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Neogene of the Polish Lowlands — lithostratigraphy and pollen-spore zones

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The Neogene deposits of the Polish Lowlands, mostly continental, occur in form of replicating complexes of clays, sands and gravels with consequent lignite benches, frequently thick ones. Lithological setting was a base of stratigraphy of these deposits during more than 100 years. The new summary of the results of lithostratigraphical works, correlation of the Neogene chrono- and lithostratigraphical units on the Polish Lowlands and adjacent areas have been presented in this paper. Fourteen pollen-spore zones (I–XIV), characterizing all the lithostratigraphical units, have been also established.

INTRODUCTION

An absence of index fossils in the Neogene, predominantly continental sediments of the Polish Lowlands, was a reason of creating of lithostratigraphic subdivision there. With years, the biostratigraphical data were continuously completed. However, some terms presently used, as for example the Poznań Clays, the Basal Coal Seam, or the Foundry Sand Group, have been informal units for the last 100–150 years. Up to the sixties, the Polish Lowlands Neogene was divided into two main lithostratigraphic groups: (1) the lignite-bearing sediments representing Miocene, and (2) the vari-coloured Poznań Clays related to uppermost Miocene and Pliocene. Lower-rank lithostratigraphic units have not been defined and the subdivision to the Lower, Middle and Upper Miocene (at that time informal one) have been used. Some parts of the Neogene stratigraphical column have been compared to the "classic" Neogene stages.

The first elements of the more detailed lithostratigraphic subdivision of the Polish Lowland Neogene have been presented by E. Ciuk (1965, 1967), and a complete Neogene stratigraphical subdivision has been published in a later paper of the same author (E. Ciuk, 1970). At the same time, the independent Neogene lithostratigraphical subdivision in Lower Silesia and the Ziemia Lubuska region has been presented by S. Dyjor (1969, 1970). Both subdivisions have been prepared on a base of good knowledge of Neogene lithological columns of Poland, mostly from the western and central parts of the country; they partly used the earlier subdivisions in Germany (a.o. W. Krutzsch, D. Lotsch, 1960; H. Ahrens, D. Lotsch, 1963; D. Lotsch, 1968). The lignite seams have been applied for regional correlations. The Miocene stratigraphic column has been divided into the informal chronostratigraphical units (Lower, Middle and Upper Miocene); all the other units have been also informal.

PRINCIPLES OF THE SUBDIVISION PROPOSAL

The recent Neogene subdivision in Europe has been established in 1975 by the 6th RCMNS Congress in Bratislava, where the international chronostratigraphic standard has been defined. The terms: Lower, Middle and Upper Miocene, previously informal ones, have been accepted as the formal units of the super-stage rank (Girondian, Cessolian, Castellanian). During the next years, this subdivision has been correlated with the Tethys and Paratethys stratigraphic schemes (a.o. F. Steininger, F. Rögl, 1993; W. A. Berggren, 1984; F. Steininger *et al.*, 1985) and this correlation has been accepted by the 8th RCMNS Congress in Budapest in 1985. The Paratethys stratigraphy has been also compared to the North Sea stratigraphical subdivision (C. H. V. Daniels *et al.*, 1985) and European continental Neogene (H. W. Zagwijn, H. Hager, 1987; F. Steininger *et al.*, 1990). In connection with these formal changes and with the general progress of geological research, a new concept of correlation of the Neogene lithostratigraphic scheme in western Poland with the stratigraphical units of the Silesian part of the Paratethys, has been elaborated by S. Dyjor (1986) and S. Dyjor, A. Sadowska (1986*a*, *b*).

The new results of stratigraphical studies and lithostratigraphical observations have made possible to precise and update the earlier correlation schemes. They also allowed to extend more widely the existing stratigraphical scheme in the Polish Lowland area, particularly in the western and central parts. Lithostratigraphical units of the Polish Lowland Neogene may be recently related to the international chronostratigraphic standard and regional stratigraphical units of the central Paratethys and the North Sea region. However, the correlation is not extremely precise, basing partly on unfrequent data dispersed in many geological profiles and on distant correlations.

Some lithological features of the Neogene sediments have been applied for correlations; lignite seams are especially usefull for that, but they are certainly diachronous. Therefore, the floristic phases and pollen-spore zones, defined in some papers (D. H. Mai, 1994; J. Raniecka-Bobrowska, 1970; M. Ziembińska-Tworzydło, 1974; P. A. Hochuli, 1978; M. Ziembińska-Tworzydło, H. Ważyńska, 1981; R. Vinken, 1988; E. Planderová, 1990) are a base of chronostratigraphical correlation and definition of geological age.

The Neogene pollen-spore zones (Tab. 1) have been defined on a base of many geological profiles in the Polish Lowlands, where palynological studies have been made taking into consideration: (1) a botanical affinity of spores and pollen taxa (M. Ziembińska-Tworzydło *et al.*, 1994) and (2) possible relations to the plants of the Arcto-Tertiary and palaeotropical floras (E. Planderová *et al.*, 1993). Species of spores and pollen grains, considered as characteristic for the defined zones, are presented in Table 1 and illustrated on Plates I–V. The pollen-spore zones, established on a base of changes of the species assemblages, have been considered as the parastratigraphical palaeoclimatic phases in the sense of O. W. Schindewolf (1960).

There was not possible to establish any universal criteria characterizing the climatic changes on a base of predomination of one or few taxa for the following reasons: (1) Neogene climatic changes were of varying-scale, and (2) very few floral assemblages in the rich Neogene floras were dominated by one or several taxa. Therefore, the authors considered two features to define the floristic phases: (1) percentage of spores and pollen grains of the plants with precised climatic requirements in the floral assemblages, and (2) frequency of species in the assemblages. The last one is a diagnostic feature for reconstruction of the predominating Neogene floral assemblages. Names of the pollen-spore zones are frequently related to the important species for the zone, but not always most abundant one; it considers particularly the entomophylous ones.

Some other bio- and mineralogical markers are also more or less significant for stratigraphic correlation. They are:

— foraminifers, recorded in the central part of Silesia (Opole vicinity) in the so-called Nysa Kłodzka Embayment (E. Odrzywolska-Bieńkowa, 1985), and in the Poznań Formation deposits of the Lower Silesia and Wielkopolska provinces (E. Łuczkowska, S. Dyjor, 1971; M. Piwocki, 1975; M. D. Giel, 1979);

— mammal remains, particularly in the geological profile of the Bełchatów lignite deposit of the Karpatian-Badenian (MN 4–6) and Pannonian (MN 9, 10) ages (J. Głazek, A. Szynkiewicz, 1987; K. Kowalski, 1990);

— tuffaceous horizons in the lignite deposits of the Konin region and the Bełchatów deposit (K. Matl, M. Wagner, 1985, 1986; L. Czarnecki *et al.*, 1992*a*, *b*; S. Lorenz, W. Zimmerle, 1993), correlative with the tuffaceous horizons of the Carpathian Foredeep; they have been dated with the fission-track method as 18.2±1.7 to 16.5±1.3 Ma BP, i.e. to Ottangian-Badenian (J. Burchard *et al.*, 1989; L. Stuchlik *et al.*, 1990; L. Czarnecki *et al.*, 1992*a*);

— fresh-water molluscs at the Bełchatów, Złoczew and Rawicz vicinities, which are known in Europe in the Ottnangian-Badenian sediments (A. Nowicki, E. Woźny, 1965; E. Woźny, 1968; E. Ciuk, M. Piwocki, 1967; M. Piwocki, 1975; E. Stworzewicz, A. Szynkiewicz, 1988).

A newly completed column of the Neogene stratigraphic subdivision of the Polish Lowlands (Fig. 1) has been prepared after the premises as above. This improved table has been correlated with the neighbouring areas (Fig. 2) and connected with the chronostratigraphic units of European Neogene. This subdivision is the one more informal proposal, because the proposed litostratigraphic units does not fulfil completely the conditions defined by the National Stratigrahic Code (*Zasady...*, 1975). The E. Ciuk's terminology (E. Ciuk, 1970, 1974, 1982), with supplements after S. Dyjor (1970, 1974, 1978, 1994), has been adapted to nomenclature of these informal units. Lower-order units (e.g. "beds") and local units, e.g. limited to an area of one lignite deposit only (Turów, Bełchatów, Złoczew), has been not defined here. The suggested new subdivision is easy to correlate with the lithostratigraphic column of the East Germany Neogene (W. Alexovsky *et al.*, 1989; G. Standke *et al.*, 1992; TGL 25234/08, 1981).

SUBDIVISION PROPOSAL

The Neogene deposits of the Polish Lowlands occur within the eastern part of the North-West European Tertiary Basin, described and defined in the monographical paper by R. Vinken (1988). The most typical Neogene profiles, complete and well-known ones, are in the western part of the Polish Lowlands. In the southwestern part of Poland, the Neogene deposits of the Polish Lowland basin adjoins the Neogene of the Upper Silesian part of the Carpathian Foredeep (S. Dyjor, A. Sadowska, 1977, 1986*a*, *b*). Neogene sediments of western Poland are 100–200 m thick in average, but their thickness increases up to 200–300 m in the areas of stronger subsidence and in tectonic depressions, extremely exceeding 400 m in some small areas.

Miocene deposits of western Poland are underlain by light grey, quartz-micaceous sands, locally with light brown silty intercalations and lignite lenses. These sediments belong to the **Leszno Formation**, which originated in brackish conditions, related to the Oligocene sea retreating towards NW. It is an equivalent of the Obere Cottbuser Folge in Germany (TGL 25234/08, 1981). There are not any markers, making possible to define an age of these deposits. It is generally accepted that these deposits mostly represent Chattian (H. Ahrens, D. Lotsch, 1963; D. Lotsch, 1968; W. Alexovsky *et al.*, 1989).

LOWER MIOCENE

Limnic-fluvial sedimentary association, together with alluvial fan sediments originated on widespread accumulation plain, following after the sea regression. These deposits represent the **Rawicz Formation** in the southern Fore-Sudetic area, and the **Gorzów Formation**, partly brackish one, in the central part of the sedimentary basin.

The **Rawicz Formation** begins with lignite-bearing association, developed as coaly clay and silt with lignite seams belonging to the IV Group of Seams (Dąbrowa Seam); the latter is of lithostratigraphical rank of member (Dąbrowa Member). It is overlain by light grey unequigranular sands with quartz and feldspar gravel grains, and light grey silt and clay, frequently kaoline ones, with vari-coloured clay intercalations. This unit has been defined after S. Dyjor (1974, 1978, 1994) as the Żary Member and it corresponds to the Spremberger Folge in East Germany (TGL 25234/08, 1981).

