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The Younger Palaeozoic deposits in the basement of the Polish Western Carpathians

Lithostratigraphy of the Devonian and Lower Carboniferous in the basement of the Polish Western Carpathians has been elaborated. The Devonian has been subdivided into five informal lithostratigraphic units (I–V). Although index fossils are usually lacking, the age of some units has been determined based on foraminifera. The top part of unit IV (laminated limestones) contains uniserial foraminifera of the Upper Frasnian. The Famennian foraminifera occur in the vadose deposits of unit V.

The foraminifers in the Lower Carboniferous limestones provide better evidence of stratigraphy. This fauna is rich in number of specimens and even more diversified in taxa, thus allowing to distinguish the Tournaisian and Visean foraminferal zones: Cf1(Tn1b-Tn2) and Cf2(Tn3), and Cf5(V2b-V3a) and Cf6(V3bc).

INTRODUCTION

The study area comprises the Young Palaeozoic basement between Cieszyn and Cracow, belonging to the southern rim of the Upper Silesian Coal Basin (USCB) overthrusted by the Flysch Carpathians (Fig. 1). The USCB developed over the Upper Silesian Massif that had consolidated in the Precambrian (A. Kotas, 1982). The Precambrian methamorphic and magmatic rocks of the Upper Silesian Massif are covered by a thick succession of the Cambrian clastic platform deposits (A. Kotas, 1973; A. Ślączka, 1976*a*). These deposits directly underlie the Variscan sedimentation cycle. In the western part of the study area, in places, the Devonian rests directly upon the Precambrian basement (Fig. 2). The Devonian-Carboniferous deposits of the southern part of the Upper Silesian foredeep are directly overlain by the Miocene deposits and by the Carpathian flysch. In the eastern margins of the study area the Devonian and the Lower Carboniferous are overlain by Jurassic carbonate deposits. The Devonian deposits, occurring on the Precambrian-Cambrian rocks of the Upper Silesian Massif, represented by thick carbonate series with a thin complex of clastic

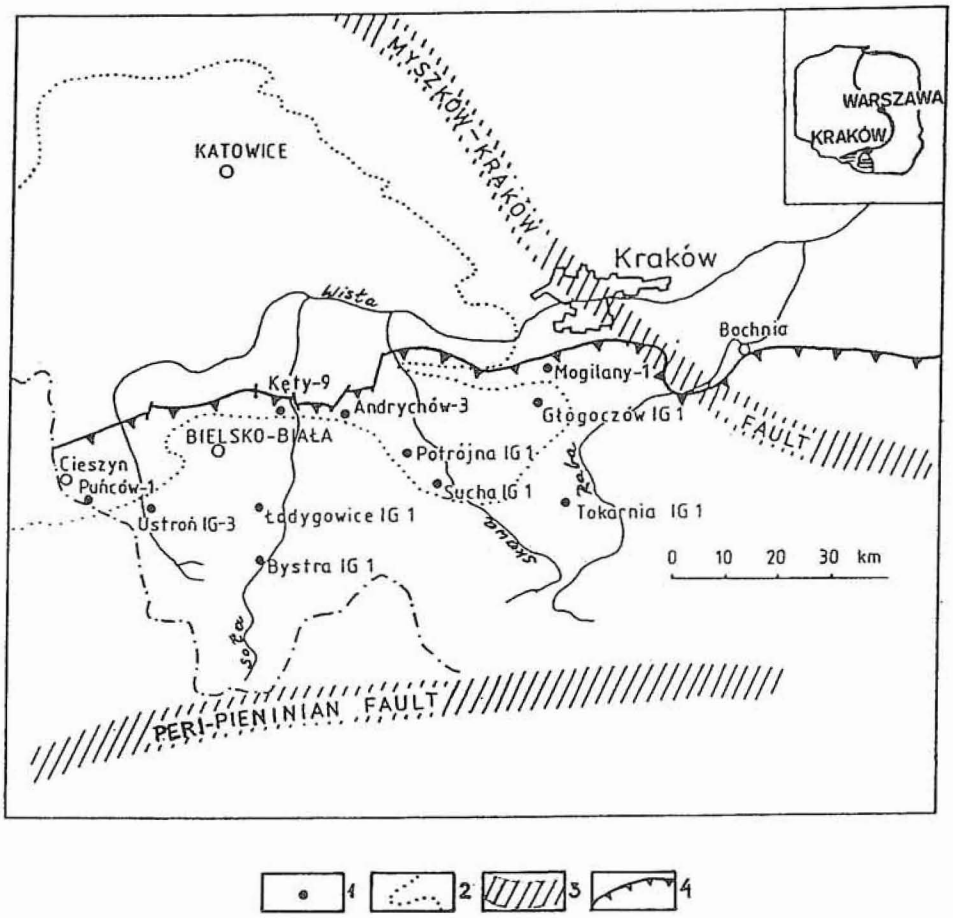

Fig. 1. Study area

1 — selected boreholes; 2 — boundaries of the Upper Silesian Coal Basin; 3 — faults delimiting the Upper Silesian block; 4 — margin of the Flysch Carpathians

Lokalizacja obszaru badań

1 — ważniejsze otwory wiertnicze; 2 — granica Górnośląskiego Zagłębia Węglowego; 3 — rozłamy ograniczające blok górnośląski; 4 — brzeg Karpat fliszowych

layers at the base, probably comprise all stages of the Devonian from the Upper Emsian to Famennian. Owing to insufficient faunal evidence, the boundaries of some stages are impossible to be established. Therefore, classification into informal lithostratigraphic units has been introduced. In almost the entire area the Famennian, and in places Frasnian, deposits are overlain by the synorogenic series of the Upper Visean and the coal-bearing Upper Carboniferous deposits. Only in the eastern part of the area (borehole Głogoczów IG 1) the Famennian is overlain by the Lower Carboniferous of the Kohlenkalk facies, above which there are Upper Visean and Upper Carboniferous deposits.

LITHOSTRATIGRAPHY

DEVONIAN

The stratigraphy of the Devonian series in the basement of the Polish Western Carpathians is a difficult problem bacause scanty and usually non-index fossils do not provide grounds for a stratigraphic division. The undertaken conodont studies were not successful. The only reliable premises for age determination have been obtained from the examination of calcareous foraminifera. Based on the lithological-microfacial and geophysical analyses the Devonian deposits have been assigned to five informal lithostratigraphic units (Fig. 2).

Lithostratigraphic **unit I** comprises clastic deposits. These are: grey, greenish and pink mudstones, claystones, and sandstones interbedded with mudstones and conglomerates. The mudstones and claystones are characterized by large accumulations of muscovite and carbonised plant remains in form of detritus and psylophite stems (K. Konior, 1968, 1969). Based on the microfloral studies these deposits have been assigned to the Lower Devonian-Upper Emsian (K. Konior, E. Turnau, 1973; E. Turnau, 1974). This thin (0–30 m), basal Devonian series gradually passes upwards into dolomites.

Litostratigraphic **unit II** is made up of dolomites without fossils. These are usually dark grey and black, pelitic or fine-crystalline marly dolomites with intercalations and lamination of marls or dolomitic mudstones. Marl contents in the dolomites, lamination as well as intercalations of claystones and mudstones at the base of the dolomites mark a gradual transition of clastic deposits (I) to carbonate ones. The thickness of the unit II varies from 30 to ca. 80 m. On account of the stratigraphic position and gradual transition from the Upper Emsian deposits, one can infer that the unit II might be of the Eifelian age.

Above, there is a thin level (3.0–13.0 m) of clastic deposits — **unit III**. The latter comprises grey or pink mudstones or claystones, showing lithological similarity to the Devonian basal series I. In borehole Kęty 9, among these grey and green mudstones there are conglomerates consisting of large, weakly rounded quartz grains (size up to 1cm).

