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Subsurface persistence of carbon degrading microbes as thawing permafrost moves between the terrestrial and marine environments

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Thawing permafrost threatens to create a positive feedback on climate change as heterotrophic microbes convert newly-available organic matter to CO_2 and CH_4. Since thawing organic carbon is transported by subterranean groundwater flow into nearby rivers or fjords, these microbial feedbacks involve communities in thawing permafrost as well as those in hydrogeologically-connected soils. Greenhouse gas emissions at the soil surface are an amalgamation of the microbial activity in all the layers underneath, so knowing the vertical layering of microbial communities is key to understanding the mechanisms of these climate change feedbacks. Svalbard, Norway (79°N) is experiencing faster warming than the rest of the high Arctic, making it a bellwether for Arctic permafrost. We examined *in situ* microbial communities using metagenomics, culturing, and extracellular enzyme assays from the surface down to 60 cm in cores collected in the active layer while frozen in April 2018 and while thawed in September 2019. We compared the vertical layering of these communities to those found in the adjacent marine fjord sediments using 16S rRNA gene libraries, metagenomics, metatranscriptomics, and metaproteomics. The active layer exhibited abrupt shifts in microbial communities with depth, switching between different classes of Acidobacteria and Actinobacteria every ~10 cm. Fjord sediments were dominated by Proteobacteria that did not change abruptly with depth. However, the class Woeseiales showed transcriptional changes with depth, suggesting that some microbes enter a modified dormant state as they are buried past the reach of their preferred electron acceptor. We suggest that these two communities, who together will be responsible for metabolizing the newly thawed carbon, respond differently to environmental depth gradients. The abrupt changes in active layer soil microbes may be caused by different availability of liquid water, since temperature transmission from the air is buffered by water phase changes in the upper layers of soil. Vertical layering of microbial communities in the marine fjords, on the other hand, appears driven by gradually diminishing access to electron acceptors. However, the abundant ferric iron in Svalbard reoxidizes sulfide produced through sulfate reduction, creating a deeper penetration of power for heterotrophic microbes than might be present in other coastal environments.