



**HAWAIIAN VOLCANO OBSERVATORY**  
**1966 QUARTERLY ADMINISTRATIVE REPORTS**  
INTRODUCTORY NOTE BY THOMAS L. WRIGHT AND JENNIFER S. NAKATA

**COMPILED BY JENNIFER S. NAKATA**

SUMMARY 41

JANUARY, FEBRUARY, AND MARCH 1966  
BY ARNOLD T. OKAMURA, ROBERT Y. KOYANAGI, AND HOWARD A. POWERS

SUMMARY 42

APRIL, MAY, AND JUNE 1966  
BY ROBERT Y. KOYANAGI, ARNOLD T. OKAMURA, AND HOWARD A. POWERS

SUMMARY 43

JULY, AUGUST, AND SEPTEMBER 1966  
BY ARNOLD T. OKAMURA, ROBERT Y. KOYANAGI, AND WILLIE T. KINOSHITA

SUMMARY 44

OCTOBER, NOVEMBER, AND DECEMBER 1966  
BY ROBERT Y. KOYANAGI, ARNOLD T. OKAMURA, AND HOWARD A. POWERS

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U.S. GEOLOGICAL SURVEY

U.S. Department of the Interior  
DIRK KEMPTHORNE, Secretary

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 (4<sup>th</sup> quarter 1959, 1<sup>st</sup> 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:

<b>Location</b>	<b>Beginning Date</b>	<b>Ending Date</b>	<b>Comment</b>
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.
Heiheiāhulu (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 1<sup>st</sup> Quarter Report of 1960 and to the 4<sup>th</sup> 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 41

January, February, and March, 1966

By Arnold T. Okamura, Robert Y. Koyanagi,  
and Howard A. Powers

Issued February 1969

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OBSERVATORY STAFF

Geology

H. A. Powers (Scientist in Charge)  
R. S. Fiske

Geophysics

D. P. Hill  
W. T. Kinoshita  
George Kojima  
R. Y. Koyanagi  
A. T. Okamura

Geochemistry

R. T. Okamura  
T. L. Wright

Support

J. C. Forbes  
W. H. Francis  
Yukie Kimura  
B. J. Loucks  
Akira Yamamoto

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## Summary of Activities

The swarm of earthquakes that accompanied and followed the eruption of December 1965 continued into the first 10 days of January 1966. As this swarm was dwindling, various followup studies of this activity got underway.

A level line was carried from the junction of the slopes of Kilauea against the flank of Mauna Loa, to Halemaumau, in the southwestern part of Kilauea caldera, around the Desert and Caldera loops, and then to and beyond Makaopuhi seismograph along the Chain of Craters road. A line was reoccupied south for 5 km from the Chain of Craters to near Kipuka Nene tilt station (fig. 2). Because the summit area had not been leveled since June 1965, the leveling of January 1966 did not reveal large amounts of collapse following the eruption of December 1965. Significantly, the largest area of collapse that did show up lay about 3 km southeast of Halemaumau rather than over the geometrical center of the caldera.

Leveling along the Hilina Pali road revealed very large changes of altitude of the area along the southern margin of the Koa'e fault system, a system that lies roughly between the Desert and Makaopuhi seismographs (fig. 1). A graben area near the south edge of the system was downdropped locally as much as 6 feet and the area just south was uplifted more than 2 feet.

Ground tilt read daily from the short-base water-tube tiltmeters at Uwekahuna showed a continuous inflation of the summit area. The inflation recorded by the east-west component was considerably in excess of that recorded by the north-south component, indicating a center of inflation lying somewhere east-southeast of Uwekahuna.

The number of daily Kilauea summit shallow quakes, which had dwindled to less than 25 during the Koa'e swarm, gradually increased to a level of more than 100 during all of March. In the last week of March, the number of long-period caldera quakes rose from an average of less than 10 a day to more than 100 daily and this swarm continued into the next quarter.

In March, a 26-foot hole was drilled into the floor of Aloi Crater, which is about 3 km southeast of Kilauea in the Chain of Craters shown on figure 1, and the thickness of the lava in December 1965 was found to be 5 or 6 feet. The base of the December 1962 lava was penetrated at 11 feet, and the hole was bottomed in a rubbly zone presumably near the base of the flow that floored Aloi Crater prior to December 1962. The temperature in this hole was ambient when the measurements were made in mid-March.

In early February, a new drilling technique was used to emplace a closed-bottom stainless steel casing through the 25-foot crust of Makaopuhi lava lake and 15 feet down into the melt. Problems with the cromel/alumel and the platinum/platinum-rhodium thermocouples were still not fully solved, but the temperature at the base of the crust was confirmed to be about 1075°C and that at the bottom of the hole was found to be 1,150°C. This casing was still open when the first quarter ended, and many temperature profiles have been taken as the crust of the lake continued to grow.

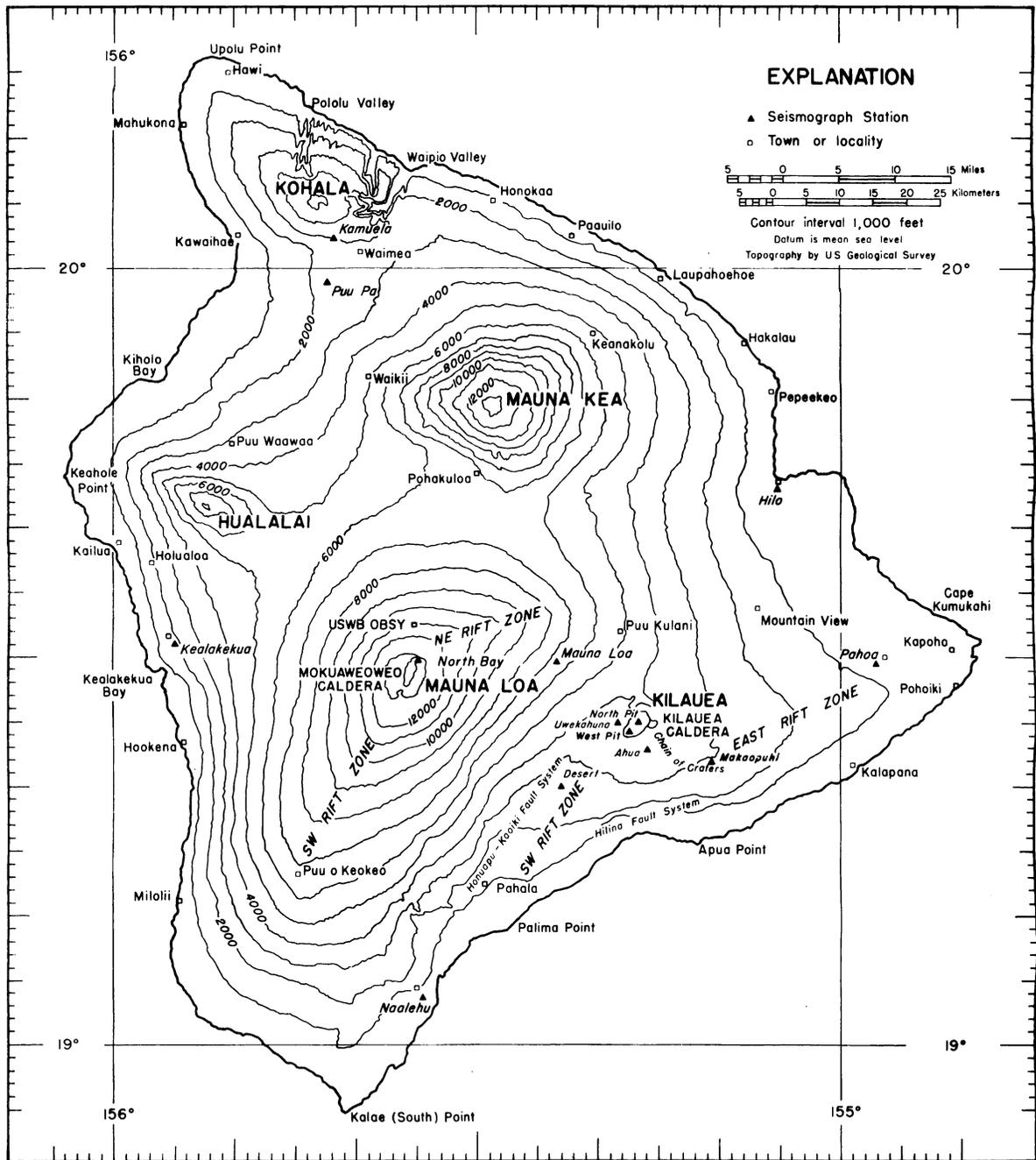


Figure 1.--Map of the Island of Hawaii showing seismograph stations operated by the U.S. Geological Survey, principal settlements, and selected geologic features. Epicenters of local earthquakes are given in terms of geographic coordinates, which are indicated at the edges of the map.

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 (table 1), 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 (table 2). 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 of this report. Table 6 is published in the first-quarter issue each year.

Table 1.--Tilt coordinates at Uwekahuna, January, February, and March, 1966

Date (1966)	N-S	E-W	Date (1966)	N-S	E-W
Jan. 2	468	507	Feb. 20	474	487
9	470	503	27	477	485
16	472	499	Mar. 7	477	486
23	474	494	13	478	486
30	475	493	20	479	486
Feb. 6	476	490	27	480	482
13	475	488			

1st Quarter, 1966

Table 2. -- Tilt coordinates and changes at bases around Kilauea caldera.

(See tilt diagram, fig. 2.)

Tilt base	Date (1966)	Tilt coordinates		Rate ( $10^{-6}$ rad/mo) and direction of tilting since last reading		Date of last reading (1965)
		N-S	E-W			
Uwekahuna (U) (on fig. 2).	March 14	484.7	476.0	14.8	N. 43.0° W.	Dec. 27
Tree Molds (TM)	16	421.0	515.4	4.2	N. 52.0° W.	29
Sand Spit (SS)	17	834.8	734.3	9.5	S. 9.2° W.	30
Kalihipaa (Kal)	This station ruined during the eruption and earthquake swarm of Dec. 24-31, 1965.					
Keamoku (Kea)	March 15	585.7	475.9	7.8	N. 69.4° W.	28
Ahua Kamokukolau (Kam).	16	634.1	630.0	1.5	S. 42.0° W.	28
Kipuka Nene (KN)	14	297.2	501.3	3.7	N. 5.7° E.	Jan. 13 (1966)
Hilina Pali (HP)	Not done this epoch.					
Kapapala Ranch (Kap).	15	491.6	509.5	.6	N. 45.4° E.	Dec. 27
Mehana (M)	17	541.5	551.5	1.3	N. 85.7° E.	29

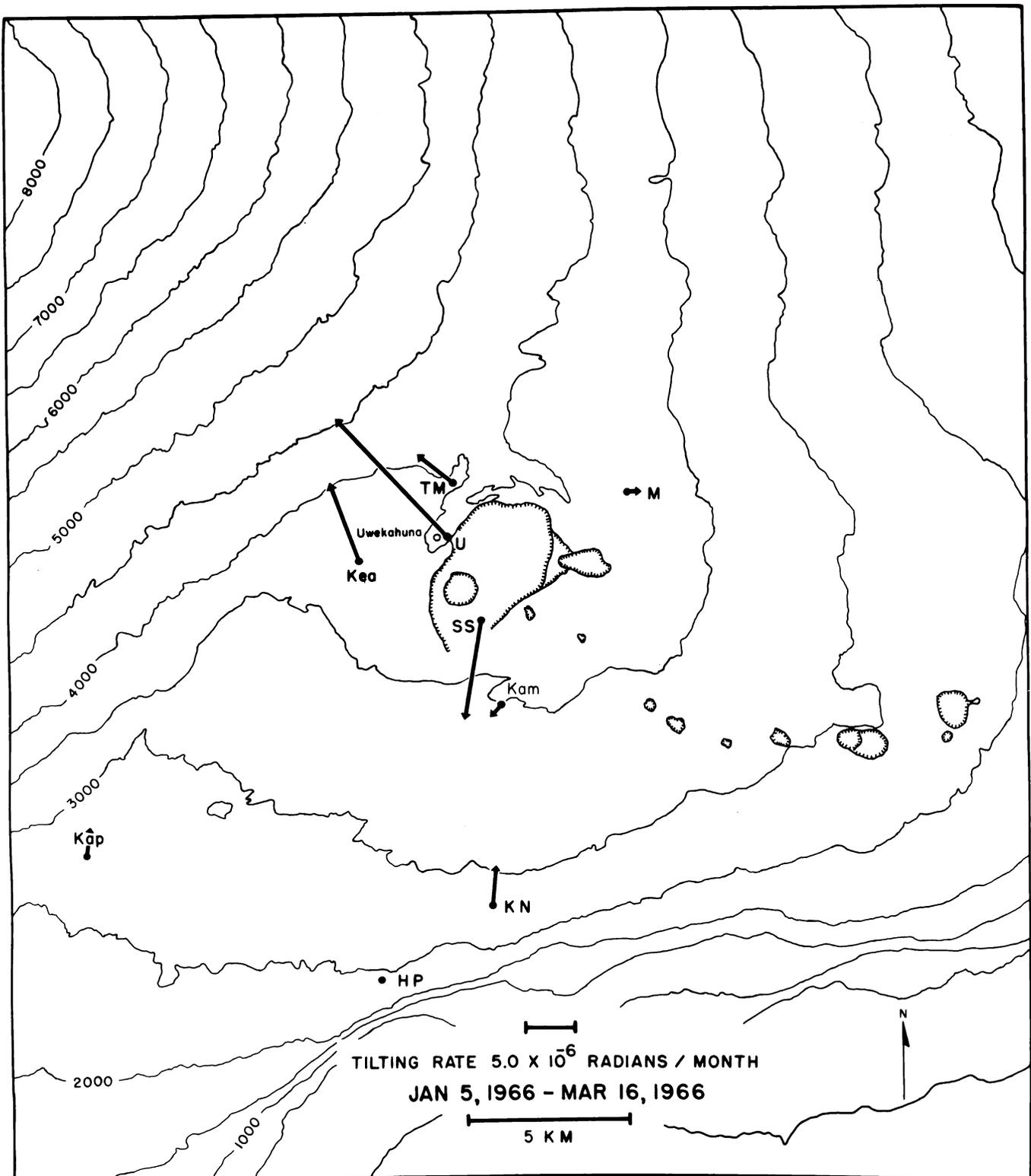


Figure 2.--Tilting of the ground around Kilauea caldera, January 5, 1966-March 16, 1966. The vector depicting tilting at a given tilt base points in the direction of maximum relative subsidence and has a length proportional to the rate of tilting during the measurement interval. Closed circles represent 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 into groups on the basis of region of origin as determined by analysis of records obtained daily at the Observatory (stations U, M, A, D, N, WP, MP).\* 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.

Beginning with this summary, data for the distant earthquakes will no longer be included in the summaries. Data for the distant earthquakes can be obtained directly from the Hawaiian Volcano Observatory.

Acknowledgments. --Several people or agencies reported "felt" earthquakes during the first quarter, 1966. Their assistance is gratefully acknowledged.

\*Location of and essential data on each seismograph station are listed in table 5 of this report. Table 5 published only in the first-quarter issue each year.

Table 3.--Number of earthquakes and minutes of tremor recorded on seismographs  
U, M, A, D, N, WP, and MP 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: Kona, Mauna Kea, etc.

