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The geological position, sedimentary record and composition of the Tylicz Conglomerate (Late Eocene–Oligocene): stratigraphical and paleogeographical implications (Magura Nappe, Polish Outer Carpathians)

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Abstract: During the Late Cretaceous to Paleogene the Magura Basin was supplied with clastic material from, non-existing today, source areas situated on the northern and southern margins of the basin. The northern source area is traditionally connected with Silesian Ridge, whereas the position of the southern one is still under discussion. The Upper Eocene–Oligocene pebbly mudstones of the Tylicz/Krynica facies zone contain exotic material derived from the south-Magura source area. The studied pebbles and clasts contain fragments of crystalline rocks, derived from a continental type of crust, and frequent clasts of Mesozoic to Paleogene deep and shallow-water limestones. Volcanites, rarely granitoides as well as schists, gneisses, quartzites and cataclasites were found in the group of crystalline exotic pebbles. The isotopic ages of "exotic" pebbles from the Tylicz section document a Variscan age of plutonic and metamorphic rocks. The composition of the Tylicz exotic conglomerates occupied the transitional position between the Jarmuta/Proč (Maastrichtian–Lower Eocene) and Strihovce (Eocene) exotic pebbles. The provenance of these rocks could be connected with Eocene exhumation of the SE sector of the Magura Basin basement. Another possibility can be explain by supply of siliciclastic material from a SE source area (Dacia and Tisza Mega-Units) and carbonate material from a S source area (ALCAPA Mega-Unit: Central Carpathian Block and Pieniny Klippen Belt).

Key words: Magura Basin, stratigraphy and paleogeography, source areas, exotic rocks.

Introduction

The Outer Carpathian sedimentary basin complex was supplied with clastics that were derived from external as well as internal source areas, with the latter being referred to as "cordilleras" (Książkiewicz 1962). Our understanding of the geological structures controlling the Carpathian source areas is based on the investigations of sedimentary blocks and "exotic" pebbles that were transported into basinal areas by submarine gravity flows (see Książkiewicz 1962). In the Outer Carpathian sedimentary basin system the most important internal source area was the "Silesian Cordillera" that corresponded to the continental Silesian, Andrychów and Marmarosh Ridges (Książkiewicz 1965; Unrug 1968; Oszczypko 1992, 2006; Golonka et al. 2000; Oszczypko et al. 2005a; Picha et al. 2006). According to Unrug (1968), the Silesian Ridge "paralleled the long axis of the flysch trough" and separated the northern Silesian Basin from the southern Magura Basin. Isotopic ages of "exotic" pebbles shed from the Silesian Ridge into the Silesian, Dukla and Magura (Rača Subunit) Basins document a Variscan age of plutonic and metamorphic rocks (Poprawa et al. 2004). During the Campanian, inversion-related uplift of the Silesian Ridge affected the northern part of the Magura Basin where it was accompanied by the onset of flysch deposition. By contrast, along the southern margin of the Magura Basin the onset of flysch deposition occurred at the Maastrichtian-Paleocene transition as manifested by the conglomerates and olistoliths of the Jarmuta and Proč Formations (Birkenmajer & Oszczypko 1989; Mišík et al. 1991a). The source areas for these clastics were uplifted exotic blocks, including internal elements of the Pieniny Klippen Belt (PKB) (Książkiewicz 1977; Oszczypko et al. 2005b). This is attributed to the collision of the Inner Western Carpathian (ALCAPA) Block with the Czorsztyn-Oravicum Ridge (Plašienka 2003) and/or the Andrusov Ridge (Birkenmajer 1986, 1988). During the Early Eocene, a deep-water submarine fan started to develop in the southern part of the Magura Basin, as evidenced by the occurrence of channel-lobe turbidites supplied from SE sources. The Eocene deposits of the Krynica Zone of the Magura Basin contain fragments of crystalline rocks, derived from a continental type of crust, and infrequent clasts of Mesozoic deep and shallow-water limestones. Mišík et al. (1991b) suggested that this material was derived from "the basement of the Magura Basin", but differs from that of the Czorsztyn-Oravicum Ridge, that was exhumed during the Early/Middle Eocene. Alternatively, this clastic material may have been derived from an Inner Carpathian type source area, located on the SE margin of the basin (e.g. tip of the ALCAPA Block, see Plašienka 2000). The aim of this paper is to present the geological position, sedimentary record and structure of the composition of the Tylicz Conglomerate (Upper Eocene–Oligocene). The special emphasis was given on provenance analyses of sedimentary clast and pebbles and their age and paleogeographical significance.

Previous works

In the southern part of the Magura Nappe (Fig. 1) the "exotic" conglomerates have been known from many years. They belong to coarse-grained deposits of the Szczawnica, Zarzecze and Magura Formations (Jaksa-Bykowski 1925; Mochnacka & Węcławik 1967; Wieser 1970; Oszczypko 1975; Oszczypko et al. 2006). The first detailed description of exotic clasts were given by Mochnacka & Węcławik (1967), who studied both crystalline as well as sedimentary pebbles from the Hieroglyphic Beds at Tylicz.

A few years later Oszczypko (1975) in the Eocene deposits of the Beskid Sądecki Range (Krynica Zone) found granitoids, gneisses, phyllites and quartzites, with a relatively small amount of basic volcanic rocks and Mesozoic carbonates. In Eastern Slovakia the Strihovce Sandstone is an equivalent of the Piwniczna Sandstone Member of the Magura Formation in Poland. The "exotic" pebbles from these beds have been studied by Mišík et al. (1991a).

The carbonates are represented by deep-water Jurassic-Lower Cretaceous sediments as well as fragments of shallow-water limestones of Triassic (Anisian), Kimmeridgian–Upper Tithonian, Lower Cretaceous (Urgonian), Upper Cretaceous, Lower and Upper Paleocene, and Lower Lutetian (Mišík et al. 1991a).

These authors also studied conglomerates of the upper part of the Strihovce Sandstone which could be regarded as an equivalent of the Poprad Sandstone Member of the Magura Formation in Poland (see Oszczypko et al. 2005b). They studied the Eliasovka, Maly Lipnik 1, Maly Lipnik 2 and Starina sections located in the Ľubovnianska Vrchovina. These conglomerates are dominated by clastic rocks and milky quartz, other components occur as an admixture in different amounts: carbonates 2.4–14.7 %, volcanites 3.4–14.7 %.

The characteristic microfacies of these locations are (Mišík et al. 1991a): the Paleozoic biohermal limestones, Middle Triassic dolomites, lower-middle Lias, upper Lias and Dogger, shallow-water Kimmeridgian–Lower Tithonian, pelagic Kimmeridgian–Upper Tithonian, Berriasian–Valanginian, Urgonian limestones (Barremian–Aptian), Upper Aptian–Lower Albian, Albian–Cenomanian, Senonian deep *Globotruncana*, and shallow-water *Pseudosiderolites* and *Orbitoides* limestones, Maastrichtian *Omphalocyclus* limestones, Paleocene biohermal limestones, and Lower Lutetian *Alveolina-Discocyclina* limestones. The Eocene material of the Krynica Zone is composed of fragments of crystalline rocks, which are derived from a continental type of crust, and infrequent clasts of Mesozoic deep and shallow-water limestones as well as Paleocene/Lower Eocene reef limestones (?Myjava Succession). This suggests a provenance of clastic material type from the Inner Carpathian source area located on the SE margin of the basin.

According to Mišík et al. (1991a,b) these exotic rocks of Eocene deposits from the Krynica Zone differ substantially from those of the Paleocene/Lower Eocene (Jarmuta and Proč Formations), dominated by the PKB carbonate clasts and volcanic clasts derived from the exotic Andrusov Ridge. According to Mišík et al. (1991b) and Maťašovský (2002) the mean rock composition of these conglomerates is as follows: 76.13 % carbonates, 4.53 % sandstones, 3.18 % quartzites, 0.6 % metamorphic rocks, 0.25 % milky quartz and 9.15 % volcanites. According to Mišík et al. (1991b)

