Volatile and light lithophile trace element geochemistry of the 2010 eruption of Merapi volcano revealed by melt inclusions

Katie Preece[1], Ralf Gertisser[2], Kim Berlo[3], Jenni Barclay[1], Richard Herd[1]

[1]School of Environmental Sciences, University of East Anglia, Norwich, NR4 7TJ, UK, [2]School of Physical and Geographical Sciences, Keele University, Keele, Staffordshire, ST5 5BG, UK, [3]Department of Earth Sciences, University of Oxford, Oxford, OX1 3AN, UK

E-mail: K.Preece@uea.ac.uk

The 2010 eruption of Merapi (VEI 4) was the volcano's largest since 1872. In contrast to recent prolonged and effusive dome-forming eruptions at Merapi, such as the previous eruption in 2006, the 2010 eruption began explosively, before a new dome was rapidly emplaced between 30 October and 4 November 2010. On 5 November, this new dome was destroyed by explosions, generating pyroclastic density currents (PDCs), predominantly consisting of dark-coloured, glass-rich, dense blocks of basaltic andesite dome lava, which travelled ~16 km from the summit, immediately followed by PDCs characterised by scoriaceous and pumiceous clasts.

In this paper, we present volatile and light lithophile element data of clinopyroxene-hosted melt inclusions from samples of the dense dome lava, scoria and pumice from the PDCs generated during the peak of the 2010 eruption. SIMS analysis of volatiles (H_2O and CO_2) and light lithophile elements (Li, B, Be) are augmented by electron microprobe analysis of major elements and volatiles (Cl, S) in the same melt inclusions and groundmass glass.

The melt inclusions are dacitic to rhyolitic in composition (63.3-71.8 wt.% SiO_2) and have variable contents of H_2O and CO_2, ranging between 0.1-3.8 wt.% and up to ~2500 ppm, respectively. The highest H_2O contents are preserved in melt inclusions from scoriaceous and pumiceous clasts. Some melt inclusions from the pumice preserve evidence of relatively high CO_2 contents at medium (~2 wt.%) H_2O contents. Chlorine contents range from 2000-5000 ppm and S is present in quantities up to 500 ppm in the melt inclusions, with the groundmass glass of pumice characterised by higher volatile concentrations than the groundmass of the dense dome. Light lithophile element analyses show a moderate range in concentration in the melt inclusions of Li (15-68 ppm) and B (25-84 ppm) and uniform Be concentrations (1-2 ppm).

Our data suggest that a simple model of equilibrium decompression-driven degassing cannot explain the H_2O and CO_2 concentrations in the analysed melt inclusions. Instead, melt inclusion data record a complex pre-eruptive storage and ascent history of the 2010 magma, highlighting open-system processes, including entrapment of melt at multiple levels within the crust, enrichment of CO_2 in some inclusions, and the influx and exsolution of Li-rich vapours at shallow depths. Despite the more explosive nature of the 2010 eruption, melt inclusions reveal a similar pre-eruptive volatile content to the 2006 eruption, suggesting that degassing behaviour rather than higher initial volatiles contents, contributed to the paroxysmal 2010 eruption.