GEOLOGICAL SIGNIFICANCE OF METEORITES.

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THE recent arrival in Siberia of large crater-forming meteorites should certainly signal the beginning of a new chapter in geology as well as in meteoritics. This is the second great fall that has been recorded in the 20th century, which is not yet half gone.

Only 39 years ago occurred the devastating encounter between the earth and a group of large meteorites that flattened a forest and left numerous pits in the Tunguska region of Siberia. Now comes word that a similar, though smaller, collision has occurred at a point some 200 miles north of Vladivostock.

Thus for the second time in a generation we see demonstrated one of the important factors in dynamic geology, a factor that even down to the very present has been denied by some of the most prominent geologists. The one most outstanding example of this kind of phenomena, namely the great Arizona Meteorite Crater, has been singled out by one of America's most respected geologists less than a year ago in a statement that flatly denied its meteoritic origin.

Let us here remind ourselves that from earliest times those who have endeavored to explore the "mysterious heaven-stones" have always met with the barrier of intellectual lethargy. A well-authenticated witnessed fall, weighing about 250 lbs., was preserved in public buildings in Alsace, France, for more than 300 years while wise men scoffed at the idea of stones falling from space.

During those three centuries many other falls occurred and the witnesses to them made several attempts to convince scientists of the facts accompanying their arrival; but all to no avail. It was only after a veritable barrage of these spacial missiles had bombarded a thickly populated district in the province of Orne, France, at the village of L'Aigle, mid-day April 26, 1803, that orthodox French scientists grudgingly admitted the arrival of matter from space and began to propagate the idea that had been ably but unsuccessfully set forth by Troili in 1766[1] and Chladni in 1794.[2]

Since the L'Aigle shower active students and observers have recorded more than 600 witnessed falls involving many thousands of individual meteorites, and following the lines of least resistance modern "scientists" have passively accepted the fact. But after the fashion of the early American redman who is said to have advocated that small trees grew "but the Great Spirit made the big ones," certain geologists, while admitting the fall of ordinary meteorites still brace themselves stubbornly against the admission of crater-forming meteorites.

It has now been 56 years since the attention of scientists was first directed to the "remarkable geological phenomenon"[3] now generally recognized as a meteorite crater in Arizona. Since that time no fewer than eight other locations have been discovered aggregating more than 30 craters, the time of whose formation is not known. Even more impressive is the fact that during this time two considerable groups of craters have been witnessed in the process of formation in connection with the arrival of meteorites.

The brief span of 56 years is certainly not a sufficient period of observation to justify any conclusion as to the frequency of geological events. But the mere fact that twice in 39 years the land surface of our planet has suffered cosmic blows of such magnitude should surely give pause for thought.

The writer has often been regarded by certain geologists as somewhat of a radical in respect to meteoritical questions, yet in his most reckless moments he has never been prepared for such a record as we now must face. In 1943 he wrote . . . . . "Meteorites of 220 tons or more (but under 50,000 tons), one in 150 years for the land surface of the earth."[4] The present century indicates a pace about five times as great.

The rate of encounter which was set forth at that time also included "meteorites of 50,000 tons or more, one in 100,000 years for the land surface of the earth." More recent observations on the phenomena accompanying stony meteorites falls have led me to conclude that this type of meteorite characterizes the majority of large as well as small encounters; but that the stony masses are disintegrated by the atmosphere and do not therefore form craters in most instances. For example, the Pasamonte, New Mexico, fall[5] left a cloud of dust aggregating about 1000 cubic miles which was formed at elevations ranging from 17 miles to about 48 miles. 1000 cubic miles of air at 30 miles elevation represents a weight of about 3,000,000 tons. Only a few small stones from this fall are known to have reached the earth, but their texture is such that they may be rubbed away with the fingers.

The mass which invaded the atmosphere on that occasion must have comprised many thousands of tons. And had it been one of the firm varieties of meteorites it would have doubtless formed a considerable crater. But 17 miles of atmosphere lay between the level of its disintegration and the soil of the earth. This tremendous shock-absorbing cushion robbed it of nearly all of its violence. Nevertheless, detonations were audible over an area of 40,000 sq. miles and tremors were felt over much of this area. There are very good reasons for believing that in space Pasamonte was a greater meteorite than that which the Russian scientists now report landing in southeastern Siberia and possibly also larger than the fall of 1908 which was estimated at 40,000 tons.

