month's computation of the tides of Boston harbor, the differences in the heights rarely exceeded more than 0.1 of a foot, and in the times more than three or four minutes. These differences arose from a slight yielding of some parts of the machine from a lack of sufficient rigidity. This, however, could be mostly remedied at small expense, if thought necessary, by making some parts of it a little more rigid.

In a comparison of the results given by the machine for three months, of the tides of San Diego, Cal., having very large diurnal components, with the times and heights from observation, the average of the differences, taken without regard to signs, was 0.29 of a foot, and in the times about ten minutes. But these differences are due mostly to meteorological causes, changes in the winds and in the barometric pressure, which cause fluctuations in the mean level of the sea, and are due only in a small measure to imperfections of the machine. These are most conspicuous in cases where the tide-wave becomes very flat from the high or low water of any day being brought very nearly to mean sea-level from the effect of large diurnal components, or where the whole range of the tide is very small; but in such cases the times of maxima and minima are very indefinite, and the error is more in appearance than in reality.

The machine is now being used in the prediction of the tides for the tide-tables of the year 1885, and is in all cases first applied for each station to some year for which there are observations for comparison, and, with the exception of the slight defect referred to, is giving entire satisfaction. The capacity of the machine for doing work is at least that of thirty to forty computers, if these were to take into account every thing which the machine does. In fact, little more time is required than that which is taken up in recording the results.

NOTES ON THE LAVA-FLOW OF 1880-81 FROM MAUNA LOA.

The Hawaiian Islands are entirely of volcanic origin. The various islands appear very distinctly to be of different ages, the volcanic agencies still being continually active in the most south-easterly one, while in those to the north-west they have been extinct for a long period of time.

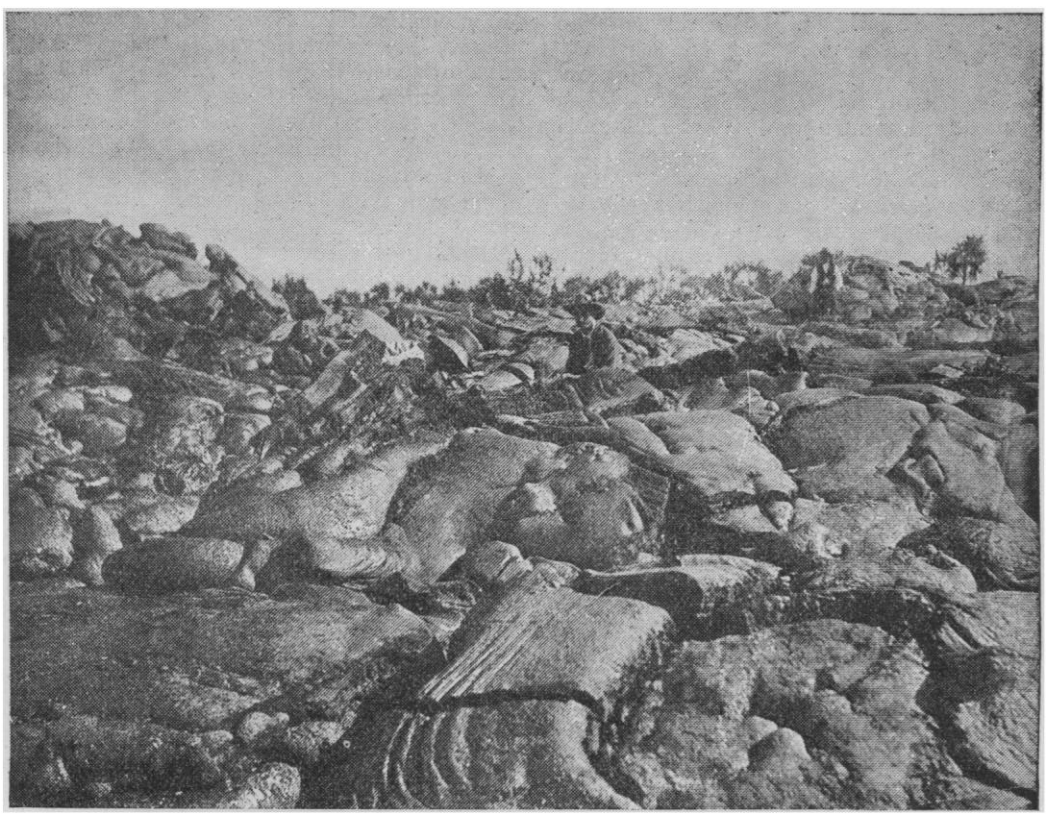
Hawaii, the largest island, situated at the extreme south-west of the group, has an area of about 4,200 square miles, being about twice the size of the state of Delaware, and not quite so large as Connecticut. It has four prominent elevations, each of which marks what is or has been a centre of activity. The Kohala Mountains, with an elevation of about five thousand feet, form the northern end of the island: though thickly covered with well preserved crater-cones, their activity ceased before the earliest traditions of the natives. Mauna Kea, the highest peak of the group, with an altitude of 13,825 feet, has also long been extinct. This lies to the south-east of the Kohala Mountains, on the eastern coast. Nearly opposite, on the western coast, is Mauna Hualalai, a little more than 8,000 feet in height. The last recorded eruption from this took place in the year 1801. When visited in the spring of 1882 by J. T. Perryman and J. S. Emerson of the Hawaiian government survey, steam was found to be issuing from several of the fissures on the summit.

