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On the Palynological Characteristic of Late Valdai Loesses in the Centre of Russian Plain

Palinologiczna charakterystyka lessów młodszego Valdaianu ze środkowej części Równiny Rosyjskiej

К палинологической характеристике поздневалдайских лёссов центра Русской равнины

ABSTRACT

Two sections of late Valdai (late Würm) loess deposits in the Desna drainage basin have been studied palynologically (including the species determination of pollen and spores). The floristic list was completed by the data on the loess sections of the same age in the adjacent territory, published by a number of Soviet palynologists. The characteristic of the late Valdai flora and vegetation in the area under investigation is given, based beside the quantitative ratios of the pollen spectres on the present-day distribution of the plant species, components of the investigated fossil flora, their ecological pattern and coenotic links.

The most active processes of loess accumulation on the territory of the Russian Plain occurred at the second half of the Valdai (Vistula→ Würm) glaciation. Loesses of this age in the Desna river basin reach 8 m in thickness. This is what predetermines our interest towards paleogeographic situation of the late Valdai stage.

One of the most informative methods of studying natural environment of Pleistocene is pollen analysis. Its significance in studying natural conditions of loess accumulation epoch increases since according to modern conceptions vegetation was one of important factors causing

the possibility of loess accumulation and its intensity. The nature of soil-vegetation complex was of defining significance both for the process of catching and accumulation of mineral particles and for that of silt transformation into loesses (I. P. Gerasimov 1962, A. A. Velichko 1982).

Loess deposits are a difficult object for palynological studies. Pollen and spore content in them is extremely low which is explained not only by low pollen productivity of local vegetation combined with high sedimentation rate, but also by destruction of the least stable pollen grains and spores upon their burial under subaerial conditions affected by soil-forming processes (according to I. P. Gerasimov 1962, loess is a soil of specifically continental conditions). Since pollen grains and spores differ essentially by exine thickness and its stability against destruction, the content of pollen grains with thick stable against destruction exine is higher in loesses (*Asteraceae, Cichoriaceae, Chenopodiaceae* and some other families) on the account of pollen and spores with thin unstable exine. It is important to note that pollen of *Graminae* (L. S. Isaeva-Petrova 1976) refers to the latter group. Selective nature of pollen spectra of loesses causes the necessity of a careful approach to the interpretation of quantitative correlations in spectra.

Examples of pollen diagrams of loesses are given on Fig. 1. The first of them (Fig. 1a) refers to the upper, loess part of the cross-section Yelisevichi on the Sudost' river — a tributary of the Desna river (Fig. 2). At a cross-section located near a late Paleolithic stand which dates back to 17,340 ± 170 years ago according to ^{14}C (Lu-360, Kh. Arslanov and E. I. Kurenkova 1975) deposits of the II terrace above the flood plain are revealed. At the depth of 1.25 m from the surface cultural remains were found which make it possible to synchronize this level to the cultural one of the stand.

Spectra of Yelisevichi cross-section are characterized by a overwhelming prevalence of pollen of the *Cichoriaceae* family and to the less exten — *Asteraceae*. The pollen of other components of NAP and arboreous species is extremely scare. Among the arboreous pollen of *Pinus silvestris* occurs more often, and seldom — that of *P. sibirica* and *Picea*. *Betula* pollen belongs both to arboreous and bush species. At this cross-section as well as at other sections of loess deposits single pollen grains are observed of oak, lime-tree, hornbeam, hazel and also pre-Quaternary pollen and spores. Bearing in mind that the enumerated broad-leaved species are incompatible in their ecology with the most part of plants determined in the spectra both of arboreous and herbaceous ones, and also that some pollen grains of the broad-leaved differed in their morphology from that of species present in the Quaternary flora

