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Elucidating the shifting controls on organic carbon cycling across a soil water content gradient

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Soil organic carbon (SOC) is stabilized principally through interactions with minerals, which provide protection from microbial enzymatic attack. Soil water content (SWC), a fundamental control on SOC cycling, dictates both plant C inputs and microbial C decomposition. Additionally, SWC affects mineral-organic stabilization mechanisms, through its influence on mineral weathering, precipitation and dissolution, and organic matter composition. At the same time, SWC is also affected by plot-scale topography and subsoil mineralogy.

To understand the effects of long-term soil moisture on SOC cycling we studied soils from upstate New York situated on a naturally occurring water content gradient, induced by plot topography and subsoil structure. Previously, it was shown that increasing long-term SWC increased SOC accumulation and decreased mineralizibility (C-CO_2per unit soil C) in these soils, while mineralizibility negatively correlated with exchangeable Ca, Mg and pH. However, it was not clear whether Ca-mediated surface interactions or occlusion in microaggregates was more important and whether other mechanisms, such as association with Fe and Al, played a role in the more acidic, Ca-poorer soils.

To test which mechanisms governed SOC stabilization we performed a sequential oxide extraction and determined the amount of C associated with each oxide phase. We also quantified C N contents, and natural isotope abundances of free and occluded particulate organic matter (fPOM and oPOM) and heavy mineral fraction. The vast majority of oxide-extractable C was in the form of Fe- and Al- organo-mineral complexes; decreasing SWC increased its contribution relative to total mineral-associated C, suggesting the importance of polyvalent cations in SOC stabilization shifted from Al and Fe to Ca. Physical fractionation of SOC indicated an increasingly microbial nature with increasing SWC. ^{13}C NMR and ATR-FTIR analyses of soil fractions are currently being used to clarify whether organic functionalities vary in composition and distribution across different water contents and contribute to differences in SOC stabilization. These results suggest that plot-scale topography and bedrock mineralogy influence SOC cycling through a combination of organic matter composition and mineralogy.