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The Pliocene flora of Kholmech, south-eastern Belarus and its correlation with other Pliocene floras of Europe*

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ABSTRACT. The aim of the study is to provide a monograph of the Pliocene carpological flora at the Kholmech site in south-eastern Belarus. Fossil material was collected from an excavation located on the right bank of the Dnieper river. Very abundant macrofossils, several tens of thousands of specimens, comprising mainly seeds, fruits and megaspores, were collected from peaty gyttja deposits. The specimens represent 170 taxa contained in 82 genera and 46 families of cryptogamic and angiospermous plants. Most (137 taxa) were identified to species level. Gymnospermous plants were represented by only one fragment of a *Picea* needle. Six species new for the Pliocene in Europe, from the genera *Ceratophyllum*, *Cyperus*, *Lycopus*, *Schoenoplectus*, and one new combination in the genus *Teucrium* are described here. All the taxa are described and illustrated, some of them using the SEM. On the basis of the taxonomic composition of the Kholmech fossil flora, its age has been established as the beginning of the Late Pliocene. Floras of this type are known at several other localities in south-western and western Belarus. The flora of the Kinelian series in the Middle Volga basin, the Simbugino flora in Bashkiria, the Dan'shino flora in central Russia, all in the east, and the floras of Kłodzko, the Vildštein Formation and Rippersroda in the west are of the same age as that from Kholmech. Comparison of the floristic compositions of the Kholmech and Mizerna floras in southern Poland reveals that the true counterpart of the Kholmech flora is complex II/III of the Mizerna flora and not Mizerna complex II as had previously been thought.

KEY WORDS: fruits, seeds, megaspores, fossil flora, palaeoenvironment, correlation, Pliocene, Belarus, Poland, Europe

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INTRODUCTION

The necessity of a precise description of particular phases of flora development in the Late Cenozoic has long been a pressing concern in palaeobotanical studies. During recent decades it has become one of the most important desiderata of Tertiary palaeobotany. One of the main factors creating this situation was the change of the Pliocene boundaries in the stratigraphic division of the Neogene which reduced the duration of its existence. The Miocene/Pliocene boundary, set at about 5.3 million years BP, is generally accepted. The upper boundary of the Pliocene has not yet been fixed precisely following controversial opinions on the beginning and duration of the Pleistocene (e.g. Starkel 1991, Lindner 1992, Makhnach et al. 2001). At first, the Pleistocene was considered exclusively as the period of continental glaciation development. Then the boundary between the Pliocene and Pleistocene was set to coincide with the palaeomagnetic inversion of Brunhes-Matuyama, i.e. at about 760 000 years BP. Later on, when the early traces of the first clear climate cooling had been defined, the lower boundary of the Pleistocene was moved to coincide with the Olduvai palaeomagnetic episode (about 1.8 million years BP). Recently new evidence has appeared, causing a further movement in the lower boundary of the Pleistocene to 2.4–2.5 million years BP. If this boundary is accepted as the beginning of the Pleistocene, the period of the Pliocene becomes considerably shorter, roughly equal to that of the Pleistocene (about 2.8 million years, e.g. Lindner 1992, Makhnach et al. 2001). It seems very small when compared with the Miocene, which existed for 17 million years.

One more difficulty in palaeobotanical studies of the Pliocene is the poor representation of deposits of this age in the European ancient glacial zone. These deposits occur as rare local layers of relatively small thickness (from a few to several tens metres). It is likely that large parts of the Pliocene deposits were destroyed by the first continental glaciers. Only their small remnants could have been preserved in depressions of erosive or tectonic origin. Only a few profiles of Pliocene deposits containing plant macrofossils are scattered in the vast region from the Pre-Ural area to the Atlantic Ocean. The macroscopic floras found in these profiles vary greatly and often bear little similarity to one another. Sometimes it is possible to include within the Pliocene transitional floras linking the Pliocene with the Late Miocene. Again Early Pleistocene floras may be considered as belonging to the Late Pliocene, particularly when the flora dating has been performed with regard to the new, enlarged formulation of the Pleistocene. Therefore arrangement of the Pliocene floras of different age, even within one region, is very difficult.

Another difficulty in the cognition and correlation of Pliocene floras arises from the different opinions among European palaeobotanists concerning the interpretation of fossil material. These differences of view involve such problems as the range of variability of extinct species, their longevity, relationship with present-day plant taxa etc. The authors of the present study prefer to distinguish many small, stenochronous taxa which can provide a basis for fossil flora correlation (Velichkevich 1994, 1999). Such an approach to the research of floras, especially those of the Pliocene, has revealed some curiosities in the taxonomic composition of floras of different ages and shown the existence of distinct groups. It has also made possible correlation of the most typical floras of different age from neighbouring or mutually separated regions.

The Kholmech flora is typically Pliocene, clearly differing from the richly exotic Miocene floras and the poor and very characteristic Pleistocene floras. This flora was formed in an isolated local water body surrounded by immense swamps and, remaining undisturbed, has provided evidence of the taxonomic composition of the plant communities present at that time. The Kholmech flora has also illustrated the level of evolution of many plant taxa of exceptional importance for Pliocene stratigraphy in the East-European Plain. The exceptional importance of the Kholmech flora for palaeofloristic studies was recognized by Mai (1995b) who accepted the “Kholmech floristic complex” as one of the key units in the correlation of the floras of the Late Pliocene in eastern and central Europe.

HISTORY OF PALAEOBOTANICAL INVESTIGATIONS

The first mention of Pliocene plant macrofossil discoveries on the right bank of the Dnieper river (between the cities of Rechitsa and Loev, in south-eastern Belarus; Fig. 1), based on a preliminary experts’ report by P.I. Dorofeev and F.Yu. Velichkevich, was included in a publication by Goretsky (1970). It gave data on the fossil floras of Dvorets (51 taxa) and Kholmech (90 taxa), estimated in age to be early (Kholmech) and late (Dvorets) Late Pliocene. Based on a letter by P.I. Dorofeev dated 15th January 1970, Goretsky (1970, p. 128) wrote: “....the Kholmech flora is undoubtedly of the Pliocene, of a Kinelian type corresponding not to the lowest but to the middle horizons of the Kinelian series in Bashkiria. The Krivobor’e flora is somewhat older, but the Ivnitsa and Dan’shino floras are very similar to the Kholmech one”.

Goretsky (op.cit.) cited a long list of extinct Pliocene species which allowed him to correlate the Kholmech and Pliocene floras in central Russia. Dorofeev (1971) described 6 new species for the Pliocene of Belarus (*Typha as-*

Fig. 1. View of the right bank of the Dnieper between Dvorets and Kholmech villages

pera Dorof., *T. pseudoovata* Dorof., *Potamogeton borysthenicus* Dorof., *P. cholmechensis* Dorof., *Nymphaea borysthenica* Dorof., and *N. pusilla* Dorof.). At that time Dorofeev and Velichkevich (1971a) produced a list of the Kholmech fossil flora containing 105 taxa, mainly herbs.

Another fossil flora, of similar taxonomic composition to that from Kholmech, was located in the neighbourhood of Kolochyn village and was studied by Yakubovskaya (1978). This flora was collected from an excavation performed on a flood terrace of the Dnieper, about 2 km upstream from the Dvorets site. The flora comprised 63 taxa, mostly characteristic for the Kholmech flora and of the same age. On the basis of later investigations in the vicinity of Kolochyn village, it was found that Pliocene deposits with a Kholmech flora occupied this part of the Dnieper valley over a distance of 10 km upstream from Kholmech village.

The special character of the Kholmech flora, its perfect state of preservation, easy access through shallow excavation and its importance as a bridge between the Pliocene floras of eastern and western Europe were reasons for further studies. In 1975 several new excavations were carried out exposing a flora-bearing layer. Some samples of flora-bearing deposits were collected for palaeocarpological studies. Very numerous macrofossils were washed out from these samples immediately on site. Dorofeev began studying the collection in the 1970s, but he worked out the flora only in part using it mainly for palaeotaxonomic studies of particular genera (e.g. *Salvinia, Azolla, Pilularia, Typha, Sparganium, Potamogeton, Acorus, Brasenia, Nymphaea, Najas, Caulinia, Ranunculus*, and *Proserpinaca*, Dorofeev 1973a,b, 1974, 1976, 1977a, 1978, 1980, 1981, 1982a,b, 1984, 1986b). After 1985 F.Yu. Velichkevich, in co-operation with Polish palaeobotanists, undertook further studies of the Kholmech flora (Velichkevich & Lesiak 1999, Velichkevich & Zastawniak 2001, 2002, 2003, Zastawniak & Velichkevich 2001).

In the 1980s Yakubowskaya (1984) worked out the fossil material from numerous borings in the vicinity of Kholmech and Dvorets. On the basis of palaeocarpological studies she found that the fossil flora in the lowest part of the Pliocene deposits, containing remains of the Taxodiaceae, *Liriodendron, Comptonia*, and *Harziella*, corresponded in age to the Early Pliocene.

Palynological studies of the main part of the Kholmech profile were performed by Rylova (1982). In a pollen diagram the proportion of coniferous plant pollen was small (1–8%, on average below 3%). Pollen of several *Pinus* species (*P.* cf. *sylvestris* L., *P.* cf. *strobus* L., *P. tertiaria* (Moreva) Anan., *P. baileyana* Trav., *P. bicornis* Zakl., and *Pinus* sp.), and single pollen grains of *Larix, Abies, Podocarpus, Picea* cf. *abies* (L.) Karst., *Tsuga*, Taxodiaceae, and *Sciadopitys* were distinguished. Angiosperms were represented by trees and shrubs: *Quercus* (4.5–21%), *Castanea* (0.6–15%), *Fraxinus* (0.3–5%), *Ulmus* (0.2–3.5%), *Tilia* (to 2%), *Alnus* (to 3%), single pollen grains of *Carpinus, Corylus, Myrica, Pterocarya, Salix, Rhamnus, Fagus, Acer*, and a high amount of Betula pollen (11–34%). In Rylova's opinion (Rylova et al. 1999) the deposits in the upper part of the Kholmech horizon, from which the macrofossil flora originated, were characterized by a regional palynozone of *Quercus-Castanea-Betula-Tilia-Fraxinus*.

The palynological profile worked out by Rylova (1982) was named as Kholmech 1. During later studies further excavations and borings were made. These were numbered consecutively (Kholmech 2–10). Some of these have also been studied palynologically (Zinova et al. 1987). The macroscopic flora discussed in this paper was collected from the principal excavation.

GEOLOGICAL SETTING

The Pliocene deposits in Belarus are located mainly in the southern and western regions (Azhgirevich et al. 2001). They were found in many borings and in several exposures in the Dnieper valley. The Pliocene deposits, formed between 5.32–1.76 million years BP, varied in thickness from several to 24.0 metres in south-eastern Belarus and up to 52.0 metres in south-western Belarus. The Pliocene sites were found mostly where older Neogene deposits occurred in the valleys of large rivers (Dnieper, Pripyat', Nemen) and their tributaries. Lithologically the Pliocene formations were not homogeneous. In the Rechitsa region (Fig. 2) they were formed of alluvial sands, loams, sapropelites and aleurites of thickness 8.0–24.0 m, whereas in the area of the Belarus anticline of the Podlasie-Briest depression, sands, loams and marls of thickness 25.0–52.0 m pre-

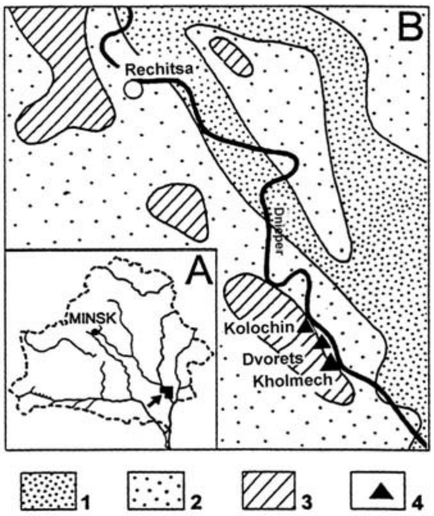

Fig. 2. Positions of fossil localities; **A** – in Belarus, **B** – in relation to the surrounding region; **1** – Upper Eocene maritime sediments, **2** – Lower Oligocene marine sediments, **3** – Upper Oligocene to Pliocene continental sediments, **4** – locality with fossil flora

vailed (Zinova et al. 1987). According to a new stratigraphic division of the Neogene deposits in Belarus (Azhgirevich et al. 1996, 2001, Rylova et al. 1999) the Pliocene deposits correspond with the Kolochyn super horizon, which is divided into a Kholmech horizon (Kimmerian, Dacian) and a Dvorets horizon (Akchagylian, Romanian). In the Kholmech horizon two subhorizons were distinguished which differed in the floristic composition of their macrofossils (Yakubovskaya 1984).

In 1969 biogenic deposits (peat and gyttja) were found for the first time in an exposure on the right bank of the Dnieper, about 22 m high, in the central part of Kholmech village (Rechitsa district, Gomel province, Goretsky 1970). In the initial exposure and its subsequent extension by human excavation, located 150 m below a ferry crossing the Dnieper, the lithologic profile is as follows:

0.0–1.5 m	fine-grained sand, bright yellow, silty with gravels and shingles from Scandinavia
1.5–11.0 m	moraine of the Dnieper (Saale) glaciation, red-brown, with Scandinavian material
11.0–11.6 m	sandy loam, grey-green, horizontally laminated, with lenticles of sand
11.6–13.1 m	moraine of the Berezina (Elster) glaciation, yellow-brown, with Scandinavian material
13.1–16.1 m	fine-grained sand, grey, with streaks of grey-brown sand, slightly humic
16.1–16.2 m	sandy loam, brown to black, humic, compacted, occurring as lenses and thin layers
16.2–20.2 m	fine-grained sand, pale grey, with layers of loamy sand, dark grey and grey-green, fine-grained
20.2–20.9 m	peaty gyttja, dark brown to black, amorphous, with wood fragments and numerous plant macrofossils
20.9–21.1 m	vari-size grained sand, dark grey, floating

Along the river, above and below the main exposure, peaty deposits were found during subsequent years which formed a lens about 200 m long with its ends merging into layers of humic sand (Zinova & Yakubovskaya 1977).

In 1979–1980 several borings were performed on the right bank of the Dnieper river to investigate the distribution of the Pliocene deposits (Zinova et al. 1987). These deposits were about 20.0 m thick at their base and at an altitude of 96.0–97.0 m a.s.l. Below the Pliocene deposits, glauconite-quartz sands of the Kiev series in the Upper Oligocene were found in an exposure on the right bank of the Dnieper near Stradubka village (Zinova et al. 1987). Fruit and seed macrofossils were noted in these sands and dated by Dorofeev (1969c) as Late Oligocene. Later on, the Rechitsa region was studied in detail geologically and has recently been accepted as a stratoregion for the Pliocene in Belarus (Azhgirevich et al. 2001). The stratoregions for Pliocene of East-European Plain are shown on Fig. 3.

MATERIAL AND METHODS

A collection of plant macrofossils at the Kholmech site obtained from sediments on the right bank of the Dnieper near Kholmech village provided the basis for the studies presented here. The macroscopic flora discussed was collected in the 1970s by the first author (F.Yu. Velichkevich) in co-operation with P.I. Dorofeev, T.V. Yakubovskaya and a student group of the Belorussian University in Minsk. To obtain the collection, the method of field palaeocarpological studies, characteristic for Russian and Belorussian palaeobotanists, was employed. The basis of this method was to wash great amounts of flora-bearing deposits on site to obtain abundant material for comprehensive studies. In order to procure sufficient fossil material many samples of peat and peaty gyttja of about 1.0 m^3 volume were taken and washed through 0.25 mm mesh sieves. Thus a great amount of plant detritus was obtained which was rinsed once more in the laboratory with no involvement of chemicals. On desiccation it was scanned under a stereoscopic microscope and plant macrofossils possible to identify were selected. Details of the palaeocarpological method were described in

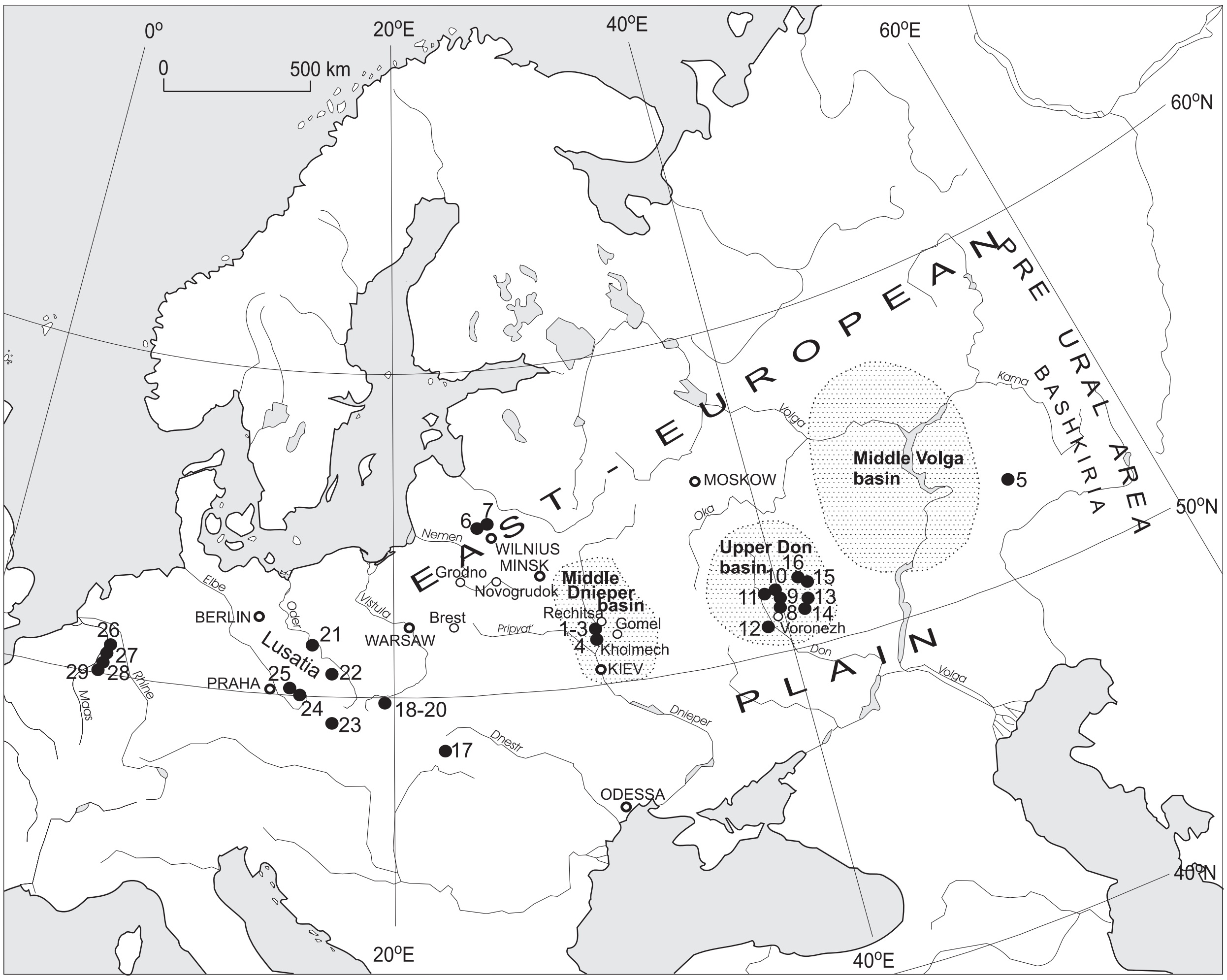

Fig. **3**. Localities of Pliocene floras in Europe. **1** – Kholmech, **2** – Dvorets, **3** – Kolochin, **4** – Stradubka, **5** – Simbugino, **6** – Shlave, **7** – Daumantai, **8** – Cherovitskoe, **9** – Krivobor'e, **10** – Ivnitsa, **11** – Dan'shino, **12** – Uryv, **13** – Moiseevo, **14** – Shekhman', **15** – Ranino, **16** – Manovitsy, **17** – Malaya Began', **18** – Mizerna, **19** – Krościenko, **20** – Grywałd, **21** – Ruszów, **22** – Kłodzko**,** **23** – Vildštein Formation, **24** – Rippersroda, **25** – Nordhausen, **26** – Reuver, **27** – Brunssum, **28** – Swalmen, **29** – Tegelen

a special paper by Dorofeev (1960c) and Nikitin (1969) and several palaeocarpological monographs (Nikitin 1957, Dorofeev 1963b, Velichkevich 1982, 1990). As a result of many years' work, over 20 000 fossil fruit, seeds, megaspores and other plant macroscopic remains were found. They formed two museum collections stored presently in the Institute of Geological Sciences, the National Academy of Sciences of Belarus in Minsk (MINM-P-BGO-2) and in the W. Szafer Institute of Botany, Polish Academy of Sciences in Kraków (KRAM-P 242). To establish the taxonomic affiliation of the macrofossils, morphological comparison formed the principal method but biometric methods were also used. Then the anatomic structure of fossil diaspores of some taxa was studied. To identify macrofossils, reference collections of seeds and fruits present in both scientific centres and a collection of fossil plant remains stored in the Museum of the Earth, Polish Academy of Sciences in Warszawa were used (WLO, MZ).

DESCRIPTION OF TAXA

SELAGINELLACEAE

Selaginella pliocenica Dorof.

Pl. 1, figs 3,4; Fig. 4: a,b

1957	*Selaginella pliocenica* Dorof.; Dorofeev, p. 489, fig. 1: 1.
1971a	*Selaginella* cf. *pliocenica* Dorof.; Dorofeev & Velichkevich, p. 154.
1984	*Selaginella pliocenica* Dorof.; Jahn et al., p. 25.
1988	*Selaginella pliocenica* Dorof.; Baranowska-Zarzycka, p. 24.

Material. MINM-P-BGO-2/1: 10 megaspores; KRAM-P 242/1: 5 megaspores.

Description. Megaspores globose, 0.5 mm in diameter, surface reticulate. Apical part of megaspore slightly projecting, with distinct te-

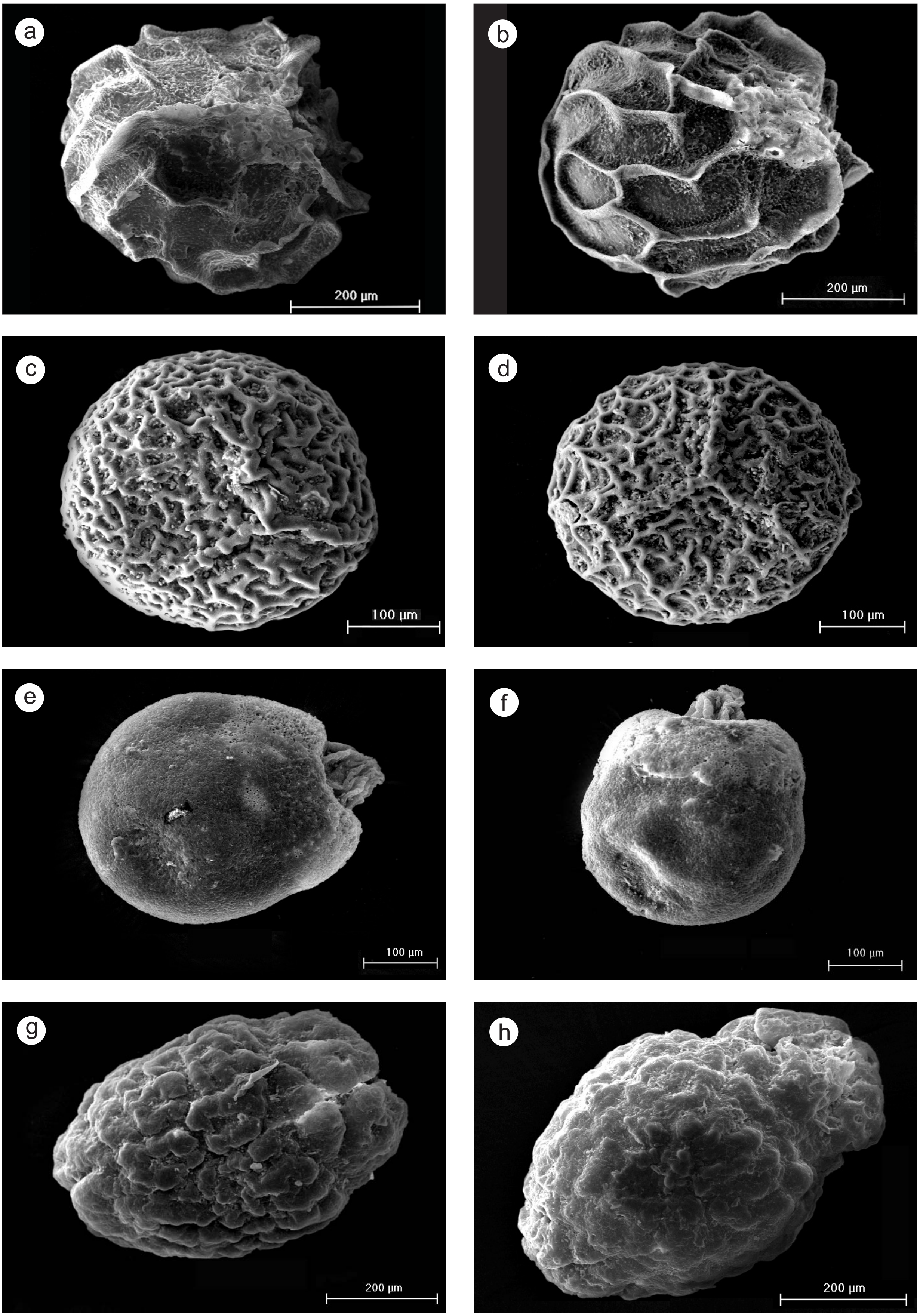

Fig. 4. **a,b** – *Selaginella pliocenica* Dorof., megaspores, SEM, × 150, KRAM-P 242/1a, b; **c,d** – *Selaginella reticulata* Dorof. & Wieliczk., megaspores, SEM, × 200, KRAM-P 242/2a, b; **e,f** – *Pilularia pliocenica* Dorof., megaspores, SEM, × 200, KRAM-P 242/3a, b; **g,h** – *Salvinia tuberculata* Nikit., megaspores, SEM, × 150, KRAM-P 242/5a, b

tradic scar. Scar rays short, uniformly protruding. Surface cells very variable in shape and size, usually 4–6 angular. Cell walls thin, sinuous, uneven, with sharp ridges, yellow-brown, slightly lustrous. Cell bases mat, smooth, dark brown.

Comparison. The described megaspores are smaller than ones from Tataria (Dorofeev 1957) which are 0.6–0.8 mm in diameter. However, the other most important diagnostic features are common to both. In the Neogene flora of Europe several different species have been described with megaspores morphologically similar to those of *Selagiella pliocenica* Dorof., but differing in size, sculpture or other tiny structural characters e.g. *S. germanica* Mai (Mai & Walter 1985), *S. tenuireticulata* Mai (Mai & Walter 1991), *S. dvorensis* Knobloch (Knobloch 1986) and *S. pannosa* Negru (Negru 1986). In the present authors' opinion, *Selaginella pliocenica* Dorof. should be treated as a polymorphic species which contains a few taxa of different ages (Miocene, Pliocene) and geographical distributions.

Occurrence. These types of megaspore have often been recorded from the numerous Neogene floras in the Asian part of Russia (Dorofeev 1963a), European Russia (Dorofeev 1957), Moldova (Negru 1986), Poland (Łańcucka-Środoniowa 1963, 1966, 1979, 1981, Lesiak 1994, Baranowska-Zarzycka 1988), Bulgaria (Palamarev 1970), Germany (Mai 1967, 2000a, Mai & Walther 1988), Italy (Mai 1995a), and Slovakia (Knobloch 1980, 1981).

Selaginella reticulata Dorof. & Wieliczk

Pl. 1, figs 1, 2; Fig.4: c,d

1971b *Selaginella reticulata* Dorof. & Wieliczk., Dorofeev & Velichkevich, p. 1174, fig. 1, 12–16, designat. typi omissa.
1986a *Selaginella reticulata* Dorof. & Wieliczk., Dorofeev, p. 53, Pl. 1, figs 1–10; holotype – Pl. 1, fig. 5.

Material. MINM-P-BGO-2/2: 100 megaspores; KRAM-P 242/2: 10 megaspores.

Description. Megaspores 0.27–0.40 mm in diameter, globose, often deformed. Apical part slightly flattened, tetradic scar distinct. Each scar branch nearly half of the megaspore radius, its ends usually surrounded by an inconspicuous circular thickening. Surface of basal part with characteristic network formed by sinuous well-defined or faint wrinkles. Some megaspores nearly smooth, surface yellow-grey. According to Dorofeev (1986a), the variations in surface relief and colour depend on the degree of maturity of the megaspores.

Comparison. The megaspores of the type collection from the younger Pliocene flora of Dvorets agree with ours for the most part, but are slightly larger (0.3–0.4 mm). Megaspores of recent *Selaginella* species from North America (*S. wallacei* Hieron, *S. oregona* D.C. Eaton) and Siberia (*S. sibirica* (Milde) Hieron) are rather similar in their main morphological features to those described above. Most similar of the recent species is the North American-Siberian *S. rupestris* (L.) Hieron.

Occurrence. Upper Pliocene, Dvorets (Dorofeev & Velichkevich 1971b, Dorofeev 1986a, Velichkevich 1990), Brest district of Belarus (Krutous 1982), Pliocene of central Russia (Dorofeev 1985).

MARSILEACEAE

Pilularia pliocenica Dorof.

Pl. 1, figs 5, 6; Fig. 4: e,f

1965 *Pilularia* cf. *globulifera* L.; Dorofeev, p. 200, Fig.1: 5, 6.
1967 *Pilularia* cf. *globulifera* L.; Dorofeev, p. 94, Pl.1, figs 1–5.
1971a *Pilularia pliocenica* Dorof.; Dorofeev & Velichkevich, p. 154.
1971c *Pilularia pliocenica* Dorof.; Dorofeev & Velichkievich, p. 171, Fig.1: 1–10, designat. typi omissa.
1981 *Pilularia pliocenica* Dorof.; Dorofeev, p. 801, fig. 3: 1–10, fig.6: 1–10, 22; holotype – Fig. 6: 4.

Material. MINM-P-BGO-2/3: 3 megaspores; KRAM-P 242/3: 5 megaspores.

Description. Megaspores 0.30–0.32 × 0.27–0.30 mm, ellipsoidal, slightly deformed, apex flattened and emarginate, with remains of exostome at the centre. Base of megaspore uniformly rounded, the upper 1/4–1/3 bearing distinct transversal incisions. Surface of upper part rough, reddish-brown, darker than base which is smooth, yellow-grey, and mat. The differences in the surface sculptures of the two parts of the megaspore are most clearly seen under the SEM (Velichkevich 1990).

Comparison. Most similar to the fossil *Pilularia pliocenica* Dorof. is the European species *P. globulifera* L. However, the megaspores of the extant species are nearly twice as large, have a thicker spore wall and are only obscurely incised.

Occurrence. Pliocene floras of Russia (Nikitin 1957, Dorofeev 1979), Bashkiria (Dorofeev 1960a, 1965), Belarus (Dorofeev 1967, Yakubovskaya 1982, 1984, Velichkevich 1990).

SALVINIACEAE

Salvinia aphtosa Wieliczk.

Pl. 1, figs 11, 12; Fig. 5: c,d

1973a *Salvinia aphtosa* Wieliczk.; Velichkevich, p. 44, Fig.1: 1–8; holotype – Fig.1: 1.

Material. MINM-P-BGO-2/6: 22 megaspores; KRAM-P 242/6: 10 megaspores.

Description. Megaspores 0.7–0.8 × 0.4–0.6 mm, ellipsoidal, rarely obovoid. Apex large, wide, its height about 1/3 of megaspore length, clearly separated from the rest of the megaspore by a circular band. Base tapering and subacute, rarely rounded. Perisporium thick, soft, outwardly white, tinged light blue or grey. Surface with small rounded tubercles throughout or mainly at the megaspore ends.

Comparison. The megaspores are very similar to typical specimens from the Eopleistocene fossil flora of Shlave in Lithuania (Velichkevich 1973a, Velichkevich et al. 1998). However, the megaspores from Shlave are smaller (0.55–0.75 × 0.35–0.55 mm) and more variable in shape.

In Mai's (Mai & Walther 1988) opinion, *Salvinia aphtosa* Wieliczk. could be a synonym of *S. rhenana* Kempf. However, the megaspores of *S. rhenana* Kempf. lack some of the most important morphological characters of *S. aphtosa* Wieliczk. such as its small tuberculate perisporium.

Occurrence. Eopleistocene of Lithuania (Velichkevich 1973a, Velichkevich et al. 1998).

Salvinia cerebrata Nikit.

Pl. 1, fig. 13; Fig. 6: a

1948 *Salvinia cerebrata* Nikit.; Nikitin, p. 1103, nomen nudum.

1955a *Salvinia cerebrata* Nikit. in Dorofeev; Dorofeev, p. 116, Pl. 2, figs 4, 5.

Material. MINM-P-BGO-2/7: 1 megaspore; KRAM-P 242/7: 1 megaspore.

Description. One megaspore compressed, the other slightly deformed, 0.45 × 0.35 mm, irregularly ovoid, asymmetric. Apex slightly narrowed, conical, blunt, not separated from the rest of the megaspore. Length of radial scar about 1/3 of the whole megaspore, base broadly rounded, surface coarsely rugose. Wrinkles sharp, deep and undulate, randomly disposed.

Comparison. This is one of the extinct species of *Salvinia* in section *Cerebrata* Dorof., whose species are distinct from those in section *Eusalvinia* Dorof. Species of section *Cerebrata* (*S. cerebratella* Dorof., *S. nikitinii* Dorof.) do appear in Siberia in the Oligocene, but they are more characteristic for the Miocene (Dorofeev 1963a). In Europe *S. cerebrata* Nikit. is characteristic for Miocene and Pliocene floras (Mai & Walther 1988). Negru (1978) described a separate species *S. mucronata* Negru in section C*erebrata* Dorof. from the Miocene of south-western Ukraine. In the present authors' opinion *S. cerebrata* Nikit. is a polymorphic species which links a few separated fossil taxa from Siberia and Europe. In the contemporary Eurasian flora there is no counterpart of this species but *S. auriculata* Aubl. (subtropical and tropical America), could be its closest relative from the taxonomic point of view (Dorofeev 1963a).

Occurrence. The species was widely distributed in Oligocene and Miocene of Siberia (Dorofeev 1963a) and in Europe from the Upper Oligocene up to the Pliocene (Dorofeev 1959b, Mai & Walther 1988, Mai 1999a, 2000c, Bůžek & Konzalová 1978, Knobloch 1978).

Salvinia glabra Nikitin

Pl. 1, figs 16, 17; Fig. 5: a,b

1957 *Salvinia glabra* Nikitin; Nikitin, p. 89, Pl. 1, figs 9–11.

Material. MINM-P-BGO-2/4: some thousands of megaspores; KRAM-P 242/4: some hundreds of megaspores.

Description. Megaspores 0.65–0.95 × 0.45–0.60 mm, ellipsoidal, rarely obovoid. Apex gradually tapering and rounded, usually not separated from the rest of the megaspore, but sometimes demarcated by a pronounced circular band. Surface smooth or occasionally shallowly pitted. Base of megaspore rounded, sometimes slightly tapering, smooth or with small crateriform pits. Outer perisporium sur-

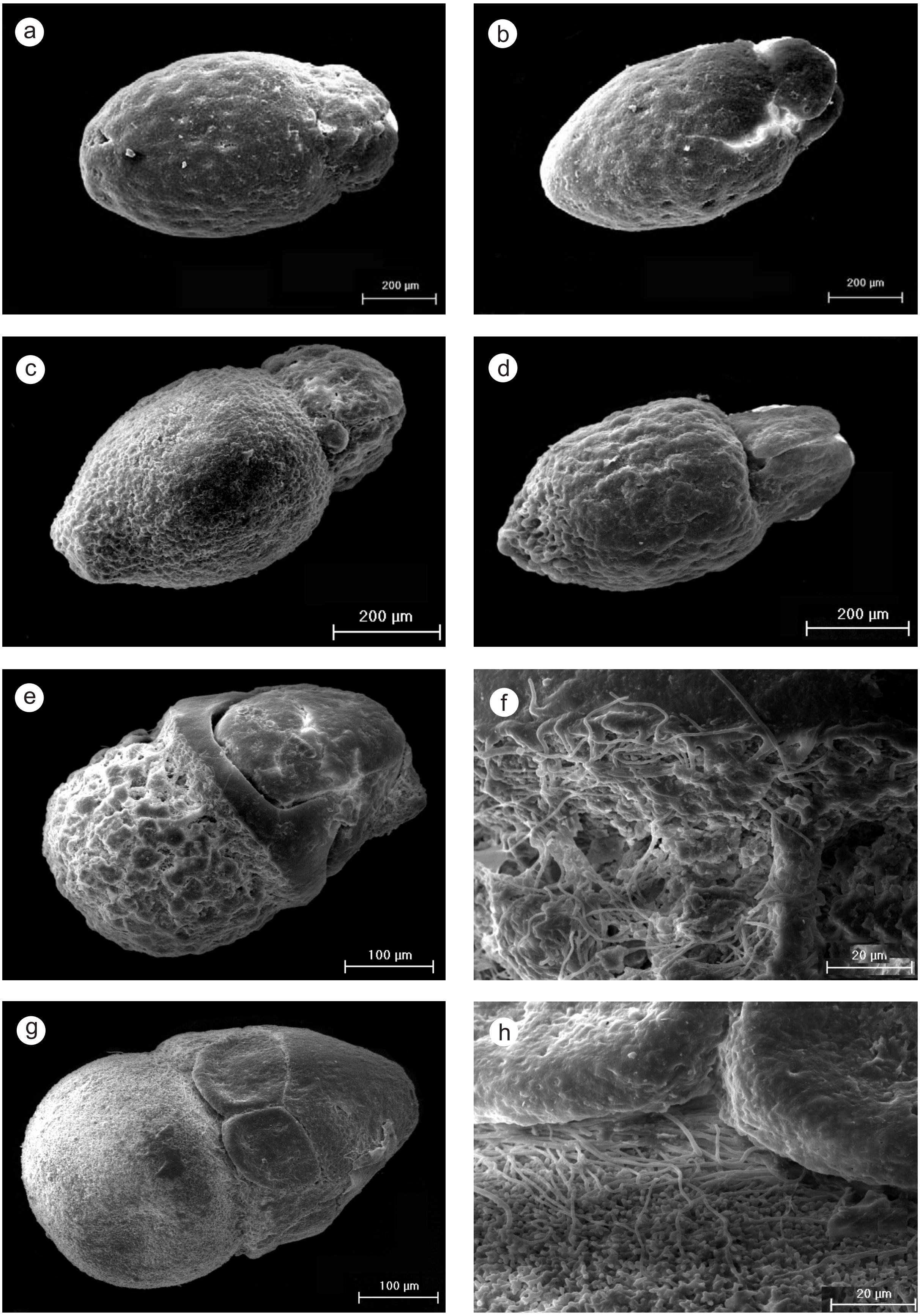

Fig. 5. **a,b** – *Salvinia glabra* Nikit., megaspores, SEM, × 100, KRAM-P 242/4a, b; **c,d** – *Salvinia aphtosa* Wieliczk., megaspores, SEM, × 100, KRAM-P 242/6a, b; **e** – *Azolla filiculoides* Lam. foss., megaspore, SEM, × 200, KRAM-P 242/8a, **f** – detail of surface, SEM, × 1000; **g** – *Azolla pseudopinnata* Nikit., megaspore, SEM, × 200, KRAM-P 242/9a, **h** – detail of surface, SEM, × 1000

face porcelain white or slightly yellow, mat or faintly lustrous.

Comparison. The megaspores agree with those typical for this species from the Pliocene flora of Krivobor'e (Nikitin 1957) in their basic diagnostic features but are more variable in shape.

Occurrence. Pliocene of central Russia (Nikitin 1957) and Belarus (Dorofeev 1967, Yakubovskaya 1984).

Salvinia tuberculata Nikitin

Pl. 1, figs 14, 15; Fig. 4: g,h

1948	*Salvinia tuberculata* Nikitin; Nikitin, p. 1104, nomen nudum.
1957	*Salvinia tuberculata* Nikitin; Nikitin, p. 88, Pl. 1, figs 7, 8.
1971a	*Salvinia* cf. *tuberculata* Nikitin; Dorofeev & Velichkevich, p. 154.

Material. MINM-P-BGO-2/5: 20 megaspores; KRAM-P 242/5: 5 megaspores.

Description. Megaspores 0.6–0.9 × 0.4–0.5 mm, ovoid or obovoid, apex pyramidal or bluntly conical, its surface rugose, separated from the rest of the megaspore by a distinct incision. Perisporium surface bearing rough tubercles of different size and shape. Megaspore narrowed to a subacute base, surface minutely tuberculate and pitted. Perisporium thick, soft, white or slightly yellow, mat or slightly lustrous.

Comparison. The megaspores described above closely resemble typical specimens of *Salvinia tuberculata* Nikitin from the Pliocene flora of Krivobor'e (Nikitin 1957), but they differ in size and surface sculpture. Megaspores of the contemporary European species, *Salvinia natans* (L.) All., are smaller with a smooth or minutely sculptured surface and rounded basal part.

Occurrence. Widely distributed in the Miocene of Siberia and in Upper Miocene and Pliocene of Europe (Dorofeev 1959b, Mai & Walther 1988).

AZOLLACEAE

Azolla filiculoides Lam. foss.

Pl. 1, figs 7, 8; Fig. 5: e,f

1938	*Azolla filiculoides* Lam.; Florschütz, p. 934, Pl. 19, figs 1, 2.
1988	*Azolla filiculoides* Lam. foss. Mai; Mai & Walther, p.58, Pl.1, figs 11–13.

Material. MINM-P-BGO-2/8: 1 megaspore; KRAM-P 242/8: 2 megaspores.

Description. Two megaspores 0.42 × 0.30 and 0.40 × 0.32 mm of typical structure for this species. Upper part conical consisting of 3 ovoid floats enclosed within a membranous indusium. Basal, semicircular part separated from the upper by a rather broad equatorial band. Megaspore covered with rounded tubercles which are conspicuous by their bright colour on the dark brown perisporium. On one megaspore thin hairs have been preserved. Massulae were not found.

Comparison. The megaspores described above are similar to those of *Azolla interglacialica* (=*A. interglacialis*) Nikit. from central Russia (Nikitin 1957). Abundant megaspores of this species have also been recorded from the Late Pliocene in Dvorets (Velichkevich 1990). *Azolla interglacialis* Nikit., most characteristic for the floras of the older Pleistocene of Belarus (Velichkevich 1982), is relatively rare in the Pliocene of Belarus and other parts of the East-European Plain. Megaspores of the species from several Pleistocene sites differ in the structure of the floating apparatus, the breadth of the equatorial band, and in the size and density of the tubercles, while some have additional floats.

The problem of the relation of the contemporary North American species *Azolla filiculoides* Lam. and the fossil *Azolla interglacialica* Nikit., recorded from the Pliocene and Pleistocene of central Russia, Belarus, Lithuania, Ukraine and from the Pleistocene of Siberia (Nikitin 1948, 1957, Dorofeev 1966a, 1967, Velichkevich 1982, 1990, Yakubovskaya 1984), calls for monographic investigations (comp. Mai & Walther 1988).

Occurrence. Pliocene and Pleistocene of Western Europe (Mai & Walther 1988).

Azolla pseudopinnata Nikitin

Pl. 1, figs 9, 10; Fig. 5: g,h

1948	*Azolla pseudopinnata* Nikitin; Nikitin, p. 1104, nomen nudum.
1955b	*Azolla cf. pseudopinnata* Dorof., Dorofeev, p. 118, Pl. 1, figs 2, 3.
1957	*Azolla pseudopinnata* Nikitin; Nikitin, p. 89, Pl.1, figs 12, 13.
1971a	*Azolla pseudopinnata* Nikitin; Dorofeev & Velichkevich, p. 154,
1980	*Azolla pseudopinnata* Nikitin var. *elegans* Dorof.; Dorofeev, p.309, Fig.6: 15, Pl.12, figs 6–13.

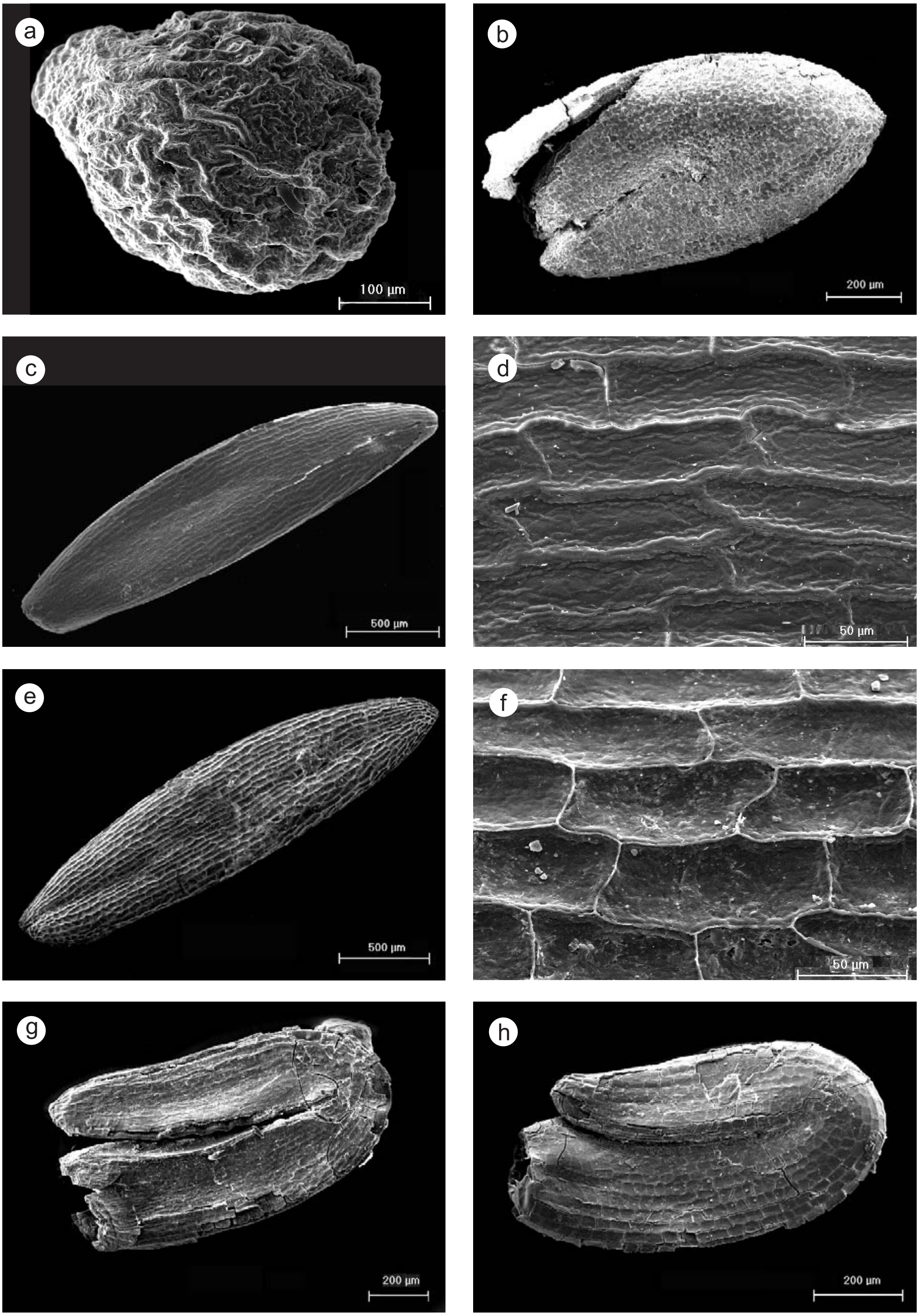

Fig. 6. **a** – *Salvinia cerebrata* Nikit., megaspore, SEM, × 200, KRAM-P 242/7; **b** – *Baldellia ranunculoides* (L.) Parl. foss., fruit, SEM, × 100, KRAM-P 242/44b; **c** – *Caulinia palaeotenuissima* Dorof., seed, SEM, × 50, KRAM-P 242/37a, **d** – detail of surface, SEM, × 500; **e** – *Caulinia scrobiculata* Dorof., seed, SEM, × 50, KRAM-P 242/38b, **f** – detail of surface, SEM, × 500; **g** – *Alisma plantago-aquatica* L., seed, SEM, × 80, KRAM-P 242/39b; **h** – *Alisma plantago-minima* (Nikit.) Dorof. ex Wieliczk., seed, SEM, × 120, KRAM-P 242/40c

1982 *Azolla pseudopinnata* Nikitin var. *elegans* Dorof.; Yakubovskaya, p. 40, Pl.1, figs 3–5.

Material. MINM-P-BGO-2/9: some hundreds of megaspores; KRAM-P 242/9: 15 megaspores.

Description. Megaspores 0.45–0.60 × 0.30–0.35 mm, ovoid to pyriform or almost ellipsoidal. Floating apparatus consisting of 9 floats, gathered into 3 sets with 3 floats in each, the sets distinctly separated from one another. Six square lower floats are situated equatorially, with three larger ovate upper floats above, which are often covered with the rest of the indusium. Basal part of megaspore semiglobose and equalling the floating apparatus or slightly broader than it. Perisporium surface smooth, downy, yellow-grey to light brown, mat. Rarely minute tubercles have been preserved in the basal part of the megaspore.

Comparison. The megaspores have diagnostic features similar to typical specimens from the Pliocene of central Russia (Nikitin 1957). However, they are smaller and narrower. Dorofeev (1980) separated these narrow megaspores into variety *elegans*. In the Kholmech flora such megaspores are very rare and, moreover, are linked by several transitional forms with other morphs of this species. In the present authors' opinion there is no basis for recognizing var. *elegans* in the species *Azolla pseudopinnata* Nikitin.

For several years the problem of the relation between the two fossil species *Azolla pseudopinnata* Nikitin and *A. tegeliensis* Florschütz has been a matter for discussion (Mai & Walther 1988, Mai 2000b). The first species is recorded predominantly from the Miocene of Siberia and the Late Miocene and Pliocene of eastern Europe, and the second from the Late Pliocene of Europe (Florschütz 1938). This latter species is characteristic for the older interglacials of western Europe (Field 1992). The two species have several features in common in the morphological structures of their megaspores.

The broad stratigraphical and palaeogeographical range and distribution does not exclude their separateness. In the opinion of Mai (letter of December 30th 2002), who saw the megaspores of *Azolla tegeliensis*.Florschütz from the locus typicus, they are identical to those of *A. pseudopinnata* Nikit. but resolution of this problem requires a comparative study of both original collecgions, including examination under the SEM.

The relationships of *Azolla pseudopinnata* Nikit. to the extant species of *Azolla* Lamarck (*A. pinnata* R.Br., *A. nilotica* Decne and *A. imbricata* (Roxb.) Nakai) are not clear, although, in Nikitin's opinion (1957), *A. pinnata* R.Br. is related to the fossil species.

Occurrence. Miocene of western Siberia (Dorofeev 1963a), Pliocene of central and southern Russia (Nikitin 1957, Dorofeev 1959b, 1966a, 1979) and Belarus (Dorofeev 1967, Krutous 1982, Yakubovskaya 1984, Velichkevich 1990), Pleistocene of Belarus and Lithuania (Velichkevich 1982).

PINACEAE

Picea sect. ***Eupicea*** Willk.

Pl. 1, fig. 22

Material. KRAM-P 242/10: 1 fragment of needle.

Description. Basal part of needle 2.8 × 0.9 mm, narrowly rhomboid in cross-section, slightly curved. Needle margins thick, rounded. Adhesion scar slightly convex, with small central tubercle. Stomatal bands distinctly visible on all four faces of this needle fragment.

Comparison. The presence of characteristic stomata bands on all four faces indicates section *Eupicea* Willk., comprising a few species sharing this needle structure (*Picea abies* (L.)Karst., *P. obovata* Ledeb., *P. fennica* (Regel) Kom.).

Occurrence. The remains of *Picea* sect. *Eupicea* Willk. occur very often and are numerous in Pliocene floras of the East-European Plain (Dorofeev 1966a, and others).

TYPHACEAE

Typha aspera Dorof.

Pl. 1, figs 20, 21

1971 *Typha aspera* Dorof.; Dorofeev, p.918, Fig.1: 2–6, designat. typi omissa.

1971a *Typha aspera* Dorof.; Dorofeev & Velichkevich, p.154.

1982a *Typha aspera* Dorof.; Dorofeev, p.22, Pl.3, figs 19–27; holotype – Pl.3, fig. 21.

Material. MINM-P-BGO-2/11: more than one thousand tegmens; KRAM-P 242/11: 20 tegmens.

Description. Tegmens 1.05–1.35 × 0.35–0.40 mm, oblong in outline, slightly swollen in the basal part, varying little in shape. Apex tapered and thickened. Micropyle top thick, with short thin style placed centrally. Tegmen tapered to the cuneiform base which is furnished with a mamillate stalk. Outer layer of seed usually destroyed or fragmentarily preserved, with clearly visible cellular structure.

Comparison. The tegmens described above are similar to those of the Miocene species *Typha tertiaria* Dorof., *T. pulchella* Dorof. and *T. tambovica* Dorof., known from different areas of the East-European Plain (Dorofeev 1982a). They are, however, narrower and their relationship to recent *Typha* species is unclear.

Occurrence. Pliocene of Belarus (Dorofeev 1982a, Yakubovskaya 1982, 1984).

Typha pseudoovata Dorof.

Pl. 1, figs 18, 19

1971 *Typha pseudoovata* Dorof.; Dorofeev, p. 918, Fig. 1: 12–16; designat. typi omissa.

1971a *Typha pseudoovata* Dorof.; Dorofeev & Velichkevich, p. 154.

1982a *Typha pseudoovata* Dorof.; Dorofeev, p. 23, Pl. 2, figs 38–45; holotype – Pl. 2, fig. 39.

Material. MINM-P-BGO-2/13: more than a thousand tegmens; KRAM-P 242/13: 25 tegmens.

Description. Tegmens 0.62–0.75 × 0.30–0.40 mm, ellipsoidal, mostly swollen centrally. Apex rather wide, micropyle top thin, with short subulate style, often inconspicuous. Tegmen base subacute with small thickened stalk. Tegmen walls rather thick, elastic, surface red-brown, lustrous.

Comparison. The tegmens of *Typha pseudoovata* Dorof. described above are similar to those of *Typha ovata* Dorof. from the Miocene flora of the Poltava area in the Ukraine (Dorofeev 1969a, 1982a). They are, however, broader, less swollen in the lower part and thicker.

Recent Asiatic and European species with small, wide tegmens, such as *Typha minima* Funk, are similar to *Typha pseudoovata* Dorof. and *T. ovata* Dorof.