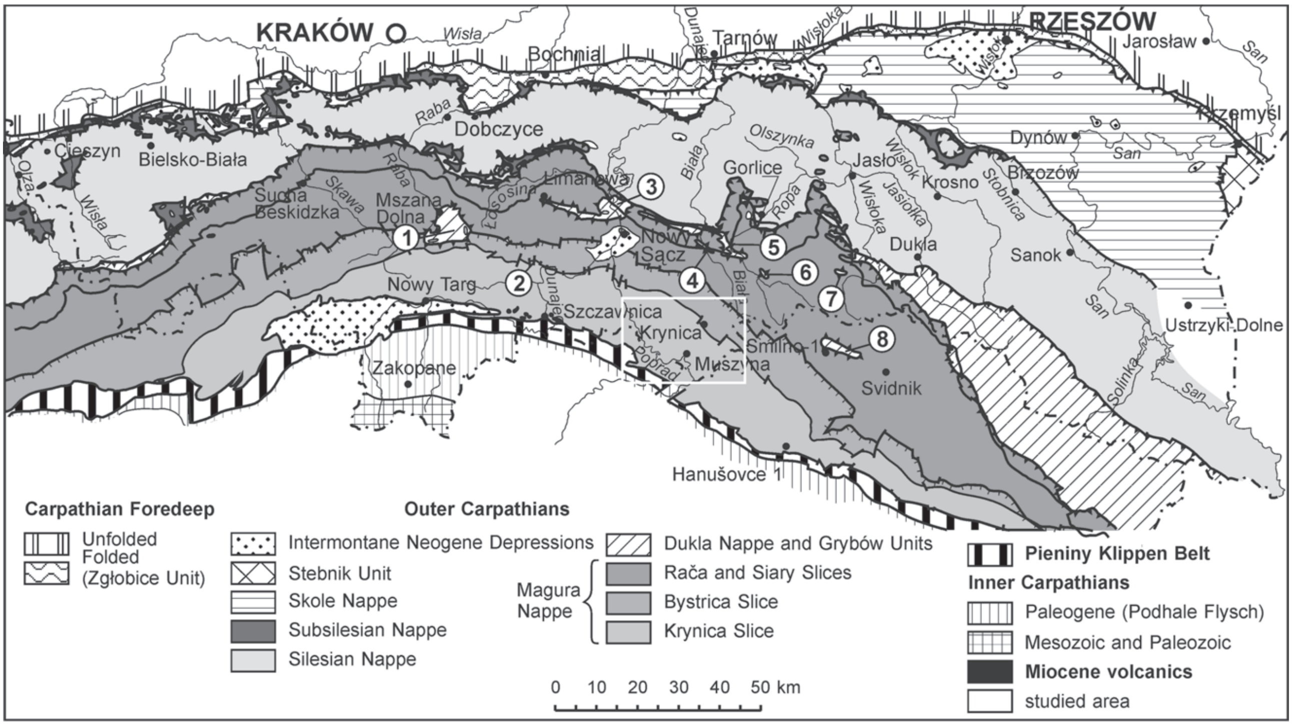

Fig. 1. Tectonic sketch of the Outer Western Carpathians (based on Żytko et al. 1989; simplified). Tectonic windows: **1** — Mszana Dolna, **2** — Szczawa, **3** — Klęczany-Pisarzowa, **4** — Grybów, **5** — Ropa, **6** — Uście Gorlickie, **7** — Świątkowa, **8** — Smilno.

these conglomerates are dominated by shallow-water Triassic Alpine limestones (with the exception of Wetterstein Limestones), pelagic facies of the Carnic-Norian, Czorsztyn (Dogger) type red limestones, microonkolite limestones with *Saccocoma* and *Globochaete*, shallow-marine Upper Tithonian and Berriasian, ?Urgonian sometimes with spineless, pelagic Albian, and shallow-water Cenomanian, Campanian and Maastrichtian, biohermal limestones of Paleogene and not frequent Lower Eocene limestones with *Nummulites*.

Geological setting

Lithostratigraphy: The studied area is situated in the south-eastern part of the Magura Nappe, at the boundary of the Bystrica and Krynica facies zones (Fig. 1). East of the Muszynka river, between the Krynica and Bystrica Zones Węcławik (1969) distinguished the transitional Tylicz Zone (Fig. 2). This author's investigations in the southern part of the Low Beskid Range documented profiles, "in the lower

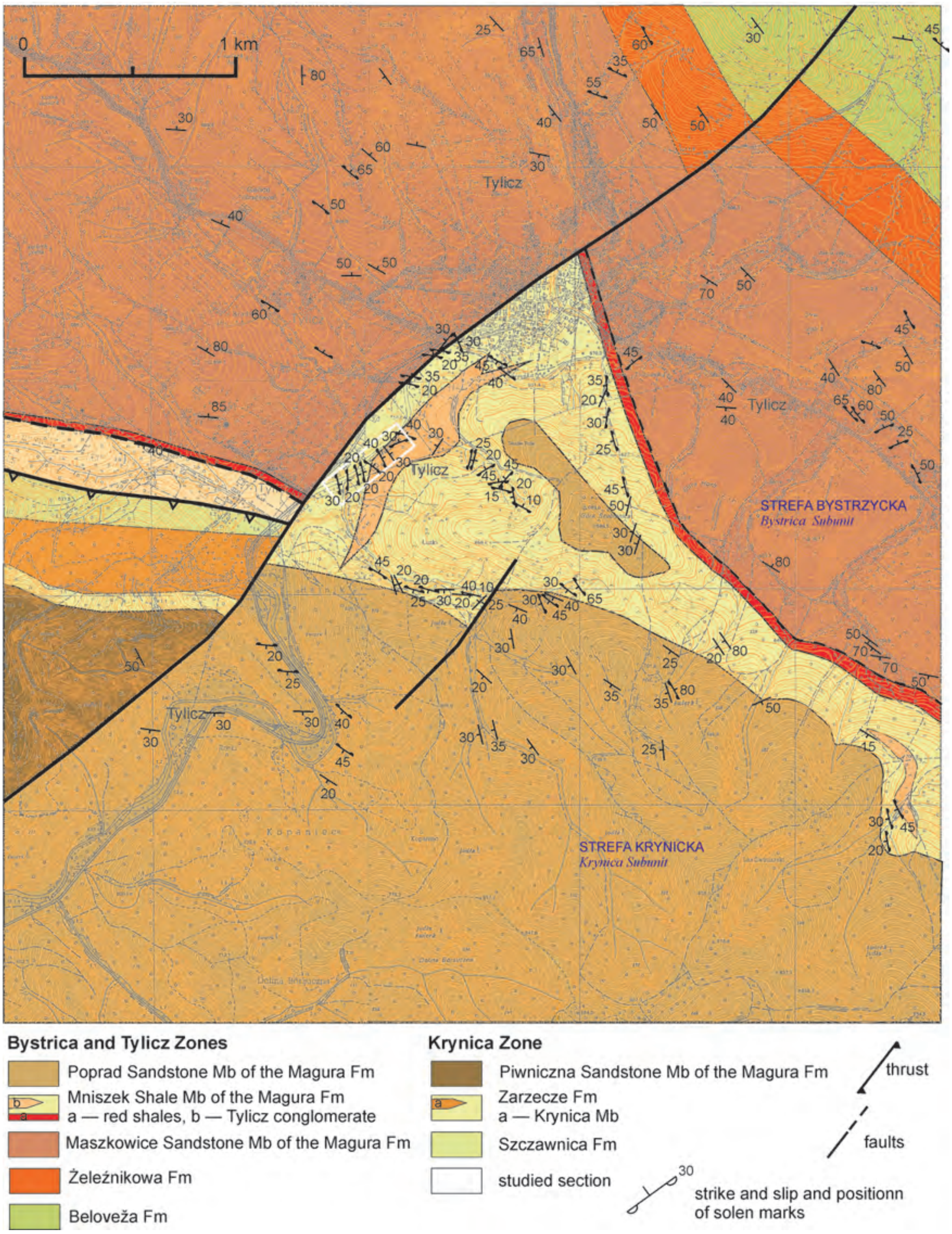

Fig. 2. Geological map of the Tylicz area (based on Oszczypko & Oszczypko-Clowes, in print, supplemented).

part of which the development of sediments is typical for the Sącz (Bystrica) Zone, whereas in the upper part it is characteristic of the Krynica Zone". The Paleogene sequence of the Tylicz Zone was distinguished as follows: the lower part — Variegated Shales with *Glomospira* (Paleocene?–Lower Eocene), Beloveža Beds (Lower Eocene), Łącko Beds (Lower Eocene–Middle Eocene); the upper part — Red Shales with *Reticulophragmium* (*Cyclammina) amplectens* (Middle Eocene), Hieroglyphic Beds with intercalations of polymictic conglomerates (Middle Eocene–Upper Eocene) and Magura Beds (Upper Eocene). The lower part of the Tylicz Zone is strongly deformed with presence of overturned folds, whereas the upper part of sequence displays strata, which gently dip southwards. This tectonic disconformity was explained by Węcławik (1969) as a result of the Late Eocene Illyrian phase, which affected the East Slovak sector of the Magura Nappe (Leško & Samuel 1968).

