Geophysical Research Abstracts
Vol. 18, EGU2016-7266, 2016
EGU General Assembly 2016

Magmatism vs mushmatism: Numerical modelling of melt migration and accumulation in partially molten crust

Katarina Roele, Matthew Jackson, and Joanna Morgan

Imperial College London, Earth Science and Engineering, London, United Kingdom (khr09@ic.ac.uk)

We present a quantitative model of heat and mass transport in a compacting crustal mush created by the repetitive intrusion of mantle-derived basaltic sills. At very low sill emplacement rates, we find that the maximum melt fraction remains small, far below that required to create an eruptible magma, and consistent with purely thermal models published previously. However, at intermediate (and realistic) sill emplacement rates, we observe the formation of a high melt fraction layer within a low melt fraction background. The high melt fraction layer migrates upwards towards the top of the mush (which is defined by the location of the solidus isotherm) and, despite occupying a high melt fraction, the melt in the layer has a composition corresponding to a progressively larger degree of fractionation during upwards migration, because it locally equilibrates with mush at progressively lower temperature. Thus the composition of the melt in the high melt fraction layer becomes progressively more evolved.

The high melt fraction layer resembles a conventional magma chamber, but is produced by changes in bulk composition in response to melt migration, rather than the addition of heat. Indeed, such a layer can form even when the mush is cooling overall. The magma within the layer is at sufficiently high melt fraction to be eruptible, but is not located in the hottest region of the mush where the temperature is highest. This is a new method to produce a magma chamber within a crustal mush, and also to evolve the composition of the melt in the chamber. Our results show that high melt fractions need not be associated with high temperature; they also show that eruptible melt fractions can be created at much lower emplacement rates than predicted by purely thermal models. These high melt fractions are transient, and spatially localized within larger mush zones. Moreover, chemical differentiation does not require fractional crystallisation in a largely liquid magma chamber. Our modelling is consistent with recent geophysical, geochemical and petrological data that suggest crustal magma chambers are normally largely crystalline, with high melt fractions present only transiently prior to eruption. The modelling provides quantitative estimates of volumes, rates and timescales for the formation of eruptible magma.