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BIOSTRATIGRAPHICAL AND PALAEOECOLOGICAL SIGNIFICANCE OF SMALL FORAMINIFERAL ASSEMBLAGES IN THE SILESIAN (CIESZYN) UNIT, WESTERN CARPATHIANS, POLAND

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Abstract: The oldest assemblage of the nonflysch marly sediments (Lower Cieszyn Shales; Tithonian) is dominated by calcareous benthic foraminifera. Some foraminifers are reported here for the first time (*Belorusiella wolinensis*, *Geinitzinita wolinensis*, *Frondicularia* cf. *inderica*, *Lenticulina* cf. *ambanjabensis*, *L. ponderosa*). The assemblages may be referred to those of the European Platform (neritic zone), but the presence of radiolarians (calcificated) suggest at least the upper bathyal environment of Cieszyn basin.

Foraminifers of Lower Cieszyn Shales originate from the Malm microfauna following destruction of north carbonate margins of Tethys, and subsidence of basin of the Tithonian age. The worldwide regression during the late Tithonian and early Berriasian corresponding to the Neocimmerian orogeny may be responsible for the supply of those neritic forms into the Cieszyn basin.

The younger microfossils from the calcareous flysch (pelitic Cieszyn Limestones; Berriasian) and shaly flysch (Upper Cieszyn Shales, Grodziszcze Beds and lower part of Veřovice Shales; Valanginian–Barremian) are composed of both calcareous and primitive agglutinated foraminifera reflecting an upper to middle bathyal environment. The foraminifera from shaly-sandy deposits – the upper part of the Veřovice Shales, lower and middle part of Lgota Beds (Aptian–Albian) – consist of arenaceous species (except for *Hedbergella* sp. and *Cibicides* sp.) and correspond to lower bathyal conditions. The described assemblages resemble the coeval faunas of the Alpine flysch troughs.

Two low-oxygen periods in the late Berriasian–Valanginian (assemblage with *Pseudoreophax cisovnicensis*) and the early Albian (assemblage with *Haplophragmoides nonioninoides*) have been recognized in the Cieszyn basin.

Abstrakt: Większość późnojurajskich form w dolnych łupkach cieszyńskich i detrytycznych wapieniach cieszyńskich (tyton), w tym również po raz pierwszy opisane we wspomnianych utworach (*Belorusiella wolinensis*, *Geinitzinita wolinensis*, *Frondicularia* cf. *inderica*, *Lenticulina* cf. *ambanjabensis*, *L. ponderosa*) wykazują podobieństwo do zespołów otwornicowych z obszarów platformowych. Obecność radiolarii w tych utworach wskazuje na głębsze środowisko basenu cieszyńskiego – co najmniej górny batial.

Zespoły wapiennych otwornic w dolnych łupkach cieszyńskich zostały redeponowane z brzegów północnej części Tetydy w czasie formowania głębokiego basenu fliszowego. Miało to miejsce w czasie regresji o zasięgu globalnym (tyton/berias), związanej z neokimeryjskimi ruchami górotwórczymi. Wczesnokredowa mikrofauna (berias–barem) jest zbliżona do fliszowych zespołów otwornicowych Karpat i Alp i wskazuje na sedymentację w warunkach niższej strefy skłonu.

W basenie cieszyńskim doszło do dwóch wydarzeń paleoekologicznych związanych z minimum tlenowym na przełomie późnego beriasu i walanżynu (zespół z *P. cisovnicensis*) oraz we wczesnym albie (zespół z *H. nonioninoides*).

Key words: biostratigraphy, paleoecology, Foraminifera, uppermost Jurassic (Tithonian), Lower Cretaceous, Western Carpathians, Poland.

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INTRODUCTION

This comprehansive study on foraminiferal assemblages from sediments of the Silesian (Cieszyn) Unit is based on samples taken from the neigbourhood of the Żywiec tectonic windows (Leśnianka stream, Soła river,

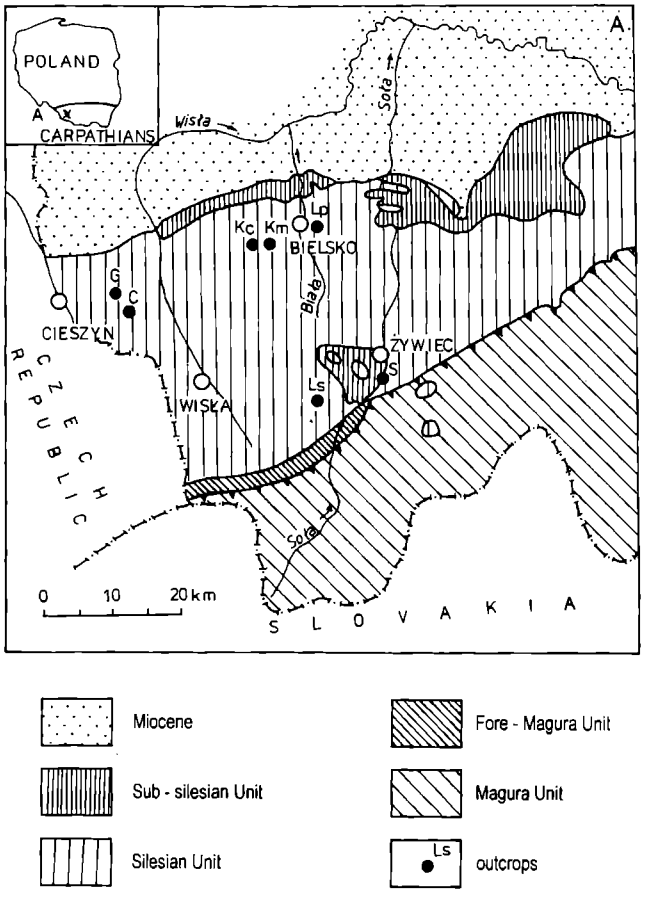

Fig. 1. Location of the studied outcrops on the base of tectonic units in the Polish Western Carpathians; (after Książkiewicz (ed.), 1962). Outcrops: G – Goleszów, C – Cisownica, Lp – Lipnik stream, Kc – Kamienica, Km – Kamienna stream, S – Soła, Ls – Leśnianka stream and Leśna Skałka klippe

