

THE EFFECT OF OXYGEN AS A LIGHT ELEMENT IN METALLIC LIQUIDS ON PARTITIONING BEHAVIOR. Nancy L. Chabot¹, E. Alex Wollack¹, and Munir Humayun². ¹Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, USA. Nancy.Chabot@jhuapl.edu ²Department of Earth, Ocean, and Atmospheric Science, & National High Magnetic Field Laboratory, Florida State University, Tallahassee, FL, 32310, USA.

Introduction: The composition of metallic liquids can dramatically affect the partitioning behavior of elements during planetary processes. In particular, the “light element” content of a metallic liquid, those components in the liquid that are present at wt% levels with atomic numbers much lower than Fe, can have a significant influence. Determining the light element influence on partitioning behavior is important for understanding planetesimal differentiation, large-scale planetary core formation, and core crystallization.

The influence of the light elements S [e.g. 1], P [e.g. 2], C [e.g. 3], and Si [e.g. 4] have been the focus of previous experimental studies. Oxygen is also considered to be a potentially important light element in planetary cores [e.g. 5], but experiments to date have been limited, due largely to challenges of working in Fe-O-bearing systems. Here we present new results from an experimental study in the Fe-S-O system. By producing equilibrium experiments with two immiscible metallic liquids, we are able to determine the effect of O as a light element in metallic liquids on element partitioning behavior.

Method: Experiments were conducted in a 1 atm vertical tube furnace. Powdered starting compositions (mixtures of Fe, FeS, FeO powders doped with >20 trace elements at hundreds of ppm each) were placed in alumina crucibles in sealed, evacuated silica tubes, similar to other experimental partitioning studies in

metallic systems [e.g. 1-4]. The enabling feature of this experimental study was that starting compositions and temperatures (1400-1600°C) were selected to produce two immiscible metallic liquids in the Fe-S-O system. Run products without solid phases and at higher temperatures facilitated reaching equilibrium in a few hours while minimizing reaction with the crucible, in contrast to previous experiments investigating partitioning between solid metal and liquid metal in the Fe-S-O system [6]. *Figure 1* shows back-scattered electron images of a typical run product, with two well-separated metallic liquids, each with a distinct quench texture. Experiments were first analyzed for the major elements of Fe, S, and O using a JEOL FE-SEM at the Carnegie Institution of Washington. Trace element concentrations were measured by laser ablation ICP-MS microanalysis at Florida State University.

Results and Implications: *Figure 2* shows the partitioning results for six experiments at 1500°C where the major difference between the runs was the O-content of the O-rich liquid. The majority of elements exhibit O-avoidance behavior, similar to their established S-avoidance tendencies. Of particular note, these experiments show that this is true for the elements Pt, Re, and Os for the first time, and thus the crystallization of an O-bearing core would not be expected to create large fractionations between these elements.

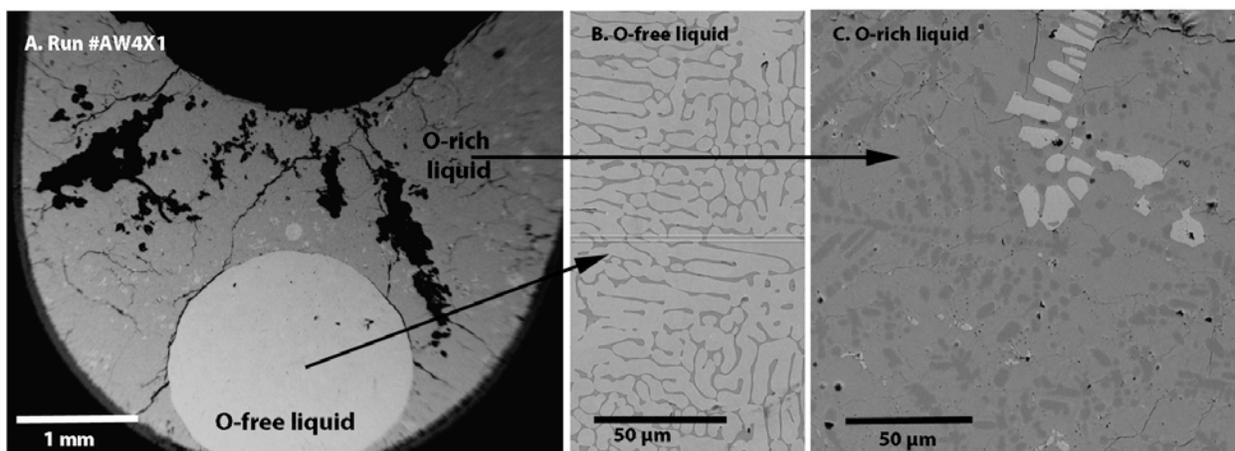


Figure 1. A. Back-scattered electron image showing a typical run product with two equilibrium, S-bearing liquids: one essentially O-free (<1 wt% O) and one O-rich (6-14 wt% O). B. The quench texture of the O-free liquid consisted of Fe dendrites surrounded by mainly FeS. C. The quench texture of the O-rich liquid consisted of FeO and Fe dendrites with a fine-grained interstitial mixture of FeO and FeS, depending on the O-content of the liquid.

