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Soil organic matter build-up during soil formation in glacier forefields around the world

Norine Khedim[1,2], Lauric Cécillon[3,4], Jérome Poulenard[1], Pierre Barré[4], François Baudin[5], Silvio Marta[6], Ludovic Gielly[2], Roberto Ambrosini[6], Antoine Rabatel[7], Cédric Dentant[8], Sophie Cauvy[9], Fabien Anthelme[10], Levan Tielidze[11], Erwan Messager[1], Philippe Choler[2], and Francesco Ficetola[2]

[1]Université Savoie Mont-Blanc, Laboratoire EDYTEM, Le-Bourget-du-Lac, France
[2]Université Grenoble Alpes, Laboratoire d'écologie alpine, Grenoble, France
[3]Normandie Université, UNIROUEN, INRAE, ECODIV, Rouen, France
[4]Ecole Normale Supérieure de Paris, Laboratoire de Géologie, PSL Research University, CNRS-ENS UMR 8538, France
[5]Sorbonne Université/CNRS, UMR ISTeP, Paris, France
[6]University of Milan, Department of Environmental Science and Policy, Milan, Italy
[7]Université Grenoble Alpes, Institut des Géosciences de l'Environnement, Grenoble, France
[8]Ecrins National Park, France
[9]IRSTEA, Department of Waters, Antony, France
[10]IRD, Plant Architecture, Functioning and Evolution (AMAP), Marseille, France
[11]Ivane Javakhishvili Tbilisi State University, Vakhushti Bagrationi Institute of Geography, Tbilisi, Georgia

Due to the continued ice retreat with global warming, areas of deglaciated forefields will strongly increase in the future, leading to the emergence of new terrestrial ecosystems in many regions of the world. The soil chronosequences resulting from glacier retreat have long been a key tool for studies focusing on the mechanisms of soil formation and soil organic matter storage.

This study aimed at identifying general patterns in soil organic matter (SOM) build-up during the initial stage of soil formation and ecosystem development (0–500 years) in different glacier forefields around the world. For this purpose, we measured total soil organic matter concentration (C and N), its stable isotopic composition (^{13}C, ^{15}N) and its distribution in carbon pools of different biogeochemical stability over time in ten soil chronosequences on glacier forefields (four Andeans, one Canadian Rockies, one Greenland, two Alps, one Caucasus, one Himalaya). The distribution of SOM in carbon pools was estimated with Rock-Eval® thermal analysis. We then tested the effect of time and climatic variables (temperature, precipitation) on the build-up of soil organic matter (total concentration, isotopic signature and distribution in carbon pools).

We found a positive correlation between the rate of SOM accumulation and the average temperature of the warmest quarter (three-month period). We also noted significant traces of atmospheric deposition of anthropogenic origin in some forefield glaciers, particularly in the northern hemisphere. The build-up of soil carbon pools showed consistent trends across the soil chronosequences of the ten glacier forefields. During the first decades of soil formation, the very low SOM quantities were dominated by a very stable carbon with a small but significant labile

carbon pool. This may highlight the presence of organic matter derived from ancient carbon on the different forefield glaciers, decomposed by an active living trophic network of soil microorganisms. The overall stability of SOM then slowly decreased with time, reflecting the soil carbon input from plants.

We conclude that while the rate of SOM accumulation is driven by climate (air temperature of the growing season), the build-up of soil carbon pools shows a consistent temporal trajectory on the different glacier forefields around the world.