Towards the central part of the basin, the Rawicz Formation sediments pass to light grey and grey-brown quartz sands with quartz gravel layers and local silt and lignite intercalations. These should be defined as a new unit — the **Gorzów Formation**. Similar sediments have been described in older German papers as the Quarzsand Gruppe or the Quarzsand Horizont (P. Sonntag, 1919; H. W. Quitzow, 1953). The updated unit — Mölliner Schichten (TGL 25234/08, 1981) is a modern equivalent of this series.

A substantial part of the described sediments has been formed during the early period of Early Miocene, but in marginal parts of the basin they probably started to develop as early as in the latest Oligocene. These deposits include pollen and spores characterizing the I and II pollen-spore zone and they correspond to the II and III Mai macrofloral zone (D. H. Mai, 1994).

The continental sediments with the I pollen-spore zone assemblage are known mostly on the Fore-Sudetic Monocline (M. Ziembińska-Tworzydło, 1974). The zone name is derived from the species *Olaxipollis matthesii* Krutzsch, representing the tropical Olacaceae family, which occurs in this zone with a particular regularity. The pollen assemblage is rich and diversified, and it includes great amount of pollen of angiosperm plants. Sporomorphs of the plants of palaeotropical geoflora are abundant and some of them belong to the palaeotropical taxa (P1), including genus *Alangiopollis barghoornianum* (Traverse) Krutzsch, very rare in Neogene, pollen of the palms *Dicolpopollis kockelii* Pflanzl and spores of the fern family Schizaeaceae — *Cicatricosisporites chattensis* Krutzsch. Arcto-Tertiary geoflora is represented unfrequently, mostly by pollen of plants of warm-temperate element (A1). Mixed mesofilous polygeneric forests, partly evergreen ones, dominated plant assemblages during the origin of substantial part of the Dąbrowa Member deposits. Area of the lignite sedimentary basin was overgrown with swamp forests, consisting mostly of *Taxodium*, *Alnus*, *Nyssa* and many Polypodiaceae in an undergrowth. The pollen assemblage indicates favourable conditions for rich exuberant vegetation in warm-temperate humid climate.

The assemblage of the II pollen-spore zone is known in some localities of the southern Wielkopolska and is extremely rich in the lower part of lignite-bearing association in the Turoszów (Zittau) Basin (M. Ziembińska-Tworzydło, 1974, 1992). The zone name is derived from very frequent pollen of the *Alnipollenites verus* (Potonié) Potonié. This assemblage is scarce and poorly differentiated. It mostly consists of pollen grains of plants belonging to warm-temperate element of Arcto-Tertiary geoflora with relatively frequent conifer pollen. Plants of palaeotropical geoflora are rare and represented by subtropical species (P2) only. The sporomorph assemblage, occurring in sediments of the same stratigraphic position, indicates inconvenient conditions for development of polygeneric mesophilous forest. Scarcity of pollen and low species frequency might be related to general climatic deterioration, which is evidenced also by sudden changes of swamp assemblage composition, going to be substantially scarce with *Alnus* and Polypodiaceae predomination. Coal-forming biomass production was very low at that time, because coal intercalations are infrequent in the upper part of the Rawicz Formation (Żary Member), and all of them contain similar pollen-spore assemblages. In small swamp basins, existing at that time, alder tree almost completely replaced *Nyssa*, a typical element of Neogene swamp forest.

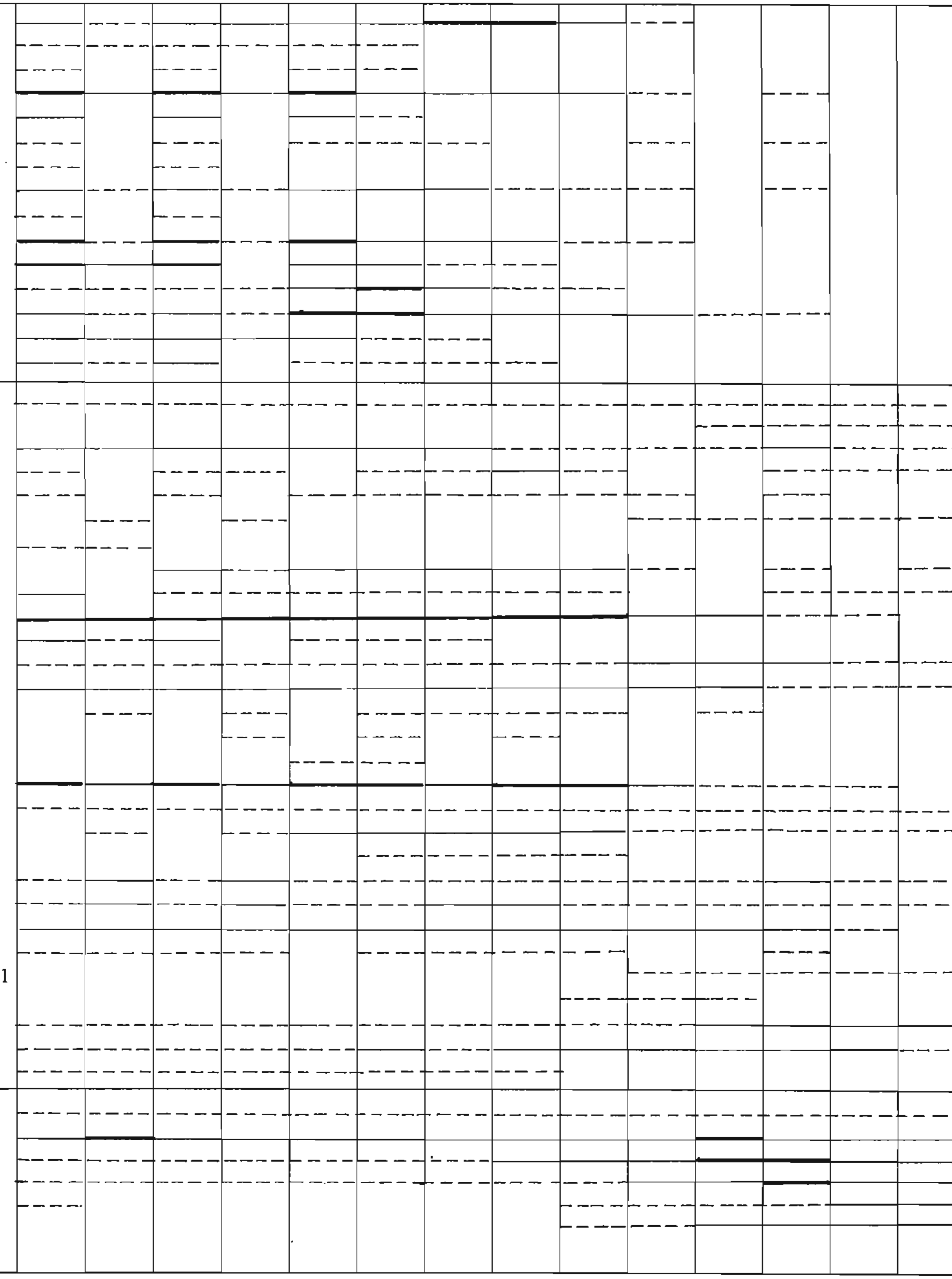
Brackish-lagoonal and fluvial-palustrine deposits of the **Ścinawa Formation** overlay the Rawicz and Gorzów formations. The Ścinawa Formation begins with lignite lenses and intercalations, belonging to the III Group of Seams (Ścinawa

Table 1

Contents of the more important spore and pollen grain species within the Neogene pollen-spore zones (I–XIV)

Climatic zones		Neogene spore and pollen zones on the Polish Lowlands	Palynological zones I *Olaxipollis matthesii*	II *Alnipollenites*	III *Arecipites parareolatus*	IV *Ulmipollenites*	V *Quercoidites henrici*	VI *Tricolporopollenites megaexactus*	VII *Iteapollis angustiporatus*	VIII *Celtipollenites verus*	IX *Tricolporopollenites pseudocingulum*	X *Nyssapollenites*	XI *Betulaepollenites-Cyperaceaepollis*	XII *Carpinipites-Juglandaceae*	XIII *Sequoiapollenites*	XIV *Faguspollenites*
1		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Palaeotropical geoflora (P)	Tropical element (P1)	*Alangiopollis barghoornianum* (Traverse) Krutzsch — P1	- - -													
		Cicatricosisporites chattensis Krutzsch — P1	- - -													
		Cornaceaepollis satzveyensis (Pflug) Ziembińska-Tworzydło — P1	- - -		- - -		- - -	- - -	- - -							
		Dicolpopollis kockelii Pflanzl — P1	- - -		- - -											
		Engelhardtioipollenites quietus (Potonié) Potonié — P1	- - -	- - -												
		Fususpollenites fusus (Potonié) Kedves — P1	—	- - -	- - -		- - -									
		Lycopodiaceaesporis (C.) helenensis (Krutzsch) Ważyńska — P1	- - -		- - -		- - -									
		Magnolipollis neogenicus Krutzsch — P1	- - -	- - -	- - -		- - -	- - -	- - -	- - -	- - -	- - -			- - -	
		Milfordiapollis incertus (Pflug et Thomson) Grabowska — P1	- - -		- - -		- - -									
		Olaxipollis matthesii Krutzsch — P1	- - -		- - -		- - -	- - -								
		Podocarpidites libellus (Potonié) Krutzsch — P1	- - -		- - -		- - -	- - -	- - -	- - -						
		Sapotaceoidaepollenites sp. sp. — P1	- - -		- - -		- - -									
		Tricolporopollenites marcodurensis Pflug et Thomson — P1	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -				
	Subtropical element (P2)	*Araliaceoipollenites edmundi* (Potonié) Potonié — P2	—	—	—	- - -	—	—	—	- - -	—	- - -				
		Arecipites parareolatus (Krutzsch) Krutzsch — P2	- - -	- - -	—											
		Castaneoideaepollis oviformis (Potonié) Grabowska — P2	—	—	—	—	—	—	—	—	—	- - -	- - -	- - -		
		Castaneoideaepollis pusillus (Potonié) Grabowska — P2	**—**	—	**—**	- - -	**—**	**—**	—	—	—	- - -			- - -	
		Engelhardtioipollenites punctatus (Potonié) Potonié — P2	**—**	—	**—**		—	—	- - -	- - -	- - -			- - -		
		Ilexpollenites iliacus (Potonié) Thiergart — P2	—	—	—	—	—	—	—	—	—	—	- - -	- - -	- - -	- - -
		Ilexpollenites margaritatus (Potonié) Raatz — P2	—	—	—	—	—	—	—	—	—	- - -				
		Iteapollis angustiporatus (Schneider) Ziembińska-Tworzydło — P2	- - -		- - -		- - -	- - -	—	- - -		- - -		- - -		
		Manikinipollis tetradoides Krutzsch — P2			- - -		- - -									
		Myricipites bituitus (Potonié) Nagy — P2	—	—	—	—	—	—	—	—	—	—		- - -		
		Myricipites myricoides (Kremp) Nagy —P2	—	—	—	—	—	—	**—**	**—**	—	- - -	- - -	- - -	- - -	- - -

