

Mineralogical variations of CM chondrites revealed from X-ray diffraction method: Application to the parent body evolution

*Naoya Imae^{1,2}, Makoto Kimura¹, Akira Yamaguchi^{1,2}

1. Antarctic Meteorite Research Center, National Institute of Polar Research, 2. The Graduate University for Advanced Studies (SOKENDAI)

Introduction

CM chondrites have been characterized by aqueous alteration in the parent body [e.g., 1,2], and subtypes have been identified [3,4]. Findings of dehydrated [5,6] and unaltered samples [7] added new views. We studied the significant variations. We newly modeled the parent body evolution.

Experiments

Samples are QUE 97990 (subtype, 2.6), Murchison (2.5), DOM 03183 (2.5), Y-791198 (2.4), QUE 99355 (2.3), SCO 06043 (2.0), MET 01070 (2.0), Y 980036 (2.4-2.5 and heating stage II), Y 980051 (2.4-2.5 II), and Jbilet Winselwan (2.4-2.7 II). Three types of equipment were mainly used: X-ray diffractometer (XRD), field emission scanning electron microscope, and electron probe microanalyzer. The measurement conditions for XRD are the same as [8]. Focused Miller indices for XRD are the same as [9].

Results and Discussion

Systematic change is observed for subtypes of unheated CMs: The intensities of olivine, pyroxenes, and kamacite plus troilite decrease with decreasing subtypes—instead, serpentines (antigorite and cronstedtite) increase. Tochilinite abundance is the highest at the intermediate subtype (2.5-2.3). The relative intensity of antigorite to cronstedtite increases with decreasing subtype. Y 980036 and Y 980051 are entirely dehydrated, and matrices are low-crystalline. The sulfide assemblages correspond to category B [10]. Chondrule phenocrysts of forsterite olivine, ferroan olivine, and clinoenstatite have not been altered. Although the mesostasis has been altered. Cronstedtite and tochilinite in Jbilet Winselwan are decomposed, but antigorite is partly survived. [11] also showed that Jbilet Winselwan is a regolith breccia. We also confirmed that textures and analyzed compositions are consistent with XRD.

Application to the parent body evolution

Based on the observed mineralogical variations of CM chondrites, we will consider the evolutionary processes of the parent body, focusing on dehydration. The hydrous alteration degree may be related mainly to temperature, potential of hydrogen, and water/rock ratio [2,12]. On the other hand, after once hydrated, dehydration has been theoretically predicted in the early history of the parent body's interior in a few million years after the formation [13]. Due to the latent heat of water, the peak metamorphic temperature is limited to be 600-800 K for the hydrous parent body with 100 km diameter, lower than that of anhydrous parent body [13]. The textures and compositions for dehydrated CM should be controlled by the diffusion length of Mg-Fe diffusion of olivine. The diffusion feature between forsterite and ferroan olivines is not noticed from intermediately heated CM. The absence of the diffusion is consistent with the estimation that any significant diffusion for the intermediate depth is not expected within the cooling time scale of 1-10 million years from 600-700K. The present model on parent body evolution is seemingly consistent with our observations.

References

[1] Tomeoka K. and Buseck P. R. 1985. *Geochim. Cosmochim. Acta* 49:2149. [2] Zolensky M. et al. 1993.

Geochim. Cosmochim. Acta 57:3123. [3] Rubin A. 2007. Geochim. Cosmochim. Acta 71:2361. [4] Howard K. T. 2011. Geochim. Cosmochim. Acta 75:2735. [5] Nakamura T. 2005. J. Min. Pet. Sci. 100:260. [6] King A. et al. 2019. Meteorit. Planet. Sci. 54:521. [7] Kimura M. et al. 2020. Polar Sci. 17:100565. [8] Imae N., et al. 2019. Meteorit. Planet. Sci. 54:919. [9] Imae N. and Kimura M. 2020. Polar Science Symp. abstract. [10] Kimura M. et al. 2011. Meteorit. Planet. Sci. 46:431. [11] Zolensky M., et al. 2016. 47th LPSC. #2148. [12] Brearley A. J. 2006. In Meteorites and the Early Solar System II. [13] Grimm R. E. and McSween H. Y. 1989. Icarus 82:244.

Keywords: CM chondrites, X-ray diffraction, hydrous minerals, Antarctic meteorites, meteorite parent body, metamorphism