7	2.8	13	19°19'	156°22'	50 km W of Hookena		
	13	07-47-40.4	2.0	13	19°25.5'	155°17.8'	Near Uwekahuna		
	15	02-49-35.9	2.3	0	19°52.7'	155°42.8'	7 km NW of Waikii		
	16	07-33-27.1	2.5	10	19°41'	156°10'	13 km SW of Keahole Point		
	16	13-23-18.9	2.2	13	19°26.2'	155°35.5'	2 km S of Mokuaweoweo Caldera		
	17	03-51-00.3	2.7	8	19°45.6'	155°26.'	8 km SE of Mauna Kea Summit		
	18	06-40-04.7	2.3	8	19°11.9'	155°36.7'	15 km NW of Naalehu		
	19	04-40-38.0	2.8	8	19°24.2'	155°25.8'	8 km NW of Desert seismometer	Kilauea Summit Area, Pahala	
	20	15-41-35.6	2.0	15	19°29.8'	155°16.2'	9 km NE of Uwekahuna seismometer		
	22	16-51-24.3	2.0	10	19°17.7'	155°04.4'	13 km SE of Makaopuhi seismometer		

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey

January, February, March 1969

Date	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	<u>h</u>	<u>m</u>	<u>s</u>			Lat. N.	Long. W.	Description	
March	23	07-03-11.3	2.4	10	19°19.3'	155°06.8'	8 km SE of Makaopuhi seismometer		
	23	19-25-36.6	2.7	35	19°18.7'	154°48.9'	18 km SE of Kalapana		
	24	08-45-29.2	2.4	0	19°29.0'	155°48.0'	13 km SE of Kealakekua		
	24	20-51-14.0	2.8	3	19°39'	156°22'	33 km SW of Keahole Point		
	25	18-36-07.8	2.4	13	19°24.8'	155°17.5'	West Kilauea Caldera		
	27	23-53-56.6	2.6	28	19°19.0'	155°21.2'	4 km SE of Desert seismometer		
	28	07-03-12.0	2.8	13	19°54.6'	155°20.5'	1 km SW of Keanakolu		
	29	06-14-18.5	2.2	10	19°20.2'	155°01.7'	5 km SW of Kalapana		
	29	09-54-53.0	2.6	13	20°01.4'	155°21.9'	2 km S of Paauilo		
	29	21-24-21.9	2.3	10	19°19.2'	155°12.0'	7 km SW of Makaopuhi seismometer		
	30	03-46-20.5	3.0	3	20°04.1'	155°22.2'	4 km N of Paauilo		

Table 5.--U.S. Geological Survey seismograph stations in Hawaii

[On island of Hawaii unless otherwise stated]

Station	Symbol	Location		Altitude (m) above sea level	Equipment (Z, vertical; N, north-south; E, east-west)
		Lat N.	Long W.		
Uwekahuna (Hawaiian Volcano Observatory)	U	19°25.4'	155°17.6'	1,240	Long-range Press-Ewing: N, E, Z. (Seismometer and galvanometer periods are 15 and 90 seconds, respectively.) Short-period Sprengnether: E, Z. HVO-1: Z ₁ /
Mauna Loa	M	19°29.8'	155°23.3'	2,010	Short-base liquid-level tiltmeter
Ahua	A	19°22.4'	155°15.9'	1,070	Remote recording HVO-2: Z ₂ /
Mauna Loa (2)	M(2)	19°27.6'	155°20.7'	1,475	Do.
Desert	D	19°20.2'	155°23.3'	815	Remote recording 1.0 sec. EV-17 Z.
North Pit	N	19°24.9'	155°17.0'	1,115	Do.
West Pit	WP	19°24.7'	155°17.5'	1,115	Do.
Makaopuhi	MP	19°21.8'	155°10.7'	885	Do.
Kealakomo	K	19°18.5'	155°09.6'	201	Do. (installed Sept. 28, 1966)
Outlet	O	19°23.4'	155°16.8'	1,084	Do.
Kipuka Nene	KN	19°20.1'	155°17.4'	924	Do. (installed Sept. 21, 1967)
Cone Peak	CP	19°23.7'	155°19.7'	1,038	Do. (installed Nov. 8, 1967)
Hilo	Hi	19°43.2'	155°05.3'	20	HVO-1: Z Wood-Anderson: N, E. Operated by Joseph De Mello at St. Joseph's School.
Kipapa, Oahu	Kip	21°25.4'	158°00.9'	76	HVO-1: Z. Operated by U.S. Coast and Geodetic Survey.
Pahoa	Pa	19°29.7'	154°56.8'	205	HVO-1: Z. Operated by Kongo Kimura at Pahoa School.

Haleakala, Maui	HA	20°46.0'	156°15.0'	2,090	HVO-1: Z. Wood-Anderson: N, E. Operated by the staff of Haleakala National Park, Maui.
Naalehu	Na	19°03.8'	155°35.2'	205	1.0 sec. EV-17 seismometer, 0.5 sec. galvanometer: Z. Operated by Mrs. E. Elarionoff at Naalehu School.
Kamuela	Ka	20°01.9'	155°42.0'	740	1.0 sec. EV-17, 0.286 sec. galvanometer. Operated by Mrs. P. Hall at H.P.A., Kamuela.
North Bay	NB	19°29.7'	155°34.8'	4,005	1.0 sec. EV-17: Z. with helicorder. Operated by U.S. Weather Bureau.
Kealahou	Ke	19°31.2'	155°55.3'	505	1.0 sec. EV-17, 0.286 sec. galvanometer: Z, EW, and NS. Operated by Henry Helson at Kona County Hospital.

¹/HVO-1 is a moving-coil, hinged, vertical-component seismograph with seismometer and galvanometer periods of 0.5 second. Overdamping of both seismometer and galvanometer is used to control the strong galvanometer reaction. This seismograph has a peak magnification of about 20,000 at a period of 0.25 second. Recording is optical, on photographic paper.

²/HVO-2 is a moving-coil, vertical-component seismograph with a seismometer period of 0.8 second. Its signal is transmitted over telephone wires to the Hawaiian Volcano Observatory, where it is recorded on smoked-paper recorders.

Table 6.--U.S. Geological Survey tiltmeter
stations in Hawaii

Station	Symbol	Location		Frequency of reading	Base length M	Description
		Lat. N.	Long. W.			
Tree Molds	TM	19°26.3'	155°17.3'	Quarterly	50.79	NS. and EW.
Sand Spit	SS	19°24.1'	155°16.8'	---do---	25.40	Equilateral triangle.
Keamoku	Kea	19°25.1'	155°19.0'	---do---	47.55	Do.
Ahua Kamokukolau	Kam	19°22.7'	155°16.6'	---do---	50.79	Do.
Kipuka Nene	KN	19°19.4'	155°16.7'	---do---	50.79	Do.
Hilina Pali	HP	19°18.2'	155°18.6'	---do---	47.73	Do.
Kapapala Ranch	Kap	19°20.5'	155°23.8'	---do---	50.79	Do.
Mehana	M	19°26.2'	155°14.3'	---do---	25.00	Do.
Uwekahuna	U	19°25.5'	155°17.4'	---do---	50.79	Do.
Uwekahuna Vault		19°25.4'	155°17.6'	Daily	3.48	NS. and EW.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HAWAIIAN VOLCANO OBSERVATORY

SUMMARY 54

April, May, and June 1969

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CONTENTS

	Page
Summary of activities -----	1
Tilting of the ground around Kilauea calders ---	8
Seismic summary -----	9

Illustrations

Figure 1. Map of the island of Hawaii showing seismograph stations and localities mentioned in the text -----	2
2. Tilting of the ground around Kilauea caldera (data not available this quarter) -----	

Tables

Table 1. Tilt coordinates at Uwekahuna vault --	8
2. Tilt coordinates and changes at bases around Kilauea caldera (data not available this quarter) -----	
3. Number of earthquakes and minutes of tremor recorded on seismographs around Kilauea caldera -----	10
4. Local earthquakes recorded by seismo- graphs of the U.S. Geological Survey -----	14

Summary of activities^{*/}

May-June Kilauea east rift eruptions

After approximately 3 months of quiescence the east rift of Kilauea begin erupting at about 04:45 on May 24. Initial fountaining apparently began from a fissure that crossed the northern part of Aloi Crater and extended as far east as due north of the west edge of Alae. The fissure quickly spread westward, crossing the Chain of Craters road at the north edge of the Aloi steam flat. Several earthquakes were felt by local residents at about this time. The fissure continued to spread westward--much as the February 22 fissure did--and crossed the Ainahou Ranch road about 450 meters south of the Chain of Craters road. Fountains from this fissure were plainly visible from the Observatory. The fissure finally reached as far west as about 150 meters west of the Ainahou road--the farthest an eruptive fissure has penetrated into the Koae fault zone during historic time. The western part of the fissure follow faithfully the pre-existing Koae fault trend, curving in just the right places. In fact, the fissure seems to follow precisely an older Koae crack--the largest crack north of the Kalanaokuaiki Pali. Vertical 9 x 9 inch color aerial photographs show that fountaining was concentrated in two areas--one from west of the Ainahou road to the Chain of Craters road, the other about halfway between Aloi and Alae Craters. (This last area has been the site of all subsequent activity.) The photos show that Aloi Crater had been filled by 25 meters of lava, nearly all of which had already drained back down the eruptive fissure that cut the floor. The photos further show that the floor of Alae Crater was already covered with new lava and that more was cascading in. The line of February spatter cones just west of Alae that had been such a tourist attraction was in the process of being buried by a flow moving down-slope from the fissure, and by the next day only the tips of the higher cones remained. Even these were covered 3 days later, and now all that remains of them is an abrupt change in slope in the new lava that covers them.

Lava from the western fissure line flowed southward before being dammed by the Kalanaokuaiki Pali, thereby saving the Ainahou Ranch from inundation. Nearly all of

^{*/}Taken from Hawaiian Volcano Observatory, USGS monthly reports.

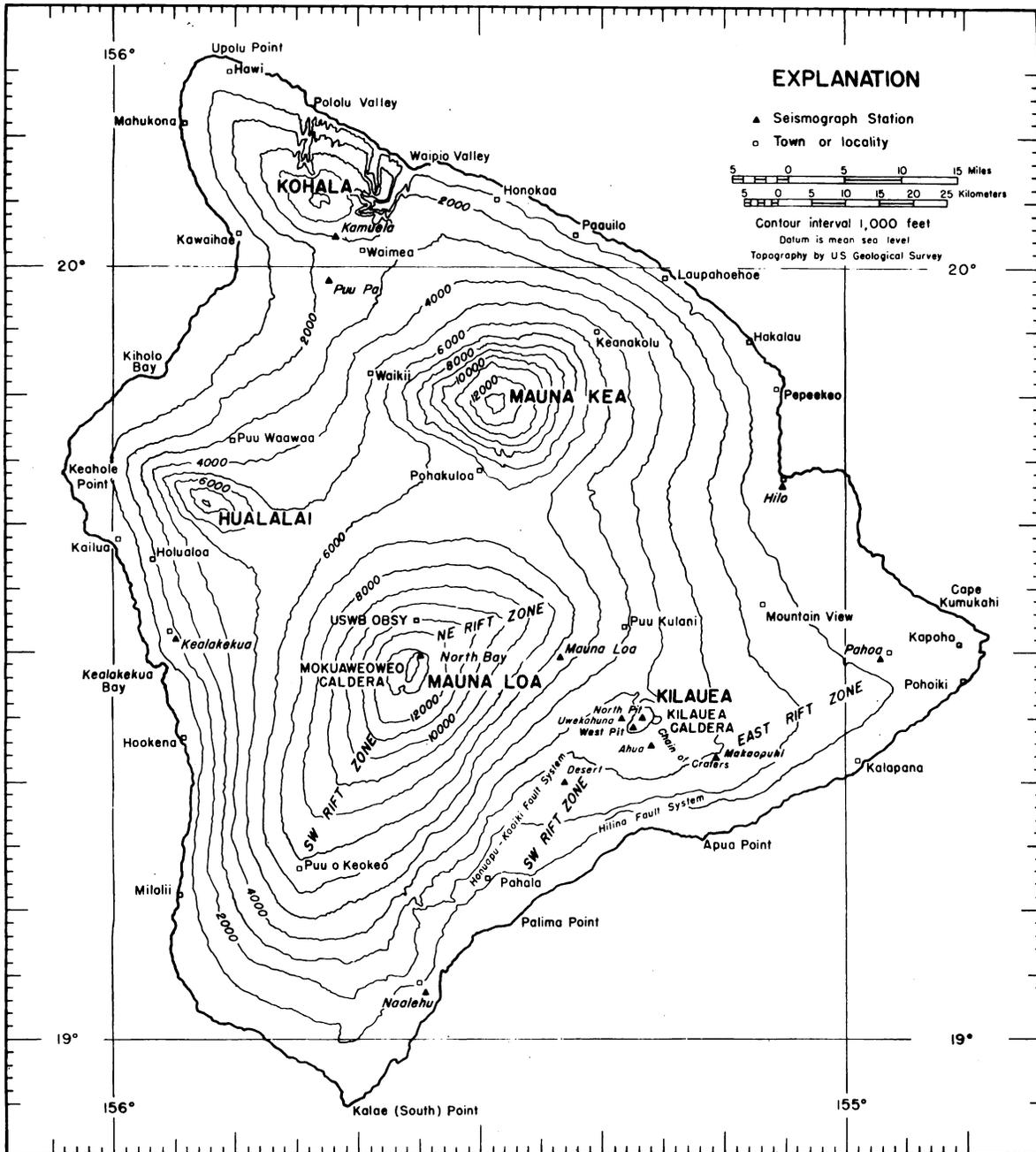


Figure 1.--Map of the Island of Hawaii showing seismograph stations operated by the U.S. Geological Survey, principal settlements, and selected geologic features. Epicenters of local earthquakes are given in table 4 in terms of geographic coordinates, which are indicated at the edges of the map.

the area bounded by the Ainahou road, the Pali, a line south of Aloi, and the fissure was covered by new lava.

Most activity stopped by 22:00, May 24, but an observation flight at 10:30, May 25, showed weak fountaining from the major vent area between Aloi and Alae. This activity ended sometime later in the day. An estimated 4.5×10^6 cubic meters of lava was erupted.

Tremor continued to be recorded by the portable seismometer on May 26 and May 27, and we were quite sure that the eruption had not ended. Sure enough, at 19:00, May 27, phase 2 fountaining resumed at the vent area between Aloi and Alae. Summit tilt delayed change until 22:45, when slow deflation began. Flows spread eastward into Alae and southward across the lava flows of phase 1 and February 22. By 17:00, May 28, the flow moving southward was about 1.5 km south of Alae, and summit tilt was still recording deflation. Tremor and tilt drop stopped within the space of 3 minutes at 09:20, May 29, and phase 2 had ended. About 3.5×10^6 cubic meters of lava erupted in phase 2. Strain and tilt changes for both phases 1 and 2 were small.

During phase 2, two vent areas were established in the main fountaining area between Aloi and Alae. These are hereafter called the eastern and western vent areas. A high spatter rampart separated the two, and spatter ramparts encircled the entire area. Both vent areas would fountain during each phase, but fountains from the eastern, and deeper, vent area were consistently higher. During interphase periods, sloshing and bubbling sounds could be heard from the eastern vent area, and we correlated these sounds with the continuous tremor that was being recorded by temporary seismometers placed at Aloi and near the Hilina Pali-Chain of Craters road junction. Never was lava visible in the fissure, however, and we were continually guessing as to what the sounds and tremor meant--degassing of stagnant lava, or evidence of active magma waiting to erupt. Needless to say, each phase gave us confidence in the latter interpretation, and it is now clear that the eruption should actually be considered as being continuous since May 24.

