Evolution of thermally metamorphosed C-complex asteroids inferred from a heated CM chondrite Jbilet Winselwan

*藤谷 渉[1]、東 久人[1]、日比谷 由紀[2]、菅原 慎吾[1]、山口 亮[3]、木村 眞[3]、橋爪 光[1]
*Wataru Fujiya[1], Hisato Higashi[1], Yuki Hibiya[2], Shingo Sugawara[1], Akira Yamaguchi[3], Makoto Kimura[3], Ko Hashizume[1]

1. 茨城大学 理学部、2. 海洋研究開発機構、3. 国立極地研究所
1. Ibaraki University, College of Science, 2. Japan Agency for Marine-Earth Science and Technology, 3. National Institute of Polar Research

Some C-complex asteroids are thermally metamorphosed as indicated by their reflectance spectra (e.g., Hiroi et al., 1993). However, the thermal history of these asteroids is poorly understood. CM chondrites are aqueously altered in their parent body, and some of them apparently underwent post-alteration thermal metamorphism (e.g., Nakamura, 2005). In this work, we study Jbilet Winselwan (JW), a thermally metamorphosed CM chondrite, to constrain the heat source for thermal metamorphism and to investigate the evolution of thermally metamorphosed C-complex asteroids.

Sulfide minerals in JW are pyrrhotite with abundant pentlandite blebs, suggesting mild heating (Kimura et al., 2011). Mass losses in thermogravimetric analysis are 0.98 and 4.1 wt% for temperature ranges of 200-400 and 400-770 °C, which correspond to OH^-/water release from tochilinite and phyllosilicate, respectively (Garenne et al., 2014). These values are much lower than the corresponding values of Murchison (3.1 wt% for 200-400 °C and 6.8 wt% for 400-770 °C). Large clumps of tochilinite/cronstedtite intergrowth (TCI), which are commonly found in CMs, are rare. TCIs in JW have lower S/SiO_2 and higher FeO/SiO_2 ratios (~0.16 and ~3.2, respectively) than expected from typical CMs (Rubin et al., 2007). These observations suggest that tochilinite, unstable at high temperatures of >170 °C (Zolensky, 1984), is decomposed by heating. The decomposition of TCIs has also been confirmed for other thermally metamorphosed CMs and an experimentally heated Murchison sample (Nakato et al., 2008).

Ca-sulfate grains are commonly surrounding calcite grains, indicating that Ca-sulfate precipitated subsequently after calcite. The Ca-sulfate is identified as anhydrite ($CaSO_4$) using Raman spectroscopy. Gypsum ($CaSO_4 \cdot 2H_2O$), stable at <110 °C (Prieto-Taboada et al., 2015), is absent. The absence of gypsum also indicates that JW underwent heating. Because we found substantial amounts of Ca-sulfate, Ca-sulfate is one of the main carriers of sulfur. We propose that sulfur in Ca-sulfate was supplied from TCIs decomposed by heating.

The ^{53}Mn-^{53}Cr age (half-life: 3.7 Myr) of JW calcites measured by SIMS is 4564.8 (+1.2/-1.5) Ma, significantly older than the ages of typical CMs (~4563 Ma) (Fujiya et al., 2012). The older age of JW calcites indicates an earlier onset of aqueous alteration. Therefore, JW contained a larger amount of radioactive ^{26}Al (half-life: 0.7 Myr) than typical CMs when aqueous alteration took place, which is consistent with a higher peak temperature experienced by JW. Thus, the energy for the heating was most likely provided by ^{26}Al decay.

In summary, the aqueous alteration and calcite formation in JW initiated ~4564.8 Ma. Then, the temperature kept increasing, which led to thermal metamorphism associated with the TCI decomposition and subsequent anhydrite precipitation. These processes were likely driven by ^{26}Al decay. It is currently unclear whether JW was located at the inner part of the CM parent asteroid, or it is derived from a

different parent asteroid than typical CMs. We will conduct Cr- and Ti-isotope analyses to investigate a genetic relationship between JW and typical CMs.

キーワード：C型小惑星、熱変成作用、CMコンドライト、Jbilet Winselwan
Keywords: C-complex asteroids, Thermal metamorphism, CM chondrite, Jbilet Winselwan