Occurrence. Pliocene of Belarus (Dorofeev 1982a, Yakubovskaya 1982).

SPARGANIACEAE

Sparganium emersum Rehm. foss.

Pl. 1, fig. 25

1984 *Sparganium simplex* Huds.; Jahn et al., p. 26.

1988 *Sparganium emersum* Rehm. foss.; Mai & Walther, p. 95, Pl. 14, fig. 6.

Material. MINM-P-BGO-2/15: 77 endocarps; KRAM-P 242/15: 5 endocarps.

Description. Endocarps 2.1–3.3 × 1.3–1.9 mm, from shortly ovoid to elongate and fusiform. Apex uniformly narrowed, forming a more or less longitudinal neck which is usually oblique. Base abruptly narrowed, often with a short, straight or curved stalk. Thin, vascular bundles penetrate the base and divide up the surface of the endocarp forming the distinct longitudinally raised parts. Surface spongy with small surface cells which are indistinct and randomly arranged.

Comparison. The endocarps of *Sparganium emersum* Rehm. foss. in the Kholmech flora vary greatly in size and shape. Comparison of fossil specimens with contemporary *S. emersum* Rehm. is often difficult, because of the remains of soft epicarp on the surface. Endocarps of *Sparganium* described above, similar to *S. emersum* Rehm., but varying to different extents from recent ones, are present in several Pliocene floras of Europe. Their exact determination is impossible because it is very difficult to pinpoint the corresponding characteristic features for the extinct ancestor of *S. emersum* Rehm.

Occurrence. Upper Miocene of western Siberia (Dorofeev 1963a) and common in the Pliocene of Europe (Nikitin 1957, Jahn et al. 1984, Bužek et al. 1985, Mai & Walther 1988, Velichkevich 1990). Typical *Sparganium emersum* Rehm. appeared in Europe from the beginning of Pleistocene (Velichkevich 1982).

Sparganium cf. ***japonicum*** Roth

Pl. 1, fig. 26

Material. MINM-P-BGO-2/16: 3 endocarps; KRAM-P 242/16: 2 endocarps.

Description. Endocarps 2.7–3.8 × 1.4–2.3 mm, fusiform, apex long and tubular, sometimes with a fragment of epicarp. Base rounded or subacute, stalk short. Faces uniformly swollen, without ribs, vascular bundles not penetrating the surface of the endocarp.

Comparison. The most similar endocarps we can find occur in the extant East-Asiatic species *Sparganium japonicum* Roth (Miki 1961).

Occurrence. The species has not hitherto been recorded in the Pliocene floras of Europe.

Sparganium noduliferum C. & E.M. Reid

Pl. 1, figs 23, 24

1915 *Sparganium noduliferum* C. & E.M. Reid; Reid & Reid, p. 57, Pl. 1, figs 19–25.

non 1946–1947 *Sparganium noduliferum* Reid; Szafer, p. 187, Pl. 15, figs 36, 37.

Material. MINM-P-BGO-2/14: 11 endocarps; KRAM-P 242/14: 3 endocarps.

Description. Endocarps 2.9–4.8 × 1.9–3.1 mm, broadly fusiform, angular. Base narrowed into a long, thick stalk, predominantly blunt, sometimes with remnants of perianth. Apex conical, with truncate top, sometimes with a long grooved appendix. On the surface of the strongly swollen central part oval apertures are visible, between which have penetrated vascular bundles.

Comparison. The endocarps of *Sparganium noduliferum* C. & E.M. Reid from Kholmech are the same as those recorded from other Pliocene sites in central Russia (e.g. Krivobor'e, Nikitin 1957) and Lithuania (Daumantai, Rishkiene 1971).

Endocarps of the same type are found in the recent North American species *Sparganium androcladum* (Englm.) Morong and *S. multipedunculatum* (Morong) Rydb., but in these species they are smaller and they have a less swollen central part.

The specimen determined as *Sparganium noduliferum* Reid from Krościenko, Poland (Szafer 1946–1947) does not belong to this species and genus. It is a fruit of *Tilia platyphyllos* Scop. according to Łańcucka-Środoniowa (11.10.1975, KRAM-P, unpubl.).

Occurrence. Miocene of southern Russia (Dorofeev 1959b), Pliocene of central Russia (Nikitin 1957, Dorofeev 1979), Belarus (Yakubovskaya 1984), Lithuania (Riskiene 1971) and Czech Republic (Bůžek et al. 1985).

Sparganium cf. ***stenophyllum*** Maxim.

Pl. 1, fig. 27

1963a *Sparganium* cf. *stenophyllum* Maxim.; Dorofeev, p. 95, Pl. 6, figs 23–27; Fig. 13: 12,13.

1984 *Sparganium* cf. *stenophyllum* Maxim.; Jahn et al., p.26, Pl. 18 figs 20, 21.

Material. MINM-P-BGO-2/17: 2 endocarps; KRAM-P 242/17: 2 endocarps.

Description. Endocarps 2.6–3.2 × 1.9–2.2 mm, short, very swollen, sometimes almost globose, the base passing into a stout stalk. Apex short, abruptly narrowed. Distinct lateral ribs are visible.

Comparison. Endocarps of this type occur in the contemporary East-Asiatic species *Sparganium stenophyllum* Maxim. However, they are more enlarged than those from the Kholmech flora. In comparison with *S. emersum* Rehm. they are larger, shorter, and with more distinct lateral ribs.

Occurrence. Upper Miocene of western Siberia (Dorofeev 1963a), Pliocene of central Russia (Dorofeev 1985) and Pleistocene of Belarus (Yakubovskaya 1976, Velichkevich 1982).

Sparganium sp. 1

Pl. 1, fig. 28

Material. MINM-P-BGO-2/18: 14 endocarps; KRAM-P 242/18: 5 endocarps.

Description. Endocarps 2.8–3.9 × 1.8–2.3 mm, from fusiform to ellipsoidal, the base narrowed into a thick stalk. Apex elongate, tubular, sides weakly and asymmetrically swollen, ribs low, flattened and irregular.

Comparison. The contemporary North American species *Sparganium androcladum* (Engelm.) Morong, *S. multipedunculatum* (Morong) Rydb., *S. americanum* Nutt. and some American populations of *S. emersum* Rehm. have a similar type of endocarp.

Sparganium sp. 2

Pl. 1, fig. 29

Material. MINM-P-BGO-2/19: 11 endocarps; KRAM-P 242/19: 3 endocarps.

Description. Endocarps 2.1–2.7 × 1.4–2.0 mm, elongate, fusiform, the apex oblique and horizontally truncate, sometimes with a short appendix. Base rounded, gradually narrowing into the thin, short stalk. Faces of endocarp swollen, smooth, without ridges or longitudinal grooves. Vascular bundles are visible on the surface of endocarps.

Comparison. Similar endocarps occur in

the extant Eurasian *Sparganium minimum* Wallr., S. *glomeratum* Laest. and the Far-Eastern S. *japonicum* Roth, but these exhibit slight morphological structural differences when compared with those of the Kholmech flora.

POTAMOGETONACEAE

Potamogeton borysthenicus Dorof.

Pl. 2, figs 20–22

1971 *Potamogeton borysthenicus* Dorof.; Dorofeev, p. 918, Fig. 1: 22, 23, designat. typi omissa.
1971a *Potamogeton borysthenicus* Dorof.; Dorofeev & Velichkevich, p.154.
1986b *Potamogeton borysthenicus* Dorof., Dorofeev, p.81, Fig. 40: 1–9; holotype – Fig.40:2.
1999 *Potamogeton borysthenicus* Dorof., Velichkevich & Lesiak, p. 16, Pl. 2, figs 16–18.

Material. (MINM-V-P1-17) MINM-P-BGO-2/20: 161 endocarps; KRAM-P 242/20: 23 endocarps.

Description. See Velichkevich & Lesiak (op. cit.), p. 16.

Comparison. See Velichkevich & Lesiak (op. cit.), p. 17.

Occurrence. Pliocene of Belarus (Dorofeev 1971, 1986b), Thuringia (Mai & Walther 1988), and central Russia (Dorofeev 1985).

Potamogeton cholmechensis Dorof.

Pl. 2, figs 16–18

1971a *Potamogeton cholmechensis* Dorof.; Dorofeev & Velichkevich, p.154.
1971 *Potamogeton cholmechensis* Dorof.; Dorofeev, p. 919, Pl. 1, figs 9–11, designat. typi omissa.
1986b *Potamogeton cholmechensis* Dorof.; Dorofeev, p. 111, Fig. 56: 35–48; holotype – Fig. 56: 35.
1999 *Potamogeton cholmechensis* Dorof.; Velichkevich & Lesiak, p. 20, Pl. 1, figs 3–5.

Material. (MINM-V-P1-26) MINM-P-BGO-2/21: 1683 endocarps; KRAM-P 242/21: 103 endocarps.

Description. See Velichkevich & Lesiak (op. cit.), p. 20.

Comparison. See Velichkevich & Lesiak (op. cit.), p. 20.

Occurrence. Pliocene of Belarus (Dorofeev 1971, 1979, 1986b) and central Russia (Dorofeev 1985).

Potamogeton crispus L.

Pl. 2, fig. 14

1999 *Potamogeton crispus* L.; Velichkevich & Lesiak, p. 21, Pl. 2, fig. 9.

Material. (MINM-V-P1-31) MINM-P-BGO-2/22: 1 endocarp.

Description. See Velichevich & Lesiak (op. cit.), p. 21.

Comparison. The single preserved endocarp is similar to endocarps of the extant *Potamogeton crispus* L.

Occurrence. Pliocene and Pleistocene of Europe (Dorofeev 1986b).

Potamogeton cf. ***felixii*** Dorof.

Pl. 2, fig. 19

1986b *Potamogeton felixii* Dorof.; Dorofeev, p. 38, Fig.15: 1–6; holotype – Fig. 15: 2.
1999 *Potamogeton* cf. *felixii* Dorof.; Velichevich & Lesiak, p. 22. Pl.2, fig. 1.

Material. (MINM-V-P1-32) KRAM-P 242/23: 1 endocarp.

Description. See Velichkevich & Lesiak (op. cit.), p. 22.

Comparison. See Velichkevich & Lesiak (op. cit.), p. 22.

Occurrence. Upper Pliocene, Dvorets (Dorofeev 1986a, 1986b), Pliocene of the Upper Don basin (Dorofeev 1985).

Potamogeton longistylus Dorof.

Pl. 3, figs 10–12

1971 *Potamogeton planus* Nikit.; Dorofeev, fig.1: 1.
1971a *Potamogeton planus* Nikit.; Dorofeev & Velichkevich, p. 154.
1977a *Potamogeton longistylus* Dorof.; Dorofeev, p. 738, Fig.1: 9–11 designat. typi omissa.
1986b *Potamogeton longistylus* Dorof.: Dorofeev, p. 27, Fig. 8: 9–14; holotype – Fig.8: 14.
1999 *Potamogeton longistylus* Dorof; Velichkevich & Lesiak, p. 17, Pl. 1, figs 14–16.

Material. (MINM-V-P1-18) MINM-P-BGO-2/24: 250 endocarps; KRAM-P 242/24: 74 endocarps.

Description. See Velichkevich & Lesiak (op. cit.), p. 17.

Comparison. See Velichkevich & Lesiak (op. cit.) p. 17.

Occurrence. Neogene of Belarus (Dorofeev 1977a, 1986b).

Potamogeton margaritae Dorof.

Pl. 3, figs 6–8

1971a *Potamogeton margaritae* Dorof.; Dorofeev & Velichkevich, p. 154.
1986b *Potamogeton margaritae* Dorof.; Dorofeev, p. 46, Fig. 20: 1–16; holotype – Fig.20: 1.
1999 *Potamogeton margaritae* Dorof.; Velichevich & Lesiak, p. 18, Pl. 2, figs 2–4.

Material. (MINM-V-P1-20) MINM-P-BGO-2/25: 302 endocarps; KRAM-P 242/25: 53 endocarps.

Description. See Velichkevich & Lesiak (op. cit.), p. 18.

Comparison. See Velichkevich & Lesiak (op. cit.), p. 18.

Occurrence. Pliocene of Belarus (Dorofeev 1986b).

Potamogeton obtusatus Dorof.

Pl. 3, figs 1–3

1971a *Potamogeton* cf. *obtusifolius* Mert. & Koch, Dorofeev & Velichkevich, p. 154 (pro parte).
1986b *Potamogeton obtusatus* Dorof.; Dorofeev, p. 97, Fig. 50: 1–10; holotype – Fig. 50: 4.
1996 *Potamogeton obtusatus* Dorof.; Velichkevich & Lesiak, p. 81, Pl. 1, figs 5–9.
1999 *Potamogeton obtusatus* Dorof.; Velichkevich & Lesiak, p.19, Pl. 2, figs 10–12.

Material. (MINM-V-P1-24) MINM-P-BGO-2/26: 144 endocarps; KRAM-P 242/26: 23 endocarps.

Description. See Velichkevich & Lesiak (op. cit.), p. 19.

Comparison. See Velichkevich & Lesiak (op. cit.), p. 19.

Occurrence. Pliocene of Belarus (Dorofeev 1986b) and southern Poland (Mizerna, Velichkevich & Lesiak 1996).

Potamogeton obtusus Dorof.

Pl. 3, figs 4, 5

1971a *Potamogeton* cf. *obtusifolius* Mert. & Koch, Dorofeev & Velichkevich, p. 154 (pro parte).
1986b *Potamogeton obtusus* Dorof.; Dorofeev, p. 97, Fig. 50: 11–20; holotype – Fig. 50: 13.
1999 *Potamogeton obtusus* Dorof.; Velichkevich & Lesiak, p. 19, Pl. 1, figs 6,7.

Material. (MINM-VP1-23) MINM-P-BGO-2/27: 16 endocarps; KRAM-P 242/27: 7 endocarps.

Description. See Velichkevich & Lesiak (op. cit.), p. 19.

Comparison. See Velichkevich & Lesiak (op. cit.), p. 18.

Occurrence. Pliocene of Belarus (Dorofeev 1986b).

Potamogeton palaeorutilus Dorof.

Pl. 2, figs 1, 2

1986b *Potamogeton palaeorutilus* Dorof.; Dorofeev, p. 103, Fig. 53: 1–9; holotype – Fig. 53: 3.
1999 *Potamogeton palaeorutilus* Dorof.; Velichkevich & Lesiak, p. 19, Pl. 2, figs 5, 6.

Material. (MINM-V-P1-25) MINM-P-BGO-2/28: 30 endocarps; KRAM-P 242/28: 12 endocarps.

Description. See Velichkevich & Lesiak (op. cit.), p. 19.

Comparison. See Velichkevich & Lesiak (op. cit.), p. 20.

Occurrence. Pliocene of Belarus (Dorofeev 1986b).

Potamogeton panormitanoides Dorof.

Pl. 3, fig. 9

1986b *Potamogeton panormitanoides* Dorof.; Dorofeev, p. 107, Fig. 54: 2–8; holotype – Fig. 54: 6.
1996 *Potamogeton panormitanoides* Dorof; Velichkevich & Lesiak, p. 85, Pl. 3, figs 23–25.
1999 *Potamogeton panormitanoides* Dorof; Velichkevich & Lesiak, p. 21, Pl. 2, fig.7.

Material. (MINM-V-P1-29) MINM-P-BGO-2/29: 5 endocarps; KRAM-P 242/29: 1 endocarp.

Description. See Velichkevich & Lesiak (op. cit.), p. 21.

Comparison. See Velichkevich & Lesiak (op. cit.), p. 21.

Occurrence. Pliocene of Belarus (Dorofeev 1986b), and southern Poland (Mizerna, Velichkevich & Lesiak 1996), Late Pleistocene of Poland (Velichkevich & Mamakowa 1999).

Potamogeton cf. ***parvulus*** Dorof.

Pl. 2, fig. 3

1986b *Potamogeton parvulus* Dorof.; Dorofeev, p. 110, Fig. 55: 18–28; holotype – Fig. 55: 28.
1999 *Potamogeton* cf. *parvulus* Dorof.; Velichkevich & Lesiak, p. 21, Pl. 2, fig. 8.

Material. (MINM-V-P1-28) MINM-P-BGO-2/30: 7 endocarps; KRAM-P 242/30: 6 endocarps.

Description. See Velichkevich & Lesiak (op. cit.), p. 21.

Comparison. See Velichkevich & Lesiak (op. cit.), p. 21.

Occurrence. Pliocene of Belarus (Dorofeev 1986b), and the Upper Don basin (Dorofeev 1985).

Potamogeton cf. ***pectinatus*** L.

Pl. 2, fig. 15

1959b *Potamogeton pectinatus* L. foss.; Dorofeev, p.166, Pl. 2, fig. 14.
1999 *Potamogeton* cf. *pectinatus* L.; Velichkevich & Lesiak, p. 21, Pl. 2, fig. 13.

Material. (MINM-V-P1-30) KRAM-P 242/31: 1 endocarp.

Description. See Velichkevich & Lesiak (op. cit.), p. 21.

Comparison. See Velichkevich & Lesiak (op. cit.), p. 21.

Occurrence. From the Miocene of southern Russia (Dorofeev 1959b) to the Pleistocene of Europe (Dorofeev 1986b).

Potamogeton praenatans Dorof.

Pl. 2, figs 12, 13

1971a *Potamogeton* cf. *natans* L.; Dorofeev & Velichkevich, p. 154.
1986b *Potamogeton praenatans* Dorof.; Dorofeev, p. 46, Fig. 19: 4–12; holotype – Fig.19: 12.
1999 *Potamogeton praenatans* Dorof.; Velichkevich & Lesiak, p. 18, Pl. 1, figs 1, 2.

Material. (MINM-V-P1-22) MINM-P-BGO-2/32: 12 endocarps; KRAM-P 242/32: 7 endocarps.

Description. See Velichkevich & Lesiak (op. cit.), p. 18.

Comparison. See Velichkevich & Lesiak (op. cit.), p. 19.

Occurrence. Pliocene of Belarus (Dorofeev 1986b).

Potamogeton pseudoacutifolius Dorof.

Pl. 2, figs 7–9

1986b *Potamogeton pseudoacutifolius* Dorof.; Dorofeev, p. 88, Fig. 45: 11–18; holotype – Fig. 45: 14.
1996 *Potamogeton pseudoacutifolius* Dorof.; Velichkevich & Lesiak, p. 83, Pl. 2, figs 12–15.
1999 *Potamogeton pseudoacutifolius* Dorof.; Velichkevich & Lesiak, p. 17, Pl. 1, figs 11–13.

Material. (MINM-P-P1-19) MINM-P-BGO-2/33: 115 endocarps; KRAM-P 242/33: 53 endocarps.

Description. See Velichkevich & Lesiak (op. cit.), p. 17.

Comparison. See Velichkevich & Lesiak (op. cit.), p. 18.

Occurrence. Pliocene of Belarus (Dorofeev 1986b) and southern Poland (Mizerna,Velichkevich & Lesiak 1996). Occurs also in the Pliocene of south-western Poland (Kłodzko, own observation).

Potamogeton rossicus Dorof.

Pl. 2, figs 10, 11

1986b *Potamogeton rossicus* Dorof.; Dorofeev, p. 52, Fig. 22: 19–25; holotype – Fig. 22: 24.
1999 *Potamogeton rossicus* Dorof.; Velichkevich & Lesiak, p. 18, Pl. 2, figs 14,15.

Material. (MINM-V-P1-21) MINM-P-BGO-2/34: 14 endocarps; KRAM-P 242/34: 7 endocarps.

Description. See Velichkevich & Lesiak (op. cit.), p. 18.

Comparison. See Velichkevich & Lesiak (op. cit.), p. 18.

Occurrence. Pliocene of Belarus (Dorofeev 1986b).

Potamogeton simplex Dorof.

Pl. 2, figs 4–6

1986b *Potamogeton simplex* Dorof.; Dorofeev, p. 99, Fig. 51: 27–36; holotype – Fig.51: 28.
1996 *Potamogeton simplex* Dorof; Velichevich & Lesiak, p. 20, Pl. 1, figs 8–10.

Material. (MINM-V-P1-27) MINM-P-BGO-2/35: 532 endocarps; KRAM-P 242/35: 53 endocarps.

Description. See Velichkevich & Lesiak (op. cit.), p. 20.

Comparison. See Velichkevich & Lesiak (op. cit.), p. 20.

Occurrence. Pliocene of Belarus (Dorofeev 1986b).

NAJADACEAE

Caulinia palaeotenuissima Dorof.

Pl. 3, figs 16, 17; Fig. 6: c,d

1965 *Najas palaeotenuissima* Dorof.; Dorofeev, p. 200, Pl. 1, figs 21–23, designat. typi omissa.

1971a *Najas lanceolata* C. & E.M. Reid; Dorofeev & Velichkevich, p. 155.
1973a *Najas lanceolata* auct. non C. & E.M. Reid; Dorofeev, Pl. 2, figs 3,4.
1978 *Caulinia palaeotenuissima* Dorof.; Dorofeev, p. 1099, Pl. 6, figs 4–11; holotype – Pl. 6, fig. 10.
2003 *Caulinia palaeotenuissima* Dorof.; Velichkevich & Zastawniak, Pl. 2, fig. 3

Material. MINM-P-BGO-2/37: 114 seeds; KRAM-P 242/37: 14 seeds.

Description. Seeds 2.2–2.8 × 0.6–0.8 mm, elongate, somewhat curved, gradually narrowing into the blunt apex; narrowed also towards the base which sometimes bears a short, stout stalk. Surface dark brown, shining, almost smooth. Surface cells of testa rectangular, elongate, two or more times longer than wide. Cell walls straight and rather thick. Testa in cross-section 3-layered. Outer layer cells larger than the others, almost uniformly thick-walled. Middle layer cells with thinner walls and more abundant than those in the outer layer. Cells of inner layer thin-walled, extremely fragile and very rarely preserved (comp. Dorofeev 1978, Pl. 6, figs 7–11).

Comparison. Similar seeds were described from the Pliocene of Bashkiria (Dorofeev 1965), which are, however, smaller (2.10–2.45 × 0.60–0.75 mm) and wider in the middle part than those we have described from the Kholmech flora. According to Dorofeev (1978), this species is widely distributed in the Pliocene floras of the European part of Russia and Belarus and is also in the Baltic countries. The seeds from the several collections differ in size and shape, but fall within the range of variability of this fossil taxon. The relationship of this species to *Najas lanceolata* C. & E.M. Reid from the Pliocene of the Netherlands (Reid & Reid 1915, p.62, Pl.2, figs 18, 19) requires fresh investigation.

Occurrence. Pliocene of Bashkiria (Dorofeev 1965), Belarus (Dorofeev 1978) and central Russia (Dorofeev 1979, 1985).

Caulinia scrobiculata Dorof.

Pl. 3, figs 18–20; Fig. 6: e,f

1971a *Najas* cf. *aspera* C. & E.M. Reid; Dorofeev & Velichkevich, p. 155.
1978 *Caulinia scrobiculata* Dorof.; Dorofeev, p. 1098, Pl. 5, figs 17–21; holotype – Pl. 5, fig. 20.

Material. MINM-P-BGO-2/38: 14 seeds; KRAM-P 242/38: 7 seeds.

Description. Seeds 2.4–2.9 × 0.5–0.8 mm, elongate, straight, with distinct cells at the testa surface, narrowing towards the base. Apex subacute. Surface cells rectangular from almost square to very elongate (length 2–3 times as a great as width). Walls of cells protruding from the testa, straight and thin. In the cross-section of the testa one layer of large, thick-walled, 5–6-angled cells is visible.

Comparison. According to Dorofeev (1978) *Caulinia scrobiculata* is a very close relative of *C. lanceolataeformis* Dorof. They were both described from the Pliocene of Bashkiria (Dorofeev 1965), but differ in that the former has more swollen seeds with a blunt apex and more prominent cells on the testa surface. The seeds of *C. palaeotenuissima* Dorof. are similar in size and shape. Both these species occur commonly in the Kholmech flora and differ markedly in testa anatomy and cell shape (Dorofeev 1978, fig. 4: 7, 8; fig. 7: 1–6).

Occurrence. Pliocene of Belarus (Dorofeev 1978) and central Russia (Dorofeev 1979).

Najas major-pliocenica Dorof. ex Wieliczk.

Pl. 3, figs 21–23

1954 *Najas marina* L., Szafer, p. 64, Pl. 18, figs 2, 4–6, 8, non 1, 3, 7, 9–13.
1971a *Najas major* All.; Dorofeev & Velichkevich, p. 154.
1986a *Najas major-pliocenica* Dorof.; Dorofeev, Pl. 2, figs 29–32, nomen nudum.
1990 *Najas major-pliocenica* Dorof.; Vielichkevich, p. 51, Pl. 12, figs 6–9; lectotype – fig. 9.

Material. MINM-P-BGO-2/36: 828 seeds KRAM-P 242/36: 20 seeds.

Description. Seeds 3.8–5.2 × 1.3–2.0 mm, longitudinally ovoid, ellipsoidal or fusiform, asymmetrical, gradually narrowed towards the subacute apex. Base truncate or rounded. Testa thick, many-layered with indistinct surface cells, sublustrous. Cells poly-angled, somewhat elongated, arranged in indistinct slanting rows.

Comparison. Seeds of the Kholmech flora species are similar to those typically described from the Pliocene of Dvorets (Velichkevich 1990), but the latter are somewhat larger, with thicker walls and prominent surface cells.

Seeds of the recent *Najas major* All. from the European part of its distribution and also from the Pleistocene floras of Belarus and neighbouring countries (Velichkevich 1973b,

1982) are somewhat larger and wider than specimens from the Kholmech flora (3.8–5.9 × 1.7–3.0 mm), and have a thicker testa (Velichkevich 1973b, Pl. 21, figs 13–17). Seeds from the Far-Eastern part of its distribution differ in size and shape from those of the Kholmech flora and recent European populations. Seeds of Asiatic populations more closely resemble those of the contemporary species *Najas marina* L. In the extant flora from different ecotypes the boundary between *Najas major* All. and *Najas marina* L. is indistinct.

Occurrence. Pliocene of central Russia (Dorofeev 1985) and Upper Pliocene of Belarus (Dvorets, Dorofeev 1986a Velichkevich 1990). The seeds of *Najas marina* L. foss. from the Upper Miocene of Bulgaria most probably belong to this species (see Palamarev 1982, p. 25, Pl. 8, figs 6–8).

ALISMATACEAE

Alisma plantago-aquatica L.

Pl. 3, figs 13, 14; Fig. 6: g

Material. MINM-P-BGO-2/39: 23 fruits and 25 seeds; KRAM-P 242/39: 10 fruits.

Description. Fruits 1.4–1.9 × 0.7–1.2 mm and seeds 1.0–1.3 × 0.6–0.7 mm. For other features see note following the description of *Alisma plantago-minima* (Nikitin) Dorof. ex Wieliczk.

Comparison. Fossil fruits and seeds found in the Kholmech flora are close to those of the Eurasian *Alisma plantago-aquatica* L.

Occurrence. Upper Pliocene and Pleistocene of the East-European Plain (Dorofeev 1963b, Velichkevich 1973b, 1982, Yakubovskaya 1976).

Alisma plantago-minima (Nikit.) Dorof. ex Wieliczk.

Pl. 4, figs 6–8; Fig. 6: h

1957 *Alisma plantago-aquatica* L. var. *minima* Nikitin; Nikitin, p. 107, Pl. 2, figs 27, 28; lectotype: Pl. 2, fig. 28.
1971a *Alisma plantago-pliocenica* Nikit.; Dorofeev & Velichkevich, p. 155.
1986a *Alisma minimum* (Nikit.) Dorof.; Dororeev p. 45, nomen nudum.
1988 *Alisma* ex gr. *plantago* L. foss.; Mai & Walther, p. 72, Fig. 8c–e.
1990 *Alisma plantago-minimum* (Nikit.) Dorof.; Vielichkievich, p. 55, Pl. 15, figs 1–6.

Material. MINM-P-BGO-2/40: 530 fruits and tegmens; KRAM-P 242/40: 30 fruits.

Description. Fruits 1.0–1.3 × 0.5–0.7 mm, variable in shape: ovoid, obovoid, cuneiform, usually asymmetric. Apex rounded on one side, sometimes with a preserved fragment of style. The dorsal fruit margin is broader than the ventral one which is convex or plane. Pericarp thin, longitudinally striate, thicker on the dorsal margin of the fruit. Fruit gradually narrowed into the base which is variable in shape and often damaged. Seeds 0.7–1.0 × 0.4–0.6 mm, hippocrepiform. Arms of the “horseshoe” contiguous, the micropylar arm narrower than the chalazal, of equal length, or the micropylar somewhat shorter. Outer layer of testa black and shining. Surface cells almost square or somewhat elongate parallel to the axis of the seed, arranged in distinct, longitudinal rows.

Comparison. The recent Eurasian species *Alisma plantago-aquatica* L. has fruits and seeds of similar shape. The fruits of *A. plantago-minima* (Nikit.) Dorof. found in the Kholmech flora are, however, much smaller and narrower. The fruits of another extant species, *Alisma orientale* (Sam.) Juz. (Far East, Japan, China), are similar in size to those described above, but are more ovoid, and have a thinner pericarp. On the ventral face a marginal rim sometimes occurs. This type of fruit is also found in another contemporary North American species, *A. triviale* Pursh. However, *A. orientale* (Sam.) Juz. and *A. triviale* Pursh. do not have the apex rounded on one side, which is very characteric for fruits from the Kholmech flora.

Occurrence. Pliocene of central Russia (Dorofeev 1979) and Belarus (Dorofeev 1986a, Velichkevich 1990).

Baldellia ranunculoides (L.) Parl. foss.

Pl. 4, fig. 1

1957 Genus 4 (cf. *Echinodorus*); Nikitin, p. 110, Pl. 2, fig. 33.
1971a *Echinodorus* sp.; Dorofeev & Velichkevich, p. 155.
1986a Alismataceae gen; Dorofeev, p. 45.
1990 Alismataceae gen. (*Baldellia*); Velichkevich, p. 56, Pl. 14, figs 1–3.

Material. MINM-P-BGO-2/44: 22 seeds; KRAM-P 242/44: 7 seeds.

Description. Seeds 1.15–1.50 × 0.55–0.65 mm, ovoid, rather thick, hippocrepiform, somewhat narrowed to the rounded apex, sometimes with an indistinct appendix. “Horseshoe arms” of seed contiguous, the narrow micropylar arm longer than the broader chalazal one. End of micropylar arm somewhat flattened, straight or curved outwards. Chalazal arm round, with a short, mamillate appendix, which is often not preserved. Each seed has a thin, fragile areola. At the areola surface circular or 4–6-angled cells are visible, concave in the centre, with thickened walls. The testa is thin, black, its surface bearing cells similar to those at the areola, but without pits or thickenings.

Comparison. The seeds of the only contemporary European species *Baldellia ranunculoides* (L.) Parl. differ in size from the fossil ones (they are smaller), have a somewhat curved axis without a mamillate appendix at the apex, a shorter micropylar arm and elongate cells at the surfaces of the areola and testa. In the Dvorets flora (Velichkevich 1990) seeds of this species, determined as Alismataceae gen., are smaller than those in the Kholmech flora and lack the mamillate appendix.

Occurrence. Pliocene of central Russia (Nikitin 1957), Belarus (Dorofeev 1986a, Velichkevich 1990), Thuringia (Mai & Walther 1988), as well as Reuver, Belfeld and Mizerna II and Pleistocene of Eastern Germany (Mai & Walther 1988).

Caldesia cylindrica (E.M. Reid) Dorof.

Pl. 3, fig. 15

1920 *Myriophyllum cylindricum* E.M. Reid; E.M. Reid, p. 71, Pl. 4, figs 2, 4.
1956 *Caldesia* sp.; Dorofeev, p. 173, Fig. 1, 14.
1959a *Caldesia proventitia* Dorof.; Dorofeev, p. 124, Pl. 9, figs 4, 5.
1960b *Caldesia tertiaria* Dorof.; Dorofeev, p. 142, Pl. 2, fig. 10.
1963a *Caldesia cylindrica* (E.M. Reid) Dorof.; Dorofeev, p. 110, Pl. 10, figs 1–7.
1971a *Caldesia cylindrica* (E.M. Reid) Dorof.; Dorofeev & Velichkevich, p. 155.
1984 *Caldesia cylindrica* (E.M. Reid) Dorof.; Jahn et al., p. 26.

Material. MINM-P-BGO-2/45: 5 endocarps; KRAM-P 242/45: 3 endocarps.

Description. Endocarps (without style) 1.9–2.7 × 1.3–1.7 mm, from truncate cuneiform to transversely ellipsoidal, asymmetric. Ventral face plane or weakly convex, very rarely somewhat concave, acute or rounded at the margin. Dorsal face broader than the ventral one, with rounded margin, sometimes with remnant tissue of the mesocarp along the endocarp axis as a partial rib. Base rounded or subacute, without stalk. Style conical, pointed and quite long, upright, appearing as a prolongation from the ventral face. Both lateral faces are somewhat convex or plane, walls of endocarp thick and strong. Endocarp surface composed of small cells and tiny apertures, rough.

Comparison. This species has a wide distribution from Europe to western Siberia, with variable endocarp morphology. The closest endocarps to those we have described are those from the Miocene of Odessa (Dorofeev 1969a), the Miocene of western Siberia (Dorofeev 1963a) and the Pliocene of Thuringia (Mai & Walther 1988). Endocarps of the similar recent European species *Caldesia parnassifolia* (Bassi) Parl., which is very common in the Pleistocene floras of the East-European Plain, are shorter and broader, with a short spiny style arising on the ventral side from a point below the apex.

Occurrence. Miocene of western Siberia, central and southern Russia (Dorofeev 1956, 1959a, 1963a, 1969a, 1985), Ukraine (Dorofeev 1969a), Moldova (Negru 1986), Slovakia (Knobloch 1980, 1981, 1992), Lusatia (Mai 2000b), Pliocene of Belarus (Dorofeev 1967), Poland (Jahn et al. 1984) and Thuringia (Mai & Walther 1988).

Damasonium alisma Mill. foss.

Pl. 4, figs 11, 12

Material. MINM-P-BGO-2/43: 5 seeds; KRAM-P 242/43: 1 fruit, 1 seed.

Description. Fruit 3.9 × 1.5 mm, conical, asymmetric, narrowed at the apex into a long, flat style, base broken off. Pericarp woody, not very thick, surface somewhat ribbed, mat. Seeds 1.9–2.0 × 0.75–0.85 mm, longitudinally ovate, somewhat curved along their axis, uniformly hippocrepiform, the “horseshoe arms” contiguous. The narrow micropylar arm overlaps the broader, chalazal one. Testa surface with slanting, short ribs. Testa cells 4–6-angled, elongate, in transverse rows. Tegmens yellow-brown, semitransparent, with lustrous surface.

Comparison. The seeds described above are very similar to those of the recent Eurasian species *Damasonium alisma* Mill., which is characterized by great variability in the shape and sculpture of the testa in its recent area of distribution. The genus also contains two other species, *D. polyspermum* Coss. from central Asia, and *D. constrictum* Juz. from the neighbourhood of the Caspian Sea, but their fruits are considerably smaller than those recorded from the Kholmech flora.

Occurrence. Fossil fruits of *Damasonium* have not hitherto been recorded. Seeds have been found very rarely in the Miocene of western Siberia (Dorofeev 1963a), Pliocene of central Russia (Dorofeev 1985), Upper Pliocene of Ukraine (Dorofeev 1966a) and Neogene of the Transcarpathians (Dorofeev 1966b).

Sagittaria sagittifolia L. foss.

Pl. 4, figs 4, 5

1946–1947 *Alisma plantago* L.; Szafer, p. 179, Pl. 15, fig. 3.
1946–1947 *Sagittaria sagittifolia* L.; Szafer, p. 179, Pl. 15, fig. 1.
1971a *Sagittaria* cf. *sagittifolia* L.; Dorofeev & Velichkevich, p.155.
1988 *Sagittaria sagittifolia* L. foss.; Mai & Walther, p. 74, Pl. 8, figs 9, 10.
1990 *Sagittaria sagittifolia* L.; Vielichkevich, p. 56, Pl. 16, figs 7–9.

Material. MINM-P-BGO-2/41: 177 seeds and tegmens; KRAM-P 242/41: 10 tegmens.

Description. Seeds 1.55–2.57 × 0.90–1.65 mm, flat, roughly hippocrepiform, shape in general from irregularly ovate to transversally elliptical. “Horseshoe arms” abruptly curved towards their ends. Micropylar arm shorter and narrower than the chalazal one, or the two of equal length and width. Testa thin, semitransparent, brown and black, easily separable from the tegmen. Testa surface cells rectangular to square, arranged in longitudinal rows. Tegmens thin, scarious, paleaceous with traces of testa cells, lustrous. Tegmens of ripe seeds red or brown, those of unripe seeds bright yellow.

Comparison. The *Sagittaria* seeds found in the Kholmech flora vary in size. The majority of them are large, just as in the contemporary European species *S. sagittifolia* L.

Occurrence. Upper Pliocene of Belarus (Dorofeev 1986a, Velichkevich 1990), Pleistocene of Belarus, Lithuania and the western part of Russia (Vielichkevich 1973b, 1982), and numerous localities in Pliocene and Pleistocene of other parts of Europe (Mai & Walther 1988).

Sagittaria sp.

Pl. 4, figs 2, 3

1971a *Sagittaria* cf. *natans* Pall.; Dorofeev & Velichkevich, p. 155.

Material. MINM-P-BGO-2/42: 41 seeds and tegmens; KRAM-P 242/42: 5 tegmens.

Description. Seeds and tegmens 1.55–1.95 × 0.75–1.15 mm, flattened, hippocrepiform. “horseshoe arms” of almost equal length and width, slightly separated. Testa thin, black, surface cells square or somewhat elongate along the axis. Tegmens red or brown.

Comparison. The remains are most similar to the extant North American *Sagittaria cuneata* Sheldon, but larger.

Occurrence. Seeds of this type were hitherto unknown.

HYDROCHARITACEAE

Hydrocharis morsus-ranae L. foss.

Pl. 4, figs 9, 10; Fig. 7: h

1988 *Hydrocharis morsus-ranae* L. foss.; Mai & Walther, p. 74, Pl. 8, figs 11–13.
1990 *Hydrocharis* cf. *morsus-ranae* L.; Vielichkevich, p. 58, Pl. 16, figs 5, 6.

Material. MINM-P-BGO-2/47: 18 seeds; KRAM-P 242/47: 5 seeds.

Description. Seeds 1.3–1.5 × 0.7–0.9 mm, ovoid, secondarily compressed during fossilization, with short conical style at the apex and broad, horizontally cut stalk. Sometimes the stalk is fragile or the base is torn. Testa thin, membranous, semitransparent, sometimes crumpled. Testa surface rugose, with elongate ovate cells arranged in indistinct longitudinal rows, 10–12 on each face. Some specimens have the testa sparsely rugose and lack clearly visible surface cells.

Comparison. *Hydrocharis morsus-ranae* L. foss. seeds from the Late Miocene of Lusatia (Mai 2000b) are similar, but possess a less distinct testa sculpture. Those from the Pleistocene of Belarus (Dorofeev 1963b) are shorter and broader and have a thinner testa than the Kholmech flora ones. The seeds of the Miocene species *Hydrocharis lusatica* Mai & Walther

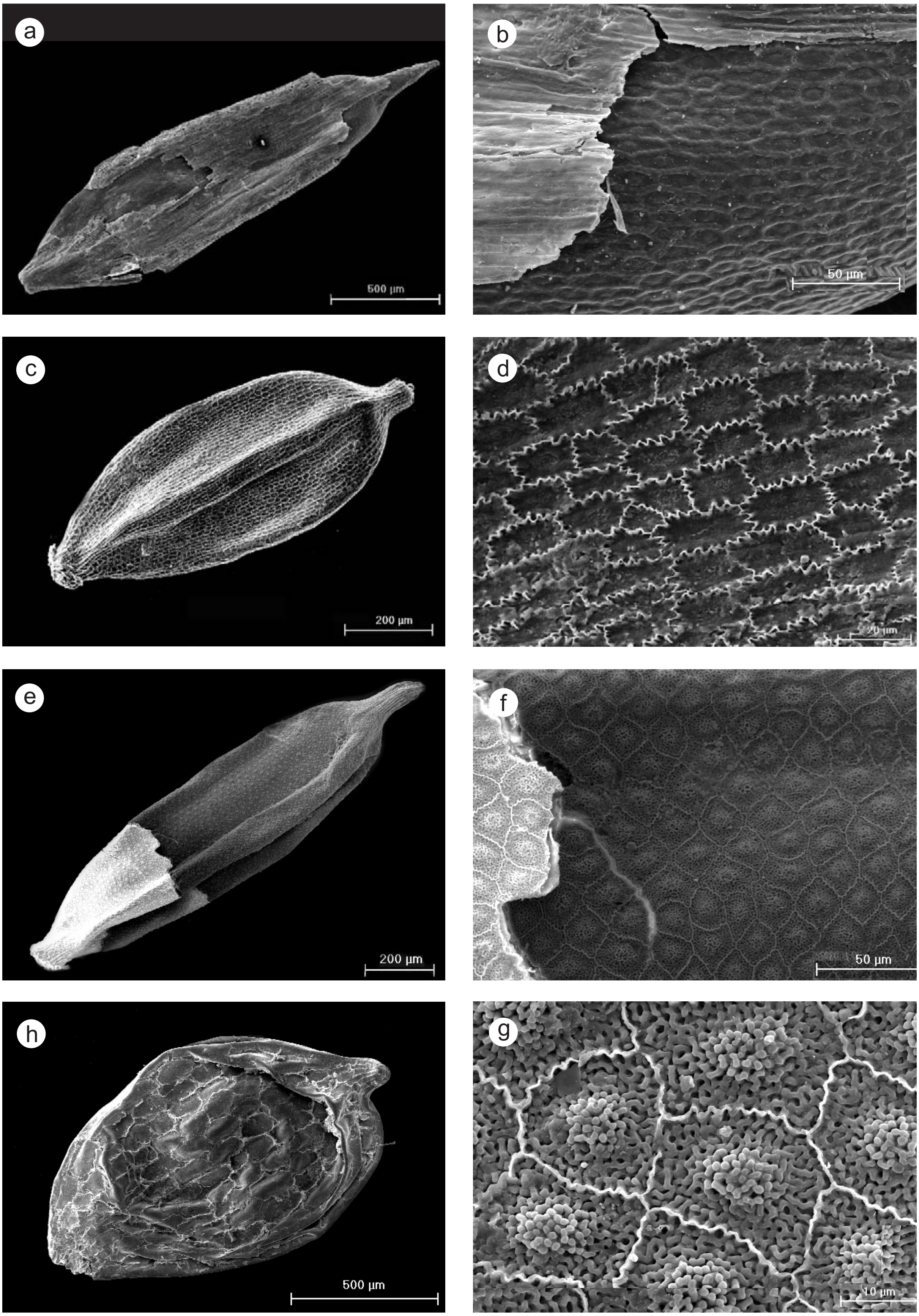

Fig. 7. **a** – *Carex klarae* Mai, fruit, SEM, × 60, KRAM-P 242/53c, **b** – detail of surface, SEM, × 500; **c** – *Scirpus atroviroides* Dorof., fruit, SEM, × 120, KRAM-P 242/63, **d** – detail of surface, SEM, × 500; **e** – *Cyperus glomeratoides* Wieliczk. & Zastaw. sp. nov., fruit, SEM, × 80, KRAM-P 242/58c; **f,g** – details of surface, SEM, × 500 and × 2000; **h** – *Hydrocharis morsus-ranae* L. foss., seed, SEM, × 70, KRAM-P 242/47b

(Mai & Walther 1991) and *H. neogenica* Mai (Mai 1999a) from Lusatia have a similar shape, but are much smaller. The seeds of the extant species are smaller, 1.0–1.2 mm in length.

Occurrence. Upper Miocene of Slovakia (Knobloch 1992) and Lusatia (Mai 2000b), Pliocene of Dvorets (Vielichkievich 1990) and Thuringia (Mai & Walther 1988), and Pleistocene of Europe (Nikitin 1957, Dorofeev 1963b, Mai & Walther 1988).

Stratiotes intermedius (Hartz) Chandler

Pl. 4, figs 26, 27

1909 *Stratiotes aloides* L. var. *intermedius* Hartz; Hartz, p. 126, Pl. 4, figs 3, 4, 9.
1923 *Stratiotes intermedius* (Hartz) Chandler; Chandler, p. 132, Pl. 5, figs 18, 19, Pl. 6, figs 17, 19.
1954 *Stratiotes intermedius* (Hartz) Chandler; Szafer, p. 61, Pl. 17, figs 11–16.
1971a *Stratiotes intermedius* (Hartz) Chandler; Dorofeev &Velichkevich, p. 155.

Material. MINM-P-BGO-2/46: 318 seeds; KRAM-P 242/46: 10 seeds.

Description. Seeds 8.1–11.4 × 2.1–3.0 mm, elongate, narrow, straight or sigmoid, sometimes somewhat twisted longitudinally, apex rounded, seed body covered with conical tubercles, the base slightly narrower and uncinate. Neck short, rough, truncate, rounded at the margin. Micropyle at the middle or above. Keel uneven, margin rarely toothed, dorsal, extending to the base and ending near the micropyle. Raphe extending along the whole keel and ending near the base. Testa thick, woody and fragile, covered with small, 4–6-angled, round or elongate cells, arranged in distinct rows. Testa surface furnished with flattened short tubercles in rows of different length. Testa surface in different specimens varies from strongly sculptured to almost smooth.

Comparison. According to Chandler (1923), this species is nearest to the recent European *Sratiotes aloides* L. The seeds of the contemporary species are smaller (7.4–9.8 × 2.5–2.7 mm, Kats et al. 1965) and have a less sculptured surface.

Occurrence. Upper Miocene of Bulgaria (Palamarev 1979), Pliocene of central Russia (Dorofeev 1979, 1985), Belarus (Dorofeev 1986a) and Poland (Szafer 1954), Pliocene and Pleistocene of Europe (Holý & Bůžek 1966, Mai & Walther 1988).

CYPERACEAE

Carex carpophora Mai & Walther

Pl. 4, figs 22, 23

1988 *Carex carpophora* Mai & Walther; Mai & Walther, p. 83, Pl. 11, figs 7–9.

Material. KRAM-P 242/55: 2 nuts.

Description. Nuts 2.7 × 1.6 and 3.2 × 1.7 mm, ovate in outline, trigonous. Apex merging into a long and thick, almost cylindrical style, base gradually passing into a thick stalk. Margins thick, rounded. Nut faces concave, the surface cells thick-walled.

Comparison. This fossil species was described from the Pliocene of Thuringia (Mai & Walther 1988). The nuts from there had similar shape and surface sculpture, but were smaller than the specimens from Kholmech. Among recent species similar nuts occur in the Far-Eastern *Carex idzurei* Franch. & Savat. and the North American *C. pubescens* Muhl.

Occurrence. Miocene of western Siberia, Upper Miocene and Pliocene of Europe (Mai & Walther 1988).

Carex klarae Mai

Pl. 4, figs 13–15; Fig. 7: a,b

2000c *Carex klarae* Mai; Mai, p. 35, Pl. 15, figs 1–4.

Material. MINM-P-BGO-2/53: 47 fruits; KRAM-P 242/53: 10 fruits.

Description. Fruits 1.45–1.80 × 0.5–0.6 mm, narrow, linear or sometimes slightly enlarged below, plano-convex, secondarily compressed. Apex narrowed into a long, aculeate style, equalling or shorter than the fruit breadth. Base gradually narrowed into a trigonous, distinct stalk. Utricle thin, membranous, adhering to the surface of the nuts, partly damaged. Veins filiform, 6–7 on each face, visibly above the utricle surface. Size and shape of nuts the same as those of the fruit as a whole, their surface composed of minute, elongate, thin-walled cells, arranged in undefined longitudinal rows.

Comparison. The nuts of the typical collection of this species from the Late Miocene of Lusatia (Mai 2000b) are very similar in size and shape to those described above. However, they are somewhat longer and narrower than the specimens from the Kholmech flora, and lack the extension in the lower part. Additionally they do not possess the membranous veined utricle. Mai (op. cit.) likens his species to the recent North American *Carex muskingumensis* Schweinf. and compares it with the Pliocene-Pleistocene species *C. paucifloroides* Wieliczk. *Carex klarae* is perhaps related to a recent European species with small-sized nuts.

Such narrow *Carex* nuts are not found among contemporary European species. Most similar to those described from Kholmech are those of the extant European *C. bohemica* Schreb., which are, however, shorter and broader (1.0–1.5 × 0.7 mm, Berggren 1969). The nuts of another extant European species, *Carex elongata* L., are longer and broader (1.6–2.0 × 0.9–1.2 mm; Berggren 1969) and differ in shape from those described above.

Occurrence. Upper Miocene of Lusatia (Mai 2000b).

Carex paucifloroides Wieliczk.

Pl. 4, figs 24, 25

1959 *Carex* sp.; Raniecka-Bobrowska, p. 213, Pl. 26, figs 8, 9.
1963a *Carex* cf. *pauciflora* Lightf.; Dorofeev, p. 128, Pl. 15, figs 25–27.
1975 *Carex paucifloroides* Wieliczk.; Velichkevich p. 125, Pl. 1, fig. 24.
1984 *Carex paucifloroides* Wieliczk.; Yakubovskaya, p. 46, 50, 70, 71, 74, 105, Pl. 6, figs 1–5.
1988 *Carex paucifloroides* Wieliczk.; Mai & Walther, p. 85, Pl. 12, figs 15–17.
1993 *Carex paucifloroides* Wieliczk; Mamakowa & Velichkevich, p. 308, Pl. 1, figs 18–25.

Material. MINM-P-BGO-2/51: 11 nuts; KRAM-P 242/51: 5 nuts.

Description. Nuts 1.9–2.4 × 0.8–1.0 mm (excluding style), elongate, from narrowly ovate in outline to nearly linear, slightly swollen in the lower or middle part, plano-convex, secondarily compressed. Apex slightly narrowed and passing rapidly into a long, tubular or aculeate style whose length does not usually exceed the breadth of the nut. Base abruptly narrowed into a short, broad stalk which is sometimes very indistinct. Both faces somewhat convex or plane, with one flattened rib preserved on one face. Surface minutely pitted and with indistinct, narrow cells. Sometimes the surface of a convex face of the nut bears 7–9 veins and remnants of the utricle adhering to it.

Comparison. This type of nut often occurs in the Neogene of Eurasia and is usually compared to the contemporary Holarctic species *Carex pauciflora* Lightf., although other extant species (*C. pulicaris* L., *C. parva* Ness., *C. microglochin* Wahlenb.) have similar fruits. The fruits of *C. pauciflora* Lightf., are shorter and broader than those of the fossil species, are trigonous in cross-section, with a very long, thin style. The nutlets of *Carex paucifloraeformis* V. Nikitin from the Miocene of Siberia (Nikitin 1976) are also similar to those described from Kholmech but are smaller (1.3–2.0 × 0.6–0.9 mm) and possess a smaller number of veins (4–6) on the surface of one face.

Occurrence. Miocene of western Poland (Raniecka-Bobrowska 1959), Pliocene of Belarus (Velichkevich 1975, 1990, Dorofeev 1986a, Krutous 1982), Upper Don basin (Dorofeev 1985), southern Poland (Mizerna, Mai & Walther 1988), Thuringia (Mai & Walther 1988), Pleistocene of Belarus, Lithuania and Russia (Velichkevich 1982), and Poland (Mamakowa & Velichkevich 1993).

Carex rostrata-pliocenica Nikit.

Pl. 4, figs 30–32

1957 *Carex rostrata* f. *pliocenica* Nikit.; Nikitin, p. 120, Pl. 3, figs 25, 26.
1977b *Carex rostrata-pliocenica* Nikit.; Dorofeev, p. 55, Pl. 4, figs 13–17.
1982 *Carex curvata* T.V. Yakub; Yakubovskaya, p. 59, Pl. 2, fig 19.
1984 *Carex inflata-pliocenica* Nikit,; Yakubovskaya, p. 105.

Material. MINM-P-BGO-2/52: 12 fruits, 102 nuts; KRAM-P 242/52: 10 fruits.

Description. Utricles 3.5–5.4 × 1.3–2.2 mm, ellipsoidal or obovoid, secondarily compressed, apex narrowed into a bifid beak. Veins thin, 8–12 on each utricle face. Nuts 2.0–2.2 × 0.9–1.2 mm, obovoid or ellipsoidal, trigonous, usually asymmetric, abruptly narrowed into the obtuse apex, with a thin, long, curved style. Nut gradually narrowed towards the base which bears at its end a thickened stalk. Margins blunt, one of them usually bearing an incision. Nut surface exhibiting clearly visible distinct large, elongate cells, in indistinct longitudinal rows.

Comparison. The nuts are very similar to those described by Nikitin (1957) from the Pliocene of Krivobor'e on the Don, but they are slightly smaller and have a characteristic incision on one margin which is lacking in the nuts from Krivobor'e. On the basis of that feature Yakubovskaya (1982) described a separate fossil species *Carex curvata* T.V. Yakub. According to Dorofeev (1977b), Mai (Mai & Walther 1988) and the present authors, this is not an important feature for species recognition and may have arisen as a result of destruction of the living plant.

Occurrence. This species is known from the Miocene of Yakutya (Dorofeev 1969b), frequent in Pliocene of the East-European Plain (Nikitin 1957, Dorofeev 1977b, 1979, 1986a, Yakubovskaya, 1982, 1984), and occurs also in Lower Early Pleistocene of Lithuania (Velichkevich et al. 1998).

Carex szaferi Dorof.

Pl. 4, figs 28, 29

1946–1947 *Carex rostrata* Stokes; Szafer, p. 183, Pl. 15, figs 19–25.
1954 *Carex flagellata* Reid; Szafer, p. 67, Pl. 18, figs 20–22.
1959 *Carex* aff. *rostrata* Stokes; Raniecka-Bobrowska, p. 212, Pl. 26, figs 3, 4.
1963a *Carex* cf. *rostrata* Stokes; Dorofeev, p. 128, Pl. 15, figs 19–24.
1969b *Carex rostrata-pliocenica* Nikit.; Dorofeev, p. 55, Pl. 7, figs 1–5.
1971a *Carex flagellata* C. & E.M. Reid; Dorofeev & Velichkevich, p. 155.
1977b *Carex szaferi* Dorof.; Dorofeev, p. 54, Pl. 4, figs 25–29.
1989 *Carex szaferi* Dorof.; Knobloch, p. 173, Pl. 9, figs 18–21.

Material. MINM-P-BGO-2/50: 3 nuts; KRAM-P 242/50: 3 nuts.

Description. Nuts 2.5–2.8 × 1.0–1.2 mm, narrowly elliptical in outline, trigonous, gradually narrowed at apex into a long curved style and abruptly curved at base to form a short, thick trigonous stalk. Margins blunt, thick, rounded at the edge. Faces weakly convex or slightly concave. Surface mat, and grey-brown, cells clearly visible.

