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The alteration of weathering rates by organic matter governs early pedogenesis and the evolution of initial soil microstructure

THOMAS RITSCHEL[1], MICHAELA AEHNELT[2] AND KAI UWE TOTSCHE[3]

[1]Friedrich-Schiller-University
[2]Friedrich Schiller-Universität Jena
[3]Friedrich-Schiller-Universität Jena

Presenting Author: thomas.ritschel@uni-jena.de

The translocation of clay as well as organic matter and soil aggregation are major processes of soil formation that ultimately manifest in the diagnostic soil horizons of mature soil. However, their onset might date to much earlier stages of pedogenesis where host rock weathering is still dominant and soil horizons have yet to be formed. Without a distinct topsoil horizon, litter from pioneer vegetation is often the only input of organic matter. To what extent aggregate formation is induced in this early stage of weathering and how colloid or organic matter transport facilitate aggregation is not yet comprehensively explored. Here, we present a time-lapse experiment on initial soil development that reveals the formation of aggregates and clay translocation in response to irrigation with and without organic matter released from a litter layer. We show how organic matter increases total carbonate dissolution capacity with a characteristic surface morphology, but simultaneously slows down the dissolution rate. With the dissolution of carbonates, clay minerals of the host rock and iron from pyrite are released. Depending on the presence of organic matter, the mobilized elements and colloids are either transported with the seepage water or form crusts and aggregates from clay minerals and freshly precipitated secondary iron oxides. The aggregates found in early states of weathering are therefore both inherited from the host rock as well as of pedogenic origin. Due to the distinct consequences for the weathering kinetics, the translocation and aggregation of organic matter and clay-sized minerals shape soil structure already during initial pedogenesis and control the route in which soil development becomes apparent.