POLLEN DATA ON UPPER QUTERNQRY LAKE SEDIMENTS IN NORTHEAST SIBERIA

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ABSTRACT

The pollen diagram from Elekchan 4 Lake is the most complete and continuos record of late Pleistocene and Holocene vegitation and climate change from northeast Siberia. This record was made by sediments of Elikchan 4 Lake located within Okhotsk-Kolyma interflue, in the Maimandzha River head. An extrapolation of series of radiocarbone datings shows that the pollen diagram cover of the time interval not less than 60 thousand years. There are two grassy pollen zones (***EL1*** and ***EL2***) on the diagram. These zones are characterized by stable composition of spore-pollen spectra and belong to Zyryan (Early Visconsin) and Srtan (Late Visconsin) intervals. ***EL3*** zone located between two grassy-pollen zones reflects the vegetation change during Kargin (Middle Visconsian) interval. The change of grassy tundra communities by the large shurb tundra and deciduous forests (***EL4*** zone) is dated by 12.5 thousand years. Radiocarbone datings make it possible to attribute ***EL5*** zone to Atlantic, Subboreal and Subatlantic periods of Holocene, during which the vegetation acquires the features close to modern ones. The research were made by support of the Russian Fund of Fundamental Research.

The pollen diagram from Elikchan 4 Lake is the most complete and continuous record of late Quaternary vegetation and climate change from northeast Siberia. The site, 3.9 km long and between 0.9 to 1.3 km wide, is located 180 km north of Magadan at an elevation of 799 m. Elikchan 4 is one of four interconnected lakes that form the headwaters of the Maimandzha River, which flows to the Okhotsk Sea. This northwest- southeast trending chain occurs within a tectonic depression that crosscuts the Okhotsk-Kolyma River drainage divide. Elikchan 4 Lake is bordered to the north and south by mountains which support a *Larix dahurica* forest at low to mid-elevations. The understory is characterized by *Pinus pumila*, *Betula middendorfii*, and *Alnus fruticosa*. A zon8e of shrub tundra, dominated by *Pinus pumila*, occurs beyond altitudinal treeline. Vegetation is sparse at highest elevations. Many slopes, especially those with high angles, are rock-covered and are devoid of vegetation. These scree deposits, which today extend to the valley bottoms, likely were responsible for the original blockage of the paleodrainage that formed these lakes.

Two flat-bottomed basins occur in the southeast (ca. 11 m depth) and central (ca. 9 m) areas of Elikchan 4 Lake. We raised two cores from each of these basins using a modified Livingstone piston corer (Wright et al, 1984) and a chain drive from the ice surface. A ca. 9.5 m core was raised from the central basin. It ended in gravels, indicating total recovery of all lake deposits. Sediment characteristics indicate that the core represents a continuous depositional history. The sediment description is as follows: 0-16 cm brown-gray water-rich silt; 16-213 cm brown-gray silt with numerous plant remains; 213-214.5 cm Elikchan tephra (Lozhkin et al., 1993); 214.5-238 cm brown- gray silt with black layers of plant fragments; 238-527 cm blue-gray clayey silt with numerous layers (1-5 mm thick) of plant remains; 527-566 cm blue-gray clayey silt; 566-762 cm gray silt with layers of fine sand and scattered mollusks and plants; 762-784 cm brown-gray well-sorted sand with many plant remains; 784-882 cm light gray silt with minor amounts of sand and numerous layers of plant remains; 882-923 cm gray sand; 923-945 cm gray silt with sand, gravel at the bottom.

The core was sampled minimally at 10 cm intervals, with many sections sampled at 1 cm, 2 cm, and 3 to 5 cm intervals. Pollen samples were prepared following standard techniques (PALE Steering Committee, 1993, pp. 49-53). B.Belaya identified more than 1000 palynomorphs in each sample. The pollen diagram was prepared using Tilia and Tilia-Graph (Grimm, 1992). The summary curves presented on the left part of the diagram follow traditional Russian methods and are calculated on a sum of all terrestrial pollen and spores. The percentages for the individual taxa, calculated on a pollen sum of terrestrial pollen alone, follow American methods. Extrapolation of sedimentation rates based on the radiocarbon-dated upper portion of the core suggests that the basal age of the core is ca. 60,000 B.P.

Changes in the pollen spectra in the Elikchan sediments correlate to trends described at other nearby sites (Lozhkin and Fedorova, 1989; Lozhkin et al., 1993). The Elikchan 4 pollen diagram was divided qualitatively into five pollen zones (Fig. 1). These zones represent two periods of herb-dominated tundra (***EL1***, ***EL3***), one interval of shrub tundra (***EL4***) and two times of taiga establishment (***EL2***, ***EL5***).

