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LATE PLEISTOCENE AND HOLOCENE IN THE PALYNOLOGICAL RECORD OF LAKE EL'GYGYTGYN, POLAR CHUKOTKA

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A 13-meter sediment core from Lake El'gygytgyn has shown the response of the vegetation of Polar Chukotka to climate change in the interval of marine isotope stages 1–8 (MIS). During the glacial stages, grassy tundra was widespread in the Anadyr Plateau and in the area of Lake El'gygytgyn. In the interstadials, alternation of large-shrub tundra and grassy-shrub tundra is observed. At the boundary of MIS6 and MIS7, larch disappears from the vegetation of the region. The need to analyze modern pollen rain in the bottom sediments of Lake El'gygytgyn is confirmed by the reconstruction of late Pleistocene and Holocene plant communities.

Keywords: Pleistocene, Holocene, isotopic stage, pollen zone, tundra.

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INTRODUCTION

Palynological analysis of Late Pleistocene and Holocene sediments of Lake El'gygytgyn confirmed the need to study modern pollen rain in the bottom sediments of the lake at the water-sediment boundary.

Lake El'gygytgyn is oval in shape, 12–14 km in size, and is located in a crater 18 km in diameter that was formed by a meteorite impact 3.58 million years ago (Layer, 2000) beyond the Arctic Circle of Chukotka in the area with coordinates 67°30' N, 172°05' E (Fig. 1). The surface of the lake water above sea level is 489 m. The peaks of the Anadyr Plateau surrounding the lake rise to 600–1000 m.

For the palynological study of Holocene sediments, a core was used, obtained by the International Expedition during the drilling of a borehole in the north-eastern part of the lake at a depth of 170 m, which exposed a 13-meter (borehole PG1351, 1998) a layer of lake silt mixed with fine-grained sand (Fig. 2).

Lake El'gygytgyn area is located in the permafrost zone. The climate of the region is characterized by an average annual air temperature of –10 °C, average July temperatures from +4 to +8 °C, and average January temperatures from –32 to –36 °C. Summer precipitation (June–September) is 70 mm and winter

precipitation is 110 mm (Nolan, Brigham-Grette, 2007). The area belongs to the subzone of southern shrubs and typical tundra. The modern boundary of larch (*Larix cajanderi* Mayr) is located 80 km to the south and west.

The vegetation cover in the vicinity of the lake is represented mainly by lichens and herbs (Kozhevnikov, 1993). On the hills the cover is often discontinuous. Low shrubs *Salix krylovii* E. L. Wolf, *S. alaxensis* Cov. occupy protected areas near open mountain valleys and in the valley of the Enmyvaam River flowing out of the lake. *Betula exilis* Sukacz. is limited to areas with accumulation of organic matter in river valleys on terraces and saddles both regionally and near the lake. On the Anadyr Plateau, mosaic low-shrub and grassy tundra with small populations of *Pinus pumila* (Pall.) Regel and *Duschekia fruticosa* (Rupr.) Pouzar is developed.

The composition of the modern spore-pollen spectra of the lake's bottom sediments is determined by the wind-blown pollen of *Duschekia fruticosa* (*Alnus*) (up to 35 %), *Betula* (20 %), and *Pinus pumila* (15 %). The total amount of shrub pollen may be 45 %. Thus, the spectra of Lake El'gygytgyn bottom sediments reflect the regional vegetation of the northern regions of Chukotka, rather than the discontinuous vegetation cover with low pollen productivity in the vicinity of the lake (Lozhkin et al., 2002).

