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

A Weekly news leaflet of the Hawaiian Volcano Research Association

TITLE PAGE AND INDEX FOR 1929

(Nos. 210-262)

SAMPLE COPY

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No. 210 RELEASED WITHOUT COPYRIGHT RESTRICTION January 3, 1929

KILAUEA REPORT No. 884

WEEK ENDING JANUARY 2, 1929

Section of Volcanology, U. S. Geological Survey

E. M. Buckingham, Temporarily in Charge

The week has been very quiet at Kilauea, with only two very feeble earthquakes and very little change at Halemaumau. The tilts noted last week have dropped back to nearly the values shown prior to those accumulated at the time of the two perceptible earthquakes of December 24 and 25.

VOLCANIC ACTIVITY NEAR TONGA

From the Apia observatory, Dr. Andrew Thomson Director, came news under date September 24, 1928, that Falcon island, the newly formed volcano fifty miles to the nortwest of Nukualofa in the Tongan islands, continues to give off steam with an occasional expulsion of a mass of cinders and ash. Its activity had diminished during the previous six months.

Dr. Thomson writes, "There is a rather striking difference between the Tonga and Samoa volcanoes, in the materials ejected. In all recent eruptions in Tonga, ashes, cinders and scoria have been thrown up, while in Savaii lava only has been ejected. The volcano Maugaloa in Savaii, which threw out such enormous quantities of lava from the Matavanu vent during 1907-11, has become dormant. The steam column, which used to issue from a vent, became smaller in size, then came only at irregular intervals and it is now several years since it has been seen at the Government residency about five miles away."

The same observatory reports a probable new submarine eruption about 120 miles farther to the northwest indicated by fields of floating pumice first observed by the S.S. Carisso, October 3, 1928, about 240 miles east of Suva, Fiji. (Science, p. XIV, Nov. 9, 1928.) During that night patches of pumice .each covering several miles, were seen along a course 70 miles to the southwest of the first patch. The S.S. Veronica sighted a patch a mile wide 30 miles farther to the west October 7, over water more than 1200 feet deep, and a very large field of pumice was found farther to the east many miles in length in an N-S direction and about a half mile wide.

The pumice first seen was at 17° 25′ south latitude, 176° 09′ west longtitude. If the vent is on the bottom of the sea near this place, it is an area in deep water of great seismic activity where ten violent earthquakes occurred between 1913 and 1920 and one of the epicenters lies about 75 miles north of where the pumice was seen. There are two principal earthquake centers, and it is a remarkable fact that all of this seismic and volcanic activity is on the line between the active volcano island Niuafou and the Tonga volcanoes further to the south. Niuafou is about 100 miles north of the region in question.

The activity of Falcon Island is well described in the December, 1928, National Geographic Magazine (Hoffmeister and Ladd, Falcon the Pacific's Newest Island, p. 757). These authors landed on the revived island in May 1928, discovering strong hydrogen sulphide fumes, no red glow at night, a roundish island with crater close to the shore on the southeast or windward side, and the greater part of the heap built to leeward of pumice, cinder, lava fragments, bombs and ash to a height of 365 feet. The island is about two and a half miles across in an east-west direction, clouds of steam and sulphur fume rise from the crater, the surface is rill marked and washed into gullies, and steep cliffs have already been cut by the sea along the windward side of the island.

The present eruptive period of Falcon Island began with its most violent eruption on record in October 1927, and minor eruptions from time to time have added to the heap since. It is an old volcanic shoal first reported in 1865 and occasionally active since.

The north shoreline consisted of coarse black cinders and pumice banked at 70°, and the ground was made up of fine ash mixed with sharp fragments of cinder, pumice and lava, with only trench-like gullies to break the uniform curve of the ridges. The profile of the island shown in a photograph exhibits a distinct wave cut platform at the east The bottom of the crater is elliptical, covered with a boiling lake, some parts of which boil incessantly, while other places bulge upward periodically, when black sediment is brought up from below. The water varies in color from milky green to yellowish white. The lake is surrounded with ash and sulphur flats, dotted with steam jets, and the steep walls of the crater are vertically fluted, with steam vents rising from the depressions which have deposited sulphur and other substances coloring the gullies yellow, orange or white in contrast with the drab ridges.

There is a younger crater with steep sides, and an outer crescent ridge, with a gulch between the two that has drained into the lake to form a low delta built out into the lake from its eastern side. The crater wall is largely fine ash and scoria but there are numerous volcanic bombs and blocks. The bombs are spindle shaped, were thrown out in a liquid condition, are often exceedingly porous, in other cases they show concentric structure. Some of the blocks are three feet in diameter, made of agglomerate or of either dense or porous lava. The vent noises are of sputtering and whistling, the lake waters have a vile taste, and sulphur dioxide appears to have been dominant, as the eyes smarted and breathing through cloth gave relief.

T.A.J.

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No. 211 RELEASED WITHOUT COPYRIGHT RESTRICTION January 10, 1929

KILAUEA REPORT No. 885

WEEK ENDING JANUARY 9, 1929

Section of Volcanology, U. S. Geological Survey

E. M. Buckingham, Temporarily in Charge

Beginning January 5 there was a marked increase in avalanching in Halemaumau pit, all from the south, and southeast walls. Since that date avalanching has been practically continuous, and a large part of the south rim has disappeared. Half the lava floor of the pit is buried under debris from a big avalanche occurring at 7:40 a. m. January 7 and carrying away the south station. The area around the tourist stand is badly shattered and has settled noticeably, rendering the bench mark at the edge of the pit valueless. Crack measurements in the vicinity show a widening of 0.8 foot in one of the cracks between December 4 and January 7, with an additional widening of 0.3 indicated by a measurement on January 8.

The avalanching is progressive and appeared to originate about one-third of the way down from the southest rim, undermining the top and lossening the lower sections by impact, and spreading progressively from south to southeast.

The seismographs at the Observatory recorded 16 very feeble earthquakes, 12 of them occurring during the interval from January 5 to 6:30 a. m. January 6. Beginning at noon of January 5 the instruments recorded a very faint continuous tremor which lasted, with varying amplitude, throughout the remainder of the week. Many of the counted earthquakes are hardly more than pronounced increases in the amplitude of this tremor.

MORE ABOUT ETNA

The eruption of Etna is said by Professor Ponte, Director of the Etna Observatory, to be much bigger than those of 1910. 1911 and 1923 (London Times, Nov. 12). The eruption started November 1 and on the 6th the velocity of the lava increased and the stream was only 200 yards from the Circum-Etna Railway at 9 a.m. The volume of lava had been increased suddenly by three arms which had been flowing separately uniting as they approached the hamlets before Mascali, and this produced accelerated movement. At one place the flow formed a huge cascade. An iron bridge began to sink at the approach of the lava, and was simply fused when the lava reached it. The spectacle is described as ominous and terrifying. Trees suddenly take fire and flare up, and orchards disappear in flames. The people in the villages continually formed processions and carried religious banners, pictures and even statutes before them while praying fervently. The preceding night big explosions were heard, with loud subterranean rumblings (Daily Telegraph, London, Nov. 7).

On November 7 Mascali, a town of 7000 inhabitants, had been destroyed, and The Illustrated London News of November 17 carries remarkable pictures showing the lumpy aa lava in the midst of this masonry town with the dome of a large church still standing. A message of this date said, "the main body of the parish church, its belfry and the new War Memorial, the last three structures standing collapsed at three o'clock this afternoon and the village is now entirely obliterated." The pictures give a vivid idea of what a Mauna Loa lava flow would do if it were to invade the newer masonry structures of Hilo such as the business blocks and the Federal Building.

Vehicles of many kinds were brought in to carry away the inhabitants. The correspondent writes "during the night the lava stream steadily advanced, obliterating house after house, and this morning (7th) when I tried to approach the town, the heat prevented me from getting within 300 yards of the last group of houses, which were already surrounded by a burning mass."

"The town hall was one of the last buildings to remain standing. For some time as the lava rose all around it the walls offered stubborn resistence. Suddenly, however, they collapsed and mingled with the mass of melted rocks."

"Several secondary craters opened on the 2nd and 3rd and on the 4th they formed one vast crevice on the side of Monte Frumento, from which poured out huge volumes of lava."

Along the eastern railway there was dense fume for more than a mile making breathing very difficult. The lava near Mascali was moving about five feet per minute but it was certain to reach the railway. The breaking of an aqueduct by the lava caused serious inconvenience and destruction of road bridges interrupted traffic. An attempt to divert the main lava stream and open an artificial outlet to the sea to prevent the destruction of important towns was being planned (London Telegraph, Nov. 8).

By the end of November 7 the flow had gone 300 feet beyond Mascali. It had now cooled sufficiently for a hard, dark crust to form on its surface. It therefor no longer presented the appearance of a river of fire, but looked rather like an enormous pile of coal. It was twenty-five feet high where it entered Mascali. Cracks appeared in the flow, revealing its fiery interior and as it advanced it made a horrible crunching noise. At night, by contrast with the surrounding darkness, it resumed its fiery aspect. The stream now stretched about ten miles from its crater. (London Daily Mail, Nov. 8).

On the 8th digging and mining new channels to lead the lava away from the large town Giarre were occupying the attention of the authorities. The most tragic scene at Mascali was the engulfment of an aged couple who had fallen asleep after nights of anxious vigil At three o'clock in the afternoon, when the lava had surrounded them, they were suddenly seen on their roof imploring help. A crowd of spectators 500 yards away were terrified and realized that help was impossible. Then the walls fell in and the unfortunate couple disappeared.

After the little church had crumbled in, the campanile or bell tower stood. It was observed to lean first in one direction and then in another and suddenly the bells rang out. The crowd was deeply affected and many of the old folk fell on their knees and prayed. The bells were still heard long after dark, and at eight o'clock the tower fell and the bells rang no more. (London Telegraph, Nov. 8).

On the ninth a huge cascade of fiery liquid rock was pouring uninterruptedly into the valley of Bove, where a lake of lava had been formed three-quarters of a mile wide, feeding the torrents that descended to the lowlands. On the 11th the railway bridge at Mascali was destroyed and the railway was obliterated. This finished the second railroad interrupting all traffic at the east end of Sicily. (London Telegraph, Nov. 10 and 12.) T.A.J.

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No. 212 RELEASED WITHOUT COPYRIGHT RESTRICTION January 17, 1929

KILAUEA REPORT No. 886

WEEK ENDING JANUARY 16, 1929

Section of Volcanology, U. S. Geological Survey

E. M. Buckingham, Temporarily in Charge

The avalanching which began last week reached a climax at noon of January 10, when a section of the southeast rim about 100 feet long fell into the pit, carrying away the 19th hole golf tee. Since that time there have been only occasional small slides, although another section of the southeast rim appears to be slowly loosening.

The continuous tremor which began at noon of the 5th died out in the afternoon of the 9th. During the week there were recorded eight very feeble local earthquakes and one teleseism, which occurred on January 12 from 1:42 to 2:14 p. m. The strongest of the local shocks was coincident with the landslide at Halemaumau on Janury 10.

MAKING ARTIFICIAL EARTHQUAKES

The Hawaiian type seismograph (described in Bull. Hawn. Vol. Obsy. vol. XV, No. 11, Nov. 1927) has been mentioned in the Volcano Letter as an instrument designed especially for local earthquakes from experience at the Hawaiian Volcano Observatory. Six pairs of pendulums of this design have been built in the Kilauea shops and set up at Hilo and Kealakekua, Hawaii, at Kodiak. Alaska, and Cheltenham, Maryland, at Mineral, California and Dutch Harbor, Alaska. The last is still in process of being installed. A seventh instrument is now set up in the Observatory shop, and is being subjected to tests with experimental earthquakes.

The readers of the Volcano Letter may be interested to know how that can be done. The late Professor Omori of Japan made a shaking table on wheels actuated by a connecting rod from the driving wheel of a steam engine. With this he set up various brick, stone and cement columns clamped to the top of the table, and then subjected the machine to rhythmical jerks or accelerations applied by the engine. By increasing the period and amplitude of these jerks to the critical value that led to the overturning or fracture of the columns, he learned much about the strength of masonry suitable for an earthquake land. Similar experiments were conducted in the engineering laboratory of the Massachusetts Institute of Technology about 1911 under the guidance of Professor C. M. Spofford and others.

The problem before us in the Hawaiian laboratory is different, in that it is desired to imitate feeble earthquakes such as frequently affect seismographs in a volcanic land, and to provide devices on the oscillating table for setting up such a seismograph with its full recording mechanism. In the summer of 1928 Mr. R. M. Wilson designed and built such an oscillating table, having the property of reducing the amplitude of motion of the machinery to which it was attached to microscopic proportions, while retaining with scientific accuracy a constant reduction ratio. This ratio is approximately 1/29, so that when the motor moves back and forth 1/10 of an inch, the shaking table moves 1/290 of an inch. Earthquakes of this small amplitude in actual motion of the ground are very common at Kilauea, and produce on the Observatory seismograph an autograph about a half inch in range of back and forth motion of the writing pen on the smoked paper.

The tool used for giving harmonic motion to the table is the chuck of a machine lathe holding an adjustable crank to which is attached a connecting rod that may be set at any desired distance from the lathe center. The other end of the connecting rod operates two upright levers attached to long steel rollers that bear the weight of the table. The table is a T-shaped body of massive concrete weighing about 800 pounds with a post of concerte rising at one end to hold the pendulum of the seimograph. At the other end is a platform to hold the clockwork and recording drum. The crank radius in the lathe chuck can be easily changed to give the required amplitude to the table, and the desired period of oscillation is obtained by changing the lathe speed. which may be governed through a wide range of motions with the belt pulleys, the speed gears, and the throttle of the power plant.

The Hawaiian seismograph is a horizontal pendulum with mass weighing 80 pounds, hinged above and below with short links of piano wire, operated usually with a free period of about seven seconds, and damped with light aluminum vanes dipping in oil near the outer end of the boom. The lever magnification is about 130 times and the time is marked on the smoked paper by a lift of the pen tips once a minute electro-magnetically. The paper speed is 1¼ inches per minute.

An account of the first tests of the Hawaiian seismograph with artificial earthquakes will appear in the August Bulletin of the Observatory (Vol. XVI, No. 8). These tests were made by Mr. Wilson with a view to checking the theoretical magnification with the observed magnification for various amplitudes and periods of forced vibration communicated harmonically to the oscillating table. The result was a magnification curve of great interest showing that oscillations representing periods between one and four seconds most nearly conformed to the theoretical curve, and indicated a magnification about 113, instead of 130 as computed from the lever system.

The effects of solid friction in relation to viscous damping and to the energy of the impressed motion were conspicuous, as usual with smoked-paper seismographs. The elimination of friction in instruments with pivoted levers entirely omitted is now being tested with interesting results.

T.A.J.

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No. 213 RELEASED WITHOUT COPYRIGHT RESTRICTION January 24, 1929

KILAUEA REPORT No. 887

WEEK ENDING JANUARY 23, 1929

Section of Volcanology, U. S. Geological Survey

E. M. Buckingham, Temporarily in Charge

There have been noticeable changes at Halemaumau during the week. A small area of the south wall, at about the point where the recent sliding originated, has been emitting a moderate but constant volume of steam since the sliding began, and may furnish the key to the cause of the sudden failure of that section of the rim.

There were 21 local earthquakes recorded during the week. Only one, occurring at 6:02 p. m. of the 20th, was strong enough to be perceptible. Its indicated distance was 19.5 miles from the Observatory. At several times during the week a very feeble continous tremor was noted. Microseisms increased noticeably toward the end of the week.

MUD VOLCANOES

A combination of natural gas and muddy water rising through cracks in formations where hydrocarbons are abundant may produce fields of mud and clay, with little cones and craters which simulate volcanoes in form. Otherwise they are not volcanoes at all. These mud and gas cones occur in many parts of the world, especially in the vicinty of petroleum-bearing strata.

A recent dispatch from Australia states that at Lake Victoria, nine miles from Paynesville, a small island was thrown up last January so as to stand about 3 feet above the surface of the lake. This was nearly washed away, but in the summer some 2000 cubic yards of slimy black clay was brought up by a combustable gas so as to make a new island at the same place 60 feet long and 30 feet wide. This stood about 4 feet above the water and contained much fibrous material resembling decomposed vegetable matter. The lake here was 12 feet deep. Gas rose through two big cracks in the island. Gas bubbles have risen through the lake in the past.

Burma is a land of mud volcanoes and the rising gas is sometimes very hot. An extraordinary report of the 29th of July, 1926, stated that at 2:10 a. m. a large flame was seen rising several hundred feet high, burning for about fifteen minutes, and then jetting up again ten minutes later. This was in Kyaukpyu township. It proved to be a mud eruption a half mile north of the village of Kin which built a considerable hill and buried many acres of cultivated land. Many young plants were distroyed by the heat. A similar eruption had occurred here forty-eight years earlier, preceded by rumbling, when a large volume of fire and smoke came forth and fine debris fell miles away from the center. There was excessive heat and leaves were scroched.

The Minbu district of Burma, 300 miles north of Rangoon on the right bank of the Irrawaddy river, is an area of blue and green Miocene clays and soft sandtones. These contain traces of oil. From small holes in the ground mud oozes out along with inflammable gases. Mud is cold and smells of petroleum. Gradually a small cone is formed with a crater. The biggest crater is six feet across. The bubbling of thick viscous mud inside is incessant and one after another bubbles two feet or more in diameter form and burst so as to splash the mud round about. Occasionally there are subterranean gurglings which alarm visitors. There are many such mud cones in different stages of development over a few acres of land near Minbu. The mud is salt. (Indian newspapers, 1926.)

In central Java 50 miles northeast of Solo there is an elevated mud plain two miles in circumference, in the center of which salt mud is thrown up to a height of from 10 to 15 feet in the form of globes which burst and emit white smoke. Two bubbles observed rose and burst seven or eight times to the minute. Some times these vents throw up two or three tons of mud. The fumes smell like gunpowder. When the bubbles burst, they throw the mud out from the center and there is a loud noise as it falls on the surrounding surface. The ground is all a quagmire round the active vents.

The smaller bubbles heave and swell, and when they burst the mud falls in concentric circles, the intervals between explosions being from a half minute to two minutes. In other places the mud is rocketted up to a height of 20 or 30 feet accompanied by vapor. This mud was too stiff to be blown into bubbles. The mud was all cold at the surface, but it is said to be warm underground. In this immediate vicinity there are salt lakes and bubbling pools with cold water of offensive smell and bitter, salt and sour taste. Here there is a mud cone and crater with bubbling mud inside. This mud is very liquid and when it rises there are rumbling noises. At several large springs in the vicinity there is gas effervescence with strong odors of hydrocarbons. The ground is hot and the boiling can be heard 30 yards away. (The Family Magazine, 1843.)

Near Turbaco, a few miles from the north coast of Colombia, there are lowland thickets on a rectangular plain where the soil is dark brown clay and there are open areas of mud volcanoes separated from one another by irregular clumps of sedges. Here there are fifty or sixty active craters in conelets two to four feet high. The craters are from one to five feet across filled with cold creamy liquid mud continously bubbling and sometimes overflowing the lip and running down the sides of the cone to harden in the hot sun. The gases are hydrocarbons with more or less carburetted and sulphuretted hydrogen and nitrogen. (The Scientific Monthly, July 1928, p. 42.)

T.A.J.

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No. 214 RELEASED WITHOUT COPYRIGHT RESTRICTION January 31, 1929

KILAUEA REPORT No. 888

WEEK ENDING JANUARY 30, 1929

Section of Volcanology, U. S. Geological Survey

E. M. Buckingham, Temporarily in Charge

There were no changes at Halemaumau during the week.

The seismographs at the Observatory recorded 10 very feeble earthquakes. Continuous tremor was still present at times, but became much fainter and died out about noon of the 28th.

Microseisms were unusually large in the early part of the week, but became normal on the 25th.

POSTSEISMIC BLOCK MOVEMENTS IN THE TANGO DISTRICT

An article in the November "Proceedings of the Imperial Academy" (Tokyo) by Chuji Tsuboi on the postseismic block movements in the Tango earthquake district presents data which may shed considerable light on the completeness of the isostatic adjustment of the earth's crust. Immediately after the Tango earthquake of March 7, 1927, the Japanese government began a network of precise levels, to be repeated periodically, to determine what earth movements, if any, were taking place in the final adjustment after the earthquake. Three surveys have been made on April 12 to June 16, 1927; June 1 to July 31, 1927; and March 3 to April 20, 1928.

While the discrepancies between these surveys are of the order of millimeters, their peculiar grouping indicates that they are actual earth movements and not instrumental errors. The movements were plotted against a projection of the lengths of the level lines and connected by a series of straight lines. A study was then made of the known fault lines of the region, and it was found that in every case discontinuities in the plotted points fell across known faults, showing that each block or group of blocks moved as a unit with an upheaval, subsidence, or tilting which was constant throughout that block.

The changes between the second and third runnings were not all of the same sense as between the first and second, showing that in some cases the forces causing movements actually reversed themselves, relative to each other if not absolutely.

The average distance across blocks is the neighborhood of four kilometers. While this cannot be taken as the width of the maximum area which will remain isostatically uncompensated, it does give an indication of the extent to which adjustment proceeds once the rigidity of the crust has been destroyed by a major earthquake. An interesting check on this deduction is seen in the system of parallel fault scraps in the neighborhood of Kilauea, which in one place reach a frequency of four faults of relatively large displacement in a distance of about two miles.

A vertical displacement on a land area of 40 feet in one movement is exceedingly rare, even with an earthquake of the first magnitude. It would therefore seem, if complete adjustment attains after each major shock, that a topographic feature of any size cannot remain uncompensated, and that isostatic compensation must be very complete indeed. E.M.B.

INTERNATIONAL CONGRESS OF OCEANOGRAPHY MARINE HYDROGRAPHY AND CONTINENTAL HYDROLOGY AT SEVILLE

Notice has been received of a meeting of the International Congress of Oceanography, Marine Hydrography and Continental Hydrology to be held at Seville, Spain, May 1-6, 1929. The subjects for discussion are:

Section of Oceanography and Marine Hydrology.

1. Relations between the vitality and the oxygen of the seas.
2. Study of the straits as means of communication between the seas.
3. Modern methods for the determination of the relief of the sea-bottom.
4. Aereous currents in the equatorial regions of the oceans.
5. Relations between oceanography and navigation of the air.
6. Cooperation in an international map of the scale of 1/1,000,000 and consideration of the suitability to complete same by a map dividing the oceanic and continental regions, including in the latter the continental plain.
7. Relation between the currents and emigration of fishes.
8. Influence of the arctic ice on the climate.
9. Methods for the determination of the density of sea-water.

Section of Continental Hydrology.

1. Solid stock.
2. Formation of bancs and deltas.
3. Methods for precise measurements of the hydraulic yield of turbines.
4. Investigations with reduced models and their laws of analogy.
5. Subterranean waters.

Persons interested should address the Secretary of the Organizing Committee, Instituto Espanol de Oceanografia, Calle de Alcala, 31, Madrid. E.M.B.

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No. 215 RELEASED WITHOUT COPYRIGHT RESTRICTION February 7, 1929

KILAUEA REPORT No. 889

WEEK ENDING FEBRUARY 6, 1929

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

Examination of Halemaumau February 2 showed the rim gone to a depth apparently 15 feet more or less south and southeast, carrying away such landmarks as the old burned boards of the 1918 outhouse and the pinnacles just inside the rim, as well as the south station. The bronze datum bench mark southeast is on cracked dangerous ground at the extreme edge of the pit. A new tourist platform for viewing the pit has been built at the east rim. The south talus was struck by the great avalanches and set in motion as a landslide so as to cover the whole south half of the lava floor. This is much like what happened just a year ago, January 11, 1928. At that time, however, liquid lava was pressed up.

There is a little steam high on the south and southwest taluses, and from the cavity in the central lava cone. Some minor wall cracks are steaming, and the SSE. rim cracks steam vigorously and show fresh soil breaks 40 feet or more back from the rim. Rocks were sliding a little on the lower south wall. February 3 and 4 a little dust rose from slides at the north corner of the pit, and gravel was heard slipping at the south. On February 5 the strongly felt earthquake of 2:25 a. m. appeared to produce little effect at the pit.

Nine very feeble earthquakes were registered at the Observatory during the week, and in addition one strongly felt earthquake (intensity IV Rossi-Forel scale) occurred at 2:25 a. m. February 5 so as to awaken sleepers generally. This shock was felt strongly also at Hilo and Kohala, appeared to be local at Kilauea seismographically, and hence may represent a deep earthquake under the east side of the island

Tilt for the week was moderate ENE. All the seismographs showed an apparent easterly tilt at Kilauea during the earthquake. This suggests that if subterranean lava was concerned with the earthquake at all, the lava movement was one of rising. Microseisms for the week were ordinary.

THE BALI ERUPTION 1926

On the ilsand of Bali, next east of Java, there is a volcanic rift line trending northwest and southeast carrying two larger volcanoes, Batoer on the northwest and Agoeng on the southeast. The latter is believed extinct, but Batoer has had lava flows in 1849, 1888, 1904, 1905, and twice in 1921. In August, 1926, a new and extensive lava flood destroyed the village Batoer with its Brahman temple.

Dr. C. E. Stehn, in charge of the Volcanologic Service of the Netherlands East Indies, has produced an interesting memoir on this eruption, with 67 pages of text, 47 photographs, 10 map plates and 14 text figures (Vulk. en Seismol. Mededeelingen No. 9, 1928, Bandoeng, Java.) There is an abstract in English, and the plates have both Dutch and English legends. Contour maps on large and small scales are presented, showing fissure eruptions, details of cones, craters, and flows, and lava tunnels which are all like Hawaii in topographic arrangement, but there is ash ejected with the lava outflow, and this is uncommon in Hawaii. The lava is an olivine-bearing pyroxene-andesite, or basalt, carrying about 52% of silica, and therefore is somewhat more acid and refractory than the Hawaiian basalt.

The upper part of Mount Batoer is an oval sink, larger than the Kilauea crater, with NW.-SE. axis 8½ miles long, and the other dimension 6 miles. Inside this there is a second cauldron 4 1/3 miles across, merging into a crescent-shaped crater lake at the southeast end of the greater caldera. This lake is 200 to 260 feet deep.

On the floor of the inner crater stands a mixed cone rising 2,000 feet above its base and 5,600 feet above sea level. This is some 1,300 feet below the highest rim cone, Mount Abang, at the southeast end of the outermost ring wall. The greater ring crater is closed with its drainage inward to the lake, and in this respect differs from Asosan, in Japan, which it somewhat resembles. The inner volcano, here as at Aso, is the scene of activity, and the historic lava flows have been filling the southern half of the inner wall valley from 1849 to the present.

Batoer is the name of the inner volcano, which has two summits, several groups of craters, and fracture lines mostly radial, which are followed by the crater cones and pits. There are some fractures which are concentric, and one that crosses the flank of Batoer. The summit pits of Batoer are 160 and 650 feet deep, and gave vent to lava flows in 1905.

Twenty-two groups of parasitic cones and craters have been found, partly built of ash and partly of lava scoriae, either loose packed or sintered together.

The eruption of 1926 began in the night of August 2, was preceded by earthquakes, and opened a long radial fissure at the southwestern base of the inner volcano Batoer. Hot slag was thrown up, and lava flowed southwestward. The following night the fracture opened to a length of 4,200 feet northeastward in the direction of the peak. The lava flow divided into two streams flowing north and south when the confining wall of the inner sink was reached, and the southern branch overwhelmed the village completely by August 27.

The progress of the eruption greatly resembled a flank eruption of Mauna Loa. At first there were 20 spurting jets along a continuous crack. After August 10 three groups of active mouths became segregated, containing 8 to 10 craterlets each. These built up in the course of the month so as to make the highest cones of ash at the northeast or highest group of vents. The middle group produced blocks, bombs, and cinder, and built cones of intermediate height. The lower openings of both groups produced lava flow with a temperature from 1,100 to 1 200° C. Lava fountains were observed. Gases escaping at the border of the lava field as late as May, 1927, still had temperatures up to 575° C. The lowermost group of vents was some 1,600 feet down the rift from the others, and during the eruption it would fling up large blobs of glowing lava from 30 to 60 feet into the air.

The uppermost lava flow was a foamy pahoehoe near the vent. The lower one was a scoriaceous aa, and both streams flowed together as a rough clinkery lava in the lower parts of the flows. Large rafts of plastered clinker 20 feet high and 40 to 50 feet across were observed on the surface of the flow transported 1¼ miles. In its upper course the lava flowed 20 feet a minute on a slope of five degrees; farther down on a horizontal floor 1.8 miles from the source the lava field was 26 feet thick and progressed 130 feet in 24 hours (Aubust 9-11). August 28 a velocity of 39 feet per hour was measured two miles from the source. Approximately 741 million cubic feet of lava was produced, the outflow ending September 21.

This memoir is of great interest in showing true lava eruptivity in the East Indies.

T.A.J.

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No. 216 — RELEASED WITHOUT COPYRIGHT RESTRICTION — February 14, 1929

KILAUEA REPORT No. 890

WEEK ENDING FEBRUARY 13, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

The lava pit of Kilauea has exhibited no conspicuous change during the past week. Occasionally rocks have been heard to fall from the walls, and the rainy weather has produced more visible vapor than is seen during dry weather.

Seven very feeble earthquakes have been registered on the seismographs at the Kilauea Observatory, and one short period of spasmodic tremor occurred on February 9 about 12:52 p. m. Two local earthquakes on February 8, at 11:17 a. m. and 6:48 p. m. both indicated an origin approximately 18 miles from the station. This origin is probably in the direction of Mauna Loa, as these earthquakes were similarly registered in Kona. The strongly felt earthquake of February 5 appears to have originated under the southern part of Kilauea Mountain, as shown by measurement of the seismograms of Hilo, Kona and Kilauea.

Tilt for the week was moderate to the SSE. at Kilauea. Microseismic motion was slight.

NGAURUHOE ERUPTION OF MARCH 1928

Ngauruhoe is a steep-sided symmetrical cone rising 7,515 feet above sea level, in the national park near the southern end of the volcanic belt that traverses the north island of New Zealand. The 1928 eruption is the eleventh recorded outbreak since 1839. The known eruptions have ejected blocks of augite hypersthene andesite. A dark colored aa lava flow found at the foot of the mountain is reported to have been poured out in 1869 (Eruption of Ngauruhoe, March, 1928, by L. I. Grange, N. Z. Jour. Sci. and Tech., Vol. X, No. 3, Oct. 1928, page 143).

On the morning of March 4, 1928, the volcano rumbled, and there were two vertical shots from the crater with an interval of half an hour between them. Blocks of lava were ejected and rolled down the side of the mountain, and black clouds of ash were blown toward the south. The rumbling and belching continued in the afternoon, and two more shots occurred in the evening. At 6 a. m. March 5 a big shot was accompanied by earthquakes that shook the Whakapapa huts, about six miles away. Twice that day the volcano roared, and for the rest of the week the mountain was clouded over. On March 11 Mr. Grange, the Government Volcanologist of New Zealand, at the foot of the mountain could sometimes hear the roar of gas vents. The crater was reached March 12 and found to be a flat-floored depression surrounded by steep walls, and partitioned into east and west divisions, with a small shallow crater occupying a part of the rim at the north. The main crater is more than 200 feet deep and about 650 feet in diameter, the inner walls exposing beds of scoria and lava flows. There were three small vents on the bottom, the central one being active, and small steam vents occured in several places in all the craters and some sulphur was being deposited.

