Direct measurement of CO_2 flux and its isotopic composition released during oxidative weathering of sedimentary rocks

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On geological timescales, oxidative weathering of sedimentary rocks can result in important emissions of carbon dioxide (CO_2) to the atmosphere, and consume atmospheric O_2. The main processes are the oxidation of rock-derived organic carbon, and the weathering of carbonate minerals by sulfuric acid (produced by oxidation of sulfides). The carbon release is thought to be as large as volcanic degassing, and together these processes govern the levels of atmospheric CO_2 and O_2, and hence Earth's climate. Despite this recognition, the natural flux of CO_2 emitted to the atmosphere by the oxidation of rock-derived organic carbon during chemical weathering is still poorly constrained.

Different approaches can be adopted to better quantify this major geological CO_2 source e.g., i) geochemical proxies of chemical weathering (e.g. the trace element rhenium) in rivers that integrate indirectly the oxidation of rock-derived organic carbon at the catchment-scale; ii) directly measuring the flux of CO_2 emanating from rocks.

Here we make the first direct field measurements of CO_2 production during oxidative weathering. We do this in the Laval catchment (Draix, Alpes de Haute Provence, France), a well monitored catchment composed of outcropping shales, characterized by high erosion rates. In the field, natural oxidation chambers are made by drilling directly into the rock (typically 3cm-diameter, 40cm-length). The flux of CO_2 evading the shales is measured using a portable EGM-5 infrared gas analyser connected to the sealed chambers. So far, the measured CO_2 fluxes are high for weathering reactions, ranging from ~20 to ~160 $gC.m^{-2}.yr^{-1}$. To partition the CO_2 between organic and inorganic-derived CO_2 (i.e. that produced by sulfuric acid weathering of carbonate, versus that from geo-respiration of organic carbon), we trap the CO_2 using active and passive reversible zeolite molecular sieves. Sampled CO_2 is released, and its isotopic composition (^{12}C, ^{13}C, ^{14}C) determined. These methods provide us with the first direct measurements of geo-respiration in the environment.