Isotopic constrains on the origin of sulfur in the Icelandic oceanic crust and hotspot

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Isotopes can be used to constrain the present occurrence and cycling of sulfur in the Earth, at both deep and shallow levels. Within the oceanic crust, sulfur is sourced from the mantle through volcanism and degassing as well as from seafloor alteration, sedimentation and microbial processes. Hitherto, most samples studied to constrain the sulfur characteristics of the mantle and oceanic crust come from submarine systems affected by seawater. Thus, it is difficult to distinguish between secondary crustal processes modifying the isotopic composition and the multiple sources of sulfur in the systems. Here we present chemical and isotope data ($\delta^{33}S$, $\delta^{34}S$, $\delta^{36}S$, $\delta^{56}Fe$, $\delta^{18}O$) of subglacial volcanic glasses, melt inclusions, crustal sulfides and sulfates and hydrothermal fluids from Iceland. The data presented include locations where the mid-oceanic ridge is above sea level and free of seawater influence, samples of submarine origin and samples affected by the Icelandic mantle plume source. Hence, the dataset provides an opportunity to constrain the mantle sulfur isotope composition, identify possible mantle heterogeneity, and assess the effects of secondary crustal processes such as hydrothermal activity on the sulfur isotope values of mafic rocks and minerals. The data display large variability in $\delta^{34}S$ values from -11.6 to +10.5‰ (H_2S) and -1.0 to +24.9‰ (SO_4) for hydrothermal fluids, -2.5 to +0.1‰ for subglacial volcanic glasses and melt inclusions and -3.2 to +24.9‰ for sulfides and sulfates. Applying isotope geochemical modeling (IsoGEM) to the dataset to quantify sources and reactions, we conclude that majority of sulfur in the Icelandic oceanic crust derives from a mantle (MORB) source with a minor seawater contribution. Both primary and hydrothermal sulfides and minor sulfates are present in the crust, with sulfur in hydrothermal fluids primarily derived from leaching of crustal sulfides and rocks with insignificant direct gas input. We have further constrained the mantle sulfur flux of Iceland using $S/^3He$ values in gases and basalts and the ^3He flux estimates and basaltic emplacement rates with pre-eruptive magma source estimates, as well as seawater sulfur contribution for submarine geothermal systems.