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Erosion, Breakup and Chemical Equilibration of Iron Diapirs in Terrestrial Magma Oceans

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Due to mechanisms such as impact heating, early atmospheric thermal blanketing or radioactive heating, the presence of at least one global magma ocean stage in the early histories of terrestrial planets seems unavoidable. In such a context, a key question is whether (and how much) iron diapirs provided by differentiated impactors emulsify during their sinking towards the bottom of an early magma ocean. Addressing this problem allows one to put strong constraints on metal-silicate equilibration processes as well as heat distribution within a young terrestrial planet.
In the past years, several workers have focused on this question using theoretical calculations, numerical modeling, or laboratory experiments. However, the results of these investigations yield opposite conclusions: Several studies indicate that diapirs would rapidly break up to mm or cm –sized droplets, rapidly equilibrating with the surrounding silicates (e.g., [1-2]), while others conclude that even kilometer-sized diapirs preserve most of their initial volume during their descent, leading to metal-silicate disequilibrium [3].
To clarify these discrepancies I have conducted a series of numerical simulations and theoretical calculations to derive the conditions and the timing for the breakup of metal diapirs of any size, sinking though a silicate magma ocean, with a large range of plausible viscosity values. Consequently, the corresponding range of governing parameters covers more than 16 orders of magnitude. The obtained breakup criterion is used to derive diapir stable sizes and their corresponding ability to equilibrate with the surrounding silicates.

References

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