Phase 3 began at 13:30 on June 12 with no premonitory tremor or earthquakes. Our survey party happened on the scene minutes after the eruption had begun. Fountaining then was only 3-4 meters high but grew into 100-meter high showers within 2 hours. The crew watched lava

advance down the May 27 channel leading southward from the fountains, and soon the vigorous flow filled and overflowed the channel. This flow eventually cascaded brilliantly over the Poliokeawe fault scarp, on down over the even steeper Holei fault scarp, and spread slowly seaward as an aa flow toward Apua Point. It stopped before noon on June 13, leaving its distal margin about a kilometer from the beach at Apua. A small amount of lava again poured into Alae Crater. The volume of erupted lava for this phase was about 4.0×10^6 cubic meters.

Phase 4, which began from the same vent area at 21:45, June 25, finally did it. Lava fed by the 220 meter high fountains poured across the June 12-13 lava, cascaded over Poliokeawe and Holei Palis, and reached the sea about a kilometer east of Apua Point at 08:35, June 26, an hour and a half after fountaining had ceased in the vent area. The aa "flow" that reached the ocean is more aptly described as a "trickle." Much pumice was produced by these fountains, and the parking lot and roadway at Alo'i were buried beneath 50 cm of the stuff. More lava poured into Alae, raising the floor to about 30-35 meters of the rim. About 4.5 cubic meters of lava was erupted during the fourth phase.

The days preceding the outbreak of the eruption on May 24 showed high counts of earthquakes from the upper east rift and shallow caldera area. Bursts of 20 to 40 quakes per 2-hour periods were commonly recorded on Makaopuhi and North Pit seismographs. Caldera quakes dropped off early on May 23, but rift quakes continued high and reached a peak of nearly 200 at the time of the onset of tremor, about 04:45, May 24. Strong tremor and large numbers of rift quakes coincided with the fountaining of phases 1 and 2. Since early June, except for a few moderate-sized swarms of earthquakes, the eruption assumed a monotonous seismic pattern of high harmonic tremor during phases and relative quiescence during inter-phases. Stations at moderate distances from the eruption site showed no tremor a few hours after a phase, but intermittent recordings taken on a portable seismometer near Alo'i indicated that local tremor fluctuates continually between phases.

The tie-in of the summit magma chamber(s) to the active rift zone was again noted. The eruption area was the main source of tremor, but immediately after major fountain activity, a secondary tremor source near the summit became quite obvious on the West Pit seismograms.

Tremor readings taken with the portable seismograph immediately after a phase also suggested relatively high tremor amplitudes at the summit and a possible link south-east to the site of eruption. A large number of tremor-like bursts beneath the caldera (referred to long-period caldera quakes), usually recorded just after an eruptive phase seem to indicate further activity of magma. These post-phase seismic activities generally fit times of rapid summit re-inflation, as recorded by the ideal Aeromsmith E-W tiltmeter at Uwekahuna.

The May 24 eruption did not come unexpected. Strain and tilt data indicated that another eruptive event was in the final stage of gestation. Cumulative caldera strains were higher than before the February eruption, and the E-W Uwekahuna tilt had recovered about 90 percent of the 40 microradians lost in February.

On May 23 the flank eruption was preceded by a 5 microradian collapse in the Uwekahuna recording tiltmeter. During the early hours of the 24th accompanying the development of tremor amplitude was a sharp drop in the Uwekahuna tilt. The Uwekahuna tilt dropped nearly 15 microradians in less than 24 hours after beginning of the eruption. After a small recovery the tilt dropped till the 29th of May for a total collapse of 25×10^{-6} radians in less than 7 days. The Uwekahuna tilt recovered 14 microradians before the June 12 eruption. This recovery was quickly lost with the onset of the outbreak in the Aloi-Alae area. Like on previous events of the year, the tilt began a rapid recovery with the termination of surface activity.

Releveling during mid-April and on 27-28 May revealed interesting altitude changes not only at the summit and eruption area, but also on the south-east flank of Kilauea.

Data from the mid-April run showed a maximum summit uplift of +11 cm and a maximum uplift of +30 cm near Kane Nui O Hamo. Unlike the summit and east rift, the south-east flank showed negative changes of -4 cm on the Hilina Pali and Chain of Craters road and about -3 cm on the Ainahou road.

The May 24 eruption did not change the sense of deformation significantly. The May 27-28 run showed a net uplift of 8 cm in the summit area with a shift in the center of inflation to the vicinity of Outlet vault. (1 1/2 - 2 km south of previous center.) Like in the February 22 eruption, the eruption area had been uplifted. A maximum

of +42 cm was recorded less than a 1/4 kilometer south of Aloi crater. A new center of uplift a kilometer south of Makaopuhi crater showed a change of +14 cm since the April run.

In deformation studies, coinciding with the leveling efforts are measurements of a horizontal strain. More recently, of these labors, the geodimeter/geodolite operation is the most impressive. Between 24-27 February and 21-23 April the summit lines extended by centimeters. Peripheral lines contracted by 25% to 50% less than the maximum summit extensions. Asymmetry of summit strains continued to be evident.

Notes of other events

In the latter part of March, as part of the continuing studies of the lower east rift, Willie Kinoshita, Robert Decker, and several members of the Kilauea Job Corps reran the Pahoa-Kalapana-Kupaupau tide gage level line and the Pahoa-Pohoiki level line in the Puna area. The lower east rift has continued to inflate during the interval 1965-1969 and the maximum uplift since 1958 has been about 0.6 to 0.7 feet at the south end of the new section of straight road constructed over the 1955 flows.

During mid-April a drilling program was initiated on the Alae lava lake formed during the February eruption. On April 14 we bottomed the first hole at 9.7 feet; with relatively poor core recovery. The crust melt interface was at a depth of about 7.5 feet. Alae lava lake drilling ceased with the loss of the drill and related equipment by an inundation of Alae with lava from the May 24 vents.

Several additional seismic observations were noteworthy during this quarter. At 04^h36^m, 7 May, a moderate-sized 4.7 magnitude quake located 65 km east-northeast of Hana, Maui was felt by residents of Hana, Kohala, and Kamuela. A larger event at 15^h33^m, 9 May, located 10 km beneath the east rift of Kilauea registered 5.0 in magnitude. The latter event was felt island-wide (with one report of minor damage in Hilo). At least one of the 50 or so aftershocks was felt at the Volcano.

The number of shallow caldera quakes during the quarter ranged from about 50 to 500 per day. During this same period were several small summit deflations, superposed on the general long term trend of inflation that corresponded to highs and lows of seismic activity.

The pattern appears to be an increase in shallow quake count with continued build-up of tilt followed by a decrease in quake count coinciding with the small tilt collapse.

Tilting of the ground around Kilauea caldera

Tilting of the ground around the summit of Kilauea is monitored daily by a short-base water-tube tiltmeter in Uwekahuna Vault, and at irregular intervals it is measured on a regional scale by means of a network of field tilt-bases and a portable water-tube tiltmeter. The attitude of the ground surface at each tilt-base is reported in terms of north-south and east-west tilt coordinates. Both coordinates at each station were arbitrarily set equal to 500 when measurements at that station were begun. Increasing tilt coordinates correspond to northward and eastward tilting of the earth's surface; that is, to a relative subsidence toward the north and east. A one-unit change in coordinate corresponds to a tilting of 1 microradian (1 mm per km) in the direction indicated.

Location of and essential data on each tiltmeter station are listed in table 6, which is published only in the first quarter issue each year.

Table 1.--Tilt coordinates at Uwekahuna
April, May, and June 1969

Date (1969)	N-S	E-W	Date (1969)	N-S	E-W
April 6	535	415	May 18	548	407
13	536	416	25	545	420
20	539	412	June 1	541	427
27	542	410	8	545	419
May 4	546	406	15	543	424
11	546	407	22	546	419
			29	543	427

Seismic summary

Events recorded by the U.S. Geological Survey seismograph network in Hawaii fall into two categories: Local earthquakes and tremor originating in the region of the Hawaiian Islands (usually within 100 km of at least one seismograph), and distant earthquakes originating more than 3,000 km from Hawaii. As an index of seismic activity at Hawaiian volcanoes, daily counts of earthquakes and minutes of tremor recorded by seismographs in Hawaii are listed in Table 3. The earthquakes are separated in groups on the basis of region of origin as determined by analysis of records obtained daily at the observatory (see Table 5 for list of stations). Earthquakes of magnitude 2.0 or greater are generally sufficiently well recorded to be located with greater precision; they are listed individually in Table 4.

Location of and essential data on each seismograph station are listed in Table 5 in the first-quarter issue each year.

Acknowledgments

Several people and agencies reported "felt" earthquakes during the second quarter, 1969. Their assistance is gratefully acknowledged.

Table 3.--Number of earthquakes and minutes of tremor recorded on seismographs around Kilauea Caldera

Tremor is separated into three categories: deep, intermediate, and shallow, on the basis of relative amplitude on seismographs in the summit region. Unless otherwise stated, tremor is presumed to be associated with movement of magma within the central complex of Kilauea Volcano.

Earthquake categories are: Kilauea summit, 30 km, earthquakes from a source about 30 km beneath the Kilauea summit region; long-period, earthquakes characterized by low-frequency waves that originate about 5 km beneath Kilauea summit; and shallow earthquakes in the Kilauea caldera region; shallow earthquakes along the SW. rift zone of Kilauea and the adjacent portion of the Kaoiki fault system; earthquakes from the upper east rift zone and the adjacent fault systems of Kilauea's south flank; shallow earthquakes along the northeast-trending Koaie fault system south of Kilauea caldera; and earthquakes from other regions: west Hawaii, Mauna Kea, etc.

10

Date (1969)	Tremor (m = minutes h = hours)			Earthquakes							Remarks
				Kilauea Summit			SW rift and Kaoiki	Upper east rift	Koaie	Others	
	Deep	Inter- mediate	Shallow	30KM	Long Period	Shallow					
April 1	.	.	.	1	.	185	17	65?	2	.	
2	.	.	.	3	.	165	10	70?	3	.	
3	.	.	.	3	.	111	7	45?	2	1	
4	.	.	.	2	.	56	9	38?	3	.	
5	.	.	.	1	.	56	6	43?	4	1	
6	122	12	68?	.	.	
7	.	.	.	2	.	101	20	66?	.	.	
8	.	3	.	2	6	79	11	45?	2	.	
9	.	.	.	2	1	74	22	27?	.	2	
10	.	.	.	8	.	75	7	75?	3	1	
11	.	.	.	1	.	102	16	17?	2	1	
12	.	.	.	2	.	144	13	12	4	.	
13	149	11	30	2	.	
14	190	8	22	3	1	
15	.	.	.	3	.	70	10	21	5	.	

Table 3.--Number of earthquakes and minutes of tremor recorded on seismographs around
Kilauea Caldera--Continued

Date (1969)	Tremor (m = minutes h = hours)			Earthquakes							
	Deep	Inter- mediate	Shallow	Kilauea Summit			SW rift and Kaoiki	Upper east rift	Koaie	Others	Remarks
				30KM	Long Period	Shallow					
April 16	.	.	.	7	.	65	7	19	5	1	
17	.	.	.	2	.	155	12	21	2	.	
18	.	.	.	1	.	273	23	8	.	.	
19	.	.	2	.	.	336	23	12	6	.	
20	.	.	.	2	.	255	15	18	.	1	
21	.	.	.	3	.	205	4	7	2	.	
22	.	5	.	3	.	217	12	11	4	.	
23	330	4	14	3	.	
24	27	87	17	53	5	.	
25	.	.	.	5	2	54	10	23	2	2	
26	.	.	.	2	.	96	19	20	2	1	
27	.	.	.	3	.	129	10	22	5	.	
28	.	.	.	2	.	232	9	15	23	1	
29	.	.	.	2	.	370	14	12	21	1	
30	20	.	.	2	.	375	5	27	15	1	
May 1	11	.	.	1	.	290	10	23	21	.	
2	189	13	23	26	.	
3	.	.	.	6	.	310	13	13	25	.	
4	.	.	.	2	2	230	7	19	8	.	
5	.	.	.	1	.	470	11	20	19	1	
6	.	.	.	3	.	191	12	10	25	.	
7	.	.	.	1	7	131	11	21	10	2	
8	23	.	.	3	9	66	7	31	3	1	
9	30	.	.	2	.	85	7	53	6	.	
10	.	.	.	1	.	173	30	34	3	.	
11	.	.	.	5	.	230	18	25	.	1	

May

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12

Start of shallow
tremor and rift quakes
at 0312, May 24.

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202
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June

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6

Strong during phases
of eruption and fluctua-
ting at low levels during
interphases

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75?
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76
100
104
110+
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118
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136
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12
12
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23
16
10
7
8
17
7
6
4
13
9
795
230
480
185+
176+
172+
115?
98?
92?
87
42
16
40+
90?
68
50
180?

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Phase 3 (1330, June
12 to 1100, June 13)

(from May 24 upper east rift quake
counts taken from EKO station located
19°21.8'N, 155°15.3'W)
Kilauea East Rift eruption Phase 1
(0445, May 24 to 1500, May 25)
Phase 2 (1900, May 27 to 0900, May 29)

Table 3.--Number of earthquakes and minutes of tremor recorded on seismographs around
Kilauea Caldera--Continued

Date (1969)	Tremor (m = minutes h = hours)			Earthquakes							Remarks
	Deep	Inter- mediate	Shallow	Kilauea Summit			SW rift and Kaoiki	Upper east rift	Koaie	Others	
				30KM	Long Period	Shallow					
June 18	.	.		1	7	14	9	90?	2	.	Phase 4 (2145, June 25 to 0700, June 26)
19	.	.		1	2	121	7	49	.	.	
20	.	.		1	.	186	8	28	1	3	
21	.	.		3	.	226	5	24	.	1	
22	.	.		1	.	190	10	8	2	1	
23	304	15	19	.	.	
24	282	3	10	.	.	
25	.	.		1	12?	160	14	68?	1	.	
26	37	7	7	.	1	
27	.	.		1	.	53	11	11	.	.	
28	.	.		2	.	95	18	27	.	.	
29	.	.		1	10	94	7	45?	3	1	
30	.	.		2	1	48	3	15?	3	2	

Table 4.--Local earthquakes recorded by seismographs of the
U.S. Geological Survey, April, May, June, 1969.

Entries for a given quake are: Date, origin time (Hawaiian Standard Time), magnitude, depth, epicenter, and felt report. All earthquakes of magnitude 2.5 and larger, as well as many favorably located smaller ones, occurring on or near the island of Hawaii are included in the list.

Date	Time <u>h m s</u>	Magni- tude	Depth (km)	Epicenter		Felt Report
				Lat. N.	Long. W.	
April 3	13-44-04.5	3.0	5	19°30.2'	155°47.8'	
April 5	07-47-50.7	2.2	8	19°25.8'	155°27.4'	
April 5	17-29-15.5	2.5	0	19°28.3'	155°48.0'	
April 5	18-32-26.1	2.0	8	19°23.0'	155°27.1'	
April 5	19-45-07.4	2.3	5	19°22.8'	155°14.8'	
April 6	03-45-07.8	2.0	10	19°21.3'	155°05.5'	
April 6	13-54-20.1	2.0	10	19°20.3'	155°07.7'	
April 6	19-30-28.3	2.8	8	19°14.9'	155°27.2'	Pahala
April 7	13-05-12.2	2.6	10	19°20.8'	155°04.2'	
April 9	07-30-56.1	4.2	13	20°59'	155°43'	Hana (Maui)
April 9	09-12-13.1	2.5	6	19°25.2'	155°25.2'	
April 9	17-42-08.8	2.2	30	19°04.7'	155°21.3'	
April 9	20-20-04.4	2.3	30	19°22.7'	155°17.8'	
April 10	18-52-10.1	2.8	30	19°22.2'	155°16.9'	Pahala
April 10	23-11-29.0	2.1	10	19°46.2'	155°25.3'	
April 11	03-06-19.7	2.4	0	19°28.1'	155°48.1'	
April 11	05-30-03.3	2.2	10	19°20.2'	155°08.7'	

Table 4.--Local earthquakes recorded by seismographs of the
U.S. Geological Survey, April, May, June, 1969.

