Diffusion in liquid iron and peridotite melt at high pressure

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Diffusive transport properties of iron and peridotite liquids at high pressures and temperatures have important kinetic implications for large-scale geodynamic processes and thermochemical evolution of planetary interiors, such as the time and length scales of metal-silicate equilibration during core formation and chemical exchange across core-mantle boundaries during cooling. Iron meteorites, which are derived from the metallic cores of early-formed planetesimals, are strongly depleted in weakly siderophile elements (Si, O, Cr) relative to model predictions [1] which is likely a result of low temperature partitioning into the overlying silicate mantle (magma ocean) during cooling. Slow diffusion rates in subsolidus iron restrict the length scale of core-mantle equilibration to a few meters [2] which is insufficient to explain the depletion of Si, O, and Cr in the cores of much larger planetesimals. Recent studies on magnetized achrondrites [3] reveal that planetesimal cores must have been molten and vigorously convecting such that the rate of Si, O, and Cr loss would be controlled by diffusion through liquid across boundary layers at the top of the core. To test this hypothesis and to extend the pressure range of experimental diffusion data for relevant geo-liquids, we have conducted experiments of Si, O, and Cr diffusion in liquid iron over the *P-T* range of 1.5—18 GPa and 1850—2450 K, and Si, O, Mg, Ca tracer and Ni, Co chemical diffusion in peridotite liquids over the *P-T* range of 4—24 GPa and 2248—2623 K in a multi-anvil apparatus.

Discontinuities in the pressure dependence of diffusion are observed in both liquid iron and peridotite melt at ~5 and ~10 GPa, respectively, due most likely changes in melt structure as has been reported in previous studies (e.g. [4, 5]). The temperature dependence of diffusion also varies with pressure for all elements studied, yielding activation energies of ~30-80 kJ/mol for Si, O, Cr in liquid iron and ~100-400 kJ/mol for Si, O, Mg, Ca, Ni, Co in peridotite melt. We apply our results in a planetesimal core chemical evolution model to interpret the mismatch between predicted core compositions and iron meteorite chemistries.

[1] Rubie *et al.* (2015) *Icarus* **248**, 89-108. [2] Pack *et al.* (2011) *MAPS* **46**, 1470-1483. [2] Weiss *et al.* (2008) *Science* **322**, 713-716. [3] SanLoup *et al.* (2000) *Europhys. Lett.* **52**, 151-157. [4] Wolf & McMillan (1995) *RIMG* **32**, 505-561. [5] Liebske *et al.* *EPSL* **240**, 589-604.