

High Arctic rivers: a transient source or sink for atmospheric CO₂?

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The chemical weathering of silicate rocks is a long-term sink for atmospheric CO₂ and is a fundamental process controlling climate in the long-term carbon cycle. However, enhanced oxidation of sulfide minerals in glaciated regions may act as a source for CO₂, counteracting CO₂ consumption by silicate weathering.

Here we present dissolved riverine solute chemistry, $\delta^7\text{Li}$ and $^{87}\text{Sr}/^{86}\text{Sr}$ measurements, with coupled $\delta^{34}\text{S}$ - $\delta^{18}\text{O}$ in sulfate from the Zackenberg River Catchment (ZRC), NE Greenland to quantify the balance of silicate, carbonate and sulfide mineral weathering in this glacial-fed and permafrost dominated high Arctic river. These tracers will allow for the determination of how cryogenic weathering processes control CO₂ release or drawdown in pristine Arctic environments which is crucial to understand future global warming.

The data show the relative proportions of silicate:carbonate:sulfide mineral weathering vary throughout the melt season. Strontium isotopic data in the Zackenberg River reflect mixing from two dominant lithologies within the catchment. Increasing Ca/Na with increased permafrost active layer thaw depth suggest increased proportions of carbonate weathering. The Li-isotopic composition also increases with active layer thaw, indicative of greater silicate weathering intensity. The S-isotopic composition in sulfate suggest the source of sulfur is from the oxidation of pyrite from two different lithological sources.

Taken together, these data indicate that the ZRC has the potential to switch between a transient sink and source of CO₂ throughout the melt season, depending on the extent of glacial melt and permafrost thaw. These findings provide important new insights into how cryogenic weathering processes may vary seasonally, thereby controlling CO₂ removal and release in the high Arctic.