

Sulfate Isotopes insights into pyrite oxidation and microbial sulfate reduction in the Himalayas

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Eroding hillslopes in mountain belts such as the Himalayas stimulate the chemical weathering of freshly exhumed rocks, including the trace mineral pyrite (FeS_2), which oxidizes in the presence of oxygen to generate dissolved sulfate (SO_4^{2-}) in rivers. However, in addition to pyrite oxidation, dissolved SO_4^{2-} can also be sourced from rapidly dissolving evaporites. The isotopic composition of sulfate ($\delta^{34}\text{S}_{\text{SO}_4}$ and $\delta^{18}\text{O}_{\text{SO}_4}$) has been utilized to resolve the sources of dissolved SO_4^{2-} . However, sulfate isotopes may not be conservative tracers of weathering lithologies if secondary processes such as microbial sulfate reduction (MSR) in anoxic environments in soils, aquifers, and riparian zones subsequently overprint the isotopic signals. While MSR's impact on $\delta^{34}\text{S}_{\text{SO}_4}$ is dampened due to subsequent re-oxidation of the reduced sulfur, $\delta^{18}\text{O}_{\text{SO}_4}$ is particularly sensitive to secondary processes. Microbial sulfate reduction proceeds with oxygen isotope equilibrium with meteoric water, which shifts the $\delta^{18}\text{O}_{\text{SO}_4}$ values heavier. Here, to derive fresh insights into pyrite oxidation and MSR in mountain belts, we analyze the $\delta^{34}\text{S}_{\text{SO}_4}$ and $\delta^{18}\text{O}_{\text{SO}_4}$ in a suite of river samples across an elevational and erosional gradient in the Alaknanda and Bhagirathi catchments in the Himalayas. We find that $\delta^{18}\text{O}_{\text{SO}_4}$ values progressively increase downstream as the erosion rate lowers, suggesting a tectonic and landscape control on MSR in the Himalayas.