Annales Societatis Geologorum Poloniae (2007), vol. 77: 147–159.

EARLY JURASSIC DINOFLAGELLATE CYSTS FROM THE KRAKÓW-SILESIA MONOCLINE, SOUTHERN POLAND: A RECORD FROM THE BLANOWICE FORMATION AT MRZYGŁÓD

Przemysław GEDL

Institute of Geological Sciences, Polish Academy of Sciences, Senacka 1, 31-002 Kraków, Poland; e-mail: ndgedl@cyf-kr.edu.pl

Gedl, P., 2007. Early Jurassic dinoflagellate cysts from the Kraków-Silesia Monocline, southern Poland: a record from the Blanowice Formation at Mrzygłód. *Annales Societatis Geologorum Poloniae*, 77: 147–159.

Abstract: A 3-m thick section of the Blanowice Formation exposed in an abandoned clay-pit at Mrzygłód (Kraków-Silesia Monocline, southern Poland) yielded rich palynological material. Besides dominating land-derived phytoclasts and sporomorphs organic-walled dinoflagellate cysts (dinocysts) occur. Presence of *Luehndea spinosa* allows considering time of deposition of studied deposits as Late Pliensbachian–earliest Toarcian. Quantitative fluctuations of main groups of palynofacies elements suggest variable sedimentological conditions of deposition within the southern part of the Polish epicontinental basin. Dominance of large-sized cuticle remains and lack of dinocysts occurs in sediments deposited in continental conditions. Occurrence of dinocysts and other aquatic palynomorphs takes place in sediments that have originated during marine ingression.

Key words: dinocysts, palynofacies, Lower Jurassic, Poland, biostratigraphy, palaeoenvironment.

Manuscript received 8 September 2006, accepted 1 August 2007

INTRODUCTION

The epicontinental Lower Jurassic of Poland was deposited mainly in continental environments. Nevertheless, during the Early Jurassic few short-termed marine ingressions entered into the Polish basin. The traces of these sea-floods can be traced in north-western Poland where deposits with marine fauna occur (e.g., Kopik, 1964; Dadlez & Kopik, 1972); in remaining, peripheral parts of the Polish basin, the marine influences were much weaker gradually passing into brackish facies. These palaeoenvironmental conditions are reflected in general scarcity of fossils except of sporomorphs, which became the most important biostratigraphical tool in the Lower Jurassic in Poland (e.g., Marcinkiewicz, 1962, 1971; Rogalska, 1976). However, sporomorphs do not allow precise datation (e.g., Marcinkiewicz *et al.*, 1960). It was Rogalska (1976) who presumably was the first who noted the presence of aquatic palynomorphs (possibly also dinocysts) in epicontinental Lias of Poland; she regarded their occurrence as reflection of marine influences during the Early Jurassic. Later studies of organic-walled Dinoflagellate cysts (dinocysts) from Lower Jurassic epicontinental deposits of Poland (Barski & Leonowicz, 2002; Gedl & Pieńkowski, 2003) show their high applicability as a biostratigraphic tool in deposits that usually lack age-diagnostic fossils. Moreover, dinocysts and palynofacies analysis allow reconstruction of palaeoenvironmental conditions of studied deposits. Discovery of rich dinocyst assemblage from the Blanowice Formation exposed at Mrzygłód allows age determination of this lithostratigraphic unit in this area. It shows high applicability of dinocysts as biostratigraphic tool in studies of Lower Jurassic of Poland, which strata are widely believed to contain very few fossils of stratigraphical value. Presence of dinocysts combined with palynofacies analysis allows reconstruction of origin of deposits in question.

GEOLOGICAL BACKGROUND

Mesozoic deposits of the Kraków-Silesia Monocline consist of Triassic and Jurassic strata that monoclinally dip at an angle up to 2° north-east (Fig. 1). This area represents the southernmost, peripheral limits of the Early Jurassic epicontinental basin in Poland. The Lower Jurassic strata in this area consist mostly of continental deposits character-

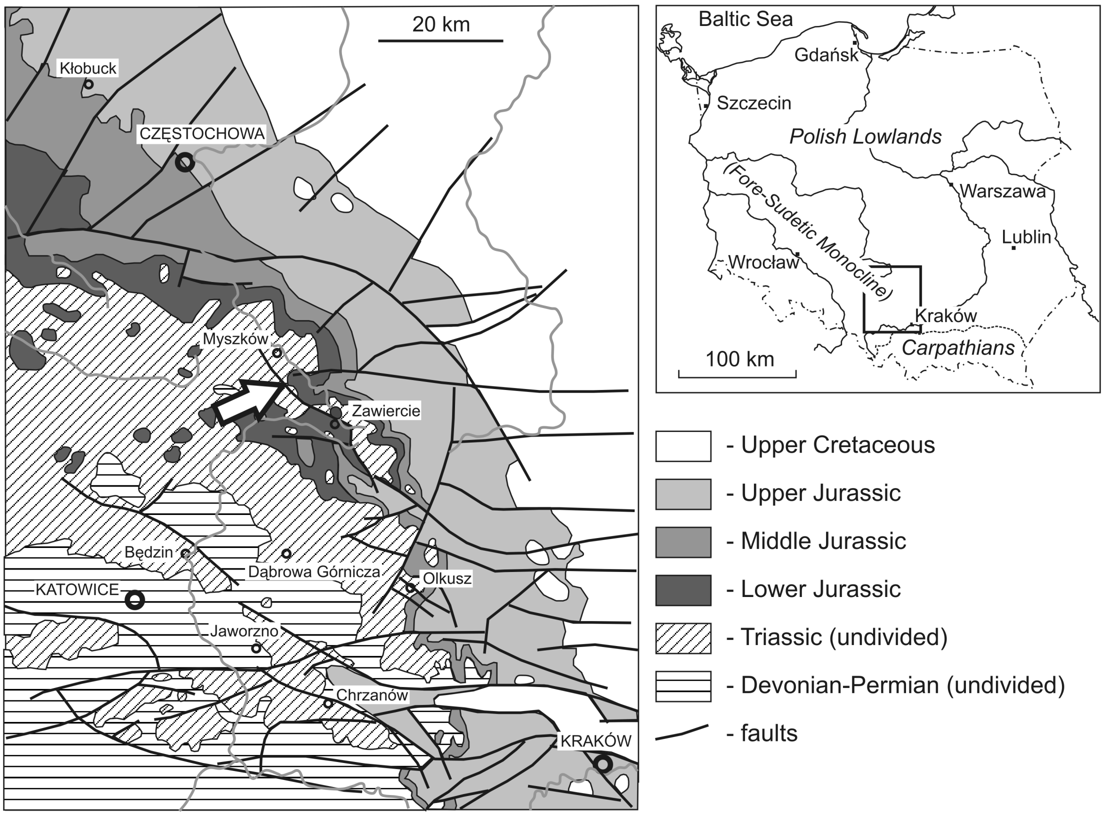

Fig. 1. Simplified tectonic sketch-map of the Kraków-Silesia Monocline (from Dadlez *et al.*, 2000) with location of the study area (arrowed)

ized by frequent facies changes and usual lack of age-diagnostic fossils – the oldest faunistically documented Jurassic marine deposits in this area are the Middle Jurassic (Aalenian–Bajocian), the so-called Kościelec sandstones (Mossoczy, 1949; Różycki, 1953; Kopik, 1967). Among them, a range of lacustrine, fluvial to near-shore marine deposits with frequent intercalations of coal layers of uncertain age has been distinguished in this area. Their stratigraphy bases mainly on superposition, correlation with faunistically documented coeval deposits from more northern central-basin facies, and sporomorph biostratigraphy. The oldest Jurassic deposits in this area are believed to be the so-called Połomia beds (Fig. 2). However, the Lower Jurassic (Hettangian?) age of this informal stratigraphical unit is highly arbitrary and based on superposition only (e.g., Znosko, 1955) since the Połomia beds contain almost no fossils (Mossoczy, 1961). These sandy-gravelly deposits occur as an isolated rock-body that cuts older substratum. Znosko (1955) described the Połomia beds as younger than the sub-coal beds (the Upper Helenów beds *sensu* Znosko, 1955) and older than the Blanowice coals. However, recently, there are no outcrops available where the Połomia beds would be covered by deposits other than Quaternary. Generally, well documented Hettangian and Sinemurian deposits are missing in the Kraków-Silesia Monocline.

The age of younger sediments, despite of fossil (sporomorph) occurrence has not been precisely determined yet. The basal sandy-loamy complex with gravel intercalations was distinguished as the so-called sub-coal beds (Rutkowski, 1923; Mossoczy, 1961), whereas the overlying dark-coloured loamy deposits with coal layers and infrequent sandstones were known as the so-called Blanowice coals [both informal stratigraphic units were formally described as the Blanowice Formation by Pieńkowski (2004; Fig. 2)]. Thickness of this complex does not exceed 40 metres. The age of the so-called sub-coal beds was believed by Mossoczy (1961) as Toarcian, whereas Dadlez (1978) regarded them as Upper Pliensbachian. Pieńkowski (2004) assigned the Blanowice Formation to the Pliensbachian.

