Snowmelt initiates an additional source of silicon to streams in Yellowstone National Park, USA

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Continental hotspot settings display among the highest silicate weathering rates on Earth. In these volcanic regions, hydrothermal fluids act as an additionnal source of acids – beside atmospheric CO_2 – for weathering reactions and thus, hydrothermal contributions largely control river weathering fluxes. However, the influence of seasonal runoff variability on the weathering fluxes remain poorly constrained, generating uncertainties on the estimates of associated atmospheric CO_2 consumption. Here we use stable silicon isotopes ($\delta^{30}Si$) and the germanium to silicon ratio (Ge/Si ratio) as geochemical tracers to assess the sources and processes controlling dissolved Si weathering fluxes in Yellowstone National Park, USA.

We determined the $\delta^{30}Si$ and Ge/Si ratios of 8 hydrothermal springs and 14 rivers in samples collected in September (at base flow) and June (spring, high discharge, during snowmelt) across 2016-2017. Elevated riverine Ge/Si ratios (29 ± 3 $\mu mol.mol^{-1}$) at base flow can be explained by a dominant contribution from hydrothermal springs (159 ± 16 $\mu mol.mol^{-1}$). During snowmelt, decreasing Ge/Si ratios in rivers and increasing dilution-corrected Si concentrations ($Si/Na_{river\ snowmelt} > Si/Na_{river\ baseflow}$) suggest an additional Si contribution to rivers in spring. Higher subsurface runoff at snowmelt may release soil solution influenced by (i) dissolution of primary minerals from rhyolite ($\delta^{30}Si_{snowmelt} < \delta^{30}Si_{baseflow}$) or (ii) clay mineral formation ($\delta^{30}Si_{snowmelt} > \delta^{30}Si_{baseflow}$) in smaller drainage basins with low discharge and higher soil water residence time. Our results demonstrate that the variability in seasonal runoff during snowmelt adds pulses of Si derived from meteoric weathering processes to riverine Si fluxes. This seasonal weathering signal, previously unaccounted for in hydrothermally active volcanic regions, directly contributes to atmospheric CO_2 consumption.