This concept was questioned by Oszczypko (1979) who suggested that the Tylicz facies zone represents the tectonic superposition of the Bystrica and Krynica Subunits of the Magura Nappe. According to him the boundary between these subunits runs along the contact of the red shales with *Reticulophragmium amplectens* (Middle–?Upper Eocene) and the Hieroglyphic Beds (sensu Węcławik), which was regarded by Oszczypko (1979) as an equivalent of Zarzecze Beds (Lower–Middle Eocene) of the Krynica Subunit. This was supported by findings of scarce Lower Eocene calcareous nannoplakton in these beds. This opinion was accepted by Birkenmajer & Oszczypko (1989) in the formal stratigraphy of the Krynica Subunit, as well as the Bystrica Zone (Oszczypko 1991).

During the last years litho- and biostratigrapy of the Beskid Sądecki (Bystrica, Tylicz and Krynica Zones) have been studied (Oszczypko et al. 1999, 2005b; Oszczypko-Clowes 2001; Oszczypko & Zuchiewicz 2007 and Oszczypko & Oszczypko-Clowes, in print). These studies documented that the youngest deposits of the Magura Nappe in this facies zone belong to the Poprad Sandstone Member of the Magura Formation (Oligocene). Aditionally in several sections the flysch Lower Miocene (NN1–NN2) has been found (Oszczypko et al. 1999, 2005b). The Oligocene age of the Magura Sandstone in the Orava region was documented by Soták (2006).

According to present-day formal lithostratigraphy the deposits of the Tylicz Zone (Fig. 2) belong to following formations: the Łabowa, Beloveža, Żeleźnikowa and Magura Formations.

- The Łabowa Formation (Lower Eocene), up to 100 m thick, is represented by red shales, in the lower part and thin-bedded flysch, with intercalations of red shales in the upper part of the formation. This formation is known only from the Mochnaczka area (see also Węcławik 1969).
- The Beloveža Formation (Lower to Middle Eocene), up to 250 m thick is composed of a thin-bedded flysch with predominance of clayey deposits.
- The Żeleźnikowa Formation (Middle Eocene), up to 300 m thick, formerly known as the Lower Łącko Beds is represented by a complex deposits where turbiditic Łącko marls are set among thin-bedded flysch of the Beloveža type of lithofacies.
- The Magura Formation has been subdivided into the Maszkowice, Mniszek and Poprad Members.
- The Maszkowice Sandstone Member is represented by 60–120 cm, fine- to very coarse-grained, poorly sorted, muscovitic sandstones bearing calcareous-muddy cement (Fig. 2, Fig. 3A,B). These sandstones display Bouma's Tabc intervals. The sandstones contain numerous clasts of mudstones, up to 15 cm in diameter, and pass upwards into strongly bioturbated mudstones, rich in mica flakes and coalified plant debris. The sandstones are intercalated by soft, dark grey marlstones (5 do 20 cm thick) or sandy/muddy couplets, up to 1 m thick. Thick to very thick-bedded (50–200 cm), clast-rich granule conglomerates, and amalgamated sandstones also occur. The Maszkowice Sandstone Member contains rare packets, up to a few meters thick, of the Łącko-type marls (Figs. 2, 3B). Thick to very thick-bedded (50–200 cm), clast-rich granule conglomerates, and amalgamated sandstones also occur. These strata display coarsening and thickening upwards sequences, typical of the channel-lobe turbidite system. In the Tylicz area, the thickness of the Maszkowice Member reaches 700–800 m. This member belongs the Middle Eocene calcareous nannoplankton Zone NP16/17 (see Oszczypko-Clowes, in Oszczypko et al. 1999).

The Mniszek Shale Member (Middle to Upper Eocene) is composed of thin-bedded strata bearing intercalations of variegated shales with *Reticulophragmiun amplectens.* The basal portion of the member is composed of two packets of red shales (Fig. 2), overlain by grey mudstones with intercalation of thin-bedded flysch (Fig. 3C). Higher up in section these thin-bedded turbidites are overlain (Tylicz area) by a lenticular conglomerate body (Fig. 3D,E) up to 1 km long and up 200–50 thick, with a packet of exotic conglomerates (Mochnacka & Węcławik 1967; Węcławik 1969). The thickness of the Mniszek Shale Member varies between 50–100 m in the Krynica area up to 250–300 m in the Tylicz area.

- The upper-most part of the Tylicz sequence belongs to the Poprad Sandstone Member (Oligocene) of the Magura Formation (Fig. 3F). This member is composed of thick-bedded (0.5–1.0 m), fine- to medium-grained, calcareous sandstones, sometime intercalated by thin-bedded flysch packets. The thickness of the Poprad Member reaches at least 600–800 m.

Structure

- The studied area belongs to two facies-tectonic subunits: the Bystrica Subunit in the North, and Krynica Subunit in the South (Fig. 2). In the Bystrica Subunit the sub-vertical thrust sheets are common. The Krynica Subunit is characterized by the presence of narrow anticlines and broad, W–E trending synclines, built up of the Piwniczna Sandstone Member of the Magura Formation.
- The Bystrica and Krynica Subunits are bounded by the NW–SE trending sub-vertical Krynica Fault (Świdziński 1972; Oszczypko et al. 1999; Oszczypko & Zuchiewicz 2007; Oszczypko & Oszczypko-Clowes, in print). East of the Muszynka river (Tylicz transitional facies zone), this fault is located inside the Magura Formation.

The Bystrica and Krynica Subunits are cut by the several NE–SW trending transversal faults. On of them, which separates the Bytrica and Krynica Subunits from the Tylicz transitional zone, runs along the Muszynka river (Fig. 2).

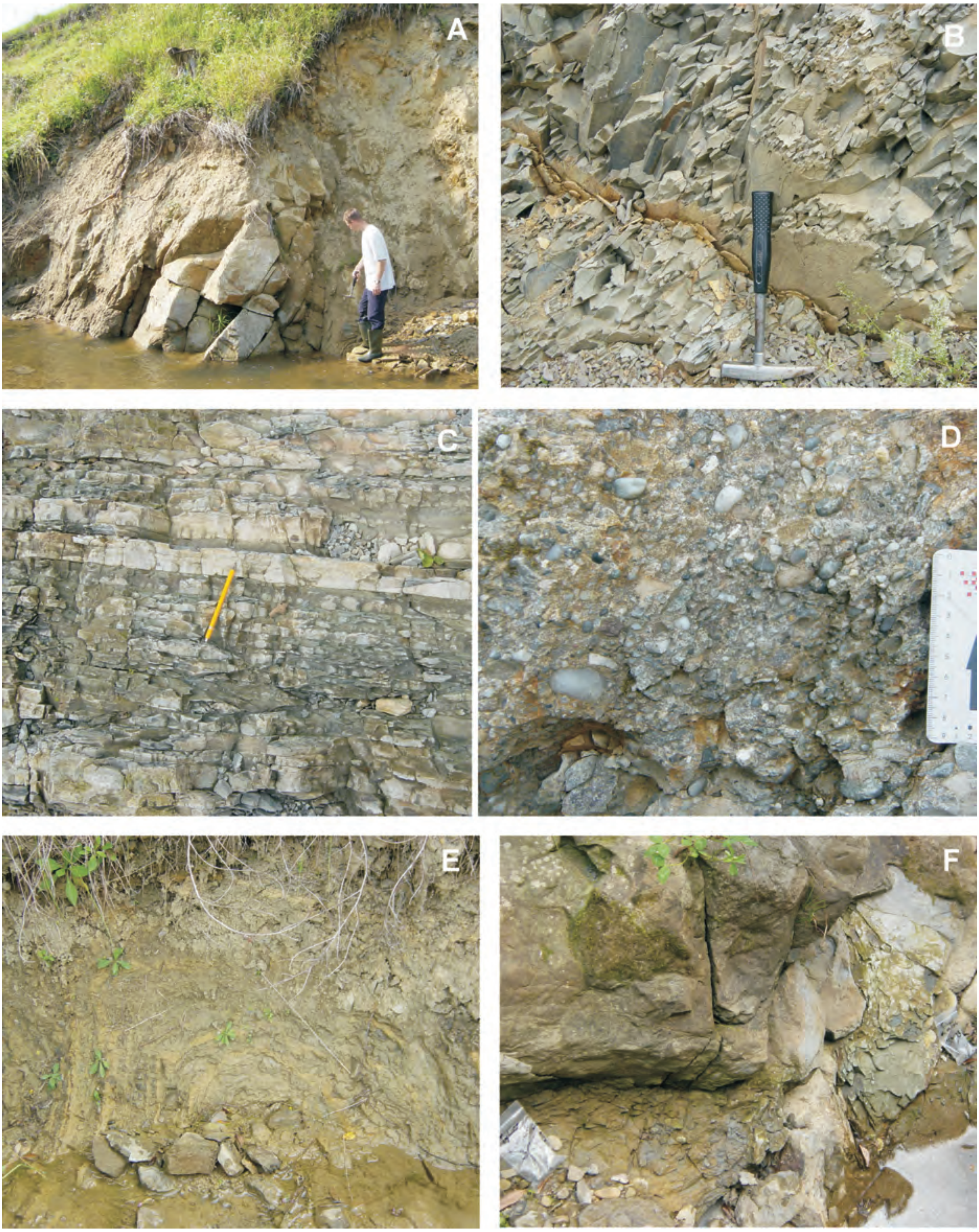

Fig. 3. Typical exposures of the upper part of the Tylicz Succession. **A** — Thick-bedded poorly cemented sandstones of the Maszkowice Sandstone Member (Middle Eocene). Muszynka river east of Tylicz; **B** — Łącko Marls of the Maszkowice Sandstone Mb. Muszynka river east of Tylicz; **C** — Grey marly mudstones and very thin-bedded sandstones, at the top of the red shales with *Reticulophragmium amplectens*. The lower portion of Mniszek Shale Mb (Late Eocene–Oligocene). Muszynka river at Tylicz; **D** — Tylicz Conglomerate, Muszynka river at Tylicz; **E** — Small anticline, thin-bedded flysch of the Mniszek Shale Mb at the top of the Tylicz Conglomerate. Muszynka river south of Tylicz; **F** — Thick-bedded sandstones with big muddy clasts of the Poprad Sandstone Mb (Oligocene), Muszynka river south of Tylicz.

