AN ULTRA POROUS LITHOLOGY IN THE PRIMITIVE CARBONACEOUS CHONDRITE ACFER 094: INVESTIGATION FOR PRISTINE PLANETRY MATERIALS.

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Introduction: Chondritic porous interplanetary dust particles (CP-IDPs) are one of the most primitive extra-terrestrial materials. They consist mainly of submicron-sized GEMS (glass with embedded metals and sulfides), olivine, pyroxene, Fe-Ni sulfide, Fe-Ni metal and organics, and contain abundant pores among the constituents [e.g., 1]. These textures are believed to have formed by accretion of dusts in the early Solar System. It implies that pristine dusts have contained abundant amorphous silicates in addition to crystalline grains. Meanwhile, most carbonaceous chondrites contain little amounts of amorphous silicates. It is suspected that most carbonaceous chondrites went through secondary alteration and/or metamorphism in their parent bodies and lost pristine amorphous silicates. For the last few decades, a few primitive carbonaceous chondrites which contain abundant amorphous silicates in their matrix have been reported [e.g., 2, 3]. These meteorites may preserve pristine planetary materials and are thus important to understand how the carbonaceous chondrite parent bodies were formed in the early Solar System. In this study, we investigated microtextural characteristics of a matrix in one of the most primitive carbonaceous chondrites Acfer 094 [e.g, 3].

Smaples and Methods: Two polished Acfer 094 sections (~2.2 mm^2 and ~6.6 mm^2) were analyzed by using FE-SEM to investigate heterogeneity of the matrix. Based on the analyses, we selected five representative regions and extracted small cube samples (~25×25×30 µm) from them using FIB-SEM. The samples were analyzed using synchrotron radiation X-ray CT (SR-XCT) at SPring-8 BL47XU to obtain 3D internal structures. Based on the SR-XCT analyses, electron-transparent foils were extracted from the samples. The foils were analyzed using (S)TEM-EDS and NanoSIMS to investigate mineralogy and isotopic compositions, respectively.

Results and Discussions: The matrix comprises ~60 vol.% of whole Acfer 094 sections and basically shows compact texture with few pores. In the matrix, we found a lot of small regions (~a few tens of μm^2) which show ultra porous textures. Hereafter we call the regions as ultra porous lithologies (UPLs). The UPLs are widely distributed in the matrix but the proportion of them to the whole matrix is small (~0.3 vol.%). In SR-XCT experiments, we confirmed some UPLs located under the polished surface of the Acfer 094 sections. These results ensure that the pores in UPLs were originally contained in the Acfer 094 meteorite (not by plucking diring polishing). We obtainded phase contrast images of UPLs and the matrix using a technique "scaning-imaging X-ray microscopy" in SR-XCT experiments [4], which enable us to estimate density of material. The estimated density of UPLs and the matrix are ~1.4 g/cm^3 and ~2.4 g/cm^3, respectively. The density of UPLs is comparable with those of CP-IDPs (~0.7 g/cm^3) [1]. TEM observations show that UPLs consist mainly of GEMS-like amorphous silicates, olivine, pyroxene, and pyrrhotite with a few hundred micrometer in size, and contains abundant pores among them. The GEMS-like amorphous silicates lack Fe-Ni metals and show relatively homogeneous Fe-rich compositions compared to GEMS in CP-IDPs. The pores are partially filled by spongy organics. The estimated porosity of UPLs (~40 %) is as high as CP-IDPs (~70 %) [1]. The matrix consists of almost same materials with UPLs but contains small amounts of hydrous minerals suggesting weak aqueous alteration. The isotopic compositions of C and N in UPLs acquired by NanoSIMS ion imaging method are similar to those in the matrix within the analytical errors. The UPLs are slightly enriched in heavy O isotopes compared to bulk Acfer 094 meteorite [5]. The O isotopic compositions of the amorphous materials are plotted along the mass fractionation line of those of GEMS. It may imply that the amorphous materials have the same origin with GEMS.

These results show that UPL shares characteristics of isotopes, mineralogy, and microtexture with CP-IDPs, and thus may have the same origin with them. We infer that UPLs originally having ice is one of the most primitive materials in the Solar System and was probably one of building blocks of carbonaceous chondrite parent bodies. We consider that in the carbonaceous chondrite parent body formation region of the early Solar System, probably in vicinity of the snow line where some amounts of ice could exist, ice-bearing UPLs and compact matrix materials, which formed by removal of ice from UPLs, were accreted (with chondrules and CAIs) to form Acfer 094 parent body. Subsequently, weak aqueous alteration was occurred in the Acfer 094 parent body after the ice melted.

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