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

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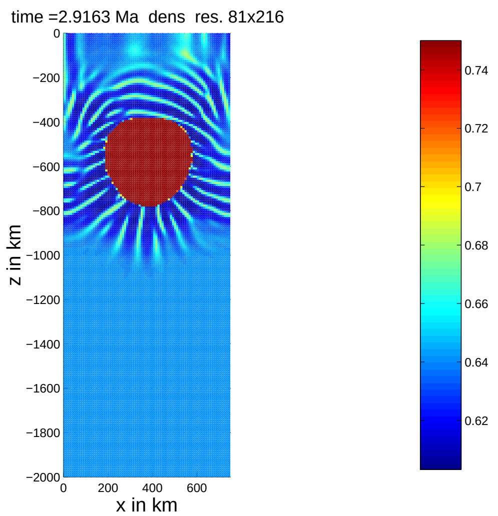
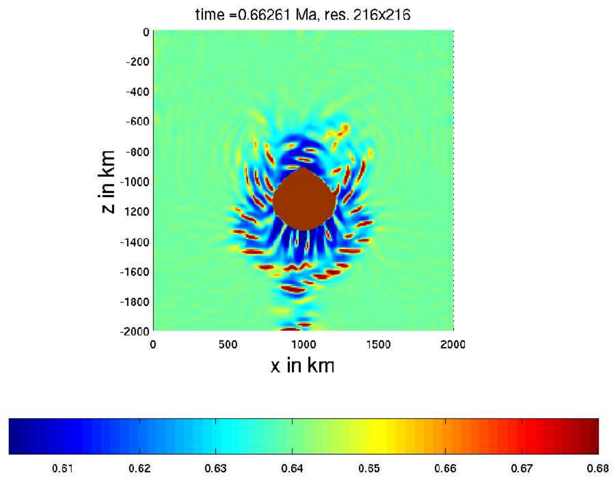
The core formation process remains poorly known. Isotopic constraints by Hf/W systematics indicate a fast process which was largely completed within 33 Ma for the Earth. An unstable gravitational configuration of a dense molten metallic layer overlying a cold chondritic protocore is predicted by most 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 compositions 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.
A systematic investigation of the physical conditions under which the melt channels can form in comparison with the isotopic time scale of core formation and whether they are applicable to the early Earth is in progress. As a result, for sufficiently small retention numbers iron-rich melt channels develop within a region of approximately twice the diapir's size as shown on Fig. 1a. This could lead to effective draining of the surrounding region and might initiate cascading daughter diapirs (Fig. 1b). The region of the protocore drained by this cascading mechanism is expected to significantly increase with depth, and thus proposes an effective mechanism to extract iron melt also from deeper parts of the initially chondritic protocore. This mechanism could effectively enhance melt accumulation in the protocore, accelerate the process of core formation and affect the metal-silicate equilibration.



a) Density plot showing the development of melt channels



b) Density plot showing the formation of small daughter diapirs

Figure 1. Induction of flow channelling and cascading mechanism