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The Possible Preservation in Concretions of Traces of Ancient Meteorites*

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ABSTRACT AND INTRODUCTION

The absence not only of admittedly genuine meteorites but also of the supposed glass meteorites (tektites) from all but the more recent geological formations is a well-established and intriguing fact. It is not known whether to interpret this absence as evidence that meteorites did not fall in earlier geological times or to look upon it as proof that such meteorites as fell long ago have been entirely destroyed or altered into unrecognizable forms under lengthy attack by the agencies of weathering and corrosion. Most meteoriticists seem to favor the second alternative. The situation just described is closely analogous to that encountered by geologists in investigations of the mineral aggregates present in the geological column. Here, too, it has been customary to explain the greater simplicity of the mineral assemblages in the older strata as the result of long-acting solvent and corrosive agents. But this hypothesis of the geologist, like the corresponding hypothesis made by meteoriticists to explain the absence of meteorites in the earlier formations, has, up to the present, lacked supporting evidence.

In this paper, it is pointed out that very recently such evidence has been supplied by the sedimentary petrologists, who have shown that calcareous concretions in sandstones may preserve within themselves in unaltered or almost unaltered condition heavy minerals and other substances that have disappeared entirely from, or have been greatly altered in the sandstone beds containing the concretions. The results of such modern sedimentary petrological study on the stability of minerals in sandstone strata and in calcareous concretions in the same sandstone suggest that, altho concretions may not be the missing ancient meteorites, as the uninitiated so often mistakenly and stubbornly insist, nevertheless, traces of hitherto undetected early meteoritic and tektitic falls may be preserved within impervious concretions. In particular, it seems open to question whether shards of silica glass found in certain Miocene concretions are fragments of tektites or of volcanic glass. It is urged that meteoriticists systematically investigate the materials preserved within large numbers of impervious concretions. Suggestions are made in regard to the meteoritical evidence to be sought for and the search procedures to be employed.

Up to the present, concretions have been one of the banes of the meteoriticist's existence, since they are habitually mistaken for meteorites by the uninformed, and the erroneous identification is clung to with a tenacity almost beyond belief. Recent investigations by sedimentary petrologists, however, strongly suggest that the concretions may prove to be natural "time capsules," in which evi-

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dence may well have been preserved that will give definite answer to one of the oldest and most puzzling questions in meteoritics. We have reference to the well-known and often debated absence of meteorites from all but the more recent of the geological formations.[1] This dearth of specimens in ancient rocks is quite as noticeable for the supposed glass meteorites (tektites) as for the iron, stone-iron and iron-stone, and stone meteorites (siderites, siderolites, and aerolites).

One clue to a possible cause of the disappearance of the tektites from the older strata is furnished by the convincing evidence of chemical corrosion that the remarkably sculptured surfaces of these bodies exhibit. Again, from Thoulet's time onward, it has been recognized that, as one ascended in the geological column, the mineral aggregates found in the sedimentary formations increased in complexity; and the greater simplicity of the mineral assemblages in the older strata has been customarily explained by geologists by assuming that, under solvent and corrosive action, certain minerals once present in these strata have disappeared entirely from them.

From the viewpoint of meteoritics, the evidence of the profoundly sculptured surfaces of the tektites and that afforded by Thoulet's observation and its customary interpretation are equally unsatisfying, for we are told how the meteorites *may* have come to *disappear* from the older geological formations without being given any assurance that such bodies were actually ever present in these formations. Until very recent studies on the differential stability of minerals, the geologists were in the same unsatisfactory predicament, for their quite reasonable hypothesis to explain Thoulet's observation had nothing more to support it than the equally reasonable hypothesis advanced by the meteoriticists to explain the curious observed absence of meteorites from the more ancient rocks. As a result of modern studies on differential mineral stability by the sedimentary petrologists, however, the hypothesis advanced by the geologists has now received strong support, for it has been found that concretions in sandstone may preserve within themselves in unaltered or in practically unaltered condition heavy minerals and other materials that either are found in greatly altered form in the sandstone beds surrounding the concretions or have disappeared entirely from those beds.[2] The absence of such heavy-mineral aggregates from a given sandstone can no longer be accepted as proof that such aggregates were never present in that particular rock.

This discovery by the sedimentary petrologists, reminiscent of the fact that concretions may be abundantly fossiliferous even when the beds in which they occur are almost destitute of fossils, is obviously of first-rate importance to meteoritics. It suggests that the meteoriticists, too greatly influenced by the compelling evidence of the effectiveness of long-continued *extraconcretionary* corrosion upon even such resistant materials as the probably cosmic tektites and the certainly terrestrial garnets, have been too prone to conclude that there is no chance of discovering tektites and meteorites in ancient rocks.

Certainly the results recently secured by detailed and systematic study of the differential stability of minerals in sandstone strata and in impervious calcareous concretions in these same sandstones strongly argue that, in the future, meteoriticists should be less inclined to content themselves with pointing out the certainly obvious (but, under *intraconcretionary* conditions, less certainly competent) agencies of weathering and chemical corrosion as the reasons for the observed absence of meteorites in the earlier geological formations and more concerned with actively searching for traces of such bodies in impervious types of concretions taken from these formations.

