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FORAMINIFERA AND CALCAREOUS NANNOPLANKTON ASSEMBLAGES FROM ?TITHONIAN-NEOCOMIAN "CIESZYN BEDS" (SILESIAN UNIT, POLISH WESTERN CARPATHIANS)

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Abstract: The oldest micro- and nannofossils of the ?Tithonian Lower Cieszyn Shales and detrital Cieszyn Limestones are dominated by redeposited calcareous benthic foraminifers and calcareous nannoplankton. These assemblages are similar to those of epicontinental seas or large shelf areas. The younger micro- and nannofossil pelitic part of the Berriasian Cieszyn Limestones and Valanginian Upper Cieszyn Shales are composed of low-diversity primitive agglutinated foraminiferids and calcareous nannoplankton that resemble coeval faunas and floras of the Tethys seas. The sequence of foraminiferal assemblages and the nature of the nannoplankton associations from the "Cieszyn Beds" reflect the subsidence or collapse of the NE European Platform margin, disappearance of shallow areas with carbonate sedimentation, and formation of a deep basin with turbidite sedimentation. These events may be related to the Neocimmerian orogeny and the worldwide regression at the Tithonian/Berriasian boundary.

Key words: Tithonian-Neocomian, Polish Western Carpathians, Silesian Unit, Cieszyn Beds, paleoecology, calcareous nannoplankton, Foraminifera.

Introduction

Preliminary analyses of foraminiferal and calcareous nannoplankton assemblages from the Silesian Series are presented. These are part of the project dealing with the onset of the subsidence of the Carpathian flysch basin. The biostratigraphical, paleoecological and paleogeographical studies refer to the oldest sedimentary rocks ("Cieszyn Beds") of the Polish Western Carpathians. The microfossils of these deposits appear to be a valuable tool for paleoenvironment interpretations and paleobiogeographical reconstructions. The results of these investigations may be regarded as making more precise and extending the former research about the initial conditions for life and a sedimentation in the early flysch basin (comp. Książkiewicz 1961, 1975; Olszewska 1984).

The study is based on samples collected from the Cieszyn-Ustroń area (Cisownica, Goleszów, Goleszów-Marglownia Quarry), the vicinity of Bielsko-Biała (Lipnik Stream, Kamienica Stream and Quarry, Jasienica Quarry) and neighbourhood of the Żywiec tectonic window (Soła River, Radziechowy Quarry), Fig. 1.

Geological setting

In the Polish Outer Carpathians, ?Tithonian non-flysch deposits and flysch-type Upper Tithonian-Lower Cretaceous sediments belong to three tectonic units: Silesian, Subsilesian and Skole nappes. The oldest sediments of the Carpathians basin are more completely developed in the Silesian Nappe of the Western Carpathians. The Silesian Nappe in the study area consists of two independent tectonic units: the

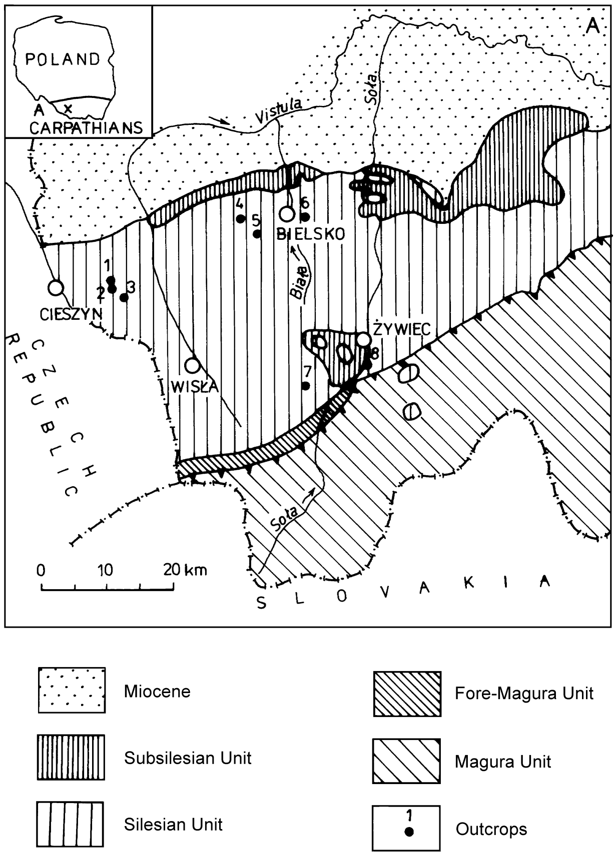


Fig. 1. Location of the studied outcrops. Tectonic units in the Polish Western Carpathians (Geroch et al. 1967). Outcrops: 1—Cisownica, 2—Goleszów; 3—Goleszów-Marglownia Quarry, 4—Jasienica Quarry, 5—Kamienica Stream and Quarry, 6—Lipnik Stream, 7—Radziechowy Quarry, 8—Soła River.

