Precursors of silicate spherules estimated from their oxygen isotopic and bulk chemical compositions

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Recent works suggest that unmelted, phillosilicate-bearing micrometeorites and hydrous interplanetary dust particles (IDPs) collected at stratosphere are related to hydrated carbonaceous chondrites. Anhydrous IDPs are supposed to be cometary origin because of their high D/H ratios and characteristic mineralogy that are distinct from any meteorites. It is difficult to clarify precursor materials of melted cosmic spherule, because of loss of their original mineralogy due to severe heating during atmospheric entry. Oxygen isotopic signature is useful for identification of planetary materials. In order to clarify the precursor of cosmic spherules, we analyzed oxygen isotopes of individual 37 cosmic spherules (36 silicate spherules and one iron-oxide spherule) with an ion probe.

As a result, oxygen isotopic compositions of Ant-arctic cosmic spherules show a wide variation from +90 permil to -35 permil in delta 18O. More than 3/4 of silicate spherules are plotted on or close to the TFL on which almost all terrestrial materials are plotted. From Mg/Al versus Si/Al, more than two thirds of close to TFL spherules are plotted around the cosmic abundance, which means that they are originally homogeneous chondritic aggregates, not affected by specific mineral grains. Both hydrous micrometeorites and IDPs, and anhydrous IDPs are plotted around cosmic abundance, but the Ca/Al ratio of the former is clearly lower than the latter. On the contrary, the spherules whose Si/Al and Mg/Al values are over 50 are supposed to be mineral fragments of olivines and/or pyroxenes, for their low Al contents (lower than 1 wt% as Al2O3).

Five spherules of 36 silicate spherules are plotted close to CCAM line. One of them is close to zero point and four of them are plotted higher than the cosmic abundance in Mg/Al and Si/Al. Bulk composition of the former is plotted the area of CAI, that is consistent with its 16O-rich oxygen isotopic composition. Bulk compositions of the latter are not CAI-like but forsterite-like (Si/Mg=0.5). CAI related forsterite have 16O-rich isotopic compositions which are comparable to CAIs spinel. Consequently, precursors of CCAM type spherules are supposed to be CAI's fragments.

One spherule plotted clearly above the TFL is 17O-rich type. It has extraordinary large 17O anomaly, up to big delta17O = 13 permil. This big delta 17O is the highest value among solid planetary materials ever reported, except for presolar grains. One interpretation is that the spherule's precursor is a chip of chondritic planetary materials of high big delta 17O, which is unknown as a meteorite, for examples, a chondrite which would have exchanged with 16O-poor nebular gas more intensely than R chondrites. The other interpretation is that the 17O-rich spherule was originally an anhydrous IDP including presolar silicates. Presolar silicates discovered in anhydrous IDPs have extremely 17O-rich isotopic compositions, and capable for affecting on bulk oxygen isotopic composition. This spherule is close to cosmic abundance in Mg/Al and Si/Al, and it has a high Ca/Al ratio (=0.75), which is just the same with the chemical characteristics of anhydrous IDPs. Mg and Si isotopic analyses were performed for the 17O-rich spherule with IMS 6F in University of Tokyo. Si isotopic ratio is normal and Mg isotopes show a slight isotopic fractionation and mass-dependent fractionation is not observed in both elements. This result cannot reject the presolar-silicate hypothesis, because expected Mg and Si anomalies are almost comparable to our analytical error (~1). Consequently, an anhydrous IDP including presolar silicates seems to be more plausible for the precursor of the 17O-rich spherule than the former interpretation. Anyway, it is firmly said that a chondritic material of such a big delta 17O composition in bulk exists in interplanetary space.