PREFACE

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

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

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

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

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

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

The Volcano Letter publications are also available in print:

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

April 2023

THE VOLCANO LETTER

No. 455 monthly **Department of the Interior** **National Park Service** **January 1938**

Hawaii National Park
Edward G. Wingate Superintendent

NE PLUS HAUSTAE AUT OBRUTAE URBES

Hawaiian Volcano Observatory
T. A. Jaggar Volcanologist

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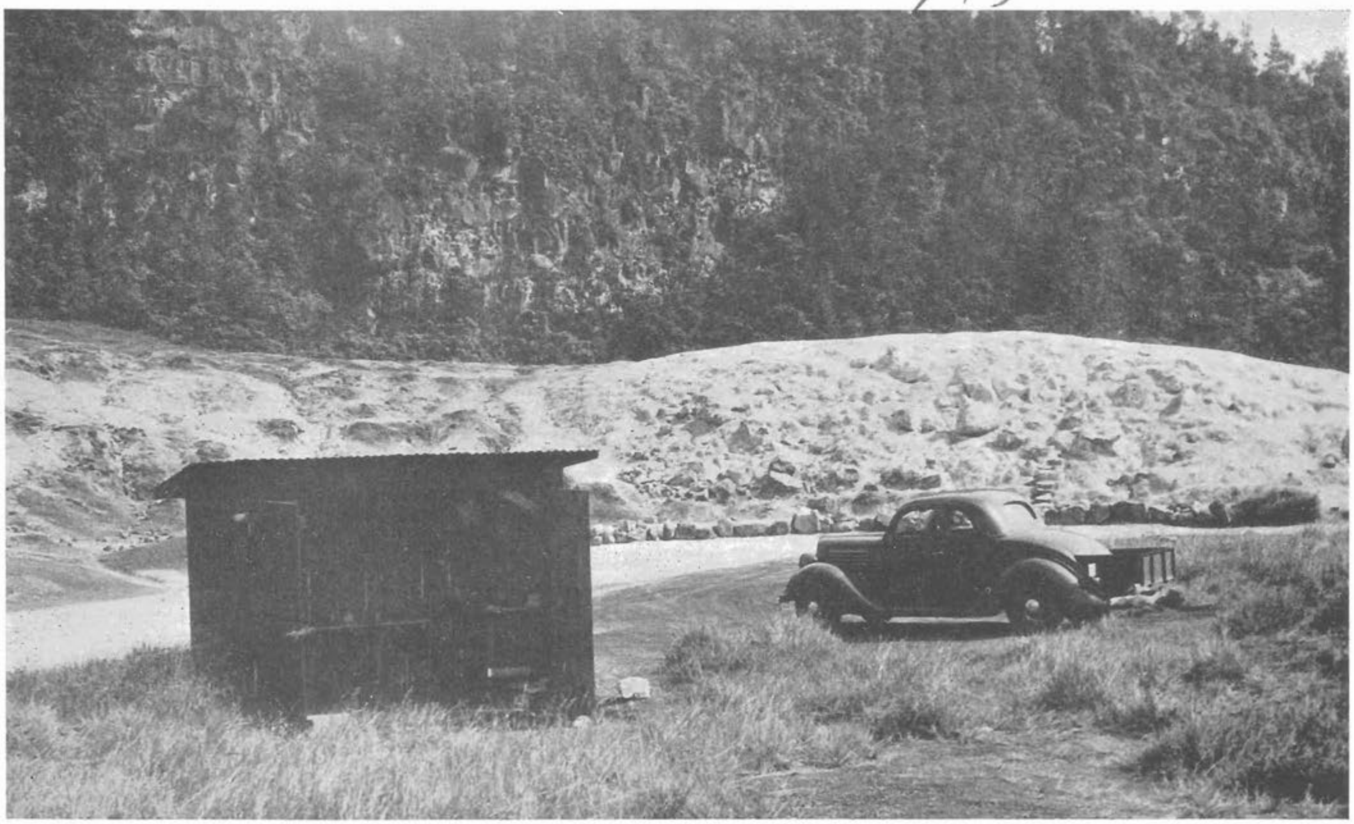

View of the Sulphur Bank, Kilauea. Notice the cliff in the background which is doubtless the wall of a Kilauea crater much older than the present one. Most of the gas collections were made at the wells which are beneath the temporary laboratory building in the left foreground.—National Park Service Photo.

THE VOLCANIC GAS PROBLEM

By Stanley S. Ballard

Research Associate in Geophysics, Hawaii National Park, and Assistant Professor of Physics in the University of Hawaii.

More and more attention is being focused upon the problem of the analysis of volcanic gases. Overlooked almost entirely until recent years, the evolution of gas is now considered to be one of the major phenomena accompanying a volcanic eruption. In fact some volcanologists feel that a satisfactory solution of the volcanic gas problem will shed much light on the fundamental problems of volcanology. In particular, it is thought that here may be found the source of some of the enormous quantity of heat that is given off at the time of eruption. The volcanic gases appear to have their origin underground in the fluid magma. As the magma rises during an eruption the hydrostatic pressure upon it is greatly decreased and at the earth's surface is so small that the gases here come out of solution and are given off into the atmosphere, usually in flames. Fortunately they can be analysed by chemists and physicists, the results of analysis being of course turned over to the volcanologist or the geochemist for interpretation.

There are at least four distinct approaches to the volcanic gas problem. First there is the possibility of photographing the spectra of the burning gases at the time of eruption. This would involve setting up a light portable spectrograph in the field near the fluid lava and focusing upon the slit of this instrument by suitable lenses the light from the flames of the burning gases emanating from cracks in the advancing lava flow. The photographs thus obtained would not be pictures of the flames themselves, but would be spectra of the substances burning in the flames. A trained spectroscopist could readily interpret these spectrograms to tell what elements or molecules in the burning gas gave rise to each of the spectrum lines. In the past volcanic flames have sometimes been examined through small hand spectroscopes, but the writer doubts whether results obtained in this way are particularly significant. Even a person experienced in spectroscopy can easily mistake the colored line of one element for some neighboring line of another element and thereby make an incorrect visual analysis. For this reason it is felt that the photographic method, giving a permanent record which can be compared later with standard spectrograms of the various suspected elements, is much preferable. It is hoped that a small field spectrograph can be obtained for use in this connection at the next eruption of Kilauea or Mauna Loa.

The second approach to the problem is through the collection of gases emanating from the fluid lava at the time of eruption, and their subsequent analysis in the laboratory by chemical and spectroscopic means. It is important to collect the gases **before** they burn, if possible, and to make the collections so as to exclude air from the surrounding atmosphere as completely as possible. Collections of volcanic gases were made at Kilauea in 1912 by Drs. Day and Shepherd of the Geophysical Laboratory of the Carnegie Institution of Washington, and further collections were made in 1917, 1918 and 1919 by Dr. Shepherd and Dr. Jaggar at Kilauea and at Mauna Loa. These samples were analysed in the Washington laboratory by Dr. Shepherd, the results being reported in papers appearing in the monthly bulletins of the Hawaiian Volcano Observatory and in national geological journals. No opportunity to collect volcanic gases has presented itself since the writer has been in the Territory, but a new type of collecting tube which it is hoped is somewhat of an improvement upon the vacuum tubes used previously has been devised. This new type of tube is described below.

The third approach consists of extracting dissolved gases from samples of cold lava after the eruption is over, and then analysing these gases. The extraction is performed by heating a ground portion of the rock in a vacuum furnace. When the rock comes up to the softening temperature large volumes of occluded gas, many times the volume of the rock in some cases, are driven off. The chief difficulty here appears to be in developing analytical methods for handling accurately the rather small samples of gas obtained. Suitable methods have been worked out by Dr. Shepherd and some analyses of gases driven off in the vacuum furnace from lava samples are given in his 1925 paper in the Journal of Geology. An attractive feature of this approach to the volcanic gas problem is that collections need not be made at the time of eruption when field conditions are seldom ideal, but may be made some weeks later after the excitement is over. In fact one should be able to go around the island of Hawaii, stop at the various dated lava flows and obtain suitable samples of rock, take them back to the laboratory, drive off their occluded gases, analyse these gas samples, and have a time-history of the composition of Hawaiian volcanic gas.

The last approach to the volcanic gas problem is by far the least direct of the four. It involves the collection and analysis of the sulphurous fumes emanating from vents in the immediate neighborhood of the crater. Of course there is often a general steam crack activity in a volcanic region, but the emanations here seem to consist largely of steam. This is doubtless ground water that has seeped down into the warmer regions of the ground, been vaporized and returned to the atmosphere as steam. There are often, however, small areas at which free sulphur is brought up from the depths and deposited at the surface, building up the so-called sulphur banks. The emanations in these cases consist of steam, sulphur vapor and additional gases. The important question here is as to how intimately volcanic these solfataras can be considered to be. Do some of the gases rise directly from the bed of molten magma that is thought to underlie the volcanic region? If so, the analysis of the readily accessible and continuously fuming solfataric gases should afford an index to the activities of the magma below. In the case of Kilauea, sulphurous fuming regions can be seen around the bottom edge of Halemaumau pit, around the edge of Kilauea crater beneath the present CCC camp, and at the edge of a still older, prehistoric Kilauea crater. This last area is located near the Hawaiian Volcano Observatory and the Kilauea Volcano House and is the Sulphur Bank that is visited by practically all tourists to the Park, being but 100 yards off the main highway. At this location collections of solfataric gases were made some 16 years ago by Dr. E. T. Allen of the Geophysical Laboratory. His results as published in the Bulletin of the Hawaiian Volcano Observatory for August 1922 are as follows:

Steam	96.2%
Fixed Gases	3.7
Sulphur Dioxide	.096
Sulphur Vapor	.004
Hydrogen Chloride	Trace

These are volume percentages for a temperature of 95.5° C and a pressure of 646 mm.

There are discussed below the collections and analyses of Kilauea Sulphur Bank gases which have been carried out by the writer during the last two years. The chief purpose of this investigation was to study the less obvious solfataric gases, that is, those other than steam and sulphur vapor. The actual collections were made at various times during an interval of over a year, and it was hoped that some variation in the constitution of the gases might be found. No significant variation has appeared, but the writer feels that collections and analyses should continue to be made at perhaps monthly intervals, the program lasting long enough to include a period of activity of Halemaumau. If variations in constitution are found to occur during the period of activity, the results will surely justify the work involved. In fact there is the possibility and hope that such variations might exist and might be correlated with volcanic activity sufficiently to enable predictions of eruptions to be made through gas anlaysis as well as through a study of seismic records. Whether such prediction will ever be possible or whether this is only a fond dream, only time can tell.

Collection of Volcanic Gases

The collection of the gases billowing forth from fluid lava at the time of eruption is ordinarily effected by the use of vacuum-type collecting tubes. A typical tube consists of a large bulb of several hundred cubic centimeters capacity to which is joined a long, narrow glass tube which may be several feet in length. The whole assembly is originally evacuated to a high degree. Then when the end of the long glass tube is thrust into the volcanic flame and the tip of the tube is broken off or melted through, gas will rush into the evacuated volume. If it can be successfully trapped there, the collection is complete. A desirable feature is that outside air may be eliminated from the collection as completely as possible.

Vacuum-type tubes of the sort used in the collections of Drs. Day, Shepherd and Jaggar are pictured on page 7 of Volcano Letter Number 437 for July 1936. The largest tube in this figure is the smallest tube shown in Figure 1. Above this tube is the largest vacuum-type tube used by them. Note the long drawn-out tip which could easily be broken off by striking the end of the tube against the lava when the time to make the collection arrived. Note also the narrowed portion of the slender tube near the large bulb which is designed for ready sealing off with a gasoline torch after the collection is completed. The tip of the lower tube has in its end a plug of glass of low melting point which should soften quickly in the intense heat of the volcanic flame, allowing the gas to rush in. The chief difficulties encountered with these tubes were in causing the tip to break or melt at the appropriate time, and in sealing the tube quickly before contaminating air entered.

The top tube in Figure 1 is the first vacuum-type collecting tube designed by the writer in collaboration with Mr. Paul Gow, Assistant Chemist at the Experiment Station of the Hawaiian Sugar Planters' Association. Features of this tube are a type of tip which is certain in its action, and a method of sealing the collected sample quickly so that no outside air can enter to contaminate it. The breakable tip is simply a crook-necked tip which is scored with a file to insure breaking at the bend, the breaking being effected by a quick jerk on a wire attached at one end to the crook and at the other to the collector's right hand, the tube being held in his left hand. After the gas has rushed into the evacuated volume it is trapped there simply by turning through ninety degrees (i.e. from open to closed position) the large vacuum-ground stopcock between the three-foot long slender glass tube and the large bulb. In Figure 2 is pictured the original tube along with two later "stream-lined" models. These differ from the original tube in two important respects. First, the side arm with small stopcock which was attached to the large reservoir bulb has been eliminated. This attachment was used in evacuating the bulb. Evacuation is now effected through a small side tube which is sealed off with an oxy-gas flame when the tube is evacuated to as high a degree as possible. The second improvement is in the greater mechanical strength obtained by making the weld between the large bulb and the stopcock very short and hence very sturdy. These latest tubes are made to order by a New York glass-blowing firm. The long slender tube is added locally in order to save freight charges. Then the breakable tip is drawn out and the tube is evacuated. The price complete per tube is under five dollars. The tubes may also be clamped to a sturdy pole, the stopcock being rotated by a "remote-control" device not shown in the figure. This recourse would be necessary in cases where the collector could not approach to within three or four feet of suitable gas sources.

No opportunity to test these tubes under actual field eruption-time conditions has presented itself as yet. The original tube pictured in the figures was tested at the Sulphur Bank in the summer of 1936, however, and appeared to work most satisfactorily. The difficulties which might be encountered with the tubes would be the result of the fragile nature of any piece of glass apparatus or of the failure of the vacuum-ground stopcock to hold a vacuum in the tubes while they are in storage awaiting eruptions. In general these stopcocks have been found to be quite satisfactory, two tubes now at the Hawaiian Volcano Observatory having held a vacuum perfectly for six or eight months to date. It should be remarked that at the Observatory there is now a complete outfit for evacuating these tubes and for doing any glass blowing and repairing that might be necessary.

Collection and Analysis of Solfataric Gases

The analyses about to be reported upon should be thought of still as preliminary studies which supplement the first analyses made by Dr. Allen in 1922. The purposes were to establish the identity of the 3.7 per cent of "fixed gases" reported by Allen, to see if there were any gases being given off which were unusual in nature, and to establish what definitely volcanic gases were emanating from the solfataras. Interest was centered particularly upon the combustible gases hydrogen and carbon monoxide which are known to burn in volcanic flames; sulphur vapor, another known volcanic gas, is very evidently a constituent of the solfataric gases. The analyses therefore do not concern themselves with either the amount of the sulphur vapor or the steam that was being given off at the vents.

The first collections were made in August and September of 1936. A temporary shack suitable to house collecting equipment was erected by the Park Service over the wells that had been sunk at the Sulphur Bank area some fifteen years ago. The best collections were made from the manifold connecting these three wells, the side wells being 15 feet deep and the center well some 70 feet deep. The figure on page 2 of Volcano Letter Number 453 for November 1937 illustrates the "vertical wet" method of collection from the wells. In this case the sulphurous fumes are drawn by a hand-vacuum pump through a collecting tube until it is thoroughly flushed with the gas, whereupon the collection is effected simply by shutting off the collecting tube stopcocks, thereby trapping some of the gas inside. By surrounding the tube with an ice pack much of the steam is made to condense and run back into the walls, thus giving a sample which is considerably enriched in the fixed gases. This type of collecting has proved the most satisfactory and dependable of the several methods tried, and a sample has been collected using this method each time the region has been visited by the writer. There were also made field collections at sulphurous fuming spots in the vicinity of the Sulphur Bank. As a "control" we collected a sample using the field collection technic at the steaming bluffs a mile or two from the Sulphur Bank along the

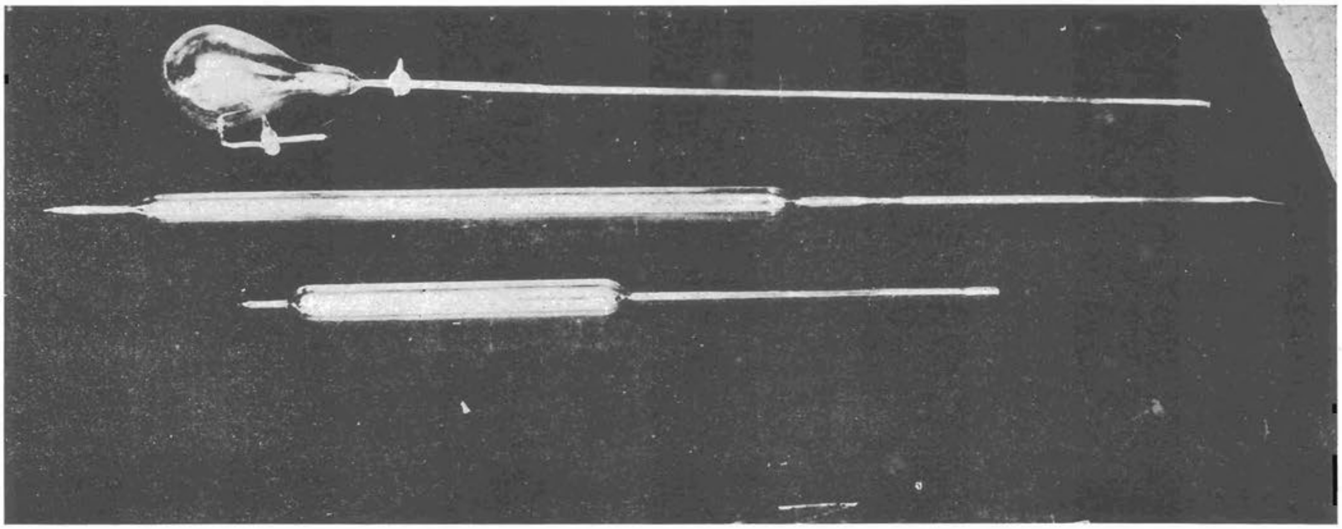

Figure 1. Old and new vacuum-type volcanic gas collecting tubes. Capacities are approximately as follows: Upper (new style) tube, 800 cc.; center tube, 450 cc.; lower tube, 350 cc.—National Park Service Photo.

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government road, in a region where no sulphur fumes could be detected. It is interesting to note that even in this non-sulphurous area sulphur dioxide to the extent of 1.3 per cent of the dry gas (i.e. air and carbon dioxide) was detected.

Upon returning to Honolulu one of the samples was tested spectrographically using the excellent spectroscopic facilities of the Experiment Station of the Hawaiian Sugar Planters' Association. The only lines or bands detected on the spectrum plates were those of carbon monoxide and hydrogen. The hydrogen lines were undoubtedly due to water vapor (steam) present in the sample, whose molecules are broken down by the high voltages applied to the spectrum tube to hydrogen and oxygen atoms, the hydrogen lines showing clearly. The predominance of carbon monoxide bands cannot be taken as a guarantee of the presence of carbon monoxide in the sample, as indeed later

These are volume percentages at room temperature and pressure in Honolulu; that is, approximately 20° C and 760 mm. All analyses were conducted with saturated water vapor present, so that the percentages are those of the **dry** gases. The residue was tested spectroscopically and found to be nitrogen, as expected. The ratio of nitrogen to oxygen is seen to be approximately 4:1, the normal atmospheric ratio. The air in the samples is hence thought to be of atmospheric origin, having leaked into the porous ground and come up again with the solfataric gases. The analysis of the 1936 gases showed that so much sulphur dioxide was present, as high as 90 per cent in some cases, that any relatively rare constituents might indeed escape detection. Therefore, we decided to make the 1937 collections in such a fashion as to eliminate this large SO_2 content.

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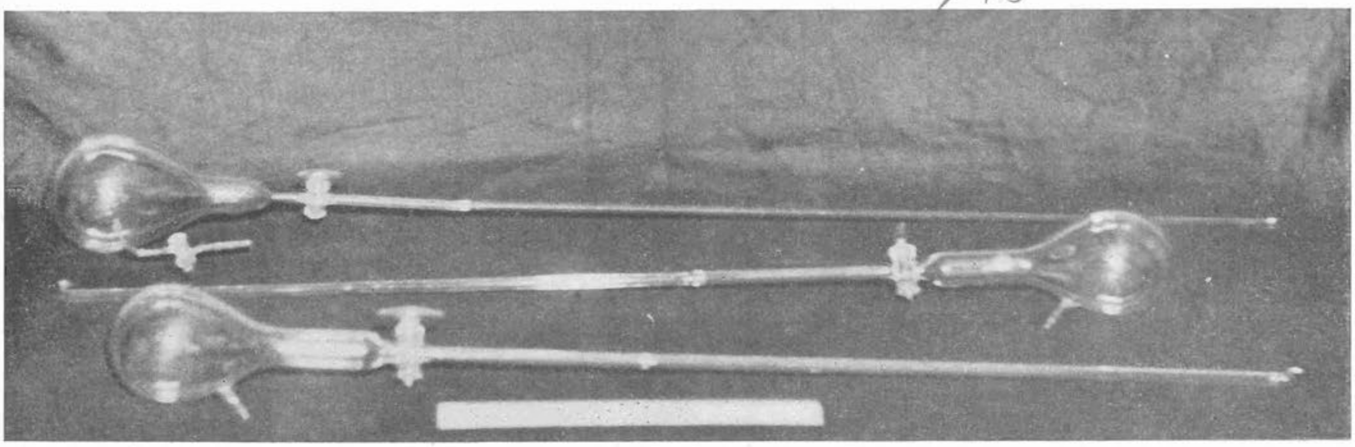

Figure 2. Improved vacuum-type volcanic gas collecting tubes. The upper tube has a capacity of 800 cc. (see Fig. 1). The two lower tubes are of the newer, sturdier construction and have capacities of 500 cc. each. Note the foot ruler which gives the scale of the figure.—University of Hawaii Photo.

chemical analysis showed. It is well known to spectroscopists that carbon dioxide gas as well as almost any organic material will break down under the extreme electrical conditions existing in a spectrum tube into carbon monoxide, which has a very strong and easily excited spectrum. These spectroscopic analyses therefore served only to show that it would be necessary to subject the samples to chemical analysis. It was at this point in the investigation that the writer called upon Assistant Professor John H. Payne of the University of Hawaii Department of Chemistry for assistance. And the Ballard-Payne collaboration has continued harmoniously since that time.

Chemical analyses were made by Dr. Payne in his university laboratory using the standard Burrell gas analysis equipment and methods. His results showed that sulphur dioxide was the chief constituent (other than steam, of course) of the solfataric gases collected. Other constituents were carbon dioxide and air, the latter being principally nitrogen and oxygen. In none of the dozen-odd samples analysed was any significant trace of combustible gases such as carbon monoxide, hydrogen, hydrocarbons, etc., found. The occurrence of definite amounts of these gases would have established beyond question of doubt the intimately volcanic origin of the Sulphur Bank gases. The amount of air present in the samples varied greatly from sample to sample, depending upon the method of collection as well as the place of collection. A sample analysis of a vertical wet collection is as follows:

Sulphur Dioxide	58.6%
Carbon Dioxide	4.6%
Oxygen	7.0%
Residue	29.8%
Combustibles	None

Several samples of gas were collected in September 1937. As illustrated in the picture printed on page 3 of Volcano Letter Number 453 for November 1937, the gas was drawn first through a condenser which was packed with ice and salt and hence removed a large portion of the steam, then through two absorption tubes which contained a 50 per cent caustic potash solution. The function of the potassium hydroxide was to absorb the major percentage of the sulphur dioxide and carbon dioxide, allowing the minor constituents of the gas, if any, to be concentrated in the sample. Analysis of these collections showed that the absorption of the sulphur and carbon dioxides was not complete. However, the last traces of these gases were removed in the laboratory and the residue was treated with hot lime and magnesium in order to absorb the nitrogen content known to be present. The gas remaining after this operation was examined spectroscopically as shown in Figure 3 and found to consist chiefly of argon, which is known to be present to the extent of about 1 per cent in the atmosphere. No traces of the other rare gases, helium, neon, krypton and xenon, could be detected. In Figure 3 is shown the complete analytical equipment which consists of the chemical train of seven pipettes which hold the solutions to absorb the various gases, the gases being forced through the solutions by the mercury-filled leveling tube held in Dr. Payne's right hand. The gas is then forced into the long horizontal tube in the center of the picture, where upon heating the calcium-magnesium mixture its nitrogen content is absorbed. Then the gas is forced over to the right into the spectrum tube, whereupon its spectrum can be observed and measured using the wavelength spectrometer shown.

It was decided that collections should be made in which there was definitely no sulphur dioxide present, and in December 1937 Dr. Payne and the writer made a flying trip to Hawaii for this purpose. This time the gas was pumped through **four** absorption tubes containing caustic potash, and this time no sulphur dioxide got through! Analysis of these samples showed nothing present but air.

In conclusion, one can state the results of these preliminary analyses as follows: The Kilauea solfataric gases tested consisted of steam, sulphur vapor, sulphur dioxide, carbon dioxide, and air (that is, nitrogen, oxygen and argon). No new combustible gases and no rare gases other than argon were detected. It is hoped, however, that when larger samples can be collected, larger residues of argon can be obtained which can be studied by more searching **spectrographic** methods which may possibly reveal traces of helium and other rare gases which could not be detected by the visual spectroscopic methods here employed. Referring again to Dr. Allen's analyses, we would judge that his 3.7 per cent of fixed gases was air and carbon dioxide. If the sulphur dioxide content of the gases has not changed since 1922, then Allen's collections must have been very badly contaminated with air. It is interesting to note that A. Brun of Geneva made partial analyses of these gases in 1910 and detected **no** sulphur dioxide. Twelve years later Allen detected a very definite amount of sulphur dioxide, and fifteen years still later sulphur dioxide was found to be by far the predominating gas, save water vapor. We are preparing for publication elsewhere a paper which will describe more fully the technical details of this program of analysis.

As regards future plans for solfataric gas analysis, we hope to establish a fixed technic of sampling—probably the vertical wet collection method, and continue to test the sulphur dioxide vs. carbon dioxide ratio, which ratio has been in the range 10:1 to 15:1 for comparable collections. If collections could be made monthly and continued long enough to include a period of volcanic activity it could readily be established whether this ratio in solfataric gases affords an index of volcanicity. It should also be of interest to make a **complete** analysis comparable to Dr. Allen's, particularly to see whether there has really been a marked increase in the amount of sulphur dioxide present in relation to the steam content, as suggested above.

This program is being supported jointly by the University of Hawaii, the Hawaiian Volcano Research Association, and the Hawaii National Park. Acknowledgment is made of the kind cooperation on the part of the Experiment Station of the Hawaiian Sugar Planters' Association in making available the glass-blowing skill of Mr. Gow and the facilities of the spectroscopic laboratory. Obviously the successful completion of the solfataric gas analyses was made possible only through the active cooperation of Dr. Payne and of his student assistant, Mr. Luther Foster, to whom thanks are due.

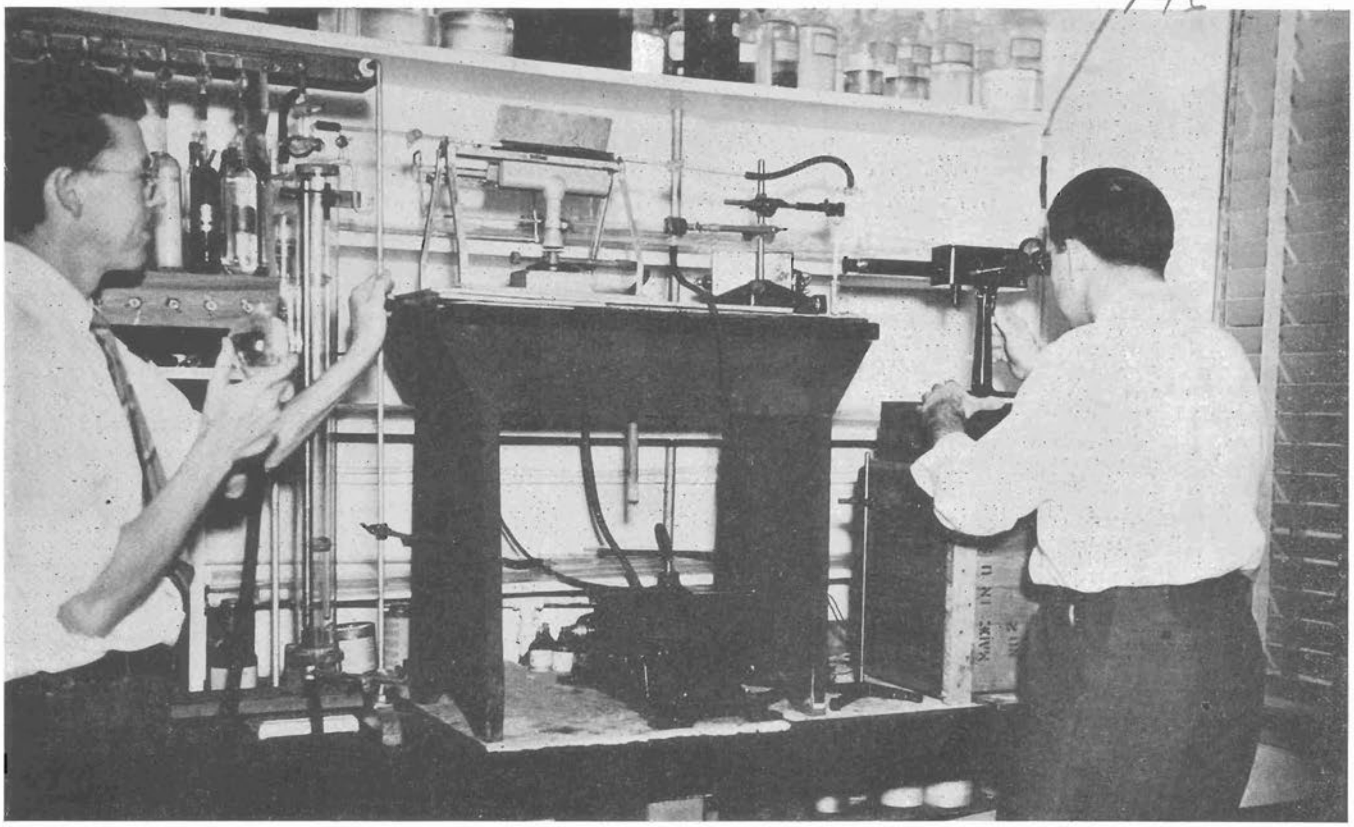

Figure 3. Apparatus set up in the University of Hawaii chemistry laboratory for the chemical and spectroscopic analysis of solfataric gases. Dr. Payne is forcing gas into the nitrogen absorption tube (center of the picture) and Dr. Ballard is measuring the spectrum of the residual gas with a wavelength spectrometer.—University of Hawaii Photo.

