COORDINATED ANALYSES OF HYDRATED INTERPLANETARY DUST PARTICLES: SAMPLES OF PRIMITIVE SOLAR SYSTEM BODIES

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Introduction: Interplanetary dust particles (IDPs) collected in the stratosphere fall into two major groups: an anhydrous group termed the "chondritic-porous (CP) IDPs and a hydrated group, the "chondritic-smooth (CS) IDPs, although rare IDPs with mineralogies intermediate between these two groups are known [1]. The CP-IDPs are widely believed to be derived from cometary sources [e.g. 2]. The hydrated CS-IDPs show mineralogical similarities to heavily aqueously altered carbonaceous chondrites (e.g. CI chondrites), but only a few have been directly linked to carbonaceous meteorite parent bodies [e.g. 3, 4]. Most CS-IDPs show distinct chemical [5] and oxygen isotopic composition differences [6-8] from primitive carbonaceous chondrites. Here, we report on our coordinated analyses of a suite of carbon-rich CS-IDPs focusing on their bulk compositions, mineralogy, mineral chemistry, and isotopic compositions.

Methods: The IDPs are embedded in elemental sulfur and partly sectioned using ultramicrotomy to produce thin sections ~50 nm thick for transmission electron microscopy measurements as well as nanoSIMS measurements of H, N, and O isotopes. The remainder of the IDP is extracted from the sulfur and pressed into Au for quantitative electron microprobe elemental analysis (including C). Following the EPMA measurements, the IDPs are analyzed with the IMS1270 ion microprobe at UCLA for their oxygen isotopic compositions. We measured the bulk compositions of 8 CS-IDPs prepared in this manner, and combined this with data from 11 CS-IDPs reported earlier by [5].

Results and Discussion: *Compositions*: The bulk compositions of the CS-IDPs are well within a factor of 2 of CI abundances except for C, which is enriched, on average, by a factor of 4X CI. The range of carbon abundance is nearly identical to that observed in CP-IDPs [9] and sets both types of IDPs apart from known meteoritic materials. The compositional ranges of CP IDPs overlap those of CS-IDPs, although in comparison, the CS-IDPs typically have lower S and Ca abundances. The S loss is related to atmospheric entry heating decomposition and oxidation of Fe sulfides, while the Ca depletion is well known from previous studies and is related to aqueous alteration effects. The remarkable similarity in chemical composition (esp. high C abundances) suggest a close link between the CP- and CS-IDPs. The fine-grained materials in CP-IDPs are known to easily and rapidly hydrate to form minerals characteristic of the CS-IDPs [1].

Mineralogy: The suite of CS-IDPs are low porosity objects dominated by fine-grained Mg-rich phyllosilicates (dominantly saponite and lesser serpentine). Mg-Fe carbonates or their thermal decomposition products, are present in ~1/2 of the particles. The microtome thin sections contain sub-μm regions of featureless carbonaceous material, and in over a 1/3 of the CS-IDPs, discrete D- and ^{15}N-rich nanoglobules. Most CS-IDPs contain minor phases such as fine-grained forsterite and enstatite, magnetite, and finely dispersed Fe,Ni-sulfide grains. Atmospheric entry heating effects include the development of magnetite on exterior surfaces, decomposition of Mg-Fe carbonates, and loss of crystalline order in phylosilicate grains – the latter two effects require thermal pulses of ~600C [10]. The observed heating effects are consistent with relatively low entry velocities and suggest these particles are derived from either asteroidal sources, or low inclination, low eccentricity cometary parent bodies.

Oxygen Isotopes: The bulk oxygen isotopic compositions of IDPs, in general, are distinct from known carbonaceous chondrite groups although there are some overlaps [6-8, 11]. Relative to the CP-IDPs, the oxygen isotopic compositions of most CS-IDPs plot on a mass dependent fractionation line towards a heavy oxygen reservoir similar to the fractionation effects observed in aqueously altered carbonaceous chondrites. However, we have recently obtained oxygen isotopic data for 4 high-C CS-IDPs [8] and these define a different trend with a steeper slope in a 3 oxygen isotope plot to the left of the Young-Russell line – the most extreme hydrated IDP (L2079E35) has δ^{18}O 23.0‰ (+/-1.8 2σ) and δ^{17}O 49.3‰ (+/- 1.7) and these IDPs may reflect exchange with a ^{17}O-rich reservoir.

Conclusions: The unusual oxygen isotopic compositions, high carbon contents, and the abundance of isotopically anomalous nanoglobules, together, suggest that the high carbon, CS-IDPs are derived from primitive sources not yet represented in meteorite collections such as outer main belt P- and D-type asteroids [12] or possibly comets.

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