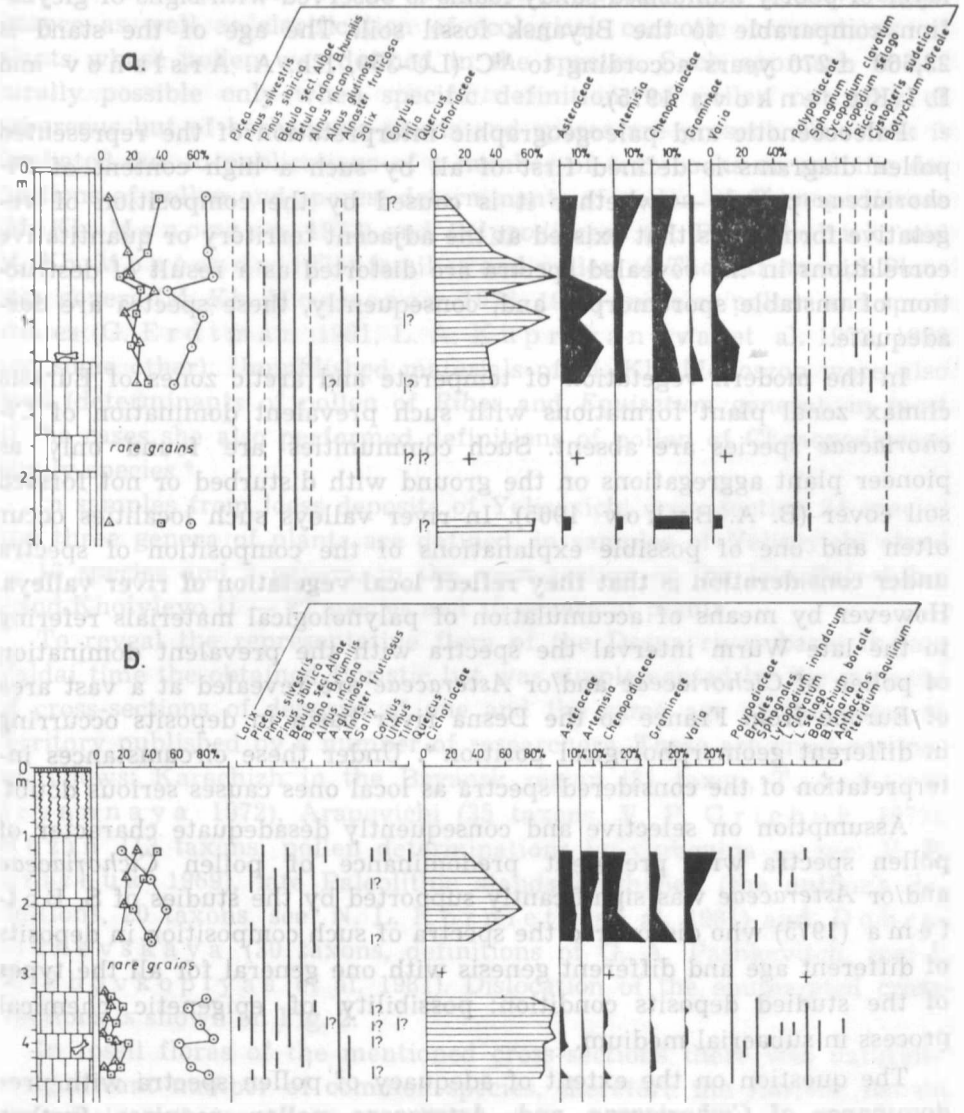

Fig. 1. Pollen diagrams of the sections Yeliesevichi (a) and Khotylevo (b)

of the region, pollen grains of the broad-leaved species along with pre-Quaternary sporomorphs are considered as redeposited.

The pollen diagram of the cross-section of the late Paleolithic stand Khotylevo II located on the Desna river is similar to the considered diagram (Fig. 1b). The stand is on the right bank of the river. The cultural layer is within the thickness of loess-like sandy loams underlain by Cretaceous bedrocks. Directly below the cultural layer an inter-

layer of poorly humusized sandy loams is observed with signs of gleyzation comparable to the Bryansk fossil soil. The age of the stand is 23,660 ±270 years according to ^{14}C (LU-359, Kh. A. Arslanov and E. I. Kurenkova 1975).

Paleocoenotic and paleogeographic interpretation of the represented pollen diagrams is defined first of all by such a high content of *Cichoriaceae* pollen — whether it is caused by the composition of vegetative formations that existed at the adjacent territory or quantitative correlations in the revealed spectra are distorted as a result of destruction of unstable sporomorphs and, consequently, these spectra are desadequate.

