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Identifying the Sweet Spot for an Impact-Induced Martian Dichotomy

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The martian crustal dichotomy predominantly refers to the 4-8 km difference in elevation between the southern hemisphere and an apparent basin covering roughly 42% of the north, with this topographical picture being strongly reflected in distribution of crust below. Other associated features include a higher density of volcanoes and visible impact craters in the south relative to the north.

Most studies attempting to explain these properties have supported one of two theories; either the dichotomy formed solely through geodynamic processes [1], or a giant impact occurred that imprinted the crustal cavity in the northern hemisphere that is observed today [2]. Recent work has proved the importance of coupling these hypotheses, introducing a hybrid exogenic-endogenic scenario whereby a giant impact triggered a localized magma ocean and subsequent superplume in the southern hemisphere [3]. This has, however, only been investigated using a very limited range of initial parameters, all of which lead to significant heating deep into the mantle. This therefore motivates an interesting area of study – is there a parameter space that leads to a hemispherically-thickened crust without significantly heating the mantle?

We aim to answer this question using a suite of smoothed-particle hydrodynamics (SPH) simulations, using the SPHLATCH code [4], that explore a large parameter-space chosen with the intention of limited internal heating. Each model includes the effects of shear strength and plasticity (via a Drucker-Prager-like yield criterion) as such effects have been shown to be significant on the scales concerned in this study [3,4]. Moreover, the sophisticated equation of state ANEOS is being used along with a Mars-specific solidus [5] to accurately calculate the physical environment in which such solid characteristics must be considered. For the analysis of the simulation outcomes we apply a newly developed scheme to estimate the thickness and distribution of (newly formed or re-distributed) post-impact crust.

Initial results have revealed promising hemispherical features in certain cases, with further analysis being made in an attempt to compare the results to those of the observational data in a quantitative manner (e.g. through bimodal fitting of crustal thickness histograms and k-means clustering). In addition, the effects of a uniform, primordial crust being present on Mars before the dichotomy-forming event are being studied, as well as an investigation into the final distribution of the impactor material as this could be chemically distinct from the primordial martian composition. Finally, the effects of material strength have been found to be non-negligible, further highlighting the importance of such aspects on the length-scales involved in planetary collisions.

References:

[1] Keller, T. and Tackley, P. J. (2009) Icarus, 202(2):429–443.

[2] Marinova, M. M., Aharonson, O., and Asphaug, E. (2008) Nature, 453(7199):1216–1219.

[3] Golabek, G. J., Emsenhuber, A., Jutzi, M., Asphaug, E. I., and Gerya, T. V. (2018) Icarus, 301:235–246.

[4] Emsenhuber, A., Jutzi, M., and Benz, W. (2018) Icarus, 301:247–257.

[5] Duncan, M. S., Schmerr, N. C., Bertka, C. M., and Fei, Y. (2018) Geophysical Research Letters, 45:10, 211–10,220.