Carbon dioxide from crumbling coasts: Rock weathering as a carbon source

Overview
The global carbon cycle controls Earth’s climate by the release and removal of carbon dioxide (CO₂) from the atmosphere. A major CO₂ emission occurs when sedimentary rocks are weathered, and this plays a central role in the geological carbon cycle, releasing as much CO₂ as volcanism (Hilton and West, 2020). The CO₂ source can come from two processes, first through the oxidation of organic carbon in rocks, a so-called “geo-respiration”. Second, sulfide minerals can oxidise and produce sulfuric acid which can release CO₂ from carbon minerals. The rates of these reactions and the controls on them have remained challenging to study. However, new methods allow us to measure the release of CO₂ during sedimentary rock weathering directly in the field (Soulet et al., 2021), using carbon isotopes to track the carbon source and pathway.

Previous work has shown that physical processes that fracture and grind up rock can enhance sedimentary rock weathering (Hilton and West, 2020). This makes regions of active tectonic uplift hotspots of CO₂ release, where landslides and erosion processes rapidly expose minerals to oxygen (Bufo et al., 2021). In these settings, the weathering of sulfides and rock organic matter may also increase with temperature (Soulet et al., 2021). Overall, this process could act as a positive feedback in the carbon cycle.

At the intercept of these physical and climatic controls on weathering are rocky coastlines. There, rising sea level can enhance erosion and expose sedimentary rocks. These processes can occur in the absence of tectonic uplift, potentially increasing CO₂ release from rock weathering in landscapes where otherwise the fluxes are low.

To date, no measurements of CO₂ release during sedimentary rock weathering exist for rocky cliff sections. This project will untangle the physical, chemical and microbiological controls on rock weathering using a combination of field and laboratory incubations, isotope geochemistry and geomicrobiology.

Methodology
Fieldwork will be undertaken to directly measure the fluxes of CO₂ release during oxidative weathering (Soulet et al., 2021). These will be coupled with measurements of the environment of oxidation (temperature, humidity). Field locations will be selected based on capturing a range of physical and geochemical characteristics that are representative of wider areas, and have a preliminary focus on the rocky coasts of the UK. Field work in regions where tectonic uplift and rocky coast erosion combine will also be targeted (e.g. Taiwan, New Zealand).
Samples will be collected to provide key insight from bulk geochemistry (%OC, %IC, %S), organic matter reactivity (ramped oxidation), and microbial community structure (16s RNA approaches). Geochemical analyses of trapped CO$_2$ (stable isotopes, radiocarbon) will be undertaken to quantify its source. Laboratory-based incubations will further explore the drivers on this CO$_2$ release during weathering.

**Timeline**

**Year 1:** The student will receive training in the measurement of CO$_2$ fluxes from field installations, in addition to bulk geochemical and petrographic analysis of sedimentary rocks undergoing weathering. Fieldwork and site selection.

**Years 2 and 3:** More focused fieldwork to establish the rates and controls on weathering reactions in coastal outcrops. Laboratory-based studies of reaction kinetics and CO$_2$ production.

**Year 4:** The student will continue to integrate data sources and complete their thesis completion, writing papers for international journals. Conference presentation of results at relevant international conference.

**Training & Skills**

- CO$_2$ concentration and flux measurements by infrared gas analyser
- Geochemistry and sedimentary rock petrology
- Field and laboratory incubation experiments
- Stable isotopes (IRMS) and radiocarbon (AMS)

**References & Further Reading**


**Further Information**

Contact: Prof. Robert Hilton (robert.hilton@earth.ox.ac.uk)