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LITHOSTRATIGRAPHY AND BIOSTRATIGRAPHY OF THE UPPER ALBIAN–LOWER/MIDDLE EOCENE FLYSCH DEPOSITS IN THE BYSTRICA AND RAČA SUBUNITS OF THE MAGURA NAPPE; WESTERN FLYSCH CARPATHIANS (BESKID WYSPOWY AND GORCE RANGES, POLAND)

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Abstract: Lithostratigraphy and biostratigraphy of the Bystrica and Rača subunits of the Magura Nappe have been studied in the southern part of the Beskid Wyspowy Range and on the northern slopes of the Gorce Range (Polish part of the Western Flysch Carpathians). Six new lithostratigraphic units (Jasień Formation, Białe Formation, Jaworzynka Formation, Szczawina Sandstone Formation, Krzysztonów Member, and Ropianka Formation) of the Upper Albian–Palaeocene age have been established, and five other units (Malinowa Shale Formation, Hałuszowa Formation, Łabowa Shale Formation, Beloveza Formation, Bystrica Formation) have been additionally described.

The newly created formations as well as the Malinowa Shale Formation and the Hałuszowa Formation have been included to a new Mogielica Group of units (Upper Albian–Palaeocene). This group of units passes upwards into the Beskid Group (Eocene–Oligocene).The Mogielica Group, spanning over 40 myrs, represents the turbidite depositional system, separated by highstand variegated clays which can be correlated with minor sequences in terms of sequence stratigraphy.

The following biostratigraphic zones have been recognised in the Cretaceous–Lower/Middle Eocene deposits: *Plectorecurvoides alternans*, *Bulbobaculites problematicus*, *Uvigerinammina jankoi*, *U. jankoi-C. gigantea*, *Caudammina gigantea*, *Remesella varians*, *Rzehakina fisistomata*, *Glomospira* div. sp., and *Saccamminoides carpathicus*. A few lithostratigraphic units consisting of calcareous sediments have been correlated with the standard calcareous nannoplankton zonation and the chronostratigraphy.

Key words: lithostratigraphy, biostratigraphy, deep-water agglutinated foraminifera, calcareous nannoplankton, Early Cretaceous–Palaeogene, Magura Nappe, Western Flysch Carpathians.

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INTRODUCTION

Four facies-tectonic subunits in the Polish sector of the Magura Nappe have been distinguished on the basis of the Eocene deposit facies differentiation. These are from the north to the south: Siary (=northern Gorlice), Rača (=southern Gorlice), Bystrica (=Sącz), and Krynica subunits (Fig. 1) (for references see Birkenmajer & Oszczypko, 1989). The present paper concerns deposits of the Rača and Bystrica subunits, which build the Beskid Wyspowy Range and the northern part of the Gorce Range.

During the last decade of detailed mapping (1992–2003), the stratigraphic standards of the Upper Cretaceous and Paleogene deposits of the Beskid Wyspowy Range and the northern part of the Gorce Range underwent considerable changes. This was due to sedimentological investigations and tectonic analyses by the first author, and detailed stratigraphic work based on microfossil studies (foraminifera and calacareous nannoplankton) by the other authors. The first results of these investigations were presented by Malata *et al.* (1996), Bąk and Oszczypko (2000), Oszczypko *et al.* (1999), Oszczypko (2001), and Oszczypko-Clowes & Oszczypko (2004). Geology of this area was also a subject of P. Kruczek's Msc thesis (1998). All these stud-

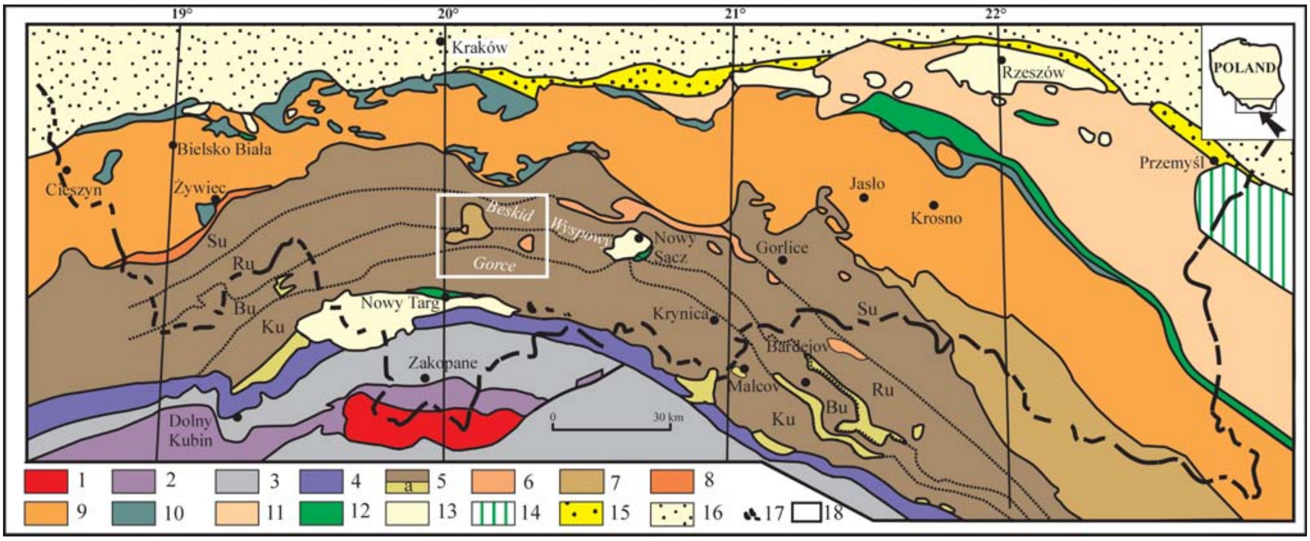


Fig. 1. Tectonic map of the Western Carpathians (compiled by Oszczypko-Clowes, 2001). *1* – crystalline core of the Tatra Mountains; *2* – High Tatric and Sub-Tatric units; *3* – Podhale flysch; *4* – Pieniny Klippen Belt; *5* – Magura Nappe; *5a* – Malcov Formation; *6* – Grybów Unit; *7* – Dukla Unit; *8* – Fore-Magura Unit; *9* – Silesian Nappe; *10* – Sub-Silesian Nappe; *11* – Skole Nappe; *12* – Lower Miocene; *13* – Miocene deposits upon the Carpathians; *14* – Stebnik (Sambir) Unit; *15* – Zgłobice Unit; *16* – Miocene of the Carpathian Foredeep; *17* – andesite; *18* – studied area. Tectonic-facial subunits of the Magura Nappe: Su – Siary, Ru – Rača, Bu – Bystrica, and Ku – Krynica

ies, supplemented by present investigations, enable us to recognize the stratigraphy and to propose a new litho- and biostratigraphic subdivisions for the Upper Albian through the Lower/Middle Eocene deposits of the middle part of the Magura Nappe in Poland.

This paper presents five formal lithostratigraphic units in a rank of formation and one in a rank of member proposed by the first author (N. Oszczypko), and a biostratigraphic division of the studied sequence presented by the co-authors. The biostratigraphy is based mainly on deep-water agglutinated foraminifera (studied by E. Malata and K. Bąk), supplemented by planktonic foraminifera (studied by K. Bąk) and calcareous nannoplankton (studied by M. Kędzierski and M. Oszczypko-Clowes).

A part of the formal lithostratigraphic units (the Malinowa Shale, Hałuszowa, Łabowa Shale, Beloveza, and Bystrica formations) corresponds to those already used in the syntheses for the other facies-tectonic units of the Magura Nappe (Birkenmajer & Oszczypko, 1989). Some of the geographical names traditionally used for a long time have been left unchanged whenever it was possible. It refers to the Kanina beds (Burtan *et al.*, 1978; Oszczypko *et al.*, 1991), the Jaworzynka beds (Burtan, 1973; Burtan *et al.*, 1978), the Szczawina Sandstone (Sikora & Żytko, 1959; Oszczypko *et al.*, 1991), and to the Ropianka beds. A new unit in the rank of a group comprises formations displaying similar lithology and corresponding to the same stage of the Magura Basin evolution. Most of the lithostratigraphic units in the studied area have diachronous boundaries. Some of the lithostratigraphic units, used in the presented division, occur also in other facies-tectonic units of the Magura Nappe. This paper has been prepared according to the Polish Stratigraphical Code (Alexandrowicz *et al.*, 1975, Racki *et al.*, 2004).

STUDY AREA

The presented lithostratigraphic and biostratigraphic subdivisions are based on detailed studies in two regions belonging to the Rača and Bystrica subunits, both located in the Polish part of the Magura Nappe (Figs. 1, 2). The first one is situated in the Beskid Wyspowy Range (Figs. 2, 3), including the area between the Łososina and Kamienica Rivers, around the hills of Jasień (1062 m) and Mogielica (1171 m). The second one is located in the northern part of the Gorce Range (Figs 2, 4), in the vicinity of the Koninki and Poręba Wielka villages.

The studied part of the Beskid Wyspowy Range is built mainly of the Upper Cretaceous–Lower/Middle Eocene strata of the Rača subunit, extending eastwards from the Mszana Dolna tectonic window and northwards from the Szczawa tectonic window (Fig. 2) (Świderski, 1953; Burtan *et al.*, 1978). This part of the Rača subunit is built up of several synclines, filled with the Magura Formation, and underlain by the older formations (Beskid Wyspowy thrust-sheet; see Mastella, 1988). The SE branch of the Beskid Wyspowy Range (with Mogielica Hill), studied by the authors, is located in the area built up of the Bystrica subunit, which includes several thrust-sheets (Fig. 3).

In the studied, northern part of the Gorce Range (south of the Mszana Dolna tectonic window), the Bystrica subunit consists of the Upper Cretaceous–Lower/Middle Eocene strata, and builds up the frontal thrust of the Magura Nappe (Fig. 4) (Burtan *et al.*, 1976, 1978; Oszczypko-Clowes & Oszczypko, 2004). This unit is visible very well in morphology forming W–E trending belt of round-of hills (Oszczypko *et al.*, 1999).

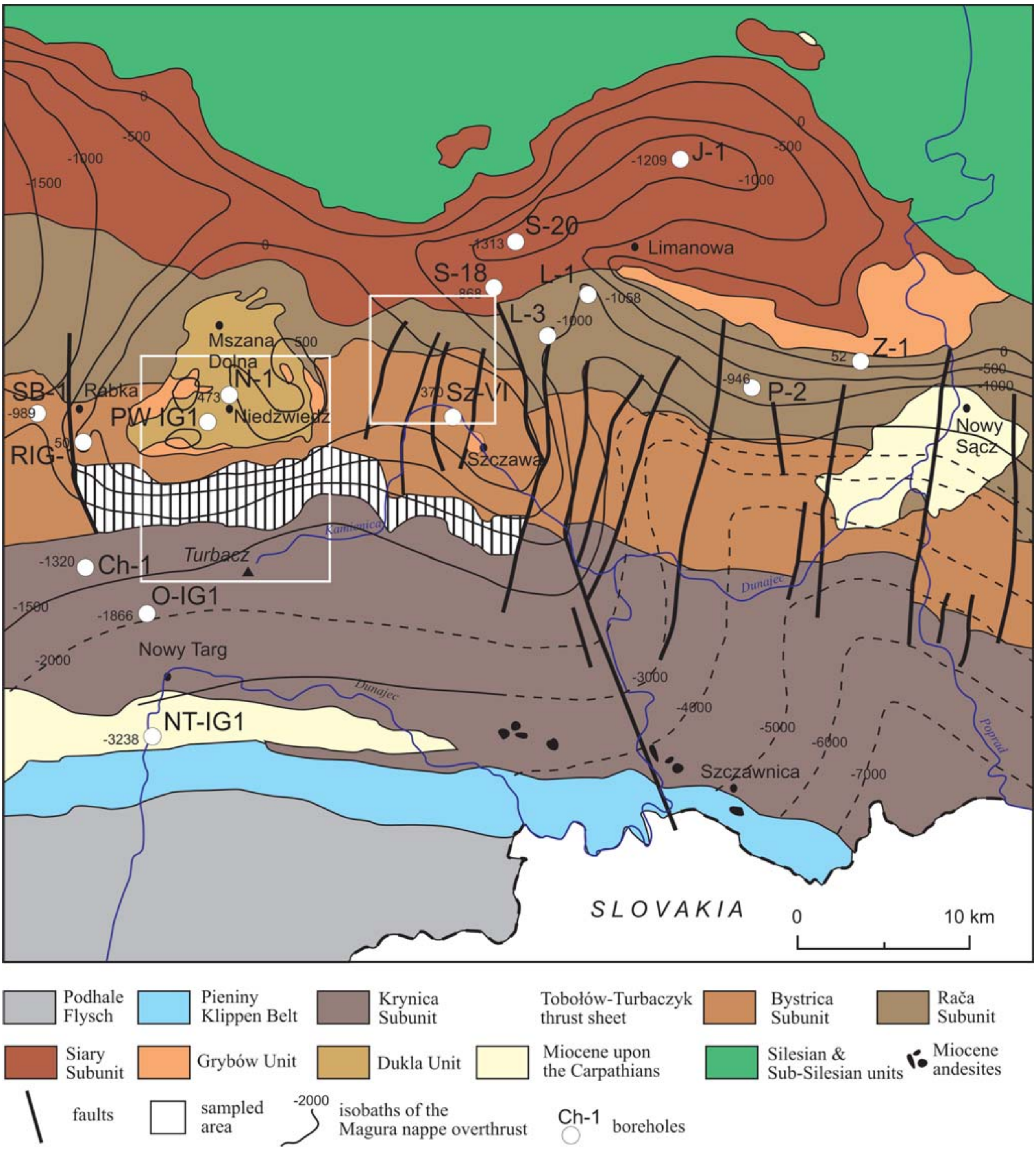


Fig. 2. Geological sketch-map of the middle part of the Western Carpathians (Poland) (after Oszczypko *et al.*, 1999b, supplemented)

MATERIAL AND METHODS

About 90 samples were collected from the sections of the Rača and Bystrica subunits for foraminiferal analyses (Figs 5, 11–14). The samples were processed by the standard micropalaeontological method. They were boiled and frozen using Na_2CO_3 solution, and then washed over a 63 μm screen and dried out. In most of the samples, all microfauna from the > 63 μm fraction were picked and mounted onto cardboard microscope slides. The material is hosted in the Institute of Geological Sciences, Jagiellonian University and in the Institute of Geography, Cracow Pedagogical University (the Półrzeczki and Bruski sections).

All samples for nannoplankton studies were prepared with the standard smear slide technique for light microscope (LM) observations. The investigations were carried out un-

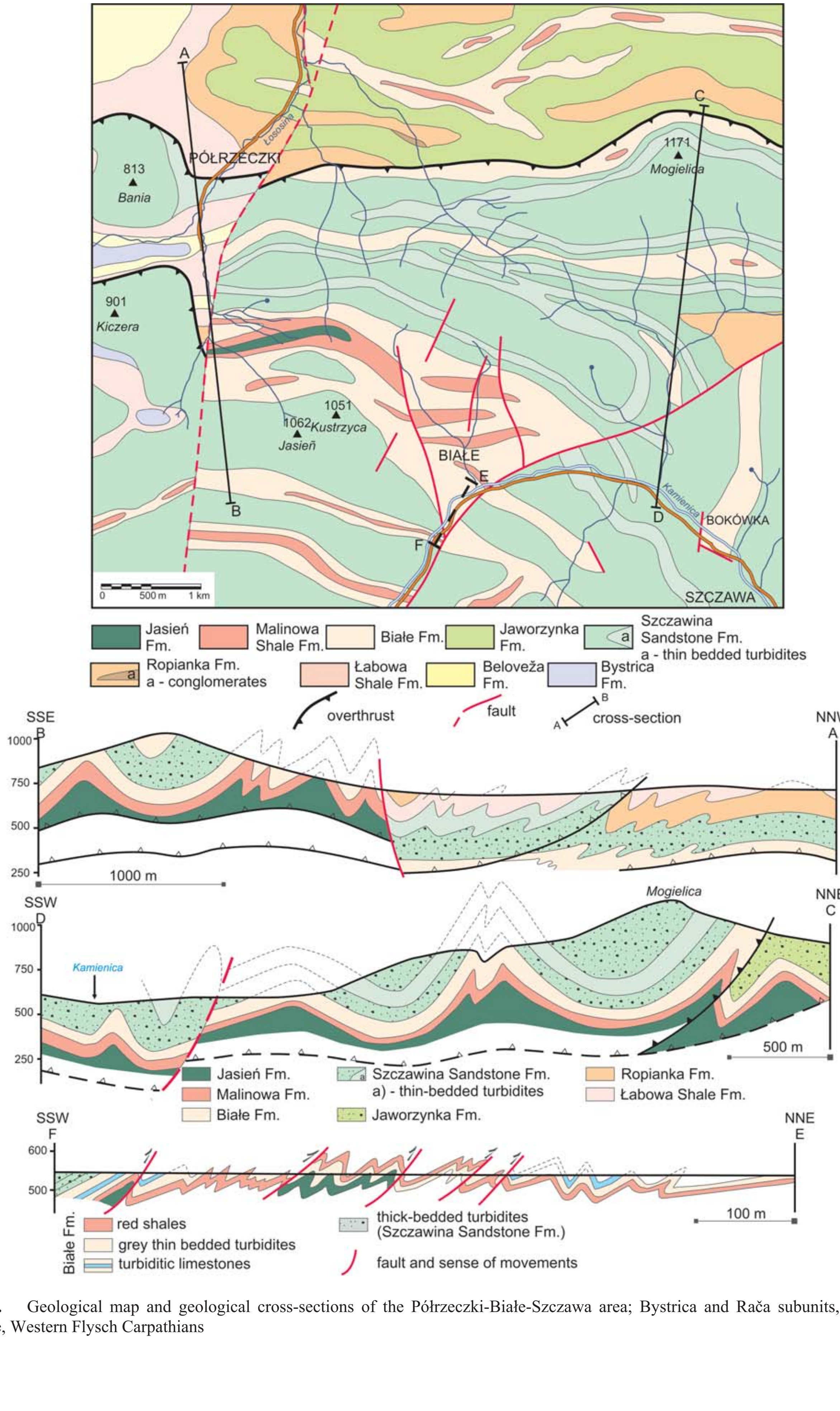


Fig. 3. Geological map and geological cross-sections of the Półrzeczki-Białe-Szczawa area; Bystrica and Rača subunits, Magura Nappe, Western Flysch Carpathians

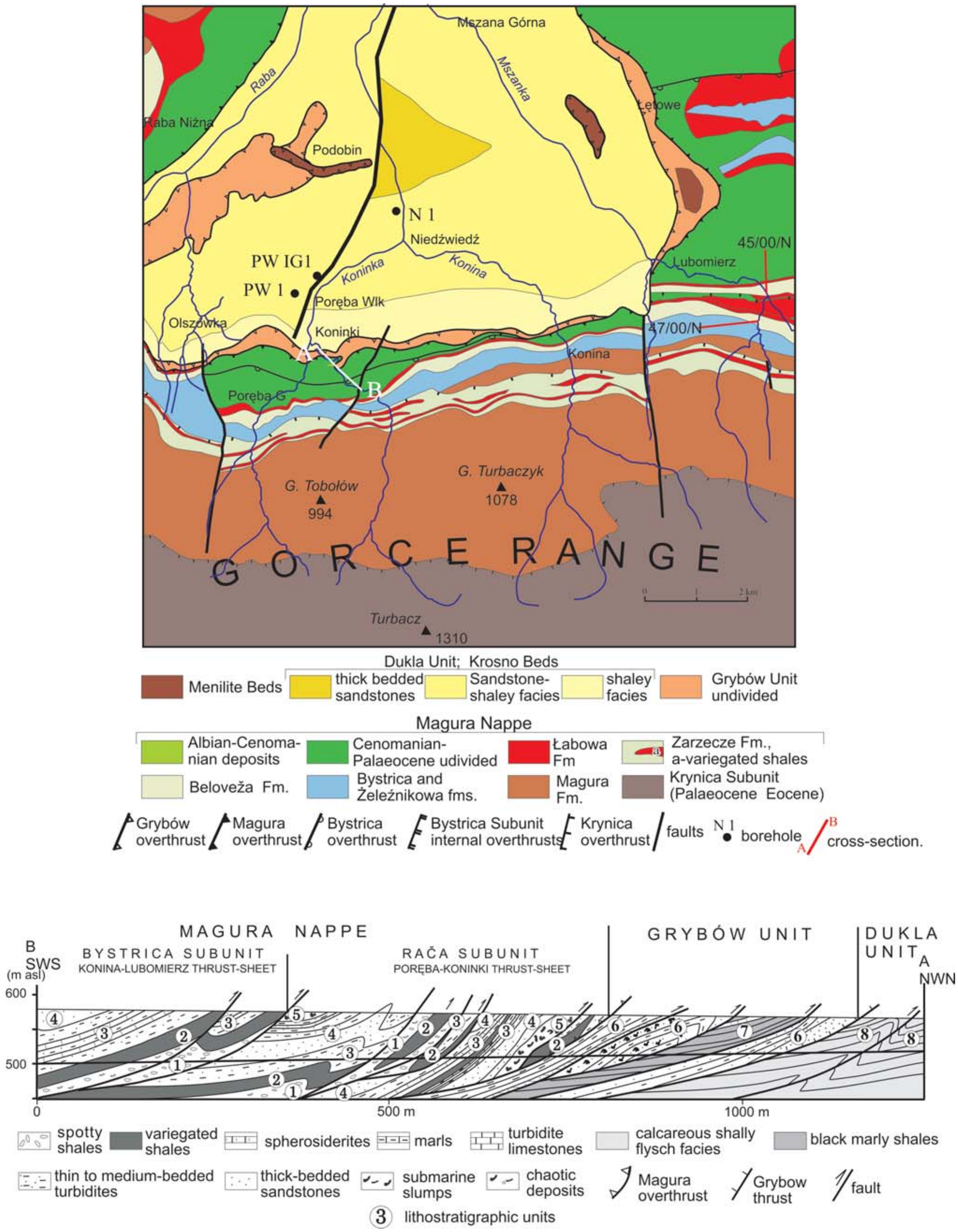


Fig. 4. Geological map of the southern margin of the Mszana Dolna tectonic window, Western Flysch Carpathians (after Burtan *et al.*, 1976; Oszczypko *et al.*, 1999b, supplemented) and geological cross-section along the Koninki stream (after Oszczypko-Clowes & Oszczypko, 2004, supplemented). Lithostratigraphic units marked on geological cross-section: 1 – Hulina Formation; 2 – Malinowa Shale Formation and Hałuszowa Formation; 3 – Białe Formation; 4 – Szczawina Sandstone Formation; 5 – Ropianka Formation; 6 – Jaworzynka Formation, 7 – Grybów Beds, 8 – Krosno Beds

der LM at a magnification of 1000× using parallel and crossed nicols. Several specimens photographed under LM are illustrated in Fig. 27. For the purpose of this work the standard nannofossil zonation of Martini (1971), Varol (1998), and Burnett (1998) were used.

LITHOSTRATIGRAPHY

The study area is built up of the Upper Albian–Lower/Middle Eocene rocks. Nine lithostratigraphic units in a rank of formation (Jasień Formation, Białe Formation, Malinowa Shale Formation, Szczawina Sandstone Formation, Ropianka Formation, Jaworzynka Formation, Łabowa Shale Formation, Beloveža Formation, Bystrica Formation) have been distinguished here. They were included to the Mogielica Group and to the Beskid Group.

MOGIELICA GROUP (a new group)

Name. After Mogielica Hill (1171 m) in the Beskid Wyspowy Range of the Polish part of the Western Carpathians. The name "Mogielica" was for the first time used by Świderski (1953) in a tectonic sense (Mogielica thrust-sheet), and then by Wójcik *et al.* (1996) as the name of the formation embracing the Senonian–Palaeocene deposits (Mogielica Fm.). This formation has not been formalized so far.
Polish name: Grupa mogielicka.
Subdivision. The Mogielica Group is subdivided into seven formations: the Jasień Formation, Malinowa Shale Formation, Haluszowa Formation, Białe Formation, Jaworzynka Formation, Szczawina Formation, and Ropianka Formation, spanning the time from Albian through Palaeocene.
Thickness. Variable, maximum 600 m in the Bystrica subunit and up to 500 m in the Rača subunit.
Dominant lithology. Spotty shales and variegated shales are dominant in the basal part of the Group. Thin-bedded turbidites with intercalations of turbidite limestones and subordinate, variegated shale horizons are predominant in the lower part of the Group. Massive, thick-bedded turbidites dominate in the middle part of the Group and thin-bedded turbidites with subordinate intercalations of variegated shale occur in the upper part of Group.

The Mogielica Group, spanning over 40 myrs, represents the turbidite depositional system, separated by highstand variegated clays, which can be correlated with minor sequences in term of sequence stratigraphy.
Boundaries. Lower boundary usually tectonic against various lithostratigraphic units; upper boundary sharp as sedimentary transition to the Beskid Group (cf. Oszczypko, 1991).
Geological age. Late Albian to Palaeocene.
Equivalents. Grajcarek Group in the peri-Klippen Belt zone of the Magura Nappe (see Birkenmajer & Oszczypko, 1989).

Jasień Formation (a new name)

History. The Albian–Cenomanian deposits of the Magura Nappe (Grajcarek Unit) of the Pieniny Klippen Belt (PKB) have been described by Birkenmajer (1977) as the Hulina Formation. Furthermore, Birkenmajer & Oszczypko (1989) regarded the green spotty marls occurring in the southern margin of the Mszana Dolna tectonic window (the Koninki-Kustrzyca thrust-sheet, see Burtan *et al.* 1978, Burtan *et al.* 1992) as an equivalent of the Hulina Formation.

