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Discussion of some thermophile palynomorphs from the Miocene sediments in the Carpathian Foredeep (Czech Republic) and Modrý Kamen basin (Slovakia)*

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ABSTRACT. The sediments from the southern part of the Carpathian Foredeep in Moravia (Czech Republic) and the Modrý Kamen basin from Slovakia were studied. The sediments are of Eggenburgian to Lower Badenian ages and of marine or brackish origin. The marine facies rapidly changes with lagoonal and deltaic facies during the Eggenburgian–Ottnangian. The palynospectra have warm-subtropical character. Saltmarsh vegetation (37% Chenopodiaceae) interchanged with swamp vegetation. In the Karpatian palynospectra marsh facies occur more uniformly. Marked azonal associations, for example marsh palm forest, riparian forest or the associations with Taxodiaceae and Tiliaceae (*Craigia*), are typical. The Ottnangian–Karpatian palynospectra from the Modrý Kamen basin were typical in the occurrence of pollen of *Pentapollenites* sp. The studied Lower Badenian sediments represent the fully marine conditions. The palynospectra were poor in pollen and spores (except Pinaceae) and rich in Dinoflagellata. At this time the climate was not extremely warm.

KEY WORDS: palynology, Miocene, Carpathian Foredeep, Czech Republic

INTRODUCTION

The sediments from the southern part of the Carpathian Foredeep in Moravia (Czech Republic) were studied palynologically. Palynomorphs have been described from many boreholes and outcrops with the sediments of the Eggenburgian to Badenian age. Palynological studies were compared primarily with sedimentological and palaeontological investigations. The studies were directed firstly on the relationship between the terrestrial and marine ecosystems. Palynological results were compared with the ones from the Modrý Kamen basin in the southern part of the Slovak Republic.

RESULTS

The sediments are of Eggenburgian to the Lower Badenian age, and are marine or brackish in origin. As a whole, the palynospectra indicate a warm-subtropical character of climate. Sapotaceae, Palmae, *Engelhardia*, *Platycarya*, Castaneoideae, *Tricolporopollenites liblarensis* (Th.) Th. & Pf., thermophile oaks, *Lygodium*, and Pteridaceae are frequent. *Symplocos*, *Reevesia*, Cornaceae, *Parthenocissus*, *Tricolporopollenites pseudocingulum* (Pot.) Th. & Pf., and families Araliaceae and Rutaceae occur regularly but in lower quantities. *Alangium* and *Neogenisporis neogenicus* Krutzsch are represented by sporadic occurrences only. Arctotertiary elements are slightly less frequent. Practically all of the palynospectra are strongly influenced by sedimentological

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facies. This fact is reflected in the proportional changes between the palaeotropic and arctotertiary elements, and it is very difficult to specify any trends in the climate development from these data. Higher percentages of the arctotertiary elements were observed locally, for example:

– Chenopodiaceae, Oleaceae, Ericaceae, *Salix*, *Potamogeton*, Ulmaceae, Taxodiaceae – in the sediments of the Eggenburgian–Ottnangian,

– *Alnus*, Ulmaceae, *Osmunda*, Polypodiaceae, Lythraceae, *Sparganium* – in the Karpatian sediments.

In the pollen diagrams of the studied Miocene sediments, no explicit climatic changes are visible. The author cannot specify at the present time if the observed changes are influenced climatologically or caused by the development of the sedimentary basin and adjacent areas.

The environment of the studied part of the Carpathian Foredeep was extraordinarily variable during the Eggenburgian–Ottnangian. The marine transgression penetrated the sea coast with highly differentiated relief configurations. The marine facies interchanged rapidly with those of lagoons and deltas. Sediments and molluscs show rapid changes in salinity, dynamics and depths, light and evaporation. The palynospectra reflected many of these changes (Nehyba et al. 1997).

Due to oscillations in salinity and occasional higher levels of evaporation halophilous vegetation grew on the coast (up to 37% Chenopodiaceae, Pl. 1, fig. 9). In some places these were accompanied with higher number of *Ephedra* and Buxaceae. Ericaceae are frequent in the facies manifesting a low salinity.

Pollen grains of the species cf. *Monocirculipollis zahnaensis* Krutzsch (Pl.1, figs 1–4) in one case even in pollen conglomerate, which most probably contradicts the redeposition from older sediments, were typical for the sediments of the Eggenburgian age. These pollen were found in all the Eggenburgian boreholes and they were absent in younger sediments. Krutzsch (1966) described these pollen types from the Palaeocene and Eocene sediments and he considered them as extinct members of the family Buxaceae. Similar pollen types were found also in the Miocene sediments from Turkey (Nurdan Yavus, pers. comm.). According to data in the literature, the pollen type seem to be similar to some members of the families Caryophyllaceae or Amaranthaceae. It is necessary to test this opinion with SEM observations on the detailed features of the pollen.

