Art. XIII.—*Recent Eruption of Mauna Loa and Kilauea, Hawaii.*

[The following are extracts from some of the accounts of the recent great eruption on Hawaii which have reached us. The reader will be aided in understanding the geography of the island by referring to a map in volume xxvii of this Journal, p. 412, (or that in the writer's Manual of Geology, p. 696.) The district of *Kona* is on the west side of the island, between *c* and *f* nearly; that of *Kau*, on the southern, from *f* to a line running S.S.E. from Kilauea; that of *Puna*, east of Kau, and south of Hilo. *Kahuku* lies almost in a direct line between the summit of M. Loa and the south cape, 12 or 15 miles north of the cape, and this line was the course of the principal fissures

and flows of lava. The *new island* is situated just south of the south cape. *Waiohinu* is about 8 miles east of Kahuku (north of *k* on the map), 5 or 6 miles from the sea at *Kaalualu*. *Honuapo* is at *i* ; *Punaluu*, 4 or 5 miles farther east on the coast. *Hiilea* lies 3 or 4 miles east of north of Punaluu. From Punuluu the road to Kilauea leaves the coast and passes through *Makaka*, *Keaiva* (about 26 m. from Kilauea), *Kapapala* (18 or 20 m. from K. and 3000 feet above the sea). Mr. F. S. Lyman lived near Keaiva. The mud-eruption of which he speaks in his letter below was a little northwest of a line between Keaiva and Kapapala; and the lava eruptions near Hiilea are west of south of the mud-eruptions; both appear to have been connected with the discharge of Kilauea, while the eruptions near Kahuku and in the line east of north from this place may have come direct from the central crater of the mountain.

The letter of Mr. Lyman to his brother, David B. Lyman of Chicago, was received by us through Prof. Lyman of New Haven. For other communications we are indebted to Prof. Alexander, of Honolulu, and the Honolulu papers.—J. D. DANA.]

1. *Letter from Rev.* TITUS COAN, (*to* J. D. DANA,) *dated Hilo, Hawaii, April* 7, 1868.

History and tradition record no such commotion on Hawaii as we have just experienced. On the 27th of March, slight and repeated shocks of earthquake were felt in Kau, the southern district of this island. On the 28th these shocks became more frequent and more energetic, extending to Hilo, Kona, and probably to all parts of the island. On this day the inhabitants of Hilo saw steam and fire shooting up from several points on the summit, and down the S. E. slope of Mauna Loa. During the same day, all Kau was startled by heavy explosions and roarings, as of a tempest, from the mountain. The mountain was rent, apparently, from near the summit crater, Mokuaweoweo, half way down its southern slope, and jets of steam and smoke went up from many points, while four distinct streams of lavas flowed out from separate fissures, and rushed down the mountain. One of these streams flowed nearly due south half way down the mountain toward Kahuku. At the same time a terrible earthquake shook down the large stone church at Kahuku, and also all the stone dwelling houses in that place, including the houses of some foreign gentlemen, who are grazing cattle at the foot of the mountain.

A letter just received from Rev. T. D. Paris, of Kealakekua, South Kona, and dated March 29th, contains some facts con-

cerning that side of the island, which I take the liberty to transcribe.

"For the last 36 hours, our house and all about us have been trembling, shaking and heaving, as if the very foundations were giving way. For ten hours there was a succession of shakes at intervals of from two to five minutes—vibrations, roaring and hissing, continuing most of the time, from one shock to another.

"Yesterday, during the heaving of the earth, four avalanches fell from the Kaanaloa precipice into the bay.

"Friday morning (27th), between 5 and 6 o'clock, we discovered the great mountain to be on fire, with immense columns and pillars of smoke; but as yet we are ignorant as to the course of the stream.

"Tuesday, April 1st. The shaking of the hill still continues. We have not undressed for sleeping since Friday night."

Thus far Mr. Paris.

On Saturday, the 28th, the lights on the mountain disappeared on all sides, from Kona to Hilo scarcely a puff of steam was seen, and all subaërial volcanic demonstrations ceased. All eyes were looking to the hills, and all were inquiring with amazement, "What has become of the eruption?"

Meanwhile the whole island trembled and shook. Day and night the throbbing and quaking were nearly continuous. No one attempted to count the sudden jars and prolonged throes, so rapid was their succession. And even during the intervals between the quakes, the ground and all objects upon it seemed to quiver like the surface of a boiling pot. The quaking was most fearful in Kau, and anxiety marked all thoughtful minds. The truth was, all the fires of the mountain and of Kilauea were sunk in subterranean caverns and chambers, and were struggling to force their way down to the ocean. The sea of lavas must have been enormous, and it was working, underground, in numerous ducts, under a tract many miles broad. The shocks and quiverings continued with different degrees of intensity until Thursday, the 2d inst.

It was now evident that Kilauea, and the mother mountain, Loa, were acting in concert. The fires in the former had become fearfully intense, shaking down avalanches of rocks from the outer walls, cracking the earth and bursting into an extinct lateral crater, called "Little Kilauea."

