Geological Quarterly, 1999, **43** (4): 479–492

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

Przemysław GEDL

Gedl P. (1999) — Palaeoenvironmental and sedimentological interpretations of the palynofacial analysis of the Miocene deposits from the Jamnica S-119 borehole (Carpathian Foredeep, Poland). Geol. Quart., **43** (4): 479–492. Warszawa.

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.

Przemysław Gedl, Institute of Geological Sciences, Polish Academy of Sciences, Senacka 1, PL-31-002 Kraków, Poland (received: June 9, 1999; accepted: July 7, 1999).

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. Głazek, E. Gaździcka, in press).

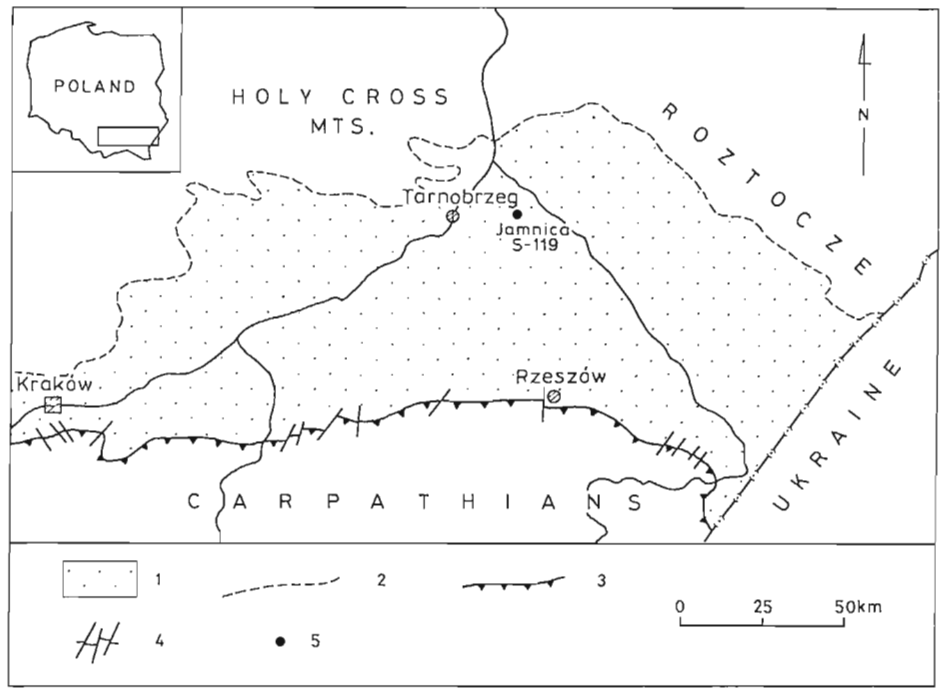


Fig. 1. Location of the Jamnica S-119 borehole (adapted from E. Gaździcka, 1994)

1 — Miocene deposits of the Carpathian Foreland; 2 — present-day north extent of the Miocene deposits; 3 — Carpathian nappes overthrust; 4 — faults; 5 — borehole

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 ($ZnCl_2$ + HCl; s.g. = 2.0 g/cm^3), 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 structeres; 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 remains (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*, *Lingulodi-*

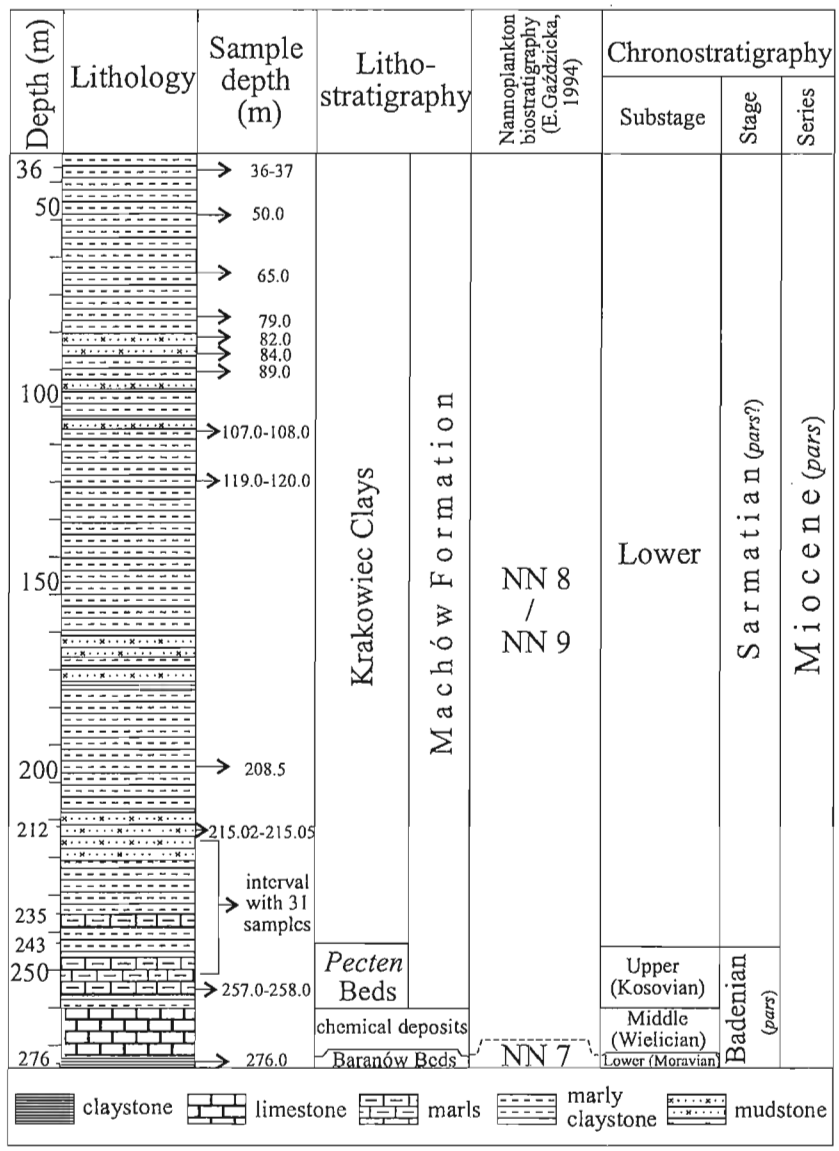


Fig. 2. Lithology, litho-, bio-, and chronostratigraphy of the Jamnica S-119 borehole with position of the studied samples

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. Andrle, 1992).