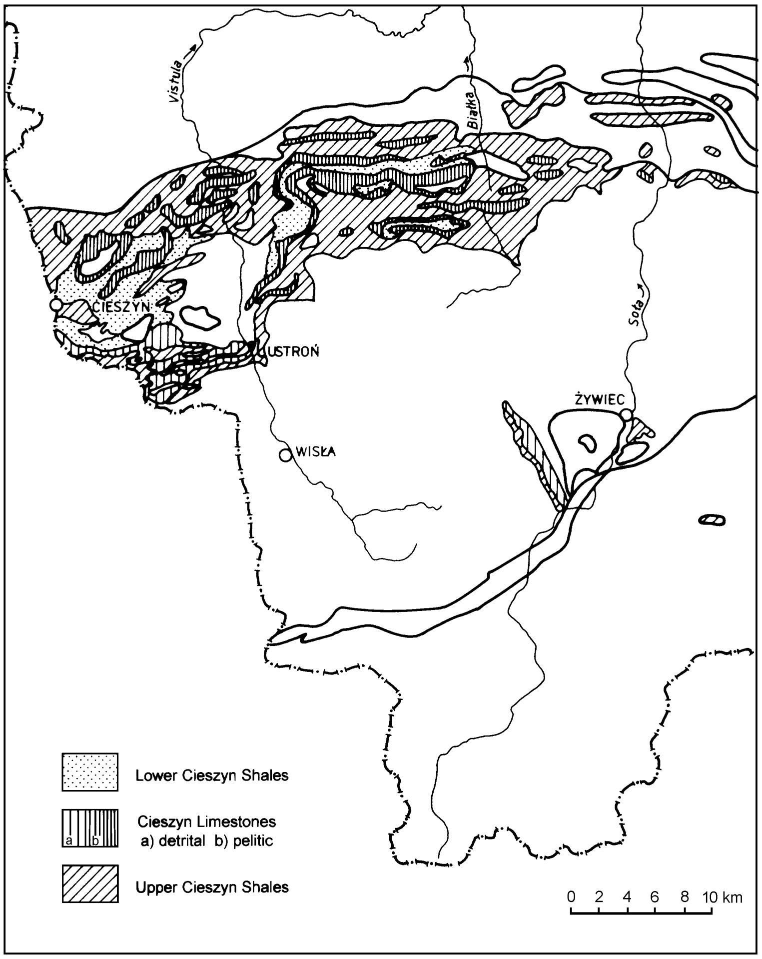


Fig. 2. The “Cieszyn Beds” in the Polish Western Carpathians (Cieszyn Unit) based on Geological atlas of Poland 1962; Nowak 1973.

Cieszyn Unit and the Godula Unit (Bieda et al. 1963). The first of these units consists of uppermost Jurassic (Tithonian) and Lower Cretaceous sediments. Part of this sequence, the so-called “Cieszyn Beds” belongs to the informal lithostratigraphical units: ?Tithonian Lower Cieszyn Shales (dark-grayish marly shales), ?Upper Tithonian-Berriasian Cieszyn Limestones (light-coloured, detrital and pelitic limestones) and Valanginian-Hauterivian Upper Cieszyn Shales (dark-grey, marly shales) (Fig. 2). The “Cieszyn Beds” as well as the overlying Grodziszcze Beds (grey-bluish marls and shales with rare sandy intercalations) have been studied for micro- and nannofossils (Fig. 3).

The base of the “Cieszyn Beds” is uncertain because of the tectonic decollement (Bieda et al. 1963) and the recently revised Kimmeridgian-Tithonian boundary (Gradstein et al. 1995). Therefore, the analysis of the oldest part of these sediments will be presented separately.

The characteristic, frequent and better preserved species of foraminifers and calcareous nannoplankton are listed (Fig. 3) and illustrated (Pls. I, II).

Results

Tithonian microfossils from Lower Cieszyn Shales and detrital Cieszyn Limestones

Foraminifera

In Goleszów section (cf. Szydło 1997) and from Marglownia Quarry, the oldest samples (i.e. ?Upper Tithonian age) yield mainly calcareous benthos: *Geinitzinita wolinensis* Bielecka & Pożaryski, few *Lenticulina: L.* ex gr. *münsteri* (Roemer), *L.* cf. *ambanjabensis* Epistalié & Sigal, *Lenticulina vistulae elongata* Bielecka & Pożaryski, numerous taxa of *Planuria* sp.: *P. cordiformis* (Terquem), *P. crepidularis* Roemer, *P. multicostata* Kusnetzova, *P.* cf. *poljenovae* Kusnetzova, *Vaginulinopsis embaensis* (Fursenko & Polenova), *Marginulinopsis robusta* (Reuss), *M. striatocostata* (Reuss), *Tristix temiricra* (Dain), *Vaginulina kochii* Roemer and *Trocholina solecensis* Bielecka & Pożaryski. In addition other badly preserved nodosariids (e.g. *Lenticulina* spp., *Lingulina* spp., *Frondicularia* spp., *Citharina* spp.) are noted. Moreover, from Marglownia Quarry common taxa of Polymorphinidae: *Eoguttulina liassica* (Strickland), *Guttulina multistriata* Bielecka are reported. Agglutinated foraminifers, including *Belorusiella wolinensis* Bielecka, *Palaeogaudryina* cf. *taurica* (Gorbachik), *Palaeogaudryina varsoviensis* (Bielecka & Pożaryski) as well as radiolarians, diatoms and fragments of ostracods, bryozoans and corals have also been found in these deposits.

