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

František TEŤÁK [1], Marek CIESZKOWSKI [2], Jan GOLONKA [3], Anna WAŚKOWSKA [3] & Mateusz SZCZĘCH [2]

[1] State Geological Institute of Dionýz Štúr, Mlynská dolina 1, 817 04 Bratislava 11, Slovak Republic; e-mail: frantisek.tetak@gmail.com
[2] Jagiellonian University, Institute of Geological Sciences, Gronostajowa 3a, 30-387 Kraków, Poland; e-mails: marek.cieszkowski@op.pl, mateusz.szczech@doctoral.uj.edu.pl
[3] AGH University of Science and Technology, Faculty of Geology, Geophysics and Environmental Protection, Al. Mickiewicza 30, 30-059 Kraków; Poland, e-mails: jgolonka@agh.edu.pl, waskowsk@agh.edu.pl

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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.

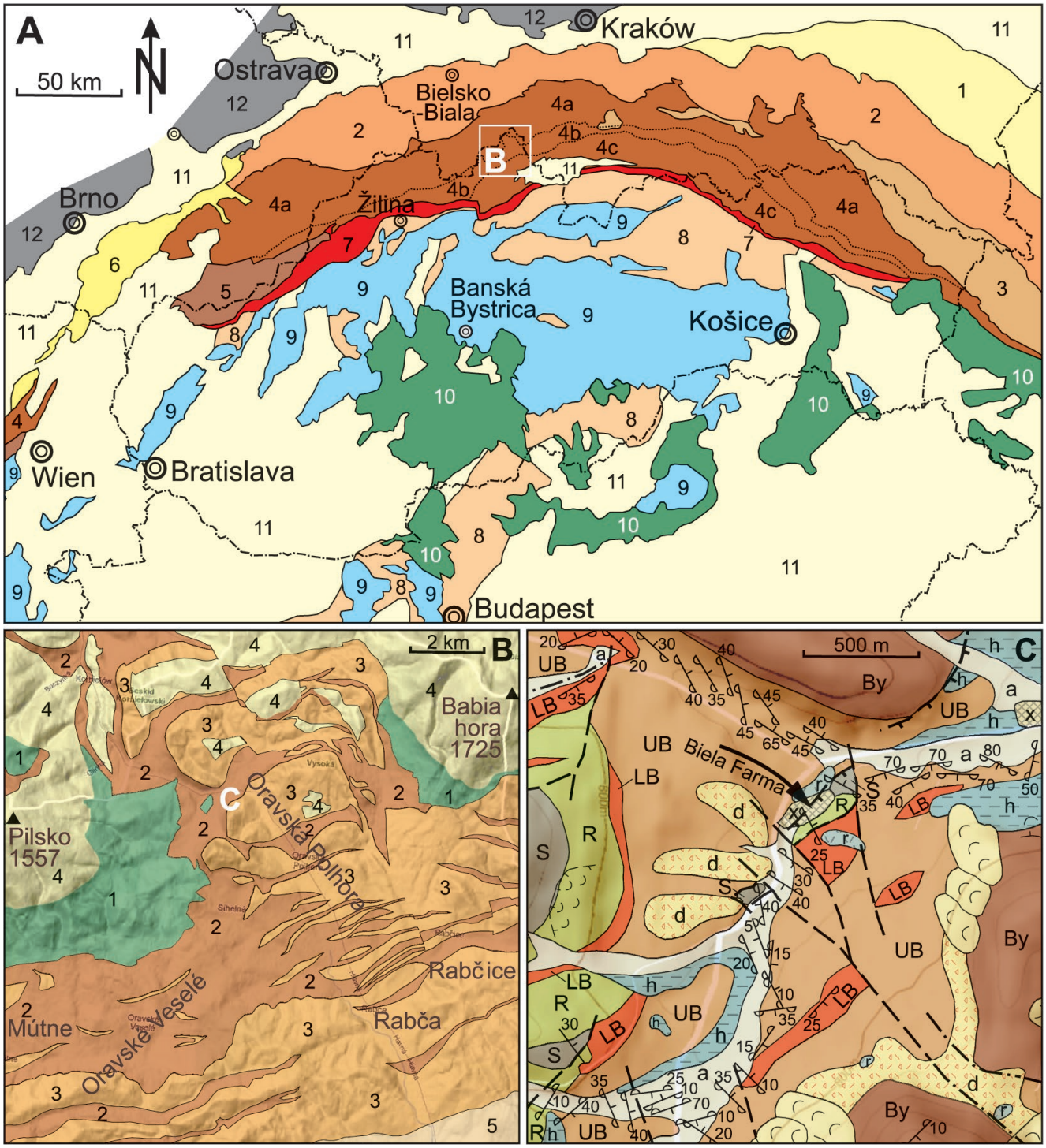

Fig. 1. Location of the study area. **A.** Simplified map of Western Carpathians and the surrounding area with location of study area (adapted from Lexa *et al*., 2000 and modified). 1 – Skole Nappe, 2 – Silesian Nappe, 3 – Dukla Nappe, 4 – Magura Nappe (4a – Rača, 4b – Bystrica, 4c – Krynica tectonic-lithofacies zones), 5 – Biele Karpaty Nappe, 6 – Ždánice-Waschberg Nappe, 7 – Pieniny Klippen Belt, 8 – Gosau, Inner Carpathian Palaeogene and Buda basins, 9 – Central Carpathians, 10 – Neogene volcanites, 11 – Neogene to Quaternary sediments, 12 – Carpathian foreland. **B.** Simplified geological map of area between Pilsko Mt and Babia hora Mt (adapted from Teťák *et al*., 2016a). 1 – Ropianka Fm with Szczawina Mbr (Inoceramian Beds), 2 – Beloveža Fm, 3 – Bystrica Mbr (Łącko Mb) and Oravské Veselé Mbr, 4 – Kýčera Mb, 5 – Krynica Zone (Zábava Fm). **C.** Geological map of studied area (adapted from Teťák *et al*., 2016a, b). S – Szczawina Mbr, R – Ropianka Fm (Inoceramian Beds), LB – Lower Beloveža Mbr with variegated claystones (Łabowa Fm), UB – Upper Beloveža Mbr, By – Bystrica Mbr (Łącko Mbr), r – peat bogs, h – humus-rich loams, a – alluvial deposits, d – deluvial deposits, x – anthropogenic deposits.

