

in the surface (the floor in many cases being several thousand feet below the surrounding surface), whereas volcanic action forms a cone with a crater on top.

The meeting was then adjourned.

Reply to criticism on Captain Urquhart's paper on the Moon.

MR. TOMKINS' objections :—

(a) That the seas are almost similar in every respect to large flat-bottomed craters; and that, if bombardment is responsible for the latter, it must also have produced the seas.

The reply to this is—

(1) That we should expect large depressions on a globe to take a more or less circular formation.

(2) That the borders of the seas do not show a continuous rampart of a similar form to that surrounding the ring formations.

(3) That the surface of the seas show numerous relics of the earlier surface formations (*vide* Elger's "The Moon," p. 3), which shows that the older surface must have been depressed, probably owing to natural shrinkage of the globe, and its formations more or less obliterated by the overflow of the liquid interior. There are no signs of an earlier surface formation left in any of the large walled plains.

(b) That the great size of the bolides required to produce such formations makes it very doubtful if the Earth could ever have thrown them out, and that the supporters of the meteoric theory usually go outside the Earth to the Solar system for their meteorites.

I have already shown that there are at least two serious objections to the bolides having come from outside the Earth-Moon system :—(1) Such bolides would very seldom strike the Moon normally to its surface. (2) Their striking velocity would be much too great to produce formations of the kind we find on the Moon's surface.

The only objection that seems to me to have any weight is the doubt whether the Earth was capable of throwing out such huge masses. I have already shown that the size of the craters would be many times the size of the missiles which

produced them. Probably a mass of about 10 miles in diameter would be the utmost limit required for the largest crater. The upholders of the volcanic theory have no hesitation in allowing a volcanic vent of any thing up to 100 miles on a comparatively small globe like the Moon, while they would consider one of a few miles diameter impossible on the Earth. As to the idea that the forces necessary to shoot out such masses would wreck the Earth, what about the recent volcanic outbursts in Japan, when masses of rock weighing many tons were thrown thousands of feet into the air, falling many miles away from the volcano, yet these disturbances did not even affect the seismometers over here.

If such eruptions take place on the Earth in its old age, how much greater must they have been in its fiery youth? And what about the evidence of activity in the more youthful members of the Solar family, *e.g.*, Jupiter and Saturn?

(c) "That the chains of inosculating craters on the Moon could not be due to bombardment." I do not maintain that these were so formed, I believe that many selenographers (*vide* Elger's "The Moon," p. 17) hold that these are actually raised above the surface and are of the nature of volcanic cones. These crater cones are evidence of former volcanic activity, and show that volcanic energy produces on the Moon similar formations to what it does on the Earth.

The absence of water in any large quantities, as far as can be seen on the Moon, is against the idea of great volcanic activity, and where volcanic activity exists it gives a similar result to what we find on the Earth. If nature worked as quietly and smoothly as is imagined during the earlier ages of the Earth, why should it result in such violent convulsions on the Moon?

The idea put forward by Mr. Ridsdale that the smaller force of gravity on the Moon would account for such widely differing results of volcanic action, seems to me untenable, and I do not think there is any foundation for it, either on mathematical or physical grounds. We know that the effect of an explosive depends largely on the resistance which it has to overcome, and the smaller the force of gravity on the surface of a globe the less the eruptive force which would be generated.

Mr. Raman objected that the Moon having once been a part of the Earth must also necessarily have retained its volcanic nature, and that hence no other explanation is required of the surface formations. Even supposing that the Moon was once a part of the Earth (which I don't at all

admit), its volcanic activity would result in similar formations to what we find on the Earth, and I have already pointed out that we have evidence of this in the "crater cones." But this does not explain the huge *depressions*. If the volcanic theory could explain all the formations on the Moon there would be no necessity to search for other explanations. The formations are exactly of the kind that would be produced by masses of matter falling on the surface of the Moon, and the direction of impact and the regular velocity could only have resulted from masses thrown out by the Earth.

Mr. Simmons' objections do not apply to the bombardment theory as I have put it forward. There are no volcanoes on the Moon similar to what we find on the Earth with the exception of the comparatively small "crater cones."

The comparative (and largely imaginative) pictures of the district round Naples and a similar region on the Moon, look all right on paper at a casual glance, but unfortunately the most important feature is absent on the Moon—there is no *vesuvius*!

The fact that the fragments of a bolide following on the Earth arrange themselves in the form of an ellipse, does not apply to the ring formations on the Moon. There is no atmosphere to explode the bolides. Besides the depressions must have been produced by masses which arrived more or less intact, and not by meteoric dust.

A. M. URQUHART.

Correspondence.

10, QUEEN'S ROAD, BOMBAY,

The 1st March 1914.

DEAR SIR,

I have read Captain Urquhart's lectures, reproduced in the June 1913 and January 1914 numbers of the Journal, with much interest. It has occurred to me that the craters may be accounted for in the following way:—

We know that the Moon is not heavy enough to retain permanently any gases. Hence, at no stage of its existence can it have had an atmosphere of appreciable density. That is to say, its surface must always have been exposed, with hardly any covering, to the cold of space.