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Microbial community composition and enzyme activities in cryoturbated arctic soils are controlled by environmental parameters rather than by soil organic matter properties

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Enzyme-mediated decomposition of soil organic matter (SOM) is controlled by environmental parameters (i.e. temperature, moisture, pH) and organic matter properties. The role of these factors as well as the role of microbial community composition and therefore the main drivers of enzymatic decomposition of SOM are largely unknown, since all of these factors are often intercorrelated. We investigated soils from three regions in the Siberian Arctic, where carbon rich topsoil material has been incorporated into the subsoil (cryoturbation). We took advantage of this combination of topsoil organic matter and subsoil environmental conditions, to identify controls on microbial community composition and enzyme activities. We found that microbial community composition (estimated by phospholipid fatty acids analysis), was similar in cryoturbated OM and in surrounding subsoil, although C and N content were similar in cryoturbated material and topsoils. These results suggest that physical conditions rather than SOM properties shaped microbial community composition. To identify direct and indirect drivers of extracellular enzyme activities (cellobiohydrolase, leucine-amino-peptidase and phenoloxidase) we included microbial community composition, C, N and clay content, as well as pH in structural equation models. Models for regular horizons (excluding cryoturbated material), showed that enzyme activities were mainly controlled by C or N. Microbial community composition had no effect. In contrast models for cryoturbated OM, where the microbial community was adapted to subsoil environmental conditions, showed that enzyme activities were also related to microbial community composition. This indicates enzyme activities and more general decomposition to be limited by microbial community composition in cryoturbated organic matter, rather than by the availability of the substrates. The controlling cascade of physical parameters over microbial community composition to enzyme activities might be one of the reasons for low decomposition rates and thus for the persistence of 400 Gt carbon stored in cryoturbated material in permafrost soils globally.