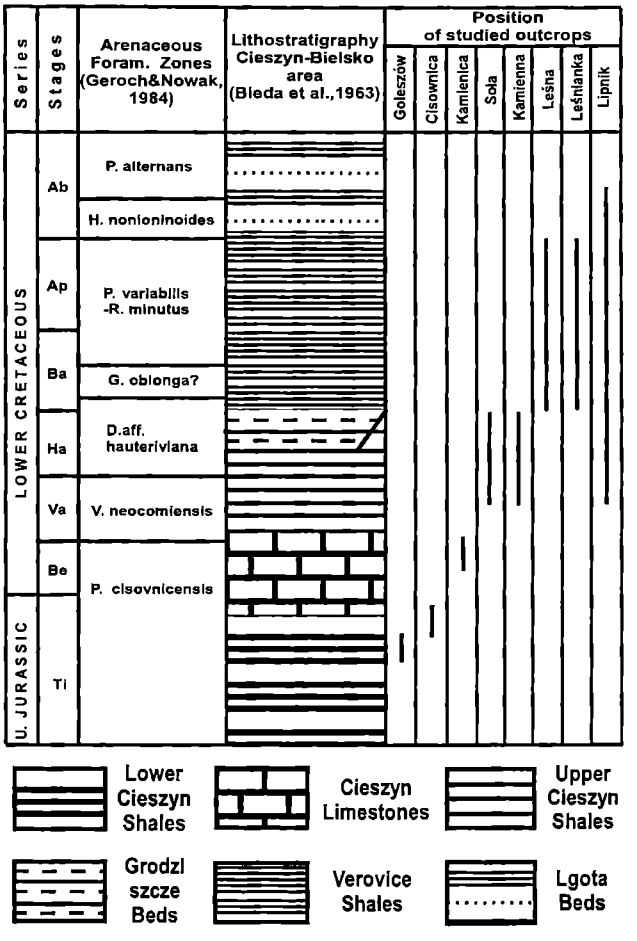

Fig. 2. Lithostratigraphy of the Silesian (Cieszyn) Unit in the Polish Western Carpathians and position of the studied samples

Leśna klippe), the vicinity of Bielsko-Biała (Lipnik stream, Kamienna stream, Kamienica) and the Cieszyn–Ustroń area (Cisownica, Goleszów) (Fig. 1). Detailed location of outcrops is presented by Nescieruk and Wójcik (*in print*).

The Silesian Nappe consists of two independent tectonic units: Cieszyn Unit and Godula Unit in the Polish Western Carpathians (Bieda *et al.*, 1963). The first unit which is studied for microfossils in this paper represents uppermost Jurassic (Tithonian) and Lower Cretaceous sediments. They belong to the following unformal lithostratigraphical units (Fig. 2): Lower Cieszyn Shales (dark-grayish marly shales), Cieszyn Limestones (ligth-coloured, detrital and pelitic limestones), Upper Cieszyn Shales (dark-grey, marly shales), Grodziszcze Beds (grey-bluish marls and shales with rare sandy intercalation), Veřovice Shales (black, clay and siliceous shales) and Lgota Beds subdivided into three parts: a) lower – conglomerates and thick-bedded sandstones, b) middle – thin-bedded sandstones with variegated shales, c) upper – bluish cherts.

RESULTS

The following foraminiferal associations comparable with assemblages of Geroch (1966) and biostratigraphical zones based upon agglutinated foraminifera (Geroch & Nowak, 1984), have been recognized during the present study (Fig. 3.)

1. Assemblage with *Palaeogaudryina varsoviensis* and *Belorusiella wolinensis*

The oldest assemblage described from dark-grayish shales in Goleszów yield: *Belorusiella wolinensis* Bielecka, *Palaeogaudryina* cf. *taurica* (Gorbachik), *Palaeogaudryina varsoviensis* (Bielecka et Pożaryski), *Geinitzinita wolinensis* Bielecka et Pożaryski, *Vaginulinopsis embaensis* (Fursenko et Polenova), *Marginulinopsis robusta* (Reuss), *Tristix temirica* (Dain), *Lenticulina münsteri* (Roemer), *Lenticulina* cf. *ambanjabensis* Epistalié et Sigal, *Frondicularia* cf. *inderica* Fursenko et Polenova, *Trocholina solecensis* Bielecka et Pożaryski. Radiolarians, diatoms and fragments of ostracods are found in these deposits.

This micropalaeontological association can be compared with "Microfauna J" reported from the Lower Cieszyn Shales (lower part of Tithonian) by Geroch (1966).

2. Assemblage with *Trocholina alpina* and *Paalzowella feifeli*

Upper Tithonian assemblages from marly shales inter-

calated between brown shales (Lower Cieszyn Shales) and detritic limestones (Cieszyn Limestones) in Cisownica is dominated by *Trocholina*: *T. aplina* (Leupold), *T. molesta* Gorbachik, *T. solecensis* Bielecka et Pożaryski, and *Lenticulina*: *L. infravolgensis* Fursenko et Polenova, *L. münsteri* (Roemer), *L. ponderosa* Mjatliuk, *L.* cf. *vistulae* Bielecka et Pożaryski. Moreover the presence of *Marginulinopsis bettenstaedti* (Bartenstein et Brand), *Marginulinopsis striatocostata* (Reuss), *Vaginulinopsis embaensis* (Fursenko et Polenova), *Saracenaria alata-angularis* (Franke), *Paalzowella feifeli* (Paalzow), *Spirillina minima* Schacko is noted here.

According to Geroch (1966), similar foraminiferids ("Microfauna J and I") occurred in the Lower Cieszyn Shales and detrital Cieszyn Limestones of late Tithonian age, corresponding to the lower part of the *Pseudoreophax cisovnicensis* Zone (Geroch & Nowak, 1984).

3. Assemblage with *Pseudoreophax cisovnicensis*

Poor assemblages are found in shales underlying the Cieszyn Limestones in the Kamienica locality. They consist of numerous primitive agglutinated foraminifera from family Ammodiscidae (*Glomospira*), Ataxophragmiidae (*Pseudoreophax cisovnicensis* Geroch) and scarce calcareous benthic forms belonging to Nodosariidae, Involutinidae (*Trocholina paucigranulata* Moullade), and also few radiolarians and ostracods.

This assemblage is characteristic of the upper part of Cieszyn Limestones of Berriasian age and corresponds with the "Microfauna II" *sensu* Geroch (1966) and the upper part of the *Pseudoreophax cisovnicensis* Zone (Geroch & Nowak, 1984). However, some features of the primitive agglutinated species enable comparison with those from the lower part of the Upper Cieszyn Shales (Valaginian) – "Microfauna III" (Geroch, 1966).

