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YOUNGER DRYAS POLLEN RECORDS FROM CENTRAL AND SOUTHERN YAKUTIA

A.A. Andreev, V.A. Klimanov and L.D. Sulerzhitsky

Analysis of palynmorphic successions from central and southern Yakutia has resulted in enhanced understanding of the effects of the Younger Dryas event. During the Alleröd, central Yakutia was marked by steppe conditions, with *Artemisia*, *Chenopodiaceae*, *Poaceae* and other taxa, in addition to shrubs *Betula nana* and *B. fructicosa*. River floodplain areas supported larch–birch forests. The transition to the Younger Dryas environment, indicated by increases in steppe and tundra elements and decreases in arboreal taxa, was marked by decreases in mean summer temperature by ±3°C, and drier conditions. Re-colonization of central Yakutia by larch–birch woodlands and "yernik" steppe assemblages dominated by shrub birch marked the conclusion of the Younger Dryas. In southern Yakutia, the Alleröd larch–alder–shrub birch vegetation assemblages were replaced by steppe assemblages dominated by bunchgrass and forbs during the Younger Dryas. Subsequently, alder re-colonized southern Yakutia, ca. 10,200–10,300 BP. © 1997 INQUA/Elsevier Science Ltd

INTRODUCTION

The present-day environmental setting of Yakutia and its central part, in particular, are generally regarded as closely analogous to that of the periglacial steppe of northern Eurasia during the Late Valdai (Gerasimov, 1952; Velichko, 1973). Due to its dry and continental climate with warm summers and winters poor in snow, relics of the periglacial complex in form of steppic and forest-steppic vegetation survived to this day in the river basins of central Yakutia, as well as those of the Yana and Indigirka (Karavaev and Skryabin, 1971). At the same time, there are very few available pollen and radiocarbon data related to the vegetation and climate of Yakutia in the final Late Pleistocene, and, particularly, on the dynamics of landscape and climatic changes at the time of transition to the Holocene.

Based on scattered evidence on the vegetation and climate of central Yakutia at the time of Late Pleistocene/Holocene transition, Giterman (1963) and Klimanov and Shofman (1982) made a conclusion about the existence of a periglacial vegetation complex in the Late Pleistocene, in the form of insular open woodland consisting of larch and birch, combined with treeless tundra and steppe communities. The transition to the Holocene was accompanied by an increased importance of forest vegetation.

According to Neustadt (1951), low bush and forest-tundra dominated by birches and shrub alder, prevailed in the vegetation of southern Yakutia (upper stretches of the Aldan river) in the Late Pleistocene. Larch forests with large amounts of birches spread in the Early Holocene. Tomskaya (1981, 1989) based on the pollen analysis of several archaeological sites, holds a different view, arguing that a particular type of "glacial" vegetation with the dominance of spores was in existence during the Late Glacial and the first half of the Holocene, with valley glaciers remaining in place until 6000 BP. At the same time, the scholar notes a short-lived amelioration in the Alleröd, followed by a cold and xerophytic stage of the Younger Dryas. The same writer argues that the modern-type vegetation was formed only by 3000 BP. The third view was advanced by Mochanov and Savvinova (1980); based on the study of the same archaeological sites, she argues that forest-type vegetation was in existence through the entire Holocene.

Hence, the available palaeogeographic evidence related to the terminal Pleistocene in Yakutia is both insufficient and controversial. The new pollen and radiocarbon data relative to the dynamics of landscape and climatic changes at the Late Glacial/Holocene boundary recently obtained by the present writers may sufficiently clarify the existing concepts.

