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Quantifying rock organic carbon oxidation from mountains to floodplains using rhenium and its isotopes

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Weathering of rocks transfers carbon between the geosphere and the atmosphere, moderating long-term climate and Earth habitability. Oxidative weathering of petrogenic organic carbon (OC_p) is a source of CO_2 comparable to the CO_2 sink flux from silicate weathering. Despite growing recognition of the importance of oxidation of OC_p in the global carbon cycle, we lack knowledge regarding the environmental controls on these fluxes, and methods to quantify them in the present day and in geological time.

Erosion has emerged as an important control on oxidative weathering of OC_p as it controls the supply of fresh material to the oxygenated weathering zone. However, transit times of eroded material through these environments are fast, and not all material can react, leading to a substantial export of unweathered material from mountains. This material may then enter floodplain environments where warm, wet, oxic conditions combined with a slower transit time could provide favourable conditions for exported OC_p to react. The relative importance of these different environments for OC_p oxidation is not well constrained, but has important implications for the varying global flux of this reaction over time on the timescales of geomorphic change.

Here we investigate oxidation of OC_p over the transition from the Andes to the Amazon floodplain in southeast Peru. We use dissolved rhenium (Re) alongside the newly emerging Re isotope system ($\delta^{187}Re$) to trace oxidation of OC_p. A large sample set of waters, sediments, and bedrocks were collected from the Madre de Dios basin over two field seasons in 2019 and 2023. Dissolved major ion chemistries are used to quantify silicate, carbonate, and sulfide weathering fluxes, and the dissolved Re concentration proxy is used to estimate the OC_p oxidation flux. We present a novel dataset of $\delta^{187}Re$ measurements to better constrain and quantify the oxidative weathering intensity of OC_p between mountains and floodplains and discuss the relative importance of these landscapes for OC_p oxidation. We consider how the $\delta^{187}Re$ of weathering products records oxidative weathering processes, and what Re isotopes could tell us about oxidative weathering of OC_p in Earth history.