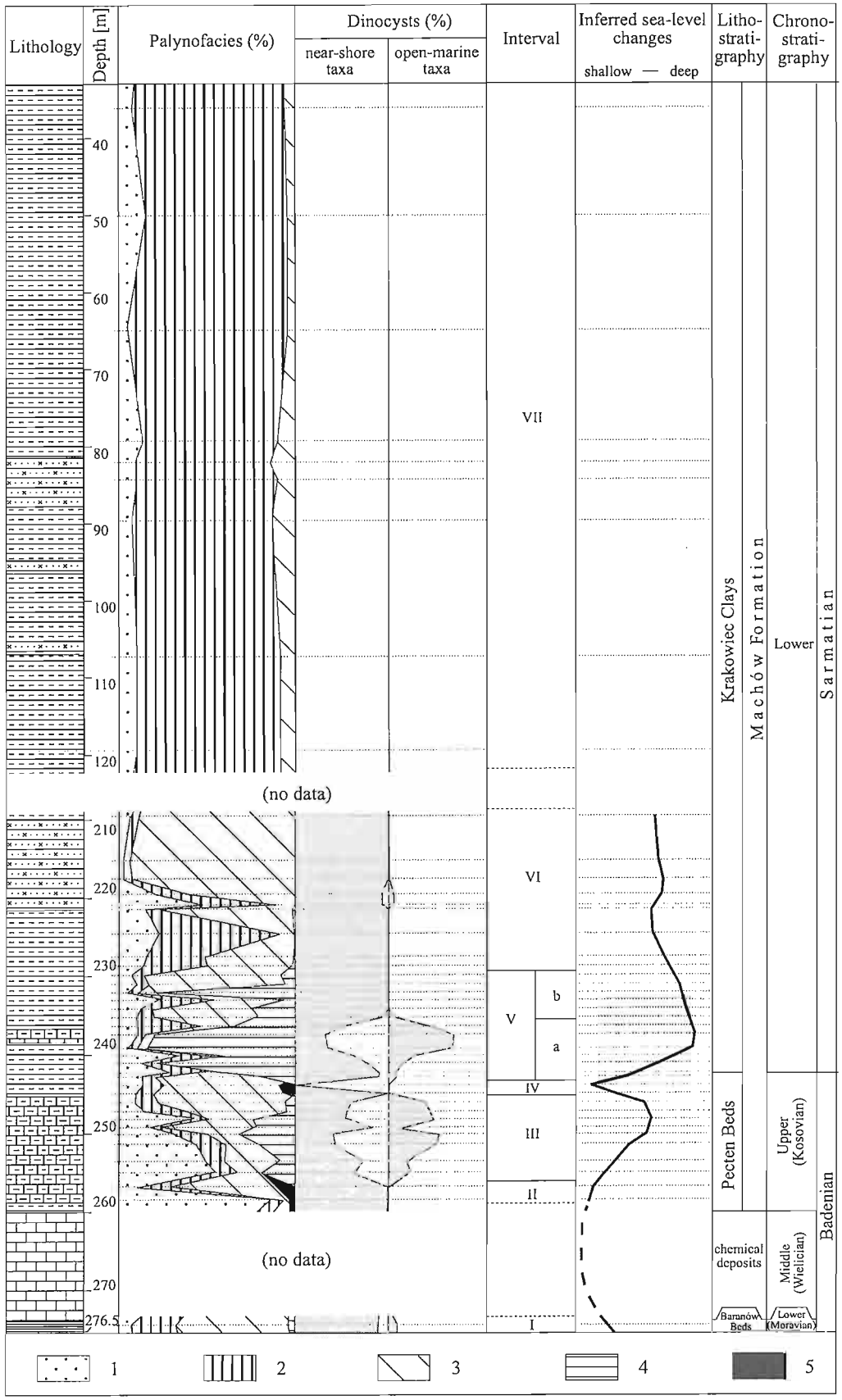
Another dinocyst group is composed of representatives of the genus *Lejeunecysta*. This genus represents peridinioid dinoflagellates, which are often associated with nutrient-rich areas, such as river deltas (e.g. U. Biffi, D. Grignani, 1983).

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)

P a l y n o f a c i e s . The palynofacies is composed almost entirely of land-derived organic matter, mostly polen grains


Lithology
Depth [m]
Palynofacies (%)
Dinocysts (%)
near-shore taxa
open-marine taxa
Interval
Inferred sea-level changes
shallow — deep
Litho-stratigraphy
Chrono-stratigraphy
40
50
60
70
80
90
100
110
120
VII
(no data)
210
220
230
240
250
260
270
276.5
VI
V
b
a
IV
III
II
I
(no data)
Krakowiec Clays
Machów Formation
Pecten Beds
chemical deposits
Baranów Beds
Lower
Upper (Kosovian)
Middle (Wielician)
Lower (Moravian)
Sarmatian
Badenian
1
2
3
4
5

