Short length-scale compositional heterogeneity in basalts and their mantle sources

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Detailed studies of a number of volcanic systems in Iceland have found significant variation in the trace element and isotopic composition of basaltic whole-rock samples. Limited compositional heterogeneity is present in whole-rock samples from individual flows. However, neighbouring flows commonly have significantly different trace element and isotopic compositions. Flows with ages that differ by <10 kyr and whose eruptive vents are separated by less than 15 km show a range in trace element composition that is comparable to the total variability observed in samples from the Icelandic Rift Zones. Olivine-hosted melt inclusions from individual flows also show significant trace element and isotope heterogeneity. Inclusions from the Haleyabunga picrite of SW Iceland show a spread in $^{208}Pb/^{206}Pb$ that covers >50% of the total range observed in Atlantic MORB. This observation indicates that large amplitude compositional heterogeneity is present within the mantle source regions of an individual eruption. The coincident trace-element and isotope trends of melt inclusion and whole-rock data from the individual volcanic systems confirms a common origin of compositional heterogeneity for melt inclusions and whole-rock samples. The melt inclusion trends can be reproduced by mixing between the two extreme inclusion compositions.

Fractional melting of compositionally heterogeneous mantle is predicted to generate a large range of melt compositions, filling a large volume in trace element and isotope compositional space. However, the observed trends lie along mixing lines in such a space. At a fixed isotopic composition, the range in observed trace element ratios is limited. The melt inclusion compositions cannot, therefore, reflect the full range of melt composition generated in the melting region under Iceland. Their composition is dominated by mixing between two extreme melts. These observations may be accounted for by mixing during channelised flow of melt in the mantle. The depleted endmember melt is produced in the shallow parts of the melting region, while the enriched endmember is itself produced by mixing in channels of melts generated over a range of depths. The distribution of isotope compositions of MORBs is therefore controlled by melt mixing at the local scale and does not reflect the distribution of compositional heterogeneity in the upwelling mantle.

Origin and evolution of adakites and high Mg# andesites in the East Philippine Arc

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The Philippine Trench marks a nascent plate margin where subduction initiation is propagating from north to south. The East Philippine Arc, which is part of this margin, has generated adakitic and high Mg# andesitic rocks and provides a unique natural laboratory for determining the origin of these magma types.

In the immature southern arc, magmatism is dominated by a continuous spectrum of compositions from high-Mg andesite to adakitic dacite and rhyolite. Isotopic ratios and most incompatible trace element ratios of this suite are indistinguishable from contemporaneous calc-alkaline magmatism [1]. These similarities point to derivation from similar sources i.e. melting of metasomatised mantle wedge. Rare earth elements, notably Dy/Yb ratios, suggest that high Mg# andesitic and adakitic compositions developed through differentiation of hydrous basaltic magma at >30km depth, where garnet is stable. In the southern East Philippine Arc, where arc crust is thin, this represents sub-Moho depths.

Adakitic rocks also occur in the northern East Philippine Arc but are less common than those produced by low-pressure differentiation of hydrous basalt. This suggests that the magma plumbing systems beneath volcanoes in the more mature part of the arc resemble those found beneath most other subduction zone volcanoes.

The transition from adakitic and high Mg# andesitic magmatism to more typical arc magmatism is interpreted as a record of thinning of arc lithosphere as it is thermally eroded from below. Lithosphere is thicker beneath the younger, southern part of the arc causing basaltic magma to stall and fractionate garnet at high pressure. In the mature, northern section basaltic magma differentiates at shallower levels, at pressures where garnet is not stable. Local variations in lithosphere thickness suggest that thinning is rapid and may be piecemeal. Fluctuations in arc lithosphere thickness during the history of this margin appear to control spatial and temporal variations in magma compositions accumulating in the arc crust.

[1] Macpherson *et al.* (2006) *Earth Planet. Sci. Lett.* **243**, 581-593. [2] Macpherson (2008) *Geology* **36**, 311-314.