Metal fragmentation by large Earth-forming impacts

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Résumé

The fragmentation of metal during Earth-forming impacts controlled the chemical equilibration between
metal and silicates, and hence the composition of the core and mantle. Knowing the degree of fragmentation of the impactor core is important to date the formation of the Earth's core from
isotopic data.
The final stage of Earth's accretion involved high-energy collisions between planetary embryos. During
each collision, the metallic core of the impacting embryo fell in a molten silicate magma ocean.
Recent fluid dynamics investigations showed that, as it fell in the ocean, the impactor core fragmented
into subcentimetric drops. However, previous studies on this fragmentation process lack an impact
stage. Hence, it is unclear whether the impactor core can fragment during the impact, prior to its fall
in the magma ocean.
To answer this question, we conduct a series of experiments on the impact and fragmentation of a
liquid volume into a lighter immiscible liquid. The liquid volume represents the impactor core while
the liquid target represents the magma ocean. In our experiments, the impact produces a crater which
collapses into a jet, as observed in numerical simulations of impact cratering.
We vary the impactor velocity and size to investigate the conditions under which the impactor fragments
into drops during the collapse of the crater. When the impact inertia is comparable to gravity,
the impactor remains coherent during the impact. In contrast, when inertia is large compared to
gravity, the impactor fragments into droplets prior to its fall in the liquid target.
Applied to planetary impacts, these results suggest that the core of impactors less than 100 km in diameter
fully fragmented into droplets, whereas the core of giant Moon-forming impactors fragmented only partially.

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