Taking into account differences in lithological development between the Hulina Formation in the stratotype section in the PKB and observed lithology in the investigated area, we have decided to use the name "Jasień Formation" for the Albian–Cenomanian deposits in the presented division.
Name. After the Jasień Hill (1052 m), 5 km south of the Półrzeczki village (Figs 3, 5A). **Polish name:** formacja z Jasienia.
Type locality. The forest road-cut at an altitude of 840– 850 m located about 1km NWN of the Jasień Hill (Fig. 3, 5A)
Reference section. Koninki creek (Figs 4, 5C) (Oszczypko *et al.*, 1999; Oszczypko-Clowes & Oszczypko, 2004), GPS position: N 49° 35, 930', E 20° 04, 257'.
Thickness. At least 15 m.
Dominant lithology. Green and olive green, noncalcareous shales with intercalations of black, green shales and spotty shales. Sometimes small manganese nodules are observed. The shales display fracture cleavage of the pencil type.
Boundary. The bottom of the formation is tectonic. Upper boundary – at the bottom of the first red shale package, belonging to the Malinowa Shale Formation.
Distribution. This formation is known from two localities in the Koninki village (Figs 4, 5C), on the southern margin of the Mszana Dolna tectonic window. The deposits similar to the Jasień Formation are also known from the Obidowa IG-1 deep borehole (Cieszkowski & Sikora, 1976; Fig. 2) and from the uppermost part of the Gault Formation (Magura Nappe) in Moravia (for details – see Švábenická *et al.*, 1997).
Equivalents. Hulina Formation of the Grajcarek Unit in the Pieniny Klippen Belt (Birkenmajer, 1977; see also Oszczypko *et al.*, 2004) and green radiolarian shales (Barnasiówka Radiolarian Shale Formation, Bąk *et al.*, 2001) in the Silesian-Subsilesian and Skole units (Bieda *et al.*, 1963).

Malinowa Shale Formation

Remarks. The Malinowa Shale Formation has been distinguished by Birkenmajer and Oszczypko (1989) in the Krynica subunit of the Magura Nappe (see also Oszczypko *et al.*, 1990). Later, this formation was described from the Bystrica subunit (Malata & Oszczypko, 1990; Oszczypko *et al.*, 1991; Malata *et al.*, 1996). In the studied region, this formation occurs both in the Półrzeczki-Szczawa area, and in the Koninki area (Figs 3, 4) (see also, Oszczypko *et al.*, 1991, 1999; Malata & Oszczypko, 1990; Oszczypko-Clowes & Oszczypko, 2004).

In the Półrzeczki-Szczawa area, the Malinowa Shale Formation crops out both on the northern and southern sides of the Mogielica Range (Fig. 3). The best outcrops occur in the Półrzeczki village and in the vicinity of Bruski hamlet, in the core of the Białe anticline (Malata & Oszczypko, 1990; Oszczypko *et al.*, 1991) and its continuation on the northern slope of Jasień and Kustrzyca hills.

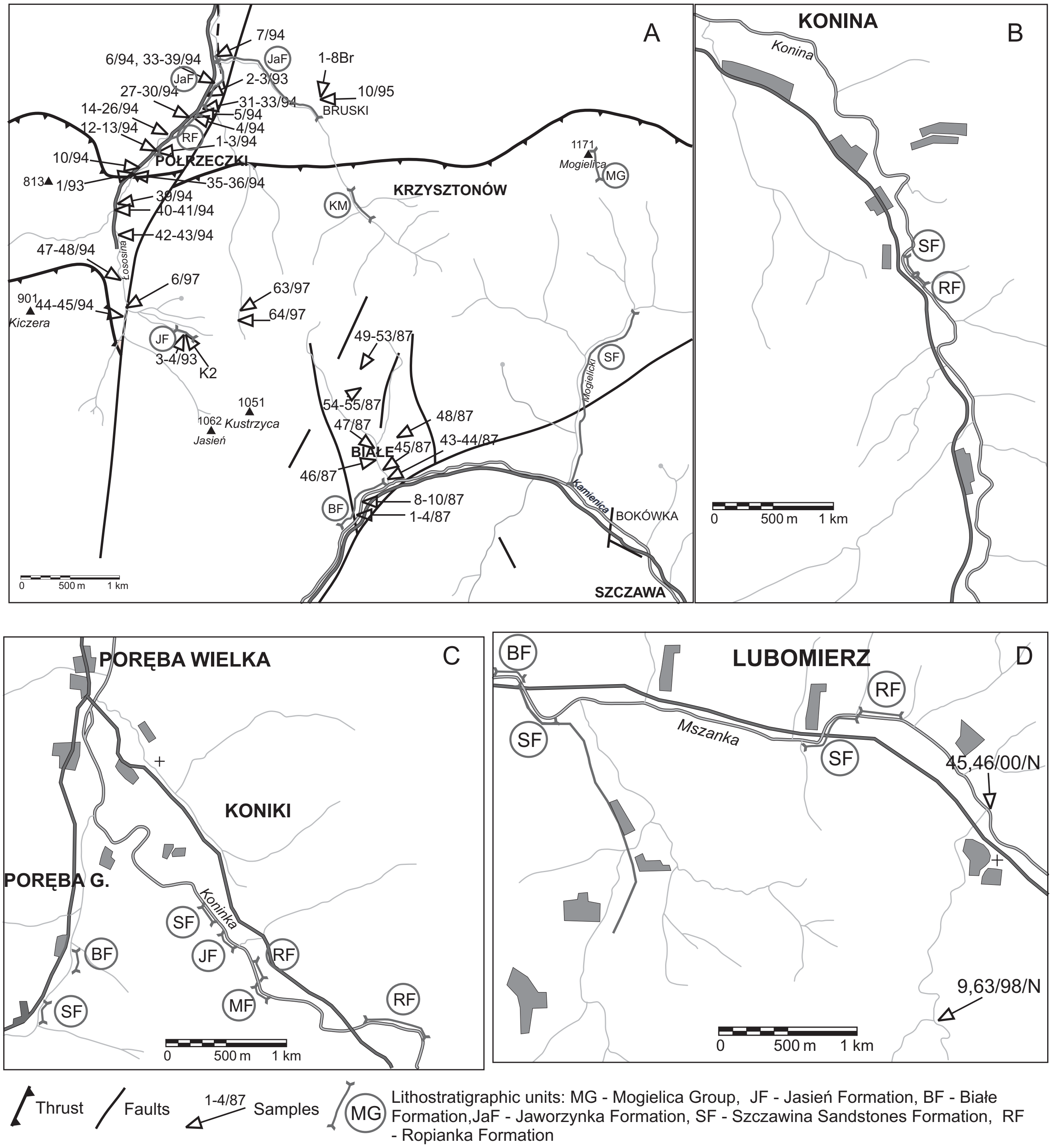


Fig. 5. Simplified geological map of the Półrzeczki-Białe-Szczawa area (Bystrica and Rača subunits; Magura Nappe) with locality of type sections and hypostratotypes of lithostratigraphic units and with position of micropalaeontological samples. 45, 46/00/N – GPS position of selected stratotype sections

The lower boundary of the Malinowa Shale Formation is sharp, located at the base of the first red shales. The cherry-red (Fig. 6A), non-calcareous shales occur in 30–50 cm layers, intercalated by grey-greenish shales, a few to 25 cm thick. Partly, grey-green shales are thicker and contain intercalations of thin-bedded (1–7 cm), single sandstone beds, 30–65 cm thick. Northeast of the Półrzeczki village at the Bruski hamlet, the Malinowa Shale Formation contains a few intercalations of thick-bedded, coarse to medium-grained quartz-glauconite sandstones, laminated quartzitic mudstones and hornstones. The thick-bedded sandstones revealed the palaeotransport from W and WNW. The frequency of grey-green shale intercalations increases in the upper portion of the formation, and deposits display sometimes features of the Hałuszowa-type facies (cf. Zasadne section; Malata & Oszczypko, 1990). The upper boundary is sharp, located at the top of the last, thick appearance of the red shales (Fig. 6B).

Fig. 6. **A** – Red shales of the Malinowa Shale Formation; Koninki stream in Koninki; **B** – Boundary between the Malinowa Shale Formation and the Białe Formation; Koninki stream in Koninki; **C** – Thin-bedded turbidites of the basal part of the Białe Formation, Kamienica River in Białe

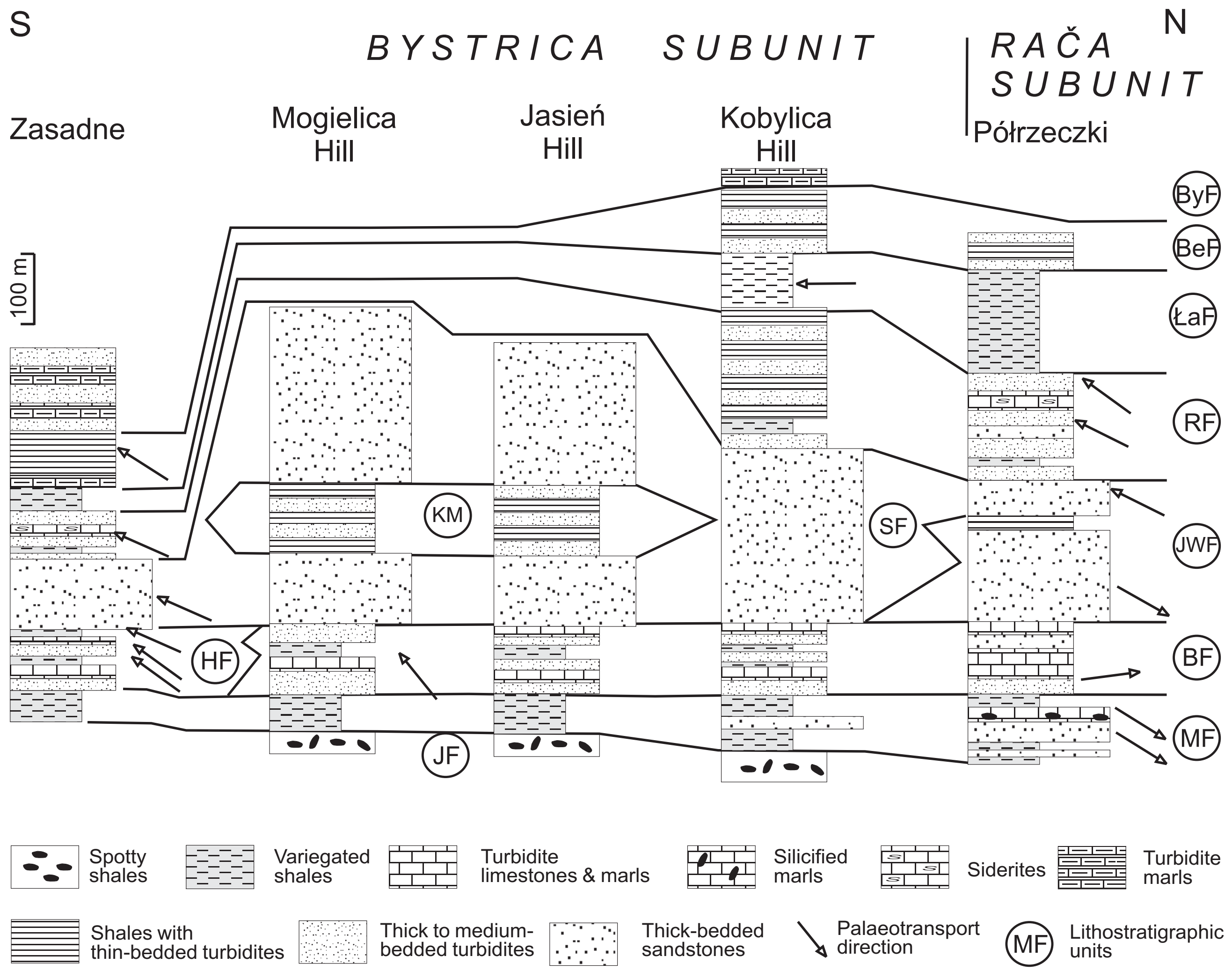


Fig. 7. Lithostratigraphic logs of the Upper Albian–Lower/Middle Eocene deposits in the Rača and Bystrica subunits in the Półrzeczki-Białe-Szczawa area, Magura Nappe, Western Flysch Carpathians. Lithostratigraphic units: JF – Jasień Formation; MF – Malinowa Shale Formation; HF – Hulina Formation; BF – Białe Formation; JaF – Jaworzynka Formation; SF – Szczawina Sandstone; KM – Krzysztonów Member, RF – Ropianka Formation; ŁaF – Łabowa Shale Formation; BeF – Beloveza Formation; ByF – Bystrica Formation

Total thickness of the Malinowa Shale Formation reaches at least 100 m in the Bruski hamlet, *ca*. 50 m on the slopes of Jasień Hill and at the Zasadne section (Fig. 7; see also Malata & Oszczypko, 1990; Cieszkowski *et al.*, 1999), and at least 40–50 m in the area of Białe village (Malata & Oszczypko, 1990). Geological age of this formation ranges between Turonian and Late Santonian (Malata & Oszczypko, 1990; Cieszkowski *et al.*, 1999, Malata, 2001).
Equivalents. Lower part of the Kaumberg Formation in the Moravia (Švábenická *et al.*, 1997) and the lower part of the Cebula Formation in the Pilsko area (Pivko, 2002, see also Sikora & Żytko, 1959; Golonka & Wójcik, 1978a, b).

Hałuszowa Formation
Remarks. The Hałuszowa Formation represents a transitional unit between the variegated shales of the Malinowa Shale Formation and thin-bedded turbidites of the Białe Formation (described below). This unit is composed of grey turbidite marls with intercalations of medium to thin-bedded turbidites and red marls. In the Zasadne and Młyńczyska sections (Malata & Oszczypko, 1990; Malata *et al.*, 1996), the Hałuszowa Formation replaces laterally the Białe Formation. In the Poręba Górna and Koninki sections, thin intercalations of red marls occur in the upper part of the Malinowa Shale Formation. Thickness of the formation reaches 100 m (Zasadne section: Malata & Oszczypko, 1990; Cieszkowski *et al.*, 1999). Geological age – Late Santonian–Campanian (Malata & Oszczypko, 1990; Cieszkowski *et al.*, 1999).
Equivalents. Upper part of the Kaumberg Formation in the Moravia (Švábenická *et al.*, 1997) and upper part of the Cebula Formation in the Pilsko area (Pivko, 2002, see also Sikora & Żytko, 1959, Golonka & Wójcik, 1978a, b).

Białe Formation (a new name)
History. The Senonian–Palaeocene deposits of the Magura Nappe have been traditionally referred to the Inoceramian beds (e.g., Bieda *et al.*, 1963). In the investigated area this unit has been sometimes divided into three divisions, known as the lower, middle, and upper Inoceramian beds (Cieszkowski *et al.*, 1987, 1989). The lower part of the Inoceramian beds is known as the Kanina beds. For the first time,

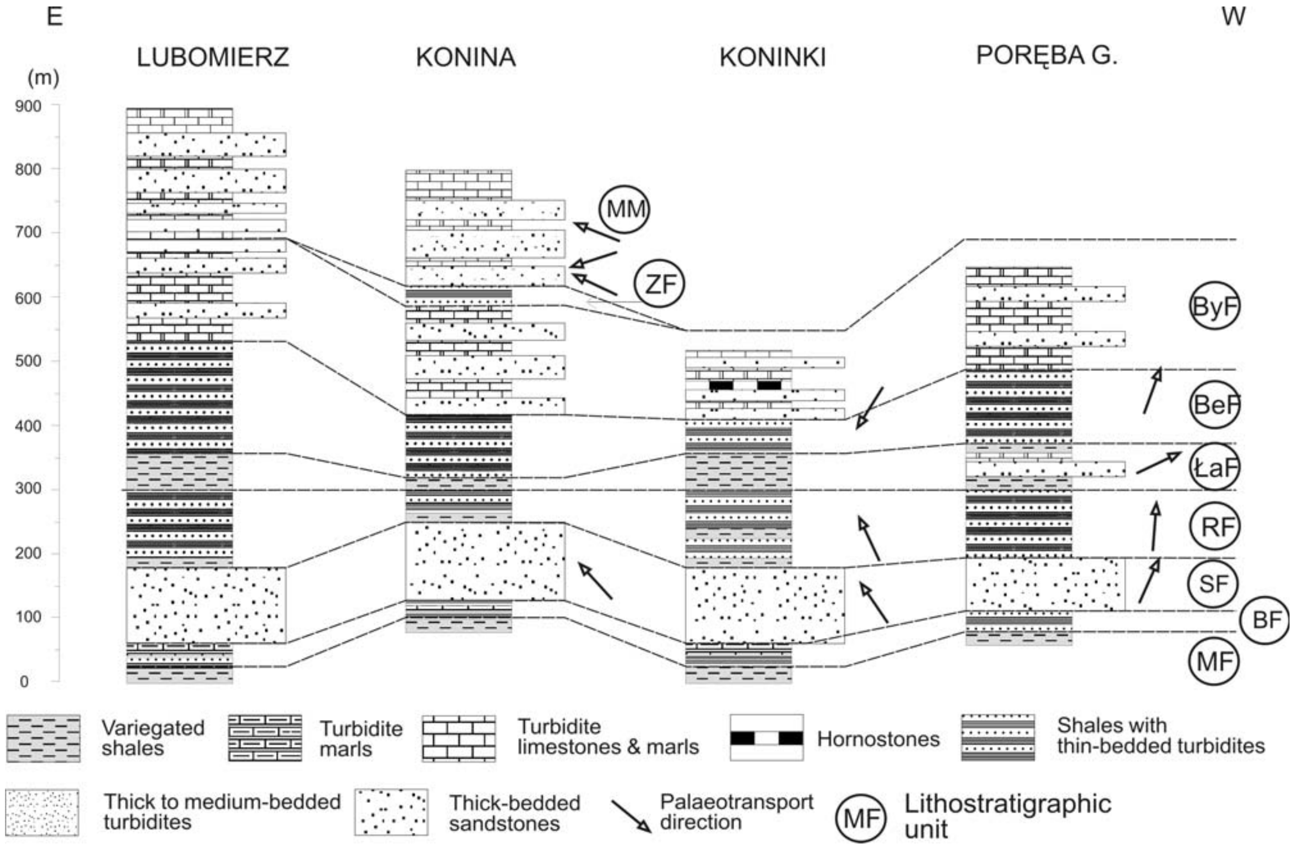


Fig. 8. Lithostratigraphical logs of the Upper Cretaceous–Eocene deposits in the Bystrica subunit in the southern margin of the Mszana Dolna tectonic window. Lithostratigraphic units: MF – Malinowa Shale Formation; BF – Białe Formation; SF – Szczawina Sandstone Formation; RF – Ropianka Formation; ŁaF – Łabowa Shale Formation; BeF – Beloveža Formation; ByF – Bystrica Formation; ZF – Żeleźnikowa Formation; MM – Maszkowice Member of the Magura Formation

the name "Kanina Beds" was used by Kozikowski (1953) in the marginal part of the Magura Nappe (Rača subunit), NW of Nowy Sącz. The subdivision of the Inoceramian beds was also used by the authors of the Detailed Geological Map of Poland (e.g., Burtan *et al.*, 1976, 1978; Paul, 1980a,b, Oszczypko & Wójcik, 1992). However, it should be stressed out that deposits included on these maps to the Kanina beds vary considerably in their stratigraphic position, lithology and thickness. Good exposures of the Kanina beds have been recently described from the Szczawa and Młyńczyska areas by Cieszkowki *et al.* (1987, 1989), Oszczypko *et al.* (1991), Oszczypko (1992b), and Malata *et al.* (1996). Due to the bad state of exposures in the Kanina area, the present authors have decided to propose a new formal lithostratigraphic unit for those deposits, which were previously described as the Kanina Beds.

Name. After the Białe hamlet, 5 km NW of the Szczawa village (Figs 3, 5A). **Polish name.** Formacja z Białego.

Type locality. 500 m long exposure along the left bank of the Kamienica River (Figs. 3, 5A); about 1 km NNW of the Białe hamlet (Bystrica subunit): GPS position – base of the section: N 49° 37, 480', E 20° 15, 060'; top of section: 49° 37, 057', E 20° 14, 536'.

Reference sections. Lubomierz section – a basal part of the Magura Nappe; Lubomierz creek, beneath the bridge across the road Mszana Dolna-Zabrzeż (Figs. 4, 5D), GPS position: N 49° 37, 140', E 20° 09, 695'; section of Poręba Górna – a basal part of the Magura Nappe overthrust, Poręba Górna creek (Figs. 4, 5C), GPS position: N 49° 35, 886', E 20° 03, 699'.

Thickness. Variable, from 10 m in Poręba – Koninki thrust sheet (Rača subunit) to *ca.* 50 m in the Konina – Lubomierz thrust-sheet (Bystrica subunit; see also Oszczypko-Clowes & Oszczypko, 2004). Thickness amounts to 100 m close to the Mogielica Hill (Figs. 7, 8).

Dominant lithology. Thin- to medium-bedded turbidites with intercalations of grey-bluish and grey-yellowish pelites (Fig. 6C). The formation is composed of 3–5 cm thick, very fine, calcareous sandstones, displaying Tc and Tcd Bouma intervals. Sporadically, 10–15 cm thick, fine-grained sandstones with Tbc+conv intervals are observed (Fig. 9A–C). Greenish and yellowish marly shales, usually bioturbated, a few to tens of centimetres thick, reveal very fine, parallel lamination. In the middle and upper parts of the formation, a complex (a few metres thick) of thin- to thick-bedded sandstones and marls, with rare intercalations of red shales and red marls has been observed (Oszczypko *et al.*, 1991). The uppermost portion of the formation displays thin-to medium-bedded turbidites with numerous, 5–7 to 30 cm thick, intercalations of turbiditic limestones (Cieszkowski *et al.*, 1989). The marls are rich in *Helminthoida* ichnosp. (= *Nereites irregularis* (Schafhautl).

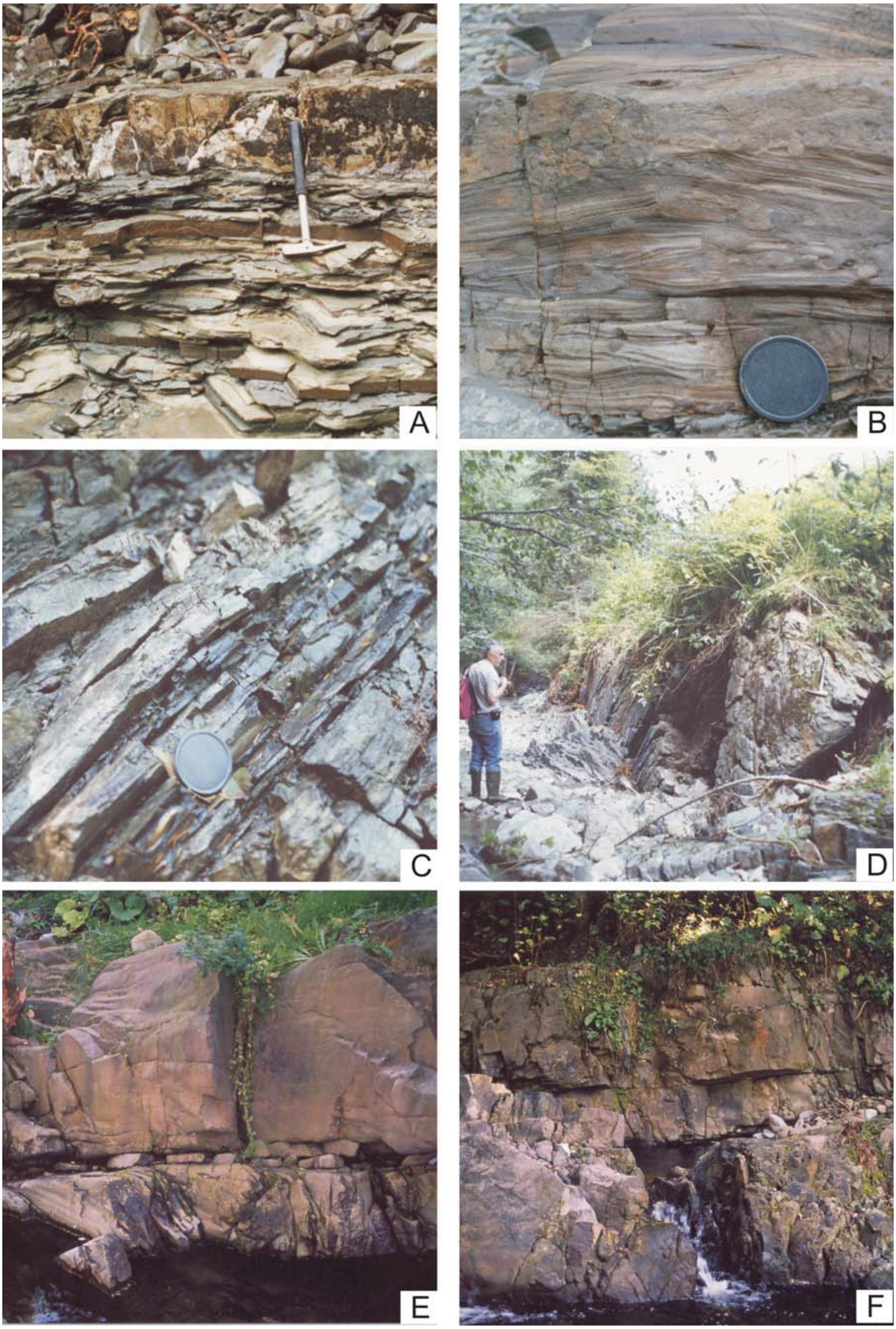


Fig. 9. **A** – Typical development of the basal of the Białe Formation, Kamienica River at Białe; **B** – Cross-laminated, medium-bedded sandstone of the Białe Formation; Kamienica River at Białe; **C** – Thin-bedded turbidites of the Białe Formation at Półrzeczki; **D** – Thick-bedded sandstones of the Jaworzynka Formation; Półrzeczki section; **E** – Thick-bedded sandstones of the Szczawina Sandstone Formation in the Koninki section; **F** – Thick-bedded sandstones of the Szczawina Sandstone Formation in the Koninki section

In the Poręba section, the lower part of the formation (see Oszczypko-Clowes & Oszczypko, 2004) is composed of grey-green, non-calcareous shales, a few metres thick. The middle part of the sequence is dominated by dark-grey mudstone/siltstone couplets and very fine-grained, thin-bedded, muscovite sandstones. The upper part of this sequence is composed of thin- to medium-bedded sandstones, intercalated by dark-grey silty/shaly couplets (green/yellowish if weathered). The yellowish siltstones are often calcareous and strongly bioturbated (*Helminthoida* ichnofacies; Cieszkowski *et al.*, 1999). In the Poręba Górna section, the Białe Formation, including a few thin intercalations of red shales, resembles the Hałuszowa Formation from the Zasadne section (Oszczypko-Clowes & Oszczypko, 2004).