At 4 p. m. on the 2d instant a shock occurred, which was absolutely terrific. All over Kau and Hilo, the earth was rent in a thousand places, opening cracks and fissures from an inch to many feet in width, throwing over stone-walls, prostrating

trees, breaking down banks and precipices, demolishing nearly all stone churches and dwellings, and filling the people with consternation. This shock lasted about three minutes, and had it continued three minutes more, with such violence, few houses would have been left standing in Hilo or Kau. Fortunately there was but one stone building in Hilo, our prison, and that fell immediately.

As this awful shock died away, the sea rose some six feet above high water mark, and all the dwellings, stores, machine shops, etc., near the shore, were in imminent peril. At the same hour all Kau experienced a much more awful convulsion.

Between Kapapala and Keaiva, about twenty-six miles from Kilauea, the earth suddenly opened, among the foot hills of the mountain, a mile or two above the road leading through Kau, and a mass of earth, stones and mud was thrown up two to three miles long, and two to three miles broad, where the opening commenced, and one half to three-quarters of a mile broad, at the terminus. This earthy eruption is said to be four to fifteen feet deep, and the disgorgement was so rapid that thirty people, and 2,500 to 2,600 bullocks and horses were crushed, and all the houses of the village buried from sight. The occurrence was on a cattle ranch belonging to Reed and Richardson, and near the sheep and goat ranch of F. S. Lyman, Esq., son of Rev. D. B. Lyman, of Hilo. At the same moment, the houses of Reed and Richardson, of Mr. Lyman, and nearly all the native houses in that district, were shaken in pieces.

Simultaneously with this, there was a submarine disgorgement of lavas into the sea,* which caused a tidal wave some 15 to 20 feet high. This was fiery red, from the enormous eruption of igneous matter which broke up under the sea for miles along the shore, sweeping away every building on the lower grounds for some fifteen miles along the coast. How many lives were lost by this influx we have not yet ascertained. I have seen forty-seven names of the killed in the earthy eruption, some six miles from the sea, and this influx of the ocean. These statistics include only the eastern portion, or less than one-fourth part of Kau. We are anxiously waiting for news from the central and western portions of the district. Before the terrible shock of the 2d, we had heard that the churches and many dwellings at Waiohinu and onward to Kahuku, were in ruins; but since that event no messenger has come from all that region to report.

It is said that the great earth eruption near Kapapala was not heated, and that there was no appearance of fire in the dis-

* So Mr. Lyman thinks.

gorgements. The whole mass was thrown out of the earth like the discharge of a cannon, with a rush of wind and an awful roar. The whole action was seen by Mr. Richardson and others on the N. E., and by Mr. Lyman and others on the S. W. side of the eruption. The premises of both these gentlemen came near being swallowed up in this upheaval.

For the last twelve days, few probably of the people of Hilo and Kau have put off their clothes for sleeping. Many have camped out in the fields, and all have been anxious to secure places of comparative safety.

We still have repeated shocks, which send us out of our houses by day and night, and our house has often jarred and quivered since I have been writing these lines. But the shocks are less frequent and severe from day to day.

The sympathy between Kilauea and Mauna Loa has been distinctly marked during this eruption. Like the divisions of a grand army, all the Plutonic forces of our island have seemed to act in concert; the fires in the mountain and in Kilauea rising and falling together, and the great subterranean movements, and the rush into the sea, being simultaneous. *The fires of Kilauea have been drawn off and the crater has sunk down several hundred feet, as in the eruption of* 1840.

For four or five weeks previous to this eruption, we had heavy and continuous rains, and a vast amount of water must have gone down into the earth, filling the subterranean streams and reservoirs, and causing them to overflow. The descent of such quantities of water to the rising columns of lava, and the rapid generation of steam, may have hastened and intensified the catastrophe.

We give you the facts so far as we are able to do so, leaving the philosophical reasonings and conclusions to our scientific friends.

April 10. Last evening news came in from Waiohinu and Kahuku, that all that region was in ruins. The terrors were awful. Not an undamaged house left. 67 lives lost by the influx of the sea, and no shore village standing. The lavas have broken ground in Kau and are flowing to the sea. Our shocks still continue at intervals.

2. *Extracts from a letter from Mr.* Frederick S. Lyman, *dated Hilo, April* 10*th*, 1868, *addressed to* D. B. Lyman, Esq., *of Chicago.*

. . . . In my last letter from Kau I left off writing Tuesday evening, the 31st ult. That night from about ten till two the shaking was almost incessant; it then subsided. Wednesday morning about sunrise there was a hard shock, and

again at 5 P. M. there was a severe and protracted earthquake, with considerable swaying to and fro of the earth. Nearly all that night the shaking was very severe with frequent shocks and a rumbling sound from the south. * * * *

