BL-3A/2019G610

X-ray diffraction analysis of dark inclusions in a meteorite from asteroid 4 Vesta

Miki Takahashi*, Tomoki Nakamura, Shota Shimizu,
Katsumi Ohgiya, Megumi Matsumoto, Yoshiki Kosaka and Yuri Fujioka
Division of Earth Sciences, Graduate School of Science,
Tohoku University, Sendai 980-8576, Miyagi, Japan

1 Introduction

Dark inclusions (DIs) are micron- to cm-size dark rock fragments in meteorites and they have mineralogical and petrological features different from the host meteorites. Some DIs show unique petrographic properties, and they may contain material information never found in meteorites. DIs have escaped high-speed impacts upon accretion on asteroids, because gravitation of asteroids is much smaller than the earth. When meteorites including DIs come to the earth, DIs do not experience high-temperature heating and high pressure upon atmospheric entry because they are enveloped within the host meteorite. In order to understand the formation and accretion process of DIs in a meteorite from 4 Vesta, we performed synchrotron X-ray diffraction analysis of individual small DIs separated from the EET 15101 eucrite.

2 Experiments

HED (Howardite, Eucrite, and Diogenite) meteorites, coming from asteroid 4 Vesta, commonly contain DIs [1]. The EET 15101 eucrite contains many small DIs and particles in the size range of 100-200 μm were taken out from each DI. Individual single-particle was exposed to X-rays at a wavelength of 2.16 Å and the obtained X-ray powder diffraction patterns was analyzed for the mineral composition of each DI. Then the DI was embedded in epoxy resin and coated by carbon deposition to be observed by FE-SEM/EDS and FE-EPMA/WDS.

3 Results and Discussion

Synchrotron X-ray diffraction analyses proved that the DIs consist mainly of hydrous silicates and are classified into two types (Fig. 1): CM chondrite (CM) and Tagish Lake or CI chondrite (TL/CI) type. Hydrous silicates in both types show the absence of (or presence of small) basal 001 reflection and the presence of prism reflections, indicating that they were heated and partially decomposed. The bulk mineralogy of TL/CI-type DI (Fig. 1) is similar to Tagish Lake and CI chondrite that are experimentally heated at 400-600°C [2,3], while that of the CM-type DI is similar to the 400-600°C heated Murchison. Murchison is known to form poorly-crystalline magnetite-like material at about 500°C [4] and thus the CM type has experienced heating at about 500°C.

Electron microscope observation of a polished cross section of the CM-type DI showed abundant occurrence of pure tochilinite (Fig. 2), which suggests the low degree of aqueous alteration, because tochilinite was decomposed by pervasive alteration. The 500°C-heating decomposed and dehydrated the tochilinite, because it was not identified in the XRD pattern (Fig.1).

Both types of DIs came from primitive hydrated asteroids that formed at outer solar nebula beyond the snow line because they show bulk mineralogy similar to meteorites from these asteroids. The DIs might have been heated during or after incorporation to asteroid 4 Vesta, because all DIs showed partial dehydration of hydrous silicates.

Acknowledgement

We thank Dr. Nakao for technical support during X-ray diffraction analysis.

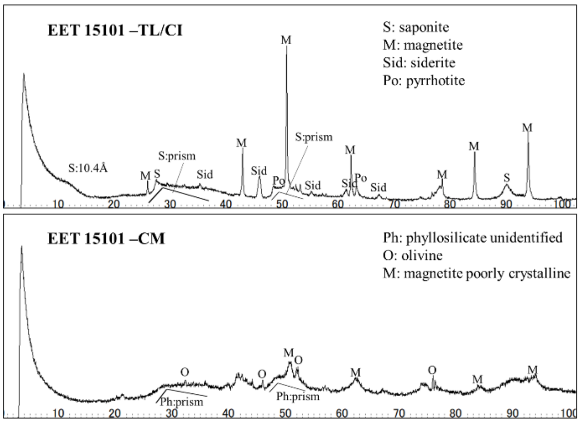

Fig. 1. X-ray powder diffraction pattern of the DIs in the EET 15101.

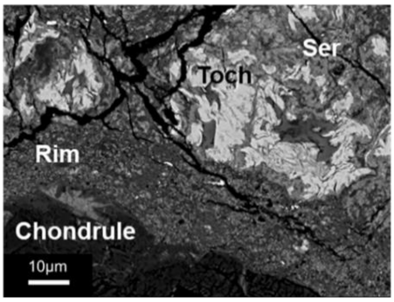

Fig. 2. SEM/BSE image at high magnification of the CM-type DI. It contains serpentine (Ser), tochilinite (Toch), a chondrule rim (Rim), and a chondrule.

References

[1] Zolensky et al. (1996) Meteoritics & Planetary Science 31, 518-537.
[2] Mogi et al. (2017) 80th Annual Meeting of the Meteoritical Society, Abstract #6225.
[3] Nozaki et al. (2005) Meteoritics & Planetary Science 41, 1095-1114.
[4] Yamashita et al. (2015) 78th Annual Meeting of the Meteoritical Society, Abstract. #5154.

*miki.takahashi.p4@dc.tohoku.ac.jp