GEOLOGICAL BACKGROUND

The Magura Nappe, the southernmost unit of the Outer Carpathians (Fig.1), was subdivided into the Siary, Rača, Bystrica and Krynica tectonic-lithofacies units (zones) by Koszarski *et al.* (1974). Their rock series of flysch megafacies, along with the Silesian Nappe and other, more external units (mostly Late Cretaceous–Palaeogene), form a fold-slice system, which was thrust over the inclined ramp of the European Platform.

The deposits of the Rača, Bystrica and Krynica zones of the Magura Nappe make up the sedimentary succession in northern Orava. They were laid down in the Magura Basin, belonging to the West Carpathian basinal Tethys domain. Sedimentation in the Rača and Bystrica zones was quite uniform during the Late Cretaceous–early Palaeogene, especially during Santonian–Paleocene times. The sedimentation became significantly differentiated from the Middle Eocene onwards.

The northwestern part of Orava belongs mostly to the Bystrica Zone. This area is characterized by a relatively complete lithological section for the zone and is diverse in terms of lithofacies and its tectonic evolution. The Upper Cretaceous–Paleocene deposits are particularly interesting. They were not very well recognized in previous mapping studies in the Slovak and Polish parts of Orava (Matějka and Roth, 1952; Roth *et al.,* 1963a, b). These deposits are underlain by the Turonian–Coniacian red shales of the Cebula Formation and overlain by uppermost Paleocene–Eocene red and variegated shales of the Łabowa Formation (Fig. 2). The Beloveža, Bystrica and the Kýčera formations are the youngest lithostratigraphic units of the Bystrica Zone in the area mentioned.

