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Early thermal state of Mars constrained from siderophile element data from meteorites and metal-silicate experiments

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The early thermal history of Mars is important for understanding some fundamental aspects of its evolution such as crust formation, mantle geochemistry, chronology, volatile loss and interior degassing, and atmospheric development. In light of data from new martian meteorites and exploration rovers, we have updated calculated martian mantle siderophile element depletions. New high pressure and temperature metal-silicate experimental partitioning data and expressions are also available since previous work. Using these new constraints, we revisit the question of what conditions the martian mantle may have equilibrated with metallic liquid. The resulting conditions that best satisfy 7 siderophile elements ? Ni, Co, Mo, W, Ga, P, and Cr ? and are consistent with the solidus and liquidus of the martian mantle phase diagram are a pressure of 11.5 +/- 2.5 GPa and temperature of 2000 +/- 150 K. The results are not consistent with either metal-silicate equilibrium at the surface or at the current day martian core-mantle boundary. However, they are consistent with recent isotopic data and modelling indicating a magma ocean of this approximate depth. Early Mars must have had a magma ocean of intermediate depth, but not global melting.

Keywords: siderophile, mantle, core formation, magma ocean, differentiation, partitioning