

THE ROPIANKA FORMATION OF THE BYSTRICA ZONE (MAGURA NAPPE, OUTER CARPATHIANS): PROPOSAL FOR A NEW REFERENCE SECTION IN NORTHWESTERN ORAVA

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Abstract: The thin- and medium-bedded, turbiditic deposits that are exposed in the Bystrica Zone of the Magura Nappe in the Slovak Orava region are the subject of this study. On the basis of lithological features as well as age and stratigraphic position, they are assigned to the Ropianka Formation. The very well exposed rocks of this formation, recognized in the Biela Farma profile in the Slovak part of the northwestern Orava region, are compared with analogous deposits in the Polish Orava and the Beskid Wysoki Mountains. Lithological and biostratigraphical documentation of the Ropianka Formation is presented. This documentation allowed the determination of the age of the rocks studied. Abundant and taxonomically diverse foraminiferal assemblages of agglutinated, benthonic and occasional planktonic forms indicate a Middle Paleocene age for the upper part of the Ropianka Fm. A new stratigraphic position for the Szczawina Sandstone, considered to be a member of the Ropianka Fm, is proposed. The lithostratigraphy of the Ropianka Fm in the Magura Nappe in Poland, Slovakia and the Czech Republic requires further investigation, including the establishment of new type and reference sections. The large outcrop at Biela Farma should be taken into consideration as a potential reference section. Studies of the new sections will lead to a new monographic elaboration of the Ropianka Fm in Poland, Slovakia and the Czech Republic.

Key words: Outer Carpathians, lithostratigraphy, Late Cretaceous–Paleocene, Magura Nappe, Bystrica Zone, Ropianka Formation, Szczawina Member, Orava.

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INTRODUCTION

The Orava region of the Carpathian Mountains lies in the Polish-Slovak borderland (Fig. 1A). In 20th century, trans-border cooperation between geologists was quite limited. As a result, the geological maps (Matějka and Roth, 1952; Roth *et al.*, 1963a, b; Książkiewicz, 1968a, b; Golonka and Wójcik, 1978a, b) on opposite sides of the border do not fit very well together. Therefore, it is necessary to integrate research on both sides of the border to remove earlier disagreements. A recent mapping effort (Teťák *et al.*, 2016a, b) allows much better correlation of the Polish and Slovak maps in the Orava and Beskid Wysoki regions as well as integration of the lithostratigraphic scheme

of this region (Fig. 1B). In this paper, a solution to disagreements concerning the Upper Cretaceous–Paleocene Ropianka Formation is proposed. For this purpose, the very well exposed section of the Ropianka Formation in the Slovak part of the Orava region (Fig. 1C) was compared with sections of the Ropianka Formation in the Polish Orava and the Beskid Wysoki Mountains. The main problem was dating of the deposits investigated and their position within the stratigraphic scheme of the Ropianka Formation in Poland, Slovakia and the Czech Republic. This problem was solved by means of micropalaeontological analysis and correlation studies.

et al. (2016a, b) presented a new view on the local lithostratigraphic inventory and discovered new areas occupied by the Ropianka Fm (or Mbr) in the Orava area (Fig. 1C).

Study area

Many small outcrops of the Ropianka Fm of the Bystrica Zone, rather poorly displaying the division discussed, occur in the area southeast of Pilsko Mt. (northern Orava). They were mapped and investigated by Teťák *et al.* (2016a, b; Fig. 1C). This study is focused on a large, very well exposed outcrop of turbiditic sediments, located behind a cottage of the Biela Farma recreational complex, northwest of Oravská Polhora village, 300 m from the main road from Namestovo to Žywiec (Figs 3–5). This is a flagship exposure of the upper part of the Ropianka Fm in the Bystrica Zone in Slovak Orava (Fig. 2). Part of the profile of the Ropianka Fm exposed in the Biela Farma outcrop (Fig. 3) is located in the sedimentary succession of the Bystrica Zone (Fig. 3), about 80 metres below the lower limit of the Ľabowa Shale Fm. The outcrop was especially well revealed during construction work to expand the recreational complex. The prevailing, normal inclination of bedding is 30° to the NE. The section consists mainly of thin-bedded flysch, glauconitic sandstones and rare intercalations of muscovitic sandstones of the Szczawina Mbr lithotype (Figs 3, 4). The uppermost sandstones crop out northeast of the section, in the stream and on the hillside above it. They are strongly fragmented tectonically. The Ropianka and Szczawina formations in the outcrop and the surroundings form an island (a tectonic window or a tectonically elevated block), surrounded by the younger rocks of the Beloveža Formation, which crop out abundantly in neighbouring streams, west of the main outcrop. Debris of red shales (Lower Beloveža Member in Slovak nomenclature, i.e., the Ľabowa Formation in the Polish literature) occurs in the field, southeast of the outcrop (Fig. 2).

LITHOLOGY

The Ropianka Fm is composed of a series of alternating sandstones and shales (Figs 3–5). Several types of thin- and medium-bedded, occasionally thick-bedded sandstones occur within the formation. Usually, 1 m of section contains 4–9 beds (Figs 3, 4). Sandstone portions of the beds are 2–25 cm thick. The sandstones are grey or grey-greenish, very fine- and fine-grained and micaceous. They are mainly cross-bedded and represent the Tc and Tcd intervals. Rarely, the Tc_{conv} and Tbc intervals occur. The sandstone grains consist mainly of quartz and muscovite. Biotite and glauconite are much less frequent. The sandstone beds are separated by mudstone and claystone beds, 1–40 cm thick, quite often non-calcareous, grey, and grey-greenish or green shales (Figs 3–5), which display sandy intercalations.

The glauconitic sandstones are less frequent. They are medium- and fine-grained and occur in beds 30–65 cm thick. They are composed of quartz, with various admixtures of feldspars and abundant glauconite and micas.

Micas, mainly muscovite, often with an admixture of plant detritus define the lamination. The grains are cemented with silica or silica-carbonate. The sandstone beds are massive in the lower part, followed by and distinctly parallel, cross-to convolute laminated upwards, with Tabc, Tac_{conv}, Tbc_{conv} intervals. Some sandstone beds appear to be massive, but in fact display a faint parallel lamination. The contact between the massive Ta interval part and the laminated Tc or Tc_{conv} intervals is sharp. Rare, thick-bedded, medium-grained sandstones, rich in muscovite sandstone layers of the Szczawina Mbr lithotype, occur in the uppermost part of the Ropianka Fm (Fig. 3). They contain many mudstone shale intraclasts. Moreover, some 2–30 cm thick, weakly lithified clayey, muddy to sandy layers, with abundant muscovite and plant detritus, are present in the outcrop. Flute casts on the lower bedding surfaces of some thicker sandstone layers indicate a palaeocurrent flow from SE (Fig. 5D). The sandstones are often cut by calcite veins, especially concentrated along a few low-amplitude faults.

The deposits investigated are rich in trace fossils (Fig. 5E, F). Several of them have been identified by Książkiewicz (1977b) and Uchman (1998). *Planolites*, *Thalassinoides*, *Phycosiphon*, *Nereites* and *Chondrites* were noted in the mudstones and claystones. *Nereites irregularis* (Schafhäutl), formerly *Helminthoida labyrinthica* Heer, occurs quite frequently in the parallel-laminated, grey-yellowish, more or less marly mudstones, at the passage from sandstone to shale. Also *Chondrites targionii* (Brongniart) and *Ch. intricatus* (Brongniart) are fairly common. *Hormosiroidea annulata* (Vialov), *Ophiomorpha annulata* (Książkiewicz), *Cosmorhapha sinuosa* (Azpeitia Moros), *Helminthopsis*, *Gordia*, *Halopoa annulata* (Książkiewicz), *Ptychoplasma vagans* (Książkiewicz), *Zoophycos*, *Megagraption*, *Protopaleodictyon*, *Paleodictyon strozzii* Meneghini and other ichnotaxa were observed in the sandstone layers, mainly on their lower bedding surfaces.