Soon after four o'clock P. M. on Thursday we experienced a most fearful earthquake. First the earth swayed to and fro from north to south, then from east to west, then round and round, up and down, and finally in every imaginable direction, for several minutes, everything crashing around, and the trees thrashing as if torn by a hurricane, and there was a sound as of a mighty rushing wind. It was impossible to stand; we had to sit on the ground, bracing with hands and feet to keep from being rolled over. While this agitation was at its height we saw bursting out, from the top of the bluff, about a mile and a half north of us, what we supposed to be an immense torrent of molten lava, which rushed across the plain below, apparently bursting up from the ground as it went, throwing rocks high in the air, and swallowing everything in its way;—trees, houses, cattle, horses, goats and men, all overwhelmed in an instant. This devouring current passed over a distance of about three miles in as many minutes, and then ceased. Some one called our attention to the ocean, and as soon as the severity of the earthquake had sufficiently subsided, we ran to a place where we could see the coast. All along the shore from directly below our place to Punaluu, a distance of three or four miles, the sea was boiling and foaming furiously. The waves covered the shore, and the water was red for at least the eighth of a mile from the land.

With our children and our native servants we went immediately to Nahala's hill, a short distance west of our house. From the hill-top we could overlook the country. At Hiilea, a short distance farther west, a small stream of black smoking lava was oozing from the earth; and outside of the harbor at Punaluu a long black column of lava pushed itself slowly into the ocean, and finally disappeared under the waves. We stood, expecting every moment to be swallowed up by the earth, for there were frequent earthquake shocks, the ground was opening with numerous fissures, every rock and crag that could fall had fallen, and there was a continual roar as if the molten lava was surging and rushing directly under our feet. * * *

The villages on the shore were swept away by the great wave that rushed upon the land immediately after the earthquake. The eruption of earth destroyed thirty-one lives, but the waves swallowed a greater number. * * *

Mr. Richardson returned to Kau on Monday, reaching his farm at Kapapala, Tuesday noon; but as the earthquakes were

very frequent and very severe, he remained only two or three hours. While he was camping, that night, on the great sand-plain southwest of Kilauea, the clouds were lifted from the mountain, and he saw a great river of lava pouring down its southern slope in the vicinity of Waiohinu or Kahuku, and entering the sea near Kaalualu bay. At Kilauea he could see neither fire nor smoke in the crater. Last evening (Thursday), with two other white men and several natives, he sailed on the sloop Live Yankee, bound for the coast of Kau, hoping to be able to rescue all who are still endangered by the volcano.

Since last Saturday evening, the earthquake shocks at this place (Hilo) have been infrequent and very slight, but the mountain still smokes furiously. I should have mentioned the fact that in the morning of the day after the great earthquake we could see that there had been small eruptions of earth in the margin of the forest all along the side of the mountain, from the high land above Mr. Richardson's house to the hill behind our house, a distance of four miles or more. The tract covered by the great eruption was nearly a mile wide and three miles long, forming a bank of moist, clayey soil fifteen or twenty feet high. It looks precisely like a great bank of red and brown clinkers (the *aa* of the natives). A stream of water is now running through it, and far below toward the ocean.

In the earlier letter of Mr. F. S. Lyman, (dated Kau, March 31st,) addressed to D. B. Lyman of Chicago, he writes as follows:

Since we last wrote you we still live in fear and trembling. You may have already heard that an eruption broke out on Mauna Loa, a little to the southwest of the summit, about six o'clock last Friday morning, the 27th inst., without any forewarning. The fire burst up out of the ground, throwing a spray of red lava high in the air; and then a great column of smoke rose straight up thousands of feet and arched over to the east; in a few minutes a new jet was thrown up a little southeast of the first, with its column of smoke. This was soon followed by another, and then by a fourth; and soon the red lava began running down the sides of the mountain in four streams, in a southerly and easterly direction. About seven o'clock we began to hear a roaring sound which grew louder and louder until the air seemed to tremble with the incessant roar of the volcano, but finally it subsided and ceased entirely about eight o'clock. But before that time the clouds had shut down on the mountain so that we could see nothing more then. About noon we began to feel slight earthquakes, and during the night they were very frequent, some of the time, every minute or two; though very slight, they were sufficient to prevent sleep, for

almost every jar would rattle the doors and windows. After sunrise Saturday morning (28th) the shocks began to be harder, coming often two together; they increased in violence until between one and two o'clock in the afternoon, when there occurred the hardest of all, with three shocks, which lasted about a minute; the swaying motion was so great that it was hard to stand up. The rest of the day the shocks were not very severe. Saturday morning we could see the smoke, and the flow had apparently gone about ten miles due south from the source, but during the day and part of the night it was covered with clouds.

Saturday night the shocks were very frequent and quite severe; and the house made such a noise and commotion at every shock that we all moved to our native house, or none of us would have slept any. The next morning, Sunday, the line of smoke had advanced about 15 miles since the morning previous, and seemed to be directly in the line toward Capt. Brown's house in Kahuku; but, what seems singular, no light had thus far been visible except an occasional show of it at the source. Sunday the shakes were less frequent, with some hard ones until about 2 P. M. when they nearly ceased; occasional and slight all that night, and Monday also, and Monday night; but to-day (Tuesday, the 31st), about ten A. M. there was quite a severe shaking, and at five P. M. a harder one.