In the modern vegetation of temperate and arctic zones of Eurasia climax zonal plant formations with such prevalent domination of *Cichoriaceae* species are absent. Such communities are found only as pioneer plant aggregations on the ground with disturbed or not formed soil cover (B. A. Bykov 1965). In river valleys such localities occur often and one of possible explanations of the composition of spectra under consideration is that they reflect local vegetation of river valleys. However by means of accumulation of palynological materials refering to the late Würm interval the spectra with the prevalent domination of pollen of *Cichoriaceae* and/or *Asteraceae* are revealed at a vast area of Europe from France to the Desna river basin in deposits occurring in different geomorphological position *. Under these circumstances interpretation of the considered spectra as local ones causes serious doubt.

Assumption on selective and consequently desadequate character of pollen spectra with prevalent predominance of pollen *Cichoriaceae* and/or *Asteraceae* was significantly supported by the studies of S. Bottema (1975) who discovered the spectra of such composition in deposits of different age and different genesis with one general for all the types of the studied deposits condition: possibility of epigenetic chemical process in subaerial medium.

The question on the extent of adequacy of pollen spectra with predominance of *Cichoriaceae* and *Asteraceae* pollen requires further research and its single solution remains for the future. However a possibility of essential distortions of quantitative correlations of components of such spectra does not allow to use the per cent correlations of present taxons as a basis for interpretation.

Therefore for paleocoenotic and paleogeographic studies an analysis

* These families were formerly considered to be subfamilies of the *Compositae* family. In published palinological materials it was not mentioned as a rule whether the pollen of this family belonged to this or that subfamily.

of floristic composition of the loess pollen spectra is of decisive significance as well as clarification of ecological coenotic connections of plants whose pollen was defined in the spectra. Such approach is naturally possible only when specific definitions of pollen not only of arboreous but of herbaceous plants and spores are present. This task is faciliated due to publications of a number of text-books on specific definitions of pollen and spores: determinants of pollen of *Chenopodiaceae* (M. Kh. Monoszon 1973) and *Polypodiaceae* (V. P. Grichuk and M. Kh. Monoszon 1971) families and pollen of *Thalictrum* and *Plantago* genera (M. Kh. Monoszon 1976, 1985) and also pollen and spore atlases (G. Erdtman 1961, L. A. Kupriyanova et al. 1972, 1978 and some other). Unpublished materials of M. Kh. Monoszon were also used (determinants of pollen of *Ribes* and *Equisetum* genera), in most of the cases she also performed definitions of pollen of *Chenopodiaceae* family species *.

In samples from loess deposits of Yelisevichi cross-section 24 species and three genera of plants are defined, in samples of Yelisevichi stand — 13 species and 5 genera, in the cross-section of the late Paleolithic stand Khotylevo II — 27 species and 10 genera of plants.

To reveal the representative flora of the Desna river basin in late Valdai time the obtained floristic list was supplemented by the material of cross-sections of deposits of one and the same age at the adjacent territory published by a number of researchers. These are cross-sections as follows: Karachizh in the Bryansk region (31 taxon, T. A. Serebryannaya 1972), Arapovichi (35 taxons, V. P. Grichuk 1972), Mezin (13 taxons; pollen determinations by Gubonina — see: V. P. Grichuk 1969), late Paleolithic stands Mezhirich (the author's definitions, 20 taxons, see: N. L. Korniets et al. 1981) and Dobranichevskaya (30 taxons, definitions of G. A. Pashkevitch, see: I. G. Shovkoplyas et al. 1981). Dislocation of the enumerated cross-sections is shown on Fig. 2.

In fossil floras of the mentioned cross-sections there was naturally a significant number of common species, therefore the floristic list on the whole includes 69 species of plants and 28 genera that were not defined more precisely. Out of this number only 39 species are present in the modern flora of the region (the number of common genera is much higher — 25 — just as it should be expected).

In their ecology the species under consideration are characterized by high diversity. Alongside the species with wide ecological amplitude cold-resistant species (*Betula nana*, *Botrychium boreale*), xerophytes and

* The author appreciates sincerely many year effective assistance of M. Kh. Monoszon in this work.

halophytes (*Kochia laniflora, K. prostrata, Atriplex tatarica*) and species adjusted to strongly continental climate (*Chenopodium acuminatum, Eurotia ceratoides*) are present.

