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Topographical controls on soil organic carbon in moist boreal forest mineral soils

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Boreal forests contain a significant portion of the global soil organic carbon (SOC) stock within a region vulnerable to climate change, yet detailed studies on the controls of this reservoir are lacking. In these moist acidic soils, soil forming processes link C dynamics and chemical weathering via organo-metal complexes (OMC), weathering products that stabilize C in the mineral soil. At the hillslope scale, microtopography influences C and water availability for these processes via its impact on flow paths, as well as the redistribution of particles throughout the landscape. Therefore, when investigating soil characteristics that control SOC content and the capacity for carbon storage, we must also consider the role of topography on the development of those characteristics.

The role of topography on SOC was investigated experimentally using soil columns built from boreal mineral horizon soils collected at different hillslope positions at the Pynn's Brook experimental watershed in Newfoundland, Canada. The gentle-sloped (6°) upslope soils had greater SOC and OMC content while the moderately-sloped (12°) downslope position was a footslope depositional zone with a higher bulk density. Solution collected from pan lysimeters installed under the organic horizon was applied to the columns as a source of dissolved organic matter and changes in particulate and dissolved organic carbon (POC and DOC, respectively) were measured.

Soil uptake of DOC was dependent on the degree to which soil OMC were already saturated with SOC, where undersaturated deep horizons sequestered significant DOC and near-saturation surface soils exhibited little net change. Downslope soils were more vulnerable to POC loss despite having less SOC, while upslope POC was more stable. Overall, vertical flow dominated the upslope soils, promoting OMC formation that controlled SOC content and C uptake, while a greater lateral flow component, reducing conditions and depositional processes operating in the downslope resulted in less OMC formation, easily mobilized POC, and consequently, lower SOC. These results highlight the variable C sequestration potential at depth in these forest landscapes and the importance of hillslope hydrology in the development of soil characteristics that control SOC content and storage at depth particularly with changing hydrology in response to climate change.

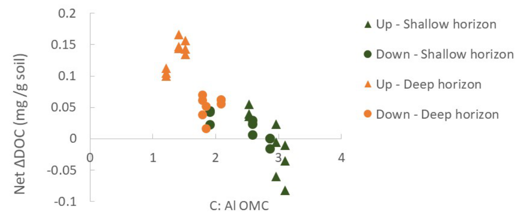

Figure 1. Dissolved organic C uptake in boreal hillslope mineral soils controlled by C saturation of organo-metal complexes (C:Al OMC)