Palaeoenvironmental and sedimentological interpretations of the palynofacial analysis of the Miocene deposits from the Jamnica S-119 borehole (Carpathian Foredeep, Poland)

Przemysław GEDL

Analysis of the palynofacies from the Miocene deposits from the Jamnica S-119 borehole allows to reconstruct the palaeoenvironmental and sedimentological conditions prevailing during deposition of the Machów Formation and upper part of the Baranów Beds in the northern part of the Carpathian Foredeep. Relatively shallow-marine environment during the sedimentation of the lower part of the Pecten Beds was replaced by a more off-shore setting in its upper part. The boundary between the Pecten Beds and the Krakowiec Clays reflects a major sea level fall and/or an increase in salinity and terrestrial matter influx. The lower part of the Krakowiec Clays was deposited as a pelagic sediment in a deep-water off-shore marine setting, whereas younger deposits of this unit are a result of deltaic sedimentation under reduced salinity.

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Key words: Carpathian Foredeep, Miocene, palynofacies, dinocysts, palaeoenvironment.

INTRODUCTION

This paper presents preliminary results of the study of palynological content from the Miocene strata of the Jamnica S-119 borehole. Acid-resistant organic matter from 44 samples has been examined for the purpose of reconstruction of depositional environments. Special attention was paid to the dinocyst assemblages as the palaeoenvironmental indicators.

GEOLOGICAL SETTING

The Jamnica S-119 borehole was located in the northern part of the Carpathian Foredeep, ca. 20 km east from Tarnobrzeg (Fig. 1). It penetrated the following succession of the Miocene deposits (Fig. 2):

— 276.5–274.5 m: detrital deposits (clays) representing the Baranów Beds;
— 274.5–260 m: chemical deposits (sulphates and salts);
— above 260 m: detrital deposits representing the Machów Formation sensu S. W. Alexandrowicz et al. (1982) developed as the Pecten Beds in the lower part (260–243 m), and as the Krakowiec Clays in the upper part (243–30 m).

The age of chemical deposits and the Pecten Beds in the Kłaj-1 borehole has been established by E. Łuczkowska (1978) on the basis of foraminifera as the Middle Badenian: Wielician and Kosovian substages, respectively. A higher part of the Krakowiec Clays has been studied by means of calcareous nannoplankton by E. Gaździcka (1994) who recognized a Sarmatian age (NN8/NN9 Zone of standard nannoplankton zonation) (Fig. 2). However, the more recent biostratigraphical studies suggest a still younger, Upper Miocene age for the uppermost part of the Krakowiec Clays (J. Glazek, E. Gaździcka, in press).
MATERIAL AND METHODS

Acid-resistant organic matter has been studied from 44 samples. One sample was taken from the deposits below the chemical horizon (i.e. Baranów Beds). The material from the chemical deposits was not available for the present study. A densely sampled interval of the Pecten Beds and the Krakowiec Clays up to the depth of 208.5 m (34 samples) is followed in the borehole by an almost 100-m thick gap in sampling. The uppermost part of the drilled deposits (120–36 m) is represented by 9 samples (Fig. 2).

The sampled rock material has been processed according to the following palynological procedure: 20–30 g of cleaned and crushed rock was treated with 38% chloric acid (HCl) to remove carbonates, sieved by 15 μm sieve (with ultrasonic treatment), treated with 40% hydrofluoric acid (HF) to remove silicates, neutralized and sieved again on 15 μm sieve (with ultrasonic treatment). The organic matter has been separated from undissolved or undissolvable particles with heavy liquid (ZnCl₂ + HCl; s.g. = 2.0 g/cm³) sieved on 15 μm nylon sieve and transferred into glycerine water for storing. Glycerine-gelatine jelly was used as a mounting medium; two slides were made from each sample. The samples are stored in the collection of the Institute of Geological Sciences, Polish Academy of Sciences in Kraków.

