Origin, distribution and residence of halogens in the North Atlantic Craton, Greenland

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The Earth's sub-continental lithospheric mantle (SCLM) has been isolated from mantle convection since its formation over 2.5 Ga years ago. Since its isolation, the SCLM has undergone varying degrees of metasomatism by halogen-rich fluids, as evidenced by the mineralogical and chemical composition of mantle xenoliths. However the origin of these volatiles, and their abundance, distribution and residence time in metasomatised SCLM is virtually unconstrained.

Ultramafic lamprophyre (UML) magmas are sourced in the asthenosphere, but interact with overlying SCLM during ascent. The asthenosphere is depleted and largely homogeneous in terms of halogen concentrations, therefore UML magma compositions are expected to be particularly sensitive to addition of halogens from metasomatised SCLM.

Here, we present novel combined elemental concentration (F, Cl, and Br) and isotopic (δ^{37}Cl) halogen data for UML and entrained metasomatised xenoliths from the North Atlantic Craton (NAC). The UML have δ^{37}Cl values of +1.0‰ to +1.2‰, consistent with recycled halogens in the UML source region. The Br/Cl composition of the UML ranges from 0.0047 to 0.0049, precluding derivation from an asthenospheric source. Br/Cl ratios of phlogopite recovered from entrained mantle xenoliths are remarkably high, ranging from 3.5 to over 80 times greater than Br/Cl ratios of MORB. These data are consistent with a scenario in which halogen-enriched fluids were liberated from a subducting plate beneath the NAC during the Palaeoproterozoic Ketilidian orogeny. This led to the percolation of halogen-enriched fluids into, and metasomatism of the NAC. This metasome was later sampled by later UML magmatism.

In conclusion, halogen delivery to the SCLM via subduction maybe a major, yet overlooked process, and the SCLM may represent a significant sink of halogens during global geochemical cycling.