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PALYNOTERATICAL COMPLEXES AS INDICATORS OF NATURAL ECOLOGICAL STRESS, PAST AND PRESENT

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ABSTRACT. The present article is a first attempt at distinguishing some types of natural palynoteratical complexes and discusses how they may have arisen. Three different forms of palynoteratical complex may be recognized: 1. dwarf pollen grains or spores of reduced size; 2. palynomorphs which are morphologically abnormal in several features simultaneously; 3. "abortive" pollen with signs of significant underdevelopment. These palynoteratical complexes are indicators of stress states in the genetic make-up of individual plants and plant communities. Palaeozoological, palaeomagnetic and the usual palynological data allow us to correlate such complexes with natural deficiencies in temperature and moisture, either separately or in combination.

KEY WORDS: Pollen, spores, palynocomplex, plant, palynomorph, palynoterate

INTRODUCTION

There are no publications dealing specifically with the problem of distinguishing between different types of palynoteratical complex. Only underdeveloped pollen complexes and spectra which diverge morphologically from the norm in several ways simultaneously have been described in the literature (Ananova 1966, Levkovskaya *et al*. 1983, Levkovskaya 1989, Spiridonova 1991). However it is often possible to find non-statistical references to different palynoteratical forms, described as abnormal, deviant, deformed, defective, unusually small, monstrous, underdeveloped, untypical, teratoid, mutagenous, hybrid, etc. This information is scattered in the publications of palaeopalynologists, palynomorphologists of contemporary pollen and selectionists. It is not possible to give the references for all abnormal palynomorph discoveries and explanations of their origin.

The pollen and spore morphology of numerous recent and fossil plants varies from taxon to taxon. Hence the criteria for distinguishing the palynomorphological norm, variants from the norm and palynoteratical (abnormal) forms must be developed separately for each taxon. In this paper the following preliminary definition of palynoterate is suggested: a palynoterate is a recent or fossil palynomorph that shows divergence from the palynomorphological norm in at least two morphological features simultaneously within one pollen grain or spore. Palynoteratical complexes are spectra in which palynoteratical pollen or spores are dominantes**.**

RESEARCH METHODS

The present article is based on numerical data assembled by the author, who, for about 40 years, has examined with the ĚÂÂ-1 biological microscope the different morphological abnormalities of every pollen grain in various samples, and has recorded the proportion of them in every single one. All this information has been obtained from Pleistocene, Holocene and subfossil sediments. SEM research on a number of palynoterates has been carried out by the author and her colleagues Tarasevitch, Gavrilova and Kartzeva at the RAS Botanical Institute during 1998. As a result of this studying the atlas (see Levkovskaya *et al.* non published report) with about 400 illustrations was prepared. An extensive range of multidisciplinary data (traditional palaeopalynological, palaeozoological, geological, palaeomagnetic, permafrost, archaeological, etc) was used for correlation or ecological reconstruction. The geographical regions from which the studied material originated exemplified modern and past climatic zones with different temperature and moisture conditions (Baltic States, St.-Petersburg region, Carpathians, Moldova, Russian Plain, Caucasus, Taimyr, Altai, Southern Arabia). The subfossil samples were collected (Levkovskaya 1971) in all the geobotanical subzones of Western Siberia (except steppe) from different types of sediment (lake, soil, peat bog, etc), which has not undergone recent contamination. Only three samples from this vast range of material are included in the present article (Figs 1–3).

RESULTS

An initial survey of the palynoteratical statistics, based on the subfossil and fossil samples, enables us to distinguish the following three preliminary types of palynoteratical complex:

1. complex dominated by dwarf palynomorphs, which may be subdivided into two classes which contain:

a) dwarf pollen of a single taxon (Fig. 1);

b) dwarf pollen of many taxa in one complex.

