Mg-Al ISOTOPIC STUDY OF A DEFORMED AND RECRYSTALLIZED LEOVILLE TYPE B REFRACTORY INCLUSION: HOT ACCRETION INTO A COLD MATRIX, AND IF SO WHEN?;

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Populations of refractory inclusions from different CV3 meteorites are not alike and preserve somewhat different clues to early solar system processes. For example, inclusions in Leoville are very large like the ones in Allende but are far less altered. However, Leoville stones show a pronounced lineated fabric when observed on sawn surfaces [*e.g.* 1], and this fabric is defined by ovoid chondrules and the flattening of many inclusions. The possibility exists that some of the isotopic characteristics in deformed inclusions may have been affected by the flattening event, and it would obviously be interesting to establish at least a relative age for this event using extinct radionuclides such as ^{26}Al. The few previous Mg-isotopic investigations of Leoville CAI have shown little evidence for pervasive isotopic reequilibration, but with the exception of [2] give insufficient descriptions to estimate the intensity of deformation of the inclusions. One of the two CAI reported in [2] does show evidence of major recrystallization, and the Mg-isotopic system is disturbed, but the highest Al/Mg value observed in the disturbed phase, melilite, is ~15. As part of a systematic petrologic, trace element and isotopic study of refractory inclusions in CV3 meteorites we have studied two Leoville CAIs: one (USNM 3537-2) is a spheroidal 1.1 cm diam. type B1 with little macro- or microscopic evidence for deformation, and the other is a very large (>3cm long) cigar- or pancake-shaped (l/w >6) type B inclusion, USNM 3537-1, whose long axis parallels the overall meteorite lineation. Thin section examination shows that the latter inclusion has been mostly recrystallized into a fine-grained polygonal-granular ("sugary") -textured mosaic of melilite, fassaite, spinel and anorthite crystals, with a few elongate islands of more-coarsely crystalline material that apparently preserve vestiges of the original type B texture. Apart from textures, the new mineralogy and mineral chemistry are indistinguishable from those in the vestigial islands, however, and for that matter from those in"normal" type B inclusions. In spite of the overall deformation of the inclusion, the minerals themselves are unstrained and apparently crystallized after deformation. Near the outer margins of the inclusion are some large (up to ~400 µm long, ~50 µm wide) elongate blades of anorthite that poikiloblastically enclose melilite and spinel; many of these blades are oriented at high angles to the elongation of the inclusion and to the meteorite lineation, again suggesting growth after deformation of the inclusion. The inclusion shows a slight concentric zonation in relative mineral proportions, which is reflected also in the mineral compositions. Melilite is on average more Al-rich (generally, Åk <~40) near the exterior than in the interior (generally, Åk >~40). Fassaite tends to be more Al-Ti-rich near the exterior than in the interior, but there is considerable overlap in composition (overall Al_2O_3 ~14-23%, TiO_2 ~4-10%). The MgO contents of anorthites in the interior of 3537-1 extend to higher values (up to ~0.45%) than those in the exterior (up to 0.1%), but again there is overlap. A unique feature of 3537-1 is that locally, along the inclusion/matrix contact, the matrix has recrystallized into long blade-like olivine crystals that nucleated on the surface of the inclusion and radiate outward into the matrix at high angles; this zone is not continuous. 3537-2 shows no such "baked" contact. All of the petrographic and mineral chemical observations suggest that 3537-1 crystallized after its deformation, and was accreted hot into a relatively cooler parent body. The most straightforward interpretation is that deformation occurred during and in response to accretion of a very hot and plastic (partially molten?) CAI. Nonetheless, ion microprobe isotopic data raise serious problems with this interpretation. All of the anorthite crystals, compared to spinel + pyroxene, show excesses of ^{26}Mg ($^{26}Mg^*$). Data from multiple points inside of each of three "coarse" vestigial anorthites from the interior spread out over a range of $^{27}Al/^{24}Mg$, such that each crystal defines an internal correlation between $^{27}Al/^{24}Mg$ and $^{26}Mg/^{24}Mg$ suggestive of *in situ* decay of ^{26}Al. However, the inferred initial abundance ratios $(^{26}Al/^{27}Al)_0$

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of the three crystals range from 2.83×10^{-5} to 4.56×10^{-5}. Although "second generation" anorthites from near the inclusion margin are disturbed, they do not yield a unique correlation line: three spots in one crystal define $(^{26}Al/^{27}Al)_0 \sim 2.8 \times 10^{-5}$, and a single spot on another anorthite gives $(^{26}Al/^{27}Al)_0 \sim 1.4 \times 10^{-6}$. Thus the apparently pervasive deformation and recrystallization of 3537-1 is **not** reflected by a well-defined "late" resetting of the radiometric clock. Isotopic data from phases in the undeformed type B1, 3537-2, define a slightly disturbed system with an upper limit for $(^{26}Al/^{27}Al)_0$ of $\sim 4.9 \times 10^{-5}$ in one anorthite crystal and a range of lower initial values down to 3.3×10^{-5} in three other anorthite crystals. Isotopically, therefore, 3537-2 presents no problems that are different from those presented by most other type B inclusions. However, of the several possible explanations for 3537-1, all have problems. For example, the deformation and final recrystallization of the inclusion might have long pre-dated incorporation into the meteorite parent body, in which case the fact that the long axis of the inclusion parallels the meteorite lineation is simply an accretionary alignment similar to that of clam shells in a sandstone. This model implies that only the outer anorthites with the lowest inferred $(^{26}Al/^{27}Al)_0$ reflect any resetting by accretionary or post-accretionary events. It does not explain the "baked contact" with the meteorite matrix, unless the baked zone also pre-dates incorporation into the parent body and actually represents reheating of an accretionary mantle [3]. Alternatively, perhaps recrystallization of the inclusion simply did not redistribute the $^{26}Mg^*$. Yet the fact remains that most other type B inclusions show some evidence of disturbance of their Mg-Al isotopic systems even though they show far fewer petrologic signs of disturbance than 3537-1 does [*e.g.* 4]. Attributing the isotopic systematics to "fossil chemical memory" [5] cannot explain why the isotopes remain so heterogeneous even in spite of severe solid state recrystallization and probable igneous solidification preceeding that, nor can it explain internal "isochrons" within individual anorthite crystals. The last possibility is that the maximum inferred initial abundance ratio $(^{26}Al/^{27}Al)_0$ of 4.56×10^{-5} in fact reflects the time of accretion of the Leoville parent body into which the hot inclusion was incorporated, and disturbances to the Mg-Al isotopic system reflect later post-accretionary events. This model requires planetesimal accretion at essentially time zero in the early solar nebula, a concept at odds with current planetary accretion models.

References: [1] Hutcheon *et al.*, 1984, Meteoritics **19**, p. 244; [2] Cain *et al.*,1986, EPSL **77**, p. 165; [3] MacPherson *et al.*, 1984, GCA **49**, p. 2267; [4] Podosek *et al.*, 1991, GCA in press. [5] D.D. Clayton, 1986, Ap. J. **310**, p. 490.