The Upper Cretaceous and Paleocene deposits are subdivided into two lithostratigraphic units (Fig. 2). The more widespread Santonian–Paleocene unit is represented by thin-bedded and medium-bedded flysch, containing grey, green-grey or grey-greenish, laminated muscovite sandstones and grey or green-grey, rarely red, partly non-calcareous mudstone and claystone shales. In Poland, this unit is known as the Ropianka Fm or the Ropianka Beds and in older publications the Inoceramian Beds, whereas in Slovakia it is called the Ropianka Member. The second unit is made of thick, medium-grained sandstones without distinct gradation, distinctly rich in muscovite, locally with fine-grained conglomerates. It is known as the Szczawina Formation or Szczawina Member (Santonian–Maastrichtian; in Poland, Campanian–Maastrichtian). The stratigraphic range of the Ropianka and Szczawina formations is more or less similar. However, the Szczawina Mbr is usually placed in the lower part of the lithostratigraphic sections, mostly above a package of thin-bedded and medium-bedded flysch. Teťák

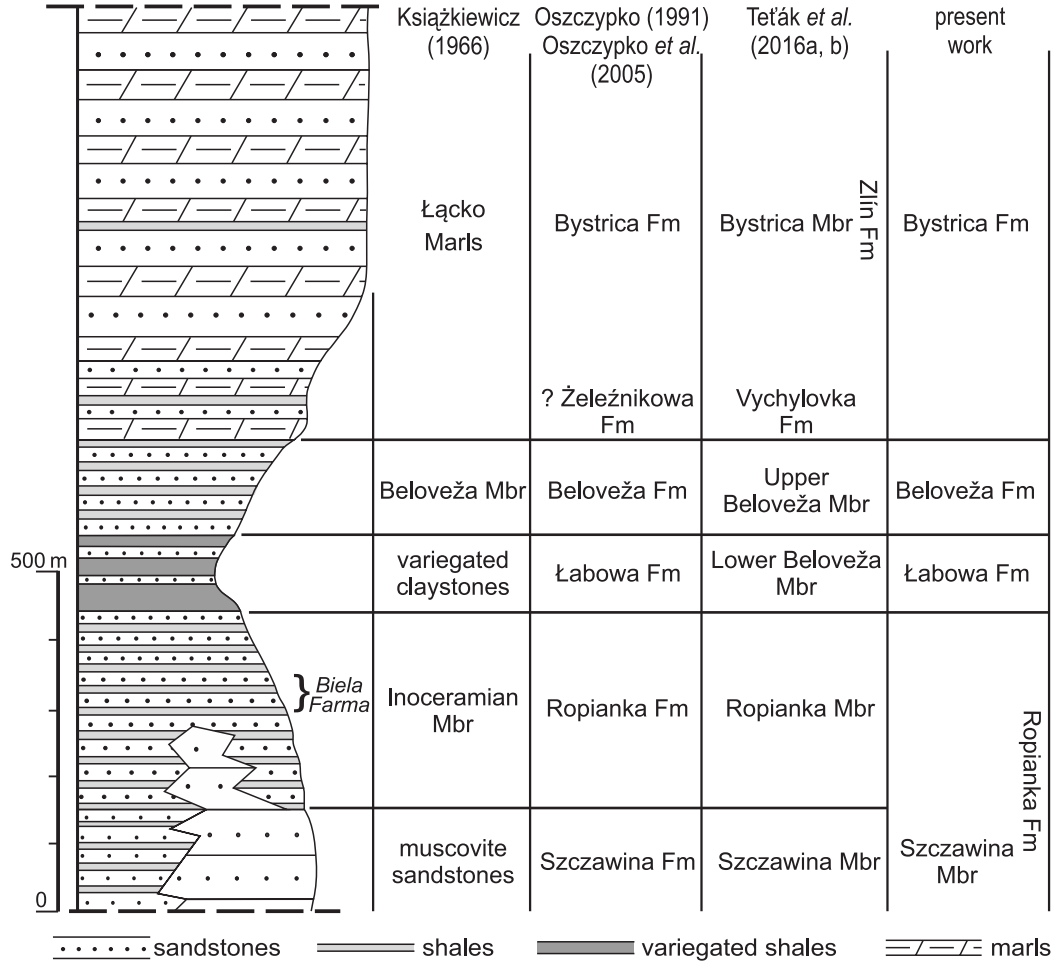

Fig. 2. Lithostratigraphy of the Bystrica Zone in the Orava region compared with that of previous works.

