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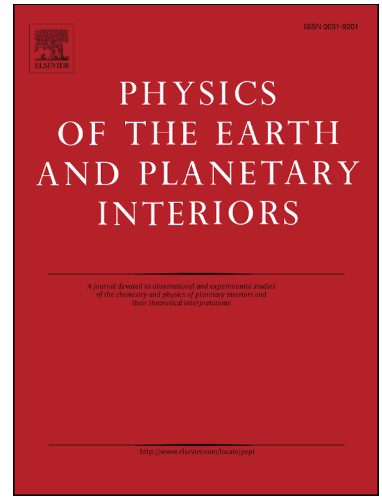

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Production, pathways and budgets of melts in mid-ocean ridges: an enthalpy based thermo-mechanical model

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Abstract

Using an enthalpy based thermo-mechanical model we provide a theoretical evaluation of melt production beneath mid-ocean ridges (MORs), and demonstrate how the melts subsequently develop their pathways to sustain the major ridge processes. Our model employs a Darcy idealization of the two-phase (solid-melt) system, accounting enthalpy (ΔH) as a function of temperature dependent liquid fraction (ϕ). Random thermal perturbations imposed in this model set in local convection that drive melts to flow through porosity controlled pathways with a typical mushroom-like 3D structure. We present across- and along-MOR axis model profiles to show the mode of occurrence of melt-rich zones within mushy regions, connected to deeper sources by single or multiple feeders. The upwelling of melts experiences two synchronous processes: 1) solidification-accretion, and 2) eruption, retaining a large melt fraction in the framework of mantle dynamics. Using a bifurcation analysis we determine the threshold condition for melt eruption, and estimate the potential volumes of eruptible melts (~3.7x $10^6 m^3/yr$) and sub-crustal solidified masses (~1- 8.8x $10^6 m^3/yr$) on an axis length of 500 km. The solidification process far dominates over the eruption process in the initial phase, but declines rapidly on a time scale (t) of 1 Myr. Consequently, the eruption rate takes over the solidification rate, but attains nearly a steady value as t > 1.5 Myr. We finally present a melt budget, where a maximum of ~5 % of the total upwelling melt volume is available for eruption, whereas ~19% for deeper level solidification; the rest continue to participate in the sub-crustal processes.

Keywords: Numerical modeling of mush; Darcy flow; melts lenses; sub-crustal solidification; eruptible magma; bifurcation theory.

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