The Białe Formation reveals a coarsening and thickening upward sequence, which contains heavy minerals of zircone-tourmaline-rutile, partly with chromite spinels (e.g., Lubomierz section, see Oszczypko & Salata, submitted to print). The sandstones of the Białe Formation reveal palaeotransport from the SE.

Boundaries. Lower boundary – at the top of the last thick intercalation of red shale package belonging to the Malinowa Shale Formation. Upper boundary – at the bottom of thick-bedded sandstones of the Szczawina Sandstone Formation (Figs 7, 8).

Geological age. Early-middle Campanian in the studied area (Bąk & Oszczypko, 2000; Malata, 2001), and late Campanian–early Maastrichtian in the Młyńczyska area (Malata *et al.*, 1966).

Distribution. The Bystrica and Rača subunits in the Polish part of the Magura Nappe.

Equivalents. The Hałuszowa Formation in the Krynica subunit (Birkenmajer & Oszczypko, 1989) and the Bystrica subunit (Zasadne section).

Jaworzynka Formation (a new name)

History: Sikora and Żytko (1959) described the biotite-feldspar beds in the marginal part of the Magura Nappe, in the Beskid Wysoki Range (Siary subunit). These beds are characterized by thick-bedded sandstones of grey (dirty)-green colour, medium to coarse-grained, with feldspars and admixture of glauconite and biotite. The thick-bedded sandstones are accompanied by thin intercalations of grey-green and black argillaceous shales with siderite concretions. According to Sikora and Żytko (1959), the age of the biotite-feldspar beds is the Late Cretaceous–Palaeocene, and their thickness reaches 200 m.

Burtan (1973) named this unit as the Biotite beds from Jaworzynka. The name was given after the village Jaworzynka, which is located SW of Żywiec. In the stratotype area (marginal part of the Magura Nappe SW of Żywiec), the Biotite beds are developed as thin to medium-bedded, flysch deposits. These beds were also described by Burtan *et al.* (1978) from the southern and eastern margins of the Mszana Dolna tectonic window, close to the Półrzeczki village. **Polish name:** formacja z Jaworzynki.

Type area. Marginal part of the Magura Nappe, SW of Żywiec.

Thickness. Variable, *ca.* 150–200 m.

Reference sections: Półrzeczki-Jurkowa creek (Figs 3, 5A) and Koninki creek.

Dominant lithology. In the Półrzeczki area, the Jaworzynka Formation is not homogenous in respect to lithology. Its lower part, *ca.* 50 m thick, is represented by thick-to very thick-bedded, green-grey, non-calcareous sandstones and fine-grained conglomerates, dominated by quartz and metamorphic pebbles with subordinate admixture of biotite and glauconite (Fig. 9D).The sandstones are intercalated by grey-greenish, non-calcareous shales. This part of the formation displays flute casts showing palaeotransport from WWN and W. The upper part of the formation, up to 150 m thick, is composed of thick-bedded, medium- to fine-grained muscovitic sandstones, which display palaeotransport from SE. These sandstones resemble the Szczawina Sandstone lithofacies (Fig. 7). In the Koninki area, this formation is represented by a 5–8 m thick, fining and thinning upward sequence. The lower part of this sequence, 3–4 m thick, is composed of thick-bedded sandstones (50–150 cm), very coarse- to medium-grained, sometimes amalgamated with Tab Bouma intervals. The thick-bedded sandstones (partly glauconitic) from this section reveal some similarities to those from the Jaworzynka beds of the Grybów Unit, displaying similar palaeotransport directions, from the NW and SE.

Boundaries. Lower boundary – transitional, from thin-bedded turbidites of the Białe Formation to thick-bedded sandstones. Upper boundary – sharp, thick-bedded sandstones against the thin-bedded turbidites of the Ropianka Formation (Fig. 7).

Distribution. The Rača and Siary subunits of the Magura Nappe in Poland; Grybów Unit in the Polish part of the Western Carpathians.

Geological age. Middle Campanian to early Maastrichtian.

Equivalents. Biotite-feldspar beds (Sikora & Żytko, 1959; Biotite beds from Jaworzynka (Burtan *et al.*, 1978, pro parte), partly Solan Formation in Moravia (Švábenická *et al.*, 1997), Szczawina sandstones (Sikora & Żytko, 1959; Cieszkowski *et al.*, 1989; Oszczypko, 1992a, b; Malata *et al.*, 1996), Szczawina sandstones of the Rača subunit (Pivko, 2002).

Szczawina Sandstone Formation (a new name)

History. The Szczawina sandstones have been described by Sikora and Żytko (1959) in the Beskid Wysoki Range (Rača subunit). This lithostratigraphic unit is commonly used in many publications for the description of the Upper Senonian–Palaeocene, thick-bedded, muscovite sandstones (Bieda *et al.*, 1963; Geroch *et al.*, 1967; Sikora, 1971; Cieszkowski *et al.*, 1989; Oszczypko, 1992a, b; Malata *et al.*, 1996). Recently, in the northern part of the Orava area (W Slovakia), Pivko (2002) has distinguished the Szczawina sandstones in two different positions: as a member of the Ropianka Formation in the Bystrica subunit, and as a formation between the Cebula and Ropianka formations in the Rača subunit.

Name. After Szczawina Hill in the Beskid Wyspowy Range (see Fig. 2 in Sikora & Żytko, 1959). **Polish name:** formacja piaskowców szczawińskich.

Type area. Central part of the Magura Nappe, south-west of

Żywiec (Sikora & Żytko, 1959) and the southern part of the Beskid Wyspowy Range (Oszczypko *et al.*, 1991; Malata *et al.*, 1996).

Reference section. In the Beskid Wysoki Range type area, the best exposures of the Szczawina Sandstone Formation are known from the nothern slope of the Pilsko Hill (1557 m) and the top of the Szczawina Hill (1356 m) (see Fig. 2 and Plate XXI in Sikora & Żytko, 1959). The following type areas from the Beskid Wyspowy Range type are recommended: the section along the right bank of the Kamienica River, between Białe and Bukówka hamlets (Figs 3, 5A; see also Oszczypko *et al.*, 1991; Cieszkowski *et al.*, 1989), Koninki and Poręba Górna (Figs 4, 5C; see also Oszczypko *et al.*, 1999; Oszczypko-Clowes & Oszczypko, 2004), GPS position: N 49° 35, 920', E 20° 04, 997' and 49° 35, 688', E 20° 03, 416' respectively. The very good exposures are also known from the Konina (Figs 4, 5B), Zasadne (Malata & Oszczypko, 1990; Cieszkowski *et al.*, 1992, Malata *et al.*, 1992), and Lubomierz sections (Cieszkowski *et al.*, 1992).

Thickness. Variable, from 20 m in the Poręba Górna area (Rača subunit), to 80–350 m in Zasadne, Mogielica Hill, Jasień Hill, and Kobylica Hill (Bystrica subunit) (Figs 5, 6).

Subdivision. In the Mogielica and Krzysztonów sections (Figs 3, 5A, 7), within the Szczawina Sandstone Formation, the Krzysztonów Member can be distinguished. This Member, 50–80 m thick; is composed of thin-bedded turbidites.

Dominant lithology. Mainly thick-bedded, grey-green sandstones with thin intercalations of shales. The thickness of sandstone beds varies from 0.5–0.6 m to a few metres (Figs 9E, F). The sandstones are coarse- to fine-grained, locally with small pebble admixture. The conglomerate beds are locally frequent in the uppermost portion of the formation. The sandstones are composed of quartz, clasts of metamorphic rocks, and feldspars. The characteristic feature of the formation is a considerable content of mica flakes (mainly muscovite) and small admixture of glauconite. The sandstones are carbonate-cemented. The sandstone and conglomerate beds are separated by layers of green, black, locally red, argillaceous shales with intercalations of thin to medium-bedded sandstones. Its basal portion, *ca*. 25 m thick, is dominated by thin- to thick-bedded calcareous sandstones with intercalations of turbidite limestones, marls and, locally, red shales. Flute-cast (Fig. 10A) measurements display palaeotransport from the south-east. This part of the sequence resembles the Kanina beds (see Cieszkowski *et al.*, 1989). The Kanina-like flysch passes upwards into thick-bedded sandstones of the Krzysztonów Member (for details – see below).

In the Poręba Górna area (Rača subunit), the Szczawina Sandstone Formation, at least 20 m thick, is dominated by thick and very thick-bedded (40–250 cm), medium to very coarse grained sandstones with slightly carbonate cement. The basal parts of the beds are composed of light-grey, quartz-glauconitic, coarse-grained sandstones, while grey, calcareous sandstones and mudstones, rich in flakes of muscovite and coalified plants, are typical at the top of the beds. The muscovite sandstones display palaeotransport also from SE.

Boundaries. Lower boundary – transitional, from thin-bedded turbidites of the Białe Formation to thick-bedded sandstones. Upper boundary – sharp; thick-bedded sandstones against the thin-bedded turbidites of the Ropianka Formation.

Distribution. The Bystrica and Rača subunits in the Polish part of the Magura Nappe.

Geological age. Middle Campanian–early Palaeocene.

Krzysztonów Member (a new name)

Name. After Krzysztonów hamlet, between Łososina River and Mogielica Hill in the Beskid Wyspowy Range (see Fig. 5). **Polish name:** ogniwo z Krzysztonowa.

Type area. Exposures along a creek (right tributary of the Łososina River) in the Krzysztonów hamlet (Bystrzyca subunit) (Fig. 5A).

Reference section. Right tributary of the Łososina River, north of Jasień Hill (Figs 5A, 7).

Thickness. Between 50–80 m (Fig. 7).

Dominant lithology. Thick-bedded sandstones (1.0–2.0 m thick), which reveal the $T_{abc+conv}$ Bouma divisions. The sandstones are very coarse- to fine-grained, muscovitic, with carbonate cement, rich in shale clasts, up to 15 cm in diameter, occasionally armoured. The sandstone beds are intercalated by rare, dark-grey shales, up to a tens cm thick. The sandstones were deposited by palaeocurrents from the SE.

Boundaries. Lower boundary – transitional, from medium-bedded turbidites to thick-bedded sandstones. Upper boundary – transitional; thick-bedded sandstones against the medium and thin-bedded turbidites.

Distribution. The Bystrica subunit in the Polish part of the Magura Nappe.

Geological age. Maastrichtian.

Ropianka Formation

History. The name Ropianka beds, established more than 130 years ago (Paul, 1869), has been very often used as an equivalent of the Inoceramian beds. Furthermore, the Ropianka Formation was established as a formal lithostratigraphic unit in the Skole nappe (Kotlarczyk, 1978). The section regarded as the stratotype of the Ropianka beds was studied by Ślączka & Miziołek (1995). They documented that this section contains deposits of different age (from the Late Cretaceous to Oligocene) belonging to the Dukla and Magura nappes. According to Ślączka and Miziołek (1995), the name "Ropianka beds" should not be applied for the rocks in the Magura Nappe, however, considering long tradition of this name, they suggested to use it only for thin-to medium-bedded turbidites of the Upper Inoceramian beds. In this sense, the name of the Ropianka beds was used by Malata *et al.* (1996). We also support this point of view in the present study.

Reference sections. The Jurkowy creek (Figs 3, 5A) in the Półrzeczki village (Rača subunit), and the following sections in the Bystrica subunit: the Jastrzębia creek and upper course of the Jeżowa Woda creek in the Młyńczyska area (Malata *et al.*, 1996), the lower course of the Głębieniec creek in the Szczawa area, the Zasadne section (Malata *et al.*, 1992), the Konina section (Figs 4, 5B), and the middle course of the Koninki creek (Fig. 5C), *ca*. 150 m higher up of the bridge (Oszczypko *et al.*, 1999; Oszczypko-Clowes &

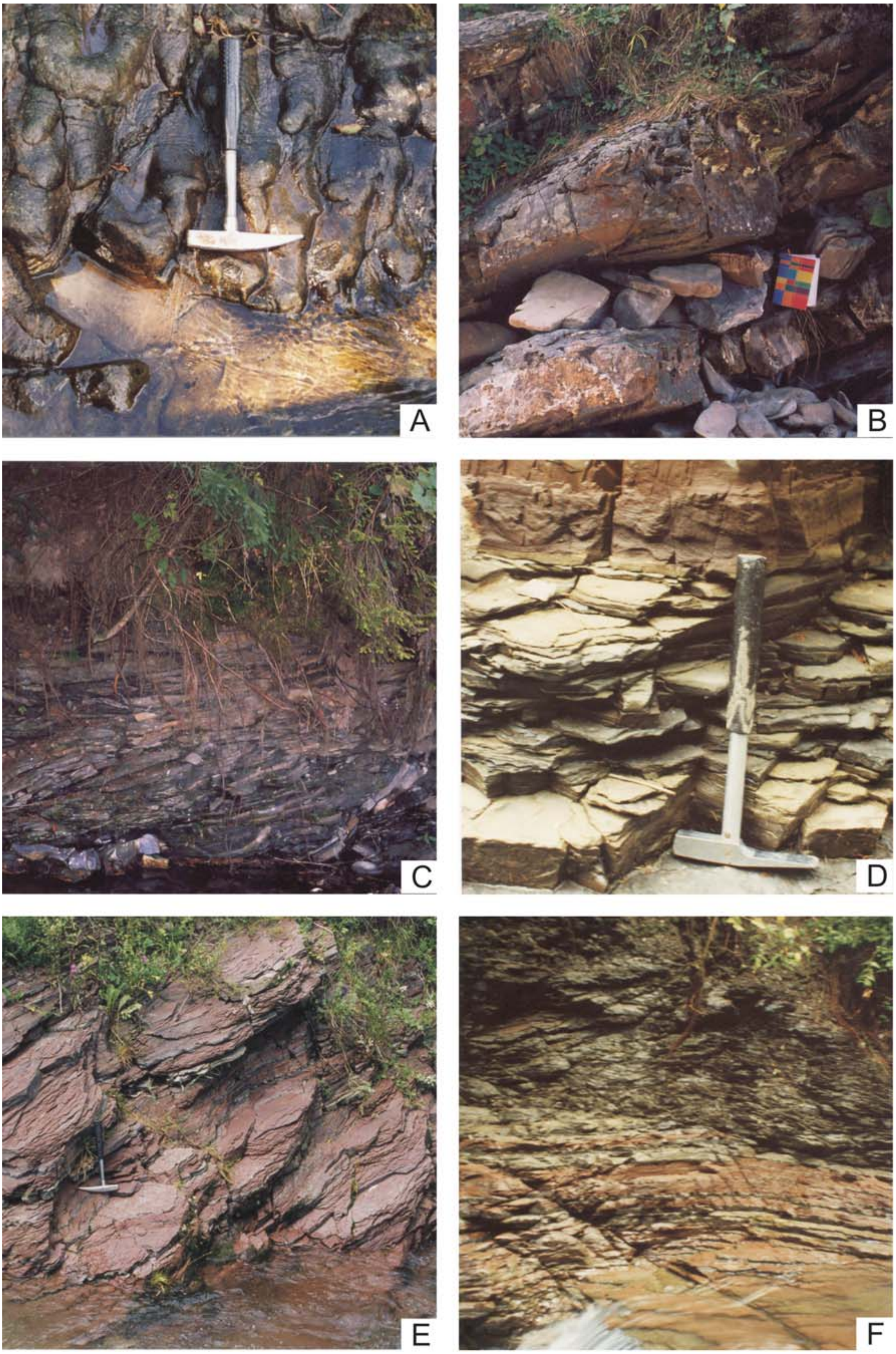


Fig. 10. **A** – Flute-casts at the base of the Szczawina Sandstone Formation in the Koninki section; **B** – Thick-bedded quartzitic sandstone at the bottom of the Ropianka Formation in the Koninki section; **C** – Thin-bedded turbidites of the Ropianka Formation in the Koninki section; **D** – Turbiditic limestone at the top of the Ropianka Formation in the Półrzeczki section; **E**– Red shales of the Łabowa Shale Formation in the Lubomierz section; **F** – Variegated shales of the Łabowa Shale Formation in the Półrzeczki section

Oszczypko, 2004), GPS position:N 49° 35, 746', E 20° 04, 786'; top of the section: 49° 37, 057', E 20° 14, 536'.
Thickness. Variable, up to 250 m in the Rača subunit and 80–100 m in the Bystrica subunit (Figs. 7, 8).
Dominant lithology. Lithological features are different in the Rača and Bystrica subunits. The lower part of the Ropianka Formation is composed of thin- to medium-bedded turbidites with subordinate intercalations of thick-bedded (0.6–1.0 m), coarse- to medium-grained, parallel-laminated sandstones (Fig. 10B–D). In this part of the sequence, a 8-cm thick intercalation of red, calcareous shales has been observed. Thin- to medium-bedded sandstone beds (5–35 cm) are mainly fine- to very fine-grained, calcareous, muscovitic, with parallel, cross and convolute lamination. Greyish-green sandstones are intercalated with dark, muscovitic mudstones, coalified plant flakes, and dark-grey and blue, usually carbonate-free shales. Locally, in the upper part of the formation, intercalations of dark-grey, medium-bedded and very fine-grained, glauconite and biotite-rich, non-calcareous sandstones are observed. Single layers of turbiditic limestones and siderites have also been found. The uppermost part of the formation (*ca*. 50–70 m thick) displays a sequence of zebra-like, thin-bedded turbidites (Tcd,Td Bouma intervals), with light-grey mudstones and dark-grey-coloured sandstones. The mudstones are often bioturbated.

In the Bystrica subunit (Figs 7, 8), this part of the formation contains locally frequent, thin intercalations of red shales (see Młyńczyska, Zasadne, Koninki, Konina). Flute-cast measurements display palaeotransport from WWN in the lowermost portion of the formation (Półrzeczki area, Rača subunit) and from to EES–SSE in the Bystrica subunit (and also in the upper part of the Półrzeczki area of the Rača subunit). The Ropianka Formation contains zircone-tourmaline-rutile heavy minerals (Oszczypko & Salata, submited to print).
Boundaries. In the Rača subunit, lower boundary is transitional from thick-bedded (60–80 cm) sandstones of the Jaworzynka Formation to medium-thin-bedded turbidites, whereas in the Bystrica subunit, this boundary is sharp, from thick-bedded sandstones of the Szczawina Sandstone Formation to very thin-bedded turbidites with intercalation of red shales. The upper boundary is sharp in both subunits, against the first few metres thick layer of the variegated shales belonging to the Łabowa Shale Formation.
Geological age. Maastrichtian–Palaeocene.
Equivalents. Upper part of the Solan Formation in Moravia (Švábenická *et al.*, 1997), Ropianka beds (Golonka & Wójcik, 1978a, b; Malata *et al.*, 1996), Ropianka Formation (Pivko, 2002).

BESKID GROUP

This group was distinguished in the Krynica subunit (for details – see Birkenmajer & Oszczypko, 1989).

Łabowa Shale Formation

Remarks. The deposits belonging to the Łabowa Shale Formation (Oszczypko, 1991) occur in the Półrzeczki area (Fig. 3) as well as at the southern margin of the Mszana Dolna tectonic window (Oszczypko *et al.*, 1999; Oszczypko-Clowes & Oszczypko, 2004), in a narrow belt between Olszówka and Lubomierz (Fig. 4). The lowermost portion of the formation is represented by red shales (Fig. 10E–F), a few metres thick, passing upwards into very fine-bedded turbidites. Very fine-grained, green, carbonate- free sandstones (with Tc Bouma interval) pass upwards into green shales, and finally to red shales, mainly soft and free of carbonates, a few cm thick. In the Poręba Górna area, the lowermost part of this formation contains two layers of thick-bedded sandstones (up to 2 m) and intercalations of grey marls. These sandstones reveal palaeotransport from ESE. Thick layers of the red shales are known from the middle part of the Lubomierz village (Fig. 10E). In the Poręba Górna and Lubomierz sections, the thickness of the formation attains 50 m. In the Półrzeczki area, the formation occurs in a broad synclinal zone, in the centre of the village, and in a narrow belt on the southern slope of Kobylica hill. In the Jurkowa creek, the lowermost portion of the formation is represented by a few metres thick sequence of red shales, passing upwards into very thin-bedded turbidites. The turbidite sequence usually begins with thin-bedded (1–6 cm), very fine-grained (Tc), green, carbonate-free sandstones, passing up to green shales, a few centimetres thick, and finally to thin package of red shales, also a few centimetres thick. The shales are mainly soft and carbonate-free. In the middle part of the formation, 2–3 m thick package of red shales occurs. Subordinately, green or blue shales with intercalations of thin-bedded sandstones are observed (Fig. 10F). Thickness of the formation varies from a few dozen metres up to 200 m in the Półrzeczki section.
Distribution. In all the facies-tectonic subunits of the Magura Nappe, with exception of the Krynica subunit (see Bieda *et al.*, 1963, Oszczypko, 1991, Leszczyński & Uchman, 1991).
Geological age. Early Eocene.

Beloveža Formation

Remarks. The Beloveža Formation (Oszczypko, 1991) is very well exposed along the southern margin of the Mszana Dolna tectonic window (Oszczypko *et al.*, 1999; Oszczypko-Clowes & Oszczypko, 2004). This formation is composed of thin- to medium-bedded turbidites (Tc+conv. and Tcd Bouma intervals). The shales, which vary in colour, distinctly prevail over sandstones. The yellowish and brown shales are usually calcareous, while the green ones are, as a rule, carbonate-free. The accompanying medium-bedded (20–40 cm), T_{bc} sandstones occur less frequently. Thickness of this formation reaches 50–120 m (Figs 7, 8). In the Półrzeczki area, the Beloveža Formation crops out along a narrow depression between Bania and Kiczora hills (Fig. 3), and in the Łososina River in the Półrzeczki village. In the basal part of the formation, a sequence of alternating layers of various coloured shales occurs. A few intercalations of red shales have also been observed in this part of the section. The accompanying muscovitic sandstones are very fine-grained and thin-bedded (5–12 cm). The medium-bedded (20–40 cm), T_{bc} sandstones appear subordinately in the Jurkowa creek. In the Półrzeczki area, the thickness of the Beloveža Formation reaches no more than 50 m.

Bystrica Formation

Remarks. The Bystrica Formation (Oszczypko, 1991) occurs in a narrow syncline between Bania and Kiczora hills and SE of Kobylica Hill. This formation comprises thin- to medium-bedded turbidites of the Beloveža-lithotype with intercalations of the Łącko Marls. The marls are massive, sometimes silicified, brown or blue to grey and whitish as weathered. The thickness of individual beds of the Łącko Marls ranges from 2 to 5 m. The intercalations of the "Beloveža-type" flysch are 0.5 to 2 m thick. The thickness of the formation can be roughly estimated at 50 m (Figs. 7, 8).

BIOSTRATIGRAPHY

FORAMINIFERA

Several stratigraphical zonal schemes, based on the deep-water agglutinated foraminifera (DWAF) have been proposed for the Cretaceous–Palaeogene deposits of the Outer (Flysch) Carpathians (e.g., Morgiel & Olszewska, 1981, Geroch & Nowak, 1984; Olszewska, 1997). Unfortunately, the distinguished zones coincide poorly with chronostratigraphic scale due to scarcity of calcareous nannoplankton and planktonic foraminifera in the Upper Cretaceous–Palaeocene sediments.

The studied succession includes practically only noncalcareous deep-water sediments; thus, the DWAF are the base for the local biostratigraphy. Planktonic foraminifera, in most cases redeposited within diluted gravitational flows, occur only as single specimens.

The distinguished biostratigraphical zones are based on the cosmopolitan DWAF species, used also in the other zonal schemes, both for the Outer Carpathians (Geroch & Nowak, 1984; Bubik, 1995; Malata *et al.*, 1996, Bąk *et al.*, 1997; Olszewska, 1997; Bąk, 2004), Northern Atlantic, and Western Tethys (Kuhnt *et al.*, 1992; Kuhnt & Kaminski, 1997). However, definitions of these zones using the same index species are different in the particular zonal schemes (cf. summary in Bąk, 2004).

The chronostratigraphy is based on comparisons with the stratigraphic ranges of identified species in the North Atlantic and the Western Tethys. The Cretaceous part of the studied succession has been compared with the chronostratigraphy by Gradstein *et al.* (1994), and the Palaeogene with a time scale of Berggren *et al.* (1995).

Deep-water agglutinated foraminiferal zones

***Plectorecurvoides alternans* Interval Zone**

Definition: Lower boundary – first appearance of *Plectorecurvoides alternans* (Noth) – not observed in the studied succession; upper boundary – the first occurrence (FO) of *Bulbobaculites problematicus* (Neagu).

Remarks: index taxon accompanied by *Hippocrepina depressa* Vašiček, *Pseudonodosinella troyeri* (Tappan), *Plectorecurvoides irregularis* Geroch, and *Gerochammina stanislavi* Neagu.

