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隕石中の炭素質ゼノリスクラストの有機物分析
Characterization of Carbonaceous Xenolithic Clasts in Meteorites

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Primitive xenolithic clasts are found in many regolith-bearing meteorites [1]. They are most commonly similar to type 1-2 carbonaceous chondrites, but significant differences usually exist. Here we report organic analyses of these carbonaceous clasts in Sharps (H3.4), Zag (H5) and Kapoeta (Howardite) using C-, N-, and O- X-ray absorption near edge structure (XANES), and Fourier transform infrared micro-spectroscopy (microFTIR), with mineralogical observations using a transmission electron microscope (TEM).

Approximately 100 nm-thick sections were extracted with a focused ion beam (FIB) at JSC from the carbonaceous clasts. The sections were analyzed using the micro FTIR, and the scanning transmission X-ray microscope (STXM) on beamline 5.3.2.2 at the Advanced Light Source, Lawrence Berkeley National Laboratory for XANES spectroscopy. After XANES analysis, some of the sections were observed by TEM.

C-XANES and FTIR spectra of clasts in Zag and Kapoeta show a mostly aromatic nature with minor aliphatic signatures. The carbonyl features obtained by C-XANES might have been caused by the focused ion beam (FIB) used in sample preparation. C-XANES spectra of clasts in Zag and Kapoeta do not show significant 1s-$\sigma*$ exciton features, suggesting that these clasts have not experienced high temperature, probably $<200^{o}$C [2], although their parent meteorites have been subjected to strong thermal processing.

The clasts in Sharps have distinctive features from those in Zag and Kapoeta. Sharps (H3.4) meteorite contains unusual large carbonaceous clasts up to ~1 cm in diameter, which have been reported earlier as poorly graphitized carbon with Fe,Ni metal [3]. C-XANES spectra show two types of carbonaceous material in the Sharps clasts: (1) aggregates of graphite-like carbon, and (2) poorly graphitized carbon with O-bearing functional groups. Graphite-like carbon aggregates show significant 1s-$\sigma*$ exciton features which indicate they have been subjected to high temperatures (~700-1000^{o}C) [2]. TEM observation indicates these aggregates are poorly-crystallized graphite with lattice fringes of 3.5-3.75 Å. The other type of carbonaceous material is distributed throughout the clast. C-XANES of these areas shows carbonyl groups as well as aromatic C=C with a small amount of aliphatic C-H. Lower 1s-$\sigma*$ exciton intensities observed in the matrix area indicate that this phase did not experience heating temperatures as high as the graphite-like carbon. TEM observation of this area reveals mainly pyroxene and olivine, the former as laths as in anhydrous chondritic interplanetary dust particles (IDPs) [4].

These primitive xenolithic clasts in Sharps, Zag and Kapoeta have organic features that are distinct from their parent meteorites and preserve their history from before final accretion on single parent bodies. However, they may also have been affected by secondary processes on their parent bodies. In addition, clasts in Sharps contain graphite-like carbon which experienced higher temperatures compared to their surrounding materials. The origin of the graphite-like carbon is probably different from its surrounding material, which indicates a very complex history. Our results from these clasts support the idea of radial mixing in the early Solar System.

References: [1] Zolensky M. Z. et al. 2009. 40th Lunar & Planetary Science Conference, Abstract #2162. [2] Cody G. D. et al. 2008. Earth and Planetary Science Letters 272: 446-455. [3] Brearley A. J. 1990. Geochimica et Cosmochimica Acta 54: 831-850. [4] Zolensky M. E. et al. 1990. Cosmic dust catalog 11. NASA Johnson Space Center/Planetary Science Branch Publication 83: 170.