The next lithostratigrahic unit (**IV**) is represented by an assemblage of beds that are characterized by the presence of the stromatoporoids (stromatopores and amphipores) occurring as single specimens or as mass accumulation. In the latter case the stromatoporoids are in a growth position and are rock-forming (in the regions of Kęty and Ustroń). The lithostratigraphic columns of unit IV are developed differently in particular boreholes (Fig. 2). Generally, each one starts either with crystalline dolomites with amphipores or with dolomites with stromatopores which contain intercalations of pelitic limestones with amphipores and granular limestones. Above, there are stromatopore limestones, amphipore limestones, micritic limestones and granular limestones. The member that ends this laterally differentiated unit comprises light beige or grey, often laminated, pelitic limestones with amphipores. The parallel or wavy lamination shows up as a darker (grey, green) clayey material. The limestones are represented by numerous microfacial types (K. Jaworowski, 1982): calcareous mudstones (micrites), wackestones (biomicrites), lumpstones (intrapelmicspars, intramicspars, intrabiomicspars), grainstones (pelspars, intrapelspars) and stromatopore biolithites. Thin laminae of fine-grained conglomerates are found here as well. Apart from stromatoporoids, brachiopods, crinoids the following microfossils are also common: calcisphaeres, algae, foraminifera and characeans. In the deposits, one group

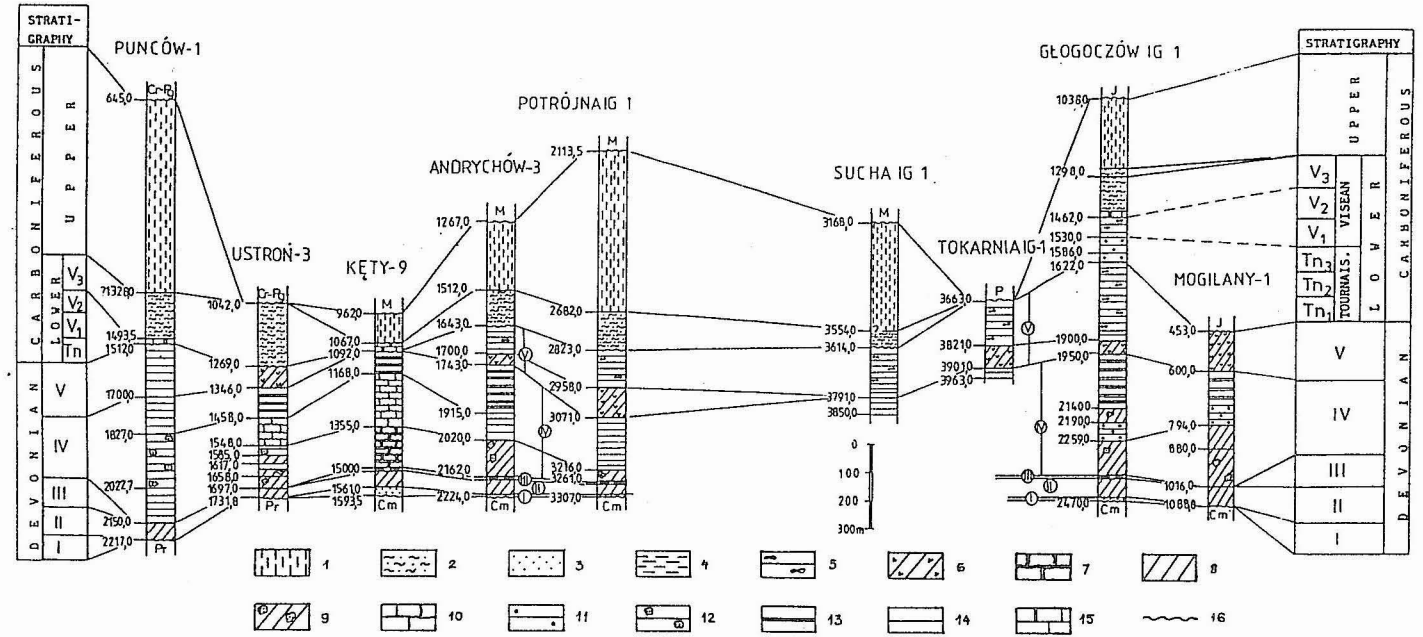

Fig. 2. Correlation of the Devonian and Carboniferous formations

1 — Upper Carboniferous paralic and limnic clastic deposits; 2 — Carboniferous synorogenic deposits; 3 — Lower Devonian clastic deposits; 4 — mudstones, claystones; 5 — vadose limestones; 6 — cavernous vadose dolomites; 7 — stromatoporoid dolomites; 8 — dolomites without fossils; 9 — dolomites with amphipores; 10 — stromatoporoid limestones; 11 — granular limestones; 12 — pelitic limestones with amphipores; 13 — laminated pelitic limestones; 14 — pelitic limestones; 15 — nodular limestones and dolomites; 16 — stratigraphic unconformity; I–V — Devonian lithologic complexes; Pr — Precambrian; Cm — Cambrian; P — Permian; J — Jurassic; Cr-Pg — Cretaceous-Paleogene (Carpathian flysch); M — Miocene

Korelacja utworów dewonu i karbonu

1 — górnokarbońskie osady paraliczne i limniczne; 2 — osady diastroficzne karbonu; 3 — utwory klastyczne dolnego dewonu; 4 — mułowce, iłowce; 5 — wapienie wadyczne; 6 — dolomity wadyczne dziurkowate; 7 — dolomity stromatoporoidowe; 8 — dolomity bez fauny; 9 — dolomity z amfiporami; 10 — wapienie stromatoporoidowe; 11 — wapienie ziarniste; 12 — wapienie pelityczne z amfiporami; 13 — wapienie pelityczne laminowane; 14 — wapienie pelityczne; 15 — wapienie gruzłowe i dolomity; 16 — niezgodność stratygraficzna; I–V — kompleksy litologiczne dewonu; Pr — prekambr; Cm — kambr; P — perm; J — jura; Cr-Pg — kreda-paleogen (flisz karpacki); M — miocen

usually predominates and forms calcisphaere-, algal- and characean limestones but yet characteristic mixed associations can be present as well, for example calcisphaere-foraminifera ones. The index foraminifera: *Eonodosaria, Lunucammina,* and *Frondilina* occurring at the top of unit IV point to the Middle-Upper Frasnian age of the limestones (A. Tomaś, R. Zając, 1992). This thick (190–435 m) lithostratigraphic unit IV is likely to represent the Givetian and the Frasnian stages. Unfortunately, due to a weak faunal evidence it is impossible to determine the border between these stages. The Devonian has been subdivided into stages in borehole Puńców 1 (K. Konior, A. Tokarski, 1959). The lowest members of the dolomites and limestones with traces of brachiopod fauna (2022.7–2217.0 m) have been assigned to the Eifelian. The Givetian has been distinguished based on the presence of *Amphipora ramosa* Phillips and *Spirifer mediotexus* d'Archiac et Verneuil (1827.0–2022.7 m). The Frasnian has been distinguished with the help of *Amphipora pervesiculata* Lecompte (1700.0–1827.0 m). The above division can be adequate, however, brachiopods and amphiporas that allowed to single out the stratigraphic stages are not index fossils.

