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Halogens in melt inclusions trace recycled mantle lithologies

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Primitive melt inclusions are key archives of mantle heterogeneity, which causes geochemically diverse primary melts to be supplied to magmatic systems. Halogens are incompatible and fluid-mobile elements that become concentrated in altered oceanic lithosphere through serpentinization. Subduction causes halogens to be recycled into the mantle, from whence they may be returned to the surface through partial melting and magmatism at ocean islands. This makes halogens potentially excellent tracers of recycled subducted lithologies in the Earth's mantle.

To explore the utility of halogens as geochemical tracers of recycled subducted material, we have measured F, Cl, Br, and trace elements in melt inclusions from Iceland and the Canary Islands. Melt inclusions from Iceland's off-axis flank zones are enriched in incompatible trace elements compared to those from the active neovolcanic rift zones, and their enriched signature is attributed to the contribution of deep melts from a recycled pyroxenitic mantle component. These compositional differences are reflected in halogen abundances and ratios. Melt inclusions from Iceland's neovolcanic zones typically contain 60-600 ppm F and 30-300 ppm Cl, with an average F/Cl ratio of ~2.7-3.0. In contrast, melt inclusions from the Snaefellsnes Peninsula flank zone contain 500-1100 ppm F, 450-700 ppm Cl, and have average F/Cl of ~1.4. Our analyses suggest that Icelandic melt inclusions contain <3 ppm Br, but accurate measurement of low Br contents in basaltic melt inclusions remains technically extremely challenging.

The high halogen contents and low F/Cl ratios of melt inclusions from Iceland's flank zones are similar to melt inclusions from the 2021 Cumbre Vieja eruption, Canary Islands, which contain 900-1800 ppm F, 450-1200 ppm Cl, and have average F/Cl of ~1.9. Numerous studies have demonstrated the importance of recycled pyroxenite-rich peridotite in generating the isotopic and trace element characteristics of Canary Islands magmas. Our data suggest that high F and Cl contents coupled with low F/Cl could be characteristic fingerprints of melts derived from recycled subducted mantle lithologies, while melt inclusion compositions from Iceland's neovolcanic zones suggest that plume-like mantle sources may be relatively halogen-poor.