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

MONTHLY U. S. Geological Survey, Hawaii National Park 1932

TITLE PAGE AND INDEX FOR 1932

Nos. 367 to 394

(Changed weekly to monthly, No. 388, June 1932)

The Volcano Letter

Two dollars per year **Ten cents per copy**

No. 367—Weekly Hawaiian Volcano Observatory, National Park, Hawaii January 7. 1932

The large northeastern fountains of lava in the bottom of Halemaumau pit, Kilauea Volcano, on the evening of the first day of the eruption, December 23, 1931. from the north-northwest rim, 7:30 p. m. Photo Higashida.

JOURNAL OF HALEMAUMAU ACTIVITY DECEMBER 28-JANUARY 3, 1931-32

It is now evident that the activity of the bottom of Halemaumau in the current eruption is stronger, and the lava fill more voluminous than in any outbreak since 1924. The current week brings to a close the eleventh day of the eruption with the fill at the highest southwestern side of the bottom of the pit at an elevation 110 feet above the corresponding floor of 1930. The progress of the week has determined a concentration of all visible inflow at the big southwestern grotto, where the lava piles up a horseshoe cone with an open cup overflowing to the floor of the pit. The topmost spatter of this cone stands 280 feet above the highest summit of the cone of 1930, and only 650 feet below the tourist station at the southeast rim of the pit. The line of central fountains disappeared after December 29, when it became evident that the southwest border of the floor was to become the top of a new mound from which flows would radiate across a swollen heap of fresh lava in the pit, and these flows have themselves developed a lake at the top of the mound bordered by a rampart of crusts which divides the lake at the southwest from the slope down to the edge of the floor at the northeast. This lake is continually fed by the torrents of lava from the fountaining craterlet, and from time to time the lake breaks through its rampart with overflows that flood the northern slopes of the mound. Seismic activity as usual has dwindled since the magma was released, harmonic tremor from the fountains is continuous, and the change in tilt from northeast to southwest at the Observatory is what would be expected with the lava ejection relieving upward pressure and replacing it by heavy weight of new fill.

December 28

At 11:20 a. m. the concentration of activity at the big southwest fountain was sending frothy jets 350 to 400 feet high and spattering halfway up the west talus. The material appeared to be basaltic froth, and in dimensions and structure the whole cone and fountain were like the Alika source cone of 1919 on Mauna Loa (Volcano Letter 348, Page Three). Heat was strong on the edge of the pit, and this grotto fountain played like a jet from a hose, swinging slowly around a central vertical position, and dropping its light spatter first on one side, then on another. The resemblance to the Mauna Loa source cone was increased by the action of the minor fountains in the central lake and the two explosive vents, at the north, of the fountain line, which are making extraordinary flings of ropy lava to a great height, and detonations accompanied by puffs of blue gas. Just these things happened in the northern cones of the Alika rift, in contrast to the big fountain, with its frothing pool, farther south.

The central fountain was a bubbling pool which occasionally sent up a string of slag even higher than the steady spray of the southwest cone, and this string would loop and bend at the top, and then fall with a slap on the pool below. Both the central fountain and the one farther north made explosive bursts with loud thudding detonations, some of which sounded like a chemical explosion. At the area of the northern fountain there were three definite streams pouring northward on a downhill slope from an edge of crust. indicating that a lake had formed within a slag heap. About 18 fountains of small size extended from the center to the southwest.

The whole area of the northern edges of the floor was cracked and mashed into pressure ridges like the slopes of the mound of 1930. There were four or five jets of blue fume in this slope area. A wide patch of crust made an island about where the big cone of 1930 had been. The lake was leaf-shaped with the southwest fountain at the stem, and the latter was building a high, cracked half circle of its hardened flings on the uphill side against the talus behind it. The inside of its cup would continually cave in revealing red-hot walls. Measurements had shown a gain in height of the built-up bottom of 100 or more feet at the southwest, and only 40 feet to the northwest of the center of the pit, showing that there was development by both overflow and tumescence around the region of maximum fountaining. A cloud of blue fume was always rising from the big fountain, and smaller amounts of it came from the other fountains.

A nationwide broadcast was sent out from the edge of the pit describing the activity for the half hour following 10:45 a. m., by KGU of the Honolulu Advertiser. A microphone attached to the end of a long timber was thrust inside the pit so that listeners might hear the roar of the big fountain and the explosive bursts of the central and north central vents. The arrangement of this apparatus, with wires for relays by radiophone, had been accomplished in less than a day, and was of interest as showing what could be done for securing assistance in case such a volcanic happening were disastrous.

New cracks were discovered in the bottom lava of Ki-

Panorama of the bottom of Halemaumau at 10 a. m. December 24, 1931, looking northwest. This shows the condition when the line of central fountains was in action, the liquid was a continuous lake except for a narrow border rampart, and the southwest grotto at the left was small. Photo Jaggar.

lauea Crater outside of Halemaumau, occasioned by the stresses which produced this eruption at the time of the earthquake of December 23, as follows: Three cracks concentric with the rim to the northeast and seven cracks concentric with the rim to the northwest within 500 feet of distance. Close under Uwekahuna bluff in the same direction appeared nine similar cracks as though the inner heap of Kilauea Crater were broken by motion on the fault of which the Uwekahuna bluff is the trace. The west, southwest, and south outer country of the Kilauea floor showed widening of old cracks and development of some new ones. Large blocks of spatter from the fountains were found to leeward of the pit, and a wounded tropic bird was picked up which had been dashed against the pit wall by the wind and was bleeding. The earthquake of December 23 had dislodged a bowlder three feet in diameter from the Uwekahuna wall and rolled it 200 feet out on the Kilauea floor. Several new steam vents were noted about the inner talus heaps of Halemaumau.

At 4 p. m the southwest grotto fountain had a quiet spell jetting only about 50 feet high, and along the inner belt there were only two sluggish small fountains southwest of the center. Sluggish lava flowed from the grotto. At 9 p. m. for about a half hour the southwest grotto was merely bubbling, but later it renewed activity. The rift fountains in the lake had almost disappeared.

December 29

At 8:30 a. m. the southwest fountain had completely revived, the pit had been bright at night, and the central fountains had gone out of action. Flows were pouring over the floor in two streams from the southwest half-cone, and at this time the northern edges of the floor appeared slumping inward, and the southern edges were being built up and the southern half of the floor was evidently becoming a mound. The flows spreading out on the floor were meandering in leaf-like forms and there was nothing that could be called a lava lake except the pool surrounding the fountain inside the cone, which was hemmed in by an island of half-hardened lava that divided the two streams in front of it. At 8 p. m. the situation remained the same except that only the western of the two torrents from the cone was open.

Elevations above sea level of various points inside Halemaumau were as follows on December 29:

Summit Southwest Grotto	2860 feet
Edge lava in front of grotto	2764 feet
Southwest floor level of pit	2763 feet
Small cone center of pit	2761 feet
West bay of floor	2744 feet
Northwest bay of floor	2743 feet
Northeast bay of floor	2740 feet
Interior floor northwest	2738 feet

It will be seen by these figures that the southwest grotto was 96 feet high, the small central cone was seven feet high by a measurement taken on a point beside it (2754 feet), and the maximum relief of the bottom area between a sagged portion of the northwest floor and the top of the southwest grotto was 122 feet. There had been a slump of from 5 to 10 feet over most of the northern floor and overflows were slowly filling the collapsed area.

December 30

At 8:30 a. m. the fountaining at the southwest grotto continued to fluctuate and as on the previous evening the torrent from the craterlet was pouring to the west of the island in front of it and spreading over the crusts of previous flows. There were some trickling flows at the northwest edge of the new fill, but otherwise the northern floor was now inactive. The last gas puffs from the central vents had been noticed on the afternoon of December 29.

At 3 p. m. the two torrents from the southwest craterlet, cascading on each side of the island in front of the open eruptive amphitheater, had reasserted themselves as glowing streams, the eastern one pouring from under a crust. The puddled flows in front showed the usual bright-line pattern radiating from the two inflows, with numerous islets of accumulation, and enough building around the edges of the big puddle (covering the greater part of the southern half of the floor) to produce the effect of 20 overflow streams out from the edges of the lake of lava. This was to develop into a definite leaf-shaped lake with ramparts about its border, and with the southwest grotto for its source well.

At 8 p. m. the fling of the big fountain was continually falling on the outside of the cone, while the bombardment and overweighting of the inside caused red-hot avalanches into a pool beneath. Two torrents poured east and west of the island in front, but the western one was now arched over with crust at its narrowest part, with a cascade pouring from the froth pool in under the crust.

During these days a single, thin column of blue smoke from the fountain rose high above the west rim of the pit making a cumulus of rain moisture above, thin on a sunny morning, thick and spectacular in the moist evenings. The sun in late afternoon here and in Kona appears like a red ball through the fume. The nights show spectacular glowing cloud effects over the pit, with the glow waxing and waning. No fume obscures the view.

December 31

At 9:30 a. m. it was evident that the area of flows was widening in front of the southwest fountain, and that the cone was growing. Only the west cascade appeared as an open channel. Some jets from the fountain appeared to go up 400 feet. There were frontal streams at the north and northeast edges of the heap. The activity appeared somewhat greater than on the previous evening.

January 1

At 11 a. m. the lake over the southwestern part of the floor continued to enlarge. The floor was now getting to be a mound with concentric ridges and ramparts within the northern half of the area and many cracked areas. The outer edge is like a spoon with some inward slope. The top of the mound is at the southwest and the big fountain is building it up with a lake at the crest. Much pumice has been found in the country outside of Halemaumau to the southwest, some of the pieces two to three inches across. In the night following this day the glow over the pit was very bright, and was added to by the development of electrical storms on the mountains which produced snow on Mauna Loa and Mauna Kea.

January 2

At 9 a. m. the activity appeared to be as strong as ever. At 10:30 a. m. it was evident that the lake in front of the fountain had definite border ramparts where some lava spilled over, the pool covering about one-third of the floor. The spatter rims of the grotto had built out about 150 feet from the large western talus, forming a typical Mauna Loa horseshoe cone with the main channel about 100 feet wide above where it divides about islands into cascades. Apparently the weight of the lake accumulations was causing the sunken northern area to rise. and measurements detected slight rising against the walls of the pit. This is the isostatic effect, frequently noticed a decade ago, when the bench magma is weighted down on one side and the other side rises. At 3 p. m. the fountain was smaller and more like normal Kilauea lava. The lake was scalloped with two big flows through its rampart. At 8 p. m. there was much cracking and foundering of crusts in large fields of half-hardened lava to the north of the lake. The lake overflows were in wide streams on top of these fields.

January 3

At 11 a. m. a single wide cascade was flowing toward the east, the ramparts around the lake were continually pushing out and being overflowed, and the fountain was more sluggish. T.A.J.

KILAUEA REPORT No. 1041

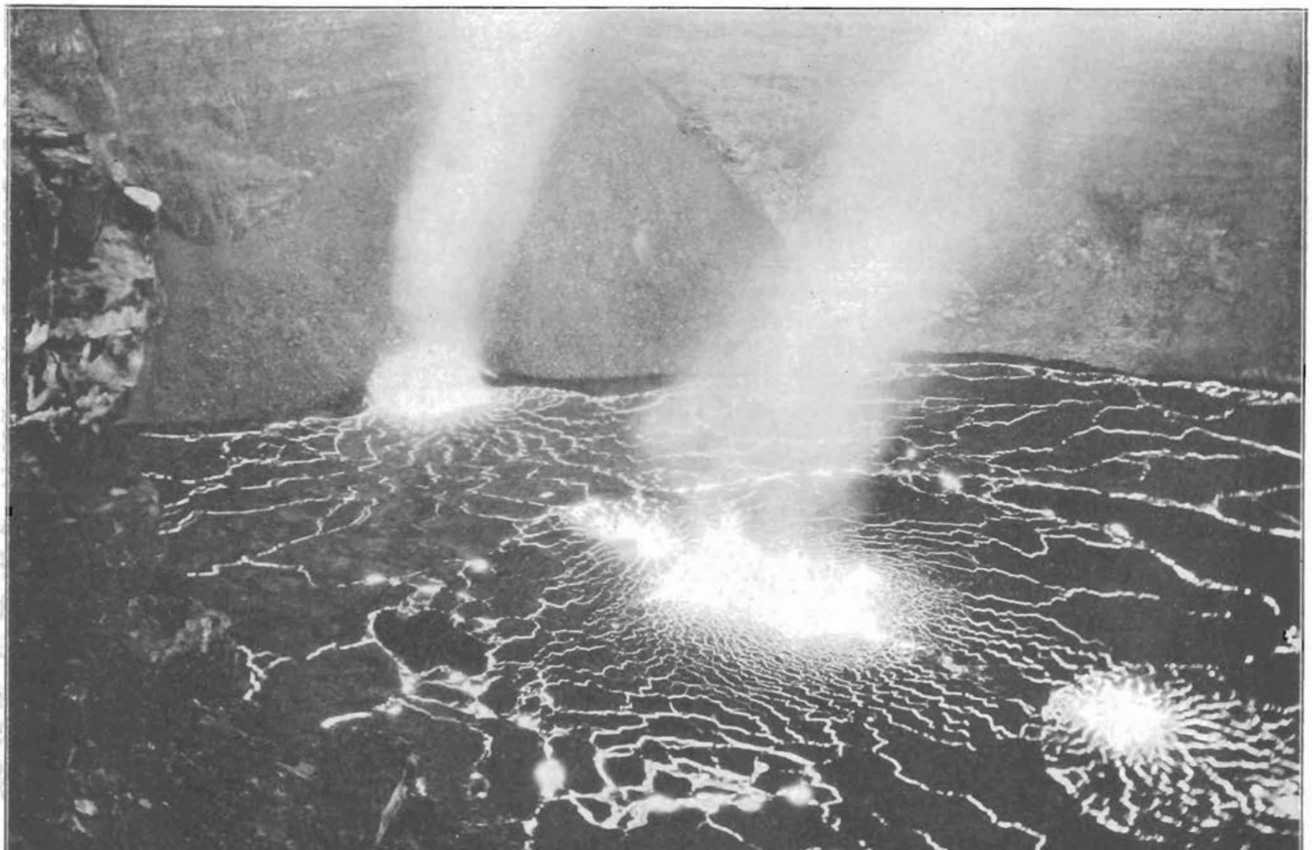
WEEK ENDING JANUARY 3, 1932

Section of Volcanology, U. S. Geological Survey

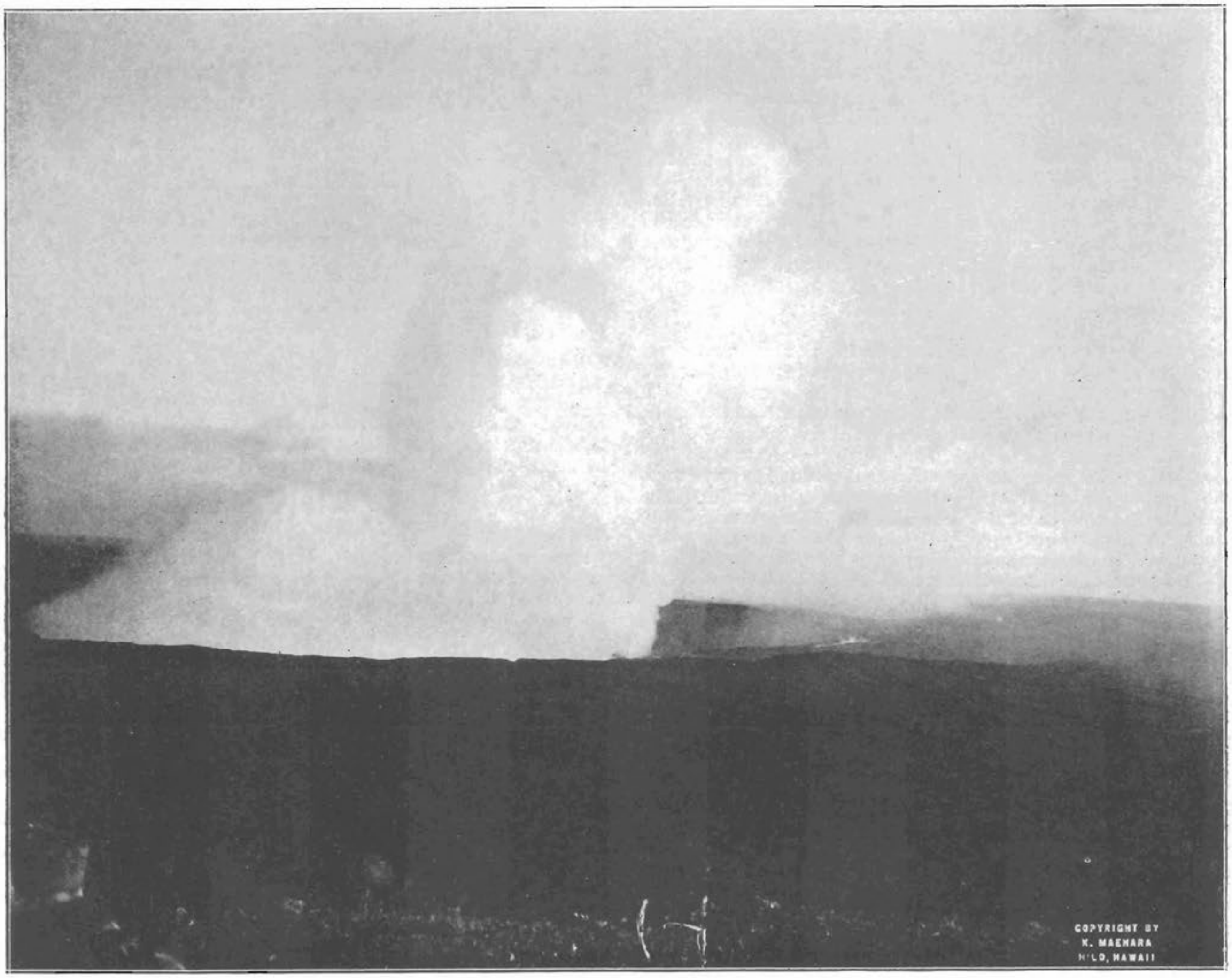
T. A. Jaggar, Volcanologist in Charge

The outbreak of Halemaumau pit in Kilauea Crater which began December 23, 1931, has produced a more voluminous fill than in any outbreak since 1924, and has brought the middle of the floor to an elevation less than 900 feet below the tourist station on the rim of the pit. The fill at the southwest on the eleventh day of the eruption was 110 feet above the corresponding floor of 1930, and the highest spatter on the talus beside the big source cone is about 650 feet below the southeast rim of the pit.

The central fountains disappeared December 29, the southwest grotto became a source cone for flows which built up the floor into a mound, and this activity still continues, with a lake built in front of the cone across the southern half of the bottom of the pit. The cone became an armchair niche 100 feet high with cascades pouring out



Halemaumau by evening light at 5:30 p. m. December 26, 1931, looking west, showing the growth of the southwest grotto at the expense of the central fountains and the co ncentration of the lake in a crescent in front of this grotto. Photo Powers



Halemaumau pit as a whole seen from the highest west bluff of Kilauea Crater on the first evening of the eruption of December 23, 1931, about 5 p. m., when blue-brown fume was puffing up from the big northeastern fountains in intolerable clouds of sulphurous gas. This stopped early the next morning. Photo about two and a quarter hours after the outbreak by Maehara.

of it to make a golden pattern of streaming across the lake. The latter made overflows about its edges, and so weighted down the heap as to cause some swelling up on the opposite side of the bottom area. On December 29 there was difference of elevation across the bottom so that the southwest cone was 122 feet higher than the northern floor. The inflow fountain diminished in size.

Harmonic tremor at the seismographs has been incessant. One feeble local seism December 30 at 11:18 p. m. was felt and indicated origin distance 14 miles. It was felt strongly at Puu Ulaula on northeast slope of Mauna Loa at elevation 10,000 feet. Three very feeble shocks occurred, of which one was felt, time 2:20 a. m. January 3. Microseisms have been heavy, and tilt was moderate SW.

THE VOLCANO LETTER

The Volcano Letter combines the earlier weekly of that name, with the former monthly Bulletin of the Hawaiian Volcano Observatory. It is published weekly, on Thursdays, by the Hawaiian Volcano Research Association, on behalf of the section of volcanology, U. S. Geological Survey. It promotes experimental recording of earth processes.

Readers are requested to send articles, photographs, publications and clippings about volcano and earthquake events, instruments and investigations, especially around the Pacific.

Subcription for non-members **two dollars** per year of 52 numbers. Address the Observatory.

HAWAIIAN VOLCANO OBSERVATORY
Founded 1911

This laboratory at Kilauea Volcano belongs to the Hawaiian Volcano Research Association and is leased and operated by the United States Geological Survey.

It maintains seismographs at three places near Kilauea Volcano, also at Hilo, and at Kealakekua in Kona District. It keeps a journal of Hawaiian volcanic activity and publishes occasional Bulletins.

Membership in the Hawaiian Volcano Research Association is limited to patrons of Pacific science who desire personally to aid in supporting the work.

The work of volcano research so supported is in collaboration with the work of the United States Geological Survey, but supplements it with buildings, research fellows, instrumental plants, explorations and special investigations for which there is no governmental provision. The Geological Survey maintains volcano stations in Alaska, California and Hawaii.

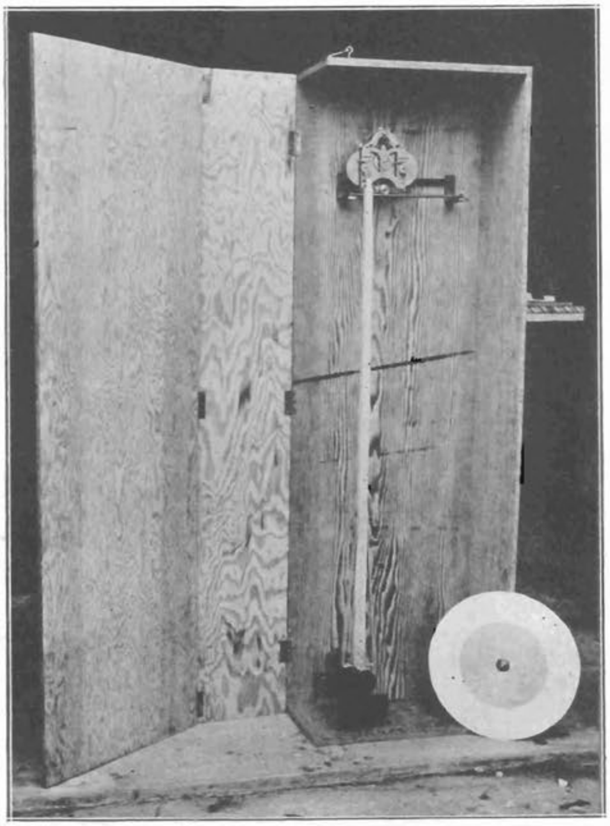
The Board of Directors includes Arthur L. Dean, President; Frank C. Atherton and Walter F. Dillingham, Vice-Presidents; L. Tenney Peck, Treasurer; Wade Warren Thayer, Richard A. Cooke and Wallace R. Farrington.

Persons desiring application blanks for membership ($5.00 or more) should address the Secretary, Hawaiian Volcano Research Association, 320 James Campbell Building, Honolulu, T. H.

The Volcano Letter

Two dollars per year | Ten cents per copy

No. 368 | Hawaiian Volcano Observatory, National Park, Hawaii | January 14, 1932



Case and shock-recorder, with cardboard seismogram and aluminum disc removed, showing the general assembly.

EDITOR'S NOTE

In November 1929 the Scientific American published an article entitled, "Amateur Seismology," describing a simple instrument in the form of a horizontal pendulum consisting of a lead weight hung on a pinched hacksaw blade with an aluminum boom and pen writing on a smoked paper disc, revolved and moved along by a simple clock after the fashion of a gramophone record. A number of experimenters in the United States have made modifications of this instrument, and at the Hawaiian Volcano Observatory we have continued to experiment.

The text herewith is a set of instructions with appropriate illustrations to accompany eight new model shock-recorders which have been sent for service in New Zealand, under the Department of Scientific and Industrial Research. These differ from the original horizontal pendulums in that the mass and boom stand upright from the wall bracket which supports them, so that the entire case may be screwed against a cellar wall in the position of an upright clock. The necessity of having a large tabular surface is avoided and the clock rollers fall into the plane of the spring barrel, which simplifies the mechanism. T.A.J.

JAGGAR SHOCK-RECORDER
VERTICAL OR WALL MODEL 1931

Instructions for Assembling

Each shock-recorder should have made for it a case, like a wall clock, a box 48 inches high, 15½ inches wide, 6½ inches deep, inside measure, with sides and cover made of 3-ply wood, the ends and back-board of more substantial planed lumber; and the metal parts are as follows:

2 narrow pieces of channel iron bolted together to form a basal support for the pendulum, and to be screwed against the back-board of the box at the bottom.

A heavy mass with two flat springs, anchored in lead inside a short iron pipe, and protruding from its side. These springs are pinched between the two channel irons about one eighth inch from where they enter the heavy mass. The heavy mass thus stands above the channel iron bracket as an inverted pendulum.

A long balsa-wood boom with a light pen at the upper end and attached at the bottom by aluminum plates and braces screwed into appropriate holes on the face of the heavy mass so that the boom stands upright.

A pair of tracks screwed against the back-board of the box at the top to hold the clockwork which rolls itself along on these tracks.

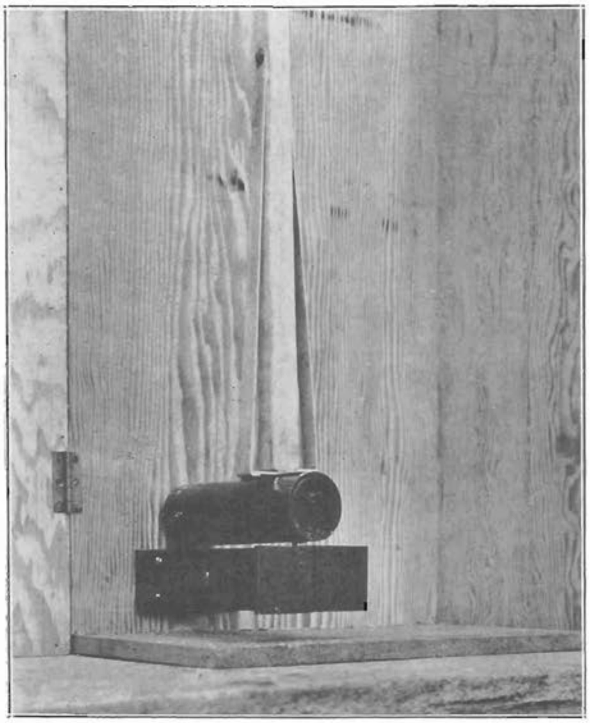
The clockwork equipped with rollers to fit the tracks, the double rollers on the back track and the single roller on the front track. The clock moves from left to right as you face it and is regulated so that its central spindle rotates once an hour when it is working.

Aluminum disc with central sleeve to fit spindle of clock, and central thumbscrew for handling the disc and for clamping to the face of the disc a circular card of white Bristol board 11 inches in diameter, punctured in the center to fit the pin of the thumbscrew cap. A smaller disc 3½ inches in diameter is clamped over the card only for smoking, in order to keep the card clean in the center.

Assemble tracks as shown on drawing, screwing the track rods on the angle bracket and placing at the back the track covered with rubber tubing. As the box is not supplied with the instrument, the placing of the parts on the back-board should be scaled from the drawing.

Clamp the flat springs of the heavy mass in the channel iron support, leaving ⅛ inch of spring between support and mass. Screw the channel irons against the back-board (1 inch round-headed brass wood screws) with the heavy mass uppermost. The lower edge of the channel irons stands ½ inch from the lower extremity of the back-board inside the box, and 4 inches from the left side of the back-board.

Lay out 36¼ inches vertically from the upper side of the channel irons to the angle of the bracket supports on the back-board, and draw a horizontal line as guide for placing these bracket supports. It is understood that the box stands upright against the wall like an old-fashioned clock. The left track bracket stands 2⅝ inches from the left side of the back-board.



Foot of case showing bolted channel iron pinching the two clock springs which are cast into the heavy mass. The boom of balsa wood is screwed to the top of the heavy mass by appropriate braces of aluminum.

Screw the balsa wood boom with its braces onto the mass, so that it stands vertical. The clock is set on the tracks with the small roller in front.

For removing and placing the disc on the spindle, the pen at the top of the boom is laid back, and the clock is simply slid well to the right, where the disc will be clear of the pen. Here the disc may be pressed by friction on the spindle or gently pulled off it by a slight rotation.

The period of the pendulum, set swinging by hand and timed with a watch, should be about ½ second to the right, and ½ second to the left, or a total of 1 second complete period. The longer the spring exposed between the clamp and the heavy mass, the longer the period. Count the number of swings for a full minute.

Needless to say, the adjustment should be such that the boom stands exactly plumb, and the arc of the needle when the point drops over against the carboard disc should bring the point, at about 45 degrees, on a horizontal line passing through the center of the disc, and about 2 inches to the left of the center.

It is possible to bend the supporting springs slightly in order to make the boom vertical, but it is undesirable to do so If these springs break, ordinary clock spring is obtained to replace them, the lead in the pipe which makes the heavy mass is melted and poured off, the springs are straightened and clamped in position, and the melted lead poured back into the pipe.

The weights and channel irons are lettered alike, in pairs. The left side of the shock-recorder box should be hinged against back-board and hooked forward top and bottom, when closed. The cover should be hinged to this side broad. Thus the left side of the instrument may be laid wide open for adjustments.

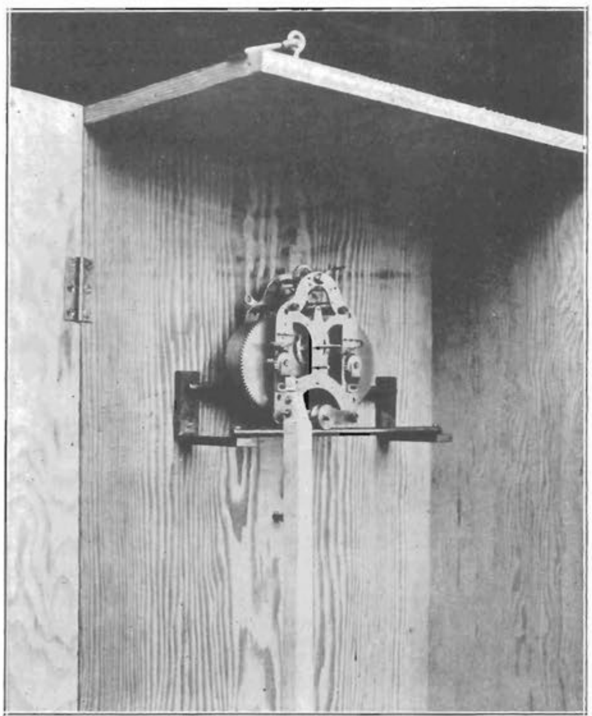
Operation of Shock-Recorder

Wind clock by removing it from tracks and place it back on the tracks. Screw a card disc on front of aluminum disc, by placing over the card the smaller disc, with its handle outward, and clamping with black rubber thumb-screw. Hold this by the back and twirl it slowly over a smoking kerosene flame (a lamp turned up to vigorous smoking of the chimney, kept for this purpose), with the card face downward until the whole card is an even light brown. Do not be afraid of putting card directly in flame provided it is kept twirling. The resulting brown if touched should streak with the finger showing pure white card. It is this brown film on which the shock-recorder pen writes a white line round and round the card during 24 hours. An earthquake interrupts these lines with a zig-zag pattern. The disc is its own clock-hand, as explained below. The smoked card should be handled entirely by the central rod so as not to smudge and disfigure the edges. Let the card, if warped by the flame, straighten itself out by cooling thoroughly.

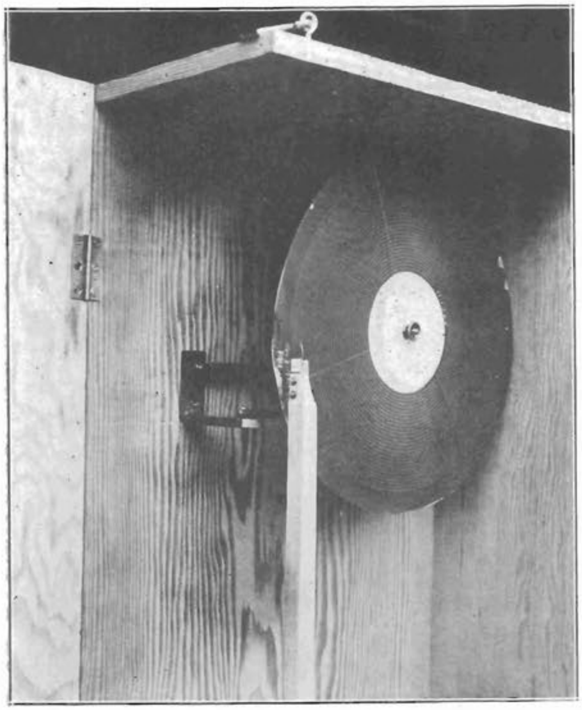
The disc is now pushed on to the clock spindle, with clock at right side of tracks, so that the edge of card is inserted behind the boom. The clock is now slid bodily to the left on the tracks until top of boom is 2 inches to the left of center of card, that is, opposite the inner part of the smoked band. Now tip the pen over, its point resting on the smoked surface. Use a stick like a painter's maul to rest the wrist on, and write with a dry point on the smoke the date, hour, and minute of starting, beside the white line which the pen makes. An ordinary pen without ink is good for this, scraping white figures on the smoke.

The machine is now at work for 24 hours and is left in complete quietness. It is vital that the wall be in a quiet cellar. Any upstairs wall will be affected by opening and shutting doors. The case should be screwed to a cellar wall where nobody goes except the operator once a day. Air currents, carpenters at work, an automobile on the ground close to the building, or a nearby engine, may make an artificial earthquake record. For good seismological work, complete quiet to the location is essential. Also look out for spiders and cockroaches.

Have a regular hour, say 8 a. m., for tending the shock-recorder. When the 24 hours is ended, mark the date and time beside the pen point, tip back the pen, slide the clock to the extreme right, gently remove the disc from the



Top of case showing driving clock on its tracks, impelled by rollers and turning the central spindle once per hour. Lateral movement 3 millimeters per hour.



Top of case with seismogram in place, showing brass pen and lines written on smoked card after 24 hours' work.

spindle by a slight right-hand rotation, and pull on the knob while the left hand holds the clock on the track.

The day's record must now be fixed for permanent keeping. Lay disc on table and carefully remove card from disc, touching card only by the edges. Prepare a flat pan, at least one foot in diameter, containing a solution of one part commercial liquid white shellac and fourteen parts denatured alcohol. This must be kept in a bottle between operations, as it evaporates rapidly. Holding the card by the edges between the two hands, pass it face downwards under the liquid once only, and hang it up to dry with a thumb tack. Data about the record, felt earthquakes, wind or weather, and the names of place and operator, may be written in ink on the white center of the seismogram card. This is now a permanent record of that day's seismical happenings at that place.

To get the time of an earthquake registered on one of the hour lines of the seismogram, it is essential that the disc rotate exactly once an hour. The clockwork may be regulated by the lever at the top in the usual manner, marked S for slower and F for faster. Prepare a tracing-cloth circle to put over the disc for reading time. Divide this circle in ink into 60 parts by tracing an ordinary clock face at the watchmaker's shop. Draw radial lines for each minute and heavier ones for each 5-minute point. Number these 0, 5, 10, etc., **backwards** as compared with an ordinary clock.

Suppose you started at 8:10 a. m. and the card disc is so marked at the inner first line of the spirals written round the disc by the day's work of the instrument. Set your radius 10 over that point with the tracing cloth centered over the seismogram. Suppose you have an earthquake recorded that was felt at 10:20 that forenoon. The first 0 reading around the line on the inner circle is 9 a. m., the second 0 is 10 a. m., and following on right to left counterclockwise 5, 10, 15, 20 minutes, the earthquake trace will lie under the 20 (10:20 a. m.) at its maximum amplitude; and the unfelt preliminaries will appear a fraction of a minute before the 20. The tail of the earthquake, or the dying away, will appear as a continuing vibration for several minutes.

By regulating the driving clock with some care for a few weeks, the amateur seismologist may get time within a minute by keeping track of the error of the clock as recorded at the end of each day's run. If the error is a constant, it may be best to leave the clock unregulated, and divide the error for 24 hours by the number of minutes in 24 hours. This gives you the error per minute. This applied to the number of minutes from the time of starting to the time of the earthquake corrects the card time for the earthquake.

A good operator should keep a good timepiece by which to mark the seismogram at the beginning and end of each day. Accuracy to the minute is probably near enough for such a rough machine, but persons with physical or astronomical training, receiving time by radio, can use this instrument as a timepiece if they are ingenious. It is customary to set up the shock recorders so that the face of the case is toward the north or south, and the pendulum thus swings east and west.

Erratum. The number of last Volcano Letter (377) should be changed to 367.

KILAUEA REPORT No. 1042

WEEK ENDING JANUARY 10, 1932

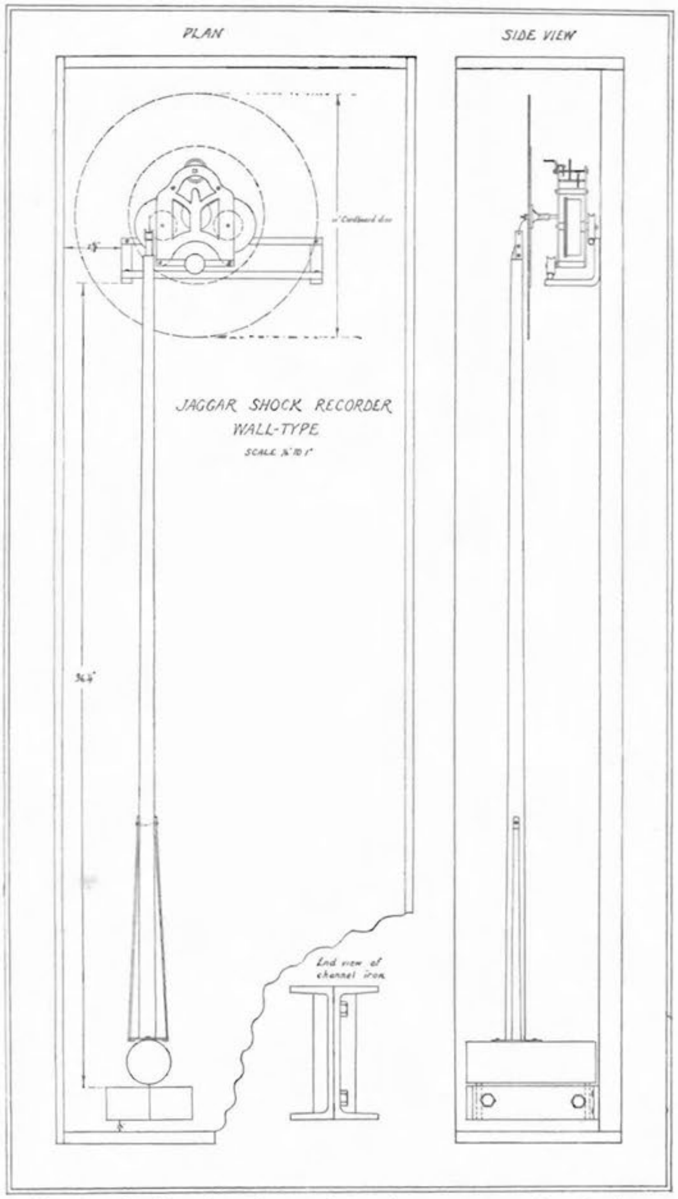
Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Activity in Halemaumau continued until January 5, then stopped, leaving a floor with a big cone at one side, as in 1930. January 4 there were three streams from the cone, and an overflowing lake below occupying one third of the floor. January 5 the fountain had spells of stopping in the early morning, though the fume column was brightly lighted. At 10 a. m. there was the usual puffing and splashing, lake ramparts were overflowing east, and 3 rapid cascades poured eastward from the channel. At 2 p. m. the big fountain stopped and a little one formed in front of it: two streams gave place to one. Some booming was heard at 2:20 p m. Tremor on the seismographs at the Observatory was showing spells of increase and decrease. There was some backstreaming from the new fountain over the black lava of the interior of the cone. During the afternoon the cascades narrowed and the fountaining fluctuated, with booming. About 6 p. m. tremor at the Observatory ceased and the fountaining stopped gradually. At 8 p. m. there was very dull red glow, the pattern of lake and cone was outlined in glow cracks, the overflows were dull, and a few glow spots appeared at north edge of floor. The channel fountain made a few spurts of sparks, and a small glow chamber broke open at the central conelet. There were noises of cracking slabs, of small southern slides from the wall, and of hissing with the spurts.

January 6 the lake had slumped leaving hummocks. There were crackling sounds. The inner wall of cone flaked away leaving glow exposed. A little fume came from the east base of cone and other points. Steam rose at southern taluses. January 7 there were two small slides northwest and northeast about 11 a. m. January 9 rain made a hissing on the new floor. There were fume spots around the lake edge and at the cone. Some rocks fell and a small slide occurred at 11:10 a. m. New debris of reddish color had added 40 feet of width to the northwest talus. January 10 a crust ridge at southeast margin of bottom emitted blue fume which showed above the whole pit in afternon light, cumulus cloud still formed above the pit at higher levels due to heat, and a few points of glow still showed at night.

The seismographs registered 24 tremors, one indicated a probable origin distance 18 miles, 4 very feeble local seisms suggested origin distances of 6, 32 and 42 miles, and teleseisms were registered at 3:53 p. m. January 4 and at 46 seconds after midnight the morning of January 9; this last indicated a doubtful origin distance of 880 miles. Microseismic motion was mostly moderate, and tilting of the ground was moderate to the south. The harmonic tremor from the fountaining lava in Halemaumau increased between 1 and 2 p. m. January 5, and then decreased until it disappeared at about 6 p. m. in remarkable coincidence with the cessation of lava inflow.



Front and side elevations of shock-recorder and end view of channel-iron bracket supporting the mass. Cardboard disc 11 inches diameter.

THE VOLCANO LETTER

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Founded 1911

This laboratory at Kilauea Volcano belongs to the Hawaiian Volcano Research Association and is leased and operated by the United States Geological Survey.

It maintains seismographs at three places near Kilauea Volcano, also at Hilo, and at Kealakekua in Kona District. It keeps a journal of Hawaiian volcanic activity and publishes occasional Bulletins.

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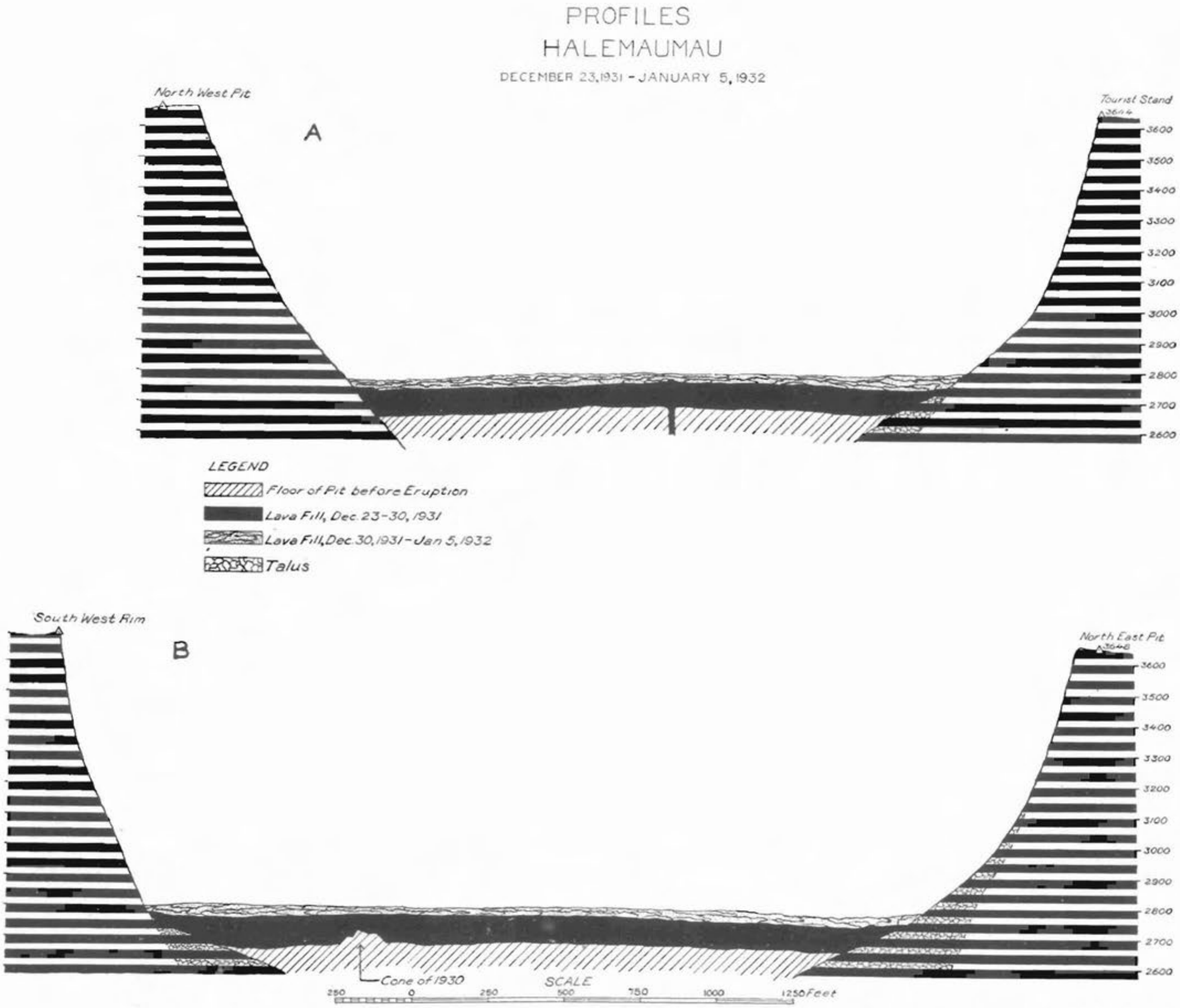


Profile sections of Halemaumau pit at the end of the eruptive period December 23, 1931, to January 5, 1932, showing topography of bottom left by the eruption. See discussion in text, and map on Page Four. Drawn by E. G. Wingate.

JOURNAL CONCLUDING HALEMAUMAU ERUPTION JANUARY 4-10, 1932

The eruption which began in Halemaumau pit of Kilauea Volcano December 23, 1931, finished its apparent surface activity the evening of January 5, 1932, after somewhat more than thirteen days of inflowing lava.

Elevations of the parts of the surface of the new bottom when the lava lake was highest, 9:30 to 11:30 a. m. January 5, 1932, reported by E. G. Wingate, were as follows:

Area over 1930 conelet filled 73 feet..........elevation 2793 feet
Southwest bay filled 134 feet........................elevation 2792 feet
Lake under southwest cone filled 125 feet..elevation 2798 feet
Lake southwest of center filled 107 feet..elevation 2777 feet
West bay filled 113 feet................................elevation 2773 feet

The amount of filling over the whole floor was about 115 feet, or some 25 feet more than was shown by the measurements of December 29-30, 1931. The accompanying section profiles show the later fill light colored and the earlier solid black. December 29 was the day when central fountains stopped. At the end the principal mound was the southwest cone itself, at the edge of the lava floor, not shown in the profile. The average bottom elevation 2789 feet, is 855 feet below the tourist station at the southeast rim of the pit.

The final heaping up of the border cone, with the fountain in its midst sending multiple cascades of lava to spread out on the floor, was quite like the closing stages of the eruption in November-December 1930. The cessation was rapid and quiet, without any marked down-sinking, within a few hours. The flowing simply stopped, the surface solidified, and the tremor at the seismographs stopped simultaneously with the end of fountaining.

January 4

The flow of lava from the southwest cone out over the floor of the pit continued as before, but there was no longer a single lake of lava filling the bottom of the pit as there had been during the first days of the eruption. The line of fountaining vents across the middle of the pit no longer appeared. Everything had been concentrated in an upflow at the big cone at the base of the southwest talus. There were doubtless intrusions going on within the heap covering the bottom of the pit, but their only effect at the surface lay in what was revealed by the surveys with transit showing differences of level of different parts of the bottom. Other effects of piling up, which produced differences of level, were due to the puddled flows from the cone as shown in the accompanying map, which have collectively been called a lake, because of a definite rampart bordering the pool in scallops and numerous islands of clustered crusts. The thickness of the new fill is various, both because of irregular heaping up, with a maximum near the southwest cone, and because of irregular topography of the mound of lava of 1930 which the new fill covered. This variability is shown in the profiles in their relation to the map.

On this morning at 7:30 a. m. there was the usual convection cloud of rain moisture due to the heat rising from the lava fountains and lake. At 8 a. m. three streams were forking from a wide river at the open side of the cone. Rapid cascades carried black crusts past two small islands in the central rivulet. The fountain was variable, as a whole not so high as at the beginning of the previous week, at times somewhat sluggish, and then developing a spurt of high jets with a roar. There were occasional brilliant slides as the red-hot sides of the cone caved in.

At 3 p. m. the fountains were bubbling steadily in the cone and spouting up from 50 to 75 feet. One river of lava poured out from the center of the horseshoe, its course at first northeast, and then deflected to the east by the slaggy slope which had been built up as a mound straight in front of the cone, when the river in earlier days had forked both east and west around an island. The western torrent no longer showed, whatever it may have been doing in tunnels, and the eastern one now divided into three streams surrounding three islands. The whole distributary system radiated out with bright lines and surfaces covered with satiny skins into a lake that covered about a third of the floor and was confined in a well defined rampart. On the west side there was much overflow amid crust islands and one small overflow stream poured from the lake to the east. Back of this was a large island which had been a remarkably persistent feature throughout the eruption, and perhaps marked the site of the cone of 1930. The rest of the floor showed pressure ridges and mounds and irregular hardened flow patterns, with chasms and cracks particularly conspicuous near the borders at the north.

January 5

Surveys were made from 9:30 to 11:30 a. m., and before this at 8 a. m. it was seen that the flow had lessened, but the fountain was still central in the cone, though weaker. The volume of outflow had lessened considerably as shown by the size of the streams, and the lake on the floor was smaller and the overflows through the ramparts had dwindled. Most of the filling appeared to be in the south bay. The river flowing from the cone forked into two streams with rapid cascades, and the islets were tending to become peninsulas. Fume above the pit had increased at 8:40 a. m. At 10 a. m. it was seen that the increased fuming was due to a revival of the fountain, which appeared quite normal with much puffing and splashing. Heat from the lake was strong at the south edge of the pit. The lake had vacated its ramparts on the west, and was overflowing ramparts to the east.

The scarp or heap in front of the main channel appeared brick-red and rusty on its upper surface. Three rapid cascades poured eastward from the channel, and over the pool on the floor of the pit there was streaming with radial zigzag bright lines fanning out to the east and northeast. Three island accumulations divided the cascades. The north floor of the pit showed scallop rampart patterns over its surface, and some pressure ridges. A remarkable feature was a group of four crevasses trending northeast toward the dike in the northeast wall of the pit. These were on the line of the first fountains of December 23, and where the line of fountains had been buried up by subsequent flows. The hardened surface, however, had become cracked on the line of the original rift and was apparently gaping open by tumescence.

The new floor of the pit was now against the rock wall between the taluses at the NE, NNW, WNW, S, and at two places on the E. The old rock wall at the southeast which had extended to the 1930 floor as a triangular ledge parting two taluses was now entirely buried. The cone and crater around the big fountain appeared to be in adjustment, and the noise of the cascades was a steady crackling.

