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Giant impacts control mantle dynamics and cripple the core dynamos of planets

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A giant impact creates a huge basin on the surface and heats a planet by the shock waves travelling in the interior. We investigate the impacts that have created the largest basins existing on terrestrial planets: Caloris on Mercury, Utopia on Mars and Aitken on the Moon, all formed before 4 Ga. Due to plate tectonics on Earth and pervasive resurfacing on Venus at 500 Ma no ancient giant basins are found on these planets. Shiva is probably the largest existing impact basin on Earth that was created at around 65 Ma, and we regard Arthemis Corona as a possible impact site on Venus. We determine the impact-induced temperature increase in the interiors of the planets using the scaling laws between an observed basin diameter and the impactor size [Holsapple, Annu. Rev. EPS, 1993], the shock wave pressure distribution model of Pierazzo et al. [Icarus, 1997] and the "foundering" shock heating model of Watters et al. [J. Geophys. Res., 2009]. The impact effects on the thermal evolution of a planet is investigated using 2D axi-symmetric and two-flow convection in a self-gravitating spherical shell of temperature- and pressure-dependent viscosity, temperature-dependent thermal conductivity, and pressure-dependent thermal expansion. The mantle is allowed to melt when its temperature surpasses the solidus. The impacts that created Shiva and Arthemis had minor effects on the internal dynamics of Earth and Venus. We determine the minimum size for an impactor required to influence the internal dynamics of these planets. For the small planets, the impact heating significantly enhances the temperature of the upper mantle and creates a superheated giant plume which ascends rapidly and develops a strong convection in the mantle of the sub-impact hemisphere, while the antipodal hemisphere remains almost undisturbed at least for the first 50 Myrs. The upwelling of the giant plume rapidly sweeps up the impact heated base of the mantle and replaces it with the cold surrounding material, thus hampering the effects of the impact-heated mantle on the core dynamo that might have existed prior to the impact. However, direct shock heating stratifies the core, suppresses the pre-existing thermal convection in the core, and cripples a preexisting thermally driven core dynamo. Depending on the size of the impactor and the planet, it takes 20-90 Myr for the stratified core to exhaust impact heat and resume global convection, possibly regenerating a core dynamo.