

**SOLID METAL-LIQUID METAL PARTITIONING OF PT, RE, AND OS: THE EFFECT OF CARBON.**

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**Introduction:** Recent <sup>187</sup>Re-<sup>187</sup>Os ( $t_{1/2}=41.6$  Gy) and <sup>190</sup>Pt-<sup>186</sup>Os ( $t_{1/2}=450$  Gy) studies have reported elevated Os isotopic ratios in mantle plume sources [1-6]. To create the elevated <sup>187</sup>Os/<sup>188</sup>Os and <sup>186</sup>Os/<sup>188</sup>Os ratios measured, the source region must contain some material that is enriched in Re and Pt relative to Os. Both partitioning experiments [e.g. 7, 8] and partitioning behaviors that have been inferred from iron meteorites [e.g. 1] suggest that crystallization of the Earth's solid inner core may increase the Re/Os and Pt/Os ratios in the liquid outer core. Using an iron meteorite analogue for the Re/Os and Pt/Os fractionation in the Earth's core, it has been proposed that a small amount (~1%) of entrainment of outer core material in the mantle can account for the observed Os isotopic signature [1, 4, 6].

If the measured Os isotopic ratios are a signature from the Earth's outer core, understanding them is a unique opportunity to understand more about the Earth's core. The distribution of elements between the Earth's solid inner core and the liquid outer core will depend on their solid metal-liquid metal partition coefficients (D). Solid metal-liquid metal partitioning data are loosely consistent with the needed fractionations between Re-Os and Pt-Os to account for the Os isotopic signature; D(Os) is greater than both D(Re) and D(Pt), and the magnitude of the partition coefficients are similar to those needed [e.g. 7, 8].

The pressure in the core, the composition of the core, and the crystal structure of the solid Fe alloy in the inner core may influence the specific values of the partition coefficients. It may thus be possible to use these sensitivities of the partition coefficients to gain insight into the conditions within the Earth's core. In this abstract, we focus on the compositional influence of C, a potential component of the light element in the Earth's core [9], on the partitioning behaviors of Pt, Re, and Os.

**Methods:** Experiments were conducted in 1 atm Deltech vertical tube furnaces at Johnson Space Center, using similar methods to previous solid metal-liquid metal partitioning studies [8, 10]. Starting mixtures consisted of Fe, Ni (~10 wt%), and C powders, with trace elements doped at ~100 ppm each. The results discussed in this abstract are just part of a larger systematic study to determine the effects of C on multiple siderophile (metal-loving) elements. Consequently, in addition to Pt, Re, and Os, experiments were also doped with Ag, As, Au, Bi, Co, Cr, Cu, Ge, Ir, Pb, Pd, Ru, Sb, Sn, and W at trace levels.

The starting mixtures were contained in alumina crucibles in sealed, evacuated silica tubes. Each evacuated silica tube was lowered into a furnace and held at

a temperature that was 30-150°C higher than the final run temperature for 2 hrs, except for the highest temperature run of 1480°C for which such a procedure was not possible. Experiments were then held at run temperatures ranging from 1480-1250°C for 12-61 hrs, with the run duration being inversely related to the run temperature. Upon removal from the furnace, runs were quenched by submersing the silica tubes in cold water.

Experimental run products were first analyzed for the major elements of Fe and Ni using the University of Arizona Cameca SX-50 electron microprobe. Values for D(Ni) determined from the microprobe measurements agreed well with previous C-bearing determinations of D(Ni) [11, 12]. The concentrations of the trace elements were analyzed by laser ablation ICP-MS at the University of Chicago. The sensitivity of the laser ablation ICP-MS technique, in contrast to that of the electron microprobe, allowed the trace elements to be doped at low levels and many trace elements to be present in each experiment consequently. Using techniques similar to previous studies [8, 13, 14], measurements were made by ablating line scans that were 50 μm wide, 300 μm long, and ~13 μm deep. The values of D(Ni) determined by the laser ablation ICP-MS method and the electron microprobe analysis agreed to within 10% of each other. Carbon contents of the metallic liquids were estimated based on the experimental run temperatures.

**Results and Discussion:** Figure 1A shows the partitioning results for Pt, Re, and Os from our C-bearing experiments. With increasing C-content of the metallic liquid, D(Os) increases while D(Re) decreases, resulting in larger fractionations between the two elements at higher C-contents. This partitioning behavior is generally consistent with the fractionation observed between Re and Os in cohenite ((Fe, Ni)<sub>3</sub>C) in iron meteorites [15]. In contrast, both D(Pt) and D(Os) increase with increasing C-content of the metallic liquid. Since D(Pt) increases faster than D(Os), the relative fractionation between Pt and Os decreases with increasing C-content.

