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A SHARP QUICK ERUPTION

DIAMOND HEAD PILED UP IN HALF AN HOUR.

Dr. Bishop in the American Geologist Seeks to Prove it by Figures—Errors of Dr. Dall.

The leading article on the American Geologist for January is an article entitled "Brevity of Tuff-Cone Eruptions" by Dr. S. E. Bishop of Honolulu. The article is one of local as well as of scientific interest and is here reprinted by permission.

Tuff-cones, of which a number have been formed on the eastern coasts of the island of Oahu, are produced by the class of eruptions distinguished as "explosive." The semi-liquid tuff has been projected in a jet or fountain to a considerable distance and having been driven laterally by the expansion of the steam and other gases contained, has fallen at some distance from the vent, building up a cone with a more or less regular rim enclosing a concave bowl. All the explosive eruptions actually observed seem to have occupied a very brief time. The greatest one, that of Krakatoa, was probably less than one hour in actual duration, although the fall of its lighter ejecta continued for several hours.

It therefore seems remarkable that an opposite opinion should have been expressed respecting the eruption which produced Diamond Head. This typical tuff-cone, lying in the suburbs of Honolulu, bounds our ocean view to the eastward. It was recently examined by Doctor W. H. Dall of the Smithsonian Institution with especial regard to the age of the fossil shells found in its debris. In the "Bulletin of the Geological Society of America," Volume II, pp. 37-60, Dr. Dall expressed conclusions respecting the age of the crater, which I feel obliged to controvert. He says:

"The conclusion to which I came was that the whole mass of Diamond Head had been slowly deposited in comparatively shallow water and gradually elevated without being subjected to notable flexure. The ejection of material at first must have been intermittent with long quiescent periods to enable the shore to have become repopulated with mollusks and corals." A good picture of Diamond Head appears opposite page 40 preceding.

It is necessary here to remark upon two serious errors of observation committed by Dr. Dall. It is true that Diamond Head was deposited in shallow water, its center being about one mile outside of the existing shoreline. I undertake, however, to question the idea that it has since been "gradually elevated." Such elevation if it occurred must have been some 200 feet to have exposed what he calls a marine formation on its seaward base. Dr. Dall should have observed the total absence of marine erosion around the sides of the cone, upon the soft material of which the action of the waves would have been extremely destructive. There is also no trace of such erosion around the evidently older tuff-cone of "Puhimau," four miles away, nor elevated beach marks along the neighboring mountains.

Dr. Dall's second error of observation was in attributing a marine origin to the mass of material lying against the seaward base of the crater. This mass is composed of mingled small angular fragments of tuff fallen from the heights above, with large quantities of calcareous beach sand. Pervading the mass are numberless laminated calcareous concretions, which Dr. Dall has mistaken for coral reef. These fragments and concretions are identical with those forming the interior structure of our numerous calcareous sand dunes. The layers constantly vary in angles of dip, corresponding to the formerly varying surfaces of the dunes. Had the tuff encased in the present position the action of the waves, so far from retaining its angular forms, it would immediately have been ground into soft mud.

The whole mass is of Aeolian formation. It is simply a great sand-dune. The contents have been assorted by the wind the eastern end being composed of the finest and lightest tuff, and the western end, one-third mile away, mainly of sand much triturated, and stained by the brown tuff. The mollusks of Tertiary age enclosed in the mass, as found by Dr. Dall, may be fully accounted for as having fallen from the heights with the tuff. They were torn off from the ancient submerged reefs and beaches traversed by the shaft of the eruption. I have found large shells embedded in the laminated tuff at Koko Head, as well as corals. Further evidence is found in the fact that the tuff encloses in its interior between the crusts in great numbers side by side with the marine shells. Both fell together from the cliffs above.

My main contention, however, is to prove the absolute impossibility that a crater like Diamond Head should be a product of "intermittent" eruptions, or "quiescent periods," even brief ones, or that it could have been "slowly deposited." I propose to prove that a cone of such peculiar form and structure could have been created only by an extremely rapid projection aloft of its material completed in a few hours at most and ceasing suddenly and finally.

My first proof of this conclusion is derived from the extreme regularity of the elevated circular rim of this cone, such as could be the result only of a single rapid, uniform, uninterrupted outflow of the tuff. Two-thirds of the elevated perimeter is part of an almost perfect circle of about 5,000 feet diameter, and of a comparatively uniform height, about 450 feet above sea-level. The tuff is piled up in this regular ridge, originally rounded on its top, in very uniform quaquaversal layers or laminae, whose steepest dip on the outside is about 32° and much less on the inside of the broad bowl. The great subaerial erosion discloses the interior structure of the rim, although it has not obliterated the really delicate symmetry of the original form.

