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Climate controls on carbon dioxide release from sedimentary rock weathering: Insight from in-situ measurements and carbon isotopes

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Erosion and weathering play key roles in the geological carbon cycle, controlling atmospheric carbon dioxide (CO_2) concentrations and Earth's climate. Silicate mineral weathering has been a focus because it draws down CO_2 and acts as a negative (stabilising) feedback on climate change and carbon cycle perturbations. Silicate weathering reactions and their sensitivity to temperature are thought to be crucial for sustaining habitable conditions at Earth's surface. However, a growing body of work shows that when sedimentary rocks are weathered they can release CO_2 at rates that locally exceed silicate weathering drawdown, via two pathways: i) the weathering of organic carbon in rocks can release CO_2 (a "geo-respiration"); ii) oxidation of sulfides can produce acid that results in CO_2 release from carbonate. Sedimentary rocks dominate Earth's surface area, but the rates and controls on these carbon emissions remain poorly constrained.

Here we present a new approach to quantify oxidative weathering by tracking CO_2 and its isotopes (stable C isotopes, radiocarbon) directly. Detailed measurements of CO_2 flux and isotopic composition were made over 2.5 years at the Draix-Bleone Critical Zone Observatory, France. Large seasonal changes in CO_2 flux released from rock organic carbon and carbonate where observed. The fluxes increase dramatically with temperature, with fluxes doubling over 10 degrees of temperature rise [1].

A similar temperature response has now been measured from weathering mudrocks in New Zealand [2], where a 7 day measurement period revealed dynamic weathering of rock organic carbon linked to the ambient hydroclimate. There, carbon isotopes show CO_2 dominated by an organic source from rocks, and in the absence of a carbonate buffer pCO_2 concentrations can regularly exceed 10,000 ppm in the shallow subsurface. Together, this new approach shows that oxidative weathering of sedimentary rocks could act as a positive feedback in the Earth system. So - is the weathering thermostat faulty? This new work calls for efforts to better constrain oxidative weathering fluxes and their temperature response to understand how the geological carbon cycle has operated.

[1] Soulet et al., (2021), *Nature Geoscience,* 14, 665-671
[2] Roylands et al., (2022), *Chemical Geology,* 608, 121024