2. A type of complex with the domination of palynomorphs which diverge from the norm in several morphological characters simultaneously (pollen grains asymmetrical, with an atypical number of apertures, etc). This type has two subdivisions:

a) divergence in several characters in a single taxon in the palynocomplex (Fig. 2);

b) divergence in several characters in many taxa in the palynocomplex.

3. A complex in which "abortive" pollen dominates, ie pollen displaying signs of significant underdevelopment of the palynomorphs (Fig. 3).

Fig. 1, which shows SEM micrograph of the dwarf pollen of a *Sonchus* sp., provides a good illustration of complex type 1a. It forms part of a palynocomplex of sediments that were collected from near the jaw of a four-month-old Neanderthal child at the Mezmaiskaya cave site in the North-West Caucasus. According to palaeozoological and the usual palynological data, these sediments were formed in a very cold and moderately dry climate (conditions found in the alpine belt of more central Caucasian areas, whereas the studied cave now

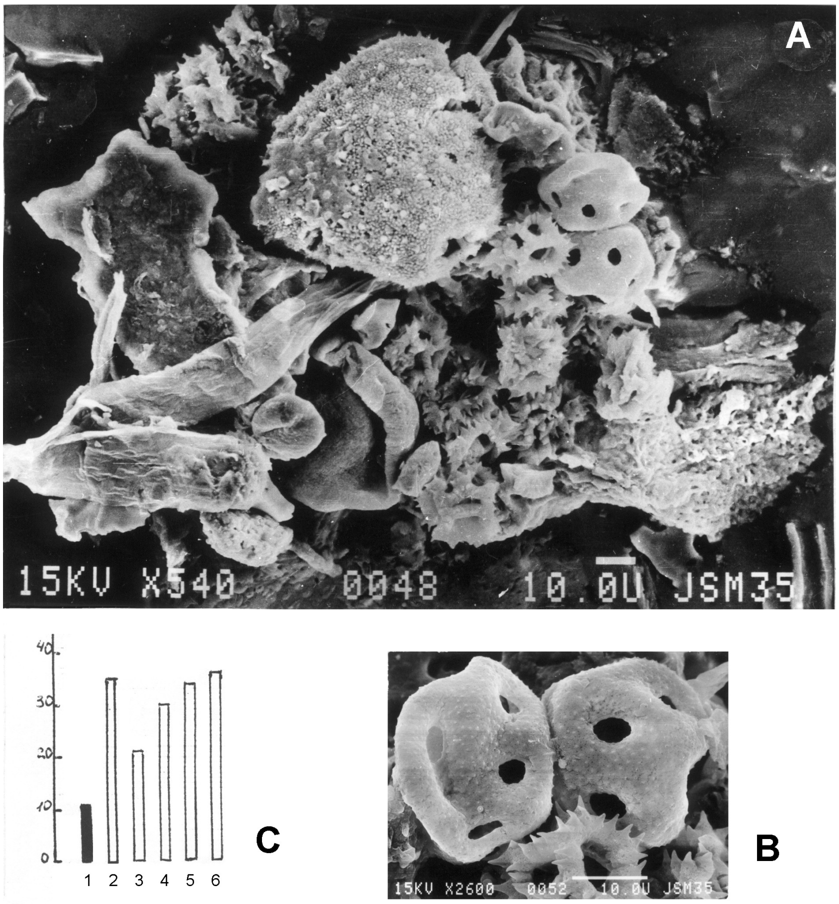

Fig. 1. An example of a palynoteratical complex with domination of dwarf pollen of a single taxon: palynoteratical complex (SEM micrograph) of sediments that were collected near the jaw of a 4-month-old Neanderthal child at the Mezmaiskaya cave site (upper part of the forest belt of North-West Caucasus). Excavations of L. Golovanova, Palynological data of G. Levkovskaya. **A** – SEM micrograph of a palynoteratical complex dominated by the dwarf pollen grains of Sonchus sp. and with occasional normal pollen of Chenopodiaceae and *Knautia* sp. (the largest grains on the SEM micrograph); some of the grains of *Sonchus* sp. represent conglomerates of underdeveloped palynomorphs; **B** – part of an SEM micrographs showing with the pollen of Chenopodiaceae, *Sonchus* sp. and scale bar; **C** – comparison of the sizes of fossil (black line) and recent (by Askerova 1987) pollen of some *Sonchus* L. species from Caucasian and other areas: 1 – *Sonchus oleraceus* L., 2 – *S. aquatilis* (Pourr.) Nyman., 3 – *S. asper* (L.) Hill, 4 – *S. palustris* L., 5 – *S. maritimus* L.

Commentary. The figure illustrates both the palynoteratical data from the funeral place of a Neanderthal child and a palynoteratical complex dominated by dwarf palynomorphs of a single taxon. Most of the fossil pollen of *Sonchus* sp. in the SEM micrograph measures less than 20 microns, although there are no pollen grains at diameter less than 19–20 microns among 315 recent species of the Cichorioideae and all recent Caucasian species of *Sonchus* L. described in the monograph on the pollen morphology of the Cichorioideae (Askerova 1987). Traditional palynological data allows us to reconstruct a landscape dominated by subalpine–alpine meadows, but these meadows were dry. The palaeozoological complex has been described by Baryshnikov (Golovanova *et al.* 1986) and was characterized by domination of steppe *Bison priscus* and the presence of inhabitants of the alpine belt (alpine meadows, prairies and steppe) – *Pyrrhocorux pyrrhocorux, P. graculus, Prometheomys* sp., *Chionomys nivalis* and *Cricetelus cricetelus*. According to the palynological and palaeozoological data low temperatures have proved to be the most important unfavourable factor for the plants in this case, although some moisture deficit occurred as well

