



## NAKHLA PYROXENES: PARENT MELT AND PARTITION COEFFICIENTS

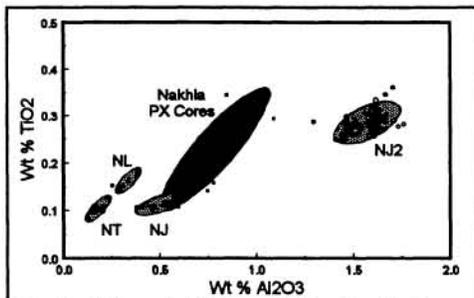
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Fig. 3.  $\text{TiO}_2$  and  $\text{Al}_2\text{O}_3$  contents of synthetic pyroxenes and natural pyroxene cores in Nakhla. Each dot represents an individual pyroxene analysis. For synthetic pyroxenes, analyses were taken on several spots per grain, several grains per charge, and several experiments per starting composition. Nakhla analyses were taken on several spots per grain, on many grains.

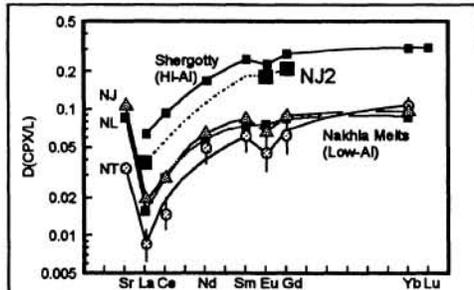


Fig. 4. REE and Sr pyroxene/liquid partition coefficients. Shergotty values are extrapolated from values observed for less calcic pyroxenes [10]. Values for low-Al Nakhla melts are from [3, 4]. Values for NJ2, our "basaltic" Nakhla parent melt composition, are new data.

$\text{Al}_2\text{O}_3$  and  $\text{TiO}_2$  contents of our synthetic pyroxenes with those of Nakhla pyroxene cores. Al contents of NT and NL pyroxenes are significantly lower than those for Nakhla, while the most Al-rich pyroxenes from our NJ experiments overlap the Nakhla field. NJ2 pyroxenes contain *considerably* more Al than the Nakhla core pyroxenes. Thus, taken at face value, the data in Fig. 3 suggest that the Al content of the Nakhla parent melt is somewhat higher than that of our low-Al starting compositions (NL, NT, and NJ), but considerably lower than that of our high-Al composition (NJ2).

**REE and SR partition coefficients.** Fig. 4 shows partition coefficient patterns for each of our Nakhla starting compositions, together with a pattern derived from our experiments on a Shergotty parent melt [10]. We computed the latter pattern by extrapolating the partition coefficients observed for  $\text{Wo}_{12-25}$  pyroxenes in our Shergotty experiments to  $\text{Wo}_{40}$  (the composition of the natural pyroxene cores in Nakhla), using equations for variation of  $D_{\text{REE}}$  with pyroxene  $\text{Wo}$  content from [10].\*

Compared with the "ultramafic" Nakhla compositions NJ, NL, and NT, the melt in the Shergotty experiments was rich in Al, and we had speculated [3, 4] that it was this difference in Al content that was largely responsible for the 3-8 fold difference in partition coefficient values. However, the Shergotty values were extrapolated, and the melts in that study differed in many compositional details from proposed Nakhla parent melts. Thus, without actual measurements for high-Al Nakhla parent melt compositions, we could not be sure that the low values might not hold even for high-Al melts.

Our new results for the NJ2 composition confirm our earlier speculation that D values from the low-Al melts are too low to be applicable if the Nakhla pyroxenes crystallized from one of the proposed high-Al melts. It is not clear whether the difference in Al content is responsible for most of the difference in D values, or whether the large difference in temperature ( $1150^\circ\text{C}$  vs.  $1200^\circ\text{C}$  -  $1230^\circ\text{C}$ ) is the most important factor. In either case, it is clear that use of the "wrong" set of partition coefficients for inverting the Nakhla pyroxenes to obtain the melt REE content can lead to errors of up to  $\sim 500\%$  in estimated REE concentrations. Thus, in order to compute the trace element composition of the Nakhla parent melt with any confidence, it is important to gain a better understanding its major element composition, especially its Al content and liquidus temperature.

**Sector zoning in pyroxene: A messy complication.** Although Fig. 3 suggests that our experiments provide good constraints on the Al content of the Nakhla parent melt, this interpretation may be oversimplified. We previously reported a strongly bimodal distribution of Al concentrations in Nakhla pyroxene cores [5]. Our early attempts at elemental mapping indicated that this distribution is not simply a result of normal core-to-rim primary zoning, but is the result of a more complex process such as sector zoning. We have not had the opportunity to collect additional mapping data on Nakhla sections, so do not yet completely understand the cause or nature of this Al zoning, or how it relates to our synthetic pyroxenes. However, a bimodal distribution of Al contents for NJ2 pyroxenes is clearly evident in Fig. 3, with one cluster of analyses around 1.5%  $\text{Al}_2\text{O}_3$  and one around 1.7%. BSE photos and elemental mapping indicate that sector zoning is responsible for this zoning. Additional work will be required to understand the implications of this zoning for attempts to constrain the composition of the Nakhla parent melt.

References: [1] Treiman (1986) GCA 50, 1061. [2] Harvey and McSween (1992) GCA 56, 1655. [3] McKay *et al.* (1992) LPS XXIII, 643. [4] McKay *et al.* (1993) LPS XXIV, 966. [5] McKay *et al.* (1993) Meteoritics 28, 395. [6] Harvey and McSween (1992) EPSL 111, 467. [7] Treiman (1993) GCA 57, 4753. [8] Longhi and Pan (1989) PLPSC 19, 451. [9] Harvey and McSween (1991) Met. Soc. Abs., 85. [10] McKay *et al.* (1986) GCA 50, 927.

\*  $D^{\text{Px/L}}$  values observed for Yb and Lu for  $\text{Wo}_{25}$  pyroxenes in [10] were nearly as high as the extrapolated  $\text{Wo}_{40}$  values in Fig. 4, but the  $D_{\text{La}}$  and  $D_{\text{Ce}}$  were closer to the values in Fig. 4 for the low-Al Nakhla melts.