

A smoking gun for copper enrichment in arc volcanoes?

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Calc-alkaline magmas above subduction zones sometimes host porphyry copper ore deposits, which supply 70% of the world's copper. As a result, there is great interest in the possible causes of copper enrichment in parental arc magmas, and copper-sulphide precipitation mechanisms, which may involve gas fluxes related to magmatic rather than hydrothermal processes [1,2].

Here we combine passive degassing SO₂ fluxes with records of Cu and S enrichment in associated eruptions. We compare open-vent volcanoes in the southwest Pacific, including Mount Mayon in the Philippines and Mount Merapi in Indonesia, and apply high-resolution crystal-scale elemental mapping to explore copper sulphide precipitation in the subvolcanic environment.

Melts preserved in channels in sieve-textured plagioclase phenocrysts erupted from Mount Mayon in 2006-2009, when there was 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 that of a relatively evolved andesite-dacite, similar to typical arc lavas but with exceptional Cu enrichment. The residual melt is rhyolitic and enriched in halogens, with up to 1 wt.% Cl (~3× typical arc magma values). Similar melt inclusions in plagioclases from the large 2000 Mount Mayon eruption, at the onset of passive degassing, and from Mount Merapi, which has SO₂-degassing fluxes one order of magnitude lower than Mayon, lack equivalent copper-enrichment.

These observations suggest that gaseous SO₂ fluxes may exert a critical control on magma copper endowment. Gaseous SO₂ fluxes might cause early sulphide saturation preventing copper enrichment of evolved magmas. Alternatively, 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 and super-large ore deposits.

[1] Blundy et al., 2015. *Nature Geosci.* [2] Henley et al., 2015. *Nature Geosci.*