Comparison. The species is close to *Carex flagellata* C. & E.M. Reid from Pliocene of the Netherlands (Reid & Reid 1915). Reid & Reid (op. cit.), describing *C. flagellata* for the first time, distinguished 2 types of nut, the first obovoid, with blunt apex, short style and broad base, almost without a stalk. The nuts of the second type were narrower, ellipsoidal, with a long style and distinct stalk. Attention was first paid to these differences by Szafer (1946–1947), who recorded the first nut type from the Krościenko flora as *Carex flagellata* C. & E.M. Reid, and the second as *C. rostrata* Stokes. Dorofeev (1963a) distinguished these two species in the Miocene of western Siberia. Later, in an account of the Pliocene flora of Simbugino in Bashkiria (Dorofeev 1977b) he named the first type of nut *C. flagellata* C.& E.M. Reid, and the second as a new species *Carex szaferi* Dorof. Usually these two types occurred together in the Miocene and Pliocene floras of Eurasia but sometimes *C. flagellata* C. & E.M. Reid was found separately, as in the Pliocene of Mizerna (Szafer 1954), in the Miocene of Rypin (Łańcucka-Środoniowa 1957), Kranichfeld (Mai & Walther 1988), southern Ukraine (Negru 1986) and in the Pliocene of Rippersroda (Mai et al. 1963). *Carex szaferi* Dorof. may also occur without an admixture of *Carex flagellata* C. & E.M. Reid, as in the Czech Republic (Bůžek et al. 1985, Knobloch 1989) and in the presently described Kholmech flora.

Among the contemporary species of this genus, most similar are the fruits of the North American *Carex squarrosa* L., although Mai has expressed the opinion that two other American species, *Carex lupulina* Muhlenb. and *C. lurida* Wahl. are also very close (Mai & Walter 1988).

Occurrence. The species is relatively frequent in the Upper Miocene of Eurasia and Pliocene of Europe (Mai & Walther 1988).

***Carex* sp. 1**

Pl. 4, figs 18, 19

Material. MINM-P-BGO-2/54: 7 fruits; KRAM-P 242/54: 3 fruits.

Description. Nuts 1.4–1.6 × 0.5–0.7 mm, almost linear, slightly swollen in the lower part, plano-convex, thick-walled, narrowed at the apex into a thin, aculeate style, the base cuneiform or almost rounded, with a short distinct stalk. Nut surface formed of minute cells which are round or somewhat elongate.

Comparison. The nuts of *Carex* sp. 1 are similar to those of *C. klarae* Mai from the Kholmech flora but are distinctly shorter, have thicker walls and a different surface sculpture. Among contemporary *Carex* species the Far-Eastern *C. remotiuscula* Wahl. has similar fruits which are, however, slightly longer and broader.

Carex **sp. 2**

Pl. 4, figs 20, 21

Material. MINM-P-BGO-2/56: 2 nuts; KRAM-P 242/56: 2 nuts.

Description. Nuts 1.8–2.1 × 0.9–1.4 mm, trigonous, from narrowly ovoid with acute apex to broadly ovoid, with rounded apex and very short, cylindrical style. Nut faces convex, margins indistinct, abruptly narrowed to the rounded base, stalk absent. Surface sculpture indistinct, of minute cells.

Comparison. Among fossil and contemporary *Carex* species similar nuts have not been found.

Carex **sp. 3**

Pl. 4, figs 16, 17

Material. MINM-P-BGO-2/57: 1 nut; KRAM-P 242/57: 2 nuts.

Description. Nuts 2.0–2.1 × 1.2–1.5 mm, almost rhomboidal, trigonous, apex passing into a stout cylindrical style, rapidly narrowing at base into a short, thick stalk. Surface sculpture indistinct.

Comparison. Similar nuts occur in the extant Far-Eastern species *Carex latisquamea* Kom., but they are smaller than those from Kholmech and have a thicker style and more distinct stalk. Nuts of the same shape sometimes occur in a contemporary species of broad distribution, *C. lasiocarpa* L., but these are never so rhomboidal.

Cyperus fuscus L. foss.

Pl. 5, fig. 20, 21

1988 *Cyperus fuscus* L. foss.; Mai & Walther, p. 88, Pl. 13, figs 12, 13.

Material. MINM-P-BGO-2/60: 3 fruits; KRAM-P 242/60: 5 fruits.

Description. Fruits 0.7–0.8 × 0.3–0.4 mm, obovoid or elliptical in outline, triquetrous, apex rapidly narrowing into the slender aculeate style, base gradually passing into a distinct, cylindrical stalk. Margins thin, sharp, faces concave. Walls thin, coriaceous, surface smooth, cells minute, visible only under high magnification.

Comparison. Fruits of the Lower Miocene species *Cyperus borealis* Mai from Lusatia (Mai 1999a) are larger, (0.9–1.0 mm long), with thicker walls. Fruits of another fossil species from this region, *C. leptodermis* Mai (Mai 1997) are closer to those found in the Kholmech flora, but they are also slightly larger, broader and have thicker walls. Fruits of the contemporary Holarctic species *C. fuscus* L. are similar to those described but are also slightly larger and have sharper margins which form a narrow rim.

Occurrence. Pliocene of southern Russia (Dorofeev 1966a), Thuringia (Mai & Walther 1988) and the Czech Republic (Bůžek et al. 1985). In the Pleistocene of Belarus (Dorofeev 1963b), central Russia (Nikitin 1957, Kats et al. 1965) and western Siberia (Nikitin 1940) where the fossil fruits are not different from extant ones.

Cyperus glomeratoides Wieliczk. & Zastaw. **sp. nov**.

Pl. 5, figs 26–28; Fig. 7: e,f,g

1982 *Cyperus glomeratus* L.; Yakubovskaya, p. 40, Pl. 2, figs 13–16.

Holotype. Pl. 5, fig. 28; KRAM-P 242/58; W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Type locality. Kholmech, south-eastern Belarus.

Stratigraphic horizon. Upper Kholmech Series, Late Pliocene.

Derivation of name. Species similar to the contemporary *C. glomeratus* L.

Diagnosis. Fruits 1.1–1.4 × 0.25–0.35 mm, linear, thin-walled, triangular in cross-section. Style short, cylindrical, distinct. Margins thin, acuminate in section. Faces flat or slightly concave.

Material. MINM-P-BGO-2/58: 86 fruits; KRAM-P 242/58: 10 fruits.

Description. Fruits 1.1–1.4 × 0.25–0.35 mm, almost linear, sometimes somewhat enlarged in the middle part, thin-walled, triangular in cross-section, secondarily flattened or otherwise deformed. Apex narrow, rounded, with short, cylindrical style. Fruit rapidly narrowed at the base into a short, broad stalk. Margins thin, sharp, faces flat or somewhat concave. Surface minutely pitted, mat, rarely with remains of the pericarp whose cells are visible.

Comparison. Fruits of the extant European species *Cyperus glomeratus* L. measure 1.0–1.1 × 0.3–0.4 mm, are slightly curved along their axis, with a very short tubercle-like style and thicker walls. Rather similar to our newly described species are nuts of some North American species: *C. distinctus* Steud., *C. pseudovegetus* Steud., *C. retractus* Engl., *C. lancastriensis* Porter, and *C. plukenetii* Fern. The new species from the Kholmech flora is most likely to have been a direct ancestor of the extant *Cyperus glomeratus* L., which appears in the Pleistocene of the East-European Plain (Dorofeev 1963b, Velichkevich 1973b, 1982).

Occurrence. The species is new for the Pliocene of Europe.

Cyperus cf. ***longus*** L.

Pl. 5, figs 9, 10

1971a *Cyperus* cf. *longus* L.; Dorofeev & Velichkevich, p. 155.
1984 *Cyperus* aff. *longus* L.; Jahn et al., p. 26.

Material. MINM-P-BGO-2/59: 20 fruits; KRAM-P 242/59: 7 fruits.

Description. Fruits 9.0–1.3 × 0.3–0.5 mm, trigonous, narrowly obovate in outline, sometimes almost linear. Apex blunt, rounded, with short, nodular style. Fruit gradually narrowed at base into an indistinct, broad, truncate stalk. Margins thick, rounded at the edge, faces flat or weakly convex, walls thick, fragile. Surface composed of minute cells, smooth, black, mat.

Comparison. The fruits of the extant *Cyperus longus* L. are similar to the fossil ones, but they differ in shape and size. At the present time this species occurs in the southern parts of Atlantic and central Europe, in the Crimea, the Caucasus and central Asia (Egorova 1976).

Occurrence. This taxon has been found hitherto in the Pliocene of Kholmech (Dorofeev & Velichkevich 1971a) and Poland (Jahn et al. 1984).

Dulichium arundinaceum (L.) Britt. foss.

Pl. 5, fig. 29

1984 *Dulichium spathaceum* Rich.; Jahn et al., p. 26, Pl. 18, figs 15, 16.
1988 *Dulichium arundinaceum* (L.) Britt. foss.; Mai & Walther, p.90, Pl. 13, figs 28–32.

Material. KRAM-P 242/48: 1 fruit.

Description. Fruit 2.9 mm long (including style) and 0.75 mm wide, plano-convex, secondarily compressed, gradually narrowed at apex into a long, pointed style. Base somewhat narrowed and truncate, with remains of bristles. Pericarp thin, resilient, its surface minutely cellular. Margins thickened, rounded.

Comparison. The extant North American species *Dulichium arundinaceum* (L.) Britt. occurred in the interglacial floras of the Pleistocene of Europe (Hartz 1905, Szafer 1930, Dorofeev 1963b, Velichkevich 1973b, 1982, Yakubovskaya 1976). Fruits from the Pleistocene floras are larger, up to 3.5 mm long and 0.90 mm wide and their surface lacks distinctly visible cells.

Occurrence. Upper Miocene of central Poland (Stuchlik et al. 1990), Pliocene of western Poland (Jahn et al. 1984, Mai & Wähnert 2000), Thuringia (Mai & Walther 1988), the Czech Republic (Bůžek et al. 1985), and Pleistocene of Europe (Szafer 1930, Dorofeev 1963b, Velichkevich 1973b, 1982, Yakubovskaya 1976, see also Mai & Walther 1988).

Dulichium vespiforme C. & E.M. Reid

Pl. 5, figs 33–35

1915 *Dulichium vespiforme* C. & E.M. Reid; Reid & Reid, p. 66, Pl. 3, figs 8–12.
1946–1947 *Dulichium vespiforme* Reid; Szafer, p. 185, Pl. 15, fig. 29.
1954 *Dulichium vespiforme* Reid s. l.; Szafer, p. 67, Pl. 19, figs 14–23.
1971a *Dulichium vespiforme* C. & E.M. Reid; Dorofeev & Velichkevich, p. 155.
1984 *Dulichium vespiforme* C. & E.M. Reid; Jahn et al., p. 26, Pl. 18, fig. 17.

Material. MINM-P-BGO-2/49: 4 fruits; KRAM-P 242/49: 4 fruits.

Description. Fruits 2.2–2.3 × 0.7–0.9 mm, ovate to elongate-ovate, plano-convex, gradually narrowed at apex into a long, conical, ultimately filiform style. Fruit abruptly narrowed at base into a broad, terete stalk. Bristles abundant, threadlike, elastic, equalling or exceeding the fruit. Margins thin, acuminate in section. Surface distinctly furnished with roundish cells, arranged in longitudinal rows.

Comparison. The fruits are similar to those of the type species *Dulichium vespiforme* C. & E.M. Reid from the Pliocene of the Netherlands (Reid & Reid 1915), but are somewhat smaller.

Occurrence. This species is characteristic for the Upper Miocene of Siberia (Dorofeev 1963a), Miocene of Lusatia (Mai 1999a, 2000c), Pliocene of Europe (Reid & Reid 1915, Jahn et al. 1984, Baranowska-Zarzycka 1988, Mai 1995a, Mai & Wähnert 2000), Russia (Dorofeev 1979) and the Czech Republic (Bůžek et al. 1985).

Eleocharis palustris (L.) Roem. & Schult.

Pl. 5, fig. 22

1954 non *Heleocharis palustris* (L.) R.Br.; Szafer, p. 66, Pl. 19, fig. 6.
1971a *Heleocharis palustris* (L.) R. Br.; Dorofeev & Velichkevich, p. 155.

Material. MINM-P-BGO-2/61: 2 fruits; KRAM-P 242/61: 1 fruit.

Description. Fruits 1.7 × 1.2, 1.7 × 0.8 and 1.3 × 0.9 mm, obovoid, biconvex, thick–walled. Apex broadly rounded, with discoid style-base. On one specimen the complete stylopodium is preserved, 0.4 mm high. Fruit gradually narrowed to a truncate base. On another specimen bristles are preserved, longer than fruit. Surface of the ripest fruit has preserved epicarp, which is smooth, lustrous, with a sculpture of indistinct cells. Surface of the other two specimens rugose with indistinct cells.

Comparison. The fruits are identical to the recent Eurasian *Eleocharis palustris* (L.) Roem. & Schult.

Occurrence. Very common in Pleistocene floras of the East-European Plain (Dorofeev 1963b, Velichkevich 1973b, 1982). One fruit illustrated in the Mizerna paper (Szafer 1954, Pl. 19, fig. 6) belongs to *E. ovata* (Roth) Roem. & Schult.

Eleocharis praemaximowiczii Dorof.

Pl. 5, figs 1–3; Fig. 8: a

1971a *Heleocharis* cf. *ovata* (Roth) Roehm. & Schult.; Dorofeev & Velichkevich, p. 155.
1986a *Eleocharis praemaximowiczii* Dorof.; Dorofeev, p. 60, Pl. 2 figs 17–25; holotype – Pl. 2, fig. 20.
1998 *Eleocharis praemaximowiczii* Dorof.; Velichkevich et al., p. 97, Pl.2, fig. 4.

Material. MINM-P-BGO-2/62: 215 fruits; KRAM-P 242/62: 20 fruits.

Description. Fruits 0.8–1.2 × 0.5–0.7 mm, clavate, trigonous. Margins thin, often indistinct. Apex rounded, tipped with a small, trigonous stylopodium, centrally furnished with a short, aculeate style. Fruit gradually narrowed to the truncate base whose margin is thickened or slightly protruding, without bristles. Surface smooth or slightly rugose, lustrous, bright brown.

Comparison. Identical fruits to those described above come from the Pliocene of Dvorets (Dorofeev 1986a), which contains isolated larger specimens. Rather similar to ours overall are the fruits of *Eleocharis microstylosa* Mai from the Pliocene of Thuringia (Mai et al. 1963), but they are smaller (0.5–0.8 × 0.3–0.5 mm), narrower, with an indistinct stylopodium but larger style. According to Dorofeev (1986a) the contemporary equivalent of the fossil species *E. praemaximoviczii* Dorof. is the Far-Eastern *E. maximowiczii* Zinserl. The fruits of Far-Eastern populations of the Eurasian *E. parvula* (Roem. & Schult.) Link., also bear some similarity to the fossil ones.

Occurrence. Pliocene of Dvorets (Dorofeev 1986a), Lower Pleistocene of Lithuania (Velichkevich et al. 1998).

Schoenoplectus lacustroides Wieliczk. & Zastaw. **sp. nov**.

Pl. 5, figs 30–32

1957 *Scirpus* sp. 10; Nikitin, p. 116, Pl. 3, fig. 12.
1971a *Scirpus lacustris* L.; Dorofeev & Velichkevich, p. 155.
1988 *Scirpus lacustris* L. foss. (*Schoenoplectus lacustris* (L.)Palla foss.); Mai & Walther, p. 92, Fig. 22a, b, Pl. 13, fig. 38.
1985 *Schoenoplectus* cf. *lacuster* (L.) Palla; Bůžek et al., p. 34, Pl. 17, figs 1–7.

Holotype. Pl. 5, fig. 30; KRAM-P 242/67; W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Type locality. Kholmech, south-eastern Belarus.

Stratigraphic horizon. Upper Kholmech Series, Late Pliocene.

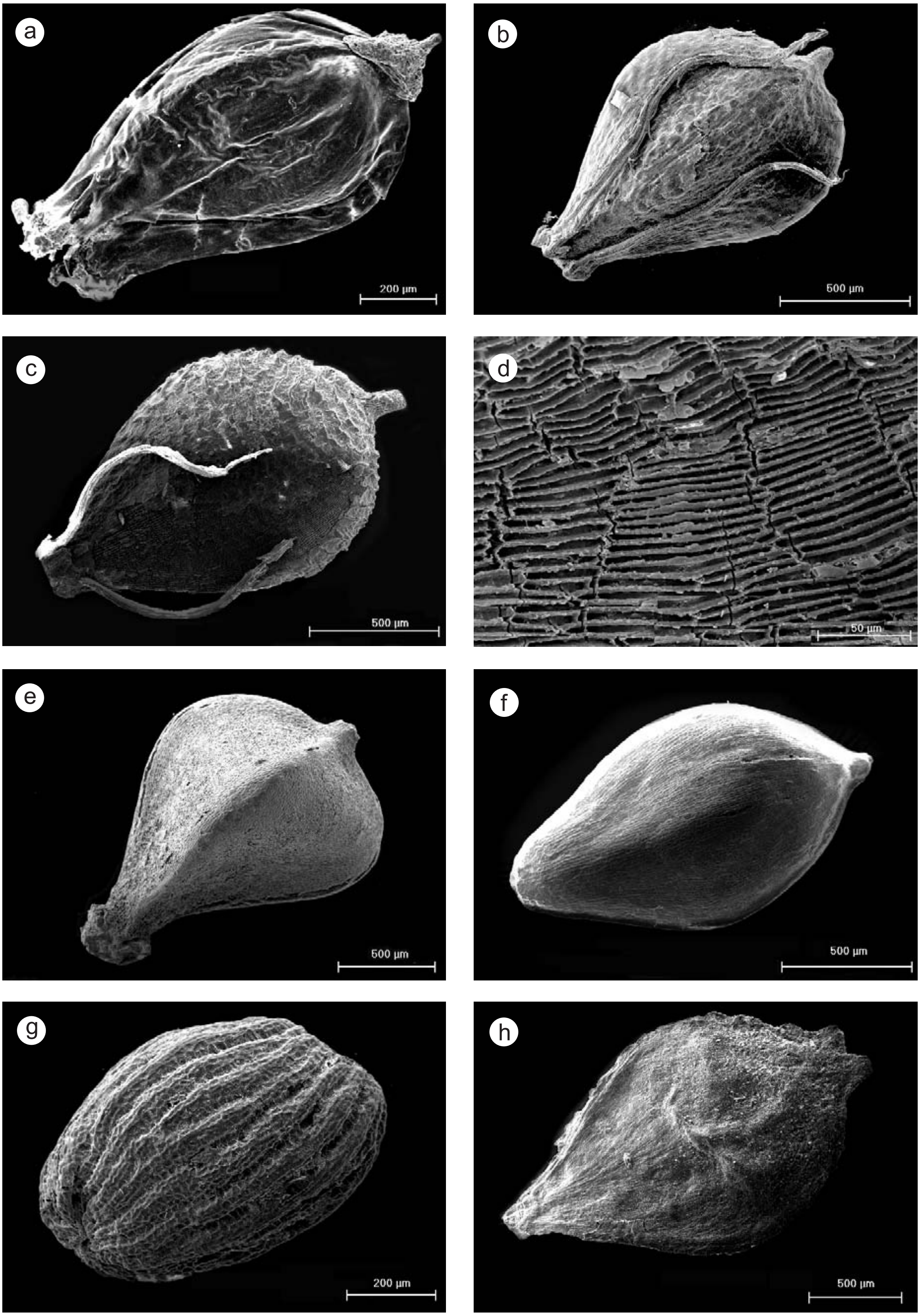

Fig. 8. **a** – *Eleocharis praemaximowiczii* Dorof., fruit, SEM, × 100, KRAM-P 242/62b; **b** – *Schoenoplectus lucens* Wieliczk. & Zastaw. sp. nov., fruit, SEM, × 70, KRAM-P 242/65a; **c** – *Schoenoplectus palaeobucharicus* Wieliczk. & Zastaw., sp. nov., fruit, SEM, × 70, KRAM-P 242/66c, **d** – detail of surface, SEM, × 500; **e** – *Scirpus pliocenicus* Szafer, fruit, SEM, × 50, KRAM-P 242/64d; **f** – *Schoenoplectus isolepidoides* Mai & Walther, fruit, SEM, × 70, KRAM-P 242/68b; **g** – *Lemna trisulca* L. foss., seed, SEM, × 120, KRAM-P 242/72a, b; **h** – *Betula cholmechensis* Dorof., fruit, SEM, × 50, KRAM-P 242/75c

Derivation of name. Similar to the extant *Schoenoplectus lacustris* (L.) Palla.

Diagnosis. Fruits 1.9–3.0 × 1.4–1.8 mm, from broadly obovate in outline to almost clavate, plano-convex, straight or axis somewhat curved. Ventral face strongly convex, with a thick, blunt central rib, which is most prominent in the middle of the nut. Margins blunt, thick. Surface smooth, mat, with a sculpture of minute cells.

Material. MINM-P-BGO-2/67: 692 fruits; KRAM-P 242/67: 20 fruits.

Description. Fruits 1.9–3.0 × 1.4–1.8 mm, broadly obovate in outline to almost clavate, plano-convex, straight or axis slightly curved, apex somewhat narrowed, rounded, with a pyramidal, long, thick style. Fruit gradually narrowed to the sometimes elongate, marginally thickened base. Bristles compressed, thread-like, rarely aculeolate, shorter than fruit, rarely preserved. Dorsal face of fruit flat, or somewhat concave, ventral strongly convex, with a thick, blunt central rib, most prominent in the middle of the nut. Margins blunt and thick at the intersection of the dorsal and ventral faces. Walls thick, strong, split longitudinally when the fruit is dry. Surface smooth, dark brown or black, mat, with a network of poorly visible minute round or slightly elongated cells.

Comparison. Among specimens of *Schoenoplectus lacustroides* Wieliczk. & Zastaw. there are two main morphotypes. The first possesses smaller fruits, with a broadly rounded apex, short base and distinctly thickened rib on the ventral face.These are similar to the fruits of the extant Holarctic species *Schoenoplectus lacustris* (L.) Palla, especially to fossil fruits of that species from the Pleistocene floras of the East-European Plain (Dorofeev 1963b, Vielichkevich 1973b). The second type has larger and narrower fruits, with a narrower apex, elongate base and indistinct rib on the ventral face. Fruits of this second type are less similar to *Schoenoplectus lacustris* (L.) Palla, and closer to the extant North American *S. carinatus* A. Grey and *Schoenoplectus americanus* (Pers.) Volkrat. Both morphotypes in the Kholmech flora are linked by several transitional specimens which form a morphological series.

It is significant that fruits of the first type are not abundant, comprising only 25% of the whole number of specimens. According to the present authors *Schoenoplectus lacustroides* Wieliczk. & Zastaw. is an ancestor of the extant European species *Schoenoplectus lacustris* (L.) Palla, which appeared in the uppermost Pliocene of Europe (Velichkevich 1990).

Similar to *Schoenoplectus lacustroides* Wieliczk. & Zastaw. is a nut recorded by Nikitin (1957) from the Pliocene of the Voronezh district under the name *Scirpus* cf. *carinatus* A. Grey. Somewhat similar also are the fruits of *Scirpus odessanus* Negru from the Miocene of southern Ukraine (Negru 1986), but there is a lack of information in its description about the rib thickening on the ventral face. It is remarked only that it is prominent and blunt. Negru (op. cit.) compared his species with the extant Holarctic *Scirpus triqueter* L., but it is difficult to agree because of the trigonous, not plano-convex cross-section of the fruit of that species. The fruits of *Scirpus liratus* Dorof. from the Pliocene of Dvorets (Dorofeev 1986a) are similar in size to those of our fossil species, but are flatter and have a convex ventral face without thickened rib.

Occurrence. Pliocene of the Voronezh district, central Russia (Nikitin 1957), Thuringia (Mai & Walther 1988) and the Czech Republic (Bůžek et al. 1985).

Schoenoplectus lucens Wieliczk. & Zastaw. **sp. nov.**

Pl. 5, figs 14–16; Fig. 8: b

Holotype. Pl. 5, fig. 15; KRAM-P 242/65; W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Type locality. Kholmech, south-eastern Belarus.

Stratigraphic horizon. Upper Kholmech Series, Late Pliocene.

Derivation of name. Lustrous (shining).

Diagnosis. Fruits 1.25–1.45 × 0.9–1.1 mm, obovate, irregularly trigonous. Surface black, with transverse, undulate wrinkles which are often indistinct. Bristles equalling or exceeding fruit.

Material. MINM-P-BGO-2/65: 92 fruits; KRAM-P 242/65: 20 fruits.

Description. Fruits 1.25–1.45 × 0.9–1.1 mm, obovate in outline, irregularly trigonous. Dorsal face flat, ventral convex, keeled, with a more or less distinct elongate, blunt rib. Apex rounded with a short, cylindrical style. Fruit gradually narrowed to the truncate base. Basal bristles compressed, filamentous, with sparse, sharp, small downward pointing prickles. Bristles equalling or somewhat exceeding fruit. Nut surface black, with transverse, undulate, usually indistinct wrinkles. Epidermis cells very narrow, forming a longitudinally striped pattern, visible only under enlargement. In the absence of epidermis, the surface is mat and dark brown, without visible sculpture.

Comparison. Rather similar nuts were described as *Schoenoplectus mucronatus* (L.) Palla foss. by Mai (Mai & Walther 1988) from the Pliocene floras of Rippersroda and Berga in Thuringia. They have similar shape and surface sculpture, but are considerably larger (2.0–2.2 × 1.2–1.4 mm).

Similar fruits occur in the extant North American *Scirpus debilis* Pursh, but they are larger, ovate or circular in outline, with an indistinct ventral rib. The surface is black, lustrous and faintly rugose. The fruits of the Eurasian *Scirpus melanospermus* C.A. Mey. are similar to those described above, but are slightly larger, broader and trigonous with a larger ventral rib. Moreover, they are distinctly transverse-rugose. The fruits of the extant East-Asiatic species *Scirpus juncoides* Roxb. are larger, more flattened, with a broad apex and less distinct wrinkles. *Scirpus smithii* Gray, a species distributed today in North America and characteristic of Pleistocene floras of the East-European Plain (Dorofeev 1963b, Velichkevich 1973b, 1982) has smaller, plano-convex fruits, with indistinct surface wrinkles, longer aculeate bristles, and tubercle-like style-base.

Occurrence. New species for the Neogene of Europe.

Schoenoplectus palaeobucharicus Wieliczk. & Zastaw. **sp. nov.**

Pl. 5, figs 17–19; Fig. 8: c,d

Holotype. Pl. 5, fig. 19; KRAM-P 242/66; W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Type locality. Kholmech, south-eastern Belarus.

Stratigraphic horizon. Upper Kholmech Series, Late Pliocene.

Derivation of name. Ancestor of *Scirpus bucharicus* Roshev.

Diagnosis. Fruits 1.35–1.60 × 0.85–1.05 mm, obovate in outline, narrow, plano-convex, strongly rugose. Bristles thin, terete, equalling fruit or shorter. Surface wrinkles transverse, undulate, thick. Surface black, faintly lustrous.

Material. MINM-P-BGO-2/66: 54 fruits; KRAM-P 242/66: 10 fruits.

Description. Fruits 1.35–1.60 × 0.85–1.05 mm, obovate in outline, predominantly narrow, plano-convex, strongly rugose. Apex rounded, sometimes narrowed with short, cylindrical style. Fruit gradually narrowed to a truncate base, thickened at the margins. Bristles arising at the nut base, thin, terete, equally nut or shorter, not preserved in several specimens. Surface black, faintly lustrous. Surface wrinkles very distinct, transverse, thick, undulate, most clearly visible at the intersection of the dorsal and ventral faces. Additionally, under enlargement, thin longitudinal stripes are visible on the surface.

Comparison. The fruits of the described species differ from *Schoenoplectus lucens* Wieliczk. & Zastaw. in the following features: they are longer and narrower, with a narrower rounded apex and more gradual tapering to the base, possess more distinct and thicker transverse surface wrinkles and are less shiny. Among contemporary species, most similar are the small fruits of *Scirpus bucharicus* Roshev., (today in Asia, from Afghanistan to China), but the Kholmech fruits are larger and broader. In addition the former have a broader apex, less distinct transverse wrinkles and longitudinal stripes. Less similar to the Kholmech species are the fruits of the Eurasian *Scirpus melanospermus* C.A. Mey., although the two species are undoubtedly related. Negru (1986) described *Scirpus meoticus* from the Late Miocene of southern Ukraine, which has nuts considerably smaller (1.0–1.1 × 0.7–0.8 mm), but similar in shape to those of *Schoenoplectus palaeobucharicus* Wieliczk. & Zastaw. Negru (op. cit.) compared his species to the extant Holarctic *Isolepis supina* (L.) R. Br. (=*Scirpus supinus* L.) and *Scirpus melanospermus* C.A. Mey. Fruits named by Nikitin (1957) as *Scirpus supinus* L. are of similar size to those of *Schoenoplectus palaeobucharicus*, but are somewhat broader, more shiny and with less densely packed wrinkles on the surface.

Occurrence. New species for the Neogene of Europe.

Schoenoplectus isolepioides Mai & Walther

Pl. 5, fig. 8; Fig. 8: f

1988 *Schoenoplectus isolepioides* Mai & Walther; Mai & Walther, p. 91, Pl. 13, fig. 33.

Material. MINM-P-BGO-2/68: 1 fruit; KRAM-P 242/68: 2 fruits.

Description. Fruits 1.6 × 0.9, 1.6 × 1.0 and 1.7 × 1.2 mm, obovate in outline, plano-convex, somewhat narrowed to the rounded apex bearing a conical style-base. Fruit narrowed to the rounded base. Bristles thin, filamentous, smooth, preserved on only one specimen. Dorsal face flat or weakly convex, the ventral one convex, without rib. Surface cells minute, narrow, arranged in longitudinal strips.

Comparison. This species was described by Mai & Walther (1988) from the Pliocene flora of Berga and Rippersroda in Thuringia. The nuts from Thuringia were similar in size and shape, but differed slightly in length/width ratio.

Fruits of the extant Eurasian species *Schoenoplectus tabernaemontani* (C.C. Gmel.) Palla (=*Scirpus tabernaemontani* C.C. Gmel.) are slightly larger (1.7–2.0 × 1.0–1.6 mm), but are otherwise very similar to the Kholmech fossil ones.

Occurrence. Upper Miocene of Moldova (Negru 1972), Upper Pliocene of Poland and Thuringia (Mai & Walther 1988) and Pleistocene of eastern Europe (Velichkevich 1982).

Scirpus atroviroides Dorof.

Pl. 5, figs 11, 12; Fig. 7: c,d

1957 *Scirpus atrovirens* Muhl.?; Nikitin, p. 116, Pl. 3, figs 10, 11.

1971a *Scirpus* cf. *atrovirens* Ait.; Dorofeev & Velichkevich, p. 155.

1982 *Scirpus atrovirens* Muhl.; Velichkevich, p. 174, Pl. 14, figs 1–34.

1984 *Scirpus atrovirens* Muhl.; Yakubovskaya, p. 69, 70, 71, 105, Pl. 6, figs 21–24.

1986a *Scirpus atroviroides* Dorof.; Dorofeev, p. 58, Pl. 2, figs 5–16; holotype – Pl. 2, fig. 12.

1988 *Scirpus radicans* Schkuhr foss.; Mai & Walther, p. 92, Pl. 13, figs 43–47.

1998 *Scirpus atroviroides* Dorof; Velichkevich et al., p. 97, Pl. 2, fig. 6.

Material. MINM-P-BGO-2/63: 104 fruits; KRAM-P 242/63: 10 fruits.

Description. Fruits 0.8–1.1 × 0.4–0.5 mm, ovate to obovate in outline, irregularly trigonous. Apex gradually passing into the short, thick, cylindrical style-base. Fruit narrowed at base into a short stalk. Fragments of bristles preserved. Faces of fruits convex, the dorsal broader than each of the two ventral. Margins narrow, but not sharp. Walls thin, resilient. Surface sculpture of minute cells, faintly lustrous. Under the SEM the surface cells are rectangular, with strongly undulate walls.

Comparison. Fruits of this type are very characteristic of the Pliocene and Pleistocene floras of the East-European Plain, where they occur abundantly. Following Nikitin (1957), who described similar fruits from the Pliocene of the Voronezh district of Russia under the name of the American species *Scirpus atrovirens* Muhl., all authors who made later discoveries of nuts of this type recorded their finds as this extant species. Dorofeev (1986a) confirmed the resemblance of the fossil fruits to those of *S. atrovirens* Muhl., but pointed out that other extant North American species also had similar nuts (*Scirpus brunneus* Muhl., *S. congdoni* Britt., *S. cyperinus* L., *S. eriophorum* Michx., *S. georgianus* Harper, and *S. lineatus* Michx.). In Europe today only one species with small fruits exists – *Scirpus sylvaticus* L. However, its fruits differ from those of the Kholmech flora as follows: they are broadly ovoid, rather than plano-convex, with thicker walls and margins and possess an indistinct rib on the ventral face. The fossil species *Scirpus praesylvaticus* Mai, described by Mai (1999a) from the Early Miocene of Lusatia is similar to the recent *S. sylvaticus* L. and differs from *S. atroviroides* Dorof. in the shape and smaller size of its fruits. In the present authors' opinion, the fruits of *Scirpus radicans* Schkuhr foss. described from the Pliocene of Thuringia, (Mai & Walther 1988), are identical to those of *S. atroviroides* Dorof. in size and shape.

Occurrence. Pliocene and Pleistocene of the East-European Plain (Nikitin 1957, Dorofeev & Velichkevich 1971a, Velichkevich 1982, Yakubovskaya 1984, Dorofeev 1979, 1986a), Pliocene of Thuringia (Mai & Walther 1988) and Pleistocene of Poland (Nita 1998).

Scirpus pliocenicus Szafer

Pl. 5, figs 23–25; Fig. 8: e

1946–1947 *Scirpus pliocenicus* Szafer; Szafer, p. 186, Pl. 15, figs 30–33; lectotype – Pl. 15, fig 32.
1971a *Scirpus tertiarius* Dorof.; Dorofeev & Velichkevich, p. 155.
1984 *Scirpus pliocenicus* Szafer; Yakubovskaya, p. 135, Pl. 6, figs 12–14.
1984 *Schoenoplectus pliocenicus* (Szafer) Łańck.-Środon.; Jahn et al., p. 26, Pl. 18, figs 7, 8.
1988 *Scirpus* sp.; Baranowska-Zarzycka, p. 25.

Material. MINM-P-BGO-2/64: more than 500 fruits; KRAM-P 242/64: 10 fruits.

Description. Fruits 1.85–2.30 × 0.90–1.40 mm, obovate in outline to clavate, triquetrous. Apex usually broadly rounded, sometimes flattened, with a short, conical or tubercle-like style-base, occasionally the apex is narrowed and rounded. Fruit gradually narrowed to the truncate, marginally thickened base. Bristles broad, flat, smooth, almost equalling fruit. Margins narrow, blunt. Faces flat or slightly concave. Walls thick, strong, the surface black, mat, with minute cells in indistinct longitudinal rows.

Comparison. From an investigation of the original fossil collection of *Scirpus pliocenicus* Szafer from the Krościenko flora, the first author discovered that the Kholmech fruits had the same shape. The nuts (excluding style) from Krościenko, which are contained in the collection KRAM-P 14/138, measured 1.7–2.1 × 0.9–1.3 mm, similar to the Kholmech ones. In the Pliocene flora of Ruszów (WLO-22) are 3 fruits recorded as *Scirpus* sp. (Baranowska-Zarzycka 1988). They have similar shape and size (1.6, 1.7 and 1.9 mm long) to those of *Scirpus pliocenicus* Szafer.

Fruits of the Lower Miocene species *Scirpus lusatica* Mai from Lusatia (Mai 1999a) are of similar size to those described from Kholmech, but are rounded at the apex and the lower part, and are more flattened. According to Mai the nuts most similar to those of *S. pliocenicus* Szafer are found in the extant North American *Scirpus fluviatilis* (Torr.) Gray (Mai & Walther 1988).

Occurrence. Miocene of Stare Gliwice (Szafer 1961). The species is common in the Pliocene of Europe (Mai & Walther 1988) and is recorded from the Pliocene of Belarus (Yakubovskaya 1984). In the Pliocene of Poland it occurs in the Krościenko flora (Szafer 1946–1947), at Mizerna (Szafer 1954), Kłodzko (Jahn et al. 1984) and Ruszów (Mai & Wähnert 2000).

ARACEAE

Acorus palaeocalamus Dorof.

Pl. 6, figs 16–18

1973b *Acorus palaeocalamus* Dorof.; Dorofev, p. 657, Fig. 1: 5, 9.

Material. MINM-P-BGO-2/69: 110 fruits, 149 seeds; KRAM-P 242/69: 10 fruits, 10 seeds.

Description. Fruits 3.5–5.0 × 1.9–3.8 mm, cuneiform, the apex convex, with a short and thick style-base and broad tubercle in the centre. Fruit gradually narrowed to the rounded, rarely truncate base. Pericarp thin at the fruit margins, with thin stripes, thicker in the upper part. Each fruit contains 1–4 seeds. Seeds 2.5–3.9 × 1.2–3.6 mm, elongate, axis straight or curved, of differing sizes and shapes. Seed apex convex, narrowed or subacute, with a broad micropyle, slightly displaced towards one margin. Seed somewhat narrowed to the rounded base, sometimes with a short stalk. Surface pitted, seed walls of medium thickness, often creased.

Comparison. In a publication by Kats (Kats et al. 1965) it is stated that Nikitin (unpubl.) found fossil remains of *Acorus* in the Middle Pleistocene of western Siberia, which he named *A. procalamus* Nikitin sp. nov. It had small seeds (up to 2 mm long) and fruits (up to 3 mm long).

Fruits of the extant Holarctic species *Acorus calamus* L. are larger than the fossil ones and more narrowed towards the base. Its seeds are longer and thin-walled.

Occurrence. Known up to now only from the Pliocene of Kholmech (Dorofeev 1973b).

Araceae gen.

Pl. 6, fig. 14

Material. KRAM-P 242/70: 1 fruit.

Description. Fruit a short prism, 3.5 mm high, somewhat narrowed towards the base. Upper part of fruit concave, unequally rhomboidal, 6.6 × 4.5 mm. Walls thick, surface is bearing minute stripes, mat.

Comparison. Fruits of this type have been recorded from the Oligocene and Miocene of

Eurasia. They are related to the fossil species *Aracistrobus drevertii* Nikit. (Dorofeev 1963a). Most often spadices were found, rarely single fruits. Their systematic determination is not clear. It is likely that they belong to *Epipremnum* Schott or another genus of the Monsteroideae.

IRIDACEAE

***Iris* sp.**

1971a *Iris* sp.; Dorofeev & Velichkevich, p. 155.

Material. MINM-P-BGO-2/71: 2 fragments of seeds; KRAM-P 242/71:1 fragment of seed.

Description. Three seeds fragments, two relatively large and one small, 5 mm in length. Testa spongy, thinner in the middle of the seed than elsewhere. Surface uneven, with a coarse cell network visible in certain areas.

Comparison. From the Pliocene of Dvorets Dorofeev (1986a) described the extinct species *Iris kryshtofovichii* Dorof. The fragments found in the Kholmech flora have a similar structure, but their systematic determination is impossible.

LEMNACEAE

Lemna trisulca L. foss.

Pl. 5, figs 4–7; Fig. 8: g

1957 *Lemna trisulca* L.? var.; Nikitin, p. 125, Pl. 3, figs 43, 44.
1971a *Lemna* cf. *trisulca* L.; Dorofeev & Velichkevich, p. 155.
1988 *Lemna trisulca* L. foss.; Mai & Walther, p. 94, Pl. 14, figs 11–18.

Material. MINM-P-BGO-2/72: more than 500 seeds; KRAM-P 242/72: 30 seeds.

Description. Seeds 0.67–0.90 × 0.57–0.72 mm, ovoid or barrel-shaped, asymmetric, ovate in cross-section. Apex truncate, rounded or emarginate, with a broad cavity. Base rounded, raphe sunken in a shallow pit. Testa thick, soft, with 8–10 distinct ribs on the one face. Surface minutely pitted, mat or somewhat shiny.

Comparison. The seeds are very similar to the extant Eurasian species *Lemna trisulca* L., but they are furnished with a larger number of ribs. In addition, among typical specimens in the Kholmech flora there are narrower, shinier seeds with indistinct ribs on the testa. They resemble those of another extant species, *L. minor* L.

Occurrence. Pliocene of the Upper Don basin (Nikitin 1957), Dvorets (Dorofeev 1986a, Velichkevich 1990) and Thuringia (Mai & Walther 1988).

MYRICACEAE

Myrica cf. ***borysthenica*** Dorof. & Wieliczk.

Pl. 5, fig. 13

1975 *Myrica* sp.; Velichkevich, p. 126, Pl. 5, figs 9, 10.
1986a *Myrica borysthenica* Dorof. & Wieliczk.; Dorofeev, p. 62, Fig. 4: 1–14; holotype – Fig. 4: 10.
1990 *Myrica borysthenica* Dorof. & Wieliczk.; Velichkevich p. 66, Pl. 21, figs 1–4.

Material. KRAM-P 242/80: half an endocarp.

Description. Part of an endocarp split in half, 1.8 × 0.9 mm, with thick, pyramidal wing.

Comparison. The endocarps of *Myrica boryshenica* Dorof. & Wieliczk., whole or split into halves are numerous in the Pliocene flora of Dvorets (Dorofeev 1986a, Velichkevich 1990) and are very close to the extant European *M. gale* L.

Occurrence. Pliocene of Dvorets (Dorofeev 1986a).

BETULACEAE

Alnus cf. ***glutinosa*** (L.) Gaertn.

Pl. 6, figs 1, 2

1946–1947 *Alnus glutinosa* Gaertn. foss.; Szafer, p. 59, Pl. 5, figs 7, 8.
1954 *Alnus glutinosa* Gaertn. foss.; Szafer, p. 22.
1971a *Alnus* sp.; Dorofeev & Velichkevich, p. 155.
1984 *Alnus* sp. 1 (*A.* cf. *glutinosa* (L.) Gaertn.; Jahn et al., p. 25.
1988 *Alnus glutinosa* Gaertner foss.; Mai & Walther, p. 131, Pl. 25, figs 1–3.

Material. KRAM-P 242/73: 2 fruits.

Description. One fruit is five-angled, 2.4 × 2.2 mm, the other broadly ellipsoidal, 1.8 × 1.8 mm. Both fruits thick-walled, slightly narrowed towards the apex and with concave base. Wings narrow, thick, with sharply acute margins. Surface indistinctly longitudinally striped.

Comparison. The fruits of the recent European *Alnus glutinosa* (L.) Gaertn. are very variable in shape and size, but some of the smaller ones closely resemble those from Kholmech.

Occurrence. The species is widely distributed in Europe (Mai & Walther 1988); in Poland it is known from the Upper Miocene of Stare Gliwice (Szafer 1961), Pliocene of Krościenko (Szafer 1946–1947), Mizerna (Szafer 1954) and Kłodzko (Jahn et al. 1984).

Betula cholmechensis Dorof.

Pl. 6, figs 9, 10; Fig. 8: h

1971a *Betula* sect. *Costatae* (Rgl) Koehne; Dorofeev & Velichkevich, p.155.
1982b *Betula cholmechensis* Dorof.; Dorofeev p. 145, Pl.143 figs 24–32; holotype – Pl. 143, fig. 27.
1984 *Betula* sp.1 sect. *Albae* Regel; Jahn et al., p. 25 (vidi).

Material. MINM-P-BGO-2/75: 336 fruits, 16 scales; KRAM-P 242/75: 20 fruits, 3 scales.

Description. Fruits 1.45–2.50 × 1.10–1.85 mm, obovate or elliptical in outline, more or less elongate, plano-convex or flat, thick-walled. Apex usually rounded, the style-base somewhat thickened, or styles adhering to the fruit apex. Lower part of fruit cuneiform, narrowing to the truncate or emarginate base. Testa cells minute, narrow, arranged in arcuate rows. Wings thin, not very broad, semi-transparent, often damaged, usually broken wholly or in part. Scales 2.1–4.3 × 1.9–3.2 mm, three-lobed, rather small, thin, lobes shortly cuneate below, rhomboid or more or less circular, not curved.

Comparison. The fruits of *Betula felixii* Dorof. from the Pliocene of Dvorets (Dorofeev 1982b) are smaller, thinner-walled and closer to the extant European species from section *Albae* Rgl. Fruits and scales similar to those of *Betula cholmechensis* Dorof. occur in a few recent species: *Betula raddeana* Trauv. (Caucasus), *B. costata* Trautv. (Korea), and *B. ermanii* Pall (Far East), but they are all 1.5–2 times as large as in the fossil species.

Specimens recorded from Kłodzko as *Betula* sp. 1 sect. *Albae* Regel (Jahn et al. 1984) are similar to the narrowest fruits of *B. cholmechensis* from Kholmecz. Only one damaged scale differed from typical ones.

Occurrence. Pliocene of Poland (Jahn et al. 1984) and Thuringia (Mai & Walther 1988).

Betula longisquamosa Mädler

Pl. 6, figs 11, 12

1939 *Betula longisquamosa* Mädler; Mädler p. 73, Pl. 6, figs 20, 21 Pl. 7, figs 13, 14.
1961 *Betula longisquamosa* Mädler; Szafer, p. 35, Pl. 9, figs 9–15.
1971a *Betula* cf. *longisquamosa* Mädler; Dorofeev & Velichkevich, p. 155.
1988 *Betula longisquamosa* Mädler; Baranowska-Zarzycka, p. 24.
1988 *Betula longisquamosa* Mädler; Mai & Walther, p. 135, Pl. 25, fig. 18.
1998 *Betula longisquamosa* Mädler; Zastawniak & Walther, p. 104, Pl. 4, fig. 10, Pl. 6, figs 1–4; Fig. 11: 1–4, Fig. 12: 1–6, 8, 10–12.

Material. MINM-P-BGO-2/74: 8 fruits; KRAM-P 242/74: 5 fruits.

Description. Fruits 2.35–3.25 × 1.75–2.25 mm, obovate to almost circular in outline, flat, thin-walled, without wings. Apex rounded or slightly elongate, bearing a short, broad style-base which is very rarely preserved. Fruit slightly narrowed to the truncate base, hilum displaced to one side of the base. Testa thin, especially in the middle part, surface uneven, indistinctly pitted, rugose, mat. The scales are absent.

Comparison. This species was described by Mädler (1939) on the basis of its characteristic scales. His publication contained an illustration of two ovate fruits whose details are difficult to see. The Miocene floras of Belarus contain larger, more circular fruits, whereas in the Pliocene floras they are smaller and narrower (Dorofeev 1982b, Velichkevich, own observation). Similar to *Betula longisquamosa* Mädler is another fossil species *B. apoda* Nikit. from the Oligocene and Miocene of western Siberia (Dorofeev 1963a), and from the Miocene of Mamontova Gora (Dorofeev 1969b). Its fruits are larger (6–8 mm long, 5.8 mm wide), elliptical or ovate in outline and thick-walled. Closer still to *B. longisqamosa* Mädler is another fossil species *B. omoloica* Dorof. from the Miocene of Yakutia (Dorofeev 1972). All these extinct species are close to the extant North American *Betula nigra* L. The fruits of that species are large, broadly elliptical or circular in outline, flat, thin-walled with broad wings. Its scales are similar to those of *Betula longisquamosa* Mädler, but somewhat shorter.

Occurrence. Fruits and scales of the same type have been found in the Miocene of Lusatia (Mai 1999b, 2001), the Upper Miocene of

Stare Gliwice (Szafer 1961) and Sośnica (Zastawniak & Walther 1998) and in the Pliocene of Ruszów (Baranowska-Zarzycka 1988) and Thuringia (Mai & Walther 1988), as well as in the Upper Miocene and Pliocene of Belarus and Ukraine (Dorofeev 1982b).

***Betula* sp.**

Material. MINM-P-BGO-2/76: 2 fruits, 1 scale; KRAM-P 242/76: 3 fruits, 1 scale.

Description. Fruits 1.6 – 1.9 × 1.1 – 1.2 mm, elliptical or almost rhomboidal in outline, biconvex, or convex on one face, concave on the other. Fruit testa thick, strong, its surface covered in indistinct minute cells or somewhat striped. Fragments of wings preserved. Scales with damaged lobes are broad, thick and distinctly striped.

Comparison. These specimens differ from the two previous species in the Kholmech flora. They perhaps belong to another section of *Betula* L., or were deformed during fossilization.

CORYLACEAE

***Carpinus* sp.**

Pl. 6, fig. 13

Material. KRAM-P 242/77: 1 fruit.

Description. Fruit 2.0 × 2.0 mm, unripe. Apex narrow, without style. Base convex to broadly rounded, walls thin, with rib fragments visible in places.

Comparison. The fruit is badly preserved, but in shape and size resembles the extant south European *Carpinus orientalis* Mill.

The fruits described as *Carpinus minima* Szafer from the Pliocene of Krościenko (Szafer 1946–1947) and Mizerna (Szafer 1954) are similar to the Kholmech flora specimen, but are more elongate and have thinner walls. According to Mai (Mai & Walther 1988, Mai & Wähnert 2000) the remains recorded as *Carpinus minimus* (Szafer) Mai do not belong to *Carpinus* and have uncertain taxonomic affinity.

***Corylus* sp.**

Pl. 9, fig. 25

Material. KRAM-P 242/78: 1 fragment of nut.

Description. Nut fragment, 12.0 × 5.5 mm. On its convex side the point of attachment is visible. Outer surface with longitudinal grooves and rounded, indistinct ribs. Inner surface minutely granulate. Nut wall thick, woody.

Comparison. The specimen is similar to the extant Eurasian *Corylus avellana* L.

FAGACEAE

***Quercus* sp.**

Pl. 6, fig. 15

Material. KRAM-P 242/79: 1 cupule of acorn.

Description. Cupule of unripe acorn, 3.7 × 3.3 mm, broadly ovoid, with a thick, curved style. Surface irregular, with short rounded appendices visible.

Comparison. The morphological characters of the cupule suggest the specimen belongs to *Quercus* sect. *Robur* Rchb.

URTICACEAE

Pilea cantalensis (E.M. Reid) Dorofeev

Pl. 6, fig. 3; Fig. 9: c

1923	*Pilea pumila* Gray var. *canatalensis* E.M. Reid; E.M. Reid, p. 317, Pl. 10, fig. 6.
1948	*Pilea pumila* Gray; Nikitin, p. 1104.
1959	*Pilea* cf. *mongolica* Wedd.; Raniecka-Bobrowska, p. 165, Pl. 16, figs 1, 2.
1963a	*Pilea cantalensis* (E.M. Reid) Dorofeev; Dorofeev, p. 164, Pl. 25, figs 21–27.
1971a	*Pilea* cf. *pumila* Gray; Dorofeev & Velichkevich, p. 155.
1982b	*Pilea pliocenica* Dorof.; Dorofeev, p. 52, Pl. 129, figs 1–6.

Material. MINM-P-BGO-2/81: 1 fruit; KRAM-P 242/81: 3 fruits.

Description. Fruits 1.0–1.2 × 0.6–0.7 mm, narrowly ovate in outline, slightly biconvex, gradually narrowed to the subacute and somewhat thickened apex. Base broadly rounded, with a small, pointed stalk. Walls thin, fragile. Surface sculpture of minute cells, with fragments of black epicarp in the form of long strands or chainlets of tubercles along the fruit axis.

Comparison. The fruits of *Pilea* in the Kholmech flora are few in number, so it is difficult to gauge their range of variation. They are slightly smaller than is usual for those of *P. cantalensis* (E. Reid) Dorof. (Dorofeev 1982b, Mai & Walther 1988), but they have

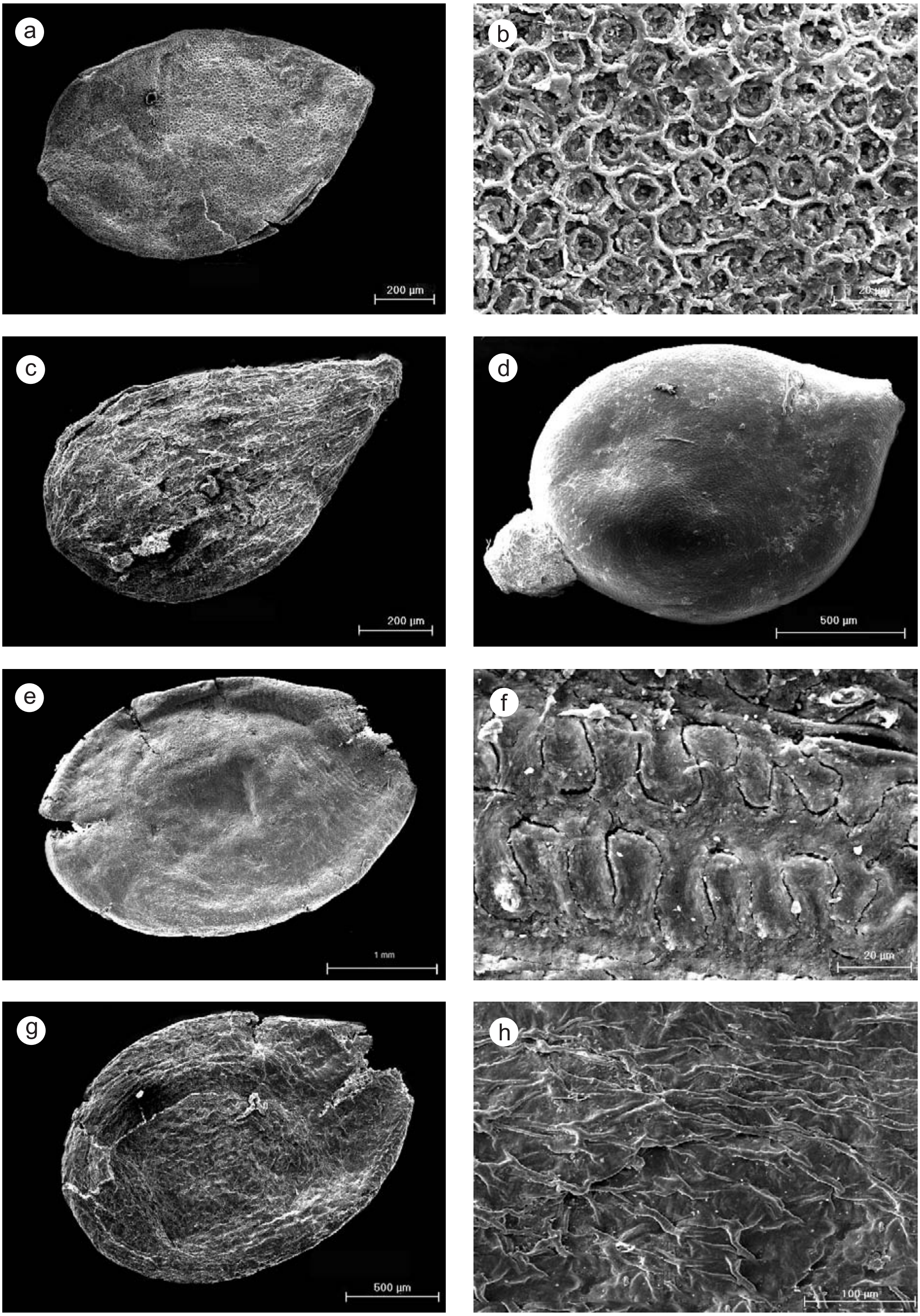

Fig. 9. **a** – *Urtica pliocenica* Dorof., fruit, SEM, × 80, KRAM-P 242/83, **b** – detail of surface, SEM, × 1000; **c** – *Pilea cantalensis* (E.M. Reid) Dorof., fruit, SEM, × 100, KRAM-P 242/81a; **d** – *Polygonum pliocenicum* Dorof., fruit, SEM, × 70, KRAM-P 242/86a; **e** – *Nymphaea borysthenica* Dorof., seed, SEM, × 30, KRAM-P 242/98a, **f** – detail of surface, SEM, × 1000; **g** – *Nymphaea pusilla* Dorof., seed, SEM, × 50, KRAM-P 242/99a, **h** – detail of surface, SEM, × 300

the same morphological features as typical ones.