Had the Pasamonte meteorite been of a metallic variety or even one of the more resistant stony varieties, it might have formed a sizable crater. As it was, all we can prove is that the massive cloud was formed in the upper atmosphere and that a few small stones were strewn over a strip of soil 28 miles in length. But almost certainly an enormous tonnage of minute particles were deposited over a much larger area.

The important point that we are trying to make is that here is a process, cosmo-geologic in nature, that must have played an important role in the history of our planet. One which we may observe in action, but which by its very nature of instant and unpredictable occurrence is difficult to make a matter of record.

FACTS CONCERNING THE ARIZONA METEORITE CRATER, ALIAS BARRINGER CRATER.

For the benefit of those who may have been influenced by the recent statement of Dr. N. H. Darton[6] to the effect that the Arizona crater is the result of a steam explosion, the writer wishes to set down certain facts.

1. This crater is characterized by a bi-lateral symmetry which is quite as pronounced as is its circularity. The Kaibab limestone, of which a thickness of about 200 feet is exposed, lies at a steep angle in both the east and west sectors of the

wall while on the north and south the beds are only slightly tilted. Also the southern sector shows a noticeable arching of the strata from east to west, while on the north the wall is low, showing a faulting downward of a considerable sector.

If there has been an explosive action, as the present writer believes, then the funnel-form result of that explosion has been superimposed upon the bi-lateral excavation that preceded it.

2. By the use of a magnetic rake designed to explore the soil to an average depth of three-fourths inch, the writer demonstrated in 1939 that meteoritic particles, 3 mm. in diameter and larger, are 22,000,000 times as abundant within a 2½ mile radius of the crater as they are in areas selected at random on the earth's surface. This survey also indicated a radiate distribution of these fragments.

3. It is of interest to note that four other areas have been found on the earth where small meteoritic particles are comparably abundant. And in about the middle of each of these areas are found craters which are essentially similar to the Barringer crater. To assume the accidental association of this multitude of meteoritic fragments with the Barringer crater one must face odds of millions to one. But to apply the same explanation to four other similar associations of meteorites with craters is nothing short of ridiculous.

4. Within a radial distance of seven miles from the crater a greater tonnage of meteoritic iron in masses of from one to 1406 lbs. each has been found than in all of the rest of the United States. Nickel-iron oxide of unquestionable meteoritic origin has been proved many times as abundant in the same area as is the metallic material. This oxide is often found enveloping metallic nickel-iron cores.

5. Many millions of tons of Coconino sandstone have been finely pulverized by a process that fractured a large percentage of its component sand grains. A portion of this has been fused into a pure silica glass pumice. Both of these products are unlike anything reported from proved volcanic craters.

6. No trace of true lava has ever been found around or in the Barringer crater, except fine cinders such as have been scattered by wind action over all of this and adjacent territory from the volcanic areas to the south and west.

7. Meteoritic material is mixed with the ejectamenta of the rim and not merely around the outside of it. Masses have been found down to depths of 27 feet in the excavations.[7]

8. According to Doctor Barringer and his associates in exploring the crater large chunks of nickel-iron oxide were encountered in each of the three drill holes that were sunk in the southern part of the crater and from the top of the south rim.[8] Although the logs of these wells are not good, I have been convinced by the study of them and by conversing with the engineers who were in charge of the operations that without doubt meteorites were encountered at depths of from 1191 ft. to 1376 ft. below the crest of the rim.

Nickel-iron oxide particles were also reported from 14 of the holes drilled in the central part of the pit. Quoting from Doctor Barringer: "This meteoric material, which invariably reacts strongly for nickel, was found in places quite abundantly, admixed with the fragmentary material filling the bottom of the crater."[9]

9. Seven drill holes sunk in the central area of the crater found undisturbed beds of red sandstone (redbeds) at depths of from 600 to 800 feet below the present floor.[10] This would seem incompatible with a steam explosion or other volcanic origin for the pit. If it be argued that a volcanic pipe comes up from the south in harmony with the bilateral form of the crater, then the advocate of the steam explosion hypothesis has the task of explaining why instead of lava in its throat we find a flock of meteorite fragments.

FURTHER CONSIDERATIONS.