3. *Extracts from a letter from* H. M. WHITNEY, *editor of the Honolulu Advertiser, dated Kealakekua, April 13th, on the eruptions near Kehuku.* (From the Advertiser.)

On ascending the ridge just west of and opposite the Mamalu Pali (precipice) of Kahuku, and which was separated from us by a valley about one-eighth of a mile wide, the whole scene opened before us in one grand panorama. The valley itself was floored over with a pavement of fresh *pahoehoe* lava (solid lava stream having a nearly smooth, though often rippled and wavy surface) from ten to twenty feet deep, which appears to have been the first thrown out, and came from a crater about ten miles up the mountain, which burst out on Tuesday morning, April 7th. This crater and stream had ceased flowing, and the lava was rapidly cooling, so that we ventured to stand on it, though at the risk of burning our boots and being choked by the sulphurous gases. On Tuesday afternoon, at 5 o'clock, a new crater, several miles lower down, and about two miles directly back of Captain Brown's residence, burst out with a heavy roar and a frightful crash. The lava stream commenced flowing rapidly down the beautiful plateau, toward and around the farm-house, and the inmates had barely time to escape with

what clothes they had on, before the houses were all surrounded and enclosed with streams of fiery *aa* lava varying from five to fifty feet in depth. Fortunately all the inmates escaped safely to Waiohinu: but how narrow the escape was, and how rapid the stream flowed, may be inferred from the fact that the path by which they escaped was covered with lava within *ten minutes* after they passed over it.

The new crater, when visited by Mr. Swain, was at least one and a half miles in extent, nearly circular, but constantly enlarging its area, by engulphing its sides. While the above gentleman was looking at it, a tract of at least five acres in extent tumbled in and was swallowed up like food for the devouring element. The enlargement is going on mainly on the lower side, toward the farm-house, and it is thought that its diameter is already about two miles. Four huge jets or fountains were continually being thrown up out of this great crater, ever varying in size and height, sometimes apparently all joining together and making one continuous spouting a mile and a half long. From the lower side of the crater a stream of liquid, rolling, boiling lava poured out and ran down the plateau, then down the side of the pali (following the track of the government road), then along the foot of the pali or precipice five miles to the sea.

This was the scene that opened before us as we ascended the ridge on Friday (10th). At the left were these four grand fountains playing with terrific fury, throwing blood-red lava and huge stones, some as large as a house, to a height varying from 500 to 1,000 feet. The grandeur of this scene, ever changing like a moving panorama, no one who has not seen it can realize.

Then there was the rapid, rolling stream, rushing and tumbling like a swollen river, down the hill, over the precipice and down the valley to the sea, surging and roaring like a cataract, with a fury perfectly indescribable. This *river of fire* varied from 200 to 800 feet in width, and when it is known that the descent was 2,000 feet in five miles, the statement that it ran at the rate of *ten to twenty-five miles an hour* will not be doubted.*

We waited till night, when the scene was a hundred fold more grand and vivid. The crimson red of the lava now doubly bright, the lurid glare of the red smoke-clouds that overhung the whole, the roaring of the rushing stream, the noise of the tumbling rocks thrown out of the crater, the flashes of electric lightning, and the sharp quick claps of thunder—altogether made the scene surpassingly grand.

* Some corrections are here introduced from Mr. Whitney's later account in the Advertiser of May 9th.—Eds.

The eruption lasted five days, it ceasing entirely in the night between the 11th and 12th.

Finding it impossible to get over to Waiohinu, either by going up the mountain or by sea, we returned to this place on Saturday, and hope to go on soon by steamer.

The number of shocks which occurred at Waiohinu from March 29th to April 10th, is estimated by Mr. Silloway to have been upward of two thousand, there having been some days between three and four hundred. The heaviest shock occurred on Thursday, April 2d, being the same that was felt so sensibly at Honolulu. This destroyed every church and nearly every dwelling in the whole district.

From 10 to 12 o'clock of that day, there had been service in the large church in Waiohinu, and it was crowded with people. Only four hours after they left the heavy shock came, the walls tumbled in, and the roof fell flat—all the work of twenty seconds. At the same instant, every man, woman and child were thrown from their feet. Horses and cattle dropped down as if dead. A man riding on horseback had his horse tumble under him so suddenly, that he found himself and horse lying flat on the ground before the thought of an earthquake entered his mind.

The earth opened all through the district, and in some places left dangerous fissures, while in others it closed up again. In one place it closed twenty feet from where it opened. These fissures make it dangerous to travel in the dark. Everywhere the roads are broken up, and it will take much money and labor to restore them to their old condition.

As the *Kona Packet* was passing the south point of the island, about three miles from the shore, a conical island, four hundred feet high, rose out of the sea, midway between the vessel and the land, emitting a column of steam and smoke. The lava river flows into the sea at this island and has extended the shore out to it one mile at least, so that it is now on the main land. The packet was so near when this island burst up, that the mud was spattered on the masts and sails of the vessel. Where the lava entered the sea, there were bluish flames emitted 10 to 20 feet high, besides steam and smoke.

