

ON THE MAGMATIC ORIGIN OF OLDHAMITE IN AUBRITES; Tammy L. Dickinson\*, Gordon A. McKay, and Gary E. Lofgren, SN2, NASA Johnson Space Center, Houston, Tx. 77058, \* SL, NASA Headquarters, Washington, DC 20546.

Aubrites are highly reduced igneous rocks that consist primarily of FeO-free enstatite, with minor olivine, diopside, and plagioclase, and a variety of accessory minerals that formed under extremely reducing conditions, such as oldhamite (CaS). Oldhamite has been shown to be the main carrier of REE in aubrites (1,2). In Norton County oldhamite occurs as isolated grains within silicates and in the mesostasis of pyroxenite clasts and as large (cm-sized) sulfide clasts (3). Ion microprobe studies of phases in Norton County aubrite show that oldhamite has REE abundances of 40-600 times CI in pyroxenite clasts and 30-150 times CI in sulfide clasts, with both occurrences having a negative Eu anomaly (4).

We have experimentally determined a self-consistent set of REE partition coefficients between silicate liquid and immiscible sulfide liquid (Fig 1.). We obtain essentially the same partition coefficients, even using different starting materials and thermal histories (5,6,7). Our most recent experimental charges consist of a mixture of CaO, SiO<sub>2</sub>, Mg, Al, and FeS<sub>2</sub>, approximating an aubrite composition. Charges were run at 1200 and 1300°C for 48 hours. (8,9,10) have done similar experiments, but with varied results. The preliminary data of (8,9) were a factor of 10 to 100 less than our partition coefficients (5,6,7). Their most recent results at 1300°C are D(Eu)=1.2 and D(Sm)=2.5 (10). These are not appreciably different from our values of D(Eu)=1.2±.1(1σ) and D(Sm)=1.8±.1(1σ). There is one significant difference in the experimental method between these studies. In our experiments CaS forms from the melt, whereas, (9) equilibrates a silicate of E-chondrite composition with CaS. Thus, their experiments require diffusion for the equilibration of CaS and silicate melt. The similarity of results obtained by these two very different approaches suggests that REE equilibrate rather quickly between CaS and silicate liquid.

A controversy exists as to the origin of the CaS in aubrites: (A) Are they relict nebular condensates (8,9,10,11) or (B) Are they the result of igneous processes (3,4)? Arguments in favor of a relict nebular condensate origin are: CaS grains from Bishopville aubrite have a variety of REE patterns and abundances, indicating that they did not equilibrate with a single silicate liquid (11) and experimentally determined sulfide liquid/silicate liquid partition coefficients for CaS are smaller than expected for an igneous origin (9,10).

We believe there is several lines of evidence to suggest that CaS in aubrites are indeed of igneous origin. (A) Preliminary REE modeling suggests that a magmatic relationship between the CaS and diopside in the pyroxenite clasts is possible. (B) The sulfide clasts in Norton County have igneous

textures, with a second immiscible sulfide phase contained within the CaS (3,4). (C) If the CaS were relict nebular condensates, it is difficult to imagine why they would not have equilibrated with the silicate liquid during partial melting of the aubrite parent body. In fact, it would appear that (10) have been able to equilibrate CaS and silicate liquid at 1300°C on laboratory time scales.

We believe that our measured partition coefficients at 1200 and 1300°C correctly represent REE behavior in this system, even though they are significantly lower than expected based on REE abundances observed in natural oldhamite. In addition we believe that CaS in aubrites is of igneous origin. The high REE contents of CaS might be explained by sub-solidus equilibration. For example, olivine phenocrysts in Prehistoric Makaopuhi tholeiitic lava lake, Hawaii, have transformed from a more Mg-rich composition during subsolidus cooling. This was not just a core-rim homogenization, but a substantial Fe-enrichment of the whole olivine phenocryst at the expense of the surrounding phases (13). We propose a similar scenario for CaS in aubrites: (A) An immiscible Ca-rich sulfide melt, with moderate REE enrichments as indicated by the partition coefficients, forms in the partially molten aubrite parent body(s). (B) During further crystallization and cooling, the REE are redistributed between the CaS and silicates phases giving rise to the extremely REE-enriched CaS. Further experiments are planned to test this hypothesis.

(1) Larimer and Ganapathy (1987) EPSL 84, 123-124. (2) Lundberg and Crozaz (1988) Met. 23, 285-286. (3) Wheelock et al. (1989) Met. 24, 340. (4) Wheelock et al. (1990) LPSC XXI, 1327-1328. (5) Dickinson et al. (1990) LPSC XXI, 284-285. (6) Dickinson et al. (1990) Met. 25, In press. (7) Dickinson et al. (1990) AGU. (8) Lodders & Palme (1989) Met. Soc. 24, 293-294. (9) Lodders & Palme (1990) LPSC XXI, 710-711. (10) Lodders et al. (1990) AGU. (11) Jones and Boynton (1983) LPSC XIV, 353-354. (12) Floss and Crozaz (1990) Met. 25, In press. (13) Moore & Evans (1967) Contrib. Min. & Pet. 15, 202-223.