The afternoon of January 5 created a new situation, with reports of avalanches, of a new position of the fountain, spells of excessive harmonic tremor at the seismographs alternating with very weak tremor, and dwindling of the cascades. The details of these changes were as follows, proving important as on this evening the eruption stopped:

At 2 p. m. the big fountain central to the cone went out of action and was replaced by a small fountain in what had been the main stream northeast from the craterlet. Inquiry from bystanders indicated that the large fountain was still erupting at 1 p. m. when the activity during 15 minutes migrated into the channel and about 1:15 the large fountain stopped. At 2 p. m. small streams were pouring down both cascades, but at 2:15 only the southern stream was visible leading from the channel fountain. It was at this time that heavy tremor at the Observatory was replaced by very weak motion.

At 2:20 p. m. booming noise was heard continuing for five minutes, and the northern cascade reasserted itself. It stopped, and the lava in the pot appeared to be rising and flowing back over part of the black lava where the central fountain had been. This action increased. At 2:42 p. m. the channel fountain appeared to be migrating northeast, somewhat smaller than before, and the streams were darker colored. Booming noise was repeated 2:58 to 3 p. m. and again at 3:15, when the cascades were small, duller in color, and flowing more slowly. At 3:24 there was a spell of vigorous fountaining. At 3:30 there was intermittent spurting with some booming. The southern cascade was very narrow and most of the outflow poured through the northern channel. At 3:55 there was a spell of rather heavy fountaining.

During the course of these changes the crater margins in the cone had caved in, the pool on the lake floor was lowering and becoming dotted with many islands and crusted lumps, and there were some fuming patches about its borders. The dwindling of inflow appears to have been gradual from 4 to 6 p. m., though at the beginning of this time the fountain sent up some spurts 50 feet high. The cessation of the tremor at 6 p. m. probably coincided with actual cessation of inflow.

At 8 p. m. there was very dull red glow over the pit, hardly perceptible on the walls as seen from a distance, and almost none on the cloud above. When the pit was visited, it was found that the pattern of the lake was outlined in bright glow cracks, that of the overflows was less bright, and the cone was clearly outlined by incandescent fissures. There were a few glowing spots at the north edge of the floor. Gas activity still asserted itself in occasional spurts of sparks from the site of the channel fountain. There were hissing noises at these times. A small central cone in the floor which had been the last remnant of the central fountains caved in about 8:15 p. m. revealing a glowing chamber inside and making a noise of cracking slabs. There were some slides heard at the south wall of the pit. It was observable that the glow pattern of the floor showed colors in blue, purple, and red, suggesting the presence of some small flames through the cracks.

January 6

At 6 a. m. there was no visible flowing lava, and cracking sounds were nearly continuous with spells when they were louder. This suggested that cooling and slumping were going on. There were numerous glowing points like a bed of coals. Occasionally a cascade of cinders would fall from the inner walls of the cone showing glow underneath. There were some squeaking noises like rubbing slabs. Where the lake had been there were parts of the outlying rampart and numerous hummocks. A little fume rose at several places in the bottom of the pit, but was not noticed at the cone. There was steam from the talus slope above. Later in the day slight fuming was noticed at the top of the new cone and still more near its eastern base. The lake surface had evidently been slumping. Vapor was noticed on the southeast talus.

January 7

The end of this eruption, as in 1930 and the other short-lived fills within Halemaumau which have occurred since 1924, showed no sinking of the entire lava column. Such sinking was a characteristic of the end of eruptive episodes between 1915 and 1924. The explanation of the difference appears to be a difference in continuity of inflow and volume of material in the upright shaft that remains fluid. These small annual eruptions of the last few years appear to come up a crack in the bottom of the pit, cover the former floor with a layer of paste which more or less congeals with the term of the eruption, the inflow concentrates at one well, and this material also congeals and forms a plug. There may be more or less pastiness and incandescence to the bottom of the temporary fill, and loss of gas from this viscous fluid accounts for some slumping of the surface, also volume is diminished by crystallization. But there is no sign of sudden back-flow into the depths, such as caused lowerings of hundreds of feet in 1916, 1919, etc. The evidence seems rather to favor the supposition that there is a steady upward pressure of magma at present released by an occasional breaking through.

On this day, January 7, the floor of the pit was very irregular and hummocky and all sounds of settling had ceased. Two small wall slides were heard at the northwest and the northeast about 10:50 a. m. Otherwise the bottom was still and motionless just as the congealing lava had left it.

January 9

During rain in the forenoon there was a slight hissing sound from the hot floor. There were fume spots chiefly about the borders of the recent lake and at the south side of the cone. Rocks fell from the walls and a small slide occurred at 11:10 a. m. The rim cracks at the northeast continued to show slight widening such as had been noticed prior to the recent eruption.

January 10

Blue fume was observable over the pit when the sun passed behind the rising vapors, especially at the southeast, and much of this came from a smoking ridge of crust at the southeast margin of the floor. Cumulus was still forming in the high air above the pit, and a few points of glow in the floor were visible at night. T.A.J.

KILAUEA REPORT No. 1043

WEEK ENDING JANUARY 17, 1932

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Volcanic activity at Halemaumau pit remains dormant, and the most interesting development of the week for the Hawaiian Volcano Observatory has been the completion of a new seismograph hut erected for the Geological Survey by the Park force. This hut is close to the southeast rim of Halemaumau, in the same location as the former hut, but capable of housing two or more instruments, for more complete measurement of local earthquakes, tremor, and tilt.

On January 12 new fallen material was observed under the southeast wall and the floor appeared more hummocky. January 13 three slides were reported near the southwest rift crack in the wall during the forenoon, and in the afternoon fume was conspicuous, especially at the southeast hummock, rocks were heard falling, and rim cracks showed slight widening. Sulphur stain appeared in spots. Rather sudden northwest tilt had appeared at the Observatory. At 8:30 p. m. January 17 a glowing crack was seen near the southwest fuming hummock and one spot of glow in front of the new cone. Occasional rocks fell from the walls and a small slide from the north wall occurred at 8:50 p. m.

The seismographs registered 63 spasmodic tremors, two indicating origin distance 18 miles, one 42 miles, and one 46 miles. Five very feeble local seisms indicated distance chiefly 14 to 18 miles. Microseismic motion was moderate, and tilt slight NW.

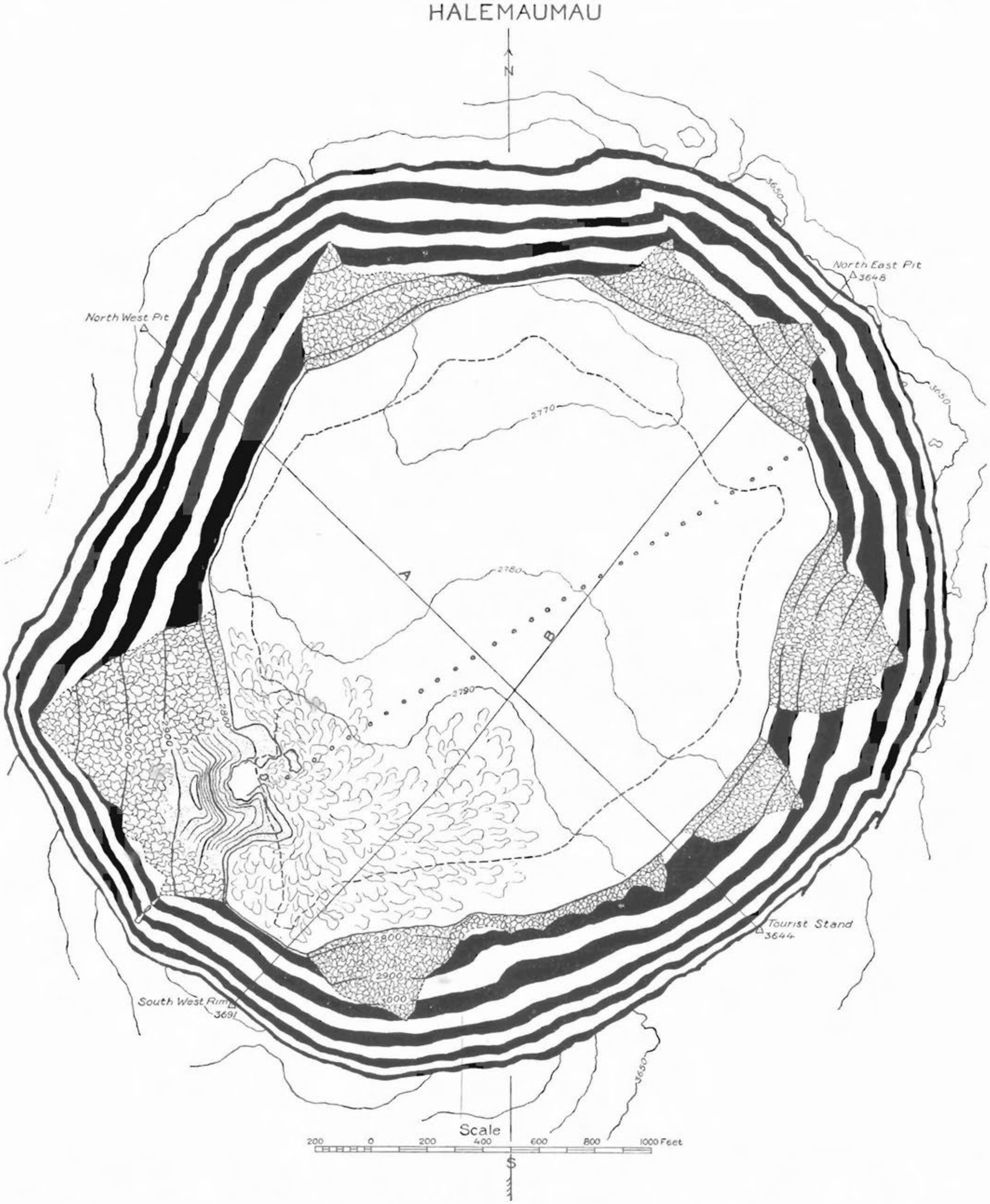
TILTING OF THE GROUND FOR DECEMBER

The following figures show the net amount of tilt by weeks at the Observatory on the northeast rim of Kilauea Crater, and its direction computed from the daily seismograms, by platting a curve smoothed by overlapping seven-day averages. This is the departure of the plumbline in seconds of arc, in the direction given.

November 30-December 6, 1931	1.4 seconds	ENE
December 7-13	0.8 second	NE
December 14-20	3.2 seconds	NE
December 21-28	2.8 seconds	WNW
December 29, 1931-January 4, 1932	2.0 seconds	WSW

Tilt on both N-S and E-W components of the seismograph, as shown by the daily plat, had at the end of the eruption of Halemaumau pit, which occurred December 23 to January 5, indicated a return to a point on the seasonal curves almost identical with the points recorded immediately before the sharp NE tilts, indicated above as occurring just before the outbreak.

This would appear to indicate that these northeast tilts beginning 10 days before the outbreak were due to tumescence that was preparing to split open the lava of the bottom of the pit. These effects were so strong in their northing at the Observatory for the first half of the week December 21-28 indicated above as to make the average tilt show some north, though the actual swing of the pendulums on the day of the outbreak December 23 was strongly south and west. It will be seen that for the time of eruption the averaged tilt of the fortnight was strongly westerly, which is a direction towards Mauna Loa. E.G.W.



Map of January 5, 1932 to accompany profiles A and B, showing new southwest cone. Dotted line was floor of 1930.

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No. 370—Weekly Hawaiian Volcano Observatory, National Park, Hawaii January 28, 1932

New floor of Halemaumau, looking southwest 11 a. m. January 5, 1932. Lava stream pouring from conelet on southwest talus. In left foreground tension cracks on rift. Note burial of talus slopes as compared with 1927 Page Four. Photo Powers.

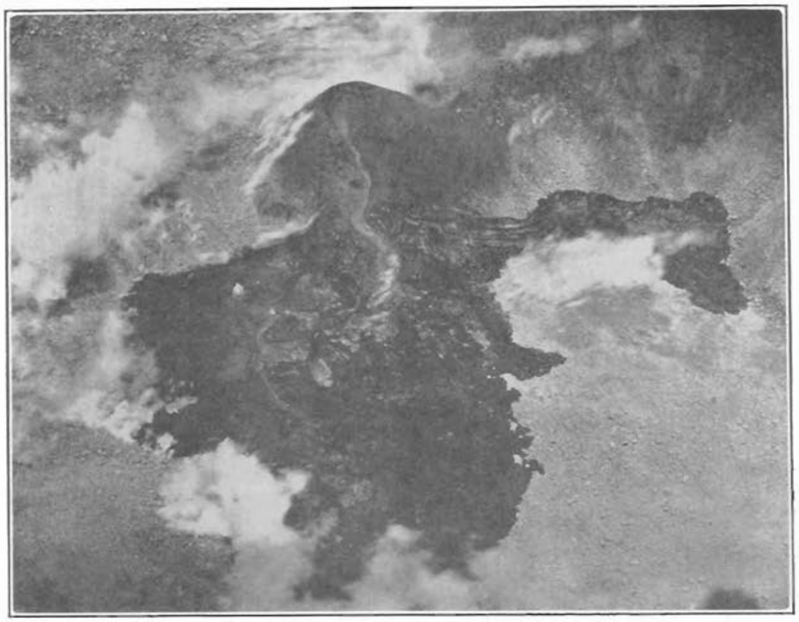
COMPARATIVE DATA ABOUT RECENT ERUPTIONS

The conclusion of the eruption in Halemaumau pit from December 23, 1931, to January 5, 1932, makes it of interest to review the data concerning recent eruptions of Halemaumau in Kilauea Volcano, which have tended to become annual. It was stated in Volcano Letter No. 366 that there had been a series of events tending to forecast the recent outbreak. Besides the expectable interval of about a year, there was accumated tilt away from the center suggesting upward pressure, there was a week of excessive tremors and earthquakes 10 days before the outburst, there was opening of measured cracks by unusual amounts leading to a rim-block avalanche at Halemaumau December 7, there was a strongish earthquake December 13 when Park rangers reported rumbling noises and slabs falling down cracks on the Kau Desert rift southwest of Kilauea, and there was an unusually strong shock on this same rift, within the crater, the forenoon of the day the eruption began. Features accompanying the eruption were the steady harmonic tremor which started and ceased in coincidence with lava inflow, occurrence of the crisis a year and 34 days after the outbreak of 1930, the sudden change of tilt accumulation at the edge of Kilauea Crater, from a tendency away from the center, to an inward tilting as soon as the gas and lava released the upward pressure; the gushing up along a straight crack on the rift line; the concentration to a conelet at one end of this crack; the accumulation of 115 feet of fill; and the duration of only 13 days.

This was all stated to resemble the incidents of former years, and it will now be profitable to compare these incidents systematically, in order to find out what was characteristic of each prelude, in how far these preludes resembled each other, and in what respects the eruptive sequences resembled each other.

Lava Inflow of 1924

The first volcanic event here following the great explo-



First lava eruption in bottom of Halemaumau after explosive crisis of May 1924. Cone and flows under west talus July 22, 1924, with lava flow spreading on bottom of pit. Photo Emerson.

sive engulfment which enlarged Halemaumau pit in May 1924, was the inpouring of lava at the bottom of that pit July 19-31, 1924. The pit was left in a condition of great instability with many avalanches and small earthquakes in June, and red-hot walls far down where intrusive rocks were exposed. A local seismic spasm led to a strong shock June 13 of grade about Rossi-Forel VI, when outside the north rim of Kilauea Crater new cracks were produced in the soil. The seismograph station is on the northeast rim of Kilauea Crater, and showed strong northeast tilts twice during the three weeks preceding the lava outbreak. Blue fume shot up from the pit at noon July 19, this at 1:45 p. m. was a jet spraying up through a vent in the southwest talus, making a small trickle of lava which collected in a puddle in the cup of talus that formed the pit floor. The jet became a fountain 125 feet above the bottom of the pit, the puddle spread about in leaf form with some internal fountaining, the cone became over a hundred feet high around the source, but the floor coating was only 25 feet thick. Harmonic tremor at the seismographs lasted from July 20 to 29.

Mauna Loa Eruption 1926

Mauna Loa broke out near the summit April 10, 1926, at 3 a. m., spread down the southwest rift i:s splitting action with frothy lava outflow, and sent a torrent to the sea which quickly ceased, but upland flows on the mountain ridge endured until April 30. At Kilauea there were numerous earthquakes indicating origins at Mauna Loa distances during several preceding months, there was a large increase in earthquake frequency during the Mauna Loa eruption, at Halemaumau there were rock slides due to quaking, and new cracks back from the rim broke the surface soil. Harmonic tremor at the Kilauea Observatory sympathized with the maxima of the Mauna Loa eruption April 10 to 22. At the same station there was slight accumulation of east tilt away from Mauna Loa during 1925-26, and very strong east tilt accordant with the Mauna Loa flowing April 11-24, and a reaction to moderate west tilt throughout May after Mauna Loa ceased.

Halemaumau Inflow 1927

After midnight July 7, 1927, a new outbreak of fountains in the bottom of Halemaumau split across the floor of 1924 in a line trending northeast-southwest, with the southernmost fountain some distance up the debris slope as before, and this was the only one which kept working more than a day. The line of four fountains lay but slightly to the west of the rift tunnel line shown by dikes in the wall of Halemaumau. Half the lava of the eruption came in during the first hour. The lake rose around the vents with the exception of the southern cone standing 120 feet above lake level. The area of new lava, shaped like a leaf with the cone at its stem, was 1760 feet long by 1420 feet wide. The new fill was about 110 feet deep when the last gushing ceased July 20, but the cone summit stood much higher.

On March 20 there had been a deep seated strong earthquake felt generally throughout the Territory, and objects were thrown down and broken in Hilo shops. On June 8 a small shock was felt about the island of Hawaii, and a strange light was seen believed to be a meteor. On the day of the outbreak July 7 a moderate earthquake at 3:21 a. m. came about three hours after the lava inflow began.

Cracks on the Halemaumau rim had widened excessively at the northeast side of the pit June 22 and thereafter, so that visitors were warned away from the edge. There was no widening after the eruption began. Tilt was to the north a fortnight before the eruption, and to NW and WNW thereafter. This westing of the tilt after the beginning of Kilauea outbreak has appeared repeatedly. Harmonic tremor at the Observatory appeared in a short spell at 10:55 p. m. July 6 about an hour before the outbreak, then was continuous for 24 hours July 7-8, and showed temporary recurrences July 10-12.

Halemaumau Inflow 1928

This eruption was very small, and its occurrence as lava upflow through cracks across the 1927 floor, in coincidence with a landslip from the northwest which compressed that floor, was explained at the time as a "false eruption" merely due to the squeezing up of 1927 lava still liquid under the crust. There is reason to revise this theory.

What happened on January 11, 1928, about 12:30 a. m. (just after midnight or midday appears to be a favorite time for eruptions), was the appearance of red glow from liquid lava in Halemaumau just after a monstrous avalanche from the northwest wall which caused a big tremor on the seismograms at 12:26 a. m. It was found that new lava had spouted up at three places on the floor corresponding approximately with the sites of the two northern fountains of 1927. How much the rosy glow seen at first was due to fountaining is not known, but it disappeared in 20 minutes and at 1 a. m. the lava areas were flows glowing through cracked crusts with some blue flame at one vent. The northwest talus cone of the bottom of the pit had been overridden by a big fall of rocks from the wall so that the entire mass of debris slid forward and out on the lava floor in a pointed heap covering a sector of the northwestern surface. Two of the outflows were near the tip of this heap, welling up cracks and flowing away from the heap, and the other was at the north some distance from the debris. If the phenomena had been wholly a squashing down of the crust and a welling up of the liquid around the crushed area, the flowing should have been toward the debris heap. The flows cooled off within a day and the avalanches thereafter ceased, a remarkable fact, for these avalanches from this uneasy wall, and also from other walls of the pit, had been tumbling for a month.

The strongest reason for considering this a true lava outbreak is found in the seismic record of the preceding month December 1927. During this month 243 local earthquakes were registered, the roars from loud avalanches were frequently heard at the Observatory two miles away December 17-28, the slides were from the northern and the southern walls notably in the vicinity of the rift belt, and the eastern cracks at the edge of the pit showed measured widening of 2 to 3 inches increasing toward the north. The July floor became overlapped with debris all around, about 8 seconds of southerly tilt accumulated at the Observatory during the month preceding the outbreak, and the December record suggested a lowering of the pit bottom. However, this may have been an error, for on January 7 the WNW rim of Halemaumau showed new cracks breaking the sod 50 feet back from the rim, and large deep cracks three feet or more wide gave up hot steam. Such widening of cracks, preceding other eruptions, appears to have indicated localized swelling under the pit, whatever may be happening to the outside rim of the greater crater, where the Observatory measures tilt. It was precisely at this WNW rim where the big avalanche occurred at the time of lava outbreak. With the release of the liquid lava the tilt at the Observatory changed from strong southwest to slight northerly. Seventy-eight local earthquakes had occurred December 2 4, more than a month before the outbreak, and the number of general shocks indicating origin distances 15 to 30 miles away, during December and early January, suggests that seismic conditions were affected by a deep-seated cause. The high frequency of local shakings changed to normal abruptly after January 11. All of this evidence goes to show that a change in magmatic pressure under Kilauea Volcano produced extraordinary seismic conditions for six weeks, there was unusual motion on the rift belt along the west side of Halemaumau pit, and the adjustment of a deep-seated block there, both released the eruption and brought the avalanching period to a close.

Halemaumau Inflow February 1929

At 12:46 a. m. February 20 molten lava gushed up in a big fountain at the northwest edge of the bottom along a straight fracture 1370 feet in length. A great lake filled the bottom east of the fracture line, some 60 feet in depth, the southern vents quickly became submerged in the lake, and the northern one built a half-cone of pumice with jets of the Mauna Loa type shooting 225 feet into the air. Pellets of basaltic pumice and Pele's hair fell outside of the pit. The pit seismograph registered tilting, accompanied by small earthquakes, two hours before the eruption was noticed, and straight away from the center. At the same instrument continuous strong volcanic tremor was written during the period of fountaining. This all ceased when the eruption ended about 1 p. m. February 21, and strong tilt was indicated back toward the center of the pit during four hours preceding the cessation of action. The eruption left a net gain of 5 seconds tilt away from the pit.

The prelude to this eruption, as shown by tilt instrument at the Observatory, was strong southerly seasonal tilt throughout the weeks before and after the outbreak, but with a gradual change from east to west. There had been tremor January 5 9 and 16 28, probably occasioned on January 5 by much avalanching, accompanying excessive opening of cracks at the tourist station on the southeast rim of Halemaumau. This necessitated changing the trail and making a new viewpoint. The climax was reached January 10, when slides became fewer. On February 5, 15 days before the outbreak, an earthquake occurred at 2:25 a. m. felt throughout the island of Hawaii.

Halemaumau Inflow July 1929

On July 25 about 4:35 a. m. the seismographs at the Observatory registered a series of very small earthquakes a few minutes apart, each accompanied by tilt to the east. Then strong continuous harmonic tremor developed. Lava again broke out at the west edge of the floor in the bottom of Halemaumau. The center was a fracture through the talus, tangential to the bottom plug, making big fountains at the base of the west talus. The seismograph at the pit showed inward tilt the first day, outward tilt thereafter, and tremor registered continuously while the lava fountains were in action. The eruption ceased the evening of July 28 and the liquid lake reached a depth of 94 feet, followed by settlement of 20 to 30 feet after solidification.

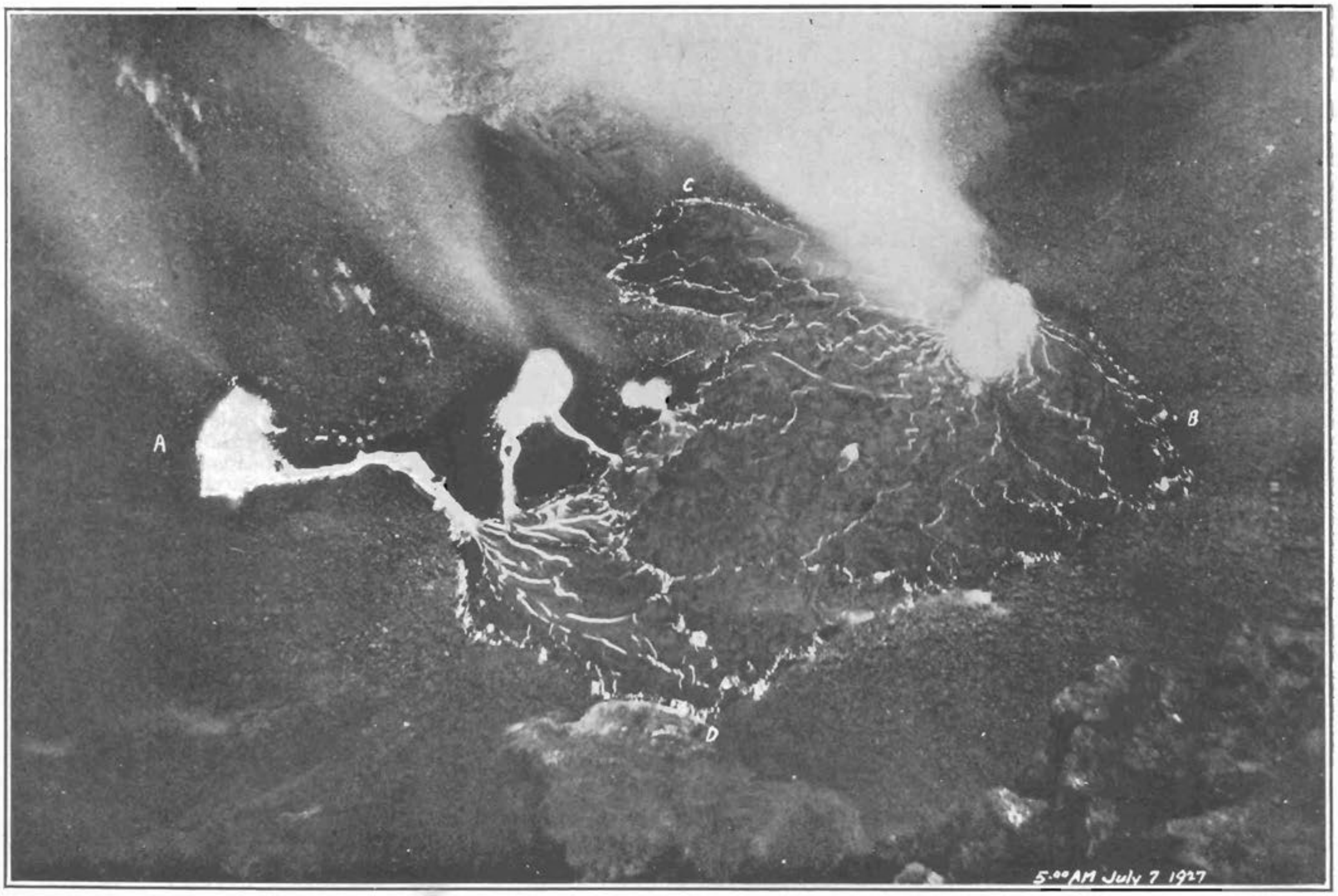
The ground tilted moderately north at the Observatory during the week preceding the eruption, and the tilt changed to southwest on the day of the eruption, becoming moderate south for the week. Cracks at the east edge of the pit had shown by measurement tendency to open since May 15 There had been two strongy felt earthquakes on the morning of June 18, occasioning avalanches on the west bluff of Kilauea Crater as well as in Halemaumau.

Halemaumau Inflow 1930

It should be here recorded that an extraordinary seismic crisis about Hualalai Volcano occurred in October 1929 which appeared to indicate a new shift of magma from under Mauna Loa in the direction of Hualalai. No lava outflow coordinate with this movement has yet appeared.

At 1:29 p. m. November 19, 1930, lava broke through the 1929 floor of Halemaumau in three fountain groups south of the central region, two of these being of small size which disappeared during the first two days, the third continuing to spout vigorously and build up a cone. The lava spread over the 1929 floor, then built a central lake of molten lava surrounded by ramparts, through which overflow on three sides removed the new lava as rapidly as it was supplied, and completely covered the former floor of the pit. After two weeks of action the lake area was 500 by 800 feet, the cone was 75 feet high and 200 feet in diameter at the base, the entire new bottom area was 2300 feet by 1700 feet, and the new mound stood above the former bottom 175 feet at the cone, 100 feet at the lake, and at the north side of the floor about 50 feet. The eruption ended December 7. Tremor accompanied the eruption as before and died away at the end. Tilt change was from moderate northeast November 10-16 to moderate southwest after the outbreak began, with a return to strong north and northeast in December. The pit seismograph had recorded tilting of the ground away from the pit and many small tremors a week before the outbreak. On the day of the outbreak this instrument recorded 18 small shocks culminating in a very feeble earthquake ot 11:06 a. m. with a slight tilt toward the pit. This was followed by a series of 30 small shocks and other earthquakes. Moderate and slight felt earthquakes and avalanches had occurred in September and October.

Reviewing the seven Halemaumau inflows in seven years, a typical eruption may be said to be heralded by one or more strongish earthquakes a few weeks before the outbreak, or by unusual seismic frequency, and 1931 produced a smart earthquake a few hours before inflow. Cracks on the rim of the pit are apt to exhibit distension of the edifice by spreading open, and so loosening the inside walls as to make avalanches. This is likely to occur along with centrifugal tilt just before the eruption. All of these eruptions appear influenced by the northeast-



Eruption in bottom of Halemaumau July 7, 1927, at 5 a. m. Shows the four main vents in line, that on the left being the high cone which persisted. Looking west-northwest. The floor of 1932 is against the wall at the top of the picture. Photo Wilson.

southwest rift belt which crosses Kilauea Crater; the final gushing splits the former floor and rapidly concentrates at one vent. There is temporary inward tilting and continuous tremor while the gas foaming of the fountains is going on. The whole series of eruptions marks an upward pressure accumulating. The eruptions have increased in volume of output and violence of effervescence, but their duration has been variable from 1 hour to 18 days, with the last two outbreaks the most enduring. T.A.J.

KILAUEA REPORT No. 1044

WEEK ENDING JANUARY 24, 1932

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

The settling down of the Halemaumau floor, the bottom of the inner pit of Kilauea Crater, is all that has happened during the past week, and the cracks in the new lava of the recent eruption are no longer seen glowing at night. After excessive rainfall for several days, the hot lava fill on January 20 was seen to be steaming from hundreds of small vents all over the surface, the new cone was ringed by steam, there was steam on the taluses and walls, and vertical lines of vapor vents could be followed up the western and southern walls. These are upright cracks in the wall where the east and west fault blocks are marked above by steam cracks parallel with rim of pit. On January 18 at 8:30 a. m. after 4.10 inches of rain in 24 hours a steam cloud rose from Halemaumau and water cascades poured from Uwekahuna. At 2 to 3 p. m. some rocks were heard falling, rim cracks N and NE showed very slight widening, a central vent in the floor showed much blue fume, and eight others showed less, and new debris overlapped the lava floor at the base of the talus slopes. January 22 the pit was absolutely quiet.

One feeble local earthquake occurred 2:06 a. m. January 19, origin distance 32 miles. There were 29 spasdomic tremors, some indicating origins 2, 6, 20, and about 35 miles away. Microseismic motion was moderate, and tilting of the ground moderate ESE.

THE VOLCANO LETTER

The Volcano Letter combines the earlier weekly of that name, with the former monthly Bulletin of the Hawaiian Volcano Observatory. It is published weekly, on Thursdays, by the Hawaiian Volcano Research Association, on behalf of the section of volcanology, U. S. Geological Survey. It promotes experimental recording of earth processes.

Readers are requested to send articles, photographs, publications and clippings about volcano and earthquake events, instruments and investigations, especially around the Pacific.

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The Volcano Letter

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No. 371—Weekly | Hawaiian Volcano Observatory, National Park, Hawaii | February 4, 1932

REVIEW OF EARTHQUAKE RECORD KILAUEA 1931

tr—tremor, value ¼ Rossi-Forel
vf—very feeble, ½ Rossi-Forel
f—feeble, 1 Rossi-Forel
SSRF—seismicity summation R.F.
sl—slight, value 2 Rossi-Forel
mod—moderate, 3 Rossi-Forel
tel—teleseism, or distant earthquake, no value for local seismicity.

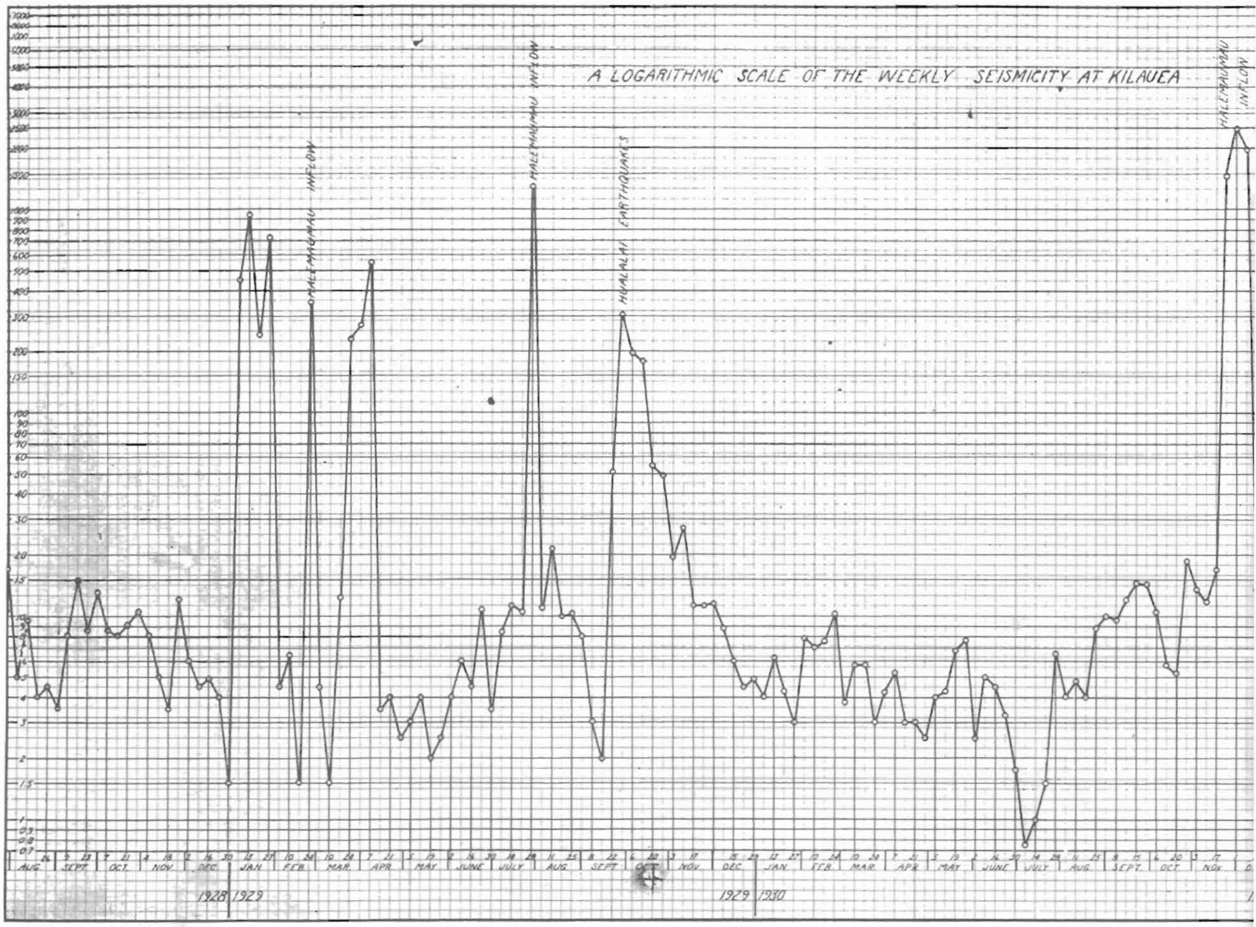
Week ending 1931	tr	vf	f	sl	mod	tel	SSRF	log
Jan. 5	55	1	1	0	0	1	15.25	1.183
12	27	3	0	0	0	0	8.25	0.917
19	22	5	0	1	0	2	10.00	1.000
26	30	14	0	0	0	0	14.50	1.162
Feb. 2	40	27	1	1	0	0	26.50	1.423
9	11	2	1	0	0	1	4.75	0.677
16	12	2	0	0	0	0	4.00	0.602
23	19	1	0	0	0	0	5.25	0.721
Mar. 2	25	2	1	0	0	0	8.25	0.917
9	16	2	0	1	0	0	7.00	0.845
16	34	3	0	0	0	0	10.00	1.000
23	22	2	0	1	0	3	8.50	0.929
30	29	3	0	0	0	1	9.75	0.989
Apr. 6	55	5	1	0	0	1	17.25	1.237
13	17	0	0	0	0	0	4.25	0.628
20	18	6	1	1	0	0	10.50	1.021
27	23	3	0	0	0	1	7.25	0.861
May 4	33	4	2	0	0	0	12.25	1.088
11	38	0	0	0	0	1	9.50	0.978
18	29	1	0	0	0	0	7.75	0.889
25	25	1	0	0	0	0	6.75	0.829
June 1	33	1	0	0	0	0	8.75	0.942
8	29	1	0	0	0	0	7.75	0.889
15	27	6	0	1	0	0	11.75	1.071
22	26	1	1	0	0	0	8.00	0.903
29	22	0	0	0	0	0	5.50	0.740
July 6	34	-2	0	0	0	0	9.00	0.954
13	18	5	0	0	0	0	7.00	0.845
20	18	3	0	0	0	0	6.00	0.778
27	19	2	0	0	0	0	5.75	0.760

Week ending 1931	tr	vf	f	sl	mod	tel	SSRF	log
Aug. 3	16	1	1	0	0	0	5.50	0.741
10	39	6	0	0	0	1	12.75	1.105
17	22	6	0	0	0	1	8.50	0.929
24	24	3	0	0	0	0	7.50	0.875
31	19	1	2	0	1	0	7.25	0.861
Sep. 7	36	5	0	0	0	0	11.50	1.061
14	56	5	1	0	0	1	17.50	1.243
21	43	1	2	0	0	0	13.25	1.128
28	26	4	1	0	0	1	9.50	0.978
Oct. 5	20	2	0	0	0	1	6.00	0.778
12	28	8	0	0	0	1	11.00	1.042
19	40	2	0	0	0	0	11.00	1.042
26	11	1	0	0	0	0	3.25	0.512
Nov. 2	40	3	2	0	0	0	13.50	1.131
9	59	0	0	0	0	0	14.75	1.169
16	81	6	0	0	0	0	23.25	1.367
23	51	2	0	0	0	0	13.75	1.138
30	22	2	0	0	0	0	6.50	0.810
Dec. 7	24	3	0	0	0	0	7.50	0.875
14	46	9	1	0	1	0	20.00	1.303
21	28	6	0	0	0	0	10.00	1.000
28	6,531	9	1	0	1	0	1641.00	3.215
1932								
Jan. 4	10,080	3	1	0	0	0	2522.00	3.419
11	2,544	4	0	0	0	2	638.00	2.805
18	63	5	0	0	0	0	18.25	1.260
25	29	0	1	0	0	0	8.25	0.915

A CHART OF KILAUEA SEISMICITY

The accompanying diagram exhibiting seismic motion of the ground is a compilation of earthquake activity, representing one of many attempts to show in a single graph a combination of the number and intensity of earthquakes for a given time. What is called seismicity, or the earthquake shakiness of a country, is compounded of tremors and small shakes and big shakes, with many of the smaller phenomena and very few of the big ones. If all are a release of some form of underground energy where magma is moving under a volcano, it is reasonable to think of a single big earthquake as in some way the equivalent of many small ones. (See discussion of Earthquake Intensity Scales, Volcano Lettetr No. 223, April 4, 1929.)

At the Hawaiian Volcano Observatory the weekly descriptions of local seisms or quakes describe them as very feeble, slight. moderate, etc., and these words are not colloquial, but are systematic. The word "slight" means relatively big as compared with "very feeble." By giving a weight or value in terms of the Rossi-Forel scale to each descriptive word, we can add together these values for the number of earthquakes of each grade for each week and secure a figure standing for the combined shakiness of that week. The following is the table of weights:



Curve of rising and falling earthquake and tremor activity, expressing combined weekly frequency and intensit measured at the Observatory on northeast rim of Kilauea Crater from August 1928 to J

Observatory Scale	Weight	Description
Tremor	¼	Can barely be seen on the seismograph records; when continuous the unit is the minute of duration.
Very Feeble	½	A slightly larger shock, not ordinarilly felt by people even when very close to the origin. Rarely reported felt by persons lying down.
Feeble	1	Felt by few or none, an earthquake on the border line between being instrumental and felt. No. I Rossi-Forel scale.
Slight	2	No. II Rossi-Forel scale. Felt slightly.
Moderate	3	No. III Rossi-Forel scale. Felt moderately.
Strong	4	No. IV Rossi-Forel scale. Felt strongly.

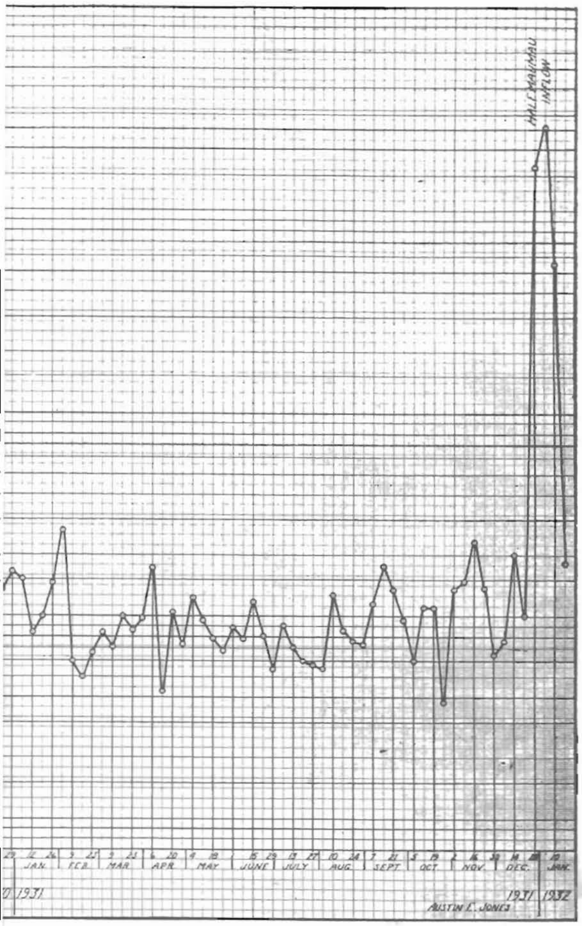
An earthquake felt strongly is still in the weak class, but from the point of view of instrumentalists, operating seismographs that magnify the earth's motion one hundred times, this quake is strong because it always dismantles the connecting bars of a sensitive seismograph. This does not mean that it breaks anything.

These grades are weighted roughly in terms of the Rossi-Forel scale as ¼, ½, 1, 2, 3, 4, and mathematically, in terms of accelerations, the Rossi-Forel scale is logical in that Grade II is twice as big as Grade I, etc., up to Grade IV. Beyond Grade IV the progression is not arithmetical.

If in one week we have 10 tremors or 10 minutes of tremor (value 2½), three very feeble shocks (1½), a slight earthquake (2), and a moderate earthquake (3), the resulting index of that week's seismicity is the summation of these values equal to 9. Thus in the accompanying tabulation the week ending July 6, 1931, had that value because of the very large number of tremors.

If we were to have several days of continuous tremor, each day would produce 1,440 minutes of tremor, or an index of 360. Such an example can be shown for the last eruptive period of Halemaumau beginning in December of 1931. During the week ending December 31, 1931, there were 11 tremors, 9 very feeble shocks, 1 feeble one, and a moderate earthquake preceding the eruption which began on December 23. The summation index to this point is 11.25. This was followed by four days and a half of tremor, the index of which amounted to 1630. The total index of seismicity for the week is obtained by adding together the two figures and amounts to 1641 units.

If this were platted on uniform coordinate paper, the figure 1641 would be about 180 times as great as that for the week mentioned above having the index of 9, so that if inches were used as units on the paper, the line would rise 135 feet. To avoid this difficulty the logarithms of



of local earthquakes, and duration of local tremors.
nuary 1932. By A. E. Jones.

all index numbers have been taken and platted for the number of units involved vertically above each date. In the accompanying table the logarithmic figure is shown in addition to the seismicity figure. On the curve a logarithmic scale has been drawn across the diagram with the seismicity sums R. F. on the left. These read from 0.7 to 9000 and the sheet is thus adequate to contain all the peaks and hollows for the three and a half years from July 1928 to January 1932.

To judge by the height of the peaks, during eruptions of lava flowing into Halemaumau in February and July 1929, November 1930, and December 1931, making a pronounced rise of the curve in each case, determined largely by continuous tremor, evaluated for each minute arbitrarily as one-quarter unit, it seems likely that this arbitrary value is much too great. The method, however, has the advantage of exhibiting an effect of these eruptions on the seismicity curve with much vividness. A.E.J.

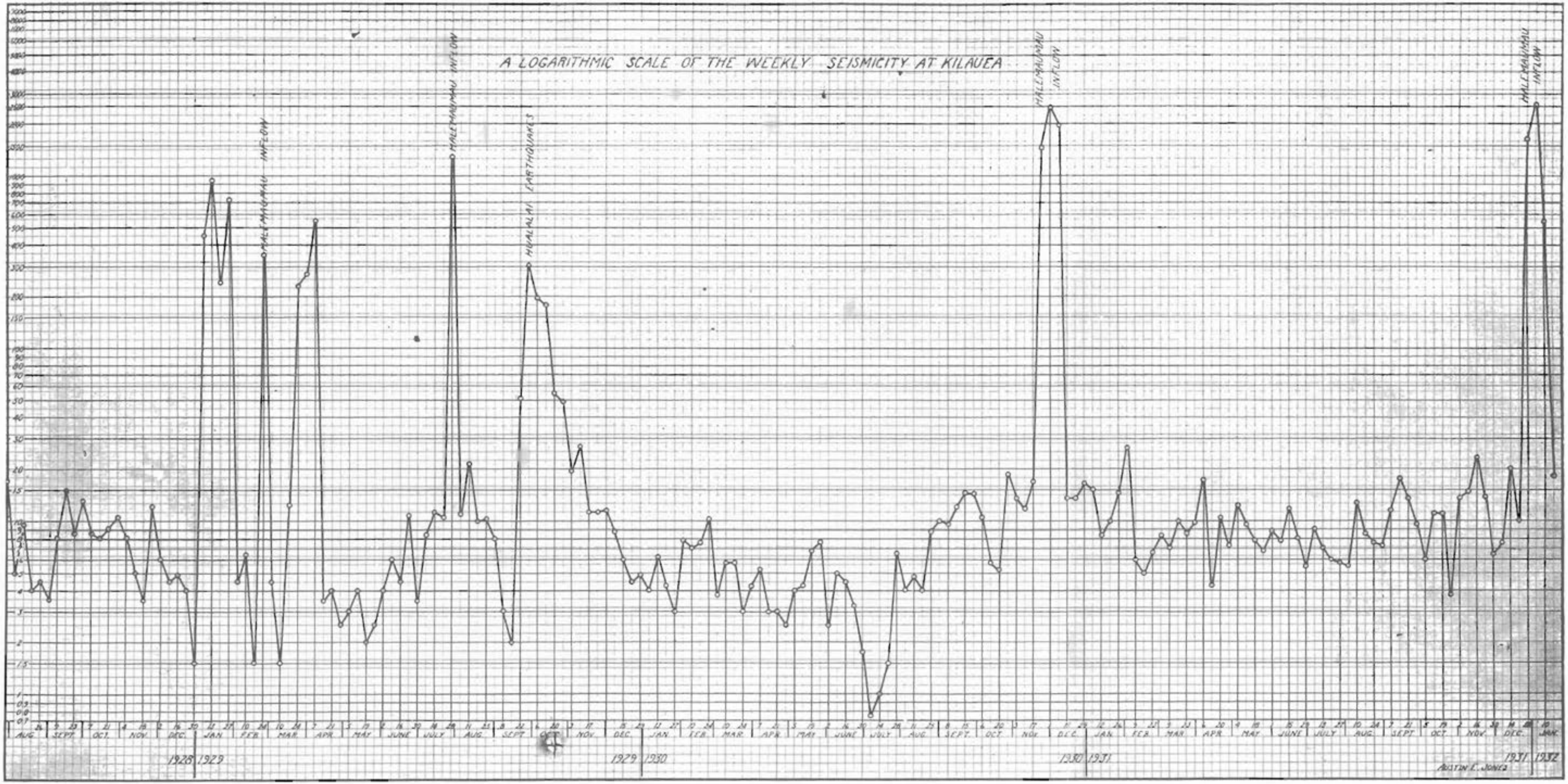
DISCUSSION OF SEISMICITY CURVE 1928-32

The table which was used by Mr. Jones in compiling the curve described above, will be better understood if it is presented in full for this past year 1931 in order to show how the curve was drawn for the right-hand side of the diagram. The table is on Page One.

Curves of earthquake frequency by months and by three-day units have been experimented with at the Hawaiian Volcano Observatory as follows: By Jaggar, monthly local earthquake frequency compared with maximum intensity from 1912 to 1916, in "Seismometric Investigation of the Hawaiian Lava Column," Bull. Seis. Soc. Amer. Dec. 1920, p. 259, when it appeared the peaks were at rythmic intervals of about nine months and increasing along with a series of Mauna Loa events. Next a study by Wilson Bull. Haw'n Volc. Obs. Dec. 1927, fig. 47, wherein the three-day frequency was smoothed by overlapping means, did not include harmonic tremor (nor did the one above), and analogy with the lunar half-month was suggested. Taking frequency alone, there was no peak accompanying the July eruption of Halemaumau 1927, but a comparative symbol indicating intense earthquakes showed a swarm of them not reflected in frequency curve, but occurring at the beginning and the end of the eruption. Thus Wilson's curve, compared with the new method by Jones, would have shot up for the 1927 eruptive period, had it embodied an integration of harmonic tremor and intensity along with frequency, as has been done in the new type of curve. In a diagram compiled by Finch for comparison with tilt (Bull. Seis. Soc. Amer. Mar. 1929, p. 41), marked peaks in monthly earthquake frequency for the years 1913-1925 are shown to accord with drops in the lava of Halemaumau and with Mauna Loa outbreaks, the highest frequency according with the tremendous drop of 1924. In 1916 when there was a sudden drop of the Halemaumau lava immediately following an outhbreak of Mauna Loa, there were two peaks of earthquake frequency side by side accompanying these events (Jaggar, Amer. Jour. Sci. Apr. 1917, fig. 2 p. 259).

The outstanding features of the curve for seismicity at Kilauea from 1928 to the beginning of 1932 are the high peaks of suddenly increased seismic activity that accompanied the four outbreaks of Halemaumau. By consulting the last number of the Volcano Letter, January 28, 1932, the reader may learn the details of these eruptions February 28, 1929, July 25, 1929, November 19, 1930, and December 23, 1931. It was there stated that in general these eruptions were progressively more intense and more enduring, and it is clear from the chart that the four peaks of seismicity are progressively higher and wider. Mr. Wilson's curve mentioned above showed a composite peak of earthquake frequency in December 1927 immediately preceding the very mild outbreak of January 1928, and this was made up of much tremor accompanying avalanches in Halemaumau pit and the widening of some cracks on the edge. If that episode were added to the left-hand side of our diagram, we should find a still smaller peak for the actual eruption week of 1928 and a big complex peak preceding it. So for the seven weeks preceding the February eruption of 1929 there is a composite and enduring peak of seismicity which was accompanied by widening of cracks and numerous avalanche tremors, as well as other seismic events distinctly premonitory to the lava inflow of February 20.