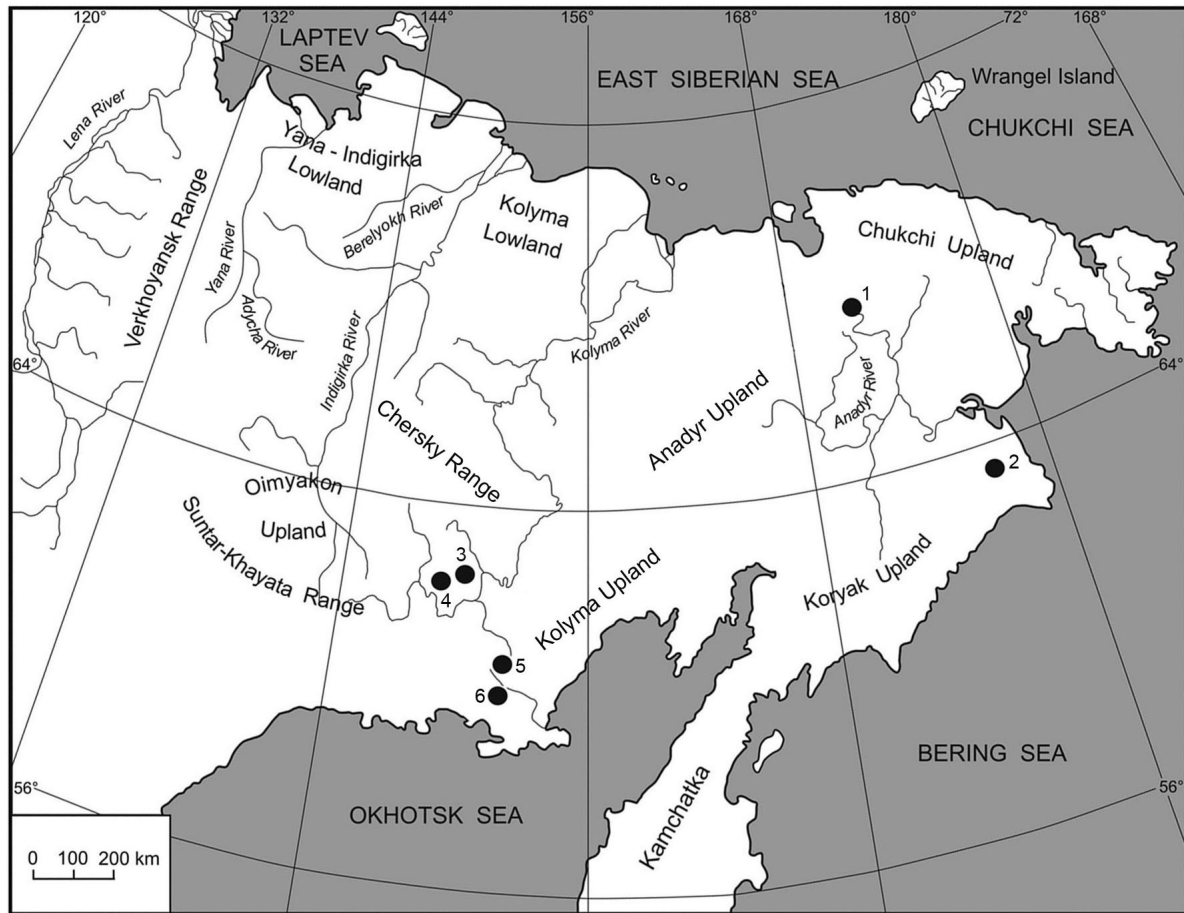


Fig. 1. Geographical position of Lake El'gygytyn (1) and lakes with continuous palynological records on the map of the Western Beringia: 2 – Lake Gytgykay, Patricia Lake; 3 – Lake Jack London, Lake Sosednee; 4 – Lake Elgennya; 5 – Lake Elikchan-4; 6 – Lake Alut.

Рис. 1. Географическое положение оз. Эльгыгытгын (1) и озер с непрерывными палинологическими записями на карте Западной Берингии: 2- оз. Гытгыкай, оз. Патриции; 3 – оз. Джека Лондона, оз. Соседнее; 4 – оз. Эльгення; 5 – оз. Эликчан-4; 6 – оз. Алут.

RESEARCH METHODS

Palynological analysis of sediments of Lake El'gygytyn was carried out according to the method proposed for studying arctic lakes and estuaries (PALE 1994). When reconstructing vegetation based on pollen analysis data, the sum of all pollen grains was taken as 100 %. At least 300 pollen grains of land plants were counted in each sample. The spore-pollen diagram shows the ratio of vegetation groups (left part of the diagram), pollen of the main trees, shrubs and herbaceous plants and spores. The content of each pollen taxon is given as a percentage of the sum of all pollen grains. The participation of spores is considered as a relative value, which is determined separately for each spore taxon from the total amount of pollen. The construction of the spore-pollen diagram was carried out using the TILIA computer program.

