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Content and Vulnerability of Fossil Organic Matter in Ice-Rich Siberian Permafrost – a Case Study

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During the late Pleistocene, a large pool of organic matter (OM) accumulated in ice-rich deposits of the arctic permafrost zone. Because of the potential re-introduction of this stored carbon into the global cycle from degrading permafrost (i.e. decomposed OM) as climate-relevant gases, the OM inventory of ice-rich permafrost deposits is important to current concerns about global warming.
The objective of this presentation is to deduce the quality of OM stored in the studied permafrost sediments. The approach to estimate the OM quality is to use degradation parameters (e.g. C/N, δ13C) based on the assumption that low degraded OM is more labile and has higher vulnerability for decomposition. Standard sedimentological and a molecular marker (biomarker) approach are applied.
The study site is located on the west coast of the Buor Khaya Peninsula (N 71.6°, E 132.2°), Laptev Sea (Russia). Stratigraphically, two sediment units are distinguished. The first unit is composed of late Pleistocene ice-rich permafrost (Yedoma). The second unit consists of Holocene thermokarst (Alas) deposits. The mean bulk density of sediments from both units is ca. 1 g/cm^3. The average total organic carbon (TOC) content is 2.4 wt% for Yedoma, 2.8 wt% for thermokarst deposits. The volumetric organic carbon contents of the Yedoma and thermokarst deposits are 13 $\pm$ 11 kg/m^3 and 22 $\pm$ 11 kg/m^3, respectively.
The degree of OM degradation from both units is low (mean C/N 10, mean δ13C -26.5 ‰ because the deposits accumulated at relatively fast rates and the OM underwent only a short time of decomposition before it was incorporated into permafrost.
Originating from microorganisms, archaeal lipids like archaeol can be used as a marker for methanogenic microbial communities or as a proxy for past microorganism activity. The archaeol concentrations reveal higher microbial activity in thermokarst deposits than in Yedoma deposits.
The n-alkane and n-fatty acid parameters (carbon preference index and average chain length) show source signal from vascular land plants and prove a minor degradation state of the OM. OM parameters such as the total amount of organic carbon and the C/N ratio and acetate concentrations indicate labile OM.