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Petrography of Fluffy Type A CAI from Efremovka meteorite and overgrowth of zoned melilite

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Calcium-Aluminum-rich inclusions (CAIs) are the oldest rocks in the solar system and preserve a record of events in the early solar system. In this study, we report petrography of Fluffy Type A CAI from Efremovka meteorite and discuss forming process of melilite from compositional zoning of melilite crystals.
A polished thin section of Efremovka meteorite was used. FE-SEM-EDS was used for petrographic study and chemical analysis. Grain boundaries of melilite were determined by EBSD. The CAI has 10 x 3 mm in size and fluffy shape which composed of melilite (52%), spinel (16.2%), diopside (12.8%), anorthite (0.58%), olivine (0.35%), hibonite (0.28%), and alteration products (1 6.7%). The CAI consists of core part which contains much amount of spinel with minor anorthite, melilite, Al-Ti-rich diopside and Flemdlinge, mantle part which composed of mainly melilite and Al -Ti-rich diopside with small quantity of spinel, rim part which contains gehlenitic melilite, Al-Ti-rich diopside, hibonite, perovskite surrounded by Wark-Lovering rim. The bulk chemical composition of the CAI falls between Type A CAI and Type B CAI in the anorthite-gehlenite-forsterite phase diagram (Stolper, 1982). The akermanite compositions of melilite ranges Ak=2-54 and the average is Ak=30. Therefore, the CAI was classified to be Fluffy Type A CAI compositionally close to Type B CAI. Melilite has 15-25 micrometer sized concentric zoning structure and each structure was identified as a single crystal. The core of each melilite crystals was reversely zoned. The melilite crystals in the rim part of CAI have reverse zoning to the end of the grain boundary and the akermanite composition at the grain boundary was Ak=15. On the other hands, the akermanite composition of the melilite crystals in the mantle part of CAI changed to normal zoning structure in 2-5 micrometer region around the grain boundaries and the akermanite composition at the grain boundary was Ak=40.
MacPherson and Grossman (1984) argue that reversely zoned melilite crystals in Fluffy Type A CAI condensed as solids from the hot solar nebula gas. Most of melilite crystals of the CAI studied in this paper could be also crystallized under such process. However, the melilite crystals with normal zoning around the grain boundaries were thought to be result of crystal overgrowth on the partially molten melilite crystals around the grain boundary by re-heating of the melilite crystallized from gas.

Keywords: CAI, melilite, grain boundary, zoning, Fluffy Type A CAI, Efremovka chondrite