The compositional and seismic properties of the Martian interior

MATTHEW C. BRENNAN[1]*, REBECCA A. FISCHER[1], AND JESSICA C. E. IRVING[2]

[1]Harvard University, Dept. of Earth and Planetary Sciences
[2]Princeton University, Dept. of Geosciences
*Correspondence: mcbrennan@g.harvard.edu

Mars, like the other terrestrial planets, is differentiated into a metallic core and silicate mantle, and the compositions of these are controlled by partitioning of the various elements. Here, we present a multi-stage model of Martian formation in which accreting material equilibrates with the proto-Mars before being added to the core or mantle. The behaviour of elements during equilibration is determined by data from high-pressure metal-silicate partitioning experiments, and calculated with self-consistent oxygen fugacity evolution. This approach does not rely on data from Martian samples, which are too few to conclusively identify bulk planetary properties. Within uncertainties, we produce a Martian mantle with major and trace element abundances consistent with published models derived from the SNC meteorites [1,2]. The major dissimilarity between the mantles of Mars and Earth is that the former has less MgO (~30 wt% vs ~37 wt%) and more FeO (~18 wt% vs ~8 wt%). This reflects more oxidizing conditions (relative to the IW buffer) of Martian formation, which may have resulted from its proximity to the protoplanetary snow line [3], and may also account for Mars' small core mass fraction. Like the terrestrial core, the core of Mars is an Fe-Ni alloy with light elemental impurities. Unlike on Earth, where the primary light elements are likely Si and O, Mars' core is S-rich. This was predicted based on the apparent enrichment of Martian volatiles [1,4], but now has been rigorously determined; we find the major light elements in the core to be S (~14 wt%) and O (~2 wt%). With these compositional data, we have constructed a mineral phase assemblage, density profile, and sound velocity profiles for the mantle. We are currently working to quantify the effects of partial equilibration on Martian compositions, as well as predict seismic travel times and whole-planet vibrational modes. These will be compared to previously-published seismic models [5] and upcoming observations from the NASA InSight mission.

[1] Wanke & Dreibus (1988) *Phil Trans. R. Soc.* **325**, 545-557. [2] Taylor (2013) *Chem. Erde* **73**, 401-420. [3] Lecar et al. (2006) *Astrophys. J.* **640**, 1115-1118. [4] Filiberto et al. (2016) *Mete. & Plan. Sci.* **51**, 1935-1958. [5] Khan et al. (2018) *J. Geophys. Res.* **123**, 575-611.