Studied section

The Tylicz Conglomerate section is located on the left bank of the Muszyna river, partly in the bed rock of the river (Fig. 2). The base and top of the conglomerate body are well exposed. The conglomerates are underlain and overlain by the thin-bedded turbidites represented by grey and dark grey marly mudstone and marly shales (Fig. 4A, Fig. 3C–D). After weathering these mudstones and claystones became green with rusty coatings. The marly-shaly deposits are intercalated by thin- to medium-bedded fine-grained sandstones with muddy/marly cement. The sandstones display the Bouma Tc and conv. divisions. The conglomerates and thick-bedded sandstones form two bodies 150 m and 50 m thick, separated by 50 m packet of thin-bedded flysch (Fig. 4A). These conglomerates represent the channel infill incised in thin-bedded turbidites. In general these coarse clastic deposits display the fining and thining-upwards sequences. The basal packet of conglomerates begins with 2 m thick-layer of coarse conglomerates and boulders (Fig. 4A, Fig. 5A), which pass upwards into 75 m thick layer of paraconglomerate packet composed of pebbly mudstones. This part of the section was deposited by cohesive debris flow (Fig. 4A, Fig. 5B–E). Higher up in the section the conglomerates pass upwards into 75 m packet of thick-bedded coarse- to very coarse-grained sandstones, deposited by high-concentrated density flow. The paleocurrent measurements suggest paleotransport from the SE.

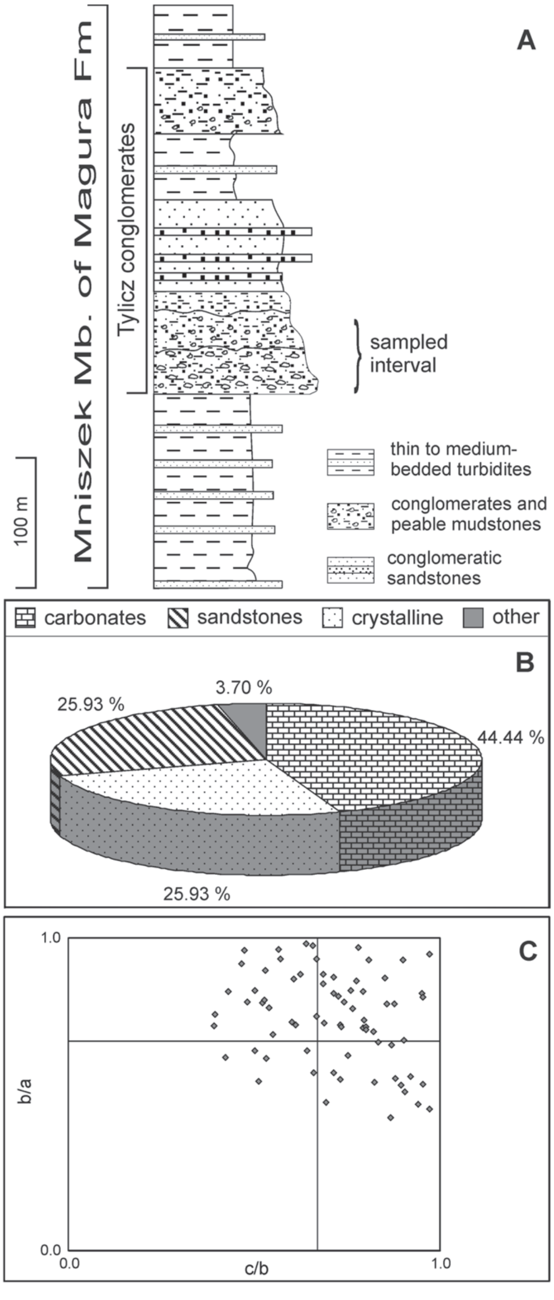

Fig. 4. A — Lithostratigraphical profile of the Mniszek Mb of the Magura Formation at Tylicz facies zone; **B** — Composition of pebbles; **C** — Zingg's diagram.

Sampling

During the field work in 2004–2005 we exploited (Fig. 4A) 172 pebbles in diameter 2.2 do 16 cm. The biggest pebbles (13.1 to16 cm) belong to sandstone and limestones respectively. For statistical purposes we divided the pebbles into four classes (Fig. 4B): carbonates (44.44 %), crystalline (25.93 %), sandstones (25.93 %) and other (3.70 %). Strong domination of sedimentary rocks (carbonates and sandstones — 70.37 %) suggest that sedimentary supply was coming from erosion of sedimentary rocks of the accretionary wedges. On the Zingg's diagram (Fig. 4C) the biggest pebbles are spindle-shaped and ellipsoidal, while the smaller are dominated by spheroidal and discoidal pebbles.

Micropaleontological part

Material and methods

This contribution presents the results of the micropaleontological study of the 41 exotic pebbles of carbonate rocks collected by one of the authors (N. Oszczypko) from the described strata.

Thin sections were examined under the Labophot 2-pol Nikon polarizing microscope. The photos of microfossils were taken with the aid of the Nikon photomicrographic attachment Microflex HFX-DX. Microfacies identification is based on Dunham's revised classification (Wright 1992) and the classification of mixed siliciclastic and carbonate rocks by Mount (1985). Microfossil study enclosed foraminifers (systematics based essentially on Loeblich & Tappan 1988), calpionellids (systematics based on Makareva 1982), calcareous cysts of dinoflagellata (systematics based on Řehánek & Cecca 1993). Additionally some other significant microfossils have also been reported.

Results

The results of micropaleontological investigations are presented in stratigraphical order from the oldest to the youngest on the basis of identified microfossils.

Fig. 5. Tylicz conglomerates. Muszynka river south of the Tylicz. **A** — Basal portion of conglomerates; **B–D** — Pebble mudstones of the basal portion of Tylicz Conglomerate.

Triassic

Triassic pelagic sediments (sample 27) are represented by "filaments-globochaete" microfacies (Fig. 6A) with rare nodosariids (e.g. *Nodosaria* cf. *rossica* Miklucho Maklay) (Fig. 6B).

Shallow-water sediments of the same age (sample A) are represented by floatstone-packstone with numerous fragments of crinoids, bivalves, brachiopods, serpulids and ostracods. Rare foraminifers such as *Nodosaria* cf. *variocamerata* Coroneou & Trofimova (Fig. 6C) are known from the Carnian of Bulgaria and the Western Carpathians (Salaj et al. 1983; Trifonova 1994).

Middle Jurassic

Middle Jurassic rich foraminiferal assemblage was identified in partly recrystallized packstone (sample 28). The assemblage was composed of: *Protomarssonella osowiensis* (Bielecka & Styk) (Fig. 6E), *Verneuilinoides* cf. *sibiricus* (Mjatliuk) (Fig. 6D), *Paleomiliolina occulta* Antonova (Fig. 6H,I), *Redmondoides lugeoni* (Septfontaine) (Fig. 6J), *Protopeneroplis striata* Weynschenk (Fig. 6G), *Spirillina* cf. *liassina* Terquem, *Bosniella croatica* (Gušić) (Fig. 6F). Fragments of crinoids and snails accompanied foraminifers. The first two species cited suggest a Callovian age for the assemblage.

Late Callovian–earliest Oxfordian

The peloidal packstone, probably of the Late Callovian–earliest Oxfordian age, contained a poor microfossil assemblage composed of foraminifers: *Conoglobigerina* cf. *bathoniana* (Pazdro) (Fig. 6K), *Spirillina tenuissima* (Gümbel), *Nodosaria* sp.; calcareous dinocysts: *Orthopithonella* sp. (Fig. 6L), chlorophycean *Globochaete alpina* Lombard and ostracods.

