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THE YEDOMA ICE COMPLEX OF SOBO-SISE ISLAND (EASTERN LENA DELTA)

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The present study of the permafrost exposed at the Sobo-Sise Yedoma cliff provides a comprehensive cryostratigraphic and organic matter inventory. It gives insight into permafrost aggradation and degradation over the last about 52 thousand years and into their climatic and morphodynamic controls on regional-scale permafrost dynamics of the Central Laptev Sea coastal region in NE Siberia. The Sobo-Sise Yedoma cliff is one of the fastest eroding permafrost features arctic-wide and releases considerable amounts of organic matter into the Lena River.

Keywords: *Yedoma, Ice Complex, late Pleistocene, cryostratigraphy, geochronology, organic matter, fluvial erosion*

The Lena Delta in northeastern Siberia is the largest Arctic delta, whose terrestrial surface is shaped by three terraces and the modern floodplain [*Grigoriev, 1993*]. The oldest terrace is mainly found in the central and eastern part of the delta, and structured by remnants of late Pleistocene Yedoma Ice Complex (IC) and its degradation features

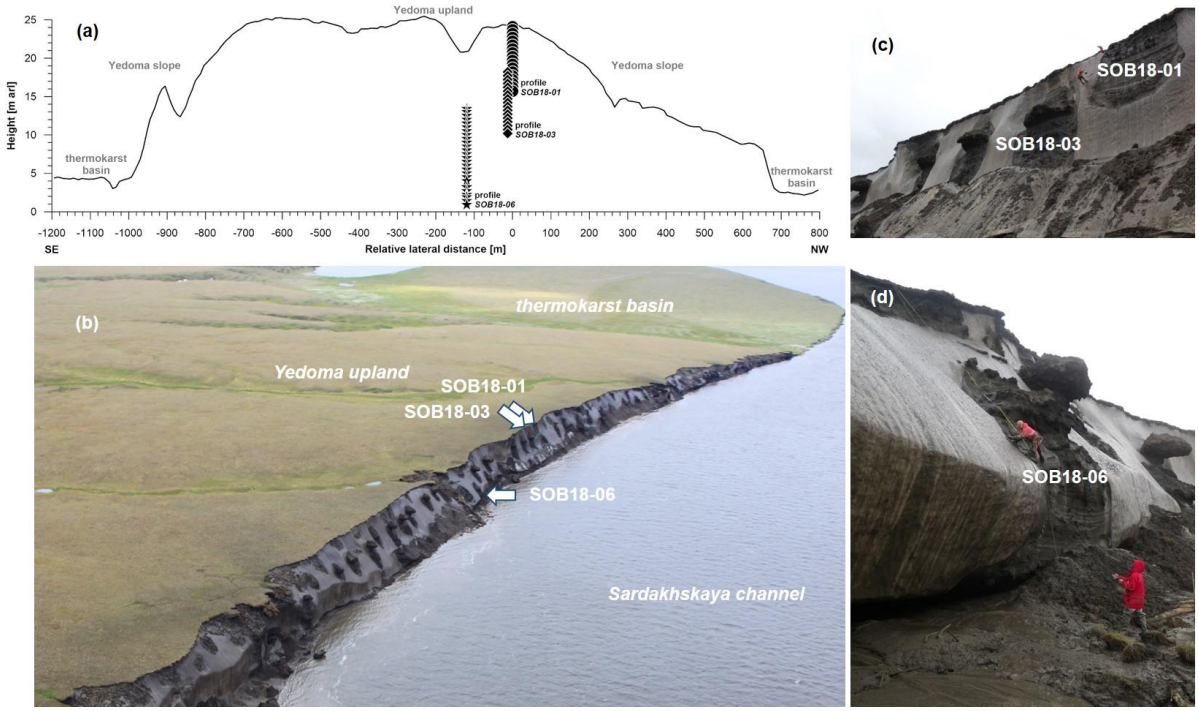

Fig. 1. Positions of sediment profiles SOB18-01, SOB18-03 and SOB18-06 shown (a) in a profile scheme, (b) in an aerial photograph, and (c) and (d) in close-up photographs.

Рис. 1. Положение разрезов SOB18-01, SOB18-03 и SOB18-06, показанных (a) на схеме разрезов, (b) на аэрофотоснимке и (c) и (d) на фотографиях крупным планом.

The studied Yedoma cliff on Sobo-Sise Island in the eastern part of the delta ranges from river level to about 28 m height and is about 1.7 km long. During a joint Russian-German field campaign in August 2018 in the course of the LENA expedition, the entire permafrost sequence of the Sobo-Sise Yedoma cliff was sampled on rope in 0.5-m vertical intervals (Fig. 1).

