

## The Farony Variegated Shale Member – a new lithostratigraphic unit of the Ropianka Formation of the Bystrica Subunit in the Magura Nappe (Outer Western Carpathians), and its documentation in the Orava region

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This study focuses on the variegated horizon of the Farony Shales occurring in the lower part of the Maastrichtian–Paleocene Ropianka Formation in the Magura Nappe (Outer Western Carpathians). It consists of a shale succession with subordinate thin-bedded sandstones, characterized by the occurrence of red shale laminae and beds. Our analyses of its lateral extent and stratigraphy have constrained its spatial distribution and the timing of sedimentation. The presence of Maastrichtian variegated shales within the Magura Nappe in the Polish and Slovak parts of the Orava region is documented, significantly extending their previously known distribution, formerly restricted to the Gorce Mts. The age of the Farony Shales is assigned to the Lower Maastrichtian, based mainly on the co-occurrence of agglutinated foraminiferal acme assemblages, including *Caudammina gigantea* (Geroch), *Caudammina ovula* (Grzybowski), *Caudammina excelsa* (Dylažanka), and the *Saccammina–Placentammina* assemblage. This variegated shale succession is formally distinguished herein as the Farony Variegated Shale Member within the Ropianka Formation. Its definition, including the elements required by the rules for establishing new lithostratigraphic units, is given in this paper.

Key words: Maastrichtian, lithostratigraphy, biostratigraphy, agglutinated foraminifera, correlation.

### INTRODUCTION

The Magura Nappe is the largest Outer Carpathian unit, composed of deposits originating within the western part of the Tethys Ocean. It is built of Upper Cretaceous–Neogene intra-basinal deposits of the Magura Basin (e.g., Golonka et al., 2005, 2019; Ślęczka et al., 2006; Oszczytko et al., 2015; Hók et al., 2019). Within it, tectonofacies units are distinguished. The lithostratigraphic content of each subunit displays a certain individuality resulting from differences in sedimentary history linked to the environment of deposition in particular basin parts. These subunits are characterized lithofacially and divided tectonically. Among them, the Bystrica Subunit is distinguished. Lithostratigraphical study of this area has a long tradition, beginning in the second half of the 19th century (e.g., Paul, 1868; Uhlig, 1888; Świdziński, 1953; Książkiewicz, 1958, 1966; Sikora and Żyto, 1960; Andrusov, 1965; Koszarski et al., 1974; Oszczytko,

1979, 1991; Birkenmajer and Oszczytko, 1989; Golonka and Waśkowska-Oliwa, 2007; Uchman and Cieszkowski, 2008; Teták et al., 2016a, b; Szczęch and Waśkowska, 2023). The formal lithostratigraphy of the Cretaceous–Paleogene deposits of the Bystrica Subunit was developed in Poland mainly by Oszczytko (1991; Oszczytko et al., 2005; see also Cieszkowski and Uchman, 2008; Cieszkowski et al., 2015), while in Slovakia it was proposed by Teták et al. (2017). These two schemes are not fully compatible with each other.

The Ropianka Beds, originally described by Paul (1869) in the Ropianka area south of Dukla within the Magura Nappe, were subsequently extended to the Eastern Carpathians (Paul and Tietze, 1877). Another name used interchangeably for these strata is the Inoceranian Beds, proposed by Uhlig (1894). The term “Ropianka Beds” was applied as a formal name in the Skole Nappe by Kotlarczyk (1978), and in the Magura Nappe by Oszczytko et al. (2005). The present study and the formalization of the variegated deposits refer to the strata of the Ropianka Formation located in the Magura Nappe. The Ropianka Formation, dating to the Maastrichtian–Paleocene, is one of the thickest successions and reaches more than 400 m in the Magura Nappe (Oszczytko et al., 2005; Teták et al., 2016b). It is built generally of thin- and me-

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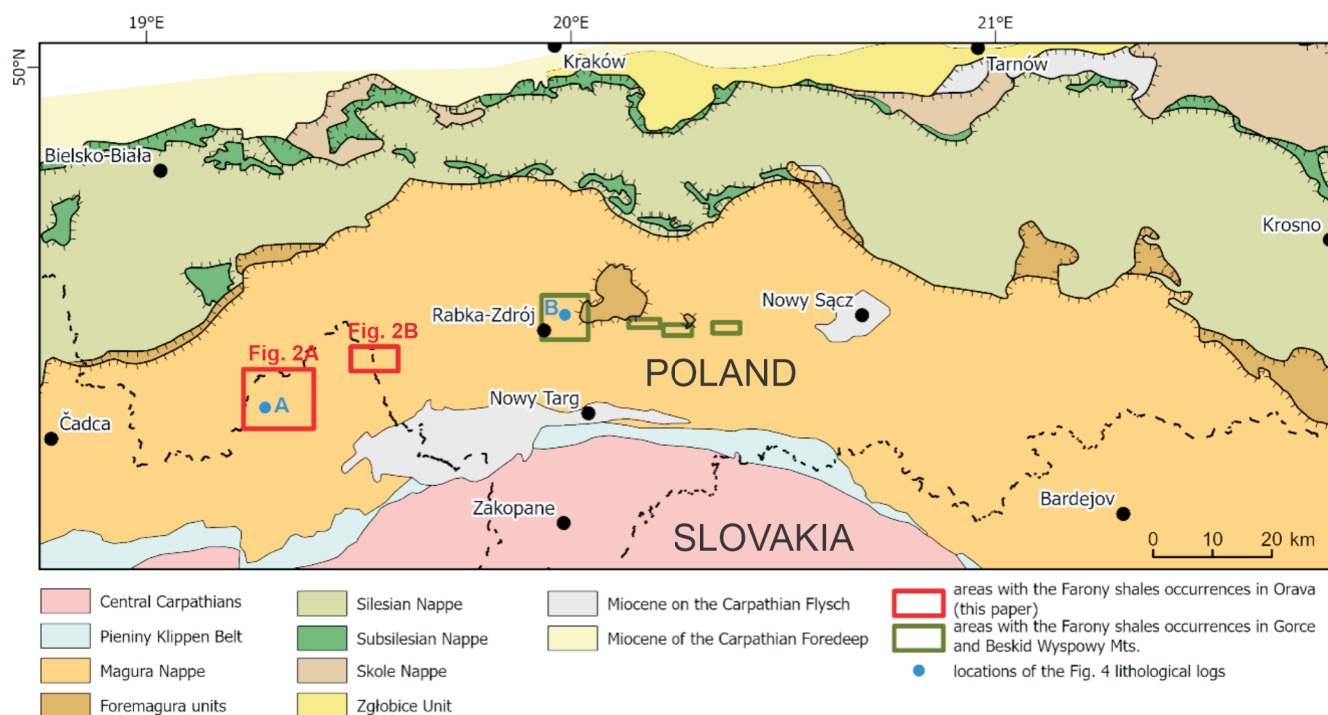


Fig. 1. Area with Farony Variegated Shales exposures (map after Lexa et al., 2000, Cieszkowski et al., 2017, modified)

dium-bedded muscovite-bearing sandstones interbedded with mudstones; although this unit shows considerable variability in the Orava region, thick-bedded muscovite sandstones prevail (Teťák et al., 2016b). In the Ropianka Fm., deposits characterized by variegated shales occur. Part of them form an isochronous horizon that was identified on the northern slopes of the Gorce Mts. (Cieszkowski et al., 1998; Szczęch et al., 2016; Waśkowska and Szczęch, 2023). Current studies indicate that their minimum extent within the Magura Nappe is much greater and spans the Gorce region; they constitute a compact, distinguishable and mappable unit, which qualifies them to be designated as a separate lithostratigraphic unit of member rank. This is consistent with the rules of the International and Polish Stratigraphic Codes (Murphy and Salvador, 1999; Racki et al., 2006), that a formal unit should reflect significant, supraregional stages in the evolution of the lithosphere.

This study provides additional new data concerning the Farony Variegated Shales regarding their occurrence and biostratigraphic documentation, in order to characterize these deposits and to establish a new lithostratigraphic unit, to supplement the lithostratigraphic scheme of the Bystrica Subunit in the Magura Nappe.

## STUDY AREA

The study area extends from the Gorce Mts. in the east, through the southern slopes of Mt. Babia Góra/hora to Mt. Pilsko in the west, onto Polish and Slovak territories (Figs. 1–3). It encompasses the central part of the Magura Nappe, a regional tectonic unit of the Outer Carpathians (Fig. 1; Książkiewicz, 1977; Golonka et al., 2005, 2019; Ślącza et al., 2006). To the south, the Magura Nappe is tectonically bordered by the Pieniny Klippen Belt, and towards the north, it is thrust over the more external Outer Carpathian nappes (e.g., Książkiewicz, 1977; Golonka et al., 2005, 2006; Ślącza et al., 2006). Five tectonofacies subunits are distinguished within it;

