Popocatepetl, and the Volcanoes of the Valley of Mexico: Discussion

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less solid scoriaceous rock, and not of loose cinder. I am unable, however, at present to suggest any other reasons for this peculiar structure.

While making my way over the 4 or 5 miles of exceedingly rugged lava which has flowed from this cone to Los Reyes, I was again much struck with a certain mechanical process which I have more than once suggested as the origin of the loose-boulder pyramids on which it was so frequently the habit of the ancient Mexicans to erect their sacrificial temples, or "teocallis." It is difficult in most cases to suppose that any original design led them to undertake the enormous labour of raising the great pyramids and mounds with this small material.

Owing to the fertility of the decomposing lava, every opportunity has been taken on the San Pablo stream to clear and plant plots of ground amongst the rocks, wherever there is the least chance of so doing. These plots are naturally made square, or as nearly so as the surface will admit, and in clearing them the small boulders and stones are deposited in a heap at the nearest convenient spot. As the adjoining square plots increase in number around this spot, it becomes by common consent the depository of loose stones, and is also approximately square. Even as it increases in height, and the stones have to be carried up its sides, the labour is less than that of conveying them a long distance. Thus commences the construction of what may be described as an unintentional pyramid, which in the course of years may assume very large dimensions. It is easy to suppose that in early ages this may eventually have suggested its completion for the purpose of rearing on its summit a temple devoted to the worship of that sun to which the success of all this toil in cultivation was primarily due. On the lava-stream of San Pablo I found two or three such undesigned pyramids actually in course of construction, though doubtless they will never now be devoted to that object.

One can hardly dismiss the subject of Popocatepetl and its colossal neighbour Ixtaccihuatl without some reference to the impression created by the scenic aspect of these magnificent snow-summits under favourable circumstances. It would be hard, I think, to discover in the world a scene more sublime than is presented for an hour before and after sunset, from the terrace of the "Holy Mount" of Amecameca, facing the two great mountains. It is one for the enjoyment of which neither scientific nor technical knowledge is needed; and few who have witnessed it can recall it without an afterthought that for that one sight alone life has been worth living.

Before the reading of the paper, the PRESIDENT said: We had the pleasure last year of listening to a paper by Mr. Howarth on the Sierra Madre of Mexico. This evening he is going to give us what will be, I think, a very interesting account of Popocatepetl and the volcanoes of the valley of Mexico. I will now ask him to read his paper.