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
	<u>h</u> <u>m</u> <u>s</u>			Lat. N.	Long. W.	
April 11	21-30-02.5	2.5	10	19°20.3'	155°08.9'	
April 13	14-49-38.3	2.8	10	19°19.8'	155°04.8'	Hilo
April 14	03-57-05.0	2.1	35	19°46.7'	156°03.0'	
April 16	18-17-27.1	2.9	30	19°22.8'	155°17.8'	Pahala
April 16	19-26-01.4	2.1	8	19°09.7'	155°36.4'	
April 17	17-41-25.1	3.0	8	19°27.2'	155°27.0'	
April 18	00-56-46.9	2.4	8	19°12.8'	155°07.2'	
April 18	02-00-39.4	2.2	10	19°21.5'	155°01.0'	
April 18	21-25-57.0	3.4	8	19°26.0'	155°26.7'	Pahala, Kil- auea Summit Area
April 19	01-24-12.1	2.5	5	19°20.2'	155°22.5'	Pahala
April 19	14-04-18.8	2.4	9	19°13.5'	155°27.4'	
April 20	07-31-29.6	2.0	0	19°22.7'	155°47.3'	
April 20	20-57-54.7	2.0	10	19°20.3'	155°12.4'	
April 23	14-44-24.8	2.7	35	19°01.0'	155°14.3'	
April 25	02-48-34.1	2.4	35	18°56.1'	155°14.3'	
April 25	21-18-34.6	2.0	5	19°29.0'	155°26.2'	
April 26	10-13-19.1	2.0	15	19°24.1'	155°18.0'	
April 26	22-56-43.0	2.6	0	19°23.7'	155°46.8'	

Table 4.--Local earthquakes recorded by seismographs of the
U.S. Geological Survey, April, May, June, 1969.

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
	<u>h m s</u>			Lat. N.	Long. W.	
April 28	04-48-25.1	3.2	9	19°24.8'	155°27.4'	Kilauea Summit Area, Kealakekua, Pahala, Poh- akuloa
April 28	10-05-38.2	2.8	30	19°13.7'	155°31.3'	
April 29	15-12-56.0	2.0	8	19°25.7'	155°25.0'	
April 29	19-15-28.3	2.5	6	19°41.3'	155°36.2'	
April 30	02-02-41.6	2.3	5	19°48.7'	155°36.2'	
May 3	08-46-53.6	2.4	30	19°22.7'	155°17.3'	
May 4	09-56-15.6	2.0	10	19°20.7'	155°05.1'	
May 4	13-53-24.6	2.4	10	19°18.7'	155°11.0'	
May 5	01-05-03.8	3.7	8	19°29.3'	155°37.9'	Island-wide
May 7	04-35-59.0	4.5	13	20°50'	155°21'	Hena (Maui), Kohala, Kam- uela, Waimea
May 7	04-48-33.5	2.2	13	20°50'	155°21'	
May 8	01-48-24.3	2.9	20	19°25.8'	155°16.7'	Kilauea Summit Area
May 8	13-45-30.5	2.0	8	19°54.8'	155°43.9'	
May 8	23-48-20.3	2.2	10	19°22.6'	155°03.1'	
May 9	07-40-52.6	2.2	10	19°20.5'	155°07.3'	
May 9	15-33-27.6	5.0	11	19°22.1'	155°04.9'	Island-wide

Table 4.--Local earthquakes recorded by seismographs of the
U.S. Geological Survey, April, May, June, 1969.

Date	Time		Magni- tude	Depth (km)	Epicenter		Felt Report
	<u>h</u>	<u>m</u>			<u>s</u>	Lat. N.		Long. W.
May	9	16-03-28.4	2.8	20	19°27.0'	155°16.8'	Kilauea Summit Area
May	9	18-14-41.4	2.6	10	19°20.4'	155°03.7'	
May	9	20-14-50.5	2.2	10	19°21.0'	155°02.8'	
May	9	20-38-08.7	2.1	10	19°20.7'	155°03.8'	
May	10	00-52-46.6	2.0	10	19°19.8'	155°07.1'	
May	10	04-50-40.9	3.1	10	19°18.3'	155°01.4'	Kalapana
May	10	16-54-16.2	2.0	10	19°20.3'	155°02.3'	
May	10	22-34-36.2	2.0	20	19°25.2'	155°16.2'	Kilauea Summit Area
May	10	23-00-26.3	2.2	10	19°18.6'	155°12.7'	
May	11	02-15-14.6	2.3	8	19°23.7'	155°25.2'	
May	11	10-24-32.7	2.5	40	19°01.7'	155°06.0'	
May	11	10-47-49.1	2.0	26	19°27.1'	155°14.5'	
May	12	16-17-12.7	2.3	0	19°28.7'	155°46.3'	
May	14	02-17-10.7	2.4	10	19°20.3'	155°03.3'	
May	14	15-26-26.0	2.3	32	19°13.6'	155°24.2'	
May	14	05-42-47.3	2.1	10	19°17.5'	155°04.1'	
May	15	12-39-18.5	2.2	5	19°23.1'	155°15.2'	
May	16	09-54-58.2	2.1	37	19°13.3'	155°24.7'	

Table 4.--Local earthquakes recorded by seismographs of the
U.S. Geological Survey, April, May, June, 1969.

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
				<u>h</u> <u>m</u> <u>s</u>	Lat. N.		Long. W.
May 16	22-38-46.0	3.0	47	19°56.8'	155°05.7'	Kilauea Summit Area
May 17	12-52-58.4	3.6	34	19°14.7'	155°25.4'	Kealakekua
May 17	13-52-23.5	2.5	32	19°12.4'	155°22.7'	
May 17	19-52-52.8	2.0	11	19°17.5'	155°04.3'	
May 17	20-56-22.2	2.5	32	19°13.0'	155°22.9'	Kealakekua
May 18	03-42-41.8	2.7	0	19°48.8'	155°48.2'	
May 19	02-30-03.0	2.9	10	20°43.1'	155°33.1'	
May 21	06-03-32.3	2.6	6	19°23.1'	155°14.9'	Kilauea Summit Area
May 22	05-25-08.5	2.6	59	20°23.7'	156°17.3'	
May 22	17-07-28.8	3.8	12	19°02.4'	155°02.3'	Kilauea Summit Area
May 22	17-10-27.5	2.9	10	19°16.5'	155°05.4'	
May 22	18-44-51.8	2.6	6	19°09.2'	154°57.4'	
May 24	04-10-54.4	2.3	6	19°21.8'	155°12.4'	
May 24	05-04-15.9	2.4	9	19°21.5'	155°17.9'	
May 24	05-34-51.0	2.7	10	19°21.4'	155°11.7'	
May 24	05-49-33.9	3.0	10	19°19.0'	156°34.7'	
May 24	06-42-41.9	2.3	8	19°23.7'	155°06.5'	
May 24	06-49-24.8	2.3	2	19°20.1'	155°05.9'	

Table 4.--Local earthquakes recorded by seismographs of the
U.S. Geological Survey, April, May, June, 1969.

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
				<u>h</u> <u>m</u> <u>s</u>	Lat. N.		Long. W.
May 24	07-29-34.7	2.7	9	19°21.6'	155°15.9'	
May 24	09-05-38.7	2.8	9	19°23.5'	155°07.0'	
May 24	09-50-36.5	2.3	2	19°21.0'	155°05.8'	
May 24	10-43-56.2	2.3	12	19°19.0'	155°08.7'	
May 24	11-29-57.4	2.2	9	19°23.3'	155°06.7'	
May 24	13-19-37.1	2.1	10	19°21.3'	155°08.9'	
May 24	14-00-23.9	2.3	10	19°23.1'	155°06.0'	
May 24	14-26-22.9	2.1	3	19°21.2'	155°14.9'	
May 24	15-48-07.2	2.6	7	19°21.5'	155°14.0'	
May 24	17-59-59.8	3.8	5	19°19.5'	155°07.7'	Kealakekua, Kilauea Summit Area
May 24	21-29-02.7	2.1	10	19°11.9'	155°08.6'	
May 25	03-43-15.1	3.7	8	19°23.8'	155°32.1'	Kilauea Summit Area, Waimea, Keal- akekua
May 25	06-55-54.4	2.0	13	19°19.9'	155°12.8'	
May 25	07-55-40.9	2.0	6	19°17.4'	155°00.9'	
May 25	18-01-49.7	3.3	4	19°20.3'	155°07.6'	Kilauea Summit Area
May 25	22-54-39.1	2.2	10	19°19.7'	155°05.7'	

Table 4.--Local earthquakes recorded by seismographs of the
U.S. Geological Survey, April, May, June, 1969.

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
				h m s	Lat. N.		Long. W.
May 26	19-58-47.4	2.5	30	19°23.3'	155°15.9'	
May 26	22-22-12.2	2.5	11	19°23.0'	155°29.0'	Pahala, Pohakuloa
May 27	09-19-20.0	3.3	19	19°25.5'	155°17.3'	Pahala
May 27	10-04-59.2	2.4	19	19°24.7'	155°16.5'	
May 27	11-40-04.6	2.4	10	19°12.9'	155°00.2'	
May 27	14-35-25.8	2.4	31	19°28.4'	155°17.0'	
May 28	20-20-12.9	2.9	10	20°06.3'	156°49.9'	
May 29	12-00-25.8	2.5	8	19°47.9'	155°36.1'	
May 30	02-15-43.5	2.1	10	19°18.4'	155°13.7'	
May 30	03-43-27.6	2.4	7	19°14.1'	155°00.7'	
May 31	02-55-08.9	2.2	39	19°27.7'	155°32.7'	
May 31	12-07-02.5	2.5	6	19°17.0'	155°06.5'	
May 31	19-22-48.4	2.7	10	19°22.6'	155°29.4'	
May 31	21-12-19.7	2.2	56	19°04.4'	154°41.1'	
June 1	06-54-04.5	2.3	2	19°20.1'	155°05.1'	
June 1	17-35-06.9	2.4	36	19°12.3'	155°28.7'	
June 2	17-33-51.6	3.3	11	19°20.1'	155°07.9'	Hilo
June 2	18-16-46.0	2.0	8	19°16.1'	155°08.2'	
June 2	21-36-41.0	2.3	8	19°22.8'	155°21.9'	

Table 4.--Local earthquakes recorded by seismographs of the
U.S. Geological Survey, April, May, June, 1969.

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
				h m s	Lat. N.		Long. W.
June 3	17-49-13.1	2.2	10	19°19.0'	155°14.2'	
June 4	03-32-56.3	3.7	10	19°18.5'	155°12.7'	Hilo, Pahala
June 4	04-11-14.2	2.3	10	19°19.8'	155°14.3'	
June 4	05-22-07.8	2.6	1	19°15.1'	155°06.1'	
June 4	09-34-31.1	2.8	11	19°26.0'	155°25.7'	Pahala
June 4	11-29-43.4	2.1	36	19°17.4'	155°01.1'	
June 4	21-09-33.2	2.0	10	19°19.3'	155°13.3'	
June 5	03-16-50.0	2.2	2	19°52.0'	155°37.9'	
June 5	10-43-26.6	2.0	10	19°20.1'	155°14.9'	
June 5	13-06-08.7	2.1	10	19°23.9'	155°23.1'	Pahala
June 5	14-12-30.9	2.3	11	19°21.6'	155°11.6'	Hilo
June 5	14-41-26.3	2.2	11	19°18.7'	155°13.2'	
June 5	14-43-41.3	3.7	9	19°19.4'	155°13.7'	Hilo, Pahala, Kilauea Summit Area, Kealakekua
June 5	14-54-46.3	3.0	9	19°19.9'	155°14.6'	Kilauea Summit Area
June 5	15-36-48.7	2.0	9	19°20.0'	155°14.2'	
June 5	17-31-33.2	2.1	9	19°20.0'	155°14.2'	
June 5	22-06-56.0	2.1	10	19°17.3'	155°13.1'	

Table 4.--Local earthquakes recorded by seismographs of the
U.S. Geological Survey, April, May, June, 1969.

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
				<u>h</u> <u>m</u> <u>s</u>	Lat. N.		Long. W.
June 6	01-37-37.6	2.6	10	19°10.7'	155°07.8'	
June 6	02-37-42.9	2.5	10	19°17.2'	155°08.1'	
June 6	09-41-46.9	4.4	11	19°25.5'	155°27.0'	Mauna Loa, Pahala, Kilauea Summit Area, Hilo, Kamuela, Paauilo
June 6	11-55-32.6	4.2	35	19°21.3'	155°16.9'	Island-wide
June 6	21-50-56.9	2.0	35	19°12.5'	155°28.8'	
June 7	00-28-11.7	2.4	34	19°20.4'	155°16.5'	
June 7	01-41-26.2	4.0	10	19°16.2'	155°11.2'	Pahala, Hilo, Kilauea Summit Area, Kealakekua
June 7	01-50-31.8	3.1	10	19°15.8'	155°11.1'	Hilo, Kealakekua
June 7	05-14-49.0	2.4	10	19°17.1'	155°13.1'	
June 7	09-33-31.9	2.1	8	19°20.6'	155°13.8'	
June 8	01-05-28.9	2.2	10	19°17.6'	155°13.2'	
June 8	07-20-54.3	2.4	13	19°20.2'	155°04.8'	
June 8	11-50-48.2	2.1	10	19°20.0'	155°15.1'	
June 10	00-53-16.7	2.2	14	19°24.3'	155°18.1'	

Table 4.--Local earthquakes recorded by seismographs of the
U.S. Geological Survey, April, May, June, 1969.

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
	<u>h</u> <u>m</u> <u>s</u>			Lat. N.	Long. W.	
June 10	06-39-59.1	2.2	11	19°10.4'	155°38.4'	
June 10	23-20-58.3	3.1	67	18°49.8'	155°41.6'	
June 11	06-06-28.5	2.1	10	19°19.9'	155°23.7'	
June 13	06-17-25.4	2.4	9	19°25.8'	155°27.5'	
June 14	13-37-23.1	2.5	51	19°09.9'	154°45.9'	
June 16	19-04-53.1	3.4	61	19°56.9'	155°06.9'	Hilo
June 17	11-27-57.6	2.5	9	19°21.6'	155°24.8'	
June 18	00-00-49.4	3.3	7	19°21.4'	155°03.0'	Pahala
June 19	03-26-54.6	2.1	6	19°24.8'	155°23.2'	
June 19	18-42-34.6	2.0	12	19°18.5'	155°10.1'	
June 20	10-15-30.3	2.3	10	19°49.2'	155°36.0'	
June 20	18-12-41.4	2.1	10	19°27.2'	155°43.6'	
June 20	18-16-03.9	2.6	6	19°28.0'	155°41.8'	
June 21	03-48-24.0	3.3	8	20°26'	156°50'	
June 22	03-28-19.6	2.0	10	19°23.7'	155°45.7'	
June 22	07-54-30.9	2.2	32	19°21.7'	155°17.0'	
June 22	10-23-01.5	2.4	9	19°25.9'	155°24.2'	
June 25	17-47-57.6	2.1	7	19°17.3'	155°03.3'	
June 26	15-24-58.4	3.1	10	20°29.9'	155°27.1'	

Table 4.--Local earthquakes recorded by seismographs of the
U.S. Geological Survey, April, May, June, 1969.