The active vent was a conelet about 70 feet in diameter where red-hot lava could be seen below a surface covering of stones that had fallen back during the eruptions. It resembled a quiescent blacksmith's fire. The lava appeared viscous, to judge from the sharp edges, smooth faces, and open contractive cracks of the hot, fresh blocks. Blue smoke was escaping with a tremendous roar,and at times there were bursts of gas darkened by ash. Sometimes the roar would cease for several seconds. The first of the gas jets was inclined west, but after 20 minutes the inclination shifted to the southwest. Red-hot fragments of lava were thrown up 50 feet. Once there was a sharp, loud explosion, throwing blocks above the rim of the main crater, into which they all fell back. In the afternoon black cauliflower clouds rose several times from the crater, and at night a red glow was reflected from the fumes. It appears that on February 21, 1928, the lava surface was about 80 feet below the rim of the vent, and descriptions of the crater floor by observers at other quiescent times indicate that the active vent has changed position. T.A.J.

VOLCANIC TREMOR AT VESUVIUS

The annual of the Vesuvian Observatory for 1925 contains an analysis of the seismograms registered during paroxysmal explosions in the crater for 24 hours November 30-December 1, 1923. (G. Imbo, Annali, del R. Osservatorio Vesuviano, Vol. II, 1925, page 149.)

Harmonic continuous vibrations and more rapid spasmodic occasional ones are distinguished at Vesuvius, just as at Kilauea. There are also longer period wave movements, and very feeble local earthquakes usually not stronger than Grade II of the Cancani scale.

The active date in question followed about three months of moderate activity. The Vesuvian crater was floored over with an active conelet on the high bottom. At 4 p .m. November 30 a lava flow poured from the west base of the conelet to the north wall of the crater, and the conelet produced nearly continuous explosions accompanied by projection of lava shreds. Scoriae were thrown up over 300 feet. By 4 p. m. of the next day a million cubic meters of lava had been produced, it ceased flowing, and the vent activity became normal.

The Vesuvian Observatory maintains a vertical component seismograph with heavy mass weighing 200 kilograms, period 2.11 seconds, and lever magnification 170. Horizontal tremor is indicated by an Agamemnone instrument.

About 724 explosions were registered in 24 hours, and the frequency exhibits three decreasing maxima and three decreasing minima. The microtremor waxed in somewhat similar pulsations to a high maximum, and then declined.

Professor Imbo on February 5, 1926, carried an accurate timepiece to the crater and compared the time of explosion with the seismograph records for 10 explosions. The mean time of propagation was 5.9 seconds for a distance of 2,670 meters, showing a superficial velocity of 450 meters per second. Probably the distance from the deep explosion was less than this over a more horizontal course. It was estimated that the depth of the explosion source was 312 meters, reducing the angle of the line from source to observatory to 4.8°; the angle from conelet to observatory is 11.2°. T.A.J.

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No. 217 | RELEASED WITHOUT COPYRIGHT RESTRICTION | February 21, 1929

KILAUEA REPORT No. 891

WEEK ENDING FEBRUARY 20, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Until midnight of Tuesday, February 19, nothing whatever was noticed in Halemaumau pit at Kilauea Volcano to make certain the immediate approach of a new lava eruption. There was merely the expectation as reported in Volcano Letter No. 209 of December 26, 1928. The past week has been quiet at the pit, a survey party noted that the steam rising from the northwestern floor was a little bluish the forenoon of February 19, and a few rocks fell from the northern walls.

About 12:30 a. m. February 20 frothy fountaining lava gushed up a new crack athwart the 1927-28 lava bottom of Halemaumau, at the base of the northwest talus.

The seismographs exhibited 17 very feeble earthquakes for the week at the Observatory. One at 10:08 p. m. February 13 gave distance to origin 24 miles. Fourteen of the shocks were just before the lava outbreak between 10:47 p. m. February 19 and 12:28 a. m. February 20. Continuous volcanic tremor began 12:46 a. m. on the 20th. Microseisms for the week were slight. Tilt for the week was moderately strong to the NNE. The pit seismograph showed a first tremor at 10:27 p. m. the 19th, accompanied by tilt away from the pit (SE.); other tremors followed each with a tilt, and continuous tremor began at 12:44 a. m.

HALEMAUMAU OUTBREAK FEBRUARY 20

In view of the forecast of December 26 (Volcano Letter No. 209) it was satisfactory to find molten lava gushing up the peripheral wall-crack of the bottom of Halemaumau northwest just after the midnight preceding February 20. This inaugurated a new eruptive spell quite like those of July 19, 1924 at 1 p m., July 7, 1927, at 1 a. m., and 12:26 a. m. January 11, 1928: but the new eruption appears more vigorous and voluminous than any of those. All four followed either midnight or midday, as though a solar influence might be present. In none of the four was a witness actually present at the first gush of gas. The 1924 eruption lasted 12 days; 1927, 13 days; 1928, 1 day.

The watchman at Volcano House and some others saw glow over Halemaumau about 12:30 a. m. The volcanic tremor on the seismograms became continuous, after some scattered trembling spells before and after midnight, at about 12:45. Strong tilt away from the pit in trembling spasms was registered at the pit seismograph 1,900 feet southeast from the center of Halemaumau. These spasms finally became continuous trembling of the ground.

A rift broke open through the lava floor and base of the talus slides, 1,370 feet long, trending N. 63° E., about 270 feet out from the northwestern edge of the floor proper. By analogy with 1927 what happened was the rush of blue sulphurous gas, carrying with it increasingly incandescent basaltic foam, until spray fountains of melt were jetting up from 100 to 300 feet all along the crack. The eruption was of Mauna Loa type. Only thin fume arose. In the first hour and a half a lava lake was formed covering all the floor except the central cone summit to a depth near 30 feet. The average rise of the lake for 11 hours was more than 5 feet per hour.

At 2 a. m. there was a group of big fountains at the north with one great jet like an upturned hose shooting 225 feet into the air; this was reduced to 100 feet by 12 noon. Next southwest came a smaller fountain building a cone. Next was a long nearly straight line of violently boiling fountains across the west side of the lake roaring like a surf for a length of 1,000 feet. The great north fountain, just under where the avalanches have been numerous for years, and about where the old Postal Card fissure was 10 years ago, is the source of a wide lava stream out into the lake.

Around the line of perpetual fountains, which played up 50 to 100 feet, at the west, the lake quickly filled in to submerge their vent fissure. These fountains were thus out in the lake with the lake surging about them making a concentric elliptical pattern in the crusts. These crusts streamed in toward the fountain line and foundered. The rest of the lake cracked in radial bright lines toward the east. Glowing lava toes pushed from under the skirt of skin around the lake edges, and the talus shores steamed a little.

The lake at noon February 20 was 1 500 feet long and 1,000 feet wide, and shaped like a properly oriented map of Australia. The old central cone at first made a crescent island with horns turned south, but was submerged by 10 a. m. By 4:30 a. m. the lake touched the rock wall northwest. The high south-southwest cone of 1927 stood 83 feet above the lake at noon February 20.

There was a little avalanching at the east in the early morning, but this was exceptional. The tremor, and the reverberation of the rumbling fountains increased as the day wore on, and as the heavy viscous lake tended to restrain the gas of the rising foam. By evening the line of fountains made thudding detonations and reddish yellow flames rose as the huge gas bubbles burst in quick succession through the boiling western part of the lake.

By 5 a. m. the northern fountains were building cones and ovens, with glowing grottoes inside, and cascades of glowing slag poured down from the higher ones. Thin blue fume, brown in transmitted light, rose from the big pit, and reflected the light of the slag pool below so as to rival the moonlight. The steady roar could be heard at Volcano House. Gray or salmon colored moisture clouds billowed up rapidly hundreds of feet above the fume veil: these were made of atmospheric humidity drawn in by convection.

Needles of lava glass and wisps of Pele's hair, along with pellets of pumice, fell to leeward and in the Kau desert. Rampart shores of the lake were forming southwest and southeast during the day. Small fountains in the lake itself became more numerous as the vent fountains diminished. At first the spray banks to leeward of the north fountains were of greenish brown pumice, later of black glass. In daylight the lava lake surface acquired a leaden color with a blocky pattern. T.A.J.

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No. 218 RELEASED WITHOUT COPYRIGHT RESTRICTION February 28, 1929

KILAUEA REPORT No. 892

WEEK ENDING FEBRUARY 27, 1929

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

In Halemaumau pit of Kilauea Volcano a new eruption of gas charged lava, which began near 12:45 a. m. February 20, and continued its fountaining throughout that day and the first half of the next, went out of action about 1:15 p. m. February 21 so far as fountains are concerned. Since that time a heavily crusted lake, with glow cracks seen at night, has remained in the bottom of the pit, and all around it stands a rampart approximately 8 feet high above the lake sufrace This implies that the lava lake subsided by shrinkage and loss of gas about 8 feet below its highest stand, and this subsidence was mostly accomplished during the 24 hours following noon of February 21. The average diameter of the new lava fill is approximately 1,600 feet, and its average depth about 64 feet. These figures give 128,680,000 cubit feet (3,640,000 cubic meters) of new lava.

The report of the watchman who saw the first evidences of the eruption from the northeast rim of Kilauea Crater, 2 miles away, was to the effect that a dark cloud arose, then a white steamy cloud, and then the glow of spouting lava. The fountaining rift in the bottom of the pit for the first 12 hours was described in Volcano Letter No. 217. The heat of the big lake on February 20 made whirlwinds at the south edge of the pit which carried needles of lava glass and small lapilli. A long rampart was building at the lake edge toward the west, and a smaller one appeared at the southeast. During the next day this rampart formed all around the lake.

At 7 p. m. February 20 the big north fountain had built a high spatter wall and oven, the lake was in contact with the northwest wall of Halemaumau, and a line of grottoes had appeared under the west rampart.

The rumbling thud of the long line of fountains west and the big geyser of slag at the north had become deep and heavy. with occasional detonations. Along with this all the seismographs showed stronger volcanic tremor, which had increased since the morning. The pattern of bright lines was concentrically elliptical around the belt of western fountains, and zigzag radial lines extended E., SE., and S. The spray from the north fountain was sometimes 100 feet high.

On February 21 after an earthquake felt about 3:33 a. m., the lava was sinking, and avalanches were sliding at the north about 10 a. m.; the west fountains, beginning at 10:30 a. m., dwindled to small spurting at the east end of their crack, and the big north jet lessened. This last had built an "armchair" grotto. At 11:30 a. m. the west fountains went out of action, seismometric tremor decreased, and about this time the lake was receding. At noon there was no trace of the line of western fountains, and it was evident that the active north fountain had built its niche by lowering and causing its cone to cave in. The second northwest conelet of the 20th was gone. The coarse blocky crust pattern showed no trace of the radial lines. In a few places the crust cracked, and glowing melt welled up. The border rampart was complete, 7 feet above the lake, with an overflow margin outside. At 1:10 p. m. the north fountain stopped, and at 1:13 p. m. a slide occurred NE.

At 8:30 p. m. a long oval glow area was defined at the west, and a glowing cove at the east, with sluggish lava welling up along the outlines. The rest of the lake had a dull cherry red pattern like a bed of coals. There was the grinding noise of foundering crusts. A northwestern slide occurred at 8:50 p. m. During the night the dark red glow on the clouds decreased. Another earthquake was felt at 12 midnight.

The forenoon of the 22nd showed brown fume hanging under the rain clouds far to the SW., but the pit appeared clear. After this the lake changed little, avalanche debris rested on the new pumice bank at the north and on the eastern talus, and glow cracks were still visible at night. On the evening of the 23rd the hot air rising above the new lava made a rain cumulus with long tails leading down to the pit. On the 24th fifteen spots were counted on the lake crust where the last lava trickles had welled up. After rain, steam had increased at the top and bottom of the south talus and at the N. edge of the new lava. Small slides at the north were heard the forenoon of the 25th, and yellow stains at the north fountain locality were seen on the 26th.

The seismographs at the Observatory registered 5 very feeble and 3 slight local earthquakes for the week, and one weak teleseism at 10:50 p. m. February 25. The felt earthquakes of February 21 at 3:33 a. m. and 2:00 p. m. indicated origins 13 miles away, and the earthquake felt at 4:51 p. m. February 24 showed distance 14 miles. Both the last named were felt at Pahala, and the first two were felt in Hilo. Volcanic tremor began 12:46 a. m. February 20 and ended 11:30 a. m. February 21. At the pit seismograph it continued until about 1:00 p. m. Tilt at the Observatory was strong SSW. Microseismic motion increased at the end of the week.

The Halemaumau seismograph, recording only NW.-SE. tilt (to and away from rim), registered 11 seconds angle of tilt to the SE. between 9:15 a. m. February 19 and 12:45 a. m. (time of outbreak) February 20. Five seconds of this accompanied small earthquakes between 10:06 p. m. the 19th and 12:35 a. m. the 20th. The rim region then tilted back to the NW. 6 seconds between 12:35 a. m. the 20th and 2:23 p. m. the 22nd;tipping was strongest between 8 a. m. and 1 p. m. the 21st. At that time there was thus a net gain of 5 seconds(11 minus 6) tilt away from the pit.

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No. 219 RELEASED WITHOUT COPYRIGHT RESTRICTION March 7, 1929

KILAUEA REPORT No. 893

WEEK ENDING MARCH 6, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

The lava activity that was observed in Halemaumau pit Febraury 20 has entirely ceased, and there remains the frozen lava lake with virtually no motion of any kind. The incandenscent pasty lava undoubtedly exists under the crust, but the shell on the lake has become too thick to show any further glow or gas action. On March 1 at 11 a. m. fresh debris lay on the eastern taluses, and there was also slight change in the northern and southern slopes. A slide was heard at the southwest. Sulphur stain was increasing near the north spatter cone, and a new patch had appeared at the south edge of the lava floor, which was steaming. At the west a crack in the floor was seen, and the south side of the lava area appeared to be settling more than elsewhere. White stain suggests fumarole action on a large red rock in the gravel near the bottom at the east. White stains are increasing on the lava crust. Columnar fluting is conspicuous at the southern end of the east sill, where also there is steam from the wall.

On March 2 the strong earthquake at 10:24 a. m. dislodged a small slide at the east wall of the pit. At 11 a. m. March 3 a little sliding was heard, there was a line of steaming up and down the top of the south talus, and fresh avalanche debris had increased at the east.

In the forenoon March 4 slides were common N. and NE., and about noon visitors throwing rocks at the edge NNE. started a slide that made a red scar in the wall, put numerous white rocks on the talus below, and made a cloud of dust. March 5 there were small rock falls N. and SE.

The seismographs registered only 6 local earthquakes for the week, 4 very feeble, 1 feeble at 10:19 a. m. March 2, and 1 slight and locally felt 10:24 a. m. March 2 of intensity III R. F. The last two indicated a distance from the Observatory of 17 miles, probably in the Kapapala direction, making the center somewhere between Kilauea and Mauna Loa. Tilt for the week was moderate to the north, and microseisms were normal.

MOUNT SHASTA MUD FLOWS

During the summers of 1924 and 1926 there were floods from Mud Creek, which drains the Konwakiton Glacier on the south slope of Mount Shasta. Owing to the depth of the mud deposited by the floods, trees were killed over hundreds of acres, roads buried, and railway traffic interrupted, while the drainage system into which Mud Creek flows was contaminated by mud for over 75 miles.

The floods were due to the rapid melting of the Konwakiton Glacier. The glacier rests on a thick deposit of unconsolidated volcanic ash. Mud Creek always carries a great amount of this ash. Light snowfalls of the winters preceding the mud flows allowed the summer sun to cause more rapid melting of the glacier than is common. The floods in Mud Creek were the result.

Some press reports, written by correspondents a considerable distance from Mount Shasta, attribute the rapid melting of the glacier to an increase in the volcanic heat of the mountain. Nothing has been found to support such a contention. The hot springs on the summit of Mount Shasta are steaming much the same as they have been for years. The highest temperature found at these springs on June 18, 1928, was 180° F., or a little below the boiling point for an elevation of 14,000 feet. R.H.F.

EARTHQUAKES ON ISLAND OF HAWAII 1928

The total number of seismic disturbances registered by the seismographs of the Hawaiian Volcano Observatory during the year 1928 is 1,053. Of these 1,034 were local earthquakes and tremor swarms.

Of the local earthquakes, the grouping by intensity is as follows: 1,004 were very feeble and so registered only by instruments; 25 were feeble, making a clean-cut earthquake seismogram, and felt by some persons; 3 were slight, making strong seismograms, and generally felt, except by persons in motion; 2 were moderate and strongly perceptible. The latter were January 4 and February 26.

The total of local shocks compares as follows with the three previous years: 1925, 922; 1926, 1,778; 1927, 1,149; 1928, 1,034. The average then is about a thousand per year at present, as 1926 was the exceptional year of the Mauna Loa outbreak, when there were 761 shocks in April alone.

The number of teleseisms for 1928 is 20, of which 4 are near the March equinox, 8 before and near the June solstice, and 8 near the September equinox.

An interesting feature was the notable increase of tremor swarms, lasting each from 2 to 34 minutes. They were conspicuous in January, March, June, and December, and were identified with pit avalanches in the late summer and autumn. T.A.J.

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No. 220 RELEASED WITHOUT COPYRIGHT RESTRICTION March 14, 1929

KILAUEA REPORT No. 894

WEEK ENDING MARCH 13, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Halemaumau continues quiet. On March 8 there was some sliding of rock from the north wall and also March 12, but in less amount On March 13 at 11 a. m. fresh red debris was observed on the east talus from a newly stripped portion of the wall two-thirds of the way down, above the big sill. A few stones were heard slipping twice during a visit of a half hour. Some stones from slides had rolled out over the new lava southeast.

The weather being sunny, no vapor was detectable rising anywhere from the new lava floor, not even from the stained area at the south edge. From the slide rocks outside the southeast edge of the floor, and from a wet spot at the top of the south talus, vapor was rising. There was also steam and moist ground at the lower ledges southeast whereas most of the talus slopes appeared dry. Hot vapor rose from fissures inside the south wall of the pit, near the top.

Four very feeble local earthquakes were registered at the Observatory during the week. A large distant earthquake began about 3h. 11m. 22s. p. m. March 6, and the long waves threw the writing pens off the drum. The indicated distance was 3,650 km., corresponding to the north side of the Aleutian Deep south of Amukta Pass. This origin was confirmed by radio report from Alaska. Small seismic sea waves were registered as following this earthquake in Hilo Harbor at the tide gauge between 7:45 and 10 p. m. March 6.

Tilt for the week was slight SSW and microseismic motion was very slight.

SEISMIC SEA WAVE MARCH 6

The large, distant earthquake registered at the Hawaiian Volcano Observatory as beginning 3 h. 11 m. 22 s. p. m. March 6, Hawaiian Standard Time (G.M.T. 1 h. 41 m. 22 s. March 7) exhibited on the seismogram very clear preliminary tremors lasting 5 minutes and 26 seconds and a well marked beginning of secondary waves, which merged without distinction into such large long waves that the writing pens of the seismographs at Kilauea and at Hilo swung off the smoked paper. These seismograms indicated an earthquake of great magnitude at a distance approximately 3,650 kilometers, or 2,270 statute miles from the Observatory. The seismogram showed signs of the return wave that had passed around the crust of the earth on the side of the globe remote from Hawaii about four hours after the start of the record. Calculation showed that the time of the actual shock at the epicenter was 6 m. 52 s. before the registration began; that is, the seismic waves through the rock under the bottom of the sea took a little less han 7 minutes to travel 2,270 miles.

This distance is slightly less than that of California from Hawaii, and the indication from the direction of first disturbance and from the excess of long wave motion in the north-south direction implied an earthquake origin lying probably either NNW or SSE from Hawaii. Toward the south this would be near the Marquesas Islands, and toward the north it would mean the well known earthquake region of the extremely deep trough (over 4.000 fathoms) that lies about 125 miles south of the Aleutian Islands. Everything indicated that one of the big Aleutian earthquakes was in progress.

In accordance with previous experience at this station (Volcano Letter No. 57, January 28, 1926) the big submarine earthquakes from Alaskan waters and also those still farther away from the sea bottom off Chile are liable to create flood waves in the ocean that may do some damage on the eastern side of the large Hawaiian Islands. The experience of February 3, 1923, had shown that a large earthquake south of the Alaskan Peninsula could make a disastrous tidal wave which arrived at Hilo about seven hours after the shock was registered at the Kilauea seismographs. Accordingly, in the present instance a tidal wave warning was sent to the harbor masters at Hilo on Hawaii, and Kahului on Maui, and through the Naval Radio to the Commandant at Pearl Harbor in Honolulu. It seemed probable that the water wave would reach Hawaii about 10 p. m., by analogy with the transit time of the sea wave of 1923.

The speed of travel of such waves is comparable to that of the wave represented by the normal daily tide, and this speed has nothing to do with the violence of the resulting shore waves, which are compounded with the natural period of the local harbor or basin, and usually keep swinging back and forth for hours at intervals of 15 or 20 minutes. The speed of the free wave in the open ocean is for the Atlantic tides about 500 miles per hour, and for an earthquake wave in the Pacific 300 miles per hour, more or less.

On March 6 the event proved that a great earthquake had occurred at the north edge of the Aleutian Deep approximately 100 miles south of Amukta Island, as reported by Japanese steamers in that vicinity, which felt the sharp bump of the quake. Also Dutch Harbor reported severe shaking. The surging waters began to swing in and out of Hilo Bay about 7:45 p. m., as recorded on the tide gauge at Pier 1 back of the breakwater, with a range of motion of something over a foot and an interval of about 15 minutes between crests. In the Wailoa River at the head of Hilo Bay the harbor master reported 16 inches between high and low level swings. I watched these swings as follows:

8:20 p. m., current inward
8:27 p. m., " outward
8:31 p. m., " inward
8:34 p. m., " outward
8:38 p. m., " inward

With higher tide the surges were watched between 9 and 11 p. m., and the intervals grew longer. The S. S. Haleakala at Pier 2 broke stern lines as result of the surging motion. The maximum was between 8 and 9 p. m., and about 10 p. m. the surges dwindled. It was evident that the speed of propagation of the water movement must have been over 400 miles per hour.

The correspondence of location of earthquake, and of sea wave as registered on the tide gauge, with published expectation in accordance with seismogram data, was completely satisfactory. The time of transit of sea wave appears to be less than that of 1923. Its resultant surges in Hilo Harbor were much lower than in 1923, when disastrous wave action reached heights about 15 feet above normal. As the earthquake of 1929 appears to have been equally intense, and the position only a few hundred miles farther west, it seems likely that local surging must depend on wave resonance with the stage of the tide, and the effects of winds and waves over the ocean intervening between the earthquake origin and the port. T.A.J.

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No. 221 RELEASED WITHOUT COPYRIGHT RESTRICTION March 21, 1929

KILAUEA REPORT No. 895

WEEK ENDING MARCH 20, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

No volcanic changes have been observed at Kilauea or Mauna Loa indicating anything unusual. Some rapid tilting, accompanied by tremor, at three seismograph stations in and around Kilauea Crater has interested the observers because of its resemblance to similar movements incident to the eruption of February 20. This interest is reinforced by prolonged tremor spasms at the Observatory March 15, 17, 18, 19, and 20, two of these accompanied by east tilt.

On March 15 at Halemaumau a small slide was heard about 9 a. m. toward the north, and the falls of rock during the forenoon were very slight. The next morning, March 16, there was very little steam in the pit, and only a few slides. March 18 at 9 a. m. there was a very little sliding at the northwest. Yellow sulphur has appeared in cracks at the stained whitish spots along the north and south edges of the new lava. The downfaulted bench around the edge of the subsided lava lake is in steps. A little steam shows sometimes quite suddenly at the north sulphur spot as though nucleated by invisible gas blown over the place from a nearby orifice. There is vapor high on the west and south taluses, on the lower east talus, and at the top of the talus NNE. On March 19 just before 6 p. m. red and gray dust rose from avalanches in Halemaumau.

Seventeen very feeble earthquakes were registered at the Observatory, of which one at 9:05 a. m. March 13 indicated origin distance two miles away, and another, 11:14 a. m. March 19, origin distance 11 miles. The tremor spasms above mentioned are not included with these earthquakes. Tilt for the week was strongish WSW., several of the shocks of March 17 until 4:14 p. m. exhibiting westerly tilt simultaneous with the tremor. Microseismic motion was normal.

HAWAIIAN VOLCANO RESEARCH ASSOCIATION 1928

The work of the Association is divided between general furtherance of the progress of the Hawaiian Volcano Observatory and the specific tasks of maintaining seismograph stations and issuing publications. The Board of Directors are L. A. Thurston, W. F. Dillingham, F. C. Atherton, L. T. Peck, W. W. Thayer, W. R. Castle, A. L. Dean. The Honolulu office is 1031 Fort street, L. W. de Vis-Norton, secretary. The Association is incorporated, and has about 180 patrons and members, and a mailing list of about 600 institutions, libraries, and individuals.

The division of work between the United States Geological Survey and the Association at the Kilauea observatory is broadly on the line between salaries and equipment: the permanent salaries are Governmental. Outside of the observatory, the Research Association employs the seismograph observers in Hawaii, and occasionally other persons on Research Fellowships.

The Observatory was founded by the Research Association in 1912, and has gradually acquired increasing Government aid. The collaboration may be compared with the demands of manufacturing associations on the Bureau of Standards. The Association has supplied shops, instruments, laboratories, expeditions, researches, books, specialists, vehicles, and machines, that have made possible path-breaking investigations which could not have been attacked under Government alone, owing to the restrictions that control Government funds.

The work of the Association in 1927-28 in seismology illustrates perfectly its influence and results. The Association built the Uwekahuna Observatory, for use as a trailside museum by the National Park Service; equipped it with a seismograph for both exhibition and research, and placed the best collections on exhibition. This accomplished three distinct advances: it provided a new seismograph and observation station in a new place; it gave the public a museum and relieved the Observatory of exposition duties; it provided the National Park with motion picture hall and apparatus for exhibiting to travelers volcano activities of other times. Government staffs immediately assumed operation expense.

The Association at the same time equipped and manned a machine shop for making seismographs. Seven instruments have now been built in that shop, new ones are installed in Kona and Hilo, many other tools and machines have been built, and the machinist is now a Government employee. The old seismograph released from Kona was rebuilt and installed in a small roofed cellar near the Kilauea pit: this instrument showed remarkably instructive tilt and tremor in the Halemaumau eruption of February 20, 1929.

In the summer of 1928 the seismologist built an oscillating table for mounting and testing seismographs by imparting to them artificial earthquakes. The "Ohiki," wheeled boat built by the Research Association and tested in a longshore trip on Hawaii, was the experimental basis of a successful season with an amphibian in Alaska.

The published work of the Association in 1928 concerns volcano notes from many lands, the weekly reports from Kilauea, Lassen Observatory notes from California, reviews of volcanologic books, popular statements of the technical work in progress on local shocks, tilt, microseismic motion, distant earthquakes, tidal waves, temperatures of borings, work of the several seismograph stations, notes on explorations, new methods and cooperative work of other bureaus, some National Park enterprises, addresses and articles on borings, Coast Survey work, gravity measurements, and on tide gauge measurements and station installation.

The improved registration of earthquakes by the Association seismographs was never better demonstrated than during the last three months, when the local earthquakes that preceded and followed the February eruption were well recorded at five stations, and all five also made record exhibiting data that bear on distance of origin, direction, and intensity, for the great Aleutian earthquake of March 6, 1929. To the radio equipment installed at Kilauea and in Kona the Observatory owes increasingly accurate time service, the time signals being sent out from Washington, D. C., and from naval stations in California and Hawaii.

T.A.J.

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No. 222 RELEASED WITHOUT COPYRIGHT RESTRICTION March 28, 1929

KILAUEA REPORT No. 896

WEEK ENDING MARCH 27, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Avalanche dust rose from the northeast side of Halemaumau at 3:10 p. m. March 20. In the forenoon of March 23 what appeared to be a fresh scar on the north wall of the pit was observed, and a very few small slides occurred. About midday March 25 the pit was quiet, except that a slide occurred at the north end of the large northeastern sill about 1 p. m.

At 8:40 a. m. March 27 the pit was very quiet, no stones fell, there was steam back of the upper edge E., N., NW., and W. outside of the pit, but the floor was not steaming. There was the usual vapor from the taluses. About 11 a. m. some dust rose from the pit.

At the Observatory 20 very feeble earthquakes occurred, and tremor in irregular recurring spasms, also very feeble, as follows: March 28, 8 to 10 a. m., 8:50 to 10:45 p. m.; March 21, 6:30 to 8 a. m., and irregularly in the afternoon; March 23, irregularly 10:12 a. m. and 3:25 p. m.; March 24, irregularly 6 to 7 a. m.; March 25, 9:34 to 9:37 p. m.; March 26, 8 of the earthquakes above mentioned, between 3:19 p. m. and 4:50 p. m., may be expansions of tremor too feeble to register continuously.

Microseisms were normal, diminishing during the week. Tilting of the ground was slight to the south.

VOLCANOES IN CHILE

The following notes from a letter received from Mr. John B. Stone are of great interest as they are written by a geologist who worked five months on the geology of Kilauea Volcano in 1925 (Bulletin 33, B. P. Bishop Museum, Honolulu, 1926).

"I have recently returned from a vacation trip to Chile" (Mr. Stone is engaged in mining geology in Peru) "during which I went as far south as the island of Chiloé. One of the objects of my trip was to get some information on the volcanoes in that region.

"In Santiago the director of the seismological service stated that the volcanoes in north Chile are not active, but that those in the region between Santiago and Chiloé are active intermittently. There are others farther to the south, but the country is almost uninhabited and little is known about them. Among the volcanoes are Llaima, near the town of Temuco; Villarica and Pueyhue, near Osorno; and Osorno Volcano, Calbuco, and Tronador, near Puerto Varas on Lake Llanquihue. These volcanoes are on the west side of the central valley of Chile (which is beautiful farming country), and are easily accessible from the excellent railway running south from Santiago to Puerto Montt."

A short time before the first of December, 1927, there were earthquakes along the coast of Chile, and at the same time several volcanoes of the southern Andes were active.

The volcano Llaima began erupting violently about November 29, 1927. Enormous flashes and a great quantity of smoke, lava, and cinders came out of the crater. Llaima is some 65 kilometers from Temuco, and it is not more than 3,000 meters high. It has two craters, and is covered with snow all the year round. It lies in latitude 38 degrees 44 minutes. The volcano had a violent eruption in 1864, and flashes of fire have frequently been seen in its craters. There are said to be 34 volcanoes between the latitudes of 24 degrees and 42 degrees.

"I went south from Valparaiso by sea, and on arriving in Puerto Montt on January 6, 1929, found that the volcano Calbuco was in eruption. The air was full of light ash, but only steam was issuing from the volcano at noon of that day. I went in an automobile to Puerto Varas, but was unable to get closer to the volcano than six or eight miles. According to the people there the eruption began about 1 a. m. January 6, 1929, and the outbreak was accompanied by a slight earthquake. The volcano then threw out ash until about 6 a. m., and there was another smaller earthquake about 4 a. m. For the rest of the day there was a fine steam plume from the peak, and once or twice I thought I saw small, dark puffs that could have been ash. Faint steam or smoke was rising over a large area of the woods at the foot of the volcano. I thought it might be caused by the fall of hot ash, but there were reports of a lava flow. On January 7, 1929, I saw the volcano from a different angle, and there appeared to be two steam jets. The only press report of the eruption that I saw was much exaggerated.

