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Discrimination and Magnetic Characterization of Cosmic Spherules

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Within the frame of an ongoing study about the magnetic properties of micrometeorites, we have extracted magnetically iron bearing spherules in the 100-600 μm size range from 3 different settings: 1) aeolian accumulations on top of a granitic mountain in Antarctica, 2) degradation products from cretaceous sandstones in the Sahara desert, 3) deep-sea Arctic sediments with low sedimentation rate ($\sim$cm/kyr). In site 1) all spherules appear to be of extraterrestrial (ET) origin, while a number of terrestrial spherules are present in 2) and 3). External morphology has been observed with a scanning electron microscope (in backscattered mode to enhance iron versus lighter elements contrast), with energy dispersive analysis. Polished sections have been analysed with a microprobe to get more precise bulk composition and reveal a contrast with the surface composition. Indeed surface composition can be biased by the atmospheric evaporation as well as secondary precipitation in the sediment. Magnetic properties of single spherules in the 50-200 μg range have been investigated using hysteresis loops and susceptibility measurements.

All Antarctic spherules appearET. Most are silicate-rich, with an average 20 wt.% total iron. Chemical fingerprints are the presence of Cr and Ni, negligible Ti, Mn, K, Na, Mg>Al, lack of carbon and sulfur inside the spherules while the surface is encrusted with carbonate and sulfate precipitation (with K, Na, Al contamination). Magnetic measurements indicate down to only 2 wt.% of magnetite, demonstrating the efficiency of magnetic extraction, and up to 20%. No metal or pyrrhotite is observed, a signature of the high temperature oxidation within the atmosphere (in agreement with chemical data: lack of C and S inside the spherules). Magnetic grain size is in the PSD range (Mrs/Ms in the 0.1-0.4 range), indicating that these spherules can contribute significantly to the remanence of a bulk sediment.

In the other two sites the crucial point is to recognize ET particles among authigenic or aeolian spherical grains, in particular in the non silicate spherules, mostly made of magnetite. Wind rounded magmatic titanomagnetite are easily identified. Framboid morphology is sometimes obvious, but we observed similar morphologies (smooth surface) for Ni bearing (likely ET) and Mn-Zn bearing (likely authigenic) magnetite spherules. Presence of sulfur can be used to exclude ET origin. This question may be complicated by the growth of a Mn-Zn rich oxide crust encapsulating an ET spherule, as observed on a few broken partly hollow spherules.