Hawaiian Volcano Observatory Report for January 1938

VOLCANOLOGY

The volcanoes of Hawaii have remained quiet. The seismicity which had increased about the solstice, again trebled in value the first three weeks of January. The most notable event of the month was a very strong earthquake January 22 that centered on Maui, doing much damage there. It was very strong on Molokai, Lanai and Kahoolawe, and alarming at Honolulu and in Kohala. It was generally felt in the Hawaiian Islands.

Apparently the middle belt of this earthquake extended from central Maui westward towards Kahoolawe. The serious character of the shock raised questions of earthquake-proof construction in Honolulu. It is of interest that the strong 1868 earthquakes affected the east-west faults of south end of Hawaii island; the 1929 disastrous shocks of north Kona extended to Mauna Kea and affected a northeast-southwest belt there; the 1938 cataclysm affects an east-west belt through Maui; and this series suggests a migration of fault movements on the transverse fractures across the west-northwest line of the Hawaiian Islands. The next important transverse fracture is the one crossing the north side of Molokai, which extended westward would pass Honolulu close to Diamond Head. If this fracture should move, it might be disastrous for Honolulu.

Of the measured earthquakes 22 were from Kilauea, 5 were from Mauna Loa, and 8 were beyond Mauna Loa. Feeble shocks somewhat felt occurred January 3, 14 and 17. A slight shock was felt in Hilo January 9. After the big Maui shock there was marked decline in seismicity. The first week of the month had been notable for some earthquakes indicating distances of origin corresponding to north Kona and Kohala.

The following are the weekly Observatory totals for Halemaumau and the seismographs.

Week Ending	Seismicity	Slides	Crack Opening	Local Tremors and Quakes
January 9	16.75	2	6.5 mm.	40
" 16	16.00	1	0.5 mm.	49
" 23	17.50	2	3.0 mm.	21
" 30	6.75	0	11.3 mm.	21

Slides at Halemaumau

The recorded slides from the wall of the pit were:

January 5, 1:25 p.m., north rim of pit.

January 9, 3:46 p.m., dust arose during moderate earthquake.

January 14, 9:25 a.m., slide from north wall, noise of falling stones heard at a distance and cloud of dust.

January 21, 9:45 a.m., north rim.

January 22, 10:03 p.m., noise of slides heard accompanying earthquake.

A fresh scar from a slide on the wall was found at Alealea pit of the Chain-of-Craters.

Measurement of Halemaumau Rim Cracks

Weekly measurement of rim crack locations resulted during January in aggregate movement as follows:

Week ending forenoon of:

January 7, 28 locations, 11 opened, 3 closed, opening 6.5 mm.

January 14, 28 locations, 5 opened, 4 closed, opening 0.5 mm.

January 21, 28 locations, 10 opened, 4 closed, opening 3.0 mm.

January 30 (nine days), 28 locations, 13 opened, 2 closed, opening 11.3 mm.

T. A. J.

SEISMOLOGICAL DATA

Earthquakes

Week Ending	Minutes of Tremor	Very Feeble Earthquakes	Feeble Earthquakes	Slight Earthquakes	Moderate Earthquakes	Distant† Earthquakes	Weekly* Seismicity
Jan. 9	29	8	1	1	1	0	16.75
Jan. 16	36	12	1	0	0	0	16.00
Jan. 23	40	5	1	0	1	0	17.50
Jan. 30	15	6	0	0	0	1	6.75

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

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

January 3, 11:36 am, very feeble, 40 miles deep under Hualalai. 20° 42.8′ N; 155° 48.0′ W.

January 3, 12:33 pm, feeble, located 47 miles deep under Mauna Loa NE rift zone. 19° 30.7′ N; 155° 25.7′ W.

January 3, 6:02 pm, very feeble, 40 miles deep under summit crater area of Mauna Loa. 19° 26.2′ N; 155° 35.8′ W.

January 3, 8:51 pm, very feeble, 1.0 mile deep, 0.5 mile SE of Pit seismograph. 19° 24.0′ N; 155° 16.7′ W.

January 5, 2:31 am, slight, 5.0 miles deep in Hilina Kupukana Fault system, 3.0 miles N of Apua Point. 19° 18.1′ N; 155° 11.6′ W.

January 9, 2:49 am, very feeble, of Kilauea origin.

January 9, 3:47 pm, moderate, 3.8 miles deep near SW rim of Kilauea Iki. 19° 24.8′ N; 155° 15.2′ W. Dismantled Pit and Observatory seismographs. Reported felt by many at CCC Camp, SE rim of Kilauea Crater and by several around the National Park Headquarters area.

January 9, 4:40 pm, very feeble, 3.4 miles deep and 3.5 miles NW of H.V.O. 19° 27.9′ N; 155° 18.0′ W.

January 10, 4:55 pm, very feeble, 1.8 miles deep and 2.8 miles SE of the Volcano Observatory. 19° 24.5′ N; 155° 13.5′ W.

January 10, 6:04 pm, very feeble, 1.3 miles deep NW rim of Kilauea Crater, 0.8 miles N NE of Uwekahuna. 19° 26.0′ N; 155° 17.2′ W.

January 10, 6:11 pm, very feeble, 4.2 miles deep in vicinity of Kipuka Puaulu. 19° 27.0′ N; 155° 18.3′ W.

January 10, 10:24 pm, very feeble, 0.8 mile deep in Byron Ledge Area, E rim of Kilauea Crater. 19° 24.6′ N; 155° 15.3′ W.

January 11, 11:37 pm, very feeble, 1.8 miles deep in Kilauea Crater, 1.0 mile SW of the Observatory. 19° 24.6′ N; 155° 16.7′ W.

January 12, 12:21 am, very feeble, 1.6 miles deep under Byron Ledge, E rim of Kilauea Crater. 19° 24.8′ N; 155° 15.6′ W.

January 13, 2:36 pm, very feeble, of shallow origin, SE rim of Kilauea Crater. 19° 23.9′ N; 155° 16.2′ W.

January 13, 3:39 pm, very feeble, of shallow origin in area immediately SE of Keanakakoi. 19° 24.0′ N; 155° 15.6′ W.

January 13, 3:29 pm, very feeble, of shallow origin, SE rim of Kilauea Crater. 19° 24.4′ N; 155° 15.6′ W.

January 13, 5:45 pm, very feeble, 0.4 mile E of Pit seismograph, 0.7 mile deep. 19° 24.3′ N; 155° 16.6′ W. Dismantled Pit seismograph.

January 14, 6:19 am, very feeble, 1.5 miles deep near SW rim of Kilauea Iki. 19° 24.8′ N; 155° 15.2′ W.

January 14, 5:40 pm, feeble, 8.0 miles deep, along seacoast 3.5 miles S of Hilina Pali. 19° 15.0′ N; 155° 17.0′ W. Reported felt in city of Hilo.

January 15, 5:33 pm, very feeble, probably originated in Mauna Loa NE rift 4.0 miles NE of Puu Ulaula.

January 17, 11:39 am, feeble, 0.8 mile deep E portion of Crater, 1.0 mile E of Halemaumau. 19° 24.6′ N; 155° 15.9′ W. Reported felt on NE rim of Kilauea Crater.

January 17, 4:27 pm, very feeble, 1.0 mile deep, in Kilauea Crater near W end of Kilauea Iki. 19° 24.9′ N; 155° 15.5′ W.

January 22, 4:36 am, very feeble, located in Mauna Loa NE rift in vicinity of Puu Ulaula. 19° 32.0′ N; 155° 26.6′ W.

January 22, 10:03 pm, moderate to strong near shock, probably centered about 60 miles below the ocean surface near a point 25 miles N of Pauwala Point, Maui. 21° 12′ N; 156°

06' W. This shock was felt throughout the Hawaiian Islands and recorded on seismographs throughout the world. It was felt most strongly on the Island of Maui and by nearly everyone. Damage to property was estimated to have been about $150,000, and included disruption of water tanks and dams, interruption of telephone service, cracked walls and roads, slides along roads and upsetting of objects in buildings. The road to Hana, Maui, was closed by slides from steep adjoining slopes. Greatest damage was in vicinity of Wailuku and Kahului. On Oahu the intensity of the shack was considerably less than on Maui but is thought to have been greater than on Hawaii. In Honolulu many people were alarmed and theatre patrons rushed hurriedly out of the buildings. Light flashes visible for 20 miles were reported from Hilo; radio transmission interference was reported on the shorter wave lengths. In the Volcano district, Hawaii, long swinging motions were described causing loose objects to move and tall slender objects such as floor lamps to sway. Pheasants squawked, dogs barked and most sleepers were awakened. Buildings creaked and doors swung on their hinges. A report from Hilo indicated that ceiling lights swung in an E NE-W SW direction. All seismographs in operation in the Hawaiian Islands were dismantled with the exception of the strong motion instrument at the Hawaiian Volcano Observatory. This instrument made a complete record. Felt portion of quake was thought to have lasted, one and one-half to two minutes.

January 26, 9:01 pm, very feeble, located 1.1 miles deep, in Kilauea Crater, 1.0 mile NE of Pit seismograph. 19° 24.9' N; 155° 16.2' W.

January 27, 5:22 am, very feeble, 2.0 miles deep, 1.3 miles SW of the Observatory in Kilauea Crater. 19° 25.2' N; 155° 16.4' W.

January 28, 2:23 am, very feeble, 2.5 miles deep and 0.7 mile N of Uwekahuno NW rim of Kilouea Crater. 19° 26.0' N; 155° 17.5' W.

January 29, 6:02 am, very feeble, probably of shallow origin near center of Kilauea Crater.

Microseismic motion of the ground at the Observatory was strong throughout the month.

27 minutes of continuous tremor began to register at the Observatory at 3:35 am, January 19.

An unidentified portion of a teleseism began recording at Kilauea at 12h 58m 25s, H.S.T., January 24.

H. H. W.

Tilting of the Ground

The following tables show tilt by weeks as recorded by the Observatory seismograph and at Holemaumau the algebraic sum of radial tilt toward or away from the Pit.

At the Observatory the total accumulated tilt for the year ending January 30, was 6.3" S and 0.48" W.

Week Ending	Observatory	Halemaumau West Station
January 9	0.75" N 53° W	5.07" N 48° W
January 16	0.86" S 5° E	6.26" S 65° W
January 23	0.51" S 4° W	8.70" S 44° W
January 30	1.58" S 30° W	4.38" N 19° E

Week Ending	Halemaumau Southeast Station	Halemaumau Resultant
January 9	2.59" N 87° W	1.84" From
January 16	6.41" N 80° W	1.28" From
January 23	3.73" N 57° W	3.29" From
January 30	16.20" S 18° W	7.45" From

H. H. W.

Crater Angles

Measurement of horizontal angles across Kilauea Crater from the Observatory, January 11, indicated closing of the Halemaumau value and slight opening of the Kilauea Crater value compared with similar measurements made December 22. The Halemaumau measurement from the SE Pit B. M. to NW Pit B. M. showed a decrease of 1.51" and the Kilauea Crater value from the SE rim to Uwekahuna showed an increase of 0.67".

H. H. W.

HAWAIIAN VOLCANO RESEARCH ASSOCIATION

The Hawaiian Volcano Research Association was founded in 1911 for the prosecution of volcano research, more particularly in the Hawaiian Islands and around the Pacific Ocean. Its laboratory at Kilauea Volcano, Hawaii, is leased and operated by the United States Government, Department of the Interior, National Park Service. The Association maintains seismograph stations at various places on the Island of Hawaii and supplements the work of the Government with buildings, research fellows, instrumental plants, explorations and special investigations for which there is no governmental provision.

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The Secretary of the Association is Mr. L. W. de Vis Norton, whose address is 320 James Campbell Building, Honolulu, T. H. Contributions of articles, photographs, publications and clippings about volcano and earthquake events, instruments and investigations are always welcome, and if suitable, will be published with due acknowledgment.

NE PLUS HAUSTAE AUT OBRUTAE URBES

THE VOLCANO LETTER

No. 456 monthly Department of the Interior National Park Service February 1938

Hawaii National Park
Edward G. Wingate Superintendent

Hawaiian Volcano Observatory
T. A. Jaggar Volcanologist

PUBLICATIONS RELATING TO HAWAIIAN VOLCANOES

T. A. Jaggar

As supplement to an address delivered by the writer at the Annual Meeting March 31, 1932, of the Hawaiian Volcano Research Association in Honolulu, there was published in Volcano Letter No. 384, May 5, 1932, a list of publications.

Since 1932 numerous articles, popular and scientific, have accumulated as the output of workers at the Hawaiian Volcano Observatory. Many of these are on hand as reprints, one of which will be sent while they last to anyone interested who addresses The Hawaiian Volcano Observatory, Hawaii National Park.

Publications of the Observatory

The suspension of the Volcano Letter. Jaggar, Volcano Letter No. 385, May 12, 1932.

Eruption in Lake Rotorua, New Zealand. Jaggar, Volcano Letter 386, May 19, 1932.

Ash Eruptions in the Andes. Jaggar, Volcano Letter 386, May 19, 1932.

Eruption of Merapi in Java. Jaggar, Volcano Letter 387, May 26, 1932.

A Note on Kamtchatkan Volcanoes. Jones, Volcano Letter 390, August 1932.

Results of One Year's Crack Measurements. Wingate, Volcano Letter 393, November 1932.

Lassen Report No. 32. Finch, Volcano Letter 395, January 1933.

Earthquake-Tidal Wave March 2, 1933. Jaggar, Volcano Letter 397, March 1933.

Puna Triangulation. Wingate, Volcano Letter 400, June 1933.

Lassen Report No. 33. Finch Volcano Letter 401, July, 1933.

What May be Learned From Tilt. Wingate, Volcano Letter 432, February 1936.

How to Make a Simple Seismograph. Finch, Volcano Letter 433, March 1936.

A Trip Up the 1935 Mauna Loa Flow. Waesche, Volcano Letter 433, March 1936.

Lassen Volcano, California. Farmer, Volcano Letter 433, March 1936.

Earthquakes in the U. S. de Vis-Norton, Volcano Letter 434, April 1936.

Volcanic Area of Bufumbira, Uganda. Palmer, Volcano Letter 434, April 1936.

The Influence of Volcanic Research in Hawaii. Jaggar, Volcano Letter 434, April 1936.

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Earthquakes at Lassen, May 1936. Swartzlow, Volcano Letter 435, May 1936.

Methods of the Hawaiian Volcano Observatory. Jaggar, Volcano Letter 435, May 1936.

Japanese Volcanology and Seismological Research. Waesche, Volcano Letter 436, June 1936.

Adventures and Methods in Studying West Indian Volcanoes. Jaggar, Volcano Letter 437, July 1936.

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The Coming Lava Flow, the Most Serious Responsibility in Our History. Jaggar, Volcano Letter 440, October 1936.

Eruption of Kilauea Volcano September 1934. Jaggar, Volcano Letter 441, November 1936.

The Bombing of Mauna Loa 1935. Jaggar, Volcano Letter 442, December 1936.

Protection of Hilo From Coming Lava Flows. Jaggar, Volcano Letter 443, January 1937.

Earthquakes. Waesche, Volcano Letter 444, February 1937.

Annual Report of Secretary, Hawaiian Volcano Research Association. de Vis-Norton, Volcano Letter 445, March 1937.

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Eruptions at Rabaul, New Guinea. Jaggar, Volcano Letter 448, June 1937.

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Kilauea Lava Flow of 1823. Waesche, Volcano Letter 450, August 1937.

Volcanoes in the National Parks. Waesche, Volcano Letter 450, August 1937.

Crater Lake National Park. Waesche and Jaggar, Volcano Letter 451, September 1937.

Triangulation and Level Changes at Kilauea. Waesche, Volcano Letter 452, October 1937.

Kilauea Volcano Laboratory of the University of Hawaii 1937. Jaggar, Volcano Letter 453, November 1937.
Work of the Observatory 1937. Jaggar, Volcano Letter 454, December 1937.
The Volcanic Gas Problem. Ballard, Volcano Letter 455, January 1938.
Publications of the Observatory. Jaggar, Volcano Letter 456, February 1938.

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Fossil Human Footprints in the Kau Desert. Paradise of the Pacific, May 1932, Vol. 46, No. 5, 5 pages.
Shipboard Plane-table and Azimuth Camera: An Experiment in Navigation. Proc. Haw'n Acad. Sci., B. P. Bishop Mus. Spec. Pub. 26, 1935, pp. 13-14.
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The Breathing of Pele. Paradise of the Pacific, Vol. 46, No. 9, Sept. 1934.
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Protection of Hilo from Coming Lava Flows. Reprinted from Hilo Tribune-Herald Jan. 20, 1937, 8 pp. (Also Volcano Letter No. 443, January 1937).
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Hawaiian Volcano Observatory Report for February 1938

VOLCANOLOGY

Much study was given the question of the meaning of the strong earthquake that affected Honolulu January 22. Parallels exist in the history of the Observatory, and several earthquakes in the past quarter century centered under Maui.

Measurements about Halemaumau pit showed increase of motion throughout February. Alternation between motions on the Hualalai-Mauna Loa rifts and much higher frequency on the Kilauea fractures continued. This alternation may imply lowering of lava under Hualalai-Mauna Loa after the 1929 and 1935 crises, and return of lava under Kilauea especially along the eastern rift belt, for an eruption that is near at hand.

The following are the weekly Observatory totals for Halemaumau pit of Kilauea Crater and the seismographs:

Week Ending	Seismicity	Slides	Crack Opening	Local Tremors and Quakes
February 6	11.75	0	2.5 mm.	37
" 13	10.00	1	6.0 mm.	36
" 20	23.25	5	10.0 mm.	55
" 27	12.50	9	9.5 mm.	38

Notable shocks were a moderate one on northeast rift of Mauna Loa February 17, and one the next day at Kilauea. There were two feeble Kilauea shocks February 20 and 21. A slight shock of Mauna Loa origin dismantled the Kona seismograph February 25. These illustrate the alternation referred to. Of all measured shocks, twenty-three were from Kilauea, two from Mauna Loa, two from Hualolai, and one from Mauna Kea.

Sequence of Events by Weeks

The first week produced nothing of importance except two distant earthquakes. The second week Kilauea remained quiet. The third week showed notable increase of tremors, number and strength of earthquakes, and some slides, with decrease of tilt at the Kilauea rim and increase at Halemaumau. Seismicity was cut in half the fourth week, though slides continued: tilt at Halemaumau changed from inward to outward by 18 seconds, and at the Observatory tripled in amount westerly. The opening of cracks at Halemaumau rim increased during the month.

Slides at Halemaumau

The recorded slides from the wall of Halemaumau were:

February 8, 9:30 a.m., fresh scars and dribbling rocks SE.
February 8, 4:22 p.m., slide north wall.
February 9, 9:11 a.m., slides at north cliff.
February 14, 9:42 a.m., dribbling rocks north.
February 20, 11:35 a.m., dust from slide N.
February 20, 12:07 p.m., slide NE.
February 21, 11:10 a.m., slide NE.
February 21, 11:30 a.m., dust rising NE.
February 21, 12:05 p.m., dust rising NE.
February 25, 9:53 a.m., slide north.

Measurement of Halemaumau Rim Cracks

Weekly measurement of rim crack locations around Halemaumau resulted during February in aggregate movement as follows:

Week ending forenoon of:

February 4 (5 days only), 28 locations, 7 opened, 2 closed, opening 2.5 mm.

February 11, 28 locations, 9 opened, 1 closed, opening 6.0 mm.

February 18, 28 locations, 11 opened, none closed, opening 10.0 mm.

February 25, 28 locations, 14 opened, 1 closed, opening 9.5 mm.

T.A.J.

SEISMOLOGICAL DATA

Earthquakes

Week Ending	Minutes of Tremor	Very Feeble Earthquakes	Feeble Earthquakes	Moderate Earthquakes	Distant† Earthquakes	Weekly* Seismicity
February 6	27	10	0	0	2	11.75
" 13	32	4	0	0	0	10.0
" 20	39	13	1	2	0	23.25
" 27	28	9	1	0	0	12.50

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

January 31, 3:57 pm, very feeble, located approximately 5.0 miles ENE summit of Hualolai at a depth of 29.0 miles. 19° 43.3′ N; 155° 47.5′ W.

February 1, 8:43 am, very feeble, probably located in Kilauea SW rift zone.

February 1, 5:44 pm, very feeble, probably originated in Chain of Craters to SE of Kilauea Crater.

February 3, 12:23 am, very feeble, 0.6 mile deep in Kilauea Crater 0.6 mile NE of Halemaumau. 19° 24.7′ N; 155° 16.4′ W.

February 3, 7:09 am, very feeble, probably originated in N portion of Kilauea Crater.

February 6, 8:05 pm, very feeble, 25.0 miles deep, 7.0 miles NW of Humuula. 19° 45.5′ N; 155° 32.8′ W.

February 6, 10:14 pm, very feeble, 11.0 miles deep, 2.0 miles SE of Kilauea Crater. 19° 23.5′ N; 155° 15.5′ W.

February 7, 11:10 pm, very feeble, 1.1 miles deep near center of Kilauea Crater. 19° 25.1′ N; 155° 16.6′ W.

February 8, 2:07 am, very feeble, 35.0 miles deep and 3.5 miles NW of summit of Hualalai. 19° 44.2′ N; 155° 53.3′ W.

February 8, 8:20 pm, very feeble, 1.2 miles deep, SE rim of Kilauea Crater, 1.2 miles E of Halemaumau. 19° 24.5′ N; 155° 15.9′ W. Report felt at CCC Camp (old).

February 9, 1:07 pm, very feeble, 1.5 miles deep SE portion Kilauea Crater. 19° 24.2′ N; 155° 16.2′ W.

February 14, 10:15 pm, very feeble, 3.3 miles deep 0.3 mile N of Puhimau Crater. 19° 24.1′ N; 155° 15.0′ W.

February 15, 10:13 am, very feeble, probably originated in Kilauea Crater near NE rim.

February 16, 3:54 pm, very feeble, 2.0 mile deep in SW portion of Kilauea Crater near SW edge of Halemaumau. 19° 24.6′ N; 155° 17.3′ W.

February 17, 2:18 am, moderate, 8.0 miles deep in NE rift zone, Mauna Loa near Puu Ulaula. 19° 33.0′ N; 155° 27.0′ W. Dismantled seismographs at Observatory and Pit, reported felt strongly in Kona and in Hawaii National Park. Felt slightly by many in Hilo.

February 17, 2:38 am, very feeble, 7.0 miles deep, Mauna Loa NE rift. 19° 32.0′ N; 155° 26.6′ W.

February 17, 4:05 am, very feeble, 1.3 miles deep in Kilauea Crater, near N rim of Halemaumau. 19° 24.9′ N; 155° 17.1′ W.

February 17, 8:41 am, very feeble, 2.0 miles deep near Keauhou Ranch House, 1.3 miles N by E of Uwekahuna. 19° 26.5′ N; 155° 17.1′ W.

February 18, 11:22 am, very feeble, of shallow origin in area between Keanakakoi and Lua Manu Crater. 19° 24.2′ N; 155° 15.7′ W.

February 18, 1:18 pm, very feeble, 2.0 miles deep near center Kilauea Crater. 19° 25.1′ N; 155° 16.4′ W.

February 18, 10:53 pm, moderate, 0.5 mile deep in E portion of Kilauea Crater. 19° 24.9′ N; 155° 15.9′ W. Felt only locally in Hawaii National Park near Kilauea Crater.

February 19, 3:15 am, very feeble, probably originated in NE portion of Kilauea Crater.

February 20, 1:37 am, feeble, 3.5 miles deep under SE portion of Kilauea Crater. 19° 24.4′ N; 155° 16.1′ W.

February 21, 3:45 am, feeble, 2.0 miles deep SE portion of Kilauea Crater. 19° 24.1′ N; 155° 16.0′ W.

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

February 23, 1:23 pm, very feeble, probably originated NE portion of Kilauea Crater.

February 24, 2:19 pm, very feeble, probably originated near center of Kilauea Crater.

February 25, 6:00 am, very feeble, "P" lost in hour mark on Observatory record. No definite location but apparently of Hualalai origin. Reported felt in Kona.

February 26, 9:16 am, very feeble, of Kilauea origin.

February 26, 4:35 pm, very feeble, of Kilauea origin.

At 8h 46m 07s am, HST February 1, the "P" waves of a teleseism began to record at the Observatory. Distance from Kilauea 5,150 miles. Reported location was west of Aru Island in Banda Sea region of the Malay Archipelago, 4.0° S; 132.50 E. Another teleseism began to register at 4h 5m 27s pm HST, February 4. Distance undetermined.

Microseismic motion of the ground at the Observatory was moderate February 2, 3, 12, 13, 14, and February 21; strong the remainder of the month.

Tilting of the ground

The following tables show tilt by weeks as recorded by the Observatory seismograph, and at Halemaumau the algebraic sum of radial tilt toward or away from the Pit.

At the Observatory the total accumulated tilt for the year ending February 27, was 3.76" S and 3.91" W.

Week Ending	Observatory	Halemaumau West Station
February 6	2.06" S 54° W	1.82" N 2° W
February 13	1.83" S 44° W	4.38" N 10° E
February 20	0.85" S 49° W	5.00" S 65° W
February 27	2.68" S 53° W	14.75" N 61° W

Week Ending	Halemaumau Southeast Station	Halemaumau Resultant
February 6	5.90" N 54° W	4.02" Toward
February 13	3.95" S 70° W	2.17" Toward
February 20	6.42" N 51° W	8.19" Toward
February 27	2.14" N 72° W	10.28" From

Crater Angles

Measurement of horizontal angles across Kilauea Crater from the Observatory February 21, indicated no change in the Halemaumau value and slight closing of the Crater value compared with similar measurements of January 11. The Halemaumau measurement from the SE Pit B. M. to NW Pit B. M., showed opening of 1.42", January 11 to February 3 but closed 1.42" between February 3 and February 21 for a total no change. The Crater measurement from the SE rim to Uwekahuna showed a closing of 0.17" January 11 to February 3 and closing of 0.67" February 3 to February 21. Total closing 0.84".

H.H.W.

HAWAIIAN VOLCANO RESEARCH ASSOCIATION

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THE VOLCANO LETTER

No. 457 monthly **Department of the Interior** **National Park Service** **March 1938**

Hawaii National Park
Edward G. Wingate Superintendent

Hawaiian Volcano Observatory
T. A. Jaggar Volcanologist

Slides at Waikane bridge, Hana belt road.

THE MAUI EARTHQUAKE OF JANUARY 22, 1938

On the evening of January 22, 1938 at about 10:03 a moderate to strong earthquake registered on all the seismographs operated by the Hawaiian Volcano Observatory. The Hilo and Kona seismographs apparently dismantled at the arrival of the first impulse of the secondary waves. The instrument at the SE rim of Halemaumau as well as that at Uwekahuna NW rim of Kilauea Crater were dismantled shortly after the preliminary waves had started to register. At the Observatory the Bosch-Omori seismograph was dismantled within a few seconds after the beginning of the preliminary wave registration as was the vertical motion instrument. The only instrument to receive a complete record of the quake was the low magnification instrument at the Volcano Observatory, NE rim of Kilauea Crater. The latter was specifically designed and built in the Observatory shops to register local shocks of strong intensities. It magnifies ground movement about eleven times.

The earthquake was classified as a near shock which includes those from 100 to 750 miles distant. It was felt throughout the Hawaiian archipelago and registered on seismographs as far away as Fordham University in New York City. In this respect it differed from the usual quakes so common in the Territory, and particularly on the Island of Hawaii, which seldom are felt more than a few miles from their point of origin and practically never register off the island on which they occur. Inasmuch as there are at least three volcanoes on the Island of Hawaii which are considered active, earthquakes there of varying intensities and of almost daily occurrence, are expected and do occur. On the other islands, earthquakes though comparatively rare, are not uncommon.

