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Aqueous Alteration Processes Recorded in Kuiper Belt Dust

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Interplanetary dust particles (IDPs) are samples of dust-producing solar system objects including many primitive and organic-rich bodies not sampled by known meteorites. Many of these IDPs contain high densities $>10^{10}$/cm^2 of solar energetic particle tracks in their constituent minerals, consistent with an origin from Edgeworth-Kuiper belt objects (EKBOs) [1]. Some of the track-rich IDPs record evidence of past aqueous activity on their parent bodies and we are investigating their mineralogical and isotopic properties through coordinated transmission electron microscope and ion microprobe analyses.

The hydrated IDPs in this study are dominated by fine-grained Mg-rich phyllosilicates (saponite and lesser serpentine) with finely dispersed Fe,Ni-sulfide grains (pyrrhotite and pentlandite), and Mg-Fe carbonates. The IDPs are carbon-rich (~4X CI) and contain carbon nanoglobules in addition to abundant finely dispersed carbonaceous material. Magnetite is uncommon, and no Ca-rich carbonates are observed.

We measured the oxygen isotopic composition of 6 track-rich hydrated IDPs and all are within error of the carbonaceous chondrite anhydrous minerals mixing line in a 3-isotope plot [2]. The O isotopic compositions of 4 of the hydrated IDPs plot above the terrestrial fractionation line and are distinct from known hydrated carbonaceous chondrite meteorite groups. The overall slope 1 trend also differs from known carbonaceous chondrite groups which show shallower slopes because of mass dependent fractionation of O isotopes during aqueous alteration. This slope 1 trend reflects mixing between ^{16}O-rich and ^{16}O-poor reservoirs that likely formed through self-shielding processes [e.g., 3,4]. Amorphous silicate grains with nanophase inclusions of FeNi metal and sulfides were the likely precursors to the phyllosilicates in hydrated IDPs [5]. We propose that reactions between ^{17,18}O-rich water and the amorphous silicate precursors produced oxidized Fe from Fe metal, and the formation of phyllosilicates through incorporation of heavy H_2O into the anhydrous amorphous silicates. The aqueous alteration activity likely resulted from heat generated by collisional processes among EKBOs.

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