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Metals in melt inclusions and volcanic gases from Kawah Ijen volcano, Indonesia

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Immiscible sulphide liquid is an important repository for sulphur and chalcophile metals in magmatic systems. During magma ascent and degassing, sulphide liquid can destabilize and contribute these elements to the melt. The volatile nature of S and many of these metals, or their complexes with S, Cl and H implies that this contribution can be transferred to an exsolving gas phase and released to the atmosphere. Melt inclusions in a scoria deposit from Kawah Ijen volcano (Indonesia) show enrichments in Tl, Pb, Zn, Co, As, Mo, Ag, Sb and Cu with decreasing pressure (pH_2O). These enrichments show an abrupt break in slope around $\sim$200 MPa, where the concentrations increase more rapidly with falling pressure. This break in slope corresponds to a change in the behaviour of S; whereas the aforementioned metals are positively correlated with S above a S concentration of $\sim$1800 ppm (the concentration of sulphur in the melt at 200 MPa), they display a strong negative correlation with S below this pressure. The metals all correlate strongly with Cu, suggesting a common source. We interpret these trends as resulting from the gradual dissolution of an immiscible sulphide liquid during magma ascent caused by degassing and oxidation of the magma until it is exhausted at $\sim$200MPa. Metal emissions from the currently active fumaroles at Kawah Ijen have been measured to establish the potential contribution of a sulphide liquid to the present-day system. The fumarole gases have similar Zn/Cu, Pb/Cu and Mo/Cu ratios to the sulphide liquid inferred from the basaltic melt inclusions, but are enriched in Tl, As and Sb. The latter elements are also enriched in melt inclusions from a more recent dacitic deposit relative to the basaltic melt inclusions and to other elements in the dacite. The current fumarolic gases at Kawah Ijen thus appear to be derived from both a basaltic magma, which is sulphide saturated at depth, and from a more evolved magma.