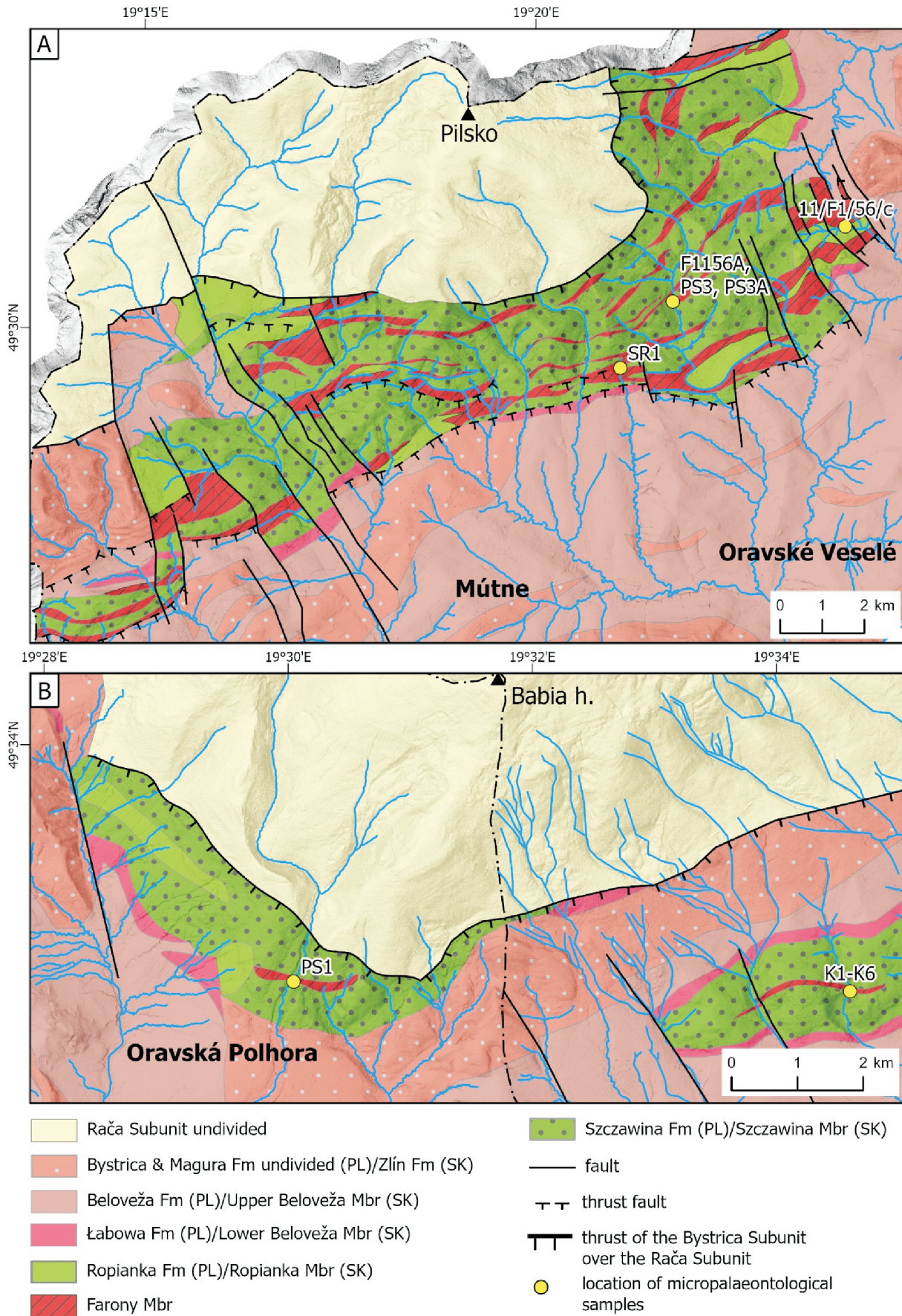
from the north, these are the Siary, Rača, Bystrica, Krynica and Biele Karpaty subunits (e.g., Koszarski et al., 1974; Hók et al., 2019). The study area is located in the Bystrica Subunit (Fig. 1). It is built of flysch rocks deposited from the Albanian up to the Oligocene within the Magura Basin (Cieszkowski et al., 2015; Szczęch et al., 2016; Teťák et al., 2019). Our research focuses on the Farony Variegated Shales (*sensu* Waśkowska and Szczęch, 2023), part of the Ropianka Formation, within the lower part of the lithostratigraphic profile of the Magura Nappe (Oszczypko et al., 2005; Teťák et al., 2016b, 2017).

## METHODS

To identify the deposits of the Farony Shales, detailed geological maps of Poland and Slovakia at a scale of 1:50,000 were analysed and, in selected areas, classical fieldwork was carried out using geological mapping methods. During the field studies, data were collected regarding the form, position and lithology, and rock samples were taken for dating.

The biostratigraphic analyses were based on agglutinated foraminifera. Foraminiferal fossils were extracted from half-kilogram mudstone samples. Under laboratory conditions, the mudstones were repeatedly subjected to heating and cooling in an aqueous solution of sodium sulphate to disintegrate them. Next, they were washed through sieves with a final mesh size of 68 µm to remove very fine clastic fractions. The residue was dried, after which bioclasts were hand-picked. The microfossils were dominated by tests of agglutinated foraminifera; rare radiolarian specimens were also present, and sporadic fish otoliths. Biostratigraphic analysis was based on the Olszewska (1997) and Waśkowska (2021) zonations, supplemented by known taxon ranges. Micropalaeontological preparation and microscopic analyses (using a Nikon VL 100POL binocular microscope) were carried out at the Department of General Geology and Geotourism, Faculty of Geology, Geophysics and Environmental Protection, AGH University of Krakow. Part of the





**Fig. 2. Location of the Farony Member on the geological map of the Orava region**

**A** – southern slopes of Pilsko (after [Teťák et al., 2016a](#), modified); **B** – southern slopes of Babia hora (after [Teťák et al., 2016a](#); [Kudlik, 2005](#), modified). PL – units according to [Oszczypko et al. \(2005\)](#); SK – units according to [Teťák et al. \(2016b\)](#)





**Fig. 3. Lithology of Farony Shale Member and surrounding deposits – field documentation from Orava region**

**A** – Szcawina-type sandstone; **B** – thinner beds of Szcawina-type sandstones intercalated with shales with slump structures and shales (49.507174°N; 19.360711°E); **C** – variegated shales with thin beds of laminated sandstone (49.490199°N; 19.330932°E); **D** – tectonically deformed greenish sandstone and red shales (49.516893°N; 19.266745°E); **E** – variegated shales with thin laminated sandstone and siltstone beds (49.487994°N; 19.275165°E); **F** – variegated shales with thinner beds of laminated sandstone (49.490199°N; 19.330932°E); **G** – massive variegated shales (49.487534°N; 19.267493°E); **H** – variegated shales with thin laminated sandstone beds (49.483566°N; 19.276319°E); **I** – folded grey shales with thin laminated sandstone beds (49.487534°N; 19.267493°E)



taxonomic identification and photographic documentation was performed (using a *FEI QUANTA 200 FEG* scanning microscope) at the Scanning Microscopy Laboratory of the AGH Faculty of Geology and Geophysics. The foraminiferal specimens are deposited at the European Micropaleontological Reference Center of the Micropress Europe Micropaleontological Foundation. Formalization was prepared in accordance with the guidelines set out in the Polish Stratigraphic Code (Alexandrowicz et al., 1975; Racki et al., 2006).

## FARONY SHALES IN THE ORAVA REGION – CHARACTERISTICS

### POSITION AND LITHOLOGY

The lithostratigraphic profile of the Bystrica Subunit of the Magura Nappe in the Orava region includes flysch deposits ranging from the Upper Cretaceous to the Oligocene (Teřák et al., 2016a, b). It begins with the Ropianka Fm. (Maastrichtian–Paleocene), followed by the Beloveža Formation and the Zlín Formation (Teřák et al., 2016a, b), the last of these being the equivalent – in Polish terminology – of the Bystrica and Magura formations (Fig. 2). Three lithofacies are distinguished within the Ropianka Formation *sensu* Teřák et al. (2016b, 2017) in the Orava Region (Pilsko and Babia hora Mts.): (1) Szczawina-type sandstones (Fig. 4A, B), (2) variegated thin-bedded flysch (Fig. 4C–H), and (3) thin- to medium-bedded non-variegated flysch (Fig. 4I). The Farony Shales succession occurs in the lower part of the Ropianka Formation, which constitutes the lithostratigraphic equivalent of the Ropianka and Szczawina formations in Polish terminology (see discussion).

The Farony Variegated Shales are thin-bedded, claystone/mudstone-dominated (shale-dominated) deposits (Figs. 4 and 5). The claystones and mudstones are red, green, grey and dark-grey, non-calcareous, and contain fine muscovite. They are interbedded with green to grey, laminated, fine-grained, and thin-bedded quartzitic sandstones (mainly  $T_{bc}$  Bouma intervals) up to 20 cm thick, containing muscovite (Fig. 4C–H). Thin beds of glauconitic fine-grained sandstone occur also. The thickness of the Farony Shales reaches 5–20 m. In the Orava Region, they typically occur within thick-bedded Szczawina-type sandstones. These sandstones are muscovite-rich, greenish-grey, massive, and form beds 30–250 cm thick; they are medium- and fine-grained, rarely coarse-grained, and locally they are conglomeratic and contain shale flakes 2–3(5) mm in size (Figs. 4A, B and 5). The sandstone succession directly underlying the Farony Shales usually comprises thinner beds. Locally, within the Farony Shales, thin- and medium-bedded sandstone-shale packets are intercalated. Within them, the sandstones are grey and muscovitic, with fine bioglyphs on the bottom surfaces. They are intercalated with grey and greenish-grey shales.

### DISTRIBUTION

The Farony Shales within the lower part of the Ropianka Formation form a belt striking E–W, more or less parallel to the thrust over the Rača Subunit. It stretches from the area of Lipnica Mała on the southern slopes of Mt. Babia Góra in Poland in the east, through the territory of Slovakia, to the Novotř–Soblówka area on the Polish/Slovak border in the west (Figs. 1 and 2). The belt-like outcrop, extending across the

Orava region for 40 km, is discontinuous, locally disappearing as a result of sedimentological and tectonic reduction. Good exposures of the variegated Farony Shales can be seen in the Bystrá stream in Oravská Polhora, the Veselianska stream in Oravské Veselé, and on the eastern slopes of Mt. Kôň (998 m a.s.l.).

