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Influence of crystalline load on magma behaviour in dykes: A numerical study

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The dynamics of magma flow is highly affected by the presence of crystalline load. For instance, in dykes the presence of crystals which are denser than the melt reduces the ascent velocity and modifies the shape of the velocity profile (from a Newtonian Poiseuille flow to a Bingham type flow). We have already demonstrated that, during granitic magma ascent, crystal-melt segregation in dykes constitutes a viable mechanism for magmatic differentiation. However, the dependency of crystals concentration, geometry, size and density on their transportation within a melt is still not well constrained. In addition, the role of inertia on magma dynamics and texture development has not been explored.

In order to address these issues, we have conducted parametric studies using 2D numerical models following the setup described in Yamato et al. (2012). This model simulates an effective pressure gradient between the base and the top of a channel (representing a dyke), by pushing a rigid piston into a magmatic mush which comprises crystals and melt and perforated by a hole. Segregation rates were then computed within the dyke using different magmatic mush configurations in which we varied the crystals concentration, size and aspect ratio. The influence of inertia and the role of the melt viscosity were also investigated.

Results show that the segregation rate is decreased when the crystal concentration increased (with a threshold reached for $\sim$20% of crystals) and that the crystals aspect ratio does not seems to affect the segregation rate. The viscosity of the melt controls the amount of drag between the rigid dense crystals and its effect on segregation is therefore inversely proportional (i.e. the lower the melt viscosity, the higher the segregation rate).

Reference:
Yamato, P., Tartèse, R., Duretz, T., May, D.A., 2012. Numerical modelling of magma transport in dykes. Tectonophysics 526-529, 97-109.