Metal–silicate equilibration in the aftermath of giant impacts

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Terrestrial planet formation is stochastic, where the final bodies experience one to several giant impacts toward the end of their formation. The compositions of the cores and mantles are directly related to the widely varying pressure and temperature conditions under which they separated. We have recently obtained shock temperature data on natural Fe-bearing minerals to improve our interpretation of the multicomponent system and revised the equation of state models for mantle and core materials to improve the calculated temperatures in giant impact simulations. Immediately after a giant impact, temperatures of the outer core are very hot, exceeding ~10,000 K in some cases. In contrast, the mantle temperatures are at or above the peridotite liquidus and generally cooler than the outer core. Most of the core material merges together in the center of the resulting body during the timescale of the event. Some core material remains dispersed in the mantle to later times, up to ~10% of the Earth's core mass in the most energetic cases. In the calculation, this material is highly shocked and neutrally buoyant; however, the hydrocode does not include thermal and chemical equilibration. We expect the shocked core material to chemically interact with the mantle as it thermally equilibrates and rains out of the cooling magma ocean toward the growing core. Thus, the final stage of core formation after a giant impact involves a relatively small amount of core material interacting with the base of the mantle at very high temperatures. It is likely that the lowermost mantle will remain enriched in Fe compared with the bulk mantle due to the enhanced metal–silicate exchange of Si and Fe at high temperatures. We suggest that the formation and persistence of an Fe-rich basal mantle layer is a direct outcome of the thermodynamics of giant impact events. Using newly fitted multi-element interaction parameters determined from metal–silicate partitioning experiments, we will examine the chemical effects of this final catastrophic event on Earth.