

SCIENTIFIC COMMUNICATIONS

THE COSMIC ORIGIN OF METALLOGENETIC PROVINCES

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It is postulated that at irregular and increasing intervals during the history of the earth there have been brief periods of intense bombardment by meteorites originating from the break-up of cosmic bodies of various composition.

The target areas struck by metallic meteorites have developed into metallogenetic provinces either directly as sedimentary deposits or indirectly through assimilation, granitization and subsequent hydrothermal action.

INTRODUCTION

A study of a recent account of the present knowledge and theories concerning the origin of the earth by W. M. Smart gives the impression that the cosmologists are becoming more confused because each new physical fact that is discovered leads to the destruction or at least modification of one theory and the proposal of several others (1). The inherent nature of the problem is, of course, the reason for the perplexity, namely to find a satisfactory theory that will account for all known facts about the earth moved back in time some 4,000 million years or more.

As the cosmologists surround the problem with increasing amounts of higher mathematics, nuclear physics and newer theories of astronomy the geologist finds himself a puzzled onlooker. He will find however that it is generally accepted that:

1. the earth passed through a wholly molten stage early in its existence.
2. meteorites are the evidence that a cataclysm has shattered at least one solar body into fragments.

The following discussion is largely based on these two statements.

THE ORIGINAL EARTH

It is customary to consider that the original molten mass solidified into a sphere of rock with uniformly layered shells around a central core according to the densities and freezing points of the mineral assemblages stable under the prevailing conditions.

Subsequent localized melting of parts of the interior resulted in the phenomenon of intrusive rocks and their associated mineral deposits. With uniform shells of rocks these intrusions and the mineral deposits would be ex-

pected to have a regularity of composition and distribution but actually they are scattered as groups in irregular and usually dissimilar areas. Hence the statement of Bateman "The fact of metallogenetic provinces is undisputable but their cause is a problem" (2). Again no two mineral deposits are alike and adjacent mineral districts can be surprisingly different.

It is suggested that this heterogeneity of ore deposits and of their metallogenetic provinces is primarily due to a cosmic origin for much of the metallic material. This is in direct contrast to the established theory that the metals are derived ultimately from deep below the crust.

METEORITES

The composition of meteorites varies from purely stone to purely metal (mostly iron with minor nickel) suggesting that they had a common source. They probably arose from the cataclysmic disintegration of a planetary body that for some reason became unstable. They are generally associated with the passage of meteors whose paths indicate that they belong to the solar system. Astronomers allow that a few may have originated outside of the solar system.

Until recently it was thought that meteorites such as we know today have been falling on the earth for only a short period in geological time beginning in the late Tertiary. V. E. Barnes now reports evidence for the type of meteorites known as tektites occurring in the Eocene of Texas (3).

The total amount of fragments from any given body flying through the solar system is gradually reduced as they are caught by the gravitational field of a planet or the sun and so absorbed. Thus the astronomers report that the comets whose paths bring them back near the earth at definite intervals are much smaller at each return.

Spectacular meteorites weighing up to several tons have been described and some of them are exhibited in museums. The meteor crater in Arizona that is 4,000 feet across and 500 feet deep must have been formed by an extremely large meteorite (millions of tons are suggested by one authority) (4).

Far more numerous however are those in the form of showers that are known to have covered as much as two million square miles as in the case of the australites which are small disk-shaped meteorites of glassy material that are found over a large portion of Australia.

Another example, with which the writer is familiar, is the large area of southern Luzon in the Philippines in which spherical tektites up to four inches in diameter are found in the recent gravels. They consist of a black glass similar to, but distinct from, obsidian in composition. They are regarded as meteorites by Dr. Otley Beyer of Manila who is an authority on their occurrence (5). The local people call them the "mother of gold" since they are often found in the gold placer deposits.

In remote geological time there may well have been a number of planetary bodies of various compositions that became unstable and disintegrated. It is therefore conceivable that since the earth became a separate entity there have been a number of periods of meteoric bombardment of varying intensity and probably on a more tremendous scale in the very early periods.

The numerous and extensive craters on the moon are regarded as possible

evidence of the enormous bombardment with meteorites that has taken place since the moon began to solidify some 4,000 million years ago. They have been preserved by the lack of an atmosphere to support the processes of weathering.

FORMATION OF METALLOGENETIC PROVINCES

During the early molten stage of the earth it is imagined that it would rapidly engulf and then incorporate the additions from outer space but as the viscosity increased with cooling so the dispersal would be less and the target areas would become enriched by the extraneous material. The composition of this introduced material would depend on that of the original body that became disintegrated, which could have been any of the elements in any proportions and combinations. At a later stage when solidification was sufficient for the successive processes of weathering, transportation, sedimentation, and deep burial any foreign material would either be dispersed or concentrated according to its nature and where it fell. Thus in a water covered area it would be concentrated as a layer in the sediments forming at that time.

Eventually deep enough burial would lead to granitization and the subsequent formation of the mineral provinces that we know today. Areas that escaped granitization and eventually re-emerged could become the so-called sedimentary ore deposits whose origin is so controversial.

EXAMPLES OF SEDIMENTARY ORE DEPOSITS

Rhodesia and Belgium Congo.—One remarkable fact about the Rhodesian-Congo copper belt is the variety of sedimentary rock types that are the hosts for the ore deposits. Another is the very limited time range represented by each host rock and the possibility that they belong to the same time range.

During the past few years there has grown the conviction amongst Rhodesian geologists that the Rhodesian copper ores are syngenetic in origin but the manner in which they were formed is a subject of much controversy.

The widespread nature of the ore deposits contrasted with their very limited vertical range and, therefore, the brief period of time for formation is a difficult situation to envisage by ordinary weathering processes.

Garlick (6) has propounded a sensitive balance of special sedimentary conditions whereby the copper and other metals derived from the weathering of an old land surface were precipitated from solution by bacterial action. That these extraordinary conditions could be so widespread and yet limited to such a short period of time is difficult to concede.

If a source outside of the earth is assumed in the form of one or more large meteoric showers then the limited time factor and variety of host rock can be reconciled.

Much of the material would be in the form of dust and over water areas would become incorporated directly in the sediments. Much of that which fell near water would soon be swept into the sedimentary basin—in large amounts for a limited period and then the remainder would be rapidly diluted by the predominating rock debris.

The sulfide nature of the present minerals could be explained as either: a), the original form of the metals in the meteorites that was not changed on entering the earth's atmosphere because it lacked oxygen in Precambrian times or, b), reduction by sulfur present in the sediments.

Colorado Plateau.—Most of the uranium ore deposits of the Colorado Plateau are characterized by being localized in old stream channels. In their descriptions of the deposits writers have suggested various sources for the uranium—from detrital to hydrothermal but with little conviction.

A meteoric source would provide heavy particles that would accumulate in the stream channels but would disintegrate on the adjacent temporary land areas of these lacustrine deposits.

Blind River.—The unexplained but presumably significant alignment of the uraniferous areas in the Blind River field of Ontario, in a belt that crosses the fold pattern, leaving large areas of otherwise favorable conglomerate host rock non-productive, could be due to an original shower of radioactive meteoric dust at the time of formation of the conglomerate.

CONCLUSION

The concept that meteoric showers in early geologic time have resulted in the metallogenetic provinces of today is at first startling but it does seem feasible. The theory offers an explanation for the haphazard distribution of mineral areas and for the controversial but important non-ferrous sedimentary ore deposits.

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