At the top of the Lower Cieszyn Shales, just below the Cieszyn Limestones (Cisownica) the uppermost Tithonian associations are noted. The first occurrence of *Trocholina* group: *T. alpina* (Leupold), *T. solecensis* Bielecka & Pożaryski and *Neotrocholina molesta* (Gorbachik), and diverse *Lenticulina*: *L. infravolgensis* Fursenko & Polenova, *L. münsteri* (Roemer), *L. ponderosa* Mjatliuk, *L.* cf. *vistulae* Bielecka & Pożaryski are observed. In addition, *Marginulinopsis bettenstaedti* (Bartenstein & Brand), *M. striatocostata* (Reuss), *Saracenaria alata-angularis* (Franke), *Paalzowella feifeli* (Paalzow), *Spirillina minima* Schacko have been distinguished (Szydło 1997). The above foraminiferids are characteristic for the detrital Cieszyn Limestones (Geroch 1966).

Calcareous nannoplankton

The samples studied from the Lower Cieszyn Shales contain poor nannoplankton assemblages. Most of the samples are dominated by species of *Watznaueria* Reinhardt (which are characteristic of poorly preserved assemblages) as well as by *Ellipsagelosphaera* Noël, which constitute about 95 % of the assemblages. Identified species are as follow: *W. barnesae* (Black) Perch-Nielsen, *W. biporta* Bukry, *E. britannica* (Stradner) Perch-Nielsen, *E. fossacincta* Black, *E. lucassi*

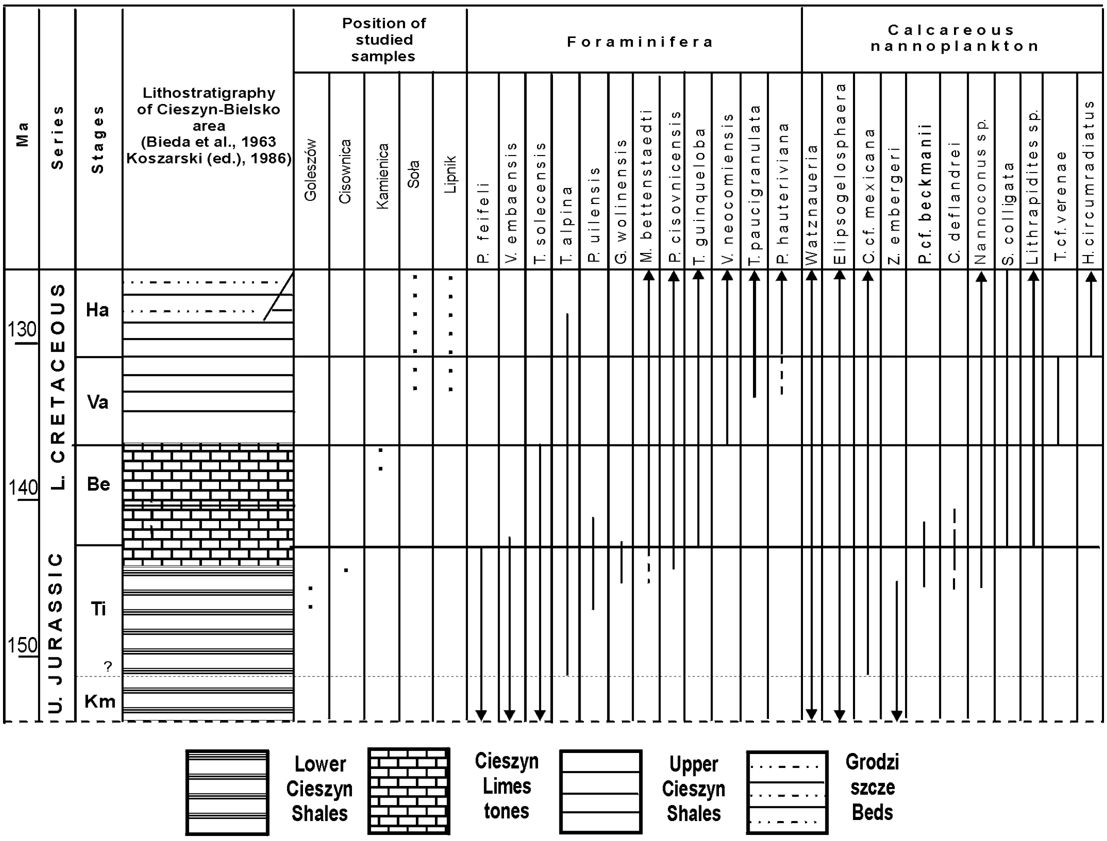


Fig. 3. Table of proposed distribution of some taxa of foraminifers and calcareous nannoplankton.