"It would be possible for an observer with headquarters at Puerto Varas, or possibly at Osorno town, to keep half a dozen volcanoes under fairly close observation. The eruption that I saw is probably typical, consisting of a short ash ejection, possibly accompanied by lava flows. The country is far more accessible than Alaska, and except for the heavy winter rains is a most agreeable place to live in. Puerto Varas, I judge, is only about 200 feet above sea level, and Calbuco volcano would appear about 5,000 feet high" (1,738 meters or 5,700 feet, according to Sapper). "I think that an expedition less expensive than those to Alaska could get important results in two or three months. December-January is the best season.

"At the Braden Copper Mine at Sewell, I found that the Talca earthquake of about December, 1928, had lasted one minute and a half and had destroyed the tailings dam at the mill, thereby causing a rush of mud that killed 43 people. A new Chilean law has established a Department of Public Works, which has as one of its chief duties the supervision of buildings to make them more nearly earthquake-proof." T.A.J.

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No. 223 RELEASED WITHOUT COPYRIGHT RESTRICTION April 4, 1929

KILAUEA REPORT No. 897

WEEK ENDING APRIL 3, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

During a half hour at Halemaumau pit about 2:30 p. m. March 29 no slides were heard. Fresh debris was observed on the north and northeast talus slopes, and scars were visible half way up the wall above both places. A ranger reported that the northeastern slide occurred about 2:30 p. m. March 27.

Measurement of cracks near the tourist outlook on the eastern rim of Halemaumau indicated that little or no change had occurred since January 18. At the former tourist outlook, farther south, where so much avalanching occurred in January, a rim crack was found to have widened 0.13 foot.

On March 30 at 8:30 a. m. a small slide removed rock from the eastern rim, and another was reported the next morning farther south. At 10 a. m. March 31 everything was quiet at the pit, and nothing new was observed. At 3:45 p. m. that day an avalanche sent up dust above the rim level.

Sixteen very feeble earthquakes were registered on the Kilauea seismographs, and irregular tremor occurred at intervals throughout the week, but very feebly. Tilt was moderate to the SSE., and microseismic motion was slight.

EARTHQUAKE INTENSITY SCALES

The attempt to define the size of an earthquake has led to making scales of earthquake severity. Where a large country is involved these scales have been based on popular reports. For scientific comparison with other places the size of the earthquake at any place ought to be expressed by a number. Just as four pounds of sugar ought to be four times as big as one pound, so a number four earthquake should be four times as big as number one. Herein lies the difficulty.

The Rossi-Forel intensity scale in common use is numbered 1 to 10, the numbers are defined by such expressions as "recorded only by seismographs," "cracking of plaster," "fall of chimneys," and by such adjectives as instrumental, moderate, and disastrous. The trouble with such a scale is that a nervous, sensitive person not used to earthquakes considers a feeble shock "stong." On the other hand, the average psychology of many people is a vaulabe criterion of intensity. The five grades (1) not felt, (2) felt by people at rest, (3) felt by everyone, (4) causing general fright, (5) causing consternation and panic, are definite.

The scientific basis of intensity, from a pendulum swinging in oil and scribing the length and time of its swings, or better, the length and time of the maximum swings of the earth while the pendulum stands relatively still, is called an "acceleration" or jerk. It is measured in rate of change of motion, millimeters per second change of motion per second (mm./sec.^{2}). The mathematical expression for this involves the square of the velocity of the earth particle divided by the amplitude of its motion. The changes of motion involve changes of direction as well as of speed. But for measurement it suffices to consider earthquake vibration a simple to and fro swinging. The seismograph pendulum assists this conception, for each instrument translates the earthquake motion into harmonic vibration in one direction only.

The Cancani intensity scale is based on a range of accelerations for each of 12 grades. The first 3 grades, from 1 to 10 mm., are instrumental only, and grade 12 would make a terrible catastrophe, reaching the acceleration due to gravity, 9,810 mm. per sec.^{2} Each grade doubles the value of the next preceding grade, expressed thus in millimeters (2½, 5, 10, etc.).

The Rossi-Forel scale, when reduced to accelerations, has values in terms of grade I as unity.

Grade	I, barely felt	equals	1
"	II, felt by few	"	2
"	III, felt by several	"	3
"	IV, feebly felt generally	"	4
"	V, felt by everyone	"	5.5
"	VI, alarm	"	7.5
"	VII, panic	"	15
"	VIII damage	"	25
"	IX, destruction	"	60
"	X, catastrophe	"	125

It is thus arithmetically good from 1 to 4, and thereafter is an ascending curve. Grade I Rossi-Forel equals Grade IV Cancani.

The following are the grades of the Mercalli scale, abridged to show human effects:

I, INSTRUMENTAL, not felt.
II, VERY SLIGHT, felt by very few.
III, SLIGHT, felt by several.
IV, MODERATE, felt by many, no alarm.
V, RATHER STRONG, felt generally, some alarm.
VI, STRONG, felt by nearly everyone, many with fright.
VII, VERY STRONG, flight from houses, some damage.
VIII, RUINOUS, great terror, some wounded, much damage.
IX, DISASTROUS, a few lives lost, general ruin.
X, VERY DISASTROUS, great loss of life and utter ruin.

In the writer's tests, and Professor Mercalli among Italian peasants evidently had similar experience, ignorant persons in city or country can understand a human scale. They usually distort or exaggerate physical effects on masonry, water, trees, chimneys, etc., because they have no training in measured or judicial statement. T.A.J.

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No. 224 RELEASED WITHOUT COPYRIGHT RESTRICTION April 11, 1929

KILAUEA REPORT No. 898

WEEK ENDING APRIL 10, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Halemaumau, the inner pit of Kilauea Crater, has been almost motionless during the past week, and the new floor of black lava which was poured out February 20, 1929, appears almost as fresh as the day it solidified. In the forenoon of April 3 vapor rose over the whole pit after light rain. At 10:30 a. m. April 6 a small slide occurred at the north wall. At 8:05 a. m. April 9 light dust arose at the northeast side of the pit. On this day white salts were noticeable on the walls and talus blocks after two dry days following rain. The next morning, when there was a little drizzle wetting the stones, much of the whiteness disappeared.

The seismographs registered five very feeble local earthquakes during the week. One at 10:13 p. m. April 3 had indicated distance 11 miles from Observatory. The spasms of tremor were not observed after April 6. Tilt was slight to the south, and microseismic motion was normal.

THE ORIGIN OF LASSEN MUD FLOWS

By R. H. Finch

The cause of the mud flow from Lassen Peak on May 19, 1915, has been disputed. Drs. Day and Allen in their book, "The Volcanic Activity and Hot Springs of Lassen Peak," attribute the flow to melting of snow by a hot blast of gas, a deposit of hot volcanic ash, and hot rain. Loomis in his book, "A Pictorial History of Lassen Volcano," contends that hot water came out of Lassen Crater.

It is hard to believe that hot water came out of the crater, and Day has shown that the mud flow started some distance below the crater rim. The hot water theory may be dismissed. The writer agrees with Loomis that there is not sufficient evidence to indicate the occurrence of a hot blast or any considerable explosion just prior to the mud flow of May 19. There was only one flood on this date, excepting the possibility of a small one below the western flow, while the known explosions on May 22 produced several small mud flows. If there was no explosion and no hot blast, then there would not have been any hot ash deposit nor warm rain. Even if there had been an explosion, any rain accompanying it would probably have been but little warmer than any other rain—certainly not hot. It is also doubtful under the conditions existing on Lassen Peak at that time whether a rainstorm, unless of very unusual intensity, could cause a flood of the magnitude observed.

The flood originated in an embayment on the northeast slope of Lassen Peak that was uniformly covered by snow with a depth of several feet over most of the area. Now it is known that a few feet of snow of uniform covering can absorb several inches of rainfall so that the rain produces but little immediate run-off. If there had been bare spots in the snow field, then water could have run under the snow in considerable quantities and, in a place as steep as the Lassen slope, started avalanches. A hot blast, unless long continued, or a slight deposit of hot volcanic ash would produce much the same effects as a rain—a melting of superficial layers of snow and an absorption of the water by lower layers. A hot blast or a hot ash fall on a steep slope not uniformly covered with snow could, as in the case of rain, start streams under the snow and also cause avalanches.

It would seem, then that the Day and Allen theory as to the cause of the Lassen mud flow on May 19 may also be questioned.

An examination of enlargements of the photographs taken by Mr. Loomis immediately after the mud flow on May 19, and of the material transported by the mud flow, indicates that a large volume of hot lava poured through the eastern notch of the crater. There is much new lava that was carried in fragments down the flood. This flow was not only much more voluminous than the one through the western notch, but as would be expected, it was probably, as a whole, more molten. The lava flow could easily have melted the snow down to the ground and sent a stream of warm water under the snow lower down the slope. An avalanche mixed with hot rock could easily have been started in this way and produced a flood of the magnitude observed.

Minor mud flows did accompany the explosions on May 22. There was a horizontal component of this explosion that was parallel with the course of the upper part of the mud flow on May 19. The area affected by this blast was much wider than the area devastated by the mud flow of May 19 and accordingly encountered snow banks with exposed edges. Considerable hot ash was also thrown out by this eruption. The largest mud flow that accompanied this explosion followed the course of the one on May 19. At places where there was still uniform snow covering, the mud flows occasioned by hot ash and perhaps mud rains of this explosion for the most part stayed on top of the snow.

TITLE PAGE AND INDEX

The Title Page and Index for 1928 is now published and has been mailed to the regular list. It will be sent to anyone desiring it.

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No. 225 RELEASED WITHOUT COPYRIGHT RESTRICTION April 18, 1929

KILAUEA REPORT No. 899

WEEK ENDING APRIL 17, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

At Halemaumau on April 11 at 3 p. m. bluish vapor was noticed rising through the talus at the east edge of the new lava floor and staining the rocks yellow. At a sulphurous patch on the north edge of the new lava, yellow vapor was observed in a jet, by one of the park rangers. Fresh red debris was observed on the north talus slope. At 3:07 p. m. a small slide occurred at the south, and some very feeble sliding of sand occurred there almost continuously.

On April 13 at 10:15 a. m. a red scar was noticed above the east end of the big sill on the eastern wall, and fresh debris lay on the talus below. The pit was visited about 9 a. m. April 15, 16, and 17, but nothing new was observed and the walls were quiet.

At Kilauea Observatory nine very feeble local earthquakes were registered during the week. One at 4:48 p. m. April 13 was felt in Hilo and indicated a distance of 11 miles from the Observatory for its origin. Another at 12:17 p. m. April 14 was weaker, and indicated a distance of eight miles. Tilt was slight to the north, and microseismic motion was normal.

SECTION OF VOLCANOLOGY 1928

The Section of Volcanology of the United States Geological Survey makes headquarters at the Hawaiian Volcano Observatory on the northeast brink of Kilauea Crater. Its work in Hawaii is greatly assisted by the Hawaiian Volcano Research Association (see Volcano Letter No. 221). It maintains in addition the Lassen Volcano Observatory at Mineral, Califorfnia, has placed a seismograph in the Loomis Museum at Viola, California, and another at Kodiak, Alaska. Service of the Kodiak instrument had to be discontinued temporarily after the closing, in August, 1928, of the Agricultural Experiment Station, where the seismograph was operated. Another seismograph with its time clock and other appurtenances has been deposited at Dutch Harbor in the Aleutian Islands. This station will be started and the Kodiak station revived in 1929.

The report of the Volcanologist for 1928 stated that "it is logical to expect activity from either Kilauea or Mauna Loa in 1929." This has been verified by the outbreak of Kilauea February 20, 1929. The new cycle of lava activity in Hawaii has proceeded with lava in Halemaumau pit in 1924, 1927, 1928, and 1929, and lava from Mauna Loa in 1926. The cycle should be half finished by January of 1930, and so approaching its maximum of lava gas pressure at that time, equivalent to that of 1919 for the last cycle.

The routine in Hawaii in 1928 consisted of mapping changes in Halemaumau, operating seismographs at the pit, Uwekahuna, the Observatory, Kona, and Hilo, measuring crater rim fissures and temperature of bore-holes, keeping track of Mauna Loa, studying the seismograms and also those of Kodiak, publishing Volcano Letter and preparing Monthly Bulletin, experimental work with new seismographs and the oscillating table, building seismographs, keeping up the office work and records, operating tide gauge and maintaining time service by radio. The routine in Lassen National Park is similar in seismological work, but includes measurements of hot springs, of marked landslip areas, and of magnetism in lava flows, and geological mapping.

The personnel in Hawaii included T. A. Jaggar, volcanologist; R. M. Wilson and E. M. Buckingham, engineers; R. B. Hodges, clerk; F. Y. Boyrie and Tai On Au, machinists; and H. Yasunaka, janitor. The Kona station was operated by R. V. Woods, the Hilo station by J. B. Albert and the Kodiak station by Mrs. E. M. Floyd. The tide gauge was operated by M. F. Lacerdo. Additional employees were S. Oda, J. H. Tahara, and Aiu Ahoi. The Lassen station was in Charge of R. H. Finch, associate volcanologist; assisted by A. E. Jones and C. A. Anderson, who made special investigations. Mr. Howel Williams also worked on Lassen geology. Mr. B. F. Loomis built a very substantial concrete and stone seismograph exhibition building next the museum at Manzanita Lake, where was installed the Finch seismograph, that had been replaced at Mineral by the Hawaiian type of instruments.

The Pavlof Expedition of the National Geographic Society under T. A. Jaggar materially advanced the exploration of Aleutian volcanoes. This has been given further impetus by the Federal Relations Committee of the National Research Council, which has formed a group of federal representatives of government scientific bureaus interested in the Aleutian Islands, to formulate a project for collaborative study of that region.

The shop of the Hawaiian Volcano Observatory has now produced eight pairs of seismographs, the wheeled boat "Ohiki," the oscillating table, special drilling apparatus whereby 34 bore-holes are now available as temperature stations, and machines for various physical experiments.

T.A.J.

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THE VOLCANO LETTER

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No 226 **RELEASED WITHOUT COPYRIGHT RESTRICTION** April 25, 1929

KILAUEA REPORT No. 900

WEEK ENDING APRIL 24, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

At Halemaumau at 2:40 p. m. April 17 thin clouds of avalanche dust were arising over the pit. A more concentrated cloud rose at the north side, and the field glass showed that men were standing at the NNE. rim, probably dropping rocks and so starting the slides. At 3:15 p. m. both the dust and the visitors were still present. On the 19th at 2:30 p. m. the cleft above the north talus was seen to be somewhat enlarged, and a fresh scar was identified west of it. Apparently a thin layer of surface debris from a comparatively large area of the wall had caused the slides of the 17th. On this day there were occasional falls of single rocks from the northern wall, and at 2:35 p. m. dust from a slide appeared in the cleft above the NNW. talus. At 10 a. m. April 22 the pit was quiet, dry, and sunny, and exhibited no change. At 9:30 a. m. April 24 artificial slides on the north side of the pit were occasioned by men dropping rocks. At 1:10 p. m. thick, reddish dust arose at the north.

The seismographs registered eight local earthquakes, or tremors, all excessively feeble except one on April 20 at 10:21 p. m., which was very feeble but indicated distance of origin about 16 miles from the Observatory.

Tilt was pronounced to the SSW. Microseismic motion was slight.

A NEEDED SHOCK RECORDER

Seismoscopes that show whether a local earthquake has occurred were invented centuries ago. Seismographs which write earthquake autographs with pencil, ink, a scraping pen on smoked paper, or a light beam on photographic paper are mostly the product of the last century.

It was an effort of the staff of the Kilauea Observatory from 1911 to make a simple local earthquake instrument. But it proved difficult. It is easy to place a marble on top of a pillar: an earthquake rolls it off. It is easy to set up a pencil on its end on a glass plate: an earthquake rocks it or topples it over. Both require watching or they tell little about the time, duration, and size of the shock. And if they are found upset, a spider or a cockroach might have done it. If they require a strongly felt earthquake to upset them, what use are they? If they are too sensitive to tell how large a big earthquake is, again what use are they?

In short, the effort to record time, duration, and size appeared to require a masonry cellar at constant temperature, timekeeping like that of an astronomer, clockwork of the finest, observers directed by physicists, and five or six seismographs of different sensitiveness to be ready for big earthquakes, medium earthquakes, and little earthquakes. The Tokyo laboratory has 15 or 20 working instruments.

The object is to secure cheapness and attractiveness, in order to get records of local motion from many places and to interest many people. This is what, for meteorology, makes the thermometer and the rain gauge so useful. There is an enormous moral and ethical inertia, and even resistance, to be overcome, in order to make the discovery of the distribution of small local earth motions interesting to the man on the street. Recently the presidential addresses of the Seismological Society of America, the work of several associates of the Hawaiian Volcano Observatory, an appeal from the president of a leading insurance company, and a letter from the Scientific American, have set the writer to experimenting, and the Jaggar Shock Recorder is the result.

The problem boiled itself down to the question, "What have we really got from our outlying seismograph stations, after running them for 10 years." We have a list of earthquakes, identifying the same ones at four different places, showing others strangely limited to single places, showing how long the jarring lasted at each place, and how great was the amplitude or back-and-forth motion of the levers. The timekeeping was not accurate beyond that of central telephone stations appealed to by the seismograph operators. The amplitudes were comparable only to such extent as the pendulums were built alike, tuned alike, and set up in like directions. Artificial jarrings were possible, from locomotives and trucks and school children. Directions of maximum motion, where a pair of pendulums is used, are of doubtful value; the reason is that each instrument place is likely to have its own swaying habit in all earthquakes, strongest always either east-west or north-south; every hillside is a pendulum. And finally, the magnification is so great in these instruments that strong shocks merely dismantle them.

Determination of distance of origin by study of the preliminary tremor is the one thing for which distributed good seismographs are important. This, however, requires expensive instruments, wireless timekeeping at each place, paid observers, and continuous attention by a central observatory. And even then, many shocks occur without good preliminary tremors, and the distance determination of centers tells nothing of how deep underground were the bumping, or gaping, or scraping fault surfaces that made the shock.

The seismologist says, "I wish I had sure knowledge of the measured size of that shock at plantations and ranches all around Mauna Loa." Then he could check up his theoretical place of origin by knowing where the shock was strongest. For this he needs a shock recorder, easy as a thermometer to read, working night and day, kept by the planter and the rancher. The need for this has grown, rather than lessened for we have recorded an astonishing number of little earthquakes felt all over the island of Hawaii.

The instrument that I have been working in the Kilauea station is made of a lead cylinder, hinged with two hacksaw blades, and writing on the face of an alarm clock. It produces an eight-inch paper disc with a line written round it like a gramophone record. The operation is no trouble at all. The paper is smoked, runs a week, and is then dipped in dilute shellac. Any quiet corner away from machinery receives the box, about three feet long, which is screwed down. It is sensitive so as to show our feeblest instrumental Kilauea earthquakes. The time is recorded by a dial printed on the paper. The cost will be about $25. When interesting earthquakes occur, any number of copies of the disc seismogram may be printed on blue paper like any engineer's drawing. In this way, if purchasers of a shock recorder care to send us their record discs, we can send them blue prints to keep of any earthquakes that interest them.

We shall be glad to correspond with any prospective purchaser of one of these instruments. T.A.J.

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No. 227 **RELEASED WITHOUT COPYRIGHT RESTRICTION** May 2, 1929

KILAUEA REPORT No. 901

WEEK ENDING MAY 1, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Halemaumau pit has been remarkably quiet during the past week with slight slides from the walls observed between 9 and 10 a. m. April 25 and about 11 a. m. May 1. These were quite possibly occasioned artificially.

Eight very feeble local earthquakes were registered at the Observatory. On the 24th of April there was very faint tremor at intervals.

Tilt for the week accumulated slightly WSW. Microseisms were normal.

GEOGRAPHICAL SHIFT OF EARTHQUAKES

Professors Terada and Miyabe (A Long Period Fluctuation in Latitude of the Seismic Activity on the Earth, Bull. Earthq. Res. Inst., Tokyo Imperial Univ., March, 1929, Vol. VI, pp. 333-343) have investigated how big earthquakes have shifted from south to north and back again in the course of five centuries on both sides of the equator.

The inquiry was suggested by successions of disasters in Japan lying on a line progressively farther north. Then it was found that in the 19th century maximum of average frequency of Eurasian earthquakes lay about latitude 35° N., whereas in the 20th century they cluster about latitude 40° N.

This led to platting mean frequency of severe world earthquakes by latitude belts. It was found that:

(1) A southing of latitude in the 16th century in Japan and Eurasia equalled a northing in the southern hemisphere for South America.

(2) A northing in Eurasia about 1600 equalled a southing in South America.

(3) A southing about 1700 in Eurasia equalled a northing in South America early in the 18th century.

(4) A northing about 1800 in Eurasia equalled a southing early in the 19th century in South America.

(5) Approaching 1900, Eurasian earthquakes moved south and South American earthquakes moved north, both starting to change direction in the 20th century.

The listing of Central American earthquakes showed some correspondence of latitude fluctuation with South America, and North American earthquakes exhibited a curve somewhat resembling the rest of the northern hemisphere. China and Japan were platted separately, and were found to have in common an east-west component of shift as well as a meridional one. In both, the successive displacements of earthquake activity are in the direction SW-NE. This corresponds in general with the axes of the great deep, the island arcs, the inner seas, and the continental structure of eastern China. For either hemisphere there is suspected from all the curves a period of about 200 years between like phases of the fluctuation. It should be remembered that these are curves of fluctuation of latitude for earthquakes where 1,000 or more casualties are reported. The curves have no bearing on general relative frequencies for latitude belts, where the epicenters are determined instrumentally (see Volcano Letter No. 198).

Seeking a cause for the northing and southing of earthquake frequency periods, the authors compare the deviation of the moon's longtitude from 1640 to 1925 with the earthquake curves (see Volcano Letter Nos. 94 and 129). De Sitter and Brown have suggested that the changes in the length of day are due to actual change in the earth's radius, and so to change of its moment of inertia. The maximum moment of inertia was near 1786 and the minimum 1897. The earthquake frequency reached higher latitudes about 1800, and moved toward the equator about 1900.

Terada and Miyabe find it easier to conceive increase and decrease in the equatorial protuberance and the polar flattening, than to assume expansion and shrinkage of the whole earth. The greatest shearing stress would be in the middle latitudes and so express itself in seismic activity. The simultaneous poleward and equatorward shifts of seismic frequency in the two hemispheres suggest that in some way the change in ellipticity of the globe shifts the earthquake latitudes.

There was an acute change in the length of day observed in 1918, believed by De Sitter as possibly explained by a general shrinkage of the earth's radius. Moreover, he considers the curve of the centuries as consisting of a succession of straight lines, changing suddenly. T.A.J.

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No. 228 RELEASED WITHOUT COPYRIGHT RESTRICTION May 9, 1929

KILAUEA REPORT No. 902

WEEK ENDING MAY 8, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Halemaumau has remained very quiet throughout the past week, with practically no changes. Only one slide was observed, occurring from the north wall at 9 a. m. today. The debris fell from near the top of the wall to its lowest point of contact with the north talus.

On May 6 fresh red scars were noticed north.

There has been a slight increase of white stain at the foot of the south talus, and some increase in the yellow stain at the west end of the spatter formed by the big fountains of February 20-21, 1929.

Four very feeble local earthquakes were registered at the Observatory. One of these was strong enough to rattle a window of one of the nearby cottages.

There was a slight accumulation of tilt to the southeast. Microseismic motion was slight.

MECHANISM OF TOKYO EARTHQUAKE

The disaster of 1923 contained as main facts:

(1) Great earthquake at Sagami Bay September 1, 1923.
(2) Coast uplifted 1 to 2 m., Oshima volcano island stood still.
(3) Bottom of bay subsided between 1912 and 1923 up to 210 m.
(4) An earthquake sea-wave flooded the coast.
(5) Region around Bay suffered clockwise horizontal displacement of vortical aspect between 1884 and 1924 as shown by triangulation.

The subordinate facts were:

(1) Land subsided and beaches retreated for 20 years before the earthquake; amount of subsidence 10 cm.
(2) The shoreline has been upheaved in ancient times.
(3) Westerly tilt was measured of 1.7 seconds July 30 to August 17, 1923.
(4) Four small faults and one big crack system were formed.
(5) The isoseismals were radial, irregular and extended to the NW.
(6) The direction of earthquake motion was somewhat vortical.
(7) Submarine cables were snapped.
(8) Deep sea fish floated dead.
(9) Landslips were common west and northwest.
(10) Mineral Springs, lakes, and wells changed.
(11) Aftershocks occurred in several zones.
(12) Decrement of aftershocks was irregular.
(13) Epicenter determinations of the great shock were conflicting, and indicated a "seismic domain."
(14) Distribution of the initial motion, somewhat doubtful, made the center probably on land due north of Sagami Bay.

The theories to account for the disturbance were as follows:

(1) Upthrust, suggested by T. Kato.
(2) Block movement, suggested by N. Yamasaki.
(3) Submarine fault, suggested by A. Imamura.
(4) Subterranean fault, suggested by S. Nakamura.
(5) T-shaped fissure, suggested by T. Shida.
(6) Plutonic intrusion, suggested by T. Ogawa.
(7) Linear rebound, suggested by M. Matsuyama.
(8) Horizontal folding, suggested by T. Terada.
(9) Vortical action, suggested by K. Suda and S. Fujihara.
(10) Magmatic action, suggested by H. Nagaoka.

S. Fujihara and T. Takayama now present somewhat fully in English the conception of a vortical shear. (On the Mechanism of the Great Sagami Bay Earthquake on September 1, 1923; Bull. Earthq. Res. Inst., Tokyo, March, 1929, Vol. VI, pp. 149-176). A vertical surface of discontinuity is believed to extend along the Japan coast with southwesterly motion on the Pacific side and northeasterly motion on the land side. A rotational motion of crustal blocks is believed to have taken place about Oshima as a center. The volcanoes have been notably rigid when other formations shifted. Oshima resisted the shear and a horseshoe distribution of stress has accumulated about Sagami Bay. This stress was last released in 1853-54. Discontinuous yielding occurred again September 1, 1923. There was a sudden warping of the horseshoe, which the authors illustrate by a model consisting of a circular rubber plate laid horizontally. An eccentric clamped vertical axis corresponds to Oshima. A tangential horizontal pull southward on the east side of the disc wrinkles it appropriately and rotates all points on the surface as the triangulation bench marks found to be moved.

The great subsidence of the bottom of the bay is believed to have been a warping for 11 years past, accelerated at the time of the earthquake. Rotation clockwise accompanied by convergence was computed for the bay, and a rotation in opposite sense for a region next to the northeast, accompanied by divergence. The primary epicenter lay in between.

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No. 229 RELEASED WITHOUT COPYRIGHT RESTRICTION May 16, 1929

KILAUEA REPORT No. 903

WEEK ENDING MAY 15, 1929

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

Halemaumau pit, the inner vent of Kilauea Crater, has remained quiet. Between 9:30 and 10 a. m. May 15 there was only one vigorous steaming area, namely at the top of the south talus. The north wall appears more freshly stripped than the others, but no slides have been observed during the week.

The upright cracks parallel to the eastern rim of the pit, and back from the edge, were measured May 15, and the 11 marked stations along the fissures showed very slight widening since March 29, 1929, the greatest movement amounting to 0.11 foot. This was at station No. 14, near where the opening crack extends tangentially into the pit wall.

Seven local earthquakes have been registered for the week, of which six were very feeble. One at 5:54 a. m. May 12 indicated an origin very close to the Observatory and was felt, the intensity being No. 3 Rossi-Forel. Microseisms for the week were slight, and tilt moderate to the northeast.

MECHANISM OF EARTHQUAKES

"A great earthquake is accompanied by topographic changes; such changes have been particularly remarkable in the three last great earthquakes that have happened in Japan. The study of these shakings has led to the conclusion that the change in the surface of the land is not such as would result in seismic rays radiating out in all directions."

"We may now consider proven the existence of blocks and block movements, using the evidence of measurements made by means of precise leveling. These measurements have demonstrated that the motions of these earth blocks are so independent that there exists little correlation between them, and there is deduced the existence of a malleable layer under the groups of blocks."

"The fact that the atmospheric pressure gradient plays an important part in the incidence of an earthquake, suggests the existence of a mobile stratum within which viscous matter is present, easily displaced under the action of differences of barometric pressure."

"Studies of the properties of magma, such as the phenomena of differentiation, the rapidity of magmatic intrusion, etc., permits us to consider the origin of seismic waves as result of shock provoked by sudden change in the kinetic moment of an intrusive."

"In the case of a feeble earthquake, there will be only the shock induced by the intrusion itself. But in the case of a big cataclysm there may be formed actual fractures in the terrestrial crust, resulting from the enormity of the disturbance."

"We have, in fact, many aftershocks following a great earthquake, which may be explained as injections of magma in the fissures formed by the first big disturbance. The topographic changes of level or of horizontal position are then accounted for as resulting from movements tending to readjust the isostatic equilibrium of the block."

"Seismic wave motion tends in fact to die out in passing a fault plane, whether that fault were the direct result of seismic happenings or other tectonic cause. The anomaly exists in the fact that seismic intensity diminishes when elastic waves pass athwart a fault plane standing perpendicular to the directions of propagation."

"In introducing magma as a cause, we can more easily explain other facts that accompany earthquake." (On the mechanism of production of seismic waves, by Misiho Ishimoto, in Japanese, abstract in French, Bulletin of the Earthquake Research Institute, Tokyo Imperial University, March, 1929, Vol. VI, pp. 127-147.)

The author discusses the relation of dykes, faults, and existing igneous outflows to earthquake rifts, presents maps and a diagram exhibiting the relations of dyke intrusion to time, specific heat, conductivity, density, thickness, distance, and temperature, and quotes Barrell (Professional Paper No. 57, U. S. Geol. Surv. 1907, pp. 157-159), to the effect that "the extension of dyke intrusions resembles volcanic eruptions in that both take place in an intermittent and paroxysmal manner."

It would appear from the facts of volcano research that lava outflow, magmatic intrusion, and swarming of earthquakes may all correlatively take place in an intermittent manner, which is cyclical and not at all paroxysmal. Paroxysm is nothing more than occasional acceleration.

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No. 230 RELEASED WITHOUT COPYRIGHT RESTRICTION May 23, 1929

KILAUEA REPORT No. 904

WEEK ENDING MAY 22, 1929

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

The past week at Kilauea and Mauna Loa has exhibited suggestion of movement on the flow rifts of the latter mountain. Kilauea has been notably quiet.

At Halemaumau about sundown May 15 a ringing noise of snapping was heard in the new lava bottom like deep cracking due to cooling as the sun's rays left the surface. On May 17 about 4 p. m. a slide occurred at the east rim. On the 19th a little dust rose at the north corner of the pit about 9 a. m., and a very small fall of rock was heard during a visit at 2:30 p. m. May 20-21 it was noticed that the wall gulches above the north and northwest taluses are deepening toward each other, as though a slab of that wall might some day fall. Some stones now lie on the east side of the 1929 floor.