CASE STUDY

Khomutakh Lake (63°43′N, 121°37′E, absolute elevation: 120 m) is located on the second terrace of the Vilyuy River, within the central Yakutian Lowland (Fig. 1). The surface of the terrace consists of loamy sand, underlain by pebbles, its elevation above the river being ca. 25 m. The thickness of perennially frozen ground reaches several hundred metres, as throughout the entire area of central Yakutia. The oval-shaped lake of inner drainage is of thermokarstic origin, with a surface area of ca. 44 hectares, and a depth of 1.5–2.0 m. A wide band of aquatic vegetation on the periphery of the lake consists mainly of bunchgrass and sedge. Sand soils around the lake are covered with bearberry and lichen pinewoods, with a rare admixture of birch (*Betula platiphylla*) and Dahurian larch (*Larix dahurica*); shrub birches (*Betula exilis* and *B. middendorfii*) are common. On the flood-plain one also notes spruce and alder (*Alnus hirsuta*) forests, as well as insular steppic birch groves alternating with areas of steppe and forest-steppe vegetation.

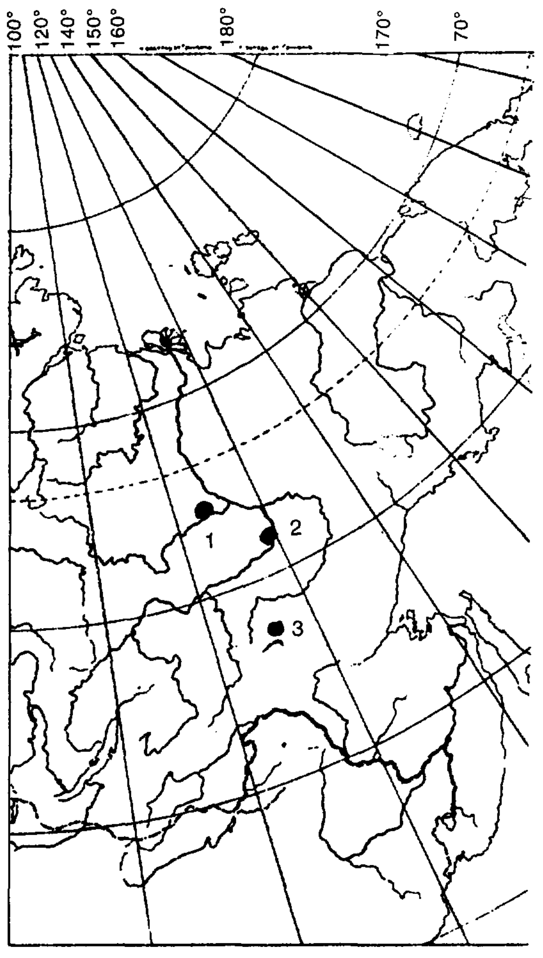

FIG. 1. Location of the sites. *Key*: 1—Khomustakh; 2—Chabada; 3—Suollakh.

Ulkhan Chabyda Lake (61°59′N, 129°22′E, absolute elevation: 200 m) is located on the erosional-alluvial plain on the left bank of the Lena River, 20 km west of Yakutsk (Fig. 1). The lake stretching from the north to the south is of inner drainage and of thermokarstic origin: its surface is 210 hectares, and the maximum depth is 0.8 m. The littoral aquatic vegetation consists mainly of bunchgrass and sedge. Sand soils around the lake are covered with bearberry and lichen pinewoods, with birch and larch, as well as shrub alder (*Alnus fruticosa*).

Mean July temperature in the area is 16–18°C, and that of January is −40 to −43°C. The mean annual temperature is ca. −10°C, and the mean annual precipitation is ca. 200 mm.

Suolakh peat-bog (57°02′N, 124°06′E, absolute elevation: 800 m) lies in a saddle-form depression, in the upper catchment of the Derput River, the secondary tributary of the Aldan, within the Chulman erosional-denudation plateau (Fig. 1). Gravelly and aggregated sand and sandy loam, and (rarely) loam, form the surface of the plateau. The thickness of perennially frozen ground is less than 100–200 m. The main element of vegetation consists of larch (more than 70%) and common pine woodlands with *Betula platiphyla* and rare *Pinus sibirica*. The underwood consists of shrub birches, shrub alder and *Pinus pumila*. Pure spruce forests and *Alnus fructosa* woodland occur in the valleys. Shrub birches dominate on the surface of the peat bog, where suppressed Dahurian larch are also rarely encountered. Sphagnum moss dominates the compact moss cover.