Date (1966)	Tremor (minutes)			Kiluea summit			Earthquakes			
	Deep	Inter- mediate	Shallow	30 km	Long- period	Shallow	SW. rift and Kaoiki	Eastern east rift	Upper east rift	Others
Jan. 1	----	-----	-----	4	-----	13	10	-----	95	-----
2	----	-----	-----	2	-----	15	10	-----	80	-----
3	38	-----	-----	5	-----	-----	7	-----	57	-----
4	----	-----	-----	3	-----	14	7	-----	57	-----
5	29	-----	-----	6	-----	17	8	-----	53	1 Kona
6	17	-----	-----	4	-----	15	9	-----	60	1 Mauna Kea, 1 off west shore of Hawaii.
7	----	2	-----	5	-----	15	13	-----	55	-----
8	----	-----	-----	3	-----	10	13	-----	45	1 Mauna Kea
9	----	-----	-----	6	-----	10	20	-----	38	1 off east shore of Hawaii
10	----	-----	-----	3	-----	15	10	1	37	1 Mauna Loa
11	----	-----	-----	6	-----	10	7	-----	37	-----
12	3	-----	-----	12	-----	14	12	-----	26	-----
13	----	-----	-----	3	-----	15	6	-----	35	-----
14	----	-----	-----	8	-----	25	7	-----	37	1 Mauna Kea, 1 Kona

Table 3.--Number of earthquakes and minutes of tremor recorded on seismographs  
U, M, A, D, N, WP, and MP around Kilauea caldera--Continued

Date (1966)	Tremor (minutes)			Kilauea summit			Earthquakes			
	Deep	Inter- mediate	Shallow	30 km	Long- period	Shallow	SW. rift and Kaoiki	Eastern east rift	Upper east rift	Others
Jan. 15	----	3	----	8	----	13	13	----	28	-----
16	----	----	----	3	----	30	15	----	19	-----
17	4	----	----	4	----	15	13	----	25	-----
18	----	----	----	3	----	15	14	1	12	-----
19	15	----	----	7	----	35	14	----	14	2 Mauna Loa
20	5	----	----	Electrical storm-----			----	----	5	-----
21	----	----	----	3	----	18	10	----	27	1 Mauna Kea, 1 Kona
22	----	----	----	1	----	38	10	----	4	-----
23	----	----	----	----	----	30	18	----	3	-----
24	----	----	----	3	----	40	9	----	3	-----
25	----	----	----	3	----	30	8	----	7	-----
26	----	6	----	3	15	45	17	----	9	-----
27	----	4	----	14	2	25	10	----	5	1 Mauna Kea
28	----	----	3	3	----	33	9	----	13	1 Kohala
29	----	----	----	3	----	45	6	----	2	-----
30	----	----	----	3	----	40	7	----	34	-----
31	----	----	----	4	----	45	11	----	26	-----
Feb. 1	----	2	----	1	3	40	14	----	5	-----
2	----	----	----	6	----	35	7	----	23	1 Hualalai
3	----	----	----	3	----	35	19	----	5	-----
4	----	----	----	6	----	48	13	----	18	1 Kona
5	----	----	----	2	----	50	20	----	95	1 Mauna Loa
6	----	----	----	----	----	35	16	----	23	-----
7	----	----	----	4	----	?	5	----	14	-----
8	----	3	----	----	----	25	4	----	10	-----
9	----	----	----	8	----	?	6	----	20	1 Hualalai
10	19	----	----	4	----	50	15	----	8	-----

Feb.	11	14	-----	-----	3	-----	56	9	-----	16	-----
	12	-----	15	-----	20	-----	105	9	-----	18	-----
	13	-----	-----	-----	6	-----	70	16	-----	11	1 Mauna Loa, 1 Kona
	14	-----	-----	-----	4	4	70	6	-----	29	-----
	15	-----	-----	-----	-----	3	80	4	-----	27	-----
	16	11	-----	-----	-----	-----	60	11	-----	20	1 Mauna Loa
	17	-----	-----	-----	4	4	60	15	-----	15	-----
	18	-----	-----	-----	10	-----	80	24	-----	18	-----
	19	-----	-----	-----	12	-----	120	18	-----	24	-----
	20	-----	-----	-----	1	4	83	26	-----	15	1 Mauna Loa
	21	-----	-----	-----	1	-----	70	26	-----	107	1 Mauna Kea
	22	-----	16	-----	7	-----	77	26	-----	17	-----
	23	-----	5	-----	5	-----	71	12	-----	12	1 Kona, 1 Mauna Loa, 1 off west shore of Hawaii
	24	23	-----	-----	11	-----	67	14	-----	4	1 Mauna Kea
	25	-----	-----	-----	1	2	72	8	-----	8	1 off NW. shore of Hawaii
	26	5	-----	-----	6	-----	72	16	-----	8	-----
	27	-----	5	-----	6	-----	74	8	-----	10	-----
	28	-----	-----	-----	2	-----	80	24	-----	12	1 off west shore of Hawaii
6	Mar.	1	36	-----	1	-----	70	5	-----	20	-----
		2	Several	-----	8	-----	60	4	-----	14	-----
		3	Several	-----	1	-----	120	12	-----	20	1 Kona
		4	-----	-----	3	2	105	12	-----	12	-----
		5	-----	-----	2	-----	110	16	-----	32	1 off NW. shore of Hawaii 1 Mauna Kea
		6	-----	8	4	15	110	5	-----	13	-----
		7	-----	-----	-----	-----	110	8	1	12	-----
		8	-----	-----	-----	5	99	9	-----	25	-----
		9	-----	6	11	-----	96	12	-----	50	-----
		10	3	-----	2	-----	110	6	1	20	1 Hualalai, 2 off west shore of Hawaii.
		11	4	-----	6	-----	130	16	-----	20	-----
		12	-----	-----	1	-----	75	11	-----	19	-----
		13	8	-----	3	-----	95	11	-----	15	-----
		14	-----	-----	3	-----	105	33	-----	16	-----
		15	-----	-----	10	-----	97	6	-----	25	1 Mauna Kea

Table 3.--Number of earthquakes and minutes of tremor recorded on seismographs  
U, M, A, D, N, WP, and MP around Kilauea caldera--Continued

Date (1966)	Tremor (minutes)			Kilauea summit			Earthquakes			
	Deep	Inter- mediate	Shallow	30 km	Long- period	Shallow	SW. rift and Kaoiki	Eastern east rift	Upper east rift	Others
Feb. 16	----	-----	-----	22	-----	107	8	-----	33	1 Hualalai
17	44	-----	-----	8	8	130	8	-----	30	1 Kona
18	----	-----	-----	-----	5	105	10	1	15	1 Kona
19	----	-----	-----	4	-----	85	12	-----	18	-----
20	----	-----	-----	4	2	83	14	-----	12	-----
21	----	-----	-----	4	5	70	8	-----	20	1 Mauna Kea
22	----	-----	-----	2	28	70	14	-----	13	-----
23	----	-----	-----	4	35	50	7	-----	8	-----
24	----	-----	-----	1	11	57	6	-----	14	1 Kona
25	17	-----	4	3	5	67	15	-----	15	-----
26	----	22	-----	7	-----	79	7	-----	10	-----
27	----	-----	6	1	14	69	16	-----	18	-----
28	----	-----	12	-----	19	83	6	-----	16	1 Kona
29	----	-----	-----	5	130	80	7	-----	12	1 off south shore of Hawaii
30	----	-----	3	3	48	69	21	-----	11	1 Mauna Loa
31	----	-----	-----	6	70	90	8	-----	6	-----

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey,  
January, February, and March, 1966

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 (1966)	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	h	m	s			Lat. N.	Long. W.	Description	
Jan. 1	10	37	55.0	2.3	5	19°20.0'	155°12.8'	6 km SW. of Makaopuhi seismometer	-----
2	04	51	10.8	3.3	8	19°07.5'	155°13.3'	15 km SSW. of Apua Point	Kilauea summit area.
4	18	51	29.0	2.2	8	19°17.9'	155°10.2'	8 km south of Makaopuhi seismometer	-----
5	00	32	56.5	2.2	0	19°32.3'	155°41.0'	25 km east of Kealakekua	-----
5	08	52	45.0	2.6	8	19°12.1'	155°07.2'	20 km SSE. of Makaopuhi seismometer	-----
6	01	38	15.0	2.2	8	19°46.8'	155°31.0'	3 km NE. of Pohakuloa	-----
6	03	51	00.2	1.7	8	19°15.9'	155°25.1'	9 km SSW. of Desert seismometer	Pahala
6	03	53	25.2	1.7	8	19°18.8'	155°26.5'	6 km WSW. of Desert seismometer	Do.
6	11	01	20.0	2.7	3	19°26.2'	155°47.1'	17 km SE. of Kealakekua	-----
7	21	21	06.0	3.2	0	19°18.8'	155°16.6'	7 km SSW. of Ahua seismometer	-----
8	06	24	44.8	3.0	8	19°42.8'	155°37.6'	16 km SSE. of Waikii	-----
8	13	43	57.3	3.5	8	19°26.3'	155°28.7'	11 km SW. of Mauna Loa seismometer	Hilo, Pahala
8	19	30	15.6	2.1	8	19°23.5'	155°18.2'	5 km NW. of Ahua seismometer	-----
9	20	46	23.9	2.2	8	19°12.3'	154°43.3'	40 km SE. of Pahoa	-----
10	12	01	03.2	1.8	5	19°21.4'	155°13.1'	5 km WSW. of Makaopuhi seismometer	-----
10	18	53	08.5	2.4	3	19°11.4'	155°39.7'	16 km NW. of Naalehu	-----
11	06	25	03.1	2.7	3	19°20.5'	155°07.2'	7 km SE. of Makaopuhi seismometer	-----
12	11	26	23.5	1.8	8	19°23.8'	155°29.1'	12 km NW. of Desert seismometer	-----
12	19	49	01.3	1.8	25	19°23.5'	155°18.3'	5 km NW. of Ahua seismometer	-----
14	06	58	42.7	2.6	8	20°01.3'	155°21.6'	13 km WNW. of Laupahoehoe	Kamuela
14	22	30	19.0	3.0	3	19°21.8'	155°51.2'	5 km ESE. of Hookena	Kealakekua
17	16	13	45.0	3.2	8	18°45.1'	155°17.7'	69 km south of Ahua seismometer	-----
18	04	11	42.5	2.2	30	19°14.7'	155°28.7'	14 km SW. of Desert seismometer	-----
19	02	44	12.2	4.0	13	19°24.3'	155°32.8'	10 km SSE. of North Bay seismometer	Pahala, Kilauea summit area, Hilo, Naalehu, Kealakekua.

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey,  
January, February, March, 1966--Continued

Date (1966)	Time			Magni- tude	Depth (km)	Epicenter		Felt Report	
	h	m	s			Lat. N.	Long. W.		Description
Jan. 19	14	01	37.4	4.1	13	19°23.8'	155°33.5'	11 km SSE. of North Bay seismometer	Islandwide
21	07	53	49.1	3.1	13	19°49.5'	155°35.6'	25 km SSE. of Kamuela	Kamuela
21	21	02	26.9	3.8	8	19°27.9'	155°52.7'	7 km SE. of Kealakekua	Kealakekua
26	06	14	22.7	3.0	8	19°10.6'	155°25.7'	6 km SE. of Pahala	Pahala
26	16	04	20.6	2.0	8	19°10.8'	155°26.1'	5 km SE. of Pahala	Do.
27	14	23	58.3	2.4	8	20°01.4'	155°19.9'	10 km WNW. of Laupahoehoe	-----
27	21	21	15.3	2.2	33	19°21.2'	155°19.0'	6 km SW. of Ahua seismometer	-----
28	11	09	18.3	2.2	26	19°22.2'	155°19.0'	5 km west of Ahua seismometer	-----
30	23	18	27.8	2.4	8	20°11.0'	155°46.9'	19 km NNW. of Kamuela	-----
31	03	05	47.2	3.3	27	19°26.1'	155°13.1'	8 km ENE. of Uwekahuna	Kilauea summit area, Pahala,
12 Feb. 2	10	38	04.6	2.4	8	19°22.8'	155°29.9'	12 km WNW. of Desert seismometer	Pahala
2	15	18	56.1	2.5	8	19°43.2'	155°44.1'	30 km NE. of Kealakekua	-----
4	19	30	53.3	2.3	0	19°21.9'	155°46.9'	24 km SE. of Kealakekua	-----
5	06	42	16.8	2.0	3	19°37.5'	155°38.4'	16 km NW. of North Bay seismometer	-----
9	09	29	43.5	2.8	0	19°40.3'	155°52.9'	17 km NNE. of Kealakekua	-----
9	22	14	03.9	2.9	22	19°24.8'	155°19.0'	3 km WSW. of Uwekahuna seismometer	Pahala, Kilauea summit area.
10	06	14	55.7	2.0	5	19°22.8'	155°13.6'	5 km ENE. of Ahua seismometer	-----
10	21	54	42.3	2.2	8	19°25.9'	155°29.2'	14 km SW. of Mauna Loa seismometer	-----
11	04	32	37.9	2.4	40	19°12.1'	155°10.8'	19 km south of Makaopuhi seismometer	-----
12	19	56	16.3	3.7	30	19°22.3'	155°18.6'	5 km west of Ahua seismometer	Hilo, Kilauea summit area, Pahala.
13	05	27	10.5	2.7	30	19°23.5'	155°17.7'	4 km south of Uwekahuna	Kilauea summit area.
13	06	07	57.1	2.7	8	19°25.0'	155°24.5'	9 km NNW. of Desert seismometer	Kilauea summit area.

Feb.	13	18	55	10.1	2.0	8	19°11.9'	155°31.9'	16 km NNE. of Naalehu	-----	
	13	23	06	50.0	2.9	5	19°31.7'	155°49.0'	11 km ENE. of Kealakekua	Kealakekua	
	14	05	34	30.8	2.2	8	19°17.2'	155°08.8'	9 km SE. of Makaopuhi seismometer	-----	
	16	01	41	21.5	2.4	8	19°28.1'	155°29.2'	11 km WSW. of Mauna Loa seismometer	-----	
	16	14	41	03.1	1.8	20	19°20.7'	155°25.7'	4 km WNW. of Desert seismometer	Pahala	
	16	15	35	09.5	2.2	8	19°11.0'	155°31.5'	16 km NE. of Naalehu	-----	
	19	03	29	48.1	2.0	8	19°22.3'	155°24.7'	5 km NW. of Desert seismometer	-----	
	19	18	23	37.7	3.3	8	19°20.7'	155°28.5'	9 km west of Desert seismometer	-----	
	20	07	51	36.5	2.8	5	19°12.0'	155°38.1'	16 km NNW. of Naalehu	-----	
	21	15	59	33.3	3.7	3	19°50.7'	155°40.2'	21 km SSE. of Kamuela	Kamuela	
	22	11	05	19.5	2.2	8	19°20.8'	155°13.2'	5 km SW. of Makaopuhi seismometer	-----	
	22	17	06	44.6	2.2	5	19°22.9'	155°12.5'	4 km NW. of Makaopuhi seismometer	-----	
	23	02	45	04.5	3.2	3	19°19.8'	155°49.5'	10 km SE. of Hookena	-----	
	23	09	29	11.1	2.0	5	19°14.0'	155°37.0'	19 km NNW. of Naalehu	-----	
	23	15	18	19.1	2.1	30	19°22.7'	155°18.2'	4 km west of Ahua seismometer	-----	
	23	18	52	35.7	2.5	8	19°25'	156°30'	62 km WSW. of Kealakekua	-----	
	24	10	13	51.9	2.0	8	19°50.9'	155°41.9'	20 km south of Kamuela	-----	
	25	03	10	51.6	3.3	30	19°22.8'	155°17.5'	3 km WNW. of Ahua seismometer	Kilauea summit area.	
	25	06	37	49.8	3.1	8	19°56.6'	156°05.9'	42 km WSW. of Kamuela	-----	
	27	06	59	42.9	2.5	8	19°22.7'	155°24.9'	5 km NW. of Desert seismometer	-----	
	28	03	56	32.8	3.1	8	19°41'	156°28'	60 km WNW. of Kealakekua	-----	
	28	06	30	38.5	2.4	8	19°19.8'	155°00.8'	5 km SW. of Kalapana	-----	
	28	20	00	11.0	4.0	10	19°24.7'	155°27.2'	10 km NW. of Desert seismometer	Kilauea summit area, Pahala, Hilo, Kealakekua.	
	Mar.	2	02	50	05.7	2.7	8	19°15.5'	155°03.1'	18 km SE. of Makaopuhi seismometer	-----
		3	14	39	23.8	2.8	0	19°38.1'	156°00.1'	1 km SW. of Kailua	Kealakekua
4		23	13	10.3	1.9	10	19°20.2'	155°14.0'	6 km SE. of Ahua seismometer	-----	
5		13	53	48.0	2.3	8	20°03.2'	155°55.5'	10 km WNW. of Kawaihae	-----	
5		16	53	15.0	2.1	45	19°52.2'	155°13.3'	22 km NW. of Hilo	-----	
10		08	00	23.3	3.7	8	19°47.0'	155°46.0'	8 km east of Puu WaaWaa	Islandwide	
10		11	47	08.6	3.3	8	19°58'	157°32'	177 km WNW. of Kealakekua	-----	

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey,  
January, February, and March, 1966--Continued

Date (1966)	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	h	m	s			Lat. N.	Long. W.	Description	
Mar. 10	19	59	43.0	3.3	8	20°00'	157°41'	190 km WNW. of Kealakekua	-----
11	17	27	35.3	2.3	30	19°23.8'	155°16.9'	4 km SE. of Uwekahuna	-----
12	18	40	02.0	3.1	50	19°17.0'	155°05.7'	12 km SE. of Makaopuhi seismometer	Pahala
14	14	04	53.6	4.1	8	19°19.1'	155°26.5'	6 km WSW. of Desert seismometer	Kilauea summit area, Pahala, Hilo, Kealakekua.
15	04	03	55.1	2.2	5	19°26.2'	155°29.1'	15 km NW. of Desert seismometer	-----
15	10	26	47.9	3.0	13	19°58.8'	155°33.5'	15 km ESE. of Kamuela	-----
15	14	43	02.7	3.5	32	19°22.6'	155°18.0'	4 km west of Ahua seismometer	Pahala
16	19	28	02.8	2.3	8	19°51.0'	156°02.7'	13 km NNE. of Keahole Point	-----
17	09	51	50.5	3.2	8	19°20.8'	155°47.2'	23 km SE. of Kealakekua	-----
18	04	45	59.5	2.4	0	19°26.4'	155°47.0'	16 km SE. of Kealakekua	-----
20	23	07	35.9	2.2	8	19°21.1'	155°25.8'	5 km WNW. of Desert seismometer	-----
21	17	56	21.6	3.2	8	20°00.3'	155°50.9'	16 km WSW. of Kamuela	Kamuela
24	18	45	33.6	2.3	0	19°33.8'	155°46.5'	16 km ENE. of Kealakekua	-----
28	13	46	46.5	2.3	0	19°28.9'	155°48.9'	12 km ESE. of Kealakekua	-----
29	05	51	55.1	2.5	35	19°01.2'	155°29.5'	11 km SE. of Naalehu	-----
30	12	22	06.0	2.6	8	19°22.5'	155°25.1'	5 km NNW. of Desert seismometer	Pahala
30	21	32	12.3	2.6	8	19°11.9'	155°37.2'	15 km NNW. of Naalehu	-----

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-period Press-Ewing: N, E, Z. (Seismometer and galvanometer periods are 15 and 90 seconds, respectively.)  Short-period Sprengnether: E, Z. HVO-1: Z <sup>1</sup> / <sub>2</sub> .  Short-base liquid-level tiltmeter. Remote recording HVO-2: Z <sup>2</sup> / <sub>2</sub> .
Mauna Loa	M	19°29.8'	155°23.3'	2,010	
Ahua	A	19°22.4'	155°15.9'	1,070	Do.
Desert	D	19°20.2'	155°23.3'	815	Do.
North Pit	N	19°24.9'	155°17.0'	1,115	Remote recording 1.0 sec. EV-17 Z
West Pit	WP	19°24.7'	155°17.5'	1,115	Do.
Makaopuhi	MP	19°21.8'	155°10.7'	885	Do.
Hilo	Hi	19°43.2'	155°05.3'	20	HVO-1: Z  Wood-Anderson: N, E. Operated by Sister Thecla at St. Joseph's School.
Kipapa, Island of Oahu.	Kip	21°25.4'	158°00.9'	76	HVO-1: Z. Operated by U.S. Coast and Geodetic Survey.
Naalehu	Na	19°03.8'	155°35.2'	205	1.0 sec. EV-17 seismometer, 0.5 sec. galvanometer: Z. Operated by Rev. D. Thompson at Naalehu School.
Pahoa	Pa	19°29.7'	154°56.8'	205	HVO-1: Z. Operated by Mr. K. Kimura at Pahoa School.
Kamuela	Ka	20°01.9'	155°42.0'	740	1.0 sec. EV-17, 0.286 sec. galvanometer. Operated by Mrs. Ed. Van Gorder, Preparatory Academy, Kamuela.