Analysis of coenotic characteristics of plant species — components of the fossil flora under study — showed that their highest number (21 species) characterizes forest coenoses — mainly light coniferous and small-leaved forests. There are much less species with tendency to open woodlands (due to unspecific natura of their flora). Just the opposite, flora of dark coniferous woods is specific to a high extent and the presence of only 8 intrinsic species (all of them occurring in other forest types as well) indicate subordinate role of dark coniferous forests in the vegetation of the Desna river and Dnieper river (mid reach) basin at the considered period.

Fig. 2. Situation of the discussed sections in the Desna and mid-Dnieper river basins 1 — late Valdai ice sheet extent; 2 — boundary of permafrost in late Valdai

Significant participation of steppe plants (17 species) is demonstrative. Pollen productivity of steppe herbs is naturally much lower than that of forest trees and bushes therefore such a representative group of steppe plants is a convincing proof of an important part played by steppe formations in the vegetation cover.

A large group of species represented in the fossil flora are components of pioneer plant assemblage on the sites with disturbed or

unformed soil cover. Such localities were typical for periglacial conditions and a great number of species of this ecological-coenotic group is a typical feature of glacial floras. Meadows, swamp and coastal communities refer to the number of intrazonal coenoses whose existence is proved by the presence of characteristic species in the fossil flora. Water flora is represented poorly.

Zonal tundra coenoses are not revealed: out of the defined species *Betula nana* alone is within such formations. However it grows besides also in bush lands at the edge of forests and on the swamps (in these localities it occurs also in the forest zone, the southern boundary of its area nearly reaching the latitudes of Moscow).

Absence of tundra species can not be explained by selective destruction of pollen or by impossibility of its definition up to the species level, since among them there are species with stable exine and those whose pollen is easily recognized in sepctra (for instance *Rubus chamaemorus*). Thus a conclusion should be drawn on the absence or very poor distribution of tundra formations in the vegetation cover of the Desna and mid--Dnieper basin in late Valdai.

Analysis of modern plant areas comprising the considered fossil flora allows to specify the nature of plant formations that composed periglacial vegetation cover. Most flora species possess wide holarctic and Eurasian areas, a number of plants refer to hemicosmopolites. Among the latter there are mainly intrazonal species (*Botrychium lunaria, Lythrum salicaria, Chenopodium album*), but forest species (*Pteridium aquilinum, Lycopodium clavatum*) occur as well.

The number of arctic plants we mentioned not to be great. These include meadow species such as *Selaginella selaginoides* and *Botrychium boreale* as well as bush birch species such as *B. nana, B. humilis*. A group of Asian (Siberian) species, including both boreal and arcto-boreal forest plants (*Larix, Pinus sibirica, Alnaster fruticosus*) and central Asian (eastern-Euroasian) steppe species: *Kochia prostrata, K. laniflora* is representative. Intrazonal species are noted whose modern area is limited by south-Siberian part of the steppe zone (*Corispermum sibiricum*). Wider Asian areas characterize also the tending to steppe communities *Artemisia commutata, A. sieversiana, Chenopodium acuminatum*.

All these data testify that Asian floristic complex played an important part in periglacial flora of central regions of the Russian Plain.

One of the methods of ecological-geographical analysis of fossil flora is determination of the region where at present grows the maximum number of species-component of this flora (V. P. Grichuk 1978). The fact that phytocoenotic timing of a species is defined by its biological and physiological properties allows us to consider the region of

maximum modern concentration of fossil flora species as a modern phytocoenotic and paleogeographic analogue of the region of habitat of the real flora of the past — a producent of that material which represents the fossil flora preserved till to-day. Determination of such a region-analogue carried out for Khotylevo and Yelisevichi cross-sections showed it to be situated in the Altai. Out of 69 species of the studied flora 53 are present in the modern Altai flora, i.e. common nature of these floras is essentially higher than those of modern and late Valdai floras of one and the same region — the Desna and mid-Dnieper basin. This enables us to use Altai vegetation, the modern analogue, as a model when characterizing the vegetation of the late Valdai.