South of the preceding three elevations is Mauna Loa, on whose summit, 13,610 feet above the sea, is the active crater of Mokuweoweo. The slopes of Mauna Loa are very gentle, and, when seen from a distance, the whole mountain appears like a gentle swell of land. On its eastern slope, at an elevation of about 4,000 feet, is the famous active crater of Kilauea. This is commonly regarded as a portion of the mountain of Mauna Loa; but it is in reality a separate mountain, though situated so near the other that the lavas from each have flowed together till the outline of this mountain has nearly been merged in that of the other. As seen from the upper portions of Mauna Loa, the individuality of Kilauea is clearly apparent.

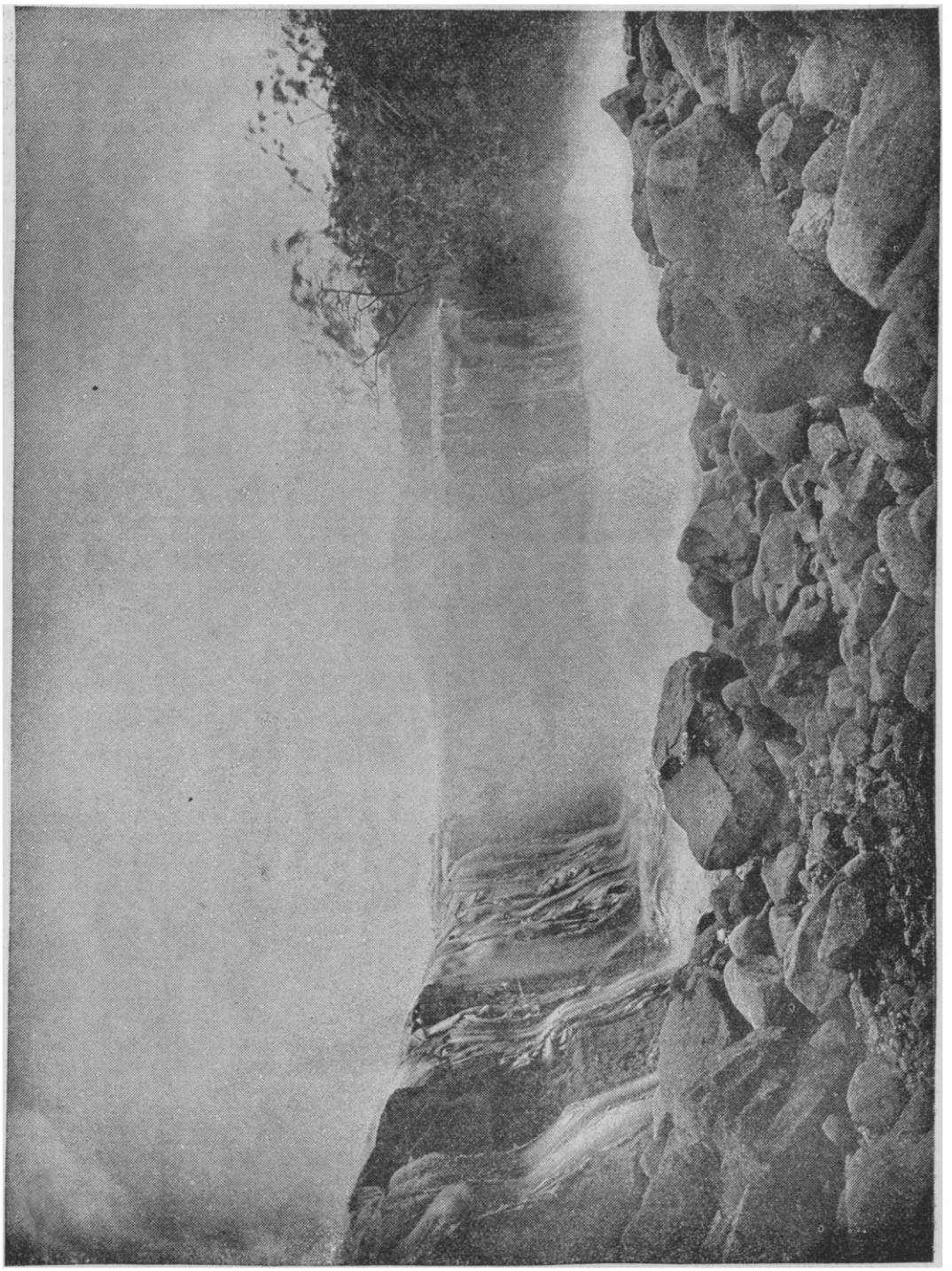
During the last hundred years many flows of lava have taken place from both these mountains; all bursting forth from the sides approximately near the summit, but none coming from the crater itself. These have been well described by Rev. Mr. Coan of Hilo, Hawaii, by W. T. Brigham of Boston, and others.