Not so clear is the explanation of the third peak between March 10, the time of low tremor following the eruption, and April 14, when general decline began. The only events of note during this time were rather protracted spasms of tremor, a certain number of avalanches, and some rather strong tilting. It seems likely that this peak in seismicity represents a distinct slump in the lava column following the eruption, but its qaulity of gradual rise and sudden fall to a point below normal is unusual.



Curve of rising and falling earthquake and tremor activity, expressing combined weekly frequency and intensity of local earthquakes, and duration of local tremors. measured at the Observatory on northeast rim of Kilauea Crater from August 1928 to January 1932. By A. E. Jones.

If we look at the curves on either side of the other Halemaumau eruptive periods as shown in our diagram, there is nothing analogous to these peaks of preparation and of aftermath.

The Hualalai earthquake crisis of September-October 1929 is developed as a very sudden rise in the seismicity curve, followed by a stepwise decline for 17 weeks, and this curve is quite in accord with the facts of observation, for the strong intensity and the strong frequency showed maxima soon after the beginning. It will be seen that this is a true earthquake curve of sudden intensity, followed by swarms of aftershocks, and quite unlike the steep bilaterial curves that accompanied the Halemaumau outbreaks.

When it comes to the general curve of seismicity in the diagram, disregarding the high peaks, it is evident that this curve as a whole tended to fall below the figure 10 from 1928 to July of 1930, and that then there was a pronounced rise in seismicity, and thereafter the small crests tended to rise above that figure. The minima approached low levels right while the maxima were reaching high ones about February 1929, again in September of that year, and the lowest of all was reached in July of 1930. In the whole diagram there is possibly some suggestion of a wave movement with troughs of minima 16 months apart. When it comes to the small oscillations, there is a marked tendency to troughs from two to six weeks apart, possibly corresponding to the lunar month and half-month. This tidal effect for both seismicity and lava movement has been discussed before. The fact of the diagram are 20 cases of complete periods occupying four to six weeks, 20 occupying three weeks, and 14 occupying two weeks. The mean is 3.4 weeks, which is near enough to the lunar month for such crude results over a short interval of time.

There are many questions raised by this diagram as to the comparability of local seisms, spasmodic tremor, harmonic tremor, and avalanche tremor, and the equivalence of the units used in terms of acceleration, or of whatever product of amplitude and period properly constitutes seismic intensity. It should be noted, however, that this is not an intensity curve, but is rather an intensity-duration curve, and this taking account of frequency is new, and the seismologist of this station is to be congratulated on the experiment. T.A.J.

KILAUEA REPORT No. 1045

WEEK ENDING JANUARY 31, 1932

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Nothing remarkable has happened at Halemaumau pit suggestive of movement of lava. The new floor is hot and a high cumulus occasionally forms above the pit. On January 26 in the forenoon no single vents on the floor could be identified as emitting fume, there had been sliding from southerly walls as shown by numerous bowlders and fresh debris on the 1932 floor SE, and red material on floor S. The northeast rim cracks continued to widen slightly by measurement. At 11:18 a. m. a slide from the northeast wall, beginning near the top, made dust.

The seismologist reports 1 very feeble local seism January 28 at 8:18 a. m. with indicated distance 6 miles. Forty-eight local tremors were recorded, 3 suugesting origin distance 9, 18, and 23 miles. A distant earthquake registered January 29 at 3 h 21 m 12 s a.m., indicating approximate origin distance 3100 miles, began too indefinitely to show direction of origin.

Microseismic motion has been moderate, and tilting of the ground moderate to the east.

THE VOLCANO LETTER

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HAWAIIAN VOLCANO OBSERVATORY
Founded 1911

This laboratory at Kilauea Volcano belongs to the Hawaiian Volcano Research Association and is leased and operated by the United States Geological Survey.

It maintains seismographs at three places near Kilauea Volcano, also at Hilo, and at Kealakekua in Kona District. It keeps a journal of Hawaiian volcanic activity and publishes occasional Bulletins.

Membership in the Hawaiian Volcano Research Association is limited to patrons of Pacific science who desire personally to aid in supporting the work.

The work of volcano research so supported is in collaboration with the work of the United States Geological Survey, but supplements it with buildings, research fellows, instrumental plants, explorations and special investigations for which there is no governmental provision. The Geological Survey maintains volcano stations in Alaska, California and Hawaii.

Persons desiring application blanks for membership ($5.00 or more) should address the Secretary, Hawaiian Volcano Research Association, 320 James Campbell Building, Honolulu, T. H.

The Volcano Letter

Two dollars per year | Ten cents per copy

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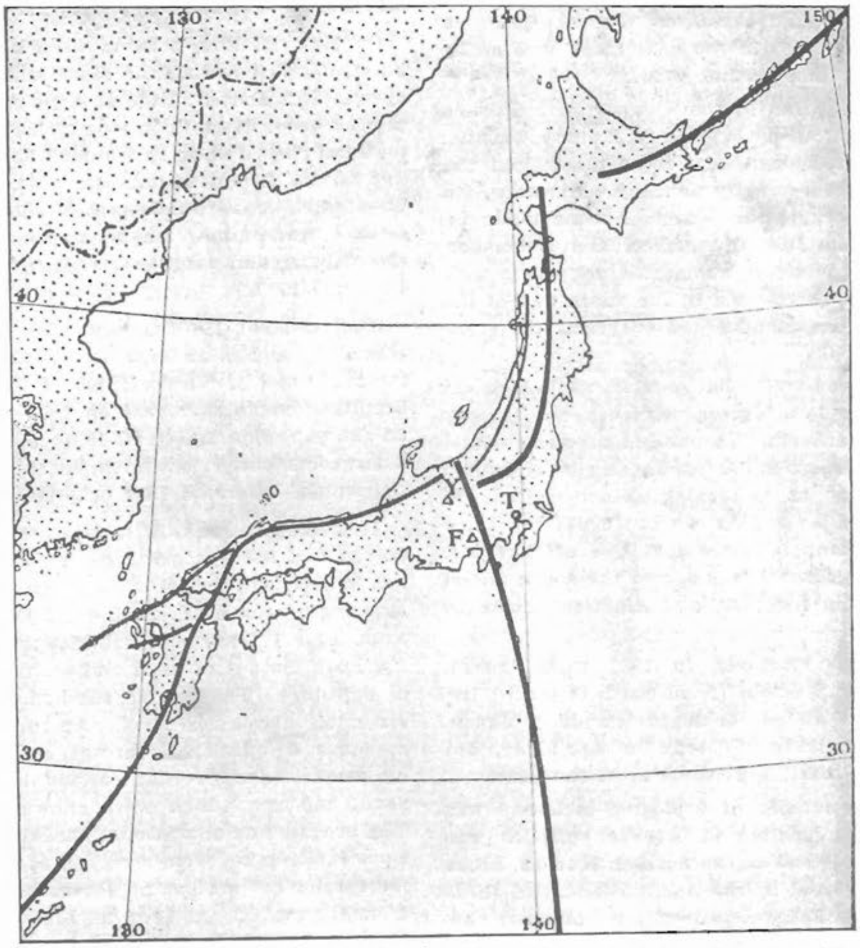

Map of volcanic arcs in Japan, showing the main central Honshu arc, with the Kurile arc at the northeast and the Ryukyu at the southwest. T=Tokyo, F=Fujiyama, Y=Yakedake. The Fujiyama zone extending to the south leads through the Ogasawara Islands. By Omori.

RECENT ERUPTIONS IN JAPAN

An impressive series of arcuate fissures in the crust of the earth, each 1200 to 1500 kilometers long, including the Ryukyu islands, the three mainland islands of Japan, the Kurile Islands at the north, and the Ogasawara line of islands south from Fujiyama, makes up the volcano domain of Japan. In all, this involves 5,000 kilometers or 3100 miles of scattered volcanoes, amid hills and mountains built above the fractures, so that as cracks they are concealed.

The eruptions from 1924 to 1931 have been tabulated by Tanakadate (Japan Jour. Astron. and Geophys. Vol. IX, No. 1, 1931, p. 47).

The activities are divided into smoke explosions, ash explosions, explosive eruptions, pumice flows, mud flows, submarine eruptions, and "increase of normal activity." This normal activity in volcanoes like Aso, Oshima, Tarumai, and Asama involves lava in the crater pit. Lava flows are rare in Japan because the andesites are siliceous and viscous, and the gas or steam of an "eruption" effervesces explosively through the incandescent slag that plugs the crater. "Fire phenomena," or "pumice flows," or "flows of lava blocks," or "glowing lapilli" are frequently described, as seen from a distance. These descriptions means an internal intrusive magma disrupted. (See Tanakadate, "Eruptive Types," Volcano Letter No. 323, March 5, 1931.)

The activity of the seven years speaks volumes for what Japan has to offer to the student of volcanology. Professor Tanakadate has made a very striking compilation of the facts, the upshot of which is that there are only a few months of each year without reported eruptions in some of the volcanic zones.

There are large shiftings from one zone to another.

There was in Japan a striking rise in distributed frequency in 1927-28, and in intensity in 1929, with a lower Japanese volcanicity before and after these three years.

It happens that these were years of sunspot maxima (see Volcano Letter No. 326), and 1928-29 produced extreme volcanicity elsewhere including the Dutch East Indies, Tonga, Chile, Guatemala, Martinique, and Italy.

Reviewing each year for Japan and beginning with September 1924, we get smoke explosions from Asamayama in central Honshu, followed in the next three months by Yakedake a short distance farther west.

In 1925 Yakedake, Asosan in south Japan, and Shirane in central Honshu were all performing in January, blowing fume and dust, and Yakedake kept it up throughout the year. Asama increased activity in May. Suwanose in the Ryukyu Islands erupted in March, Asosan made increasing explosions in July, November, and December. And in the aut mn came a submarine eruption, with floating pumice fields, at Hatoma in the south end of the Ryukyu Island line. Kamchatka had eruptions the same year.

In 1926 Yakedake was active but quieter, while Tokachi in the north island made a big explosive eruption in May and continued in the autumn. Tarumai in the same island erupted in October, Asama in central Japan renewed fume explosions preliminary to increasing demonstrations in succeeding years, and Asosan in the south did the same but more violently throughout the last half of the year. The north island, the central island, and the south island were now all in action together, and Aleutian volcanoes also broke out.

This continued and increased in 1927 with Asosan, Yakedake, Asama, and Tokachi (from south to north) the main performers, and all on the main islands of Japan. All four had ash explosions, chiefly in April-May, but Asama reached such maxima at the end of the year.

While in 1928 the number of explosive incidents was less, the diversity of location of intense episodes was greater. Matuwa, an island in the northen Kuriles, broke out in February, Tarumai in the north island had three eruptions, and nearby Tokachi had one; all of these concern the northern area. For central Honshu, Asama was fiercely active the first half of the year, Shirane again blew out crater holes, and Oshima near Tokyo revived in the summer. Yakedake slept. Asosan in Kyushu had four eruptive spasms, of which one was an ash eruption and one was accompanied with mud flow.

The year 1929 produced two major explosive eruptions, Komagadake in the north island in June, and Asama in central Japan in September. Tarumai had another outburst, Yakedake had two, and Asosan had two, of which the last was an ash explosion in October. Komagadake had a revival in September, and Asama had fume explosions four times, in addition to its major eruption. Kamchatka volcanoes were active.

A marked dwindling occurred in 1930, with Asama, however, making ash explosions four times in summer and autumn. Matuwa in the Kurile Islands again exploded in its favored month, February. Yakedake had two explosions in the spring, and Asosan one in the autumn. The Aleutian region reported two eruptions.

The late spring of 1931 produced outbreaks in Asama, Yakedake and Asosan, and the same season was notable for activities in the Aleutian Islands and a major eruption at Aniakchak on the Alaskan Peninsula.

Now let us consider the details of some of the Japanese events. The Tokachi eruption beginning May 7, 1926, was in the center of the north island at a sulphur mine operated at a solfatara on the side of a peak 2,077 meters high. Explosions with fume and sulphur flame increased in violence at a place not historically known to be strongly active. But this is in the Ainu wilderness, and merely shows, as elsewhere in all the solfataric belts of the world, that sulphur and heat may anywhere develop a volcano.

On May 24 three persons were killed in a preliminary burst, debris covering the slope and overwhelming a hot-spring bath house. Then at 4:10 p. m. a tremendous explosion upset five million tons of the mountain flank. This material rushed down in two mud flows devastating forests and farms. The dead numbered 144, the wounded 207, and twenty-five square kilometers of country were devastated. Lava lumps of new magma appeared later as bombs in the debris, and eruptions continued but diminished in 1927 and 1928.

Komagadake, 1140 meters high, is near the city of Hakodate, and is an impressive volcano like Vesuvius at the south end of the north island. It has a record of big eruptions, some as recent as 1905 and 1919. There was an ash explosion in July of 1924. Beginning June 16, 1929, a large destructive eruption began "which ranks next in importance after the 1914 eruption of Sakurajima."

At midnight June 16 a small explosion originated at cracks and fissures extending radially from a small lava hill in the central part of the main crater. Ash fell next morning at the southern foot of the mountain. At 9:30 a. m. June 17 enormous cauliflower clouds arose resembling huge masses of wool and emitting continuous flashes of lightning. The column reached an altitude more than six miles above sea level. At 10 a. m. there were tremendous detonations, roarings, and tremblings, followed by smoke columns that carried blocks of rock, lapilli, sand, and ash which were showered over the country. The ground was almost continuously in vibration, and distinct earthquakes were recorded at the seismograph of the meteorological station at Hakodate, 33 kilometers south from the crater. At 11 a. m. blocks of pumice and small stones were falling at the southeastern foot of the volcano where the forest was devastated, while the village of Sikabe, 13 kilometers to the southeast, had its fields and fishing grounds covered with three or four feet of lapilli.

In the afternoon at frequent intervals glowing masses of pumice blocks ran down the radial valleys in several directions, resembling the glowing blasts (**nuées ardentes**) as described at Mont Pelee in Martinique. These pumice flows traveled in places more than five miles from the crater. At 7 p. m. "fire columns" hung over the crater in the smoke cloud with continuous lightning flashing. The eruptive activity culminated about 10 p. m., after which it gradually declined and towards midnight ceased.

Extraordinary changes took place in the caldera crater of the volcano. The floor was elevated by tumescence, to which relief was added by accumulation of lumps of lava. Three main vents were formed on the domed floor; a round craterlet at the west, a T-shaped fissure at the north, and twin craterlets at the southeast corner, all pouring out white fume. In addition there were numerous minor fissures on the dome.

Quantities of ejectamenta consisting of acidic andesite covered 538 square kilometers of country. Pumice flows in addition, occupying several valleys, covered 27 square kilometers. One person was killed, four were wounded, 65 domestic animals were destroyed, 3500 acres of farm lands were ruined, and about 87,000 acres of pasture and forest were devastated.

There was a renewal of explosive cauliflowers accompanied by tremblings the afternon of September 6.

Asamayama is the Vesuvius of Japan, characterized by explosions with rumbling, quaking, and air shocks, the projectiles consisting of ash, lapilli, bombs, and blocks several tons in weight. Tanakadate says, "Most of the ejecta are considered as not being juvenile" or magmatic, but the reviewer would question this, for the bottom area in the crater which he saw in 1907, appeared to be a typical andesitic aa lava.

After eruptions and earthquakes in 1924, 1927, and 1928 of increasing vehemence at Asama, there came a great eruption on September 18, 1929, at 1 a. m. which began with roarings followed by detonations. The villagers saw glowing smoke clouds ascending from the crater more than a half mile high. Red-hot blocks of lava were hurled up, and atfer three paroxysmal explosions accompanied with such fire phenomena, the energy of the eruption gradually declined, but rumbling continued. Air shocks were unusually strong, ash rain fell to the east, lava blocks were scattered about the crater, the eastern part of the crater wall was destroyed, and new pits were left in the floor of the crater. About 3.4 million cubic meters of material were thrown out.

Other explosions of Asama and earthquakes followed in 1930. On August 20 of that year a sudden explosion accompanied by a heavy downpour of projectiles killed six persons who had ventured too near the crater rim. On September 5 the explosion clouds were accompanied by incandescence, and the ash rain fell in Tokyo 140 kilometers to the south. Some of the earthquakes, centering at Asama, are registered at Tokyo.

The eruptions of Yakedake and Asosan are of the same general character as those described for Asama, with occasional "fire" and much damage to rice fields by showers of ash, and of fine cindery sand called "yona" in the Aso district. In all cases there is more or less trembling and lightning and earthquakes. The flinging out of red-hot breadcrust bombs which make new landmarks on the edges of the craters, and repeated changes in the configuration of the bottoms, are characteristics of Japanese eruptions.

After our experience at the Kilauea Observatory in trying to decide what physical phenomena may be measured all the time near an active crater, and what active craters are most useful for continuous observation, it is of great interest to study these Japanese records. The seven-year table here under discussion shows 26 incidents for Asama, 25 for Yakedake, and 24 for Asosan, with Yakedake dominant 1924-25, Asosan dominant 1926-27, and Asamayama dominant 1928-31. Oshima which fumes all the time in Sagami Bay, and has a red-hot vent in the lava cone of its inner crater, is only mentioned as throwing up ash once August 7-8, 1928, and showing fire at night to the villagers. Yet Oshima with its basaltic lava is for many reasons the ideal volcano for an observatory. It is well placed near the Tokyo center of research, it was near the center of the terrible earthquake of 1923, and it is near the middle of all the volcano belts. A headquarters observatory at Oshima could maintain substations at Asama, Tarumai, Yakedake, and Asosan, and would thereby cover well all the zones. It is a very striking fact that Aso, Yakedake, Asama, and Tarumai all lie at the intersections of two volcanic belts, and it seems likely on this account that the angle between two crustal fissures is the place of most continuous emission. T.A.J.

TILTING OF THE GROUND FOR JANUARY

The following figures show the net amount of tilt by weeks at the Observatory on the northeast rim of Kilauea Crater, and its direction computed from the daily seismograms, by platting a curve smoothed by overlapping seven-day averages. This is the departure of the plumb line in seconds of arc, in the direction given.

January 5-11	0.6 second	S
January 12-16	0.4 second	NNE
January 19-25	2.1 seconds	ESE
January 26-February 1	1.6 seconds	S

E.G.W.

KILAUEA REPORT No. 1046

WEEK ENDING FEBRUARY 7, 1932

Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge.

Halemaumau continues dormant. In the forenoon February 1 two or three rocks fell from the walls. Cracks on the northeast rim continued slight widening. Five vents emitting slight blue fume were counted on the floor. On February 2 rocks were falling almost continuously and slight widening of rim cracks continued. Surveys showed that the greatest amount of vertical shrinking in the new January lava floor of Halemaumau amounts to between 40 and 50 feet in the southern part. The lava here now stands 30 feet above the top of the former 1930 cone, whereas when it was liquid January 5 the depth was estimated over 70 feet. The edges of the flood have remained stationary, and the average vertical shrinkage out in the middle is between 10 and 20 feet. The average depth of fill is about 110 feet.

The seismographs recorded 1 very feeble shock with indicated origin distance 4 miles. Sixteen tremors were registered, one showing distance 23 miles. There was prolonged tremor for 4 minutes February 3 and for 18 minutes Febraury 6, this latter indicating origin distance 18 miles probably NW. Microseismic motion was moderate, and tilting of the ground moderate SSW.

Map of active and extinct volcanoes in Japan by S. Kozu. Hatoma is at the extreme southwest near Taiwan, and Matuwa is north of the middle of the Chishima zone.

THE VOLCANO LETTER

The Volcano Letter combines the earlier weekly of that name, with the former monthly Bulletin of the Hawaiian Volcano Observatory. It is published weekly, on Thursdays, by the Hawaiian Volcano Research Association, on behalf of the section of volcanology, U. S. Geological Survey. It promotes experimental recording of earth processes.

Readers are requested to send articles, photographs, publications and clippings about volcano and earthquake events, instruments and investigations, especially around the Pacific.

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The Volcano Letter

Two dollars per year | **Ten cents per copy**

No. 373—Weekly | Hawaiian Volcano Observatory, National Park, Hawaii | February 18, 1932

Big Steamer at Supan's Springs June 13, 1931. Photo from Finch.

LASSEN REPORT No. 31

WORK OF LASSEN VOLCANO OBSERVATORY IN 1931

Mineral, California

R. H. Finch, Associate Volcanologist

Outlying Seismographs

Besides the main station at Mineral, placed in the Forest Reserve three miles outside of Lassen Volcanic National Park to the southwest, seismographs are operated at Viola, seven miles outside the accompanying map at the northwest, and at Mount Harkness in the forest lookout station at the southeast corner of the Park. These seismographs are all of the horizontal pendulum type, those at Mineral and Mount Harkness being Hawaiian type instruments, made in the shop of the Hawaiian Volcano Observatory.

The seismograph at the Loomis Museum near Viola was started in operation for the summer on June 20. 1931, and operated by Mrs. F. J. Hermann, wife of the Park Naturalist. Except during occasional clock trouble, the seismograph registered continuously until September 25.

The seismograph on Mount Harkness was kept in operation from June 30 until October 23 by A. J. Free, Park Service fire lookout. This instrument gave some excellent records of distant earthquakes, and the seismograms were loaned for stuly to the seismographic station of the University of California.

Tilting of the Ground

It will be remembered (Volcano Letter No. 336) that in the report of the Lassen Observatory for 1930 that the accumulation of tilt to the southwest at Mineral, (that is, away from Lassen Peak), was less during 1930 than in former years, and that the Harkness station when first set up indicated southeast tilt, which also is in general away from the Lassen center of volcanism. The correction for accumulated tilt on all seismographs operated by the Lassen Observatory in 1931 was less than during 1930.

Local Earthquakes

Nearly all of the earthquakes, registered on the instruments at Lassen, appear to originate under the big volcano itself. The seismograph at Mineral registered 38 earthquakes during the year 1931. The distribution of these shocks by months was as follows:

January	7 shocks	July	0 shocks
February	2 "	August	9 "
March	1 "	September	2 "
April	3 "	October	4 "
May	2 "	November	4 "
June	3 "	December	1 "

The numbers of shakings recorded during each of the last five years are as follows:

1927	266 shocks
1928	37 "
1929	96 "
1930	74
1931	38 "

Rainfall

The total rainfall and the total snowfall for 1931 compared with previous years were as follows:

Rainfall		Snowfall	
Year	Precipitation	Winter	Snowfall
1927	43.32 inches	1926-27	168 inches
1928	42.10 "	1927-28	106 "
1929	38.65 "	1928 29	130 "
1930	38.94 "	1929 30	138 "
1931	46.30 "	1930-31	64 "
		1931-32	114 " to Jan. 1, 1932

It will be seen by these tables that the variation in the rainfall is less than that of the snowfall, and that the latter was extraordinarily different for the season 1930-31. only 64 inches, as compared with 1926-27 when 168 inches accumulated. The winter of 1931-32 is another time of very heavy snows, and Mr. Finch has recently written under date December 30, 1931, "For the past two weeks, it has been about all that I could do to keep up the ordinary routine. We have had over 78 inches of snow during that time. I climb down a flight of stairs, cut in the snow, to get into the office, and to the instrument shelter. So far I have not been able to get any help in removing the snow, but hope to find someone within a few days. It is still snowing and there is considerable possibility of our getting snowed in." The Mineral station is in the midst of big evergreen trees, high in the mountains, and has recently been something of a resort. for winter sports, for people from the Sacramento valley (T.A.J).

In June 1931 some data on slump scarps were obtained. Many examples of this type of cliff can be found in northern California. A note for publication on this subject is being prepared.

Hot Springs Temperatures

Temperature measurements for comparison with the records of former years (as recorded in the 'Bulletin of the Hawaiian Volcano Observatory' and in the 'Volcano Letter' from time to time.), the measurements being made with corrected maximum Fahrenheit thermometers as part of the routine of the station, resulted as follows:

Big Steamer at Supans Springs

(Southwest part of Park west of Diamond Peak)

Date	Temperature
June 13, 1931	190° F.
July 11	195° F.
August 8	196° F.
August 30	199° F.
October 11	194° F.

Bumpass Hell

(Southwest part of Park, south of Bumpass Mountain)

On August 24, 1931, the highest temperature was 198° F. at a mud pot in the center of the area, measured at a depth of 8 feet. The highest temperature of any of the boiling springs was 196° F.

Lassen Crater

(At the summit of Lassen Peak shown in the map above the word "Lassen" in the middle of west end of Park)

On September 1, 1931, the air temperature was 78° F. and there was no snow in the crater The following were the temperatures of the several vents:

Northwest vent	130° F.
North vent	110° F.
Northeast vent	110° F.
South vent	136° F.

Morgan Springs

(Outside the Park, southwest corner of map)

On October 30. 1931, measurements of the several springs were as follows:

No. 3 Larvae Pool	156° F.
No. 14 North	152° F., flowing vigorously
No. 17	200° F.
No. 20	200° F.
Upper Geyser	202° F.

Boiling Lake

(South side of Hot Springs Creek, southern part of Park)

On September 7, with air temperature 66° F., the lake was high within four inches of the outlet. The following measurements were made:

Northwest edge	120° F.
Large mud pot, west	201° F.
Boiler, south end, water	170° F.
Boiler, south end, mud	199° F.

Devil's Kitchen

(Upper Hot Springs Creek, southern part of Park)

The following were measurements of September 7, 1931:

Small pool north side	194° F.
Mud pot north side (thick mud, surface exposure)	144° F.
Small hole at side of pool north side	200° F.
Mud pot northwest	196° F.
Pyrite pool northwest	190° F.

New Steam Vent

(South slope of Diamond Peak southwest part of Park)

The discovery of this vent was described in Volcano Letter No. 362. It is in an ancient solfataric area and had a temperature of 198° F. when it was measured October 14, 1931.

Changes at Supan's Springs

No movement was detected at the line of stakes which had been set up to measure movement, in the landslip area of Supan's Springs, near the bend in the road on Sulphur Creek west of Diamond Park, where for many years there have been fresh cracks across the valley indicating a creep of surface materials. As reported in 1930, the earlier stakes had been broken off, and a new set of iron stakes was installed in that year. New measurement in 1931 showed that no movement could be detected parallel with the valley, nor on the transit line laid out for repeated observations across the valley. There were signs of chemical erosion. The basin at the Big Steamer at Supan's Springs had moved westward a few feet. The volume of the basin had increased by about 50 cubic feet without any surface outflow to account for mechanical loss of eroded material.

On his trip to investigate Akutan Volcano and to inspect seismopragh stations in the Aleutian belt of Alaska, Mr. Finch was absent from the Lassen station from June 25 to September 13. Mr. C. A. Huff operated the station during his absence.

EARTHQUAKE IN THE SOLOMON ISLANDS OCTOBER 1931

We reported registering on seismographs (Volcano Letter No. 355) a large distant earthquake approximately 3750 miles away to the southwest, and another estimated 3500 miles away, the dates being October 3 and October 9, 1931. It has since been reported (Volcano Letter No. 361) that the first of these earthquakes wrought damage in the British Solomon Islands and was followed by a disastrous seismic sea wave, which recorded on the tide gauge at Hilo eight hours after the earthquake occurred in the Coral Sea. Northeast of this Coral Sea lies a line of active volcanoes extending through the New Hebrides, the Santa Cruz Islands, the Solomon Islands, and New Mecklenburg, the whole belt extending northwest in the region between New Guinea and Fiji, and lying between the Micronesian Islands of the western Pacific and the Coral Sea which lies outside of the Great Barrier Reef of northeastern Australia. The inhabitants of this volcanic belt are Melanesians.

The "Church of England Newspaper" January 8, 1932, publishes a report by Dr. Fox, Principal of All Hallows School, Pawa, Solomon Islands, saying the earthquakes lasted more than 15 days. On Sunday October 4 at 5:45 a. m. there was a very big earthquake lasting four and a half minutes. and then a prolonged quiver for two hours, and then small quakes every half hour or so day and night for 15 days. But there was a second big one, worse than the first, on October 10, at 11 a. m., followed by a succession of big shocks every few minutes, till the worst of all came at 3 p. m., a violent wriggling followed by convulsive waves, when it was hardly possible for a man to keep his feet. Then smaller qaukes occurred every hour gradually getting milder.

All the mission tanks were thrown down, two of the plate timbers of the house were broken, and a wall was torn out. The boys' houses leaned over and another house had a list. The chapel survived the shock best. The tower swayed violently back and forth, and the flag-pole snapped and was thrown down. A Dover stove was smashed anl much small stuff was broken.

The mission staff slept on the shore in a leaf house, but continued to conduct services in the chapel. The boys slept on the shore, as the hill country rocked violently. During the earthquake of 3 p. m. October 10, the ocean suddenly receded from the bay to much beyond the lowest low-tide mark, and in about three minutes swirled back to about four feet above high tide mark. This happened twice, and then the water remained at high-tide level for hours when it should have been low. Dr. Fox, watching it, reported that the wave seemed to come from the east or northeast and judged the origin to be a hundred miles or so away, and wondered whether it was created by a submarine volcano.

A similar report from a station at Aitape in New Guinea (United Empire, London, January 1932) described what is presumably the October 10 quakes of 11 a. m. as occurring at 11:40 a. m. of the local time, when suddenly a rumble came from the sea. Everything heaved and swayed, chairs and other things were overturned, coconuts fell from the trees, cement piles were cracked, and water tanks telescoped and spilt. Cracks opened in the ground. A trestle bridge was thrown out of alignment. The first shock lasted 40 seconds, followed by other severe ones, while small shocks and tremors continued for a fortnight.

Another Solomon Islands earthquake was registered on seismographs November 20, 1931, and one in the New Hebrides January 9, 1932. T.A.J.

KILAUEA REPORT No. 1047

WEEK ENDING FEBRUARY 14, 1932

Section of Volcanology, U. S. Geological Survey

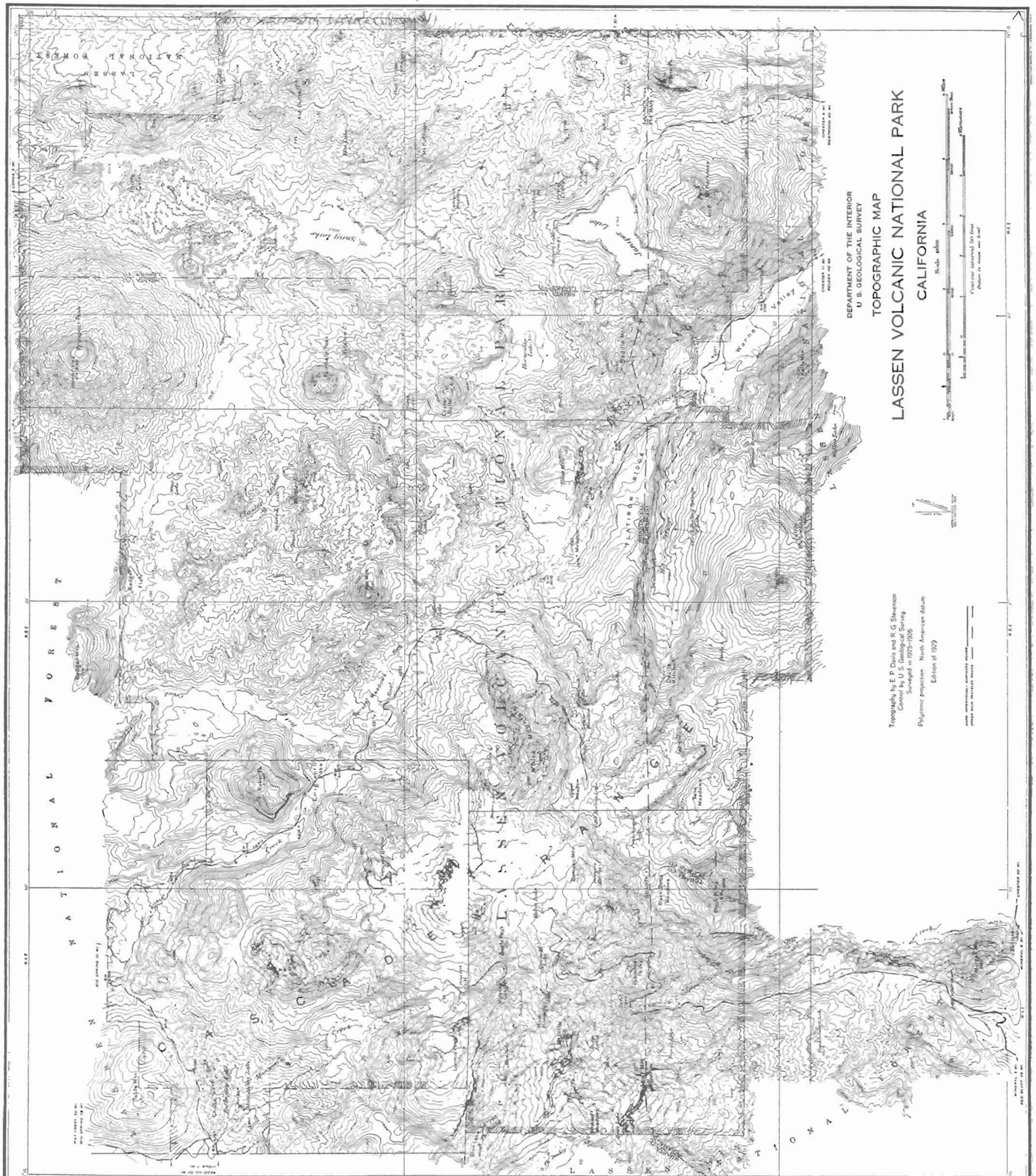
T. A. Jaggar, Volcanologist in Charge.

On February 8 fume was noticed at a spot under the west wall of Halemaumau and in a spot in the center of the pit. A small slide fell from the north wall at 9:46 a. m., and rocks fell intermittently. Cracks measured showed slight widening, especially on the northeast rim. On February 12 afternoon a new spot was found fuming in puffs at the west end of the southwest talus on the edge of the talus and floor. Sulphur has been forming there. Moderate fume was noted at the spot under the west wall, and slight fume was issuing from the center of the floor. At 4:10 p. m. a roar of an avalanche was heard at Uwekahuna. Its debris fell from the wall above the southwest bay and appears to be the largest since the recent lava activity. On February 14 there was no change in fuming. At 10:20 a. m. a large avalanche was heard from Uwekahuna by Park rangers. Dust obscured part of one side of the pit.

The seismographs at the Observatory recorded 23 tremors and 3 very feeble local seisms. One of the tremors originated at 14 miles distance, two of the seisms 18 miles, and one seism 14 miles. Two of the latter class were reported felt at Kapapala.

Microseismic motion was moderate throughout the week. The average tilt movement was slight SE.

Edge of glassy lava flow on the west side of Glass Mountain October 19, 1931. These obsidian flows are 80 miles north of Lassen and the rocks are being studied by Dr. C. A. Anderson. Photo from Finch.



Map of Lassen Volcanic National Park, U. S. Geological Survey. Lassen Peak is in the center of the western half with name erased.

THE VOLCANO LETTER

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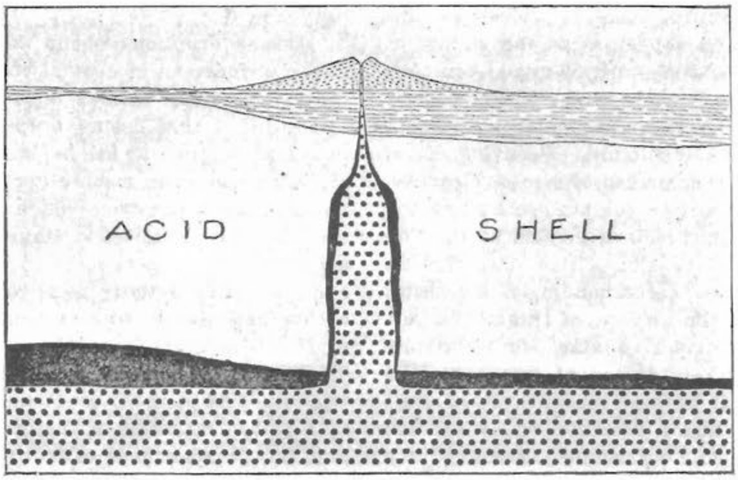
No. 374—Weekly | Hawaiian Volcano Observatory, National Park, Hawaii | February 25, 1932



Diagramatic section through the earth's crust showing sediments under a volcano, supposed siliceous continental shell, black solidified layer of basalt, and dotted liquid basalt of the substratum extending up into the fissure leading to the volcano. The cone is represented as 5,000 meters high. After Daly.

TYRRELL'S BOOK ON VOLCANOES

Dr. G. W. Tyrrell, lecturer in geology in the University of Glasgow, has recently produced a very readable book entitled, "Volcanoes." (No. 152 in the Home University Library, 1931, Thornton Butterworth, Ltd., London.) This is a small book of 252 pages divided into eight chapters and a bibliography. The introductory chapter describes the general facts about volcanoes. The following is an interesting paragraph:

"The most feasible method of harnessing volcanic energy in the service of man is by utilizing steam jets and hot springs. In Iceland hot springs are used by housewives for cooking and laundry purposes. A beginning has been made in that country on a project for supplying Reykjavik and other towns with a hot water supply from boiling springs. In Tuscany, natural steam power has been used for three-quarters of a century. Over an area of 100 square miles are numerous hot springs and steam jets, which yield boric acid. These natural springs and fumaroles have been largely extended and changed by industrial development. Shallow wells have been bored to tap the steam, which in one of the borings is yielded at the rate of 52,800 lb. per hour at a pressure of one atmosphere (14.7 lb. per square inch), or 28,600 lb. of steam per hour at a pressure of five atmospheres. The steam is often superheated, as its temperature varies between 100° C. and 190° C. A deep boring has now (1928) tapped steam at a pressure of 75 lb. per square inch, which can be directly used to drive turbines. Calculations based on the total production of boric acid in relation to steam, indicates that several million pounds of steam per day are now available in this field.

"Of a somewhat similar nature is the steam-well field which is now being exploited at The Geysers in California. Observations and tests prove that at this locality there is a great store of hot steam, which increases with depth. The first well was drilled in September 1922, and steam from this well furnished the power for boring the second well which was completed in July 1923. From all indications the steam both in Tuscany and California is of deep-seated origin and of practically inexhaustible quantity."

In discussing cycles, Dr. Tyrrell is impressed with the longer geological cycle, as is natural in the viewpoint of a geologist, and he makes the following statement concerning the phases of a long-term cycle:

"If volcanic manifestations are considered in relation to geological time they are found to fall into definite cycles. These cycles seem to have begun with vast floods of basalt lava, with which are usually associated swarms of dikes, and, in proportion to the bulk of lava erupted, were accompanied by an insignificant amount of explosive activity resulting in fragmental products. These enormous lava floods are therefore believed to have been emitted from fissures, and to have rushed up directly from the superheated liquid stratum which at times is formed immediately beneath the crust.

"As the cycle progresses the volcanic activity becomes localized at definite points, which develop into central volcanoes. Lava is still poured out in great bulk, and central volcanoes in this early stage build up enormous flat domes consisting mainly of basalt. At the present day these shield volcanoes occur in Hawaii and Samoa, and also in Iceland. In the earlier stages of the present volcanic cycle, the flows from adjacent shield volcanoes linked up to form great spreads of lava only inferior in size to those from fissures.

"With the waning of the volcanic cycle, the direct uprise of magma from the depths is checked. It collects in underground chambers, and its contained gases now come into full play in determining the kind of volcanic activity at any center. Hence the volcanoes typical of this stage of the cycle are those in which explosive activity takes a prominent part. The resulting central volcanoes are naturally smaller than shield volcanoes as the supply of magma is now limited. The cones are of mixed composition, partly lava, partly fragmental products of volcanic explosion, and are known as **strato-volcanoes** because of their well-bedded or stratified structure. Vesuvius, Etna, and Fuji-san are well known examples of strato-volcanoes. With the progress of solidification (crystallization) in the magmatic chamber the amount of lava yielded by the volcano gradually lessens, and its composition may change, while the activity of gases correspondingly increases, resulting in an increase in the amount of fragmental material ejected. A purely explosive stage is ultimately reached; and if a new vent is drilled at this stage the resulting volcanic cone will be built up entirely of fragmental materials. Some small volcanic cones of this character (e.g. Monte Nuovo near Naples) are due to a single explosive outburst. The gases which are liberated in this late stage of the volcanic cycle consist chiefly of steam, and the explosions may be of such violence as partly to destroy the cone built up in earlier stages, (Katmai, Alaska; Bandaisan, Japan.)

"As the explosive activity gradually dies away, the final stage of the volcanic cycle is reached with the relatively quiet discharge of steam and other gases from jets or fumaroles (Tuscany, Iceland, California, New Zealand), associated with erupting springs or geysers, boiling or hot springs, and the emanation of carbon dioxide and sulphuretted hydrogen from fissures."

The second chapter deals with the products of volcanism, gaseous, liquid and solid. In this the author follows the usual and regrettable geological dictum that steam is more important than hydrogen as a fundamental volcanic gas. Other chapters deal with the phenomena of volcanic eruption, the shield volcanoes of Hawaii and Iceland, strato-volcanoes such as Etna and Vesuvius, decadent volcanoes such as Katmai and Lassen Peak, the roots of volcanoes and ancient volcanoes, and finally, distribution of volcanoes and origin of igneous rocks. In this last the author follows with interest the theories of Joly and Holmes to the effect that the ultimate causes of igneous activity in general are to be traced to the known facts of storage of heat through the radioactivity of the rocks.

A reading of the book shows that the author has studied carefully some up-to-date volumes on volcanic eruptions such as Perret on Vesuvius, Griggs on Katmai, and Koto on Sakurajima, that he is influenced by the time-honored but trite work of Judd on Krakatoa; and is perhaps without access to the remarkable series of modern monographs of the Dutch East Indies Volcanologic Service; that he is thoroughly acquainted with the work of the petrographers on ancient volcanoes and on the rocks collected from fossil intrusive bodies, but that he is insufficiently acquainted with the seismometric side of the subject as expounded in the big volumes by Omori on Asama, Usu, Oshima, and Sakurajima. The geodetic and engineering side of volcanology is hardly touched. The notion that intrusive volcanism is in progress today, and may be measurable in hot spring districts, does not appear in the book, but there is ample recognition that the study of volcanoes has entered upon a new phase with the establishment of volcanological observatories. The scholarship of the modern German and Italian workers, as recorded in Friedlaender's Zeitschrift and in Sapper's book, is not much quoted. The style is excellent and the author is at his best in the chapter on "The Roots of the Volcanoes." The following is a sample:

"Fissure eruptions occur at the present day only as minor phenomena of central volcanoes, especially those of the shield type. Various lines of evidence, however, lead to the belief that fissure eruptions played a leading part in volcanic action at the beginning of the present volcanic cycle, and in more remote geological periods." (This appears to mean the cycle which has become decadent since the Miocene.) "Basaltic lavas have been poured out on a colossal scale, accompanied by only the most insignificant explosive activity relatively to the effusive mode of action, and usually with swarms of associated dikes, some of which must be regarded as the feeders of the flows. There are no signs of volcanic cones at all commensurable with the size of these eruptions. These stupendous floods of basalt cover areas of the order of 200,000 square miles, and may be thousands of feet thick. Naturally, accumulations of relatively hard rocks such as basalt are extremely durable, and remain in and on the earth's crust as witnesses to volcanic events the magnitude of which has not been approached at the present time.

"The youngest basalt flood is that of the Columbia Plateau in the northwestern United States, which occupies an area of over 200,000 square miles mostly in Washington and Oregon. The Columbia region was formerly mountainous, but in Miocene times it was levelled up by enormous floods of basalt lava, and the former mountains now appear as islands and peninsulas projecting from a monotonous plain of lava. The Columbia and Snake rivers (see Page Four) have cut deep gorges through the plain which expose in places almost the entire thickness of the formation. The plateau is built of a large number of thin, confluent, interlocking flows, between which occur slaggy surfaces, thin sheets of ash, and beds of lacustrine sediments. The supposed feeding dikes are numerous and narrow, seldom reaching 150 feet, and averaging less than 30 feet in width. Igneous activity has continued almost to the present day, especially in Oregon and Idaho, with the production of youthful-looking cones and craters, and fresh, slaggy, lava flows. The average thickness of the plateau is estimated at 3300 feet, and it is known to reach a maximum thickness of at least 5200 feet. Hence the total volume of lava emitted must be of the order of 120,000 cubic miles. Great basaltic plateaux of about the same age as the Columbia plateau occur in Syria and Arabia.

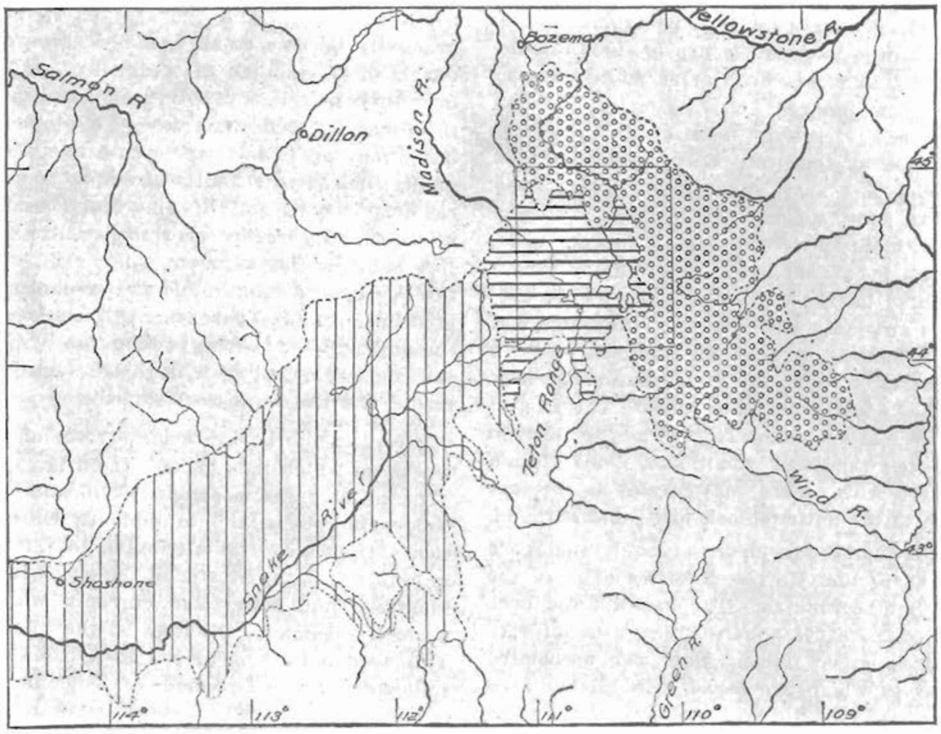
"Another enormous basalt flood is that of the Deccan in Peninsular India, which occupies an area of 250,000 square miles. As this formation is nearly 10,000 feet thick on the Bombay coast, and thins out toward the east and north, it is thought to have had an equally large extension in the adjacent foundered parts of the Indian Ocean. Its total area may therefore have been 500,000 square miles . . . . in one place a boring encountered 29 distinct flows with an average thickness of 40 feet. Large dikes and other intrusive masses are found at a number of places around the margins of the basalt region The eruption appears to have taken place towards the end of the Cretaceous period, or at the beginning of the succeeding Eocene."

"The Stormberg basalt lavas of South Africa, which occupy an area of 20,000 square miles in Basutoland alone, and there form the great mountain scarp of the Drakensberg, are regarded by Dr. A. L. du Toit as mainly due to fissure eruptions. One hundred and fifty volcanic vents have indeed been found, and many more await discovery; but the greater number of these are filled with pulverized sedimentary material, and have never emitted lava; and the remaining active centers pierce the lowermost basalts only. The average thickness of the plateau appears to be about 3,000 feet, and individual flows are from 100 to 150 feet thick. Correlated basalt extrusions make up the 300-mile-long Lebombo range in the eastern Transvaal, and also a large area of country around the Victoria Falls in Rhodesia. The extrusion of these great masses of lava probably took place in early Jurassic times. The Stormberg lavas are intimately connected with the Karroo dolerite sills; and the relatively small lava fields of this episode, as compared with others, may be due to the fact that a greater part of the activity took place underground.

"In recent years it has become clear that exact analogues to the Stormberg lavas and Karroo dolerites exist in the Parana region of South America. The basalt flows here cover an area of over 300,000 square miles with an estimated bulk of 50,000 cubic miles. They are associated with intrusive masses which are found in a further area of 75,000 square miles. Basaltic lava plateaux of the same age as those of South Africa and South America (mid-Mesozoic) are known also in Tasmania, Antarctica, Peninsular India, and in the eastern United States."

With regard to major cycles in Europe and Asia, Dr. Tyrrell points out that crustal movement (page 228) has worked up to at least four great climaxes during known geological time, and that in the intervals minor disturbances have occurred. The geological cycle begins with the comparatively-sudden emergence of continental land masses, which rapidly become broad and high, with the simultaneous production, especially near their margins, of long ranges of fold-mountains in which the rocks are intensely compressed. The oceans at this stage are relatively small and deep. Igneous and earthquake activity is at a maximum, and on the continents there is extensive glaciation and desert formation. Climatic conditions are thus severe and extreme. At the present day the earth appears to have not long emerged from one such phase of the geological cycle. This revolutionary stage is followed by a protracted period of relative quiet, both as regards earth movement and igneous activity. The continents gradually become small and low owing to the combined effects of erosion and the gradual advance of shallow seas over their margins. The general quiescence is occasionally broken by local disturbances during which igneous activity may again become prominent. Earth movement is finally limited to a gentle up and-down heaving over wide regions, igneous activity dies away completely, and climatic equability ensues over the greater part of the earth. But beneath the apparent quiet the revolutionary earth forces gather strength, and the geological cycle is terminated by a renewed paroxysm of mountain-making and continental uplift. . . . The explanation of igneous activity is thus closely bound up with the explanation of earth movements and the geological cycle."

Errors in the book are largely copied from the original works on which it is based. If on page 55 the statement, "Torrential rains accompany volcanic eruption," means condensing steam, this is dubious. On page 60 the formation of Pele's hair is attributed to "strong winds," when in reality it is the bluster of the gases rushing through the fountains and convection currents which may occur in perfectly still air. On page 93 the "Death Gulch" of the Yellowstone Park is placed in Arizona. On page 67 and following, the discussion of volcanic earthquakes attributed to "explosive subterranean release of magmatic gases" is quite erroneous and inadequate. There is the usual erroneous distinction from tectonic earthquakes, without explanation or discussion of depth or mention of isostasy. The statement on page 84, "Hawaiian explosive activity is of a mild type, caused by the rapid emission of gases from the surface of a lava lake," certainly needs modification if the steam blast activity of 1924 is "explosive." On page 87 Pelèe and Soufriére are stated to be characterized by the "intermittent ejection of white-hot clouds composed of an emulsion of glowing gas and solid particles, which, instead of rising into the air were projected downwarls." These were exceptional and not charactistic, and the downward-directed cloud in the major explosion in each case was but one component, most of the clouds being directed vertically, and in no case being "white-hot." Down-rushing blasts are common elsewhere. The belief of Penck quoted on page 109 that the 1789 eruption of Kilauea "marked the inception of the volcano" might well have been omitted. T.A.J. and R.H.F.



Region of eastern part of the great Snake River basalt fields as related to the early Tertiary rhyolites (horizontal lines) and andesites (circles) of the Yellowstone Park, itself a place of boiling springs and Tertiary volcanoes. After Daly.