On the whole the performed studies show the following groups of plant formations to have been present in the vegetation cover at the characterized time interval:

Steppe formations — *Artemisia commutata*$^{+}$, *A. sieversiana*$^{+}$, *A. dracunculus*$^{\circ}$, *Ephedra distachia*$^{\circ}$, *Kochia prostrata*$^{\circ}$, *Chenopodium acuminatum*$^{+}$, *Eurotia ceratoides*$^{\circ}$, the latter as well as *Chenopodium vulvaria* are peculiar to solonetz-like steppes. Some of the mentioned species occur in different plant communities now from semi-desert and desert (*Eurotia ceratoides*) up to primitive plant assemblages on deposits with disturbed or unformed soil cover (*Ephedra distachya*). In the Altai however they are typical species of steppe formations distributed there (A. V. Kuminova 1960).

Forest and open woodlands: light-coniferous, small-leaved and mixed. To formations of this type refers the majority of forest species whose pollen is observed in the spectra: *Betula pubesces, B. pendula, Pinus sylvestris, Larix*$^{+}$, *Lycopodium clavatum, L. selago, Pteridium aquilinum, Impatiens noli-tangere*. Though the mentioned arboraceaus species (except larch) are rather powerful producents of pollen, participation of the latter in spectra is rather small. Pine and birch pollen is resistant against destruction so we have to make a conclusion that coenoses of this type did not occupy large areas. Similar to the Altai we may believe that (alongside small plots of forests and woodlands on flat interfluves) valley forests existed in the valleys of the Desna and mid-Dnieper rivers.

Dark coniferous forests (*Picea, Pinus sibirica*$^{+}$) were evidently located in river valleys as well.

Riverain bush — *Alnaster fruticosus*$^{+}$, *Salix, Ribes nigrum* and other species of this genus.

Meadows — the following species which are absent in the modern flora of the region: the arctic species *Botrychium boreale* and arcto-alpine — *Selaginella selaginoides*, and also *Lycopodium inundatum*,

Thalictrum contortum^{+}, *Polemonium coeruleum*. Species of *Centaurium* genus are peculiar mainly to meadow communities on saline grounds.

Communities on grounds with destroyed or unformed soil cover — *Chenopodium album, Ch. botrys, Ch. rubrum, Convolvulus arvensis, Fagopyrum sagittatum, F. tataricum*$^{\circ}$, *Corispermum sibiricum*$^{+}$, *C. hyssopifolium*, on saline grounds — *Chenopodium glaucum*.

Swamps coastal communities — *Lythrum salicaria, Alisma plantagoaquatica, Menyanthes trifoliata, Calla palustris*.

Water coenoses — species of *Potamogeton* and *Sparganium* genera. (In this list ($^{+}$) denotes Siberian plants, ($^{\circ}$) — the plants with a different type of the area growing now in the Altai and absent in the modern flora of the region under investigation).

The above given list does not exhaust in any way the floristic composition of the enumerated groups of vegetation formations. However inspite of its incomplete nature we can see a characteristic property of periglacial vegetation communities: plants essentially different in the type of modern areas occur in the same formations (we may judge upon this on the basis of coenotic dislocation of the considered species). Jointly with species peculiar to the modern flora of the investigated region (and those that grew there in the preceding Mikulino=Eemian Interglacial) plants peculiar now to southern Siberia, north Siberian and arctic migrating plants grew as well. Climatic conditions of the glacial epoch contributed to distribution and settling of three latter groups. This circumstance and also the fact that more or less close analouges of periglacial coenoses are now found only in vegetation of mountain regions show formation of periglacial vegetation communities to have taken place as a result of radical reconstruction of vegetation formations that formerly existed and was accompanied by migration of individual floristic groups (and not integral zonal units of vegetation). As a result new typical for periglacial zone structural units of vegetation cover were developed.

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STRESZCZENIE

Lessy są obiektem trudnym do badań palinologicznych, nie tylko ze względu na niską produktywność miejscowej roślinności pierwotnej rozwijającej się przy tym w warunkach intensywnej akumulacji pyłu, ale także z powodu zniszczenia mniej odpornych elementów fossylizowanych zespołów pyłkowych w środowisku subarealnym. Ostatnia okoliczność warunkuje selektywny charakter zachowanych zespołów pyłkowych w lessach, a w rezultacie poważną deformację ilościowych sto-

sunków między ich komponentami. Dlatego przy interpretacji danych palinologicznych oprócz zasad ogólnie stosowanych duże znaczenie ma analiza składu florystycznego spektrów i ekologicznych osobliwości roślin, których pyłki zostały stwierdzone.

