STXM-C-XANES, IR microspectroscopy, and Raman microspectroscopy analysis of organic matter in the Chwichiya 002 C3.00-ungrouped chondrite

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Chwichiya 002 is a C3.00-ungrouped carbonaceous chondrite discovered in Western Sahara in 2018. The presence of hydrated phases in Chwichiya 002 was not confirmed by XRD analysis, and only a faint water and Si-O band attributed to phyllosilicate were observed by infrared transmission spectroscopy, indicating a very low degree of aqueous alteration (Meteoritical Bulletin, 2020). The structural order of polycyclic aromatic hydrocarbons evaluated by Raman spectroscopy indicates that the effect of thermal metamorphism is less severe than in the Semarkona meteorite, an LL3.00 ordinary chondrite (Meteoritical Bulletin, 2020). Chiwichiya 002 is a very primitive carbonaceous chondrite and an important information source for the early stage of the evolution of organic matter in the solar system. In this study, we investigated the molecular structure and distribution of organic matter in Chiwichiya 002 by Carbon X-ray Absorption Near Edge Structure (C-XANES) analysis using a Scanning Transmission X-ray Microscope (STXM). The STXM-C-XANES analysis has a spatial resolution of 20~100 nm and can observe the spatial distribution of organic materials in microstructures. In addition, to investigate the degree of thermal metamorphism of the organic matter, micro-IR, and micro-Raman spectroscopic analyses were performed. In addition, the Murchison CM2 chondrite was also analyzed for comparison. To evaluate contamination during analytical procedures, antigorite, which was heated in air at 500˚C for 5 hours to eliminate organic matter was also analyzed in the same manner. The samples were milled into 100 nm-thick, thin sections using a Focused Ion Beam (FIB), and C-XANES spectra were obtained using the STXM at the High Energy Accelerator Research Organization, Photon Factory (PF), BL-19B. The obtained C-XANES spectra were smoothed and then fitted with Gaussian functions using the method of Le Guillou et al. (2018).
The C-XANES showed that the ratio of oxygenated functional group (ketone, phenolic) carbons in Chwichiya 002 was lower than in Murchison, whereas the ratio of aliphatic carbons was almost the same. This may reflect the low degree of aqueous alteration of Chwichiya 002.
In addition, contamination peaks were detected at 287.3-287.7 eV and 288.3-288.7 eV in the C-XANES spectra of some of the antigorite samples. The source of these peaks is under investigation.
Raman spectroscopic analysis showed that the intensity ratio of the D band to the G band of Chwichiya 002 was slightly higher than that of Murchison. IR absorption spectra showed aromatic absorption at 1630 cm^{-1}, but there was little absorption due to aliphatic C-H around 2900 cm^{-1}. These results suggest that the organic matter in Chwichiya 002 may be more heated than in Murchison.

Reference

International Society for Meteoritics and Planetary Science. (2020). Meteoritical Bulletin Database. Retrieved February 16, 2023, from https://www.lpi.usra.edu/meteor/metbull.php?code=69684

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