In conducting such searches, it must be kept in mind that *imperviousness* of the concretions studied is all important. Bramlette[3] has cited an interesting case in which of two closely adjacent concretions, one was "not as dense and impermeable" as the other. In this less impervious concretion, it was found that "the abundant biotite was nearly as much altered . . . as in the adjacent sand," whereas the biotite was black and little altered in the nearby dense and impermeable concretion. In addition to the important factor of imperviousness, it is desirable to work with as large numbers of as big concretions as possible in order to increase the probability that meteoritic materials falling at random from the skies will have found lodgment in the concretions examined. The laboratory techniques (crushing, sieving, centrifuging, *&c.*) to be applied in analyzing concretionary contents are thoroly treated in the standard works on heavy-mineral analysis and sedimentary petrography.[4]

As regards the meteoritical evidence to be looked for in concretionary contents, it may be classified as: (1) *megascopic,* (2) *microscopic,* and (3) *analytic.*

Megaseopic evidence would be furnished by the discovery inside concretions of pieces of meteorites (or tektites), visible to the naked eye or under a hand lens, that had survived in recognizable form because of the protection against weathering and corrosion afforded by the concretionary shell. Actually, the so-called "volcanic-glass shards," found in some abundance by Bramlette inside calcareous concretions taken from the Hambre sandstone of Miocene age, may be, conceivably, pieces of tektites, for the scant data on the physical properties of the shards so far published by no means exclude a tektitic origin for these glass fragments.

Microscopic evidence would be supplied by finding in concretions either submacroscopic fragments of meteorites (or tektites) or such probably meteoritic substances as the minute, magnetic particles of globular shape found in deep-sea deposits,[5] or of spherical and cindery form found in cosmic dust collected from the atmosphere.[6] Such evidence would be provided also by the isolation and identification of such definitely nonterrestrial minerals as moissanite (meteoritic SiC), schreibersite, and daubréelite. Among such minerals, moissanite, because of its extreme durability and stability, naturally suggests itself as the test mineral, *par excellence.* Unfortunately, use of this otherwise ideal test mineral is possible only if the experimenter takes extraordinary precautions, because of the world-wide distribution of its artificial congener, carborundum. The hazards incident to the use of moissanite as a test mineral are well illustrated by the experience of Ohrenschall and Milton, who, in 1931, published a paper on their supposed discovery of moissanite in heavy-mineral residues from oil-well cores.[7] In 1932, their identification of this substance as meteoritic SiC was questioned by Edelman,[8] who pointed out that, by very careful laboratory procedures, it had been possible, in every case of which he had knowledge, to trace the occurrence of supposed moissanite in heavy-mineral residues to contamination resulting from the use of polishing pastes and similar compounds containing carborundum.

In spite of Edelman's trenchant criticism, the belief seems to persist in certain quarters that both Ohrenschall and Milton and Mrs. Fanny Edson, while Subsurface Geologist for the Roxana Petroleum Corporation, actually found and identified moissanite in heavy-mineral residues. Since the matter is of great importance to the meteoriticist, I directed an inquiry to Dr. C. H. Edelman, Director of the Landbouwhogeschool, Afdeling voor Regionale Bodemkunde, Geologie en Mineralogie, at Wageningen, Holland; and, in reply, under date of

1948 December 14, he kindly sent me the following statement, which would seem to settle the issue once and for all:

"There is no question about cosmic moissanite in sediments. In my laboratory, in those of my former pupils and co-workers in Ghent, in Paris, and in the large sediment petrological laboratory of the Royal Shell at Amsterdam, hundreds of thousands of sedimentary rocks have been analyzed under the microscope, and the mineral moissanite is never found unless as contamination, which can easily be controlled. This is the opinion of 30 or 40 scientists who have worked in our line in the last 20 years."

Since meteoritic SiC does occur at the Barringer (= Canyon Diablo, Arizona,) Meteorite Crater, and, according to the very extensive experience of Edelman and his associates, does *not* occur naturally in terrestrial deposits, its discovery within concretions would be quite conclusive proof that these had entrapped and preserved meteoritic materials—provided, of course, that precautions had been taken, precluding the possibility of contamination by carborundum. This same remark would apply with equal force if, at some time in the future, moissanite were discovered at some of the curious cryptovolcanic structures and meteoriteless meteorite craters, the origin of which now seems shrouded in mystery.

Analytic evidence that the resistant nickel-iron alloys of the siderites had probably been present in concretions would be furnished by chemical or spectroscopic proof that these objects are, *e.g., nickel-rich* in comparison with the surrounding sedimentary beds. Under extraconcretionary conditions, it may be presumed that the leaching away of the nickel content of meteoritic iron and the subsequent deterioration of the meteoritic material into an unrecognizable form would be completed in short periods of time, geologically speaking. On the contrary, within impervious concretions, nickel leaching might be so retarded that, even after millions of years, the extremely sensitive nickel tests now available would detect the presence of this element.

In connection with the analytic identification of extremely small quantities of ferrous and ferric iron, nickel, cobalt, copper, and other metallic elements in concretions, as in the analogous problem for the presumably cosmic magnetic dusts collected from the atmosphere, urgent need exists for improvements on and extensions of the standard dimethylglyoxime test. For some time, a project for the development of a *suite* of precisely such ultrasensitive tests has been under way in the Research and Development Division of the New Mexico School of Mines at Socorro, under the supervision of Dr. William D. Crozier. New tests employing organic reagents have been devised, and, as perfected, these have been tried out on typical samples of meteoritic dusts supplied for the project by the Institute of Meteoritics of the University of New Mexico. Oral and written reports on the results obtained from such testing, recently received from Dr. Crozier, are most encouraging. It seems very probable that extremely sensitive, new analytical tools will soon be added to the meteoritical armamentarium.

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[3] Bramlette, M. N., *loc. cit.,* ([2]), p. 34.

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