ISOTOPIC STAGES AND POLLEN ZONES

The spore-pollen diagram (Fig. 3) includes information on isotopic stages corresponding to marine oxygen isotope stages (MIS) 6, 7 and 8 (upper layer) (Lisiecki, Raymo, 2005) of the Middle Pleistocene, Late Pleistocene (MIS2, MIS3, MIS4, MIS5) and Holocene (MIS1). Significant similarity is noted between the spectra of MIS2, MIS4, MIS6 and MIS8, characterizing the dominance of sedge-grass communities in the vegetation cover, replaced in drained areas by communities of *Artemisia*, *Papaveracea*, *Selaginella rupestris* and other herbaceous plants that developed during periods of deep climatic cooling.

The spectra of interstadial MIS3 and MIS7 reveal many common features. These spectra show a regional distribution of shrub tundra, composed mainly of birch (*Betula exilis* Sukacz.), willow

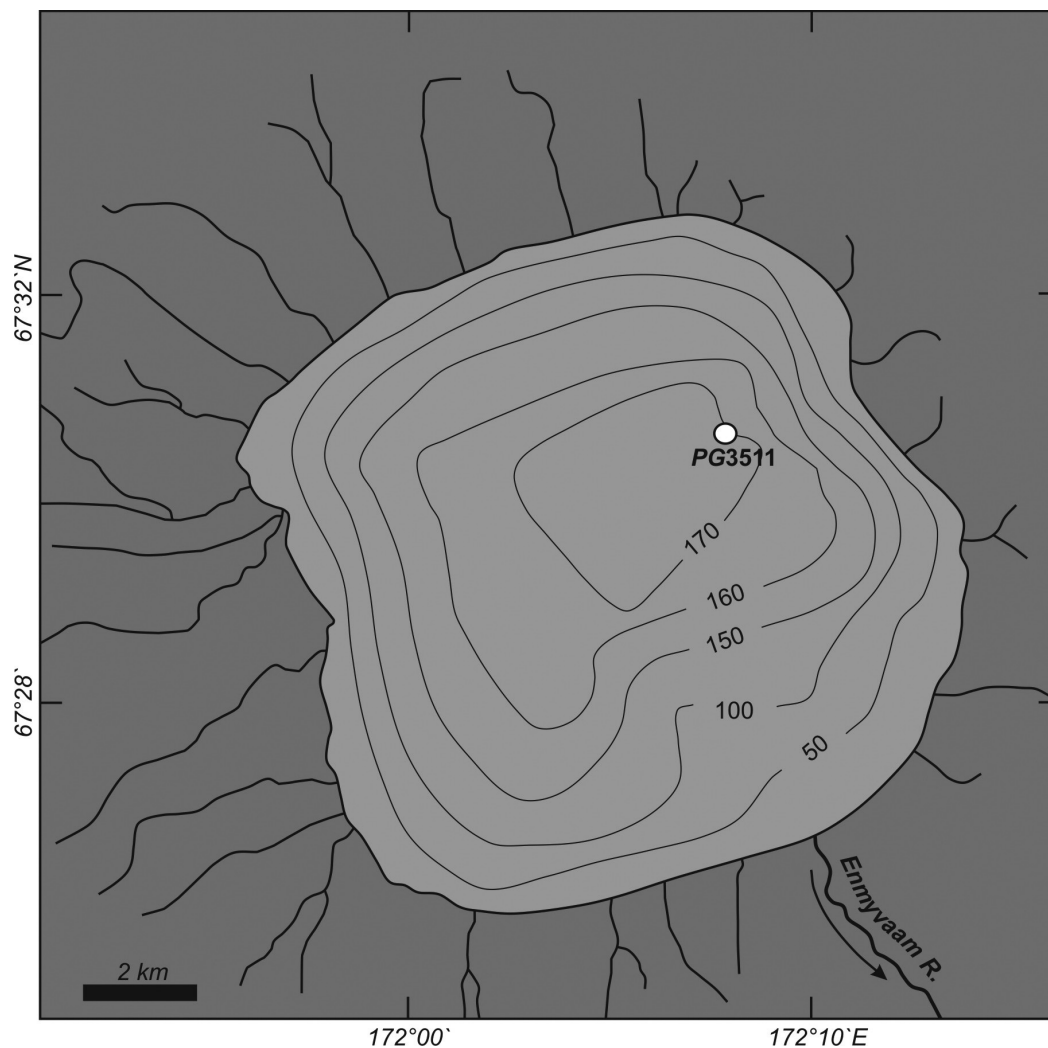


Fig. 2. Bathymetry of Lake El'gygytyn (lake depths are given in meters). Location of bore-hole PG3511 (light circle). Streams flowing into the lake, and the Enmyvaam River flowing out of the lake.

Рис. 2. Батиметрия оз. Эльгыгытгын (глубины озера даны в метрах). Положение скважины PG3511 (светлый кружок). Ручьи, впадающие в озеро, и вытекающая из озера р. Энмываам.

(*Salix krylovii* E. L. Wolf, *S. alaxensis* Cov.) with the participation of alder (*Duschekia fruticosa* (Rupr.) Pouzar.), and, probably, dwarf pine (*Pinus pumila* (Pall.) Regel). As in the glacial stages, vast areas were occupied by sedge-grass meadows, and *Artemisia* communities developed on the slopes of the valleys.

