METEORITIC ASPECTS OF THE S-ASTEROID ISSUE: A PERSPECTIVE FOR THE NEAR-MISSION
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Perhaps the most critical stage of any scientific investigation is the formulation of the initial question or questions to be addressed. A properly formulated question focuses effort on the central issues which can be addressed by that investigation and allows efficient utilization of limited resources. An improperly formulated question diverts effort into inefficient, fruitless or trivial efforts, requiring addition resources (often not available in a timely fashion) to redo the analysis or to salvage results from inappropriate measurements. To properly define the question, one must consider it in the context on the broader issues to be addressed.

The NEAR mission is currently scheduled to rendezvous with the near-Earth asteroid 433 Eros in early 1999. The instrument package was fixed early in the mission design process and could not be fully optimized to the specific target. (Since no optimized state-of-the-art spectral instrumentation currently exists for asteroid studies, this is a familiar situation for asteroid observers.) However, a clear understanding of the scientific issues for Eros in particular and the asteroid-meteorite connection in general will help maximize the scientific results of the NEAR mission. Our perceptions will effect how we plan the NEAR spacecraft measurements and how we initially analyze the data returned by the spacecraft.

Identification of the specific source bodies of meteorites has been a Holy Grail of asteroid science. Such identifications would allow the chronological constraints and geochemical evolutionary histories derived from the detailed laboratory study of individual meteorites or meteorite groups to be assigned to specific heliocentric locations in the early solar system or the latest solar nebula. This quest has been successful in two cases (the basaltic achondrites and 4 Vesta [1]; the enstatite achondrites and the Hungaria Family via Apollo asteroid 3103 (1982 BB) [2]); and plausible candidates have been identified for most meteorite assemblages although specific dynamic pathways have not been established [3]. However, the actual source of the most common type of meteorites (the ordinary chondrites, OC's) has been a source of considerable controversy. Should - or can - the resolution of this issue be the central focus of the NEAR scientific investigation?

The "ordinary chondrite paradox" derives, like most paradoxes, largely from an improper formulation of a model. In its most basic form the OC paradox focuses on the huge discrepancy (~2500:1, which with the plausible identification of the mainbelt OC-like object 3628 Boznemcova [4] the discrepancy is now merely enormous) between the ordinary chondrite dominance (~75%) of meteorite falls and their virtual absence (~0.03%) among observed mainbelt asteroids. The "paradox" arose due to the initially reasonable explicit or tacit assumption that the abundance of various meteorite types should be correlated to their abundances in the source population.

Over the past two decades, this basic assumption has been largely discredited. A wide range of theoretical and observational investigations have addressed the mechanisms for delivering asteroid samples to the Earth's surface. The critical advances include:

I. Observational studies which have located plausible parent bodies or outcrops for most or all meteorites in the asteroid belt [3].
II. During time intervals on the order of a few tens or hundreds of millions of years, the material being delivered into Earth-crossing orbits will be dominated by a few mainbelt bodies favorably located near a chaotic resonance region, especially the 3:1 [5,6] and the ν^6 resonances [7] in the inner belt.
III. Higher ejection velocities from impacts onto larger or stronger (i.e., metallic vs. hard mafic silicates vs. weaker phyllosilicate assemblages] controls the delivery of fragments into these chaotic zones from bodies not proximate to the resonances [1,8].
IV. The compositions of meteorite falls during geologically short intervals (a few million years) are dominated by a few bodies in especially favorable Earth-crossing orbits.

V. The strong selection process is seen in types other than the ordinary chondrites, such as the olivine and basaltic achondrites which show at least a 400-fold discrepancy between asteroid parent body abundances and relative fall abundances of these meteorite types [3]. This discrepancy is primarily the result of basaltic eject from the sole large basaltic asteroid (4 Vesta) injected into the 3:1 resonance [1].

Fall statistics of meteorite types are dominated by the selection processes of the delivery mechanisms during any interval. Thus the "OC paradox" evaporates when the underlying assumption is properly restated as:

"For meteoritic samples collected over a short time interval (<10 Myr), there is no expectation that there should be ***any*** *correlation between the abundance of lithologic types in the asteroid belt and the abundance of equivalent meteorite types."*

As a consequence, the ordinary chondrites are dethroned from their place (in some eyes) as the fundamental Rosetta stone for understanding the solar nebula and the early solar system. The importance of the ordinary chondrites is that they represent an extremely well-sampled subset of the chondritic suite which represents a library of Rosetta stones from this period.

How then should we regard the asteroid-meteorite connection and 433 Eros in the S-asteroid and NEAR contexts? Several factors appear significant, and provide a useful context for planning and analyzing the NEAR measurements.

A. The diversity of meteoritic assemblages is a fundamental property to understanding the asteroid-meteorite connection. Although dynamical selection mechanisms dominate the compositional pattern of meteorite falls, a sufficiently large meteorite sample population (or one which integrates a long time interval) should contain representatives from all compositional types present in the source population. This is commonly expressed as the minimum number of source bodies required to provide the observed meteorites. The meteorites require many more differentiated parent bodies than undifferentiated parent bodies. For example, the ordinary chondrites, even including OC inclusions in other meteorites (e.g., in the type IIE irons), require fewer that ten parent bodies to provide their chemical and isotopic range [e.g., 9]. Fewer than twenty parent bodies are required to supply the entire range undifferentiated meteorites. By contrast, at least fifty distinct parent bodies are required to provide the differentiated iron and stony-iron meteorites, and perhaps ten parent bodies to provide the partially differentiated meteorites. The sampled diversity of igneous (differentiated and partially differentiated) parent bodies is several times greater than that of the chondritic (undifferentiated) parent bodies.

B. The S-asteroids include a diverse range of assemblages from partially to fully differentiated parent bodies [10]. This diversity represents the effect of a variety of parameters including: parent body size (gravity) and initial composition, intensity of post-accretionary heating, cooling and solidification times versus timescale of large impacts, and efficiency and timing of melt extraction during partial melting. The S-asteroids may also include a few undifferentiated or metamorphosed (i.e., heated but partial melting temperatures not attained) assemblages.

It would unnecessarily limit the scientific return of the NEAR mission to focus primarily on addressing the ordinary chondrite paradox. A much more important focus of the measurement strategies and data analysis for the NEAR mission should center on the discrimination of those parameters (primarily spectral) which allow characterization of the specific initial conditions and geochemical processes which formed the assemblage present on Eros.

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