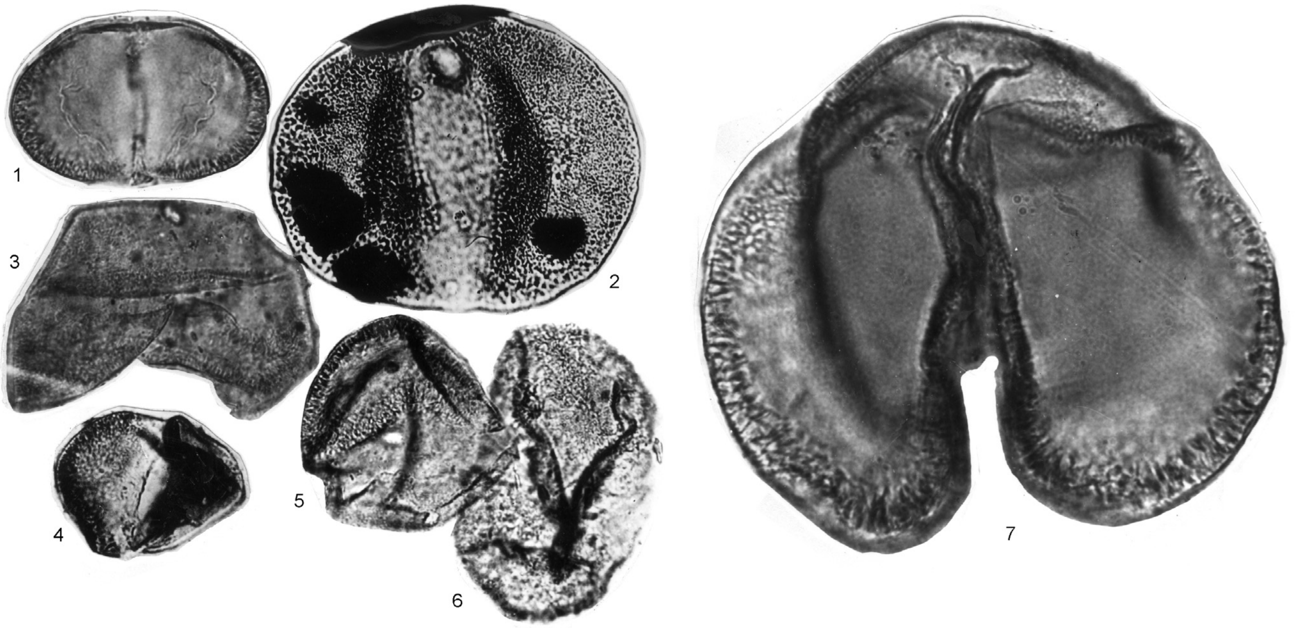

Fig 2. An example of a palynoteratical complex with divergence of several characters in a single taxon within the palynocomplex: microphotographs of deviant and normal pollen grains of *Picea* sp. from the low humus horizon of the Upper Palaeolithic Kostenki 14 site (Voronezh area of the forest-steppe zone of the Russian Plain, basin of the Don river). Excavations by Rogatchev A.N. Palynological data of G. Levkovskaya (Levkovskaya *et al.* 1983). **1** – normally developed but dwarf pollen grain: general view; **2** – Cretaceous pollen of *Pseudopicea* sp. (for comparison) Apt–Alb: Ognevskaya suite (after Mtchedlishvili 1977, Tab. 5, fig. 2); **3, 4** – palynoterates with asymmetrical sacs; **3** – palynomorph with two asymmetrical sacs (pollen grain obtained from the Ketrosi archaeological site in the Dniesr river basin is shown for comparison); **4** – dwarf pollen grain with one normally developed sac; **5, 6** – mutually adherent palynoteratical grains from a single anther with poorly developed ornamentation; **5** – crumpled pollen grain; **6** – pollen grain with undifferentiated sacs; 7 – palynoteratical giant grain. Scale: 1 – 7 ×400.

C o m m e n t a r y. Nowadays *Picea* is absent from the flora of the forest-steppe zone but a *Picea* sp. was growing in ravines near the Kostenki 1, 14 and 17 sites during the period of formation of the low humus horizon. Evidence for this is provided by the data of students of fossil coal remains – Moskaleva V.E., Lisizina G.N., Blochina N.G. and many palynologists — Fedorova R.V., Gritchouk M.P., Gritchouk V.P., Levkovskaya G.M., Maliasova E.S., Spiridonova L.A., Berdovskaya G.M., Chomutova V.I., Fedorova V.I. and Tarasevitch V.A. (Gritchouk 1969, Praslov & Rogatchev eds, 1982, Levkovskaya *et al.