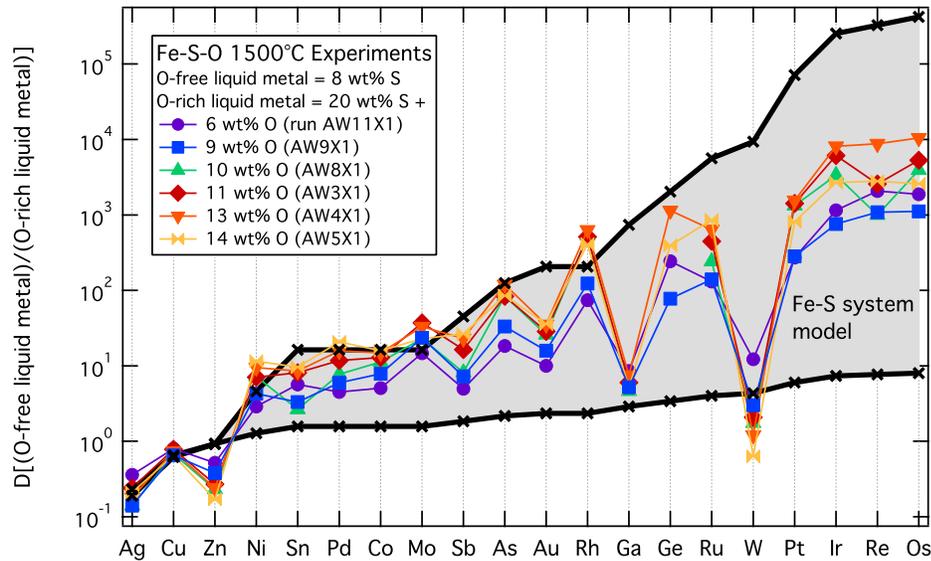


Figure 2. Partitioning results for experiments with two liquids in the Fe-S-O system at 1500°C. The grey shaded region represents the general partitioning values that would be expected in the O-free Fe-S system for these elements, based on the model of [9]. For ease of comparison, elements are ordered by increasing partition coefficient as calculated by this model.

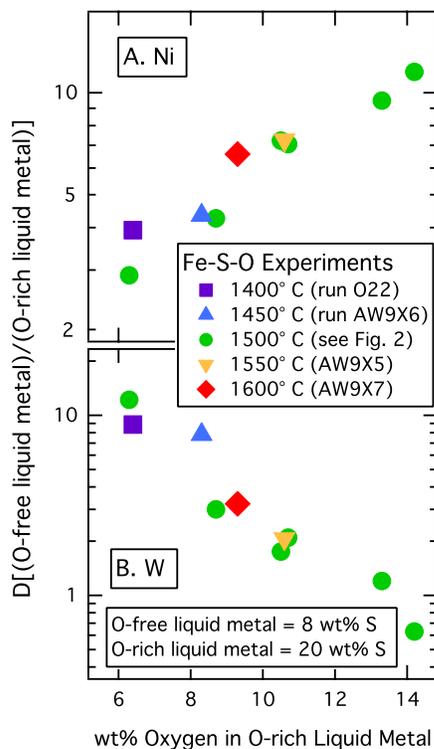


Figure 3. All experimental results for **A. Ni** and **B. W**, illustrating similar partitioning behavior for 1400-1600°C experiments.

In contrast, W and Ga, and to a lesser extent Zn, show an affinity, rather than an avoidance, for O in the metallic liquid, partitioning more strongly into the metallic liquid when O is present. This observation is consistent with earlier solid metal/liquid metal experi-

ments [6] and a recently reported meteoritic example [7]. Thus, an O-bearing metallic liquid phase during planetary core formation, for example, could significantly influence the metal/silicate partitioning behavior of W and Ga in a manner opposite to that of other siderophile elements [8].

Figure 3 plots results for Ni and W from all experiments in our study. The effect from varying temperature between 1400-1600°C is minor in comparison to the influence of O on the partitioning behavior.

These new experimental results enable the effect of O as a light element in metallic liquids on partitioning behavior to be taken into account when modeling planetary processes. Additionally, the distinctive chemical signature imposed on W and Ga by the presence of O in the metal can be used to evaluate if an O-bearing metallic liquid was involved during planetary evolution scenarios.

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References: [1] Chabot N. L. et al. (2009) *MAPS* 44, 505-519. [2] Corrigan C. M. et al. (2009) *GCA* 73, 2674-2691. [3] Chabot N. L. et al. (2006) *GCA* 70, 1322-1335. [4] Chabot et al. (2010) *MAPS* 45, 1243-1257. [5] Hillgren V. J. et al. (2000) In *Origin of the Earth and Moon*. The University of Arizona Press, pp. 245-263. [6] Chabot N. L. and Humayun M. (2011) LPS XLII, Abstract #1590. [7] Horstmann M. et al. (2013) *MAPS*, in press. [8] Humayun M. (2011) *Geochem. Geophys. Geosyst.* 12, Q03007, doi:10.1029/2010GC003281. [9] Chabot N. L. and Jones J. H. (2003) *MAPS* 38, 1425-1436.