

PALYNOLOGICAL CORRELATION OF
THE NEOGENE OF THE CENTRAL
PARATETHYS

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Development of the theme*

In 1990 an initiative of the International Secretariat of the Geological Institute of Hungary made it possible to develop common scientific plans for the Geological Institutes of the countries participating in the Alps-Adriatic programme. For this reason I presented to the Pentagonale a plan of collaboration of the Central Paratethyan Neogene palynologists of Hungary, Austria, Yugoslavia and Czechoslovakia. I requested the palynologists of these countries to collaborate, what they accepted. The responsible organisation notified us through official channels about the acceptance of the project. Shortly afterwards the Polish palynologists requested in official way to join this working group.

The organiser of the Pentagonale informed me that we would not get any financial support unless from our own institutes. In spite of this fact the contacts between the palynologists were continuous, we used all possible occasions for collaboration. The bilateral agreements of our institutes for the exchange of scientists gave us the possibility to visit our colleagues almost yearly and to discuss our results. In 1992 Éva Planderová organised a symposium in Bratislava, where the results of our research work were presented. These lectures were printed in a volume by the Dionýs Štúr Geological Institute, Bratislava. In this volume a joint paper was published from the data of our Neogene palynological research work (Planderová et al. 1993). In 1992 I published a chapter in my monograph about this subject: "Comparisons made between the Neogene palynoflora of Hungary and of the surrounding areas" (Nagy 1992, p. 367–372).

These summaries have not given satisfactory display of all palynological problems of the Central Paratethyan Neogene. In one hand they have not contained the whole region of the Central Paratethys: e.g. Romania was not participating in the above mentioned working group, on the other hand some of the participants (in the volume) do not belong to this territory, e.g. Belorussia. I took advantage of the opportunity of the Hungarian Research Found (OTKA) for continuing the work on the theme. I tried to summarise the large amount of palynological data, and to discover the palaeobotanical coherences. This work was justified by Hungary's central position and my enormous experience.

* I wish to thank Géza Hámor (Budapest) and Miklós Kedves (Szeged) for critical comments on the manuscript.

The geological basis of this work was provided by the “Neogene Palaeogeographic Atlas of Central and Eastern Europe” (Hámor et al. 1988), and the table of Géza Hámor (1995, 1997) “The evolutionary, palaeogeographical and facies model of the Pannonian Basin with lithostratigraphic units” (A Pannon medence neogén fejlődéstörténeti, ösföldrajzi és fáciesmodellje, litosztratigráfiai egységekkel. /Hámor Géza 1995/.)

Palynological results of the individual countries

1. HUNGARY
2. CROATIA
3. SLOVENIA
4. BOSNIA-HERCEGOVINA
5. YUGOSLAVIA
6. MACEDONIA
7. ALBANIA
8. GREECE
9. BULGARIA
10. ROMANIA
11. UKRAINE
12. SLOVAKIA
13. MOLDOVA
14. CZECH REPUBLIK
15. AUSTRIA
16. POLAND



Fig. 1. Sketch map of the countries dealt with in the present paper

Croatia

The map sheet No. 1 of the palaeogeographical atlas edited by Hámor et al. (1988) contains the extension of the Egerian stage, namely the final state of the Egerian sea according to oral information by Géza Hámor. The Egerian sea was extended from Northern Hungary, with the adjacent territory of Southern Slovakia, continued in the Danube bend, over the Buda Mountains, followed in SW direction with a passage crossing Transdanubia in the direction of Croatia to Slovenia. In Slovenia it is of little extension and terminates in the line of Istria. The connection was uncertain with the Transylvanian Basin, marked on the map with a “?”. Only in the southern part of the Great Hungarian Plain was there a contact area.

In Croatia Šećerov has palynological data from the Egerian (Chronostratigraphie und Neostratotypen, Miozän der Centralen Paratethys, Band V. Egerien, pp. 160–163, 165–166) from the localities of the facies stratotype Krapina-Radoboj-Golubova (author S. Muldini-Mamuzić). The localities are brown coal bearing sequences. Šećerov found only a small quantity of spores, only 5 taxa *Gleicheniaceae*, *Osmundacidites quintus*, *Polypodiaceae*, and Gymnospermae taxa can be mentioned *Pinus haploxylon*, *P. sylvestris* and *Taxodiaceae* (coaly facies). The angiosperms have been found in higher quantity: *Engelhardtia*, *Momipites punctatus* (*Triatriopollenites coryphaeus*) are very characteristic of the Early and Middle Miocene. Fewer pollen grains are present from *Carya*, *Pterocarya*, *Alnus*, *Tilia*, *Tricolpopollenites liblarensis*, *Tricolporopollenites cingulum*, *Cyrilla*, *Nyssapollenites contortus* (*kruschi*), *Monocolpopollenites tranquillus*, *Plicatopollis plicatus*, *Intratriporeopollenites magnificus*. There is a good figure on p. 166 (Abb. 31) about the extension of the Egerian beds in Croatia. On the same figure also the occurrence of the Badenian beds is indicated. On the map Hámor 1995 Hungary has contact SW with Croatia. On the map No. 3, in the Karpatian – Early Badenian time, the marine sedimentation of the Central Paratethys continued from the Hungarian Central Basin to Croatian territory. There were also terrestrial areas. From one of these derived Krizmanić's (1995) palynological data, from the locality Gorja Jelenska, as verified by freshwater algae: *Botryococcus braunii* Kütz., *Zygnemataceae* div. sp., and freshwater vegetation e.g. *Nymphaeaceae* pollen grains. According to the sporomorphs the locality belongs to the Mecsekisporites main zone (Nagy 1992, p. 363–364). The author found in the material *Rudolphisporis* and also *Bifacialisporites badenensis*, which can be used to distinguish the two range zones. After the Hungarian experience the material is probably of Karpatian age.

More uncertain is the stratigraphic position of the locality Krabavsko Polje Lika (Jurišić-Polšak, Krizmanić et Hajek-Tadesse 1993). The palynomorphs are rather characteristic of the Early Miocene, even if some of them occur, with 1–2 exemplars in the Late Miocene, too, e.g. *Zelkovaepollenites thiergarti*, *Magnoliaepollenites simplex*, *Plicatopollis plicatus*, *Engelhardtoidites microcoryphaeus*, *Platycaryapollenites miocaenicus*, *Momipites punctatus*, *Myricipites rurensis*. Explicitly tropical flora elements e.g. *Sapotaceae*, *Symplocaceae* are lacking. From the spores *Leiotriletes*, *Laevigatosporites*, *Lycopodiumsporites* are mentioned without species names and without any quantitative data. These beds are considered to be of freshwater facies, but no planktonic organisms are mentioned. The other fossils (ostracods, molluscs) have also not solved the stratigraphical problems. The conclusion of the authors was that these beds are Miocene, without more precise determination.

Late Pontian localities were examined by Špoljarić (1952). Xylotomical work was complemented with palynology. To the xylotomy he made photos, but the palynological part was illustrated with drawings only. In North Croatia East from Varaždin three localities were examined: Ivanec, Pešćeno, Pitomača. They are coal bearing sequences, without stratigraphical data. *Congeria* sp. is mentioned without species determination, obviously after the opinion of the geologists. Croatia is in the S part of the Pannonian Basin, in all probability we have to do with the bed "F", after Adolf Papp, the *Congeria balatonica*, *C. neumayri* zone. According to the author's communication the material was gathered from coaly clay, so the samples are from freshwater facies. The drawings (pp. 179–180) are identified as *Ovoidites ligneolus* (*Polygonum?* by the author). The coal with three seams and with little coal streaks, corresponds to Hungarian equivalents at Petőfi mine (Nagy 1958), Torony and the neighbouring territories (Draxler, Nagy et al. 1997). 11 genera of conifers, 17 genera of deciduous trees and shrubs, 5 genera from herbs, water plants and many fungi, moss spores have been determined. Naturally the majority of the sporomorphs belong to the *Taxodiaceae*. Two types of *Sequoia*, *Taxodium* and perhaps *Glyptostrobus* were found. *Tilia* occurs in great quantity, but the other deciduous trees are present only in few exemplars what is evident in a swamp forest. Between the ferns there are some thermophilic forms such as *Schizaeaceae*, *Gleicheniaceae* and *Sporonites haardtii*, too.

The results of the palynological investigations in Croatia are very similar to those in Hungary, but unfortunately the palynological examinations are missing for some stages of the Neogene.

Slovenia

Marina de Costa Grum carried out palynological research in Slovenia on the Neogene – from Badenian till Pontian – and she sent me her manuscript in 1993. The research area was – according her figure – partly near to SW Transdanubia (Dankovci, Benica, Petišovci), partly in the Zagreb Basin (Globoko), where I had studied also some materials, requested by the Geological Institute of Ljubljana.

The borehole Dankovci cut Badenian, Sarmatian, Pannonian and Lower Pontian beds. Only two samples of the Badenian part of the section contained palynological material. There were chiefly marine planktonic organisms: *Micrhystridium* sp., *Hystrichosphaeridia* sp., *Leiosphaeridia* sp., *Acritarcha* and other *Dinoflagellata*, *Chytroeisphaeridia* sp. and some undeterminable bisaccate conifers. The material of the Sarmatian samples indicated a brackish water sea (with *Hidasia*). The swamp forest is verified with sporomorphs of *Taxodiaceae*, *Nyssa*, *Myrica*, *Myriophyllum*, *Typha*, *Polypodiaceae*, *Osmundaceae*. The great number of pollen grains of *Alnus*, *Ulmus*, *Zelkova*, *Celtis*, *Quercus*, *Fagus*, *Juglans*, *Ostrya* refer to riparian forest. Less abundant are *Ilex*, *Oleaceae*, *Caryophyllaceae*, *Gramineae*, *Vitaceae*, *Araliaceae* and only sporadically are present the pollen grains of *Ginkgo*, *Sciadopitys*, *Ephedra*, *Liquidambar*, *Magnolia*, *Arecipites*, *Punica*, *Eucommia*, *Artemisia*, *Plantago*, *Sapotaceae*, *Umbelliferae*. The mountains are marked by the great number of the pollen grains of conifers: *Pinus*, *Picea*, *Abies*, *Tsuga*, *Cedrus* and *Podocarpus*.

The swamp forest in the Pannonian was very similar to that of the Sarmatian, only the *Osmunda* are missing, – contrary to Hungary. The *Nymphaeaceae* refer to a quiet water surface. By the riverside lived *Alnus*, *Ulmus*, *Carya*, *Pterocarya* and others. In the deciduous forest *Fagus*, *Quercus*, *Tilia*, *Juglans*, *Betula*, *Liquidambar*, *Carpinus*, *Ostrya* were dominant. Rare were *Acer*, *Ilex*, *Arecipites*, *Magnolia*. The underwood was composed by *Compositae*, *Ericaceae*, *Poaceae*, *Chenopodiaceae*. Between the conifers dominated the *Pinus haploxylon* and *Pinus sylvestris*; less common were *Picea*, *Abies*, *Cedrus*, *Podocarpus*. Compared to Sarmatian there are less marine algae. In the lower part of the Pannonian there is more brackish-water plankton (*Hystrichosphaeridae*, *Pleurozonaria* sp., *Pixidiella* sp., *Hidasia* sp.), and also some freshwater algae (*Spirogyra* sp., *Ovoidites ligneolus*, *Botryococcus braunii*).

For the upper part of the Pannonian – after M. Sütő (1985) – were characteristic the different varieties of *Spiniferites bentori*, *Gonyaulax digitale*,

Chytroeisphaeridia cariacensis, *C. tuberosa*, *Thalassiphora balcanica*, *Millioudodinium foveolatum*, *M. punctatum*, *Impagidinium globosum*, *Pontadinium pecsvaradensis*, *Dinoflagellata* “prevalvate” stage, but also *Spirogyra* sp. is present. This zone in Slovenia corresponds to the upper part of the *Spiniferites bentori* zone in Hungary.

The Pontian flora of the examined 5 boreholes according to de Costa Grum, composed the coal seams, therefore it is very uniform. The narrow coal seams are present everywhere in the Pontian, but they are most important in the Upper Pontian. The palynological data are from a swamp in the Lower Pontian. The swamp forest was composed by *Taxodiaceae*, *Nyssaceae* and *Polypodiaceae*, and the riverside mixed deciduous forest – according to the author – by *Pinus*, *Picea*, *Abies*, *Cedrus*, *Quercus*, *Fagus*, *Liquidambar*, *Juglans*, *Engelhardtia*, *Tilia*, *Acer*, *Betula*, *Myrica*, *Myriophyllum*, *Carpinus*, *Corylus*, *Ulmus*, *Zelkova*, *Carya*, *Pterocarya*, *Ilex*, *Oleaceae*, *Ericaceae*, *Gramineae*. There are also brack-water algae present: *Dinoflagellata*, *Hystrichosphaeridae*, *Gonyaulax digitale*, *Impagidinium spongiosum*, *I. globosum*, different varieties of *Spiniferites bentori*, *S. validus*, *Chytroeisphaeridia cariacensis*, *C. hungarica*, *C. tuberosa*, *Millioudodinium punctatum*, (M. Sütő 1990) and freshwater algae: *Cooksonella circularis*, *Spirogyra* sp. and a few *Botryococcus braunii*.

In the uppermost part of the Pontian there are more and more freshwater algae: *Zygnemataceae*, *Spirogyra* sp., *Mougeotia* sp., *Cooksonella circularis*, *Tasmanitaceae* and *Botryococcus braunii*. The *Dinoflagellata* and *Hystrichosphaeridae* are very rare. On the fringes of the swamp forest deciduous plants were living: *Myrica*, *Carya*, *Pterocarya*, *Engelhardtia*, *Betula*, *Alnus*, *Carpinus*, *Fagus*, *Quercus*, *Castanea*, *Ulmus*, *Celtis*, *Liquidambar*, *Acer*, *Tilia*, and *Arecipites*. The underwood was composed by *Polygonaceae*, *Compositae*, *Poaceae*. On the hillside between the conifers the *Pinus sylvestris* and *P. haploxylon* are dominant, besides also *Picea*, *Abies*, *Tsuga*, *Cedrus*, *Podocarpus* pollen grains are present.

The brown coal is very rich in sporomorphs. The *Taxodiaceae* are dominant, but there are typical thermophilic elements, too: *Polypodiaceae*, *Nyssaceae*, *Myricaceae*, *Engelhardtia*, *Magnolia*, *Arecaceae*. The paleoflora is very similar to those known from the other parts of the Pannonian Basin. There are quantitative differences as local phenomena.

According to the opinion of the author there was no significant change in the palaeoflora from the Sarmatian till the Pontian. The palynological composition was changed from sample to sample independently from the age.

The differences can be traced back to faciological changes which are the consequences of palaeogeographic changes.

The planktonic organisms in the Badenian are of marine character. In the Sarmatian, Pannonian, Lower Pontian they are brackish and less numerous. In the Upper Pontian the numbers of the freshwater plankton organisms and of the angiosperm pollen grains are increasing.

Pantić referred to the palynological data (Weyland, Pflug et Pantić 1958) of a Slovenian locality. In the NW part of Slovenia, near to Austrian boundary is located Velenje, considered to be Pannonian. The age of the locality is probably Pontian, as the age was inferred by *Planorbis*, *Paludina* and *Mastodon arvernensis* remains. The list of the flora corresponds to the Hungarian one, but there are no quantitative data. The palaeovegetation divided into swamp, riparian, deciduous and hillside forests contains also subtropical, tropical elements. The taxa mentioned are: *Sciadopitys*, *Tsuga*, *Taxodium* or *Glyptostrobus*, *Cyrilla*, *Araliaceae* or *Cornaceae*, *Nyssa*, cf. *Parthenocissus*.

The Slovenian palynological data have been produced by using the Hungarian palynological literature (see the references of de Costa Grum) and by personal connections with the Hungarian palynologists. The nearly identical palaeogeographical and palaeoclimatological circumstances of the two territories brought about nearly identical palaeofloras, as it is visible from the Slovenian palynological literature.

Yugoslavia – Bosnia

The part of the Pannonian Basin east from Croatia is Serbia, from where I have no Miocene palynological data.

In Bosnia a paper by Pantić et al. (1966) refers to palynological data of the Egerian stage. In the terrestrial, lacustrine Zenice-Sarajevo Basin the Koscan Series is marked as Oligo-Miocene. From this locality 28 taxa have been mentioned after the nomenclature of Thomson et Pflug (1953). Out of these I identified 24 with the Hungarian material. The tropical elements among them are *Monocolpopollenites tranquillus*, *Myricipites rurensis*, *Momipites punctatus (coryphaeus)*, *Tricolporopollenites henrici*, *T. microhenrici*, *T. cingulum*, *Nyssapollenites contortus (kruschi)*, *Cyrillaceaepollenites megaexactus*. These facts support that both areas were in the subtropical zone. In Hungary, North of the Egerian holostratotype there was a mountain chain (Ostrovski-Vepor, Gemerida), while South of it the Paratethys sea. They pro-

ducted climatic circumstances like the "Riviera" has today. This supposition is supported also by Pantić (1986, p. 420, the upper part of Fig. 1).

In Northern Bosnia the coal seam of Ugljevik has been ranged to the Chatian on the basis of both the macroflora and the finding of *Anthracotherium minus* (Weyland, Pflug et Pantić 1958). According to Pantić the fossil pollen grains correspond to the lowermost Miocene of the country (leaf prints from Ravna Reka, Banovci). Tropical elements are, *Engelhardtia*, *Symplocaceae*, *Rhus*, *Cyrillaceae*, cf. *Parthenocissus*, *Nyssa*, *Sapotaceae*, *Palmae*. (Quatitative data are missing). The 33 taxa by Pantić were identifiable with the Hungarian's (from the holostratotype of Egerian 212 taxa were determined, Nagy 1992).

These localities are Early Miocene, but have no contact with the Paratethys, because according to the Eggenburgian map No. 2 (Háamor et al. 1988), there was no sea on the Balkan Peninsula. These Early Miocene layers represent a continental facies. The palaeovegetation with the climate has to settle the simultaneity.

In the Zenice-Sarajevo Basin the following palynological data are from the Zenice-Kakanj-Breza Series with coal seams (Pantić et al. 1966). The lower sample of the section named by the authors M₁ - could be Eggenburgian. In this sample 21 taxa have been found. In the upper sample there were 30 taxa, this could be Ottnangian. Both of them contained *Divisisporites* sp., which after Thomson et Pflug (1953) occurs in Germany in the Wehmingen (Paleocene). Both samples are from coal facies, therefore in both there were also pollen grains of *Taxodiaceae*, *Myrica*, *Nyssa* and *Cyrillaceae*.

The next sample of the Zenice-Kakanj-Breza Series in the Zenice-Sarajevo Basin is marked as M₂, could be ?Karpatian-?Badenian, with 23 taxa. A common taxon with the previous, Ottnangian sample unit is *Laevigatosporites discordatus* (after Thomson et Pflug (1953) which occurs in Germany in the Lower Paleogene). In Hungary it is represented in few exemplars in the Neogene from the Egerian till the Lower Badenian. The appearance of the *Corylus* in the Badenian coincides with the Hungarian data.

The upper part of "die obermiozäne Kohlenvorkommen Serie" marked with M₃ (Pantić et al. 1966) differs both from the main coal seam and from the Pliocene part of the section. It has yielded so few fossils that it was impossible to determine the age more precisely. In this sample there were 23 taxa, many *Laevigatosporites haardtii*, spores of *Osmunda*, *Pinus sylvestris* and *Alnus* pollen. This area is not a part of the Central Paratethyan region after the map No. 3 (Háamor et al. 1988). It could be in the vicinity of the sea only in Badenian time, when the coal series could have developed.

In Northern Montenegro at Plevja there is also a coal series (Weyland, Pflug et Pantić 1958). Pantić studied the plant macrofossils of the hanging wall. The finding of *Chalicotherium grande* supported the Middle Miocene age of the locality. The palynological determination resulted in 34 taxa. Tropical elements were *Symplocaceae*, *Araliaceae* or *Cornaceae*, *Nyssa*, cf. *Parthenocissus*, cf. *Rhus*, *Palmae*. Also *Corylus* occurs here. The age of the locality could be Early Badenian.

Despotovać is in Eastern Serbia (at longitude of 21° cca 25' East and latitude of 44° North). According to the map No. 4 (Hámor et al. 1988) and also Weyland, Pflug et Pantić (1959) in the section of this locality marine and freshwater layers alternate. The section contains 4 clay horizons. Horizon II B was examined palynologically. Its age is "Tortonian-Sarmatian". The hanging wall of the coal is greyish green sandy clay with macrofauna of *Cerithium*, *Ervilia* and ostracods, the microfauna consists of *Nonion*, *Elphidium*, *Rotalia beccarii*, *Miliola*. The macroflora has been collected from the hanging wall. In the opinion of Pantić this is a typical Tortonian-Sarmatian vegetation. The number of exines is 25. The *Taxodiaceae* are *Glyptostrobus* (macrofossil), *Sequoia* or *Cryptomeria*. Besides there are pollen grains of *Pinus*, *Picea*, *Abies*, *Engelhardtia*, *Juglans*, *Carya*, *Ulmus*, cf. *Zelkova*, *Corylus*, *Betula*, cf. *Rhus*, *Phellodendron*, *Nyssa*, cf. *Parthenocissus*, *Araliaceae* or *Cornaceae*, cf. *Catalpa*, *Palmae* e.g.

The youngest part of the Zenice-Sarajevo Basin, the lignite of Rakovice-Kasindol has been ranged into Pliocene (Pantić et al. 1966), marked as Lower Pliocene. Here were identified 30 taxa, many *Osmunda*, *Sabal* and conifers. Typical of the facies is the massive presence of *Taxodiaceae*, and *Tsuga*, *Picea* and other conifers. There are many pollen grains of *Corylus*, *Betula*, *Carpinus*, *Quercus*. For the first time in the Zenice-Sarajevo basin appear *Fagus*, *Salix* and *Symplocos*, *Sapotaceae*. The fact that in Hungary in a Pannonian section (borehole Berhida 3) I found also the pollen grains of the last two families, confirmed the opinion of Pantić that before the Pontian time the boundary of the subtropical climate was located in Northern Hungary (Pantić, 1990, p. 81 in *Chronostratigraphie und Neostatotypen*, Band VIII. Pontien).

North of the Fruskagora, Beocin I examined Pannonian samples. Margit Korpás Hódi brought 5 samples for palynological examination in 1981 (Sakotinac, Beocin, Grgeteg, Arau Jankuli). The results were published (Nagy et Planderová 1965, pp. 586–615, in *Chronostratigraphie und Neostatotypen*, Band VII. Pannonian). The beds of *Congeria banatica* correspond to the *Spiniferites bentori* zone. The palynoflora of these samples is the same as that

of the Pannonian in Hungary. In later examination of the borehole Berhida 3, Western Hungary, as I mentioned above, also pollen grains of *Symplocaceae* and *Sapotaceae* have been found in the Pannonian of Hungary.

The biostratigraphical ranging of the coal basin of Kreka, including also Tuzla originated from Stefanović (Weyland, Pflug et Pantić 1958). Of the four coal seams the lowest one is Lower Pontian, the main seam and the hanging rock belong to the lower part of the Upper Pontian, the hanging coal seams and overlying clay and sand beds represent the upper part of the Upper Pontian. The macroflora of the main coal seam has already been examined by Engelhardt (1901), those of the somewhat younger horizon by Pantić (1956). These studies were completed by the authors with palynology. 38 taxa have been determined: spores, conifers (*Taxodiaceae*, *Sciadopitys*, *Cedrus*), angiosperms (*Nyssa*, *Cyrillaceae*, *Araliaceae* or *Cornaceae*, *Symplocaceae*, cf. *Engelhardtia*, *Palmae*?).

The southern prolongation of the Pannonian Basin in Serbia was divided in Pontian time into two parts: 1) the Southern area Bačka, Banat and the area South of the Sava line, and 2) the East of the Carpathian-Balkan Mountains, and the Western part of the Dacian Basin the Eastern Serbian area. These areas were subdivided into different parts on the basis of geography and ecology (Pantić et Dulić 1993), after Pantić's experiences from Okefenokee and the Everglades (USA). The flora is identical with the Hungarian one. Even quantitative differences are not concluded from the text. Very important is the description of leaves of *Taxodium distichum* and *T. distichum* var. *nuttans*. The latter has two types of needles: "needles characteristic of *Glyptostrobus* (scale-like), and needles of a more sizable variety of *Taxodium* (longer needles, usually on sprouts at the trunk). This seems to indicate a past close affinity between the two genera which are more individualized at present" (Pantić 1990, p. 875, and Pantić et Dulić 1993, p. 185). These morphological observations are very important, because the research work on the recent genera may throw light on the separation of the fossil genera.

Nikolić (1966/ treated palynologically the soft brown coal basin in Kosovo, and considers it Pontian, supported with Prosodacna (Prosodacna) cf. vutskitsi Brus. molluscs. He has described 58 sporomorphs and found freshwater algae: *Spirogyra* sp. and *Ovoidites ligneolus*. Also *Mougeotia* was present, after his figures.

In the Pontian volume Pantić (1990) published three papers. In these he summarised the whole palaeobotanical knowledge concerning the Balkan Peninsula, and in particular Yugoslavia. His own research work has been complemented with other macro- and micropalaeobotanical data (D. Mihaj-

lović and Vera Pantić). The first article deals with the palaeoclimate (pp. 80–85). On Fig. 3 is represented the subtropical climatic belt before and after the Pontian (referring to Walter 1984, *Vegetation und Klimazonen*, Fig. 160). In his opinion before the Pontian the area between the 48–49° latitudes of the Central Paratethys belonged to the subtropical zone. After the Pontian this climatic belt moved down the Balkan to the shore of the Adriatic sea and through Macedonia and Bulgaria, to the Black Sea. In the same article Fig. 4, (p. 84) he shows the migration of the coal formation during the Pannonian and Pontian, respectively in the Middle Pliocene. The Vienna Basin, the Slovak territory and perhaps the foreland of the Mátra Mountain could be correlated (Nagy 1958). Palynological data proved that the coal forming occurred in the Early Pontian in Mátra foreland in the lignite area of Torony and Burgenland (Draxler, Nagy et al. 1996). Identically with us, Pantić has the same opinion: the coals were formed in the Bakony, Mátra, Bükk Mts in the same “oscillating” period. Pantić speaks also about a Pontian lignite area of the Mecsek Mountains after Sütő (1989). The palaeoclimate was suitable in the Mecsek area for a swamp forest (see the pollen spectrum of the borehole Hidas 53, 73.3–89.5 m in Nagy 1969, 1992). Pantić mentioned as the third period of the Pontian the Portaferrian where he ranged Kostolac, Kolubara and the localities of Kreka, South of the Pannonian lake, and finally the fourth and youngest the Macedonian (Greece).

The second article (pp. 294–299) is a review of the Pontian localities of Yugoslavia, mostly on the basis of macrofloral relicts, and their ecological types based on the knowledge of the Okefenokee swamp forest (USA).

The third article (pp. 870–889) contains an important pollen diagram (Fig. 79) of unknown geographical position, but displaying quantitative data. It shows the dominance of the conifers and the high quantity of the *Taxodiaceae*. The numerous *Nyssa* pollen grains are conspicuous, equally with the *Taxodiaceae*, in contrast to Hungary. The riparian forests were characterised by *Carya*, *Alnus*, *Betula*, *Salix*, *Laevigatosporites haardtii*, the rims of the swamp by *Cyrilla*, *Myrica* shrubs. This area was warmer than the Hungarian part of the basin, as indicated by the higher quantity of the *Cyrilla* and *Rhus* pollen grains, which are very rare in the Pontian in Hungary.

Forming the picture of the palaeovegetation in Yugoslavia (Serbia, Montenegro), and Bosnia N. Pantić and his co-workers have played an important role. The geography of this territory is very diversified, in consequence the climate is diversified, too. On this relative large territory very few palaeobotanical and even fewer palynological works have been published. The most comprehensive work concerns the Zenice-Sarajevo basin, but the strati-

graphical ranging was not determinative enough. During their work the researchers always referred to the Hungarian results (Pantić, Nikolić). Pantić is a geologist, but having worked on macroflora, he already had a considerable botanical knowledge when he began to work with his wife also in palynology. He was very much impressed – just like me – by the visit to the Okefenokee swamp forest (USA), which gave a good picture about the circumstances of coal formation. He made very important morphological observations on the resemblances of *Taxodium* and *Glyptostrobus*. Macropalaeobotanists very often even in the Late Neogene admit the presence of *Glyptostrobus* and deny the occurrence of *Taxodium*. During coalification the degradation is so intensive that the morphologically similar pollen grains of *Taxodium* and *Glyptostrobus* can hardly be distinguished. Therefore newly the *Taxodiaceapollenites* name is used. But for those scientists who had the possibility to see one of the *Taxodium* swamp forests in SE USA, it is very difficult to get rid from the *Taxodium distichum* and his variant species. It is a pity that I could not see the single original biotope of the *Glyptostrobus* in China. The Chinese referred to the nearness of Taiwan but I could see only *Glyptostrobus* trees planted in line along a canal in the garden of the University in Kanton.

The palaeofloras and palaeovegetations of Yugoslavia resemble to those of Hungary. As I mentioned earlier, despite of the considerable latitudinal differences between the Balkan peninsula and Hungary, the higher mountains brought about similar climatic circumstances.

Albania

For the delimitation of the territory of the Central Paratethys from the Tethyan region, I studied also the palynological literature of Albania. In Muhameti's paper (1990) there is a very short English summary and in the Albanian text a pollen diagram. On the help with these I try to survey the palynological situation in the Tortonian and Messinian. In the Tortonian no data are shown, but in the Messinian there were many marine planktonic organisms: *Leptodinium*, *Hystriochokolpoma*, *Thalassiphora*, *Spiniferites pachydermus*, *S. mirabilis* etc. characterised the descendant of the Tethys. The most part of the spores – compared with the list of spores the Messinian monograph of Italy (Trevisan 1967) – seem to be redeposited. Along the shore line there was *Taxodium* swamp forest and also mangrove marked by pollen grains of *Avicennia* (Nagy 1990, 1991). The palaeovegetation was

very rich. Among the temperate floral relicts there were present also tropical and subtropical floral elements in great number: *Engelhardtia*, *Platycarya*, *Rhoiptelea*, *Magnolia*, *Sapotaceae*, *Symplocaceae*, *Meliaceae*, *Myrtaceae*, *Palmae*. There were also typical Mediterranean taxa: *Cedrus*, *Zelkova*, *Quercus coccifera* type, *Olea*, *Cistus*. In the Late Miocene the Central Paratethyan palaeoflora was similar to the Albanian in the high proportion of the pollen grains of conifers and herbs. The spores of *Laevigatosporites haardtii* were always present in high quantity. There were also xerophilic plants: *Ephedra*, *Chenopodiaceae-Amaranthaceae*. The palaeoenvironment indicates a very favourable climate of the sea shore. Some species of the palaeoflora claimed warmer climate than it was in the other parts of the Balkan Peninsula. In the other part of the peninsula there were high mountains and the valleys, terrestrial basins were open to the North. The seashore of the former Tethys is indicated by the great number of marine planktonic organisms.

Bulgaria

Based on the maps Nos 3. 4. 5. 6 (Hámor et al. 1988) there was no direct contact between the sea of the Pannonian Basin and the Bulgarian territory. Even on the map No. 3, when the Paratethys was the most extended no connection is shown. On the map No. 5 there is a “?” in the area of Timok Basin. On the No. 5 Sarmatian satellite map there is some approach by the Central and Eastern Paratethys in the NW territory of Bulgaria. Since we are dealing with the question of the connection of the fossil floras and vegetations, we have looked also for the relations with Bulgaria.

Ivanov wrote in 1994 in a paper “Palynological zonation of Miocene sediments from North-West Bulgaria” that in the South-Eastern part of the Central Paratethys Basin in Montana district, near to Slavotin village there was a borehole C-1 the material of which was palynologically investigated. The section was marine Badenian (420–353.5 m) and Sarmatian (353.5–42.5 m). The lithostratigraphical description of the area was made by Kojumdzieva et Popov (1988). The author relied on the macrofloristical results of Petkova (1977), Palamarev et Petkova (1987), Palamarev (1991). The author separated 4 pollen zones in the borehole: zone “A” is Badenian, zones “B” and “C” are Volhynian, zone “D” is Volhynian-Bessarabian in age. The list of the flora is: *Pinus sylvestris* type, *P. haploxylon* type, *Abies-Keteleeria*, *Picea*, *Cedrus*, *Tsuga*, *Sequoia*, *Taxodiaceae*, *Cupressaceae*, cf. *Podocarpus*, *Alnus*, *Salix*, *Nyssa*, *Ulmus-Celtis*, *Platanus*, *Carya-Pterocarya*, *Engelhard-*

tia, *Myrica*, *Rhus*, *Araliaceae*, *Arecaceae*, *cf. Pandanus*, *Sparganium*, *Pteridophyta*. The *cf. Pandanus* disappeared from the zone "C". Sporadically appeared the *Taiwania sp.*, the *Magnolia pyramidalis* type, the *Liquidambar cf. formosana*, *Chloranthus sp.*, *Eucommia ulmoides foss.*, *Planera aquatica* type, *Zelkova sp.*, *Juglans sp.*, *Platycarya sp.*, *Bumelia lanuginosa* type, *Reevesia sp.*, *Symplocos sp.*, *Staphylea sp.*, *Oleaceae* etc. *Chloranthus* was present in Hungary also in the Badenian (Middle) and in the Sarmatian, *Platycarya* has been found also in the Pannonian, but only in the borehole Berhida 3.

Ivanov described (1994, *Fitologia* 47) from Slavotin 88 spores and pollen taxa. These are not very different from the Hungarian data. Only the spores are of more tropical character, what is not typical for the Late Miocene of Hungary. In Slavotin were found a few exemplars of *Anemia*, *Pteris*, *Gleichenia*, *Dicksonia*.

Petrov and Drazheva-Stamatova (1971, 1972, 1973) described pollen grains of *Cyclocarya*, *Reevesia* and *Itea*, SW from Sofia at Chukurovo in a Middle Miocene (Helvetian-Tortonian) coal basin. In the Neogene of Hungary till now I have found the pollen grains of *Reevesia* only.

Ivanov described (1995) from boreholes of NW Bulgaria four pollen grain types and one subtype of *Symplocos*. Palamarev (1971, 1989) and Palamarev et Petkova (1991) described the macroremains of *Symplocos* from the coal basin of Chukurovo. These taxa lived in hygrophyton, mesophyton forests, probably in *Quercus-Magnolia* forests, respectively in mixed palaeocommunities (Palamarev 1991), together with *Magnolia*, *Liriodendron*, *Quercus*, *Fagus*, *Celtis*, *Castanea*, *Eucommia*, *Cornus*, *Carpinus*, *Parthenocissus*, *Pteris*, *Lygodium* etc. species. These are reminding of the Badenian flora of Hungary.

Very important data are there in Ivanov's Theses (1995, in Bulgarian), about his palynological results concerning the Badenian, Sarmatian, Meotian and Pontian stages. In the diagrams there are quantitative data. There are borehole sections with the possibility to make geographical, geological correlations, many data of molluscs, foraminifers, ostracods and lists of palaeofloras. The flora indicates a warmer climate with many *Cedrus*, *cf. Podocarpus*, *Ginkgo*, *Ostrya*, *Nyssa*, *Corylopsis*, *Celtis*, fewer *Magnolia*, *Altingia*, *Symplocos*, *Reevesia*, *Pandanus*, *Eurya* (*Theaceae*). Interesting is the presence of *Verrucatisporites tekeresensis* in Bulgaria. Ivanov found in two boreholes this species in Sarmatian-Volhynian and Upper Meotian sections. In Hungary there were found in Eggenburgian, Sarmatian, lower and Upper

Pannonian-Pontian boreholes, and in the denominative borehole Te keres 1 in the Pleistocene, too (Nagy 1985).

