

REFRACTORY LITHOPHILE PARTITIONING IN TYPE B CAI MATERIALS;

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A dominant feature of Type B CAI's is their igneous character. Yet, even this type CAI appears to reflect a multistage history (e.g.,1). We are analyzing synthetic and natural Type B phases for refractory lithophile trace elements. The objective is to determine which aspects of the chemistry of these elements can be ascribed to igneous processes and which cannot.

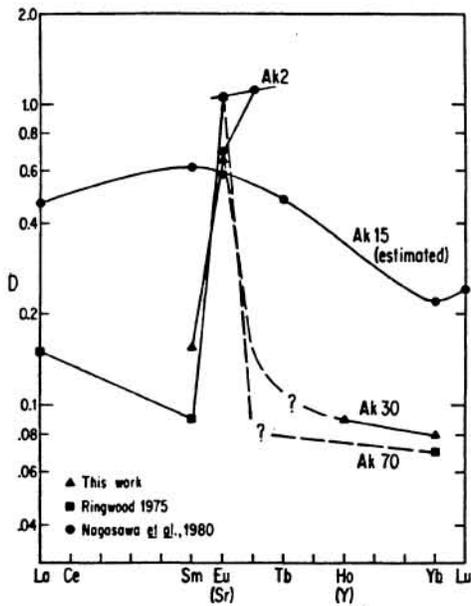
Our syntheses are based on the crystallization sequences determined by Stolper and Paque [2,3]. John Beckett prepared the starting material (a spinel-deficient Type B composition). This was spiked with Sr, Y, Zr, Sm, and Yb (<500 ppm) and with Th-230 and U-235 (~ 50 ppm). Typical runs were: a few hours at about 1370 C, slowly cooled (at about 2 deg/hr), then held for a few hours around 1260 C. After minor spinel crystallization, melilite is the initial major phase to crystallize. Suitably large melilite crystals in the 100 micron range were usually obtained. Trace element analyses to date have been made by synchrotron radiation X-ray fluorescence (SXRF) at the BNL National Synchrotron Light Source (NSLS) using a broad "white light" spectrum that is relatively flat in the 3-30KeV range. The samples were irradiated in air at 45° with respect to both the incident beam and the EDS (Si[Li]) detector. To eliminate deadtime and pulse pileup, a 450 micron Kapton filter was used to attenuate the major element X-rays. Ionization chambers were used to monitor relative photon intensities. The incident beam was collimated to 20-50 micron dimensions using Ta slits. The depth response of an SXRF analysis is determined by the absorption length of the fluorescent X-rays and can be large (e.g. 300-500 microns for Sr K-alphas in silicate materials). Thus, we prepared free-standing, doubly-polished sections of accurately known thicknesses, in the 80-100 micron range. Only homogeneous (single phase) regions were chosen for analysis, as judged from optical microscopy viewing of both sides of the sections. Concentrations are calculated in two stages (4). First the background is subtracted and fits are made to partially overlapping lines. In cases of almost totally-blended lines, corrections based on measurements of auxiliary peak intensities and known peak intensity ratios were always possible. The corrected line intensities are converted to concentrations using a first-principles theoretical relative intensity calculation and normalizing to an independently determined Ca content.

Our measured partition coefficients (Fig. 1) are given in terms of a REE partition coefficient diagram, with Y plotted as Ho and Sr as divalent Eu. These have not been corrected for fractional crystallization (5). However, electron microprobe analyses of the glass compared to a superliquidus quench sample indicate total amounts of spinel and melilite crystallization of about 30%. Consequently the fractional crystallization corrections will not be large. A larger source of variability (crystal to crystal) is due to the fact that crystals are grown over a temperature range; however, inter-crystal analytical differences are not large. Compared to literature data(6,7), there are no clear regularities in Fig. 1, which may indicate experimental/analytical discrepancies or large complicated (temperature, composition) variations in the partition coefficients, or both. There are relatively large differences in the experimental conditions, so considerable variations in partition coefficients are possible, but our experiments simulated the crystallization path of actual Type B CAI's (2,3). Our data indicate that strong, positive Eu anomalies should be observed, which is consistent with the data from (6) and observations of meteoritic melilite; on the other hand (7) concludes that these anomalies would be absent.

Given the possibility of complexities in melilite partition coefficients, it is premature to attempt detailed fractional or equilibrium crystallization modelling of Type B CAI systems. Nonetheless, simple comparisons of natural and synthetic data appear useful. Our meteoritic Y-Sr data is shown in Fig. 2, which also plots (open rectangle) the predicted Y and Sr concentration ranges given our measured partition coefficients for a range of fractional crystallization from 0 to 30%, assuming starting abundances of Type B CAI bulk compositions (18X CI chondrite levels). This comparison is not unreasonable, because we analyzed the cores of large crystals. Statistically, these regions should represent the initial stages in melilite crystallization of a Type B CAI melt, corresponding to what we have simulated in our lab experiments. The primary feature is that the natural Y and Sr concentrations are both much higher than expected for our partition coefficients. For reference a line is shown representing materials with varying degrees of lithophile element enrichment but with an average solar system Y/Sr. One melilite has solar Y/Sr, but the rest show Sr enrichments over Y. Since, except for the background correction, the Y/Sr ratio is almost totally independent of the corrections applied to the raw data, this may reflect pre-melting processes. In contrast to the trace elements, our Allende melilite Ti contents are close to what would be expected from our measured Ti partition coefficients (not shown).

We have measured natural fassaite trace element concentrations. Compared with solar abundance ratios, Zr is enriched relative to Y and Sr. Comparison with predictions for fractional crystallization is much less certain for the case of fassaite. We have not yet measured fassaite partition coefficients, and fassaite is a late-crystallizing phase, following a relatively large amount of melilite crystallization. Nevertheless, based on estimates from available synthesis data, we calculate core fassaite Y and Zr concentrations that are much lower than the meteoritic values. For Sr there is good correspondence between measured and calculated contents, but uncertainties are large and this correspondence is probably fortuitous, since Sr was not modelled well for melilite. For both melilite and fassaite, it appears that the trace element contents are not explained by igneous processes. Perovskite is an obvious candidate for a relict phase to explain the meteoritic refractory lithophile element contents, but there are problems with this notion. REF: (1) Murrell M. & Burnett D. (1987) GCA 51, 985. (2) Stolper E. (1982) GCA 46, 2159. (3) Stolper E. and Pague J.M. (1986) GCA 50, 1785. (4) Sutton et al. (1987) Nucl.Instrum.Meth B24/25, 405.

Figure 1



- (5) Benjamin et al. (1983) GCA 47, 1695.
 (6) Ringwood (1975) The Moon 12, 12.
 (7) Nagasawa et al. (1980) EPSL 46, 431.

Figure 2