Mean July temperature in this area reaches 16°C, and that of January −35 to −36°C. The mean annual temperature is −6–8°C, and the mean annual precipitation is 450–550 mm.

Organic deposits of all three sites have been cored with the use of the Russian peat sampler. Lake Khomustakh was cored in July 1984 from a pneumatic boat to the depth of 7.4 m. Ulkhan Chabyda Lake was sampled in April 1989, from 1.5 m thick ice to the depth of 9.75 m. A core on a pingo of the Suollakh peat-bog reached the depth of 3.95 m. The samples were taken each 10 cm in the core of Lake Khomustakh; each 5 cm in that of Ulkhan Chabyda Lake; and each 5–10 cm in the core of Suollakh peat-bog. The samples were processed according to the Grichuk and Zaklinskaya (1948) method, and studied under 400× magnification. In each sample 300–500 grains were counted, and the estimation of the percentages of species was based on the total sum of the pollen. Diagrams were plotted for each of three sections (Figs 2–4).

The botanical analysis of peat and gyttja were carried out at the Botanical Laboratory of the "Torfgeologiya" Industrial Enterprise. Radiocarbon measurements were conducted at the Laboratory for Isotope Geochemistry and Geochronology by means of βcounting on liquid scintillation counters from the benzene converted from the alkaline extraction.

Quantitative characteristics of climate (mean July, January and annual temperatures, and mean annual precipitation) were estimated for each pollen spectrum with the use of an information-statistical method (Klimanov, 1976, this volume).

RESULTS AND DISCUSSION

The study of the Lake Khomustakh sequence resulted in the pollen diagram and nine radiocarbon measurements covering the time-span of the last 11,000 years (Fig. 2). The pollen diagram of Ulkhan Chabyda Lake (Fig. 3) also covers the Late Glacial and Holocene. The pollen sequence of the Suollakh peat-bog peat for which eight radiocarbon measurements were obtained includes the time-span from the Alleröd to the Sub-Boreal (Fig. 4). All this evidence sheds new light on the landscape and climate changes which occurred in Yakutia at the time of the Late Pleistocene/Holocene transition.

Central Yakutia

Reliably Late Glacial sediments were established only in the Lake Khomustakh sequence, where the date of 10,400±600 BP (GIN-4176) was obtained for the basal sandy ooze. One may suggest that the bulk of these deposits is of older age and their accumulation started in the late Alleröd. Similar pollen spectra were obtained at the bottom of Ulkhan Chabyda Lake, on which evidence

