Investigation of silicic segregations in the Ferrar Dolerite sills, Antarctica, using fluid dynamic experiments

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The Ferrar Dolerite sills are a series of 100–350 m thick Jurassic sills which are exposed over an area of ~10^5 km^2 in Antarctica. Coarse-grained leucocratic segregations in the upper parts of these sills form anastomosing sub-horizontal lenses 0.1–3 metre thick and extending tens of metres along strike. All segregations have sharp upper contacts and some have sharp lower contacts with the host rock, while in others the lower contact is diffuse. Segregations are temporally, spatially and chemically related to the Ferrar Dolerites and range in composition from diorite to granodiorites. They have geochemical trends that are compatible with residual liquids after crystallization of pyroxene and plagioclase from the parent dolerite. Segregations are thought to form by an imperfect filter pressing mechanism that forms in response to gravitational instability, such as: tearing of the crystallizing pyroxene-plagioclase mush when its weight exceeds its strength; compaction and dilation of the mush (Philpotts, et al., 1996); or by compaction of large mushes.

One issue in the formation of segregations concerns the amount of mixing experienced by liquids entering the porous network, since some segregations appear homogeneous and others show stratification. Preliminary experiments investigated mixing between two homogeneous liquids with differing viscosities (n_1, n_2) and densities (r_1, r_2). A porous disk, representing the mush, was dropped through a stratified liquid, and the mixing observed between overlying liquid and liquid injected through the pores. Controlling parameters are dimensionless numbers describing the balance of processes within the system: the Reynolds number ($Re = r_1UL/n_1$), the Froude number ($Fr = U/[g(r_2-r_1)/r_2L]^{1/2}$ and the viscosity ratio (n_2/n_1) of the two liquids. U is the velocity of injecting liquid through the mush, and L is the size of the pore space. Complete mixing occurs at relatively high Re and Fr numbers with small viscosity contrast, while no-mixing occurs at relatively low Re and Fr numbers. At intermediate Re and Fr numbers an incomplete mixing pattern occurs. These and other results suggest that segregations with internal stratification and diffuse contacts form as a result of high viscosity contrast between the interstitial liquid in the mush and the infilling liquid. Homogeneous segregations may form at relatively high Re and Fr flow regimes.

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