Organic matter extracted from the cored material has been divided into five main groups, depending on their terrestrial or marine origin and state of preservation. The land derived organic matter is represented in the studied material by a phytoclast group comprising diversely preserved land plant remains, ranging from: (1) well preserved cuticules with still visible cell structures; to (2) completely oxidized black, non-transparent woody particles (the intermediate forms are observed) and (3) palynomorph group (pollen and spores). The marine organic matter group is represented by palynomorphs: (4) dinocysts, (5) multicellular algae, foraminiferal linings and fungi remnants (only dinocyst and multicellular algae appear as a major constituent of this group). Analysis of palynofacies changes (i.e., the changes of the terrestrial vs. marine components) allow to estimate the kind of predominating sedimentation (e.g., the palynofacies of the deltaic sediment is enriched in land-derived organic particles, whereas the off-shore, pelagic sediment contains the overwhelming marine elements).

Another tool for palaeoecological reconstructions used in this study are the dinocysts. Many Miocene forms, still living today, have well known environmental preferences (e.g. D. Wall et al., 1977). Hence, analysis of the dinocyst assemblages may help estimate such palaeoenvironmental factors as the depth of the basin, its salinity, temperature and primary productivity. Within the dinocysts recognized in the studied material, two groups of taxa with known bathymetrical preferences have been distinguished:

1. Near-shore group comprising the dinocysts which inhabit a broad range of shallow, shelf environments. These are Spiniferites, Achomosphaera, Operculodinium, Lingulodin-
Fig. 2. Lithology, litho-, bio-, and chronostratigraphy of the Jamnica S-119 borehole with position of the studied samples

Palm nium or Polysphaeridium (e.g. D. B. Williams, 1971; B. Dale, 1983; R. Harland, 1983; A. McMinn, 1990).

2. Open-marine group comprising Nematosphaeropsis and Impagidinium; these taxa are frequently found in recent oceanic, deep-water sediments. The latter taxon is almost exclusively known from the oceanic settings (e.g. R. Harland, 1983; L. E. Edwards, V. A. S. Andrel, 1992).

Another dinocyst group is composed of representatives of the genus Lejeunecysta. This genus represents peridinioid dinoflagellates, which are often associated with nutrient-rich areas, such as river deltas (e.g. U. Biffi, D. Grignani, 1983).

PALYNOFACIES

In the material from the Jamnica S-119 borehole, seven intervals characterized by different palynofacies have been distinguished (Fig. 3).

INTERVAL I (276.5–274.5 M; BARANÓW BEDS)

Palynofacies. The palynofacies is composed almost entirely of land-derived organic matter, mostly pollen grains
<table>
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<tr>
<th>Lithology</th>
<th>Palynofacies (%)</th>
<th>Dinocysts (%)</th>
<th>Interval</th>
<th>Inferred sea-level changes</th>
<th>Lithostratigraphy</th>
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**Diagram:**
- **Lithology:** indicated by different rock layers.
- **Palynofacies (%)** and **Dinocysts (%)** are shown across depth intervals.
- **Interval Changes:** shallow to deep are marked.
- **Inferred sea-level changes** are indicated by graphical representations.
- **Lithostratigraphy** is divided into sections like 'VII', 'VI', 'V', etc.

**Legend:**
- 1: Chemical deposits
- 2: Lower Poscon Beds
- 3: Middle Poscon Beds
- 4: Upper Poscon Beds
- 5: Baltistan
and land plant tissues (Pl. II, Fig. 1). Marine palynomorphs (dinocysts) are very rare, the most common being Systematophora ancyrea (Pl. I, Fig. 4) and Spiniferites ramosus s. l. (Pl. I, Fig. 2).

**Dinocysts.** Spiniferites ramosus s. l., S. pseudofurcatus, Systematophora ancyrea, Operculodinium centrocarpum, Lingulodinium machaerophorum, Selenopemphix nephroides, Melitasphaeridium choanophorum, Nematosphaeropsis labirynthea, and Palaeocystodinium stratogranaum.

**Redeposition.** The reworked taxa are relatively numerous; Paleogene taxa are represented also by Areosphaeridium? pectiniforme, Areoligera coronata, Homotrebiyllum pallidum, the Cretaceous taxa by Circulodinium sp., Odontochitina operculata and Oligosphaericidium complex.

