

Introduction. Type B1 CAIs have a mantle composed predominantly of melilite and a core that contains melilite, fassaite, and anorthite. Spinel can occur throughout these CAIs. These CAIs have attracted considerable attention over the last decade or so, as they present the strongest case for melt crystallization of CAIs. The Allende Type B1 CAI 5241 has been particularly important, with 3 major petrographic and chemical papers proposing a variety of origins to explain various features [1,2,3]. Meeker [3] found an interesting feature in melilite in 5241 by digital x-ray mapping with an electron microprobe. He reported that in the innermost 400 μm of the melilite mantle, immediately adjacent to the fassaite-rich core, there exist several concentric bands of what appears to be oscillatory-zoned melilite in the x-ray images. Careful inspection of the published images suggests to us that the banding is manifested within each crystal as a variation of X_{Ak} with distance along the axis of each crystal, first increasing, then decreasing and finally increasing toward the center of the inclusion. Our working hypothesis for the cause of the reverse zoning in 5241 is the same as in other Type B inclusions; namely, under rapid cooling conditions, fassaite crystallizes, driving down the Mg/Al ratio of the liquid and X_{Ak} in the cocrystallizing melilite, and then anorthite crystallizes, driving up the Mg/Al ratio in the liquid and X_{Ak} in the melilite. To test this hypothesis and expand our knowledge of Type B1 CAIs, we have begun a reexamination of 5241. We report here the results of further petrographic and trace element studies of this CAI.

Melilite. We conducted a number of detailed (2–3 μm point spacing) quantitative electron probe traverses in melilite. We measured trace elements with an ion microprobe along one long electron microprobe profile through a large melilite crystal that extends from the mantle into the interior of the CAI. In this crystal, \AA k content increases from $\sim\text{\AA k}_{30}$ to $\sim\text{\AA k}_{58}$, drops to \AA k_{45} and increases again, somewhat irregularly, reaching a maximum of $\sim\text{\AA k}_{70}$. This profile shows the reversed melilite zoning that has been reported previously. Trace elements behave in a similar fashion to other Allende Type B1 CAIs [4]: with increasing \AA k , REE contents drop, REE patterns become more steeply LREE enriched (Y/La increases by 80 \times), Sr gradually increases and melilite is relatively rich in Ba. Some of these features are difficult to explain with existing melilite/melt partition coefficients [5,6], but they are the same as seen in other CAIs.

Fassaite. We have measured detailed electron and ion microprobe profiles across two large fassaite crystals. One is a 1.5 mm spinel-free fassaite, called “spinel-free

island 1” by previous workers [1,2]. This crystal is shown in a high-contrast backscattered electron (bse) image in Fig. 1. Several concentric bands are apparent. The bse albedo is largely a function of the TiO_2 content of fassaite. Going from the center of the crystal outward, there are two prominent bright bands, where the TiO_2 content increases for a short distance and drops again. The TiO_2 content drops to fairly low levels at the edge of the crystal. Similar TiO_2 spikes have been reported in other Allende Type B CAIs [7]. Those previously reported are accompanied by spikes in V and were attributed to redox changes during fassaite crystallization, which changed the oxidation states of Ti and V and changed fassaite/liquid partition coefficients.

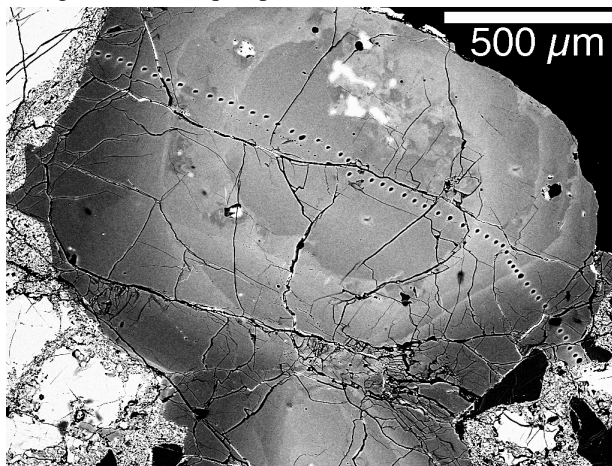


Fig. 1. BSE image of spinel-free island 1, a large zoned fassaite crystal. The BSE albedo is controlled by the TiO_2 content; the line of holes are ion microprobe analysis spots.

Chemical profiles across this crystal are shown in Fig. 2 and selected trace elements are plotted vs. Sc in Figs. 3 and 4. As in fassaite from other CAIs [7], spikes in V accompany the Ti spikes. As Simon et al. [8] have reported for fassaite in Type B CAIs, a number of trace elements show strong correlations with Sc. Sc is a strongly compatible element in fassaite, so the Sc content of the melt and the fassaite crystallizing from it falls as crystallization proceeds and Sc is a good indicator of degree of crystallization. In Fig. 3, the plot symbols are different, depending on whether the analysis spot is in the inner, intermediate or outer zone of fassaite (see Figs. 1 and 2). Careful examination of Fig. 3 shows that data points from the three zones fall on parallel, but not colinear trajectories. The differences for Ti and V could be due to change in redox state and the resulting change in the valence of the Ti and V cations, but Sc, Y, and Zr

do not change valence with redox state of the melt. It thus appears that the intermediate and outer zones crystallized from melts that had progressively higher Ti/Sc and V/Sc and lower Zr/Sc and Y/Sc ratios. The three zones may have resulted from several episodes of crystallization interspersed with partial melting, where both crystallization and partial melting are in part kinetically controlled and are not simply the inverse of one another.