The scene at the eruption was a most melancholy one to witness. There were hundreds of fine cattle grazing around the farm-houses, when the lava streams surrounded them and hemmed them in. The poor animals seemed aware of the danger, but saw no way to escape. The fiery lava drew nearer and nearer, till the heat made them restless, but they would not run. They bravely looked the foe in the face, stood firm till it reached them, then fell in the stream—a sudden cloud of smoke

followed, and not a sign remained. Thus one after another fell till over two hundred were consumed.

An incident which ought not to be omitted is the shower of ashes which preceded the eruption. During Monday night (the 6th), prior to the eruption, the ground throughout the district was covered with a coating of fine sand and light pumice stone, of a light yellowish color. Where this shower of sand and pumice stone came from is as yet unknown, but probably from some vent hole near the summit crater.

The tidal wave was much greater than before stated. It rolled in over the tops of the cocoanut trees, probably sixty feet high, and drove the floating rubbish, timber, etc., inland a distance of a quarter of a mile in some places, taking out to sea when it returned, houses, men, women, and almost everything movable. The villages Punaluu, Ninole, Kawaa and Honuapo were utterly annihilated.

4. *Letter of* Dr. Wm. Hillebrand, *on the Crater of Kilauea and the eruptions southwest*, published in the Hawaiian Gazette.

Dr. William Hillebrand visited the crater of Kilauea and the scene of the mud flow, and has published a very interesting report of his observations, from which the following extracts are taken.

The ground around the crater of Kilauea, particularly on the eastern and western sides, is rent by the great number of fissures, one near the Puna road more than twelve feet wide and very deep. Others of lesser size run parallel to and cross the Kau road so as to render travel on it very dangerous. The look-out house is detached from the mainland by a very deep crevasse, and stands now on an isolated, overhanging rock, which, at the next severe concussion, must tumble into the pit below. Many smaller fissures are hidden by grass and bushes, forming so many traps for the unwary. The Volcano House, however, has not suffered, nor is the ground surrounding it broken in the least. From the walls of Kilauea large masses of rock have been detached and thrown down. On the west and northwest side, where the fire had been most active before the great earthquake of April 2, the falling masses probably have been at once melted by the lava and carried off by its stream, for the walls there remain as perpendicular as they were before, but that this portion of the wall has lost portions of its mass, is shown too evidently by the deep crevices along the western edge just spoken of, and the partial detachment in many places of large prisms of rock. But it is on the east and northeast wall particularly, that the character of the crater has undergone a change. Along the descent on the second ledge, large

masses of rock, many more than one hundred tons in weight, obstruct the path and form abutments to the stone pillars—small buttress hills, similar to those observed in front of the high basaltic wall in Koolau, Oahu. So also in the deep crater itself, the eastern wall has lost much of its perpendicular dip, and has become shelving in part.

The crater itself was entirely devoid of liquid lava; no incandescence anywhere; pitchy darkness hovered over the abyss the first night. I say the first night, because during the second night of our stay, between twelve and one A. M., detonations were heard again, and light reappeared for a short time in the South Lake. White vapors of steam issued from the floor in a hundred places, but of those stifling, sulphurous and acid gases formerly so overpowering in the neighborhood of the lakes and ovens, only the faintest trace was perceived. The heat was nowhere so great over the bottom that we could not keep our footing for a minute or more, although in many places it would forbid the touch of the bare hand. The great South Lake is transformed into a vast pit, more than five hundred feet deep, the solid eastern wall projecting far over the hollow below, while the remaining sides are falling off with a sharp inclination, and consist of a confused mass of sharp *aa*. More than two-thirds of the old floor of Kilauea has caved in, and sunk from one hundred to three hundred feet below the level of the remaining floor. The depression embraces the whole western half, and infringes in a semicircular line on a considerable portion of the other half. It is greatest in the northern and rather gradual and gentle in its southern portion. Entering upon the depressed floor from the southern lake, it was some time before we became fully aware of its existence. It was only on our return from the northwest corner, where it is deepest, that there presented itself, through the mist in which we were enveloped, a high wall of three hundred feet of grotesque and fantastic outlines. At first we were quite bewildered, fancying that we beheld the great outer wall of the crater. On nearer approach, we soon satisfied ourselves that this singular wall represented the line of demarcation of a great depression in the floor of the crater, a fact that surprised us the more, as a bird's eye view from above had altogether failed to apprise us of its existence.

As we had been informed that the principal activity of the crater before the great earthquake had been in the northwest corner, we proceeded in that direction on leaving the south lake. Having arrived at about the middle of the depression, a considerable rise in the ground presented itself on our left—to the west. Having ascended this, we found ourselves at the

brink of a fearful chasm, which fell off on our side with a beetling wall to the depth of several hundred feet, and extended about half a mile from north to south. Very hot air rose from it. Around it, toward its northern extremity, the lava is thrown up into an indescribable confusion; pile upon pile of *aa*, gorge and ridge by turns.