The geochronological record of the Sobo-Sise Yedoma spans the last 52 ka cal BP based on radiocarbon dating and age-height modelling [*Wetterich et al., 2020*]. The permafrost sequence differentiates into three cryostratigraphic units that are interstadial Yedoma IC (unit A; 52–28 ka cal BP), stadial Yedoma IC (unit B; 28–15 ka cal BP) and the Holocene cover (unit C; 7–0 ka cal BP). The cryostratigraphic sequence of the Sobo-Sise Yedoma cliff is not continuous, but has chronological gaps (hiatus) at 36–29 ka cal BP, at 20–17 ka cal BP and at 15–7 ka cal BP (Fig. 2).

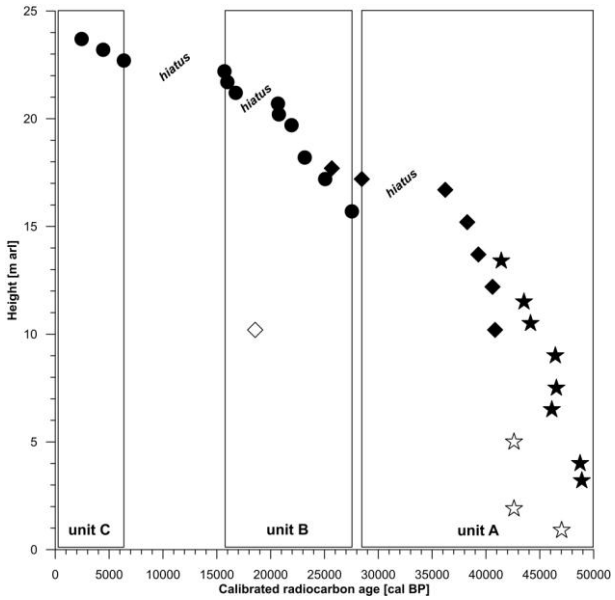

Fig. 2. Age-height relation of the Sobo-Sise Yedoma cliff exposure shown in calibrated radiocarbon ages. Note the sampling overlap of the profiles SOB18-01 (circles), SOB18-03 (diamonds) and SOB18-06 (stars) and their alignment to cryostratigraphic units A, B and C. The hollow symbols indicate ages of redeposited material or infinite radiocarbon ages.

Рис. 2. Зависимость возраста от высоты обнажения обрыва Собо-Сисе Едома в калиброванных радиоуглеродных возрастах. Обратите внимание на перекрытие выборки профилей SOB18-01 (кружки), SOB18-03 (ромбы) и SOB18-06 (звезды) и их выравнивание по криостратиграфическим единицам A, B и C. Незакрашенные символы указывают возраст переотложенного материала или запредельный радиоуглеродный возраст.

The chronologic gaps represent traces of past changes in climatic conditions as well as in sediment deposition and/or erosion regimes. Similar observations have been made on adjacent Yedoma Ice Complex sites on Bykovsky Peninsula and Kurungnakh-Sise Island (Fig. 3). The two older gaps are likely related to repeated changes in the regional hydrological systems due to outburst floods of glacial Lake Vitim along the Lena Valley into the Arctic Ocean as proposed by Margold et al. [*2018*], while the youngest hiatus corresponds to deglacial permafrost thaw (thermokarst) that took place arctic-wide at the late Pleistocene-Holocene transition.

The cryostratigraphic units of the Yedoma cliff are characterized by differing properties of their clastic, organic and ice components. All units are built of poorly sorted sandy silt but differ in prevalent grain-size fractions ranging from fine silt to middle sand. The organic matter content is highest in the thin Holocene cover (unit C: TOC of 11.3±9.9 wt%, TN of 0.6±0.3 wt%), but still substantial in interstadial Yedoma Ice Complex (unit A: TOC of 4.5±2.5 wt%, TN of 0.3±0.1 wt%) and stadial Yedoma Ice Complex (unit B: TOC of 2.1±1.3 wt%, TN of 0.2±0.1 wt%).

The presence of huge syngenetic ice wedges in all units and the high content of intrasedimentary ice amounts to a total volumetric ice content of 88.4 vol% [Fuchs et al., 2020] in the Sobo-Sose Yedoma cliff. The high ice content in combination with the exposition of the cliff towards the Sardakhskaya channel results in a very high susceptibility to thaw and fluvial thermo-erosion. The high mean cliff erosion rate of 15.7 m yr^{-1} (2015-2018) results in large

organic-matter quantities entering the Lena River (5.2±3.3 x 10^6 kg organic C per year, 0.4±0.2 x 10^6 kg N per year; 2015-2018) along the Yedoma cliff [*Fuchs et al., 2020*].

Ongoing fluvial dynamics and changing runoff regimes with extended ice-free seasons and warmer water will most likely maintain high erosion rates at the Sobo-Sise Yedoma cliff in the future and further facilitate high fluxes of terrestrial fossil organic matter into the riverine and eventually marine ecosystems.