Geoflora	Element	Taxon
Palaeotropical geoflora (P)	Subtropical element (P2)	*Myricipites rurensis* (Pflug et Thomson) Nagy —P2
		Neogenisporis neogenicus Krutzsch — P2
		Platycaryapollenites miocaenicus Nagy — P2
		Quercoidites henrici (Potonié) Potonié, Thomson et Thiergart — P2
		Quercoidites microhenrici (Potonié) Potonié, Thomson et Thiergart — P2
		Reevesiapollis triangulus (Mamczar) Krutzsch — P2
		Radialisporis radiatus (Krutzsch) Krutzsch — P2
		Symplocoipollenites sp. sp. — P2
		Symplocoipollenites rotundus (Potonié) Potonié — P2
		Tricolporopollenites exactus (Potonié) Grabowska — P2
		Tricolporopollenites fallax (Potonié) Krutzsch — P2
		Tricolporopollenites megaexactus (Potonié)Thomson et Pflug — P2
		Tricolporopollenites pseudocingulum (Potonié)Thomson et Pflug — P2
		Tricolporopollenites quisqualis (Potonié) Krutzsch — P2
		Verrucatosporites alienus (Potonié) Thomson et Pflug — P2
Arcto-Tertiary geoflora (A)	Warm- temperate element (A1)	*Aceripollenites* sp. sp. — A1
		Aesculidites hippocastaneoides Sadowska — A1
		Caryapollenites simplex (Potonié) Raatz — A1
		Celtipollenites verus (Raatz) Ziembińska-Tworzydło — A1
		Cercidiphyllites minimireticulatus (Trevisan) Ziembińska-Tworzydło — A1
		Corsinipollenites sp. sp. — A1
		Ephedripites (Distachyapites Krutzsch) sp. sp. — A
		Ericipites roboreus (Potonié) Krutzsch — A
		Eucommioipollis parmularius (Potonié) Ziembińska-Tworzydło — A1
		Inaperturopollenites (*Taxodium, Glyptostrobus* type) — A1
		Intratriporopollenites insculptus Mai — A1
		Juglandipollis maculosus (Potonié) Kohlman-Adamska — A1
		Liquidambarpollenites stigmosus (Potonié) Raatz et Potonié — A1
		Liriodendroipollis verrucatus Krutzsch — A1
		Liriodendroipollis semiverrucatus Krutzsch — A1
		Lythraceaepollenites decodonensis Stuchlik — A1
		Nyssapollenites sp. sp. — A1
		Oleoidearumpollenites sp. sp. — A1
		Osmundacidites sp. sp. — A1
		Ostryoipollenites rhenanus (Thomson) Potonié — A1
		Pterocaryapollenites stellatus (Potonié) Thiergart — A1
		Sciadopityspollenites sp. sp. — A1
		Sequoiapollenites sp. sp. — A1
		Spinulaepollis arceuthobioides Krutzsch — A1
		Theligonumpollenites baculatus (Stachurska, Sadowska et Dyjor) Thiele-Pfeiffer —A1
		Trapapollis illingensis (Klaus) Kohlman-Adamska — A1
		Tricolporopollenites retiformis (Pflug et Thomson) Krutzsch — A1
		Tsugaepollenites sp. sp. — A1
		Zelkovaepollenites sp. sp. — A1
	Cool-temperate element (A2)	*Abiespollenites* sp. sp. — A2
		Alnipollenites verus Potonié — A2
		Betulaepollenites betuloides (Pflug) Nagy — A2
		Carpinipites carpinoides (Pflug) Nagy — A2
		Chenopodipollis stellatus (Mamczar) Krutzsch — A2
		Corylopollis coryloides (Pflug) Ziembińska-Tworzydło — A2



Tab.1 continued

1		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Arcto-Tertiary geoflora (A)	Cool-temperate element (A2)	*Cyperaceaepollis* sp. sp. — A										----	——	----	——	——
		Diervillapollenites megaspinosus Doktorowicz-Hrebnicka — A2											----	----	----	----
		Ericipites callidus (Potonié) Krutzsch — A2	----	----	----	----	----	----	----	----	----	----	----	----	----	----
		Ericipites ericius (Potonié) Potonié — A2	----	----	----	----	----	----	----	----	----	----	----	----	----	----
		Faguspollenites verus Raatz — A2									----	----	——	——	——	▬▬
		Graminidites sp. sp. — A2										----	----	——	——	▬▬
		Intratriporopollenites instructus (Potonié) Thomson et Pflug — A2		----		----		----	----	----	----	----	----	——	——	——
		Laevigatosporites haardti (Potonié et Venitz)Thomson et Pflug — A											——			——
		Persicarioipollis sp. sp. — A											----	----	----	----
		Piceapollis sp. sp. — A	----	----	----	----	----	----	----	----	----	----	----	----	----	----
		Pinuspollenites sp. sp. — A	——	——	——	——	——	——	——	——	——	——	——	——	——	——
		Quercoidites sp. sp. — A								----	----	----	——	——	——	——
		Stereisporites sp. sp. — A	----	----	----	----	----	----	----	----	----	----	----	----	----	----
		Ulmipollenites undulosus Wolff — A2	----	----	----	----	----	----	----	----	----	----	----	——	——	——
		NAP — A2								----	----	----	----	——	——	▬▬

A — Arcto-Tertiary geoflora: A1 — warm-temperate element, A2 — cool-temperate element; P — palaeotropical geoflora: P1 — tropical element, P2 — subtropical element; frequency of occurrence: ---- single, —— seldom, ▬▬ abundant

Seam). Brown sand, silt and coaly silt with small lignite lenses lay above and the II Group of Seams (Lusatia Seam) occurs at the top of the column. Glauconite grains, sponge spicules, aglutinate foraminifers, remains of marine phytoplankton and brackish-marine trace fossils are sporadic in the sequence.

The Ścinawa Formation with two coal seams: the Ścinawa Seam at the bottom and the Lusatia Seam at the top, is well-developed mostly in the southern part of the West Poland Miocene Basin. It corresponds to the Unterer Briesker Folge complex with the 3rd and 2nd Lusatia lignite seams (TGL 25234/08, 1981) of the southern Brandenburg and Lower Lusatia.

In the central part of the basin, the Ścinawa Formation deposits are replaced with brackish sediments: quartz silty and clayey sand with abundant mica blasts. Up to four thin lignite seams may appear in the upper part of the profile. This series should be defined as a new unit: **Krajenka Formation**. In East Germany, the Formsand Gruppe or Formsand Horizont of the older German papers (P. Sonntag, 1919; H. W. Quitzow, 1953) and updated Untere Malliser Folge (TGL 25234/08, 1981) are related to the Krajenka Formation.

The sediments described above originated during Early Miocene and they correspond to the III–V pollen-spore zones of the microfloral pattern. They may be correlated to the IV–VIII macrofloral Mai zones (D. H. Mai, 1994).

The deposits of the III pollen-spore zone — well-evidenced palynologically — are known from numerous sites in the Polish Lowlands, particularly in its western part (M. Ziembińska-Tworzydło, 1974; A. Sadowska, 1977) and in the Turów lignite deposits (M. Ziembińska-Tworzydło, 1992).

The zone name is derived from the palaeotropical species *Arecipites parareolatus* (Krutzsch) Krutzsch, occurring regularly mostly in southwestern Poland. Cool and scarce palynological assemblage of the former phase enriched gradually, mostly with the subtropical element (P2) of palaeotropical geoflora, which existed during the previous phase as an accessorial element only. Pollen of tropical plants (P1) appeared sporadically, and pollen contents of warm-temperate plants (A1) of the Arcto-Tertiary geoflora substantially decreased. Both number and percentage of species in the spectra were smaller than before.

The swamp-forest plant communities with *Taxodium* and *Nyssa* were a main coal-forming community during deposition of this series. Climate was warm-temperate close to subtropical and it was the warmest during the whole Miocene period.

Sediments containing an assemblage of the IV pollen-spore zone have been evidenced in some localities on the Fore-Sudetic Monocline and in the Polish Lowlands (M. Ziembińska-Tworzydło, 1974; M. Ziembińska-Tworzydło, H. Ważyńska, 1981).

The zone name is derived from mass-frequent pollen grains of the family Ulmaceae (*Ulmipollenites undulosus* Wolff). The assemblage consists of unfrequent species only and it is dominated by temperate element (A1) of Arcto-Tertiary geoflora with great contents of conifers. Pollen of the palaeotropical element is unfrequent and species are not much diversified.

Conifer forest with *Pinus, Sciadopitys* and *Tsuga* predominated in the described phase. The scarce pollen assemblage with very rare palaeotropical elements shows a substantial deterioration of climatic conditions, which were favourable to rich deciduous (partly evergreen) forest vegetation during the previous phase. The deep floral changes might resulted from not only cooler, but also drier climate.

The deposits with the V pollen-spore zone assemblage occur in the whole Polish Lowlands. The zone name is derived from the species Quercoidites henrici (Potonié) Potonié, Thomson et Thiergart, which occurs frequently everywhere in the sediments,somewhere being mass-frequent. The pollen species Tricolporopollenites pseudocingulum (Potonié) Thomson et Pflug, with undefined botanical position, is also frequent. Other palaeotropical geoflora representatives (P1), with some different palm species and other tropical plants, co-occur in the deposits. The warm-temperate taxa (A1), not so frequent, represent Arcto-Tertiary geoflora. Pollen of Nyssa and Taxodiaceae and bush plants of the Cyrillaceae and Myricaceae families were dominating the swamp forest during this phase. Such pollen assemblage allows to suspect that swamp forest and bushwood grew over widespread humid and overflooded areas of the Polish Lowlands. More dry areas were overgrown by mesofilous deciduous forest with high contents of evergreen plants.

MIDDLE MIOCENE

The new stage of continental, mostly fluvial sedimentation began during Middle Miocene particularly in marginal parts of the lowland basin. Sediments of the **Adamów Formation** have been deposited on alluvial plain. These are quartz sands and silts with sandy lignite intercalations, usually with coal dust and with clay in the top part of the sequence. In places, sands are silicified; these layers may be defined as lower-order lithostratigraphic units. In the central part of the basin, the Adamów Formation interfingers with brackish deposits of the **Pawłowice Formation**, consisting of quartz sand with glauconite, foraminifers, sponge spicules and ichnocoenoses characteristic of brackish and shallow-marine facies. It contains lignite seams of the IIA Group of Seams (Lubin Seam). Both these formations are equivalents of the Obere Briesker Folge with the Oberbegleiterflöz (Upper Accompanying Coal Seam) and of the Obere Malliser Folge (TGL 25234/08, 1981) in Lower Lusatia and Brandenburg.

The VI and VII pollen-spore zones, corresponding to the IX and X Mai macrofloral zone (D. H. Mai, 1994), occur in these lithostratigraphic units.