The January 22 earthquake was an exception: it definitely was not located on the Island of Hawaii. It was felt about equally on Oahu and Hawaii. The Island of Kauai was apparently least disturbed, although it was reported as being the strongest ever felt there by older residents. All indications, both instrumental and by reports, were that the center of the disturbance was in the vicinity of the Island of Maui. The exact center was difficult to locate because of the disruption of seismographs and somewhat misleading observations received from persons near the epicenter. The final location, as determined by the Observatory, by the Coast and Geodetic Survey and by the Jesuit Seismological Association is in very close agreement. Taking an average of these determinations, the epicenter would be located in the ocean about eighteen miles north of Pauwalo Point on the Island of Maui.

First reactions of some of the Oahu residents were interesting. Felt quakes in Honolulu are comparatively rare and the people of that city are inclined to overlook the fact that they most certainly live in a region where earthquakes are assured, and that strong ones may occur at any time. Consequently when this shock was felt no one suspected that such a thing as an earthquake could possibly be centered nearer Honolulu than to Kilauea Volcano on the Island of Hawaii. Consequently, the radio stations and telephone communications between the Islands were busy with calls from Honolulu trying to find out whether the "Big Island" had been completely blown off the map or had sunk into the sea. Their first thought was that if the shock was that strong in Honolulu, it must be terrific on Hawaii. The Observatory was swamped with calls from all directions. It is suspected that there was a tinge of disappointment from those elsewhere who discovered that on this island the earthquake not only had been of relatively moderate intensity but that most of the people seemed actually to have enjoyed it.

REPORTS FROM THE SEVERAL ISLANDS

Kauai:

Reported as severest quake in memory of older residents. Felt as two separate shocks resulting in some minor damage to some household articles.

Oahu:

Because of the early hour at which it occurred most of the people apparently felt the earthquake. A great deal of excitement resulted. Hotels and theaters were filled with people; at the Alexander Young Hotel elevators stuck, dancers on the roof were forced to scurry down the stairs, orchestras continued to play while entertainers went on with their performances. There was a rush from all the downtown theaters. The Waikiki Theater was completely emptied in a few minutes. The excitement of persons downtown was shared by those in private homes who rushed from their houses to see what had occurred. Residents of Manoa Valley reported three separate shocks, at 10:03, five minutes later, and a third shock at 10:23. A check by the County police division showed that no bridges nor roads had been damaged, no highways blocked, though apparently 40 rocks rolled on the Kamehameha highway at Kipapa Gulch. The largest was about two feet in diameter. One automobile was damaged when it struck a rock in the road, but there were no injuries. At the Oahu Prison a four pound strip of ceiling fell in one cell. Preparations were made for the removal of prisoners if the tremor continued. However, no damage apparently was done to either telephone or power lines. Damage on Oahu seemingly was limited to breakage of crockery and glassware. Hanging objects swung from the ceilings and some small articles were knocked from shelves.

Molokai:

The quake here opened cracks between two and three inches in width and twenty five to one hundred feet in length on the east Molokai road at Mapulehu. From Ohia to Mapulehu stone walls collapsed, otherwise damage was confined to crockery and other household possessions.

Lanai:

A radiogram received at the Observatory from the manager of the Pineapple Company on Lanai, stated that "the quake did no damage to the reservoir or water development project. There was a two inch crack in the breakwater twenty feet leeward of the light, accompanied by slight settling. The pipe lines of the Maunalei Gulch above and below the pumphouse were broken in several places by falling rocks. There was no damage to pipes running over palis to the reservoir. Slight damage occurred to plumbing in houses. In stores some supplies were thrown on the floor. A crack 10 feet wide and 15 feet deep was reported in the Maunalei region."

Maui:

The north coast of East Maui was probably the hardest hit of any portion of the Territory. There the earthquake took no toll of life, and resulted in few injuries, but inflicted considerable property damage throughout Maui's most isolated communities. Two large oil tanks owned by the Standard Oil Company were lost. Both tanks, containing diesel oil and kerosene respectively, were shattered. Thirty thousand gallons of the oil flowed into the nearby sea from the damaged tanks. The little town of Hana, Maui, was completely blocked by road slides between Paliku and Hana. The worst landslide was at Waikane. The Kaupo-Kieahu trail was blocked by bad landslides. The Keanae stone crusher was completely covered by a landslide. The powerhouse of the Kaeleku Sugar Company was thrown out of commission. Immediately following the quake Hana was without lights for fifteen minutes. Ranches in southern Maui suffered heavy damage as water tanks and stone walls were razed by the quake. Mr. H. A. Baldwin of the Maui Agricultural Company, Ltd. reports as follows:

"Your letter of the 4th inst. to hand some time ago and I apologize for not replying sooner; however, I have not yet been able to learn definitely just what happened on Kahoolawe during the earthquake. I hope to get this information within a few days and will write you again. I know there was considerable of a shake up as a watertank on the northern coast of the Island, which was set on a comparatively solid foundation, was turned over. I think part of the foundation was built of loose rocks.

"You say you wish to know if Pauwela or Kahoolawe got the severest shock. I think the idea that Pauwela experienced more of a shock than other portions of Maui is erroneous. Certainly the greatest damage in the way of slides on gulch sides and road cuts was east of Pauwela. The country from Kailua on to Nahiku received what was apparently a very much heavier shock than at any time during my life, which goes back 67 years. The road has not yet been fully opened up and there were numerous slides blocking up our ditches for considerable distances up the gulches."

Concrete buildings in Lahaina were cracked. A landslide broke the intake pipe near the Lahaina River and flumes were used Sunday to carry water from the stream to the old intake. Storage tanks between Wailuku and Kahului were damaged. Kahului was without water for a brief period. At Wailuku the Hollister drugstore, the Kress store, and the Courthouse showed some damage to the interiors of the three buildings. Walls of the Kahului Theater were cracked by the quake, while the fire station tower was moved one-half inch. According to Mr. Edgecomb of the US Lighthouse Service mercury was thrown from the floats of the revolving mechanism of some of the big lighthouses on Maui. District Ranger Peck of the Hawaii National Park stationed at Haleakala on Maui reported as follows:

"The earthquake that occurred on the evening of the 22nd jarred many tons of rocks into the road, several of them very large, and a number of small cracks appeared in the pavement. Fortunately the road was not completely blocked and by noon today we had it cleared enough to make it safely passable.

"I think we can clear the road in a reasonable length of time with the one man I have for help, provided mother earth does not soon decide to go into another dance.

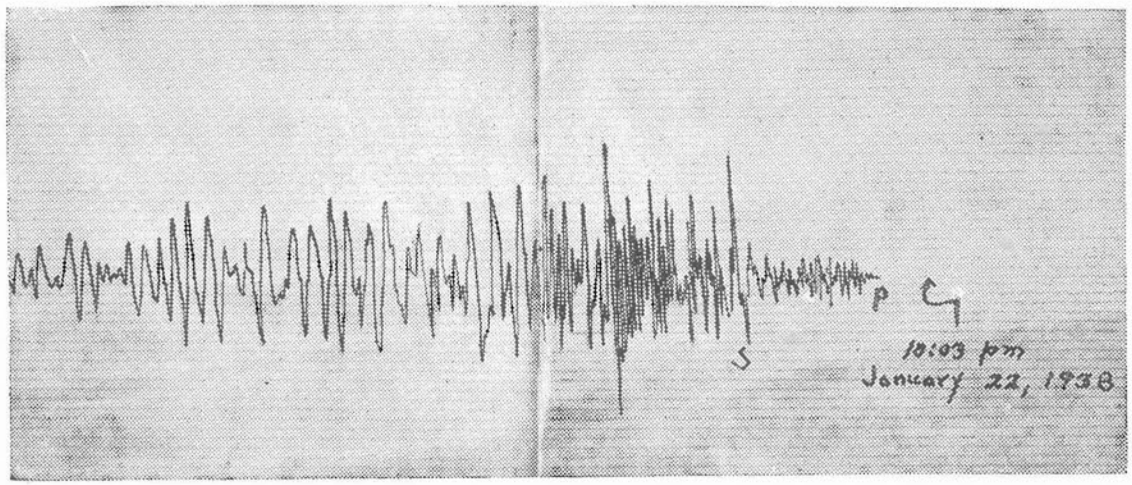
"I have not yet had time to inspect the Halemauu trail, which I fear may be in bad shape. I will inspect it very soon and report.

"No apparent damage was done to any of the buildings. Numerous cracks appeared in the road below the park area, some of them one and one half inches wide."

Communication with the town of Hana was completely severed, for several days. The only communication was by way of observation from an airplane which was chartered in Honolulu.

Hawaii:

Compared with the residents of the other islands, those on the Island of Hawaii were quite calm. The shock was felt by most people but was no greater in intensity in most parts of the island than shocks which commonly occur here. At first Mauna Loa or Kilauea were thought to be responsible for this earthquake. Examination of the records at the Observatory, however, changed that opinion and by the next morning the evidence indicated a near shock 100 miles or more from Kilauea. Throughout this island the earthquake motion was apparently of a slow, swaying type. Concensus of opinion expressed by residents throughout the Big Island was that the quake, while one of the longest ever experienced, was not as severe as some of the big shocks of 1929, which climaxed the series of earthquakes, apparently centered under the Hualalai district. Certainly the intensity of this quake was not as great as that recorded June 28, 1935, when stone walls in Hilo were cracked, nor was this quake as great in intensity on the records of the Volcano Observatory as that of 11:58 p.m. the night of September 30, 1935. Reports indicate that the shock was strongly felt in the Kohala district and gradually became less intense toward the southern tip of the Island of Hawaii. In Kohala, dishes were broken in many homes throughout the district. Pictures were knocked from walls, chandeliers crashed to the floor and furniture was generally disarranged. Small landslides occurred along the Kohala Mountain road. The shock was likewise strongly felt along the Hamakua Coast district. At the home of George Becker in Honomu many dishes were broken when china cabinets swayed and their contents crashed to the floor. At the home of John M. Ramsay, Manager of the Honomu Plantation, a large crack appeared in the ceiling going straight through the house from front to back. Despite the severity of the shock, there was no panic in any section of the island. In Hilo, people were awakened and ran from their homes but the excitement soon subsided. It appears to have been most strongly felt in the Pueo district, which usually reports earthquakes as stronger than in other sections of town. In that area some homes reported that stoves and iceboxes were moved as much as two or three inches from their original positions.

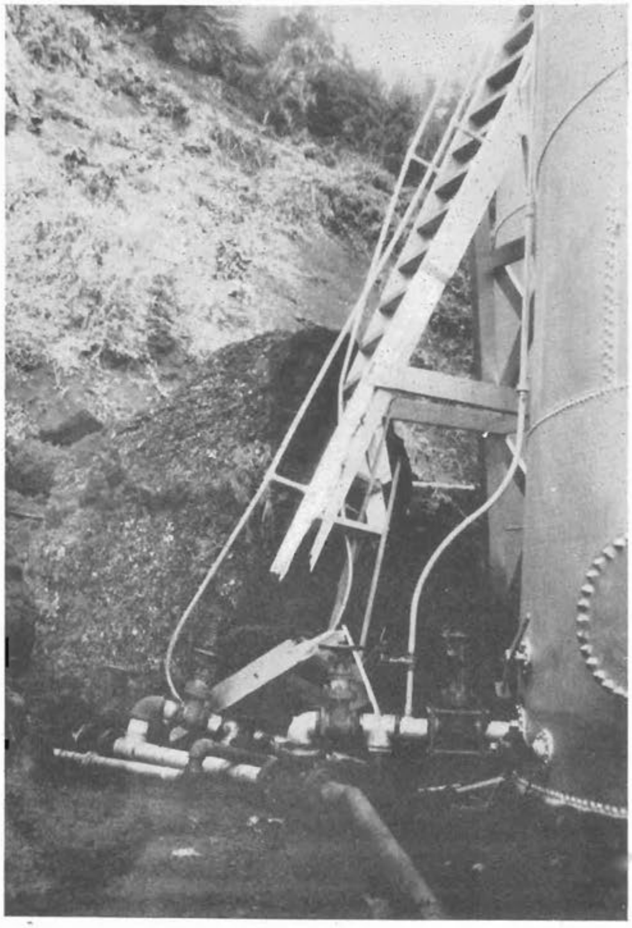


This seismograph record shows plainly the vibrations set up by the earthquake of January 22nd, 1938. Reading from right to left—note the normal line at the right, the intensification of the record and then the still disturbed line which shows that tremors were running through the earth long after they could be felt by human beings.

Location of the Epicenter by Seismograms

Only one complete record of the earthquake was available for study. That record was the one from the low magnification instrument located at the Hawaiian Volcano Observatory, NE rim of Kilauea Crater. Partial records were available from the US Coast and Geodetic Survey seismograph located at the University of Hawaii in Honolulu, and instruments operated by the Volcano Observatory in Hilo, Kealakekua, Uwekahuna Bluff (Kilauea Crater), SE rim of Halemaumau, the Bosch-Omori at the Observatory and a vertical component instrument also at the Observatory. All of these were dismantled at either the beginning of the preliminary phases or a few seconds afterward. The Hilo and Kona instruments apparently dismantled with the first impulse of the secondary phase.

The location was made from azimuths determined by the first impulses of the preliminary waves on the several seismograms and from Hawaiian travel times compiled by Mr. A. E. Jones, formerly of this organization. Also available was the preliminary arrival time at the Honolulu station, which is in charge of Commander J. H. Peters, who is making an intensive study of all phases of the earthquake. Assembly of all the information available resulted in a comparatively reliable location although considerable checking and rechecking of the data was necessary to attain this end. First reports from the Volcano Observatory placed the disturbed area 154 miles N, 55° W of Kilauea. The distance was determined by the S-P interval of 22.8 seconds from the low magnification record and the azimuth indicated by the Bosch-Omori instrument to the same location. From these data the epicenter was tentatively placed at a point in the sea 20 miles S of Palaoa Point, Lanai. Comdr. Peters in Honolulu, using the first impulse time value at the University of Hawaii in conjunction with that at the Observatory, made his preliminary location at a point off the South Point of Maui, Cape Hanamanioa. The preliminary waves began to register at Kilauea at 10h 03m 20s p.m. HST; at the University of Hawaii at 1h 03m 15s p.m. HST. Using these two time values the location was definitely on a line running roughly



Boulder which hit S. O. Co. tanks at Hana in slide from north slope of Kauiki hill.

NE-SW through the western portion of Kahoolawe and Pauwela Point, Maui. On the basis of direction determined from the Bosch-Omori instrument the quake was thought to be about sixty or seventy miles deep and in the vicinity of the channel between Maui and Kahoolawe.

When seismograms from Kona, Hilo and other stations around Kilauea were examined directions did not agree with those of the Bosch-Omori. Macroseismic reports likewise did not agree completely with the preliminary location. Directions from all the stations except the Observatory converged on a general locality to the north of Pauwela Point north of Maui. The directions were:

Volcano Observatory	N 55° W
Pit Seismograph	N 24° W
Uwekahuna	N 23° W
Hilo	N 28° W
Kealakekua	N 3° W

Meanwhile, it appeared that the Hilo and Kealakekua instruments had not dismantled until the beginning of the secondary phase. On this assumption the graphical method of Isikawa was applied to the three stations, Hilo, Kealakekua and Volcano Observatory, using the Jones travel times for the S-P values determined. More careful study placed the Bosch-Omori S-P value at 22.3 seconds. The resulting location agreed roughly with directions indicated above, omitting the Observatory. A depth of 65 miles was indicated. This was the final location as determined from the Observatory (See Volcano Letter 455, January 1938). The epicenter thus determined was a point 25 miles N of Pauwela Point, Maui, 21° 12′ N; 156° 06′ W. By other methods Commander Peters had arrived at approximately the same location. The final computations from completely assembled data of local as well as distant stations places the epicenter at the above value. Time of origin was 10h 03m 08s p.m. HST.

Rossi-Forel Intensity values for a few localities on the Island of Hawaii were

Kilauea	IV
Kealakekua	IV-V
Puu Waawaa	VI
Hookena	IV

Kohala—probably same as Puu Waawaa

Excerpts from the Volcano Observatory Record Book:

Bosch-Omori

Period	Trace Amplitude	Phase	*Time (HST)
0.2	— 0.3 mm	i P ENZ	10:03: 20.0 p.m.
	+ 0.2		
0.7	— 4.0	i E	10:22: 07.0 } Dismantled
	+ 2.0		
	+ 90.0	i N	11:23: 07.0

* Ten and one half hours behind Greenwich Time.

Low Magnification Instrument

		i PEN	10:03: 20.0 pm
		i SEN	10:03: 42.3
		f N	03: 53.3
0.9	—20.0 m		
	+ 11.0	i ME	04: 05.0
	— 9.0		
	—19.0	i MN	04: 15.4
		F E	10 42±

Some of the local residents thought this was probably the heaviest earthquake in 20 years. Dr. Jaggar has gone over the records since 1912 and has compiled the following list of near shocks showing that their occurrence has been relatively frequent.

Quakes—Hawaiian Volcano Observatory—150 to 500 Km

1912—Oct. 13, record imperfect
Dec. 5, 279 miles
1913—July 31, 136 miles
1914—Mar. 30, 93 miles
Aug. 8, 140 miles

1916—June 6, 93 miles
June 7, 125 miles
July 23, 140 miles
1918—June 14 ..? Felt Maui?
Nov. 2 ? Felt Maui
1919—Jan. 29, 177 miles, felt in Honolulu.
Sept. 14 ? Maui?
Sept. 18 ? Felt Maui?
1920—Mar. 30, 33 miles, felt Maui?
May 15, 60 miles, felt Maui? and Honolulu.
1923—Dec. 25 ? Felt Lanai, Maui, Honolulu and Molokai.
1926—Mar. 19, 124 miles, felt Maui and Honolulu. Mauna Loa eruption came April 10.
1927—Mar. 20, 110 miles from HVO. 4:52 a.m. Seismogram illustrated Fig. 14. Bulletin March, 1927. Felt in all Hawaiian Islands.
Aug. 3, felt in Honolulu? 9:42 a.m., moderate.

Hawaiian Volcano Observatory Report for March 1938

VOLCANOLOGY

The month at Kilauea Volcano showed decline in seismicity and opening of cracks, but some increase of slides during the last two weeks. The following are the weekly Observatory totals for Halemaumau and the seismographs.

Week Ending	Seismicity	Slides	Crack Openings	Local Tremors and Quakes
March 6	27.50	0	6.5 mm.	62
" 13	11.50	1	15.0 mm.	40
" 20	4.75	0	7.0 mm.	11
" 27	11.50	10	7.0 mm.	39
April 3	5.50	4	3.0 mm.	20

Crack in Wailua pali road above Keanae flats.

The writer has examined the records of the ones of March 1926 and 1927. They are in many respects similar to that of January 22, 1938. Their distances of 124 and 110 miles respectively would be correct for East Maui with Haleakala in mind.

It is very definitely a mistake to think that earthquakes are unlikely in other parts of Hawaii. The imposing list shown here is proof that they can and may occur at frequent intervals. Their intensity is unpredictable and consequently it would be well to take that into consideration in discussing constructional developments in the Hawaiian Islands.

Twenty-seven of the measured shocks were of Kilauea origin, four were of Mauna Loa, and four were from beyond Mauna Loa. A moderate felt shock of Kilauea origin occurred February 28, slight felt shocks occurred March 2 and 7, the first under Kilauea Crater, and the second a deep source under Kilauea.

Distant earthquakes were registered March 22 and 25, this occurrence just after equinox being usual.

Sequence of Events by Weeks

The first week produced nothing of importance except that the tilt at Halemaumau continued to be away from the pit. This tendency lasted until March 20, and with it the Observatory cellar began to show northeasterly tilts. The second week there were some sliding and increased opening of cracks. The third week was quiet. The fourth week showed notable increase of slides, and just after the equinox the tilt at the Halemaumau cellars turned inward. The fifth week was quiet.

Slides at Halemaumau

The recorded slides from the wall of the pit were:
March 8, 4:34 p.m., small slide NE wall.
March 22, 10:19 a.m., slide heard from W cellar.
March 22, 10:30 a.m., slide from N wall.
March 25, 10:23 a.m., small slide N wall, from near bottom.
March 25, 10:55 a.m., dust cloud from W wall.
March 25, 11:03 a.m., dribble of rock, N wall.
March 25, 11:06 a.m., dust above W wall.
March 25, 11:11 a.m., dust over W wall.
March 25, 11:20 a.m., dribbling of rock N and W wall.
March 25, 3:15 and 4:15 p.m., dust above N wall.
March 26, 10:20 p.m., noise of slide in pit.
March 29, 1:25 p.m., noise below W rim.
March 29, 2:20 p.m., noise from N wall.
March 30, 9:25 a.m., noise of slide NE and NW walls.
March 30, 5:43 p.m., dust cloud over NE rim.

Measurement of Halemaumau Rim Cracks

Weekly measurement of rim crack locations resulted during March in aggregate movement as follows:

Week ending forenoon of:

March 4, 28 locations, 10 opened, 2 closed, opening 6.5 mm.

March 11, 28 locations, 15 opened, 0 closed, opening 15.0 mm.

March 18, 28 locations, 10 opened, 1 closed, opening 7.0 mm.

March 25, 28 locations, 11 opened, 0 closed, opening 7.0 mm.

April 1, 28 locations, 6 opened, 1 closed, opening 3.0 mm.

T.A.J.

SEISMOLOGICAL DATA

Earthquakes

Week Ending		Minutes of Tremor	Very Feeble Earth-quakes	Feeble Earth-quakes	Slight Earth-quakes	Moderate Earth-quakes	Distant† Earth-quakes	Weekly* Seis-micity
March	6	52	13	3	1	1	0	27.50
"	13	16	5	2	0	1	1	11.50
"	20	11	4	0	0	0	0	4.75
"	27	32	7	0	0	0	2	11.50
April	3	18	2	0	0	0	0	5.50

* Including teleseisms or earthquakes of over 5000 km from Kilauea.

† For local seismicity definition see Volcano Letter 371.

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

February 28, 5:44 pm, very feeble, 2.1 miles deep in Kilauea Crater 0.6 mile E of Halemaumau. 19° 24.6′ N; 155° 16.2′ W.

February 28, 9:40 pm, moderate, dismantled both components of Observatory seismograph and felt at Hawaii National Park Headquarters area; 2.8 miles deep in Kilauea Crater near N rim of Halemaumau. 19° 24.8′ N; 155° 17.1′ W.

March 1, 7:58 am, very feeble, 2.4 miles deep in Kilauea Crater 0.4 mile NE of Halemaumau. 19° 25.0′ N; 155° 16.7′ W.

March 1, 1:20 pm, very feeble 1.0 mile deep near center of Kilauea Crater. 19° 24.9′ N; 155° 16.5′ W.

March 1, 1:48 pm, feeble, 1.6 mile deep under Byron Ledge, E rim of Kilauea Crater. 19° 24.8′ N; 155° 15.7′ W.

March 1, 2:40 pm, very feeble, 1.0 mile deep in NE portion of Kilauea Crater. 19° 25.4′ N; 155° 15.8′ W.

March 1, 6:24 pm, very feeble, 1.3 mile deep SE rim area of Kilauea Crater. 19° 24.4′ N; 155° 15.4′ W.

March 1, 7:29 pm, feeble, 2.1 miles deep in Kilauea Crater 0.6 mile E of Halemaumau.

March 1, 9:52 pm, very feeble; of Kilauea Crater origin.

March 1, 10:50 pm, very feeble, of Kilauea Crater origin.

March 2, 3:16 am, slight, 2.7 miles deep, Chain of Craters rift near Kokoolau Crater. 19° 21.9′ N; 155° 15.1′ W.

March 2, 4:22 am, very feeble, 1.3 mile deep SE rim area of Kilauea Crater. 19° 24.4′ N; 155° 15.4′ W.

March 3, 3:47 am, of shallow origin probably near center of Kilauea Crater.

March 3, 5:13 am, feeble, probably originated near SE rim of Kilauea Crater in vicinity of Keanakakoi.

March 3, 6:00 am, very feeble, probably originated in NE portion of Kilauea Crater.

March 4, 5:53 am, probably of Kilauea origin.

March 7, 12:04 am, very feeble, 30.0 miles deep in saddle between Mauna Loa and Mauna Kea. 19° 43.0′ N; 155° 27.0′ W.

March 7, 5:56 am, moderate, 28.0 miles deep, Mauna Loa NE rift about 8.0 miles SW of Hilo. 19° 42.0′ N; 155° 32.0′ W. Reported felt by many in Hilo, Kona and Hawaii National Park.

March 8, 4:05 am, feeble, probably of Kilauea origin.

March 8, 4:06 a.m., very feeble, of shallow origin in Kilauea Crater.

March 10, 4:15 am, very feeble, probably originated in NE portion of Kilauea Crater.

March 10, 6:42 am, feeble, probably originated near Halemaumau in Kilauea Crater.

March 15, 1:30 am, very feeble, originated in NE portion of Kilauea Crater.

March 15, 11:12 am, very feeble, 1.5 miles deep, Kilauea Crater 0.8 mile E of Halemaumau. 19° 24.7′ N; 155° 16.3′ W.

March 20, 11:00 am, very feeble, 20.0 miles deep under Mauna Loa summit Crater. 19° 27.0′ N; 155° 37.0′ W.

March 21, 10:02 am, very feeble, probably originated near Halemaumau in Kilauea Crater.

March 25, 6:14 pm, very feeble, probably originated in Mauna Loa SW rift.

March 26, 9:12 pm, very feeble, of Hualalai origin. Windows reported to have rattled in building in Hookena.

March 31, 9:05 am, very feeble, probably originated in Mauna Loa NE rift.

April 3, 2:56 pm, very feeble, 4.0 miles deep, 1.7 miles NW of Kilauea Crater in vicinity of Kipuka Puaulu. 19° 26.1′ N; 155° 18.7′ W.

Teleseisms were:

March 7, 7h 30m 06s pm HST, beginning of unidentified portion.

March 22, 5h 5m 34s am, HST, beginning of secondary wave recording. Location by reports from U. S. Coast and Geodetic Survey, 53° N; 131°8 W, in vicinity of Queen Charlotte Island, Southern Alaska.

March 25, 5h 36m 35s am, HST, beginning of unidentified portion.

Microseismic motion of the ground at the Observatory was:

Light, March 20, 22 and 23.

Moderate, March 4, 5, 6, 7, 12, 13, 14, 15, 16, 21, 31. April 1 and 2.

Strong, the remainder of the month.

Tilting of the ground:

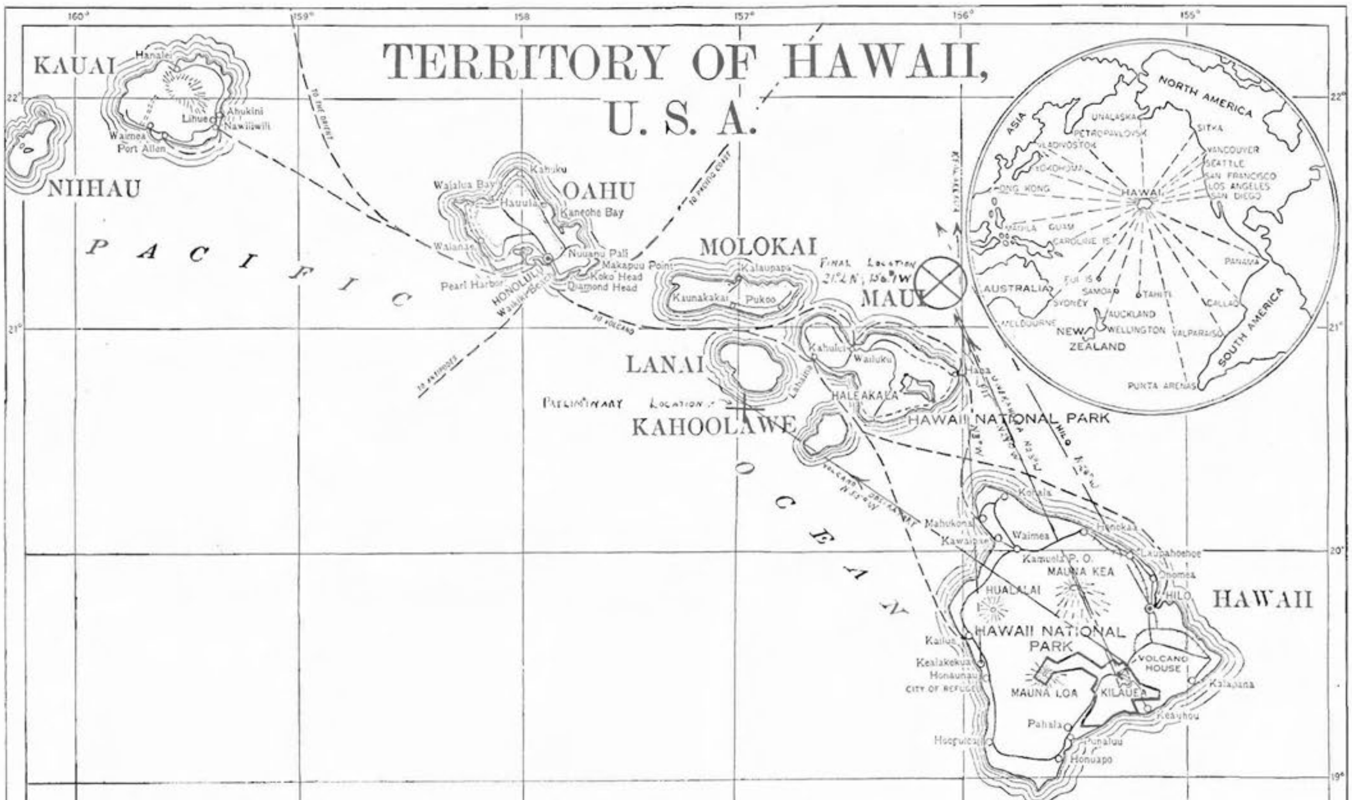
The following tables show tilt by weeks as recorded by the Observatory seismograph and at Halemaumau, the algebraic sum of radial tilt toward or away from the Pit:

At the Observatory the total accumulated tilt for the year ending April 3, was 3.64"S and 4.42"W.

