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Ge/Si and $\delta^{11}B$ for quantifying hydrothermal inputs in river solute fluxes in active volcanoes in the Southern Andes

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Rivers draining volcanic regions are key to the global flux of solutes towards the ocean and in the consumption of atmospheric CO_2 through silicate weathering[1]. However, in active volcanic regions degassing and hydrothermal inputs can be an additional supply to weathering fluxes from high-temperature water-gas-silicate reactions[2,3]. Continental volcanic arcs, such as the Southern Andes, are characterized by multiple surface hydrothermal manifestations and substantial degassing. Therefore, subduction volcanic systems may play a greater role in consuming CO2 released through degassing and hydrothermal alteration. Here we focus on the Southern Andes as one of the most active volcanic provinces[4] with more than 200 hydrothermal manifestations[5]. Due to distinctive elevated Ge/Si ratios[6] and low $\delta^{11}B$[3] values in geothermal springs, combining both tracers might prove a viable method for quantifying hydrothermal inputs to river solute fluxes.

We sampled 22 rivers and 15 hot-springs at high and low discharges from different volcanic basins in the Southern Andes. The volcanic basins present waters of the calcium/magnesium bicarbonate type and the relationship between the Ca+Mg flux and the cationic Na flux is consistent with silicate weathering of mostly basalt-andesite to andesite rocks. Using Ge/Si and the relation between Cl/B vs $\delta^{11}B$ it is possible to identify rivers affected by hydrothermal inputs with both tracers agreeing in most cases. In these rivers, the dissolved cation load from hydrothermal activity varies between 6.9% and 98.4%, in line with the global average of ~40% from other volcanic regions. These estimates show that high-temperature silicate weathering fraction in the Southern Andes represents 4.4% and 82.3% of the total solute weathering budget. Our results underline the importance of estimating hydrothermal inputs to solute fluxes in large volcanic regions to improve our understanding of the silicate weathering feedback on the global carbon cycle.

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