### AGE AND BIOSTRATIGRAPHY

In total, 12 samples were collected from the Farony Shales at 5 localities in the Orava Region (Appendix 1; Figs. 2, 5–7):

- six samples (nos. K1 to K6) from the Kiczory section, located in the Zwiotkowski stream (49.544528° N, 19.576722° E), Poland;
- one sample (no. PS1) from the Oravská Polhora section, located in the Bystrá stream (49.544500° N, 19.503056° E) in Slovakia;
- three samples (nos. F1156A, PS3, and PS3A) from Oravské Veselé, located in the Veselianska stream (49.50361° N, 19.36255° E) in Slovakia;
- one sample (no. 11/F1/56/c) from Sihelné, located in the Sihelniansky stream (49.513975° N, 19.399302° E) in Slovakia;
- one sample (no. SR) from the locality in Oravské Veselé, in the Hlboký stream (49.494400° N, 19.351330° E) in Slovakia.

### GENERAL CHARACTERISTICS OF THE FORAMINIFERAL ASSEMBLAGES

The samples are dominated by assemblages of moderate or low taxonomic diversity; high diversity occurs in only two samples, K1 and F1156A (Appendix 1; Figs. 5–7). Small specimens occurring in the fine fractions are abundant. Samples with higher taxonomic diversity contain a greater proportion of larger forms. The preservation state of the microfossils is variable; in most samples, the foraminifera are silicified. In general, the foraminiferal assemblages in the samples are taxonomically similar.

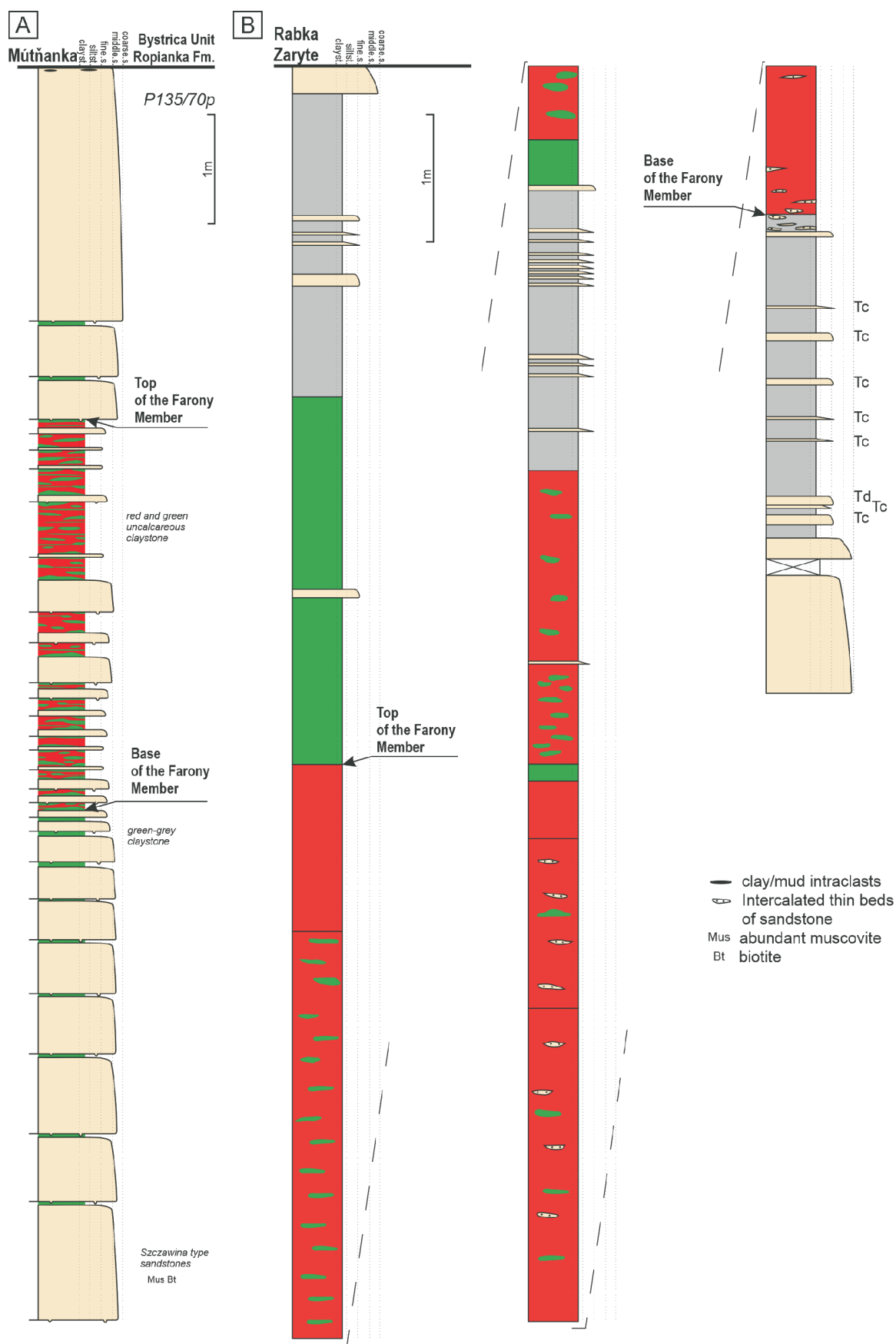
Fragments of tubular foraminifera of *Nothia*- and *Bathysiphon*-type dominate. In samples with increased taxonomic diversity, *Psammosiphonella* occurs abundantly (Appendix 1; Fig. 5). In addition, foraminifera of the *Recurvoides* group and the *Paratrochamminoides*–*Trochamminoides* group are present and common. The biostratigraphically important *Caudammina* occurs ubiquitously. Among the species identified, *Rzehakina inclusa* (Grzybowski) has the shortest stratigraphic range. It is an index species for a range zone spanning the upper Campanian to the Maastrichtian/Paleocene boundary (Olszewska, 1997). It occurs in samples from the Kiczory locality (samples K1 and K4) and the Oravské Veselé locality (sample SR; Appendix 1; Fig. 6). Samples from the Kiczory, SR, and F1156 localities show the presence of a *Caudammina* acme (*sensu* Wařkowska, 2021), represented by the following forms:

*Caudammina ovula* (Grzybowski). In mudstones from the Kiczory and Oravské Veselé localities, samples SR, 1156A and K2–K6 contain 11.5%, 16.5% and 7.5–18.5%, respectively of *C. ovula* excluding tubular forms.

*Caudammina excelsa* (Dylařanka). Sample K1 contains 25% *C. excelsa* excluding tubular forms, while SR contains 23.5%.

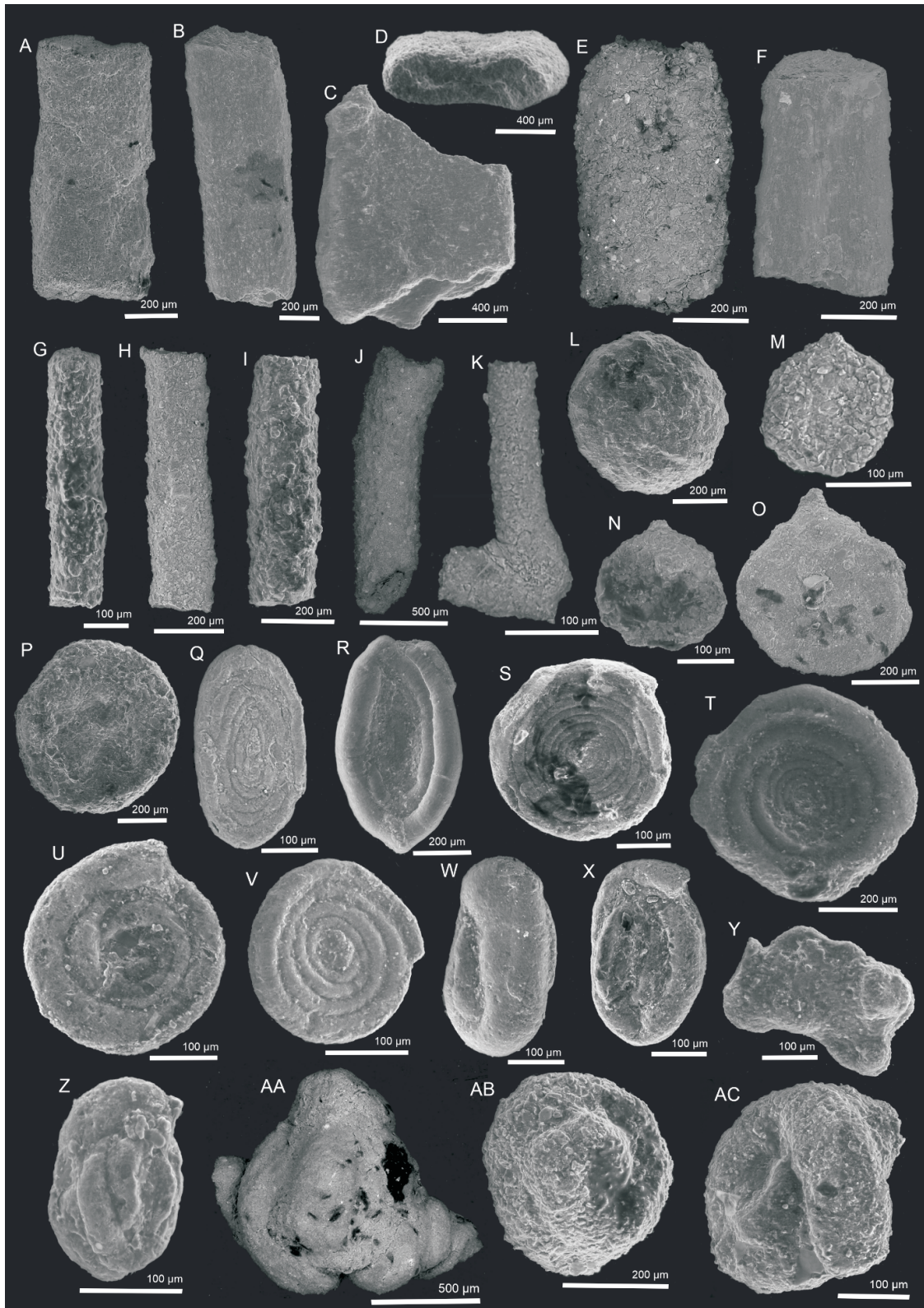
*Caudammina gigantea* (Geroch). Samples K3–K5 contain 7.5–18.5% *C. gigantea* excluding tubular forms and SR 7% (Appendix 1; Fig. 6).