Occurrence. From the Miocene of western Siberia (Dorofeev 1963a) to the Pliocene and Lower Pleistocene of Europe (Dorofeev 1982b, Mai & Walther 1988).

Urtica dioica L.

Pl. 6, figs 4, 5

1971a *Urtica* cf. *dioica* L.; Dorofeev & Velichkevich, p. 155.
1984 *Urtica* cf. *dioica* L.; Jahn et al., p. 25.
1990 *Urtica dioica* L.; Velichkevich, p. 69, Pl. 22, figs 1–3.

Material. MINM-P-BGO-2/82: 53 fruits; KRAM-P 242/82: 8 fruits.

Description. Fruits 0.8–1.1 × 0.6–0.8 mm, elliptical or ovate in outline, biconvex, gradually narrowed to the sometimes elongate and somewhat thickened apex; narrowed and cuneiform below, base obtuse with a distinct, cylindrical stalk. Walls thin, resilient. Surface sculpture of distinct minute cells.

Comparison. The fruits of the extant cosmopolitan species *Urtica dioica* L. in the Kholmech flora differ from *U. pliocenica* Dorof. in shape (they are narrower), a more distinct stalk and larger surface cells. Described by Mai (Mai & Walther 1988), *Urtica dioica* L. foss. has fruits similar to those of extant East-Asiatic species such as *U. platyphylla* Wedd.

Occurrence. *Urtica dioica* L. is very rare in the Pliocene, but characteristic for Pleistocene floras, particularly the interglacial ones of the East-European Plain in which it sometimes occurs very abundantly (Dorofeev 1963b, Velichkevich 1973b). No specimens of *Urtica dioica* L. recorded by Szafer (1954) were found in the collection of Mizerna II/III and III flora, KRAM-P.

Urtica pliocenica Dorof.

Pl. 6, figs 7, 8; Fig. 9: a,b

1955b *Urtica dioica* L.; Dorofeev, p. 5, Fig.1: e, zh.
1957 *Urtica dioica* L.; Nikitin, p. 130, Pl. 4, figs 10, 11.
1966a *Urtica dioica* L.; Dorofeev, p. 63, Fig. 17.
1982b *Urtica pliocenica* Dorof.; Dorofeev, p. 48, Pl. 126, figs 3–10 ; holotype – Pl. 126, fig. 3.
1990 *Urtica* cf. *pliocenica* Dorof.; Velichkevich, p. 69, Pl. 22, figs 4–7.

Material. MINM-P-BGO-2/83: 1 fruit; KRAM-P 242/83: 3 fruits.

Description. Fruits 1.0–1.2 × 0.65–0.85 mm, broadly elliptical in outline, flat or somewhat biconvex. Apex subacute bearing a thickened style-base. Base rounded, with a very short, indistinct stalk, walls thin, coriaceous. Surface uniformly covered with small rectangular cells visible under magnification.

Comparison. The fruits are identical to those of *Urtica pliocenica* Dorof. from the Late Pliocene of western Siberia (Dorofeev 1982b) and from the Pliocene of Dvorets (Velichkevich 1990). The specimen of *Urtica urens* L., recorded from the Pliocene of Kłodzko (Jahn. et al. 1984), is very similar to those of *U. pliocenica* Dorof. from Kholmech, but is damaged.

Occurrence. Upper Miocene of Ukraine (Negru 1979), Pliocene of Ukraine (Dorofeev 1955b), central Russia (Nikitin 1957), western Siberia (Dorofeev 1982b) and Belarus (Velichkevich 1990).

POLYGONACEAE

Polygonum aviculare L.

Pl. 7, figs 14, 15

1946–1947 *Polygonum aviculare* L.; Szafer, p. 79, Pl. 7, fig. 9.

Material. MINM-P-BGO-2/84: 5 fruits; KRAM-P 242/84: 3 fruits.

Description. Fruits 1.9–2.7 × 1.2–1.6 mm, elliptical in outline, compressed trigonous (one face narrower than the other two), gradually narrowed and somewhat curved towards the apex, obtusely angled at the base which bears a small, pyramidal stalk. Walls thick, strong, faces flat or slightly concave, margins blunt. Surface furnished with minute tubercles which are round, arranged in longitudinal rows.

Comparison. The fruits of *Polygonum aviculare* L. s. l. have been recorded from the Miocene of Siberia (Dorofeev 1963a), in Poland from the Upper Miocene of Stare Gliwice (Szafer 1961) and the Nowy Sącz basin (Łańcucka-Środoniowa 1979). The fruits recorded from the Kholmech flora are identical in size and shape to those of the extant, cosmopolitan *Polygonum aviculare* L.

Occurrence. This species is known from the Pliocene of Belarus (Yakubovskaya 1984, Velichkevich 1990) and numerous Pleistocene localities of the East-European Plain (Dorofeev 1963b, Velichkevich 1973b, 1982).

Polygonum lapathifolium L.

Pl. 7, figs 16, 17

1963a *Polygonum lapathifolium* L.; Dorofeev, p. 169, Pl. 26, figs 28, 29.
1971a *Polygonum* ex gr. *lapathifolium* L.; Dorofeev & Velichkevich, p. 155.
1990 *Polygonum* ex gr. *lapathifolium* L; Velichkevich, p. 70, Pl. 23, fig.7.

Material. MINM-P-BGO-2/85: 8 fruits; KRAM-P 242/85: 4 fruits.

Description. Fruits 1.7–2.2 × 1.2–1.7 mm, broadly elliptical, or suborbicular in outline, flattened or biconcave. Apex rounded, rapidly narrowed into the broad, conical style-base, which is divided at its tip. Stalk broad, pyramidal. At the base of the stalk there are filiform, resilient divided bristles, equalling, or in some cases, exceeding the fruit. Fruits surface smooth, lustrous.

Comparison. The fossil fruits are slightly smaller and thinner-walled than those of the contemporary, Holarctic species, *Polygonum lapathifolium* L.

Occurrence. Miocene of Siberia (Dorofeev 1963a), Pliocene of Poland (Mizerna, Szafer 1954) and Belarus (Yakubovskaya 1984, Velichkevich 1990). A characteristic species for the Pleistocene of the East-European Plain (Dorofeev 1963b, Velichkevich 1973b, 1982).

Polygonum pliocenicum Dorof.

Pl. 7, figs 1–3; Fig. 9: d

1965 *Polygonum pliocenicum* Dorof.; Dorofeev, p. 204, Pl. 2, figs 43–47; lectotype – Pl. 2, fig.45.
1971a *Polygonum pliocenicum* Dorof.; Dorofeev & Velichkevich, p. 155.
1971 *Polygonum pliocenicum* Dorof.; Dorofeev, p. 917.
1988 *Polygonum pliocenicum* Dorof.; Mai & Walther, p. 144, Pl. 26, fig. 16.

Material. MINM-P-BGO-2/86: 116 fruits; KRAM-P 242/86: 10 fruits.

Description. Fruits 1.45–2.05 × 1.20–1.75 mm, ovate or almost circular in outline, biconvex. Apex gradually narrowed into the conical, thickened style-base. Fragments of the bifurcate style rarely preserved. Base rounded with a short, thick stalk upon which fragments of bristles are preserved. Fruit surface smooth, faintly lustrous with sculpture of indistnict minute cells.

Comparison. The fruits match those described from the Pliocene of Bashkiria (Dorofeev 1965), but are more variable in size. The fruit of *Polygonum persicaria* L. foss. from the Nochten-Ost profile in Lusatia illustrated by Mai and Wähnert (2000, Pl. 4, fig. 8) is quite similar to the Kholmech material.

The closest extant species, according to Dorofeev (1965), is the Eurasian *Polygonum persicaria* L., whose fruits are polymorphic, being trigonous, plano-convex or biconvex. The Kholmech fruits are also similar to the extant *Polygonum czukavinae* A. Skvor. (India) and *P. foliosus* Lindl. (Japan), but they are slightly larger and broader. The fruits of *Polygonum japonicum* Meissn. (Japan) are elliptical in outline and larger than the fossil ones.

Occurrence. Pliocene of Bashkiria (Dorofeev 1965), Belarus (Dorofeev 1971), Thuringia (Mai & Walther 1988) and Italy (Mai 1995a).

Rumex acetosella L.

Pl. 6, fig. 6

Material. KRAM-P 242/87: 2 fruits.

Description. Fruits 1.0 × 0.7 and 1.1–0.7 mm, broadly elliptical in outline, trigonous. Apex subacute, base rounded, with an indistinct, very small stalk. Faces convex, smooth, margins blunt, rounded, fruit surface smooth, lustrous.

Comparison. The fossil fruits do not differ from those of the contemporary *Rumex acetosella* L.

Occurrence. The species is very common in the Pleistocene of the East-European Plain (Dorofeev 1963b, Velichkevich 1973b, 1982).

Rumex cf. ***ucrainicus*** Besser ex Spreng.

Pl. 7, figs 12, 13

Material. MINM-P-BGO-2/88: 31 fruits; KRAM-P 242/88: 5 fruits.

Description. Fruits 1.2–1.9 × 1.1–1.3 mm, ellipsoidal or ovoid in outline, narrowed at the base into a clavate, curved stalk, which equals or exceeds the fruit. Perianth segments ovate, with 3–4 (rarely more) fimbriae at the margin and an ellipsoidal tubercle, more than twice as long as wide, in the centre of each face.

Tubercle surface minutely reticulate or with distnict cells visible. Nutlets ovoid or ellipsoidal, smooth-walled, with acute margins and slightly concave faces.

Comparison. The fruits of the contemporary Eurasian *Rumex ucrainicus* Besser ex Spreng. are slightly larger. The fruits described as *Rumex ucrainicus* Fisch. from the Pleistocene of southern Poland (Ściejowice) belong to *R*. cf. *acetosella* L. (Velichkevich & Mamakowa 1999).

Occurrence. Pliocene of the Upper Don basin (Nikitin 1957).

***Rumex* sp. div.**

Material. MINM-P-BGO-2/89: 4 fruits; KRAM-P 242/89: 5 fruits.

Description. Triquetrous fruits, differing in size, shape, surface sculpture, acuteness of margins.

Comparison. Three morphotypes were distinguished in the Kholmech flora. Fruits determined only to the genus *Rumex* L. are very often recorded in fossil floras of the Pliocene and Pleistocene, but without a preserved perianth their determination to species is impossible.

CHENOPODIACEAE

Chenopodium album L. foss.

Pl. 7, fig. 6

1971a *Chenopodium album* L.; Dorofeev & Velichkevich, p. 155.
1988 *Chenopodium album* L. foss.; Mai & Walther, p. 143, Pl. 26, figs 11, 12.

Material. MINM-P-BGO-2/90: 15 seeds; KRAM-P 242/90: 5 seeds.

Description. Seeds 1.1–1.2 mm in diameter, almost circular or broadly reniform in outline, asymmetrically biconvex, convexity more pronounced in the bottom part. Raphe curved, visible at the margin, gradually fading and disappearing short of the micropyle in the centre. Seed surface black, lustrous, the bottom part with indistinct elongate appendices and the upper with indistinct, radially arranged furrows.

Comparison. The seeds of the cosmopolitian species *Chenopodium album* L. are larger (up to 1.5 mm diameter) and more regularly circular in outline.

Occurrence. Common in the Pliocene and Pleistocene of Europe (Mai & Walther 1988).

Chenopodium glaucum L.

Pl. 7, fig. 8

1971a *Chenopodium rubrum* L.; Dorofeev & Velichkevich, p.155.

Material. MINM-P-BGO-2/91: 77 seeds; KRAM-P 242/91: 10 seeds.

Description. Seeds 0.7–1.1 × 0.6–0.9 mm, rounded-reniform, asymmetrical, uniformly biconvex. Raphe arcuate, gradually extending from the margin to the centre. Surface black, lustrous. Small, closely packed tubercles are visible in the centre of both faces of the seed.

Comparison. Two extant Eurasian species *Chenopodium glaucum* L. and the cosmopolitan *Ch. rubrum* L. have seeds of the same type. The seeds from the Kholmech flora are closer to those of *Chenopodium glaucum* L., but are slightly smaller, and have an indistinct surface sculpture.

Occurrence. Pliocene of Dvorets (Velichkevich 1990).

Chenopodium hybridum L.

Pl. 7, fig. 5

1957 *Chenopodium hybridum* L. var. 2; Nikitin, p. 138, Pl. 4, fig. 33.
1971a *Chenopodium hybridum* L.; Dorofeev & Velichkevich, p. 155.
1990 *Chenopodium hybridum* L.; Velichkevich, p. 71, Pl. 23, figs 1, 2.

Material. KRAM-P 242/92: 1 fragment of seed.

Description. Fragment (almost half) of a seed 1.4 mm long and 0.6 mm wide, with large, circular pits on each face arranged in indistinct, concentric rows characteristic for this species. On one surface a shallow raphe is visible.

Comparison. Seeds of the contemporary cosmopolitan species *Chenopodium hybridum* L. have the same surface structure as those of the fossil specimen, but are much larger (1.5–1.8 mm diameter).

Occurrence. Pliocene of the Upper Don basin (Nikitin 1957), central Russia (Dorofeev

1979, 1985), the Dvorets flora (Velichkevich 1990) and the Pleistocene of the East-European Plain (Velichkevich 1982).

Chenopodium polyspermum L.

Pl. 7, fig. 7

Material. MINM-P-BGO-2/93: 130 seeds; KRAM-P 242/93: 10 seeds.

Description. Seeds 0.7–0.9 mm in diameter, circular or broadly reniform, uniformly biconvex. Raphe visible on the bottom face which has a circular, shallow pit at its centre. The top face has the micropyle at its centre. Surface smooth, with small, ovate, faint tubercles, variable in form, and spirally arranged.

Comparison. Seeds of the contemporary Eurasian *Chenopodium polyspermum* L. differ only in being somewhat larger. Seeds of the similar extant species *Ch. rubrum* L. have a much more distinct surface sculpture.

Occurrence. Pliocene of Dvorets (Velichkevich 1990), Pliocene and Pleistocene of the Upper Don basin (Nikitin 1957) and Pleistocene of Belarus (Velichkevich 1982).

Polycnemum cf. ***arvense*** L.

Pl. 7, fig. 4

1957 *Polycnemum arvense* L. var.?; Nikitin, p. 137, Pl. 4, fig. 28.
1990 *Polycnemum arvense* L. ; Velichkevich, p. 72, Pl. 23, fig. 3.

Material. KRAM-P 242/94: 2 seeds.

Description. Seeds 0.95 × 0.80 and 1.05 × 0.90 mm, ovate in outline, biconvex, with a lateral incision. Surface uniformly covered with prominent tubercles, which are flattened at the top, smooth and lustrous. The tubercles are widely spaced, even being up to their own diameter apart. On the radicle surface the tubercles are smaller, densely packed, contiguous. Testa of medium thickness, fragile.

Comparison. The seeds are similar to the contemporary, Eurasian *Polycnemum arvense* L. The only difference is that the tubercles in the extant species are contiguous.

Occurrence. Pliocene of Dvorets (Dorofeev 1986a, Velichkevich 1990), Pliocene and Pleistocene of central Russia (Nikitin 1957, Dorofeev 1985).

SILENACEAE

Lychnis flos-cuculi L.

Pl. 7, fig. 10

Material. MINM-P-BGO-2/95: 3 seeds; KRAM-P 242/95: 3 seeds.

Description. Seeds 0.9–1.0 × 0.7–0.8 mm, reniform, with uniformly convex hemispherical dorsal margin and concave ventral one. The conical hilum is situated at the centre of the ventral margin. Submarginally, both faces of the seed are weakly convex, gradually becoming so towards the dorsal margin. Surface covered in stout tubercles with pointed tips which are black, lustrous and mutually separated. Surface grey-mat.

Comparison. The seeds of *Lychnis flos-cuculi* L. foss. from the Pliocene of Thuringia (Mai & Walther 1988) are distinctly smaller and more circular in outline. Seeds of the extant Eurasian *Lychnis flos-cuculi* L. are similar to those from the Kholmech flora, but are slightly smaller.

Occurrence. Seeds of this type are known from the Pliocene and Pleistocene of Europe (Mai & Walther 1988).

Stellaria holostea L. foss.

Pl. 7, fig. 9

1946–1947 *Stellaria* sp.; Szafer, p. 80, Pl. 7, fig. 11.
1988 *Stellaria holostea* L. foss.; Mai & Walther, p. 142, Pl. 26, fig. 10.

Material. MINM-P-BGO-2/96: 1 seed; KRAM-P 242/96: 1 seed.

Description. Seeds circular, 1.2–1.3 mm in diameter. Faces somewhat convex, margins rounded gradually so towards the dorsal margin. Surface furnished with large, prominent, elongate tubercles with flattened tips, arranged in irregular, concentric rows, the hilum sculpture differing from that of the remainder of the surface.

Comparison. The seeds are similar to the extant Holarctic species *Stellaria holostea* L., but are smaller.

Occurrence. Pliocene of Poland (Szafer 1946–1947, Mai & Walther 1988) and Thuringia (Mai & Walther op.cit.).

Stellaria palustris Retz.

Pl. 7, fig. 11

Material. KRAM-P 242/97: 1 seed.

Description. Seed 1.0 × 0.8 mm, ovate in outline, biconvex, margins rounded weakly so towards the dorsal margin. Surface covered in large, elongate, curved tubercles, arranged in 6–7 irregular, concentric rows on each face. Hilum distinct.

Comparison. The seeds of the Early Miocene species *Stellaria praepalustris* Mai from Lusatia (Mai 1999b) are more elongate, with thicker and longer tubercles on the testa surface. The Kholmech seed is similar to the extant Eurasian species *Stellaria palustris* Retz., but is slightly smaller.

Occurrence. Pleistocene of the East-European Plain (Dorofeev 1963b, Velichkevich 1982).

NYMPHAEACEAE

Nuphar canaliculata C. & E.M. Reid

Pl. 8, figs 17, 18

1915 *Nuphar canaliculata* C. & E.M. Reid; Reid & Reid, p. 86, Pl. 7, figs 1–3.
non 1946–1947 *Nuphar canaliculatum* Reid; Szafer, p. 100, Pl. 9, figs 7, 8.
1957 *Nuphar advena* Ait.; Nikitin, p. 148, Pl. 5, figs 1, 6, 7.
1971a *Nuphar canaliculata* C. & E.M. Reid; Dorofeev & Velichkevich, p. 155.
1974 *Nuphar canaliculata* C. & E.M. Reid; Dorofeev, p. 79, Pl. 86, fig 19; lectotype – Pl. 110, figs 7, 8, Pl. 112, figs 7–10; Figs 46, 47.

Material. MINM-P-BGO-2/100: 140 seeds; KRAM-P 242/100: 10 seeds.

Description. Seeds 4.2–6.5 × 3.2–5.2 mm, ovoid, rarely ellipsoidal, somewhat asymmetric, thick-walled. Operculum elliptical, micropyle circular, proud. Hilum ovate, often elongate, situated at the narrower end of the operculum. Hilum and micropyle mutually separated. Surface black, lustrous. Testa surface cells small, 4–6-angled, well-defined, transverse and elongate in the upper part of the seed, isodiametric below, in indistinct, longitudinal rows. Testa thick, fragile, easily split. In cross-section two testa layers are visible. The outer layer consists of narrow cells with thick outer walls and thin lateral and inner ones (see Dorofeev 1974, Fig. 47). The inner layer is broad, formed of irregularly ovate, thin-walled, elongate cells arranged in 3–5 transverse rows.

Comparison. The seeds described above differ from the extant European *Nuphar lutea* (L.) Sibth. & Sm. and Eurasian *Nuphar pumila* (Timm) DC. in the structure of their operculum and the very thick, fragile testa with smaller surface cells. The anatomical structure of the *Nuphar canaliculata* C. & E.M. Reid testa is similar to those of *Euryale* Salisbury and *Brasenia* Schreb. The species belongs to a group of extinct species from section *Nupharella* Dorof. of Eurasian distribution (Dorofeev 1974).

The specimens found by Nikitin (1957) and named *Nuphar advena* Ait. were examined by E. Reid, the author of the species, and included in *N. canaliculata* C.& E.M. Reid (see Dorofeev 1974, p. 80).

Several seeds of *Nuphar lutea* (L.) Sibth. & Sm. from the Pliocene of Kłodzko (Jahn et al. 1984) probably belong to *N. canaliculata* C. & E.M. Reid, a view supported by the characteristic structure of the operculum (even though the micropyle and hilum are not separated).

Remains described as *Nuphar canaliculatum* Reid from the Pliocene of Krościenko (Szafer 1946–1947) belong to *Mahonia staphylaeformis* Mai (revised by Mai, 1985, KRAM-P, unpubl.).

Occurrence. Known from the Neogene of Belarus (Dorofeev 1971, Yakubovskaya 1982, 1984) and Bulgaria (Palamarev 1982), widely distributed in the Pliocene of Europe from the Netherlands to central Russia (Dorofeev 1974, 1985). Recently Mai (1999b) has found this species in the Miocene of Lusatia.

Nuphar lutea (L.) Sibth. & Sm. foss.

Pl. 7, figs 20, 21

1907 *Nymphaea lutea* L. foss.; Reid & Reid, p. 212, Pl. 11, fig. 13.
1954 *Nuphar luteum* (L.) Sibth. & Sm.; Szafer, p. 34, Pl. 7, fig 14.

Material. MINM-P-BGO-2/101: 4 seeds; KRAM-P 242/101: 3 seeds.

Description. Seeds 3–4 mm long, deformed, thin-walled, somewhat lustrous. Testa surface with large, regular 4–6-angled cells, generally indiscriminantly arranged, but approximating to transverse rows near the apex.

Operculum elliptical, micropyle and hilum adjacent. Testa two layered in cross-section, the outer layer composed of one row of cells whose outer walls are thicker than the lateral and inner. Inner layer formed by a few rows of large, thin-walled cells of different sizes.

Comparison. The seeds distinctly differ from those of *Nuphar canaliculata* C.& E.M. Reid in testa thickness, structure of the operculum, size of testa surface cells, and anatomical structure (comp. Dorofeev 1974, Figs 47 and 50). The seeds of *Nuphar lutea* (L.) Sibth. & Sm. from the Pleistocene of the East-European Plain (Dorofeev 1963b) are larger (even up to 7.5 mm long and 5.3 mm wide), from ellipsoidal to pyriform, with a truncate apex, thinner testa and very distinct testa surface cells.

The specimen described as *Nuphar luteum* (L.) Sm. foss. from the Middle Miocene of Stare Gliwice (Szafer 1961, KRAM-P 56/112) is a fruit of *Viscum* sp. (revised by Łańcucka-Środoniowa, 1971, KRAM-P, unpubl.). Numerous seeds from the flora of Mizerna (Szafer 1954) described as *Nuphar luteum* (L.) Sibth. & Sm. (KRAM-P 15/146 154, 155, 189) do not have the features characteristic for that species, and, additionally, the structure of the operculum suggests that they belong to some extinct species similar to *Nuphar canaliculata* C. & E.M. Reid, from which they differ in their thinner testa. Specimens of *Nuphar luteum* (L.) Sm. from the Pliocene of Kłodzko (Jahn et al. 1984) probably belong to the fossil species *N. canaliculata* C. & E.M. Reid.

Occurrence. Upper Miocene and Pliocene (Mizerna) of Poland (Szafer 1954, Raniecka-Bobrowska 1959) and Thuringia (Mai & Walther 1988).

***Nuphar* sp.**

Pl. 7, fig. 22

Material. KRAM-P 242/102: 2 seeds.

Description. Seeds 4.0 × 2.9 and 4.3 × 3.3 mm, elliptical in outline, slightly asymmetric, secondarily compressed during fossilization. Operculum preserved on one seed, upon which the micropyle and hilum are close together. Testa thick, surface cells in one specimen large, concave with protruding walls, distinct. Surface cells of the second seed smaller, more similar to the seed surface of *Nuphar lutea* (L.) Sibth. & Sm.

Comparison. The taxonomic position of the two seeds is not clear, because their morphological features differ from those found in the seeds of *Nuphar canaliculata* C. & E.M. Reid, the extant European *N. lutea* (L.) Sibth. & Sm. and Eurasian *N. pumila* (Timm) DC. It is likely that the specimens are representatives of some extinct, unknown species of *Nuphar*.

***Nymphaea borysthenica* Dorof.**

Pl. 7, figs 23–25; Figs 9: e,f; 10

1971 *Nymphaea borysthenica* Dorof.; Dorofeev, p. 919, Fig. 1: 18–19, designat. typi omissa.

1971a *Nymphaea borysthenica* Dorof.; Dorofeev & Velichkevich, p. 155.

1974 *Nymphaea borysthenica* Dorof.; Dorofeev, p. 83, Pl. 114, figs 9–14, Pl. 115, figs 15,16, Fig. 53: 7; holotype – Pl. 114, fig.11.

Material. MINM-P-BGO-2/98: 250 seeds; KRAM-P 242/98: 10 seeds.

Description. Seeds 2.7–4.2 × 2.0–2.9 mm, elliptical or ovate in outline, compressed during fossilization. Operculum not large, somewhat convex, with the circular and tubercle-like micropyle in the centre and ovate hilum nearby. Testa surface dark brown or black, faintly lustrous with cell structure clearly visible. Cells with intensely undulate walls, rectangular, narrow, elongate perpendicularly to the seed axis, arranged in indistinct, longitudinal rows. Among the rows thin hairs are sometimes preserved. Testa cells rectangular in cross-section, of variable length. Their lateral and inner walls are somewhat thickened, the outer walls thick, with tooth-like appendices directed towards the interior of the cell (Fig. 10).

Comparison. The seeds are variable in size, testa cell shape and abundance of hairs among the rows, but all are characterized by the same testa structure when viewed in

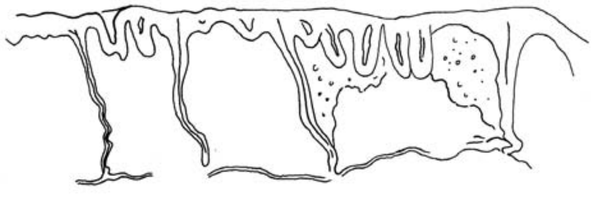

Fig. 10. *Nymphaea borysthenica* Dorof., cross-section of testa, × 280

cross-section. The seeds of the extant European and Asiatic species of *Nymphaea* are smaller, their testa cells shorter, wider and have more gently undulate walls. Hairs among the rows absent. Large seeds with hairs among the rows are characteristic for the recent Australian species, *N. gigantea* Hook. Smaller seeds, also with hairs, occur in the extant palaeotropical *N. lotus* L. (Asia and tropical Africa).

The seeds described from the Kholmech flora differ from those of the recent European species *Nymphaea alba* L., Eurasian *N. candida* C. Presl and Holarctic *N. tetragona* Georgi in the shape of the testa cells and presence of hairs between them. The seeds of the extinct *N. cinerea* Weliczk., described from the Pleistocene of Belarus (Velichkevich 1973b) are smaller than those of *Nymphaea borysthenica* Dorof., lack hairs and differ again in the structure of the testa cells.

According to Dorofeev (1971, 1974) the seeds of *Nymphaea borysthenica* Dorof. are similar to those described from the Miocene of Rypin under the name *N. alba* L. foss. (Łańcucka-Środoniowa 1957). On the basis of a study of the original collection held in KRAM-P, their similarity was confirmed, but, without anatomic investigation, their unequivocal determination is impossible.

Occurrence. The species has been known hitherto from the Pliocene of Kholmech (Dorofeev 1971) and central Russia (Dorofeev 1985).

Nymphaea pusilla Dorof.

Pl. 7, figs 18, 19; Figs 9: g,h; 11

1971 *Nymphaea pusilla* Dorof. ; Dorofeev, p. 919, Fig. 1: 20, 21, designat. typi omissa.
1971a *Nymphaea pusilla* Dorof.; Dorofeev & Velichkevich, p. 155.
1974 *Nymphaea pusilla* Dorof.; Dorofeev, p. 85, Pl. 114 figs 3–8, Pl. 115, figs 6–8, Fig. 53: 1–4; holotype – Pl. 114, fig.5.

Material. MINM-P-BGO-2/99: 72 seeds; KRAM-P 242/99: 10 seeds.

Description. Seeds 1.15–2.20 × 0.90–1.55 mm, ovate or elliptical to almost pyriform in outline, apex slightly elongate and usually damaged. Operculum not preserved. Testa surface light brown, somewhat lustrous, surface cells square, testa cell walls gently undulate, central part of cell faces somewhat concave. Testa cells square or slightly elongate in cross-section, walls thin (Fig. 11).

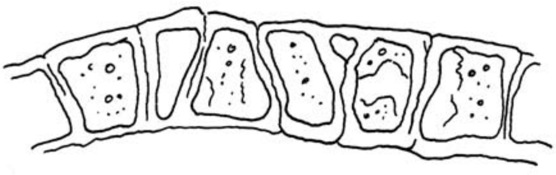

Fig. 11. *Nymphaea pusilla* Dorof., cross-section of testa, × 240

Comparison. The larger seeds from the Kholmech flora are similar to those of the contemporary European species *Nymphaea alba* L., but are smaller and have a distinctly elongate apex. They differ also in the testa cell structure, when viewed in cross-section. According to Dorofeev (1971), *N. pusilla* Dorof. was an ancestor of *N. alba* L.

Nymphaea borysthenica Dorof. and *N. pusilla* Dorof. are distinct species, without intermediate forms.

Occurrence. The species was known hitherto only from the Pliocene of Kholmech (Dorofeev 1971) and central Russia (Dorofeev 1979, 1985).

CABOMBACEAE

Brasenia angustata Dorof.

Pl. 8, figs 1–3; Fig. 12a

1971a *Brasenia tanaitica* Dorof.; Dorofeev and Velichkevich, p. 155, pro parte.
1984 *Brasenia angustata* Dorof.; Dorofeev, p. 146, Fig. 3:2, Fig. 7: 9–15; holotype – Fig. 7: 10.

Material. MINM-P-BGO-2/103: 578 seeds; KRAM-P 242/103: 30 seeds.

Description. Seeds 2.9–3.7 × 2.0–2.7 mm, obovoid or barrel-shaped, somewhat narrowed to the horizontally or obliquely truncate apex. Operculum small, deeply recessed into the narrow seed cavity. Surface usually abundantly furnished with small tubercles, mainly on the lower part of the seed, sometimes over the whole surface, occasionally absent altogether. Testa thick, strong, in cross-section two-layered, the outer layer consisting of protruding narrow cells, with very thick walls, lumina absent. Some cells, particularly those beneath tubercles, have cell lumina preserved in the form of a narrow club (Fig. 12a). Inner layer cells broad, irregularly ovate, walls scarcely thickened and only fragmentarily preserved.

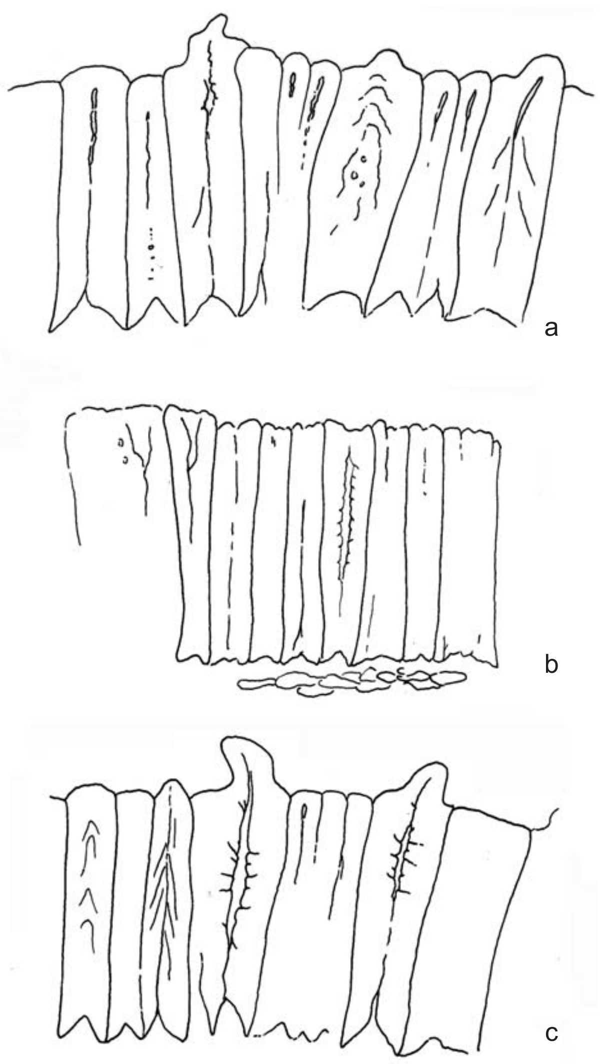

Fig. 12. **a** –*Brasenia angustata* Dorof., **b** – *B. obovata* Dorof., **c** – *B. tuberculata* C. & E.M. Reid, cross-section of testa, × 270

Comparison. The seeds differ from those of *Brasenia tuberculata* C. & E.M. Reid (see p. 183) in being smaller, narrower, more narrowed towards the base, and in having less abundant tubercles in the lower part of the seed. They differ also in the anatomical structure of the testa. According to Dorofeev (1984, p. 146) the species *B. angustata* Dorof. is directly related to *B. tuberculata* C. & E.M. Reid.

In the Pliocene of Mizerna, complex II, Szafer (1954) found one seed of *Brasenia*, which he associated with the extant *B. purpurea* (Michx.) Casp. Upon study of the original specimen (KRAM-P 15/48) it appeared that it was very similar to *B. angustata* Dorof. from the Kholmech flora. The specimen illustrated by Szafer (1954, Pl. 7, fig. 10) probably belong to *Brasenia holsatica* (Web.) Weberb., characteristic for the Eemian floras of Europe (Velichkevich 1982, 1991). On the photograph illustrated by Szafer (1954, Pl. 7, fig. 11) only the upper part of a seed of *Brasenia* Schreb. can be seen.

Occurrence. Pliocene of Kholmech (Dorofeev 1984) and Mizerna.

Brasenia obovata Dorof.

Pl. 8, figs 7, 8; Fig. 12b

1971a *Brasenia tanaitica* Dorof. ; Dorofeev & Velichkevich, p. 155, pro parte.
1984 *Brasenia obovata* Dorof.; Dorofeev, p. 147, Fig.3:1, Fig. 7: 1–8; holotype – Fig. 7: 4.

Material. MINM-P-BGO-2/104: 120 seeds; KRAM-P 242/104: 80 seeds.

Description. Seeds 2.3–2.7 × 1.7–2.2 mm, obovate, elliptical (or slightly elongate) in outline, asymmetrical. Apex flattened, operculum not proud, rarely preserved, seed cavity broad. Seed surface smooth or rough, with a few tubercles at the base. Testa thick, two-layered. Outer layer cells quite prominent, predominantly narrow, their upper margin uneven. Cell lumina rarely preserved (Fig. 12b).

Comparison. The seeds very much resemble those of *Brasenia tanaitica* Dorof. from the Pliocene of Dan'shino in Russia (Dorofeev 1974), especially those which are short, distinctly narrowed towards the base, with a small number of tubercles or none at all. Typical specimens of *B. tanaitica* Dorof. differ in shape from those described from Kholmech, being in outline, elongate, smooth and lustrous at the surface, without tubercles. According to Dorofeev (1984, p. 147), *Brasenia obovata* Dorof. is not related to *B. tuberculata* C. & E.M. Reid, but is close to *B. reidiae* Dorof. from the Miocene of western Siberia (Dorofeev 1974).

In D.H. Mai's opinion (letter of December 30th, 2002) there are only small differences in the anatomical structure of the seeds of *Brasenia obovata* Dorof. and *B. angustata* Dorof., so *B. obovata* Dorof. seems to be a variety of *B. angustata* Dorof. However, in the Kholmech collection the seeds of both species are very numerous. Their identification is not difficult because there are no transitional morphotypes present.

Occurrence. Only in the Pliocene of Kholmech (Dorofeev 1984).

Brasenia tuberculata C. & E.M. Reid

Pl. 8, figs 4–6; Fig. 12c

1915 *Brasenia tuberculata* C. & E.M. Reid; Reid & Reid; p. 86, Pl. 6, figs 25–27.
1971a *Brasenia tuberculata* C. & E.M. Reid; Dorofeev and Velichkevich, p. 155.
1974 *Brasenia tuberculata* C. & E.M. Reid; Dorofeev, p. 58, Pl. 98, figs 8–12, Fig.27: 1; lectotype – Pl. 86, fig. 17.

Material. MINM-P-BGO-2/105: 34 seeds; KRAM-P 242/105: 25 seeds.

Description. Seeds 3.2–3.9 × 2.6–3.1 mm, elliptical in outline, sometimes weakly narrowed towards the base, the surface abundantly furnished with small tubercles. In the upper half of the seed these are arranged in indistinct longitudinal rows, in the lower part randomly. Testa thick, woody, 2 – layered in cross-section. Outer layer composed of a single layer of narrow, columnar cells, with very thick walls (Fig. 12c). Cell lumina very narrow, crevice-like, broader at the cell base. Inner testa layer composed of large, irregularly ovate, thin-walled cells, usually damaged.

Comparison. The seeds from the Kholmech flora are the same size as those of *Brasenia tuberculata* C. & E.M. Reid from the Lower Pliocene of the Netherlands (3.25–4.0 × 2.5–3.0 mm, Reid & Reid 1915). In the original publication the authors of the species (Reid & Reid, op. cit.) provided only a single photograph of a seed of *B. tuberculata* C. & Reid. It was elliptical with abundant small tubercles on the surface, in the upper part arranged in longitudinal rows. This evidence is insufficient to define the species and exhibit its range of variability. Seeds are known from only a few fossil sites of the Middle Miocene in Siberia (Dorofeev 1963a, 1974) and the Pliocene of Europe (Reid & Reid 1915, Nikitin 1957). In the Pliocene flora of Krivobor'e (Upper Don basin, Nikitin op. cit.) the seeds of *Brasenia tuberculata* C. & E.M. Reid are accompanied by seeds of another species of the genus, similar to those in the Kholmech flora. The Krivobor'e seeds are similar in size (2.7–4.1 × 2.2–3.2 mm), but variable, some bearing tubercles, others are quite smooth.

Occurrence. Miocene of Siberia (Dorofeev 1963a, 1974), Pliocene of the Netherlands (Reid & Reid 1915) and Russia (Voronezh district, Nikitin 1957).

CERATOPHYLLACEAE

Ceratophyllum dorofeevii Wieliczk. & Zastaw. **sp. nov**.

Pl. 8, figs 14–16; Fig. 13

1971a *Ceratophyllum demersum* L.; Dorofeev & Velichkevich, p. 155.

Holotype. Pl. 8, fig. 15; KRAM-P 242/106; W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Type locality. Kholmech, south-eastern Belarus.

Statigraphic horizon. Upper Kholmech Series, Late Pliocene.

Derivation of name. In honour of the eminent Russian palaeobotanist Pavel Ivanovich Dorofeev (1911–1985).

Diagnosis. Fruits 4.1–6.1 × 2.1–2.8 mm, elongate, sometimes somewhat swollen in the upper part, slightly asymmetric, length/width ratio 1.8–2.3. Three spines are always present, the apical spine is seated to one side of the longitudinal axis of the fruit. Surface somewhat rugose; in some specimens scattered, small tubercles are visible. Outer layer of fruit wall consisting of large, elongate, curved, thick-walled cells with narrow lumina (Fig. 13).

Material. MINM-P-BGO-2/106: 240 fruits; KRAM-P 242/106: 30 fruits.

Description. Fruits 4.1–6.1 × 2.1–2.8 mm, elliptical or linear in outline, mainly elongate, sometimes somewhat swollen in the upper

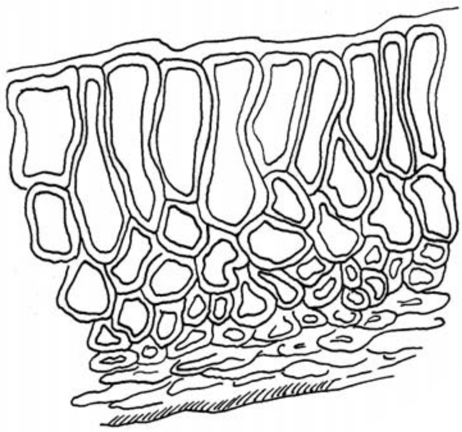

Fig. 13. *Ceratophyllum dorofeevii* Wieliczk. & Zastaw. sp. nov., cross-section of testa, × 240

part, slightly asymmetric. Long and narrow fruits prevail, though a few are short and broad. Length/width ratio is 1.8–2.3, 3 spines always present. Apical spine aculeolate, somewhat flattened at the base, as long as or longer than the fruit, slightly departing from the line of the longitudinal axis and not appearing as a prolongation of it. Basal spines shorter and thinner, more flattened. Faces of fruits weakly convex, margins mostly rounded, only in some specimens subacute. Fruit surface somewhat rugose, occasionally with scattered, small tubercles. Fruit wall composed of a few (3–4) layers poorly separated from one another. The outer layer consists of large, elongate, mainly curved, thick-walled cells with narrow lumina (Fig. 13). This layer constitutes 1/3–1/2 of the thickness of the fruit. The next layer comprises 2–3 rows of smaller, rounder but also thick-walled cells. The innermost layer consists of 2–4 rows of ovate, thin-walled cells, transversely elongate.

Comparison. Fruits of the newly described species are similar to the contemporary European *Ceratophyllum pentacanthum* Haynald. They are somewhat similar in shape and size, but are slightly shorter and broader and additionally have a single, short, broad, flat protuberance on their faces (comp. Velichkevich & Mamakowa 1999, Pl. 1, figs 27, 28). The fruits of another extant Eurasian species *Ceratophyllum demersum* L. are considerably shorter and broader (length/width ratio 1.4–1.6), ovoid, with basal spines poorly developed and less flat at the base, the fruit surface smooth, without tubercles. Their fruit wall distinctly differs from that of the fossil species (Fig. 14).

In respect of the anatomical structure of the fruit wall, the newly described species resembles the south-east European species *Ceratophyllum tanaiticum* Sap., which also has the cells of the outer layer columnar and protruding, but it has quite differently shaped fruits.

In the Pliocene of Krościenko Szafer (1946–1947) found 2 types of fruit which he included in the extant species *Ceratophyllum demersum* L. and *C. submersum* L. Determination of the first species is uncertain due to damage of the only fruit (KRAM-P 14/141). The other fruits can be assigned to *Ceratophyllum submersum* L. foss. Mai & Walther. The same taxon occurred in the Pliocene flora of Mizerna (southern Poland, KRAM-P 58/12).

Occurrence. New species for the Pliocene of Europe.

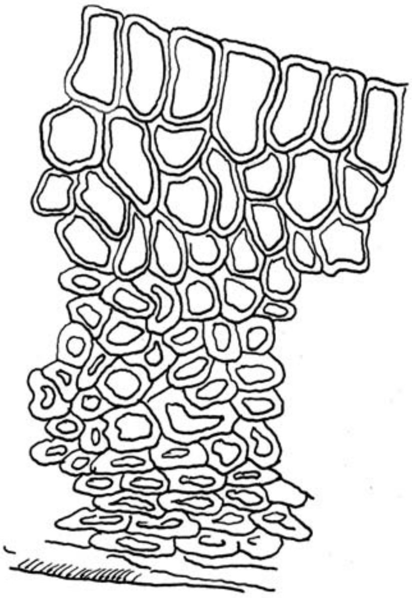

Fig. 14. *Ceratophyllum demersum* L., cross-section of testa, × 240

RANUNCULACEAE

Batrachium sp.

Pl. 9, fig. 1

1971a *Batrachium* sp.; Dorofeev & Velichkevich, p. 155.

Material. MINM-P-BGO-2/107: 1 fruit; KRAM-P 242/107: 1 fruit.

Description. Fruits 0.7 × 0.6 and 1.0 × 0.75 mm, one ovate, the other obovate in outline, biconvex, with characteristic transversely rugose surface. Wrinkles undulate, with ridged or rounded crests, the surface among them displaying minute stripes.

Comparison. The fruits of *Batrachium* S.F. Gray are very variable in shape, size and surface sculpture and specific determination requires biometric investigation. Such fruits occurred abundantly in all complexes at Mizerna (Szafer 1954).

Ranunculus cf. *acris* L.

Material. KRAM-P 242/108: 1 fruit.

Description. Fruit 2.2 × 1.7 mm, broadly obovate in outline, biconvex, asymmetric. Apex rounded, with short, pointed style, directed ventrally in relation to the longitudinal axis of the fruit. Lower part of fruit narrowly cuneiform, base blunt, without stalk. Fruit margins rounded, with a narrow rim. Surface cells covered with spongy mesocarp tissue and consequently difficult to see.

Comparison. Fruits of the extant Eurasian species *Ranunculus acris* L. are very variable and among them one can find fruits quite similar to that described here.

Occurrence. This species has been described as *Ranunculus acer* L. foss. from the Pliocene of Thuringia (Mai & Walther 1988). The species is frequent in the Pleistocene of central and eastern Europe (Velichkevich 1973b, 1982).

Ranunculus cf. ***caucasicus*** Bieb.

Pl. 8, figs 9, 10

1962 *Ranunculus* sp.; Dorofeev, p. 797, Fig. 3: 26.
1957 *Ranunculus* sp. 9; Nikitin, p. 154, Pl. 5, fig. 37.
1974 *Ranunculus* cf. *caucasicus* Bieb.; Dorofeev, p. 106, Pl. 118, fig.10.

Material. KRAM-P 242/109: 2 fruits.

Description. Fruits 2.7 × 2.0 and 2.85 × 2.30 mm, obliquely obovate in outline, biconvex, thick-walled. Apex rounded, with very short, pointed style, fruit narrowed towards the obliquely truncate base. Fruit margins compressed into arris, rim broad, fibrous. Fruit faces weakly convex, somewhat concave adjacent to rim, cell structure distinctly visible.

Comparison. The fruits are similar to those of the extant Caucasian species *Ranunculus caucasicus* Bieb., which is characterized by its mainly short and broad fruits with a sharp marginal arris. Two North American species (*Ranunculus bloomeri* Wats. and *R. arcuatus* Stell.) have fruits of similar size, but possess larger and thicker styles.

Occurrence. Pliocene of the Upper Don basin and Bashkiria (Nikitin 1957, Dorofeev 1962, 1974).

Ranunculus gailensis E.M. Reid

Pl. 9, figs 2, 3; Fig. 15: c

1920 *Ranunculus gailensis* E.M. Reid; E.M. Reid, p. 65, Pl. 3, fig. 2.
1948 *Ranunculus sceleratoides* Nikitin; Nikitin, p. 1104 (nomen nudum)
1951 *Ranunculus sceleratoides* Nikitin in Dorofeev; Dorofeev, p. 35, Pl. 19
1959 *Ranunculus gailensis* Reid; Raniecka-Bobrowska, p. 176, Pl. 18, fig 11–13.
1971a *Ranunculus sceleratioides* Nikit.; Dorofeev & Velichkevich, p.155.
2001 *Ranunculus gailensis* E.M. Reid; Mai, p. 45, Pl. 4, figs 6–9.

Material. MINM-P-BGO-2/112: 478 fruits; KRAM-P 242/112: 12 fruits.

Description. Fruits 0.6–1.0 × 0.45–0.85 mm, ovate, almost circular, rarely obovate in outline, biconvex, asymmetric. Fruit margin fashioned into a generally broad rim of varying breadth and thickness, with indistinct surface cells. However, on occasion, the rim is narrow and indistinct. At their centres the fruit faces are weakly convex, transversely rugose. The wrinkles may be distinct, faint, or totally absent.

Comparison. The larger round fruits with thick rim and poorly developed wrinkles in the centre of the faces are very similar to the fruits of the extant Holarctic species *Ranunculus sceleratus* L. (Pl. 8, figs 12,13). The smaller fruits, with more distinct, convex wrinkles and an indistinct rim more closely resemble the fossil species *R. sceleratoides* Nikit. ex Dorof., distinguished in the Pliocene flora of western Siberia (Nikitin 1948), and later described by Dorofeev (1951) from the Late Miocene of southern Ukraine. Almost all the numerous findings of fruits of this type have been described as *Ranunculus sceleratoides* Nikit. ex Dorof. According to Mai (2001) the name *R. gailensis* E.M. Reid has priority.

Occurrence. This fossil species occurred in the Oligocene of Siberia, the Miocene and Pliocene of Europe (Mai 2001) and Siberia (Nikitin 1948, Dorofeev 1951, 1959b, 1963a, 1965, 1974, 1986a, Rishkiene 1979, Yakubovskaya 1984, Mai & Walther 1988, Velichkevich 1990, and Knobloch 1992), rarely in older interglacials of the Pleistocene (Velichkevich 1982).

Ranunculus pliocenicus Dorof.

Pl. 9, fig. 4, 5

1957 *Ranunculus pedatifidus* Smith.?; Nikitin, p. 153, Pl. 5, fig. 29.
1962 *Ranunculus pliocenicus* Dorof.; Dorofeev, p. 795, Fig. 3: 17–19, designat. typi omissa.
1974 *Ranunculus pliocenicus* Dorof.; Dorofeev, p. 104, Pl. 119, figs 1–5; holotype – Pl. 119, fig. 5.

Material. KRAM-P 242/110: 2 fruits.

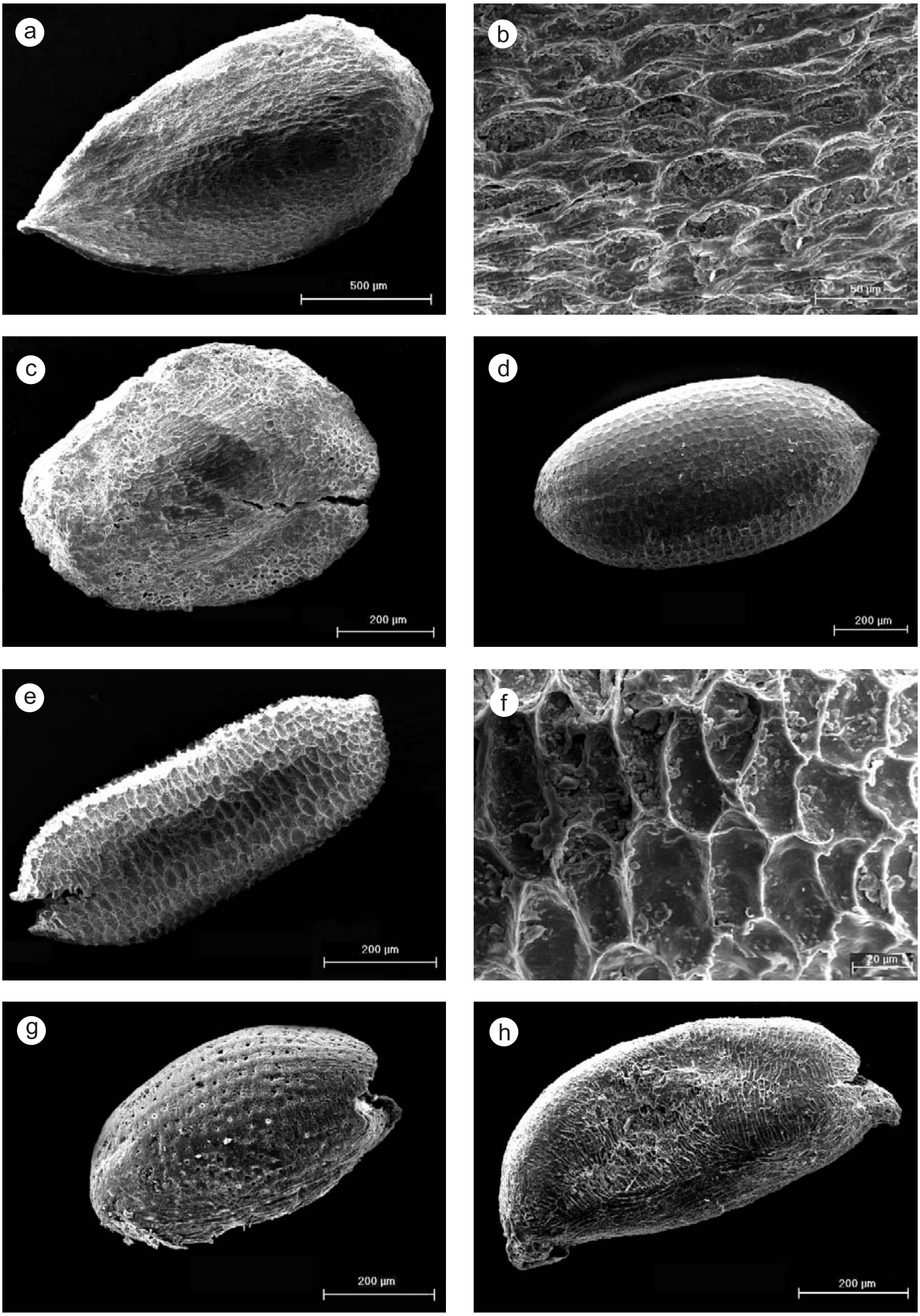

Fig. 15. **a** – *Ranunculus pseudoflammula* Dorof., fruit, SEM, × 70, KRAM-P 242/111a, **b** – detail of surface, SEM, × 500; **c** – *Ranunculus gailensis* E.M. Reid, fruit, SEM, × 130, KRAM-P 242/112; **d** – *Hypericum tertiaerum* Nikit., seed, SEM, × 100, KRAM-P 242/131b; **e** – *Hypericum foveolatum* Dorof., seed, SEM, × 150, KRAM-P 242/132b, **f** – detail of surface, SEM, × 800; **g** – *Ludwigia chandlerae* Knobloch, seed, SEM, × 150, KRAM-P 242/134a; **h** – *Ludwigia* sp., seed, SEM, × 150, KRAM-P 242/135b

Description. Fruits 1.4 × 1.3 and 1.65 × 1.20 mm, one broadly ovate, the second obliquely obovate in outline, both biconvex. Styles not visible. The obovate fruit has a somewhat indistinct stalk, but this is lacking in the other. Faces very convex, the rim narrow, thickened. Surface cells minute, indistinct, round and visible only under high magnification.

