TWO GENERATIONS OF HEXAGONAL CaAl₂Si₂O₈ (DMISTEINBERGITE) IN THE TYPE B2 FUN CAI STP-1.

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Introduction: Dmisteinbergite (dmist) is a metastable hexagonal form of CaAl₂Si₂O₈ with space group of P6₃/mcm, a = 5.10Å and c = 14.72Å [1]. First occurrence of meteoritic dmist has been reported in the Allende Type B2 FUN CAI STP-1 [2], where it appears to have crystallized from a ¹⁶O-rich (Δ¹⁷O ~ −25‰) silicate melt via rapid cooling [3]. Here we report on another textural occurrence of dmist in STP-1 – ¹⁶O-poor (Δ¹⁷O ~ −2‰) fine-grained crystals in alteration zone of the inclusion.

The mineralogy and mineral chemistry of STP-1 were studied with the UH field-emission JEOL JXA-8500F electron microprobe and JEOL JSM-5900LV equipped with electron back-scattered diffraction detector HKLNordlys. Oxygen isotopes were measured in situ with the UH Cameca ims-1280 ion microprobe using primary Cs⁺ ion beam with ~2 μm beam size.

Results and Discussion: STP-1 is a Type B2 CAI composed of melilite, Al,Ti-diopside, spinel, dmist, and minor hibonite. Melilite in the CAI periphery is partly replaced by secondary nepheline, sodalite, grossular, Al-diopside, hexagonal dmist, and triclinic anorthite. Secondary dmist occurs as acicular crystals whereas secondary anorthite forms anhedral massive grains. Secondary dmist and anorthite contain up to 1 wt% of Na₂O, whereas primary dmist is Na-free. On a three-oxygen isotope diagram, secondary dmist and anorthite plot along slope-1 line have ¹⁶O-poor compositions (Δ¹⁷O ~ −2‰); one dmist grain is ¹⁶O-enriched (Δ¹⁷O ~ −10‰). In contrast, O-isotope compositions of coarse-grained igneous dmist plot along ~slope-0.5 line with Δ¹⁷O ~ −25‰. Experimental studies show that in supercooled melts dmist crystallizes prior to anorthite at temperatures below metastable liquidus (1400°C) [e.g., 4]. These observations and the fractionated O-isotope compositions of coarse-grained igneous dmist in STP-1 suggest that it crystallized from a supercooled melt that experienced evaporation, possibly at low total pressure (<10⁻⁶ bar) [5]. On the contrary, fine-grained dmist coexisting with secondary minerals is likely to have formed by hydrothermal alteration on the CV parent asteroid, which is consistent with its ¹⁶O-depleted composition and elevated Na₂O content. Experimental studies suggest during hydrothermal alteration at 200–250°C, reaction of gehlenitic melilite with SiO₂ dissolved in an aqueous solution/fluid may result in formation of hydrogrossular [6]. Subsequent heating may transform hydrogrossular into dmist that is stable up to 1000°C [7]. We infer that STP-1 contains two generations of dmist – igneous and hydrothermal. Crystallization of igneous dmist from a Type B2 FUN CAI melt indicates that the melt experienced supercooling at the final stages of crystallization. Subsequently, STP-1, like many typical CV CAIs, experienced hydrothermal alteration on the CV parent asteroid.