Tithonian

The Tithonian microfossilss were represented by several distinct assemblages.

The Early Tithonian radiolarian-wackestone, (sample d) besides numerous radiolarians, contained calcareous cysts of dinoflagellata with the zonal marker *Parastomiosphaera malmica* (Borza) (Fig. 7A). The index species was accompanied by: *Comittosphaera pulla* (Borza) (Fig. 7B), *Colomisphaera lapidosa* (Vogler), *Carpistomiosphaera* cf. *borzai* (Nagy). The chlorophycean species *Globochaete alpina* Lombard was also present.

Younger sediments are represented by wackestone of the Middle/Late Tithonian calpionellid *Praetintinnopsella andrusovi* Zone (samples 16,G,H). The index species (Fig. 7C,D) was accompanied by another calcareous dinocyst *Comittosphaera pulla* (Borza) and radiolarians.

To the Late Tithonian (Zone *Intermedia*) were assigned assemblages (samples 4,20,h) containing *Crassicollaria intermedia* (Durand Delga), *Calpionella alpina* Lorenz (Fig. 7E), *Calpionella grandalpina* Nagy (Fig. 7F) and *Tintinnopsella carpathica* (Murgeanu & Filipescu) (Fig. 7H). The calcareous dinocysts: *Colomisphaera carpathica* (Borza) (Fig. 7G), *Cadosina fusca* Wanner and radiolarians occur rarely.

Cretaceous

Berriasian

A typical shallow-water Berriasian assemblage was found in the microbial grainstone (sample 30). The assemblage was composed of foraminifers: *Paleogaudryina bukoviensis* (Cushman & Glazewski), *Rumanoloculina mitchurini* (Dain), *Quinqueloculina stellata* Matsieva & Temirbekova (Fig. 7J), *Protopeneroplis ultragranulata* (Gorbatchik) (Fig. 7I), *Melathrokerion spirialis* Gorbatchik, *Andersenolina alpina* (Leupold), *Neotrocholina molesta* (Gorbatchik) (Fig. 7K), *Dobrogelina ovidi* Neagu (Fig. 7L). Other characteristic microfossils include the calcareous algae (*Salpingoporella* sp.), *Thaumatoporella parvovesiculifera* Rainieri and calcimicrobes of the group "*Porostromata*".

Valanginian–Hauterivian

Calpionellid assemblages with *Tintinnopsella carpathica* (Murgeanu & Filipescu) and *Tintinnopsella longa* (Colom) (Fig. 8E) found in dark wackestones (samples i,j,58) probably belong to the *Tintinnopsella carpathica* Zone. In the Carpathians the zone represents the interval late Early Valanginian-Hauterivian (Reháková 1995).

The assemblage (sample 6) composed of *Colomisphaera heliosphaera* (Vogler) (Fig. 8A), *Stomiosphaera wanneri* Borza (Fig. 8B) and *Hedbergella* sp. (Fig. 8C) may be of the same age.

Barremian–Aptian

Shallow-water carbonate platform microfossils of the Urgonian-type were found in samples 39, 42 and L1E1. Foraminiferal assemblage contained characteristic orbitolinid species *Palorbitolina lenticularis* (Blumenbach) (Fig. 8G) as well as: *Dorothia praeoxycona* Moullade (Fig. 8F), *Everticyclammina hedbergi* (Maync), *Glomospira urgoniana* Arnaud Vanneau (Fig. 8H), *Bolivinopsis labeosa* Arnaud Vanneau (Fig. 8D), *Charentia cuvilieri* Neumann (Fig. 8K), *Rumanoloculina pseudominima* (Bartenstein & Kovatcheva) (Fig. 8I), *Trocholina paucigranulata* Moullade (Fig. 8J), *Arenobulimina* sp. A significant part of assemblages was made up of calcareous algae (*Dasycladales*), microproblematics (*Baccinella irregularis* Radoičić) and calcimicrobes ("*Porostromata*").

Paleogene

Paleocene

The foraminiferal-algal-bryozoan packstone of sample No. 67 was tentatively assigned to the Paleocene. The foraminiferal assemblage included: *Haddonia heissigi* Hagn (Fig. 9H), *Lobatula lobatula* (Walker & Jacob) (Fig. 9A),

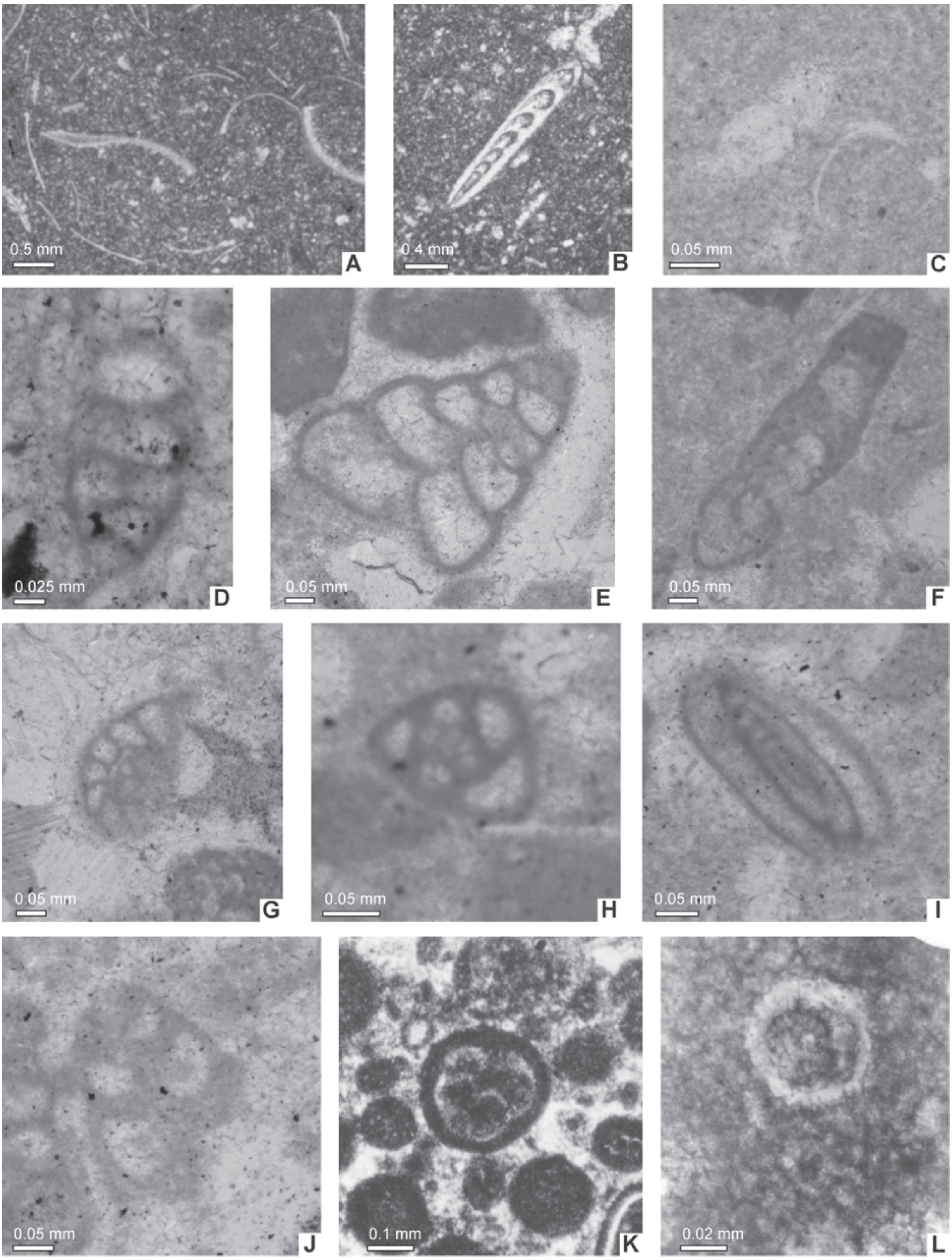

Fig. 6. Microphographs of the Triassic to Oxfordian foraminifers. **A** — "filaments-Globochaete" microfacies, sample 27, Triassic; **B** — *Nodosaria* cf. *rossica* Miklucho Maklay, longitudinal section, sample 27, Triassic; **C** — *Nodosaria* cf. *variocamerata* Coroneou & Trofimova, fragment of longitudinal section, sample A, Triassic; **D** — *Verneuilinoides* cf. *sibiricus* (Mjatliuk), axial section, sample 28, Middle Jurassic; **E** — *Protomarssonella osowiensis* (Bielecka & Styk), longitudinal section, sample 28, Middle Jurassic; **F** — *Bosniella croatica* (Gušić), axial section, sample 28, Middle Jurassic; **G** — *Protopeneroplis striata* Weynschenk, equatorial section, sample 28, Middle Jurassic; **H** — *Paleomiliolina occulta* Antonova, transversal section, sample 28, Middle Jurassic; **I** — *Paleomiliolina occulta* Antonova, longitudinal section, sample 28, Middle Jurassic; **J** — *Redmondoides lugeoni* (Septfontaine), axial section, sample 28, Middle Jurassic; **K** — *Conoglobigerina* cf. *bathoniana* (Pazdro), longitudinal section, sample 12, Late Callovian-earliest Oxfordian; **L** — *Orthopithonella* sp., sample 12, Late Callovian-earliest Oxfordian.