The Blanowice Formation is covered by over 40-metres thick complex of muddy-loamy deposits of brackish origin, the so-called lower Łysiec beds (*sensu* Znosko, 1959) or the so-called Estheria beds (*sensu* Mossoczy, 1961). The lowermost Toarcian age of these informal lithostratigraphic units was based mainly on correlation with sediments from north-western part of Polish basin (Dadlez, 1978). Higher up, the deposits passes into more sandy-loamy complex – the so-called Upper Łysiec beds representing presumably Upper Toarcian (Znosko, 1959; Deczkowski, 1962). Its variable thickness reaches up to 35 metres.

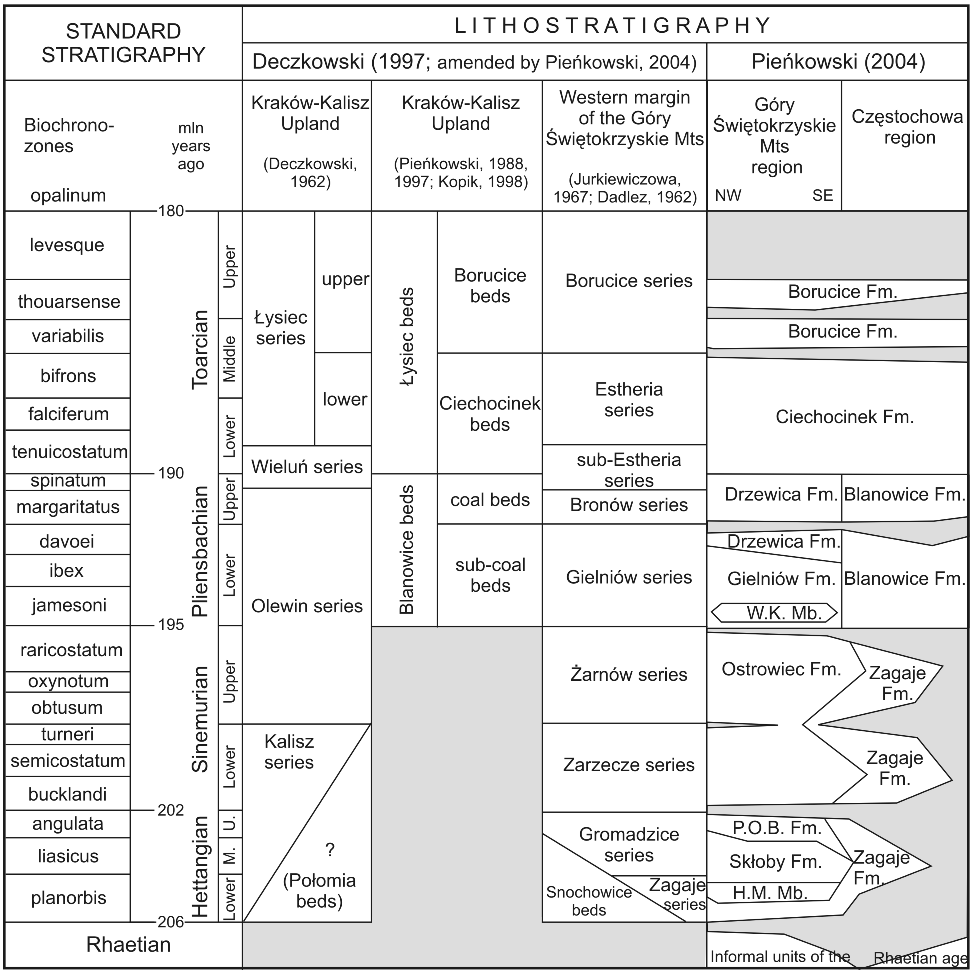

Fig. 2. Lithostratigraphic division and correlation of epicontinental Lower Jurassic of Kraków-Silesia Monocline and western surroundings of the Góry Świętokrzyskie Mts, Poland (from Pieńkowski, 2004)

MATERIAL

The studied outcrop is situated in an abandoned clay-pit at Mrzygłód (Fig. 3), where clays were exploited up to the end of the 20th century. It is located at the western bank of a lake that fills dumped pit (Fig. 3A, B; GPS coordinates: N50 31 27.1, E19 21 20.9; 332 m a.s.l.). Studied section represents the topmost part of several metres thick Blanowice Formation succession once exposed here during clays exploitation. It contains nearly 3-m thick profile of dark-coloured non-calcareous clays with a single 10-cm thick coal seam in its upper part (Fig. 4). Basal 2 metres of the section consists of dark brown clays with rhythmic lamination of very thin (up to 0.1 mm), undisturbed silt laminas. Higher, a 10-cm thick coal seam occurs. It is underlied by a 15-cm thick layer of grey clay with abundant coalified plant detritus. The coal seam is covered by blackish clays devoid of that clear lamination as in the lower part of the section.

Three samples were taken from the studied exposure. Sample Mrz1 was taken 12–15 cm above the coal seam, sample Mrz2 was taken 10 cm below it from greyish clays, whereas sample Mrz3 was collected 1.2 m below the coal seam from stratified basal dark-brown clays (Fig. 4).

METHODS

The samples were processed following standard palynological procedure including 38% hydrochloric acid (HCl) treatment, 40% hydrofluoric acid (HF) treatment, heavy liquid ($ZnCl_2$+HCl; density 2.0 g/cm^3) separation, ultrasound for 10–15 s and sieving at 15 µm on a nylon mesh. No 100% fuming nitric acid (HNO_3) treatment was applied. Microscope slides were made using glycerine jelly as a mounting medium. The quantity of rock processed was 20 g for each sample. The rock samples, palynological residues and slides are stored in the collection of the Institute of Geological Sciences, Polish Academy of Sciences, Kraków.

Dinocysts from sample Mrz3 were counted up to a total of 300. In case of sample Mrz1, which contains very rare dinocysts, all specimens from two slides were counted. Palynofacies ratio was calculated on the base of 1000 counts.

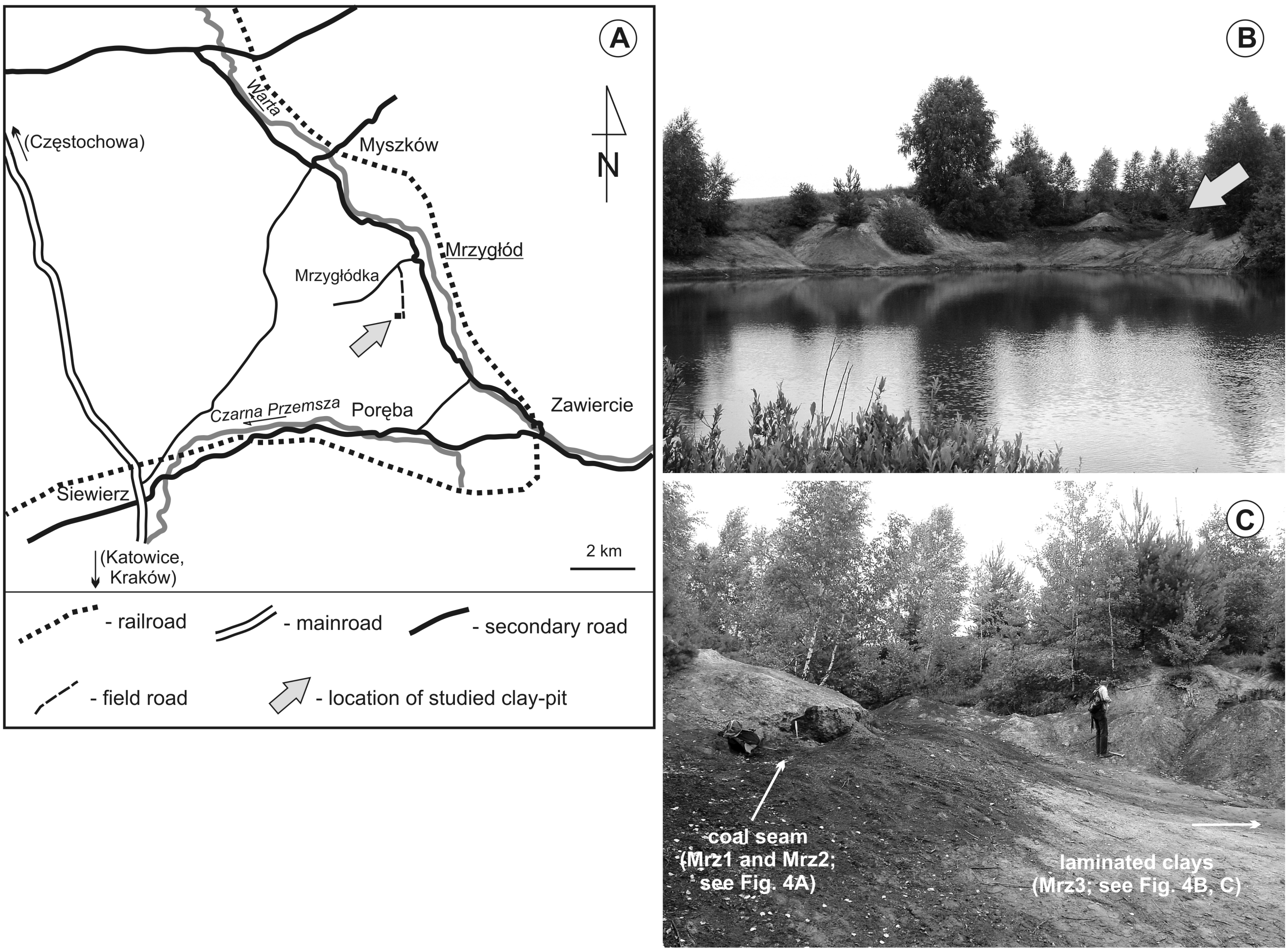

Fig. 3. Location of study area: **A** – location of abandoned clay-pit at Mrzygłód (arrowed); **B** – view on the studied section at the western bank of the lake filling the excavation (arrowed); **C** – close up at the higher part of the section