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

Station	Symbol	Location		Altitude (m) above sea level	Equipment (Z, vertical; N, north-south; E, east-west)
		Lat. N.	Long. W.		
Haleakala, Island of 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.
North Bay	NB	19°29.7'	155°34.8'	4,005	0.8 sec. EV-17: Z. with helicorder. Operated by U.S. Weather Bureau.
Kealakekua	Ke	19°31.2'	155°55.3'	505	1.0 sec. EV-17, 0.286 sec. galvanometer: Z, EW, and NS. Operated by Mr. H. Nelson 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. The response of this seismograph is similar to that of HVO-1. Records from these seismographs at M, A, and D, and at N, WP, and MP (Benioff) are recorded on two 3-component drums to permit more accurate comparison of arrival times at these stations.

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 42

April, May, and June, 1966

By Robert Y. Koyanagi, Arnold T. Okamura,  
and Howard A. Powers

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OBSERVATORY STAFF

Geology

R. S. Fiske  
H. A. Powers (Scientist in charge)

Geophysics

D. P. Hill  
W. T. Kinoshita  
George Kojima  
R. Y. Koyanagi  
A. T. Okamura

Geochemistry

R. T. Okamura  
T. L. Wright

Support

J. C. Forbes  
W. H. Francis  
J. B. Judd  
Yukie Kimura  
B. J. Loucks  
Akira Yamamoto  
K. M. Yamashita

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## Summary of activities

Swelling of Kilauea continued at a moderate rate during April, May, and June. Both tilt and level measurements indicated that the center of swelling was about 1 km east of Halemaumau. The greatest rise was 0.17 ft and the gradient of the swelling about this center is compatible with the computations for a model at 4 km depth to the center of expansion. Outlet tilt station (read daily), a short-base tilt station located midway between North Pit and Ahua seismograph stations (fig. 1), is much closer to the center of rise than is Uwekahuna station; therefore, the accumulation of outward tilt (southwest) at Outlet was four times as great as at Uwekahuna. During the only notable spurt, between June 6 and June 19, Outlet tilted at a rate of nearly 40 microradians a month.

The daily count of earthquakes local to Kilauea caldera was greater than average during most of the quarter. The daily total ranged from 125 to 300 quakes on all but about 15 days; it was less than 100 from April 22 through May 1. A swarm of deep caldera quakes occurred at the beginning of the quarter, on April 1 and 2; deep quakes continued at an average rate of 2 or 3 per day for the rest of the period. During the second week in May there was a peak in the rate of energy release, with 9 quakes having magnitudes that averaged about 3.

There appeared to be no demonstrable correlation between the flurries of higher seismicity and the details of the pattern of swelling.

During early April, a network of lines whose length can be measured very accurately with electronic measuring instruments (we are using a geodimeter) was laid out across Kilauea summit and Kilauea's two upper rift zones. Remeasurement of these surface distances indicates the location and amount of surface stretching and shrinking associated with the swelling and contraction of the volcanic structure.

Temperature measurements with thermocouples in stainless steel tubes thrust several feet into melt beneath the "base of crust" had been constantly suspect because of contamination of the wires of the thermocouple. In June 1966, two different techniques were used to correct the problem. Silver, gold, and germanium oxide were used to calibrate the thermocouple profiles with known melting point temperatures; heavy-gage CrAl wire was selected after the discovery that it did not contaminate rapidly.

The surface of the lava lakes in Kilauea Iki, Alae, a pit crater about 2 km west of Makaopuhi seismograph, and Makaopuhi, near Makaopuhi seismograph (fig. 1), were releveled, and temperature measurements were made in two holes still open in Alae. The highest temperature measured in Alae was 475°C at a depth of 39 feet below the surface in hole 12 where the body of new lava is 49 feet thick.

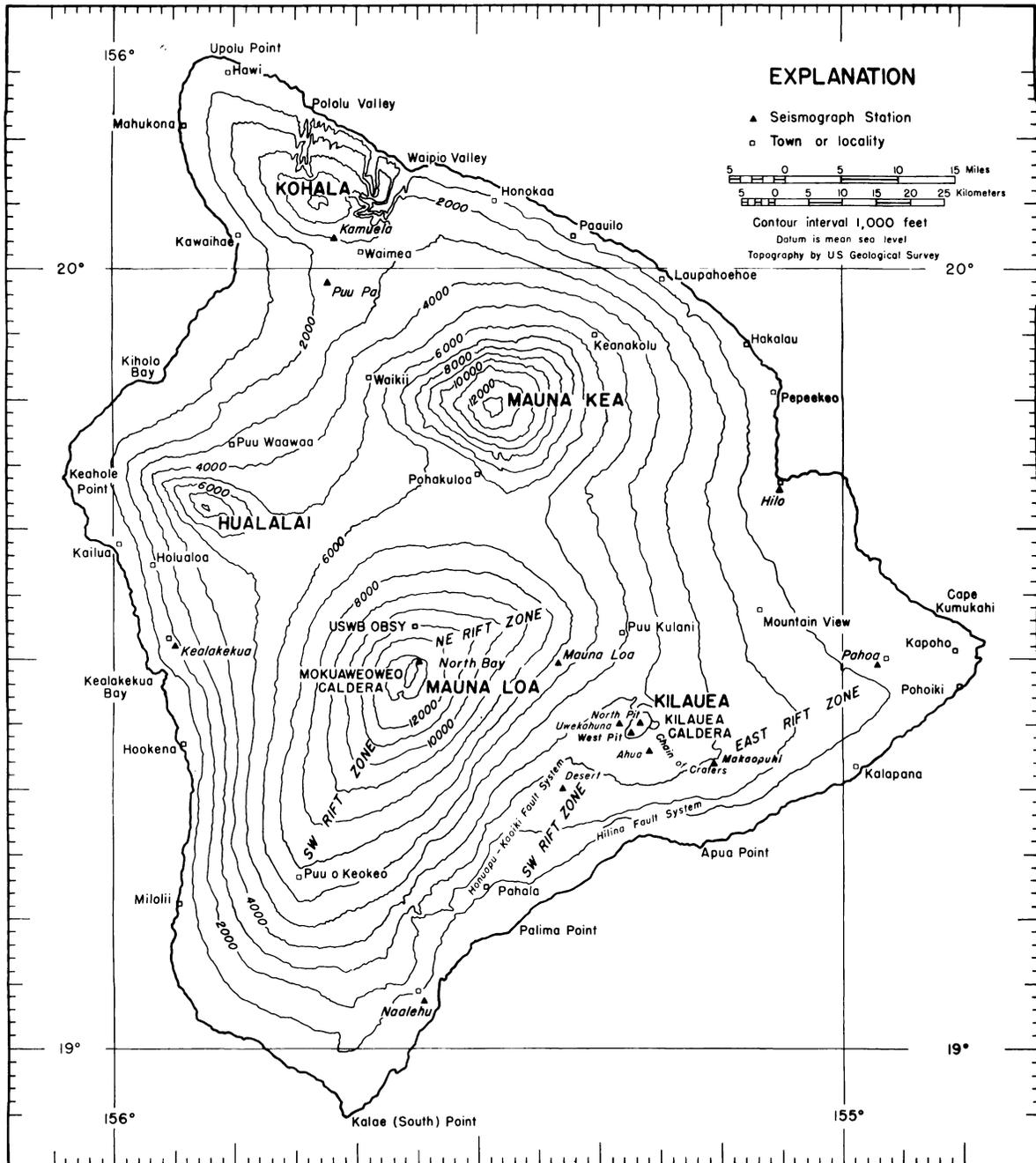


Figure 1.--Map of the Island of Hawaii showing seismograph stations operated by the U.S. Geological Survey, principal settlements, and selected geologic features. Epicenters of local earthquakes are given in table 4 in terms of geographic coordinates, which are indicated at the edges of the map.

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 (table 1), 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 (table 2). 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.

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 into groups on the basis of region of origin as determined by analysis of records obtained daily at the Observatory (stations U, M, A, D, N, WP, MP). 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 of the first-quarter issue each year.

Acknowledgments.--Several people or agencies reported "felt" earthquakes during the second quarter, 1966. Their assistance is gratefully acknowledged.

Table 1. --Tilt coordinates at Uwekahuna, April,  
May, and June, 1966

Date (1966)	N-S	E-W	Date (1966)	N-S	E-W
April 3	481	479	May 22	482	475
10	481	479	29	483	474
17	481	478	June 5	484	471
24	482	475	12	486	472
May 1	480	478	19	486	472
8	481	474	26	488	474
15	482	474			

2d Quarter, 1966

Table 2. --Tilt coordinates and changes at bases around Kilauea caldera,

(See tilt diagram, fig. 2)

Tilt base	Date (1966)	Tilt coordinates		Rate ( $10^{-6}$ rad/mo) and direction of tilting since last reading		Date of last reading (1966)
		N-S	E-W			
Uwekahuna (U on fig. 2)	June 7	500.3	461.8	7.4	N. 42.4° W.	Mar. 14
Tree Molds (TM)	8	430.2	513.3	3.3	N. 12.9° W.	16
Sand Spit (SS)	8	829.7	721.3	5.1	S. 68.7° W.	17
Kalihipaa	This station ruined during the eruption and earthquake swarm of Dec. 24-31, 1965.					
Keamoku (Kea)	6	489.9	464.8	4.3	N. 69.4° W.	15
Ahua Kamokukolau (Kam).	8	612.0	620.4	8.6	S. 23.6° W.	16
Kipuka Nene (KN)	9	299.0	501.0	.6	N. 10.8° W.	14
Hilina Pali (HP)	9	463.4	506.0	.3	S. 89.1° W.	Jan. 10
Kapapala Ranch (Kap)	6	492.3	508.5	.1	S. 20.7° E.	Mar. 15
Mehana (M)	16	543.9	555.6	1.6	N. 60.5° E.	17

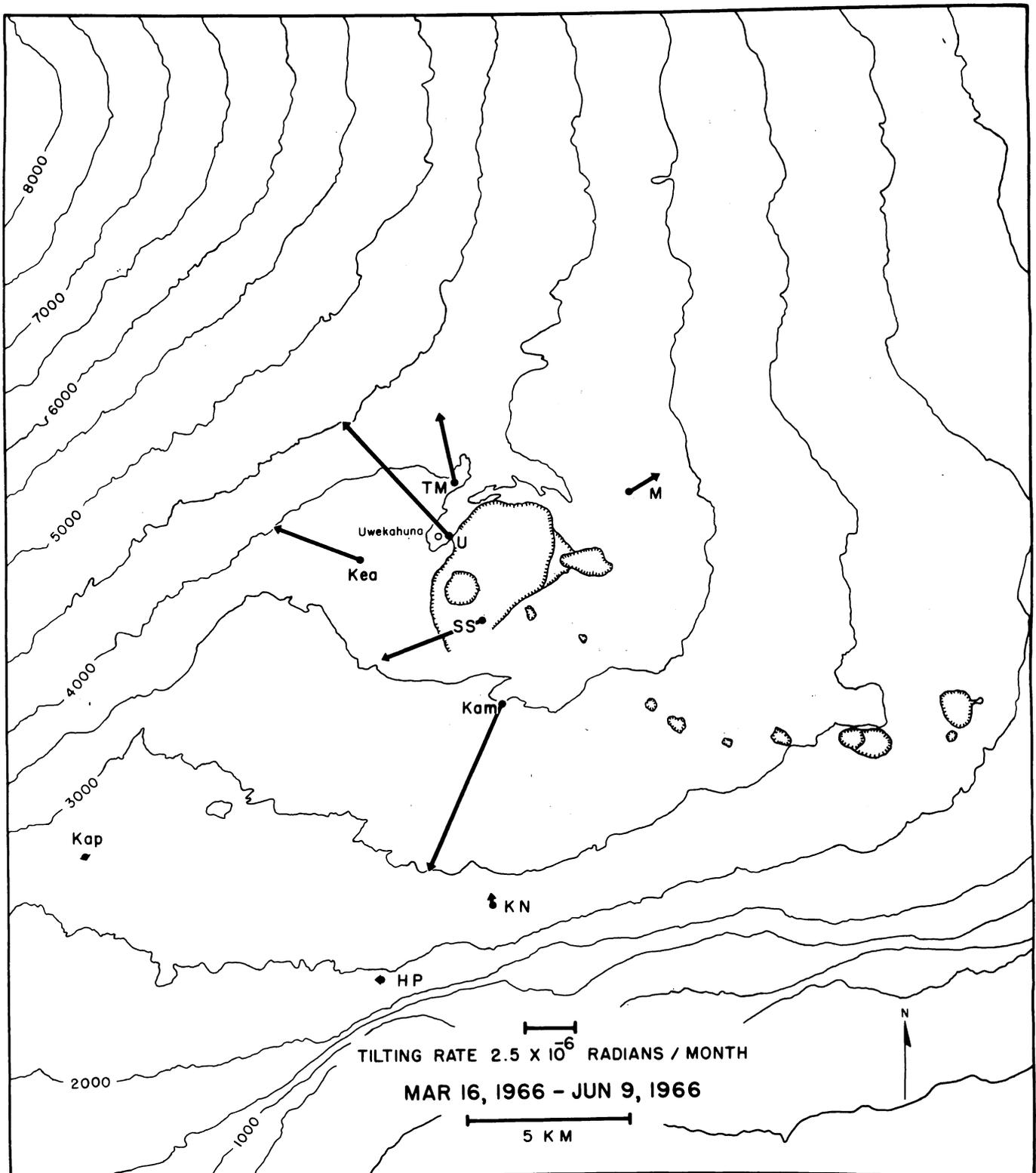


Figure 2.--Tilting of the ground around Kilauea caldera, March 16, 1966-June 9, 1966. The vector depicting tilting at a given tilt base points in the direction of maximum relative subsidence and has a length proportional to the rate of tilting during the measurement interval. Closed circles represent field tilt bases; open circles, short-base water-tube tiltmeters. See table 2 for explanation of abbreviations.

