Abstract

Ongoing deglaciation in the Arctic is rapidly exposing and mobilising organic matter (OM) overridden by previous glacial advances, releasing an important biogeochemical legacy into downstream ecosystems. This thesis investigates the critical interface between glacial and proglacial zones, bridging the gap between inferred subglacial dynamics and measurable proglacial processes. Analysis of freshly thawed subglacial sediments from a wide range of retreating Arctic glaciers reveals that subglacial OM is extensively degraded by in situ microbial activity, with the resident microbial community structure correlated with ^{14}C age and decomposition stage of the organic substrate. These sediments provide sufficient phosphorus but limited nitrogen and labile carbon for early proglacial succession. Analysis of microbial assemblages exported from Arctic glaciers shows how microbial processes in the subglacial ecosystem are linked to subglacial hydrological evolution and dependent on local energy sources and identifies specific taxa as sensitive indicators of hidden subglacial microhabitats often undetectable via bulk chemistry analysis. Finally, experimental simulations of deglaciation and the associated ecosystem transition demonstrate that mixing distinct glacial substrates induces non-additive priming effects: anoxic conditions significantly enhance CH_4 production, whereas oxic conditions suppress it. Collectively, these findings establish the subglacial environment as a biogeochemical precursor that shapes the trajectory of proglacial ecological succession, with an important role of the increasingly connective supraglacial ecosystem in the process.