The caving in of the floor seemed to be still in progression, for twice during our exploration of the crater our nerves were disturbed by a prolonged heavy rumbling and rattling noise, as from a distant platoon fire of musketry, coming from the northwest corner. * * * * *

Thus far as to what we have seen. Now allow me to relate what I learned from Kaina, who has resided near the volcano without interruption for the last five months, and whose strong nerves sustained him during the fearful catastrophe introduced by the earthquake of April 2. He and the Chinaman who keeps the house, were the only persons who remained at Kilauea. He says for two months preceding the first shock, viz: from January 20 to March 29—the crater had been unusually active, eight lakes being in constant ebullition and frequently overflowing. During all this time (the date of its first appearance could not be ascertained exactly) there was in the northwest corner a "blow-hole," from which, at regular intervals of a minute or less, with a roaring noise, large masses of vapor were thrown off, as from a steam engine. This ceased about the 17th of March. At the same time the activity of the lakes became greatly increased, and Kaina anticipated mischief. March 27 the first shock was perceived. Two days later, Mr. Fornander found the bottom of the crater overflowed with fresh lava and incandescent.

Thursday, April 2, at a few minutes past four P. M., the great earthquake occurred, which caused the ground around Kilauea to rock like a ship at sea. At that moment there commenced fearful detonations in the crater; large quantities of lava were thrown up to a great height; portions of the wall tumbled in. This extraordinary commotion, accompanied with unearthly noise and ceaseless swaying of the ground, continued from that day till Sunday night, April 5, but from the first the fire began to recede. On Thursday night it was already confined to the regular lakes; on Saturday night it only remained in the great south lake, and on Sunday night there was none at all—Pele had left Kilauea. The noises now became weaker and were separated by longer intervals. By Tuesday, April 7, quiet reigned in Kilauea. On that afternoon the lava burst out at a distance of forty miles southwest, in Kahuku.

In Kapapala we were told that fire had been seen several nights in a southeast direction, and that natives had reported flowing lava there. We rode over on the morning of April 20. At a distance of five miles from Mr. Reed's dwelling, where the Puna road turns off from the Kilauea road, heavy clouds of white vapor were seen to issue from the bush, which sparsely covered the *pahoehoe* south of the road. Half an hour's ride brought us up to the place, but we were obliged to leave our horses some distance before reaching the spot, on account of fissures. After having crossed a number of them, heading for the heaviest cloud of vapor, we at last came to a deep crevasse in the *pahoehoe* at least twenty-four feet in width, no bottom visible. It narrowed and widened out in places, but nowhere was less than eight feet wide. Its length was estimated at four hundred feet. Parallel with this great crevasse, constituting a belt about six hundred feet in width, were a number of smaller ones on each side, diminishing in size with distance from it, from six feet to a few inches. From the larger openings in the former, heavy white columns of hot steam issued, which had a decidedly alkaline smell. Smaller jets of vapor, to the number of thirty, rose from the smaller fissures. We could not discover fire in any place, but it is very probable that during dark nights the reflection of the underlying lava should be thrown up; for as the steam did not seem to contain combustible material, it is unlikely that the light seen should have been produced by it. The mean direction of all the fissures was northeast nine degrees north, southwest nine degrees south, or nearly the direction of a line connecting Kilauea with Waiohinu and Kahuku. The distance of these fissures from Kilauea is thirteen miles.

Since the earthquake of April 2 reached its greatest intensity in this district, so as even to rend in twain the framework of a mountain and hurl down on the plain a portion of its flank, it is necessary to give a short description of the country in order to insure a proper understanding of the disturbance. The locality in question is that comprised between the ranch station of Messrs. Reed & Richardson, on the east, and Mr. F. S. Lyman, on the west, a distance of five miles. The government road connecting these two places runs through a fine grassy plain, which has a very gentle fall toward the sea, its elevation being about two thousand feet. Into this plain project from the slope of Mauna Loa three parallel hills, or spurs, each about one mile in length, and from eight hundred to one thousand feet in height. They include two broad valleys between them. The upper portions of these valleys rise with a steep inclination toward a ridge which runs at right angles with

the spurs, and is covered with a dense pulu forest, which extends far up the gentle slope of the dome of Mauna Loa. In the second one of these valleys—that next to Mr. Lyman's—the so-called *mud flow* took place; but very extensive landslides, confined simply to the loose earth and conglomerate, also occurred in the other valleys.