* 1983). However, this was the period of *Chenopodiaceae* open communities with sparse and stressed *Picea* forest. Palaeozoologically, the low humus horizon was characterized by the prevalence of the forest-steppe *Equus latipes* V. Gromova (see Praslov & Rogatchev eds, 1982) with some steppe elements (*Ochotona pusilla* Pall., *Marmota bobac* Mull., *Allactaga jaculus* Pall., *Citellus major* Pall**.**, *Lagurus lagurus* Pall., *Equus hidrunthinus* Regalia and *Saiga tatarica* L.). The whole palynoteratical complex was formed during xeric conditions in the past. The moisture deficit was the most unfavourable factor for *Picea* sp**.** at this time, although the climate was cooler then it is now

lies in the *Abies nordmanniana – Picea orientalis* forest belt). More detailed information about this sample is given in the commentary to Fig. 1.

The type 2a complex is illustrated by microphotographs (Levkovskaya *et al.* 1983; Fig. 2 in the present paper) of aberrant and normal pollen grains of *Picea* sp. from the low humus horizon of the Upper Palaeolithic Kostenki 14 site and from some other sediments. According to palaeozoological and the usual palynological data these sediments were formed in a moderately cold, but very dry climate (conditions of dry periglacial Chenopodiaceae steppe with thin stressed *Picea* forest, though now it is forest-steppe of the Russian Plain with deciduous mixed forest lacking *Picea*). More details of this sample are given in the commentary to Fig. 2.