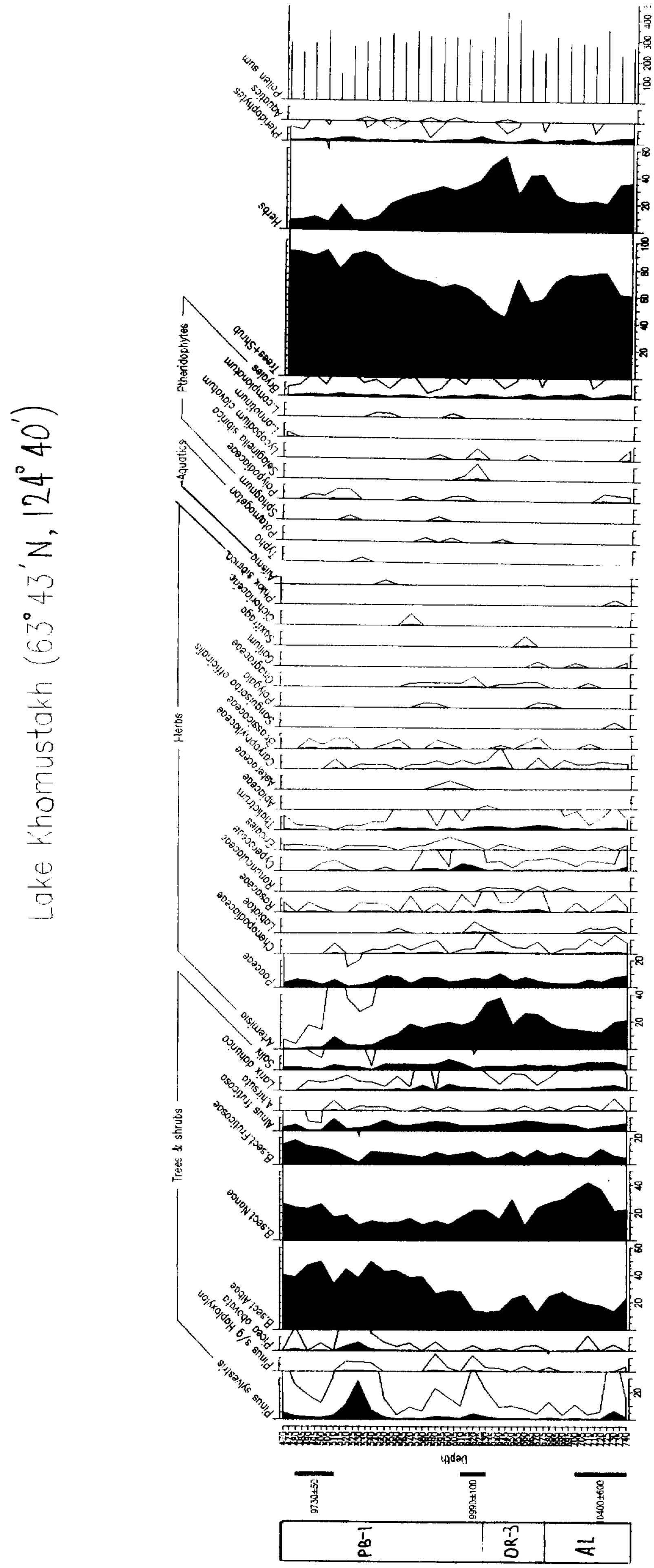

FIG. 2. Pollen diagram of Khomustakh Lake.