Trusting that the recent pummelling of our planet will finally convince the doubting Thomases of the reality of the meteoritic factor in geology, let us look at the probable long range effects of this process.

There has never been cited any reason why we should assume that the Arizona crater represents the largest impact that our planet has been called upon to absorb. In fact there is good reason to assume that larger bodies ranging up to the magnitude of the planetoids have from time to time collided with the earth. A very near miss was sustained in 1937 involving a body estimated by astronomers to have been of the order of a billion tons. But other planetoids have encroached upon the earth's orbit which were much larger. It is entirely within the possibilities and by many is believed probable that bodies much larger than Hermes have buffeted the earth. Indeed, in the light of astronomical knowledge of the solar system, it seems inevitable that such encounters have occurred. Now what of the results of such collisions?

In the opinion of the writer such large-scale encounters have played an important part in the initiation of the crustal movements that have characterized the geological revolutions that stratigraphy records. This belief does not involve any disregard of the forces usually assumed to have been responsible for these epochal changes, but it is believed that the strains and stresses built up in the crustal rock have been periodically set into motion by the trigger action of gigantic meteoritic, cometary, or planetoidal encounters. In view of the known fact that several planetoids have recently encroached upon the earth's domain and at least one came near to colliding; and the further fact that astronomers admit that no adequate search for these close-in members of our solar system has ever been made and some astronomers believe, on the basis of recorded observations, that there must be a large number of such bodies crossing or closely approaching our orbit from time to time, it seems inevitable that large scale collisions have occurred throughout geologic time. The moon shows effects which can best be explained in terms of such collisions. On our planet where continents float on a more or less fluid substratum, large scale collisions would logically initiate great continental movements such as are believed to have taken place during the various geologic revolutions.

Truly large encounters of this sort should not be expected to leave their marks in the form of craters. Within a certain range of sizes they would result rather in the development of lava plains. Their penetration would be such as to release pressure on rocks which would at once begin liquifaction and thus give rise to a period of volcanism. Such impact-volcanism would differ only slightly from strictly terrestrial volcanism in that it would consist primarily of fusion at and near the surface, accompanied or not by secondary protracted extrusion of lava, depending upon the depth of penetration, which in turn would depend upon the size, character of colliding mass, and its speed relative to the earth. The caldera type of volcano would more nearly resemble and may even represent such impacts.

Wide-spread fissuring of the earth's crust by large impacts might also result in numerous volcanoes or vents of the terrestrial type in association with the more strictly impact form of volcanism.

Assuming the recurrence of such collisions it is not more strange that we should have failed to detect the evidence than that we should have failed to believe in crater-forming meteorites until two considerable clusters of them had been formed before witnesses in a single generation.

External rather than internal forces, or better stated, internal forces released by external impact will far more easily explain such phenomena as shifting of the poles, planetary drift, arcuate coast lines, the birth of continents, and curving mountain ranges.

Geologists have shown no hesitancy in calling upon almost infinite time to explain the workings of isostasy, deposition, metamorphism, and evolution. If the same generous allowance of time is applied to the process of meteoritic increment, and if the bounds of meteoritic dimensions are expanded so as to be consistent with the observations of recent years, then it becomes obligatory to admit meteoritical encounters as an active factor in dynamic geology.

After centuries of denial of the entire process Science has recorded in four generations 600 witnessed falls from which meteorites have been recovered and the formation of a half hundred craters; besides the discovery of 700 additional falls and more than 30 craters the arrival of which were not witnessed. In a single generation we have seen our earth's orbit encroached upon by a number of planetoids and have, on October 9, 1946, sailed through the tenuous portion of a cometary swarm sufficient to brighten our skies by the disintegration of a half billion meteorites. Each year we are witnesses to the cremation of the straggling remnants of the infinitely greater swarms of Leonids, Perseids, Lyrides, Andromedes, and a host of unnamed processions.

The atmosphere, which is equal to a steel jacket 54 inches thick, serves as the incinerator for more than a million meteorites each hour of day and night ranging in size up to what ever is necessary to pierce that massive armor. It is now believed that probably somewhere on this sphere this protective armor is pierced every day. In short, this planet moves through not empty space but a veritable cosmic barrage.

Both experience and reason shout loudly and clearly that not merely the atmosphere but also the lithosphere has been pierced by missiles from space.

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