Week Ending	Observotory	Halemaumau West Station
March 6	1.81" S 27° W	9.54" N 85° W
March 13	1.40" N 66° E	5.90" S 74° W
March 20	0.66° S 75° W	5.90" N 80° W
March 27	1.52" S 55° W	3.07" N 12° W
April 3	0.20" N 40° E	4.17" N 80° W

Week Ending	Halemaumau Southeast Station	Halemaumau Resultant
March 6	2.59" S 79° W	8.94" from
March 13	6.48" N 29° W	0.51" toward
March 20	2.33" S 22° W	6.79" from
March 27	5.18" N 24° W	4.72" toward
April 3	7.52" N 13° W	2.78" toward

H.H.W.



EPICENTRAL LOCATION OF EARTHQUAKE OF JANUARY 22, 1938.
(Pointers indicate directions from various seismograph stations on Island of Hawaii.)

HAWAIIAN VOLCANO RESEARCH ASSOCIATION

The Hawaiian Volcano Research Association was founded in 1911 for the prosecution of volcano research, more particularly in the Hawaiian Islands and around the Pacific Ocean. Its laboratory at Kilauea Volcano, Hawaii, is leased and operated by the United States Government, Department of the Interior, National Park Service. The Association maintains seismograph stations at various places on the Island of Hawaii and supplements the work of the Government with buildings, research fellows, instrumental plants, explorations and special investigations for which there is no governmental provision.

The Volcano Letter, a monthly, eight-page, illustrated publication dealing with volcanic and seismic interests in Hawaii, the Pacific area, and other sections of the world, is issued by authority of the Department of the Interior, and is supplied free of charge to members of the Association and to a restricted exchange list. It is non-technical in nature and promotes popular interest in its particular field of science.

The Secretary of the Association is Mr. L. W. de Vis Norton, whose address is 320 James Campbell Building, Honolulu, T. H. Contributions of articles, photographs, publications and clippings about volcano and earthquake events, instruments and investigations are always welcome, and if suitable, will be published with due acknowledgment.

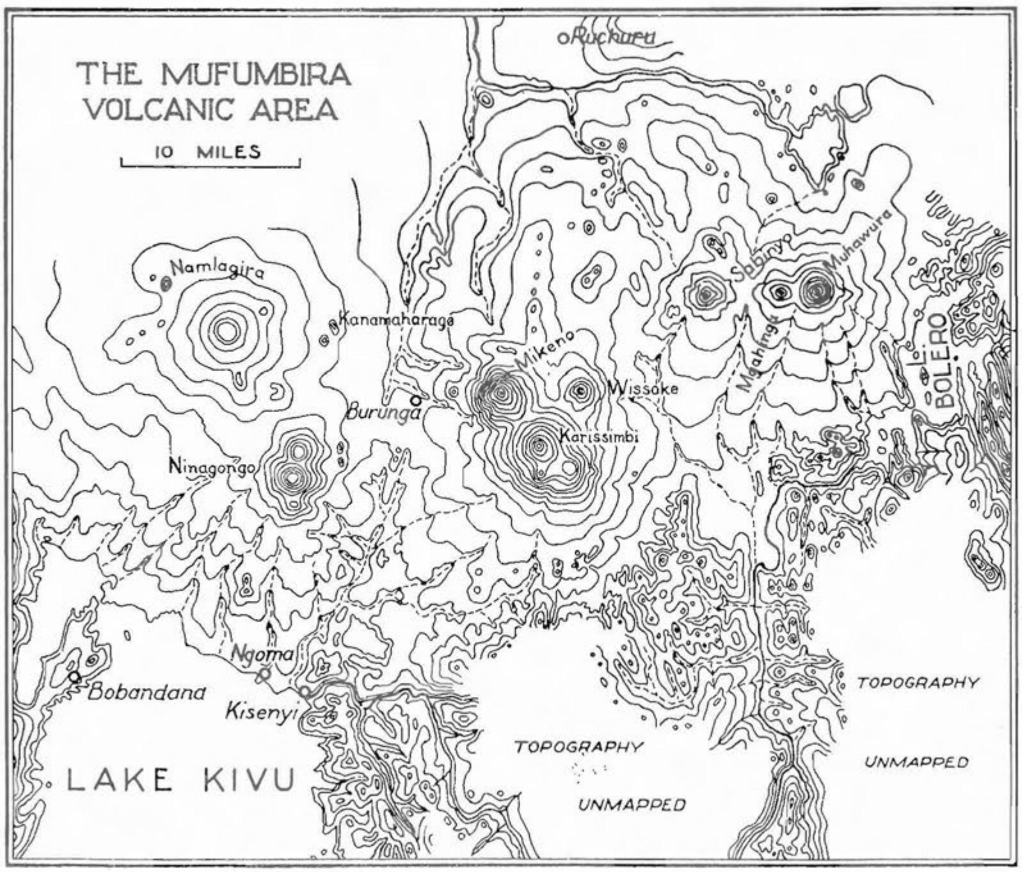
THE VOLCANO LETTER

No. 458 monthly   Department of the Interior   National Park Service   April 1938

Hawaii National Park
Edward G. Wingate Superintendent

NE PLUS HAUSTAE AUT OBRUTAE URBES

Hawaiian Volcano Observatory
T. A. Jaggar Volcanologist



Map of Virunga or Mufumbiro Volcanoes (after Bowen).

EXCURSION TO NYAMLAGIRA VOLCANO, VIRUNGA OR MUFUMBIRO RANGE, PARC NATIONAL ALBERT

By P. PHILIPPSON
(Translated by Jaggar)
(Bulletin de Club Alpine Belge Sept.-Dec. 1934, p. 137)

In order to reach Lake Kivu in coming from the north by the mail route of Rutshuru the automobile road crosses the Virunga volcanic belt, passing between imposing profiles of the extinct volcanoes Mikeno (4,437 meters) and Karisimbi (4,506 meters) on the East; and the active volcanoes Nyamlagira (3,058 meters) and Niragongo (3,470 meters). The most active unit and doubtless the most recent of the whole group is Nyamlagira, situated about 15 kilometers from the route that we leave, when an hour's march south from the Mission of Tongres-Ste-Marie, in order to enter upon a pilgrimage across a plain of lava of more or less ancient origin. The most recent fields of lava were crossed first showing a vegetation of ferns and shrubs growing in the crevices of the rock, whereas on the flank of the mountain proper the very old age of the lava flows shows decomposition with the formation of soil and development of forest.

Nyamlagira is a dome, shaped like a turtle back, and is thereby distinguished from the other volcanoes of the chain, some of which are pointed (Karisimbi) or truncated cones (Niragongo) and others have peaks of jagged rock (Mikeno and Sebinyo). There are fresh tracks of herds of elephants; pigeons flap their wings on all sides, brilliantly colored butterflies flit about the undergrowth or are abundant on the orchids that are both terrestrial and aerial. One of the most remarkable kinds is an orchid possessing a white flower with a scarlet heart seen in large numbers during June and July on tree trunks covered with moss; another species is much smaller with fleshy flowers that are blood red.

Along the trail there are frequent leopard tracks, and occasionally the mark of lions. At places where the lava is covered with earth and moss, the footprints of the wild animals show with remarkable distinctness.

The track had been recently cleared and we travelled without difficulty, but this appears to be not invariable; the guide told us that shortly the trail would be blocked again by trees overthrown by elephants, or by windfalls that result from storms of extraordinary violence. Some months before our visit, four native porters had been frozen to death by a storm of hail that took them by surprise on the flank of the mountain.

After a march of about two hours and a half we passed a pond in the bottom of old craters. It is the watering place of elephants, for everywhere one sees their tracks. The water, which is the product of rain, is foul. This is the only water found between here and Kannusi, which is about four hours' march beyond this place.

On emerging from the crater we reach immediately the camp called Mushumangobo that commands a superb view of the whole country. Off to the east the magnificent cones of Mikeno and Karisimbi stand out in sharp relief; to the south is Niragonga and to the west Nyamlagira. Toward the south and southwest, between the two last named volcanoes, numerous subsidiary volcanoes produce an impression of much volcanic outpouring.

We continue our march toward the camp Mumurima, on the north side of the volcano close to 2,400 meters of altitude. The trail traverses a lava plain apparently older than the first part crossed before arriving at Mushumangobo. The jungle becomes denser and in places we passed through lovely old forests where the lava with bare surfaces is not so often seen.

A few hundred meters before arriving at the camp, we crossed the bed of a lava torrent and after a short climb found ourselves in a clearing where there are huts for the porters. Here we pitched our tent and soon the night enveloped us. In the big trees around the camp a goodly number of wood pigeons roosted and out of the bush came the calls of the wood partridge, more properly called francolins. We could also distinguish the whistle of the rock rabbit (hyrax) and from the valley came the bleat of a "harness" antelope calling to its mate. The landscape by moonlight was splendid; the ocean of jungle on the Rutshuru plain extended away to infinity, framed both east and west by a border of mountains.

Early the next morning we set out for the mountain top. Vegetation gradually disappeared. First through a cold lava channel, in the midst of equatorial plants and giant shrubs, then over a desert region, we arrived at the rim of the crater. It was truly fantastic. In a depression 2.3 km. in diameter bluish water vapor and greenish sulphur fume surrounded a rocky islet: truly a vision of the magic castle of the fairy stories. From the bottom of this enormous pit 150 meters deep the dull rumble of molten lava gave the impression of fiery power, and of the role of heat as creator and destroyer within our globe.

We set up our two tents close to the edge of the crater, on a solidified platform, where the wind incessantly brought to us sulphur smells. The night is cold and the porters have disappeared. They are entombed in a long subterranean gallery. By moonshine we reach the margin of the inner crater by way of plains covered with sulphur in ebullition. The spectacle is Dante-esque: here are glowing lavas in fusion bursting through the midst of black surfaces, and active eruption cones growling and emitting jets of flame and whirls of vapor.

Early in the morning we extracted our blacks from under the lava plain (the underground gallery where they lived had only a small opening) and we climbed down into the inferno for a depth of 100 meters. Surrounded by steam and sulphur we found the walking troublesome on this lava, that may break in underfoot at any moment. We approached within a few meters one of the active cones where fused lava was boiling; strong gushes of sulphur gas prevented any long stay.

The edges of the vents, yellow with crystals of sulphur, made contrast with the red of the boiling lava; on the interior crust of these little craters from two to twenty meters in diameter, and ten in number, there are clinging long tresses of hair (filamentous lava) which are agitated by the currents of hot air. After visiting several of these cones, and dodging the lava spatter and the dense clouds of sulphur vapor that they disgorged, we finally reached the base of the central island by walking across hot lava surfaces. The island is of massive rock 80 meters high.

After studying the map, I undertook the first ascent of the craggy height and in 20 minutes reached the summit. The only difficulty was a climb through a chimney for a height of four meters. The summit is covered with volcanic gravel surrounding a shallow funnel. The panoramic view was extensive.

Toward the north on the middle platform, could be seen the active region with its cracks, chimneys and cones spouting lava, lava which poured incessantly through subterranean tunnels into the big pit in the southwestern part of the crater. The bottom of this pit forms a lower platform. The level of the bottom of this large pit, 750 meters across, was in January 1932 at elevation 2,767 meters, in January 1933, 2,810 meters, and in June 1933, 2,828 meters. This regular elevation gives a measure of the amount of lava that has poured into this lower pit from the active area amounting to about twenty million cubic meters per year. At this rate the lower pit will be filled with lava about September 1934, and the level of the middle platform will be built up in from 3 to 4 years to elevation 2,904 meters, corresponding to the height of the active sources; unless a flank eruption of Nyamlagira drains the crater and again lowers the level of the bottommost flow.

The last eruption of Nyamlagira in 1912 was by way of the new subsidiary volcano Rumoka, situated 20 kilometers south-southwest from the main dome. Another eruption in about the same direction came from the Singiro vent erroneously called Nahimbi, 6.5 kilometers from Rumoka and about 15 kilometers from Nyamlagira. Between these two outbreaks there was another in 1905 from the volcano Kanamaharagi, 11 kilometers east of Nyamlagira, and about 13.5 kilometers N.N.E. from Niragongo.

From 1901 to 1912 there were four eruptions. From 1912 to 1933 external outbreaks have not occurred, but the level of the crateral lava within Nyamlagira has always risen. It is possible to calculate almost exactly the time when the lava level will reach the elevation (2,952 meters) of the upper platform, which is also the level of the overflow of this great volcano; but usually a breach occurs elsewhere.

The study of the two active volcanoes of Albert National Park is part of the programme of the Belgian Scientific Institution. Such study will be of great interest to the geologists.

Hawaiian Volcano Observatory Report for April 1938

VOLCANOLOGY

Slides at Halemaumau pit were erratic with the greatest concentration in numbers during the first and third weeks. The slides undoubtedly were responsible for many of the tremors reported during those periods. Seismic activity showed a slight increase toward the latter half of the month. Occurrence of earthquakes indicating distance of origin Mauna Loa as well as Kilauea shows that movement is taking place at both volcanoes. At Kilauea tilt and angle measurements would suggest that lowering of the crater floor is continuing. A summary of data for the Kilauea station for April 1938 follows:

Week Ending	Seismicity	Slides	Crack Openings	Local Tremors and Quakes
April 10	13.50	21	9.0 mm.	50
" 17	8.50	1	6.0 mm.	28
" 24	11.75	23	—0.5 mm.	35
May 1	12.25	11	4.5 mm.	43

April 7, 8:05 a.m., W wall.
April 7, 8:10 a.m., NW wall.
April 7, 8:15 a.m., W wall.
April 7, 8:24 a.m., W wall.
April 7, 8:40 a.m., W wall.
April 7, 10:16 a.m., W wall.
April 7, 10:25 a.m., W wall.
April 7, 11:00 a.m., W wall.
April 7, 11:40 a.m., W wall.
April 17, 12:17 p.m., small slide NW wall, noise heard at Uwekahuna.
April 21, 12:45 p.m., dust over W rim.
April 23, 9:15 a.m., dust clouds NW.
April 23, 11:10 a.m., dust clouds NW.
April 23, 11:12 a.m., dust clouds NW.
April 23, 11:15 a.m., dust clouds NW.
April 24, 9:00 a.m., dust from W rim.
April 24, 9:10 a.m., dust from W rim.
April 24, 9:18 a.m., dust from W rim.
April 24, 9:31 a.m., dust from W rim.

Photograph of model of summit of Nyamlagira as viewed from southwest. (W, main outer crater-wall; T, inner terrace; P, lava pit; F, fountain-basin; I, island; S, sink-hole.)

Four of the quakes were of proper distance for Mauna Loa northeast rift, five may have originated deep under Mauna Loa elsewhere, a shock April 15 was felt strongly at Kapapala and a feeble earthquake April 12 was located twenty miles from Kilauea. The sixteen earthquakes remaining originated under or near Kilauea crater.

Frequency of Events by Weeks

The first week produced slides at Uwekahuna, very slight tilt at the Observatory, more pronounced tilt at Halemaumau. The second week had less sliding and crack opening, and increased tilt at the Observatory. The third week showed increase of earthquakes and slides, unusual closing of the Halemaumau rim cracks and notable change of direction of tilting at the Observatory and at Halemaumau west. The fourth week produced additional slides and less tilting.

Slides at Halemaumau

The recorded slides from the wall of Halemaumau were:
April 4, 9:25 a.m., W wall.
April 4, 11:25 a.m., NW wall.
April 4, 11:44 a.m., NW wall.
April 4, 12:27 p.m., NW wall.
April 4, 1:27 p.m., NW wall.
April 4, 1:30 p.m., N wall.
April 4, 5:00 p.m., large dust cloud from NNE rim.
April 7, 7:45 a.m., W wall.

April 24, 10:05 a.m., dust from W rim.
April 24, 10:12 a.m., dust from W rim.
April 24, 10:16 a.m., dust from W rim.
April 24, 10:31 a.m. dust from W rim.
April 24, 11:02 a.m., dust from W rim.
April 24, 11:08 a.m., dust from W rim.
April 24, 11:23 a.m., dust from W rim.
April 24, 12:09 p.m., dust from W rim.
April 24, 12:15 p.m., dust from W rim.
April 24, 12:23 p.m., dust from W rim.
April 24, 12:25 p.m., slides from N rim.
April 24, 2:00 p.m., slides from N rim.
April 24, 3:06 p.m., slides from N rim.
April 24, 3:12 p.m., slides from N rim.
April 25, 11:02 a.m., slide from N or NW walls.
April 25, 11:05 a.m., slide from N or NW walls.
April 25, 12:25 p.m., slide from N or NW walls.
April 25, 1:16 p.m., slide from N or NW walls.
April 25, 1:25 p.m., slide from N or NW walls.
April 25, 2:28 p.m., slide from N or NW walls.
April 28, 1:45 p.m., slide from W rim.
April 29, 10:50 a.m., moderate slide from N rim near hot crack.
April 29, 2:30 p.m., slide from W rim.
May 1, 12:25 p.m., slide from N rim.

Measurement of Halemaumau Rim Cracks

Weekly measurements of rim crack locations around Halemaumau resulted during April in aggregate movement as follows:

Week ending forenoon of:

April 9, 28 locations, 13 opened, 1 closed, opening 9.0 mm.
April 15, 28 locations, 11 opened, 3 closed, opening 6.0 mm.
April 22, 28 locations, 7 opened, 5 closed, closing 0.5 mm.
April 29, 28 locations, 8 opened, 1 closed, opening 4.5 mm.

T.A.J.

SEISMOLOGICAL DATA

Earthquakes

Week Ending	Minutes of Tremor	Very Feeble Earthquakes	Feeble Earthquakes	Distant* Earthquakes	Weekly† Seismicity
April 10	46	4	0	0	13.50
April 17	24	3	1	0	8.50
April 24	25	8	1	1	11.75
May 1	37	6	0	0	12.25

* Including teleseisms or earthquakes of over 5000 km from Kilauea.

† For local seismicity definition see Volcano Letter 371.

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

April 7, 8:28 pm, very feeble, 2.2 miles deep, Kilauea Crater, near NE rim of Halemaumau. 19° 24.9′ N; 155° 17.0′ W.

April 9, 3:00 am, very feeble, probably originated in area about 1.0 mile NE of Kilauea NE crater rim.

April 10, 7:04 pm, very feeble, of shallow origin near Byron Ledge. 19° 24.6′ N; 155° 15.4′ W.

April 10, 7:05 pm, very feeble, of shallow origin near W portion of Kilauea Iki. 19° 24.9′ N; 155° 15.3′ W.

April 12, 8:48 am, a feeble earthquake registered. It was probably of Mauna Loa origin although there was no record of it either at Hilo or Kealakekua. Distance from the Observatory was 20.0 miles.

April 15, 2:36 pm, very feeble, no location but reported felt at Kapapala Ranch. Distance from the Observatory 18.0 miles.

April 16, 12:57 am, very feeble, 22.0 miles deep in vicinity of Kapapala Ranch. 19° 18.5′ N; 155° 29.5′ W.

April 19, 2:12 am, very feeble, 1.9 miles deep in NW portion of Kilauea Crater. 19° 25.4′ N; 155° 16.8′ W.

April 19, 2:56 am, very feeble, 2.6 miles deep, in vicinity of Lua Manu Crater. 19° 24.0′ N; 155° 15.5′ W.

April 19, 8:48 am, very feeble, probably originated under NW rim of Kilauea Crater.

April 19, 8:46 pm, very feeble, of Kilauea Crater origin.

April 22, 1:04 am, very feeble, of shallow origin, SE rim area of Kilauea Crater. 19° 24.1′ N; 155° 16.2′ W.

April 23, 5:51 am, feeble, of Kilauea origin.

April 23, 8:21 pm, very feeble, located at junction of SW rift with Kilauea Crater. Reported felt at CCC camp, SE rim of Kilauea Crater and at the Kilauea Military Camp, N rim of Kilauea Crater.

April 23, 8:22 pm, very feeble, location probably same as preceding shock.

April 24, 4:54 am, very feeble, probably located in Kilauea SW rift about 20.0 miles SW of the Observatory.

April 27, 3:42 pm, very feeble, probably originated in NE portion of Kilauea Crater.

A period of continuous tremor, lasting 20 minutes, began recording at 12:59 pm, April 5.

An unidentified portion of a distant earthquake began to register at 6h 02m 24s pm, H.S.T., April 21.

Microseismic motion of the ground at the Observatory was light April 14, 15, 16, and 21; moderate April 4, 5, 10, 11, 12, 13, 22, 23, 24, 25, 26, 30; strong the remainder of the month.

Tilting of the ground

The following tables show tilt by weeks as recorded by the Observatory seismograph and at Halemaumau, the algebraic sum of radial tilt toward or away from the Pit.

At the Observatory the total accumulated tilt for the year ending May 1, was 1.62″ S and 1.30″ W.

Week Ending	Observatory	Halemaumau West Station
April 10	0.37″ S 45° E	4.32″ N 76° W
April 17	1.22″ S 69° W	2.83″ N 80° E
April 24	1.29″ N 45° E	8.05″ S 84° W
May 1	0.68″ N 30° W	2.29″ S 66° E

Week Ending	Halemaumau Southeast Station	Halemaumau Resultant
April 10	1.59″ S 49° W	1.35″ from
April 17	4.96″ N 64° W	1.55″ toward
April 24	5.96″ N 44° W	0.61″ toward
May 1	3.08″ N 62° W	1.11″ toward

Crater Angles

Measurement of horizontal angles across Kilauea Crater from the Observatory April 20, indicated closing of the Halemaumau value and slight opening of the crater value compared with similar measurements of February 21. The Halmoumau measurement from SE Pit BM to NW Pit BM showed closing of 2.58″ and the crater measurement from the SE Crater rim to Uwekahuna showed an opening of 0.90″.

H.H.W.

THE VOLCANO LETTER

No. 459 monthly Department of the Interior National Park Service May 1938

Hawaii National Park
Edward G. Wingate Superintendent

Hawaiian Volcano Observatory
T. A. Jaggar Volcanologist

ERUPTION OF NYAMLAGIRA VOLCANO 1938

(A letter from Dr. Jean Verhoogen)

Nyamlagira Volcano north of Lake Kivu in the Belgian National Park of the Congo District is a volcano of first magnitude containing lava pits in its crater similar to those of the Hawaiian volcanoes. It is characterized by dominant outflows of lava, and is distinguished as an intensely active lava producer in the midst of the interior of the great continent of Africa. It ranks with Mauna Loa and Etna, and yet is as remote from the ocean as they are near it. Its height is 3,058 meters, its position 1° 35′ S latitude, 29° 11′ E longitude. It had a voluminous eruption of lava estimated three cubic kilometers in 1894, an ash eruption from a side crater to the southwest in 1899, a lava flow in 1902 from a southern parasitic crater and it formed new mixed cones in 1904 and 1905. Other eruptions were in 1907 and 1912, the latter a flank lava flow that put out very liquid streams that reached Lake Kivu. Other activity in 1920 and 1926 shows how continuous is the release of pressure at this volcano and in 1904 there was an eruption from the bottom of the northwest corner of Lake Kivu with boiling of great surfaces of the lake accompanied by rumbling. There were possibly sixty-six eruptions in all between 1801 and 1914. (Sapper.)

From April 27 to May 26, 1935, Mr. Jean Verhoogen worked at the Hawaiian Volcano Observatory as a student sent from Belgium to prepare himself for volcanological work in the Belgian Congo. He acted as a temporary assistant at the Kilauea laboratory in order to learn the routine, and afterwards worked in graduate geological studies on California volcanoes. He published "Mount St. Helens" (Bull. Dept. Geol. Sci. Univ. Cal. 24-9-263, 1937), and took courses at both California universities; afterwards he became a teacher at Brussels.

Under date of June 12, 1938, Dr. Verhoogen writes to the Volcanologist at Hawaii National Park that he is at work on Nyamlagira volcano. When word came that a major eruption had begun the National Park Institute sent Verhoogen by airplane to Africa arriving February 1938. Dr. Verhoogen writes:

"What happened is this: you remember from Bowen's description that in September-October 1929 (N. L. Bowen, Trans. Amer. Geophys. Union 1929-30, pp. 301-307, 10 figures) the crater of this volcano consisted of a sink-hole SW, a middle platform, and an upper one, all enclosed within the walls of a caldera. The lava was issuing from tunnels in the edge of the middle platform, down the cliff margin of the sink and filling the latter.

"In 1934 the sink-hole got filled up. The lava began to pile up on the middle platform until it reached the level of the upper platform in December 1937. A few flows spread out through a gap in the caldera wall into the local 'Kau Desert' (by analogy with Kilauea, Hawaii.)

"On January 28, 1938, four fissures opened simultaneously on the SE and SW sides of the volcano, and a deluge of exceedingly fluid lava poured out. Gigantic sinking took place in the crater, and the middle platform and the sink hole appeared again. The flows from the fissures stopped quite soon.

"A new volcano was born lower down half an hour after the stoppage of the flows, on the SW side, and about a mile from Nyamlagira crater. It has been active up to June 1938 and the history is following, from up-hill down the slope.

"(a) An ever increasing number of spatter cones, all on two main lines, spitting vesicular lava in the early days of their existence, and only flames later.

"(b) A lava lake, 100 meters long, 60 meters wide, in which the lava entered from the south and disappeared all around the northern banks.

"(c) The source of a lava flow which flows down the mountain at 12 miles an hour in the open part of the channel. Total discharge has been one hundred million cubic meters from this stream (June 1938). This flow is almost entirely buried in a self-made tunnel. The construction of this tunnel was most interesting to watch.

"The intermediate lava lake on the mountain flank over the rift has had a most surprising behavior. The level sank steadily, until one day it divided up into two smaller lakes. In the southern pool, lava was fed from below the southern bank (the feeder was visible), but in the northern pool lava entered from the north. The level of the northern pool continued to lower, and as the pool got smaller and smaller, the lava which kept on entering from the same vent had to run down a bank quite a distance to the pool. Then this stream of lava solidified.

"Now there is still a circulation in the pool, lava entering apparently from below the banks. Activity on these pools consists of rising gases, folding crust, engulfment of the crust, and wild fountains which last a few minutes, so that there results a rapid sinking of the level. The level starts rising again, a crust is formed, folds appear, engulfment begins, a fountain sprouts up, and the level sinks. At the present time the whole cycle takes about 10 minutes in the southern pool, and is very irregular in the northern pool. It suggests more a geyser action than anything else.

"I have with me an optical pyrometer which works wonders, as it allows measurement in inaccessible spots. A number of measurements has shown that the lava is just as hot in the stream half a mile below its source as it is in the hottest fountain.

"I have taken still pictures, movie films and color films. The attempt to collect gases with vacuum tubes was only partially successful, as the tubes broke in transport, and the fusible tips failed to fuse. I think I have one air-free sample.

"I am expecting a spectograph. The spatter cones keep on day and night heaving huge yellow flames, almost sufficient to read by: I have not seen blue flames."

This is a perfect description of the Halemaumau activities of 1917-19, the masking and heat-holding effects of lava tunnels, the rift eruption of Kau Desert 1919-20, and the concealing of vent cracks as soon as lava covers them and forms concentric banks.

A translation showing what preceded the 1928 eruption was printed in the April Volcano Letter.

T. A. JAGGAR.

Hawaiian Volcano Observatory Report for May 1938

VOLCANOLOGY

The measurements at Halemaumau pit showed nothing exceptional until the forenoon of May 28. On that day, beginning about 6:00 a.m., almost continuous quaking developed with several moderate shocks that were generally felt. On that same day it was discovered that one large crack and numerous small ones were developing in an East-West direction, athwart the Chain-of-Craters road between Pauahi and Aloi pits, east rift of Kilauea Volcano.

The nature of the development appeared to be block faulting with downthrow to the south and there is possibly some graben faulting. This motion along the eastern rift belt of Kilauea mountain implies extension westward of the active cracks of 1924 at Kapoho, 1922 at Makaopuhi and 1923 in the upland west of Makaopuhi. A hot spot on the cracks which is killing the verdure indicates the presence of active lava below.

Diminishing seismic activity continued to the end of the month and a seismoscope was placed near the Chain-of-Craters road. Halemaumau showed no sign of breaking out.

Location of the earthquakes indicates that their epicenters were partly some five to six miles from the Observatory and a few of them were as close as two miles distant. These distances correspond to the southeast rim of Kilauea, and to Pauahi pit or slightly beyond.