Date	Time		Magni- tude	Depth (km)	Epicenter		Felt Report	
	<u>h</u>	<u>m</u>			<u>s</u>	Lat. N.		Long. W.
June 28	21	11	48.8	2.3	5	19°16.0'	155°02.8'	
June 29	02	01	17.9	2.3	35	19°22.3'	155°16.0'	
June 29	22	52	59.5	2.7	10	19°09.3'	155°41.1'	
June 30	08	51	.1	3.2	8	20°36'	154°54'	
June 30	15	21	00.4	2.4	35	19°17.2'	155°13.8'	
June 30	22	41	20.8	2.1	8	19°20.9'	155°01.2'	
June 30	23	17	59.2	2.0	10	19°36.3'	155°42.5'	

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HAWAIIAN VOLCANO OBSERVATORY

SUMMARY 55

July, August, and September 1969

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CONTENTS

	Page
Summary of activities.....	1
Changes in the seismic net.....	4
Tilting of the ground around Kilauea caldera.	4
Seismic summary.....	6

Illustrations

Figure 1. Map of the island of Hawaii showing seismograph stations and localities mentioned in the text.....	2
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Tables

Table 1. Tilt coordinates at Uwekahuna vault.	5
2. Number of earthquakes and minutes of tremor recorded on seismographs around Kilauea caldera.....	8
3. Local earthquakes recorded by seismographs of the U.S. Geological Survey.....	14

Summary of activities

Eruptive activity that began in the second quarter of 1969 on May 24 continued through the third quarter. The vent area resumed its May 24 vigor on July 15. Fountain activity which persisted for 8 hours fed a flow with a course similar as the June 26 flow. The new flow terminated near the base of Holei Pali.

Except for nearly continuous tremor local to the vent, there was no preliminary seismic activity. Prior to the fountaining on July 11, lava was observed rising slowly deep in the throat of the western vent. Samples were collected when the lava rose to favorable heights. Visible fountaining began shortly before 0430. By 0430 fountain heights rose over 350 meters. Surface activity and tremor ceased abruptly at 1222, and summit inflation resumed immediately. Approximately 2 hours later, tremor resumed in the vent area. Fuming continued, and during degassing mobile lava was occasionally visible in the western vent. Most of the new lava had gone under the crust of the Alae lava lake and had lifted the crust en masse to within 50 feet of the Alae crater rim.

On July 20 the lava column beneath the vent was observed rising and falling in 50-meter intervals. The level of the new lava approached within 3-6 meters of the vent level and would fall to a lower level in crudely determined cycles. The lava usually took about an hour to rise to its highest level and less time to fall to its lowest level. This type of activity continued on to July 31, occasionally interrupting the change in lava level with violent spattering and a more rapid change in the height of the lava column within the vent.

At 1715, August 3, violent fountaining up to 150 meters high marked another period of high level activity. Fountaining ended at 0000, August 4. A lava flow filled Alae Crater to within 10 meters of the rim. As on July 15 the old crust had been lifted en masse by the new lava that invaded Alae Crater. Between 0400 and 0430, August 4, seismometers recorded a vigorous episode of harmonic tremor and earthquakes. This episode accompanied tremendous ground cracking and graben formation between Alae Crater and Kane Nui o Hamo. The cracks intersected the floor of Alae Crater, and probably in the span of a half hour Alae drained to a level below the mezzanine that was buried during February. Over 10 million cubic meters of lava had been drained out. The graben surface, where observed just east of Alae Crater, was about 10 meters wide and 60-70 meters deep (limit of visibility). A Geodimeter line across the graben showed considerable extension.

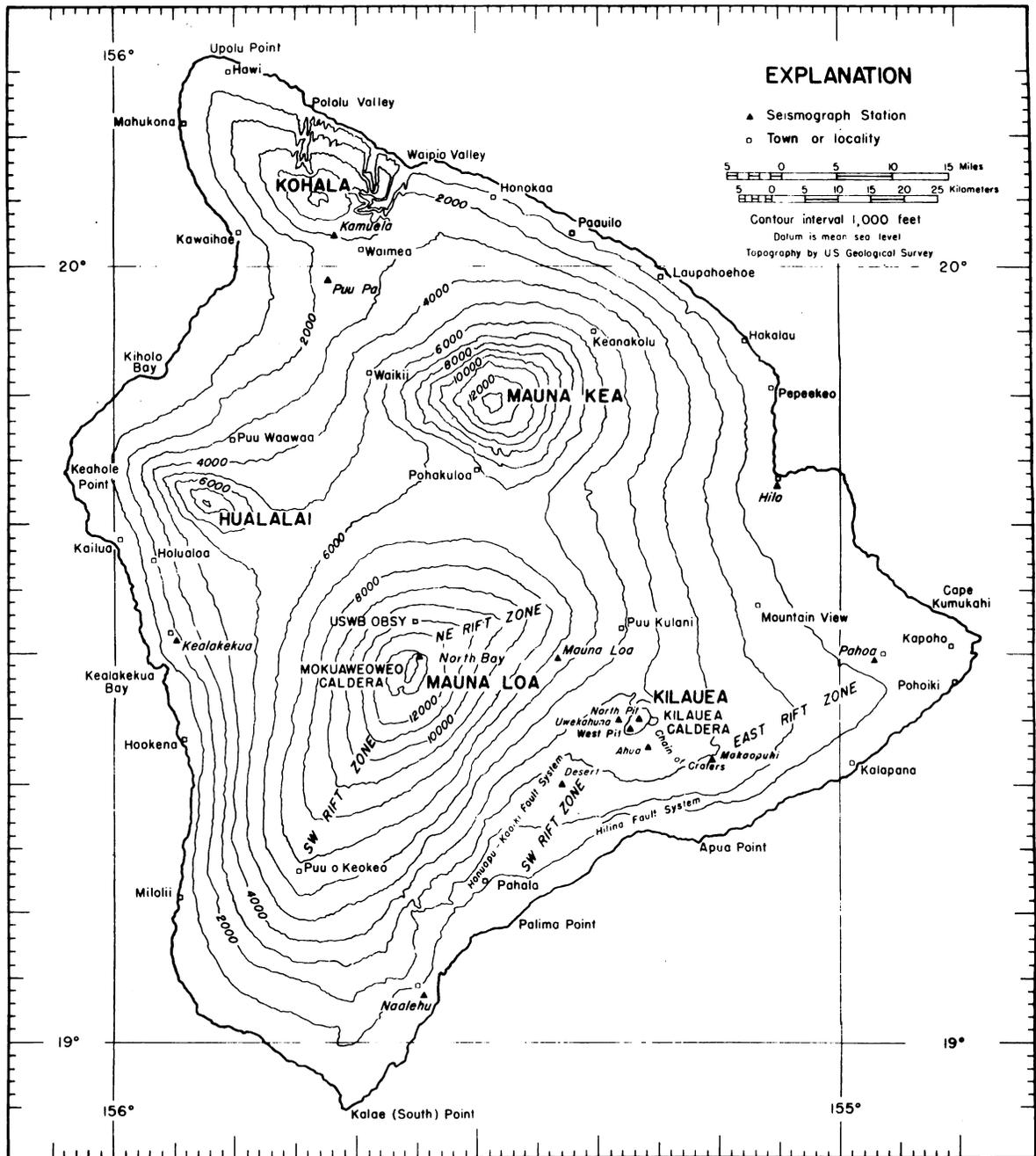


Figure 1.--Map of the Island of Hawaii showing seismograph stations operated by the U.S. Geological Survey, principal settlements, and selected geologic features. Epicenters of local earthquakes are given in table 3 in terms of geographic coordinates, which are indicated at the edges of the map.

At 1400, August 4, characteristic eruption-type fume clouds were observed to be coming from a zone along the East Rift, east of Napau Crater. Only lava oozing out from fissures could be seen from the air. There was little or no fountaining. A narrow tongue of lava flowed east for 1.2-1.3 km from a point less than 1 km northwest of Puu Kamoamoia. Samples collected from the flow were richer in olivine than any lava that drained from Alae Crater.

At 2100, August 5, fountaining several tens of meters high was occasionally observed in the vent area. An aa lava flow continued into Alae Crater. Large remnants of overfill that had clung to the sides of the crater were rafted across the crater. The crater floor had taken on an unusual character consisting of aa, rafted blocks, and talus.

At 1130, August 21, spattering up to 15 meters high started to build up a cone.

At 0015, August 22, the highest fountains, more than 400 meters high, were in the western vent area. Activity was spread along a fissure both east and west of the main vent complex. A flow developed southward for 1 km. Nearly all erupted material flowed into Alae Crater (2.7×10^6 cubic meters), raising the level of the floor to 34 meters below the rim. Activity has better defined a cone of spatter and pumice to the south side of the main vent.

At 1930, September 6, there was strong activity at the vent preceding actual lava fountaining. Nearly degassed lava rose and fell with rapidity in the vent area. Volumetric changes were estimated to be 20,000-30,000 m³. In almost continuous sequences the lava column in the vent rose 40 meters in 40 minutes and drained back within 5 minutes or less. The column commonly rose within 10 meters of the vent level. As with the drop in fuming, tremor was low or absent during periods of rising lava columns. Fuming and tremor (local to the vent area) picked up suddenly and remained at high levels during drainback. At 1930 Kilauea summit seismometers began recording higher level tremor and fountaining was first observed at about this time. Fountaining was confined to the western vent. By 0415, September 7, a lava flow had completely filled Alae Crater. Smaller flows developed at two points on the southwest rim. At 2100 a westward flow began cascading into Aloi Crater. Eventually it covered the floor with 10 meters of aa. Two other flows extended from the south edge of the new cone. One flow reached Poliokeawe Pali, where it split into two tongues, one of which stopped at the bottom of the cliff. The other tongue continued over Poliokeawe Pali and flowed a short distance from the base of the Pali. The largest newly developed cone is now 30 meters high and is visible from the Observatory. All of the current lava and spatter is moderately to highly olivine rich, whereas the early material contains only sparse olivine. Fountains at 2200 reached 540 meters in height but by 2300 were down to 400-420 meters, where they stayed until about 0130, when the heights abruptly decreased to about 300 meters. At 0425 in the span of 5 minutes, high-level surface activity ceased.

Changes in the seismic net

FM radios for continuous seismic telemetry were installed at the following locations:

	Lat	Long	Elevation (m)	Date began (1969)
a) Puu Huluhulu - PHH	19°22.5'N	155°12.4'W	1021	July 28
b) Makaopuhi - MPR	19°22.1'N	155°09.8'W	881	July 31
c) Kahuku - KHU	19°14.9'N	155°37.1'W	1939	August 8
d) Hale Pohaku - HPU	19°46.6'N	155°27.3'W	3231	August 19

With the exception of MPR, all stations transmitted directly to Uwekahuna. Like VCO signals that are telemetered via rented telephone lines, FM radio signals are discriminated and recorded on a develocorder unit.

During this quarter, the University of Hawaii, under contract from ESSA, installed a transmitter at HVO to telemeter Honuapo tide gauge data and seismic data from HVO's Pahoa and Waiohino stations. Their receiver is located at the Mauna Kea Observatory.

Tilting of the ground around Kilauea caldera

Tilting of the ground around the summit of Kilauea is monitored daily by a short-base water-tube tiltmeter in Uwekahuna vault, and at irregular intervals it is measured on a regional scale by means of a network of field tilt-bases and a portable water-tube tiltmeter. The attitude of the ground surface at each tilt-base is reported in terms of north-south and east-west tilt coordinates. Both coordinates at each station were arbitrarily set equal to 500 when measurements at that station were begun. Increasing tilt coordinates correspond to northward and eastward tilting of the earth's surface; that is, to a relative subsidence toward the north and east. A one-unit change in coordinate corresponds to a tilting of 1 microradian (1 mm per km) in the direction indicated.

Location of tiltmeter stations and essential data on each station are listed in table 6, which is published only in the first-quarter issue each year.

Table 1.--Tilt coordinates at Uwekahuna vault,

July, August, and September 1969

Date (1969)	N-S	E-W	Date (1969)	N-S	E-W
July 6	544	418	Aug. 31	546	408
13	545	416	Sept. 7	543	415
20	544	418	14	541	418
27	546	410	21	543	412
Aug. 3	547	418	28	543	409
10	544	418			
17	546	410			
24	545	410			

Seismic summary

Events recorded by the U.S. Geological Survey seismograph network in Hawaii fall into two categories: Local earthquakes and tremor originating in the region of the Hawaiian Islands (usually within 100 km of at least one seismograph), and distant earthquakes originating more than 3,000 km from Hawaii. As an index of seismic activity at Hawaiian volcanoes, daily counts of earthquakes and minutes of tremor recorded by seismographs in Hawaii are listed in table 3. The earthquakes are separated in groups on the basis of region of origin as determined by analysis of records obtained daily at the observatory. Earthquakes of magnitude 2.0 or greater are generally sufficiently well recorded to be located with greater precision; they are listed individually in table 4.

Location of seismograph stations and essential data on each station are listed in table 5 in the first-quarter issue each year.

Acknowledgments

Several people and agencies reported "felt" earthquakes during the third quarter, 1969. Their assistance is gratefully acknowledged.

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Table 2.--Number of Earthquakes and minutes of tremor recorded on seismographs around Kilauea

Tremor is separated into three categories: Deep, intermediate, and shallow, on the basis of relative amplitude on seismographs in the summit region. Unless otherwise stated, tremor is presumed to be associated with movement of magma within the central complex of Kilauea Volcano.

Earthquake categories are: Kilauea summit, 30 km, earthquakes from a source about 30 km beneath the Kilauea summit region; long-period, earthquakes characterized by low-frequency waves that originate about 5 km beneath Kilauea summit; and shallow earthquakes in the Kilauea caldera region; shallow earthquakes along the S.W. rift zone of Kilauea and the adjacent portion of the Kaoiki fault system; earthquakes from the upper east rift zone and the adjacent fault systems of Kilauea's south flank; shallow earthquakes along the northeast-trending Koaie fault system south of Kilauea caldera; and earthquakes from other regions: west Hawaii, Mauna Kea, etc.

Date (1969)	Tremor (in minutes)			Earthquakes								Remarks
	Deep	Inter- mediate	Shallow	Kilauea Summit			SW rift and Kaoiki	Upper east rift	Koaie	Others		
				30 KM	Long Period	Shallow						
July 1	15	.	.	1	45	80	5	45	0	.		
2	.	.	.	1	0	109+	7	269+	1	.		
3	.	.	.	7	0	105	?	804+	?	1		
4	.	.	.	2	45+	127	11	60	5	.		
5	.	.	.	2	20	128	12	58	15	.		
6	.	.	.	3	6	50	10	28	1	.		
7	.	.	.	0	4	136	2	29	9	.		
8	.	.	.	1	0	220	13	145(?)	1	.		
9	6	.	.	1	0	189	5	72(?)	0	1		
10	.	.	.	0	0	31	3	20(?)	0	.		
11	5	.	.	0	?	30	7	60(?)	0	1		
12	.	.	.	3	?	17	6	37(?)	0	1		
13	.	.	.	0	0	6	14	67(?)	0	1		
14	.	.	.	3	Several hundreds	14	16	42(?)	0	1		
15	.	.	.	0	6+	3	14	40(?)	2	1	(Phase 5 0345 July 15 to 1222 July 15)	
16	.	.	.	1		14	2	15(?)	1	.		
17	.	.	.	0		15	5	12(?)	0	1		
18	.	.	.	0	10	18	3	17	0	.		
19	.	.	.	0	79+	16	21	22	0	.		

July

20	.	.	1	16+	22	9	51	1	1
21	12	.	0	69+	33	16	43(?)	0	1
22	120	.	1	12+	33	6	31	1	.
23	.	.	1	72+	35	20	24	1	.
24	20	.	0	?	36	7	14	0	.
25	.	.	0	0	70	4	15	0	.
26	.	.	0	0	54	6	16	0	2
27	.	.	0	0	44	6	13(?)	1	.
28	32	.	0	2	64	6	21	4	.
29	.	15	0	0	103	3	17	1	.
30	.	.	1	1	76	3	29	2	.
31	21	.	0	?	60	12	13	2	.

