Correlated Microanalysis of Extraterrestrial Carbonaceous Nanoglobules

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Recent work has shown the common presence of tiny (<1µm), often hollow, carbonaceous spheres ("nanoglobules") in the insoluble organic matter (IOM) of carbonaceous chondrites, interplanetary dust particles and Wild-2 samples [1-4]. Nanoglobules are enriched in D and/or ^{15}N, relative to bulk IOM and hence comprise a portion of isotopic "hotspots [5]." To better understand the origin and processing histories of the nanoglobules we are performing spatially correlated studies of meteoritic and cometary organic matter to characterize the same sub-micron samples for their molecular chemistry, morphology, structure and isotopic compositions. We have now performed TEM and X-ray absorption near-edge structure spectroscopy (XANES) on several globules and surrounding non-globule IOM in the residues of 6 primitive chondrites and two globules identified in Wild-2 samples [4]. Data analysis is in progress but preliminary results indicate that in a given meteorite, globules exhibit similar C-XANES spectra to the bulk IOM, but with slightly enhanced C-O bonding (e.g. carboxyl and vinyl-keto groups). Some globules with highly distinct spectra are observed, however (e.g., purely aromatic C). Isotopic measurements of the analyzed globules are in progress. The 2 Wild-2 globules are distinct in both molecular chemistry and isotopic composition [4].

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On the origin of OIB and LVZ – Some new perspectives

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Island-averaged OIB data show systematic compositional variation as a function of the lithosphere thickness [1]. Si_{72} and Al_{72} decrease whereas Fe_{72}, Mg_{72}, Ti_{72}, P_{72}, La/Sm and Sm/Yb increase with increasing lithosphere thickness. These systematics suggest a first-order control on the global OIB geochemistry by lithosphere thickness variation that limits the final depth of melting. OIB source materials rise to a shallow level and thus melt more by decompression beneath thin lithosphere, but have restricted upwelling and thus melt less by decompression beneath thick lithosphere. This required *decompression* demands dynamic upwelling of OIB source materials, and has critical implications for the mantle plume debate. OIB sources are more enriched in incompatible elements than the primitive mantle (PM) and more so for the more incompatible elements. This requires that OIB sources be pre-enriched by low-degree melt metasomatism. The apparent coupling between radiogenic isotopes and incompatible elements in many OIB suites suggests that the metasomatism be ancient. Recycled oceanic lithosphere [2] and mantle wedge [3] are good candidates. On the other hand, most OIB melts have radiogenic isotopes more depleted than the PM despite their incompatible element enrichments. Such first-order decoupling requires that OIB sources also undergo recent enrichment. The major melting event for the OIB genesis is inadequate to account for this enrichment. The presence of an incipient melt in the LVZ is required [4,5]. This has implications for the LVZ debate [4-7]. Presence of a small melt fraction due to volatiles (e.g., H_2O, CO_2) may be the cause of the LVZ. Low-degree melt metasomatism is widespread in continental and oceanic lithospheric mantle.

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