SIDEROPHILE ELEMENT CONSTRAINTS ON THE CONDITIONS OF CORE FORMATION IN MARS.

K. Righter[1] and M. Humayun[2], [1]NASA-JSC, Mailcode KT, 2101 NASA Pkwy., Houston, TX 77058; [2]National High Magnetic Field Laboratory, Florida State University, Tallahassee, FL 32310.

Introduction: Siderophile element concentrations in planetary basalts and mantle samples have been used to estimate conditions of core formation for many years and have included applications to Earth, Moon, Mars and asteroid 4 Vesta [1]. For Earth, we have samples of mantle and a diverse collection of mantle melts which have provided a mature understanding of the how to reconstruct the concentration of siderophile elements in mantle materials, from only concentrations in surficial basalt (e.g., [2]). This approach has led to the consensus views that Earth underwent an early magma ocean stage to pressures of 40-50 GPa (e.g., [3,4]), Moon melted extensively and formed a small (~2 mass %) metallic core [5], and 4 Vesta contains a metallic core that is approximately 18 mass % [6,7]. Based on new data from newly found meteorites, robotic spacecraft, and experimental partitioning studies, [8] showed that eight siderophile elements (Ni, Co, Mo, W, Ga, P, V and Cr) are consistent with equilibration of a 20 mass% S-rich metallic core with the mantle at pressures of 14 +/- 3 GPa. We aim to test this rather simple scenario with additional analyses of meteorites for a wide range of siderophile elements, and application of new experimental data for the volatile siderophile and highly siderophile elements.

New analyses: Analyzes of six shergottites were made using a rastering LA-ICP-MS approach described by [9]. Comparison of our new results to previous analyses of these meteorites shows good agreement, and also includes many additional elements that have not been reported previously.

Mantle concentrations of siderophile elements: We examine Ge-Si, In-Yb, Cu-Ti, W-Ta, Zn-Ti, and Cd-Yb combining our new analyses with previous work (see references in [9]) – all siderophile elements paired with lithophile elements of similar compatibility in igneous fractionation processes. For Ge, terrestrial peridotite and basalt define a very clear line in correlation with Si, and therefore the slightly lower concentrations of Ge in martian basalt result in the martian mantle estimate just below the terrestrial trend (see [9]). Cu shows a significantly larger depletion relative to the terrestrial peridotite and basalt. Our new W data help better define the W depletion derived by [8]. New Zn and In data indicate little to no depletion in the martian mantle, and Cd is depleted more in the martian mantle than in the terrestrial mantle.

Implications: All of these new mantle concentration estimates, combined with partitioning studies, are used to test the concept of a 14 GPa early martian magma ocean. The moderately siderophile elements (W, Mo) are consistent with this idea, even with revised depletions and significant new experimental data. The volatile siderophile elements Ge, In, Cu, Zn and the highly siderophile elements Au and Pd (and possibly Pt and Ir) are all consistent with a 14 GPa magma

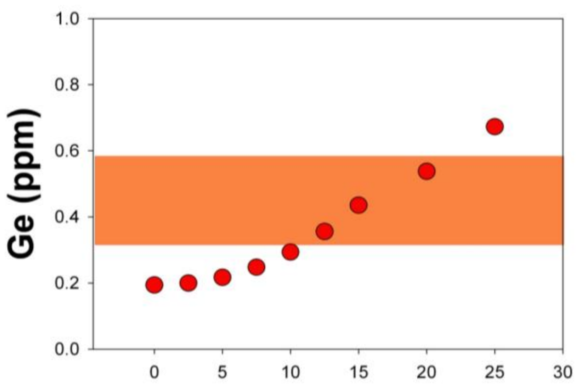

Figure 1: Calculated Ge content of the martian mantle, as pressure increases along a magma ocean adiabatic gradient during growth of Mars. Horizontal band is the estimated range of Ge contents from the Ge-Si correlations from [8]. The calculated mantle Ge contents during growth of Mars coincide with the horizontal band between 12 and 20 GPa, and thus are consistent with a magma ocean scenario like that proposed by [8].

ocean (see Ge in Figure 1). This suggests Mars experienced continuous growth of a metallic core, and did not require changing redox conditions or a late chondritic additions to explain these elements, as argued for Earth (e.g. [4]). In addition, the magma ocean scenario is supported by lithophile isotopic systems Nd and Hf [10].

References: [1] Righter, K. (2003) Ann. Rev. Earth Planet. Sci. 31, 135-174; [2] Drake, M.J. (1980) Rev. Geophys. 18, 11-25; [3] Righter, K. (2011) EPSL 304, 158-167; [4] Wade, J. et al. (2012) GCA 85, 58-74; [5] Righter, K. (2002) Icarus 158, 1-13; [6] Righter, K. and Drake, M.J. (1997) MaPS 32, 929-944; [7] Russell, C.T. et al. (2012) Science 336, 684-686; [8] Righter, K. and Chabot, N.L. (2011) MaPS 46, 157-176; [9] Righter, K. and Humayun, M. (2012) 43rd Lunar and Planetary Science Conference, #2465; [10] Debaille, V. et al. (2008) EPSL 269, 186-199.