4. Assemblage with *Praedorothia hauteriviana*

Younger microfauna which occur in the Grodziszcze Beds (Lipnik stream) and the Upper Cieszyn Shales (Kamienna stream, Soła river) includes mainly Ataxophragmiidae and scarce Nodosariidae. The former are assigned to: *P. hauteriviana* (Moullade) which builds its test of carbonate material. The latter are represented by arenaceous species: *Falsogaudryinella tealbyensis* (Bartenstein), *Pseudoreophax cisovnicensis* Geroch, *Verneuilinoides neocomiensis* (Mjatliuk), and *Ammobaculoides carpathicus* Geroch.

The described microfossils have been called "Microfauna IV" by Geroch (1966), and represent the *Dorothia* aff. *hauteriviana* Zone (Hauterivian–the earliest Barremian) of Geroch and Nowak (1984).

5. Assemblage with *Verneuilinoides subfiliformis* and *Gaudryinella sherlocki*

Barremian–Aptian assemblage, typical of the lower part of the Veřovice Shales, was found in the vicinity of Leśna klippe, at Leśnianka and also at Lipnik stream. Only the noncalcareous foraminifera found there: *Pseudobolivina variabilis* (Vašiček), *Sherochorella minuta* (Tappan), *Verneuilinoides neocomiensis* (Mjatliuk), *V. subfiliformis* Bartenstein, *Gaudryina oblonga* Zaspelová, *G. filiformis*

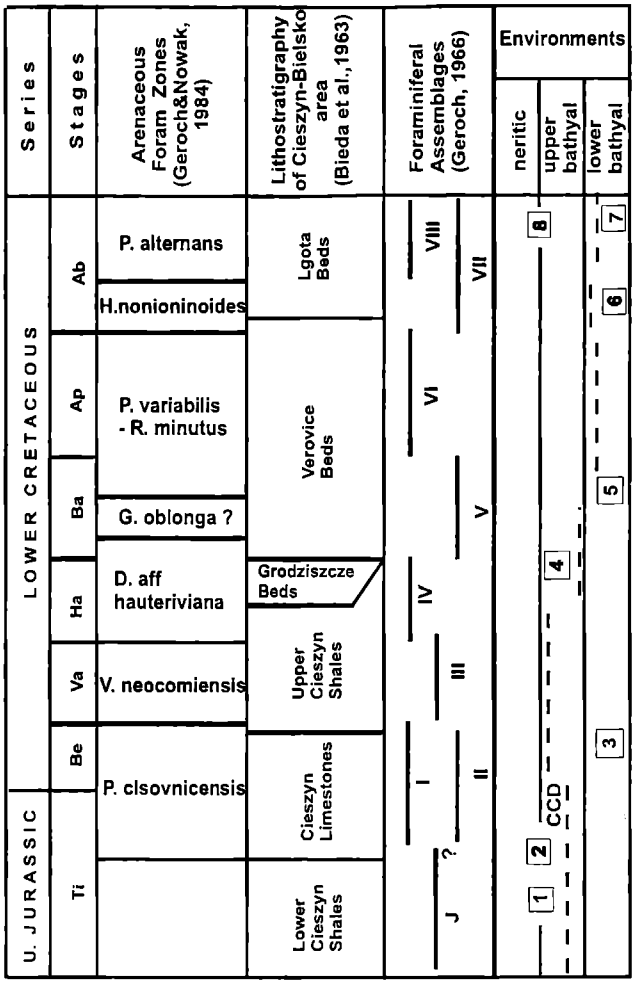

Fig. 3. Paleoecology of foraminifera in the Cieszyn basin *delrioensis* (based on: Sliter & Backer, 1972; Książkiewicz, 1975; Haig,1979; Sliter,1980). Foraminiferal assemblages with: 1 – *Paleogaudryina varsoviensis* and *Belorusiella wolinensis*, 2 – *Trocholina alpina* and *Paalzowella feifeli*, 3 – *Pseudoreophax cisovnicensis*, 4 – *Praedorothia hauteriviana*, 5 – *Verneuilinoides subfiliformis* and *Gaudryinella sherlocki*, 6 – *Haplophragmoides nonioninoides*, 7 – *Recurvoides imperfectus*, 8 – *Hedbergella delrioensis*

Berthelin, *Gaudryinella sherlocki* Bettenstaedt (scarce species). The above assemblage, reported by Geroch (1966) as "Microfauna V" from Cieszyn–Bielsko area, may be correlated with the *Gaudryina oblonga* Zone (early Barremian) and *Pseudobolivina variabilis–Reophax minutus* Zone (late Barremian–Aptian) *sensu* Geroch and Nowak (1984). The youngest association of small foraminifera found at Lipnik stream is characteristic of the middle and upper part of Lgota Beds.

6. Assemblage with *Haplophragmoides nonioninoides*

This assemblage conists of generally poor and badly preserved areanaceous foraminifera, principally Lituolidae (*Haplophragmoides nonioninoides*) and very rare *Hippocrepina depressa* Vašiček, *Gaudryina filiformis* Berthelin and *Sherochorella minuta* Tappan mentioned from the lower part of Veřovice Shales (at Lipnik) as characteristic for its upper section at the Lipnik stream. The foraminiferal

association mentioned above represents "Microfauna VII" (Geroch, 1966), which can be correlated with the lowest part of *Haplophragmoides nonioninoides* Zone (early Albian) of Geroch and Nowak (1984).

7. Assemblage with *Recurvoides imperfectus*

Many specimens of *Thalmannammina neocomiensis* Geroch, rare specimens of *Recurvoides imperfectus* Hanzliková, *Plectorecurvoides irregularis* Geroch, *Haplophragmoides nonioninoides* (Reuss) indicate an Albian age for the Lgota Beds shales in the Lipnik stream. Moreover there occurr species: *Caudammina ovula* (Grzybowski), *Saccammina placenta* (Grzybowski), *Ammodiscus tennuisimus* (Grzybowski), *Glomospira charoides* (Jones et Parker).

Similar assemblages also containing *Plectorecurvoides alternans* Noth and *Haplophragmoides gigas minor* Nauss are known as "Microfauna VII" *sensu* Geroch (1966), and correspond to the *Plectorecurvoides alternans* Zone of Geroch and Nowak (1984).