The next (V) lithostratigraphic unit comprises vadose limestones and vadose dolomites. The lower part of the unit is a massive complex of light coloured, cavernous dolomites without any fossils (Fig. 2), whereas the upper part is built of light coloured, pelitic limestones interbedded with cavernous dolomites. The only exception is the profile of borehole Sucha IG 1 that is entirely represented by limestones with intercalations of cavernous dolomites. Limestones of the unit V exhibit features of vadose deposits in the caliche facies and comprise horizons corresponding both to buried soils and micrite envelopes. These are peloidal, peloidal-lump calcareous mudstones with fenestral structure, sometimes bioturbated. In places, they are characterized by microlamination which might be associated with the presence of algal mats. Here, the laminae of limy grainstones with accumulated fine, micrite intraclasts, peloids and coated grains are also found. Inserts of homogenous micrites and algal biolithite are found here as well. The limestones are often dolomitised and contain admixture of quartz and nodules of silica. Accumulations of vermiform gastropods, ostracods, unicellular foraminifera and calcisphaeres are observed in certain horizons. In a few cases (boreholes: Potrójna IG 1, Sucha IG 1, Tokarnia IG 1), a scarce foraminifera assemblage of Tournayellidae family (Table 1) that points to the Famennian age of the deposits (A. Tomaś, R. Zając, 1992) occurs in the vadose limestones. Both cavernous dolomites and overlying limestones with intercalations of cavernous dolomites have been assigned to the Famennian. The upper parts of unit V were partly or completely eroded almost in the entire. Probably the complete profile of the Devonian is preserved only in borehole Głogoczów IG 1, where it is possible to determine an approximate thickness of the unit for 328 m.

CARBONIFEROUS

Until recently the Lower Carboniferous in the Kohlenkalk facies has only been identified in borehole Głogoczów IG 1. The Tournaisian is represented by granular limestones: intraclastic-peloid-bioclastic wackestones, lumpstones and grainstones. As regards the organic remains, calcisphaeres, ostracods, algae, crinoids and brachiopods might occasionally be very numerous. The foraminiferal assemblages are very characteristic here (Table 1) and are indicative of the Tournaisian zones Cf1(Tn1b-Tn2) and Cf2(Tn3). Above there is

Table 1

Foraminifera in limestones of the Earlier Palaeozoic in the basement of the Polish Western Carpathians

Foraminifera	Devonian		Carboniferous			
	Frasnian	Famennian	Tournaisian		Visean	
			Tn1b-Tn2	Tn3	V2b-V3a	V3bc
Tikhinella cannula (Bykova)						
Eonodosaria evlanensis Lipina						
Eonodosaria cf. *solida* Konoplina						
Frondilina tailferensis Mamet et Preat						
Lunucammina devonica (Lipina)						
Lunucammina reperta (Bykova)						
Lunucammina indigena (Bykova)						
Septabrunsiina sp.						
Septatournayella sp.						
Tournayella sp.						
Glomospiranella sp.						
Pseudoglomospira sp.						
Rectoseptatournayella sp.						
Chernyshinella glomiformis (Lipina)						
*Chernyshinella tumulos*a Lipina						
Tournayellina sp.						
Paleospiroplectammina sp.						
Latiendothyra paracosvensis (Lipina)						
Endothyra latispiralis Lipina						
Spinoendothyra sp.						
Tournayella discoidea Dain						
Eoforschia gigantea (Lipina)						
Mediocris mediocris (Vissarionova)						
Diplosphaerina sp.						
Eostaffella parastruvei Rauzer-Chernousova						
Brunsia sp.						
Pseudoammodiscus volgensis (Rauzer-Chernousova)						
Howchinia gibba (Moeller)						
Vissarionotaxix exilis (Vissarionova)						
Vissarionotaxis compressa (Brazhnikova)						
*Endothyra brady*i Mikhaylov						

Endothyranopsis compressa (Rauzer-Chernousova et Reitlinger)					—	—
Tuberitina sp.						—
Archaediscus convexus Grozdilova et Lebedeva						—
Archaediscus cornuspiroides Brazhnikova et Vdovenko						—
Archaediscus donetzianus Sosnina						—
Archaediscus grandiculus Schlykova						—
Archaediscus koktjubensis Rauzer-Chernousova						—
Archaediscus krestovnikovi Rauzer-Chernousova						—
Archaediscus moelleri Rauzer-Chernousova						—
Archaediscus reditus (Conil et Lys)						—
Archaediscus stilus Grozdilova et Lebedeva						—
Neoarchaediscus sp.						—
Nudarchaediscus concinnus (Conil et Lys)						—
Cribrostomum sp.						—
Paleotextularia sp.						—
Forschia sp.						—
Lituotubella sp.						—
Endostaffella parva (Moeller)						—
Endostaffella shamordini (Rauzer)						—
Endothyra pulchra Brazhnikova et Potievskaya						—
Endothyra spirilliniformis (Brazhnikova et Potievskaya)						—
Globoendothyra globulus (Eichwald)						—
Endothyranopsis crassa (Brady)						—
Omphalotis minima (Rauzer-Chernousova et Reitlinger)						—
Tetrataxis angusta Vissarionova						—
Tetrataxis barkhatovae Grozdilova et Lebedeva						—
Tetrataxis conica Ehrenberg						—
Tetrataxis decurrens Brady						—
Tetrataxis paraminima Vissarionova						—
Tetrataxis subcylindricus Conil et Lys						—
Valvulinella sp.						—
Eostaffella mosquensis (Vissarionova)						—
Eostaffella proikensis Rauzer-Chernousova						—
Pseudoendothyra sp.						—

a series of vadose deposits: peloid-fenestral calcareous mudstones with unicellular foraminifera, ostracods and vermiform gastropods. This series is likely to belong to the Lower Visean (V1-V2). The vadose deposits terminate the Kohlenkalk series.

The latter is overtopped with synorogenic deposits (the Culm facies) which are developed alike from Cieszyn to Głogoczów (Fig. 2). They start with conglomerates or sandstones with inserts of tuffite, black granular and crumbled limestones and dolomites. The limestones contain a rich fauna: gigantoproductuses, crinoids and corals (K. Konior, A. Tokarski, 1959; K. Matl, S. Stopa, 1970; S. Gucik, 1975; A. Ślączka, 1976*b*, 1985). Higher in the profile, there is a series of claystones and mudstones interbedded with sandstones. The Culm deposits in the western part of the study area are called Malinowice Beds while in the eastern part — Zalas Beds. The Malinowice Beds are characterized by a predominance of claystone and mudstone with subordinate arenaceous rocks whereas the Zalas Beds contain more sandstone intercalations and, in some places, traces of vegetation in form of stigmaria soils. The synorogenic series confines the Upper Visean and Lower Namurian (K. Konior, A. Tokarski, 1959; K. Matl, S. Stopa, 1970; A. Kotas, 1982). In borehole Głogoczów IG 1, in the base part of the discussed rocks, there are limestone intercalations represented by granular limestone: foraminifera-calcisphaere wackes in which the foraminifera of the Upper Visean are present (V2b-V3a, zone Cf5). In boreholes Potrójna IG 1 and Sucha IG 1, in the base part of the synorogenic deposits, there are intercalations of arenaceous, silty and ferruginous limestone highly differentiated facially. They comprise: calcareous wackestones, lumpstones, grainstones and conglomerates. Here, organic remains are abundant and include mainly: crinoids, brachiopods, foraminifera and bryozoa. In some places limestones are parallel laminated or crumbled and contain coated grains. The foraminifera present in the limestone provide evidence of the Upper Visean age of the deposits (V3bc, zone Cf6). The top part of the marine synorogenic deposits is delimited by the Štur marine band. This band in the region of Bielsko-Biała–Cieszyn has been described by K. Matl (1969). That is one of the most important correlation layers of the Upper Silesian Carboniferous. The border between the Lower and Upper Carboniferous is sometimes very difficult to establish. In borehole Bielsko-2 (K. Matl, S. Stopa, 1970) this border has been determined precisely in the middle of the synorogenic series but it is very difficult to define in borehole Sucha IG 1 (A. Ślączka, 1976*b*), where the top parts of the Zalas Beds (Fig. 2) gradually pass to a monotonous mudstone-sandstone series. The latter contains intercalations and seams of coal in its upper parts. In the profile of borehole Głogoczów IG 1 the Štur band has been determined at a depth of 1268.4–1274.9 m (Ł. Musiał, 1975). This way the top of the Zalas Beds and the base of the paralic formation have been evidenced, while the border between the Lower and the Upper Carboniferous has been determined at a depth of 1289.0 m (A. Kotas, 1975). The thickness of synorogenic deposits of the Culm facies varies in the study area from 25 to 227 m.