Petrov and Drazheva-Stamatova (1974) found 21 taxa of sporomorphs NW of Sofia in the Pontian Belobreg basin. The authors mentioned the genera *Thalictrum*, *Eucommia*, *Apocynum*, *Periploca*, *Plantago*. In Hungary *Periploca* was found in very low number in the Sarmatian. It is also a very rare taxon in Bulgaria, it was found only in younger stage than in Hungary in accordance with the latitude differences.

South of the Hungarian Pannonian Basin, on the Balkan Peninsula the former Yugoslavia and the adjacent Macedonia were chiefly terrestrial areas during the Neogene. According to the palaeovegetation preserved in freshwater sediments, it was a transitional territory between the Central Paratethys and Tethys area. It was very important to pay attention to the relevant literature in which we can state the slow change of the palaeoflora and with this the possibility of making correlation.

The Neogene flora of Bulgaria refers to a slightly warmer climate as that of Hungary. This is justified by the more southern geographic situation. The area was and is semicircular, bordered by the Balkan Mountains and the Rhodope, and open in the East to the Black Sea area. The vegetation has a very favourable position there. Bulgaria belongs geologically to the Eastern Paratethys, but according to the palynological results is a part of the Central Paratethyan region.

Greece

From the Greek palynological investigations concerning the Central Paratethys the Upper Miocene-Pliocene terrestrial freshwater brown coal areas are worth of discussion. There are situated in the NW part of the country, belong to Macedonia and their center is Ptolemais. This area unites the Paratethyan region with the Tethyan. This basin system is in Western Macedonia and extends in NNW-SSE direction, cca 120 kilometres from the Yugoslavian village Bitola (Monastiraki) to the Greek village Servia. This is a graben system and with all probability it took its origin in the Miocene. It was filled with more than 800 m thick, limnic and fluvatile young Tertiary and Quaternary sediments (Kaouras 1989, p. 7). In these sediments in some places there are very important coal seams, the palynologists deal with them.

In 1957 Weyland and Pflug wrote about macro- and microflora finds from this area. They disposed of only two samples, but they made also palaeocli-

matic conclusions. In 1958 Weyland, Pflug and Pantić worked at Vevi in the Northern part of the coal basin. The spoil-bank of the upper coal seam consists of lignite pieces (chiefly angiosperms), the lower one was very rich in sporomorphs. From these 39 taxa were determined, without quantitative data. The important forms were: *Taxodium* or *Glyptostrobus*, *Sequoia* or *Cryptomeria*, *Sciadopitys*, *Engelhardtia?*, *Zelkova*, *Symplocaceae*, *Rhus?*, *Araliaceae* or *Cornaceae*, *Nyssa*, *Sapotaceae*, *Palmae?*.

In 1960 Weyland et Pflug completed the work, with new material collected by Mueller. They described 32 taxa from Ptolemais.

In 1983 Anne van de Weerd described in a monograph of the Western Macedonian coal basin her sampling places. She illustrated the lithological sections, with the numbers of the samples, and for the samples the per cent values of the important taxa. The rare species are listed. She used the palynological zones of Benda (1971) from Turkey. In this work she gave account – very briefly – also about her palynological research on Crete. For stratigraphical valuation she used the Tethyan nomenclature also for Macedonia (Serravallian, Tortonian, Messinian). According to her research work there are no great floristical differences. The Upper Miocene beds are terrestrial, the younger are marine, with *Dinoflagellata*. These belong to the Tethyan region.

According of her stratigraphic evaluation (Weerd 1983, p. 7, Fig .2) in the West Macedonian coal area the oldest is Vevi. The most of the coal layers were formed in the Messinian and only their upper part is Pliocene. Weyland et Pflug (1957) stated also, that Vevi is isolated from the other parts of the coal basins. Weyland, Pflug et Pantić (1958, p. 76) wrote: “ ... Braunkohle, die schon ausserlich einen ganz anderen Charakter hat an die von Ptolemais”... The other localities: Vegora, Ptolemais, Prosilion are ranged by Weerd into the Pliocene. Benda separated the Pannonian (Kizihisar-zone) from the Pontian (Akça-zone) with the decreasing ratio of the number of *Pinus sylvestris* and *P. haploxylon*. Weerd contradicted Benda because it is not always possible to distinguish these two types of fossil pollen grains. My opinion is the same. The greatest part of Weerd's photo tables originated from Ptolemais. On plate 11, the number 2,3, marked from Ptolemais mf and 4, from Ptolemais lower samples figured *Tricolporopollenites sibiricum*, which is present in Hungary in few exemplars even in the Pliocene, too (Nagy 1992, pp. 299–300, 377–374, Riate III–IV). After Draxler (Draxler, Nagy et al. 1997) it is no more present in the zone “F”. This is only of local importance, because in the Eastern Mediterranean Rossignol-Strick (1973) found this form in sediments of the uppermost Pliocene, respectively at the

bottom of the Pleistocene. The origin of this taxon could be both of the southern part of Greece and Turkey. Both countries are possible, since Weerd has pictures from Greece as mentioned above and in Turkey they were also found in Seytömer brown coal material studied by Nurdan Yavuz's.

Ioakim (1964) published palynological data from 4 boreholes of the brown coal basin of Ptolemais. She established pollen zones of the sporomorphs marked with A, B, C, D, E. She made correlation between them and parallelised them with Suc's Western Mediterranean zones, and with the boreal zones correlated by Suc and Zagwijn. The climatic stratigraphical conclusion was that the material correlates with that of the Northern part of the West Mediterranean, in the Tabianian; the greatest part of the series is Plaisancian in age.

The Thesis of Georgios Kaouras (1989) deals with the same brown coal area. The material was sampled from Kariochori. From the very thorough geological description it is evident that the basin system of Ptolemais is encircled both East and West by high mountains. The basins are separated from each other by mountains. The central Ptolemais basin is 700 m above sea level. It is bordered to the East by the Vermion Mountain (2061 m), to West by the Askion and Siniatsiko Mountains (2140 m). The climatic effect of these mountains surely were present in the vegetation of the Late Miocene – Pliocene. The author made also very efficient coal petrological research in the territory. The results of the palynological research were well figured and evaluated in diagram. Kaouras compared his data with the zonations of Middle Europa, as well as with the sporomorph groups of Krutzsch (thermophilic, intermediary, arctotertiary, facies element). The conclusion is: “wir haben hier vor uns höchstwahrscheinlich eine Unterpliozäne Mikroflora” (p. 138). That would mean the age is Pontian. The fundamental ecological circumstances were determined by the palaeogeography, a subtropical swamp forest with *Symplocos* the absence of *Sapotaceae*, relatively high elevation, bordered with high mountains, the oscillations indispensable for coal formation.

The coal formation was very uniform due to the palaeovegetation in the studied areas. The coal was originated from the woods of the swamp forests trees in the Late Tertiary. These belong mainly to the family *Taxodiaceae* (in-different whether they were *Taxodium* or *Glyptostrobus*!). Contributed to this the woods of some other conifers and some angiosperm trees, too.

Weyland et Pflug (1961) made the palynological investigation of the Megalopollis brown coal basin, farther south the in the Peloponesos area. In this article the authors established floristical and also areal connections be-

tween the Balkan Peninsula and Hungary, on the basis of the monograph by Nagy 1958. It is true that this similarity was extended to the Pliocene of Iceland, too. (This agrees with my opinion about the similarity of the swamp forests in the Neogene!). According to the opinion of the geologists of this area (G. Marinos and J. Anastopoulos) only a little part of this territory is Pliocene, most of the coal seams are Pleistocene. The soft brown coal of freshwater origin contains very little lignite. Weyland and Pflug in this article dealt with the vegetation without any quantitative data. They mentioned that if we are going from the South to the North across the Balkan Peninsula there are unambiguous changes in the vegetation: the number of the entomophilous plants is decreasing, particularly the *Myrtaceae*, *Compositae* and *Umbelliferae*. Characteristic taxa are the *Magnoliaceae*, *Nymphaeaceae*, the monocotyledones (*Palmae*, *Liliflorae*), the anemophilic species of quercoid type, as well as the *Lauraceae* and *Oleaceae*. Towards the North increases the number of *Betulaceae*, *Ulmaceae*, *Juglandaceae*, further the castanoid, nysoid, tilioid pollen grains, the *Ericaceae* tetrades, conifers with air bladders, *Tsuga*, conifers without air bladders *Larix*, *Taxodium*, *Sequoia*, spores of *Laevigatosporites haardtii*, *Pteris* type, *Osmundaceae*. There are very few pollen grains of freshwater plants, seeds and other plant remnants. The comparison could be done with the help of the "Riviera" factor: the mountain to the North (Mátra, Hungary), protected the area from the unfavourable northern climatic effects. The Greek North Macedonian area was protected from the East and the West and partly also from the South in this case from the warmer climatic influences. In spite of the number of the plants of warmer character is higher then in the foreland of the Mátra Mountains (this is described in more detail in Weyland et Pflug 1961, p. 116).

The palynological investigations in Greece are complementing the others from the Balkan Peninsula. The investigations have been focused on the coal basins in very different times. The result is that in consequence of generally identical constituents there are many common features. The differences are appropriately pointed out by Weyland and Pflug in their article on Megalopolis (1961).

Romania

The sea of the Egerian holostratotype is connected with the Transylvanian basin only with a "?"— on the map No. 1 (Hámor et al. 1988), however it had indirect contact with the Szolnok flysh area. Palynological investigations of

the Egerian layers have been made from two areas in the Transylvanian Basin. The coal territory of Petroseni, the palaeontological finds of the Zsil valley became known very early. In the last century was printed Staub M. 1887: Die aquitanische Flora des Zsilthales im Comitatu Hunyad. – Jb.Kgl.Ung. Geol. Anst. 7/6:223–417. – Budapest, a monograph of the fossil macroflora. Several papers were made on the macroflora of this territory by Givulescu (1978, 1981, 1985). In 1986 Givulescu and Petrescu write a joint paper on the macro- and microflora of the Zsil valley (Valea Jiului). Givulescu listed 68 macrofossils, Petrescu 80 palynomorphs. From these last 67 taxa were common with the Hungarian ones. Unquestionable is the floral identity with the holostratotype of Egerian. This area on the map No. 1 of Hámor et al. is marked as brackish. The identical and thermophilic elements are: dinoflagellates, *Osmundacidites primarius*, *Cibotiidites zonatus* (*Trilites multivallatus*), *Cicatricosisporites chattensis*, *Polypodiaceoisporites gracillimus*, *Laevigatosporites maxoides*, *Podocarpidites libellus*, *Monocolpopollenites tranquillus*, *Dicolpopollenites* sp., *Tricolporopollenites cingulum*, *T. henrici*, *T. microhenrici*, *Myricipites rurensis*, *Momipites punctatus*, *Engelhardtoidites microcoryphaeus*, *Proteacidites* sp., *Sapotaceoideaepollenites obscurus*, *Nyssapollenites contortus* (*kruschi*), *Cyrillaceaeepollenites* sp., *Intratropopollenites insculptus*, *Araliaceoipollenites edmundi*, *Reevesiapollis triangularis*.

Near the holostratotype area in the North-Western part of Transylvania there are many Egerian localities. The nearest are according to the palynological data (Petrescu et Nicorici 1987) of boreholes in the valley of Sebes Körös (Crisul Repede) in the Western part of Vad-Borod (Báród). The mollusc fauna of this area is: *Piranella plicata moldensis*, *P. plicata quinquenodosa*, *Terebralia bidentata fusiformis*, *Tympanotonus margaritaceus grateloupi*, *Nassa dujardini*, *Anadara* cf. *moltensis*, *Ostrea fimbriata* etc. The authors indicate as the most characteristic taxa of the Egerian stage: *Dicolpopollenites kockeli*, species of *Pentapollenites*, *Intratropopollenites insculptus*, *Tricolporopollenites marcodurensis*, *Proteacidites egerensis*.

The other Egerian locality is the kaolin mine of the gypsum factory of Egeres also in the NW part of the Transylvanian Basin. Three articles deal with this locality. The first (Petrescu, Barbu et Balla 1986) presented the stratigraphical, tectonical description of three quarries held to be Upper Oligocene in the Aghireş-Corneşti area. They indicated also the localities of the macroflora. The second article (Petrescu, Givulescu et Barbu 1995) is the beginning of the evaluation. On a generalised lithological section the three macroflora localities are marked. Section “A” was named after the characteristic fossil *Acrostichium*. The recent *A. aureum* is a tropical, subtropical

mangrove fern. Section "B" was characterised by foliar prints of dicotyledonous angiosperms. The *Osmunda lignitum* and *Pronephrium stiriacum* ferns are characteristic of this level. The recent representatives are living in warm, swampy, peaty areas. For section "C" the *Taxodium dubium* is characteristic, representing – according to the authors – the subtropical swamps of Florida. The *Acrostichium lanzaeanum* could be Eocene – to Early Oligocene in age, the *Taxodium dubium* Late Oligocene, Chattian.

Out of the determined 30 spore species were present in the horizon "A" the 3 *Leiotriletes maxoides* subspecies and the *Polypodiaceosporites marxheimensis*. There are characteristic for a warm, wet environment. In horizon "B" *Osmunda* is living also in swampy, peaty environment. In case of horizon "C" the authors speak about "neogenisation", i. e. decreasing temperature. For this horizon the *Polypodiidites secundus* and *P. cerebriformis* are characteristic. The last holotype was in Eger in the "k" level, and in North Hungary it found as far in Ottnangian and Karpatian (Nagy 1963, 1985).

Out of the determined 20 conifer species there were only a few in the horizon "A", has been a little more in the horizon "B", and nearly all in the horizon "C". *Taxodiaceae* were particularly abundant.

The third article (Petrescu, Givulescu et Barbu 1997) gives account about the angiosperms, too for the three horizons (A, B, C), respectively. Horizon C is of Early Chattian age, i.e. Oligocene. Comparing the lists of the palynoflora with the Egerian the spores are in 90% identical, the conifers in 90.1%, the angiosperms in 70%. By the spores it occurs that some species are in Hungary in the Egerian, which Petrescu found only till the level "B", the same happened by the conifers. In the Hungarian material there are no *Resioniides*, *Aglaoreidia*, *Cupaneidites*, *Gothanipollis*. There are no planktonic organisms present in the list, which were very characteristic in this stage.

Petrescu (1971) wrote about an Eggenburgian locality, in Tihau district in the Almaşului (Almás páta) valley, where earlier (1969) he made macroflora research. He named on the basis of palynological investigations 30 taxa, making probable the Eggenburgian stage with *Polypodiidites favus*, *P. alienus*, *Polypodiaceopollenites gracillimus*, *Momipites punctatus*, *M. quietus (levis)*, *Engelhardtia sp.*, *Tricolpopollenites liblarensis*, *Cistacearumpollenites marcodurensis*, without any quantitative data.

Petrescu et Nicorici (1989) gave account of Eggenburgian-Ottnangian palynological results of the Bozovici basin. This is near Caranşebes-Mehadia basin and the authors therefore believed that also this is Badenian. The Early Miocene age was first suggested by a *Brachyodus onoides* molar. The palynological investigations also verified the Eggenburgian + Ottnangian de-

posit in the Bozovici basin. In the borehole profile (90 m) 2 palynological levels were distinguished. In both were included clay layers. In spite of them only in 9 sample preserved fossil microflora. This allowed the differentiation into two horizons: A and B. In the lower A horizon the next taxa proved the Eggenburgian: *Gleicheniidites microstellatus*, *Favoisporis trifavus*, *Polypodiaceoisporites cyclocingulatus*, *P. lusaticus*, *Microfoveolatosporis neogramuloides*, *Cedripites oligocaenicus*, *Ephedripites E. treplinensis*, *E. D. tertarius*, *Plicatopollis plicatus*, *Momipites quietus*, *Proteacidites egerensis* and *Pentapollenites sp.* The B horizon characterizes the Ottnangian: *Osmundacidites primarius*, *Polypodiaceoisporites gracillimus*, *Monocolpopollenites tranquillus*, *Dicolpopollis kockeli* and *Diervillapollenites mega-spinosus*.

The third Eggenburgian deposit was in Brad-Săcărimb basin (Hunyad) (Petrescu et Fazecas 1989). The investigated borehole profile was 84 m. The lowest three samples were Eggenburgian. The characteristic sporomorphs were: *Osmundacidites primarius*, *Polypodiaceoisporites gracillimus*, *Perinomonoletes spicatus*, *Cupressacites bockwitzensis*, *Tricolpopollenites liblarensis*, *Momipites punctatus*, *Proteacidites egerensis*, *Cistacearumpollenites marcodurensis*, *Porocolpopollenites vestibulum*.

At the bottom of the second part of the borehole there were coals, like in Northern Hungary where the Salgótarján Browncoal Formation is in the Lower Ottnangian. There are not too many pollen grains of *Taxodiaceae*, only 3%, however were many swamp and water plants: *Sparganiaceae-pollenites sp.*, *Myricipites rurensis*, *M. myricoides*, *Nyssapollenites kruschi*, *Cyrillaceae-pollenites magaexactus*. To a riparian forest refer the *Caryapollenites simplex*, *Pterocaryapollenites stellatus*, *Alnipollenites verus*, *Betulaepollenites betuloides*. Signalling the age are the *Polypodiaceoisporites torosus*, *P. gracillimus*, *Dicolpopollis kockeli*, *Proteacidites egerensis*. *Myrtaceidites myrtiformis* was also present described by Simoncsics (1964) from the Hungarian brown coal territory of Salgótarján. At the end of the stage, a climatological cooling occurred according to the authors (without pollendiagrams we can not check this statement).

The last four samples of the borehole are Badenian. The topmost sample of the profile is the richest. These samples are similar in pollen material to the Caranşebes area, where the Badenian age is proved by *Orbulina suturalis*. The Badenian flora was very rich and there is a qualitative change in it (see in Hungary the boreholes in the area of Szokolya /Nagy 1992/). Unfortunately the authors have not signaled these spores which are characteristic of the Middle Miocene (*Mecsekisporites*, *Ricciaesporites*). We do not know what is hidden under the names *Corrugatisporites sp.*, *Polypodiaceoisporites sp.*,

and *Verrucingulatisporites* sp.? The high quantity of *Cedrus* is stressed among the conifers. Characteristic are among the angiosperms the *Myricipites rurensis*, *Caryapollenites*, *Momipites punctatus*, the quercoid pollen grains, the *Ulmaceae*, *Sapotaceae*. Less abundant are *Engelhardtoidites microcoryphaeus*, *Liquidambar*, *Nyssa*, *Fagus*, *Rhoipites pseudocingulum*, *Cyrillaceae*, *Oleaceae*, *Platycaryapollenites miocaenicus*, *Cistacearumpollenites marcodurensis*, *Alangiopollis barghoornianum*.

The Karpatian stage is not represented in the Romanian palynological material. This is probably due to the lithology, there are no evaluable spectra. The NN5 Nannoplankton zone – referred by the Romanian authors – according to Hungarian data belongs to the Karpatian and Lower Badenian. Between the Pannonian and Transylvanian Basins there was extensive contact according to the map No. 3 in the Karpatian-Early Badenian, and according to the map No. 4 in the Middle and Late Badenian (Hámor et al. 1988), too.

The section North of the Poiana Ruscă, in the Neogene Lăpuş Basin belongs to the NN5 Nannoplankton zone and is Early Badenian (Petrescu, Mészáros, Chira et Filipescu 1990). The sporomorphs are very well preserved. The ferns are 37%, the conifers 16%, the angiosperms 47%. The dominant ferns are *Cibotiides zonatus* (*Trilites multivallatus*), *Corrugatisporites* (*Trilites*) *corrivallatus* and *Polypodiidites* (*Verrucatosporites*) *favus*. Old elements are *Leiotriletes maxoides*, *Gleicheniidites microstellatus*, *Cicatricosisporites mecsekensis*. There are 23 fern species, while in Hungary 136 were described from the Karpatian and 165 from the Badenian (Nagy 1992). The conifers are dominant and chiefly the group of *Pinus* (in Hungary from the Badenian the conifers are dominant). The dominant angiosperms are *Engelhardtia*, *Tricolporopollenites cingulum*, *T. microhenrici*, *T. henrici*, *Tricolporopollenites liblarensis*, *Caryapollenites simplex*, *Betulaepollenites betuloides*, *Cyrillaceaepollenites magaexactus*, the species of *Myricipites*, *Momipites punctatus*, *Intratripopollenites instructus*, *I. insculptus*, *Pterocaryapollenites stellatus*, *Nyssapollenites kruschi*, *Sabalpollenites areolatus*, *Monocolpopollenites* sp. Also *Platycaryapollenites miocaenicus*, *Plicatopollis plicatus*, *Oloxipollis mathesi*, *Porocolpopollenites vestibulum*, *Sapotaceoidaepollenites microrhombus* etc. are present. The microfaua, molluscs and coral fauna of the locality have also been described.

The salt layers of Ocna-Dej (Désakna) are verified also with palynological investigations as Middle Badenian (Petrescu et Meseşan 1993–1994). In the palynoflora very few fern spores are mentioned, e.g. the *Polypodiaceosporites gracillimus*. Dominant is the *Taxodiaceae* family (indicating a not too far sea) and the *Pinaceae*. The *Abies* and the *Cedrus* pollen grains are

common. The angiosperm taxa are *Alnus*, *Myrica*, *Carya*, *Pterocarya*, *Nyssa-pollenites kruschi*, *Cyrtillaceapollenites exactus*, *C. megaexactus*, *Araliaceoipollenites edmundi*, further *Momipites punctatus*, *Engelhardtia*, *Ulmipollenites undulosus*, *Plicatopollis plicatus* etc. Above the salt layers there is a layer with Radiolaria. The climate is of warm temperate character. In the Badenian volume (Chronostratigraphie und Neostatotypen. 1978, p. 50, Abb. 10) there is a map about the position of the salt and gypsum formations in the Carpathian Foredeep.

Petrescu, Mészáros, Filupescu et Buda (1988) reported on the palynological investigation of the Upper Badenian – Lower Sarmatian borehole Meresti 12 in Harghita district. The borehole was 326 m deep. From the base to 126 m the rocks are Upper Badenian, and the upper part is Sarmatian. Lithological studies were also joined to the Nannoplankton, Foraminifera and palynological investigations. The Paratethyan connection is visible on the satellite map of No. 4 (Hámor et al. 1988). The palynological results indicate the impoverishment of the flora. The species number of the ferns is very low, 6. The conifers species make up 52% of the spectrum. This is resembling the Hungarian value. *Podocarpus* is very rare, the number of *Taxodiaceae* is also low. *Pinaceae* are dominant, *Cedrus* is common. *Abies*, *Picea* are well represented, *Keteleeria*, *Tsuga* only a little. The occurring angiosperms are *Engelhardtia*, *Platycarya*, *Myrica*, *Cyrilla*, *Carya*, *Pterocarya*, *Zelkova*, *Betula*, *Tricolporopollenites cingulum oviformis*, *T. cingulum pusillus* etc. The observed change in the flora could be influenced by the palaeogeographical variations, the tectonical activity in Moldova, the elevation of new elements of the Carpathians, closing of the connection between the Mediterranean and Paratethys. (This opinion is contrary to that of Pantić, but it is possible because the situation was not the same in the fairly closed Transylvanian Basin and Pannonian Basin region more opened to the South.) The mean temperature decreased to 14–16 °C.

The Sarmatian of this borehole is divided in two parts. The lower part reminds more of the Upper Badenian, the quantity of the conifers is less (15%), with *Pinus* dominancy. The *Abies*, *Picea*, *Cedrus*, *Tsuga*, *Keteleeria* are common. The composition of the angiosperms resembles the Badenian, only the quantity of *Tricolporopollenites microhenrici* and the pollen grains of *Carya* are increased. The climate resembled to that of the Badenian. In the upper part of the Sarmatian the quantity of the conifers were increasing (38%), and the components are different. The value of the *Taxodiaceae* (*Cupressaceae*) is 20%. The genus *Pinus* is dominant. The thermophilic elements of the angiosperms are more than in the lower part of the Sarmatian. This concerns

Engelhardtia, *Reevesia*, *Platycarya*, *Myrica*, *Palmae* and out of the ferns the *Polypodiidites favus*.

At Cluj-Napoca (Kolozsvár) palynological investigations were made on Sarmatian Upper Volchynian "Iris" quarry marly-clay formations interbedded in volcanic tuff (Mészáros, Petrescu et Marza 1991). In the spore-pollen spectra the *Pinaceae* are dominant (cca 65%), the *Taxodiaceae* represent only 5–8%. The other conifers are sporadical: *Cedrus*, *Picea*, *Abies*, *Cathaya*, *Tsuga*. The angiosperms indicate a wet-marshy environment (*Myrica*, *Alnus*, *Nyssa*).

Definitive connection existed between the Pannonian and Transylvanian Basins during the Pannonian stage (Hámor et al. 1988) according to the map No. 5 South of the Apuseni (Bihar) Mountains. The Pontian inland sea had only uncertain connection, marked with "?" for both the Transylvanian and Dacian Basins according to the map No. 6. The lower part of the borehole at Oradea-East (Nagyvárad) is Pannonian, the upper part Pontian (Petrescu, Nicorici, Wanek et Blidaru 1979). The upper layers correspond to beds "D" and "E" of the Vienna Basin, and the Congerian zone of the Hungarian Basin (*Congeria subglobosa*, *C. czjeki*, *Dreissena auricularis*, *Melanopsis vindobonensis*). From the Pannonian part of the borehole 33 palynomorph taxa are listed, as well as *Botryococcus* alga and dinoflagellates. The conifers are represented by 3 *Tsuga* species, *Cedrus* and *Taxodiaceae*, from the angiosperms *Magnolia*, *Myrica*, *Carya*, *Lonicera* are remarkable. The flora resembles to the Hungarian, Yugoslavian (Bačka, Banat) and Slovakian (Danube Basin) Pannonian floras.

The palynomorphs of the upper part of this borehole indicate the Pontian. The two *Stereisporites* species are remarkable, because in Hungary they are very characteristic in the Pannonian and Pontian. I have described from the Pannonian 6, and from the Pontian 14 *Stereisporites* species. The taxon number of the conifers is high enough, but there are no more pollen grains of *Tsuga* and *Cedrus*. *Sciadopitys* and *Podocarpidites nageiafomis* occur; however, the last occurs in Hungary both in the Pannonian and the Pontian. The pollen grains of *Fagus* are present in great number, like in Hungary, in particular in the northern part of the country (Nagy 1992).

Along the East Carpathian range there are numerous small basins: through these are running little rivers and brooks. From the North to the South the following have been investigated palynologically: In Maramures Chiusbaia (Kisbánya) is an important macrofloral locality, treated by Givulescu. It was also palynologically investigated by Givulescu et Diakoneasa (1985). This is the so-called locality "H". The ratio of conifers-angiosperms is equal

(50–50%). In the lowest sample *Picea* represents 21.66%, in the next samples their number decreased, this indicates aridity. Upwards in the section a *Fagaceae-Juglandaceae-Ulmaceae* episode is supposed, the same occurred in Northern Hungary (Nagy 1992). Later the conifers moved ahead opposite to angiosperms, this indicates a cooling. Then the number of *Picea* was higher again than that of the other conifers, but at this time the number of *Carya* and *Fagaceae* mainly the *Quercus* increased. Finally the authors give account of the increase of the number of the *Picea* and the angiosperms. According to the authors – these data were available only due to the palynology. With the help of the palynology it was possible to follow the climatical changes, to state two warm and two cool phases. This climate is suitable for the Pannonian G/F, for the Late Pontian s. str., that is Bosphorian.

In the Eastern Carpathians South of the eruptive Calimani Mountains there is the Pliocene Borsec coaly Basin. Emil Pop treated this important palaeobotanical locality in 1936. The marl layers are the hanging rocks of the lignite in the Nyires valley. Pop referred to geologists, described the following section: 1) basal conglomerate, 2) white sandstones, 3) blue clay with lignite *Dreissensia* cf. *münsteri* Brus. in the upper part, 4) clayey marl which is blue the bottom, yellow at the top. Both contained plant fossils, but the yellow marl contains more. The fossiliferous layers are in some places 14 m thick. 5) the Pliocene layers are covered with soil. The geologist attributed different ages to these layers, from Sarmatian till Dacian. The correction of the age is possible with the coal; it is Late Dacian or Romanian. The diatoms, *Peridinium*, *Phragmites*, *Cyperus*, *Typha* refer to freshwater. The altitude of sea level is not primary – today it is 820 m –, because the Carpathians have been uplifted 500, 1000 m, since the Pliocene. From the last century there have been collected plant remains, e.g. Kantner (Hungarian Geological Institute), Koch; his material was determined by Staub, etc. The greatest collection has Pop with 1200 pieces. He made also palynological investigations and could determine diatoms, *Pteridinae*, moss and *Lycopodium* spores, tissue of conifers, the pollen grains of *Gramineae*, *Typhaceae*, *Ericaceae*, *Tilia*, *Corylus*, as well as *Tsuga* and *Picea*.

The Borsec Basin was investigated by Petrescu, Nicorici, Atudorei, Harlav et Giosu (1987). On the marginal part, at the coal beds there were in *Congeria coquina* two determinable species: *Congeria zahalkay* Spalek and *C. cf. croatica* Brusina. The greatest part of the *coquina* is made up by *C. zahalkay*. This species occurs in Austria and Czechoslovakia near Pontian coal seams in *coquinas* of the zone “F”. In Romania Marinescu found it in the Crivina sector together with *Congeria unglucaprae*, *C. croatica*, *C. spatulata*, *Limno-*

cardium cf. apertum, *Melanopsis fossilis* foss., *M. f. rugosa*, *M. impressa* and ostracods, *Amplocypris ancissa*, *Candona truncata* etc. also in Lower Pontian (Odessian). Petrescu and his co-workers have investigated in many boreholes the coal layers of Borsec and have distinguished the following units:

1) Lower Pontian. P – 1 zone. Conglomerate and sandstone. *Taxodiaceae* cca 10%, *Pinaceae* 15–20%, chiefly *Pinus haploxylon* and *diploxylon*, a few *Cathaya*, *Picea*, *Abies*, *Tsuga*, *Keteleeria*, *Cedrus*. Dominant are the angiosperms (60–70%). The Monocotyledones are few, the Dicotyledones are more numerous: *Alnus*, *Carya*, *Tilia*, *Myrica*, *Fagus*, *Ulmus-Zelkova*, *Quercus*. Less are the *Engelhardtia*, *Pterocarya*, *Carpinus*, *Betula*, *Castanea*, *Liquidambar*. Only sporadic are the *Reevesia*, *Araliaceae*, *Symplocos*, *Che-nopodiaceae*, *Ericaceae*. For this zone the warm elements are characteristic: *Palmae*, *Reevesia*, *Symplocos*, *Engelhardtia*. The part of this zone, marked P – 1b are the coal layers with wet and swamp elements: *Alnus*, *Liquidambar*, *Myrica*, *Nymphaea*.

2) Pontian – Dacian. P – 2 zone. The lower part is bluish clayey marl, with a bed of *Congerina*, therefore it is held for Pontian. The upper part is more marly and yellowish, this may be Dacian. It is from these layers that Emil Pop collected his material. In this zone are there many conifers. They are chiefly *Pinaceae* (45–60%). The occurrence of *Taxodiaceae* is sporadic. There are many leafy trees. The climate was cooling and more continental, with plenty of microtherm conifers (P – 2 a–c).

3) Romanian. P – 3 zone. Sand, sandy clay. Part of the pollen material is redeposited (5%). Most of the ferns are *Laevigatosporites haardtii*, but there are also some *Osmunda*. The percentage of conifers is decreasing. The number of angiosperms is very high (to 75%). There are again palms, *Engelhardtia*, *Reevesia*, *Nymphaeaceae*, *Parthenocissus*, *Castanea*, *Acer* etc. This indicates that the climate was warmer than in the Dacian. The increasing number of the *Sparganiaceae* and the presence of the *Nymphaeaceae* refer to the shrinking of the lake, of its lukewarm and freshwater. The basalt volcanism contributed to the warming. This happened probably in the second part of the Romanian age.

A small intramontane basin in the Eastern Carpathians is the Baraolt (Baróti) Basin (Petrescu, Buda et Boér 1988) similar to the Ciuc (Csíki) Basin and the Borsec (Borszéki) Basin. The Baraolt Basin belongs to the Țara Birsei depression, was “formed as a result of the downthrows occurring in this area during the tardy Attic orogenic stage in the Lower Pontian and the subsequent dam-forming volcanic eruption” (l. c. p. 6). In the Ciuc Basin from the study of Miocene sediments they made the conclusion that this ba-

sin was a gulf of the Transylvanian Basin, only isolated by the Pliocene volcanic eruption in the Harghita Mts. This phenomenon was indicated by freshwater molluscs, *Sparganium* and *Typha* pollen grains and *Botryococcus* and *Zygnemataceae* algae. Between the Baraolt Basin and the Transylvanian Basin only a narrow passageway it supposed, as proved by the common mollusc and ostracod genera, and by the endemicity of the most fauna assemblages. In the Baraolt and Borsec Basin the characteristic fossils are comparable to those in the Central Paratethys (Paradacna abichi, Congeria associations) the presence of *Congeria zahalkay* and *C. cf. croatica* proves the connection of these intramontane basins with the Pannonian Basin.

The lower part of the Baraolt Basin as shown by the investigated boreholes has two parts,

1) Productive Formation: this is Pontian. It has been subdivided into two parts: A) Productive Subformation and B) *Limnocardium* Marl Subformation.

The upper part of the basin:

2) Ostracod Marl Formation (Dacian – Romanian). The hanging rocks are of Pleistocene age.

1/A) The Productive Subformation: the flora consists of a few ferns (*Polypodiaceae*, monolete *Laevigatosporites haardtii*, and trilete forms, too) apart from the mentioned freshwater algae. The conifers make up 30–40%, dominant were *Pinaceae*: *Picea*, *Abies*, *Tsuga*, *Pinus*, *Cedrus*, few numbers of *Keteleeria*, *Cathaya*, *Podocarpus*, *Taxodiaceae*. The presence of *Cycas* is uncertain. The angiosperms represent 45–60%, the Monocotyledones are rare, and the *Nymphaeaceae*, too. There are many *Alnus*, from the *Juglandaceae* family *Carya* and *Pterocarya* are common, less the *Engelhardtia*. Rather rare are *Aquifoliaceae*, *Araliaceae*, *Salicaceae*, *Sterculiaceae* (*Reevesia*), *Acer*, *Ericaceae*, *Oleaceae*, *Asclepiadaceae* (*Manikinipollis*). The temperate floral elements are dominant, but the tropical elements represent still 8–10%.

1/B) In the *Limnocardium* Marl Formation the percentage of Coniferae is somewhat increasing (40–45%). Most of them are *Pinaceae*, with *Picea* dominancy. The number of the warm elements decreases among the angiosperms too, represented by the *Myrica*, *Eucommia*, *Engelhardtia*. Besides *Ulmaceae* there are *Alnus* (12–15%), *Fagus* (6–9%), *Quercus*, *Carya*, *Pterocarya*.

2) The lower part of the Ostracod Marl Formation resembles palynologically to the *Limnocardium* Marl Formation, the upper part to the Productive Subformation, but the warm elements make up only 4–6%: *Podocarpus*, *Magnolia*, *Myrica*, *Engelhardtia*, *Eucommia*, *Araliaceae*. *Arecipites longi-*

colpus, *A. butomoides*, and *Cycadopites* are also mentioned, what the authors hold improbable. This warming of the climate may have occurred at the beginning of the Romanian. The flora resembled to that of the eastern part of the USA.