**Fig. 4. Lithological logs of the Farony Member – example**

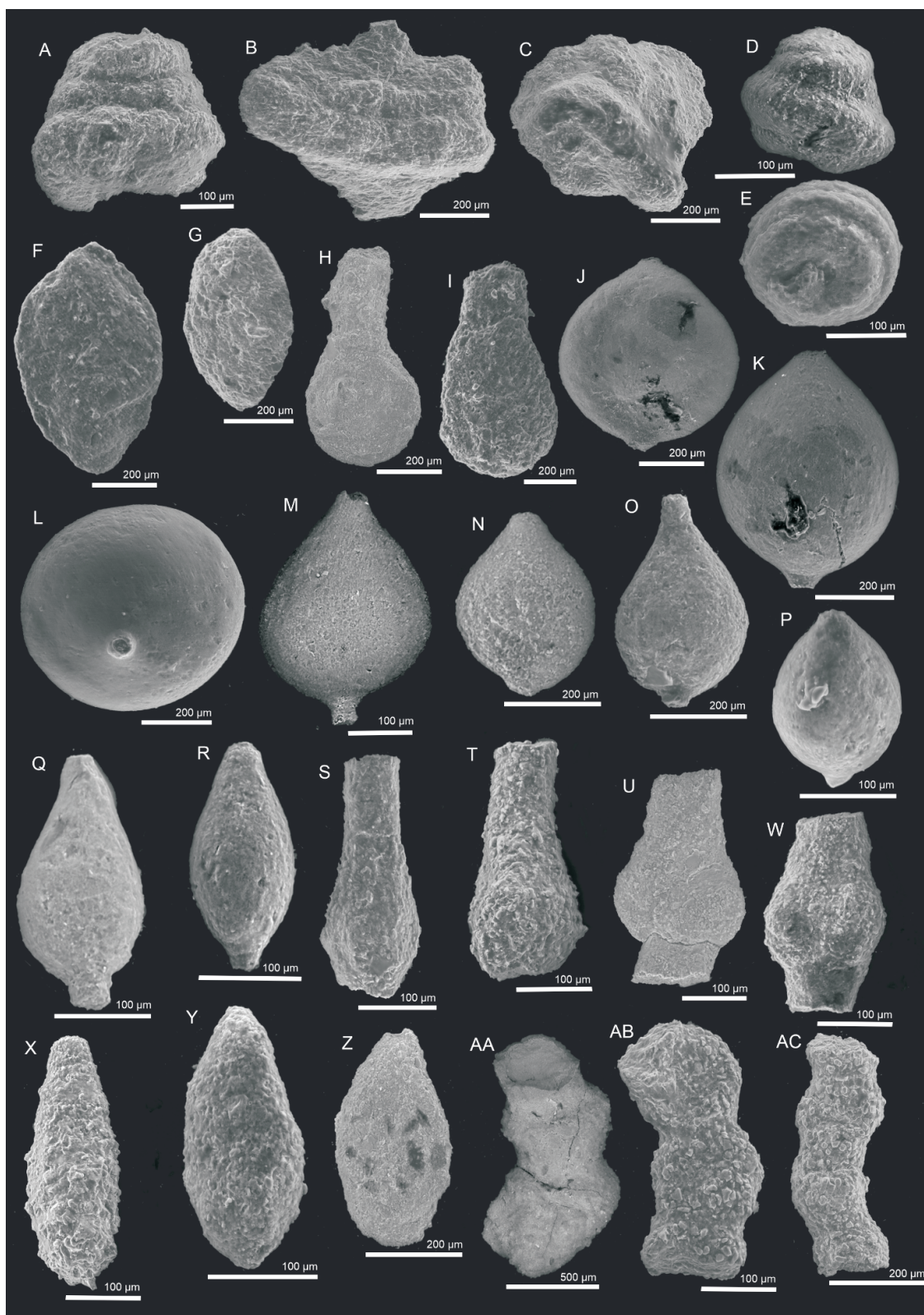
**A** – Mútňanka River section (western part of the exposure belt; 49.483566°N; 19.276319°E); **B** – Rabka Zaryte section (eastern part of the exposure belt; 49.620833°N; 19.977777°E)



**Fig. 5. SEM images of agglutinated foraminifera from the Orawa Farony Shale Member**

**A** – *Nothia excelsa* (Grzybowski) fragment (sample (s.) F1156A); **B** – *Nothia excelsa* (Grzybowski) fragment (s. K1); **C** – *Nothia latissima* (Grzybowski) fragment (s. SR); **D** – *Nothia robusta* (Grzybowski) fragment (s. SR); **E** – Tubular form fragment (s. K1); **F** – *Bathysiphon* sp. (s. K1); **G** – *Psammosiphonella cylindrica* (Glaessner) fragment (s. K1); **H** – *Psammosiphonella cylindrica* (Glaessner) fragment (s. SR); **I** – *Psammosiphonella cylindrica* (Glaessner) fragment (s. K5); **J** – *Rhizammina* sp. fragment (s. K1); **K** – *Rhabdammina* sp. fragment (s. K1); **L** – *Psammosphaera* sp. (s. K1); **M** – *Saccammina grzybowskii* (Schubert) (s. K3); **N** – *Saccammina grzybowskii* (Schubert) (s. K4); **O** – *Placentammina placenta* (Grzybowski) (s. K1); **P** – *Placentammina placenta* (Grzybowski) (s. K6); **Q** – *Ammodiscus* ex. gr. *peruvianus* Berry (s. K4); **R** – *Ammodiscus peruvianus* Berry (s. F1156A); **S** – *Ammodiscus glabratus* Cushman et Jarvis (s. K5); **T** – *Ammodiscus cretaceous* (Reuss) (s. PS3A); **U** – “*Ammodiscus*” *pennyi* Cushman et Jarvis (s. K1); **V** – *Annectina* sp. (s. SR); **W** – *Annectina grzybowskii* (Jurkiewicz) (s. K1); **X** – *Annectina grzybowskii* (Jurkiewicz) (s. K1); **Y** – *Glomospira glomerata* Grzybowski (s. K6); **Z** – *Agathamminoides* sp. (s. K1); **AA** – *Glomospira glomerata* Grzybowski (big sized) (s. K6); **AB** – *Glomospira* sp. (s. K1); **AC** – *Glomospira irregularis* (Grzybowski) (s. K1)