KILAUEA REPORT No. 1048

WEEK ENDING FEBRUARY 21. 1932

Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge.

On February 15 at 9:30 a. m. the slide of the previous day was found to have fallen from the north wall between the north and northwest taluses, causing a fresh scar on the wall and a mound of new debris on the floor. Debris added at 1:20 p. m. February 16, from the same place, built the mound to from 50 to 100 feet high. Fume was strongish at the foot of the southwest talus and under the west wall. The northeast rim cracks continued slight widening. A small scar formed during the night of the 15th from a slide at a point just west of the top of the northwest talus. Fume was quite strong from a spot at the foot of the southwest talus and came from two points about 50 feet apart. Rocks and small slides were heard falling from the north walls more or less continuously about every five minutes from 2 to 4 p. m. On February 17 the district was visited by a southwesterly rain and wind storm which caused some water to enter the seismograph cellar at Halemaumau. The pit during the forenoon was a huge cauldron of steam. Sulphurous fume was blown over the tourist stand. Keanakakoi had seven waterfalls. A lake a thousand feet long and two to three hundred feet wide formed on the southwest Kilauea floor. A little hail fell during the storm, and there was thunder and lightning near. Many trees were uprooted and a garage was blown over.

On February 21 at 10 a. m. the pit had blue fume. The north wall showed a fresh scar from an avalanche and few rocks were heard falling.

The seismographs at the Observatory recorded 11 tremors and two very feeble local seisms. One of the tremors indicated origin distance 25 miles and another about four miles. The two seisms indicated distances of 9 and 32 miles. None was reported felt. High winds during the week caused unusually strong microseismic motion, the Kona storm of the 17th being responsible for vibrations of four seconds' period. The average tilt movement for the week was moderate SW by W.

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HAWAIIAN VOLCANO OBSERVATORY
Founded 1911

This laboratory at Kilauea Volcano belongs to the Hawaiian Volcano Research Association and is leased and operated by the United States Geological Survey.

It maintains seismographs at three places near Kilauea Volcano, also at Hilo, and at Kealakekua in Kona District. It keeps a journal of Hawaiian volcanic activity and publishes occasional Bulletins.

Membership in the Hawaiian Volcano Research Association is limited to patrons of Pacific science who desire personally to aid in supporting the work.

The work of volcano research so supported is in collaboration with the work of the United States Geological Survey, but supplements it with buildings, research fellows, instrumental plants, explorations and special investigations for which there is no governmental provision. The Geological Survey maintains volcano stations in Alaska, California and Hawaii.

Persons desiring application blanks for membership ($5.00 or more) should address the Secretary, Hawaiian Volcano Research Association, 320 James Campbell Building, Honolulu, T. H.

The Volcano Letter

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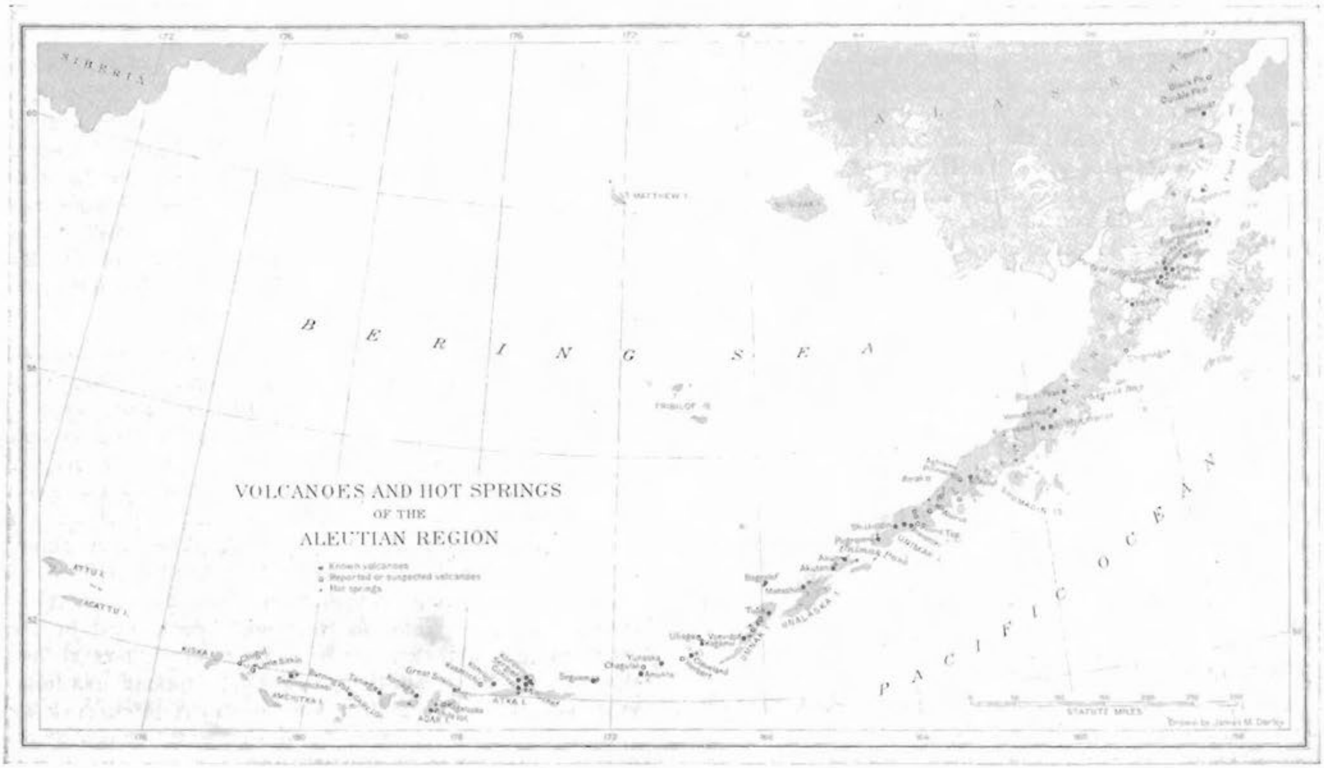


Map of volcanoes and hot springs of the Aleutian region, scale 216 miles to the inch. After Griggs, National Geographic Society, 1922. Black Peak is mislocated at Purple Crater, and Aniakchak is northeast of it.

ALEUTIAN ERUPTIONS 1930-32

Notes on activities in the Aleutian Islands and in the volcanoes on the Alaskan Peninsula were published in Volcano Letter Nos. 246 and 357. The year 1931 appears to have brought to a focus the unrest which appeared in several volcanoes in 1929 and 1930 by producing a considerable explosive eruption from Aniakchak Crater on the Peninsula 45 miles NNE from Chignik. But activity of one sort or another appears to be always present in the restless magma which underlies 1700 miles of arched and faulted Tertiary strata from Mount Spurr to Attu, and if one could picture the ridge in its entirety at any one time, some puffing gas would probably be seen.

Our reports have indicated that Akutan was smoking in 1928 and its lower slopes were covered with ash June 18, 1929. "A mountain to the west of Kanatak" was reported fuming in March 1929, and this description might apply to Chiginagak Volcano on the Peninsula east of Aniakchak. Mount Cleveland and a volcano west of it in the Islands of the Four Mountains were fuming in March 1929 and volcanoes of the Katmai group continued fuming. Shishaldin on Unimak Island was "flaming high" May 28, 1929, and glowing matter overwelled the edge of the crater and rolled down the slopes; it was reported fiery again June 23, 1929, opening three new craters low on the north side. Gareloi in the western Aleutians was said to erupt so violently in 1930 as to change its appearance by lava flows from fissures. To a volcanologist the imperfection of these accounts is their chief baffling characteristic, but the observations of mariners confirm the notion of continuous activity somewhere.

We now come to 1931, when on May 1 Aniakchak erupted, on May 20 Pavlof farther west on the Peninsula made explosions and glow and ashfall, two other volcanoes on the Peninsula were reported fuming, ash from Aniakchak fell a great distance away, and on May 30 a severe earthquake was felt in Attu at the extreme western end of the Aleutian chain.

Our observer at Dutch Harbor, Mrs. Wendhab, reports that Captain Nelson of the Alaska Commercial Company ship "Eunice" passed Tulik Volcano on the east end of Umnak Island March 21, 1931, and its crater was sending up thick black smoke where he has observed only white steam heretofore. He thought its action very unusual and indicative of a coming greater eruption. On March 29 two earthquake shocks of unusual intensity were felt at Dutch Harbor (east end Unalaska). On May 13, 1391, the Umnak eruption was reported by Captain Nelson to be "the volcano on the east end of Umnak Island, fourth peak northwest from Tulik Mountain, pouring out black smoke and heavy clouds of steam," a place that has been dormant until recently. A singular note by Mrs. Wendhab at this time states that Mount Makushin Volcano in the northwest part of Unalaska Island, which has been very active, is now ominously quiet, causing worry." Makushin is usually a crater of quiet steam depositing sulphur. The eruptions of Shishaldin, Pavlof, and Aniakchak are reported by the radio operator at Squaw Harbor on Unga Island in the Shumagin group south of the Alaskan Peninsula to produce a particularly vicious type of static, interfering with radio communication over a wide area.

While not connected with volcanic happenings, it may be of interest to the meteorologists to know that Attu experienced September 30-October 2, 1930, a terrific northwesterly gale for three days, with barometer at 26.40 inches. Two native sod houses and Government buildings were demolished. A still stronger gale in January 1931 was the worst in the history of Attu Island, according to the natives, and drove seas into Chichagof village.

Captain Nelson saw fire issuing from Bogoslof October 31, 1931, and found qauntities of pumice near Umnak Island south of it. This observer believed Bogoslof to be continually smoking, according to his experience, but the "fire" was unusual.

The Eruption of Aniakchak

Aniakchak Crater is one of a chain of remarkable volcanoes spaced out rather evenly about 40 miles apart in the Alaskan Peninsula between Port Heiden on the north and Chignik Bay on the south. Beginning at the southwest end of the series west of Chignik and going northeast, these are Veniaminof (8400 feet), Purple Crater (3020 feet), Aniakchak (4200 feet), Chiginagak (7020 feet), and Mount Peulik (4080 feet). Veniaminof and Chiginagak are covered with glaciers. Aniakchak Crater was mapped by Sargent, described first by W. R. Smith (Professional Paper 132 U. S. Geological Survey, 1925), and mapped geologically by R. S. Knappen (Bulletin 797-F U. S. Geological Survey, 1929). Knappen's colored map is copied in half-tone herewith and shows the even spacing of Veniaminof, Purple Crater, and Aniakchak, and the vast size of the crater bowls, as well as their circularity. Aniakchak Crater has a maximum diameter of six and three-quarter miles, the lowest part of the crater floor is 1100 feet above sea level and contains Surprise Lake, two square miles in area. The walls rise almost vertically 1200 feet to 3000 feet above the bottom of the crater. A large truncated cinder cone rising 2200 feet above Surprise Lake occupies the south central part of the crater floor. Aniakchak River breaks through the east side of the rim of the great crater in a picturesque canyon named "The Gates." The area of the bottom of the crater is 30 square miles. Upper Jurassic sedimentary rocks with fossils occur in the canyon and also quartz diorite, overlaid by layers of lava and agglomerate, while all the valleys of the surrounding country are covered by thick deposits of ash, pumice, and agglomerate. Much of the lava is obsidian.

In the National Georgaphic Magazine for September 1931, Father B. R. Hubbard presents a wonderful series of pictures of the Aniakchak and Veniaminof country made from photographs taken during an exploration in the summer of 1930. Among the most remarkable of these is a picture of curving colunar structure in obsidian, and another of a subordinate crater of crescent shape in the northwestern part of the larger bowl containing an inner cinder cone from which about eight festooned dark-red basaltic lava flows radiated. The festoons were crevassed in concentric arcs. This secondary crater was investigated and hot fumaroles were found, some of which followed a fissure up the sides of a cliff and yielded steam hot enough for cooking. There were multicolored crystals and incrustations surrounding the vents, and solfataric odors of volcanic gases were perceptible. Near Surprise Lake on the west side there is a warm soda and iron bicarbonate spring, and this stains much of the lake shore with orange color. The presence of the warm springs and the hot solfataras indicated that Aniakchak was not dead but sleeping.

Explorations by Father Hubbard in the summer of 1931 (Saturday Evening Post January 2 and 16, 1932) discovered that an observer at Meshik, 20 miles west of Aniakchak, on May 1, 1931, at 10 a. m., saw a dense column of steam shooting up from the volcano. This rose for two hours in billowing clouds, followed by a big blast at noon. A dense black cloud rose over 20,000 feet, spread out like a mushroom, and started to descend. The earth shook, and there was a fiery display of lava bombs making trajectories. Lightning and thunder were added to incessant detonations from the volcano, accompanied by the crash of falling rocks. Then came light cinders at first the size of peas and then larger. Eruptions continued until May 11, when a final blast made it pitch dark for several hours at distances 60 miles away. There was a field of floating pumice with individual blocks 9 or 10 inches across in individual patches five miles in diameter on Bristol Bay, north of the volcano. Dense clouds of gas and smoke continued to rise, and another major eruption May 20 made detonations heard 200 miles away. For several days more the Ugashik cannery, 53 miles NNE from Aniakchak, reported rumbling like distant surf.

At Chignik the fall of ash was reported a pound per hour for each square foot 45 miles SSW from the source. At Ugashik the ashfall was heavier, and in the country between Kodiak and the head of Bristol Bay a mantle of ash a quarter inch deep was formed. Light ash fell in the interior of Alaska at distance of 300 miles. There was much loss of life among wild animals. There were many showers of pisolitic mud balls, and the neighboring snow-covered country and the glaciers were buried under a gray pall.

When the volcano was visited at the end of May, there were clouds of blowing dust and many dust whirlwinds. Everything was covered with ash. The vegetation was gone. Black cinders became coarser at the crater. The water of all streams was muddy. The central inner cone had a crack in its side and gas clouds rising on top. Surprise Lake was choked and muddy. The explosion vent had formed a new crater under the northwest rim, whence rose yellow and brown gas and clouds of steam. A new lava dome was being pushed up above the crater floor, showing large, tumbled blocks. This was like Novarupta at Katmai. Beside the dome was a deep pit. Hydrogen sulphide was strong. Occasional puffs of brown smoke rose with a rumble from the new vent. The interior of this vent was found to be highly colored with yellow, red, and brown stains, and several pits more than a mile in circumference had formed in the crater floor. Quantities of vapor rose from the new lava dome. The ground was very hot near the vent, more than 200° C., and there were green deposits and signs of hydrochloric acid. There were many impact craters made by falling bowlders. The lava dome lay in the center of a depression three miles in circumference. The lava moved somewhat, there were falls of blocks, and there was much sulphur. In an airplane flight, Hubbard noted that Veniaminof Volcano, with its great circle of glaciers, which he had seen the year before snowy white, was completely mantled with dark colored ash. It may be noted in passing that Hubbard reported in his National Geographic article that an ascent to the edge of Veniaminof Crater was made from the north side, and that this crater, which is known to the natives as Black Peak, and is full of ice, was smoking in unusual fashion in the summer of 1930. The source of this smoke was found to be a cone in the center of the ice, "smoking on two sides of its upbuilt rim from slag heaps of lava, and now and then coughing out black ashes over the surrounding white snow." The ice had impressive chasms where the heat had melted the glacier. There were layers of black volcanic ash and sand a few feet thick alternating with glacial ice more than 20 feet thick. Hubbard suggested that some time-scale of Veniaminof's eruptions might be interpreted from such exposures.

On May 2, 1931, the radio operator at Kanatak, 90 miles NE of Aniakchak, reported ashfall there. On May 13 the ash from Aniakchak was more than a half inch deep and very black, falling continuously at Squaw Harbor in Unga, approximately 140 miles SW of Aniakchak. The Katmai group of volcanoes was reported to be active at this time. The Aniakchak ash that fell at a great distance was fine as flour. On May 12 a freighter at sea off the Aleutian Islands received a fall of sand during a storm (locality not given).

Later Eruptions

Captain Nelson of the "Eunice" brought word on January 18, 1932, that Mount Cleveland on Chuginadak Island, a peak 8156 feet high, approximately 150 English miles west of Dutch Harbor, had again broken into eruption, starting about January 1, 1932. It was reported to him that seven great puffs had occurred in one hour, the volcano sending up very dense smoke. Generally only a little steam had been seen at the crater during previous visits. He passes these Islands of the Four Mountains three or four times a year in his trading trips for the Alaska Commercial Company. He was suprised to see such dense volumes of black fume when he passed the island in early January, the sky being continuously darkened.

On February 10, 1932, a radio from John Gardner in False Pass informed me that Shishaldin erupted February 1, 1932, the outbreak lasting for several days with glowing material flowing down the mountain. A newspaper dispatch of February 4 called this eruption the "most violent and spectacular seen in the past century" for this volcano. The report from Squaw Harbor described "streams of lava flowing down the sides," but this glowing material is quite as likely to be trains of red-hot bowlders for these Aleutian cones. A strong wind carried the ashes many miles northward over the Bering Sea. A dispatch of February 16 said that Shishaldin had again renewed its activity with boomings coming from the creater at two-minute intervals, the volcano hurling hot rocks thousands of feet into the air.

The general map of the Aleutian belt reproduced herewith shows the distribution of volcanoes as compiled by Griggs (Valley of Ten Thousand Smokes, by Robert F. Griggs, National Geographic Society, 1922, page 60). This will give some idea of the great number of active cones along this curved line, and the geological map by Knappen shows how characteristic are the big volcanic heaps lying in a line adjacent to the coastal plain of Bering Sea on the northern side of the Aleutian ridge. This arrangement extends far to the west in the islands, where, for examples, in both Unalaska and Atka the north half of the island is volcanic and the southern half consists of older rocks. Here in the Aniakchak region the belt of mountains southeast of the volcanoes reaches heights rarely exceeding 3000 feet and consists of gently folded Jurassic and Tertiary rocks, which contain fossil plants and shells, and are overlaid by old volcanic rocks which probably date from the Miocene. The slope under the Pacific to the south reaches abysmal depths, the slope to the north, from Unalaska eastward, is very flat to a shallow sea. The line of volcanoes apparently represents a tension crack at the edge of this shallow fill of Bering Sea, through the folded strata, and following in plan a singularly perfect curve for several hundred miles. To the south of the region here considered there is a trough under the ocean parallel with the Pacific shore more than 20,000 feet deep.

T.A.J.

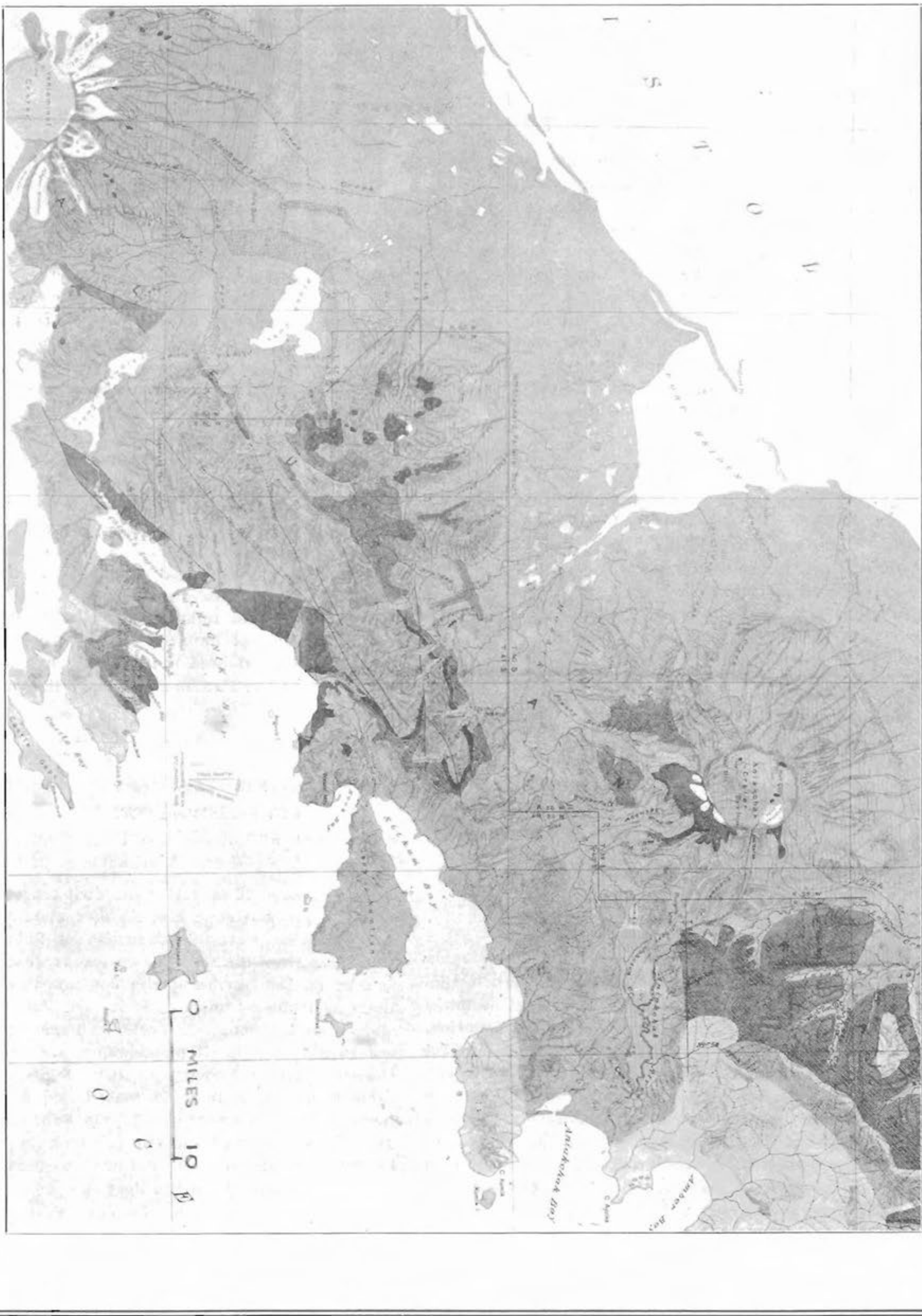
KILAUEA REPORT No. 1049

WEEK ENDING FEBRUARY 28, 1932

Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge.

On February 22 at 9:15 a. m. dust from a slide at Halemaumau pit was seen and another slide was reported at the northeast wall the afternoon of February 21. Blue fume rose from the floor at two places west and southwest. Cracks on the northeast rim continued widening, one of them as much as one-half inch. On February 23 a small slide from the rim at the north wall occurred at 9:55 a. m., cracks SW showed slight widening, and cracks NE and N showed slight to strong widening. February 24 at 9 a. m. fume appeared to have increased and a new crack was found back of the north wall. On February 26 crack No. 31 NE had widened one-qaurter inch in four days. On February 28 after much rain, fume was pronounced SW and much steam rose from the floor.

At the Observatory instruments 45 tremors were recorded, one of them indicating distance exceeding 14 miles. Of nine very feeble shocks, three indicated origin distance 2 miles, two 3 miles, three 4 miles, and one 9 miles. Two feeble shocks of the felt class occurred. One of these February 23 at 1:30 a. m. indicated origin distance 2 miles. One during the noon hour February 26 indicated origin distance only 1 mile. Microseisms caused by windy weather were strong except on February 24 and 28, when they were moderate. Tilting of the ground was moderate SW.



Geological map of Aniakchak district copied from a colored sheet. Geology by R. S. Knappen (Bulletin 797-F, U. S. G. S.), topography by R. H. Sargent. Scale 11 miles to the inch. The three circular areas at the northwest are the volcanoes Aniakchak, Purple Crater, and Veniaminof. Surveyed in 1922-23. The faulted belt at the south and the dark area northeast are Jurassic to Tertiary sediments.

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Crater in ice of Makushin Volcano, Unalaska Island, photographed in 1907, and resembling the snow crater on Mount Baker described by Rusk in 1903. Photo Jaggar.

NOTES ON VOLCANOES OF THE CASCADE RANGE

For purposes of the volcanologist, every bit of information concerning craters or heat on mountains known to be volcanoes is of value. In Volcano Letter No. 363 there was published a review with maps concerning some of our northwestern volcanoes other than Lassen Peak. In "Tales of a Western Mountaineer" (Houghton Mifflin 1924) Mr. C. E. Rusk publishes notes made during mountain climbs on some of these volcanoes which are unusual and worthy of quotation.

The crater of Mount Baker or Kulshan is illustrated by a photograph taken about 1900 by the party of John A. Lee. This shows a circular crater opened through snow and ice, with fume rising, and with crevasses extending up a smooth nevé above it. In 1903 Rusk climbed the east side of the main peak of Mount Baker accompanied by George G. Cantwell. They went to Morovits Ranch, and camped at the timber line. The whole east side of the mountain is forbidding and covered with snow and ice. There are two peaks of which the southern is the lower. When well up the slope, on glancing upward, they saw large volumes of smoke rolling from between the two peaks. When they reached the top, it appeared that for several hours the smoke from the crater had been hidden from them by the south shoulder of the main peak. As they emerged from the chimney there burst into view a most thrillingly weird spectacle.

In a bowl-like depression immediately between the two peaks of Mount Baker there was a great orifice in the snow, perhaps 50 feet across. The west side was partly blocked with snow so that the opening was somewhat half-moon shaped. Two hundred feet away a semicircular crevasse swept halfway around the pit. Up from the unknown depths of this abyss black fume boiled out. It drifted away, guided by the shifts in the wind currents, until it dissolved in the upper air. Mr. Rusk speaks of the wild, unearthly loneliness of the scene, which "impressed us profoundly, for its counterpart perhaps does not exist on earth."

This description is astonishingly like that of the ice crater containing sulphur on the summit of Makushin Volcano in Unalaska (Page One). This was photographed and described by the reviewer, and the picture published, in 1908 (Technology Review, Boston, Vol. X, No. 1, Journal of the Technology Expedition to the Aleutian Islands 1907, by T. A. Jaggar, pp. 11-12). "The rim of the greater crater of Makushin was finally reached at 12:45 July 3, 1907. Within was an expanse of snow, probably two miles in diameter, through which three or four steaming vents have maintained openings. We saw a steaming cavity ahead to the right. Examination proved this to be a new crater opening, a vertical cavity in the snow, 75 feet in diameter, with a 300-foot wall of bedded ice and snow behind it and sulphurous steam incessantly rising through it. A great tumble of snow or ice blocks rested in front of it, and, where the steam drifted across these, their white surfaces were yellowed with sulphur. An inner cone of bowlders and sand was seen beyond this pit and south of it. This was visited and found to contain a crater some 2,000 feet in diameter, with very active solfataras working on its northern side, and sulphurous coatings about the vents.'

Rusk's climb was 11 hours from the timber line to the top of Mount Baker, and was presumably early in the season of 1903. When photographed in August 1906 by F. H. Kiser, the crater gave no sign of snow orifice, nor of smoke. There was only a slight depression in the snow and the remnant of a crevasse. Professor George Davidson saw Mount Baker in very active eruption in the early fifties.

Mount Rainier or Tacoma Volcano is described by Rusk as having a great crater from a quarter to a half mile in diameter inclosed by bare cliffs 30 or 40 feet high. The bottom is filled with snow which makes of the interior a comparatively level field. Around the rim are many small vents in the rock, from which jets of steam issue. In places, and at times, this steam melts the snow, leaving cavern-like fissures between the snow and the wall of the crater. The highest point of Mount Rainier is a dome of snow just west of the crater. Mr. Rusk writes: "I crossed the crater alone. On the farther side I was surprised to find lichens clinging to the bare rock surface. I found a jet of steam issuing from a small hole in the sloping face of the rock. I stooped to see if I could detect any odor coming from the place and received a little steam-scald for my pains. The rocks were quite warm, and I have no doubt one could place a frying pan over some of these orifices and there do considerable elementary cooking. I scrambled out of the crater and a short, easy climb brought me to Columbia's Crest, the actual summit."

Glacier Peak is a volcano 10,400 feet high, easy to climb, and Mr. Rusk reached the summit at 11 a. m. The old crater is directly on top, from one-quarter to one-half mile in diameter, broken down in many places, leaving craggy pinnacles around the circumference. One of these on the southern edge is the summit. The crater is filled by a big snow field. On the east the snow feeds into a great ice-fall, the chief branch of Cool Glacier. This peak was climbed by I. C. Russell, and is not described as steaming.

In the case of Mount Hood, the only mention of heat by Mr. Rusk is described from the summit, when, looking far below, near Crater Rock, he saw big jets of steam rising into the air and drifting upward to mingle with the fleecy clouds that were idling across the face of the peak.

During the exploration of Mount Adams, Rusk mentions on the north side a dry stream course that produced a glacial torrent. This started running in the middle of the afternoon, kept flowing part of the night, and was dry the next morning as a daily occurrence which is not explained. This is a part of the Klickitat drainage.

Going up Mount Adams by the southern way, Rusk's party found thousands of dead grasshoppers on a snow-filled saddle south of the first summit. There were also other insects as well as a humming-bird and a duck, each occupying its own little depression in the snow. Rusk states on different occassions, while climbing Mount Adams, he had found numbers of such birds and insects; and once his party found a dead mouse at an elevation of nearly 12,000 feet. One often finds live spiders crawling over the snow at high altitudes, and sometimes, but not often, live butterflies and other insects are seen. Rusk believes that the dead organisms are accounted for by gales of wind, or else during high flights these creatures are blinded by snow, when they fall bewildered and chill to death. It is an interesting question whether there could be any volcanic carbon dioxide or other gas to asphyxiate the insects.

From the pictures reproduced, the Klickitat Glacier must occupy the former crater of Mount Adams, between the summit and the Ridge of Wonders. Professor H. F. Reid, who has climbed among these volcanoes, expressed the opinion that some fused fragments of rock appeared less than 100 years old (Rusk, page 98).

The following are Mr. Rusk's comments on heat in the crater region of Mount Shasta. When he was turning down from the summit, in 1923, he writes: "I had read much of the so-called boiling sulphur spring, and when we were a short distance down the talus slope, a little to the west of where we had come up, we heard a mighty gurgling roar and saw steam rising from farther down the slope. This subterranean cataract appears to start well up the talus slope and only a little below the highest summit of the mountain. It rushes down nearly to the foot of the pinnacle and apparently turns and disappears along a depression between the main summit and another nearby peak just to the south. From the noise it makes, there must be a veritable river of it, and it is certainly forced upward through some internal chimney from a cauldron in the heart of the mountain. The whole thing would doubtless be invisible, had not visitors pricked its outer covering. The underground channel is overlaid by several inches of what seems to be a blue clay. Wherever holes have been gouged in this by the points of alpenstocks or other sharp insturments, the boiling water bubbles through, making animated little springs from which the steam floats away. We saw several of these. The loose rocks on top are so hot that it is hardly possible to hold the hand on some of them, and the whole clay surface is uncomfortably warm."

"I caught some of the boiling water in my cup and the taste was agreeable and rather sour, resembling lemonade. I drank a considerable quantity and suffered no ill effects. On the little flat just below where we sat were several rock inclosures that had been piled up for shelter by men who had spent one or more nights at this place. Even in a severe storm it is possible for a man to survive, as the heat of the rocks on the slope above the boiling spring would keep one from freezing." T.A.J.

TILTING OF THE GROUND FOR FEBRUARY

The following figures show the net amount of tilt by weeks at the Observatory on the northeast rim of Kilauea Crater, and its direction computed from the daily seismograms, by platting a curve smoothed by overlapping seven-day averages. This is the departure of the plumbline in seconds of arc, in the direction given.

February 2-8	............1.4 seconds SE
February 9-15	............1.6 seconds SW
February 16-22	............2 0 seconds SW
February 23-29	............1.8 seconds S

E.G.W.

KILAUEA REPORT No. 1050

WEEK ENDING MARCH 6, 1932

Section of Volcanology, U. S. Geological Survey

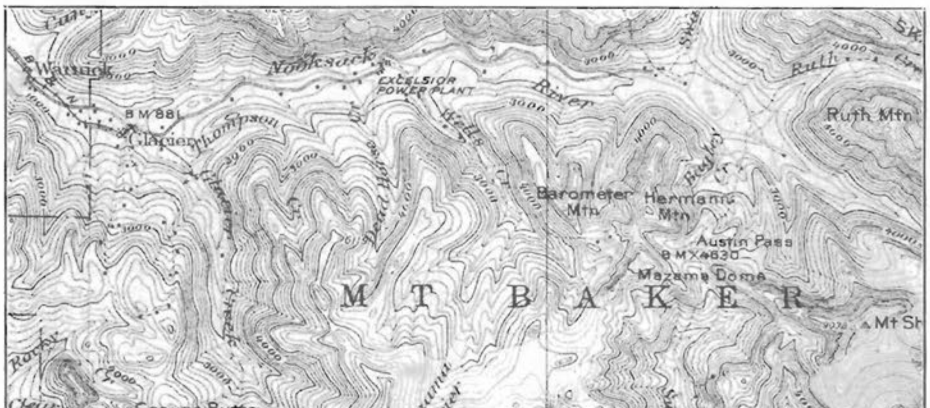
T. A. Jaggar, Volcanologist in Charge.

The widening of crack No 31 NE at the edge of Halemaumau pit has resulted in a crisis of collapse at that portion of the rim. On February 29 there was an avalanche at the northeast wall at 10:17 a. m., and the block in front of crack No. 31 appeared to be instable to judge from the continued widening of the crack. Fume was rather dense under the southwest talus. After a slight earthquake generally felt at 4:43 a. m. March 3, there was seismographic evidence at Halemaumau of strong ESE tilt. The cracks had continued widening and the northeast rim was roped off after an avalanche at 2:10 p. m. There were other avalanches during the day. Fresh debris lay under the northeast wall.

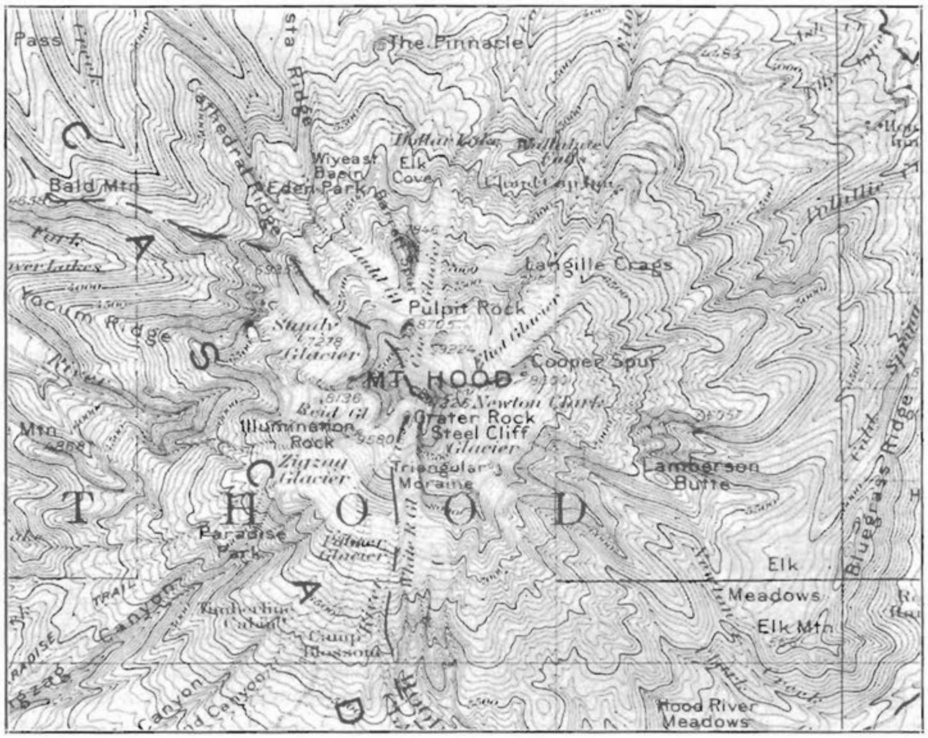
March 4 produced an unusual seismic crisis at Halemaumau and the development of glowing cracks in the January floor. The quaking spasm, which began about 12:53 p. m. and continued for six hours, was strongest for the first hour and a half, and produced eight felt shocks, and much continuous tremor. A visit to the pit showed fresh scars of slides at the west, north, and east walls and small slides were tumbling northeast. Fume was denser than usual, with sulphur odor. There was a large avalanche NE at 2:15 p. m. and others during the afternoon, as well as one NW. Crack No. 31 NE had widened one-half inch in a day. After nightfall two of the deeper cracks in the edge of the lava floor on the east side of the south bay showed distinct glow as though the seismic stress had warped open the thick shell over the still hot January lava.

March 5 produced culmination of the northeastern opening of rim cracks by collapse of the wall. At 11:10 a. m. much new debris was seen under the northeast wall and a small avalanche occurred there. There were numerous fresh cracks, back of the older ones which had been measured. The rim itself had fallen in as far back as the measuring point at crack No. 31. E. G. Wingate ran levels from the sandspit mark in the south end of Kilauea Crater to the northeast rim of Halemaumau and discovered this rim had risen 1.3 feet since the first half of September 1931. This means a swelling upward of the inner dome of the Kilauea floor to accompany the opening of rim cracks. At 3:28 p. m. a section of the northeast rim 500 feet long and 50 feet deep horizontally collapsed in a tremendous avalanche, measuring points Nos. 2, 31, and 35, the danger sign, and the protecting rope were all carried away, and the material overlapped the 1932 lava floor for a length of about 200 feet and a width of 20 feet. Most of this fell after Saturday noon March 5, but the measurements represent the total loss as seen at 9:30 a. m. March 6. The avalanche was accompanied by a small earthquake. Blue fume continued vigorous SW and slight fume rose from the glow cracks which were incandescent as before. A northern slide occurred at 10 p. m. March 6.

The Observatory registered 125 seismic disturbances for the week, including one moderate, 8 slight, 2 feeble, 37 very feeble shocks, and 77 tremors. Of these the spasm of the afternoon of March 4 from 12:53 p. m. to 6:44 p. m. included 1 moderate, 7 slight, 2 feeble, and 31 very feeble earthquakes, and 16 tremors. This spasm indicated mostly



Map of Mount Baker in Washington, scale four miles to the inch, contour interval 200 feet. Surveyed 1907-09, U. S. Geological Survey.



Map of Mount Hood in Oregon, scale two miles to the inch, contour interval 100 feet. Surveyed 1924, U. S. Geological Survey.

a seismometric distance of two miles, corresponding to the distance of Halemaumau. Other indicated distances of the week were 3, 4, 7, and 9 miles, some of which may have been variation in depth under the Halemaumau center. A very feeble shock of 11 p. m. March 1 was felt at Kapapala and the slight shock of 4:43 a. m. March 3, with indicated distance of seven miles from the Observatory, was generally felt on the east side of the island. Microseismic motion was moderate to weak, and tilting of the ground was moderate S to SSE: this tilt was strong for two days prior to March 4, and there were sudden tilts during the earthquake swarm.

THE VOLCANO LETTER

The Volcano Letter combines the earlier weekly of that name, with the former monthly Bulletin of the Hawaiian Volcano Observatory. It is published weekly, on Thursdays, by the Hawaiian Volcano Research Association, on behalf of the section of volcanology, U. S. Geological Survey. It promotes experimental recording of earth processes.

Readers are requested to send articles, photographs, publications and clippings about volcano and earthquake events, instruments and investigations, especially around the Pacific.

Subcription for non-members two dollars per year of 52 numbers. Address the Observatory.

HAWAIIAN VOLCANO OBSERVATORY
Founded 1911

This laboratory at Kilauea Volcano belongs to the Hawaiian Volcano Research Association and is leased and operated by the United States Geological Survey.

It maintains seismographs at three places near Kilauea Volcano, also at Hilo, and at Kealakekua in Kona District. It keeps a journal of Hawaiian volcanic activity and publishes occasional Bulletins.

Membership in the Hawaiian Volcano Research Association is limited to patrons of Pacific science who desire personally to aid in supporting the work.

The work of volcano research so supported is in collaboration with the work of the United States Geological Survey, but supplements it with buildings, research fellows, instrumental plants, explorations and special investigations for which there is no governmental provision. The Geological Survey maintains volcano stations in Alaska, California and Hawaii.

Persons desiring application blanks for membership ($5.00 or more) should address the Secretary, Hawaiian Volcano Research Association, 320 James Campbell Building, Honolulu, T. H.

The Volcano Letter

Two dollars per year — Ten cents per copy

No. 377—Weekly — Hawaiian Volcano Observatory, National Park, Hawaii — March 17, 1932

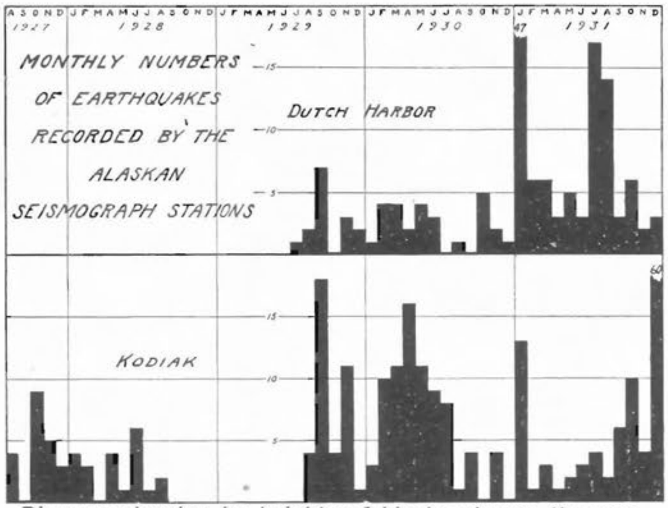


Diagram showing by heights of black columns the comparative frequency of Aleutian earthquakes, by numbers of shocks, per month, at Kodiak and Dutch Harbor (Unalaska) seismograph stations of the Section of Volcanology, U. S. Geological Survey. A. E. Jones.

EARTHQUAKES RECORDED AT THE KODIAK AND DUTCH HARBOR STATIONS

The United States Geological Survey is interested in the seismic activity of the Alaskan volcanoes. Towards that end the Section of Volcanology has placed two seismograph stations at strategic positions. As these places are more than 600 miles apart, neither records the smaller earthquakes local to the other. To facilitate a study of these records, a map of the Alaskan Peninsula and the Aleutian Islands has been prepared which is shown on Pages Two-Three. On this map circles of successive 50-mile distances have been scribed about the two stations. These 50-mile zones aid in the rough location of the earthquakes. With better earthquake reception, or more stations, closer positions could be given. These records are for the purpose of reconnaissance only.

Kodiak Earthquake Registration

The seismograph at Kodiak, Alaska, was put into operation early in August 1927 and was kept in operation until September 1928. It is at the former Agricultural Experiment Station on the hill back of Kodiak village. During this period of 13 months, 35 earthquakes were recorded. The majority of these were local to the Alaskan Peninsula. Fourteen of these quakes originated at distances of 100, 115, and 127 miles and could be attributed to either the nearer active volcanoes of the Aleutian Range or to the steeper part of the ocean bottom. There was one of 520 miles distance, reported from the Yakutat Bay region. Fifteen were teleseisms that were outside the North Pacific area. The remaining 20 shocks were at unassignable distances, but show by the quick period of the long waves that they were local to that area. Probably the 200-mile circle would include them all. Lacking an attendant the station was discontinued for a year.

The next series of records of the Kodiak station begins in the middle of August 1929. During the five months of 1929, six earthquakes were recorded from distances of 20 to 60 miles, two of which were felt by many persons. Thirty-one shocks were recorded that were not teleseisms but show distances of origin otherwise indefinite, but are probably not farther away than 200 miles. There are no teleseisms listed for that period.

During 1930, 25 shocks came from distances of 20 to 70 miles away. One of these was strong enough to be felt generally; it dismantled the seismograph. Fifty-one local shocks of unknown distances of origin were recorded, and only one of 83 miles distance, that could have originated near Kukak Volcano. Six local earthquakes were apparently strong enough to have been felt, but were not so reported. Only one teleseism is listed for the year.

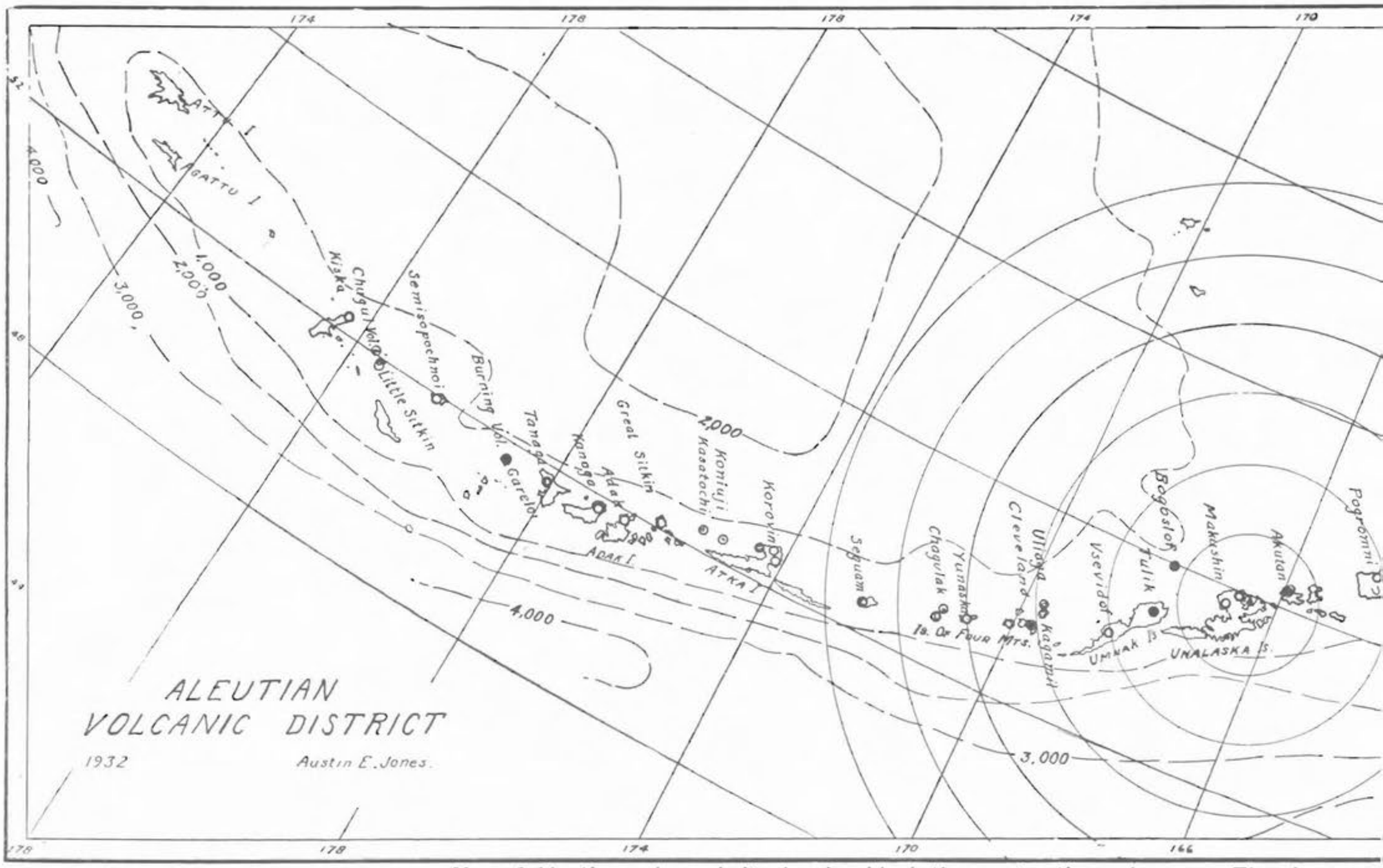
Time used is Kodiak Standard (K.S.T.), 10 hours slower than Greenwich.

Earthquakes recorded at Kodiak, Alaska

Lat. 57° 48′ 40″ N; long. 152° 24′ 20″ W; elev. 300 ft minus

Two Hawaiian-type horizontal pendulums weighing about 70 kg. set up in N-S and E-W directions. Static magnification 135 times with critical oil damping.