Age: late Albian–early/middle Cenomanian.

***Bulbobaculites problematicus* Interval Zone**

Definition: Lower boundary – the FO of *Bulbobaculites problematicus* (Neagu); upper boundary – the FO of *Uvigerinammina jankoi* Majzon.

Remarks: index taxon accompanied by *Caudammina crassa* (Geroch), *Recurvoides imperfectus* Hanzlikova, *Thalmannammina neocomiensis* Geroch, *Plectorecurvoides alternans* (Alth), *P. irregularis* Geroch and *Gerochammina stanislavi* Neagu.

Age: Middle Cenomanian–Cenomanian/Turonian boundary.

***Uvigerinammina jankoi* Interval Zone**

Definition: Lower boundary – the FO of *U. jankoi*; upper boundary – the FO of *Caudammina gigantea* (Geroch).

Remarks: in the lower part of the zone the index species is very numerous. The species known from the abyssal oceanic deposits such as ?*Praecystammina globigeriniformis* Krasheninnikov, *Trochammina gyroidinaeformis* Krasheninikov are relatively frequent in this part of the zone. Other abyssal species, such as *Pseudobolivina cuneata* Krasheninikov and *P. munda* Krashenninikov may be also present. The upper part of the zone is characterized by the abundant presence of *Gerochammina* spp. with small amount of the index taxon. *Rzehakina inclusa* (Grzybowski) has its FO in the uppermost part of the zone.

Age: Turonian–early Campanian.

***Uvigernammina jankoi-Caudammina gigantea* Concurrent Range Zone**

Definition: Lower boundary – FO of *Caudammina gigantea* (Geroch); upper boundary – last occurrence (LO) of *Uvigernammina jankoi* Majzon.

Remarks: A change in the DWAF assemblage is recorded in this zone by the disappearance of *Gerochammina* typical for the red facies and more frequent occurrence of siliceous-walled taxa.

***Caudammina gigantea* Partial Range Zone**

Definition: Lower boundary – the LO of *U. jankoi* Majzon; upper boundary – the FO of *Remesella varians* (Glaessner).

Remarks: the appearance of the index taxon may be connected with the lower-middle Campanian event (LMCE). The index taxon is often accompanied by frequent *Caudammina ovulum* (Grzybowski). In the Maastrichtian *C. gigantea* is less frequent.

Age: Campanian–early-?middle Maastrichtian.

***Remesella varians* Interval Zone**

Definition: Lower boundary – the FO of *R. varians*; upper boundary – the FO of *Rzehakina fissistomata* (Grzybowski).

Remarks: Kuhnt and Moullade (1991) defined the lower boundary of this zone as middle-late Maastrichtian in the North Atlantic. In the Zumaya section (Spain), Kuhnt and Kaminski (1997) distinguished the *R. varians* subzone) in the upper Maastrichtian. According to Olszewska (1997) *R. varians* has its FO in the early Maastrichtian.

Age: middle-late Maastrichtian.

Rzehakina fissistomata **Taxon Range Zone**
Definition: range of *R. fissistomata*.
Remarks: *Annectina grzybowskii* (Jurkiewicz) is a very characteristic species of this zone and in case of absence of *Rzehakina fissistomata* may be regarded as an equivalent index taxon.
The FO of the *Rzehakina fissistomata* (Grzybowski) is close to the Cretaceous /Tertiary boundary in the abyssal non-calcareous environments, as it was confirmed on the basis of integrated biostratigraphical studies in the Magura Nappe (Czech part of the Outer Carpathians: Bubik *et al.*, 1999).The LO of this taxon is within the late Palaeocene, however it has not been precisely defined.
Age: Palaeocene.

Glomospira **div. sp. Acme Zone**
Definition: This zone corresponds to the numerous occurrence of *Glomospira* spp.
Remarks: Numerous occurrence of small specimens of *G. charoides* (Jones & Parker) and *G. gordialis* (Jones & Parker), accompanied by numerous *Paratrochamminoides*, *Trochamminoides*, *Recurvoides*, *Karrerulina* and tubular forms; all of them have small dimensions, against underlying and overlying assemblages. This assemblage has been distinguished by Morgiel & Olszewska (1981) in the Outer Carpathians, and since that time it has been in use in the North Atlantic and the Western Tethys zonal schemes.
Age: early Eocene.

Saccamminoides carpathicus **Interval Zone**
Definition: Lower boundary: the FO of *Saccamminoides carpathicus*; upper boundary: the FO of *Reticulophragmium amplectens* – not observed in the studied succession.
Remarks: Index taxon is rare, accompanied by relatively numerous *Recurvoides* spp., *Paratrochamminoides* spp., *Glomospira* spp., and *Karrerulina conversa* (Grzybowski). Calcareous benthic species *Nuttallides truempyi* (Nuttall) has its FO.
Age: late early Eocene.

CALCAREOUS NANNOFOSSILS

Recognised calcareous nannoplankton zones

UC 15 Nannofossil Zone
Definition: Interval between the FO of *Misceomarginatus pleniporus* to the LO of *Eiffellithus eximius*.
Author: Burnett (1998).
Age: Upper early Campanian throughout upper part of late Campanian.
Remarks: The zone is dominated by the presence of genus *Watznaueria* and *Micula*. Occurrence of *C. aculeus* may indicate for at least second subzone of this Zone named by Burnett (1998) UC 15B^{TP}. From among other taxa, the species of *Broinsonia parca*, *Prediscosphaera ponticula*, and the genus *Arkhangelskiella* prevail. This subzone was distinguished primarilyonly for the Tethyan-Intermediate province for the Indian Ocean (Burnett, 1998).
Locality: Półrzeczki, Jaworzynka Beds.

Markalius inversus **Nannoplankton Zone (NP 1)**
Definition: Interval between the LO of *Arkhangelskiella cymbiformis* and the FO of *Cruciplacolithus tenuis*.
Author: Hay and Mohler (1967) emended by Martini (1971).
Age: early Danian.
Remarks: The species of *B. sparsus* is common in this Zone. *Placozygus sigmoides* first occurs within this Zone. *Cruciplacolithus primus* has its first entry in the upper part of NP 1 Zone what may be compared with the base of the *Cyclagelosphaera alta* nannoplankton Zone (NNTp2) according to Varol (1998). It is worth to add that all NP 1 Zone lays below the FO of *Coccolithus pelagicus* which is very common in the Paleocene sediments of the Ropianka Formation.
Locality: Półrzeczki, the upper part of the Ropianka Formation.

Chiasmolithus danicus **Nannoplankton Zone (NP 3)**
Definition: Interval between the FO of *Chiasmolithus danicus* and the FO of *Ellipsolithus macellus*.
Author: Martini (1970).
Age: middle Danian.
Remarks: Although the index species has not been found, the presence of genera *Chiasmolithus* and the occurrence of *Coccolithus pelagicus* are characteristic for this zone.
Locality: Półrzeczki, the upper part of the Ropianka Formation.

Heliolithus kleinpellii **Nannoplankton Zone (NP 6)**
Definition: Interval between the FO of *Heliolithus kleinpellii* and the FO *Discoaster mohleri*.
Author: Mohler & Hay in Hay *et al.* (1967).
Age: late Palaeocene (Thanetian).
Remarks: This zone is tentatively introduced herein, due to the lack of zone-marker species. The only occurrence of the *Sphenolithus* cf. *anarrophus* which ranges from NP 6 to NP 9 may indicate at least that age. This zone is also characterised by the occurrence of the *C. pelagicus* and genus *Cyclagelospahera* or *Elipsogelosphaera*. State of preservation is rather poor, the re-worked Cretaceous species are much better preserved.
Locality: Półrzeczki, the upper part of the Ropianka Formation.

Tribrachiatus contortus **Nannoplankton Zone (NP 10)**
Definition: Interval between the FO of *Tribrachiatus bramlettei* and LO of *Tribrachiatus contortus*.
Author: Hay (1964).
Age: earliest Eocene (early Ypresian).
Remarks: This zone is characterised by an occurrence of the genus *Tribrachiatus*, especially *T. orthostylus* is often found, what corresponds with upper part of NP 10 Zone (Martini, 1971). FO of this species is used by Varol (1998) for defining the base of the NNTe1 Zone.
Locality: Półrzeczki, the upper part of the Ropianka Formation.

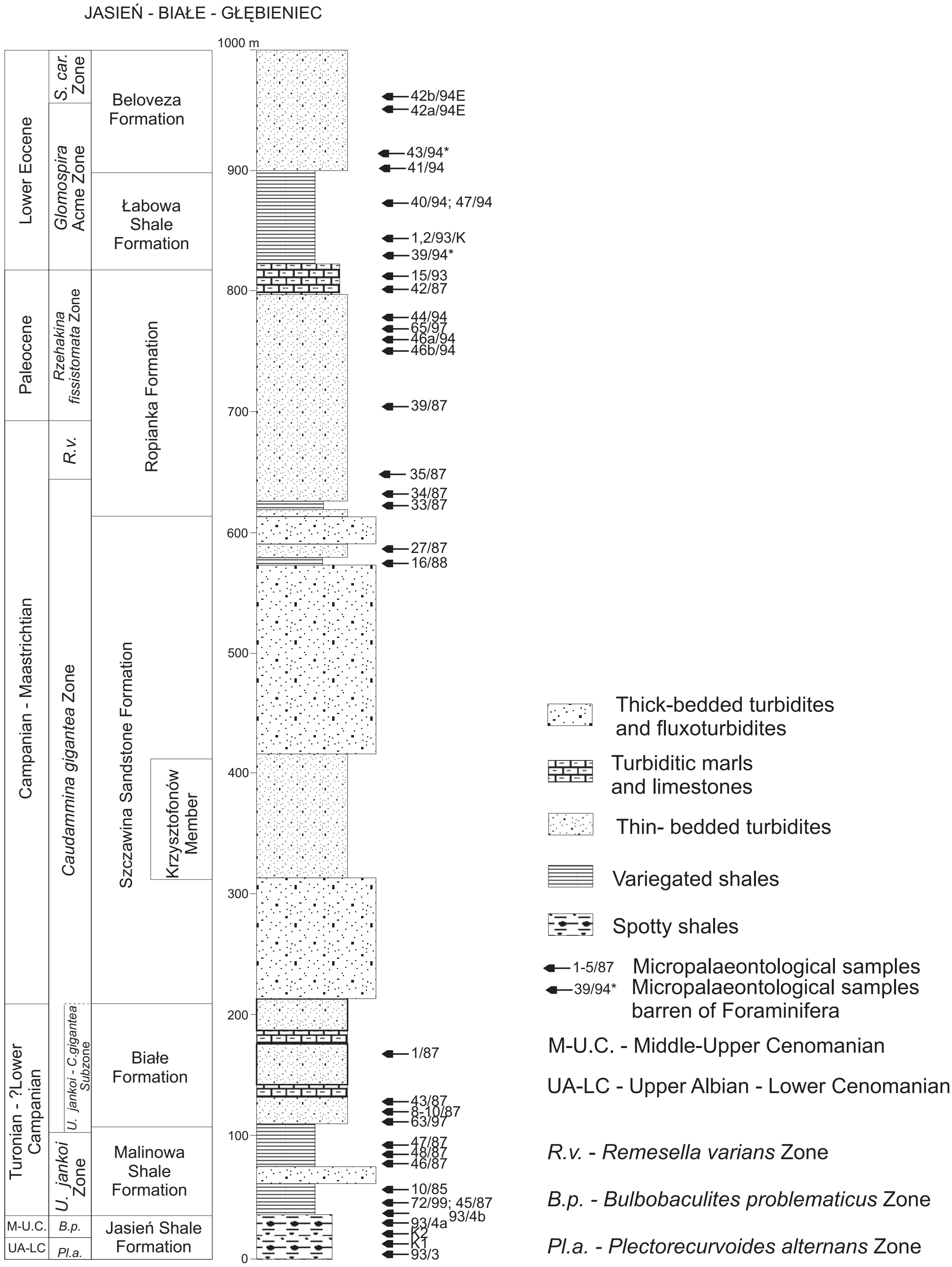


Fig. 11. Lithostratigraphic log of the Bystrica subunit in the Jasień – Białe – Głębieniec area (Bystrica subunit; Magura Nappe) with position of micropalaeontological samples

***Nannotetrina fulgens* Nannoplankton Zone (NP15)**
Definition: the base of the zone is defined by FO of *Nannotetrina fulgens*, and the top by the FO of *Rhabdolithus gladius*.
Author: Hay in Hay *et al.* (1967), emend. Martini (1970), Bukry (1973).
Age: middle Eocene.
Remarks: This zone was identified in sample 46/00/N. The zone assignment is based on the presence of genus *Nannotetrina*. According to Perch-Nielsen, the species belonging to *Nannotetrina* are dificult to distinguish in the heavily overgrown assemblages. In such case, the FO of *Nannotetrina* can be used to approximate theNP14/15 boundary in badly preserved material. The assembage does not contain the species of *Chiasmolithus gigas*. The interval between the FO and the LO of *Chiasmolithus gigas* defines Bukry's subzone CP13b (Bukry, 1973). Subzone CP13b is the equivalent of middle part Martini's NP15 zone (Martini, 1970). Thus, it can be concluded that the assemblage represents either the lowest or highest part of NP15 zone. At the same time, no species indicating NP16 was observed.

***Discoaster tani nodifer* Nannoplankton Zone (NP16)**
Definition: the base of the zone is defined by the LO of *Rhabdolithus gladius*, and the top by the LO of *Chiasmolithus solitus.*
Author: Hay *et al.* (1967), emend. Martini (1970).
Age: middle Eocene.
Remarks: This zone was identified in samples 63/98/N, 9/98/N, 45/00/N, Lubomierz, Beloveza Formation. The zone assignment is based on the presence of *Cyclicargolithus floridanus*. At the same time, *Discoaster tanii* is not present. According to Aubry (1986), the FO of *Cyclicargolithus floridanus* takes place in zone NP16.

BIOSTRATIGRAPHY VERSUS LITHOSTRATIGRAPHY

Jasień Formation

The foraminiferal assemblages are composed entirely of agglutinated taxa, varying in abundance and state of preservation (Fig. 17: samples: 93/3, K1, K2, 93/4).

The oldest assemblage is relatively poor and of low number of specimens and species diversity. However, there are present a few stratigraphically important species such, as *Hippocreppina depressa* Vasiček (Fig. 19 A), *Plectorecurvoides alternans* Noth (Fig. 19 F, and *P. irregularis* Geroch. In the succeeding samples, apart from the already mentioned species, new taxa appear and species diversity and number of specimens grow. *Pseudonodosinella troyeri* (Tappan) (Fig. 19 C) is relatively numerous, the other species, such as *Haplophragmoides falcatosuturalis* Neagu, *Buzasina pacifica* (Krasheninnikov), *Trochammina vocontiana* Moullade, and *Gerochammina stanislavi* Neagu (Fig. 19 J) are less numerous but also important for age determination. A single specimen of *Bulbobaculites problematicus* (Neagu) has also been noticed. The age of these assemblages may be included within the **late Albian–middle Cenomanian** interval due to the ranges and co-occurrence of the mentioned taxa. The first occurrence (FO) of *P. alternans* and *H. falcatosuturalis* is in the Late Albian (Neagu 1990), while the last occurrence (LO) of *T. vocontiana* has been noticed at the Albian/Cenomanian boundary. According to Geroch and Nowak (1984) and Bąk (2000), *B. problematicus* has its FO in the Middle Cenomanian, whereas according to Olszew- ska (1997) it marks the Albian/Cenomanian boundary. In the Jaworki Formation of the Pieniny Klippen Belt, *Plectorecurvoides alternans* Zone is correlated with the planktonic zones of the Early Cenomanian (Bąk, 1998). Outside the Polish Carpathians, the FO of *B. problematicus* varies; in the Romanian Carpathians it is noticed at the Albian/Cenomanian boundary, while in the marginal and oceanic basins it is regarded as a marker of the Cenomanian/Turonian boundary (Kuhnt & Kamiński, 1990). The data mentioned above suggest that this species had appeared first in the deep, flysch basins and then migrated into other environments.

The top of the Jasień Formation (Fig. 11, s. 93/4a) yielded an assemblage with relatively numerous *B. problematicus* (Fig. 19 D, E), accompanied by *Thalmannammina neocomiensis* Geroch, *Plectorecurvoides irregularis* Geroch, and less abundant *Caudammina crassa* (Geroch) (Fig. 19 B), *Recurvoides imperfectus* Hanzlikova, *Plectorecurvoides alternans* Noth, and *Trochammina gyroidinaeformis* Krashenninikov. A few juvenile specimens of *Uvigerinammina jankoi* Majzon have also been recorded. This assemblage may be correlated with the *B. problematicus* Zone representing the Middle-Upper Cenomanian (cf. Bąk, 2000) and *Uvigernammina jankoi* Zone, whose base is close to the Cenomanian/Turonian boundary (Geroch & Nowak, 1984).Thus, the Jasień Formation belongs to the *P. alternans*, *B. problematicus* and the base of *U. jankoi* zones, correlated with the later Albian–early Turonian interval.

Malinowa Shale Formation

The Malinowa Shale Formation of the Bystrica subunit, studied in the Jasień-Białe-Głębieniec and Koninki sections (Figs 11, 14), consists of exclusively agglutinated assemblages of foraminifera displaying medium species diversity from about 20 to 25 species (Figs 16, 17). In the lower part of the unit, specimens are relatively small in size. *Uvigerinammina jankoi* Majzon (Fig. 19 K, L) is the most characteristic species, usually represented by numerous specimens, and the other two genera *Gerochammina* (Fig. 19 I, J) and *Recurvoides* are generally also abundant. In some samples (Fig. 11, s. 72/99, 45/87), *Hormosina excelsa* Dylążanka, *Ammosphaeroidina pseudopauciloculata* (Majtliuk), and *Trochammina gyroidinaeformis* Krashenninikov (Fig. 19 M–O) are also numerous. The species *Pseudobolivina cuneata* Krashenninikov and *P. munda* Krashenninnikov (Fig. 19 G, H), though very rare, are also worth mentioning. These latter taxa as well as *Trochammina gyroidinoides* were described from the oceanic abyssal clays (Krashenninikov, 1973, 1974), and in the Magura Nappe were noticed for the first time in the Zasadne section (Malata & Oszczypko, 1990). Thus, the presence of these species sug-

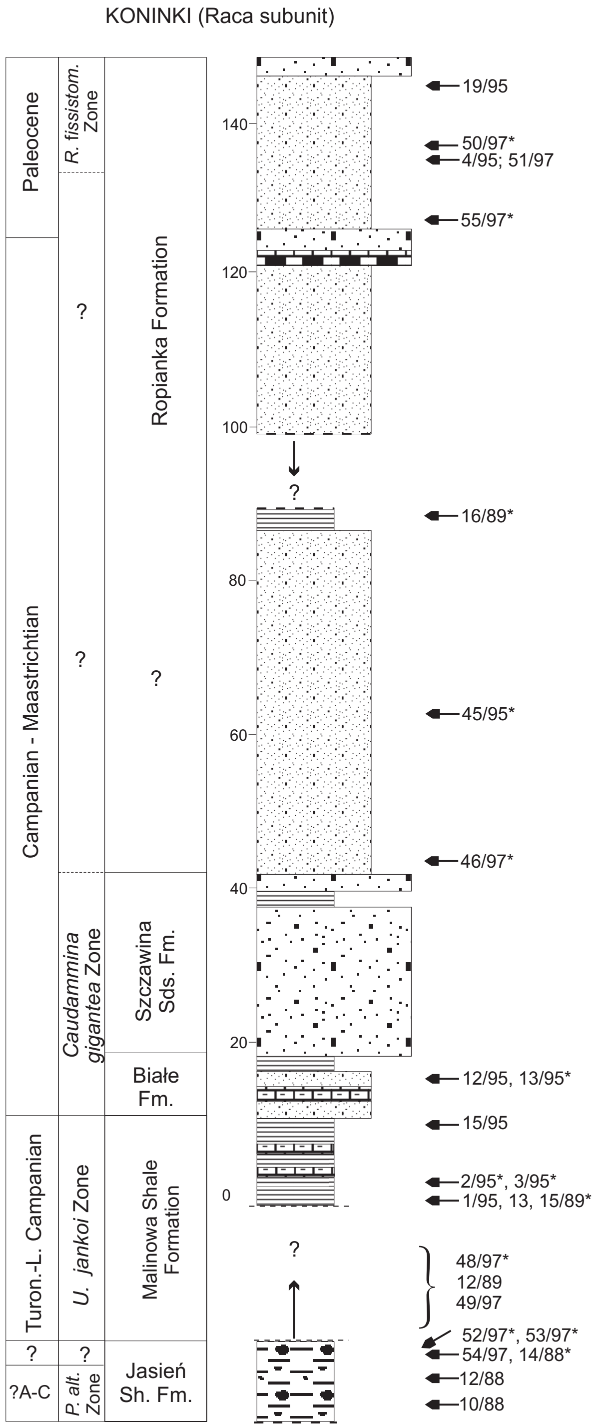


Fig. 12. Lithostratigraphic log of the Rača subunit in the Koninki area (Mogielica Range) with the position of samples. For lithological explanations – see Fig. 11

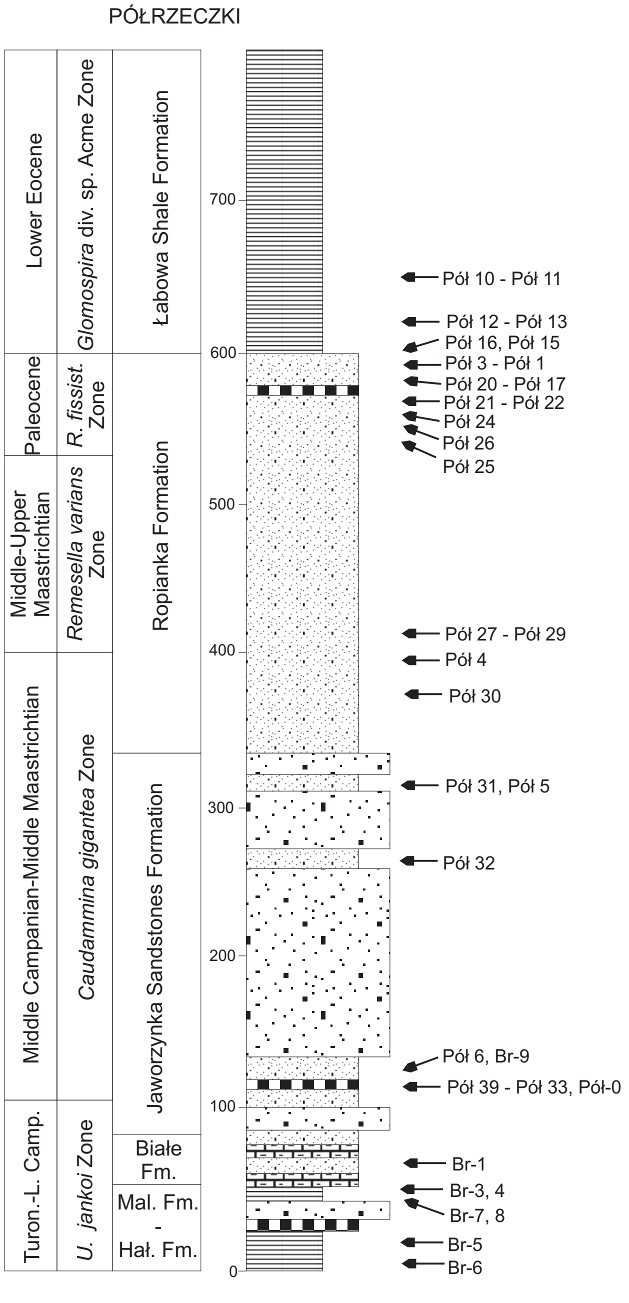


Fig. 13. Lithostratigraphic log of the Rača subunit in the Półrzeczki area (Mogielica Range), with the position of samples. For lithological explanations – see Fig. 11

gests some similarities to the abyssal type of deep-water agglutinated foraminifera (Kuhnt & Kaminski, 1989).

The species *Uvigerinammina jankoi* Majzon was used as a stratigraphic marker both in the North Atlantic and the Tethyan realm within every zonal scheme (e.g., Geroch & Nowak, 1984; Moullade *et al.*, 1988; Kuhnt *et al.*, 1989; Kuhnt & Moullade, 1991; Bąk, 2000). Its FO datum was noted in most localities just above or in the highest part of anoxic deposits representing the Cenomanian–Turonian boundary event. The LO of *U. jankoi* was recorded from the early Campanian through the middle/late Campanian (e.g., Alexandrowicz, 1975; Geroch & Nowak, 1984; Moullade *et al.*, 1988; Kuhnt *et al.*, 1989; Neagu, 1990; Kuhnt & Kaminski, 1997; Bąk, 2000). Due to lack of planktonic foraminifera and calcareous nannoplankton and taking into account the occurrence of *U. jankoi*, the age of the Malinowa Shale Formation is stated here broadly within the *Uvigerinammina jankoi* Zone *sensu* Geroch & Nowak (1984), correlated with the Turonian through the early Campanian.

In the Rača subunit sequence, studied both in the Półrzeczki and Koninki sections (Figs. 12, 13), the foraminiferal assemblage is very similar to that from the Bytrica subunit (Figs. 15, 18). Deep-water agglutinated foraminifera are the only component in these deposits, associated by moulds of Radiolaria. DWAF are poorly and medium diversified (up to 26 taxa per sample), with dominance of reddish-walled specimens of *Recurvoides*. The latter taxon makes up to 65 percent of the whole assemblage (mean 47%). Reddish-walled specimens of *Gerochammina*, *Trochammina*, *Paratrochamminoides*, *Reophax* and, tubular forms (mainly *Rhabdammina*) are frequent.