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 stratogranulatum.*

Redeposition. The reworked taxa are relatively numerous; Paleogene taxa are represented by *Areosphaeridium? pectiniforme, Areoligera coronata, Homotryblium pallidum,* the Cretaceous taxa by *Circulodinium* sp., *Odontochitina operculata* and *Oligosphaeridium 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 256–255 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 symmetrica, 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, Labirynthodinium truncatum* subsp. *modicum, Lingulodinium machaerophorum, Polysphaeridium zoharyi, Impagidinium* sp., *Hystrichokolpoma rigaudiae, Reticulatosphaera actinocoronata, Hystrichosphaeridium tubiferum,* and *Homotryblium plectilum.*

Redeposition. Reworked taxa appear as single specimens only in samples 253.03 and 250.5 m; Paleogene taxa *Charlesdowniea clathrata, Homotryblium* 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 divoid 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 nearshore 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

Fig. 3. Results and interpretation of palynofacial analysis of the Miocene deposits from the Jamnica S-119 borehole

1 — black woody particles; 2 — land plant tissues; 3 — sporomorphs (bisaccate pollen grains and spores); 4 — dinocysts; 5 — *Leiosphaeridia* sp.; for the lithology explanations see Fig. 2

in the whole subinterval Vb (*Impagidinium* sp. disappears in this subinterval). In the upper part of the subinterval Vb, *Operculodinium centrocarpum* (Pl. I, Fig. 1), *Systematophora ancyrea* (Pl. I, Fig. 4) and *Lejeunecysta* sp. appear more frequently.

Dinocysts. *Spiniferites ramosus s. l.*, *S. pseudofurcatus*, *Homotryblium plectilum*, *Svenkodinium* sp., *Systematophora ancyrea*, *Operculodinium centrocarpum*, *O. israelianum*, *O. piaseckii*, *Impagidinium* sp., *Lingulodinium machaerophorum*, *Dapsilidinium pseudocolligerum*, *Melitasphaeridium choanophorum*, *Hystrichosphaeridium tubiferum*, *Tectatodinium* sp., *Polysphaeridium zoharyi*, *Reticulatosphaera actinocoronata*, *Hystrichosphaeropsis* sp., *H. minimus*, *H. obscura*, *Batiacasphaera sphaerica*, *Selenopemphix nephroides*, *Cordosphaeridium minimum sensu* Benedek et Sarjeant (1981), *Lejeunecysta* sp., *Labirynthodinium truncatum* subsp. *modicum*, and *Hystrichokolpoma truncata*.

Redeposition. Reworked taxa are very rare in this interval. A few Paleogene forms appear in sample 236.06–236.03 m (*Deflandrea heterophlycta*, *Areosphaeridium? pectiniforme*) and 234.10–234.09 m (*D. 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.

Dinocysts. *Spiniferites ramosus s. l.*, *Systematophora ancyrea*, *Operculodinium israelianum*, *O. centrocarpum*, *Hystrichokolpoma rigaudiae*, *Impagidinium* sp., *Reticulatosphaera actinocoronata*, *Nematosphaeropsis labirynthea*, *Lejeunecysta* sp., *Polysphaeridium zoharyi*, and *Lingulodinium machaerophorum*.

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 *Wetzeliella* sp., *Homotryblium* sp., *Areosphaeridium diktyoplokus*, *Deflandrea phosphoritica*, *Glaphyrocysta* sp. and *Rhombodinium longimanum*.

Interval 208.5–120 m (middle part of the Krakowiec Clays). 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*, *Spiniferites 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 diktyoplokus*, *A? pectiniforme*, *Wetzeliella symmetrica* subsp. *incisa*, *W. gochtii*, *Thalassiphora pelagica*, *Homotryblium* sp., *H. plectilum*, *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 Clays). 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 deposits of the northern surroundings of the Carpathian Foredeep. These are the most common reworked taxa that appear in the material from the Jamnica S-119 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 (*Nematosphaeropsis 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 labirynthea* 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 Kobeřice, 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 terrigenous 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-Kulczycka (Polish Geological Institute, Warszawa) is greatfully 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.

REFERENCES

ALEXANDROWICZ S. W., GARLICKI A., RUTKOWSKI J. (1982) — Podstawowe jednostki litostratygraficzne miocenu zapadliska przedkarpackiego. Geol. Quart., **26** (2): 470–471.

BIFFI U., GRIGNANI D. (1983) — Peridinioid dinoflagellate cyts from the Oligocene of the Niger Delta, Nigeria. Micropaleontologica, **29** (2): 126–145.

DALE B. (1983) — Dinoflagellate cysts: "benthic plankton". In: Survival strategies of the algae (ed. G. A. Fryxell): 69–136. Cambridge University Press. Cambridge.

EDWARDS L. E., ANDRLE V. A. S. (1992) — Distribution of selected dinoflagellate cysts in modern marine sediments. In: Neogene and Quaternary dinoflagellate cysts and acritarchs (eds. M. J. Head, J. H. Wrenn): 259–288. Am. Ass. Stratigr. Palynol. Found.

GAŹDZICKA E. (1994) — Nannoplankton stratigraphy of the Miocene deposits in Tarnobrzeg area (northeastern part of the Carpathian Foredeep). Geol. Quart., **38** (3): 553–570.

GŁAZEK J., GAŹDZICKA E. (in press) — Nannoplankton evidence of the Late Miocene age of the Krakowiec Clays in Zarzecze near Nisko and its paleogeographic consequences (Carpathians Foredeep, Southern Poland).

HARLAND R. (1983) — Distribution maps of recent dinoflagellate cysts in bottom sediments from the North Atlantic Ocean and adjacent seas. Palaeontology, **26** (2): 321–387.

ŁUCZKOWSKA E. (1978) — Faziostratotypus: Bohrung Kłaj-1, Karpatische Vortiefe in Polen. In: Chronostratigraphie und Neostratotypen Miozän M4 Badenien (A. Papp *et al.*): 155–158.

McMINN A. (1990) — Recent dinoflagellate cyst distribution in eastern Australia. Rev. Palaeobot. Palynol., **65**: 305–310.