On the 6th of November, 1880, the latest of these flows burst from the north-eastern side of Mauna Loa, at an altitude of about 10,000 feet. From this point it gradually passed down the slope of the mountain, at first toward the north-east; then, making a sharp bend, it flowed for some distance toward the south-east, and then, once more making a sharp bend, took a course directly toward Hilo, a small but pretty village on the eastern coast. The first portion of its course was over a country composed entirely of naked lava above the limits of vegetation. It then entered the belt of forest which skirts the mountain with a

width of seven to ten miles. Through this it slowly ate its way, making a clear, clean path, and finally appeared on the lower side within five miles of Hilo. When within less than two miles of the village, it divided into two branches, one still continuing directly toward the village, and the other taking a course toward the Waiakea sugar-mill, which is about one mile south of Hilo. Finally, in the middle of August, 1881, the flow suddenly ceased, when the Hilo branch was just one mile from the town-house, and the Waiakea branch thirty-six hundred feet from the mill. It had then been flowing a little more than nine months, and had passed over a distance of about forty-five miles.



I arrived in Hilo on the 8th of September, 1881, and immediately visited the flow. This was about three weeks after its cessation, but I found it still very warm. Standing on Halai, a small crater-cone near its lower extremity, nearly its whole length could be traced by the steam arising from it after a shower. I found its surface to be seamed with cracks and fissures in all directions. Some of these were mere cracks, while others were six and eight inches, perhaps more, in width. This made walking over it rather difficult. There are two common forms of lava known there, — the *pahoehoe* (satin) and the *a-a*. The former, which is far the more abundant, has much the appearance of folded satin, and usually spreads out in broad, level fields. Sometimes it swells up through some hole in the surface, and forms large dome-like masses. The above view gives a very fair idea of this variety of lava. The *a-a*, which forms only a very small portion of this flow, is very rough and jagged, and is almost impassable, being totally so to horses. An adequate description of this peculiar formation is impossible. It must be seen to be appre ciated. I have as yet seen no adequate explanation why lava sometimes takes this form. Analyses show the chemical constitution of the two varieties to be about the same. It seems to occur, without any particular reason, at various points on the flow, in areas varying from a few rods to an acre or so. In its pas-