The deposits of the VI pollen-spore zone represent a final part of the period of most extensive coal-forming accumulation. They are known in the Fore-Sudetic Monocline (A. Sadowska, 1977), Wielkopolska region (M. Ziembińska-Tworzydło, 1974) and central Poland (L. Stuchlik, 1964; A. Kohlman-Adamska, 1993). Pollen of the *Tricolporopollenites megaexactus* (Potonié) Thomson et Pflug, which gives the name to the zone, is very frequent in the spectra of this phase. This represents probably warm-like entomophylous plants of swamp bush, belonging to the families Cyrillaceae and Clethraceae. High frequence of this species is independent on facies and it allows to interpreted this as an indicator of climatic change. The subtropical element (P2) of palaeotropical geoflora is frequent too within the same zone, and extremely warm-like species (P1) are accessory. Pollen species of the warm-temperate plants are also common. A composition of the pollen spectra, in relationship to the former phase, indicates probably a significant drying and inconsiderable cooling. The plant communities were dominated by bushes of overflooded areas and by mesophylous deciduous and mixed forests. They characterize a relatively warm dry period, which followed the humid and hot period, when the Ścinawa Seam coals were formed.

The name of the VII pollen-spore zone is derived from the pollen species *Iteapollis angustiporatus* (Schneider) Ziembińska-Tworzydło, which represents extremely warm-like entomophylous plants. This zone is the last one in Neogene, where this species occur regularly, though rather infrequently (up to 1%). Other warm-like species are quite frequent, though more scarce than in the V and VI phases. Temperate climatic indicators with pollen of deciduous trees of the *Acer, Alnus, Celtis, Carpinus, Eucommia, Fagus, Ostrya, Ulmus, Zelkova* and conifers of the *Pinus, Sciadopitys, Tsuga* are more frequent than in the former phases.

Increasing participation of plants with temperate climatic requirement suggests a cooling in relationship to the former phase. In this phase, palaeotropical species are still relatively frequent in spite of significant expansion of Arcto-Tertiary geoflora elements. Climate was warm-temperate and not too humid. Widespreaded mires did not form during that time and, therefore, coal intercalations in the sequence were rare and thin. The pollen assemblage in this phase indicates favourable conditions for vegetation of temperate deciduous and mixed forests with small addition of warm-like plants and relatively high contents of conifers.

MIDDLE AND UPPER MIOCENE–PLIOCENE

Sediments of the **Poznań Formation** originated in the Polish Lowlands during latest Middle and Late Miocene, and partly probably also during Pliocene. Its profile begins with grey and grey-greenish clay, in places calcareous and often coaly, with frequent leaf remains, and with intercalations of coaly sands and of the I Group of Seams (Middle Polish Seam) at the bottom (occurring in form of a continuous coal bench), and of the IA Group of Seams (Oczkowice Seam) in the upper part (occurring in form of coal lenses).

We propose to determine the deposits described above as the Grey Clay Member (i.e. Middle Polish Member), including the bottom part of the Poznań Formation.

The middle and upper part of the Poznań Formation consists of clay and silt, greenish, green-blue and vari-coloured in the top parts, with clayey sand intercalations and lignite lenses of the 0 Group of Seams (Orłowo Seam, E. Ciuk, 1987). Two members may be distinguished here: (1) the lower Green Clay Member, consisting of clay and silt, generally greenish,

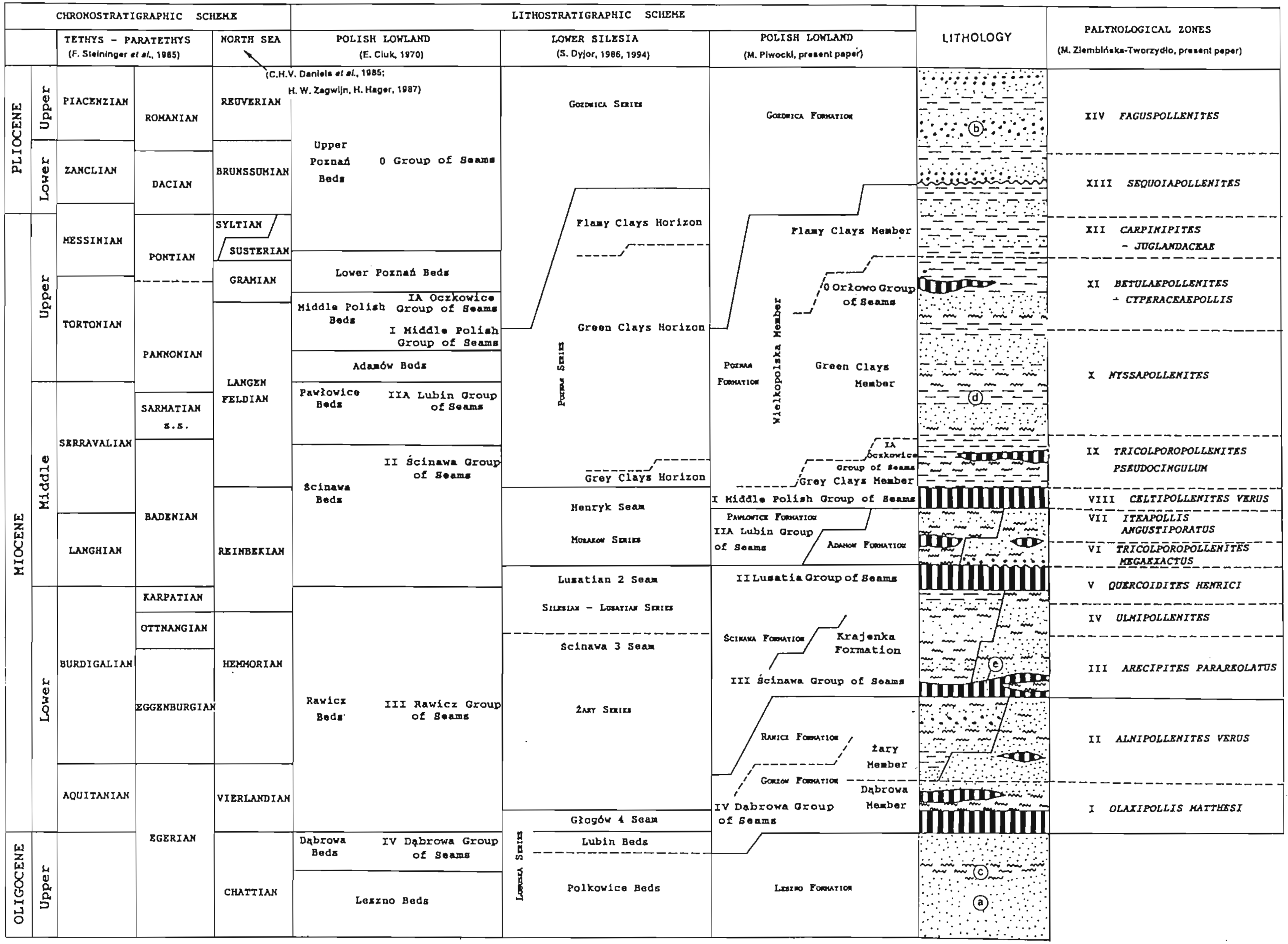


Fig. 1. Lithostratigraphic schemes and the spore and pollen zones of the Neogene of the Polish Lowlands within a chronostratigraphic scheme
a — sands, b — gravels, c — silts, d — clays, e — lignite
Schemat litostratygraficzny i poziomy sporowo-pyłkowe neogenu Niżu Polskiego na tle chronostratygrafii
a — piaski, b — żwiry, c — mułki, d — iły, e — węgle brunatne miękkie

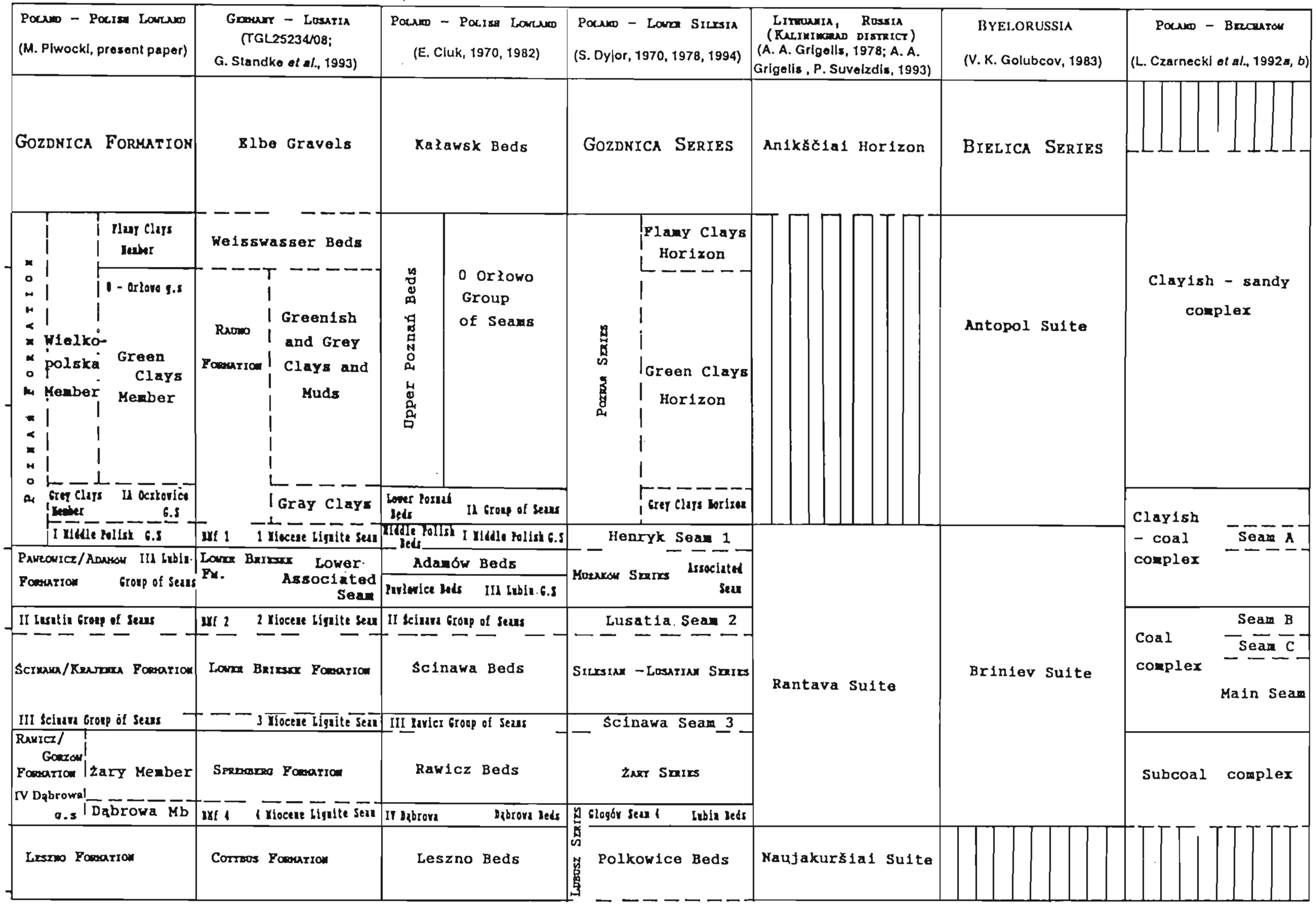


Fig. 2. Correlation of lithostratigraphic units in the Neogene of the Polish Lowlands and neighbouring countries

BNf 1–4 — Lusatian lignite seams 1–4

Korelacja wydzieleń litostratygraficznych w neogenie na Niżu Polskim i w krajach ościennych

BNf 1–4 — łużyckie pokłady węgla brunatnego 1–4 and (2) the upper Variegated Clay Member (Flame Clay Member), consisting of characteristic variegated clay with silt and sand intercalations. From the practical point of view, joining of the both last described members into a new one Wielkopolska Member is more convenient, because variegated clays occur not only in the upper part of the Poznań Formation, but also in the whole sequence in form of thin interfingering intercalations. Therefore, it is not easy to univocally define the lithological boundary between the green and variegated (flame) clay series. In Mazovia, the Grey Clay Member, Green Clay Member and Variegated Clay Member correspond respectively to the Jędrzejnik Beds, Rycice Beds and Karczew Beds (after M. D. Baraniecka, 1976, 1979).