Table 2.--Number of earthquakes and minutes of tremor recorded on seismographs around Kilauea -- Continued

Date (1969)	Tremor (in minutes)			Earthquakes							Remarks
	Deep	Inter- mediate	Shallow	Kilauea Summit			SW rift and Kaoiki	Upper east rift	Koa'e	Others	
				30 KM	Long Period	Shallow					
August	1	.	.	2	0	56	8	52	1	1	
	2	.	.	0	0	44	4	83	4	.	
	3	.	.	2	5	10	11	183+	0	.	
	4	.	.	?	10	8	?	50(?)	?	1	(Phase 6, -17:15 Aug. 3 to 00:08 Aug. 4)
	5	.	.	2	?	8	11	32(?)	?	.	
	6	.	.	0	325+	16	11	117+	0	1	(Phase 7, 2100 Aug. 5 to 0545 Aug. 6)
	7	.	.	0		14	23	17	0	3	
	8	.	.	0		6	4	5	3	.	
	9	.	.	0		5	7	7(?)	0	.	
	10	.	.	1	several thousands	18	11	50(?)	0	1	
	11	.	.	0	2	14	6	60(?)	0	1	
	12	.	.	1	3	12	6	75	2	.	
	13	.	.	1	5	26	14	75	0	.	
	14	.	.	0	0	18	10	?	0	2	
	15	.	.	1	9	10	20	17	0	1	
	16	30	.	0	10	8	9	27	0	.	
	17	40	7	0	6	14	4	13	0	.	
	18	.	.	0	9	8	5	17(?)	0	.	
	19	.	.	0	0	7	5	14	0	1	
	20	29	.	1	0	47	9	15	0	3	
	21	.	.	2	8	22	2	4	0	.	
	22	.	31	0	18+	11	2	4+	?	1	(Phase 8, 00:15 Aug. 22 to 04:40 Aug. 22)
	23	.	.	0	?	4	4	2	0	.	

August

24	.	.	2	16+	7	11	32	?	1
25	.	.	0	1	9	7	11	1	1
26	.	.	1	10	16	16	6	0	1
27	.	.	0	4	10	5	5	1	.
28	.	.	0	5	21	8	6(?)	2	.
29	.	.	2	2	56	5	10	2	2
30	.	.	5	6	30	14	10	2	1
31	.	.	3	2	31	5	9	6	.

Table 2.--Number of earthquakes and minutes of tremor recorded on seismographs around
Kilauea -- Continued

21

Date (1969)	Tremor (in minutes)			Earthquakes							Remarks
				Kilauea Summit			SW rift and Kaoiki	Upper east rift	Koaie	Others	
	Deep	Inter- mediate	Shallow	30 KM	Long Period	Shallow					
September 1	.	.		2	2	54	6	17	2	3	
2	29	.		1	0	23	5	4(?)	0	1	
3	.	.		0	1	19	8	5(?)	0	.	
4	.	30		0	3	101	4	4	2	.	
5	.	.		0	3	72	8	1	1	1	
6	.	.		0	?	59	8+	4+	?	.	
7	20	20		0	several thousands	3(?)	7	5+	?	.	(Phase 9 - 19:30 Sept. 6 to 04:30 Sept. 7)
8	.	.		0		3	4	2+	0	.	
9	.	.		0		22	8	7	0	3	
10	.	.		0		11	5	13	0	.	
11	.	.		0	17+	15	6	8	1	1	
12	.	.		0	0	15	7	9	0	.	
13	.	.		0	5	6	4	6	0	.	
14	.	.		?	37	8	?	15	?	1	
15	.	.		3	30+	8	15	11+	0	.	
16	.	.		2	13	12	7	26	0	.	
17	.	.		0	16	21	14	17	0	2	
18	.	.		5	13	23	16	20	1	2	
19	.	.		0	3	26	4	4	0	4	
20	.	.		0	0	28	10	3	0	.	
21	.	.		0	7	18	6	5+	0	.	
22	.	.		0	3	23	6	11	0	2	
23	.	.		5	6	16	5	6	0	.	

September

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66+

0
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3(?)
3(?)
20
15
15+

0
0
0
0
18
9
4+

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Table 3.--Local earthquakes recorded by seismographs of the U.S. Geological Survey, July, August, September, 1969.

Entries for a given quake are: Date, origin time (Hawaiian Standard Time), magnitude, depth, epicenter, and felt report. All earthquakes of magnitude 2.5 and larger, as well as many favorably located smaller ones, occurring on or near the island of Hawaii are included in the list.

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
	<u>h</u> <u>m</u> <u>s</u>			Lat. N.	Long. W.	
July 2	09-50-36.2	2.4	7	19°22.1'	155°11.4'	
3	06-57-36.6	3.0	5	19°21.9'	155°12.0'	Kilauea Summit Area
3	07-04-08.5	2.1	10	19°21.4'	155°12.7'	
3	07-07-24.1	2.1	8	19°23.1'	155°14.5'	
3	07-22-16.9	2.4	7	19°22.6'	155°15.2'	Kilauea Summit Area
3	09-47-47.2	2.2	10	19°20.0'	155°11.9'	
3	18-08-21.2	2.0	10	19°39.8'	156°02.7'	
6	11-37-24.2	3.5	32	19°20.8'	155°21.6'	Kealakekua
7	04-59-16.3	2.2	32	19°21.8'	155°18.1'	
7	18-58-20.0	2.0	10	19°15.6'	155°04.8'	
9	04-30-05.1	2.8	4	19°17.9'	155°06.9'	
9	01-17-27.4	2.4	3	19°19.0'	155°06.9'	
9	21-34-23.5	2.4	20	19°18.8'	155°50.8'	
10	08-32-06.1	2.9	9	19°20.9'	155°29.2'	Pahala
11	23-32-46.7	2.4	28	19°10.0'	155°32.4'	
12	11-14-20.8	3.1	0	19°13.3'	155°37.6'	
13	01-22-08.0	4.2	8	19°12.2'	155°34.8'	(Kilauea Summit Area Pahala, Kealakekua)
13	09-38.07.5	2.0	9	19°48.6'	155°35.6'	
15	17-54-14.5	3.3	13	18°28'	156°48'	
17	20-06-49.6	2.1	8	19°21.4'	155°14.1'	
17	23-14-58.9	2.2	10	19°22.8'	155°29.0'	
20	04-47-13.1	3.6	10	19°23.7'	155°54.8'	Kealakekua
21	16-13-26.3	3.0	16	19°55.7'	155°32.0'	
22	13-41-35.0	2.7	9	19°23.1'	155°25.5'	
26	00-11-02.5	2.2	6	19°32.0'	155°41.8'	
26	00-25-03.3	2.3	10	19°19.7'	155°09.3'	

Table 3.--Local earthquakes recorded by seismographs of the
U.S. Geological Survey, July, August, September, 1969.

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
				h m s	Lat. N.		Long. W.
July 26	23-00-48.4	2.3	10	19°26.6'	155°45.3'	
29	02-19-26.0	2.1	9	19°21.7'	155°13.5'	
30	02-29-51.7	2.5	2	19°19.2'	155°05.3'	
August 1	10-14-11.7	2.3	11	19°17.4'	155°07.5'	
1	19-17-31.3	3.0	2	19°52.3'	155°35.7'	
2	07-47-13.0	2.0	32	19°21.6'	155°16.8'	
3	10-50-12.0	2.4	10	19°25.4'	155°28.2'	
3	16-40-24.9	2.6	1	19°19.0'	155°05.7'	
4	02-54-29.6	2.0	7	19°21.6'	155°13.3'	
4	16-50-13.6	2.7	0	19°28.6'	155°40.4'	
6	18-42-17.2	3.5	4	19°41.9'	156°02.7'	Kohala
7	02-58-20.5	2.0	7	19°24.2'	155°23.4'	
7	14-53-07.7	2.3	25	19°13.3'	155°30.0'	
7	18-08-08.8	2.2	6	19°13.1'	155°27.5'	
7	18-13-21.7	2.8	10	19°03.0'	155°02.5'	
7	23-19-05.7	3.0	10	20°15.9'	155°32.5'	
9	01-12-27.1	2.2	6	19°21.7'	155°13.6'	
9	16-08-59.3	2.3	8	19°24.8'	155°23.1'	
10	09-37-27.8	2.5	62	19°29.1'	155°37.5'	Hilo
10	17-30-14.0	2.3	36	19°24.4'	155°22.2'	
11	02-10-22.2	2.4	8	19°18.6'	155°16.3'	
11	22-59-07.0	2.8	10	19°56.6'	155°31.0'	Pohakuloa
14	12-27-20.0	2.5	10	19°05.0'	156°43.4'	
14	14-30-44.3	3.0	13	19°42.3'	155°36.0'	
15	09-57-02.9	2.6	48	19°21.6'	155°35.1'	
15	19-14-04.3	2.2	37	19°19.1'	155°30.7'	

Table 3.--Local earthquakes recorded by seismographs of the
U.S. Geological Survey, July, August, September, 1969

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
	<u>h</u> <u>m</u> <u>s</u>			Lat. N.	Long. W.	
August 19	05-50-53.8	2.3	48	19°24.5'	155°33.8'	
19	06-58-56.7	2.0	26	19°19.5'	155°17.8'	
19	15-57-13.8	2.0	24	19°21.4'	155°29.8'	
20	01-18-31.2	2.1	13	19°23.5'	155°17.3'	
20	17-46-42.7	2.0	42	19°25.5'	155°37.7'	
20	21-54-08.1	2.7	5	19°27.5'	155°32.3'	
20	23-39-20.7	2.2	4	19°10.5'	155°31.3'	
22	17-59-28.6	2.5	46	19°54.3'	155°29.4'	
22	20-49-45.0	2.3	30	19°20.9'	155°16.8'	
24	06-38-55.7	2.4	10	19°25.9'	155°54.0'	
24	21-47-55.3	2.1	14	19°27.3'	155°24.1'	
25	14-26-14.4	2.2	12	19°24.3'	155°25.6'	
25	21-49-01.5	2.7	4	19°13.4'	155°34.1'	
26	14-32-53.2	2.4	10	19°18.0'	155°51.0'	
27	01-11-55.6	2.2	0	19°12.6'	155°19.5'	
28	23-21-05.3	2.2	6	19°17.6'	155°01.4'	
29	02-53-35.8	2.5	8	19°10.9'	155°33.5'	
29	04-11-33.2	2.3	32	19°30.8'	156°03.8'	
30	14-27-11.3	2.9	10	19°38.3'	156°28.3'	
September 1	02-22-14.2	2.3	10	19°18.6'	155°44.8'	
1	04-42-14.4	2.6	10	19°57.7'	155°44.6'	
1	07-16-54.2	2.6	10	19°19.2'	155°14.4'	
1	12-17-51.2	2.2	17	19°23.8'	155°16.4'	
1	16-54-55.5	2.6	15	20°01.3'	155°46.8'	
2	05-06-22.0	3.3	10	19°34.9'	156°23.3'	
2	23-23-50.8	2.4	20	19°56.0'	155°38.6'	

Table 3.--Local earthquakes recorded by seismographs of the
U.S. Geological Survey, July, August, September, 1969

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report	
	<u>h</u> <u>m</u> <u>s</u>			Lat. N.	Long. W.		
September 3	09-40-09.4	4.3	31	19°20.0'	155°25.0'	Islands of Hawaii and Oahu	
5	20-05-12.9	2.1	8	19°27.1'	155°35.5'		
8	01-40-27.6	2.2	9	19°20.8'	155°13.8'		
8	16-35-42.6	2.3	10	19°34.5'	155°18.8'		
8	17-35-23.7	2.2	9	19°23.9'	155°25.9'		
9	00-09-23.0	2.8	10	19°53.9'	155°47.7'		
9	10-49-47.1	2.1	71?	19°26.2'	155°58.1'		
9	18-27-37.5	2.2	10	19°41.2'	155°41.5'		
11	08-00-52.0	2.5	0	19°53.3'	155°41.4'		
11	20-24-13.3	2.1	8	19°20.6'	155°07.9'		
13	13-06-41.6	2.3	7	19°18.5'	155°15.4'		
14	10-08-55.7	2.9	12	19°44.0'	155°47.0'		
15	11-44-01.2	2.5	7	19°20.5'	155°12.7'		
15	14-04-01.2	2.4	27	19°23.0'	155°30.0'		
16	11-31-56.7	2.3	7	19°20.1'	155°11.2'		
17	04-39-03.3	2.6	47	19°26.5'	155°57.9'		
17	12-06-54.0	2.1	34	19°23.0'	155°20.6'		
17	13-10-38.5	2.3	5	19°17.1'	155°15.8'		
17	12-50-30.9	2.4	5	19°10.2'	155°34.2'		
17	23-43-45.7	2.6	7	19°24.8'	155°25.6'		
18	01-31-22.1	2.6	6	19°25.5'	155°45.4'		
18	12-39-26.9	2.3	26	19°21.8'	155°30.9'		
18	14-38-15.9	2.6	13	19°16.5'	155°45.1'		
18	22-03-35.4	2.9	7	19°22.9'	155°24.3'		Pahala
19	05-15-28.7	3.1	43	19°56.5'	155°17.9'		
19	08-24-34.6	3.0	83?	19°42.0'	156°11.3'		

Table 3.--Local earthquakes recorded by seismographs of the
U.S. Geological Survey, July, August, September, 1969.

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
	<u>h</u> <u>m</u> <u>s</u>			Lat. N.	Long. W.	
September 19	11-25-09.4	2.4	26	19°41.0'	156°04.0'	
19	13-28-19.6	2.0	1	19°56.5'	155°30.2'	
19	15-45-51.8	2.8	3	19°11.8'	155°31.6'	
19	17-23-50.2	2.3	7	19°24.1'	155°25.2'	
19	19-14-13.5	2.0	6	19°26.9'	155°27.4'	
20	18-29-40.2	2.0	5	19°22.9'	155°27.9'	
21	00-16-03.9	2.1	6	19°22.0'	155°25.1'	
22	04-28-41.7	2.4	40	19°37.0'	156°03.9'	
22	05-52-15.5	2.2	13	19°23.1'	155°25.8'	
22	18-28-59.8	2.2	3	19°29.4'	155°40.1'	
23	15-54-25.5	2.3	6	19°13.7'	155°28.7'	
23	16-31-44.8	2.0	15	19°24.7'	155°16.4'	
27	13-23-15.4	2.2	0	19°19.6'	155°05.2'	
28	09-51-49.5	2.0	8	19°35.3'	155°51.7'	
28	10-00-36.6	2.2	0	19°32.6'	155°41.4'	
28	14-23-14.8	2.3	6	19°20.5'	155°12.7'	
28	22-00-45.1	2.4	0	19°30.8'	155°46.9'	
28	22-11-13.3	2.8	8	19°24.2'	155°28.0'	
29	04-27-48.4	2.7	3	19°14.4'	155°21.6'	Pahala
30	11-43-33.0	2.7	6	19°13.7'	155°08.3'	
30	21-27-47.6	2.1	5	19°10.2'	155°06.8'	
30	22-48-21.9	2.1	0	19°13.4'	155°21.5'	

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HAWAIIAN VOLCANO OBSERVATORY

SUMMARY 56

October, November, and December 1969

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CONTENTS

	Page
Summary of activities -----	1
Seismic notes -----	8
Tilting of the ground around Kilauea caldera -----	10
Seismic summary -----	11
Publications of special interest and HVO contributions, 1969-	28

Illustrations

Figure 1. Map of the island of Hawaii showing seismograph stations and localities mentioned in the text---	2
2. Tilting of the ground around Kilauea caldera (data not available this quarter) -----	

Tables

Table 1. Tilt coordinates at Uwekahuna vault -----	10
2. Tilt coordinates and changes at bases around Kilauea caldera -----	10a
3. Number of earthquakes and minutes of tremor recorded on seismographs around Kilauea caldera-	12
4. Local earthquakes recorded by seismographs of the U.S. Geological Survey -----	18

Summary of activities

At 0900, on October 10 fountaining was observed in the main vent area. Significant tremor was first recorded shortly after the initial observation by Park personnel. A slow decline in summit tilt probably recorded the true beginning of the obvious surface activity. This activity lasted for more than 3 days (ending at about 1100 on October 13, with sporadic periods of spattering spread over the following 36 hours), yet it produced only about $2 \times 10^6 \text{ m}^3$ of lava (excluding Alae drainout), which was supplied by fountains 15-25 m high. New lava covered the Sept. 6 lava (plus some forest along the southeast base of Puu Huluhulu), refilled Alae Crater (whose floor had lowered 5 meters as a result of degassing and probable draining out its graben outlet since Sept. 6), and spread southward from the southeast lip of Alae for about a kilometer. The flow which entered Alae Crater spread slowly across the floor from the feeder lava cascade near the vent area. The floor was not completely covered until 1230 (3.5 hours after the start of the phase). Shortly thereafter, lava started spilling into the outlet graben, which quickly became choked with lava so it could no longer accept the runoff from Alae, and the Alae floor began to rise again. At about 1400, the lowest lip of Alae was overwhelmed, and from then on lava spilled out of the crater along an arc several hundred meters long.