NEY R., BURZEWSKI W., BACHLEDA T., GÓRECKI W., JAKÓBCZAK K., SŁUPCZYŃSKI K. (1974) — Outline of paleogeography and evolution of lithology and facies of Miocene layers on the Carpathian Foredeep (in Polish with English summary). Pr. Geol. Komis. Nauk Geol. PAN, Kraków, **82**: 3–65.

OSZCZYPKO N. (1996) — The Miocene dynamics of the Carpathian Foredeep in Poland (in Polish with English summary). Prz. Geol., **44** (10): 1007–1018.

PERYT T. M., KAROLI S., PERYT D., PETRICHENKO O. I., GEDL P., NARKIEWICZ W., ĎURKOVIČOVÁ J., DOBIESZYŃSKA Z. (1997) — Westernmost occurrence of the Middle Miocene Badenian gypsum in central Paratethys (Kobeřice, Moravia, Czech Republic). Slovak Geol. Mag., **3** (2): 105–120.

WALL D., DALE B., LOHMANN G. P., SMITH W. K. (1977) — The environmental and climatic distribution of dinoflagellate cysts in modern marine sediments from regions in the north and south Atlantic Oceans and adjacent seas. Mar. Micropalaeont., **2**: 121–200.

WILLIAMS D. B. (1971) — The occurrence of dinoflagellates in marine sediments. In: The micropalaeontology of oceans (eds. B. M. Funnel, W. R. Riedel): 231–243. Cambridge University Press. Cambridge.

PALEOŚRODOWISKOWA I SEDYMENTOLOGICZNA INTERPRETACJA ANALIZY PALINOFACJALNEJ MIOCEŃSKICH UTWORÓW Z OTWORU JAMNICA S-119 (ZAPADLISKO PRZEDKARPACKIE)

Streszczenie

W obrębie badanych osadów z otworu wiertniczego Jamnica S-119 (fig. 1 i 2) wyróżniono siedem interwałów o odmiennych palinofacjach odzwierciedlających zróżnicowane warunki sedymentacji (fig. 3).

Interwał I (276,5–274,5 m; warstwy baranowskie występujące w spągowej części otworu). Palinofacja (tabl. II, fig. 1) sugeruje normalne warunki morskie. Zdecydowana większość dinocyst to formy przybrzeżne, jednak obecność kilku przedstawicieli form oceanicznych (*Nematosphaerospsis* — tabl. I, fig. 3) nie może wykluczyć głębszego środowiska depozycji.

Interwał II (258–255 m; dolna część warstw pektenowych). Palinofacja (tabl. II, fig. 2) wskazuje na stosunkowo płytkowodne i przybrzeżne środowisko, przy czym obecność glonów *Leiosphaeridia* sp. może świadczyć o wciąż zaburzonym chemizmie wody będącym pozostałością po poprzedzających osadach chemicznych (por. T. M. Peryt i in., 1997).

Interwał III (254,0–246,1 m; środkowa i górna część warstw pektenowych). Utwory zaliczane do tego interwału (tabl. III, fig. 1) powstały najprawdopodobniej w warunkach sedymentacji pelagicznej w stosunkowo głębokim (100–200 m) i odległym od brzegu środowisku.

Interwał IV (245,9–244,0 m; najwyższa część warstw pektenowych). Palinofacja (tabl. III, fig. 2) wskazuje na silne spłycenie w stropowej partii warstw pektenowych, połączone być może ze wzrostem zasolenia. Możliwe jest zjawisko transportu z płytszych stref basenu, przy czym zupełny brak form otwartego morza wydaje się to wykluczać.

Interwał V (242,9–229,02 m; dolna część iłów krakowieckich). Ze względu na zróżnicowanie zespołu dinocyst wyróżniono dwa subinterwały: subinterwał Va (w części spągowej: 242,9–237,0 m) charakteryzujący się dużym udziałem oceanicznego rodzaju *Impagidinium* (tabl. IV, fig. 2), oraz subinterwał Vb (236,03–229,02 m) ze zróżnicowanym zespołem dinocyst pozbawionych jednak form głębokowodnych (tabl. IV, fig. 1). Utwory tego interwału powstały w wyniku sedymentacji pelagicznej w zbiorniku o zmiennej batymetrii. Subinterwał Va reprezentuje największe pogłębienie zbiornika w czasie powstawania badanych utworów (głębokość mogła przekroczyć 200 m), natomiast osady subinterwału Vb osadzały się w znacznie płytszych warunkach.

Interwał VI (228,17–208,5 m; dolna część iłów krakowieckich). W wyższej części interwału (tabl. V, fig. 1) pojawiają się liczniej dinocysty z rodzaju *Lejeunecysta*, opisywanego często z osadów deltowych (np. U. Biffi, D. Grignani, 1983). Obecność pojedynczych osobników głębokowodnych wskazuje na wciąż stosunkowo głębokie środowisko.

Interwał VII (120–36 m; górna część iłów krakowieckich). Palinofację tego interwału można zinterpretować jako powstałą w wyniku sedymentacji delty rzecznej (tabl. V, fig. 2). W przeciwieństwie do utworów interwału VI, które najprawdopodobniej stanowią osady dystalne delty, utwory z interwału VII to osady proksymalne delty.

W niektórych odcinkach badanych utworów stosunkowo licznie występują dinocysty redeponowane (z reguły są to odcinki o zwiększonej dostawie materii lądowej). Ze względu na różny stan zachowania, który wynika z rozmaitych miejsc pochodzenia, wyróżnia się wśród nich dwie grupy. Dobrze zachowane formy (występują praktycznie w całym profilu) pochodzą z kredowych i paleogeńskich utworów Niżu Polskiego (tym samym wskazują na brzeg północny jako obszar alimentacyjny). Źle zachowane dinocysty paleogeńskie pochodzą natomiast z erodowanych utworów Karpat fliszowych i występują wyłącznie w interwale VII.