1931		Character	K S. T. h. m.	Distance Miles	Remarks
Jan.	1	Tremor	0 30 a.m.		
	2	Feeble	7 40 p.m.	157	
	4	15 Tremors	p.m.	75-115	Two indicate distance.
	7	Tremor	0 30 a.m.		
	7	Very feeble	3 00 a.m.	20	
	8	Very feeble	11 30 p.m.	83	
	9	Very feeble	1 40 p.m.	20	
	9	Very feeble	8 20 p.m.	143	
	11	Very feeble	3 15 p.m.	50	NE-SW.
	11	Tremor	4 30 p.m.		
	14	Teleseism	5 p.m.		Long waves.
	25	Tremor	6 37 a.m.	110	
	27	Feeble	6 35 a.m.	215 or over.	Begins in hour mark. Felt in Seward and Anchorage. Epicenter 61° N 150° W.
	27	Teleseism	11 a.m.		Part of a distant earthquake. Epicenter 31° N 108° E.
Feb.	2	Tremor	6 p.m.	100	



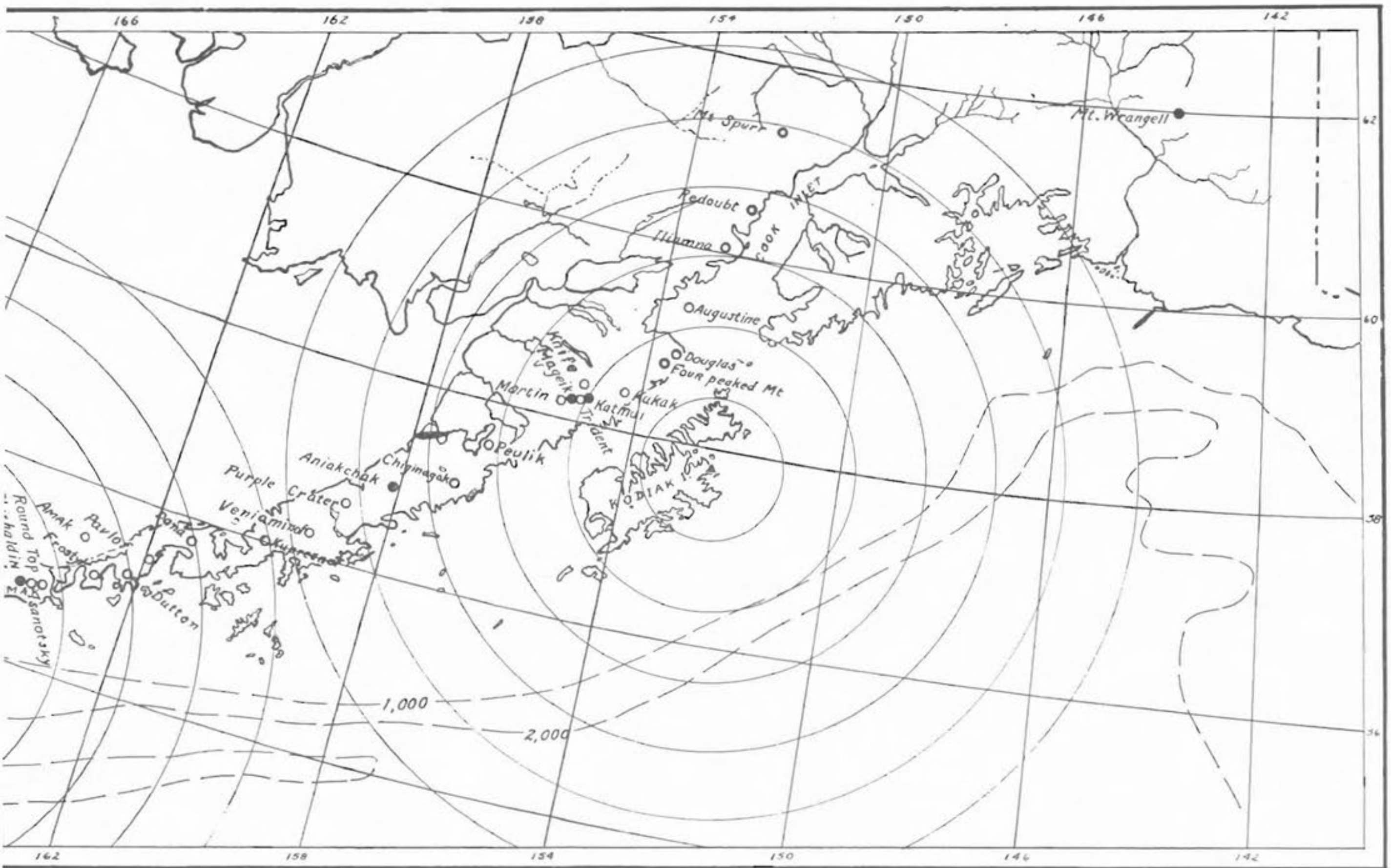
Map of Aleutian volcano belt, showing black the most active volcanoes. The rings aro
Soundings in Bering Sea at the north and Pacific

Mar.	18	Very feeble	5 05 p.m.	100	
	21	Tremor	p.m.	32 or over.	
	22	Tremor	a.m.		
Apr.	22	Tremor	p.m.		
May	16	Feeble	10 45 p.m.	147	
	28	Feeble	6? 15 p.m.	320	Epicenter 58° N 158° W.
June	14	Very feeble	7 30 p.m.	32	NW-SE.
	16	Tremor	7 00 p.m.	74	
	27	Very feeble	7 35 p.m.	18	NW-SE.
July	5	Tremor	2 00 a.m.	30 or over.	
	26	Tremor	10 17 a.m.	64?	
	26	Tremor	2 15 p.m.	110	
Aug.	1	Tremor	7 15 p.m.		
	22	Tremor	3 00 p.m.		
	27	Teleseism	6 20 a.m.		Long waves, part of earthquake. Epicenter in Baluchistan 30° N 67° E.
Sept.	1	Teleseism	3 50 p.m.	600 or greater—felt locally.	
	9	Tremor			
	10	Tremor			
	10	Very feeble	12 00 p.m.	55	NE-SW.
	25	Very feeble	1 30 p.m.	60	
	26	Very feeble	5 00 a.m.	55	NE-SW.
	29	Very feeble	0 55 a.m.	160 or greater.	
Oct.	3	Teleseism	10 a.m.		Part of Solomon Islands earthquake, epicenter 10° S 161.°4 E.
	12	Very feeble	3 35 a.m.	46	NE-SW.
	16	Very feeble	3 20 p.m.	64	
	17	Feeble	2 50 a.m.	172	NE-SW.
	18	Feeble	2 15 p.m.	50	NW-SE.
	25	Tremor	p.m.	108	
	25	Tremor	p.m.		
	26	Slight	1 00 a.m.	55	NE-SW.
	29	Feeble	9 45 p.m.	32	NE-SW.
	31	Tremor	2 00 a.m.		
Nov.	17	Tremor	2 40 p.m.		
	20	Very feeble	0 55 a.m.	267	NW-SE.
	20	Tremor	1 25 a.m.		
	25	Feeble	9 50 p.m.	74	NW SE.
Dec.	7	Very feeble	2 50 p.m.	78	
	9	Very feeble	2 30 a.m.	106	Over 30 similar earthquakes having no recognizable P phase between Dec 8 11 p. m. and Dec. 9 7 a. m.
	11	Very feeble	8 30 a.m.	305	20 to 25 tremors during 7:30 to 9:30 a. m.; no distances assignable.

In the above record there were 19 local quakes that originated at distances of 20 to 80 miles. Four of these came from 74 to 78 miles away and could have originated under the near side of the volcanic Aleutian Range. Seventeen occurred at places from 80 to 320 miles away, and it can be estimated that a fair percentage of these were from near volcanoes. There were 13 shocks, mostly graded as tremors, as well as three swarms of 13, 30, and 20, to which there could be assigned no epicentral distance other than that they were not farther away than about 200 miles. Parts of five teleseisms were recorded.

Dutch Harbor Earthquake Registration

The Dutch Harbor seismograph was installed July 1929 and has been run continuously. During the last half of



nd Kodiak and Dutch Harbor seismograph stations are progressive 50 mile distances.
Ocean at the south are in fathoms. A. E. Jones.

that year one shock was recorded from a distance of 37 miles. Akutan Volcano, about 30 miles to the east, was in eruption during the late summer and autumn, and it is more likely that this earthquake occurred there than under the slope of the ocean deep to the south. Eight shocks occurred in the next zone and can be assigned either to the volcanic island Umnak or to the slope of the deep. Six other local quakes of unknown distances were recorded and one teleseism. No earthquakes were reported as felt.

During 1930 four shocks were definitely from within the first zone. One on November 6, 1930, at 3:20 a. m. local time, was felt very strongly at Dutch Harbor and originated 46 miles away. Six more shocks were from the second zone and two occurred at greater distances. There were also 15 local quakes from unknown distances. Only one teleseism was recorded during the year.

Time used is Pacific Standard Time, (P.S.T.) 8 hours slower than Greenwich.

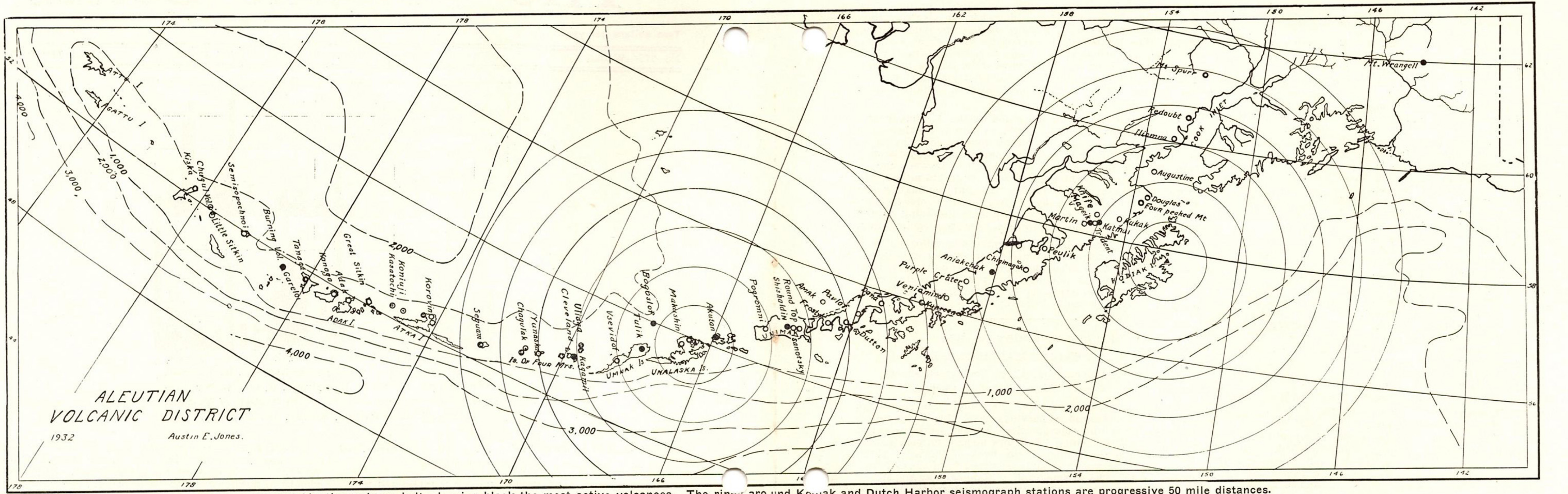
Earthquakes Recorded at Dutch Harbor

Lat. 53° 53′ 09″ N; long. 166° 32′ 05″ W; elev. 15 ft.

Two Hawaiian-type horizontal pendulums weighing about 70 kg., set up in N-S and E-W directions. Static magnification 135 times with critical oil damping.

1931		Character	P. S. T. h. m.	Distance Miles	Remarks
Jan.	2	Tremor	8 25 a.m.	69	
	3	Tremor	11 00 a.m.		
	6	Tremor	8 35 p.m.	60	
	9	Very feeble			
	11	Tremor	6 45 p.m.	42	
	23	Tremor	4 30 p.m.		
	28	5 tremors	p.m.		
	30	35 tremors	p.m.	23-28-32-37-51 59;	one at each distance.
	31	Tremor	5 02 p.m.		
Feb.	1	Tremor	5 30 a.m.	57	
	3	Tremor	2 00 p.m.	23	
	10	Tremor	5 30 p.m.	64 or 92;	according to interpretation of phases.
	11	Tremor	9 25 a.m.		
	13	Tremor	4 10 p.m.		
	15	Tremor	7 30 a.m.		
Mar.	2	Very feeble	7 30 a.m.	120	
	2	Tremor	11 35 a.m.	46	
	27	Tremor	5 40 a.m.	147	
	29	Feeble ePEN	9 26 28 a.m.		Felt in Dutch Harbor.
		iSE	9 27 01	106	ESE.
	29	Slight ePN	11 13 36 a.m.		Felt in Dutch Harbor.
		iSE	11 14 08	147	
	29	Tremor	0 52 p.m.	120 or over.	
Apr.	3	Tremor	7 25 a.m.	111	
	5	Tremor	4 15 a.m.	64	
	18	Tremor	8 30 p.m.	140 or over.	
May	4	Tremor	10 55 a.m.	51	
	5	Tremor	2 15 a.m.	147?	
	9	Tremor	7 00 a.m.		
	20	Tremor	a.m.		
	20	Tremor	0 10 p.m.	23?	
June	19	Tremor	a.m.		
	27	Very feeble	0 50 a.m.	46	NW-SE?
	27	Tremor	p.m.		
July	12	Tremor	5 30 p.m.	46	
	13	Tremor	1 45 p.m.	50?	
	18	*Teleseism	3 20 a.m.		

* The Jesuit Seismological Association lists the following 1931 distant earthquakes from this region: May 27, Lat. 56° N Long. 168° E, Commander Islands off Kamchatka; May 29, 58° N, 158° W, Bristol Bay west of Katmai; May 30, 52° N, 177° E, near Kiska and disastrous at Attu; July 18, 58° N, 169° E, west of Kamchatka. The May 29 shock was registered at Kodiak, and that of July 18 at Dutch Harbor.



Map of Aleutian volcano belt, showing black the most active volcanoes. The rings around Kodiak and Dutch Harbor seismograph stations are progressive 50 mile distances. Soundings in Bering Sea at the north and Pacific Ocean at the south are in fathoms. A. E. Jones.

	19	Very feeble	0 05 p.m.	100-200	
	24	6 tremors	p.m.		
	24	Tremor	8 20 p.m.	83	
	29	8 tremors	11 a.m. to 12 m.	18	Distance of one only.
Aug.	2	Tremor	0 10 a.m.	46	
	5	Tremor	2 05 p.m.	500?	Part of a distant quake.
	8	Very feeble	4 45 a.m.	97	
	8	Tremor	5 15 p.m.		Part of a distant quake.
	9	3 tremors	p.m.		
	11	Very feeble	6 40 a.m.	88	
	11	Tremor	8 00 a.m.		
	11	14 tremors	4 00 p.m. to 8 30 p.m.		
	14	Feeble	a.m.	110	
	14	Tremor	6 00 p.m.	97	
	15	Tremor	4 40 a.m.	120	
	19	Tremor	6 10 a.m.	360?	
	19	Tremor	6 50 p.m.	130	
	24	Tremor	3 30 a.m.	330?	
	31	Tremor	6 00 a.m.	115	
Sept.	2	Very feeble	p.m.	110	
	8	Tremor	8 30 a.m.	42	
	18	Very feeble	a.m.	55	
Oct.	2	Very feeble	4 50 p.m.	100	NE-SW?
	10	Teleseism			
	10	Tremor			
	10	Tremor	6 40 p.m.	37	
	14	Feeble	2 00 a.m.	115	
	17	Tremor	6 35 a.m.		
	17	Very feeble	8 35 p.m.	55	NE-SW
Nov.	22	Tremor	a.m.	64?	
	23	Very feeble	a.m.	60	NE-SW.
Dec.	1	Very feeble	p.m.	125	ENE-WSW.
	6	Moderate	11 10 p.m.	46	NE-SW. Felt by all. Seismographs dismantled; dishes rattled.
	14	Feeble	a.m.	125	ENE-WSW.
	23	Teleseism	9 45 a.m.	900?	

In the above table 13 earthquakes originated in the first zone about Dutch Harbor, while 17 were in the second zone, 11 in the third zone, possibly two in the fourth zone, two outside the zones at 330 and 360 miles, and two more occurred at the probable distances of 500 and 900 miles away. Four teleseisms were recorded completely or in part. One from the Kamchatka region was remarkable for its large single S period. At least 70 local earthquakes were recorded in such small amplitudes that no distance could be determined. During the summer of 1931 there were over 200 artificial disturbances, probably caused by workmen. There were three earthquakes reported felt at Dutch Harbor. The accuracy of the location of earthquakes in these zones is largely dependent on the depth of focus of the earthquake.

During the years 1929-30 the Kodiak station recorded about 2½ times as many earthquakes as the Dutch Harbor station, while in 1931 the Dutch Harbor station recorded 37 per cent more. This would seem for seismicity to parallel Petroff's statement for volcanicity, that when the volcanoes in one part of the Aleutian chain become quiet, others in some other part of the chain become active. This relative localized shift of seismicity also shows in the graph.

Tremors

The numbers of tremors in the tables stand out. Three times as many were recorded by the Dutch Harbor seismograph as were recorded by the Kodiak seismograph, probably because Dutch Harbor is much nearer the subterranean volcanic rift line. They are seismic in character, representing sizable shocks when originating at a distance. They probably could have been felt by any one over, or near, their origin. After having traveled 50 or 100 miles, the earthquake waves have so decreased in size that they are barely registered as tremors on the receiving seismograph. The Kodiak station recorded 36 of these tremors, only 10 being pronounced enough to show distance by the S-P interval. They fall into groups of 30, 70, and 105 miles. The Dutch Harbor station recorded 105 tremors, 35 indicating distance. Most of these originated at distances from 20 to 150 miles away.

The volcanic magma underground on the Alaskan Peninsula near Kodiak may be about as active as that near Dutch Harbor if seismic distance is considered. The latter station is at about 8 and the former at 80 miles distance from part of the Aleutian volcanic rift. If we compare the tremors received at Kodiak from 100 to 115 miles, with those received at Dutch Harbor from approximately the same distance, there are five in each case received on instruments of nearly equal sensitivity. Referring to the map, there are volcanoes at those ranges from each station.

While there are only two indicated 100 miles on each side of Dutch Harbor, there are other smaller craters unlocated, near both Vsevidof and Pogromni, and both Unimak and Umnak islands have produced recent eruptions. The Katmai group is 100 miles from the Kodiak station. (See Volcano Letter No. 375.) A.E.J.

KILAUEA REPORT No. 1051

WEEK ENDING MARCH 13, 1932

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge.

On March 7 fume from near the foot of the southwest talus was as strong as on previous days. The fuming spot under the west wall was inactive. Cracks were measured and showed little change. Two new measuring points were established on the northeast rim back of the area which avalanched last week. A slide occurred from the NE wall at 10:32 a. m. The seismograph at Halemaumau registered sudden tilt in the morning, without tremor, to the east, and a gradual tilt to south. Two glowing cracks reported last week were plainly visible in the evening.

Dust from an avalanche was seen March 8 at 1:13 p. m. from the Observatory. A small quake was felt at Halemaumau at 2:07 p. m. A few rocks were heard falling.

Nothing new was observed during a circuit of the pit on March 9 in the forenoon.

Much dust from big slides was seen about 1 p. m. March 10.

On March 11 much fume was visible from the Volcano House, rising in concentrated puffs during the forenoon. At 10:08 a. m. there was a small slide from the northwest wall. Sulphur stain slowly increases about the fume spots. A slight widening of cracks was noted northeast. The glow from one of the cracks has nearly disappeared. The crack southwest of this continues to be visible at night, but not so bright as formerly.

On the evening of March 12 one glow-crack remained visible. On March 13 fume activity showed no change. A quake at 8:26 a. m. registered stronger on the Halemaumau seismograph than at the Observatory. Moderate tilt to the east was registered during a quake at 1:15 a. m.

The seismographs at the Observatory recorded 41 tremors, 12 very feeble seisms, and one feeble seism at 11:04 p. m. March 8 felt in Hilo. A very feeble seism at 1:15 p. m. March 11 was also reported felt in Hilo. Distance phases of most of the disturbances indicate origins near Kilauea. Microseismic motion was moderate for the first three days of the week, followed by two days of strong microseisms, and decreased to light at the close of the week. Average tilt for the week was strong SSE.

THE VOLCANO LETTER

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The Volcano Letter

Two dollars per year | **Ten cents per copy**

No. 378—Weekly | Hawaiian Volcano Observatory, National Park, Hawaii | March 24, 1932

Stucco building damaged by earthquake of August 31, 1926, in Horta, Azores. Photo Agostinho.

FREEMAN'S BOOK ON EARTHQUAKE INSURANCE

This monumental work of 904 pages ("Earthquake Damage and Earthquake Insurance,' by John Ripley Freeman, McGraw-Hill, 1932) includes "studies of a rational basis for earthquake insurance and of engineering data for earthquake-resisting construction."

The twenty-two chapters cover: the present situation; earthquake causes and motion; measure of earthquake violence; frequency and violence in the United States and Canada; the narrow destruction zone; structural lessons from San Francisco and Charleston; structural safety and local ground; structural lessons from other American earthquakes; earthquake-resisting buildings in Japan 1923; lessons from Italian earthquakes; lessons from Nicaragua and New Zealand; prediction of time, place and damage; figures on earthquake loss ratio; insurance rates by stock companies; affiliation of earthquake and fire insurance; municipal building codes; textbooks on earthquake-resisting design; shaking tables; the motion of the ground in an earthquake; design of earthquake-resisting buildings; data from seismograms; suggestions for a program of earthquake research.

This book by a great engineer, President of the Manufacturers Mutual Fire Insurance Company, is something entirely new in the realm of seismological literature. It is a book which should be in the office of every large corporation interested in insurance of its property, and still more in every office interested in writing property insurance. The earthquakes of California, Japan, Central America, Italy, and New Zealand, in recent years accompanied with conflagration, and affecting large cities containing modern expensive structures, have created a new problem. This problem is the economic one of enforcing adequate construction to resist either earthquake or fire or both. Mr. Freeman states in the introduction:

"The following pages are addressed to structural engineers, insurance executives, and property owners. In the beginning the author was by no means so well convinced of the prudence of writing earthquake insurance as he has become by studying the information accumulated. The facts brought together demonstrate that the actual hazard is really extremely small when considered as a mathematical ratio. Earthquake insurance might advantageously be incorporated in every fire insurance policy at remarkably small additional cost. Local building laws should be remodelled. Destructive earthquakes are infrequent, area of destruction is small, successful resistance of many buildings is remarkable, average proportion of damage is small, and earthquake-resisting buildings can be built at small additional cost."

Construction requirements are summed up as follows: "All buildings in a region liable to earthquake violence, equivalent to that of the known seismic regions of Italy, Japan, and of the United States, should be designed to resist a horizontal earthquake force, applied at each floor level, equal to one-tenth of the weight of all of the structure above that level, plus the weight of the actual contents, resting upon the floors, including the roof."

This amounts to provision for the application of a horizontal force of one-tenth of the weight of superincumbent structure and contents, applied at each portion. Requirement in building codes anywhere, of design to withstand one-twentieth of superincumbent weight horizontally applied suddenly, is recommended as a part of the structural factor of safety against all emergencies of wind or quake. The utmost practicable structural rigidity is desirable. The oscillation period of a building should be as short as possible.

Prediction of time, place, and damage from earthquakes presents a variety of problems. Place and time are wholly generalized with reference to the future. Meteorological, electrical, and astronomical controls are unreliable. Tidal stresses probably have some effect. Earth-tilt as a forerunner of earthquakes is coming to be regarded as important in Japan. Location of concealed slipping planes in motion is the subject of an elaborate instrumental investigation near Los Angeles. An engineering survey in advance is quite capable of predicting expectable damage in any locality, in case a great earthquake should occur, by report on the stability of the ground and the quality of design in structures. With reference to maximum expectable violence, it is improbable that anything bigger than the earthquakes of the past will happen. And it must be remembered that fire did most of the damage in several of these.

The earthquake insurance hazard at Los Angeles is probably a very little smaller than that at San Francisco. A region of greatest earthquake frequency may possibly be the safest. A region of fewest earthquakes may give the greatest loss when an earth-slip does come. Certain belts are liable to recurrent great earthquakes. Such places have immunity periods after the last great shock. Soft fluvial or made land deposits are shaken much more violently than rigid ground. Rigid buildings of good design and faithful workmanship will be found practically earthquake-proof. A rigid massive foundation is important. The expected loss ratios on American experience are 3 per cent for steel-concrete and wood-frame on good foundations, 5 per cent for steel-brick and well designed factories of brick in cement mortar, 10 per cent for brick residences not exceeding 4 stories, 25 per cent on brick-veneered buildings with wood or concrete frames, and 50 per cent for concrete-block and hollow-tile buildings. Stone buildings are not mentioned.

The following is Mr. Freeman's probable loss ratio for the United States. The expected average earthquake damage in cents per year for $100 of structural value is:

California, coast	10 cents
California, great valley	5 cents
California, Sierra	7 cents
Washington and Oregon, coast	6 cents
Washington and Oregon, inland	4 cents
Rocky Mountains	3 cents
Northern mid-continent	1 cent
Mississippi bottom lands	2 cents
Great Lakes region	1 cent
Atlantic region, interior	½ cent
Atlantic coast	1 cent

One cent per $100 per year is equivalent to an average damage of $1 per year on a house worth $10,000.

The discussion of insurance is elaborate, by districts, and types of construction. Roughly the total earthquake damage (excluding fire) in the United States and Canada in a hundred years has been forty million dollars. It must be remembered that San Francisco in numerous earthquakes has lost only $20,000,000, as compared to $414,000,000 by four conflagrations. Premiums differ from probable loss in that overhead must be added.

In San Francisco, if the owner insures for not less than 70 per cent of cash value of property against earthquake, he pays a premium rate, per $100 value per year, of from 15 cents to $2.50 progressively from Class I to Class VIII of buildings, and must himself assume loss from 5 per cent to 15 per cent of the total value in such matters as cracked plastering or minor cracks in walls. This proviso enables the insurance company to avoid payment for earthquake damage on a large proportion of all buildings, where the loss does not exceed this percentage.

East of the Rockes there are four rating zones, the highest risks being places of historical earthquakes such as South Carolina, New England, and the New Madrid region of the Mississippi; the lowest are the central states and the Gulf coast. The lowest rate is 4 cents per $100 per year, or $5 per year on a wooden dwelling valued at $12,500. In Zone 1 of greatest risk, this $5 would purchase earthquake insurance of only $5,000 on a wooden house. As before there are several classes of structure of progressively greater risk and higher premium.

The book is profusely illustrated. There are splendid airplane views of the new city district construction in Los Angeles and San Francisco. There are many isoseismal maps of earthquakes, panoramic photographs of conflagrations such as San Francisco, diagrams of the possible roller joints in a design for the basement supports on an earthquake-proof building, diagrams of the displacement effects of earthquakes on buildings, distribution diagrams for severe earthquakes; a discussion with diagrams of the triangulation displacement in California published in 1924, which contained an error of 24 feet of alleged crustal creep, and the correction of this in 1928; pictures of earthquake effects on all kinds of structures in many lands, and very modern photographs of the ruins in Managua and Napier.

Mr. Freeman has been recently in Japan and has been much impressed by the admirable work of the Japanese engineers in reconstruction. He is equally impressed by the inadequacy of much seismological work, as concerned with the needs of theory rather than the needs of humanity and engineers. Mr. Freeman considers the devotion to "acceleration" in mathematical studies of earthquake damage as "worship of a false god." The assumption of harmonic motion, the formula based on amplitude, period and gravity, and the short time within which the maximum change of motion acts, all render this theoretical acceleration of small value where the relatively prolonged racking of building and ground in several directions is involved. Freeman is greatly interested in the experiments on model buildings, with mechanical shaking machinery, made in Japan and at Stanford University. He is everywhere impressed by the lack of real knowledge of the earthquake **at the place and time** where the damage is done.

He concludes with twenty-two recommendations for a practical program of earthquake research, including systematic study and translation of the Japanese works; study of dominant local oscillations; make research on artificial explosions; extend the shaking-table research; develop a strong-motion seismograph and place it; investigate all factors of public safety in every American earthquake through the U. S. Geological Survey; run levels and straight reference lines in critical places; establish tilt measuring lines; reorganize the Seismological Society of America along the lines of protection of life and property; and get contributions for research from the great power, construction, and insurance corporations. He concludes with an apt quotation from the late President Branner: "The registration of an earthquake two thousand miles away can hardly be expected to interest a man whose family lies buried beneath the ruins of a house built of improper materials upon ground that any geologist might have told him to keep away from." T.A.J.

KILAUEA REPORT No. 1052

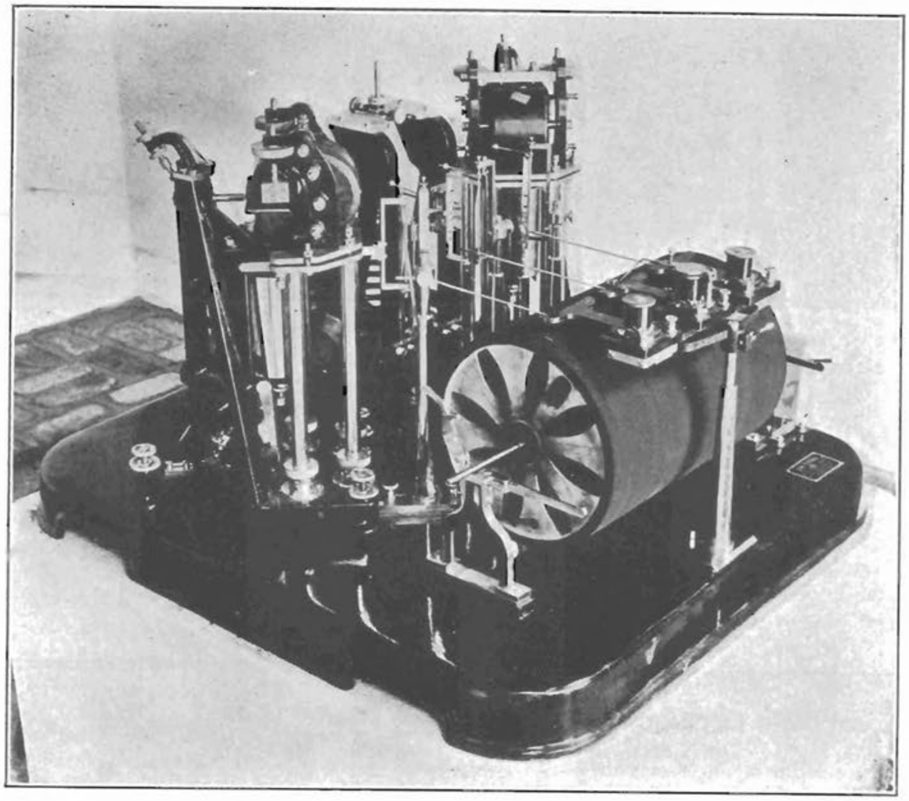
WEEK ENDING MARCH 20, 1932

Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge.

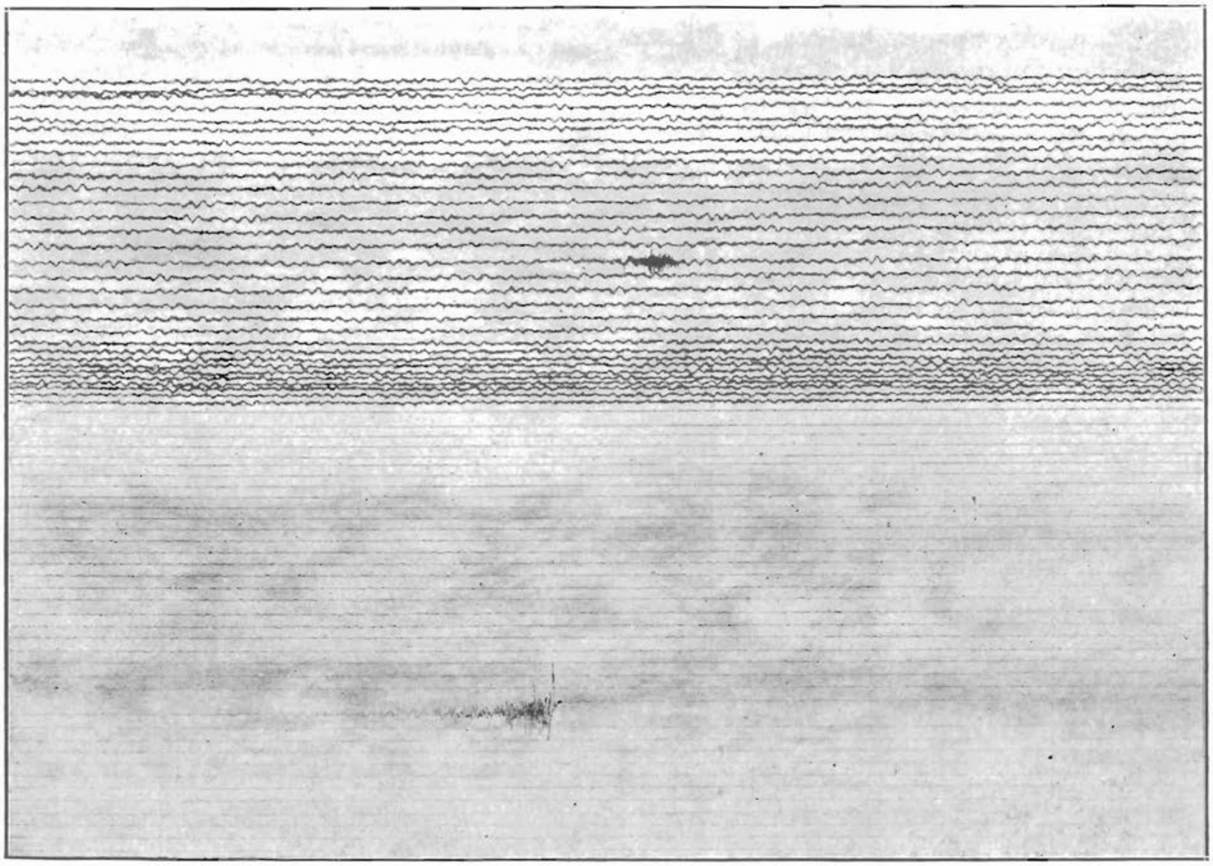
Several slides occurred in Halemaumau during the forenoon of March 14, one larger than the others at 9:37 a. m. over the north wall buttress. Fume appeared about the same. A very slight widening of the northeast rim cracks continued. At night, 8:30 to 9:30, a circuit of the pit was made to locate possible glow spots. Only the one place noted last week, at the southeast, was visible, and this was brighter and larger when viewed from the northeast rim. On March 16 fume showed little change, except that in the forenoon about 11 o'clock none could be seen at the foot of the west wall. At 3:30 p. m. blue fume was plainly visible from the Observatory. On March 17 at 10:15 p. m. fume was again easily visible, and rose from a stained spot by the west talus. At 10:30 a. m. March 18 fume was strong at the same location. On the 19th fume appeared during the forenoon to have decreased slightly. Sulphur stains were quite heavy about the fume spots. Conditions were quiet at Halemaumau. The pit was visited about 7 p. m. and two glowing spots were found at the southeast.

The seismographs at the Observatory recorded 35 tremors, four very feeble seisms, and two feeble seisms. Of the very feeble seisms, one showed origin distance about 4 miles, one about 9 miles, and two about 16 miles. Both feeble quakes showed origin distance about 23 miles. One at 6:31 p. m. March 18 was felt at Kilauea and Hilo; the other at 8:11 p. m. March 19 was felt near Kilauea.

Tilt for the week was strong SW. Microseismic motion was light the first day, moderate the next two days, strong two days, and moderate the remaining two days of the week.



Japanese seismograph designed by Imamura, with three pens writing on a single drum covered with smoked paper. Time marked by lifting pen tips with electromagnets connected with a wall clock. Pendulums record up-down, east-west, north-south motion and are damped with horseshoe magnets.



A seismogram or earthquake autograph written at Kilauea Volcano. The record of crater movement when an eruption stopped. Tremulous upper lines record the eruption. Crowding of lines records tilt. The two groups of crowded oscillations are earthquakes.

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HAWAIIAN VOLCANO OBSERVATORY
Founded 1911

This laboratory at Kilauea Volcano belongs to the Hawaiian Volcano Research Association and is leased and operated by the United States Geological Survey.

It maintains seismographs at three places near Kilauea Volcano, also at Hilo, and at Kealakekua in Kona District. It keeps a journal of Hawaiian volcanic activity and publishes occasional Bulletins.

Membership in the Hawaiian Volcano Research Association is limited to patrons of Pacific science who desire personally to aid in supporting the work.

The work of volcano research so supported is in collaboration with the work of the United States Geological Survey, but supplements it with buildings, research fellows, instrumental plants, explorations and special investigations for which there is no governmental provision. The Geological Survey maintains volcano stations in Alaska, California and Hawaii.

Persons desiring application blanks for membership ($5.00 or more) should address the Secretary, Hawaiian Volcano Research Association, 320 James Campbell Building, Honolulu, T. H.

The Volcano Letter

Two dollars per year | Ten cents per copy

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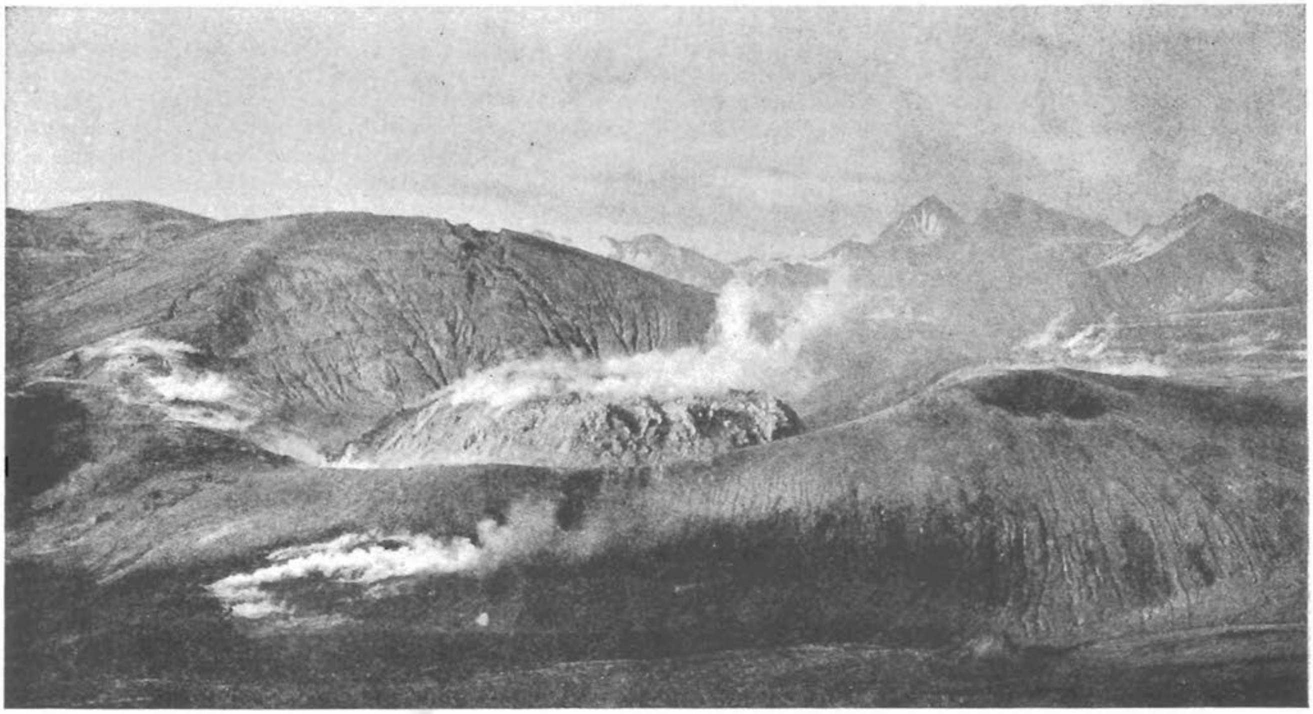


Novarupta dome of siliceous soda rhyolite, near Katmai in Alaska, which rose in 1912 in the bottom of a new explosion crater in a valley, and developed a heap 800 feet across and 200 feet high. Photo National Geographic Society.

WILLIAMS ON LAVA DOMES

An essay of unusual importance for volcanology, with excellent illustrations and a thoughtful, philosophical summary of conclusions has just been published by Dr. Howel Williams (The History and Character of Volcanic Domes, Bull. Dept. Geol. Sci., University of California, Volume 21, No. 5, Berkeley 1932, 95 pages, 37 figures).

Dr. Williams became interested, in the subject of lava flows which arise so stiffly as to build up at once a plug or dome, by his work at Lassen Volcanic National Park where there are 13 such domes within an area of 50 square miles on an even grander scale than the puys of the Auvergne. Massive protrusions are now known to be common manifestations of volcanic activity. There are plug domes which represent upheaved conduit fillings, domes that grow essentially by expansion from within, and domes built by surface effusion. In the last class the large Hawaiian overflow heapings are better described as "shield volcanoes."

The domes described consecutively are those of the Caribbee Islands including notably the dome and spine of Mont Pelée and the dome at the volcano of Guadeloupe. Next come the Central American domes of Santa Maria in Guatemala, Popocatepetl in Mexico, and some minor ones in these countries. South America has numerous lava domes which are imperfectly known, of which the best example is the acid andesite dome, consisting of viscous hardened lava, having an extremely jagged surface, from which steam and fragmental eruptions continually issue, in the crater of Galeras Volcano. In North America, besides the Lassen domes there are those in the chain of craters south of Mono Lake, California. Here at Panum Crater the obsidian lava was so nearly solid that it rose with essentially vertical walls to about 150 feet without exhibiting a tendency to flow in any direction, so that a deep moat separates the dome from the surrounding rim of lapilli. At the Marysville Buttes in California there are banded rhyolites which form intrusive domes among Tertiary sediments along the flanks of an andesitic laccolith, steep-sided and of oval outline from a quarter mile to a mile in length. They were viscous and contained steam, and the rise of the domes was attended by violent steam explosions, some of which blasted a crater, measuring a mile in diameter, through the core of the laccolith. Next come descriptions of Bogoslof in the Aleutian Islands and its numerous domes, and of the remarkable siliceous dome of Novarupta near Katmai on the Alaskan Peninsua. "The rise of this dome, like that of almost all domes, was preceded by strong pyroclastic explosions, whereby a crater almost three quarters of a mile in diameter was opened," and coarse ejecta measuring eight feet in diameter were flung a quarter mile from their source. The explosive phase was followed by the welling up of viscous magma, which as it was slowly thrust upward broke into huge blocks. It was heaped about 800 feet in diameter and 200 feet high. The glassy lava is banded in general parallel to the margins. "Apparently the magma rose to the surface by the active solution of the country rocks, retaining its heat largely by gas reaction. The original magma was a siliceous soda rhyolite with 75 per cent of silica containing partly fused inclusions of andesite country rock with 62 per cent of silica."

Next come descriptions of Tarumai and Usu domes in Japan, Merapi and Galunggung in Java, and Ruang in the Sangi Islands. A submarine dome during April, 1904, appeared in these islands, and after 1913 three rocks were left emergent above the water. In 1919 a short-lived dome rose above the surface, forming an island 70 meters in diameter and up to 12 meters in height. It consisted of lava blocks of amphibole andesite. There are many other stiff lava domes in the craters of the Dutch East Indies.

Ascension Island in the Atlantic has crater domes of trachyte, and the trachytic eruptions were in all cases preceded by eruptions of basalt. The protrusion of the domes followed long periods of dormancy and was heralded by explosions flinging up obsidian ejecta. The explanation appears to be that after the early outpourings of basalt, the residual magma became differentiated and capped by a siliceous slag. "This sequence of events thus affords another instance of the explosion of a gas-rich, differentiated magma, followed by the quiet upwelling of pasty lava to form" interior heaps in the craters, a sequence apparently common in dome eruptions. The trachytes are poor in vesicles in contrast with the rhyolites and basalts. The diameters of the Ascension Island domes are 400 to 500 meters, and the heights 200 meters more or less. In the Ragged Hill dome, the dome structure is indicated by a pronounced concentric rifting, with plates dipping away 35 degrees, and the platy structure apparently due to thermal contraction. There are inclusions of common basalt in the trachyte. In the case of the Riding School dome, the trachyte flowed over the rim of a basaltic crater after forming a large body in the center of the depression, and then after making a thick flow 700 meters long away from the crater, the surface of the inner dome sank back to form a basin. This withdrawal of magma in the center happened in another dome where the platy structure has an inward dip of from 2 to 5 degrees. At St. Helena there are phonolite domes more deeply eroded than those on Ascension Island, the largest of which, called Great Stone Top, was originally 300 meters high, was fed by a dike only 10 to 15 meters wide, and was accumulated, not in an old crater, but on an almost level floor of basalt. In Samoa there are rhyolite and trachyte domes closely analogous to those of Ascension Island, here also overlying older basalts.

The puys of the Auvergne in France have black basaltic cinder cones with pale-colored craterless domes of trachyte within them, and Scrope in 1825 described them correctly. He observed that basalts tend to yield low, broad cones, because of their high fluidity, whereas lavas of "low specific gravity, especially when combined with a coarse, crystalline texture, will occasion a minimum of fluidity. The trachytic lava seems to have risen upwards from the vent in so pasty or imperfectly liquid a state as to have accumulated above it in the form of a dome or bell, just as would a body of melted wax, or one of moistened clay, if forced outwards through an orifice in the cover of any containing vessel."

The domes of Auvergne are divided into three types, (1) Peléan domes, acid and basic, (2) Peléan domes with craters or with trachyte ejecta, (3) domes with elevated portions of the adjacent rocks. The augite trachyte dome of the Grand Sarcoui has the form of an overturned bowl with a maximum slope of 60 degrees, measures 750 meters across the base, and is 250 meters high. It has a smooth surface and no rock pinnacles, due apparently to the lava having poured uniformly in all directions from a summit vent. On the east flank there are quarries revealing buried talus and the rough structure of an underlying pinnacled dome. This inner heap was of the Pelée type and the overflows at the top were a late phase. In the Puy de Dôme there has been left an irregular truncated pyramid 550 meters high. It is a trachytic protrusion covered by debris from a summit vent. Lacroix explains the sequence by the opening of a fissure in the underlying rocks consisting of granite, gneiss, etc., permitting lava that was partly viscous and partly solid to rise to the surface and build a steep dome. Its crust crumbled, forming great banks of talus cemented by fine dust. Both dome and talus are biotite trachyte. Later eruptions from a new summit crater deposited fragments including pieces of the bedrock pumice, breadcrust bombs, and angular pieces of trachyte. The trachyte ejecta of these final eruptions differed mineralogically from the materials of the dome, and in texture from glassy to coarsely crystalline. The same thing was observed in the dome of Mont Pelée.

The Gulf of Santorini, in the island of Thera of the Grecian Archipelago, produced the first dome eruption well known to European geologists. In February 1866 a new islet appeared in this crater bay composed of lava blocks, pumice, and bottom debris. Steam explosions were frequent. The mass grew without earthquake or visible projection of fragments, silently, but so rapidly that it seemed like the blowing of a soap bubble. It seemed like an expansion movement with the rocks incessantly displaced from the center towards the edge. On the second day the growth was from the edge towards the center. The dome above water measured 70 to 30 meters and was 20 meters high. One could walk on top, although the lava was still glowing beneath. There was no summit crater, but rather a confused heap of big blocks grayish in daytime, fuming, and at night lighted by incandescence, while the lower slopes were covered with cooler debris. There were long crescentic fissures, almost complete circles, on top of the dome. Similar cracks have been observed at Novarupta, Alaska, and at Chaos Crags near Lassen. The first Santorini dome was named Georgios, and on February 15 a second dome, Aphroessa, rose quietly above the sea on its flank. Within two days it grew enormously, and in five days its length had reached 380 meters. Its mode of growth, like the first dome, showed nothing but a progressive displacement of lava blocks. There were, however, occasional eruptions of cinders and lapilli which decapitated and flattened the Georgios dome. On March 8 this measured 350 by 100 meters and stood 50 meters high. The blocks were either scoriaceous or compact glassy andesite. There was an incessant crackling noise and a tinkle like broken porcelain. The fumaroles had temperatures up to 300 degrees C. and the vapor contained hydrochloric and sulphuric acid. On March 10 a third dome, Reka, arose still more quietly without any crackling of blocks breaking asunder in cooling. This heap became joined to Aphroessa. Fouqué called these domes cumulo-volcanoes. New hillocks of blocks were piled up and destroyed, the shapes changed, the rates of growth varied, and Georgios developed a pile of blocks on top enclosed by a circular trench. The end of the activity was on Georgios in October 1870, four years and eight months after the beginning of activity, and the new islet finally stood 120 meters above the sea.

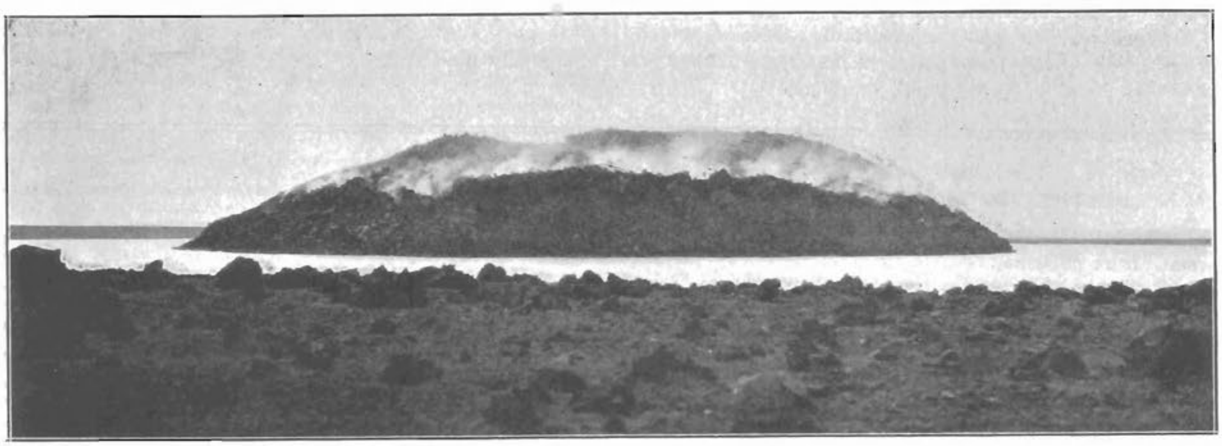
Fifty-five years later in September 1925, the same kind of activity was renewed when Fouqué dome appeared near the earlier island, circular in plan, 150 meters in diameter, and 50 meters high above a plateau of new lava on September 19. The shape of the dome continually changed. There were violent eruptions and a continuous redistribution of the loose blocks. The explosions sent up black cauliflower clouds. The temperature of the upper part of the interior of the dome was 700° to 800° C., there was no definite crater, and small jets of white vapor were emitted all over the surface. The vulcanian explosions took place from different places, mostly near the summit, blowing out loose blocks which fell back, and occasionally decapitating the dome. The blocks were solid and angular, dense, vitreous, and black, and there were no well-defined breadcrust bombs. There were concentric crevices which made a thin ring of bright red incandescence, and in daytime semicircular batteries of narrow jets of gray vapor which formed a crown around the dome. The lava flows associated with the dome had blocky crusts over compact vitreous lava free from vesicles. One small dome on the surface of the flow exhibited concentric banding. In the Georgios dome the lava contained many basic inclusions, very little gas, very little combined water, 65 per cent of silica, and may be called a glassy pyroxene dacite.

In 1831 an island formed by submarine eruption near Pantelleria in the Mediterranean appeared on July 16, had become 65 meters high and 3700 meters in circumference early in August, and was washed away by the end of October. The material was volcanic sand, lapilli, and scoriae arranged in strata around a crater. There appears to have been an upthrust of lava in viscous condition and broken at the top, similar to Bogoslof. There was trachytic pumice, but the island was basaltic. There was much carbon dioxide gas.

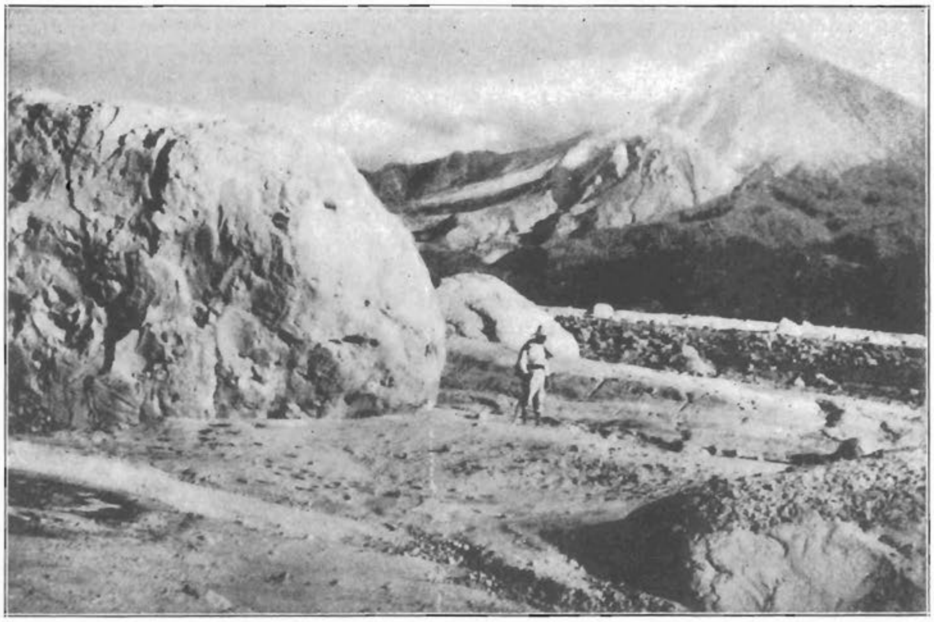
Other domes are described in the Lipari Islands and in the older lavas of Italy, in the Eifel region and elsewhere in Germany, in the Milos Archipelago of Greece, among the Virunga volcanoes of East Africa, in Kamchatka, in the Philippines, in Iceland, in the Azores, and in several places in California including the flanks of Mount Shasta.

