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Impacts of warming and permafrost thaw on chemical weathering and riverine carbon fluxes on the Qinghai-Tibet Plateau

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Climate warming and associated permafrost thaw can have multi-faceted impacts on carbon fluxes from organic and inorganic sources. Permafrost thaw unlocks large stores of organic carbon that can be mineralized and emitted as carbon dioxide (CO_2) from rivers to the atmosphere, or transported downstream. Concurrently, permafrost thaw exposes minerals to weathering reactions that can both sequester or emit carbon. Finally, climate warming can affect reaction kinetics and the cycling of reactive fluids through the subsurface. To date, the tradeoff between these competing effects and their net effect on landscape-scale carbon fluxes remain unclear.

Here, we present fluxes of dissolved solutes, riverine CO_2 emissions, and carbon-isotope data from rivers that drain over 700,000 km^2 of the Qinghai-Tibet Plateau, and that span a gradient in permafrost cover and temperature. Our data provide evidence for an interplay of organic-carbon degradation and inorganic chemical weathering that appear to modulate the balance of carbon sinks and sources. We find that net CO_2 drawdown-fluxes from rock-weathering across the region account for ~35% of river CO_2 emissions. Importantly, chemical weathering and organic carbon fluxes vary across the sampled permafrost gradient. In catchments underlain by continuous permafrost, CO_2 drawdown from chemical weathering accounts for only ~15% of riverine CO_2 outgassing. Conversely, carbon drawdown from weathering substantially outpaces riverine emissions in catchments with discontinuous or isolated permafrost.

Based on these results, carbon fluxes from chemical weathering may become increasingly important with ongoing permafrost thaw, potentially even outpacing riverine CO_2 emissions. In landscapes where carbonate and silicate weathering dominate – such as over a large part of the QTP – a substantial portion of additional CO_2 production from permafrost thaw could, therefore, be buffered by weathering on human timescales.