Glauconite and Badenian foraminifers have been found in the lower part of the Green Clay Member (S. Dyjor, 1968; E. Łuczkowska, S. Dyjor, 1971; M. Piwocki, 1975; M. D. Giel, 1979). Foraminifers appear also in the upper part of the Grey Clay Member.

In East Germany (Lower Lusatia, Brandenburg), the Poznań Formation corresponds to the Raunoer Folge sediments with the 1st Lusatia Lignite Seam at the bottom, and to the Weisswasser Clay — Schichten von Weisswasser (TGL 25234/08, 1981; S. Dyjor, 1986).

The lower part of the Poznań Formation, i.e. the Grey Clay Member (Middle Polish Member) with the Middle Polish Seam, originated during Middle Miocene. The upper part of this formation, i.e. the Wielkopolska Member, including the Green Clay Member and Variegated Clay Member, has been formed during Middle and Late Miocene, and probably also during Early Pliocene in the central part of the basin.

The Poznań Formation includes several pollen-spore assemblages determining the VIII–XIII pollen-spore zones. These zones may be correlated to the XI–XIII Mai macrofloral zones (D. H. Mai, 1994).

The sediments with the VIII pollen-spore zone assemblage are almost completely related to the I Group of Seams. They are widespread in southwestern (A. Sadowska, 1977) and central Poland (M. Ziembińska-Tworzydło, 1974; A. Kohlman-Adamska, 1993). The zone name is derived from the common pollen species *Celtipollenites verus* (Raatz) Ziembińska-Tworzydło, which compose in places up to 30% of the spectrum. This species represents the warm-temperate element (A1) of Arcto-Tertiary geoflora. Palaeotropical assemblage consists still numerous taxa, but it composes only a small part of the spectrum. The pollen assemblage is generally similar to the one of the former phase, and the most important differences are: (1) less-abundant pollen of cool-temperate climate plants (A2) with the *Carpinus* and *Fagus*, and (2) more abundant pollen of paludal plants with the *Alnus, Nyssa* and *Taxodium.* Climate was probably quite warm and humid and widespread mires, overgrown with swamp forest or overflooded bush, occurred at that time. More dry areas were overgrown with mixed forest with great amount of *Sciadopitys* and *Tsuga*, and with the warm-temperate element (A1) of Arcto-Tertiary geoflora with *Carya, Pterocarya, Juglans* and infrequent species of evergreens, existing mostly in a forest undergrowth.

Grey clay sediments with coal lenses of the IA Seam Group, containing the IX pollen-spore zone assemblage, have been evidenced in Wielkopolska, South-West Poland, the middle part of Silesia and the Silesian part of the Metacarpathian Range (J. Oszast, 1960; M. Ziembińska-Tworzydło, 1974; A. Sadowska, 1977; S. Dyjor, A. Sadowska, 1986*b*; A. Kohlman-Adamska, 1993). The zone name is derived from the species *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug which appears regularly in this zone for the last time. It is also a final occurrence of the most part of other taxa. The spectrum of this phase is quantitatively dominated by the taxa of temperate climate (A). Palaeotropical elements (P2), co-occurring there, are represented by numerous taxa, but their quantity is small. It indicates warm, mild, relatively humid climate, favourable for mire and riparian forest vegetation, with the small evergreen addition in undergrowth.

Pollen-spore assemblages of the X and XI zones occur within the sequence of the Wielkopolska Member.

Sediments with the X pollen-spore zone assemblage are known from a few localities in the Polish Lowlands. The Gozdnica flora (A. Stachurska *et al.*, 1971; A. Sadowska, 1992), where a layer of high *Nyssapollenites* sp. abundance occurs in the upper part of the profile, may be related to this zone. Representatives of palaeotropical vegetation appear in the zone only sporadically. Arcto-Tertiary geoflora is much more frequent and diversified, and it consists of species of both the warm-temperate (A1) and the cool-temperate elements. Vegetation was dominated by riparian forest with small addition of evergreens. Climate was temperate and humid.

An assemblage of the XI pollen-spore zone has been evidenced in the Orłowo profile (J. Doktorowicz-Hrebnicka, 1957). Its name is derived from high content of pollen of birch (*Betula*) and of herbs; Cyperaceae pollen is most common there. The pollen assemblages consist of small species number, but single pollen grains of evergreens of palaeotropical geoflora (P2) and warm-temperate plants (A1) of Arcto-Tertiary geoflora (*Sequoia, Pterocarya, Juglans*) occur there. However, they are dominated by the genera with typical cool-like character (A2).

MIOCENE–PLIOCENE

The **Gozdnica Formation**, developed as a piedmont alluvial sedimentary cover, originated on the Sudetic Foreland during the latest Miocene (probably since the Pannonian and during the Pontian), and Pliocene. It is represented by white sands and gravels with kaoline clay, containing clayey-silty lenses with plant remains. These sediments have been defined and described as the white gravel and kaoline clay series (S. Dyjor, 1964, 1966). They may be correlated to sandy series of uppermost Pliocene (Reuverian), evidenced in the Różce borehole profile (L. Stuchlik, 1987; M. D. Baraniecka, 1991), which consists of vari-grained sand with gravel and clay intercalations. Deposition of the Gozdnica Formation started during Upper Miocene, but their substantial part has been related to Pliocene. After the palaeobotanic stratigraphic column (A. Sadowska, 1993), few localities of the Gozdnica Formation including XI–XIV pollen-spore zones have been recorded.

The name of the XII pollen-spore zone is derived from frequent hornbeam pollen (*Carpinipites carpinoides* (Pflug) Nagy) and pollen of the Juglandaceae family. There are only few well-evidenced profiles, a.o. the Sośnica profile (A. Stachurska *et al.*, 1973), typical of South-West Poland. Pollen representative for palaeotropical geoflora (P) is almost completely absent. The cool-temperate (A2) genera of trees (*Alnus, Betula, Quercus, Ulmus*) take the main part among the Arcto-Tertiary assemblage. Contrary to the former phase, herb pollen is infrequent there.

The deposits including an assemblage of the XIII pollen-spore zone have been found within the Gozdnica Formation at the Ruszów locality (A. Stachurska *et al.*, 1967). After A. Sadowska (1995), this profile is comparable to the Brunssumian profile in the Netherlands. During that time, the mammoth-tree forest developed in West Europe, but in Poland *Sequoia* pollen is strongly dispersed in the related sediments. The name of the zone is derived from the last appearance of this pollen (*Sequoiapollenites* sp.) in Poland. The warm-like plant communities are represented by the taxa of the warm-temperate element (A1) of Arcto-Tertiary geoflora with chestnut-tree pollen (*Aesculus*); pollen of these taxa occur rarely. Pollen of plants common in Quaternary, as *Betula, Ulmus, Carpinus* and *Alnus*, occurs in a mass and herb pollen (grass, sedges, mugworts) is more and more frequent. This floristic image indicates that the climate is dry as in the stepp. Development of (1) forest with scarce tree genera with large woodless areas, and (2) moss-sedge peatlands and adlertree swamps was caused by climatic severing. A distinct difference exists between submountain plant communities, consisting mostly of conifer forest, and lowland plant communities, consisting of deciduous forest with small addition of the warm-temperate taxa.

The XIV pollen-spore zone with high beech pollen content (*Faguspollenites* sp.), defined as characteristic for the zone, occurs quite consequently in the youngest part of the Gozdnica Formation and it has been recorded in the Różce site and in the Bełchatów area (D. Krzyszkowski, A. Szuchnik, 1995). In this assemblage, a group of the Arcto-Tertiary taxa is dominated by the cool element (A2). The warm-temperate element (A1) occurs only in the relic form (mostly bushes). Herbs are frequent and their pollen content (NAP) reaches up to 30% in the spectrum.

CORRELATION

The correlation of the Neogene lithostratigraphical units of the Polish Lowlands with the subdivisions defined for Neogene of East Germany, Lithuania and Byelorussia (Fig.2) is relatively simple. A correlation with the units of East Germany has been presented in the first part of this paper in more detail, because the German units are identical or very close to the Polish ones. The presented subdivision has been based on the obligatory standards (TGL 25234/08, 1981), with small supplements and changes (W. Alexovsky *et al.*, 1989; P. Suhr *et al.*, 1992).

In Russia (the Kaliningrad District), Miocene deposits lie on the micaceous sands of the Naujakuršiai Suite (A. A. Grigelis, 1978), corresponding in Poland to the Leszno Formation, and belonging to Upper Oligocene. Miocene deposits are represented by the Rantava Suite (A. A. Grigelis, 1978), consisting of unequigranular sands and silts with sandy lignite intercalations. The same sediments have been evidenced also in East Lithuania (A. A. Grigelis, P. Suveizdis, 1993). They may be correlated to the Rawicz/Gorzów Formation, Ścinawa/Krajenka Formation and Adamów/Pawłowice Formation, representing the deposits of lignite-bearing association. There are no equivalents of the Poznań Formation in the Kaliningrad District and Lithuania. In Lithuania, the sandy-silty sediments (partly coaly ones) with the Anikščiai Horizon are included to Pliocene; these correspond probably to the Gozdnica Formation or to the Pliocene sand of the Różce profile.

