A FIB-NanoSIMS-TEM study of Unmelted Antarctic Micrometeorite TT006D107.

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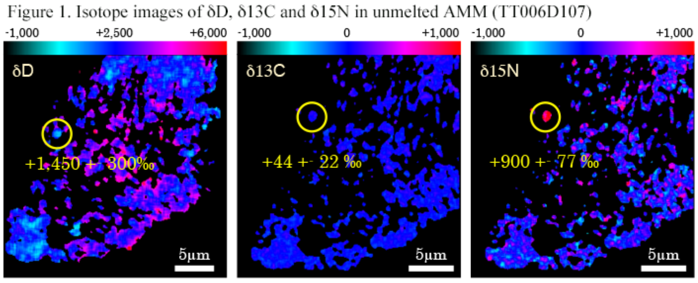
Introduction: Micrometeorites are dominant flux of the extraterrestrial materials for the accreting of the Earth [1]. So far many types of micrometeorites (Antarctic micrometeorites: AMMs) were collected from Antarctic snow and ice [e.g., 2, 3]. AMM is classified into (1) unmelted type (fine-grained, coarse-grained), (2) partially melted scoriaceous type and (3) melted type based on their texture. Chemical and mineralogical data indicate that most of the AMMs are related to carbonaceous chondrites (CI, CM, and CR types) [4]. In this study, we report a systematic isotopic and mineralogical investigations for unmelted Antarctic micrometeorite by using NanoSIMS ion microprobe and TEM/STEM.

Experiments: We used an unmelted micrometeorite, TT006D107, as a sample that collected at Tottuki in Antarctica in 2000 [3]. The TT006D107 is irregularly shaped with ~60 x 50 µm in size, and was pressed onto the Gecko Tape made by carbon-nanotube (Nitto Denko corp.). A first investigation by an EPMA with EDS (JEOL JXA-8200) was carried out at National Institute of Polar Research to obtain bulk elemental abundances, SE and BSE images. The sample was sent to the JAMSTEC Kochi Institute of Core Sample Research for further investigation. A cross-section of the sample (30 x 30 x 2 µm) was prepared by the single FIB (Hitachi SMI4050). We have applied a rastered ion imaging by the JAMSTEC NanoSIMS 50L to acquire isotope maps of H, C, N and O as well as elemental maps of Si, Mg as MgO, Al as AlO, Ca as CaO, and Fe as FeO on the sample. The sample was transferred into the FE-SEM (JEOL JSM-6500F at Kochi University) for observation of the sample surface. We, then, determined the detailed mineralogy and microstructure of the same area that we acquired isotope/elemental maps to gain insight into its petrogenesis by TEM (JEOL ARM-200F equipped with EDS) followed by the single FIB to prepare an ultra thin section for TEM.

Results and Discussions: We, first, acquired images of δ^{18}O, Si, MgO, AlO, CaO and FeO for minerals in the sample. The ^{18}O isotopic composition in mineral phases of the sample shows homogeneous distribution of 18 ± 2 permil. This value is broadly consistent with previous O isotopic compositions for various AMMs [e.g., 5, 6]. No presolar grains were found in the sample. Next we obtained isotope images of δ^{13}C, δ^{15}N and then δD for carbonaceous materials (C and N rich regions) in the sample. The carbonaceous materials in the sample shows average values of δ^{13}C, δ^{15}N and then δD of -2 ± 5 permil, 50 ± 8 permil, and 2,424 ± 62 permil, respectively. The high average δD values is good agreement with δD from CR and OC chondrites [7, 8]. However, the values of δ^{13}C and δ^{15}N are similar to the those of CI and CM chondrites [8]. It is noted that there is a C and N hot spot with a size of ~ 200–300 nmϕ in the measured area, and its isotopic compositions were δ^{13}C = 44 ± 22 permil, δ^{15}N = 900 ± 77 permil and δD = 1,450 ± 300 permil (Fig. 1) that are similar to the values that reported in previous study [e.g., 9].

Figure 1. Isotope images of δD, δ13C and δ15N in unmelted AMM (TT006D107)



We, then, have conducted STEM/TEM observations for part of the sample. The unmelted AMM consists mainly of Mg-Fe-Al-bearing amorphous silicate. Fe-Ni-S-O spherules smaller than < 30 nm in diameter were found to be embedded in the amorphous material, although their mineral phases could not be identified due to their complex electron diffraction patterns.

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