CONSTRAINTS ON THE ORIGIN OF EUCRITIC MELTS: AN EXPERIMENTAL STUDY.

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Introduction. Eucrites are plagioclase-, pyroxene-rich meteorites that crystallized from basaltic liquids at low pressure. Two models have been proposed for the origin of these liquids. Stolper (1), noting that eucrite bulk compositions cluster around the olivine-pyroxene-plagioclase peritectic, proposed that some eucrites crystallized from nearly primary melts produced by partial melting of a peridotitic source. An alternative model (2-4) is that all eucrites are residual liquids produced by extensive fractional crystallization of olivine and pyroxene from more mafic melts. In the fractional crystallization model, diogenites are considered cumulates produced by separation of pyroxene from liquids parental to the eucrites (2). In this case, generation of eucritic bulk compositions near the peritectic requires that pyroxene-olivine boundary curves are either cotectic (2) or approximately radial to the composition of pyroxene (4). Otherwise, fractional crystallization of pyroxene-saturated liquids would produce liquid lines of descent crossing into the pyroxene stability field, bypassing the peritectic point and eucrite bulk compositions.

The validity of a fractional crystallization model can be tested by determining the nature of olivine-pyroxene boundary curves for liquid compositions relevant to eucrites. As a first step, we have determined the equilibrium crystallization path of "Liquid A" proposed by Ikeda and Takeda (3) as the parent melt composition for eucritic liquids. Since most estimates of bulk composition of the eucrite parent body lie on or near the plane defined by olivine and Liquid A (e.g., 5-7), Liquid A ± olivine can be used to study most liquids that could have generated eucrites by fractional crystallization of olivine and pyroxene.

Experimental techniques. An oxide mix corresponding in composition to Liquid A (3) was decarbonated in air for 2 days and then equilibrated at 1080°C in a flowing H_2-CO_2 gas mix at wüstite-iron (WI) for 5-7 days. Samples were suspended in the hot spot of a vertical Del Tech DT-31 furnace using Mo wire loops for 3 - 24 hrs. All experiments were conducted in a gas mix one order of magnitude more reducing than WI.

Experimental Results. Experiments were conducted in the range 1180-1320°C. Olivine is the liquidus phase followed by low-Ca pyroxene at 1281-1310°C. Olivine (Fo73-81) and glass (mg=(Mg/(Mg+Fe)=0.48-0.59) become progressively more Fe-rich and pyroxene slightly more calcic (Wo2→Wo4) with decreasing temperature. $K_{D,i}^{Fe-Mg} = (X_{FeO}^{i}/X_{MgO}^{i})/(X_{FeO}^{liq}/X_{MgO}^{liq})$ is 0.34 for olivine, consistent with (8), and 0.31 for pyroxene. Olivine is in a reaction relationship with the melt: the amount of olivine decreasing from 47 wt% to 40 % between 1280 and 1180°C. Observed mg values of synthetic pyroxenes (0.75-0.80) are within the range of those observed in diogenites (9). This suggests that our results can be used to constrain the relationship between diogenites and eucrites if they formed from the same parental melts.

Glass compositions from this study are shown in Figure 1 projected from Diopside(DI) onto Olivine(OL) + Plagioclase(PL) + Quartz(Q) (10). Also shown are the nominal bulk composition of Liquid A (3), the experimentally determined peritectic for eucrites (1), synthetic pyroxene compositions, noncumulate eucrite bulk compositions (11) and an olivine-pyroxene glass composition (Bi-4) produced by (1) using the basaltic achondrite Binda as starting material. For equilibrium crystallization of Liquid A, Q contents of the melt decrease with decreasing temperature due to the fact that olivine is in a reaction relationship with the melt. Based on this preliminary result, the composition of a parental melt fractionally crystallizing olivine that intersects the olivine-pyroxene boundary curve will leave that curve as pyroxene crystallizes and bypass the eucrite composition field. We cannot yet rule out the possibility that fractional crystallization of parental melts more Fe-rich than Liquid A could have produced eucritic liquids. However, even if this is the case, the more magnesian diogenitic and howarditic orthopyroxenes can not be readily explained as products of fractional crystallization of liquids parental to the eucrites.

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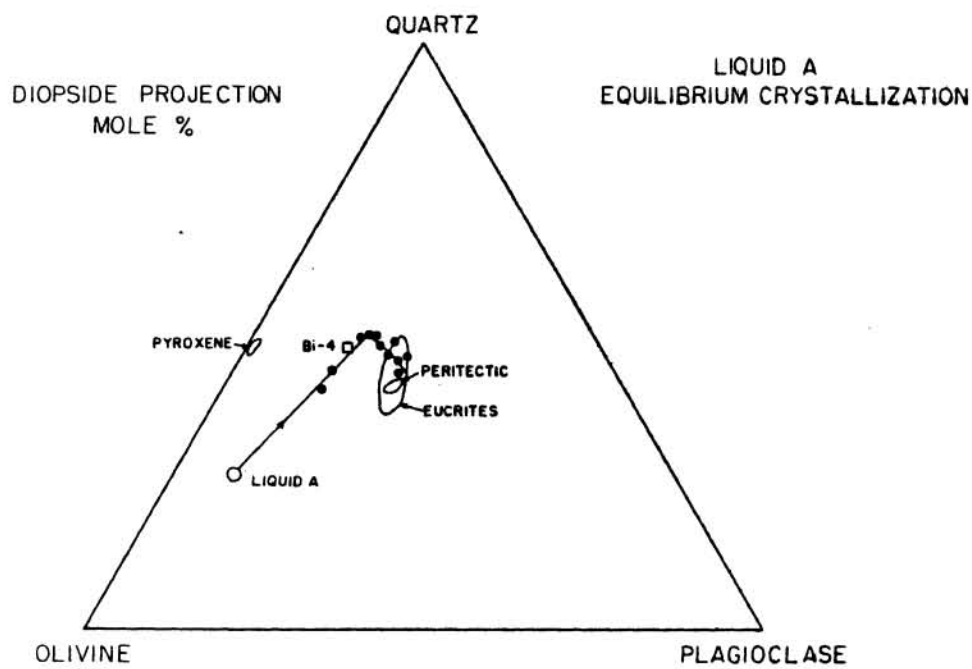

Fig. 1. Projection of experimental glass compositions from DI onto the plane OL - PL - Q.