The Briniev Suite represents the Miocene lignite-bearing association in the West Byelorussia (V. K. Golubcov, 1983). The Antopol Suite, lying above, consisting of grey, grey-greenish and variegated montmorillonite clay with inferior sandy and silty intercalations (V. K. Golubcov, 1983), may be correlated to the Poznań Formation. Sandy-silty-clayey deposits of the Bielice Series, subdivided to some minor units of the "suite" rank (V. K. Golubcov, 1983; A. K. Karabanov, 1987), overlay the Antopol Suite after a distinct gap. They belong to Pliocene and correspond to the Gozdnica Formation and to the Upper Pliocene sand of the Różce borehole in Mazovia.

There is also possible to present the Neogene lithostratigraphic units of the Polish Lowlands in relationship to the international chronostratigraphic subdivision and regional stratigraphical columns of the Central Paratethys and the North Sea (Fig. 1). However, it is not very precise, because it is based on a few, not particularly exact biostratigrahic and chronostratigraphic markers.

The lithostratigraphical units defined in the Polish Lowlands are more or less diachronous, and the Oligocene-Miocene and Miocene-Pliocene boundaries have not been precisely defined. In a practical way, a simplified approach is possible, that the Leszno Formation belongs to the Upper Oligocene, and a deposition of the Gozdnica Formation began already in the Miocene, though substantial part of it belongs to the Pliocene. There is also impossible to distinguish the Tertiary sediments and the Quaternary preglacial deposits, because their lithological composition is exactly the same or very similar (M. D. Baraniecka, 1991). Therefore, there is incorrect to treat the lithostratigraphic units of the Polish Lowlands as the chronostratigraphic ones, what have been done sometimes.

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LITOSTRATYGRAFIA I POZIOMY SPOROWO-PYŁKOWE NEOGENU NA NIŻU POLSKIM

Streszczenie

Brak skamieniałości przewodnich w przeważnie lądowych osadach neogenu na Niżu Polskim spowodował, że ich podział przez ponad 100 lat miał charakter litostratygraficzny. Pierwszy taki całościowy podział znajduje się w pracy E. Ciuka (1970). Odrębny pod względem nomenklatury podział litostratygraficzny neogenu Dolnego Śląska i Ziemi Lubuskiej przedstawił równolegle S. Dyjor (1969, 1970). Obydwa podziały złożone są z nieformalnych jednostek litostratygraficznych. Dla korelacji regionalnych wykorzystano pokłady węgla brunatnego.

W artykule, na podstawie wielu opracowanych palinologicznie profilów z Niżu Polskiego, wyznaczono i zdefiniowano 14 poziomów sporowo-pyłkowych (I–XIV) neogenu (tab. 1), które uznano za fazy o charakterze paleoklimatycznym. Wszystkie taksony spor i ziarn pyłku, ważne dla wyznaczenia poziomów sporowo-pyłkowych, zostały zilustrowane na tabl. I–V.

Znaczenie korelacyjne i stratygraficzne dla przedstawionych porównań i zestawień mają też:

— otwornice poznane na Śląsku Opolskim w tzw. zatoce Nysy Kłodzkiej (E. Odrzywolska-Bieńkowa, 1985) oraz otwornice z osadów formacji poznańskiej na Dolnym Śląsku i w Wielkopolsce (E. Łuczkowska, S. Dyjor, 1971; M. Piwocki, 1975; M. D. Giel, 1979);

— szczątki ssaków, zwłaszcza w profilu złoża węgla brunatnego „Bełchatów" wieku karpat-baden (MN 4–6) i pannon (MN 9–10) (J. Głazek, A. Szynkiewicz, 1987; K. Kowalski, 1990);

— poziomy tufitowe w złożach węgla brunatnego okolic Konina i w Bełchatowie (K. Matl, M. Wagner, 1985, 1986; L. Czarnecki i in., 1992*a*, *b*; S. Lorenz, W. Zimmerle, 1993), korelowane z poziomami tufitowymi w zapadlisku przedkarpackim i datowane metodą trakową na od 18,2±1,7 do 16,5±1,3 mln lat, tj. ottnang-baden (J. Burchard i in., 1989; L. Stuchlik i in., 1990; L. Czarnecki i in., 1992*a*, *b*);

— mięczaki słodkowodne z okolic Bełchatowa, Złoczewa i Rawicza, znane w Europie z osadów odpowiadających ottnangowi-badenowi (A. Nowicki, E. Woźny, 1965; E. Ciuk, M. Piwocki, 1967; M. Piwocki, 1975; E. Stworzewicz, A. Szynkiewicz, 1988; E. Woźny, 1968).

Według tych przesłanek zestawiono uzupełniony schemat podziału litostratygraficznego neogenu na Niżu Polskim (fig. 1). Schemat skorelowano z obszarami sąsiednimi (fig. 2) i powiązano z jednostkami chronostratygraficznymi neogenu Europy.

Jest to nadal podział nieformalny, gdyż wyróżnione jednostki nie spełniają warunków określonych w *Zasadach polskiej klasyfikacji...* (1975).

Jednostki litostratygraficzne wyróżniane i zdefiniowane w neogenie na Niżu Polskim mają mniej lub bardziej wyraźny charakter diachroniczny, a granice oligocen-miocen i miocen-pliocen nie są określone ściśle. Dla celów praktycznych z dużym uproszczeniem można przyjąć, że formacja leszczyńska należy jeszcze do górnego oligocenu, natomiast formacja gozdnicka zaczęła się osadzać jeszcze w miocenie, ale w zasadniczej masie reprezentuje już pliocen. Rozdzielenie osadów trzeciorzędowych od preglacjalnych utworów czwartorzędowych jest niemożliwe ze względu na zbliżony lub identyczny skład litologiczny (M. D. Baraniecka, 1991).

Przypisywanie jednostkom litostratygraficznym w neogenie Niżu Polskiego znaczenia chronostratygraficznego, spotykane niekiedy w praktyce geologicznej, jest błędne.

EXPLANATIONS OF PLATES

PLATE I

Fig. 1. *Dicolpopollis kockelii* Pflanzl (P1)
Fig. 2. *Engelhardtioipollenites quietus* (Potonié) Potonié (P1)
Fig. 3. *Castaneoideaepollis oviformis* (Potonié) Grabowska (P2)
Fig. 4. *Castaneoideaepollis pusillus* (Potonié) Grabowska (P2)
Fig. 5. *Tricolporopollenites exactus* (Potonié) Grabowska (P2)
Fig. 6. *Tricolporopollenites megaexactus* (Potonié) Thomson et Pflug (P2)
Fig. 7. *Iteapollis angustiporatus* (Schneider) Ziembińska-Tworzydło (P2)
Fig. 8. *Fususpollenites fusus* (Potonié) Kedves (P1)
Fig. 9. *Tricolporopollenites fallax* (Potonié) Krutzsch (P2)
Fig. 10. *Tricolporopollenites quisqualis* (Potonié) Krutzsch (P2)
Fig. 11. *Olaxipollis matthesii Krutzsch* (P1)
Fig. 12. *Engelhardtioipollenites punctatus* (Potonié) Potonié (P2)
Fig. 13. *Sapotaceoidaepollenites* sp. (P1)
Fig. 14. *Milfordiapollis incertus* (Pflug et Thomson) Grabowska (P1)
Fig. 15. *Quercoidites microhenrici* (Potonié) Potonié, Thomson et Thiergart (P2)
Fig. 16. *Quercoidites henrici* (Potonié) Potonié,Thomson et Thiergart (P2)
Fig. 17. *Arecipites parareolatus* (Krutzsch) Krutzsch (P2)
Fig. 18. *Myricipites bituitus* (Potonié) Nagy (P2)
Fig. 19. *Myricipites rurensis* (Pflug et Thomson) Nagy (P2)
Fig. 20. *Tricolporopollenites marcodurensis* Pflug et Thomson (P1)
Fig. 21. *Reevesiapollis triangulus* (Mamczar) Krutzsch (P2)
Fig. 22. *Lycopodiaceaesporis (C.) helenensis* (Krutzsch) Ważyńska (P1)
Fig. 23. *Myricipites myricoides* (Kremp) Nagy (P2)
Fig. 24. *Cornaceaepollis satzveyensis* (Pflug) Ziembińska-Tworzydło (P1)
Fig. 25. *Cicatricosisporites chattensis* Krutzsch (P1)
Fig. 26. *Alangiopollis barghoornianum* (Traverse) Krutzsch (P1)

PLATE II

Fig. 1. *Tricolporopollenites retiformis* (Pflug et Thomson) Krutzsch (A1)
Fig. 2. *Platycaryapollenites miocaenicus* Nagy (P2)
Fig. 3. *Eucommioipollis parmularius* (Potonié) Ziembińska-Tworzydło (A1)
Fig. 4. *Cercidiphyllites minimireticulatus* (Trevisan) Ziembińska-Tworzydło (A1)
Fig. 5. *Tricolporopollenites pseudocingulum* (Potonié) Thomson et Pflug (P2)
Fig. 6. *Spinulaepollis arceuthobioides* Krutzsch (A1)
Fig. 7. *Lythraceaepollenites decodonensis* Stuchlik (A1)
Fig. 8. *Aceripollenites* sp. (A1)
Fig. 9. *Symplocoipollenites* sp. (P2)
Fig. 10. *Neogenisporis neogenicus* Krutzsch (P2)
Fig. 11. *Ilexpollenites margaritatus* (Potonié) Raatz (P2)
Fig. 12. *Manikinipollis tetradoides* Krutzsch (P2)
Fig. 13. *Symplocoipollenites rotundus* (Potonié) Potonié (P2)
Fig. 14. *Magnolipollis neogenicus* Krutzsch (P1)
Fig. 15. *Ilexpollenites iliacus* (Potonié) Thiergart (P2)
Fig. 16. *Verrucatosporites alienus* (Potonié) Thomson et Pflug (P2)
Fig. 17. *Radialisporis radiatus* (Krutzsch) Krutzsch (P2)
Fig. 18. *Araliaceoipollenites edmundi* (Potonié) Potonié (P2)
Fig. 19. *Podocarpidites libellus* (Potonié) Krutzsch (P1)

PLATE III

Fig. 1. *Inaperturopollenites* (*Taxodium, Glyptostrobus* typ) (A1)
Fig. 2. *Ostryoipollenites rhenanus* (Thomson) Potonié (A1)
Fig. 3. *Juglandipollis maculosus* (Potonié) Kohlman-Adamska (A1)
Fig. 4. *Nyssapollenites* sp. (A1)