Very similar is the situation in the boreholes drilled in the Braşov-Tirlungeni area in the SE part of the Țara Birsei depression (Petrescu et Buda 1986). In these beds there are no biostratigraphically decisive fauna associations, therefore this area was correlated by means of lithology and with the knowledge of palynological associations of other basins.

The lower horizon is Pontian brown-earthly coal with many seams. The bottom of this horizon is conglomerate without any pollen grains. The following clay and coal beds are rich in *Botryococcus* colonies and *Zygnemataceae-Ovoidites* remnants, consequently the water was freshwater. The coal formation has two distinct levels:

a) The first level was characterised by well preserved *Cedrus* pollen grains up to 15%, subordinate (5–10%) are the pollen grains of *Pinus*, *Abies*, *Tsuga*, *Picea*, sporadic the pollen grains of *Podocarpus* and *Taxodiaceae*. The angiosperms exceeded 55%. They are represented by *Myrica*, *Betula*, *Carpinus*, *Quercus*, *Castanea*, *Fagus*, *Carya*, *Pterocarya*, *Tilia*, *Ulmus*, *Zelkova*, *Celtis*, *Eucommia*, *Umbelliferae*, *Chenopodiaceae*, *Palmae* etc. The fern spores were 5% (*Laevigatosporites* sp. only). There was also redeposition from the Mesozoic.

b) The second level is characterised by the abundance of Angiospermae. There are very few Monocotyledones (1%), *Gramineae*, *Typha*, *Palmae*. The Dicotyledones are 50%, dominant are the *Alnus*, *Carya*, *Tilia*, common are *Myrica*, *Carpinus*, *Quercus*, *Castanea*, *Fagus*, *Pterocarya*, *Ulmus*+*Zelkova*, *Celtis*, *Nyssa*, *Compositae*, and sporadic the *Corylus*, *Hammamelidaceae*, *Parthenocissus*, *Araliaceae*, *Ericaceae*, *Jussiaea* etc. Single exemplars were from *Cupaneidites* cf. *eucalyptoides*, *Myrtaceidites* cf. *myrtiformis* Sim. and *Reevesiapollis triangulus*. The conifers make up 20–25%. The quantity of *Taxodiaceae* pollen grains were higher 3%. The *Pinaceae* species differ from those of the first level, *Cedrus* is relatively rare (3%). The ferns are nearly exclusively *Polypodiaceae* (25%), their high quantity signals the humidity, the swamp environment.

The middle, marly horizon is Dacian. This is the *Picea* bearing level. The Coniferae make up 35%, among them *Picea* is 20%, the second is *Pinus* 10%, *Tsuga*, *Abies*, *Cedrus* 5%. This is a “paliocenization” phenomenon, and the opinion of the authors is that the horizon is of Dacian age. The angiosperms (55%) are mainly Dicotyledones: *Alnus*, *Ulmus-Zelkova*, *Celtis*,

Quercus, Carya, Betula, Myrica, Pterocarya, Castanea, Fagus, Tilia, Ericaceae, Lonicera, Ilex, Cruciferae, Chenopodiaceae.

The upper, argillo-arenaceous horizon (?Romanian) is sandy clay, then sand. The parallelisation was made only with lithology after the sequence of other intramontane basins. The overlying stony, sandy, limy sequence with sandstone, may be Pleistocene.

South of the Carpathians, East of Turnuseverin, between Dedovita and Negresti there is an outcrop Late Pontian=Bosphorian – Early Dacian=Getian in age (Petrescu et Malan 1991–1992). For the Late Pontian are characteristic the ferns 2%, the conifers 67%, the angiosperms 31%. Among the conifers the *Pinaceae* are dominant in which the *Cedrus* is 29%. 10% of the angiosperms is *Quercus*. Forest zone developed in the rising mountains. *Cedrus* was characteristic in the Late Pontian, according to the authors this indicate subalpin climate.

In the vegetation of the Early Dacian, above the coal layers in marly-sandy-beds the value of the warm elements was higher, 12%, also *Itea* was present. This pollen grain was until now not known in the Hungarian Neogene, only in the Paleogene. In the geographically nearer Bulgaria it is present in the Middle Miocene. In this part of Romania *Itea* is associated with *Myrica, Reevesia, Engelhardtia* and presumably with *Palmae*, indicating increase of temperature. The warming was increased also by the Carpathians located to the North. It is naturally that some floral elements are the same in the palaeoflora in Northern Bulgaria.

In the quarry of Husnicioara (Mehedinți county, SW Romania) between the Danube and the river Motru palynological investigation was done on the Lower Dacian lignite bed IV (Petrescu et al. 1989). The proportion of the fern spores is high enough (7–22%), most of them are *Polypodiaceae Laevigatosporites haardtii* and *Leiotriletes wolffi*. Besides there are also *Hydrosporites levis, Verrucatosporites arctotertiarius* and *Osmunda*. From the conifers are always present the *Taxodiaceae* (2–12%), *Sciadopitys* and probably *Glyptostrobus (Inaperturopollenites hiatus)*, the *Cupressaceae* generally is 1–2%. *Pinaceae* make up 30–40%, with the genera *Pinus, Picea, Tsuga* and *Cedrus, Cathaya. Abies* and *Cycadopites* are rare. From the monocotyledonous Angiospermae are present *Arecipites, Monocolpopollenites, Typha* and *Graminaea*, from the dicotyledonous ones *Carya* 10–12%, *Pterocarya* 1–9%, *Quercus* 3–4.5%, *Ulmaceae /Ulmus, Zelkova*, rarely *Celtis/* 4–5%, *Compositae* 2–5%, *Fagus* 3–4%. Rare are *Carpinus, Betula, Salix, Nyssa, Parthenocissus, Liquidambar, Tilia, Chenopodiaceae, Ericaceae, Myrica, Corylus, Reevesia, Acer, Jussiaea*, a.o. have a sporadical occurrence, but they

indicate the warmer climate. – In some samples there are numerous *Alnus* and *Nymphaeaceae*.

About the palynological data of the lignite outcrop by Lupoia (Gorj county) gives account an article by Petreccu, Nica, Filipescu, Barbu, Chira, Avram et Valaczkai (1989). The age of the locality is Late Dacian-Middle Romanian. The Dacian sediments are sand, marly clays alternating with coal seams. The territory was affected by the separation from the Pannonian Basin and perhaps also from the Euxinic Basin. The Romanian sediments are fluvial, and fluvio-lacustrine in origin. They are often rich in detritus, swamp sediments with many organic remains. The investigations concern mostly the Romanian part of the outcrops. The major part of the ferns are *Laevigatosporites haardtii*; there is less *Leiotriletes wolffi*. *Hydrosporites levis*, *Osmunda*, *Echinosporis*, *Perinomonoletes pliocaenicus* also occurred. In all samples *Pinaceae* make up 21–41% with the species of *Picea*, *Pinus*, *Tsuga*, *Cathaya*, *Cedrus*, *Abies*, *Keteleeria*, *Taxodiaceae* 1–4%. In those samples which indicate warming the numbers of the pollen grains of *Cathaya*, *Pinus haploxyton*, *Cedrus*, *Abies* are higher. The monocotyledonous angiosperms are represented by *Graminea*, *Typha*, *Sparganium*, *Arecipites*, *Monocolpopollenites*. The dicotyledonous angiosperms make up 42–50%.

The pollen grains of *Myrica* are very common in the Romanian period. The *Carya* is dominant with 7–15%, *Pterocarya* is less, 3–5%. *Engelhardtia* is also not redeposited. The pollen grains of *Betula* are more common in the Romanian, than in the Dacian. In some samples there are also many *Carpinus* and *Alnus*, too. The quantity of the pollen grains of *Quercus* is constant enough, the quantity of *Fagus* is varying, the greatest quantity being in the uppermost sample. The *Ulmus* is common, the quantities of *Zelkova* and *Celtis* are more than in the Dacian of Husnicioara. *Salix*, *Liquidambar*, *Eucommia*, *Tilia*, *Nyssa*, *Corylus*, *Urticaceae*, *Parthenocissus* are rare, *Reevesia*, *Periploca*, *Symplocos*, *Engelhardtia*, *Momipites punctatus* are only sporadic. It can be stated that the climate got considerably warmer in the Early Romanian.

Summarised: the Transylvanian Basin was connected with the Hungarian Central Paratethys during the Neogene. The Rumanian scientists ranged into the Late Oligocene the lower part of the Egerian. The characteristic Egerian floral elements are present in these localities. In the other parts the floral elements characteristic of the Lower Miocene stages are present. The palynological investigations are missing from the Karpatian stage probably due to lithological reasons. The vegetation of the Middle and Late Miocene was similar to that of the Central Paratethyan area, also in the dominance of coni-

fers. The most of the investigations concerned the Late Miocene. When we are going towards the South among the conifers of the small basins we found more and more *Cedrus*. This must be a consequence of Mediterranean influence. The amount of thermophilic floral elements was also increasing. This phenomenon is more explicit in localities South of the Carpathians.

Moldova

The Podolian beds of the Early Badenian Moravian substage were palynologically investigated from 4 boreholes by Medjanik (1990). The pollen grains of the trees and scrubs make up 54–80% of the spectra, the subscrubs and herbs 18–46%, the spores 0–1.6%. The angiosperms are dominant with 70%. The tree-like plants are today also in similar quantities in warm temperate and subtropical regions. The conifers represent 6–13%. The most common broad leaves families are *Juglandaceae*, *Fagaceae*, *Betulaceae*, *Tiliaceae*, *Ulmaceae*, *Salicaceae*. Rarer are *Liquidambar*, *Myrtaceae*, *Rhus*, *Salix*, *Rhododendron*, *Eucommia*, *Nyssa*, *Acer*, *Cornus*, *Cotinus*, *Ericaceae*. The list of the flora is rich, trees and scrubs are 47, subscrubs and herbs 18, (in generally names of genera), and 5 ferns: *Ophioglossum sp.*, *Pteridium sp.*, *Polypodium sp.*, *Polypodiaceae*, *Azolla sp.* By the Coniferae there are in low percentages the *Cupressaceae*, *Taxaceae*. The *Taxodiaceae* are only 0.7–1%. *Pinus haploxylon* represents the maximum with 7–14%. Among the Angiospermae are a few *Engelhardtia*, *Carpinus*, *Fagus*. The *Chenopodiaceae* are dominant (28–46%); *Artemisia* (11–19%), *Poaceae* (12–14%). These data indicate the drying of the climate. That is typical of this area. In low quantities are present *Campanulaceae*, *Ranunculaceae*, *Lamiaceae*, *Plantaginaceae*, *Euphorbiaceae*, *Apiaceae*, *Brassicaceae*, *Fabaceae*. The number of the water plants is low (*Typhaceae*, *Sparganiaceae*), like the ferns (*Polypodiaceae*, massulae of *Azolla*). The vegetation indicates a subtropical, dry climate.

In the SW part of Moldova in the volcanic formation of Vinovgradovska district Medjanik (1985) made palynological investigations on a Pontian outcrop. The section is divided into 8 lithological units: clay, silt with sand, sandy clay with silt, limestone, sandstone, clay, coal and limestone. On the basis of the palynological investigations a lower horizon with coal and an upper horizon are distinguished. The lower horizon consists in 80–90% of pollen grains of trees. The tree pollen grains (60–87%) are Gymnospermae, from these 48–65% are *Taxodiaceae*, from these 42–70% are *Taxodium dis-*

tichum (L.) Rich. The *Pinus* pollen grains make up 7–9%, the *Picea omorica*, *Abies*, *Tsuga*, *Sequoia* 1%. The pollen grains of broad leaves trees are mostly *Ulmus*, *Zelkova*, fewer *Fagus*, *Quercus*, *Castanea*. Rare are the pollen grains of *Alnus*, *Corylus*, *Betula*, *Carpinus*, *Acer*, *Tilia*, *Fraxinus*. The pollen grains of the herbaceous plants are 2–13%: *Chenopodiaceae*, *Poaceae*, *Asteraceae*, *Brassicaceae* etc. There are also some *Typhaceae* pollen and spores.

In the upper horizon the angiosperms prevailed with 86–94%, the percentage of gymnosperms is 5–7%, and the spores are 1–2%. From the angiosperm families are 18–18% the *Ulmaceae*, *Juglandaceae*. There are a few pollen grains of water plants: *Myriophyllum*, *Typhaceae*. Very few conifers occur: *Pinus*, *Picea*, *Tsuga*, *Taxodiaceae*, *Cupressaceae*. The ferns represent only 1%: *Adiantum*, *Salvinia*, *Lycopodiaceae*.

The third Eopleistocene article is mentioned only as an illustration of a really new vegetation type (Medjanik et Bukatsuk 1991). Here appeared a new explicitly forest-steppe with xerophitic plants, marking the boundary of the Central Paratethys.

The Badenian flora of Moldova is in its character Eastern Paratethyan (Hámor et al. 1988, No. 3, Moldavian Platform) with a dryer climate. The bottom of the Pontian stage with a few coal layers includes some pollen material from a swamp forest. The riparian forest elements are very few and the herbaceous plants are rather xerophytic. In the upper horizon the angiosperms are dominant, in contrast to the flora of the area of the Central Paratethys.

Ukraine

According to the map No. 1 (Hámor et al. 1988) the whole territory of the NE Carpathians was covered by sea in the period of the Egerian. This is verified by the article of Andreyeva-Grigorovich et Gruzman (1994) by dinocysts, planktonic foraminifers and nannoplankton. Common species are in the Egerian holostatotype locality, in the borehole Fót 1, and in the Krosno Formation in flysch facies in the northern side of the NE Carpathians *Deflandrea stellulata*, *D. phosphoritica*, *Cordosphaeridium cantharellum*, *Thalassiphora pelagica*. On the base of figure No. 4 of the authors the Oligocene-Miocene boundary is between the Lower and the Middle Krosno Subformations. The lower boundary of the Egerian stage is marked by the occurrence of *Turborotalia opima opima*, the upper boundary by that of *Globigerinoides primordius*. The Egerian volume of the “Chronostratigraphie und Neostrato-

typen” does not deal with the Krosno layers (p. 30) for the reason “wird in diesem Band die Charakteristik solcher Schichtengruppen und Formationen nicht einbezogen, die zwar zeitlich mit Sicherheit in das Egerien gehören, jedoch keinen typischen oder stratigraphischen oder anderen Kriterien für eine Charakteristik dieser Stufe bieten. Solche sind einigen Flyschzonen in der West- und Ostkarpaten (z.B. die Krosno-Schichten)”. Surveying the references of the article, another reason seems to have been that the scientists were not participating in the edition of this volume, although studying this area earlier they had valuable results (1975).

From the palynological investigations of an Upper Badenian brown coal section in the NE Carpathians (Vinogradovska /Nagyszöllös/ district) wrote Shchekina (1958). The pollen grains of conifers and angiosperms are present in more or less equal quantities. The pollen grains of *Pinus sylvestris* are dominant, in some part of the spectra with 50%. The maximum of *Taxodium* is above 14%, the *Cupressaceae* 13%. There are *Abies*, *Picea*, *Tsuga*, *Sciadopitys*, *Podocarpus*, too. Here and there are in great number *Myricaceae*, 33–54%. The water plants are *Typha*, *Sparganium*, *Alismataceae*, *Nymphaeaceae*, *Hydrocharitaceae*, *Cyperaceae*. In the riparian forest there are *Carya*, *Pterocarya*, *Alnus*, *Betula*, *Salix*, farther *Ulmaceae*, *Platycarya*, *Quercus*, *Fagus*, *Castanea*, *Liquidambar*. A warmer climate is indicated by *Magnolia*, *Liriodendron*, *Sterculia*, *Rhamnaceae*, *Rhus*, *Sapindaceae*, *Diospyros*, *Nyssa*, *Vitis*. There are many fern spores *Polypodiaceae*, *Dryopteris thelypteris*, *Polypodium*, *Pteridium*, *Lygodium*, *Osmundaceae*, *Ophioglossum*, other *Filicales* and *Equisetum*. Altogether 87 sporomorphs are listed. The work was complemented with investigation of diatoms. The author writes about a “large flowing lake”. The richness of the flora is inconsistent with the flora of the Pannonian basin. From the Early Badenian I have described 400 taxa, from the Middle Badenian 103 taxa. In the Late Badenian were 76 taxa and a transgression has been proved with marine planktonic organisms (Nagy 1992). The investigated material rather belongs to the Middle Badenian.

About Middle Sarmatian palynological research gives account the article of Syabryaj et Vodoryan (1975) from the NE Carpathian territory in the depression of Čop (Csap)- Munkacevo (Munkács). The profile consists of clay, silt, tufa, lignite, sand. The age of the beds is verified by foraminifers, molluscs (*Cardium* sp., *Tapes* sp., *Macra* sp.) and ostracods. The nearshore situation is verified with palynological and diatomological investigations. Out of the conifers some sort of *Pinus* (3–60%) were dominant, besides *Abies*, *Tsuga*, *Cedrus*, *Keteleeria*, *Larix*, *Taxodium*, *Sequoia*, *Cupressaceae*, *Pod-*

carpaceae, *Ginkgo*, *Araucaria?* or *Agathis?*. From the angiosperms there are more *Juglans*, *Carya*, *Pterocarya* present, and less *Engelhardtia*, *Platycarya*, further *Castanea*, *Quercus* (to 15%), *Fagus*, *Betula*, *Alnus*, *Carpinus*, *Corylus*, *Ostrya*, *Acer*, *Tilia*, *Platanus*. Thermophilic taxa are *Nyssa*, *Moraceae*, *Rosaceae*, *Oleaceae*, *Ericaceae*, *Celastraceae*, *Cornaceae*, *Elaeagnaceae*. Tropical plants are *Araliaceae*, *Myrtaceae*, *Santalaceae*, *Symplocaceae*, *Rhus*, *Magnoliaceae*, *Palmae*. Water plants are *Typhaceae*, *Sparganiaceae*, *Hydrocharitaceae*, *Nymphaeaceae*, *Cyperaceae*, *Liliaceae*, *Ranunculaceae*, *Lobeliaceae*, *Asteraceae*, *Plantaginaceae*. Among the ferns the most common are *Polypodiaceae* (*Polypodium*, *Onoclea*) and the *Osmundaceae*. Only few exemplars were from *Gleicheniaceae?*, *Cyatheaceae?*, *Ophioglossum*, *Lycopodium*, *Selaginella*. 93 taxa are listed, from these 80 are similar to the Hungarian, but the identification is difficult because no species determinations have been made. In the Hungarian Sarmatian there were 174 taxa (Nagy 1992, p. 160).

A complete Pannonian section was studied by Syabryaj (1975) in the Solotvinian (Aknaszlatina) depression. The sediments are clay, sand, a few lignite lenses. A few molluscs (*Planorbis* sp., *Ancylis* sp.) and some ostracods are present from the lower and the upper Pannonian. According to palynological research, the section has 3 parts. The lower complex is characterised by the great number of conifers (55–60%), the sorts of *Pinus* are represented up to 40%, *Picea* to 3%, *Taxodiaceae* 10%, *Tsuga* – *Podocarpus* 2–2%. The percentage of angiosperms is 31–42%, out of this *Juglandaceae* make up 10%, from this *Carya* to 6%, *Juglans*, *Pterocarya*, *Platycarya*, *Engelhardtia* are less. Besides these there are the pollen grains of *Quercus*, *Fagus*, and more *Castanea*, *Ulmaceae* 7%, chiefly *Ulmus*, *Zelkova* in low numbers, appear *Liquidambar*, *Parrotia*, *Hammamelidaceae*, *Myricaceae*, *Tilia*, *Acer*, too. Thermophilic taxa are *Aralia*, *Rhus*, *Dyospyros* to 4%. Spores were a few *Polypodiaceae*, *Cyatheaceae* (?), *Osmundaceae*.

In the middle complex the conifers represent 70–80%, of this the pollen grains of *Pinus* are 35–40%, *P. haploxylon* is more to 28%, *P. diploxylon* to 15%, *Picea* 11–12%, *Abies* to 3%, *Tsuga* to 4%, few *Keteleeria*, *Podocarpus*, *Cedrus*, *Ginkgo*. From *Taxodiaceae* *Taxodium* and *Glyptostrobus* are present. The angiosperms are *Juglandaceae* *Carya*, *Pterocarya*, *Juglans*, *Platycarya*, *Engelhardtia*, *Ulmaceae* *Ulmus*, *Celtis*, *Zelkova*, *Fagaceae* *Quercus*, *Castanea*. *Corylus*, *Alnus* to 3.5%, *Tilia*, *Acer*, *Rosaceae*, *Caprifoliaceae*, *Myricaceae* to 3% in the spectrum. The herbs are present in very small number, some water plants are among them. The spores are represented by *Polypo-*

diaceae, *Osmundaceae*, *Lycopodium cf. selago* L., *L. cf. clavatum* L., and *Gleicheniaceae* (?).

In the third complex in contrast to conifers the numbers of the pollen grains of angiosperms are a little higher. *Quercus* is up to 5%, *Fagus* to 2%, *Juglandaceae* to 6%, *Ulmaceae* to 5%. Beside *Corylus*, *Betula*, *Myrica* appears *Salix*. In the same period in Western Transdanubia plenty of *Salix* macrofossiles was found by L. Rákosi (verbal information). There are also pollen grains from *Tilia* to 1.5% what is very high value for this taxon. Among the herbs there are many aquatic plants. From the spores are first to be mentioned the *Sphagnidae*, a characteristic feature, because in this stage there are many species of these in the whole Central Paratethyan area.

In the Vihorlat-Gutin Mountain the Ilintsa (Ilinai) deposit belongs to the volcanic formation containing also brown coal, lignite layers, with clay, sand and tuffite. There are two palynological papers about it: Ribakova (1966) and Syabryaj (1967). Both subdivided the section into two parts. The difference is that Ribakova ranged the lower coal layers in the Middle, the upper coal layers in the Upper Pliocene, while Syabryaj both units in the Upper Pliocene, in the Levantian. The question is only how is interpreted the age? Probably the age of the layers could be Pontian. The angiosperms are dominant (60–89%), the conifers are about 35%. The highest value has the *Ulmaceae* up to 30%, *Juglandaceae* 10–12%, *Quercus*, *Fagus* 9–10%, *Liquidambar* 2–3%. The evergreens are 2–2.5% represented by *Myrtaceae*, *Magnoliaceae*, *Aquifoliaceae*. Further fern spores and pollen grains of water plants and *Taxodiaceae* are present. Out of these *Taxodium* is 10%, *Glyptostrobus* 3–8%.

The palynological articles dealing with Southern Ukraine, at the Black Sea by no means concern the Central Paratethys area (Shekina 1977 on the Crimean Peninsula Upper Pontian, Shekina 1977 Kerch Peninsula Kimerian). They describe the typical xerophytic, steppe vegetation of the Russian Plain.

That's palaeofloras of Ukraine which belong to the Carpathian Basin naturally resemble to the floras of the Central Paratethys. It is characteristic the occurrence of *Sphagnidae* and *Salix* in the Pannonian and Pontian ages.

Slovakia

On the basis of the map No. 1 (Hámor et al. 1988) Southern Slovakia is a part of the Northern Hungarian Paleogene Basin. The last monograph of É.

Planderová (1990) summarized the results of the palynological investigations in Slovakia from the Egerian till the Sarmatian. She began the description with the Late Egerian, but in the Fig. 8 also the Early Egerian is represented. The Early Egerian palynological investigations were made by P. Snopková (1975, 1988). Her report on the borehole DV-1, the examined samples are of Late Oligocene character. There are also *Deflandrea spinulosa* and *Polypodiaceoisporites gracillimus*. The holotype of the latter was described from the upper part the locality of the Egerian holostratotype (Nagy 1963). There are *Plicatopollis plicatus* and all the tropical and subtropical elements, that were characteristic of the period. A conspicuous difference is the presence of *Cicatricosisporites doregensis*, instead of *C. chattensis* f. *minor* which occurred in the holostratotype. *Plicatopollis pseudoexcelsus* is also absent in the holostratotype. From the Egerian part of the borehole FV-1 (Snopková 1988), she was found *Boehlensipollis* cf. *hohli* W.Kr. which is an explicitly Oligocene element. A mitigating circumstance is that "cf." is written. Snopková figured on a diagram in the same work in the lowermost Egerian all these taxa which are generally characterised that stage: *Leiotriletes neddeni*, *Monocolpopollenites tranquillus*, *Tricolporopollenites cingulum*, *T. cingulum oviformis*, *T. microhenrici*, *Momipites punctatus*, *Engelhardtoidites microcoryphaeus*, *Tricolpopollenites liblarensis*, *Sapotaceoidaepollenites* sp., *Myricipites rurensis*, further *Osmundacidites quintus*, *Lycopodiumsporites* sp., *Cibotioidites zonatus* (*Trilites multivallatus*), *Cicatricosisporites* (*doregensis*), *Favoisporis* sp. From the Gymnospermae are so far remarkable the *Cycadopites* sp., *Podocarpidites* sp., from the Angiospermae the *Myricipites bituitus*, *Rhoipites pseudocingulum*, *Porocolpopollenites vestibulum*.

Planderová named and illustrated the boreholes which were used for the evaluation (1990, Fig. 1–2). In the Early Egerian she indicated the *Boehlensipollis* sp., probably after Snopková. *Plicatopollis plicatus* was only in the Early Egerian in the Slovakian material, while in the holostratotype in the Late Egerian, like in Romania, too. *Cicatricosisporites chattensis* is the last occurring in Hungary in the Late Egerian, but in the Slovak material it is present only in the Early Egerian. *Proteacidites egerensis* is in the Hungarian localities from the Late Egerian, in Slovak material in the Early Egerian, too. On Fig. 8 the lack of *Engelhardtoidites microcoryphaeus* is probably a drawing mistake as it is a Paleogene species. The differences between the Slovak and Hungarian material are limited, the parent plant of some species could have appeared earlier or later also in closer areas, due to the different biotopes.

Upper Egerian sections are known in Slovakia in three basins: along the Ipele (Ipoly) river, in the basin of Lučenec (Losonc) and Rimavska kotlina (Rimaszombat). According of the view of Planderová the upper part of the Egerian is the same in Slovakia as in Hungary.

The author proposes stratigraphical changes (p. 120). The Oligocene-Miocene boundary between the Early and Late Egerian in my view is for many causes impossible: Chattian-Aquitania would be enough. At first if this were possible the Egerian stage would not be necessary. The palynological research shows that the Egerian stage support to itself. In the monograph in 1992 I determined many taxa for the characterisation of the holostratotype locality. The planktonic organisms are e.g. *Deflandrea spinulosa* Alberti, *D. phosphoritica* Eisenack, the spores *Cicatricosisporites chattensis* W.Kr., *Gleicheniidites elegans* Nagy, *Dicolpopollenites calamoides* Nagy. The Lower and Upper Egerian are separated, the Upper Egerian being characterised by the appearance of *Proteacidites egerensis* Nagy, *Favoisporis hungaricus* Nagy, *F. concavus* Nagy, and numerous other sporomorphs (Nagy, 1992, p. 14, 19, 362).

Pacltová published (1961) the results of the palynological investigation of a borehole in the environs of Košice (Kassa), Drinovec. The material is Upper Oligocene – Lower Miocene. Pacltová's article (1963) gives account of palynological investigation of the brown coal basin of Modrý Kameň (Kékkő), mentioning *Deflandrea* genus as indicative of the Upper Oligocene age. In the same periodical there is a paper of Horák et Pacltová (1963), where with Pacltová's palynological investigation Chattian-Aquitania sediments are proved SE from Banská Bystrica (Besztercebánya). Similarly the Chattian-Aquitania question in Slovakia is the theme of an article by Pacltová (1966). A borehole in the Ipele basin contains Upper Egerian material. Based on this experience she has found in a borehole Upper Egerian material in the Banská Bystrica basin. After the photoplates the plankton and the sporomorphs are the same as in the holostratotype.

Finally about my palynological investigation in the Slovakian Rimaszombat basin, in Csíz district (1978, 1980). The borehole material originated from Dr. Mária Horváth (ELTE, Budapest). The 31 samples with corroded material had been taken from micaceous sand and silt. In spite of these materials I found in them plankton and sporomorphs very typical for the Egerian.

In Planderová (1990) on the Fig. 15 shows that the Slovak scientists who deal with the Neogene had many changes of view to attain the present standpoint in the question of the Oligo-Miocene boundary (Vass 1964, 1976, Vass et al. 1979, 1987, Szenes 1989).

The Eggenburgian sea in Slovak territory was of very small extension (map No. 2 in Hámor et al. 1988). Planderová after Gasparik (1979) mentioned 4 areas of the Eggenburgian sediments: NW, Middle, East and South Slovakia. The species on the whole agree with the Hungarian ones. The extent and delimitation of the Eggenburgian stage from the Ottnangian are problematic, but this is above all not a palaeobotanical problem. After L. Hably's studies (1985, p. 127) in the rhyolite tuff there are prints of an Eggenburgian palaeoflora. The rhyolite tuff is the boundary between the Eggenburgian and Ottnangian stages. The palaeofloras of the two stages are not very separable. The talks with Géza Hámor support my supposition that the rhyolite tuff, a conspicuous geological phenomenon, is very suitable for dividing two geological units, because its absolute age is also established. An other problem is that the brown coal of the Salgótarján Formation would be ranged by Planderová also in the Eggenburgian. In this way nearly the whole Ottnangian would disappear. Planderová compared her material with the Ottnangian holostratotype material investigated by Hochuli's, which indicated a cooler climate. Evidently the palaeovegetation and palaeoclimate of Ottnang Schanze (Hochuli 1979) of higher latitude and higher elevation could not be identical with the vegetation and microclimate of a coal forming swamp forest.

The microflora of Slovakia essentially is the same as the Hungarian one, although those spores are not mentioned which I have used to characterised the Eggenburgian (Nagy 1992, p. 362–363).

Planderová (1971) in the Eggenburgian volume of the "Chronostratigraphie und Neostratotypen" presented the palynological data of the Slovakian faciostratotype (the Eggenburgian part of borehole Sveperek No.13 Pb-1, 5 samples). The material was compared with the Egerian and Ottnangian palynoflora of Slovakia. She believed that this flora was warmer than the other two. Their descriptions and figures correspond to the Hungarian Eggenburgian palaeoflora (there are *Momipites quietus* and *Polypodiisporites histiopteroides* (she used an other name, but after the photos there are present).

Pacltová (1978) investigated the brown coal of Handlova and mentioned that its footwall is Eggenburgian.

The Ottnangian sea was of very small extension and brackish according to the satellite map No. 2, Hámor et al. 1988. The Slovakian Ottnangian area is small and connected with the Salgótarján territory. Planderová stated in the monograph (1990) after Gasparik that the area consisted of not connected pieces of basins. The flora of the lower Ottnangian contains many tropical,

subtropical elements, suitable for coal forming. Both the Hungarian and Slovakian areas belong to the Salgótarján Browncoal Formation, naturally the palaeofloras are the same. The Upper Ottnangian is characterised by transgression that covered the swamp forest and the vegetation remained only on the heights, including cooler floral elements. The vegetation type corresponds to the palaeoflora of the holostratotype (Hochuli 1979). The cooling of the climate appears also in the diagram plotted from Hungarian palynological data (Nagy 1990, 1992, 1993).

The palaeoflora indicates that a chronostratigraphical unit, the Early Miocene is finished and a new one began, the Middle Miocene. This would support the superstage subdivision according to Géza Hámor (1995).

The Karpatian stage related to Ottnangian was more extended and a deeper sea is figured on the satellite map No. 3 (Hámor et al. 1988) not only in Hungary but also in Slovakia. Planderová (1990) wrote about three Karpatian areas: the Carpathian Foredeep, the Southern- and Eastern Slovakian Basins. The palynological data are summarised in two parts, the lower Karpatian with the upper Ottnangian and the upper Karpatian with the lower Badenian. Properly the Karpatian stage disappears, although with the establishment of the Mecsekisporites main zone it is easy to separate the Lower and Middle Miocene (Nagy 1992, p. 363 and Nagy 1993, p. 132). The Karpatian sporomorphs indicate the assemblage zones MF-4 and MF-5 (Planderová 1978), according to the above mentioned divisions. On the Fig. 11 (Planderová 1990) depicted some sporomorphs: *Platycaryapollenites mio-caenicus*, *Engelhardtoidites microcoryphaeus*, *Sabalpollenites areolatus*, *Tricolpopollenites liblarensis*, *Rhoipites pseudocingulum*, *Araliaceoipollenites edmundi*, *Momipites punctatus*, *Sapotaceoideaepollenites sp.*, *Porocolpopollenites vestibulum*, *Tricolporopollenites henrici*, *T. microhenrici*. Naturally these species are all characteristic of the Karpatian, but they are also present in the Ottnangian and in the Badenian. They do not separate, rather they unite the stages. Regretfully my monograph escaped her attention; the manuscript was in her hand, among her references (1990) it is present with the date 1989, with a hypothetical title.

The first volume of the “Chronostratigraphie und Neostratotypen” was the Karpatian (1967). In it Planderová published her that-time palynological results (p. 289). The data are from Southern Slovakia (one borehole and two outcrops). In the material there were many tropical elements e.g. *Pentapollenites sp.* on the photos Taf. 7G 22–24 (marked as *Tricolporopollenites sp.*). At the end of this volume there is a summary of the palaeontological articles (p. 286–290), where also the name of Planderová appears. The last sen-

tence is that the Karpatian is a new phase in the development of the fauna and flora “ die man nicht mit dem Helvetien verbinden kann, dessen paläontologischer Charakter wiederum eng mit dem Burdigalien verknüpft ist.” That conclusion is possible perhaps from the zoological data, but not from the botanical, palynological ones. In the Karpatian stage we have to do with a warm palaeoflora of subtropical character, with peculiar, new floral elements such as *Mecsekisporites*, *Rudolphisporis*, *Phaeocerosporites transversus*, *Riccaesporites transdanubicus* (Nagy 1992).

The Lower Badenian substage has relative small extension in Central, Southern and Eastern Slovakia (map No. 3, Hámor et al. 1988). These territories were studied by Planderová (1990). As it was told Planderová assembled the upper Ottnangian with the lower Karpatian in the MF zone 5; this is cooler. The Late Karpatian – Early Badenian was warmer. There were no swamp forests, however *Schizaeaceae* were common. There are many *Platycaryapollenites miocaenicus*, *Engelhardtoidites microcoryphaeus*, *Sabalpollenites areolatus*, *Rhoipites pseudocingulum*, *Araliaceoipollenites edmundi*, *Momipites punctatus*, the pollen grains of *Sapotaceae*, *Symplocaceae*. On the basis of the Hungarian paleoflora the Karpatian and the lower part of the Badenian are combined into the main zone of the *Mecsekisporites* (Nagy 1992). My remark to the climate: in my opinion the climate ought to be very favourable because many new taxa appeared. The climate must not be tropical, rather subtropical, warm-temperate, even the species of the *Mecsekisporites* and *Riccaesporites* could be such species which required temperate climate (Nagy 1985).

The Middle Badenian local climate of the brown coal forming swamp forests naturally must have been warm. This is indicated also with the simultaneous activity of the volcanism in the Carpathian Basin. This climate could be subtropical; for the vegetation of the swamp forest this is convenient.

Planderová divided the Badenian stage in to two parts Lower and Upper Badenian (1990, p.13).

The peculiarity of the Middle Badenian in Eastern Slovakia are the salt layers. They are characterised by a xerophytic flora (in this way she admitted the Middle Badenian). On the map No. 4, Hámor et al. 1988 in Slovakia is present the Middle Badenian sea.

A typical feature of the Late Badenian microflora is the impoverishment also in Slovakia. The conifers are present in high number (the transgression inundated the swamp forests therefore the vegetation of the higher areas are present). This is the last appearance of some tropical elements in Slovakia (*Sapotaceae*, *Symplocaceae*, *Schizaeaceae*, zone MF 6, Planderová 1978).