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 Żywiec (Figs 3–5). This is a flagship exposure of the upper part 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 Łabowa 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 Łabowa 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)*, Cosmorhaphe sinuosa* (Azpeitia Moros)*, Helminthopsis, Gordia, Halopoa annulata* (Książkiewicz), *Ptychoplasma vagans* (Książkiewicz)*, Zoophycos, Megagrapton, 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

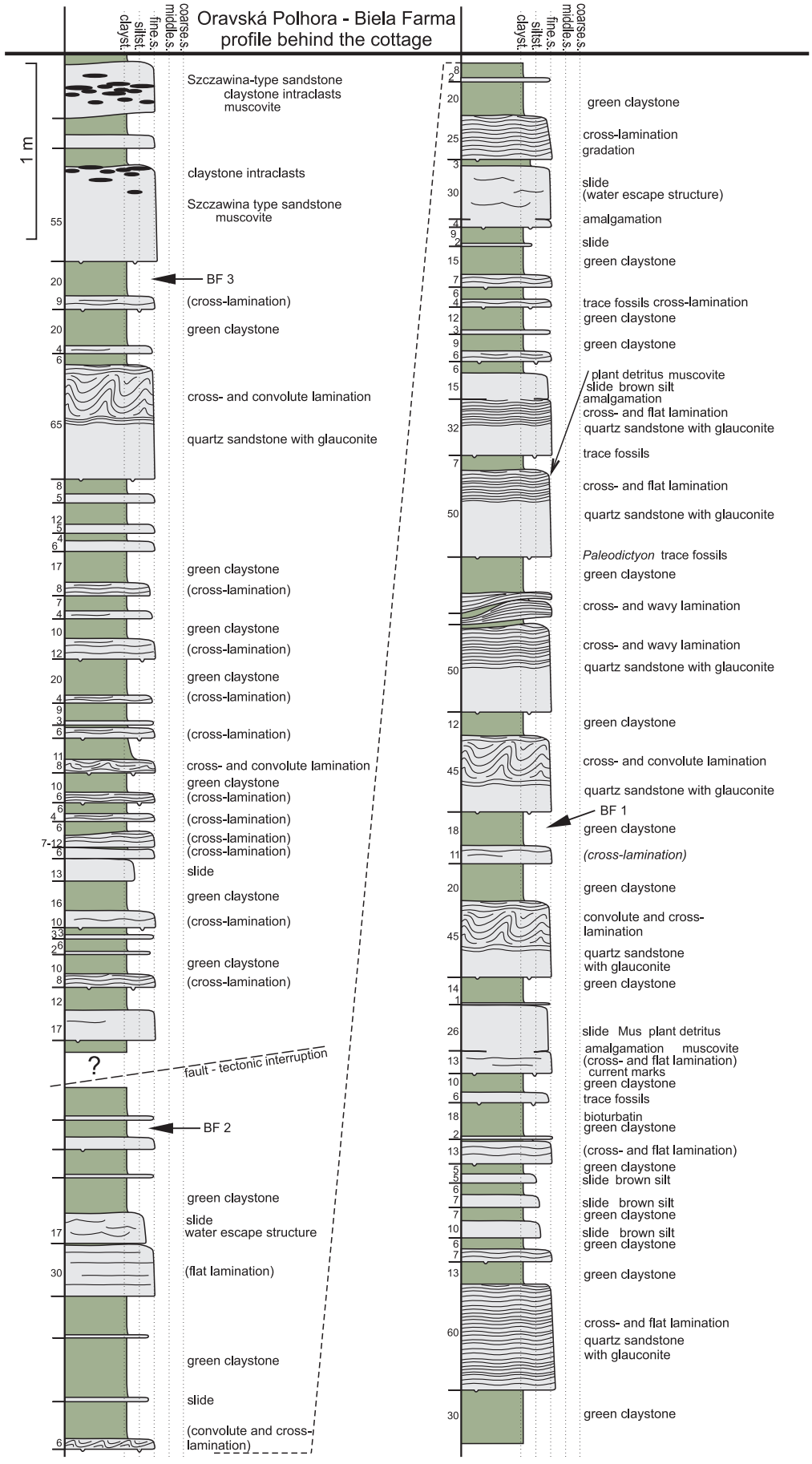

Fig. 3. Sedimentological log of the Ropianka Fm in Biela Farma section. BF 1 – location of sample for micropalaeontological analysis.