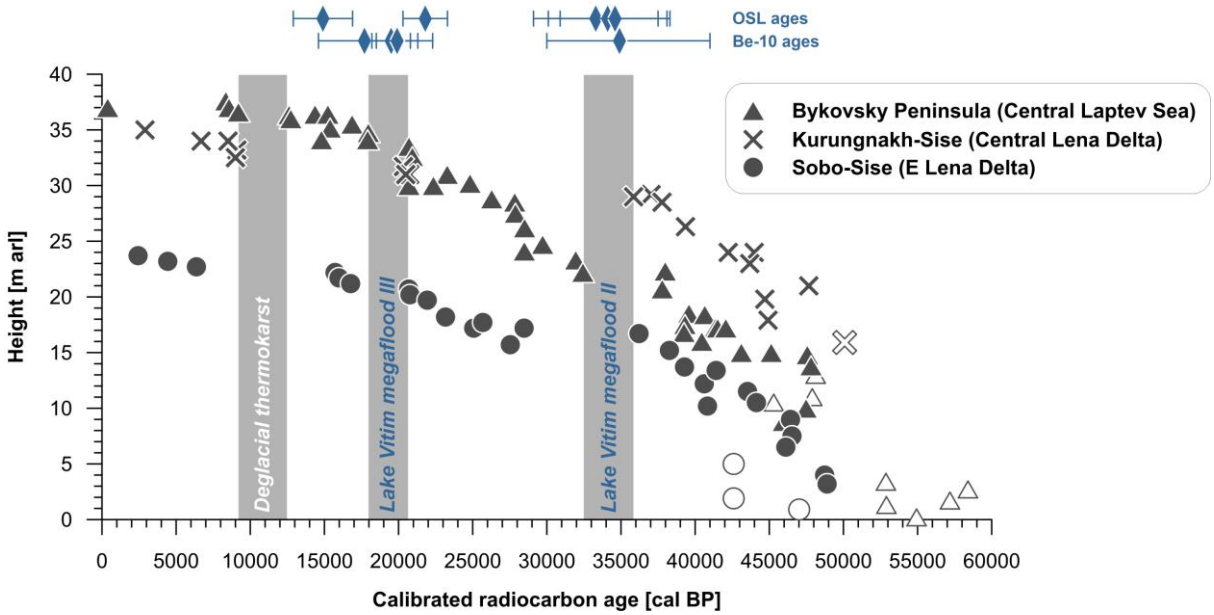

Fig. 3. Comparison of interpreted chronology gaps (shaded rectangles) in the Yedoma IC records from Bykovsky Peninsula [*Schirrmeister et al., 2002*], Sobo-Sise Island [*Wetterich et al., 2020*] and Kurungnakh-Sise Island [*Schirrmeister et al., 2003; Wetterich et al., 2008*]. Infinite radiocarbon dates are given as hollow symbols. Age evidence for repeated megafloods from the glacial Lake Vitim along the Lena Valley into the Arctic Ocean [*Margold et al., 2018*] is shown for comparison by blue symbols.

Рис. 3. Сравнение интерпретированных пробелов в хронологии (закрашенные прямоугольники) в разрезах Yedoma IC с полуострова Быковский [*Schirrmeister et al., 2002*], острова Собо-Сисе [*Wetterich et al., 2020*] и острова Курунгнах-Сисе [*Schirrmeister et al. др., 2003; Wetterich et al., 2008*]. Запредельные радиоуглеродные даты обозначены полыми символами. События повторяющихся мегапаводков из ледникового озера Витим вдоль долины Лены в Северный Ледовитый океан [*Margold et al., 2018*] показаны для сравнения синими символами.

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ЛЕДОВОЙ КОМПЛЕКС ЕДОМЫ ОСТРОВА СОБО-СИСЁ (ВОСТОЧНАЯ ЧАСТЬ ДЕЛЬТЫ ЛЕНЫ)

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Настоящее исследование вечной мерзлоты, обнаженной на утесе Собо-Сисе, обеспечивает всестороннюю криостратиграфическую характеристику и свойства органического вещества. Это дает представление о разрастании и деградации вечной мерзлоты за последние ~52 тысячи лет, а также о климатическом и морфодинамическом контроле динамики вечной мерзлоты регионального масштаба в прибрежном районе моря Лаптевых в северо-восточной части Сибири. Скала Собо-Сисе Едома - один из самых быстро разрушающихся островов, сложенных вечной мерзлотой в масштабах всей Арктики, здесь происходит значительный сброс органического вещества в реку Лена.

Ключевые слова: *Едома, ледовый комплекс, поздний плейстоцен, криостратиграфия, геохронология, органическое вещество, речная эрозия*.