The abundance and origin of Cl, Br an I in the Earth's mantle

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The unknown extent to which submarine magmas assimilate seawater-derived volatiles has been a serious obstacle to investigating mantle volatile abundances: recent estimates for Bulk Silicate Earth (BSE) vary from ~1 to 35 ppm Cl, which has important implications for infering the degree of Earth's depletion in Cl, Br and I relative to CI chondrites, and for investigating accretionary processes in the solar system and early Earth.

High precision Cl, Br, I and K analyses of submarine glasses, together with H_2O and trace element data, enable assimilated components to be unambiguously resolved, and provide important inferences on the sources of halogens in the Earth's mantle. The method has now been applied to submarine glasses from Atlantic, Indian and Pacific mid-ocean ridges (MORB), ocean island basalts (OIB) with variable $^3He/^4He$ associated with EM1, EM2, HIMU and FOZO mantle end-members (Pitcairn, Society, Samoa, St Helena, Foundation and Baffin Island); backarc basin basalts (BABB) from Manus, Woodlark, N. Fiji and Lau and a boninite from the Tonga arc.

Systematic co-variation of Cl, Br, I, K and H_2O indicates lavas from the Galapagos Spreading Centre, NW Lau, central Manus, and Samoa assimilated seawater components in brines with 55±15 wt % salts. In these cases assimilation in crustal magma chambers accounts for up to 95% of the melts total Cl and 40% of the total H_2O; whearas assimilation was not detected in melts at the other locations investigated.

The expanded dataset for samples deemed free of assimilated seawater define indistinguishable MORB and OIB Br/Cl of $(2.7\pm0.7)\times10^{-3}$, I/Cl of $(6\pm4)\times10^{-5}$, and a median K/Cl of 17±6. Together with mantle K, and estimated surface inventory, these data refine BSE concentration estimates to 17±7 ppm Cl, 60±40 ppb Br and 6±5 ppb I (2σ). BABB are distinguished from MORB by higher halogen content, low K/Cl and variably elevated I/Cl ratios that decrease across the arc and overlap the MORB range in subduction enriched BABB from 3/5 locations investigated. The data confirm the Earth is depleted in Cl, Br and I relative to CI chondrites, and reveal that halogens (concentrated in the surface reservoir) were introduced into the modern mantle almost exclusively by subduction.