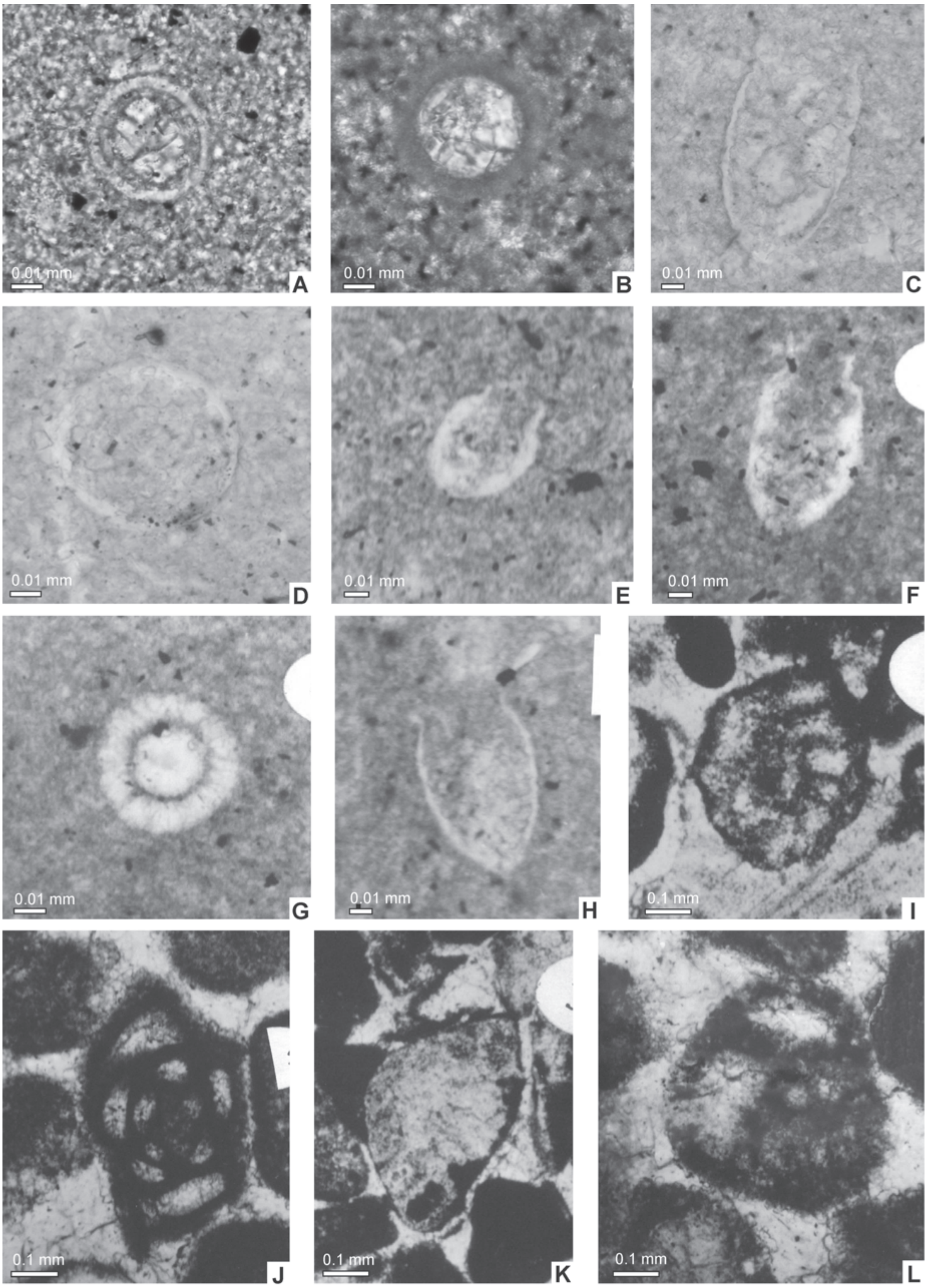

Fig. 7. Microphotographs of the Tithonian to Berriasian foraminifers. **A** — *Parastomiosphaera malmica* (Borza), sample d, Early Tithonian; **B** — *Comittosphaera pulla* (Borza), sample d, Early Tithonian; **C** — *Praetintinnopsella andrusovi* Borza, longitudinal section, sample H, Middle/Late Tithonian; **D** — *Praetintinnopsella andrusovi* Borza, transversal section, sample H, Middle/Late Tithonian; **E** — *Calpionella alpina* Lorenz, longitudinal section, sample 4, Late Tithonian; **F** — *Calpionella grandalpina* Nagy, longitudinal section, sample 20, Late Tithonian; **G** — *Colomisphaera carpathica* (Borza), sample 4, Late Tithonian; **H** — *Tintinnopsella carpathica* (Murgeanu & Filipescu), longitudinal section, sample 4, Late Tithonian; **I** — *Protopeneroplis ultragranulata* (Gorbatchik), axial section, sample 30, Berriasian; **J** — *Quinqueloculina stellata* Matsieva & Temirbekova, transversal section, sample 30, Berriasian; **K** — *Neotrocholina molesta* (Gorbatchik), axial section, sample 30, Berriasian; **L** — *Dobrogelina ovidi* Neagu, sample 30, oblique section, sample 30, Berriasian.