Even the presence of small tri- or tetracolporate grains of Rutaceae is typical for some localities. A large amount of *Platanus* pollen was also observed in some samples.

Saltmarsh vegetation developed in time and space to the various growth stages of the swamp and riparian vegetation. For example facies with *Myrica* pollen (Pl. 1, fig. 13) overlapping 40%, or Taxodiaceae approaching values of 50% are visible. The freshwater flora with *Nelumbo*, *Potamogeton*, *Sparganium*, and Cyperaceae has been ascertained. *Lygodium* (Pl.1, fig.14) was also frequent, in one locality its frequency reached more than 5%.

Later on, the character of the coast development changed, with the relief becomming flatter. The transgression stage follows in the Ottnangian, the sea probably penetrated further to the north into the area. The sediments include the so called *Rzehakia* beds (Nehyba et al. 1997). Facies with moorland and marginal swamp appeared in the palynospectra. Taxodiaceae are also frequent. The climate at this time appears to be more humid. Pollen spectra contain a larger amount of spores of thermophile ferns as *Lygodium*, Pteridaceae, Gleicheniaceae together with *Riccia* and *Selaginella* (Pl. 1, fig. 10). *Ilex* is relatively plentiful. The higher representation of *Symplocos* pollen is interesting in the samples of Ottnangian age.

Striking members in some palynospectra are the higher proportions of *Selaginella* (up to 6%), their occurrence being visible in the Eggenburgian/Ottnangian and Ottnangian/Karpatian border sediments. They are accompanied by an increased frequency of other pteridophytes. The humid climate was probably connected with the transgression.

The Karpatian sedimentation began by gradual transgression on the relatively flat coast, which was connected with anoxic conditions. The frequent alteration of palynomorphs caused by precipitation and growth of pyrite is visible. Later on, fully marine conditions with schlieric sediments developed. In the Karpatian palynospectra the marsh facies occur more uniformly than in the Eggenburgian–Ottnangian. Pollen and spores also confirm a warm to warm-temperate climate.

The markedly azonal associations, for example marsh palm forest with Palmae (Pl. 2, figs 9,10), Poaceae, *Lygodium*, *Sparganium*, and *Potamogeton*; riparian forest with *Alnus*, (Pl. 2, fig. 4), Myricaceae (Pl. 2, fig. 3), Lythraceae (Pl. 2, figs 1,2), or *Selaginella* (Pl. 2, fig. 13) are frequent in Karpatian sediments. The associations with Taxodiaceae, *Intratriporopollenites insculptus* Mai (Pl.2, figs 6,7) and Pteridaceae (up to 10%) are typical. According to recent investigations (Kvaček et al. 2002) *Intratriporopollenites insculptus* belongs to the genus *Craigia* (Malvaceae–Tilioideae). Very similar associations were also described from the lower Miocene of Northern Bohemia (Konzalová 1976). These pollen types were found also in the Eggenburgian sediments of the Carpathian Foredeep. In all the cases they are accompanied with high amount of other hygrophilous elements (except the ones mentioned above also Ericaceae and *Salix*).

Assotiations of markedly colder climatic conditions, known from the adjacent areas (e.g. Slovakia, Austria) from the end of the Ottnangian and the lower Karpatian (Hochuli 1978, Planderová 1990) have not been found. Proportional changes between palaeotropical and arctotertiary elements seems to be influenced by facies in all of the samples studied.

The schlieric sediments, representing marine conditions, contain a large amount of Pinaceae and an increasing amount of Oleaceae (Pl. 2, figs 8,12). Sapotaceae have not been found in the uppermost studied Karpatian sediments. Arctotertiary elements increased slightly. However, there are not sufficient data to enable a more exact interpretation of this as representing a colder climate interval.

Conglomerations of pollen (*Monocirculipollis*, Chenopodiaceae, *Platanus*, Oenotheraceae, Myricaceae, *Alnus*, and others) were found in some facies from the whole of the Lower Miocene. Their presence confirms the low-flow water dynamics and short transport distances to the place of sedimentation.

