

**THE PARTITIONING OF SI BETWEEN METAL AND SILICATE: IMPLICATIONS FOR PLANETARY CORES.** Valerie J. Hillgren<sup>1</sup> and Y. Fei<sup>1</sup>, <sup>1</sup>Geophysical Laboratory, Carnegie Institution of Washington, 5251 Broad Branch Rd NW, Washington D.C. 20015 (vhillgren@ciw.edu).

**Introduction:** Because under reducing conditions Si can partition into metal, it has been suggested that Si may be the light element in Earth's core [for review see 1] and also Mercury's [2-3]. In order to assess how much Si may reside in the cores of Mercury and Earth, we need a good parametrization of the partitioning behavior of Si between metal and silicate. Several earlier experimental studies [4-7] explored the dependence of Si partitioning on temperature (T), pressure (P) and the degree of polymerization of the silicate melt (NBO/T). When we combined all this experimental work, we were best able to fit it to an equation of the form:

$$\log K_D = a + \frac{b}{T} + \frac{c \cdot P}{T} + d \cdot X_{MgO}^{Sil} + e \cdot X_{CaO}^{Sil} + f \cdot X_{SiO_2}^{Sil}$$

Where:

$$K_D = \frac{\left[ X_{FeO}^{Sil} \right]^2 \left[ X_{Si}^{Met} \right]}{\left[ X_{Fe}^{Met} \right]^2 \left[ X_{SiO_2}^{Sil} \right]}$$

And X represents the mole fractions of various species in either the metal or the silicate. This parameterization implies that the partitioning of Si between metal and silicate is strongly dependent on the silicate liquid composition. However, this parameterization can only marginally reproduce the data that it is derived from. Therefore, we have begun an experimental study to further explore the metal-silicate partitioning of Si. In the current work we wished to clarify the temperature and compositional dependences.

**Experimental:** Experiments were conducted at 2 GPa in a piston cylinder apparatus at the Geophysical Laboratory. The piston cylinder assembly consisted of a graphite tube heater insulated with a pyrex glass sleeve surrounded by a talc shell. The temperature was measured with a W/Re thermocouple in contact with the top of the MgO sample capsule. Run temperatures were varied from 1700 to 1900 °C with the bulk of the runs being performed at 1800 °C. The standard run time was 30 minutes, but we also performed a time series of 5, 15 and 30 minutes. Silicate starting materials were either a basaltic glass doped with V, Cr, and Mn or oxide mixtures of SiO<sub>2</sub>, MgO, Al<sub>2</sub>O<sub>3</sub>, Na<sub>2</sub>O, K<sub>2</sub>O, and TiO<sub>2</sub> in peridotitic proportions with varying amounts of CaO and Fe<sub>2</sub>O<sub>3</sub>. Metal starting materials consisted of powders of Fe<sub>91</sub>Si<sub>9</sub> and Fe<sub>83</sub>Si<sub>17</sub> alloys from Goodfellow or mixtures of Fe<sub>91</sub>Si<sub>9</sub> and pure Fe. After the run, samples were recovered, polished and the compositions of the metal and silicate phases were

analyzed with a JOEL 8900 electron microprobe. An accelerating voltage of 15KeV and a beam current of 30 na were used. Peak counting times ranged from 30 to 120 seconds

**Results and Discussion:** The resulting run products spanned a wide compositional range. The Si concentration in the metal run products ranged from 1 to 14.5 wt. %. The FeO concentration in the silicate liquid ranged from 0.04 wt. % to 0.9 wt. %. The CaO in the silicate liquid varied from 0.2 to 7.8 wt. %.

In order to assess whether equilibrium was being reached during the runs, for one composition a time series of 5, 15 and 30 minutes was performed at 1800°C, and for two other compositions runs were performed at both 5 and 30 minutes at 1800°C. The results are plotted in figure 1. It appears that 15 to 30 minutes is adequate to achieve equilibrium, but 5 minutes may not be for all compositions. Many partitioning experiments are normally only run for 2 to 3 minutes to minimize interaction with the capsule. This may not be adequate to reach equilibrium.