Interval 274.5–258.0 m (chemical deposits and the lowermost part of the pecten beds). There were no samples available for this study.

**INTERVAL II (258–255 M; LOWER PART OF THE PECTEN BEDS)**

**Palynofacies.** The palynofacies of this interval is dominated by terrestrial sporomorphs and phytoclasts (Pl. II, Fig. 2): pollen grains and land plant remains (256–255 m) or black woody particles (258–257 m). Dinocysts, although not numerous, are rather diversified. In the lower part of the interval, Spiniferites ramosus s. l. (Pl. I, Fig. 2) is the most common taxon among dinocysts. There are no “deep-water” forms. Marine palynomorphs are represented also by Leiosphaeridia sp. (Pl. II, Fig. 2) which appear as the most numerous among all marine palynomorphs in sample 256–257 m.

**Dinocysts.** Spiniferites ramosus s. l., S. pachydermus, S. pseudofurcatus, Operculodinium centrocarpum, O. israelianum, Lingulodinium machaerophorum, Selenopemphix nephroides, and Systematophora ancyrea.

**Redeposition.** The reworked taxa are relatively frequent only in sample 258–257 m; Paleogene (Oligocene?): Wetzeliella symmectra, Fibrocysta sp., Charlesdowniea clathrata.

**INTERVAL III (254.0–246.1 M; MIDDLE AND UPPER PARTS OF THE PECTEN BEDS)**

**Palynofacies.** A characteristic feature of this interval is the abundance of dinocysts (Pl. III, Fig. 1), with dominating Nematosphaeropsis labirynthea (Pl. I, Fig. 3), a open-marine taxon (the second in frequency is Spiniferites ramosus s. l. — up to 60%). Dinocysts represent 20–30% of the palynofacies. A relatively high content of black woody particles (20–50%) was stated. The most common terrestrial elements are bisaccate pollen grains which constitute up to 70% in some samples (Fig. 3). Another characteristic feature of this interval is a very low content of land plant tissues.

**Dinocysts.** Spiniferites ramosus s. l., Nematosphaeropsis labirynthea, Operculodinium centrocarpum, O. israelianum, Systematophora ancyrea, Melitasphaeridium choanophorum, Labrynthodinium truncatum subsp. modicum, Lingulodinium machaerophorum, Polyphagidium zoiharyi, Impagidinium sp., Hystrichokolpoma rigaudiae, Reticulatosphaera acetinocoronata, Hystrichosphaeridium tubiferum, and Homotrebiyllum plectillum.

**Redeposition.** Reworked taxa appear as single specimens only in samples 253.03 and 250.5 m; Paleogene taxa Charlesdowniea clathrata, Homotrebiyllum sp. and Areosphaeridium? pectiniforme.

**INTERVAL IV (245.09–244.1 M; UPPERMOST PART OF THE PECTEN BEDS)**

**Palynofacies.** The palynofacies of this one-metre interval is completely different from those below and above. It is dominated by terrestrial palynomorphs (mostly pollen grains, although in the sample 246.11–245.08 m spores appear frequently) and land plant tissues. Marine palynomorphs are represented almost exclusively by Leiosphaeridia sp. This resembles the palinofacies of the II interval, however, the discussed section is almost devoid of dinocysts, which are present as single specimens only.

**Dinocysts.** Cordosphaeridium minimum sensu Benedek et Sarjeant (1981), Spiniferites ramosus s. l., Operculodinium centrocarpum.

**Redeposition.** One Paleogene taxon was found in this interval: Charlesdowniea sp.

**INTERVAL V (242.90–229.02 M; LOWER PART OF THE KRAKOWIEC CLAYS)**

**Palynofacies.** A general feature of this interval is the abundance of marine palynomorphs (dinocysts constitute up to 80%) and of terrestrial palynomorphs which are represented almost exclusively by bisaccate pollen grains. Two different dinocyst assemblages can be distinguished, each characteristic for different bathymetrical conditions:

1. Subinterval Va (242.9–237.0 m): dinocyst assemblage characterized by relatively high content of oceanic taxon Impagidinium (Pl. IV, Fig. 2).

