Radiogenic and stable Sr isotope ratios as tracers of silicate and carbonate weathering in Iceland

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Several studies have examined the geochemistry of Icelandic rivers to quantify the role of basalt weathering in the long-term C cycle. Recently, Jacobson *et al*. (2015)[1] used Ca isotope ratios ($\delta^{44/40}$Ca) to trace sources of Ca in glacial and non-glacial rivers. The study concluded that significant amounts of Ca derive from hydrothermal calcite rather than basaltic silicate minerals, particularly in glacial watersheds where mechanical erosion rates are high. Because Icelandic hydrothermal calcite contains mantle C, long-term CO_2 consumption rates determined from riverine Ca and alkalinity fluxes are likely lower than previously realized.

To test these results – especially the impact of calcite weatheirng on riverine dissolved loads – we measured radiogenic and stable Sr isotope ratios (^{87}Sr/^{86}Sr and $\delta^{88/86}$Sr, respectively) for the same river, rock, and mineral samples analyzed in Jacobson *et al*. (2015). On a plot of ^{87}Sr/^{86}Sr versus Ca/Sr, rivers display three-component mixing between basalt, hydrothermal calcite, and precipitation (assumed to resemble seawater). In non-glacial rivers, Sr derives from basalt and precipitation (60 – 67% and 33%, respectively) with a small contribution from calcite (1 – 9%). In glacial rivers, Sr originates from basalt and calcite (61 – 89% and 2 – 31%, respectively), with a small contribution from precipitation (9%).

Icelandic rivers have higher $\delta^{88/86}$Sr values compared to bedrock. On average, glacial and non-glacial rivers have $\delta^{88/86}$Sr values of 0.412‰ and 0.388‰, respectively, while basalt has a $\delta^{88/86}$Sr value of 0.256‰. However, on plots of $\delta^{88/86}$Sr values versus ^{87}Sr/^{86}Sr and Ca/Sr ratios, three-component mixing between basalt, calcite, and precipitation best explains riverine data. The combined interpretation of all tracers suggests that fractionation during weathering is not required to explain riverine $\delta^{88/86}$Sr values. To the extent our findings for Iceland apply to other basaltic settings (which remains to be demonstrated), we suggest that downturns in the marine ^{87}Sr/^{86}Sr record attributed to basalt weathering on the continents cannot be used to estimate long-term CO_2 drawdown rates without first accounting for the calcite weathering contribution.

[1] Jacobson *et al*. (2015) Earth. Plan. Sci. Lett. **416**, 132-142.