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Understanding Sb, As and W enrichment processes in magmas using geochemical databases

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Magmatic heat sources allow hydrothermal fluids to transport and deposit various types of metals and metalloids. In hydrothermal deposits, antimony (Sb) may be associated with various amounts of other elements, such as arsenic (As) and tungsten (W). In Variscan settings, Sb mineralisation is frequently spatially associated with mafic intrusions, although source-sink relationships remain poorly constrained. Whether mafic magmas contribute fluids, metals and metalloids to hydrothermal systems at the origin of Sb mineralisation remains uncertain.

We investigated the Sb, As and W contents of magmatic rocks available in the literature, to assess mafic magmas as a potential source for metals and metalloids. Sb, As and W are highly covariant, suggesting a common behaviour during magmatic processes. Their concentrations in oceanic magmatic rocks increase with increasing K_2O content: up to two orders of magnitude in mafic compositions, and one order of magnitude through intermediate and differentiated compositions. Thus, differentiated alkaline magmas generally yield higher concentrations of Sb, As and W. The geochemical modelling of major and trace element variations allows evaluating the contribution of variable magmatic processes during magma generation and differentiation. This reveals a major role of mantle source processes in controlling Sb, As and W contents in magmatic rocks, and a minor contribution from fractional crystallisation. In particular, Sb, As and W concentrations in MORBs show a good correlation with the La/Sm ratio, and an absence of correlation with $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ isotopic ratios. This suggests a crucial control of partial melting processes in MORBs, whereas Sb, As and W variabilities in OIBs suggest a more important role of the mantle source in intraplate settings.

Magmatic rocks of continental settings show a strong Sb, As and W variability, with values up to 3 orders of magnitude higher than rocks from oceanic settings. This suggests crustal contamination to be a key process to produce Sb-As-W-rich magmas. Post-magmatic alteration does not seem to have any systematic effect on Sb, As and W concentrations.

We finally give particular attention to mafic rocks spatially and temporally associated with Sb-Hg ± As-W-Au-Ag deposits, and discuss the possible processes at the origin of their specific enrichment.