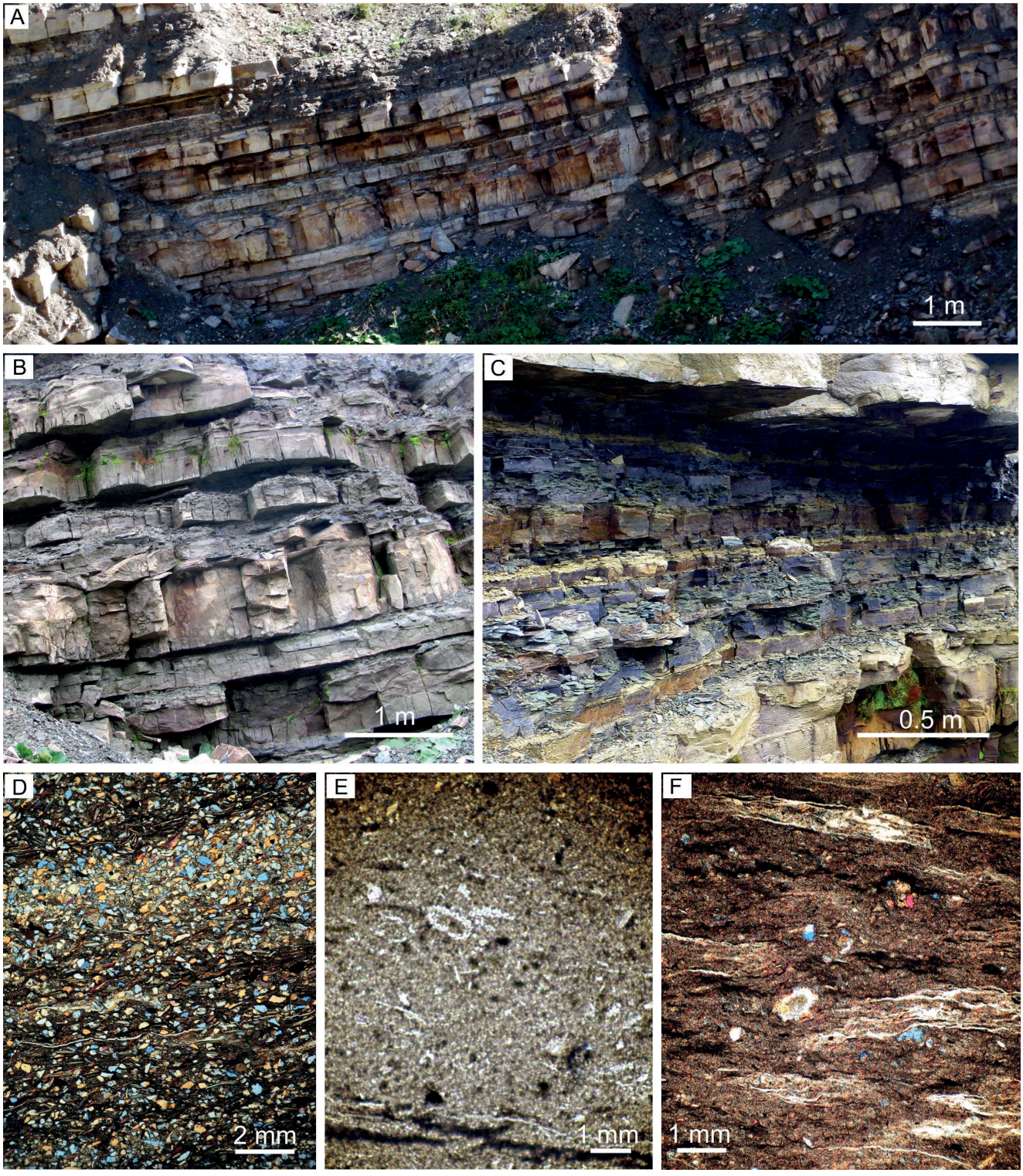

Fig. 4. The Ropianka Fm in Biela Farma section. **A.** General view of thin- and medium-bedded turbidites of the Ropianka Fm. **B.** Turbidites with sandstone domination. **C.** Turbidites with shales domination. **D-F.** Thin section of shales with *Bathysiphon* tests and different amount of psammitic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