BIOSTRATIGRAPHY

Several samples were taken for biostratigraphic analysis from the shaly intervals of the upper part of the Ropianka Fm in the Biela Farma section, but only three samples (Table 1) contained microforaminifers and the others were barren. The samples were processed by standard micropalaeontological technique: 0.5 kg of shales were macerated in Glaubert's salt solution by heating and cooling the solution and then washed on 0.68 mm sieves. At least 300 foraminiferal specimens from each sample were separated from the clastic residue. The microfossils are represented by foraminifera, mostly agglutinated; calcareous foraminifers occur as single, corroded specimens and usually they occur in their entirety or partly as steinkerns. The accompanying bioclasts are represented by rare fish teeth, radiolarian steinkerns and echinoid spines. The taxonomic determinations and part of the photographic documentation were made in Department of General Geology and Geotourism WGiOŚ AGH.

Relatively large-size and coarse-grained, "flysch-type", agglutinated specimens predominate among the foraminifera

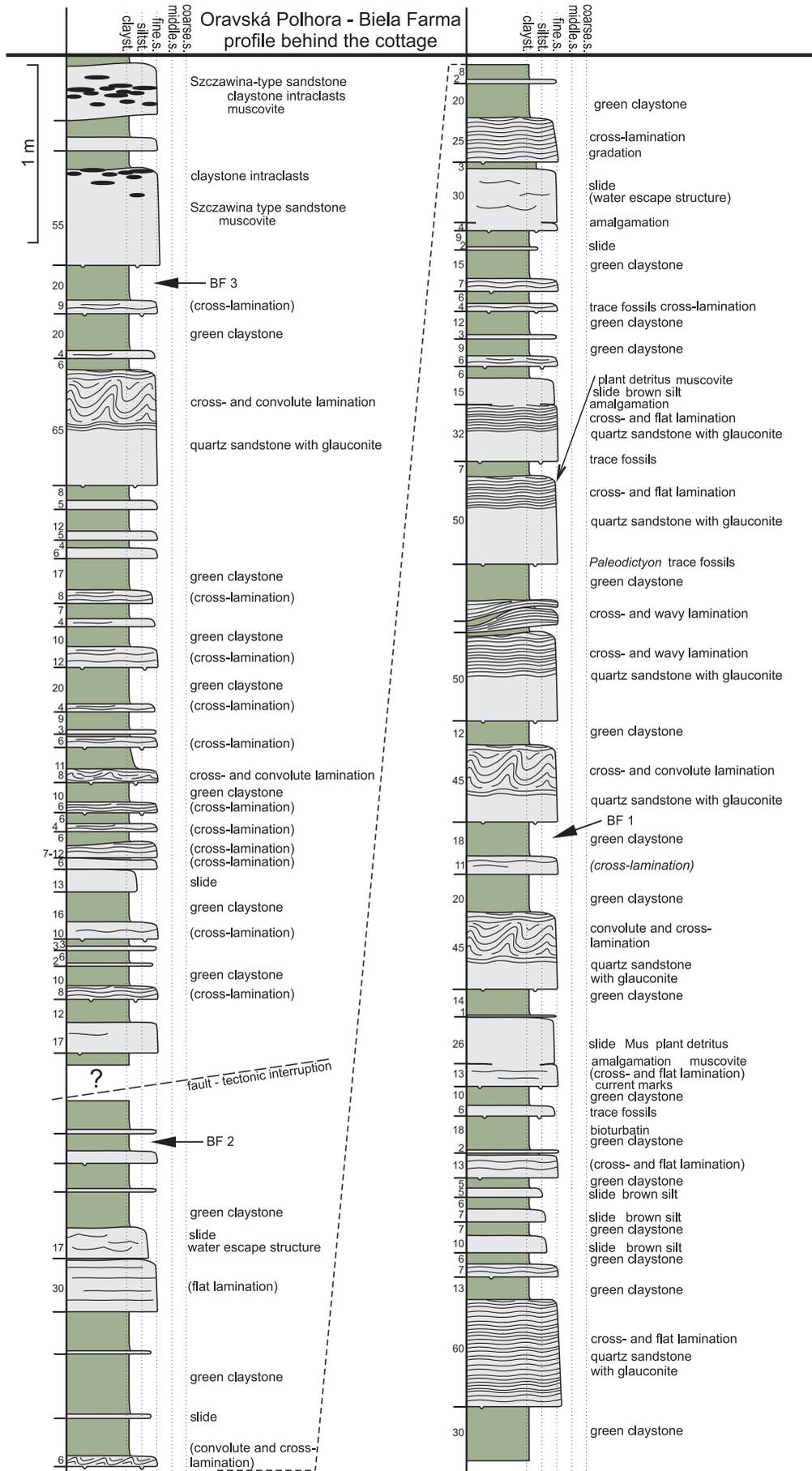


Fig. 3. Sedimentological log of the Ropianka Fm in Biela Farma section. BF 1 – location of sample for micropalaeontological analysis.

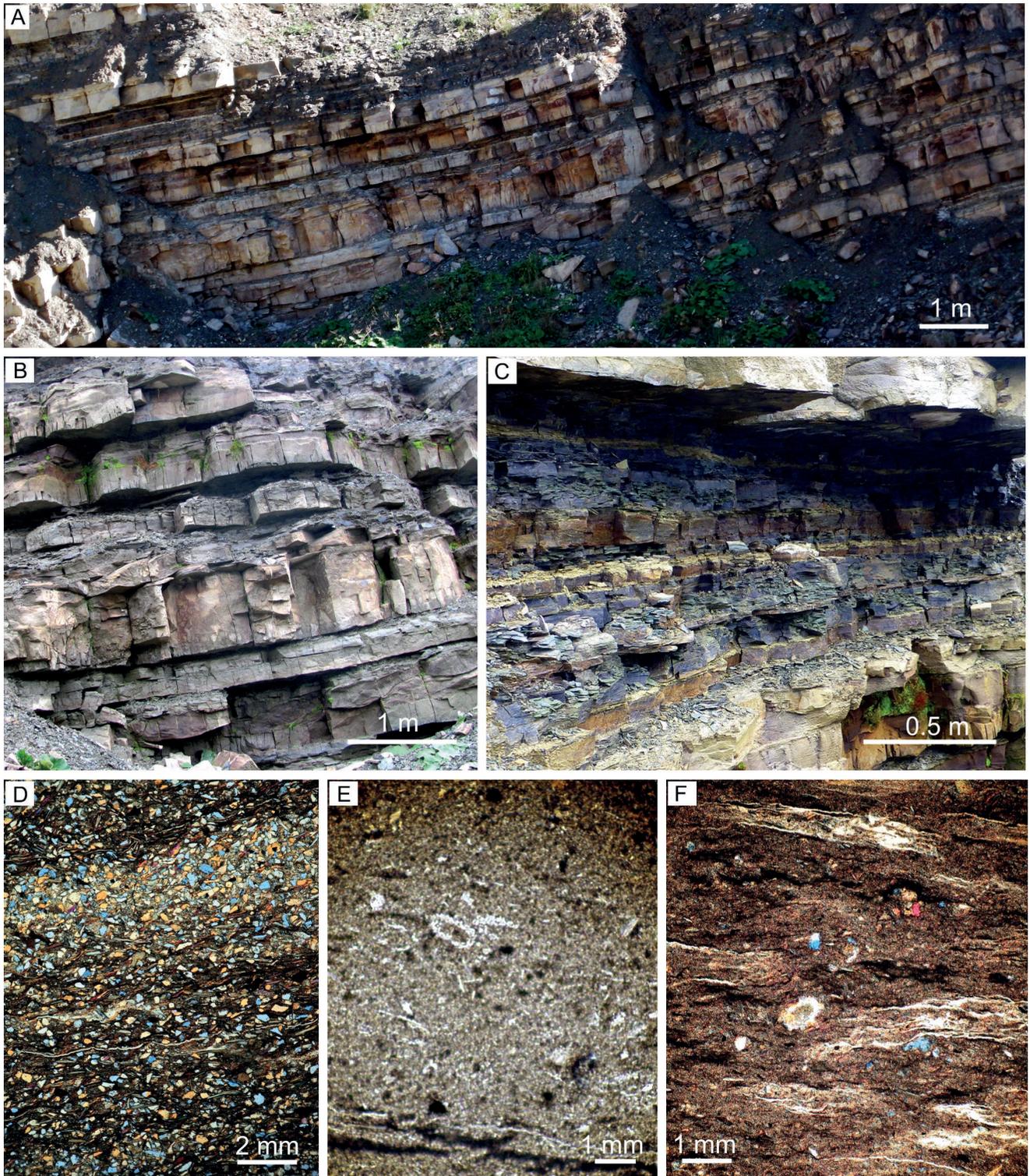


Fig. 4. The Ropianka Fm in Biela Farma section. **A.** General view of thin- and medium-bedded turbidites of the Ropianka Fm. **B.** Turbidites with sandstone domination. **C.** Turbidites with shales domination. **D-F.** Thin section of shales with *Bathysiphon* tests and different amount of psammitic material.