The following are the local weekly data for the month at the Observatory and Halemaumau:

Week Ending	Seismicity	Slides	Crack Openings	Local Tremors and Quakes
May 8	10.50	3	2.5 mm.	36
May 15	11.75	5	5.5 mm.	40
May 22	8.75	0	3.0 mm.	27
May 29	247.75	8	4.0 mm.	726

Shocks capable of being felt occurred on May 5, of Kilauea origin, and also of May 28 to 30 as indicated above. Shocks of Mauna Loa origin occurred May 17, felt at Kapapala and Pahala. The last three weeks of the month were notable for strong distant earthquakes six in number located near Mexico, Papua, Borneo, Japan, the Philippines, and Oregon. This world-wide sympathy in time, with a similar seismic activity of downbreaking fault blocks of Kilauea, occurring a month before the summer solstice season of 1938, is worthy of close attention.

It should be noted that the accumulated tilt for the year always tending southward at the Observatory, and the tendency of levelling surveys to show the south bench marks of the Kilauea rim low with reference to the Halemaumau rim, and much evidence of crater angles closing, all tend to agree with downsinking of fault blocks. It should be noted that whenever the levelling (see October and December Volcano letters 1937) reports relative elevation of Spit bench mark (a southern rim bench of Kilauea crater) and the northwest Pit bench mark at Halemaumau, the statement that the crater floor has lowered may mean that the southern rim bench has been raised. And the statement that the Halemaumau rim is higher, may mean that the Spit bench mark is relatively lower. The northwest station on the Halemaumau rim is on the Mauna Loa side of the rift belt; Spit bench mark is on the side of Hilina Pali fault blocks. If one of the fault blocks adjoins Kilauea crater, its movement downwards might produce a relative tilt to the northwest between Spit bench mark and the western rim of Halemaumau. There has been a notable amount of northwest tilting lately in the Halemaumau southeast station. The spell of downfaulting with road cracks and earthquakes at the Chain-of-Craters rift belt is confirmatory of a trend noticed for years past, suggesting southwesterly tilt at the Observatory, and general lowering of the southern side of Kilauea crater and its floor.

Sequence of Events by Weeks

The first week produced westerly tilt at all stations and otherwise nothing exceptional. Second week showed increase of slides, quakes and opening of cracks and the Halemaumau tilt increased to the northwest. The third week was quiet, but the Observatory tilt increased to the southwest. The fourth week was the time of excessive earthquakes and numerous slides. Crack openings were moderate, Observatory tilt was away from the crater, Halemaumau west station tilted east, and Halemaumau southeast station tilted north; the resultant for these two was exceptional tilt toward the pit.

Slides at Halemaumau

The recorded slides from the wall of the Pit were:

May 2, 3:00 p.m., slide from W rim sent up dust cloud.
May 7, 9:35 a.m., dust rose at N wall.
May 8, 3:43 p.m., slide from N rim.
May 9, 10:25 a.m., N rim.
May 11, 5:40 p.m., large dust cloud N rim.
May 12, 9:52 a.m., rocks dribbled continuously from N wall.
May 12, 11:30 a.m., dust from N wall.
May 15, 12:30 p.m., N rim.
May 25, 9:45 a.m., N rim.
May 25, 9:55 a.m., N rim.
May 27, 10:36 a.m., N rim.
May 27, 10:46 a.m., W wall.
May 27, 1:15 p.m., N rim.
May 28, 1:33 p.m., N rim.
May 28, 1:40 p.m., N rim.
May 29, 4:55 p.m., N wall.

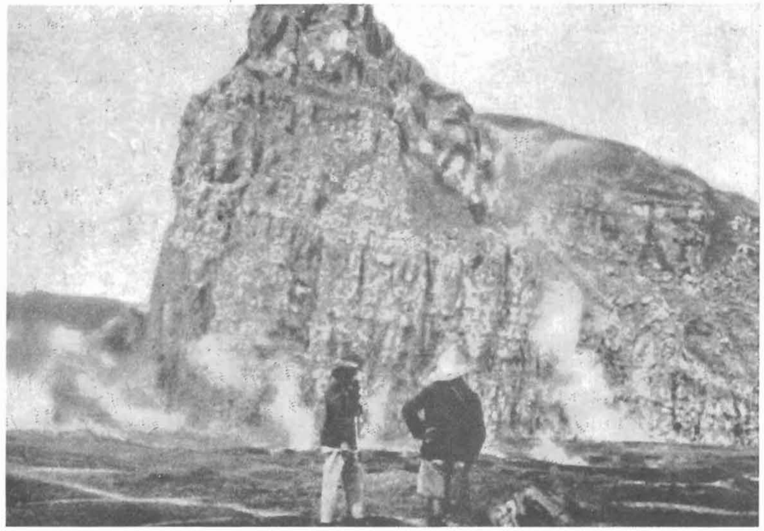
Measurement of Halemaumau Rim Cracks

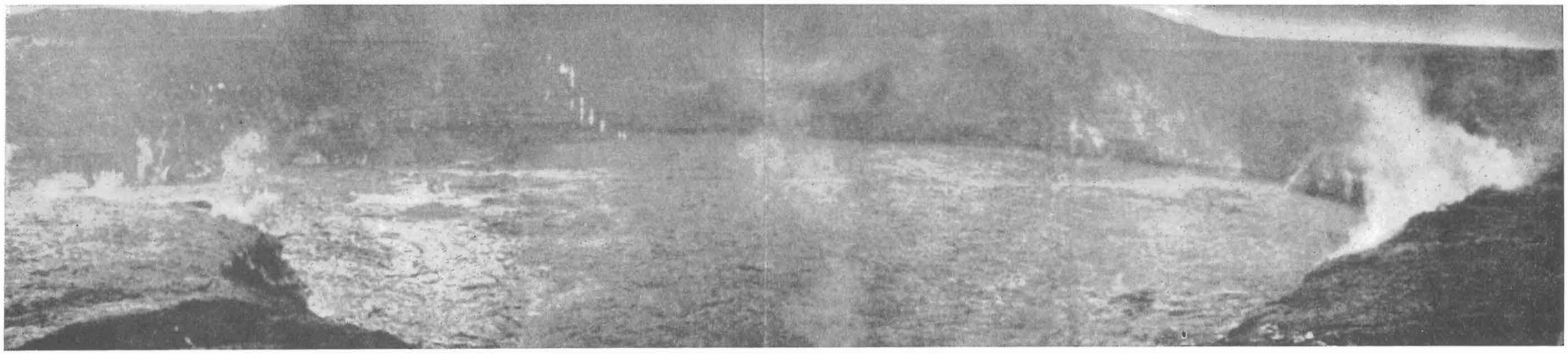
Weekly measurement of rim crack locations around Halemaumau pit resulted during May in aggregate movement as follows:

Week ending forenoon of:
May 6, 28 locations, 6 opened, 2 closed, opening 2.5 mm.
May 13, 28 locations, 9 opened, 1 closed, opening 5.5 mm.
May 20, 28 locations, 7 opened, 2 closed, opening 3.0 mm.
May 27, 28 locations, 5 opened, 0 closed, opening 4.0 mm.

Chain-of-Craters Crisis

The continuous tremor that began at 6:05 a.m. May 28 and continued until 1:00 p.m. the same day marked an outbreak of seismic motion that included numerous felt earthquakes. This unusually heavy swarm of tremors and earthquakes at the Hawaiian Volcano Observatory was accompanied by visible evidence of breaking and shearing of the ground along the Chain-of-Craters road near Pauahi crater. It was remarkable that this entire seismic spasm continuing into June was localized and shallow, and even the moderate felt earthquakes of Kilauea were not felt at all in Hilo and Pahala. While some of the shocks had epicenters near Devil's Throat, slides at that overhanging pit were not reported until June. The appearance of the tremor on the seismograph record was similar to that which appears during lava movement. Recent discovery of a new hot area in the forest near Kokoolau crater makes the





Pahoehoe lava on middle platform, central crag, and southern sinkhole of Nyamlagira Crater in 1933. (Philippson).

Puna rift belt a possible location for rising lava that has been recovering its pressure since 1924. Kokoalau is a mile toward Kilauea from Devil's Throat, and the new vapors have killed the vegetation within the last year or two. The combination of events probably represents both crustal adjustments and underground lava rising.

On the evening of May 28 a large crack across the Chain-of-Craters road was reported. At least eleven sets of new cracks had developed across the road between Pauahi and Aloi pits with general direction East-West. Seventeen individual cracks were counted on the evening of May 29.

The largest break in the asphalt paving of the road near Pauahi crater had caused the pavement to cave in in a chasm widest toward the west and narrowing half-way across the road to a three-inch crack extending on in the country rock beyond. There is evidence in the bushes away from the road of an old chasm in the rock. The cracks cross the road obliquely in plan. The widest part of the big hole in the road was five to six feet across. A hump in the paving near the Devil's Throat was higher than before as tangential compression had there been at work. This hump has been growing since the road was built some years ago, and its increase, as well as the development of the Kokoalau hot area indicates that the movements of the present crisis are accelerations of a process long continued.

The evidence for shallow depth of these earthquakes, and the correspondence of the distance of epicenters with the crack area of the Chain-of-Craters, and the location of some of the shocks much closer to Kilauea, as well as the strength of the vertical record, make it certain that we have good correspondence here between deformation of the land and epicentral distance. If an outbreak of Halemaumau follows, the expectancy will agree with the outcome. T.A.J.

SEISMOLOGICAL DATA

Earthquakes

Week Ending	Minutes of Tremor	Very Feeble Earthquakes	Feeble Earthquakes	Slight Earthquakes	Moderate Earthquakes	Distant† Earthquakes	Weekly* Seismicity
May 8	32	3	1	0	0	0	10.50
May 15	33	7	0	0	0	2	11.75
May 22	21	5	1	0	0	3	8.75
May 29	593	107	9	14	3	1	247.75

* Including teleseisms or earthquakes over 5000 km from Kilauea.

† For local seismicity definition see Volcano Letter 371.

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

May 5, 11:38 am, very feeble, 18 miles deep under area 15 miles east of Summit Crater of Mauna Loa and seven miles NW of Kilauea Crater. Reported felt at Kapapala Ranch. 19° 27.0′ N; 155° 21.5′ W.

May 5, 3:17 pm, feeble, 1.5 miles deep in SE rim area of Kilauea Crater. 19° 24.5′ N; 155° 15.6′ W.

May 6, 8:15 am, very feeble, 1.3 miles deep and 0.4 mile SE of Keonakokoi. 19° 23.9′ N; 155° 14.4′ W.

May 6, 8:18 am, very feeble, 1.7 miles deep in Kilauea Crater 1.5 miles SW of the observatory. 19° 24.7′ N; 155° 16.3′ W.

May 9, 2:30 am, very feeble, 0.9 miles deep near Puhimau Crater. 19° 23.6′ N; 155° 14.9′ W.

May 10, 3:50 pm, very feeble, 22.0 miles deep and 10.0 miles N of summit of Mauna Kea. 19° 57.5′ N; 155° 27.0′ W.

May 10, 10:05 pm, very feeble, 1.8 miles deep in Kilauea Crater 1.0 mile SW of the observatory. 19° 25.2′ N; 155° 16.1′ W. Reported felt at CCC camp NE rim of Kilauea Crater.

May 14, 3:47 am, very feeble, probably originated in Kilauea SW rift about 13.0 miles SW of the Crater.

May 15, 9:16 am, very feeble, probably of Kilauea Crater origin.

May 15, 12:44 pm, very feeble, 0.6 mile deep in SE rim area of Kilauea Crater near Keanakakoi. 19° 24.3′ N; 155° 16.1′ W.

May 16, 3:35 am, feeble, 11.0 miles deep in Hilina-Kapukapu Fault system. 4.0 miles south of Makaopuhi Crater. Reported felt rather strongly in Pahala and at Kapapala.

May 16, 4:36 am, very feeble, of Kilauea Crater origin.

May 17, 2:13 am, very feeble, 27.0 miles deep under Mauna Loa summit Crater. Reported felt at Kapapala Ranch and at Pahala. 19° 27.5′ N; 155° 33.5′ W.

May 20, 8:18 pm, very feeble, probably originated near Kokoolau Crater.

May 23, 11:33 am, very feeble, 3.2 miles under Kilauea Crater. 19° 25.1′ N; 155° 16.4′ W.

May 23, 11:46 am, feeble, of shallow origin near SE rim of Kilauea Crater in vicinity of Keonakakoi. 19″ 24.3′ N; 155° 15.9′ W.

May 23, 11:50 am, very feeble, of Kilauea Crater origin.

May 23, 1:25 pm, very feeble, 1.8 miles deep in Kilauea Crater 1.0 mile SW of the observatory. 19° 25.2′ N; 155° 16.1′ W.

May 24, 3:15 am, very feeble, probably originated in Chain-of-Craters rift near Devil's Throat.

May 28-29: beginning at 6:05 am, May 28, a period of continuous tremor lasting 414 minutes began to record at the Volcano Observatory and ended at about 1:00 pm the same day. Within that period of 7 hours there occurred 3 moderate, 12 slight, 7 feeble and 66 very feeble earthquakes for a total of 88 disturbances excluding the tremor. The greatest concentration of these was between 6:00 and 9:00 am, during which period the tremor reached its greatest intensity and there were 3 moderate, 7 slight, 4 feeble and 52 very feeble shocks. Seismic activity continued abnormally high the remainder of the week. For the entire day, May 28, there were 3 moderate, 12 slight, 7 feeble, 85 very feeble earthquakes and 499 minutes of tremor. There was considerable decrease in activity on May 29 although seismic activity was high. On that day there occurred 2 slight, 1 feeble, 16 very feeble earthquakes and 84 tremors.

Moderate earthquakes:

May 28, 6:32 am, distance from observatory 4.0 miles.
May 28, 6:52 am, distance from observatory 4.0 miles.
May 28, 6:57 am, distance from observatory 5.0 miles.

Slight earthquakes:

May 28, 6:22 am, distance from observatory 4.3 miles.
May 28, 6:33 am, distance from observatory ? miles.
May 28, 6:34 am, distance from observatory 5.0 miles.
May 28, 6:47 am, distance from observatory ? miles.
May 28, 7:26 am, distance from observatory 2.4 miles.
May 28, 8:13 am, distance from observatory 3.8 miles.
May 28, 8:21 am, distance from observatory 5.0 miles.
May 28, 9:32 am, distance from observatory 4.6 miles.
May 28, 9:38 am, distance from observatory 3.5 miles.
May 28, 10:21 am, distance from observatory 2.7 miles.
May 28, 11:07 am, distance from observatory 3.8 miles.

May 28, 11:46 am, distance from observatory, 3.2 miles.
May 29, 9:48 am, distance from observatory 4.0 miles.
May 29, 6:32 pm, distance from observatory ? miles.
Feeble earthquakes:

May 28, 6:07, 6:19, 6:32, 6:52, 8:05, 11:42 am, 12:46 pm; May 29, 10:01 pm with distances averaging about same values as slight and moderate shocks.

The 101 very feeble earthquakes were of similar origin with the exception of one that registered May 28, 7:32 pm, which apparently originated under summit crater of Mauna Loa and May 29, 12:55 pm which indicated a distance of 18.3 miles.

Residents of the Hawaii National Park and at Kilauea Military Camp were generally awakened by the first moderate shock of 6:32 am, May 28. Houses creaked, doors and windows rattled, dogs barked, pheasants squawked and hanging objects swayed. A few articles on shelves were overturned. The Bosch-Omori and vertical seismographs at the observatory and the Hawaiian type seismograph at the SE rim of Halemaumau were dismantled. Slight earthquakes and the tremor perceptably shook the ground until after the moderate shocks of 6:52 and 6:58 respectively. Although these disturbances were registered on the Hilo and Kona seismographs, the recordings were of a minor nature and the shocks were felt only a few miles from Kilauea crater.

The evening of May 28, new cracks in the Chain-of-Craters road SE of Kilauea crater were discovered. Eleven groups of them crossed the road between Pauahi and Aloi craters. Near Pauahi crater and where the most northerly of the cracks crossed the road, a section of the road caved in. The cracks ran roughly in an E-W direction.

General locations of this series of earthquakes fell within an area extending from Kilauea Crater to Alealea Crater along the Chain-of-Craters rift. Development of the road cracks was undoubtedly associated with these earth disturbances and the relationship was very close.

The moderate earthquakes of May 28 indicated greater successive distances from the observatory. The location of that of 6:32 am was 1.9 miles deep in the Chain-of-Craters area near Kokoolau Crater. 19° 23.3′ N; 155° 14.6′ W. The moderate shock of 6:52 am, probably originated near Devil's Throat and the one of 6:58 am, near Pauahi Crater. The earlier quakes seemed to be closer to Kilauea Crater than the later ones as though some sub-surface disturbance was from the Kilauea Crater, southeastward.

A hump in the road near Devil's Throat was noticeably increased in relative height.

Depths of the earthquakes of this series ranged from shallow ones near the surface to two and one half miles.

A portion of the preliminary waves of a teleseism began to register at Kilauea at 4h 37m 38s am, May 11; from news reports, it was located off W coast of Mexico 16° 8 N; 100° 7 W. The preliminary waves of a second teleseism began recording at 5h 19m 24s am, location in vicinity of East Papua, adjoining New Britain, 4,350 miles from Kilauea; 5° S; 147° E. At 6h 51m 05s am, May 19, the preliminary waves of a teleseism began to register, distance 5,750 miles, located 0.5° N, 119° E, near Borneo. May 22, 8h 58m 32s pm, the preliminary waves of an earthquake strongly felt in Japan began registering at the observatory. It was 3,815 miles from this station. At 10h 04m 01.0s pm, the same day the preliminary waves of a quake felt in Manila reached Kilauea; it was 5,500 miles distant. A portion of a teleseism whose reported location was in Oregon, U.S.A., began registering at Kilauea 12h 57m 51s pm, May 27. All time is Hawaiian standard.

Microseismic motion of the ground at the Observatory was moderate May 3, 13, 14, 18, 19, 20, 22, 23, 24, 27, 28 and strong the remainder of the month. H.H.W.

Tilting of the ground

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

At the observatory the total accumulated tilt for the year ending May 29 was 3.5″ S and 5.7″ West.

Week Ending	Observatory	Halemaumau West Station
May 8	0.90″ S 72° W	3.19″ S 43° W
May 15	0.52″ S 73° W	4.38″ W
May 22	1.10″ S 62° W	2.44″ S 67° W
May 29	0.74″ N 43° E	4.98″ N 73° E

Week Ending	Halemaumau Southeast Station	Halemaumau Resultant
May 8	6.22″ S 85° W	0.98″ toward
May 15	7.11″ N 59° W	2.16″ toward
May 22	6.25″ N 30° W	4.38″ toward
May 29	6.09″ N 3° W	9.01″ toward

Crater Angles

Measurement of horizontal angles across Kilauea Crater from the observatory May 18, indicated slight opening of the Halemaumau value and closing of the crater value compared with similar measurements of April 20. The Halemaumau measurements from the SE Pit BM to NW Pit BM showed opening of 0.08″ and the crater measurement from the SE Crater Rim to Uwekahuna showed closing of 1.74″. H.H.W.

Errata:

"The Maui Earthquake of January 22, 1938," by H. H. Waesche, Asst. Geologist at the Hawaiian Volcano Observatory; Volcano Letter No. 457, March 1938, page 4, column 2, under Bosch-Omori should be iE, 10:03:22.7 pm and iN 10:03:23.7 pm (Dismantled). H.H.W.

THE VOLCANO LETTER

No. 460 monthly Department of the Interior National Park Service June 1938

Hawaii National Park
Edward G. Wingate Superintendent

Hawaiian Volcano Observatory
T. A. Jaggar Volcanologist

PLANNED PROGRAM FOR THE HAWAIIAN VOLCANO RESEARCH ASSOCIATION

By T. A. JAGGAR

The following statement on the subject of financing technical publication of the records of the Hawaiian Volcano Observatory was presented April 1, 1938, to a group of business leaders of Hawaiian industry in Honolulu at the call of the Board of Directors of the Hawaiian Volcano Research Association. The meeting was held in the Board of Directors' room of the Hawaiian Sugar Planters' Association.

The Hawaiian Volcano Observatory under the Whitney fund of Massachusetts Institute of Technology was proposed in 1909 with a view to continuous record of Kilauea and Mauna Loa volcanoes. It aimed at an engineering science of volcanic phenomena of all kinds, in order to increase safety of life and property.

The Research Association was founded to safeguard the precious records for Hawaiian use. The financing was by $5 members and voluntary contribution of donors from year to year. It was supplemented by government.

In 1933 the government cut its appropriation. This was the fourth severe crisis that had to be met. As before the Research Association and the University saved the Volcano Observatory. This was followed by an extraordinary scientific success in 1935, namely, the printed prediction of all details of a disastrous eruption of Mauna Loa. A blasting enterprise with army aid led to the eruption stopping. This had been a plan fostered by the late honored L. A. Thurston many years ago.

In 1937 another public service was inaugurated by the association, extending the national park to the whole of Mauna Loa, and surveying for barriers to defend Hilo harbor against lava flow with United States engineers as designers.

The reason for disheartening financial crises depended on the essential instability of annual congressional appropriation 5,000 miles away. The cure is to create a sponsor for technical volcanology which is permanently Hawaiian, to assist the Government.

What is technical volcanology? It is like clinical surgery. Our population is the patient. Volcanic fever or shaking is the disease. Selecting an earthquake-resistant or lava-resistant human intelligence, will make Hawaiians different from peoples of other volcanic lands. Our publications have taught foreign scientists. A Matson ship rescued the people being overwhelmed by a volcano in Papua. The British government sent to us when volcano and earthquakes were wrecking Montserrat. When Napier was demolished, New Zealand sent to Hawaii for instruments.

Volcanology has started making a volcano science publishing the results of observation. It assists soil and water geology, safety by patrols at eruptions, prediction based on history, preparedness based on organization. Hilo and Honolulu are organized.

Hawaiian volcanology has sent forth trained men: Wood at Pasadena, Finch in California and Alaska, Stearns, Powers and Wentworth in Hawaii, Perret in Martinique, Wingate, superintendent of Hawaii National Park, Wilson in Washington, Jones in oil geophysics.

Among its by products are the park itself, Uwekahuna museum and the Kilauea military camp, volcanology in California and Alaska, the Mauna Loa and Haleakala roads. In education your association has collaborated with the University of Hawaii since the college was founded. The University now helps the Association immeasurably. The Government has assisted Hawaiian volcanology liberally since 1919, under respectively weather bureau, geological survey and national parks.

Throughout all the 26 years, however, the anchor to windward that has never dragged has been the Hawaiian Volcano Research Association. Publishing an outline of observations in monthly bulletins has informed scholars what we are doing. Critical eruptions with thousands of earthquakes, and other measurements, have left voluminous records that are still not worked up. Your present director is growing old. He knows these records, notes taken by 15 former workers. They need publication as scientific memoirs during the next 10 years.

Important discovery emerges from codifying and plotting the figures of old series of measurements. In 1929 we recorded times, sizes and places of 6,000 earthquakes in three weeks, North Kona was being shaken to bits. We had no time then to do more than place instruments, cheer up the ranchers, keep the recording going, and cover as much ground as possible. It is for such a crisis that we want a simple shock-recorder at every telephone exchange. I wish we had had them in Maui and Oahu on January 22, this year, 1938.

The record of 1929 contains eruptions of Kilauea in February and July, a simultaneous eruption at Tin Can island in Tonga, and the Kona earthquakes as a sign the lava of Mauna Loa was shifting northwest to a new place. The completed story is greatly needed by the British and Tongan scientists studying Samoa and New Zealand. To publish the facts of 1929 is one of many tasks lying in filing cabinets: Notes, maps, curves, photographs and seismograms.

The next eruption of Mauna Loa in December, 1933, was farther north than 1926 and wholly in the summit crater. The northern 1929 earthquake spasm informed us Pahala and Waiahinu at the south were less in danger, the Hilo direction in greater danger. The lava outlets had migrated along the crack up the south slope to the summit ever since 1868. We studied the intervals, arrived at a probable two years after 1933 for an outbreak still farther north threatening Hilo, and published the facts. The flow came exactly two years after 1933 with outlet five miles farther north, it threatened Hilo, and the bombing deflected it.

This episode, of our Association's 26 years, is only one of many critical studies made, which are of use to this territory.

Let us look at large earthquakes: A fracture that broke open Hualalai volcano in 1800; a quake that ripped open a huge crack at Pohalo in 1823; a jolt and lava flow in Puna in 1840 a terrific one with two lava flows including Mauna Loa in 1868. It suggests migration in the direction of Kahala and Maui.

Next a bad earthquake in Hilo in 1887; the 1929 series of shocks at Puuwaowaa; the January, 1938, a crash at Maui affecting Honolulu. What about the great fracture still farther northwest across the north side of Molokai? Projected westward it hits Diamond Head on the map, and Diamond Head is Honolulu city.

In all, we find a series of big earthquake spasms, extending through a century, from the Kilauea-Mauna Loa axis to the Haleakala-Kahoolawe axis. Will the Molokai-Diamond Head axis move? It is worth study.

We have many unstudied records. We need to learn everything possible about cycles and intervals, and about building codes and fire safety. Mr. Stearns is perfectly sound in recalling the Haleakala eruption of the Kaupo gap about 1750. It is merely asking, are our records, that cost us $260,000, worth preserving in permanent form before they are mere scrap paper?

The superintendent of schools, after the recent earthquake in Honolulu, wrote me asking what to do in case of severe earthquakes for reconstruction or discipline, in second class school buildings. I told him of California, New Zealand and Japan experiences, and referred him to the authorities.

The national guard officer asked me to criticize a written out problem of discipline and organization for Hilo. The terrific destruction of hospitals, roads, cliffs, drug stores, banks, water supply and docks in Napier, New Zealand, was the model. I sketched and put in print the plan of organization.

The Chamber of Commerce, during the fright of 1935 when lava was pouring down Wailuku valley above Hilo, asked what Hilo should do in case of a quicker flow from a nearer vent straight toward the harbor. We consulted engineers, studied the contour maps, examined precedents and costs, and the barrier plan was the answer. Incidentally, it turned out that such a flow is very probable.

The Association has no sufficient money in the next 10 years to print the records the society has filed. The immediate need is to publish technical results under our own imprint before the present director is incapacitated.

The national park does not publish technical volcanology. It is not economy to spend $260,000 through a quarter century for precious records, and leave them to fire and cockroaches.

The volcanologist is no more a prophet of evil than an army officer. They both have expensive jobs over large areas making war against evils.

The one has popular government money, the other is unknown. Hawaii has taken the lead to make seismic strategy known.

A famous scientist was asked by a lady, "What use is it?" He replied, "What use is a baby?" In the 19th century we had leaf hoppers, now we have parasites; then smallpox and plagues, now vaccination and quarantine; then floods and storms, now control and resistant construction; then slums and overgrown roads, now welfare and cantoneering. It took a century to persuade people to use common sense sciences.

Volconology is a common sense science. There was earthquake, lava and tidal wave destruction, now there is earthquake proof construction, air bombing and seismic foretelling of waves. Then there was city congestion and panic, now city planning and education. Then there was resistless lava filling, now constructed barriers as planned. Then there was disaster and death, now preparedness organiaztion.

The Government offers us the plan of a $125,000 reinforced concrete building for the new volcano observatory at Kilauea, with large laboratories, library, exhibit rooms, auditorium, map room and safe storage.

A group of generous local donors has given a sum of money for beginning the publication of monographs.

Summarizing this question of publishing valuable scientific archives of the Territory of Hawaii, there is needed:

1. Fifteen thousand dollars a year for the next 10 years.
2. To get the $125,000 government laboratory proposed.
3. To complete publications in technical form.
4. To appoint a scientific board to oversee publication.
5. To shift current work and routine publication gradually to Hawaii National Park, with the consent of the park service.
6. To allow the volcanologist to edit finished reports as his chief remaining work.
7. To present this program to the Secretary of the Interior, from the Hawaiian Volcano Research Association, as representing the contributors who have accumulated these records.

Hawaiian Volcano Observatory Report for June 1938

VOLCANOLOGY

The crisis of downfaulting of benches south of Chain-of-Craters that began at the end of May continued into the first week of June, but died away completely to a quiet spell at the end of the third week, or just at the time of solstice. New cracks were discovered on the trails extending north and south from Chain-of-Craters road and about June 5 caving in of the Devil's Throat was discovered and rock falls into that pit continued for a week. It was evident that the breakage crossing the line of the Chain-of-Craters on cracks trending ENE about Pouahi Crater were now being supplemented by the breakage northeastward along the mapped cracks that lie to the southwest of the Devil's Throat. The month of June developed no sign of Halemaumau activity.

The following are the local weekly data for the month at the Observatory at Halemaumau:

Week Ending	Seismicity	Slides	Crack Openings	Local Tremors and Quakes
June 5	65.00	3	3.5 mm.	195
" 12	24.50	12	2.0 mm.	80
" 19	8.00	1	3.0 mm.	24
" 25	15.00	0	0.5 mm. closed	48

Sequence of Events by Weeks

The first week produced notable reduction in the value of seismicity, the second week further reduction and increase of slides, the third week notable diminution of both, and the fourth week the ordinary increased frequency of local tremors and the registration of one distant earthquake, that would be expected after solstice.

Slides at Halemaumau

The recorded slides from the wall of the Pit were:

May 31, 10:00 a.m., 12:20 p.m., 12:29 p.m., dust cloud NE.
June 6, 11:20 a.m., 5:30 p.m., N rim.