The Upper Carboniferous is represented by: the upper part of the synorogenic series, paralic and limnic formations (A. Kotas, 1982). The paralic formation, known as Marginal Beds in older stratigraphic divisions, comprises the whole paralic formation of the coal-bearing part of the Carboniferous of the Silesian Basin and corresponds to the Namurian (A. Kotas, W. Malczyk, 1972). The paralic formation is outstanding due to the presence of coal seams together with marine and brackish deposits. In the study area the largest thickness of these partially eroded layers has been stated in borehole Puńców 1 (K. Konior, A. To-

karski, 1959) where it reaches 535 m. Eastward, the thickness of the paralic series decreases and is 151 m in borehole Potrójna IG 1. In the latter the series is represented by the Sarnów and Flora Beds (A. Ślączka, 1985). The Sarnów Beds are composed of: mudstones and grey claystones as well as fine-grained, clayey-siliceous-carbonate sandstones interlaminated with carbonised plant detritus, mica and clayey material. The upper member of the Marginal Beds consists of the Flora Beds developed as: mudstones interlaminated with carbonised plant detritus and with arenaceous material, claystones as well as subordinate fine-grained, greywacke and siderite sandstones. In the Flora Beds, in borehole Potrójna IG 1, there are 9 coal seams and coal-bearing shales being 0.2–0.8 m thick (A. Ślączka, 1985).

The youngest deposits of the Upper Carboniferous stated in the study area in borehole Potrójna IG 1 are the limnic series represented by the Upper Silesian Mudstone Series and by the Cracow Sandstone Series, Westphalian in age (A. Ślączka, 1985). The Upper Silesian Mudstone Series comprises Załęże and Orzesze Beds. The former are grey mudstones, occasionally sandy, and claystones with sandstone leniticiles and sporadically with sandstones layers. In the Załęże Beds, in borehole Potrójna IG 1, there are 9 coal seams and coal-bearing shales being 0.3–1.7 m thick. The Orzesze Beds are light grey, thick- and medium-bedded, unequigranular sandstones cross-laminated with carbonised plant detritus. Among the sandstones the horizons of grey arenaceous mudstones are found, while in the upper part of the Orzesze Beds a 3.5 m thick coal bed has been stated. The youngest member of the Upper Carboniferous, preserved in borehole Potrójna IG 1, is the Cracow Sandstone (Łaziska Beds). These are light grey, thick-bedded, unequigranular, arkose sandstones, conglomeratic with clayey-siliceous cement. They are, in places, laminated with plant detritus and contain inserts of grey mudstones and claystones. Four coal seams, 0.6–5.2 m thick, occur in the Łaziska Beds. The Upper Carboniferous profile in borehole Potrójna IG 1 is incomplete. At the erosional contact, the Miocene deposits and the overthrusted folded structures of the Flysch Carpathians (Fig. 2) rest on the Łaziska Beds.

COMMENTS ON SEDIMENTATION OF THE DEVONIAN AND LOWER CARBONIFEROUS CARBONATE DEPOSITS

In the Devonian the study area was a small part of the southern margin of the carbonate platform which extended from Moravia to the region of Lublin (M. Narkiewicz, G. Racki, 1987). The basal Devonian series (**unit I**) — clastic deposits, being of terrestrial origin, pass continuously into dolomites without fossils (**unit II**), interbedded and laminated with clayey-silty material. That proves both proximity to land and a very shallow, quiescent sedimentary basin. The presence of the second clastic complex (lithostratigraphic **unit III**) indicates a considerable shallowing of the basin and a temporary return to terrestrial sedimentary conditions. The deposits of lithostratigraphic **unit IV** — limestones and dolomites with stromatoporoids indicate an extending and slightly deepening sedimentary basin. It comprised a shallow sublittoral-littoral, an open marine environment of an outer lagoon or a confined basin of an inner lagoon (J. L. Wilson, 1975). These deposits formed in very warm and well illuminated waters. The energy varied but a higher one predominated that can be confirmed by the abundant stromatoporoids detritus as well as by intraclasts or even calcareous rudites. Occasionally the waters were more quiescent and a connection with

an open sea was cut off, so there were deposited calcareous muds enriched in calcisphaeres, unicellular foraminifera and characeans. In the region of Ustroń and Kęty, as in the Holy Cross Mts. or the Nida Basin and Silesian-Cracow Upland (J. Kicuła, H. Żakowa, 1972; A. Łaptaś, 1983; M. Narkiewicz, I. Olkowicz-Paprocka, 1983; G. Racki, 1980, 1985; M. Narkiewicz *et al.*, 1990) organic stromatoporoid structures were periodically developing in the Givetian and Frasnian. The age of the top part of **unit IV** is documented by the uniserial foraminifers indicating the Upper Frasnian. The last lithostratigraphic unit (V), whose Famennian age was accepted based also on the foraminifers, developed under different conditions. The sedimentary environment became quiescent and the micrites became more abundant. Except for a few cases, the conditions did not promote the development of an organisms. That could have been caused by a limited water circulation and weak ventilation, increased turbidity of water and changes in its salinity. In the Famennian profile there are inserts of limestones with large accumulation of ostracods, vermiform gastropods, calcisphaeres and unicellular foraminifera. The basin was very shallow and the deposits forming in it were subaerally exposed several times and modified due to vadose diagenesis (T. M. Peryt, 1984). During this diagenesis at least a part of intraclasts, peloids, coated grains and nodules of silica could have formed. At the end of the Famennian, the sea basin showed regressive tendencies, and thus there is a sedimentation gap in almost the entire study area as well as in its vicinity (H. Jurkiewicz, H. Żakowa, 1972; J. Kicuła, H. Żakowa, 1972; M. Chorowska, 1972; Z. Bełka, 1985). In the predominating part of the study area the gap comprises the Famennian or its upper part, and the Lower Carboniferous. A slightly different situation is observed in borehole Głogoczów IG 1, where granular limestone with the foraminifera indicative of the Lower Tournaisian (Tn1b-Tn2) rest on the Famennian vadose deposits. That allows to conclude that in the eastern part of the study area the changes in sedimentation could have taken place gradually. Unfortunately, the contact between two stages is unknown as cores have not been sampled from this section. The transition between the Devonian and Carboniferous in borehole Głogoczów IG 1, i. e. transition between the extreme shallow water deposits being periodically exposed subaerally and the granular limestone indicating the sea deepening, remains an open question. The Lower Tournaisian limestone (Tn1b-Tn2) and the overlying granular and micrite limestone of the Upper Tournaisian (Tn3) developed in the shallow of the sublittoral-littoral zone, in the environment of the moderate and increased energy. In borehole Głogoczów IG 1, the documented Tournaisian is overlain by vadose deposits without index fauna that give evidence of a subsequent shallowing of the basin or even of a periodical exposure. The stratigraphic position of these deposits indicates that they might represent the lower members of the Visean. Moreover, these deposits terminate the Kohlenkalk sedimentation. The overlying synorogenic series of the Upper Visean provide evidence of a definite change in the character of sedimentation and in basin type. The platform had subsided and deposits of the Culm facies with goniatites, crinoids and brachiopods, being the equivalents of the flysch association developed in the Moravia-Silesian geosyncline, were developing (A. Kotas, 1982).