Comparison. The fruits described from the Pliocene of Bashkiria (Dorofeev 1962) are somewhat larger than the specimens from the Kholmech flora (1.6–2.1 × 1.1–1.9 mm). The extant European species *Ranunculus auricomus* L. and *R. cassubicus* L. are rather similar.

Occurrence. Pliocene of the Upper Don basin and Bashkiria (Nikitin 1957, Dorofeev 1962, 1985).

Ranunculus pseudoflammula Dorof.

Pl. 9, figs 6–8; Fig. 15: a,b

1971a *Ranunculus pseudoflammula* Dorof.; Dorofeev & Velichkevich, p. 155.
1974 *Ranunculus pseudoflammula* Dorof.; Dorofeev, p. 105, Pl. 121, figs 1–6; holotype – Pl. 121, fig.4.
1989 *Ranunculus* cf. *flammula* L.; Knobloch, p. 159. Pl. 2, figs 7–11.

Material. MINM-P-BGO-2/111: 183 fruits; KRAM-P 242/111: 20 fruits.

Description. Fruits 1.1–1.8 × 0.5–1.1 mm, obovate in outline, ranging from broad to narrow, biconvex, asymmetric. Apex rounded on one side, sometimes furnished with a tuberculate style-base. Fruit narrowed to the acute base, sometimes somewhat concave on the ventral margin. Rim of fruit narrow, more clearly visible on the ventral margin. Faces convex, their surface uniformly covered with 4–6-angled or ovate cells with thin walls. Some fruits have damaged surface cells and thus their surface is longitudinally striped, the stripes directed towards the base where they merge. Walls thick, woody.

Comparison. Fruits of the extant Eurasian species *Ranunculus flammula* L. have similar size and the same surface structure. Among the predominantly shorter and broader fruits, one can also find elongate ones, very similar to those described here.

In the original collection of the flora of Mizerna (KRAM-P 15/42), only one fruit named by Szafer (1954) as *Ranunculus flammula* L. is preserved, which undoubtedly belongs to *R. pseudoflammula* Dorof., on account of its size (1.6 × 0.95 mm), shape and surface morphology.

Occurrence. Pliocene of central Russia (Dorofeev 1974, 1979, 1985), the Czech Republic (Knobloch 1989) and Poland (Mizerna).

Ranunculus tanaiticus Dorof.

Pl. 8, fig. 11

1957 *Ranunculus* sp. 9; Nikitin, p. 154, Pl. 5, figs 5, 36.
1957 *Ranunculus* sp. 10; Nikitin, p. 154, Pl. 5, fig. 38.
1974 *Ranunculus tanaiticus* Dorof.; Dorofeev, p. 105, Pl. 120, figs 2–5; holotype – Pl. 120, fig.4.

Material. KRAM-P 242/113: 1 fruit.

Description. Fruit 2.9 × 1.6 mm, obovate in outline, flat. Apex rounded, with large, broad style measuring 0.7 × 0.7 mm, obliquely inclined to the longitudinal axis of the fruit.Tip of style somewhat curved towards the dorsal face of the fruit. Basal part of fruit cuneiform, without stalk. Rim broad, thick, fibrous, up to 0.5 mm wide on the dorsal margin, on the ventral margin thinner. Fruit faces slightly concave with distinct cell sculpture. Cells subcircular, deep, with thick, rounded walls.

Comparison. The fruits of the extant North American species *Ranunculus bloomeri* Wats. are the most similar to those described above, but they have a shorter style and narrower rim. Somewhat similar also are the fruits of another extant East Asiatic species, *Ranunculus chinensis* Bunge, but the cells on the faces of its fruit are less distinct and the fruits have a thick stalk.

Occurrence. Pliocene of Russia (Dorofeev 1956, 1985, Nikitin 1957) and Thuringia (Mai & Walther 1988).

Thalictrum cf. ***simplex*** L.

Pl. 9, fig. 14

Material. MINM-P-BGO-2/114: 1 fruit; KRAM-P 242/114: 3 fruits.

Description. Fruits 1.35–1.80 × 0.7–1.1 mm, obliquely ellipsoidal, ribbed, terete. Apex elongate in a short, mamillary style. Fruit narrowed towards the rounded base, without stalk. Ribs low with rounded margins, varying from thick to thin and indistinct on different parts of the fruit surface.

Comparison. The seeds of the extant Eurasian species *Thalictrum simplex* L. differ only in size (to 3 mm long).

Occurrence. Pleistocene of central Russia and western Siberia (Kats et al. 1965).

DROSERACEAE

Aldrovanda eleonorae Nikit.

Pl. 9, figs 15–17

1957 *Aldrovanda eleonorae* Nikit.; Nikitin, p. 158, Pl. 6, fig. 2.
1971a *Aldrovanda eleonorae* Nikit.; Dorofeev & Velichkevich, p. 155.

Material. MINM-P-BGO-2/115: 106 seeds; KRAM-P 242/115: 10 seeds.

Description. Seeds 1.1–1.5 × 0.8–1.0 mm, elliptical in outline, slightly asymmetric. Chalaza conical, rounded at the tip, distinct, merging with the raphe, which takes the form of a smooth rib along the seed. Neck cylindrical, horizontally or obliquely truncate, straight or somewhat curved, the seed cavity covered by an operculum furnished with a micropylar tubercle in the centre. Testa thick, fragile. Seed surface uniform, black, very lustrous, minutely tuberculate under high magnification. Tubercles not prominent, flattened.

Comparison. The seeds of *Aldrovanda eleonorae* Nikit. from the type collection of the Pliocene of Krivobor'e (Nikitin 1957) vary in shape and size (0.94–1.43 × 0.74–1.02 mm). The seeds of another closely similar species, *Aldrovanda europaea* Negru from the Upper Miocene of Ukraine (Negru 1973), are slightly larger than the ones described from Kholmech (single specimens to 1.7–1.8 mm in length), with a shorter neck and distinctly tuberculate surface. Yakubovskaya (1990) studied the structure of the fossil seeds of various species of *Aldrovanda* under the SEM, thereby gaining greater knowledge of these seeds. According to Yakubovskaya (op. cit.) the seeds of *A. eleonorae* Nikit. from the Kholmech flora differ somewhat from the type specimens from Krivobor'e, but not sufficiently to justify a revision of the status of the species. Some probably unripe seeds named as *Aldrovanda* cf. *eleonorae* Nikit. in the Pliocene flora of Dvorets (Velichkevich 1990) look similar, possessing features characteristic for this fossil species.

Occurrence. Upper Miocene of Siberia (Dorofeev 1963a), Pliocene of Belarus (Dorofeev 1967, Yakubovskaya 1984, Velichkevich 1990), Russia (Nikitin 1957, Dorofeev 1979), and Europe (Mai 1985).

ROSACEAE

Crataegus **sp. 1**

Pl. 9, fig. 21

Material. MINM-P-BGO-2/116: 7 half–stones; KRAM-P 242/116: 1 half–stone.

Description. Half-stones 5.1–5.8 × 1.9–2.5 mm, elongate, axis somewhat curved, cuneate in cross-section. Ventral margin plane, subacute, style situated below the apex. Dorsal margin broad, weakly convex. Apex slightly swollen, unevenly convex. Half-stones gradually narrowed towards the base, the seat of attachment of adjoining stones located on the ventral margin, above the base. Walls moderately thick, outer surface coarse, the inner smooth or weakly rugose.

Comparison. Such narrow stones have not been found among endocarps of extant species.

Crataegus **sp. 2**

Pl. 9, fig. 22

Material. MINM-P-BGO-2/117: 1 stone; KRAM-P 242/117: 1 stone.

Description. One stone 5.0 × 2.9 mm, nearly hemispherical, narrowed towards the base, compressed from both faces. Second stone 4.5 × 2.5 mm, dorsiventrally compressed, convex on the dorsal margin, cuneiform on the ventral margins. A small style is present on both stones, below the apex, on the ventral margins, and on the dorsal ones elongate keels are visible. Walls thick, the surface of the keels coarse, black, mat.

Comparison. The extant Crimean species, *Crataegus atrofusca* Stev. ex Fisch. & Mey., has similar stones.

The specimen described as *Crataegus monogyna* Jacq. from the Pliocene of Krościenko (Szafer 1946–1947, Pl. 10, fig. 1, KRAM-P 14/79) does not belong to the genus *Crataegus* L.

Fragaria cf. ***viridis*** Duchesne

Pl. 9, fig. 13

Material. KRAM-P 242/118: 2 achenes.

Description. Achenes 1.2 ö 0.9 mm, obliquely elliptical in outline, biconvex, ventral margin straight, acute. Dorsal margin falcate, blunt. Achene narrowed, rounded towards the apex, and becoming somewhat curved on the ventral margin. Base broadly rounded. Achene surface smooth, with thin, unequal veins, originating at the base to provide a flabellate venation.

Comparison. The achenes of the extant European species, *Fragaria viridis* Duchesne, vary greatly in their surface structure, from nearly smooth to being covered with numerous veins. Fruits of the extant Holarctic species *Fragaria vesca* L., are similar in size, but differ in the shape of the ventral margin.

Occurrence. Taxon found for the first time in the Pliocene floras of Belarus.

Potentilla anserina L.

Pl. 9, figs 23, 24

1971a *Potentilla anserina* L.; Dorofeev & Velichkevich, p. 155.

Material. MINM-P-BGO-2/119: 1 half-achene; KRAM-P 242/119: 2 half-achenes.

Description. All 3 halves belong to different achenes, they measure 1.8 × 1.3, 1.9 × 1.1 and 1.9 × 1.4 mm. Outer faces of half-achenes convex, smooth or slightly rough, mat and black. Inner faces paler, strongly lustrous. Ventral margin straight, with short, pointed style in the centre, dorsal margin falcate. Achene walls very thick, with a distinct groove which is clearly visible in the swollen part of the achene.

Comparison. The half-achenes are similar to those of the extant cosmopolitan species *Potentilla anserina* L.

Occurrence. The species is common in the Pleistocene of the East-European Plain (Dorofeev 1963b, Velichkevich 1982) but rather rare in Pliocene floras.

Potentilla cf. ***supina*** L.

Pl. 9, fig. 9

Material. MINM-P-BGO-2/120: 3 achenes; KRAM-P 242/120: 2 achenes.

Description. Achenes small, 0.5–0.65 × 0.4–0.5 mm, obliquely elliptical in outline, biconvex, rugose. Dorsal margin semicircular, rounded. Ventral margin nearly straight, acute, with a small, tuberculate appendix in the centre. Wrinkles rather broad, uneven, sometimes forked, somewhat lighter in colour than the remainder of the surface.

Comparison. The fruits of the extant cosmopolitan species *Potentilla supina* L. are similar in size, but have a more convex ventral margin. The achenes of *P. supina* L. foss. from the Pliocene of Thuringia (Mai & Walther 1988) are somewhat larger, and, unlike the Kholmech ones, quite smooth. They do not have surface wrinkles so characteristic of the recent *P. supina* L. and the specimen named as *Potentilla* cf. *supina* L. from the Miocene of the Nowy Sącz basin (Łańcucka-Środoniowa 1979). A smooth achene named *Potentilla supina* L. foss. by Mai (2001) was recorded from the Late Miocene of Lusatia.

Occurrence. The species is common in the Pleistocene of the East-European Plain (Dorofeev 1963b, Velichkevich 1982).

Potentilla **sp. 1**

Pl. 9, fig. 10

Material. MINM-P-BGO-2/121: 228 achenes; KRAM-P 242/121: 5 achenes.

Description. Achenes 0.95–1.35 × 0.70–0.85 mm, elliptical in outline, elongate, biconvex, axis somewhat curved, smooth. Ventral margin nearly straight, blunt-edged, with tuberculate style slightly below the apex. Dorsal margin uniformly convex, edge rounded. Walls of medium thickness. Achene surface smooth with a sculpture of indistinct, minute cells.

Comparison. Many extant species of *Potentilla* have smooth achenes. Determination of such achenes in the fossil state is difficult, because they have no distinguishing characteristics. Similar achenes are found in a number of European species, *Potentilla alba* L., *P. reptans* L., *P. virgata* Lehm., *P. humifusa* Willd., and others.

Potentilla **sp. 2**

Pl. 9, fig. 11

Material. KRAM-P 242/122: 1 achene.

Description. Achene 1.05 × 0.85 mm, semicircular in outline, somewhat narrowed towards the apex, biconvex, rugose. Ventral margin straight, edge acute, style inserted just below the apex. Faces furnished with arcuate ribs, most distinct in the upper part of the achene. Surface between the ribs indistinctly celled, darker and mat.

Comparison. Among extant species with rugose achenes the Eurasian *Potentilla argentea* L. is the most similar. Its achenes are roughly equal in size, but narrower.

***Potentilla* sp. 3**

Pl. 9, fig. 12

Material. KRAM-P 242/123: 1 achene.

Description. Achene 0.6 × 0.5 mm, semicircular in outline, somewhat narrowed towards the apex, biconvex, weakly rugose. Ventral margin nearly straight, with a shallow apical pit by apex and a small style below it. Wrinkles indistinct, lighter in colour than the rest of the surface.

Comparison. Similar achenes are found in the extant Eurasian species *Potentilla norvegica* L. and *P. orientalis* Juz.

Rubus cf. ***sachalinensis*** Levl.

Pl. 9, figs 26, 27

Material. MINM-P-BGO-2/124: 1 endocarp; KRAM-P 242/124: 3 endocarps.

Description. Endocarps 1.95–2.60 × 1.05–1.85 mm, reniform in outline, biconvex, pitted, the ventral margin somewhat concave or nearly straight, the dorsal semicircular. The pits are deep, somewhat elongate along the axis of the endocarp, with thick walls.

Comparison. Endocarps most similar to the Kholmech ones are found in the extant Far-Eastern *Rubus sachalinensis* Levl., which is regarded as the Asian equivalent of the European *R. idaeus* L. The endocarps of *R. idaeus* L. are smaller than those described from Kholmech, more elongate, elliptical and have shallower surface pits. However, the endocarps of extant *Rubus sachalinensis* Levl. are larger, have deeper and broader pits uniformly arranged on the surface of the endocarp. Endocarp morphological differences in the extant *Rubus* L. species are so slight that they can only be determined by statistical analysis.

Occurrence. New taxon for the Pliocene of Europe.

***Rubus* sp.**

Material. KRAM-P 242/125: one fragment of endocarp.

Description. A small fragment of endocarp with large, deep surface pits, which on the both faces are ovate in outline and at right angles to the endocarp axis. Near the margin they are larger and somewhat angular.

Comparison. The preserved fragment differs from the *Rubus* cf. *sachalinensis* Levl. previously described in its larger and deeper pits which have thicker walls and are arranged perpendicularly to the axis.

In the publication of the Kholmech flora (Dorofeev & Velichkevich 1971a) one endocarp of *Rubus* cf. *caesius* L. was recorded. It is likely that the fragment belongs to this species, but certain determination is impossible.

Spiraea cf. ***gomeliana*** Dorof.

Pl. 9, fig. 28

1986a *Spiraea gomeliana* Dorof.; Dorofeev, p. 65, Pl. 6, figs 1–8, Fig.5: 1–9; holotype – Pl. 6, fig. 4.

Material. KRAM-P 242/126: 1 fruit.

Description. Fruit 3.5 × 2.8 mm, dorsiventrally compressed to form on ovate disc. When the centrally curved upper part is viewed from above follicles are visible, the view from below reveals an infundibuliform base with a central stalk.

Comparison. Numerous very well-preserved specimens of this species were recorded from the flora of the Pliocene of Dvorets (Dorofeev 1986a). They enabled us to identify the primary morphological characters of the Kholmech specimen. The extant East-Asiatic *Spirea betulifolia* Pall. (Dorofeev op. cit.) is very close to the fossil species.

Occurrence. Pliocene of Belarus (Dorofeev 1986a).

STAPHYLEACEAE

Staphylea cf. ***trifolia*** L.

1946–1947 *Staphylea* cf. *trifolia* L.; Szafer, p. 138, Pl. 11, fig. 15.

1971 *Staphylea* sp.; Dorofeev, Fig.1: 17.

Material. MINM-P-BGO-2/127: 1 seed fragment.

Description. Seed fragment 4.0 × 1.4 mm. Surface smooth or slightly rough, mat, not thick. Inner part of testa lighter in colour, smooth and lustrous.

Comparison. In Dorofeev's paper (1971), devoted to preliminary results of the Kholmech Pliocene flora, one seed of *Staphylea* sp. was illustrated, which was not later refound. It was broadly elliptical in outline, 4.9 × 4.0 mm, biconvex, with a slanting incision at the apex. Its surface was smooth, and weakly lustrous. On the basis of the illustration from Dorofeev's (1971) paper and the preserved fragment, the specimen from Kholmech is most similar to the extant North American species *S. trifolia* L., as are specimens from the Pliocene of Krościenko (Szafer 1946–1947, KRAM-P 14/100) and those determined by Łańcucka-Środoniowa (KRAM-P, unpubl.) as *Staphylea* sp. KRAM-P 14/101, 14/180). In the Mizerna flora other species occur: *Staphylea pinnata* L., *S. colchica* Stev. foss. and *S. pliocenica* Kink. (KRAM-P 15/82 and 15/83).

The seeds of the European-Caucasian species *Staphylea pinnata* L. are considerably larger than those of the specimens from Kholmech and have a thicker testa. The seeds of another Caucasian species, *S. colchica* Stev., also are larger than those described, thick-walled, with an uneven testa outer surface.

The fossil species *Staphylea bessarabica* Negru from the Miocene of Moldova (Negru 1972) has seeds of similar size, but they are narrower and have a faintly rugose surface.

Occurrence. Pliocene of Poland (Szafer 1946–1947) and Belarus (Dorofeev 1971).

EUPHORBIACEAE

Euphorbia **sp.**

Pl. 10, figs 24, 25

Material. MINM-P-BGO-2/139: 3 schizocarps, 1 seed ; KRAM-P 242/139: 1 schizocarp.

Description. Schizocarps 3.0–4.3 × 1.4–1.6 mm, irregularly ovate in outline, elongate, dorsal face convex, ventral concave. Apex weakly rounded, base slightly narrowed, uncinate. Walls thick, woody, transversely striped on the convex face, and obliquely striped on the concave one. Surface of both faces mat, black. Seed 3.3 × 2.6 mm, ovate in outline, in cross-section circular, thin-walled, testa surface somewhat rough.

Comparison. Remains of this type were first distinguished in the Pliocene flora of Pont-de-Gail (the Netherlands) by Reid (1923), who determined them as fragments of endocarps of *Clerodendron* L. Later Nikitin (1957) recognized them as belonging to the genus *Euphorbia* L. and compared them to the European species *Euphorbia villosa* Waldst. & Kit. ex Willd. In the Kholmech flora only a few damaged schizocarps are preserved, so comparison with extant species is not possible.

ACERACEAE

Acer cf. ***negundo*** L.

Pl. 9, fig. 18

Material. KRAM-P 242/128: 1 endocarp.

Description. Endocarp 5.9 × 1.9 mm, elongate cuneiform, without a wing, somewhat deformed, narrowed at the base into a long, pointed appendix, fruit walls thin, membranous, with straight longitudinal marginal veins present towards the base.

Comparison. The endocarps of the extant American *Acer negundo* L. are similar to the fossil ones, but are larger and have thicker walls.

Occurrence. Taxon found for the first time in the Pliocene of Belarus.

Acer sect. ***Platanoidea*** Pax

Pl. 10, figs 26, 27

1946–1947 *Acer* cf. *pictum* Thunb.; Szafer, p. 130, Pl. 10, fig. 35.

Material. KRAM-P 242/129: 1 half of an endocarp.

Description. One half of an endocarp preserved, 6.0 × 5.0 mm, with a broken wing and fractured at the septum separating the two samaras; irregularly ovate in outline, plano-concave, woody. Outer surface uneven, somewhat rugose, dark brown, mat. Inner smooth, lighter, indistinctly striped.

Comparison. The size and ovate, nearly circular shape of the endocarp undoubtedly suggest that it belongs to the series *Campestria* (Pax) Pojark., section *Platanoidea* Pax. The endocarps described from the flora of Krościenko under the name *Acer* cf. *pictum* Thunb. (Szafer 1946–1947) represent sect. *Platanoidea* Pax (KRAM-P 14/94, rev. D.H. Mai 1985, unpubl.). Very similar endocarps occur in the Mizerna flora and were determined as *Acer campestrianum* Dorof. (KRAM-P 15/76, det. M. Łańcucka-Środoniowa 1989, unpubl.).

Occurrence. The fossil remains of sect. *Platanoidea* Pax occur in central and eastern Europe from the Lower Miocene (Mai 1995b) and are very common in the Pleistocene of the East-European Plain (Dorofeev 1963b, Velichkevich 1973b, 1982).

TILIACEAE

***Tilia* sp.**

Pl. 10, fig. 19

Material. MINM-P-BGO-2/130: 3 fruits; KRAM-P 242/130: 2 fruits.

Description. Fruits 1.25–2.25 × 1.35–2.25 mm, globose, somewhat ribbed. Apex with compressed, tuberculate style, fruit somewhat narrowed towards the truncate base. Walls thick, woody, the surface smooth, sometimes slightly rough, mat.

Comparison. The described specimens resemble unripe fruits of the contemporary European *Tilia platyphyllos* Scop. and the Eurasian *T. cordata* Mill. One may suppose that in the Kholmech flora some *Tilia* L. species with small fruits occurred. In the whole collection no more ripe lime fruits or fragments could be found.

HYPERICACEAE

***Hypericum foveolatum* Dorof.**

Pl. 10, figs 1–3; Fig. 15: e,f

1986a *Hypericum foveolatum* Dorof.; Dorofeev, p. 66, Pl. 8, figs 26–39; holotype – Pl. 8, fig. 37.

Material. MINM-P-BGO-2/132: 40 seeds; KRAM-P 242/132: 7 seeds.

Description. Seeds 0.55–0.85 × 0.30–0.40 mm, cylindrical, axis almost straight to distinctly curved, apex and base rounded, with very small, sometimes indistinct tubercles at the tips. Testa surface sculpture of distinct, minute hexagonal cells, deep, narrow, with thin walls, arranged in indistinct, longitudinal rows.

Comparison. The seeds from the type locality, Dvorets, are very variable in size (0.65–1.05 × 0.25–0.35 mm), with the more elongate specimens predominant. In the Kholmech collection relatively short seeds prevail. Dorofeev (1986a) compared the fossil species *Hypericum foveolatum* Dorof. with a few extant species of the genus, the European *H. quadrangulum* L., *H. elegans* Steph., *H. tetrapterum* Fries, the East Asiatic *H. attenuatum* Cheisy, *H. kamtschaticum* Ldb., and *H. yezoense* Maxim., and the North American *H. nudiflorum* Michx. and *H. microsepalum* Torr. & Grey. All these species have smaller and shallower testa surface cells than *Hypericum foveolatum* Dorof. (Dorofeev op. cit.).

Occurrence. Pliocene of Dvorets (Dorofeev 1986b).

***Hypericum tertiaerum* Nikit.**

Pl. 9, figs 19, 20; Fig. 15: d

1957 *Hypericum tertiaerum* Nikit.; Nikitin, p. 169, Pl. 6, figs 50, 51.
1971a *Hypericum tertiaerum* Nikit.; Dorofeev & Velichkevich, p. 155.
1984 *Hypericum* sp.; Jahn et al., p. 26.
1988 *Hypericum* cf. *tertiaerum* Nikitin; Baranowska-Zarzycka, p. 24.
1992 *Hypericum* sp.1; Dyjor et al., p. 32, Pl. 16, figs 1, 2.
1992 *Hypericum* sp.3; Dyjor et al., p. 32, Pl. 16, figs 4, 5.

Material. MINM-P-BGO-2/131: 690 seeds; KRAM-P 242/131: 45 seeds.

Description. Seeds 0.8–1.05 × 0.4–0.55 mm, ellipsoidal, rarely nearly cylindrical, somewhat swollen in the lower part. Apex and base rounded, with small tuberculate micropyle and hilum, connected by the thin, fibrous raphe, which is visible only in some specimens. Many have lost the outer testa layer. The surface of these is black, lustrous (in unripe seeds light brown), with irregular 4–6-angled or nearly circular cells, somewhat elongate perpendicular to the seed axis. These cells are arranged in 9–11 indistinct longitudinal rows. Some seeds have the outer testa layer preserved. It is thin, membranous, distinctly celled; cells somewhat transversely elongate in relation to the seed axis, arranged in distinct rows.

Comparison. The species was described from the brown coals of Krivobor'e (Upper Don basin) on the basis of numerous seeds, and later recorded also from other sites in that region (Nikitin 1957). Earlier Reid, who had received seeds from Nikitin for determination, named the specimens as the extant European *Hypericum pulchrum* L., which had been found in Tegelen in the Netherlands (Reid & Reid 1907). However, later, Nikitin (1957), taking into consideration important differences in the testa sculpture, recorded them as an extinct Pliocene species. The specimens found in Kholmech agree with those from the Krivobor'e type locality in their dimensions (0.7–1.0 × 0.45–0.60 mm, Nikitin op. cit.), shape and testa sculpture.

Hypericum tertiaerum Nikit. is represented in the Late Miocene flora of Gozdnica, where it was described (Dyjor et al. 1992) as *Hypericum* sp. 1 (KRAM-P 83/3) and *Hypericum* sp. 3 (KRAM-P 83/196, 268, 298; Mai 2001). One damaged seed found in the Late Miocene flora of Sośnica (Łańcucka-Środoniowa et al. 1981, KRAM-P 54/718) probably belongs to species *Hypericum* cf. *tertiaerum* Nikit. One typical seed of *H. tertiaerum* Nikit., of size 0.9 × 0.5 mm, occurred in the flora of Ruszów and was described as *Hypericum* cf. *tertiaerum* Nikit. (Baranowska-Zarzycka 1988, MZ No. 3/1).

The extant species of the genus with seeds most similar to those of *Hypericum tertiaerum* Nikit. are the East-Asiatic *H. japonicum* Blume and the North American *H. virginicum* L. and *H. tubulosum* Walt.

Occurrence. Miocene of Siberia (Dorofeev 1963a), Poland (Łańcucka-Środoniowa 1979, Dyjor et al. 1992), Lusatia (Mai 2000a), Pliocene of central Russia (Nikitin 1957, Dorofeev 1979), Belarus, (Yakubovskaya 1984, Velichkevich 1990), Thuringia (Mai & Walther 1988), and Poland (Kłodzko, Jahn et al. 1984, Ruszów, Baranowska-Zarzycka 1988).

***Hypericum* sp.**

Pl. 10, fig. 4

1971a *Hypericum* sp.; Dorofeev & Velichkevich, p. 155 (pro parte).

Material. MINM-P-BGO-2/133: 16 seeds; KRAM-P 242/133: 5 seeds.

Description. Seeds 0.65–0.85 × 0.25–0.40 mm, cylindrical or somewhat swollen at one end, axis slightly curved, rarely straight. Both ends of seed rounded, with distinct tuberculate micropyle and hilum, somewhat displaced towards the concave ventral margin. Raphe indistinct, the surface sculpture of the testa consisting of large, square to round shallow cells, arranged in longitudinal rows.

Comparison. In the extant flora, more than 10 *Hypericum* species of similar seed structure are known. These are species of section *Roscyna* (Spach) Endl. including *Hypericum ascyron* L. (Siberia, Ussurian Land), *H. gebleri* Ldb. (Siberia, East Kazakhstan), *H. pyramidatum* Ait. (North America), and *H. balearicum* L. (Mediterranean Area). The East-Asiatic *H. patulum* Thunb. (Japan, Tibet) has similar seeds but they are somewhat longer than the fossil ones and their surface cells are elongate perpendicularly to the seed axis. Short, somewhat curved seeds occur in *Hypericum ascyron* L. but most are usually longer than those described above. Among the seeds of *H. salicifolium* Sieb. & Zucc. (Japan) one can also find some rather similar to those from Kholmech, but they are larger, more curved and have more elongate testa surface cells. None has been found identical to those we have described, so it not excluded that in the Kholmech flora some extinct Pliocene species occurs which is morphologically linked to a few extant *Hypericum* species.

ONAGRACEAE

Ludwigia chandlerae Knobloch

Pl. 10, figs 7, 8; Fig. 15: g

1948 *Hypericum coriaceum* Nikt.; Nikitin, p. 1105, nomen nudum

1963 *Ludwigia palustris* (L.) Elliott foss.; Mai et al., p.786, Pl. 4, figs 14, 15.

1971a *Hypericum* e gr. *coriaceum* Nikit.; Dorofeev & Velichkevich, p. 155.

1981 *Hypericum coriaceum* Nikitin; Łańcucka-Środoniowa et al., p. 109.

1982 *Hypericum coriaceum* Nikit.; Yakubovskaya, p. 42, Pl. 4, figs 1, 2.

1988 *Ludwigia chandlerae* Knobloch; Knobloch, p. 109, Pl. 2, figs 1–10.

Material. MINM-P-BGO-2/134: 475 seeds; KRAM-P 242/134: 25 seeds.

Description. Seeds 0.45–0.65 × 0.30–0.45 mm, obliquely ovoid to obliquely obovoid, ovate or circular in cross-section. Apex rounded, split, rarely with a tuberculate style. Seed narrowed towards the base and curved towards the ventral margin. Raphe rarely clearly visible, on the lower part of the seed, but sometimes very distinct along its entire length. Testa thin, coriaceous, resilient. Testa surface brown, weakly lustrous. Testa cells large, with rounded corners, concave in the centre, arranged in distinct longitudinal rows.

Comparison. Nikitin (1948) first distinguished seeds of this type in the Neogene flora of western Siberia and named them *Hypericum coriaceum* Nikit., without description. Later the name *Hypericum* ex gr. *coriaceum* Nikit. was often used by Russian (Dorofeev 1959b, 1963a, 1979) and Belorussian palaeobotanists (Yakubovskaya 1982, Velichkevich 1982, 1990). The taxonomic status of these seeds was explained by Mai (Mai et al. 1963), who referred them to *Ludwigia palustris* (L.) Elliott foss. Later Knobloch (1988) described a new species *L. chandlerae* Knobloch from the Late Miocene and Pliocene of Moravia and Slovakia, which he compared with the contemporary European species *L. palustris* (L.) Elliott. According to Mai (2001) seeds of this type from the Miocene and Pliocene of Europe should be named *Ludwigia chandlerae* Knobloch.

The seeds of the extant species *Ludwigia palustris* (L.) Elliott are similar to the fossil ones in size and shape, but have a larger raphe on the ventral margin and very narrow cells on the testa surface, arranged in distinct longitudinal rows forming transverse lines.

Occurrence. Upper Miocene and Pliocene up to the Pleistocene of central and eastern Europe (see Mai 2001).

Ludwigia sp.

Pl. 10, figs 5, 6; Fig. 15: h

Material. MINM-P-BGO-2/135: 213 seeds; KRAM-P 242/135: 20 seeds.

Description. Seeds 0.6–0.9 × 0.3–0.6 mm, of varying shape, from obliquely ellipsoidal to cigar-shaped, axis curved, circular in cross-section, usually deformed. Apex rounded, with small tuberculate style, seeds narrowed at base into a short, curved stalk, raphe indistinct, appearing as a fibrous line. Testa thin, soft, surface minutely rough, faintly lustrous. Testa surface cells very narrow, visible only under high magnification, often indistinct.

Comparison. The described seeds differ from those of *Ludwigia chandlerae* Knobloch in their larger size, more elongate shape, obscurely visible raphe and indistinct testa surface cells. They are not similar to those of the fossil species *Ludwigia krauseli* Mai and *L. cucullifera* Mai (Mai & Walther 1978, Mai 2001) from the Late Oligocene and Miocene of Lusatia, nor to any of the extant species *Ludwigia longifolia* (DC.) Hara, *L. mulerlii* Mulertt, *L. octovalvis* (Jacq.) Raven, *L. ovalis* Miq., *L. palustris* (L.) Elliott, *L. prostrata* Roxb., and *L. pubescens* Hara.

FLACOURTIACEAE

Poliothyrsis hercynica Mai

Pl. 10, fig. 11

1915 *Viola* sp. 3; Reid & Reid, p. 120, Pl. 13, fig. 27.
1977b *Viola* sp. 2; Dorofeev, p. 73, Pl. 14, figs 3, 4.
1980 *Poliothyrsis hercynica* Mai; Mai, p. 292, Pl. 112, figs 14, 15.

Material. KRAM-P 242/136: 2 seeds.

Description. Seeds 1.8 × 1.0 and 1.75 × 1.15 mm, ellipsoidal. Apex pointed, somewhat oblique, the base broadly rounded, chalaza prominent and broad. Raphe thin, taeniate, pale- coloured, visible along its entire length. Walls strong, moderately thick. Testa surface indistinctly celled, faintly lustrous.

Comparison. Mai (1980) described this species from the Pliocene of Berga, Germany. It occurred also in the Pliocene of Simbugino in Bashkiria (Dorofeev 1977b). It is worthy of note that the fossil seeds of this genus, *Poliothyrsis* Oliver in Hooker, occur in the Pliocene of southern Poland (Mai, op. cit.).

Occurrence. Pliocene of Reuver (Holland), Berga (Germany) and Italy, also of Bashkiria (Dorofeev 1977b).

VIOLACEAE

Viola sp. 1

Pl. 10, fig. 10

Material. MINM-P-BGO-2/137: fragment of seed; KRAM-P 242/137: 1 seed.

Description. Seed 1.35 × 0.70 mm, narrowly ellipsoidal, slightly asymmetric, circular in cross-section. Apex short, blunt, slightly oblique. Base rounded. Place of attachment narrow, raphe distinct. Testa surface somewhat longitudinally striped, dark grey, mat. On the testa surface the remains of paler, spongy tissue are present.

Comparison. Such narrow, elongate seeds occur in some European populations of a few species e.g. *Viola arvensis* Murray, *V. palustris* L., *V. pumila* Chaix and *V. rupestris* F.W. Schmidt, but all of them have a caruncle at the apex which masks the shape of the seeds. The morphological features of closely related *Viola* species intergrade so exact taxonomic determination is often difficult and uncertain.

***Viola* sp. 2**

Pl. 10, fig. 9

Material. MINM-P-BGO-2/138: 1 seed; KRAM-P 242/138: 1 seed.

Description. Seeds 1.0 × 0.7 and 1.0 × 0.65 mm, narrowly ovoid, slightly asymmetric. The apex of one specimen is pointed and curved, that of the second blunt. Hilum narrow, slightly convex. Surface somewhat shining, its sculpture consisting of minute, elongate cells arranged in longitudinal rows.

Comparison. The seeds are smaller than any that can be found in reference collections.

LYTHRACEAE

Decodon gibbosus (E.M. Reid) Nikit.

Pl. 10, figs 15, 16

1920 *Diclidocarya gibbosa* E.M. Reid; E.M. Reid, p. 82, Pl. 4, figs 23, 25.
1929 *Decodon gibbosus* (E.M. Reid) Nikit.; Nikitin, p. 37, Pl. 589, figs 8–9.
1971a *Decodon globosus* (E.M. Reid) Nikit.; Dorofeev & Velichkevich, p. 155 (pro parte).
1957 *Decodon globosus* (Reid) Nikitin; Raniecka-Bobrowska, Pl. 7, figs 7–11.
1959 *Decodon globosus* (Reid) Nikitin; Raniecka-Bobrowska, p. 187, Pl. 21, fig. 7.

Material. MINM-P-BGO-2/140: 873 seeds; KRAM-P 242/140: 30 seeds.

Description. Seeds 0.9–1.5 × 0.8–1.1 mm, variable in shape, from inverse pyramidal to cuneiform. Apex broad, somewhat convex, folding under at the margins to create a blunt rim. Ventral face slightly convex, with obovoid germination valve. The end of the valve may be directed into the seed or curved towards the outside. The valve surface is distinctly celled, the cells being large, nearly square or rectangular, somewhat transversely elongate and arranged in distinct, longitudinal rows. The dorsal face of the seed is clearly keeled with pointed central rib, the sides are flat or somewhat concave. Testa rather thick, smooth, pale brown, somewhat lustrous. Seed cavity small, irregularly circular.

Comparison. The seeds are very variable, but are distinguished by their characteristic, angular shape and structure of the valve on the ventral face. They are very similar in size (0.9–1.5 × 0.9–1.5 mm) and shape to those found in the Tertiary of Siberia (Dorofeev 1963a). Also similar are the seeds of another fossil species, *Decodon bashkiricus* Dorofeev (Dorofeev 1977b), which differ in possessing a broader upper part and other features. A closely related extant species is the North American *Decodon verticillatum* (L.) Gmel. However, the Kholmech fossil seeds differ from the extant ones by their more angular shape, thicker dorsal testa and narrower valve.

Occurrence. Very common in the Tertiary of southern Russia (Dorofeev 1959b), Siberia (Dorofeev 1963a, 1969b), Neogene of Belarus (Yakubovskaya 1984), Miocene of Poland (Łańcucka-Środoniowa 1979), the Czech Republic (Knobloch 1981), Slovakia (Knobloch 1992), and Lusatia (Mai 2000a, 2001).

Decodon globosus (E.M. Reid) Nikit.

Pl. 10, figs 17, 18

1920 *Diclidocarya globosa* E.M. Reid; E.M. Reid, p. 81, Pl. 4, figs 24.
1929 *Decodon globosus* (E.M. Reid) Nikit.; Nikitin, p. 33, Pl. 589, Figs 1,3,5,7.
1971a *Decodon globosus* (E.M. Reid) Nikit.; Dorofeev & Velichkevich, p. 155 (pro parte).
1957 *Decodon tetraedriformis* Raniecka-Bobrowska; Raniecka-Bobrowska, p. 80, Pl. 7, figs 16, 17.

Material. MINM-P-BGO-2/141: 22 seeds; KRAM-P 242/141: 10 seeds.

Description. Seeds 1.1–1.4 × 0.9–1.3 mm, broadly obovate in outline, trigonous in cross-section. Apex shallowly rounded, almost imperceptibly merging with the sides. Ventral face slightly concave, with broad, concave valve which is distinctly cellular. Dorsal face convex, weakly keeled, central rib is low, blunt. Testa thick, seed cavity small.

Comparison. The described seeds differ from those of *Decodon gibbosus* (E.M. Reid) Nikitin in their more ovate outline, lack of apical rim, more convex dorsal face, less distinct cells on the valve surface and in the thicker walls. In the Kholmech flora the seeds of *D. globosus* are relatively scarce and very distinct, without intermediate forms between them and *D. gibbosus* (E.M. Reid) Nikit.

Occurrence. Very common in the Tertiary of Eurasia (Łańcucka-Środoniowa 1957, Nikitin 1957, Szafer 1961, Dorofeev 1959b, 1969b, Yakubovskaya 1984, Bůžek et al. 1985, Baranowska-Zarzycka 1988, Mai & Walther 1988, Knobloch 1980, 1992, Mai 2000a, 2001).

HALORAGACEAE

Myriophyllum praespicatum Nikit.

Pl. 10, fig. 29

1957 *Myriophyllum praespicatum* Nikit.; Nikitin, p. 174, Pl. 7, figs 11, 12.

1971a *Myriophyllum praespicatum* Nikit.; Dorofeev &Velichkevich, p. 155.

Material. MINM-P-BGO-2/142: 2 endocarps; KRAM-P 242/142: 2 endocarps.

Description. Endocarps 1.2–1.6 × 0.7–0.8 mm, elongate, triangular in cross-section. Apex truncate, base regularly rounded. Ventral face cuneate with acute rib. Chalaza at junction of base and ventral rib. Dorsal face somewhat convex with a line of tubercles straddling the intersection of the ventral and dorsal faces. Tubercles broadly rounded at the base, and pointed at the apex. Over the remainder of the endocarp the tubercles are indistinct, rounded and randomly situated. Among them, on the endocarp surface, relatively large, round cells are visible.

Comparison. Endocarps from the type collection from Krivobor'e (Upper Don basin), described by Nikitin (1957), are similar to those of the species from the Kholmech flora in size, but they have more tubercles on the dorsal face and the chalaza is situated above the base. The endocarps of *Myriophyllum praespicatum* Nikit. from Thuringia (Mai & Walther 1988) have thicker tubercles on the dorsal face, which are broader at the base, and distinctly pointed at the tip. The endocarps of *M. spicatum* L. foss. also described from Thuringia (Mai & Walther op. cit.), are longer and have only a few indistinct tubercles. Comparable with the Kholmech specimens are endocarps from the Late Pliocene of the Czech Republic, described as *Myriophyllum* cf. *spicatum* L. (Knobloch 1989). The endocarps of another extinct species, *Myriophyllum pseudospicatum* Dorof. (Dorofeev 1986a), are smaller, with smaller, blunt tubercles.The fossil endocarps of *Myriophyllum praespicatum* differ from the extant *M. spicatum* L. by their distinct surface cells. Szafer (1954) distinguished *Myriophyllum spicatum* L. in the Pleistocene of Mizerna (complexes III and III/IV) while Mai (Mai & Walther 1988) recorded *M. praespicatum* Nikit. for complex II/III (Pliocene/ Pleistocene). Both taxa are absent from the KRAM-P Mizerna collection.

Occurrence. Miocene of western Siberia (Nikitin 1965) and the Neogene of Europe (see Mai & Walther 1988).

Myriophyllum ex gr**. *verticillatum*** L.

Pl. 10, fig. 28

Material. MINM-P-BGO-2/143: 10 endocarps; KRAM-P 242/143: 3 endocarps.

Description. Endocarps 1.3–2.0 × 0.8–1.1 mm, from short and broad to elongate, narrow, axis somewhat curved. Ventral face angled, creating a subacute rib, the dorsal falcate, with a distinct longitudinal central groove. This groove is deep on some specimens and then it creates two undulations on the dorsal face. Chalaza basal and horizontal. Surface rough, without tubercles, black, mat.

Comparison. Endocarps of the extant species *Myriophyllum verticillatum* L. are, generally, similar to the described ones, but are smaller and narrower, and the groove on the dorsal face is indistinct or totally absent. Another recent Far-Eastern species *Myriophyllum ussuriensis* Maxim., has similar endocarps, but they are narrow and have a shallow groove on the dorsal face. The shorter endocarps from the Kholmech flora are similar to those of *Myriophyllum pliocenicum* T.V. Jakub. (Yakubovskaya 1984) from the Pliocene of the Grodno district, Belarus, which are, however, thicker-walled, have blunter ribs on the ventral face and walls curved in the neighbourhood of the seed cavity. It is very likely that in the Neogene of the East-European Plain a number of extinct species related to *M. verticillatum* L. existed. As only single specimens are found in fossil collections, unravelling the features which separate them is very difficult.

Occurrence. Rare in the Pliocene of Europe (Yakubovskaya 1984), common in the Pleistocene of the East-European Plain (Nikitin 1957, Dorofeev 1963b, Velichkevich 1982).

Proserpinaca europaea Dorof.

Pl. 10, fig. 20

1957 *Proserpinaca reticulata* C. & E.M. Reid; Nikitin, p. 174, Pl. 7, figs 8, 9.
1967 *Proserpinaca pterocarpa* Dorof.; Dorofeev, p. 5, Fig. 4: 12, 13.
1971a *Proserpinaca pterocarpa* Dorof.; Dorofeev & Velichkevich, p.155, pro parte.
1976 *Proserpinaca europaea* Dorof.; Dorofeev, p. 1038, Fig. 1:11–14; holotype – fig. 14.
1985 *Proserpinaca reticulata* C. & E.M. Reid; Bůžek et al., p. 29, Pl. 16, figs 1–5.

Material. MINM-P-BGO-2/145: 2 endocarps; KRAM-P 242/145: 2 endocarps.

Description. Endocarps 2.1–2.5 × 1.6–1.9 mm, slightly elongate, swollen towards the base, triangular in cross-section. Margins subacute, with thick, scattered veins linked by secondary and lower order veins, the whole forming a skeletal network, all that remains of unpreserved wings. Apex obliquely truncate, base blunt, cuneiform. Faces smooth, with thin, slightly branched veins, whose ends project beyond the apex.

Comparison. This extinct Pliocene species was described from Kholmech (Dorofeev 1979) and was later found in a few Pliocene sites in Belarus (Yakubovskaya 1984). The extant North American species, *Proserpinaca palustris* L., is the most similar to *P. europaea* Dorof. Another fossil species from this group is the Miocene *P. pterocarpa* Dorof. from Siberia (Dorofeev 1958, 1976). The endocarps of that species are somewhat larger, shorter and broader than those found in the Pliocene of Kholmech. The endocarps of another Miocene species, *Proserpinaca brevicarpa* Dorof., from the Brest district (Dorofeev 1976), are distinctly smaller (1.45–1.70 × 1.3–1.4 mm).

In the Pliocene of Belarus *Proserpinaca europaea* Dorof. occurred on its own or with another Pliocene species, *P. reticulata* C. & E.M. Reid. According to the present authors, endocarps described earlier from the Pliocene of Europe as *P. pterocarpa* Dorof. (Nikitin 1957, Raniecka-Bobrowska 1959) may well represent *P. europaea* Dorof., since *P. pterocarpa* Dorof. is characteristic only for the Miocene floras of Siberia.

Proserpinaca europaea Dorof. and *P. reticulata* C. & E.M. Reid are closely related species, seemingly distnict, although some authors have thought that both taxa belong to one fossil species (D.H. Mai, letter of Dezember 3th, 2002). Resolution of this question needs detailed study involving comparison of the fossil material from the original collections.

Occurrence. Pliocene of Belarus (Dorofeev 1976, Yakubovskaya 1984), Russia (Dorofeev 1979), Thuringia (Mai & Walther 1988) and the Czech Republic (Bůžek & Holý 1964, Bůžek et al. 1985).

Proserpinaca reticulata C. & E.M. Reid

Pl. 10, figs 21, 22

1915 *Proserpinaca reticulata* C. & E.M. Reid; Reid & Reid, p. 123, Pl. 14, figs 14–19.
1971a *Proserpinaca pterocarpa* Dorof.; Dorofeev & Velichkevich, p.155, pro parte.

Material. MINM-P-BGO-2/144: 1 endocarp; KRAM-P 242/144: 3 endocarps.

Description. Endocarps 1.7–1.9 × 1.4–1.6 mm, short and broad, trigonous. Apex infundibuliform, with thickened, rounded margin, neck rather distinct. Base rounded or slightly concave, without stalk. Ribs narrow, blunt, without wings. Middle and lower parts of endocarp faces somewhat convex, uneven, nodular.Thin vascular bundles visible on the faces and ribs, forming a delicate reticulate pattern on the surface. Walls thick and strong.

Comparison. This extinct European species is related to the extant *Proserpinaca pectinata* Lam., whose endocarps have a broader apex, very indistinct neck and more distinct reticulate pattern on the surface.

Occurrence. Miocene of Poland (Raniecka-Bobrowska 1959), southern Russia (Dorofeev 1959b), western Siberia (Dorofeev 1963a), Slovakia (Knobloch 1980, 1992), Bulgaria (Palamarev 1982), and Lusatia (Mai 2000a, 2001), Pliocene of Russia (Dorofeev 1979) and Belarus (Dorofeev 1979, Yakubovskaya 1984), Pliocene and Lower Pleistocene of Poland (Szafer 1946–1947, 1954, Baranowska-Zarzycka 1988). For other occurrences see Mai and Walther (1988).

APIACEAE

Cicuta virosa L. foss.

Pl. 10, figs 13, 14

1971a *Cicuta virosa* L.; Dorofeev & Velichkevich, p. 155.
1988 *Cicuta virosa* L. foss.; Mai & Walther, p. 188, Pl. 36, figs 11, 12.

Material. MINM-P-BGO-2/146: 9 halves of fruits; KRAM-P 242/146: 3 halves of fruits.

Description. Fruit halves 1.3–2.3 × 1.1–1.5 mm, semicircular, secondarily compressed during fossilization, indistinctly ribbed. Ribs black, fibrous, broad and flattened on the ventral face and at the margin, narrow, convex, rounded on the dorsal face. Surface between the ribs indistinctly celled, light in colour.Ventral margin somewhat convex, with broad raphe.

Comparison. The extant and Pleistocene fruit halves of this species are quite similar to those described from Kholmech, but less variable in size, with thinner walls and more distinct ribs on the dorsal face.

Occurrence. Rare in the Pliocene of Europe (Szafer 1946–1947, see also Mai & Walther 1988), as the extant species *Cicuta virosa* L. in complex II (Pliocene) and complexes II/III and III (Pleistocene) of Mizerna (Szafer 1954), common in interglacial floras of the East-European Plain (Dorofeev 1963b, Velichkevich 1982).

Oenanthe aquatica (L.) Poir. foss.

Pl. 10, fig. 12

1971a *Oenanthe aquatica* L.; Dorofeev & Velichkevich, p. 155.
1982 *Oenanthe aquatica* (L.) Poir. foss.; Palamarev, p. 20, Pl. 6, fig. 4.
1984 *Oenanthe aquatica* (L.) Poir.; Jahn et al., p. 26.

Material. MINM-P-BGO-2/147: 96 halves of fruits; KRAM-P 242/147, 10 halves of fruits.

Description. Fruit halves 2.1–4.0 × 1.3–2.2 mm, from ovate to elongate elliptical in outline, axis more or less curved, rarely straight, fruit ribbed, thick-walled, gradually narrowed towards the apex which is sometimes topped with the conical stylopodium, base rounded. Dorsal ribs rounded on the back, thick, their surface distinctly celled or longitudinally striped. The two lateral ribs are broader than the others and curved on the ventral face. The individual ribs are wider then the spaces between them. Surface between ribs smooth and dark.Ventral face slightly concave, chalaza broad, gradually narrowed towards the apex and base.

Comparison. The extant and Pleistocene fruit halves of the species are smaller (2.2–3.0 × 1.1–1.5 mm) and have ribs with a less distinctly celled surface. Fruits from the Pliocene of Kłodzko, recorded as *Oenanthe aquatica* (L.) Poir. (KRAM-P 197/151–153, Jahn et al. 1984), differ distinctly from those of the extant taxon and are very similar to the ones described from the Kholmech flora. However, halves of fruits from the Pliocene of Krościenko (*Oenanthe* sp., KRAM-P 14/115, Szafer 1946–1947,) are similar to numerous specimens from the Mizerna profile (KRAM-P 15/97, 156, 157, Szafer 1954) and are typical for *O. aquatica* (L.) Poir.

Occurrence. Upper Miocene of Bulgaria (Palamarev 1982), Pliocene of Thuringia (Mai & Walther 1988) and as an extant species in the Pliocene (Szafer 1954, Jahn et al. 1984) and Pleistocene of Poland (Szafer 1954).

Apiaceae gen.

Material. KRAM-P 242/148: 1 fruit.

Description. Fruit 4.1 × 1.2 mm, lanceolate, secondarily compressed during fossilization. Apex rounded, with short, curved style. Fruit gradually narrowed to the truncate base, with damaged ribs on the dorsal face, of which only thin veins remain. Surface between these veins smooth, somewhat lustrous, walls thin, membranous, fragile.

Comparison. The elongate shape, length/width ratio and presence of style at the apex liken the fruit to those of *Carum*.

CORNACEAE

Swida cf. ***gorbunovii*** (Dorof.) Negru

Pl. 10, fig. 23

1954 *Cornus* cf. *suecica* L.; Szafer, p. 49, Pl. 12, fig. 12.
1955a *Cornus gorbunovii* Dorof.; Dorofeev, p. 137, Pl. 6, figs 13–16.
1958 *Cornus gorbunovii* Dorof.; Dorofeev, p. 252, Pl. 44, figs 14–25.
1959 *Cornus* sp. 1; Raniecka-Bobrowska, p. 196, Pl. 22, figs 8, 9.
1961 *Cornus alba* L. foss.; Szafer, p. 76, Pl. 20, figs 1–3.
1972 *Swida gorbunovii* Negru; Negru , p. 148.
1981 *Swida gorbunovii* (Dorofeev) Negru; Knobloch, p. 214, Pl. 2, figs 16–19, Pl. 3, fig. 1.
1982 *Cornus gorbunovii* Dorofeev; Palamarev, p. 20, Pl. 6, figs 6, 9, 11.

Material. MINM-P-BGO-2/149: 1 fragment of endocarp; KRAM-P 242/149: 1 endocarp.

Description. Endocarp 3.6 × 4.1 mm, transversely elliptical (broader than long) in outline, bilocular, very deformed. Apex rounded, surmounted by the broadly conical stylopodium. Base of endocarp rounded and somewhat concave. Vascular bundles at margins of endocarp not preserved, grooves formerly occupied by them narrow and deep. Surface between grooves slightly convex. Walls thick and woody.

Comparison. It is most likely that the described endocarp belongs to the fossil species *Swida gorbunovii* (Dorofeev) Negru. The same species is represented in the Pliocene flora of Mizerna under the name *Cornus* cf. *suecica* L. (KRAM-P 15/88) and in the Pliocene flora of Ruszów (MZ sample 8/2–17). Endocarps of the extant Eurasian species *Swida alba* (L.) Opiz are variable in shape, but among them one can find specimens resembling the Kholmech ones, especially endocarps from the Manchurian population of the species. The Chinese endocarps are slightly elongate, while those of the North American species *Swida stolonifera* (Michx.) Opiz are smaller.

Occurrence. From Upper Oligocene up to the Upper Pliocene, mainly in eastern Europe and western Siberia (see Mai 2001), Upper Miocene of Moravia and Slovakia (Knobloch 1980, 1981), Miocene of Bulgaria (Palamarev 1982), Miocene and Pliocene of Poland (Raniecka-Bobrowska 1959, Szafer 1954, 1961, Jahn et al. 1984), up to the Middle Pleistocene of central Europe (Knobloch 1981, Mai & Walther 1988, Mai 2000a).

PRIMULACEAE

Lysimachia nikitinii Dorof.

Pl. 11, fig. 6

1986a *Lysimachia nikitinii* Dorof.; Dorofeev, p. 71, Fig. 7: 20–27; holotype – Fig. 7: 25.

Material. MINM-P-BGO-2/151: 44 seeds; KRAM-P 242/151: 10 seeds.

Description. Seeds 0.7–1.1 × 0.6–0.7 mm, angular-ovate to nearly rhomboidal in outline in dorsal or ventral view. Basal margins acute, sometimes sharped. Dorsal face flat or somewhat concave, rarely slightly convex. Ventral face truncate-pyramidal, with a narrow, acute margin containing the hilum. Hilum length less than half that of seed. Ventral face walls flat or slightly convex. The intersection of the ventral and dorsal faces is thin, acute, sometimes slightly undulate. Testa 2-layered, the outer consisting of spongy, grey-brown, mat tissue, inner layer thin, membranous, black and lustrous.

