Sulphur flushing as a driver of copper accumulation in magmatic arcs

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Porphyry copper ore deposits in magmatic arcs supply ~75% of the world's copper. Because copper is a critical element in our race to decarbonise, there is great interest in the possible causes of copper enrichment in parental arc magmas, and copper-sulphide precipitation mechanisms, which may involve external gas fluxes as well as hydrothermal processes. Here we combine volcanic SO2 degassing fluxes with the petrological record of Cu and S enrichment in associated lavas. We focus on recent eruptions of Mount Mayon open-vent volcano in the Philippines, which had notably different explosivity and SO2 flux. We apply high-resolution crystal-scale element mapping to explore copper sulphide precipitation in the subvolcanic environment immediately preceding these different eruptions.

Melt inclusions preserved in sieve-textured plagioclase phenocrysts erupted between 2006-2009, after an elevated SO2 degassing flux, are extensively crystallised and contain clinopyroxene and magnetite together with droplets of copper sulphide (digenite). The bulk composition of the melt inclusions (including crystals) is andesite-dacite, similar to typical arc lavas but with exceptional Cu enrichment. The residual melt is dacitic and contains up to 1 wt.% Cl (~3× typical arc magma values). Similar melt inclusions in plagioclases from the large 2000 eruption, before the rise of SO2 degassing flux, lack equivalent copper-enrichment.

These observations suggest that external SO2 fluxes may exert a critical control on copper localisation in arc magmas. Flushing of shallow plagioclase mushes with sulphur-rich vapours as well as Cu-bearing magmatic brines might be a critical step in the enrichment of arc magmas necessary for the production of large porphyry copper deposits.