Summarizing the characteristics of dome outflow, the largest are one to two miles across and the smallest only a few meters. In shape most of them are truncated domes and pyramids with lower slopes concealed by talus. Breaking up of crusts during upheaval, and the formation of concentric or radial ridges are characteristic features. Slickensides or scrapings are often to be seen along the walls of fissures. Glassiness is very characteristic of the lava of domes, also porphyritic structure, and and the upwelling of the lava is preceded by explosions flinging out pumice and tuff. There are usually many basic inclusions. The rocks are mostly andesties, trachytes, and rhyolites. The temperatures at times of protrusion are estimated to have been less than 850° C. Shepherd and Merwin estimated that the gas pressure inside the Pelée dome was about 100 atmospheres. Intense solfataric action is seldom conspicuous during and after upheaval. The gas content of the lavas is small, 0.15 per cent by weight at Lassen, 0.10 per cent at Santorini. The breadcrust bombs of Pelée contain six times as much gas as the material of the dome. The gases listed as extracted from rock of Pelée, Lassen, and Kilauea show excessive carbon dioxide, sulphur, chlorine, and fluorine for the former and relatively high hydrogen and carbon monoxide for an aa lava of the latter. Lassen Peak andesites have excessive combined water. One is impressed by the great excess in all these analyses of H_2O, 70 to 96 per cent, as compared with H_2, one per cent or less; CO_2, one to 20 per cent, as compared with CO, measuring from less than one to three per cent; and SO_2, on the other hand, always less than one per cent, is in less amount than the sulphur from which it is derived, which approaches one or two per cent. The unoxidized hydrogen reaching its maximum in the Kilauea lava (6.18 per cent), and the fact that one of Day and Shepherd's analyses of the gas from the liquid lava yielded seven per cent, makes it reasonable to suppose that hydrogen is the fundamental volcanic gas, but that it oxidizes during the rise of magma and consolidation, just as do the metallic ingredients in combination with silica.

The rate of growth of domes is rapid. That at Santa Maria rose 100 meters in a week, the dome of Mont Pelée rose 25 meters in a day, that of Tarumai rose 100 meters in four days. The internal structure may have concentric layering, or it may have fan structure, or it may spread



Lava heap of Bogoslof Volcano in the Aleutian Islands, surrounded by warm salt-water lagoon and ring bars of explosion debris. Activity of 1926-28, photo Wheeler.



In distance Santa Maria Volcano in Guatemala after eruption of November 2, 1929, in middle distance the lava dome which had risen in the crater in the flank of the volcano, and in foreground gigantic bowlders carried with floods of the eruption. Photo Sapper and Termer.

with irregular fissuring and sprouting like aa lava. In most cases talus forms around the border. The propelling force Williams considers to be the expansive pressure of internal gas, and generally the dome is the top of a plug forming a seal to the conduit at the close of an active period. T.A.J.

KILAUEA REPORT No. 1053

WEEK ENDING MARCH 27, 1932

Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge.

In Halemaumau pit the afternoon of March 21 the fume at the foot of the southwest talus appeared denser than usual. Scars of two small slides had appeared on the south wall; one over the northwest talus at 2:24 p. m. raised a cloud of dust. On March 22 at 10:55 a. m. a sound like floor cracking was heard. Slide dust arose at 12:30 p. m. March 23, and a larger avalanche at 1:40 p. m. dumped fresh debris on NW talus. At 2 p. m. dust continued to rise. The avalanche tremor was registered by the pit seismograph. This avalanche fell directly from the rock of the northwest rim for a length of 150 feet, and left large bowlders below. On March 26 glow was still reported visible in evening in crack at south edge of Halemaumau floor.

Observatory seismographs registered 66 tremors for the week, and two very feeble local seisms, one of which indicated origin 16 miles away. A distant earthquake was recorded beginning at 1:36:32 p. m. Hawaiian time (10 hrs. 30 m. slower than Greenwich) March 25, of probable distance 2980 miles from Hawaii. Tilting of the ground was very slight to the east, and microseismic motion was generally moderate.

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The Volcano Letter

Two dollars per year | **Ten cents per copy**

No. 380—Weekly | Hawaiian Volcano Observatory, National Park, Hawaii | April 7, 1932

Construction of Perret's upper station on Mont Pelé proper, November 1930, at Morne Lenard. Photo Perret.

THE NEW DOME OF PELE'E

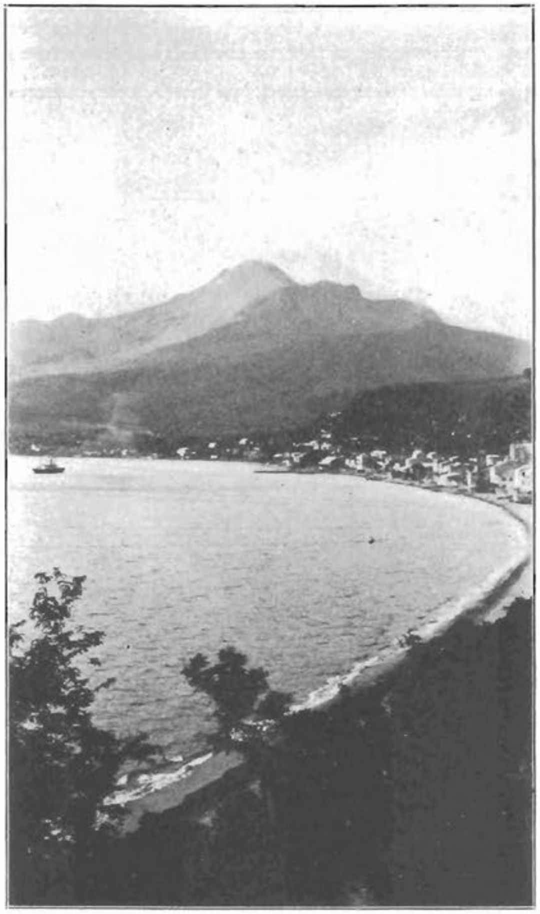
The renewed activity of Mont Pelé was mentioned in Volcano Letter No. 262. Ash eruptions were reported to have begun September 16, 1929. It appears that notes on the evolution of the dome were published in "Comptes rendus" 190-761, 190-623, and 191-1253, 1930-31, by H. Arsandaux. F. A. Perret has added two notes in the same publication, C. R. 193-1342, 193-1439, 1931. These last are reviewed here.

The formation of cone-in-cone structure by dwindling activity of mixed eruption, like Vesuvius in the ring of Monte Somma. is well known. The absence of a chimney in the center of a lava dome makes an interior edifice unexpected. Perret in January, 1930, when he first saw the Peléan dome of 1903, was interested to find it deeply caved in from the explosive process of September 1929. In the center of this cavity was an active eruptive cone.

The new excavation was a depression which widened from southwest to northeast, with a rocky ridge in the wound. The greater part of this was conical, but not the highest part. The explosive phase of eruption which continued in January and February exhibited two sources for steam-blast cauliflower clouds: a large one north, and a smaller and higher one southeast. The undermining produced a horseshoe cup with a medial extension like the latter "E.". With the kernel of the dome surrounded by talus, it was surprising to see the outer shell of weakest material hold itself up in steep walls, while the solid rock of the interior was removed. Evidently eruptive material rose high enough to form a shell whence eruptions diverged before destroying the lateral walls. From the time of the first 1929 eruption, all the explosions were from the inside of the dome of 1902-03.

The inner rocky ridge extended downhill ENE-WSW like a cock's comb, with the lower end a row of needles. Still lower at the ancient opening of the 1902 horseshoe, a series of vents in a line sent up puffs of ash. It could not be determined whether these were in new magma or a rocky remnant of the old dome.

The central ridge was not simple. It was a castellated group of towers. These were round, smooth, and spirally grooved. They appeared tubular. and often lava poured from apertures at the bottom. On the 20th of April, 1930, after an enormous downrush, round columns were left on the dome, black by daylight, but probably incandescent. The towers change rapidly. January 28 they appeared to be destroyed. But the activity appeared rather to be constructive, for on February 3 the towers appeared consolidated into an enlarged mass with the profile of a true dome. On the crest were rudimentary needles. Then came lava activity. that would have been 'Strombolian' if there had been explosive ejection, and this motion never ceased. Such crises were at first rhythmic, and alternating with the cauliflower jets, and they gradually resolved themselves into a regular constructive process, producing numerous needles On all sides of the new dome emerged slender incandescent lava flows. with emission of light transparent vapor. The process was comparable to that of lava cupolas on Vesuvius. The incandescence was dark orange under a thin crust in the darkest places, and elsewhere it was so bright that the illumination reflected on the cloud was visible at Fort-de-France. The flows were liquid a short distance apparently, then presented the well



St. Pierre as it is today, 1932. Photo Perret. Mont Pelé in background.

known "aa" streaming of fragments. The dome grew higher and on February 19 the summit was flat, crowned with small needles, and at the sides were straight talus slopes.

Two mechanisms are involved in the Pelée dome, the spread of lava and the thrusting out of needles. These last tend to rise vertically. This vertical rising is natural enough on the summit, but how about a slope of débris at 35°, where a line of vertical obelisks arises? Why does the internal magma push skyward and through chaotic material? This explanation appears to be the perforating power of rising gas. A fissure holding magma is opened to the surface by gases burrowing upward in a row of aligned chimneys. The magma follows, shells over in contact with the chimney wall, and the pencil so formed is pushed up. The lava flows are similar, but the orifices being more free, the slag remains hot and fluid.

During two months the carapace on the dome was so thin and the mass so fluid that the needles overturned on a pasty base, resembling large pears. The most conspicuous spine began March 25, promptly overturned, and rolled down the slopes. Examination of details at two spines showed one rising a meter per hour, the slope of the dome opening, like a soil clod with a mushroom pushing through. Pasty magma rose in a collar around the needle, then solidified, when the spine was three meters high. In the second case the paste was accompanied by gusts of vapor emerging between the spire and the slope. The needle remained small, but the steam jet continued several weeks. The average height of spines was 12 to 18 meters.

The dome of 1902 grew toward the northwest, overlapping the ridge there (Petit Bonhomme), so that its débris slope extended beyond the ancient crater of the E'tang Sec. The new inner dome has left a gulch on that side, but toward the east and southeast has overtopped the older dome, sent its débris slope down against the wall of the ancient valley on that side, and chilled and ceased activity there, except for fumaroles. In September 1931 the dome was migrating southwest and the long slope of ejecta was overtopping the ridges there so as to threaten the trail to the summit of the mountain. The new dome is 231 meters above Petit Bonhomme, and somewhat higher than was the peak of the old dome.

All the hot blasts (nuées ardentes) emerge from fractures in the dome of 1902 and mostly from the two openings, low north, and high southeast. After the new dome developed, the character of these gushes changed gradually. Four types of downrush are distinguished by Perret. The first is occasioned by an avalanche formed by the squeezing out of a small quantity of magma. It is an imitation of a true hot blast. The magma, not being greatly charged with gas, merely makes a heavy tumble of rocks, which slide down the slope, and excavate a trench. Dense, ashy, light-colored cauliflower clouds arise. The second type is occasioned by heavy rain falling on the dome which seems to penetrate it after a quarter hour or more, so as to start ejections of steam charged with dust which descend the slope rapidly as a gaseous emulsion. After heavy precipitation these down-blasts are certain to come, and they are important, some of them in the spring of 1930 following the gorge of the Riviére Blanche and out to sea for several kilometers. The last two types of gushing are avalanches of incandescent blocks without significant dust clouds, and finally a cooler ash phenomenon where blocks of uniform size roll rapidly and far, carrying imperfectly oxidized carbon gases, and emerging from a part of the dome which has partially congealed.

In the southeast part of the new dome there are fumaroles in a horizontal line, due to water, where the old and new domes are in contact beneath. Where the summit of chilled lava is in contact with active lava, bluish transparent vapor emerges at high temperature.

Mr. Perret has used a microphone for determining the variation in mass of the vibrating active dome. His theory is that an active edifice makes a definite note of lower pitch the greater the mass. The combined roar of slides, blowing of vapor, fall of spines, at any given moment make a musical tone, the timbre of which may be defined in terms of mi, fa, sol, la, si, etc., so the augmentation or diminution of the dome may be followed. His upper station was on the flank of Pelée at Morne Lénard.

At the beginning of November 1930 the tone was si flat. Three months later the dome was bigger and the tone was deeper, exactly la. April 13, 1931, it was sol sharp; June 4, sol; June 25, a little below sol; but on August 10 the pitch had risen to sol sharp, and it continued to become sharper, showing that the mass of the dome was decreasing, and that the arrival of new magma, inside, no longer equalled the loss by slides into the valley, and by erosion.

Establishment of a Research Center at St. Pierre

Mr. Perret has sent the following letter to the Hawaiian Volcano Research Association:

February 2, 1932.

"All the world remembers the destruction of St. Pierre, in 1902, by a terrific eruption of Mont Pelé. St. Pierre was not only the commercial center of Martinique, but the cultural metropolis of the Lesser Antilles. Excavations reveal the exquisite taste of the former inhabitants, and the relics unearthed from time to time are of great beauty, and of interest as showing the effects of the blast of hot gas and ash, which it is useful to study. Those objects—instead of being dispersed as found—should be preserved for all time in a collection, along with photographs of the beautiful ruins, fast disappearing in the rebuilding of the town.

"The recent eruption of Mont Pelé has reawakened scientific interest in this volcano, whose special type of activity is almost unique, and the products of eruption—breadcrust bombs, ash, and lava blocks in new forms—are most interesting. A complete collection of these, placed for comparison with the materials of other volcanoes, and with photographic studies of all their phenomena, is a scientific necessity.

"I may say that my own work here has resulted in a further demonstration of the pratical value of volcanology as an applied science. Eighty million francs of invested capital, depreciated to zero by panic and uncertainty, was restored to par value through diagnosis and prediction based on sound scientific deductions, with the help of apparatus devised for these purposes. For the further development of these methods, the creation of standardized instruments, the bringing together and preserving of the materials, etc., I am now founding at St. Pierre this research center, organized as museum—observing station—laboratory.

"A private institution, out of politics, and not governmental; its continuance, after me, is guaranteed by a Fiduciary Committee, consisting of men of the highest standing in the colony, including honorary memberships of the Mayor and Curé of St. Pierre. Its founding at the present time has been extraordinarily facilitated by the cession to me of a most ideal site for its emplacement, on the beautiful Morne d'Orange, 350 feet above the town, but easily accessible, and commanding a superb view over St. Pierre and of the entire massif of the imposing volcano.

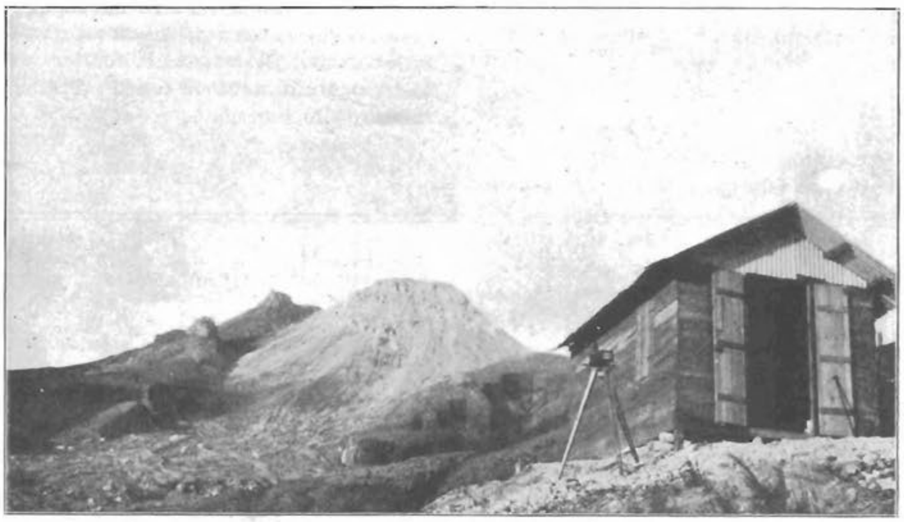
"Construction cost is largely covered by local contributions. This is not to be an American institution, but an American contribution to science in a location where this science can be best developed—a gift to St. Pierre as a continuation of American good will. St. Pierre is visited annually by some thousands of American tourists, whose interest will be quintupled by having a definite goal, where what they most desire to see will be on view.

"The contribution of one thousand dollars, as a minimum, makes the donor a founder of the institution, and the name will be on a marble tablet at the entrance, and upon the stationery of the museum. A few subscriptions are desired, above those already received, when this account will be closed. A total of ten thousand dollars is sought for the foundation.

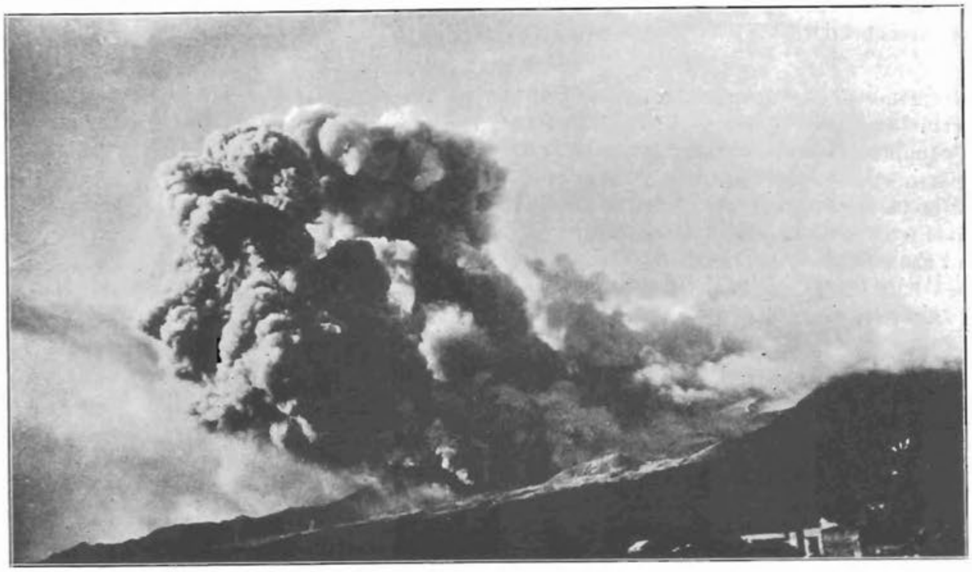
"This work—at once scientific, artistic, and humanitarian—is believed to accomplish more, with a small amount of money, than anything heretofore instituted. It will be selfsupporting through its museum, of direct service by its observation work, and world-contributing in its laboratory research. Contribution involves no obligation of future support.

"You are earnestly invited to become one of its few, distinguished founders."

Mr. Perret has been living at St. Pierre since 1929, and has already started the foundation with contributions from the Carnegie Foundation of Washington, Vincent Astor, and George F. Baker. It is to be hoped that members of the Hawaiian Volcano Research Association will be added to the list of founders, for it was Mr. Perret who camped



The upper station, Mont Pelé, after completion. Photo Perret.



Hot blast from the dome, Mont Pelé, February 9, 1930. Photo Perret.

alone on the edge of Halemaumau pit in 1911, and so started the work which established our Association. T.A.J.

TILTING OF THE GROUND FOR MARCH

The following figures show the net angular tilt by weeks at the Observatory on the northeast rim of Kilauea Crater, and its direction, computed from the daily seismograms, by platting a curve smoothed by overlapping seven-day averages. This is the departure of the plumbline in seconds of arc, in the direction given.

March 1-7	4.6 seconds SSE
March 8-14	3.3 seconds SW
March 15-21	1.5 seconds SW
March 22-28	1.1 seconds SSW

The accumulation of tilt to March 28 since January 1 is 17.4 seconds south, 0.7 second west. This is greater southerly tilting than whole years have produced usually, with the exception of 1924. E.G.W.

KILAUEA REPORT No. 1054

WEEK ENDING APRIL 3, 1932

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge.

On March 28 at 11 a. m. fume was issuing from a crack at the foot of the south talus in Halemaumau, and steam on this talus was abundant 100 feet south of the fume vent. Fume at the yellow vents at the foot of the southwest talus was unusually prominent. A slide at the north wall made dust at 11:53 a. m. Crack movements at rim of pit have shifted from northeast rim, now quiet, to southeast rim, where slight opening of fissures is now measurable. The rest of the week showed no changes.

The Observatory seismographs registered 5 very feeble local seisms, three registering distances of 14, 25, and 46 miles. There were 25 tremors, one indicating origin 18 miles away. Microseismic motion was strong March 31 and moderate at other times. Tilting of the ground was moderate to the south.

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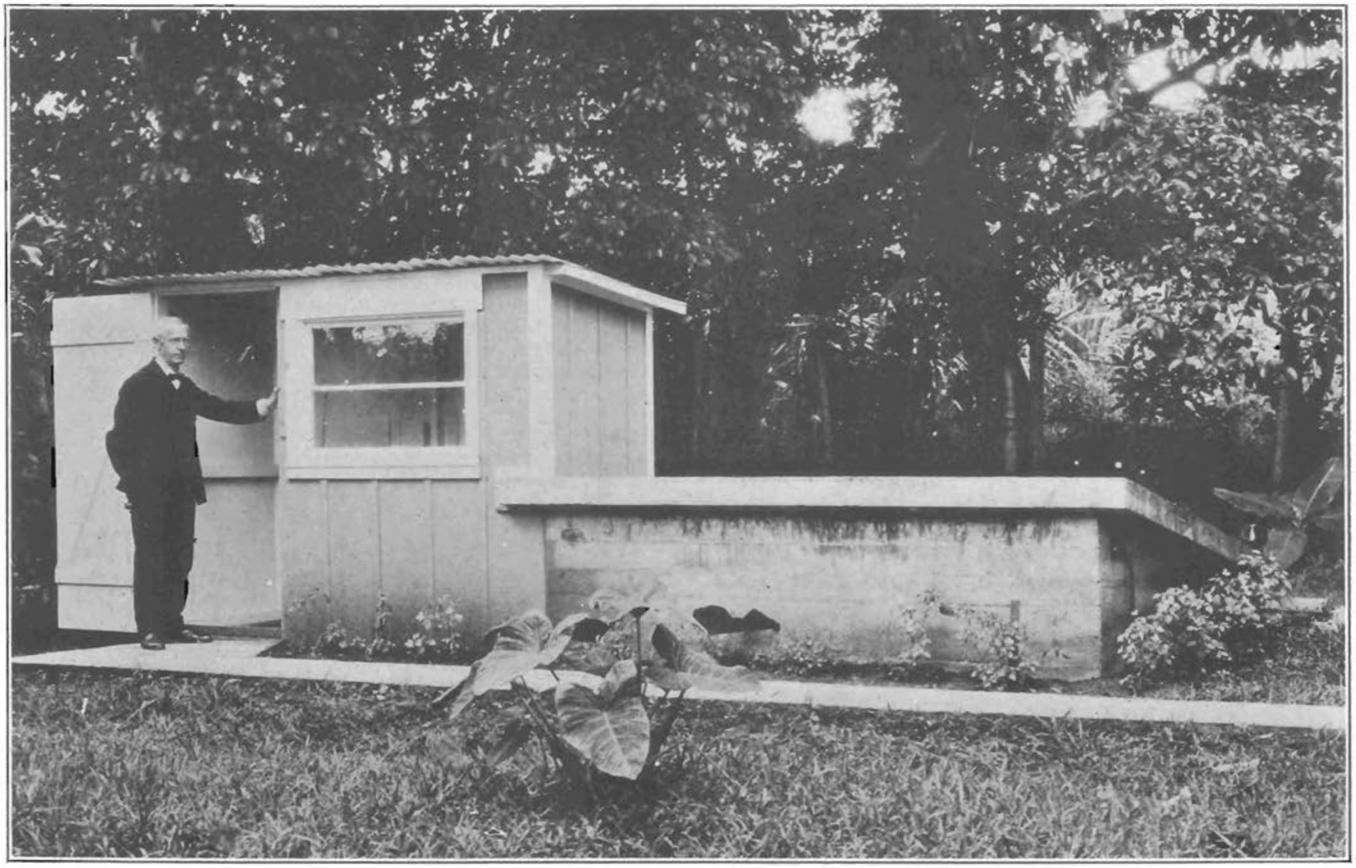


Seismograph cellar of the Hilo station of the Hawaiian Volcano Research Association, built in 1927. Brother J. B. Albert is the observer. The instrument consists of two heavy horizontal pendulums, with clock checked by wireless time signals.

TWENTY YEARS OF VOLCANO STUDY IN HAWAII

Address by T. A. Jaggar at Annual Meeting Hawaiian Volcano Research Association in Honolulu, March 31, 1932.

Administration

The Hawaiian Volcano Observatory was founded by an association formed in Honolulu in 1911 which undertook to finance a geological station on Kilauea Volcano established by the Massachusetts Institute of Technology. Ground was broken for the building on February 15, 1912, when Dr. T. A. Jaggar, who was then Professor of Geology at the Massachusetts Institute, had come to Hawaii for the purpose of establshing permanent volcano research. The Hawaiian society became a chartered corporation named the Hawaiian Volcano Research Association.

In 1919 the work was first assisted by the Government in collaboration with the Hawaiian association, and the governmental supervision was assigned to the United States Weather Bureau. The plant was leased by the Association to the Government at a nominal rental with the understanding that the Weather Bureau would furnish personnel and salaries. Since 1924 this arrangement has been transferred to the United States Geological Survey, which through the interest of the Congress has been enabled to enlarge the work to a Section of Volcanology with small stations in California and Alaska added to the Hawaiian establishment. Routine publication, now carried on through the Volcano Letter, has remained with the original Association.

The objects of the work from the beginning have been: (1) To keep and publish a record of Hawaiian volcanic activity and associated earth movements, (2) to invite specialists to Hawaii or to send them elsewhere for volcanologic studies, and (3) to do everything possible to promote the establishment of permanent volcano stations all over the world.

(1) Recording Hawaiian Volcanic Activity

The preliminary reconnaissance of the Hawaiian field was made by T. A. Jaggar and R. A. Daly in 1909. Mr. Jaggar had been engaged before this time in studies of Mont Pelée and Soufrière in the Caribbee Islands, of

Vesuvius after its eruption in 1906, of the Aleutian Islands in 1907, and through association with F. A. Perret he had been interested in the Messina earthquake. It was evident after the terrible disasters of Messina, Vesuvius, and St. Pierre, along with the earthquake-fire of San Francisco, that more studies of the earth from permanent stations should be made. This had been the subject of a crusade at Harvard and at the Massachusetts Institute of Technology, and a small endowment was obtained at the Institute for geophysical research, having in view the protection of life and property. This is called the Whitney Fund.

With the aid of this fund and through cooperation with the Geophysical Laboratory of the Carnegie Institution of Washington, Dr. E. S. Shepherd of that laboratory along with Mr. Perret, the former a chemist and the latter volcanologist, were induced to spend the summer of 1911 at Kilauea with a view to physical studies of the lava pit. Mr. Perret built a hut at the actual edge of the pit and made weekly reports to the press on measurements of change in the lava column. A cable was stretched across the pit and measurements of temperature of the liquid lava were made with electric thermometers.

The actual foundation of the Research Association was arranged at a luncheon in the University Club of Honolulu, October 5, 1911, when the late L. A. Thurston pointed out that there should be no break in the collection of records at Kilauea, and a subscription list which had been started in 1909 was revived. Mr. Jaggar arrived January 17, 1912, and weekly reports were reestablished. Through special subscriptions raised in Hilo, the present main Observatory building was constructed in February, with the Whitney Laboratory of Seismology in its basement. A topographic map of the proposed Kilauea National Park area was made by the U. S. Geological Survey as a basis for field work. The National Park became a fact in 1916 when Mr. Jaggar went to Washington to draft the final bill. The Volcano Research Association built and gave to the National Park Service the museum on Uwekahuna bluff in 1927.

The keeping of record books at the Observatory has been continuous from 1912 to the present. Mr. H. O. Wood came to the station as seismologist in the summer of 1912, a number of seismographs were set up, and the records were enriched by reports on tremors, earthquakes, and tilting of the ground, which proved to be motions of great interest, when studied in relation to the rising and falling lava.

The year 1912 was a time of vigorous activity in the lava pit, in 1913 the lava column became low and smoky, and thereafter until 1919 there was a steady rise with increasingly good opportunity for making comparative photographs. Mauna Loa broke out in 1914, 1916, and 1919, and these eruptions added to the interest of the work. In the summer of 1912 Doctors Day and Shepherd returned to Kilauea for gas collections at the live lava, and the temperatures proved to be various and somewhat proportionate to the volume of gases discharged by the many fountains. Mr. Jaggar was able to keep up the gas collections in subsequent years and to send the specimens to the Geophysical Laboratory for analysis.

The years from 1912 to 1924, however unfavorable they may have been financially, were fortunate ones from the volcanologic standpoint at Kilauea, in that they represented an eleven-year cycle of extraordinary vehemence for both Kilauea and Mauna Loa, with great variety of action, and a marvelous finale in 1924 when the crater pit of Halemaumau caved in through the recession of the lava, and a steam-blast eruption occupied the month of May 1924 in a fashion not seen here since 1790. The incessant measurements of change in gases, change in temperature, change in elevation of the lava column, and the photographic records accompanied by notes and transit measurements that produced maps of the crater fills and flows, all combined to yield a record of a decade of volcanic activity, in the most primitive volcanoes on earth, such as science had never possessed before. By primitive is meant the quality in a volcano, that exhibits the pure heat and magma, of the material under the primitive earth crust, not complicated with the impure mixtures of sea-bottom sediments and organic life such as occur on the continents. Vesuvius, Lassen Peak, and Katmai are all volcanic heaps made where the blast furnace of the earth crust has discharged through such rocks as limestone, sandstone, and slates. The glowing slag underneath has absorbed unkown amounts of carbon, lime, silica, and alumina.

After 1924 a quiet condition at Kilauea leads people to think the volcano is dead. Instead of this, we are recording some kind of outbreak nearly every year. Mauna Loa had a great eruption and destroyed a village in 1926, and an earthquake crisis on Hualalai in 1929 recalled the wonderful lava flows from that mountain in 1800, a time ten years after the last explosive eruption from Kilauea. The year 1934 will be ten years after the new explosive eruption. Are we to look for more lava flows from Hualalai? The present decade, therefore, is making a record which is a valuable asset, the like of which has not been obtainable since the end of the eighteenth century.

When it comes to earthquakes, the instruments for recording ground movements at Kilauea have been steadily improved, and the experience of 20 years with many ups and downs of the lava column, and outbreaks on Mauna Loa, and big earthquakes on Hualalai, has accumulated thousands of seismograms in the files of the Observatory. These are pieces of smoked paper fixed with shellac, on which automatic pendulums have written a graph of each earthquake or tremor or tilt, and have recorded the clock time. They are all different. Science can interpret from each graph the distance away of the source, the strength of movement, and how the elastic waves passed through the rock. Some of the instruments are in Hilo and Kona, so that when the distances indicated there are compared with the distances from the Observatory, the place underground may be found where the lava split its way upward and made a jolt. As some sets of earthquakes accompanied eruption, on the south flank of Mauna Loa, others on the different flanks of Kilauea, and yet others occurred on Hualalai, it becomes possible to classify Hawaiian earthquakes from their autographs, and the making of this classification promises years of valuable work. Those who think there is nothing to do at a volcano observatory during a quiet time should start studying some of these pieces of smoked paper.

The publishing of results is no small part of the work, and this involves, first, summarizing every week the essential observations at the Kilauea pit, at the seismographs, or on Mauna Loa or elsewhere if activity occurs. These summaries must be published in the papers, and also printed in more permanent form. It is further necessary to assemble observations of like kinds, and coordinate them for understanding the underground processes. An observatory is always a detective, trying to find out what is going on underground, from information the layman does not possess, yielded by a chemical collection, or a measurement with transit, thermometer, level bubble, or pendulum. These assembled observations have been published in scientific journals and it is one of the functions of the Volcano Letter to assemble similar communications from observatories in other lands, in order to make them known to our people here. There is much excellent work in Dutch, Japanese, Italian, French, German, and Spanish from the East Indies, Japan, Europe, and South America, for which a translation institute ought to be endowed, in order to sift out important facts which are now lost to most of the world.

Recording is nothing more than description. It is very hard to use language so as to tell the truth. The reading of any newspaper will prove this. Accurate description is all that is meant by "a theory." Modern physics is not trying to explain the "why," or to explain anything;

it is trying to describe the "how." This is what we are trying to learn about an active volcano, "how" it works. A mere quantitative measurement in figures by itself means nothing. Recording, to be accurate, meaning careful, must be checked all the time by quantitative measurements. These measurements may be put together to make a description, so that the difference between one event and another is dependent on the readings of the measurements, and not on guesswork. When enough of these differences have been collected, it becomes possible to classify events, and then the classifications fall into sequences, and the complete description of a sequence suddenly discovers (or uncovers) what has been going on, in the under-earth, at a place which was invisible. This final description of things unseen is a "theory."

Take in illustration of this the matter of prediction. How can you predict when a volcano is going to erupt? It is first necessary to measure an eruption and to tell the truth as to what an eruption is. If you classify as "eruption" the smoke from an island seen by a mariner, entirely unmeasured, and compare it with the rise of lava for six years measured in Halemaumau pit by scientists, you get nowhere. You do not know whether the mariner's "smoke" happened all the time, or every year, or every six years. You can not describe the "how." In the case of Kilauea, the scientists continue for another five years and find the lava going down and out. Then comes a lull for two or three years. They study the records for a hundred years back and find many measured risings for six years, and sinkings for five years, followed by a lull. Then they find that two volcanoes adjoining took part in this sequence. Perhaps they find in separate years that the biggest risings were in the autumn and the sinkings in the spring. This is a measurement by seasons and years, just as other measurements are by heights and depths. They average all the results. The average shows an eleven-year cycle as a probability for that pair of volcanoes. They may even find that this eleven years corresponds with sunspots, and then that the irregularities in numbers of sunspots which depart from the average, correspond with the irregularities in highest rise of the lava during the century. They know nothing about the "why," but here is a very interesting "how." Knowing all these things, they can "predict" that the next "eruption" will occupy eleven years, will begin by rising and end by sinking, will have its annual rising spasms higher in winter, and if the term is not exactly eleven years, it is likely to depart from that figure in the same way that the sunspots do. Knowing the relation of the two volcanoes, they perhaps can say, that in the course of this eruptive cycle, Mauna Loa is sure to help out Kilauea once or twice during the eleven years.

What is now an eleven-year theory, a seasonal theory, a relationship theory, and a sunspot theory, may eventually advance a step farther so as to describe how all these things are related to some bigger processes in the crust of the earth. They will then all become facts and not theories, but the larger process will remain in the realm of theory. Science is merely piled up descriptions.

(2) Studies by Specialists

In addition to work which has already been mentioned, Dr. E. T. Allen of the Geophysical Laboratory spent a season at Kilauea analyzing the vapor at the sulphur vents, and determined it to contain 96% steam and less than 1% of the sulphurous products. Boring indicated that the temperature, 204° F., is extraordinarily constant.

For two seasons Dr. Arnold Romberg worked at the Observatory on seismograph instruments, and set up optical instruments to determine in what direction the wave movements known as microseisms are propagated through the ground at this place. Also special instruments were designed to measure the tilting of the ground, which was found to have a half-daily and semi-annual change. These changes must be allowed for when measuring what tilts are made by the pressure of the lava underground. Some remarkable changes of tilt have coincided with sudden risings and fallings of lava shown by outbreaks of Kilauea and Mauna Loa. The microseismic waves were found to coincide in direction with the high cliffs of the Hamakua coast bombarded by tradewind waves.

Messrs. J. B. Stone and C. K. Wentworth at different times have studied the geology of Hawaii, and Mr. H. T. Stearns and others have produced a Bulletin of the Geological Survey on the geology of Kau. Dr. Howard Powers is at work on the geology of Kona. All of these studies are providing new knowledge of the soils of the island in relation to the lava flows and the deposits of ash from past eruptions. A basis is being laid for classification of formations and interpretation of the past history of the earlier volcanic vents which preceded the active volcanoes of today. Dr. Wentworth has made a special study of the ash, especially the cinder of the many small cones on the slopes of Mauna Kea, and has greatly enlarged our knowl edge of how those cones were formed and of the differences between the gas eruption there and the liquid lava eruptions on Mauna Loa at the present day.

Mr. Jaggar has been four times in Japan, three times in Alaska, and once each in New Zealand, Costa Rica and the Tonga Islands for studies of earthquakes and volcanoes. These comparative studies are of value not only in showing how different are the volcanoes of different lands, but also the contacts with men of science tend to encourage the last of the three objects above enumerated, namely, promotion of new volcano observatories elsewhere Mr. Finch visited volcanoes in the East Indies in 1929 and Mr. Stone explored and photographed several craters in Chile the same year, both of these men being commissioned by the Hawaiian Volcano Research Association.

Messrs. Wood and Finch have completed a bulletin now in press in Washington listing in technical form all the measured earthquakes registered on the seismographs of the Observatory from 1912 to 1923. This list comprises thousands of shocks and is illuminating in showing the large number of earthquakes which accompany sinkings of the lava, the frequency varying with the rapidity and depth of the sinking. An increase of frequency of earthquakes also accompanies sudden risings of the lava in Halemaumau. In Mauna Loa eruptions the freqnency is greater at the beginning of an outbreak, and as the frequency declines the strength of the shocks becomes greater. In general the comparison of times of fewer earthquakes in Hawaii, with times of high frequency, shows that the greatest intensities of quaking (or the strongest shocks) come when the number of shocks is at a minimum.

(To be continued)

KILAUEA REPORT No. 1055

WEED ENDING APRIL 10. 1932

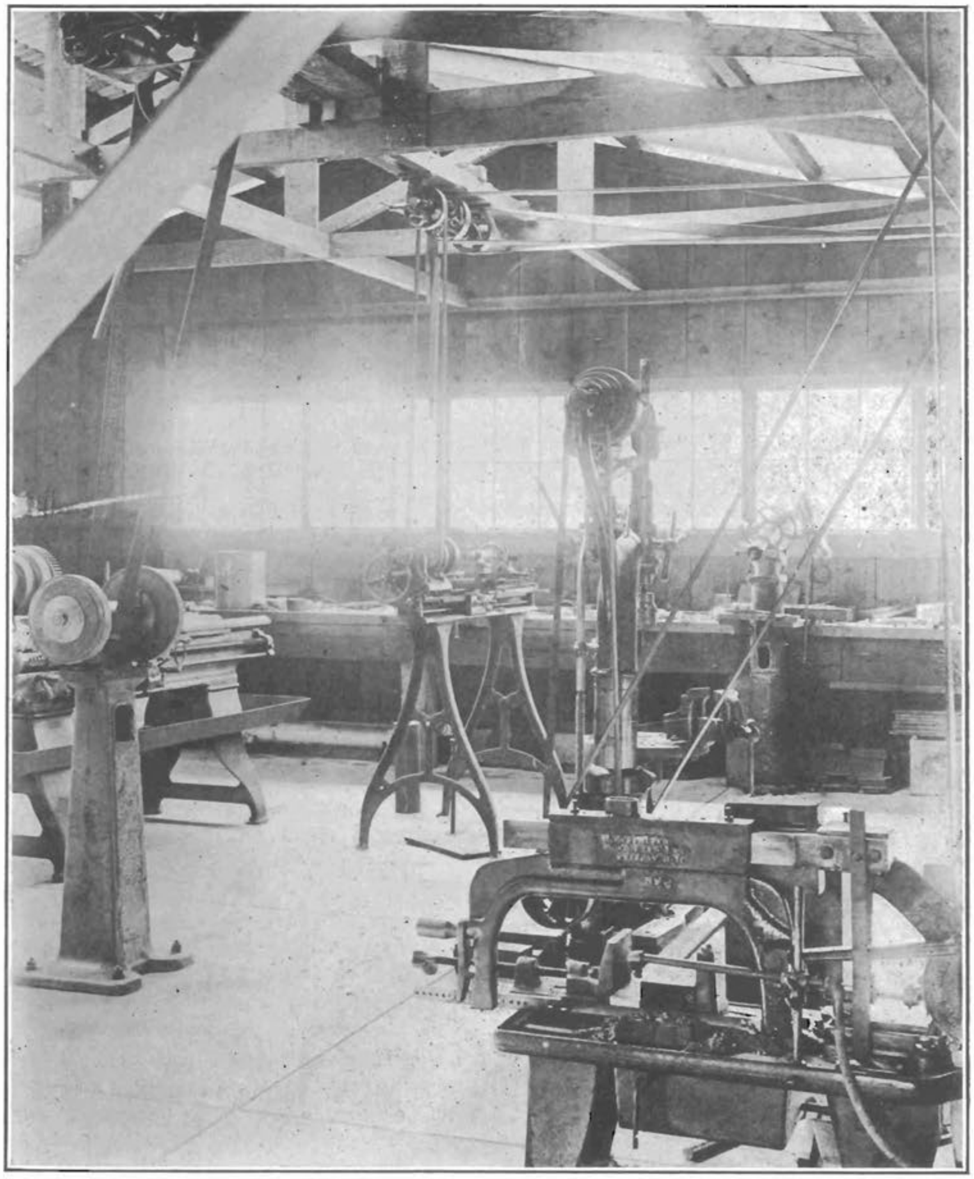
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge.

Conditions at Halemaumau show little change. The pit was quiet April 4, with slight steam and little variation in fume.

Crack measurements showed very slight changes. On April 6 fume was moderate at the foot of the southwest talus and the spot under the southeast wall and talus still fumed slightly. Brilliant yellow sulphur stain showed at the fume area by the southwest talus. The scar from a small slide was seen on the northeast wall. On April 7 fume at the foot of the southwest talus was dense all day and some fume was visible at the spot under the southeast wall. On April 9 fuming activity had not changed. The seismograph at the pit showed ESE tilt accompanying the earthquake at 5:50 a. m. One tremor showed E tilt

The seismographs at the Observatory recorded 52 tremors, four very feeble seisms, and two feeble seisms. One tremor at 6:25 a. m. April 5 was felt at Waimea and Puuwaawaa and had origin distance 46 miles from the Observatory. One feeble seism at 4:50 a. m. April 9 was felt at the place called "Twenty-nine Miles."

Average tilt for the week was slight NE by N. Microseismic motion was moderate during the first three days of the week, light for the next three days, and moderate on the seventh day.



Machine shop at the Hawaiian Volcano Observatory, installed by the Research Association. There are two lathes, two drill presses, a machine hacksaw, and a grinder, while in the adjacent carpenter shop are power plant, boring machine, and circular saw.

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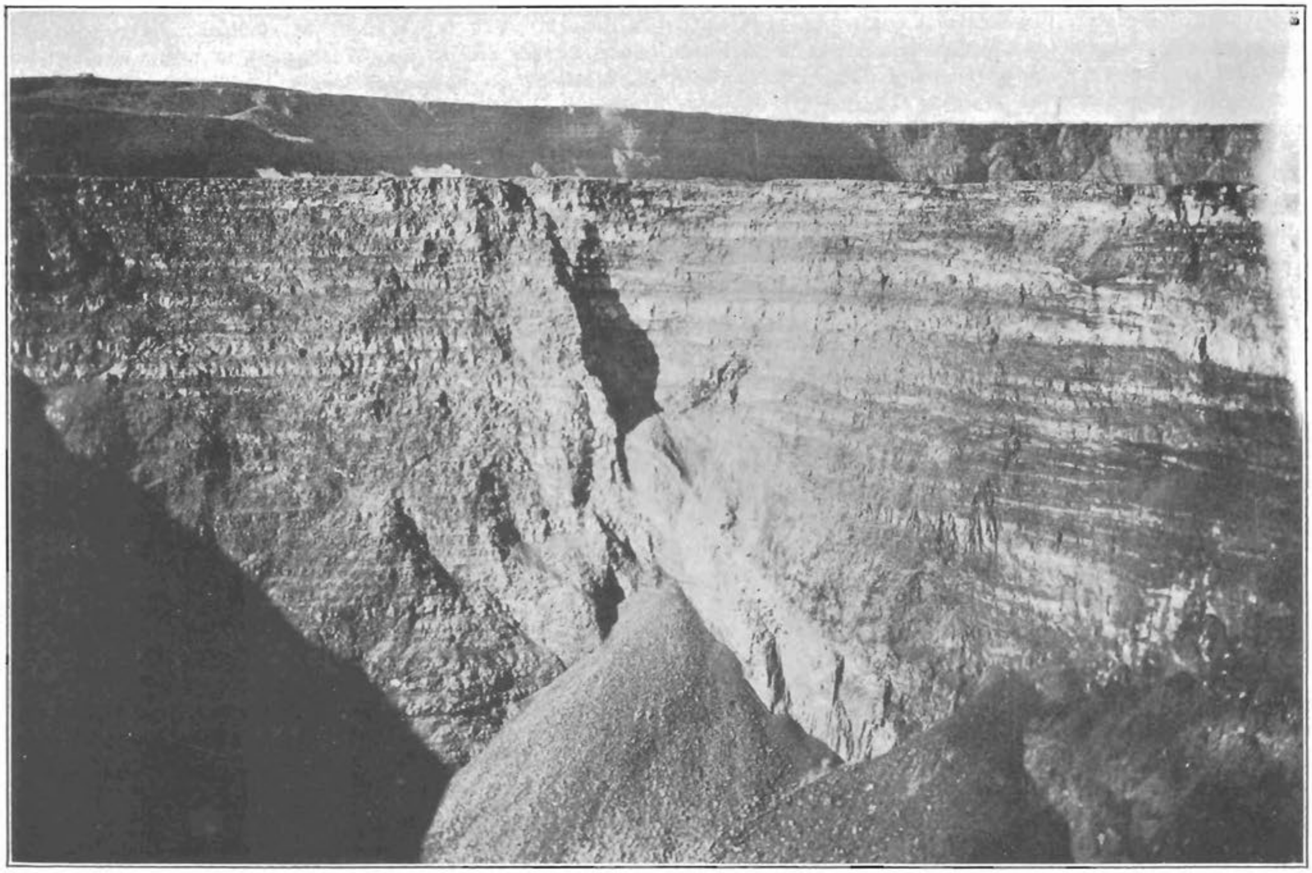
The Volcano Letter

Two dollars per year | Ten cents per copy

No. 382—Weekly | Hawaiian Volcano Observatory, National Park, Hawaii | April 21, 1932



Interior of the present Halemaumau pit, showing the north corner, and behind it the cliff bounding the outer Kilauea Crater. The U-curve of white ledge at bottom is the cross section of a former pit. It shows a talus in cross-section above the white ledge. The white ledge was revealed red hot by the engulfment of 1924. The horizontal layers are lava flows, all produced in the nineteenth and twentieth centuries. Photo 1927 by Wilson.

THE RESULTS OF VOLCANO RESEARCH

(Continued from Volcano Letter No. 381)

Second Part of Address by T. A. Jaggar, Annual Meeting Hawaiian Volcano Research Association in Honolulu March 31, 1932.

(3) World Volcano Stations

In 1926 a seismograph station and observatory were established at Lassen Volcanic National Park in California under Mr. R. H. Finch, who had been in Hawaii. This station has recorded hot spring temperatures and earthquakes, and has served as a base for geological studies in that interesting volcanic region. The work is being extended to other volcanoes of the northwest. Seismograph stations have been placed at two other points in Lassen Park.

In 1927 a seismograph station was established on Kodiak Island, near the Katmai group of volcanoes of the Alaskan Peninsula, and in 1929 a second station was fitted out at Dutch Harbor, on Unalaska Island in the eastern part of the Aleutian chain. In the hands of resident observers these instruments have been operated so that the seismograms are sent for study to the Hawaiian Volcano Observatory. A moderate number of local earthquakes at these stations and at Lassen indicates that some seismic activity accompanies the underground movement of volcanic magma in these places, but there is no such earthquake frequency as exists in Hawaii.

Beginning about 1918 the government of the Netherlands East Indies started a volcanologic service under their Bureau of Mines with headquarters at Bandoeng. This work has steadily grown for 15 years, a small pamphlet each month describes the temperature measurements and earthquakes and volcanic activities at several volcanoes, mostly in Java, and large, beautifully illustrated monographs in the Dutch language, latterly with summaries in English, have been published dealing with important eruptions of several of the great volcanoes and the volcanic islands belonging to the group. A number of small observatories are maintained.

The Japanese Empire has maintained a government earthquake investigation service since 1892, in which Professor F. Omori became the dominant figure. The motive of this service from the beginning was to find out everything possible about local earthquakes with a view to alleviation of disaster. To this end engineers. physicists, seismologists, geologists, and other specialists in universities were employed by the government, largely gave their services free, and published a series of important memoirs continuously in both English and Japanese for 30 years. Professor Omori concentrated on volcanoes during the last 15 years of his life, and his serial monographs on Asama, Sakurajima, Usu, Oshima, and other volcanoes, written in English, are among the most important of his productions. Earthquake investigation was reorganized after his death in 1923. and researches directed particularly to tilt and level changes, and to the needs of engineering, have been elaborated since the Tokyo earthquake. Professor H. Tanakadate has studied volcanoes. Seismographs of many kinds are distributed all over Japan, but a permanent volcano service has not yet been organized.

,In Italy, which established an observatory on Vesuvius in the middle of the nineteenth century, the publications about volcanic activity have been largely separate papers in scientific journals from the workers at the observatory and from seismologists and geologists in the universities. In 1924 a new series of volcanologic bulletins was started under Dr. Malladra, Director of the Vesuvian Observatory through the International Geophysical Union. Also some revival has been made of the Annals of the observatory. Mount Etna has also an observatory building on its high slopes, but the workers dwell at the university in Catania. In Naples Dr. I. Friedlaender has established at private expense a Volcanologic Institute and publishes in beautifully illustrated form a long series of volcano researches in several languages by workers all over the world. The first volume was published January 1914.

There have been a number of disasters due to earthquake and volcanoes in New Zealand, and in 1920 the writer as delegate from the Hawaiian Volcano Research Association gave a series of lectures in the universities of New Zealand on the observatory work in Hawaii and on the opportunity for continuous observation which the New Zealand volcanoes offer. The terrible earthquakes of Murchison in the South Island in 1929 and Napier in the North Island in 1931 have served to concentrate governmental attention in New Zealand on alleviation of disaster. Before these earthquakes Mr. L. Grange had been appointed to act as a volcanologic geologist and had done much mapping in the Rotorua volcanic district. Since the earthquakes, the Hawaiian Volcano Research Association has been able to assist somewhat by supplying simple seismographs for distribution in New Zealand under the government Department of Scientific and Industrial Research.

Seismologic services studying local earthquakes exist in Chile, Greece, Austria, Germany, Mexico, India, and Russia, and in some of these places some attempt has been made to begin the study of volcanoes. The Soviet has organized expeditions in Kamchatka, a little work has been done in Salvador and in the Caribbee Islands, some special expeditions have reported on Iceland and on volcanoes near New Guinea. Excellent studies have been made from the university in Athens of the active volcano Santorin and other volcanoes of the Grecian Archipelago. There are enormous volcano belts in the southwest Pacific, in Africa, the whole length of the west side of South America, and of the west side of Central America, which still await a prophet.

Three activities should be mentioned which deal with volcanoes effectively by the statistical method and by expeditions. The universities of Germany have produced Karl Sapper and F. Von Wolff. each of whom has written a textbook on volcano science. Sapper deals with geography and Von Wolff with geology of volcanoes. The Carnegie Institution of Washington through the workers under Dr. A. L. Day has sent out a series of expeditions and published monographs on Katmai, The Geysers in California. Lassen Volcano, Vesuvius, and some other places, and this work sets standards for analyses of gases, sublimates, and rocks, as well as hot waters, in accordance with critical dicta of physical chemistry. The third activity is the publication of the Geographical Society of Geneva, under th Red Cross, which has been issued quarterly since 1924, dealing with the study of calamities. as subjects of scientific prevision and alleviation (Matériaux pour l E'tude des Calamités). This organization has had subcommittees in many countries, and the assemblage of facts has been of great value.