Noël. At the boundary with the Cieszyn Limestones other species (up to 5 in the sample) have been encountered. They are: *Conusphaera* cf. *mexicana* Trejo*, Cyclagelosphaera deflandrei* (Manivit), *C. margerelii* Noël, *Diazomatolithus lehmanii* Noël*, Microstaurus chiastus* (Worsley) Grün, *Polycostella* cf. *beckmannii* Thierstein*, Zeugrhabdotus embergei* (Noël) Perch-Nielsen.

Samples collected from the uppermost part of the Lower Cieszyn Shales probably represent at least the top of the Zeugrhabdotus embergeri Zone of Worsley (1971). The nannoplankton assemblages of this zone, dominated by *Ellipsagelosphaera.* FO of *C. mexicana, P. beckmannii,* indicate the top of this zone (Wind 1978; Hamilton 1982), i.e. the uppermost Early Tithonian. However, according to studies by Bralower et al. (1989) from land sections of south-western Europe, FO of *P. beckmannii* indicates at least the lower part of the Upper Tithonian.

The oldest assemblages described from the non-flysch marly Lower Cieszyn Shales are dominated by calcareous benthic foraminifers and scarce nannoplankton. Assemblages with common trocholinas also resemble the microfauna of detrital Cieszyn Limestones (cf. Geroch 1966). Samples from Radziechowy and Jasienica limestones quarries are devoid of microfossils. The accompanying radiolarians as well as the style of deposition of these sediments (Słomka 1986) suggest that the shallow-water calcareous foraminifers (mainly nodosariids and trocholinas) and nannoplankton taxa (e.g. *Conusphaera mexicana,* Thierstein 1976) have been redeposited.

Berriasian and Valanginian microfossils from Cieszyn Limestones (pelitic part) and Upper Cieszyn Shales (lower part)

Foraminifera

In the Kamienica Quarry, improverished and badly preserved assemblages are found, in shally intercalation of the Cieszyn Limestones. They consist of numerous primitive agglutinated forms such as: *Rhizammina indivisa* Brady, *Hyperammina gaultina* Dam, *Ammodiscus* sp., *Glomospira* sp.*, Pseudoreophax cisovnicensis* Geroch, *Trochammina quinqueloba* Geroch and scarce calcareous benthic taxa (e.g. *Trocholina paucigranulata* Moulladae). Forms belonging to Nodosariidae (*Lenticulina*) and Involutinidae (*Trocholina, Neotrocholina*) have corroded tests. A few radiolarians and ostracods were also observed.

Calcareous nannoplankton

The calcareous nannofossil assemblages of the Cieszyn Limestones are similar to those from the Lower Cieszyn Shales. However, *Nannoconus* spp. Kamptner and *Speetonia colligata* Black have been found in one sample. The examined material from the Upper Cieszyn Shales has been devoid of calcareous nannoplankton. Nevertheless, occurrence of *Nannoconus* spp. and *S. colligata* may suggest at least the Early Berriasian age of the studied samples.

Low-diversity and poor foraminiferal assemblages are characteristic of the Berriasian-Valanginian Cieszyn Limestones (pelitic part) and Upper Cieszyn Shales (without their uppermost part; compare with Geroch 1966). These assemblages are composed mainly of agglutinated taxa belonging to: Ammodiscidae, Ataxophragmiidae, Astrorhizidae and may be consider as autochthonous fauna. These microfossils represent the slope of a deep flysch basin (cf. Książkiewicz 1961, 1975; Olszewska 1984). Moreover, the sedimentological data confirm this opinion (Słomka 1986; Malik 1986, 1994).

Uppermost Valanginian-Hauterivian microfossils from Upper Cieszyn Shales (uppermost part) and Grodziszcze Beds (lower part)

Foraminifera

Microfauna of the Upper Cieszyn Shales (Lipnik Stream, Soła River) and the lower part of the Grodziszcze Beds (Lipnik Stream) includes mainly Ataxophragmiidae and scarce Nodosariidae (mainly *Lenticulina* with corroded tests). To the former belong *Praedorothia hauteriviana* (Moullade) with calcareous agglutinated test and arenaceous species: *Pseudoreophax cisovnicensis* Geroch and *Verneuilinoides neocomiensis* (Mjatliuk) which are characteristic of the Upper Cieszyn Shales (upper part) and the Grodziszcze Beds (cf. Geroch 1966). Other forms i.e. *Falsogaudryinella tealbyensis* (Bartenstein), *Ammobaculoides carpathicus* Geroch also occur in the Grodziszcze Beds samples.

