Fast-spreading mid-ocean ridge magma chamber processes: Insights from the Oman ophiolite

C.J. MacLeod[1], R.M. Thomas[1] and L.A. Coogan[2]

[1]School of Earth, Ocean & Planetary Sciences, Cardiff University, Cardiff CF10 3YE, UK (macleod@cf.ac.uk)
[2]School of Earth & Ocean Sciences, University of Victoria, Victoria, BC, V8W 3P6, Canada (lacoogan@uvic.ca)

We investigate the physical and chemical processes in axial magma chambers and constrain the mechanisms of accretion of the lower crust at fast-spreading mid-ocean ridges by means of a combined structural, petrological and geochemical investigation of gabbroic lower crustal sections in the Oman ophiolite. Magmatically-deformed layered gabbros with fabrics parallel to the petrological Moho form the lower half of the plutonic sections. These normally pass upward via a transitional horizon a few hundred metres thick into massive, non-layered gabbros with vertical magmatic foliations and lineations, and thence into a thin (~200m) horizon of heterogeneous varitextured gabbros. We have previously suggested that the varitextured gabbros represent a fossil melt lens that was filled with variably fractionated, essentially basaltic liquids [1], overlying cumulates formed in the underlying crystal mush from which liquids were efficiently extracted. The vertical foliated gabbros we have interpreted as relict channelways of ascending melts that fed the melt lens.

In this study we present major- and trace-element whole-rock and mineral chemical data together with quantitative textural and petrofabric information from complete lower crustal sections in Oman, with the aim of constraining the processes operating in the lower crustal crystal mush. Systematic changes in mineral trace element characteristics are observed. For example, La/Nd ratios in cpx in the layered gabbros increase progressively up section and show little intra-crystalline variability; however, at the transition into the foliated gabbros the extent of intra-crystal variability increases significantly. Whereas the variation in La/Nd between layered gabbro samples could, in isolation, be interpreted as being due to variations in parental melt composition, the same trends within individual crystals and the progressive change in ratio up-section are difficult to interpret in this way. Instead, they may be successfully reproduced using an assimilation–fractional crystallisation model of magmatic metasomatism: probably compaction-driven reactive porous flow of melt migrating upward through the crystal mush. Possible implications for magma chamber models will be discussed.

References

[1] MacLeod C.J., and Yaouancq G. (2000), *Earth Planet. Sci. Lett.* **176** 357-373.

Differentiation of basaltic melt in the shallow mantle wedge: Implications for mass fluxes into the arc crust

Colin G Macpherson

Department of Earth Sciences, University of Durham, Durham, UK. (colin.macpherson@durham.ac.uk)

In general, magmatic differentiation is regarded as a process that affects primary basaltic melts after they have encountered a significant density interface. For this reason, many studies of differentiation in arc lithosphere focus on processes occurring at, or above, the Moho. However, there is ample evidence that subduction zone magmas can interact with the mantle wedge. Recent work in Surigao, eastern Mindanao, indicates that hydrous basaltic melt can also differentiate beneath the Moho [1].

The Surigao suite comprises a continuous spectrum of compositions from high-Mg andesite to adakitic rhyolite. Isotopic ratios and most incompatible trace element ratios are indistinguishable from contemporaneous calc-alkaline magmatism. These similarities point to derivation from similar sources i.e. metasomatised mantle wedge. Rare earth elements, notably Dy/Yb ratios, demonstrate that high-Mg andesitic and adakitic compositions developed through differentiation of hydrous basaltic magma at >30km depth, where garnet is stable. In the Philippines, where arc crust is thin, this represents sub-Moho depths.

The Philippine example suggests that both adakitic and high-Mg andesitic magmatism should be regarded as part of the natural range of magmatic compositions that might arise in any subduction zone. Their presence, or absence, reflects the suitability of a particular subduction zone to generate and then preserve these distinctive compositions. Crust-hosted differentiation could overprint or obscure the distinctive magma chemistry produced at deeper levels, which may be more widespread than is currently percieved.

Adakitic rocks, in particular, are often emplaced where subduction has unusual characteristics e.g. above young slabs or slab edges, and the majority of previous effort has been directed at linking the chemistry of magmatic products to features of the down-going plate. Specifically, both high-Mg andesitic and adakitic magmatism has been linked to melting of subducted oceanic crust. Data from the Philippines and several other locations challenge this finding and suggest that differentiation at more than 30km depth could generate adakitic magma from hydrous basaltic precursors. Differentiation at such levels will have important implications for mass fluxes from the mantle to the arc crust and, potentially, for the evolution of mantle wedge compositions.

Reference

[1] Macpherson CG, Dreher ST, and Thirlwall MF. (2006) *Earth Planet. Sci. Lett.* **243**, 581-593.