During much of October 11 and 12, most of the lava that was entering Alae must have been draining out somewhere at depth. There was little or no evidence of either uplift of the Alae floor or continued outflow south of the crater. Late in the day of October 12, however, marked outflow resumed, as shown by fires at the front of advancing flows. It is hard to estimate the volume that apparently drained from Alae, but it could have been as much as $2 \times 10^6 \text{ m}^3$, if eruption rates of the first day can be extrapolated across the next 2 days. East rift surveying showed no large changes between Alae and Kane Nui o Hamo, so

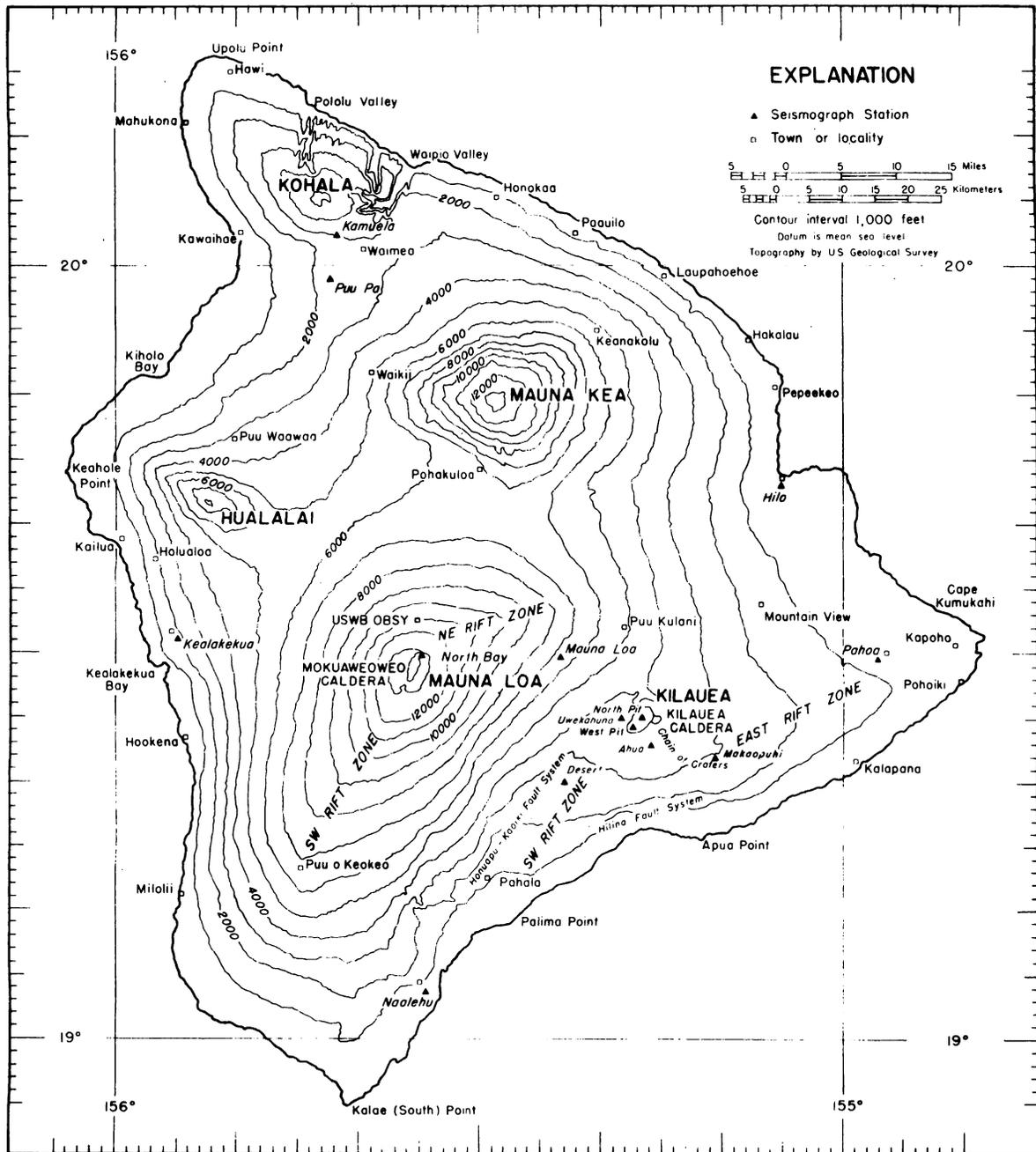


Figure 1.--Map of the Island of Hawaii showing seismograph stations operated by the U.S. Geological Survey, principal settlements, and selected geologic features. Epicenters of local earthquakes are given in table 4 in terms of geographic coordinates, which are indicated at the edges of the map.

if the lava exited via the graben it probably moved farther downrift than Kane Nui o Hamo.

At 0100, on October 20 strong surface activity resumed at the main vent. Lava quickly filled the depression in the vent area and spilled outward into Alae and Aloi Craters. By 0230, violent fountains were playing 300 meters above the fissure. A high-level obstruction in the vent directed the fountaining towards the Puu Huluhulu observation point for a short length of time. Spatter fell as far as 10-20 meters over the south edge of the old Puu Huluhulu vent. Fountains reached a maximum height of about 300 meters by 0230 and persisted until about 0615, then began to diminish in height and volume. By 0640, the fountains had dropped to 150 meters, a height they maintained with a few pulsations until the end of the phase, which came quickly at 0820 (within 2-3 minutes the phase was over). As the fountains waned, lava filling the surface depression in the vent area began pouring back down the fissure, carrying solidified crust with it. Jetted gas from the fissure propelled fragments of this dark crust back out of the fissure and high into the air, resulting in an ominous black, billowing cloud that continued to rush forth for several minutes before it died as the gas escaped.

Spattering took place from two vents along the eastward projection of the eruptive fissure. One vent was in the area of minor vents during phase 8, the other in a new area almost due north of the northern rim of Alae. These vents were active for only an hour or two in the early morning.

Sometime between 0415 and 0615, these large cracks opened across the road constructed over the May 24 flow just west of Aloi. These cracks have an aggregate tensional displacement of 30-50 cm and lie about 50-75 m south of the May 24 fissure.

Except for the latest flows, most of the $10.5 \times 10^6 \text{ m}^3$ of lava from this eruption is poor in olivine. Most of the lava went into two flows (one fed directly from the vent area, the other flowing out of the full Alae Crater) which cascaded over Poliokeawe and Holei Palis before coming to rest near the base of the scarps. The flow from Alae endangered the Chain of Craters road at the crest of the scarps but failed to cross it; the other flow followed the channels of preceding flows over the palis. Another flow moved eastward north of Alae, covering the Christmas Eve tilt station. A relatively small volume of lava entered Aloi Crater, but considerable spatter was added to the cone. This cone is now 60 meters above its pre-eruption base, and both of its two summits are plainly visible from the Observatory.

On October 24, lava was reported to be oozing down the Kalapana Trail, about 2.5 km southeast of Alae Crater. The gas-poor pahoehoe was traced upslope to an opening of a lava tube approximately 1 km southeast of Alae Crater. Apparently, lava was moving out of Alae, over its drowned southeastern rim, as the crust of the cooling lake settled. This lava was flowing through tubes in the most recent flow and emerging about a kilometer away. Over the course of 4 days since the end of the most recent fountaining, the oozing lava had created its own pahoehoe flow, and the active lava that was crossing the Kalapana Trail was flowing through tubes in it. The oozing ended by October 29. Two sections of the trail were covered, and the oozing came close to, but did not reach, the highway at the trail crossing. The oozing probably stopped when the crust of Alae lake solidified down to the top of the drowned rim, because the lake clearly did not drain down to that level, since the buried rim has no surface expression.

For most of the quarter, active lava was visible in the vent. On several occasions the lava column reached the surface and stayed

there for periods of from several hours to 2 or 3 days. During three of these times (November 12-13, 15, and 19), lava filled the vent depression and flowed into Alae and over its drowned rim for short distances. These active periods were characterized by dome-shaped upwellings of lava, as if the lava column were simply projecting 5-10 meters above the ground surface, without any spattering, and taking on the general appearance of an artesian well. At times there was also spattering, but some (though not all) of this seems to have been associated primarily with times of drainback (every 10-15 minutes in the normal rise-and-fall cycle) and may have resulted from liberation of entrapped air carried down during drainback. This spatter built three small cones, and it provides good material for sampling, as it is commonly quite dense. This nonviolent action allowed closeup use of the optical pyrometer, which in fume-free close-in conditions normally gave temperatures of 1165°-1175° C.

From November 19 to 30, all activity was confined within the fissure; only Pele's hair escaped to the surface. The top of the lava column was visible at times and out of sight at other times. Periodic rise and fall of the column throughout an amplitude of several meters could be observed or inferred from audible sounds at the vent, and marked fluctuations in the amount of fume were also keyed to the rise-fall pattern (much fume accompanied spatter released during falls).

At 0830, November 30, lava was nearly at the surface and was flowing from the west end of the fissure into the east end (an estimated distance of 75 meters), where it plunged 15-20 meters into a seething pool. Suddenly, at about 1100, the pool in the east end rapidly filled and blossomed into a dome fountain several meters high. This started a 2.5 day-long episode of surface activity. Between periods of drainback, the vent depression would fill and then spill

out in broad lava rivers, many of which reached the remaining rim of Alae and either cascaded into the crater or flowed around it and extended southward across the slightly older flows of October and November. This activity resulted in the addition of $1.1 \times 10^6 \text{ m}^3$ of lava to the surface.

All was quiet at the main vent area from the night of December 2-3 until December 13, but three new segments of the eruptive fissure opened sometime between December 3 and 8, most likely on December 5, between 800 and 1500 meters downrift. Several small spatter ramparts were built, and pahoehoe flows that erupted from these three segments (offset in a right an echelon sense from the main fissure and from each other) spread out across most of the February 1969 lava between Alae Crater and February 22 lava west of Makaopuhi. This outbreak was not accompanied by harmonic tremor detectable by any of the Observatory seismographs, but summit tilt showed a small deflation that may have been associated with the activity. The new pahoehoe has a volume of about $.5 \times 10^6 \text{ m}^3$.

Surface activity resumed at the main vent early in the morning of December 13, and by 0830 one flow had already reached Aloi Crater. Throughout the next 5 days (but especially on December 13 and 14), low broken dome fountains and simple upwellings of the entire lava column fed small flows that left the vent depression and spread toward Aloi and Alae; a few flows eventually reached both craters. About $0.8 \times 10^6 \text{ m}^3$ of lava was added to the surface.

On December 14, lava was observed flowing eastward in the fissure during rises and standstills of the lava column. By 1300, December 15, the current had reversed to a westward direction, which it maintained until some time between 1700 and 2000, December 18, when it resumed flowing eastward. During this time, summit tilt recorded at Uwekahuna was nearly flat, but during the night of December 18-19 the summit

began to rise gradually. By 0930, December 9, all flow of lava had stopped within the fissure, and the top of the lava column was at a depth of about 15 meters and was periodically rising and falling throughout an amplitude of only 2.3 meters. On December 23, the level of lava dropped out of sight, although a faint glow reflected by glassy spatter clinging to the wall of the fissure provided evidence of a turbulent lava column at depth. Computations show that between 500 and 100 m³/minute was being cycled through the fissure on December 14, and the flow velocity increased subsequently, so that volume rates for December 15-18 were probably closer to 1000-1500 m³/minute. A total of about 58 x 10⁶ m³ of lava was erupted from the day the eruption began, on May 24, to the end of this quarter.

Seismic Notes

Seismic activity was concentrated in several zones: Southeast flank of Kilauea, south flank of Kilauea, northeast flank of Mauna Kea, and the southeast flank of Mauna Loa. Quakes on the southwest flank increased from less than 10 per day to more than 20 per day starting September 28. The activity increased further to a moderate swarm and reached a peak on October 7-9, when nearly 400 quakes were recorded on the Desert seismograph. These earthquakes appeared to have been centered between the central southwest rift and west end of Hilina Pali. The larger shocks of this group, nearly 3 in magnitude, were reported to have been felt at Kapapala Ranch.

At about the time the southwest flank seismic activity peaked, upper east rift and Poliokeawe fault quakes increased in number. The pick-up of larger Poliokeawe quakes was very obvious. The largest shock from the area at 1256, October 14, registered about 3-1/2 magnitude and was strongly felt by residents of Hilo.

Kilauea upper east rift quakes increased to over 200 on November 3, when, during a short-lived but impressive flurry between 1100 to 1200, quakes began to occur at 3 to 4 per minute. Several shocks measuring nearly 3 in magnitude were felt by Volcano residents.

During the early morning hours of November 5, Hamakua coast residents were disturbed by a half dozen shocks. These were the largest (magnitude 3 to 3-1/2) of 35 northeast Mauna Kea quakes recorded on the Mauna Loa seismograph. The source area appears to have been near Keanakolu on Mauna Kea's northeast flank.

The largest earthquake during November occurred beneath the Honuapo-Kaoiki fault system near the town of Pahala. It registered a magnitude of 4 to 4-1/2 and was felt over nearly half the island (strongest in Kau). Considerable numbers of aftershocks were recorded. During the first 5 hours, 130 shocks were recorded by

a recently installed radio-telemeter station from the upper Kahuku Ranch area.

Many small Kilauea caldera quakes were recorded during the quarter, and seismographs continued to respond to the different levels of volcanic activity. The count of shallow Kilauea Caldera quakes showed changes in the generally expected way: During periods of continuous inflation on the Uwekahuna E-W tiltmeter, quake counts increased to high levels with frequent hour to several-hour long flurries, whereas periods of minor deflation were characterized by low quake activity.

Tilting of the Ground Around Kilauea Caldera

Tilting of the ground around the summit of Kilauea is monitored daily by a short-base water-tube tiltmeter in Uwekahuna vault, and at irregular intervals it is measured on a regional scale by means of a network of field tilt-bases and a portable water-tube tiltmeter. The attitude of the ground surface at each tilt-base is reported in terms of north-south and east-west tilt coordinates. Both coordinates at each station were arbitrarily set equal to 500 when measurements at that station were begun. Increasing tilt coordinates correspond to northward and eastward tilting of the earth's surface; that is, to a relative subsidence toward the north and east. A one-unit change in coordinate corresponds to a tilting of 1 microradian (1 mm per km) in the direction indicated.