2. Subinterval Vb (236.03–229.02 m): a relatively diversified dinocyst assemblage composed almost entirely of near-shore taxa (Pl. IV, Fig. 1).

Within the subinterval Va, Impagidinium sp. (Pl. I, Fig. 6) represents 10 to 60% of the whole dinocyst assemblage, the second in frequency Spiniferites ramosus s. l. (Pl. I, Fig. 2) is the most numerous in the lower part of the subinterval Va and...
in the whole subinterval Vb (Impagidinium sp. disappears in this subinterval). In the upper part of the subinterval Vb, Operculodinium centrocarpum (PI. I, Fig. 1), Systematophora ancyrea (Pl. I, Fig. 4) and Lejeunecysta sp. appear more frequently.


Redeposition. Reworked taxa are very rare in this interval. A few Paleogene forms appear in sample 236.06–236.03 m (Deflandrea heterophylcta, Areosphaeridium? pec­ tiniforme) and 234.10–234.09 m (O. phosphoritica).

INTERVAL VI (228.17–208.50 M; LOWER PART OF THE KRAKOWIEC CLAYS)

Palynofacies. The palynofacies of this interval is composed almost entirely of terrestrial elements (Pl. V, Fig. 1). These are mainly pollen grains and land plant tissues occurring in variable ratios. Marine palynomorphs are represented by very rare dinocysts, with the genus Lejeunecysta appearing as one of the most common in the uppermost part of this interval.


Redeposition. Reworked taxa are in many samples much more numerous than those presumed to be in situ. Cretaceous dinocysts appear for the first time in such a high number: Circulodinium sp., Oligosphaeridium sp. Paleogene taxa are represented by Wetzeliiella sp., Homotryblium sp., Areosphaeridium ditytoplous, Deflandrea phosphoritica, Glaphyrocysta sp. and Rhabdominium longimanum.

Interval 208.5–120 m (middle part of the Krakowiec Clay). No samples were available from this interval.

INTERVAL VII (120–36 M; UPPER PART OF THE KRAKOWIEC CLAYS)

Palynofacies. The palynofacies of this interval is composed of well preserved land plant tissues and, subordinately, of bisaccate pollen grains (Pl. V, Fig. 2). Miocene dinocysts are either absent or appear as single specimens only (presumably reworked).

Dinocysts. Lingulodinium machaerophorum, Spini­ ferites ramosus s. l., S. pseudofurcatus, Dapsilidinium pseudocolligerum, Systematophora ancyrea, Cordosphaeridium cantharellum, and Hystrichokolpoma rigaudiae.

Redeposition. In most samples of this interval reworked taxa represent the only dinocysts. A characteristic feature is the appearance of poorly preserved forms (in contrast to very well preserved reworked specimens found in the previous intervals). Poorly and well preserved Paleogene taxa appear together. The well preserved Paleogene taxa are represented by Areosphaeridium ditytoplous, A? pectiniforme, Wetzeliiella symmetrica subsp. incisa, W. gochtii, Thalassip­ hora pelagica, Homotryblium sp., H. pectillum, Glaphyrocysta sp., and Deflandrea phosphoritica. Much less numerous Cretaceous taxa are represented by Circulodinium sp. and Surculosphaeridium? longifurcatum.

REDEPOSITION

Reworked dinocysts appear relatively frequently in those intervals where terrestrial material is significant. They are most abundant (in many cases even more abundant than the forms in situ) in such intervals which were characterized by environmental conditions unfavourable for life of dinocysts (i.e., in the interval just above the chemical deposits or in the uppermost part of the Krakowiec Clay). The reworked forms are represented by the Cretaceous and Eocene–Oligocene dinocysts. Their state of preservation indicates two sources. Very well preserved forms were derived from platform depo­ sits of the northern surroundings of the Carpathian Foredeep. These are the most common reworked taxa that appear in the material from the Jamnica S–I19 borehole. The second group of reworked dinocysts is characterized by poor state of preservation that is typical of dinocysts from the Flysch Carpathians. They appear exclusively in the upper part of the studied section (interval VII; 208.5–36 m), within the interval interpreted as deltaic sediments.

