Geodynamical and Geochemical Implications of a Long Lasting Basal Magma Ocean

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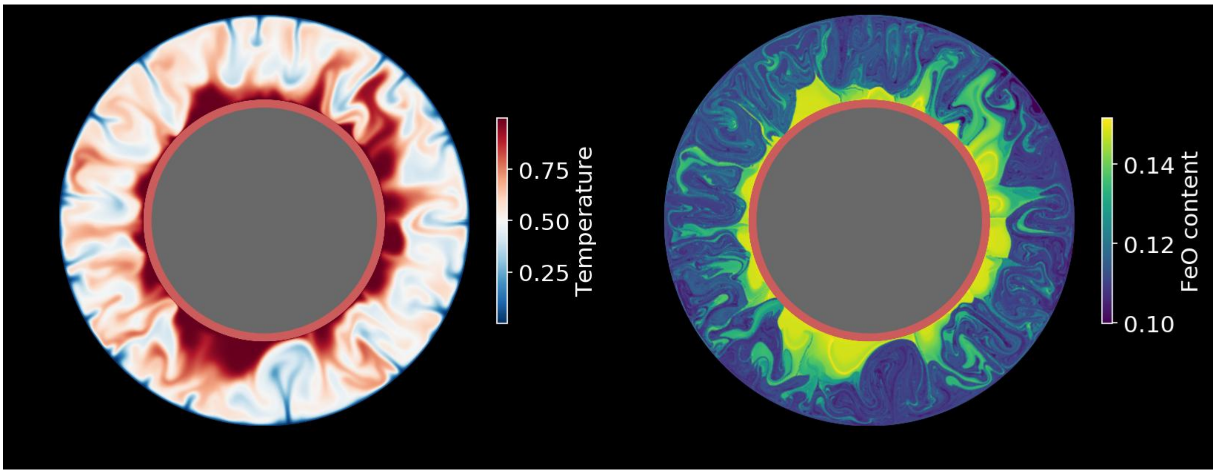
The seismically detected ultra-low velocity zones (ULVZ) have been suggested to be the remnants of a long-lived dense basal magma ocean (BMO). The presence of a BMO for a few Gyr of the Early history of the Earth should have affected the dynamics of the mantle and the thermal and compositional evolution of the whole Earth. We study these implications using a numerical model solving mantle convection in a spherical shell coupled with the evolution of the basal magma ocean and the core. The model includes the effects of the melting and fractional crystallisation at the bottom of the solid mantle, allowing flow through the boundary by phase change, net motion of the crystallisation front, fractional crystallisation of the magma and the associated dynamical effect of the compositional variations in the solid mantle. In the early stages, the dynamics of the solid is controlled by downwelling currents with a passive return flow, without any hot plumes. Starting with a solid mantle of uniform composition, in chemical equilibrium with the BMO, fractional crystallisation leads to gradual enrichment of the magma in FeO and, subsequently, of the cumulates which eventually become so dense as to resist entrainment by convection. At this stage, the difficulty of down-welling currents to penetrate the dense cumulate layer leads to the formation of a hot boundary layer, the onset of hot plume convection and the pilling-up of FeO enriched solid, forming structures akin to the seismically detected large low velocity provinces. Full crystallisation of the BMO takes a very long time to be accomplished, because of the combined effects of progressive enrichment in heat-producing elements and in FeO, which



leads to a decrease in the BMO solidus temperatures. This suggests that ULVZs could indeed be the last drops of the once global basal magma ocean.

Mots-Clés : Magma oceans, mantle convection.