More than one third of the organic carbon exposed by the world's largest thaw slump (Batagay, Siberia) is not directly available for mineralization but geochemically stabilized

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Abstract

Mineral-organic carbon (OC) interactions account for 30 – 80 % of the total permafrost OC pool. Quantifying the nature and controls of mineral-OC interactions is necessary to better assess permafrost-carbon-climate feedbacks. This is particularly true for ice-rich environments that are impacted by rapid thaw and the development of thermokarst landforms. Retrogressive thaw slumps are amongst the most dynamic forms of slope thermokarst and they expand through the years due to the ablation of an ice-rich headwall. These phenomena are important to consider in the permafrost carbon budget since they expose deep OC sometimes tens of thousands of years old that would not have re-entered the modern carbon cycle if these disturbances had not occurred. Here, we analyzed sediment samples collected from the headwall of the Batagay megaslump, East Siberia, locally reaching 55 m high. The series of discontinuous deposits comprises also older sediment up to ~650 ka old. We present total element concentrations, mineralogy, and mineral-OC interactions in the different stratigraphic units. The mineralogy in the deposits is very similar across the sedimentary series. Our data show that up to 34 ± 8 % of the total OC pool is stabilized by mineral-OC interactions. For most of the analyzed samples, associations to poorly crystalline iron oxides do not have a significant role in OC stabilization. Hypothesizing a retreat rate of 26000 m^2/yr and constant thickness of stratigraphic units within the headwall, we provide a first order estimate of ~ 2 × 10^7 kg of OC is exported annually downslope of the headwall, with ~ 38 % being geochemically stabilized by complexation with metals or associations to poorly crystalline iron oxides. These data support that more than one third of the organic carbon exposed by this massive thaw slump is not directly available for mineralization, but rather stabilized geochemically.

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