Isotope stage 5 reflects the change of plant communities in the Late Pleistocene interglacial. This change is very clearly emphasized by pollen zones Eg6, Eg7, Eg8. The spore-pollen spectra of zone Eg8 are characterized by peaks of pollen of *Betula* (52 %) and *Alnus* (50 %), indicating the dominance of tall shrub tundra formed by birch and alder in the regional vegetation cover. It is also possible to assume the penetration of tree-like birches, such as *Betula platyphylla* Sukacz., into the

region of Lake El'gygytyn and the Anadyr plateau. This assumption is supported by the extremely sharp change in the spectra of pollen zones characterizing the grassy tundra of MIS6 (pollen zone Eg5) and the spectra of shrub tundra (and birch forest tundra), which did not show the distribution of sedge-grass meadow communities in MIS6 (pollen zone Eg6).

Pollen zone Eg7 is quite distinctive. Spore-pollen spectra are characterized by peaks of *Pinus* subgen. Haploxylon pollen (up to 62 %), which was undoubtedly produced by *Pinus pumila*. Against the background of the dominance of *Pinus* pollen, the participation of *Betula* and *Alnus* pollen in the spectra is quite low (up to 10 %). Such a composition of the spectra indicates a very wide distribution of dwarf pine thickets on the slopes of the Anadyr plateau and in river valleys. Just as in pollen zone Eg6, the