Zone ***EL1*** corresponds to the Zyrian interval of the late Pleistocene (early Wisconsinan equivalent in North America). This pollen assemblage is dominated by Poaceae (48%) and Cyperaceae (35%) pollen. *Artemisia*, *Salix*, and Ericlaes pollen occur in moderate amounts. Minor herb taxa sum to up to 40% of the pollen sum. The ***EL1*** spectra are also characterized by numerous spores, especially of *Selaginella rupestris* (up to 69%; Fig. 2).

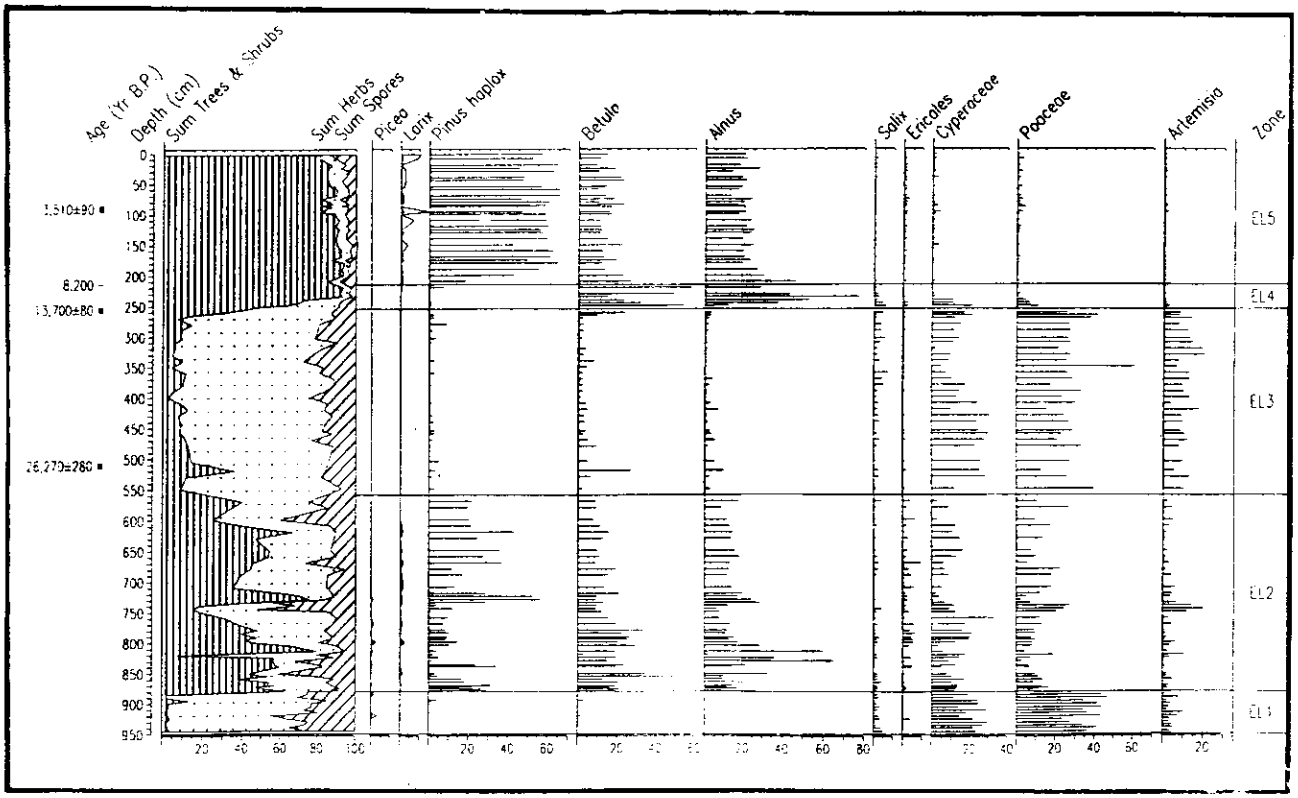

Fig. 1. Percentages of the major pollen taxa and subsums for Elikchan Lake.
The *Larix* curve has been exaggerated by a factor of 10X. The 8,300 B.P. date is based on the location of the Elikchan tephra.

