

SIMS STUDIES OF PLANETARY CUMULATES: MODELING DIOGENITE PETROGENESIS; G.W. Fowler, C.K. Shearer, J.J. Papike; Institute of Meteoritics, Department of Earth & Planetary Sciences, University of New Mexico, Albuquerque, NM 87131, U.S.A.

INTRODUCTION. It is commonly accepted that the diogenites and eucrites come from the same parent body, probably 4 Vesta. However, there is continuing debate concerning the petrogenetic relationship between eucrites and diogenites. In some models [1, 2] the diogenites are related to the eucrites by fractional crystallization, whereas in other models [3, 4], the diogenites and eucrites are magmatic products of multiple sets of parental magmas each produced by different degrees of partial melting. However, any model must take into account trace element variations for the orthopyroxenes in diogenites. These variations indicate that the diogenites themselves represent 70-90% fractional crystallization [5, 6, 7] if they represent cumulates from a single magmatic reservoir. In this study we attempt to model diogenitic magmas by back calculating SIMS analyses of orthopyroxene in diogenites.

RESULTS AND DISCUSSION. If the diogenites and eucrites are petrogenetically related by a single or series of fractional crystallization events, then this should be supported by the trace element systematics of these respective magmas. Partition coefficients of 0.1 for Ti [8] and 0.04 for Yb [9] were used to estimate parental melt concentrations. These concentrations calculated from orthopyroxene core compositions are shown in figure 1 along with bulk eucrite compositions [10, 11] and the Kapoeta basaltic clast compositions [12]. Kapoeta is a howardite that contains a wide compositional range of basaltic (eutectic) clasts with only the high and low end members shown in figure 1. Although this trend does overlap with a few diogenite parental melt compositions, the main trend of diogenite parental melt compositions is much broader in composition and is more enriched in Yb than the eucrite trend. These two trends are directly comparable since eucrite bulk compositions are essentially eucrite melt compositions. Therefore it seems highly unlikely that the eucrites are residual melts derived from the fractional crystallization of a magma that produced the diogenites.

Incompatible element versus incompatible element systematics can be useful in modeling the petrogenetic relationships among the diogenite cumulates. Three such models are tested in this study and shown in figures 2a, b, and c. These figures are Ti-Yb plots for calculated 'diogenitic melt compositions'. In order to create the fractional crystallization trajectory observed in figure 2a a starting ratio of Ti(wt%) to Yb(ppm) ~0.085 is needed. Quite arbitrarily a starting melt composition of 1.76 ppm Yb and 0.15 wt% Ti was chosen to represent the starting melt composition. Ranges of back calculated melt compositions and back calculations of estimated core compositions are shown for five diogenites in these figures.

Model 1, shown in figure 2a, assumes that the diogenites are a product of fractional crystallization and crystal accumulation of a single, parental basaltic magma. The orthopyroxenites represent the crystallization of that magma in the orthopyroxene stability field. Figure 1 indicates that over 90% fractional crystallization of an orthopyroxene phase is necessary to explain the range of incompatible elements observed in the diogenites assuming a constant D.

Model 2, shown in figure 2b, is identical to Model 1 except that the D's used in the modeling increase with decreasing temperature and changing melt composition. The D's are assumed to vary by a factor of three over the observed range of melt compositions. In the calculation of the percent fractional crystallization line shown in figure 2b it was assumed that the D's increase by a factor of three in a linear fashion from 0 to 100% crystallization. These two assumptions obviously conflict, therefore the 70-80% fractional crystallization needed to explain the observed range is underestimated.

Model 3, shown in figure 2c, assumes that diogenites represent products of multiple parental magmas. Here the diogenites represent cumulates of compositionally distinct parental basaltic magmas that were produced by either different degrees of partial melting or partial melting of a heterogeneous planetary mantle. If we assume there were three parental magmas that represent equal degrees of fractional crystallization, assuming a constant D, 55-60% fractional crystallization of each reservoir is needed to explain the entire range.

Both Models 1 and 2 appear to be improbable for fractionation of a basaltic melt. To have orthopyroxene as a single liquidus phase over 80% fractional crystallization of a basaltic magma appears highly unlikely. If we increase the number of multiple reservoirs in Model 3 we could come up with a reasonable degree of fractional crystallization for a basaltic system. Although there is some basis for

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assuming multiple reservoirs, e.g. different eucrite trends, it is somewhat undesirable to introduce such an unconstrained variable to any model. As an alternative to this dilemma, the melts that were parental to the diogenites could have been highly orthopyroxene normative in composition [5]. If correct, this suggests that the mantle source for diogenite parental magmas is more orthopyroxene normative than is traditionally believed.

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