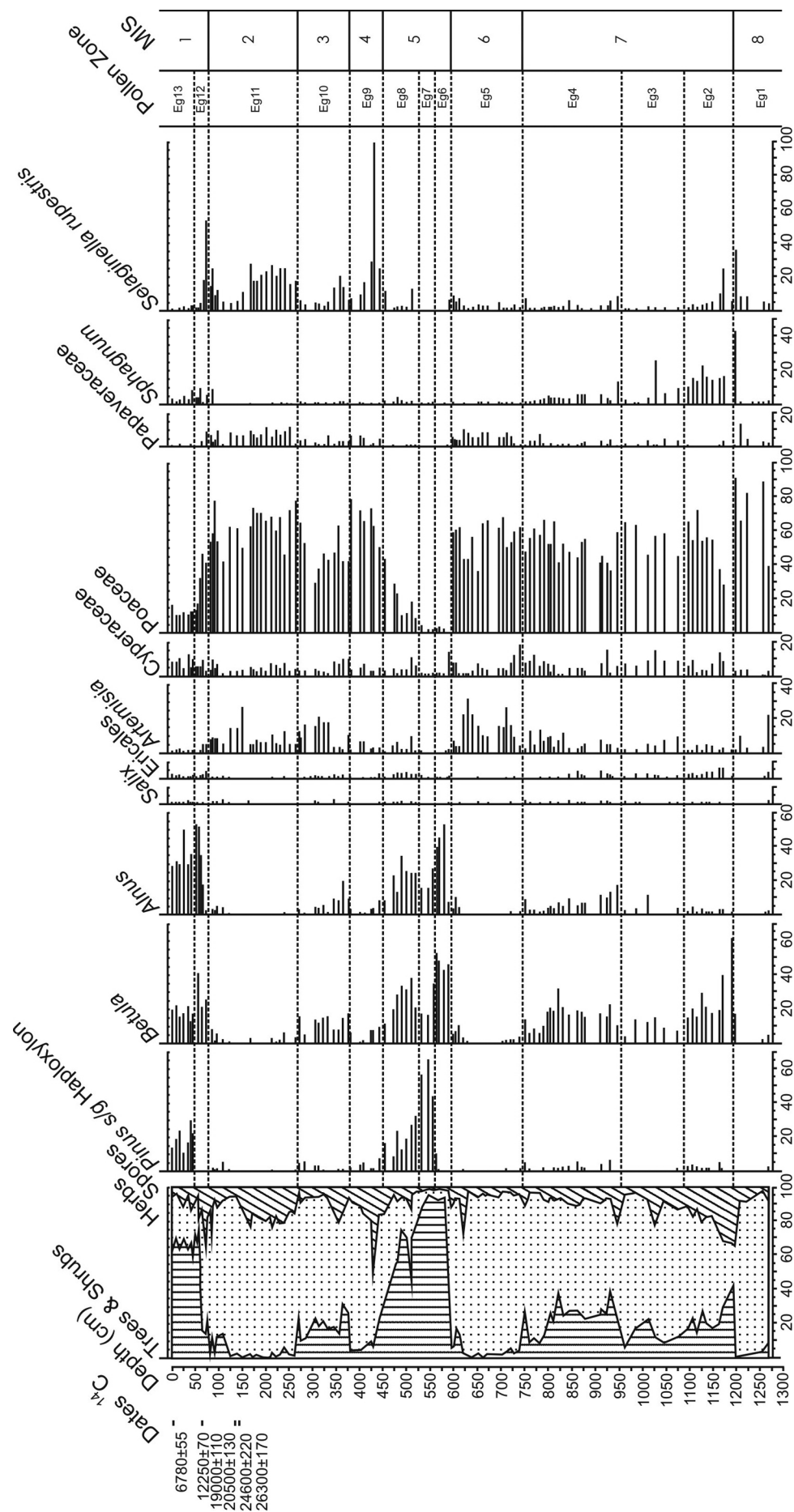


Fig. 3. Ratio of vegetation groups, main pollen, and spore taxa in the spectra of Lake El'gygytyn sediments MIS1–MIS8.

Рис. 3. Соотношение групп растительности, основных пыльцевых и спорных таксонов в спектрах осадков MIS1–MIS8 оз. Эльгыгытгын.

Table. Radiocarbon and calibrated dates of Lake El'gygytyn sediments

Таблица. Радиоуглеродные и калиброванные датировки осадков оз. Эльгыгытгын

Sample depth, cm	^{14}C age	Median cal age	Sample number	Material dated
21–23	6780±55	7 630	OS-22643	HUMIC ACIDS
64–66	12 250±70	14 200	OS-22644	HUMIC ACIDS
88–90	19 000±70	22 930	OS-22645	HUMIC ACIDS
118–120	20 500±130	24 670	OS-22646	HUMIC ACIDS
134–136	24 600±220	28 850	OS-22647	HUMIC ACIDS
142–144	26 300±170	30 570	OS-22648	HUMIC ACIDS

spectra of zone Eg7 do not show the existence of sedge-grass-forb meadow communities.

The spore-pollen spectra of pollen zone Eg8 reflect the high-shrub *Pinus pumila* – *Duschekia fruticosa* tundra with the participation of *Betula middendorffii*. In all likelihood, this tundra was similar to the modern high-shrub tundra of southern Chukotka. The spread of such tundra in the area of Lake El'gygytyn in the final stage of the Late Pleistocene interglacial was most likely caused by a cooling of the climate. As a result of the cooling, sedge-grass and *Artemisia* – *Selaginella rupestris* communities on the drained slopes of river valleys reappear, as in MIS8–MIS6.