Location of tiltmeter stations and essential data on each station are listed in table 6, which is published only in the first quarter issue each year.

Table 1.--Tilt coordinates at Uwekahuna vault,
October, November, and December 1969

Date (1969)	N-S	E-W		Date (1969)	N-S	E-W
Oct. 5	544	404		Nov. 23	543	398
12	543	407		30	544	397
19	539	416		Dec. 7	545	398
26	541	413		14	546	393
Nov. 2	543	406		21	547	391
9	542	404		28	548	386
16	543	402				

Table 2.--Tilt coordinates and changes at bases around Kilauea cladera. (Figure 2, tilting around Kilauea, will not be included in this summary).

Tilt base	Date (1969)	Tilt N-S	Coordinates E-W	Rate (10^{-6} rad/mo) and direction of tilting since last reading		Date of last reading
Uwekahuna (U)	Dec. 3	591.2	373.0	1.33	N40.0°W	Feb. 6, 1961
Tree Molds (TM)	Oct. 30	473.6	500.6	0.48	N69.0°W	Feb. 6, 1969
Sand Spit (SS)	31	940.8	673.9	2.34	N13.7°W	Feb. 12, 1967*
Keamoku (Kea)	27	527.7	388.5	0.48	N53.4°W	Jun. 6, 1967*
Ahua Kamokukolau (Kam)	31	449.1	540.0	0.54	S58.8°W	Jun. 5, 1967*
Kipuka Nene (KN)	28	298.7	308.5	0.58	S 0.2°E	Dec. 5, 1968
Hilina Pali (HP)	29	452.3	494.9	0.45	S47.4°W	Oct. 16, 1968
Kapapala (Kap)	27	490.4	513.8	0.32	S62.6°E	Aug. 28, 1968
Mehana (M)	30	573.5	581.2	0.42	S60.6°E	Feb. 5, 1969

*For purposes of continuity of the tilt coordinates, we are disregarding all 3-pot readings and reverting to the last set of 2-pot readings used in the summary. All readings hereafter will be of the 2-pot system.

Seismic summary

Events recorded by the U.S. Geological Survey seismograph network in Hawaii fall into two categories: local earthquakes and tremor originating in the region of the Hawaiian Islands (usually within 100 km of at least one seismograph), and distant earthquakes originating more than 3,000 km from Hawaii. As an index of seismic activity at Hawaiian volcanoes, daily counts of earthquakes and minutes of tremor recorded by seismographs in Hawaii are listed in table 3. The earthquakes are separated in groups on the basis of region of origin as determined by analysis of records obtained daily at the observatory. Earthquakes of magnitude 2.0 or greater are generally sufficiently well recorded to be located with greater precision; they are listed individually in table 4.

Location of seismograph stations and essential data on each station are listed in table 5 in the first-quarter issue each year.

Acknowledgments

Several people and agencies reported "felt" earthquakes during the fourth quarter, 1969. Their assistance is gratefully acknowledged.

Table 3.--Numbers of earthquakes and minutes of tremor recorded on seismographs around

Kilauea Caldera

Tremor is separated into three categories: Deep, intermediate, and shallow, on the basis of relative amplitude on seismographs in the summit region. Unless otherwise stated, tremor is presumed to be associated with movement of magma within the central complex of Kilauea Volcano.

Earthquake categories are: Kilauea summit, 30 km, earthquakes from a source about 30 km beneath the Kilauea summit region; long-period earthquakes characterized by low-frequency waves that originate about 5 km beneath Kilauea summit; and shallow earthquakes in the Kilauea caldera region; shallow earthquakes along the S.W. rift zone of Kilauea and the adjacent portion of the Kaoiki fault system; earthquakes from the upper east rift zone and the adjacent fault systems of Kilauea's south flank; shallow earthquakes along the northeast-trending Koaie fault system south of Kilauea caldera; and earthquakes from other regions: west Hawaii, Mauna Kea, etc

Date (1969)	Tremor (in minutes)			Earthquakes							
	Deep	Inter- mediate	Shallow	Kilauea Summit			SW rift and Kaoiki	Upper east rift	Koaie	Others	Remarks
				30 KM	Long Period	Shallow					
October 1	44	22	3	1	.	
2	21?	27	66	19	6	.	
3	.	.	.	1	17?	13	45	14	2	2	
4	3	9	35	10	3	4	
5	9	14	26	17	4	2	
6	.	.	.	1	8	21	22	27	1	2	
7	6	71	159	64	61	2	
8	.	.	.	5	3	85	151	40	10	3	
9	.	.	.	4	4	44	11	34	12	3	

October 10	.	.		3	15?	6	45	9	.	3	(0900 Oct. 10, 1100 Oct. 13 eruption phase 10)
11	.	.		2	1?	7	21	13	4	2	
12	.	.		.	?	10	33	13	4	1	
13	.	.		1	14?	13	12	31	5	1	
14	.	.		2	21?	12	37	31	9	2	
15	.	.		1	17	7	24	10	2	.	
16	.	.		.	.	8	18	13	2	.
17	.	.		2	75	15	7	17	7	1	
18	.	.		1	10	23	19	17	4	.	
19	.	.		1	45	27	32	12	4	.	
20	.	.		1	45?	5?	6	24?	3	1	(0100 Oct. 20, 0820 Oct. 20 eruption phase 11)
21	.	.		.	2?	15?	17	7	.	.	
22	.	.		?	?	?	?	?	?	.	
23	.	.		4	1	12	11	8	6	.	
24	.	.		.	1?	7	5	2	2	.	
25	.	.		.	2	6	17	4	3	.	
26	.	.		4	10?	7	12	11	5	.	
27	12	.		2	3	28	6	10	3	1	
28	.	.		3	30	44	7	8	3	1	
29	.	.		2	.	330	7	30?	3	.		Shallow summit and upper east rift quake count increase due to instrument adjustment
30	33	.		4	2	316	15	43	5	.	
31	.	.		.	6	346	9	21	3	1	

Strong during phases of eruption and fluctuating at low
levels during interphases.

Table 3.--Numbers of earthquakes and minutes of tremor recorded on seismographs around

Kilauea Caldera--Continued

Date (1969)	Tremor (in minutes)			Earthquakes							Remarks
				Kilauea Summit			SW rift and Kaoiki	Upper east rift	Koa'e	Others	
	Deep	Inter- mediate	Shallow	30 KM	Long Period	Shallow					
November 1	1	508	15	8	5	.	
2	42	.	.	5	2	360	12	19	2	.	
3	.	.	.	4	2	92	11	225?	3	.	
4	78	13	27	2	1	
5	1	65	15	18	1	24	Mauna Ken earthquake flurry
6	.	.	.	3	.	114	8	4	5	5	
7	1	52	3	2	2	3	
8	8	129	5	6	1	.	
9	.	.	.	1	2	100?	35	5	1	1	
10	1	220	10	3	.	8	
11	15?	164?	16?	22?	3?	6	
12	36	.	.	.	9?	158	17	25	7	1	
13	.	.	.	1	5	174	10	22	3	.	
14	3	235?	7	13	3	3	
15	3	.	.	.	2	268	5	12	1	1	
16	.	.	.	2	.	421	5	23	2	1	
17	12?	224	11	46	49	4	

November 18	.	9		2	3	436	9	27	1	2
19	.	.		.	?	186	13	185?	.	1
20	.	.		.	2?	598	10	9	.	.
21	4	.		.	2	1000	2	13	.	1
22	.	.		.	1	430	6	14	1	1
23	.	.		.	4	974	13	205?	1	1
24	.	.		1	.	647	19	138?	.	4
25	.	.		1	.	407	12	95?	3	1
26	.	.		.	.	308	11	110?	.	1
27	.	.		.	1	1200	6	36	1	1
28	.	.		.	3	325	9	24	.	.
29	.	.		.	.	178	11	23	1	.
30	.	.		1	5	95	17	15	.	3

Table 3.--Numbers of earthquakes and minutes of tremor recorded on seismographs aroundKilauea Caldera--Continued

Date (1969)	Tremor (in minutes)			Earthquakes							Remarks
				Kilauea Summit			SW rift and Kaoiki	Upper east rift	Koa'e	Others	
	Deep	Inter- mediate	Shallow	30 KM	Long Period	Shallow					
December 1	25	.		1	?	251	14	28	1	3	
2	.	.		1	2	220	11	22	.	.	
3	.	.		2	7	242	9	38	4	1	
4	.	.		1	3	203	5	27	1	2	
5	.	.		.	1	199	6	7	.	.	
6	287	15	15	1	1	
7	.	.		.	4	353	11	91	2	1	
8	390	17	164?	1	1	
9	.	.		1	1	240	5	85	2	1	
10	.	.		.	1	213	8	10	.	.	
11	.	.		.	3	517	6	5	1	1	
12	.	.		.	1	294	2	164?	1	.	
13	.	.		.	2?	77?	4	60?	1	.	
14	.	.		4	.	57	11	8?	5	1	
15	.	.		.	1	190	8	11	1	1	
16	.	75		.	1	228	24	29	2	1	
17	.	.		.	2	236	6	25	2	2	

December 18	3	3	.	1	281	15	12	.	.
19	.	.	.	2	486	13	78	.	.
20	.	.	.	.	1248	12	150	2	1
21	.	.	2	5	1290	13	18	5	.
22	.	.	1	.	1020	19	60?	13	.
23	.	.	2	5?	615	7	10?	5?	.
24	.	.	.	2	?	8	227?	.	1
25	.	.	.	.	?	6	13	4	.
26	.	.	.	1	286	6	13	1	.
27	.	.	.	.	287	5	159	?	1
28	.	.	?	.	178?	?	84	10	1
29	.	.	.	4	47	4	44	7	.
30	.	.	2?	176?	218?	15?	54?	6?	.
31	.	.	.	?	39?	28	17?	1	.

(0500 Dec. 30,
1830 Dec. 30
eruption phase 12)

Table 4.--Local earthquakes recorded by seismographs of the U.S.Geological Survey, October, November, December, 1969.

Entries for a given quake are: Date, origin time (Hawaiian Standard Time), magnitude, depth, epicenter, and felt report. All earthquakes of magnitude 2.5 and larger, as well as many favorably located smaller ones, occurring on or near the island of Hawaii are included in the list.

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
				h m s	Lat. N.		Long. W.
October 1	12-31-22.2	2.1	5	19°14.3'	155°21.0'	
2	23-10-35.4	2.0	7	19°10.8'	155°20.6'	
3	01-14-45.0	2.4	9	19°20.3'	155°46.9'	
3	19-24-48.3	2.0	2	19°12.7'	155°20.0'	
3	19-25-56.2	2.8	22	18°49.0'	155°23.1'	
3	23-16-55.1	2.0	2	19°17.4'	155°12.3'	
4	05-47-52.7	2.2	6	19°26.7'	155°42.3'	
4	11-08-45.5	2.4	10	19°09.6'	155°14.0'	
4	17-22-24.4	2.0	5	19°11.6'	155°20.5'	
4	18-13-12.8	2.9	7	19°12.7'	155°20.2'	
4	18-37-08.2	2.0	2	19°11.2'	155°20.0'	
4	21-06-10.2	2.1	3	19°32.9'	155°38.0'	
4	23-43.59.7	2.1	7	19°31.3'	155°37.9'	
5	12-55-51.0	2.1	14	19°10.2'	155°21.1'	
5	13-41-11.0	2.5	8	19°10.1'	155°36.8'	
5	18-56-34.9	2.7	6	19°18.0'	155°06.6'	
6	00-42-39.2	2.0	0	19°17.7'	155°00.4'	
6	04-13-22.0	2.3	6	19°14.8'	155°20.9'	near Pahala
6	08-34-41.4	2.6	8	19°10.3'	155°12.9'	
6	22-54-32.8	2.9	23	20°08.5'	155°49.4'	near Paauilo, Kohala
7	10-41-25.7	2.5	6	19°11.7'	155°21.0'	
7	10-43-02.7	2.1	7	19°15.0'	155°20.7'	
7	12-36-04.9	2.7	16	20°07.3'	155°48.3'	
7	14-29-53.7	2.1	6	19°14.4'	155°20.2'	
7	14-49-37.4	2.6	7	19°14.5'	155°20.1'	

Table 4.--Local earthquakes recorded by seismographs of the U.S.

Geological Survey, October, November, December, 1969

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
				h m s	Lat. N.		Long. W.
October 7	15-26-46.3	2.6	4	19°11.6'	155°21.3'	
7	15-30-05.6	2.6	5	19°11.3'	155°20.9'	
7	17-35-13.2	2.1	11	19°13.8'	155°20.9'	
7	21-45-44.4	2.6	10	19°01.8'	155°06.2'	
7	23-27-13.3	2.5	6	19°14.6'	155°20.4'	
8	00-12-34.6	2.7	8	19°13.4'	155°20.2'	
8	03-57-55.5	2.0	4	19°21.2'	155°01.1'	
8	04-51-06.3	2.2	7	19°13.0'	155°21.1'	
8	08-37-58.4	2.0	5	19°14.1'	155°21.0'	
8	08-44-34.4	2.0	4	19°15.5'	155°20.8'	
8	09-43-01.6	2.7	10	19°01.8'	155°10.5'	
8	11-13-31.1	2.4	8	19°25.3'	155°49.7'	
8	12-58-34.1	2.0	11	19°23.4'	155°24.2'	
8	14-17-20.1	2.9	5	19°13.3'	155°20.8'	near Pahala
9	01-18-38.7	2.1	5	19°14.2'	155°20.1'	
9	02-39-02.7	2.3	31	19°25.5'	155°34.8'	
9	08-05-20.1	2.0	4	19°13.9'	155°20.4'	
9	12-31-08.8	2.0	35	19°21.8'	155°11.6'	
9	15-41-11.8	2.4	5	19°23.0'	155°03.4'	
9	17-59-22.0	2.2	18	19°02.7'	155°13.4'	
9	21-50-34.5	2.0	5	19°13.7'	155°19.8'	
10	01-58-06.6	2.8	9	19°20.4'	155°48.2'	
10	04-02-35.6	2.1	7	19°21.9'	155°07.7'	
10	06-12-10.6	2.1	7	19°14.6'	155°19.8'	
10	18-17-06.8	2.1	6	19°32.8'	155°39.5'	
10	20-25-55.9	2.8	4	19°11.6'	155°20.2'	

Table 4.--Local earthquakes recorded by seismographs of the U.S.

