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

Mingming Zhang[1],Yangting Lin[1], Guoqiang Tang[1], and Ingo Leya[2],[1]Institute of Geology and Geophysics, Chinese Acadmy of Sciences (IGGCAS), No.19, Beituchengxi Road, Chaoyang District, 100029, Beijing, China, zhang-mingming113@mails.ucas.ac.cn, [2]Physical Institute, Space Sciences and Planetology, University of Bern, 3012 Bern, Switerland, ingo.leya@space.unibe.ch.

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 melilite; another is relict island of coarse-grained Al-Ti-diopside, melilite, anorthite, and spinel. ^{26}Al-^{26}Mg isotope systematics showed that the poikiloblastic unit contains little or no excess ^{26}Mg, while the relict island unit has typical initial $^{26}Al/^{27}Al$ 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 mm^2; L/W~ 2) Type B1 CAIs with a blurred core-mantle structure. Its mantle is mostly intact and consists predominantly of melilite 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-diopsides and anorthites. 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, melilite, 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 melilite 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 ^{16}O-enriched with an average $\Delta^{17}O$=-23.3 ± 1.4‰ (2sd). In the core, those euhedral Al-Ti-diopsides and anorthites remain ^{16}O-enriched ($\Delta^{17}O$=-23.3 ± 1.3‰, 2sd), while those flowed counterparts have relatively fluctuant oxygen isotopic compositions with $\Delta^{17}O$ range from -23.5‰ to -14.6‰. Similarly, those diopsides of WL rim that existed in the interior of the inclusion have a relatively wide range of oxygen isotopic compositions ($\Delta^{17}O$: -24.1‰ to -12.7‰). In contrast, melilites from both the core and mantle are significantly ^{16}O-depleted with $\Delta^{17}O$ range from -3.87‰ to 0‰ (average: -1.94 ± 1.6‰, 2sd). Furthermore, the melilite from the WL rim and the CAI clasts in the nearby matrix are slightly less ^{16}O-depleted with $\Delta^{17}O$ 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 chondrite 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 ^{16}O-enriched compositions of anorthite and the ^{16}O-depleted compositions of melilite, which are decoupled from each other, the temperature would be higher than 800℃ and lasted for some time after it buried in the parent body. While the melilites at the WL rim or the chondrite matrix were less affected and been more ^{16}O-enriched. More discussions will be made at the conference.

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