THERMAL AND COMPOSITIONAL EVOLUTION OF THE MARTIAN MANTLE. Thomas Ruedas[1], Paul J. Tackley[2], and Sean C. Solomon[1], [1]Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, D.C., USA, [2]Institut für Geophysik, ETH Zürich, Switzerland.

Introduction: We present new numerical models for the thermochemical evolution of the mantle of Mars over the past 4 Gy. Among other questions, we examine if a perovskite+ferropericlase layer exists at the base of the martian mantle, if long-lived plumes can explain the volcanic provinces, under which circumstances Mars may still be volcanically active, and the iron and radionuclide abundances of the martian mantle. Specifically, we have developed a parameterized model of composition and thermoelastic properties of mantle material and combined it with the two-dimensional, anelastic, compressible convection and melting algorithm of STAGYY [1,2] in a spherical annulus geometry [3]. These models include a detailed treatment of the effects of solid–solid phase transitions and of compositional changes that accompany generation and removal of mantle partial melt during magmatism, especially the redistribution of radionuclides and, in a subset of the models, water. The thermal evolution of the core is included as a parameterized one-dimensional model after Nimmo et al. [4].

Results: The results of the models are compared with geophysical and chemical observations from spacecraft and information from martian meteorites (Fig. 1). Most models yield crustal thicknesses between ~75 and 90 km, ancient depths for the Curie temperatures of candidate magnetic minerals that include the entire crust, and mechanical lithosphere thicknesses that increased from less than 100 km in the Noachian to ~200–250 km now. Generally, models with a large core, Mg#=0.75, and radionuclide contents based on those suggested by [5] tend to explain observations best; an example is shown in Figure 2. However, only a subset of the models develops a pattern of mantle convection that evolves towards two or three large, long-lived plumes, and it takes at least ~2 Gy before this stage is reached. Moreover, the temporal stability of plumes decreases strongly if the influence of water on mantle viscosity is included, and models with a very low-viscosity deep mantle barely develop whole-mantle plumes at all. As Tharsis and probably Elysium are older than 2.5–3 Gy, model assumptions more complex than those made in this study are required to explain these major volcanic provinces.

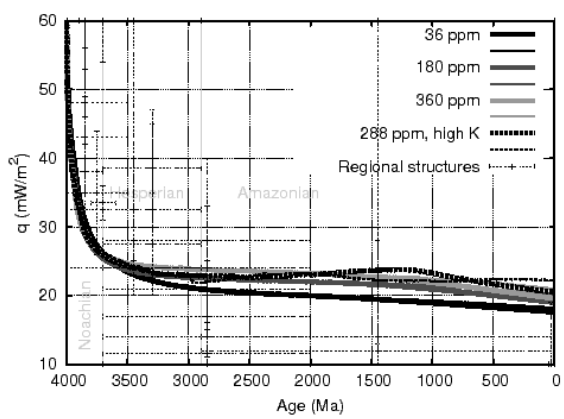

Figure 1: Average surface heat flux for models with varying mantle water concentrations (given in ppm). ^{40}K in the "high K" model is 3 times higher than in [5]. Regional heat fluxes are from various studies (e.g., [6]).

References: [1] Tackley P. J. (2008), *PEPI, 171*, 7–18. [2] Ruedas T. and Tackley P. J. (2008), *LPS XXXIX*, Abstract #1504. [3] Hernlund J. W. and Tackley P. J. (2008), *PEPI, 171*, 48–54. [4] Nimmo F. et al. (2004), *GJI, 156*, 363–376. [5] Wänke H. and Dreibus G. (1994), *Phil. Trans. R. Soc. Lond., A349*, 285–293. [6] Ruiz J., López V. and Dohm J. M. (2010), *Icarus, 207*, 631–637.

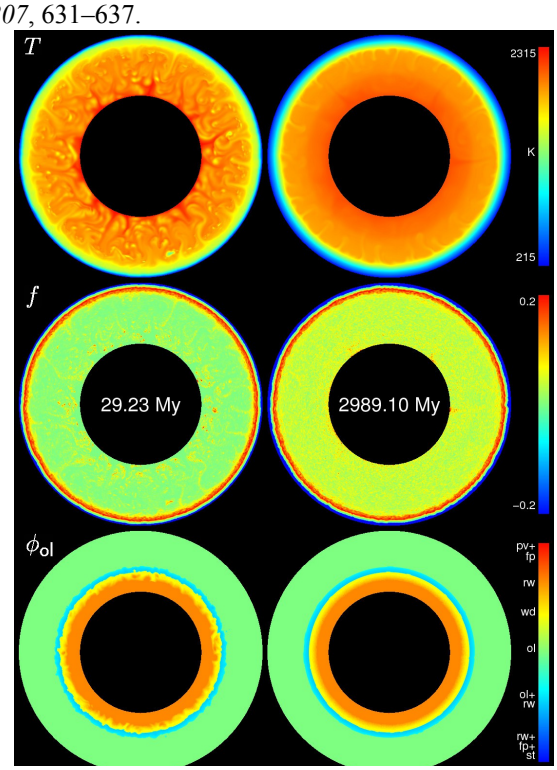

Figure 2: Two snapshots of the temperature, melting degree, and $(Mg,Fe)_2SiO_4$ phase fields of a water-free model with a large core (r_c=1690 km) and an initial potential mantle temperature of 1873 K.