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Mars' Split Personality: Explaining the Crustal Dichotomy and Other Characteristics Through Large-Scale Impact Simulations Coupled to Long-Term Thermochemical Models.

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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. Other associated features include a higher density of volcanoes and visible impact craters in the south relative to the north.

Some studies have attempted to explain these properties through endogenic means; namely via degree-1 mantle convection studied using large-scale thermochemical models (e.g. Keller and Tackley, 2009). Others have taken the exogenic route, proposing that a giant impact early in Mars' history caused the excavation of a large mass of material from the northern hemisphere, thus giving rise to the observed dichotomy (e.g. Marinova et al., 2008). Given that such collisions are expected to be very common in the final stages of terrestrial planetary accretion, this approach is highly feasible. The latter studies have, however, generally ignored any long-term geodynamical consequences on the martian interior that such an event may cause.

We use an approach that aims to couple these two hypotheses into a hybrid exogenic-endogenic scenario, whereby a giant impact triggered a localised magma ocean and subsequent superplume in the southern hemisphere. This consists of two separate components which are coupled in a hybrid scheme (Golabek et al., 2018): smoothed-particle hydrodynamic (SPH) simulations of the initial impact, and the subsequent long-term thermochemical evolution of the interior of Mars over the following 4.5 Gyr to the present day. The parameter-space of these models will be constrained by the upcoming results from the Insight lander on Mars.

Here we present initial results of high resolution (10^5–10^7 particle), SPH simulations that are being used for this purpose, with varying impact angles, velocities and impactor radii (generally on the $\approx$1000km scale). These simulations also incorporate shear strength and plasticity (via Drucker-Prager-like yield criterion), as these effects have been shown to be significant on the scales concerned in this study (Emsenhuber et al., 2018). Further to this, the sophisticated equation of state (M-)ANEOS is being used along with a Mars-specific solidus to accurately calculate the parameter-space in which such solid characteristics must be considered.

Another interesting feature of Mars is that of its two miniature moons, Phobos and Deimos, which may also be a result of a giant impact with Mars soon after its formation (Hydo et al., 2017; Canup and Salmon, 2018). This hypothesis is also being studied through the aforementioned simulations, initially via a study into the effects that the material strength and the numerical resolution may have on the resulting disk mass.

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