The boundary of the Pleistocene and Holocene in the sediments of Lake El'gygytyn is determined based on a sharp change in the spore-pollen spectra from the spectra characterizing the grassy tundra that dominated in MIS8 of the Late Pleistocene to the spectra of large-shrub birch tundra, then birch-alder tundra that spread in the early Holocene. The Holocene-Pleistocene boundary in the palynological record of Lake El'gygytyn is dated to $12,250 \pm 70$ years ago at a depth of 64–66 cm, which basically determines the thickness of the Holocene sediments in the lake. Pollen zone Eg12, reflecting the tundra shrub birch-alder communities of the Early Holocene, is replaced in the Middle Holocene by shrub tundra with *Pinus pumila* (Eg13) as one of the main taxa of the shrub pine-birch-alder tundra, which had a regional distribution. Radiocarbon dating of $6,780 \pm 55$ years ago (depth 21–23 cm) refers to the climatic optimum of the Middle Holocene (Table).

CONCLUSION

A 13-meter sediment column from Lake El'gygytyn showed the response of Polar Chukotka vegetation to climate change in MIS1–MIS8. Glacial MIS2, MIS4, MIS6, MIS8 reflect the regional distribution of grassy tundra. Unstable climatic

conditions of interstadial MIS3 and MIS7 determined the development of shrub tundra or grassy-shrub tundra. Interglacial Late Pleistocene MIS5 reflects a sharp warming of the climate at the boundary of the Middle and Late Pleistocene.

Radiocarbon dating of the Holocene-Pleistocene boundary in sediments of Lake El'gygytyn has close or similar dates in continuous palynological records in other lakes in various areas of Western Beringia: Lake Patricia, Lake Gytgykay in southern Chukotka; Lake Elikchan-4, Lake Alut in Northern Priokhotye; Lake Jack London, Lake Sosedneye, Lake Elgenya in the Kolyma River basin.

The discrepancy between radiocarbon dates of the Pleistocene-Holocene boundary in lake sediments (Late Quaternary..., 2002) and the dating given by L. E. Lisiecki and M. E. Raymo (2005) in their study of the oceans – 14 thousand years ago, can be explained by the different reactions of the marine environment and the continental environment to climatic events. Differences in the methods for solving this problem are also important.

Spore-pollen spectra showed that larch (*Larix sibirica*, *Larix cajanderi*) as the main forest-forming coniferous species disappears from the vegetation of the Anadyr plateau and Lake El'gygytyn area on the border of MIS6 and MIS7. Larch is absent from the vegetation cover of the Late Pleistocene and Holocene.

The necessity of analyzing modern pollen rain in bottom sediments of Lake El'gygytyn at the water-sediment boundary is confirmed by the reconstruction of Late Pleistocene and Holocene plant communities.

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ПОЗДНИЙ ПЛЕЙСТОЦЕН И ГОЛОЦЕН В ПАЛИНОЛОГИЧЕСКОЙ ЗАПИСИ ОЗЕРА ЭЛЬГЫГЫТГЫН, ПОЛЯРНАЯ ЧУКОТКА

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13-метровый керн осадков оз. Эльгыгытгын показал реакцию растительности Полярной Чукотки на изменение климата в интервале изотопных стадий 1–8 (MIS). В ледниковые стадии на Анадырском плоскогорье и в районе оз. Эльгыгытгын распространялась травянистая тундра. В интерстадиалы наблюдается чередование крупнокустарниковой тундры и травянисто-кустарниковой тундры. На границе MIS6 и MIS7 из растительности региона исчезает лиственница. Необходимость анализа современного пылевого дождя в донных осадках оз. Эльгыгытгын подтверждается при реконструкции позднеплейстоценовых и голоценовых растительных сообществ.

Ключевые слова: плейстоцен, голоцен, изотопная стадия, пылевая зона, тундра.

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