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3D numerical model for the formation of the martian dichotomy and the Tharsis rise

Giovanni Leone[1], Gregor J. Golabek[2], Taras Gerya[1], Paul J. Tackley[1]
[1]*Institute of Geophysics, ETH Zürich, 8092 Zürich, Switzerland*
[2]*Laboratoire des Sciences de la Terre, ENS Lyon, 69364 Lyon Cedex 07, France*
giovanni.leone@erdw.ethz.ch

Introduction. One of the outstanding questions regarding Mars is the formation of its crustal dichotomy and of the Tharsis rise, positioned at the equator astride the northern lowlands-southern highlands boundary. Several authors have proposed different models, involving endogenic [1 - 5 and references therein] or exogenic processes [5 and references therein], but it seems that hybrid models (combining both exogenic and endogenic processes) [5 and references therein] [6] are potentially able to give an explanation to the various problems [7 + 8] of the single approach models. Furthermore, the successful models must consider the chronological constraints placed by the magnetic anomalies present mostly in the southern highlands [5 + 9] and the cratering rate present in the lowlands of Mars [5 + 10]. The resulting scenario is that a giant impact centred in the southern subpolar highlands and able to generate a large magma ocean covering nearly two thirds of the Martian surface may have occurred at the end of the planet's accretion and core formation [5 - 6]. The thermal anomaly caused by this impact event has subsequently triggered convection in the martian mantle with the consequent formation of a super-plume that built the Tharsis rise [5 and references therein].

New 3D model. Following previous work on 2D numerical modelling of the martian dichotomy, we developed a new 3D model based on finite-difference/finite volume marker in cell approach to: a) investigate the position and the migrations of the super-plume that generated the Tharsis rise (an operation not possible in previous 2D work for geometrical restrictions, see [5] and references therein for technical details) and b) study the geological match for the main super-plume at the base of the Tharsis rise as well as for the plumes at the base of the other volcanic centres scattered around it. We will introduce new combinations of parameters respect to the set used in previous 2D work, see [5] for a comprehensive list, and explore the consequences they will have on the modelling as a whole.

Preliminary results. The first runs have shown how the impactor hit the southern polar region, reached the planet's core, and generated a magma ocean spreading on the surface and thickening at the impact centre (see Composition part of Figure 1). The temperature map shows minor (white coloured) upwellings producing melt patches (see Temperature part of Figure 1) that will then form a thinner crust covering the northern regions opposite to the impact centre (also see a complete view of the model evolution at http://www.ethz.ch/erdw/people/geophysics/leoneg/research). In order to test various scenarios for the formation of crustal dichotomy and the Tharsis rise in a self-consistent manner, the results from the core formation model will be combined with the long term mantle convection simulations. Special emphasis will be given to modelling of crustal growth and topography development on Mars based on free planetary surface approximation via weak external layer approach.

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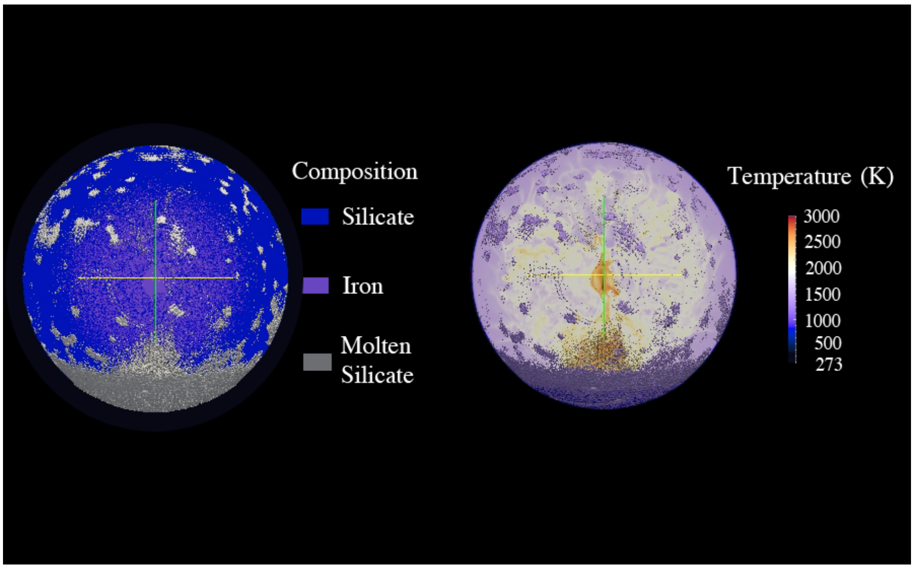

Figure 1: Screenshot of composition and temperature inside and on the surface of the planet after the impact event (see preliminary results text for details).