Evaluation of parental objects of cosmic dust based on mineralogy and isotope signatures of Antarctic micrometeorites

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Cosmic dust is extraterrestrial particles less than 1 mm in diameter. Cosmic dust located close to the orbit of the Earth is captured by the gravitational force and accretes to the Earth. Although most cosmic dust evaporates during heating in the atmosphere, some of them survive to reach the Earth's surface. Cosmic dust recovered from blue ice fields in Antarctica is called Antarctic micrometeorites (AMMs). In this study, AMMs were identified among particles recovered from the blue ice fields by the Japanese research group at the 'Cape Tottuki' in Antarctica. Then sequential analyses were performed on individual AMMs: Synchrotron X-ray diffraction using Gandolfi camera for bulk mineralogy, SEM / EDS and EPMA analysis for mineral chemistry, and isotope analysis with SIMS for oxygen isotope composition.

AMMs were divided into three groups based on the classification scheme proposed by Maurette et al. (1991): melted, scoria, and unmelted groups. Our EPMA data show that bulk compositions of unmelted AMMs are generally similar to the solar abundance, while melted and scoria AMMs show depletions in volatile elements such as S because of atmospheric entry heating.

The combination of chemical and mineralogical features enables us to classify unmelted AMMs into 4 types: (1) CM chondrites type, (2) CI chondrites type or Tagish Lake carbonate-poor type, (3) Tagish Lake carbonate-rich type, and (4) other than those above. The chemical compositions suggest that most unmelted AMMs consisted mainly of phyllosilicates that are similar to those in hydrous carbonaceous chondrites, but X-ray diffraction analysis of these AMMs indicates the absence of phyllosilicates. This suggests that original phyllosilicates are decomposed and dehydrated by heating during atmospheric entry (Nozaki et al. 2006). The reflectance spectrum studies indicated that CM and CI type carbonaceous chondrites and Tagish Lake type carbonaceous chondrites came from C- and D-type asteroids, respectively. Therefore, AMMs with chemical compositions similar to carbonaceous chondrites come from hydrous C- or D-type asteroids, but dehydrated during atmospheric entry.

The oxygen isotope ratios of unmelted AMMs indicate that they are isotopically heterogeneous and falling along widely the terrestrial fraction line (TFL) (ranging from delta^{18}O$_{SMOW}$ = -30 to 30 permillage). Scoriaceous and melted AMMs also have oxygen compositions similar to those of unmelted AMMs. Unmelted AMMs of CM and CI carbonaceous chondrites type have oxygen isotope ratios that are closer within the ranges of those of the CM and CI chondrites, respectively. This indicates that AMMs that have CI/CM mineralogical signatures have CI/CM isotopical signatures. This confirms that type 1 and 2 AMMs come from C-type asteroids. Also, our results indicate that one AMM of type 4 has an unique oxygen composition. This suggests the possibility that AMMs of type 4 come from new type objects that do not have meteorite counterparts. Our study showed that based on the mineralogy and isotope signatures it is possible to evaluate parental objects of unmelted AMMs that experienced phyllosilicate decomposition during atmospheric entry.

Reference: Maurette et al. (1991) *NATURE* 351, 44-46, Nozaki et al. (2006) *MAPS* 41, 1095-1126