In addition to the results shown in Fig. 1A, we also have partitioning data for many other trace siderophile elements, as previously listed. Of particular note, D(W) and D(Cr), like D(Re), exhibit "C-loving" behavior and decrease with increasing C-content of the metallic liquid. The partition coefficients for all of the other trace elements increase with increasing C-contents. Our partitioning results are consistent with all available previous C-bearing studies: D(W) as determined by [12], D(Ge) and D(Ir) as determined by [11],

and the one reported value by [11] for D(Au), D(Cu), and D(Cr).

An interesting observation about the Pt, Re, and Os C-bearing data is that the effects from C are very different than the effects from S [8], as shown in Fig. 1B. In the Fe-Ni-S system, the partition coefficients for all three elements increase with increasing S-content of the metallic liquid. The S-content of the metallic liquid can cause order of magnitude changes in the partition coefficients, but both D(Re) and D(Os) are found to be similarly affected by the S-content of the metallic liquid, resulting in limited fractionation between the two elements. In the Fe-Ni-S system, D(Pt) also increases with increasing S-content, but unlike in the Fe-Ni-C system, D(Pt) remains less than D(Os) even as both partition coefficients increase.

If C is present in the Earth's core, it will be one of multiple light elements; carbon cannot account for the observed outer core density deficit of about 10% on its own [9, 16]. As our results show, different light elements can cause very different relative fractionations between Re-Os and Pt-Os. Combinations of multiple light elements offer even more fractionation possibilities.

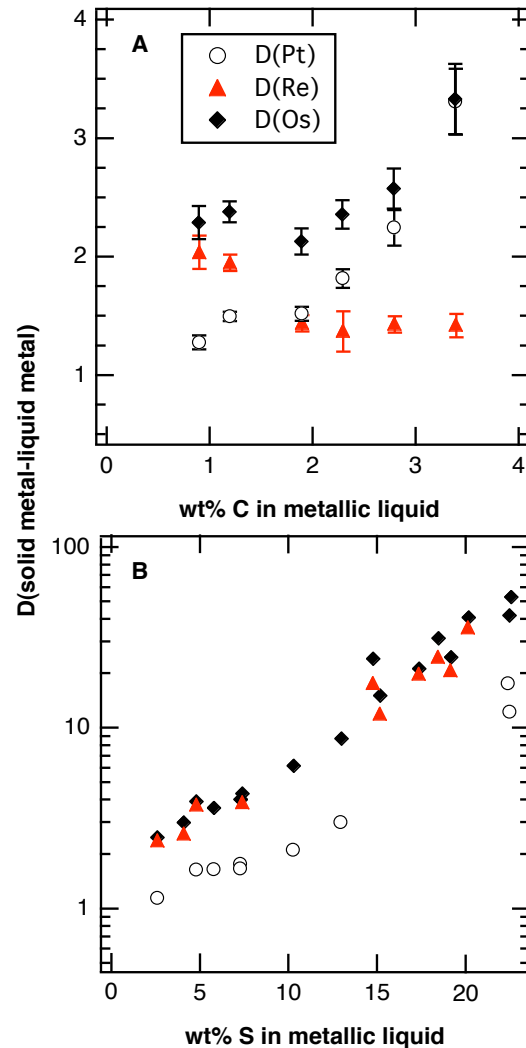
Given Fig. 1, it is natural to wonder about the partitioning of Pt, Re, and Os in the Fe-Ni-S-C system, for example. Unfortunately, it is not really known how the effects from the two light elements will interact, especially when S and C have opposing effects, as is the case for D(Re). It may be possible that a small amount of C in the core would enhance the Re-Os fractionation and decrease the Pt-Os fractionation. How siderophile elements partition in systems that contain multiple light elements may be particularly relevant to the Earth's core. A recent review by [9] suggests that there are likely multiple light elements in the Earth's outer core, with some possibilities including not only S and C, but also O and Si.

There is clear motivation for additional experimental work involving other metallic compositions and compositions that contain multiple light elements. Any effects on the partitioning behaviors from different solid metal phases and higher pressures would also be interesting to explore. A comparison of the effects from S and C, as done in this abstract, is illustrative that different compositions can have quite different effects on the relative partitioning behaviors of Pt, Re, and Os. This is an encouraging result for future studies, suggesting that if the observed Os isotopic signature is representative of the Earth's outer core, there is the potential to gain insight into the light element composition of the core by understanding the behavior of D(Pt), D(Re), and D(Os).

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**Acknowledgements:** This work was supported by NASA grants NAG5-12831 to N. L. C., NAG5-13133 to M. H., and NAG5-11122 to R. P. Harvey. We thank NASA JSC for use of experimental facilities, and K. J. Domanik and M. J. Drake for electron microprobe use and assistance.



**Fig. 1.** The effect of (A) C [this work] and (B) S [8] on D(Pt), D(Re), and D(Os) are compared ( $\pm 1\sigma$  error bars).