

HIGH PRESSURE REACTIONS BETWEEN FE-METAL AND MANTLE SILICATES. Valerie J. Hillgren and R. Boehler, both at: Hochdruck Mineralphysik, Max Planck Inst. für Chemie, Postfach 3060, 55020 Mainz, Germany, e-mail: hillgren@mpch-mainz.mpg.de

Introduction

Two long standing problems in the origin and evolution of the Earth's core are the identity of the light alloying element(s) and the origin and nature of the seismically anomalous D" layer directly overlying it. It is possible that the key to both these problems lies in high pressure and temperature chemistry. Ringwood and colleagues [1,2] showed that high pressure increased the solubility of O and other oxides in Fe-metal. Thus, at high pressures elements O and Si may become soluble enough in Fe-metal for them to contribute significantly to the light element budget in the core. In addition, one proposed origin of the D" layer is a chemical reaction between the liquid metal outer core and the solid silicate mantle overlying it [3,4]. In order to investigate the nature and extent of these possible chemical interactions, we have begun a diamond anvil cell study of the high pressure and temperature reactions between metal and silicate.

Knittle and Jeanloz [3,4] and Goarant *et al.* [5] have also studied high pressure and temperature reactions between metal and silicate in the diamond anvil cell. However, Knittle and Jeanloz studied the interaction of perovskite and Fe-metal, but the presence of magnesiowüstite should be important because it is likely that O would actually dissolve in Fe-metal as FeO. Goarant *et al.* were only able to analyze for the presence of O in the metal qualitatively with TEM. Perhaps most important is that in both studies a small laser hot spot with large temperature gradients (~1000 K/ μm) was scanned across the sample, and it is questionable that chemical equilibrium was attained. In neither study were wet versus dry conditions explicitly

studied. Whether an experiment is wet or dry will effect the re-dox potential and hence the solubility of both O and Si in Fe-metal. In this study we attempt to improve upon the above shortcomings.

Experimental Procedures

Our basic sample consisted of a plate of pure Fe in contact San Carlos olivine (Fo₈₈) which was covered with either a San Carlos olivine, San Carlos enstatite, or Al₂O₃ plate. Normally the diamond cell was placed in an approximately 100 °C vacuum oven overnight to ensure that the sample was thoroughly dried. The oven was then repressurized with Ar and the cell was sealed. In order to study the effects of re-dox state on any possible chemical interactions, we also performed "wet" runs. The wet samples were breathed on immediately prior to sealing the cell. The interface between the Fe-metal and San Carlos olivine was heated with an YLF laser with a hot spot size of at least 20 μm . There is an average temperature gradient across the hot spot of 25 K/ μm . However this is not indicative of the true temperature distribution across the hot spot as the temperature gradient is very flat across the central part but increases dramatically as the edges are approached. We did not scan the laser across the sample but held it in one spot to ensure as close an approach to equilibrium as possible under these conditions. In most runs the Fe-metal was melted during heating, and the initially clear San Carlos olivine darkened, presumably due to the transformation of the olivine to perovskite and magnesiowüstite. The run pressure was determined through the position of fluorescence peaks of rubies

scattered throughout the sample. After the run the sample was recovered and polished down to the heated surface.

Results

The results of electron microprobe analyses of three samples are presented in Table 1. Two of the samples were dry and one was wet. In both of the dry samples the Fe was molten, but the wet sample only reached a maximum temperature of 2250 K which is below the melting temperature of Fe. Because of the variability of the run conditions for each sample, we can not say anything about systematic trends of the solubility Ni, O or Si in Fe-metal with temperature, pressure, or redox state. However, our results do indicate that in general O and Si are not very soluble in Fe metal and are therefore unlikely to comprise a major portion of the light element in the

Earth's core. In addition, the only significant chemistry we see occurring is the oxidation of some of the Fe-metal to FeO in the silicate in our samples at higher redox states.

In our future work we will explore the effects of yet higher pressures and of differing compositions of metal and silicate. In addition we plan to more rigorously control fO_2 , and explore new analyses options such as TOF SIMS.

References: [1] Ringwood and Hibberson (1990), *Phys. Chem. Min.*, vol. 17, pp. 313-319. [2] Ringwood *et al.* (1990), *Nature*, vol. 347, pp. 174-176. [3] Knittle and Jeanloz (1989), *GRL*, vol. 16, pp. 609-612. [4] Knittle and Jeanloz (1991), *Science*, vol. 251, pp. 1438-1443. [5] Goarant *et al.* (1992) *JGR*, vol. 97, pp. 4477-4487.

Table 1: Tmax is the maximum temperature in the laser heated hot spot.

Conditions	Dry 450-500 kbar Tmax=2800 K	Dry 500-550 kbar Tmax=3000 K	Wet ~600 kbar Tmax=2250 K
Cover Plate	Olivine	Al ₂ O ₃	Enstatite
FeO in Silicate (in wt. %)	8.0-8.5	9.5-10.2	10-12
Ni in Metal (in wt. %)	0.17 ±0.09	0.07 ±0.007	0.03 ±0.02
Si in Metal (in wt. %)	0.07 ±0.01	0.1 ±0.04	0.06 ±0.04
O in Metal (in wt. %)	0.3 ±0.03	0.4 ±0.08	0.27 ±0.05