The studied sediments from the Modrý Kamen basin include the *Rzehakia* beds and the schlieric layers (Ottnangian–Karpatian). The palynospectra are similar to the ones from the Carpathian Foredeep. The biggest difference is based on the typical occurence of pollen of the formal genus *Pentapollenites* (Pl. 2 fig. 14–16) which after Krutzsch (1962) is characteristic for Palaeogene. These pollen have also been described from Miocene sediments by Planderová (1990) and Nagy (1985). Planderová interprets these types of pollen as typical for the coal facies of the Slovakian Lower Miocene. However, the author has not observed these pollen types in the Carpathian Foredeep. According to the recent literature (Reille 1995) part of our material is very close to the genus *Haplophyllum* (Rutaceae). Hofmann and Zetter (2001) described this pollen from the Palaeocene/Eocene of Austria and considered them belonging within the Simarubaceae.

The studied Lower Badenian sediments represent the development of fully marine conditions with a high oxygen content. The palynospectra are generally poor in pollen and spores (except for Pinaceae), and are comparatively rich in Dinoflagellata. The tapeta of foraminifers have also been identified. It is probable that the conifer pollen accumulated in these marine sediments due to their wind dispersal properties.

The environment on the seashore was probably rather wet as noted by the presence of spores of Fungi, Polypodiaceae, pollen of *Alnus* and *Ulmus* and ranging up to swampy as represented by the pollen of Taxodiaceae and Myricaceae. There are visible only slight changes in the pollen diagrams between the Karpatian and Lower Badenian pollenspectra. In the Badenian a decreasing number of some thermophilous members, such as *Engelhardia*, *Platycarya*, *Tricolpopollenites henrici* (Pot.) Th. & Pf. and *T. microhenrici* (Pot.) Th. & Pf., and Castanoideae are observed. Oleaceae were also less frequent, although Taxodiaceae regularly have a higher representation while *Alnus* has steadily lower percentages. In the Badenian palynospectra the higher differentiation of the pollen of thermophilous forms of oaks such as *Tricolpopollenites henrici* (Pot.) Th. & Pf. and *T. microhenrici* (Pot.) Th. & Pf. or forms probably similar to the *Quercus ilex* as well as deciduous ones, are observed (Pl. 2, figs 18–19).

The present author cannot currently specify if the changes observed are influenced climatologically or are caused by the development of the sedimentation basin and its adjacent areas.

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PLATES

Plate 1

Sporomorphs of Eggenburgian – Ottnangian

× 1000, except figs 3,4 and 13

1–4. *Monocirculipollis zahnaensis* Krutzsch, Čejkovice 176.8 m, Eggenburgian–Ottnangian

3. SEM × 2300

4. SEM × 5500

5. *Reevesiapollis triangulus* (Mamczar) Krutzsch, Líšeň, Ottnangian

6. *Sapotaceoidaepollenites* sp., Miroslav 78.4 m, Eggenburgian–Ottnangian

7, 8. *Rutaceaepollenites* sp., Šafov 12, 17.5 m

9. *Chenopodipollis multiplex* (Weyl. & Pf.) Krutzsch, pollen conglomerate, Miroslav 78.4 m, Eggenburgian–Ottnangian

10. *Echinatisporis miocenicus* Krutzsch & Sontag in Krutzsch, Trboušany 65.8 m, Eggenburgian–Ottnangian

11. *Symplocoipollenites vestibulum* (Potonié) Potonié, Líšeň, Ottnangian

12. *Potamogetonpollenites* sp., Líšeň, Ottnangian

13. *Myricipites* sp., pollen conglomerate, Trboušany 49.7 m, Eggenburgian–Ottnangian, × 500

14. *Leiotriletes maxoides maximus* (Pflug) Krutzsch, Trboušany 49.7 m, Eggenburgian–Ottnangian