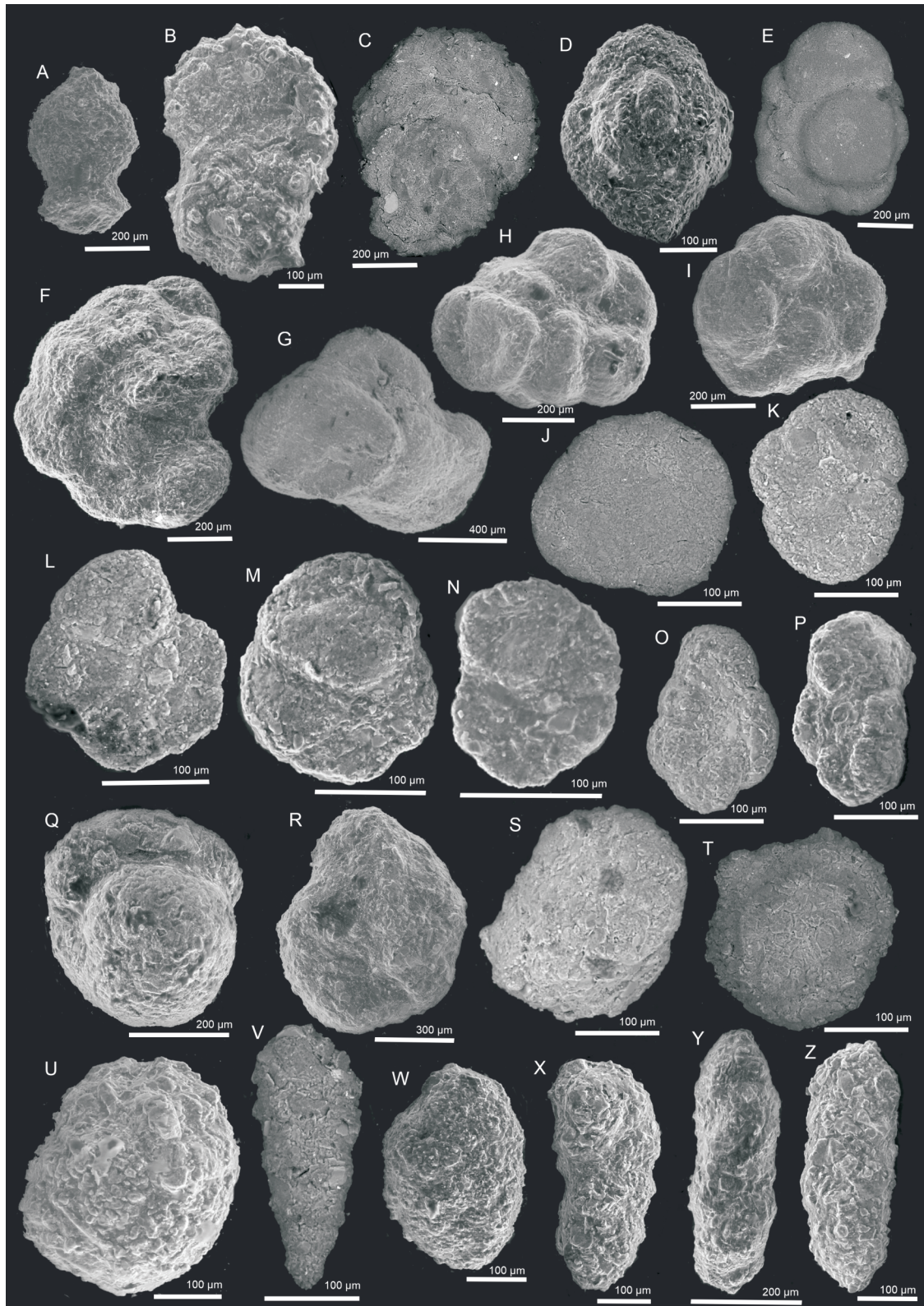




**Fig. 6. SEM-images of agglutinated foraminifera from the Farony Shale Member**

**A** – *Arenoturrispirillina waskowskae* Hikmahtiar et Kaminski (sample (s.) K1); **B** – *Glomospira* sp. (s. K1); **C** – *Glomospira irregularis* (Grzybowski) (s. K3); **D** – *Glomospira charoides* (Jones et Parker) (s. K1); **E** – *Glomospira charoides* (Jones et Parker) (s. K1); **F** – *Rzehakina inclusa* (Grzybowski) (s. SR); **G** – *Rzehakina inclusa* (Grzybowski) (s. K4); **H** – *Hyperammina* sp. fragment (s. K1); **I** – *Hyperammina* sp. fragment (s. PS3A); **J** – *Caudammina gigantea* (Geroch) fragment (s. K3); **K** – *Caudammina gigantea* (Geroch) fragment (s. K2); **L** – *Caudammina gigantea* (Geroch) fragment (s. F1156A); **M** – *Caudammina ovula* (Grzybowski) fragment (s. K5); **N** – *Caudammina ovula* (Grzybowski) fragment (s. F1156A); **O** – *Caudammina ovula* (Grzybowski) fragment (s. K3); **P** – *Caudammina ovula* (Grzybowski) fragment (s. K2); **Q** – *Caudammina* cf. *ovuloides* (Grzybowski) fragment (s. K6); **R** – *Caudammina* cf. *ovuloides* (Grzybowski) fragment (s. K3); **S** – *Caudammina excelsa* (Dyłażanka) fragment (s. K1); **T** – *Caudammina excelsa* (Dyłażanka) fragment (s. K3); **U** – *Caudammina excelsa* (Dyłażanka) fragment (s. SR); **W** – *Caudammina excelsa* (Dyłażanka) fragment (s. SR); **X** – *Subreophax* sp. fragment (s. K1); **Y** – *Subreophax* sp. fragment (s. PS3A); **Z** – *Lagenamina* sp. (s. K1); **AA** – *Subreophax pseudoscalaris* (Samuel) (s. K1); **AB** – *Subreophax* cf. *aduncus* (Brady) fragment (s. K3); **AC** – *Subreophax aduncus* (Brady) fragment (s. K2)





**Fig. 7. SEM-images of agglutinated foraminifera from the Farony Shale Member**

**A** – *Subreophax* sp. fragment (sample (s.) K1); **B** – *Reophax duplex* Grzybowski (s. K1); **C** – *Reophax duplex* Grzybowski (s. K1); **D** – *Paratrochamminoides gorayskii* (Grzybowski) (s. K1); **E** – *Paratrochamminoides subcoronatus* (Grzybowski) (s. K4); **F** – *Paratrochamminoides acervulatus* (Grzybowski) (s. K3); **G** – *Paratrochamminoides heteromorphus* (Grzybowski) (s. K1); **H** – *Trochamminoides variolarius* (Grzybowski) (s. K5); **I** – *Conglophragmium* cf. *irregularis* (White) (s. K4); **J** – *Praesphaerammina gerochii* Hanzlikova (s. K3); **K** – *Ammosphaeroidina pseudopauciloculata* (Myatlyuk) (s. SR); **L** – *Haplophragmoides kirki* Wickenden (s. K1); **M** – *Haplophragmoides kirki* Wickenden (s. K5); **N** – *Haplophragmoides kirki* Wickenden (s. K5); **O** – *Haplophragmoides* sp. (s. K3); **P** – *Haplophragmoides* sp. (s. K5); **Q** – *Recurvoides anormis* Myatlyuk (s. K5); **R** – *Recurvoides anormis* Myatlyuk (s. K5); **S** – *Recurvoides* sp. (s. F1156A); **T** – *Recurvoides* sp. (s. K2); **U** – *Recurvoides* cf. *nucleolus* (Grzybowski) (s. K1); **V** – *Spiroplectammina* cf. *navarroana* Cushman (s. K2); **W** – *Karrerulina* sp. (s. F1156A); **X** – *Karrerulina horrida* (Mjatluk) (s. K2); **Y** – *Karrerulina conversa* (Grzybowski) (s. K5); **Z** – *Karrerulina horrida* (Mjatluk) (s. K5)



## BIOSTRATIGRAPHY

The foraminiferal assemblages of the Orava Farony Shales are dominated by deep-water agglutinated forms that are mostly cosmopolitan and of low biostratigraphic significance. *Rzehakina inclusa* (Grzybowski) is the taxon with the shortest stratigraphic range and provides unequivocal evidence for an upper Campanian–Maastrichtian age (cf. Morgiel and Olszewska, 1981; Malata and Oszczypko, 1996; Olszewska, 1997; Cieszkowski et al., 2007; Waśkowska et al., 2019).

Taking into account taxonomic acmes, a lower Maastrichtian age is inferred for the deposits from the Kiczory and Oravské Veselé localities. In the Outer Carpathians, the co-occurrence of *Caudammina gigantea* (Geroch) and *Caudammina excelsa* (Dylańska) acmes has been documented in the lower Maastrichtian. All samples from the Kiczory locality show the presence of the *Saccamina*–*Placentamina* acme (up to 22% excluding tubular forms; Appendix 1; Fig. 5), which is recorded from the uppermost Campanian to the Danian, thus encompassing the age interval in question.

For the remaining localities, the age interval could not be constrained as precisely and includes the uppermost Campanian–Maastrichtian/Paleocene for locality F1156, whereas for the other sites, it is broadly indicated as Campanian–Paleocene or Campanian/Paleogene.

## SEDIMENTARY ENVIRONMENT AND PALAEOGEOGRAPHY

During the Campanian–Maastrichtian, the Magura Basin reached depths of ~2–3.5 km (Poprawa et al., 2002). At that time, the Outer Western Carpathian basins remained under the influence of increased tectonic activity and a relatively prolonged sea-level fall. These conditions influenced an enhanced supply of clastic material into the basin and contributed to the facies heterogeneity of the deposits, including the sandstone-rich Szczawina Member and the Ropianka Formation. The occurrence here of the shale-dominated Farony Variegated Shales is a result of a reduction in the sedimentation rate in the early Maastrichtian and a temporarily limited supply of sandy material to the Bystrica Zone. The deposition of a variegated shale succession, despite fluctuations in clastic supply, took place within a sedimentary regime which extended across the central part of the Magura Basin in the Late Cretaceous. The Szczawina-type sandstones indicate sediment transport from the S and SE, as documented in the Piłsko and Babia Góra areas by Ryłko (1992) and later by Teták et al. (2019). This palaeocurrent direction is opposite to that of the depositional systems along the external margin of the Magura Basin (Soláň, Jaworzynka, and Mutne formations) and differs from that of the lithologically similar but younger Magura-type Kýčera sandstones, which show an east–west transport direction (Teták et al., 2019; Waśkowska et al., 2021).

