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Quantifying and characterising organic carbon in newly-developed soils following glacier retreat in northern latitudes

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Arctic and sub-arctic regions contain a globally significant reservoir of easily degradable glacial organic carbon (GOC) held within glacier ice, subglacial sediments, and proglacial sediments and soils. 21st century warming will result in global glacier retreat with the potential to expose and release GOC, degradation of which can produce CO_2 and/or CH_4 through physical, chemical or biological processes. Newly-exposed nutrient rich glacial landscapes may develop soils and ecosystems. However, current understanding of the nature of glacial carbon cycling is very weak. In this study, sources and transformations of organic carbon (OC) within proglacial environments were determined using a combination of organic biomarkers, DNA sequencing and elemental concentrations.

Soil development was characterised in three contrasting glacial systems (Oræfajökull ice cap in Iceland, Tarfala in Sweden and Zackenberg in Greenland) in order to understand the main source of OC in soils exposed after glacier retreat and soil development along downstream transects from the glacier front. Water, soil and sediment samples were collected during four successful field campaigns (Iceland and Sweden in summer 2018, Greenland and Iceland in summer 2019). Soil and sediment samples were analysed for organic carbon and nitrogen concentrations, bacteriohopanepolyol biomarkers (BHPs), a group of membrane lipids that can be used to trace major microbial groups, DNA sequencing and major elements (using ICP-OES and IC).

Soil samples from moraines showed highest OC concentrations (up to 5.5% in Iceland), while fluvial sediment samples from all study areas had low to no OC. BHPs were rare in fluvial sediments, observed in riverbank soils and most common in moraines. Both total BHP concentration and R'soil index (up to 50.5 µg/g ΣBHPs in a Little Ice Age and 0.41 R'soil in a 2500-year-old Icelandic moraines) show development of soils over time along the downstream transect from the glacier front. DNA concentrations in soil extracts are much higher than fluvial sediment samples. Particulate OC concentration in glacial meltwater streams and proglacial lakes was low (up to 0.03 mg/L), perhaps due to the high total suspended sediment concentrations (up to 0.96 mg/L) in most of the streams. Water chemistry analyses showed significant Ca, S, Na, Fe, Mg and Al concentrations, that potentially would fertilise the Arctic Ocean.

Based on these preliminary data, it can be concluded that direct glacial output of organic carbon is low, but soil and ecosystem development in front of retreating glaciers leads to the build-up of

new terrestrial OC stores. Erosion of OC from these pro-glacial landscapes by glacial meltwater might highly affect estimates of GOC. Future glacier retreat in deglaciating systems in the Arctic (Greenland and Sweden) and sub-arctic (Iceland) regions might increase terrestrial OC productivity and carbon export, as well as seeding biological production downstream.