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Coupling giant impacts and long-term evolution models

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Abstract

The crustal dichotomy [1] is the dominant geological feature on planet Mars. The exogenic approach to the origin of the crustal dichotomy [2-6] assumes that the northern lowlands correspond to a giant impact basin formed after primordial crust formation. However these simulations only consider the impact phase without studying the long-term repercussions of such a collision.

The endogenic approach [7], suggesting a degree-1 mantle upwelling underneath the southern highlands [8-11], relies on a high Rayleigh number and a particular viscosity profile to form a low degree convective pattern within the geological constraints for the dichotomy formation. Such vigorous convection, however, results in continuous magmatic resurfacing, destroying the initially dichotomous crustal structure in the long-term.

A further option is a hybrid exogenic-endogenic approach [12-15], which proposes an impact-induced magma ocean and subsequent superplume in the southern hemisphere. However these models rely on simple scaling laws to impose the thermal effects of the collision.

Here we present the first results of impact simulations performed with a SPH code [16,17] serially coupled with geodynamical computations performed using the code I3VIS [18] to improve the latter approach and test it against observations. We are exploring collisions varying the impactor velocities, impact angles and target body properties, and are gauging the sensitivity to the handoff from SPH to I3VIS.

As expected, our first results indicate the formation of a transient hemispherical magma ocean in the impacted hemisphere, and the merging of the cores. We also find that impact angle and velocity have a strong effect on the post-impact temperature field [5] and on the timescale and nature of core merger.

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