MAJORITE-GARNET PARTITIONING OF THE HIGHLY SIDEROPHILE ELEMENTS: NEW RESULTS AND APPLICATION TO MARS.

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Introduction: HSE and Os isotopes are used to constrain processes such as accretion, mantle evolution, crustal recycling, and core-mantle mixing, and to constrain the timing and depth of differentiation of Mars [1,2]. Although [2] showed that the HSE contents of the martian mantle [3] could have been established by metal-silicate equilibrium in early Mars, the role of a cooling magma ocean and associated crystallization [4] in further fractionating the HSEs is unclear. Garnet is thought to have played an important role in controlling trace element concentrations in the martian mantle reservoirs [4]. However, testing these models, including Os isotopes, has been hindered by a dearth of partitioning data for the HSE in deep mantle phases - majorite, wadsleyite, ringwoodite, akimotoite - that may be present in the martian mantle. We examine the partitioning behavior of HSEs between majorite garnet (gt), olivine (oliv), and silicate liquid (melt).

Methodology: A silicate composition which represents the Martian mantle was chosen after [5]. Experiments were carried out in a 5 mm TEL multi-anvil assembly with a graphite capsule, at 13 (207) and 14 (208) GPa on the 880-ton press at NASA JSC. These runs were heated to 1730 °C, held for 10 minutes, and power quenched. Powdered metal highly siderophile elements (Ru, Rh, Pd, Re, Os, Ir, Pt, Au) were added to the starting material in equal abundances, at a total dopant level of 10 wt%. HSE, Sc, V, Cr, Mn, Co, Ni, Nb, Mo, and W partitioning was determined by laser ablation ICP-MS at the Plasma Analytical Facility at FSU using an ESI™ New Wave UP193FX laser ablation system coupled to a Thermo Element XR™ ICP-MS [2]. Line scans (15 µm wide) and spots (25 µm) were ablated at 50 Hz. Metal nugget contamination of the analyses was removed by identifying and eliminating HSE spikes from time-resolved analyses.

Results: D(Sc) gt/melt was found to be 2.3, in agreement with previous studies [6], whereas D(Mo) and D(W) gt/melt were 0.066, higher than measured by [7]. D(Pt,Os) appear to be close to 1, but partition coefficients could not be accurately determined for Os, Ir and Pt because of inhomogeneous distribution in both melt and solid phases. In comparison, D(Pd,Au,Re,Rh,Ru) gt/melt are all <0.25, and most < 0.1. All elements are incompatible in olivine with D<0.05, and again D(W) oliv/melt being 0.0017 in good agreement with [7]. From these results, ratios of incompatible HSE (IHSE - Re, Pd, Au) vs. compatible HSE (CHSE - Ir, Os) may be sensitive to the involvement of garnet in mantle melting. We will use the new results to evaluate whether a range of IHSE/CHSE ratios in an enriched martian mantle can be produced by mixing of trapped melt and depleted cumulates [4] or by involvement of garnet in melting processes.

References: [1] Walker, R.J. 2009. Chem. Erde-Geoch. 69, 101-125. [2] Righter, K. et al. 2015. MaPS 50, 604-641. [3] Brandon, A.D. et al. 2012. GCA 76, 206-235. [4] Debaille et al., 2008. EPSL 269, 186-199. [5] Agee et al. 2004. EPSL 224, 415-429. [6] Draper, D. et al. 2003. PEPI 139, 149-169. [7] Righter, K. and Shearer, C.K. 2003. GCA 67, 2497-2507.