Table 3. --Number of earthquakes and minutes of tremor recorded on seismographs U, M, A, D, N, WP, and MP 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 (1966)	Tremor (minutes)			Kilauea summit			Earthquakes			
	Deep	Inter- mediate	Shallow	30 km	Long- period	Shallow	SW. rift and Kaoiki	Eastern east rift	Upper east rift	Others
April 1	----	-----	-----	2	51	81	15	-----	11	-----
2	----	-----	-----	36	185	70	12	-----	10	-----
3	----	-----	8	8	31	106	17	-----	4	-----
4	----	-----	-----	5	4	96	26	-----	3+	-----
5	----	-----	-----	9	-----	93	11	-----	7+	2 Mauna Loa
6	----	5	-----	2	-----	89	7	-----	16	-----
7	----	-----	-----	3	4	113+	10	-----	23	-----
8	----	-----	7	2	11	117	7	-----	17	-----
9	27	-----	14	9	5	150	13	-----	29	-----
10	----	-----	-----	4	6	142	14	-----	26	-----
11	----	-----	-----	8	10+	133+	10	-----	26	1 Mauna Kea
12	----	5	-----	5	12	180	6	-----	37	Do.
13	----	-----	-----	7	30	115	6	-----	21	-----
14	----	-----	15	2	53	120	7	-----	21	-----
15	----	-----	-----	2	54	91	10	-----	8	1 Mauna Kea
16	----	-----	3	3	121	79	8	-----	16	-----

Table 3.--Number of earthquakes and minutes of tremor recorded on seismographs  
U, M, A, D, N, WP, and MP around Kilauea caldera--Continued

Date (1966)	Tremor (minutes)			Kilauea summit			Earthquakes			
	Deep	Inter- mediate	Shallow	30 km	Long- period	Shallow	SW. rift and Kaoiki	Eastern east rift	Upper east rift	Others
April 17	----	-----	-----	3	150	110	15	-----	16	-----
18	----	-----	-----	11	30	112	7	-----	27	-----
19	----	-----	-----	9	70	85	7	-----	20	-----
20	----	-----	-----	3	70	90	8	-----	42	-----
21	----	-----	4	-----	122	64	21	-----	39	-----
22	----	-----	-----	5	20	65	7	-----	15	-----
23	----	-----	-----	4	9	54	8	-----	10	1 off SE. shore of Hawaii
24	----	-----	-----	8	17	88	14	-----	14	-----
25	----	-----	-----	3	5	150	12	-----	8	2 Mauna Loa, 1 Hualalai
26	4	-----	-----	4	-----	120	8	-----	5	-----
27	----	-----	-----	4	5	78	3	-----	10	-----
28	----	-----	-----	2	2	82+	14	-----	29	-----
29	----	-----	-----	2	-----	90	9	-----	25	-----
30	----	-----	-----	2	8	120	7	-----	35	-----
May 1	----	-----	-----	-----	2	80	8	-----	10	-----
2	----	-----	-----	-----	15	70	13	-----	11	1 Mauna Kea
3	----	-----	-----	5	3	128	7	-----	15	1 west Hawaii
4	----	-----	-----	7	10	158	4	-----	20	1 off SE. shore of Hawaii
5	5	-----	-----	5	4	145	12	-----	12	1 west Hawaii
6	----	-----	-----	2	22	166	13	-----	14	-----
7	----	-----	-----	2	38	166+	15	-----	4	-----
8	----	-----	-----	-----	46	210	19	-----	14	-----
9	----	-----	-----	2	49	189	8	-----	28	-----
10	11	-----	-----	3	108	166	24	-----	27	-----
11	----	-----	-----	1	61	151	10	-----	16	-----
12	----	10	-----	3	21+	139+	12	-----	31	2 w. Hawaii, 1 Mauna Loa, 1 Mauna Kea, 1 off east shore of Hawaii.

May	13	----	10	3	25	130	9	----	34	1 off west shore of Hawaii
	14	----	-----	3	79	130	16	----	26	-----
	15	5	-----	1	6	126	11	----	17	-----
	16	----	-----	3	50?	?	15	----	?	-----
	17	30	-----	4	10	124	4	----	17	-----
	18	----	10	-----	18	175	12	----	22	1 off west shore of Hawaii
	19	----	-----	1	39	191	8	----	39	1 Mauna Loa
	20	----	-----	6	80	110	14	----	20	-----
	21	16	-----	4	91	145	9	----	16	-----
	22	----	-----	3	39	120	13	----	11	-----
	23	----	17+	10	16	108	21	----	25	-----
	24	4	-----	16	13	95	19	----	26	1 west Hawaii
	25	----	-----	10	6	72	18	----	10+	-----
	26	11	-----	11	7	132	17	----	14	-----
	27	33	-----	-----	20	186	12	----	8	-----
	28	----	-----	6	28	170	18	----	30	2 west Hawaii
	29	----	-----	3	29	152	11	----	22	-----
	30	----	-----	3	21	117	12	----	20	-----
	31	----	-----	1	33	132	11	----	45	-----
June	1	36	-----	4	32	187	11	----	34	-----
	2	13	-----	5	6	210	4	----	35	-----
	3	----	-----	3	11	148	22	----	17	-----
	4	----	-----	2	2	102	20	----	7+	-----
	5	----	5	10	3	109	14	----	7	-----
	6	----	-----	11	3	93	17	----	19	-----
	7	----	8	7	18	117	10	----	26	-----
	8	----	-----	2	2	72	16	----	20	-----
	9	----	-----	4	6	57	12	----	6	-----
	10	----	3	3	24	128	25	----	23	-----
	11	----	4	2	14	129	15	----	22	1 Mauna Kea, 1 west Hawaii
	12	----	4	8	134	161	12	----	29	-----
	13	----	-----	6	71	148	17	----	16	-----
	14	----	-----	1	33	116	17	----	6	-----
	15	----	-----	5	52	102	14	----	9	-----
	16	----	-----	3	24	130	14	----	16	-----
	17	----	-----	-----	26	99	7	1	7	1 west Hawaii
	18	----	-----	-----	47	98	4	1	9	1 west Hawaii
	19	----	-----	1	49	113	6	----	18	2 off NW. shore of Hawaii
	20	----	8	4	24	112	6	----	17	-----
	21	----	4	1	32	77	9	----	27	-----
	22	----	-----	-----	23	96	12	----	23	-----
	23	13	-----	1	37	83	14	----	20	-----

Table 3.--Number of earthquakes and minutes of tremor recorded on seismographs  
U, M, A, D, N, WP, and MP around Kilauea caldera--Continued

Date (1966)	Tremor (minutes)			Kilauea summit			Earthquakes			
	Deep	Inter- mediate	Shallow	30 km	Long- period	Shallow	SW. rift and Kaoiki	Eastern east rift	Upper east rift	Others
June 24	----	-----	-----	1	25	51	6	-----	12	-----
25	----	-----	3	11	54	71	10	1	24	-----
26	----	-----	-----	-----	21	61	10	1	76	-----
27	----	-----	6	4	7	71	5	-----	15	1 west Hawaii
28	----	-----	-----	1	16	86	5	-----	21	1 Hualalai
29	----	-----	12+	1	51	69	14	-----	22	-----
30	----	-----	16+	2	63	105	14	-----	34	-----

Table 4. --Local earthquakes recorded by seismographs of the U.S. Geological Survey, April, May, and June, 1966

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 (1966)	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	h	m	s			Lat. N.	Long. W.	Description	
April 2	08	15	41.7	2.3	30	19°13.7'	155°30.5'	5 km NW. of Pahala	-----
2	09	07	02.9	3.4	30	19°22.8'	155°17.5'	1 km NW. of Ahua seismometer	Kilauea summit area, Mauna Loa.
4	16	33	50.5	2.7	5	19°23.4'	155°27.2'	9 km NW. of Desert seismometer	Kilauea summit area.
4	23	14	16.6	2.5	30	19°21.5'	155°15.9'	2 km south of Ahua seismometer	Kilauea summit area.
5	04	53	23.5	2.4	5	19°24.0'	155°32.1'	11 km SSE. of North Bay seismometer	-----
5	05	28	33.5	3.3	8	19°20.5'	155°25.7'	5 km WNW. of Desert seismometer	Pahala
5	07	14	47.0	2.1	8	19°26.4'	155°38.6'	9 km SW. of North Bay seismometer	-----
6	00	36	05.6	2.4	8	19°17.9'	155°10.4'	7 km south of Makaopuhi seismometer	-----
9	12	44	50.5	2.4	5	19°14.0'	155°12.8'	3 km SW. of Apua Point	-----
10	02	23	16.5	2.0	8	19°23.1'	155°25.3'	7 km NW. of Desert seismometer	-----
10	14	00	50.7	3.5	30	19°21.0'	155°19.5'	7 km WSW. of Ahua seismometer	-----
10	18	49	20.2	2.2	27	19°18.5'	155°19.7'	7 km SE. of Desert seismometer	-----
11	14	18	41.1	2.1	8	19°48.7'	155°19.0'	26 km WNW. of Hilo	-----
12	06	00	27.7	2.2	8	20°00.6'	155°32.1'	17 km ESE. of Kamuela	-----
12	06	16	55.3	2.0	8	19°19.0'	155°25.7'	5 km WSW. of Desert seismometer	-----
12	18	03	50.3	2.0	20	19°26.6'	155°18.2'	2 km NNW. of Uwekahuna seismometer	-----
12	10	57	35.4	2.0	8	19°19.7'	155°10.8'	4 km south of Makaopuhi seismometer	-----
15	06	16	29.5	2.4	8	19°58.6'	155°30.8'	20 km ESE. of Kamuela	-----
18	00	18	30.3	2.1	40	19°15.1'	155°09.1'	12 km SSE. of Ahua seismometer	-----
18	20	40	30.9	2.1	27	19°21.9'	155°17.7'	4 km WSW. of Ahua seismometer	-----
19	00	16	11.7	2.1	25	19°22.7'	155°18.0'	4 km WNW. of Ahua seismometer	-----
21	00	11	14.8	3.2	8	19°21.1'	155°04.1'	12 km ESE. of Makaopuhi seismometer	Hilo

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey,  
April, May, and June, 1966--Continued

Date (1966)	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	h	m	s			Lat. N.	Long. W.	Description	
April 21	06	35	26.4	1.5	10	19°19.1'	155°13.6'	7 km SE. of Ahua seismometer	-----
23	15	15	43.4	2.4	4	19°24.5'	155°27.5'	10 km NW. of Desert seismometer	-----
23	15	16	21.5	2.7	5	19°24.1'	155°27.3'	10 km NW. of Desert seismometer	-----
23	18	27	36.6	2.8	40	18°59.7'	155°17.9'	31 km ESE. of Naalehu	-----
25	05	14	48.1	2.2	13	19°08.0'	155°38.3'	9 km NW. of Naalehu	-----
25	06	35	38.3	2.7	8	19°35.4'	155°43.1'	22 km ENE. of Kealakekua	-----
25	10	44	41.2	2.4	8	19°42.1'	155°48.9'	9 km SSE. of Puu Waa Waa	-----
26	03	39	15.7	2.0	25	19°23.0'	155°18.6'	5 km SSW. of Uwekahuna	-----
26	06	21	33.2	2.5	5	19°27.0'	155°29.5'	12 km SW. of Mauna Loa seismometer	-----
29	04	23	58.7	2.3	8	19°20.1'	155°13.1'	6 km SW. of Makaopuhi seismometer	-----
May 2	15	38	32.4	2.2	8	19°57.4'	155°30.8'	22 km SE. of Kamuela	-----
2	22	14	23.8	2.6	8	19°19.7'	155°30.1'	12 km west of Desert seismometer	-----
3	08	36	22.8	2.4	0	19°30.8'	155°48.2'	12 km east of Kealakekua	-----
4	04	21	28.4	2.1	8	18°46.0'	155°08.1'	55 km SSE. of Apua Point	-----
5	04	45	18.0	2.2	30	19°21.0'	155°17.9'	5 km SW. of Ahua seismometer	-----
5	18	08	14.4	2.7	0	19°28.5'	155°47.0'	16 km SE. of Kealakekua	-----
5	18	12	34.5	2.0	3	19°25.5'	155°25.4'	10 km NNW. of Desert seismometer	-----
6	20	47	58.8	2.7	5	19°16.9'	155°04.4'	14 km SE. of Makaopuhi seismometer	Hilo
7	03	01	48.9	2.7	43	19°18.9'	155°06.0'	10 km SE. of Makaopuhi seismometer	-----
11	06	54	41.1	2.5	5	19°13.0'	155°27.0'	4 km NE. of Pahala	-----
11	07	06	39.4	3.2	27	19°23.0'	155°18.0'	4 km WNW. of Ahua seismometer	-----
12	00	01	49.7	2.7	0	19°29.8'	155°47.7'	14 km ESE. of Kealakekua	-----
12	05	55	04.7	2.8	30	19°21.8'	155°35.1'	15 km south of North Bay seismometer	-----
12	07	39	04.2	2.0	5	19°26.0'	155°27.0'	10 km SW. of Mauna Loa seismometer	-----
12	15	45	06.6	2.4	0	19°36.1'	155°47.3'	17 km NE. of Kealakekua	-----
12	18	02	26.5	3.8	13	18°52'	153°19'	175 km ESE. of Cape Kumukahi	-----
12	19	41	23.2	3.0	8	19°48.0'	155°33.8'	6 km NW. of Pohakuloa	-----
13	02	45	11.9	3.0	8	19°35'	156°24'	52 km WNW. of Kealakekua	-----
18	12	52	43.6	3.1	13	19°30'	156°27'	56 km west of Kealakekua	-----
19	04	54	45.3	2.5	3	19°22.1'	155°05.9'	9 km east of Makaopuhi seismometer	-----

May	19	06	22	17.0	2.9	8	19°14.1'	155°37.3'	20 km NNW. of Naalehu	Kealakekua
	20	16	00	56.6	2.3	5	19°25.8'	155°28.9'	15 km NW. of Desert seismometer	-----
	21	00	44	16.7	2.8	27	19°22.0'	155°19.3'	6 km west of Ahua seismometer	-----
	21	00	46	30.2	2.8	27	19°22.0'	155°19.3'	---do-----	-----
	21	04	40	39.5	3.0	32	19°22.8'	155°19.6'	6 km SW. of Uwekahuna seismometer	-----
	24	09	37	38.5	2.3	0	19°21.2'	155°46.0'	15 km ESE. of Hookena	-----
	25	02	50	01.0	2.4	8	19°20.3'	155°11.7'	4 km SW. of Makaopuhi seismometer	-----
	25	06	17	49.2	2.2	20	19°24.0'	155°17.0'	3 km SE. of Uwekahuna	-----
	27	01	05	46.0	3.7	40	19°13.1'	155°03.6'	20 km SE. of Makaopuhi seismometer	Kilauea summit area, Pahala.
	28	15	14	10.4	2.7	13	19°46'	156°07'	7 km NW. of Keahole Point	-----
	28	15	32	51.4	2.0	0	19°26.8'	155°48.1'	15 km SE. of Kealakekua	-----
	29	10	50	11.1	2.3	8	19°22.0'	155°08.9'	4 km east of Makaopuhi seismometer	-----
June	2	19	22	08.2	2.5	9	19°27.0'	155°15.9'	4 km NE. of Uwekahuna	Kilauea summit area.
	3	13	14	30.1	2.0	5	19°26.0'	155°28.2'	12 km SW. of Mauna Loa seismometer	-----
	5	01	13	30.5	2.1	8	19°23.0'	155°03.8'	12 km ENE. of Makaopuhi seismometer	-----
	5	11	36	48.2	2.1	5	19°22.0'	155°25.5'	5 km NNW. of Desert seismometer	-----
	5	22	25	08.0	2.7	30	19°39.1'	155°17.3'	20 km NE. of Mauna Loa seismometer	-----
	6	06	13	27.5	2.4	30	19°23.9'	155°17.1'	4 km SSE. of Uwekahuna	-----
	6	15	53	28.7	2.6	8	19°21.9'	155°07.0'	7 km east of Makaopuhi seismometer	-----
	11	02	41	38.5	2.5	0	19°36.0'	155°52.5'	10 km NE. of Kealakekua	-----
	11	12	03	09.1	2.7	8	19°54.8'	155°45.5'	15 km SW. of Kamuela	-----
	12	12	27	57.2	2.6	3	19°19.4'	155°05.6'	10 km SE. of Makaopuhi seismometer	-----
	16	02	27	29.2	2.4	8	19°26.8'	155°28.7'	11 km SW. of Mauna Loa seismometer	-----
	17	04	34	46.8	2.8	27	19°20.2'	155°19.2'	7 km east of Desert seismometer	-----
	17	15	06	22.5	2.4	0	19°25.2'	155°42.8'	24 km SE. of Kealakekua	-----
	17	19	54	49.4	2.0	5	19°22.5'	155°27.4'	9 km NW. of Desert seismometer	-----
	18	21	21	26.9	3.5	0	19°21.1'	155°45.1'	16 km ESE. of Hookena	Kealakekua
	19	12	50	15.1	2.9	13	20°02.9'	155°52.9'	5 km west of Kawaihae	-----
	19	15	17	10.0	2.5	13	20°02.2'	155°58.1'	15 km west of Kawaihae	-----
	20	00	26	47.8	2.2	3	19°13.9'	155°25.9'	12 km SSW. of Desert seismometer	-----
	21	03	55	07.6	3.3	3	19°21.8'	155°30.8'	13 km WNW. of Desert seismometer	Pahala, Kilauea summit area.

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey,  
April, May, and June, 1966--Continued

Date (1966)	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	h	m	s			Lat. N.	Long. W.	Description	
June 24	21	01	36.8	2.4	8	19°19.0'	155°10.0'	6 km SSE. of Makaopuhi seismometer	-----
26	16	34	39.5	2.3	8	19°19.8'	155°10.2'	5 km SSE. of Makaopuhi seismometer	-----
26	18	01	29.0	2.0	3	19°22.6'	155°02.8'	8 km WNW. of Kalapana	-----
27	00	12	07.0	2.3	5	19°23.2'	155°26.6'	8 km NW. of Desert seismometer	-----
27	05	18	33.3	2.2	0	19°31.4'	155°41.4'	24 km east of Kealakekua	-----
27	16	01	49.1	2.4	25	19°21.9'	155°17.5'	3 km WSW. of Ahua seismometer	-----
28	04	24	57.9	2.6	13	19°50.7'	156°00.3'	14 km NE. of Keahole Point	-----
28	20	35	33.8	2.2	3	19°21.2'	155°07.5'	6 km east of Makaopuhi seismometer	-----
29	16	58	32.3	2.8	8	19°19.2'	155°13.7'	8 km SW. of Makaopuhi seismometer	-----
30	12	36	56.3	2.3	3	19°22.8'	155°06.0'	8 km ENE. of Makaopuhi seismometer	-----

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY

HAWAIIAN VOLCANO OBSERVATORY

SUMMARY 43

July, August, and September, 1966

By Arnold T. Okamura, Robert Y. Koyanagi,  
and Willie T. Kinoshita

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OBSERVATORY STAFF

Geology

R. S. Fiske  
H. A. Powers (Scientist in charge)

Geophysics

D. P. Hill  
W. T. Kinoshita  
George Kojima  
R. Y. Koyanagi  
A. T. Okamura

Geochemistry

R. T. Okamura  
T. L. Wright

Support

J. C. Forbes  
W. H. Francis  
J. B. Judd  
Yukie Kimura  
B. J. Loucks  
Akira Yamamoto  
K. M. Yamashita

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## Summary of activities

Swelling of Kilauea continued through July, August, and September of 1966, and the apparent center of rise moved north of Halemaumau, then to the east of Halemaumau with an elongation southward. The rate of rise increased so that the net relative rise of the caldera floor was 1/3 foot in 3 months. The swelling was accomplished in 3 surges, indicated by the pattern of the daily tiltmeter readings, the rises taking place in the last 2 weeks of July, the last half of August, and from September 12 through October 2.