About 6 p. m. May 15 a smoky film of cloud was observed above the normal rain cloud that lay over Mauna Loa. At 8 p. m. May 17 Honomalino Ranch reported Mauna Loa to be smoky. The Puu o Keokeo district, about the 8,000-foot level of the southwest rift of Mauna Loa, was examined by ranchmen, and nothing new could be found on the mountain. The sulphur patch of 1926 was fuming slightly. Mauna Loa was absolutely clear in brilliant sunlight this morning, May 22.

Only three local earthquakes, all very feeble, have been registered, but two of these indicated a distance of origin appropriate to the south end of Mauna Loa; namely, 9 a. m. May 19, distance 34 miles, and 1:45 a. m. May 20, distance 28 miles. It may be added that two small earthquakes registered last week were: 6:16 a. m. May 14, felt at Honomalino, distance from Observatory 38 miles; and 12:05 a. m. May 15, distance 31 miles.

Tilt for the week was strong WSW., and microseismic motion was slight.

ACTIVITY OF KRAKATOA IN 1928-29

Krakatoa, in Sunda Strait between Java and Sumatra, was in new activity between December and April, 1927-28, as previously reported (Volcano Letter Nos. 167, March 8, and 196, September 27, 1928). The outbreak of 1928 was in the ocean between the three islands that had been left by the gigantic eruption of 1883, and a cone was built up on the sea bottom which was piled above sea level occasionally in 1928, and then washed by the waves. The third phase of activity was in April.

This third phase was characterized by a series of little eruptions lasting until May 15. From 6 a. m. May 14 till 8 a. m. May 15 a total of 7164 jets occurred, and 14 of these reached a height of 100-400 meters. Dr. Stehn reports that on May 1 after 7 p. m. strong glare was seen above the crater in the ocean accompanied by steam, which he attributed to the flowing of lava over the rim of the submarine crater. Flames were also seen above the vent of orange-yellow color, making the surface of the sea look as if it were ablaze. The flames rose about 10 meters and were suspected as being due to hydrogen.

The fourth phase of activity lasted from May 18 to May 27. An ash eruption rose 500 meters. Each period of activity was preceded by volcanic tremors registered on the island seismograph. The directions of motion of the seismic components suggested an inclined vent underground and some slow displacement of the position of maximum action.

June 1 and 2 there were slight eruptions. The submerged crater rim lay from 5 to 10 meters below sea level. The fifth phase of activity began July 6 and ended July 13, with small eruptions reaching a maximum height of 250 meters. Soundings indicated a lowering of the submerged cone. Explosions and tremors were renewed at the end of August and early in September. In October Krakatoa was quiet except for bubblings of gas and tremors recorded by the seismograph. Many audible explosion noises were heard in November, and seismic activity was renewed. The noises are described as peals, reports, and rumblings. The shaking was strong enough to cause noteworthy avalanches from the summit of Rakata Peak. Small eruptions occurred in December, one on the 20th throwing up ashes and bombs 80 meters with glow and rumblings.

Except for tremors, Krakatoa was quiet at the beginning of January, 1929. The seventh phase of activity began on January 12 with steaming above the eruption point and bombs of old pumice material floating about as long as they remained hot and charged with gas. Activity slightly increased, reaching a maximum January 20-21, when 8817 separate jets were counted within 24 hours, the maximum height being 1100 meters. On that day the crater rim was built up above the sea as a loose pile of bombs and blocks. Only a strong surf marked the spot the next day. Then the activity decreased somewhat, but after January 25 the eruptions increased and created a new island called "Anak Krakatau," meaning child of Krakatoa. Enormous masses of solid material were thrown out from two or three crater openings, eruption columns reached 1,200 meters in height with a width of 500 meters, and the photographs presented show a crescent-shaped island with magnificent explosive jets of dark material radiating upward surrounded by a wreath of white steam at sea level.

The greatest number of separate jets was counted February 3-4, amounting to 11,791 spurts within a period of 24 hours. On Febraury 9 the new island was 21 meters high, and on Febuary 18, 38 meters. Electric discharges were sometimes observed in the eruption columns. The building up of the island wall around the crater cut off the view of minor eruptions from the station on Lang Island, as did the dust cloud when the wind was unfavorable. Pauses in activity increased from February 4 to Febraury 18, when the seventh phase of explosion ended. The island was examined from an airplane, the horns of the crescent pointed WSW., and the length was about 250 meters. (Bulletin Netherlands East Indian Volcanologic Survey No. 17, March, 1929, and preceding numbers.)

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No. 231 **RELEASED WITHOUT COPYRIGHT RESTRICTION** May 30, 1929

KILAUEA REPORT No. 905

WEEK ENDING MAY 29, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Halemaumau has remained quiet during the past week, and nothing more has been heard from Mauna Loa. The afternoon of May 24 showed a few rocks on the new floor at the southeast and some appearance of fresh debris of large size at the top of the north talus, with appropriate fresh red scars in the wall above. A small slide at 12:05 p. m. May 27 and another at 1:35 p. m. sent up dust at the north corner of the pit.

Seven very feeble local earthquakes were registered for the week, of which one at 4:07 a. m. May 28 was felt in Hilo and Papaikou, the seismogram at Kilauea indicating distance of origin 21 miles. A big distant earthquake beginning 12 h. 17 m. 34 s. p. m. Hawaiian Time May 26 gave evidence of origin about 6,800 kilometers from east Hawaii, or something over 4,200 English miles. As Honolulu recorded 6,500 kilometers, the possible location might have been anywhere in the belt extending north and south through Japan Otherwise the distance would correspond to the ocean north of New Zealand or to Central America.

Tilt was moderate WNW., and microseismic motion slight for the week.

TEMPERATURES OF CRYSTALLIZING MINERALS

The older text books possessed little information about the temperatures of mineral formation, and so the loose generalizations of the 19th century imagined that basaltic lavas were cooler than deep-seated magma like granite, which was conceived to crystallize under enormous temperatures and pressures. The facts almost completely reverse this, and extensive laboratory work has thrown light on the temperature meaning of the mineral crystals found in the rocks. Besides the direct measurements of temperature of lava at craters, we now have many measurements of the melting temperatures of minerals, the inversion temperatures of minerals which change from one crystalline form to another, like quartz to tridymite, and to cristobalite, the melting temperatures of mineral mixtures, the temperature at which a mineral decomposes, and the effect on fusion or on chemical reaction of increased pressure in depth and of included gaseous mineralizers. (The Temperatures of Magmas, by E. S. Larsen, The American Mineralogist, Vol. XIV, pp. 81-94, 1929.)

Rocks crystallize from a liquid condition, or melt from a solid condition over a temperature interval which is greatly affected by the pressures involved and by the presence of steam or other gaseous ingredients which exist in the deep magma underground when the paste is congealing, but do not exist in the powdered rock of the open crucible heated in a furnace. Basalt melts through a temperature interval from 980° to 1,260° C., and granite 1,215° to 1,260°. Obsidian or rhyolite, the lava equivalent of granite, with much water in its composition melts easily until it loses its water, but thereafter it can be made liquid only at a much higher temperature. The two forms of quartz, the commonest mineral of granite, are stable up to 870°, above that to 1,470° silica becomes tridymite, and above that to 1,720° it becomes crystobalite. Quenched at any higher temperature silica takes the form of glass.

The apparent discrepancy between the higher melting range of the granitic magma as compared with basalt, and the much lower crystallizing range of temperatures which are evidenced by its minerals, can be explained as due to the gases in solution which are in the granitic magma, but are not in the rock when it is melted in a crucible. The slow cooling of a magma intermediate between rhyolite and basalt shows first the crystallization of lime-feldspar and dark minerals, leaving the remaining liquid richer in the material for quartz and orthoclase feldspar. There is finally left a liquid with a composition near that of pegmatitic granite. The original magma with the composition of basalt required a higher temperature to keep it liquid, and the granitic material was liquid at a lower temperature. The conclusion is that rhyolite or granite crystallize at the lowest temperature of the group. The magma in the throat of a volcano may be excessively hot owing to gas reactions and surface oxidation. When a mineral crystallizes from a solution, the temperature must be below the melting point of the mineral. But that does not tell how much below, as most of the rock minerals are in a condition of what is called "solid solution" and the crystallizing temperature differs with the composition. Most basaltic magmas remain almost completely liquid at a temperature below 870°.

The following is a summary of conclusions: (1) Rhyolitic magmas have lower temperatures than basaltic magmas. (2) Measurements of the basalt of Kilauea vary from 750° to over 1,200°, those at Vesuvius vary nearly as much. (3) The melting temperatures of minerals yield only maximum temperatures. Some biotite mica must form below 850°. (4) The inversion temperatures of silica show that some basalts and most rhyolites and quartz latites are nearly completely liquid at temperatures below 870° and probably all magmas crystallize above 570°. (5) Common hornblende inverts to basaltic hornblende at a rising temperature of 753°. Hence most hornblende rhyolites and quartz latites and many andesites containing common hornblende, crystallize below that temperature. (6) Since the inversion of quartz inclusions to tridymite or cristobalite is very rare, and this inversion takes place without a flux at an appreciable rate at 1,250°, very few magmas have so high a temperature. (7) The lack of fusion of most granitic and arkose inclusions indicates a temperature below 1,150° but mineralizers would permit fusion at much lower temperatures. (8) The results show that some basalts have temperatures below 870°, many are below 1,000°, very few are as high as 1,260°, and most are not far from 800° to 900°. (9) Rhyolite or granite magma has lower temperatures, in the range between 573° and 870°. Most of these rocks crystallize below 850°, the temperature of decomposition of biotite, and below 750°, the changing point of common hornblende, for they contain both these minerals. Hence most rhyolites or granites had temperatures between 600° and 700°.

T.A.J.

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No. 232 RELEASED WITHOUT COPYRIGHT RESTRICTION June 6, 1929

KILAUEA REPORT No. 906

WEEK ENDING JUNE 5, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Examination of Halemaumau pit at 5:50 p. m. May 30 showed that the whole northwest talus was covered with new gray debris, this overlapped the lava floor of 1929, and the wall showed fresh breaks above this talus clear to the top. Sliding at the north corner had been observed the previous day. On June 3 at 8:45 a. m. a large dun colored dust cloud from an avalanche was seen to rise over the northwestern half of the pit.

Eight very feeble earthquakes were registered for the week, one of these coincident with the above mentioned avalanche cloud. Tilt was moderate NNE., and microseismic motion was slight.

OCEAN SALTS FROM VOLCANOES

Visitors to the sulphur bank near the hotel at Kilauea have been impressed with the heavy layers and beautiful crystals of sulphur, with steam at 96° C. puffing up and smelling of sulphur dioxide. In the summer 1922 Dr. E. T. Allen determined that the vapor from the bore-holes has the following composition by volume:

Steam	96.2
Fixed gases (nitrogen etc.)	3.7
Sulphur dioxide	.096
Sulphur vapor	.004
Hydrochloric acid	trace
	100.00 percent

In one or two years the big iron pipes that encase the bore-holes become lined with an inch or so of compacted crystals of pure sulphur over a thin layer of sulphide of iron, a black coating that is next to the metal. All of this, and the heavy banks of sulphur that cover the old ash deposits, are laid down from .004 per cent sulphur vapor in the steam. (Bull. Haw'n Volc. Obsy. Vol. X, No. 8.)

Dr. E. G. Zies determined at the Valley of Ten Thousand Smokes near Katmai, Alaska, that the fumaroles gave off 26 million liters of steam per second containing about 0.2 per cent of hydrochloric acid, hydrofluoric acid, and hydrogen sulphide. Figuring the volumes given off per year and reducing to weights, this amounts to 1,250,000 tons annually of hydrochloric acid gas, 200,000 tons of hydrofluoric acid gas, and 300,000 tons of hydrogen sulphide gas.

The temperatures of these gases in 1919, seven years after the eruption, exceeded 500° C., the incrustations lining the cracks showed how powerful had been the solvent action of the gases, indicating the power of such an agency to concentrate valuable ore deposits.. At the Kilauea sulphur banks there is abundant pyrite, a product of the action of the fumarole gases on the lava.

The power and rapidity of this deposition, despite the tiny percentage of the ingredients in the steam, only appears when we consider the agregate quantity of even the least significant of the acid gases when continually discharged into the atmosphere at these rates. The average river contains insufficient chlorine to convert its sodium into salt; the ocean contains much more chlorine than sodium. One hundred million tons of hydrochloric acid is the annual requirement to account for the saltiness of the sea. In about 40 inches of world-wide rainfall this would amount to one-fifth of a millionth part of chlorine. Yet in ordinary chemical determinations one part in a million is considered insignificant. Hence we see what a large part can be played by volcanic steam which never ceases.

Of this 100 million tons of hydrochloric acid gas the Katmai area alone of the 450 active volcanoes of the world was contributing more than one per cent in 1919, and Kilauea, with its bare trace of chlorine, contributed about 30,000 tons. Many volcanic districts discharge acid gases. It appears that volcanoes, of which also there are many on the sea bottom mostly unknown, are quite competent to supply to the ocean the excess of chlorine needed for its salt.

The fluorine content of seawater is only one-twenty-fourth that of chlorine. The fluorine becomes locked up in the incrustations, and when it gets into the sea is absorbed into the bones and shells of marine animals, all of the phosphate beds of the vast ancient oceans showing a fluorine content of from 1.0 to 1.5 per cent. This element forms an insoluble compound with calcium, in contrast to chlorine which with sodium forms the highly soluble common salt. This disparity between the amounts of fluorine and chlorine in sea water, and the relatively large amounts of fluorine given off by volcanoes, disposes at once of the argument that volcanoes get their chlorine from the sea. Everything indicates that both these halogen gases are derived from the lava itself. (Annual Report Director Geophysical Laboratory, Year Book No. 27, 1928 Carnegie Institution, page 81.)

Sea water contains calcium carbonate as well as other salts. This is secreted from the water in the body of globigerina, a tiny organism ceaselessly dying and depositing billions of skeletons that make chalk on the ocean bottom. Locally the ocean floor is built up a foot per annum. Ten thousand years would shoal the ocean, but there have been millions of years, and the ocean is still deep.

The accumulation of heavy chalk or globigerina ooze is partly kept low by isostasy, the crust sinking and the continents rising. But this could not take care of millions of years of globigerina hailtsones. And what furnishes the lime to the salt water? Shifting shorelines and erosion of limestones on the land has furnished new lime to the rivers and the sea. But has the amount of rising limestone equalled the vast seabottom, which covers seven-tenths of the surface of the earth?

But though globigerina is everywhere in the upper waters, two-thirds of the seabottom has no chalk. What could account for chalk banks being absent? The chalky bottoms are where the ocean is not so deep. It was found that where the ocean is more than two and a half miles deep, where the pressure approaches three tons per square inch, sea water can readily dissolve the chalk skeletons. And so, with the circulation of the oceans the lime salts are brought back and secreted over again by the live organisms. (Liverpool Echo, January 26, 1929, citing J. Stanley Gardiner, professor of zoology, Cambridge.)

T.A.J.

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No. 233 | RELEASED WITHOUT COPYRIGHT RESTRICTION | June 13, 1929

KILAUEA REPORT No. 907

WEEK ENDING JUNE 12, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

Halemaumau remains practically unchanged, with occasional slides from the walls. Debris from recent slides was noticed on the northwest talus June 5, at 2 p. m., with larger bowlders on the lava floor. A small slide was observed on the south wall at 9:30 a. m. June 8. The pit otherwise was very quiet. On June 9 nothing new was seen. There was a small rockfall north about 10 a. m. today. Very thin dust from a slide rose north at 2:15 p. m.

Twice as many earthquakes were recorded this week as for the preceding week; namely, 16 of very feeble intensity. The accumulation of tilt was slight to the northwest Microseismic motion was normal.

WEATHERING OF HAWAIIAN LAVA

Many people who visit Hawaii ask the question "How long does it take for these fresh lava flows to make soil?" The first of a series of papers on the chemistry of decomposition of basaltic lavas in Hawaii (The Composition of Lavas and Soils from Kauai, by N. E. A. Hinds, Am. Jour. Sci. April, 1929) has been published by Professor Hinds, including reviews of many analyses made by Kelley, McGeorge, and Thompson, Bulletin 40, Hawaii Agricultural Experiment Station.

On all the islands there are astonishing differences of rainfall and of climate, wet on the side of the trade winds, dry on the opposite side. On the dry sides lava remains unaltered, on the wet sides it breaks down rapidly.

The predominant lavas of Kauai, the western of the larger islands, are olivine basalts, composing 85 per cent of the dome visible above sealevel; next come augite andesites and olivine augite andesites, while subordinate in amount are the basic lavas largely augite and olivine and some rare nephelite and melilite basalts.

Olivine is very conspicuous in most of the rocks as large and numerous visible crystals. Hinds found these in approximately 92 per cent of 400 specimens. Most of the lava is of the blocky or aa type, the ratio of aa to pahoehoe (smooth lava) being about 3 to 1. The chemical composition of the Kauai lavas when fresh, (and the smaller island Niihau to the west is very similar,) is as follows: Silica 40-49 per cent, alumina 8-14, iron 11-14, magnesia 7-16 lime 9-12, alkalies 2-5, water 0.30-1.00, and titanium oxide 2-3.

Rainfall on windward Kauai varies from 50 to 100 inches along the eastern and northern coasts, and from 10 to 30 inches on the western coast which is 12 to 15 miles from the summit of the single volcano dome that makes up the island. This summit slightly over 5,000 feet in height, is possibly the rainiest locality in the world, where for a seven-year period the extraordinary average of 473 inches per annum of precipitation was measured. The main average temperature yearly for elevations varying from 14 to 300 feet ranges from 68° to 79° F.

Most of the weathering is chemical. There is a little frost on the uplands, and the detritus is moved by streams, landslides, and ocean waves, but the mineralogical and chemical changes in the soil vary mostly with the climate of different sections of the island. There are no analyses as yet from the swampy region of the summit plateau. The soils and subsoils are in the main from decomposition in place of lavas and agglomerates, the latter from local vents where this material has been dumped about subsidiary cones on the weathered lavas. There are some alluvial soils at the mouths of rivers, and some coral detritus near the shores.

Throughout the Hawaiian islands rock alteration varies with the climate and the age of the domes. Younger domes are Haleakala, Mauna Kea, Hualalai, Mauna Loa, and Kilauea; older ones are Kauai, east and west Oahu, east and west Molokai, west Maui, Kohala, Niihau, Lanai, and Kahoolawe. The last three have dry climates and are less dissected and better preserved than the wet islands. The stage of topographic evolution therefore is not a measure of age.

Some weathered lavas and their disintegrated products from Oahu yield the following:

	Lava (Per Cent)	Disintegrated Product
Silica	52	20
Alumina	11	38
Iron	10	18
Lime	10	0.33
Magnesia	6	0 20
Alkalies	3	0.50
Titanium ox.	4	4.7
Water	1	17

On Kauai bright brick-red soil is found in the dry regions, brown and dark red soil in the wet, the powdered and clayey decomposition material passing downward into brown, yellow, gray, or green rotten rock in marked contrast to the soils and subsoils, for the latter retain none of the original texture. In the lower zone are great numbers of concentrically weathered bowlders (onion structure), having spherical or ellipsoidal masses of relatively fresh rock at the core. Going down farther we come to relatively unaltered rocks, the depth of the weathered zone depending on the amount of rainfall.

An average of eight soil analyses from Kauai gives percentage of insoluble residue, mostly silica 39, alumina 17 iron 14, magnesia 3, lime 0.89, alklalies 0.42, titanium oxide 2.3, water 12, averaged from a range of from 4 to 19.

The mechanical analyses of a typical soil gave in percentage volatile matter 19, fine gravel 0.02, coarse 1.57, fine sand 5.48, silt 6.449, fine silt 33.40, clay 33.50. The content of water in soils and subsoils is about the same, an average of 26 soils and subsoils together giving 8.6 per cent, of eight subsoils alone 8.14, and of 26 soils alone 9.16.

T.A.J.

NOTE: Address of Secretary, Hawaiian Volcano Research Association, is 300 James Campbell Building, Honolulu, T. H.

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No. 234 RELEASED WITHOUT COPYRIGHT RESTRICTION June 20, 1929

KILAUEA REPORT No. 908

WEEK ENDING JUNE 19, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

On June 13 at noon the north wall of Halemaumau was dusty with fresh red and gray scars and new material on the northwestern talus appearing fresh. There was other new red debris northeast, from the middle of the wall above. On June 18 the felt earthquake at 8:42 a. m. produced some sliding in the pit, but much stronger sliding was occasioned by the earthquake of 9:31 a. m. when much dust rose above the pit. Examination showed a gouge down the middle of the west wall where large fragments of rim rock had fallen so that broken debris lay on the lava floor below. At 11:40 a. m. rocks were heard and seen falling at the north, west, and south walls of the pit. On the west wall of Kilauea Crater north of Uwekahuna a fresh avalanche scar was produced by the large shock, with new talus below. A party near the Halfway House in the Kau Desert noted the earthquake of 9:31 as a shock accompanied by a rumble, and sufficiently strong to cause the trees to wave back and forth. At the Observatory the dominant effect was a slow east-west swaying with creaking of the building. The high magnification seismographs were dismantled.

It is worthy of note that this seismic disturbance occurs close to solstice, and that the press reports an eruption of Komagatake in the north island of Japan, and a disastrous earthquake in the southern district of New Zealand.

The seismographs registered for the week two distant earthquakes, two moderate local shocks, several very feeble local shocks, and one tremor lasting two minutes. The first of the two strongly felt Hawaiian shocks, at 8:42 a. m. June 18, indicated distance of origin 11 miles, and the second one, much stronger, at 9:31 a. m., 44 miles. The tremor following this lasted 10 minutes. The first distant earthquake was weakly recorded about 11:06 p. m. June 12. The second was more pronounced, beginning 12h. 28m. 46s. p. m. June 16. The indication of distance is 8,100 kilometers, and possibly this was the New Zealand shock.

Microseismic motion was light throughout the week. Tilt accumulated, moderate to the WSW.

ENGULFMENT AT KRAKATOA 1883

An important review of the history of the Krakatoa group of islands, bringing up to date the geology and the eruptive history, has just been published by the Volcanological Survey of the Netherlands East Indies as a special report for the Fourth Pacific Science Congress, Java, 1929 (The Geology and Volcanism of the Krakatau Group, by Dr. Ch. E. Stehn). The following is a summary of the constructive and destructive periods in the building of what is now a group of three islands at the corners of a triangle, with a new eruption in progress building a new islet in the sea between them (Volcano Letter No. 230).

I. Formation of a hypothetical ancient single volcano about 2,000 m. high of which the last lava streams and ejecta were hypersthene andesite with tridymite, and a microlithic devitrefied glass. The period involved the destruction of this volcano, leaving four remnant islands, with a sea basin in the center.

II Formation of an eccentric basaltic volcano covering the southern Rakata remnant, 800 meters high.

III. Submarine activity of two andesitic volcanoes, Danan and Perboewatan. Formation northward of an island, Krakatau proper, which joins up with the basaltic volcanic cone of Rakata. The same magma penetrates into the Rakata cone through a dyke fissure. Fresh activity in May, 1680.

IV. May 20, 1883, commencement of a new eruption which continued with short pauses, and became the gigantic famous eruption.

August 26-28, 1883, the greatest activity. Considerable increase in size of Rakata, Verlaten Eiland, and Lang Eiland from ejecta of andesitic magma, obsidian, pumice, and older rocks. Terminating with destruction of the volcanoes Perboewatan and Danan and half the basaltic cone of Rakata Peak. Formation of a basin 279 m. deep between the three islands left.

V. Severe abrasion by ocean waves especially on the west coasts, and extension of the low northern portion of Verlaten Eiland by the building of a spit.

VI. Submarine activity beginning June, 1927, and becoming an eruption December 29, 1927. Submarine cone of basaltic bombs, ashes, and old material appeared above the surface of the sea January 25, 1928, and later washed away. Submarine lava streams. The submarine crater rim appeared again January 28, 1929, forming new basaltic island "Anak Krakatau."

From May to August, 1883, smaller eruptions left their products close to the active craters and threw out much pumice. The paroxysm came on August 26 and thereafter. On August 27 Perboewatan subsided and a severe explosion followed, directing its discharge eastward. In no case were collapses preceded by explosions.

Fresh subsidences took place associated with tidal waves which formed bluffs. About six hours after the first subsidence August 27 came the gigantic collapse, followed by an explosion which piled unsorted pumice to thicknesses of 100 meters, strewed ash over 827,000 square kilometers, ejected ash clouds over 70 kilometers high, and made noises heard in Australia.

More subsidences and fractures occurred involving the basaltic Rakata Peak, and a second explosion that followed within an hour of the big one was believed to destroy Danan Volcano as shown by the sequence of the present strata. This disrupted the remainder of the big island and part of the sea bed, left a submarine ridge between the two explosion centers, and deposited some shells and coral in the strata. More fractures followed and another engulfment of the northeastern part of Rakata and the south part of Lang Eiland, causing the last tidal wave.

Verbeek in 1885 prophesied "In any renewed activity of the volcano, islands will arise in the middle of the sea basin, just as formerly the craters Danan and Perboewatan formed in the sea within the old crater wall." This is just what is going on now.

In the light of what was observed showing engulfment the dominant process at Kilauea in 1924, Dr. Stehn's conclusion that collapse was the dominant process at Krakatoa in 1883 is of fundamental interest in volcanology.

T.A.J.

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No. 235 RELEASED WITHOUT COPYRIGHT RESTRICTION June 27, 1929

KILAUEA REPORT No. 909

WEEK ENDING JUNE 26, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

The week at Halemaumau has produced very few changes. On June 20 all was quiet. One or two rocks fell south at 3:45 p. m. There was nothing new in the bottom or on the walls. On June 24 with a stiff NE. breeze, dust was disturbed on the northeast and south walls. Light rock falls were heard south and southwest. A dusty slide occurred northeast at 11:55 a. m. At 5 p. m. more dust was observed thinly spread over the pit. Today at 2:45 p. m. was seen the scar of slides from midway the north-northeast wall, and a pile of new gray debris at the foot. The ground back of the southeast rim shows very slight signs of caving at the cracks which opened in January, as though further movement had occurred there.

Earthquakes registered by the seismographs at the Observatory included seven very feeble local shocks, one two-minute tremor beginning 12:16 a. m. June 22, and one moderate earth shock also on June 22 at three minutes past noon. This earthquake, which was felt locally, had an indicated distance to origin of nine miles.

Tilt for the week accumulated moderately NNW. Microseismic motion was very slight.

NEW INVESTIGATIONS

Section of Volcanology.

Changes of personnel at the Hawaiian Volcano Observatory have recently occurred, and new investigations are now beginning. Mr. R. M. Wilson rejoined the Topographic Branch of the Survey in California in November, 1928, and Mr. Earl M. Buckingham was temporarily appointed in his place as topographic engineer at the Observatory. Mr. Buckingham made a new map of Halemaumau after changes in the walls had been made by the avalanches of January, 1929, and a new lava floor had been created by the eruption of February 20. He also continued investigations which had been started by Mr. Wilson dealing with mean sea level at Hilo, and with tilting of the ground at the Observatory as determined with level-bubble. Mr. Buckingham also joins the Topographic Branch of the Survey in California on July 1, 1929. Mr. Howard A. Powers, instructor in petrography at Harvard University, has been appointed Junior Geologist on the Survey as chief assistant at the Hawaiian Volcano Observatory, beginning July 1, 1929. Mr. Powers will specialize on the study of minerals in the rocks of the Hawaiian Islands along with mapping of the geologic formations on the basis of the excellent topographic maps of Hawaii made by the Topographic Branch in cooperation with the Territory under Captain A. O. Burkland. These atlas sheets are now finished and in process of engraving for the whole of this island, and some geologic work has already been started by the Survey. This will now be carried forward, and the specimen collections of the Observatory will be subjected to microscopic and chemical examination. For the first time the Observatory will enter on the field of investigation of the older lavas of the island and their relation to the past history of the volcanoes.

For continuation of the seismologic work started in the Aleutian belt of Alaska, Mr. Austin E. Jones left Seattle on the Coast Guard cutter June 8, 1929, for Kodiak and Dutch Harbor, and in both those places he will establish seismograph recording. A new observer will be found for the seismograph at Kodiak, the service of which was discontinued in August, 1928, and the Hawaiian type seismograph now stored at Dutch Harbor will be set up in a cellar constructed for the purpose and operated in connection with the Naval Radio Station at that place. Mr. Jones is now at work building the cellar.

Hawaiian Volcano Research Association.

Professor Chester K. Wentworth of Washington University, St Louis, has been appointed Research Fellow of the Association for the summer months of 1929, and is now at work investigating the volcanic tuffs soils, wind-blown deposits, and other related loose materials on the island of Hawaii His special topic is the origin of the yellow tuff so well known in the Kau district from Pahala to South Points. These tuffs are important in that district as marking a dividing line between older and newer series of lavas Mr. Wentworth will subject the specimens to microscopic investigation and also make comparisons in the field of the relationships of these deposits to the surrounding rocks in the different districts of Hawaii where they are found. It is hoped in this way to determine the meaning of an important dividing line in the volcanic stratigraphy of Hawaii.

Dr John B Stone now with the Cerro de Pazco Copper Corporation in Oroya, Peru, has been appointed Research Fellow of the Association to make an exploration and report in Chile during the winter months of 1929-30. The investigation has in view a study of the volcanoes on the west side of the central valley of Chile with especial reference to the beautiful cone of Osorno and the recently active volcano Calbuco on Lake Llanquihue. Dr. Stone will make a volcanological reconnaissance of the region with the special object of securing photographs and specimens and of bringing the Hawaiian Volcano Observatory in closer touch with the volcanologic work of Chile. This country is little known, but is important because of its many earthquakes and numerous volcanic vents.

Dr. Stone and Professor Wentworth have both done geological work in Hawaii in the past. Dr. Stone investigated the products and structure of Kilauea during the summer and autumn of 1925 under a Bishop Museum fellowship awarded by Yale University (Bulletin 33, Bernice P. Bishop Museum, 1926.) Mr. Wentworth was Bishop Museum Fellow 1923-24 investigating the sediments of the Pacific islands and published studies of the geology of Lanai and the pyroclastic geology of Oahu (Bulletins 24 and 30, Bernice P. Bishop Museum, 1925 and 1926.) T.A.J.

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No. 236 RELEASED WITHOUT COPYRIGHT RESTRICTION July 4, 1929

KILAUEA REPORT No. 910

WEEK ENDING JULY 3, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

The Kilauea lava pit has remained quiet throughout the past week. At 9 a. m. June 29 a compact cloud of dust from an avalanche rose near the northeast rim. Because of its whiteness, the dust at first had the appearance of a cloud of steam. At 10 a. m. July 1 Halemaumau was so densely obscured in rain and fog that observations were impossible. All was quiet and no sounds were heard. A light dust cloud from a small slide was seen at 2:30 p. m. from near the Halemaumau seismograph station on the Kilauea floor.