8. Assemblage with *Hedbergella delrioensis*

A very different assemblage with planktonic foraminifera belonging to *Hedbergella delrioensis* (Carsey) and *H. planispira* (Tappan), the benthic forms from genera of *Cibicides*, *Gyroidinoides*, some radiolarians (*Dicyomitra* cf. *multicostata* Zittel), and sponge spicules was found in samples of shales from the Lipnik stream (upper section of the Lgota Beds) below the Mikuszowice Cherts (uppermost part of the Lgota Beds); reflecting an Albian age.

This type of assemblage described as "Microfauna VIII", as found by Geroch (1966) in thin sections of sandstones and cherts.

DISCUSSION

The palaeoecological interpretation of the assemblages described above is primarily based on studies of the life conditions and bathymetry of the Carpathians flysch basins (Książkiewicz, 1961, 1975). A number of deductions in this paper are also based on many palaeoecological analysis (cited in this paper) from the Atlantic and Pacific oceans, as one can assume that shallow-water exchange between the North Atlantic, Tethys Sea and Pacific existed beginning about 150 Ma (Malm) and that the exchange of mid-depth waters existed at least since Aptian–Albian times (Sliter, 1980; Bartenstein, 1979).

Other environmental factors no doubt played an important role in the flysch basin. For example, low oxygen and oxygen-minimum conditions in the flysch basins at different depths, (from 200 m to 2200 m according to Ryan & Cita; 1977), restricted circulation due to shallowing of the basins (Einsele & von Rad, 1979), eustatic sea level change (Cooper, 1977) and decreased latitudinal and vertical temperature gradients (climatic changes) or influxes of land-derived, detrital organic material (Schlanger & Jenkyns, 1976; Weissert *et al.*, 1979; Wieczorek, 1993).

Assemblage with *Palaeogaudryina varsoviensis* and *Belorusiella wolinensis* (Lower Cieszyn Shales) originates from the Malm microfauna following subsidence or destruction of carbonate margins during the Tithonian. The worldwide regression during the late Tithonian and early Berriasian (Zeiss, 1983) corresponding to the Neocimmerian orogeny (Nowak, 1973) may be responsible for the occurrence of a neritic assemblage with *Trocholina alpina* and *Paalzowella feifeli* (Lower Cieszyn Shales and detrital Cieszyn Limestones) in a Cieszyn basin.

Olszewska (1982) reported ?oldest agglutinated foraminiferal assemblage with *Trochammina* sp. (particularly *T. quinqeloba* Geroch) at the Jurassic/Cretaceous boundary, in the Cieszyn Limestones. According to Olszewska, these microfauna, probably represent the oldest arenaceous foraminiferal population, which settled new created flysch environment in the Outer Polish Carpathians.

In deeper, partly hemipelagic sediments in the upper part of the Cieszyn Limestones and lower part of the Upper Cieszyn Shales (Berriasian–Valanginian), poor and badly preserved assemblage with *Pseudoreophax cisovnicensis* was found (first oxygen minimum). In the uppermost part of Veřovice Shales and lower part of Lgota Beds (lower Albian), assemblage with *Haplophragmoides nonioninoides* was observed. Shallow-water foraminiferids (assemblages with *Praedorothia hauteriviana* and with *Hedbergella* spp.) were transported into the anoxic bathyal zone – Grodziszcze Beds, Veřovice Shales and Lgota Beds (Malik & Olszewska, 1984; Geroch, 1966).

Second autochthonous, but the earliest, so diversified, agglutinated foraminiferal assemblage occurred in the Barremian–Aptian (assemblage with *Verneuilinoides subfiliformis* and *Gaudryinella sherlocki*) in the upper part of the Veřovice Shales, and again in the Albian (assemblage with *Recurvoides imperfectus*) in the middle part of the Lgota Beds. The assemblage represents the deeper bathyal zone, near or below the local CCD (Fig. 3), at a water depth of approximately 2000 m (cf., Sliter, 1980; Olszewska, 1984).

Two ecologically meaningful associations are recognized here: the *Marssonella* Association and the *Recurvoides* Association *sensu* Haig (1979). Their bathymetric interpretation based on studies by Olszewska (1984), Sliter (1980), Sliter and Baker (1972), Gordon (1970) is given below.

The *Marssonella* Association comprises agglutinated and calcareous species. The former are represented by Ataxophragmiidae (*Paleogaudryina varsoviensis*, *Praedorothia hauteriviana*). Associated calcareous foraminifera belong to the families Nodosariidae and Involutinidae. These microfauna are characteristic for outer shelf environments above the CCD.

Foraminiferal assemblage containing highly diversified Nodosariidae and *Trocholina* (Lower Cieszyn Shales, detrital Cieszyn Limestones) with minor agglutinated foraminiferids represents the sublitoral zone – "shelf assemblage" *sensu* Gordon (1970).

Assemblage composed mainly of Ataxophragmidae and few Nodosariidae (typical of the upper part of the Cieszyn Limestones, the Upper Cieszyn Shales, the Grodziszcze Beds, and the lower part of Veřovice Shales) may represents an upper bathyal zone environment.

Recurvoides Association composed only of silicified

Ataxophragmiidae (*Verneilinoides filiformis*, *V. subfiliformis*, *Gaudryinella sherlocki*, *Falsogaudrinella tealbyensis*; Veřovice Shales), Lituolidae (*Recurvoides imperfectus*, *Thalmannammina neocomiensis*, Ammodiscidae, Saccamminidae; Lgota Beds), and radiolarians is characteristic of the deeper bathyal zone (not abyssal), close to local CCD (see Haig, 1979; Olszewska, 1984).

The occurrence of a *Marssonella* Association close to the *Recurvoides* Association (cf., Grodziszcze Beds; Malik & Olszewska, 1984) may signify redeposition from continental margins owing to tectonic activity, changing eustatic sea level, or changes in climate during the Early Cretaceous (Wieczorek, 1993).

It is believed that the *Recurvoides* Association reflects recolonization the basin floor after hostile anoxic periods caused by an abundant supply of terrigenous material during transgressional stages. Oxygen-minimum associations dominated by primitive agglutinated forms are transitional to the *Recurvoides* ecologic type. For example, a sequence containing the described assemblages in the uppermost part of the Veřovice Shales (with *Haplophragmoides nonioninoides*) and in the lower part of the Lgota Beds (with *Recurvoides imperfectus*) may be an effect of recolonization following oxygen-minimum periods.

CONCLUSIONS

Benthic foraminifera have important significance for palaeoecology because they are very sensitive to changes in their environment (Moullade, 1984; Olszewska, 1984).