Fig. 5. Sandstones and shales in the Ropianka Fm – selected examples. **A–C.** Sandstones with different types of laminations. **D.** Flute moulds. **E.** Ichnofossil *Chondrites targionii* (Brongniart). **F.** Bioturbated lower bedding surface of a sandstone bed. **G.** Interval rich in green and grey shales.



Fig. 6. Foraminifera from the Ropianka Fm. **A, B.** *Bathysiphon/Nothia* sp. (sample BF1). **C.** *Nothia excelsa* (Grzybowski) (sample BF1). **D.** *Psammosiphonella cylindrica* Glaessner (sample BF1). **E, F.** *Psammosiphonella/Rhabdammina* sp. (sample BF1). **G.** *Hyperammina* sp. (sample BF2). **H.** *Subreophax pseudoscalaris* (Samuel) (sample BF2). **I, J.** *Subreophax scalaris* (Grzybowski) (sample BF2). **K.** *Caudammina excelsa* (Dylążanka) (sample BF2). **L, M.** *Placentammina placenta* (Grzybowski) (sample BF1). **N.** *Placentammina placenta* (Grzybowski) (sample BF3). **O.** *Ammodiscus peruvianus* (sample BF1). **P.** *Ammodiscus* sp. (sample). **Q.** *Annectina* sp. (sample BF1). **R.** *Ammodiscus tenuissimus* Grzybowski (sample BF1). **S.** *Glomospira diffundens* Cushman et Renz (ventral and dorsal site) (sample BF1). **T, U.** *Glomospira irregularis* (Grzybowski) (sample BF2). Scale bar is 100 μ m.

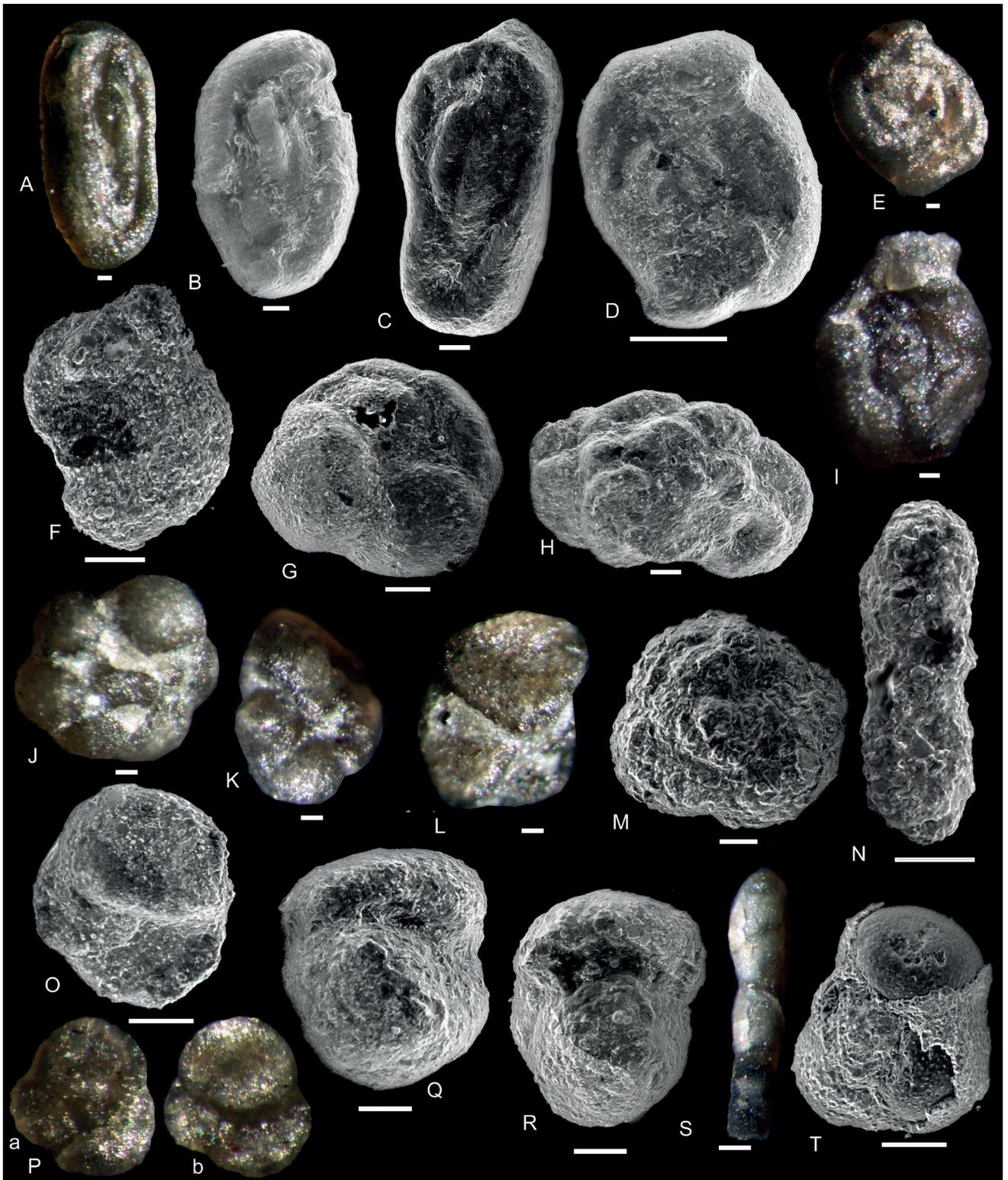


Fig. 7. Foraminifera from the Ropianka Fm. **A.** *Annectina grzybowskii* (Jurkiewicz) (sample BF1). **B, C.** *Annectina grzybowskii* (Jurkiewicz) (sample BF2). **D, F.** *Rzehakina epigona* (Rzehak) (sample BF2). **G.** *Trochamminoides variolarius* (Grzybowski) (sample BF2). **H, J.** *Trochamminoides subcorontus* (Grzybowski) (sample BF1). **I.** 9 – *Paratrochamminoides heteromorphus* (Grzybowski) (sample BF1). **K.** *Haplophragmoides* cf. *walteri* (Grzybowski) (sample BF2). **L.** *Haplophragmoides horridus* (Grzybowski) (sample BF2). **M.** *Trochammina globigeriniformis* (Parker et Jones) (sample BF2). **N.** *Karrerulina conversa* (Grzybowski) (sample BF1). **O.** *Ammosphaeroidina pseudopauciloculata* (Mjatliuk) (sample BF3), **P.** *Ammosphaeroidina pseudopauciloculata* (Mjatliuk) (ventral and dorsal site) (sample BF2). **Q.** *Recurvoides anormis* Mjatliuk (sample BF1). **R.** *Cribrostomoides subglobosus* (Cushman) (sample BF2). **S.** *Nodosaria/Dentalina* sp. (sample BF1). **T.** *Subbotina* cf. *triloculinoides* Plummer (sample BF1). Scale bar is 100 μ m.

Table 1.