CONCLUSIONS

1. Based on the results of the lithological-microfacial analyses the Devonian has been subdivided into five informal lithostratigraphic units: I — clastic deposits, II — dolomites without fossils, III — clastic deposits, IV — limestones and dolomites with stromatoporoids, and V — dolomites and vadose limestones.

2. Lithostratigraphical units I, II, III and the lower members of unit IV have no stratigraphical documentation. The top part of unit IV that is formed by laminated micritic limestone represents the Upper Frasnian.

3. Unit V — dolomites and vadose limestones have been assigned to the Famennian, based on the presence of foraminifera as well as on the origin of these deposits and on the occurrence of the cavernous dolomite intercalations within the limestones.

4. The Lower Carboniferous in the Kohlenkalk facies has been ascertained in borehole Głogoczów IG 1. It is represented by granular limestones and micrites with foraminifers indicative of the Tournaisian and probably by vadose sediments of the Lower Visean. The vadose deposits do not have faunal documentation and have been assigned to the Lower Visean based on the stratigraphic sequence.

5. In the lower part of the synorogenic series (the Culm facies) the intercalations of granular and nodular limestones with foraminifers indicative of the Late Visean are found.

6. In the whole study area (borehole Głogoczów IG 1 excluding) there is a stratigraphic gap comprising the Famennian or its upper part, the Tournaisian and the Lower Visean.

7. Sedimentation of the Devonian and Carboniferous carbonate series took place over the carbonate platform, in the shallow sublittoral-littoral zone, in the environment of the external or internal lagoon or the shallow open shelf.

8. It results, from the comparison of the analyzed deposits of the Upper Devonian and the Lower Carboniferous in the Kohlenkalk facies with the deposits in the neighbouring areas that they represent much shallower facies. This fact confirms the southward shallowing of the basin. However, the nature of the examined deposits does not indicate unambiguously the proximity of the land.

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UTWORY MŁODSZEGO PALEOZOIKU W PODŁOŻU POLSKICH KARPAT ZACHODNICH

Streszczenie

Utwory dewonu i karbonu w podłożu polskich Karpat Zachodnich należą do południowej części zapadliska górnośląskiego, rozwiniętego na prekambryjskim masywie górnośląskim. Utwory te leżą na osadach platformowych kambru lub bezpośredno na cokole prekambryjskim.

Na podstawie analizy litologiczno-mikrofacjalnej i badań geofizyki otworowej wyróżniono w dewonie pięć nieformalnych jednostek litostratygraficznych.

Pierwszą jednostkę litostratygraficzną budują utwory klastyczne — mułowce, iłowce, piaskowce i zlepieńce szare, zielonawe i różowe, z licznym nagromadzeniem muskowitu i zwęglonego detrytusu roślinnego. Badania mikroflorystyczne przeprowadzone przez E. Turnau wskazują na dolnodewoński (górnoemski) wiek utworów klastycznych. Miąższość podstawowej serii dewońskiej wynosi 0–30 m.

Drugą jednostkę litostratygraficzną tworzą ciemnoszare i czarne dolomity pelityczne lub drobnokrystaliczne bez fauny. W części spągowej cechują się laminacją i cienkimi przewarstwieniami iłowcowo-mułowcowymi, co oznacza stopniowe przejście od utworów klastycznych do węglanów. Miąższość dolomitów bez fauny wynosi od 30 do 80 m. Pozycja stratygraficzna i ciągłe przejście od utworów górnego emsu pozwalają przypuszczać, że dolomity bez fauny mogą być eifelskie.

Trzecią jednostkę litostratygraficzną stanowi cienki (3–13 m) poziom utworów klastycznych wykształconych analogicznie jak jednostka pierwsza.

Czwarta jednostka litostratygraficzna jest reprezentowana przez gruby (190–450 m) zespół wapieni i dolomitów, których cechą charakterystyczną jest obecność stromatoporoidów, od pojedynczych okazów po nagromadzenia masowe (otwory Ustroń IG 1 i Kęty 9). Profil rozpoczynają dolomity krystaliczne z amfiporami lub dolomity stromatoporowe, z przewarstwieniami wapieni pelitycznych i ziarnistych. Wyżej występują wapienie stromatoporowe, amfiporowe, mikrytowe i ziarniste. Ogniwem wieńczącym czwartą jednostkę są wapienie przeważnie pelityczne, rzadziej ziarniste, często laminowane, o barwach jasnych — beżowych lub szarych. Laminacja równoległa lub falista znaczy się ciemniejszym (szarym, zielonym) materiałem ilastym. W części stropowej wapieni laminowanych występują otwornice wskazujące na fran.

Piątą jednostkę litostratygraficzną stanowią wapienie i dolomity wadyczne. W dolnej części są to dolomity jasne dziurkowate, w górnej natomiast wapienie pelityczne fenestralne z przewarstwieniami dolomitów dziurkowatych. Obecność poziomów gleb kopalnych i pokryw mikrytowych wskazuje na okresowe ekspozycje subaeralne osadów. W profilu jednostki piątej obserwuje się poziomy ze ślimakami wermetoidalnymi, małżoraczkami, otwornicami jednokomorowymi i kalcisferami. Ponadto występują tu nieliczne zespoły otwornic z rodziny Tournayellidae, które wskazują na fameński wiek utworów. Górne partie jednostki piątej prawie na całym obszarze badań zostały częściowo lub całkowicie zniszczone przez erozję. Jedynie w otworze Głogoczów IG 1 zachowany jest prawdopodobnie pełny profil osadów dewonu i jest możliwe określenie przybliżonej miąższości piątej jednostki na około 320 m.

Karbon dolny w facji wapienia węglowego na omawianym obszarze stwierdzono dotychczas jedynie w otworze Głogoczów IG 1. Turnej reprezentowany jest przez wapienie ziarniste (około 90 m) zawierające zespoły otwornic charakterystyczne dla zon: Cf1 (Tn1b-Tn2) i Cf2(Tn3). Wyżej występują pelityczne wapienie fenestralne (osady wadyczne) z mikrofauną (ślimaki wermetoidalne, małżoraczki, otwornice jednokomorowe). Wapienie te mogą należeć do wizenu niższego (V1-V2). Wyżej leżą osady diastroficzne wizenu górnego i dolnego namuru (facja kulmu), wykształcone podobnie na całym omawianym obszarze polskich Karpat Zachodnich (od Cieszyna po rejon Głogoczowa). Zalegają one (z wyjątkiem otworu Głogoczów IG 1) na różnych ogniwach famenu, a nawet franu. Seria diastroficzna reprezentowana jest przez zespół ciemnych mułowców, iłowców, piaskowców o miąższości 40–230 m. Rozpoczynają ją zlepieńce lub piaskowce z warstwami czarnych wapieni gruzłowych i ziarnistych, dolomitów i tufitów. Wapienie zawierają liczne gigantoproduktusy, liliowce, mszywioły, korale i otwornice. Te ostatnie dokumentują niższy wizen górny (V2b-V3a, zona Cf5) w otworze Głogoczów IG 1 i wyższy wizen górny (V3bc, zona Cf6) w otworach Sucha IG 1 i Potrójna IG 1. Strop serii diastroficznej wyznacza tzw. poziom Štura z masowym nagromadzeniem ramienionogów. Został on opisany przez Ł. Musiał (1975) w otworze Głogoczów IG 1 na głębokości 1268 m. W ten sposób został udokumentowany strop serii diastroficznej i spąg serii paralicznej, a granica między karbonem dolnym i górnym została wyznaczona przez A. Kotasa (1975) na głębokości 1298 m.