The index taxon, *Uvigerinammina jankoi* has been found only in the lower part of the Malinowa Shale Formation, most probably because of the gradual change of facies and environmental conditions up the section, which have been unfavourable for this taxon. *Uvigerinammina jankoi* was recorded only from well oxygenated environments with low input of terrigenous material in the Tethys and North Atlantic (Moullade *et al.*, 1988; Kuhnt *et al.*, 1989; Kuhnt & Moullade, 1991; Bąk, 2000). The uppermost part of the Malinowa Shale Formation consists of many sandstone and siltstone intercalations, associated with grey-green shales against the true cherry-red shales, practically devoid of coarser material in the lower part of the Malinowa Formation.

The lack of planktonic foraminifera and calcareous nannoplankton prevents precise age determination of the formation, which is stated broadly as Turonian–early/middle Campanian, similarly to the Bystrica subunit.

In the Koninki section (Fig. 12), the upper part of the Malinowa Formation consists of exclusively agglutinated assemblages of foraminifera, displaying medium species diversity (Fig. 18). The assemblages contain more numerous, in comparison with the underlying Malinowa Shale Formation, siliceous-walled forms (*Ammodiscus, Glomospira, Caudammina*) with first representatives of rzehakinids.

The most characteristic taxa of this assemblage are *Rzehakina epigona* (Rzehak), *Rzehakina inclusa* (Grzybowski), *Spiroplectinella dentata* (Alth), and single specimens of *Uvigerinammina jankoi* Majzon. These species enable to state that the Malinowa Shale Formation represents the upper part of the *Uvigerinammina jankoi* Zone, most probably correlated with the Santonian–early/middle Campanian (cf. Geroch & Nowak, 1984), on the basis of co-occurrence of these species. The FO of *Rzehakina inclusa* (Grzybowski) has been documented close to the Santonian/Campanian boundary in deep-water environments (Geroch & Nowak, 1984), and the LO of *U. jankoi* is considered to occur close to the early-middle Campanian (see discussion above).

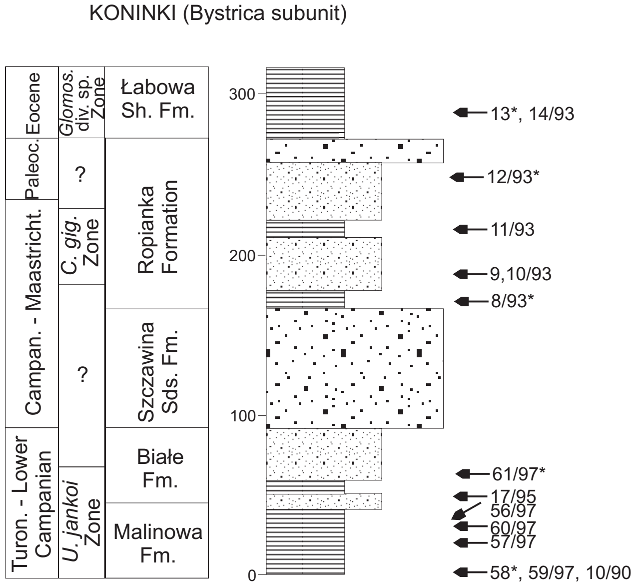


Fig. 14. Lithostratigraphic log of the Bystrica subunit in the Koninki area, with the position of samples. For lithological explanations – see Fig. 11

Białe Formation

Foraminiferal assemblages of this formation, studied in the Bystrica subunit of the Jasień-Białe-Głębieniec and Koninki sections (Figs. 11, 14) and in the Rača subunit of the Półrzeczki and Koninki sections (Figs. 12, 13), consist of exclusively agglutinated taxa showing some similarities to those from the Malinowa Shale Formation; displaying however, lower species diversity and abundance. The assemblages are characterised by a presence of rare specimens of *Uvigerinammina jankoi* and *Rzehakina inclusa* (Grzybowski) (Figs. 15, 17). Tubular forms and *Recurvoides* are almost permanent components of assemblages. The FO of *Caudammina gigantea* (Geroch), which is the index taxon of the next foraminiferal zone, has been noticed in this formation. Single specimens of this taxon have been found at the base of the formation (s. 63/97; Fig. 17), occurring together with *Uvigerinammina jankoi*.

The foraminifera recovered from the Rača subunit (Figs 15, 18) represent similar assemblage in relation to its composition and diversity, however, the base of the formation in the Półrzeczki section is devoid of *C. gigantea*, against an occurrence of *U. jankoi* (Fig. 15). On the other hand, the sample taken from the top of the formation (Koninki section; Fig. 18) does not include *U. jankoi*. This may suggest that the base of the succeeding *Caudammina gigantea* Zone occurs in the upper part of the Białe Formation. Index taxon is accompanied there by tubular forms, *Saccammina placenta* (Grzybowski), *Glomospirella diffundens* (Cushman et Renz), *Rzehakina inclusa* (Grzybowski), *Kalamopsis grzybowskii* (Dylążanka), *Caudammina ovulum* (Grzybowski), *Paratrochamminoides* spp., and *Gerochammina* spp.

Consequently, the lower boundary of the Białe Formation is diachronous. In the Rača subunit, it represents the top of the *U. jankoi* Zone, and in the Bystrica subunit, it is at the base of *U. jankoi – C. gigantea* concurrent range Zone (correlated with the early Campanian; cf. Neagu, 1990; Kuhnt & Moullade, 1991; Bąk, 2000). The upper boundary is also diachronous. It is at the top of the *U. jankoi – C. gigantea* Zone in the Bystrica subunit and at the base of *C. gigantea* Zone in the Rača subunit (correlated broadly with the middle Campanian).

Jaworzynka Formation

Only agglutinated foraminifera have been found in deposits of the Jaworzynka Formation. Samples are characterised by the common occurrence of tubular forms of the su-

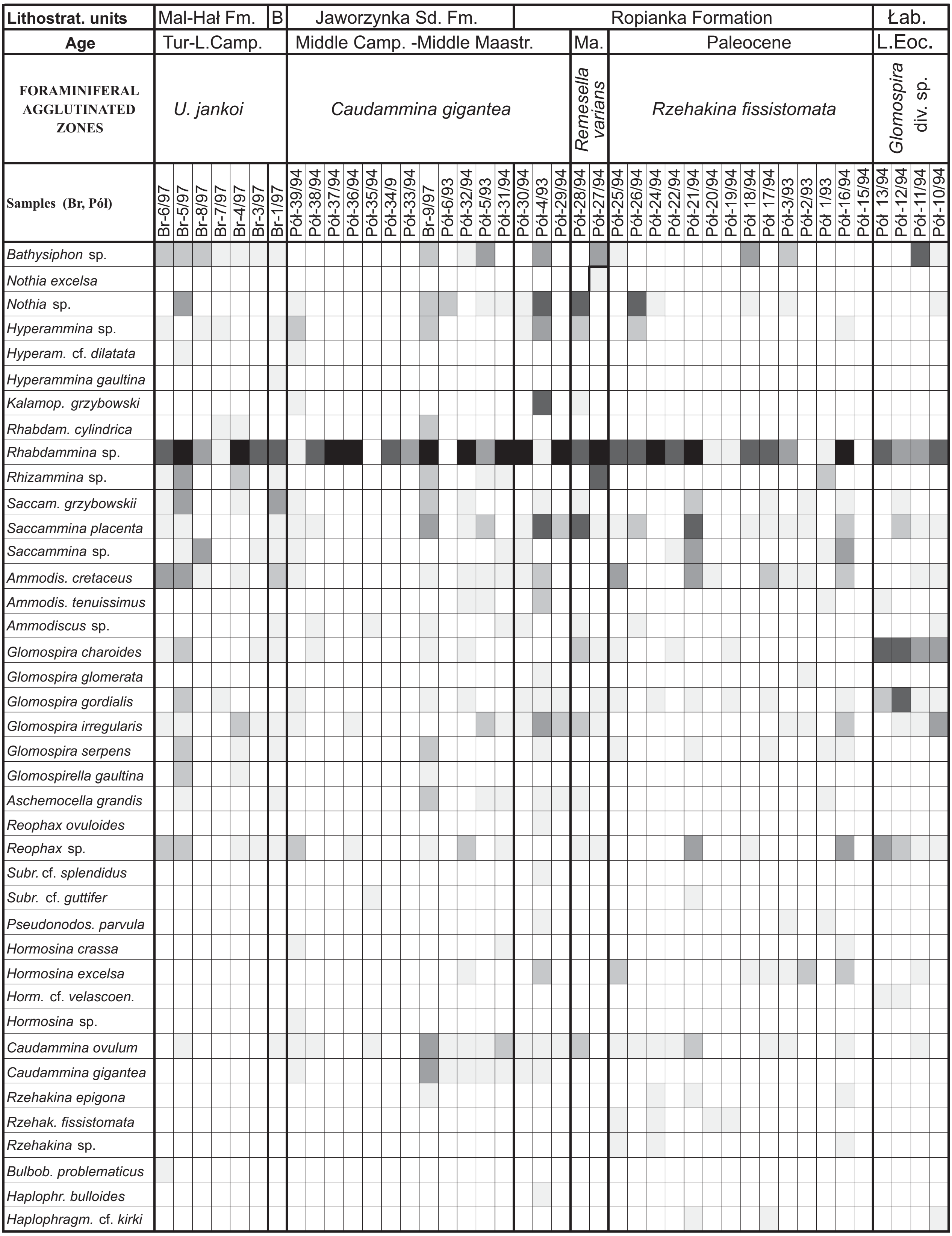
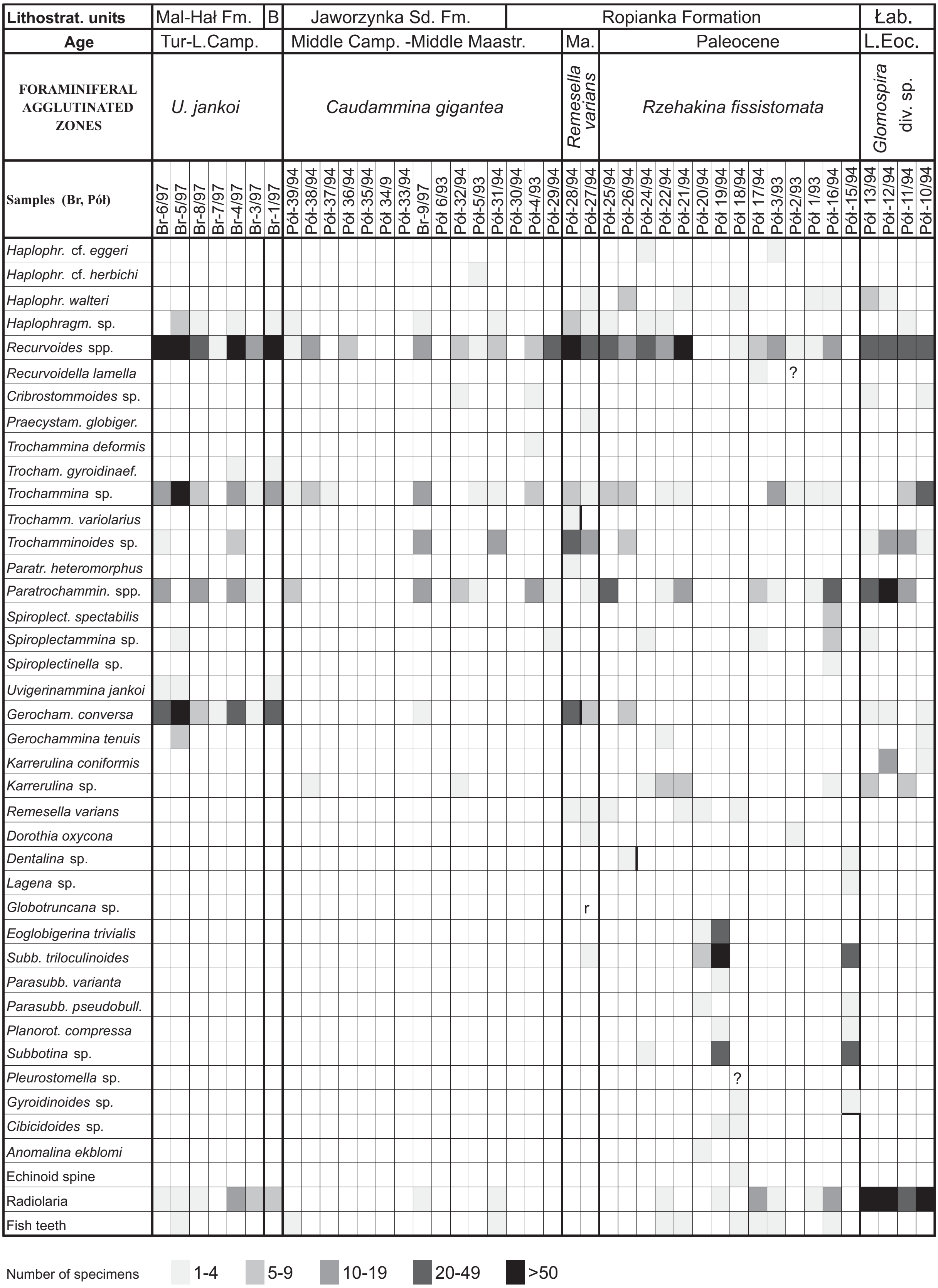


Fig. 15. Occurrence range chart of the Turonian through early Eocene Foraminifera in the Rača subunit in the Półrzeczki area. Mal Fm. – Malinowa Shale Formation; Hał Fm. – Hałuszowa Formation; B – Białe Formation; Jaworzynka Sd. Fm – Jaworzynka Formation; Łab – Łabowa Shale Formation; Ma – Maastrichtian


Lithostrat. units
Mal-Hał Fm.
B
Jaworzynka Sd. Fm.
Ropianka Formation
Łab.
Age
Tur-L.Camp.
Middle Camp. -Middle Maastr.
Ma.
Paleocene
L.Eoc.
FORAMINIFERAL AGGLUTINATED ZONES
U. jankoi
Caudammina gigantea
Remesella varians
Rzehakina fissistomata
Glomospira div. sp.
Samples (Br, Pól)
Br-6/97
Br-5/97
Br-8/97
Br-7/97
Br-4/97
Br-3/97
Br-1/97
Pół-39/94
Pół-38/94
Pół-37/94
Pół 36/94
Pół-35/94
Pół 34/9
Pół-33/94
Br-9/97
Pół 6/93
Pół-32/94
Pół-5/93
Pół-31/94
Pół-30/94
Pół-4/93
Pół-29/94
Pół-28/94
Pół-27/94
Pół-25/94
Pół-26/94
Pół-24/94
Pół-22/94
Pół-21/94
Pół-20/94
Pół 19/94
Pół 18/94
Pół 17/94
Pół-3/93
Pół-2/93
Pół 1/93
Pół-16/94
Pół-15/94
Pół 13/94
Pół-12/94
Pół-11/94
Pół-10/94
Haplophr. cf. eggeri
Haplophr. cf. herbichi
Haplophr. walteri
Haplophragm. sp.
Recurvoides spp.
Recurvoidella lamella
Cribrostommoides sp.
Praecystam. globiger.
Trochammina deformis
Trocham. gyroidinaef.
Trochammina sp.
Trochamm. variolarius
Trochamminoides sp.
Paratr. heteromorphus
Paratrochammin. spp.
Spiroplect. spectabilis
Spiroplectammina sp.
Spiroplectinella sp.
Uvigerinammina jankoi
Gerocham. conversa
Gerochammina tenuis
Karrerulina coniformis
Karrerulina sp.
Remesella varians
Dorothia oxycona
Dentalina sp.
Lagena sp.
Globotruncana sp.
Eoglobigerina trivialis
Subb. triloculinoides
Parasubb. varianta
Parasubb. pseudobull.
Planorot. compressa
Subbotina sp.
Pleurostomella sp.
Gyroidinoides sp.
Cibicidoides sp.
Anomalina ekblomi
Echinoid spine
Radiolaria
Fish teeth
?
r
?
Number of specimens
1-4
5-9
10-19
20-49
>50

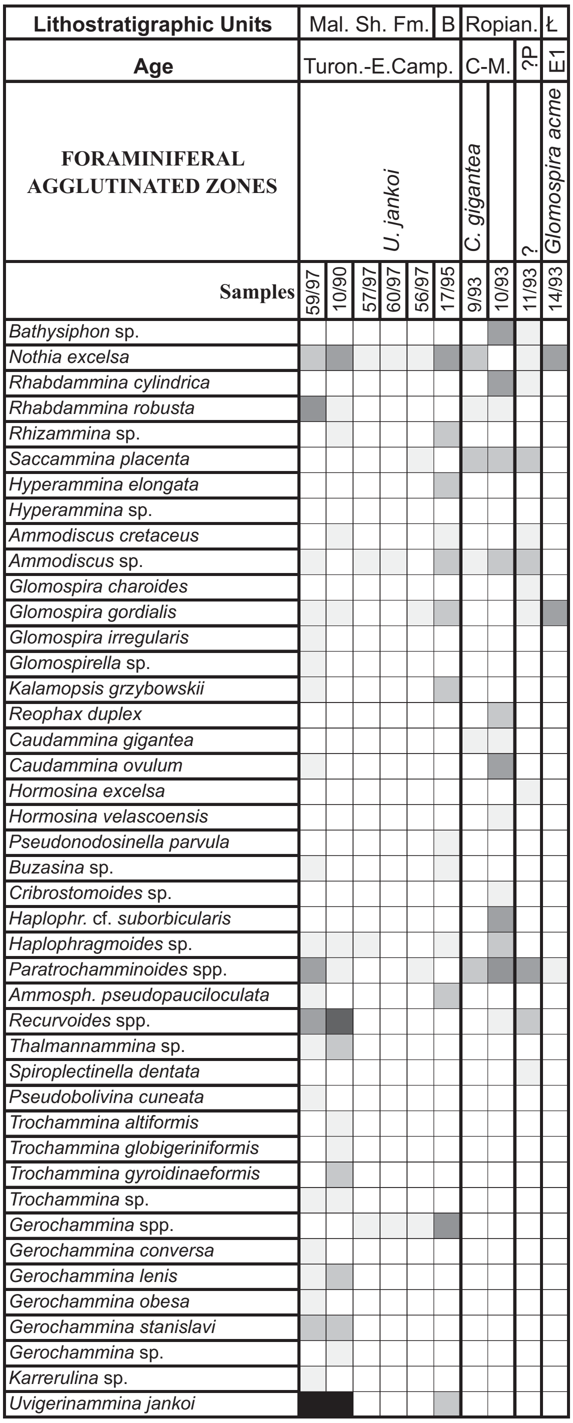


Fig. 16. Occurrence range chart of the Turonian through early Eocene Foraminifera in the Bystrica subunit in the Koninki area. Mal. Sh. Fm. – Malinowa Shale Formation; B – Białe Formation; Ropian – Ropianka Formation; Ł – Łabowa Shale Formation; C–M – Campanian–Maastrichtian; P – Palaeocene; E1 – Early Eocene

perfamily Astrorhizacea (Fig. 15). Moreover, there are numerous specimens of the following genera: *Paratrochamminoides*, *Trochamminoides*, *Reophax*, *Trochammina*, *Recurvoides*, and of such species as: *Saccammina placenta* (Grzybowski) (Fig. 20C), *S. grzybowskii* (Shubert), *Caudammina ovulum* (Grzybowski) and, *C. gigantea* (Geroch). Other foraminifera of predominantly siliceous-walled species occur occasionally.

Caudammina gigantea (Geroch) is the biostratigraphic marker of these deposits. The first occurrence (FO) of this species was noted by many authors from the early-late Campanian. Geroch & Nowak (1984) have reported its FO during the early Campanian in the Polish Flysch Carpathians, co-occurring with *Uvigerinammina jankoi* Majzon. In the Romanian Flysch Carpathians (Neagu, 1990) *C. gigantea* has been reported to appear within the *Globotruncanita elevata* planktonic foraminiferal Zone (early Campanian), similarly to the Pieniny Klippen Belt, where it was documented from the lower part of this zone (Bąk, 2000). Accepting stratigraphic significance of *Caudammina gigantea* (and lack of *U. jankoi* in the assemblage), the Jaworzynka Formation represents the lower part the *Caudammina gigantea* Zone *sensu* Geroch & Nowak (1984), which may broadly correspond with the middle-Upper Campanian through ?early Maastrichtian.

An unusual assemblage of microfauna, described in details by Bąk & Oszczypko (2000), has been found in the lowest part of the Jaworzynka Formation. Sample Pół-0/93 (Fig. 13), taken from 10 cm thick chert layer (silicified mudstone) contains very well preserved, rich assemblage of planktonic and benthic (calcareous and agglutinated) foraminifera. Silicified (most recrystallised), small radiolaria are also numerous in this assemblage. This microfauna is a typical assemblage of *Planomalina buxtorfi-Rotalipora appenninica* Zone corresponding to Late Albian, known from pelagic environments (e.g., the Pieniny Klippen Belt; Gasiński, 1988; Bąk, 1992; M.Bąk, 1999).This unusual assemblage of microfauna has been interpreted (Bąk & Oszczypko, 2000) as an example of redeposition of microfauna in the clay clasts derived from the shallower part of the basin with pelagic sedimentation in the submarine plateau environment.

Other samples from dark and black shales taken at the base of this formation are practically devoid of foraminifera. Only tubular, pyritized forms have been found there. The studied black shales and siliceous mudstones could represent the older part of the *C. gigantea* Zone *sensu* Geroch & Nowak (1984). Their tectonic position, the occurrence of siliceous facies, and scarcity of benthic foraminifera may suggest their correspondence to the upper part of the lower-middle Campanian event (LMCE). Kuhnt (1987) described similar benthic-free deposits representing the LMCE in the flysch units of the Gibraltar Arch area between *U. jankoi* and *C. gigantea* zones. Kuhnt *et al.* (1992) documented deposits in the North Atlantic devoid of benthic foraminifera that are directly overlain by the beds characterised by low-diversity agglutinated tubular forms and ammodiscids. In the Tethyan pelagic realm, the LMCE is characterised by an occurrence of biosiliceous facies (e.g., Neagu, 1968; Butt; 1981). It coincides with a taxonomic change in agglutinated foraminifers – the *U. jankoi* assemblage is replaced by the *C. gigantea* assemblage in the flysch series (Kuhnt *et al.*, 1992). The LMCE deposits have not yet been noted from the Carpathian flysch, however, the changes in agglutinated assemblages are well documented (Jurkiewicz, 1961; Geroch & Nowak, 1984; Geroch & Koszarski, 1988; Neagu, 1990).

Sample 7/94 (Fig. 13), located in the basal portion of the Jaworzynka Formation, contains a poorly to moderately preserved nannofossils assemblage dominated by the Cretaceous forms, such as *Watznaueria barnesae* or *Micula staurophora*. It yielded also *Broinsonia parca parca* and *Ceratolithoides aculeus* which indicate early Campanian (UC15 Zone), according to Burnett (1998).

Szczawina Sandstone Formation

Due to its lithological character, this formation is generally devoid of foraminifera. Only in the upper part of the formation, in the Jasień-Białe-Głębieniec section, a poor assemblage was recovered (Fig. 18). In sample 16/88, apart from a few agglutinated taxa, some poorly preserved specimens of Cretaceous planktonic foraminifera of the *Marginotruncana*- or *Globotrunacana*-type have been noticed, while in sample 27/87 there have been numerous flysch-type forms, including mainly *Rhabdammina* spp. and *Paratrochamminoides* spp., accompanied by rare specimens of *Aschemocella carpathica* (Neagu), *Caudammina gigantea* (Geroch), *C. ovulum* (Grzybowski), *Recurvoides* spp., and *Gerochammina obesa* Neagu. This assemblage belongs to the *Caudammina gigantea* Zone, correlated with the middle Campanian–early (?middle) Maastrichtian. The upper limit of this zone is diachronous in deep-water environments; the index species disappeared at different times during the Maastrichtian (Geroch & Nowak, 1984; Kuhnt *et al.*, 1992; Olszewska, 1997, Bąk, 2004).

This formation was studied earlier in the other area of the Bystrica subunit (Beskid Wyspowy Range: Młyńczyska section; Malata *et al.*, 1996), where the foraminiferal assemblage was also poorly diversified with non-characteristic deep-water agglutinated forms. However, the upper part of this formation in that region represents the lowermost Palaeocene, documented by the occurrence of planktonic foraminifera.

Ropianka Formation

Foraminiferal assemblages occurring in the Ropianka Formation vary in the state of preservation, abundance, and species diversity from section to section. The richest and stratigraphically significant assemblages have been recovered in the Półrzeczki area of the Rača subunit (Fig. 15), whereas only the uppermost part of the formation is preserved in the Koninki area. Most samples include well preserved and highly diversified DWAF. Moreover, relatively numerous Palaeocene planktonic foraminifera have been found at the top of the formation.

The lower part of this formation is characterised by numerous occurrences of tubular astrorhizids (Fig. 20A, B), *Paratrochamminoides* spp. (Fig. 22D), *Trochamminoides* spp. (Fig. 22C), and *Saccammina placenta* (Grzybowski), accompanied by ammodiscids (Fig. 21A, D–H, *Hormosina excelsa* (Dylążanka) (Fig. 20E), *Recurvoides* spp. (Fig. 22E–J) *Recurvoidella lamella* (Fig. 22K), and *Trochammina* spp. (Fig. 22N, O). A distinctive feature of this assemblage is the presence of the index taxon, *Caudammina gigantea*. The presence of this species and simultaneous lack of other short-ranging agglutinated species, suggest that the lower boundary of this formation is within the *C. gigantea* Zone, corresponding, most probably, to the early-middle Maastrichtian. The described foraminifera could be correlated with the *Saccammina-Bathysiphon* Assemblage from the Dukla Nappe (Bąk, 2004), and to the similar in taxonomic compositition, *Aschemocella-Saccammina placenta* Assemblage from the Numidian Flysch of Northern Morocco (Kaminski *et al.*, 1996). Both of them are characterised by abundant presence of the index taxa and the common occurrence of *Rhabdammina* and *Paratrochamminoides*.