Autorka badała dwa profile utworów lessowych młodszego Valdaianu (młodszego Würmu) w dorzeczu Desny. Dla uzyskania reprezentatywnych danych wykaz roślin stwierdzonych w tych profilach uzupełniono danymi, uzyskanymi dla innych profili z terenów sąsiednich, opublikowanymi przez wielu palinologów radzieckich. Wykaz obejmuje ogółem 69 gatunków roślin i 28 rodzajów, a konkretyzując — roślin nie określonych ściślej gatunkowo. Obok gatunków umiarkowanie termofilnych (np. *Betula pubescens*, *B. pendula*) stwierdzono mikrotermy, a równocześnie kserofity, halofity i gatunki roślin adaptowanych do klimatu skrajnie kontynentalnego. W dzisiejszej florze badanego rejonu występuje tylko 39 gatunków, gdy tymczasem na Ałtaju 53 gatunki. Najliczniejsze były gatunki właściwe dla lasów drobnolistnych oraz świetlistych iglastych, formacji stepowych i pionierskich zbiorowisk właściwych dla gruntów o naruszonym lub nie wykształconym profilu glebowym. W składzie tych samych formacji występują rośliny różniące się w sposób istotny charakterem dzisiejszych zasięgów.

Chociaż peryglacjalna flora młodszego Valdaianu zbadana jest niedostatecznie, uzyskane wyniki świadczą, że kształtowanie się peryglacjalnych zbiorowisk roślinnych następowało w rezultacie radykalnych zmian fitocenoz istniejących wcześniej, z towarzyszącą migracją poszczególnych grup florystycznych, głównie azjatyckiej (syberyjskiej). W rezultacie powstały nowe, charakterystyczne jednostki strukturalne szaty roślinnej, co podkreśla osobliwości warunków kształtowania się pokrywy lessowej w tym okresie.

РЕЗЮМЕ

Лёссы — трудный объект для палинологического исследования, не только из-за низкой пыльцевой продуктивности местной растительности в сочетании с быстрым темпом осадконакопления, но и вследствие разрушения менее стойких пыльцевых зерен в субаэральной среде после захоронения. Последнее обстоятельство обусловливает селективность пыльцевых спектров лёссов и, следовательно, возможность существенного искажения количественных соотношений их компонентов. Поэтому при интерпретации палинологических данных в дополнение к общепринятой методике важное значение приобретает анализ флористического состава спектров и эколого-ценотических свойств растений, пыльца которых в них обнаружена.

Автором исследовано два разреза лёссовых отложений в бассейне р. Десны. В целях получения репрезентативной флоры флористический список был дополнен по данным из разрезов одновозрастных лёссовых отложений на прилегающей территории, опубликованным рядом советских палинологов. Список включает 69 видов растений и 28 родов, точнее — до уровня вида — не определенных. Наряду с умеренно-термофильными видами (как например *Betula pubescens*, *B. pendula*) отмечены микротермы, а с другой стороны — ксерофиты, галофиты и виды растений, приспособленные к резко континентальному климату. Только 39 видов присутствует в современной флоре района, в то время как на Алтае сейчас произрастает 53 вида. Наиболее многочисленные виды мелко-

лиственных и светлохвойных лесов, степных формаций и пионерных группировок на грунтах с нарушенным или несформированным почвенным покровом. Характерно, что в составе одних и тех же формаций присутствуют растения, существенно различающиеся по типу их современных ареалов.

Хотя перигляциальная флора позднего валдая изучена еще далеко недостаточно, имеющиеся данные свидетельствуют о том, что формирование перигляциальных растительных сообществ происходило в результате радикальной перестройки существовавших ранее фитоценозов, которой сопутствовали миграции отдельных флористических групп, в первую очередь — азиатской (сибирской). В результате сложились новые, характерные для этого времени структурные единицы растительного покрова, что подчеркивает своеобразие условий формирования поздневалдайских лёссовых толщ.