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Observation on organic nanoglobules in carbonaceous chondrites using microtomography

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In carbonaceous chondrites, IDPs, and dust from comet 81P/Wild2, spherical organic matters called organic nanoglobules were found [1-3]. The size of the nanoglobules is about a few hundred micrometers and most of them have hollow structures. It is suggested that the organic nanoglobules were formed from organics-ice particles in the molecular cloud or the protoplanetary disk in the solar system[4]. Aqueous alteration of organic matters is also suggested as alternative possible formation processes [5]. If one of the hypothesises is true, hollow regions of the globules might be filled with H2O-rich ices or fluids. However they have not been detected because they had been lost during destructive observations, such as transmission electron microscope (TEM) observation, in previous studies.
In the present study, we have tried to determine the existence of fluids in the hollows of organic globules non-destructively using synchrotron radiation-based X-ray microtomography. The imaging experiments were made at the beamline BL47XU of SPring8 with the photon energy of 7.0 or 8.0keV. CT images were reconstructed from 1800 or 900 projections and successional CT images of about 800 slices were obtained for the 3-D structure of each sample. The voxel size in the CT images is 40.8x40.8x40.8 nm, which gives effective spatial resolution of about 200 nm. We succeeded to identify many spherical objects that are the candidates of organic nanoglobules in the CT images. Then, we microtomed some samples and observed the samples under a TEM. Comparison between the CT and the TEM images showed that at least some objects are actually the organic nanoglobules. Moreover, we can determine quantitative 3-dimensional shapes of the organic globules from the CT images and revealed that they are not really spherical but oblate with the aspect ratio of about 0.8. However, we cannot determine whether or not any fluids are present in the cores of the globules by the CT images at present because the contrasts of the spherical objects in the cores in the CT images were largely affected by X-ray refraction. So, we will try to evaluate CT images by considering correction of the X-ray refractions to detect any materials in the cores.
In this study, three-dimensional positions of the nanoglobule candidates in the meteorite samples can be obtained non-destructively in the 3-D CT images. In future work, we will grind the samples to the positions right above the nanoglobules and analyze the chemical and isotopic compositions of these nanoglobules using microanalysis, such as nano-SIMS, if they are filled with fluids.

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