FORMATION OF THE FLOWED CORE IN A LEOVILLE TYPE B CAI: PLASTIC DEFORMATION OR HOT ACCRETION?

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Introduction: Calcium-aluminum-rich inclusions (CAIs) from the highly shocked (S3) reduced-type CV3 chondrite Leoville are typically elongated and deformed (Cain et al., 1986; Scott et al., 1992). Caillet et al. (1993) described a flattened (L/W > 6) Leoville Type B inclusion (3537-1) with two distinct petrologic units, one exhibits poikiloblastic texture, which anorthite blades enclose numerous round crystals of Al-Ti-diopside and melilitite; another is relict island of coarse-grained Al-Ti-diopside, melilitite, anorthite, and spinel. 26Al/27Al isotope systematics showed that the poikiloblastic unit contains little or no excess 26Mg, while the relict island unit has typical initial 26Al/27Al of ~ 4.6 × 10^-5. To explain its unique petrologic and isotopic characteristics, Caillet et al. (1993) proposed that this inclusion was accreted onto the Leoville parent body while still very hot, and deformed into its elongate shape at the instant it impacted. Here we present a petrology and oxygen isotope study of a Leoville Type B CAI, which may also indicate a hot accretion process.

Results: BBL2-1 is slightly flattened (~9.5 × 4.5 mm²; L/W ~ 2) Type B1 CAIs with a blunted core-mantle structure. Its mantle is mostly intact and consists predominantly of melilitite with minor intergranular anorthite and Al-Ti-diopside. Its core, identified by the coarse-grained (up to 0.8 mm in length) anorthite and Al-Ti-diopside as well as aggregates of large spinel crystals (up to 80 μm), is highly flattened and flowed, especially for the Al-Ti-diopside and anortiotics. It starts from the middle left of this inclusion to the entire center part and finally arrives the middle right with a shape like a “bird”. Nearly 80% of the inclusion is surrounded by a Wark-Lovering (WL) rim composed of spinel + perovskite, melilitite, spinel, Al-Ti-diopside, diopside + forsterite (from innermost to outermost). The middle left part of the inclusion is lack of WL rim. Noteworthy, the WL rim material and chondrite matrix were involved with the “bird-flowed core” into the interior of the inclusion. Round clasts of CAI materials, including melilit and Al-Ti-diopside with/without the WL rim, are present in the nearby chondrite matrix. The matrix was melted with olivines nucleated at high angles to the clast surface, and also contains tiny globules of metal and sulfide.

The mantle Al-Ti-diopside and anorthite are homogeneously 16O-enriched with an average Δ17O = -23.3 ± 1.4‰ (2sd). In the core, those euhedral Al-Ti-diopside and anortiotics remain 16O-enriched (Δ17O = -23.3 ± 1.3‰, 2sd), while those flowed counterparts have relatively fluctuant oxygen isotopic compositions with Δ17O range from -23.5‰ to -14.6‰. Similarly, those diopside of WL rim that existed in the interior of the inclusion have a relatively wide range of oxygen isotopic compositions (Δ17O: -24.1‰ to -12.7‰). In contrast, melilitites from both the core and mantle are significantly 16O-depleted with Δ17O range from -3.87‰ to 0‰ (average: -1.94 ± 1.6‰, 2sd). Furthermore, the melilitite from the WL rim and the CAI clasts in the nearby matrix are slightly less 16O-depleted with Δ17O range from -12.1‰ to -2.6‰, and from -8.2‰ to -1.8‰, respectively.

Discussions: (1) How the WL material and the chondrule matrix involved into the interior of the inclusion? Since the middle left part of the inclusion, where the core flow starts, is absent of WL rim, we believe that the WL rim material, as well as the chondrule matrix, was conveyed into the CAI interior by the flowed core minerals; (2) Which process triggered the flow of core minerals? Solid-state plastic deformation during shock event would be capable, but no signs of plastic deformation of anorthite and Al-Ti-diopside were observed in previous transmission electron microscope studies on Leoville chondrules and matrix (Cain et al., 1986; Nakamura et al., 1992), though we cannot rule out this possibility based on this. On the contrary, hot accretion would be possible. If the CAI was incompletely solidified, trace amount of residual melt would be flowed and transported the crystallized core minerals, broken WL rim materials, and the chondrite matrix inside the inclusion during the impact event that happened immediately after it accretion. To explain the relatively homogeneous 16O-enriched compositions of anorthite and the 16O-depleted compositions of melilitite, which are decoupled from each other, the temperature would be higher than 800°C and lasted for some time after it buried in the parent body. While the melilitites at the WL rim or the chondrite matrix were less affected and been more 16O-enriched. More discussions will be made at the conference.