Calcareous nannoplankton

The similarity of specific compositon of nannofossil assemblages between the Grodziszcze Beds and underlying beds (Lower Cieszyn Shales, Cieszyn Limestones) have been observed. Moreover, the presence of *Haqius circumradiatus* (Stover) Roth, *Lithraphidites* sp. Deflandre, and *Tubodiscus* cf. *verenae* Thierstein in the Grodziszcze Beds samples have been noted. According to Crux (1982) the range of *H. circumradiatus* is from the Hauterivian to the Campanian, or according to Mutterlose (1991) from the Kimmeridgian to the Barremian in Tethys. The presence of *T.* cf. *verenae* probably suggest a Valanginian age of the investigated samples (Mutterlose 1989).

The microfauna indicates outer shelf and slope environments for the flysch basin (cf. Malik & Olszewska 1984). Mixed foraminiferal assemblages with poorly preserved and low diversified nannoplankton associations may be connected with tectonic activity of the flysch basin (Haq 1973; Książkiewicz 1975; Słomka 1986), caused by sea level fluctuations (Haq 1973; Cooper 1977; Leszczyński & Malik 1996) or climate changes (Haq 1973).

Conclusion

The microfauna characteristic of the northen margins of Tethys dominating the Tithonian sediments was replaced by Neocomian flysch taxa, which represent the slope environment of the Cieszyn Basin.

The Tithonian foraminiferal assemblages containing highly diversified calcareous benthos of the families: Nodosariidae (*Geinitzinita, Lenticulina, Marginulinopsis, Planularia, Saracenaria, Vaginulina, Vaginulinopsis*), Involutinidae (*Trocholina, Neotrocholina, Paalzowella*), Polymorphinidae (*Eoguttulina, Guttulina*) and minor agglutinated foraminiferids belong to Ataxophragmiidae family (*Paleogaudryina, Belorusiella*) may be correlated with the “shelf assemblages” of Gordon (1970).

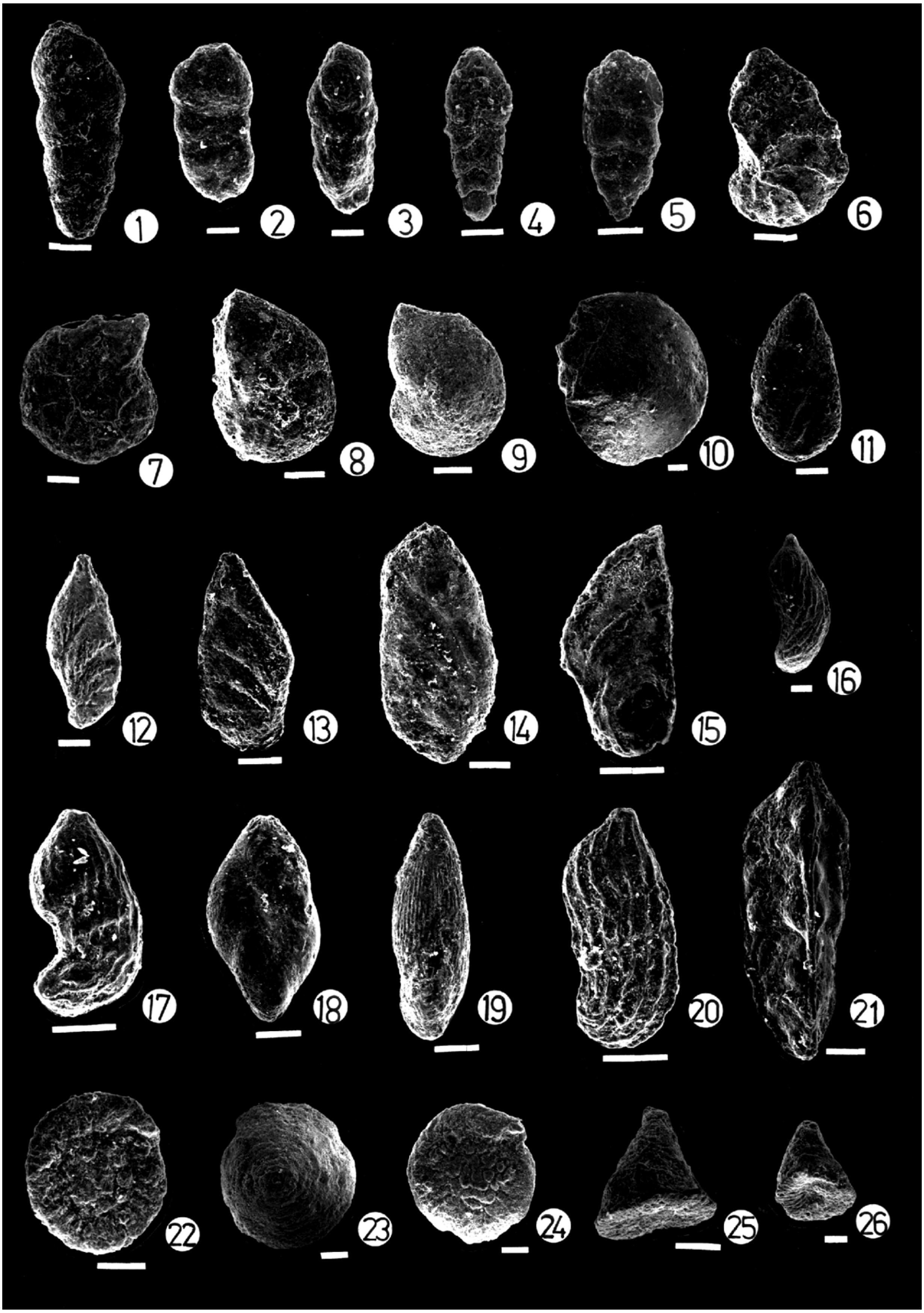
Certain species of *Watznaueria* and *Ellipsagelosphaera* are well preserved and dominate calcareous nannoplankton assemblages. The other identified taxa are relatively poorly preserved. *C. mexicana* and *Nannoconus* spp. most probably preferred the epicontinental seas and large shelf areas (cf. Thierstein 1976).

