Rock respiration: Sub-soil carbon oxidation in the unsaturated bedrock of a forested hillslope

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In many terrestrial environments, rooting depths extend into the weathered regolith and bedrock beneath soils. However, the effect of deep rooting on the associated storage and respiration of organic carbon (OC) via rhizodeposition and root penetration is poorly constrained, due to the difficuly of sampling water and gas in unsaturated, weathered rock. Here we present two years of data collected at the Eel River Critical Zone Observatory (ERCZO) in a novel vadose zone monitoring system (VMS) that samples water and gas over an 18 m thick, variably saturated argillite weathering profile. We observe significant CO_2 production which peaks meters beneath thin soils, leading to low pH, increased dissolved inorganic carbon (DIC), and a net efflux of CO_2 from the vadose zone to the base of the soil which persists throughout the year.

The source of this OC is critical to accurate model development for both respiration and weathering. Reasonable descriptions may involve (1) the delivery of surface-derived labile carbon through rapid transport pathways; (2) the deposition of root exudates by mature trees reaching many meters into the weathered regolith; and (3) the oxidation of lithogenic OC derived from the shale bedrock. To discern these pathways, fraction modern (FM) radiocarbon of solid phase OC recovered from drill cuttings were contrasted with gas phase CO_2 collected both at the height of the dry and wet seasons. Our analysis demonstrates a solid phase OC profile with FM values which trend from 0.25 at the top to 0.02 at the base. In contrast, the contemporanous gas phase CO_2 profiles in both dry and wet seasons are consistently FM >1.0 throughout the entire 16 m interval. These result indicate that respired OC is of a modern origin, delivered from the surface to the vadose zone, and that the concentrations of this labile source is highest between 5 – 8 m below the soil surface, thus strongly suggesting rhizodeposition.