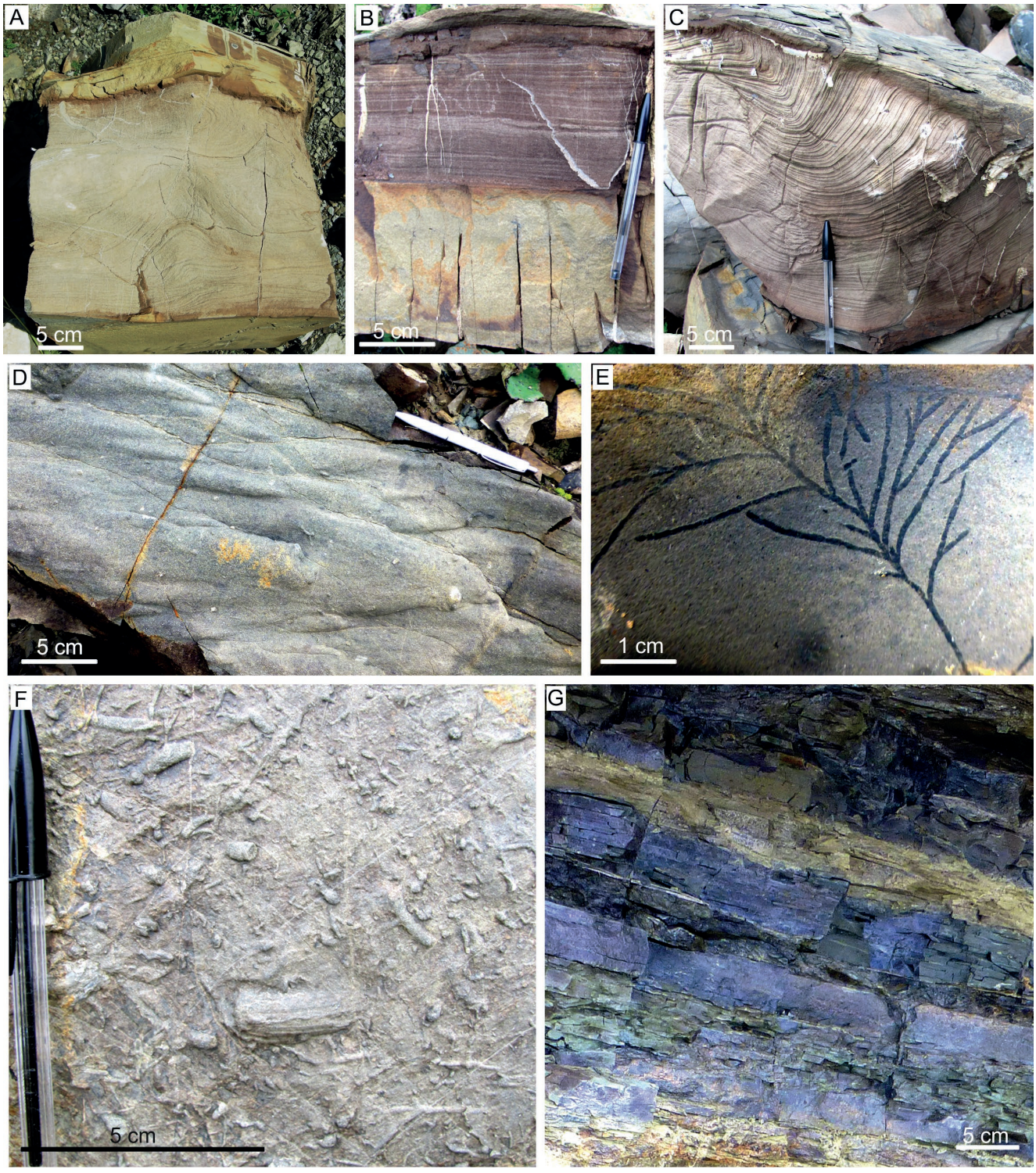

Fig. 5. Sandstones and shales in the Ropianka Fm – selected examples. **A–C.** Sandstones with different types of laminations. **D.** Flute moulds. **E.** Ichnofossil *Chondrites targionii (Brongniart)*. **F.** Bioturbated lower bedding surface of a sandstone bed. **G.** Interval rich in green and grey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

Fig. 6. Foraminifera from the Ropianka Fm. **A, B.** *Bathysiphon/Nothia* sp. (sample BF1)1. **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 μm.