The dominance of Poaceae and Cyperaceae pollen indicates a widespread graminoid community typical of very cool dry glacial climates. Trace amounts of *Polygonum aviculare*, *P. amphibium*, *Koenigia islandica*, *Pedicularis*, *Sanguisorba*, *Allium*, *Cardamine*, Ranunculaceae (9%), Polemoniaceae and Umbelliferae pollen suggest the presence of wetter areas in the valley bottom (e.g., bordering the lake and outlet stream). The consistent but minor appearance of *Claytonia vassilievii*, a species more characteristic of the middle Pleistocene, is further evidence of wet, fine tundra soils. Despite the variety of moisture-tolerant forbs, this community was probably dominated by more mesic species of Cyperaceae and Poaceae. The high frequency of *Selaginella* spores in combination with moderate pollen percentages of *Artemisia* (up to 11%). Asteraceae (5%), Cruciferae (10%), and Ericales (4%) and trace amounts of Cichoriaceae, Caryophyllaceae, Leguminosae, Saxifragaceae, Papave8raceae, *Corydalis*, Rosaceae, *Draba*, *Potentilla*, and *Dryas*, indicate the presence of more discontinuous vegetation cover (e.g., fell field), probably at mid-elevations in the mountains. The highest elevations likely were barren. *Salix* (5% pollen) is perhaps the only shrub species present on the Elikchan landscape and was most likely found in the mountain tundra and in areas bordering streams. However, a high shrub tundra of *Pinus pumila*, *Betula middendorfii*, *Alnus* fruticosa and *Picea obovata* may have been present in the lowland of the Yama River, ca. 180 km to the east of Magadan (Lozhkin and Anderson, in press). This shrub tundra association likely represents a relict population of the Kazantsev interglaciation (Sangamon equivalent of North America).

Zone ***EL2*** (882-560 cm) falls between the two herb zones (zones ***EL1*** and ***EL3***) and corresponds to the Karginsk interstadial (middle Wisconsinan equivalent in North America). The boundary between zones ***EL1*** and ***EL2*** is extrapolated to be ca. 50,000 B.P. This age has previously been suggested for the Zyrian-Karginsk boundary (e.g., Kind, 1974). The *EL2* pollen spectra have high percentages of *Alnus* (up to 64%) and *Betula* (up to 50%). Percentages of *Pinus pumila* are also high (up to 57%), but fluctuate to low values of ca. 5%. *Larix* pollen is present in minor amounts through much of the zone, whereas trace percentages of *Picea* pollen are restricted to lower zone *EL2*. The herb component is dominated by Poaceae (up to 28%), Cyperaceae (up to

33%), *Artemisia* (up to 20%), Cruciferae (up to 12%), and Caryophyllaceae (up to 10%) pollen. As in zone ***EL1***, there is a great diversity of minòr herb taxa (Liliaceae, *Polygonum* (at least three species), Chenopodiaceae, *Claytonia acutifolia*, *Claytonia vassilievii*, Ranunculaceae (10%), Thalictrum (4%), Papaveraceae, *Corydalis*, *Cardamine*, *Draba*, Saxifragaceae (2%), Rosaceae, *Spiraea*, *Potentilla*, *Dryas*, Sanguisorba, Leguminosae, Onagraceae, Umbelliferae, Primulaceae, Plumbaginaceae, Gentianaceae, Polemoniaceae, Labiatae, Scrophulariaceae, *Pedicularis*, Rubiaceae, Valerianaceae, Asteraceae (2%) and Cichoriaceae). *Sphagnum* and *Equisetum* (up to 92%) spores are abundant in zone ***EL2***, whereas spores of *Selaginella rupestris* show a marked decrease from zone ***EL1***.