Many of the foraminifera, already known from the Lower Cieszyn Shales and the detrital part of the Cieszyn Limestones, and those reported for the first time from these sediments (such as *Belorusiella wolinensis*, *Geinitzinita wolinensis*, *Frondicularia* cf. *inderica*, *Lenticulina* cf. *ambanjabensis*, *Lenticulina ponderosa*) may be referred to the European platform. Late Jurassic foraminifera, described from the studied outcrops in the Silesian (Cieszyn) Unit may be correlated with the foraminiferal faunas of the Polish Lowlands (Bielecka & Pożaryski, 1954; Bielecka, 1975), the Western Polish Carpathians (Bielecka & Geroch; 1974; Geroch & Olszewska, 1990), the Czech Carpathians (Hanzliková, 1965) and the Crimea (Kuznietzova & Gorbachik, 1985). The Lower Cretaceous assemblages described in here from the pelitic part of the Cieszyn Limestones to the Lgota Beds are comparable to those of the flysch basins of the Carpathians and Alps. Similar assemblages are known, in particular from the Subsilesian and Skole units in the Polish Outer Carpathians (Książkiewicz & Liszkowa, 1959; Bieda *et al.*, 1963; Geroch *et al.*, 1967; Liszkowa, 1972; Geroch & Nowak, 1984; Olszewska, 1984), Czech and Slovakian Carpathians (Hanzliková, 1956; Andrusov, 1959), Romanian Carpathians (Neagu, 1962), Alps (Decker & Rögl, 1988) and Betic Mountains (Kuhnt, 1995). Jurassic/Cretaceous boundary and Lower Cretaceous assemblages of noncalcareous agglutinated foraminifera are regarded as reflecting a deep water environment in the Cieszyn basin.

The calcareous foraminifera from the oldest marly sediments (Lower Cieszyn Shales and detrital Cieszyn Limestones) lived in a comparitively shallow neritic zone. Assemblages comprising both calcareous and primitive arenaceous species from *Marssonella/Recurvoides* associations in the pelitic Cieszyn Limestones, shaly-marly Upper Cieszyn Shales, shaly Grodziszcze Beds, were probably derived from the upper bathyal zone above CCD – compare with "Neocomian facies" (Borza *et al.*, 1995). During this time was an increased supply of terrigenous material to the basin. Noncalcareous agglutinated forms (*Recurvoides* Association) from shaly-sandy sediments (upper part of the Veřovice Shales, Lgota Beds) formed in lower bathyal but probably not abyssal conditions, near the CCD at the latest Early Cretaceous.

When attempting to reconstruct the palaeoenvironment in the Cieszyn basin, it should be remembered redeposition of foraminiferids. The assemblage with *Hedbergella* spp. may be derived from the shallower zone of the basin and be enplaced by suspension currents into deeper regions where they accumulated in the Lgota Beds (Geroch, 1966). The calcareous benthos occurring in the Lower Cieszyn Shales (Nowak, 1973), the Cieszyn Limestones (Geroch, 1966; Geroch & Olszewska, 1990) or the Grodziszcze Beds (Malik & Olszewska, 1984) could be also allochthonous. Other element in the paleoenvironmental analyses is a barren character of the facies. The pelitic Cieszyn Limestones, the Upper Cieszyn Shales (assemblage with *Pseudoreophax cisovnicensis*), the uppermost part of the Veřovice Shales and lower part of the Lgota Beds (assemblage with *Haplophragmoides nonioninoides*) may indicate a high rate of terrigenous input which caused a dramatic rise of the CCD (Fig. 3) and stagnation of the bottom water, eliminating benthic life (Butt, 1977; Kaminski *et al.*, 1995).

SYSTEMATIC PALEONTOLOGY

Taxonomical designation of selected species identified in samples from the Silesian (Cieszyn) unit listed in early chapter, is presented below. The stratigraphical range of many species of the Late Jurassic and the earliest Cretaceous was reported after many stratigraphical schemes, so Kimmeridgian–Tithonian and Berriasian scale and correlation according to Gradstein *et al.* (1995) is presented here (Fig. 4).

Ammobaculoides carpathicus Geroch, 1966
Fig. 5c

1959. *Ammobaculites*? sp.: Geroch, p. 117, pl. 12, figs. 1–3.
1966. *Ammobaculoides carpathicus* Geroch: Geroch, p. 444, fig. 13 (13–22).

Remarks: Test elongate, initial part forming a streptospiral whorl; biserial part is poorly visible and uniserial part consists of low and rounded chambers (increasing gradually).
Occurrence: Upper Tithonian–Barremian (Polish Western Carpathians); Hauterivian, ?lowermost Barremian (Gresten Klippen Belt, Eastern Alps, Austria).

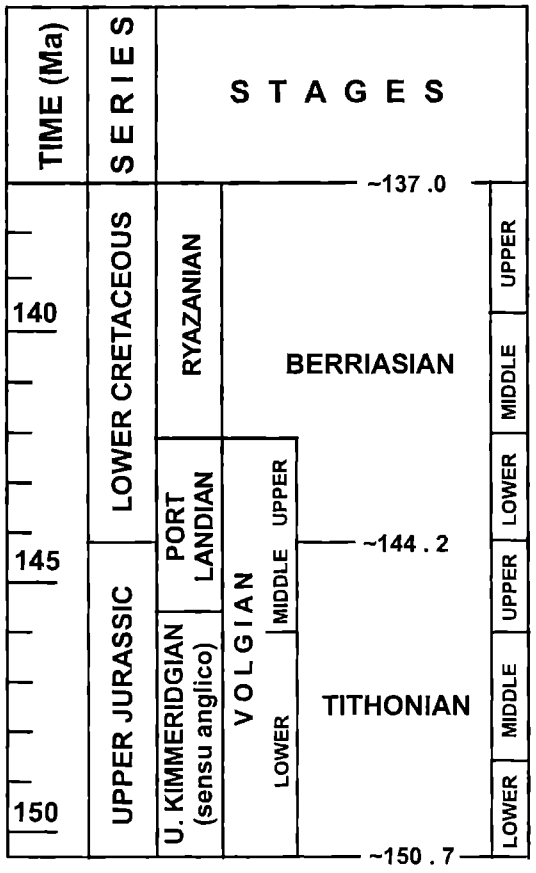

Fig. 4. Upper Jurassic (Kimmeridgian–Tithonian) and earliest Cretaceous (Berriasian) stratigraphic division and correlation (Gradstein *et al.*, 1995)

Pseudobolivina variabilis (Vašiček, 1947)
Fig. 5k

1947. *Bigenerina variabilis* Vašiček: p. 246, pl. 1, figs. 10–12.
1966. *Pseudobolivina variabilis* (Vašiček): Geroch, p. 445, fig. 14 (1–4).