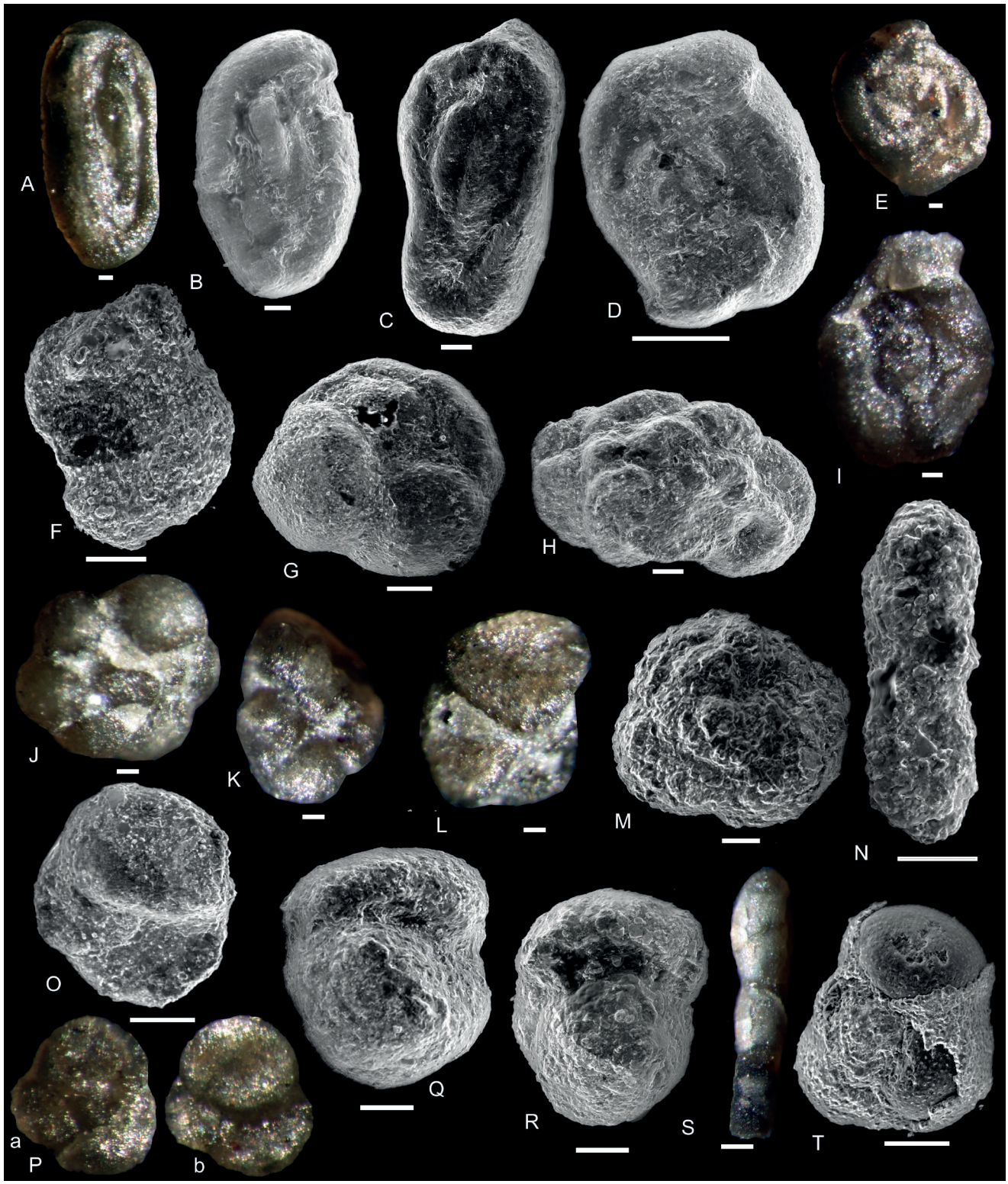

Fig. 7. Foraminifera from the Ropianka Fm. **A.** *Annectina grzybowskii* (Jurkiewicz) (sample BF1). **B, C.** *Annectina grzybowskii* (Jurkiewicz) (sample BF2). **D, F.** *Rzehakina epigona (Rzehak)* (sample BF2). **G.** *Trochamminoides variolarius* (Grzybowski) (sample BF2). **H, J.** *Trochamminoides 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 µm.

Table 1.