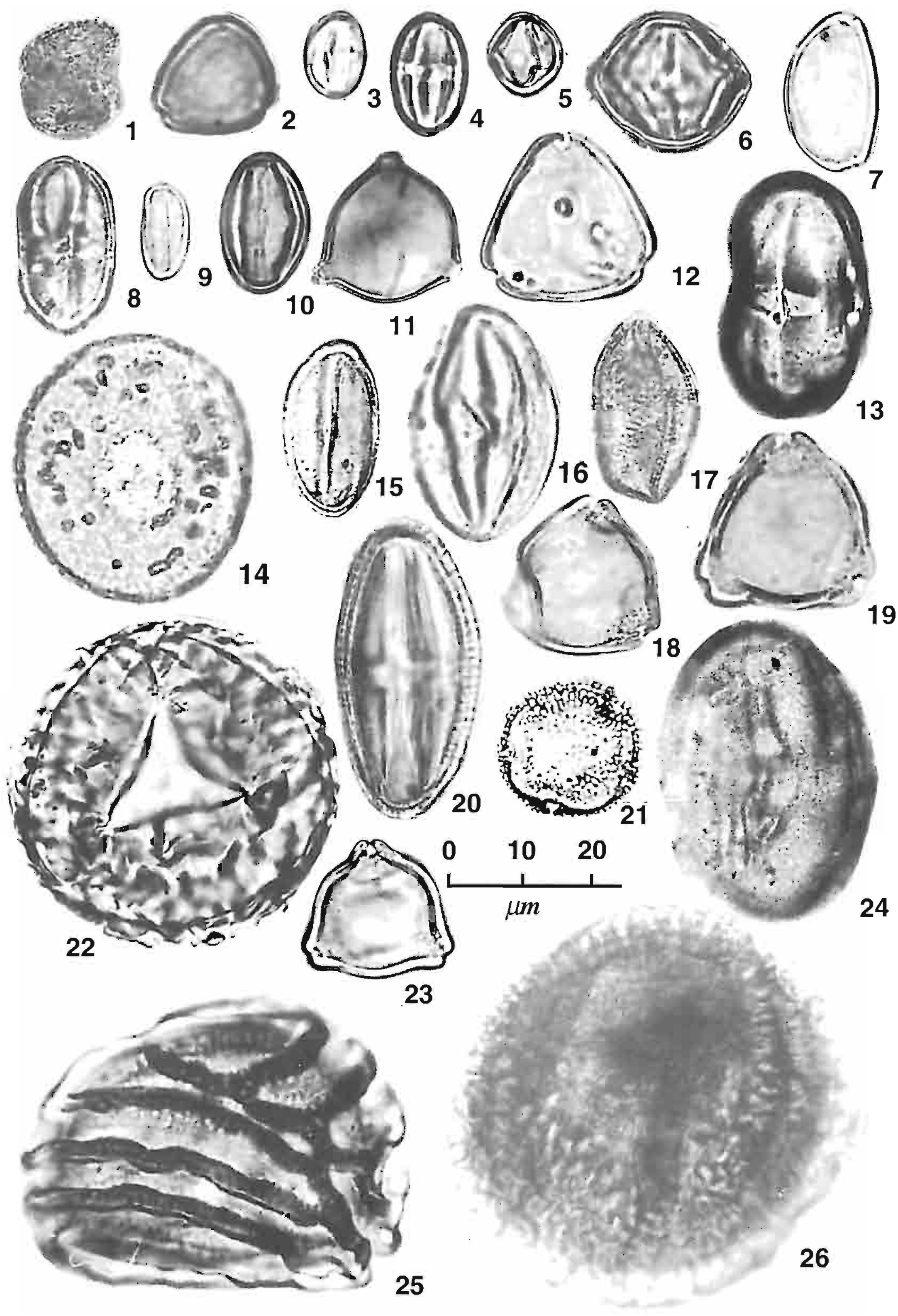
Fig. 5. *Sequoiapollenites* sp. (A1)
Fig. 6. *Pterocaryapollenites stellatus* (Potonié) Thiergart (A1)
Fig. 7. *Zelkovaepollenites* sp. (A1)
Fig. 8. *Oleoidearumpollenites* sp. (A1)
Fig. 9. *Caryapollenites simplex* (Potonié) Raatz (A1)
Fig. 10. *Aesculidites hippocastaneoides* Sadowska (A1)
Fig. 11. *Celtipollenites verus* (Raatz) Ziembińska-Tworzydło (A1)
Fig. 12. *Liriodendroipollis semiverrucatus* Krutzsch (A1)
Fig. 13. *Intratriporopollenites insculptus* Mai (A1)
Fig. 14. *Theligonumpollenites baculatus* (Stachurska, Sadowska et Dyjor) Thiele-Pfeiffer (A1)
Fig. 15. *Osmundacidites* sp. (A1)
Fig. 16. *Ephedripites (Distachyapites* Krutzsch) sp. (A)
Fig. 17. *Liriodendroipollis verrucatus* Krutzsch (A1)

PLATE IV

Fig. 1. *Corsinipollenites* sp. (A1)
Fig. 2. *Sciadopityspollenites* sp. (A1)
Fig. 3. *Ericipites roboreus* (Potonié) Krutzsch (A)
Fig. 4. *Abiespollenites* sp. (A2)
Figs. 5, 6. *Pinuspollenites* sp. sp. (A)
Fig. 7. *Tsugaepollenites* sp. (A1)
Fig. 8. *Piceapollis* sp. (A)