There were very few caldera quakes (both short-period and long-period types) from July 1 through August 18. However, during this period of low seismicity at the caldera, there were two seismic events of note. Between June 29 and July 13 there were nearly 200 earthquakes that originated under the east end of the East rift zone. Eight of them were felt in the vicinity of Pahoa and the largest was of magnitude 3.0. The swarm showed 3 peaks of intensity--33 quakes recorded on July 3, 23 on July 9, and 40 on July 13. The second event began less than an hour before midnight of July 5, when a swarm of quakes originated from shallow depth near Aloi crater, midway between Ahua and Makaopuhi seismographs, in the region of the junction of the Koaie fault zone with the upper East rift. More than 500 quakes were recorded in about 2 hours; the maximum frequency of 7 per minute was reached at the end of the first half hour. All the quakes were small; the largest had a magnitude of 2.8 and was felt locally at 01:11 July 6. Coincident with the onset of earthquakes, collapse tilting (toward the caldera) at the rate of 2 microradians per hour began to record at Uwekahuna. The rate of tilting remained high for half an hour up to the peak in earthquake frequency, then it slackened somewhat until the time of the strongest earthquake, when the collapse tilting stopped entirely.

On August 18 and 19 there was a swarm of deep Kilauea caldera quakes, five of them strong enough to be felt; the strongest was recorded at magnitude 3.9. During the same interval, the number of long-period caldera quakes increased to between 200 and 500 a day and remained that large until September 2.

A swarm of more than 90 quakes took place on September 5 and 6 along the northeast portion of the Honuapu-Kaoiki Fault System. One was larger than magnitude 4 and four others were of magnitude 2.5.

More satisfactory temperature data in the lava-lake studies were obtained during September. Hole 24 in Makaopuhi was cased with 40.5 feet of stainless steel, 29 feet in crust and 11.5 in melt below the crust. The measured profile was checked by repeated measurements and against the melting of germanium oxide, gold, and silver and gave 1,137°C at 40.5 (11.5 feet in melt), 1,075°C at 29 feet (base of rigid crust), and 500°C at 10 feet below the surface of crust.

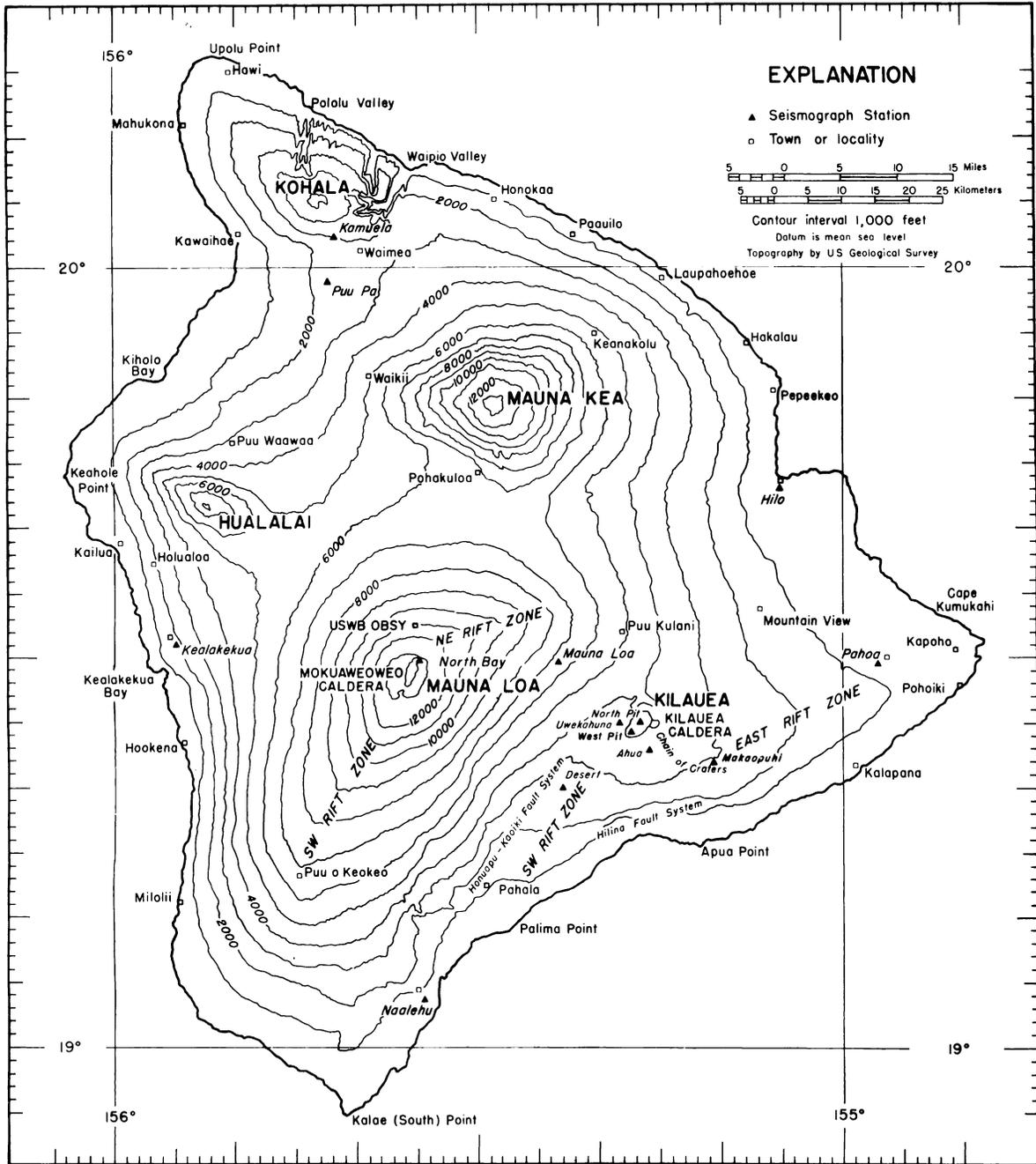


Figure 1.--Map of the Island of Hawaii showing seismograph stations operated by the U.S. Geological Survey, principal settlements, and selected geologic features. Epicenters of local earthquakes are given in table 4 in terms of geographic coordinates, which are indicated at the edges of the map.

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 at Uwekahuna (table 1), 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 (table 2). 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.

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 into groups on the basis of region of origin as determined by analysis of records obtained daily at the Observatory (stations U, M, A, D, N, WP, MP). 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 third quarter, 1966. Their assistance is gratefully acknowledged.

Table 1. -- Tilt coordinates at Uwekahuna, July,  
August, and September, 1966

Date (1966)	N-S	E-W	Date (1966)	N-S	E-W
July 3	489	466	Aug. 21	492	455
10	490	467	28	492	453
17	489	463	Sept. 4	493	450
24	491	461	11	492	451
31	491	458	18	492	448
Aug. 7	491	459	25	492	445
14	491	461			

3d Quarter, 1966

Table 2. -- Tilt coordinates and changes at bases around Kilauea caldera.  
 (See tilt diagram, fig. 2.)

Tilt base	Date (1966)	Tilt coordinates		Rate ( $10^{-6}$ rad/mo) and direction of tilting since last reading		Date of last reading (1966)
		N-S	E-W			
Uwekahuna (U on fig. 2).	Sept. 13	513.3	446.7	6.1	N. 49.2° W.	June 7
Tree Molds (TM)	12	437.1	508.7	2.6	N. 33.5° W.	8
Sand Spit (SS)	12	824.8	703.1	5.9	S. 74.9° W.	8
Keamoku (Kea)	6	492.0	452.7	4.0	N. 80.2° W.	6
Ahua Kamokukolau (Kam).	8	586.3	615.5	8.5	S. 10.8° W.	8
Kipuka Nene (KN)	7	300.0	500.9	.3	N. 4.5° W.	9
Hilina Pali (HP)	Not done this epoch.					
Kapapala Ranch (Kap).	6	491.4	508.8	.1	S. 73.4° E.	6
Mehana (M)	12	548.5	559.5	2.0	N. 40.4° E.	16

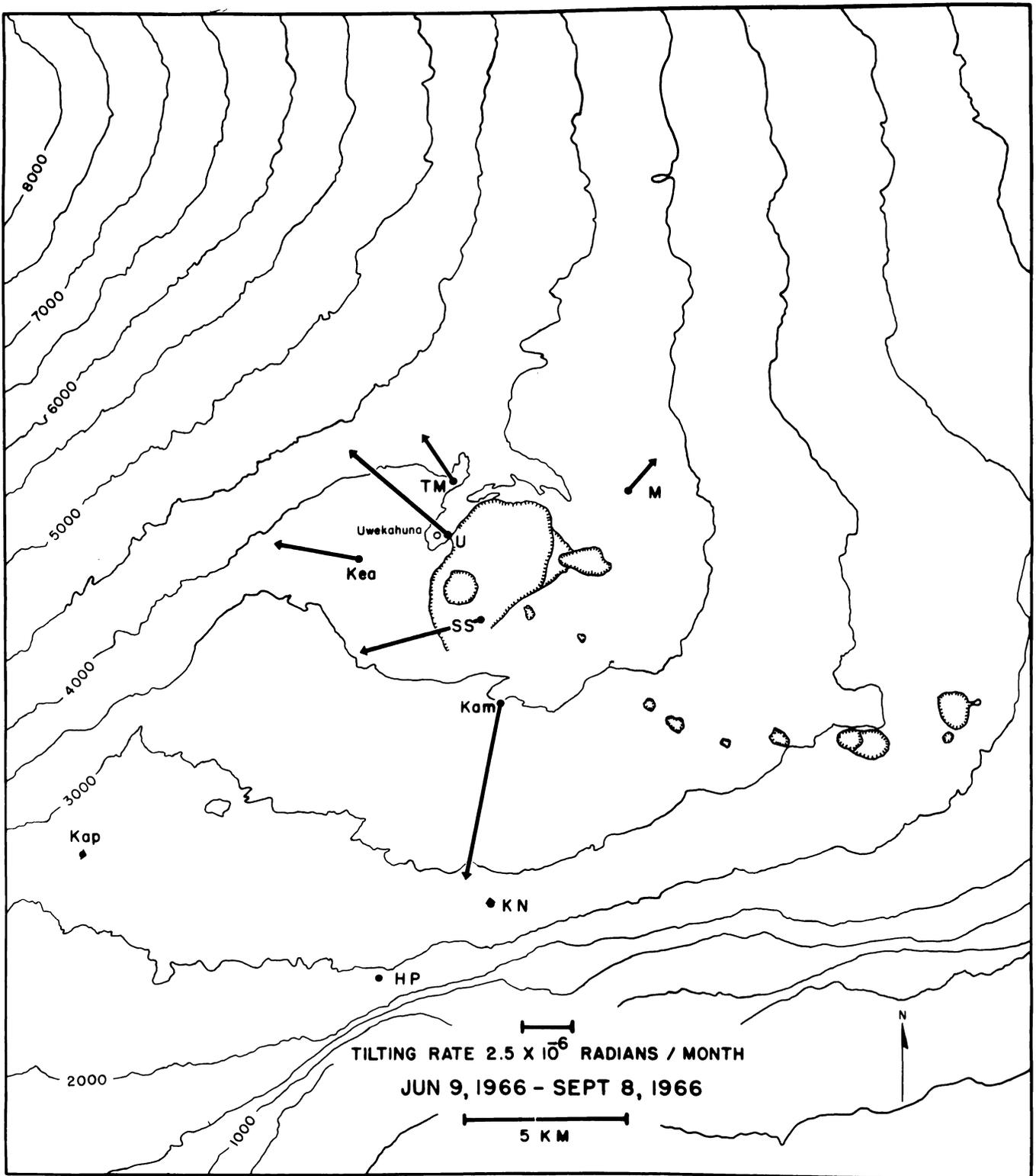


Figure 2.--Tilting of the ground around Kilauea caldera, June 9, 1966-September 8, 1966. The vector depicting tilting at a given tilt base points in the direction of maximum relative subsidence and has a length proportional to the rate of tilting during the measurement interval. Closed circles represent field tilt bases; open circles, short-base water-tube tiltmeters. See table 2 for explanation of abbreviations.

Table 3.--Number of earthquakes and minutes of tremor recorded on seismographs  
U, M, A, D, N, WP, and MP 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 with 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 (1966)	Tremor (minutes)			Kilauea summit			Earthquakes			
	Deep	Inter- mediate	Shallow	30 km	Long period	Shallow	SW. rift and Kaoiki	Eastern east rift	Upper east rift	Other
July 1	----	10	-----	2	70	65	14	3	29	-----
2	----	-----	-----	-----	86	53	14	17	34	1 west Hawaii
3	----	-----	-----	3	51	78	15	33	8	-----
4	----	17	-----	2	49	73	13	17	24	1 west Hawaii
5	----	-----	-----	4	21+	45+	7	21	500+	-----
6	5	3	-----	1	38	41	8	8	28+	-----
7	----	-----	-----	-----	42	48	2	3	27	-----
8	----	4	-----	1	31	65	6	3	20	-----
9	----	-----	-----	4	16	55	11	23	10	-----
10	----	-----	-----	3	18	61	10	11	17	1 west Hawaii
11	----	-----	-----	3	16	56	10	4	6	2 Mauna Kea
12	----	12	-----	1	27	63	23	5	7	1 Mauna Loa
13	11	-----	-----	6	48	45	8	40	15	1 off SW. shore of Hawaii
14	----	-----	-----	3	27	59	5	2	13	-----

Table 3.--Number of earthquakes and minutes of tremor recorded on seismographs  
U, M, A, D, N, WP, and MP around Kilauea caldera--Continued

Date (1966)	Tremor (minutes)			Kilauea summit			Earthquakes			
	Deep	Inter- mediate	Shallow	30 km	Long- period	Shallow	SW. rift and Kaoiki	Eastern east rift	Upper east rift	Others
July 15	----	-----	-----	2	43	60	10	1	2	-----
16	----	-----	-----	1	59	35	11	2	5	-----
17	----	-----	-----	3	24	48	11	7	4	-----
18	45	-----	-----	-----	37	56	10	4	17	1 off SE. shore of Hawaii
19	36	-----	-----	2	11	56	5	8	8	1 Mauna Loa
20	----	-----	-----	3	46	40	13	4	11	-----
21	----	13	-----	1	28	35	28	3	13	-----
22	----	15	-----	2	9	55	2	4	5	-----
23	----	-----	-----	-----	13	62	8	4	5	-----
24	----	2	-----	2	-----	-----	6	1	18	1 west Hawaii
25	----	-----	-----	1	10	99	4	7	22	-----
26	----	26	-----	6	39	104	6	6	28	1 Kona
27	----	5	-----	2	22	94	10	2	23	1 Mauna Loa, 1 Kohala
28	----	7	-----	4	14	74	10	13	13	-----
29	----	-----	-----	-----	11	60	11	24	12	-----
30	----	-----	-----	-----	14	61	14	18	16	-----
31	----	-----	-----	(?)	18	66	(?)	12	7	-----
Aug. 1	----	-----	-----	2	14	64	12	34	17	-----
2	----	-----	-----	3	33	74	3	4	19	-----
3	----	-----	-----	1	26	67	9	4	7	1 Mauna Loa
4	----	-----	-----	7	4	58	5	-----	5	1 off NE. shore of Hawaii
5	----	3	-----	3	24	64	8	2	9	-----
6	----	-----	-----	-----	22	55	11	22	4	-----
7	----	5	-----	2	23	59	7	-----	5	-----
8	----	-----	-----	3	12	38	7	-----	10	-----
9	----	-----	9	1	7	40	10	-----	5	-----
10	----	-----	-----	3	4	54	8	-----	9	-----
11	----	7	-----	2	2	58	12	-----	11	-----
12	----	-----	-----	-----	6	63	5	-----	5	-----
13	----	-----	-----	-----	6	63	3	-----	18	-----