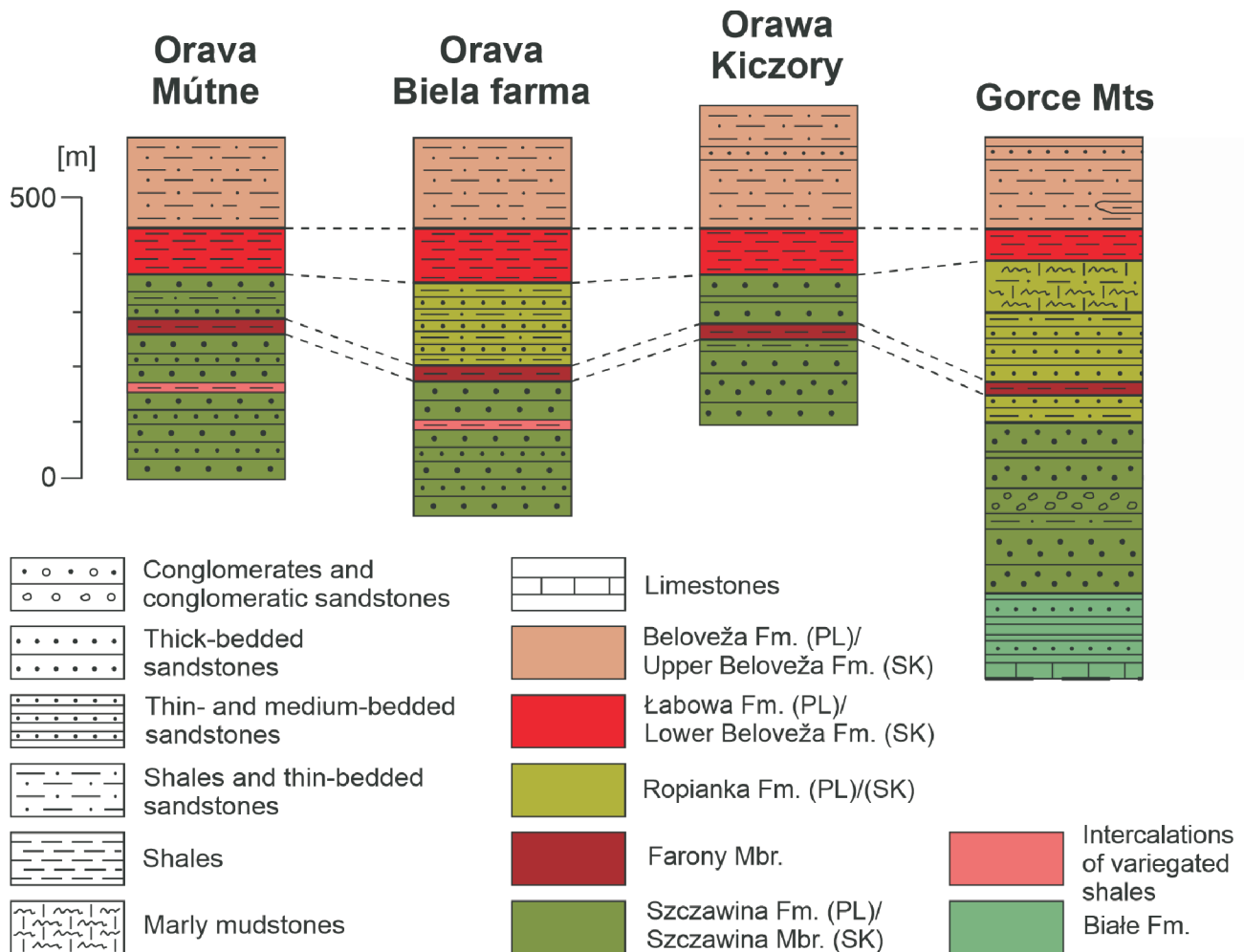
The intrabasinal Szczawina Ridge, located in the central part of the Magura Basin and interpreted as the source area of the Szczawina-type sandstones, was composed predominantly of magmatic and metamorphic rocks (Oszczypko and Salata, 2005; Teták et al., 2016b, 2019; Teták, 2022). Oszczypko and Salata (2005) also suggested the presence of a small local intrabasinal ridge supplying Szczawina-type clastic material, possibly located along the boundary between the Krynica and Bystrica units. Based on geological mapping and palaeocurrent measurements of the Szczawina-type sandstones (Sikora and Żytko, 1960; Gucik et al., 1962; Książkiewicz, 1966; Ryłko, 1992; Teták et al., 2016b), at least four submarine fans have

been identified across the Bystrica and Rača units (Książkiewicz, 1966; Ryłko, 1992; Oszczypko and Salata, 2005; Teták et al., 2019).

## DISCUSSION

Field analyses conducted in the Polish and Slovak parts of the Orava region revealed the presence of a variegated shale succession within the lower part of the Ropianka Formation of the Bystrica Subunit (Figs. 1, 2 and 4). This succession corresponds in terms of lithological development, lithostratigraphic position and age to the Farony Variegated Shales distinguished by Waśkowska and Szczęch (2023) in the Gorce region (Fig. 8). In descriptions of the Ropianka Formation, there are references to the occurrence of red shales at various stratigraphic levels (Cieszkowski et al., 1998). Among these, the Farony Variegated Shales show stability, significant thickness, and lateral continuity (Fig. 8). New data indicate that, alongside the Gorce Mts., where a belt of variegated shales was documented between Szczawa and Rabka Zaryte (Waśkowska and Szczęch, 2023), they also occur in more western parts of the Bystrica Zone in the Orava region, forming a strip between Lipnica Mała in the east and Soblówka in the west (Figs. 1–3). In total, the variegated shales belt stretches over a distance of 100 km, with an outcrop gap ~30 km in length between Rabka Zaryte and Lipnica Wielka. The thickness of these deposits is relatively consistent; in the Gorce Mts., it usually amounts to several tens of metres. Similar thicknesses occur in the Orava region, although in some places their thickness decreases to <10 m.

The Farony Variegated Shale horizon extends from the Gorce region in the east, where it occurs within medium- and thin-bedded sandy-shaly deposits, which westwards, in Orava, are laterally replaced by thick-bedded sandy deposits (Fig. 8). The stratigraphic position of the Farony Variegated Shales in the Outer Carpathians is stable. Dating by micropalaeontological methods indicates the lower Maastrichtian; less precise dating indicates the upper Campanian–lower Maastrichtian interval (Waśkowska and Szczęch, 2023). They form a level within the Ropianka facies which shows lateral variability from east to west, and it is defined differently in Polish and Slovak lithostratigraphic classifications. These deposits were described in older literature as the Ropianka Beds or Inoceramus Beds (e.g., Książkiewicz, 1971; Burtan et al., 1978a, b; Paul and Ryłko, 1986, 1987; Paul et al., 2021, 2022a, b). In the Gorce area, they show clear lateral differentiation and a distinctly bipartite development. On that basis, Oszczypko et al. (2005) distinguished two formations: the Szczawina Formation (Maastrichtian) and the Ropianka Formation (Maastrichtian–Paleocene). The Szczawina Formation consists of grey, muscovite-rich, thick-bedded sandstones, commonly amalgamated, fine- to coarse-grained with rare conglomerates. The sandstones are typically massive with laminations in their upper parts. Above them, deposits of the Ropianka Formation occur, which are built of medium- and thin-bedded sandstone-shale deposits. The sandstones are steel-grey, muscovite-rich, fine-grained, graded, with parallel, wavy, and convolute lamination with trace fossils at bed bases. They are intercalated with grey and greenish shales, with numerous trace fossils. Grey or yellowish-grey marly shales are less common. From the Polish sector of the Orava and further westwards, the Ropianka facies is represented by deposits dominated by greenish-grey, thick-bedded sandstones ranging from the Maastrichtian to the Paleocene (Sikora and Żytko, 1960; Książkiewicz, 1966, 1971;



**Fig. 8. Lithostratigraphic correlation of the Ropianka Formation in the Gorce-Orava region**  
(Książkiewicz, 1971; Szczęch et al., 2016, modified)

PL – units according to Oszczypko et al. (2005); SK – units according to Teták et al. (2016b, 2017)

Teták et al., 2016b, 2017). These deposits were distinguished as the Ropianka Formation by Teták et al. (2016b, 2017) but refer to the Szczawina Formation *sensu* Oszczypko et al. (2005).

The Farony Shales were originally regarded as a local correlative unit within the Upper Cretaceous deposits of the Ropianka Formation of the Bystrica Subunit of the Magura Nappe, on the northern slopes of the Gorce Mountains, in the area of Szczawa and Lubomierz (Cieszkowski et al., 1998; Szczęch et al., 2016). Subsequent detailed studies in Gorce corroborated a broader distribution of these deposits along the entire northern margin of the Gorce Mts., from Rabka to Szczawa (Waśkowska and Szczęch, 2023). However, as documented above, this unit is considerably more widespread and also occurs in the Orava region, on the southern slopes of the Pilsko and Babia Góra Mts., between Kiczora and Novot'. Field observations have shown that these deposits display very similar lithological characteristics both in the Orava region and in the Gorce Mts. Moreover, the structure and the taxonomic composition of the foraminiferal assemblages of the Farony Shales from the Orava region correspond well with foraminiferal assemblages noted from the Gorce Mts. (Waśkowska and Szczęch, 2023). The similarity includes the occurrence of the *Saccammina-Placentammina* acme and the *Caudammina* acme, with the species *Caudammina gigantea* (Geroch) and

*Caudammina ovula* (Grzybowski). Additionally, a *Caudammina excelsa* (Dylańska) acme was also recorded in the Orava area (cf. Waśkowska and Szczęch, 2023, and the discussion therein). The acmes of deep-water agglutinated foraminifera enable stratigraphic correlation of sub-CCD deposits throughout the western Tethys and even with the Indo-Pacific region (Kuhnt et al., 1992; Kaminski et al., 2024; Flores et al., 2026), indicating deposition under similar environmental conditions and comparable ecological settings.

The lower Maastrichtian age determined for the variegated shales from Orava corresponds well with the age of the Farony Shales recognized in the Gorce Mts. This shale succession contains foraminiferal assemblages with co-occurring *Rzehakina inclusa* (Grzybowski) and the *Caudammina* acme, including *Caudammina gigantea* (Geroch) – *Caudammina ovula* (Grzybowski), as well as the *Saccammina grzybowskii* Schubert – *Placentammina placenta* (Grzybowski) acme (Appendix 1). These biostratigraphic determinations, together with other results based on faunal lists reported from the Ropianka Fm, do not exclude an upper Campanian age for the Ropianka Formation in the Rača Zone and, consequently, for the Farony Shales (Waśkowska and Szczęch, 2023). In the light of the new data, however, an upper Campanian age is not confirmed.



Formalization carries significant practical value by unifying terminology and thereby supporting, *inter alia*, geological mapping and related activities. Codes of stratigraphy assume the presence of lower-rank units within a formation, and such units include this member. According to established rules, its designation is justified when lithological variability occurs within a formation (Alexandrowicz et al., 1975; Murphy and Salvador, 1999; Racki et al., 2006). In the lithostratigraphic scheme, the Ropianka Formation in the Bystrica Subunit (Slovakia) has been distinguished as an independent unit. It is characterized by a dominance of medium- to thin-bedded sandstones interbedded with grey muddy shales, with the inclusion of a thick-bedded sandstone unit of the Szczawina Member (Teřák et al., 2017), which in some places completely replace thin- and medium-bedded sandstone-shale deposits (Teřák et al., 2016a). In the eastern part of the Bystrica Subunit, the deposits of the Szczawina Member according to the division of Oszczypko et al. (2005) constitute a separate formation occurring below the Ropianka Formation.