After the reading of the paper, the following discussion took place :—

MR. WILFRID AMOR: First of all, I have to offer my thanks to Mr. Howarth for his address. As regards the theory of the formation of the valley, I think there can be no doubt about it that the general idea of Mr. Howarth is perfectly correct. Nevertheless, I believe that there is some importance to be attached to the general fact that these valleys of Toluco, Mexico, and Puebla, and the valley of Morelia still further to the west, lie parallel to each other, and to the ridges between them, and are longer in the north and south direction than in the east and west. That seems to point out, I think, to their being formed by the crumpling up of the surface of the Earth in a general direction parallel to the Sierra Madre, Rocky mountains, and the Andes. A very interesting point is the question of the age of the rocks. He has pointed out that on the north and west of the valley of Mexico they belong to the older formations, whereas on the eastern and southern boundaries they belong to the Tertiary, or more modern formations; that might perhaps militate against the idea of all the valleys being formed by the folding and wrinkling of the surface. But I think, considering it a little more carefully, the antagonism will only appear to be superficial, because the masses of rock will be thrown out on the line of least resistance, and the cone of Popocatepetl would be, as Mr. Howarth pointed out, one of the more recent ones. Mr. Howarth has remarked that Ixtaccihuatl and Popocatepetl are both called volcanoes. It is only an instance out of many in which the original words in Mexico have lost their true meaning. To the average Mexican in Mexico, "volcano" means "a snow-capped mountain" more than a vent of volcanic action. Thus the mountain of Colima is known as Volcan de Fuego, others are called volcanoes. Another interesting point is, that the crater is inclined towards Atlixco, and the inclination, in so large an opening, deludes those who ascend the mountain into the belief that they have reached the summit when they have attained the lower lip and look over into the crater, whereas there still remains a long climb. With regard to the nature of the soil in the valley of Mexico, there are some remarkable points which I don't think have been put on record before. One is the extreme lightness of the soil of which the valley is composed. I had occasion to have a cubic foot weighed on several occasions in different parts of the valley, and it was found that at from 1 to 5 metres in depth, the weight of 1 cubic foot was 73 lbs., and only 57 lbs. when dry. It shrank about one-eighth of its volume; so really the specific gravity was practically the same as water, between 62 and 64 lbs. At 5 metres' depth, the weight of the material was only 47 lbs., which is lighter than water, and it shrank $5\frac{1}{2}$ inches in depth over the whole cubic foot, very nearly one-half, and then the weight of the remainder was 21 lbs., which would make the cubic foot a little less than 40 lbs., two-thirds of the weight of water. This material extends to the depth of about 60 metres, as has been found out by sinking artesian wells. It is well known that the earthquakes or earth-tremors were very frequent and severe in the valley of Mexico before twenty-five years ago. They have become very much less frequent and very much less serious ever since artesian wells were sunk in the valley. Finally, I have in my hand a rather curious specimen. It is an egg that was found at a depth of $4\frac{1}{2}$ metres in the valley of Mexico. I don't profess to know what species it belongs to; it is not a fossil, but it was found with four others, three of which were sucked by the Indians who discovered them, and it was perfectly full of liquid at the time and very heavy. Now it feels more as if it had been blown; but, as will be seen, it has no pin-holes. The moisture gradually evaporated in that very dry climate. The remarkable fact is that the egg was found at a depth of $4\frac{1}{2}$ metres, and at a depth of 1 metre there is throughout the valley a hard layer of marl, of varying hardness and

thickness, from 6 to 18 inches, and the hardness is such that in some places it requires a pick to dig it out, while at other places it crumbles in the hand. In general it is very hard. This egg was found 2 or 3 metres below that hard layer. At a point not 20 kilometres from where this egg was found, above the marl, there has been discovered the perfect skull of a mastodon, besides other remains. Now, that would indicate that this egg was laid long before the mastodons had left the neighbourhood, and I believe the species still exists from which this egg came. Its age I leave wiser heads than mine to discuss.

Father JOHN GERARD: I am afraid I cannot say anything on my own authority about the egg, but I took it down to Mr. Bowdler-Sharpe, and, after some investigation, we came to the conclusion that it is the egg of the *Pelicanus erythrorhynchus Americanus*. The American pelican is still extant, but, it would seem, was in existence before the mastodon became extinct. The appearance of the egg tends to show that it was originally laid in a salt marsh, and I fancy the saline liquid found in the egg was water from that salt marsh. Mr. Amor mentioned to me, that as it evaporated it did so with a hissing sound, which he heard in the drawer in which it was kept. It can scarcely have been the original yolk and white which the Indians sucked.

Mr. GEORGE T. PRIOR: As Mr. Howarth has been good enough to place under our keeping at the Natural History Museum many of the rock specimens which he collected in Mexico, I need scarcely say that I have listened with great interest to the paper to-night, in which he describes the geographical features of the country from which those specimens came. As I have never had an opportunity myself of visiting Mexico, the few remarks I should like to make must be purely from the museum point of view, and rather of petrological than geographical interest. First, by way of mild criticism, I cannot help thinking that Mr. Howarth is inclined to lay just a little too much stress upon the differences in outward aspect which he noted in the field between what he calls the older porphyries and the more recent lavas. From an examination of the hand specimens which we have at the Museum, I cannot help concluding that the so-called porphyries are lavas, equally with those of Popocatepetl. As Mr. Howarth has pointed out, they certainly present striking differences in outward aspect, but they both belong to that type of igneous rock, to which the name of andesite has been given, owing to its prevalence in the Andes. They differ, however, so far in chemical composition that the lavas of Popocatepetl are more basic, dark, and somewhat glassy hypersthene-andesites; while the lavas of Ixtaccihuatl are lighter and more porphyritic, horn-blende andesites. Of course, I cannot say anything as to the relative ages of these two lavas. Mr. Howarth may perhaps be able to give us a little more information on that point. The ridge-like appearance of Ixtaccihuatl, and the absence of any definite crater, suggest that its lavas may possibly have been erupted by a quiet fissure eruption, somewhat similar to that which gave rise to the enormous lava-flow from Huasco, described by Mr. Howarth. In this connection, it may be of some interest to mention that in earlier stages of the Earth's history there have been flows of lava beside which this Huasco flow sinks into insignificance; for example, the Deccan basalts of India attain a thickness of about 4000 feet, and are estimated to cover an area of 200,000 square miles. Before I sit down, I should like to say that at the Museum we owe a debt of gratitude to Mr. Howarth for the great trouble he must have taken in collecting and bringing home the excellent specimens which are now deposited in the Museum. I shall be only too glad to show them to anybody who may be induced by the interesting paper which we have listened to to-night to come and see them.