Eight very feeble local earthquakes were registered on the Bosch-Omori seismographs at the Observatory. One of these, registered at 5:14 a. m. June 28, had an indicated distance to origin of 17.3 miles. In addition is the feeble record of a distant shock, beginning at 2:36:53 a. m. June 27.

Microseismic motion continued to be very slight, although a little stronger near the close of the week. Tilt accumulated slight to the WSW.

LASSEN REPORT No. 18

Lassen Volcano Observatory, Mineral, Calif.,

R. H. Finch in Charge

HOT SPRINGS OF THE COAST RANGES

The following table shows the result of hot springs measurements together with the Waring (G. A. Waring, Water-supply Paper 338, U. S. Geological Survey) data for comparison. (See Volcano Letter Nos. 120, 135, 136.)

Location	Temperature	1927	Waring Data
Calistoga:			
Throat of Plummer's Geyser	218 (F.)	Mar. 22	
Pool at Plummer's Geyser	143		Highest of natural vents,
Pacheteaus, side of capped geyser	213.5		173
Well back of Calistoga Hotel	143		
Harbin Hot Springs:			
Entrance of bricked-in pool	119	Mar. 26	122
Anderson Hot Spring: (Practically abandoned as a resort.) Highest temperature found in a board-covered spring on east side of hot spring canyon	116	Mar. 26	146
Castle Springs:			
In storage tank a little way from intake	152	Mar. 26	164
Seigler Springs:			
Magnesia	61	Mar. 27	72
Arsenic	96		90
Hot Iron	106		100
Sulphur	106		
Near Sulphur	118		119
do	125		126
Howard Springs:			
Borax	91	Mar. 26	95
Iron sulphur	110		110
Magnesia	108		102
Iron soda	88		
Excelsior lithia	72		
Sulphur Bask:			
Pool in old shaft near road	106	Mar. 27	120
Highland Springs: (Appeared to be abandoned.)			
Magic Bath	78	Mar. 28	
Diana Spring	78		80
Skagg Springs:			
Upper	132	Mar. 28	120
Middle	120		122
Lower	128		135

The average rainfall for the area in which the above springs are located is 48 inches, though the amount varies greatly from year to year.

The most recent volcanic activity in this section of the Coast Ranges took place at the Sulphur Banks, to the east of Mt. Konocti. Becker thought it might have occurred within the last 1,000 years, and mentioned Indian tradition of activity at Sulphur Bank. Judging from erosion, Mt. Konocti may have had its last activity much more than 1,000 years ago. The remnant of a crater is still discernible, however, on the south peak of Mt. Konocti. In the hills to the east of the Sulphur Bank there is a fairly well preserved crater. As one goes south from Clear Lake there appears to be a progressive increase in the ages of the last lava flow that capped a good deal of the country. There is, however, a well preserved crater above the Petrified Forest to the west of Calistoga. Considerable volcanic ash is found in its vicinity that has been faulted since its deposition.

The rock mass of the Coast Ranges in this vicinity has been greatly faulted, folded, and crushed, with the main faults trending northwest-southeast, the direction of the main valleys. Folds in the rock appear to be better preserved in the region to the southwest of Clear Lake than farther south.

From the summit of St. Helena, Napa Valley might once have extended much farther north, and drainage from the north was interrupted by lava flows from a small cone to the southwest of Mt. St. Helena. There appears to have been another interruption a little farther north caused by lava flows or upheaval. Above the Palisade Mine there is well preserved evidence of a fissure eruption. Judging from the numerous faults and the recentness of the last activity, it is surprising that this section of the Coast Range has so few earthquakes.

R.H.F.

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No. 237 RELEASED WITHOUT COPYRIGHT RESTRICTION July 11, 1929

KILAUEA REPORT No. 911

WEEK ENDING JULY 10, 1929

Section of Voicanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

No noteworthy changes have taken place at Halemaumau. On Sunday, July 7, avalanches occurred, one about 12:30 p. m. filling the entire interior of the pit with dust. There were other slides later in the afternoon.

Observations on July 8 showed that the top fourth of the north talus was covered with fresh material. The north wall appeared to be the only site of avalanching.

On July 10 thick steam was rising out of the fire pit during the forenoon after several hours of good rain. Prior to this there had been a long dry period at Kilauea. At 3 p. m. it was noted that there were many very active steam jets in the Halemaumau bottom, making an interesting sight as they projected straight upward. A southerly rainstorm was in progress.

During the week there were registered on the seismographs 28 very feeble local shocks, one feeble earthquake at 11:04 p. m. July 9 with an indicated distance to origin of 23 miles, and three teleseisms. This is the greatest number of earthquakes registered in one week since the week ending November 28, 1928, when 30 very feeble local shocks were recorded.

Two of the teleseisms occurred on July 5, one at 3:57 a. m. and the other just after 4:08 p. m. They were not well enough recorded to distinguish phases. The third teleseism began at 11:01:06 a. m. July 7. A preliminary determination of distance to epicenter is 7,480 kilometers from Kilauea.

Tilt for the week was moderately south-southwest. Microseismic motion was very slight.

LASSEN REPORT No. 19

Lassen Volcano Observatory, Mineral, California,

R. H. Finch in Charge

Lava Flows

There are several post-glacial lava flows in the vicinity of Lassen Peak in addition to the three at Cinder Cone and the small one that started through the western gap of Lassen Crater in 1915. There is a series of flows along a north-south line extending south from Tamarack Peak.

Another fresh-looking flow had its origin between the two Prospect peaks. Another flow originates near the northeastern corner of the park east of Cinder Cone. The above flows were not very fluid and consist of broken blocks. A typical basalt flow that was quite fluid extends for miles in Hat Creek valley just below the Hat Creek fault scarp. It contains a great many lava tubes. About 15 miles to the east-southeast of Mineral there is a flow that contains both aa and pahoehoe and formed lava tubes.

Lassen Peak

An ascent of Lassen Peak was made on August 5-6, 1927, supplies being carried on a pack animal. Camp was made inside the main crater about 30 feet below the western rim, above and to the west of the lake in the crater. Rock falls from different walls were frequent. By 7 p. m. ice was forming over the lake, though at the camp, about 50 feet above the lake, the lowest temperature during the night was 46° F., and on the crater rim the temperature was still higher. Steam cracks afforded an easy method of heating food. Lassen Peak may be thought of as being composed of three lobes.

When the doming pressure incident to the 1914-15 activity became sufficiently great, the north lobe cracked away slightly from the other two and opened an east-west crack that probably was very superficial. From the gaps that already existed in the crater wall, it seems that the cracking was along an old break. A massive layer with scars shows that material broke off from it both into the crater and down the outer slope. The layer was in the same plastic condition when it was deposited as was the incipient flow that went through the eastern and western gaps. The flow through the eastern gap was blown or slid on down the mountain side while that through the western gap is still in place.

The flows had probably just started when the explosion blew away the source material. Mud deposits in the Lost Creek Valley indicate that there have been one or more explosions and mud flows from Lassen within the last 500 years. The 500-year limit was obtained from the conditions of preservation of tree trunks buried in the mud flow and recently unearthed by stream erosion.

Dacite pumice in the ash material of the 1915 eruption was scattered over a wedge-shaped area extending from Bumpass Hell nearly to Chaos Crags and from the Peak itself for 12 miles to Butte Lake on the northeast. Just to the north of Hat Mountain, near the center of the area, the ground appears to have been covered with the pumice. Great quantities of this pumice are to be found on the summit of East Prospect Peak, the rock of which is basalt.

Glass Mountain

Following several newspaper accounts of Forest Service officials discovering activity at Glass Mountain, which lies about 70 miles north of Lassen, and after telephone conversation with a Forest Service supervisor familiar with that country, it seemed advisable to investigate the acitivity. Accompanied by G. L. Collins of the National Park Service, an attempt was made to photograph and take temperature measurements at the scene of activity, but we were forced to go back on account of heavy snow. Contact was made with G. L. Courtright, of Dry Lake, about 12 miles east-northeast of Glass Mountain, and from him was obtained an account of an explosion on Glass Mountain in 1910. (Volcano Letter No. 144, 1928.) From other people was obtained an account of a small lake that had formerly existed on the mountain. Mr Courtright said that he is now unable to find this lake. An explosion under the lake could account for the mud reported on vegetation after the explosion, as well as for the disappearance of the lake. R.H.F.

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No. 238 RELEASED WITHOUT COPYRIGHT RESTRICTION July 18, 1929

KILAUEA REPORT No. 912

WEEK ENDING JULY 17, 1929

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

There appear to have been no volcanic changes at Halemaumau throughout the past week. No slides have been noticed, nor are there signs indicating that stripping of the walls has occurred.

On July 13 a semicircle of moisture was noted at the top of the big west talus. This was like an arch just under the uppermost point of the talus which as a whole is shaped like an inverted V. The effect is as though a crescent-shaped crack marks a deep break in the talus cone. The crack emits some vapor, and there are steaming spots in the middle of the talus below. The south talus shows a linear up-and-down fissure steaming at its top.

A slight increase of steam at the center of the west talus was observed at 3 p. m. July 17.

A total of 18 local earthquakes was registered by the instruments at the Observatory during the week. Two of these were felt locally, one on July 10 at 1:27 p. m. and the other July 15 at 10:02 a. m. The felt shock of July 10 had an indicated distance to origin of 10 miles; that of July 15 had no distinguishable phases on account of being immediately preceded by the waning tremor of a very feeble earthquake. There was continuous tremor July 17 from 5:14 to 5:16 a. m.

Tilt accumulated moderately strong SSE. Microseismic motion was extremely slight.

LASSEN REPORT No. 20

Lassen Volcano Observatory, Mineral, California
R. H. Finch, In Charge

The following measurements refer to landslipping in progress at Supan's steam holes, Lassen National Park, and to temperatures at various hot springs. (Compare Day and Allen, 1925, Volcanic Activity of Lassen Peak, Carnegie Institution.)

The line of stakes across new cracks that was placed 50 feet apart in November, 1927, parallel with the valley containing the sulphur works was retaped on July 27, 1928. The following table shows that there was downhill slipping in the upper part of the 1,00-foot line that was practically compensated by over-riding lower down.

	Stake Intervals	New Measurement	Change
	0— 1	50.1 feet	+0.1
	0— 2	100.1 "	+0.1
	2— 3	51.4 "	+1.4
	3— 4	51.3 "	+1.3
	4— 5	50.0 "	0.0
	5— 6	49.4 "	—0.6
	6— 7	49.6 "	—0.4
	7— 8	49.8 "	—0.2
	8— 9	49.8 "	—0.2
	9—11	99.5 "	—0.5
(Note: †10 moved)	10—11	49.9 "	—0.1
	11—12	50.2 "	+0.2
	12—13	49.6 "	—0.4
	13—14	49.9 "	—0.1
	14—15	49.9 "	—0.1
	15—16	49.8 "	—0.2
	16—17	49.9 "	—0.1
	17—18	50.0 "	0.0
	18—19	50.0 "	0.0
	19—20	†20 moved	

The line was extended 300 feet and three lines run across the valley by transit: one at the upper end of the stake-line, one near the middle, and one at the lower end.

Temperatures of Hot Springs

Supan's.

The highest temperature found at the "Big Steamer" at Supan's solfatara on July 28, 1928 was 240°. The same vent on September 5, the driest part of the season, was but 235°. As the temperature of such hot springs varies inversely as the amount of water discharged, the slight cooling of the spring was contrary to what was expected.

Morgan Hot Springs, August 7, 1928.

No.		Fahr.	No.		Fahr.
1		177	12	muddy water	188
3	middle pool	185		mud	172
	lower "	196		clear water	195
4	north "	190	14		178
	middle "	168	17		201
	south "	176	19		144
5		172	20		200
6		176	Between 12 and 14	in black earth	160
7		196	23		192
8		156	24		198
9		106	Geyser		200

Live, wiggling larvae in mud algae at No. 3 with temperature of 120°. When temperature was 140° the larvae was dead.

Boiling Lake, August 11, 1928.

Water north end of lake	130 Fahr.
Mudpot north end of lake	198
Milky pool southwest edge of lake	192
Site of Cornpopper, south end of pool	204

(The ground at this site sank several feet since the fall of 1927.)

Devil's Kitchen.

Bluish-gray pool of water near northwest end	171 Fahr.
Deep pool just above one with stream flowing through it near upper end of "kitchen"	195
Splashing pool upper north side	169
Yellow pool northwest end	189
Pool in rock southwest edge	198
Small splashing vent southwest	199
Large splashing pool southwest	199

Bumpass Hell, September 5, 1928.

No.		
8		194 Fahr.
9	mud pot	194
10	pool	174
11	steam vent	192
13	" "	194
14	east side	190
16		194
17		195
Several small vents depositing sulphur crystals		195

The highest temperature observed at Bumpass Hell in 1928 was considerably lower than the highest for 1927.

R.H.F.

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No. 239 RELEASED WITHOUT COPYRIGHT RESTRICTION July 25, 1929

KILAUEA REPORT No. 913

WEEK ENDING JULY 25, 1929

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

A quiet flow of lava broke out in the bottom of Halemaumau about 6 a. m. today. The flow at first was from two fountains loudly splashing just above the lower edge of the big west talus. About 8 a. m., before the new lava had covered the floor formed last February, a crack opened athwart its center with much gasrushings, releasing a line of fountains in direction approximately northeast-southwest. The fountains are about 200 feet high.

The eruption is one of a series of minor, short-lived flows characteristic of this period of cyclical events at Kilauea. It can not be stated how long the flow will continue, though at the present time it is strong.

The last activity in Halemaumau occurred on February 20 and 21, 1929. It filled the bowl-shaped bottom of the pit with lava to a depth of about 60 feet, forming a floor a little less than 1,200 feet below the rim. Few changes occurred at the volcano since that time. No great avalanches took place that might denote a great subsidence of the lava column, and it was therefore thought that magma lay not far below the surface of the volcano edifice, and another eruption during 1929 was accordingly considered possible.

The usual harmonic tremor indicative of flowing lava is registering on the seismographs at the Observatory. This began to be somewhat steady at 6:46 a. m. Beginning at 8 p. m. July 24 there were spells of tremor fairly regularly every 16 seconds and lasting nearly an hour.

The earthquakes for the week ending July 24 at 8 p. m. total 19. These were all of very feeble intensity and not large enough to be felt. At numerous times throughout July 21 the seismographs registered short spells of microscopic tremor. The seismograph on the crater floor near Halemaumau did not record this tremor, however.

Tilt accumulated moderately NNE. Microseismic motion remains very slight.

VESUVIUS IN JUNE 1929

The following is quoted from Nature, June 15, 1929, showing that Vesuvius has recovered from its 1906 engulfment to the stage where it makes external lava flows:

"After the great paroxysmal eruption of Vesuvius in 1906 there followed seven years of obstruction and comparative repose. In 1913 the conduit became open and the normal type of external activity began. Since then the crater has been steadily filling from a succession of central conelets, and at intervals in recent years there have been minor crescendos of explosive and effusive activity. By far the greatest and most spectacular of these broke out in the early hours of June 3. The outburst began with tremendous explosions and the hurling into the air of masses of incandescent material. The central conelet split and collapsed. As it fell back into the crater lava welled out and occupied the northeastern quadrant of the crater. (This was the lowest lip left in 1906. T.A.J.) Professor Malladra announced on June 3 that he considered the eruption to be one of the periodic recrudescences of activity; that it was unlikely to last more than two or three days; and that a disastrous eruption of the culminating type—such as those of 1872 and 1906—was not yet to be expected.

"On the morning of June 4 it became clear that for a minor eruption the manifestations were more than usually violent. The interior of the crater now became a lake of effervescing lava some 500 yards in diameter. The lava overflowed into the Valle dell Inferno and escaped down the outer slopes into the valley of Cuppaccio and towards the little town of Terzigno, following the course of the 1834 lava stream. After a short interval of quiescence from 2:30 to 7:30 p. m. there was a sudden paroxysm of activity for three-quarters of an hour. Incandescent matter rose 1,500 feet above the crater and fell in glowing showers on the slopes of the volcano. Afterwards there were loud and frequent explosions, followed by an ash cloud that rose to still greater heights. From 11 p. m. on June 5 to 3 a. m. on June 6 there were further tremors and explosions, and columns of lava were thrown into the air to break into incandescent bombs. Since then there have been (at the moment of writing) no further reports of activity. The lava stream has extended five miles down the southeastern slopes, widening to a frontage of 900 yards, destroying 110 acres of cultivated land and wiping out three small hamlets. Although Terzigno was evacuated with the prompt aid of the military, the township itself has fortunately been spared, the lava having halted 300-400 yards from the houses. It is estimated by Professor Malladra that the volume of lava approaches half that emitted during the 1906 eruption." T.A.J.

THE NEW ZEALAND EARTHQUAKES OF JUNE 1929

On Hogben's map (Geography of New Zealand, p. 243, by P. Marshall, Christchurch, Whitcombe and Tombs) of larger New Zealand earthquakes, eight principal shocks appear in the middle belt between the north and south islands, only two in the northern region of active volcanoes, and four in the southern mountains and fjords. The Wellington earthquake of 1855 elevated the shoreline. Now comes a series of disastrous shocks in the north mountains of the south island, the region extending southwest from Nelson, with the worst damage at Murchison, which was virtually destroyed.

The new series began on June 17 in the Buller Gorge, but within three months there had been another serious earthquake with many landslides in the Otira Gorge. These are sites of two of the south island's famous roadways. The new crash occurred all along the route between Greymouth and Westport, on the west coast of the north end of the South Island, and the north coast at Nelson, seat of a college. The college, a large masonry building, was wrecked. The roads were split open in huge crevasses, landslides wrecked quarries, railways, and homesteads, some peole were killed and wounded, even frame houses were lurched and collapsed, communications were destroyed, roads disappeared, bridges collapsed, and railway tracks were warped, twisted, and destroyed. (Auckland Weekly News, June 26, 1929.) All the chimneys came down, telephone poles fell over, and trains were derailed. Valleys were blocked and lakes formed. People were thrown off their feet. The time of the major shock was about 10:25 a. m. local time June 17.

Riverview Observatory at Sydney calculated the epicenter 100 miles east of the South Island, but the Wellington seismograph station did not agree to this: field evidence indicated an epicenter in the mountains. Messrs. Ferrar and Grange of the Geological Survey of New Zealand are investigating the movement, which is believed to be a fault displacement. T.A.J.

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No. 240 RELEASED WITHOUT COPYRIGHT RESTRICTION August 1, 1929

KILAUEA REPORT No. 914

WEEK ENDING JULY 31, 1929

Section of Volcanology, U. S. Geological Survey
H. A. Powers, Temporarily in Charge

The lava activity reported last week as beginning about 6 a. m. July 25 continued until 7:42 p. m. July 28, when all fountaining ceased. The lake formed during the flow reached a maximum depth of 94 feet in the center of Halemaumau, and nearly buried the south cone of 1927 which was well up the talus slope prior to the eruptions of 1929.

Following the cessation of flow there was still some activity in the lake as the sluggish liquid continued to seek its level, but cooling of the crust was rapid. The crust settled, and the cracking noises of this process can still occasionally be heard. There is glow at night from numerous scattered points. No avalanching has followed the eruption.

Seventeen very feeble local earthquakes were registered by the instruments at the Observatory. In addition was the harmonic tremor accompanying the lava activity. This tremor was continuous after 6:32 a. m. July 25, although the fume was first noticed at about 6:10 a. m. The tremor waxed and waned at times, but grew stronger on July 27. Fountain action was also stronger. About 7 p. m. July 28 the tremor weakened and after 7:11 p. m. it was unsteady. It ended entirely at 7:42 p. m., when the fountains also went out of action.

There was moderate WNW. tilt during the two days preceding the eruption, slight SSE. tilt during the flow of lava and until July 29, and very slight WSW. tilt for the next two days. The net accumulation of tilt for the week was moderate to the south. Microseismic motion is still very slight.

HALEMAUMAU OUTBREAK JULY 25-28, 1929

Halemaumau has again been the scene of volcanic activity. The eruption began on the morning of July 25 and continued until the evening of July 28. It was one of a series of short-lived, quiet rises of magma which has characterized the present cycle of activity in Kilauea. The lava column attained a maximum height in the pit of 2,640 feet above sea level, a gain over the fill of February 20-21, this year, of 94 feet.

The first indication of the renewal of activity was a series of very small earthquakes a few minutes apart beginning at 4:35 a. m., each accompanied by a slight tilt to the east. The shocks and the tilt made only a slight record on the north-south component of the instrument. They were followed by spasmodic tremor, caused by fountain action, which became stronger and continuous after 6:30 a. m. and lasted so throughout the eruption.

The first observed activity was a cloud of smoke noticed by the machinist of the Observatory at 6:10 a. m. At 6:40 a. m. two fountains of lava were spurting from vents above the lower edge of the middle of the large western talus bank. A high column of blue smoke, pungent with the odor of sulphur dioxide, rose continuously from the fountains, and occasionally spurts of brown sulphur fumes were mixed with the smoke. By 7 a. m. a moisture cumulus had gathered over the pit.

The fountains strengthened rapidly so that by 7:20 a. m. they were throwing pumice and bombs at least 200 feet in the air, and two-thirds of the old floor was covered with new lava.

At 7:45 a. m. steady blasts, sounding like gas rushing through small orifices, were audible above the pounding of the lava fountains. These increased until, at 8 a. m., several small lava fountains, yielding brown fumes and apparently flaming, broke through cracks at the eastern edge of the old floor. Simultaneously, the western fountains lowered slightly, though their fuming increased. A little later the rapidly foundering old floor west of the new fountains was split by a large crack. By 10:20 a. m. it was covered by a lava lake, but its position was marked by a linear fountain, most active at its eastern end.

The filling continued steadily until, at 12:45 p. m., the old floor was nearly covered by a lake 25 feet deep over its lowest points. Fountaining continued with increasing vigor in the western and central areas, but the gas blasting had ceased. Blue smoke still issued from the fountains, but little brown fume was in evidence. About this time two phenomena became evident which, with the fountaining, characterized the remainder of the activity, namely, the cracking and foundering of the surface crust, and the pouring of cascades over ramparts built up near the margins of the lake.

The western fountains gradually strengthened at the expense of the central fountains until, at 6 p. m., 12 hours after the start of activity, spouting was confined to the western marginal fountains. These remained constant and strong (throwing material 300 feet high) until the morning of the fourth day, July 28. During this day the vigor showed periodic increase and decline. About 4:30 p. m. fountaining ceased entirely for 15 minutes, then increased suddenly to nearly the former vigor. Spouting continued with constant force until about 7 p. m., then gradually decreased until it stopped completely at 7:42 p. m.

The influx of lava continued constantly during the life of the fountains. The margins of the lake were extended during the rise by cascading over the marginal ramparts. Tilting of the bench lava beneath the lake, and convection currents in the lake influenced the advancing of the lake margins in such a manner that cascading and spreading was strong first on one side of the lake and then on the other.

During the first 24 hours the lava rose 44 feet above the level of the old floor. At the end of 48 hours the depth had increased to 77 feet, and on the morning of the fourth day, Sunday July 28, the pit had been filled 88 feet. The maximum elevation of the lake surface, reached July 28 after 85 hours of flowing, was 2,640 feet above sea level, 94 feet above the old floor.

The lake, shaped somewhat like an ivy leaf with the broad stem lying toward the southwest, has a maximum width of 1,700 feet and a length of 2,100 feet. Its area is approximately 50 acres.

Soon after the cessation of activity, withdrawal of the supply of molten lava and some shrinkage accompanying crystallization of the crust permitted the surface of the middle of the lake to settle. A survey of the pit made the next day shows that the existing floor has an elevation above sea level of 2,600 feet. This central floor is bounded by in-facing fault scarps from 20 to 30 feet high. The narrow lake margin, between these scarps and the walls of the pit, varies in elevation from 2,615 to 2,630 feet. From these data it has been estimated that approximately eight million tons of rock have been left in the bottom of Halemaumau by this eruption. H.A.P.

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No. 241 RELEASED WITHOUT COPYRIGHT RESTRICTION August 8, 1929

KILAUEA REPORT No. 915

WEEK ENDING AUGUST 7, 1929

Section of Volcanology, U. S. Geological Survey

H. A. Powers, Temporarily in Charge

There has been no renewal of volcanic activity at Kilauea. Appearances at the fire pit indicate that there will be several weeks of quietude before another flow of lava occurs. A few slides have fallen north and east, but otherwise Halemaumau remains unchanged.

Recent measurements of the east rim cracks show no significant changes over the measurements of May 15, the largest amount of movement being 0.135 foot.

A substantial increase in the number of earthquakes during the past week may mean slight subsidence of the invisible lava column. Twenty-seven very feeble local shocks were registered at the Observatory. In addition there was a two-minute period of microtremor 5:14-5:15 a. m. August 7; also two felt earthquakes, one at 10:43 p. m. August 5 and the other at 2:42 a. m. August 7. The distance to origin of the former can not be determined because the preliminary phase was destroyed by the minute mark; the latter shock originated about nine miles from the Observatory.

Microseismic motion was slight throughout the week except for a temporary feeble increase early August 2. The accumulation of tilt was slight to the NNE.

FOURTH PACIFIC SCIENCE CONGRESS

Mr. R. H. Finch, Associate Volcanologist in charge of Lassen Volcano Observatory in California, was delegated by the United States Geological Survey to attend the Fourth Pacific Science Congress as representing the Section of Volcanology of the Survey. In this journey he received assistance also from the Hawaiian Volcano Research Association as their delegate.

Mr. Finch reports that Dr. Maclawin of New Zealand represented the New Zealand Government so as to be able to give advice on extending the observations on New Zealand volcanoes. At a Japanese dinner in Singapore Mr. Finch met Dr. H. Tanakadate, volcanologist of Sendai University. The return trip from Java May 31 was on a Japanese freighter passing by Borneo and Celebes, and through the Sulu Archipelago and Sulu Sea. Most of the large islands of the Philippines was seen, as well as the southeast side of Luzon. A small fume cloud was observed over Mayon. Dr. Kozu from Sendai, and S. Kunitomi, seismologist of the Central Meteorological Observatory of Tokyo, were passengers. The program of papers at the Congress was serious and of sustained high quality. Mr. Finch feels that he benefitted much by his contacts at the Congress. He reports:

"The opening meeting of the Fourth Pacific Science Congress was held in Batavia, Java, on May 16, 1929. The Congress then moved to Bandoeng, Java, where in the delightful climate appropriate to an elevation of 2,000 feet the scientific sessions of the Congress were held from May 18 to May 24.

"The Congress was organized under the supervision of the General President, Dr. O. De Vries and Dr. H. J. Lam, General Secretary. About 250 foreign delegates were present, as well as a strong delegation from the Dutch East Indies. The delegates came from 24 different countries, with South American countries and Mexico not represented.

"One of the most interesting excursions prior to the opening of the Congress was to the volcano Krakatau. With the steamer 'Rumphius' provided by the Royal Packet Navigation Company (K.P.M.), excellent views were obtained of the three older islands of the Krakatau group. Landings were made on these islands, as well as on Anak Krakatau (Baby Krakatau), the island that was formed by explosions early in 1929. Exhibitions of native dances and native industries of the principal tribal groups of the Dutch East Indies were other outstanding features of the entertainment provided before the Congress opened. Both foot and airplane trips were made during the session of the Congress to Tangkoeban Prahoe volcano. After the Congress adjourned on May 25, there were excursions until June 4, many of which were to active volcanoes.

"For the most part papers were not presented before the Congress by the authors themselves. Papers on closely related topics were grouped and reviewed by one person. The time saved by this method was devoted to open discussion. Printed abstracts of most of the papers were available before they came up for review and discussion. The papers will be printed in full in the proceedings of the Congress.

"There were four sectional meetings under the head of volcanology. Many questions of interest to volcanologists were discussed in the sections of seismology and petrology. Of especial interest under seismology was the evidence offered on the occurrence of earthquakes with a focal depth of from 180-240 miles. The papers of Dr. Kozu on the influence of temperature upon the volume of granite and some lavas given under petrology proved of great interest to volcanologists.

"The invitation of Canada to hold the next Congress in Vancouver, B. C., in 1932, was accepted." R.H.F.

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No. 242 RELEASED WITHOUT COPYRIGHT RESTRICTION August 15, 1929

KILAUEA REPORT No. 916

WEEK ENDING AUGUST 14, 1929

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

Dust from slides in Halemaumau was seen at various times during the forenoon of August 8, possibly caused by persons dropping rocks.

On August 11 it was noted that slumping since the July eruption leaves a terraced fault bank high along the west side where the deeper conduit was. The deeper withdrawal occurred there, and the deepest part of the slump appears to be at the northwest in the floor surface. There is little change of the east side of the bottom. Twenty or more hummocks are at the west. One of these is open and round like a tree mold, and stands up like a huge pipe 20 feet across. There are avalanche rocks on the steep down-faulted terrace at the edge of the floor under the northwest talus.

Blue smoke continues to come from the east rampart, and there is the usual steam from vents in the west and south taluses.

Earthquakes for the week number 28. None was felt, all being of very feeble intensity. Two of the shocks were of the continuous tremor type, one occurring 12:45 - 12:47 p. m. August 7 and the other 10:43 - 10:53 p. m. August 10.

Tilt accumulated slight to the NW. Microseismic motion was slight, with a little strengthening on August 10.

VOLCANIC LIGHT, HEAT AND POWER

In view of the possibility of warming the rooms of the hotel at Kilauea Volcano by natural steam with the aid of a hot water radiator system, it is of interest to learn what has been done in other places. At Kilauea the four bore-holes at Sulphur Bank close to the hotel yield constantly great quantities of steam at 96° C. If this were passed through a tubular boiler containing the water circulation for the hotel radiators, with the pipe properly insulated, every room might contain an adjustable heater filled with pure water from the tanks. There would thus be no waste of water. The slight corrosive effect of the acid steam would be met by building the boiler of a suitable resistant metal. The hot water system would be a great comfort to many guests in cold, rainy weather and by drying the building would act as a preservative against mildew.

Even in ancient times it was the dream of mankind to utilize volcanic heat. This does not mean harnessing the eruptions of volcanoes, but rather making use of the fumaroles and boiling springs generally found in volcanic districts. For many years the steam of fumaroles has been used in Iceland for the heating of schools and other public buildings. In Japan there is a village heated in winter with the aid of volcanic steam led into the buildings. Most of this is the steam of ground water brought to the boiling point through the agency of underground magma or of volcanic gases. The latter are dominantly hydrogen, carbon, chlorine, and sulphur, and their compounds through union with oxygen of the air.

Even farmers have made use of volcanic energy to assist them in agriculture. On the island Ischia, near Naples, the peasants make use of numerous fumaroles to warm their tomato plants and so make them sprout sooner. On the bottom of the extinct Agnano Crater a gardener found the volcanic heat useful in order to keep his vegetable crop producing all the year around by distributing his sowing and his harvesting in accordance with an irrigation system dependent on hot springs. Recently a company has been formed that makes use of volcanic steam for the warming of hot houses where useful plants are produced.

It is well known that in many places in Iceland, North America, the tropics, and New Zealand hot springs are used as laundries, and of course they have been used from time immemorial as baths beneficial in certain diseases.

Near Lardarello in Tuscany boric acid has been produced from scalding natural steam for more than a century. Prince Ginori Conti began there in 1904 to operate a small steam engine by curbing a natural steam vent. Further development of the steam power was hampered by the low pressure and temperature of the surface steam and the rapid eating away of the metal by the acid vapor.