The younger part of the formation (about 100 m above its lower boundary), including intercalations of calcareous shales, contains a more abundant foraminiferal assemblage. Its overall composition is similar to those described above (Fig. 15); however, there are also other taxa, such as: *Gerochammina conversa* (Grzybowski), *Karrerulina coniformis* (Grzybowski), *Reophax* sp., *Haplophragmoides* spp., and stratigraphically important species *Remesella varians* (Glaessner) (Fig. 23D–F). The first occurrence of *Remesella varians* has been reported by Kuhnt *et al.* (1989), and Kuhnt & Moullade (1991) from the middle Maastrichtian of the North Atlantic and its marginal seas. The same authors documented its FO in the upper Maastrichtian from the Zumaya section (northern Spain). Malata *et al.* (1996) described the index taxon from the Maastrichtian in the Magura Nappe (Polish Outer Carpathians), co-occurring with *Rzehakina inclusa* (Rzehak). Thus, it seems that this part of the Ropianka Formation represents the *Remesella varians* Zone, correlated with the middle-late Maastrichtian. The mentioned zones (*C. gigantea* and *R. varians*) have not been found in this formation in the Koninki area.

Well preserved specimens of *Subbotina triloculinoides* (Plummer) have been found a few metres above the earlier described deposits (s Pół-27/94; Fig. 15), documenting the base of Palaeocene in the studied section. The Cretaceous/Tertiary boundary may be situated within thin-bedded turbidites, represented by green-bluish and grey-greenish shales and marly shales, and thin-bedded (up to 10 cm) sandstones occurring in the Półrzeczki section (Fig. 13).

Rzehakina fissistomata (Grzybowski) (Fig. 21L), commonly regarded as a Palaeocene deep-water agglutinated species, has been found *ca.* 120 m above the base of the Palaeocene (s. Pół-25/94; Fig. 15). Single specimens of *Rzehakina epigona* (Rzehak) (Fig. 21I–K), *Remesella varians* (Glaessner) and numerous *Recurvoides* spp., *Karrerulina coniformis* and *Gerochammina conversa* have been also recovered from this part of the Ropianka Formation.

The Palaeocene age of the highest part of the Ropianka Formation in the Półrzeczki section is well documented by abundant planktonic foraminifera (cf. s. Pół-20, Pół-19, Pół-15; Fig. 15), including: *Eoglobigerina trivialis* (Subbotina) (Fig. 24H–K), *Parasubbotina pseudobulloides* (Plummer), *Parasubbotina varianta* (Subbotina) (Fig. 24A–G), *Subbotina triloculinoides* (Plummer) (Fig. 23N, O; Fig. 24L–O), and *Globanomalina compressa* (Plummer). *Subbotina triloculinoides* and *E. trivialis* are most frequent.

Lithostratigraphic Units	Jasień Sh				Malinowa Fm.							Białe Formation						Sz.		Ropianka Formation										Łabowa				Belov.		
Age	A3-C2		C2-T		Turonian - ?Early Campanian												Cam.-Maast.						Paleocene							Early Eocene						
FORAMINIFERAL AGGLUTINATED ZONES	*P.alt*		*B.p*		*Uvigerinammina jankoi*												*C. gigant.*					*R.v.*	*R.fiss-A.grzyb.*							*Gl.acme*				?		*S.c.*
Samples	933	K1	K2	93/4a	93/4b	72/99	45/87	10/85	46/87	48/87	47/87	8/87	9/87	10/87	43/87	1/87	63/97	16/88	27/87	33/87	34/87	35/87	39/87	46b/97	46a/97	65/97	44/94	42/87	15/93	1/93/K	2/93/K	40/94	47/94	41/94	42a/94E	42b/94E
Bathysiphon sp.																																				
Nothia excelsa																																				
Rhabdammina spp.																																				
Rhizammina sp.																																				
Psammosphaera sp.																																				
Saccammina grzybowskii																																				
Saccammina placenta																																				
Hyperammina elongata																																				
Hyperammina sp.																																				
Hippocrepina depressa																																				
Ammodiscus cretaceus																																				
Ammodiscus infimus																																				
Ammodiscus peruvianus																																				
Ammodiscus siliceus																																				
Ammodiscus tenuissimus																																				
Ammodiscus sp.																																				
Glomospira diffundens																																				
Glomospira charoides																																				
Glomospira glomerata																																				
Glomospira gordialis																																				
Glomospira irregularis																																				
Annectina grzybowskii																																				
Glomospirella cf. *gaultina*																																				
Rzehakina fissistomata																																				
Rzehakina epigona																																				
Rzehakina inclusa																																				
Rzehakina minima																																				
Aschemocella carpathica																																				
Aschemocella cf. *grandis*																																				
Aschemocella subnodosiformis																																				
Kalamopsis grzybowskii																																				
Reophax duplex																																				
Reophax nodulosus																																				
Reophax pilulifer																																				
Subreophax spp.																																				
Hormosina excelsa																																				
Hormosina velascoensis																																				
Caudammina gigantea																																				
Caudammina crassa																																				
Caudammina ovulum																																				
Pseudonodosinella troyeri																																				
Buzasina pacifica																																				
Buzasina sp.																																				
Haplophragmoides cf. *bulloides*																																				
Haplophragm. falcatosuturalis																																				
Haplophragmoides horridus																																				
Haplophragmoides kirki																																				
Haplophragmoides cf. *miatliukae*																																				
Haplophragm. suborbicularis																																				
Haplophragmoides walteri																																				
Haplophragmoides sp.																																				
Paratrochamminoides div. sp.																																				
Trochamminoides spp.																																				
Phenacophragma beckmanni																																				
Ammosph. pseudopauciloculata																																				
?Praecystam. globigeriniformis																																				
Saccamminoides carpathicus																																				
Recurvoides imperfectus																																				
Recurvoides spp. indet																																				

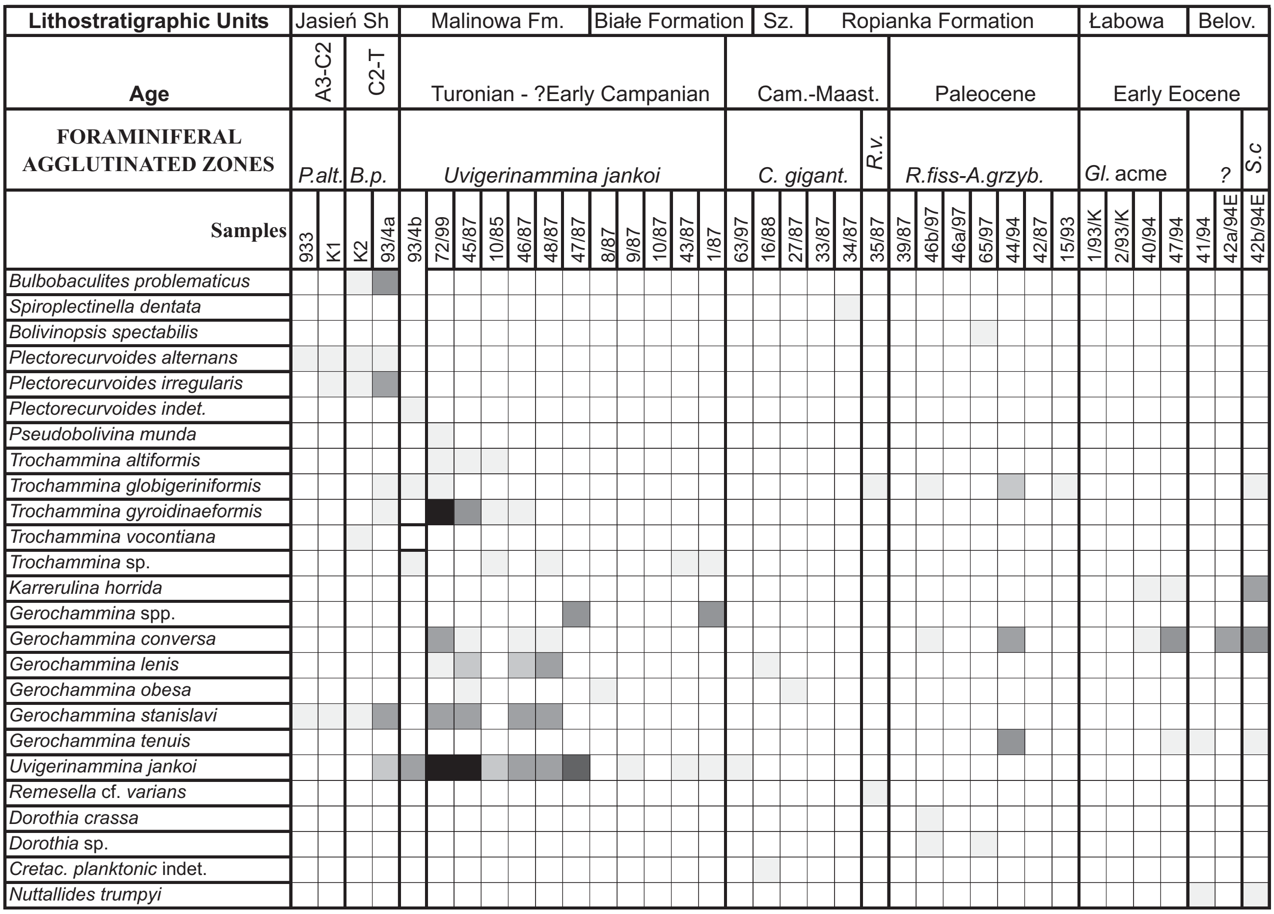


Fig. 17. Occurrence range chart of the Albian through early Eocene Foraminifera in the Bystrica subunit in the Jasień – Białe – Głębieniec area. Jasień Sh. – Jasień Shale Formation; Malinowa Fm – Malinowa Shale Formation; Sz – Szczawina Sandstone Formation; Łabowa – Łabowa Shale Formation; Belov. – Beloveža Formation; A3-C2 – late Albian – middle Cenomanian; C2-T – middle Cenomanian – Turonian; *P.al. – Plectorecurvoides alternans*; *B.p. – Bulbobaculites problematicus*; *C. gigant. – Caudammina gigantea*; *R. – Remesella varians*; *R. fiss. – Rzehakina fissistomata*; *Glom. – Glomospira* div. sp.; *S.c. – Saccamminoides carpathicus*

Planktonic species make up almost 100% of the entire microfauna in these three samples. Taking into account the stratigraphic ranges of these planktonic foraminifera (after Berggren & Norris, 1997) (Fig. 26), the studied assemblage may be correlated with the upper part of the P1c Zone through the P2 Zone (Berggren *et al.*, 1995). In the Polish Flysch Carpathians, this microfauna corresponds to the "assemblage with *Globigerina daubjergensis*" of Jednorowska (1975), "*Globigerina triloculinoides-Globigerina varianta* Zone of Olszewska & Smagowicz (1977), "*Rzehakina epigona fissistomata* Zone" of Geroch & Nowak (1984), "*Morozovella pseudobulloides* Zone of Malata *et al.* (1996), and "*Rzehakina fissistomata* Acme Zone" of Olszewska (1997).

The DWAF assemblage recovered from the other samples in the upper part of the Ropianka Formation is characterised by the relatively abundant *Spiroplectammina* spp. (s. Pół-16/94; Fig. 15), with the FO of *Spiroplectammina* (*Bolivinopsis*) *spectabilis* (Grzybowski). This species has been used as an index taxon of the Late Palaeocene zone by Geroch & Nowak (1984) in their zonation of the Polish Flysch Carpathians. The earlier appearance of *S. spectabilis* (latest Maastrichtian, near the Cretaceous–Tertiary boundary) was documented from the Trinidad by Kaminski *et al.* (1988) and from the Eastern Alps by Peryt *et al.* (1997). Accepting the autochthonous position of foraminiferal assemblage with abundant planktonic forms, the FO of *S. spectabilis* is suggested here near the top of the Early Palaeocene. Comparing various facies with *S. spectabilis* occurrences, it seems that its FO could be related to the depth of the basins; this species has not been reported from the abyssal facies. Thus, its appearance in the studied sections may be connected with the period when the depth of the basin exceeded the bathyal depths.

Taxonomic composition and stratigraphic position of the DWAF from the Ropianka Formation of the Bystrica subunit is similar to that described above (Fig. 17). The lower part of the section is characterised by the assemblage with *Caudammina gigantea* (Geroch), then assemblage with *Remesella varians* (Glaessner) and, finally, by assemblage with *Rzehakina fissistomata* (Grzybowski) with *Annectina grzybowskii* (Jurkiewicz).

The Jasień-Białe-Głębieniec section appears to be the most complete section of this formation, whereas in the Koninki area, only assemblage with *C. gigantea* was documented (Fig. 16). The higher part of this section is devoid of significant taxa; thus, it is not possible to prove its Palaeocene age.

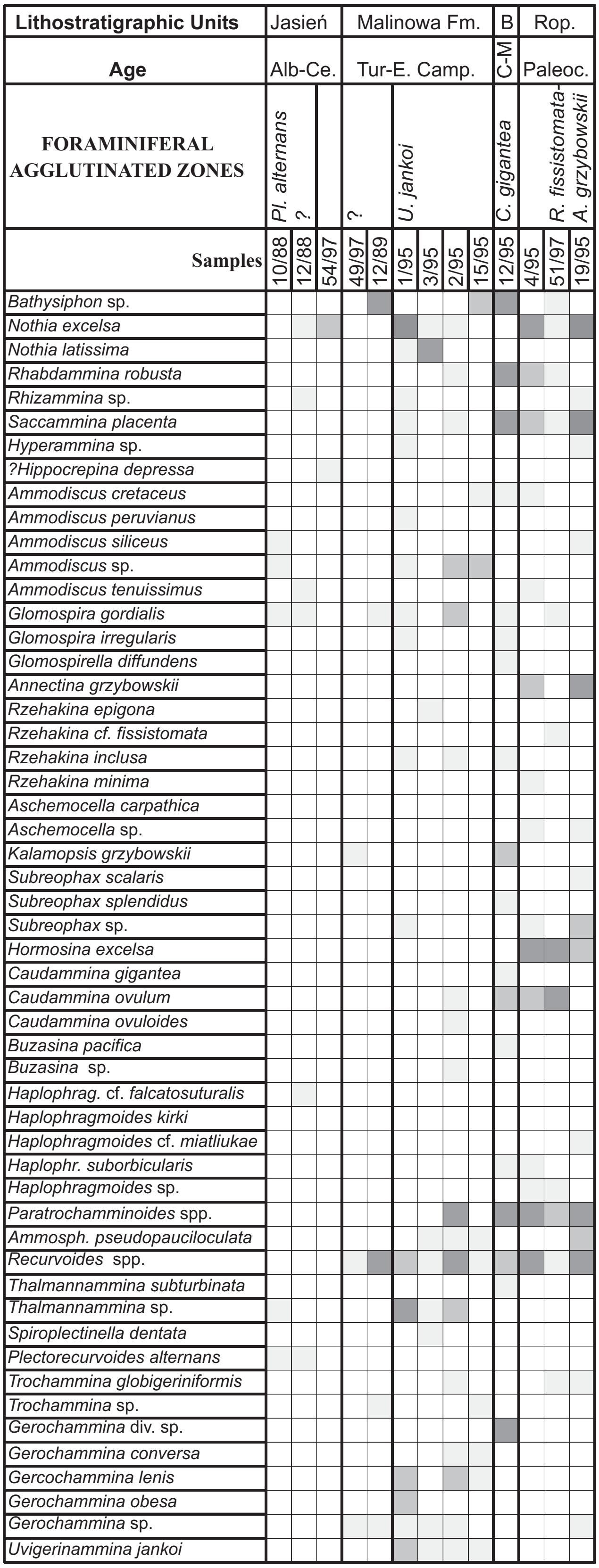


Fig. 18. Occurrence range chart of the Albian through Paleocene Foraminifera in the Rača subunit in the Koninki area. Jasień – Jasień Shale Formation; Malinowa Fm. – Malinowa Shale Formation; B – Białe Formation; Rop. – Ropianka Formation; Alb-Ce. – Albian–Cenomanian; C-M – Campanian-Maastrichtian

The studied rock samples yielded a poor and rather badly preserved nannofossil assemblage. The state of preservaion of calcareous nannoplankton should be determined as E-3, according to a scheme of Roth and Thierstien (1972). It means that studied rock material contains scarce solution-resistant species. However, some exceptions can be made for the sample 22/94 where the state of preservation (E-1) and frequency (1–10 nannofossils per field of view) are acceptable. The samples 18/94, 24/94, 27/94, II/1, II/3 do not contain recognisable calcareous nannofossils, though different methods of preparation have been used. The nannofossil assemblages from the rest of the samples point out the early Palaeocene through early Eocene age of the autochthonous sediments.

The early Palaeocene is characterised by the occurrence of *Biantholithus sparsus* and *Cruciplacolithus primus* within sample 22/94 (Fig. 26). This corresponds to the early Danian or NP 1 Zone *sensu* Martini (1971). According to Varol (1998), the FO of *C. primus* indicates the base of the NNTp2 Zone. The occurrence of *Chiasmolithus* sp. suggests that sample 1/94 may belong to the middle part of Danian (NP 3 *sensu* Martini, 1971) where genus *Chiasmolithus* had its first entry (Varol, 1998).

The late Palaeocene has been distinguished basing on the presence of *Sphenolithus* cf. *anarrophus* that may represent the NP6 throughout NP10 Zone *sensu* Martini (1971).

At least the early Eocene can be determined, basing on the presence of *Tribrachiatus orthostylus* – a marker species for the NNTe1 Zone (Varol, 1998; or NP 10 Zone *sensu* Martini, 1971) in the case of sample 15/94. However, genus *Helicosphaera* has been recorded within this sample as well, indicating at least NNTe3 *sensu* Varol (1998) or NP 12 *sensu* Martini (1971).

Łabowa Shale Formation

Foraminiferal assemblages of the Łabowa Shale Formation studied in both subunits (in the Półrzeczki section and the Jasień-Białe-Głębieniec section; Figs 15, 17) are dominated by ammodiscids with acme of *Glomospira charoides* (Jones & Parker) (Fig. 21B, C) and *Glomospira gordialis* (Jones & Parker), associated with numerous specimens of *Trochamminoides*, *Paratrochamminoides*, and *Recurvoides* (Fig. 22G). This type of microfauna is well known from the early Eocene of the Polish Carpathians (e.g., Morgiel & Szymakowska, 1978; Morgiel & Olszewska, 1981; Oszczypko *et al.*, 1990; Malata *et al.*, 1996; Bąk *et al.*, 1997; Olszewska, 1997; Bąk 2004), and it has been also reported from the early Eocene deposits of the Atlantic (e.g., Kaminski *et al.*, 1989).

Taking into account a criterion for the recognition of the Palaeocene/Eocene boundary, proposed by the decision of the Voting Members of International Subcomission on Palaeogene Stratigraphy (Aubry, 2001), and its connection with the benthic foraminiferal extinction event, an appearance of *Glomospira* Assemblage could be regarded as the base of the Eocene (for detail discussion – see Bąk, 2004; Galeotti *et al.*, 2004).

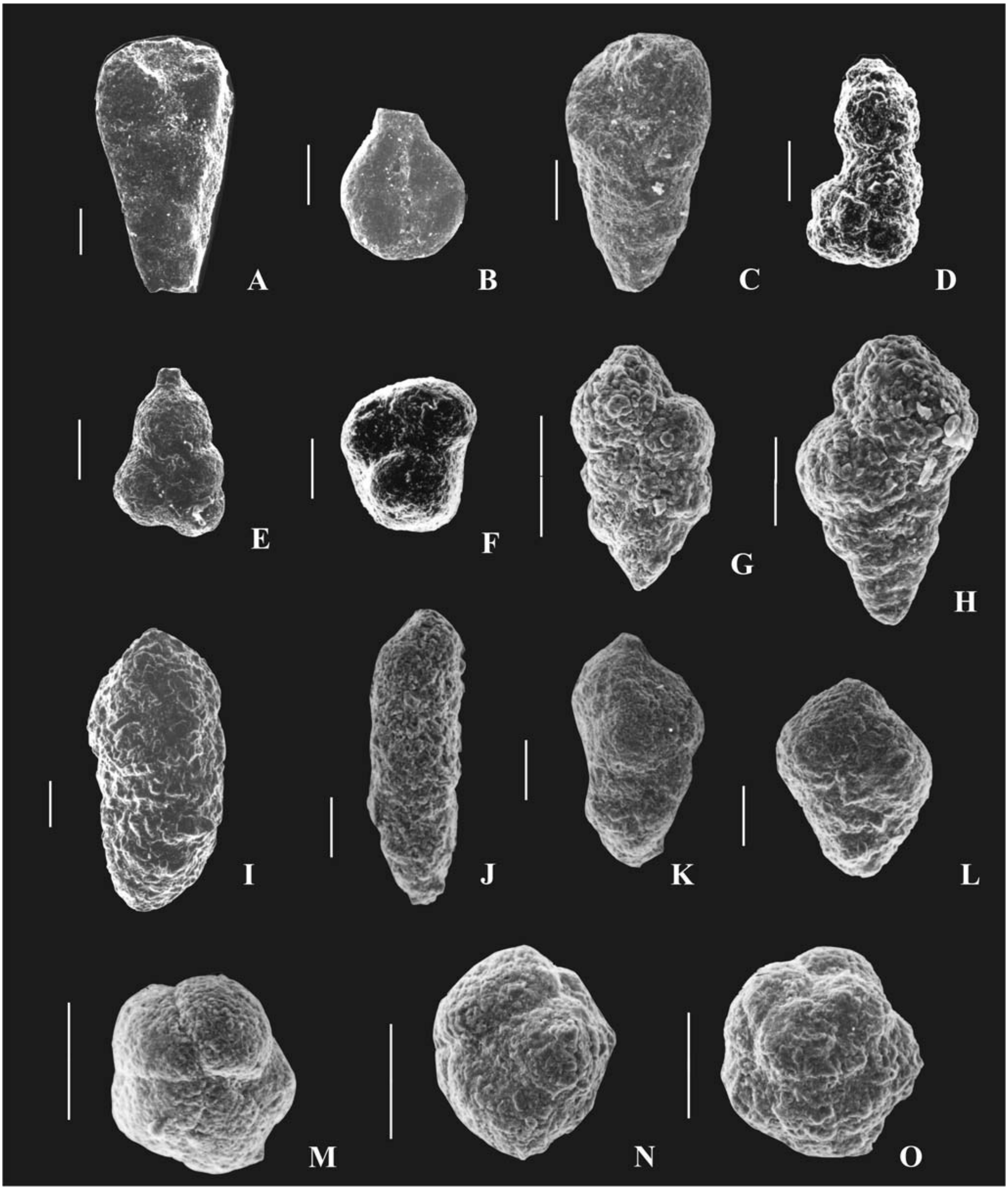


Fig. 19. Late Cretaceous deep-water agglutinated foraminifera of the Jasień Shale and Malinowa Shale Formations from the Półrzeczki-Białe area (Mogielica Range). **A** – *Hippocrepina depressa* Vasicek, K2; **B** – *Caudammina crassa* (Geroch), 46/87; **C** – *Pseudonodosinella troyeri* (Tappan), K2; **D, E** – *Bulbobaculites problematicus* (Neagu), 93/4; **F** – *Plectrorecurvoides alternans* Noth (juvenile form), K2; **G** – *Pseudobolivina cuneata* Krasheninnikov, 59/97; **H** – *Pseudobolivina munda* Krasheninnikov, 72/99; **I** – *Gerochammina lenis* (Grzybowski),1/95; **J** – *Gerochammina stanislavi* Neagu, 59/97; **K, L** – *Uvigerinammina jankoi* Majzon, 72/99; **M, N, O** – *Trochammina gyroidinaeformis* Krasheninnikov, 72/99; Scale bar – 100 μm