Redeposited foraminiferids of the Lower Cieszyn Shales and Cieszyn Limestones (Geroch 1966; Nowak 1976; Geroch & Olszewska 1990), the nature of calcareous nannoplankton (Thierstein 1976; Perch-Nielsen 1979), associated with the presence of radiolarians (Książkiewicz 1975) confirm the opinion that carbonate material was transported by turbidites into a deeper environment (at least an upper bathyal zone) from the northern platform or reef margins of Silesian (Cieszyn) Basin (Geological Atlas of Poland 1962; Atlas of paleotransport 1976, Słomka 1986; Michalík & Soták 1990). According to Sliter (1980), shallow-water exchange between the Boreal and Tethys realms was initiated at about 150 Ma (i.e. during Malm).

At the Jurassic/Cretaceous boundary, the first agglutinated foraminiferal population appeared in the Cieszyn Limestones (with *Trochammina* sp.) as microfauna that started to colonize the new created flysch environment in the Outer Polish Carpathians Basin (Olszewska 1982). This trend is represented by autochthonous assemblage with *Pseudoreophax cisovnicensis* which occurred in the Berriasian-Valanginian Cieszyn Limestones and the Upper Cieszyn Shales (without the uppermost part).

Poor and badly preserved assemblages with *Pseudoreophax cisovnicensis* resemble the ”*Recurvoides*” Association of Haig (1979) and represent the slope of the flysch basin (bathyal zone) close (pelitic Cieszyn Limestones) or below (Upper Cieszyn Shales) the local CCD level.