The author supposed a rise in the temperature at the Late Badenian-Sarmatian boundary, since brown coal was formed (Handlova-Nováky). There are no more tropical elements in the flora, although she mentions *Cyatheaceae*, tree ferns living in tropical subtropical zones. She assumes also the presence of *Nyssa*, *Aralia* species, which are living at least in subtropical regions. Slovakia is connected with the Hungarian basin, so there could not be very great differences between them. The local and microclimate could give surprises, however: if these species are present, the statement that in the zone MF 7 there are no more tropical species is not true.

Pacltová (1958) made palynological investigations in the district of Handlova in many places. The floral lists indicate Upper Miocene (Upper Tortonian-Sarmatian). The coal formations are characterised by *Taxodiaceae* pollen grains. The article of Pacltová (1961) presents her palynological investigations made in the surroundings of Košice (Kassa). The age of borehole Bč 1 is Tortonian-Sarmatian and contains many hygrophilic elements.

The article in the Badenian volume (1978, "Chronostratigraphie und Neostatotypen", Planderová, Nagy, Roman et Ticleanu) contain only flora lists. The most important statement concerns the Late Badenian floral impoverishment in Slovakia, Hungary and Romania.

The Sarmatian brackish sea was present also in SW-SE Slovakia according to the satellite map No. 5, Hámor et al. 1988. Planderová (1990) made, *Umbelliferae*, *Oenotheraceae*, *Chenopodiaceae* palynological investigations in the Danube Lowlands and in the Inner Carpathian basins. The characteristic feature of the Lower Sarmatian (zone MF 8) is the increasing number of the conifers: *Picea*, *Abies*, *Tsuga*, and especially the species *Sequoiapollenites*. To these joined the pollen grains of angiosperms: mainly *Oleoidearumpollenites chinensis*, and *Fagus*, *Quercus*, *Ulmus*, *Carya*, *Pterocarya*, *Carpinus*, *Ostrya*, *Cornaceae*, *Caryophyllum*. The rich assemblage supposes warm climate favorable for the development of mixed deciduous forests.

After Planderová (1990) in the upper part of the Sarmatian the conifers are dominant: *Pinuspollenites labdacus*, *Tsugaepollenites igniculus maximus*, *Piceapollenites excelsa*, the angiosperms *Ulmipollenites undulosus*, *Betulaepollenites betuloides*, *Chenopodipollis multiplex*, *Compositoipollenites taraxacifolia*, and other xerophytic plants (*Compositae*, *Artemisia*, *Chenopodiaceae*, *Gramineae*). There are spores too, *Lycopodium*, *Osmunda*. They suppose warm temperate, dry climate.

The Pannonian sea or inland sea is only a small area in Slovakia (map No. 5, Hámor et al. 1988) extended from the Vienna basin to the Danube Low-

land and SE Slovakia. This is presented in the work of Planderová (1972), where there is a little sketch map with the investigated localities (p. 210).

The characteristic sediments of the Pannonian (Malvensian) beds in Slovakia (Planderová 1972, p. 211) are the grey, green, limy clays, in some places with macrofauna. With the lower part of the Early Pannonian the Caspian-brackish formation came to an end and deposition of the freshwater layers began. In the Pannonian the subtropical elements gradually decreased in the flora. Abundant were the temperate elements: *Betula*, *Alnus*, *Quercus*, *Fagus*, the conifers: *Pinus*, *Abies*, *Picea*, *Larix* and the cryptogams: *Polypodiaceae*, *Sphagnum*, *Osmunda*. However, there are mentioned the *Cyatheaceae*. These are tree ferns, so they could not live in this temperate climate. In the monograph of 1990 already only once is mentioned the *Cyateaceae* in connection with the *Leiotriletes wolffi* W.Kr. *brevis* W. Kr. The statement that the pollen associations of the Pannonian, Pontian are richer than those of the other parts of the Miocene is certainly erroneous.

She hold inseparable the Sarmatian from the lower part of the Pannonian. In Hungary I separated them with pollen grains of very small number (*Tsugaepollenites helenensis*, *Manikinipollis*). If they are not present in the spectra it is very difficult indeed to draw a boundary. In Hungary we have the plankton zones in the Pannonian after M. Sütő-Szentai. This brackish planktonic organisms are absent in the Slovakian freshwater beds, while in Hungarian territory there are only very few sporomorphs in the Sarmatian in reason of the lithology.

In the Pannonian volume ("Chronostratigraphie und Neostratotypen" 1985, p. 586–615) in the article of Nagy et Planderová, Planderová indicated the most typical and most important boreholes for the Slovakian Pannonian in the environs of Nyitra. Planktonic organisms are very few, chiefly the freshwater algae *Spirogyra* are present. Among the underwood of the mixed deciduous and leafy forest there are many xerophytic elements such as *Ephedra*, *Ilex*. The low number of the pteridophytes is also indicated. The great quantity of conifers indicate the nearness of mountains. In contrast to Hungary some subtropical taxa are absent.

The Pontian according to the map No. 6 (Hámor et al. 1988) has nearly the same extension in Slovakia as the Pannonian. According to Planderová (1972) in its lower part there are coal bearing series, while in the upper part there are variegated series.

The third unit is the Romanian (Levantian), according to the map No. 7 (Hámor et al. 1988). This occurs in the Danube basin, in the direction of the Váh (Vág) valley and in SE Slovakia in lacustrine facies.

The palynological studies indicate that in the Pontian more conspicuous is the disappearance of the subtropical elements and the appearance of some herbs in great quantity: *Asteraceae*, *Rhamnaceae*, *Ericaceae*, *Liliaceae*, *Gramineae*. In Planderová's opinion for the variegated series in the Pontian and in the Romanian is characteristic the appearance in major quantity of the *Salicaceae*, *Acer*, *Betula*, *Alnus*, further of many *Elaeagnus* species, *Asteraceae*, *Gramineae*.

In the Pontian volume of the "Chronostratigraphie und Neostratotypen" (1990) Planderová et Papšíková wrote about the results of the palynological investigation of some boreholes in the Danube Lowland. There are no Pontian outcrops, therefore these boreholes were chosen as facio-stratotype. The boreholes are characterized by coaly clays, with lignite seams. The sporomorph list is the same as in Hungary: spores *Polypodiaceae*, *Osmunda*, *Lycopodium*, *Sphagnum*, (the *Cyatheaceae* are mentioned!), conifers *Taxodiaceae-Cupressaceae*, *Tsuga*, *Sequoia*, *Cedrus*, *Sciadopitys*, *Pinus sylvestris* and *haploxylon* type, *Abies*, *Keteleeria*, *Picea*, further *Ephedra*, angiosperms *Tilia*, *Malvaceae*, *Carya*, *Pterocarya*, *Betula*, *Alnus*, *Corylus* and different sorts of *Salix* are common, besides *Juglans*, *Liquidambar*, *Ilex*, *Ulmus*, *Ostrya*, *Carpinus*, *Quercus*, *Fagus*, *Rhus*, *Acer*, *Tricolporopollenites asper*, *T. microhenrici*, *Tricolporopollenites liblarensis*, *Caryophyllaceae*, *Polygalaceae* and other pollen grains of herbs *Chenopodiaceae*, *Lamiaceae*, *Asteraceae*, *Ericaceae*, *Poaceae*, *Nymphaeaceae*, *Liliaceae*. Many of the elements belong to the temperate zone, but sporadically there are subtropical taxa, too: *Engelhardtia*, *Myrica*, *Sciadopitys*.

Pacltová (1961) wrote also about her palynological results SW of Košice (Kassa) at Baška village, from a Pliocene outcrop.

The Neogene flora of Slovakia can not be separated from the Hungarian one of the Central Paratethys: it is a natural Northern complementary area. The differences are not greater than those between the North and South in the Hungarian territory. We have often the possibility to correlate our Hungarian and Slovak data. Obviously the tropical and subtropical elements disappeared somewhat earlier in Slovak territories, what is not only a consequence of the latitudinal difference, but it is also connected with the geomorphological differences. The greatest deviation is the appearance of evaporites in the Middle Badenian of Eastern Slovakia. This is a geological phenomenon, but since in the evaporite there are very few sporomorphs they cause no serious trouble in the correlation. In the youngest Neogene formations in the consequence of the lack of inland sea the brackish water planktonic organisms are absent in Slovakia. The terrestrial vegetation of both territories is the same.

Czech Republic

According to the Neogene palaeogeographical atlas of Hámor et al. 1988, in the Czech Republic the Central Paratethys was extended only to the Southern part of Moravia in prolongation of the Vienna Basin. About this give evidence the maps No. 1, 2, 3. The sea is the most extended on the last one. The presence of the sea may be supposed even in the Karpatian stage (satellite map of No. 3).

The results of the palynological investigations are examined for comparing the palaeovegetation independently from the presence of the sea.

Zdražilková (1993) made palynological investigations on Eggenburgian, Ottnangian, Karpatian borehole sections in Southern Moravia in the Carpathian Foredeep belonging to the Central Paratethys. The pollen spectra contained constant tropical-subtropical taxa: *Lygodium*, *Sapotaceae*, *Palmae*, *Araliaceae*, *Engelhardtia*, temperate climate demanding taxa: *Tsuga*, *Sciadopitys*, *Fagus*, *Betula*. The humid elements are rare: *Taxodiaceae*, *Polypodiaceae*. There are numerous xerophytic plants: *Ilex*, *Chenopodiaceae*, *Ericaceae*. In addition there are *Quercus*, *Platanus*, *Buxaceae*, common are the *Oleaceae*, *Pinaceae*. Planktonic organisms are the *Botryococcus*, dinoflagellates without projections, *Stigmopollis laevigatoides* Kr. et Paclt. which the authors assign to *Cyanophyta*. Pacltová (1982) found a similar association in the Cheb basin, in the Cypris Formation. The Ottnangian-Karpatian palynoassociation is different. The author observed no cooling in the Ottnangian, in contrast to Hochuli. The number of the pollen grains of *Sapotaceae* is decreasing, but the presence of the *Symplocaceae*, *Palmae*, *Lygodium* is increasing. The "arctotertiary" elements are rare (*Tsuga*, *Betula*, *Fagus*). On the top of the Ottnangian there are many hygrophilic plants *Taxodiaceae*, *Myrica*, *Nyssa*, *Alnus*, *Polypodiaceae*. There are many *Selaginella* spores. The *Tasmanaceae* cysts and *Dinoflagellatae* indicate transgression. In the higher samples the *Taxodiaceae* swamp forest appears. In the boreholes there are two associations: the first is *Myricipites megagranifer*, *Laevigatosporites haardtii*, *L. discordatus*, *Alnus*, the second is in great quantity *Poaceae* and *Palmae*, *Sparganiaceae*, *Botryococcus*, *Ovoidites*. In some places (Nosislav, Medlov) in the upper part of the Karpatian the dinoflagellates indicate marine influence. They are many "arctotertiary" elements: *Betula*, *Carpinus*, *Juglans*, *Tsuga*. *Sapotaceae* pollen grains occur too, but the saccate conifers are dominant. The spectrum is very similar to the South Slovakian one.

In Bohemia the localities of the palynological studies are out of territory of the Central Paratethys. Pacltová (1958) made palynological investigations in Southern Bohemia, on the Oligo-Miocene Mydlovary section. The lignite mine by Mydlovary village has two coal seams (Pacltová 1960). The freshwater is proved by planktonic organisms (*Pediastrum* sp., *Ovoidites* sp.) and with *Azolla* massula, and *Sparganium* pollen grains, too. The association of the sporomorphs verifies the age of the sediments *Leiotriletes adriennis* ssp. *pseudomaximus*, *Corrugatisporites solidus*, *Osmundacidites quintus*, *Polypodiaceoisporites marxheimensis*, *Polypodiisporites alienus*, *Myricipites bituitus*, *Engelhardtoidites microcoryphaeus*, *Momipites punctatus*, *Myricipites megagrifer*, the pollen grains of *Symplocaceae*, *Sapotaceae*, *Palmae*, *Cyrillaceae*, *Tricolporopollenites henrici*, *T. microhenrici*, the species of *T. cingulum*, *T. satzveyensis*, *Tricolporopollenites liblarensis*. These taxa are present in the holostatotype, too. This fact does not diminish the importance of the typical species of the Egerian (Nagy 1963, 1979, 1992).

The Northern Bohemian Basin is located in NW Bohemia. The basement of the Basin is limnic Paleogene. In the Miocene a productive brown coal formation developed. In the area between the towns of Chomutov and Žatec many scientists worked. The age of the basal sand and clay is surely Paleogene, above the upper part of the volcanic series is possible the presence of the Neogene. The lower Underlying Formation sandy-clay beds with the lower coal seam are surely Miocene. On the following layers palynological investigations were made by Konzalová (1976). There is a coal bearing formation, with two coal seams with a dead rock in between and after that the upper formation (Overlying Formation), again a dead rock and at last an upper coal seam. One part of the work was done in the western area (Chomutov-Žatec), and the other on the volcanic series in the Eastern area (at Most city). The lower formation is Miocene, from Late Aquitanian till Early Burdigalian. Konzalová refers to numerous authors, who compared the North Bohemian Basin with the Cheb and Sokolov Basins chiefly by means of animal fossils. With these data however one can not separate the palynological material in stages, because the formations are referred very rarely, in most cases only the boreholes are named. Freshwater algae are *Botryococcus*, *Pediastrum*. The ferns are *Azolla*, *Salvinia*, *Osmundacidites primarius*, *Schizaeaceae* (*Lygodium*, *Leiotriletes maxoides*), *Histiopteris* sp., *Polypodiaceoisporites* sp. and *Corrusporis* sp. From the conifers are listed the most important genera of *Cupressacites* and the *Abietinae*. She described one *Ephedra* and 59 angiosperm taxa, from these 43 are common with the Hungarian Early and Middle Miocene. Characteristic taxa are in the Central Pa-

ratethys area in the Early Miocene: *Magnolia*, *Persicariopollis meuseli*, *Myricipites rurensis*, *M. megagrifer*, *Engelhardtoidites microcoryphaeus*, *Momipites punctatus*, *Tricolporopollenites henrici*, *Araliaceopollenites edmundi*, *Dicolpopollis kockeli*. The most part of the further taxa are to be found in the whole Neogene: freshwater alga and ferns, and other freshwater plants. By the coal forming there are always present the *Taxodiaceae* family and other swamp forest plants (*Nyssa*, *Oenothera*, *Gramineae*). The difficulty of more precise ranging of the stage probably is also due to the lack of other fossils, so the author tries to make a correlation with other areas supposedly similar in age, e.g. the Cheb Basin. The research area is not far from the former GDR localities, that is why naturally the author tries to make correlation with them. Mai (1967) made a zonation from his macroflora data numbered with I–XIII to the area of the GDR. Here and there he made comparison with the palynological data of W. Krutzsch. He referred to the results of some German (Gothan, Kräusel, Potonié, Kirchheimer) and Polish authors (Szafer, Lancucka-Środoniowa). He mentioned the better founded subdivision of the Paratethyan area, the stages, but evidently, he could do no correlation with the data of the Paratethys.

In Western Bohemia the Cheb Basin is South of the former. Konzalová (1981) made also there palynological investigations in the years of 1977, 1978. From the lower part of the investigated borehole (V–1) 180.2 m are Tertiary. The upper section of the borehole is the Vildštejn Formation of Pliocene – Pleistocene age, below them the Cypris Formation could be of Karpatian-Ottnangian age (Fejfar 1977), and the Lower Miocene Main Coal Seam overlying the Basal sandy-clay Formation is probably Paleogene. The age of the coaly clay between the main coal seam and the Cypris claystone is upper Ottnangian-Karpatian as indicated by its mammalian fauna.

In the area between Františkovy Lázně and the Odrava basin many boreholes were deepened which contained ichthyofauna. Some of them were investigated by Konzalová and Stuchlik (1983). The samples have rich sporomorph spectra: a great number of pollen grains of *Pinaceae* and less of the group *Taxodiaceae-Cupressaceae*, which increases towards the upper part of the sequence. There are many aquatic and swamp plants (*Alismataceae*, *Butomus*, *Sparganium*, *Equisetum*, *Typha*, *Gramineae*), as well as *Alnus*, *Ulmus*. Characteristic angiosperms are in the entire borehole the *Carya*, *Engelhardtia* and the *Oleaceae-Caprifoliaceae* group. The mesophytic mixed forest and humid habitats appear in the spectrum with *Fraxinus*, *Acer*, *Castanea*, *Quercus*, *Carpinus*, *Ostrya*, *Celtis*, *Fagus*, *Magnolia*, *Tilia*, *Nyssa*, *Liquidambar*. Several elements of the family *Pinaceae* and the genus

Cunninghamia represented the conifers. The shrub level consisted of *Ilex*, *Rhus*, *Rosaceae* (*Crataegus*, *Prunus*-type), *Hammamelidaceae* (*Corylopsis*-type), *Rutaceae* vel *Rubiaceae*, *Vitaceae*, *Rhamnaceae*, *Oleaceae-Caprifoliaceae*, *Sterculiaceae* (*Reevesia*), *Araliaceae*. The semi-parasitic *Loranthaceae* have also been found in the North-Bohemian Basin and in the Most area. With special interest were followed the thermophilic elements because although they are only a few in number, but they are characteristic for the vegetation (*Sapotaceae*, *Symplocaceae*, *Arecaceae*, *Schizaeaceae* families), and in the evergreen forest the *Ilex*, *Reevesia*, *Buxus* and *Araliaceae*, too. Few pollen grains are present from ferns and herbs, only water plants, *Cyperaceae*, *Gramineae* were found and in the upper samples there were *Botryococcus* colonies.

These spectra were compared with the spectrum of the main coal seam, where there are more swamp plants (*Myrica*, *Taxodiaceae-Cupressaceae*) and pollen grains characterised the warmer climate: *Tricolporopollenites henrici*, *Rhoipites pseudocigulum*, *Engelhardtia*, *Arecipites areolatus*, *Symplocaceae*, *Sapotaceae*, *Nyssa*, *Araliaceae-Cornaceae*, etc. The Cypris clay layers are impoverished in pollen grains, but the relative values of certain elements are rather high (*Keteleeria*, *Pinus* sp. div.). There are many *Tilia*, *Fagaceae*, *Pterocarya*, *Juglans*, *Chenopodiaceae* and in general pollen types of anemophilous plants.

The results of their research were compared with those of the palynological investigation of the Mecsek Mountains (Nagy 1969), such as the clay marl with fish-scales, and the "Schlier", mentioning the most important localities: borehole Hidas 53, Kistrét, Magyaregregy-Leánykő, Melegoldal, boreholes Zengővárkony 59 and Komló 120. It would be very interesting to know the one-time exposition of the places. The Cheb basin is of much more northern position, it could have been of southern exposition, while the localities in the Mecsek Mountains are in the northern part on the Mountains. This could be also the cause of the similarity.

The Vildštejn Formation is the youngest in the Cheb basin. Stuchlik (1982) studied palynologically three sections. He determined 127 taxa and identified three vegetation units. In the lowest clay layer there was a broad leaves *Alnus-Sphagnum* swamp forest with *Pinus*, or an *Ericaceae*, *Salicaceae*, *Cyperaceae*, *Betulaceae* and mesophytic forest with *Pinus* dominance, with *Quercus*, *Tilia*, *Ulmus* and *Rosaceae*. The botanical characteristic of the second clay layer was a swamp forest with *Alnus*, *Taxodiaceae-Cupressaceae*, mesophytic deciduous forest with great shrub stock (*Rhamnaceae*, *Viburnum*, *Vitis*, *Rosaceae*) and *Tsuga*. The third unit was an open

swamp and marsh, with many herbs. The botanical associations equally contain Tertiary and Quaternary elements. Since the spectrum contains such Tertiary elements like *Arceuthobium*, *Aralia*, *Corylopsis*, *Keteleeria*, *Liquidambar*, *Myrtaceae*, *Nyssa*, *Ostrya*, *Reevesia*, *Rhus*, *Sapotaceae*, and the ratio NAP/AP refer to Neogene the time of origin, indicating the end of the Pliocene with transitional character to the Pleistocene.

Pacltová (1963) published the results of the palynological investigations made in the Třeboň basin in Southern Bohemia. The stratigraphical subdivision of the area was made after the quantitative division of Reuver, Tegelen and young Quaternary elements. The Reuver elements are: *Sequoia* (*Cryptomeria*, *Metasequoia*), *Taxodium* (resp. *Glyptostrobus*), *Sciadopitys*, *Nyssa*, *Liquidambar*, *Cedrus*, *Zelkova*. Tegelen elements are: *Tsuga*, *Pinus haploxylon*, *Phellodendron*, *Carya*, *Pterocarya* and probably *Juglans*, *Castanea*. Quaternary elements are: *Picea*, *Abies*, *Pinus sylvestris*, *Betula*, *Corylus*, *Alnus*, *Carpinus*, *Quercus*, *Fagus*, *Salix*, *Ulmus*, *Tilia*, *Ilex*. On this basis the section of Lednice is ranged in the Reuver (similarly to the Pontian of Hungary). The author mentioned coaly clay and "schwach durchkohlten Hölzern". She wrote in the same article about the results obtained in the Cheb Basin, too. The beds of Vonšov – Nová Ves range in Pretegelen-Tegelen agree with the results of Szafer, Oszašt, Zagwijn like Mizerna II/III and Kaproc in the Polish Western Carpathians.

From the stratigraphic point of view the results of the palynology easier to correlate in areas which were in contact with the Paratethys, and more difficult in case of the rest. The comparison in the latter case is made even more difficult by the different geomorphological circumstances.

Austria

On the basis of Hámor 1995 it is evident that in the Early Miocene the Paratethys had a connection between the norther part of Hungary and Austria through Middle Slovakia. The marine contact was established through the Carpathian zone. A direct sea contact developed in the Karpatian stage and it was the most extended in the Badenian. Before these stages the Paratethys extended to the West as far as to Switzerland. The sea, however, was not further extended to the West in Badenian time, only to the Vienna Basin.

From the territory of Austria there are not too many Neogene palynological works. Klaus (1971) reports about the palynological investigation of phosphoritized coprolites from the Egerian in Hinzenbach („linzer Phos-

phorit Sande"). On the basis of the predominance of the pollen grains of *Tsuga*, *Carya* and *Pinus sylvestris* he thinks the material is nearer to the Burdigalian than to the Oligocene, so we can identify it as Upper Egerian. The list of the flora is: *Hystrichosphaeridae* fragments, *Fungi*, *Pinus sylvestris*, *P. haploxylon*, *Picea*, *Tsuga cf. diversifolia*, *Sciadopitys cf. verticillata*, *cf. Sequoia*, *Cupressaceae*, *Taxaceae*, *Carya*, *Momipites punctatus*, *Engelhardtia*, *Myricaceae*, *Quercus*, *Pollenites henrici*, *P. microhenrici*, *Rhoipites pseudocingulum*, *Poll. cingulum fusus*, *Oleaceae*, *Poll. gertrudae*, *Nyssa*, *Ilex*, *Sapotaceae*, *Ephedra*, *cf. Ericaceae*, *Sabal*, *Poll. emmaensis*, *Polyatriopollenites vestibulum*, *Poll. fallax*, *Poll. marcodurensis*, *Poll. parmularius*, *Gramineae*, *Acer*, *Alnus*, *Zelkova*, *Betula*.

In the article of Planderová, Klaus et Nagy (1975, "Chronostratigraphie und Neostratotypen", Egerien) there are two floral lists from Klaus, one is of the schlier of Hinzenbach (the same see above) and the second of the section of Klein Rust. In the first there are no spores, in the second there are. *Cicatricosporites dorogensis* is mentioned, which may be rather *C. chattensis*. Among the conifers the *Pinus haploxylon* type is dominant, this refers to the Early Egerian. Remarkable older elements are *Engelhardtia*, *Tricolporopollenites microhenrici*, *Myrica*, *Rhus* and *Poll. fallax*.

Hochuli (1978) made palynological research in a very extended area (from Switzerland to Hungary and from Southern Bavaria to Northern Tyrol) and very great interval of time (from upper Eocene till Ottnangian). Naturally he does not deal very much with sections, but one-two samples were investigated in a locality. This was his diploma work. From the Austrian material I chose four Miocene localities. The first one is Lower Egerian, an outcrop in Unter Rudling (Oberösterreich), 3 samples. The material could be correlated with the Puchener Series, consequently it is of Early Egerian age. The flora according to the author's opinion is rich in "arctotertiary" elements such as: *Sciadopitys serratus*, *Tsugaepollenites maximus*, *T. neogenicus*, *T. spinulosus*. The conifers more than 55% are *Cupressacites insulipapillatus*, 5.5% *Taxodiaceae*, 4.5% *Sequoiapollenites*. Warm elements are only a few; among conifers the *Podocarpidites libellus*, among the angiosperms *Magnolia*, *Intratropopollenites instructus*, *Tricolporopollenites henrici* (9.4%), *Myricipites rurensis*, *Engelhardtoidites microcoryphaeus*, by the spores *Foveotriteles crassifovearis*, *Polypodiisporites alienus*. The phytoplankton agrees mostly with the material of the Rupelian (Kiscellian) part in the Eger brickyard borehole. In the holostratotype in Hungary the number of these planktonic organisms is decreasing, because the shoreline was nearer, only there

are more *Pleurozonaria* species. The Austrian areas are probably of open sea facies.

The second locality is Hinzenbach near Eferding (Oberösterreich), which the author identified with the upper part of the holostratotype and ranged in the Neogene II created by himself. The lower part of the Neogene II, after his figure (p. 4, Abb. 1) the base of the Egerian is identical with zone NN1, I chose this locality. This locality was described by Klaus in 1971 and in the Egerian volume in the article of Pländerová, Klaus et Nagy in 1975. Hochuli investigated 3 samples, only in two of them was material. The author drew the conclusion that in the material occur mostly warm elements, and therefore it belongs to the Late Egerian, and accordingly to Neogene II. The planktonic material is similar to the former. From this *Deflandrea spinulosa* is present only till the top of the holostratotype. In the same time in both of the Egerian localities there is abundant phytoplankton, chiefly hystrichosphaeres, which are present in the holostratotype only as fragments. The sporomorphs in Hinzenbach are: *Cupressacites* 60%, *Sequoia*+*Taxodiaceae* cca 10%, a few *Nyssa*, *Sparganiaceae* (these are after Krutzsch “facies elements”), “thermophilic elements”: *Leiotriletes maxoides maximus*, *Polypodioidites secundus*, *Podocarpidites nageiaformis*, *Myricipites rurensis* (why is this not a facies element?), *Plicatopollis plicatus*, *Momipites punctatus*, *Engelhardtoidites microcoryphaeus*, *Platycaryapollenites miocaenicus*, *Tricolporopollenites henrici*, *T. marcodurensis*, *Araliaceoipollenites* and the pollen grains of *Sapotaceae*.

As “intermediary elements” are mentioned the temperate climate *Abies*, the rather mediterranean *Cedripites*, and *Ephedripites*, *Betula*, *Carya*, *Pterocarya*, *Juglans*. “Arcotertiary elements” are the *Polypodiaceoisporites gracillimus* (in my opinion it is a warm element! (Nagy 1963), described from the Upper Egerian and present only in the Lower Miocene, too), *Picea*, *Tsugaepollenites maximus*, *T. spinulosus*, *Sciadopityspollenites serratus*, *S. quintus*, *Carpinus*, *Ulmus*, *Acer*, *Liquidambar*, *Fagus*.

In the flora of the holostratotype in Hungary there are no significant differences as would be in case of a great change in the climate between Early and the Late Egerian. The most characteristic taxon in the flora is the *Sapotaceae*. This is present almost in equal quantities in both parts of the Egerian. There are not too many, different fern species. *Polypodiaceoisporites gracillimus* is in Hochuli’s opinion an “arcotertiary element” – but it appears even in the upper part of the lower Egerian, and is present in the upper part of the Egerian, too. In both parts there are *Pentapollenites* species and *Cyrilla*. There are more *Tricolporopollenites liblarensis* in the upper part, but from

Rhus are more present in the lower part. It is possible that in our statement there are mistakes (Planderová, Klaus et Nagy 1976), or Hochuli's statement is not true, since his advisers knew better the palynological situation in the Central Patatethys.

The third Austrian locality is the holostratotype of Eggenburgian Eggenburg, Brunnstuben Graben (Niederösterreich). In the rich flora the *Momipites punctatus* and *Engelhardtoidites microcoryphaeus* are dominating. According to the author the *Gramineae* and *Compositae* are more numerous than they were in the Egerian. The phytoplankton is the same, chiefly *Hystrichosphaeridae*. The spores are *Foraminisporis granoverrucatus*, *Polypodiisporites alienus*, *Corrusporis chattensis*, *Laevigatosporites haardtii*, the pollen grains: *Piceapollenites alatus*, *Abietinaepollenites microalatus*, *Pinuspollenites* sp. (38%), *Cupressacites insulipapillatus*, *Ericipites ericius*, *Alnipollenites verus*, *Chenopodipollis multiplex*, *Ilexpollenites iliacus*, *I. margaritatus*, *Inaperturopollenites* sp., *Sequoiapollenites* sp., *Taxodiaceapollenites* sp., *Dicolpopollis kockeli*, *Nyssapollenites kruschi* ("facies elements"). Warm elements are *Osmundacidites primarius*, *Leiotriletes maxoides maximus*, *Trilites multivallatus*=*Cibotiides zonatus*, *Polypodiidites favus*, *P. histiopteroides*, *Podocarpidites libellus*, *P. nageiaformis*, *Myricipites rurensis*, *Plicatopollis plicatus*, *Engelhardtoidites microcoryphaeus*, *Momipites punctatus* (29.6%), *Platycaryapollenites miocaenicus*, *Tricolporopollenites henrici*, *Cyrillaceaepollenites exactus*, *Sapotaceoidaepollenites sapotoides*. "Intermediary elements" are: *Abies*, *Betula*, *Carya*, *Juglans*. "Arctotertiary elements" are: *Picea*, *Tsugaepollenites neogenicus*, *Polypodiaceopollenites gracillimus*!!, *Graminea*, *Slovakipollis hippophaeoides*, *Ulmipollenites undulosus*, *Liquidambarpollenites stigmatosus*.

The fourth locality is Ottnang (Oberösterreich). The holostratotype is Ottnang-Schanze from where one schlier sample was investigated. The sample contains well preserved phytoplankton and sporomorphs. The chief characteristic is the decrease of the tropical elements. The marine phytoplankton is mostly *Hystrichosphaeridae*, some of these are in Hungary in the Rupelian and the Egerian. The sporomorphs are labelled after Krutzsch (1967) as: "Facies elements": *Laevigatosporites haardtii*, *Piceapollenites alatus*, *Abietinaepollenites microalatus*, *Pinuspollenites* sp. 72.4%, *Ericipites baculatus*, *Alnipollenites verus*, *Chenopodipollis multiplex*, *Ilexpollenites iliacus*, *I. margaritatus*, *Sequoiapollenites* sp., *Taxodiaceapollenites* indet., *Sparganiaceapollenites* fsp., *Nyssapollenites kruschi*. "Thermophilic elements": *Leiotriletes wolffi*, *Cibotiidites zonatus*, *Polypodiidites favus*, *Podocarpidites libellus*, *Myricipites rurensis*, *Momipites punctatus* (15.1%), *Platycary-*

apollenites miocaenicus, *Tricolporopollenites henrici*, *Sapotaceoidaepollenites sapotoides*. "Intermediary elements": *Abiespollenites* fsp., *Cedripites* fsp., *Ephedripites tertiaris*, *Betulaepollenites betuloides*, *Caryapollenites simplex*, *Pterocaryapollenites stellatus*, *Juglanspollenites maculosus*. "Arctotertiary elements" are: *Neogenisporis* fsp., *Ricciaesporites* sp., *Perinomonoletes spicatus*, *Sciadopityspollenites serratus*, *Graminidites* sp., *Slovakipollis hippophaeoides*, *Ulmipollenites undulosus*, *Liquidambarpollenites stigosus*, *Lonicerapollis* cf. *gallwitzii*, *Faguspollenites pseudocruciatus*, *Compositae* div. fsp.

In the Ottományian of Hungary the number of temperate elements in palynoflora is increasing, but in the scrub level relatively many tropical ferns occur. We can well observe this in the Mecsek Mountains. In Northern Hungary in connection with the palaeogeographical circumstances there were brown coal forming swamp forests and swamps, which assured the warmer habitat for the vegetation.

It is a pity that Hochuli in his work took over from Krutzsch (1967) the climatological categories of Tertiary palynological elements, in which botanical, climatological, ecological and geological ideas have been mixed.

By Geras (Niederösterreich) in Langau there is a brown coal seam, which was studied palynologically by Obritzhauser-Toifl (1954). She refers for the stratigraphical ranging to the palaeontological research of Zapfe, who with Mastodon teeth rests verified the Burdigalian age of the brown coal. The xylitic, soft brown coal contains freshwater algae, chiefly *Zygnemataceae*: different morphological varieties of *Ovoidites ligneolus* (*Spirogyra* sp., *Mougeotia* sp. which – after the manuscript of Klaus thesis from Neufeld – she marked with the *Tetrapidites* genus name). In the spectra – according to the nomenclature of Klaus – the bladderless conifers are dominant. Further the spectra contained all sporomorph taxa, which are present in the Hungarian Eggenburgian localities. The spores are: *Osmundacidites primarius*, *Lygodioisporites adriennis*, *Polypodiisporites favus*, *Laevigatosporites haardtii*, the conifers: *Pinus* sp., *Larix*, *Podocarpus*, the angiosperms: few *Alnus*, many *Momipites punctatus* (*Pollenites coryphaeus*), *Cyrtaceaeipollenites exactus*, *C. megaexactus*, *Tricolporopollenites microhenrici*, *Tricolpopollenites liblarensis*, few *Carya*, *Pterocarya*, *Ulmus*, many *Engelhardtia*, *Pollenites gertrudae*, *Rhus*, *Ilex* (*margaritatus*, *propinquus*), *Intratripopollenites instructus*, *Araliaceoipollenites edmundi*, *Porocolpopollenites triangulus* (*Symplocaceae*), *Sapotaceoidaepollenites manifestus*, *Ericipites ericius*, *E. roboreus*, *Compositae*, *Pollenites oculus noctis*, *Smilax*, *Typha*.

Pannonian “F” after Adolph Papp. Klaus (1952) very shortly, compared the Hausruck brown coal sections with his dissertation material from Neufeld (Lajtaújfalu, Burgenland). He investigated 78 samples from the section. The *Pinus labdacus minor* type is dominant opposite to *Pinus microalatus minor*. There are many conifers *Picea*, *Abies*, *Tsuga*, *Sequoia* (*Cryptomeria*), *Taxodiaceae*, *Cupressaceae*, *Sciadopitys* and many other *Pinus* types, angiosperms: *Fagus*, *Nyssa*, *Liquidambar*, *Carya*, *Pterocarya*, *Castanea*. The Miocene index fossils are missing.

From the western Hausruck (Oberösterreich) brown coal section Klaus investigated 23 samples. The age is the earliest Pliocene (Klaus 1952). He has not investigated the Eastern part of the Hausruck area, but the age is Early Pliocene verified by *Hipparion gracile* (Kaup) teeth.

In the jubilee volume of cooperation of the Hungarian – Austrian Geological Institutes there is an article about the results on the palynological investigations about the boundary Upper Pannonian, Pontian brown coal sections (Draxler, Nagy et al. 1997). From Austrian side 3, from Hungarian 2 boreholes were compared. The data were fully in harmony.

In SE Burgenland at Badersdorf in coaly clay Zetter et Keri (1989) found fossil *Nelumbo* pollen grains. According to their determination the finding is *N. europea* Kuprijanova et Tarasevic. They could not identify it with a recent species and therefore it could not be used for climatological evaluation.

