

Glacial weathering, sulfide oxidation, and the geologic evolution of CO₂

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Links between glaciation, chemical weathering, and the carbon cycle have the potential to influence global climate over timescales from Quaternary cycles to Snowball Earth events. In this work, we present a new compilation of hydrochemical data from glacierized catchments, aiming to synthesize recent decades of research and gain a synoptic understanding of the first-order influence of glaciation on weathering and climate-carbon cycle feedbacks.

By comparing data from our new compilation to weathering signatures from non-glacierized rivers, we gain insight into the dominant chemical reactions associated with glacial weathering globally. Total weathering yields from catchments in our compilation are ~2x higher than the global average weathering yields. Our analysis confirms previous suggestions that glacierized weathering is, on average, characterized by a greater predominance of weathering of trace sulfide and carbonate minerals when compared to non-glacierized weathering. We attribute these high fluxes to increases in physical erosion rates associated with glaciation, exposing highly reactive pyrite to oxidation.

To assess the carbon cycle implications, we use an inversion of solute sources to predict the ratio of alkalinity to dissolved inorganic carbon (DIC) generated by weathering reactions in glacierized river catchments. For the majority of model solutions, this ratio is between one and two, meaning that pyrite weathering is largely buffered by production of rock-derived alkalinity. Thus weathering is unlikely to act as a major CO₂ source over Quaternary glacial-interglacial cycles. However, inferred alkalinity:DIC ratio < 2 suggests that glacially-driven pyrite weathering may act as a net source of CO₂ to the atmosphere-ocean system over longer timescales. This source could act as a negative feedback preventing runaway glaciation over million-year timescales, a conclusion that contrasts with the more widely discussed notion of glacially-driven silicate weathering acting to remove atmospheric CO₂.