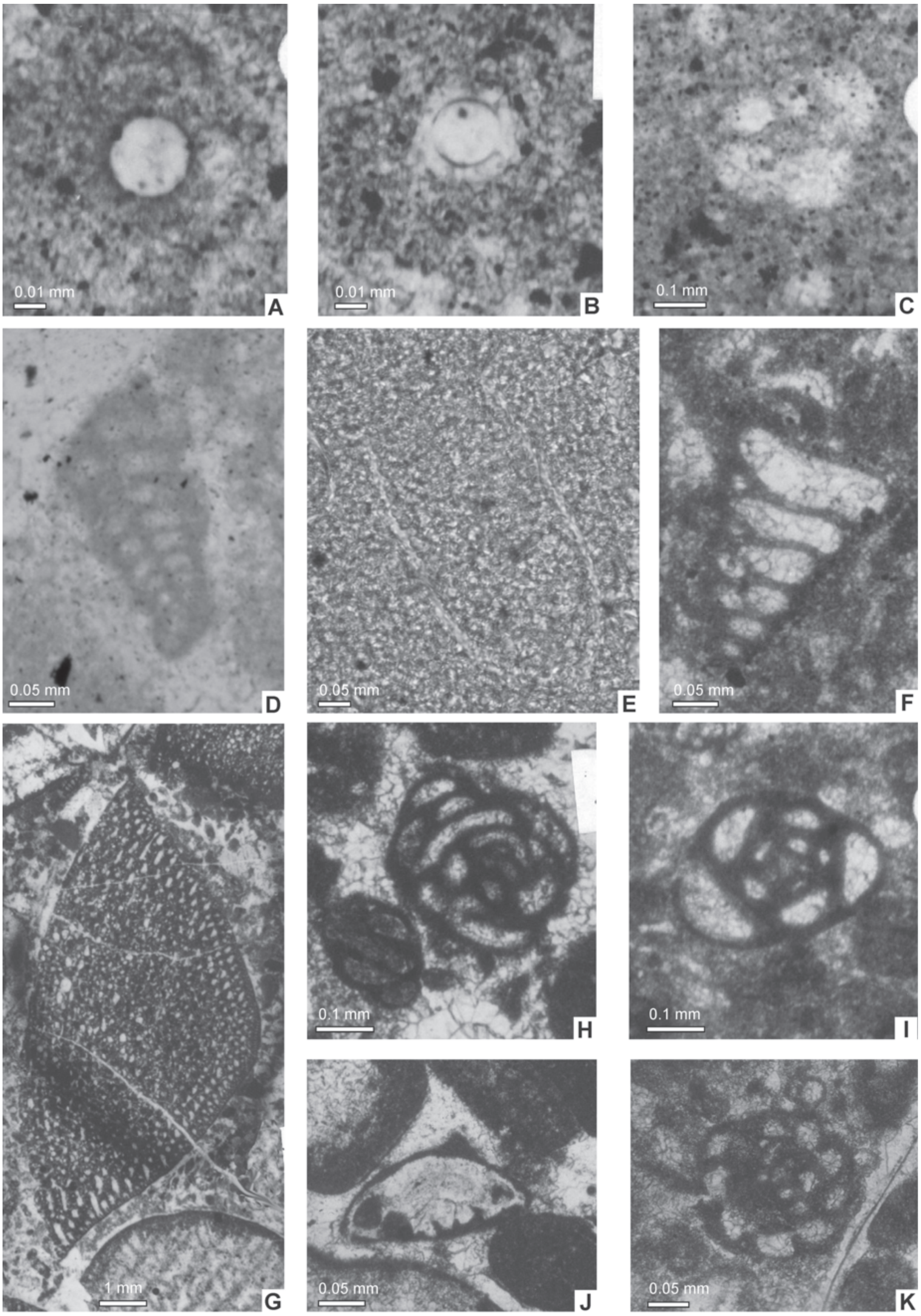

Fig. 8. Microphotographs of the Valanginian-Hauterivian to Aptian foraminifers. **A** — *Colomisphaera heliosphaera* (Vogler), sample 6, Valanginian-Hauterivian; **B** — *Stomiosphaera wanneri* Borza, sample 6, Valanginian-Hauterivian; **C** — *Hedbergella* sp., axial section, sample 6, Valanginian-Hauterivian; **D** — *Bolivinopsis labeosa* Arnaud-Vanneau, longitudinal section, sample 42, Barremian-Aptian; **E** — *Tintinnopsella longa* (Colom), longitudinal section, sample 58, Valanginian-Hauterivian; **F** — *Dorothia praeoxycona* Moullade, oblique section, sample L1E1, Early Aptian; **G** — *Palorbitolina lenticularis* (Blumenbach), subaxial section, sample L1E1, Early Aptian; **H** — *Glomospira urgoniana* Arnaud Vanneau, oblique section, sample L1E1, Early Aptian; **I** — *Rumanoloculina pseudominima* (Bartenstein & Kovatcheva), transversal section, sample 39, Barremian–Aptian; **J** — *Trocholina paucigranulata* Moullade, axial section , sample 42, Barremian–Aptian; **K** — *Charentia cuvilieri* Neumann, oblique section, sample L1E1, Early Aptian.

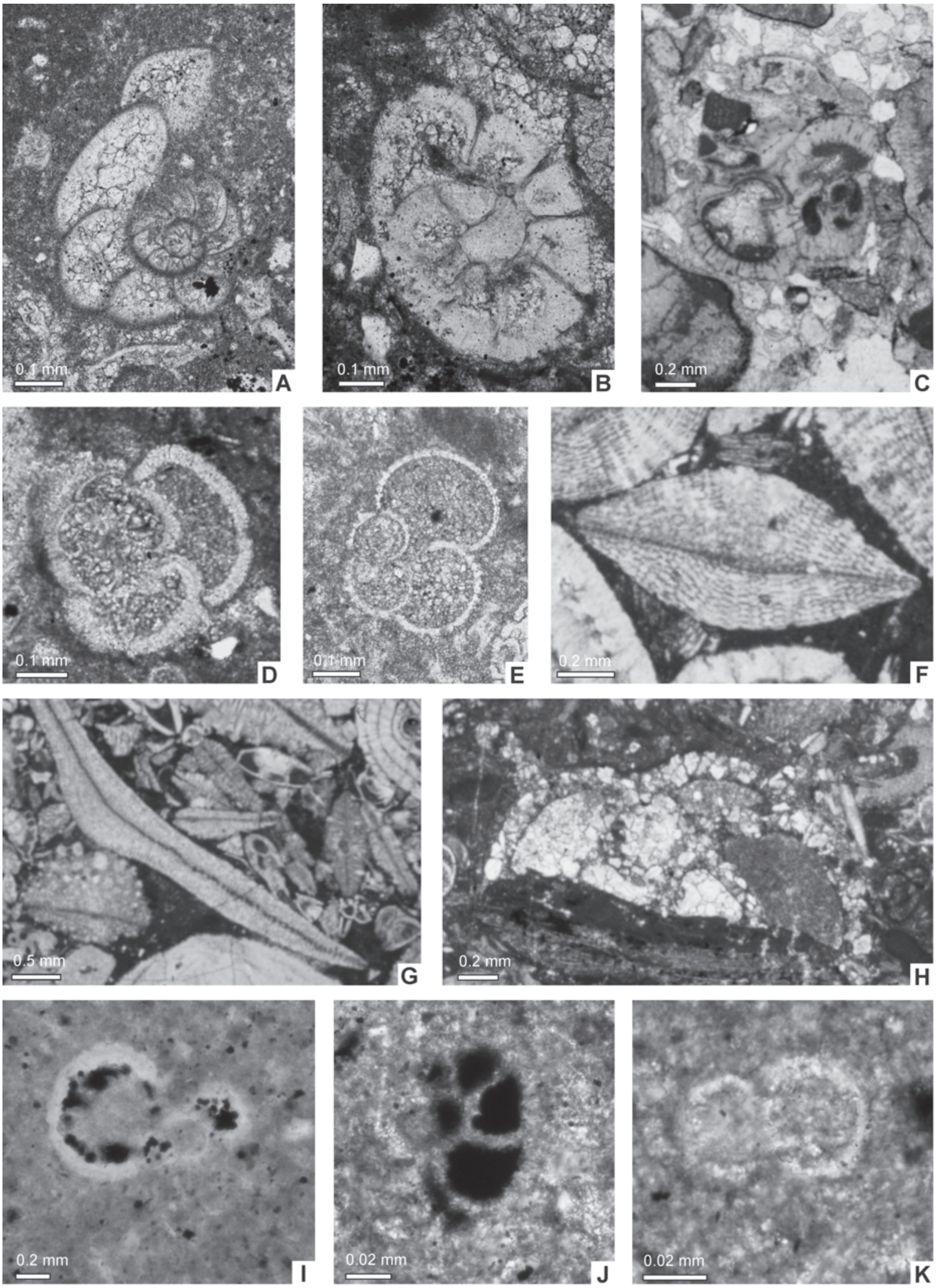

Fig. 9. Microphotographs of the Paleocene to Oligocene foraminifers. **A** — *Lobatula lobatula* (Walker & Jacob), transversal section, sample 67, Paleocene; **B** — *Pararotalia lithothamnica* (Uhlig), oblique section, sample 68, Middle-Late Eocene; **C** — *Eorupertia cristata* (Gümbel), axial section, sample 68, Middle-Late Eocene; **D** — *Turborotalia cerroazulensis* (Cole), oblique section, sample 68, Middle-Late Eocene; **E** — *Globigerina* cf. *eocaena* (Gümbel), axial section, sample 68, Middle-Late Eocene; **F** — *Discocyclina chudeaui* (Schlumberger), axial section, sample 68, Middle-Late Eocene; **G** — *Discocyclina sella* (d'Archiac), subaxial section, sample 68, Middle-Late Eocene; **H** — *Haddonia heissigi* Hagn, vertical section, sample 67, Paleocene; **I** — *Tenuitella* sp., axial section, sample E, Oligocene. **J** — *Cibicides* sp., oblique section, sample E, Oligocene; **K** — *Chiloguembelina* sp., transversal section, sample E, Oligocene.

Quinqueloculina cf. *hexacostata* Le Calvez, *Planorbulina cretae* Marsson. The characteristic algal species include *Polistrata alba* (Pfender), *Neogoniolithon* sp. and stromatolitic structures.

Eocene

Algal-bryozoan rudstone with foraminifers indicating the Middle–Late Eocene age was found in sample No. 68. The foraminiferal assemblage contained large and small foraminifers, characteristic for open shelf carbonate environment: *Discocyclina sella* (d'Archiac) (Fig. 9G), *Discocyclina chudeaui* (Schlumberger) (Fig. 9F), *Marssonella* cf. *lodoensis* Israelsky, *Eorupertia cristata* (Gümbel) (Fig. 9C), *Pararotalia lithothamnica* (Uhlig) (Fig. 9B), *Mississippina binkhorsti* Reuss, *Cibicides praeventratumidus* Mjatliuk, *Globigerina* cf. *eocaena* (Gümbel) (Fig. 9E), *Turborotalia cerroazulensis* (Cole) (Fig. 9D). The foraminifers were accompanied by numerous fragments of *Lithothamnium* sp. and bryozoans.

Oligocene

Brownish mudstones with organic matter and pyrite concretions (samples E, F, f) yielded rare and very small sections of foraminifers usually observed in thin plates from the Lower Oligocene sediments (Olszewska 1997a,b). Representatives of the following genera have been identified: *Tenuitella* sp. (Fig. 9I), *Globigerina* sp., *Chiloguembelina* sp. (Fig. 9K), *Cibicides* sp. (Fig. 9J) and ?*Virgulinella* sp.