June 8, 9:20 a.m., N rim.
June 9, 8:45 a.m., 8:50 a.m., 3:15 p.m., N rim.
June 10, 9:55 a.m., 10:45 a.m., 10:58 a.m., N rim.
June 12, 12:35 p.m., 1:25 p.m., 1:40 p.m., N rim.
June 17, 5:20 p.m., N rim.

Measurement of Halemaumau Rim Cracks

Weekly measurement of rim cracks located around Halemaumau pit resulted during June in aggregate movement as follows:

Week ending forenoon of:
June 3, 28 locations, 7 opened, 6 closed, opening 3.5 mm.
June 10, 28 locations, 8 opened, 5 closed, opening 2.0 mm.
June 17, 28 locations, 5 opened, 2 closed, opening 3.0 mm.
June 24, 28 locations, 2 opened, 3 closed, closing .05 mm.

Chain-of-Craters Crisis

During the week ending June 5 new cracks were discovered on the road to Ainahou Ranch leading south from Pauahi Crater; these were extensions of the cracks which had fractured the Chain-of-Craters road. Eight distinct groups of cracks were counted on the Ainahou road and one on the road leading toward Puu Huluhulu about two hundred yards from the main road leading east. All the older cracks showed some evidence of opening and in some cases down-faulting to the south was pronounced.

On June 6 cracking of the ground around Devil's Throat was discovered and there was evidence of slides from the rim of this pit within the past twenty-four hours. Most of the slides had occurred at the east and south rim, at 2:30 p.m. June 6 rocks were heard falling in Devil's Throat, and cracks were noticed in the masonry wall on its southwest side. Some new cracks were seen on the opposite side and it was evident that the circle of the pit was under stress on all sides. Rock falls continued in this pit during the remainder of the week, and the area was closed to visitors. T.A.J.

SEISMOLOGICAL DATA

Earthquakes

Week Ending	Minutes of Tremor	Very Feeble	Feeble	Slight	Moderate	Distant*	Weekly† Seismicity
June 5........	158	31	3	2	1	1	65.00
June 12........	68	9	3	0	0	2	24.50
June 19........	18	5	1	0	0	1	8.00
June 26........	40	6	2	0	0	2	15.00
July 3........	43	10	1	1	0	0	18.75

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

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

May 30, 1:43 am, slight, 1.3 miles deep in SE portion of Kilauea Crater, 0.6 mile E of Pit Seismograph. 19° 24.4′ N; 155° 16.5′ W.

May 30, 11:52 am, very feeble, of shallow origin in rifts 1.2 miles SW of Pauahi Crater. 19° 21.6′ N; 155° 14.5′ W.

May 30, 8:54 pm, very feeble, probably originated in Kilauea SW rift about 15 miles from the crater.

May 31, 1:13 am, very feeble, probably of shallow origin, vicinity of Hiiaka crater.

May 31, 1:19 am, very feeble, of shallow origin in rifts 0.5 mile SW of Pauahi crater. 19° 22.0′ N; 155° 14.0′ W.

May 31, 4:53 am, very feeble, 1.3 miles deep under SE rim of Kilauea crater. 19° 24.5′ N; 155° 15.8′ W.

May 31, 5:58 am, feeble, originated at junction of Lele o Kalihipaa and Kalanaokuaiki Palis, 1.7 miles SW of Pauahi crater. 19° 21.4′ N; 155° 14.8′ W.

May 31, 2:16 pm, very feeble, of shallow origin, vicinity of Hilina Pali. 19° 18.8′ N; 155° 16.3′ W.

June 1, 10:27 am, feeble, 3.0 miles deep in area immediately S of Kilauea Iki. 19° 24.8′ N; 155° 15.2′ W.

June 1, 10:38 am, moderate, 7.0 miles deep in Hilina Pali area about 3.0 miles N of Apua Point. 19° 18.2′ N; 155° 11.5′ W. Dismantled seismographs at observatory and SE rim of Halemaumau.

June 1, 8:03 pm, very feeble, probably originated in vicinity of Pauahi crater.

June 2, 3:25 am, very feeble, 1.0 mile deep in Kilauea crater, SE rim cracks 0.4 mile W of Keanakakoi. 19° 24.2′ N; 155° 16.4′ W.

June 2, 4:42 am, very feeble, 12.0 miles deep, Mauna Loa NE rift 4.5 miles NE of Puu Ulaula. 19° 34.5′ N; 155° 24.5′ W.

June 2, 8:24 am, very feeble, 4.3 miles deep, N rim area of Kilauea crater. 19° 26.1′ N; 155° 16.7′ W.

June 2, 3:33 pm, slight, 15.0 miles deep, Kilauea SW rift near Kaoe, 3.5 miles SW of Kilauea crater. 19° 21.7′ N; 155° 19.5′ W.

June 2, 8:55 pm, very feeble, of shallow origin under Byron Ledge, E rim of Kilauea crater. 19° 24.6′ N; 155° 15.7′ W.

June 2, 10:10 pm, very feeble, 1.8 miles deep under NE portion of Kilauea crater. 19° 25.2′ N; 155° 16.2′ W.

June 4, 2:48 am, very feeble, 0.7 mile deep, SE rim of Kilauea crater. 19° 24.3′ N; 155° 15.9′ W.

June 4, 7:57 pm, very feeble, probably originated in Kilauea crater, near N rim of Halemaumau.

June 4, 9:46 pm, very feeble, 0.8 mile deep, NE portion of Kilauea crater, 0.9 mile S by E of Volcano observatory. 19° 25.2′ N; 155° 14.8′ W.

June 5, 1:18 am, very feeble, of shallow origin, near center of Kilauea crater.

June 5, 1:47 am, feeble, 1.0 mile deep near center of Kilauea crater, 0.6 mile NE of Pit seismograph. 19° 24.7′ N; 155° 16.7′ W. Reported felt by many in Hawaii National Park.

June 6, 1:14 am, feeble, probably originated in cracks about 1.0 mile W of Hiiaka crater. Reported felt by many in Hawaii National Park.

June 6, 7:46 am, very feeble, probably originated in Chain-of-Craters area, vicinity of Hiiaka and Devil's Throat.

June 6, 11:53 am, very feeble, probably originated in rifts, 1.0 mile W of Pauahi crater.

June 7, 11:59 pm, very feeble, 1.7 miles deep under Byron Ledge, E rim of Kilauea crater. 19° 24.9′ N; 155° 15.6′ W.

June 8, 12:07 am, very feeble, 1.8 miles deep in E portion of Kilauea crater. 19° 24.8′ N; 155° 15.9′ W.

June 8, 5:39 am, feeble, of shallow origin in fault blocks along NE rim of Kilauea crater. 19° 25.7′ N; 155° 15.8′ W. Felt by several around National Park Headquarters area.

June 8, 8:32 pm, very feeble, thought to have originated in NE portion of Kilauea crater.

June 9, 7:17 am, very feeble, of shallow origin, SE rim area of Kilauea crater. 19° 24.3′ N; 155° 15.8′ W. Reported felt by few in the National Park.

June 10, 12:27 am, very feeble, 1.1 miles deep in E central portion of Kilauea crater. 19° 24.8′ N; 155° 16.2′ W.

June 10, 12:51 am, feeble, 1.4 miles deep, E portion of Kilauea crater near Byron Ledge. 19° 25.0′ N; 155° 15.8′ W. Reported felt at new CCC Camp and by residents along NE rim of Kilauea crater.

June 12, 3:39 pm, very feeble, of shallow origin in Kilauea crater about 1.2 miles NE of Pit seismograph. 19° 25.0′ N; 155° 16.7′ W.

June 14, 12:13 am, 1.5 miles deep in NE portion of Kilauea crater. 19° 25.4′ N; 155° 15.9′ W.

June 17, 5:18 am, very feeble, 0.5 mile deep, E portion of Kilauea crater. 19° 24.8′ N; 155° 15.8′ W.

June 17, 7:34 pm, very feeble, probably of shallow origin in NE portion of Kilauea crater.

June 18, 6:26 am, feeble, 1.1 miles deep, in N portion of Kilauea crater. 19° 25.5′ N; 155° 15.4′ W.

June 19, 12:55 pm, very feeble, 1.3 miles deep near center of Kilauea crater (NE rim area of Halemaumau) 19° 25.0′ N; 155° 16.8′ W.

June 19, 6:59 pm, very feeble, probably originated in NE portion of Kilauea crater.

June 20, 10:01 am, very feeble, 1.0 mile deep in N portion of Kilauea crater about 1.0 mile NE of Uwekahuna. 19° 25.9′ N; 155° 16.6′ W.

June 20, 5:22 pm, very feeble, 2.2 miles deep, Chain-of-Craters, near Pauahi crater. 19° 22.4′ N; 155° 13.7′ W.

June 23, 5:46 am, feeble, 1.2 miles deep E portion of Kilauea crater. 19° 24.8′ N; 155° 16.0′ W. Reported felt at new CCC camp and at the observatory.

June 23, 5:53 am, very feeble, of shallow origin near center of Kilauea crater, 1.0 mile NE of Pit seismograph. 19° 24.9′ N; 155° 16.4′ W.

June 26, 1:45 am, feeble, 1.8 miles deep in E portion of Kilauea crater. 19° 24.8′ N; 155° 16.0′ W.

June 27, 1:58 pm, very feeble, 0.8 mile deep, E rim area of Kilauea crater. 19° 24.8′ N; 155° 15.9′ W.

June 27, 3:23 pm, very feeble, of Kilauea crater origin.

June 28, 12:30 pm, very feeble, probably of shallow origin in Kilauea crater near E rim of Halemaumau.

June 30, 11:42 pm, very feeble, 19.0 miles deep under Mauna Loa, 3.0 miles NE by N of Summit crater. 19° 32.2′ N; 155° 33.8′ W.

July 2, 1:29 pm, very feeble, 21.0 miles deep, Mauna Loa NE rift, 9.0 miles NE of Puu Ulaula. 19° 35.5′ N; 155° 20.2′ W. Reported felt strongly at Kapapala Ranch.

July 2, 2:20 pm, slight, 8.0 miles deep in Chain-of-Craters rift 6.0 miles SE of the Volcano observatory. 19° 23.0′ N; 155° 11.5′ W. Reported felt at Kapapala and in National Park area.

July 2, 3:16 pm, feeble, 10.0 miles deep, in Kilauea SW rift 6.0 miles SW of the crater. 19° 22.0′ N; 155° 22.2′ W.

Distant Earthquakes

May 30, "P" waves at 4h 09m o3s am, located 3660 miles from Kilauea. 20° 4′ S; 169° 4′ E in the Solomon Island area.

June 8, "S" waves at 9h 7m 25s am, origin in the Malluca Sea, Dutch East Indies, 5550 miles from Kilauea. 3° 1′ S; 125° 7′ E.

June 9, "P" waves, 11 h 35 m 22s pm, originated off NE coast of Formosa, 5000 miles from Kilauea. 25° 2′ N; 124° 6′ E.

June 15, "P" waves, 3h 56m 22s pm, off the SW tip of Kyushu Japan along E border of China Sea. 29° 2′ N; 127° 7′ E. Distance 4750 miles.

June 20, unidentified portion began to register at 3h 50m 04s am.

June 23, "P" waves at 2h 34m 43s am, located in the vicinity of New Hebrides, 3615 miles from this station. 19° 1′ S; 168° 9′ E.

Hawaiian standard time used in above reports.

Microseismic motion of the ground at the observatory light June 10, 12, 14 to 25 and June 30 to July 3; moderate May 30, June 2 to 6, June 9, 11, 13 and 26 to 29, dates inclusive. It was strong May 31, June 1, 7 and 8. H.H.W.

Tilting of the Ground

The following tables show tilt by weeks as recorded by the observatory seismograph and at Halemaumau, the algebraic sum of radial tilt toward or away from the Pit.

At the observatory the total accumulated tilt for the year ending July 3 was 3.76″ S and 6.42″ W.

Week Ending	Observatory	Halemaumau West Station
June 5	0.75″ S 42° W	6.20″ S 16° W
June 12	0.16″ S 46° E	8.02″ N 68° W
June 19	0.67″ N 27° E	4.44″ W
June 26	0.54″ N 12° W	4.32″ S 78° W
July 3	0.62″ N 10° W	2.18″ S 81° W

Week Ending	Halemaumau Southeast Station	Halemaumau Resultant
June 5	7.91″ S 27° E	9.56″ from
June 12	1.65″ N 69° W	5.85″ from
June 19	6.54″ N 35° W	1.85″ toward
June 26	10.11″ N 85° W	2.33″ toward
July 3	4.28″ N 55° W	1.80″ toward

Crater Angles

Measurement of horizontal angles across Kilauea crater from the observatory June 17, indicated closing of both the Halemaumau value and the total crater value. The Halemaumau measurement from the SE Pit BM to NW Pit BM showed closing of 0.84″ and the crater measurement from the SE crater Rim to Uwekahuna showed closing of 1.66″.

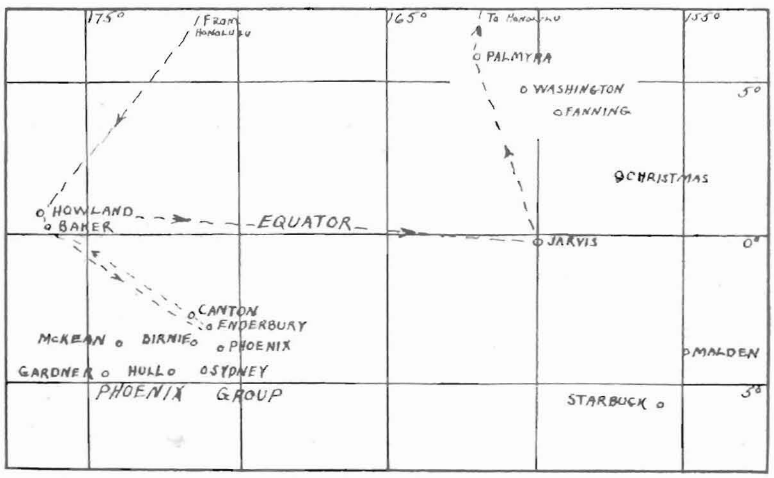
H.H.W.

THE VOLCANO LETTER

No. 461 monthly Department of the Interior National Park Service July 1938

Hawaii National Park
Edward G. Wingate Superintendent

Hawaiian Volcano Observatory
T. A. Jaggar Volcanologist



Map of Pacific Equatorial Islands showing route of the 1938 Spring expedition of the Roger B. Taney.

AN EQUATORIAL CRUISE

By Hugh H. Waesche, Assistant Geologist

For some years the Department of the Interior of the United States government has sponsored and maintained colonists on the tiny Pacific Equatorial Islands, Howland, Baker and Jarvis. Reference to the accompanying map will show their location to other islands. These pin-points of coral sand are not suitable for sustaining human life as they are practically of desert climate. This has necessitated regular trips to the Islands to deliver supplies to, and replacements in, the colonizing personnel. The colonists who are young Hawaiian men are transferred from island to island and are not allowed to remain away from their homes in Hawaii for more than nine consecutive months at a time. Transportation to and from the islands is part of the regular duties of the U. S. Coast Guard. The Cutter, "Roger B. Taney," makes about three trips per year to these Islands, usually late autumn, early spring and mid-summer.

Mr. E. G. Wingate, superintendent of Hawaii National Park, conceived the idea of some member of the Observatory staff making one of these trips to make general observations, the main issue being the practicability of establishing seismograph stations as an aid in seismological studies of the mid-Pacific areas. Selected for this reconnaissance were Messrs. S. H. Lamb, Park Naturalist, and Hugh H. Waesche, Assistant Geologist of the Hawaiian Volcano Observatory. Mr. Lamb was to make natural history studies of fauna and flora, and Mr. Waesche was to set up instruments for seismometric studies.

There was no opportunity to construct a conventional seismograph. The alternative was to take shock recorders of the mercury cup, annunciator type, developed during the past year by Dr. T. A. Jaggar for use on the Island of Hawaii. These instruments are of little value for recording distant earthquakes but have been of value in studies of local shocks. They are relatively sensitive and will readily indicate the very feeble earthquakes which are not generally felt here in Hawaii. These shock recorders register only maximum intensity for any particular shock giving no indication of phase. They are designed for use by people who have no technical training whatever. Registration of any earthquake is accomplished by annunciators which show a number from one to six, depending on the intensity of the earthquake. Once an earthquake has recorded, the value remains until reset to zero manually, by the observer. If a number of such seismoscopes were well distributed over an area, they should show relative increases of intensity toward the epicenter from all directions with diminishing values in the opposite directions. As no seismologists or otherwise scientifically trained men were among the colonists of the Equatorial Islands the shock recorders were apparently the most desirable; also they were easily portable and could be set up in any given locality with only a screw driver and a pair of pliers in a few minutes. No record paper was necessary, with the other complications which go with recording devices either on smoked paper or by photographic means. All that was necessary was a solid base and daily observation. These were assured.

Two of the shock recorders were available so were crated and prepared for shipment to Honolulu. No definite locality was predetermined for their placement. They were to be placed on the most desirable islands with regard to location and personnel. Tentatively chosen were Howland and Jarvis if landing were easy; they are widely separated giving a desirable variation of location. On arrival in Honolulu the instruments were put aboard the Cutter and preparations made for the expedition.

The "Taney" sailed from Honolulu at 5:00 p.m. Sunday, February 16, 1938. After four rather uneventful days the party arrived off Howland Island. At 7:00 a.m., March 4, a change in the colony personnel was made but no supplies were taken ashore. That afternoon a landing was made through heavy surf at nearby Baker. Originally Howland Island had been considered as the probable location of one of the shock recorders. However, the day before arrival there, Mr. Black announced that a colony was to be established on Canton Island in the Phoenix Group and suggested that one of the shock recorders be placed on it as the greatest number of more technically skilled colonists were to be there, and that both a shelter and concrete base for the instrument would be found, left by the eclipse expedition the preceding year.

Landing supplies at Enderbury.

Howland Island is located about forty miles north of the Equator and about one hundred miles west of the 175th meridian. Baker Island is about thirty-five miles S. by E. of Howland and the two might well be considered together. They are similar in appearance, geology, and climate. Both are of coral, shells, and lithothamnia and might well have been atolls or parts of atolls formerly although there is no water in their interiors at present. In the vast Pacific Ocean, both are mere specks of land. Howland Island is elongated in shape in a more or less N-S direction with a length of about three and one half miles and a maximum width of about 1.1 miles. Maximum elevation about mean sea level is about ten feet. Baker Island is smaller than Howland, not so elongated, and has a maximum elevation of about fifteen feet. They are saucer-shaped with high ridges of coral sand and debris along the shore line and the low points near, or only slightly above sea level toward their interiors. No evidence of rocks other than of coral or marine organic life were noticed on this trip nor have been reported by any previous visitors. Along the beach are coral sands of varying texture and rather massive reef rock and coral conglomerate near the water's edge. Inland, the sand was of fine texture with accumulations of bird guano in all low or basin areas. As in some other Pacific Islands this guano had been previously worked for commercial use.

The climate of the two islands is quite uniform. This is true of the temperature in particular which probably does not vary greatly from a minimum of about 78° to a maximum of 94° F. daily. Precipitation is light, mostly falling at night or in the early morning before daybreak. Sun pouring on the brilliant white coral sand is reflected as heat. The rising hot air causes rain-producing clouds approaching the islands either to break up or dissipate. Many observers report that clouds moving from the east with the prevailing winds will separate on reaching the edge of the island and pass to the north and south. As would be expected, vegetation is scant. Christophersen reports Boerhaavia and Portulaca as abundant in open spaces. A few clumps of Cordia were reported also on Howland. Attempts are being made to develop a growth of coconut palms brought with soil from Palmyra, but the results so far have not been promising.

Gas-operated lighthouses have been constructed by the colonists on both Howland and Baker. They are automatic and will operate for six months or more without attention. They are about twenty-five feet in height. The lighthouse at Howland has a diorite or similar dark igneous block above the doorway inscribed "Amelia Earhart, 1937" and is a memorial to that flyer who was lost while enroute to tiny Howland Island from New Zealand.

After brief stops at Baker and Howland Islands the "Taney" headed in a southeasterly direction, crossing the Equator about 6:30 p.m. Friday, March 4. On Saturday morning ceremonies were held on deck for benefit of those who had never crossed the "Line" before. King Neptune and Court saw to it that all "pollywogs" became "shellbacks."

Enderbury Island was sighted early the morning of Sunday the 6th. Like Howland and Baker, bright coral sand which reflected the sun's rays with great intensity was the first thing to impress the visitor. It was in strong contrast to the surrounding blue sea. Work of unloading supplies for the new colony to be established was started immediately. Food and water, the latter in old oil drums, were taken ashore. The food was taken through the surf in ship's boats. The water was floated ashore in the drums. This was accomplished by removing one gallon of water from each drug, lashing four to six of them together and then towing them from ship to island. The fresh water in the drums also added to their buoyancy.

Except for thousands of booby (gannet) and frigate (man-o'-war) birds, Enderbury was uninhabited. There were also in evidence the red-tailed tropic bird and several varieties of terns including the very beautiful "love-bird". The latter are snow-white and hover in pairs over the heads of intruders. They seem as though carved from exceptionally white porcelain. The "Taney" remained throughout the day, but sailed for Canton after sundown, leaving a camp, complete supplies and four Hawaiian colonists behind.

Enderbury Island is similar to Howland. It is a coral island about three miles long and one mile wide. It, too, is saucer-shaped with a decided depression toward its center. The low areas are partially filled with soft muddy materials which are principally bird guano. Around one of the muddy areas were several small coconut palms. At the southeastern end of the island were many large angular blocks of rock. From the ship these seemed dark and even looked as though they might be igneous rocks. Close observation showed them to be coral conglomerates evidently tossed upon the beach by wave action.

Enderbury is located about three degrees below the Equator and about one hundred and seventy-one degrees west. Canton Island, the most northerly of the Phoenix group, is about forty-three miles to the northwest.

A party from the "Taney" landed on Canton about 9:00 a.m. Monday, March 7. The American colonists began immediately to put up a temporary camp and to land supplies. As had been anticipated by Mr. Black, an old building with a concrete floor had been left by the Eclipse Expedition of 1937 (see National Geographic Magazine, June 1938). That afternoon a shock recorder was brought ashore and placed in operation. It was oriented to record earth waves only in a N-S direction. At the Hawaiian Volcano Observatory these shock recorders vibrate with slight motion of the pen continuously. This is probably caused by the microseismic motion of the ground. Vibration of the same nature was observed at Canton. In Hawaii wave motion of the sea on the NE shore of the Island is a suspected cause. This view might be even more readily acceptable on Canton where the motion of the sea acts only on a very narrow strip of land.

Canton is a typical coral atoll. A strip of coral sand and coral conglomerate, 150 feet to a third of a mile in width, almost completely enclosing a shallow coral-bottomed lagoon about nine miles long and three miles wide. The distance along the atoll around the lagoon is reputed to be about twenty-seven miles. To the southwest of the lagoon is a channel connecting it with the open sea. The channel is deep enough for small boats and if deepened could be utilized by larger craft. At

View at Canton Island. Shock recorder located in long low building at right.

various times of the day strong currents move in the channel so that it is used only at times when these are not dangerous. The channel may be as much as a quarter of a mile wide. It is well filled with large sharks which seem to prefer that locality to any other.

The atoll has two beaches, one to the open sea and one to the lagoon. Exploration of the area around the western lip of the channel revealed only coral sand, fragments and conglomerate. What appeared to be a peculiar rounded earthen mound about a mile and a half from camp turned out to be only a kou tree about twenty feet high which afforded a nesting place for a multitude of birds. The beach to the open sea along the southeast portion is broken by the presence of large quantities of angular slabs of coral conglomerate similar to the ones observed on Enderbury. On the lagoon side the beach is smooth, made up of coral sand and small shell fragments. Tide and waves in the lagoon have had a sorting effect, as various shells and sizes of sand show definite zones of stratification. Low areas lie inland between the beaches, and they as on the other islands contain deposits of guano. Also, one part of Canton rises some twenty feet above sea level.

The climate is mild, has steady easterly winds and a temperature maximum in the daytime of between 85° and 90° F. Rainfall is scant, but enough for several groves of coconut palms to have obtained a good start.

Monday night, March 7, 1938, the "Taney" returned to Enderbury. It remained there until noon Tuesday, completing final arrangements for the party left behind, and then returned to Canton, arriving there at 4:00 p.m. On Tuesday the shock recorder was again checked and it was moved to a more desirable location in the same building, and oriented for E-W movement instead of N-S as previously set up. Final instructions were given to an army sergeant who was to observe the instrument periodically. No registration occurred the two days the writer was at Canton. Apparently none has occurred since. It is not like a volcanic region where local shocks would be expected. A seismograph for recording of distant earthquakes located on Canton should produce some interesting results.

Wednesday evening, March 9, the "Taney" sailed for Howland and Baker Islands, arriving at the former at 8:30 a.m. Friday. By 1:00 p.m. landing of supplies and replacement of colonists had been completed and the ship left for Baker, which was reached at 4:30 p.m. Supplies were landed there and then at 8:20 p.m. the "Taney" again sailed for Howland to transfer a colonist to that island from Baker. Early Saturday morning, March 12, the "Taney" headed east for Jarvis Island nearly one thousand miles away. It was reached early the morning of March 15.

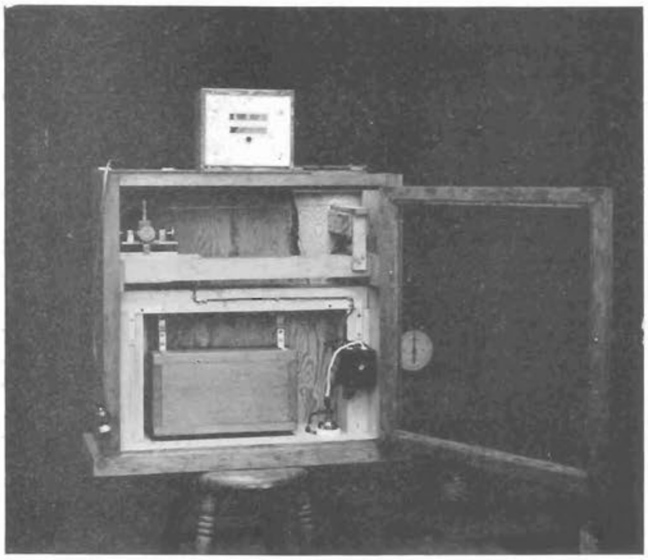
Jarvis is another isolated, saucer-shaped coral island. It is small, having a land area of 1.7 miles. It is about one mile wide and two miles long. The location is 160° W. longitude, 00° 23′ S latitude. Jarvis is probably higher above sea level than any of the other islands visited. The beach slopes steeply up from the sea to a rim twenty feet or more above. This rim encircles the entire island. Toward the interior there is a gentle slope which produces the saucer effect. The lowest portion of the depression is in places slightly below sea level, and over most of the area is probably between this low and an elevation of ten feet. As was true of the other islands, the interior depressions are collecting spots for bird guano. The beach is made up of coral sand, and shell fragments of other marine organisms. Along most of the north and east shores there is a bench along the lower portion of the seaward slope. The bench is made up of stratified calcareous conglomerates which have been formed by cementation and consolidation of beach deposits. They are made up of corals and corallines and remains of other marine organisms. Above the conglomerate along the northeast shore are flat, roughly circular coral rocks tossed up by the waves and lying at low angles. Wentworth calls these "coral shingles." They were undoubtedly formed by wave action which was responsible both for their shape and location.

The second shock recorder was taken ashore at Jarvis and set up for operation. The only concrete base available was the floor of the lighthouse. This was considered desirable at first, but Mr. Edgecombe thought that it would be dangerous to place an electrical recording device which produced open sparks so near the gas supply. As an alternate the recorder was set up temporarily in the living quarters of the colonists. This proved very unsatisfactory as the moving of the people around the house caused a great deal of disturbance to the instrument. It was finally decided that the instrument be left in the house as set up but with the current shut off until the colonists stationed at Jarvis could build a concrete base and small shelter nearby. This has been done with the shock recorder oriented to record motion in a N-S direction, at right angles to the one left on Canton.

Explorations of the west and northwest beaches of Jarvis were made and the interesting remains of the barkentine "Amaranth" wrecked in 1913 were examined. It was apparently loaded with coal as pebbles of the black material are well distributed along the adjoining beach. These pebbles are well rounded and water worn.

The "Taney" left Jarvis the same day and sailed for its last stop of the trip, Palmyra Island, where it arrived in the early morning of Thursday, March 17. The day was very stormy with heavy rainfall. The small tree-covered islets composing Palmyra were visible only rarely during the day. Crew members fishing off the stern caught several black-finned sharks and a few red snappers. The sky cleared after sundown. Many "booby" birds and terns hovered about the ship throughout the day and several "boobies" flew aboard after dark attracted by the lights.

It had been agreed that there would be a landing party the next day regardless of weather conditions. Conditions were much more favorable on the morning of March 18, so that two of the ship's boats were sent as near the island as feasible. Two small boats with outboard motors were also towed in and with the party were landed on Home Island. From Home Island the party went across the large western lagoon to Cooper Island on the north side. After exploration there the boats returned across the lagoon to the south side, landing in the vicinity of



Type of shock recorder left on Canton and Jarvis Islands.

