HIGH PRESSURE EXPERIMENTS ON MAGNESIAN EUCRITE MAGMAS: CONSTRAINTS ON MAGMATIC PROCESSES IN THE EUCRITE PARENT BODY, K.S. Bertels and T.L. Grove, Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139

Melting experiments have been carried out on two magnesian eucrite compositions, Kapoeta Rho (1) and Yamato 7308 (2) over a range of oxygen fugacity and pressure conditions. 1-atm experiments were run at the iron-wustite (IW) and quartz-fayalite-iron (QFI) oxygen buffers. In the 1-kbar experiments oxygen fugacity was near QFI. At 1 kbar the olivine(oliv)-pigeonite(pig)-plagioclase(plag)-spinel(sp)-metal multiple saturation boundary is olivine-normative, and lies near the pyroxene-anorthite join in the Oliv-Anorthite(An)-SiO₂ projection (3).

Experiments: Synthetic analogs of Kapoeta Rho and Yamato 7308 were prepared from high-purity oxide starting materials following the method of Grove and Bence (4). The 1-atm experiments carried out at IW used FePt alloy loops to minimize the exchange of Fe between the silicate sample and the loop. 1-atm experiments were also carried out using high-purity Fe capsules sealed in evacuated silica glass tubes with the assemblage QFI. The 1 kbar experiments were performed in TZM pressure vessels using Ar as the pressure medium. The eucrite starting materials were placed in Fe-foil tubes that were welded on one end and folded over and crimped on the other end. An Fe-foil tube containing quartz plus olivine was prepared in a similar way and placed along with the two eucrites in a Pt tube that was welded shut. The 1 kbar experiments were terminated by removing the TZM vessel from the furnace and inverting it so that the Pt capsule falls to the base of the pressure vessel and cools rapidly, minimizing crystal growth during quenching.

Results: Fig. 1 and 2 show the results of experiments on Kapoeta (K) and Yamato (Y) compositions in the Oliv-An-SiO₂ projection of Stolper (3). The points plotted are electron microprobe analyses of glasses from experiments containing the assemblage oliv-plag-metal. The oliv-plag-metal saturated 1-atm liquids produced at IW are nearly identical in composition to those produced at QFI. Furthermore, both the IW and QFI 1-atm liquids plot near the projected composition of Stolper's 5-phase boundary (point 'A' in Fig. 1) based on his experiments on Juvinas and Sioux County. Fig. 1 and 2 show that at 1 kbar the oliv-plag-metal-liquid boundary plots at lower SiO₂ values and equivalent proportions of Oliv-An compared to the 1-atm boundary. The boundary is very slightly olivine-normative in composition and plots near the pyroxene-anorthite join.

Constraints on magmatic processes on the eucrite parent body: Eucrite basalts erupted on the surfaces of asteroid-sized bodies where central pressures were about 1 kbar (The asteroid Vesta is often cited as an analog of the eucrite parent body and has a radius of 275 km and density of 3.5 g/cc (5)). The important problems in eucrite magma genesis are determining the compositions of partial melts generated from the mantle of the planetesimals over this pressure range and the effect of fractional crystallization on these primary magmas. Stolper (3) noted that some eucrite compositions are similar to liquids saturated at 1-atm with the 5-phase assemblage oliv-pig-plag-metal and proposed these eucrites were primary magmas generated by partial melting of the eucrite mantle. Mason (6) and others (2,7) have suggested that eucrites are produced by fractional crystallization of pyroxenes and/or olivine from more mafic melts. In order for this second possibility to be viable, the oliv-plag-metal boundary must be nearly cotectic. Beckett and Stolper (8) showed that the oliv-plag-metal boundary was a reaction curve at 1-atm, a result confirmed by our experiments. However, our results also show that with increasing pressure the oliv-plag-metal boundary moves to lower SiO₂ values. At 1 kbar the oliv-plag-metal boundary is a cotectic that lies nearly parallel to the pyroxene-plag join.

Melts that are in equilibrium with the mantle assemblage in eucrites over the entire range of pressures likely to have been present in these small planetesimals will lie along a line from the 1-atm to the 1 kbar 5-phase boundaries. If a partial melt is produced at 1-kbar, delivered to shallower depths and allowed to differentiate, fractionation will follow the oliv-plag-metal boundary and the liquid will approach the low pressure 5-phase boundary. However, model results show that a liquid produced by such a process would be more Fe-rich than the eucrites that plot near the 1-atm 5-phase boundary. Although most non-cumulate eucrites cluster near the 1-atm 5-phase boundary, samples such as Cachari (C) and Bereba (Be) are similar to the experimentally produced 1-kbar liquids (See Fig. 2). These
HIGH PRESSURE EUCRITE EXPERIMENTS: K.S. Bartels and T.L. Grove

Eucrites may represent small degree partial melts generated at deeper levels in the mantle of the eucrite parent body.

Our results also indicate that there is a pressure range within eucrite parent bodies where high degree partial melts saturated with oliv-pig-sp could undergo differentiation to produce diogenite cumulates. At a pressure of about 0.8 kbar the oliv-pig-sp boundary lies on the pyroxene-plag join. Fractionation of a melt such as Kapoeta rho (point K on Fig. 2) along the oliv-pig-sp boundary at 0.8 kbar would involve pig as the dominant silicate phase, and could produce cumulate diogenites.

In conclusion, our experiments indicate that a variety of processes operated throughout the entire parent body to form eucrite basalt. This conclusion supports a complex serial magmatism model (9).

References


Figs. 1 and 2 show a portion of the Oliv-An-SiO2 pseudoternary of Stolper (3). Fig. 1 shows Stolper's 5-phase point 'A' with the oliv-pig-sp boundary modified after Beckett and Stolper (8) and the 5-phase saturated liquids from our 1-atm and 1-kbar experiments. Fig. 2 shows the 1-atm and 1-kbar boundaries located using the experiments reported in Fig. 1 and compositions of eucrites.