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 ramosus*

Fig. 3. *Nematosphaeropsis labirynthea*

Fig. 4. *Systematophora ancyrea*

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

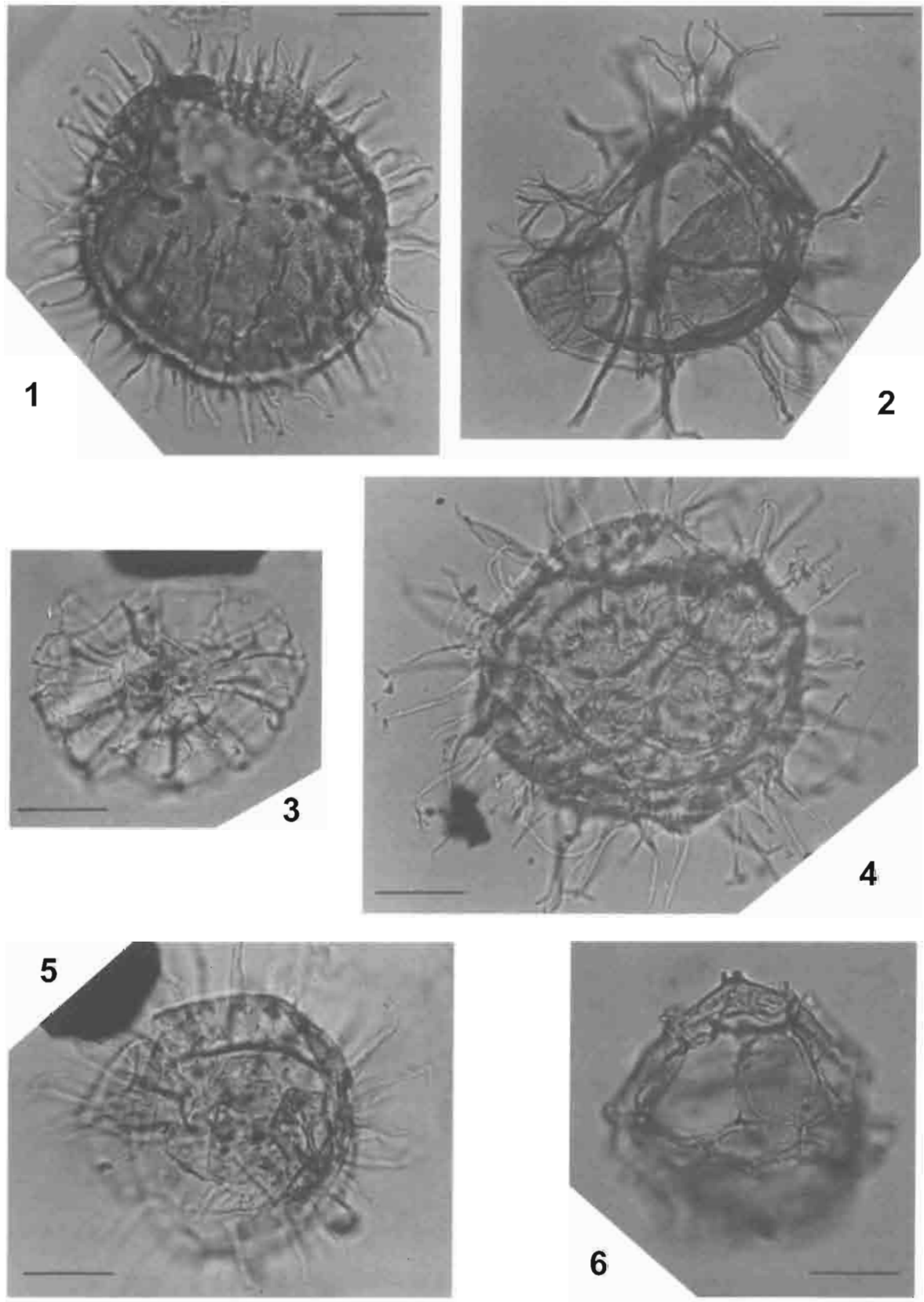
PLATE V

Palynofacies of the Miocene deposits from the Jamnica S-119 borehole; scale bar = 100 μm