Comparison. Seeds from the type collection from the Pliocene flora of Dvorets (Dorofeev 1986a) are slightly larger and less variable in size, but one can find seeds among them identical to those in the Kholmech flora.

Seeds with similar testa structure occur in three extant species of *Lysimachia*: the European *Lysimachia punctata* L., the Eurasian *L. vulgaris* L. and the East-Asiatic *L. davurica* Ledeb. In relation to seed structure (shape, outer testa layer and acute margin) the Kholmech specimens are most similar to the last of these.

Occurrence. Pliocene of Dvorets (Dorofeev 1986a).

Lysimachia cf. ***vulgaris*** L.

Pl. 11, fig. 7

1971a *Lysimachia* cf. *vulgaris* L., Dorofeev & Velichkevich, p. 156.

Material. MINM-P-BGO-2/152: 200 seeds; KRAM-P 242/152: 20 seeds.

Description. Seeds 0.8–1.2 × 0.6–0.8 mm, angular-ovate in dorsal or ventral view, in side view truncate-pyramidal. Margins of base narrow, blunt. Ventral faces slightly convex, narrowed towards the subacute apex, hilum elongate, straight. Dorsal face flat or slightly convex, its surface structure consisting of indistinct minute cells, rough, black and mat.

Comparison. The described seeds of this species vary from those of *Lysimachia nikitinii* Dorof. in their more ovate outline, shorter apex and lack of acute margins at the base. In the Kholmech flora the two *Lysimachia* L. species are very distinct with intermediate morphs absent.

The seeds of the Eurasian *L. vulgaris* L. are slightly larger, less angular, and more ovate at the base in dorsal or ventral view.

Lysimachia seeds are very fragile and badly preserved in the fossil state so they are rare in fossil floras, even Pleistocene ones. The abundance of *Lysimachia* seeds in the Kholmech flora is exceptional.

Occurrence. The species is known from the Pliocene and Pleistocene of the East-European Plain (Dorofeev 1963a, 1979, Velichkevich 1982).

Naumburgia subthyrsiflora (Nikit.) Nikit.

Pl. 11, figs 26, 27; Fig. 16: f

1935 *Lysimachia subthyrsiflora* Nikit.; Nikitin, p. 134 (nomen nudum).
1957 *Naumburgia subthyrsiflora* (Nikit.) Nikit.; Nikitin, p. 179, Pl. 7, figs 31, 32.
1971a *Naumburgia subthyrsiflora* Nikit.; Dorofeev & Velichkevich, p. 156.
1992 *Naumburgia* aff. *subthyrsiflora* Nikit.; Knobloch, p. 73, Pl. 11, fig. 12.

Material. MINM-P-BGO-2/150: 32 seeds, some fragments of capsule; KRAM-P 242/150: 10 seeds.

Description. Seeds discoid, circular in outline, 1.5–1.8 mm in diameter. Dorsal face generally very convex, hemispherical, raphe of one or two lines. Occasional seeds have the dorsal face less convex and slightly flattened or even concave. Ventral face more or less concave, with radial small wrinkles which are characteristic for this species. Hilum elongate, black, somewhat projecting from the surface, its length usually equalling half the seed. Seed margins generally acute, but when the ventral face is particularly concave, the edges become rounded and form a circular rim. Testa two-layered, the outer consisting of narrow, elongate cells and the inner thin, black, with a minutely pitted and somewhat shining surface. Within the collection there are also fragments of capsules with thin, fragile walls, upon whose inner surface the shape of the seed cells is visible.

Comparison. Seeds from the type collection from Krivobor'e (Upper Don basin, Nikitin 1957) are more variable in size (1.2–2.1 × 1.1–1.7 mm) and shape. Among them are ovate seeds as well as circular ones. Their dorsal faces are somewhat convex. The seeds of *Naumburgia subthyrsiflora* (Nikit.) Nikit. from the Miocene of western Siberia (Dorofeev 1963a) also have a very convex, nearly hemispherical dorsal face. The seeds of another fossil species, *Naumburgia cupulisperma* Negru, described from the Late Miocene of Moldova (Negru 1979), are somewhat larger than the specimens from Kholmech and have a flattened dorsal face. It should be noted that the convexity of the dorsal face and the depressed ventral face could be secondary features, which arose during fossilization.

Occurrence. The species is common in the Neogene of central Europe and Asia (see Mai 2001).

MENYANTHACEAE

Menyanthes trifoliata L.

Pl. 11, fig. 13

1971a *Menyanthes trifoliata* L.; Dorofeev & Velichkevich, p. 156.

Material. MINM-P-BGO-2/153: 42 seeds; KRAM-P 242/153: 10 seeds.

Description. Seeds 2.4–2.9 × 2.1–2.6 mm, ovate to nearly circular in outline, biconvex, sometimes with shallow depressions, rounded at the margin. Micropyle and hilum situated in a small pit near the apex. Testa thick, spongy, covered on the outside with a lustrous epidermis furnished with short stripes. Seeds lacking epidermis have a rough, grey-brown, mat surface with narrow, elongate cells arranged in concentric circles.

Comparison. Seeds of the extinct species *Menyanthes carpatica* Jentys-Szaferowa & Truchanowiczówna (Mizerna I/II and II, Szafer 1954) are much smaller, nearly circular and have a thinner testa. Seeds of the extant Holarctic species *Menyanthes trifoliata* L. are similar to the fossil ones, but have more convex faces and are more variable in size.

Occurrence. The Late Pliocene of central Russia (Nikitin 1957) and Belarus (Yakubovskaya 1984, Dorofeev 1986a, Velichkevich 1990), common in the Pleistocene of Eurasia (i.a. Dorofeev 1963b, Velichkevich 1973b, 1982). In Poland from the Middle Miocene (Truchanowiczówna 1964, Łańcucka-Środoniowa 1966, 1979, Stachurska et al. 1971) up to the Late Pleistocene (Szafer 1954, Velichkevich & Mamakowa 1999).

LAMIACEAE

Lycopus cholmechensis Wieliczk. & Zastaw. **sp. nov**.

Pl. 11, figs 16–18; Fig. 16: e

1967 *Lycopus antiquus* E.M.Reid; Dorofeev, p. 95, Pl. 4, figs 17–25, Fig. 3: 7–13.
1971a *Lycopus interglacialicus* Dorof.; Dorofeev & Velichkevich, p. 156.

Holotype. Pl. 11, fig. 16; KRAM-P 242/154; W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Type locality. Kholmech, south-eastern Belarus.

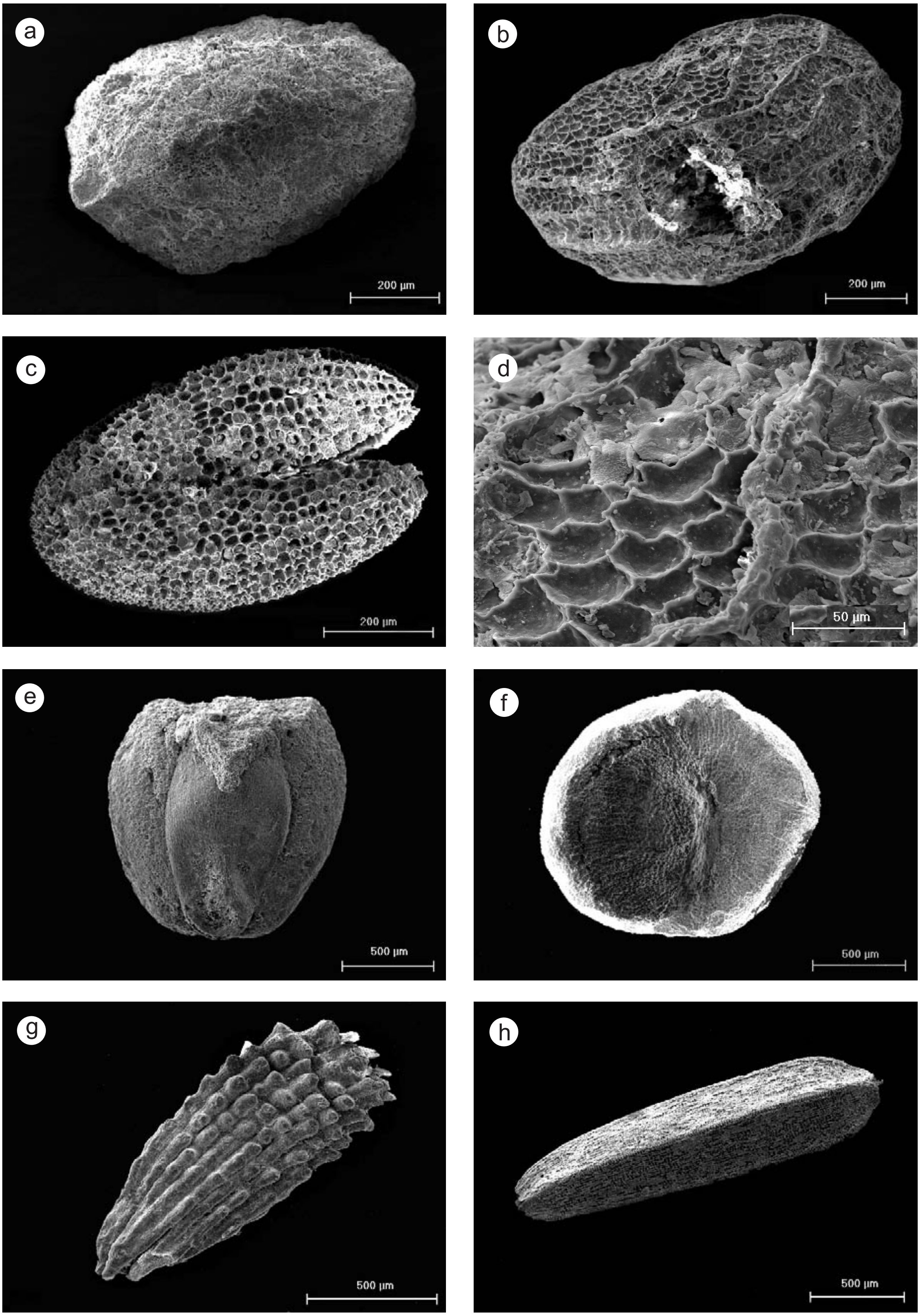

Fig. 16. **a** – *Mentha pliocenica* Dorof., fruit, SEM, × 120, KRAM-P 242/158b; **b** – *Teucrium tatianae* Nikit., fruit, SEM, × 110, KRAM-P 242/156b, **c** – detail of surface, SEM, × 500; **d** – Caprifoliaceae gen., seed, SEM, × 150, KRAM-P 242/161; **e** – *Lycopus cholmechensis* Wieliczk. & Zastaw. sp. nov., fruit, SEM, × 50, KRAM-P 242/154c; **f** – *Naumburgia subthyrsiflora* (Nikit.) Nikit., seed, SEM, × 50. KRAM-P 242/150b; **g** – *Taraxacum tanaiticum* Dorof., fruit, SEM, × 70, KRAM-P 242/168a; **h** – *Eupatorium cannabinum* L., fruit, SEM, × 50, KRAM-P 242/170a

Stratigraphic horizon. Upper Kholmech Series, Late Pliocene.

Derivation of name. From the Kholmech locality.

Diagnosis. Fruits 1.3–1.8 × 0.9–1.2 mm, trapezoidal in outline, with a broad, spongy rim. Upper margin of rim horizontal, straight or somewhat concave, sometimes undulate, in some specimens with small auricles. In the upper part of the convex ventral face is a large triangular tubercle of spongy tissue. At the fruit base on the dorsal side the ends of the rim usually coalesce, but sometimes remain with a narrow gap between them.

Material. MINM-P-2/154: 118 fruits;
KRAM-P 242/154: 10. fruits

Description. Fruits 1.3–1.8 × 0.9–1.2 mm, trapezoidal in outline, with a broad, spongy rim. Dorsal face flat, the ventral convex with the elliptical or circular hilum at its base. Upper margin of rim horizontal, straight or slightly concave, sometimes undulate, in some specimens with small auricles. Both lateral branch of rim are broad, parallel edges straight or slightly curved. In the upper part of the convex ventral face a large tubercle of spongy tissue, similar to that forming the rim, is preserved. The tubercle is usually triangular or irregular in shape. At the base of the fruit on the dorsal face, the ends of the rim usually approach each other and coalesce, but sometimes remain separate with a narrow gap between them.

Comparison. The fossil species *Lycopus antiquus* E.M. Reid was described from the Late Miocene of Point-de-Gail (Reid 1920), but its illustrated documentation is inadequate to define it. However, we can infer from the publication of Reid (op. cit.) that *L. antiquus* E.M. Reid had small, relatively broad fruits, with a rim. The upper margin of the rim was uneven and lacking auricles, the fruit faces were convex and also uneven. Single fruits of this type occur in the Kholmech flora, but most are elongate, distinctly differing from those which prevailed in the type of *Lycopus antiquus* E.M. Reid. Fruits similar to those which we have described *L. antiquus* E.M. Reid from the Late Miocene flora of western Siberia (Dorofeev 1963a), but they have a circular cross-section in the upper part, coalesced ends of the rim on the dorsal face, and an elongated tubercle on the ventral face. Fruits of *L.* cf. *antiquus* E.M. Reid from the Late Miocene of Ukraine (Dorofeev 1955a) are slightly smaller than those from Kholmech and their upper margin is not horizontal. Similar enough to specimens from Kholmech is a single *Lycopus* sp. fruit from the Middle Miocene of southern Russia (Dorofeev 1959). Very similar too is a specimen of *L. antiquus* E.M. Reid from the Oberoderwitz Miocene (Lower Lusatia, Germany) described by Mai (2000a), and illustrated in his work in Pl. 21, fig.7. It is characterized by a horizontal upper edge to the rim which possesses rather obscure auricles similar to those in *Lycopus cholmechensis* sp. nov., but the fruit is much smaller and lacks the tubercle of tissue in the upper part of the ventral face.

It seems a fair assumption that the name *Lycopus antiquus* E.M. Reid has been applied to more than one extinct species which were widely distributed in Europe and Siberia from the Miocene to the Pliocene inclusive. Among the extant species of *Lycopus* L. whose fruits most resemble those described above is the East-Asiatic *Lycopus lucidus* Turcz. (Japanese populations), the fruits of which are elongate, have the upper margin of the rim somewhat convex and possess a small tubercle of spongy tissue on the ventral face. The elongate fruits of the extant Eurasian *Lycopus exaltatus* L. (particularly populations from the Caucasus) are also somewhat similar but the upper margin of their rim is convex, with uneven edges. Fruits of other extant species of the genus are less similar.

Occurrence. New species for the Neogene of Europe.

***Lycopus* sp. div.**

1971a *Lycopus* sp.; Dorofeev & Velichkevich, p. 156.

Material. MINM-P-BGO-2/155: more than a thousand fruits; KRAM-P 242/155: 100 fruits.

Description. Fruits without rim, 0.8–1.2 × 0.4–0.7 mm, very variable in shape and size, often secondarily compressed and deformed. Fruits obovate in outline, plano-convex, with circular apex and round or oval hilum at the narrow base.

Comparison. The most important diagnostic feature of *Lycopus* species is the structure of the rim. As the rim has not been preserved in a significant proportion of the fruits in the investigated flora, specific determination of many of them is impossible. It seems, however, that among them different species are represented, as well as *Lycopus cholmechensis* Wieliczk. & Zastaw. Sufficiently similar fruits without a rim were compared by Mai (2001) with the fossil species *Lycopus antiquus* E.M. Reid, and also with the extant *L. europaeus* L. (Mai 2001, Pl. 33 figs 9–11), but there are slight differences among them.

Glechoma hederacea L. foss.

Pl.11, fig. 2

Material. KRAM-P 242/160: 1 fruit.

Description. Fruit 2.1 × 1.1 mm, elongate, almost linear, dorsiventrally compressed. Apex gently rounded, fruit somewhat narrowed towards the obliquely truncate base. Ventral face compressed to form a narrow, elongate acute rib. Dorsal face flat. Surface rough, with a sculpture of indistinct, minute cells, dark brown, mat.

Comparison. Fruits of the extant *Glechoma hederacea* L. are slightly smaller, but exhibit no other morphological differences.

Occurrence. Pleistocene of western Siberia and the Lower Volga Basin (Kats et al. 1965).

Mentha pliocenica Dorof.

Pl. 11, fig. 20; Fig. 16: a

1971a *Mentha* sp.; Dorofeev & Velichkevich, p. 156.
1986a *Mentha pliocenica* Dorof.; Dorofeev, p. 69, Fig. 7: 1–9; holotype – Fig. 7: 5.

Material. MINM-P-BGO-2/158: 150 fruits; KRAM-P 242/158: 15 fruits.

Description. Fruits 0.70–1.05 × 0.40–0.60 mm, elliptical or obovate in outline, sometimes slightly swollen in the lower part, trigonous in cross-section. Apex gently rounded, the basal part triangular-pyramidal. Ventral face slightly convex, dorsal face flat or somewhat convex. Pericarp 2-layered, very fragile, outer layer consisting of thick, spongy and easily destroyed tissue, forming an uneven, rough surface, but without large pits. Inner layer thin with a scultpure of minute cells, black, faintly lustrous.

Comparison. Fruits in the type collection from the Pliocene of Dvorets (Dorofeev 1986a) closely resemble the Kholmech ones in size and shape, but they are lighter in colour and have the outer spongy layer of the fruit wall better preserved. Dorofeev (op. cit.) expresses the opinion that morphologically *Mentha pliocenica* Dorof. combines features of two extant species: the south-Eurasian and north African *Mentha aquatica* L. and the Eurasian *M. arvensis* L. The fruits of the first are larger and broader and the outer pericarp layer is thick, with circular pits which are absent in *Mentha pliocenica* Dorof. The fruits of *Mentha arvensis* L. are smaller, more elongate, without pits and the pericarp is less thick.

Occurrence. Pliocene of Dvorets (Dorofeev 1986a).

Stachys cf. ***pliocenica*** Dorof.

Pl. 11, fig. 11

1971a *Stachys palustris* L.; Dorofeev & Velichkevich, p. 156.
1982 *Stachys palustris* L. foss.; Palamarev, p. 23, Pl. 6, fig. 10.
1986a *Stachys pliocenica* Dorof.; Dorofeev, p. 69, Fig. 7: 16–19; holotype – Fig.7: 19.

Material. MINM-P-BGO-2/159: 17 fruits; KRAM-P 242/159: 5 fruits.

Description. Fruits 1.3–2.3 × 0.8–1.5 mm, obovate to almost ovate in outline, apex rounded, fruit narrowly cuneiform basally. Ventral face keeled, the keel sometimes taking the form of a blunt rib with the ovate hilum at its base. Dorsal face slightly convex. Fruit surface dark brown or black, rough, with small elongate tubercles. In fruits without the rough outer pericarp the surface sculpture is of minute cells, smooth and paler in colour.

Comparison. The fruits from the type collection of the Dvorets flora (Dorofeev 1986a) are somewhat larger (1.75–2.35 × 1.00–1.50 mm), among them numerous large and elongate ones, whereas in the Kholmech collection, small fruits prevail. However, part of the fossil material of the two floras is identical. The specimens described above differ from the extant Eurasian *Stachys palustris* L. in having a distinctly tuberculate surface. The fruits of *Stachys cretica* L. from the Crimea have the same type of surface but are shorter and relatively broader than those from Kholmech.

Occurrence. Upper Miocene of Bulgaria (Palamarev 1982), Pliocene of Dvorets (Dorofeev 1986a).

Teucrium pripiatense (Dorof.) Wieliczk. & Zastaw. **comb. nov.**

Pl. 11, figs 23, 24

1957 *Teucrium* sp. 2; Nikitin, p. 182, Pl. 8, fig. 2.

1967 *Ajuga pripiatensis* Dorof.; Dorofeev, p. 722, Pl. 1, figs 21–26, designat. typi omissa.

Lectotype. *Ajuga pripiatensis* Dorof.; Dorofeev 1967, Pl. 1, fig. 25. The Institute of Geological Sciences, National Academy of Sciences of Belarus, Minsk.

Type locality. Zhytkovichy, south-western Belarus, borehole 2, depth 28.2 m.

Stratigraphic horizon. Lower Pliocene.

Derivation of name. From the name of the River Pripyat'.

Material. MINM-P-BGO-2/157: 3 fruits; KRAM-P 242/157: 3 fruits.

Description. Fruits 1.40–1.85 × 1.25–1.40 mm, elliptical or nearly circular in outline, slightly asymmetric. Ventral face concave, with a round cavity of diameter about the length of the fruit in the lower part. Margins of cavity inwardly curved, operculum convex. Surface veins sufficiently thick and distinct to form large, shallow, polygonal pits. Walls of fruits thick, strong.

Comparison. The fruits of *Ajuga* differ from those of *Teucrium* in being larger (2.5–3 mm), ovate to obovate in outline, with a distinctly pitted surface. The cavity on the ventral face equals or exceeds the fruit length.

Fruits of the type collection from the Lower Pliocene of Zhytkovichy described as *Ajuga pripiatensis* Dorof. (Dorofeev 1967) are somewhat larger (1.6–1.9 × 1.0–1.4 mm), but in all other features are identical to those from Kholmech as are those of *Teucrium* sp. 2 from the Pliocene of the Upper Don basin (Nikitin 1957).

Among extant *Teucrium* species the south Eurasian *T. chamaedrys* L. has fruits displaying a similar structure, but they are larger, the operculum is less convex and the surface pits indistinct. Fruits of the extant south Eurasian *Teucrium polium* L. and *T. botrys* L. differ from the Kholmech ones in being more elongate and having distinct surface pits.

Occurrence. Pliocene of Belarus (Dorofeev 1967).

Teucrium tatjanae Nikit.

Pl. 11, fig. 3; Fig. 16: b,c

1948 *Teucrium tatjanae* Nikit.; Nikitin p. 104 (nomen nudum).

1955a *Teucrium tatjanae* Nikit. in Dorof.; Dorofeev, p. 138, Pl. 6, figs 19, 20.

1957 *Teucrium tatjanae* Nikit.; Nikitin, p. 182, Pl. 8, fig. 3.

1971a *Teucrium tatjanae* Nikit; Dorofeev & Velichkevich, p. 156.

Material. MINM-P-BGO-2/156: more than 800 fruits; KRAM-P 242/156: more than 100 fruits.

Description. Fruits 0.70–1.15 × 0.45–0.75 mm, elliptical in outline, circular or ovate in cross-section. Lower half of the ventral face occupied by the somewhat convex operculum bearing a central tubercle. Base truncate. Surface veins 3–5, thin, distinct, in the lower part of the dorsal face straight, repeatedly branching above to form a reticulum. Surface between veins celled, cells distinct, roundish, somewhat angular. Fruit walls thin, strong, fragile. Surface dark brown, veins paler.

Comparison. A few species have been described from the Tertiary of western Siberia which have venation similar to that of *Teucrium tatjanae* Nikit. These are the Oligocene *T. sibiricum* Dorof., the Miocene *T. elongatum* Dorof. (Dorofeev 1963a) and *T. baluevae* V. Nikit. from the Miocene of Mamontova Gora (Nikitin 1976). So far, related forms have not been found among extant species. In the Tertiary of Eurasia a group of closely similar extinct fossil species existed, of which only one, *Teucrium tatjanae* Nikit., survived until the Pliocene.

Fruits of the extant species *Teucrium orientale* L. (Caucasus, Iran) are similar to those from Kholmech in shape and in having straight veins in the lower part of the dorsal face, but they are considerably larger. *Teucrium scordioides* Schreb. and *T. hircanicum* L. (Caucasus, Iran) have fruits similar in size to those of the fossil species, but possess a different type of venation.

Occurrence. In the Oligocene and Miocene of western Siberia (Dorofeev 1963a, Nikitin 1965), Miocene of Lusatia (Mai 2000a, 2001), Miocene and Pliocene of central and southern Russia (Dorofeev 1955a, 1959b, Nikitin 1957), Pliocene of western Siberia (Nikitin 1948), Belarus (Dorofeev 1967, Yakubovskaya 1984), and Thuringia (Mai & Walther 1988).

SOLANACEAE

Datura cf. ***stramonium*** L.

Pl. 11, fig. 22

Material. KRAM-P 242/163: 1 seed.

Description. Seed 3.9 × 2.8 mm, reniform, thick, with bluntly pectinate margin. Incision small, shallow, with tuberculate raphe in the centre. Testa thick, strong. Testa surface tuberculate, rugose, with irregular pits, grey-brown, mat. Testa cells small, round, with thin, somewhat undulate walls. Cavity evident in the centre of some cells.

Comparison. Seeds of the extant Eurasian species *Datura stramonium* L. are similar in shape and size, but differ by having a black epidermis on the testa surface.

Occurrence. Taxon found for the first time in the Pliocene floras of Belarus.

Physalis alkekengi L. foss.

Pl. 11, fig. 21

1915 *Physalis alkekengi* L. foss.; Reid & Reid, p. 43.
1957 *Physalis alkekengi* L.; Nikitin, p. 186, Pl. 8, fig. 22.
1977b *Physalis alkekengi* L.; Dorofeev, p. 80, Pl. 17 (not 18), figs 6–11.
1988 *Physalis alkekengi* L. foss.; Mai & Walther 1988, p. 198, Pl. 38, figs 16, 17; Fig. 95. d–f.

Material. KRAM-P 242/164: 1 seed.

Description. Seed 1.70 × 1.75 mm, obovate in outline, biconvex, with a small incision in the lower part. Testa surface cells large, shallow, with thin, very undulate walls. In the centre of the seed the cells are nearly ovate and randomly disposed; near the margin they are almost square and arranged in concentric circular rows.

Comparison. Seeds of the fossil species *Physalis pliocenica* Szafer from the Pliocene of Krościenko (Szafer 1946–1947) agree with those of *Ph. alkekengi* L. in shape and testa surface sculpture. According to Szafer (op. cit.) the smaller seeds provided the basis for the recognition of a new species. The seeds of *Ph. pliocenica* Szafer from the Pliocene of Kłodzko (Jahn et al. 1984) also probably belong to *Ph. alkekengi* L. foss.

Seeds of the extant Holarctic species *Ph. alkekengi* L. are slightly larger, elliptical to nearly circular in outline, thicker, with the testa surface composed of more distinct cells with less undulate walls.

Occurrence. Miocene of Siberia (Dorofeev 1963a), Pliocene of Europe (Reid & Reid 1915, Nikitin 1957, Palamarev 1970, Dorofeev 1977b, Jahn et al. 1984, Mai & Walther 1988) and Pleistocene of Germany (Mai & Walther 1988).

Solanum cf. ***persicum*** Willd.

Pl. 11, fig. 25

Material. MINM-P-BGO-2/162: 3 seeds; KRAM-P 242/162: 1 seed.

Description. Seeds 1.5–1.9 × 2.2–2.4 mm, reniform, flat. Hilum narrowed and somewhat detached. Testa surface distinctly celled. Cells small, elongate, randomly arranged in the centre, in concentric rows near the margin. Cell walls thin, weakly undulate. Testa thin, fragile.

Comparison. Seeds of the extant species *Solanum persicum* Willd. (Lower Volga, Caucasus, central Asia) are somewhat larger and thicker, the hilum is less detached from the seed and the cells of the testa are broader.

Occurrence. The taxon found for the first time in the Pliocene of Belarus.

CAPRIFOLIACEAE

Sambucus nigra L. foss.

Pl. 11, fig. 9

1892 *Sambucus nigra* L. foss.; C. Reid, p. 358.
1984 *Sambucus nigra* L.; Jahn et al., p. 26, Pl. 17, fig. 16.
1988 *Sambucus nigra* L. foss.; Mai & Walther, p. 196, Pl. 37, figs 18–21; Fig. 92a, b.

Material. MINM-P-BGO-2/167: 1 seed; KRAM-P 242/167: 3 seeds.

Description. Seeds 4.8–5.0 × 1.8–2.0 mm, elongate, somewhat swollen towards the broadly rounded base, conically narrowed to the blunt apex, elliptical to irregularly rhomboid in cross-section. Hilum subapical on the ventral face. Testa thick, strong, its surface tuberculate-rugose. Tubercles small, elongate, united below to form undulate, transverse or slanting round-topped ribs. Tubercle surface minutely pitted, grey-brown or black, mat. Inner testa surface lighter brown, transversely striped, faintly lustrous.

Comparison. Seeds similar to those from Kholmech occur in the Mizerna flora under the name *Sambucus nigra* L. (Szafer 1954). One seed described from Mizerna as *S. pulchella* C. & E.M. Reid (Szafer op. cit.) is considerably smaller (2.5 × 0.9 mm) than the seeds of the Kholmech flora. Seeds of the same type were recorded by Mai (Mai et al. 1963) from the Pliocene of Rippersroda under the name *Sambucus pulchella* C. & E.M. Reid. Yet again seeds of *S. racemosa* L. from southern Russia described by Dorofeev (1966a) are similar to those from Kholmech. The fossil species *Sambucus clementii* Negru from the Late Miocene of southern Ukraine (Negru 1986) has smaller seeds, broader at the base, which are sometimes obliquely truncate. In the same publication Negru (op. cit.) described the seeds of *Sambucus szaferi* which are broadly elliptical in outline with a thicker testa surface sculpture. The seed size is recorded differently in the description and illustration.

Seeds similar in size to those from Kholmech have been recorded as *Sambucus pulchella* C. & E.M. Reid (Bůžek et al. 1985), but according to Mai (Mai & Walther 1988) this fossil species has seeds no longer than 2.5–3.0 mm. The extant European species *Sambucus nigra* L. and *S. racemosa* L. have seeds measuring of 4.0–5.0 mm or more.

Occurrence. Miocene of southern Ukraine (Dorofeev 1955a), Pliocene of Poland (Szafer 1954, Jahn et al. 1984), Belarus (Yakubovskaya 1984), Bashkiria (Dorofeev 1977b), and Pleistocene of Europe (Mai & Walther 1988).

Caprifoliaceae gen.

Pl. 11, figs 14, 15; Fig. 16: d

Material. MINM-P-BGO-2/161: 98 fruits; KRAM-P 242/161: 15 seeds.

Description. Seeds 0.50–0.85 × 0.35–0.55 mm, ovoid or ellipsoidal, sometimes cylindrical, ovate in cross-section, somewhat asymmetric. Apex rounded, seed slightly narrowed and faces becoming concave towards the base. Surface sculpture of distinct minute cells which are 4–6-angled with thin walls, arranged in regular, longitudinal rows.

Comparison. The surface morphology of the Kholmech seeds resembles that found in the fruits of some *Mentha* species from section *Spicathae* L., but while all *Mentha* fruits are narrowed towards the base, their faces do not become concave. The exterior cells are also smaller, creating a smoother surface. The seeds described above also bear some resemblance to those of the of the Far-Eastern species *Dysophyla jatabeana* Makino and to seeds of the Brassicaceae. In D.H. Mai's opinion (letter of December 30th, 2002) the seeds are similar to those of the Miocene species *Diervilla tertiaria* V. Nikitin from Mamontova Gora (Nikitin 1976).

Occurrence. Upper Pliocene of Oberzella/Rhön (coll. F. Gümbel, D.H.Mai, op. cit.).

VALERIANACEAE

Patrinia cf. ***rupestris*** (Pall.) Dufr.

Pl. 11, fig. 10

1971a *Patrinia* sp.; Dorofeev & Velichkevich, p. 156.

Material. KRAM-P 242/166: 1 fruit.

Description. Fruit 1.7 × 1.0 mm, ellipsoidal in outline, secondarily compressed during fossilization. Dorsal face smooth, with very narrow marginal rim. Ventral face with a central vein which is thin in the lower part of the fruit, thickening upwards. This vein does not reach the apex and ends in the hilum. Fruit surface minutely pitted, black and mat.

Comparison. Fruits of the fossil species *Patrinia palaeosibirica* Dorof. from the Pliocene of Bashkiria (Dorofeev 1962) are considerably larger (2.0–3.0 × 1.0–1.9 mm) with remains of the pericarp preserved, thereby changing entirely the shape of the fruit. Fruits of the extant East Asiatic *P. rupestris* (Pall.) Durf. are larger, plano-convex and winged. Fruit of *P.* cf. *rupestris* (Pall.) Dufr. from the Late Pliocene flora of Dvorets (Velichkevich 1990) is better preserved, with style and marginal winds.

Occurrence. Upper Pliocene of Dvorets, Belarus (Velichkevich 1990).

Valeriana simplicifolia (Rchb.) Kabath foss.

Pl. 11, fig. 1

1971a *Valeriana pliocenica* Dorof.; Dorofeev & Velichkevich, p. 156.

Material. MINM-P-BGO-2/165: 1 fruit; KRAM-P 242/165: 1 fruit.

Description. Fruits 1.7 × 0.8 and 1.6 × 0.7 mm, narrowly obovate in outline, flat. Apex of one specimen rounded, that of the other somewhat emarginate. Fruits narrowed towards the truncate base. The dorsal face has 3 thin, straight veins and the ventral one central vein. Lateral veins are also preserved. Fruit surface dark brown, mat, with no trace of pappus hairs. Walls of fruit thin, fragile.

Comparison. The fruits of the fossil species *Valeriana pliocenica* Dorof. from the Pliocene of Bashkiria (Dorofeev 1962) are larger (1.80–2.45 × 0.75–1.20 mm), with a narrower apex and the dorsal veins closer together. Fruits from the Late Miocene of southern Ukraine (Dorofeev 1955a), described as *Valeriana* sp. are similar in size to those from Kholmech (1.8 × 0.8 mm), but they have a truncate apex and the dorsal veins do not reach the apex. Among the extant species of *Valeriana*, the European *V. simplicifolia* (Rchb.) Kabath has the most similar fruits, but they are considerably larger.

Occurrence. The taxon found for the first time in the Pliocene of Belarus.

LOBELIACEAE

Lobelia pliocenica (Dorof.) Mai

Pl. 11, figs 4, 5

1960a *Typha pliocenica* Dorof.; Dorofeev, p. 20, Pl. 1, figs 8–14 (designat. typi omissa).
1982a *Typha pliocenica* Dorof.; Dorofeev, p. 25, Pl. 6, fig. 6.
1957 *Typha* sp.; Nikitin, p. 94, Pl. 5, figs 35, 36.
1963a *Typha pliocenica* Dorof.; Dorofeev, p. 89, Pl. 4, figs 16–22, text-fig. 112/5–7.
1963 *Gentiana pneumonanthe* L. foss.; Mai et al., p. 787, Pl. 4, figs 6, 7.
1973a *Typha* ex gr. *pliocenica* Dorof.; Velichkevich, p. 47, Fig. 1/13, 14.
1975 *Typha pliocenica* Dorof.; Velichkevich, p. 120, Pl. 1, figs 7, 8.
1979 *Typha lipetskiana* Dorof.; Dorofeev, p. 91, Pl.1, figs 6–9.
1982a *Typha bescheulica* Dorof.; Dorofeev, p. 25, Pl. 6, figs 11–18.
1982a *Typha lipetskiana* Dorof.; Dorofeev, p. 25, Pl. 6, figs 19–27.
1985 *Typha* cf. *lipetskiana* Dorof.; Bůžek et al., p. 36, Pl. 19, figs 31–36.
1988 *Typha pliocenica* Dorof.; Mai & Walther, p. 97, Pl. 14, Fig. 27.
1989 *Typha* aff. *lipetskiana* Dorof.; Knobloch, p. 175, Pl. 7, fig. 10.
1990 *Typha pliocenica* Dorof.; Velichkevich, p. 39, Pl. 6, figs 1–4.
1990 *Typha lipetskiana* Dorof.; Velichkevich, p. 39, Pl. 6, figs 5–8.
2000c *Lobelia pliocenica* (Dorof.) Mai; Mai, p. 484. Pl. 1, figs 1, 2.

Material. MINM-P-BGO-2/12: 17 seeds; KRAM-P 242/12: 10 seeds.

Description. Seeds 0.70–1.15 × 0.25–0.35 mm, fusiform, most swollen centrally or below. Upper part long, attenuate in a cylindrical neck which is somewhat infundibuliform towards the end, thickened at the margin and truncate at the tip. Base cuneiform, blunt, without stalk. Testa surface distnictly celled, dark brown. Cells of outer layer of testa oblong, narrow, in longitudinally straight or slightly curved rows. Inner layer of testa (tegmen) thin, membraneous, elastic.

Comparison. Fossil seeds of this type, in their shape and size, resemble very much the seeds of *Typha*. *Typha* seeds in the fossil state have no testa with characteristic surface cells but are represented only by tegmens. Dorofeev (1982a) was of the opinion, that the presence or absence of testa in fossil seeds resulted from different fossilization conditions and had no diagnostic value. Dorofeev (1960a, 1963a, 1966a, 1979, 1982a) described several extinct *Typha* species from the Pliocene and Miocene of Siberia and central Russia (*Typha pliocenica* Dorof., *T. beczeulica* Dorof., and *T. lipetskiana* Dorof.). Recently Mai (2000c) has demonstated that without doubt the seeds of the *Typha pliocenica* Dorof. type belong to the genus *Lobelia* (Lobeliaceae) and published a new combination *Lobelia pliocenica* (Dorof.) Mai comb.nov. According to Mai (op. cit.), there was only one species of this genus (*Lobelia pliocenica* (Dorof.) Mai) in the Neogene of Europe and Siberia, and two other fossil species, *Typha beczeulica* and *T. lipetskiana*, should be considered its synonyms.

Occurrence. Pliocene of Siberia, Pre-Ural area, central Russia (Dorofeev 1960a, 1963a, 1979, 1985), Belarus (Dorofeev 1982a, Velichkevich 1990), Lithuania (Velichkevich 1973a), the Czech Republic (Bůžek et al. 1985), Moravia (Knobloch 1989) and Germany (Mai 2000c).

ASTERACEAE

***Carduus* sp.**

Pl. 11, fig. 12

1971a *Cirsium* cf. *palustre* L.; Dorofeev & Velichkevich, p. 156.

Material. MINM-P-BGO-2/169: 13 fruits; KRAM-P 242/169: 4 fruits.

Description. Fruits 2.8–3.6 × 1.2–1.4 mm, elongate, axis somewhat curved, secondarily compressed. Fruit gradually narrowed to the rounded base which has a small incision. Apex obliquely convex, with a small, thin "crown", which is not preserved in most specimens. Walls coriaceous, moderately thick. Outer surface indistinctly longitudinally striped, with smooth transverse ribs, more clearly visible in the lower part of the fruit. Fruit surface yellow-grey to brown, mat.

Comparison. Fruits similar to those described occur in the Pliocene of Bashkiria (Dorofeev 1962, 1977b) under the name *Carduus* sp. 1. They are somewhat smaller and narrower towards the base. Among extant species the most similar to the Kholmech ones are the European species *Carduus personata* (L.) Jacq. and *C. humulosus* Ehrh. The fruits of other *Carduus* species have a more distinct surface sculpture.

Eupatorium cannabinum L.

Pl. 11, fig. 8; Fig. 16: h

1971a *Eupatorium cannabinum* L.; Dorofeev & Velichkevich, p. 156.

Material. MINM-P-BGO-2/170: 62 fruits and many fragments; KRAM-P 242/170: 10 fruits.

Description. Fruits 2.0–3.1 × 0.5–0.7 mm, elongate, 5-angled in cross-section, straight or axis somewhat curved, slightly narrowed towards the base, ribbed. Ribs unequally spaced, the surface between them flat. Fruit slightly narrowed to the truncate apex. Apex furnished with a round "crown" to which the pappus hairs were formerly attached, the latter not having survived fossilization. Fruit walls thin, very fragile. Outer surface of fruits dark grey or black, mat, furnished with minute tubercles. Inner surface smooth, indistinctly longitudinally striped.

Comparison. Fruits of the extant European species *Eupatorium cannabinum* L. are similar to those described in shape and size, although sometimes somewhat larger and narrower towards the base.

Occurrence. Pleistocene of Europe (Dorofeev 1963b, Velichkevich 1973b, 1982, Kats et al. 1965).

Taraxacum tanaiticum Dorof.

Pl. 11, fig. 19; Fig. 16: g

1966a *Taraxacum tanaiticum* Dorof.; Dorofeev, p. 81, Pl. 6, figs 14–19.

Material. MINM-P-BGO-2/168: 5 fruits and fragments; KRAM-P 242/168: 3 fruits.

Description. Fruits 1.5–2.0 × 0.5–0.7 mm, cuneiform, from short to elongate, circular in cross-section, secondarily compressed. Faces ribbed, with 5–8 ribs on each. The upper half of each rib is furnished with tubercles. The lower ones are short and rounded, closer to the apex they become longer and more pointed. The apex is somewhat convex, with a fragment of cylindrical style in the centre and with broad, sometimes outwardly curved, small valves. Fruit surface dark brown or black, slightly shining.

Comparison. Fruits similar to those described have been recorded from the Pliocene of southern Russia (Dorofeev 1966).

Occurrence. Pliocene of southern Russia (Dorofeev 1966a).

TAXONOMIC COMPOSITION AND GEOGRAPHICAL ELEMENTS

The Kholmech flora is composed of 170 taxa included in 84 genera and 48 families of cryptogamic and angiospermous plants (Tab. 1). Coniferous plants were represented only by one needle fragment of *Picea* sect. *Eupicea* Willk. in the whole flora 137 species were identified, including 25 taxa which were compared to extant or fossil species (cf.). For 17 taxa of *Azolla*, *Baldellia*, *Chenopodium*, *Cicuta*, *Cyperus*, *Damasonium*, *Dulichium*, *Hydrocharis*, *Lemna*, *Oenanthe*, *Physalis*, *Sagittaria*, *Sambucus*, *Sparganium*, *Stellaria*, and *Valeriana*, the names of present-day species were retained and the word "fossilis" added. Morphological differences between extant taxa and the fossil remains were in these cases too minute to enable individual species to be recognized, especially where single specimens or fragments only were to hand.

Six species of *Ceratophyllum*, *Cyperus*, *Lycopus*, *Schoenoplectus*, and one combination of *Teucrium*, new for the Pliocene in Europe, are described, 27 taxa have been identified to genus level and 3 to family level. The remains

Table 1. List of macrofossil plant remains from the Late Pliocene of the Kholmech locality
Abbreviations: **mgs** – megaspore, **en** – endocarp, **f** – fruit, **n** – needle, **nt** – nuts, **s** – seed, **ach** – achene, **sc** – scale, **t** – tegmen, **fr** – fragment, + **–** extinct species, **Am** – tropical and subtropical America, **As** – Asian, **cosm** .– cosmopolitan, **E-As** – east-Asiatic, **Eu –** European, **Hol** – Holarctic, **Na** – North American.

Taxon	Type of remains	Number of specimens	Extinct species	Geographical elements
Pteridophyta				
Lycopsida				
Selaginellaceae				
Selaginella pliocenica Dorof.	mgs	15	+	Na
S. reticulata Dorof. & Wieliczk.	mgs	110	+	As, Na
Pteropsida				
Marsileaceae				
Pilularia pliocenica Dorof.	mgs	8	+	Eu
Salviniaceae				
Salvinia aphtosa Wieliczk.	mgs	32	+	Eu
S. cerebrata Nikit.	mgs	1	+	Am
S. glabra Nikit.	mgs	> 3000	+	Eu
S. tuberculata Nikit.	mgs	25	+	Eu
Azollaceae				
Azolla filiculoides Lam. foss.	mgs	3		Na
A. pseudopinnata Nikit.	mgs	> 1000	+	cosm
Gymnospermae				
Pinaceae				
Picea sect. *Eupicea* Willk.	n	1 fr		Hol
Angiospermae				
Monocotyledones				
Typhaceae				
Typha aspera Dorof.	t	> 1000	+	Eu-As
T. pseudoovata Dorof.	t	> 1000	+	Eu-As
Sparganiaceae				
Sparganium emersum Rehm. foss.	f	82		Hol.
S. cf. *japonicum* Roth	f	5		As
S. noduliferum C. & E.M. Reid	f	14	+	Na
S. cf. *stenophyllum* Maxim.	f	4		E-As
Sparganium sp. 1	f	19		Na
Sparganium sp. 2	f	14		E-As
Potamogetonaceae				
Potamogeton borysthenicus Dorof.	f	184	+	As
P. cholmechensis Dorof.	f	1786	+	Eu
P. crispus L.	f	1		cosm
P. cf. *felixii* Dorof.	f	1	+	As
P. longistylus Dorof.	f	324	+	
P. margaritae Dorof.	f	355	+	Hol
P. obtusatus Dorof.	f	167	+	Hol
P. obtusus Dorof.	f	23	+	Hol
P. palaeorutilus Dorof.	f	42	+	Hol
P. panormitanoides Dorof.	f	6	+	Eu
P. cf. *parvulus* Dorof.	f	13	+	Eu
P. cf. *pectinatus* L.	f	1		cosm
P. praenatans Dorof.	f	19	+	Hol.
P. pseudoacutifolius Dorof.	f	168	+	Eu
P. rossicus Dorof.	f	21	+	cosm
P. simplex Dorof.	f	585	+	Hol.

Table 1. Continued.

Taxon	Type of remains	Number of specimens	Extinct species	Geographical elements
Najadaceae				
Caulinia palaeotenuissima Dorof.	s	128	+	Eu
C. scrobiculata Dorof.	s	21	+	Eu
Najas major-pliocenica Dorof. ex Wieliczk.	s	848	+	Eu-As
Alismataceae				
Alisma plantago-aquatica L.	f, s	58		Eu-As
A. plantago-minima (Nikit.) Dorof. ex Wieliczk.	f, t	560	+	Eu
Baldellia ranunculoides (L.) Parl. foss.	s	29		Eu
Caldesia cylindrica (E.M. Reid) Dorof.	en	8	+	Eu
Damasonium alisma Mill. foss.	f, s	7		Eu-As
Sagittaria sagittifolia L. foss.	s, t	187		Eu-As
Sagittaria sp.	s, t	46		Eu-As
Hydrocharitaceae				
Hydrocharis morsus-ranae L. foss.	s	23		Eu-As
Stratiotes intermedius (Hartz) Chandler	s	328	+	Eu
Cyperaceae				
Carex carpophora Mai & Walther	nt	2		Na-As
C. klarae Mai	f	57	+	Eu-As
C. paucifloroides Wieliczk.	nt	16	+	Hol
C. rostrata-pliocenica Nikit.	f, nt	124	+	Hol
C. szaferi Dorof.	nt	6		Na
Carex sp. 1	nt	10		Eu-As
Carex sp. 2	nt	4		
Carex sp. 3	nt	3		Eu-As
Cyperus fuscus L. foss.	f	8		hol
C. glomeratioides Wieliczk. & Zastaw. sp. nov.	f	96	+	Na
C. cf. *longus* L.	f	27		Eu-As
Dulichium arundinaceum (L.)Britt. foss.	f	1		Na
D. vespiforme C. & E.M. Reid	f	8	+	Na
Eleocharis palustris (L.) Roem. & Schult.	f	3		Eu-As
E. praemaximowiczii Dorof.	f	235	+	As
Schoenoplectus lacustroides Wieliczk. & Zastaw. sp. nov.	f	712	+	Hol
S. lucens Wieliczk. & Zastaw. sp. nov.	f	112	+	Hol
S. palaeobucharicus Wieliczk. & Zastaw. sp. nov.	f	64	+	As
S. isolepioides Mai & Walther	f	3		Eu-As
Scirpus atroviroides Dorof.	f	114	+	Na
S. pliocenicus Szafer	f	> 500	+	Na
Araceae				
Acorus palaeocalamus Dorof.	f, s	279	+	Hol
Araceae gen.	f	1		
Iridaceae				
Iris sp.	s	3 fr		Eu
Lemnaceae				
Lemna trisulca L. foss.	s	> 500		Eu-As
Dicotyledones				
Myricaceae				
Myrica cf. *borysthenica* Dorof. & Wieliczk.	en		+	Eu
Betulaceae				
Alnus cf. *glutinosa* (L.) Gaertn.	f	2		Eu
Betula cholmechensis Dorof.	f, sc	375	+	Eu

Table 1. Continued.

Taxon	Type of remains	Number of specimens	Extinct species	Geographical elements
Betula longisquamosa Mädler	f	13	+	Na
Betula sp.	f, sc	7		Eu
Corylaceae				
Carpinus sp.	f	1		Eu
Corylus sp.	nt	1 fr		Eu
Fagaceae				
Quercus sp.	f	1		Eu
Urticaceae				
Pilea cantalensis (E.M. Reid) Dorof.	f	4	+	Na
Urtica dioica L.	f	61		cosm
U. pliocenica Dorof.	f	3	+	Eu-As
Polygonaceae				
Polygonum aviculare L.	ach	8		cosm
P. lapathifolium L.	f	12		Hol
P. pliocenicum Dorof.	ach	126	+	Eu-As
Rumex acetosella L.	ach	2		Eu-As
R. cf. *ucrainicus* Besser ex Spreng.	f	36		Eu-As
Rumex sp. div.	f	9		
Chenopodiaceae				
Chenopodium album L. foss.	s	20		cosm
Ch. glaucum L.	s	87		Eu-As
Ch. hybridum L.	s	1 fr		cosm
Ch. polyspermum L.	s	140		Eu-As
Polycnemum cf. *arvense* L.	s	2		Eu-As
Silenaceae				
Lychnis flos-cuculi L.	s	6		Eu-As
Stellaria holostea L. foss.	s	2		Hol
S. palustris Retz.	s	1		Eu-As
Nymphaeaceae				
Nuphar canaliculata C. & E.M. Reid	s	150	+	Na
N. lutea (L.) Sibth. & Sm. foss.	s	7		Eu
N. sp.	s	2		Eu
Nymphaea borysthenica Dorof.	s	260	+	Eu
N. pusilla Dorof.	s	82	+	Eu
Cabombaceae				
Brasenia angustata Dorof.	s	578	+	Na-As
B. obovata Dorof.	s	200	+	Na-As
B. tuberculata C. & E.M. Reid	s	59	+	Na-As
Ceratophyllaceae				
Ceratophyllum dorofeevii Wieliczk. & Zastaw. sp. nov.	f	270	+	Eu-As
Ranunculaceae				
Batrachium sp.	ach	2		
Ranunculus cf. *acris* L.	f	1		Eu-As
R. cf. *caucasicus* Bieb.	f	2		Eu
R. gailensis E.M. Reid	ach	490		Hol
R. pliocenicus Dorof.	ach	2	+	Eu
R. pseudoflammula Dorof.	ach	203	+	Eu-As
R. tanaiticus Dorof.	f	1	+	E-As-Na
Thalictrum cf. *simplex* L.	f	4		Eu-As

Table 1. Continued.

Taxon	Type of remains	Number of specimens	Extinct species	Geographical elements
Droseraceae				
Aldrovanda eleonorae Nikit.	s	116	+	Eu
Rosaceae				
Crataegus sp. 1	f	8		
Crataegus sp. 2	f	2		Eu
Fragaria cf. *viridis* Duchesne	f	2		Eu
Potentilla anserina L.	ach	3		cosm
P. cf. *supina* L.	ach	5		cosm
Potentilla sp. 1	ach	233		Eu
Potentilla sp. 2	ach	1		Eu-As
Potentilla sp. 3	ach	1		Eu-As
Rubus cf. *sachalinensis* Levl.	en	4		E-As
Rubus sp.	en	1 fr		Eu-As
Spiraea cf. *gomeliana* Dorof.	f	1	+	As
Staphyleaceae				
Staphylea cf. *trifolia* L.	s	1 fr		Na
Euphorbiaceae				
Euphorbia sp.	f, s	5		Eu
Aceraceae				
Acer cf. *negundo* L.	f	1		Na
A. sect. *Platanoidea* Pax	f	1		Eu
Tiliaceae				
Tilia sp.	f	5		
Hypericaceae				
Hypericum foveolatum Dorof.	s	47	+	Eu-As
H. tertiaerum Nikit.	s	735	+	E-As-Na
Hypericum sp.	s	21		
Onagraceae				
Ludwigia chandlerae Knobloch	s	> 500	+	Eu
Ludwigia sp.	s	233		
Flacourtiaceae				
Poliothyrsis hercynica Mai	s	2		Eu
Violaceae				
Viola sp. 1	s	2		
Viola sp. 2	s	2		
Lythraceae				
Decodon gibbosus (E.M. Reid) Nikit.	s	903	+	Na
D. globosus (E.M. Reid) Nikit.	s	32	+	Na
Haloragaceae				
Myriophyllum praespicatum Nikit.	en	4	+	cosm
M. ex gr. *verticillatum* L.	en	13		cosm
Proserpinaca europaea Dorof.	en	4	+	Na
P. reticulata C. & E.M. Reid	en	4	+	Na
Apiaceae				
Cicuta virosa L. foss.	f	12		Eu-As
Oenanthe aquatica (L.) Poir. foss.	f	106		Eu-As
Apiaceae gen.	f	1		
Cornaceae				
Swida cf. *gorbunovii* (Dorof.) Negru	en	1 + 1 fr	+	Eu-As

Table 1. Continued.

Taxon	Type of remains	Number of specimens	Extinct species	Geographical elements
Primulaceae				
Lysimachia nikitinii Dorof.	s	54	+	Eu-As
L. cf. *vulgaris* L.	s	220		Eu-As
Naumburgia subthyrsiflora (Nikit.) Nikit.	s, f	42 + fr	+	Hol
Menyanthaceae				
Menyanthes trifoliata L.	s	52		Hol
Lamiaceae				
Lycopus cholmechensis Wieliczk. & Zastaw. sp. nov.	f	128	+	E-As
Lycopus sp. div.	nt	> 1000		Eu-As
Glechoma hederacea L. foss.	f	1		Eu
Mentha pliocenica Dorof.	f	164	+	Eu
Stachys cf. *pliocenica* Dorof.	f	22		Eu-As
Teucrium pripiatense (Dorof.) Wieliczk. & Zastaw. comb. nov.	f	6	+	Eu-As
T. tatianae Nikit.	f	995	+	Eu
Solanaceae				
Datura cf. *stramonium* L.	s	1		Eu-As
Physalis alkekengi L. foss.	s	1		Hol
Solanum cf. *persicum* Willd.	s	4		Eu-As
Caprifoliaceae				
Sambucus nigra L. foss.	s	4		Eu
Caprifoliaceae gen.	s	113		E-As
Valerianaceae				
Partinia cf. *rupestris* (Pall.) Dufr.	f	1		E-As
Valeriana simplicifolia (Rchb.) Kabath foss.	f	2		Eu
Lobeliaceae				
Lobelia pliocenica (Dorof.) Mai	f	27	+	Eu-Na
Asteraceae				
Carduus sp.	f	21		Eu
Eupatorium cannabinum L.	f	72 + fr		Eu
Taraxacum tanaiticum Dorof.	f	8	+	Eu

of these taxa were represented by single specimens, usually badly preserved, originating from genera difficult to identify (e.g. *Carex*, *Potentilla*, *Sparganium*, and *Viola*). The fruits of similar species within these genera differed so slightly relative to one another that their precise determination was often impossible.

