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Thermal Evolution Of The Core And Mantle Of Mars: Effects Of A Sequence Of Basin-Forming Impacts

James Roberts (1) and Jafar Arkani-Hamed (2)

(1) Johns Hopkins University Applied Physics Laboratory, Laurel, MD, United States (James.Roberts@jhuapl.edu), (2) University of Toronto, Toronto, ON, Canada (jafar@physics.utoronto.ca)

Several giant impact basins have been identified on Mars [1-2]. The youngest of these basins [1] are completely demagnetized [3], indicating that a global magnetic field [4] vanished in the mid-Noachian. Shock heating from the seven largest impacts penetrates below the core-mantle boundary (CMB) [5]. Previous investigations of coupled core cooling and mantle convection [5-6] showed that a single basin-forming impact could halt dynamo activity for 100 My, and that the core would not become fully convective again for nearly 1 Gy after the impact. However, the interval between impacts [1] is shorter than the timescale for dynamo activity to resume following an impact. Sub-sequent impacts may delay this recovery. Here, we expand this investigation into 3D and consider the full sequence of basin-forming impacts large enough to affect the core. Our goal is to obtain a better estimate of the timescale for resumption of dynamo activity.

We compute the shock heating due to formation of the seven largest impact basins in the core and mantle using ray-tracing and scaling laws [7-8]. We model 3D mantle convection using CitcomS [9-10], and core cooling with a 1-D parametrization [5]. The temperature is initially adiabatic, with thermal boundary layers (TBL) at the surface and both sides of the CMB. At the time of each impact [1] we introduce a temperature perturbation resulting from shock heating into the core and mantle, and allow the core to stratify [11]. At a given timestep, we fix the mantle temperature and solve the 1D enthalpy equation in the core and lower TBL of the mantle over a time corresponding to a mantle timestep. We update the temperature at the CMB and TBL, and let the mantle convection progress for another timestep. We continue this iteration until the next impact occurs, or until the entire core is again convecting.

Only the outermost core is affected by the impact heating. Because the conductivity of the core is higher than that of the mantle, the top of the core will cool by conduction into the deeper core faster than across the CMB, deepening the zone of stable stratification. Further core cooling should result in a convecting zone at the top of the core that propagates downwards as the thermal gradient becomes adiabatic at greater depths. The timescales at which dynamo activity is halted and resumed, and at which the core again becomes fully convective are under investigation.

References: [1] Frey H.V. et al. (2008) GRL, 35, L13203. [2] Mannoia L.M. and Frey H. V. (2014) LPSC, 45, 1892. [3] Lillis R.J. et al. (2008) GRL, 35, L14203. [4] Acuña, M. et al., 1999, Science, 284. 790 [5] Arkani-Hamed J. (2012) PEPI, 196-197, 83-96. [6] Roberts, J.H. and Arkani-Hamed J. (2014) JGR, 119, 729-744. [7] Pierazzo E. et al. (1997) Icarus, 127, 208-223. [8] Watters W. et al. (2009) JGR, 114, E02001. [9] Zhong S. et al. (2000) JGR, 105, 11,063-11,082. [10] Tan, E. et al. (2014), GGG, 7, Q06001. [11] Arkani-Hamed J. and Olson P. (2010) JGR, 115, E07012.