

Investigation of Organic Matter in the Matrix of Allende Meteorite by Compact Scanning Transmission X-ray Microscopy

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1 Introduction

Allende meteorite (Allende), which is classed as carbonaceous meteorite (CV3), fell in Pueblito de Allende, Chihuahua State, Mexico, on February 8, 1969. Allende is composed of chondrule, calcium-aluminium-rich inclusions (CAIs), amoeboid olivine aggregates (AOAs), Fe/Ni metal, and matrix. Organic matter (OM) is contained in matrix phase. Distribution of OM in the matrix of Allende at the submicron-scale, however, has not investigated yet.

2 Experiment

In this study, we investigated a focused ion beam (FIB) milled thin section (approximately 150 nm) of Allende transected a region of fine-grained matrix employing carbon X-ray absorption near-edge structure (C-XANES) spectroscopy using compact scanning transmission X-ray microscope (compact STXM), which is installed to BL-13A at Photon Factory, high energy acceleration research organization. The specimen is shown in Figure 1.

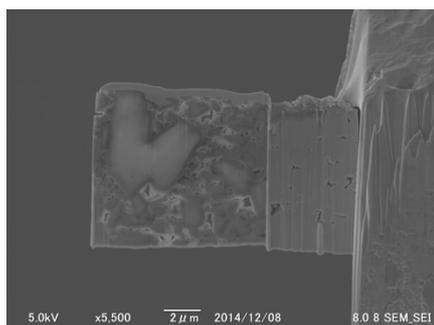


Fig. 1: SEM secondary electron image of the thin foil specimen for compact STXM.

3 Results and Discussion

The compact STXM analysis revealed that the thin section of matrix of Allende contains C-rich grains and diffuse OM (Figure 2). The C-XANES spectra were obtained from seven of C-rich grains, which are similar to Allende's insoluble organic matter (IOM) reported by Cody *et al.* (2008). Some of seven C-rich grains has

exciton peak of the diamond (288.6-288.9 eV). Existence of this peak indicates the possibility that nano-diamonds are contained in these grains. In addition, one of the C-rich grains has possibility of contain of C-N bond (nitrile or heterocyclic imine).

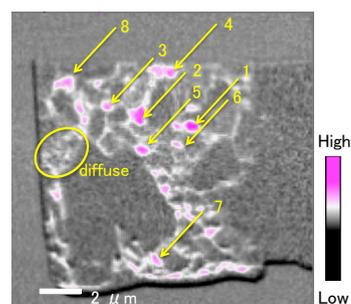


Fig. 2: Carbon elemental image of the specimen.

As to diffuse OM, distributing like vein, whose C-XANES were carboxylic rich OM compared to grains. Diffuse OM was investigated in CM and CI chondrites by C-XANES, whose compositions were mainly labile- and low-molecules OM and which was carboxylic rich OM was reported by Le Guillou *et al.* (2014). However, C-XANES of diffuse OM, was investigated in this study, is different from that reported previously. This difference caused from the difference of empirical temperature between CV, CI, and CM.

From these results, OM is existed in matrix phase as small grain and diffuse OM. And compact STXM measurement was revealed that speciation of OM. Grains have IOM-like feature, and possibility of containing nano-diamonds and C-N compounds. Diffuse OM is carboxylic-rich OM.

As to the future work, existence of nano-diamonds and C-N compounds should be confirmed by TEM observation and N-XANES, respectively. In addition, metamorphosis between OM and inorganic minerals when thermal denaturation should be investigated by compact STXM and Raman microscopy.

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