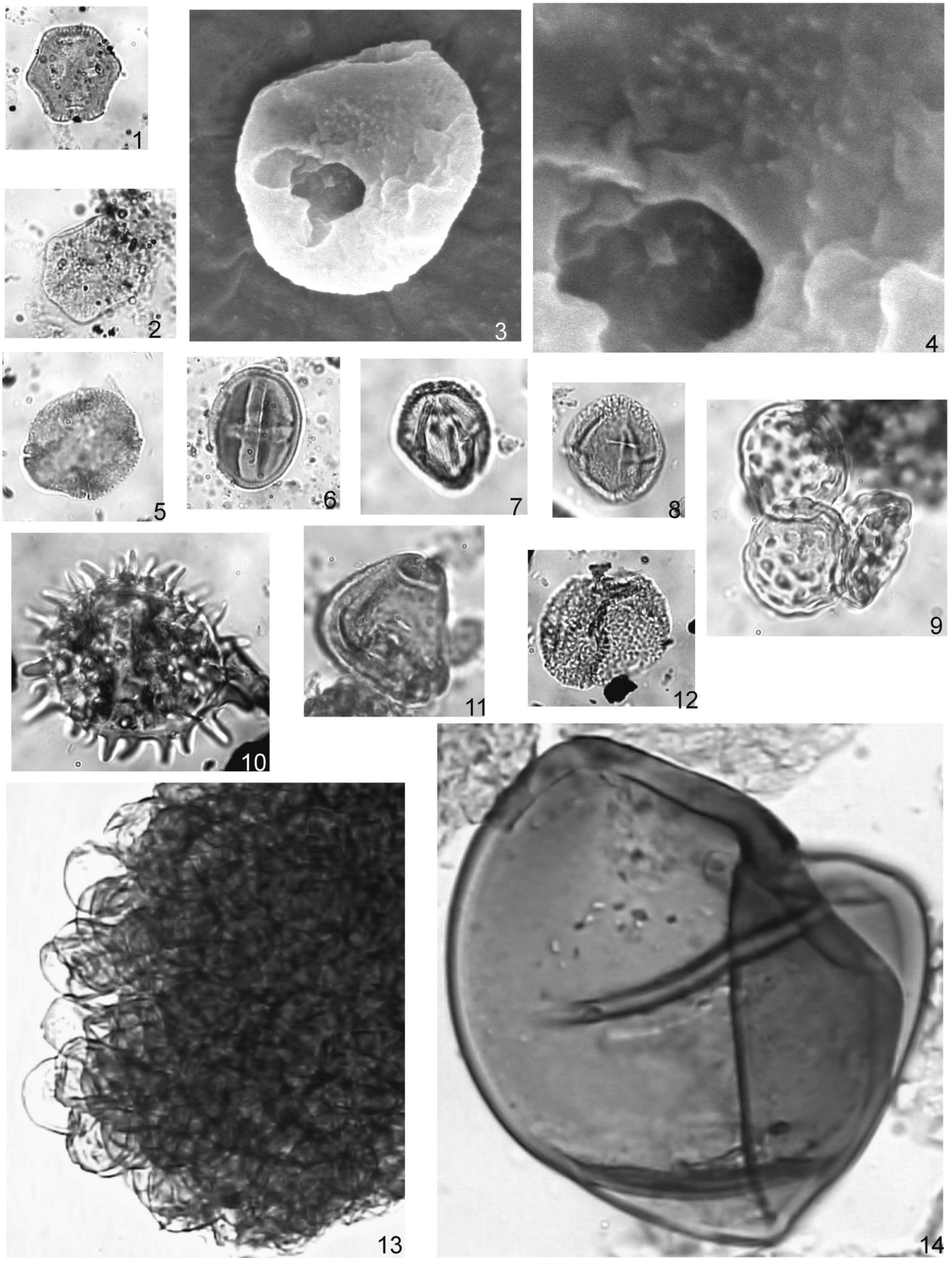
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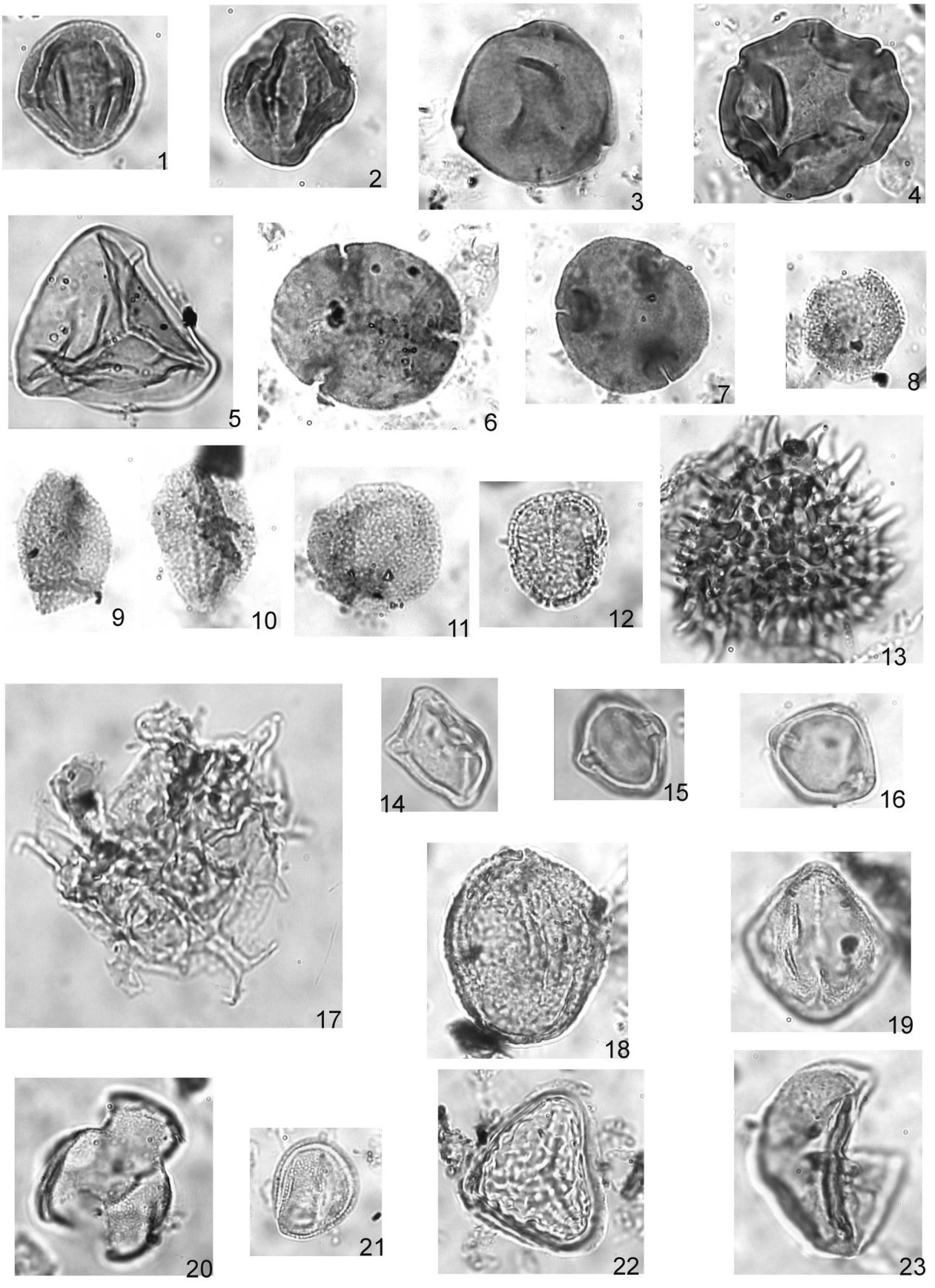
Plate 2

