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Channelizing of melt flow by reactive porosity waves and its impact on chemical differentiation

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Many geodynamic processes are coupled. For example, in the partially molten mantle, the solid and molten mantle phases interact chemically during porous melt flow. For such two-phase reactive melt migration, solid and melt densities are functions of temperature, pressure, and chemical composition. Numerical models of such coupled physical-chemical systems require special treatment of the various couplings and concise numerical implementation. We elaborate a 2-D thermo-hydro-mechanical-chemical (THMC) numerical model for melt migration by porosity waves coupled to chemical reactions (Bessat et. al., 2021). We consider a simple ternary chemical system of forsterite-fayalite-silica to model melt migration within partially molten peridotite around the lithosphere-asthenosphere boundary. Our THMC model can simulate porosity waves of different shapes depending on the ratio of shear to bulk viscosity and the ratio of decompaction to compaction bulk viscosity. For an initial circular (blob-like) porosity perturbation, having a 2-D Gaussian shape, the geometry of the propagating reactive porosity wave remains blob-like if all viscosities are similar. If the decompaction bulk viscosity is smaller than the compaction bulk viscosity, so-called decompaction weakening, then the propagating porosity wave evolves into a channelized form. Our simulations quantify the variation from a blob-like to a channel-like porosity wave as a function of the viscosity ratios. We describe the 2-D THMC numerical algorithm which is based on the pseudo-transient finite difference method. Furthermore, we quantify the impact of channelization on the chemical differentiation during melt flow. Particularly, we quantify the evolution of the total silica concentration during melt migration as a function of the degree of channelization.

References

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