IMPACT HEATING AND COUPLED CORE COOLING AND MANTLE DYNAMICS ON MARS. James H. Roberts[1] and Jafar Arkani-Hamed[2], [1]Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Rd., Laurel, MD 20723 (James.Roberts@jhuapl.edu), [2]Dept. of Physics University of Toronto, 60 St. George St., Toronto, ON, Canada M5S 1A7 (jafar@physics.utoronto.ca)

Introduction: Several giant impact basins of mid-Noachian age have been identified on Mars [1], the youngest of which are demagnetized [2]. Passage of the shock waves generated by the hypervelocity impacts [3] that formed these basins would have increased the temperature of the interior [4], modified the pattern of mantle convection [5,6], and suppressed core cooling [7], potentially contributing to the cessation of dynamo activity [8]. Here, we investigate the thermal and dynamo evolution of Mars in response to heating by a basin-forming impact, which instantaneously change the temperature structure in the core and mantle. We study the thermal coupling of the core and mantle while both are simultaneously cooling, using coupled models of mantle convection and parameterized core cooling.

Modeling: At the time of an impact we introduce a temperature perturbation resulting from shock heating into the core and mantle [4,6]. The core temperature becomes stratified, largely erasing lateral variations [7]. Exploiting this symmetry, we couple a 1-D parameterization of core cooling to 2-D axisymmetric mantle convection models using the finite element code Citcom [9], appropriate for a single vertical impact scenario. This allows us to more accurately model the thermal evolution of both core and mantle, when the core is not necessarily adiabatic and convecting [10].

Results: Figure 1 shows the evolution of the temperature in the core and lower thermal boundary layer of the mantle. after the vertical impact of a 1000-km diameter rocky projectile at 10 km/s. Just after impact, the stratified core is stable to convection and the temperature may exceed 3000K just below the CMB. The top of the core cools into the mantle, and the lower mantle material is swept into a large hemispheric upwelling. The hot layer at the top of the core disappears after a few tens of My. Further core cooling results in formation of a convecting zone at the top of the core that propagates downwards as the thermal gradient becomes adiabatic at greater depths. As the convecting region of the core thickens, the magnetic Reynolds number increases (see Figure 2), and a strong dynamo is possible after ~120 My to 150 My.

Conclusions: A large basin-forming impact results in stable stratification of the core, and halts core convection and pre-existing dynamo activity for more than 100 My. Our results are consistent with electron reflectometry observations [2] that show a lack of remanent magnetism in the younger Noachian giant impact basins [1], and supports a causal link between basin formation and cessation of dynamo activity [5,8].

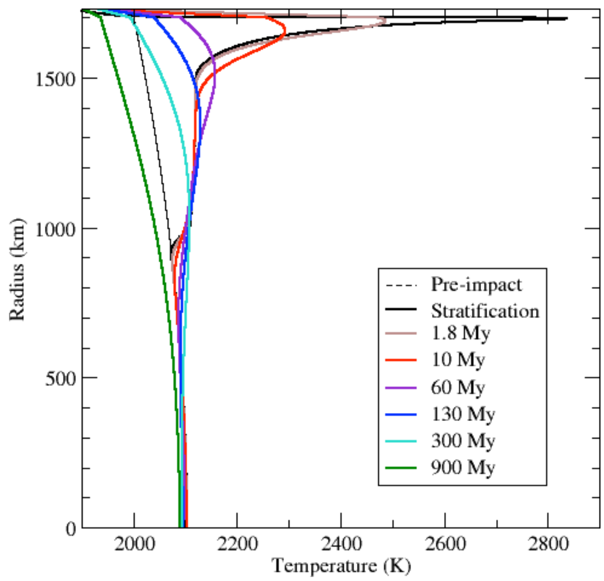

Figure 1: Radial temperature profile in the core and lower thermal boundary layer of the mantle following the impact heating.

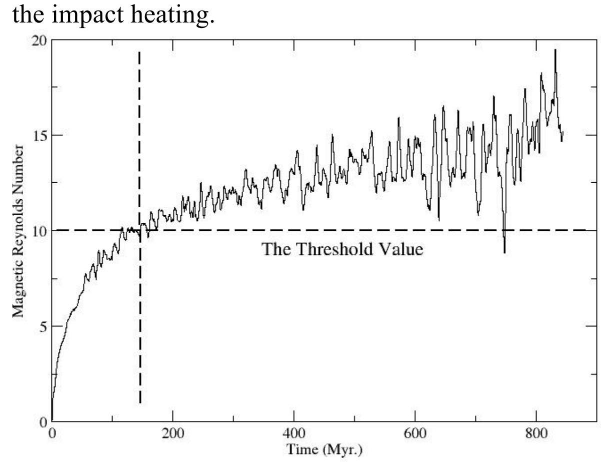

Figure 2: Post-impact evolution of the magnetic Reynolds number of the core for the case shown in Figure 1.

References: [1] Frey H. V. et al. (2008) *GRL, 35*, L13203. [2] Lillis R. J. et al. (2008) *GRL, 35*, L14203. [3] Pierazzo E. et al. (1997) *Icarus, 127*, 208-223. [4] Watters W. et al. (2009) *JGR, 114*, E02001. [5] Roberts J. H. et al. (2009), *JGR, 114*, E04009. [6] Roberts J. H. and Arkani-Hamed J. (2012), *Icarus, 218*, 278-289. [7] Arkani-Hamed J. and Olson P. (2010) *JGR, 115*, E07012. [8] Arkani-Hamed J. (2012) *PEPI, 196-197*, 83-96. [9] Roberts J. H. and Zhong S. (2004), *JGR, 109*, E06013. [10] Ke Y. and Solomatov V. S. (2009), *JGR, 114*, E07004.