Aug.	14	-----	-----	-----	1	3	75	2	-----	10	-----
	15	-----	10	-----	-----	2	68	(2)	-----	11	-----
	16	-----	-----	-----	-----	2	34	2	1	(?)	1 Mauna Kea
	17	-----	-----	-----	3	20	56	3	-----	12	-----
	18	-----	-----	-----	12	15	48	2	-----	3	-----
	19	-----	-----	-----	7	11	101	9	-----	2	-----
	20	-----	-----	-----	15	51	131	9	-----	15	-----
	21	-----	-----	-----	11	375±	50	-----	1	1	2 Mauna Loa
	22	-----	-----	-----	15	600±	60	6	-----	8	-----
	23	-----	-----	-----	4	450	79	11	1	14	-----
	24	-----	-----	-----	6	225	92	5	-----	31	2 Mauna Loa, 1 off NE. shore of Hawaii.
	25	-----	-----	-----	4	240	82	6	1	10	-----
	26	-----	-----	-----	2	300±	81	10	-----	14	-----
	27	-----	3	-----	4	300±	61	15	4	18	-----
	28	-----	-----	-----	5	340	55	20	-----	21	-----
	29	-----	-----	-----	2	385	51	11	-----	15	-----
	30	-----	-----	-----	3	405	70	5	1	25	-----
	31	-----	-----	12	2	375	70	8	-----	18	1 off NE. shore of Hawaii
o	Sept. 1	-----	-----	-----	-----	275±	100	8	-----	12	-----
	2	-----	-----	3	2	90	142	11	5	22	1 Kohala, 1 west Hawaii
	3	-----	-----	-----	-----	79	106	11	-----	25	1 Mauna Kea
	4	-----	1	-----	-----	8	44	24	-----	7	-----
	5	-----	34	-----	5	5	75	66	-----	-----	-----
	6	-----	-----	-----	2	2	83	12	-----	11	-----
	7	-----	-----	-----	3	13	50±	-----	-----	10	-----
	8	-----	-----	-----	1	16	88	13	-----	12	-----
	9	-----	-----	-----	3	16	99	6	-----	12	-----
	10	-----	-----	-----	-----	21	63	2	7	5	-----
	11	-----	-----	-----	-----	13	78	12	6	16	-----
	12	-----	-----	-----	-----	45	107	5	-----	18	1 Mauna Loa
	13	-----	-----	-----	2	4	93	6	4	19	-----
	14	-----	-----	-----	-----	7	93	5	5	9	-----
	15	-----	46	-----	-----	7	90	6	1	14	-----
	16	-----	-----	-----	2	16	66	3	2	4	-----
	17	-----	-----	-----	-----	12	92	5	11	2	-----
	18	-----	6	-----	-----	6	108	7	-----	11	-----

Table 3.--Number of earthquakes and minutes of tremor recorded on seismographs  
U, M, A, D, N, WP, and MP around Kilauea caldera--Continued

Date (1966)	Tremor (minutes)			Kilauea summit			Earthquakes			
	Deep	Inter- mediate	Shallow	30 km	Long- period	Shallow	SW. rift and Kaoiki	Eastern east rift	Upper east rift	Others
Sept. 18	----	6	-----	-----	6	108	7	-----	11	-----
19	----	-----	-----	2	22	103	8	1	17	-----
20	----	-----	-----	51+	79	130	6	-----	11	-----
21	----	-----	-----	4	24	148	8	-----	18	-----
22	----	-----	-----	3	21	96	-----	-----	7	-----
23	----	9	-----	7	26	90	5	1	13	-----
24	39	-----	-----	3	3	90	8	2	13	-----
25	----	7	-----	1	47	75	8	1	17	-----
26	----	-----	-----	1	7	70	3	-----	10	-----
27	----	-----	6	-----	20	53	5	-----	15	-----
28	----	-----	-----	1	38	78	7	-----	9	-----
29	38	-----	-----	3	12	76	10	-----	26	-----
30	18	-----	-----	3	12	79	7	-----	13	1 Mauna Loa

Table 4. -- Local earthquakes recorded by seismographs of the U.S. Geological Survey,  
July, August, September, 1966

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 (1966)	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	h	m	s			Lat. N.	Long. W.	Description	
July 1	05	04	28.5	3.7	10	19°19.5'	155°27.3'	7 km WSW. of Desert seismometer	Pahala, Volcano, Hilo.
2	16	13	39.9	2.5	5	19°20.3'	155°10.2'	4 km SSE. of Makaopuhi seismometer	-----
2	19	15	42.2	2.6	0	19°24.0'	155°02.5'	15 km ENE. of Makaopuhi seismometer	-----
2	19	54	35.1	2.0	3	19°27.6'	155°48.8'	14 km SE. of Kealakekua	-----
4	00	20	54.5	2.3	8	19°24.4'	155°24.1'	8 km NNW. of Desert seismometer	-----
4	03	43	36.8	2.5	3	19°29.8'	155°47.8'	13 km ESE. of Kealakekua	-----
5	04	45	27.4	2.5	5	19°25.8'	155°27.1'	12 km NW. of Desert seismometer	-----
5	22	23	41.5	2.1	5	19°22.9'	155°25.2'	6 km NW. of Desert seismometer	-----
5	23	10	58.0	2.7	0	19°26.1'	154°57.1'	8 km south of Pahoa	Pahoa
5	23	51	40.2	1.3	5	19°20.4'	155°13.0'	4 km SW. of Makaopuhi seismometer	-----
5	23	52	59.4	1.5	5	19°19.4'	155°11.6'	5 km SSW. of Makaopuhi seismometer	-----
5	23	55	51.1	1.9	5	19°19.7'	155°12.2'	5 km SW. of Makaopuhi seismometer	-----
5	23	58	05.6	1.5	5	19°20.9'	155°11.9'	3 km SW. of Makaopuhi seismometer	Kilauea summit area.
5	23	59	18.4	2.0	5	19°19.8'	155°12.9'	5 km SW. of Makaopuhi seismometer	-----
6	00	02	57.7	1.5	3	19°21.7'	155°13.3'	5 km WSW. of Makaopuhi seismometer	Kilauea summit area.
6	00	05	52.7	1.4	5	19°20.6'	155°13.3'	5 km WSW. of Makaopuhi seismometer	-----
6	00	22	11.3	1.8	3	19°20.4'	155°13.0'	5 km SW. of Makaopuhi seismometer	-----
6	00	31	20.0	1.5	5	19°19.8'	155°12.3'	5 km SW. of Makaopuhi seismometer	-----
6	00	35	45.6	2.4	5	19°20.4'	155°12.2'	4 km SW. of Makaopuhi seismometer	-----

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey,  
July, August, September, 1966--Continued

Date (1966)	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	h	m	s			Lat. N.	Long. W.	Description	
July 6	00	37	58.2	2.3	3	19°19.2'	155°12.6'	5 km SW. of Makaopuhi seismometer	-----
6	01	11	52.7	2.8	5	19°20.5'	155°13.8'	6 km SW. of Makaopuhi seismometer	Kilauea summit area.
6	01	33	40.2	1.8	5	19°18.5'	155°17.0'	7 km SSW. of Makaopuhi seismometer	-----
8	06	35	51.2	2.3	0	19°26.8'	154°55.3'	6 km SSE. of Pahoa	-----
10	20	08	40.0	2.5	3	19°31.8'	155°46.8'	15 km east of Kealakekua	-----
11	03	53	36.7	2.4	8	19°55.2'	155°23.5'	17 km SW. of Laupahoehoe	-----
11	04	55	40.1	2.4	8	19°55.2'	155°23.5'	17 km SW. of Laupahoehoe	-----
11	06	04	52.8	2.5	30	19°28.2'	155°10.5'	15 km ENE. of Uwekahuna	-----
12	03	26	21.9	2.7	3	19°21.3'	155°45.2'	26 km SE. of Kealakekua	-----
12	09	56	46.5	2.2	5	19°20.8'	155°28.8'	10 km west of Desert seismometer	-----
12	23	09	56.1	2.0	25	19°27.6'	155°13.4'	8 km NE. of Uwekahuna	-----
13	02	03	44.8	3.0	3	19°25.5'	154°53.5'	12 km SE. of Pahoa seismometer	Kapoho
13	08	30	59.0	2.7	3	19°19.3'	156°04.8'	27 km SW. of Kealakekua	-----
13	13	08	41.2	2.1	33	19°22.8'	155°17.7'	3 km west of Ahua seismometer	-----
16	20	48	54.8	2.1	5	19°22.7'	155°05.2'	10 km ENE. of Makaopuhi seismometer	-----
17	15	47	46.4	2.3	8	19°25.2'	155°28.2'	13 km NW. of Desert seismometer	-----
17	16	39	33.5	2.0	5	19°18.1'	155°15.2'	8 km SSE. of Ahua seismometer	-----
17	22	16	10.6	2.4	5	19°28.4'	154°52.2'	9 km ESE. of Pahoa	Pahoa
18	00	14	28.0	2.6	8	19°15.2'	155°29.0'	13 km SW. of Desert seismometer	-----
18	11	29	23.1	2.2	5	19°21.7'	155°11.8'	3 km SW. of Makaopuhi seismometer	-----
18	13	48	13.2	2.7	35	19°01.9'	155°29.0'	12 km ESE. of Naalehu	-----
19	01	09	11.3	2.7	5	19°20.5'	155°26.2'	5 km west of Desert seismometer	-----
19	17	00	08.0	2.0	3	19°14.5'	155°34.0'	20 km NNE. of Naalehu	-----
23	21	19	19.2	2.7	25	19°04.1'	155°30.9'	9 km east of Naalehu	-----
24	15	22	03.3	3.0	0	19°27.2'	155°45.5'	18 km ESE. of Kealakekua	west Hawaii
25	17	29	42.0	2.0	8	19°18.1'	155°33.5'	19 km WSW. of Desert seismometer	-----
25	23	02	28.5	1.9	27	19°23.5'	155°17.9'	3 km NW. of Ahua seismometer	-----
26	14	13	12.6	2.5	3	19°23.3'	155°56.2'	4 km west of Hookena	-----
26	14	32	36.8	2.6	10	19°26.1'	155°16.9'	2 km NE. of Uwekahuna	-----

July	27	14	04	31.5	3.2	31	19°23.1'	155°16.9'	2 km NW. of Ahua seismometer	Pahala
	27	19	03	48.3	2.6	8	19°38.0'	155°41.0'	19 km NW. of North Bay seismometer	-----
	27	23	13	44.0	2.7	8	20°03.0'	155°51.0'	2 km NW. of Kawaihae	-----
	29	05	28	21.0	2.2	3	19°26.2'	154°55.5'	8 km SSE. of Pahoa	-----
	30	16	58	22.3	4.3	8	19°25.0'	155°28.2'	13 km NW. of Desert	Islandwide
	31	20	01	39.0	2.3	0	19°28.5'	154°54.3'	5 km SE. of Pahoa	Kapoho
Aug.	1	02	25	07.1	2.5	0	19°27.0'	154°55.2'	7 km SE. of Pahoa	Pahoa, Kapoho
	1	19	02	20.2	2.7	0	19°27.1'	154°55.1'	-----do-----	Do.
	3	18	48	33.6	2.4	8	19°11.9'	155°37.4'	15 km NNW. of Naalehu	-----
	4	05	17	05.3	3.0	13	20°54'	154°55'	127 km NE. of Kamuela	-----
	6	20	57	37.1	3.7	3	19°28.8'	154°54.2'	5 km ESE. of Pahoa	Pahoa, Hilo, Kilauea summit area.
	8	09	34	41.7	2.9	0	19°17.5'	154°57.1'	5 km south of Pahoa	-----
	9	05	12	51.0	2.0	8	19°21.2'	155°25.5'	5 km WNW. of Desert seismometer	-----
	11	05	01	01.0	2.0	8	19°19.7'	155°11.1'	5 km south of Makaopuhi seismometer	-----
	11	18	30	32.8	2.3	3	19°25.9'	154°54.7'	8 km SE. of Pahoa	Kapoho
	12	08	13	45.5	1.8	5	19°17.0'	155°15.1'	10 km south of Ahua seismometer	-----
	15	00	15	41.2	3.5	3	19°27.2'	154°55.1'	6 km SE. of Pahoa	Hilo, Mt. View, Pahoa.
	16	01	25	40.3	2.7	8	19°50.7'	155°46.5'	23 km SW. of Kamuela	-----
	17	09	58	49.8	3.0	5	19°24.6'	155°26.9'	10 km NW. of Desert seismometer	Pahala
	18	08	30	04.0	2.8	5	19°14.1'	155°25.3'	12 km SSW. of Desert seismometer	Do.
	18	12	22	39.3	2.0	5	19°21.5'	155°11.8'	3 km SW. of Makaopuhi seismometer	-----
	19	05	21	49.2	3.9	30	19°23.0'	155°18.5'	5 km WNW. of Ahua seismometer	Pahala, Pahoa, Hilo, Kilauea summit area, Paauilo.
	19	05	24	54.1	2.8	27	19°21.6'	155°19.0'	6 km WSW. of Ahua seismometer	Pahala, Kilauea summit area, west Hawaii, Hilo, Naalehu.
	19	05	33	00.4	2.7	27	19°20.9'	155°19.4'	7 km ENE. of Desert seismometer	Kilauea summit area.
	19	06	26	20.2	3.1	30	19°20.9'	155°19.4'	7 km ENE. of Desert seismometer	Pahala
	21	10	31	00.5	3.0	27	19°22.8'	155°19.3'	6 km west of Ahua	-----
	22	00	04	53.7	2.3	5	19°24.5'	155°27.0'	11 km NW. of Desert seismometer	-----
	22	01	36	29.6	2.4	13	19°09.0'	155°12.9'	24 km south of Makaopuhi seismometer	-----
	22	15	04	19.0	2.7	5	19°19.3'	155°11.4'	5 km SSW. of Makaopuhi seismometer	-----

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey,  
July, August, September, 1966--Continued

Date (1966)	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	h	m	s			Lat. N.	Long. W.	Description	
Aug. 22	16	04	55.3	2.1	10	19°25.4'	155°27.4'	12 km NW. of Desert seismometer	-----
23	15	02	58.0	2.1	30	19°21.2'	155°17.5'	3 km SW. of Ahua seismometer	-----
24	02	24	10.2	2.4	3	19°30.6'	155°45.7'	16 km east of Kealakekua	-----
24	07	44	55.1	2.5	0	19°27.3'	155°32.5'	5 km SE. of North Bay seismometer	-----
24	10	39	55.1	2.5	3	19°23.7'	155°22.9'	7 km north of Desert seismometer	-----
24	21	25	35.2	2.6	45	19°52.0'	155°00.0'	20 km NE. of Hilo	-----
25	04	39	33.5	1.9	25	19°22.2'	155°19.1'	5 km west of Ahua seismometer	-----
26	15	00	43.9	3.1	8	19°24.7'	155°23.9'	8 km NNW. of Desert seismometer	-----
28	14	03	10.5	2.4	3	19°21.6'	155°27.5'	8 km WNW. of Desert seismometer	Pahala
31	04	19	05.6	2.3	40	19°55.9'	155°05.5'	24 km north of Hilo	-----
Sept. 1	18	05	17.0	2.2	8	19°24.5'	155°24.7'	8 km NNW. of Desert seismometer	-----
1	23	53	22.2	2.3	8	19°25.2'	155°29.9'	15 km NW. of Desert seismometer	-----
2	00	50	22.0	2.3	0	19°26.3'	155°47.3'	16 km SE. of Kealakekua	-----
2	06	36	10.4	2.2	8	19°25.7'	155°29.2'	15 km NW. of Desert seismometer	-----
2	08	40	49.9	2.6	40	19°19.7'	154°51.7'	21 km SE. of Pahoa	-----
2	13	56	58.5	3.4	13	20°02.2'	155°53.1'	5 km west of Kawaihae	Waimea
2	19	37	23.4	2.5	5	19°25.2'	155°28.8'	13 km NW. of Desert seismometer	-----
3	10	46	00.7	2.5	5	19°22.5'	155°13.3'	5 km east of Ahua seismometer	-----
3	11	37	16.0	2.8	8	19°51.0'	155°44.8'	21 km SSW. of Kamuela	-----
3	13	21	20.2	2.0	3	19°23.7'	155°05.9'	9 km ENE. of Makaopuhi seismometer	-----
4	10	28	16.1	2.4	5	19°26.4'	155°24.5'	12 km NNW. of Desert seismometer	-----
5	06	33	21.9	4.5	8	19°21.2'	155°26.2'	6 km WNW. of Desert seismometer	Islandwide
5	10	08	09.0	2.8	5	19°25.0'	155°26.0'	10 km NNW. of Desert seismometer	-----
5	10	17	21.5	2.3	8	19°25.5'	155°25.3'	10 km NW. of Desert seismometer	-----
5	12	55	16.2	2.2	25	19°22.2'	155°18.8'	5 km west of Ahua seismometer	-----
5	22	45	20.0	3.0	5	19°21.2'	155°28.8'	10 km WNW. of Desert seismometer	Pahala
5	06	45	34.5	2.3	5	19°23.8'	155°27.1'	9 km NW. of Desert seismometer	-----
6	03	36	06.7	2.4	8	19°26.8'	155°28.8'	17 km NW. of Desert seismometer	-----
7	02	46	44.2	2.0	8	19°19.2'	155°10.3'	5 km south of Makaopuhi seismometer	-----
8	15	03	52.6	2.1	5	19°22.3'	155°28.2'	10 km WNW. of Desert seismometer	Pahala
9	13	16	11.3	2.0	5	19°21.0'	155°11.2'	3 km SW. of Makaopuhi seismometer	-----
12	03	13	06.2	2.3	3	19°13.2'	155°31.5'	19 km NE. of Naalehu	-----

