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Incubation experiments reveal that microbial activity likely drives oxidation of petrogenic organic carbon in sedimentary rocks

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In the geological carbon cycle, carbon can be stored in sedimentary rocks as petrogenic organic carbon (OC_{petro}) on timescales of millions of years, before re-emerging to the surface via orogenesis and erosion. The Earth sciences community has classically accepted that this refractory carbon is largely unaffected by weathering, and that it returns to sediments after erosion in a cycle operating as a “closed loop”.[1] However, recent research shows that the oxidative weathering of OC_{petro} in montane landscapes results in significant CO_2 fluxes towards the atmosphere.[2,3] To better understand the mechanisms involved, we incubated marly limestone and shale material from the Terre Noire region of the Prealps, France, a badland landscape known to display temperature-sensitive *in situ* CO_2 emissions and seasonally variable microbial biomass. Surface regolith (ca. 0–5 cm depth) and subsurface rock (ca. 5-10 cm) was retrieved from two catchments with different OC_{petro} (0.45–0.78% wt.) and carbonate (30–45% wt.) contents, transferred to airtight bottles with saline media and CO_2-free headspace, and incubated at 4, 10, 16, 30 and 40 degrees Celsius. Half of the bottles were sterilised with mercuric chloride ($HgCl_2$) prior to incubation. The gas phase was monitored weekly for four weeks and analysed for $CO_{2(g)}$ concentrations and stable isotopic (^{13}C) composition. Early terminations of triplicate bottles allowed us to monitor changes in microbial biomass and community composition during the incubation experiment, using phospholipid fatty acids, and 16S rRNA and fungal ITS sequencing, respectively. Our data reveal that microorganisms accelerated the oxidation of OC_{petro} at higher temperatures, particularly in the higher OC_{petro}-containing material. This work demonstrates that the temperature sensitivity of CO_2 fluxes from sedimentary rocks operates predominately via temperature control on microorganisms, bringing us one step closer to understanding the mechanics behind oxidative weathering in sedimentary rocks.

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