Geological Survey, October, November, December, 1969

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report	
	<u>h</u> <u>m</u> <u>s</u>			Lat. N.	Long. W.		
October 10	21-55-31.5	2.9	15	19°10.8'	155°35.8'	Hilo	
11	10-34-08.7	2.0	1	19°10.5'	155°17.3'		
11	12-00-07.2	3.0	5	20°20.0'	155°03.3'		
11	14-17-43.2	2.0	5	19°40.0'	155°04.7'		
11	24-41-00.3	2.4	2	19°13.6'	155°20.6'		
12	15-28-11.0	2.4	10	20°49.3'	156°04.6'		
13	05-30-15.8	2.5	10	19°24.1'	155°24.7'		
13	06-45-05.0	2.2	7	19°19.3'	155°01.7'		
13	14-13-11.0	2.1	16	19°04.1'	155°14.1'		
14	12-55-31.9	4.0	8	19°22.9'	155°04.2'		
14	13-15-08.0	2.2	4	19°15.1'	154°59.9'		
14	16-29-15.3	2.5	5	19°16.2'	155°06.7'		
14	16-52-53.9	2.0	5	19°18.4'	154°59.7'		
14	16-57-36.5	2.4	8	19°23.1'	155°02.4'		
14	17-26-41.7	2.6	5	19°13.6'	155°20.0'		
16	13-12-36.1	2.3	3	19°12.0'	155°21.4'		
17	05-13-02.9	2.9	27	19°22.8'	155°20.2'		
17	17-00-01.7	2.6	9	19°11.1'	155°36.1'		
18	21-16-31.1	3.2	7	19°21.5'	155°03.7'		
19	15-38-11.1	2.3	4	19°13.5'	155°21.4'		
19	15-49-53.4	2.2	9	19°19.5'	155°13.7'		
20	16-35-49.4	2.5	9	19°53.3'	155°29.8'		
21	13-01-56.6	2.0	12	19°21.9'	155°26.0'		
22	01-28-37.8	2.0	16	19°25.2'	155°16.9'		
22	03-26-30.0	3.3	11	19°22.7'	155°23.5'		near Pahala, Hilo, Mt. View
22	17-18-50.3	2.0	10	19°24.2'	155°24.5'		

Table 4.--Local earthquakes recorded by seismographs of the U.S.Geological Survey, October, November, December, 1969

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
	<u>h</u> <u>m</u> <u>s</u>			Lat. N.	Long. W.	
October 23	05-21-56.9	3.0	4	19°16.6'	155°05.0'	
23	07-09-12.4	2.0	4	19°23.6'	155°01.8'	
27	13-39-09.3	2.2	19	19°45.6'	155°23.9'	
28	14-47-03.2	2.5	31	19°22.0'	155°15.9'	
28	18-13-21.4	2.3	9	19°30.4'	155°45.8'	
29	10-48-57.9	2.0	7	19°11.4'	155°12.1'	
30	08-59-24.6	2.4	36	19°13.0'	155°23.6'	
30	10-19-29.9	2.4	11	19°16.9'	155°04.4'	
31	07-17-33.4	2.9	11	19°24.0'	155°24.1'	near Pahala
31	17-00-52.4	2.9	128?	20°14.9'	156°06.8'	
November 2	08-09-31.5	2.7	9	19°19.5'	155°07.3'	
3	02-21-38.2	2.4	33	19°21.4'	155°17.1'	
4	06-26-36.9	2.2	32	19°48.2'	155°11.0'	
5	05-15-48.0	2.5	4	19°58.8'	155°18.5'	
5	05-21-24.6	3.6	9	19°58.5'	155°21.4'	near Paauilo, Hilo, Honokaa
5	05-23-03.5	2.7	8	19°54.6'	155°20.0'	Honokaa
5	05-32-13.9	2.2	10	19°46.6'	155°23.0'	
5	05-33-48.3	2.4	6	19°56.8'	155°18.9'	
5	05-39-02.3	2.9	9	19°54.0'	155°19.6'	near Paauilo
5	05-43-03.0	2.0	6	19°47.8'	155°18.9'	
5	05-44-06.1	3.7	10	19°59.6'	155°21.5'	near Paauilo, Hilo, Kilauea, Honokaa
5	05-46-46.7	2.1	10	19°50.5'	155°20.7'	
5	06-35-51.9	2.1	10	19°45.1'	155°21.4'	
5	06-45-29.8	2.4	10	19°54.3'	155°20.1'	Honokaa

Table 4.--Local earthquakes recorded by seismographs of the U.S.Geological Survey, October, November, December, 1969

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
				h m s	Lat. N.		Long. W.
November 5	06-57-11.0	3.5	9	19°55.4'	155°20.0'	Honokaa, near Paauilo, Kilauea
5	07-00-07.3	3.4	9	19°59.1'	155°21.5'	near Paauilo, Honokaa
5	07-02-32.7	2.5	10	20°00.5'	155°20.8'	Honokaa
5	07-10-09.2	2.3	10	19°52.7'	155°20.8'	Honokaa
5	07-23-05.3	2.7	10	20°14.0'	155°23.7'	Honokaa
5	07-38-11.2	2.8	10	20°05.6'	155°21.9'	Honokaa, Hilo
5	07-46-43.3	2.5	8	19°54.4'	155°19.1'	Honokaa
5	07-49-33.0	2.3	10	19°53.2'	155°20.7'	
5	07-51-47.3	2.4	17	19°54.4'	155°20.0'	
5	08-54-48.4	2.6	10	19°52.4'	155°20.7'	Honokaa
5	09-01-04.9	2.4	10	19°46.2'	155°41.3'	
5	09-26-38.9	3.7	10	20°00.7'	155°19.7'	near Paauilo, Hilo
5	16-32-35.3	2.7	6	20°00.1'	155°19.5'	
5	16-51-07.0	2.8	34	19°32.9'	156°18.8'	
6	03-41-11.5	2.5	10	19°24.8'	155°24.0'	
6	05-30-51.8	2.9	8	19°59.4'	155°21.6'	
6	05-32-12.7	2.1	10	19°50.7'	155°20.1'	
6	23-26-41.9	2.8	7	19°56.1'	155°18.4'	
7	00-46-49.1	2.8	9	19°57.7'	155°21.3'	
7	00-52-17.9	2.5	4	20°01.1'	155°17.6'	
7	11-01-00.5	3.3	6	20°00.9'	155°48.5'	
8	03-16-18.2	2.3	1	19°13.9'	155°05.2'	
9	01-29-34.3	2.6	15	19°51.2'	155°21.0'	
9	01-56-57.2	2.1	8	19°21.6'	155°09.9'	

Table 4.--Local earthquakes recorded by seismographs of the U.S.

Geological Survey, October, November, December, 1969

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
	<u>h</u> <u>m</u> <u>s</u>			Lat. N.	Long. W.	
November 9	10-40-04.5	2.1	11	19°25.3'	155°25.3'	
9	19-12-12.2	4.5	8	19°10.6'	155°30.7'	Pahala, Hilo, Kilauea, Naalehu, Kealakekua
9	19-42-21.2	2.3	6	19°11.3'	155°30.5'	
9	20-23-21.4	2.2	8	19°10.8'	155°31.2'	
9	23-00-17.1	2.0	5	19°10.6'	155°30.1'	
10	02-05-02.3	2.1	40	19°22.9'	155°14.8'	
10	13-34-37.4	2.5	8	19°10.0'	155°30.6'	
10	21-16-56.7	2.7	10	19°57.6'	155°21.5'	near Paauilo
10	21-20-25.7	3.1	10	19°57.9'	155°21.3'	near Paauilo
10	21-26-33.5	2.3	9	19°56.9'	155°20.6'	
10	21-35-51.7	2.3	7	19°59.6'	155°20.2'	
10	21-36-43.4	2.9	11	19°57.8'	155°21.4'	near Paauilo
10	21-42-54.0	2.4	9	19°50.6'	155°19.2'	near Paauilo
10	21-44-12.1	2.1	8	19°51.1'	155°19.0'	
11	03-26-29.6	2.6	7	20°00.2'	155°20.4'	near Paauilo
11	03-32-36.4	2.6	9	19°58.4'	155°21.1'	
11	03-41-19.5	2.4	9	19°58.2'	155°20.9'	near Paauilo
11	05-27-18.4	2.3	10	19°20.8'	155°46.4'	
11	09-24-42.0	2.6	8	19°58.8'	155°20.5'	
11	14-19-32.2	3.2	10	19°11.1'	154°50.8'	
12	02-24-22.1	2.6	9	19°52.9'	155°19.5'	
12	11-10-34.7	2.9	10	19°54.8'	155°19.7'	
13	02-02-21.6	2.6	10	18°51.1'	155°09.6'	
13	07-06-47.0	2.9	27	19°22.4'	155°16.5'	

Table 4.--Local earthquakes recorded by seismographs of the U.S.

Geological Survey, October, November, December, 1969

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
	<u>h</u> <u>m</u> <u>s</u>			Lat. N.	Long. W.	
November 13	11-52-43.3	2.5	24	19°29.1'	155°09.5'	
13	14-44-59.3	2.5	4	19°17.1'	155°07.2'	
14	02-33-07.3	3.6	9	19°32.1'	155°36.2'	
14	02-41-31.4	2.3	7	19°32.7'	155°39.0'	
14	03-01-42.9	2.1	6	19°32.1'	155°37.4'	
14	14-11-29.3	2.3	7	19°17.3'	155°16.9'	
14	17-48-54.1	2.1	11	19°23.0'	155°24.4'	
15	02-22-11.3	2.6	9	19°51.1'	155°19.4'	
16	07-06-37.2	2.2	10	20°17.0'	156°14.8'	
16	12-20-16.7	2.9	9	19°53.5'	155°19.5'	
17	05-35-47.4	2.1	7	19°09.8'	155°30.0'	
17	10-29-05.8	2.6	10	19°51.3'	155°21.2'	
17	11-37-39.9	3.2	10	19°54.4'	155°54.0'	
17	16-49-51.8	2.3	5	19°24.5'	155°37.2'	
17	23-05-17.0	2.9	10	19°36.8'	156°31.6'	
17	23-56-34.7	2.6	4	19°33.0'	155°39.9'	
18	01-05-28.5	2.5	1	19°11.2'	155°17.6'	
18	03-00-52.8	2.6	9	19°59.2'	155°21.6'	Paauilo
18	16-56-28.2	3.0	9	19°56.7'	155°20.2'	
19	11-10-10.3	2.5	9	19°53.2'	155°19.7'	
19	22-18-54.7	2.6	9	19°18.6'	155°13.8'	
21	02-21-14.3	2.1	9	19°56.8'	155°20.8'	
22	14-05-44.0	3.6	17	19°33.5'	155°05.2'	Mt. View, Kilauea, Hilo, Paauilo, Pahala
23	13-34-16.0	3.2	32	19°53.1'	155°31.0'	Paauilo, near Pahala

Table 4.--Local earthquakes recorded by seismographs of the U.S.Geological Survey, October, November, December, 1969

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
	<u>h</u> <u>m</u> <u>s</u>			Lat. N.	Long. W.	
November 23	18-57-51.8	2.3	7	19°17.8'	155°28.1'	
24	05-15-52.2	2.6	10	19°09.6'	155°35.5'	
24	09-12-22.9	4.5	35	19°41.8'	156°03.5'	northern half of island
24	09-44-09.1	2.7	45	19°43.4'	156°10.9'	
24	12-51-28.0	2.5	3	19°19.7'	155°52.8'	
25	10-42-57.4	2.6	6	19°11.6'	155°31.3'	
26	22-09-17.9	2.7	35	19°42.4'	156°05.1'	
27	23-56-09.7	2.8	15	19°20.2'	155°56.5'	
30	04-58-47.5	2.3	10	20°03.6'	155°47.4'	
30	21-11-14.0	3.9	10	20 3/4°	162°	
30	23-56-23.3	3.5	9	19°57.9'	155°20.3'	Paauilo
December 1	01-43-52.4	2.4	10	19°55.2'	155°20.4'	
1	04-48-22.3	2.7	9	19°53.1'	155°19.6'	Paauilo
1	07-56-15.3	2.8	9	19°54.0'	155°19.5'	Paauilo
1	22-02-00.1	2.6	7	19°25.6'	155°16.3'	Kilauea
3	15-02-24.7	2.5	10	19°47.4'	155°48.9'	
4	10-12-28.6	2.5	13	20°01.6'	155°21.6'	Paauilo
4	11.36-28.2	2.7	9	19°53.2'	155°19.9'	
5	01-30-57.6	2.0	6	19°18.5'	155°08.0'	
6	18-45-29.3	2.5	6	19°18.3'	155°00.9'	
6	20-22-18.9	2.7	31	19°02.4'	155°21.4'	
6	22-34-29.9	3.1	10	19°20.2'	155°06.3'	Mt. View
7	09-36-03.2	2.3	0	19°02.2'	155°05.5'	
8	11-13-53.8	2.8	10	19°54.9'	155°20.0'	Paauilo
9	00-24-20.5	2.0	6	19°15.1'	155°25.9'	

Table 4.--Local earthquakes recorded by seismographs of the U.S.

Geological Survey, October, November, December, 1969

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
	<u>h</u> <u>m</u> <u>s</u>			Lat. N.	Long. W.	
December 9	17-09-43.0	2.6	10	19°01.3'	154°43.3'	Hilo
9	22-56-11.2	2.6	10	19°21.7'	155°15.8'	
9	23-01-45.1	2.5	9	19°20.5'	155°12.4'	
10	04-13-58.6	2.4	9	19°20.0'	155°13.2'	
10	18-17-14.9	2.0	9	19°20.1'	155°12.4'	
11	00-01-04.7	2.1	23	19°20.7'	155°15.8'	
11	02-19-53.6	3.5	10	19°10.4'	155°37.2'	
11	04-57-17.8	2.7	2	19°14.9'	155°05.7'	
12	14-58-34.1	2.3	8	19°20.6'	155°02.1'	
12	18-27-04.6	3.2	10	19°18.6'	155°14.4'	
12	18-29-03.9	3.1	9	19°18.3'	155°14.1'	
13	00-43-38.0	2.1	9	19°18.8'	155°14.3'	
13	08-59-10.9	2.7	9	19°21.6'	155°09.8'	
14	00-59-58.5	2.4	75?	19°30.8'	155°22.0'	
14	11-00-07.5	2.4	7	19°21.8'	155°02.4'	
15	07-57-57.2	2.1	29	19°19.9'	155°17.8'	
15	18-39-31.9	2.6	10	19°22.1'	155°10.4'	
15	22-03-46.1	2.4	29	20°00.3'	155°37.8'	
16	04-02-42.0	2.0	8	19°30.4'	155°46.2'	
16	23-37-58.0	2.3	8	19°20.0'	155°13.3'	
17	08-43-10.8	2.5	9	19°18.0'	155°14.8'	
17	19-42-25.3	3.1	13	19°03'	156°48'	
17	21-59-31.8	2.0	8	19°26.9'	155°50.6'	
20	03-40-33.5	2.0	7	19°11.3'	155°48.7'	
21	04-48-01.4	2.6	9	19°19.4'	155°13.7'	
22	16-14-14.1	3.4	10	19°19.7'	155°27.8'	

Table 4.--Local earthquakes recorded by seismographs of the U.S.Geological Survey, October, November, December, 1969

Date	Time	Magni- tude	Depth (km)	Epicenter		Felt Report
	<u>h</u> <u>m</u> <u>s</u>			Lat. N.	Long. W.	
December 22	16-16-18.3	2.1	9	19°20.0'	155°28.2'	
23	08-03-37.7	2.0	8	19°22.8'	155°27.4'	
23	22-53-33.9	2.3	28	19°17.5'	155°18.6'	
24	13-35-10.9	2.2	8	19°20.4'	155°09.4'	
24	19-34-12.0	2.9	13	20°45'	154°54'	
24	19-39-34.1	3.2	25	19°30.0'	155°08.9'	Kilauea, Hilo
25	00-43-10.6	2.0	5	19°15.4'	155°06.7'	
25	03-28-26.7	3.3	32	19°21.4'	155°17.2'	Kilauea, near Pahala
25	07-42-30.9	2.1	25	19°21.9'	155°16.2'	
26	02-13-32.3	2.1	1	19°11.4'	155°17.7'	
26	12-05-00.3	2.0	7	19°23.2'	155°16.9'	
27	16-59-44.0	4.1	9	19°19.1'	155°14.6'	Hilo, Kilauea
27	17-36-31.4	3.2	10	19°07.4'	155°09.7'	
27	19-37-20.8	3.7	10	19°19.0'	155°13.3'	Hilo, Kealakekua Paauiilo
28	11-01-24.0	2.5	19	19°56.5'	155°36.8'	
28	13-52-03.8	2.6	8	19°16.5'	155°13.0'	
28	22-44-29.4	2.0	6	19°23.6'	155°16.8'	
29	06-00-52.7	3.6	10	19°20.1'	155°28.7'	near Pahala
30	10-58-14.6	2.1	29	19°21.3'	155°19.8'	
30	19-43-42.0	2.2	9	19°21.2'	155°12.4'	

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