Plate I: Fig. l. *Palaeogaudryina varsoviensis* (Bielecka & Pożaryski). **Fig. 2.** *Pseudoreophax cisovnicensis* Geroch. **Fig. 3.** *Verneuilinoides neocomiensis* (Mjatliuk). **Fig. 4.** *Geinitzinita wolinensis* Bielecka. **Fig. 5.** *Lingulina* sp. **Fig. 6.** *Lenticulina vistulae elongata* Bielecka & Pożaryski. **Fig. 7.** *Lenticulina* ex gr. *münsteri* (Roemer). **Figs. 8–10.** *Lenticulina* sp. **Fig. 11.** *Planularia cordiformis* (Terquem). **Fig. 12.** *Planularia multicostata* (Kusnetzova). **Fig. 13**. *Planularia crepidularis* Roemer. **Fig. 14.** *Planularia uilensis* Kusnetzova. **Fig. 15.** *Vaginulina kochii* Roemere. **Fig. 16.** *Marginulinopsis* cf. *bettenstaedti* (Bartenstein & Brand). **Fig. 17.** *Marginulinopsis striatocostata* (Reuss). **Fig. 18.** *Eoguttulina liassica* (Stricland). **Fig. 19.** *Guttulina multicostata* Bielecka. **Fig. 20.** *Vaginulinopsis embaensis* Fursenko & Polenova. **Fig. 21.** *Tristix acutangulus* (Reuss). **Fig. 22.** *Trocholina solecensis* Bielecka & Pożaryski. **Figs. 23–24.** *Neotrocholina molesta* Gorbachik. **Fig. 25.** *Trocholina alpina* (Leupold). **Fig. 26.** *Paalzowella feifeli* (Paalzow). Length of bars: 0.1 mm.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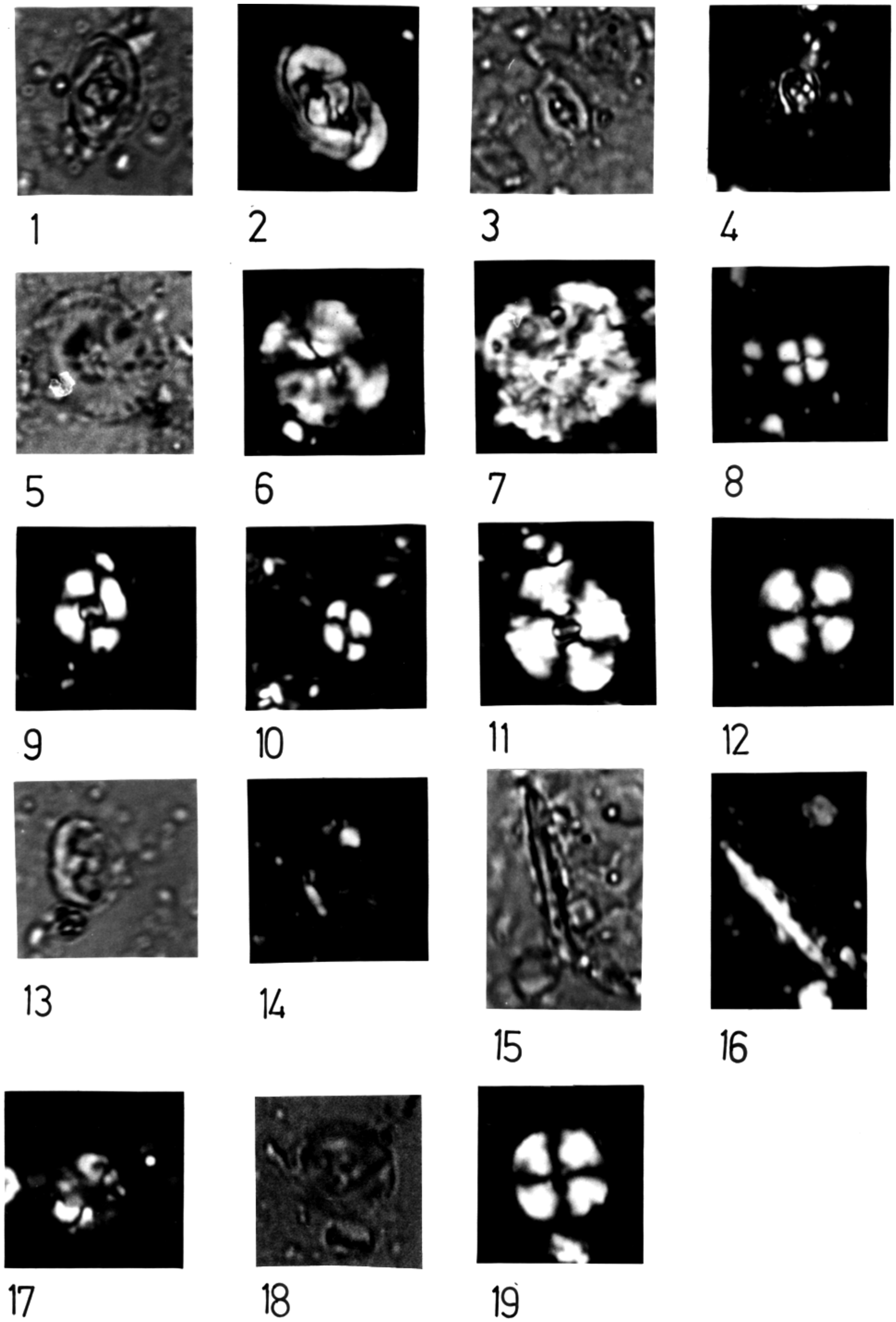
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The low-diversity agglutinated microfauna (mainly with *P. cisovnicensis*) may be correlated with the first oxygen minimum episode in the Cieszyn Basin (comp. Szydło 1997). The foraminiferal morphotypes of these assemblage contains mainly small, elongated, planispiral-flattened and cylindrical forms with high surface area—to volume ratios. This fact may be related to the extent of anoxia (Bernhard 1986). Probably, during this time (i.e. earliest Cretaceous) the supply of terrigenous material to the vast flysch basin increased. Rapid rise of the CCD, related to the restricted conditions (e.g. stagnation of the bottom water) caused elimination of benthic life and, consequently, occurrence of very impoverished foraminiferal associations (Butt 1977; Kaminski et al. 1995; Holbourn & Kaminski 1997).

The uppermost Valanginian-Hauterivian Upper Cieszyn Shales and Grodziszcze Beds yielded both arenaceous and rare calcareous foraminifers which the resemble "*Marssonella/Recurvoides*" associations of Haig (1979). The specific composition of these foraminiferal assemblages with the accompanying scarce calcareous nannoplankton most probably reflect a transgression-regression cycle in the flysch basin (Haq 1973; Leszczyński & Malik 1996) connected, in turn, with the short duration of tectonic activity of the northen margins of the basin at the end of the Valanginian (Słomka 1986).