In order to obtain higher pressures and temperatures, bore-holes were drilled which yielded a rush of steam at 190° C. and 14 atmospheres of pressure. There was finally obtained at Lardarello from several bore-holes 250,000 kgs. of steam per hour averaging two atmospheres of pressure and a temperature from 120° to 190° C.

In order to avoid the corrosion of expensive machinery, the high-pressure natural vapors were condensed under pressure, the fixed gases were assembled and conserved as by-products, and pure water was heated above the boiling point in a low pressure boiler so as to make steam, utilized by expanding it in low pressure turbines.

At Castel Nuovo a well 130 meters deep operates three turbo-generators of 2,000 kilowatts capacity. At present the plant yields some 12,000 kilowatts and no exhaustion of the resources of the ground has yet appeared.

In Java experiments at Kawah Kamodjang Crater with a bore-hole 128 meters deep yields a volume of steam at six atmospheres pressure estimated capable of producing 900 kw. At the Geysers in the St. Helena Range in California a great store of hot steam has been revealed by drilling, and this increases with depth. Borings for power have been made here discovering temperatures from 99° to 173° C. and pressures from 60 to 169 pounds. The wells vary in depth from 154 to 636 feet. Both temperature and pressure increases with depth. These wells also have been harnessed for power. The geological conditions indicate that the region overlies intrusive volcanic magma. (Volcanoes which heat Towns, by Dr. L. Steinberg, Weser Zeitung April 26, 1929, Bremen. Steam Wells at the Geysers, California, by E. T. Allen and A. L. Day, Carnegie Institution Publication No. 378, 1927.) T.A.J.

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No. 243 RELEASED WITHOUT COPYRIGHT RESTRICTION August 22, 1929

KILAUEA REPORT No. 917

WEEK ENDING AUGUST 21, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

A slide was reported at the north wall of Halemaumau about 3 p. m. August 16, and the next morning a fresh scar was observed there. Notably little visible steam appears about the new lava floor. A small crack at the east edge of the floor yields blue fume, and on August 17, at 9:45 a. m. the upper edge of the northern grotto niche at the west side of the floor began to yield blue smoke. This was very slight and diminished on succeeding days. The talus slopes make a little vapor visible on cool, moist days.

Nineteen very feeble earthquakes were registered at Kilauea and one feebly perceptible shock at 12:38 p. m. August 14. This had indicated distance to origin of 30 miles. Microseismic motion increased slightly during the nights of August 15-16 and August 19-20.

Tilt accumulated moderately NNE.

THE RISING LAVA IN HALEMAUMAU

The three short-lived eruptions which have occurred in the inner pit Halemaumau since 1925 have brought into the bottom of the pit a total of 8,692,000 cubic yards of solidified lava and have filled the bottom to a depth of 210 feet. Expressed in terms of the old Halemaumau which was overflowing in 1921, and was a much smaller shaft, this volume of lava would have meant in the old pit a rise of level of 350 feet.

Because of the fact that the dimensions of the pit have been increasing owing to the breakdown of the walls, and also because the bottom has been changing, it has been necessary from time to time to revise the topographic map of the actual pit crater. By keeping this map up to date it has been possible to compute with fair accuracy the actual amount of lava added during each eruptive period.

Before the outbreak of July 7, 1927, the bottom of Halemaumau stood at an elevation of 2,390 feet above sea level. It was 1,260 feet below the observation station on the southeast rim. During the 1927 eruption the level of the lava rose to an average elevation of 2,500 feet above sea level, and the total area of the new surface was 30 acres. After making proper allowance for the slope of the containing walls, the volume of new lava was computed to be 85,430,000 cubic feet.

Heavy avalanching during the months following, and other avalanches at the time when an internal landslip in the pit in January, 1928, was accompanied by an upward squeezing of red hot lava, produced burial of much of the 1927 lava floor beneath debris from the walls.

A new eruption of lava came February 20, 1929, pouring its floods over 19 acres of the 1927 lava that still remained unburied by debris. During the 36 hours of activity, a lava lake was formed which had an average depth when frozen of 45 feet, a surface area of 40.5 acres, and a total volume of 51,900,000 cubic feet. The new floor thus formed had an elevation of 2,546 feet above sea level and was 1,104 feet below the rim at the observation station.

The last eruption which began on July 25, 1929, and continued for 85 hours built up the floor of Halemauamu to a point 1,050 feet below the observation station. The total volume of this lava of July, 1929, in the new floor is 97,350,000 cubic feet and the surface area is 54 acres.

The figures given for the volume of each flow represent only the actual amount of lava which remained in the pit after activity had ceased. In each case a great deal of the frothy liquid material extruded during the eruption was either withdrawn from the lake when the lava column sank into the earth at the end of the active period, or else contracted by loss of gas. During the eruption of July, 1929, the inflated lava lake at the time of maximum activity before any recession contained a total volume of 126,850,000 cubic feet of molten lava.

A tabulation of these data facilitates comparison:

	Depth	Area	Volume
July, 1927	110 ft.	30 acres	85,430,000 cu. ft.
Feb., 1929	45 "	40.5 "	51,900,000 " "
July, 1929	55 "	54 "	97,350,000 " "

H.A.P.

THE NEW CYCLE IN HALEMAUMAU

The above figures computed by Dr. Powers exhibit the facts of a true rising of the lava column of Kilauea since the explosive eruption of 1924. After that engulfment the funnelling talus had its lowest point 1,330 feet below the observation station. The depression of the bottom was diminished by 70 feet with the lava filling of July, 1924. by 110 feet with that of 1927, by 45 feet with that of February, 1929, and by 55 feet with the eruption of July, 1929. As the talus of the bottom opens out funnelwise at an angle of 30 degrees, the areas have increased and in general the volumes have increased. The duration of eruption in the two outbreaks of 1929 was less than in the outbreaks of 1924 and 1927, while the volume of inpouring per day was much greater. The 1924 eruption lasted 10 days and the 1927 eruption 13 days, while the two outbreaks of 1929 each stopped suddenly at the end of a day and a half and three days and a half, respectively.

The fountaining at the beginning of all these eruptions was of the Mauna Loa type, throwing up basaltic pumice. The fountains of 1924 were estimated to be 150 feet high, those of 1927 125 feet high, those of February, 1929, 200 feet high, and those of the last day of the July eruption, 1929, reached maxima of 300 feet at times. The 1927 eruption was estimated to pour out 50 per cent of its volume during the first hour, and something similar was true in 1924. Both these eruptions built up cones at single vents, whereas the two 1929 eruptions opened fissures at the floor margins, and the largest fountains left only niches. This history seems to indicate that the intensity of gas action and the freedom of flowing has increased in 1929, and at the same time the interval between outbreaks has decreased.

A platted curve of the rate of rising now in progress, with an average fill of about 70 feet for each eruption, and a diminishing interval between eruptions, should make the next inflow of lava take place some time between now and November, 1929. This expectancy might be interfered with if Mauna Loa should erupt, but that would be an equally satisfactory demonstration that the Hawaiian lava column is alive.

T.A.J.

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No. 244 RELEASED WITHOUT COPYRIGHT RESTRICTION August 29, 1929

KILAUEA REPORT No. 918

WEEK ENDING AUGUST 28, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

The pit Halemaumau at Kilauea Volcano has shown no movements of interest during the past week. A round convection cloud hung over the pit during the night August 23-24, gradually vanishing with forming and reforming as the sun's heat dried the air about 8 a. m. On August 25 at 2 p. m. the weather was rainy and this developed steam at hot places in the wall of the pit above the northeast and southwest taluses and on the talus slopes. Blue vapor rose from the crack at the niche at the western edge of the floor where the northernmost source fountain had been in July, 1929.

Sixteen very feeble earthquakes were registered at Kilauea, including several spells of spasmodic tremor August 21, mostly during the noon hour and possibly occasioned artificially. One slight perceptible shock occurred at 1:45 a. m. August 28 with origin not more than four miles from the station according to the seismographic evidence.

Microseismic motion was slight, with some increase August 21-22. Tilt to August 24 accumulated moderately SSW. Tilt measurement was temporarily interrupted thereafter by repairs to the seismograph basement.

MEASURED DEFORMATION FROM TOKYO EARTHQUAKE

Tanakadate calls attention to the fact that regional deformation by uplift, sinking, or sidewise motion of the land has only been measured in relation to earthquakes within the last 40 years. (Geomorphology of the Kwanto Earthquake in Japan—in Italian—by H. Simotomai Tanakadate, R. Accad. delle Sci. Fis. e Mat. Napoli, December 3, 1927.) This has been done for the San Francisco earthquake 1906 and, for the Japanese Empire, in the cases of the earthquake of Nobi 1891, of Omati 1918, Kagi in Formosa 1906, and the recent Tango earthquake.

After the great Kwanto earthquake of September 1, 1923, the Naval Institute of Hydrography measured the bottom of Sagami Bay in comparison with soundings of 12 years before, and found enormous changes. A belt extending SSE. from the central part of the bay had lowered from 110 to 210 meters, and a horseshoe of the bottom enclosing this on the northwest had been lifted or shallowed to a maximum of 250 meters. The maximum subsidences were, in a pocket near the head of the bay of 300 meters, and in the channel leading to Tokyo Bay of 400 meters. The biggest belt of sea bottom elevation trends northwest along the northeastern half of the bay, and the biggest belt of sea bottom depression trends out to sea from the southern half of the bay, interrupted by a belt of 100 meters of elevation, between the active volcano island Oshima and the mainland northwest of it.

In other words the belts of elevation and depression are along northwest-southeast axes alternating, with the southern elevation axis lying along the active volcano line Oshima-Fuji. Although the entire northeastern belt of elevation exhibits such positive uplifts as 100, 180, 230, and 250 meters, which cannot possibly be accounted for by the filling of bottom depressions by submarine landslip, the immediately adjacent shorelines rose only one or two meters. The same may be said of the Idu Peninsula on the opposite side of the bay, immediately adjacent to the undersea ridge raised 100 meters and undersea depression from 100 to 300 meters; this shoreline moved hardly at all. The bottom of the bay appears to be sharply differentiated mechanically from the solid rocks of the shore.

The area of the sea bottom region lowered was 700 square kilometers and the bulk displaced 50 cubic kilometers. The area of the sea bottom region elevated was 240 square kilometers and the bulk displaced 20 cubic kilometers.

Coming now to the shoreline, it was mostly elevated somewhat, at the instant of the earthquake, from the head of Tokyo Bay to the mouth of Sagami Bay. A region back in the interior, extending northeastward from Fuji Volcano, was slightly depressed. The axis bounding these two belts is northeast and southwest, or about at right angles to the Sagami Bay axis. Precise levels run by the Military Institute of Geography immediately after the earthquake discovered elevations of one or two meters or less at the southern end of the Boso Peninsula east of Sagami Bay, and at the extreme head of the bay near Kodu. The maximum uplift was at Hemuro Mountain 21 kilometers north of Kodu amounting to 2.65 meters. This maximum land uplift was a localized hump clear inside the Fuji belt of depression. The subsidences in this last belt were small, of the order of tens of centimeters.

The relative horizontal movements of bench marks relocated by precise triangulation in 1924-25, compared with the geodetic net of 1884-89 from base lines measured in 1882 and in 1924, reached a maximum on the volcano Oshima, of 3.78 meter, in a direction N. 8° E. In general the displacement is at a maximum around Sagami Bay of the order of one or two meters, and is north on the west side of the bay, eastward to the north of the bay, and southeastward to the northeast of the bay. This encircling movement diminishes in the interior country. The displacement at Oshima island is toward the bay.

The country has been shown to be broken up into small fault blocks and the two peninsulas where the maximum shore movements occurred consist of lithified tuffs of Tertiary age excessively dislocated from that time to the present, and much of this dislocation extends into broken shore terraces directly related to Quaternary and recent earthquakes. Tanakadate shows that by investigation of the tide gauge at the Miura Peninsula, nearest to the earthquake center, the shore had been gradually sinking about 10 centimeters in the last 23 years. Before that, on the authority of researches by scientists, and of a careful investigation of 150 fishing villages, the evidence shows that prior to the earthquake of 1923 there had been gradual lowering of the shore, and encroachment of the sea, of the order of three feet in 65 years. This applies especially to the two peninsulas. The evidence goes to show that in just such measure as the subsidence prior to the earthquake had been greater, so much the higher was the elevation or springing up of the ground at the moment of the earthquake.

A great earthquake in the same region in 1703 produced elevation of the Boso Peninsula and lifted dry land areas unknown before, said to have been from one to four kilometers wide, at different places along the shore. Accordingly it seems likely that from Tertiary time to the present this has been a region of "hereditary earthquakes," like southern Italy, where magmatic invasion brings about elevation, eruptions, and earthquakes. T.A.J.

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No. 245 RELEASED WITHOUT COPYRIGHT RESTRICTION September 5, 1929

KILAUEA REPORT No. 919

WEEK ENDING SEPTEMBER 4, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

On August 29 dust rose from Halemaumau pit at 1:30 p. m. in two small clouds separated by an interval of about one minute. At 12:05 p. m. August 30 a large dust cloud rose from the east side of the interior of the pit with protuberances projecting upward, an indication that a strong avalanche had occurred. The pinkish dust hung visibly over the pit for many minutes. The effects of this were seen at 10 a. m. August 31 in that the north side of the new lava floor was dusted by the outward projections from a big avalanche that had fallen from the north wall, and that corner of the pit was still sliding. There were some large stones on the north side of the floor. Much fresh rock was in evidence on the northeast talus. Above the northern niche at the edge of the floor west, blue smoke appeared as though puffing. Small patches of milky stain lay on the edge of the floor south and north-northwest.

Fifteen very feeble earthquakes were registered. The day records of August 30 and September 3 were interrupted by repairs. Microseismic motion was slight.

MURCHISON EARTHQUAKE, NEW ZEALAND

At 10:17 a. m. June 17, 1929 New Zealand time (11h. 30m. faster than Greenwich) a disastrous earthquake struck middle New Zealand with maximum damage in the Buller Gorge of the mountainous district of the north end of the South Island.

The shock was severe in Wellington, dismantling the Milne-Shaw seismographs. Aftershocks on these instruments indicated epicenters in the northern part of South Island. Murchison suffered the most damage. Landslips in precipitous country destroyed four homesteads and killed fourteen people. Numerous chimneys and two clock-towers were broken, many walls cracked, one badly built two-story house partially collapsed after the second severe quake; on these data the preliminary statement of the Geological Survey Office makes the intensity at Murchison R. F. VIII.

There was a severe aftershock June 23. This and the main earthquake appeared to center on the White Creek fault-plane that crosses the Buller River 7 miles west of Murchison. It was possibly a twin-earthquake with second centrum on the Kongahu fault-plane off NW coast of South Island. Many aftershocks occurred, some perhaps on other fault-planes. Differential movement of about 14 feet displacement was found at the White Creek fault. In 1928 this fault had been mapped for seven miles, but it is not known whether the displacement since was sudden or gradual, nor whether movement has yet ceased.

At Whitecliffs on the west coast a strip of sea-bottom was uplifted 100 feet, forming a ridge 180 feet wide by 4000 feet long, apparently the west side of a small fault-block tilted. Tilting of the land at Kelburn is suspected.

Dr. E. Marsden, Minister for Scientific and Industrial Research, called a conference of scientists June 26 on earthquake investigation, seismograms are being registered at Wellington and Christchurch, a seismograph and sound-ranging instruments were set up at Murchison, having in view study of focal depth of aftershocks, and the Milne seismograph was set up at Westport to locate aftershocks, and check time-curves of the permanent instruments. Questionnaires were broadcasted and geological investigations are in progress. The air Defense Service will photograph the faults from airplanes. Soundings were made off the west coast, and repeat observations in levelling and triangulation are in progress. Bench marks have been placed and occupied on each side of the active White Creek fault, which appears to have allowed movements of earth blocks to take place since the earthquake.

On request of Dr. Marsden drawings and specifications of the Jaggar shock-recorder were sent to Wellington from the Hawaiian Volcano Observatory June 29 and he writes that two of these have been constructed. It is planned to have some of these shock-recorders distributed about the country, and to have an additional major station with three-component seismograph in the middle of the North Island. A full report of the earthquake will be published later. (Circular of N. Z. Geol. Surv. "Murchison Earthquake Investigations" by H. T. Ferrar, Acting Director, 31 July, 1929 (mimeographed.)

New Zealand has an exceptionally good field for pathbreaking in the study of the relation of local earthquakes to instrusive magma. There are cold springs, warm springs, hot springs and boiling springs; active volcanoes, inactive volcanoes and ancient volcanoes, mountain folds, live faults, dykes and batholiths. There is much Tertiary and Recent mountain uplift. There is an axis of gradation of these things from Samoa to the South Island, from Hawaiian type volcanism to Norwegian type fjords.

No one knows what causes an earthquake. No one ever will know until local observers with local instruments and controlled experiments investigate local earthquakes in a strategic field. The doctrines of emergence angle, epicenters, distance, depth, nature of source, as nowadays applied to distant earthquakes, (and that means big earthquakes,) are not doing clinical work on local patients. The earthquake problem needs a Pasteur. Omori and the Italians were the pioneers.

T.A.J.

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No. 246 **RELEASED WITHOUT COPYRIGHT RESTRICTION** September 12, 1929

KILAUEA REPORT No. 920

WEEK ENDING SEPTEMBER 11, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

The week at Halemaumau lava pit has produced nothing new. Occasional dust is seen from small slides, but these are often caused by visitors rolling stones. Two notches up the wall north and northwest are deepening by avalanche erosion, and the buttress between them is likely to fall in the future.

Near the 1919 desert chasm, a quarter mile southwest of the Kilauea rim, there are patches one or two feet long of Pele's hair and pumice droplets scattered about in the holes of the sand. These have accumulated to leeward from the February and July lava fountains of Halemaumau.

Only four very feeble local earthquakes are registered for the week at Kilauea. The day records of September 5 and September 10 were omitted, owing to repairs. Microseismic motion increased slightly September 6 to Septem- 9. Apparent tilt, imperfectly recorded, was moderate NE.

ALEUTIAN NOTES

Alaskan Volcanoes 1929.

Mr. Austin E. Jones, seismologist for the Section of Volcanology, has spent the summer at Dutch Harbor and Kodiak establishing seismograph stations. He reports that a party landed on Bogoslof Volcano July 27, 1929, and found it very quiet. This is in line with its behavior in 1928, when the heap of steaming lava, in the midst of the circular lagoon, which had been so active in 1926-27, was much cooler and showed less steam than in the previous year.

Akutan Volcano had been reported in strong activity in 1928, and this year on June 18 the lower slopes were lightly covered with ash. It was reported fuming again during July, 1929.

Mount Cleveland and a volcano to the west of it, in the region of the Islands of the Four Mountains, were smoking heavily in July. A mountain west of Kanatak on the Peninsula was reported fuming in March. In the Katmai group Mount Martin and Mageik have been seen steaming throughout the year. Shishaldin, the great volcano on Unimak Island, was "flaming high" on May 28, 1929, and glowing matter was overwelling the edge of the crater and rolling down the slopes. On June 17 Shishaldin was quiet though steam was visible when the crater was inspected with field glasses. It was fiery again June 23 and appeared to have opened three new craters low on the north side. On August 4 the summit steam was barely visible to the naked eye. In 1928 Shishaldin was smoking heavily in August.

The above note on the fuming of Mount Cleveland recalls the heavy earthquake just south of those islands at the edge of the Aleutian deep reported in the Volcano Letter No. 220. This occurred March 6, 1929.

Aleutian Seismograph Stations.

Mr. Jones started work in the middle of June, 1929, at Dutch Harbor digging a cellar and building a hut over it to house the seismograph in the reservation of the U. S. Naval Radio Station at Dutch Harbor, Unalaska Bay, on Amaknak Island, a mile to the north of Unalaska village. The instrument was making a test run on July 16 and thereafter. It is a pair of Hawaiian type horizontal pendulum recording E-W and N-S components on smoked paper. The magnification is X135 and the damping by vanes immersed in oil. The time control is a Howard master clock, and an electric connection makes it possible for the operator from the radio station to impress directly on the seismogram the time signal received daily from Mare Island, California. The location of the hut is lat. 53° 53′ 08″ N. and long. 166° 32′ 07″ W. The distance is about 400 feet SSE. from the radio station on the line of the hand railway leading to the station jetty. The excavation was carried to a depth of five and a half feet where rock was reached. The hut is a 10 by 10 foot shed projecting one and one-half-feet above ground at the back, with double sheathing and a double window, roofed with tar paper, and banked up with earth and sod.

The instrument pier is Y-shape so that the stem holds the drum and the two arms carry uprights at their ends, all of concrete, which support the pendulums. The concrete is reinforced with steel.

The station is operated by Mrs. McDonald, wife of the Chief Radioman, using 120th meridian time (Pacific Coast). Microseisms were very faint in July, and the instruments registered two small local shocks and an earthquake indicating epicenter about 90 miles distant, not felt.

Work was started on reestablishment of the Kodiak seismograph station, by Mr. Jones, early in August. The 1927-28 station has been in the basement of the dwelling house of the Agricultural Experiment Station on the hill back of Kodiak, now turned over to the Bureau of Fisheries. On August 10 the concrete dairy house of the station was turned over to the Geological Survey for use as a seismograph laboratory. This is sturdily built of concrete with walls in places 30 inches thick. The Bureau of Fisheries occupies the establishment only during the summer season, but a local operator has been secured for year-around recording with the two-component Hawaiian seismograph, identical in model with those at Dutch Harbor, Lassen Volcano Observatory, Kealakekua, and Hilo.

Mr. Jones is to be congratulated on his successful season in constructing these stations, much of which he did with his own hands, and the Section of Volcanology is grateful for the cordial assistance given by the officers and men of the Bering Sea Patrol. U. S. Coast Guard, and the Naval Radio Service, and by the officers of the Bureau of Fisheries at Kodiak. T.A.J.

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No. 247 RELEASED WITHOUT COPYRIGHT RESTRICTION September 19, 1929

KILAUEA REPORT NO. 921

WEEK ENDING SEPTEMBER 18, 1929

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

The inner pit at Kilauea remains quiet. There is a little steam on the southern talus slopes. Dust from avalanches was seen at 3:10 p. m. September 11 and 2:55 p. m. and 3 p. m. September 12. The slides of September 12 made a dense gray dust cloud of moderate size which hung over the northeast rim for a few minutes, and after the second slide the air within the pit was full of dust for many minutes. At 9 a. m. September 14 there was fresh debris on the north talus; and September 16 there was no change.

The seismographs have registered one feeble earthquake at 7:31 p. m. September 16, indicating origin distance five miles from the Observatory, and eight other very feeble disturbances. A teleseism of moderate amplitude was registered for about 50 minutes beginning 9:04 a. m. September 17. The long waves developed soon after the start and no preliminary waves were detected. Microseismic motion was slight, and tilt was imperfectly recorded with moderate WSW. trend.

ROCK BENEATH THE DEEP SEA

What is called the deep ocean includes depths of two or more miles. Professor Twenhofel, a leader in sedimentation studies, has made an important contribution in answer to the question, "How thick are the deposits under the deep sea?" (Magnitude of the Sediments under the Deep Sea, by W. H. Twenhofel, Bull. Geol. Soc. Amer. Vol. XL, pp. 385-402, June 30, 1929.)

The text books have asserted that the deposits in the very deep oceans are trivial, and recent theories, such as that of July, would lead one to expect basalt only a short distance below the red clay at depths of 18,000 feet of water. "The rates of deposition in the deep sea are unknown, and no methods seem to have been devised by which they may be measured." Sediments from rivers have been thought to remain near the lands where they originate, and it was always believed impossible to transport considerable thicknesses of land sediments out to the deep oceans.

Twenhofel corrects all this, with evidence to indicate the deep sea sediments may even exceed those of the shallow water, that the quantity of lime in the earlier deep sea sediments was small in comparison with the lime in those of later geologic ages. On the basis of the deposition of 20 tons of mineral matter per annum over each square mile of an ocean basin averaging, since the beginning of Devonian time, an area of 115,000,000 square miles, and according to current estimates of geologic time, he finds there has been deposited in the deep sea approximately 80,000,000 cubic miles of inorganic sediments.

During the same time there was deposited an unknown volume of lime carbonate, silica, and other substances, the precipitating agencies being surface organisms which have increased in effectiveness in later geologic ages.

Underneath these deep sea sediments there is buried an unknown and possibly large volume of shallow water and continental slope sediments, the total thickness of which is dependent on what length of time in the pre-Paleozoic represented shallow water conditions, for the areas that subsided in the Devonian and later, on the basis of Walther's conclusions.

It is suggested that the deep sea sediments of the early ages contain more insoluble and undecomposed materials, in contrast to the ages since the late Mesozoic, during which the organisms of the surface waters have deposited much lime over the lesser depths, and this lime is permanently removed from the continental masses.

The major factors in the problem are the length of geologic time, the dimensions of the deep ocean basins, and the fact that few deep sea sediments have ever really been destroyed, whereas the shallow water sediments have been repeatedly uplifted and partially destroyed, and with each uplift have contributed their constituents to the deep abysses of the sea.

Calcareous organisms are deposited all over the sea bottom, but the shells pass into solution at depths beyond 16,000 feet. The siliceous shells go into solution around 18,000 feet. Over the entire area of the deep sea there is a shower of inorganic material such as clay, silica, iron oxide, small particles of resistant minerals, manganese oxides, phosphatic matter, minerals of igneous rocks whose direct origin is uncertain, matter which clearly is of volcanic origin, and rare particles believed to come from meteorites. There is also some lime of inorganic precipitation.

The atmosphere transports fine materials for long distances, as shown by the vast loess deposits of the continents. Europe has received 266 tons per square mile per annum during 3,000 years; 850,000,000 tons of dust are carried 1,440 miles in the air of the Mississippi Valley each year. This material falls over the sea as over the land.

Flocculated particles are carried by the currents of the sea, and the muds of the Amazon are visible 300 miles from its mouth. No one knows how much volcanic matter comes up through the sea bottom or falls from the air.

Sea water contains 1,500 tons of solid matter per cubic mile. This is precipitated more rapidly in warm tropical waters. As the waters of the deep sea cover 115,000,000 square miles with average depth of two miles, they contain 234,000,000,000 tons of sediment in suspension, or more than 21 times the amount carried to the sea by streams.

The length of geologic time since the beginning of the Paleozoic may be estimated to be at least 567,000,000 years, and since the beginning of large deep oceans 300,000,000 years. At the rate of only one foot of sediment in 87,100 years there would be deposited since the Devonian about 4,000 feet, or 0.7 mile, of mineral matter from all sources over the present deep sea bottom.

Twenhofel concludes that the sediments on the continent above sea level are little more than half the calculated volume of the inorganic sediments in the deep sea deposits, and only about 28 per cent of the total volume of all deep sea sediments including limestones. These astonishing conclusions add new zest to the project of boring beneath the mud of the deep sea bottom, the last stronghold of nature unexplored by man, and constituting more than 70 per cent of the earth's surface.—T.A.J.

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No. 248 RELEASED WITHOUT COPYRIGHT RESTRICTION September 26, 1929

KILAUEA REPORT No. 922

WEEK ENDING SEPTEMBER 25, 1929
Section of Volcanology, U. S. Geological Survey
T. A. Jaggar, Volcanologist in Charge

The week at Kilauea has been entirely lacking in visible volcanic activity. The lava pit Halemaumau has been quiet, and no changes have been noted. From time to time dust from avalanches has been observed, sometimes caused by earthquakes originating at distant points.

On September 19 at 11:50 a. m. a small cloud of dust rose NE. On September 21 at 2:30 p. m. a few stones were heard falling NE., and very slight smoke was noted at the north July grotto at intervals. On September 22 a new line of sulphur at the floor edge north of the grottoes was observed. Steam was slight on the west talus and normal on the south talus. At 6 p. m. dust from a slide was seen from the Volcano House.

On September 24 at 9 a. m. there was no change. New debris lay on the north talus. At 3 p. m. an avalanche occurred, sending up dust. At 4:15 p. m. and thereabouts there were other clouds from larger slides, the buff-colored dust probably originating on the red north wall of the pit. Today two new bright scars can be seen on the south wall from the Observatory.

An extraordinarily large number of seismic disturbances have occurred during the week, the total count being 221. This is an especially surprising number when contrasted with the total of nine shocks for the week preceding. The earthquakes appear to originate in North Kona District, on the west side of the island of Hawaii, but are felt all over the island, intensity decreasing with distance. Due to crowded and overlapping lines on the seismograms some shocks could not be counted.

The earthquakes appear to portend lava activity, but at the present time nothing has been observed to indicate flow. It may be significant that the shocks fall on the equinoxial period. Many of them are of the very feeble, or imperceptible, class; others are classed as feeble, slight, and moderate, and can usually be felt. Moderate shocks are generally strong enough to dismantle the seismograph pens.

The earthquake distances vary from 14 to 37 miles from the Observatory. Plotting these distances on a map of the island, in conjunction with distances shown by records of two other seismograph stations at Hilo and Kealakekua, the epicenters of the shocks appear to fall on points along lines extending both northwest and northeast of the summit of Mauna Loa. The apparent locations of a large number of the shocks are in the region lying between Mokuaweoweo and Hualalai.

Some of the shocks showed distances in miles as follows: 2, 14; 3, 17; 5, 18; 2, 20; 7, 23; 4, 25; 1, 26; 1, 28; 1, 30; 1, 32; 2, 37.

Frequently the distance phase of earthquakes is obliterated by long tremors obscuring the preliminary wave of the shocks. In such cases it is impossible to compute distance.

A few of the earthquakes of this series are tremors varying from two to 17 minutes in length, which occasionally wax in aplitude sufficient to become perceptible. Tilt for the week accumulated slight NNE.

SEISMIC CRISIS ON HAWAII

Numerous tremors beginning soon after noon September, 19, 1929, at Puu Waawaa Ranch, seven miles north of the summit of Hualalai Volcano, a mountain 8,269 feet high on the west side of the island of Hawaii, inaugurated a seismic crisis. This has gone on increasing to September 25, and implies new movement of the Hawaiian Lava column.

At Puu Waawaa there were more tremors September 20, becoming shock groups in continuing series on September 21. The spasms were at first separated by several hours, later they were lenghtened so that the intervals of quiet were only for an hour or two. Also the motion spread to the entire Kona District and perceptible earthquakes became numerous at equal distances from Hualalai to the north and northeast. The belt shaken most is about 35 miles from Hualalai as a center, and the region of the Kau, Puna and South Hilo districts has received the least shaking. The seismograps at Kilauea Volcano have shown increased disturbance both in intensity and frequency.

At Puu Waawaa on September 21 there were 13 shocks in 10 hours, on September 22 there were 79 seismic spells in 22 hours, and on September 23-24 there were 86 spells in 26 hours. This makes the number of disturbances per hour 1.3 for September 21, 3.6 for September 22, and 3.3 for September 23-24.

Huehue Ranch, eight miles northwest of the Hualalai summit, recorded 73 felt shocks in 34 hours, averaging 2.2 per hour. At the F. R. Greenwell residence, Honokahau, six miles WSW. from Hualalai summit, 444 shocks were felt in 73.5 hours, averaging 6.0 shocks per hour. Slight rumble through the ground seeming to come from the mountain was observed with some of the quakes at Huehue and and Honokahau. This was not heard at Puu Waawaa.