RESULTS

All samples contain very rich palynological material. It consists in overwhelming majority of land-derived particles: large-sized cuticle fragments, variously preserved land-plant debris, sporomorphs and amorphous organic matter (Figs 5 and 6). Dinocysts have been found in samples Mrz1 and Mrz3 (Figs 7–9). They occur subordinarily, especially in sample Mrz1 being very strongly dispersed by terrestrial elements. Although palynofacies of all studied samples shows overwhelming dominance of terrestrial elements, there are some qualitative differences (Fig. 5A). Lowermost sample Mrz3 collected from laminated dark-brown claystones contains palynofacies dominated by pollen grains (Fig. 5C), which constitute over 50% of total palynofacies (spores constitute up to 7%). Cuticle and wood debris do not exceed 38% and these are mainly small-sized cuticles and black opaque phytoclasts. Another characteristic feature of palynological content from this basal sample is an occurrence of relatively frequent dinocysts that occur up to 2% of the palynofacies (Fig. 5A). These are mainly representatives of the genus *Nannoceratopsis* – over 99% (see chapter Dinocyst assemblages); single specimens of *Mendicodinium spinosum*, *Luehndea spinosa* and *Batiacasphaera* sp. also occur. Additionally, very rare specimens of Tasmanitids (presumably cysts of green algae representing Prasinophyceae) were found. These are two species differing by thickness and structure of the wall (Fig. 9M–O).

A different palynofacies was recorded in sample Mrz2 taken from greyish claystones with frequent coalified plant debris. It is dominated by large-size cuticles (80%); pollen grains occur as 16% of the palynofacies whereas amorphous matter does not exceed 7% (Fig. 5A). This sample contains no dinocysts.

Very rare dinocysts (less than 1%) represented by the genus *Nannoceratopsis* have been found in the sample Mrz1 taken above the coal seem (see chapter Dinocyst assemblages). Its palynofacies consists chiefly of large- and middle-sized cuticles (up to 40%) and pollen grains (30%; Fig. 5A, B). Amorphous organic matter (approximately 15%), which occur in this sample consists of very small-sized, strongly dispersed particles and larger, relatively

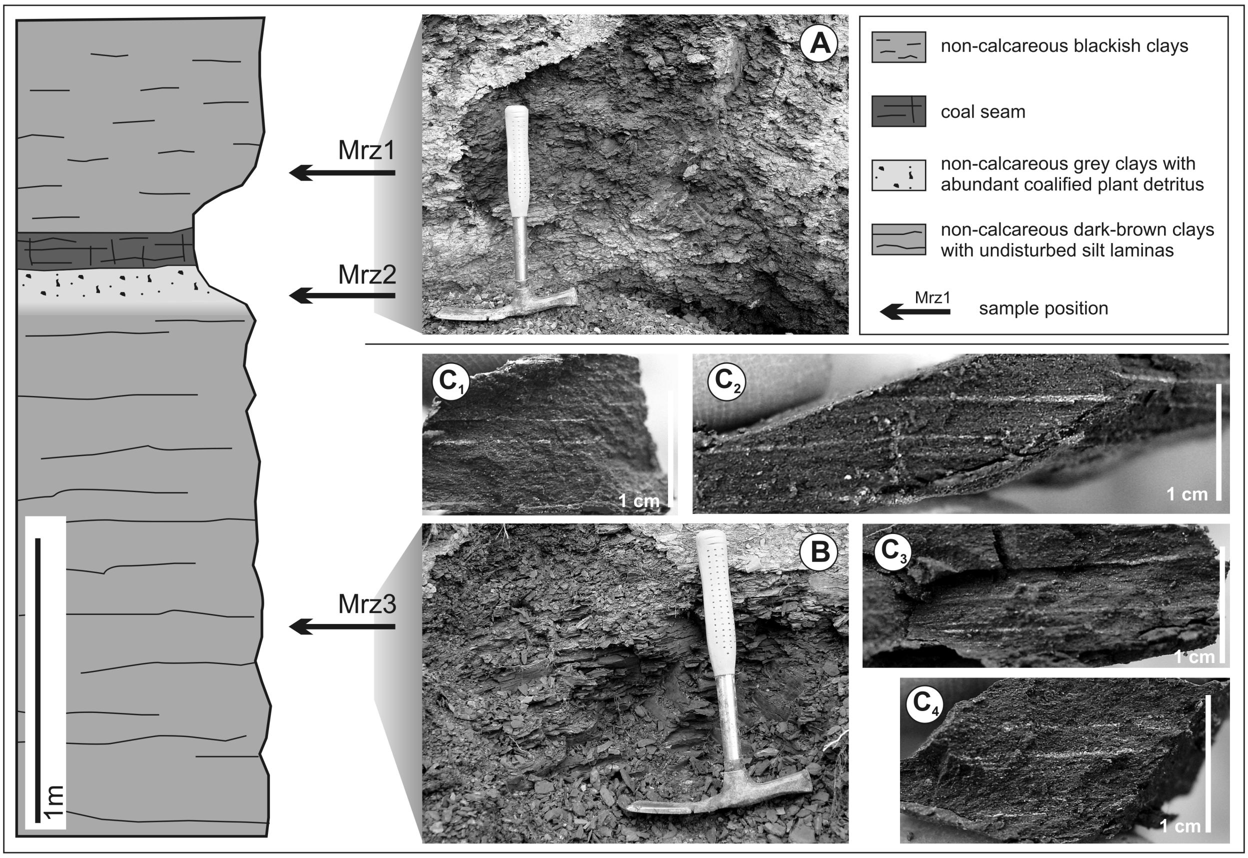

Fig. 4. Lithology of studied section of the Blanowice Formation exposed at Mrzygłód clay-pit and position of collected samples: **A**, **B** – lithology of upper (A) and lower (B) part of the section (hammer length – 32 cm); **C1-4** –detailed lithologies of the shales from the lower part of the section showing undisturbed lamination

thick cloaks (Fig. 6). Woody debris (elongated and equidimensional) represents up to 10% of the palynofacies.

Dinocyst assemblages

Dinocysts were found in two samples: Mrz1 and Mrz3. In both samples their assemblages are dominated by the genus *Nannoceratopsis*. Despite this, these two assemblages differ quantitatively and, less distinctively, qualitatively (Fig. 5A).

Dinocyst assemblage from sample Mrz1 is composed entirely of representatives of the genus *Nannoceratopsis*. Specimens are rare being strongly dispersed by land plant tissue remains. They represent *Nannoceratopsis globiformis* (Fig. 7A, B) and *N. raunsgaardii* (Fig. 8A, B) that occur in approximately the same ratios; very rare specimens of *N. triceras* were also found (Fig. 9A–C). No other dinocyst species were found in this sample.

Sample Mrz3 contains dinocyst specimens, which are much more frequent than in sample Mrz1. The genus *Nannoceratopsis*, which represents over 99% (Fig. 5A) of the whole assemblage, is much more taxonomically diversified than in sample Mrz1. The most frequent species are *N. raunsgaardii* (Fig. 8C–M) that constitute over half of the assemblage and *N. globiformis* (over 20%; Fig. 7C–K). Besides *N. triceras* (Fig. 9B, C) that was found also in sample Mrz1, few other species of this genus occur exclusively in this sample. These are *N. spiculata* (over 10% of the assemblage; Fig. 8N, O), *Nannoceratopsis* sp. A (Fig. 7L–P), and very rare *N. ridingii* (Fig. 9D) and *N. deflandrei* subsp. *senex* (Fig. 8P). Additionally, very rare specimens of *Batiacasphaera* sp. (Fig. 9E–G), and single specimens of *Mendicodinium spinosum* (Fig. 9H, L) and *Luehndea spinosa* (Fig. 9I–K) were found.

Dinocysts found in the Mrzygłód samples are characterized by thin and delicate cyst wall. This concerns specimens of *Batiacasphaera* sp. and all *Nannoceratopsis* species except of *N. deflandrei* subsp. *senex*. These dinocysts have very thin autofragm, which is devoid of any traces of even low relief – it is smooth or very faintly micropunctate. They show very pale (pale yellowish) colouration of the walls. The only exception is single specimen of *N. deflandrei* subsp. *senex*, which cyst wall is relatively thick. Single specimen of *Luehndea spinosa* shows, in contrast, much darker (dark yellow) colour of relatively thick cyst wall.