The specific composition of nannofossil assemblages (poor, low-diversity, badly preserved) has also been observed in Neocomian sediments (from the pelitic Cieszyn Limestones to the Grodziszcze Beds).

Widespread orogenic events and regression episodes are followed by reduction in the quantity of calcareous nannoflora (Haq 1973).

The sequence of foraminiferal assemblages and the nature of the nannoplankton association from the "Cieszyn Beds" reflect the subsidence or collapse of the NE European margin of the platform, the disappearance of areas with shallow carbonate sedimentation and formation of a deep basin with flysch sedimentation.

The geotectonic desintegration of the carbonate platform system preceded formation of the Carpathian deep flysch basin (Leszczyński & Malik 1996). Therefore, the Neocimmerian orogeny (Nowak 1976) and the worldwide regression at the Tithonian/Berriasian boundary (Zeiss 1983) may be responsible for this event.

Foraminifers and some taxa of calcareous nannofossils, reported from the ?Tithonian Lower Cieszyn Shales are comparable to those of epicontinental seas or large shelf areas, for example the European Platform (cf. Bielecka & Pożaryski 1954; Bielecka & Geroch 1974; Bielecka 1975; Thierstein 1976; Kuznietzova & Gorbachik 1985). Their origin may be related to the sedimentation area of the Pavlov platform (Hanzliková 1965a: the youngest part of the Klentnice Beds; Eliáš & Eliášova 1986). The presence of certain foraminiferids (e.g. trocholinas) with fragments of macrofauna (e.g. bryozoans, ostracods, corals) in the Lower Cieszyn Shales may represent part of the eroded material from the nearby Inwałd klippe (Książkiewicz 1971; Słomka 1986).

Moreover, species of *Watznaueria* and *Ellipsagelosphaera* and *Z. embergeri* have consistent occurrences in both the Tethyan and Boreal realms. Thus, these species represent an eurytropic flora (Muterlose 1992).

The microfauna described from the Neocomian deposits in the Cieszyn flysch basin (northern margin of Tethys) suggests that the sedimentation conditions were similar to those of the Slovak Western Carpathians and deeper (scarce *Epistommina*) than those in the Western Mediterranean region (Borza et al. 1995). However, bathimetrically these conditions were similar to those calculated for the Slovak Carpathians (Hanzliková 1956a,b; Andrusov 1959), Romanian Carpathians (Neagu 1962), Eastern Alps (Decker & Rögl 1988) and Betic Mountains (Kuhnt 1995), and shallower than those from the North Atlantic (Sliter 1980). Certain cosmopolitan species e.g. *Rhizammina indivisa, Hyperammina gaultina, Pseudoreophax cisovnicensis, Trochammina quinqueloba*, have been noted in the coeval sediments of the Indian Ocean (Holbourn & Kaminski 1997).

The Early Cretaceous nannofossils: *C. mexicana*, *Nannoconus* spp., *S. colligata*, *P. beckmannii* have been restricted to the tropical and subtropical paleolatitudes. However, *C. mexicana* and *Nannoconus* spp. are characteristic of the Tethyan paleobiogeoprovince. Nevertheless, they are very scarce or absent in the Pacific realm (cf. Thierstein 1976; Perch-Nielsen 1979; Mutterlose 1992).

Mixed microfossils from different environments have been distinguished from Tithonian sediments (Lower Cieszyn Shales, detrital Cieszyn Limestones) and uppermost Valanginian-Hauterivian deposits (uppermost part of the Upper Cieszyn Shales, Grodziszcze Beds), consequently these sediments may be interpreted as resedimented (Olszewska 1983; Słomka 1986; Leszczyński & Malik 1996).

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Plate II: Figs. 1–2. *Zeugrhabdotus embergeri* (Noël) Perch-Nielsen. **Figs. 3–4.** *Parhabdolithus liasicus* Deflandre. **Figs. 5–7.** *Cyclagelosphaera deflandrei* (Manivit). **Fig. 8.** *Cyclagelosphaera margerelii* Noël. **Fig. 9.** *Ellipsagelosphaera lucasii* Noël. **Fig. 10.** *Ellipsagelosphaera fossacincta* Black. **Fig. 11.** *Ellipsagelosphaera britannica* (Stradner) Perch-Nielsen. **Fig. 12.** *Watznaueria barnesae* (Black) Perch-Nielsen. **Figs. 13–14.** *Speetonia* cf. *colligata* Black. **Figs. 15–16.** *Lithraphidites* sp. Deflandre. **Fig. 17.** *Polycostella* cf. *beckmannii* Thierstein. **Figs. 18–19.** *Haqius circumradiatus* (Stover) Roth (all specimens magnification ×2400).

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