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Earth's core formation aided by flow channelling induced by Rayleigh-Taylor instabilities

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The core formation mechanism remains poorly known. Geochemical constraints by Hf/W systematics indicate a fast process which was largely completed within 33 Ma for the Earth.

An unstable gravitational configuration of a dense molten metallic layer overlying a cold chondritic protocore is predicted by most studies, which leads to the formation of a Rayleigh-Taylor instability. We propose the application of Stevenson's (1989) stress-induced melt channelling mechanism in the region surrounding an incipient iron diapir. We therefore perform numerical experiments solving the two-phase, two composition flow equations within a 2D rectangular box with symmetrical boundary conditions. We apply the Compaction Boussinesq Approximation (CBA) and include a depth-dependent gravity. For simplicity we use a constant viscosity for the solid phase and melt-fraction dependent rheology for the partially molten region around the diapir. We investigate the physical conditions under which the melt channels can form in comparison with the geochemical time scale of core formation and whether they are applicable to the early Earth. As a result, for sufficiently small melt retention numbers iron-rich melt channels develop within a region of approximately twice the diapir's size. This mechanism could effectively enhance melt accumulation in the protocore and accelerate the process of core formation.