Another notice worth feature of the Mrzygłód dinocysts is the loss of epicyst in many specimens of *Nannoceratopsis*

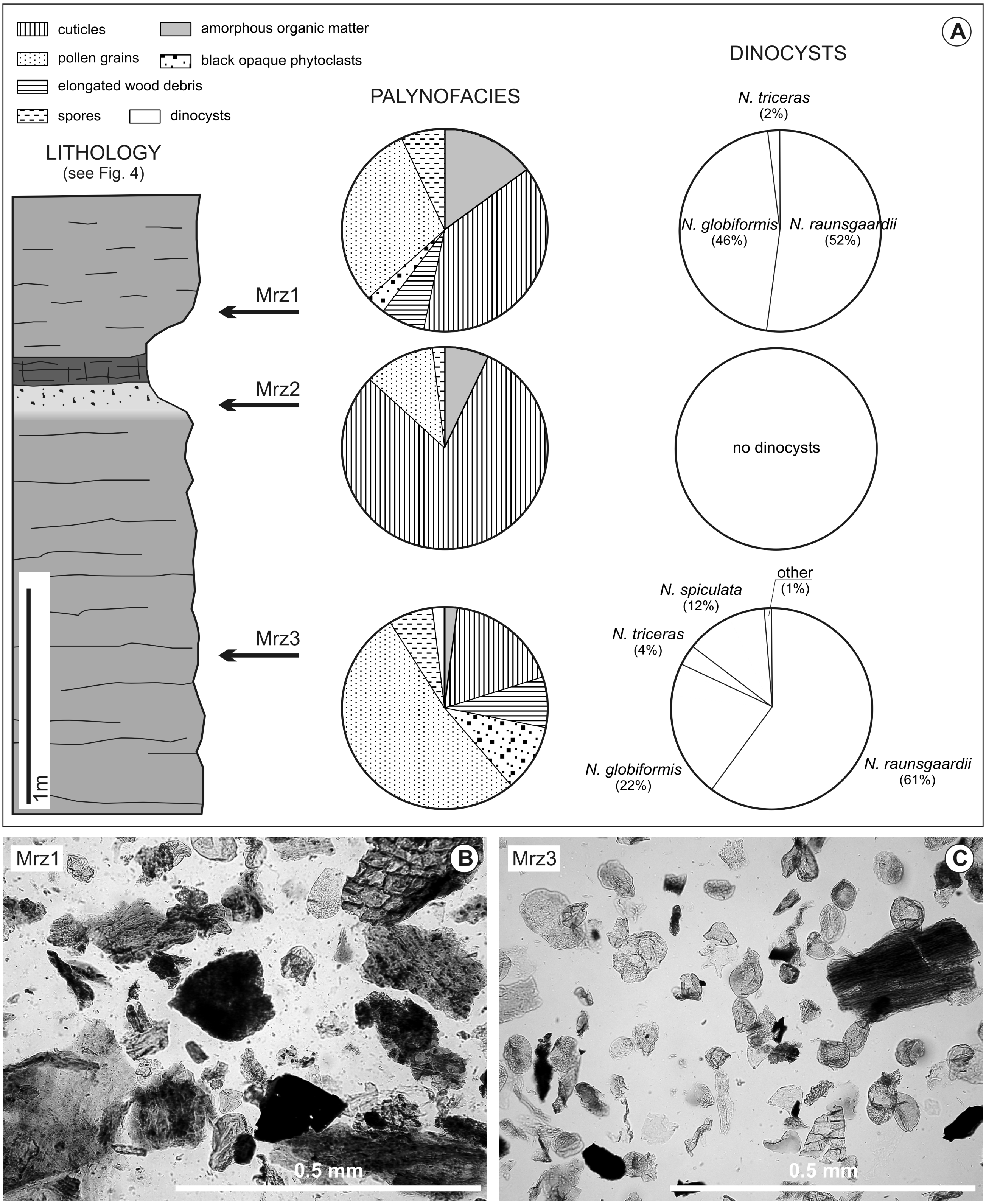

Fig. 5. Palynofacies and dinocyst assemblages in studied samples (**A**). Examples of palynofacies from upper part of section (**B**) dominated by large-sized phytoclasts, and (**C**) lower part with frequent pollen grains and small-sized phytoclasts

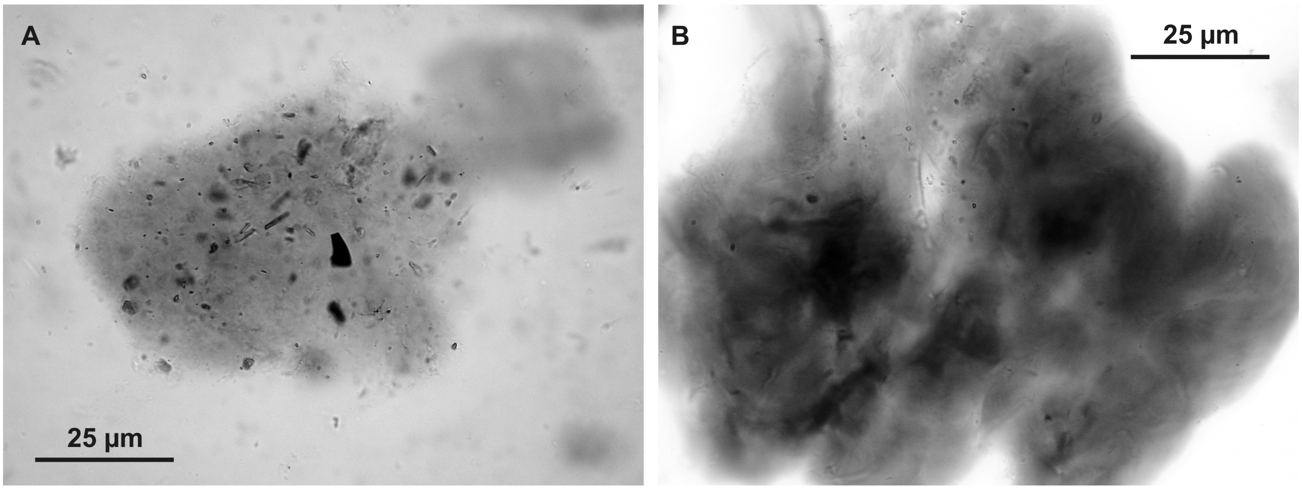

Fig. 6. Amorphous organic matter from the Blanowice Formation at Mrzygłód (sample Mrz1)

(e.g., Fig. 7C–F, J, M; Fig. 8A, C, E). This feature, noted also by other authors (e.g., Evitt, 1961; Gocht, 1964; Fensome, 1979) was explained by the latter author as a result of weakening of paracingulum due to loss of a mid-dorsal paracingular paraplate (i.e., the archaeopyle formation; Fensome, 1979).

AGE OF STUDIED DINOCYST ASSEMBLAGE

Although the Mrzygłód dinocyst assemblage is taxonomically undiversified, it contains dinocyst species that are good age indicators allowing relatively precise suggestion of its age. *Luehndea spinosa*, found as single specimen in sample Mrz3, according to several author has range that spans Late Pliensbachian (Margaritaus Ammonite Zone) through earliest Toarcian (Tenuicostatum Ammonite Zone; e.g., Riding & Thomas, 1992). This age-range can be applied to the sediment in question because the other dinocysts (e.g., *Mendicodinium spinosum* – Late Pliensbachian–Aalenian according to Bucefalo Palliani & Riding, 1997), have much wider stratigraphic ranges.

The genus *Nannoceratopsis*, the dominating one in studied material, is known to have appeared exclusively during Jurassic ranging from Early Pliensbachian through Tithonian, being a very frequent element of dinocyst flora mainly during Late Pliensbachian to Bajocian. Although relatively long-ranging as the genus, particular species have much shorter stratigraphic ranges. *N. gracilis* and *N. deflandrei* subsp. *senex*, the oldest known species, appeared for the first time during Early Pliensbachian (e.g., Bucefalo Palliani & Riding, 1997). But the main radiation of this genus took place during Late Pliensbachian when several species appeared for the first time. Among those found in Mrzygłód, *N. ridingii*, *N. raunsgaardii* and *N. triceras* appeared for the first time then (*N. ridingii* appeared till Toarcian whereas two remaining species appeared till Bajocian).

PALAEOENVIRONMENT

Combination of sedimentological observation and palynological analysis may provide important clues for palaeoenvironmental reconstruction. The most outstanding feature of palynological content of the Mrzygłód samples is overwhelming dominance of land-derived phytoclasts and palynomorphs, and almost monospecific dinocyst assemblage of *Nannoceratopsis*. The latter feature must reflect restricted conditions in the photic zone during formation of studied deposits. *Nannoceratopsis* is considered by several authors to be a euryhaline genus (e.g., Riding, 1983; Bucefalo Palliani & Riding, 1997). Also the occurrence of Tasmanitids in sample Mrz3 may indicate low-salinity conditions (see Riding, 1983). Prasinophycea are known to appear in wide range of environments, from marine to brackish, being most frequent in near-shore marine environments (e.g., Tappan, 1980; Guy-Ohlson, 1996). Prauss & Riegel (1989) considered climatological and palaeogeographical causes responsible for their distribution. According to these authors, prasinophycean algae might have favoured cold-water low-salinity environments.