Paradise Islet. Lunch was eaten on the south side of that island. Soon after noon rain squalls began and occurred at intervals the remainder of the afternoon. A number of pictures were obtained in the morning but weather conditions prevented photographic work later in the day. Most of the afternoon was utilized in making underwater observations of marine life in the channels around Home and Paradise Islets and on the coral shelf to the west of the group.

Palmyra Island, otherwise known as Samarang or Palmoore, is located in the north Pacific Ocean 960 miles S. by W. of the city of Honolulu, Hawaii. Latitude 5° 53′ North, longitude 162° 05′ W. The island is a regular atoll, well covered with vegetation wherein it differs from other equatorial islands such as Jarvis and Howland. Altogether, Palmyra consists of a group of some fifty-two islets all of which are projections above the ocean surface from one underlying mass of coral growth and debris occupying a space of five and two-thirds miles in an east-west direction and one and one-half miles in the north-south direction. Including the entire extension of reef under water the length is nearly eight miles, east-west. The atoll encloses three large lagoons and one small one. All the larger lagoons have depths of at least twenty fathoms and the large western lagoon has a depth of 28 fathoms. In one of the lagoons are several small islets which are exposed at low tide. The greatest elevation is located on Eastern Islet and is about six feet above sea level. The U. S. Hydrographic Chart gives a maximum elevation of the trees as 91 feet above sea level and these may be observed from a ship 15-20 miles at sea. The largest islet is 46 acres in area and the smallest is reputed to be 0.47 acres.

An extensive coral flat extends to the westward of the islet for about three miles from the shore line where the depth is 6-7 fathoms at high tide. More or less cylindrical coral heads rise from the shelf nearly to the water's surface and are often five feet or more in diameter. Their number increases toward the island proper where the water becomes very shallow and a person can readily walk on the coral bottom. Boat landings can only be made in this vicinity at high tide, and it is the only portion of the island group where one may go ashore safely. At low tide no boats can pass over the coral shelf nearer than one mile from the shore.

Heavy surf of white-foamed breakers continuously roars against the reef from the open sea, to the north, east and south. They are never more than a few hundred feet from shore. This condition is to be expected as Palmyra is in the trade wind area of prevailing northeast and southeast winds the year around. This also accounts for the western side or lee side being the only safe landing point.

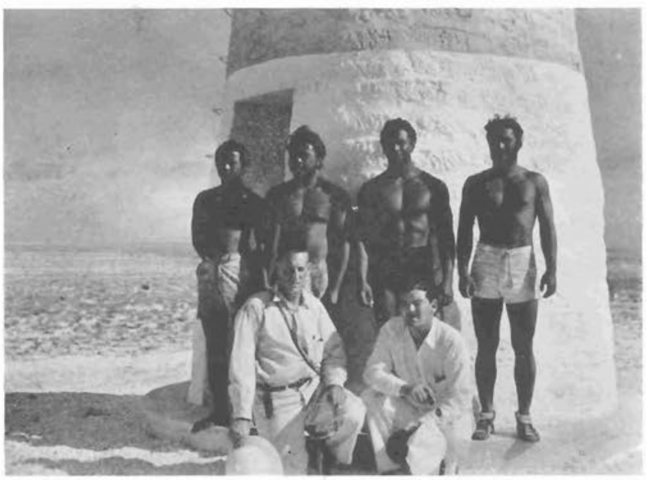
On the lagoon side the islets are bordered by strips of white coral sand which may extend inward in the form of spits. At high tide this sand is covered by about ten inches of water; at low tide it is often exposed and dry with never over an inch or two of water. The islets are separated by narrow channels through which flows considerable current at high tide. At low tide the channels are often blocked or the current obstructed by sand bars on the lagoon side. They deepen seaward. It is possible to walk between most of the islands as the water in the channels is seldom more than waist deep. The bottom is sandy toward the lagoon and becomes more rugged with new coral growth toward the sea. This is a natural gradation typical of atolls in general.

The weather at Palmyra is probably rather uniform. No visits to the island have apparently been of length sufficient to make accurate observations. The dense vegetative cover of the island indicates ample rainfall. Determinations for short periods indicate a rainfall of at least one hundred inches per year and probably as much as one hundred and fifty inches per year. All visitors report rain at Palmyra and heavy rainfall occurred the two days of this visit. Daily and yearly temperature range is probably not great. Rock reports a high of 90° during the day and a low of 78° during the night. Tropic islands completely surrounded by ocean and far from other land masses are likely to have a mild and equitable climate.

Palmyra is near no existing commercial ocean traffic lane. It is reached only by privately owned vessels capable of making long ocean voyages or by government vessels of the Coast Guard or Navy. Some people of the Hawaiian Islands visit the island annually in privately owned ships.

The map of Palmyra shows that the group is open at the western end and closed with a point at the eastern end. Prevailing winds and ocean currents from a general easterly direction are probably responsible for this condition as this fits in with the general rule. According to such a rule the coral growth should be most favored on the current side and along the northern and southern tip extremities of the western end of the island where the seaward current carrying the greatest quantities of coral food is likely to flow by and eddy backward, greatly retarded in speed. Corals and calcareous algae are sensitive marine organisms demanding close adjustment of temperature, depth, aeration, condition of water and amount of sandy material present. As a result coral growth would be accelerated on the windward, and less on the more protected, portions of the island. This is borne out by the facts illustrated by the reef extension to the westward and the diminishing of coral growth inward from the sea in the inter-island channels. Coral growth is greatly retarded in the lagoons and over the entire area surrounded by the islets, where sand and debris brought in from the sea is deposited, destroying the living coral.

During the approach of high tide and for considerable time afterward there is much scouring action in the channels which keeps their seaward end very clean. The slowing of the current in passing through the channels causes deposition of the sand to build fans and shoals into the lagoon. Presumably this process continued over a long period would cause the filling up and elimination of the lagoon, which would go through a brackish marsh stage before attaining that end. After the lagoon had been filled by debris in this manner it seems likely that eventually wave action building up the resulting shore line would produce the elongated saucer type of coral island so common in the South Pacific. Probably because of the open west end on the lee side offering less resistance to the flow of water, the current return to the ocean at low tide seemed to be



Typical colonists on Jarvis Island.

less through channels than at high tide inflow. This also would tend to increase the chance of eventual elimination of the channels by building up from the sea. The heavy surf on the seaward side of the island prevents accumulation of sand or small debris in spits or bars. The outer beaches are of sand and some of coarse gravel and Tridacna shells.

Some coral grows in the inner lagoons contributing to the building processes but is much less vigorous than that on the outer portions of the island, as debris accumulation in the interior is more plentiful and food less available. The inner beaches are formed of fine coral and shell-fragment sand which at some localities become a fine mud quite soft, and often ankle deep. Heavy rains wash great quantities of bird guano into these mud flats. Beach water-lines fluctuate widely between high and low tide over these areas because of their very low angle of deposition. No evidence points to former sea levels above the present ocean level. The inner portions of the various islets are made up of coarse detrital materials with a few composed of calcareous sandstones and conglomerates. The islands to the east are apparently the youngest, and no doubt other islands may develop even farther eastward superseding the existing line of growth.

In order to make proper tide connections the return to the ship was made at 4:00 p.m. Stormy weather was again in evidence on the morning of March 19th. One squall about 8:00 a.m. with a wind velocity of over 60 miles per hour tore away a large portion of the "Taney's" awning. It was thought that weather conditions would not improve so the ship weighed anchor and set a course for Honolulu. The ship arrived at that port at 6:00 p.m., March 21, ending a most interesting cruise of 23 days.

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4. Wentworth, Chester K.; Bernice P. Bishop Museum, B., Occasional Papers, Volume IX, Number 15, Whippoorwill Expedition, Publication Number 15, Whippoorwill Expedition, Publication Number 3, 1931.
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Hawaiian Volcano Observatory Report for July 1938

VOLCANOLOGY

With the exception of the last two weeks of July rock slides from the north and east rim walls of Halemaumau were numerous during the month. The excessive sliding of the first fortnight along with several earthquakes indicating origins of about Halemaumau distance (2 miles) and the occurrence of higher seismicity after the sliding stopped, justifies the inquiry whether the recent fault movements southeast are extending themselves to the Kilauea block. Fuming from the southeast solfatara on the floor has continued. Seismic activity has been ordinary with most of the disturbances indicating Kilauea origins. Three felt earthquakes July 2 were of Mauna Loa origin. The Kona seismograph recorded only five small disturbances, indicating that there is only minor activity taking place under Mauna Loa and Hualalai. Kilauea seems to be currently the most active volcanic center on Hawaii. Two rather feebly recorded distant earthquakes were registered during the week ending July 24.

Observations from time to time of the cracks in the vicinity of Pauahi crater have been made and slight earth movements there are continuing, with a tendency shown both on the ground and by seismic distances for the fault movements to extend themselves northwestward. The hump in the road near Devil's Throat has increased in height. The large crack near Pauahi pit increased in width with increased downthrow to the southeast. The large crack near Aloi pit has widened. Systematic measuring of these cracks is provided for.

Temperature measurements at the hot area near Kokoolau pit have been made with highest readings about 85° C. The area does not appear to have increased its dimensions.

The Chief Ranger reported the discovery Friday, July 15, on an inspection trip to patrol the telephone line, along the trail up Mauna Loa northeast of the summit, that new cracks about four inches wide broke the surface of the trail at three places. The first one encountered was about 1.5 miles above Puu Ulaula resthouse at elevation 10,800 feet approximately; the other two were in the vicinity of 12,000 feet elevation, or about opposite and to the east of the main cone source of the 1935 flow. This is important as suggesting a breakage on the rift belt of Mauna Loa farther east than the fracture of 1935. It is worthy of note that earthquakes near Puu Ulaula shook Mauna Loa after the middle of January 1938, when the startling earthquake of Maui and Honolulu occurred: and that ten days before the earthquake crisis at Chain-of-Craters began, a deep earthquake occurred under Mauna Loa summit crater. These two Mauna Loa seismic events may be correlated with the new cracks.

The following are the local weekly data for the month of July at the Observatory and Halemaumau.

Week Ending	Seismicity	Slides	Crack Openings	Local Tremors and Quakes
July 3	18.75	30	7.0 mm.	55
" 10	10.25	15	0.5 mm.	17
" 17	18.25	28	0.0 mm.	50
" 24	23.25	3	3.5 mm.	67
" 31	20.00	3	0.5 mm. closed	60

One slight and two very feeble earthquakes were felt at Kapapala Ranch July 2. One very feeble earthquake July 13 was felt in Kilauea National Park.

Sequence of Events by Weeks

The first week was notable for many Halemaumau slides and Mauna Loa earthquakes. Slides continued the second week but tremors were less frequent. During the third week slips of rock from the wall of Halemaumau were numerous around the northern and eastern rims and seismic activity increased both at Kilauea and Mauna Loa. For the fourth week numbers of slides decreased to a low figure but earthquakes and tremors increased in number. The fifth week showed Halemaumau very quiet with reference to both slides and crack movements but seismicity remained high; many shocks were of Kilauea origin, a few showed Mauna Loa distance and one seismogram indicated Hualalai.

Slides at Halemaumau

The recorded slides from the wall of the Pit were:

July 1, 8:58 a.m. to 12:58 p.m., 13 slides N and NE.

July 2, 9:32 a.m. to 2:47 p.m., 14 slides N and NE.

July 3, 10:08 a.m., 1:03 p.m., 1:40 p.m., slides from northern walls.

July 4, 1:05 p.m., small slide from new crack high up N wall; rocks dribbled down SW and N walls for a half hour.

July 5, 12:57 p.m., slide N rim.

July 6, 9:33 a.m., 3:29 p.m., 3:37 p.m., 3:41 p.m., N rim.

July 7, 10:49 a.m., 11:19 a.m., N rim.

July 9, 9:45 a.m., 10:00 a.m., 10:45 a.m., 1:07 p.m., 1:30 p.m., 2:50 p.m., northern walls.

July 11, 9:00 a.m., 9:28 a.m., 9:35 a.m., 10:10 a.m., 10:11 a.m., 11:03 a.m., 11:11 a.m., slides from N, NE or E walls.

July 11, 6:47 p.m., dust clouds N rim, indicated large slide.

July 13, 8:50 a.m. to 12:05 p.m., 18 slides from N, NE and E walls.

July 15, 10:00 a.m., N rim.

July 17, 10:40 a.m., 1:13 p.m., northern wall slide.

July 18, 3:43 p.m., NE rim.

July 20, 9:45 a.m., N rim.

July 28, 9:10 a.m., NE rim.

July 28, 9:50 a.m., 10:05 a.m., N rim.

Measurement of Halemaumau Rim Cracks

Weekly measurement of rim crack locations around Halemaumau pit resulted during July in aggregate movement as follows:

Week ending forenoon of:

July 1, 28 locations, 11 opened, 1 closed, opening 7.0 mm.
July 8, 28 locations, 2 opened, 3 closed, opening 0.5 mm.
July 15, 28 locations, 5 opened, 5 closed, opening 0.0 mm.
July 22, 28 locations, 4 opened, 1 closed, opening 3.5 mm.
July 29, 28 locations, 3 opened, 4 closed, closing 0.5 mm.

T.A.J.

SEISMOLOGICAL DATA

Earthquakes

Week Ending	Minutes of Tremor	Very Feeble Earthquakes	Feeble Earthquakes	Distant* Earthquakes	Weekly† Seismicity
July 10	35	3	0	0	10.25
July 17	33	14	3	0	18.25
July 24	45	20	2	2	23.25
July 31	42	17	1	0	20.50

* Including teleseisms or earthquakes of over 5000 km from Kilauea.

† For local seismicity definition see Volcano Letter 371.

Frigate birds, found on all islands except Palmyra.

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

July 4, 2:13 pm, very feeble, probably originated near Pauahi crater.

July 7, 1:56 pm, very feeble, 0.4 mile deep in E portion of Kilauea crater. 19° 24.7′ N; 155° 16.0′ W.

July 12, 9:58 am, very feeble, of shallow origin, Kilauea SE crater rim. 19° 24.2′ N; 155° 16.3′W.

July 13, 10:45 am, feeble, 0.9 mile deep, Kilauea crater, 1.2 miles E of Halemaumau. 19° 24.6′ N; 155° 15.7′ W.

July 15, 4:12 am, feeble, location same as preceding.

July 15, 4:58 am, very feeble, 0.6 mile deep in Kilauea crater rim area near Kilauea Iki. 19° 25.1′ N; 155° 15.4′ W.

July 15, 5:34 am, very feeble, probably originated in Chain of Craters rift near Lua Manu.

July 15, 5:56 am, feeble, 1.6 miles deep in NW portion of Kilauea crater. 19° 25.7′ N; 155° 16.7′ W.

July 15, 11:04 pm, very feeble, probably originated in Chain of Craters rift near Lua Manu.

July 16, 6:52 am, very feeble, 1.4 miles deep, E rim of Kilauea crater, 19° 24.9′ N; 155° 15.7′ W.

July 17, 8:49 pm, very feeble, of shallow origin, NW rim area of Kilauea crater, 1.1 miles SW of the Observatory. 19° 25.2′ N; 155° 16.2′ W.

July 17, 10:51 pm, very feeble, 0.7 mile deep in Kilauea crater, 1.1 miles SW of the Observatory. 19° 25.2′ N; 155° 16.2′ W.

July 18, 4:37 am, very feeble, 1.0 mile deep, Waldron Ledge, NE rim of Kilauea crater. 19° 25.4′ N; 155° 15.5′ W.

July 19, 12:36 am, feeble, of shallow origin (0.3 mile), Kilauea crater, 0.4 mile E by N of pit seismograph. 19° 24.4′ N; 155° 16.3′ W.

July 19, 3:58 am, very feeble, of shallow origin 0.5 mile SE of pit seismograph. 19° 24.1′ N; 155° 16.6′ W.

July 21, 2:36 pm, very feeble, 0.6 mile deep SE rim, Kilauea crater, 1.6 miles E of pit seismograph. 19° 24.2′ N; 155° 15.5′ W.

July 22, 4:29 am, very feeble, 1.7 miles deep, Kilauea crater, 1.2 miles NE of pit seismograph. 19° 25.1′ N; 155° 16.4′ W.

July 22, 4:42 am, very feeble, 0.7 mile deep near Puhimau crater. 19° 24.0′ N; 155° 15.3′ W.

July 22, 5:02 am, very feeble, 0.8 mile deep, NE rim Kilauea crater (Byron Ledge), near Kilauea Iki. 19° 25.2′ N; 155° 15.6′ W.

July 22, 5:49 pm, very feeble, of shallow origin E rim of Kilauea crater. 19° 24.6′ N; 155° 15.7′ W. Felt in National Park residential area.

July 22, 7:32 pm, very feeble, 1.0 mile deep under N portion of Halemaumau. 19° 24.8′ N; 155° 17.2′ W.

July 23, 9:38 am, very feeble, probably originated in vicinity of Kilauea Iki.

July 23, 4:06 pm, very feeble, of Kilauea crater origin.

July 23, 10:09 pm, very feeble, probably originated in N central portion of Kilauea crater.

July 24, 12:54 am, very feeble, probably of Kilauea crater origin.

July 24, 5:20 am, very feeble, probably originated in Chain of Craters near Puhimau.

July 24, 7:51 pm, feeble, of shallow origin (0.6 mile) in SE rim area of Kilauea crater. 19° 24.5′ N; 155° 16.1′ W.

July 25, 7:16 am, very feeble, of Kilauea crater origin.

July 25, 9:31 am, very feeble, 1.5 miles deep, NW rim of Kilauea crater 0.5 mile NE of Uwekahuna. 19° 25.7′ N; 155° 17.1′ W.

July 28, 7:50 am, very feeble, probably originated in Mauna Loa NE rift in vicinity of Puu Ulaula.

July 30, 11:36 am, very feeble, 1.4 miles deep in NE portion of Kilauea crater, 1.4 miles NE of pit seismograph. 19° 25.2′ N; 155° 16.1′ W.

July 30, 9:43 pm, very feeble, 1.7 miles deep, 1.6 miles SE of pit seismograph in vicinity of Puhimau. 19° 23.6′ N; 155° 15.8′ W.

July 30, 9:50 pm, feeble, 0.7 mile deep Kilauea crater, 1.0 mile NE of pit seismograph. 19° 24.9′ N; 155° 16.3′ W.

July 31, 2:54 am, very feeble, 1.5 miles deep, E portion of Kilauea crater. 19° 24.8′ N; 155° 15.9′ W.

July 31, 8:27 am, very feeble, of Kilauea crater origin.

July 31, 8:45 am, very feeble, 2.0 miles deep N central portion of Kilauea crater. 19° 15.1′ N; 155° 16.4′ W.

At 11:49 am, July 9, 22 minutes of continuous tremor began to register.

Distant Earthquakes:

July 21, unidentified portion began recording at the Observatory at 9h 37m 24s pm, H.S.T.

July 24, unidentified portion, 3h 00m 30s am, H. S. T.

Microseismic motion of the ground at the Observatory was light July 4-8, 13, 14, 19-25; moderate July 9, 11, 12, 15-18, 26-31 and strong July 10.

Tilting of the Ground:

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

At the Observatory the total accumulated tilt for the year ending July 31 was 1.85″ S and 6.30″ W.

Week Ending	Observatory	Halemaumau West Station
July 10	0.61″ N 26° E	5.00″ N 75° W
July 17	0.56″ N 35° W	4.71″ S 75° W
July 24	0.87″ N 14° W	4.47″ S 85° W
July 31	0.85″ N 50° E	4.83″ S 65° W

Week Ending	Halemaumau Southeast Station	Halemaumau Resultant
July 10	4.73″ S 55° E	9.14″ from
July 17	12.70″ N 22° W	7.38″ toward
July 24	5.60″ N 37° W	1.03″ toward
July 31	3.24″ S 47° E	7.71 from

Crater Angles:

Measurement of horizontal angles across Kilauea crater from the Observatory July 21 indicated closing of both the Halemaumau value and the total crater value. The Halemaumau measurement from the SE pit BM to NW pit BM showed closing of 0.83″ and the crater measurement from the SE crater rim to Uwekahuna showed closing of 0.84″.

H.H.W.

HAWAIIAN VOLCANO RESEARCH ASSOCIATION

The Hawaiian Volcano Research Association was founded in 1911 for the prosecution of volcano research, more particularly in the Hawaiian Islands and around the Pacific Ocean. Its laboratory at Kilauea Volcano, Hawaii, is leased and operated by the United States Government, Department of the Interior, National Park Service. The Association maintains seismograph stations at various places on the Island of Hawaii and supplements the work of the Government with buildings, research fellows, instrumental plants, explorations and special investigations for which there is no governmental provision.

The Volcano Letter, a monthly, eight-page, illustrated publication dealing with volcanic and seismic interests in Hawaii, the Pacific area, and other sections of the world, is issued by authority of the Department of the Interior, and is supplied free of charge to members of the Association and to a restricted exchange list. It is non-technical in nature and promotes popular interest in its particular field of science.

The Secretary of the Association is Mr. L. W. de Vis-Norton, whose address is 320 James Campbell Building, Honolulu, T. H. Contributions of articles, photographs, publications and clippings about volcano and earthquake events, instruments and investigations are always welcome, and if suitable, will be published with due acknowledgment.

THE VOLCANO LETTER

No. 462 Department of the Interior National Park Service August-December, 1938

Edward G. Wingate Superintendent
Hawaii National Park

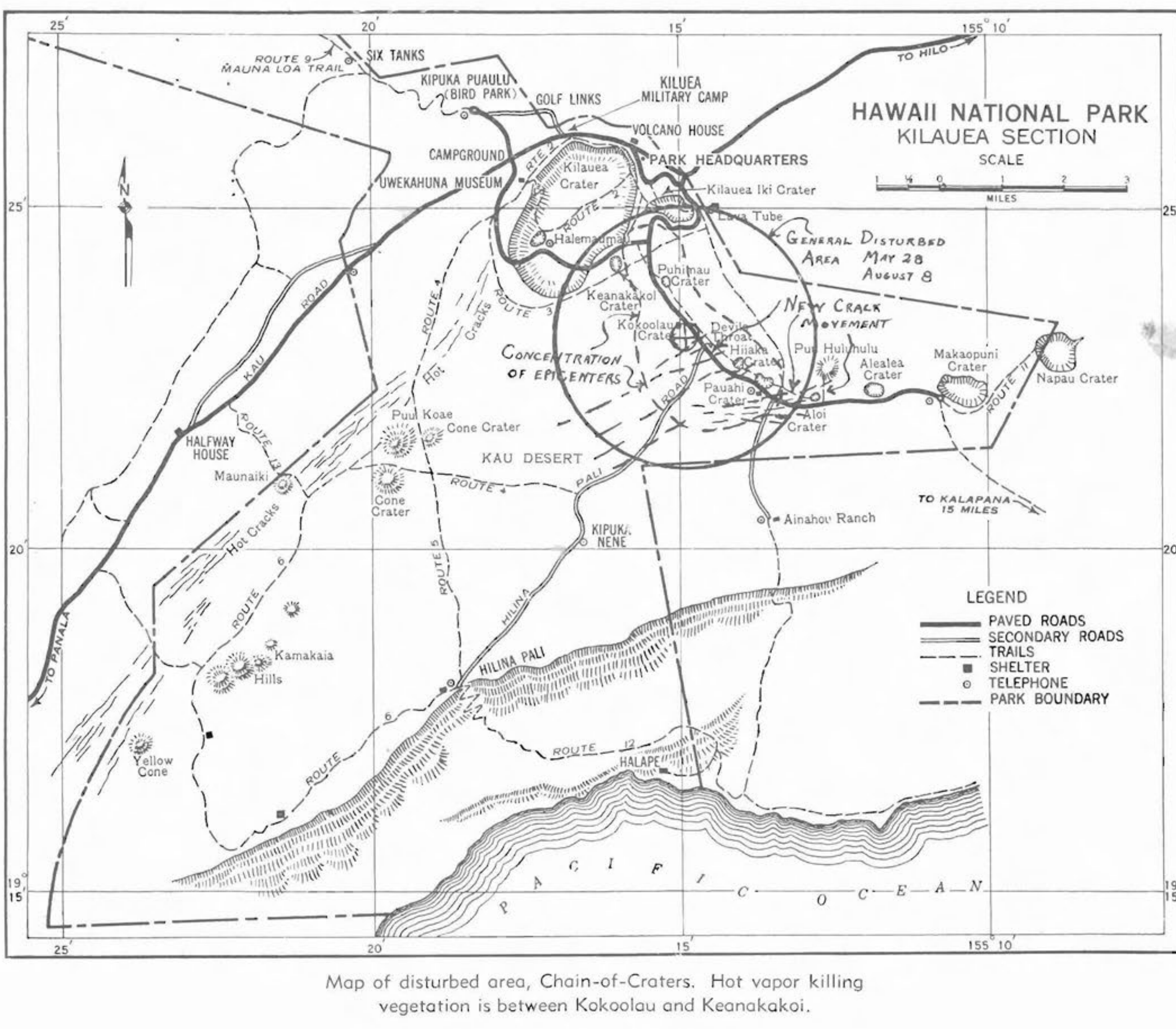
Hawaiian Volcano Observatory
T. A. Jaggar Volcanologist

NE PLUS HAUSTAE AUT OBRUTAE URBES

NOTICE CONCERNING PUBLICATIONS

This number of the Volcano Letter completes the 1938 series, and is published by the University of Hawaii. Hereafter the Letter will be published as a quarterly and will be sent out from the publication office of the University of Hawaii. Members of the Hawaii Volcano Research Association will receive it without cost.

The Third Special Report of the Hawaiian Volcano Observatory has been published by the Hawaiian Volcano Research Association: Ash Formations of the Island of Hawaii, Chester K. Wentworth, 1938, pp. 183; and is ready for distribution upon application to the Secretary, 320 Jas. Campbell Bldg., Honolulu, T. H. $3.00 per copy, postage free.



Map of disturbed area, Chain-of-Craters. Hot vapor killing vegetation is between Kokoolau and Keanakakoi.

Hawaiian Volcano Observatory Report for August-December 1938

VOLCANOLOGY

AUGUST 1938

During this month there was another disturbance of the fault blocks making new crack movement along Chain-of-Craters road similar to the one of May 28, 1938. There were felt earthquakes the forenoon of August 8, the road hump near Devil's Throat increased in elevation, eight new cracks were found between Devil's Throat and Hiiaka pit, and a large number of local shocks were registered instrumentally during the second week of the month. They were not felt in Hilo, but eleven shocks August 8-10 were from Mauna Loa. There were slides in Devil's Throat and Pauahi pit.

Opening of cracks in the road near Devil's Throat amounted to 2.5 and 4.00 mm. between August 10 and 12. The third week two Devil's Throat cracks opened 7.5 mm., and of three cracks between Pauahi and Aloi pits two opened 8.5 mm. The fourth week, of seven cracks marked along the Chain-of-Craters road, one at Devil's Throat opened 1.0 mm., another a half mile east of Pauahi opened 16.0 mm., and one near Aloi closed 14.5 mm. A heavy slide from the west rim of Pauahi crater occurred August 26. Kilauea quakes had decreased in number after August 14 and all but two of the measured shocks showed Mauna Loa distances.

The following are the local data for August:

Week Ending	Halemaumau Slides	Halemaumau Crack Openings	Seismic Disturbances
August 7	0	0.0 mm.	26
" 14	5	7.0 mm.	454
" 21	0	1.0 mm.	24
" 28	0	5.0 mm.	11

SEPTEMBER, 1938

Slides September 3 at the north wall of Kilauea crater made a new talus there. The week ending September 5 showed some recurrence of movement along Chain-of-Craters rift with settlement of the rim of Pauahi pit, and a new crack at Devil's Throat. On September 26 the large road crack near Pauahi crater caved in farther under the impact of a car.

Inspection of northeast rift of Mauna Loa September 15 showed recent disturbance of the new cracks at 11,000 feet elevation, and the 1935 cone was fuming and depositing sulphur.

The following are the local data for September:

Week Ending	Halemaumau Slides	Halemaumau Crack Openings	Seismic Disturbances
September 4	[illegible]	1.5 mm.	11
" 11	5	2.5 mm.	11
" 18	2	0.5 mm. closing	9
" 25	1	7.5 mm.	11
October 2	0	5.5 mm. closing	12

OCTOBER 1938

The first week of the month produced no earthquakes and few tremors although there was increase of slides at Halemaumau. During the second week there were no slides and only two small earthquakes. The third week was seismically the quietest of the year to date. The last week produced an earthquake at 6:12 p.m. October 27 on the southwest rift of Mauna Loa that cracked a concrete floor in the village of Naalehu.

The following are the local data for October:

Week Ending	Halemaumau Slides	Halemaumau Crack Openings	Seismic Disturbances
October 9	24	2.5 mm.	12
" 16	0	5.5 mm.	13
" 23	1	0.5 mm.	6
" 30	0	2.5 mm.	12

NOVEMBER 1938

The month was notable in the Pacific area in producing eleven distant earthquakes, and the local field here was extraordinary in developing large numbers of small slides from the Halemaumau wall, and also some avalanches from the northern corner of Kilauea crater. It is remarkable that the measured local earthquakes of the fortnight ending November 27 were dominantly from sources in the island not within Kilauea Volcano, although there were great numbers of Halemaumau slides.

