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Emplacement-related layering in magma slurries

N. Petford

Bournemouth University, Poole, United Kingdom, BH12 5BB (npetford@bournemouth.ac.uk)

Textures and structures such as layering, grading and foliations preserved in igneous rocks offer a glimpse into the magma emplacement process. However, despite recent advances, a full and proper understanding of the fluid dynamics of congested fluid-particle mixtures during shear remains elusive. This is a shame as without recourse to such fundamental understanding, the interpretation of structural field data in the context of magma flow remains problematic. One way to gain insight into the process is to treat flowing magma as a dynamic material with a rheology similar to sheared, congested slurries. The idea that dense magma equates to a high temperature slurry is an attractive one, and opens up a way to examine the emplacement process that does not rely on equilibrium thermodynamics as a final explanation for commonly observed igneous structures. Using the Basement Sill, Antarctica, as a world class example of a magmatic slurry, shearing at high Peclet (Pe) number where particle diffusion is negligible has the potential to impart a rich diversity of structures including layering, grading and flow segregation. Work to model numerically the flow of the Basement Sill slurry using a range of theoretical and experimentally-derived non-Newtonian magma rheologies will be presented and assessed. A key impilcation is that in addition to more classical explanations such as compaction and gravitational settling, igneous layering can also arise spontaneously during shear associated with the ascent and emplacement of congested magma. A final aspect of the emplacement model considers the irregular geometry of the Basement Sill boundaries. Movement of magma along these boundaries results in the formation of local eddies and fluid swirl/back-flow that add additional complexity to macroscopic flow field.