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

	BF 1	BF 2	BF 3
BENTHIC FORAMINIFERA			
Ammodiscus peruvianus Berry	I	I	
Ammodiscus cretaceus (Reuss)	I	I	
Ammodiscus tenuissimus Grzybowski	I	I	
Ammosphaeroidina pseudopauciloculata (Mjatliuk)	X	V	I
Annectina grzybowskii (Jurkiewicz)	V	V	
Aschemocella grandis (Grzybowski) (fragments)		I	
Ammolagena clavata (Jones et Parker)		I	
Bathysiphon sp. and *Nothia* sp. (fragments)	W	W	W
Caudammina excelsa (Dylążanka) (fragments)	I	I	
Cribrostomoides subglobosus (Cusmhan)	V	X	
Dorothia sp.	I		
Dentalina sp. / *Nodosaria* sp. (fragments)	I	I	
Glomospira charoides (Jones et Parker)		I	
Glomospira diffundens Cushman et Renz	I	I	
Glomospira irregularis (Grzybowski)	I	I	
Glomospira gordialis (Jones et Parker)			I
Haplophragmoides horridus (Grzybowski)		I	
Haplophragmoides walteri (Grzybowski)	I	I	
Hormosinelloides guttifer (Brady)	I	I	
Hyperammina sp.		I	
Karrerulina conversa (Grzybowski)	I	I	
Paratrochamminoides and *Trochamminoides* div. sp.	W	W	W
Placentammina placenta (Grzybowski)	W	X	I
Psammosiphonella sp. / *Rhabdammina* sp. (fragments)	X	X	V
Praesphaerammina gerochii Hanzlikowa		V	
Recurvoides div. sp.	W	W	X
Reophax duplex Grzybowski	I	V	
Rzehakina epigona (Rzehak)		I	
Rzehakina minima Cushman et Renz			I
Saccammina grzybowskii (Schubert)		I	
Subreophax scalaris (Grzybowski) (fragments)	I	V	I
Subreophax splendidus (Grzybowski) (fragments)	I		
Subrepohax pseudoscalaris (Samuel) (fragments)	I	I	
Reophax duplex Grzybowski	I	V	
Trochammina sp.		I	I
PLANKTONIC FORAMINIFERA			
Parasubbotina cf. *varianta* Subbotina		I	
Subbotina cf. *trianagularis* (White)	I		
Subbotina cf. *cancellata* Blow		I	
Subbotina cf. *triloculinoides* Plummer		I	
Plankton (mainly *Subbotina* – *Parasubbotina* 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 pseudopauciloculata* (Mjatliuk), *Annectina grzybowskii* (Jurkiewicz), *Glomospira* div. sp., *Haplophragmoides* div. sp., *Reophax duplex* Grzybowski, *Placentammina 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), *Caudammina excelsa* (Dylążanka), *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; Sztejn *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; Waśkowska-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; Waśkowska, 2015 and references therein). In sample BF2, *Praesphaerammina gerochii* Hanzlikova 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; Waśkowska *et al*., 2014), locally from the Lower Eocene (Geroch and Koszarski, 1988; Bąk, 2004; Kaminski and Gradstein, 2005; Bubík, 2006; Golonka and Waśkowska, 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 *Saccammina* 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. *varianta* Subbotina, *Subbotina* cf. *trianagularis* (White) and S*ubbotina* cf. *triloculinoides* (Table 1). The two last taxa indicate a Middle Paleocene age, cording 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 Waśkowska-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 Oszczypko, 1991; Oszczypko *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*, *Spirorhaphe*, *Cosmorhaphe*, *Paleomeandron,* and in the muscovite sandstones, he observed *Zoophycos*, *Paleochorda* [not the currently recommended name], *Helicorhaphe*, *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 Głębieniec 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 Veselé Fm, but later (Pivko, 2002) changed the name of the Veselé 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 Kýčera 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 Potfaj, 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 Oszczypko *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; Ślączka *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. Ślączka 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, Oszczypko *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 Inoceramian Beds (Sikora, 1957; Sikora and Żytko, 1959; Książkiewicz, 1966), the Ropianka Beds or the Ropianka Formation (Golonka and Wójcik, 1978a, b; Oszczypko and Zuchiewicz, 1992; Ryłko *et al*., 1992; Oszczypko *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 Altlengbach Fm of the Rhenodanubian Flysch Belt in the Austrian Alps (Schnabel, 1992; Faupl, 1996; Švábenická *et al*., 1997) or to the Biotite-glauconite 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-glauconite Beds) by Burtan (1973), and later the Jaworzynka Fm (Oszczypko *et al*., 2005, see also Cieszkowski *et al*., 2006, 2007) and the Szczawnica Fm in the Krynica Zone (Birkenmajer and Oszczypko, 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 in to consideration as a potential reference section.

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