Taxonomic list of foraminifera (Ropianka Fm, Biela Farma locality)

	BF 1	BF 2	BF 3
BENTHIC FORAMINIFERA			
<i>Ammodiscus peruvianus</i> Berry	I	I	
<i>Ammodiscus cretaceus</i> (Reuss)	I	I	
<i>Ammodiscus tenuissimus</i> Grzybowski	I	I	
<i>Ammosphaeroidina pseudopauciloculata</i> (Mjatliuk)	X	V	I
<i>Annectina grzybowskii</i> (Jurkiewicz)	V	V	
<i>Aschemocella grandis</i> (Grzybowski) (fragments)		I	
<i>Ammolagena clavata</i> (Jones et Parker)		I	
<i>Bathysiphon</i> sp. and <i>Nothia</i> sp. (fragments)	W	W	W
<i>Caudammina excelsa</i> (Dyląganka) (fragments)	I	I	
<i>Cribrostomoides subglobosus</i> (Cushman)	V	X	
<i>Dorothia</i> sp.	I		
<i>Dentalina</i> sp. / <i>Nodosaria</i> sp. (fragments)	I	I	
<i>Glomospira charoides</i> (Jones et Parker)		I	
<i>Glomospira diffundens</i> Cushman et Renz	I	I	
<i>Glomospira irregularis</i> (Grzybowski)	I	I	
<i>Glomospira gordialis</i> (Jones et Parker)			I
<i>Haplophragmoides horridus</i> (Grzybowski)		I	
<i>Haplophragmoides walteri</i> (Grzybowski)	I	I	
<i>Hormosinelloides guttifer</i> (Brady)	I	I	
<i>Hyperammina</i> sp.		I	
<i>Karrerulina conversa</i> (Grzybowski)	I	I	
<i>Paratrochamminoides</i> and <i>Trochamminoides</i> div. sp.	W	W	W
<i>Placentammina placenta</i> (Grzybowski)	W	X	I
<i>Psammosiphonella</i> sp. / <i>Rhabdammina</i> sp. (fragments)	X	X	V
<i>Praesphaerammina gerochii</i> Hanzlikowa		V	
<i>Recurvooides</i> div. sp.	W	W	X
<i>Reophax duplex</i> Grzybowski	I	V	
<i>Rzehakina epigona</i> (Rzehak)		I	
<i>Rzehakina minima</i> Cushman et Renz			I
<i>Saccammina grzybowskii</i> (Schubert)		I	
<i>Subreophax scalaris</i> (Grzybowski) (fragments)	I	V	I
<i>Subreophax splendidus</i> (Grzybowski) (fragments)	I		
<i>Subreophax pseudoscalaris</i> (Samuel) (fragments)	I	I	
<i>Reophax duplex</i> Grzybowski	I	V	
<i>Trochammina</i> sp.		I	I
PLANKTONIC FORAMINIFERA			
<i>Parasubbotina</i> cf. <i>variata</i> Subbotina		I	
<i>Subbotina</i> cf. <i>triangularis</i> (White)	I		
<i>Subbotina</i> cf. <i>cancellata</i> Blow		I	
<i>Subbotina</i> cf. <i>triloculinoides</i> Plummer		I	
Plankton (mainly <i>Subbotina</i> – <i>Parasubbotina</i> group) - unidentifiable	V	V	
FISH TEETH			
	X	I	I
RADIOLARIAN STEINKERNS			
	V	V	X
ECHINODERMATA SPINES (fragments)			
	I		

I : 1-4 specimens

V: 5-10 specimens

X: 11-20 specimens

W: 21-50 specimens

(Figs 6, 7). Two of the three samples, BF1 and BF2, contain taxonomically diverse assemblages. More than 35 species of agglutinated foraminifers were recognized (Tab. 1). The tubular forms, *Recurvoides* and *Paratrochamminoides* – *Trochamminoides* predominate. Other common taxa include *Ammodiscus* div. sp., *Ammosphaeroidina pseudopau-ciloculata* (Mjatluk), *Annectina grzybowskii* (Jurkiewicz), *Glomospira* div. sp., *Haplophragmoides* div. sp., *Reophax duplex* Grzybowski, *Placentamina placenta* (Grzybowski). A complete list of the taxa recognized is presented in Table 1. Most of the agglutinated taxa are typical for the Late Cretaceous–Early Palaeogene interval. Among them, *Annectina grzybowskii* (Jurkiewicz), *Caudamina excelsa* (Dylańska), *Glomospira diffundens* Cushman et Renz, *Rzehakina epigona* (Rzehak) and *Rzehakina minima* Cushman et Renz are known from a narrower age range in the Outer Carpathians, from the Coniacian–Maastrichtian interval (e.g., Hanzlíková, 1972; Jednorowska, 1975; Morgiel and Szymakowska, 1978; Szejn *et al.*, 1984; Kaminski and Gradstein, 2005 and references therein), but *Annectina grzybowskii* (Jurkiewicz) and *Glomospira diffundens* Cushman et Renz are from the Maastrichtian (Olszewska *et al.*, 1996; Olszewska, 1997). Their last occurrences are known from the Late Paleocene (e.g., Morgiel and Szymakowska, 1978; Olszewska *et al.*, 1996; Olszewska, 1997; Bąk, 2004; Waškowska-Oliwa, 2008 and references therein) and were terminated by the mass extinction of benthic fauna, related to the Paleocene–Eocene Thermal Maximum (e.g., Bąk, 2004; Olszewska and Malata, 2006; Waškowska, 2015 and references therein). In sample BF2, *Praesphaerammia gerochii* Hanzlíková occurs. This species was described and recognized in the Outer Carpathians, mainly from the Paleocene (e.g., Jurkiewicz, 1967; Hanzlíková, 1972; Olszewska *et al.*, 1996; Waškowska *et al.*, 2014), locally from the Lower Eocene (Geroch and Koszarski, 1988; Bąk, 2004; Kaminski and Gradstein, 2005; Bubík, 2006; Golonka and Waškowska, 2014). Therefore, the age of the upper part of the Ropianka Fm sampled can be narrowed to the Paleocene. The large number of *Paratrochamminoides* – *Trochamminoides* specimens, typical of Paleocene in the Outer Carpathians (Morgiel and Olszewska, 1981), and the relatively large number of *Saccamina* are noteworthy in the assemblages investigated.

A more precise biostratigraphical study was possible on the basis of planktonic foraminifera, even though the taxonomic determinations were conducted on the poorly preserved, single specimens, preserved as steinkerns and only occasionally with the remnants of the tests. The foraminiferal tests are corroded and mechanically deformed and many of diagnostic features are not present. Therefore, the determinations of them are based on the shape of the tests. Some specimens were unidentifiable, but part represents the *Subbotina-Parasubbotina* group. They show the features of Paleocene species, and over a dozen specimens were determined in the open nomenclature. They include *Subbotina* cf. *cancellata* Blow, *Parasubbotina* cf. *variata* Subbotina, *Subbotina* cf. *trianagularis* (White) and *Subbotina* cf. *triloculinoides* (Table 1). The two last taxa indicate a Middle Paleocene age, concurring to the foraminiferal age ranges after Olsson *et al.* (1999), Premoli-Silva *et al.* (2003) or the middle – earliest Late Paleocene (BouDagher-Fadel 2015).

Comparison to the Ropianka Formation in Polish Orava and Beskid Wysoki regions

The Ropianka Fm crops out frequently in the Bystrica Zone of the Magura Nappe in the western part of the Polish Outer Carpathians (Golonka and Waškowska-Oliwa, 2007). The Upper Cretaceous–Paleocene deposits of this zone occur at Lipnica Wielka in the Polish part of Orava, ca. 15 km from the Biela Farma outcrop, in the Slovak part of Orava. These deposits form the cores of the Zosiak and Kiczora anticlines. They were mapped there and described by Książkiewicz (1966) as the Inoceramian Beds, so named for the first time by Uhlig (1885) (Fig. 2). Later, Książkiewicz (1968a, 1970) considered that the name Ropianka Beds is better for this unit, because it was used first in deposits of the Magura Nappe by Paul (1869); therefore, he applied this last name consistently in his later publications (e.g., Książkiewicz, 1974a, b, 1977a).

The classic, typical Ropianka (Inoceramian) Beds, highlighted by Książkiewicz (1966, 1968 a, b; 1970), crop out in the Zosiak hamlet, at Lipnica Wielka. They consist of thin- and medium-bedded sandstones, intercalated with shales. The sandstone layers are a few to several centimetres and occasionally up to 50 cm thick. The Ropianka Beds at Zosiak are overlain by variegated shales, described as the Łabowa Shale Formation (name after Oszczytko, 1991; Oszczytko *et al.*, 2005). Samples taken from these deposits contained Early Palaeogene assemblages of small foraminifera (Jednorowska, 1966).

