Argon behavior during magma ocean crystallization

C. R. M. JACKSON[1], N. R BENNETT[1] AND Y. FEI[1]

[1]Geophysical Laboratory, Carnegie Institution for Science, District of Columbia, USA

Measurements of xenon in OIB indicate that the mantle contains geochemical reservoirs that were isolated within the first 80 Ma of Solar System history [1] [2]. The noble gases associated with these early-forming, and likely lower mantle, reservoirs have remained robust to complete homogenization since their isolation. Thus, their geochemistry provides information regarding the processes active during Earth's earliest stages. Here, we focus on experimentally determining the behavior of noble gases during Earth's accretion (e.g., in magma oceans) to provide a framework for interpreting ancient noble gas signatures. Our preliminary findings indicate that high-pressure silicate liquids and bridgmanite have similar capacities to dissolve argon. This result implies that argon may partition nearly equally between liquid and crystals during the initial stages of magma ocean crystallization. If true, this suggests that (1) noble gas uptake during the early stages of magma ocean crystallization may be significant, (2) portions of the deep mantle that remain solid following giant impacts can retain substantial concentrations of noble gases, and (3) basal magma ocean liquids may not be strongly enriched in noble gases during crystallization.

Experiments were conducted using laser-heating diamond anvil cell (DAC) techniques. Samples comprising either basaltic glass or bridgmanite were loaded into a stepped rhenium gasket. Pure argon was used as the pressure medium in all experiments, which both fixes its activity in the experimental system and allows for accurate pressure measurements associated with each heating spot. The emission spectrum of the sample was used to monitor temperature during laser-heating. Multiple heating spots were completed on each sample, allowing for some exploration of time and temperature dependencies of argon solubility. Argon concentrations were quantified using silicon drift detector EDS.

Additional experiments are in preparation using DAC and multi-anvil techniques for a range of high-pressure phases. Data from the present and planned experiments should help to address any inconsistencies regarding argon solubilty measurements in bridgmanite collected using different techniques [3].

[1] Mukhopadhyay (2012) *Nature*, **486**, 101-104. [2] Peto et al. (2013) *EPSL*, **369**-**370** [3] Shcheka and Keppler (2012) *Nature*, **490**, 531-534