Remarks: The textularoid test with. slit-like terminal aperture and smooth surface closely resembles the holotype.
Occurrence: Barremian–Albian (Polish and Slovakian Western Carpathians).

Palaeogaudryina varsoviensis
(Bielecka et Pożaryski, 1954)
Fig. 5f

1954. *Neobulimina varsoviensis* Bielecka et Pożaryski: p. 194, pl. 10, fig. 50.
1966. *Palaeogaudryina varsoviensis* (Bielecka et Pożaryski): Maync, p. 12, pl. 6, figs. 5–8.

Remarks: Test elongated with triangular outline, poorly developed initial triserial stage, and biserial stage comprised of 6 chambers. Aperture is terminal, comma-shaped.
Occurrence: Uppermost Oxfordian–lower part of Kimmeridgian (Central Poland); upper Oxfordian–Tithonian (Slovakian Western Carpathians), Tithonian–lower Hauterivian (Outer Polish Carpathians).

Belorusiella wolinensis Bielecka, 1975
Fig. 5g

1975. *Belorusiella wolinensis* Bielecka: p. 313–314, pl. 3, figs. 2–4.

Remarks: The specimens are badly preserved. Test elongated, flattened with poorly visible initial triserial part and well-defined biserial part consisting of 5–7 pairs of chambers. Forms with more chambers are frequent.
Occurrence: Middle Portlandian (Polish Lowlands); ?upper Tithonian (Western Polish Carpathians).

Gaudryinella sherlocki Bettenstaedt, 1952
Fig. 5j

1952. *Gaudryinella sherlocki* Bettenstaedt: p. 268, pl. 1, figs. 1–5.

Remarks: Test is slightly elongated and curved. Triserial part is poorly visible, following biserial part is composed of large and distinct chambers. Some specimens have uniserial part with a terminal aperture. Surface is rough.
Occurrence: Hauterivian–Albian (Polish Western Carpathians).

Pseudoreophax cisovnicensis Geroch, 1961
Fig. 5l

1961. *Pseudoreophax cisovnicensis* Geroch: p. 159, pl. 17, figs. 1–20.

Remarks: Test elongated, slighty curved and often deformed. Studied specimens consist of 4 chambers in one series. Their surface is smooth.
Occurrence: Upper Tithonian–Barremian, most frequent in the Valanginian (Polish Western Carpathians); Hauterivian, ?lowest Barremian (Gresten Klippen Belt, Eastern Alps, Austria).

Geinitzinita wolinensis Bielecka, 1975
Fig. 6a

1975. *Geinitzinita wolinensis* Bielecka: p. 335, pl. 6, figs. 11–13.

Remarks: Elongated test consists of 5 curved chambers; proloculus spherical. The last chamber higher than the preceeding ones.
Occurrence: Middle Portlandian (Polish Lowlands); ?upper Tithonian (Western Polish Carpathians).

Lenticulina cf. *ambanjabensis* Epistalié et Sigal, 1963
Fig.6b

1963. *Lenticulina* cf. *ambanjabensis* Epistalié et Sigal: p. 35, pl. 12, figs. 3, 5–6.

Remarks: This form is comprised of only 3 chambers in the final part. Differs from the holotype in its less distinctive terminal stage.
Occurrence: Upper Jurassic–Valanginian (Madagascar); upper Tithonian–Hauterivian (Crimea); ?upper Tithonian (Western Polish Carpathians).

Lenticulina ponderosa (Mjatliuk, 1939)
Fig. 6d

1939. *Cristellaria magna* Mjatliuk: p. 52, pl. 3, figs 32a, b, 34a, b.
1971. *Lenticulina ponderosa* (Mjatliuk): Mjatliuk p. 200.

Remarks: Test slightly elongated with triangular chambers (about 9) and arcuate sutures. Apertural area is narrow and convex.
Occurrence: ?Upper Tithonian (Western Polish Carpathians, Caucasus), upper middle Portlandian (Polish Lowlands); middle Volgian (Russian Platform).