Sept.	12	16	47	13.0	2.9	5	19°20.8'	155°11.3'	3 km SW. of Makaopuhi seismometer	Hilo
	14	00	03	37.2	2.4	5	19°25.8'	155°25.8'	9 km NW. of Desert seismometer	-----
	15	22	16	52.7	2.1	8	19°02.8'	155°10.0'	36 km south of Makaopuhi seismometer	-----
	16	12	41	54.5	2.1	5	19°21.9'	155°26.5'	7 km WNW. of Desert seismometer	Pahala
	16	16	58	53.6	2.0	3	19°19.8'	155°11.3'	4 km SSW. of Makaopuhi seismometer	-----
	20	01	31	57.0	2.3	3	19°21.7'	155°12.9'	4 km west of Makaopuhi seismometer	-----
	20	09	55	56.0	3.7	27	19°24.1'	155°20.0'	5 km SW. of Uwekahuna	-----
	20	14	26	52.8	2.4	30	19°21.8'	155°18.5'	5 km WSW. of Ahua seismometer	-----
	21	01	45	48.5	3.4	27	19°23.9'	155°17.9'	3 km south of Uwekahuna	Naalehu, Pahala
	21	02	10	42.1	2.1	25	19°23.9'	155°19.7'	5 km SW. of Uwekahuna	-----
	21	04	22	53.5	2.3	26	19°23.0'	155°18.7'	5 km west of Ahua seismometer	-----
	22	18	31	30.5	2.5	5	19°19.2'	155°11.5'	5 km SSW. of Makaopuhi seismometer	-----
	23	01	44	22.5	2.2	10	19°21.8'	155°03.8'	13 km east of Makaopuhi seismometer	-----
	23	10	33	47.0	2.8	3	19°27.9'	154°56.5'	4 km south of Pahoa	Pahoa
	27	21	24	51.2	2.1	10	19°28.5'	155°23.3'	3 km south of Mauna Loa seismometer	-----
	28	12	03	21.4	3.5	5	19°26.0'	155°25.1'	8 km SW. of Mauna Loa seismometer	Hilo, Mt. View, Mauna Loa Summit.
	28	23	36	44.4	2.3	8	19°17.9'	154°59.9'	21 km SE. of Makaopuhi seismometer	-----
	29	15	55	59.2	2.1	3	19°20.1'	155°09.1'	5 km SE. of Makaopuhi seismometer	-----
	30	00	56	59.5	3.0	0	19°21.7'	155°48.2'	21 km SE. of Kealakekua	-----

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY

HAWAIIAN VOLCANO OBSERVATORY

Summary 44

October, November, and December, 1966

By Robert Y. Koyanagi, Arnold T. Okamura

and Howard A. Powers

Issued February 1969

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OBSERVATORY STAFF

Geology

R. S. Fiske  
H. A. Powers (Scientist in charge)

Geophysics

W. T. Kinoshita  
George Kojima  
R. Y. Koyanagi  
A. T. Okamura

Geochemistry

R. T. Okamura  
T. L. Wright

Support

J. C. Forbes  
W. H. Francis  
Yukie Kimura  
B. J. Loucks  
Akira Yamamoto  
K. M. Yamashita

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## Summary of activities

The rate of swelling of Kilauea decreased during October, November, and early December, and the area of rising broadened as determined from the pattern of changes on the long-base tiltmeter net and the summit net of geodimeter lines; inclement weather prevented releveling the caldera level lines. Then in mid-month, the two tiltmeters that are read daily began to show that the rate of swelling increased and the center of inflation shifted southward during the last half of December. This shifting was confirmed by surveying done early in January 1967.

Earthquake activity was spotty during the quarter. Throughout the period, seismicity on the East rift of Kilauea was double that of the previous quarter, and a swarm in mid-November included several local quakes felt only in the vicinity of Pahoa-Kapoho. However, the daily number of caldera quakes was considerably below 100 except during 6 days in mid-October, 3 days in November, and 6 days scattered in December. There were two swarms of 30-km Kilauea summit quakes: 62 on November 26-29, and 67 on December 31.

Preparations were completed to commence drilling in January in the crust of Kilauea Iki lava lake (2 km east of North Pit), with a new Longyear "24" core drill capable of taking  $2\frac{1}{4}$ -inch core.

Seismic activity beneath the summit of Mauna Loa remained at a low level. During the entire year of 1966 there was no evidence of any revival in Mauna Loa.

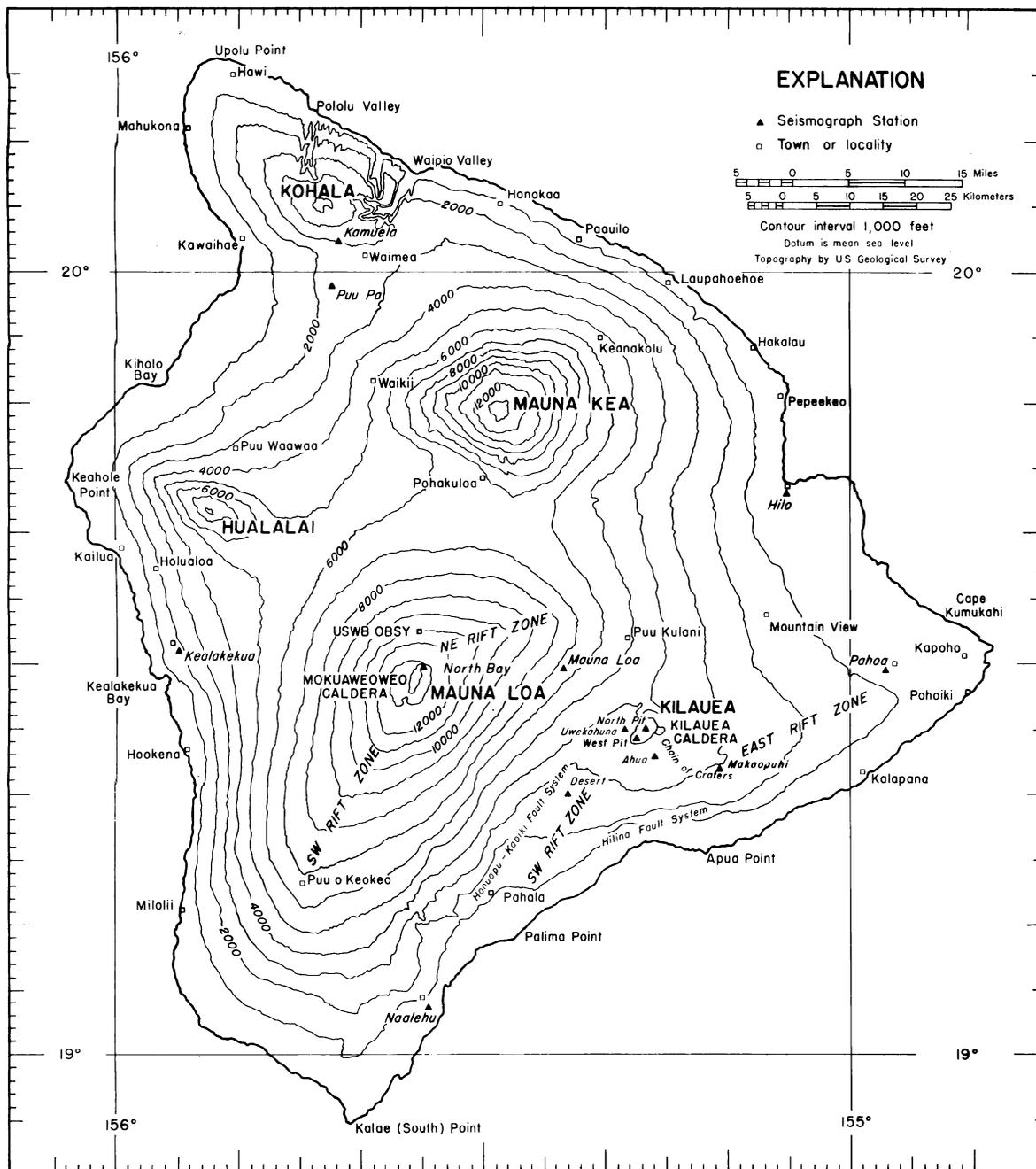


Figure 1.--Map of the Island of Hawaii showing seismograph stations operated by the U.S. Geological Survey, principal settlements, and selected geologic features. Epicenters of local earthquakes are given in table 4 in terms of geographic coordinates, which are indicated at the edges of the map.

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 at Uwekahuna (table 1), 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 (table 2). 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, October, November, and December, 1966

Date (1966)	N-S	E-W	Date (1966)	N-S	E-W
Oct. 2	492	443	Nov. 20	486	440
9	487	447	27	486	438
16	487	446	Dec. 4	486	439
23	486	446	11	485	439
30	487	446	18	488	437
Nov. 6	488	440	25	487	434
13	486	439			

## 4th Quarter, 1966

Table 2.--Tilt coordinates and changes at bases around Kilauea caldera.

(See tilt diagram, fig. 2.)

Tilt base	Date (1966)	Tilt coordinates		Rate ( $10^{-6}$ rad/mo) and direction of tilting since last reading		Date of last reading (1966)
		N-S	E-W			
Uwekahuna (U on fig. 2)	Dec. 8	521.1	434.4	5.1	N. 57.7° W.	Sept. 13
Tree Molds (TM)	8	446.1	504.1	2.9	N. 27.0° W.	12
Sand Spit (SS)	5	820.7	700.1	1.8	S. 36.1° W.	12
Keamoku (Kea)	6	483.8	448.7	3.0	S. 25.8° W.	6
Ahua Kamokukolau (Kam).	5	573.5	601.2	6.5	S. 41.9° W.	8
Kipuka Nene (KN)	7	301.9	500.3	.6	N. 17.9° W.	7
Hilina Pali (HP)	7	463.8	505.6	.1	N. 47.6° W.	June 9
Kapapala Ranch (Kap).	6	491.7	509.8	1.1	N. 72.4° E.	Sept. 6
Mehana (M)	9	552.7	562.8	1.8	N. 37.7° E.	12

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 into groups on the basis of region of origin as determined by analysis of records obtained daily at the Observatory (stations U, M, A, D, N, WP, MP, Mx, Kx). 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 fourth quarter, 1966. Their assistance is gratefully acknowledged.

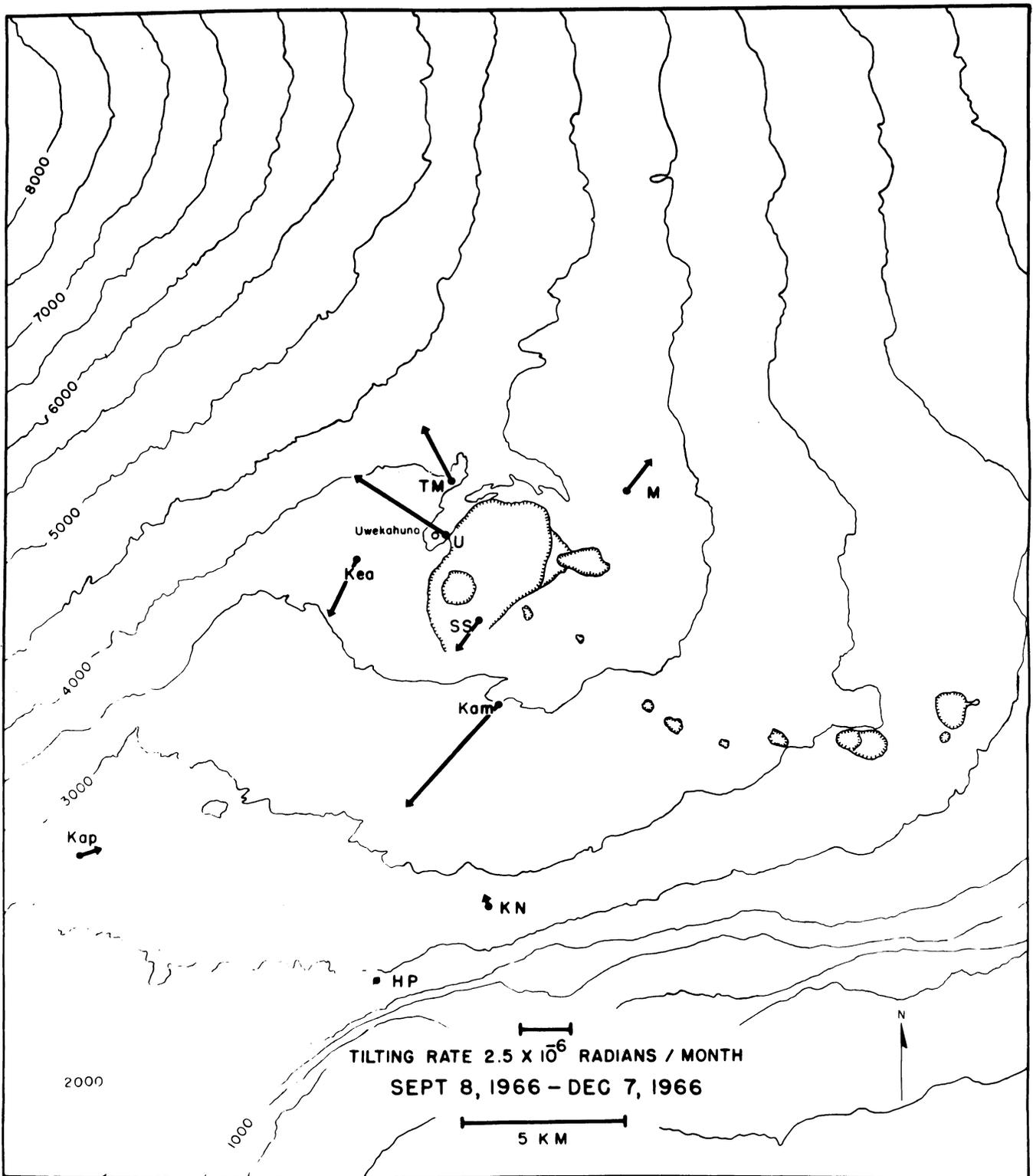


Figure 2.--Tilting of the ground around Kilauea caldera, September 8, 1966-December 7, 1966. The vector depicting tilting at a given tilt base points in the direction of maximum relative subsidence and has a length proportional to the rate of tilting during the measurement interval. Closed circles represent field tilt bases; open circles, short-base water-tube tiltmeters. See table 2 for explanation of abbreviations.

Table 3. -- Number of earthquakes and minutes of tremor recorded on seismographs U, M, A, D, N, WP, MP, Mx, and Kx 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.

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 (1966)	Tremor (minutes)			Kilauea summit			Earthquakes			
	Deep	Inter- mediate	Shallow	30 km	Long- period	Shallow	SW. rift and Kaoiki	Eastern east rift	Upper east rift	Others
Oct. 1	----	-----	-----	1	10	64	14	5	28	1 west Hawaii
2	----	-----	-----	6	23	95	7	3	31	-----
3	----	-----	-----	5	26	72	5	2	25	-----
4	----	-----	-----	7	16	93	3	5	15	-----
5	----	-----	-----	-----	10	80	3	3	16	-----
6	----	-----	-----	3	9	68	3	8	17	-----
7	----	4	-----	-----	30	55	5	5	8	-----
8	----	-----	-----	1	40	57	12	3	20	-----
9	----	-----	off-electrical	storm	-----	-----	-----	2	-----	-----
10	----	-----	off-electrical	storm	-----	-----	-----	2	-----	1 Mauna Loa
11	----	-----	off-electrical	storm	-----	-----	-----	8	-----	-----
12	----	-----	-----	5	44	70	8	4	48	-----
13	----	-----	2	1	34	95	8	2	55	-----
14	----	-----	-----	1	34	107	6	2	27	-----
15	13	-----	-----	2	31+	71+	8	3	26	-----
16	----	-----	-----	-----	33	119	11	-----	31	-----

\* See note on page 10.

