Geophysical Research Abstracts
Vol. 15, EGU2013-7992-1, 2013
EGU General Assembly 2013

3D numerical model of the southern polar giant impact for the formation of the Martian dichotomy

Giovanni Leone, Paul J. Tackley, Taras Gerya, David A. May, and Guizhi Zhu
ETH Zurich, Institute of Geophysics, Geophysical Fluid Dynamics, Zurich, Switzerland (giovanni.leone@erdw.ethz.ch)

Lack of volcanism and/or crustal flows in the northern lowlands poses serious problems to the hypothesis of formation of the Borealis basin by giant impact in the Northern Polar region of Mars. We use numerical modeling integrated with a geologic and volcanologic study of the surface of Mars to investigate an alternative process of formation that involves a giant impact on the South Pole, resulting in a hemispherical magma pond and resulting thicker crust. We have performed 3D simulations of Martian evolution from the immediate post-impact stage to the present day for different combinations of impactor sizes and compositions, ranging from 900 km radius and sideritic composition (up to 80% radius iron) to 1750 km radius and mesosiderite-type composition (50% radius iron; nickel neglected at the moment). The main reason for considering siderites is the presence of M-type asteroids like 16 Psyche (and several others) in the asteroid belt, the likely remnants of larger parent bodies in the 1-2 AU range which then migrated to their current position after giant impacts with protoplanets. We assume an impactor speed similar to the escape velocity of the target body, consistent with N-body simulations. Our results show that this is a viable formation hypothesis for the southern highlands. Our preferred scenario is of a lunar sized impactor of 1600 km radius with a 70% iron (by radius) fraction, hitting the south Pole at a speed of 5 km/s (the escape velocity of Mars), melting much of the interior and 1/2 of the planetary surface with the creation of a magma ocean that formed the highlands upon cooling and solidification. Regarding timing, we find that this should have happened after 4 Ma after CAI, because before this the strong heating from short-lived radiogenic elements coupled with the thermal anomaly generated by the giant impact would erase by re-melting any newly formed crust. Using a combination of I3ELVIS (immediate post-impact and core formation) and STAGYY (long-term) thermo-mechanical codes, we are now studying the long-term consequences of such a giant impact: a) thermal and compositional effect on core formation; b) triggering of a transient magnetic field, traces of which have been detected on both the hemispheres; c) start-up of migrating mantle plumes from the southern polar region to the equator following two preferential paths, northwest to Tharsis and northeast to Elysium.