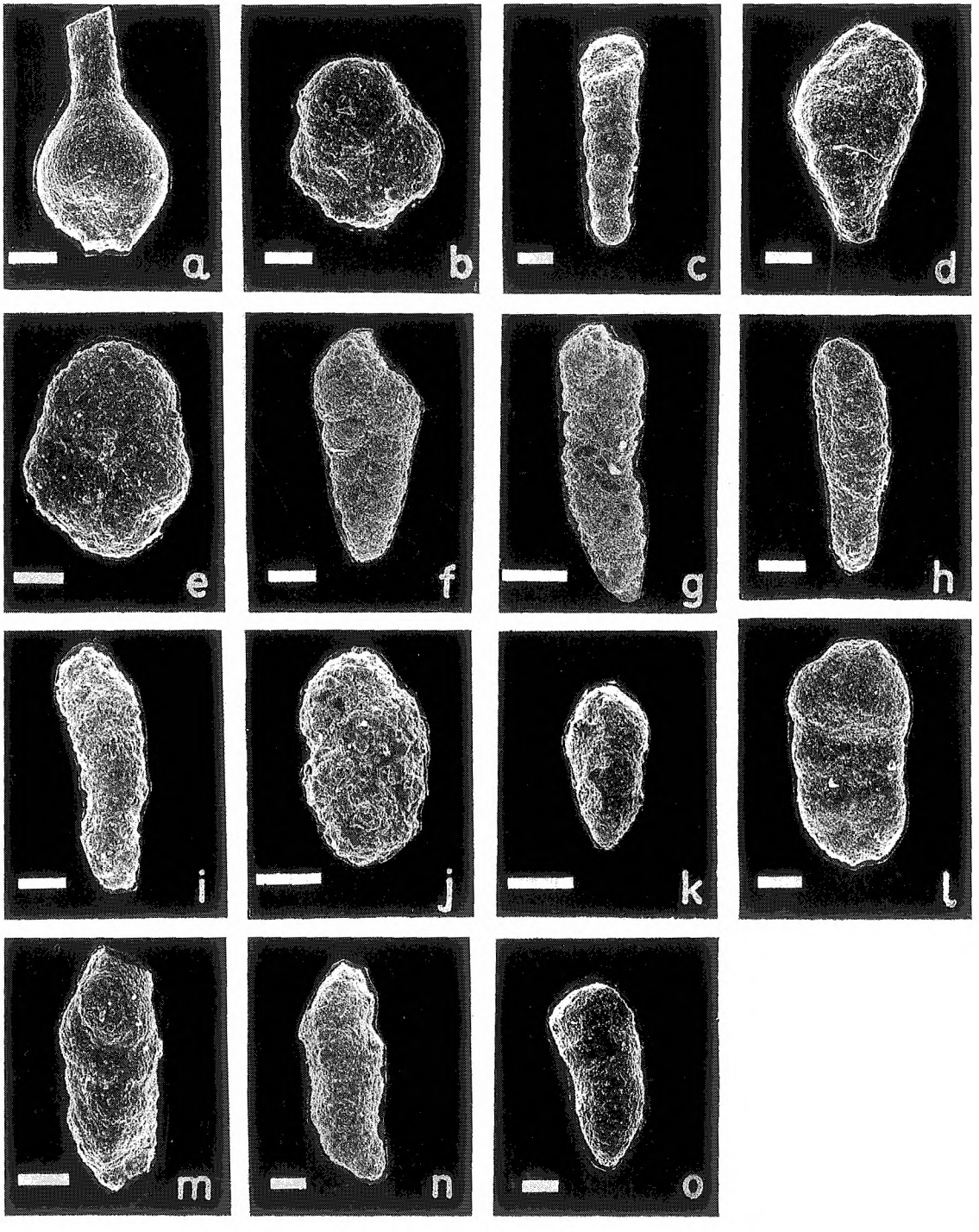

Fig. 5. SEM micrographs: **a.** *Caudammina crassa* (Geroch), **b.** *Haplophragmoides kirki* Wickenden, **c.** *Ammobaculoides carpathicus*, **d.** *Pseudobolivina variabilis* (Vašiček), **e.** *Trochammina vocontiana* Moullade, f. *Palaeogaudryina varsoviensis* (Bielecka et Pożaryski), **g.** *Belorusiella wolinensis* Bielecka, **h.** *Gaudryina filiformis* Berthelin, **i.** *Gaudryina oblonga* Zaspelová, **j.** *Gaudryinella sherlocki* Bettenstaedt, **k.** *Falsogaudryinella tealbyensis* (Bartenstein), **l.** *Pseudoreophax cisovnicensis* Geroch, **m.** *Verneuilinoides neocomiensis* (Mjatliuk), **n.** *Verneuilinoides subfiliformis* Bartenstein, **o.** *Praedorothia hauteriviana* (Moullade). Length of scale bars – 0.1 mm

Vaginulinopsis embaensis (Fursenko et Polenova, 1950)
Fig. 6g

1950. *Cristellaria embaensis* Fursenko et Polenova: p. 36, pl. 3, figs. 9–13.

1975. *Vaginulinopsis embaensis* (Fursenko et Polenova): Bielecka: p. 338, pl. 7, figs. 4–5; pl. 8, fig. 2.

Remarks: Test elongated, flattened on sides with characteristic ledge-like ribs set parallel to margins along the whole length of the test. In the lower part of the test the ribs form a loop.

Occurrence: Upper Kimmeridgian, lower and middle Portlandian (Polish Lowlands); Tithonian (Western Polish Carpathians), lower and middle Volgian (Russian Platform); Portlandian (Slovakian Western Carpathians, Madagascar).