High amount of terrestrial organic matter points at intense supply and accumulation of land-derived organic particles from surrounding land areas. This, combined with a low-salinity signal concluded from dinocyst assemblage composition suggests that studied section, representing a part of the Blanowice Formation, was deposited in a proximal area under brackish conditions. However, fluctuations of palynofacies and dinocyst assemblage composition (Fig. 5) show on changeable conditions, reflecting salinity changes. Intervals with coal seams and closely surrounding detrital sediments were deposited during periods of more intense supply of terrestrial organic matter associated with more distinct salinity drop caused by freshwater influx. Clayey intervals, in turn were accumulated during periods of more intense marine influences resulting in brackish conditions favourable for *Nannoceratopsis* and Tasmanitids.

Decomposition of high amounts of organic matter, supplied into the basin during deposition of the Blanowice Formation, depleted oxygen content in bottom waters. Presumably, anoxic conditions at the basin floor can be suggested on the base of primary lamination intact by bottom dwelling organism activity (Fig. 4C) and presence of amorphous organic matter (Fig. 6). High amount of the latter is usually associated with bacterial decay of organic matter in anoxic environments (e.g., Tyson, 1987). The relatively low amounts of amorphous organic matter in Mrzygłód samples may result from high accumulation rate, which may prevent its more widespread formation.

DISCUSSION

The Blanowice Formation represents deposits accumulated in the southernmost areas of the Polish epicontinental basin during the Early Jurassic. The hitherto conducted studies of this lithostratigraphic unit (and its former counterparts) concluded with relatively imprecise age, based mainly on lithostratigraphic correlation with deposits from northern areas of the basin with faunistically documented age. According to Rogalska (1954), the coals from the Blanowice Formation represent Lias α (i.e., Hettangian and lower Sinemurian), Mossoczy (1961) suggested their Toarcian age, and Dadlez (1976) believed them to represent the Upper Pliensbachian. The results of present study show that at least the upper part of this lithostratigraphic unit was deposited during the Late Pliensbachian through earliest Toarcian. Pieńkowski (2004) suggested significant regressive event in the area of study during Late Pliensbachian, which presumably resulted in appearance of environmental conditions favourable for coal seam formation (i.e., the sedimentation of the ex "Blanowice coals"). This period was followed according to Pieńkowski (2004, fig. 71.11) by marine transgression during the Early Toarcian. Dinocyst assemblage found in the Mrzygłód outcrop is presumably a result of marine influences associated with that transgression.

Similar dinocyst assemblages were found by Barski (*in* Barski & Leonowicz, 2002) in the Ciechocinek Formation exposed in the Kraków-Silesia Monocline north-westwards from the Mrzygłód area. These approximately coeval assemblages (occurrence of *Luehndea spinosa*) from the Ciechocinek Beds are also dominated by *Nannoceratopsis* species. Moreover, Barski noted similar relation between dinocyst assemblage composition and palynofacies: samples with higher amounts of large-sized woody debris contain monospecific *Nannoceratopsis* assemblages, whereas those samples, which contain palynofacies with higher ratio of sporomorphs contain also *Luehndea spinosa*. This points at similar, restricted conditions during Late Pliensbachian–earliest Toarcian time in Polish epicontinental basin, which represented marginal area of the northwest European epicontinental basin. It was a shallow basin with high, but variable rate of terrestrial material input. A consequence was fluctuating salinity level, ranging from freshwater conditions when coals accumulated, to restricted marine (=brackish) environments with monospecific blooms of *Nannoceratopsis*. In more central areas of this basin, i.e. in the British Isles (e.g., Riding, 1984, 1987; Riding *et al.*, 1991), Germany (e.g., Morgenroth, 1970; Wille & Gocht, 1979; Wille, 1982; Prauss, 1989) or Denmark (Poulsen, 1992), the late Early Jurassic dinocyst assemblages, although contain frequently numerous specimens of *Nannoceratopsis* (e.g., Riding, 1982) are more diversified reflecting marine palaeoenvironments.

SELECTED TAXONOMY

Division DINOFLAGELLATA (Bütschli 1885)
Fensome *et al.* 1993
Subdivision DINOKARYOTA Fensome *et al.* 1993
Class DINOPHYCEAE Pascher 1914
Subclass DINOPHYSIPHYCIDAE Möhn 1984
ex Fensome *et al.* 1993
Order NANNOCERATOPSIALES Piel et Evitt 1980
Family NANNOCERATOPSIACEAE Gocht 1970

Genus *Nannoceratopsis* Deflandre 1938
emend. Poulsen 1992
Type species: *Nannoceratopsis pellucida* Deflandre 1938

Nannoceratopsis sp. A
(Fig. 7L–P)

Description. A subtriangular to rounded subtriangular species of *Nannoceratopsis* having two relatively short and of equal size and shape, pointed antapical horns. Concavity between these horns has triangular outline: the inner edges of the antapical horns are straight lines, which cross at the angle of 110–140°. The autophragm is relatively thin and its surface is microperforate to microreticulate. The sagittal band is not thickened. The epicyst is frequently missing.

Dimensions:
length of the cyst: 38–48 μm (with epicyst attached);
width of the cyst: 36–42 μm.

Comparison. This species differs from all *Nannoceratopsis* species that have two antapical horns by the shape of concavity between these horns. It has triangular shape created by two straight inner margins of the horns.

CONCLUSIONS

1. Upper part of the Blanowice Formation exposed at Mrzygłód contains dinocysts. Presence of *Luehndea spinosa* suggests Late Pliensbachian–earliest Toarcian age of studied assemblages. Thus, dinocysts appear to be good age indicators in epicontinental Lower Jurassic strata of Poland, which usually lack age-indicative fossils (see also Barski & Leonowicz, 2002).