The ground around Reed & Richardson's station is intersected by numerous small cracks and fissures, running in every direction * * * * The magnitude of the force was such as to shake off the face of the pali, burying in a minute thirty-one human beings, many hundred head of cattle, entire flocks of goats, and ending four miles from its beginning in a mighty river of mud. Before reaching this mud flow, from Reed's house, we passed two considerable streams of muddy water, of a reddish yellow color, emitting a strong odor of clay, such as may be perceived in potteries. Both streams have their origin in the landslide of the first valley. When we passed them again, two days later, they had nearly disappeared. They evidently owed their origin to the drainage of the fallen mass. The mud flow is met with three miles from Reed's. It projects itself from the spurs of the hills two miles down on the plain; begins at once with a thickness of six feet, which, toward the middle, where it forms a small hill, rises to thirty feet, averages about three-fourths of a mile in width, and contracts toward its end. From this end a long cue of boulders bears witness to the violent action of a torrent which shot out of the mud after it was deposited, and which has since perpetuated itself in a stream of some size, quite muddy, and emitting the above mentioned pottery odor, when we saw it first, on April 20, but perfectly clear and inodorous when we passed it three days later. A little higher up, a koa grove gives still stronger evidence to the strength of the propelling force. The trees first seized are snapped off and prostrate, yet the mud in that place is only a few feet deep. The mass itself is nothing but the loose red soil of the mountain side, with a good sprinkling of round boulders, with here and there stumps of trees, ferns, happuu and amaumau and entire lehua trunks. Near the lower end, a vigorous, healthy taro plant stood erect in the mud, as if it had been planted there. From its sides protruded portions of the bodies of many cattle and goats, overwhelmed in their flight; a gain of one second in time might have saved them. The surface of the mud in this lower course was rather smooth, as if it had been forced down by the agency of water, and it was still so soft that the feet sank deep into it. After we had flanked it for some distance along the side of the hill, the mud became solid enough to bear our weight, and we walked upon it to the head of the pali. The surface gradually

became more rough; the boulders increased, and detached portions of earth and stone were scattered beyond its borders, which also flattened out gradually. The ascent soon became steep, and here, on a short spur, just in the middle of the mud, stands a native house on an island of grass and taro, flanked by two trees. A poor woman who happened to be in it at the time of the outbreak escaped the awful fate which doomed the remaining members of her family, and was removed from her perilous situation a few days after, when the crust had become solid enough to bear a man's weight.

As we went on, the mass became more rough and hard, tree trunks and boulders increased, even angular rocks appeared, until, at last, the mud ceased entirely, and gave place to a sea of huge rocks, all angular and exhibiting fresh fractures, large trunks of trees crushed between and under them, and streamlets of fresh, clear water, meandering between them. This continued for the last three hundred feet of rise, and ended in a perpendicular wall of solid rock some twenty feet high, after having climbed which, we reposed under the refreshing shade of tall fern trees, for we had entered at once the great pulu forest. Seated on the trunk of a prostrate tree, we could survey the whole field of devastation we had just traversed. Immediately at our feet the rocky framework of the pali was torn up, and its contents turned topsy-turvy in dire confusion. The rocky wall we had just climbed continued itself, until it reached the sides of the two flanking hills. A perpendicular cut in the side of the latter laid open some forty feet of red earth and conglomerate. Looking behind us, we saw that the rock we were resting on was separated from the mountain by a deep crevasse, parallel to the wall and only partly visible, as it extended under the dense trees. To our left, a clear, sparkling mountain stream leaped in a bouncing cascade over the crag, and after losing its course amid the maze of rocks, gathered itself again, flowing over the solid bed rock in a deep gorge cut in the mud. This stream had existed here before, but ere it reached half down the pali, became lost in the soil. It can easily be imagined what an amount of subsoil water must have been deposited here. Bearing this in mind, and the great depth of soil and conglomerate on this slope, as indicated by the cuts in the hill sides, there seems to be no great difficulty to explain how such enormous masses of earth, at first propelled horizontally through the air, hurled down the valley by the tremendous force which tore off the side of the mountain, should then have been seized by the propelling force of the now liberated subsoil water, and carried in a mighty stream far beyond the place where at first they were deposited.

On returning, we concluded to reach and follow the ridge of the hill flanking the stream on our left. Having arrived there, we could survey the extent of the landslides on the opposite side of the hill, which were considerable. From this place, our guide pointed out to us a human figure in the distance, moving slowly over the dreary field. It was a husband searching for the body of his wife. Our guide himself, poor fellow, mourned the loss of a wife, two little boys, and both parents. All slept their long sleep under that field of desolation. Following the crest of the hill, still covered with grass and wood, we were startled by the number of fissures and crevices intersecting it in every direction. In some places one was tempted to say, that more space was occupied by them than by the solid crust.

The direction of the solid rock wall and the *crevasse* in the forest, is northeast by north to southwest by south, nearly parallel to a line connecting Kilauea with the lava outbreak in Kahuku. The stream running from the mud-flow is likely to remain permanent, as it is a continuation of the mountain stream above, and now runs upon exposed solid bed rock.

All this destruction was the work of the great earthquake of April 2. During the five days preceding it, over one thousand shocks had been counted. On that afternoon, Mr. Harbottle, at Reed's with his men, was driving cattle across the hill toward Hilo when suddenly the earth shook violently, and a great detonation was heard behind them. Horses and cattle turned round involuntarily. The whole atmosphere before them was red and black. In a very short time this subsided—some say in one minute, others in five minutes—but a black cloud continued to hover over the scene for some time. A native, who resided less than half a mile from the scene and who had friends living on the hill, found courage enough to run to it, half an hour after the occurrence. He thrust his hand in the mud and found it cold.

