An isotopic and mass balance framework for sulfate redox processes from the Andes mountains to Amazon floodplain

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Mountainous terrains exhibit rapid weathering rates due to physical erosion that supplies fresh minerals. When this weathering involves carbonic acid, it leads to CO_2 consumption. Sulfide minerals such as pyrite are common in rapidly eroding environments, and when oxidized produce sulfuric acid. As a weathering agent sulfuric acid can lead to CO_2 release if carbonate rocks are weathered. When sulfate released from pyrite oxidation is reduced to H_2S or a secondary sulfide mineral, some of the associated CO_2 release is negated. Previous work has shown that the majority of weathering in the Andes is from sulfuric acid (and therefore releases CO_2), while in the Amazon floodplain the majority of weathering is from carbonic acid (and therefore consumes CO_2). The open question remains, however, of what happens to the sulfate that is released from pyrite oxidation as it moves from its mountainous origin across a tropical floodplain. Here, we employ dual isotopic measurements of aqueous sulfate ($\delta^{34}S$ and $\delta^{18}O$) to understand the fate of sulfate released from pyrite oxidation and the associated carbon cycle implications. We employ three different interpretive frameworks (dual isotopes, oxygen isotope gradient and sulfate mass balance) to show that sulfate released from pyrite oxidation in the Andes does not undergo any quantitatively significant redox recycling of sulfate – and therefore no negation of CO_2 release. Our results support the hypothesis that uplift and erosion of sedimentary rocks rich in sulfide minerals drives the release of CO_2 on geologic time scales.