The southwest third of the perimeter of the crater is massive, and of the present height of 762 feet. It is severely wasted by the impact of storms, and was once probably 1,000 feet high. The original rounded summit must have been considerably to seaward of the present sharp peak. The original form may be best understood by comparison with those of Koko Head and of Lehua Island, which are of somewhat similar form and dimensions, but remain substantially unaltered in their rounded summits. The immense enlargement of the southwest portions of these craters, as well as of many others is undoubtedly correctly attributed by W. L. Green to the action of the strong trade winds deflecting to leeward the lofty jet of tuff, and piling it up disproportionately on that side.

With due allowance for the single disturbing influence of the wind upon the summit of the mighty fountain, it is evident that the very perfect symmetry of the main portion of the rim could have been produced only by an extremely regular fall of the spreading fountain of ejecta at a uniform and unvarying distance from the vent. Any interruption or intermission would have so

disturbed that precise uniformity of projection as to have piled the falling tuff in irregular positions. The beautiful symmetry of its sudden and rapid formation. It forbids any other conception.

My second evidence of the brevity of the eruption which created the crater-cone is derived from an arithmetical computation of the time required to deposit the actual mass of the cone by a fountain of adequate height to deliver its ejecta upon the existing rim of the bowl. Data are easily secured for a sufficiently approximate estimate of the time to show that it could have occupied a very few hours at most. Let us first compute the solid contents of the tuff deposited. The average diameter of the bowl is about 5,000 feet. Two-thirds of the perimeter is 450 feet high, to which 50 feet may be added on account of the average depth of sea at the distance from the shore where the eruption occurred. The outer third of the perimeter was occupied by a conical mass probably 1,000 feet high, but standing in perhaps 250 ft. depth of sea. Estimating this cone as 1,250 feet high with 5,000 feet diameter of base, its solid content would be about 8,000,000,000 cubic feet. Such an altitude of the other two-thirds of the perimeter would be about 5,000,000,000 cubic feet, making with the cone a mass of 13,000,000,000 feet of tuff in the entire crater.

A similar result is obtained by assuming a base equivalent to 5,000 feet square, and an average height of 500 feet, which gives a solid content of twelve and a half billions of cubic feet. It is evident that such an estimate is sufficiently large.

Now, to have ejected the whole mass in five hours would have required an average height of a solid column of half billions of cubic feet of tuff in an hour, or of 694,444 feet in one second. Supposing the vent to have a sectional area of 2,000 feet, which I believe to be much too small, the velocity of emission would be only 347 feet in a second, which is equivalent to a theoretical height of only 1,300 feet of projection aloft. It is evident that this is totally inadequate. Assume then only two hours' duration of the eruption. This gives us 875 feet of velocity of emission equivalent to a height of projection of 1,925 feet. Such an altitude of the fountain might be adequate to the actual distribution of the ejecta to an average distance of 2,500 feet from the vent. But it must be noted that the height attained with the assumed velocity could hardly be more than two-thirds of the theoretical one, on account of the resistance from the falling tuff encountered by the ascending jet. It is also evident that the fountain must have been a very lofty one for the tuff to have been driven a mile to the seaward by even a heavy gale, as so much of it was done in building up the massive cone.

The real area of the vent can be less accurately estimated. The partially exposed vent of the neighboring crater of Punch Bowl is apparently fully a hundred feet in diameter. The only completely open vent of the kind which I have seen is that of Kalaupapa at the leper settlement on Molokai. This is a rocky well with vertical sides reaching down to salt water, which is 800 feet deep. The diameter of this well or shaft was, as I remember it, from 100 to 150 feet. Guided by these data I should consider 5,000 square feet as a very conservative estimate for the sectional area of the shaft from which issued the tuff of Diamond Head, instead of the 2,000 feet assumed above. Such increased area would reduce the two hours' duration assumed, to 48 minutes. It would be much less if we allow a greater velocity of ejection, so as to get a height of the fountain adequate to allow of its extensive deflection by wind. I incline to the belief that the eruption did not last more than half an hour. It is absolutely impossible that it could have continued many hours.

These explosive eruptions are of gigantic force and brief duration. Honolulu, November 14th, 1900.

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TIME TABLE

From and After January 1st, 1899.

TRAINS

STATIONS (Outward) Daily ex. Sun. Daily ex. Sun. Daily ex. Sun. Daily ex. Sun. Daily ex. Sun.

Honolulu 7:10 9:15 11:05 8:15 10:10

Pearl City 8:03 9:45 11:40 8:47 10:50

Ewa Mill 8:57 10:45 12:00 9:45 11:10

Waialua 10:50 12:00 1:00 11:45 12:45

Kahuku 11:55 12:45 1:45 12:50 1:40

STATIONS (Inward) Daily ex. Sun. Daily ex. Sun. Daily ex. Sun. Daily ex. Sun. Daily ex. Sun.

Kahuku 6:35 7:35 8:35 7:30 8:30

Waialua 7:30 8:30 9:30 8:30 9:30

Waianae 8:25 9:25 10:25 9:25 10:25

Pearl City 9:15 10:15 11:15 10:15 11:15

Honolulu 10:10 11:10 12:10 11:10 12:10

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