

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. A systematic investigation of the physical conditions under which the melt channels can form in comparison with the time scale of core formation and whether they are applicable to the early Earth is in progress. As a result, for sufficiently small melt retention numbers iron-melt focussing channels develop within a region of approximately twice the diapir's size. This could lead to effective draining of the surrounding region and might initiate cascading daughter diapirs or the formation of dykes. The mechanism could effectively enhance melt accumulation in the protocore and accelerate the process of core formation.

Tracing oceanic sulphate with phosphorite geochemistry

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Sedimentary phosphorites contain francolite (carbonate fluorapatite) as the major mineral phase. Francolite is thought to incorporate SO_4^{2-} in proportion to its concentration in ambient pore fluids (Jarvis *et al.*, 1994) and thus could be a potential indicator of past seawater sulphate concentrations. This is attempted by relating $\text{SO}_4/\text{P}_2\text{O}_5$ ratios of recent and ancient phosphorite rocks to ocean sulphate levels.

Phosphorite can form under diverse redox conditions, which can lead to variations in incorporated SO_4^{2-} . By comparing francolite-bound sulphate $\delta^{34}\text{S}$ and $\delta^{18}\text{O}$ and carbonate $\delta^{13}\text{C}$, the impact of sulphate reduction and sulphide reoxidation on sulphate concentrations can be better constrained. Weathering is also considered to lead to the loss of SO_4^{2-} in francolite, and this can be partially evaluated by CO_2 concentrations in francolite. However, our study suggests that sulphate is only lost from associated organics and pyrite during weathering.

The sulphate concentration and $\delta^{34}\text{S}$ of phosphorites do not correlate with Ce-anomaly, which is a redox-dependent parameter. The decoupling of REE from SO_4^{2-} and $\delta^{34}\text{S}$ may result from the different timings and mechanisms of incorporation of REE and sulphate into the francolite lattice. Therefore, REE do not provide reliable constraints on the degree of preservation of francolite sulphur systematics.

Francolite SO_4^{2-} is found to be lower than previously reported in Miocene phosphorites. This could relate to the removal of all non-francolite S during sample preparation in our study. SO_4^{2-} levels in Neoproterozoic and Cambrian francolites are also low. Uppermost $\text{SO}_4^{2-}/\text{P}_2\text{O}_5$ ratios from the best preserved samples (from the Miocene, Cambrian and Ediacaran) in our study can be used to constrain minimum SO_4^{2-} concentrations in the ocean.

Reference

Jarvis *et al.* (1994) *Eclogae. Geol. Helv.* **87**, 643-700.