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Chlorine isotope heterogeneity in the convecting mantle from deeply subducted lithosphere

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Subduction of volatile-bearing lithosphere into the mantle can affect the chlorine isotope composition ($\delta^{37}Cl$) of the convecting upper mantle. Previous studies have examined the $\delta^{37}Cl$ values of mantle-derived mid-ocean ridge basalt (MORB) and ocean island basalt (OIB) glasses, but large inter-study discrepancies and a paucity of data have prevented a consensus on the $\delta^{37}Cl$ values of different chemical reservoirs in the mantle. We measured the $\delta^{37}Cl$ values of basaltic glasses via SIMS from well-studied HIMU and EM OIB suites that sample deeply subducted lithosphere, as well as MORB, to determine the extent and source of subduction-derived $\delta^{37}Cl$ heterogeneity in the convecting mantle. We also measured the oxygen ($\delta^{18}O$) and boron ($\delta^{11}B$) isotope compositions of these glasses via SIMS to constrain assimilation of seawater-altered material.

HIMU $\delta^{37}Cl$ values range from -2.7‰ to +1.5‰ (±0.5‰, average 2SE), consistent with previously published data, but extending to higher and lower $\delta^{37}Cl$ values. This $\delta^{37}Cl$ range is similar to the range observed in altered oceanic crust (AOC), supporting the argument that the HIMU mantle source contains deeply subducted AOC. EM $\delta^{37}Cl$ values range from +0.7‰ to +2.8‰ (±0.4‰, average 2SE), significantly higher than estimates of depleted MORB-source mantle (DMM) $\delta^{37}Cl$ values. These ^{37}Cl-enriched values are higher than subducted sediments, indicating either an additional subducted source of Cl in the EM mantle or isotopic fractionation of Cl during subduction.

MORB $\delta^{37}Cl$ values range from -0.9‰ to +0.7‰ (±0.3‰, average 2SE). MORB samples with Cl/K>0.1 extend to the lowest $\delta^{37}Cl$ values, consistent with assimilation of low-temperature fluids or altered crust prior to eruption. For samples without signs of assimilation, the average $\delta^{37}Cl$ value ≈ 0.3‰. However, there are strong correlations between Mid-Atlantic Ridge (MAR) MORB $\delta^{37}Cl$ values and element ratios (e.g. K_2O/TiO_2) and radiogenic isotope ratios (e.g. $^{143}Nd/^{144}Nd$). The most depleted MORB samples have $\delta^{37}Cl$ values ≈ -0.3‰, similar to previous DMM $\delta^{37}Cl$ value estimates. The most enriched MORB samples have $\delta^{37}Cl$>0.7‰, indicative of higher $\delta^{37}Cl$ values due to a subducted crustal component. This work indicates that subducted lithosphere can introduce significant Cl isotope heterogeneity to the DMM as well as deep mantle plume sources.