

Fossil organic carbon in Siberian Yedoma and thermokarst deposits

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During the late Quaternary, a large pool of organic carbon accumulated in the ice-rich syngenetic frozen deposits and soils preserved in the arctic and subarctic permafrost zone. Because of the potential release of organic carbon from degrading permafrost, the organic-matter (OM) inventory in Yedoma deposits and its degradation features are relevant to current concerns about the effects of global warming. In this context, it is essential to improve the understanding permafrost-stored OM composition and availability. The objective of this study is to develop an approach of OM quantification in frozen deposits including OM quality estimation.

We analyzed OM characteristics like total organic carbon content, stable carbon isotopes and carbon-nitrogen ratios. Moreover, lipid biomarkers (alkanes, fatty acids and glycerol dialkyl glycerol tetraether) and sediment parameters like grain size and bulk density of Yedoma and thermokarst deposits exposed at Duvanny Yar (lower Kolyma River, Siberia) and the west coast of Buor Khaya Peninsula (Laptev Sea, Siberia) were studied.

With the biomarker approach it is possible to distinguish deposits which were accumulated and frozen during the Pleistocene and Holocene. Biomarker indices, like the compound specific index, average chain length and tetraether characteristics supply feasible results for past permafrost environments. Late Pleistocene biomarker records indicate cold conditions during the growth/summer period for the late Pleistocene and generally low degradation of the stored OM. In contrast, Holocene thermokarst deposits indicate warmer conditions. The averaged volumetric OM content of the studied Yedoma and thermokarst deposits are greater than 10 kg/m³ and do not exceed 30 kg/m³.

Given that Yedoma deposits accumulated at relatively fast rates and at low temperatures, the OM underwent a short time of decomposition before it was incorporated into a permanently-frozen state. Consequently, such deposits contain a labile carbon inventory as reflected by the biomarker results.

We conclude that Yedoma with its degradation features at Duvanny Yar and Buor Khaya contain an organic-carbon inventory which is lower than in other published Yedoma profiles. Nevertheless, these deposits contain a significant carbon pool because of low OM decomposition rates and for this reason a potential high risk for its activation and release under warming conditions.