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How large are present-day heat flow variations across Mars' surface?

Ana-Catalina Plesa (1), Nicola Tosi (1,2), Matthias Grott (1), and Doris Breuer (1)

(1) German Aerospace Center (DLR), Institute of Planetary Research, Berlin, Germany (ana.plesa@dlr.de), (2) Technical University Berlin, Department of Astronomy and Astrophysics, Berlin, Germany

The upcoming InSight (Interior exploration using Seismic Investigations, Geodesy and Heat Transport) mission, to be launched in 2016, will carry the first in-situ Martian heat flow measurement and provide an important baseline to constrain the present-day heat budget of the planet and, in turn, the thermal and chemical evolution of its interior. Currently, the Earth and the Moon are the only bodies on which in-situ surface heat flow measurements have been performed. Here, strong spatial variations of the surface heat flow are primarily caused by plate tectonics and the heterogeneous distribution of heat producing elements over the surface (e.g., the so-called Procellarum KREEP Terrane PKT on the lunar nearside). In the absence of plate-tectonics and large-scale geochemical anomalies, on Mars, surface heat flow is expected to vary less with geological location, being mainly influenced by variations in the thickness and HPE content of the crust [1], and by mantle plumes [2].

We have tested this assumption by running thermal evolution models for Mars in 3D spherical geometry, using the mantle convection code Gaia [3]. In our calculations, we employ a crust of fixed thickness with a north-south dichotomy in crustal thickness, a low conductivity compared to the mantle and enriched in radiogenic heat producing elements. Our results show that including compressibility effects, phase transitions and different core sizes, surface heat flow variations are mainly dominated by the crust contribution, unless the mantle viscosity increases more than three orders of magnitude with depth. In the latter case, heat flow variations due to mantle upwellings are ~ 8 mW/m^2 relative to surface average and remain confined to limited surface regions. Both surface heat flow variations on Mars obtained from numerical models and the heat flow measurement planned for the InSight mission will permit to address the question of a possible plume underneath Elysium and also to test the feasibility of present-day volcanism on Mars.

[1] B. C. Hahn et al., GRL, 2011.
[2] W. S. Kiefer and Q. Li, GRL, 2009.
[3] C. Hüttig and K. Stemmer, PEPI, 2008.