Thick-bedded (50–70 cm, occasionally up to 2 or even 3 m thick), medium- and coarse-grained, calcareous sandstones occur in the Ropianka (Inoceramian) Beds in the Kiczora hamlet at Lipnica Wielka (cf. Książkiewicz, 1966, 1970), in recent time poorly exposed. The sandstones are very rich in muscovite (with occasional biotite). Therefore, Książkiewicz called them the “muscovite sandstones”, which could be comparable to the Szczawina Mbr type. Thinner sandstone beds, more often glauconitic, with intercalations of grey, green and occasional variegated shales, are present higher up the section. Also down the section sandstone layers undergo thinning. Książkiewicz (1966) listed numerous trace fossils from the sandstones, including *Paleodictyon*, *Spirorhappe*, *Cosmorhappe*, *Paleomeandron*, and in the muscovite sandstones, he observed *Zoophycos*, *Paleochorda* [not the currently recommended name], *Helicorhappe*, *Scolicia* and *Halopoa*. In the shales intercalated in the sandstones, the authors also found relatively common *Nereites irregularis* (former *Helminthoida labyrinthica*), as well as *Phycosiphon*, *Chondrites* and *Planolites*. Abundant *Nereites irregularis* occurs in the Głębieńiec Mbr (Paleocene) in the upper part of the Ropianka Fm in the Gorce Mts (Uchman and Cieszkowski, 2008; Cieszkowski *et al.*, 2015). Such facies of the Ropianka (Inoceramian) Beds are similar to the facies occurring in the Oravská Polhora region, especially to those exposed at Biela Farma. Jednorowska (1966), on the basis of small foraminifera, estimated the age of the Inoceramian Beds in the Kiczora hamlet as “late Senonian”, and the strata overlain by variegated marls and shales as Paleocene. Wojtaszek (1993), using determinations of foraminiferal assemblages by

E. Malata, suggested that the variegated shales intercalations in the upper part of the Ropianka (Inoceramian) Beds are late Maastrichtian and late Maastrichtian–Paleocene. Flute-casts in sandstone beds indicate palaeocurrents from the S or SW (Książkiewicz, 1966).

Sikora and Żytko (1959) described several basic, lithological variations of the Ropianka (Inoceramian) Beds from the Beskid Żywiecki Mts, west of Pilsko Mt. In the lowest part, there is a horizon about 50 m thick with black-grey shales 1–4 m thick and covered with Fe oxides. They are divided by packages of solid dark-grey fine-grained sandstones 50–150 cm thick and rich in glauconite, biotite and feldspar. Thin layers of pelitic Fe carbonates also were observed. Above these deposits, part of the section about 100 m thick is composed of variegated shales, interbedded with laminated sandstones with abundant muscovite and well indurated, laminated sandstones, 0.5 to 100 cm thick. Up the section, a series of medium- to coarse-grained sandstones and conglomerates (later described as the Szczawina Fm), up to 220 m thick, is present. Sikora and Żytko (1959) named this complex the Szczawina Sandstones after Szczawina Mt. (in Slovakia Trup Mt.), north-west of Pilsko Mt. They described the Szczawina Sandstones as a complex of thick-bedded sandstones with thin shale interbeds. Grey-greenish thick-bedded, not so well indurated, fine- to medium-grained sandstones predominate there. The sandstone layers are typically 1–3 m, rarely up to 8 m thick. They are typified by abundant muscovite, visible especially on parting surfaces parallel to the bedding. Biotite and glauconite make up only a minor admixture in the sandstones. Toward the base of individual beds, the sandstones only rarely pass into fine-grained conglomerates, which contain clasts up to 3 mm in diameter, formed by quartz, green and black shales, phyllites and feldspars. The sandstones beds are interbedded with layers of green, dark grey, rarely red shales with small muscovite flakes, and up to a few tens of centimetres thick. Thin sandstone layers with trace fossils are rare. The youngest part of the formation is exposed in the Biela Farma section. Sikora and Żytko (1959) did not determine whether the recurrence of the sandstone-conglomerate deposits (Szczawina Fm) at several positions in the sections is primary or caused by tectonic repetition. For the formation discussed, occurring in the southern part of the Rača Zone, Pivko (1998) proposed the name Veselý Fm, but later (Pivko, 2002) changed the name of the Veselý Fm for lack of definition and changed it to the Ropianka Fm. He included the variegated shales in this formation. Teťák *et al.* (2016a) presented the alternation of the Szczawina and Ropianka members on the geological map of the area around Pilsko Mt. Matějka and Roth (1952) and Pesl (1968) associated the sandstone series (Szczawina) incorrectly with the much younger Babia Hora Sandstone (the recent Kýchera Fm). The Szczawina Fm can be compared with the muscovite sandstones of the Inoceramian Beds (Książkiewicz, 1966). According to Ryłko (1992), they are comparable to the generally defined “Ropianka complex beds”.

The age of the Ropianka Formation was estimated as the Maastrichtian to Paleocene (Sikora and Żytko, 1959;

Korábová and Pottfaj, 1991). Bieda *et al.* (1963, 1967) determined a Senonian to Paleocene age, based on *Inoceramus* fragments and agglutinated foraminifera. The Paleocene age of the upper part of the Inoceramian Beds (recent Ropianka Fm) was determined by Cieszkowski *et al.* (1989) and Oszczytko *et al.* (1991) in the Bystrica Zone. Later, the age of this division was determined as Late Maastrichtian–Paleocene (e.g., Cieszkowski, 2006; Uchman and Cieszkowski, 2008; Cieszkowski *et al.*, 2015).

DISCUSSION

In the Magura Nappe the Ropianka Fm is a lithologically diverse lithostratigraphic unit, but usually without very sharp lithologic contrasts. Thin-bedded flysch predominates as grey or grey-greenish laminated muscovite sandstones and grey or green-grey marly or non-calcareous shales. Thin beds of red shales are seen occasionally. Glauconitic sandstones and thick, massive sandstones with abundant muscovite of the Szczawina Mbr lithotype are rare.

Paul (1869) was the first to distinguish the lithostratigraphic units bearing the name Ropianka, i.e., the Ropianka Beds (originally Ropianka Schichten) on the basis of outcrops near the village Ropianka, located south of Dukla, in Poland. The name Inoceramian Beds was used commonly in the older Polish literature (e.g., Sikora, 1957; Sikora and Żytko, 1959; Bieda *et al.*, 1963; Książkiewicz, 1966; Ślęczka *et al.*, 2006, and references therein) as an equivalent for the Ropianka Beds. Uhlig (1885) introduced the Inoceramian Beds for Senonian flysch facies, consisting of calcareous sandstones with abundant mica, originally distinguished as the Lower Hieroglyphs beds (Paul and Tietze, 1877, 1879). Kotlarczyk (1978) formalized the Inoceramian Beds on the Skole Nappe under the name Ropianka Formation and stressed that this formation can be used for the Magura to Skole nappes because of strong similarities in facies. Ślęczka and Miziołek (1995) revised the type locality of the Ropianka Beds in the Magura Nappe and concluded that this lithostratigraphic unit in the original sense of Paul (1869) includes sediments from the Late Cretaceous to the Oligocene, not only in the Magura Nappe, but also in the adjacent Dukla Nappe. Only the complex, located in southern part of continuous outcrops, studied by Paul at Ropianka village and Late Cretaceous–Paleocene in age, belongs to the Magura Nappe. Despite such doubts, Oszczytko *et al.*, (2005) formalized the Cretaceous and lower Palaeogene lithostratigraphic units in the Magura Nappe and defined an upper part of the Inoceramian Beds as the Ropianka Formation. They justified their decision on the fact that the name “Ropianka Beds” is well established in the geological nomenclature on the Magura Nappe. In their proposal, the previous Inoceramian Beds were subdivided into three formations, i.e., the Białe Fm in the lower part (called also the Kanina Beds in Burtan, 1977, 1978; Burtan *et al.*, 1978a, b), the Szczawina Sandstone Fm in middle part, and the Ropianka Fm in the upper part. This division has been applied with some modifications in several publications about the geology of the Gorce Mts (e.g., Cieszkowski,

