GEOCHEMISTRY OF THE MARTIAN CRUST AND MANTLE: CONSTRAINTS FROM THE InSIGHT LANDER MISSION. S. M. McLennan[1], L. Ojha[2], A.-C. Plesa[3], S.E. Smrekar[4] and M. A. Wieczorek[5] and the InSight Science Team, [1]Department of Geosciences, Stony Brook University, Stony Brook, NY, 11794-2100, U.S.A. (scott.mclennan@stonybrook.edu), [2]Department of Earth & Planetary Sciences, Johns Hopkins University, Baltimore, MD, 21218, U.S.A. (Luju@jhu.edu), [3]Institut für Planetenforschung, DLR, Rutherfordstraße 2, 12489 Berlin, Germany (Ana.Plesa@dlr.de) [4]Jet Propulsion Laboratory, M/S 183-501, Pasadena CA, 91109, U.S.A. (Suzanne.E.Smrekar@jpl.nasa.gov) [5]Observatoire de la Côte d'Azur, CS 34229, 06304, Nice Cedex 4, France (mark.wieczorek@oca.eu).

Introduction: The InSight Lander mission represents the first dedicated geophysical platform that has been sent to Mars but the basic data that it will collect about the internal structure and thermal character of the planet will also have many fundamental implications for its large-scale geochemistry, including the compositions of the Martian core, mantle and crust [1]. In this presentation, we focus on some of the implications for the composition of the Martian crust and mantle.

The seismology experiment (SEIS), for the first time, will provide direct measures of the sizes and internal structure of the fundamental petrological reservoirs (crust, mantle, core) [e.g., ref. 2] and the heat flow experiment (HP^3) will measure the surface heat flow in the vicinity of the InSight landing site [3] and help calibrate the overall heat flow distribution for the planet's surface. In turn, knowing the relative sizes of the core and mantle greatly constrains, for example, how much iron may be partitioned between core (Fe^0) and primitive mantle (FeO). When combined with other geochemical data (e.g., gamma ray elemental mapping of the near-surface, Mars meteorite geochemistry, Mars rover *in situ* geochemical data), understanding the overall thickness (size) of the crust and any internal structure within the crust (e.g., lower vs upper) may further constrain how heat production may be partitioned throughout the crust and mantle and further constrain the overall scale of silicate differentiation of the planet.

The Martian Crust: Our understanding of the chemical composition of the Martian crust and its importance as a geochemical reservoir is rudimentary at best [4]. The available composition is based on a combination of Martian soil/regolith data (corrected for added volatiles (S, Cl) and a minor meteoritic component) and Mars Odyssey gamma ray spectroscopy, notably for the heat producing (and incompatible lithophile) elements K and Th [5]. These "sampling" approaches are only relevant for the upper few decimeters (GRS penetration depths) to perhaps a few km (depths of impacts and other erosion to form soils) of the crust. Added confidence for this compositional model comes from extensive analyses of ancient sedimentary rocks on Mars, by the various Mars rovers, that broadly supports the crustal composition derived from the GRS/soil data [6]. Nevertheless, a crucial assumption, that is in serious need of testing, is that these near-surface compositions can be extrapolated throughout the full thickness of the crust [4,7]. For the Earth's highly complex, compositionally layered continental crust, such an assumption is woefully inappropriate but for Mars' basaltic crust, evaluating the suitability of such an assumption is less straight forward [4]. In addition, the average thickness of the Martian crust is poorly constrained with a recent estimate being 57±24 km [8]; even this level of uncertainty may be a minimum, especially if the crust is more dense than commonly assumed [e.g., ref. 9].

Several key observations from InSight should lead to a better understanding of Martian crustal composition and the size of the geochemical reservoir that is represented by the crust. The first is to better constrain the overall thickness of the Martian crust, by a factor of at least 4-5 (i.e., ±5 km). The second is whether or not seismology further provides any evidence for significant layering (i.e., velocity contrasts of ±0.5km/s over ~5km) within the crust that could be interpreted as compositional/petrological layering. Another key observation will be the heat flow at the InSight landing site, that when combined with gamma ray measurements of near-surface heat producing elements (HPE) K, Th and by inference U (i.e., surface heat production – heat flow relationships) may provide some tests for various geochemical models of the vertical distributions of the HPE (and by inference highly incompatible elements in general) throughout the Martian crust (e.g., constant crustal composition with depth, exponentially decreasing HPE with depth, underplating/resurfacing layered models).

The Martian Primitive Mantle: A long-standing geochemical paradigm for Mars is that, compared to Earth, the primitive mantle (mantle + crust) is enriched in iron and moderately volatile lithophile elements (e.g., K, Rb, Cs), along with a variety of other geochemical differences (e.g., siderophile and chalcophile elements). This so-called Wänke-Dreibus model is based on the composition of Martian (SNC) meteorites and basic cosmochemical principles [10-13], and has proven remarkably robust even in the face of about a twenty-fold increase in the number of discovered SNC meteorites since it was first proposed [13]. The Martian primitive mantle is accordingly thought to have a factor of >2 more Fe compared to the Earth (FeO_T~18% *vs* ~8% for Earth) and about 50% more K (~310ppm *vs* ~180-260ppm for Earth).

InSight has the capacity for providing critical tests of the Wänke-Dreibus model (and other compositional models for that matter) and generally improving our understanding of the composition of the Martian primitive mantle. For example, the Wänke-Dreibus model determination of the FeO_T content of the Martian primitive mantle is indirect, relying on a the average SNC meteorite FeO/MnO ratio (39.1) and MnO abundance (0.46%) derived from chondritic meteorites [e.g., ref. 12]. InSight may offer a more accurate measure of the size of the Martian core (i.e., proportion of the planetary complement of Fe present as metal) with the core radius determined to within at least ±200km and in due course perhaps to within about ±75km, and consequently may allow for a more direct determination of the FeO_T content of the primitive mantle. A second test could come from InSight heat flow data, which should lead to a more robust independent estimate of planetary concentrations of HPE using mean global heat flow and geophysical estimates of the so-called Urey ratio (radioactive heat production / global surface heat loss) [1,14,15].

Silicate Differentiation of Mars and the Terrestrial Planets: A key feature in understanding planetary evolution is the nature and timing of silicate differentiation, effectively the separation of the primitive mantle into present-day mantle and crust. A convenient way to quantify silicate differentiation is to estimate the degree and timing of the transfer of heat production (K, Th, U) into planetary crusts. Our current understanding of Martian crust and mantle reservoirs suggests that ≥50% of the Martian primitive mantle HPE may have been differentiated into the crust, mostly very early in its history [4,7,16], a value also consistent with geodynamical modeling [17]. If correct, silicate differentiation of Mars is considerably greater than for Earth (~25-35%) or Venus (~15-20%) and perhaps more similar to the Moon and Mercury [18]. However, such calculations have very large uncertainties related to the sizes and exact compositions of the mantle and crustal reservoirs. By providing greatly improved estimates for the size and composition of the Martian crust and mantle, InSight should allow us to significantly refine such calculations for Mars.

Discussion: In this presentation, we will explore the nature of the geochemical implications of InSight geophysical data for better understanding the chemical composition and geochemical evolution of Mars and its basic petrological reservoirs (core, mantle, crust). In addition, we will provide any updates of how preliminary data, that may be returned from the InSight Lander, bear on these questions.

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