Discussion

Microfossils and the age of examined pebbles show that generally they follow the same stratigraphical and paleoenvironmental trends discovered by study of exotic pebbles from other localities in the Outer Carpathians. Previous research (Malata et al. 2006), revealed that the most common carbonate exotics in the Outer Carpathians represent the Middle Triassic, Middle–Upper Jurassic, and Middle Eocene. Rocks of other ages (Devonian, Early Cretaceous, Paleocene) occur more rarely. Pebbles of pelagic origin occur more frequently in internal parts of the Outer Carpathians (Pieniny Klippen Belt, Magura and Fore-Magura Nappes). They generally represent deposits of major regional transgressions. In external parts of the Outer Carpathians (Skole, Silesian Nappes) pebbles of neritic origin predominate.

Triassic

The Triassic pelagic assemblage closely resembles the basinal "filament-*Globochaete*" microfacies described from the Reifling Limestone Formation of the Central Western Carpathians (Masaryk et al. 1993). The formation is characteristic of the Middle Triassic of the Choč Nappe of the Tatra Mountains.

Packstone-floatstone with numerous fragments of macrofossils, to the certain extent, resembles assemblages of shallow intraplatform facies of the Zámostie Formation of the same nappe.

Similar types of Middle Triassic exotic pebbles was recognized (B. Olszewska) in the Upper Cretaceous gravelstone of the Sromowce Formation of the Pieniny Klippen Belt.

Middle Jurassic

Identification of the Middle Jurassic (?Callovian) shallow-water carbonate type foraminiferal assemblage supports the view of considerable extension of carbonate platforms during this period (Bassoullet 1997; Velić 2007). The species *Protomarssonella osowiensis* (Bielecka & Styk) and *Bosniella croatica* (Gušić) were also observed in exotic pebbles from the Sromowce gravelstone (Pieniny Klippen Belt). Identification of the latter species in the Middle Jurassic sediments on the Cracow-Wieluń Upland indicates unrestricted connection between epicontinental basins and the Tethyan carbonate sedimentation areas.

Late Jurassic

Sediments of the early part of the epoch (Oxfordian–Kimmeridgian) are poorly represented. They may be absent from the area or their soft lithology (e.g. mudstone) facilitated erosion. On the contrary Tithonian carbonate pebbles are frequent and numerous, suggesting considerable expansion of sediments of this age. The presence of common in the Carpatho-Balkan region calpionellides and calcareous dinocyst index species (Reháková 1995, 2000) supports the suggestion.

Cretaceous (Berriasian)

The characteristic Berriasian assemblage belongs to the carbonate shallow-water biota of the Northern Tethyan shelf. It was found not only in the Western and Eastern Carpathians (Bucur 1988; Vašíček et al. 1994; Olszewska 2005) but also in the Eastern Alps (Gawlick et al. 2005), Moesian Platform (Ivanova et al. 2008) and Crimea (Krajewski & Olszewska 2007). The same assemblage was encountered on the southern edge of the Western European Platform as well (Olszewska 1999, 2001; Gutowski et al. 2005).

Valanginian–Hauterivian. Argillaceous limestones of this age coincide with the Valanginian world wide transgression that brought pelagic organisms such as calpionellids, calcareous dinocysts and planktonic foraminifers and changed the type of sedimentation from carbonate to siliciclastic (Lini et al. 1992). The discussed microfossil assemblage of the exotic pebbles may be compared to assemblages of the same age found in the Polish Outer Carpathians flysch sequence (Olszewska 2005).

Barremian–Aptian. The Urgonian-type foraminiferal assemblage contains taxa known from the Urgonian sediments of the Tatra Mts (Lefeld 1968; Vašíček et al. 1994) and many other European sites of Barremian-Aptian carbonate sedimentation (Arnaud-Vanneau 1980). Similar but very rich Urgonian-type foraminifers occurred in exotic pebbles from the Upper Cretaceous–Paleogene flysch sediments of the Pieniny Klippen Belt (Krobicki & Olszewska 2005).

Paleogene (Paleocene)

The foraminiferal-algal-bryozoan assemblage resembles those typical for the "in situ" carbonate deposits of the Pańska Góra locality within the so-called "Andrychów Klippes" in the north-western part of the Outer Carpathians and in the Slovak part of the Pieniny Klippen Belt (Scheibner 1968; Krobicki et al. 2004; Köhler & Buček 2005). Similar assemblages were found in pebbles of allodapic limestones in Babica Clays of the Polish Outer Carpathians (Rajchel & Myszkowska 1998).

Eocene

A rich shallow-water microfossil assemblage encountered during the research represents widespread Middle-early Late Eocene carbonate platform associations common on the northern Tethyan shelf. In the Outer Carpathians those associations are found in carbonate sediments known as "the Łużna/Koniaków limestone" which occur as exotic pebbles in the Oligocene Menilite and lower Krosno Beds. The only area where those sediments are "in situ" are the northern slopes of Tatra Mts and there they are known as "the Nummulitic Eocene" (Olszewska & Wieczorek 1998). According to Arni's sedimentological model (Arni 1965) both types predominantly represent an open shelf environment because of numerous discocyclinids and the presence of planktonic foraminifers.

Oligocene

The general paucity of microfossils in the Oligocene–Lower Miocene sedimentary sequence of Carpathians is also reflected in thin section assemblages. They are composed of only a few characteristic forms, predominantly planktonic foraminifers of the genera: *Globigerina*, *Tenuitella*, *Chiloguembelina*. Benthic microfossils are rare because of dysaerobic conditions at the bottom of basins unfavourable for life and preservation.

Conclusions

In the Paleogene deposits of the southern part of the Magura Nappe (Krynica Zone) the exotic pebbles have been recognized in two stratigraphical position:

a) In the thick-bedded sandstones of Zarzecze Formation — the Krynica Sandstone Member (Lower/Middle Eocene) and the Piwniczna Sandstone Member (Lower/Middle Eocene) of the Magura Formation and its equivalent the lower part of the Strihovce Sandstone (Čerhova Sandstone, Middle Eocene, see Nemčok 1990a,b). These conglomerates are rich granitoids, gneisses, phyllites and quartzites, with a relatively small amount of basic volcanic rocks and Mesozoic carbonates (Oszczypko 1975; Mišík et al. 1991a; Oszczypko et al. 2006). The later pebbles are represented by deep-water Jurassic-Lower Cretaceous sediments as well as fragments of shallow-water limestones of the Triassic (Anisian), Kimmeridgian–Upper Tithonian, Lower Cretaceous (Urgonian), Upper Cretaceous, Lower and Upper Paleocene, and Lower Lutetian (Mišík et al. 1991a).

b) In the thick-bedded sandstones and conglomerates of the Poprad Member (Upper Eocene-Oligocene) of the Magura Formation (see the Tylicz Conglomerate, this issue) and the upper part of the Strihovce Sandstone Mišík et al. (1991a) (see also lower Malcov Beds-Strihov Beds (Middle/Upper Eocene; Nemčok 1990a,b). These conglomerates contain variable amounts of carbonate pebbles, with up to 44 % in the Tylicz section. This population is dominated by Mesozoic shallow-water limestones, with subordinate amounts of the deep-water clasts. The oldest pebbles belong to the Late Paleozoic, the youngest to the Late Eocene and Oligocene.

The composition of carbonate material and microfossil assemblages of the Tylicz Conglomerate (Late Eocene–Oligocene) indicates similarity to both the Jarmuta/Proč and Strihovce exotic pebbles. In contrast the amounts of the sandstone clasts is relatively high in both the Tylicz and the Strihovce sandstones, 25.93 % and 44.0 % respectively, and very low in the Jarmuta and Proč Formations (3.18 % see Mišík et al. 1991b and Maťašovský 2002). This suggests erosion of the older accretionary wedge during the Late Eocene to Oligocene deposition in the southern part of the Magura Basin. The other possibility can be explained by supply of siliciclastic material from a SE source area (Dacia and Tisza Mega-Units) and carbonate material from S source area (ALCAPA Mega-Unit: Central Carpathian Block and Pieniny Klippen Belt). This solution can be deduced from Oligocene?/Early Miocene paleogeographical restoration (see Fig. 6, Ustaszewski et al. 2008).

The stratigraphical position (above variegated shales with *Reticulophragmium amplectens*) and composition of exotic pebbles of the Tylicz Conglomerate is the same as the Hervatov Conglomerate located south of Bardejov (see Nemčok 1990a,b). According to this author these paraconglomerates were deposited by the debris flow and contain blocks and cobbles of Mesozoic carbonates up 5 m in diameter as well as crystalline and sandstone pebbles, whereas muddy-sandy matrix the "*Lamellibranchiata*" macrofauna were found (see also Świdziński 1961).

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