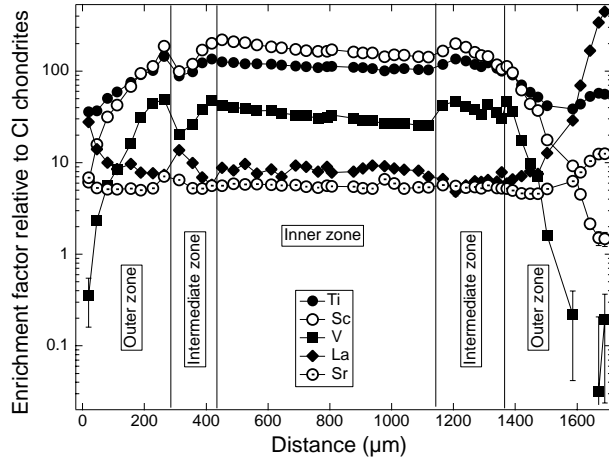


Fig. 2. Ion microprobe profile across the fassaite crystal shown in Fig. 1. Uncertainties are $\pm 1\sigma$, based on counting statistics.

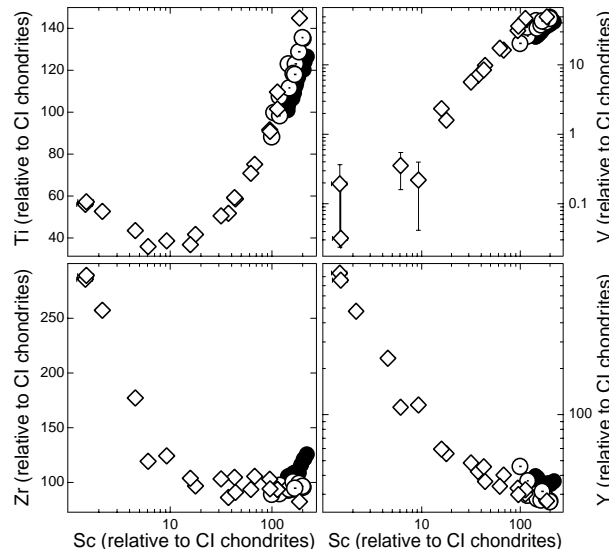


Fig. 3. Scatter plots of fassaite analyses shown in Fig. 2. Closed circles are from the inner zone, open circles the intermediate zone and open diamonds the outer zone.

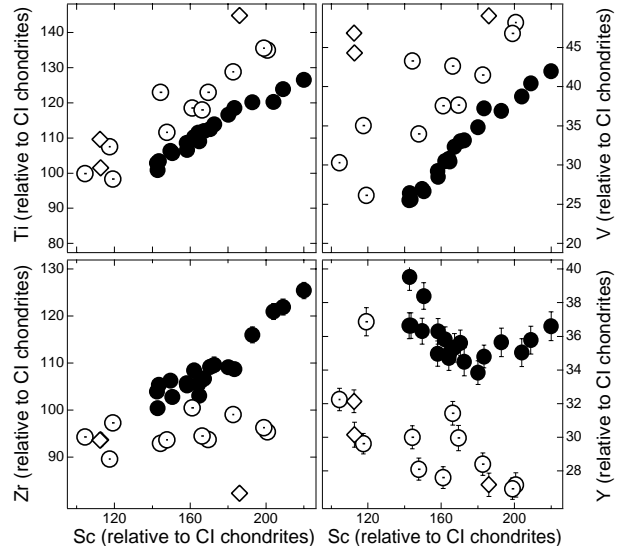


Fig. 4. An expanded version of Fig. 3. Note the distinct difference in Ti/Sc, V/Sc, Zr/Sc and Y/Sc between analysis spots from the inner (closed circles) and intermediate (open circles) zones. Analysis spots from the outer zone (open diamonds) appear to have slightly higher Ti/Sc and V/Sc than those from the intermediate zone.

We agree with MacPherson et al. [2] that the coarse fassaites were resorbed during formation of 5241, but this does not necessarily indicate that they are xenoliths. It appears most likely to us that 5241 did not monotonically cool and was reheated several times during its cooling history. Multiple heating has been proposed for other CAIs, e.g. [9].

References. [1] El Goresy A. et al. (1985) *GCA* **49**, 2433. [2] MacPherson G. J. et al. (1989) *GCA* **53**, 2413. [3] Meeker G. P. et al. (1995) *Meteoritics* **30**, 71. [4] Davis A. M. (1992) *LPS* **23**, 281. [5] Davis A. M. et al. (1996) *LPS* **27**, 291. [6] Simon S. B. et al. (1996) *LPS* **27**, 1201. [7] Simon S. B. et al. (1992) *Meteoritics* **27**, 289. [8] Simon S. B. et al. (1991) *GCA* **55**, 2635. [9] MacPherson G. J. and Davis A. M. (1993) *GCA* **57**, 231.