The seven characters distinguishing the type 3 complex were described by Ananova (1966) as follows. The pollen grains a) do not have well-defined morphological features (especially in relation to their ornamentation); b) differ in size from dwarf to normal and giant in single sample (the same applies to the different morphological features of each palynomorph); c) have a glass-like glitter; d) are of a yellowish-green or (coniferous) dark brown colour, which differs from that of normally developed grains; e) are often flattened or wrinkled; f) are often stuck together as conglomerations in the samples; g) are difficult to identify systematically: often it is a problem to determine even the family of the plant. The features a, b, e, f and g can be seen in some of the forms shown in Fig. 3 which is an SEM micrograph of an “abortive” palynocomplex from the Mousterian layer at the Betovo site in the Brianskaya region (Russian Plain). According to palaeozoological data this complex was formed in extremely cold and dry conditions. More detail about this sample is given in the commentary to Fig. 3).

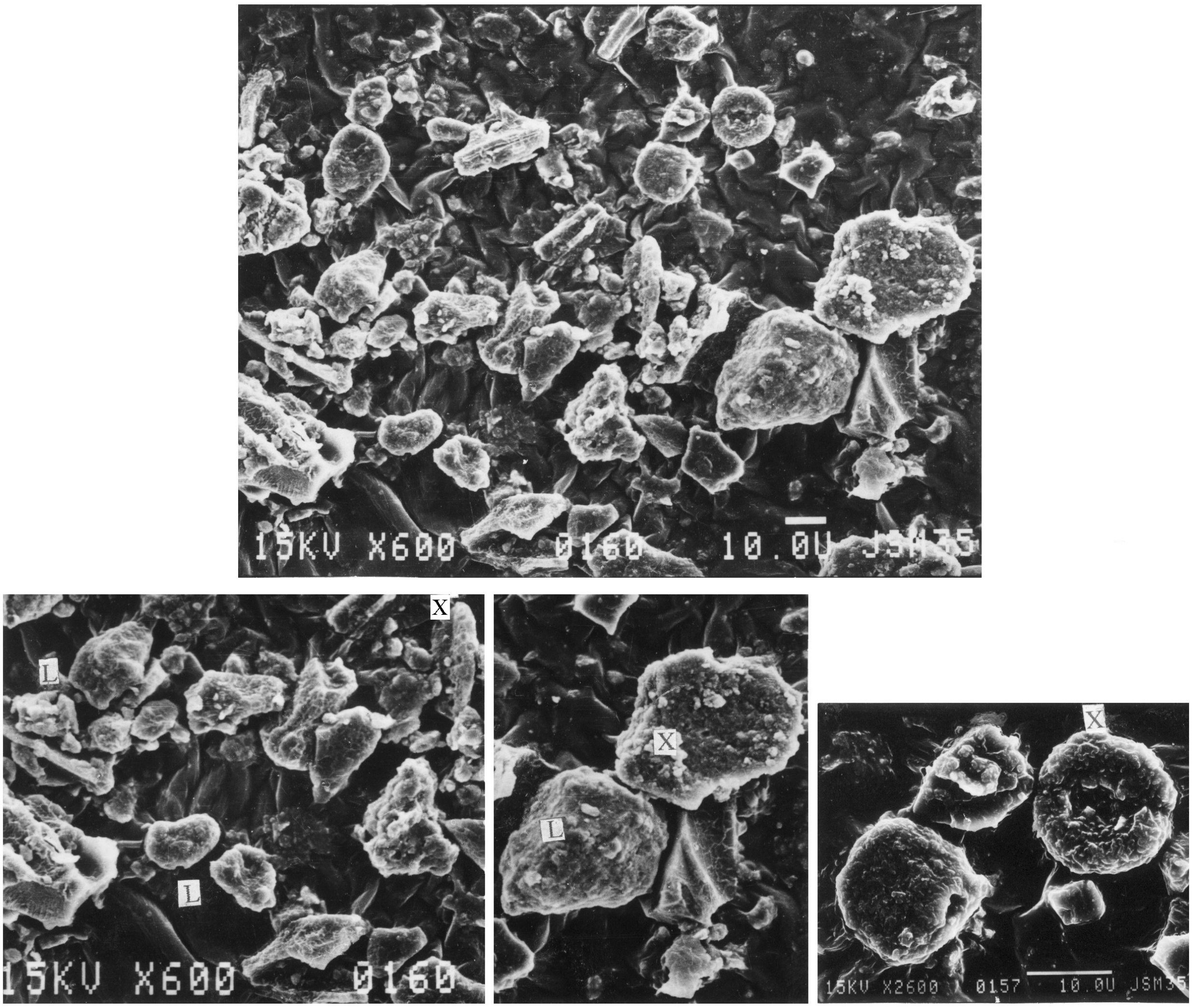

Fig. 3. An example of a palynoteratical complex dominated by "abortive" pollen, showing signs of significant underdevelopment of palynomorphs: palynoteratical complex (SEM micrograph) from the Mousterian layer at the Betovo site (Briansk area of the forest-steppe zone of the Russian Plain, Desna river basin). Excavations by L.M. Tarasov. Palynological data of G. Levkovskaya. Examples of underdeveloped pollen grains (X:600 and 2600): + – identified, × – non-identified, L – outlines typical of the "abortive" forms of grains

C o m m e n t a r y. Figure 3 illustrates a palynoteratical complex with many outlines resembling underdeveloped pollen grains, but with only one dwarf pollen grain of the Poaceae identified and others undetermined. The features a, b, e, f and g of an "abortive" palynocomplex (see the text of the present article and the description of a complex of underdeveloped palynomorphs by Ananova 1966) can be found in some of the forms in Pl. 3. The complex is an indicator of unfavourable conditions for the normal development of pollen in a number of different taxa simultaneously.