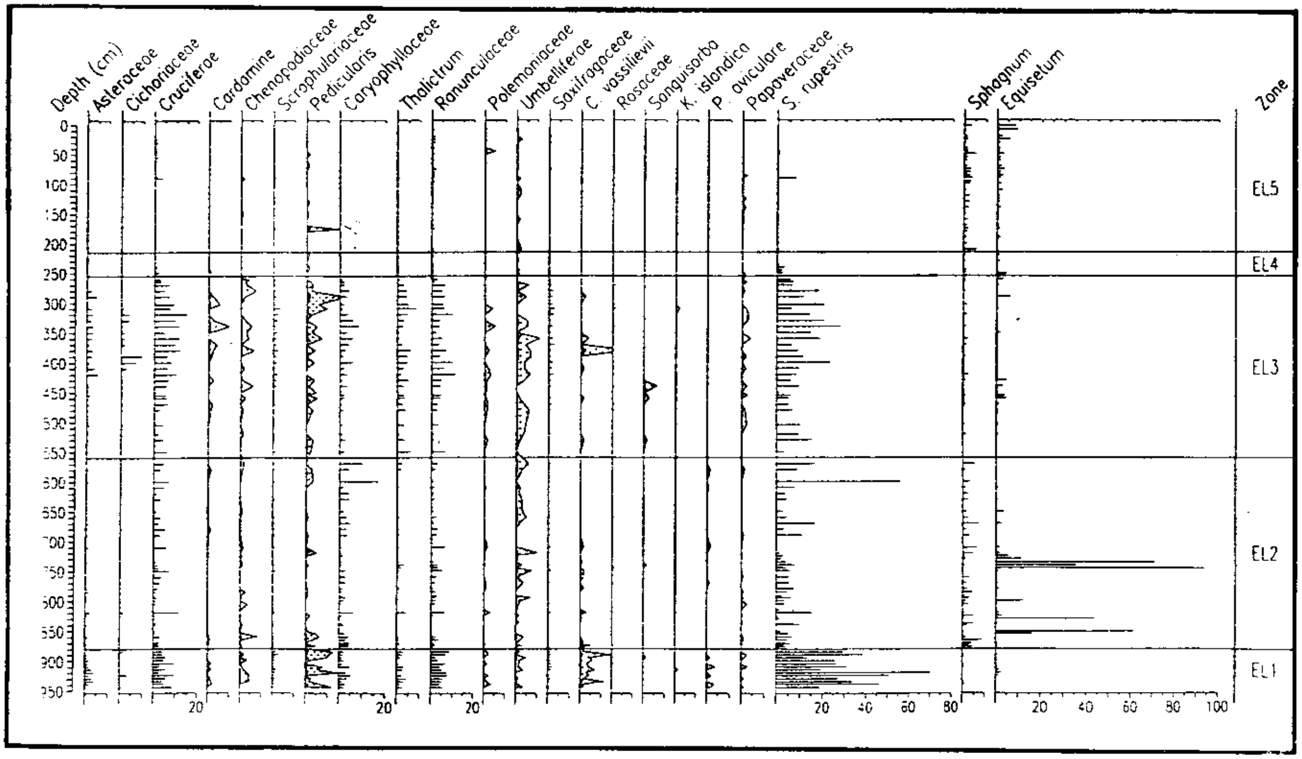

Fig. 2. Percentages of minor herb taxa and major spore types.
Dotted curves have been exaggerated by a factor of 10X.

This assemblage indicates that a *Larix* forest with a *Pinus pumila-Betula* understory was established in the Elikchan Lakes area during the Karginsk interstadial. Tree density was probably low, and this open forest likely was limited to the valley bottom and lower elevations of the nearby mountains. At least during the earlier part of this interval, the forest may have included *Picea*. Increases in *Sphagnum* and *Equisetum* spores suggest a greater abundance of moist sites than previously, perhaps including some local bog development. Like in zone ***EL1***, the minor herb taxa indicate a variety of ecological settings near the lake. A zone of forest-tundra dominated by *Larix* and *Pinus pumila* characterized mid-elevation slopes. *Alnus fruticosa* may have been common along mountain draws as well as bordering streams in the valley lowland. This vegetation type was replaced at slightly greater elevations by a high shrub tundra with *Pinus pumila*, *Betula middendorfii*, *Alnaster fruticosa*, and Ericales. A herb-low shrub tundra grew at still higher elevations, eventually diminishing to a mixture of scattered cushion plants and scree on the highest mountain peaks.

The changes in pollen and spore taxa between zones ***EL1*** and ***EL2*** indicate an interstadial climate that generally was warmer with greater effective precipitation than that of the Zyrian stade (***EL1***). However, variations in shrub and to a lesser extent tree pollen within zone ***EL2*** (e.g., 800-740 cm and 710-640 cm) indicate periods of cooler conditions (probably cool moist summers), although not as extreme as during the Zyrian stade (cool dry summers). These events may correspond to the Kirgilyach and Konoschylskoye intervals, times of climatic deterioration noted elsewhere in Siberia (Kind, 1974; Shilo et al., 1983). During these cooler times, the deciduous shrub and herb-shrub tundras probably expanded, and altitudinal treeline was lowered, restricting the *Larix* forests to only the most favorable sites of the river valley. The rapid and extreme variations in individual pollen-spore taxa and/or subsums seen in zone *EL2* suggest that conditions for forest growth were somewhat marginal near the lake, and the Elikchan area was particularly sensitive to climatic shifts during the interstadial. This sensitivity is in contrast to the Holocene interglacial vegetation (zone *EL5*) near Elikchan 4 Lake, which remained stable despite significant changes in vegetation and climate patterns observed for other regions of northeast Siberia during the current interglaciation (Lozhkin, 1993).

