In-situ Observations of Organic Carbon Oxidation in Shale Regolith and Implications for Bedrock Weathering

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Project Abstract:

Oxidation of organic carbon hosted in bedrock (petrogenic OC, OC_{petro}) is increasingly recognized as a source of CO_2 to the atmosphere on century and millennium timescales as sedimentary bedrock is exposed to oxidizing conditions through uplift, channel incision, and erosion. Recent studies point towards the near-surface as a region of enhanced OC_{petro} oxidative weathering in watersheds. However, we do not know how the exposure of OC_{petro} in bedrock to this dynamic, oxidative, and vegetated environment affects the rates of OC_{petro} oxidation along the gradient of environmental conditions that exist within the near-surface weathering profile. Here, we use specialized in-situ samplers distributed throughout a shale weathering profile to determine the rate of OC_{petro} oxidation at the same location where significant respiration rates have been documented in weathered bedrock. The 16 m deep argillaceous weathering profile is located along a steep, rapidly eroding hillslope in the Northern California Coast Ranges, where deep tree roots seasonally withdraw water from depths of up to 12 m. CO_2 production within the deep root zone in bedrock constitutes between 2 and 29% of the total flux of CO_2 from the ground surface. Chemical depletion of OC_{petro} in the solid phase beneath the root zone where no modern OC was present in the solid shows that OC_{petro} is removed from weathered bedrock at a rate of 0.12 $gC/m^3/year$. This rate is much smaller than the 557.1 $gC/m^3/year$ oxidation rate of OC_{petro} from lab incubations, indicating significant controls that limit the full oxidation of OC_{petro} in the weathering profile. In addition, radiocarbon analyses of the gas phase are entirely modern to 15 m, undermining the ability to determine the amount of removed OC_{petro} that is oxidized within the weathered bedrock profile. These results highlight the importance of investigating the controls on respiration of recently photosynthesized OC. This study finds that recently fixed carbon dominates respiration in a weathered bedrock profile where roots are deep, masking any potential OC_{petro} oxidation at the rates at which it is removed from the solid phase, and pointing towards further avenues of study to understand the limitations on OC_{petro} oxidation.