2. The studied section of the Blanowice Formation at Mrzygłód is characterized by variable palynofacies content

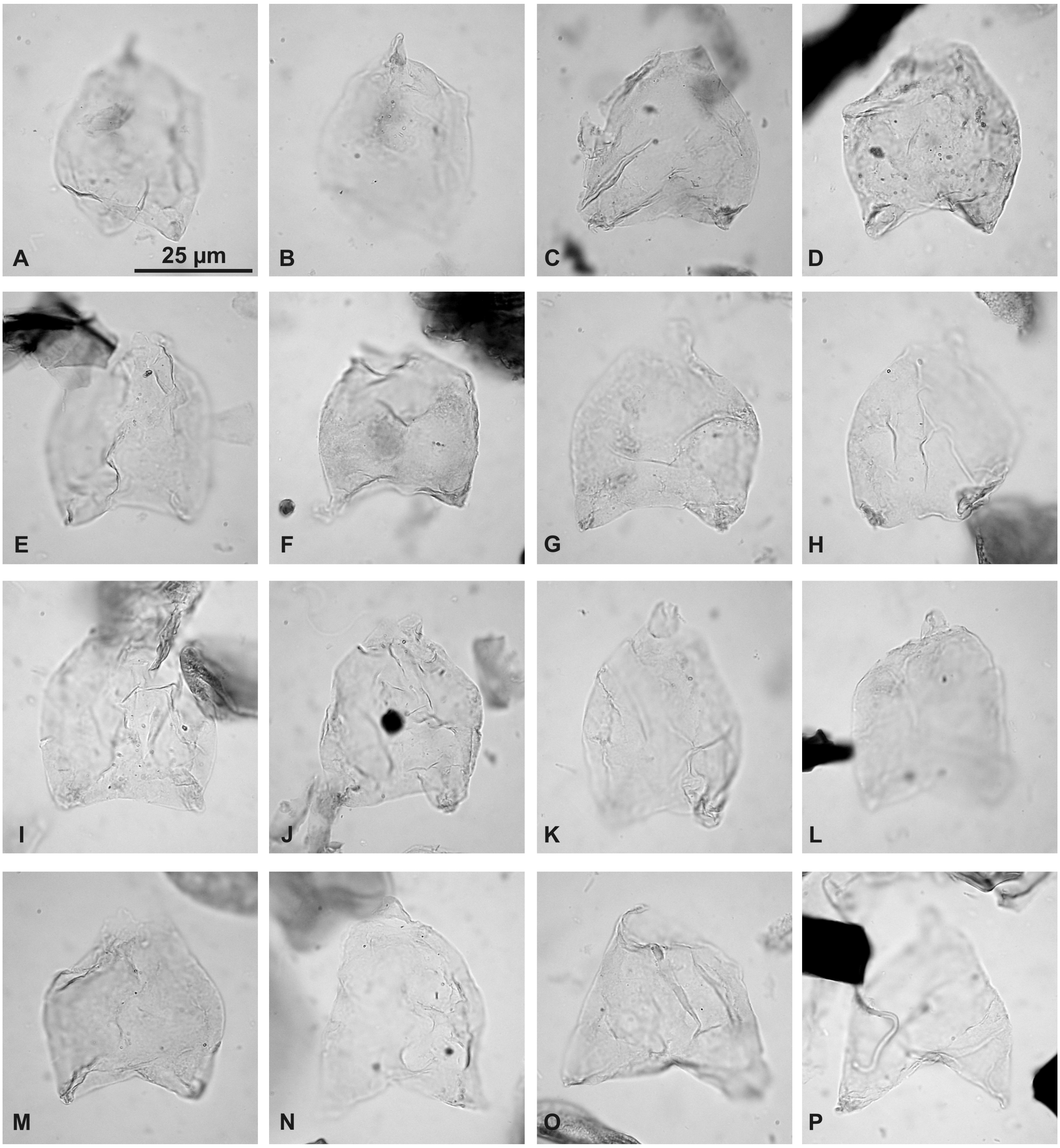

Fig. 7. Dinocysts from the Blanowice Formation at Mrzygłód. **A–K** – *Nannoceratopsis globiformis*: A, B – Mrz1, C–K – Mrz3 (note the presence of epicyst in specimen at photomicrograph A, K – the remaining specimens of *N. globiformis* are devoid of epicyst); **L–P** – *Nannoceratopsis* sp. A: all specimens from sample Mrz3. Scale bar in (A) refers to all other photomicrographs

reflecting unstable environmental conditions during their formation. Laminated blackish clays exposed in the basal part of the exposure yielded relatively rich dinocyst assemblage, which reflect period of marine influence. The exposed higher up grey clays with abundant coalified detritus that underlie a 10-cm thick coal seam contains terrestrial palynofacies composed chiefly of large-sized phytoclasts. This section interval was thus deposited during freshwater (lacustrin?) conditions. Occurrence of rare dinocysts represented by monospecific assemblage above the coal seam suggests gradual turning into brackish environment.

3. Palynofacies analysis, supported by dinocyst assemblage analysis appears to be a valuable tool for palaeoenvironmental reconstructions of Lower Jurassic epicontinental

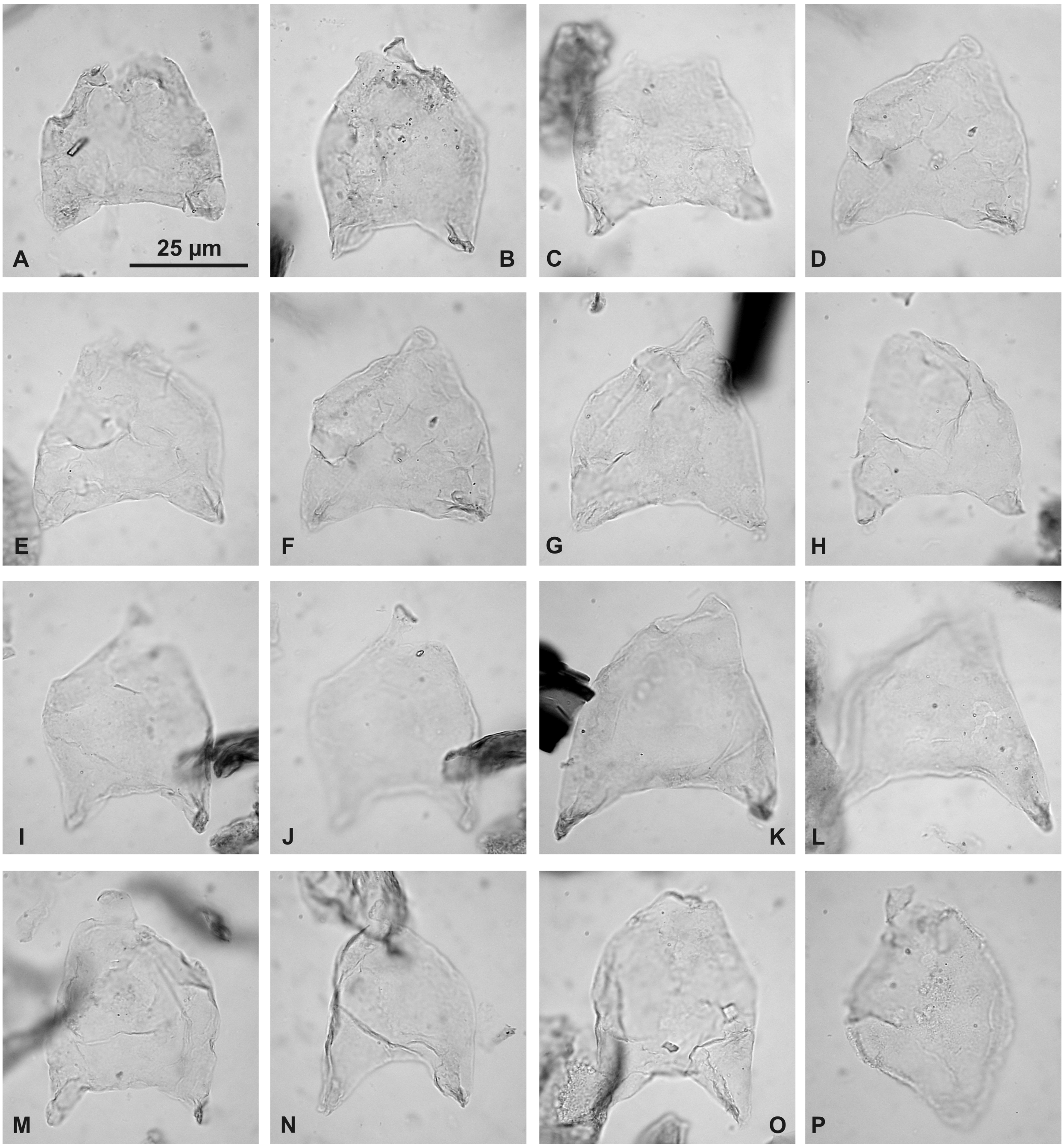

Fig. 8. Dinocysts from the Blanowice Formation at Mrzygłód. **A–M** – *Nannoceratopsis raunsgaardii* (A, B – Mrz1, C–M – Mrz3); **N, O** – *Nannoceratopsis* ?*spiculata*: both specimens from sample Mrz3; **P** – *Nannoceratopsis deflandrei* subsp. *senex* (Mrz3). Scale bar in (A) refers to all other photomicrographs

deposits of Poland. Sediments deposited in terrestrial environment contain palynofacies composed entirely of land-plant remains, frequently large-sized. Marine influences are recorded in the sediment by usually smaller dimensions of phytoclasts, higher frequences of sporomorphs (particularly pollen grains) and occurrence of dinocyst assemblages. The composition of the latter show gradual passages from monospecific *Nannoceratopsis* assemblages reflecting presumably brackish conditions into more diversified ones associated with marine environment.

Acknowledgement

I would like to thank Dr. Mariusz Paszkowski (Institute of Geological Sciences, Polish Academy of Sciences, Kraków) for introduction into geology of study area, assistance in sample collection and discussion during this study. I also thank M. Barski (Faculty of Geology, Warsaw University) for critical reading the manuscript and valuable comments. K. Bąk (Institute of Geography, Pedagogical University, Kraków) is acknowledged for editorial proof.