Zone *EL3* (560-255 cm), which corresponds to the Sartan stade (late Wisconsinan equivalent), is characterized by high percentages of Poaceae (up to 62%), Cyperaceae (up to 87%), *Artemisia* (up to 20%) and Cruciferae (15%). Minor herb taxa include Caryophyllaceae (up to 9%), Ranunculaceae (10%), *Thalictrum* (8%), Saxifragaceae (3%), Ericales (2%), Scrophulariaceae (3%), Asteraceae (6%) and Cichoriaceae (10%). Shrub pollen percentages (e.g., *Betula* and *Pinus pumila*) typically are 1% or less, although *Salix* pollen is more abundant (up to 6%). The regional vegetation is characterized by a variety of tundra types, including fell fields on the dry, stony slopes (as indicated by high percentages of *Selaginella rupestris*) and Cyperaceae-moss communities with prostrate *Salix* on moist sites at mid- to lower elevations. Numerous radiocarbon-dated sites throughout northeast Siberia suggest that the Sartan-Karginsk boundary is dated to ca. 27,400 B.P. (Lozhkin, 1991), in concurrence with the 26,270 B.P. +/- 280 B.P. (Beta-59381) date from the Elikchan 4 core.

Zone *EL4* (255-215 cm) is characterized by the rapid increase in pollen of *Betula* (up to 66%) followed by *Alnus* (up to 77%). Herb pollen taxa (e.g., Poaceae, Cyperaceae, *Artemisia*, Cruciferae, and Ranunculaceae) that were important in *EL3* show a significant decrease. This zone, informally referred to as the birch-alder zone, marks the widespread replacement of the full-glacial herb tundra communities by high deciduous shrub tundra. Such a sharp change in the pollen assemblages between *EL3* and *EL4* suggests that climate change was rapid with an increase in summer temperatures to ca. 12.5-13 C.

Zone *EL5* (215-0 cm) is marked by the consistent appearance of trace amounts of *Larix* pollen and a rise in percentages of *Pinus pumila* pollen, with a concurrent decline in pollen of *Betula* and *Alnus*. The boundary between these two zones is also marked by the presence of the Elikchan tephra dated to ca. 8300 B.P. (Lozhkin et al., 1993). This interval marks the establishment of the modern vegetation.

ACKNOWLEGEMENTS

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REFERENCES

Grimm, E.C., 1992. Tilia and Tilia-Graph: Pollen spreadsheet and graphics program. - In: 8th Intern. Palynol. Congr., Aix-en-Provence, Program and Abstracts: 56.

Kind, N., 1974. Geochronology of the late Anthropogene using isotope data. - M.: Nauka.

Lozhkin, A.V., 1991. Questions of geochronology and paleogeography of the Quaternary period of North East USSR. - In: Geology of the Transition Zone between Ocean and Land in Northeast Asia. Magadan: NEIRSI FEB RAS: 47-59.

Lozhkin, A.V., 1993. Geochronology of late Quaternary events in northeastern Russia. - Radiocarbon 35(3): 429-433.

Lozhkin, A.V., and , Anderson, P.M., in press. The last interglaciation in Northeast Siberia. - Quaternary Res.

Lozhkin, A.V., and Fedorova, I.N., 1989. Late Pleistocene and Holocene vegetation and climate of northeastern USSR based on data from lake sediments. - In: Topography and Corresponding Deposits, northeastern USSR. Magadan: NEISRI FEB RAS: 3-9.

Lozhkin, A.V., Anderson, P.M., Eisner, W.R., Ravako, L.G., Hopkins, D.M., Brubaker, L.B., Colinvaux, P.A., and Miller, M.C., 1993. Late Quaternary lacustrine pollen records from southwestern Beringia. - Quaternary Res. 39: 314-324.

PALE Steering Committee, 1993. Research Protocols for PALE Paleoclimates of Arctic Lakes and Estuaries. -PAGES Workshop Rep. Ser. 94-1. Bern. 53 p.

Shilo, N.A., Lozhkin, A.V., Titov, Ye.Ye., and Schumilov, Yu.V.,1983. Kirgilyatskii Mammoth (Paleogeographic Aspect). - M.: Nauka. 241 p.

Wright, H.E., Jr., Mann, D.H. and Glaser, P.H., 1984. Piston corers for peat and lake sediments. - Ecology 65: 657-659.