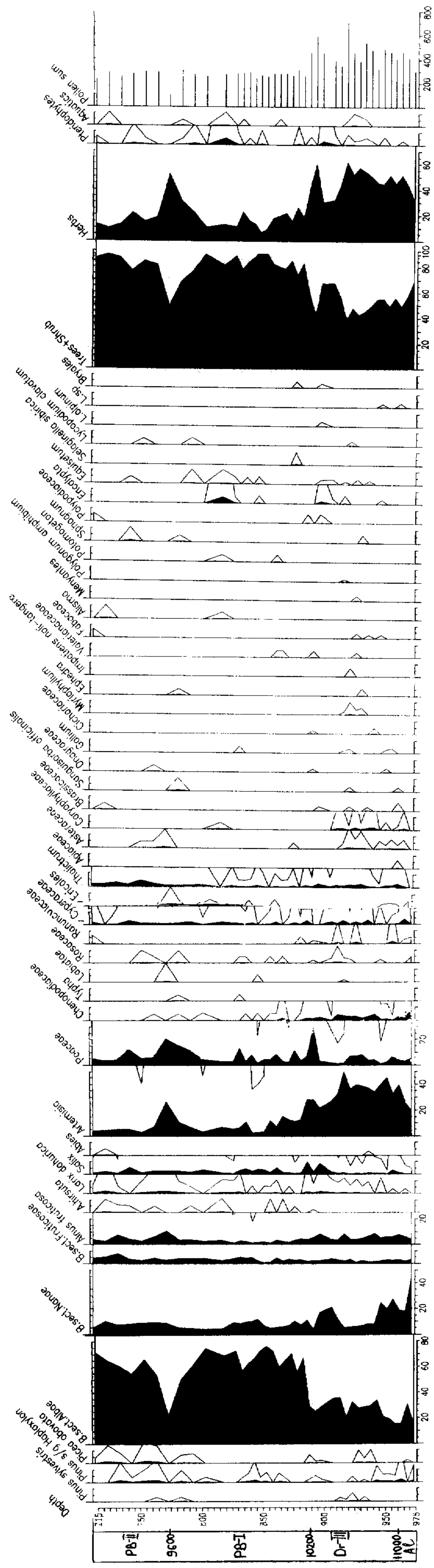

FIG. 3. Pollen diagram of Chabada Lake.

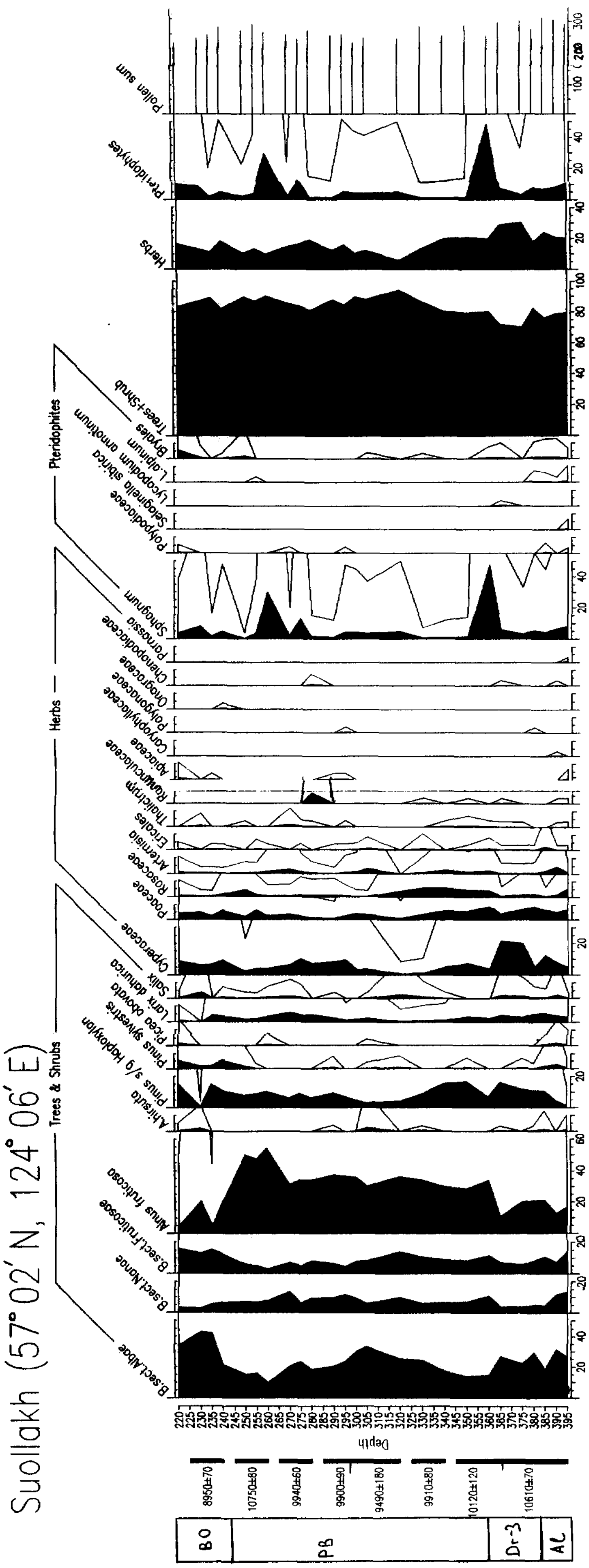

FIG. 4. Diagram of the Suollakh peat-bog.

they are also considered as Alleröd. Judging from the pollen spectra, the vegetation at that time was dominated by steppic formations with the prevalence of *Artemisia*, *Poaceae*, *Thalictrum*, *Chenopodiacese* and steppic taxa (*Polygala*, *Rubiaceae*, *Sanquisorba*, *Lamiaceae* and others). A significant amount of *Betula* sect. *Nanae* and *B. Fructicosa* is indicative of large areas taken up by shrubs.

