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The halogen cycle in subduction zones: insight from back-arc basin basalts

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The extent to which the subduction process preserves the volatile elements signature of the downgoing slab and the mechanisms by which these elements are transferred into the mantle wedge are not well understood. Halogens (Cl, Br, I) are good candidates to trace these processes, due to their incompatibility and their relatively high concentrations in seawater and marine sediments. A technique developed at the University of Manchester allows the high precision measurements of these elements on neutron-irradiated samples using noble gas mass spectrometry.

To better constrain the cycle of halogens in subduction zones, we analyzed the halogens in 15 volcanic glasses (BABB) from three back-arc basins which are known to contain slab-derived components viz Manus basin, Lau basin and Mariana trough.

The three back-arc basins have relatively constant Br/Cl weight ratios ($4.0\pm0.4\times10^{-3}$) which are 2x higher than the mid-ocean ridge basalts (MORB) value. The I/Cl weight ratios (0.9 to 7.1×10^{-5}) range from values close to seawater to MORB values. These results suggest that the halogen composition of the BABB mantle source is affected by a slab-derived component. However, the I/Cl ratios positively correlate with Ba/Nb ratios that are between 5-33 (weight), which reflect the extent of the slab contribution. Thus, it indicates the presence of an unknown end member with a MORB-like Ba/Nb ratio and with low I/Cl and high Br/Cl ratios. It is notable that the halogen ratios of this component are similar to that of the fluid phases trapped in altered oceanic crust. Another component with higher Ba/Nb, higher I/Cl and lower Br/Cl ratios, is consistent with the presence of a sedimentary-derived component. The possible origins of the signature of the halogen BABB mantle source will be discussed by comparing with the different components characterizing the subducted oceanic crust.