



Effect of Pressure and the FCC to HCP Phase Transition on Trace Element Partitioning between Metal and Sulfide Melt

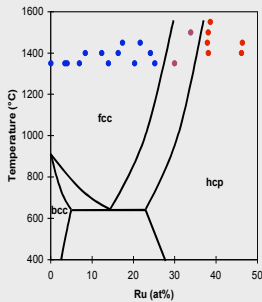
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Introduction

Most of what we understand about the chemical behavior of iron alloys, even at high pressure, pertains to the fcc phase. However, it is widely thought that the relevant structure in the Earth's core is hcp, not fcc. In this study we aim to understand the effects of pressure and the fcc-hcp transition on siderophile element partitioning between metal and coexisting sulfide melt. This is important, for example, in evaluating models in which Re-Os-Pt isotope fractionations are attributed to partitioning between the Earth's inner and outer core. Recent Os isotope studies (e.g., Brandon et al., 2003; Walker et al., 1998) have assumed that the partitioning behavior of Re, Os, and Pt between the Earth's inner and outer cores is similar to that observed in iron meteorites; in other words, the assumption has been that the effects of pressure and phase change do not negate the models of Os isotopic evolution in the core. Our experiments are designed to test these assumptions.

We report experiments at 1 bar and at 6 GPa, to evaluate the effect of pressure. To examine the effect of the fcc-hcp phase transition, we employ an analog system for hcp-Fe: Fe-Ru alloys. Partitioning experiments were carried out over a range of Ru contents in Fe-Ru alloy, crossing the fcc-to-hcp transition in composition. This allows the effect of the structural transition to be observed, and also to account for the effect of composition.



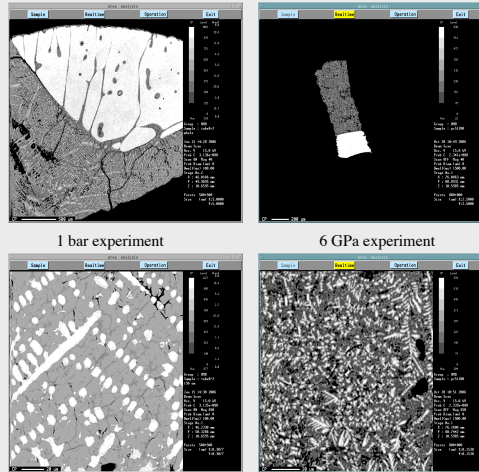
The Fe-Ru phase diagram, showing the compositions of our 1 bar experiments, is shown above. The degree of melting in the Fe-Ru-S system decreased with increasing Ru, so a range of temperatures was used to deconvolute the effects of Ru in metal vs. S in melt.

Methods

Starting materials:
 Mixtures of Fe, FeS, Ru powders
 5000 ppm Ni and 500 ppm each of
 Re, Os, Ir, Pt as trace elements

1 bar experiments:
 Sealed silica tubes in a tube furnace
 Temperature 1350 to 1550 °C
 Run time 6 to 96 hr., varying with T
 Drop quenched in water

6 GPa experiments:
 Multi-anvil press, 18/11 assembly
 MgO sample capsule
 Temperature 1100 to 1200 °C
 Run time 24 hr.



Electron microprobe analysis:
 Major elements (Fe, Ru, S) and Ni measured.
 Metal compositions from average of 6 points.
 Melt compositions more challenging because
 of dendritic quench pattern.
 Determined from average of up to 100
 analyses, each covering a 10 μm x 10 μm
 area.

Laser ablation ICP-MS analysis:
 Trace elements (Ni, Re, Os, Ir, Pt) measured.
 Line scans, or single spots when area limited.
 Beam size 35 to 80 μm.
 Average of 3 to 5 analyses, ensuring that
 broad area of quenched melt region is
 analyzed.
 Standardized to probe analysis for Fe; Hobo
 (IVB iron meteorite) used as calibrant.
 Reported uncertainties are 2σ error on mean.

References

- Brandon et al. (2003) ¹⁸⁶Os, ¹⁸⁷Os systematics of Gorgona Island komatiites: Implications for early growth of the inner core. *Earth Planet. Sci. Lett.* 206, 411-426.
- Chabot N. L. and Jones J. H. (2003) The parameterization of solid metal-liquid metal partitioning of siderophile elements. *Meteorit. Planet. Sci.* 38, 1425-1436.
- Van Orman et al. (2006) High pressure solid-metal/liquid-metal partitioning of Os, Re, and Pt in the Fe-S system. *Goldschmidt Conf.* (abstract).
- Walker D. (2000) Core participation in mantle geochemistry. *Geochim. Cosmochim. Acta* 64, 2897-2911.
- Walker R. J. et al. (1995) Osmium-187 enrichment in some plumes: Evidence for core-mantle interaction? *Science* 269, 819-822.

Results

The fcc-to-hcp phase transition has no resolvable effect on the partition coefficients D(Ni), D(Re), D(Os), and D(Ir) in this study. This is best seen in the D(Ni) vs. Ru plot below, in which the D(Ni) trend is undisturbed by the phase transition (indicated by color of the symbols). A crystal structure-induced change of D(Pt) by ~5x is suggested by our data (inset), but its magnitude is uncertain because of the confounding effects of metal and melt compositions.

The effect of pressure can be determined by comparisons within our data set, and also by comparison of our data to the 1 bar parameterization of Chabot and Jones (2003) for partitioning in the Fe-S system. We find that increasing the pressure by 6 GPa reduced D(Ni) by a factor of approximately 1.5. Pressure effects of similar magnitude were also found for D(Re), D(Os), and D(Ir), consistent with the results of Van Orman et al. (2006). However, we can resolve no pressure effect on D(Pt).

