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Oxidised yet sulfur poor magmas in the Manus back-arc Basin

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The association of copper porphyry formation with subduction-related, oxidised and sulfur (S) -rich magmas has been long recognised. Yet the processes that lead to sulfur enrichment and oxidation of arc magmas are uncertain. The prevailing view is that the dehydration of the subducting slab promotes flux melting, leading to the generation of hydrous, oxidised and S-rich magmas. Their oxidised and S-rich nature are intimately linked, as S solubility highly depends on its oxidation state. However, how, where, and when arc magmas acquire their oxidation state and S cargo is speculative.

Twenty-nine submarine glasses from the Manus Basin associated with the subduction of the Solomon oceanic plate have been analysed for $S^{6+}/\Sigma S$ and $Fe^{3+}/\Sigma Fe$ ratios using XANES, and S, Se, and Cu contents using enhanced LA-ICP-MS/MS techniques developed for this study. MORB, BABB, and arc lavas have been identified as the main magma types in this study area and range between 3.4 – 8.7 wt.% MgO. We find no obvious indication of S loss via degassing or seawater alteration. Sulfur contents range between 209 – 1472 μg g^{-1}, where the lowest S contents are found in samples most oxidised (FMQ +2), and influenced by a slab-derived component (i.e. Ba/Nb > 100, $^{206}Pb/^{204}Pb$ > 18.5). This is while maintaining PM-like S/Se ratios (2688 ± 706 versus 2635 ± 1423) across all magma types.

We show that - despite a clear involvement of a slab-derived component – S contents (including Se and Cu) in Manus Basin magmas are readily explained by partial melting of sulfide. Consequently, this indicates that slab-derived materials do not necessarily enrich the overlaying mantle with S. Furthermore, the presence of sulfide in the source requires that these magmas do not become oxidised until after partial melting. This may suggest that slab-derived fluids do not drive the oxidation of the mantle wedge, as is commonly believed.

Our findings seemingly contradict the relationship between S capacity and the oxidation state of magmas. Evidently, high S capacity does not necessarily translate into high S content, which in the Manus Basin is ultimately limited by a S -depleted mantle source and slab component.