2006; Uchman and Cieszkowski, 2008; Cieszkowski *et al.*, 2015). In general, the Ropianka Fm is the same as the Inoceranian Beds (Sikora, 1957; Sikora and Żytko, 1959; Książkiewicz, 1966), the Ropianka Beds or the Ropianka Formation (Golonka and Wójcik, 1978a, b; Oszczytko and Zuchiewicz, 1992; Ryłko *et al.*, 1992; Oszczytko *et al.*, 2005) in the Polish sector of the Magura Nappe, and the “Mudstone-sandstone Beds” (Pesl, 1968), or partly as the Soláň Fm in (Švábenická *et al.*, 1997; Picha *et al.*, 2006) in the Rača Subunit of the Magura Nappe in Western Slovakia and Moravian in the Czech Republic. It is also similar to the top part of the Aitlengbach Fm of the Rhenodanubian Flysch Belt in the Austrian Alps (Schnabel, 1992; Faupl, 1996; Švábenická *et al.*, 1997) or to the Biotite-glaucconite Beds and the Mutne Sandstone in the western marginal part of the Magura Nappe in Poland (Sikora and Żytko, 1959). Deposits assigned to the Ropianka Formation also have been distinguished as the Jaworzynka Beds (Biotite-glaucconite Beds) by Burtan (1973), and later the Jaworzynka Fm (Oszczytko *et al.*, 2005, see also Cieszkowski *et al.*, 2006, 2007) and the Szczawnica Fm in the Krynica Zone (Birkenmajer and Oszczytko, 1989). The complex history of lithostratigraphy shows that the Ropianka Fm requires further investigations, including redefinition of the type sections in the Magura Nappe in Poland, Slovakia and the Czech Republic. The Biela Farma locality should be taken into consideration through the recognition of new reference sections in the Bystrica Zone of the Magura Nappe. The muscovite sandstones of the Szczawina Mbr lithotype occur within the thin-bedded complexes, typical for the Ropianka Formation in the Bystrica Zone of the Magura Nappe in Slovak and Polish Orava. Therefore, the Szczawina Member as part of the Ropianka Formation seems to be a valid lithostratigraphic unit.

CONCLUSIONS

The Ropianka Formation was documented in the Bystrica Zone of the Magura Nappe in the north-western part of Orava, in the Slovak Republic. It is the most southerly surface occurrence of the Ropianka Fm in the Bystrica Zone. Here, the Ropianka Fm is composed of thin- and medium-bedded, sandy and shaly, turbiditic deposits, with occasional intercalations of the thick-bedded, muscovitic sandstones of the Szczawina Mbr lithotype. Abundant and diverse, agglutinated benthonic and occasional planktonic foraminifers indicate a Middle Paleocene age for the upper part of the Ropianka Fm. The development of the Ropianka Fm is similar to that in Poland, in outcrops in the Bystrica Zone in northern Orava at Lipnica Wielka and along northern foothills of the Gorce Mts. An overview of the lithostratigraphic nomenclature shows that different lithostratigraphic names have been applied to particular stratigraphic subdivisions. The lithostratigraphy of the Magura Nappe requires regional unification of the formal units and the Ropianka Fm needs redefinition and determination of a new type section and reference sections. The large outcrop at Biela Farma should be taken into consideration as a potential reference section.

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REFERENCES

- Bąk, K., 2004. Deep-water agglutinated foraminiferal changes across the Cretaceous/Tertiary and Paleocene/Eocene transitions in the deep flysch environment; eastern Outer Carpathians (Bieszczady Mts, Poland). In: Bubík, M. & Kaminsky, M. A. (eds), *Proceedings of the Sixth International Workshop on Agglutinated Foraminifera*. Grzybowski Foundation Special Publication, 8: 1–56.
- Bieda, F., Geroch, S., Koszarski, L., Książkiewicz, M. & Żytko, K., 1963. Stratigraphie des Karpates Externes Polonaises. In: *Association géologique Karpato-Balkanique VI – Éme congrès Varsovie – Cracovie 1993*, Recherches géologiques dans les Karpates, 10, pp. 1–181.
- Bieda, F., Jednorowska, A. & Książkiewicz, M., 1967. Stratigraphy of the Magura Series around Babia Góra. *Biuletyn Instytutu Geologicznego*, 21: 293–324.
- Birkenmajer, K. A. & Oszczytko, N., 1989. Cretaceous and Palaeogene lithostratigraphic units of the Magura Nappe, Krynica Subunit, Carpathians. *Annales Societatis Geologorum Poloniae*, 59: 145–181.
- BouDagher-Fadel, M. K., 2015. *Early Evolutionary History of Planktonic Foraminifera*. University College London, 298 pp.
- Bubík, M., 2006. Results of mapping and stratigraphic research in the Silesian Unit on the Horní Bečva map sheet. *Zpráva o geologických výzkumech v roce 2006*, pp. 9–14.
- Burtan, J., 1973. *Objaśnienia do Szczegółowej Mapy Geologicznej Polski, skala 1: 50 000, arkusz Wisła*. Wydawnictwa Geologiczne, Warszawa. [In Polish.]
- Burtan, J., 1977. *Szczegółowa Mapa Geologiczna Polski, skala 1: 50 000, arkusz Mszana Dolna*. Wydawnictwa Geologiczne, Warszawa, 37 pp. [In Polish.]
- Burtan, J., 1978. *Objaśnienia do Szczegółowej Mapy Geologicznej Polski, skala 1: 50 000, arkusz Mszana Dolna*. Wydawnictwa Geologiczne, Warszawa, 68 pp. [In Polish.]
- Burtan, J., Paul, Z. & Watycha, L., 1978a. *Objaśnienia do Szczegółowej Mapy Geologicznej Polski, skala 1: 50 000, arkusz Mszana Górna*. Wydawnictwa Geologiczne, Warszawa, 68 pp. [In Polish.]
- Burtan, J., Paul, Z. & Watycha, L., 1976. *Szczegółowa Mapa Geologiczna Polski, skala 1: 50 000, arkusz Mszana Górna*. Wydawnictwa Geologiczne, Warszawa. [In Polish.]
- Cieszkowski, M., 2006. Scientific geological attractions of the Gorce National Park and its surroundings. *Ochrona Beskidów Zachodnich*, 1: 45–57.
- Cieszkowski, M., Chodyń, R. & Szczęch, M., 2015. Gorce - góry fliszowe. In: Czarnota, P. & Stefanik, M. (eds), *Gorczański*

