Solid-liquid equilibrium in the Earth's Lower Mantle in a numerical model of global-scale convection

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Recent studies show that solid-liquid transition (beginning of melting, [1, 2]) is close to conditions proposed for the Earth's mantle at around Core-Mantle Boundary (CMB) [3]. These data match observations of ULVZ, which are supposed to contain partial molten material (e.g. [4]). Goal of our study is to perform long-term (millions of years) numerical simulation of the Earth mantle in a range of CMB temperatures to understands possibility and consequences of melting.

We've made an empirical model of melting using data by [1, 5-11]. Physical properties (densities) were adjusted using data of [5, 10, 12], and database from [13] was used to calculate solid-liquid density difference, which controls direction and velocity of melt filtration. This model was included in StagYY numerical code (e.g. [14]), which is designed to simulate convection within the Earth mantle.

Our model predicts, that in case of melting iron-rich dense liquid forms a thin layer around CMB. Further heating of material atop it will form partial melt, which will filtrate downward through Fe-depleted rock. This layer of iron-depleted material will prevent furhter melting of rocks. Liquid filtration seems to be a plausible mechanism to prevent these liquid piles from being involved in solid mantle convection.

Thickness of molten or partially molten material strongly depends on actual CMB temperature (reaching up to 20 km at T(CMB)=4500K, while at T(CMB)=3800K no melt will form). These values depend on efficiency of melt extraction, actual K_D of components between liquid and solid counterparts, thermal conductivity of melt-bearing rocks, and some other parameters.

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