The PRESIDENT: We have to thank Mr. Howarth for an exceedingly instructive

paper, suggesting a great number of very interesting points, but I wish, before proposing a vote of thanks to Mr. Howarth, to make a few remarks on the subject of the first recorded eruption of the great volcano of Popocatepetl. I understood Mr. Howarth to say that an actual eruption of fire and red-hot stone had not taken place for many hundreds of years. Now, that charming old writer, Bernal Diaz, a soldier in the army of Cortes, describes with great minuteness the eruption the Spaniards saw from a short distance, when marching to Mexico. He says, "A great column of smoke rose straight into the air to a considerable height, and then spread out as a large cloud." But he also says, "With this smoke there was to be seen flame in various directions, red-hot stones being thrown up in great quantities and with violent explosions. The people," he says, "were terrified, not at the smoke, which was of very common occurrence, but at the flames and red-hot missiles flying out of the crater, which they had never seen or heard of before. They believed that the tyrants who had been cruel to them were being roasted in that volcano, and consequently they were horrified when they beheld these fiery tyrants flying out of the crater and spreading over the earth." When Diego Ordaz, a companion of Diaz, volunteered to examine the crater, the Indians whom he asked to come with him positively refused to go beyond a certain place, which they called the cave of their gods. There they stopped, while Diaz and his companions pushed on. When they got near they felt most violent tremors of the earth, accompanied by a pouring out of flame and missiles, and they hid themselves or sheltered themselves from its violence in some of the crevices of the rocks; but when this lulled they pressed onwards, and did reach the lip of the crater, looked down, and saw a mass of fire below, and it is particularly interesting that when they returned to Cortes with a report of this eruption, they brought with them some of those great icicles which Mr. Howarth has described. Now, with regard to the second ascent ordered by Cortez, which was conducted by Montano, we must recollect that Montano, so far as we know, never said he was lowered down 500 feet. The only person who said so was Don Antonio Herrera. If Montano said that he was lowered down 5 feet, Herrera would be quite likely to say that he was lowered 500 feet. I can see nothing extraordinary in the fact that, when ordered to collect sulphur, they may have been lowered down in a basket to scrape the inner surface. Bernal Diaz further mentions that there was a second great eruption twenty years afterwards, in 1539. I will not detain you longer with further remarks, but I am sure that the meeting will wish me to return most cordial thanks to Mr. Howarth for his interesting paper, and for the way in which he has illustrated it, and especially for showing us that gigantic tree at Oajaca, although, as he said, it has nothing to do with the volcano of Popocatepetl.

THE CENTRAL CAUCASUS.*

FROM time to time, while Mr. Douglas W. Freshfield was engaged in opening the Caucasus to European mountaineers, he has communicated to the Royal Geographical Society reports of his journeys, which have appeared in the Society's monthly publication; and his first visit was treated at greater length in 'Travels in the Central Caucasus and Bashan,' published twenty-seven years ago. Now when the fruit of his sowing has to a large extent been gathered in, and when relief from

* 'The Exploration of the Caucasus.' By Douglas W. Freshfield. With illustrations by Vittorio Sella. London: Edward Arnold, 1896. 2 vols. Maps and plates.