From that Thursday to Sunday, the earth constantly rocked and swayed, the hills seemed to alternately approach and recede. Most people became sea-sick. Strange roaring and surging noises were heard under the ground. When the ear was applied to the earth, it would often receive a distinct impression, as if a subterranean wave struck against the earth's crust.

Another account states that Dr. Hillebrand had visited the scene of the Kahuku eruption, and had found that there was there a fissure ten to twenty feet wide, from which the lavas issued, instead of a proper crater.

5. *From the Hawaiian Gazette of April 15th, on the earthquakes of April 2d, in northern as well as other parts of Hawaii, and at the islands of Maui, Lanai, and Oahu.*

The whole island was shaken, but most violently along the western, southern and eastern flank of Mauna Loa, the damage extending from Kealakekua on the west to Hilo on the northeast. On the northern side of Hawaii, through Hamakua, Kohala and Kopa, the shocks, though frequent, were comparatively light, except the one on Thursday afternoon, but even this, though causing people to run out of their houses, did no damage to buildings. The Kohala plantation chimney and buildings were not injured. We believe that the immunity of the northern districts is owing to the mountains of Mauna Kea, Hualalai, and the Kohala Range which intervenes between them and Mauna Loa. It is believed that the Kohala Mountains are the oldest formation on the island, the volcanic fires having moved southward as successive portions of the island were thrown up.

At Kona the shock of Thursday was terrific. We are again indebted to Mr. Williamson for accurate observations of this and of the other shocks which visited that district. The vibrations are described by the residents as continuous for hours at a time, the windows and doors rattling with increasing and diminishing violence in response to the movements of the earth. A few buildings were thrown down, and the sea ebbed and flowed, leaving fish stranded on the rocks. The motion of the water was equal to about eight feet perpendicular. The people of this and the Kau district were made sick by the motion, the same as if at sea, with nausea and pains in the stomach and loss of sleep at night.

The great shock of Thursday afternoon, according to a letter from Judge Jones of Lahaina in the Hawaiian Gazette of the 8th, was felt at that place on Maui and lasted 90 seconds. It shook furniture, pictures, and walls, and the sea receded to a small extent about 5 P. M. The sea ebbed and flowed several times, the intervals between the successive flows 7 or 8 minute Similar shocks occurred on Lanai.

Still farther from the scene of eruption, on Oahu (150 miles from Hawaii) the earthquakes were slight. At 4 P. M. on Thursday, the first of them occurred. It was very light, and was noticed mostly by those inside of stone buildings. The majority of our people were not aware that a tremble had occurred. The motion was lateral and quick. The sea, as at Lahaina, was observed to recede and flow, but the disturbance was not great.

On Friday night we were visited again at 12:30, with another severe shock. The vibration was very perceptible, windows

and doors rattled, and many were awaked from their sleep. Another lateral shock occurred about 1 o'clock A. M., and two others before 3 o'clock.

The same shocks were noticed at Kaneohe, and one planter rushed out to look after his sugar house chimney; no harm came to it. Probably these shocks of Friday night extended over all of this Island.

[The fact that northern Hawaii was much less shaken by earthquakes than southern, the island Maui just northwest of Hawaii, feebly so, and Oahu only 150 miles distant, much more feebly, indicates that the source of the disturbance was situated directly beneath Mauna Loa, and not far (if at all) below the level of the part of the ocean's bottom lying within the Hawaiian seas, and that therefore it was eminently a local phenomenon.

The submarine rocks of the island, everywhere cavernous or somewhat loosely put together as common with volcanic accumulations, must have all cavities filled with water from the suberincumbent ocean. Mauna Loa, although nearly 14,000 feet high, and 3000 square miles in area, has only one or two surface streams over more than three-fourths of this area. As the writer observes in his Geological Report on the Sandwich Islands, the larger part of the moisture that falls annually upon the cavernous lavas becomes subterranean. Owing to the numerous vertical fractures and dikes that intersect the mountain to its base (each eruption in its history having been connected with one or more deep rendings of its sides), a portion of these waters may descend vertically to great depths, while the rest follows subterranean slopes, to emerge along the shores or beneath the ocean. (Submarine outlets of fresh water streams are common about all the volcanic islands of the Pacific.) It is to be noted further that the subterranean water-courses may have in some cases considerable size from under-ground erosion.

These facts appear to afford an explanation of the recent volcanic operations. As Rev. Mr. Coan observes, the abundance of rain during the preceding months may have been a predisposing cause. The vertical channels of the mountains, filled to the brim from the rains, would have brought immense hydrostatic pressure upon the deep-seated water-chambers below. The water may thus have been forced deeply into the hot rocks ; and there suddenly converted into steam, it caused new fissures, with attendant earthquakes, and opened passages to hotter fires; thence came vaster rendings of the mountain and severer shocks, and, as a natural sequence, all that subsequently took place. J. D. D.]