

Metal-silicate partitioning and the effect of S, Si, and H during core formation.

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The idea that the presence of light elements alloyed with Fe in the Earth's core may account for the seismically observed density deficit is well documented (Poirier, 1994). The nature of the light elements can provide important constraints not only on the overall bulk composition of the Earth but on the conditions under which the core segregated from the mantle. It may also shed some light on the processes currently in operation at the core-mantle boundary. One of the main constraints on core formation concerns the present concentrations of siderophile elements in the mantle. Our present understanding of metal-silicate partitioning suggests that the mantle exhibits an over abundance of siderophile elements and a depletion in some elements not normally considered to be siderophile.

A recent geochemical model based on element ratios in chondritic meteorites (Allègre *et al.*, 1995) yields a core composition containing 7.3 wt.% Si and 2.3 wt.% S. In order to account for the observed density deficit a further 4 wt.% O was added. The S content of the core was further constrained by Dreibus and Palme (1997) by comparison with Zn, a non-siderophile element of similar volatility. They propose a S concentration of 1.7 wt.%. Recently it has been shown that H partitions into Fe under high pressure conditions, above 3 GPa (Yagi and Hishinuma, 1995, Okuchi, 1997) so that some H might also be expected to be present in the core.

We have performed high pressure experiments to investigate the solubility of Si, S, and H in molten Fe and the partitioning of lithophile and siderophile elements between liquid metal and silicate melt. The experiments, conducted at 3 and 8 GPa, consisted of reacting intimately mixed powders of synthetic basalt and metallic Fe, FeSi and FeS, in MgO capsules. The experiments involving H used an ultramafic silicate containing brucite, the decomposition of which provided H. Each composition was doped with a suite of trace elements ranging from Ti to Re. Analysis was performed using electron microprobe

and SIMS.

Run products consisted of a spherical metallic bleb which segregated from the surrounding silicate glass. Dendritic quench textures are evident in both phases indicating that both phases were molten during the run. During analysis it was necessary to use a defocused beam to determine the average composition of the two phases. The interaction between the silicate melt and the MgO capsule allows the f_{O_2} to be determined relative to the Iron-Wüstite oxygen buffer, thus the FeO content of the capsule material close to the interface was also determined.

As expected f_{O_2} is strongly dependent on the Si content of the metal. In the absence of H a metallic phase containing 8 wt.% Si has the effect of lowering the f_{O_2} to 6 log units below IW. Under these conditions it has been found that S becomes lithophile and partitions into the silicate phase (Kilburn and Wood, 1997). In the presence of H the f_{O_2} is only 5.2 log units below IW and preliminary data show that 4.7 wt.% S can coexist in the metallic phase with 8.7 wt.% Si.

Under strongly reducing conditions (8 wt.% Si in the metal) Cr and Mn become siderophile and partition into the metallic phase. Mantle abundances of these elements could therefore be explained by core formation in the presence of significant amounts of metallic Si. It is also possible to dissolve Ti in a metal containing 20 wt.% Si. As the mantle shows no depletion in Ti relative to chondrites this may provide an upper limit for the Si content of the core. The partitioning of these elements does not appear to be affected by the presence of H in the metal.

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