3D structure of primitive carbonaceous chondrite Acfer 094: investigation of amorphous silicates

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Introduction: Amorphous silicates known as a major constituent material in chondritic porous (CP-) IDPs are one of the most primitive materials in the solar system. However, amorphous silicates in the meteorites are rarely observed [e.g., 1, 2, 3], and the relationship with that in CP-IDPs has not been clarified yet. Acfer 094 is recognized as one of the most primitive carbonaceous chondrites, since it includes abundant presolar grains and minor hydrous minerals [e.g., 1, 4, 5]. In addition, some researchers reported that Acfer 094 is one of the unique meteorites that contains much amorphous silicates in the matrix [1, 2]. We have focused on the 3D structure of textures including amorphous silicates in Acfer 094 matrix to understand the origin, the earliest stage of accretion and aqueous alteration processes in the solar system.

Methods: FE-SEM observation was carried out on approximately 1x2 mm polished section for understanding the heterogeneity of the sample. Based on the obtained EDS/BSE-map, we selected some areas and fibbed about 25x25x30 μm for nondestructive Synchrotron radiation (SR)-based X-ray computed tomography (SR-XCT). We obtained 3D structures of the samples with the voxel size of ~100 nm by using SR-XCT at SPring-8 BL47XU in Japan. A method using absorption contrasts called "dual-energy tomography" (DET) to obtain 3D distribution of minerals [6], a newly developed technique using phase and absorption contrasts called "scanning-imaging x-ray microscopy" (SIXM) to discriminate between void, water and organic materials [7], and their combined analysis [8] were applied to all fibbed samples.

Results and Discussion: FE-SEM observation revealed that the matrix shows rather homogeneous texture and chemical composition. In addition, we found some unique phase that are similar to cosmic symplectite (COS) in the texture and chemical composition [8]. Typical COS is only observed in Acfer 094 matrix, and shows very heavy oxygen isotopes [8]. We expected that COS can be a good indicator of the primitive area including amorphous silicates in the Acfer 094 matrix, since the unique isotopes should be changed easily by thermal and/or aqueous alteration on the parent body. Thus, we picked up 2 samples, one is from the area having COS and another is from the representative matrix area, using FIB for SR-XCT. Based on the SR-XCT observations, we identified several lithologies having different porosity and texture within both sample. A lithology (lith4) showing low porosity and fibrous minerals as same as aqueous alteration product, and another lithology (lith1) showing extensively high porosity are complexly mixed. The lith1 (10-20 μm in size) distributes throughout the matrix and shows distinct boundary between other lithologies. According to DET analysis obtained by SR-XCT, the estimated texture and chemical composition of the lith1 is similar to that of CP-IDP. It suggests that lith1 mainly consists of amorphous silicates. We will present the results including detailed TEM observation of lith1, and discuss the relationship between each lithology, the primitiveness, and presence or absence of amorphous silicates.

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