CONCLUSIONS

1. Palynological content of the lowermost sample representing the Baranów Beds (interval I) indicates a relatively shallow-marine, near-shore depositional setting. However, the presence of a few deep-water specimens (Nematosphaeria­opsis labirynthea) may indicate a slightly deeper setting. The overlying chemical deposits have not been investigated in this study. The data from other localities (P. Gedl in: T. M. Peryt et al., 1997), as well as a shallow-marine palynomorph assemblage from strata just above the chemical deposits, indicate shallow-marine conditions prevailing during its deposition.

2. The lower part of the Pecten Beds (interval II) was most presumably deposited in a shallow, near-shore environment (lack of deep-water dinocysts and dominance of terrestrial palynomorphs).
3. A much deeper environment developed (interval III) in the upper part of the *Pecten* Beds: the depth of the basin can be estimated at 100–200 m (outer shelf). This is indicated by the presence of numerous representatives of *Nematosphaeropsis labyrinthae* and single specimens of *Impagidinium*, both being open-marine taxa. Input of terrestrial material was reduced, as compared with the previous interval: this indicates a more distally off-shore depositional setting.

4. Shallow-marine conditions returned for a short time near the Badenian/Sarmatian boundary (interval IV): near-shore dinocyst assemblage and prevailing terrestrial palynomorphs indicate an abrupt, prominent shallowing. This might be associated with an increase in salinity, since an abundance of *Leiosphaeridia*, the only marine palynomorph found in the chemical deposits at Kobefice, Moravia (P. Gedl in: T. M. Peryt et al., 1997), is registered from this interval. However, such a palynofacies may develope as a result of increased circulation.

5. The lowermost part of the Krakowiec Clays (subinterval Va) formed in open-marine conditions: the presence of numerous *Impagidinium* specimens indicate an outer shelf or pelagic depositional setting with water depth in excess of 200 m. Variable content of more near-shore taxa and terrestrial palynomorphs might reflect an off-shore current transport. This interval represents the deepest and most pelagic setting within the whole section of the studied Miocene deposits from the Jamnica S-119 borehole.

6. Palynological content of the upper part of the Krakowiec Clays (up to the depth of 228 m; subinterval Vb) indicates a much more shallow, although still pelagic setting: the dominating dinocysts are almost entirely represented by shallow-marine taxa.

7. An abrupt change in sedimentation type began at the depth of 228 m (interval VI): terrigenous elements are the prevailing component of the palynofacies, whereas dinocysts become very rare. Among rare dinocysts, *Lejeunecysta*, a genus typical for nutrient-rich, brackish environments appears. This palynofacies may be interpreted as a result of deltaic sedimentation combined with reduction of salinity.

8. A similar type of palynofacies is present in the uppermost part of the Krakowiec Clays (interval VII): there is no data from the 208.5–120.0 m interval. A difference is the lack of the *in situ* dinocysts and the overwhelming presence of large, well preserved land plant tissues. Their occurrence suggests deltaic sedimentation with a relatively close alimentary area, than that of the interval VI, which may be interpreted as distal deltaic deposit.

**DISCUSSION**

The results obtained from the above palynological analysis are at variance with those of previous authors working in the same area. E. Gaździcka (1994), on the basis of the calcareous nannoplankton, suggested near-shore environment for the *Pecten* Beds and the lower part of the Krakowiec Clays, whereas the dinocyst data indicate a near-shore conditions only for the lower part of the *Pecten* Beds and for a short interval close to the boundary between the *Pecten* Beds and the Krakowiec Clays. E. Gaździcka (1994) reported also from a lower part of the Krakowiec Clays layers very rich in nannoplankton, which she interpreted as pelagic sediments. These layers might be correlated with those intervals where the dinocysts (pelagic element) dominate. A deltaic sedimentation in the upper part of the Krakowiec Clays, as based on the presence of predominating terrogenous elements, was also suggested by E. Gaździcka (1994). She interpreted the presence of numerous reworked nannoplankton in the upper part of the section as a result of deltaic sedimentation.