The palaeozoological evidence from the site (Tarasov 1987) shows a domination of tundra elements with large quantities of the remains of steppe inhabitants. The fauna was characterized by the domination of the tundra *Dicrostonyx* cf. *torquatus* Pall. and the tundra-steppe *Microtus* (*stenocranius*) cf. *gregalis* Pall. with abundant steppe *Lagurus* (L.) *lagurus* Pall and the remains of tundra birds. A fauna of this type suggest a very continental, cold and dry climate, more rigorous than the present climate of the Taimyr peninsula. Ananova correlated a palynocomplex of underdeveloped palynomorphs with glacial sediments. The Betovo data shows that a harsh climate, deficient in both rainfall and warmth, existed in all seasons

It is possible to interpret such a palynocomplex as an indicator of unfavourable conditions for the normal development of pollen in many taxa simultaneously, resulting in harsh palaeobotanical stress or catastrophe (Levkovskaya1996a, 1996b) for the genetic make-up of most of the plants of the studied area. The "abortive" palynocomplexes are sometimes correlated with the stages of extinction of floristic relicts.

The maximum incidence of dwarf and other types of palynoterate were found in some (but not at all) samples of the subfossil sediments from the northern tree limit in western Siberia. The author's data on the southern tree limit has not been analysed so far. The palynoteratical complexes of type 1a (with the codomination of dwarf palynomorphs of the microtherms *Betula nana* and *Alnaster*) were obtained from sediments of the isotope O^{16}/O^{18} stage 6 (glacial, cold), while those of type 2b came from the early (warm but dry) phase of the interglacial stage 5e in the Denisova cave at Altai (Levkovskaya 1998). The features of the complexes 1b and 2b match those described for the transition from the cold and wet to the cold and dry Sartansky (Late Würm) periglacial stages for Enisei area of southern Siberia (Jamskikh & Jamskikh 1992).