Before leaving world volcano stations, the recent work of the American, Frank A. Perret, a distinguished volcanologist who wrote the great monograph of the Carnegie Institution on "Vesuvius," should be mentioned. He has been living at St. Pierre in Martinique since the end of 1929, and has obtained support for a museum and research center at St. Pierre, which it is planned to make self-supporting through charges to tourists who visit the ruins of the great disaster of 1902 by thousands. This will be a private institution, for which an ideal site has been granted by the French government with construction cost covered by local contribution. The idea is a non-national institution created as a gift to St. Pierre, as a continuation of American good will. Each contributor of $1,000 or more will become a founder, and those who have started the foundation are the Carnegie Institution of Washington, Vincent Astor, and George F. Baker. It is to be hoped that the Hawaiian Volcano Research Association will be added to the list of founders, for it was Mr. Perret who started our work here in 1911, and who published on the eruption of Teneriffe in the first memoir of Friedlaender's Zeitschrift in 1914. In many respects Mr. Perret is thus the founder of modern volcanology from an experimental viewpoint.

(4) Results of Volcano Research

Two principles have been kept in mind, which are unusual in guiding the work in Hawaii: (1) Appeal to people of ordinary education in describing our results; (2) Use people in ordinary life in order to get those results. These mean, first, that the motives should be humane and not highbrow, and the work should be describable as meaning something to business men who want to know why it is done. Secondly, the harnessing of a large piece of country with observations, or instruments, or measurements, can never be done by distributing physicists permanently all over that country. The experts won't go. They prefer the council-chamber of the university. This difficulty may be met only by interesting ordinary people in a method of measuring earthquake or tremors or tiltings, so that they will send us a postcard every week. In order to do this, the method must be simple. The high-brow may sometimes scorn simple methods. And yet Darwin's and Faraday's greatest works were done by simple methods. So it must be in compelling the earth to tell the story of how its breathings in Alaska are different from its breathings in Hawaii.

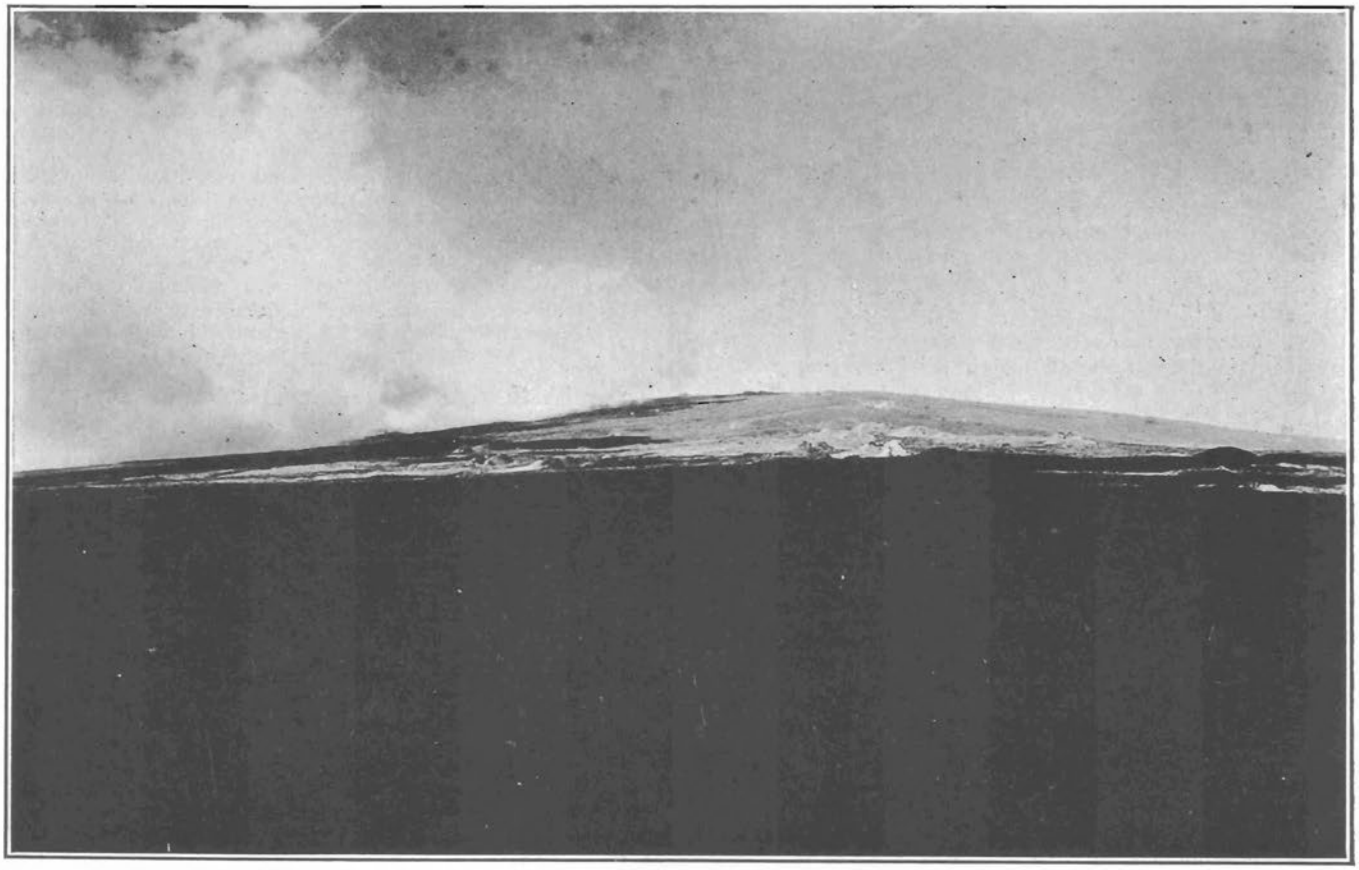
Here are a few of the facts suggested by work of the last twenty years:

1. That volcanism everywhere has unity.
2. That gas is its prime mover.
3. That hydrogen and olivine basalt are fundamental constitutents.
4. That water is a secondary oxidation product.
5. That sulphur is concentrated at craters.
6. That engulfment is a common process.
7. That explosive eruption is secondary.
8. That major earthquakes may be magmatic in origin.
9. That magma continually presses upward.
10. That cycles are caused by yielding to pressure.
11. That this applies equally to earthquakes and volcanoes.
12. That small crust units involve short cycles.
13. That large crust units involve compound cycles.
14. That these may be of several orders.
15. That a volcanic cycle may exist at intrusions.
16. That intrusions may be studied by tilt and earthquakes.
17. That every volcano has intrusions under it.
18. That submarine outflow of lava is important.
19. That the present is a decadent time in earth volcanism.
20. That from Midway to Hawaii and along the volcanic rift, the crust has thickened and condensed.

We can think of the globe as at some time an incandescent member of the Sun's family. Up cracks as it cooled there piled up lava ridges. Our Hawaiian Territory is one such ridge. Studying the outpouring lava at Kilauea we found it divided into half-hardened, and frothy liquid, portions. We sounded the liquid and found it shallow. The half-hardened stuff was below. We took temperatures and found that the liquid was hottest above, where the most gas was burning. We found that Mauna Loa outbreaks ended with a Kilauea collapse. We found that splitting open the mountain visibly was attended by many earthquakes when lava burst up cracks. It turned out that there was local swelling of the ground. This was greatest at the pit edge. Tilt pendulums showed that it was happening farther away. It proved eventually that there are seasonal and daily tides in the lava and in the swelling of the mountain. The gases rising are mostly hydrogen, carbon monoxide and sulphur. They make flames. Water vapor, carbon dioxide and sulphur dioxide are in the greatest volume, because the burning goes deep. Boring to study ground temperature showed that hot places are due to vapor cracks. In 1924 the steam-blast eruption was preceded by a splitting of the mountain out to seashore, and accompanied by a sinking of lava and engulfment of the walls of the pit. The conviction that the lava escaped under the sea was unavoidable. The groundwater entered the hot hole and exploded. It extended the engulfment and made rhythmic geyser explosions. The last such cataclysm was in 1790. A super-cycle of 134 years was indicated, the interval between two lowerings of lava below the groundwater level for Hawaii.

With this outline for working hypothesis, it is easy to see how interesting it is to be the workers to build tilt and tremor instruments, and try to harness the crater and the island in order to interpret what is going on underground. This is what we are working on today with the instrument, designed at the Observatory, called a "clinoscope." It is a heavy horizontal iron ring, hung on wires, with a light vertical magnifying lever pointing upward in the middle. At the top is a dial. The ground tilts and the pointer wanders away from the center of the dial. This wandering each day is to be read in three cellars 400 feet back from the Halemaumau rim. These cellars are to be kept quiet and at constant temperature If the lava is swelling under the botttom of the pit as a center, the three cellars will show tilt away from the center on the clinoscope readings. If the lava is lowering they will show inward tilt. Eventually we expect to have these cellars wired so that each instrument may be called up by automatic telephone, and the pointer position will report itself electrically to the Observatory. This is the latest result of twenty years of work at the Hawaiian Volcano Observatory.

Kapoho, east point of Hawaii, looking northeast at one of the cones of the Kilauea rift zone near the sea. The fresh cracks in the foreground were produced in April 1924, when "the steam-blast eruption was preceded by a splitting of the mountain out to seashore." Photo Maehara.



Just as the Hawaiian islands form a lava ridge, so on Mauna Loa the southwest rift is a flat ridge. Here we are looking up the ridge, formed of source cones of many eruptions, from 8,500 feet elevation. These are true "fissure eruptions" and here is a vast experimental laboratory for the volcanology of the future. Photo Emerson 1923.

KILAUEA REPORT No. 1056

WEEK ENDING APRIL 17, 1932

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge.

Some fume was visible at the foot of the southwest talus on April 12. Cracks within old roped-off area at the southeast rim showed definite but very slight widening. On April 13 at 10:15 a. m. fume could be seen eastward from the southwest talus area, and slight odor of sulphur could be detected. Countless small steam vents were giving out feathery clouds in Halemaumau after rain, and steam at the larger vents was dense. Fume was also visible under the southeast wall in cracks in the new lava fill. Occasionally rocks trickled down the north wall. On the 14th fume was as usual at the foot of the southwest talus, but was not visible southeast. The northeast rim cracks showed no change On the 15th at 10 a. m. Halemaumau remained without changes. On the 17th the sulphur spot at the southwest fuming area showed increase of stain.

The seismographs at the Observatory registered 15 tremors, two very feeble seisms, and one feeble seism. Two of the tremors showed doubtful origin distances of 42 and 56 miles, respectively; the two feeble seisms, 32 miles and 25 miles; and the feeble seism, 10 miles WNW of the Observatory. This last shock awakened sleepers at the volcano, and in Honomu, Kona and Hilo at 2:55 a. m. April 17.

Microseismic motion was moderate through the week. Tilting of the ground averaged very slight to the east.

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The Volcano Letter

Two dollars per year | Ten cents per copy

No. 383—Weekly | Hawaiian Volcano Observatory, National Park, Hawaii | April 28, 1932

The official party April 19, 1927, at the opening and dedication of Uwekahuna Observatory and Museum on the high western bluff of Kilauea Crater. Presented by the Hawaiian Volcano Research Association to the National Park Service. Right to left, the late Hon. Stephen Tyng Mather, Director of the National Park Service, Hon. Hubert Work, Secretary of the Interior, Volcanologist Jaggar, and Hon. Wallace R. Farrington, Governor of Hawaii.

PROGRESS OF HAWAIIAN VOLCANO RESEARCH

(Continued from Volcano Letter No. 382)

Third part of address of T. A. Jaggar, Annual Meeting of Hawaiian Volcano Research Association in Honolulu, March 31, 1932.

We have seen the growth of twenty years of volcano study in Hawaii by the observatory method, the growth of world volcano stations and some scientific results of volcano research in general. It will now be of interest to the members of this society to review the material progress of the work in Hawaii for the past ten years. The work of the first decade was outlined in the Monthly Bulletin in various annual addresses of 1913, 1915, 1916, 1917, and 1922. The year 1920 had started a new five-year program for the Association, with installation of seismographs at Hilo, Hilea, and Kona, and Dr. Omori, who had visited the Observatory with the Pan-Pacific Science Congress of 1920 had advised us to concentrate on the Mauna Loa center so as to interpret the direction, distance, and depth of the original impulses which make our local earthquakes. A second project was to do core drilling in the vicinity of Kilauea Crater for securing new light on temperatures, volcano power, the relation of volcanism to mining, underground water, and the relation of underground heat to gas. The third project was to secure publication of certain voluminous scientific papers which were ready, but unfinanced.

The Science Congress had recommended a central scientific bureau for dissemination of volcano news about the Pacific. This our Association has somewhat done by publication of the Volcano Letter. A second resolution of the Congress to the effect that the dwellers in volcano lands should be educated on the meaning of volcanoes and earthquakes, and on safeguards and insurance against them, has been promoted by the Volcano Letter, and by such magnificent work in America, Japan, the Dutch East Indies, New Zealand, etc., as is summarized in Sapper's book on Volcano Science, von Wolff's book of Vulcanism, and Freeman's book on "Earthquake Damage and Earthquake Insurance." A third resolution was that ecological studies should be carried out dealing with the rehabilitation of lava and lava soil by organisms, and this was started in Hawaii by Dr. Skottsberg under the Bishop Museum with some assistance from us, by marking ten-meter squares on lava flows of known date, and listing the lichens and other organisms found. These were to be reoccupied at future dates. Another study bearing on this subject has been published by Dr. Howard Powers of the Hawaiian Volcano Observatory in association with Messrs. Ripperton and Goto (Bull. 66 Hawaii Ag. Exper. Sta.), whereby the ash and lava soils of Kona have been specially classified for their adaptability to coffee culture. A last resolution of this Congress recommending that a station be placed on the top of Mauna Loa for combined aerology and volcanology remains still as a goal, but some progress toward it has been made by improvement of trail, and surveys for a road, by the National Park.

The year 1921 produced important material progress at the Observatory in a first shop and electric plant, in a revision of crater surveys for years back, in a beginning of monthly maps of the pit, in new crater experiments, in improved photographic apparatus, in computed curves of the lava tide investigation, in new money for an archives building and for boring, and in the discovery, by the topographers of the United States Geological Survey, of probable elevation of the rim of Kilauea Crater by from two to three feet between 1912 and 1921.

In 1922 the boring experiments were begun, were continued with both churn and core drills until May 1923, and were revived with air drills in 1926 and discontinued in the winter of 1927-28. There resulted 34 drill holes on the crater floor and the crater rim of Kilauea, which are valuable assets of the Observatory for all time as places for experiment and for measurement of change in temperature and gas chemistry. The iron Archives Building was built in 1922, furniture and garages were improved, a chemical laboratory was started, and Mr. R. M. Wilson produced a first draft of "the Volcano Local System of Levels and Triangulation," which now in 1932 he is finishing in Washington in order to exhibit the important changes by land moment, precisely measured, which have occurred during activities at Kilauea Crater.

This year 1922, beginning the second decade of our work, was one of extraordinary progress for the Research Association in buildings, seismology, drilling for temperatures, and improved equipment. Machinery, tanks, cabinets for seismograms, chemical laboratory, and shop for instruments were added. Seismograms began to appear from Hilo, Hilea, and Kona. Dr. Allen came from the Geophysical Laboratory in Washington to work on the physical chemistry of the bore-hole steam at Sulphur Bank. Here an iron hut had been set up over the hot wells.

In 1923 Dr. O. H. Emerson was employed as chemist and general assistant, Dr. Jaggar was sent to Japan for three months to investigate the Tokyo earthquake, a remarkable motion picture film was obtained there, he made explorations in Tokyo, Yokohama, Kamakura, Boshu, Oshima, and Hakone, he assisted at some committee meetings of Japanese engineers and seismologists, and it was determined by the United States Government after the disaster that a plan for the new embassy should be referred to the Bureau of Standards. It is of interest to note that the earthquake-proof embassy of the United States in Tokyo is now finished. Mr. Jaggar insisted then as now that the volcano Mihara on Oshima Island, in Sagami Bay close to the seismic center of the great earthquake, one of the few volcanoes in Japan which produces lava in its crater most of the time, is a remarkably important place for a permanent observatory.

The scientific staff of the Observatory at this time consisted of Messrs. Jaggar, Finch, and Emerson. The record books were complete to 1923, and these books, typewritten in loose-leaf covers, including photographs and transcriptions of notebook sketches, were duplicated so that one set was kept in Washington. In the winter of 1923-24 the director of the station went to the eastern United States, read three papers at the American Association meeting in Cincinnati, and gave 26 lectures in Cincinnati, Washington, at Maryland University, in New York, New Haven, Cambridge, Boston, Brooklyn, Chicago, Urbana, and Philadelphia. He published articles, setting forth the work of the Association, in the National Geographic Magazine, the American Magazine, Asia, Scribner's, Popular Science Monthly, Bulletin of the Seismological Society, Monthly Weather Review, and the New York Times and Herald-Tribune. The steam-blast eruption of Kilauea occurred in May, 1924, and was admirably cared for by Messrs. Finch and Emerson, the director returning the end of May. The station was transferred to the Geological Survey July 1, 1924. Mr. Boles of the National Park Service ran levels across the disturbed area of Kapoho in Puna, which were of great value in outlining the down-dropped block of country there, which had lowered about 10 feet. It was at this time that numerous papers were published showing that tides, tilts, and cycles affected the lava of Kilauea.

Up to this time the Massachusetts Institute of Technology had continued to be a valued contributor to the Association. In later days the Institute has transferred its experimental work in geophysics to New England fields, but the highest appreciation should be expressed on behalf of the Hawaiian Volcano Research Association to this solid engineering school for bringing about the foundation of the work in 1911 which the Government and the Association have carried forward.

With the entrance of the United States Geological Survey on the work, the Government cooperation had been in progress, since the execution of a lease of the laboratory, from the Association to the Weather Bureau, April 19, 1919. Every assistance and most sympathetic collaboration was given by Chief Charles F. Marvin to volcanology while it was under the U. S. Weather Bureau. Dr. Marvin is himself a seismologist of note. The Research Association has been left entirely independent as a collaborating organization, but at all times the initiative for new methods, new discoveries, new apparatus, outside stations in Hawaii, and for publications and library, has rested with the Association. Also Research Fellows such as Dr. Romberg and Dr. Emerson, called in for studies of physics and chemistry, have been employees of the Association The regular staff is salaried by the Government, but much of the upkeep and nearly all of the improvement in buildings and apparatus has come from the Association.

During the 15 years since the work was started, the Research Association had seen grow the interest of the Congress of the United States in seismology and volcanology; the interest of scientific journals in Italy, Germany, Holland, Great Britain, France, America, and Japan, and of seismological and volcanological establishments in Geneva, Paris, Oxford, and Naples; the interest of the Carnegie Institution, the Pan-Pacific Union, the Weather Bureau, the Coast Survey, the Geological Survey, the National Geographic Society, and the universities and museums in the United States; and the establishment of bureaus and commissions on volcanoes, especially in Japan, the Dutch East Indies, the Philippines, New Guinea, New Zealand, Mexico, and Costa Rica; and it has seen fresh activity in the national and international geophysical unions and congresses.

The Bishop Museum invited Dr. Jaggar to join an expedition, in September 1924, to the Howland and Baker islands in the U. S. S. S. Whippoorwill. This was of geat interest for a volcanologist in view of Darwin's generalizations concerning atolls as representing subsidence. Howland and Baker appear to be the nucleus of an atoll, and as such show no evidence of subsidence, nor of the transition from a previous condition of fringing and barrier reefs. They appear to be accumulations on a submarine bank not significantly related to subsidence, elevation, nor retreat of the sea, but closely related to trade wind and equatorial current.

In 1925 a visit by a Congressional committee headed by Hon. L. C. Cramton of Michigan was destined to advance volcanology immeasurably. Mr. Cramton asked Mr. Jaggar to accompany him in June to Lassen Volcanic National Park and this was the signal for creation in 1926 of enlarged appropriation for a Section of Volcanology to include California and Alaska with Hawaii. Meantime Colonel C. H. Birdseye, in charge of the Topographic Branch of the Geological Survey, undertook to cooperate with volcanology by sending an engineer, Mr. J. C. Beam, for leveling, and for triangulation of the net of proposed bore holes that would determine how the temperature of the crater lava changes horizontally from place to place. In the machine shop we were experimenting with compressed air drills, and have to thank Messrs. W. F. Dillingham and Frank West of the Hawaiian Contracting Company for assistance. Leveling reconnaissance was now indicating that the edge of Halemaumau pit had gone down several feet during the explosions of 1924. Experiments were being tried in the seismological laboratory with earthquakes, with tilt recorders, and with overturning prisms for calibrating strong-motion earthquakes. Mr. E. G. Wingate was surveying Mokuaweoweo Crater, and it is impossible to express all that the Observatory owes to the late Captain A. O. Burkland, in charge of topographic mapping in the Hawaiian Islands.

In 1926 it had become the custom of the Volcanologist, to make a forecast each year, in his report to the Director of the Geological Survey, by way of experimenting with prediction. The report of December 31, 1925, stated that low earthquake frequency and accumulated tilt suggested rising lava and that location of some earthquake centers implied motion in Mauna Loa. This was confirmed by Mauna Loa breaking out April 10, 1926, and producing the Hoopuloa flow. A similar forecast for Halemaumau December 31, 1926, was followed by the outbreak in that pit in July 1927. Forecasting data are growing increasingly accurate.

General reorganization was permitted in 1926. Mr. R. H. Finch in September founding the Lassen Volcano Observatory, Mr. R. M. Wilson becoming engineer and chief assistant at the Hawaiian station, and Mr. R. B. Hodges becoming clerk and disbursing officer. Mr. Beam remained from

December 30, 1925, to May 21, 1926, tested two level lines 1,000 feet long for changes of tilt, releveled old circuits about Kilauea, surveyed the bore-hole net, remapped Halemaumau, and triangulated the Wilson net. Japanese workmen were sent from station to station, on the Kilauea floor, for boring holes 10 feet deep and 1,000 feet apart at the corners of equilateral triangles. There were added to the equipment compressor, truck, and drill, some tested thermometers, one of the modern high-speed cameras, and up-to-date surveying instruments from the Survey.

Meantime the Research Association had met the Congressional increase of funds by a drive for $20,000 for an exhibition room, projection apparatus, and furniture on the top of the great western cliff of Kilauea Crater, which was duly built and turned over to the Secretary of the Interior and the Director of the National Park Service in April 1927. At the same time the Association ordered from Japan an exhibition seismograph, and the best of the mineral collections were placed in the museum. The machine shop of the Observatory was enlarged and a skilled machinist secured for one year. A tide gauge had been installed in Hilo, and the Geological Survey cooperated in securing leveling by the Coast Survey from sea-level to the top of Mauna Loa, and in measuring gravity on the island of Hawaii in the autumn and winter of 1926-27. This work was done by Engineers Simmons, Brown, and Bainbridge. In the summer of 1927 Mr. Jaggar went to Alaska, established a seismograph at Kodiak, sailed to the west end of the Aleutian Islands and back, and inspected the Lassen station. Meantime several new seismographs of a distinctive Hawaiian type, large two-component instruments, were built at Kilauea, one of which was placed in a new cellar constructed for it in Hilo. Engineer Wilson entered on new mapping of Halemaumau, improvement of wireless time service, new leveling and triangulation to determine ground movement, measuring marked fissures at Halemaumau pit, and making artificial earthquakes with an oscillating table.

The year 1928 was thus entered upon with the Hawaiian Volcano Observatory, which had been estabilshed 16 years before by the Hawaiian Volcano Research Association, as the central headquarters in the middle of the Pacific Ocean, for a Section of Volcanology of the United States Geological Survey, maintaining substations in California and Alaska, and so doing its bit, of observing active volcanoes, at the east, north, and center of the Pacific Ocean. The Volcano Letter, issued weekly, was distributing notes about the world on volcano science, particularly with reference to the Pacific. Seismograms were being studied from four places on the Island of Hawaii, and one place each in California and Alaska. The Hawaiian station was equipped with a tide-gauge, a machine shop, a number of permanent bore holes, a chemical laboratory, general laboratory, dark room, fire-proof archives building, library, and vehicles, and the needs of the public had been suitably transferred to the National Park Service by means of a museum and lecture room. Triangulation and leveling had proved elevation and distension of Kilauea Crater before 1924, depression and construction thereafter. Mapping topographically had covered the whole of the Island of Hawaii, and was nearly completed for the Territory. Marked cracks were being systematically measured around Halemaumau pit, and at Lassen by stakes at Supan's Springs. New leveling and gravity measurement had extended to the top of Mauna Loa. A project had been formulated for possible cooperation of several Government bureaus in studying the natural history of the Aleutian Islands.

The National Geographic Society was now taking an active interest, after numerous explorations in volcanic fields, from the time of the Caribbean eruptions of 1902 onward. This Society employed Mr. Jaggar in the summer of 1928 to conduct an expedition to explore and map topographically 2,500 square miles around Pavlof Bay, near an active volcano of the same name, one of the beautiful snowy cones of the Aleutian belt on the south side of the Alaskan Peninsula. This expedition was timely, as Dr. Griggs for the Society had conducted a series of expeditions near Katmai Volcano, and our Section was laying a foundation for expeditions in the Aleutian Islands, two of which has already been made, with studies of Makushin, Bogoslof, Korovin, Gareloi, and Chugul volcanoes. In the Pavlof Expedition the topographic map was made by McKinley and published by the Survey, numerous photographs and motion pictures were taken by Stewart, and the geology and volcanology were studied by Jaggar, and a preliminary report published in the National Geographic Magazine.

It had become evident at the Hawaiian station in 1924 that the tremendous slope, to depths of two or three miles in only a few miles distance east and west of Hawaii under the ocean, is an important basal part of the active volcanic system. An outflow to the west under the sea in 1877, singular waves and submarine noises during lava flows from Mauna Loa into the sea, and a probable submarine flow unperceived off the east point in 1924, all made the study of the volcanic sea bottom by new methods a fundamental part of future volcanology. Accordingly, the development of work from boats is essential. The Pavlof Expedition employed a steel amphibian boat built for the National Geographic Society which was afterwards turned over by the society to the Research Association in Hawaii. The activities of such boats were experimented with in 1927 and 1928 on the east and west sides of Hawaii, as they possess the great advantage, where laboratory work is to be considered at a permanent station, of running up the beach on wheels with all their equipment and collections into a suitable house. Their bottoms may thus be altered or mechanized for any kind of sounding, dredging, probing, or tubular bottom photography with artificial lights in shallow water, and the ordinary disadvantages, of a boat exposed to all weathers, at anchor most of the time, with its bottom fouling, are eliminated. There is very important work to be done close to shore in Hawaii in determining the escape of the groundwater through submarine fresh water springs, by bottom sampling and hydrometer tests. Such submarine springs are known in many places on the active volcanic sides of the island, where no springs whatever emerge above sea level. This is true of many of the volcanic islands of the South Pacific, where the coral reef problem is affected by fresh water, from the ground-water surface beneath the rainfall belt of a lava mountain. As the explosive eruption of 1924 was probably occasioned by lava outflow under the sea, and groundwater inflow to the hot void so created under Halemaumau, it will be seen that critical surveys of the sea-bottom near Hawaii are absolutely necessary for the progress of volcanology. Therefore it is proposed to begin with small vessels close to shore, and to develop apparatus for such volcanologic surveys. It is to be hoped that the Navy and other boating organizations of the Government will give assistance in this work. The Board of Harbor Commissioners of the Territory of Hawaii kindly permitted the Association to use a discarded warehouse at Keauhou in Kona as a shelter for the steel boat "Honukai," where this amphibian is kept for explorations on the west side of Hawaii.

Engineer R. M. Wilson was obliged to return to Washington in November 1928, and was replaced by Engineer E. M. Buckingham, who remained until July 1, 1929. His place was taken by a geologist, Dr. H. A. Powers, who came from Harvard University, and entered upon geologic mapping of the west side of Hawaii, in addition to service as general assistant at the Observatory. Mr. Wilson had completed a contour map of Halemaumau after the bottom changes of 1927. Mr. Buckingham made another after the bottom changes of February 1929. Mr. Powers as petrologist started microscopic studies of rocks from Hawaii and Alaska, and also drafted diagrams of tilt from 1913 to 1930. Mr. A. E. Jones was sent to Alaska in 1929 and established a new seismograph station at Dutch Harbor.

Experiments of 1929 at the Hawaiian station dealt with construction of leverless seismographs tested on the oscillating table, of several models of vertical-component seismographs, wherein it was attempted to make the constants equivalent to the Hawaiian-type horizontal-component instrument, and of several different sizes of shock-recorders designed as simple instruments to put into the hands of amateurs. Also mechanical devices were made the subject of experiment for securing smooth smoking of seismogram paper. For many months a seismograph was operated with a restraining bumper against the pendulum arm having in view the elimination of microseisms and tilt.

and the recording of local earthquakes only. The shock-recorders were successfully used at Puuwaawaa in western Hawaii during the extraordinary and disastrous earthquakes of September-October 1929.

In the Lassen station a new Hawaiian model seismograph was set up and the older instrument was transferred to the Loomis Museum near Viola. Messrs. Howel Willams and C. A. Anderson, in addition to Mr. Finch, were at work on problems of the geology of the vicinity of Lassen Volcano. Dr. Wentworth investigated the geology of Hawaii June-September 1929, Dr. Stone the volcanoes of Chile November-January 1929-30, and Mr. Finch attended the Java Science Congress April-June 1929. On January 12 the Director of the U. S. Geological Survey, Dr. George Otis Smith, called a meeting under the Federal Relations Committee of the National Research Council for conference on scientific cooperation in the Aleutian Islands. This was in line with recommendations of the Pacific Science Congress of 1923. Dr. Jaggar addressed the meeting, and was made chairman of a committee to further Aleutian investigations.

This brings the review of volcanologic activities centering about Hawaii up to 1930-31. The buildings of the Hawaiian station were now enlarged and rehabilitated, tilt studies on a larger scale were prepared for, the Volcano Letter was enlarged and illustrated, a course in volcanology was given annually in the summer session of the University of Hawaii, a journey to the active volcano on the island Niuafoou in Tonga, by Mr. Jaggar, secured valuable photographs and records under the Eclipse Expedition of the U. S. Naval Observatory, shock-recorders were placed there and in New Zealand, Mr. Finch explored Akutan Volcano in Alaska and tested a shock-recorder there, the first clinoscope was constructed, Professor H. S. Palmer joined Dr. Powers in studies of shore-line changes on Hawaii, and finally, beginning July 1, 1931, the Congress of the United States enlarged the funds and activities of the Section of Volcanology by adding two scientific workers.

These are Engineer E. G. Wingate and Seismologist A. E. Jones, and the motive for this enlargement of staff is largely to concentrate measurements on tilting of the ground about an active crater in relation to local earthquakes. These motions have been found significant for prediction. There is certainly such tilting around the Kilauea center, there is presumably such tilting around the Mauna Loa and Hualalai centers, and there should be generalized tilting around the outskirts of the island. The formulation of what the local motions are, in direct relation to the passage of time and the coming of activity at a definite volcanic center, and what such motions show as to location and motion of definite lava underground, is the aim of volcanology. This has led to the placing of clinoscopes, as heretofore described, in three cellars around Halemaumau pit.

The Research Association met the enlargement provided by Congress by supplying new and enlarged buildings and laboratories, and greatly increasing the facilities of the Hawaiian station. We have every reason to express our keen appreciation of the invariable assistance and cordial cooperation of Hawaii National Park. The Research Association owes a debt of gratitude to Delegate Houston, Governor Farrington and to Director Smith of the Geological Survey for bringing about our enlarged opportunities, and equally to his successor, Director W. C. Mendenhall, and to the Chief Geologist of the Survey, Dr. T. W. Stanton.

The Scientific Director of the Association takes this opportunity to express his very keen and heartfelt gratitude to the late honored L. A. Thurston, for many years our President, enthusiastic in support of everything which concerned the study and exploration of Hawaiian volcaones, and skilled as a special pleader and publicist through his extraordinary learning and memory concerning everything Hawaiian. All honor should be paid also by all students of volcanology to the gentlemen of Honolulu who from time to time have served gratuitously and loyally on the Board of Directors of this Association, and especially to the six men in recent years who have served with Mr. Thurston in making for growth of the science through business leadership, public influence, financial judgment, scientific interest, and legal advice, Messrs. Cooke, Atherton, Dillingham, Peck, Dean, and Thayer. Mr. L. W. de Vis-Norton should be especially commended for his long and painstaking service as Secretary and Assistant Treasurer, in attending to the irksome details of the work of recorder, sometime editor, bookkeeper, and correspondent, and in advising with the Scientific Director on all manner of subjects, as well as doing a large amount of literary work which has made volcano research known.

KILAUEA REPORT No. 1057

WEEK ENDING APRIL 24, 1932

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge.

At Halemaumau pit of Kilauea Volcano the week has shown little change. The weather has been normal of the trade-wind type, and at 9 a. m. April 18 the yellow fume patch at the west side of the floor showed thin vapor. Crack measurements about the eastern rim showed but slight widening in the measurements of April 19. The fume emitted continued thin, but is always in evidence as a bluish haze over the western half of the pit in early afternoon light. An avalanche from the northern wall of the pit about 10:05 a. m. April 21 was followed five minutes later by a much larger one which appears to have been registered somewhat as a vibration recorded on the seismographs of the Observatory two miles away. The fallen rocks overlapped the January lava floor, the roar was loud, and a dust cloud arose. There were several other slides on this day and one at 4:38 p. m. was observed April 22 at the northeastern rim.

Seismic activity registered at the Observatory was mild. One very feeble shock indicated origin distance close at hand, something over two miles, and 26 tremors were registered during the week, three of which were sufficiently defined seismically to suggest origin distances of 28, 42, and 46 miles. Microseismic motion for the week changed from moderate to light, and tilting of the ground was strong to the west with slight tendency north.

THE VOLCANO LETTER

The Volcano Letter combines the earlier weekly of that name, **with** the former monthly Bulletin of the Hawaiian Volcano Observatory. It is published weekly, on Thursdays, on behalf of the section of volcanology, U. S. Geological Survey. It promotes experimental recording of earth processes.

Readers are requested to send articles, photographs, publications and clippings about volcano and earthquake events, instruments and investigations, especially around the Pacific.

HAWAIIAN VOLCANO OBSERVATORY
Founded 1911

This laboratory at Kilauea Volcano belongs to the Hawaiian Volcano Research Association and is leased and operated by the United States Geological Survey.

It maintains seismographs at three places near Kilauea Volcano, also at Hilo, and at Kealakekua in Kona District. It keeps a journal of Hawaiian volcanic activity and publishes occasional Bulletins.

Membership in the Hawaiian Volcano Research Association is limited to patrons of Pacific science who desire personally to aid in supporting the work.

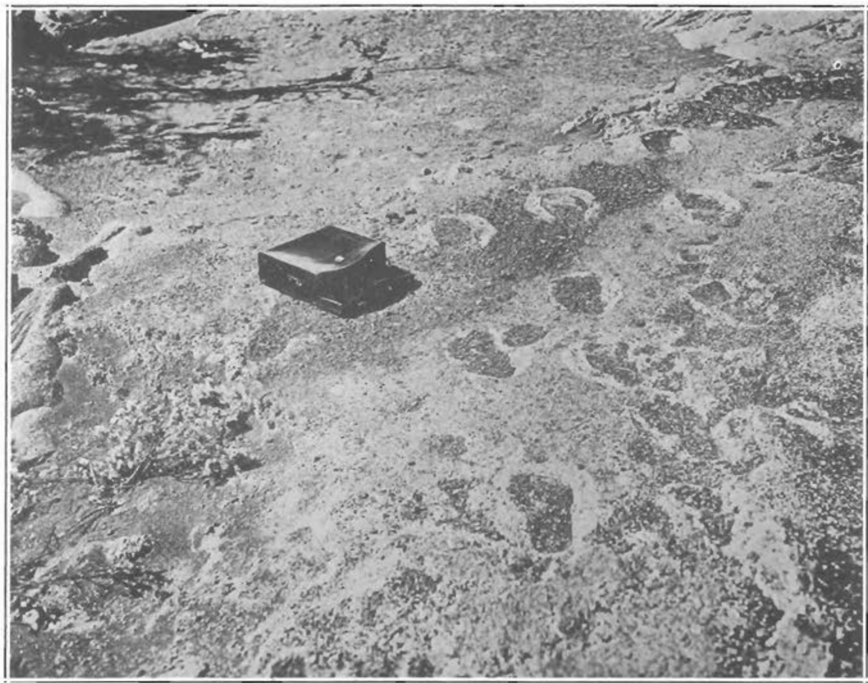
The work of volcano research so supported is in collaboration with the work of the United States Geological Survey, but supplements it with buildings, research fellows, instrumental plants, explorations and special investigations for which there is no governmental provision. The Geological Survey maintains volcano stations in Alaska, California and Hawaii.

Persons desiring application blanks for membership ($5.00 or more) should address the Secretary, Hawaiian Volcano Research Association, 320 James Campbell Building, Honolulu, T. H.

The Volcano Letter

Two dollars per year | **Ten cents per copy**

No. 384—Weekly | Hawaiian Volcano Observatory, National Park, Hawaii | May 5, 1932



Hardened human footprints in the Kilauea ash of 1790, Kau Desert six miles southwest of the crater. The pedestrians were headed north and their bare feet squashed up the mud around the footprints. The mud solidified like cement. The pellets formed by the warm mud rains of the eruption are shown at the right. See Volcano Letter No. 273 and Bulletin Hawaiian Volcano Observatory July 1921.

PROGRESS OF HAWAIIAN VOLCANO RESEARCH

(Continued from Volcano Letter No. 383)

Appendix to Address of T. A. Jaggar, Annual Meeting of Hawaiian Volcano Research Association in Honolulu March 31, 1932.

Publications

In order that the reader of the foregoing review of twenty years of work at the Hawaiian Volcano Observatory may have some references for volcanologic reading, the following list of publications is compiled, first, to show the bulletins of the Hawaiian Volcano Observatory which contain special reviews, lists of publications, and discussions of special subjects, and second, to give references to the scientific papers by the staff which have covered the more important subjects of investigation since 1916. In Bulletin of Hawaiian Volcano Observatory Vol. IV, No. 4, April 1916, was printed a list of publications to that date.

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The amphibian boat "Ohiki," Wilson, XVI No. 4, Apr. 1928.

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In addition it should be mentioned that the "Volcano Letter" has been issued weekly since January 1, 1925, and as a four-page leaflet with illustrations, replacing the former "Bulletin" since January 1, 1930. T.A.J.

KILAUEA REPORT No. 1058

WEEK ENDING MAY 1, 1932

Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge.

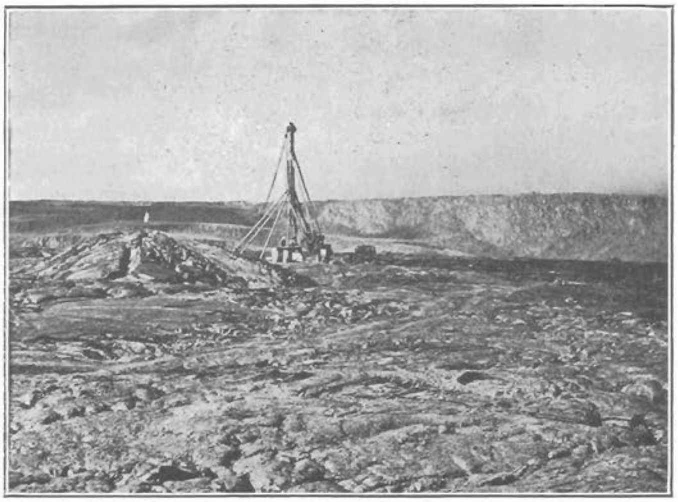
No changes were observed in Halemaumau on April 25, except possible increase in sulphur stain on the floor at the foot of the north talus. Crack measurements on the 26th showed no changes. At 8 p. m. no glow was to be seen. On the 27th fume was as usual and nothing new to been seen. At 10:30 a. m. fume rose on the west side of Halemaumau conspicuously in puffs. On the 28th at 8:30 a. m. fume appeared denser at the southwest talus due to damp, cloudy morning. No change in fume observed on the 29th at 9 a. m. There appeared to have been a small slide over west end of the north sill during the night. On the 30th at 8:45 a. m. there was nothing new and fume was as usual at the southwest talus.

The seismographs at the Observatory recorded 13 tremors, two very feeble shocks, and three feeble earthquakes which were felt. The tremors indicated varying distances, from 23 to 70 miles. The two very feeble shocks showed origin distances 6 and 16 miles. The first of the three feeble earthquakes occurred at 1:59 a. m. April 26. It was felt in Haina, Honomu, Hilo, Kamuela, Kohala, Waikii, and at the Observatory. Its record indicated distance 32 miles from the Observatory, 23 miles from Kealakekua, and 42 miles from Hilo. It is calculated to come from a point five miles below the saddle between Mauna Loa and Hualalai.

The second feeble earthquake was registered at 3:17 a. m. April 28 and was not reported felt by many. The origin was 12 miles from the Observatory. The third feeble earthquake was at 6:24 a. m. May 1, and although probably more generally felt, reports from distant parts of the island have not yet had time to arrive. Reports of perceptibility have come from Honomu, Hilo, and near the Observatory. Records indicate distances 16 miles from the Observatory and 31 miles from Hilo.

Microseismic motion was mainly moderate. Average tilting was slight SE by S.

The Observatory is getting very good cooperation from earthquake observers. Card forms will be furnished anyone willing to report felt shocks.



Churn drill at work on eastern lava field of the floor of Kilauea Crater July 21, 1922. Looking north showing Waldron's Ledge and the Volcano House in the distance. This is one of the numerous temperature wells drilled to shallow depths in the crater floor. These discovered that high temperatures are always on cracks which bring up hot vapor. See Bulletin Hawaiian Volcano Observatory 1922 and 1927.

THE VOLCANO LETTER

The Volcano Letter combines the earlier weekly of that name, **with the** former monthly Bulletin of the Hawaiian Volcano Observatory. It is published weekly, on Thursdays, on behalf of the section of volcanology. U. S. Geological Survey. It promotes experimental recording of earth processes.

Readers are requested to send articles, photographs, publications and clippings about volcano and earthquake events, instruments and investigations, especially around the Pacific.

HAWAIIAN VOLCANO OBSERVATORY
Founded 1911

This laboratory at Kilauea Volcano belongs to the Hawaiian Volcano Research Association and is leased and operated by the United States Geological Survey.

It maintains seismographs at three places near Kilauea Volcano, also at Hilo, and at Kealakekua in Kona District. It keeps a journal of Hawaiian volcanic activity and publishes occasional Bulletins.

Membership in the Hawaiian Volcano Research Association is limited to patrons of Pacific science who desire personally to aid in supporting the work.

The work of volcano research so supported is in collaboration with the work of the United States Geological Survey, but supplements it with buildings, research fellows, instrumental plants, explorations and special investigations for which there is no governmental provision. The Geological Survey maintains volcano stations in Alaska, California and Hawaii.

Persons desiring application blanks for membership ($5.00 or more) should address the Secretary, Hawaiian Volcano Research Association, 320 James Campbell Building, Honolulu, T. H.

The Volcano Letter

No. 385 Hawaiian Volcano Observatory, National Park, Hawaii May 12, 1932

THE SUSPENSION OF THE VOLCANO LETTER

Among the reductions of governmental appropriation for the fiscal year ending June 30, 1933, is one changing the allotment to volcanology in the U. S. Geological Survey from $35,000 to 15,000. A large proportion of this concerns the Hawaiian Volcano Observatory, which is cooperatively maintained by a personnel chiefly of government employees, and by equipment and expenses, including publication, supplied in large measure by the Hawaiian Volcano Research Association.

The drastic reduction by fifty-seven per cent will permit the continuance of the Hawaiian station and a working staff only by abolishing the weekly Volcano Letter in its present form, as the publication of that periodical has been the largest item of expense from the cooperative fund furnished by the Research Association. This money will be needed to keep alive the work of the Hawaiian Volcano Observatory after July 1, 1932, and therefore it is deemed wise by the Board of Directors of the Association to take action immediately in preparing to reduce the Volcano Letter to a monthly leaflet after the issue of May 26, 1932. As before it will contain reports of the volcano observatories of the U. S. Geological Survey, and volcanologic notes.

As this crisis is a serious one for fundamental research concerning American volcanoes, all friends of volcano research are requested to rally to the support of the Hawaiian Volcano Research Association by subscribing any sum whatever, from one dollar up, and by securing new members and patrons for the Association wherever possible either firms or individuals, and anywhere in the world. The regular annual membership fee of the Association is five dollars, and necessarily the two dollar subscription for the Volcano Letter as a weekly publication is hereby abolished. After July 1, 1932, the monthly Volcano Letter will be sent only to paid up memberships and exchanges.

There will be no suspension of the work done. though the official staffs of the California, Hawaiian, and Alaskan stations will be reduced and some workers eliminated. There will be every effort to enlist new amateur workers who live near volcanoes and in land subject to small earthquakes, and who may be willing to send in official postal cards describing the happenings which come to their notice. The coming year will be an opportunity to bring to publication in scientific journals the material which has accumulated through recording twenty years of varied activities.

T.A.J.

NOTICE TO MEMBERS AND SUBSCRIBERS

Honolulu, May 2, 1932.

To Members and Subscribers,
Hawaiian Volcano Research Association.

This communication is ordered by resolution of your Board of Directors on this date, to the following effect:

Resolved:

That the work of the Association shall be carried on, but that every possible avenue of economy shall be followed, including the abolition of the Volcano Letter in its present form. That the Directors approve of the proposed budget as revised for the balance of the current calendar year, with the proviso that further cuts be made, and that every effort be exerted to collect donations not yet received.

Accordingly, this letter is addressed to those who have subscribed two dollars per annum for the Volcano Letter and to regular members and patrons of the Association.

A cut of fifty-seven per cent by the Government, forces us to limit expenses to bare necessities, in order to save the Hawaiian Volcano Observatory.

After May 26, 1932, the Volcano Letter will be reduced to a monthly leaflet, but subscribers will be sent scientific papers from time to time. You are asked to accept this for the good of the cause, but two-dollar subscribers or members who except and require a weekly periodical, and who so notify the Assistant Treasurer, will have their full subscription returned.

Those able to help by enlarging their subscriptions or winning new subscribers, will be benefactors of scientific research in a time of serious crisis.

T. A. JAGGAR,
Scientific Director;
Hawaii National Park, T. H.

L. W. de VIS-NORTON,
Assistant Treasurer,
320 James Campbell Bldg.,
Honolulu, T. H.

KILAUEA REPORT No. 1059

WEEK ENDING MAY 8, 1932

Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

On the forenoon of May 2 Halemaumau pit showed fresh debris which had fallen since the previous day on the floor in the south bay from the wall above. Bluish fume remained constant at the sulphurous cracks at the edge of the floor west. Measurement of southeastern rim cracks showed very slight widening. Inspection at 8 p. m. revealed only a quiet pit and no glow. On May 3 at 9 a. m. the western fume was denser, probably owing to moisture content, as the weather was rainy. At 9 a. m. May 6 some fresh sliding at the south wall of the pit had added to the pile of fragments on the floor.

Progress in construction of the two tilt cellars near Halemaumau west and north shows concrete work in place at the former, and the digging practically complete at the latter

The seismographs recordel three very feeble shocks 23, 28, and 69 miles distant, the last rattling windows at Huehue in North Kona for about 15 seconds May 6 at 5:28 p. m. Twenty-one tremors were registered, one indicating distance 46 miles, and another 9 miles. Tilting of the ground was practically absent, and microseismic motion was moderate.

HAWAIIAN VOLCANO OBSERVATORY
Founded 1911

This laboratory at Kilauea Volcano is maintained cooperatively by the United States Geological Survey and the Hawaiian Volcano Research Association. It operates seismographs at three places near Kilauea Volcano, also at Hilo and Kona. The Geological Survey does other volcano investigation in California and Alaska. Persons desiring to join the Hawaiian association should address the Secretary, 320 James Campbell Building. Honolulu, T. H.

The Volcano Letter was a weekly from 1925 to 1932 (May), and is now a monthly leaflet. Readers are requested to send notes, photographs, publications, and clippings about volcano and earthquake events.

The Volcano Letter

No. 386 | Hawaiian Volcano Observatory, National Park, Hawaii | May 19, 1932

KILAUEA REPORT No. 1060

WEEK ENDING MAY 15, 1932

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

On the forenoon of May 9, with northeasterly squalls and rain, the fume rising from the west edge of the floor of Halemaumau appeared slightly denser than before, and some odor of sulphur was detected at southeast rim of pit. In the afternoon the fume seemed dense and a few wall rocks fell. On May 11, 9 to 10 a. m. the fume was less dense, and some small sliding had taken place at the north. A slide at the south wall in the afternoon agrees in location with a slight opening of the SSE rim cracks recently measured. With damp air May 12 blue fume rose above the rim infrequently.

Experimental runs are now being made with clinoscopes for measuring tilt, in the southeast Halemaumau cellar, by E. G. Wingate.

Observatory seismographs registered one feeble local shock at 10:16 p. m. May 9, felt in Hilo, apparent distance from Kilauea to origin 14 miles. Three very feeble shocks occurred, two indicating distance 18 miles, one a possible distance of 115 miles. Twenty-six tremors were recorded. Microseismic motion was slight to moderate, and tilting of the ground was slight north.

A large distant earthquake May 14 with first preliminary at 2h 52m 57s a. m. H.S.T. (10h 30m slower than Greenwich) indicated distance 5300 miles wsw. This location checks with press report of damage and loss of life at this time in Minahassa, the northern peninsula of Celebes island, a volcanic area of the Netherlands East Indies.

TILTING OF THE GROUND FOR APRIL

The following figures show the net tilt by weeks at the Observatory on the northeast rim of Kilauea crater, and its direction, computed from the daily seismograms, by platting a curve smoothed by overlapping seven-day averages. This is the departure of the plumbline in seconds of arc, in the direction given.

March 29-April 4	1.0 second NE
April 5-11	0.8 second E
April 12-18	0.8 second NW
April 19-25	0.3 second SE
April 26-May 2	0.6 second SSW

E.G.W.

ERUPTION IN LAKE ROTORUA, NEW ZEALAND

A semi-volcanic eruption up through the bottom of the southern cove of Lake Rotorua occurred about 7:45 p. m. January 18, 1932. The place was about one hundred yards away from the shore off the mouth of the Puarenga Stream, the torrent of warm water that pours northward into the lake from the Whakarewarewa Geysers. The place is directly opposite the town of Rotorua. A column of steam, water, mud and stones was hurled up from an aperture in the solfataric shallows from 200 to 400 feet. There was little noise, and a few minutes after it occurred the surface of the lake was again smooth. The Maoris reported it the largest mud-geyser eruption since the explosion of Waimangu in 1917.

The area covered by the falling mud and stones was several acres. For more than one hundred yards along the shores of the lake, and for many yards back from the water, the ground was coated with thick slimy mud, and the point of land which projects in the direction of the vent under the lake was lengthened by 30 yards. People who happened to be on the balcony of the Ward Bathhouse had a splendid view of the outburst.

This explosion here is not the first. It is in the same general locality as two other outbursts a few months earlier, when the Ngapuna pa was startled by a sensational disruption of the flats, a native garden was engulfed and property was threatened. This area is reputed dangerous. The ground is a mass of brittle and steaming solfataric deposits, which crumble underfoot, there are many hot springs, and occasional patches of quicksand. At Whakarewarewa, a mile and a half away to the south, are the famous geysers and paint pots visited by tourists, in a verdant valley filled with boiling springs of varied aspect, and it seems likely that there are volcanic faults extending down the Puarenga valley to the lake. The whole district is highly volcanic, and the hot magma is probably not far from the surface

T.A.J.

