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The role of amphibole in Merapi arc magma petrogenesis: insights from petrology and geochemistry of lava hosted xenoliths and xenocrysts

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Recently, increasing attention has been paid to the role of amphibole in the differentiation of arc magmas. The geochemical composition of these magmas suggests that deep to mid crustal fractionation of amphibole has occurred. However, this phase is typically an infrequent modal phenocryst phase in subduction zone eruptive deposits(1). Nevertheless, erupted material only represents a portion of the magmatism produced in subduction zone settings, with many opportunities for melts to stall on route to the surface. This discrepancy between whole rock geochemistry and petrological interpretation of arc magmas has lead many scientists to postulate that, at mid to deep crustal levels, there may be significant volumes of amphibole bearing lithologies. Amphibole instability at shallow levels can also contribute to its scarcity in eruptive deposits. This argument is strengthened by field and petrological evidence, including the widespread occurrence of amphibole-rich intrusive rocks in exhumed orogenicbelts formed during subduction zone activity, e.g.
the Adamello batholith (2),as well as the presence of amphibole-rich xenoliths and xenocrysts preserved in arc lavas worldwide, e.g.
in Indonesia, Antilles, and Central America. Thus, amphibole appears to play an integral role in subduction zone magmatism and identifying and constraining this role is central to understanding arc magma petrogenisis. Amphibole-rich melts or bodies in the deep to mid crust could be a significant hydrous reservoir for intra-crustal melts and fluids (1).

In this preliminary study, we have carried out petrological and geochemical analyses of recent basaltic andesite and amphibole bearing crystalline igneous inclusions and xenocrysts from Merapi volcano in Java, Indonesia. The basaltic andesite geochemistry is consistent with amphibole fractionation and the crystalline inclusions are cogenetic to the Merapi magmatic system. These inclusions are likely to represent fractionation residues reflecting deep- to mid-crustal processes given the stability field of amphibole. The individual amphibole xenocrysts are also co-genetic to the Merapi magma system and indicative of high-pressure crystallisation. Hydrogen isotope analyses of these large amphibole megacrysts, record a broad range of dD ratios (permil deviation of D/H isotope ratio from Standard Mean Ocean Water). The dD values of some of these crystals appear to be modified significantly from expected primary compositions, particularly towards the rims of amphiboles showing breakdown textures. The measured dD values possibly result from H-isotope re-equilibration with surrounding volatile vapour during eruption or via dehydration reactions. Mossbauer analysis of a selected pristine amphibole megacryst from this suite records 67 % of iron as Fe^{3+} in the M-sites. Complementary IR spectroscopy of this amphibole indicates no serious loss of OH groups. High H_2O pressures at formation depth for this crystal have stabilized full hydrous compositions at $\sim$ 2% H_2O concentration in the amphibole. Such fully hydrated amphiboles could release their H_2O on depressurisation on ascent prior to eruption, a process that consistent with the dD data.

Analysis of these samples is ongoing, however this initial data indicates that amphibole is a key phase in Merapi magmatic evolution and is a likely source of volatiles through dehydration on ascent. This is of particular significance given the fact that water content of magma has a considerable impact on the explosive potential of subduction zone volcanism.

(1) Davidson *et al*., 2007. Geology, 35: 787-790. (2) Tiepolo *et al*., 2002 Contrib. Min. Pet., 144:1–15.