Magma evolution and the formation of a 'Daly Gap' in the volcanic and plutonic rocks of Akaroa Volcano, New Zealand

EVA HARTUNG[1], CHAD DEERING[2], BEN KENNEDY[1], ALEYSHA TRENT[1], JONATHAN GANE[1], ROSE TURNBULL[3]

[1]Geological Sciences, University of Canterbury, Christchurch, 8140, New Zealand (eva.hartung@pg.canterbury.ac.nz)
[2]Earth and Space Sciences, University of Washington, Seattle, WA 98195-1310, USA (cdeering@u.washington.edu)
[3]GNS Science, Dunedin, 9016, New Zealand

The origin of compositional gaps in volcanic deposits remains controversial. In Akaroa Volcano (9.6-8.6 Ma), New Zealand, a dramatic compositional gap exists in both eruptive and co-genetic intrusive products between basalt and trachyte, and between gabbro and syenite respectively. Previously, the formation of more evolved magmas has been ascribed to crustal melting. However, the interpretation of new major and trace element analysis from minerals and bulk-rocks coupled with the mechanics of crystal-liquid separation offers an alternative explanation that alleviates the thermal restrictions required for crustal melting models.

Major and trace element trends can be reproduced by polybaric Rayleigh fractionation from dry melts (<0.5 wt.% H_2O) at the QFM buffer in a two-stage model. In the first stage, basalt and trachybasalt are produced by separation from an olivine-pyroxene dominant primitive mush at 50-80 vol. % crystallinity near the crust-mantle boundary (10-12 kbar). In the second stage, trachyte melt is extracted from the more evolved trachybasalt mush at mid-crustal levels (3-5 kbar) after the melt has reached 50 vol.% crystallinity. The fractioned assemblage of plagioclase, clinopyroxene, olivine, magnetite and apatite is left in a cumulate residue and corresponds to mineral assemblages of ultramafic enclaves. Trace element modeling of crystal fractionation using this extraction window is consistent with the concentration measured in trachyte (= liquid) and enclaves (= cumulate residue). Similar to the compositional gap observed in the eruptive products, feldspar data also show a distinct gap between the mineral compositions of basalt and trachyte. Yet, importantly, the feldspars from co-magmatic enclaves fill the feldspar compositional gap observed between the basalt and trachyte.

The results of these models indicate that the bimodal distribution of the volcanic products formed from punctuated melt extraction within an optimal crystal fraction window of 50 – 80 % at shallow depth.

Serpentinization and subsequent metamorphism in Mid-Atlantic Ridge peridotites from Hole 1268a, ODP Leg 209: Seawater vs. hydrothermal alteration

J. HARVEY*, I.P. SAVOV AND R.J. NEWTON

School of Earth & Environment, University of Leeds, Leeds LS2 9JT, UK (*correspondence: feejh@leeds.ac.uk)

Material recovered from Hole 1268a, ODP Leg 209, comprises heavily serpentinized peridotite. Subsequent serpentine-to-talc metamorphism and accompanying Si-metasomatism has been attributed to interaction with seawater modified by hot underlying gabbroic intrusions [1]. Sulphur abundances are elevated ([S] ≤2 wt %; [2]) and $\delta^{34}S$ in peridotite-hosted sulphides from talc-metamorphosed lithologies is significantly heavier than in nearby peridotites serpentinized at low-temperatures [3]. These values are consistent with high-temperature ultramafic-hosted hydrothermal vents elsewhere on the Mid-Atlantic Ridge [4] and suggests that the influence of high-temperature fluids from the nearby Logatchev hydrothermal field may extend to a radius of at least 15 km. Using a combination of radiogenic (Sr, Nd) and stable (B, S, O) isotopes this study aims to quantify fluid-rock ratios and chemical exchange, and the relative effects of seawater and hydrothermal fluids on the chemical and mineral evolution of peridotites from Hole 1268a. Preliminary results demonstrate Sr isotope ratios that are relatively uniform throughout the length of the borehole and indistinguishable from those of seawater This suggests particularly high (>100) fluid/rock ratios and contrasts with peridotites and gabbros from other, less altered ODP-drilled Holes nearby (e.g. Hole 1275). It is expected that this will be more precisely constrained with Nd and B isotopes.

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