Yet, as the analysis of surface samples in the basins of the Vilyuy and Yana has shown, the insignificant occurrence of larch in the spectra is by no means indicative of its real presence in the vegetation, which has also been noted by other scholars (Vas'kovsky, 1957; Popova, 1961; Giterman, 1963; Savvinova, 1975; Tomskaya, 1981; Ukraintseva, 1981). Woodlands seem to have occurred only on the landforms favorable for their growth: mostly on river floodplains, similarly to the present-day steppic birch and larch forests in central Yakutia. At that time, mean July temperature was by 1.5–2°C below the present values, that of January by −2 to °5°C, and the mean annual ones by −3 to −4°C.

The pollen spectra of the Younger Dryas show a considerable increase in the content of wormwood, grass and steppic herbs, indicating a marked increase in the area of wormwood–grass–forb formations. Shrubs and particularly woodlands were severely restricted. According to palaeoclimatic estimates, the mean summer temperature dropped by 3°C, and that of January by 6–7°C. The precipitation was 150 mm less than present.

The Late Glacial/Holocene boundary is indicated in each section by an abrupt increase in the rate of arboreal pollen, and by a change in sedimentation: sandy ooze grading into gyttja poor in organic matter. Based on the radiocarbon measurement of the sample from the overlaying gyttja at 6.1–6.2 m (9990±100 BP, GIN-4173), in the sequence of Lake Khomustakh, the transition to the Holocene may be dated to 10,300 BP, as elsewhere in northern Eurasia. Larch and birch woodlands with steppic elements (as the present-day birch forests in the forest-steppic central Yakutia) became dominant in the vegetation. Large areas were taken up by the communities of shrub birches, or *yerniks*, common in the present vegetation. The transformation of steppic coenoses was proceeding at various rates. In the area of Lake Khomustakh this occurred at ca. 9800 BP (the radiocarbon date of the overlaying gyttja is 9730±50; GIN-4174). Further east, in the area of Lake Boguda (63°40′N, 123°37′E, absolute elevation: 120 m) the total disappearance of steppic elements is dated to 7780±100 BP (GIN-4510).

Still further east, in the area of Ulkhan Chabyda Lake, the total disappearance of steppic elements at the depth of 7.58–7.73 m, in the gyttja, is radiocarbon dated to 7570±150 (GIN-6796). It should be noted that steppic formations are now widely spread in southeastern central Yakutia (the Lena–Amga interfluve).

Palaeoclimatic estimates indicate that the mean July temperature was below the present values by 0.5–1°C, that of July by 1.0–1.5°C, and the annual ones by 1°C. The annual precipitation was 25 mm less than now.

Southern Yakutia

The radiocarbon measurement for the basal layer of the sphagnum fen at the Suollakh peat-bog (3.65–3.95 m) yielded an age of 10,610±70 BP (GIN-4363). The paludification started in small mires formed in the mountain saddles in the course of the recession of valley glaciers.

The pollen spectra of the lower peat (3.8–3.95 m), formed at the end of the Alleröd and partly at the beginning of Younger Dryas, are dominated by birches and shrub alder. The higher proportion of larch still does not adequately reflect its participation in the vegetation. In all probability, the surrounding landscape was dominated by open larch and birch woodland, with a considerable participation of shrub alder, shrub pine and shrub birches (*Betula* sect *Nanae* and *Fruiticosae*) in the underwood. Similar woodlands occur presently in north-east Yakutia. Rare occurrences of spruce and common pine pollen show either the total absence of these species or their suppressed state. The occurrence of wormwood is seen as evidence for the presence of steppe vegetation, probably on the south-oriented slopes.