In figure 2, we plot the simple metal-silicate partition coefficient D for Si against the *f*O<sub>2</sub> relative to the iron-wüstite buffer (calculated from the mole fractions of Fe and FeO in the metal and silicate respectively). A strong correlation is observed as expected. However, plotting the distribution coefficient KD which normalizes for *f*O<sub>2</sub> against temperature (figure 3) shows no discernable trend, although KD should depend strongly on temperature. This suggests that there are strong compositional influences. However, plotting the KD versus NBO/T and versus individual oxides in the silicate melt also produces no discernable trends. Attempts at multivariate regressions for various combinations of the oxides in the silicate liquid do not produce good fits. The NBO/T and the oxides should act as proxies for the activity coefficients of FeO and SiO<sub>2</sub> in the silicate liquid. The lack of any correlation with any of these proxies suggests that it is the composition of the metal, *i.e.*, the activity coefficients of the Fe and Si which is most strongly influencing the partitioning of Si between metal and silicate.

**References:** [1] Hillgren V. J. *et al.* (2000) *Origin of the Earth and Moon* (Ed. Canup and Righter), 245–264. [2] Fei *et al.* (2011) 42<sup>nd</sup> LPSC Abstract #194, [3] Malavergne V. *et al.* (2010) *Icarus*, 206, 199-209. [4] Kilburn M. R. and Wood B. J. (1997) *Earth Planet. Sci. Lett.* **152**, 139-148. [5] Geßmann C. K. and Rubie D. C. (1998) *Geochim. Cosmochim. Acta* **62**, 867-882.

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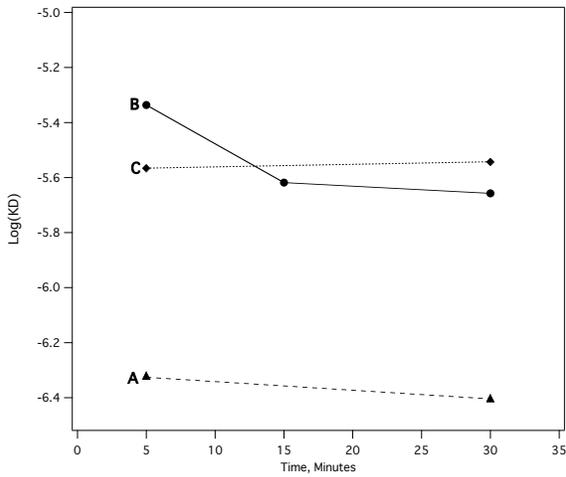


Figure 1: Results of Time Series. Composition A was the basaltic glass with  $Fe_{91}Si_9$ , composition B was an oxide mix with  $Fe_{91}Si_9$  and composition C was the same oxide mix with  $Fe_{83}Si_{17}$ .

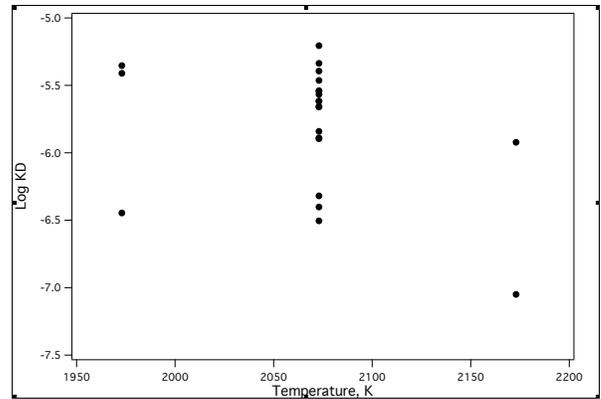


Figure 3: Log KD for Si Plotted versus T.

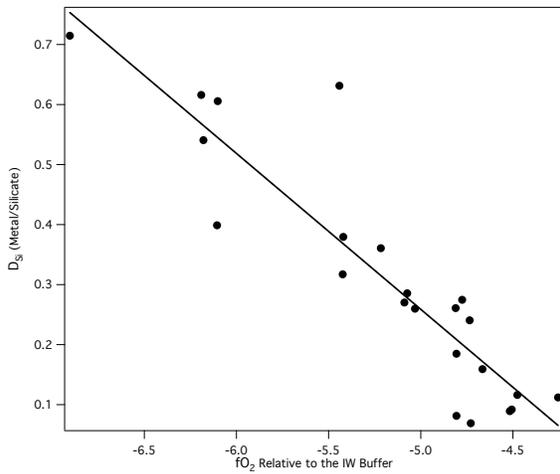


Figure 2: Metal-Silicate D for Si Plotted versus  $fO_2$ .