Kovar-Eder (1987) used not only the macroflora data, but took into attention the results of the palynological investigations, too for the evaluation of the Pannonian vegetation and climate of the Central Paratethys. She compared her own data with the results obtained in Romania, Hungary, Czechoslovakia, Poland and Western Germany. About the climate this is written: “Although of Pannonian age, the climatic evaluation of the flora from the Mátra Mountains (Nagy 1958) may provide a good model for the slightly older floras in the Pannonian Lake area. Nagy’s study is the only one that considers the microclimates of the single habitats. The composition of the flora does not differ principally from those of the Pannonian so that these results have at least some validity for the Pannonian.” Then she reported numerical all my climate data. Then: “Perhaps the most critical element in these interpretations is the possibility that while some microclimates may have experienced considerable frosts other may have been more or less frostfree.” Later: “more attention should be paid to possible microclimatic differences caused by topographical factors such as differences in elevation, extension of mountains as well as distance from stream and river banks and the Pannonian Lake. Nagy’s (1958) climate analysis of the flora from the Mátra Mountains

clearly illustrates possible differences in microclimate in different habitats. It offers interpretation of climatically favoured areas and climatic variation associated with elevation.” (Kovar-Eder 1987, pp.125–126).

The palynological data the Neogene of Austria apart from the geomorphological differences correspond to the Hungarian ones.

Poland

In the atlas of Hámor et al. (1988) on the maps Nos. 3–4 (Karpatian-Badenian), it is marked that the Paratethys was extended to the South of Poland only. The first Neogene palynological articles are written about these stages. Oszczytko and Stuchlik (1970, 1972) demonstrated freshwater beds from the uppermost part of the Karpatian (then Upper Helvetian), as well as brackish and salt water layers from the Lower Badenian (then Lower Tortonian) in Nowy Sącz Basin SE of Krakow. The authors with palynological analysis of the freshwater layers determined 82 taxa. These were divided into 3 groups: conifers, genera of the Miocene, and Quaternary taxa. In the first group, the conifers, *Pinus sylvestris* prevailed, fewer were the *Taxodiaceae*, *Cupressaceae*, and only sporadically occurred *Pinus haploxylon*, *Picea*, *Tsuga*. The second group were the Tertiary genera *Castanea*, *Carya*, *Pterocarya*, *Platycarya*, *Engelhardtia*, *Celtis*, *Myrica*, *Ilex*, *Nyssa*. No old Tertiary elements were present. The third group consisted of taxa occurring both in the Tertiary and in the Quaternary. Apart from *Alnus* and *Betula* the other components of mixed deciduous forest were of no greater significance. From the stratigraphical point of view the freshwater sediments are underlying in the basin brackish and marine sediments, which are the lowermost part of the Lower Badenian, while the freshwater sediments are the upper part of the Karpatian.

Oszast’s article (1967) concerns the palynological investigation of the sulphur deposit at Piaseczno near Tarnobrzeg. The opencast sulphur mine, Tortonian limestones and sulphuriferous clays are overlain by Pleistocene sediments. The analysis was made from 40 samples of Tortonian (Badenian) sediments. Among the conifers the pollen grains of *Taxodiaceae* and *Pinus* were dominant. There are a little more *Picea* than *Abies*, *Tsuga*, *Sciadopitys*. Among the angiosperms the *Ericaceae* were dominant. To the vicinity of the seashore refer the pollen grains of *Chenopodiaceae* and *Plantago cf. maritima*. Farther from the sea the representatives of the deciduous forests were *Platanus*, *Ulmus*, *Corylopsis*, *Ailanthus*, *Acer*, *Styrax*, *Carya*, *Pterocarya*, on the hights there are *Fagus*, *Zelkova*, *Carpinus*, *Eucommia*, in dryer

places *Quercus*, *Celtis*, *Ostrya* and *Tilia*, *Salix*, *Liquidambar*, *Dyospyros*, *Parrotia*, *Ligustrum*, *Sorbus*, *Crataegus*, *Buxus*, *Ilex*, *Punica*, *Smilax*, *Vitis*, *Rhus*. The flora reminds the author to the Transcaucasian flora, and the shrub level (*Punica*, *Nerium*, *Berberis*, *Rhamnus*, *Cassia*) to the Mediterranean macchia (but the latter is the result of forest cut-over!). The author believes that the climate was warm temperate, in its character Mediterranean. This palaeoflora was rich, but indicates a cooler climate than the Hungarian one.

A similarly Tortonian flora is in the brick-yard clay at Stare Glivice (Oszast 1960). The investigated outcrop section was divided into three parts. In all three conifers were dominant. The middle one was more humid, there were more *Taxodiaceae-Cupressaceae*, the lower and upper part were dryer, there were dominant the *Sequoia* pollen grains. There were warm elements, though there were no more *Symplocos* and *Sapotaceae* pollen grains, similar to the previous locality. As compared to the Hungarian Badenian in correspondence with the latitudinal differences, Stachurska et Sadowska (1973, p. 162) hold the locality of Stare Glivice for Sarmatian and supposed that the area was near the Paratethyan seashore. This is however impossible after the maps Hámor et al. (1988), it could be only in the Late Badenian.

Oszast in a monograph (1973) refers to the palynological investigation of the Domański Wierch borehole on the highest point of the Western part of the Nowy Targ Basin. She presented the results of the investigation and for stating the age refers to the other palynological results of the Nowy Targ Basin. On the basis of lithological considerations out of the 306 samples only 77 were evaluable. The forest vegetation was dominant, mainly the conifers. More numerous were the *Picea*, fewer the *Tsuga*, *Sciadopitys*, *Taxodiaceae*. On the hill-side deciduous forest was found with *Acer*, *Aesculus*, *Carpinus*, *Carya*, *Castanea*, *Fagus*, *Juglans*, *Quercus*, *Sorbus*, *Tilia*, *Ulmus*. Underwood in shrub level were *Cornus*, *Corylus*, *Rubus*, *Sambucus*, *Viburnum*. By the riverside were living *Alnus* (in some places 70%), *Fraxinus*, *Salix*, *Pterocarya*, in the forests *Polypodiaceae*, *Osmunda*. Herbs were *Filipendula*, *Lysimachia*, and water plants *Batrachium*, *Potamogeton*, *Sparganium*, xerophytic plants *Artemisia*, *Centaurea jacea*-type, *Chenopodiaceae*, *Compositae*, *Ephedra*, *Gramineae*, *Helianthemum*, *Hippophaë*, *Rumex acetosa*, *Scabiosa*. Evergreen trees, shrubs and explicitly tropical plants were not present. The vegetation indicates a temperate humid climate. The stratigraphic position of Domański Wierch according to Oszast is the youngest Pliocene. To prove this she studied the palynological data of many localities in the Nowy Targ Basin, taking into consideration also other palaeobotanical data (chiefly those of Szafer and Zastawniak). These are:

Huba locality is in the Eastern part of the basin. The section is 8.6 m blue-green clay alternating with sand. The fossil material was rich in Tertiary elements. Among them the conifers the *Taxodiaceae-Cupressaceae* (*Taxodium*, *Cryptomeria*, *Sequoia*, *Glyptostrobus*) were dominant. Among the deciduous plants there were Tertiary elements: *Lyriodendron*, *Magnolia*, *Aesculus*, *Carya*, *Celtis*, *Corylopsis*, *Engelhardtia*, *Eucommia*, *Nyssa*, *Ostrya*, *Platykarya*, *Pterocarya*, *Rhus*, *Zelkova*. Among the herbs the most common were the *Cyperaceae*. The other water plants were *Brasenia*, *Euryale*, *Nuphar*, *Trapa*.

Krościenko is on the river Dunajec, where 80 samples have been collected from a 12 m brick-yard clay section. The sedimentation occurred in quiet circumstances, as evidenced by the water plants, especially of the high percentage of *Nuphar*. The palynological investigations supported the macrofloral research of Szafer (Szafer 1946–47). The conifers were dominant, in particular the *Picea*, but also the *Abies*, *Pinus*, *Sciadopitys*, *Tsuga*. Near the reservoir there was a mixed deciduous forest with *Acer*, *Alnus*, *Betula*, *Carpinus*, *Carya*, *Castanea*, *Celtis*, *Corylopsis*, *Corylus*, *Fraxinus*, *Ostrya*, *Pterocarya*, *Salix*, *Tilia*, *Ulmus*. In agreement with Szafer the climate was temperate, cooler than at Huba. The age of the locality is Early Pliocene.

At Czarny Dunajec one borehole (1000 m) was drilled, many samples of which were void of pollen grains. By the preliminary analysis of samples with well-preserved sporomorphs leads to the assumption that the Czarny Dunajec profile comprises two Neogene horizons: one younger Lower Pliocene and one older, Miocene. In the younger horizon the *Picea* was dominant (cca 50%), and other conifers: *Pinus sylvestris*, *P. haploxylon*, the *Taxodiaceae-Cupressaceae* group, and in smaller amount *Abies*, *Sciadopitys* and *Tsuga*. In the lower part the *Picea* was decreasing with the simultaneous increase of the *Pinus haploxylon* type, and the *Taxodiaceae-Cupressaceae* group, among the deciduous tree the *Engelhardtia*. In the upper segment only the pollen grains of *Alnus glutinosa-incana* type occurred, whereas in the lower horizon the pollen grains of the *Alnus kefersteinii* type were present.

To the question of the age: she compared the sporomorphs of the Tertiary, Quaternary herbaceous plants and on these base she made diagrams about the important sites of South Poland (Piaseczno, Stare Gliwice, Huba, Czarny Dunajec, Krościenko). She established that the boundary between Tertiary and Quaternary did not coincide with the immediate disappearance of the Tertiary elements. First disappeared the explicitly tropical elements, and only later the more resistant ones. Some of these were present in the Pleistocene, too (*Tsuga*, *Sciadopitys*, some *Taxodiaceae*/, and the quantity of the pollen grains

of some of them was simultaneously increasing (*Pinus sylvestris*, *Picea*, *Abies*, *Alnus*).

Finally she prepared the pollen diagram the locality of Mizerna on the base of palynological investigations and states in contrast to Szafer that there is no transition from the Pliocene to the Pleistocene, but the entire section originated within one climatic period similarly to the uppermost part of the locality Domanski Wierch.

Tran Dinh Nghia (1974) published in a monograph the palynological investigations on three localities in the Western part of Nowy Targ – Orava Basin. In the South there is the Chyżne profile, where in the lower part the *Taxodiaceae-Cupressaceae* swamp forest was dominant, in the upper part there was a riparian forest association of *Alnus* and shrubs. In the Lipnica Mala profile the trees and shrubs were dominant, *Taxodiaceae-Cupressaceae*, *Taxodium*, *Pinus*, *Alnus*, *Osmunda*, *Polypodiaceae*. Rarer occur *Glyptostrobus*, *Betula*, *Cyperaceae*, *Gramineae*, *Sparganium*, *Engelhardtia*, *Carya*, *Pterocarya*, *Ulmus*, *Celtis*, *Quercus*, *Larix*, *Tsuga*, *Picea*. In this profile there are *Symplocos*, *Liquidambar*, *Corypha*, too. In the Lipnica Wielka profile the trees and shrubs were also dominated by *Taxodiaceae-Cupressaceae*, *Taxodium*, *Osmunda*, *Polypodiaceae*, *Ulmus*, *Quercus*, *Larix*, *Tsuga*, opposite to the herbaceous plants. The last two profiles agree with the lower part of Chyżne profile. The upper part of the Chyżne profile, with *Alnus* riverside forest was somewhat younger. The author compared his localities with the other palynologically investigated Upper Miocene areas and concluded that they are the same as the second climatic phase of Stare Glivice.

The article of Oszast et Stuchlik (“The Neogene vegetation of the Podhale (West Carpathians, Poland)” 1977) deals with the Polish part of the Nowy Targ-Orava Basin. The investigated two deep boreholes are at Czarny Dunajec and Koniówka in the Dunajec river valley. Both of them have been built up of fluvial sediments, mainly clay, with admixture of fine-medium and coarse-grained sands, sometimes of gravel at some levels there are strata of organic material, plant detritus, lignite and brown coal. The substratum is formed by the Jurassic and Cretaceous rocks of the Pieniny Klippen Belt in the southern part (Koniówka) and Flysch rocks of the Magura unit in the central part (Czarny Dunajec). For the palynological investigations 1516 samples have been collected, from these only 285 contained enough spores to allow the calculation of percentage pollen spectra. The spores of the samples demonstrated the vegetation, at first swamp forest and marshy areas. The *Taxodiaceae-Cupressaceae-Nyssa* forest were like those in North America and Vietnam, they differ only by the presence of *Taxodium* or

Glyptostrobus. To the swamp forest were joined shrub forests with *Betula*, *Myrica*, *Cyrilla* association and herbs (*Cyperaceae*, *Gramineae*), and *Cercidiphyllum*, *Liquidambar*, *Decodon* (*Lythraceae*). The recent *Decodon verticillatum* composes shrub forest and grass associations in North America. The riparian forests were made up by *Alnus*, *Populus*, *Salix*, *Platanus*, *Pterocarya*, *Liquidambar*; the two last are absent from the upper part of the sections. On the dryer hill-side there were *Fagaceae*, *Juglandaceae*, *Ericaceae*, *Leguminosae*, further *Lyriodendron-Magnolia*, *Tilia*, *Betula*, *Pinus*, *Tsuga* species. The shrubs consist chiefly of *Rhamnaceae*, *Rosaceae* and there were also *Corylopsis*, *Fothergilla*, *Ilex*, *Parrotia*. The latter has only one species today, the *Parrotia persica* in Persia. In connection of the humidity were present *Rhamnus*, *Cornus*, *Diospyros*, *Elaeagnus*, *Araliaceae* species, and as lians *Vitis* and *Parthenocissus*. Water plants were few and the tropical plants were absent, (some of them however are figure on the diagrams). The ferns were cosmopolitan.

The authors used this long profile of Czarny Dunajec for the evaluation of the vegetation and the other boreholes as auxiliary material. The lower part of the Czarny Dunajec profile is Miocene, the upper one is Pliocene. In the profile the following phases were stated as valuable for the whole Nowy Targ Basin:

Phase I. The lower part of the Czarny Dunajec and Koniówka profiles belong here. It is characterised by Tertiary taxa. The dominant plant group is *Taxodiaceae-Cupressaceae*, among the angiosperms *Engelhardtia* (in some places are 20%), abundant were *Cyperaceae*, *Osmundaceae*, *Polypodiaceae*. The climate was warm and humid. The age is Badenian (M₄). This area is comparable with the Slovakian Western Carpathians, the Nowy Sącz Basin, Podhale, Piaseczno.

Phase II. The samples from Czarny Dunajec 848–565 m, one part of Koniówka, Lipnica Mała, Lipnica Wielka, Chyżne (Tran Dinh Nghia 1974), Huba (Oszast 1973). It is characterised by great floristic diversity and abundant Tertiary taxa. Dominant plant communities were the forests, mostly deciduous trees and shrubs. The climate was warm temperate, similar to that in phase I, but dryer. It corresponds to the Sarmatian (M₅).

Phase III. Comprises the Czarny Dunajec samples of the 565–478 m interval, and one – not characteristic – part of the Koniówka profile. It is an unstable plant community, with the appearance of new temperate climate plant genera. Changes occur from horizon to horizon, in one the warm, in the other the temperate elements are dominant. The appearance of *Picea* in great quantity is very characteristic. It was present also till now, but only in very small

amount or sporadically. Oscillation occurred in the flora and in the climate, too and the climate became temperate. This Mio-Pliocene stage is the Pannonian (MP). The authors cited Menke (1976), according to him in Western Europe the upper boundary of the typical Miocene genera is here: *Engelhardtia*, *Rhoipites pseudocingulum*, *Quercopollenites henrici*, *Q. microhenrici*.

Phase IV. Comprises the top segments of the Czarny Dunajec profiles. In the upper part the Quaternary genera prevail over the Tertiary ones and the amount of herbaceous plants increases. Dominant are the conifers, *Picea*, *Pinus*. Among the angiosperms the *Alnus incana-glutinosa* type is abundant. The proportion of the *Pteridophyta* increased. The tropical elements are absent. The age of the phase is Early Pliocene, Pontian (P₁).

The establishment of these phases made possible the correlation with the Central Paratethys region.

The Neogene stages in the Polish Western Carpathians are as follows:

Karpatian – M₃, characterised by Tertiary elements: *Taxodiaceae-Cupressaceae*, *Castanopsis-Castanea*, *Celtis*, *Engelhardtia*, *Nyssa*, *Platycarya*. The “old” Tertiary elements *Sapotaceae*, *Symplocaceae* are absent. The *Pinaceae* played no greater role in that time. The climate was warm-temperate, with subtropical tendency, with high rainfall. Only one freshwater profile was described from the Nowy Sącz Basin (Oszczypko et Stuchlik 1972).

Badenian – M₄. The swamp forest (*Taxodiaceae-Cupressaceae-Nyssa*) still played a significant role. Some thermophilous taxa disappeared gradually (*Castanea*, *Castanopsis*, *Cyrilla*, *Platycarya*), while *Engelhardtia* still played an important role. The percentage of “arctotertiary” species increased in the flora. Among the herbaceous plants occurred *Cyperaceae* and *Pteridophyta*. The climate was warm-temperate, fairly humid. The profiles of Czarny Dunajec and Koniówka belong to this stage.

Sarmatian – M₅. The mesophytic deciduous forests dominated, which were very rich in species. The percentage of “arctotertiary” genera increased. The climate was still warm-temperate, but dryer than in the two previous stages. They are several profiles in this area: Czarny Dunajec, Koniówka, Huba, Lipnica Mała, Lipnica Wielka, Chyzne.

Pannonian – MP, the transitory zone between Miocene and Pliocene. In this period occurred the greatest change in plant communities. The percentage of Tertiary elements decreased, giving place to those of the Quaternary. The percentage of these two groups oscillated around 50%. Characteristic was the rich appearance of the *Picea*, which formed a mountain floristic zone of *Picea* forests. Herbaceous plants played a major role. The climate was tem-

perate, but instable with alternating warmer oscillations, and relatively dry. This stage was palynologically determined at Czarny Dunajec and Koniówka.

Pontian – P₁. This stage is characterised by Quaternary genera. In the mountains the *Picea* and *Pinus* forests, in the valleys *Alnus incana-glutinosa* forests developed. Among the herbaceous plants *Polypodiaceae*, *Cyperaceae*, *Gramineae* predominated. The climate was temperate and rather dry. The Pontian stage is known from Czarny Dunajec and Koniówka.

Dacian – P₂. The conifers dominated, the main component was *Picea*, with *Pinus* and some Tertiary genera as *Sciadopitys* and *Tsuga*. Among the angiosperms the temperate elements were significant, from the Tertiary remained the *Pterocarya*. The herbaceous plants were common with many species. The climate was temperate. This stage was investigated at Krościenko and Domański Wierch.

Stuchlik in the volume of the Neogene Congress held in Athens (1979) summarized the palaeobotanically founded chronostratigraphy of Southern Poland belonging to the Central Paratethys. On the base of Ney et al. (1974) the first Neogene transgression occurred in the Egerian. This entered from the West through the Moravian Gate and covered only small areas on the Sudetic foreland. According to Raniecka-Bobrowska only the macrofloristic remains discovered in some tuff samples represent this period. The Eggenbugian transgression reached the limits of Poland only in the Late Eggenbugian, advancing from the Ukraina to the Jasło-Krosno depression. This period has no palaeobotanical data. The transgression of Ottnangian produced, a narrow gulf only, to the West, passing through the Jasło-Krosno depression, the Nowy Sacz basin and reached probably the Nowy Targ region. From this time there was no palaeobotanical investigation. – Further the author presents the already known results of the palaeobotanical investigations from the Karpatian.

From the western Silesian part of the northern Paratethys Sadowska (1989) provided significant information. In Opole district at the villages Biała and Twardawa palynological investigations were made from two boreholes. The Tertiary sediments overlie the Cretaceous, in the western part of the Carpathian Foredeep close to the margin of the Paczków-Kędzierzyn graben which during the Miocene constituted an embayment of the Paratethys sea. On a sketch map is represented the embayment with the two boreholes. By means of the palynological investigation the boreholes could be identified the Karpatian, Badenian and Sarmatian stages.

The Karpatian Kłodnica beds were characterised by the Paratethys sea-shore swamp and wet forests with *Taxodiaceae-Cupressaceae* and *Alnus*. The underwood was constituted chiefly by *Polypodiaceae* ferns. In the shore forest were living some *Pinus* species, *Cupressus*, *Quercus*, *Olea*, *Engelhardtia*, the thermophilic *Lygodium*, *Magnoliaceae*, *Meliaceae*, *Myrtaceae*, *Palmae*, *Platycarya*, *Sapotaceae*. In limited numbers occurred *Castanea*, *Myrica*, *Liquidambar*, *Pterocarya*, *Carpinus*. The quantity of the warm elements is limited (less than 1%, *Araliaceae*, *Cyatheaceae-Schizaeaceae*, *Quercoidites henrici*, Sadowska 1986). In higher position, in dryer places there was mixed deciduous forest with *Engelhardtia*, *Quercus*, *Carya*, *Ulmus*, *Fagus*, *Tilia*, *Acer*, *Castanea*, *Pinus*, *Picea*, *Abies*, *Sciadopitys*, many shrubs such as *Oleaceae*, *Rosaceae*, *Rhus*, *Caprifoliaceae*, *Leguminosae*. The author assumes a warm, Mediterranean-type of climate.

The vegetation was like in the whole northern part of the Paratethys area in Poland. Contrary to the Polish Lowland there were swamp forests and shrubby peat bogs, from which brown coal seams were to develop.

The marine strata of the Badenian stage (Skawina and Grabowiec beds) were characterized by high abundance of conifer pollen grains. *Pinus sylvestris* dominated over *P. haploxylon* type, *Abies*, *Picea*, *Tsuga*, *Cedrus*. *Taxodiaceae-Cupressaceae* are of lesser importance than in Kłodnica beds, only *Sequoia* has a greater role. Among the deciduous trees and shrubs the more numerous were: *Quercus*, *Ulmus*, *Betula*, *Fagus*, *Rhus*, *Engelhardtia*, *Carya*, *Pterocarya*. In both section there were marine planktonic organisms, mostly *Hystrichosphaeridae*. The herbs are not significant (ferns, grasses and *Chenopodiaceae*). In the Badenian at the sea shore probably there was a swamp forest with *Taxodium* and *Alnus*, but of smaller extension than in the Polish Lowland.

The Sarmatian Kędzierzyn beds indicate rich forest communities. Important were the swamp forests with *Taxodium*, *Alnus*, *Nyssa*, *Liquidambar* and *Salix*. This forest lived in swampy habitats, which persisted after the regression the Paratethys sea at the beginning of the Sarmatian. The mesophylous, deciduous forest was characteristic with *Ulmus*, *Celtis*, *Quercus*, *Carya*, *Pterocarya*, *Betula*, *Carpinus*, *Engelhardtia*, *Acer* and others, accompanied by *Pinus*, *Picea*, *Abies*, *Tsuga*, *Sciadopitys*, *Sequoia* and shrubs, on dryer terrain. *Celtis* was very typical in the Sarmatian of SW Poland, it was present probably in pioneer forest on relatively dry terrain. It is typical that both types of *Pinus* pollen have similar frequencies. This refers to the decreasing role of the swampy species *Pinus sylvestris*. The amount of Miocene warm elements was decreasing. At the same time the percentage of the "arctotertiary" ele-

ments was increasing. In the climate a gradual cooling and may be some drying occurred.

In Silesian territory in the Stara Kuźnia region within the Kędzierzyn graben the sediments of two young Tertiary palaeogeographical provinces occur in touch: the Paratethys Basin and the Central European Polish-German Furrow (Dyjur et Sadowska 1984). The borehole section of Stara Kuźnia has been subdivided into two sedimentary cycles: 1) an older series of marine deposits related to the Silesian part of the Carpathian Foredeep, and 2) a younger series (Poznań Series) related to the Polish Lowland Basin.

1) The older series consists of grey non laminated clays with marine fauna and plant debris, clay stones with sand lenses. These correspond to the Grabowiec Beds. Further below there are Gypsiferous Beds, gypsiferous clays with layers of coarse-crystalline gypsum. These are underlain by carbonatic claystone, which is thought to represent the Skawina Beds.

2) The younger series consists of continental deposits such as green, grey-green, steel-grey clays, with some interbeds of coal clays and brown coal seams. These correspond to the upper part of the "green clay horizon" of the Poznań Series under the name "Kędzierzyn Beds". The Grabowiec Beds have been palaeontologically dated as uppermost Badenian, as the overlying clays of the Poznań Series (Kędzierzyn Beds) have been considered as Sarmatian.

In the Stara Kuźnia section there is continuous sedimentation from the marine Grabowiec Beds to the continental Poznań Series. Up to now in the Silesian part of the Paratethys Basin, only one section has been known (Stare Glivice) with a similar marine-continental-transition, but in this latter palaeobotanical investigation was only on the continental sediments (Oszast 1960, Szafer 1961). The Stara Kuźnia palynological profiles allowed the reconstruction of the distinct boundary of the two periods. In the pollen spectra of the marine deposits the saccate pollen grains: *Pinus sylvestris* type, *P. haploxylon* type, *Abies*, *Tsuga* were dominant. Less common are *Taxodiaceae-Cupressaceae*, *Picea*, *Sciadopitys*, among the deciduous trees *Quercus*, *Fagus*, *Ulmus*, *Carya*, *Pterocarya*, *Betula*. Significant warm-demanding genera were *Rhus*, *Engelhardtia*, *Quercoidites henrici*, *Myrica*. Marine planktonic organisms (*Hystrichosphaeridae*) are common in the underlying Gypsiferous Beds, too. In these the palynological spectra are like in the Grabowiec Beds. This suggests that both belong to the same stratigraphic stage. In the upper continental Poznań Series (the Kędzierzyn Beds) the saccate conifers were reduced, there was a higher percentage of *Taxodiaceae-Cupressaceae*. Increased were also the deciduous trees *Alnus*, *Celtis*. The

warm-demanding elements were decreasing, some of them disappeared, together with the marine planktonic organisms. The differences could be due to palaeoecological changes. The regression of the sea, the disappearance of the warm elements and warm temperate climate characterized the Sarmatian. With the help of the sections of Stara Kuźnia and Stare Gliwice the correct age of the Poznań Series and under the age of the underlying brown coal could be established.

With this area the work with the correlation of the Paratethyan area could be finished, but from the palaeobotanical, palynological point of view it is necessary to look a little farther – just like in the South – also to the North.

Dyjur and Sadowska summarized and presented already in 1977 their conception about the age and the possibility of correlation of the Upper Miocene brown coal seams in Western Poland. The brown coal seam Henryk lies on the Mużakow Series and its hanging rock is the grey clay of the Poznań Series. The age is Late Miocene and is identical with that of the formations of Western and Central Poland. The brown coal was palynologically studied in 31 localities. Their plant associations are well known, and were very similar: swamp forest including damp brushwood peats were dominant, in the dryer places mixed deciduous forests. These two plant communities represented the vegetation. There were more warm elements and less temperate elements. The palaeogeographical circumstances produced only little differences.

In the NW part of the Carpathian Foredeep the brown coal and brown coaly clay under the Poznań Series has other character, less warm elements and many temperate elements are present, the climate was warm temperate. These layers are the Kędzierzyn Beds, the stage is Sarmatian.

Dyjur et Sadowska in an article (1986) summarised the results of their research on the correlation of the Late Miocene with the Silesian part of the Carpathian Foredeep and the SW area of the Polish Lowland. For the palynological correlation (Sadowska 1986) used the material of the marine Badenian localities: Stara Kuźnia, Stare Gliwice, Twardawa, Biała, Racibórz, Głubczyce. The high numbers of the pollen grains of conifers are characteristic, the *Pinus sylvestris* type is dominant over the *P. haploxylon* type, besides there are *Abies*, *Picea*, *Cedrus*, *Tsuga*. The *Taxodiaceae-Cupressaceae* group is abundant, the *Sciadopitys* is subordinate. From the deciduous trees *Quercus*, *Ulmus*, *Fagus*, *Rhus*, *Engelhardtia*, *Carya*, *Pterocarya* are common. In some sections there are *Betula*, *Tilia*, *Carpinus*, *Castanea*, *Oleaceae*, *Rosaceae*. Herbs did not play a big role: *Chenopodiaceae*, *Labiatae*, *Gramineae*. More numerous are the *Polypodiaceae*. There are many *Hystrichosphaeridae* and other marine planktonic organisms (in particular in the

gypsum). For the Polish Lowland the marshy, wet environment is characteristic. There are very few *Alnus*, *Liquidambar*, *Myrica*, and only very sporadically appear *Cyrilla*, *Ilex*, *Nyssa*. The thermophilic taxa are common: *Araliaceae*, *Arceuthobium*, *Itea*, *Magnoliaceae*, *Meliaceae*, *Palmae*, *Platycarya*, *Reevesia*, *Rubiaceae*, *Rutaceae*, *Symplocos*, *Tricolpopollenites liblarensis*, *Cyatheaceae-Schizeaceae*. The Upper Badenian sections presumed in different distances the presence of the Paratethys sea, and a river flowing into, with swamp forests and shrubby vegetation. The mixed but chiefly conifer forests of the Upper Silesian Upland and the Eastern Silesian Mts are also present in the pollen associations.

The Sarmatian localities at the Poznań Series (Kędzierzyn Beds) in the Silesian part of the Carpathian Foredeep where the author made the palynological investigations are Biała, Twardawa, Stara Kuźnia, Głuboczyce, Racibórz, Rybnik, Kędzierzyn, Paczków. The water-shed area (Wrocław, Opole, Wrzoski) and the green clay horizon of the Poznań Series in the Lower Silesian Lowland (Legnica), have also been studied. The pollen spectra are very uniform with the dominance of *Taxodiaceae-Cupressaceae* and *Alnus*. There are high quantities of *Osmunda* and *Polypodiaceae*. The constituents of the deciduous forests are *Quercus*, *Ulmus*, *Celtis*, *Fagus*, *Carya*, *Pterocarya*, *Engelhardtia*, *Betula*, *Carpinus*, *Rhus*, *Liquidambar* and in some sections *Salix*, *Nyssa*. *Pinus sylvestris* and *P. haploxylon* are in equal proportions, the quantity of other conifers is insignificant. The number of the warm Miocene elements is low, a little more numerous are *Rhus*, *Engelhardtia*, *Myrica*. Very sporadic are only in some section occur *Araliaceae*, *Oleaceae*, *Palmae*, *Quercoidites henrici*, *Symplocos*, *Tricolpopollenites liblarensis*. The marine plankton is missing or only some exemplars can be found at the bottom of the Sarmatian. The Early Sarmatian scenery is characterized by plain wet forests after the regression in the Carpathian Foredeep. On the hillside lived mixed forests, with *Celtis*. This is a very typical Merditerranean element (after Axelrod 1973). We meet these type of vegetation in the Silesian part of the Carpathian Foredeep, in the neighbouring Metacarthian Ridge and on small uplifts within the basin of the Poznań Series in Lower Silesia. The pollen spectra of the Poznań Series (Kędzierzyn Beds) of the western Carpathian Foredeep, from the watershed area, from upper members of the green clays horizon in the Polish Lowland are fairly analogous. We can assume that these are of the same age and were deposited in the Early Sarmatian.

More difficult is to compare the pollen spectra of marine deposits of the Upper Badenian (Grabowiec Beds) with the Upper Tortonian profiles of con-

tinental deposits in Lower Silesia (the brown coal seam "Henryk" (I Lusatian Series) and they overlying grey clay horizon of the Poznań Series). The pollen diagrams from the Polish Lowland are characterized by the dominance of swamp and peat plants and a few saccate conifers, mostly *Pinus*. In both regions the amounts of deciduous trees requiring temperate climate and thermophilic Miocene taxa are similar. While in the Sarmatian *Pinus sylvestris* and *P. haploxylon* were present in more or less equal quantities, in the marine Badenian deposits and in the continental Tortonian deposits in the Polish Lowland *Pinus sylvestris* is predominant. That means that two different *Pinus* species were dominant in these two stages of the Miocene (Sadowska 1977).

Finally the authors stated that the marine Badenian sediments of the Silesian part of the Carpathian Foredeep and the continental Upper Tortonian sediments of Lower Silesia are of the same age. The brown coal seam "Henryk" (I Lusatian Series) and the grey clay horizon of the Poznań Series can be correlated with the Grabowiec Beds of the Carpathian Foredeep as Upper Badenian sediments. The floristic records of these two stages show only slight differences, determined by decrease in thermophilic genera and by increase of the number of "arctotertiary" taxa in the Badenian, as compared to the Karpatian. After the Badenian the warm elements gradually disappeared and appeared in greater number the temperate elements. In the Sarmatian in SW Poland after the disappearance of the warm Miocene sea, and the formation of new mountain ridges in the Sudetes and Carpathians, the climate became dryer and cooler.

In the Polish palynological literature there are many papers concerning different areas of the Polish Miocene, but from the stratigraphical point of view the most significant is the activity of Sadowska. She had succeeded with Dyjor to connect the territory of SW Poland with the Paratethys region. Their common work is summarised in a table in the paper of 1986, Fig. 2. This shows the correlation of the stratigraphical units of the Silesian parts of the Carpathian Foredeep, the Meta Carpathian Ridge and the Polish Lowland from the Karpatian till the end of the Pliocene. The other areas of Poland have to be inserted by means of radiometric datation.

The palynological investigations on the Miocene of the Middle and Northern Polish areas till now depended mainly on the results of the German palaeobotanists. The German palaeobotanical research achieved very significant results in the last century (Gothan, Kräusel etc.). In the environs of Wrocław Goeppert published palaeobotanical studies in 1855. The link of the Polish scientists with the Germans is quite natural since the Polish and Ger-

man Lowlands have geological and also geographical connections. The common facies has a common insufficiency: in both territories there were no marine sedimentation and marine fauna which in the Paratethys area facilitated the stratigraphic correlation.

The following areas do not belong to the Paratethyan territories, but we are looking at what happened with the vegetation in the northern territories.

The article of Stachurska-Dyjur-Sadowska (1967) deals with the botanical analysis of the Pliocene section at Ruszów West of Wrocław. Sośnica is also a Pliocene locality near Wrocław. The above-mentioned three authors (Stachurska-Sadowska-Dyjur 1973) reported on the results of the geological and palynological investigations of the locality. Sośnica is an old macroflora locality, already Goeppert considered it a Pliocene locality. It is typical Poznań clay, but without underlying brown coal. The upper green glauconitic clay and the variegated clay horizons were studied. In Sośnica the hanging rock Gozdnicza series contains no sporomorphs. The investigated Poznań series from the palynological point of view consist of two parts. The lower part is very rich in conifers, the *Pinus sylvestris* and *haploxylon* are dominant, the others are not significant (*Abies*, *Podocarpus*, *Picea*, *Sciadopitys*, *Tsuga* and the *Taxodiaceae-Cupressaceae* group). The deciduous trees are *Alnus*, *Betula*, *Carya*, *Pterocarya*, *Engelhardtia*, *Liquidambar*, *Ulmus*, *Quercus*. In the upper part there are less conifers and the deciduous trees are more numerous: *Carpinus*, *Fagus*, *Parrotia*, *Pterocarya*, *Quercus*, *Ulmus*, *Zelkova*. Water plants are *Butomus*, *Potamogeton*, *Sparganium*, *Typha*. Most of the plants are Central European (*Alnus*, *Betula*, *Carpinus*, *Fagus*, *Ulmus*), fewer are from Atlantic North America (*Carya*, *Nyssa*, *Rhus*, *Taxodium*), even less from Eastern Asia (*Cercidiphyllum*, *Engelhardtia*), from the Mediterranean region (*Olea*, *Ostrya*) and from the Caucasian region (*Parrotia*, *Zelkova*). These plants which originated from the Tertiary also required temperate climate. The tropical plants are missing. The plant community refers to Neogene e.g. the big quantity of *Pinus*. Although the quantities of the two *Pinus* species are equal, the other conifers are few, but the proportion of deciduous trees and trees living today in Europe indicate Pliocene age. The authors compared the flora of Sośnica with the SW Polish Neogene floras and on this basis stated that its age is Early Pliocene.

