Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.29008

Fluorine- and bromine-rich cratonic mantle roots: a perspective from alkaline rocks

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The cratonic mantle lithosphere has been shown to have a large halogen inventory, resulting from comprehensive, multistage metasomatism by deep mantle melts including carbonate-rich melts. However, natural carbonatites and kimberlites show highly variable halogen contents, indicating that the behavior and compositions of halogens in carbonate-rich melts and in metasomatized cratonic mantle domains remain poorly constrained. Primitive intraplate alkaline rocks at Aillik Bay in Labrador, eastern Canada, are the closest analogues for incipient mantle melts formed by melting at the base of metasomatized lithosphere during three stages of lithospheric thinning and rifting of the North Atlantic craton. Here we present halogen data (F, Cl, Br, I) for ca. 1.4 Ga lamproites, 590–555 Ma ultramafic lamprophyres and carbonatites, and 142 Ma nephelinites from Aillik Bay. Compared to MORBs, the lamproites and ultramafic lamprophyres, which originated from 150-180 km depths, have high F content (1260-6040 ppm), similar I/Cl ratios but high Br/Cl ratios (1.5-13.3×10^{-3} molar). Although degassing probably resulted in the depletion of Br and Cl contents in these dyke samples, the high Br/Cl ratios inherited from the metasomatized mantle source indicate the presence of a Br-rich reservoir in the cratonic root. The Mesozoic nephelinites derived from shallower depths of 70-90 km show high F contents (1470-2430 ppm), MORB-like Cl, Br and I contents as well as Br/Cl ratios (0.5-1.0×10^{-3} molar), lower than those of the more deeply derived potassic magmas. Thus, we suggest that deep volatile-rich magmas are characterized by high F and Br contents. These data reveal that fluorine- and bromine-rich cratonic mantle roots formed by metasomatism, as also suggested by the occurrence of significant amounts of F-rich minerals and high bulk Br/Cl ratios (3.9-19.2×10^{-3} molar) in cratonic mantle peridotite xenoliths.