The palaeoclimatic estimates show the annual temperature was 0.5–1°C below that of today, and the annual precipitation was 25 mm below the present value.

The overlaying peat accumulated during the Younger Dryas (or, rather, in its coldest phase), features an increase in the content of grasses (mainly bunchgrass and forb) and the disappearance of spruce and pine pollen, thus indicating a considerable cooling. The palaeoclimatic estimates show that the July temperature was 2–3°C less than now; that of January—less by 4–5°C. The annual temperature was 3–4°C below the present value, and the annual precipitation was 75 mm below that of today.

The pollen spectra at the depth of 2.4–3.6 m are rich in the pollen of *Alnus fruiticosa*. Based on two radiocarbon measurements: 10,120±120 (GIN-4362) for a sample from 3.5–3.6 m and 9910±80 BP (GIN-4361) from 3.2–3.5 m, the rapid change in the character of the pollen spectra, which occurred at the Late Glacial/Holocene boundary, may be dated to ca. 10,200–10,300 BP. Judging from the dominance of the shrub alder typical of the sub-recent spectra in the larch woodland of northern Yakutia, one may suggest that the larch woodland of north-taiga type with a large participation of shrub alder in the underwood, formed the main type of vegetation of southern Yakutia in the Preboreal period. The radiocarbon measurement of a sample from the depth of 2.25–2.45 m (8950±70 BP; GIN-4358) indicates that the abrupt fall in the content of shrub alder and shrub birches occurred at the beginning of the Preboreal. These changes were probably related to a further amelioration of climate resulting in the larch woodlands of the northern type being transformed into those of the present day middle-taiga type.

At the time of the optimum Preboreal warming, the mean July temperature was 0.5°C, that of January 1.5°C, and the annual temperature 1°C below the present-day values. The annual precipitation is estimated as 25 mm less today.

It should be noted that a large series of similar radiocarbon dates were obtained for the samples of Preboreal age: 9910±80 BP (GIN-4361) for a sample from 3.2–3.5 m; 9900±90 BP (GIN-4359) for a sample from 2.8–3.0 m, and 9940±60 BP (GIN-4358) for a sample from 2.6–2.8 m. At the same time an inverse date was obtained for the Preboreal/Boreal boundary: 10,750±80 BP (GIN-4357). Series of anomalous dates in the range of 9000–11,000 BP are also known from other areas of Siberia. The possible cause of this phenomenon may be the enrichment of the atmosphere by carbon dioxide of volcanic origin at the Late Glacial/ Holocene boundary (Melekestsev *et al.*, 1986).

CONCLUSION

The obtained pollen and radiocarbon data considerably clarified the changes in the vegetation and climate at the boundary of the Late Glacial and Holocene in central and southern Yakutia (the upper stretches of the Aldan River).

The periglacial vegetation complex, with the steppic bunchgrass-forb communities and various grasses, combined with shrub (*yernik*) communities, the steppic birch and larch groves, were dominant in central Yakutia in the Alleröd. At the same time, open larch woodlands with the participation of arboreal birch (sect. *Albae*) and shrub alder, shrub birches, shrub cedar, combined with the *yernik* and grass communities, existed in southern Yakutia.

Wormwood–grass communities considerably increased in importance in the vegetation assemblages of central Yakutia in the Younger Dryas, while sedge-grass associations increased in the southern part of the country. All these are indicative of considerable cooling. Based on the palaeoclimatic estimates one may ascertain that the landscape differences acknowledgeable between central and southern Yakutia were due to the distinction in climate, which at that time was sharper than now.

The transition to the Post Glacial, at ca. 10,200–10,300 BP, was marked in central Yakutia by the initial transformation of the periglacial vegetation complex into the larch and birch forests of the north taiga type. This process proceeded gradually, the steppic landscapes surviving longer in the northeast. The Late/Post Glacial boundary in southern Yakutia was marked by the transformation of open larch woodland of forest-steppic type into those with a greater participation of shrub alder.

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