In the Kholmech flora tree and shrub remains, excluding *Betula*, were represented by single fruits or only by fragments. In relation to the great amounts of deposits studied, the number of tree remains was low. However, these were quite distinct and 18 taxa of tall deciduous trees (*Acer*, *Alnus*, *Betula*, *Carpinus*, *Quercus*, and *Tilia*), understorey trees and shrubs (*Corylus*, *Crataegus*, *Myrica*, *Sambucus*, *Spiraea*, *Staphylea*, and *Swida*) were distinguished. Coniferous trees in mixed forest must have grown further from the place of sedimentation, as indicated by palynological data (Rylova 1982). Pollen grains of several species of *Pinus*, also *Abies*, *Larix*, *Picea*, *Podocarpus*, *Sciadopitys*, and *Tsuga* were noted in the profile.

The Pliocene forest flora was even more complex than that prevailing today. In addition to taxa associated with current European species (*Alnus* cf. *glutinosa* (L.) Gaertn., *Betula cholmechensis* Dorof. (ancestor of the present-day birch from the *Alba* section), *Carpinus* sp., *Quercus* sp., *Acer* sect. *Platanoidea* Pax and others), which doubtless dominated in the forest at that time, species of other geographical elements also grew there. For example, we may cite the North American species (*Acer* cf. *negundo* L., *Staphylea* cf. *trifolia* L. and an extinct species, *Betula longisquamosa* Mädler, which may be compared to the North American *Betula nigra* L.; Tab. 2) and east-Asiatic elements (*Spiraea gomeliana* Dorof. and *Swida gorbunovii* (Dorof.) Negru; Tab. 3).

Table 2. North American element in the Kholmech flora

Fossil taxa	Extant North American species
Acer cf. *negundo* L.	*Acer negundo* L.
Carex szaferi Dorof.	*Carex squarrosa* L., *C. lurida* Wahl.
Cyperus glomeratoides Wieliczk. & Zastaw.	*Cyperus distinctus* Steud., and others
Decodon gibbosus (E.M. Reid) Nikit.	*Decodon verticillatus* Ell.
D. globosus (E.M. Reid) Nikit.	*D. verticillatus* Ell.
Scirpus pliocenicus Szafer	*Scirpus fluviatilis* (Torr.) Gray
Pilea cantalensis (E.M. Reid) Dorof.	*Pilea pumila* (L.) Gray
Proserpinaca europaea Dorof.	*Proserpinaca palustris* L.
P. reticulata C. & E.M. Reid	*P. pectinata* Lam.
Naumburgia subthyrsiflora Nikit.	*Lysimachia quadrifolia* L.
Scirpus atroviroides Dorof.	*Scirpus atrovirens* Willd., and others
Schoenoplectus lucens Wieliczk. & Zastaw.	*Schoenoplectus debilis* Pursh, and others
Staphylea cf. *trifolia* L.	*Staphylea trifolia* L.

Table 3. East-Asiatic element in the Kholmech flora

Fossil taxa	Extant east-Asiatic species
Potamogeton borysthenicus Dorof.	*Potamogeton manshuriensis* A. Benn.
P. felixii Dorof.	*P. fryeri* A. Benn.
Eleocharis praemaximowiczii Dorof.	*Eleocharis maximowiczii* Zinserl.
Carex klarae Mai	*Carex bohemica* Schreb. (Japan populations)
Sparganium cf. *japonicum* Roth	*Sparganium japonicum* Roth
Polygonum pliocenicum Dorof.	*Polygonum japonicum* Meissn.
Urtica pliocenica Dorof.	*Urtica platyphylla* Wedd.
Rubus cf. *sachalinensis* Leveille	*Rubus sachalinensis* Leveille
Lycopus cholmechensis Wieliczk. & Zastaw.	*Lycopus lucidus* Turcz.
Patrinia cf. *rupestris* (Pall.) Juss.	*Patrinia rupestris* (Pall.) Juss.
Spiraea gomeliana Dorof.	*Spiraea betulifolia* Pall.

Among herbs the domination of European elements was marked. However, it should be pointed out that the boundaries separating European, Eurasian and east-Asiatic elements were, in many cases, somewhat arbitrary. This was particularly true for extinct species whose morphological structure could have been associated with several extant species of different geographical distributions, such as *Alisma plantago-minima* (Nikit.) Dorof. ex Wieliczk. equally close to the east-Asiatic *A. orientale* (Sam.) Juz. and the North American *A. triviale* Pursh., *Hypericum tertiaerum* Nikit. seeds were similar to those of the Far-Eastern *H. japonicum* Bl., as well as to those of the North American *H. virginicum* L. Similarly *Selaginella reticulata* Dorof. & Wieliczk. was associated with the Siberian species *S. sibirica* (Milde) Hieron and with the North American *S. oregona* (DC.) Eaton and *S. wallacei* Hieron. However, most of the species in the Kholmech flora were related to species in the European flora: *Pilularia pliocenica* Dorof. was close to *P. globulifera* L.; *Potamogeton praenatans* Dorof. and *P. margaritae* Dorof. were comparable to European morphotypes of *Potamogeton natans* L.; *Potamogeton obtusus* Dorof. and P. *obtusatus* Dorof. had endocarp design structure similar to that of *P. obtusifo-*

lius Mert. & Koch; *P. pseudoacutifolius* Dorof. was probably an ancestor of *P. acutifolius* Link.; the extinct Pliocene species *Caulinia palaeotenuissima* Dorof. was similar to *C. tenuissima* (A. Br.) Tzvel.; *Najas major-pliocenica* Dorof. ex Wieliczk. seeds fully corresponded to seeds of some forms of *N. major* All.; *Acorus palaeocalamus* Dorof. differed slightly from *A. calamus* L.; *Ceratophyllum dorofeevii* Wieliczk. & Zastaw. seeds were anatomically different but morphologically similar to those of *C. demersum* L.; the newly described species *Schoenoplectus lacustroides* Wieliczk. & Zastaw. and *S. lucens* Wieliczk. & Zastaw. were similar to the extant *S. lacustris* (L.) Palla and *S. bucharicus* Roshev respectively; the fossil fruits of the Pliocene species *Ranunculus pliocenicus* Dorof. and *R. pseudoflammula* Dorof. were close to those of the extant European *R. auricomus* L., *R. cassubicus* L,. and *R. flammula* L., although they differed slightly in shape. Further examples could be given, because within many extant Holarctic or even cosmopolitian genera such relationships were characteristic (e.g. in *Carex*, *Myriophyllum* and some species of *Potamogeton* and *Schoenoplectus*).

In cases where it was difficult to decide whether a species was extant or fossil the word “fossilis” was added to the name of the extant species. It was introduced to the palaeobotany of the Neogene by Reid (1920). It concerned fossil seeds which were of similar morphological structure to those of extant species but differed somewhat in size, shape or surface sculpture. The taxonomic rank of these features often happened to be ambiguous, particularly in specimens found singly (e.g. *Cicuta, Cyperus*, *Damasonium*, *Physalis*, *Stellaria*, and *Valeriana*) or in taxa showing great variability. Then they formed various morphotypes in different parts of their area (*Lemna*, *Oenanthe* and *Sagittaria*). The North American *Azolla* and species widespread in Europe such as *Baldellia ranunculoides* (L.) Parl., *Valeriana simplicifolia* (Rchb.) Kabath, the Eurasian *Damasonium alisma* Mill., *Sagittaria sagittifolia* L., *Hydrocharis morsus-ranae* L., *Lemna trisulca* L., *Cicuta virosa* L., *Oenanthe aquatica* (L.) Poir., the Holarctic *Sparganium emersum* Rehm., *Cyperus fuscus* L., *Stellaria holostea* L., *Physalis alkekengi* L., and the cosmopolitan *Chenopodium album* L. were included in this group.

It should be noted that in many cases the relation between the Pliocene taxa and their extant counterparts was far from clear. It seems that in the Pliocene, especially the Early Pliocene, there were far fewer finally formed extant species than might have been supposed in 1980s (e.g. Jahn et al. 1984, Bůžek et al. 1985).

The fossil species closely related to present-day East-Asian species formed a relatively small group in the Kholmech flora (Tab. 3). Within it were taxa which are presently found in the eastern part of Siberia. Fossil species closely related to extant North American species distributed mainly in the eastern part of the continent from the Great Lakes to the Gulf of Mexico (Tab. 2) were almost equally as numerous as the East-Asian and Siberian elements.

Defining the relationship between some extinct species of the Kholmech flora and present-day taxa was problematic because forms with the same or similar morphological features were not found in the available reference collections. For example *Azolla pseudopinnata* Nikit., was different from *A. pinnata* R.Br. (south-eastern Asia, America, Australia, New Guinea, Madagascar) and *A. nilotica* Decais. (eastern Africa). The megaspores of *Selaginella pliocenica* Dorof., were somewhat similar in structure to those of several extant American species of that genus but none of them could be accepted as related. *Sparganium noduliferum* C. & E.M. Reid only slightly resembled the North American *S. androcladum* (Englm.) Morong, while *Caulinia scrobiculata* Dorof. seeds differed in morphology and testa anatomy from the extant species *C. tenuissima* (A. Br.) Tsvel. There was a lack of forms in the reference fossil flora similar to the three species of *Brasenia* distinguished. The same was true for *Nymphaea borysthenica* Dorof., *N. pusilla* Dorof. and *Nuphar canaliculata* C. & E.M. Reid, although some comparable morphological seed features were observed in tropical representatives of these genera. The question of how to explain the relations among *Salvinia tuberculata* Nikit., *S. glabra* Nikit., *Typha aspera* Dorof., *T. pseudoovata* Dorof., *Potamogeton longistylus* Dorof., *P. cholmechensis* Dorof., *Dulichium vespiforme* C. & E.M. Reid, and others was left with no answer. It would seen that these taxa were relics of an older Tertiary flora, descendants of ancient taxa that did not adapt themselves to the cooler Pliocene climate, did not survive in refugia and became extinct.

RECONSTRUCTION OF THE VEGETATION AND PALAEOENVIRONMENT

The Kholmech flora originated from biogenic deposits sedimented in a small isolated water body. The small thickness of the flora-bearing deposits (less than 1 m) and their homogeneous lithological composition provide evidence that this flora represented a single floristic complex, within which it is impossible to investigate floristic variation in time. However, the complex has been preserved in good conditions and represents the vegetation which grew in this area over several thousands or even tens of thousands of years. The material under study was obtained from a sample of large volume which seemed to be representative. It should be stressed that there was a complete absence of forms of different ages redeposited from elsewhere. Hence it has been possible to obtain a picture of the taxonomic composition of an undisturbed biocoenosis and of the whole natural environment during the short stage of Pliocene flora development in the East-European region.

The environmental conditions during the formation of the Kholmech flora are reflected in great precision by the quantitative and qualitative relations among the herbs, in which hydro- and hygrophytes dominated. Among the hydrophytes three plant groups could be distinguished. The first contained bottom-rooted submerged aquatic plants (*Batrachium*, *Caulinia*, *Ceratophyllum*, *Hippuris*, *Myriophyllum*, *Najas*, *Pilularia*, the majority of *Potamogeton* species, *Proserpinaca*, and *Stratiotes*). They formed a dense submerged jungle.

To the second group belonged bottom-rooted aquatics with floating leaves (*Brasenia*, *Hydrocharis*, *Nuphar*, *Nymphaea*, and some *Potamogeton* species). The plants covered the water surface with a thick carpet.

Gaps among the floating leaves were occupied by plants of the third group, free-floating aquatics with short roots (*Aldrovanda*, *Azolla*, *Lemna*, and *Salvinia*). All the above mentioned groups of hydrophytes were represented in the Kholmech flora by very abundant megaspores, seeds and fruits. Among plants of the first group *Najas major-pliocenica* Dorof. ex Wieliczk., *Caulinia palaeotenuissima* Dorof., *Stratiotes intermedius* (Hartz) Chandl., some *Potamogeton* species, especially *P. cholmechensis* Dorof. (1786 endocarps) were represented most abundantly. In the second group, remains of *Brasenia angustata* Dorof., *B. obovata* Dorof., *Nymphaea borysthenica* Dorof., *Nuphar canaliculata* C. & E.M. Reid, *Potamogeton* species from the *Natans* (*P. margaritae* Dorof.), and *Manshuriensis* (*P. borysthenicus* Dorof.) groups were abundant. The third group was represented by exceptionally numerous megaspores of *Salvinia glabra* Nikit. (over 3000), *Azolla pseudopinnata* Nikit. (over 1000) and seeds of *Lemna trisulca* L. foss. (over 500). Such a high number of hydrophyte remains in all these groups is very rare in fossil floras. They show that the plants occupied the place of sedimentation, where habitat conditions were particlarly favourable for their growth.

The above mentioned water body was small, rather shallow, sheltered from the wind, with a complete spectrum of aquatics in relatively warm water. It was surely a small lake, being part of the old river-bed of the Pra-Dnieper. The water body was surrounded by quite a narrow belt of riverine vegetation where hygrophytes, particularly heliophytes, prevailed (Fig. 17). Plants growing along the margin of the lake were included in this group. They were tolerant of a wide range of water conditions from periodical flooding to desiccation

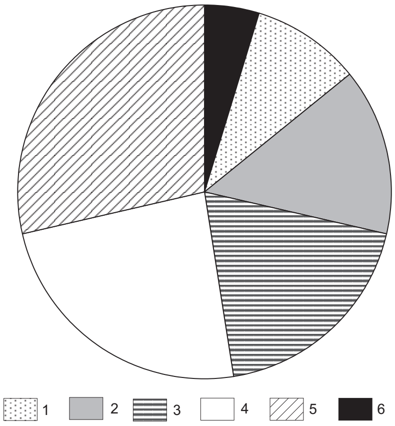

Fig. 17. Percentage of fossil plant remains of various ecological groups in the Pliocene flora of Kholmech. **1** – submerged bottom-rooted aquatic plants, **2** – bottom rooted aquatic plants with floating leaves, **3** – floating aquatics with or without roots, **4** –littoral plants, **5** – plants of fens, sandy banks and woods, **6** – trees and shrubs

but they could not survive long-lasting inundation (Hejny 1960). Species of *Sparganium*, *Typha*, *Schoenoplectus*, *Scirpus*, *Alisma*, *Sagittaria*, *Acorus*, *Iris*, *Baldellia*, *Damasonium*, *Cicuta*, *Oenanthe*, *Decodon*, *Dulichium*, *Cyperus*, and some *Carex* species were included in this group. Almost all the plants contained in it were equally frequent, with no dominants, for example *Alisma plantago-minima* (Nikit.) Dorof. ex Wieliczk., *Sagittaria sagittifolia* L. foss., *Schoenoplectus lacustroides* Wieliczk. & Zastaw., *Scirpus pliocenicus* Szafer, *Decodon gibbosus* (E.M. Reid) Nikit., and *Carex rostrata-pliocenica* Nikit. Seeds and fruits of this group usually easily entered the place of sedimentation, so the presence of fewer of their remains than those of hydrophytes truly reflects the relationship between these groups in the different plant communities of Kholmech.

Outside the belt of riverine vegetation, a wide zone of swamps, wet meadows and shrubby thickets was represented by the highest number of taxa in the Kholmech flora (Fig. 18). Representatives of *Caldesia*, *Eleocharis*, *Pilea*, *Urtica*, *Lychnis*, *Stellaria*, *Ranunculus*, *Thalictrum*, *Euphorbia*, *Potentilla*, *Hypericum*, *Mentha*, *Stachys*, *Lysimachia*, *Lycopus*, *Viola*, *Teucrium*, *Ludwigia*, *Solanum*, *Eupatorium*, and *Menyanthes* were contained in this group. Almost all of them were represented by low numbers of specimens which could be significant because of the high diaspore production in some taxa (e.g. *Eleocharis*, *Urtica*, *Thalictrum*, and *Hypericum*). It is likely that the water body was surrounded by a plain extending for many kilometres. When one considers that the present-day valley of the Pripyat', the main river of the Belorussian Poles'e, is in some places over 70 km wide, it is highly likely that the swampy habitats of the Pliocene primeval rivers in southern Belarus covered similar or maybe even larger areas. Fossil remains of this plant group had little prospect of reaching the place of sedimentation of the fossil flora, even during flood. However, the proportions of riverine, aquatic and swamp-meadow plants in the Kholmech flora were comparable with the extant biocoenosis of hydro- and hygrophytes. This provides further evidence of the indigenous origin of the flora and the undisturbed nature of the floristic complex of Kholmech, correctly recognized by Mai (1995b) as one of the standards for the Pliocene of eastern Europe.

A small part of the Kholmech flora did consist of plants of disturbed habitats, i.e. bank landslides and sandy shallows, separated by Nikitin (1957) into an "erosionophilous" plant group. *Chenopodium*, *Polycnemum*, some *Rumex* species and *Polygonum* were included within it. These species were not very frequent in the flora, indicating the small role played by disturbed habitats in the neighbourhood of the water body.

In the elevated areas, which could have been many tens of kilometres from the water body, thin, probably insular mixed forest with dominant deciduous trees and shrubs occurred. At the end of the Neogene, the forest, as a result of climatic cooling, was much poorer than in the Miocene but it still differed considerably from the present-day forest in this area. A similar, poor representation of trees and shrubs was characteristic for the Kinelian floras of the Grodno region (Dorofeev 1967) which are of the same age as the Kholmech flora. It shows the lack of widespread forest to have been a regional phenomenon, at least for this territory at that time.

It should be noted that the composition of forest communities in the Kholmech flora is distinctly different from that of forest in the Late Pliocene represented in the Dvorets flora (Dorofeev 1986a, Vielichkevich 1990). The very high number of coniferous remains, particularly of *Larix* and *Pinus* followed by *Picea* and *Juniperus*, was characteristic of the Dvorets flora. The almost complete absence of coniferous trees, less frequent remains of trees and shrubs and the presence of taxa such as *Acer*, *Staphylea*, *Betula longisquamosa* Mädler, and *Swida gorbunovii* (Dorof.) Negru in the Kholmech flora were responsible for this difference.

GEOLOGICAL AGE AND CORRELATION OF THE KHOLMECH FLORA

One way of defining the age of a fossil flora is to express the number of extinct species as a percentage of all the taxa identified. In the Kholmech flora almost 48% of all taxa are extinct. The species could be divided into three groups differing in abundance and stratigraphic value. The first group, relatively small, comprised species such as *Sparganium noduliferum* C. & E.M. Reid, *Stratiotes inter-*


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medius (Hartz) Chandler, *Caldesia cylindrica* (E.M. Reid) Dorof., *Dulichium vespiforme* C. & E.M. Reid, *Scirpus pliocenicus* Szafer, *Brasenia tuberculata* C. & E.M. Reid, *Nuphar canaliculata* C. & E.M. Reid, *Ludwgia chandlerae* Knobloch, *Decodon gibbosus* (E.M. Reid) Nikit., *D. globosus* (E.M. Reid) Nikit., *Proserpinaca reticulata* C. & E.M. Reid, and *Betula longisquamosa* Mädler. The presence of these species indicates a close relationship among the Pliocene floras in western and eastern Europe and Siberia.

A second, more numerous, group was formed by species such as *Selaginella pliocenica* Dorof., *Pilularia pliocenica* Dorof., *Salvinia aphtosa* Wieliczk., *S. cerebrata* Nikit., *S. glabra* Nikit., *S. tuberculata* Nikit., *Azolla pseudopinnata* Nikit., *Lobelia pliocenica* (Dorof.) Mai, *Potamogeton obtusus* Dorof., *P. panormitanoides* Dorof., *P. palaeorutilus* Dorof., *Caulinia palaeotenuissima* Dorof., *Alisma plantago-minima* (Nikit.) Dorof. ex Wieliczk., *Carex rostrata-pliocenica* Nikit., *C. szaferi* Dorof., *Pilea cantalensis* (E.M. Reid) Dorof., *Urtica pliocenica* Dorof., *Polygonum pliocenicum* Dorof., *Ranunculus tanaiticus* Dorof., *R. pseudoflammula* Dorof., *R. pliocenicus* Dorof., *Aldrovanda eleonorae* Nikit., *Hypericum tertiaerum* Nikit., *Myriophyllum praespicatum* Nikit., *Swida* cf. *gorbunovii* (Dorof.) Negru, *Naumburgia subthyrsiflora* (Nikit.) Nikit., *Teucrium tatianae* Nikit., *T. pripiatense* (Dorof.) Wielczk. & Zastaw., and *Taraxacum tanaiticum* Dorof., all described from the Pliocene floras of the East-European plain, Middle Volga basin, Pre-Ural basin and western Siberia. This group of species clearly indicated a relationship connecting the Kholmech flora with the Pliocene floras of the Upper Don basin (Shik 1985), the Kinelian series of the Middle Volga basin (Dorofeev 1956, 1957), Bashkiria (Dorofeev 1960a, 1962, 1977b) and western Siberia (Dorofeev 1963a). Some of these species occurred also in the Pliocene of Moldova (Negru 1972, 1979, 1986), Poland (Jahn et al. 1984, Baranowska-Zarzycka 1988), Lithuania (Rishkiene 1979), the Czech Republic (Bůžek et al. 1985) and Germany (Mai & Walther 1988, and others), indicating close palaeogeographical associations between the eastern and western parts of the Eurasian continent during the Pliocene.

The third group of species was the most numerous. All were common to the Kholmech and Late Pliocene floras from the neighbouring site of Dvorets (Dorofeev 1986a, Velichkewicz 1990). *Selaginella reticulata* Dorof. & Wieliczk., *Typha aspera* Dorof., *T. pseudoovata* Dorof., almost all species of *Potamogeton* (e.g. *P. borysthenicus* Dorof., *P. cholmechensis* Dorof., and *P. longistylus* Dorof.), *Caulinia scrobiculata* Dorof., *Najas major-pliocenica* Dorof. ex Wieliczk., *Carex paucifloroides* Wieliczk., *C. klarae* Mai, *Cyperus glomeratioides* Wieliczk. & Zastaw., *Eleocharis praemaximowiczii* Dorof., *Scirpus atroviroides* Dorof., *Schoenoplectus lacustroides* Wieliczk. & Zastaw., *Sch. palaeobucharicus* Wieliczk. & Zastaw., *Sch. lucens* Wieliczk. & Zastaw., *Acorus palaeocalamus* Dorof., *Myrica borysthenica* Dorof. & Wieliczk., *Betula cholmechensis* Dorof., *Nymphaea borysthenica* Dorof., *N. pusilla* Dorof., *Brasenia angustata* Dorof., *B. obovata* Dorof., *Ceratophyllum dorofeevii* Wieliczk. & Zastaw., *Spiraea* cf. *gomeliana* Dorof., *Hypericum foveolatum* Dorof., *Proserpinaca europaea* Dorof., *Lysimachia nikitinii* Dorof., *Lycopus cholmechensis* Wieliczk. & Zastaw., *Mentha pliocenica* Dorof., and *Stachys pliocenicus* Dorof. constituted this group. Some species could have been endemic plants for the whole Belorussian Pliocene flora. Others, including those described for the first time in this paper, could have been cited earlier for the European Pliocene flora bearing names of extant taxa accompanied by “cf.”, “ex gr.”, “sp.”, “foss.”. However, comparative studies of original material would be needed to resolve this problem.

It should be noted that it was difficult to settle relationships among Pliocene floras from distant regions on the basis of their taxonomic compositions. The difficulties could have arisen from different approaches to the taxo-

Fig. 18. Reconstruction of the Pliocene vegetation on the basis of fossil plant remains found in Kholmech (drawing by A. Stańczyk) **1** – *Acer*, **2** – *Betula*, **3** – *Tilia*, **4** – *Quercus*, **5** – *Picea*, **6** – *Typha*, **7** – *Sagittaria*, **8** – *Alisma*, *Caldesia*, **9** – *Stratiotes*, **10** – *Brasenia*, **11** – *Sparganium*, *Carex*, **12** – *Caulinia*, *Najas*, **13** – *Potamogeton*, **14** – *Azolla*, *Salvinia*, **15** – *Nuphar*, **16** – *Pilularia*, **17** – *Hippuris*, *Myriophyllum*, **18** – *Ceratophyllum*, **19** – *Lemna*, **20** – *Nymphaea*, **21** – *Acorus*, *Iris*, **22** – *Eleocharis*, **23** – *Euphorbia*, **24** – *Comarum*, *Potentilla*, **25** – *Cyperus*, **26** – *Lysimachia*, **27** – *Ranunculus*, **28** – *Lycopus*, *Stachys*, **29** – *Ajuga*, *Teucrium*, **30** – *Thalictrum*

nomy of fossils, different degrees of morphological differentiation in species and intraspecies and the rates of evolution within particular genera and species in the Pliocene flora. In the beginning, European palaeobotanists identified new, extinct species, very carefully estimating the age of the fossil flora on the basis of well-known and widespread species described mainly at the beginning of the 20th century. Representatives of the Russian palaeocarpological school (P.A. Nikitin, P.I. Dorofeev), and their successors in Belarus, described extinct, stenochronous and endemic species for each new Neogene flora. Some of these were found later in central and west-European floras.

In connection with the age of the Kholmech flora, attention must be paid to the correlation table (Tab. 4) arranged by Iosifova on the basis of Dorofeev's data (Iosifova 1985). Dorofeev placed the Kholmech flora in the upper part of the Kimmerian (=Dacian) and accepted it as of the same age as the following floras: the Daumantai in Lithuania, the Kryvobor'e and Uryv from the Upper Don basin and also the III chebien'kovsky horizon in Bashkiria. The Dan'shino flora was placed by Dorofeev in the lower part of the Akchagylian (=Romanian), and the Dvorets flora in the middle of this period. He compared the Dvorets flora to those at the Shekhman', Ranino and Manovitsy sites. The correlation of the upper part of the Pliocene deposits in this area has been discussed in detail in another paper (Velichkevich 1990).

BELARUS AND LITHUANIA

Fossil floras of the Kholmech type, i.e. floras of the same age, are known also at other sites in Belarus, for example in Kolochyn village whose flora was described by Yakubovskaya (1978) on the basis of small samples collected from excavations. This site is located about 10 km upstream from Kholmech village along the Dnieper river. Fossil tree remains comprising several species of *Betula*, including *Betula* ex sect. *Costatae* (Regel) Kohene, which probably belongs to *B. longisquamosa* Mädler, were found there. A large group of extinct herb species, known also in the Kholmech flora, such as *Salvinia glabra* Nikit., *S. tuberculata* Nikit., *Azolla pseudopinnata* Nikit., *Selaginella reticulata* Dorof. & Wieliczk., *Typha aspera* Dorof., *T. pseudoovata* Dorof., *Potamogeton borysthenicus* Dorof., *P. cholmechensis* Dorof., *P. pseudoacutifolius* Dorof., *P. longistylus* Dorof., *Alisma plantago-minima* (Nikit.) Dorof. ex Wieliczk., *Najas* (*Caulinia*) *palaeotenuissima* Dorof., *Stratiotes* cf. *intermedius* (Hartz) Chandler, *Acorus palaeocalamus* Dorof., *Nuphar canaliculata* C. & E.M. Reid, *Aldrovanda*

Table 4. Correlation scheme of Pliocene after Dorofeev (Iosifova 1985)

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<tr><th colspan="2">STAGES, SUBSTAGES</th><th colspan="2">UPPER DON</th><th>VOLGA</th><th>BELARUS</th><th>LITHUANIA</th><th>ZAKARPAT'E</th></tr>
<tr><td colspan="2" rowspan="2">Apsheron</td><td colspan="2">Il'inskie layers Moiseevo</td><td rowspan="3">?</td><td rowspan="3">?</td><td rowspan="6">Shlave</td><td rowspan="3"></td></tr>
<tr><td colspan="2" rowspan="2">?</td></tr>
<tr><td rowspan="4">Akchagylian</td><td>upper</td></tr>
<tr><td>middle</td><td colspan="2">Goryanskaya serie-Shekhman', Ranino Manovitsy</td><td>Zilim-Vasil'evsky horizon</td><td>Dvorets</td><td>Malaya Began'</td></tr>
<tr><td rowspan="2">lower</td><td rowspan="3">Uryvskaya serie</td><td rowspan="2">Dan'shino</td><td>Kumurlinsky horizon</td><td rowspan="2"></td><td rowspan="3"></td></tr>
<tr><td>Karlamansky horizon</td></tr>
<tr><td colspan="2">Kimmerian</td><td>Krivobor'e Uryv</td><td>III Cheben'kovsky horizon</td><td>Kholmech</td><td>Daumantai</td></tr>
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eleonorae Nikit., *Potentilla pliocenica* E.M. Reid, *Brasenia tanaitica* Dorof. (=*B. obovata* Dorof.), *Nymphaea borysthenica* Dorof., *N. pusilla* Dorof., *Hypericum tertiaerum* Nikit., *Decodon gibbosus* (E.M. Reid) Nikit., *D. globosus* (E.M. Reid) Nikit., *Taraxacum tanaiticum* Dorof., *Teucrium tatianae* Nikit., and *Lycopus antiquus* E.M. Reid (= *L. cholmechensis* Wieliczk. & Zastaw.) was also found. The great similarity of the Kolochyn flora to that at Kholmech indicated their similar age and provided evidence that the Pliocene deposits of Loev-Rechitsa, Pridnieprov'e district were formed in several, mutually isolated water bodies within the valley of the Pra-Dnieper. During periods of flood they could have become joined, resulting in an exchange of diaspores which would reduce the differences between the floristic complexes.

Floras of the Kholmech type are not confined to south-eastern Belarus but are also to be found in the west of the country near Grodno. Samples from there, studied by Dorofeev (1967), came from the following borings: No. 505 at a depth of 43.45–46.0 m; No. 510, depth 40.2–40.4 m; No. 3, depth 82.6–87.0 m; No. 2, depth 99.1–104.1 m. They contained rather sparse carpological remains which included species typical for the Pliocene and characteristic for the Kholmech flora such as *Salvinia glabra* Nikit., *Azolla pseudopinnata* Nikit., *Pilularia* cf. *globulifera* L. (=*P. pliocenica* Dorof.), *Alisma plantago-minima* (Nikit.) Dorof. ex Wieliczk., *Aldrovanda eleonorae* Nikit., *Sparganium noduliferum* C. & E.M. Reid, *Stratiotes intermedius* (Hartz) Chandler, *Dulichium vespiforme* C. & E.M. Reid, *Hypericum tertiaerum* Nikit. and *Proserpinaca pterocarpa* Dorof. Trees and shrubs were represented by seeds and needles of the coniferous plants *Pinus*, *Picea*, *Larix* and the deciduous *Salix*, *Betula*, *Alnus*, *Pterocarya*, *Crataegus*, and *Daphne*, which indicated that mixed forest was much more abundant in this area than it is today. Coniferous trees were present in relatively high numbers in these floras, whereas in south-eastern Belarus they were much less frequent. Among the fossil material from the above mentioned borings were older Pliocene deposits containing taxa such as *Epipremnum reniculatum* (Ludw.) Kirchh., *Myrica goretskyi* Dorof., *Aracispermum ovale* Dorof., *Aldrovanda* cf. *clavata* Dorof., *Potamogeton tertiarius* Dorof., *Comptonia costata* Dorof., and *Carpolithus rosenkjaeri* Hartz. The Kholmech species *Sparganium noduliferum* C. & E.M. Reid, *Decodon globosus* (E.M. Reid) Nikit., *Hypericum tertiaerum* Nikit., and *Caldesia cylindrica* (E.M. Reid) Dorof. were also present in the Grodno complex, but were less frequent there. In Dorofeev's opinion (1967) the latter could have been a separate floristic complex, transitional from the Late Miocene to the Early Pliocene, but he still included it in the Early Pliocene.

Yakubovskaya (1977) found a Pliocene flora, of the same type as that at Kholmech, near Novogrudok (central-western Belarus), in deposits of the middle horizon of the Bielitsa series. The flora-bearing deposits occurred in many borings located north of the city, at different depths from 50 to 156 m. She found a group of characteristic taxa consisting of extinct Neogene species known also in the Kholmech flora (*Salvinia glabra* Nikit., *S. tuberculata* Nikit., *Azolla pseudopinnata* Nikit., *Potamogeton planus* Nikit. (= *P. longistylus* Dorof.), *Myriophyllum praespicatum* Nikit., *Stratiotes intermedius* (Hartz) Chandler, *Scirpus atrovirens* Muhl. (=*S. atroviroides* Dorof.), *Najas* (*Caulinia*) *lanceolata* C. & E.M. Reid (= *C. palaeotenuissima* Dorof.), *Aldrovanda eleonorae* Nikit., *Decodon globosus* (E.M. Reid) Nikit., *Nuphar canaliculata* C. & E.M. Reid, and others). Older species, missing from the Kholmech flora (*Salvinia intermedia* Nikit., *S. miocenica* Dorof., *Azolla* ex gr. *poltavica* Dorof., and others), occurred rather infrequently in the same deposits. This was probably a consequence of the specific regional character of the Pliocene flora in different parts of Belarus.

The flora at the Daumantai site in south-eastern Lithuania has not yet been completely documented. Data already published (Rishkiene 1971, 1979) has indicated univocally its Pliocene age. It contained some species also present in the Kholmech flora (*Salvinia glabra* Nikit., *Azolla pseudopinnata* Nikit., *Pilularia pliocenica* Dorof., *Sparganium noduliferum* C. & E.M. Reid, *Dulichium vespiforme* C. & E.M. Reid, *Betula longisquamosa* Mädler, and *Teucrium tatianae* Nikit.). A rich collection of macroremains from that site, collected directly from the exposure in the 1970s by Belorussian palaeobotanists accompanied by Dorofeev, is housed in the Palaeobotanical Museum of the Institute of Geological Sciences, National

Academy of Sciences of Belarus in Minsk. After examining the material Velichkevich (pers. observ.) found that the flora comprised over 100 taxa with their fossil fruits and seeds and had numerous extinct species in common with the Kholmech flora. The Daumantai flora contained the taxa *Salvinia cerebrata* Nikit., *Selaginella pliocenica* Dorof., *Najas major-pliocenica* Dorof. ex Wieliczk., *Caldesia cylindrica* (E.M. Reid) Dorof., *Stratiotes intermedius* (Hartz) Chandler, *Carex paucifloroides* Wieliczk., *Brasenia tuberculata* C. & E.M. Reid, *Ranunculus pseudoflammula* Dorof., *Aldrovanda* cf. *eleonorae* Nikit., *Decodon gibbosus* (E.M. Reid) Nikit., *D. globosus* (E.M. Reid) Nikit., *Naumburgia subthyrsiflora* (Nikit.) Nikit., *Lycopus cholmechensis* Wieliczk. & Zastaw., and many other taxa of the genera as *Typha, Potamogeton, Sagittaria, Scirpus, Schoenoplectus, Carex, Nymphaea, Hypericum, Mentha, Stachys, Swida, Lysimachia,* and *Teucrium*. Present also were older taxa such as *Leitneria, Boehmeria* cf. *sibirica* Dorof., *Liriodendron, Phyllanthus, Vitis, Nyssa, Melastomatites, Acanthopanax, Trichosanthus, Circaea, Euryale,* and *Spirematospermum wetzleri* (Heer) Chandler, which were absent from the Kholmech flora. The plant remains of these taxa were not frequent and often incomplete, but their presence clearly made this flora older than the Kholmech one. The remains, doubtless traces of a Miocene flora, indicate the Daumantai flora to be of Early Pliocene age close to the lower Kholmech series of the Pliocene in Belarus (Yakubovskaya 1984).

RUSSIA – UPPER DON BASIN

The Pliocene floras in the Upper Don basin in central Russia were closely related to the Kholmech flora in respect of their geographical position and taxonomic composition. The classic floras of Kryvobor'e, Uryv and Chertovitskoe (Nikitin 1926, 1927, 1928, 1957) were located there. The Pliocene deposits in the Upper Don basin were the first to be investigated carpologically. Later, in 1964–1978, Dorofeev performed complementary palaeobotanical studies of the above mentioned sites on the basis of newly collected material (Dorofeev1985). In 1979 Dorofeev published the results of a study on the interesting Late Pliocene flora of Dan'shino in the Lipetsk district of central Russia. Correlation of the Kholmech flora with those of the Krivobor'e type was straightforward because of their similar taphonomy and formation under comparable habitat conditions.

The Krivobor'e flora was the richest of those in the Pliocene localities of the Upper Don basin (Kholmovoy 1985). Most of its exotic species were present also in the Kholmech flora (*Salvinia tuberculata* Nikit., *S. glabra* Nikit., *Azolla pseudopinnata* Nikit., *Selaginella reticulata* Dorof. & Wieliczk., *Lobelia pliocenica* (Dorof.) Mai, *Potamogeton borysthenicus* Dorof., *Stratiotes intermedius* (Hartz) Chandler, *Carex rostrata-pliocenica* Nikit., *Brasenia tuberculata* C. & E.M. Reid, *Nymphaea borysthenica* Dorof., *N. pusilla* Dorof., *Nuphar canaliculata* C. & E.M. Reid., *Hypericum tertiaerum* Nikit., *Naumburgia subthyrsiflora* (Nikit.) Nikit., and others.

The Uryv flora was different from that of Krivobor'e through the presence of several older taxa (*Typha meotica* Dorof., *Caldesia cylindrica* (E.M. Reid) Dorof., and *Stellera* sp.) and by the absence of a number of taxa characteristic for Krivobor'e (e.g. *Nymphaea borysthenica* Dorof., *N. pusilla* Dorof., and *Nuphar canaliculata* C. & E.M. Reid). The lack of these taxa and *Brasenia tuberculata* C. & E.M. Reid seeds, features of another flora in this area (Chertovitskoe site) was noted. Despite these differences it could be said that all three of the above mentioned floras are of the same type and well-characterized by the Kryvobor'e stage of Pliocene flora development in the East-European plain. Relics of a Miocene flora and also species known from the Early Pliocene in western Europe (Reuver, Brunssum and Swalmen localities; Reid & Reid 1915) such as *Epipremnum crassum* C. & E.M. Reid, *Spirematospermum wetzleri* (Heer) Chandler, and *Sparganium noduliferum* C. & E.M. Reid occurred in these floras, but not very frequently.

Floras of the Kryvobor'e type, the oldest Pliocene floras in the central areas of the East-European Plain (Nikitin 1957), were comparable with those of the Cheben'kovsky III horizon in Bashkiria (Yakhimovich 1981). According to the division of the Pliocene into three parts, as was the practice at that time, Nikitin (1957) regarded these floras as Middle Pliocene. Dorofeev (1985) was of the same opinion, considering the floras to be older than those of the Akchagylian deposits. In accordance with the more recent division of the

Pliocene, the floras should be included in the Kimmerian or upper part of the Kholmech horizon of the Pliocene of Belarus (Azhgirevich et al. 2001).

The flora at the Dan'shino site in central Russia was closely related to that at Kholmech (Dorofeev 1979, 1985). In Dorofeev's opinion the Dan'shino flora was of the same age as those of the Kumurlinsky horizon at Bashkiria, including that from Simbugino, an exposure which he had described earlier (Dorofeev 1977b). The Dan'shino flora, with over 100 taxa, contained about 30 which featured in the Kholmech flora, including such characteristic species as *Azolla pseudopinnata* Nikit., *Pilularia pliocenica* Dorof., *Lobelia pliocenica* (Dorof.) Mai, *Sparganium noduliferum* C. & E.M. Reid, *Potamogeton borysthenicus* Dorof., *P. cholmechensis* Dorof., *Caulinia palaeotenuissima* Dorof., *Stratiotes intermedius* (Hartz) Chandler, *Carex rostrata-pliocenica* Nikit., *Eleocharis pseudoovata* Dorof. (= *E. praemaximowiczii* Dorof.), *Dulichium vespiforme* C. & E.M. Reid, *Nymphaea borysthenica* Dorof., *Brasenia tanaitica* Dorof. (= *B. angustata* Dorof., and *B. obovata* Dorof.), *Ranunculus pseudoflammula* Dorof., *Aldrovanda eleonorae* Nikit., *Proserpinaca reticulata* C. & E.M. Reid, and *P. europaea* Dorof. Similar proportions of present-day species of *Sparganium*, *Sagittaria*, *Scirpus*, *Eleocharis*, *Chenopodium*, and *Polygonum* were found in both floras. Numerous plant remains in the Dan'shino flora were identified only to genus level (*Lycopus*, *Mentha*, *Typha*, *Teucrium*, *Stachys* among others). It is likely that within this group further taxa also present in the Kholmech flora could have been found. However, in the Dan'shino flora the remains of trees and shrubs (*Picea*, *Pinus*, *Larix*, *Myrica*, *Betula*, *Alnus*, *Swida*, and *Weigela*) were much more abundant than at Kholmech. Very frequent *Picea*, *Pinus* and *Larix* remains indicated the dominance of coniferous trees in the mixed forest. On this basis Dorofeev (1979) considered the flora to be of taiga type. Dorofeev (1985) placed the Dan'shino flora at the boundary of the Kumurlinsky and Karlamansky horizons in Bashkiria, above Kholmech.

In view of the new data this does not seem to be entirely correct. The Dan'shino and Kholmech floras are closer in age than Dorofeev (1979, 1985) assumed and they should be included in the upper part of the Kimmerian. In comparison with the Kryvobory'e-Uryv stage they no doubt represent a later stage of Pliocene flora development in the East-European Plain. The Dan'shino and Kholmech floras are clearly younger than those of Krivobory'e-Uryv, but are older than floras of the Dvorets type.

RUSSIA – MIDDLE VOLGA BASIN AND PRE–URAL AREA

The fossil floras of the Kinelian series in the Middle Volga basin are less closely related to the Kholmech flora. The Kinelian series is divided into 6 horizons. The oldest, Chebien'kovsky I, is followed by Chebien'kovsky II, Chebien'kovsky III and the Karlamansky, Kumurlinsky and Zilim-Vassil'evsky horizons. Each Chebien'kovsky horizon is divided into two subhorizons (Yakhimovich 1981). The floras of all three Chebien'kovsky horizons underlying the Akchagylian deposits clearly differed from the fossil floras in central Russia, surely a consequence of the influence of the Ural Mountains nearby. After Dorofeev (1965) in the fossil floras contained in Chebien'kovsky III horizon were found older Miocene taxa such as *Epipremnum crassum* C. & E.M. Reid, *Alnus pliocenica* Dorof., *Filipendula praeulmaria* Dorof., *Scirpus longispermus* Dorof., as well as typical Kholmech taxa such as *Salvinia tuberculata* Nikit., *S. glabra* Nikit., *Azolla pseudopinnata* Nikit., *Caulinia palaeotenuissima* Dorof., *Alisma plantago-minima* (Nikit.) Drof. ex Wieliczk., *Polygonum pliocenicum* Dorof., and *Ranunculus gailensis* E.M. Reid (= *R. sceleratoides* Nikit.). These floras were undoubtedly older than the Kholmech flora and closer to floras of the Krivobor'e type.

The floras situated in the lower part of the Kama river are representative of the Pliocene in central Russia and were worked out by Dorofeev (1956, 1957). Some of them, especially those of the upper part of the Sokol'sky horizon of the Kinelian series in the Middle Volga basin, roughly correspond to the Kholmech flora. Represented in the lower Kama river floras, as in the floras of the Karlamansky and Kumurlinsky types in Bashkiria, were numerous trees and shrubs (*Picea*, *Pinus*, *Tsuga*, *Larix*, *Acer*, *Alnus*, *Betula*, *Morus*, *Mitella* cf. *nuda* L., *Swida*, *Daphne* cf. *altaica* L., *Prunus*, and *Sambucus*), and a group of typical Kinelian herb species as *Salvinia glabra* Nikit., *Azolla pseudopinnata* Nikit., *Caulinia lanceolata* (C. & E.M. Reid) Dorof., *Ranunculus gailensis* E.M. Reid, and *Decodon globosus* (E.M. Reid) Nikit.

The Simbugino flora included in the Kumurlinsky horizon by Dorofeev (1977b) was composed of 127 taxa, half of them identified to species level. It had a markedly forest character containing dominant remains of coniferous trees (*Pinus* sect. *Strobus*, *Pinus* sp., *Picea* sp., *Abies* sp., and *Taxus* cf. *baccata* L.). Deciduous trees and shrubs were represented by *Alnus*, *Corylus*, *Quercus*, *Morus* cf. *alba* L., *Cerasus* cf. *avium* (L.) Moench, *Prunus* cf. *fruticosa* Pall., *Padus uralensis* Dorof., *Acer campestrianum* Dorof., *A. bashkiricum* Dorof., *Paliurus* cf. *spina-christi* Mill., *Frangula* sp., *Tilia tomentosella* Dorof., *T. uralensis* Dorof., *Aralia bashkirica* Dorof., *Eleuterococcus uralensis* Dorof., *Swida*, *Viburnum*, *Sambucus*, and *Weigela*. Although the remains of deciduous trees and shrubs were not very frequent (often single specimens), their taxonomic variety provided evidence of the presence in the area of mixed forest much more diversified than today. The Simbugino flora (Dorofeev 1977b), contained relatively few extinct herb species present in the Kholmech flora: *Salvinia tuberculata* Nikit., *Carex rostrata-pliocenica* Nikit., *C. szaferi* Dorof., *Ranunculus sceleratoides* Nikit. ex Dorof. (= *R. gailensis* E.M. Reid), *Decodon* ex gr. *globosus* (E.M. Reid) Nikit., and *Naumburgia subthyrsiflora* (Nikit.) Nikit. The contribution of extant herb species in the Simbugino flora was also not great, constituting, as in the Kholmech flora, about a quarter of the total number of species present. That the Simbugino and Kholmech floras were so dissimilar resulted from the fact that they derived from vegetation of different, mutually remote, geographical areas: the Simbugino floras originated in the Ural Mountain Foreland (= pre-Ural area) and the Kholmech flora in the lowlands of the Belorussian Poles'e.

There was a marked presence of the Kinelian-Kholmech floristic complex throughout the whole East-European Plain from the Volga river and the Ural Mts in the east across central Russia to Belarus and Lithuania in the west. This complex began to form at the end of the Miocene. It existed during the Kimmerian and the greater part of the Akchagylian and was replaced by a flora of near Quaternary type by the end of the Pliocene (Dvorets complex).

The floras from the Karlamansky and Kumurlinsky horizons of the Kinelian series of Bashkiria, particularly the latter, are closely related to the Kholmech flora. However, these floras are quite poor, with *Salvinia tuberculata* Nikit., *Selaginella pliocenica* Dorof., *Sparganium crassum* Nikit., *Swida gorbunovii* (Dorof.) Negru, *Morus tertiaria* Dorof., *Tilia tuberculata* Szafer, *Acer* sp., *Caulinia lanceolataeformis* Dorof., *Dulichium* aff. *arundinaceum* (L.) Britt., and *Decodon globosus* (E.M. Reid) Nikit. (Dorofeev 1965) being the only species to be recorded also at Kholmech.

CENTRAL AND WESTERN EUROPE

Correlation of the Pliocene floras in the East-European plain with those of the same age in central and western Europe is very difficult at present. Classic Pliocene carpological floras in Europe were studied using old methods so that on the whole only the larger macroscopic remains were taken into account. Details of plant remains in publications in the first half of the 20th century were incomplete. Illustrations of the fossil remains were infrequent and usually of poor quality which made it difficult to understand the composition of the floras and, above all, to compare actual species. Furthermore, the age of these floras was not defined precisely. Despite all this, it can be said that the Pliocene fossil floras in western Europe were of richer taxonomic composition and possessed greater variety than comparable floras in the East-European Plain.

The difficulties inherent in correlating the fossil floras of eastern and western Europe are illustrated by the Pliocene floras of Poland, relatively close geographically to the Russian and Belorussian sites. The Pliocene localities known in Poland, where carpological remains have been studied, such as Krościenko (Szafer 1947–1948), Mizerna (Szafer 1954), Grywałd (Łańcucka-Środoniowa, KRAM-P, unpubl.), and Ruszów (Baranowska-Zarzycka 1988, 1996, Mai & Wähnert 2000) represented older parts of the Pliocene. One complex in Mizerna (comp. p. 229) and the Kłodzko flora can be included in the Late Pliocene. Łańcucka-Środoniowa investigated the Kłodzko flora (Jahn et al. 1984) using the present-day method of palaeocarpological analysis, based on the disintegration of deposits in water and washing them though 0.25 mm mesh sieves. Thus numerous, very small (about 1 mm and less) plant remains, mainly of herbs, were obtained. The Kłodzko flora was composed of 98 taxa, including about 60 identified to species level. In this flora herbs prevailed, just as at Kholmech, comprising nearly 90% of the total fossil flora. The two floras had many extinct species in common such as *Selaginella pliocenica* Dorof., *Betula* sect. *Costata* (= *B. longisquamosa* Mädler), *Betula cholmechensis* Dorof. (determined as *Betula* sect. *Alba*), *Alnus* cf. *glutinosa* (L.) Gaertn., *Ranunculus sceleratoides* Nikit. ex Dorof. (= *R. gailensis* E.M. Reid), *Ludwigia chandlerae* Knobloch (identified as *Hypericum coriaceum* Nikit.), *Decodon globosus* (E.M. Reid) Nikit., *Swida gorbunovii* (Dorof.) Negru, *Caldesia cylindrica* (E.M. Reid) Dorof., *Dulichium vespiforme* C. & E.M. Reid., *D. spathaceum* Rich. (=*D. arundinaceum* (L.) Britt.), *Schoenoplectus pliocenicus* Szafer, *Nuphar canaliculata* C. & E.M. Reid (identified as *Nuphar lutea* (L.) Sm.), and *Potamogeton psuedoacutifolius* Dorof. (identified as *Potamogeton* sp.).

On the basis of revised fossil material from Kłodzko, housed in the W. Szafer Institute of Botany, Polish Academy of Sciences in Kraków (KRAM-P No. 197), it has been stated that among many megaspores of *Salvinia*, identified as *S. indermedia* Nikit. type (Jahn et al. 1984), there are also single megaspores similar to *S. glabra* Nikit., which differed in a number of small details. However, in the authors' opinion, all other megaspores represented unknown, extinct species related to *S. intermedia* Nikit.

Among the nuts of *Carex* spp. distinguished by Łańcucka-Środoniowa (in: Jahn et al. 1984) as "type 2" (KRAM-P 197/46, 65, 71), several were included in the extinct species *Carex szaferi* Dorof. In other samples (KRAM-P 197/50–51, 67, 69), nuts and utricles of *Carex rostrata-pliocenica* Nikit. were identified. One achene of *Pilea cantalensis* (E.M. Reid) Dorof. (KRAM-P 197/158) and some achenes of *Rubus* cf. *sachalinensis* Levl. (KRAM-P 197/182–185) were also found. Nuts identified as belonging to *Schoenoplectus* aff. *triqueter* (L.) Palla were included in the fossil species *Scirpus (Schoenoplectus) liratus* Dorof. described from Dvorets (Dorofeev 1986a). *Schoenoplectus pliocenicus* Szafer from Kłodzko (Jahn et al. 1984) is closer, in respect of nut morphology, to Kholmech specimens of the species than to those specimens from its locus typicus (Krościenko, Szafer 1946–1947). *Scirpus sylvaticus* L. nuts were included in *S. atroviroides* Dorof. Tegmens of *Typha* in the Kłodzko flora were similar to the extant European *Typha latifolia* L. and *T. angustifolia* L., although several specimens were clearly shorter and wider, very similar to *Typha ovata* Dorof. and *T. pseudoovata* Dorof. The only achene of *Urtica urens* L. was very similar to *Urtica pliocenica* Dorof. (KRAM-P 197/241).

The Kłodzko flora, in comparison with that from Kholmech, contained for more numerous remains of trees and shrubs from the abundant and diversified mixed forest. In addition to genera known from the Pliocene in Belarus (*Picea*, *Pinus*, *Abies*, *Betula*, *Alnus*, *Carpinus*, *Acer*, *Swida*, and *Sambucus*), taxa absent from floras in the East-European plain, but frequent in the Pliocene floras of western Europe such as *Cupressus* vel *Chamaecyparis*, *Ostrya* aff. *japonica* Sarg., *Magnolia cor* Ludw., *Liriodendron geminata* Kirchh., *Actinidia* sp., *Meliosma* sp., *Vitis parasylvestris* Kirchh., *Ampelopsis* sp., *Aralia* cf. *longisperma* Dorof., *Cephalanthus kireevskiana* (Dorof.) Ran.-Bobr., and *Weigela szaferi* Łańc.-Środ. were found in the Kłodzko flora.

It is true to say that the Kłodzko and Kholmech floras were most similar to each other in their herbal content.

In Łańcucka-Środoniowa's opinion (in Jahn et al. 1984) the Kłodzko flora, despite clear differences, was closest to the Mizerna II complex (Szafer 1954) which was much more abundant and diversified, a feature which could have resulted from the fact that the complex was formed by plant remains from different habitats and altitudes. On the other hand the Kłodzko flora, extracted from a low number of deposit samples, reflected a local vegetation. According to us, the essential difference between the Kłodzko flora and the Mizerna II complex was not the quantitative differences in the taxa but the presence of plant macroremains in the Mizerna II complex, whose existence in the Late Pliocene of Europe is hard to believe (*Olea*, *Styrax*, *Nyssa*, *Alangium*, *Paliurus*, *Sinomenium*, and others).

Comparison of the Kholmech flora with the Neogene floras of central and western Europe revealed its great similarity to the fossil flora of lacustrine deposits in the Czech Republic, i.e. in the Vildštein Formation (Bůžek et al. 1985). The floristic complex of these sediments was composed of three units of similar age. They complemented one another and formed a quite rich flora (95 taxa) included by the authors in the Late Pliocene. Though the Vildštein Formation flora, as with other floras in western and central Europe, contained far more remains of trees and shrubs than was observed in the Kholmech flora, the two were very close in respect of herb composition, mainly extinct species. There were relatively few common exotic species such as *Sparganium noduliferum* C. & E.M. Reid, *Dulichium vespiforme* C. & E.M. Reid, *D. arundinaceum* (L.) Britt., *Decodon globosus* (E.M. Reid) Nikit., *Carex szaferi* Dorof., *Lobelia pliocenica* (Dorof.) Mai, and *Proserpinaca reticulata* C. & E.M. Reid. However, their presence convincingly demonstrated the doubtless taxonomic similarity of the Kholmech flora with that of the Vildštein Formation, as well as their Late Pliocene age.

On the basis of many good quality photographs of fossil plant remains in the publication of the Vildštein Formation flora (Bůžek et al. 1985), it is possible to define precisely some of the Kholmech taxa which were incomplete or problematic, thereby enhancing the similarity of the two floras. *Brasenia* seeds (58 specimens), quite frequent in the Vildštein Formation flora, were identified as *B.* cf. *tanaitica* Dorof. (Bůžek et al. 1985). While they are in fact similar to this fossil species in shape and size, they are much closer to the Kholmech species *B. obovata* Dorof. (comp. Dorofeev 1984), which was initially identified as *B.* cf. *tanaitica* Dorof. (Dorofeev 1971, Dorofeev & Velichkevich 1971a). *Brasenia* seeds in the Vildštein Formation and Kholmech floras were not only very similar in size (2.5–3.0 × 2.0–2.4 mm and 2.3–2.7 × 1.7–2.2 mm respectively), but were predominantly obovoid, while in the type collection of *B. tanaitica* Dorof. from Dan’shino on the Don (Dorofeev 1974) ovoid or barrel-shaped seeds prevailed. The fact that *Brasenia* seeds from the Vildštein Formation and Khlomech are very similar, while those of Dan’shino stand apart could be accounted for by the similar nature of the territory surrounding the Czech and Belorussian floras, but there is no doubt that it provides evidence of the similarity in age of the two floras.

