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The basal magma ocean and the delayed onset of the geodynamo

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Presence of partial melting in the lowermost mantle has been proposed to explain the ultra low velocity zone. The cooling of the core necessary to have maintained the geodynamo for at least 3.2 Gyr implies a larger amount of melt in the past, that can be connected to an early magma ocean at the bottom of the mantle. The gravitational stability of such a melt layer can be explained by the small volume change upon melting at that pressure and a larger amount of FeO in the melt than in solid in equilibrium.

Solving the thermal-chemical evolution of the deep Earth involving a basal magma ocean, we show that, to first order, the mass of melt decreases exponentially with time. Many parameters involved in this evolution are poorly known but can be constrained using geochemical observations. Indeed, the basal magma ocean is the perfect hidden reservoir that can store 20% of the Earth inventory in incompatible elements, provided its initial mass is around 10^{24} kg. In addition, the systematic difference in ^{142}Nd between Earth and chondrites can be used to constrain the timescale of crystallisation.

Because of the large amount of radiogenic and latent heat to extract from the basal magma ocean early in Earth's history, the heat extracted from the core is different from the value that enters the solid mantle. In particular, early in Earth's history, radiogenic heating in the basal magma ocean might have prevented convection in the core, hence the maintenance of the geodynamo. The requirement that the dynamo has been operating for at least 3.2 Gyr therefore provides a constraint independent from the geochemical ones on the evolution of the basal magma ocean.