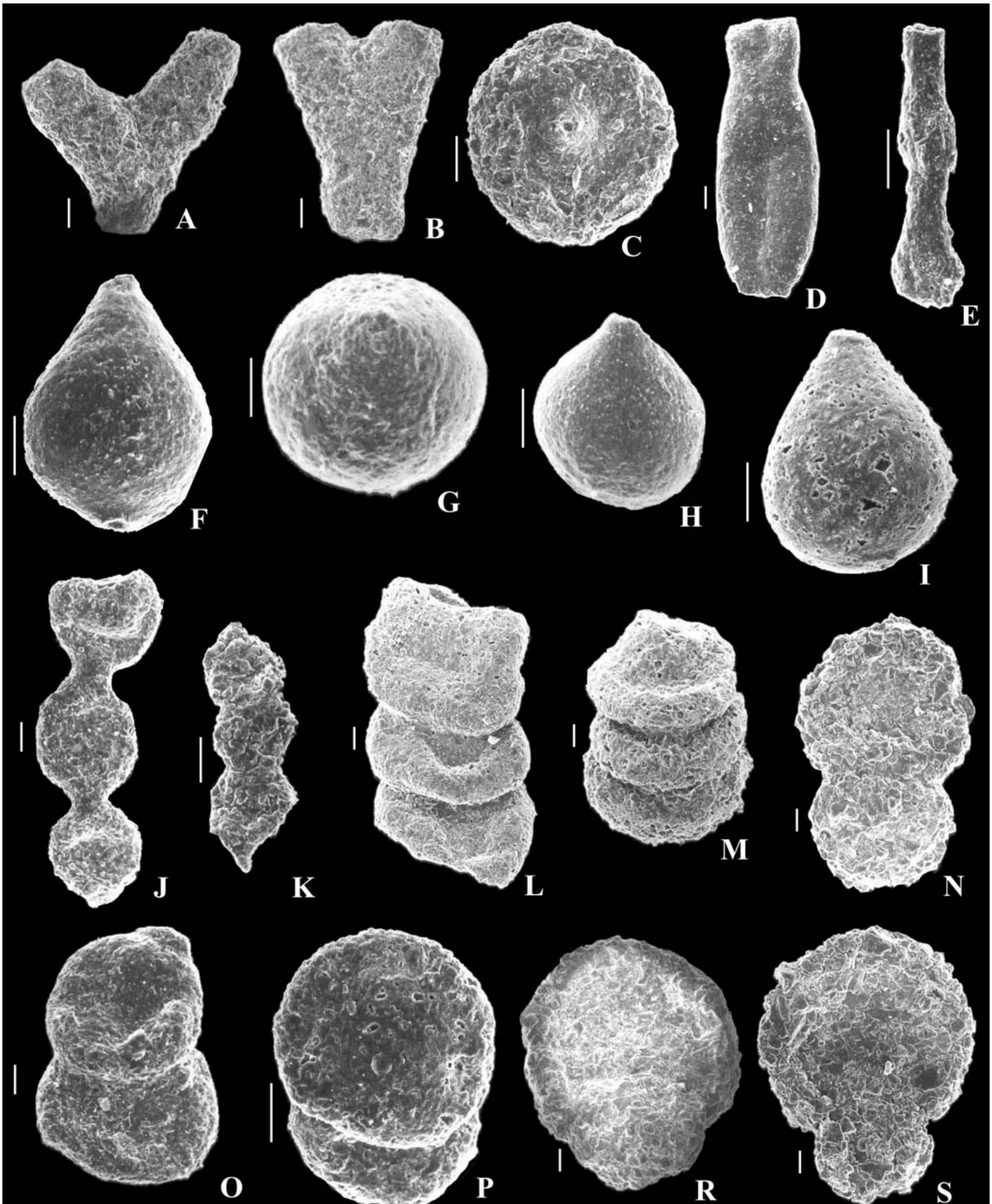


Fig. 20. Late Cretaceous–early Eocene deep-water agglutinated foraminifera from the Półrzeczki-Białe area (Mogielica Range). **A, B** – *Nothia excelsa* (Grzybowski), A – Pół-27, B – Pół-26; **C** – *Saccammina placenta* (Grzybowski), Pól-5; **D** – *Kalamopsis grzybowski* (Dylążanka), Pół-4; **E** – *Hormosina excelsa* (Dylążanka), Pół-25; **F–I** – *Caudammina ovulum*, F – Pół-4, G-I – Pół-26; **J, K** – *Subreophax splendidus* (Grzybowski), J – Pół-4, K – Pół-4; **L, M** – *Reophax* sp., Pół-21; **N** – *Ashemocella grandis*, Pół-29; **O** – *Subreophax guttifer*, Pół-35; **P** – *Ashemocella grandis*, Pół-31; **R** – *Ashemocella grandis*, Pół-28; **S** – *Subreophax guttifer*, Pół-21; Scale bar – 100 μm

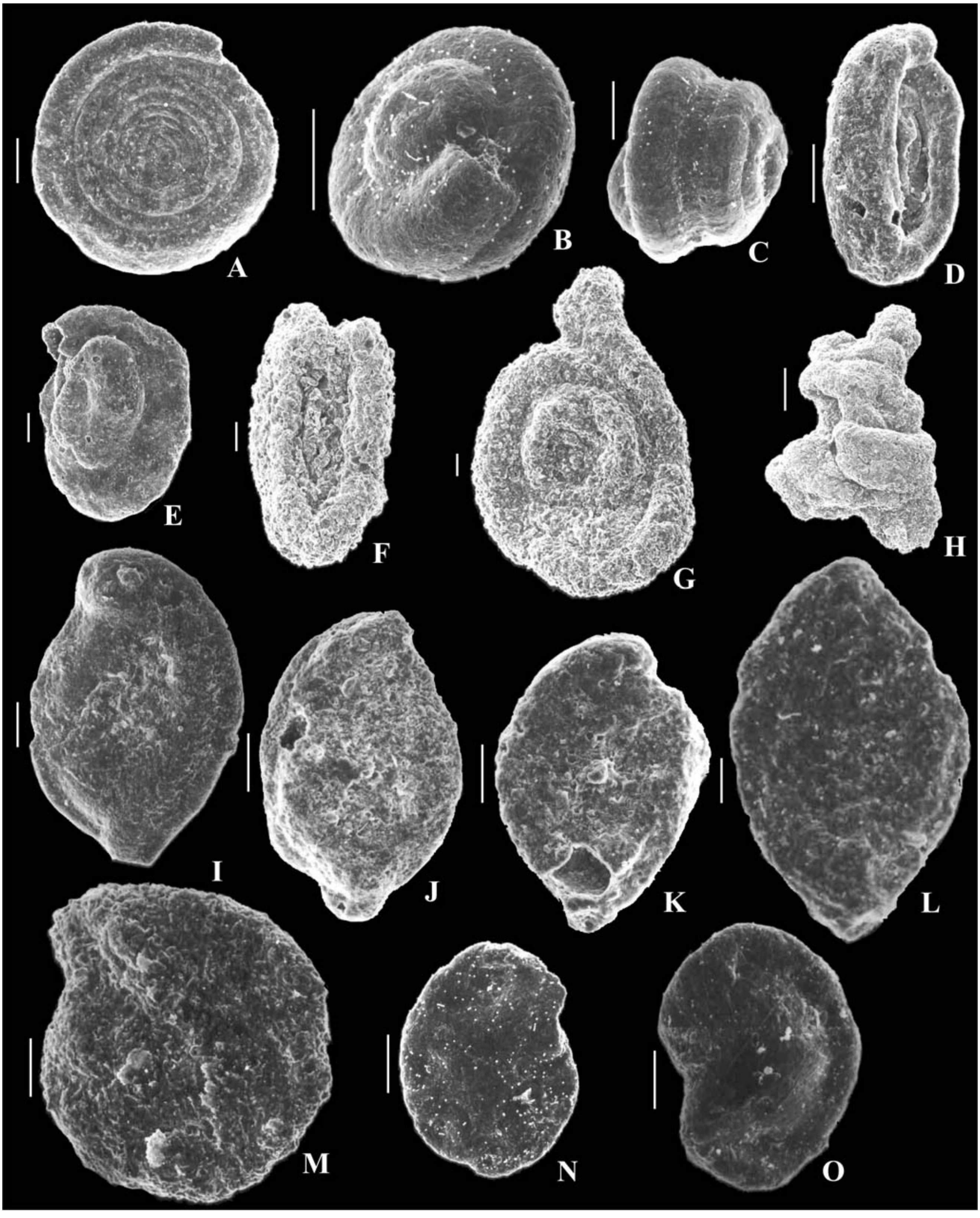


Fig. 21. Late Cretaceous–early Eocene deep-water agglutinated foraminifera from the Półrzeczki-Białe area (Mogielica Range). **A** – *Ammodiscus tenuissimus* Grzybowski, Pół-4; **B, C** – *Glomospira charoides* (Parker & Jones), Pół-12; **D** – *Glomospira serpens* (Grzybowski), Pół-17; **E, F** – *Glomospira* cf. *serpens* (Grzybowski), E – Pół-25, F – Pół-21; **G** – *Glomospira irrerularis* (Grzybowski), Pół-29; **H** – *Glomospira glomerata* (Grzybowski), Pół-2; **I–K** – *Rzehakina epigona* (Rzehak), I – Pół-16, J – Pół-21, K – Pół-24; **L** – *Rzehakina fissistomata* (Grzybowski), Pół-24; **M** – *Haplophragmoides* sp., Pół-12; **N, O** – *Haplophragmoides walteri* (Grzybowski), N – Pół-27, O – Pół-12; Scale bar – 100 μm

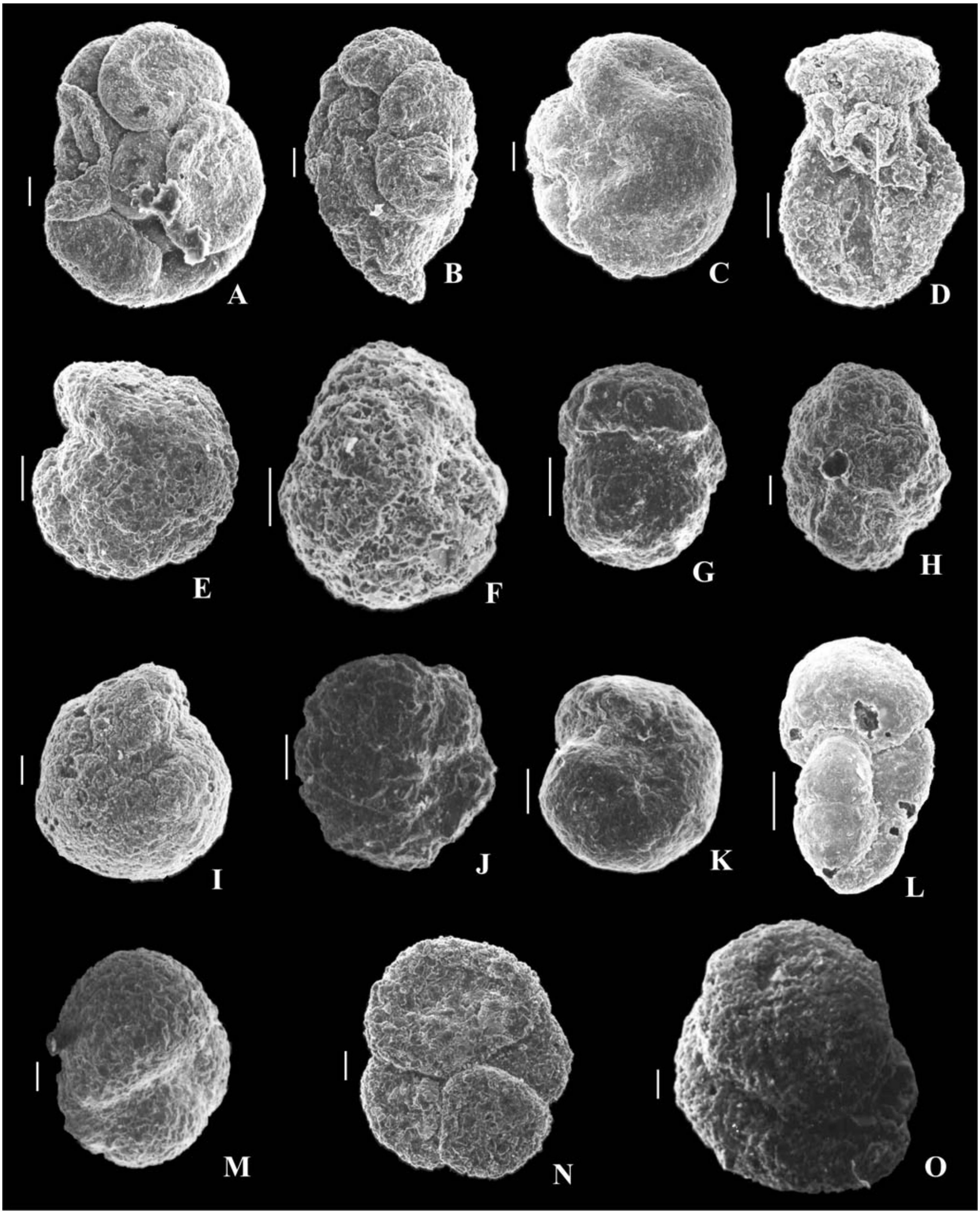


Fig. 22. Late Cretaceous–early Eocene deep-water agglutinated foraminifera from the Półrzeczki-Białe area (Mogielica Range). **A, B** – *Trochamminoides variolarius* (Grzybowski), Pół-28; **C** – *Trochamminoides* sp. Pół-28; **D** – *Paratrochamminoides* cf. *heteromorphus* (Grzybowski), Pół-28; **E–J** – *Recurvoides* sp., E – Pół-21, F, H – Pół-27, G, J – Pół-12, I – Pół-2, J; **K** – *Recurvoidella lamella* (Grzybowski), Pół-17; **L** – *Haplophragmoides* cf. *herbichi*, Pół-5; **M** – *Praecystammina globigeriniformis* (Krasheninnikov), Pół-27; **N, O** – *Trochammina* sp., Pół-4; Scale bar – 100 μm

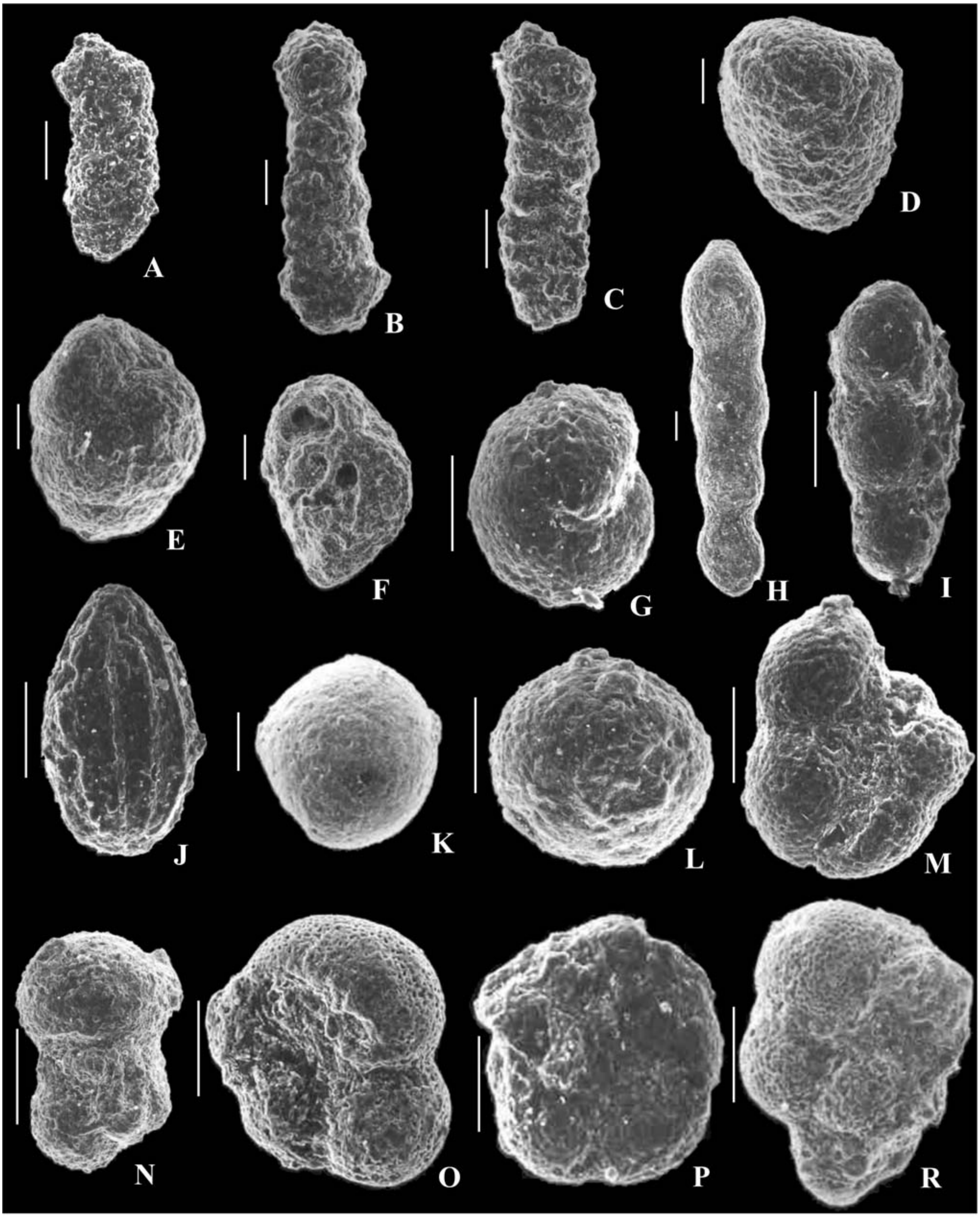


Fig. 23. Late Cretaceous–early Eocene deep-water agglutinated foraminifera, calcareous benthic foraminifera, and Palaeocene planktonic foraminifera from the Półrzeczki-Białe area (Mogielica Range). **A** – *Gerochammina conversa* (Grzybowski), Pół-12; **B** – *Bulbobaculites problematicus* (Neagu), Br-6; **C** – *Spiroplectammina* sp., Pół-17; **D–F** – *Remesella varians* (Glaessner), Pół-27; **G** – *Gyroidinoides* sp., Pół-15; **H, I** – *Dentalina* sp., H – Pół-26, I – Pół 15; **J** – *Lagena* sp., Pół-15; **K, L** – Radiolaria, Pół-12; **M** – *Parasubbotina varianta* (Subbotina), Pół-15; **N** – *Subbotina triloculinoides* (Plummer), Pół-15; **O** – *Subbotina triloculinoides* (Plummer), Pół-27; **P, R** – ?*Parasubbotina* sp., Pół-15; Scale bar – 100 µm

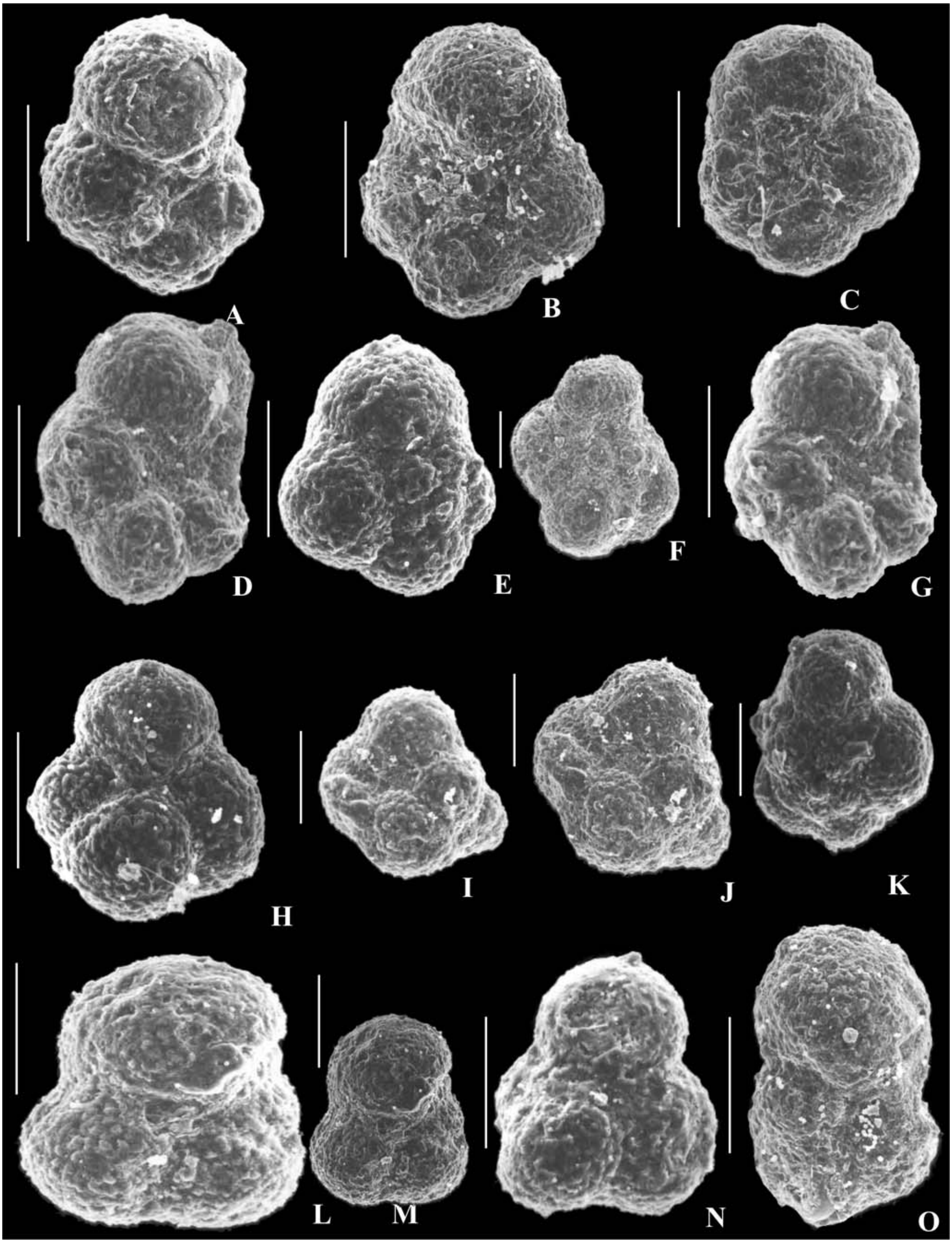


Fig. 24. Palaeocene planktonic foraminifera from the Półrzeczki-Białe area (Mogielica Range). **A, B** – *Parasubbotina varianta* (Subbotina); **C** – *Parasubbotina* cf. *varianta* (Subbotina); **D–G** – *Parasubbotina varianta* (Subbotina); **H–K** – *Eoglobigerina trivialis* (Subbotina); **L–O** – *Subbotina triloculinoides* (Plummer). All specimens from sample Pół-15; Scale bar – 100 μm

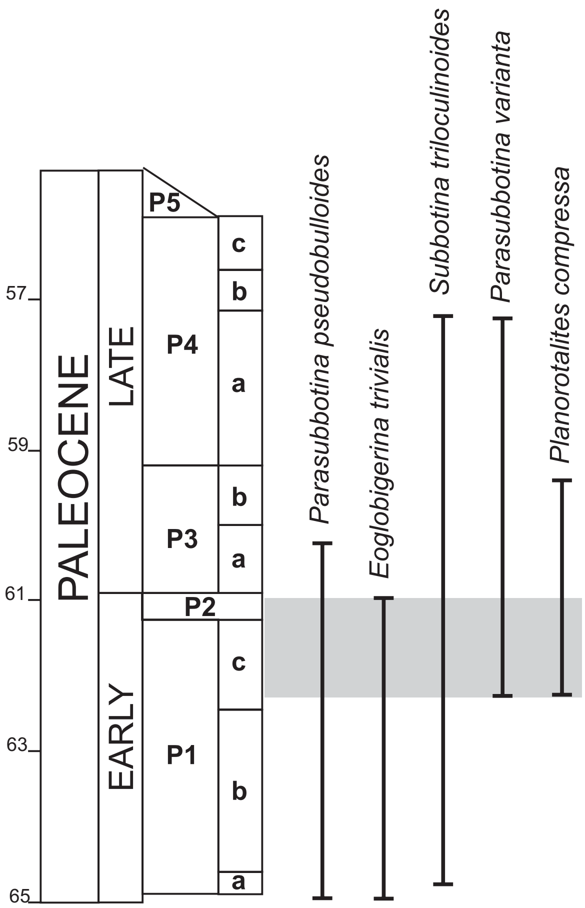


Fig. 25. Ranges of selected early Palaeocene planktonic Foraminifera (based on Berggren & Norrris, 1997)

Recrystallised radiolarians (Fig. 23K, L) are also important element of the microfauna within the early Eocene *Glomospira* Assemblage (cf. section Półrzeczki; Fig. 15). Rich radiolarian fauna in the early and middle Eocene is known from many localities in the Atlantic (e.g., Foreman, 1973), the Pacific (e.g., Riedel & Sanfilippo, 1978), Antarctic Southern Oceans, Arctic, California, in the former Soviet Union, Japan, and other places (e.g., Clark & Campbell, 1942; Chen, 1975; Kiminami *et al.*, 1990; Lipman, 1950; Takemura, 1990). This radiolarian abundance episode has been noted from many localities in the Polish Flysch Carpathians (e.g., Morgiel & Szymakowska, 1978; Bąk *et al.*, 1997). According to Bąk *et al.* (1997), these radiolaria represent the *Buriella clinata*, *Phormocyrthis striata striata* and *Theocotyle cryptocephala cryptocephala* zones *sensu* Sanfilippo *et al.* (1985), corresponding to the early Eocene (upper part of NP12 Zone of Martini & Worsley, 1971) through the lowermost part of the middle Eocene (NP14 Zone of Berggren *et al.*, 1995).

Beloveža Formation

This formation was studied in the Lubomierz section (Figs 5D, 7). Two types of foraminiferal assemblages have been recognised (Fig. 17). The first one belongs to the *Glomospira* acme Zone, consisting entirely of DWAF, dominated by *Recurvoides* and numerous *Glomospira*. The second one, apart from abundant *Recurvoides* spp., contains relatively numerous *Karrerulina conversa* (Grzybowski), accompanied by *Nothia excelsa* (Grzybowski), *Glomospira charoides* (Jones et Parker), *Glomospira gordialis* (Jones et Parker), *Paratrochamminoides* spp., and *Haplophragmoides walteri* (Grzybowski). This assemblage includes stratigraphically important species *Saccamminoides carpathicus* Geroch. This is an index form of the zone distinguished in the late of the early Eocene by Geroch & Nowak (1984).

Calcareous nannoplankton examined from this formation includes a fairly well preserved assemblage of low diversity. The autochthonous assemblage is dominated by *Cyclicargolithus floridanus* (Roth & Hay) and *Coccolithus pelagicus* (Wallich), whereas *Zygrhablithus bijugathus* (Deflandre), *Reticulofenestra dictyoda* (Deflandre & Fert), and *Sphenolithus radians* Grasse are less common. Sporadically, the species of *Nannotetrina* were determined. The zone assignment is based on the presence of *Nannotetrina* and can be used to approximate the NP14/15 boundary in badly preserved material. Higher up in the section, the FO of *Cyclicargolithus floridanus* is taking place. According to Aubry (1986), the FO of *Cyclicargolithus floridanus* takes place in zone NP16.

