STABLE ISOTOPES: A NONCARBONACEOUS PEDIGREE FOR UREILITES, IN COMMON WITH ALMOST ALL DIFFERENTIATED PLANETARY MATERIALS.

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The abundant, diverse ureilite meteorites are peridotitic asteroidal mantle restites that have remarkably high bulk carbon contents (average 3 wt%) and have long been linked to the so-called carbonaceous chondrites. This term is "somewhat of a misnomer" [1], because the high petrologic type carbonaceous chondrites are, if anything, C-poor compared to ordinary chondrites. But it has long been customary to describe as "carbonaceous" a distinctive set of chondrites that show kinship in various ways without necessarily being carbon-rich. Here, the word carbonaceous is used in that strict, meteoritics-customary sense.

Ureilite oxygen isotopic compositions, i.e., diversely negative $\Delta^{17}O$, viewed in isolation, have long been viewed as confirming the carbonaceous-chondritic pedigree hypothesis. However, a very different picture emerges through analysis of a compilation of recently published high-precision isotopic data for Cr [2-8; especially 8], Ti [9-10] and Ni [11-13] for ureilites and various other planetary materials (earlier publications by same first authors not cited). Ureilites have lower $\varepsilon^{62}Ni$ and far lower $\varepsilon^{50}Ti$ and $\varepsilon^{54}Cr$ than any known variety of carbonaceous chondrite. On a plot of $\varepsilon^{50}Ti$ vs. $\varepsilon^{54}Cr$, and similarly $\Delta^{17}O$ vs. $\varepsilon^{54}Cr$, ureilite compositions cluster far from and in a direction approximately orthogonal to a trend internal to the carbonaceous chondrites, and the carbonaceous chondrites are separated by a wide margin from all other planetary materials. Thus, notwithstanding the impressive resemblance to carbonaceous chondrites in terms of diversely negative $\Delta^{17}O$, the ureilite precursors accreted from preponderantly noncarbonaceous (sensu stricto) materials.

Despite total depletion of basaltic matter, ureilites retain moderate *py* (≡ pyroxene/[olivine+pyroxene]) ratios, averaging 30 vol%; a result expected from simple partial melting of moderate-SiO_2/(FeO+MgO) noncarbonaceous chondritic matter, but implying an additional process of major reduction of FeO if the precursor material were carbonaceous-chondritic. The ureilites' diversity in *py*, silicate-core *mg* and $\Delta^{17}O$ implies the parent asteroid accreted a diverse mélange of noncarbonaceous materials.

The striking bimodality of planetary materials on the $\varepsilon^{50}Ti$ vs. $\varepsilon^{54}Cr$ and $\Delta^{17}O$ vs. $\varepsilon^{54}Cr$ diagrams may be an extreme manifestation of the effects of episodic accretion of early solids in the protoplanetary nebula. However, an alternative, admittedly speculative, explanation is that the bimodality corresponds to a division between materials that originally accreted in the outer solar system (carbonaceous) and materials that accreted in the inner solar system (noncarbonaceous, including the ureilites).

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