- Park Narodowy. Przyroda i krajobraz pod ochroną, 35-lecie GPN. Gorczański Park Narodowy, Poręba Wielka*, pp. 39–51. [In Polish, with English summary.]
- Cieszkowski, M., Golonka, J., Waškowska-Oliwa, A. & Chodyń, R., 2007. Type locality of the Mutne Sandstone Member of the Jaworzynka Formation, Western Outer Carpathians, Poland. *Annales Societatis Geologorum Poloniae*, 77: 269–290.
- Cieszkowski, M., Oszczytko, N. & Zuchiewicz, W., 1989. Upper Cretaceous siliciclastic – carbonate turbidites at Szczawa, Magura Nappe, West Carpathians, Poland. *Bulletin of the Polish Academy of Sciences, Earth Sciences*, 37: 231–245.
- Cieszkowski, M., Golonka, J., Waškowska-Oliwa, A. & Chrustek, M., 2006. Geological structure of the Sucha Beskidzka – Świnna Poręba region (Polish Flysch Carpathians). *Geologia, Kwartalnik AGH*, 23: 155–201. [In Polish, with English summary.]
- Faupl, P., 1996. *Tiefwassersedimente und tektonischer Bau der Flyschzone des Wienerwaldes. Exkursion A2, Exkursionsführer, Sediment 96*. Geologische Bundesanstalt, Wien, pp. 1–32.
- Geroch, S. & Koszarski, L., 1988. Agglutinated foraminiferal stratigraphy of the Silesian flysch through. *Abhandlungen der Geologischen Bundesanstalt*, 41: 73–79.
- Golonka, J. & Waškowska, A., 2014. Palaeogene of the Magura Nappe adjacent to the Pieniny Klippen Belt between Szczawnica and Krościenko (Outer Carpathians, Poland). *Geology, Geophysics & Environment*, 40: 359–375.
- Golonka, J. & Waškowska-Oliwa, A., 2007. Stratigraphy of the Polish Flysch Carpathians between Bielsko-Biała and Nowy Targ. *Geologia, Kwartalnik AGH*, 33: 5–28. [In Polish, with English summary.]
- Golonka, J. & Wójcik, A., 1978a. *Szczegółowa Mapa Geologiczna Polski, skala 1: 50 000, arkusz Jeleśnia*. Wydawnictwa Geologiczne, Warszawa, 40 pp.
- Golonka, J. & Wójcik, A., 1978b. *Objaśnienia do Szczegółowej Mapy Geologicznej Polski, skala 1: 50 000, arkusz Jeleśnia*. Wydawnictwa Geologiczne, Warszawa. [In Polish.]
- Hanzlíková, E., 1972. Carpathian Upper Cretaceous foraminifera of Moravia. *Rozprawy Ústředního Ústavu Geologického*, Praha, 39: 1–160.
- Jednorowska, A., 1968. Mikrofauna brzeżnych jednostek płaszczowiny magurskiej i jej znaczenie stratygraficzne. *Prace Geologiczne Polskiej Akademii Nauk*, 50: 7–89. [In Polish, with Russia and French summaries.]
- Jednorowska, A., 1975. Small Foraminifera assemblages in the Paleocene of the Polish Western Carpathians, *Studia Geologica Polonica*, 47: 1–149. [In Polish, with English summary.]
- Jurkiewicz, H., 1967. Foraminifers in the Sub-Menilitic Palaeogene of the Polish Middle Carpathians. *Biuletyn Instytutu Geologicznego*, 210: 5–128. [In Polish, with English summary.]
- Kaminski, M. A. & Gradstein, F. M., 2005. *Atlas of Palaeogene cosmopolitan deep-water agglutinated foraminifera*. Grzybowski Foundation Special Publication no. 10, 547 pp.
- Korábová, K. & Potfaj, M., 1991. Mikropaleontologické vyhodnotenie vzoriek z mapy okolia Pilska na základe foraminifer a vápňitého nanoplanktónu. In: Pivko, D., Beňuška, P., Korábová, K., Kováčik, M., Potfaj, M., Siráňová, Z. & Vranovská, A. (eds), *Výsvetlivky ku geologickej mape okolia Pilska 1 : 25 000 na listoch 26-142 Mútne a 26-231 Oravské Veselé*. Čiastková záverečná správa, Manuskript – archív Geofondu, ŠGUDŠ, Bratislava, pp. 1–78. [In Slovak.]
- Koszarski, J., Sikora, W. & Wdowiarz, S., 1974. The flysch Carpathians. In: Mahel', M., (ed.), *Tectonics of the Carpathian-Balkan Regions, Explanations to the Tectonic Map of the Carpathian-Balkan Regions and their Foreland*. Štátny geologický ústav Dionýza Štúra, Bratislava, pp. 180–197.
- Kotlarczyk, J., 1978. Stratigraphy of the Ropianka Formation or of Inoceraman Beds in the Skole Unit of the Flysch Carpathians. *Prace Geologiczne Oddziału PAN w Krakowie*, 108: 1–82. [In Polish, with English summary.]
- Książkiewicz, M., 1966. Geologia regionu babiogórskiego. In: Książkiewicz, M. (ed.), *Przewodnik XXXIX Zjazdu Polskiego Towarzystwa Geologicznego – Instytut Geologiczny*. Warszawa, pp. 5–59. [In Polish.]
- Książkiewicz, M., 1968a. *Objaśnienia do Szczegółowej Mapy Geologicznej Polski, skala 1: 50 000, arkusz Zawoja*. Wydawnictwa Geologiczne, Warszawa, 54 pp. [In Polish.]
- Książkiewicz, M., 1968b. *Szczegółowa Mapa Geologiczna Polski, skala 1: 50 000, arkusz Zawoja*. Wydawnictwa Geologiczne, Warszawa. [In Polish.]
- Książkiewicz, M., 1970. Contributions to the geology of the Wadowice Region. Part II. *Rocznik Polskiego Towarzystwa Geologicznego*, 40: 369–375. [In Polish, with English summary.]
- Książkiewicz, M., 1974a. *Szczegółowa Mapa Geologiczna Polski, skala 1: 50 000, arkusz Sucha Beskidzka*. Wydawnictwa Geologiczne, Warszawa. [In Polish.]
- Książkiewicz, M., 1974b. *Objaśnienia do Szczegółowej Mapy Geologicznej Polski, skala 1: 50 000, arkusz Sucha Beskidzka*. Wydawnictwa Geologiczne, Warszawa, 85 pp. [In Polish.]
- Książkiewicz, M., 1977a. The tectonics of the Carpathians. In: Pożarski, W. (ed.), *Geology of Poland, Volume IV, Tectonics, The Alpine Tectonic Epoch*. Wydawnictwa Geologiczne, Warszawa, pp. 476–620.
- Książkiewicz, M., 1977b. Trace fossils in the Flysch of the Polish Carpathians. *Palaeontologica Polonica*, 36: 1–208.
- Lexa, J., Bezák, V., Elečko, M., Mello, J., Polák, M., Potfaj, M. & Vozár, J., 2000. *Geological map of Western Carpatians and Adjacent Areas 1 : 500 000*. MŽP SR a GÚDŠ, Bratislava.
- Matějka, A. & Roth, Z., 1952. Zpráva o výskumu magurského flyše v povodí Bílé Oravy. *Věstník Ústředního ústavu geologického*, 27: 212–216. [In Czech.]
- Morgiel, J. & Olszewska, B., 1981. Biostratigraphy of the Polish External Carpathians based on agglutinated foraminifera. *Micropaleontology*, 27: 1–30.
- Morgiel, J. & Szymakowska, F., 1978. Stratigraphy of Palaeocene and Eocene of the Skole Unit. *Biuletyn Instytutu Geologicznego*, 310: 39–171. [In Polish, with English summary.]
- Olsson, R. K., Hemleben, C., Berggren, W. A. & Huber, B. T., 1999. *Atlas of Paleocene Planktonic Foraminifera*. Smithsonian Contribution to Paleobiology, 85: 1–252.
- Olszewska, B., 1997. Foraminiferal biostratigraphy of the Polish Outer Carpathians, A record of basin geohistory. *Annales Societatis Geologorum Poloniae*, 67: 325–337.
- Olszewska, B. & Malata, E., 2006. Analiza paleośrodowiskowa i paleobatymetryczna zespołów mikroskamieniałości polskich Karpat zewnętrznych. In: Oszczytko, N., Uchman, A. & Malata, E. (eds), *Palaeotectonic evolution of the Outer Carpathian and Pieniny Klippen Belt Basins*. Instytut Nauk