CONCLUSION

In the limited research which has been undertaken by palaeopalynologists in the past abnormal palynomorphs have been seen as indicators of previous natural glacial (Ananova 1966), dry periglacial (Levkovskaya *et al.* 1983), interstadial (Spiridonova 1980) or other conditions. The specific features mentioned above illustrations of the 1a*,* 2a and 3 and the ecology of palynoteratical complexes were based on multidisciplinary materials and palaeozoological data obtained from the archaeological sites at Mezmaiskaya (North-West Caucasus), Kostenki 14 (Russian Plain, Voronezh area) and Betovo (Russian Plain, Briansk area). (Tables 1, 2, 3 and accompanying commentaries). Samples show that these palynocomplexes are indicators of palaeobotanical stress resulting from excessively low temperature (complex of dwarf type), a probable moisture deficit (complex with departures from the norm of several signs of every characters in all taxa simultaneously) or both in combination (complex of underdeveloped "abortive" palynomorphs). But these ecological conclusions are provisional. Their confirmation will require further study, because written types of palynoteratical complexes may be the result of hybridization, palaeomutation or different kinds of other types palaeoecological stresses.

The author's statistical data shows that the above-mentioned palynoteratical criteria enable us to distinguish the following complexes of natural ecological stages: 1. single palynoterates; 2. abnormal pollen grains of individual trees spp.; 3. those dominated by palynoterates in most identified tree spp.; 4. complexes with the codomination of palynoterates of most arboreal and non-arboreal taxa simultaneously. A consequence is that palynoteratical complexes can be used for distinguishing (Levkovskaya 1996, 1996b*)* the catastrophic, stressed or non-stressed states of the genetic fund not only of individual plant species but plant communities as well. But palynoteratical complexes are absent from sediments which were laid down under non-extreme conditions such as occured in some of the non-optimal Holocene stages in eastern Latvia (Levkovskaya 1987) in contrast to some of the Late Glacial cold and dry stages in this area. The palynoteratical complex of dwarf palynomorphs (type 1a) is presented some, but not all, subfossil West Siberian forest-tundra complexes (Levkovskaya 1971) which were formed under conditions in which the trees suffered stress from low temperatures but received adequate moisture during present day Holocene interglacial. Such condition were bad for trees on vast territories during cryohydrotic climatic stages of interglacial-glacial cycles. The "abortive" palynoteratical complex was typical for extreme dry and sharp cold xerohydrotic climatic stages of glacial epochs (for their final phases).

Lately it has been the fashion to connect (without statistics) the appearance of palynoterates in recent anthers with some unfavourable natural (Romanova 1983) or anthropogenic conditions (Rovnina editor 1996, pp. 35, 40, 42, 65). However, it is possible to find palynomorphs exhibiting an abrupt deviation from the norm in almost every recent anther which developed in ecological conditions normal for the taxon (Pozhidaev 1993) or was collected for palynomorphological study before the full development of the pollen in the anthers (Ananova 1958).

Thus, finds of single (without statistics) palynoterates in sediments or in recent anthers, are not valid indicators of environmental stress. More significant statistical information can be obtained from fossil and subfossil sedimentous palynoteratical complexes as opposed to palynoteratical forms or spectra obtained from recent anthers.

The author's material, collected over 40 years, will allow her to estimate later of some quantitative natural ecological limits for the formation of the above described palynoteratical complexes. Such limits will possibly be useful for contemporary ecological control (the author has begun to study the subfossil sediments of the area around the nuclear power station at Sosnov Bor).

The author's palynoteratical collections and statistical data will be available for research on a joint project with computer technology specialists and palynologists, studied palynoteratical data from different geological periods (including the present one). The author is looking for financial support for either the publication of a palynoteratical atlas involving four coauthors or for a joint research theme to continue the investigations into palynoteratical problems.

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