The Farony Variegated Shales, dominated by green and red mudstones with rare and very thin sandstone interbeds, clearly distinguish themselves from the surrounding sandstone-rich Ropianka-type deposits (Fig. 4). These deposits meet the criteria to be distinguished as a separate unit within the Ropianka Formation. In addition to their lithological distinctiveness, they are characterized by clear boundaries, internal coherence, significant thickness ranging from several metres in the Gorce Mts., to several tens of metres in the Orava region, and lateral continuity, although stratigraphic rules do not impose fixed standards regarding the extent or thickness of a member. These features justify the introduction of a new lithostratigraphic unit with the rank of a member, encompassing variegated deposits dominated by mudstones within the grey, medium- and thin-bedded deposits of the Ropianka Formation. This new unit is important for correlation, particularly in fieldwork. The variegated deposits act as marker horizons within the surrounding units, due to the presence of distinctive red shales, whose occurrence at outcrop is also visible through the colour of the weathering cover. They constitute important correlation levels that serve as stratigraphic reference horizons and key markers in geological mapping. Variegated deposits are not common in the Outer Carpathians. Within the Bystrica subunit, apart from the Farony Shales, there are few deposits containing red mudstones; these include the Cenomanian–Turonian Malinowa and Paleocene–Lower Eocene Łabowa formations, as well as the Middle–Upper Eocene Mniszek Member within the Magura Formation (Oszczypko, 1991; Oszczypko et al., 2005).

## FARONY VARIEGATED SHALE MEMBER – A NEW LITHOSTRATIGRAPHIC UNIT

**History:** The variegated shales occurring within the Upper Cretaceous deposits of the Magura Nappe were recognized by Marek Cieszkowski during geological mapping in the Szczawa and Lubomierz regions in the 1990s (Cieszkowski et al., 1998). The designation “Farony red/variegated shales” was usually used by him informally in personal communications, functioning as a working name to distinguish these deposits. Subsequently, this unit was marked on the geological map of the Gorce region (Cieszkowski et al., 1998; Cieszkowski, 2006) and then on the lithostratigraphic log of the Bystrica Subunit (Cieszkowski and Uchman, 2008). The term “Farony Shale Member” was used without formalization by Cieszkowski et al. (2015) and subsequently by Szczęch et al. (2016) in describing the general

lithostratigraphical characteristics of the Gorce Mts. Subsequent research conducted by Cieszkowski, Szczęch, and Wařkowska (Szczęch et al., 2016; Wařkowska and Szczęch, 2023) allowed determination of its age as Campanian–Maastrichtian, traced its extent over a distance of 30 km, and established its use as a regional correlation horizon (Wařkowska and Szczęch, 2023). The deposits at the localities described by Wařkowska and Szczęch (2023) as the Farony Shale Member were classified on the Detailed Geological Map of Poland (1:50,000) as variegated shales within the Cretaceous deposits of the Ropianka Formation (formerly Inoceramus Beds; Książkiewicz, 1971; Burtan et al., 2021; Paul et al., 2021). On the northern slopes of the Gorce Mts., in Rabka-Zaryte, they were partly erroneously classified as the much older Turonian–Cenomanian Malinowa Formation (Paul et al., 2022a, b). The wide distribution of these deposits was documented as intercalations in the Ropianka Formation on the Detailed Geological Map of Slovakia (1:50,000) by Teřák et al. (2016a, b) in the Orava region. Initially, the Szczawa section located in the Głębień stream was proposed as a type section for this unit (Cieszkowski et al., 1998; Szczęch et al., 2016). The original exposures in which Cieszkowski first described the Farony Shales are currently inaccessible (Szczęch et al., 2016). This results from burial of the bedrock by alluvial deposits and slope wash (diluvial material), a consequence of local river channel regulation and the partial reinforcement of its bed. More comprehensive studies connected with the lithology, age, stratigraphic position, thickness, and extent of the Farony Shales were conducted in 2020–2025.

**Name:** The Farony Variegated Shale Member, or in short, the Farony Member; Polish names: *ogniwo pstrych łupków z Faronów*, *ogniwo farońskie*; Slovak name: *faronské vrstvy*. The geographical segment of the name, Farony, derives from the Farony hamlet, which encompasses the Głębień valley in the village of Szczawa, the location where these deposits were first described. The name is used following Marek Cieszkowski, who first coined the term, introduced it into informal lithostratigraphy, and initiated the study of these deposits.

**Type section:** Outcrop in the Kamienicki Creek, Rzeki hamlet, Lubomierz village (49.592889° N, 20.235167° E).

**Reference sections:** Reference section 1: Outcrop on the left bank of the Bystrý potok stream, north of Mútne village (49.487994° N, 19.275165° E).

Reference section 2: Outcrop in the Ratulowiec Creek, Bořki hamlet of the Lubomierz village (49.614629° N, 20.170706° E).

**Boundaries:** Both the lower and upper boundaries of the Farony Shale Member are sharp and clearly marked by the presence of red shales. This unit is situated in the lower part of the Ropianka Formation. There is no significant lateral lithological variation within the unit itself; however, the lithology of the enclosing deposits changes markedly laterally. In the eastern sector, encompassing the Gorce Mts., this succession occurs within thin- to medium-bedded sandstone–shale deposits of the Ropianka Formation. In the Orava region, deposits of the Farony Member occur within the thick-bedded Szczawina sandstones and locally within thin- to medium-bedded sandstone–shale sequences. In thick-bedded sections, directly below the Farony Member, a pronounced decrease in the thickness of sandstone beds is observed, from 1–2.5 m down to several tens of centimetres. In the Orava region, above the Farony Member, thick-bedded sandstones are observed.

**Thickness:** The Farony Shale Member thickness is 5–20 m regardless of the locality.

**Dominant lithology:** The Farony Shale Member consists of variegated, predominantly red and greenish, claystone and mudstone deposits. The red deposits are dominant or constitute about half of the section. The thickness of individual red shale beds ranges from a few centimetres to >10 cm. The green intervals are thinner, ranging from a few millimetres to a few centimetres. These shales are hard, silicified, and fracture into sharp-edged, angular blocks and fragments.

Within the shale succession, single layers of fine-grained, thin-bedded sandstone occur. In the upper part of the profile, several-decimetre-thick turbidite packages are present, composed of parallel-laminated, fine-grained, grey, thin-bedded sandstones alternating with green shale interbeds. Sporadically, medium-bedded, muscovite-rich sandstone layers are observed.

**Age:** Lower Maastrichtian based on agglutinated foraminifera (interval of the co-occurrence of *Caudammina gigantea* (Geroch), *Caudammina ovula* (Grzybowski), *Caudammina excelsa* (Dyląganka), *Saccammina–Placentammina* acmes and *Rzehakina inclusa* (Grzybowski)).

**Distribution:** The Farony Variegated Shale Member is laterally extensive, occurring as a belt of east–west orientation, with a length corresponding to that of other lithostratigraphic units, positioned more or less parallel to the thrust of the Bystrica Subunit onto the Rača Subunit. The unit occurs within the lower part of the Ropianka Formation in the Gorce Mts., and the Orava region, forming a strip between the villages of Młyńczyska and Sobłówka.

## CONCLUSIONS

In the Orava region, within the lower part of the sandstone-rich Ropianka Formation, a horizon ranging from a few to about ten metres in thickness, dominated by shales (including variegated shales), has been identified. In terms of its lithostrati-

graphic position in the Bystrica Subunit of the Magura Nappe, lithology, foraminiferal content, and age, it corresponds to the Farony Variegated Shale Member of the Gorce Mts. and constitutes their prolongation. The regional extent of the Farony Variegated Shale Member has been documented; their outcrop extends over a 100 km distance from Novot' to Młyńczyska, which significantly expands their known geographic range.

The age of the Farony Variegated Shale at Orava has been refined using foraminiferal biostratigraphy. The timing of their sedimentation has been determined as early Maastrichtian, based on the co-occurrence of *Rzehakina inclusa* (Grzybowski) and acmes of *Caudammina gigantea* (Geroch), *Caudammina ovula* (Grzybowski), *Caudammina excelsa* (Dyląganka), and *Saccammina–Placentammina*.

The lower Maastrichtian variegated shales have been formally defined as the Farony Variegated Shale Member within the Ropianka Formation, and their lithostratigraphic characteristics have been provided. These deposits show clear lithological distinctiveness, significant thickness, and regional extent, making them a characteristic and easily distinguishable unit within the Ropianka Formation, laterally persistent throughout the Gorce Mts. and the Orava region.