For intensity Honokahau registered 71 that were sharp, and Puu Waawaa about the same number, the intensity increasing between September 19 and September 25. As the number of sharp shocks increased, the perception of them over the island at great distances also increased. For frequency the Kealakekua seismograph gave a consistent record for five days beginning September 19-20 of 13, 21, 60, 92, and 280 disturbances per day. For distance of origin from the three seismograph stations Kilauea, Hilo, and Kealakekua, the records suggest the saddle between Hualalai and Mauna Loa volcanoes as an important epicenter, and other seismographs imply motion both northwest and northeast from the central crater of Mauna Loa. The local felt earthquakes all indicate motion on the northwest flank of Hualalai.

The writer examined the summit region of Hualalai September 22, found no fresh cracks, no signs of heat, and felt no earthquakes. The Hualalai and Mauna Loa profiles have been clear, and as yet have shown no fume.

Summarizing, the situation shows increasing tremor earthquakes of volcanic quality centering about the northwest region of Hualalai, accompanied by deeper earthquakes centering about the northern slopes of Mauna Loa and extending their perceptibility to the whole north half of Hawaii Island. Everything suggests that the Mauna Loa lava column, which has sent out its flows from the southwest rift of that mountain during the last 25 years, is now transferring its upward wedging in the direction of Hualalai. This is just what happened in 1801, ten years after the explosive eruption of Kilauea. The present time is five and a third years after the explosive eruption of 1924.

T.A.J.

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No. 249 RELEASED WITHOUT COPYRIGHT RESTRICTION October 3, 1929

KILAUEA REPORT No. 938

WEEK ENDING OCTOBER 2, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Halemaumau continues to be very quiet and without lava activity. Numerous earthquakes during the week have probably been the cause of several slides.

A total of 244 shocks were counted on the seismograms. In addition to these were several spells of spasmodic tremor. Some of the tremor occasionally waxes into wide amplitude and earthquakes. Earthquakes registered were as folows by days: September 25, 63; 26, 61; 27, 27; 28, 27; 29, 29; 30, 15; October 1, 19, October 2, 3. September 25 and October 2 are incomplete days coming at the beginning and at the end of the period covered by this report. It should be stated that many more shocks are felt in West Hawaii, the apparent center of the present seismic disturbance, than are recorded at Kilauea.

Thirteen shocks give distance 23 miles, 10 distance 28 miles, 6 distance 30 miles, 7 distance 32 miles; others distances varying from 14 to 46 miles from the Observatory.

Microseismic motion was slight throughout the week. Tilt was strong ENE.

CONTINUED HAWAIIAN SEISMIC CRISIS

The development of swarms of earthquakes, as reported last week, on the west side of the island of Hawaii, has continued throughout a second week without the appearance of lava activity to date (noon October 1). The concentration of local shaking in frequency and intensity has remained about Hualalai volcano. In general until September 26 the frequency mounted to a maximum, and thereafter it systematically declined. The intensity of individual shocks has occasionally been extremely strong between September 25 and September 30, but no shock has exceeded grade IX R. F.

The strongest shock of the series to date appears to have been at 6:20 p. m. September 25, felt generally throughout the inhabited Hawaiian Islands. This inaugurated groups of heavy shocks which have occurred in west Hawaii 6:20 to 11:00 p. m. September 25, 10:00 to 12:00 p. m. September 27, 3:18 to 5:18 September 28, 5:00 to 6:00 a. m. and 10:00 to 11:00 p. m. September 29. Extremely severe shocks have occurred (other than 6:20 p. m. September 25) at 10:50 a. m. September 27, 7:08 a. m. and 3:18 p. m. September 28, and 11:55 a. m. September 30. All of these have added greatly to damage of tanks, masonry, stone fences, chimneys, roadways and weak buildings on slopes. There have been numerous other wrenching shocks in the North Kona district which would rank as very strong.

The Count of Earthquakes

As before, the two places which have received larger numbers of groups of felt shocks were Honokahau and Puuwaawaa. Thus for the twenty-four hours midnight to midnight September 24, Puuwaawaa counted 144 earthquakes, Kealakekua only 40. For September 25 Puuwaawaa 171, Kealakekua 30. Kealakekua is twenty miles south of Puuwaawaa. These were felt spasms or groups of shocks. For a twenty four hour period, September 24-25, about 210 shocks were registered at Kealakekua by an 80-times magnifying seismograph.

A shock recorder of magnifying power 25 was set up on a verandah at Puuwaawaa Ranch and for each twenty-four period beginning midnight September 26 registered individual quakes, small and great, in the following numbers:

September	26	599 shocks	
"	27	541 "	
"	28	400 "	(about)
"	29	334 "	
"	30	221 "	

The Kealakekua seismograph was injured by the earthquake of 6:20 p. m. September 25, but thanks to the prompt action of Captain R. V. Woods, was re established September 26. It showed some decline in frequency and amplitude of earthqaukes September 25 to 27, the decline in frequency becoming pronounced on September 27, but with it there came seven shocks of much larger amplitude September 27 to 28. The seimogram of September 30 to October 1 shows an increase of frequency to about 100 shocks.

Comparison With 1868 Crisis

The summary of the situation on October 1. 1929, is that a period of tremor began at Hualalai volcano in west Hawaii at noon September 19, produced a damaging shock of grade IX, six and one half days later, then produced decline in frequency and some increase in intensity of shock groups for five days more. The populace nearest to the mountain is sleeping in the open air, stone walls have been thrown down with notable fracturing away from the mountain, and the stronger shocks have been of the quality to displace furniture, throw down and overturn loose objects, move buildings, crack masonry and produce slides on steep slopes.

In the quality of growing gradually to a maximum from tremor to bumping shocks, and from bumping shocks to oscillations of longer period, this seismic crisis in Hawaii is quite unlike such earthquakes as those of San Francisco and Tokyo. These latter are called tectonic, and begin with a terrific earthquake, thereafter declining with aftershocks. Therefore it seems probable that the present Hawaiian series is volcanic, and marks the shift of magma underground from the Mauna Loa center toward the Hualalai center. We have a close parallel to this in the shift of magma from the northeast rift of Mauna Loa, to a new series of eruptions in the southwest rift, in the year 1868. There were no southwestern Mauna Loa eruptions recorded prior to 1868. In that year on March 9 came a hard earthquake in Kona, on March 27 the beginning of continuous quaking at the south end of Hawaii, on March 28 a very severe damaging shock of the same quality as the one of September 25, 1929, and thereafter an increase of very hard shocks along with many small ones, so that just as in the present year the earthquakes were felt farther and father away. On April 2 came a terrific shock of grade X producing a landslide near Pahala, destroying wooden houses as well as masonry ones, and leading four days later to a rapid outflow of lava, from the south end of Mauna Loa, that endured less than a week. Earthquakes gradually ceased, though there were still two or three a day, five months later.

In 1868 the shift of lava was from northeast to southwest. Now apparently the shift of lava is from southwest to northwest, if rising lava is making the earthquakes. That it should do so a few years after the explosive eruption of Kilauea of 1924, agrees perfectly with 1801, when Hualalai erupted after the 1790 explosions of Kilauea.

T.A.J.

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No. 250 RELEASED WITHOUT COPYRIGHT RESTRICTION October 10, 1929

KILAUEA REPORT No. 924

WEEK ENDING OCTOBER 9, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

No lava has appeared on the island of Hawaii. Halemaumau showed thin dust clouds from slides the forenoons of October 3 and October 5, and there were big slides in the pit and from the walls of Kilauea Crater at the time of the strong earthquake 9:22 p. m. October 5. There were more slides at the pit the forenoon of October 6 and examination of Halemaumau October 7 and 8 showed that falls from the rim had left streaks, the new lava floor is staned with dust from a big slide at the northwest, and a long strip of rim has fallen at the southeast. At that rim also cracks had widened. Small new talus cones were piled at the base of the western wall.

The Observatory seismographs registered 129 earthquakes for the week, and in addition there were spells of spasmodic tremor October 2, 4, 5, 8, and 9. The numbers of earthquakes for complete days midnight to midnight beginning October 3 and ending October 8 were 15, 18, 30, 19, 10, and 16. This shows a distinct frequency maximum on October 5, the day of the very strong earthquake, and does not support the notion that a decrease of frequency precedes violent shocks. This big earthquake began at 9:22 p. m. October 5. No preliminary waves were present to indicate distance of origin. The long slow waves moved the pendulums for an hour.

Seismometric evidence of distance of origin indicated two principal groups of centers, one from 24 to 28 miles from the Observatory, the other from 34 to 37 miles away. There were eight shocks for the shorter distance and seven for the longer. Other shocks indicated distances varying from 18 to 40 miles.

Microseismic motion was slight and tilt for the week was strong WNW. It is of interest to note that for the three weeks of the seismic crisis the tilts at the Observatory have all been northerly with increase of strength first easterly and now westerly. This suggests a swelling pressure under Kilauea.

THREE WEEKS OF HAWAIIAN EARTHQUAKES

The earthquakes that began in West Hawaii September 19 reached maximum of frequency the last week of September and have declined irregularly since that time both in frequency and in intensity.

The outstanding event of the first week of October was a very strong earthquake at 9:22 p. m. October 5, 1929, which was more disastrous than the one of September 25. There is good reason for believing also that it was more intense, as its effects in cracking roadfills and overthrowing embankments at the road spurs in North Kona introduced new phenomena. For the rest, the effects on buildings extended the damage for masonry and water tanks to Waiki and Waimea, while in Kona the long siege of shaking had weakened foundation posts, walls, and tanks with some 200 shocks recorded as sharp prior to October 5. Many of these had been very hard jolts, usually with maximum fling down the mountain slopes as shown by the collapse of hundreds of stone walls in a seaward direction.

Thanks to the Naval Air Service the writer inspected the districts of South Hilo; Puna, Kau, Kona, and South Kohala from an airplane at elevation 10,000 to 12,000 feet in the early morning hours of October 3, traveling approximately 160 miles from Hilo over Kilauea, across the south flank of Mauna Loa, and across the divide between Mauna Loa and Hualalai. The visibility was good, and all the upland of the three active volcanoes was revealed as showing not a trace of new outbreak. Other flights have since been made by the airmen, and the mountains have been clearly seen repeatedly including this date, October 9. Moreover the seismographs show no trace of continuous harmonic tremor, which is characteristic of fountaining lava.

The big shock of October 5 was reported by an observer in Hilo as no more severe than one of an earlier date. It seemed to last fully a minute, nothing in that house was overturned, no water was spilled from a glass three-quarters filled, and the cement basement was not cracked. Cement is reported cracked in the Federal Building.

In the concrete basement of the Observatory the writer perceived a long, gentle, swaying motion which dismantled the seismographs and subjected them to much strain: there was no jerking. Rocks were heard falling from the Kilauea cliffs and several fresh scars were seen on the high northwestern walls and elsewhere. One or two small cracks in the soil were reported.

In Kealakekua the motion was a heavy jerk, somewhat prolonged, and applied very suddenly. Vertical retaining walls broke on the downhill side of roads and of filled land, stone houses were cracked, tanks burst or were thrown off their foundations, and some weak structures collapsed. Furniture was moved and loose objects were thrown about.

Puuwaawaa Ranch received the brunt of the disturbance as usual, unbraced foundation posts went over, the masonry of the basement of the main house was partly thrown down, new avalanches fell in the gulches of Puuwaawaa Hill, bowlder fences were generally prostrated, and a chimney stump was broken for the second time. The effects suggest Grade IX Rossi-Forel for a radius of nine miles around Puuwaawaa Hill, and Grade VIII for a radius of 20 miles around a point northeast of that hill. Grade VII appears to include the Kohala sugar district and the region of Kealakekua Bay.

The count of felt earthquakes from October 1 to October 6 was 5 to 14 shocks per day at Kealakekua, 17 to 83 shocks per day at Holualoa, and 89 to 241 shocks per day as registered on the shock-recorder at Puuwaawaa. In each case there was decline in numbers during the week, with some revival for the day of the big shock October 5. Prior to the big shock there was a marked lull in frequency during the daylight hours. The seismographic registration gives the following numbers of shocks October 1 to 4 for different places: Hilo 38, 26, 13, 74; Kealakekua 155, 110, 96, 138; Puuwaawaa 241, 117, 97, 114. Each of these thus shows a revival before the big shock of October 5. The intensity relations, obtained by counting the numbers of strongish shocks, indicate a general correspondence between the curve of intensity and the curve of frequency; that is, there were maxima in numbers of strong shocks about September 24-25 and about October 5.

T.A.J.

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No. 251 RELEASED WITHOUT COPYRIGHT RESTRICTION October 17, 1929

KILAUEA REPORT NO. 925

WEEK ENDING OCTOBER 16, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in charge

Halemaumau the inner pit of Kilauea remains quiet and as yet no lava activity has appeared elsewhere, although the felt earthquakes in West Hawaii continue. October 9 the four jets of steam on the northeast rift of Mauna Loa at about 12,000 feet elevation were conspicuous owing to still air, but they have been there for many years without change.

Halemaumau has developed nothing new. The morning of October 10 there were many vapor jets owing to a night of rain. An avalanche fell at the north wall 1.23 p. m. October 11. This left a fresh scar above the northwest talus.

In general Halemaumau shows wet patches on the west talus and the three lava niches of the July fountains at the edge of the black lava floor at the foot of this talus. The south talus has a line of wet fissures with steam up and down its upper portion. The floor extends over the whole bottom area with only a few stones from slides overlapping it. It has a large area of white and yellow stain at its south edge and many cracks. The recent dust stain over the northwest side of the floor has been washed away.

The seismographs at Kilauea registered 97 shocks and tremor spasms, a decrease of 32 from the previous week. The average indicated distance of 39 shocks by Omori's formula is 44.3 miles. This is exactly the distance from the Observatory to Hualalai summit. The number per day October 9-15 was 15, 14, 10, 9, 9, 14, 23, thus showing marked revival October 15.

Microseismic motion for the week was strong. Tilt was slight NNW. The intensity of the earthquakes increased October 14-15 as well as the frequency.

THE EARTHQUAKE CRISIS

Hawaii has now had four weeks of unusual earthquakes centering about Hualalai volcano. There is no question about this epicenter. The local damage shows it, the perceptibility records show it, the instrumental frequency registration shows it, and the instrumental measures of distance show it at three stations Hilo, Kilauea and Kealakekua.

The seismograms of 39 local earthquakes during the past week at Kilauea Observatory, critically measured, indicated 20-30 miles for three shocks, 30-40 miles for 11 shocks, 40-50 miles for 13 shocks, and 50-60 miles for 13 others. The average distance measured is 44.3 miles, exactly the distance of the center of Hualalai mountain. The shocks fall into three principal groups, of distances 34-37 miles, 42-46 miles, and 51-60 miles respectively. These distances correspond to the east, middle and west parts of Hualalai ridge.

The history of the week ending midnight October 15 reports earthquakes in the Kona district diminishing in frequency and strength from October 9 to October 13, and increasing strongly October 14-15. There was a strong shock in Kona 11:35 p. m. October 14, and four strongish ones occurred on October 15 at 9:59 a. m., 1:04 p. m., 5:41 p. m., and 10:05 p. m. At the same time small shakings increased greatly.

At Kilauea the strong shock of 11:35 p. m. was registered as moderate and barely felt, dismantling one seismograph pen. The others registered with 3 to 4 centimeters of amplitude on the seismograms of about 120 times magnification. They would rank as slight earthquakes.

Hilo reported two shocks felt October 8 and 9 each, one each day October 10 and 11, and none October 12 to 14. The Kealakekua observer in Kona reported five October 7, three October 8, two October 9, eight October 10, six October 11, three October 12, and two October 13.

The Kealakekua seismograph showed

59	shocks and tremors	October	7-8
94	" " "	"	8-9
61	" " "	"	9-10
42	" " "	"	10-11
41	" " "	"	11-12
43	weaker ones	"	12-13
25	very weak	"	13-14

It is of interest to review the whole crisis from September 19 to the present time. The Kilauea Observatory seismographs jumped in their registration from only 9 shocks the week ending September 18, to 221, 244, 129, and 97 the four following weeks. The climax in frequency of local earthquakes was thus the week ending October 2, and the strongest shock of the series came at 9:22 p. m. October 5.

The number of shocks registered at Kilauea, and those of intensity corresponding to Kona earthquakes moderate, strong and very strong, were for the week ending

Sept.	18	Total	9	All Small					
"	25	"	221	12	Moderate	2	Strong		
Oct.	2	"	244	18	"	12	"	1	Very Strong
"	9	"	129	9	"	3	"	1	" "
"	16	"	97	6	"	1	"		

The agreement between frequency and intensity of shakings is good, and the decline in both frequency and intensity during the last fortnight is so pronounced as shown by these figures, that the prospect is reassuring. However there is always a possibility of a very big earthquake when the lava breaks forth in a new place.

The concentration of seismicity at the north side of Hualalai volcano; the waxing of earthquakes in both size and number to a maximum about October fifth; and the persitency of seismic action still, although it seems to be lessening, all imply preparation for a volcanic outbreak as result of the intrusion of basaltic magma underground near the surface. The splitting jerks are now less, perhaps because the mountain fissures are more open, and the earth crust is in tension. Lava outbreak is expectable.

—T.A.J.

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No. 252 RELEASED WITHOUT COPYRIGHT RESTRICTION October 24, 1929

KILAUEA REPORT NO. 926

WEEK ENDING OCTOBER 23, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in charge

There has been no lava activity on Hawaii. Halemaumau pit remains quiet. Wet streaks have been noticed on the wall above the south talus, and higher there is steam at ancient cracks. Small avalanches tumble occasionally.

The seismographs at Kilauea registered 3 feeble earthquakes of the faintly perceptible class, 9 very feeble ones, and 41 prolonged tremors, very feeble, which were small earthquakes at their origin in Kona; total number 53 seismic disturbances as compared with 97 for the previous week. Microseisms were strong and tilt was very slight WNW.

The average distance of nine shocks computed seismometrically was 41 miles, corresponding to Hualalai. An earthquake was strongly felt in Kona about noon October 21. The observer there October 16-19 counted small shakes per day three, four, four, one, as felt. The Hualalai seismic crisis has declined.

VOLCANIC TUFF AND SUGAR CANE ON HAWAII

Studies of volcanic ash and tuff on the Island of Hawaii during the past summer show that the sugar industry is dependent partly on products of explosive vulcanism for its annual $1,250,000 crop. These materials, together with the slightly coarser agglomerate, either aa lava or of explosive origin, form the surface mantle where sugar is grown, and their weathering has apparently been essential to the production of a sufficiently deep and fertile soil on this Island.

On other islands of the Hawaiian group sugar cane grows on soils derived by the weathering of lava rocks, old enough so that a deep soil cover has been developed in those areas which have a moderate to heavy rainfall. The island of Hawaii, is mostly of such recent origin that in few of the areas where aa or pahoehoe lava forms the surface has a soil cover of value for sugar cane culture been produced. In the Kohala district, the sugar growing areas are underlain by agglomerate, made up of small fragments, and much more readily weathered than pahoehoe flow lava. Here the presence of detrital volcanic materials produced by explosive eruptions may be partly responsible for the soil in which cane is grown.

Very little is known as to the actual rates at which either lava or ash might weather under the varied conditions found in Hawaii. The rate of decay on the moist windward slopes, possibly may be ten or twenty times that on drier, leeward slopes. A considerable growth of trees and ferns may develop on lava flows in so short a time as 20 or 30 years under favorable moisture conditions. But the soil condition which will support such vegetation is still far short of that required for the growth and especially for the proper tillage of sugar cane. It may be doubted whether a soil sufficiently deep for commercial sugar production would develop from lava in a period shorter than a thousand years under the most favorable conditions found anywhere in the group.

On the other hand, the fine grained, powdery ash which has been produced at many different times by explosive eruptions on Hawaii, Oahu and other islands of the group has formed a mantle several feet thick over large areas in which weathering must have proceeded much more rapidly. Such material has from the beginning a constitution permitting plowing and cultivating and it seems likely that the finer grained phases of it may become sufficiently leached and modified to permit the growth of sugar cane in a few decades.

The soils of the Hamakua coast and Hilo districts as well as those of the Pahala district have been developed in this way, and the sharp southward limit to sugar growth which follows closely the course of the Wailuku River is the line along which the comparatively young Mauna Loa flows have covered the older ash from the Mauna Kea summit cones. The soils of the Olaa district are mainly derived from agglomerate, partly decomposed aa lava, similar to that of the Kohala region.

It thus appears that if a volcano must erupt and by spreading its product over the land, temporarily interrupt the growth of crops and other human activities, an explosive eruption is much to be preferred to lava. This is apparent if we attempt to compare the value of an acre of land freshly ash-covered with the value of an acre freshly lava-covered. If we take $200 as an average value for good sugar land and from the discussion above assume that perhaps 100 years may elapse before ash-covered land can attain this value through weathering we can easily compute the initial value of the ash-covered land. If the rate of appreciation is fixed at 6% per annum the initial value at the beginning of the hundred year holding would be $0.632 per acre.

Similarly if we assume that lava under favorable rainfall might attain an equally fertile and arable soil in 1000 years its initial value would be a very small fraction of one cent, and even at the end of the first 500 years an area of the size of the state of Texas would be worth only a cent from the sugar viewpoint.

All this is equivalent to saying that, whereas a fresh lava flow is about as worthless agriculturally as any terrane could be, a fresh ash-fall, even of great thickness, has a moderate but tangible worth. The good fortune of the Island of Hawaii is that its legacy was left largely in the form of volcanic tuff which in the twentieth century has attained its financial maturity in a crop worth a million and a quarter dollars. —C. K. Wentworth.

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NO. 253 RELEASED WITHOUT COPYRIGHT RESTRICTION October 31, 1929

KILAUEA REPORT NO. 927

WEEK ENDING OCTOBER 30, 1929

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

The week has produced no lava activity and the Kona earthquake crisis has continued. Halemaumau pit at Kilauea showed a few new slide rocks on the crater floor west the morning of October 26, but there has been no evident motion there except what the usual small earthquakes will account for.

Seismographs at Kilauea have registered 86 local disturbances divided among 56 tremors, 39 very feeble quakes, and one feeble earthquake at 4:04 p. m., October 29. The average distance for thirteen of the shocks measures 51 miles from the observatory seismometrically, corresponding to the west end of Hualalai volcano. The frequency is higher than the previous week.

Holualoa in North Kona reports numbers of felt shocks for the days beginning October 20 as follows: 6, 69, 5, 2, 8, 2, 1. The seismograph at Kealakekua gave a similar record with about 30 per cent more shocks shown instrumentally. Evidently the volcanic agency that started this seismic crisis is still at work, with marked revivals on such days as October 21 and 23. On these two days there were 41 and 31 disturbances respectively at the Kilauea instruments.

Microseismic motion at Kilauea declined during the week to normal, and tilt was slight NNE. Hilo reports two tremors felt October 18 and three October 21.

VOLCANIC MUD-FLOW IN JAVA

Professor B. G. Escher (L'Eboulement Préhistorique de Tasikmalaja et le Volcan Galounggoung, Leidsche Geologische Mededeelingen, Deel I, Aflevering 1, XI 1925, Blz. 8—21) reports on a quantitative study of the missing sector of the cone of Galounggoung volcano in Java, and its relation to the "Ten Thousand Hills of Tasikmalaja" nearby. There have been mapped a total of 3,648 of these hills or hillocks. Escher groups these into categories according to heights (0 to 10, 10 to 20, 20 to 30, 30 to 40, 40 to 50, 50 to 60, and 60 to 70 meters) and computes their total aggregate volume as 142,000,000 cubic meters.

The hillocks are composed of very fine material enclosing large blocks. Various exposures were studied where recent cuts had been made to get out the andesitic blocks for road materials.

The cone of Galounggoung is young and still smooth and nearly perfect except for a wedge-shaped valley sector on the southeast slope. A first glance at the topographic map suggests that this trench is a radial down-sunken block, narrow above and widening down the slope. Escher restored the original contours across the trench and by comparison with the actual contours prepared a map which shows by 100 meter layers the thickness which has been removed. Multiplying by the areas, he gets the total volume of the missing part of the cone as about 2,866,000,000 cubic meters, or about 20 times the 140,000,000 cubic meters of the hillocks.

The aggregate volume of hillocks is far too small to correspond directly to the missing part of the cone. One agency, though a minor one, is erosion that has carried part of the hillocks into the ocean.

A second probability is that the hillocks are only projections from a broad layer of similar rock and mud material. The underlying mixture forms a layer which is at least 20 meters thick at the center though it thins toward the margins of the area it covers. Escher holds that the underlying material and that of the hillocks are due to a single tremendous landslide or mud flow. Where the hillocks are highest is where the moving mass had its greatest energy. Within historic times mudflows caused by rains have produced similar deposits at the other volcanoes in Java. The thickness is difficult to compute. It could only be done where a capping of lava had protected and preserved the whole thickness, and such a capping is unfortunately lacking. It is clear that the volume of the hillocks is not the total volume of the landslide material for the underlying part must be added.

A third point to be considered in connection with the origin of the debris is the nature of the fluid which on its release caused the landslide. The two hypotheses which suggest themselves are that the liquid was lava and that it was water. Escher excludes lava for no lava is found in any of the cuts. It must have been water, which implies that the crater must have had an impervious lining capable of making a crater lake. The barrier must have consisted of alternating beds of lava and explosion material which were held in place by their great weight. Some very unusual condition must have arisen to allow it to be broken. Taverne has shown that the first eruptions of Galounggoung were from a central crater, and that later a new vent opened a little to the southeast which gnawed into the southeast wall of the first crater. A third vent was a little farther southeast and gnawed still more into the southeast wall of the original crater and finally thinned it to the breaking point.

When the crater wall had thinned sufficiently the crater lake broke through and caused an extremely violent and watery landslide. The hillocks represent the fixation of the last materials of the slide, clots that remained standing higher, the principal mass having slowed down because of increasing bottom friction as it spread out fanwise and lowered, and as it lost part of its water. The surficial parts continued their movement for the friction against the air was small.

The air pressure of the resulting landslide wind must have been tremendous and would undoubtedly have annihilated such a town as Tasikmalaja had there been one there at the time. Therefore one can confidently speak of the landslide as prehistoric for such an event would surely have been recorded had there been any written records.

It is not specifically so stated by the author, but the reviewer concludes that the volume of the hillocks plus the volume of the underlying layer of similar material may well be equal to the volume of the missing sector of the cone.

HAROLD S. PALMER

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No. 254 | RELEASED WITHOUT COPYRIGHT RESTRICTION | November 7, 1929

KILAUEA REPORT NO. 928

WEEK ENDING NOVEMBER 6, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

All has remained quiet in the volcanic districts of Hawaii during the past week. Small earthquakes have continued in the North Kona District with some slight revival about November 4, the shocks as usual being feebly felt in Hilo.

On Thursday, October 31, about 1:30 p. m., a considerable avalanche fell from above the northeast talus in Halemaumau crater. The wall continued to work during the afternoon and two more slides were reported about 3 p. m. These breaks in the wall left a scar noticed on November 2, and there was new dust on the northeast edge of the July lava floor. This was whitish pink and similar fresh material was seen on the east talus slope. A lump had been left in relief protruding from the red boss in the middle of the eastern wall.

On the morning of November 4, at 9:30 a. m., there had been more than two inches of rain and all walls of the pit were dark red with moisture while many small steam jets arose from cracks of the crater floor. The steam was specially conspicuous at the several sulphurous spots of the floor. A few rocks were heard falling on the north talus. At 10:15 a. m., November 6, dust rose from a slight slide at the north side of the pit.

The seismographs at Kilauea registered 57 local disturbances, of which 35 were tremors and 21 very feeble earthquakes. One earthquake slightly more intense ranked as feeble at 3:03 a. m. November 5. This and a preceding shock 12 minutes earlier indicated distances from Kilauea seismometrically of only 18 and 12 miles. They were felt in Hilo, and suggest jarrings local to the east side of the island. The distances for nine other shocks registered indicate origins 50 to 60 miles away, corresponding as heretofore in the recent seismic crisis, with the western or northern parts of Hualalai. Microseismic motion was slight, and tilt was slight to the south.

The Kealakekua observer reports many slight tremors and only three earthquakes in the preceptible class. Hilo reports four felt shocks for the week.

LASSEN REPORT NO. 21

TEST FOR ARSENIC AT MORGAN SPRINGS

There are rather persistent rumors that one or more of the individual vents at Morgan Hot Springs, about six miles south of Lassen Peak, are poisonous, because of the fact that cattle have died in this vicinity. The deposits at Morgan Springs contain silica and various sulphates as well as common salt. Because of the latter, they are commonly frequented by live stock. To keep stock away from the heavier deposits of salts, most of the larger springs have been fenced in.

During the latter part of the summer of 1929, the flow from many of the smaller springs was very low and some had ceased entirely. The quantity and temperature of the discharge from the larger springs were about normal. The incrustation of common salt, alum, and other material around the springs was heavier than usual, as might be expected during an unusually dry season.

The presence of arsenic in the springs has been offered as a possible explanation of the death of cattle in this vicinity. The Marsh test for arsenic of a number of samples of suspiciously colored water and incrustations from the springs failed to show any trace of arsenic.

Near the springs there is at least one poisonous plant which might account for the known death of cattle. An overdose of alum, epsom salts, and other material mixed with the deposits of common salt might result in the death of stock that used the springs for their source of salt.

CHAS. A. HUFF.

VOLCANOES OF FLORES

An admirable monograph on this subject has been published by Kemmerling accompanied by excellent photographs and maps (Vulk. en Seismol. Meded. No. 10, Vulkanen von Flores, by G. L. L. Kemmerling, Bandoeng, 1929, pp. 138, photos 54, plates 10). There are from 100 to 200 eruption points on the island, the young volcanic mountains making about one half its surface. The cones are arranged in rows either parallel or at right angles to the fold structure of the Tertiary rocks. Volcanism is older at the west. In the east, lines of young volcanic cones trend either E-W or N-S.

There are 14 active volcanoes, the records are scanty, and it appears that lava effusion is still important in the Indian Archipelago. Lava streams and lava plugs are common. Table mountains of loose ejecta have sometimes funnel-shaped explosion craters, which change to kettles with wide bottoms ascribed to a hardening of the central region, and cylindrical pits are rare. Lava slag heaps are very rare.

The volcano regions are comparatively uninhabited. There is indirect danger, however, of collapse near the sea causing huge tidal waves. The lavas are basaltic andesites with feldspars high in anorthite. The recent ejecta are basaltic and underlying gabbro or granodiorite is indicated by fragments.

T. A. G.

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No. 255 RELEASED WITHOUT COPYRIGHT RESTRICTION November 14, 1929

KILAUEA REPORT No. 929

WEEK ENDING NOVEMBER 13, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Volcanic quiet continues in Hawaii. Seismic activity, however, is still going on in the region of Hualalai Volcano. The frequency of local earthquakes there has averaged about the same as the previous week.