Do karbonu górnego na omawianym obszarze należy najwyższa część serii diastroficznej, seria paraliczna (namur) i limniczna (westfal). Serie paraliczna i limniczna charakteryzują się występowaniem pokładów węgla kamiennego. Miąższość węglonośnych utworów karbonu górnego w podłożu polskich Karpat Zachodnich jest zredukowana erozyjnie i wynosi od około 100 do 680 m. Na różnych ogniwach karbonu górnego i wizenu górnego leżą osady miocenu lub flisz karpacki, a w części wschodniej omawianego obszaru pod miocenem i fliszem karpackim występują jeszcze utwory jurajskie.

PLATE I

Fig. 1. *Bisphaera* sp.
Głogoczów IG 1borehole, depth 1975.5–1984.5 m, Givetian-Frasnian
Fig. 2. *Paracaligella* sp.
Potrójna IG 1 borehole, depth 3205.0–3208.8 m, Givetian-Frasnian
Fig. 3. *Tikhinella* sp.,
Potrójna IG 1 borehole, depth 2901.5–2905.0 m, Givetian-Frasnian
Fig. 4. *Tikhinella cannula* (Bykova),
Głogoczów IG 1 borehole , depth 1975.5–1984.5 m, Frasnian
Figs. 5–7. *Frondilina tailferensis* Mamet et Preat
Ustroń 3 borehole, depth 1396.0–1402.5 m, Frasnian
Figs. 8–10. *Lunucammina indigena* (Bykova)
Głogoczów IG 1 borehole, depth 1975.5–1984.5 m, Frasnian
Fig. 11. *Lunucammina devonica* (Lipina)
Głogoczów IG 1 borehole, depth 1975.5–1984.5 m, Frasnian
Figs. 12–16. *Eonodosaria evlanensis* Lipina
Głogoczów IG 1 borehole, depth 1975.5–1984.5 m, Frasnian
Fig. 17. *Eonodosaria* cf. *solida* Konoplina
Głogoczów IG 1 borehole, depth 1975.5–1984.5 m, Frasnian
Fig. 18. *Septatournayella* sp.
Potrójna IG 1 borehole, depth 2880.0–2882.0 m, Famennian
Fig. 19. *Tournayella* sp.
Potrójna IG 1 borehole, depth 2880.0–2882.0 m, Famennian

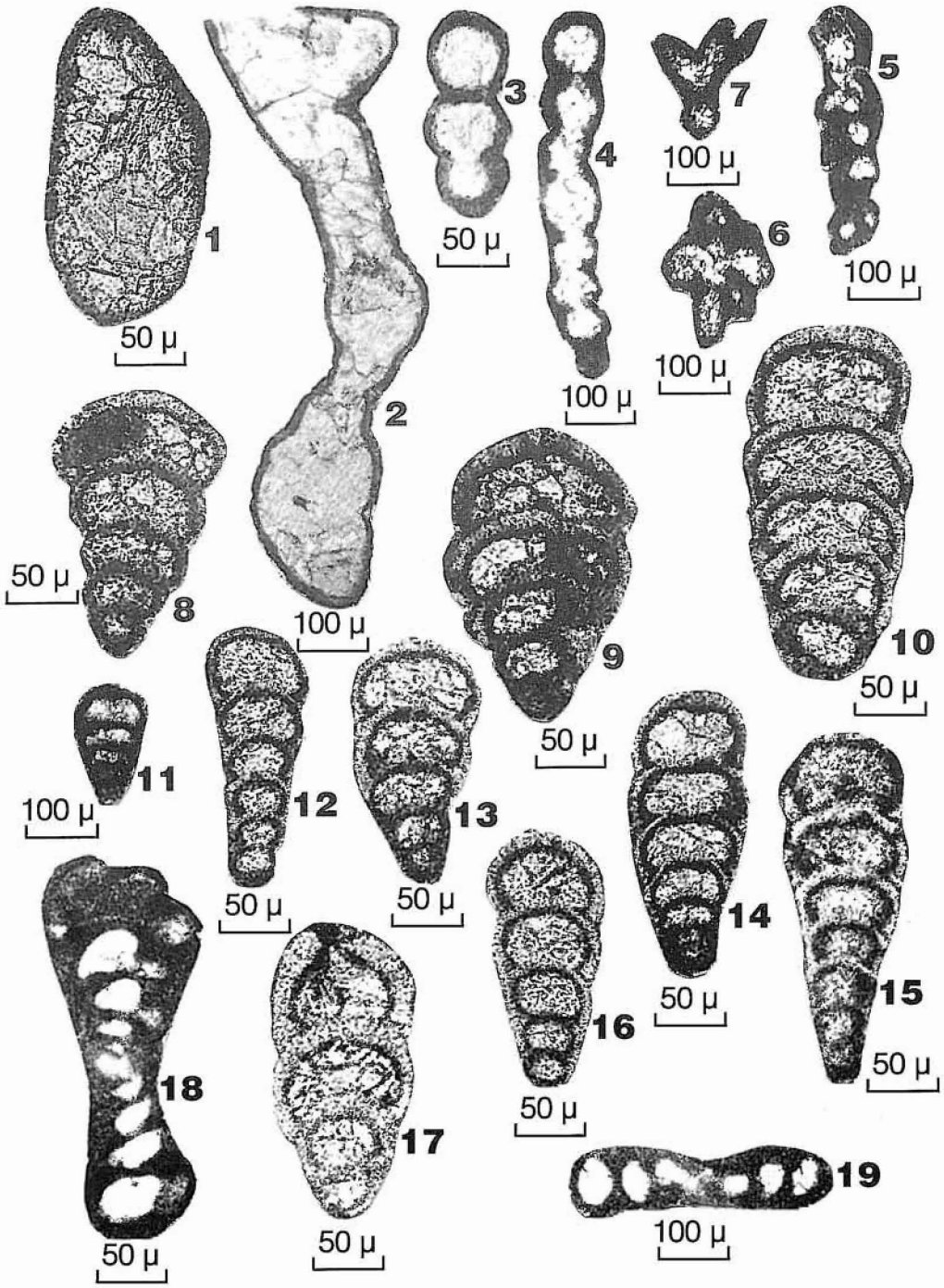

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PLATE II

Fig. 1. *Chernyshinella tumulosa* Lipina
Głogoczów IG 1 borehole, depth 1561.5–1565.0 m, Middle Tournaisian (Tn2)
Figs. 2, 3. *Eoforschia gigantea* (Lipina)
Głogoczów IG 1 borehole, depth 1530.2–1534.2 m, Upper Tournaisian (Tn3)
Fig. 4. *Tournayella discoidea* Dain
Głogoczów IG 1 borehole, depth 1530.2–1534.2 m, Upper Tournaisian (Tn3)
Fig. 5. *Vissarionotaxis exilis* (Vissarionova)
Sucha IG 1 borehole, depth 3586.5–3595.5 m, Upper Visean (V3bc)
Fig. 6–8. *Endothyra bradyi* Mikhaylov
Fig. 6 — Potrójna IG 1 borehole, depth 2785.4 m, Upper Visean (V3bc); Figs. 7, 8 — Głogoczów IG 1 borehole, depth 1447.0–1454.5 m, Upper Visean (V2b-V3a)
Fig. 9. *Tetrataxis subcylindricus* Conil et Lys
Sucha IG 1 borehole, depth 3566.0–3574.3 m, Upper Visean (V3bc)
Figs. 10, 11. *Vissarionotaxis compressa* (Brazhnikova)
Sucha IG 1 borehole, depth 3586.5–3595.5 m, Upper Visean (V3bc)
Fig. 12. *Endothyra pulchra* Brazhnikova et Potievskaya
Sucha IG 1 borehole, depth 3586.5–3595.5 m, Upper Visean (V3bc)