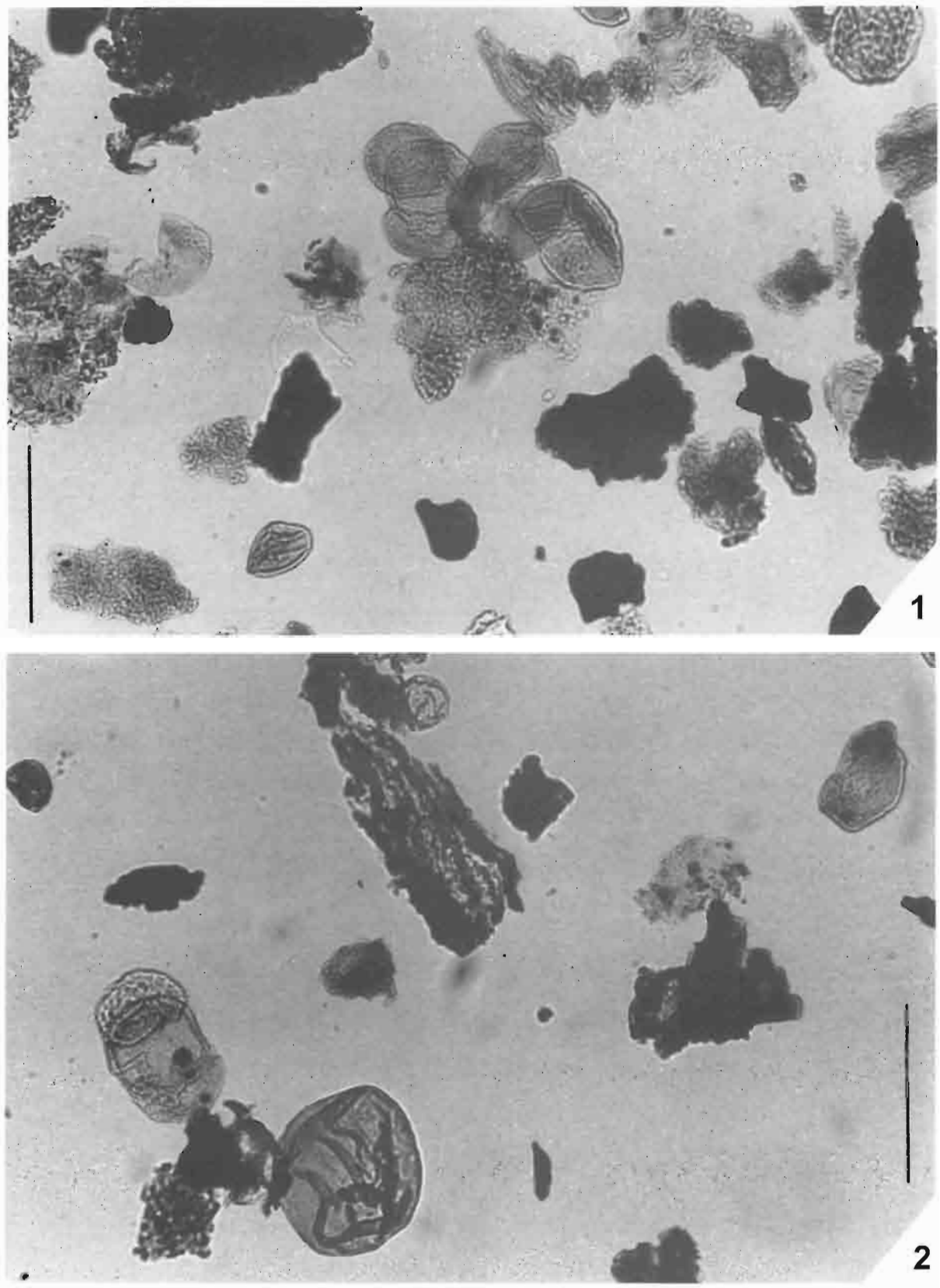
Fig. 1. Interval VI; 217.03–217.03 m; Krakowiec Clays

Fig. 2. Interval VII; 82.0 m; upper part of the Krakowiec Clays

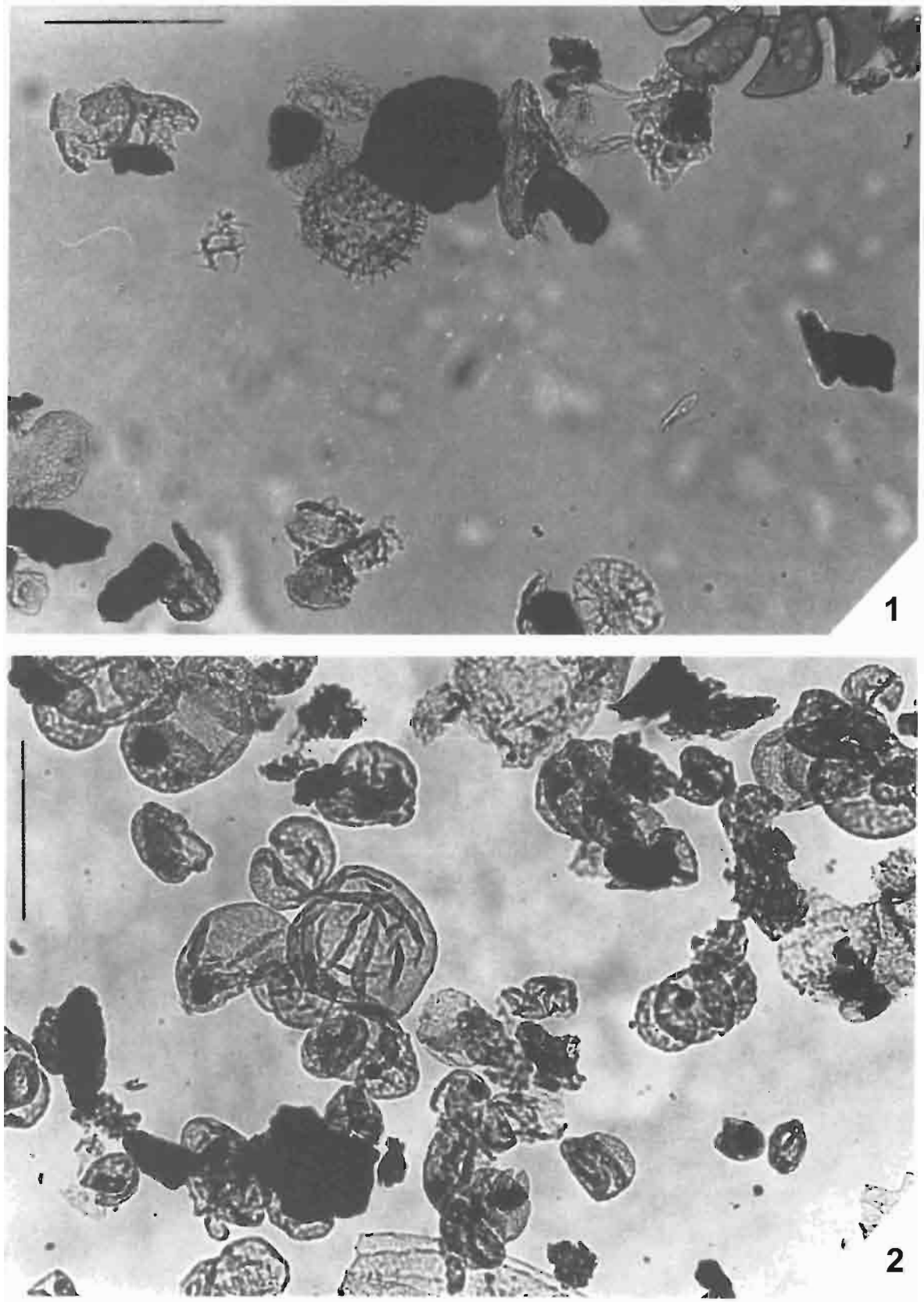
Geol. Quart., 1999, **43** (4)