- Geologicznego Uniwersytetu Jagiellońskiego, Kraków, pp. 61–84. [In Polish]
- Olszewska, B., Odrzywolska-Bieńkowska, E., Giel, M. D., Pożaryska, K. & Szczuchura, K., 1996. Rząd Foraminiferida Eichwald, 1830. In: Limanowska, L. & Piwocki, M. (eds), *Budowa geologiczna Polski. Atlas skamieniałości przewodnich i charakterystycznych. Kenozoik. trzeciorząd. paleogen. t 3, cz. 3a*. Państwowy Instytut Geologiczny, Warszawa, pp. 45–215. [In Polish.]
- Oszczypko, N., 1991. Stratigraphy of the Palaeogene deposits of the Bystrica Subunit (Magura Nappe, Polish Outer Carpathians). *Bulletin of the Polish Academy of Sciences, Earth Sciences*, 39: 433–445.
- Oszczypko, N., Cieszkowski, M. & Zuchiewicz, W., 1991. Variable orientation of folds within the Upper Cretaceous–Palaeogene rocks near Szczawa, the Bystrica Subunit, Magura Nappe, West Carpathians. *Bulletin of the Polish Academy of Sciences, Earth Sciences*, 39: 67–84.
- Oszczypko, N., Malata, E., Bąk, K., Kędzierski, M. & Oszczypko-Clowes, M., 2005. Lithostratigraphy and biostratigraphy of the Upper Albian-Lower/ Middle Eocene flysch deposits in the Bystrica and Rača subunits of the Magura Nappe; Western Carpathians (Beskid Wyspowy and Gorce Rages, Poland). *Annales Societatis Geologorum Poloniae*, 75: 27–69.
- Oszczypko, N. & Zuchiewicz, W., 1992. Zarys stratygrafii płaszczowiny magurskiej. In: Oszczypko, N. & Zuchiewicz, W. (eds), *Przewodnik LXIII Zjazdu Polskiego Towarzystwa Geologicznego, Koninki*. Polskie Towarzystwo Geologiczne, Kraków, pp. 17–19. [In Polish.]
- Paul, C. M., 1869. Die geologischen Verhältnisse des nördlichen Saroser und Zempliner Comitates. *Jahrbuch der Geologischen Reichsanstalt*, 18–19: 241–280.
- Paul, C. M. & Tietze, L., 1877. Studien in der Sandsteinzone der Karpaten. *Jahrbuch der Geologischen Reichsanstalt*, 27: 33–130.
- Paul, C. M. & Tietze, L., 1879. Neue Studien in der Sandsteinzone der Karpaten. *Jahrbuch der Geologischen Reichsanstalt*, 29: 189–304.
- Pesl, V., 1968. Litofacie paleogénu v magurské jednotce vnějších flyšových karpát na území ČSSR a PLR. *Sborník Geologických Věd, Západné Karpaty*, 9: 71–118. [In Czech.]
- Picha, F. J., Stráňák, Z. & Krejčí, O., 2006. Geology and hydrocarbon resources of the Outer West Carpathians and their foreland, Czech Republic. In: Golonka, J. & Picha, F. (eds), *The Carpathians and their Foreland: Geology and Hydrocarbon Resources*. American Association of Petroleum Geologists, Memoir, 84, pp. 49–175.
- Pivko, D., 1998. Cycles of different scale in the turbidites of the Magura Nappe on the northern Orava, Western Carpathians (Campanian–Upper Eocene). *Slovak Geological Magazine*, 4: 95–106.
- Pivko, D., 2002. Geology of Pilsko Mountain and surroundings (Flysch belt on northern Orava). *Acta Geologica Universitatis Comenianae*, 57: 67–94.
- Premoli-Silva, I., Rettori, R. & Verga, D., 2003. Practical manual of Paleocene and Eocene planktonic foraminifera. In: Rettori, R. & Verga, D. (eds), *International School on Planktonic Foraminifera, 2nd Course*. Università degli Studi di Perugia, Perugia, pp. 1–152.
- Roth, Z., Benešová, E., Čechovič, V., Eliáš, M., Hanzlíková, E., Chmelík, F., Matějka, A. & Picha, F., 1963b. *Výsvetlivky k prehľadnej geologickej mape ČSSR 1:200 000, list Trstená*. Geofond, Bratislava, pp. 7–59. [In Slovak.]
- Roth, Z., Matějka, A. & Picha, F., 1963a. *Geologická mapa ČSSR, 1:200 000, list Trstená*. ÚÚG, Praha.
- Rytko, W., 1992. Lithostratigraphy of the Magura Nappe deposits in the south-eastern part of Beskid Żywiecki Mts (Outer Carpathians). *Biuletyn Państwowego Instytutu Geologicznego*, 368: 37–63. [In Polish, with English summary.]
- Rytko, W., Żytko, K. & Rączkowski, W., 1992. *Objaśnienia do Szczegółowej Mapy Geologicznej Polski, skala 1:50 000, arkusz Arkusz Czadca – Ujsoły*. Państwowy Instytut Geologiczny, Warszawa. [In Polish.]
- Schnabel, W., 1992. New data on the Flysch Zone of the Eastern Alps in the Austrian sector and new aspects concerning the transition to the Flysch Zone of the Carpathians. *Cretaceous Research*, 13: 405–419.
- Sikora, W., 1957. New data on the stratigraphy of the Magura Series in the vicinity of Grybów (Middle Carpathians). *Geological Quarterly*, 1: 498–512. [In Polish, with English summary.]
- Sikora, W. & Żytko, K., 1959. Budowa Beskidu Wysokiego na południe od Żywca. *Biuletyn Państwowego Instytutu Geologicznego*, 141: 60–204. [In Polish.]
- Ślącza, A., Kruglov, S., Golonka, J., Oszczypko, N. & Popadyuk, I., 2006. The general geology of the Outer Carpathians, Poland, Slovakia, and Ukraine. In: Golonka, J. & Picha, F. (eds), *The Carpathians and their foreland: Geology and hydrocarbon resources*. American Association of Petroleum Geologists, Memoir, 84, pp. 221–258.
- Ślącza, A. & Miziołek, M., 1995. Geological setting of Ropianka beds in Ropianka (Polish Carpathians). *Annales Societatis Geologorum Poloniae*, 65: 29–41. [In Polish, with English summary.]
- Švábenická, L., Bubík, M., Krejčí, O. & Stráňák, Z., 1997. Stratigraphy of Cretaceous sediments of the Magura Group of nappes in Moravia (Czech Republic). *Geologica Carpathica*, 48: 179–191.
- Sztejn, J., Liskowa, J., Morgiel, J., Szymakowska, F. & Lefeld, J., 1984. Typ Protista, Gromada Reticularia Lankester, 1885, Rząd Foraminiferida Eichwald, 1830. In: Malinowska, L. (ed.), *Budowa geologiczna Polski, Vol. 3. Atlas skamieniałości przewodnich i charakterystycznych. Part 2. Mezozoik, Kreda*. Wydawnictwa Geologiczne, Warszawa, pp. 28–89. [In Polish.]
- Teťák, F., Kováčik, M., Pešková, I., Nagy, A., Buček, S., Maglay, J. & Vlačíky, M., 2016a. *Geologická mapa regiónu Biela Orava v mierke 1 : 50 000*. MŽP SR/ŠGÚDŠ, Bratislava. [In Slovak.]
- Teťák, F., Kováčik, M., Pešková, I., Nagy, A., Buček, S., Maglay, J., Vlačíky, M., Laurinc, D., Žecová, K., Zlinská, A., Liščák, P., Marcin, D., Žilka, A., Kucharič, L., Gluch, A. & Baláz, P., 2016b. *Výsvetlivky ku geologickej mape regiónu Biela Orava v mierke 1 : 50 000*. MŽP SR/ŠGÚDŠ, Bratislava. [In Slovak.]
- Uchman, A., 1998. Taxonomy and ethology of flysch trace fossils: revision of the Marian Książkiewicz collection and studies of complementary material. *Annales Societatis Geologorum Poloniae*, 68: 105–218.
- Uchman, A. & Cieszkowski, M., 2008. Stop 5 – Szczawa-Głębieńiec – upper part of the Ropianka Formation (Palaeocene): Nereites ichnosubfacies of the Nereites ichnofacies and ichnological

- evidence of turbiditic sedimentation in shales. Post-Congress field trip B – the Carpathian Flysch. In: Pieńkowski, G. & Uchman, A. (eds), *Ichnological sites of Poland, the Holly Cross Mountains and the Carpathian Flysch. The Pre-Congress and Post-Congress Field Trip Guide Book. The Second International Congress of Ichnology, Cracow, Poland, August 29 – September 8, 2008*. Polish Geological Institute, Kraków, pp. 115–118.
- Uhlig, V., 1885. Zur Stratigraphie der Sandsteinzone in West-Galizien. *Verhandlungen der Kaiserlich-Königlichen Geologischen Reichsanstalt*, pp. 33–46.
- Waškowska, A., 2015. The Eocene Hieroglyphic beds of the Silesian Nappe in the Western Polish Carpathians – their development and foraminiferal record. *Geological Quarterly*, 59: 271–299.
- Waškowska, A., Cieszkowski, M., Golonka, J. & Kowal-Kasprzyk, J., 2014. Paleocene sedimentary record of ridge geodynamics in Outer Carpathian basins (Subsilesian Unit). *Geologica Carpathica*, 65: 35–54.
- Waškowska-Oliwa, A., 2008. The Paleocene assemblages of agglutinated foraminifera from deep-water basin sediments of the Carpathians (Subsilesian Unit, Poland) – biostratigraphical remarks. In: Kaminski, M. A. & Coccioni, R. (eds), *Proceedings of the Seventh International Workshop on Agglutinated Foraminifera. Grzybowski Foundation, Special Publication*, 13, pp. 227–265.
- Wojtaszek, M., 1993. *Budowa geologiczna płaszczowiny magurskiej na południowy wschód od Babiej Góry w rejonie Lipnicy Wielkiej*. Master's dissertation. Jagiellonian University, Kraków, Poland. [In Polish.]