From SW Poland the geological and palaeobotanical investigations based on the Gozdnicza region were summarised in 1992 (edited by E. Zastawniak). In the Lower Silesian Lowland on the geomorphological margin of the Lower Silesian Upland, between the villages Ruszów and Gozdnicza numerous sites contain fossil floras. In this area in Poznań and Gozdnicza Series

loam and kaolin clay have been exploited by the brick-clay industry. As a result of prospective drilling and quarrying activity many Tertiary floras have been exposed. The object of the investigations are the Mużakow Series, the Henryk Brown Coal seam, the Poznań Series and the Gozdnica Series.

The uppermost part of the Mużakow Series was the object of the research. This consists of silt with coal detritus, alternating are fine grained sand, sandy silt with coal and mica (poorly preserved foraminifers, sponges spicules, indeterminate fragments of molluscs, and in the palynological profiles marine plankton were also found). The palynological investigation found in great percentage conifers: *Pinus sylvestris*, *P. haploxylon*, *Taxodiaceae-Cupressaceae*, many *Sequoia*, *Abies*, *Picea*, *Tsuga*, *Sciadopitys*; from the deciduous trees the most numerous are the *Quercus*, *Ulmus*, *Fagus*, *Betula*, *Alnus*, *Nyssa*, *Carya*, *Engelhardtia*, *Pterocarya*. There are few shrubs, chiefly *Myrica*, *Rhus*, *Cyrillaceae-Clethraceae*, *Ericaceae*, *Rosaceae*, herbs *Polypodiaceae*, *Sphagnum*, *Osmunda*, *Gramineae*. Wet medium is indicated by *Sparganium*, dinoflagellates and other planktonic organisms.

The Henryk Brown Coal seam is characterised by two plant associations: 1) Shrub swamp with *Rhus*, *Ilex*, *Rosaceae*, *Cyrillaceae-Clethraceae*, *Cornaceae* (*Tricolporopollenites edmundi*), *Araliaceae*, *Myrica*, *Symplocos*, *Leguminosae* and high percentage of *Quercoidites henrici*. 2) Swamp forest with *Taxodium*, *Nyssa*, *Alnus*. *Pinus*, *Sequoia*, *Fagus*, *Quercus* on the dryer terrains only and in low percentages are present.

The Henryk Brown Coal seam and the overlying Grey Clay Horizon of the Poznań Series can be correlated with the I Lusatian Series in the Polish Lowland (Raniecka-Bobrowska 1970), and with the Grabowiec Beds in the Silesian part of the Paratethys, the stage is Upper Badenian (Dyjur et Sadowska 1985, Sadowska 1989, 1990). The top part of the Variegated Clay Horizon in the Poznań Series is Upper Sarmatian, identical in age with the Kędzierzyn seam (Dyjur et Sadowska 1977, 1984 etc.).

The sediments of the Gozdnica Series have been investigated at the Gozdnica-Stanislaw locality. The fossil flora has almost dry character. The mixed deciduous forest consists of *Pinus*, *Abies*, *Cedrus*, *Sequoia*, *Tsuga*, *Betula*, *Fagus*, *Quercus* and the underwood belongs to *Rosaceae*. The small swamp is represented by *Alnus*, *Liquidambar*, *Nyssa*, *Ilex*, *Myrica*, *Rhus*, *Tricolporopollenites edmundi*, and the little swamp forest by *Taxodium*, *Nyssa*, *Alnus*, the shrub swamp by *Myrica*, *Ericaceae*, the forest with wet soil by *Liquidambar*, *Carya*, *Pterocarya*, *Alnus*, *Acer*, *Ulmus*, *Symplocos*, *Cercidiphyllum*. The parasite *Arceuthobium* lived on the conifers. The age of the outcrop is possibly Pannonian, considering the high percentage of *Pinus sylvestris*, the de-

crising number of *Taxodiaceae-Cupressaceae*, and the small number of the warm elements. The Sarmatian and Pannonian vegetation and climate are very difficult to separate. For the Early Pannonian is very characteristic on this territory the swamp forest with great number of *Fagus*. After the swamp forest disappeared gradually, replaced by a *Pinus*, *Sequoia*, *Tsuga*, *Fagus*, *Quercus*, *Betula*, *Ulmus* forest. The climate in the Paratethys region was warmer than here, with many subtropical genera (Planderová 1972, 1978, 1991, Nagy 1990a,b).

Middle Pliocene or the latest Early Pliocene is the age of Ruszow locality. In the swamp forest *Alnus* is dominant. The deciduous mesophylic forest is characteristic, with conifers and lots of herbs, and very few thermophilic elements. The climate was temperate and warm temperate.

The youngest locality of the Gozdnicza Series is Kłodzko. Its age is Late Pliocene (Jahn et al. 1984). The climate cooling is characteristic, the number of the conifers was increasing, chiefly *Picea*. There were many herbs and lots of Quaternary elements opposite to the Tertiary. Conifers are *Pinus sylvestris*, *Picea*, *Tsuga*, *Sciadopitys*, deciduous trees *Alnus*, *Fagus*, *Quercus*, *Ulmus*, *Carya*, *Carpinus* and here and there *Aesculus*. Shrubs were *Caprifoliaceae*, *Ericaceae*, *Leguminosae*, *Rosaceae*, herbs *Gramineae*, *Cyperaceae*, *Labiatae*, *Umbelliferae* and water plants.

The continental Polish Lowland was first investigated by Raniecka-Bobrowska (1970). North of Wrocław on the Polish Lowland also Ziemińska-Twozydło (1974) made palynological studies. She investigated borehole materials from many localities (Ustronie, Oszkowice, Nowa-Wieś, Gierlachowo, Gołębin Stary, Krosinko, Mosina, Ślepuchowo etc.). The author based her stratigraphical ranging on the palaeobotanical changes that followed the cyclical changes of the climate. This method originated from East-German scientists (Mai, Krutzsch, Majewski 1967). After the general knowledge from the Oligocene till the Pleistocene a slow cooling was going on. Mai with the cyclical change of "arctotertiary" and "palaeotropical" elements established 13 zones from the Upper Oligocene till the Upper Miocene. The author tried to reconcile the Polish material with these zones. The Upper Oligocene material (boreholes of Nowa Wieś, Oczkowice) indicate regressive brackish sediments with some *Dynophyceae*. Among the sporomorphs many are identical with the Hungarian Egerian materials. Beside the conifers there are many *Momipites punctatus*, *Sapotaceae*, *Quercoidites henrici*, *Q. microhenrici*, *Tricolpopollenites liblarensis*, *Tricolporopollenites cingulum* (all the three sub-species), *Leiotriletes maximus* are the most important. The author considers this locality for the Oligocene-Miocene

boundary. This corresponds – according to the author’s opinion – to the II Phase (zone of Mai). The first phase is missing. In the Early Miocene – after the author – there were 3 phases. In Phase III could have been many “arctotertiary” elements and only sporadically “palaeotropical” elements. The Polish material is not of this kind, there developed Miocene brown coals with *Taxodiaceae*, *Taxaceae*, warm elements such as *Sapotaceae*, *Symplocaceae*, *Oleaceae*. The flora was poor. Upwards the flora becomes richer, there were many *Pterocarya*, *Carya*, *Carpinus* and lots of *Osmunda*. In great numbers was present *Alnus*. Pacltová wrote also about an “invasion of *Alnus*” in Southern Slovakia in the faunistically proved Chattian – Aquitanian. This *Alnus* phenomenon is considered so important that in 1997 (Piwoczki et Ziemińska-Twozydło) in their article the zone II is named *Alnipollenites verus* palynozone. On Fig. 1 it was correlated with the Paratethyan zones, with the top of the Upper Egerian and nearly with the whole Eggenburgian. The question arises, how is possible to create a zone with a “facies” element? Namely already in 1974 she took over on her plates Krutzsch’s labelling of plants from 1967!

In the Phase IV there is in all profiles brown coal with warm elements: *Araliaceipollenites edmundi*, *A. euphorii*, *Palmae*, *Sapotaceae*, *Cyrilla*, *Quercoidites henrici* etc. This agrees with Mai ‘s zone IV.

Phase V again does not agree with Mai’s zone, because according to Mai the climate was cooling with dominancy of “arctotertiary” elements, but the Polish material contains warm temperate elements: *Podocarpaceae*, *Oleaceae*, *Araliaceipollenites edmundi*, *Intratropipollenites instructus*. Apart from the “intermediary” taxa of *Carya*, *Pterocarya*, *Quercus*, *Betula*, *Osmunda*, are the pollen grains of *Tsuga*, *Sciadopitys*, *Fagus*, *Carpinus*, *Corylus*, *Ulmaceae* are common.

Phases VI, VII, VIII belong to the Middle Miocene. Phase VI with lignite and coaly clay layers is a warm period in agreement with Mai zones. Phase VI is characterised by *Quercoidites henrici*, *Q. microhenrici*, *Rhoipites pseudocingulum*, *Araliaceipollenites edmundi*, *Symplocos*, *Reevesia*, *Olaxipollis matthesi*. In Phase VII there is a gradual change in the pollen spectrum. The warm elements are decreasing, along with the “facies” elements *Taxodiaceae*, *Cupressaceae*, *Taxaceae*, *Nyssa*, *Ilex*, there are “intermediary” *Carya*, *Pterocarya*, *Juglans*, *Celtis*. Phase VIII with Middle Miocene lignite seams agrees Mai’s carpological founds of subtropical character, and the coal seams Lusatian II. The Polish palynological data are corresponding: *Quercoidites henrici*, *Rhoipites pseudocingulum*, *Olaxipollis*, *Symplocos*, *Eucommia*, *Reevesia*.

Phase IX, according to the author, has not been worked out properly by Mai. On the basis of Krutzsch's unpublished data this phase is characterized by a decrease of the warm elements and an increase of the "arctotertiary" elements. In the profile of Gierlachowo a great number of *Sciadopitys* pollen are present. This phenomenon is well-known from the data of the German palynologists (Thiergart 1938, 1949, 1953, Thomson 1950, Thomson et Rein 1951, Rein 1951, von der Brelie 1968 (corresponding to the Lusatian layers I, II) and in Poland from those of Raniecka-Bobrowska 1970).

To the Upper Miocene belong the Phases X, XI, XII, XIII, XIV. According to Ciuk (1970) it includes the Adamow and Middle Polish Beds. In the not very thick lignite seams there are very rich warm elements in the palynoflora. In the clay layers of the Lusatian coal seams are rich mastixia flora, the age of which is identical with that of the coal of the Adamow Beds. The top of the Adamow Beds consists of clay, coaly muds, these belong to Phase X. In Mai's opinion in this mastixia flora percentage of the "arctotertiary" elements is higher than in the preceding warm phases. In the profile of Gerlachowo the temperate elements are: *Quercus*, *Parthenocissus*, *Zelkova*, *Celtis*, *Osmunda*, *Tsuga*, *Sciadopitys* and *Fagus*, *Carpinus*, *Ulmus*, too. The percentage of warm elements is very low. These are *Quercoidites henrici*, *Cyrillaceapollenites*, *Palmae*, *Araliaceopollenites edmundi*, while *Hedera*, *Sapotaceae*, *Tilia*, *Eucommia*, *Reevesia*, *Itea* are only sporadical. The last two are in her opinion important for the verification of warm climate. They indicate a very warm climate in Phase X. Phase XI and XII are the highermost layers of coal and clays present the greatest interpretative problem. In the southern part of the territory in the Ustronie profile they are in conformity with the Lusatian Seam I. With the temperate and "intermediary" elements together are in great percentage warm elements: *Araliaceopollenites edmundi*, *Rhoidites pseudocingulum*, *Symplocaceae*, *Eucommia*. Mai identified the Lusatian Seam I with climatic Phase XII and on the basis of macroflora determined it as nearly subtropical, despite that in this phase there are 50 percent "arctotertiary" elements. The Phase XIII of Lusatia as characterized by Mai, the Lusatian Seam I is overlain by small brown coal and clays which could be identified with the Middle Polish Beds (Ciuk 1970). In Lusatia Phase XIII is marked by an impoverishment of warm-liking elements, nearly 90% of the species are "arctic" and "intermediary" elements. The climate was temperate, wet, with frosty winter (Mai 1967). On the territory of Great Poland the palynological investigations on the highermost coal layers indicate a decrease of warm-liking elements. The pollen grains of *Pinus*, *Alnus*, *Nyssa* are predominant, *Sciadopitys*, *Betula*, *Ulmus* are common. In some samples

the sporomorphs of *Taxaceae*, *Taxodiaceae* and *Polypodiaceae* are present in high numbers. Grabowska found the same in the Poznań area. The palynological results of the Great Poland area are fairly different from those of Lusatian Seam I, and from the brown coal series I of the Ustronie borehole. The brown coal layers of the environs of Poznań seem to be formed later than those of Lusatia and may be synchronized with Mai's phase XIII.

NE from Wrocław in Konin area Kremp (1949) made palynological investigations on the brown coal section. The outcrop of the coal seam near Morzysław contains some fine granular quartz sand. 50% of the sporomorphs are conifers, but the greater part of the vegetation was deciduous, considering that the entomophilous plants have smaller pollen output. As a new element is mentioned *Cedrus*. He deals in detail with the bladderless conifers e.g. with *Cryptomeria*. He stated that in the *Pollenites cingulum* group the "rauche Form", the *fusus* is present in higher number at the bottom of the coal seam. The material was compared with the other German results and it was established that the age of the Niederlausitz brown coal is Late Miocene. For comparison with the data of Kremp serves the monograph of Mamczar and Doktorowicz-Hrebniczka (1960). Mamczar investigated an outcrop 1.5 kilometre from Kremp's locality, and found out the identity with Kremp's data. Doktorowicz-Hrebniczka stated the same for the materials of 6 boreholes in the Bydgoszcz and Poznań areas.

With the age of the brown coal of Konin – Turek region in Patnów deals also the article of Sadowska et Giza (1991). The Middle Polish (Konin) Seam belongs to the Middle Polish Beds, and has one coal seam. This overlies, 75 m fine grained sand quartz-micaceous silt, with coal-dust, called Adamów Beds (Ciuk 1970). Above the coal seam occur the clays of the Poznań series ranged to the Lower Poznań Beds (grey clay and silt often intercalated with coal clays or lenses of brown coal with flora remains). These are overlain by green and blue clays (Upper Poznań series) and variegated clays. In the geological publications it is generally accepted that the age of the coals of the Konin region is Late Miocene. The authors presented the literature about the Konin brown coal region, and their own palynological research. On the base of the data of foraminifers dated the stage as Upper Tortonian. In relation to the Paratethyan marine deposits, on the basis of geological and palynological investigations, the age is Late Badenian (Dyjur 1986, Dyjur et Sadowska 1984, 1986a, b). The flora contains a lower amount of warm-liking taxa (*Rhus*) and a higher percentage of moderate climate demanding trees. The pollen diagrams of Patnów are concurrent with those of the Henryk seam.

The fact is that the communities which formed the brown coal seam were spread all over the broad Polish Lowland.

It seems to be the most important, that comes to light from the works of Sadowska, to correlate the brown coals with each other, at least in the subtropical, and warm temperate areas of the Upper Tertiary where the geological and palaeoecological situation was suitable for brown coal formation. The other Polish palynological works also contain palynological investigations on brown coal. These territories do not belong to the Paratethys area, but are connected with each other by the palaeovegetations and – chiefly through the studies of Sadowska and her co-workers – we can make also stratigraphic correlations.

Such a work is by Stuchlik, Szienkiewicz, Lańcucka-Srodonowa, Zastawniak (1990).

This monograph deals with the biggest opencast brown coal mine of Middle Europe: “Bełchatów” in Middle Poland. The Bełchatów tectonic graben began to develop at the Oligocene-Miocene boundary, extending in East-West direction, along the line of Kamięnsk-Kleszczów (40 km long, 2.5 km wide) filled with Tertiary and Quaternary sediments, the average thickness of which is 60 m, in some places 250 m. It is underlain by Jurassic and Cretaceous rocks.

More than 900 boreholes were drilled in the Bełchatów area between 1960–1977. On this basis Raniecka-Bobrowska (1962) made the first palynological investigations. After her figure in the main coal seam there are two types of vegetation: the dry mesophytic facies with the prevalence of *Rhus*, *Engelhardtia*, a small *Cupuliferae* (*liblarensis*) and *henrici* group, and the swamp forest facies with *Taxodiaceae-Cupressaceae*. Seam III is characterized by small percentages of *Rhus* and the *liblarensis* group, and higher proportion of *Engelhardtia*. The swamp forest facies as in the main seam. Seam II represents a facies with prevalence of *Pinus* and NAP (*Cyperaceae*, *Gramineae*) and high percentage of *Engelhardtia*. Seam I is a typical swamp forest with *Taxodium* and *Alnus*.

Grabowska et al. (1964) distinguished five pollen assemblage zones: Zone I. (lower part of the main brown coal seam) with *Triatriopollenites coryphaeus* (*Myrica*, *Engelhardtia*), *Taxodiaceae-Cupressaceae*, *Fagaceae* (*Castanea*), *Palmae*. Zone II. *Taxodiaceae-Cupressaceae*, *Myricaceae*, *Betulaceae*, *Tricolporopollenites pseudocingulum* (*Castanea*), *T. fallax* (*Leguminosae*), *T. henrici*. Zone III. *Tricolporopollenites pseudocingulum*, *T. liblarensis*, *T. fallax*. Zone IV. with predominance of *Myricaceae*. Zone V. (upper part of the brown coal) predominance of *Taxodiaceae-Cupressaceae*,

with *Salix*, *Platanus*, *Myricaceae*, *Tricolporopollenites henrici* and *microhenrici*.

The most complete evaluation was made by Ziemińska-Tworzydło (1966). Summarising her investigations up to 1966 we can say that the main coal seam is Middle Miocene in age, the coal seam underlying the main seam is Early Miocene, and the upper part, probably the seams III, II, I are Late Miocene or Early Pliocene.

On the basis of the geological investigations of the outcrop at Bełchatów the synthetic geological (lithological) profile has been established. Since 1980 samples were systematically collected by the authors. Altogether 25 profiles were sampled, and some were already examined palaeobotanically and palynologically. The development of the vegetation is characterised first by the change of the open landscape was to swamp forest and later to dry habitat. The swamp forest is in all profiles more or less similar; *Taxodiaceae-Cupressaceae* forest, *Nyssa*, *Alnus* and with other species. The drier habitats are more differentiated. In some profiles 18 facies were distinguished, these were subdivided into 6 cycles from the swamp forest to the dry habitat forests. The oldest coal seam is known only in borehole, there the older elements are characteristic: *Engelhardtia*, *Quercoidites henrici*, *Q. microhenrici*, older *Myrica*, *Rhoidites pseudocingulum* (*Rhus* or *Anacardiaceae*) and *palms*. It has been compared with other Polish, Czech, Slovak territories and the age of the oldest brown coal seam at Bełchatów was determined as Egeburgian. The uppermost part of the main brown coal seam and the seam III are characterized by *Rhus*, *Engelhardtia* and with high percentages of *Quercoidites henrici* and *microhenrici* and other warm temperate elements. Compared with other Polish and Czech results (Cheb basin) they are considered as Ottnangian. The age of these layers is also confirmed by radiometric dating: according to the fission track method the age of the volcanic tuffites is 18.1 ± 1.7 Ma. The small mammal fauna of this layers is attributed to the MN 4 zone which is Ottnangian/Karpatian. In the upper part of the profile measurement was made with the same method and it is dated to 16.2 ± 1.3 Ma, so the flora can be Karpatian. In this flora there are no more older elements such as *Quercus*, *Myrica* but there are *Rhus*, *Caprifoliaceae*, *Engelhardtia*, herbaceous *Leguminosae* and *Graminea*, *Typha*, *Polypodiaceae*. The profile VI differs from the other profiles by its many "arctotertiary" elements; the warm temperate elements occur only sporadically. The main vegetation was a temperate forest with the predominance of *Pinus*, *Fraxinus*, *Ulmus*, *Alnus*, *Fagus*, *Quercus*, *Carpinus* and many herbaceous plants and a few Tertiary elements: *Carya*, *Pterocarya*, *Ilex*, *Liquidambar*, *Castanea*, *Taxodiaceae*

which determine the Neogene age of the flora. They are many similarities to the flora of Ruszow and Sośnica (Stachurska et al. 1967, 1973).

A more northern part of Poland is dealt with in the monograph of Kohlman-Adamska (1993). The palynological investigations were made from three localities of the Wyrzysk region of NW Poland. The age of the localities are: Early Miocene (Rawicz Beds, Ścinawa Beds), Middle Miocene (Adamów Beds, Middle Polish Beds), Late Miocene (Poznań Beds). A total of 258 taxa of sporomorphs from 69 genera have been identified. On 28 pages there is information about the botanical connections, the geographical extension, the ecological characteristics. By the general characterisation of the vegetation two great groups are distinguished: the mixed deciduous-coniferous forest with dry, respectively moderately wet ground and the marsh vegetation (swamp forest, shrubby peat swamp, sedge-swamp and aquatics). In the author's opinion this subdivision is very schematic, because many sporomorphs were determined to genus level only and the species could live in different environments. In her opinion in the forest vegetation the changes of the tropical and subtropical floral elements play the most important part during the Neogene. She characterized the vegetation types one by one:

In the mixed deciduous-coniferous forest (mixed mesophytic forest) of the Wyrzysk region the deciduous trees are dominating, the evergreen plants were very few. In higher levels at the moderately wet places besides many kinds of *Pinus* dominated *Sciadopitys*, *Sequoia*, *Tsuga*, fewer *Picea*, *Abies*, *Cryptomeria*, *Cunninghamia*, *Podocarpus*, *Metasequoia*, *Keteleeria*. To these joined deciduous plants *Corylus*, *Carpinus*, *Acer*, *Tilia*, *Fagus*, *Zelkova*, *Juglans*, *Quercus*, *Carya*, *Liriodendron*, *Castanea*, *Platycarya*, *Eucommia*. The number of the subtropical-tropical genera is very small, cca 15. These are trees and shrubs: *Engelhardtia*, *Reevesia*, *Corylopsis*, *Ilex*, *Magnolia*, *Itea* and some *Sterculiaceae-Rutaceae*, *Symplocaceae*, *Palmae*, *Amaryllidaceae*, *Araliaceae-Cornaceae*, *Anacardiaceae*, *Leguminosae*.

In the riparian forest of the Wyrzysk area genera characteristic in the Middle Miocene are joined to these: *Celtis*, *Ulmus*, *Pterocarya*, *Quercus*, *Alnus*, but *Fraxinus*, *Liquidambar*, *Salix* are present, too. Joined to these are creeper plants such as *Parthenocissus*, *Vitis*, *Cissus*, *Calystegia*.

The swamp forest has two types in this area. In the Early and Middle Miocene there is the typical Neogene Taxodiaceae-Cupressaceae swamp forest (*Taxodium*, *Glyptostrobus*, *Nyssa*) and on the top of the Middle Miocene directly under the Poznań Beds is the other with the dominance of *Alnus* and *Nyssa*. The underwood in the swamp forest consists of *Polypodiaceae*, *Osmundaceae*, *Cyperaceae*, *Gramineae*, *Typha* and shrubs *Salix*, *Betula* and

palms. The peat-swamp and aquatic plants accompanied other plant communities in the Wyrzysk region through all the Miocene. The shrubby peat-swamp consists of two plant groups: *Cyrillaceae-Clethraceae* and *Myricaceae*; *Salix*, *Betula* and *Ericaceae* are added to these. In the upper part of the Middle Miocene the peat-swamps are characteristic with 50% *Cyperaceae* and 20% *Gramineae*. Few trees: *Alnus*, *Ulmus*, *Salix* and *Sphagnum*, *Gleicheniaceae*, *Lycopodium inundatum*, *L. cernuum* are present. On the water-edge and shallow water the *Liliaceae-Iridaceae*, *Typha*, *Sparganium*, *Potamogeton*, *Utricularia* were present. The subtropical climate is indicated by the *Gleicheniaceae* and *Lycopodium cernuum*. The character of the vegetation – in the author’s opinion – in NW Poland is dominantly the warm temperate “arctotertiary” flora with few subtropical flora elements. The author in the Wyrzysk region has distinguished 6 phases of the plant cover according to the changes of the warm temperate climate (warming or cooling). Ziemińska-Tworzydło’s 14 phases are not applicable because of the more Northern position of this territory. The phases I–IV belong to the mixed mesophytic forests, but in these appears the swamp forest, too. Generally the “arctotertiary” elements are dominating. Phase I is Early Miocene (Rawicz Beds), Phase II also (Scinawa Beds) where the “arctotertiary” and “palaeotropical” elements are in balance, – that was the maximum warming of the climate. Phase III belongs to the Middle Miocene with thin layers of brown coal. These are the so-called Adamów Beds and lower Middle Polish Beds. The climate was damp and decidedly cooler than in the previous phase. In phase IV takes its origin the Middle Miocene coal seam (the upper Middle Polish Beds). Phases V–VI represent riparian forests. The strongest climatic cooling occurred in phase V. This phase is characterized by riparian forest of *Ulmus*, *Quercus*, *Alnus*, accompanied by *Celtis*, *Pterocarya*. “Palaeotropical” elements are *Engelhardtia*, *Leguminosae*, *Tricolporopollenites pseudocingulum*, *Palmae* and relatively numerous of *Sterculiaceae-Rutaceae*. Conifers are only *Pinus* and *Sciadopitys*. Phase VI is the latest phase of the Middle Miocene, there was a climatic warming. This phase is characterised by *Celtis*, *Quercus*, *Ulmus*, *Pterocarya*, shrubs *Betula*, *Salix*, creepers (*Parthenocissus*). In dryer habitats there are *Sciadopitys*, *Acer*, *Ilex*. “Palaeotropical” elements are *Corylopsis*, *Araliaceae-Cornaceae*, *Palmae*. One part of the upper Middle Polish Beds belongs to this phase.

Stuchlik’s monograph (1964) deals with the palynological investigation of the Miocene deposits of Rypin (Eastern part of North Polish Lowland). The author divided the sporomorphs into three climatical groups from the Neogene of borehole Rypin II: 1) tropical, subtropical climate demanding:

Psilotum, *Lygodium*, *Mohria*, *Gleicheniaceae*, *Cyathea*, *Alsophila*, *Castanopsis*, *Pasania*, *Engelhardtia*, *Gunnera*, *Meliaceae*, *Ptelea*, *Sapindus*, *Cyrillaceae*, *Symplocos*, *Sapotaceae*, *Bignoniaceae*, *Vitex*, *Apocynaceae*, *Restoniaceae*, *Corypha*. 2) warm temperate climate demanding and transitional to temperate: *Osmunda claytoniana*, *O. bromeliifolia*, *Podocarpus*, *Cedrus*, *Sciadopitys*, *Sequoia*, *Taxodiaceae*, *Glyptostrobus*, *Cryptomeria*, *Taiwania*, *Cunninghamia*, *Callitris*, *Ephedra*, *Ostrya*, *Corylus americana*, *Myrica*, *Juglandaceae*, *Celtis*, *Eucommia ulmoides*, *Loranthaceae*, *Hammamelidaceae*, *Magnoliaceae*, *Lauraceae*, *Garcinia*, *Cassia*, *Gynometria*, *Caragana*, *Decodon*, *Nyssa*, *Myrtaceae*, *Rutaceae*, *Elaeagnaceae*, *Anacardiaceae*, *Ilex*, *Staphylea*, *Vitis*, *Parthenocissus*, *Araliaceae*, *Styrax*, *Forsythia*, *Rubiaceae*, *Diervilla*, *Tulipa*, *Dulichium*. 3) the group of plants of temperate with transition to a cold temperate climate: *Osmunda regalis*, *Polypodiaceae*, *Lycopodium*, *Pinus*, *Tsuga*, *Abies*, *Picea*, *Larix*, *Betula*, *Alnus*, *Carpinus*, *Corylus*, *Fagus*, *Quercus*, *Salix*, *Ulmus*, *Polygonum*, *Chenopodiaceae*, *Caryophyllaceae*, *Ranunculaceae*, *Cruciferae*, *Nymphaeaceae*, *Rosaceae*, *Lythraceae*, *Oenotheraceae*, *Tilia*, *Acer*, *Umbelliferae*, *Cornus*, *Rhamnaceae*, *Ericaceae*, *Pirolaceae*, *Solanaceae*, *Labiatae*, *Plantago*, *Fraxinus*, *Viburnum*, *Lonicera*, *Valerianaceae*, *Campanulaceae*, *Compositae*, *Butomus*, *Potamogeton*, *Liliaceae*, *Cyperaceae*, *Gramineae*, *Sparganium*, *Typha*. – The author is aware that since the taxa are not determined at species level changes are possible in the dating. In my opinion also more caution would be necessary in the ranging.

From the edaphic point of view 4 groups of plants were distinguished: 1) Water, shore and peat plants: *Lycopodium inundatum*, *Anthoceros*, *Sphagnum*, *Nymphaeaceae*, *Lythraceae*, *Decodon*, *Myriophyllum*, *Halorrhagis*, *Trapa*, (*Gramineae*), *Potamogeton*, *Cyperaceae*, *Cladium*, *Dulichium*, *Sparganium*, *Typha*. 2) Plants of swamp forest: *Taxodiaceae*, *Glyptostrobus*, *Alnus*, *Nyssa*, (*Rhus*), (*Vitis*), (*Parthenocissus*), (*Araliaceae*). The taxonomic units enumerated in brackets comprise species with various ecological demands. 3) Plants of damp brushwoods: *Myricaceae*, *Cyrillaceae*, *Cyatheaceae*, *Engelhardtia*, *Liquidambar*, *Sapindaceae*, *Symplocaceae*, *Sapotaceae*, *Ericaceae*. *Osmunda*, *Betula*, *Salix*. 4) Plants of forests and brushwoods on dryer habitats: *Lycopodium clavatum*, *L. annotinum*, *Polypodium*, *Tsuga*, *Pinus*, *Sequoia*, *Cryptomeria*, *Ostrya*, *Betula*, *Carpinus*, *Corylus*, *Quercus*, *Pasania*, *Castanea*, *Juglandaceae*, *Cassia*, *Caragana*, *Ilex*, *Cornus*, *Rhododendron*, *Ulmus*, *Acer*, *Hippophaë*.

On the basis of pollen diagrams from the Rypin II section the author distinguished 3 periods of the vegetations. Period I: the lower part of the section

has tropical, subtropical vegetation. This period belongs to the Late Oligocene, Chattian. Period II is characterized by subtropical vegetation, the climate was dryer than in the previous period. The period belongs to the beginning of the Early Miocene, Aquitanian. Period III: the vegetation is claimed to have been warm-temperate, temperate. This is the uppermost part of the section, the age is Late Miocene.

Two papers deal with – a little different – palynological and stratigraphical evaluation of SW, W and Northern Poland. Sadowska presented the opinion about the stratigraphic position of the Polish Neogene floras at the International Symposium of Bratislava in 1992. Her paper was published in the volume of the symposium (1993, pp. 133–139), where in a table she summarized the state of the palaeofloras. The units are represented according to the Paratethys nomenclature. The lithological ranges of the two units are a) the Carpathian Foredeep and Metacarthian Ridge (after Alexandrowicz, Alexandrowicz and Kleczkowski), b) the Polish Lowland Basin (after Dyjor, Ciuk, Piwoczki). According to the palaeogeographical situation the fossil floras are represented also in two parts. She shows on a sketch the extension of the Paratethys and the Poznań Series on Polish territories in the Neogene with the localities of the investigated palaeofloras. Then on the basis of the Polish literature she presented the changes of the flora from the Egerian till the Pleistocene. From the description and from the above mentioned table comes to light that she holds only the upper part of the Egerian stage for Miocene, while the lower larger part for Oligocene. After her table in the Carpathian Foredeep there are no Lower Miocene stratigraphical units, they are represented only in the Polish Lowland. The ranges of the stratigraphical units are also different from ours, because she closed the Lower Miocene with the Karpatian, to the Middle Miocene belong the Badenian and Sarmatian and to the Upper Miocene the Pannonian and the Pontian. The subtropical flora of the Upper Egerian is in her opinion not of Miocene character (with domination of *Tricolporopollenites cingulum fusus* and *pusillus*, *T. henrici*, *T. microhenrici*, *Tricolporopollenites liblarensis*). For this reason she did not range the brown coal there occurring to the Early Miocene but to the Late Oligocene and identified it with the 4th Lusatian series. (In the same volume, in the article of Planderová and al. the Polish colleagues write about Egerian section and floras in Poland!).

According to Sadowska the Eggenburgian and Ottnangian are represented by the Żary Series and the lower part of the Silesian-Lusatian Series (Ścinawa Beds and Rawicz Beds). The palynoflora is known from the Ścinawa brown coal seam (3rd Lusatian series) and from Turosszów (Western Poland)

and from Lubstów, Bełchatów (Middle and Northern Poland). To these localities she attributes at the beginning of the Miocene temperate elements like *Pinus*, *Taxodiaceae-Cupressaceae*, *Alnus*, *Carpinus*, *Fagus*, *Picea*, *Ulmus*. It is much cooler in comparison to the subtropical flora of the Late Oligocene. – However in my knowledge of the *Taxodiaceae* family when in case of the coal biding they are present in great mass, there must have been at least a warm temperate climate. – During the Early Miocene the climate gradually became warmer as shown by *Engelhardtia*, *Myrica*, *Palmae*, *Tricolpopollenites liblarensis*, *T. retiformis*, *Tricolporopollenites henrici* in great quantities.

The Karpatian is represented by floras of the Lusatian seam (2nd Lusatian series) in the western and middle part of the Lowland and of some localities in the Carpathian Foredeep. There were extensive swamp forests and bogs in the Lowland with *Taxodium*, *Nyssa*, swampy species of *Quercus*, (*Q. henrici*), *Rhus*, *Liquidambar*, *Myrica*, *Ilex*, *Alnus*, *Cyrillaceae*, *Ericaceae*, *Araliaceae*, *Sequoia*, *Engelhardtia*, *Symplocos*. In the Paratethys region the mixed deciduous forest were more typical with *Pinus*, *Engelhardtia*, *Carya*, *Alnus*, *Quercus*, *Ulmus*, *Fagus*, *Tilia*, *Castanea*, *Rhus*, *Oleaceae*, *Rosaceae*. This difference was due to the Mediterranean type of climate during in the Miocene in this part of Poland.

The Early Badenian vegetation in the Carpathian Foredeep in the Cracow region is characterised by the dominance of deciduous trees over conifers and a considerable amount of thermophilic taxa. In the Late Badenian in the Silesian part of the Paratethys sea (Kędzierzyn region), the Nowy-Targ – Orawa Basin and the northern part of the Paratethys the coniferous forests dominated (*Pinus*, *Abies*, *Picea*, *Cedrus*, *Tsuga*). The deciduous trees were *Quercus*, *Ulmus*, *Fagus*, *Rhus*, *Engelhardtia*, *Carya*, *Pterocarya* with shrubs and herbaceous plants. On the Polish Lowland there were swamp forests and peat-bogs of the Henryk brown coal seam (1st Lusatian series). There were *Taxodium*, *Glyptostrobus*, *Nyssa*, *Alnus*, *Liquidambar*, *Pinus* in the swamps and *Myrica*, *Rhus*, *Cyrillaceae-Clethraceae*, *Ericaceae*, *Cornaceae*, *Mastixiaceae*, *Rosaceae*, *Leguminosae* in the bogs. In the driest forest *Quercus*, *Betula*, *Ulmus*, *Sequoia* were growing.