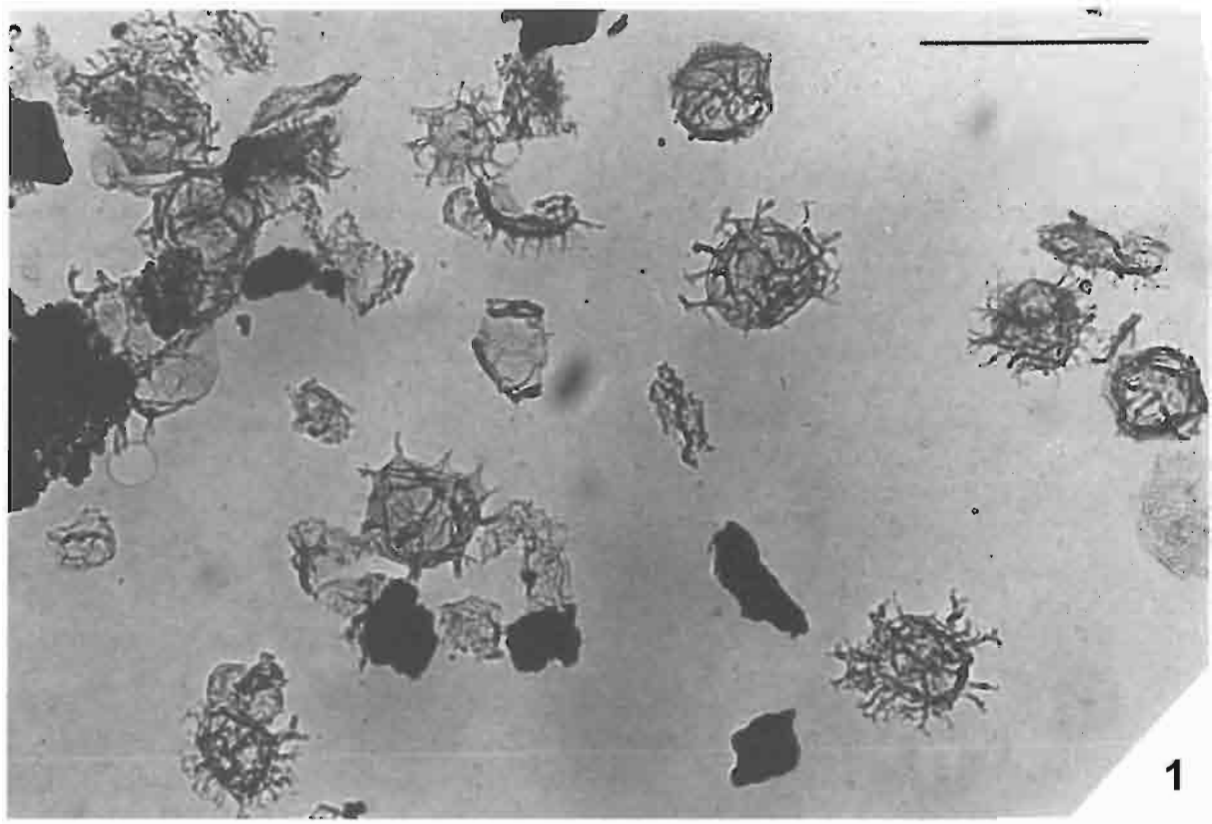
Przemysław GEDL — Palaeoenvironmental and sedimentological interpretations of the palynofacial analysis of the Miocene deposits from the Jamnica S-119 borehole (Carpathian Foredeep, Poland)

