CM chondrites: Classification and anomalous CMs

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CM chondrites are the most abundant group of carbonaceous chondrites, and are likely to be related to samples returned by the Hayabusa2 and OSIRIS-REx missions. CMs experienced varying degrees of aqueous alteration and thermal metamorphism [1-4]. Kimura et al. [5] recently reported three CM chondrites, Asuka (A) 12085, A 12169, and A 12236, that experienced very low degrees of aqueous alteration and thermal metamorphism. Here we discuss the classification of CM chondrites, especially subtypes, anomalous CMs, and CM-CO clan.

A 12085, A 12169, and A 12236 experienced neither significant aqueous alteration nor thermal metamorphism. These chondrites are the most primitive CM chondrites so far reported [5]. This is recently supported by [6]. CM chondrites have been classified into CM2.7-2.0 [2], based on the criteria such as the alteration degree, matrix composition, metal abundance, TCI feature, sulfide mineralogy, and occurrence of carbonate. However, most of these criteria cannot be applied for the classification of A 12085, A 12169, and A 12236. Instead, many characteristic features of these chondrites show very low degrees of the aqueous alteration, higher than subtype 2.7.

Rubin [2] hypothesized that CM3.0 should have some distinct features if present. I modified his criteria, and propose the following criteria for CM3.0 to 2.8. CM3.0: abundant primary glass and feldspar in chondrule mesostasis, rare or no phyllosilicate in the matrix, unaltered phenocryst, abundant metal (>2 vol.%), no TCI, abundant troilite, and no carbonate. CM2.9: glass>phyllosilicate in chondrule mesostasis, and rare phyllosilicate in the matrix. CM 2.8: phyllosilicate>glass in chondrule, minor phyllosilicate in the matrix, and rare carbonate. From these criteria, A 12169, A 12236, and A 12085 are classified as subtype 3.0, 2.9, and 2.8, respectively.

Many carbonaceous chondrites are classified as ungrouped or anomalous. Especially, CM group abundantly contains anomalous chondrites. I investigated the modal compositions from our data and Meteoritical Bulletin database, including anomalous CMs. Although the modal compositions of matrix show a wide variety, they mostly range from 50 to 90 vol.%. They are systematically higher than those of COs (<50 %). The average chondrule diameters of CMs are usually larger than those of COs. Although they belong to the CM-CO clan, these features distinguish CM from CO chondrites, and suggest that CMs and COs were derived from different parent bodies or precursor materials. However, some of anomalous CMs show a wide variety of oxygen isotopic compositions [7]. The primordial materials of CMs had been rich in diversity.

References

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