At the beginning of the Early Sarmatian, after the withdrawal of the Paratethys sea from the Western Carpathian Foredeep, and the subsidence of the Metacarthian Ridge the separated basins became connected and the plant communities became more similar. It is already possible to distinguish geobotanical provinces in Poland.

– In my opinion this is natural in a big country like Poland where the geographical circumstances are so very diversified. –

The Polish palynologists have results data the Sarmatian stage from many localities in Poland. The most important community is the mixed mesophytic forest with *Quercus*, *Ulmus*, *Celtis*, *Fagus*, *Acer*, *Betula*, *Carpinus*, *Juglandaceae*. The cypress-alder swamp forest covered only small areas. In the Western Carpathians conifers prevailed over angiosperms. In the northern part of the Central Paratethys the small-leaved *Leguminosae*-type plants dominated. In Western Poland which belongs in the Sarmatian to the Western European province, the forests contained high amounts of wet and warm elements, which have formed small brown coal seams or lenses (Kędzierzyn seam).

The most difficult problem is – according to Sadowska – the evaluation of the Upper Miocene. There are no marine sediments and only a few localities in the Lowland, because the large and deep Poznań lake was situated in Western and Middle Poland. For the Pannonian forest of the Nowy Targ – Orawa Basin was characteristic that the quantity of the Tertiary elements of the swamp forest decreased, the *Picea* and herbaceous plants increased. In Western Poland there is a very important locality, Gozdnicza near Żary, rich in palaeobotanical elements, which probably belongs to the Pannonian. This forest is rich in “arctotertiary” elements, but was also abundant in “palaeotropical” elements (after Mai (1965) younger mastixioidean flora).

Pontian flora was investigated only from the Pieniny Mts. (Szafer, Oszast). In the higher region of the Carpathians coniferous forest with *Picea*, *Tsuga*, *Abies*, *Pinus*, in the lower part deciduous forest with holarctic elements dominated. The herbaceous plants were *Cyperaceae*, *Gramineae*, *Polypodiaceae*. In the wet valleys *Alnus* was common.

During the Early Pliocene in the Carpathian Foredeep in the mountains there were conifers, in lower territories mixed forests, where the Quaternary genera prevailed over the Tertiary ones. In the Western part of the Polish Lowland the localities are rich in fossil floras (Sośnica, Gnojna). The deciduous trees are *Carpinus*, *Ulmus*, *Quercus*, *Fagus*, *Parrotia*, *Betula*, *Acer*, *Engelhardtia*, in the wet forest *Alnus*, *Carya*, *Liquidambar*, *Pterocarya*, *Salix* and small amount of *Taxodium*, with bushes and herbs, mainly *Gramineae*. In the upper part of the Early Pliocene (Ruszow) there were mesophyllous deciduous forests with *Quercus*, *Betula*, *Fagus*, *Carpinus*, *Acer* and *Alnus* on the wet areas. The role of herbaceous plants was increasing.

The Late Pliocene flora is known from two localities: Mizerna in Pieniny Mts. and Kłodzko in Sudety Mts. Coniferous forests dominated, with *Picea*,

among the deciduous trees the most important were *Acer*, *Carpinus*, *Fagus*, *Quercus*, *Ulmus*, *Aesculus*, *Carya*, *Pterocarya*. In the Carpathians the forests contained more dry elements than in Western Poland. The water basins were overgrown with *Alnus*. Herbaceous plants were plentiful. Thermophilous, typical Miocene taxa were rare (Sadowska 1993).

The lithological and palynological zonation of the Polish Lowland was established by Piwoczki and Ziemińska-Tworzydło (1997). Their stratigraphic subdivision contains all the nomenclatures used in the Tethys, Paratethys and North Sea areas. For the lithology they apply the patterns of Ciuk, Dyjor and Piwoczki. It looks that between the opinion of the last two geologists there are not so great differences. The authors try to make correlation between lithological and palynological results of the Polish Lowland and the Paratethyan data, but their table demonstrated only that the two zonations are parallel. On their table there is a general section and the palynological zonation (I–XIV) after Ziemińska-Tworzydło. This zonation is based on the sporomorphs which are important for the author. Their names are arranged after Mai in two geofloristical groups: “palaeotropical” and “arctotertiary”.

In my opinion it is more useful to compare the fossil floras with the recent ones because so we can draw conclusions about the origin of the floras, and also palaeoclimatological ones.

Our knowledge about the Northern part of the Paratethys has been extended in great degree by the outstanding Polish scientists. From their research work it is evident that the huge territory of Poland with the great latitudinal differences is suitable also for vegetational differences. They were smaller in the early Miocene in consequence of the fact that the ridges of the Carpathians were not developed so far. After their uplift the warm elements disappeared more quickly.

Turkey

Turkey is an important part of the Eastern Mediterranean region. In 1992 I made a comparison between the Hungarian and the Turkish Neogene floras on the basis of Benda (1971). On the tables of my monograph (Nagy 1992, tables 17, 18, 19) I made comparison between the palaeoflora of Hungary and the European countries and the Turkish palaeofloras, too. Benda's opinion was that the young Tertiary freshwater pollen flora of SW Turkey is comparable with the Vienna Basin on the base of Vertebrate fauna, but it by no means can be correlated with the marine planktonic foraminiferal zones of

the Tethys. (Later he made correlations in Benda et Meulenkamp 1972, Benda 1973, Benda et al. 1977, Benda et Meulenkamp 1990).

In 1997 Nurdan Yavuz from Middle East Technical University, Ankara, was my student with a Ph.D. scholarship. We worked on samples from a brown coal section of Western Anatolia. The palynomorphs were in very bad condition, (Benda referred to this already in 1971, p. 22) but it was possible to draw some conclusions on the coal facies.

The coal seam originated from Kütahya province, Seyitömer coal Basin, Anatolia. The 66 samples were collected from a 45 m thick Middle-Upper Miocene coal, marl, shale, mudstone sequence in an open-pit coal mine. In the badly preserved material the conifers were dominant (47.4%), the most part belonging to the *Pinus* genus, – from the structureless pollen grains it was difficult to distinguish the *Pinus sylvestris* and *haploxylon* types. In some cases I was only able to recognize the *Cathaya* or *Cedrus* types. 36% of the conifers were *Taxodiaceae*; this refers to a swamp forest. From the angiosperms were relatively well recognisable the *Carya*, *Pterocarya* and *Engelhardtia*, they characterised the riparian forest with fewer *Alnus*, *Betula*, *Ulmus* and very few *Salix*. From the *Fagaceae* the *Quercus* and *Tricolporopollenites cingulum oviformis* were common. The swamp forest was marked by *Taxodiaceae* and *Nyssa*, the bush swamp by *Cyrilla*, *Myrica*, *Jussiaea*, *Caprifoliaceae*, the open quiet water surface by *Nymphaeaceae*, *Myriophyllum*, *Trapa*, *Sparganium*. The freshwater is indicated by the *Zygnemataceae* family, which was present nearly in all samples. *Polypodiaceae* (*Laevigatosporites haardtii*) occurred practically in all samples while *Osmunda* was present only on the lower third part of the sequence. In the forest with dryer ground were living the trees with quercoid pollen grains (*Castanea*) and *Juglans*, *Carpinus*, *Tilia*, *Corylus*, *Ostrya*, fewer *Lonicera*, *Diervilla* and herbaceous plants. Around the basin on the mountains the conifers were dominant. Warm tropical elements were present only in small numbers (*Araliaceae*, *Sapotaceae*, some ferns). Subtropical, mediterranean plants are more numerous (*Taxodiaceae*, *Cedrus*, *Podocarpus*, *Rhus*, *Oleoidearumpollenites*). In this basin surrounded with mountains only warm temperate vegetation could have existed.

We can state that there is very great similarity among the Neogene floras of the Central Paratethys area and in particular in the coal facies. In the swamp forest the chief constituent part is the *Taxodiaceae* family. The great number of their pollen grains characterises the brown coal samples (Nagy, 1975).

Evaluation

A palynological evaluation of the Neogene of the Central Paratethys was published for the first time in the monograph of 1992 (Nagy). I cherished with the idea of this comparison already many years ago. Besides the literature it was necessary also the personal contact with the scientists of the neighbouring countries, so the exchange of reprints was easier and I could even visit the most important localities.

The mentioned evaluation concerned at first also the Central Paratethys, but there was no comprehensive work that would marked out the territory of the Central Paratethys. Such a work is now the atlas of Hámor et al. (1988). The territory of the Eastern Paratethys represents another floral area and this huge area has not been studied properly. This monograph (Nagy 1992) passed in western direction the boundary of the Central Paratethys because in the German territory many good palaeobotanists have worked and their data represented a good basis of comparison. This comparison was only a chapter of the monograph. Later when the work was already printed many papers and monographs were published by palynologists of the countries of the Central Paratethys. This supported the necessity of a more thorough evaluation. That time when the idea of the Pentagonale was raising up this gave the idea to join it.

The collective work initiative of the Pentagonale terminated with the Bratislava symposium in 1992. After the symposium due to Éva Planderová's tragic death, the edition of the proceedings was passed on to the Polish palynologists. From our common work there is a short paper in it, which – naturally – does not deal with the whole territory of the Paratethys region.

Figure 2 summarizes my previous experience. On this basis the present paper at first intends to make a correlation of the Neogene palynofloras of the whole territory of the Central Paratethys and secondly, to compare the flora elements comparing the vegetation types, which are in close connection with the palaeoenvironments. The changes of the flora and vegetation are very closely connected also with the climate. The palaeoclimate left lasting traces in the palaeovegetation, therefore the comparison of the above-mentioned data, besides of establishing the micro- and local climates, makes it possible to state the change of the climate zones, – if enough data are available.

The question of the EGERIAN stage, whether it belongs to the Oligocene or to the Neogene, is a matter of dispute even today. In Hungary it is possible to separate it from the other parts of the Miocene, but it can also be connected

to them with the help of palynological data. The sequence of the holostrato-type of the Egerian has been divided into two parts, without significant change in the climate of the lower and upper substage (Nagy 1963, 1979, 1992). The extension of the Egerian sea was not too large (map No. 1. Hámor et al. 1988). According to novel information (a lecture of Á. Dávid et L. Füköh 1997. 11.19) the central part of the Egerian sea was connected with the Northern Italian territory through Croatia and Slovenia. As far as the extension of the Egerian sea is concerned, they are not too numerous palynological data.

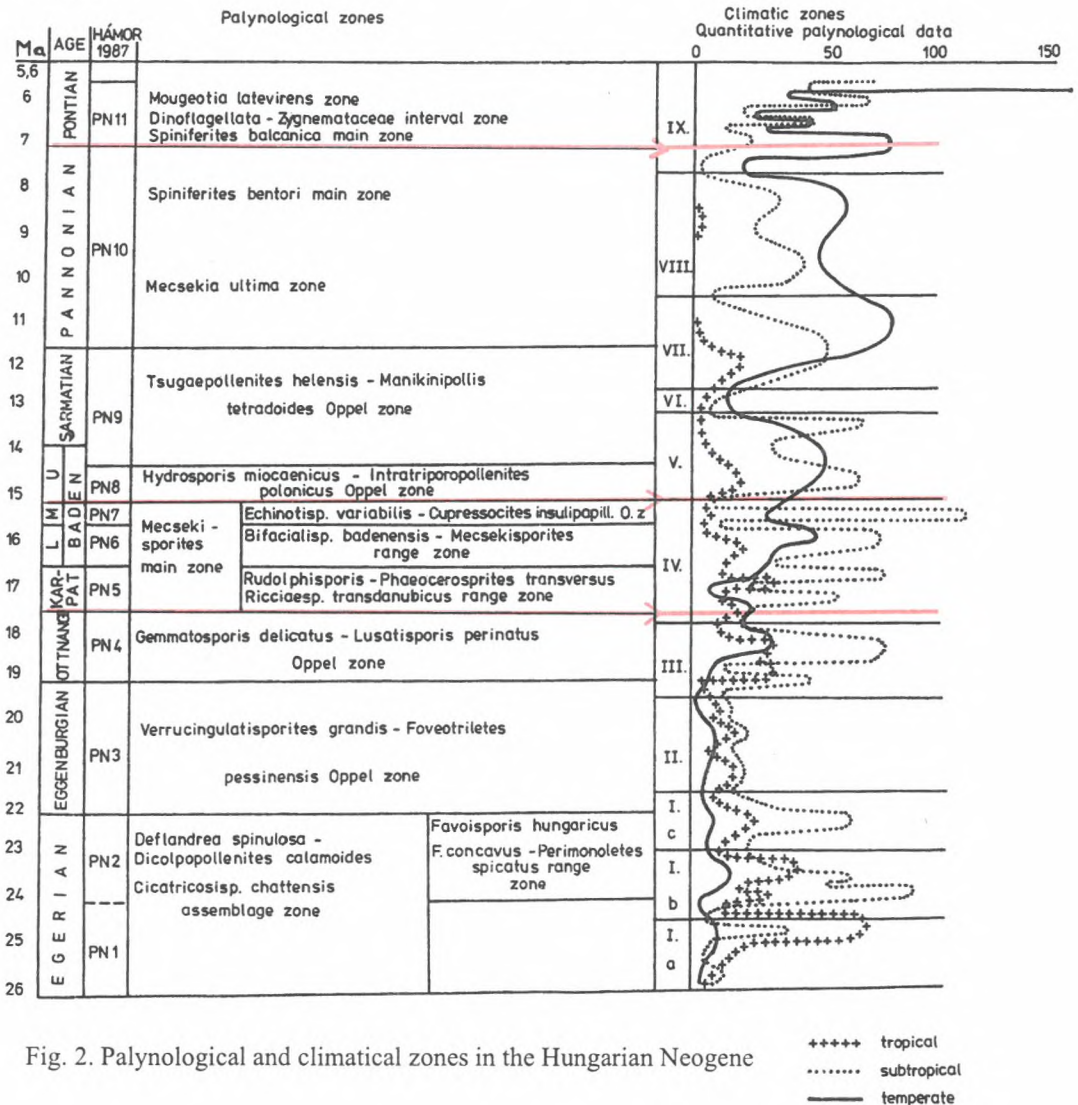


Fig. 2. Palynological and climatic zones in the Hungarian Neogene

In addition to the Hungarian data in Croatia Šećerov (in the Egerian volume, 1975 listed data on the faciostratotype), in Bosnia Pantić (1958, 1966), in Romania Petrescu (1986, 1987), Petrescu, Givulescu, Barbu (1995, 1997), in Ukraine Andrejeva, Grigorovich, Gruzman (1994), in Slovakia Planderová (1990), Snopková (1988 and a manuscript from 1975), Pacltová (1961, 1963, 1966), in Austria Klaus (1971), Hochuli (1978) informed us about palynological data of the Egerian. Being in relatively small areas, the palaeofloras were fairly uniform. When the authors studied also the planktonic material, this too was uniform enough. A great number belong to the form group of *Deflandrea spinulosa*. There were less marine planktonic organisms at the shoreline near the holostratotype, while more in Austria and Ukraine. In the central part of the Egerian sea in Hungary (Eger, Fót), in Slovakia (Ipoly, Losonc, Rimaszombat) the palaeoflora was the same, but they are identical in localities of Austria and Transylvania, too. In the South in Bosnia the palaeoflora is also very similar, the fern species are the same. This territory was near the shoreline of the Paratethys but on the continental margin. The uniformity of the Egerian flora is indicated also by the fact that North of the central area Pacltová (1958, 1960) and Konzalová (1976) wrote about the same palaeoflora, as in the Western part of the Polish Lowland Ziembieńska-Tworzidło (1974). This last flora in spite of its similarity with the other Egerian floras and its many warm elements, differs by the absence some characteristic taxa: the *Gleicheniidites*, *Cicatricosisporites*, *Proteacidites egerensis*, *Engelhardtoidites*, *Plicatopollis plicatus* and among the conifers the *Podocarpidites*. These absences can be explained by the more northern location of the territory.

The geographical extension of the EGGENBURGIAN stage on the basis of map No.2 (Hámor et al. 1988) in the central part is relatively small. It was extended only in the North Central Mountains in Hungary and to the joined territory in Southern Slovakia. This central part is only with “?” connected with the Transylvanian Basin and had no contact with the territories of the Carpathian Mountains and Alps, where the sea was more extended. With the delimitation of the Eggenburgian stage there are also difficulties as it is evident from the literature. From the Eggenburgian literature I have used the following papers in Croatia Krizmanić (1993, Jurišić-Polšak, Krizmanić, Hajek-Tadesse), in Bosnia Pantić et al. 1966, in Romania Petrescu 1971, Petrescu et Nicorici 1989, Petrescu et Fazecas 1989, in Slovakia Pacltová 1958, Planderová 1971, 1990, in Moravia Zdražilková 1993, in Bohemia Pacltová 1960, Konzalová 1976, in Austria Klaus 1952, Obritzhauser-Toifl

1954, Hochuli 1978. This is completed with the data of the Polish Lowland which are believed to be identical in age.

Comparing the list of the Hungarian Egerian and Eggenburgian floras, there are only little, but characteristic differences between them. The planktonic organisms could be very different in function of whether the area was marine or terrestrial in origin.

In Bosnia in the Zenice – Sarajevo Basin was the sample investigated from the coal seam of the Zenice – Kakanj series (Pantić et al. 1966), marked by the authors as M₁, so it is supposed to be Eggenburgian. The list of the flora is only a little different from the former, indicating an Egerian age. (There were no *Sphagnum* spores, *Osmunda* was less numerous and there were many *Laevigatosporites haardtii*).

In Romania, the Eggenburgian connection between the Transylvanian Basin and Pannonian Basin is perfectly evidenced by palaeobotanical data. There are Eggenburgian palynological data from three localities: Tihău (Almaşului Valley) (Petrescu 1971), the Bozovici Basin (Petrescu, Nicorici 1989), the Brad – Săcărimb Basin (Petrescu, Fazecas 1989). The taxa listed by the authors may belong to the Eggenburgian flora, but could be Egerian, too. In these localities it is rather the lack of some characteristic taxa that hints at the Eggenburgian e.g. the *Cicatricosisporites*, or the quantity of some elements could refer to it.

The Eggenburgian palynoflora published from Slovakia (Planderová 1971, 1990) essentially agrees with the Hungarian one, what is a consequence of the palaeogeographical situation. Pacltová (1958) hold the footwall of the coal seam of Handlova as Burdigalian (Eggenburgian), but from the corroded material she stated only that in that period the climate might have been warmer (from the *Sapotaceae* pollen grains and *Lygodium* spores), than it was in the top of the investigated boreholes in the Tortonian-Sarmatian.

In Moravia Eggenburgian borehole sequences were investigated by Zdražilková (1993) from the Carpathian Foredeep. The deposits of the shoreline are characterized by dinoflagellates and *Botryococcus* algae. Between the sporomorphs there are always tropical-subtropical elements. The temperate elements were sporadic. The aquatic plants were rare, the dry elements are abundant. There are many *Pinus* and pollen grains of the *Oleaceae* family.

The holostratotype of the Eggenburgian is in Austria. At Eggenburg palynological investigation was made from the Brunnstuben-Graben outcrop (lower part of the Gaudendorf beds) by Hochuli (1978). This is of more open

marine facies, than the Hungarian localities, with numerous marine planktonic taxa. Their palynoflora is like the Hungarian, with many Egerian taxa.

Klaus (1952), Obritzhauser-Toifl (1954) investigated the coal seam of Langau. The age of the locality, beside the palynological investigations, was verified with remains of Mastodon teeth as Burdigalian = Eggenburgian.

There is more uncertainty about the stratigraphical range of the territories outside of the Paratethyan area. The palynological investigations (Konzalová 1976) in North Western Bohemia in the North Bohemian Basin have not produced reliable data. The so-called lower beds with the lower coal seam could be from Late Aquitanian to Burdigalian in age. After the species names given by Konzalova the Eggenburgian stage is possible (*Lygodium*, *Leiotriletes maxoides*, *Histiopteris*, *Magnolia*, *Pesicarioipollis meuseli*, *Myricipites rurensis*, *Engelhardtoidites microcoryphaeus*, *Momipites punctatus*, *Tricolpopollenites henrici*, *Araliaceipollenites edmundi*, *Dicolpopollenites koczeki*).

There are no Eggenburgian palynological data from Southern Poland. In this area which belongs to Central Paratethys there was a transgression towards the end of the Eggenburgian (Stuchlik 1979).

Farther North, in the Polish Lowland the palynologists naturally have established contact with the German scientists, because the two territories are connected. But they wanted to correlate their data with the Paratethys area, too, because this is stratigraphically better founded and the Southern part of the country belongs to that area. The most important brown coal exploration was done in the Polish Lowland, in the Bełchatów area. The published palynological data are of the Lower Miocene from below the main coal seam (Stuchlik et al. 1990). The characteristics of the oldest coal seam are *Engelhardtia*, *Quecoidites henrici*, *Q. microhenrici*, old *Myrica*, *Rhoipites pseudocingulum* and *palms*. The authors stated that the age is Eggenburgian. The tropical elements of the Paratethys region there have not been found; the palynological investigation indicates different flora assemblages in the Polish Lowland and in the Paratethys region.

The OTTNANGIAN stage according to the satellite map No. 2 (Hámor et al. 1988) represents small extension with brackish-water sea, in Northern Hungary and Southern Slovakia. The two palaeofloras belong to the Salgótarján Browncoal Formation. Planderová (1990) held the poorly extended Ottnangian of Slovakia for deposits of basins independent from one another. The connection of these parts to the other parts of the Ottnangian area is very uncertain. In Bosnia in the Zenice-Kakanj-Breza Series the M₁ marked part (Pantić et al. 1966) could be Ottnangian; the coal sequence has swamp forest

elements (*Taxodiaceae*, *Nyssa*, *Myrica*, *Cyrillaceae* and many fern spores). In Romania the second part of a 84 m deep borehole the Brad-Săcărîmb Basin could be Ottnangian (Petrescu et Fazecas 1989). At the base of the sequence there was coal forming, with not too much *Taxodiaceae*, but a lot of water and swamp plants. *Myrtaceidites myrtiformis* is also present, described by Simoncsics (1964) from the brown coal of Salgótarján. In Moravia Zdražilková (1993) studied boreholes from Nosislav, with Ottnangian and Karpatian sequences. In the upper part of the Ottnangian sequences she found no climate cooling, in contrast to Hochuli. The number of *Sapotaceae* pollen grains are decreasing, but the palms, *Symplocaceae* and the number of the *Lygodium* spores are increasing. At the top of the stage the numbers of the humid elements were higher, just as in the other parts of the Paratethys region, and the appearance of dinoflagellates indicates a transgression. In Austria one sample of the holostratotype Ottnang-Schanze was investigated (Hochuli 1978). The most important is, according to the author, the decrease in the number of tropical elements. The *Sapotaceoideaepollenites sapotoides* were 2%. We can state that the Hungarian Ottnangian was warmer, in particular when we include to thermophilous taxa the subtropical species, too. In Poland it is being tried to find the connection in time with the Paratethys area. In Bełchatów radiometric determinations were made for some samples. Those from the top of the main coal seam, and above the III seam were dated as Ottnangian.

The Karpatian volume was printed in the year 1967, so in the article of Pantić et al. 1966 could not occur the term KARPATIAN. In Bosnia in the Zenice-Kakanj-Breza Series next above sample, which the authors figured as M₂, according to the pollen material is not Karpatian. In Romania the scientists have not published data from the Karpatian, although on the satellite map No. 3, between the central Hungarian Basin and the Transylvanian Basin there was strong connection. The reason of this lack could be that the sediments were not suitable for the fossilisation of sporomorphs.

About Karpatian sporomorphs in Czechoslovakia Planderová reported in the Karpatian volume (1967). There is no contradiction between the list of the palaeoflora and our present knowledge, and the presence of tropical elements can also be stated. Complemented with Planderová's monograph (1990), we get a suitable picture of the Karpatian flora and vegetation in Slovakia, which is the same as in Hungary. In Moravia the lower part of the Karpatian is characterised by a wet flora (Zdražilková 1993). From the microplanktonic organisms she concluded to oscillation. She distinguished two facies: 1) *Myricaceoipollenites aff. ex gr. megagranifer*, *Laevigatosporites*

haardtii, *L. discordatus*, *Alnus*, *Palmae*, *Sparganiaceae* and with freshwater planktonic *Ovoidites* and *Botryococcus*. – This is the same as the Karpatian stage in the Mecsek Mountains in Hungary. – 2) This facies is characterised by *Intratropopollenites insculptus*. Both facies are close to the Northern Bohemian one. She supposed for the upper part of the Karpatian marine environment, with many temperate elements, but also with *Sapotaceae*. This reminded the author of South Slovakia. – This is naturally the same in Hungary. – Already out of the territory of the Paratethys is in Western Bohemia the Cheb Basin where palynological investigations were made by Konzalová (1981). The age of the Cypris clay and of the main coal seam – on the basis of Mammalian fossils – is Ottnangian-Karpatian. The material of the borehole between Františkovy Lázně and the Odrava Basin on the basis of palynological research (Konzalová et Stuchlik 1983) is similar to the palynological spectrum of the Karpatian of the Mecsek Mountains in Southern Transdanubia.

In SE Poland there are palynologically proved Karpatian freshwater sediments (Oszczyk et Stuchlik 1970, 1972), with few tropical elements. Oszaś et Stuchlik (1977) at first mentioned the Karpatian by the summarising the Neogene profile of the Polish West Carpathians. In the flora were dominating the so-called Tertiary elements (*Taxodiaceae-Cupressaceae*, *Castanopsis-Castanea*, *Celtis*, *Engelhardtia*, *Nyssa*, *Platycarya*). *Sapotaceae*, *Symplocaceae* were absent. Among the conifers the *Pinaceae* were dominant. The tendency of the warm temperate climate has a subtropical character, with much rain. About the palynoflora of the Silesian Paratethys area wrote Sadowska (1989). The Kłodnica beds represent the Karpatian stage. The vegetation is characterized by a shoreline swamp forest. The number of the tropical elements is small. The author supposes a Mediterranean climate. The palaeovegetations of both Polish areas connected with the Paratethys were very similar.

On the Polish Lowland the palynological investigations of the Bełchatów brown coal area (Stuchlik et al. 1990) with radiometric dating are suitable for correlation with the Paratethys area. The examined profile of Bełchatów with micro mammals fauna proved to be Ottnangian-Karpatian. Radiometric dating performed in a part of this profile gave 16.2 ± 1.3 Ma, that is Karpatian. The standpoint of Sadowska (1993) is that the Polish Neogene floras at the Western and Middle Polish Lowland and the Carpathian Foredeep correspond to the second Lusatian series in the upper part of the Karpatian stage.

The occurrence of the BADENIAN stage in Croatia is verified by the map No. 3 (Hámor et al. 1988). The palynoflora of the terrestrial locality Gorja

Jelenska belongs to the Mecsekisporites main zone (Nagy 1992). In the freshwater sediment *Rudolphisporis* and also *Bifacialisporites* occurred, therefore the question is, whether the age is Karpatian or Early Badenian.

In Slovenia Marina de Costa Grum investigated Badenian samples in a borehole at Dankovci. They were only some marine planktonic organisms in and corroded bisaccate conifers.

In Bosnia the upper part of the Zenice-Sarajevo basin Pantić et al. (1966) studied and marked the sample with M₃ in the “die obermiozäne Kohlenvorkommen Serie”. In this there were few fossils and it was not possible to range it stratigraphically. It could be anything from Late Badenian till the top of the Miocene. In Northern Montenegro the coal sample of the locality Plevlja after the palynological data could be Badenian (Weyland, Pflug et Pantić 1958), after *Chalicoterium grande* are Middle Miocene. In Eastern Serbia at Despotovac 4 coal seams alternate with dead rocks. The sample marked II B was investigated palynologically (Weyland, Pflug et Pantić 1958). Their hanging rock was investigated for macro- and microfauna and macroflora. These are Tortonian-Sarmatian, so the coal seam might be Badenian.

The lithostratigraphic description of the boreholes of North Western Bulgaria derived from Kojumdzieva et Popov. The palynological investigations of the Badenian part of this boreholes were made by Ivanov (1994, 1995). The flora is rich and in character warmer than the Hungarian, with many tropical fern spores. SW of Sofia from a “Helvetian-Tortonian” coal basin Petrov et Drazheva-Stamatová described tropical plants (1971, 1972, 1973). On account of the southern geographical position of Bulgaria the character of the flora is warmer than in Hungary.

The Transylvanian Basin after the maps No. 3, 4 (Hámor et al. 1988) was in very close connection with the central part of the Paratethyan Basin. From Lower Badenian the palynological investigation (Petrescu, Mészáros, Chira et Filipescu 1990) at the locality of Poiana Rusca found a very rich assemblage of fern spores and a significant stock of conifers. Among the angiosperms there were many thermophilic elements, which are characteristic of the lower part of the Badenian. The palynological research verified the Middle Badenian age of the salt layers at Ocna-Dej (Désakna) (Petrescu et Meseşan (1993–94), with fewer fern spores than the former. The *Taxodiaceae*, the pollen grains of *Nyssa*, *Myrica* and *Cyrilla* indicate a wet area. The riparian forest is also represented. About Late Badenian informs the article of Petrescu, Mészáros, Filipescu et Buda (1988). The lower part of the borehole drilled in Harghita district is Late Badenian, the upper part Early Sarmatian. The flora is impoverished in the Late Badenian similarly to the

central part of the Paratethys region, the number of the fern spores is small, the conifers dominate the spectrum. Among the angiosperms there are in small quantity warm elements.

The Moldavian Lower Badenian referred to by Medjanik (1990) palynologically indicate that this territory was outside the Central Paratethys region. According to the palynological investigations in the Podolian layers the vegetation was explicitly dry. The dominating taxa belong to *Chenopodiaceae*, *Artemisia* and *Poaceae*. Water plants and ferns are very scarce.

From that part of the Ukraine which belongs to the Carpathian basin there are Late Badenian palynological results (Shchekina 1958). The palaeobotanical assemblage resembles rather to the coal facies of the Hungarian Lower and Middle Badenian, with many fern spores and tropical elements.

The Badenian flora of Slovakia (Pländerová 1990) is the same that the Hungarian one due to the close geographical connection. The difference is that in the Early Badenian a considerable number of new, mainly subtropical taxa appear. In the Middle Badenian a specific feature is the evaporite formation with xerophytic plants in Eastern Slovakia. In the Late Badenian there was an impoverishment of the flora connected with the transgression. It was the last appearance of some characteristic tropical plants like *Sapotaceae*, *Symplocaceae* and *Schizaeaceae*. At the Badenian-Sarmatian boundary there were shoreline swamp forests, with coal forming (Pacltová 1958).

Although the holostratotype of Badenian is in Austria, till now there was not too much palynological work done on this time unit. In Burgenland from freshwater layers a significant tropical flora has been described by Draxler et Zetter (1991). The swamp forest could be small, but there were many conifers from the rising Alps.

In Southern Poland the Middle Badenian evaporite beds are of the same age as the Slovakian ones. In the overlying gypsum marl layers there is an opencast sulphur mine. On the basis of the palynological investigation the flora has Transcaucasian character with Mediterranean climate (Oszast 1967). The flora indicates a cooler climate than in Hungary. According to Oszast (1960) the material of the Upper Silesian brickyard outcrop in Stare Glivice is Late Badenian (Tortonian). In this flora there were no more *Sapotaceae* and *Symplocaceae* just as in Slovakia. In the Nowy Targ – Orawa Basin palynological investigations found out (Tra Ding Nghia 1974, Oszast et Stuchlik 1977) that some parts of the section are Badenian (M₄). Characterising the Badenian flora they wrote that the *Taxodiaceae* – *Cupressaceae* swamp forest were still significant, but the warm elements disappeared, only *Engelhardtia* was present. The herbaceous plants were mostly *Cyperaceae*

and *Pteridophyta*. The climate was warm temperate, humid. In the meantime in the central part of the Paratethys Basin there were many thermophilic taxa, the climate was subtropical. The palynological results concerning the Polish Badenian indicate that the cooling effect of the high mountains prevailed.

According to the characterisation by Sadowska (1989) the Badenian flora in the Silesian Paratethys was similar to that of the Polish Western Carpathians. Along the seashore there were small swamp forests. Among the deciduous trees there were *Engelhardtia*, *Rhus*, *Carya*, *Pterocarya*, and the herbaceous plants were pteridophytes, grasses and *Chenopodiaceae*.

Silesia is the point where the Upper Badenian (Grabowiec) grades with continuous sedimentation to the continental Sarmatian Kędzierzyn beds of the Poznań Series (Dyjur 1986, Dyjur et Sadowska 1984). By means of this connection the correlation of the Paratethys Region with the Boreal Region can be established.

By the correlation of the Carpathian Foredeep and the SW Polish Basin (Dyjur et Sadowska 1985) we can state that the marine Badenian sediments of the Silesian Carpathian Foredeep and the continental Upper Tortonian sediments of the Lower Silesian are of the same age. The “Henryk” brown coal layers (Ist Lusatian Series) and the Gray Clay Series could be correlated with the Grabowiec beds of the Carpathian Foredeep as Upper Badenian beds.

According to Sadowska (1993) in the Lower Badenian of the Carpathian Foredeep for the palaeoflora the dominance of the deciduous trees was characteristic, with many warm elements. The best knowledge about the Upper Badenian is from the Silesian part of the Paratethys region, where the most important were from the conifers *Pinus*, *Abies*, *Cedrus*, *Tsuga*, and from the deciduous trees *Quercus*, *Ulmus*, *Fagus*, *Rhus*, *Engelhardtia*, *Carya*, *Pterocarya*. That time on the Polish Lowland extended swamp forests existed as well as the peat-bogs of the Henryk brown coal seam.

The sediments of the SARMATIAN stage according to the satellite map No. 5 (Hámor et al. 1988) were present on the territory of the Central Paratethys in smaller extension, in brackish-water facies. In Slovenia according to the palynological examination there were brackish planktonic organisms in the Sarmatian samples. At the shoreline swamp forests might have existed. Beside drier mesophytic forests with few warm elements and rich mountain forests with conifers characterized the palaeoenvironment.

The lower part of boreholes drilled in NW Bulgaria is Badenian, while the upper part Sarmatian, Volchinian or Bessarabian, respectively. In the list of the palaeoflora there are more tropical – subtropical elements than in the Hungarian one, in accordance with the latitudinal differences. In the Sarma-

tian part of the boreholes some tropical elements were missing e.g. *Pandanus* as compared to the Badenian. On the basis of the palaeogeographic maps, the Bulgarian part of the sea was connected with the Eastern Paratethys, although the vegetation can be identified with that of the Central Paratethys.

In the Transylvanian Basin, the lower part of a borehole drilled in Harbita district (Petrescu, Mészáros, Filipescu et Buda 1988) is Upper Badenian, the upper part is Lower Sarmatian. The Lower Sarmatian part can be divided in two parts. The lower part of the flora and also the climate is similar to the Upper Badenian, but in the upper part there is a greater change. The percentage of the conifers increased from 15% to 38%, out of that the *Taxodiaceae-Cupressaceae* were 20%. Among the angiosperms there were more warm elements than in the Lower Sarmatian. Another Sarmatian locality is near to Cluj-Napoca (Koložsvár), where besides *Pinaceae* dominance there were a lot of humid elements (Mészáros, Petrescu et Mărza 1991).