Sporomorphs of Ottnangian–Karpatian–Badenian

× 1000

1,2. *Lythraceaepollenites* sp., Ždánice 67, 780–785 m
3. *Myricipites rurensis* (Pf.& Th.) Nagy, Ždánice 67, 780–785 m, Karpatian
4. *Alnipollenites verus* Potonié, Ždánice 67, 785–790 m, Karpatian
5. *Leiotriletes wolffii wolffii* Krutzsch, Nosislav 3, 323 m, Karpatian
6,7. *Intratriporopollenites insculptus* Mai, Ždánice 68, 815–820 m, Karpatian
8,12. *Oleoidearumpollenites* microreticulatus (Th. & Pf.) Ziembińska-Tworzydło, Nosislav 3, 280.8 m, Karpatian
9,10. *Sabalpollenites areolatus* (Potonié) Potonié, Ždánice 67, 795–800 m, Karpatian
11. *Potamogetonpollenites* sp. Ždánice 67, 795–800 m, Karpatian
13. *Echinatisporis miocenicus* Krutzsch & Sontag in Krutzsch, Nosislav 3, 343 m, Karpatian
14. *Pentapollenites* fsp. 1, Modrý Kamen Basin, N91, 345 m, Ottnangian–Karpatian
15, 16. *Pentapollenites* fsp. 2, Modrý Kamen Basin, N91, 345 m, Ottnangian–Karpatian
17. Marine Dinophyta, Židlochovice, Badenian
18. *Quercoidites granulatus* (Nagy) Słodkowska, Židlochovice, Badenian
19. *Quercoidites* sp. 1 – *Quercus ilex* type, Židlochovice, Badenian
20. *Cercidiphyllites minimireticulatus* (Trevisan) Ziembińska-Tworzydło, Židlochovice, Badenian
21. *Platanipollis ipelensis* (Pacltová) Grabowska, Lysice, Badenian
22. *Polypodiaceoisporites corrutoratus* Nagy, Židlochovice, Badenian
23. *Inaperturopollenites hiatus* (Potonié.) Th & Pf. – *Glyptostrobus* type, Ždánice 68, 815–820 m, Karpatian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