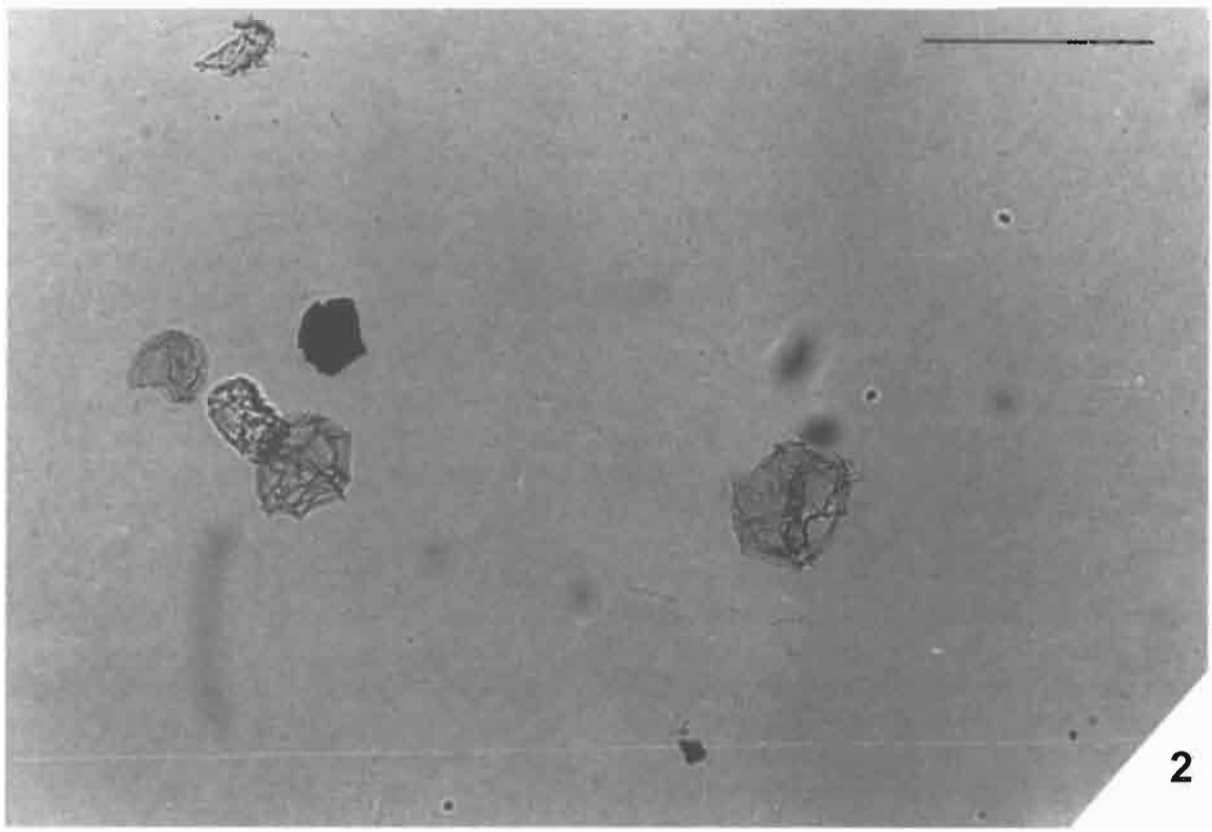


Przemysław GEDL — Palaeoenvironmental and sedimentological interpretations of the palynofacial analysis of the Miocene deposits from the Jamnica S-119 borehole (Carpathian Foredeep, Poland)

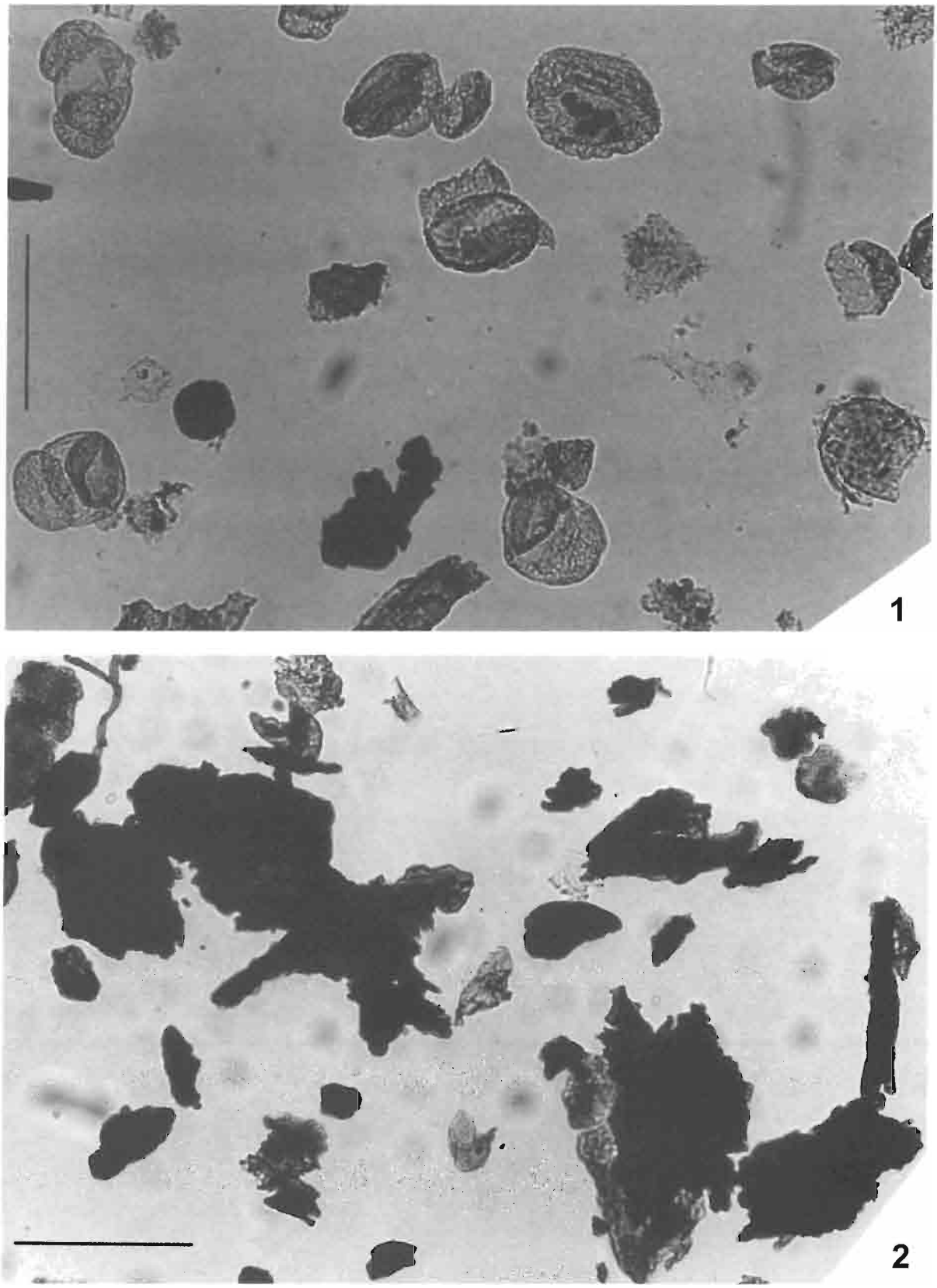


Przemysław GEDL — Palaeoenvironmental and sedimentological interpretations of the palynofacial analysis of the Miocene deposits from the Jamnica S-119 borehole (Carpathian Foredeep, Poland)





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



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