Table 3.--Number of earthquakes and minutes of tremor recorded on seismographs  
U, M, A, D, N, WP, MP, Mx, and Kx around Kilauea caldera--Continued

Date (1966)	Tremor (minutes)			Kilauea summit			Earthquakes			
	Deep	Inter- mediate	Shallow	30 km	Long- period	Shallow	SW. rift and Kaoiki	Eastern east rift	Upper east rift	Others
Oct. 17	----	-----	-----	1	22	92	6	2	31	-----
18	----	-----	-----	-----	15	91	3	8	38+	-----
19	----	-----	-----	2	36	35	2	1	53	1 Mauna Loa
20	----	-----	-----	5	18	90	3	3	20	-----
21	----	-----	-----	2	12	108	6	-----	11+	-----
22	----	-----	-----	4	9	164	3	1	17	-----
23	----	31	-----	3	15	144	12	-----	36	-----
24	----	-----	-----	3	18	120	12	-----	36	-----
25	----	-----	-----	2	16	90	8	-----	15	-----
26	----	-----	-----	1	9	54	5	-----	25	-----
27	----	-----	-----	-----	13	49	4	-----	50	-----
28	----	-----	-----	-----	15	38	4	1	25+	-----
29	----	-----	-----	1	19	33	7	-----	27	1 west Hawaii
30	----	-----	-----	5	5	60	11	-----	42	-----
31	----	-----	4	2	9	52	10	-----	39	-----
Nov. 1	----	-----	-----	3	1	46	12	5	44	-----
2	----	-----	-----	2	4	31	5	5	33	-----
3	----	-----	-----	(?)	3	41	(?)	3	27	-----
4	----	-----	off-electrical	storm			-----	2	-----	-----
5	25	-----	-----	1	3	47	7	10	17	1 west Hawaii
6	----	-----	-----	2	4	54	4	17	36	1 Mauna Loa
7	----	-----	-----	3	2	71	5	2	40	-----
8	----	-----	-----	3	2	76	8	6	22	1 west Hawaii
9	----	-----	-----	2	2	58	8	5	55	-----
10	----	-----	-----	-----	7	57	9	7	21	-----
11	----	-----	-----	1	9	60	2	5	27	-----
12	----	2	-----	-----	9	71	3	19	28	-----
13	----	-----	-----	2	6	66	5	26	35	-----

Nov.	14	----	5	----	1	(?)	(?)	2	18	26	-----
	15	----	5	----	2	7	91	8	7	32	1 west Hawaii
	16	----	-----	----	2	11	195	5	15	96	-----
	17	----	20	----	2	25	130	4	10	54	-----
	18	65	----	----	1	48	75	4	10	28	2 Mauna Loa, 1 Kohala
	19	----	4	----	-----	15	91	5	19	14	-----
	20	----	-----	----	1	10	57	7	5	19	-----
	21	16	----	----	-----	4	66	3	2	30	-----
	22	----	-----	----	-----	3	78	3	4	25	-----
	23	----	-----	----	3	11	72	11	2	32	1 west Hawaii
	24	----	8	----	4	7	27	8	-----	35	-----
	25	----	-----	----	1	4	50	6	4	20	-----
	26	----	4	----	30	6	64	9	3	14	-----
	27	----	-----	----	18	-----	76	11	3	46	1 Mauna Loa
	28	----	-----	----	3	-----	73	11	-----	25	-----
	29	----	-----	----	11	7	81	16	1	35	-----
	30	----	-----	----	4	5	111	13	2	52	-----
Dec.	1	----	7	----	5	5	104	18	-----	64	1 west Hawaii
	2	----	-----	----	5	-----	88	15	2	40	-----
	3	----	-----	----	12	10	85	14	1	33	-----
	4	----	-----	----	4	10	85	8	1	36	1 off N. shore of Hawaii
	5	----	-----	----	2	10	83	16	-----	42	-----
	6	4	----	----	10	6	95	7	-----	40	-----
	7	----	7	----	8	9	140	9	-----	37	1 off SE. shore of Hawaii
	8	61	----	----	4	13	73	7	-----	22	-----
	9	40	----	----	2	-----	68	15	3	22	1 Mauna Loa
	10	----	-----	----	3	17	108	12	3	11	1 off W. shore of Hawaii
	11	----	-----	----	7	7	85	24	2	15	1 west Hawaii
	12	----	-----	----	4	-----	64	7	1	11	-----
	13	----	-----	----	1	9	80	2	-----	5	1 off SW. shore of Hawaii
	14	----	-----	----	2	6	69	7	-----	8	-----
	15	----	-----	----	-----	7	62	7	-----	9	-----
	16	----	-----	----	2	5	51	12	-----	15	-----
	17	24	----	----	3	4	91	12	-----	8	-----
	18	----	-----	----	7	4	88	8	-----	14	-----
	19	----	-----	----	4	-----	77	8	2	10	-----
	20	----	-----	----	5	3	65	10	1	9	-----

Table 3.--Number of earthquakes and minutes of tremor recorded on seismographs  
U, M, A, D, N, WP, MP, Mx, and Kx around Kilauea caldera--Continued

Date (1966)	Tremor (minutes)			Kilauea summit			Earthquakes			
	Deep	Inter- mediate	Shallow	30 km	Long- period	Shallow	SW. rift and Kaoiki	Eastern east rift	Upper east rift	Others
Dec. 21	-----	-----	-----	2	-----	72	6	-----	(?)	-----
22	-----	-----	-----	3	10	85	9	1	10	-----
23	13	-----	-----	6	-----	119	11	6	35	-----
24	-----	-----	-----	5	-----	115	16	1	29	-----
25	-----	4	-----	10	6	138	8	2	38	-----
26	-----	-----	3	1+	2	40	2+	2	8+	-----
27	-----	-----	-----	electrical storm			-----	2	-----	-----
28	29	-----	instrument off	-----	2+	30+	inst. off	5	inst. off	-----
29	-----	-----	18	2	2	85	8	6	14	-----
30	-----	-----	-----	12	-----	82	15	5	10	-----
31	-----	-----	-----	67	-----	77	32	1	6	-----

Note: During the quarter two additional seismographs were installed.

Station	Symbol	Location		Altitude above sea level	Type instrument
		Lat. N.	Long. W.		
Mauna Loa (2)	Mx	19°27.6'	155°20.7'	1475 m	EV-17 vertical
Kealakomo	Kx	19°18.5'	155°09.6'	201 m	EV-17 vertical

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey,  
October, November, and December, 1966

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 (1966)	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	h	m	s			Lat. N.	Long. W.	Description	
Oct. 1	01	12	24.7	2.8	8	19°24.7'	155°59.8'	14 km SW. of Kealakekua	-----
1	14	50	40.8	2.6	8	19°25.0'	155°25.4'	10 km NW. of Desert seismometer	-----
3	03	49	17.2	3.5	25	19°22.5'	155°17.5'	3 km west of Ahua seismometer	Kilauea summit area, Pahala.
4	01	10	47.5	2.2	25	19°23.8'	155°17.0'	4 km SSE. of Uwekahuna	-----
4	22	41	24.1	2.4	3	19°22.1'	155°05.8'	10 km east of Makaopuhi seismometer	-----
7	02	26	39.5	2.3	5	19°23.1'	155°27.9'	10 km NW. of Desert seismometer	Pahala
9	06	27	40.1	2.5	5	19°21.8'	155°27.0'	8 km WNW. of Desert seismometer	-----
10	21	17	31.6	2.5	8	19°25.3'	155°33.5'	8 km SE. of North Bay seismometer	-----
12	01	21	01.2	2.0	13	19°23.7'	155°19.0'	5 km SW. of Uwekahuna	-----
12	11	21	58.0	2.5	0	19°15.3'	155°02.0'	12 km east of Apua Point	-----
12	13	34	22.4	2.3	3	19°23.4'	155°05.5'	10 km ENE. of Makaopuhi seismometer	-----
13	13	59	14.5	3.0	10	19°21.3'	155°07.9'	5 km ESE. of Makaopuhi seismometer	Hilo
13	22	00	52.8	2.7	0	19°19.9'	155°13.2'	7 km SE. of Ahua seismometer	-----
14	23	55	09.4	2.4	10	19°22.6'	155°09.0'	3 km NE. of Makaopuhi seismometer	-----
15	07	06	06.0	2.3	25	19°24.0'	155°19.3'	5 km SW. of Uwekahuna	-----
16	01	49	33.6	1.9	8	19°25.2'	155°25.7'	10 km NNW. of Desert seismometer	Pahala
16	02	15	21.3	2.4	3	19°16.1'	155°23.4'	8 km south of Desert seismometer	Do.
16	02	15	57.8	2.3	3	19°16.1'	155°23.4'	8 km south of Desert seismometer	Do.
16	07	46	12.5	2.6	0	19°21.1'	155°09.3'	3 km SE. of Makaopuhi seismometer	Do.
17	05	05	38.3	2.8	10	19°14.3'	155°26.7'	13 km SW. of Desert seismometer	Do.
19	12	49	46.8	3.0	5	19°20.9'	155°07.2'	6 km ESE. of Makaopuhi seismometer	Hilo, Kilauea summit area.
19	20	08	09.0	3.1	8	19°12.2'	155°39.0'	16 km NW of Naalehu	-----
22	14	07	41.1	2.3	5	19°23.7'	155°26.0'	8 km NW. of Desert seismometer	-----
23	02	25	59.4	3.0	8	19°33.2'	155°09.8'	5 km west of Mt. View	Hilo

Table 4.--Local earthquakes recorded by seismographs of the U.S. Geological Survey,  
October, November, December, 1966--Continued

Date (1966)	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	h	m	s			Lat. N.	Long. W.	Description	
Oct. 27	20	08	57.8	2.4	5	19°21.7'	155°11.7'	2 km west of Makaopuhi seismometer	Kilauea summit area.
28	19	18	24.4	2.8	3	19°24.1'	155°02.1'	15 km ENE. of Makaopuhi seismometer	Pahala
29	12	04	47.1	2.7	8	19°26.7'	155°49.0'	15 km SE. of Kealakekua	-----
30	18	49	25.5	4.0	8	19°19.2'	155°28.0'	8 km WSW. of Desert seismometer	Islandwide
30	21	18	13.5	2.2	8	19°20.8'	155°12.6'	5 km SW. of Makaopuhi seismometer	-----
30	21	21	13.0	2.1	3	19°26.5'	155°00.2'	10 km SW. of Pahoa	-----
31	02	08	14.1	2.7	8	19°21.1'	155°07.0'	7 km ESE. of Makaopuhi seismometer	-----
31	18	10	03.6	2.5	8	19°19.3'	155°14.0'	6 km SE. of Ahua seismometer	-----
Nov. 1	18	50	37.7	1.8	5	19°19.0'	155°11.9'	6 km SW. of Makaopuhi seismometer	-----
2	09	51	11.3	3.3	10	19°21.3'	155°06.8'	7 km ESE. of Makaopuhi seismometer	Hilo
4	11	29	48.6	3.0	13	19°19.3'	155°13.6'	7 km SE. of Ahua seismometer	-----
5	09	42	30.0	3.8	3	19°30.0'	155°54.2'	3 km SE. of Kealakekua	Kealakekua
6	06	37	55.3	2.7	0	19°27.2'	154°55.2'	7 km SE. of Pahoa	Kapoho
6	10	00	06.9	2.6	5	19°25.1'	155°30.7'	11 km SE. of North Bay seismometer	-----
6	11	26	02.5	2.6	8	19°16.5'	155°13.5'	3 km WNW. of Apua Point	-----
7	23	51	44.5	2.4	0	19°26.3'	155°00.8'	10 km SW. of Pahoa	-----
8	01	22	56.0	2.2	3	19°23.7'	155°17.8'	4 km south of Uwekahuna	-----
8	11	15	03.5	2.4	8	19°42.9'	156°01.4'	5 km SE. of Keahole Point	-----
9	16	41	29.7	2.6	3	19°20.3'	155°09.8'	4 km SE. of Makaopuhi seismometer	-----
9	16	43	15.5	2.3	3	19°20.1'	155°08.5'	5 km SE. of Makaopuhi seismometer	-----
12	03	21	47.3	2.5	3	19°22.0'	155°06.0'	9 km east of Makaopuhi seismometer	-----
13	01	32	10.4	2.5	3	19°26.2'	154°53.4'	9 km SE. of Pahoa	Kapoho
13	13	08	08.5	2.8	31	19°21.0'	155°17.8'	4 km SW. of Ahua seismometer	-----
14	02	58	51.3	2.6	0	19°29.0'	154°54.1'	5 km ESE. of Pahoa	Kapoho
15	05	48	48.5	2.3	8	19°26.1'	155°24.2'	8 km SW. of Mauna Loa seismometer	-----
15	13	18	18.9	2.6	0	19°13.6'	155°49.2'	35 km SSE. of Kealakekua	Kealakekua
16	19	19	27.1	3.0	0	19°25.9'	154°54.6'	8 km SE. of Pahoa	Kapoho
17	05	17	09.1	3.5	0	19°26.5'	154°56.0'	7 km SSE. of Pahoa	Do.
17	19	41	01.8	2.0	3	19°22.1'	155°06.0'	10 km east of Makaopuhi seismometer	-----
17	22	17	58.5	2.4	0	19°20.2'	155°32.8'	16 km west of Desert seismometer	-----
18	13	00	20.8	2.9	20	19°30.1'	155°31.6'	6 km ENE. of North Bay seismometer	Mauna Loa Observatory, Kilauea summit area.

Nov.	18	00	39	57.4	2.7	8	20°12.1'	155°43.8'	18 km NNW. of Kamuela	-----
	18	14	17	43.5	2.7	8	19°18.7'	155°44.0'	31 km NW. of Naalehu	-----
	18	23	29	20.0	2.3	0	19°20.6'	154°59.3'	2 km SW. of Kalapana	-----
	20	07	37	21.3	2.8	13	19°19.9'	155°20.9'	4 km east of Desert seismometer	-----
	23	06	33	25.0	2.2	5	19°20.3'	155°09.8'	4 km SE. of Makaopuhi seismometer	-----
	23	18	47	42.4	2.4	3	19°27.5'	155°48.7'	13 km ESE. of Kealakekua	Kealakekua
	23	20	59	08.5	3.4	10	19°20.1'	155°14.0'	6 km SE. of Ahua seismometer	Kilauea summit area, Mt. View, Hilo, Kealakekua
	24	14	52	46.0	1.9	8	19°20.9'	155°06.8'	7 km SE. of Makaopuhi seismometer	-----
	27	13	19	34.0	3.5	0	19°19.2'	155°44.2'	32 km NW. of Naalehu	-----
	27	18	28	25.6	2.3	3	19°24.1'	155°25.9'	9 km NW. of Desert seismometer	-----
	27	11	54	51.3	3.6	10	19°18.1'	155°13.8'	9 km SE. of Ahua seismometer	Mt. View, Kilauea summit area, Hilo, Pahala.
	27	11	57	52.3	2.5	8	19°19.2'	155°13.2'	9 km SE. of Ahua seismometer	Pahala
	28	08	52	10.4	2.9	8	19°23.4'	155°24.1'	6 km NNW. of Desert seismometer	Do.
	30	05	47	32.5	2.4	26	19°21.8'	155°18.5'	5 km WSW. of Ahua seismometer	-----
Dec.	1	20	00	31.9	2.6	40	19°08.2'	155°20.8'	22 km SSE. of Desert seismometer	-----
	1	16	03	14.5	2.8	8	19°31.6'	155°44.9'	17 km east of Kealakekua	Kealakekua
	1	19	57	16.8	2.7	8	19°24.3'	155°23.2'	8 km north of Desert seismometer	Pahala
	2	14	37	24.3	2.6	40	19°13.8'	155°07.2'	8 km SE. of Apua Point	-----
	3	03	26	39.0	2.8	8	19°23.3'	155°26.5'	8 km NW. of Desert seismometer	-----
	4	12	57	42.6	3.3	8	20°23.8'	155°46.7'	17 km NNE. of Upolu Point	-----
	5	22	21	26.4	2.8	10	19°18.5'	155°12.9'	9 km SE. of Ahua seismometer	-----
	6	19	23	04.2	2.0	8	19°19.3'	155°13.6'	7 km SE. of Ahua seismometer	-----
	6	19	34	41.8	2.0	8	19°15.9'	155°14.7'	13 km south of Ahua seismometer	-----
	7	03	39	53.5	2.2	40	19°03.7'	155°23.2'	22 km east of Naalehu	-----
	9	03	48	50.8	2.3	31	19°21.8'	155°18.5'	5 km WSW. of Ahua seismometer	-----
	9	10	27	38.0	2.4	8	19°27.9'	155°38.1'	7 km SW. of North Bay seismometer	-----
	10	00	34	24.9	3.1	8	19°33.6'	156°04.5'	17 km WNW. of Kealakekua	-----
	10	03	01	28.0	2.0	8	19°19.2'	155°12.9'	7 km SW. of Makaopuhi seismometer	-----
	11	17	53	42.3	3.0	3	19°23.0'	155°00.0'	13 km SW. of Pahoa	-----
	11	19	44	01.0	3.7	8	19°28.5'	155°52.4'	7 km SE. of Kealakekua	Kealakekua
	13	05	41	15.0	3.9	8	19°16'	156°17'	47 km SW. of Kealakekua	-----
	13	19	57	02.7	2.0	8	19°22.2'	155°08.1'	5 km ENE. of Makaopuhi seismometer	-----
	15	04	00	23.3	2.5	0	19°24.7'	155°16.8'	3 km SE. of Uwekahuna	Kilauea summit area.
	16	02	33	13.5	2.6	8	19°26.0'	155°28.0'	11 km SW. of Mauna Loa seismometer	Kilauea summit area.

Table 4. -- Local earthquakes recorded by seismographs of the U.S. Geological Survey,  
October, November, December, 1966--Continued

Date (1966)	Time			Magni- tude	Depth (km)	Epicenter			Felt Report
	<u>h</u>	<u>m</u>	<u>s</u>			Lat. N.	Long. W.	Description	
Dec. 18	00	18	10.0	2.2	8	19°13.5'	155°29.8'	17 km SW. of Desert seismometer	-----
23	19	46	25.1	2.1	5	19°22.6'	155°07.3'	6 km ENE. of Makaopuhi seismometer	-----
25	09	59	28.2	2.2	26	19°23.7'	155°19.0'	5 km SW. of Uwekahuna	-----
26	03	51	32.0	3.5	8	19°20.3'	155°07.0'	8 km ESE. of Makaopuhi seismometer	Hilo
30	18	00	31.9	2.4	30	19°23.0'	155°18.7'	5 km SW. of Uwekahuna seismometer	-----
31	17	21	38.1	2.7	27	19°23.0'	155°18.7'	5 km SW. of Uwekahuna	-----
31	17	04	51.5	3.9	22	19°23.5'	155°18.5'	4 km SW. of Uwekahuna	Islandwide
31	19	12	19.6	3.5	27	19°23.5'	155°20.0'	7 km SW. of Uwekahuna	Kilauea summit area, Puu Kulani.

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