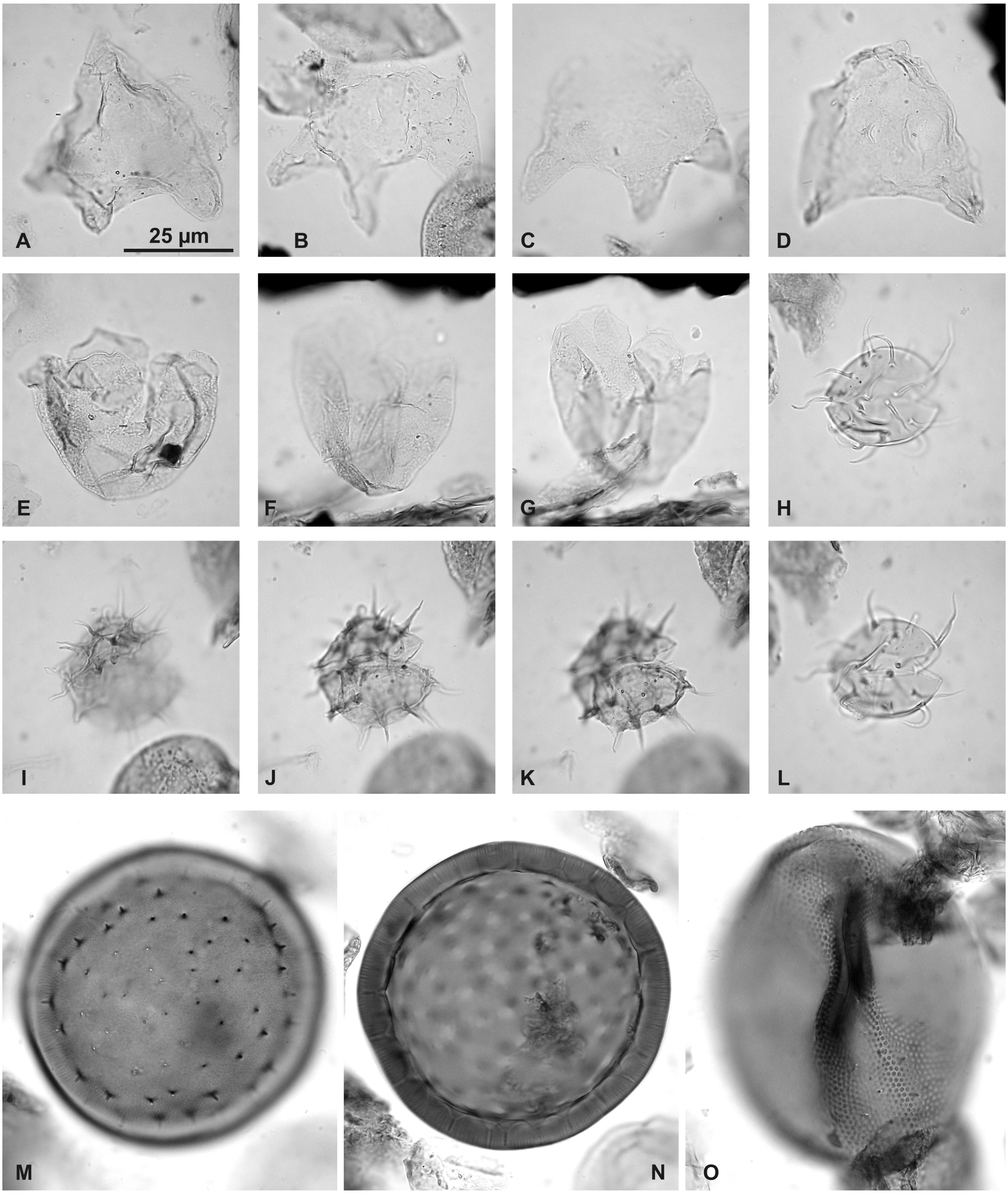

Fig. 9. Dinocysts and Tasmanitaceae from the Blanowice Formation at Mrzygłód. **A–C** – *Nannoceratopsis triceras* (A – Mrz1, B,C – Mrz3); **D** – *Nannoceratopsis ridingii* (Mrz3); **E–G** – *Batiacasphaera* sp. (all specimens from sample Mrz3; F, G – the same specimen, various foci); **H**, **L** – *Mendicodinium spinosum* (Mrz3; the same specimen, various foci); **I–K** – *Luehndea spinosa* (Mrz3; the same specimen, various foci); **M–O** – Tasmanitaceae: M, N: the same specimen of a species (*Tasmanites*? sp.) with thick wall perforated by regularly distributed pores (N); O: species with thinner wall (*Tytthodiscus suevicus*?). Scale bar in (A) refers to all other photomicrographs

APPENDIX

An alphabetical listing of dinocyst taxa found in the Mrzygłód section is provided below. Taxonomic citations are given in Williams *et al.* (1998). Numbers in parentheses refer to the appropriate photomicrographs in Figures 6 to 8.

Batiacasphaera sp. (Fig. 9E–G)
Luehndea spinosa Morgenroth 1970 (Fig. 9I–K)
Mendicodinium spinosum Bucefalo Palliani, Riding & Torricelli 1997 (Fig. 9H, L)
Nannoceratopsis deflandrei subsp. *senex* (van Helden 1977) Ilyina 1994 (Fig. 8P)
Nannoceratopsis globiformis Bucefalo Palliani & Riding 1997 (Fig. 7A–K)
Nannoceratopsis ridingii Poulsen 1992 (Fig. 9D)
Nannoceratopsis ?*spiculata* Stover 1966 (Fig. 8N, O)
Nannoceratopsis triceras Drugg 1978 (Fig. 9A–C)
Nannoceratopsis sp. A (Fig. 7L–P)

REFERENCES

Barski, M. & Leonowicz, P., 2002. Dinoflagellates of Lower Jurassic outcrops at Kozłowice and Boroszów (southern Poland). *Przegląd Geologiczny*, 50: 411–414.

Bucefalo Palliani, R. & Riding, J. B., 1997. The influence of palaeoenvironmental change on dinoflagellate cyst distribution. An example from the Lower and Middle Jurassic of Quercy, southwest France. *Bulletin du Centre Recherches Elf Exploration Production*, 21: 107–123.

Dadlez, R., 1962. Equivalents of the Połomia beds of the Częstochowa Lias in the western margin area of the Święty Krzyż Mountains. (In Polish, English summary). *Kwartalnik Geologiczny*, 6: 447–459.

Dadlez, R., 1976. Lower Jurassic. In: Sokołowski, S., Cieśliński, S. & Czermiński, J. (eds), *Geology of Poland*, vol. I: *Stratigraphy*, part 2: *Mesozoic*. Wydawnictwa Geologiczne, Warszawa, 199–241.

Dadlez, R., 1978. State of lithostratigraphy of the epicontinental Lower Jurassic in Poland and proposals of its systematization. (In Polish, English summary). *Kwartalnik Geologiczny*, 22: 773–790.

Dadlez, R. & Kopik, J., 1972. Selected problems of Liassic stratigraphy and sedimentation in the area between Świnoujście and Gryfice (north-west Poland). (In Polish, English summary). *Kwartalnik Geologiczny*, 16: 620–636.

Dadlez, R., Marek, S. & Pokorski, J., 2000. *Geological map of Poland without Cainozoic deposits*. Państwowy Instytut Geologiczny, Warszawa.

Deczkowski, Z., 1962. Lias stratigraphy and lithology in the Kalisz-Częstochowa area. (In Polish, English summary). *Kwartalnik Geologiczny*, 6: 50–71.

Deczkowski, Z., 1997. Table 36 – Lithostratigraphic division of the Lower Jurassic in Polish Lowland. In: Marek, S. & Pajchlowa, M. (eds), *The epicontinental Permian and Mesozoic in Poland*. *Prace Państwowego Instytutu Geologicznego*, 153: p. 195.

Evitt, W. R., 1961. The dinoflagellate Nannoceratopsis Deflandre: morphology, affinities and infraspecific variability. *Micropalaeontology*, 7: 305–316.

Fensome, R. A., 1979. Dinoflagellate cysts and acritarchs from the Middle and Upper Jurassic of Jameson Island, East Greenland. *Grønlands Geologiske Undersøgelse*, *Bulletin*, 132: 1–98.

Gedl, P. & Pieńkowski, G., 2003. Wstępne wyniki badań wczesnojurajskich cyst Dinoflagellata z wiercenia Gorzów Wielkopolski. *Tomy Jurajskie*, 1, supplement.

Gocht, H., 1964. Planktonische Kleinformen aus dem Lias/Dogger-Grenzbereich Nord- und Süddeutschlands. *Neues Jahrbuch für Geologie und Paläontologie*, *Abhandlungen*, 119: 113–133.

Guy-Ohlson, D., 1996. Prasinophycean algae. In: Jansonius, J. & McGregor, D. C. (eds), *Palynology: principles and applications*, 1. American Association of Stratigraphic Palynologists Foundation, Dallas, Texas, pp. 181–189.

Jurkiewiczowa, I., 1967. The Lias of the western part of the Mesozoic zone surrounding the Świętokrzyskie (Holy Cross) Mountains and its correlation with the Lias of the Cracow-Wieluń Range. (In Polish, English summary). *Instytut Geologiczny*, *Biuletyn*, 200: 5–132.

Kopik, J., 1964. The stratigraphy of the Lower Jurassic, based on the fauna of the Mechowo IG 1 bore-hole. In: Results obtained in bore-hole Mechowo IG 1. (In Polish, English summary). *Instytut Geologiczny*, *Biuletyn*, 189: 43–55, 135–140.

Kopik, J., 1967. Bajocian ammonites from the Kościelisko beds in the vicinity of Przystajń (Cracow-Wieluń Jura). (In Polish, English summary). *Instytut Geologiczny*, *Biuletyn*, 209: 5–50.

Kopik, J., 1998. Lower and Middle Jurassic of the north-eastern margin of the upper Silesian Coal Basin. (In Polish, English summary). *Biuletyn Państwowego Instytutu Geologicznego*, 378: 67–129.

Marcinkiewicz, T., 1962. Rhaetian and Lias megaspores from bore-hole Mechowo near Kamień Pomorski and their stratigraphical value. (In Polish, English summary). *Instytut Geologiczny*, *Prace*, 30 (part 3): 469–493.

Marcinkiewicz, T., 1971. The stratigraphy of the Rhaetian and Lias in Poland based on megaspore investigations. (In Polish, English summary). *Instytut Geologiczny*, *Prace*, 65: 1–58.

Marcinkiewicz, T., Orłowska, T. & Rogalska, M., 1960. Age of the Upper Helenów Beds (Lias) in view of mega- and microspore investigations (geological section Gorzów Śląski-Praszka). (In Polish, English summary). *Kwartalnik Geologiczny*, 4: 386–398.

