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The distribution of secondary mineral phases along an eroding hillslope and its effect on carbon stabilization mechanisms and the fate of soil carbon fractions

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Soil redistribution processes can change soil carbon (C) dynamics drastically by moving carbon from high decomposition and re-sequestration environments at the eroding hillslope to low decomposition and burial at the depositional footslope and valley basin. This leads to not only spatially diverse soil carbon storage throughout the landscape, but also to qualitative changes of the transported carbon and the mineral phase. The interaction between those parameters and the effect on stabilization mechanisms for soil C are still a matter of debate.

Here, we present an analysis that aims to clarify the bio/geo-chemical and mineralogical components involved in stabilizing C at various depths along an eroding cropped slope and how this affects the abundance of microbial derived carbon. We use the results of an incubation experiment combined with the abundance of amino sugars in different isolated soil C fractions as a tracer for the stability of the respective fraction. We applied further (i) a sequential extraction of the reactive soil phase using pyrophosphate, oxalate and dithionite-citrate-bicarbonate, and (ii) a qualitative analysis of the clay mineralogy, to analyze the changes in the mineral phase for the different isolated fractions along the slope transect.

Our results emphasize the importance of physical protection within microaggregates to stabilize buried, chemically labile C. Our data further indicates that the stability of these aggregates is related to the presence of organo-mineral associations and poorly crystalline minerals. However, decreasing contents of these minerals with depth indicate a temporal limitation of this stabilization mechanism. Non-expandable clay minerals experience a relative enrichment at the depositional site while expandable clay minerals experience the same at the eroding site. These changes in clay mineralogy along the slope are partly responsible for the abundance of silt and clay associated C and the effectiveness of the clay fractions to stabilize C. In summary, our data clearly show that a variety of stabilization mechanisms together with changes in the organic and the mineral phase of soils need to be considered to understand this highly dynamic environment.