Halogens in subduction zones and the Earth's mantle

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We report the first high precision data for all halogens (F, Cl, Br and I) in submarine arc glasses. The investigated arc glasses from the Hunter Ridge and N Tonga include adakites, boninites and arc tholeities. Additional subduction-influenced glasses from nearby backarc basins in the SW Pacific were also investigated. The glasses range from basaltic to dacitic in composition. The basalts and andesites typically have ~500-2500 ppm Cl and all the subduction-influenced glasses are strongly enriched in fluid mobile elements with high Ba/Nb, Cl/Nb, Br/Nb and I/Nb and moderately elevated F/Pr.

The lavas with the highest Ba/Nb that are most strongly influenced by subduction have F/Cl of less than MORB in a similar range as sediments and altered ocean crust and lithosphere. This implies that F as well as Cl is efectively mobilised through magmatic arcs and argues against the idea that F is preferentially subducted into the deep mantle, which is also not supported by the similar F/Cl of MORB and OIB.

The Br/Cl and I/Cl ratios of arc lavas are considerably more variable than MORB. All subduction-related lavas have Br/Cl of less than seawater and much less than sediments or pore waters. All the arc and backarc glasses investigated have Br/Cl and I/Cl ratios overlaping the compositional range of altered ocean crust and lithosphere. In contrast, a strong sediment pore water signature is recorded by forearc serpentinites.

The data can be explained if sediment pore waters are flushed out through forearcs and volatiles in the hydrated oceanic crust and lithosphere dominate the halogen budgets of the arc and deeper mantle. The average Br/Cl and I/Cl ratios of: i) altered oceanic crust and lithosphere, ii) arc and backarc lavas, and iii) mid-ocean ridge and ocean island basalts are all similar. However, varience decreases from altered crust, through the arc into the mantle. This suggests that fluid-mobile halogens in different parts of the oceanic crust and lithosphere are blended together during subduction-related metamophism with a small portion transferred to the deep mantle. Subducted halogens therefore control the I/Cl ratio of the depleted mantle, which is lower than the primitive mantle. Seafloor hydrothermal processes and subduction appear to control the relative abundances of halogens in the Earth's mantle.