Experimental evidence for non-linear behaviour of melt fraction vs. temperature and implications for magmatic evolution

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The original source of arc magmas lies within the mantle wedge. However, primitive, mantle-derived magmas are rather rare in volcanic arcs, proving that magmas undergo differentiation prior to eruption. The location, mechanism and timing of this differentiation have direct implications for the range of eruption products of a volcano

A series of experiments were carried out on high-MgO and low-MgO basalts in order to evaluate the chemical consequences of basalt differentiation in the shallow- to lower-crust.

The key result shows that the melt fraction (F) temperature (T) relationships are non-linear and varies with H_2O content. The principle control on the F-T relationships is compositional contrast between the crystallizing assemblage and coexisting melt. Rapid change in F occurs during eutectic-like behaviour. That means melt and crystalline residues have similar compositions. Contrariwise, during peritectic reaction F changes only slightly when change in melt composition could be substantial. For instance, orthopyroxene and plagioclase are compositionally very close to basaltic melts and a rapid decrease in F will be observed on saturation with these minerals, but residual melt composition will hardly change, and this consistent with dry experiments (initial H_2O <0.6 wt%) at 2 and 10 kbar. In contrast, amphibole and melt differ greatly in composition and lower dF/dT is observed upon amphibole saturation in the experiments with initial H_2O > 2 wt%. However, the change in melt composition is significant.

This demonstrates that initial H_2O content has significant influence on the differentiation path of primary magmas.

Compilation of these experimental results and existing data on Cascades showed that the entire array of Cascades magma compositions could be produced by polybaric crystallisation of primitive basalts with variable initial H_2O content.