Similar bathymetrical conclusions concerning the lower part of the studied section were drawn by N. Oszczypko (1996) who suggested a shallowing during the deposition of the upper part of the Skawina Beds (i.e., equivalent of the Baranów Beds in the area of Jamnica S-119 borehole) and the chemical deposits. However, the conclusions about the shallow basin during the deposition of the Krakowiec Beds (N. Oszczypko, 1996) do not agree with those obtained in the present study. In the present author’s opinion, at least the lower part of the Krakowiec Beds was deposited in a deeper basin, in excess of 200 m.

**Acknowledgements.** Dr. J. Paruch-Kulezycka (Polish Geological Institute, Warszawa) is greatly acknowledged for encouragement for this study and sample supply. Prof. Dr. N. Oszczypko (Institute of Geological Sciences, Jagiellonian University, Kraków) is acknowledged for very helpful discussion and Dr. B. Słodkowska (Polish Geological Institute, Warszawa) is acknowledged for critical reading of the manuscript. Special thanks are due to Prof. Dr. K. Birkenmajer (Institute of Geological Sciences, Polish Academy of Sciences, Kraków) for his editorial help and discussion while preparing this paper for publication.

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PALEOSRODOWISKOWA I SEDIMENTOLOGICZNA INTERPRETACJA ANALIZY PALINOFACJALNEJ MIOCEŃSKICH UTWÓRÓW Z OTWORU JAMNICA S-119 (ZAPADLSKO PRZEDKARPACKIE)

Streszczenie

W obrębie badanych osadów z otworu wiertniczego Jamnica S-119 (fig. I i 2) wyróżniono siedem interwałów o odmiennych palinofacjach odwzorowujących zróżnicowane warunki sedimentacji (fig. 3).

Inteval I (276,5–274,5 m; warstwy baranowskie występujące w spłaszczonej formie) przedstawia normalne warunki sedimentacji w górnym poziomie studni. Palinofacja (tabl. I, fig. 1) sugeruje normalne warunki sedimentacji w zbiorniku o zmiennościach chemicznych (Por. T. M. Peryt in.).

Inteval II (258–255 m; dolna część warstw pektengowych). Palinofacja (tabl. II, fig. 2) wskazuje na stosunkowo płasko wyrównane strefy sedimentacyjne, które były obecnie w niższych warstwach produkcyjnych. Dinocysty z tabl. II i fig. 2 wskazują na obecność glonów o specyficznej morfologii, które mogą być świadczeniem o badanych warunkach (Por. T. M. Peryt in.).

Inteval III (254,0–246,1 m; środkowa i górna część warstw pektengowych). Utwory zaliczane do tego interwala (tabl. III, fig. 1) zapewniały normalne warunki sedimentacji w stosunkowo głębokim (100–200 m) i odległym od brzegu środowisko. Dinocysty z tabl. III i fig. 3 wskazują na silne spłycenie w stopowej strefie warstw pektengowych, połączone mogą być ze wzrostem zasolenia. Możliwe jest zjawisko transportu z płaskich stref basenu, przy czym zewnętrzne warunki mogą wskazywać na występowanie powietrza w strefie warstw pektengowych. Dinocysty z tabl. III i fig. 2 wskazują na obecność glonów o specyficznej morfologii, które mogą być świadczeniem o badanych warunkach (Por. T. M. Peryt in.).

Inteval IV (245,9–244,0 m; najwyższa część warstw pektengowych). Palinofacja (tabl. III, fig. 2) wskazuje na silne spłycenie w strefie warstw pektengowych, połączone mogą być ze wzrostem zasolenia. Możliwe jest zjawisko transportu z płaskich stref basenu, przy czym zewnętrzne warunki mogą wskazywać na występowanie powietrza w strefie warstw pektengowych. Dinocysty z tabl. IV i fig. 1 wskazują na obecność glonów o specyficznej morfologii, które mogą być świadczeniem o badanych warunkach (Por. T. M. Peryt in.).