At 9:15 a. m. November 9 a few new rocks lay on the northwest edge of the floor of Halemaumau, and a pink streak up the wall above, as well as fresh purple dust below, indicated a recent slide. The dust on the northeast floor had washed away. A circuit of the pit November 10 at 3:30 p. m. showed that much steam rises from the middle and the top of the large west talus cone as well as up the middle of the south talus. This last line of steam jets curves eastward into the wall above. About 4 p. m. there were two small falls of rock at the west and northwest walls.

The seismographs at Kilauea registered 62 local disturbances for the week. Of these 32 were tremors, 28 were very feeble earthquakes, and there were two feeble shocks.

These last were felt generally in Hawaii; one was at 8:19 p. m. November 10, indicating a distance of 34 miles, the other at 8:17 p. m. November 11, distance 30 miles from the Observatory. Fourteen records gave an average distance of 44 miles from the Observatory as measured seismometrically, and this corresponds with the location of Haulalai summit.

Tilt for the week was moderate NNE., and microseismic motion was slight.

A VERTICAL MOTION SEISMOGRAPH

For some weeks we have been experimenting in the shop of the Volcano Observatory on a companion instrument for the horizontal pendulums, to register vertical motion of local earthquakes. For seventeen years, with the aid of two Japanese instruments, and with experimental machines optical and mechanical, this problem of measuring vertical motion has been studied here, but without any success in solving it. It is a very old problem in seismology. The vertical motion of an earthquake is smaller than the horizontal motion. To measure it we must secure a mass acting as an up-and-down pendulum, with exactly the same properties as the horizontal pendulums otherwise, in weight, damping, magnification and friction. Then if they register E-W and N-S motion, the new pendulum will register up-down motion, and we can calculate something of the vertical angle by which the earthquake waves emerge from the ground. This in turn furnishes data as to the depth of the local bumping or grating that is the cause of the quake.

The angle of emergence is a very important element of earth motion. Mallet at the Neapolitan earthquake measured it by the vertical angles of cracks across the corners of broken buildings. Dutton at the Charleston earthquake found buildings at the seismic center with the second storey fireplaces telescoped into the first storey chimney-piece. The thrust there was upward. By Mallet's theory the buildings more distant from the seismic center would be more vertically cracked, those nearer to the center would show cracks more nearly horizontal. Angle of emergence was of great practical importance in the earth waves that destroyed stone fences to the value of many tens of thousands of dollars in Kona recently. The walls were flung over in the direction away from the mountain in many cases, which was also the direction away from the seismic center. There is needed an instrument less crude than the breaking of masonry, for measuring this angle, and for measuring it during all the different phases of the progress of the earthquake.

The obvious answer of all machinists has been a spiral or flat spring with a weight on the end. Many vertical motion seismographs have been made this way. But unfortunately springs are also thermometers, so much so that in the Wiechert vertical instrument a temperature change of one tenth degree moves the writing pen three centimeters. This is compensated by a lever holding the spring supported by iron and zinc rods which expand on warming. To get a slow natural period in a helical spring seismograph, where the spring is counteracting gravitation, the usual method is to attach a horizontal rod to the support at a hinge-line, weight the end of the rod remote from the hinge, attach a spiral spring vertically to a support above the rod, and then attach the lower end of the spring to the rod so that the angle ULH (upper support, lower attachment and hinge) is so much less than 45 degrees that instability begins to set in. The weighted rod sways up and down on the spring, and at the lower part of its journey it tends to flop. When this is the adjustment, the natural period may be slowed to six or seven seconds. Meanwhile the stiffness of the spring, the weight to be carried, the size of the spring, and the frictionless quality of the hinge all play their parts.

What we need in Hawaii is a vertical moving pendulum with a mass equilvalent to 225 pounds, eight inches from the hinge line, a natural period of six seconds, a magnification at the pen of 120 times, complete correction against temperature change, against horizontal motion, and against tilt of the ground, and with recording mechanism, damping and friction identical with the Hawaiian type horizontal instruments. The experiments have been made with a small model, and then with a full size model wherein a variety of spring arrangements have been installed having in view temperature correction. Further progress will be reported from time to time. T.A.J.

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No. 256 RELEASED WITHOUT COPYRIGHT RESTRICTION November 21, 1929

KILAUEA REPORT NO. 930

WEEK ENDING NOVEMBER 20, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

There are no changes in the dormancy of Hawaiian volcanoes. Kona continues to feel about one earthquake a day, but the seismic activity has greatly declined.

Halemaumau has shown no changes except increase of steam due to heavy rain. Mauna Loa at 7 a. m. November 20 showed two remarkable convection clouds, each with pine-tree shape, a narrow stem with widened tabular top. One of these was over the summit crater, and the other over the steam-jet region of the northeast rift. Both were mere rain clouds induced by peculiar still atmospheric conditions, and both disappeared in the course of 20 minutes.

The seismograph at the Observatory registered 28 local disturbances and one distant earthquake. There were 16 very feeble shocks of which 5 indicated origin distance averaging 46 miles from the Observatory. The other local movements were tremors. The distant earthquake began at 7:39 a. m., November 15, recorded about 36 minutes, and showed imperfect phases. Microseismic motion was slight, increasing to strong at the time of the easterly wind storm November 17-18, and diminishing thereafter. Tilt for the week was slight SE.

EARTHQUAKES DUE TO MINE COLLAPSE

Earthquakes became numerous on the Witwatersrand mining district after 1907. (The Rand's earthquakes, by A. G. Boyden, South African Mining Review, December, 1928, p. 328.) Loss of life underground is occasioned by these disturbances, falls of rock trapping and crushing the miners, the collapse being the effect of the earth movement. The Rand syncline is unstable owing to many dykes and dislocations, the mine excavations constitute a belt of weakness many miles long and nearly a mile deep, and earthquakes have increased as this belt settled.

On the surface the major tremors have been alarming, but damage to property above ground has been slight. The following is the record of underground accidents:

Year	Local Tremors	Accidents	Killed	Wounded
1923		71	44	83
1924		79	45	76
1925	484	168	28	160
1926	528	137	34	143
1927	666	143	32	161
1928 (10 months)	558	130	22	168

The quakes are believed due partly to slipping on faults and dykes making frictional vibration, and partly to the reaction of a hammer-like blow of a large mass of falling rock for which this slipping is responsible. The collapse is taking effect in many ancient workings, and the jarring results in "rock-bursts" at the live workings, the yielding of pillars of ore left to support stopes. There are also "rock punches," when hard columns break through softer rock below them.

Committees appointed at three different times have grappled with the situation. Seismographs have been set up. The ore pillars have been replaced by timber and stone packs, designed to let the stopes close gradually. Another device was to fill the worked-out cavities with sand sent down fluid through pipes or bore-holes. This must be done on a large scale to lessen the big falls of "hanging wall." It seems the best procedure for preventing loss of life. An instrument is needed, delicate enough to detect increasing strain in the rock. The miners themselves hear and feel dangerous ground. T. A. J.

EARTH TILTING IN TOKYO

An Omori tiltometer compared with the registration of an Ishimoto clinograph (On the Tilting of the Earth Observed at Tokyo, by S. Haeno, Proc. Imp. Acad. IV, 1928, No. 4, p. 151) gave a daily and annual variation in approximate agreement with the corresponding variations of the earth's temperature at a depth of 10 cm. No agreement was found between tilting and precipitation nor between tilting and barometric pressure.

The daily variation exhibits a plumb-line swing counterclockwise ESE in the morning, WNW. in the forenoon and afternoon, and ESE again from about 4 p. m. to midnight. The plumb-line swings in a flattened elliptic curve with major axis 0.57 second N. 80°W.

The annual variation of tilt causes the plumb line to describe a clockwise swing N. 50° E. from July to February of 10 seconds, and SW. from February to July, with marked departures from regularity. The minor axis of the ellipse described (annual NW.-SE. variation) is 3 seconds. The abnormal movements may be connected with seismic phenomena. Agreement is close in direction and amount of annual tilting between Tokyo and Kilauea (Bull. Haw'n. Volc. Obs. Dec. 1927, fig. 48). T. A. J.

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No. 257 RELEASED WITHOUT COPYRIGHT RESTRICTION November 28, 1929

KILAUEA REPORT NO. 931

WEEK ENDING NOVEMBER 27, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

The week has been uneventful at the Hawaiian volcanoes and the seismic activity in North Kona has continued to decline, though the registered earthquakes continue to indicate a source near Hualalai Volcano.

Halemaumau showed no changes November 20 and the next day appeared unaffected by a small earthquake which occurred that evening. Rock falls were heard at the pit at 12:08 p. m. November 24 and 7:45 a. m. November 26. They were heard at the Observatory because of the southerly wind. A very heavy rainstorm from the southwest with repeated wind thunder, and lightning crises between November 23 and November 26 flooded the country and coated Mauna Loa and Mauna Kea with snow. Consequently much steam rose from Halemaumau November 25, and after more than seven inches of rain for the 24 hours preceding the forenoon of November 26, the road near Keanakakoi was washed out. The July floor of Halemaumau showed about 25 new vapor jets clustered in front of the cone made by the lava fountain at the west, there were many scattered steaming places on the floor, and the stained areas at the floor edge south and northwest were steaming conspicuously. The walls of the pit were also steaming. The rock falls made a fresh scar at the west.

The Observatory seismographs at Kilauea registered 32 local disturbances, of which two were feeble, 12 very feeble, and 18 tremors. The two feeble shocks were in the perceptible class, and one of these at 8:29 p. m. November 20 was strongly felt in Hilo and feebly felt near Kilauea. Its indicated distance to origin was 12 miles. The other shock at 6:59 a. m. November 24 was felt strongly in Kona and had indicated origin distance 40 miles. The average origin distance of five such Kona earthquakes for the week was 48 miles, corresponding as recently during other weeks, to Hualalai Volcano.

Tilt for the week was moderate ESE., and microseismic motion became strong November 22-25, declining thereafter.

THE TENGGER CALDERA

Many craters in different parts of the world have the character of a large cauldron miles across surrounded by cliff walls, floored with the products of several inner vents, and broken at one side by a radial valley leading down the mountain. The radical valley is not an essential, but is common. In Java and Bali there are four notable calderas of different sizes, Idjen of diameter 16 km., Batoer 14 km. (Volcano Letter No. 215), Tengger 8 km., and Roeang 2 km. Escher defines caldera as "A very large steep depression with a flat floor in the top of a volcano, the diameter of the upper rim being much larger than that of necks." by "necks" are meant the inner conduits up which lava rises, these being smaller units than the whole caldera.

The caldera conception may be very well illustrated by Mokuaweoweo and Kilauea in Hawaii, each over 5 km. across and containing inner pits or cones that lie over necks. The Kau Desert is somewhat like a radial valley leading from Kilauea Crater.

Calderas have been subjects of controversy in geology. The disputes concern the question whether the large orifice overlies a magma column of that large size, whether the large cauldron was produced gradually or by a single titanic eruption, whether it was made by the up-welling and sinking back of lava, whether it was made by a gigantic explosion, whether it could have been made by gradual down-faulting and this be related to a down-faulted sector that made the radial valley, or finally whether it was produced by a plexus of causes not always the same in different cases. The last seems most reasonable, and is the moderate viewpoint of Dr. Escher in discussing Tengger (Vesuvius, the Tengger Mountains, and the problem of Calderas, by B. G. Escher, Leidsche Geol. Meded. Deel. II, pp. 51-114, 1927, Royal Geological Museum of Leiden).

The Tengger is a large crater ring in eastern Java near the resort Tosari, and famous for the activity of the crater Bromo and the wonderful photographic views which have been made of the sand-sea, the great smoking volcano Smeroe, and the marvelous landscape of the huge caldera which surrounds Bromo.

Bromo is in the Tengger caldera along with four other smaller craters. Off to the northeast extends the Sapikerep Valley leading away from the caldera. The older explanation was that there was first a big double volcano which had an enormous eruption accompanied by engulfment and such lava flows out through the valley as to break down that side of the mountain. Then came deposits of loose materials and finally younger lava filling through small new vents inside the caldera.

Escher was greatly impressed by the scouring effect of the gas phase in the eruption of Vesuvius in 1906 which he calls an eruption of the Perret type. He draws analogy for explaining Tengger from the sequence of events in Vesuvius between 1906 and 1926. This sequence in Vesuvius was (1) a small high crater, (2) the big eruption and the large deep crater, (3) crumbling walls, (4) building up the inner floor, and (5) high crater floor, one principal inner cone, some smaller cones and some lava domes.

The history of Tengger was probably as follows: (1) a twin volcano 4,000 meters high with one strongly developed erosion valley, (2) a gas phase in the eastern of two craters scoured out a deep funnel, (3) a gas phase and collapse funnel in the western crater, (4) lava overflowed this western crater into the eastern one and later into the radial valley, (5) a repose period, valley erosion, and subsidence of the eastern crater lava, (6) minor activity in the five inner craters of which Bromo is the survivor.

Assisted by Kuenen the author carries out experiments in gas erosion of upright funnels through sand with a compressed-air blast to make cylindrical and other chimneys by gas erosion. The paper contains striking maps, photographs, and block diagrams showing stages in the crateral evolution T.A.J.

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No. 258 | RELEASED WITHOUT COPYRIGHT RESTRICTION | December 5, 1929

KILAUEA REPORT NO. 932

WEEK ENDING DECEMBER 4, 1929

Section of Volcanology, U. S. Geological Survey

H. A. Powers, Temporarily in Charge

Seismic conditions on the Island of Hawaii remain unchanged. Fewer earthquakes were recorded this week, but distances indicate sources in the North Kona District of west Hawaii.

Kilauea Volcano has had some increase of steam activity at the various vents in and about the outer crater and in Halemaumau pit, due to southerly rainstorms. Small rock falls from the walls occurred from time to time, but no large avalanches have been noted or reported. At 3:10 p. m., November 27, after heavy rain, there was only one spot with vigorous steam, the sulphur stain on the southeast floor of the pit. A fresh scar was noticed on the east wall, and a slide was heard in that region. On November 30 at 9:30 a. m. much steam was coming from cracks on the floor, thickest at the southwest stained area. On December 2, about 9:30 a. m., there was a small avalanche over the north talus, and steam was still noticeable at the southwest sulphur stain. At 11 a. m., December 4, more slides were heard from the north wall, one from the rim sliding down the niche at the north end of the big sill. This part of the pit shows by scars that it has more slides than other sections have. Little steam was to be seen. Cracks of the lava floor are stained brown, giving them clear outline.

Twenty-five seismic disturbances were counted on the seismograms of the Bosch-Omori instruments, classified as follows: 10 tremors, 13 very feeble earthquakes, and 2 feeble earthquakes. One of the feeble earthquakes, at 2:06 p. m., December 1, was reported felt in Kona; it had indicated distance to origin 42 miles. Seven earthquakes showing distance phases give an average distance of 46 miles from the Observatory, corresponding very closely to average distances of previous weeks.

Tilt for the week accumulated slightly to the southwest. Microseismic motion was slight.

THE MURCHISON EARTHQUAKE, NEW ZEALAND

On the 17th of June, 1929, the South Island, New Zealand, was shaken by an earthquake which had its center in the northern part of the island near Murchison. The intensity of the shock is reported as VIII on the Rossi-Forel scale, as chimneys were shaken down and masonry walls cracked through an area over a hundred miles in diameter (Geological Reconnaissance in the Murchison Earthquake Area, by H. T. Ferrar and L. I. Grange, New Zealand Journal of Science and Technology, Vol. XI, No. 3, 1929, pp. 185-191). After the initial shock which did the damage the "northwest corner of the South Island continued to creak like the deck of a ship for weeks" due to the gradual release of earth-stresses.

The authors review the New Zealand earthquakes of the past and point out that, in most cases, they were associated with movements on fault-planes which were known to geologists to be active faults. A reconnaissance of the area disturbed by the quake of June 17, however, showed that earth movement had occurred only along the White Creek and Kongahu fault-zones, both classed by geologists as dormant faults. Further, most New Zealand faults are concave toward the upthrow block, whereas the White Creek fault is convex toward its upthrow side.

Marked differences in the extent of damage in different localities within the disturbed area are cited and explained in general by the effect of geologic structure on the transmission of the earthquake waves. For instance, Blenheim seems to have been protected considerably by the Wairau fault-plane which passes between that town and the quake center on the White Creek fault.

The disturbance on the Kongahu fault upraised a considerable area of sea-floor in the vicinity of Whitecliffs. This area is to be studied in detail next summer. The movement on the White Creek fault has been studied by H. E. Fyfe and is reported in the same issue of the Journal (Movement on the White Creek Fault, New Zealand, pp. 192-197).

The White Creek fault is the eastern one of two almost parallel faults which bound a strip of Tertiary rocks, inset by the faults in granite country rock. The dip of the plane is nearly 90 degrees, and its trace is slightly concave to the west trending slightly east of north. It has been known as a dormant fault for several decades. The fault is located about seven and a half miles west of Murchison.

At its intersection with the fault-plane, the Murchison-West Coast road was offset vertically 14 feet 9 inches, the east side of the fault having risen relatively to the west side. There was no detectable horizontal movement. The trace of the fault was clearly marked by shattered ground and disturbed vegetation for a distance of at least three miles.

Data obtained by releveling part of the Nelson-West Coast railway show that the level of the country east of the fault-line has been changed for a distance of about nine miles from the fault. At the fault, the eastern block was found to have risen 14 feet 9 inches, the total throw of the fault. The maximum measured increase in elevation of the eastern surface was 16.08 feet, about 25 chains east of the fault.

A graph showing the nature of displacement along the White Creek fault is compared with the graph by Reid illustrating the displacement of the surface along the San Andreas fault after the 1906 earthquake. In the California quake, the movement was horizontal and the total displacement was divided between the two blocks so that each block moved relative to a fixed point in the fault-plane. The movement along the White Creek fault-plane was vertical and, according to the data at hand, the entire displacement is accounted for by the upthrow of the eastern block. The author postpones his discussion of the application of Reid's elastic-rebound theory until the whole White Creek area has been releveled and the absolute movement of both blocks determined. H. A. P.

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No. 259 RELEASED WITHOUT COPYRIGHT RESTRICTION December 12, 1929

KILAUEA REPORT No. 933

WEEK ENDING DECEMBER 11, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Everything remains quiet at the Hawaiian volcanoes. At Halemaumau pit a slide on the north side at 11:05 a. m., December 10 made a roaring noise and produced a small dust cloud. A bigger avalanche occurred at noon, December 11, making a loud roar and sending up dust which remained visible for 15 minutes.

Seventeen local earthquake disturbances were registered at the Observatory. Nine of these were tremors, 8 were very feeble earthquakes, and 5 of these indicated distances averaging 47 miles from Kilauea. The duration of the most prolonged of the tremor spasms was 2 minutes. Tilting of the ground accumulated moderately to the west, and microseismic motion was slight.

LASSEN REPORT No. 22

Lassen Volcano Observatory, Mineral, California

R. H. Finch, Associate Volcanologist

During the afternoon and evening of November 17, 1929, eleven earthquakes were registered on the seismographs at Mineral. Another shake occurred during the early morning of November 18. Two of the earthquakes were plainly perceptible. The one that occurred at 7 p. m., November 17 gave buildings a sharp jolt. The disturbances can undoubtedly be classed as Lassen shocks as the indicated distance to origin, 12 miles, is equal to the distance to Lassen Peak from Mineral.

NOTICE

Recipients of the Volcano Letter are requested to examine the address on the envelopes and to notify the Hawaiian Volcano Observatory of any changes desired.

MAYON VOLCANO

On July 1, 1928, Mayon, the "Fujiyama" of the Philippines, was in mild eruption, sending blocky incandescent lava flows from notches in the rim of the summit crater, and emitting dust laden steam. Chlorine and sulphuric acid were found in the dust. The climax was reached about July 20, and in August the volcano reurned to its normal state, emitting steam vapors (Mayon Volcano and its Eruptions, by Leopoldo A. Faustino,, Phil. Jour. Sci. Vol. 40, No. 1, Sept. 1929, pp. 47, 24 illustrations). The lavas are andesitic basalts, with plagioclase, augite, hypersthene, magnetite, and hematite.

Mayon is in southeastern Luzon, 23 hours by rail from Manila. It is 2,421 meters high, and has had 28 eruptions in 114 years since a destructive eruption in 1814. There were two long quiet periods, 1814-27 and 1900 28. The normal condition is continuous mild activity. The most violent eruptions are followed by the longest periods of rest. The beautiful cone has never been destroyed, and the conduit has always been in the center. The losses of life have been by asphyxiation, dust blasts, overpowering incandescent slides, flood, and earthquake. The last two are secondary. The incandescent slides appear to be thrusts clear to the sea of unbalanced slopes attacked by radial aa flows above and bombardment of falling material. The lava flows follow the steep gulches and rise above them, forming ridges where trenches were before.

There were disastrous outbreaks in 1814 and 1897. The greater damage was the overwhelming of shore villages by a torrent of "fire, lava, and large hot stones." Two great disasters by flood and typhoon, in 1766 and 1875, were occasioned by heavy rainfall causing the unstable volcanic slopes to wash down to the sea as mud flow, with high mobility and great rapidity. Thousands perished and much property was destroyed. The path of the waters was an expanse of bowlders and sand, with pieces of wood, to mark the place where was once a thriving community.

The events in 1928, after 28 years of quiet, began with rumblings in January. June 16 the steam jets increased in volume and crater glow was seen. Dust "cauliflowers" began June 24. Incandescent flows overlipped the crater June 27. Army fliers June 29 circled the crater at 2,500 meters, and photographed the cauldron at 200 meters distance. They felt the heat strongly, inhaled sulphur, and estimated the crater diameter at 500 meters. It was circular, with vertical inner walls, a deposit of cindery material on the sides, and a pool of bubbling hot lava in the center. The rim is notched with a main chute or horseshoe opening on the eastern side. Aluminum sulphate and sulphur are common in the crater during quiet times.

Fragments were shot into the air, reports were heard, lava poured out through the notches in the crater wall and followed the gullies, forming snakelike trickles radiating from the summit. The molten material crusted over and cracked, and the impact of falling glow-stones made fireworks.

At the end of June the lava streams lengthened, resembling red hot glaciers covered with moraines. Black clouds of dust-laden steam swept down the mountain. The explosions waxed and waned until July 20. Hollows filled with the molten material and the junction of two valleys assumed the appearance of a subordinate crater. July 16 volcanic materials were descending the northern slopes. There was periodicity of three to five hours in the spells of roaring, hissing, cracking, and tumbling noise. At the climax there was a spectacular evening display of bombs describing parabolic curves of fiery rocketing at the summit. A column of heavy dark clouds rose 8,000 meters above the summit, the top of the mountain was rose red, brilliant lightning flashed from dustcloud to dustcloud, and streams of lava flowed in all directions. Sometimes the column moved spirally. When the wind arose, "the volcano appeared like a gigantic locomotive puffing on a heavy grade." T. A. J.

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No. 260 RELEASED WITHOUT COPYRIGHT RESTRICTION December 19, 1929

KILAUEA REPORT NO. 934

WEEK ENDING DECEMBER 18, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

No lava activity has occurred, but stormy weather has produced much steam in Kilauea Crater. On December 12, at 1:19 p. m., a steady roar from Halemaumau pit was heard at the Observatory caused by an avalanche lasting several seconds, which finally sent up dust above the east rim which drifted toward the north. A prolonged very feeble earthquake movement registered on the seismographs coincided with the slide.

A southwest rainstorm December 16 flooded the country and condensed much vapor over Kilauea and Halemaumau. Violent wind wrecked the Observatory weather-vane at 10:05 a. m. At noon, December 18, the pit was quiet and in spite of rainy weather there was hardly any steam on the south talus. Fresh debris lay on the north and east talus cones.

The Observatory seismograph registered 13 local disturbances during the week, of which nine were very feeble earthquakes and four were tremors. Seismometric evidence for five shocks indicated an average distance of 48 miles for the location of the origin. This corresponds to North Kona as in other recent weeks, and earthquakes are still felt in that district.

Tilting of the ground at the Observatory was moderate SSW. Microseismic motion increased December 16, accompanied with wind tremor. With the change of wind to northeast December 17, the microseisms remained large and rythmical.

A large distant earthquake was registered December 17, beginning 12:37 a. m., the preliminary phase indicating distance of origin 4,300 km. (2,600 miles). This distance corresponds to the north end of the Tonga Deep, the west end of the Aleutian Deep, the cordilleran belt of the west coast of North America, or the west end of the Alaskan Peninsula. The Kodiak station reports fire and smoke from three volcanoes between Kodiak and Unalaska.

THE CENTER OF THE TOKYO EARTHQUAKE

Professor Imamura, Director of the Seismological Institute of Tokyo Imperial University, has just published a brief summary concerning the most recent information about the location of several centers for the great Kwanto earthquake of September 1, 1923 (On the multiple source of origin of the Great Kwanto Earthquake of 1923 and its relation to the fault system connected with the Earthquake, by A. Imamura, Proc. Imp. Acad., Oct. 1929, Vol. V, No. 8, p. 330).

It was found that the Tango earthquake of 1927 had a double source of origin. It may be that the Tokyo earthquake had a multiple series of epicenters. The seismic waves that caused such widespread destruction emerged from at least three different places, along a line NE-SW. beginning at the middle of Sagami Bay. Two of these points were in the bay and one in the mountains north of Fujiyama. The first break was from the middle of the bay, the second from the mountains three seconds later, and the third, 7.5 seconds still later, came from the head of the bay west of Kamakura. Everything that succeeded these early phases of the earth motion, if the process repeated itself, was masked by the exceptionally large earth movements that lasted for more than a minute.

The Seismological Institute at Tokyo stood broadside to the big NW-SE. trending faults, and so with several pairs of seismographs could interpret the direction of motion of the earliest phases.

Imamura has continued the work of the late Professor Yamasaki in mapping the fault systems surrounding the epicenters. These have been interpreted in connection with precise leveling and triangulation. There emerges from this mapping a series of east-west faults across the Bosyu Peninsula and the eastern part of Sagami Bay; a series of very big faults along the volcanic axis NW.-SE. extending from the bay to the mainland along the Oshima-Fujiyama belt; and a series of N.-S. faults tending to curve westward in the entrance to Tokyo Bay and in the region west of Yokohama. Fifteen faults and flexures have been worked out with lengths varying from 1 to 22 km. and vertical displacements varying from 0.3 meter to 2.0 meters Some of these topographical changes accompanied the first earthquake and others were probably adjusted along with the big after-shocks.

The details of these movements are worked out in accordance with the strength of effects and sensations in different places, and with seismogram records in different places. A map is presented exhibiting the directions of initial motion as recorded on seismographs all over central Japan, and the facts seem accordant with two main epicenters, one in the bay and one on the mainland. The time-distance curves of the preliminary tremors also accord with the double origin.

Imamura concludes that shearing stresses tore asunder the bottom of the bay on a weak zone and then leapt to the Tanzawa Mountain to release a second violent rending of the earth's crust. This was succeeded by a still bigger collapse in the bottom of the bay, when the whole countryside was thrown into agitation. It will be seen that this analysis is totally different from Imamura's earlier theories which attributed the earthquake to tectonic movements under the Pacific off to the east. T. A. J.

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No. 261 RELEASED WITHOUT COPYRIGHT RESTRICTION December 26, 1929

KILAUEA REPORT NO. 935

WEEK ENDING DECEMBER 25, 1929

Section of Volcanology, U. S. Geological Survey

T. A. Jaggar, Volcanologist in Charge

Kilauea remains quiet. There are no avalanches. A white stain has appeared in a niche of the wall at the top of the northwest talus. On wet days fog has condensed over the pit and in it, but the steam on the talus slopes has diminished.

The Kilauea seismographs have registered 10 tremors and 3 local earthquakes, making 13 disturbances. Two of the local shocks indicate distances of 34 and 51 miles. These were felt in North Kona. Microseisms were slight, and tilting of the ground was stationary.

The distant large earthquake of December 17 is located by "Science Service" at the west end of the Aleutian Deep, near Attu.

A BIG ATLANTIC EARTHQUAKE

A powerful movement of the earth crust under the Atlantic Ocean along the steamer track between New York and Liverpool is unusual. Such an earthquake recalls the Charleston disaster of 1886. This is not a place of deep holes under the ocean like the earthquake centers off Japan and Chile.

The shock occurred about 3:40 p. m., eastern standard time, November 18, 1929, 180 miles south of the Newfoundland coast, off the edge of the continental shelf, and probably moved a large area of sea bottom. The bottom is fairly steep, and possibly submarine landslip accounted for the breaking of Atlantic cables in several places. The location of center was about lat. 44° N., long. 58° W.

The first reports told of very heavy shocks in Nova Scotia lasting for many minutes. Halifax was severely shaken. In Windsor chimneys were knocked down and dishes were broken. In St. John's, Newfoundland, the shock was only "half a minute" long, and not so strong, but the Burin Peninsula in south Newfoundland received a violent shaking. From Boston to Maine in the United States the phenomenon was described as "sharp earthquake shocks."

The big steamship "Olympic" was 300 miles from the center, and the captain felt the vessel suddenly quiver, as though she had lost a propeller blade, and this was followed by vibrations for two minutes. The ship was found to be uninjured.

Sea waves piled into the Newfoundland inlets along the west shore of Placentia Bay two and a half hours after the earthquakes. Burin and La Maline bays were most damaged. At Burin whole families were trapped at their dinner tables as a wall of water 15 feet high swept inland Boats and schooners were lifted from their moorings and dashed against the waterfront buildings and wharves. A mother, who was with her two children alone in her home, rushed to the door to learn the cause of the roar of waters. When she ran back to rescue the children, the wave broke over the house, drowned them all, and washed the wreckage out to sea.

Women and children were the greatest sufferers, as the men were away with the fishing fleets. Nine lives were lost at Burin, and 17 others at Lord's Cove and La Maline. In Long Harbor, at the head of a narrowing inlet, fishing booms and weirs were damaged and 75 yards of roadway were destroyed.

Twelve out of 22 telegraph cables in the epicentral earthquake area were fractured, and 10 of these cross the ocean. Two Western Union cables were severed at 90 fathoms depth off Nova Scotia, and a third at a depth of 900 fathoms. Thus the dislocation of the sea bottom was distributed. Davison reports (Nature, Nov. 30, 1929, p. 859) that such an earthquake occurred in 1884, breaking three cables along a straight line on the southeastern slope of the Newfoundland Bank, and that probably the present earthquake had a multiple origin.

Boston was 700 miles from the supposed center, and the U. S. Coast Survey (Science News, Science, Nov. 29, 1929, page X) estimates perceptible shaking over a million and a half square miles, and strong shaking over 200,000 square miles. This is a very large disturbed area, and yet not the slightest trace of this earthquake appeared on the Bosch-Omori seismograph of magnification x120 at Kilauea Volcano in Hawaii This distance is only 5,800 miles, and yet the Porto Rico earthquake at similar distance recorded clearly on these instruments.

It is 43 years since the last great earthquake (1886) on the Atlantic seaboard of the United States. That one, the Charleston cataclysm, was preceded a year and a half before (1884) by a disturbance breaking cables along a straight line off the Newfoundland Bank. In 1929 there is a new disturbance breaking 12 cables off the Newfoundland Bank.

We do not know what cycle controls the marginal movement of the North Atlantic basin around Bermuda as a center, but these west Atlantic earthquakes are so rare that seismological measurement should be made practical in the eastern United States during the next few years, with special attention to local frequency of small movements.

T. A. J.