In the Ukraine, in the North – Eastern Carpathian area in the Chop (Csap)–Mukachevo (Munkács) depression the material subjected to palynological investigation, and verified also with foraminifers and molluscs, is considered as Sarmatian (Syabryaj et Vodoryan 1975). The mentioned tropical taxa are: *Araliaceae*, *Myrtaceae*, *Santalaceae*, *Symplocaceae*, *Rhus*, *Magnoliaceae*, *Palmae*, few *Gleicheniaceae*, *Cyateaceae* (?).

In Slovakia the Badenian – Sarmatian boundary coals and coal clays indicate swamp forest (Pacltová 1958, Sitar, Planderová et Čierna 1987). In the Danube Lowland (Kis Alföld) and in the Inner Carpathian basins the palynological investigation (Planderová 1990) revealed a rich Sarmatian sporomorph association, of with warm climate, without tropical taxa. In the Late Sarmatian the conifers and many dry elements were dominant. The climate was warm temperate and dry.

In Austria Klaus studied (1955) some samples from Karinthia, which he considers Sarmatian.

In Poland in the Nowy Targ – Orawa Basin the second phase was Sarmatian (M₅) (Oszast et Stuchlik 1977). There are many palynological papers on this region. The Tertiary taxa were characteristic, the deciduous trees and shrubs were dominant. The climate was warm temperate and dryer than the Karpatian and Badenian.

In the Silesian part of the Paratethys Basin according to the palynological results (Sadowska 1989) at the Sarmatian Kędzierzyn beds after the transgression of the sea a swampy area remained where *Taxodium-Alnus* swamp forest was living. The mesophyl forest, rich in species was dominant. The number of the tropical species were decreasing. The climate became gradu-

ally cooler and a little dryer. Besides the disappearance of the warm sea to the transformation of the climate contributed the rising of the Sudetes and the Carpathian ranges, too.

The Late Sarmatian age of the Poznań Series variegated clays was shown by Dyjor et Sadowska (1986) and Sadowska (1989, 1990).

According to Sadowska (1990) the most characteristic type of the Early Sarmatian flora was the mesophyl deciduous forest in the Western Carpathians, in the Silesian part of the Carpathian Foredeep and on the Polish Lowland. The *Taxodiaceae-Alnus* swamp forest was only moderately widespread. Conifers dominated in the Western Carpathian. North of the Central Paratethys area the angiosperms were present with many small leaves species (*Leguminosae*-type). Western Poland in the Sarmatian belonged to the West European flora province; its forests still contained high amounts of wet and warm elements with small brown coal seams.

The PANNONIAN sea of reduced salinity was a little more extended, but more isolated than the Sarmatian sea (map No. 5 in Hámor et al. 1988). Therefore it may be called a lake or internal lake, too. From Croatia there are no palynological data. The palynological data obtained from the boreholes drilled in NW Slovenia (Weyland, Pflug et Pantić 1958), and near the Croatian boundary in the Zagreb area (de Costa Grum 1993) are very similar to the Hungarian ones. The Lower Pannonian vegetation in Slovenia was very similar to the vegetation of the Mecsek Mountains. The planktonic organisms were also the same in the two territories. The Slovenian Late Pannonian corresponds to the upper part of the *Spiniferites bentori* zone (M. Sütő 1989).

In Bosnia in the Zenice – Sarajevo Basin the youngest formation is the Rakovice – Kasindol lignite (Pantić et al. 1966) which the authors range to the Lower Pliocene. The composition of the flora and the warm elements are the same as in the Hungarian Neogene swamp forests. There are some palynological data North of the Fruskagora, from the Beocin marl, that indicate the *Spiniferites bentori* zone.

The boreholes drilled in the North Western part of Bulgaria – according to the Eastern Paratethys nomenclature – are Meotian. This corresponds to the Pannonian (Ivanov 1995), in the opinion of Steininger et Rögl (1984) to the upper part of the Pannonian. In the material of these boreholes there are hardly differences from the Hungarian Pannonian palaeofloras. There are some tropical elements which have not been found in Hungary till now (*Euryale*, *Corylopsis*), but naturally there are also some Mediterranean taxa which are not present e.g. *Pistacia* and there are some which are more numerous (*Cedrus*, *Zelkova*). Ivanov indicates the beginning of a drier period

from the end of the Bessarabian, or the first part of the Meotian, which would be characteristic for the whole Balkan peninsula.

In Romania Pannonian palynoflora in the Transylvanian Basin of Oradea (Nagyvárad) in the lower part of a borehole was found, confirmed with ostracods (Petrescu, Nicorici, Wanek et Bildaru 1971). This palaeoflora is the same both in planktonic organisms as in sporomorphs like the other Pannonian palaeofloras published from Romania, Yugoslavia, Czechoslovakia and Hungary.

In the Ukraine in the North – Eastern Carpathian area from the basin of Aknaszlatina (Ignativska) a whole Pannonian section was studied by Syabryaj (1975). She submitted the section to palynological, molluscs and ostracods investigations. The palaeoflora was the same as in the Central part of the Paratethys Basin.

In Slovakia the Pannonian lake occupied only a small area (Hámor et al. 1988). This is verified by the palynological research of Planderová (1972, 1990). The most typical is the Pannonian of the boreholes at Nitra (Nagy et Planderová 1985). At the base of the Pannonian stage the brackish formation comes to an end and afterwards there are only freshwater sediments, with freshwater planktonic organisms. This territory is North of Hungary consequently the number of the subtropical elements decreased faster and that of the temperate species increased.

In Southern Poland in the Western Carpathian area and in the Nowy Targ – Orawa basin in the valley of the river Dunajec on the basis of palynological investigations on a number of sequences flora phases were established (Oszast et Stuchlik 1977). The upper parts of the sections by Czarny Dunajec and Koniówka are considered as Pannonian (MP). In this time the climate and vegetation oscillated, the instability was characteristic. There were temperate elements, in one horizon the warm, in the other the temperate species were dominant. In the mountains a great deal of *Picea* pollen grains occurred. In Poland this is the boundary of the presence of typical genera considered by the Polish scientists as Miocene. The climate was temperate, with warm oscillations and relatively dry.

The correlation of the Southern Polish area and Polish Lowland was presented in a table by Sadowska (1993), already with the nomenclature of the Paratethys area. Nevertheless for the younger stages than the Pannonian she showed the West European nomenclature, too. The palaeovegetation is doubtless cooler climate demanding than in the Central Paratethys region. Here could be drawn the boundary which separates the flora and the vegetation of the Paratethys area and the Northern territories. This boundary is not

irrefutable, because there are very great changes in the nature, on the surface of the Earth, by transgression and regression, by orogeny, differences in the exposition of the mountains, which produce great changes in the flora also today.

According to our present knowledge the PONTIAN stage is the highest level of the Miocene. According to map No. 6 (Hámor et al. 1988) it is somewhat more extended than the Pannonian. The territory of Croatia is in close connection with the central part of the basin. In Northern Croatia East of Varaždin there are coal-bearing sections, the macroflora of which was investigated by Špoljarić (1952), who studied the palynoflora, too. This place is connected with the Hungarian localities not only by the freshwater organisms, but also by the swamp vegetation, with a relatively high number of *Tilia* pollen grains and warm demanding ferns.

The results of the palynological investigation confirm our supposition of a connection between the Slovenian and the Hungarian basins. The upper part of the boreholes discussed at the Pannonian belong to the Pontian (de Costa Grum 1993). In these there are coal seams, which originally were swamp forests. In drier places there were deciduous forests. In the dead rock of the boreholes freshwater algae were found. In North – Eastern Slovenia palynological investigations were made by Weyland, Pflug et Pantić (1958) *Planorbis*, *Paludina* and *Mastodon arvernensis* remains were also found indicating also the Pontian age. The vegetation could be arranged to swamp, riparian, deciduous, and hillside forests, with warm elements.

In North – Eastern Bosnia the biostratigraphic dating of the coal basin originates from Stefanović (Weyland, Pflug et Pantić 1958), who ranged the four coal seams and their hanging rock in the Lower and in the Upper Pontian, respectively. The plant macrofossils and the palynological investigations supported this age.

In Serbia Pantić et Dulić (1993) divided the territory South of the Central part of the Pannonian Basin in the Pontian into two parts: 1) Southern part of the Pannonian Basin (Bačka, Banat and the territory South of the Sava line), 2) Eastern Serbia, the Western part of the Dacian Basin East of the Carpathian-Balkan Mountains.

The Kosovo brown coal basin was studied by Nikolić (1966). He described the sporomorph assemblages characteristic for the Hungarian Pannonian and freshwater planktonic organisms. The Late Pannonian is supported also by the mollusc fauna with *Prosodacna* cf. *vutskitsi* Brus.

It is worthy to be mentioned Pantić's explanation in the Pontian volume (1990) of climatic reasons of identities of lignite facies in the Balkan and in

Hungary. His conclusion was based on the palynological investigations of the lignite area by Ptolemais in Macedonia (Weyland, Pflug 1957). In these investigations also Pantić participated (Weyland, Pflug et Pantić 1958). The lignites of Ptolemais were investigated by many scientists from numerous localities (Ioakim 1964, Weerd 1983, Kaouras 1989) with palynological method. The vegetation was chiefly *Taxodiaceae-Nyssa* swamp forest with many warm elements. The age of the lignite is given in different nomenclatures as Pontian, Plaisancian-Tabianian, Serravallian, Messinian or Pliocene. These data also emphasize the consequences of the similarity in facies, and how important the radiometric dating would be.

In some boreholes in North – Western Bulgaria there are Pontian layers, too (Ivanov 1995). There are no great differences between the palynological diagrams of the Pontian and Pannonian. In the Pontian there are slightly more cf. *Podocarpus*, *Ginkgo*, *Hedera*, *Liquidambar*, *Juglans*, *Pistacia* pollen grains. About the palynological investigation of a Pontian locality NW from Sofia inform us Petrov and Drazheva-Stamatova (1964).

In Romania there are numerous Pontian localities with palynological data. The upper part of a borehole drilled at Oradea is Pontian (Petrescu, Nicorici, Wanek et Bildaru 1978). The *Sphagnum* with many species and the increased number of *Fagus* pollen grains are similar to the Hungarian data. In the range of the Eastern Carpathians there are many small Pontian basins. In Maramures is located Chiusbaia locality where famous plant macrofossil investigations were made by Givulescu, but there were palynological investigations, too (Givulescu et Diakoneasa 1985). At the bottom *Picea* was dominant, but later its number decreased as the climate became drier and a deciduous tree ensembles appeared; they suppose a *Fagus* era. The same phenomenon is observed in Hungary in the Pontian. South of the Monts Călimani (Kelemen Havasok) is the Pliocene Borsec (Borszéki) Basin. The first palaeobotanical research was made by Emil Pop (1936). In his work the accent was on the study of the macroflora, but he reported about many sporomorphs, too. That time the age was uncertain, but this was solved in a later work (Petrescu, Nicorici, Atudorei, Harlav et Giosu 1987). They investigated in many boreholes the coal bearing sections, complemented with the study of molluscs and divided the sections in 3 parts. 1) Lower Pontian where the angiosperms were dominant (60–70%), with many warm elements. The coaly layers with swamp forest. 2) Pontian-Dacian. The lower part is blue clayey marl with a coquina of *Congerina* (therefore they hold it for Pontian). The upper part is marly and yellow, this is Dacian and it was on this that Emil Pop worked. There are many conifers, mainly *Pinaceae* (45–60%). In the climate a cool-

ing was going on. 3) Romanian. The number of conifers was decreasing, the angiosperms were increasing (to 75%). On the basis of the palynoflora the lake became a completely freshwater one, its extension smaller and the climate warmer.

The Baraolt Basin is a small intramontane basin, which was formed as a result of the downthrow of this area during the late Attic orogenic phase in the Early Pontian and the subsequent dam-forming volcanic eruptions (Petrescu, Buda et Boer 1988). The investigated borehole has been divided into two parts: 1) Pontian Productive Formation. At the base Paradacna abichi occurs with congerias, therefore this part is considered to be Lower Pontian. The vegetation differs from the Hungarian: the *Taxodiaceae* stock was smaller, the swamp would have taken its origin from other water plants and shrubs. After the volcano had closed the area from the brackish water, a quiet freshwater lake developed with freshwater algae and *Nymphaeaceae*. In the vegetation there were many warm elements, because of the southern position and being protected by the surrounding mountains. There were *Asclepiadaceae* (*Manikinipollis*), which were present in Hungary only in the Sarmatian. Among the conifers *Picea* was dominant, probably in consequence of the high mountains. *Cedrus* indicated the Mediterranean. In the spectrum the angiosperms were dominant, they constituted the swamp. In the overlying Linnocadium marl the warm elements were decreasing, the conifers increasing. This part of the sequence may be Upper Pontian. 2) Dacian-Romanian Ostracod Marl Formation. The vegetation is like that of the Upper Pontian. Presumably in Romanian time there was a slight climatical warming, but were only 4–6% the warm elements (*Arecipites*, *Podocarpidites*, *Magnolia*, *Myrica*, *Engelhardtia*, *Eucommia*, *Araliaceae*).

The 4 boreholes drilled in the Braşov-Tirlungeni area East of Braşov have similar palaeovegetation as the above mentioned (Petrescu et Buda 1986). Above the bottom conglomerates there is the Pontian lower horizon with brown coal (brown-earthy group) divided in two parts. For the lower part are characteristic many *Cedrus* pollen grains, lots of angiosperms and a few fern spores. In the second part there were many angiosperms but with taxa characterising a warmer climate. Sporadically are present *Araliaceae*, *Parthenocissus*, *Cupaneidites cf. eucalyptoides*, *Myrtaceidites myrtiformis*, *Reevesia-pollis triangulus*. Among the conifers there are relatively few *Cedrus* pollen grains. There are numerous fern spores, characteristic of a swamp. In the middle marl level there are so many *Picea* pollen grains that it was named "picea level" and referred to the Pliocene, Dacian. The overlying grey, argillo-arenaceous horizon is considered on the basis of lithology as belonging

to the Romanian stage. At the top there is Quaternary: gravels, sands, block boulders, limestone blocks and sandstones.

South of the Carpathians the Neogene palynological studies indicate nothing older than Pontian. An outcrop East of Turnușeverin (Petrescu et Malan 1991–1992) in Upper Pontian beds the conifers are dominant (67%), characterised by great number of *Cedrus*. *Quercus* makes up 10% of the angiosperms. Above the coal seams in the Lower Dacian marly sandy layers the number of the warm elements was increasing (*Itea*, *Myrica*, *Reevesia*, *Engelhardtia* and palms). This basin is South of the Carpathians; it is protected from northern climatical influences and its flora is similar to the palaeofloras of North Eastern Bulgaria.

In SW Romania in the Husnicioara area there is an outcrop with lignite layers. From one of them palynological investigation was made (Petrescu, Cernita et al. 1989). The palaeoflora is very similar to that of the other Pontian lignites. Another lignite locality is at Lupoiaia (Gorj county) the age of which is Dacian-Romanian. The palynological examinations were made mostly in the Romanian stage. The rich palaeoflora indicates a considerable warming.

In South Western Moldova there is a Pontian outcrop which Medjanik divided (1985) into two parts on the basis of the results of palynological investigations. The lower part is a coal unit, the upper part is made up by limestone, silt, sand and clay. The lower level contains 88–90% of tree pollen grains, 60–87% of these are gymnosperms, of this 48–65% *Taxodiaceae* pollen grains. The other pollen grains refer to broad leaf mesophyl forest. In the upper level dominated (86–94%) the angiosperms, with explicitly xerophilous character.

In the Ukraine the investigated locality is in the W-SW part of the lowland of Chop (Csap), in the Ilinskaja beds. These consist of brown coal, lignite, clay, sand and tuffite. Two palynologists investigated these layers. Ribakova (1966) ranged the layers with two coal seams into the Middle, respectively into the Upper Pliocene, while Syabryaj (1967) put both into the Upper Pliocene, into the Levantian. Angiosperms prevailed in the palaeoflora; this indicates Late Pliocene, but the high number of the warm elements concludes to Early Pliocene. This phenomenon might be also the consequence of the local climate of a well-protected area.

According to Planderová (1972) in Slovakia the Pontian stage is divided into two formations. The lower one is a coal series, the upper one a variegated clay series. Above them are the Romanian, respectively the Levantian layers. On the basis of the map No. 7 (Hámor et al. 1988) the Pontian was extended in Slovakia in the Danube Lowland, in direction of the Váh (Vág) val-

ley, and in SE Slovakia with small extension, in lacustrine facies. In the Pontian the disappearance of the subtropical elements and the spreading of the herbaceous plants is very conspicuous (Planderová et Papsiková 1990). The list of the palaeoflora is not different from the Hungarian.

In the Western part of Bohemia, in the Cheb Basin the youngest formation is the Vildštejn Formation. By the palynological investigation (Stuchlik 1982) it was divided into three botanical units. The lowest was an *Alnus* – *Sphagnum* swamp and mesophyl forest, the second *Alnus-Taxodiaceae-Cupressaceae* swamp forest and mesophyl deciduous forest with big shrub stock. The third one was an open swamp and marsh with many herbaceous plants. Tertiary and Quaternary elements are equally present in the spectra and the NAP/AP ratio refers also to the Neogene. The age of the Formation is according to the author Pliocene, with transitional character to the Pleistocene. In South Bohemia in the Třebon basin Pacltová (1963) made palynological investigations and she ranged the section of Lednice into the Reuverian. The spectra are very similar to those of the Pontian in Hungary. The author ranged the sediments of Vonšov – Nova Ves in Cheb Basin into the Pretegele – Tegelen on the basis of the data of Szafer, Oszast, Zagwijn.

Klaus' Thesis in manuscript deals with the Pontian flora of Neufeld (Austria). In a paper about the brown coal at Hausruck he wrote briefly about the Neufeld flora, too. The Hausruck flora was in his opinion also Pontian. In the framework of the Hungarian-Austrian geological cooperation a paper was prepared on some boreholes of the boundary area of the same brown coal formation. The data were very similar in the Pontian "F" layers (after Adolph Papp) /Draxler, Nagy et al. 1997/.

In Poland in the Western Carpathian area, in the valley of the Czarny Dunajec river, Oszast and Stuchlik (1977) made palynological investigations. From the phases of the floral changes which the authors established the IVth is the Pontian. The top of the sequences of the locality of Czarny Dunajec and Koniówka is considered as Pontian. In this the conifers were dominant and from the angiosperms the *Alnus incana* – *glutinosa* type. There were no more tropical elements. The sporomorphs indicate temperate climate. The last mentioned Pontian localities are the profiles of Krościenko and Domański Wierch which are considered as Dacian. The conifers were dominant. The angiosperms referred also to temperate climate, among them there were a few *Pterocarya*, too. The climate was temperate also here.

From the *floristical* point of view we can state with the help of the flora determined by the palynological investigations and the vegetation reconstructed from these that during the lower part of the Neogene the territories

adjacent to the Paratethys were sufficiently uniform. In the Northern Polish territories certain tropical elements are absent. The Central Paratethys area kept the “central” character also in the Lower and Middle Neogene when the ranges of the Alps and Carpathian Mountains were rising. The palaeovegetation was very similar to that of the Pannonian Basin in Croatia, Slovenia, Serbia, Bosnia, Transylvanian Basin, North Eastern Carpathian area, Hungary, Slovakia, South Moravia, Vienna Basin, and in the examined area of Styria. In the Middle Miocene some tropical taxa are absent in South Poland even at the shoreline of the Paratethys sea. South of the central part rather more warm elements are to be found, in spite of the fact that on the high mountains the highland vegetation was increasing, e.g. in Transylvania and in Bosnia. The Late Miocene is characterised by the fact that the water of the Paratethys became brackish and the sea itself narrower. In the whole the vegetation of the Miocene represents certain unity due to the presence of the swamp forests. The swamp forests are composed mainly by the *Taxodiaceae* family and contain more or less warm, respectively tropical elements. This is connected with the location of the swamp forest, namely in which part of the subtropical area they grew. Therefore the Hungarian brown coal territory is comparable with the Greek or even with the Turkish brown coal territories. The vegetation boundary of the Paratethys area in the West is the Alps and Dinarides, in the East the Carpathian Mountains and the East European dry vegetation; in the South there is a gradual transition to the Mediterranean area in Greece, while in the North the boundary is the Southern line of the Polish Lowland.

The *palaeogeographical* circumstances in the Early Miocene were still not very varied in the Paratethyan territory, that is why the palaeofloras are so similar. In the Middle Badenian in the time of the Laithaian orogenic cycle the effect of the developed mountain systems already appeared in the palaeofloras, palaeovegetation. In Southern Poland, at the end of the Karpatian stage when the Paratethys sea was present, the character of the flora and vegetation was subtropical, but some tropical species were missing, which in the central area are very characteristic. On the other hand South of the Pannonian Basin the Balkan area, due to the geographical position, with mountains in the North and partly being open to the Eastern Paratethys have plenty of warm flora elements in younger geological time.

The change in the palaeoflora and palaeovegetation is connected with the changes of the *palaeoclimate*. During the whole Neogene the climate was not tropical in the area of the Central Paratethys. According to the palynologists working on the Neogene the general trend was in the climatic changes from warm subtropical climate to temperate climate. On the basis of the palyno-

logical data of the Lower Miocene the climate was more uniform before the rise of the young mountain chains. There are many flora elements common with the middle part of the Central Paratethys and the Northern areas, but the Polish palynologists showed unambiguously that some "Paleogene" elements are missing in their territory.

The Lower Miocene palynological data of Hungary are the same that those in Austria and in Transylvania. It is an other question what kind of species are considered by the author as tropical or subtropical or even as "arctotertiary" elements (Hochuli 1978). In the case of the Transylvanian Basin the authors (Prtrescu, Givulescu, Barbu 1997) the Cornești-Aghireș palaeoflora is totally identical with the Egerian holostratotype considered to be Chattian. To settle this question is a duty of the geologist stratigraphers.

It is a pity that the palynology of the Lower Miocene in the territory South of the Pannonian Basin has been studied only incompletely. The few data from Northern Bosnia led to the conclusion that the palaeoflora is unambiguously identical with that of the central territories and so the climatic identification is possible.

The palaeoflora of the Middle Miocene was varied, because of the coal formation on the West, and evaporite on the East. Just because of that it is very difficult to determine their evolution in the time and to correlate the coal seams. Namely, the coal formation is considerably connected with palaeogeographical factors, it is not entirely simultaneous. The peculiarity in the Middle Miocene is that not so far from the humid coal formation, there are dry circumstances, evaporite formation (in Slovakia, Poland, Romania). There is a remarkable change in the flora and vegetation in the Middle Miocene. The abundant new flora elements are more subtropical and belong to the underwood. This phenomenon refers to the cooling of the climate. This is supported by the fact that the vegetation is represented by many pollen grains of the temperate forests. North of the central part in the Polish area a warm temperate climate, South of them a warm subtropical climate was characteristic.

In the Upper Miocene North of the central area the climate was temperate, chiefly in consequence of the regression of the Paratethys, but also influenced by the young high mountains. The climate of the central part was in the Early Pontian subtropical in accordance with the opinion and figure of Pantić (1990). Later, after the Pontian this character came to the end and the climate was warm temperate to temperate. The Southern area, however, has preserved this character.

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EGERIAN

I.

- 1–2. *Pleurozonaria manumi* (Kriv.-Hutter 1963) Rákosi 1973
3. *Deflandrea spinulosa* Cooks. et Eis. 1965
4. *Cicatricosisporites lusaticus* W. Kr. 1957
- 5–6. *Favoisporis hungaricus* Nagy 1983
7. *Polypodiaceoisporites gracillimus* Nagy 1963
8. *Leiotriletes maxoides* W. Kr. 1962 *maxoides*
9. *Polypodiisporites alienus* (R. Pot. 1931) Nagy 1973

II.

10. *Keteleeriaepollenites komloënsis* Nagy 1969
- 11–12. *Pinuspollenites longus* Nagy 1985
13. *Ulmipollenites stillatus* Nagy 1969
14. *Plicatopollis plicatus* (R. Pot.) W. Kr. 1962
- 15–16. *Sapotaceoidaepollenites manifestus* (R. Pot. 131) R. Pot. 1960 *contractus* Pf. 1953

BADEMAN

I.

1. Plankton "A"
- 2–3. *Mecsekisporites cerebralis* Nagy 1968
- 4–5. *Bifacialisporites grandis* Nagy 1985
- 6–7. *Bifacialisporites medius* Nagy 1969
8. *Leiotriletes wolffi*: W. Kr. 1962 *wolffi*

II.

- 9–10. *Cedripites eocenicus* Wodeh. 1933
11. *Liquidambarpollenites orientalisformis* Nagy 1969
12. *Faguspollenites vivus* Nagy 1969
- 13–14. *Sapotaceoidaepollenites obscurus* (Th. et Pflug 1953) Nagy 1969
- 15–16. *Sapotaceoidaepollenites cf. microrhombus* (Pf. 1953) Nagy 1969
- 17–18. *Myricipites rurensis* (Pf. et Th. 1953) Nagy 1963

19. *Avicennia* sp.
20. *Quercopollenites robur* type
21. *Armeria* sp.
22. *Caryapollenites simplex* (R. Pot. 1931) Raatz 1937 *simplex*
23. *Momipites punctatus* (R. Pot. 1931) Nagy 1969
24. *Juglanspollenites maculosus* (R. Pot. 1931) Nagy 1969

III.

- 25–28. *Tricolporopollenites sibiricum* (Ludomirova 1974) Nagy 1992
- 29–30. *Rutacearumpollenites komloënsis* Nagy 1969
31. *Caprifoliipites andreanszkyi* Nagy 1969
32. *Piceapollenites*, *Zelkovaepollenites*, *Ulmipollenites*, *Rutacearumpollenites*, *Chenopodipollis*

PONTIAN

I.

1. *Cooksonella circularis* Nagy 1965
- 2–3. *Botryococcus braunii* Kützg. 1849
4. *Abiespollenites absolutus* Thierg. 1937

II.

- 5–6. *Abiespollenites sivaki* Nagy 1985
7. *Stereisporites Stereisporites megastereis* W. Kr. 1965
8. *Tsugaepollenites igniculus* (R. Pot. 1934) R. Pot. et Venitz 1934
- 9–10. *Cedripites deodoraesimilis* (Nagy 1969) Nagy 1985

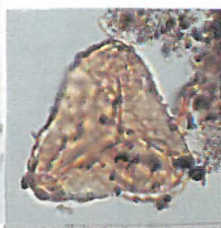
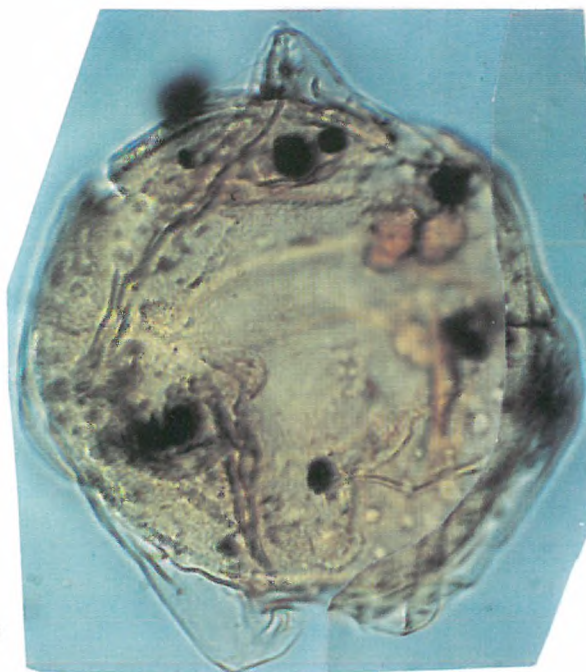
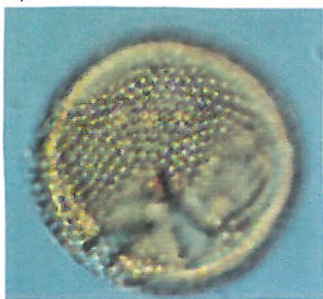
III.

- 11–12. *Tsugaepollenites gracilis* (W. Kr. 1971) Nagy 1985
13. *Piceapollenites neogenicus* Nagy 1969
14. *Tsugaepollenites maximus* (Raatz 1937) Nagy 1985
- 15–16. *Intratrisporopollenites cordataeformis* (Wolff 1934) Mai 1961
17. *Caryapollenites simplex* (R. Pot. 1931) Raatz 1937 *simplex*

PLATES

Egerian: I–II. Photos from the Egerian holostatotype
All photos are magnified by 800x

EGERIAN I.



EGERIAN II.



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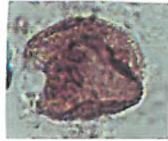
19



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17



18

Badenian: I–II–III. Early Badenian palynomorphs from Northern Hungary

BADENIAN I.



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BADENIAN II.



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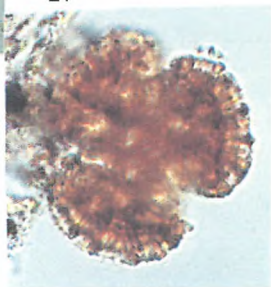
18



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24

BADENIAN III.



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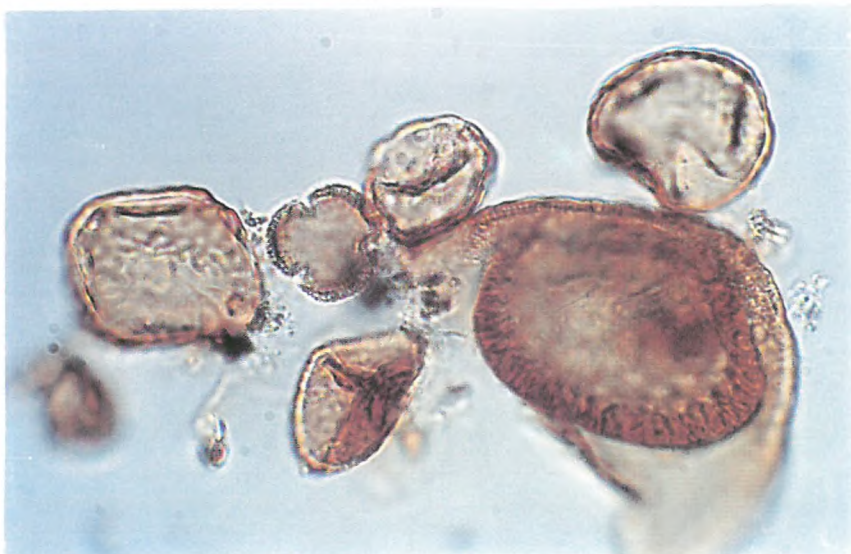
27



28



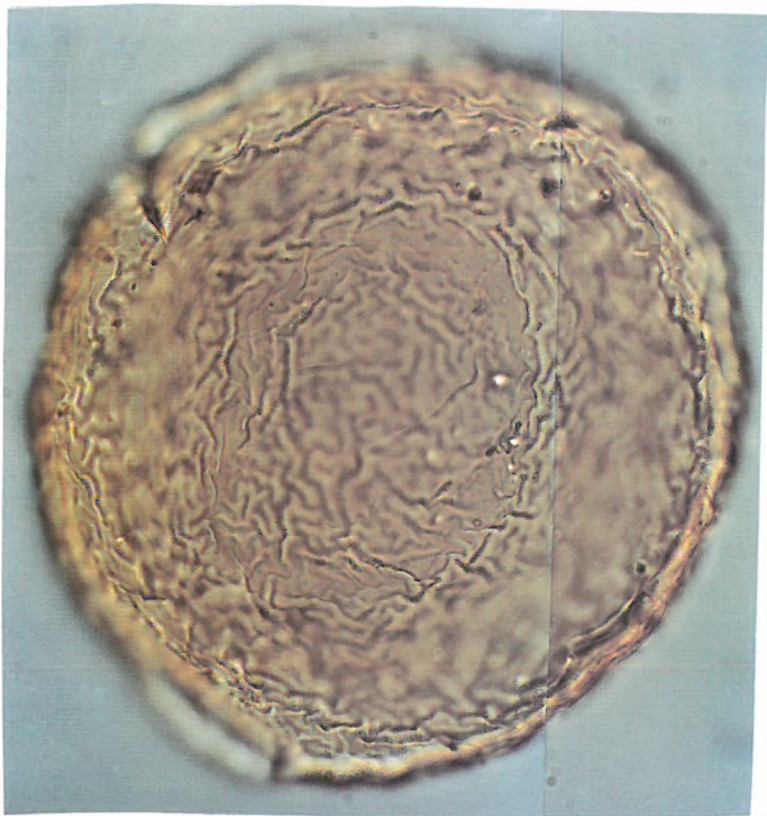
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32

Pontian: I–II–III. Pontian palynomorphs from Western Hungary

PONTIAN I.



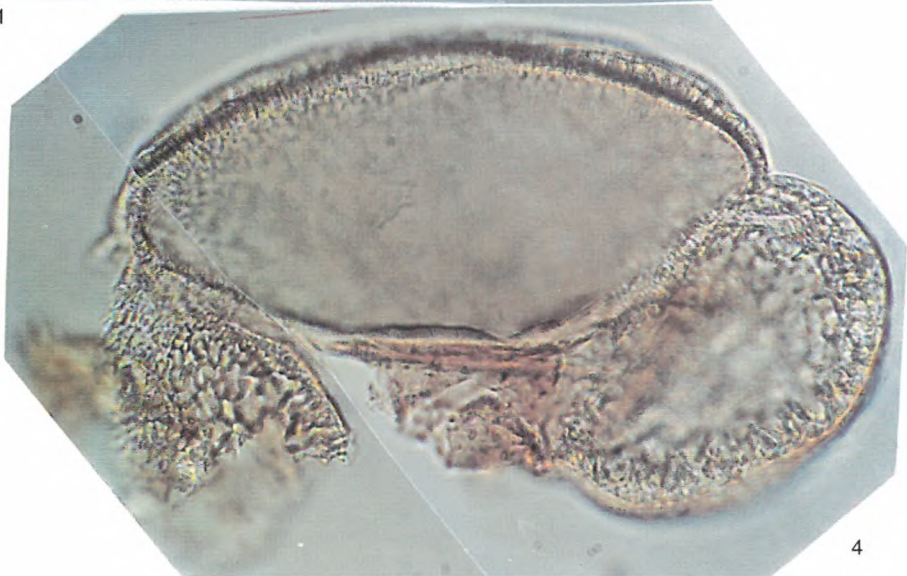
1



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PONTIAN II.



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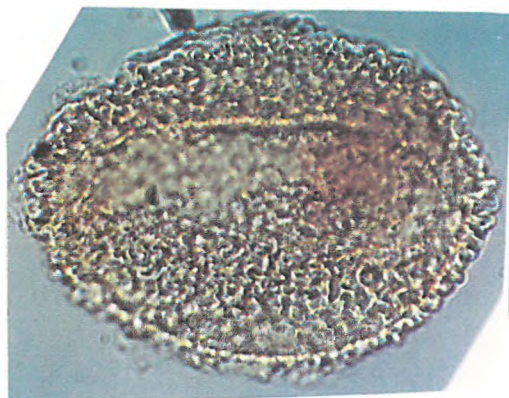
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PONTIAN III.



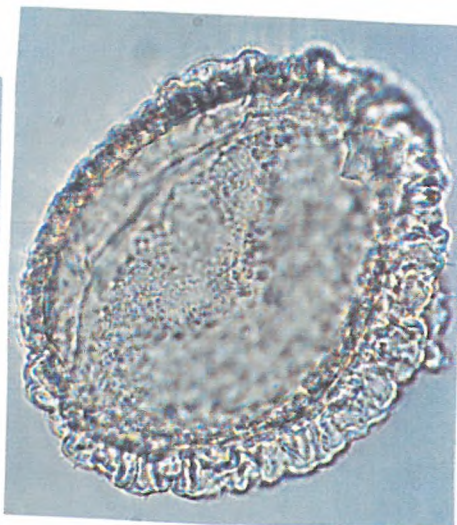
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