Inteval V (236,03–237,02 m) charakteryzuje się obecnością glonów o specyficznej morfologii, które mogą być świadczeniem o badanych warunkach (Por. T. M. Peryt in.). Obecność glonów o specyficznej morfologii, które mogą być świadczeniem o badanych warunkach (Por. T. M. Peryt in.).

Inteval VI (228,17–208,5 m; dolna część warstw pektengowych). W wyższej części interwala (tabl. V, fig. 1) pojawiają się liczne dinocysty z rodzaju Lejeuneicysta, opisywanych często z osadów deltowych (np. U. Biffi, D. Grignani, 1983). Obecność pojedynczych osobników glonów o specyficznej morfologii wskazuje na obecność glonów o specyficznej morfologii, które mogą być świadczeniem o badanych warunkach (Por. T. M. Peryt in.).

Inteval VII (120–36 m; górna część warstw pektengowych). Palinofacja (tabl. VII, fig. 2) wskazuje na silne spłycenie w strefie warstw pektengowych, połączone mogą być ze wzrostem zasolenia. Możliwe jest zjawisko transportu z płaskich stref basenu, przy czym zewnętrzne warunki mogą wskazywać na występowanie powietrza w strefie warstw pektengowych. Dinocysty z tabl. VII i fig. 2 wskazują na obecność glonów o specyficznej morfologii, które mogą być świadczeniami o badanych warunkach (Por. T. M. Peryt in.).

Subinterval VB (236,03–237,02 m) charakteryzuje się obecnością glonów o specyficznej morfologii, które mogą być świadczeniami o badanych warunkach (Por. T. M. Peryt in.). Obecność glonów o specyficznej morfologii, które mogą być świadczeniami o badanych warunkach (Por. T. M. Peryt in.).

Subinterval VII (120–36 m; górna część warstw pektengowych). Palinofacja (tabl. VII, fig. 2) wskazuje na silne spłycenie w strefie warstw pektengowych, połączone mogą być ze wzrostem zasolenia. Możliwe jest zjawisko transportu z płaskich stref basenu, przy czym zewnętrzne warunki mogą wskazywać na występowanie powietrza w strefie warstw pektengowych. Dinocysty z tabl. VII i fig. 2 wskazują na obecność glonów o specyficznej morfologii, które mogą być świadczeniami o badanych warunkach (Por. T. M. Peryt in.).
EXPLANATIONS OF PLATES

PLATE I

Dinocysts from the Miocene deposits of the Jamnica S-119 borehole; scale bar = 20 μm
Fig. 1. Operculodinium centrocarpum
Fig. 2. Spiniferites runosus
Fig. 3. Nematosphaeropsis labirynthea
Fig. 4. Systematophora ancyra
Fig. 5. Lingulodinium machaerophorum
Fig. 6. Impagidinium sp.

PLATE II

Palynofacies of the Miocene deposits from the Jamnica S-119 borehole; scale bar = 100 μm
Fig. 1. Interval I; 276.5 m; Baranów Beds
Fig. 2. Interval II; 256–255 m; Pecten Beds

PLATE III

Palynofacies of the Miocene deposits from the Jamnica S-119 borehole; scale bar = 100 μm
Fig. 1. Interval III; 250.5 m; Pecten Beds
Fig. 2. Interval IV; 244.11–244.10 m; uppermost part of the Pecten Beds, near the Badenian/Sarmatian boundary

PLATE IV

Palynofacies of the Miocene deposits from the Jamnica S-119 borehole; scale bar = 100 μm
Fig. 1. Subinterval Va; 241 m; lowermost part of the Krakowiec Clays
Fig. 2. Subinterval Vb; 239.2–239.1 m; lower part of the Krakowiec Clays

PLATE V

Palynofacies of the Miocene deposits from the Jamnica S-119 borehole; scale bar = 100 μm
Fig. 1. Interval VI; 217.03–217.03 m; Krakowiec Clays
Fig. 2. Interval VII; 82.0 m; upper part of the Krakowiec Clays
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