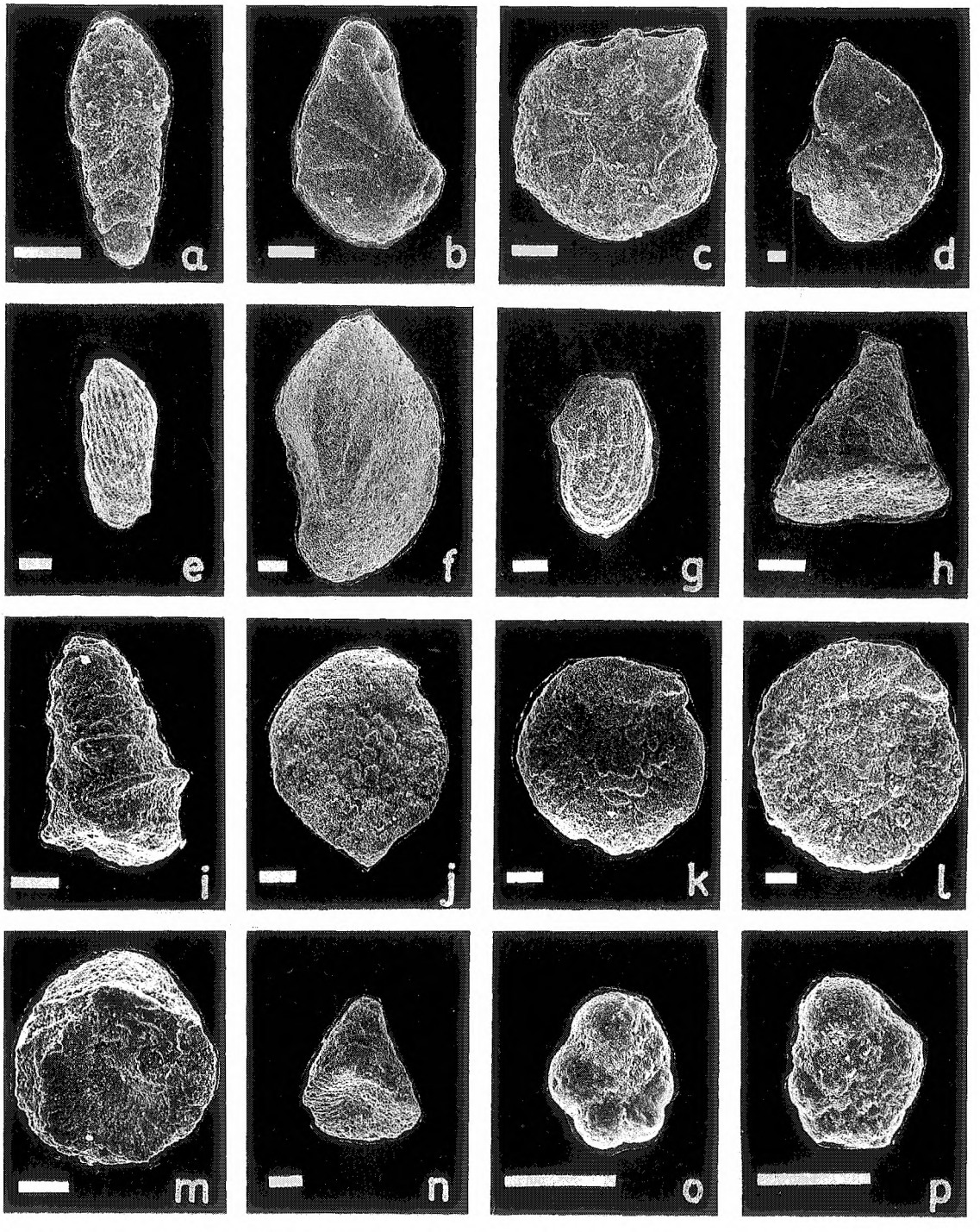

Fig. 6. SEM micrographs: **a.** *Geinitzinita wolinensis* Bielecka. **b.** *Lenticulina* cf. *ambanjabensis* Epistalié et Sigal, **c.** *Lenticulina* ex gr. *münsteri* Roemer, **d.** *Lenticulina ponderosa* Mjatluk, **e.** *Marginulinopsis bettenstaedti* (Bartenstein et Brand), **f.** *Saracenaria alata-angularis* (Franke), **g.** *Vaginulinopsis embaensis* Fursenko et Polenova, **h.** *Trocholina alpina* (Leupold), i. *Trocholina* sp., **j, k.** *Trocholina molesta* Gorbachik, **l.** *Trocholina solecensis* Bielecka et Pożaryski, **m, n.** *Paalzowella feifeli* (Paalzow), **o, p.** *Hedbergella delrioensis* (Carsey)

Trocholina alpina (Leupold, 1935)
Fig. 6h

1935. *Conscinoconus alpinus* Leupold: Leupold & Bigler: p. 610, pl. 18, figs. 1–11.
1963. *Trocholina alpina* (Leupold); Guillaume, pl. 3, figs 38–39, 41–43, 45–48; pl. 4, figs. 49, ?50, ?51, 53–55.

Remarks: Large test formúcal part is flat and covered with many granulae of different size, poorly visible.
Occurrence: Upper Tithonian, Berriasian, upper Valanginian, lower Hauterivian (Polish Outer Carpathians), Tithonian, Berriasian (Russian Platform).

Trocholina solecensis Bielecka et Pożaryski, 1954
Fig. 6l

1954. *Trocholina solecensis* Bielecka et Pożaryski: p. 69, pl. 11, figs. 57a–c.

Remarks: Test shape is a low cone. Ventral part is typically very broad with radially sculptured margin surrouding numerous granulae.

Occurrence: Upper Oxfordian, Kimmeridgian, lower Portlandian (Polish Lowlands), Tithonian (Polish Western Carpathians, Slovakian Western Carpathians).

Paalzowella feifeli (Paalzow, 1932)
Fig. 6m, n

1932. *Trocholina feifeli* Paalzow: p. 140, pl. 11, figs. 4, 6, 7.
1965. *Paalzowella* ex. gr. *feifeli* (Paalzow); Hanzliková: p. 94, pl. 9, figs. 20a–c, 21.

Remarks: Test trochospiral and conical, often high. Ventral side is covered by a number of radially grooves which occupy more than half of this side.

Occurrence: Lower Malm (Slovakian Western Carpathians); Oxfordian (Central Poland); ?upper Tithonian (Polish Western Carpathians).

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Streszczenie

BIOSTRATYGRAFICZNE I PALEOEKOLOGICZNE ZNACZENIE ZESPOŁÓW MAŁYCH OTWORNIC JEDNOSTKI ŚLĄSKIEJ (CIESZYŃSKIEJ) W POLSKIEJ CZĘŚCI KARPAT ZACHODNICH

Andrzej Szydło

Najstarsze osady margliste (tyton) w jednostce cieszyńskiej (dolne łupki cieszyńskie, detrytyczne wapienie cieszyńskie) zawierają wapienne otwornice dokumentujące sedymentację tych osadów w strefie zewnętrznego szelfu. Pelityczne wapienie cieszyńskie, łupkowo-margliste górne łupki cieszyńskie i łupkowe warstwy grodziskie (neokom) są zasobne zarówno w wapienne jak i prymitywne, aglutynujące formy (asocjacje *Marssonella/Recurvoiedes*), które żyły w środowisku górnego, bądź środkowego batiału w warunkach częstej dostawy materiału terygenicznego. Łupkowo-piaskowcowe osady (łupki wierzowskie, warstwy lgockie) wzbogacone głównie w formy aglutynujące (zespół z *Recurvoides*), tworzyły się w strefie dolnego batialu, w pobliżu CCD. Świadczyć o tym może obecność wapiennych form aglutynujących (*Verneuilinoides neocomiensis*), wapiennego bentosu (*Cibicides*) oraz planktonu (*Hedbergella*). Niemniej jednak mikrofauna w tych osadach mogła być redeponowana. Zespół z *Hedbergella* związany, z płytszymi strefami basenu mógł być przemieszczony przez prądy zawiesinowe w głębsze partie, gdzie tworzyły sie warstwy lgockie (Geroch, 1966). Wapienne formy bentoniczne, w tym niektóre Ataxophragmiidae, występujące w dolnych łupkach cieszyńskich (Nowak, 1973), detrytycznych wapienich cieszyńskich (Geroch 1966; Nowak, 1973) i warstwach grodziskich (Malik & Olszewska, 1984) mogą mieć również charakter allochtoniczny.

Ubogie w mikroskamieniałości pelityczne wapienie cieszyńskie, górne łupki cieszyńskie (zespół z *P. cisovnicensis*), najwyższa część łupków wierzowskich (zespół z *H. nonioninoides*) osadzały się prawdopodobnie w warunkach częstej dostawy materiału terygenicznego, stagnacji przydennych wód przy podwyższonym poziomie CCD.

Większość późnojurajskich form w dolnych łupkach cieszyńskich i detrytycznych wapieniach cieszyńskich (tyton), w tym po raz pierwszy opisanych w tych osadach (*B. wolinensis*, *G. wolinensis*, *F.* cf. *inderica*, *L.* cf. *ambanjabensis* and *L. ponderosa*) wykazuje podobieństwo do zespołów otwornicowych z obszarów platformowych. Obecność radiolarii (skalcyfikowanych) wskazuje jednak, iż ówczesny zbiornik cieszyński reprezentował głębsze środowisko – co najmniej górny batiał. Mikrofauna wczesnokredowa jest zbliżona do fliszowych zespołów otwornicowych innych części Karpat i Alp.