The textural and chemical records of mushy magma dynamics

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Subduction zone magmas, and their plutonic equivalents, are a blend of different solid and liquid components that reflects complex trans-crustal processing as well as source variability. Whole rock geochemical data represents the blended mixture and is useful for identifying longer-term system changes. However, clear identification of the origins of individual components is essential to interpret mineral and melt geochemistry, and to understand the relative importance of different processes. Quantitative studies of mineral partitioning are an important complement to whole-rock analysis. The inclusion of mafic minerals such as amphibole can expand our knowledge of melt differentiation compared with typical melt inclusion suites. Data from Mount St Helens (USA) illustrate that mid-crustal fractionation of intermediate magmas is dominated by amphibole, with upper-crustal fractionation of dacites dominated by plagioclase. Variations in HFS element concentrations may be linked to repeated scavenging of partially-remelted, older intrusive materials throughout the magmatic system, probably including materials derived from intraplate-like parental melts. In contrast, data from Mount Lamington (Papua New Guinea) largely reflect a long history of mixing between intermediate (basaltic andesite) and silicic (rhyodacite) melts.

We also argue that the textures of older intrusive materials are a critical control on the rejuvenation of mushy material during episodes of unrest and eruption. The primary microstructure of the accumulating crystal mush depends strongly on physical crystallisation conditions. Our observations show that slowly cooled, melt-bearing cumulates typically show pervasive grain-boundary melt films, whereas more rapidly cooled materials tend to form planar contacts and increased crystal aspect ratios. Mush may therefore be preferentially remobilised in mature arc systems. Experimental and numerical validation of the observed textures would be a valuable step forward in understanding processes involving magma generation, storage and priming before eruption.