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# APPENDIX 1

## List of foraminifera from the Farony Shale Member from the Orava region

| Taxa                                                                                                                                       | Sample number | PS3A | PS3 | F1156A | PS1 | SR  | K1 | K2  | K3  | K4 | K5 | K6 |
|--------------------------------------------------------------------------------------------------------------------------------------------|---------------|------|-----|--------|-----|-----|----|-----|-----|----|----|----|
| <i>Ammosphaeroidina pseudopauciloculata</i> (Mjatluk)                                                                                      |               |      |     | 24     | X   | 96  | 28 |     | 24  | 72 | 12 | 8  |
| <i>Ammodiscus</i> div. sp. (mainly <i>A. cretaceus</i> (Reuss), <i>A. glabratus</i> Cushman et Jarvis))                                    | X             | X    | 34  |        |     |     | 12 |     | 8   | 8  | 8  |    |
| <i>Ammodiscus tenuissimus</i> Grzybowski                                                                                                   | X             | X    |     |        |     |     |    |     |     |    | 5  |    |
| <i>Ammodiscus</i> ex. gr. <i>peruvianus</i> Berry                                                                                          | X             |      | 26  |        | 10  | 10  | 12 | 2   |     |    |    | 5  |
| <i>Ammodiscus</i> sp. (small sized)                                                                                                        | X             |      | 30  |        | 22  | 15  | 17 | 6   |     |    | 3  | 3  |
| <i>Ammolagena clavata</i> (Jones et Parker)                                                                                                | X             |      |     |        |     |     |    |     |     |    |    |    |
| <i>Annectina grzybowskii</i> (Jurkiewicz)                                                                                                  |               |      | 16  |        |     | 2   |    |     |     |    |    |    |
| <i>Annectina</i> sp. (small sized)                                                                                                         |               |      |     |        | 3   | 4   |    |     |     |    |    |    |
| <i>Arenobulimina</i> sp.                                                                                                                   | X             |      |     |        |     |     |    |     |     |    |    |    |
| <i>Arenoturrispirillina</i> div. sp.                                                                                                       |               |      |     |        |     | 3   | 3  | 8   |     |    |    |    |
| <i>Arthrodendron</i> sp. (chambers)                                                                                                        |               |      | 6   |        |     | 7   |    |     |     |    |    |    |
| <i>Caudamina excelsa</i> (Dyląganka) (chambers)                                                                                            | X             |      | 20  |        | 166 | 256 |    | 8   |     |    |    | 16 |
| <i>Caudamina gigantea</i> (Geroch) (chambers)                                                                                              |               |      | X   |        | 48  | 6   | 8  | 88  | 40  | 72 | 56 |    |
| <i>Caudamina</i> div. sp. (mainly <i>C. ovula</i> (Grzybowski)) (chambers)                                                                 | X             |      | 232 |        | 82  | 4   | 56 | 88  | 142 | 32 | 32 |    |
| <i>Conglophragmium irregulare</i> (White)                                                                                                  |               |      | 4   |        |     | 12  |    |     |     | 14 |    |    |
| <i>Glomospira charoides</i> (Jones et Parker)                                                                                              |               |      |     |        |     | 10  | 42 | 8   |     |    |    | 8  |
| <i>Glomospira</i> ex. gr. <i>irregularis</i> (Grzybowski)                                                                                  |               | X    | 18  | X      | 15  | 15  | 8  | 9   |     |    |    |    |
| <i>Glomospira gordialis</i> (Jones et Parker)                                                                                              |               |      | 16  | X      |     | 4   |    | 8   |     |    |    |    |
| <i>Glomospira glomerata</i> Grzybowski                                                                                                     |               |      |     |        |     |     |    |     |     |    |    | 2  |
| <i>Agathamminoides</i> ex. gr. <i>serpens</i>                                                                                              |               |      | 13  |        |     | 3   |    |     |     |    |    |    |
| <i>Glomospirella</i> cf. <i>diffundens</i> (Cushman et Renz)                                                                               |               |      |     |        |     |     |    | 8   |     |    |    |    |
| <i>Haplophragmoides kirki</i> Wickenden                                                                                                    |               |      | 16  |        |     | 2   |    |     |     |    | 5  |    |
| <i>Haplophragmoides</i> div. sp. (mainly <i>H. ex. gr. walteri</i> (Grzybowski) (small sized))                                             | X             |      | 13  |        | 16  | 4   |    | 8   |     |    | 3  | 16 |
| <i>Hormosina</i> sp. (chambers)                                                                                                            |               |      | 16  |        |     |     | 16 |     |     |    |    |    |
| <i>Hyperammina</i> sp. (chambers)                                                                                                          | X             |      |     | X      |     | 2   |    |     |     |    |    |    |
| <i>Karrerulina conversa</i> (Grzybowski)                                                                                                   |               |      | 40  |        |     |     |    |     |     |    | 7  |    |
| <i>Karrerulina coniformis</i> (Grzybowski)                                                                                                 |               |      | 22  | X      |     |     |    |     |     |    |    |    |
| <i>Karrerulina horrida</i> (Mjatluk)                                                                                                       |               |      | 20  |        | 32  | 1   | 4  |     |     |    | 8  |    |
| <i>Lagenammina</i> sp.                                                                                                                     |               |      |     |        |     | 3   |    |     |     |    |    |    |
| <i>Nothia</i> div. sp. (mainly <i>N. excelsa</i> (Grzybowski), <i>N. robusta</i> (Grzybowski)) and <i>Bathysiphon</i> div. sp. (fragments) | XX            | XX   | XX  | XX     | XX  | XX  | XX | XX  | XX  | XX | XX | XX |
| <i>Paratrochamminoides acervulatus</i> (Grzybowski)                                                                                        | X             | X    | X   | X      | X   | X   | X  | X   | X   | X  | X  | X  |
| <i>Paratrochamminoides heteromorphus</i> (Grzybowski)                                                                                      |               |      | 2   |        |     | 6   |    | 16  |     |    |    |    |
| <i>Paratrochamminoides contortus</i> (Grzybowski)                                                                                          |               | X    | 44  | X      | 16  | 12  |    |     |     | 14 |    | 16 |
| <i>Paratrochamminoides gorayskii</i> (Grzybowski)                                                                                          |               |      |     |        |     | 10  | 7  |     |     |    |    |    |
| <i>Paratrochamminoides olszewski</i> (Grzybowski)                                                                                          |               |      | 6   |        | 16  | 4   | 42 | 150 | 8   |    |    |    |
| <i>Paratrochamminoides multilobus</i> (Dyląganka)                                                                                          |               |      |     | X      |     | 6   |    |     |     |    |    | 16 |
| <i>Paratrochamminoides mitratus</i> (Grzybowski)                                                                                           |               |      |     |        |     | 9   |    |     |     |    |    |    |
| <i>Paratrochamminoides deflexiformis</i> (Noth)                                                                                            |               |      |     |        |     |     |    | 24  |     |    |    |    |
| <i>Trochamminoides subcoronatus</i> (Grzybowski)                                                                                           |               | X    | 8   | X      | 16  | 36  |    | 8   | 8   | 16 | 16 |    |
| <i>Paratrochamminoides, Trochamminoides</i> and <i>Conglophragmium</i> div. sp.                                                            |               | X    | 2   | XX     | 22  | 170 | 50 | 64  | 86  | 84 | 56 |    |
| <i>Placentammina placenta</i> (Grzybowski)                                                                                                 | X             |      | 28  | X      | 24  | 50  | 24 | 60  | 24  | 24 | 32 |    |
| <i>Psammosiphonella</i> div. sp. (mainly <i>P. cylindrica</i> (Glaessner) and <i>Rhizammina</i> div. sp. (fragments)                       | X             |      | XX  |        |     | XX  |    | X   | X   |    |    |    |
| <i>Praesphaerammina gerochii</i> Hanzlikova                                                                                                | X             |      |     |        |     |     |    | 2   |     |    |    |    |
| <i>Psammosphaera</i> sp.                                                                                                                   |               |      |     |        |     | 7   |    |     |     |    |    |    |
| <i>Reophax</i> cf. <i>pilulifer</i> Brady                                                                                                  |               |      | 2   |        |     | 8   |    |     |     |    |    |    |
| <i>Reophax duplex</i> Grzybowski                                                                                                           |               |      |     |        | 8   | 8   |    |     |     |    |    |    |
| <i>Haplophragmoides porrectus</i> Maslakova                                                                                                |               |      |     |        |     | 2   |    |     |     |    |    |    |
| <i>Recurvovoides</i> div. sp.                                                                                                              | XX            | XX   | 660 | XX     | 76  | 71  | 72 | 72  | 88  | 50 | 48 |    |
| <i>Rzehakina inclusa</i> (Grzybowski)                                                                                                      |               |      | ?   |        | 1   | 1   | ?  |     | 1   |    |    |    |
| <i>Rzehakina epigona</i> (Rzehak)                                                                                                          |               |      |     |        | 4   |     |    |     |     |    |    |    |
| <i>Trochammina globigeriniformis</i> (Parker et Jones)                                                                                     |               |      | 6   |        |     | 4   | 8  | 16  |     | 8  |    |    |
| <i>Trochammina</i> sp.                                                                                                                     |               |      |     |        |     | 2   |    |     |     |    |    |    |
| <i>Trochamminoides valioralius</i> (Grzybowski)                                                                                            |               |      | 6   |        |     | 24  |    |     |     | 5  |    |    |
| <i>Trochamminoides</i> Grzybowski Kaminski et Geroch                                                                                       |               |      |     | X      |     | 1   |    |     |     |    |    |    |
| <i>Saccammina</i> div. sp. (mainly <i>S. grzybowskii</i> (Schubert))                                                                       |               |      | 8   |        | 16  | 164 | 16 | 56  | 35  | 44 | 8  |    |
| <i>Subeophax</i> ex. gr. <i>adunkus</i> (Brady)                                                                                            |               |      |     |        |     | 4   | 8  | 5   |     |    |    |    |
| <i>Subreophax</i> div. sp. (mainly <i>S. scalaris</i> (Grzybowski)) (fragments)                                                            | X             |      | 58  |        | 8   | 7   | 24 | 3   |     |    |    |    |
| <i>Subreophax pseudoscalaris</i> (Grzybowski)                                                                                              |               |      |     |        |     | 6   |    |     |     |    |    |    |
| <i>Spiroplectammina navarroana</i> Cushman                                                                                                 |               |      | 4   |        |     |     | 3  |     |     |    |    |    |
| <i>Spiroplectammina</i> sp.                                                                                                                | X             |      |     |        |     |     |    |     |     |    |    |    |

x – occurrence of a taxa (uncounted), xxx – large number of taxa