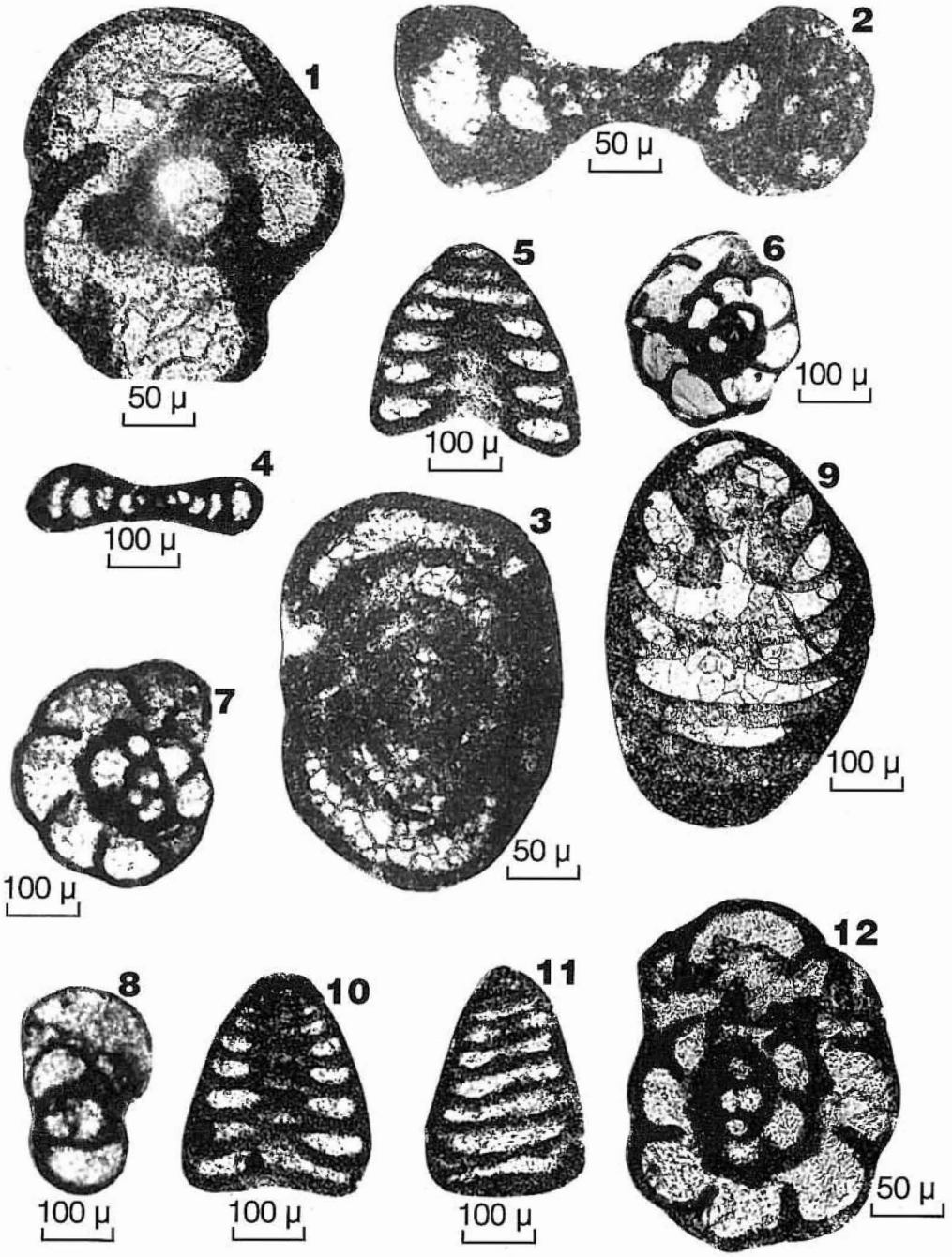

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PLATE III

Fig. 1. *Endothyra spirilliniformis* (Brazhnikova et Potievskaya)
Sucha IG 1 borehole, depth 3586.5–3595.5 m, Upper Visean (V3bc)
FIg. 2. *Omphalotis minima* (Rauzer-Chernousova et Reitlinger)
Sucha IG 1 borehole, depth 3566.0–3574.3 m, Upper Visean (V3bc)
Fig. 3. *Endothyranopsis compressa* (Rauzer-Chernousova et Reitlinger)
Sucha IG 1 borehole, depth 3586.5–3595.5 m, Upper Visean (V3bc)
Fig. 4. *Endothyranopsis crassa* (Brady)
Sucha IG 1 borehole, depth 3586.5–3595.5 m, Upper Visean (V3bc)
Fig. 5. *Globoendothyra globulus* (Eichwald)
Potrójna IG 1 borehole, depth 2785.4 m, Upper Visean (V3bc)
Fig. 6. *Eostaffella parastruvei* Rauzer-Chernousova
Głogoczów IG 1 borehole, depth 1447.0–1454.5 m, Upper Visean (V2b- V3a)
Fig. 7. *Eostaffella mosquensis* (Vissarionova)
Potrójna IG 1 borehole, depth 2785.4 m, Upper Visean (V3bc)
Fig. 8. *Eostaffella* sp.
Potrójna IG 1 borehole, depth 2785.4 m, Upper Visean (V3bc)
Figs. 9, 10. *Endostaffella parva* (Moeller)
Fig. 9 — Potrójna IG 1 borehole, depth 2785.4 m, Upper Visean (V3bc); Fig. 10 — Sucha IG 1 borehole, depth 3566.0–3574.3 m, Upper Visean (V3bc)