PLATE V

Fig. 1. *Stereisporites* sp. (A)
Fig. 2. *Laevigatosporites haardti* (Potonié et Venitz) Thomson et Pflug (A)
Fig. 3. *Quercoidites* sp. (A)
Fig. 4. *Faguspollenites verus* Raatz (A2)
Fig. 5. *Intratriporopollenites instructus* (Potonié) Thomson et Pflug (A2)
Fig. 6. *Alnipollenites verus* Potonié (A2)
Fig. 7. *Carpinipites carpinoides* (Pflug) Nagy (A2)
Fig. 8. *Corylopollis coryloides* (Pflug) Ziembińska-Tworzydło (A2)
Fig. 9. *Graminidites* sp. (A)
Fig. 10. *Ulmipollenites undulosus* Wolff (A2)
Fig. 11. *Betulaepollenites betuloides* (Pflug) Nagy (A2)
Fig. 12. *Ericipites callidus* (Potonié) Krutzsch (A2)
Fig. 13. *Cyperaceaepollis* sp. (A)
Fig. 14. *Persicarioipollis* sp. (A)
Fig. 15. *Chenopodipollis stellatus* (Mamczar) Krutzsch (A2)
Fig. 16. *Ericipites ericius* (Potonié) Potonié (A2)
Fig. 17. *Diervillapollenites megaspinosus* Doktorowicz-Hrebnicka (A2)
Fig. 18. *Trapapollis illingensis* (Klaus) Kohlman-Adamska (A1)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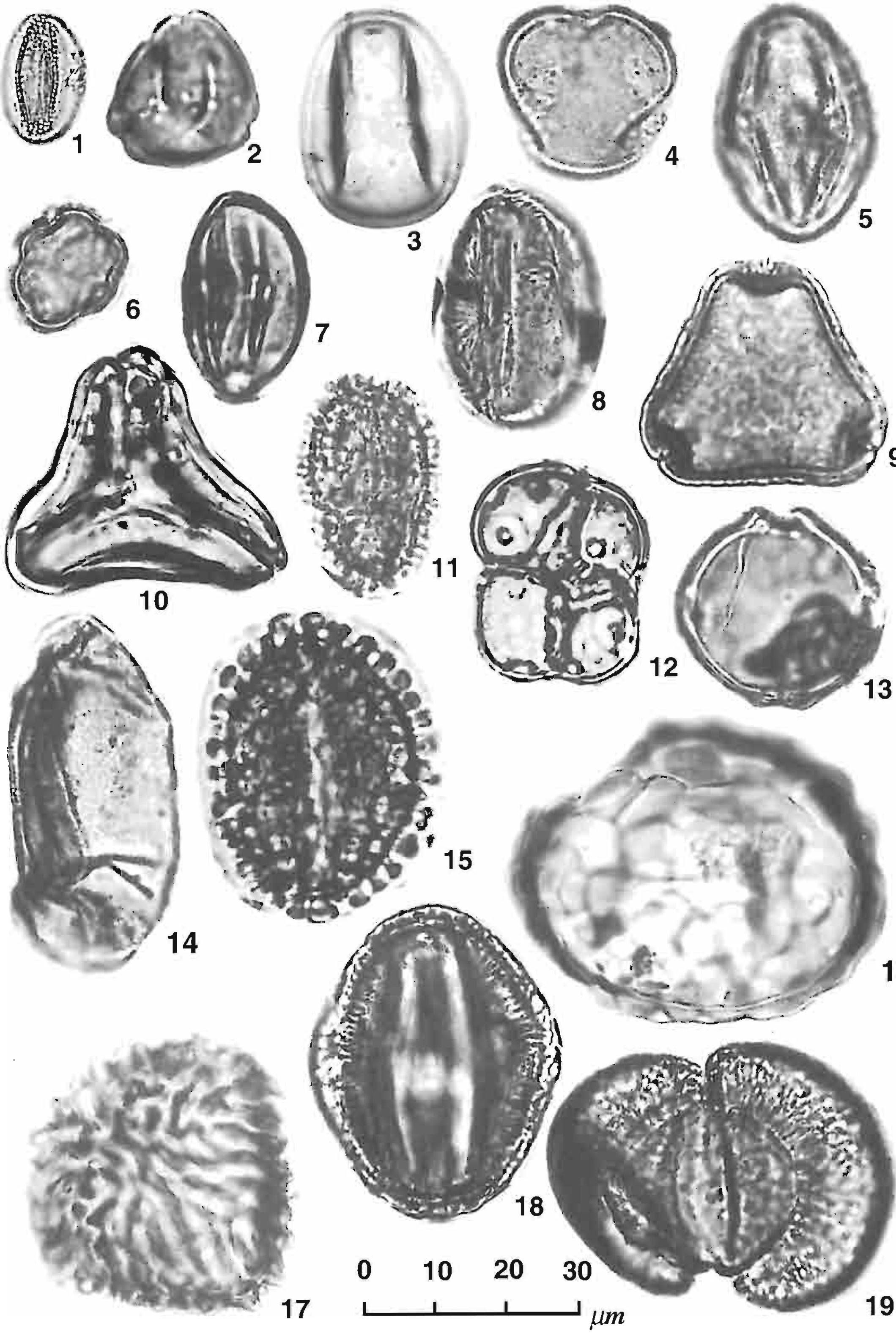
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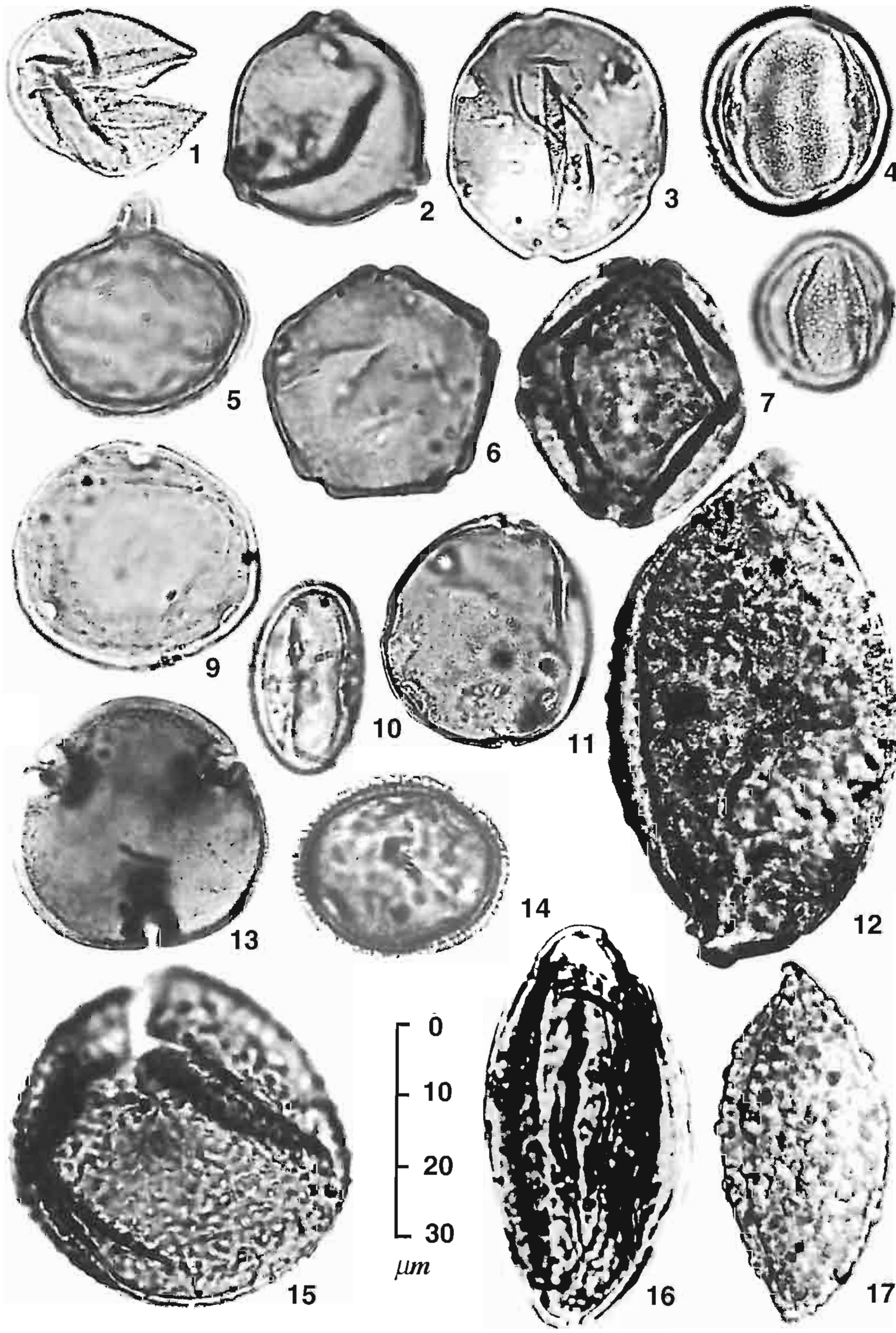
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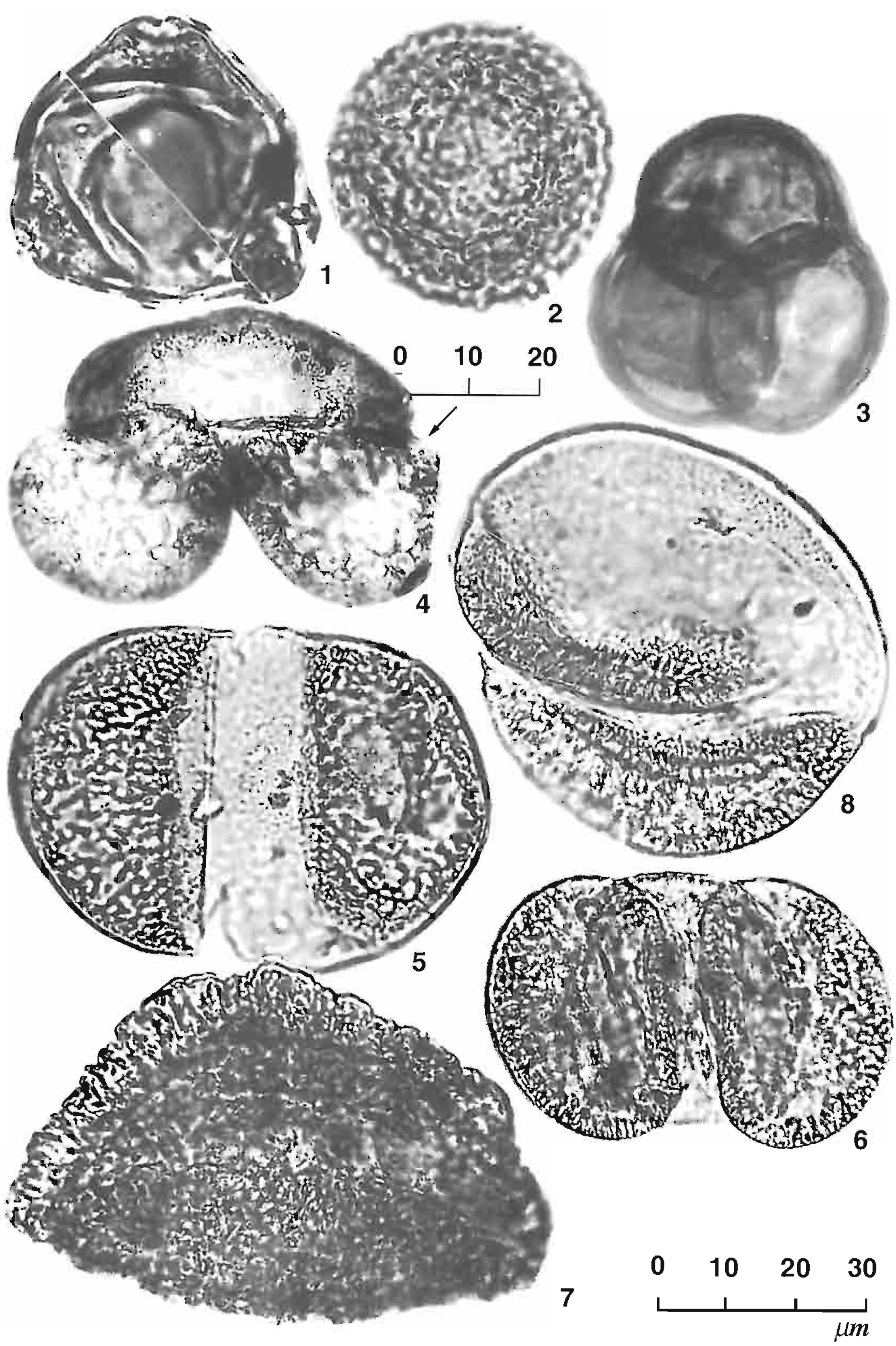
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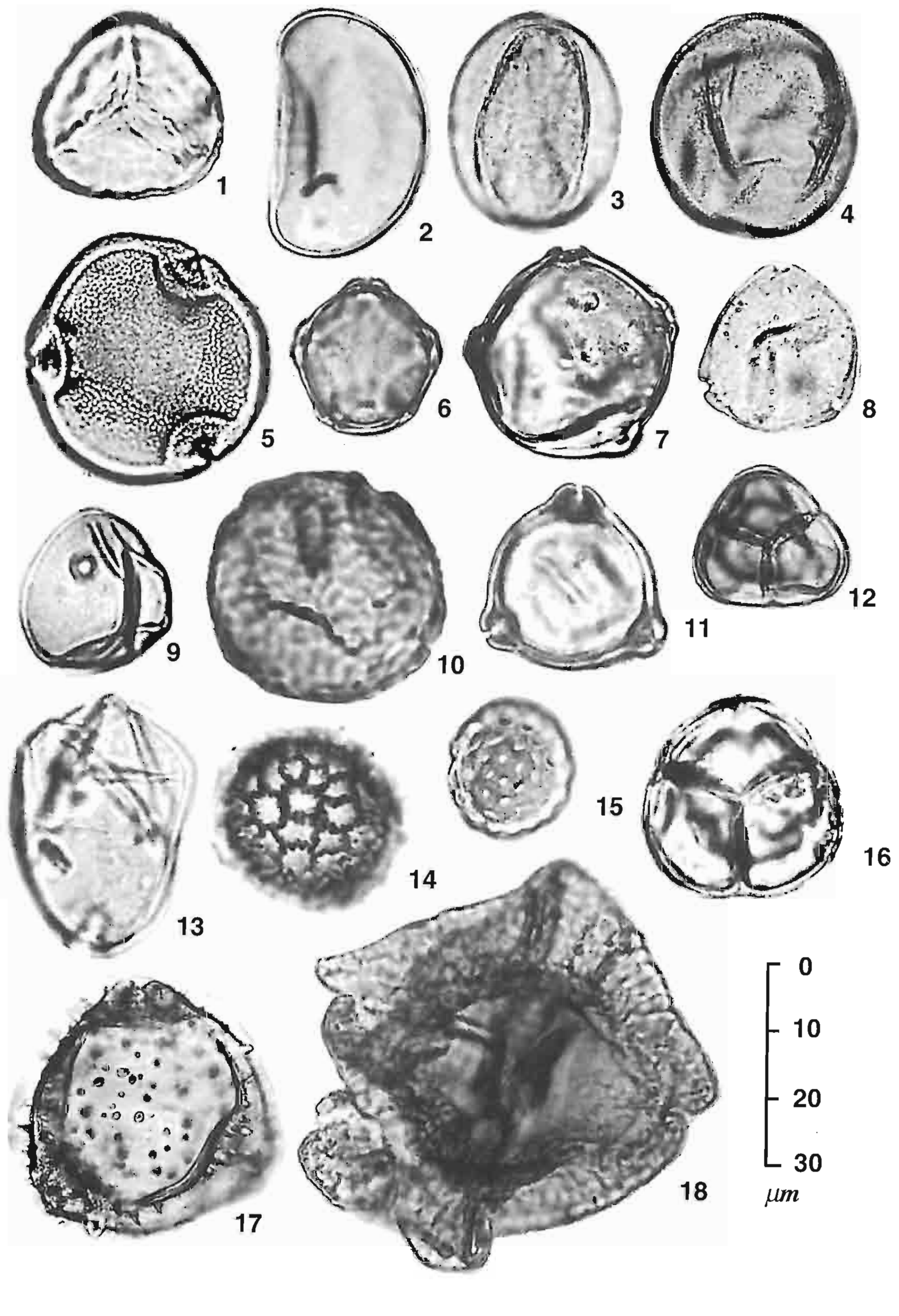
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