ASH ERUPTION IN THE ANDES

From the 10th to the 13th of April 1932 there were extensive steam-blast eruptions in the Andes of Argentina near the Chilean border, eight volcanoes being named, and the towns Malargue and San Rafael in Mendoza province received the heaviest ash-fall. Ash fell at Buenos Aires in Argentina 800 miles from the source, at Santiago in Chile and at Montevideo in Uruguay. In the mountain towns two to three feet of ash and sand are said to have fallen. Darkness enveloped much of the country, and earthquakes and fissures were reported, and glow from the craters. The volcanoes mentioned are the Descabezado group, Tinguiririca, Tupungato, Juncal, San Jose, Maipu and Peteroa, and probably a volcano in the Neuquen district of northern Patagonia. The volcano Quizapu in the first group has been the subject of anxious observation by the Chilean Seismological Service since April, 1929. The ash blanket covered thousands of square miles and made the mountains look as though covered with snow (Press reports.)

T.A.J.

HAWAIIAN VOLCANO OBSERVATORY

Founded 1911

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The Volcano Letter

No. 387 U. S. Geological Survey, Hawaii National Park May 26, 1932

KILAUEA REPORT No. 1061

WEEK ENDING MAY 22, 1932

Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

Halemaumau, the inner pit of Kilauea Crater has shown no significant changes during the week. Measurements of cracks May 16 at the rim east and south indicated little movement. A dust cloud at the north wall at 10:55 a. m. May 17 during high wind was accompanied by no visible slide. At 4:45 p. m. the blue fume from the western sulphur spot of the bottom was plainly visible above rim of pit as seen from the Observatory. At 9 a. m. May 18 the scar from a slide was visible above the middle of the "canoe sill" in the lower northeastern wall of the pit.

The building of the tilt cellars west and north of Halemaumau has proceeded so that the western one now has the instrument chamber encased with built-up rubble, and the entrance way has been walled up on either side of the stone stairway at the approach. A heavy slab roof of concrete, separated by an air space from the inner chamber will be built across the top The chamber is thus insulated by air spaces, and will have double doors at the entrance.

Seismic activity has been extraordinarily feeble for the week. Only three volcanic tremors were recorded, one indicating a possible origin at 120 miles distance. There has been much artificial tremor from heavy road-working machinery. One very feeble local seism occurred. A distant earthquake indicating origin 4,400 statute miles away, began at 11h 50m 43s p. m. May 20, 1932. reported location Salvador. Microseismic motion for the week was moderate, and tilting of the ground was slight to the north with tendency eastward

The Volcano Letter will hereafter be monthly.

ERUPTION OF MERAPI IN JAVA

There are two important volcanoes named Merapi, of which one is in Sumatra. The volcano here considered is in central Java, and started a disastrous eruption November 25, 1930. and permitted a stiff, blocky variety of lava to exude from the crater throughout most of 1931. (Der Ausbruch des Merapi, by N. Van Padang, Zeitsch. für Vulk., 1931 page 135, and Bull. Neth. East Ind. Volc. Surv. 1930-1931.)

Except for the volcano on Bali named Batoer, the flowing of lava is rare in the Dutch East Indies, though the slow push upward there of andesitic domes within craters is well known.

There had been an increase of tremors from January to May 1930 at Merapi, and the temperature of the solfataras was about 600° C. in October 1930, but this was not unusual for this place. In November large and small tremors increased, explosions were heard November 23, 1930, and these continued. When the glowing lava in the crater appeared on November 25, 1930, large tremors, which had been caused by crater avalanches, came to an end.

The lava was very tough and irregular in flowing, its glow was variable, with rough blocks falling from the front, which burst and formed small clouds, that mixed with the general cauliflower clouds of the jets from the crater. This lava formed a short, stubby outflow at the crater gulch. Such sluggish flowing, with small gas concentration, continued until December 18, 1930.

The eruption had characters similar to those of Mount Pelé in Martinique, including hot blasts downward and across country, known, in Martinique as "nuées ardentes" or glow clouds. After December 18 big blasts occurred, throwing out old material mixed with fresh lava, and these emerged from a big, deep chasm or gulch in the slope of the mountain opening from the summit crater. Great avalanches, and streams of blocks rushed down, and followed valleys, along with a drifting cloud of sand, ash and gas. While the debris followed the ravines, the whirling hot sand clouds would keep their own direction, with tornado effects, and make fearful destruction.

The largest such glow-cloud blast descended the mountain on December 19, 1930, killed more than 1,300 villagers, devastated 22 square kilometers of country, and spread more than 10 kilometers from the center. The stream of debris in the valleys was 10 to 50 meters thick, and the sand covering beyond was from 1 to 40 centimeters thick.

There had been lava domes which had arisen during eruptions on the summit of Merapi, beginning in 1883, by rise of andesite lava through broken material in the bottom of a crater 100 meters deep There was renewed rise of the lava in 1888. a dome above the top of the mountain had formed in 1909, side by side with this eastern dome there arose a western dome between it and the crater wall in 1911-13, and in 1922 there came out a lava stream at the western wall crack, the source material of which made a triple dome in the crater along with two earlier ones. The sequence is vividly shown in a series of diagrams by Van Padang. In 1930 a new dome and flow were formed beside the others in November-December, and the great eruption of December 18-19 caused collapse of the older domes, but after a succession of hot blasts thick lava rose again which formed a new dome in the chasm, somewhat away from the center of the mountain. The entire description of this eruption coincides strikingly in quality with that of Santa Maria in Guatemala November 2, 1929. (Volcano Letter No. 356)

In January 1931 lava issued from various parts of the new lava dome, blocks fell noisily from the crust as the dome repeatedly burst, and the mud and debris slides in the valleys ("lahars") solidified and cooled. The rains made water explosions against dry. hot debris in the valleys just as at Soufrière and Pelée in the Caribbee Islands in 1902. The rivers carried quantities of sand. Light seen above the lava dome, which showed only fumarolic action in daytime. was indicated at night to be flame from burning gas. The smell of sulphur dioxide was strong, and temperatures of some known fumaroles, formerly 500° C., had lowered to 60° C. On the other hand, solfataric action was spread over a greater area.

On March 25, 1931. there was an older lava stream of 1930 from the gash under the summit, and a younger one emerged March 10, 1931, and increased after March 15, so that on March 19 the lava tongue was 180 meters lower than the week before. There were many small blasts, with much avalanching, and glowing spots on top of the dome marked places where lava was gushing.

Erosion was now etching rill patterns rapidly in the deep, hot, debris fills of the valleys. Mud geysers were thrown up 50 meters high where eroding streams of water made contact with gravel beds almost incandescent. Measured temperatures recorded 280° C. The fumarole activity at the head of Senowo River, where the temperature in October 1930 had been 610° C., had ceased altogether in April 1931.

Lava flowing and hot blasts continued in May and June 1931. A new local observatory was built 4 kilometers from the summit, at elevation 1,279 meters. on the northwest slope of the mountain, with a tunnel to provide safe refuge against hot blasts. In this tunnel a seismograph was placed. In July and August 1931 lava flow and avalanches continued, and at night dark red glow could be seen at the crater, where in day time vapor arose. T.A.J.

The Volcano Letter

No. 388 U. S. Geological Survey, Hawaii National Park JUNE, 1932

KILAUEA REPORT FOR JUNE, 1932

Six weeks period from May 22 midnight to July 3, midnight

Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

Volcanology

For the week ending June 5, there were slight falls of rock during an earthquake 1:52 p. m. May 29, and a slide sent up dust at the northeast wall at 12:22 p. m. June 1. On June 6 a slide above the northwest talus at 1:10 p. m. left some new bowlders on the floor.

An event of volcanologic interest from the standpoint of experiment with methods, was the descent about 10 a. m. June 12 to the bottom of Halemaumau of Rikan Konishi, a rigger and contractor of Hilo. This was for the recovery of two dead bodies on the east talus resulting from a local tragedy. Mr. Konishi gave the preceding seven days to setting up an A-frame at the south rim, spanning the east arc with cable, and improvising a trolley. In a wooden cage strongly bound with iron, the task was completed by Mr. Konishi personally going alone to the bottom between 10 a. m. and 5 p. m. He had about fifty helpers and numerous tractors.

The specimens collected of the east edge of the 1932 bottom lava were shred pahoehoe basalt, black with brown stain, highly vesicular, glassy without visible olivine, with reddish brown glaze on inner surfaces. The grade of the talus was 34 degrees. The cage landed on the talus 250 feet above bottom. Time of collection about 3 p. m. June 12, 1932. The lava ledges at the edge of the floor were about 7 feet high, those out in the middle over 40 feet high. Temperature measured at border ledges, 15 minute exposure, 73 degrees Fahr. Temperature up talus 5 minute exposure 85 degrees: at floor edge farther north insufferably hot; at some places on the talus rubber soles were burned. The lava was curled over in shells with cavernous spaces. Mr. Konishi noticed "thin air", a difficulty of breathing, about 600 feet down: this was probably a streak of the fume with sulphuric acid gas from the solfa'ara at the west side of the floor. The Observatory is under obligation to Mr. Konishi for the specimens and the data.

Rim cracks at Halemaumau southeast, measured for the width between opposite sides with calipers, June 13 showed very slight widening at three localities. The pronounced earthquake generally felt on Hawaii about 4:52 a. m. June 14 was apparently accompanied by ESE tilt in the seismograph cellar southeast of Halemaumau. A few rocks were heard falling the forenoon of June 20. The instrument cellars for recording tilt at the pit southwest and north have been completed during the month.

T.A.J.

Earthquakes

During the last six weeks the following teleseisms were recorded on the seismographs of the Observatory. (Hawaiian standard time 10h. 30m. slow G.M.T.)

One May 26 at 5:47:50 a. m., distance 3,250 statute miles.

One June 3 at 0:15:54 a. m., wrote a very large record. It was destructive in Mexico and sea waves originating on that shore were visible in Hilo. These waves arrived in Hilo soon after 7 a. m., were about two and a half feet in height range, and 18 minutes in period, with the maxima between 7:30 and 10:30 a. m. A second series of water waves about a foot high came about 3:30 p. m. These were probably the reflections from the South American shore as the time computation is nearly correct for that path.

Fragments of teleseisms were recorded at 10:59 p. m. June 4 and 10:21:28 p. m. June 6. The latter was slightly destructive in Eureka, California, and only the P and M phases recorded. A teleseism 11:51:22 p. m. June 17 was followed between 7 and 9 a. m. June 18 by a tidal wave two to three inches high in Hilo Bay.

A teleseism June 19 at 11:13 p. m. was fragmentary, consisting of long, sinusoidal waves lasting but a few minutes. June 22 at 2:38:18 a. m. another teleseism began recording from southern Mexico. The P and M phases only were recorded. A slight ocean wave was recorded on the Hilo tide gauge after 9 a. m.

A moderate local earthquake occurred 4:51:45 a. m. June 14. Reports showed that it awakened people generally over the island of Hawaii. It was also reported from Maui. The Bosch-Omori seismograph at Kilauea was dismantled. The approximate center located by distances from two stations and by a direction from a third, was in lat. 19° 28' N., long. 155° 22' W., and about 13 km. deep. It probably occurred on the below-ground projection of the fault between Mauna Loa and Kilauea. This earthquake was estimated to be about III Rossi-Forel.

On May 29 at 1:51:27 p. m. a slight earthquake (about II Rossi-Forel) was felt at both Kilauea and Hilo. Distances from three stations placed it at 19° 21' N., 155° 17' W. and about 12 km. deep.

On June 5 at 6:53 p. m. a feeble shock was felt at Kilauea, about 9 miles away from this station.

A very feeble shock was felt on the Hamakua coast May 25 at 1:42:13 p. m. The epicenter was probably a few miles seaward from that coast.

Twenty other very feeble shocks were recorded at the Kilauea station. Ten of these occurred at distances from 3 to 9 statute miles; eight of the others occurred about 20 miles away, one at 70 and one at 150 miles away from Kilauea.

One hundred fifty-nine tremors were recorded. Due to their small size and inconspicuous phases, very few of these can be located. Some similar tremors have been reported as earthquakes from the north part of the island. In preparing to study these earthquakes a small seismograph hut was completed on June 29. It is located at Waikii telephone station on the northwest slope of Mauna Kea. It is planned that a seismograph, transferred from one of our abandoned Alaskan stations, will be placed there in October 1932.

A.E.J.

Tilting of the Ground

The following figures show the net tilt by weeks at the Observatory on the northeast rim of Kilauea crater, and its direction, computed from the daily seismograms, by platting a curve smoothed by overlapping seven-day averages. This is the departure of the plumbline in seconds of arc, in the direction given. The last record was in Volcano Letter No. 386.

May 3-9	0.4 second NNE
May 10-16	1.0 second NNE
May 17 23	1.1 second NW
May 24-30	0.8 second SW
May 31-June 6	0.4 second NNE
June 7-13	0.8 second NE
June 14-20	0.7 second SW
June 21-27	1.0 second N

The accumulated tilt at the Observatory since January 1, 1932 to June 27 is 14.2 seconds S. and 1.4 second W. These records are from the modified two-component Bosch-Omori seismograph which has stood in this cellar for twenty years.

E.G.W.

The Volcano Letter

No. 389—Monthly | U. S. Geological Survey, Hawaii National Park | JULY, 1932

KILAUEA REPORT FOR JULY, 1932

Including weekly press reports Nos. 1068 to 1071, July 3 to July 31 midnight

Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

Volcanology

A slide from the west wall of Halemaumau July 4 left a mound of debris 20 feet high on the floor, and noisy slides raised dust that forenoon. The 1932 conelet southwest had slumped. A northwest wall slide occurred 6:40 a. m. July 13, and another left a scar southeast July 16. The rock above the canoe sill in northeast wall made a slide big enough to make the 1932 lava floor dusty about July 27, and in the night following July 29 a block of the actual rim of the pit south left a wide scar down the wall, visible from the Observatory. Yellow dust and sand was left covering the western half of the floor, while the south bay showed large bowlders and smaller debris. The pit seismograph showed NW or inward tilt accompanying this slide, and two cracks back of the south rim had widened.

Fresh cracks in the ash soil of the northeast rim were occasioned by the slides of July 4. Measured rim cracks northeast on that date showed at 5 p. m. slight general opening compared with June 21. At 7 a. m. July 8 nine out of nineteen eastern rim cracks showed opening compared with July 4, but very slight. At 9:30 a. m July 12 very slight widening apart of eastern cracks continued, and at the end of the month it was found that only the two fissures back of the slide of July 29 showed significant opening, and that less than one sixteenth inch. This work is done carefully at marked and numbered places, with caliper and rule.

At the southeast Halemaumau cellar seismic movements and tilts occur quite different from those registered at the Observatory on the northeast edge of the greater crater of Kilauea. E. G. Wingate is operating this cellar, which contains both clinoscope and Hawaiian type seismograph. The following figures show weekly totals of peculiar pit tremors, sudden small jerking movements of quick period and very slight amplitude, the frequency variable on different days, and generally showing tilt, or widening apart of the seismogram lines, simultaneous with the trembling. This motion is most conspicuous on the east-west pendulum, and as the cellar is to the east of the pit, the dominant tilt which accompanies the tremors is eastward or away from the volcanic center. The action appears to be seismic, and may prove an important index of magma rising below. The new instrument magnifies about 120 times, and is more sensitive than the one in operation prior to the autumn of 1931 at this place. The frequency, or number of tremors counted, was:-

July 3 - 9	343
July 10 - 16	300
July 17 - 23	150
July 24 - 30	137

It happens that there were lower values in May, and an increase in June, so that the maximum was around the solstice (June 20), and the four weeks of July show graded decrease. This tremor frequently at the pit thus is in accord with the seismicity decrease (earthquakes) shown below by Mr. Jones. The idea that these pit tremors are creakings of the inner dome of Kilauea crater floor being pushed up by magma below, is in accord with the opening of the rim cracks, and evidence by topographic surveys which suggest that the ground is rising and that the opposite walls of Kilauea crater are spreading apart The clinoscopes have been placed in the west and north pit cellars, and their operation for a few months should throw new light on the question, is the ground tilting away from Halemaumau in all directions? During very feeble earthquakes July 16 and 17 slight east and south tilt showed on the seismograms, this being inclination away from the pit; whereas during the south avalanche of July 29, the seismographic tilt at the southeast station was northwest or inward toward the pit.

T.A.J.

Earthquakes

The following is a tabulation of the tremors, very feeble and moderate local shocks recorded by the seismographs at the Hawaiian Volcano Observatory during the interval July 4 to 31 inclusive, 1932. Hawaiian Standard Time is 10h. 30m. slower than Greenwich. The seismicity index (seis.) is the summation of weighted numbers given each type of shock, as explained in Volcano Letter No 371.

Date	tr	vf	mod	seis
July 4 to 10	37	5	1	14.75
July 11 to 17	42	2	0	11.50
July 18 to 24	22	0	0	5.50
July 25 to 31	29	2	0	8.25

The seismicity for the preceding two months was;-

Week ending	May 15	seis. 9.00
	May 22	1.25
	May 29	7.25
	June 5	8.75
	June 12	5.25
	June 19	13.00
	June 26	9.75
	July 3	14.25

The moderate shock of July 7, at 10h. 30m. 49s. p. m. was felt generally on the island of Hawaii and was reported from one locality on Oahu. Its focus was about 8 miles south of the Observatory and about 6 miles deep. It was followed on July 8 by two very feeble aftershocks, about 7 miles distant, and by 15 tremors of unknown distance. The change in earth-tilt a few hours before and a few hours after the earthquake was noticeable. Moderate NW tilt preceded and moderate S tilt followed.

The very feeble shocks, other than those mentioned above, occurred at approximate distances of 9, 9, 11, 16 18. 23, and 24 mles. The few tremors for which distances could be estimated occurred at 4, 9, 20, 34, and 40 miles. A fragment of a distant earthquake was recorded beginning 9:13 a. m. July 12, and a second one beginning 10h. 53m. 04s. p. m. July 24, with a secondary wave at 11h. 04m. 59s. p. m. Microseismic motion was light at the beginning and at the end of July, and moderate during the middle fortnight.

A.E.J.

Tilting of the ground

The following figures show the net tilt by weeks at the Observatory on the northeast rim of Kilauea crater, and its direction, computed from the daily seismograms, by platting a curve smoothed by overlapping seven-day averages. This is the departure of the plumbline in seconds of arc, in the direction given. The last record was in Volcano Letter 388. The total accumulated tilt from January 1 to August 1, 1932 is 12.6 seconds S., and 2.2 seconds W.

June 28 - July 4	0.6 second	N
July 5 - 11	0.4 second	SSW
July 12 - 18	1.0 second	NNW
July 19 - 25	0.6 second	NE
July 26 - August 1	0.8 second	NW

E.G.W.

Personnel

Mr. Jaggar has been engaged in editing papers for publication and in teaching volcanology to a class of fifty-six at the lecture hall of Hawaii National Park, summer session of the University of Hawaii. Mr. Finch has returned from Shishaldin volcano in Alaska to his duties at Lassen Volcano Observatory. Mr. Wingate has been resurveying the Kilauea triangulation net. Mr. Jones has been computing travel time curves for Hawaiian earthquakes. Mr. Powers has been transferred to geological surveys on Haleakala volcano, Water Resources Branch.

The Volcano Letter

No. 390—Monthly | U. S. Geological Survey, Hawaii National Park | AUGUST 1932

KILAUEA REPORT FOR AUGUST 1932

Including weekly press reports Nos. 1072 to 1075, July 31 to August 28 midnight.

Section of Volcanology, U. S. Geological Survey

E. G. Wingate temporaily in charge

Volcanology

A visit to the summit of Mauna Loa was made by Park rangers August 9 to 11. They discovered much steam along the upper part of the northeast rift, blue fume and steam about the central cones of Mokuaweoweo, the summit crater of Mauna Loa and the usual steam at the foot of the west wall. Another party led by Messrs. Squire and Corey of Hilo visited the summit on August 17. They reported steam and fume at Mokuaweoweo as usual. The fume over Mokuaweoweo as seen from Kilauea has occasionally been visible in late afternoon as a tenuous volute of definite outline; and several times the northern position of the sunset light has brought out the steam jets of the northeast rift. These things are not unusual in summer time.

Volcanic conditions at Halemaumau in Kilauea have been relatively quiet and inactive during the month. A small slide took place on the sixth. Only four or five rocks falls occurred during the rest of the month. A night observation trip 8 p. m. August 24 showed everything quiet and dark in the pit. The cracks on the rim of the pit of Halemaumau showed no change the first week of August. For the next three weeks six cracks consistently opened for an approximate total of a sixteenth of an inch each. The very local pit tremors have decreased in numbers, the count was 141, 203, 107, and 29 on successive weeks.

A note on Kamchatkan Volcanoes.

A very interesting communication was received from P. T. Novograblenof of the Kamchatka Museum. He describes an eruption at one of their great volcanic cones, Kluchevskaya which is nearly 16,000 feet high. There had been no eruption either in it or its parasitic cones since sometime prior to the Russian invasion of the peninsula in 1696 A. D. For a period of four months preceding the eruption of January 25, 1932 earthquakes were felt almost daily, some being almost destructive in intensity. The eruption started quietly with black fume rising some thousands of feet, above the parasitic cone at the base of the volcano. The explosive phase began two hours later and explosions recurred at intervals of six to seven hours. There were no lava flows. The eruptive products were fume, ash, sand, lapilli and volcanic bombs. Immediately after the culmination of activity on January 29 a party visited the vicinity of the cone. They reported it as growing no less than 12 meters a day. After seven days of explosive activity it quieted and gradually declined. Smoke and glow from the crater could be seen on the day and night of February 12 1932. Karimsky volcano was the only other Kamchatkan volcano in eruption at this time.

Earthquakes

The following is a tabulation of the tremors, very feeble and feeble earthquakes recorded by the Observatory seismograph during the interval August 1 to 29. All of these are of intensity one Rossi-Forel scale. The term tremor is applied to the smallest. For weekly seismicity or seismis index see Volcano Letter No. 371.

date	tremor	v. f.	feeble	seis
Aug. 1 to 7	29	5	0	12.00
Aug. 8 to 14	23	2	1	7.75
Aug. 15 to 21	20	3	1	7.50
Aug. 22 to 28	26	9	1	12.00

One of the very feeble shocks, August 4, was felt by a person sitting on a ledge at Puu Koae in the Kau desert. A partial record of a distance earthquake began 5h; 01m; 12s p. m. H. S. T. August 11. The origin as given by the U. S. C. & G. S. was in the Aleutian Islands near Umnak Island. August 19 a shock was felt in Kona and Kohala. It recorded feebly at Kilauea. Instrumental location placed it two miles at sea near the extension of the Hualalai rift, and about three miles north of Keahole Point on the west side of Hawaii. It was about 12 miles below sea level. A feeble earthquake was felt August 23 by an observer three miles east of the Observatory. The record showed that it was followed in less than two minutes by four very feeble after-shocks, the preliminaries being too weak to indicate distance. A very feeble shock was reported felt in the same neighborhood on August 27. It was nine or ten miles from the Observatory.

The average weekly seismicity at Kilauea for the period of low values since the last lava inflow, ending January 5, 1932, has been about ten. The average for all values during the last four years has been about 80. The values for August are close to the average low for part of this year.

A.E.J.

Ground movement and Tilt

Field work on triangulation of the Kilauea net was completed early in August. Sixteen stations were occupied in the course of the survey and thirty-one triangles closed with and average error of 02″.55. A complete report on the ground movements detected by this survey will be made the subject of a separate paper at a later date.

The clinoscope at the seismograph hut at Halemaumau is performing usefully, after several months of various tests. The hut is located 1,800 feet from the center of the pit, in azimuth 325 degrees, and 400 feet back from the rim. The clinoscope is housed in a seperate glass-inclosed room which has a daily range of slightly less than two degrees F. Readings are made once daily. Actual magnification of the clinoscope is about 50 times.

The 'Table of Tilt' shows the net tilt by weeks, as computed from seismograms at the Observatory and from clinoscope readings at Halemaumau. The table represents the movement of the ground, in seconds of arc, in the direction given. The total accumulated tilt at the Observatory from January 1 to September 1, 1932 is 10″.5 South and 02″.9 West.

TABLE OF TILT

Date	Observatory	Halemaumau
July 31 - Aug. 7	0″.5 NNE	0″.4 NW
Aug. 8 - Aug. 14	1″.0 NW	0″.4 WNW
Aug. 15 - Aug. 21	0″.4 NW	0″.5 NNW
Aug. 22 - Aug. 28	0″.6 NNE	0″.9 WNW

Clinoscopes of similar design to that above have been installed in the west and north tilt cellars, and are being given experimental runs. The two cellars, together with the seismograph hut, form an equilateral triangle about the center of Halemaumau.

E.G.W.

The Volcano Letter

No. 391—Monthly | U. S. Geological Survey, Hawaii National Park | SEPTEMBER 1932

KILAUEA REPORT FOR SEPTEMBER 1932

Including weekly press reports Nos. 1076 to 1080, August 29 to October 2 midnight.

Section of Volcanology, U. S. Geological Survey

E. G. Wingate temporarily in charge.

Volcanology

A small slide and a few rocks falls in the pit of Halemaumau in Kilauea crater were noted by observers during the last three days of August. A small slide fell from the east wall soon after daybreak September 8. A second small slide fell from over the Southwest talus slope and a few rocks fell from the east wall during that afternoon. The rim cracks back of the west wall showed widening on this day by fresh looking hair cracks in the overlying ash. Three small slides occurred after the above date and before September 18. Since then no slides large enough to be reported have occurred.

Measurements on the rim cracks under weekly observation have been taken five times, in the period covered by this report. The changes are largely confined to a few cracks that show nearly constant movement. The number of cracks that have opened a slight but measureable amount for each successive week are four, zero, six, ten, and four.

Observations and measurements of tilt at the pit during the last month seem to indicate that upward pressure is beginning to be exerted. The tilt changed abruptly from inward tilting to a direction away from the pit following the felt quake of September 7. During the last two weeks of September there began to be noticed a more or less continuous trickling of rocks from the walls, notably from the north and west, with evidences of very small sliding.

A New Map of Halemaumau

During the month of September a complete map of the pit was made by plane-table surveys on a scale of 400 feet to the inch. This is the first map of the entire pit made since the survey by R. M. Wilson in 1928. A comparison of the two maps reveals some interesting changes in the crater.

Halemaumau still retains its general circularity, though the northeast-southeast diameter is greater. The diameters at present are 3504 by 3008 feet. Avalanching from the walls has had the greatest effect on the area extending southward from the tourist lookout. The maximum amount of rim change has taken place in this area, amounting to 130 feet in one place. Other noticeable rim changes occur in the neighborhood of the old 14 ton boulder some 600 feet north of the tourist lookout, where 80 feet of the rim has fallen; along the east rim over the east talus, 80 feet; and 60 feet over the north buttress.

The general floor level has risen 280 feet, at present being 870 feet below the bronze tablet at the lookout. In area the floor has increased from 19 acres in 1928 to 88 acres, while the pit as a whole has enlarged its size only 4 acres. These figures give an approximate volume of fill, by lava extrusion, of 21,000,000 cubic yards, of which the last eruption accounted for almost 13,000,000 cubic yards.

The cone in the southwest corner of the pit is 120 feet above the floor level and the larger hummocks on the floor are from 15 to 20 feet in height.

E.G.W.

Earthquakes

The following is a tabulation of the earthquakes that were recorded during the week preceding the date below.

date	tremor	v. f.	feeble	seis.
September 4	44	8	0	15.00
September 11	19	4	1	6.75
September 18	23	7	1	10.25
September 25	36	5	1	12.50
October 2	10	5	0	5.00

These earthquakes were not larger than No. 1 Rossi-Forel scale.

During the last three days of August a swarm of thirty tremors were recorded on the seismographs of the Hawaiian Volcano Observatory. From measurements on a very few, the seismic disturbances appeared to have occurred from 30 to 60 statute miles away. Since no reports came in from other parts of the island, they probably occurred deep under the island.

A very feeble shock was felt near Kilauea at 2:45 p. m. September 6. It was about five miles away.

A feeble shock awakened people near Kilauea on the seventh at 4:38 a. m. It was also reported from Hilo. Distances and directions from the Hilo and Observatory stations indicated that the focus was under Kilauea crater and nearly under the pit.

A feeble shock, not felt, was recorded September 12 at 5:50 p. m. It was about three miles away from the Observatory. The instruments at the pit showed south and westerly tilt effects for 24 hours following the shock.

A very feeble shock was recorded September 16 at 4:51 p. m. Later, reports came in saying that an earthquake had been felt at Waikii at that time.

A feeble shock was recorded 7:32 a. m. September 24. It occurred about four statute miles from the Observatory and was well recorded on all seismographs at Kilauea. It was not reported felt. It recorded at Hilo as a very feeble shock and at Kona as a tremor.

An earthquake was felt in Kamuela at 9:38 a. m. September 27. It recorded as very feeble at the Hilo and Observatory stations. Distances interpreted from the records placed it about under Kamuela.

The seismic index (seis.), as is shown above, has not been very far from the average low between eruptions.

A.E.J.

Tilting of the ground

The 'Table of Tilt' shows the net tilt by weeks, as computed from seismograms at the Observatory and from clinascope readings at Halemaumau. The table represents the movement of the ground, in seconds of arc, in the direction given. The total accumulated tilt at the Observatory from January 1 to October 2,1932 is 09."6 South and 00."5 West.

TABLE OF TILT

Date	Observatory	Halemaumau
Aug. 29 - Sept. 4	0."7 NE	5."5 NNE
Sept. 5 - Sept. 11	0."4 SSE	6."9 S
Sept. 12 - Sept. 18	1."1 NE	8."2 WNW
Sept. 19 - Sept. 25	0."7 SE	17."0 S
Sept. 26 - Oct. 2	1."0 NNE	14."0 W

That the values for Halemaumau given above are not excessive is shown by spirit levels run on September 27. These levels indicate that the east rim, 400 feet from the B. M. at the clinascope station, has lowered 0.3 feet since March 5 of this year. Between April 5, the date of installation of the clinascope, and September 27, there had accumulated 01' 22."0 of tilt in the direction of the pit, which, at a distance of 400 feet, would amount to 0.12 feet. A much closer actual agreement seems to be indicated, as March 5, the date of latest comparable levels, was the culmination of a minor period of uplift of the Kilauea dome.

E.G.W.

The Volcano Letter

No. 392—Monthly U. S. Geological Survey, Hawaii National Park OCTOBER 1932

KILAUEA REPORT FOR OCTOBER 1932

Including weekly press reports Nos. 1081 to 1084, October 2 to 30 midnight

Section of Volcanology, U. S. Geological Survey

E. G. Wingate temporarily in charge.

Volcanology

Conditions at Halemaumau pit of Kilauea crater remain quiet and inactive. For the first week of the month rock trickling was quite noticeable. From the daily observations and reports of visitors it appeared that there was an almost constant falling of rocks from the walls of the pit. During the next two weeks this was unnoticeable, probably on account of the high winds that may have masked the sound of any falling rocks. For the last week of the month reports showed that there had been a small amount of rock trickling followed by two small slides from the north and northwest walls of the pit. The fume was less noticeable for the greater part of the month. Air conditions on October 26 and 27 apparently increased the visibility of the fume, which appeared in occasional puffs.

Comparison of the October measurements of the rim cracks with the measurements of the past months show that there has been a slight increase in the number opening. Each measuring point on these cracks, consists of two marked copper pins, fixed on either side of the crack. Every week the distance between the marks on the pins is measured to the nearest half millimeter or about one-fiftieth of an inch. The numbers that showed widening for the successive weeks in October were four, eight, eight, and seven, These movements are irregular and scattered among the observation points. In only one case has a crack consistently opened since September 24. Since then it has opened about a sixteenth of an inch each week until at present its total widening is about a quarter of an inch.

Earthquakes

The following is a tabulation of the earthquakes recorded by the seismographs of the Hawaiian Volcano Observatory during the intervals October 3 to 30 inclusive. The instrumental record consists only of tremors and very feeble shocks. The weekly seismicity (seis.) is the summation of weighed numbers given each type of shock as explained in Volcano Letter No. 371.

date	tremor	v. f.	seis.
Oct. 2 to 9	21	1	5.75
Oct. 10 to 16	26	1	9.25
Oct. 17 to 23	41	2	11.25
Oct. 24 to 30	41	1	11.00

Inconsistencies in the above table are due to the duration of tremors.

An earthquake was felt in Kona October 9 at 2:20 p.m. It recorded plainly on the Kealakekua seismograph a few miles away from the epicenter. It recorded as a tremor, not indicating distance, on the Observatory seismograph.

An earthquake was felt at Waikii at 6 a. m. October 27. It was about 60 statute miles from the Observatory but was not recorded. The records of all stations were searched but not a tremor could be found within an hour of that time. As the new instrument at the Waikii station was not in good adjustment it did not record the shock.

Parts of distant earthquakes were recorded on October 16 and 30. Only the long waves of these teleseisms recorded slightly. The microseisms were light on October 7, 8, 9, 28, 29, and 30; and strong on October 19. During the other days of the month the ground vibrations were of moderate intensity.

A.E.J.

The Study of Ground Tilts at the Observatory

At the very beginning of observations at Kilauea in 1913 exceptional tilting of the ground about the volcano became apparent, and with the passing of years became a subject of increasing interest and importance. The accumulation of data, obtained by measuring from a fixed datum line the displacement from day to day, of the writing pens on the seismograph seemed to point to a volcanic origin for a portion of the observed tilts. Certain eruptive periods showing a decided tilt away from the crater preceding the eruption, and the collapse in 1924 showed inward tilting to the amount of 81 seconds of arc between January 1 and July 1 of that year. In Vol. 19, No. 1, March, 1929, Bulletin of the Seismological Society of America, Dr. T. A. Jaggar and R. H. Finch have discussed, "Tilt Records for Thirteen Years at the Hawaiian Volcano Observatory". Their work undertakes the correlation of reults from precise levels and triangulation, atmospheric temperature, rainfall, seismicity, and the rise and fall of the Hawaiian lava column with the observed tilts as measured at the Observatory.

The present program of investigation is a continuation and extension of past work. It was felt that a new site for instrumental measurement was necessary as the location of the observatory proper on the outer rim of Kilauea, with earth cracks about it and a much faulted cliff in front as well as the distance (three miles) from the object of study, was not such as to obtain fully reliable records of volcanic tilts. In 1928 a one component seismograph was installed a few hundred feet southeast from Halemaumau. This instrument was in operation until December 1931 when it was dismantled to make way for the building of the first of three tilt cellars centered about the pit. Uplifts and depressions of as much as 15 feet are not uncommon about the rim of Halemaumau, and it was felt that with instrument stations located on the crater floor a short distance from the active pit it would be possible to make a much closer correlation between observed tilts and the rise and fall of the lava column.

Three clinoscopes, for direct measurement of tilt, and one Hawaiian Type seismograph are now in operation on the crater floor and measurements from seismograms at the observatory are being continued. The differential movement of benchmarks is determined by spirit levels from time to time and the horizontal angular value between two points on opposite sides of the pit is measured from the Observatory periodically. The net of triangulation and level stations about Kilauea is resurveyed at five year intervals. This net is to be extended eastward along the Puna rift and an independent net established at its eastern end. This section was the scene of disastrous earthquakes and shore line sinking in 1823, 1868 and 1924. Straight lines of sight, with intervisible marked points, spanning the fault country south of the volcano are contemplated. Records are kept, with daily and smoothed curves platted, of atmospheric temperature, rainfall and atmospheric pressure. Rainfall and temperature are also observed and platted at Halemaumau.

Tilting of the ground

The "Table of Tilt" shows the net tilt by weeks, as computed from seismograms at the Observatory and from clinoscope readings at Halemaumau. The table represents the movement of the ground, in seconds of arc, in the direction given. The total accumulated tilt at the Observatory from January to October 30, 1932 is 6."4 South and 2."1 East.

TABLE OF TILT

Date	Observatory	Halemaumau
Oct. 3 - Oct. 9	1."5 NE	9."7 N
Oct. 10 - Oct. 16	1."9 NNE	27."2 NE
Oct. 17 - Oct. 23	0."7 SE	5."5 ENE
Oct. 24 - Oct. 30	0."6 NE	6."8 SSW

E.G.W.

The Volcano Letter

No. 393—Monthly U. S. Geological Survey, Hawaii National Park NOVEMBER 1932

KILAUEA REPORT FOR NOVEMBER 1932

Including weekly press reports 1085 to 1088, October 30 to November 27 midnight.

Section of Volcanology, U. S. Geological Survey
E. G. Wingate temporarily in charge.

Volcanology

The pit of Halemaumau in Kilauea Crater remains quiet. Fume has been less noticeable than during October. Fume was present during the first three weeks but was not reported during the last week. Rock trickling has died down and there were only a few slides. Slides occurred on November 1, 4, 6, 12, 16 and 21. Puffs of fume were plainly seen November 4, 5, 6. A swarm of 11 tremors was recorded in less than half an hour, about 5 p. m. November 4. No distances could be estimated for these tremors, and as they coincided with fume and sliding at the pit, they were assumed to have occurred deep under Kilauea, rather than under Mauna Loa.

Concentric cracks around the pit have been measured every Saturday. These measurements show that the crack 100 feet north of the tourist stand continues to open. The number of cracks that widened each week were six, eight, four, and ten. The weekly average number of cracks that widened during the past month is slightly larger than the average for October. This increase has been going on ever since July when there was an average of two that widened.

Earthquakes

The following is a tabulation of the frequency of earthquakes recorded by the seismographs of the Hawaiian Volcano Observatory at Kilauea. The weekly seismicity (seis.) is the summation of weighted numbers given each type of shock, as ¼ for a minute of tremor, ½ for a very feeble shock, one for a feeble shock, two for a slight shock, and three for a moderate earthquake. These units follow roughly the numbers of the Rossi-Forel scale. The table gives number of occurrences of each type of shock:—

Date	tr.	v. f.	f.	seis.
Oct. 31 to Nov. 6.	53	2	0	14.25
Nov. 7 to Nov. 13.	30	5	1	11.00
Nov. 14 to Nov. 20.	31	1	1	9.25
Nov. 21 to Nov. 27.	27	5	1	11.25

Hawaiian Standard Time (H. S. T.) is 10h. 30m. slower than Greenwich.

Three feeble earthquakes were recorded at the Observatory during the past month. The first was felt about two miles east of the Observatory, at 8:35 p. m. November 11. estimated distance from Observatory 30 statute miles. The second was at 2:43 a. m. November 14, distance 20 miles, not reported felt. The third was felt at Hilo and at Hawaii National Park, 4:36 p. m. November 26, distance twelve miles.

Three very-feeble shocks were felt near the volcano. The first was felt at Uwekahuna, at 11:35 a. m. November 9. The other two were felt at a location about two miles east of the Observatory at 2:28 and 2:32 a. m. H. S. T. The first was about 2, and the two later ones about 15 and 16 statute miles distant. Only one of the above six earthquakes was reported felt from more than one place or by more than one person. They were number I Rossi-Forel scale.

The preliminary of a teleseism was recorded at 6:26:43 p. m. H. S. T. November 12 Dispatches place the epicenter in the Sea of Japan.

A.E.J.

Tilting of the ground

The "Table of Tilt" shows the net tilt by weeks, as computed from seismograms at the Observatory and from clinoscope readings at Halemaumau Southeast. The table represents the tipping of the ground, in seconds of arc, in the direction given. The total accumulated tilt at the Observatory since November 27, 1931 is 3."8 South and 7."3 East.

TABLE OF TILT

Date	Observatory	Halemaumau
Oct. 31 - Nov. 6	0."4 SW	13."8 S
Nov. 7 - Nov. 13	0."9 ESE	8."2 WNW
Nov. 14 - Nov. 20	0."8 SE	12."8 SSW
Nov. 21 - Nov. 27	2."9 NE	31."3 NNE

E.G.W.

Results of One Year's Crack Measurements

In the Monthly Bulletin of the Haw. Volc. Obs., Vol. XV, No. 7, on page 54 is the following statement by Mr. R. M. Wilson, then engineer at the Observatory, "Thinking that the steadiness in the widening of the cracks may prove interesting, 15 points for routine measurements were marked and measured along the east rim." These concentric cracks were measured in 1927-28 with some degree of regularity by Mr. Wilson. In 1929-30 the measurements were at irregular intervals.

Topographic Engineer E. G. Wingate on coming to the Observatory in 1931 extended the number of points observed and made some changes in the method of measurement to increase their accuracy. The work is done with special calipers inside of gaping rock fissures marked with paint. Routine observations were begun at weekly intervals for all points and any showing excessive movement are measured once a day or oftener. The points are also measured after any felt quakes of moderate intensity.

In the table are given the results of observations for one year. The last column shows the total accumulated movement through the year for each numbered point observed. And, though it will be noted that all except three points have shown an increase in width, the condensed table cannot show how this took place, wether by a slow gradual opening of the crack or in sudden jerks accompanying earthquakes. Actually both of these movements occurr, and in certain areas where avalanching from the walls and rim has later taken place, the movement has been accelerated up to the time of collapse.

A review of all the observations taken during the year shows two dates when a moderate quake accompanied a sudden opening of cracks. These were Dec. 7, 1931, when the opening was general but slight, and on Dec. 23, between 9:00 a. m. and 11:00 a. m., the shock preceding the last eruption accompanied moderate opening at most of the points, though some were unaffected and three indicated a slight closing of the crack.

Crack point No. 30 illustrates the several kinds of opening described. This crack is on the east side of the pit eighty feet back from the rim. The points were set Nov. 23, 1931 and the original width was 20.05 cm. This width remained unchanged until the avalanche of Dec. 7, 1931 caused increase of 0.15 cm. A slow gradual widening then commenced. amounting to 0.15 cm. at 9:00 a. m. Dec. 23, 1931. When the points were again measured at 11:00 a. m. following the quake at 10:40, the crack had widened 1.?5 cm. During the eruption December 23 to January 5. and for five weeks thereafter an opening of 1 mm per week took place. This became 2mm Feb. 1, 1932 and from that time on until the spasm of quakes and avalanching on Mar. 4. 5, and 6, it exhibited the same acceleration of movement as was noted, more strongly, at several other points: attaining a maximum widening of 1.30 cm. per week and 0.40 cm. per day. From Mar. 7 to the last date of measurement Nov. 26, 1932 a steady increase of 0.05 cm. every two weeks has been recorded.

Lack of space prohibits a more complete analysis of these observations here. In the appended table the measurements of Dec. 23, 1931 were made three hours before the last eruption commenced, and Mar. 7, 1932 is selected for comparison, as for the preceding several days avalanching had been general, doming up of the crater rim had been observed, and a swarm of earthquakes occurred on March 5. Widths are given in centimeters.

E.G.W.

Table of Crack Measurements, Rim of Halemaumau

Widths in Centimeters.

Point No.	Nov. 23, 1931	Dec. 23, 1931	Mar. 7, 1932	Nov. 26, 1932	Total widening
16	52.95	52.65	53.15	53.75	0.80
17	64.40	64.25	64.75	65.50	1.10
18	62.65	62.65	63.45	63.95	1.30
20	68.35	70.85	71.00	71.05	2.70
5	28.80	28.70	29.00	29.65	0.85
22	20.35	20.80	21.15	21.45	1.10
10	45.00	45.15	45.70	46.10	1.10
9	91.15	91.75	92.85	94.90	3.75
11	74.75	74.65	74.65	74.65	—0.10
24	22.10	23.00	23.25	23.30	1.20
25	37.75	49.35	49.50	Fell in March 6	
25 New	....	....	20.05	20.70	0.65
28	17.30	17.80	18.95	18.75*	1.45
30	20.05	21.70	24.20	25.20	5.15
29	46.75	48.65	49.25	49.50	2.75
27	46.90	47.40	47.60	48.00	2.10
26	60.55	61.05	61.75	62.55	2.00
33	....	46.65	49.30	49.15*	2.50
32 Dec. 9. 1931	16.45	16.80	16.80	16.80	0.35
34	....	83.70	85.10	86.10	2.40
31 Dec. 9. 1931	20.85	22.60	32.65	Fell in March 6.	
31 New	....		12.80	12.80	0.00
35 Aug. 23, 1932		....	86.55	86.65	0.10
36 Sept. 3, 1932		....	27.30	27.00	0.00
37 Nov. 11, 1932		....	23.90	24.00	0.10

* Indicates that point was disturbed.

E.G.W.

The Volcano Letter

No. 394—Monthly U. S. Geological Survey, Hawaii National Park DECEMBER 1932

KILAUEA REPORT FOR DECEMBER 1932

Including weekly press reports 1089 to 1093, November 27 to January 1 midnight.

Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

Volcanology

The pit Halemaumau within Kilauea crater has shown no lava activity. It is floored with lava of January, 1932 at an average depth below Tourist Lookout southeast of 870 feet. (See map on back). There is a sulphurous patch at the west edge of the floor, where most of the blue fume arises. Excessive rain December 1-2 (3.25 inches) penetrated the hot lava, caused hundreds of vapor jets, and dull thuds were heard, becoming infrequent in the course of two days, and more like distant gun shots. Sliding of debris was continuous for a day. Much of the sliding left scars at the east wall. By December 10 the sliding was inconspicuous, and the bottom was clear, but steam through the south talus keeps the rocks wet. A mound near the center of the foor is cracked and sulphur-stained. There were slides north December 14, northeast December 17, and a western slide December 19 covered part of the sulphur patch. There were other small slides toward the end of the month.

For the summit crater of Mauna Loa the National Park Service reports no changes observed about December 12.

Measurements of rim cracks about Halemaumau edge showed 10 out of 23 crack points widened for the week ending December 3, thirteen December 10, four December 17, eight December 24, and six December 31. Crack point No. 9, which had widened 3.75 centimeters during the year ending November 26, 1932, was conspicuous as widening one or two millimeters per week, but this motion ceased December 24-31 for the first time in several months (see table, Volcano Letter No. 393).

Two new crack-measuring points were marked by Engineer Edward G. Wingate December 16, making the total 25 points (see map). The number of the crack is marked on the lava with white paint, and is recorded on the map. The measuring points are upright copper pins, one on either side of the crack, with a slight cut across the head. A steel tape is used to read directly the distance between the cuts to the nearest half millimeter. Closing together of crack walls is rare, opening out is the usual movement, but highly variable. Owing to fragments in the cracks, it is natural that they should fail to close: (see wedge theory of crater fills, Bull. Hawn. Volc. Obsy. Volume XII, No. 12, December 1924, page 120). The opening of a crack is due either to tension in the floor, or to migration of the inner slab toward the pit. If it is tension in the floor, it should correspond to upward arching of the floor of Kilauea crater, that is, upward pressure under Halemaumau pit. The cracks in question are mostly back from and parallel to the line of the pit edge. In some cases several measuring points are marked at different places along the same fissure.

Earthquakes

The following table shows the frequency of local earthquakes recorded by the seismographs of the Hawaiian Volcano Observatory at Kilauea Volcano. The weekly seismicity (seis., see Volcano Letter 371) is the summation of weighted numbers given each type of shock, as ¼ for a minute of volcanic tremor, ⅕ for a very feeble shock (v. f.), 1 for feeble (f), 2 for slight (sl.), and 3 for moderate (mod.). One, two, and three follow roughly the numbers of the Rossi-Forel Scale. The table shows the weekly number of occurrences of tremors (not by minutes) and of each type of shock . Teleseisms or large distant earthquakes are indicated by (tel.).

Dates 1932 to 1933	tr.	v. f.	f.	tel.	seis.
Nov. 28 to Dec. 4	35	1	1	1	10.25
Dec. 5 to Dec. 11	25	3	0	1	7.75
Dec. 12 to Dec. 18	33	3	0	0	9.75
Dec. 19 to Dec. 25	21	2	0	2	10.25
Dec. 26 to Jan. 1,	19	2	1	0	6.75

The average of weekly seismicity is about 80, so that these numbers stand for weak volcanic tremor and earthquake activity. In what follows the times given are Hawaiian Standard (H. S. T.), 10h 30m slower than Greenwich. Estimate distances are from phases on the seismogram, using travel-time curves modified by local experience.

A feeble local shock at 1:34 p. m. December 3, was reported felt in Puna. The approximate epicenter was placed at sea from 30 to 40 statute miles NE of Hilo.

A feeble shock was felt in Hilo, Glenwood, and at Kilauea crater at 1:21:05 p. m. December 27. It was about four miles SW of the observatory. A field trip was made into the area of the supposed epicenter, no fresh cracks were found, although there were many cracks opened by former eruptions and earth movements.

A very feeble shock was felt in Hawi, Kohala, December 1 at 8:21 p. m. A small record was found only on the Waikii record for that time.

A very feeble shock was reported felt in Pahoehoe and Pahala 7:04 a. m. December 26. Its epicenter was apparently under the SW rift of Mauna Loa.

A very feeble earthquake was felt at Kilauea and Pahoehoe 8:55 p. m. December 27. Its epicenter was probably in the desert 11 miles to the SW of the Observatory.

No other shocks were reported. The tremors were generally less than a minute in duration. December 19 there was a 15 minute period of tremor ending in a very feeble shock about 3 miles distant. December 22 there was one 3 minute period of tremor.

A record of a teleseism was recorded beginning 8:53:44 p. m. December 3. The P and S phases were recorded, the latter being doubtful. An epicenter was given in dispatches for an earthquake in the North Atlantic on this date. The P and L waves of the Nevada earthquake were recorded here, beginning at 7:47:18 p. m. December 20. A teleseism at 3:47:40 p. m. recorded four phases fairly well. The long waves of a teleseism were recorded at 6:15 a. m. December 7.

The seismicity for December has been slightly lower than the November seismicity, however they are both very close to an average of ten, which has been the average since March 1932.

A.E.J.

Tilting of the ground

The "Table of Tilt" shows the net tilt by weeks, as computed from seismograms at the Observatory and from clinoscope readings at Halemaumau Southeast. The table represents the tipping of the ground, in seconds of arc, in the direction given. The total accumulated tilt at the Observatory since January 1, 1932 is 7.5" South and 3.4" East.

TABLE OF TILT

Date	Observatory	Halemaumau
Nov. 28 - Dec. 4	1.5" WSW	20.3"SEE
Dec. 5 - Dec. 11	0.4" SW	9.7" SSW
Dec. 12 - Dec. 18	0.9" ESE	5.2" WNW
Dec. 19 - Dec. 25	0.8" NE	16.6" NNE
Dec 26 - Jan. 1, 1933	2.2" SW	5.3" SE

E.G.W.

Postal card earthquake records

In March, 1932, special postal cards of the U. S. Geological Survey were placed at twenty-five stations on the island Hawaii, to be sent to Kilauea Observatory reporting felt shocks At the present time sixty-one card records of the new series are on file. These are of value in showing what shocks were general, and what ones were localized. A report of the results of these records will be published by A. E. Jones, seismologist. We shall be glad to supply other reporters who are interested. The following have earned the gratitude of the Observatory by sending in postals:—

L. P. Lincolu, Hookena
R. Lyman, Pahoa
J. B. Fordyce, Hawaii National Park
Kohala Sugar Co. Hawi
C. S. Ishii, Kamuela
R. Buzzard, Waikii
R. V. Woods, Kealakekua
J. B. Albert, Hilo
R. B. Hodges, Hawaii National Park
R. E. Baldwin, Hilo
R. L. Hino, Kukuihaele
Honokaa Sugar Co, Haina
Hutchinson Sugar Plantation Co. Naalehu
J. B. Oliver, Honomu
L. Loon Pahala
Hakalau Plantation Co. Hakalau
J. Johnston, Ookala
Kukuihaele Manager, Kukuihaele
E. Brumaghim, Hawaii National Park
Archdeacon Walker, Kohala
R. R. Craik, Hilo
W. Akau, Kawaihae
J. M. Ross, Hakalau