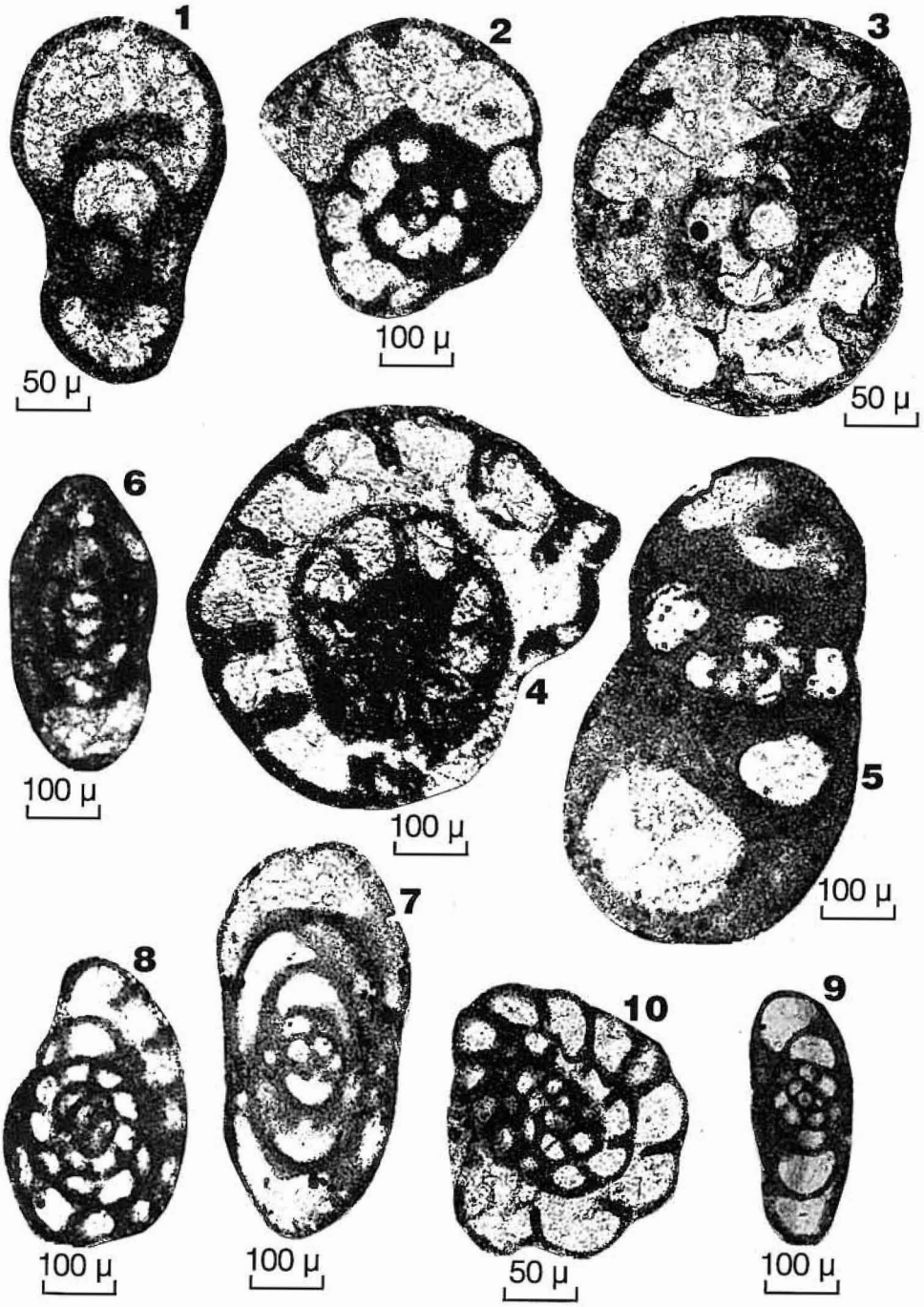

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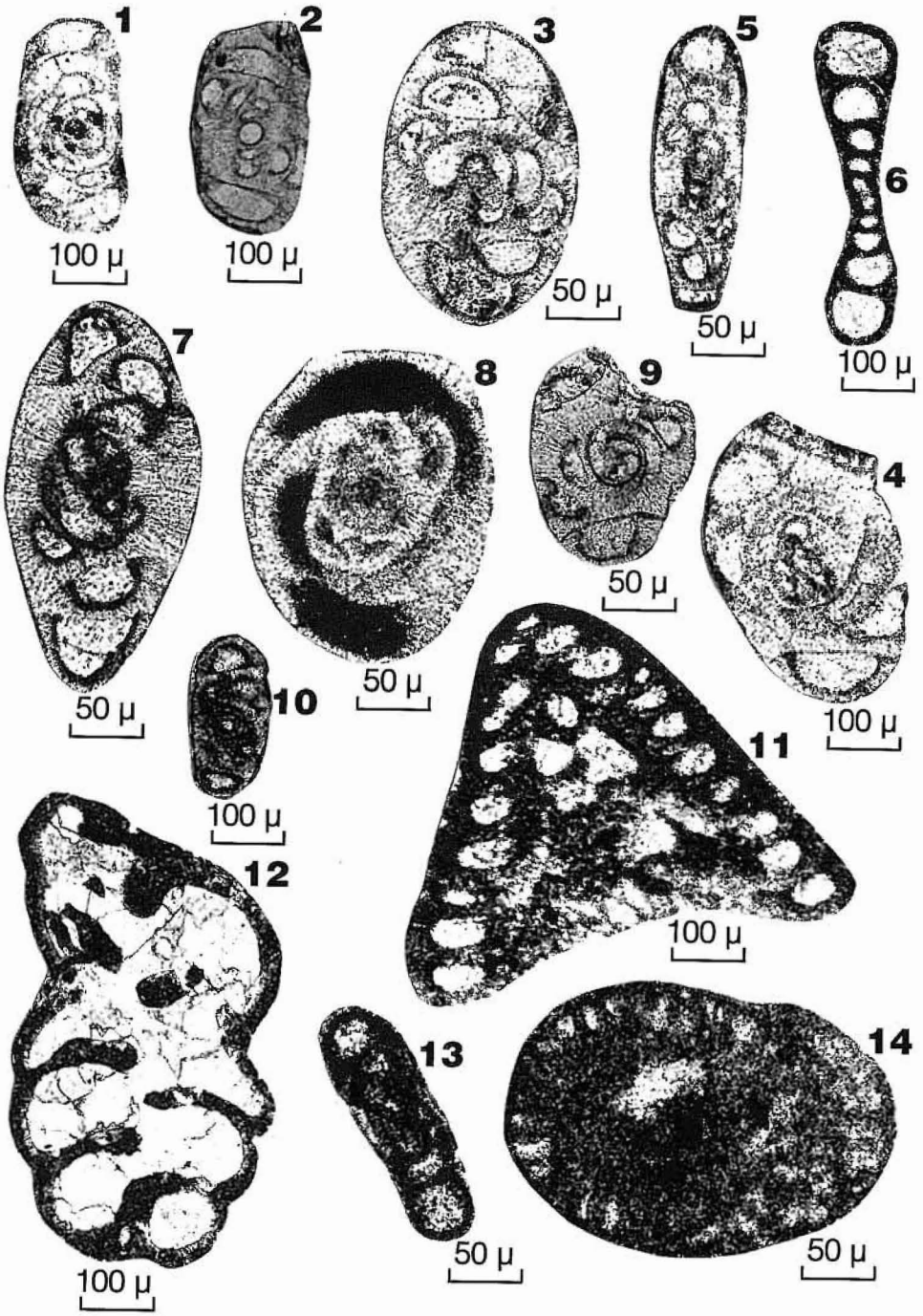
PLATE IV

Fig. 1. *Archaediscus cornuspiroides* Brazhnikova et Vdovenko
Sucha IG 1 borehole, depth 3566.0–3574.3 m, Upper Visean (V3bc).
Fig. 2. *Archaediscus donetzianus* Sosnina
Potrójna IG 1 borehole, depth 2785.4 m, Upper Visean (V3bc)
Figs. 3, 4. *Archaediscus convexus* Grozdilova et Lebedeva
Sucha IG 1 borehole, depth 3586.5–3595.5, Upper Visean (V3bc)
Fig. 5. *Archaediscus stilus* Grozdilova et Lebedeva
Sucha IG 1 borehole, depth 3586.5–3595.5 m, Upper Visean (V3bc)
Fig. 6. *Pseudoammodiscus volgensis* (Rauzer-Chernousova)
Sucha IG 1 borehole, depth 3566.0–3574.3 m, Upper Visean (V3bc)
Fig. 7. *Archaediscus reditus* (Conil et Lys)
Sucha IG 1 borehole, depth 3586.5–3595.5 m, Upper Visean (V3bc)
Fig. 8. *Neoarchaediscus* sp.
Sucha IG 1 borehole, depth 3566.0–3574.3 m, Upper Visean (V3bc)
Fig. 9. *Archaediscus moelleri* Rauzer-Chernousova
Sucha IG 1 borehole, depth 3566.0–3574.3 m, Upper Visean (V3bc)
Fig. 10. *Archaediscus krestovnikovi* Rauzer-Chernousova
Sucha IG 1 borehole, depth 3566.0–3574.3 m, Upper Visean (Vbc3)
Fig. 11. *Tetrataxis barkhatovae* Grozdilova et Lebedeva
Sucha IG 1 borehole, depth 3586.5–3595.5 m, Upper Visean (V3bc)
Fig. 12. *Cribrostomum* sp.
Sucha IG 1 borehole, depth 3586.5–3595.5 m, Upper Visean (V3bc)
Fig. 13. *Nudarchaediscus concinnus* (Conil et Lys)
Sucha IG 1 borehole, depth 3586.5–3595.5 m, Upper Visean (V3bc)
Fig. 14. *Valvulinella* sp.
Sucha IG 1 borehole, depth 3586.5–3595.5 m, Upper Visean (V3bc)



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