Petro-geochemical evidence for vapour transport in andesite shear fractures

Melissa Plail[1], Marie Edmonds[2], Jenni Barclay[1], Madeleine C.S. Humphreys[3], Richard A Herd[1]

[1]University of East Anglia, UK, [2]University of Cambridge, UK, [3]University of Oxford, UK

E-mail: m.plail@uea.ac.uk

The andesitic Soufrière Hills Volcano (SHV), active since 1995, emits large fluxes of volcanic gases (dominantly H_2O, CO_2, SO_2, HCl), even during eruptive pauses. Effective open-system degassing at dome forming eruptions may control eruption style. It has been observed that the flux of gas is largely decoupled from the flux of magma to the surface, indicating efficient magma-vapour segregation. Evidence for vapour transport through magma is not often preserved in the erupted rocks, perhaps due to overprinting during eruption, or because the transport zones themselves are not usually erupted. We present petro-geochemical evidence for vapour transport through shear fractures in andesite at SHV and a model for their formation.

Andesite blocks in deposits from two recent eruptive events from SHV contain narrow shear zones, up to 2 m in length and 2-10 cm in width, with alternating darker fine-grained and lighter coarser-grained bands. Analysis has shown that the dark, fine-grained bands (grain size ~30-70 μm) have low porosity (~1%), oxides (<8% vol), orthopyroxene, cordierite microlites ($Mg_{1.3\text{-}1.7}Fe_{0.4\text{-}0.8}Al_{3.7\text{-}4.0}Si_{4.9\text{-}5.2}O_{18}$), groundmass cristobalite, quartz and sieve–textured plagioclase. The light, coarse bands (grain size ~100-350 μm) has higher porosity (7-19 vol %) and consists of broken plagioclase, orthopyroxene, clinopyroxene and sparse large amphibole crystals, and a reduced abundance of oxides (<2.4% vol). Glass is rare to absent in both types of band. Mineral compositions in the shear zones are identical to those established in the SHV andesite. However, bulk ICP-MS analyses indicate that some metal concentrations (Cu, Ni, Pb, Au and Zn) are greatly enhanced relative to the surrounding andesite. For example, Cu and Au concentrations are up to and over ten times higher than in the andesite host. Cu is present as copper sulphide inclusions in Ti-magnetites and plagioclase phenocrysts.

We hypothesise that the elevated metal concentrations and presence of abundant, disseminated metal-bearing grains are evidence that these zones are relict vapour transport pathways in the shallow volcanic system. Rapid shear of andesitic material formed brittle fractures either at the conduit wall or in the shallow dome, along which metal-bearing vapour or fluid was transported. Partial melting occurred as a result of frictional heating during shearing, and volatile resorption occurred as the melt cooled. The unusual presence of volcanic cordierite is likely to have crystallised from a peraluminous partial melt that formed by preferential melting of plagioclase at elevated temperatures. These sheared zones provide the first petrological evidence for vapour transport at SHV, and a window onto the early stages of mineralization at island arc volcanoes.