SUMMARY

Detailed geological mapping, sedimentological investigations, tectonic analyses, and biostratigraphic studies based on foraminifera and calcareous nannoplankton, allowed to distinguish six, new formal lithostratigraphic units in the Beskid Wyspowy Range and on the northern slopes of the Gorce Range (Bystrica and Rača subunits of the Magura Nappe). These are as follows: Jasień Formation, Białe Formation, Jaworzynka Formation, Szczawina Sandstone Formation, Krzysztonów Member, and Ropianka Formation.

These new units, together with the Malinowa Shale Formation and Hałuszowa Formation were included into the new Mogielica Group (Upper Albian–Palaeocene). The Mogielica Group of units, spanning over 40 myrs, represents the turbidite depositional system, separated by highstand variegated clays, which can be correlated with the minor sequences in term of sequence stratigraphy.

The Late Albian through Palaeocene turbidite system (see also Oszczypko, 2001; Oszczypko & Oszczypko-Clowes, 2002), is about 500–600 m thick. It begins with pelitic basinal deposits (spotty shales of the Jasień Formation), which pass into hemipelagic variegated shales (Malinowa Shale Formation), thin- and medium-bedded basinal turbidites with intercalations of allodapic limestones and marls (Hałuszowa and Białe Formations), and then into thick-bedded turbidites (Szczawina Sandstone, Jaworzynka and Jarmuta Formations). Finally, there are thin-bedded turbidites of the Ropianka and Szczawnica Formations.

These deposits are overlain by a 20–50 m thick complex of variegated shales (Łabowa Shale Formation) of early to middle Eocene age, which begins the new turbidite system of the Beskid Group (Eocene–Oligocene).

		RAČA SUBUNIT							BYSTRICA SUBUNIT						
	Lithostratigraphy	ROPIANKA FM.							BELOVEŽA FM.				BYSTRICA FM.		
	Age	Campanian Lower	Campanian Upper	Palaeocene Lower			Palaeocene Late	Early Eocene	Middle Eocene				Middle Eocene		
	Calcareous nannofossil zones	UC 15b	UC 15d		NP 2			NP10/ NP11	NP 15	NP 16	NP 16	NP 16	NP 16	NP 16	NP 16
	sample	7/ 94	23/ 94	1/ 94	II/ 94	22/ 94	19/ 94	15/ 94	47/ 00/N	63/ 98/N	9/ 98/N	45/ 00/N	64/ 98/N	66/ 98/N	52/ 98/N
	sample abundance	L	L	VL	VL	M	L	L	L	VL	L	M	M	M	L
	nannofossil preservation	P	P	VP	VP	M	P	P	P	VP	M	M	P	M	P
CRETACEOUS SPECIES	*Arkhangelskiella cymbiformis*					X									
	Broinsonia parca constricta	X				X									
	Broinsonia sp.					X									
	Calculites obscurus		X			X									
	Calculites ovalis					X									
	Ceratolithoides aculeus	X	X												
	Cyclagelosphaera sp.						X								
	Eiffellithus eximius					X									
	Eiffellithus turriseffelii					X									
	Markalius inversus					X									
	Micula sp.					X		X							
	Micula staurophora	X	X			X									
	Quadrum gartneri	X													
	Thoracosphaera sp.					X									
	Uniplanarius trifidus		X												
	Uniplanarius sissinghi					X									
	Watznaueria barnesae	X	X			X	X	X							
	Watznaueria biporta							X							
	Zygodiscus sp.					X									
PALAEOGENE SPECIES	*Biantholithus sparsus*					X									
	Braarudosphaera bigelowii					X								X	
	Chiasmolithus sp.			X					X						
	Chiasmolithus grandis											X			
	Coccolithus pelagicus			X	X	X	X		X	X		X	X	X	X
	Cruciplacolithus primus					X									
	Cyclicargolithus floridanus									X		X	X	X	X
	Dictyococcites bisectus									X		X			X
	Dictyococcites scripsae									X			X		
	Discoaster barbadiensis									X	X	X			
	Discoaster binodosus											X			
	Discoaster deflandrei									X					
	Ericsonia formosa									X		X		X	
	Helicosphaera sp.							X							
	Helicosphaera lophota													X	
	Nanntetrina sp.								X						
	Neococcolithes dubius									X					
	Reticulofenestra dictyoda											X	X		X
	Reticulofenestra hillae													X	
	Sphenolithus cf. *anarrophus*						X								
	Sphenolithus moriformis									X				X	
	Sphenolithus pseudoradians											X			
	Sphenolithus radians											X		X	
	Toweius gammation												X		
	Transversopontis pulcheroides											X			
	Tribrachiatus orthostylus							X							
	Zygrhablithus bijugathus									X			X		X

Fig. 26. Occurrence range chart of the Campanian through middle Eocene calcareous nannoplankton in the Rača and Bystrica subunits, from the Ropianka, Beloveža, and Bystrica Formations. Sample abundance: VL – very low; L – low; M – middle. Nannofossil preservation: VP – very poor, P – poor, M – middle

The established lithostratigraphic units have been correlated with other units in the Magura Nappe within the Polish territory (Fig. 28) and compared with the lithostratigraphic units in the Western Slovakia, Moravia and Austria (Rhenodanubian Flysch).

Abundant occurrence of deep-water agglutinated foraminifera in the studied deposits, used as a biostratigraphical tool, allowed us to specify the boundaries of the distinguished lithostratigraphic units. The boundaries have been correlated with the zonation based on the cosmopolitan DWAF (zonation after Geroch & Nowak, 1984; partly modified). Planktonic foraminifera and calcareous nannoplankton, which occur sporadically and only in the youngest deposits of the studied succesion, have been used as an

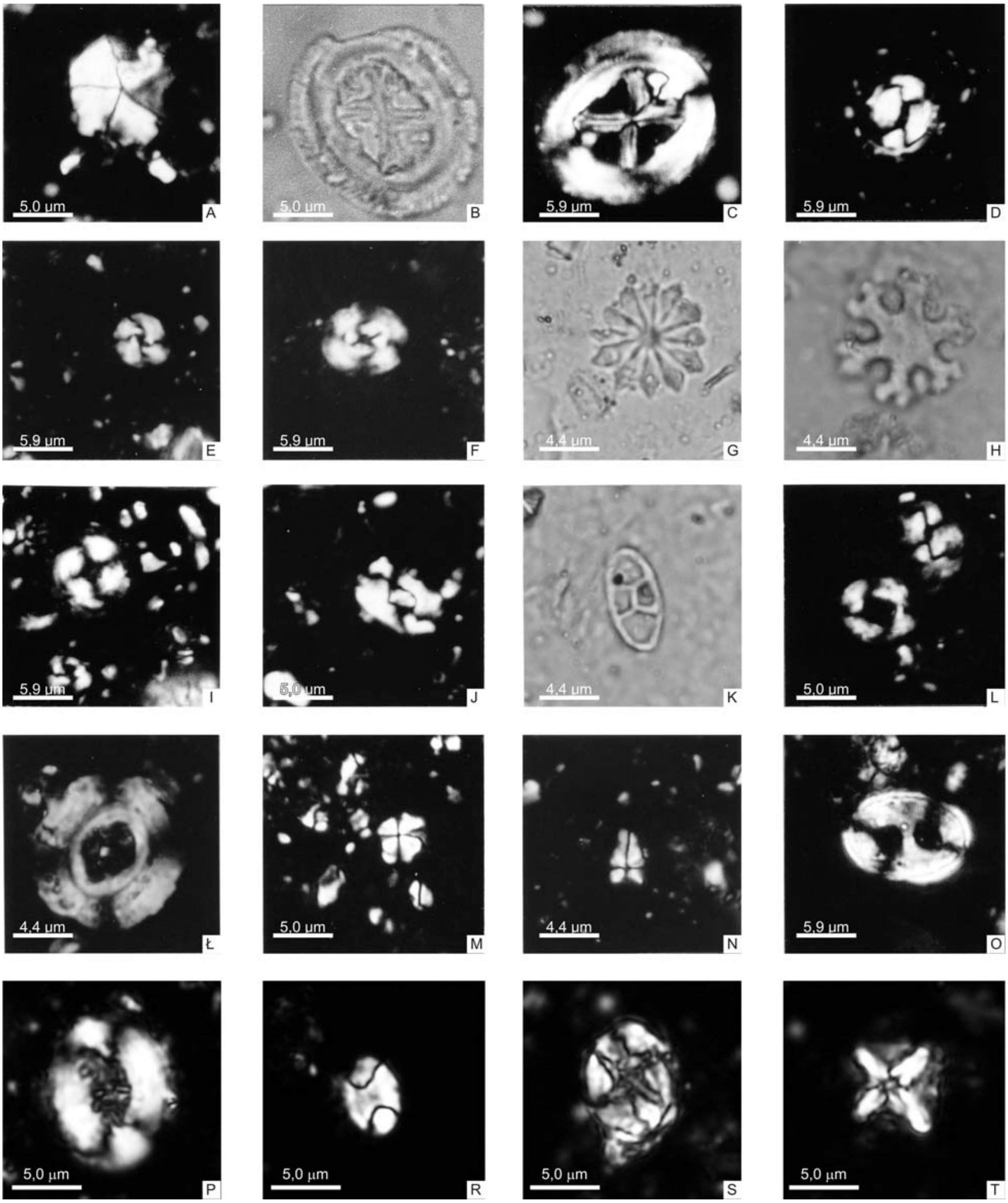


Fig. 27. LM photomicrographs of the Eocene calcareous nannoplankton in the Rača and Bystrica subunits from the Beloveža and Bystrica formations. **A** – *Braarudosphaera bigelowii*, sample 66/98/N, **B** – *Chiasmolithus grandis*, sample 45/00/N, **C** – *Chiasmolithus grandis*, sample 45/00/N, **D** – *Coccolithus pelagicus*, sample 47/00/N, **E** – *Cyclicargolithus floridanus*, 63/98/N, **F** – *Dictyococcites bisectus*, sample 63/98/N, **G** – *Discoaster barbadiensis*, sample 45/00/N, **H** – *Discoaster deflandrei*, sample 63/98/N, **I** – *Ericsonia formosa*, sample 45/00/N, **J** – *Helicosphaera lophota*, sample 66/98/N, **K** – *Neococcolithes dubius*, sample 63/98/N, **L** – *Reticulofenestra dictyoda*, sample 52/98/N, **Ł** – *Reticulofenestra hillae*, sample 66/98/N, **M** – *Sphenolithus moriformis*, sample 66/98/N, **N** – *Sphenolithus radians*, sample 45/00/N, **O** – *Transversopontis pulcher*, sample 45/00/N, **P** – *Broinsonia parca constricta*, sample 22/94, **R** – *Calculites obscurus*, sample 22/94, **S** – *Eiffellithus turriseiffelii*, sample 22/94, **T** – *Micula staurophora*, sample 22/94

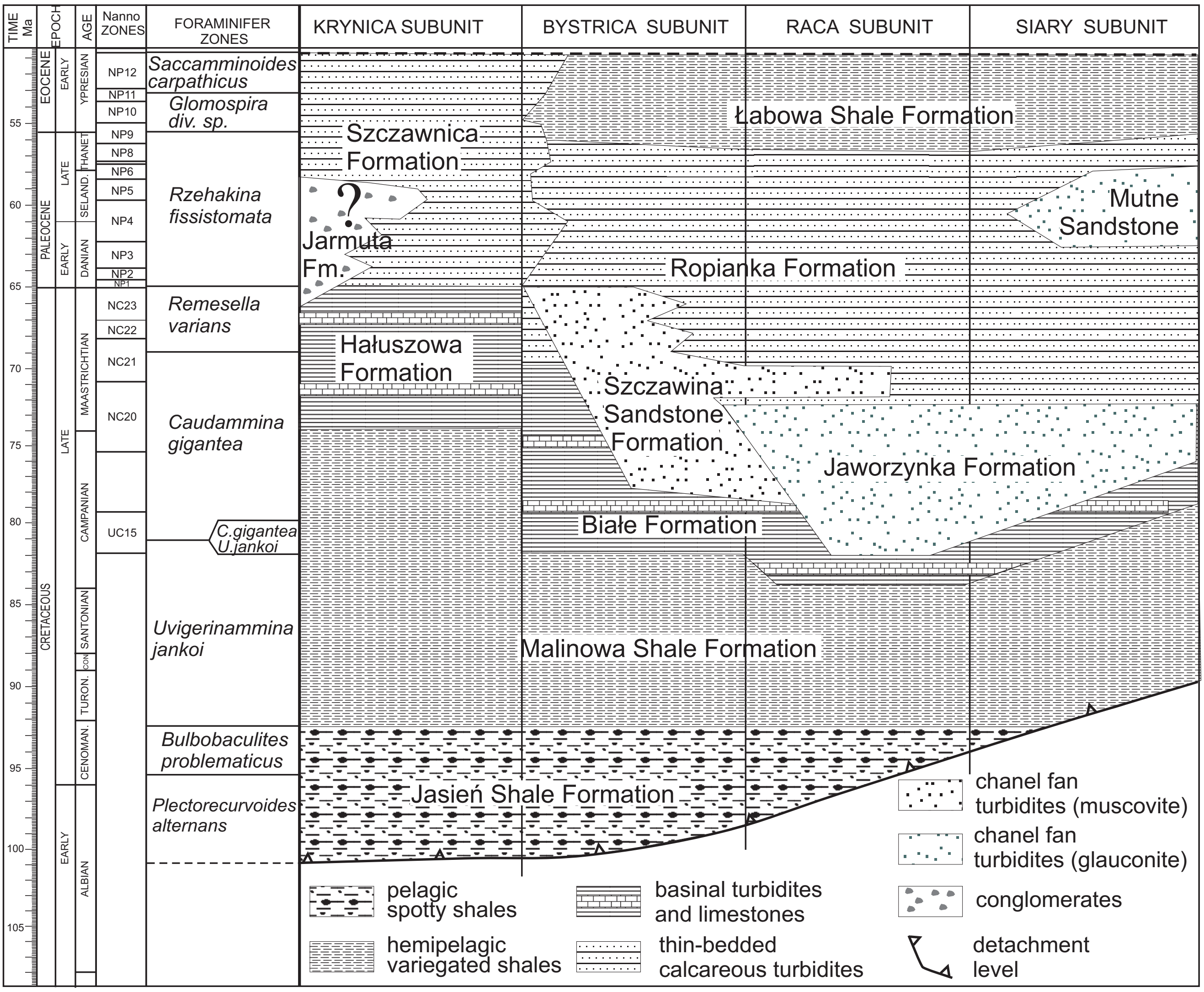


Fig. 28. Stratigraphy of the Upper Albian–Lower Eocene deposits of the Magura Nappe (Mogielica Goup) based on deep-water agglutinated foraminiferal and calcareous nannoplankton; biostratigraphy – after Oszczypko & Oszczypko-Clowes (2002). Chronostratigraphy – after Berggren *et al.* (1995) and Gradstein *et al.* (1994)

additional stratigraphic tool for the Palaeocene–Early Eocene.

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Streszczenie

LITO- I BIOSTRATYGRAFIA UTWORÓW FLISZOWYCH GÓRNEGO ALBU–DOLNEGO/ŚRODKOWEGO EOCENU W JEDNOSTCE BYSTRZYCKIEJ I RACZAŃSKIEJ PŁASZCZOWINY MAGURSKIEJ W BESKIDZIE WYSPOWYM I GORCACH (ZACHODNIE KARPATY FLISZOWE)

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Płaszczowina magurska, największa jednostka tektoniczna zewnętrznych Karpat Zachodnich (Fig. 1), jest całkowicie odkorzeniona od swego podłoża. Utwory serii magurskiej starsze od turonu znane są jedynie z jednostki Grajcarka (sukcesja magurska pienińskiego pasa skałkowego), wiercenia Obidowa IG-1 oraz z kilku niewielkich odsłonięć przy południowym obrzeżeniu okna tektonicznego Mszany Dolnej (Fig. 2, por. Birkenmajer & Oszczypko, 1989).

W jednostce Grajcarka, ponad głębokowodnymi utworami jury górnej i neokomu, występuje "czarny flisz" formacji wronińskiej (alb–cenoman) oraz zielone łupki radiolariowe cenomanu (formacja hulińska) (Birkenmajer, 1977, por. Oszczypko *et al.*, 2004). Szaro-zielone łupki plamiste albu–cenomanu, znane z południowego obrzeżenia okna tektonicznego Mszany Dolnej, zdefiniowane zostały w pracy jako formacja łupków z Jasienia. Formacja ta, o miąższości niemniejszej od kilkunastu metrów, zazębia się w stropie z łupkami czerwonymi formacji z Malinowej. W Beskidzie Wyspowym i Gorcach ponad łupkami pstrymi formacji z Malinowej (turon–santon/kampan) oraz poniżej łupków pstrych formacji z Łabowej (eocen dolny i środkowy) występują zróżnicowane facjalnie osady fliszowe, zaliczane dotychczas do różnych nieformalnych jednostek litostratygraficznych, takich jak: warstwy z Kaniny, piaskowce ze Szczawiny (strefa bystrzycka i raczańska) oraz warstwy z Jaworzynki (strefa raczańka i strefa Siar). Najwyższą pozycję stratygraficzną zajmują utwory tradycyjnie nazywane "warstwami inoceramowymi" lub ropianieckimi.

Na podstawie szczegółowych badań lito- i biostratygraficznych wyżej wymienionych utworów kredy górnej i paleocenu, zaproponowano cztery nowe formalne jednostki litostratygraficzne w randze formacji: formację z Białego (dotychczasowe warstwy z Kaniny), formację piaskowców ze Szczawiny (dotychczasowe piaskowce ze Szczawiny), formację z Jaworzynki (dotychczasowe warstwy z Jaworzynki) oraz formację ropianiecką (dotychczasowe warstwy ropianieckie). Ponadto badano pięć innych górnokredowo-eoceńskich formacji: łupków z Malinowej, z Hałuszowej, łupków z Łabowej, beloweskiej i bystrzyckiej, które dodatkowo opisano.

Wszystkie nowo zdefiniowane formacje oraz formacje: łupków z Malinowej oraz z Hałuszowej, włączono do nowo wydzielonej grupy Mogielicy (górny alb–paleocen). Grupa ta przechodzi w stropie w grupę beskidzką (eocen–oligocen) opisaną przez Birkenmajera & Oszczypkę (1989). Grupa Mogielicy, obejmująca okres czasowy liczący ponad 40 mln lat, reprezentowana jest przez turbidytowy system depozycyjny, ograniczony w stropie i spągu przez osady łupków pstrych, związanych z okresem wysokiego względnego poziomu morza.

Wśród zespołów mikrofauny otwornicowej albu – dolnego/środkowego eocenu, znalezionych w badanych utworach płaszczowiny magurskiej, rozpoznano większość poziomów biostratygraficznych opracowanych dla polskich Karpat zewnętrznych przez Gerocha & Nowaka (1984) oraz przez Olszewską (1997). Do tego schematu włączono również poziomy charakterystyczne dla utworów płaszczowiny magurskiej.

Poziom Plectorecurvoides alternans (poziom interwałowy IZ)

Definicja: dolna granica – pojawienie się gatunku *Plectorecurvoides alternans* Noth (w badanym materiale dolna granica nie jest uchwycona, odpowiada początkowi profilu sukcesji magurskiej), górna granica – pojawienie się *Bulbobaculites problematicus* (Neagu);
Uwagi: otwornice aglutynujące nieliczne, towarzyszące gatunki to *Hippocreppina depressa* Vasiček, *Glomospira gordialis* (Jones et Parker), *Pseudonodosinella troyeri* (Tappan), *Buzasina pacifica* (Krasheninnikov), *Plectorecurvoides irregularis* Geroch i *Gerochammina stanislavi* Neagu; wiek: poźny alb–wczesny/ środkowy cenoman;
Występowanie: formacja z Jasienia.

Poziom Bulbobaculites problematicus (IZ)

Definicja: dolna granica – pojawienie się gatunku indeksowego, górna – pojawienie się *U. jankoi*;
Uwagi: gatunek indeksowy relatywnie liczny, inne gatunki aglutynujące to m.in.*Caudammina* crassa Geroch, *Recurvoides imperfectus* Hanzlikova, *Thalmannammina neocomiensis* Geroch, *Plectorecurvoides alternans* (Alth), *P. irregularis* Geroch i *Gerochammina stanislavi* Neagu; wiek: środkowy cenoman – granica cenoman/turon;
Występowanie: formacja z Jasienia.

Poziom Uvigerinammina jankoi (IZ)

Definicja: dolna granica – pierwsze pojawienie się (FO) *U. jankoi*; górna granica – pierwsze pojawienie (FO) *Caudammina gigantea* (Geroch);
Uwagi: Poziom ten w dolnej części charakteryzuje się dominacją ilościową gatunku *Uvigerinammina jankoi* Majzon oraz występowaniem gatunków opisanych z abysalnych osadów oceanicznych takich jak *Praecystammina globigeriniformis* Krasheninnikov,

Trochammina gyroidinaeformis Krasheninnikov, *Pseudobolivina munda* Krasheninnikov, *Pseudobolivina cuneata* Krasheninnikov; w wyższej części takson indeksowy jest nieliczny natomiast jego miejsce zajmuje relatywnie licznie reprezentowany rodzaj *Gerochammina* z gatunkami *G. obesa* Neagu, *G. lenis* (Grzybowski). W wyższej części poziomu obserwuje się pierwsze pojawienie *Rz. inclusa* (Grzybowski);
Wiek: turon – wczesny kampan
Występowanie: formacja łupków z Malinowej, formacja z Białego.

Poziom Uvigerinammina jankoi-Caudammina gigantea (poziom współwystępowania CRZ)
Definicja: dolna granica – pierwsze pojawienie się (FO) *Caudammina gigantea* (Geroch); górna granica – ostatnie wystąpienie (LO) *Uvigernammina jankoi* Majzon.
W poziomie tym obserwuje się zmianę charakteru zespołu DWAF – rodzaj *Gerochammina* typowy dla facji pstrych jest nieliczny a w większej ilości pojawiają się inne taksony o krzemionkowych ściankach;
Wiek: wczesny kampan;
Występowanie: formacja z Białego.

Poziom Caudammina gigantea (poziom częściowego zasięgu PRZ)
Definicja: dolna granica – ostatnie wystąpienie (LO) *U. jankoi* Majzon; górna granica – pierwsze pojawienie się (FO) *Remesella varians* (Glaessner);
Uwagi: w niższej części poziomu obserwuje się rozkwit gatunku indeksowego; licznie jest też reprezentowany gatunek *Caudammina ovulum* (Geroch). Jego odpowiednikiem może być zespół z Rzehakina inclusa (Grzybowski) i *Hormosina excelsa* (Dylążanka), w którym *H. excelsa* (Dylążanka) bywa relatywnie liczna, a *Rz. inclusa* (Grzybowski) reprezentowana jest przez pojedyncze okazy; wiek: środkowy kampan – wczesny mastrycht;
Występowanie: formacja z Białego, fomacja z Jaworzynki – strefa raczańska, formacja piaskowców ze Szczawiany, formacja ropianiecka.

Poziom Remesella varians (IZ)
Definicja: dolna granica – pojawienie się gatunku *Remesella varians* (Glaessner); górna granica – pojawienie się *Rzehakina fissistomata* (Grzybowski);
Uwagi: w poziomie tym występują powszechnie gatunki z poprzedniego zespołu; są to m.in. *Rz. inclusa* (Grzybowski), *Hormosina excelsa* (Dylążanka), *Glomospira diffundens* Cushman et Renz, *H. ovulum* Grzybowski, *Rzehakina epigona* (Rzehak); czasem pojawiają się pojedyncze formy wapienne;
Wiek: środkowy-późny mastrycht;
Występowanie: formacja ropianiecka.

Poziom Rzehakina fissistomata (poziom zasięgu TRZ)
Uwagi: *Annectina grzybowskii* (Jurkiewicz) jest bardzo charakterystycznym gatunkiem dla tej zony i w przypadku nieobecności *Rz. fissistomata* może być traktowana jako gatunek wskaźnikowy. Ostatnie pojawienie się *Rzehakina fissistomata* (Grzybowski) notowane jest blisko granicy kreda/paleocen;
Wiek: paleocen;
Występowanie: formacja ropianiecka.

Poziom Glomospira div. sp. (poziom rozkwitu AZ)
Definicja: poziom ten charakteryzuje się licznym wystąpieniem *Glomospira* spp.;
Uwagi: licznie występującym małym okazom *G. charoides* (Jones & Parker) i *G. gordialis* (Jones & Parker), towarzyszą również relatywnie liczni przedstawiciele rodzajów *Paratrochamminoides*, *Trochamminoides*, *Recurvoides*, *Karrerulina* oraz formy rurkowate; wszystkie te okazy są mniejszych rozmiarów niż te występujące w niżej i wyżejległych utworach. Zespół z *Glomospira* reprezentuje mikrofaunę, która przetrwała wczesnoeoceński termiczny kryzys (por. Bąk, 2004);
Wiek: wczesny eocen;
Występowanie: formacja łupków z Łabowej.

Poziom Saccamminoides carpathicus (IZ)
Definicja: dolna granica – pierwsze pajawienie (FO) *Saccamminoides carpathicus* Geroch; górna granica – pierwsze pojawienie (FO) *Reticulophragmium amplectens* (Grzybowski) – nie zaobserwowano w badanej sukcesji;
Uwagi: takson wskaźnikowy rzadki, towarzyszą mu relatywnie liczne okazy *Recurvoides* spp., *Paratrochamminoides* spp., *Glomospira* spp. i *Karrerulina conversa* (Grzybowski). Wapienny bentoniczny gatunek *Nuttallides trumpyi* (Nuttall) pojawia się po raz pierwszy;
Wiek: późny wczesny eocen;
Występowanie: formacja beloweska.