Ranunculus achenes in the Vildštein Formation flora were identified as *R. flammula* L. Several illustrated achenes are indeed very similar to those of the present-day species (Bůžek et al. 1985, Pl. 7, figs 15–18), while others, more elongated (Bůžek et al., op. cit., Pl. 7, figs 19–23), are closer to those of the fossil species *R. pseudoflammula* Dorof. (Dorofeev 1974), present in the Kholmech flora. This is confirmed by the size of *R. pseudoflammula* Dorof. achenes, which in the Kholmech flora measure 1.1–1.8 × 0.5–1.1 mm, for the type collection in Dan’shino 1.2–1.8 × 0.4–0.9 mm, and for the Vildštein Formation 1.1–1.7 × 0.8–1.1 mm.

The elongate shape of Vildštein *Schoenoplectus* fruits identified as *S.* cf. *lacustris* (L.) Palla (Bůžek et al. 1985, cited as “*lacuster*”), was identical with that of fruits of the extinct species *S. lacustroides* Wieliczk. & Zastaw., described in the present paper. The specimens illustrated in Bůžek et al. (1985, Pl. 17, figs 1–7) differed distinctly from the fruits of the extant *S. lacustris* (L.) Palla in their slightly larger size and more elongate shape.The achenes also did not show the thickened ventral face which is a characteristic feature for extant *S. lacustris* (L.) Palla.

Several endocarps of *Proserpinaca reticulata* C. & E.M. Reid illustrated in Bůžek et al. (1985, Pl. 16, figs 6–8) are more similar to another species, *P. europaea* Dorof., present also in the Kholmech flora. At least two endocarps of *Caldesia* (Bůžek et al. op.cit., Pl. 19, figs 7–8) most probably belonged to *C. cylindrica* (E.M. Reid) Dorof. The third specimen (Bůžek et al. op.cit., Pl.19, fig. 9) belonged rather to the extant species *C. parnassifolia* (Bassi) Parl., because of the different position of the style on the endocarp. Also among the *Hypericum* seeds (Bůžek et al., 1985, Pl. 7, figs 32–35) identified as *H.* cf. *septestum* Nikit., at least one of them (Bůžek et al., op. cit., Pl. 7, fig. 33) belonged to *H. tertiaerum* Nikit., represented abundantly in the Kholmech flora.

It should be noted that the seeds identified as *Typha* cf. *lipetzkiana* Dorof. (Bůžek et al. op. cit., Pl. 19, figs 31–36) which, according to Mai (2000c), belong to the genus *Lobelia*, are not all of the same shape. The specimens illustrated in Pl. 19, figs 31 and 32, and maybe also 33 (Bůžek et al. op. cit.), are similar, to some extent, to the seeds of *Lobelia* from Kholmech. However, those shown in Pl. 19, figs 34 and 36 (Bůžek et al. op. cit.) are more similar to seeds of *Lobelia pliocenica* (Dorof.) Mai. This species occurred also in the Dvorets flora (Dorofeev 1986a, Velichkievich 1990), from where it was identified as *Typha pliocenica* Dorof. According to Mai (2000c), all seeds of this type belong to one polymorphic species *Lobelia pliocenica* (Dorof.) Mai.

Other exotic species which the Kholmech flora could have shared with the Vildštein Formation flora may have existed within the genera *Caulinia*, *Najas*, *Eleocharis*, *Lycopus*, *Sambucus*, *Aldrovanda*, and *Nymphaea*. However, such speculations cannot be accepted without comparative studies of the original material from the two collections. In spite of this, there remains a striking similarity between the floras of Kholmech and the Vildštein Formation. A likely cause is the similar conditions of the natural environment surrounding an isolated water body sited in vast swamps.

The floristic complexes of the Late Pliocene in Thuringia, Rippersroda and Nordhausen (Mai & Walther 1988) were very similar to the Kholmech flora. That in Nordhausen was composed of 63 taxa, mainly herbs. Somewhat infrequently occurring exotic species which were also found in the Kholmech flora include *Azolla filiculoides* Lam. foss., *Carex paucifloroides* Wielczk., *Naumburgia subthyrsiflora* (Nikit.) Nikit., *Proserpinaca reticulata* C. & E.M. Reid, *Salvinia cerebrata* Nikit., *Stratiotes intermedius* (Hartz) Chandler, *Teucrium tatianae* Nikit., and *Lobelia pliocenica* (Dorof.) Mai. Trees and shrubs in the Nordhausen flora were represented by *Betula cholmechensis* Dorof., a species characteristic for the Kholmech flora. However, species bearing the names of present-day taxa augmented by the term “fossilis” prevailed in the Nordhausen flora. This indicated their limited similarity to their contemporary analogues. Such species occurred also in the Kholmech flora, e.g. *Alnus glutinosa* (L.) Gaertn. foss., *Alisma plantago-aquatica* L. foss., *Chenopodium album* L. foss., *Hydrocharis morsus-ranae* L. foss., *Lemna trisulca* L. foss., and *Sagittaria sagittifolia* L. foss. This feature suggests that the two floras were of similar age. Their taxonomic composition reflected the final phase in the development of the Pliocene flora, gradually to be replaced by that of the Pleistocene. The Kholmech flora seems to be more exotic than that at Nordhausen because of the low proportion of strictly extant species prevailing in the latter.

The Kholmech flora was also similar to that at Rippersroda, which was recognized as transitional between floras of the Reuver and Tegelen types and comparable with the Mizerna II floristic complex in Poland (Mai et al. 1963). In a recent paper on the Rippersroda flora 90 taxa have been listed, most identified to species level (Mai & Walther 1988). A small group of species such as *Salvinia tuberculata* Nikit., *Caldesia cylindrica* (E.M. Reid) Dorof., *Stratiotes intermedius* (Hartz) Chandler, *Potamogeton borysthenicus* Dorof., *Scirpus pliocenicus* Szafer, *Brasenia tuberculata* C. & E.M. Reid, *Decodon globosus* (E.M. Reid) Nikit., *Proserpinaca europaea* Dorof., and *Myriophyllum praespicatum* Nikit., typical for the Pliocene in western, central and eastern Europe, was found there. The occurrence of these species indicates a close relation between the Rippersroda and Kholmech floras which is additionally confirmed by a numerous group of younger species closely related to present-day taxa: *Baldellia ranunculoides* (L.)Parl. foss., *Sagittaria sagittifolia* L.foss., *Lemna trisulca* L. foss., *Sparganium emersum* Rehm. foss., *Ranunculus sceleratus* L. foss., *Thalictrum simplex* L. foss., *Urtica dioica* L. foss., *Alnus glutinosa* (L.) Gaertn. foss., *Corylus avellana* L. foss., *Oenanthe aquatica* (L.) Poir. foss., and *Sambucus nigra* L. foss. However, most of these taxa were distinctly different from their extant analogues. That they have not been described as extinct species is solely a consequence of the fossil material being insufficient for this to be possible. The material of several species in the Rippersroda flora which have been very precisely described and illustrated, could be interpreted in a manner somewhat different from that given in the publication by Mai and Walther (1988). For example, the nut of *Schoenoplectus lacustris* (L.) Palla (Mai & Walther op. cit., Pl. 13, fig. 38) was little different from that of *Sch. lacustroides* Wieliczk. & Zastaw. in the Kholmech flora, but substantially differed, in our opinion, from that of the extant species. It also seemed that among seeds of *Alisma* ex gr. *plantago-aquatica* L., small specimens belonged to *Alisma plantago-minima* (Nikit.) Dorof. ex Wieliczk. *Scirpus radicans* Schkuhr in the Rippersroda flora corresponded precisely to *S. atroviroides* Dorof. in the Kholmech flora and among seeds of *Najas marina* L. foss. in the Rippersroda flora, seeds identical with those of *N. major-pliocenica* Dorof. ex Wieliczk. were found. However, any real degree of morphological similarity or discrepancy of particular taxa in the floras of Rippersroda and Kholmech could only be established on the basis of compared fossil material. It should be noted that the Rippersroda flora was somewhat older than the Kholmech flora as is indicated by the presence of extinct species such as *Salvinia rhenana* Kempf, *Dichostylis protohamulosa* Mai, *Epipremnum reniculum* (Ludwig) Kirchh., *Magnolia cor* Ludwig, *Ceratophyllum protanaiticum* Dorof., *Hartziella rosenkjaeri* (Hartz) Szafer, *Phellodendron elegans* (Reid) C. & E.M. Reid, *Meliosma wetterawiensis* (Ludwig) Mai, and *Ampelopsis malvaeformis* (Schloth.) Mai, all missing from Kholmech. Some of these species were present in the older, Early Pliocene floras of Belarus (Dorofeev 1967, Yakubovskaya 1984).

The correlation of the Kholmech flora with floras at sites located further west, on the Dutch-German border Reuver, Brunssum, Swalmen, Tegelen (Reid & Reid 1915), is difficult because of the lack of new data on these floras. Floras worked out at the beginning of the 20th century need to be reassessed in view of later studies on the Pliocene in central Europe. Revision of these floras would complete the analysis of the series of Pliocene floras stretching across to central and eastern Europe.

Comparative analysis of the Pliocene floras in eastern and central Europe has established that the Dan'shino floras in central Russia (Dorofeev 1979, Kholmovoy et al. 1985), the floras of Kinelian type in the Middle Volga basin (Dorofeev 1956, 1957) and the Simbugino flora (Dorofeev 1977b) in the Pre-Ural area are the most closely related to the Kholmech and Belorussian floras. Those at the Kolochyn site and from borings in the Grodno and Novogrudok regions have been found to be of the same age (Dorofeev 1967, Yakubovskaya 1978, 1984). To the west, the floras in Kłodzko and Mizerna II/III in Poland, the Vildštein Formation flora in the Czech Republic and the Rippersroda flora in Germany are similarly of the same age as the Kholmech flora. According to the stratigraphic division of the Pliocene in Europe, Mai (1995b) placed the floras of Rippersroda, Kłodzko and Mizerna II between those of Reuver A and Tegelen C, i.e. between 2.8 – 1.8 million years BP. However, it seems that the whole flora group occurred somewhat earlier within the Late Pliocene, about 3 million years BP.

THE MIZERNA FLORA IN THE LIGHT OF COMPARABLE INVESTIGATIONS OF THE FOSSIL FLORAS OF THE LATE PLIOCENE OF EASTERN EUROPE

On the basis of fossil flora studies of the Neogene in the Nowy Targ basin, Szafer 1946–1947, 1954) proclaimed Pliocene floras at the Krościenko, Huba and Mizerna sites. At the last he distinguished 7 distinct floristic complexes (Mizerna I, I/II, II, II/III, III, III/IV and IV). The floras at Krościenko, Huba and Mizerna I and I/II were, in Szafer's opinion, the oldest within the Pliocene. He defined them as pre-Günz and accepted them as counterparts of the Reuver flora in western Europe. The age of the Huba flora was verified on the basis of later palynological investigations by Oszast (1973), who included this flora in the Miocene.

The Krościenko and Mizerna floras originated from the Carpathian foreland which contained abundant communities of mixed forest with many different species of conifer (*Chamaecyparis*, *Thuja*, *Juniperus*, *Abies*, *Tsuga*, *Picea*, *Pinus*, and *Larix*), excluding the Taxodiaceae. Deciduous trees and shrubs such as *Betula*, *Alnus*, *Carpinus*, *Corylus*, *Fagus*, *Liriodendron*, *Magnolia*, *Liquidambar*, *Corylopsis*, *Fothergilla*, *Bucklandia*, *Aesculus*, *Juglans*, *Pterocarya*, *Meliosma*, *Styrax*, *Nyssa*, *Alangium*, *Prunus*, *Crataegus*, *Rhus*, *Olea*, *Actinidia*, *Vitis*, *Ampelopsis*, *Stewartia*, *Staphyllea*, *Paliurus*, *Sinomenium*, *Pteris*, *Ceanothus*, and *Aralia* dominated in the forest communities. The remains of herbs such as *Sparganium*, *Caldesia*, *Sagittaria*, *Carex flagellata* C. & E.M. Reid, *Scirpus pliocenicus* Szafer, *Euryale carpathica* Szafer, *Nuphar canaliculata* C. & E.M. Reid, *Ranunculus reidii* Szafer, *Polygonum*, *Stellaria*, *Agrimonia*, *Proserpinaca reticulata* C. & E.M. Reid, *Hippuris*, *Physalis*, *Solanum*, *Valeriana*, and others were not very frequent. Most of them were characteristic for the Early Pliocene in western Europe, as were the above mentioned genera of trees and shrubs which established the Early Pliocene age of the Krościenko and Mizerna I and I/II floras.

Szafer (1954) considered the Mizerna II complex as Late Pliocene, despite the high proportion of trees and shrubs and additionally *Quercus borealis* Michx., *Q. pubescens* Willd., *Carya tomentosa* Nutt., *Eucommia*, *Tilia tomentosa* Moench, *Hedera*, *Fatsia*, *Acantopanax*, and *Stephanandra* providing similarity to the Krościenko flora. Furthermore herbs such as *Najas marina* L., *Stratiotes intermedius* (Hartz) Chandler, *Peucedanum*, *Oenanthe* and *Cicuta*, mostly identified as extant species, were found there. Dating of the Mizerna II complex at Late Pliocene was verified by investigations of *Potamogeton* remains in Mizerna (Velichkevich & Lesiak 1996). The investigations resulted in the placing of most of the fossil endocarps in extinct species widespread in the Early Pliocene of eastern Europe. Earlier they had been included by Mądalski (Szafer 1954), in extant European species. Analysis of the original material of *Scirpus*, *Eleocharis*, *Carex*, *Sparganium*, and *Nuphar*, housed in the Palaeobotanical Museum of the W. Szafer Institute of Botany, Polish Academy of Sciences in Kraków, revealed that in many cases they were not extant species but extinct ones. Hence, Early Pliocene should be accepted as the age of the Mizerna II complex, since its flora is undoubtedly older than that of the Late Pliocene Kholmech flora.

The Mizerna II/III floristic complex represented, according to Szafer (1954), vegetation of the Early Pleistocene (Günz), when the transition of the Pliocene flora into the Pleistocene was taking place in the Carpathians. However, taxa typical for the Pliocene such as *Corylopsis*, *Meliosma*, *Pterocarya*, *Stephanandra*, *Actinidia*, and *Ampelopsis* occurred in this complex. Nonetheless, many herb species from the Ranunculaceae, Apiaceae, Lamiaceae, Cyperaceae, Polygonaceae and Potamogetonaceae first appeared in the Mizerna profile. These species were usually widespread throughout the Pliocene but their affiliation to extant species is scarcely credible (Velichkevich & Lesiak 1996). All the evidence suggests that the Mizerna II/III complex does not date from the Pleistocene. Its exact age could not be ascertained on the basis of material included in Szafer's publication (1954). It is likely that the Mizerna II/III complex is similar in age to the Kholmech flora, i.e. it represents the lower Late Pliocene.

The Mizerna III and III/IV complexes corresponded, according to Szafer (1954, p.116), to the first and oldest Pleistocene Günz-Mindel interglacial, "Tegelen stage". In the Mizerna III complex the remains of several exotic trees such as *Liriodendron*, *Actinidia*, *Corylopsis*, *Pterocarya*, *Vitis*, *Ampelopsis*, and *Aralia* were preserved. Among the herbs, elements typical for the Kinelian flora such as *Caulinia lanceolata* (C. & E.M. Reid) Dorof., *C.* ex gr. *tenuissima* (A. Br.) Tzvel., *Najas major* All. (= *N. major–pliocenica* Dorof. ex Wieliczk.), *Stratiotes intermedius* (Hartz) Chandler, and probably extinct species of *Carex*, *Ranunculus*, *Nymphaea*, *Polygonum*, and *Potamogeton*, occurred in the East-European plain. The age of the Mizerna III complex should therefore be accepted as Early Romanian (=Akchagylian), placing it in the Early Pliocene (Mai & Walther 1988).

In view of the above analysis, only the Mizerna III/IV and IV complexes with *Picea*, *Juniperus*, *Larix*, *Pinus*, *Salix*, *Sorbus*, and *Selaginella selaginoides* (L.) Link should be recognized as Quaternary.

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PLATES

Plate 1

1, 2. *Selaginella reticulata* Dorof. & Wieliczk., megaspores, × 60, KRAM-P 242/ 2a, b
3,4. *Selaginella pliocenica* Dorof., megaspores, × 60, KRAM-P 242/1a, b
5,6. *Pilularia pliocenica* Dorof., megaspores, × 60, KRAM-P 242/ 3a, b
7,8. *Azolla filiculoides* Lam. foss., megaspores, × 60, KRAM-P 242/8a, b
9,10. *Azolla pseudopinnata* Nikit., megaspores, × 60, KRAM-P 242/9a, b
11,12. *Salvinia aphtosa* Wieliczk., megaspores, × 50, KRAM-P 242/6a, b
13. *Salvinia cerebrata* Nikit., megaspore, × 60, KRAM-P 242/7
14,15. *Salvinia tuberculata* Nikit., megaspores, × 50, KRAM-P 242/5a, b
16,17. *Salvinia glabra* Nikit., megaspores, × 50, KRAM-P 242/4a, b
18,19. *Typha pseudoovata* Dorof., tegmens, × 30, KRAM-P 242/13a, b
20,21. *Typha aspera* Dorof., tegmens, × 30, KRAM-P 242/11a, b
22. *Picea* sect. *Eupicea* Willk., fragment of needle, × 15, KRAM-P 242/10
23,24. *Sparganium noduliferum* C. & E.M. Reid, endocarps, × 15, KRAM-P 242/14a, b
25. *Sparganium emersum* Rehm. foss., endocarp, × 15, KRAM-P 242/15a
26. *Sparganium* cf. *japonicum* Roth, endocarp, × 15, KRAM-P 242/16a
27. *Sparganium* cf. *stenophyllum* Maxim., endocarp, × 15, KRAM-P 242/17a
28. *Sparganium* sp. 1, endocarp, × 15, KRAM-P 242/18a
29. *Sparganium* sp. 2, endocarp, × 15, KRAM-P 242/19a

Phot. A. Pachoński

Plate 1

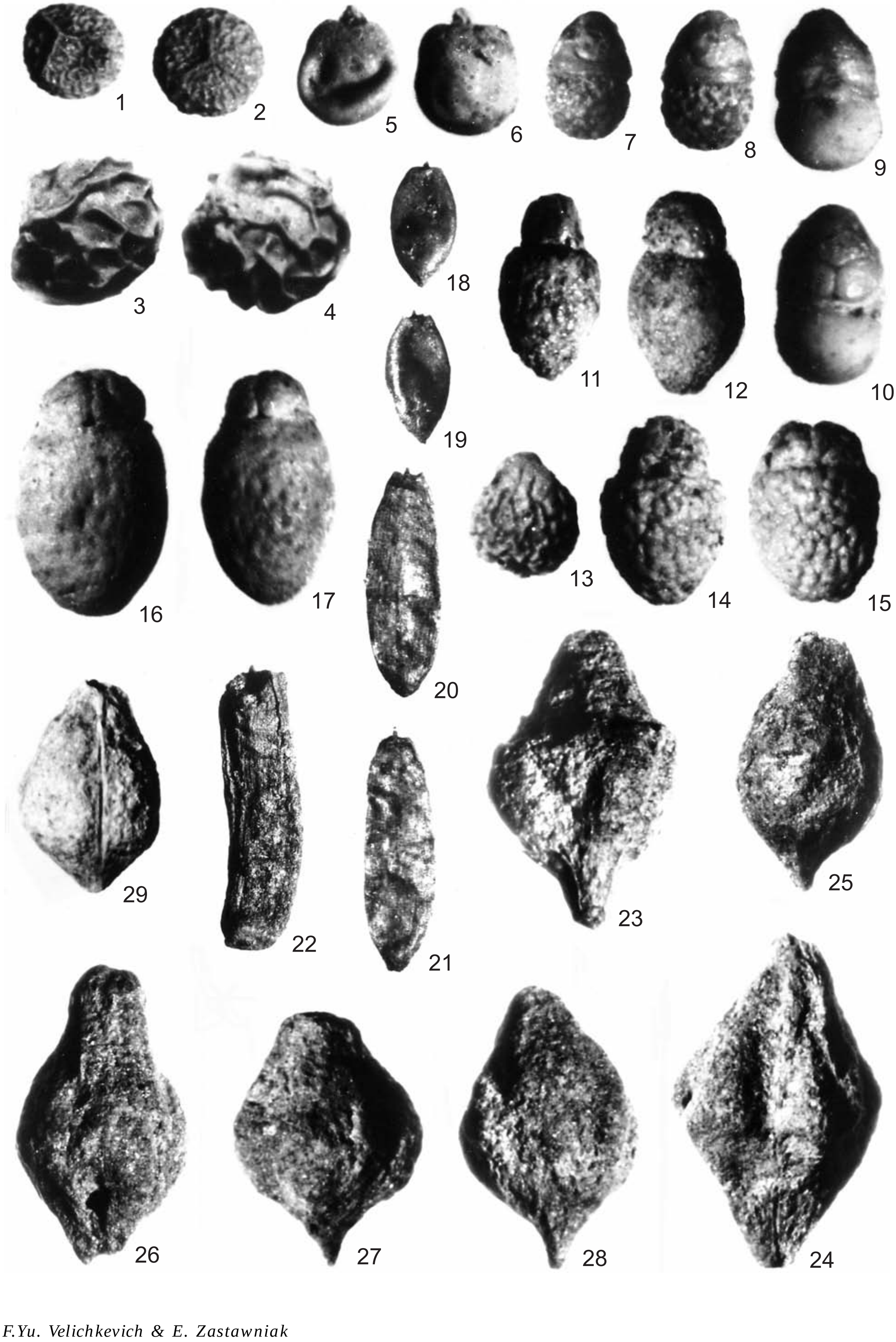

Plate 2

1,2. *Potamogeton palaeorutilus* Dorof., endocarps, × 15, KRAM-P 242/28a, b
3. *Potamogeton* cf. *parvulus* Dorof., endocarp, × 15, KRAM-P 242/30a
4–6. *Potamogeton simplex* Dorof., endocarps, × 15, KRAM-P 242/35a, b, c
7–9. *Potamogeton pseudoacutifolius* Dorof., endocarps, × 15, KRAM-P 242/33a, b, c
10,11. *Potamogeton rossicus* Dorof., endocarps, × 15, KRAM-P 242/34a, b
12,13. *Potamogeton praenatans* Dorof., endocarps, × 15, KRAM-P 242/32a, b
14. *Potamogeton crispus* L., endocarp, × 15, KRAM-P 242/22
15. *Potamogeton* cf. *pectinatus* L., endocarp, × 15, KRAM-P 242/31
16–18. *Potamogeton cholmechensis* Dorof., endocarps, × 15, KRAM-P 242/21a, b, c
19. *Potamogeton* cf. *felixii* Dorof., endocarp, × 15, KRAM-P 242/23
20–22. *Potamogeton borysthenicus* Dorof., endocarps, × 15, KRAM-P 242/20a, b, c

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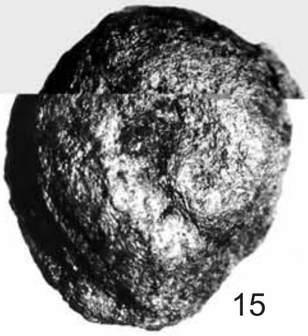
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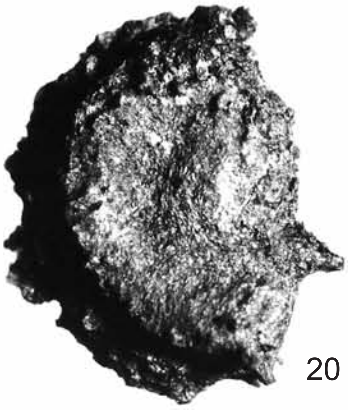
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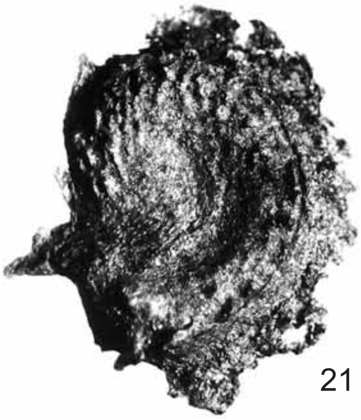
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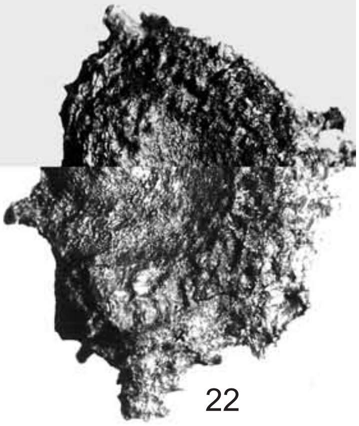
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Plate 3

1–3. *Potamogeton obtusatus* Dorof., endocarps, × 15, KRAM-P 242/26a, b, c
4,5. *Potamogeton obtusus* Dorof., endocarps, × 15, KRAM-P 242/27a, b
6–8. *Potamogeton margaritae* Dorof., endocarps, × 15, KRAM-P 242/25a, b, c
9. *Potamogeton panormitanoides* Dorof., endocarp, × 15, KRAM – P 242/29
10–12. *Potamogeton longistylus* Dorof., endocarps, × 15, KRAM-P 242/24a, b, c
13,14. *Alisma plantago-aquatica* L., seed and fruit, × 20, KRAM-P 242/ 39a, b
15. *Caldesia cylindrica* (E.M. Reid) Dorof., endocarps, × 15, KRAM-P 242/45a
16,17. *Caulinia palaeotenuissima* Dorof., seeds, × 20, KRAM-P 242/37a, b
18–20. *Caulinia scrobiculata* Dorof., seeds, × 20, KRAM-P 242/38a, b, c
21–23. *Najas major-pliocenica* Dorof. ex Wieliczk., seeds, × 15, KRAM-P 242/36a, b, c

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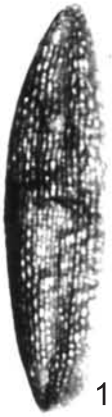
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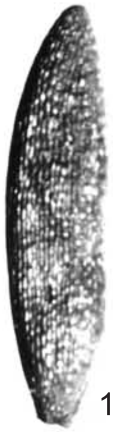
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Plate 4

1. *Baldellia ranunculoides* (L.) Parl. foss., seed, × 20, KRAM-P 242/ 44
2,3. *Sagittaria* sp. seeds, × 15, KRAM-P 242/ 42a, b
4,5. *Sagittaria sagittifolia* L. foss., seeds, × 15, KRAM-P 242/41a, b
6–8. *Alisma plantago-minima* (Nikit.) Dorof. ex Wieliczk., seeds (6, 7), fruit (8), × 20, KRAM-P 242/40a, b, c
9,10. *Hydrocharis morsus-ranae* L. foss., seeds, × 20, KRAM-P 242/47a, b
11,12. *Damasonium alisma* Mill., foss., seed (11), fruit (12), × 15, KRAM-P 242/43a, b
13–15. *Carex klarae* Mai, fruits, × 20, KRAM-P 242/53a, b, c
16,17. *Carex* sp. 3, nuts, × 15, KRAM-P 242/57a, b
18,19. *Carex* sp. 1, nuts, × 15, KRAM-P 242/54a, b
20,21. *Carex* sp. 2, nuts, × 15, KRAM-P 242/56a, b
22,23. *Carex carpophora* Mai & Walther, nuts, × 15, KRAM-P 242/55a, b
24,25. *Carex paucifloroides* Wieliczk., fruits, × 20, KRAM-P 242/46a, b
26,27. *Stratiotes intermedius* (Hartz) Chandl., seeds, × 7, KRAM-P 242/46a, b
28,29. *Carex szaferi* Dorof., nuts, × 15, KRAM-P 242/50a, b
30–32. *Carex rostrata-pliocenica* Nikit., nut (30), fruits (31, 32), × 15, KRAM-P 242/52a, b, c

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Plate 4

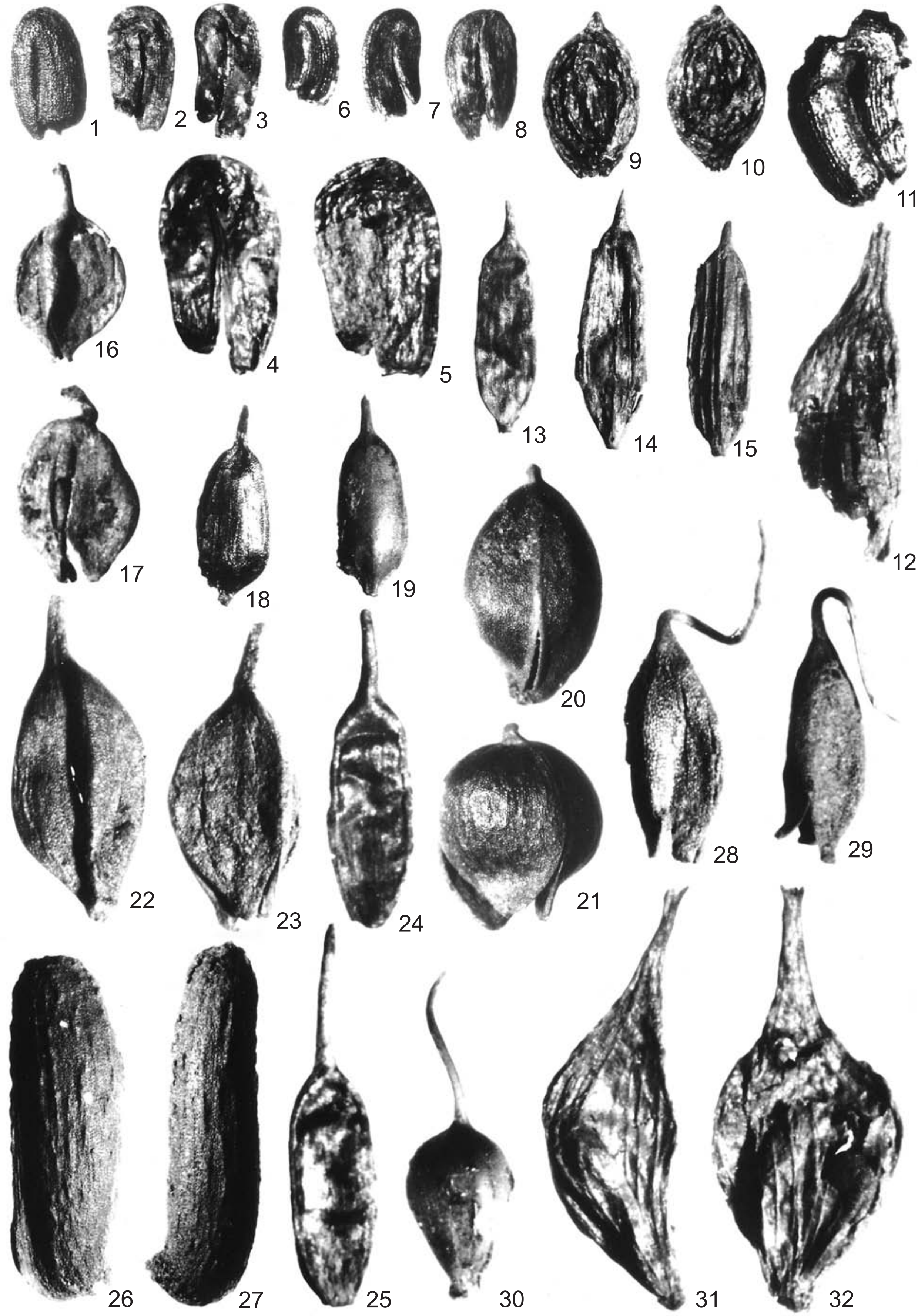
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Plate 5

1–3. *Eleocharis praemaximowiczii* Dorof., fruits, × 20, KRAM-P 242/62a, b, c
4–7. *Lemna trisulca* L. foss., seeds, × 30, KRAM-P 242/72a, b, c, d
8. *Schoenoplectus isolepioides* Mai & Walther, fruit, × 20, KRAM-P 242/68
9,10. *Cyperus* cf. *longus* L., fruits, × 30, KRAM-P 242/59a, b
11,12. *Scirpus atroviroides* Dorof., fruits, × 40, KRAM-P 242/63a, b
13. *Myrica* cf. *borysthenica* Dorof. & Wieliczk., half of fruit, internal view, × 20, KRAM-P 242/80
14–16. *Schoenoplectus lucens* Wieliczk. & Zastaw. sp. nov., fruits, × 20, KRAM-P 242/65a, b, c; holotype – fig. 15
17–19. *Schoenoplectus palaeobucharicus* Wieliczk. & Zastaw. sp. nov., fruits, × 20, KRAM-P 242/66a, b, c; holotype – fig. 19
20,21. *Cyperus fuscus* L. foss., fruits, × 40, KRAM-P 242/60a, b
22. *Eleocharis palustris* (L.) Roem. & Schult., fruit, × 20, KRAM-P 242/61
23–25. *Scirpus pliocenicus* Szafer, fruits, × 20, KRAM-P 242/64a, b, c
26–28. *Cyperus glomeratoides* Wieliczk. & Zastaw. sp. nov., fruits, × 30, KRAM-P 242/58a, b, c; holotype – fig. 28
29. *Dulichium arundinaceum* (L.) Britt. foss., fruit, × 20, KRAM-P 242/48
30–32. *Schoenoplectus lacustroides* Wieliczk. & Zastaw. sp. nov., fruits, × 15, KRAM-P 242/67a, b, c; holotype – fig. 30
33–35. *Dulichium vespiforme* C. & E.M. Reid, fruits, × 20, KRAM-P 242/49a, b, c

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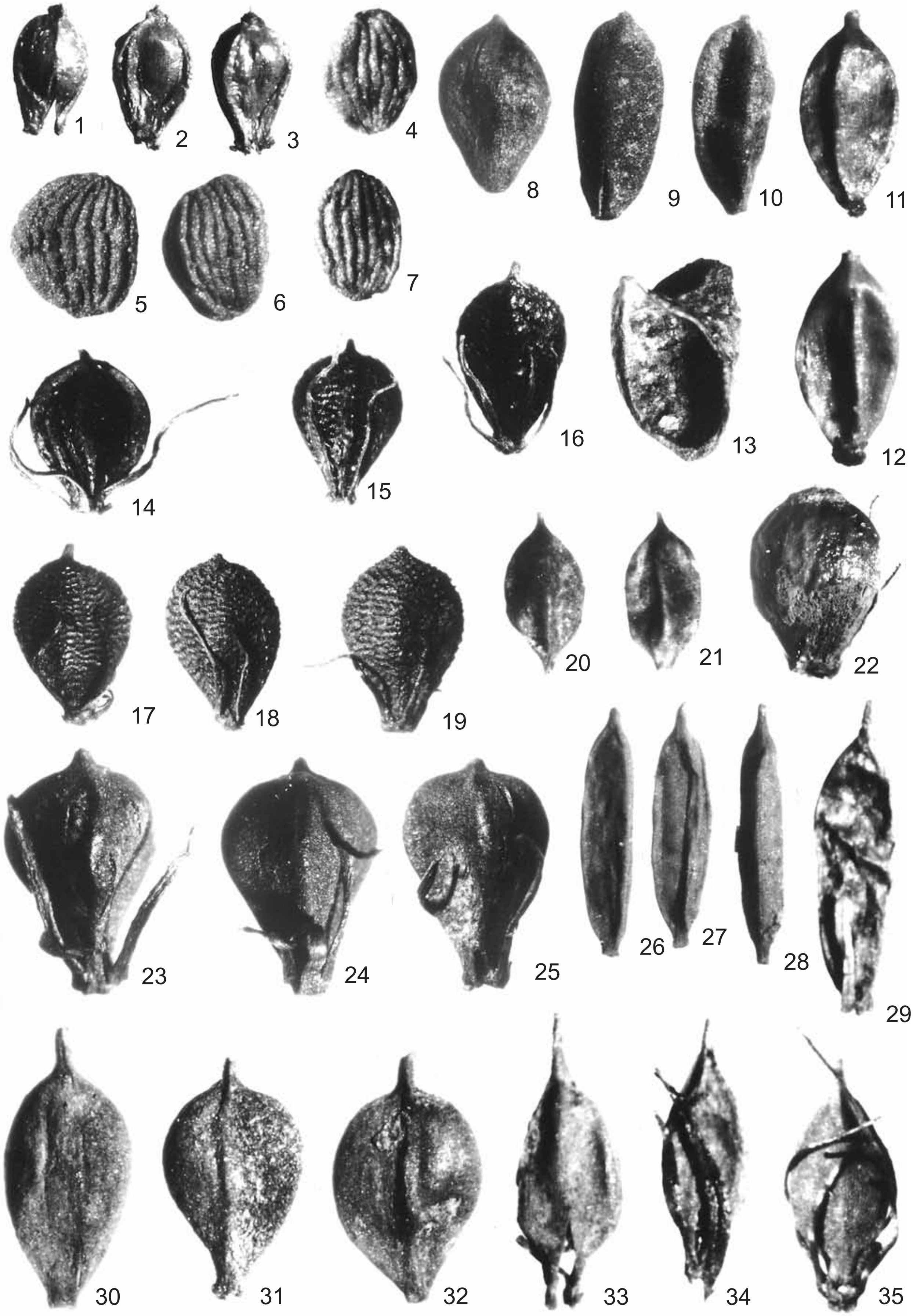
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Plate 6

1,2. *Alnus* cf. *glutinosa* (L.) Gaertn., fruits, × 20, KRAM-P 242/73a, b
3. *Pilea cantalensis* (E.M. Reid) Dorof., fruit, × 25, KRAM-P 242/81
4,5. *Urtica dioica* L., fruits, × 25, KRAM-P 242/82a, b
6. *Rumex acetosella* L., achene, × 25, KRAM-P 242/87
7,8. *Urtica pliocenica* Dorof., fruits, × 25, KRAM-P 242/83a, b
9,10. *Betula cholmechensis* Dorof., scale (9) and nut (10), × 20, KRAM-P 242/75a, b
11,12. *Betula longisquamosa* Mädler, nuts, × 20, KRAM-P 242/74a, b
13. *Carpinus* sp., nut, × 20, KRAM-P 242/77
14. Araceae gen., fruit, × 10, KRAM-P 242/70
15. *Quercus* sp., young cupule, × 15, KRAM-P 242/79
16–18. *Acorus palaeocalamus* Dorof., seeds (16, 17) and fruit (18), × 15, KRAM-P 242/69a, b, c

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Plate 6


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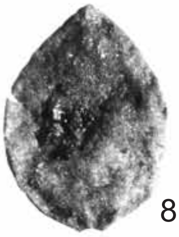
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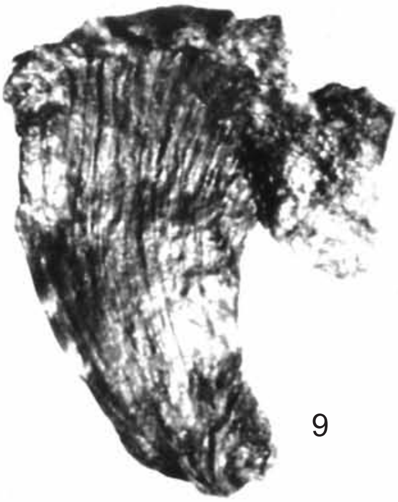
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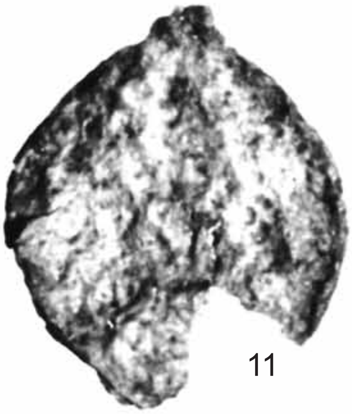
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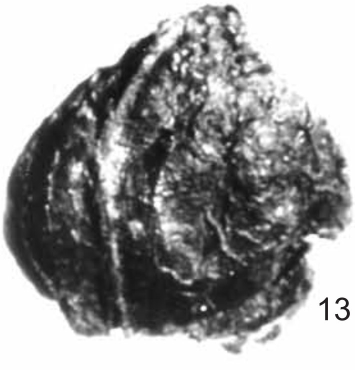
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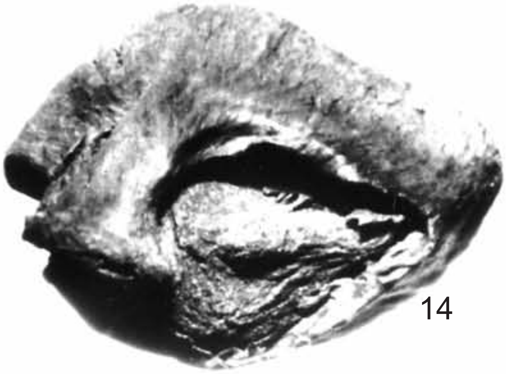
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Plate 7

1–3. *Polygonum pliocenicum* Dorof., achenes, × 20, KRAM-P 242/86a, b, c
4. *Polycnemum* cf. *arvense* L., seed, × 25, KRAM-P 242/94
5. *Chenopodium hybridum* L., fragment of seed, × 25, KRAM-P 242/92
6. *Chenopodium album* L. foss., seed, × 25, KRAM-P 242/90
7. *Chenopodium polyspermum* L., seed, × 25, KRAM-P 242/93
8. *Chenopodium glaucum* L., seed, × 25, KRAM-P 242/91
9. *Stellaria holostea* L. foss., seed, × 25, KRAM-P 242/96
10. *Lychnis flos-cuculi* L., seed, × 25, KRAM-P 242/95
11. *Stellaria palustris* Retz., seed, × 25, KRAM-P 242/97
12,13. *Rumex* cf. *ucrainicus* Besser ex Spreng., fruits, × 20, KRAM-P 242/88a,b
14,15. *Polygonum aviculare* L., achenes, × 20, KRAM-P 242/84a,b
16,17. *Polygonum lapathifolium* L., fruits, × 20, KRAM-P 242/85a, b
18,19. *Nymphaea pusilla* Dorof., seeds, × 15, KRAM-P 242/99a, b
20,21. *Nuphar lutea* (L.) Sibth. & Sm. foss., seeds, x12, KRAM-P 242/101a, b
22. *Nuphar* sp., seed, × 12, KRAM-P 242/102
23–25. *Nymphaea borysthenica* Dorof., seeds, × 15, KRAM-P 242/98a, b, c

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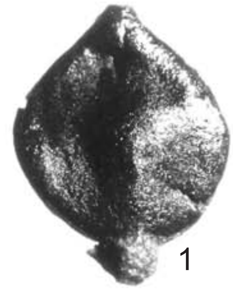
Plate 7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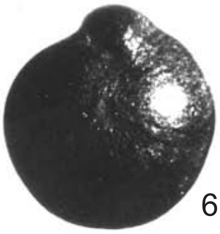
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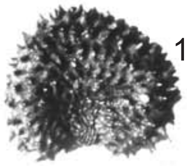
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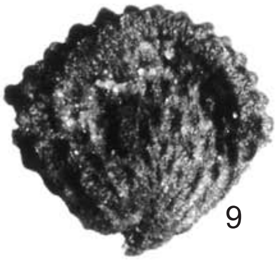
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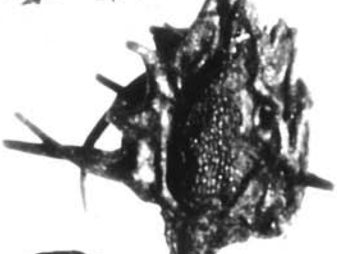
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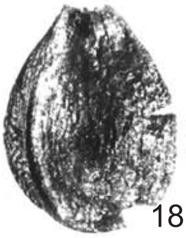
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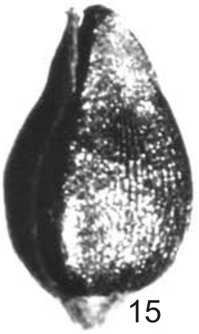
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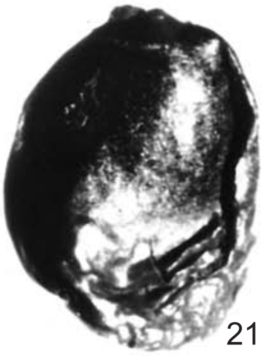
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Plate 8

1–3. *Brasenia angustata* Dorof. seeds, × 15, KRAM-P 242/103a, b, c
4–6. *Brasenia tuberculata* C. & E.M. Reid, seeds, × 15, KRAM-P 242/105a, b, c
7,8. *Brasenia obovata* Dorof., seeds, × 15, KRAM-P 242/104a, b, c
9,10. *Ranunculus* cf. *caucasicus* Bieb., fruits, × 15, KRAM-P 242/109a, b
11. *Ranunculus tanaiticus* Dorof., fruit, × 15, KRAM-P 242/113
12,13. *Ranunculus sceleratus* L., extant fruits, × 25, KRAM-P 242/112a, b
14–16. *Ceratophyllum dorofeevii* Wieliczk. & Zastaw., fruits, × 10, KRAM-P 242/106a, b, c; holotype – fig.15
17,18. *Nuphar canaliculata* C. & E.M. Reid, seeds, × 12, KRAM-P 242/100a, b

Phot. A. Pachoński


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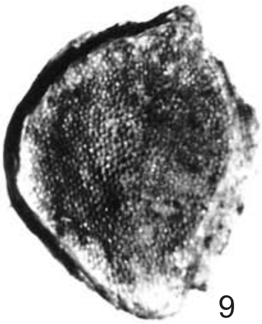
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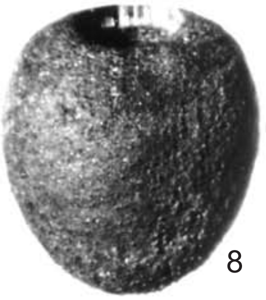
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Plate 9

1. *Batrachium* sp., achene, × 25, KRAM-P 242/107
2,3. *Ranunculus gailensis* E.M. Reid., achenes, × 20, KRAM-P 242/112a, b
4,5. *Ranunculus pliocenicus* Dorof., achenes, × 25, KRAM-P 242/110a, b
6–8. *Ranunculus pseudoflammula* Dorof., achenes, × 25, KRAM-P 242/111a, b, c
9. *Potentilla* cf. *supina* L., achene, × 30, KRAM-P 242/120a
10. *Potentilla* sp. 1, achene, × 30, KRAM-P 242/121
11. *Potentilla* sp. 2, achene, × 30, KRAM-P 242/122
12. *Potentilla* sp. 3, achene, × 30, KRAM-P 242/123
13. *Fragaria* cf. *viridis* Duchense, achene, × 30, KRAM-P 242/118
14. *Thalictrum* cf. *simplex* L., fruit, × 25, KRAM-P 242/114
15–17. *Aldrovanda eleonorae* Nikit., seeds, × 25, KRAM-P 242/115a, b, c
18. *Acer* cf. *negundo* L., endocarp, × 10, KRAM-P 242/131a, b
19,20. *Hypericum tertiaerum* Nikit., seeds, × 40, KRAM-P 242/131a, b
21. *Crataegus* sp. 1, fruit stone, × 10, KRAM-P 242/116
22. *Crataegus* sp. 2, fruit stone, × 10, KRAM-P 242/117
23,24. *Potentilla anserina* L., half of achene, both faces, × 20, KRAM-P 242/119
25. *Corylus* sp., fragment of nut, × 7, KRAM-P 242/78
26,27. *Rubus* cf. *sachalinensis* Levl., endocarp, × 20, KRAM-P 242/124a,b
28. *Spiraea* cf. *gomeliana* Dorof., fruit from apex, × 15, KRAM-P 242/126

Phot. A. Pachoński

Plate 9


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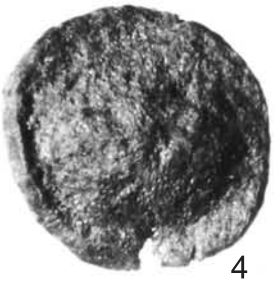
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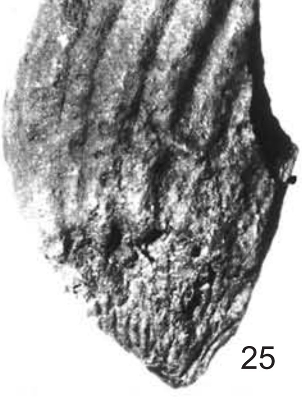
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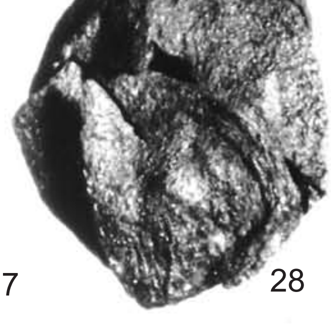
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Plate 10

1–3. *Hypericum foveolatum* Dorof., seeds, × 40, KRAM-P 242/132a, b, c
4. *Hypericum* sp., seed, × 40, KRAM-P 242/133
5,6. *Ludwigia* sp., seeds, × 40, KRAM-P 242/135a,b
7,8. *Ludwigia chandlerae* Knobloch, seeds, × 40, KRAM-P 242/134a, b
9. *Viola* sp. 2, seed, × 30, KRAM-P 242/138
10. *Viola* sp.1, seed, × 30, KRAM-P 242/137
11. *Poliothyrsis hercynica* Mai, seed, × 30, KRAM-P 242/136
12. *Oenanthe aquatica* (L.) Poir. foss., fruit, × 15, KRAM-P 242/147
13,14. *Cicuta virosa* L. foss., fruits, × 15, KRAM-P 242/146a, b
15,16. *Decodon gibbosus* (E.M. Reid) Nikit., seeds, × 20, KRAM-P 242/140a, b
17,18. *Decodon globosus* (E.M. Reid) Nikit., seeds, × 20, KRAM-P 242/141a, b
19. *Tilia* sp., fruit, × 15, KRAM-P 242/130
20. *Proserpinaca europaea* Dorof., endocarp, × 15, KRAM-P 242/145
21,22. *Proserpinaca reticulata* C. & E.M. Reid, endocarps, × 15, KRAM-P 242/144a,b
23. *Swida* cf. *gorbunovii* (Dorof.) Negru, endocarp, × 10, KRAM-P 242/149
24,25. *Euphorbia* sp., half of fruit, both faces, × 15, KRAM-P 242/139
26,27. *Acer* sect. *Platanoidea* Pax, half of fruit, both faces, × 10, KRAM-P 242/129
28. *Myriophyllum* ex gr. *verticillatum* L., endocarp, × 30, KRAM-P 242/143
29. *Myriophyllum praespicatum* Nikit., endocarp, × 30, KRAM-P 242/142

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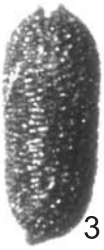
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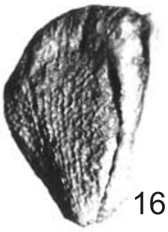
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Plate 11

1. *Valeriana simplicifolia* (Rchb.) Kabath foss., fruit, × 25, KRAM-P 242/165
2. *Glechoma hederacea* L. foss., fruit, × 20, KRAM-P 242/160
3. *Teucrium tatianae* Nikit., fruit, × 30, KRAM-P 242/156

4,5. *Lobelia pliocenica* (Dorof.) Mai, fruits, × 30, KRAM-P 242/12a, b

6. *Lysimachia nikitinii* Dorof., seed, side view, × 30, KRAM-P 242/15
7. *Lysimachia* cf. *vulgaris* L., seed, side view, × 30, KRAM-P 242/152
8. *Eupatorium cannabinum* L., fruit, × 20, KRAM-P 242/170
9. *Sambucus nigra* L. foss., seed, × 10, KRAM-P 242/167
10. *Patrinia* cf. *rupestris* (Pall.) Dufr., fruit, × 15, KRAM-P 242/166
11. *Stachys* cf. *pliocenica* Dorof., fruit, × 25, KRAM-P 242/159
12. *Carduus* sp., fruit, × 20, KRAM-P 242/169
13. *Menyanthes trifoliata* L., seed, × 15, KRAM-P 242/153

14,15. Caprifoliaceae gen., seeds, × 30, KRAM-P 242/161a, b

16–18. *Lycopus cholmechensis* Wieliczk. & Zastaw. sp. nov., fruits, × 25, KRAM-P 242/154a, b, c; holotype – fig. 16

19. *Taraxacum tanaiticum* Dorof., fruit, × 20, KRAM-P 242/168
20. *Mentha pliocenica* Dorof., fruit, × 30, KRAM-P 242/158
21. *Physalis alkekengi* L. foss., seed, × 20, KRAM-P 242/164
22. *Datura* cf. *stramonium* L., seed, × 12, KRAM-P 242/163

23,24. *Teucrium pripiatense* (Dorof.) Wieliczk. & Zastaw. comb. nov., fruit, both faces, × 25, KRAM-P 242/157

25. *Solanum* cf. *persicum* Willd., seed, × 30, KRAM-P 242/162

26,27. *Naumburgia subthyrsiflora* (Nikit.) Nikit., seed, both faces, × 30, KRAM-P 242/150

Phot. A. Pachoński


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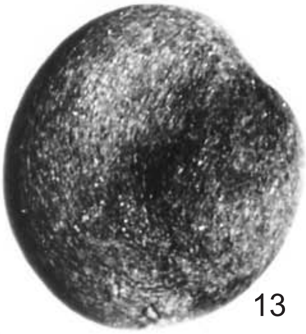
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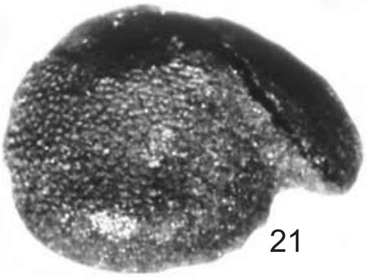
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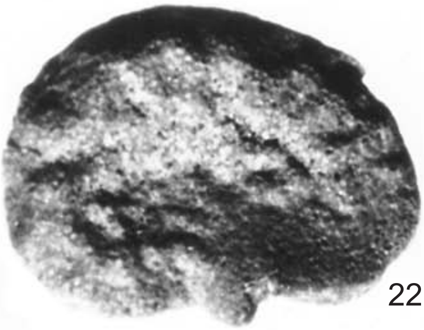
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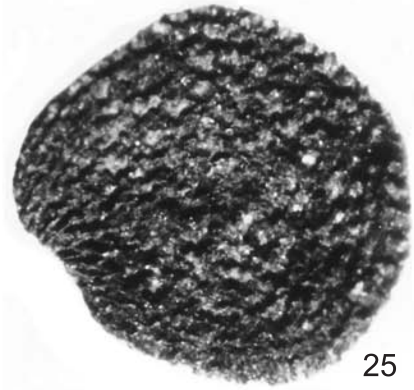
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