The following are the local data for November:

Week Ending	Halemaumau Slides	Halemaumau Crack Openings	Seismic Disturbances
November 6	3 (Kilauea)	0.0 mm.	33
" 13	1 (Halemaumau)	4.5 mm.	10
" 20	23 "	4.0 mm.	24
" 27	93 "	3.5 mm.	30

DECEMBER 1938

The first week showed slides in some of the pits of Chain-of-Craters, and also on the Puna cliffs towards the sea. There was one day of slides in Halemaumau. During the third week some motion occurred along the Chain-of-Craters.

Inspection of Mauna Loa northeast rift December 9-10 showed the upper cone of 1935 steaming and smelling of sulphur dioxide and hydrogen sulphide; parts of the bright yellow sulphur coatings had the orange tinge of either iron or selenium.

The following are the local data for December:

Week Ending	Halemaumau Slides	Halemaumau Crack Openings	Seismic Disturbances
December 4	7	4.5 mm.	38
" 11	0	1.0 mm.	8
" 18	3	3.5 mm.	17
" 25	0	2.0 mm.	14

T.A.J.

SEISMOLOGY AND GROUND MEASUREMENTS

Earthquakes

AUGUST 1938

Week Ending	Minutes of Tremor	Very Feeble Earthquakes	Feeble Earthquakes	Slight Earthquakes	Moderate Earthquakes	Distant† Earthquakes	Weekly* Seismicity
Aug. 7	17	9	0	0	0	0	8.75
Aug. 14	1,014	184	56	36	3	0	482.50
Aug. 21	17	6	1	0	0	0	8.25
Aug. 28	10	1	0	0	0	0	3.00

† Including teleseisms or earthquakes of over 5000 km from Kilauea.

* For local seismicity definition see Volcano Letter 371.

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

August 2, 8:51 am, very feeble, probably originated near center of Kilauea Crater.

August 2, 9:17 am, very feeble, probably originated in NE portion of Kilauea Crater.

August 3, 9:53 am, very feeble, probably originated near center of Kilauea Crater.

August 4, 9:50 pm, very feeble, same as preceding.

August 5, 8:59 pm, very feeble, 0.9 mile deep under Byron Ledge. 19° 25.5′ N; 155° 15.5′ W.

August 6, 2:59 am, very feeble, 12.0 miles deep under Mauna Kea about 5.0 miles S of Summit. 19° 45.5′ N; 155° 27.0′ W.

During the week, August 7-14 inclusive, 454 local seismic disturbances were recorded on the seismographs of the Hawaiian Volcano Observatory. Between midnight August 7 and 2:10 am August 8, there were three tremors and one very feeble earthquake. At 2:14 am, 840 minutes of continuous tremor began to register, ending at 4:38 pm August 8. During the remainder of the day there were 74 tremors, 184 very feeble, 56 feeble, 36 slight and 3 moderate earthquakes.

The moderate earthquakes were:

5:12 am, 1.3 miles deep, 0.4 miles SW of Hiiaka Crater.

9:44 am, thought to have originated in the vicinity of Devil's Throat.

11:41 am, probably originated in cracks about 0.6 mile W of Kokoolau Crater.

It may be noted that the three were successively closer to Kilauea Crater, indicating distances from the Observatory of 4.7, 3.5 and 3.2 miles respectively.

These and associated shocks were felt by most residents of Hawaii National Park. Those asleep were awakened by the early disturbances. The swarm of earthquakes began after the continuous tremor. The shocks were not felt at any great distance from Kilauea Crater.

For the week there are the following data:

Date	Disturbances	Minutes of Tremor*	Very Feeble Earthquakes	Feeble Earthquakes	Slight Earthquakes	Moderate Earthquakes
Aug. 8	323	917	166	45	31	3
Aug. 9	83	60	11	8	4	....
Aug. 10	22	16	4	1	1	....
Aug. 11	10	8	2	....	....	....
Aug. 12	6	6	....	....	....	....
Aug. 13	8	5	1	2	....	....
Aug. 14	2	2	....	....	....	....
Totals	454	1,014	184	56	36	3

*—840 continuous and 77 spasmodic.

Focal distances of the shocks were between 0.5 and 6.0 miles from the Observatory. The circle on the accompanying map shows the general area of disturbance. The majority of the shocks were located by determinations derived from a study of seismograms from the Observatory, Pit and Uwekahuna seismographs. The epicenters thus determined fell within the irregular area inside the circle on the map. The center of the circle (+) was apparently the center of greatest disturbance and was determined by averaging all the S-P values from the three stations mentioned above. The earthquakes were most strongly felt within the areas indicated. The fact that they were not felt at any great distance (probably not over 7.0 miles) from their source indicates they were local to the Kilauea Crater area, particularly in the Chain-of-Craters to the SE and were of shallow origin. By graphic methods of determination depth of focus was in no case more than two miles. Most were less than 1.0 mile and in many cases appeared to have been less than 0.5 mile. A substantial number indicated depths of 1.5 to 1.8 miles.

Accompanying the earthquakes there was apparently considerable movement of probably preexisting cracks between Kokoolau and Hiiaka Craters. The cracks which had shown movement during May disturbances apparently changed slightly. The latter were located between Pauahi and Aloi Craters. Concentric cracks around Devil's Throat increased and more rockfalls from the rim occurred. Slides also occurred in Pauahi. The hump in the Chain-of-Craters road near Devil's Throat increased in height and the road surface was considerably fractured. Other cracks opened 10 feet north. Three sets of cracks in the road developed to the S of Devil's Throat, i.e., between Devil's Throat and Hiiaka and on the S rim of Hiiaka. Many shocks originated in Kilauea Crater.

One slight shock felt at Kapapala Ranch at 9:45 am, August 8, was apparently located 15.0 miles deep in the Hilina Fault system 7.5 miles SW of the Observatory. 19° 19.0′ N; 155° 15.0′ W.

Another (very feeble) from same general locality registered at 5:53 pm. A third (very feeble) located in Hilina Fault System near the junction with the SW rift 8.0 miles deep occurred at 1:24 am, August 10. 19° 16.0′ N; 155° 19.5′ W.

Other August earthquakes were:

August 15, 6:46 am, very feeble, originated 8.0 miles deep in Kilauea SW rift, 13.0 miles from Halemaumau. 19° 14.5′ N; 155° 24.0′ W.

August 15, 6:14 pm, very feeble, 2.0 miles deep, SE portion of Kilauea Crater. 19° 24.7′ N; 155° 26.1′ W.

August 16, 7:43 pm, feeble, 25.0 miles deep under Mauna Loa, about 20.0 miles W of Kilauea Crater. 19° 25.0′ N; 155° 34.0′ W. Strongly felt in Pahala and at Kapapala Ranch.

August 20, 3:12 pm, very feeble, 2.0 miles deep, Kalanaokoai Pali, 2.0 miles WSW of Pauahi Crater.

August 20, 5:06 pm, very feeble, 14.0 miles deep, Mauna Loa NE rift about 3.0 miles E of Puu Ulaula. 19° 32.5′ N; 155° 26.0′ W.

August 22, 1:19 am, very feeble, 15.0 miles deep, Mauna Loa SW rift, 14.0 miles SW of summit. 19° 18.5′ N; 155° 43.5′ W.

Microseismic motion of the ground at the Observatory was light August 1-8; moderate August 9-13, 18, 24-28 and strong August 14-17, 19-23 inclusive.

Tilting of the Ground

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

At the Observatory the total accumulated tilt for the year ending August 28 was 1.49″ S and 6.6″ W.

Week Ending	Observatory	Halemaumau West Station
August 7	0.40″ N 15° W	3.19″ N 75° W
August 14	1.20″ N 42° E	8.08″ N 60° W
August 21	0.32″ S 59° W	4.17″ N 69° W
August 28	0.12″ N 68° E	1.61″ S 50° W

Week Ending	Halemaumau Southeast Station	Halemaumau Resultant
August 7	8.42″ N 54° W	5.15″ toward
August 14	10.69″ N 39° W	4.13″ toward
August 21	7.06″ N 72° W	4.01″ from
August 28	2.79″ N 72° W	1.09″ toward

Crater Angles

Measurement of horizontal angles across Kilauea Crater from the Observatory August 10 and 22, indicated slight opening of the Halemaumau value and closing of the total Crater value compared with similar measurements July 21. Between July 21 and August 10, the Halemaumau measurement from SE Pit BM to NW Pit BM showed closing of 0.26″ and between August 10 and 22, opening of 0.59″. Total opening 0.33″. Between July 21 and August 10 the Crater measurement from SE rim station to Uwekahuna showed opening of 0.67″ and between August 10 and 22, closing of 1.01″. Total closing 0.34″.

H.H.W.

Earthquakes

SEPTEMBER 1938

Week Ending	Minutes of Tremor	Very Feeble Earth-quakes	Feeble Earth-quakes	Distant* Earth-quakes	Weekly† Seismicity
September 4	7	3	1	1	4.25
September 11	10	1	0	0	3.00
September 18	6	3	0	0	3.00
September 25	8	3	0	0	3.50
October 2	9	3	0	0	3.75

* Including teleseisms or earthquakes of over 5000 km from Kilauea.

† For local seismicity definition see Volcano Letter 371.

New hump in road near Devil's Throat, May and August 1938.

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

August 29, 2:30 pm, very feeble, 10.0 miles deep. Mauna Loa NE rift 4.0 miles NE of center of summit crater. 19° 30.5′ N; 155° 32.2′ W.

September 2, 2:53 am, feeble, 13.0 miles deep, Kilauea SW rift, 8.0 miles SW of Halemaumau. 19° 20.0′ N; 155° 23.0′ W. Reported felt at Kapalapala and Pahala.

September 2, 4:09 am, very feeble, 17.0 miles deep, Mauna Loa NE rift, 7.0 miles NE of summit crater. 19° 31.5′ N; 155° 29.0′ W. Reported felt at Kapalapala Ranch.

September 3, 7:13 am, very feeble, probably originated about 4.6 miles S of Pit seismograph station in Kalanaokuaiki.

September 9, 6:58 am, very feeble, probably located in Kilauea SW rift near Pahala.

September 14, 5:38 pm, very feeble, 1.6 miles deep in vicinity of Puu Huluhulu, Chain-of-Craters rift. 19° 22.7′ N; 155° 12.6′ W.

September 16, 2:42 pm, very feeble, 1.8 miles deep in Kalanaokuaiki fault, 1.8 miles E of Puu Ohale. 19° 21.2′ N; 155° 15.2′ W.

September 21, 6:17 pm, very feeble, probably originated in Kilauea SW rift about 11.0 miles SW of Halemaumau.

September 24, 1;49 pm, very feeble, 11.0 miles deep, 3.0 miles N of Halfway House between Kilauea and Mauna Loa. 19° 21.4′ N; 155° 25.2′ W.

October 1, 9:04 pm, very feeble, 2.8 miles deep, near center of Kilauea Crater. 19° 25.1′ N; 155° 16.4′ W.

Distant Earthquakes

"P" waves began recording at Kilauea at 1h 30m 33s am, H.S.T., August 30. Distance from the Observatory estimated at 4,400 miles.

Microseismic motion of the ground at the Observatory was light September 3, moderate August 29, 31, September 1, 2, 4, 5, 10-15 and strong August 30, September 6-9, 16-30 and October 1 and 2.

Tilting of the Ground

The following tables show tilt by weeks as recorded by the Observatory seismograph and at Halemaumau, the algebraic sum toward or away from the Pit.

At the Observatory the total accumulated tilt for the year ending October 2, was 0.73″ S and 5.36″ W.

Week Ending	Observatory	Halemaumau West Station
September 4	0.72″ N 65° E	2.38″ N 41° W
September 11	0.70″ N 24° E	3.73″ N 45° W
September 18	0.84″ N 39° E	6.05″ N 80° W
September 25	0.70″ N 24° E	2.00″ N 20° W
October 2	0.75″ S 4° W	1.85″ S 61° W

Week ending	Halemaumau Southeast Station	Halemaumau Resultant
September 4	4.57″ S 16° E	5.41″ from
September 11	10.40″ N 39° W	7.99″ toward
September 18	5.64″ N 4° E	1.43″ from
September 25	14.42″ N 31° W	13.49″ toward
October 2	8.88″ N 63° W	6.30″ toward

Crater Angles

Measurement of horizontal angles across Kilauea Crater from the Observatory, September 7 and 22, indicated closing of the Halemaumau value and closing of the total Crater value compared with similar measurements August 22. Between August 22 and September 7, the Halemaumau measurement from SE Pit BM to NW Pit BM showed closing of 2.66″ and between September 7 and September 22, closing of 0.58″. Total closing 3.24″. Between August 22 and September 7 the Crater measurement from SE rim station to Uwekehuna showed closing of 0.66″ and between September 7 and 22 closing of 0.67″. Total closing 1.33″.

Levelling at Kilauea

Since December 9, 1937 three sets of levels have been run in Kilauea Crater from the S pit BM, SE rim area of Kilauea Crater and the NW pit BM on the NW rim of Halemaumau. The first run, February 8, 1938 showed a relative lowering of NW pit BM with reference to S pit BM of 6.7 centimeters within the preceding two-month period. Similar measurements July 24, indicated a raising of the NW pit BM of 4.6 centimeters since February 8 and from July 24 to September 15, a raising of 0.5 centimeter. As in the February run, the last two are with reference to the S pit BM. It is possible that the movement indicated February 8, may have been a raising of S pit with reference to NW pit and in the last two cases S pit may have lowered. The latter movement seems quite plausible in view of recent visible earth movements along Chain-of-Craters road where cracks indicate apparent downward movements to the south. These measurements give only relative changes between two stations with no reference in either case to changes relative to sea-level.

H.H.W.

OCTOBER 1938

Earthquakes

Week Ending	Minutes of Tremor	Very Feeble	Slight	Distant*	Weekly† Seismicity
October 9	12	0	0	0	3.00
October 16	11	2	0	0	3.75
October 23	5	1	0	2	1.75
October 30	7	3	2	0	7.25

* Including teleseisms or earthquakes of over 5000 km from Kilauea.

† For local seismicity definition see Volcano Letter 371.

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

October 10, 11:52 am, very feeble, 4.7 miles deep, NW rim area of Kilauea Crater about 0.5 mile N of Uwekahuna, 19° 25.7′ N; 155° 17.4′ W.

October 13, 5:09 am, very feeble, 33.0 miles deep, Hualalai-Puu Waawaa area. 19° 47.0′ N; 155° 52.7′ W.

October 19, 7:25 am, very feeble, 15.0 miles deep in Chain-of-Craters area 4.0 miles SE of the Observatory, 19° 23.4′ N; 155° 13.6′ W.

October 25, 12:18 pm, slight, 16.0 miles deep, near Glenwood, 18.5 miles SSW of Hilo. 19° 27.8′ N; 155° 09.5′ W. Reported felt by many in Hilo and by a few in Hawaii National Park.

October 26, 9:38 am, very feeble, 2.6 miles deep in Chain-of-Craters, vicinity of Aloi and Puu Huluhulu. 19° 22.1′ N; 155° 12.6′ W.

October 27, 6:11 pm, slight, 15.0 miles deep under Hualalai. 19° 42.0′ N; 155° 50.2′ W. Reported felt by many in Kona and at Naalehu.

October 29, 7:07 am, very feeble, of Mauna Loa origin.

October 30, 2:46 am, very feeble, probably originated south of Kilauea Crater in cracks near Puu Ohale.

Distant Earthquakes

"P" waves began recording at Kilauea at 4h 01m 58s pm, H.S.T., October 19. Probably originated about 5500 miles from the Observatory.

Unidentified portion began registering at 1h 10m 56s am, H.S.T., October 20.

Microseismic motion of the ground at the Observatory was light October 13, 14, 15; moderate October 12, 16, 17, and strong the remainder of the month.

Tilting of the Ground

The following tables show tilt by weeks as recorded by the Observatory seismograph and at Halemaumau, the algebraic sum toward or away from the Pit.

At the Observatory the total accumulated tilt for the year ending October 30, was 0.52″ N and 4.74″ W.

Week Ending	Observatory	Halemaumau West Station
October 9	1.22″ N 40° E	5.00″ S 43° W
October 16	0.12″ W	2.68″ N 18° W
October 23	0.15″ S	4.53″ S 83° W
October 30	1.24″ N 19° E	5.96″ N 73° W

Week Ending	Halemaumau Southeast Station	Halemaumau Resultant
October 9	4.96″ N 63° W	0.64″ toward
October 16	2.92 S 20° W	2.22″ from
October 23	10.27″ S 40° W	6.90″ from
October 30	4.44″ N 47° W	1.13″ from

Crater Angles

Measurement of horizontal angles across Kilauea Crater from the Observatory, October 11 and 25, indicated little change in the Halemaumau value but closing of the Crater value compared with similar measurements September 22. Between September 22 and October 11, the Halemaumau measurement from SE pit BM to NW pit BM showed closing of 0.43″ and between October 11 and 25, opening of 0.50″. Total opening 0.07″. Between September 22 and October 11, the Crater measurement from SE rim station to Uwekahuna showed closing of 1.66″ and between October 11 and October 25, closing of 0.50″. Total closing 2.17″.

H.H.W.

NOVEMBER 1938

Earthquakes

Week Ending	Minutes of Tremor	Very Feeble	Feeble	Distant*	Weekly† Seismicity
November 6	26	6	1	4	10.50
November 13	31	2	1	4	9.75
November 20	18	7	1	2	9.00
November 27	24	6	0	1	9.00

* Including teleseisms or earthquakes of over 5000 km from Kilauea.

† For local seismicity definition see Volcano Letter 371.

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

October 31, 1:05 pm, very feeble, 20.0 miles deep, Hualalai, 5.0 miles SE of summit. 19° 39.2′ N; 155° 47.7′ W. Reported felt at Puu Waawaa ranch house.

November 2, 12:14 am, very feeble, probable origin, E portion of Kilauea Crater.

November 3, 12:53 pm, very feeble, probable origin, Hilina Fault system about 4.0 miles SE of Makaopuhi.

November 4, 7:40 am, very feeble, 2.8 miles deep in N portion of Kilauea Crater. 19° 25.6′ N; 155° 16.6′ W.

November 5, 10:37 am, very feeble, 1.7 miles deep, 0.5 mile NE of Hiiaka Crater. 19° 23.0′ N; 155° 13.6′ W.

November 5, 10:27 pm, feeble, 2.0 miles deep, 0.4 mile W of Kokoolau. 19° 23.2′ N; 155° 15.2′ W.

November 7, 6:15 am, feeble, 25.0 miles deep, 4.0 miles W of summit of Hualalai. 19° 42.8′ N; 155° 56.0′ W. Reported felt in Kona district.

November 9, 12:01 am, very feeble, probably originated in NE rim area of Kilauea Crater.

November 12, 9:37 pm, very feeble, probably originated in NE rim area of Kilauea Crater.

November 14, 12:17 am, very feeble, probably originated under Halemaumau, Kilauea Crater.

November 18, 2:29 am, very feeble, 28.0 miles deep, 10 miles W by S of summit of Mauna Kea, 14 miles E by N of Puu Waawaa. 19° 47.8′ N; 155° 38.0′ W.

November 18, 3:48 am, very feeble, 3.8 miles deep, 0.8 mile S of Pauahi Crater. 19° 21.7′ N; 155° 13.4′ W.

November 20, 5:31 pm, feeble, 13.0 miles deep in Hilina-Kapukapu fault system, 4.0 miles S by W of Makaopuhi. 19° 19.0′ N; 155° 12.0′ W. Reported felt by several persons in Hawaii National Park Headquarters area.

November 20, 6:08 pm, very feeble, probably originated in Hilina fault system about 3.0 miles SE of Kamakaia Hills.

November 21, 11:13 pm, very feeble, probably originated near Kokoolau, Chain-of-Craters.

November 22, 10:48 am, very feeble, of Mauna Loa origin, NE rift.

November 27, 9:21 am, very feeble, of Kilauea Crater origin, vicinity of Halemaumau.

Four minutes of continuous tremor registered November 10, beginning at 10:33 am. The tremor was superimposed on a portion of a teleseism. At Halemaumau it was equivalent in size to a feeble shock so probably originated in Kilauea Crater near Halemaumau.

Three minutes of tremor registered November 16 beginning at 4:09 pm.

Teleseisms

November 4, 10h 23m 20s pm, "P" waves, distance from Kilauea 3775 miles.

November 5, 12h 30m 05s am, "P" waves, distance 4025 miles. Located in Northern Japan where some damage resulted. Also reported felt in Tokyo.

November 5, 10h, 33m 41s pm, "P" waves, distance 3880 miles.

November 6, 11h 18m 37s am, "P" waves, distance 3550 miles.

November 8, 11h 13m 18s pm, unidentified portion.

November 10, 9h 55m 42s am, "P" waves, distance 2485 miles. Apparent location was near Shumagin Islands off S coast of Alaska. U.S.C. & G.S. location of origin was 55° N; 159° S. Seismographic registration of this shock was unusually strong throughout the world. Maximum waves dismantled Bosch-Omori seismograph at the Hawaiian Volcano Observatory at 10:07 am. Small tidal wave was observed in Hawaiian Islands between 3:00 and 3:30 pm. Reported felt over large portion of Alaska but no damage reported.

November 10, 2h 34m 49s pm, "P" waves, distance 3370 miles.

November 13, 12h 49m 42s pm, unidentified portion.

November 14, 1h 46m 09s am, unidentified portion.

November 16, 5h 31m 37s pm, "P" waves, distance 2420 miles. According to news dispatches, originated Aleutian Islands, Alaska, at approximately same locality as earthquake of November 10.

November 21, 2h 54m 02s pm, "P" waves, distance 3725 miles.

Time used above is Hawaiian Standard, 10h 30m behind G.C.T.

Microseismic motion of the ground at the observatory was moderate December 17, 18, 19 and 26 and was strong the remainder of the month.

Tilting of the Ground

The following tables show tilt by weeks as recorded by the Observatory seismograph and at Halemaumau, the algebraic sum toward or away from the Pit.

At the Observatory the total accumulated tilt for the year ending November 27 was 1.1" S and 4.43" M.

Week Ending	Observatory	Halemaumau West Station
November 6	0.92" S 20° E	2.68" S 75° W
November 13	1.13" N 80° E	4.17" N 40° W
November 20	0.40" S 47° W	6.05" S 77° W
November 27	0.93" N 35° E	3.33" S 55° W

Week Ending	Halemaumau Southeast Station	Halemaumau Resultant
November 6	3.30" S 80° W	1.08" from
November 13	3.24" N 5° W	0.97" from
November 20	2.91" N 71° W	3.68" from
November 27	3.89" N 55° W	0.73" toward

Crater Angles

Measurement of horizontal angles across Kilauea Crater from the Observatory, November 23, indicated closing of the Halemaumau value and opening of the Crater value compared with similar measurements made October 25. During that period the angle between SE pit BM and NW pit BM closed 1.58" and the angle between SE rim Station and Uwekahuna opened 1.48". H.H.W.

DECEMBER 1938

Earthquakes

Week Ending	Minutes of Tremor	Very Feeble	Feeble	Distant*	Weekly† Seismicity
December 4	23	11	4	1	15.25
December 11	6	2	0	0	2.50
December 18	20	6	0	0	8.00
December 25	21	2	0	0	6.25
January 1	9	5	0	0	4.75

* Including teleseisms or earthquakes of over 5000 km from Kilauea.

† For local seismicity definition see Volcano Letter 371.

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

November 28, 2.03 pm, very feeble, 1.8 miles deep, 1.0 mile west of Puhimau and 0.6 mile south of Keanakakoi in Chain-of-Craters, 19° 23.7′ N; 155° 15.9′ west.

November 29, 5:43 am, feeble, 4.0 miles deep in SW portion of Kilauea Crater immediately W of Halemaumau. 19° 24.7′ N; 155° 17.6′ W. Reported felt in Hawaii National Park.

November 29, 9:59 am, very feeble, probably originated in Chain-of-Craters area near Kokoolau.

November 29, 10:18 am, very feeble, of Kilauea Crater origin.

November 29, 10:19 am, feeble, of Kilauea origin. Reported felt in national park residential area.

November 30, 4:17 am, very feeble, probably originated in Kilauea SW rift about 2.0 miles from Halemaumau.

November 30, 2:05 p.m., very feeble, of shallow origin in Chain-of-Craters near Puhimau and Kokoolau. 19° 23.4′ N; 155° 15.2′ W.

November 30, 3:08 pm, feeble, 3.2 miles deep, Chain-of-Craters, 1.0 mile N of Hiiaka. 19° 23.5′ N; 155° 14.1′ W. Reported felt in national park residential area.

November 30, 3:13 pm, very feeble, 1.2 miles deep, 0.8 mile E of Keanakakoi, 19° 24.2′ N; 155° 15.2′ W.

November 30, 8:57 pm, feeble, 4.0 miles deep, 1.4 miles W of Pauahi Crater. 19° 22.3′ N; 155° 14.8′ W. Reported felt in Hawaii National Park residential area and at CCC camp.

December 1, 4:32 pm, very feeble, location approximately same as preceding shock.

December 2, 6:53 pm, very feeble, 8.0 miles deep, Mauna Loa NE rift 3.5 miles SW of Puu Ulaula. 19° 30.7′ N; 155° 31.0′ W.

December 2, 9:27 pm, very feeble, same general locality as preceding shock. 19° 31.5′ N; 155° 31.0′ W.

December 4, 4:32 am, very feeble, originated in Mauna Loa NE rift near Puu Kulua.

December 4, 7:34 am, very feeble, 2.2 miles deep in Chain-of-Craters near Hiiaka and Pauahi craters. 19° 22.7′ N; 155° 13.3′ W.

December 8, 11:09 pm, very feeble, of comparatively shallow origin, Mauna Loa NE rift, vicinity of Pohaka Hanalei. 19° 30.0′ N; 155° 33.6′ W.

December 10, 7:59 pm, very feeble, 12.0 miles deep under N slope of Mauna Loa about 5.0 miles N of Puu Ulaula. 19° 36.5′ N; 155° 26.8′ W.

December 13, 7:26 am, very feeble, E slope of Mauna Loa, 5.0 miles E of summit crater. 19° 28.3′ N; 155° 31.0′ W.

December 13, 10:11 am, very feeble, 8.0 miles deep under coast line S of Hilina Pali and 4.0 miles W of Keahou Point. 19° 16.5′ N; 155° 18.0′ W. Reported felt in Hilo.

December 14, 12:13 am, very feeble, in Hilina Fault system, 4.5 miles SE of Makaopuhi.

December 16, 1:18 pm, very feeble, of shallow origin near Devil's Throat. 19° 22.9′ N; 155° 14.5′ W.

December 16, 1:27 pm, very feeble, possibly 35.0 miles deep, under E slope of Mauna Loa. 19° 26.5′ N; 155° 32.0′ W.

December 17, 1:31 pm, very feeble, originated in Kilauea Crater, probably under Halemaumau.

December 19, 5:24 pm, very feeble, probably originated in Kilauea SW rift near Junction with Hilina Fault system.

December 20, 12:51 pm, very feeble, originated in Kilauea Crater near E rim of Halemaumau.

December 23, 7:18 am, a tremor which registered as feeble on Mauna Loa seismograph and originated in Mauna Loa NE rift.

December 26, 6:23 pm, very feeble, probably originated in area 3.2 miles E of Kilauea Iki.

December 27, 6:33 am, originated in Kilauea crater under Halemaumau.

December 28, 3:12 am, very feeble, 1.2 miles deep, Chain-of-Craters, 0.9 mile east of Keanakakoi. 19° 24.7′ N; 155° 15.2′ W.

Continuous tremor:

10 minutes, beginning at 3:45 pm, December 15.

10 minutes, beginning at 7:22 pm, December 19.

Teleseisms

Unidentified portion began to register at the Observatory 4h 17m 28s pm, HST, November 29. Located in Japan, E coast of Honshu. 37° 5′ N; 141° 3′ W.

Microseismic motion of the ground at the Observatory was moderate December 9 and 10 and strong the remainder of the period between November 28 and January 1 inclusive. Stormy weather prevailed at sea contemporaneously.

Tilting of the Ground

The following tables show tilt by weeks, as recorded by the Observatory seismograph and at Halamaumau, the algebraic sum toward or away from the Pit.

At the Observatory the total accumulated tilt for the year ending January 1, 1939, was 0.86″ S and 6.82″ W.

Week Ending	Observatory	Halemaumau West Station
December 4	1.12″ S 68° W	7.36″ N 71° W
December 11	0.80″ E	6.00″ S 76° W
December 18	1.10″ N 12° W	0.42″ N
December 25	2.17″ S 30° W	3.22″ S 57° W
January 1	0.80″ N 66° W	3.43″ S 60° W

Week Ending	Halemaumau Southeast Station	Halemaumau Resultant
December 4	2.08″ N 34° W	4.76″ from
December 11	7.08″ N 12° W	0.92″ toward
December 18	3.97″ N 41° E	0.81″ toward
December 25	8.10″ S 49° W	3.32″ from
January 1	10.05″ N 49° E	2.32″ from

Crater Angles

Measurement of horizontal angles across Kilauea Crater from the Observatory, December 29, indicated opening of both the Halamaumau and the crater values compared with similar measurements of November 23. Between November 23 and December 13 the Halemaumau measurement from SE pit BM to NW pit BM showed opening of 0.35″ and between December 13 and 29, opening of 0.57″. Total opening of 0.92″. Between November 23 and December 13, the crater measurement from SE rim station to Uwekahuna showed closing of 1.07″ and between December 13 and 29, opening of 1.51″. Total opening 0.44″. H.H.W.