A CATARACT OF RED-HOT LAVA FALLING INTO A POOL OF WATER.

sage through the forest, the flow encountered trees of all sizes, to a yard or more in diameter. Flowing around these, it solidified sufficiently to retain a complete mould of the trunks before they burned off. By means of these upright moulds or wells it is comparatively easy to measure the depth of the lava at any point throughout this portion of its length. This I found to average about twenty feet, though varying very much in particular instances, according to the nature of the surface over which it flowed.

As their trunks burned off, the trees fell upon the surface of the still plastic lava with sufficient force to impress upon it a mould of a portion of their outline.

In both the vertical and horizontal moulds a peculiar impression was made upon the surface of the lava in contact with the tree. It took on a honeycomb structure, presenting a series of indented squares. The cause of this peculiar form I have been unable to determine. The indentations are certainly not the impression of the bark of the trees, and they are altogether too regular to be the result of the expansion of gases.

The general structure of the flow, throughout its entire length, is that of a long, central tunnel with numerous lateral branches. Flowing lava cools very rapidly, — indeed, so quickly, that I have often passed over the surface of that which I had seen flowing fifteen minutes before. Being a good non-conductor, the heat of the inner portions is long retained after the surface is once solidified. In this way a long central tube is formed, from the lower end of which the lava continually flows, while it continually extends the length of the tube. The pressure along the tube is constantly becoming too great for its sides to bear, and lateral off-shoots are formed, increasing the width of the flow. These lateral tunnels usually fill up, and finally become solid. The central tunnel, however, remains hollow throughout a large portion of its length, and may often be traversed for long distances after the flow has become cool. On my first visit to the flow, the top of this central tunnel had fallen through in many places, and I was able to look into it for some distance; but in every case I found the heat still too intense to allow me to descend into it. At later visits this became possible. The roof is commonly rough, a broken surface of lava, but in many cases is smooth and shiny, and covered with numerous stalactitic forms, seldom more than an eighth of an inch in diameter, but often having a length of five and six inches.

The stalagmite form was very rare, and only in one case did I find any of large size. In this instance the lava had flowed over a small precipice in a sheet in such a manner as to leave an opening between the sheet and the face of the precipice. Directly at the foot of the precipice were two peculiar stalagmitic forms made of drippings of lava about a quarter of an inch thick and three and four inches long. The larger of these was about a foot in height; the smaller, not more than half that size. These had evidently been formed by the lava covering a small spring, the steam generated from which had kept the lava above in a semi-plastic condition for some time. These specimens attracted much attention, as nothing of the kind had before been found. They may now be seen in the museum of the Boston society of natural history.

Owing to this peculiar property of lava to form tubes for itself in which to flow, it has the power to flow over small elevations, thus presenting the phenomenon of a liquid flowing up hill. It has the power to continue this till the pressure becomes too great for the strength of the sides of the tube.

The opposite view is from a photograph taken on the spot during the flowing of the lava. It shows the lava in the act of flowing over a precipice about fifteen feet in height. Each of the small streams seen trickling down the face of the rock is red-hot lava. This illustrates the fact that lava flows at the steepest angles, which is sometimes questioned. In this view the lava is flowing into a small pool of water, the resultant steam from which is seen arising like the mist of a cataract. This depression was afterward so entirely covered by the lava, that at my visit the spot could not be distinguished.

It would be interesting, if possible, to give an approximate estimate of the amount of lava which was forced above the surface during this eruption; but with the present data it is impossible. No survey of the flow has been made, and it is exceedingly difficult to estimate its dimensions by the eye. As a very rough estimate, I should place it at something more than five hundred million cubic yards.

GEO. H. BARTON.

THE STATE OF EXPLORATION IN AFRICA.

THE exploration of the dark continent continues with unabated vigor, in spite of the occurrences in the Sudan which nevertheless, in the form of disturbing rumors, must, even at a considerable distance, exercise an evil influence upon the native population.