Morgenroth, P., 1970. Dinoflagellate cysts from the Lias Delta of Lühnde/Germany. *Neues Jahrbuch für Geologie und Paläontologie*, *Abhandlungen*, 136: 345–359.

Mossoczy, Z., 1949. Report on geological research carried out westward from Częstochowa (Central Poland) in 1947. (In Polish, English summary). *Państwowy Instytut Geologiczny*, *Biuletyn*, 54: 20–23.

Mossoczy, Z., 1961. New stratigraphic division of Lias in the northern par of Cracov-Częstochowa Jura. (In Polish, English summary). *Kwartalnik Geologiczny*, 5: 81–100.

Pieńkowski, G., 1988. Facies analysis of the uppermost Triassic and Liassic of the Cracow-Wieluń Upland and prospects for occurrence of clay deposits. (In Polish, English summary). *Przegląd Geologiczny*, 36: 449–456.

Pieńkowski, G., 1997. Sedymentologia i stratygrafia sekwencyjna na podstawie wybranych profilów. In: Marek, S. & Pajchlowa, M. (eds), *The epicontinental Permian and Mesozoic in Poland*. *Prace Państwowego Instytutu Geologicznego*, 153: 217–235.

Pieńkowski, G., 2004. The epicontinental Lower Jurassic of Poland. *Polish Geological Institute Special Paper*, 12: 1–154.

Poulsen, N. E., 1992. Jurassic dinoflagellate cyst biostratigraphy of the Danish Subbasin in relation to sequences in England and Poland; a preliminary review. *Review of Palaeobotany and Palynology*, 75: 33–52.

Prauss, M., 1989. Dinozysten-Stratigraphie und Palynofazies im Oberen Lias und Dogger von NW-Deutschland. *Palaeontographica*, *Abt. B*, 214: 1–124.

Prauss, M. & Riegel, W., 1989. Evidence from phytoplankton associations for causes of black shale formation in epicontinental seas. *Neues Jahrbuch für Geologie und Paläontologie*, *Monatshefte*, 671–682.

Riding, J. B., 1982. Jurassic dinocysts from the Warboys Borehole, Cambridgeshire, England. *Journal of Micropalaeontology*, 1: 13–18.

Riding, J. B., 1983. The palynology of the Aalenian (Middle Jurassic) sediments of Jackdow Quarry. Gloucestershire, England. *Mercian Geologist*, 9: 111–120.

Riding, J. B., 1984. A palynological investigation of Toarcian to early Aalenian strata from the Blea Wyke area, Ravenscar, North Yorkshire. *Proceedings of the Yorkshire Geological Society*, 45: 109–122.

Riding, J. B., 1987. Dinoflagellate cyst stratigraphy of the Nettleton Bottom Borehole (Jurassic: Hettangian to Kimmeridgian), Lincolnshire, England. *Proceedings of the Yorkshire Geological Society*, 46: 231–266.

Riding, J. B. & Thomas, J. E., 1992. Dinoflagellate cysts of the Jurassic system. In: Powell, A. J. (ed.), *A Stratigraphic Index of Dinoflagellate Cysts*. Chapman & Hall, London, pp. 7–97.

Riding, J. B., Walton, W. & Shaw, D., 1991. Toarcian to Bathonian (Jurassic) palynology of the Inner Hebrides, northwest Scotland. *Palynology*, 15: 115–179.

Rogalska, M., 1954. Spore and pollen analysis of the brown coal of the region of the so-called Blanowice coal in Upper Silesia. (In Polish, English summary). *Instytut Geologiczny*, *Biuletyn*, 89: 1–46.

Rogalska, M., 1976. Stratigraphy of the Lower and Middle Jurassic in the Polish Lowlands on the basis of spore and pollen analysis. (In Polish, English summary). *Instytut Geologiczny*, *Prace*, 78: 1–61.

Różycki, S. Z., 1953. Górny dogger i dolny malm Jury Krakowsko-Częstochowskiej. *Instytut Geologiczny*, *Prace*, 17: 1–412.

Rutkowski, F., 1923. Preliminary report on the geology of the Zawiercie – Siewierz coal-field. (In Polish, English summary). *Sprawozdania Państwowego Instytutu Geologicznego*, 2: 117–150.

Tappan, H., 1980. *The paleobiology of plant protists*. W. H. Freeman and Company, San Francisco, 1028 pp.

Tyson, R. V., 1987. The genesis and palynofacies characteristics of marine petroleum source rocks. In: Brooks, J. & Fleet, A. J. (eds), *Marine petroleum source rocks*. Geological Society, London, Special Publication, 26: 47–67.

Wille, W., 1982. Ewolution and ecology of Upper Liassic dinoflagellates from SW Germany. *Neues Jahrbuch für Geologie und Paläontologie*, *Abhandlungen*, 164: 74–82.

Wille, W. & Gocht, H., 1979. Dinoflagellaten aus dem Lias Süddeutschlands. *Neues Jahrbuch für Geologie und Paläontologie*, *Abhandlungen*, 158: 221–258.

Williams, G. L., Lentin, J. K. & Fensome, R. A. 1998. The Lentin and Williams index of fossil dinoflagellates, 1998 edition. *American Association of Stratigraphic Palynologists*, *Contributions Series*, 28, 1–856.

Znosko, J., 1955. Rhaetic and Lias between Cracow and Wieluń (south-west Poland). (In Polish, English summary). *Instytut Geologiczny*, *Prace*, 14: 1–146.

Znosko, J., 1959. Preliminary description of stratigraphy of Jurassic sediments in southwestern part of Polish Lowland. (In Polish, English summary). *Kwartalnik Geologiczny*, 3: 501–528.

Streszczenie

WCZESNOJURAJSKIE DINOCYSTY Z KRAKOWSKO-ŚLĄSKIEJ MONOKLINY, POLSKA POŁUDNIOWA: ZAPIS Z FORMACJI BLANOWICKIEJ W MRZYGŁODZIE

Przemysław Gedl

Epikontynentalna dolna jura w Polsce wykształcona jest w większości w facjach kontynentalnych. We wczesnej jurze zaznaczyło się jednak kilka ingresji morskich na teren dzisiejszej Polski, których najbardziej kompletny zapis znany jest z Polski północno-zachodniej. W pozostałych, peryferyjnych obszarach basenu zapis ingresji jest znacznie słabiej udokumentowany z uwagi na brak skamieniałości. Z tego powodu, jednostki litostratygraficzne epikontynentalnej dolnej jury tej części Polski (Fig. 1, 2) są często pozbawione precyzyjnych datowań biostratygraficznych. Podjęte w ostatnich latach badania organicznych cyst Dinoflagellata (dinocyst) z epikontynentalnej jury Polski pokazują dużą ich przydatność dla biostratygrafii oraz, wraz z analizą palinofacji – dla rekonstrukcji środowiska sedymentacji tych osadów. Takie badania, podjęte w dolnojurajskim profilu formacji blanowickiej w nieczynnym wyrobisku cegielni w Mrzygłodzie (Fig. 3), są prezentowane w niniejszym artykule.

Blisko 3 metrowy profil (Fig. 4) odsłania ciemne iłowce z zachowaną pierwotną laminacją, przechodzące ku górze w jasnoszare iły z licznym uwęglonym detrytusem roślinnym, które podścielają 10 cm pokład węgla. Powyżej odsłaniają się ponownie ciemno zabarwione iły. Z profilu pobrano 3 próbki, które poddano standardowej maceracji palinologicznej.

Wszystkie próbki zawierają bardzo bogaty materiał palinologiczny zdominowany przez roślinne elementy pochodzenia lądowego. W próbce Mrz2 najliczniej występują dużych rozmiarów fitoklasty (Fig. 5); podobnie w próbce Mrz1, gdzie pojawiają się jednak nieliczne dinocysty z rodzaju *Nannoceratopsis*. W próbce tej zaznacza się również udział organicznej materii amorficznej (Fig. 6). Dinocysty najliczniej występują w próbce Mrz3, gdzie stanowią blisko 2% palinofacji. Próbka ta charakteryzuje się również dużym udziałem sporomorf (Fig. 5). Zespół dinocyst jest wyraźnie zdominowany przez przedstawicieli rodzaju *Nannoceratopsis* (Fig. 7, 8, 9). Jedynie w próbce Mrz3 pojawiają się pojedynczy przedstawiciele innych gatunków: *Batiacasphaera* sp., *Luehndea spinosa*, *Mendicodinium spinosum*.

Obecność *Luehndea spinosa* wskazuje, że badane osady reprezentują górny pliensbach-najniższy toark. Analiza palinofacji wskazuje na zmienne warunki sedymentacji osadów z badanego profilu. Najniższa jego część powstawała w warunkach morskich, których odzwierciedleniem jest obecność dinocyst. Wyższa część profilu, w obrębie której występuje węgiel, powstała zapewne w środowisku lądowym (jeziorzyskowym?). Pojawienie się nielicznych dinocyst w stropowej partii profilu wskazuje na stopniowy powrót warunków morskich (brakicznych?) w trakcie jego powstawania.