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TYPE LOCALITY OF THE MUTNE SANDSTONE MEMBER OF THE JAWORZYNKA FORMATION, WESTERN OUTER CARPATHIANS, POLAND

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Abstract: The Mutne Sandstone Member occurs within the Jaworzynka Formation of the Magura Nappe deposits, typical for the western marginal Siary subunit. In the area north of Jeleśnia it is represented by the thick sandstone complex. Typical and complete profile of this division is located in Mutne village next to Jeleśnia, on the slope of Janikowa Grapa Mt. This locality represents the type section for the Mutne Sandstone Member, while three others: Jaworzynka, Rychwałdek and Kuków–Rzyczki serve as reference sections. The age of the Mutne Sandstone Member was determined as Maastrichtian–Palaeocene; but only Maastrichtian is documented by foraminiferal assemblages. The Palaeocene age comes however from the superposition of this lithosom within the Magura Nappe profile. The Campanian/Maastrichtian–Palaeocene complex of Siary Subunit deposits provides the perfect example for application of supersequences to the Western Flysch Carpathian basin. It fits the Upper Zuni IV supersequence and global time slice. The Mutne type locality is also a prime geotourist attraction and object of inanimated nature proposed for protection.

Key words: Mutne Sandstone Member – a new formal lithostratigraphic unit, Jaworzynka Formation, lithostratigraphy, biostratigraphy, deep-water agglutinated foraminifera, Cretaceous–Palaeocene, Magura Nappe, Western Flysch Carpathians.

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INTRODUCTION

The Western Flysch Carpathians are composed of a stack of nappes and thrust-sheets spreading along the Carpathian arc, which are mainly built up of up to six kilometers thick continuous flysch sequences, representing the Jurassic through Early Miocene time span (Golonka *et al.*, 2005). The nappe succession from the highest to the lowest ones includes the Magura Nappe, Fore-Magura group of nappes, Silesian Nappe, Subsilesian Nappe, and Skole (Skiba) Nappe (Fig. 1).

The Magura Nappe is the innermost and largest tectonic unit of the Western Flysch Carpathians (Matějka & Roth, 1950; Oszczypko 1992; Picha *et al.*, 2006; Ślączka *et al.*, 2006) thrust over various tectonic units of the Fore-Magura group of nappes and of the Silesian Nappe (Fig. 1). The Magura Nappe has been subdivided into four subunits (facies-tectonic zones): Krynica (Oravská Magura – Krynica), Bystrica (Nowy Sącz), Rača and Siary. These subunits coincide, to a large extent, with the corresponding facies zones (Golonka, 1981; Koszarski *et al.*, 1974; Matějka & Roth 1950; Ślączka *et al.*, 2006).

Numerous papers were devoted to the litho- and biostratigraphy of the Cretaceous and Palaeogene deposits of the Magura Nappe as the whole as well as to the lithological differences between its subunits. During the last two decades the attempts were made to formalize the Magura Nappe's deposits stratigraphy according to the Polish Stratigraphic Code (Alexandrowicz *et al.*, 1975; Racki & Narkiewcz, 2006). These works (e.g. Birkenmajer and Oszczypko, 1989; Oszczypko, 1991; Oszczypko *et al.*, 2005) are dealing mainly with lithostratigraphy of the Krynica and

Fig. 1. Position of the Mutne Sandstone Mb. localities on the Western part of the Polish Flysch Carpathians

Bystrica subunits. The outer, marginal Siary subunit of the Magura Nappe is still waiting for the integrated modern approach to the lithostratigraphy of Cretaceous and Palaeogene flysch deposits. The first attempt was made by Cieszkowski *et al.* (2006) during their regional description of the Polish Western Flysch Carpathians between Sucha Beskidzka and Świnna Poręba (Cieszkowski *et al.*, 2006). These authors discussed the various aspects of litho- and biostratigraphy of the Siary subunit in this area. This discussion clearly indicated the necessity to conduct the detailed integrated approach to stratigraphy of formations and members in their type localities. This paper attempts to provide such an integrated approach to the lithostratigraphy of the Mutne Sandstone Member of the Jaworzynka Formation. The present authors plan to conduct similar work in the other type localities within the Siary subunit, for example in Jawo- rzynka, Zembrzyce, Budzów in the Polish Western Flysch Carpathians.

GEOLOGICAL SETTING AND LITHOSTRATIGRAPHY

The Siary subunit constitutes the northernmost, marginal unit of the Magura Nappe in the Western Flysch Carpathians. Its northern border in the western part of the Polish Flysch Carpathians is marked by the line running along the arc from the Czech Republic border in the vicinity of Jaworzynka village in the Silesia, through Koniaków, Milówka, Żywiec, Harbutowice, Myślenice, Skrzydlna, Żegocina, Rajbrot, Łososina Dolna to Tęgoborze and Zbyszyce upon Dunajec. The above mentioned division of the Magura Nappe into the four subunits is based mainly on individual characteristics of the sequences of rocks representing the Magura Basin deposits. The tectonic features are secondary. The subunits of the Magura Nappe are in places thrust over each other, but the thrust amplitude is often smaller however than the size of smaller thrust-sheets within the subunits (Cieszkowski, 1992).

The Mutne sandstones occur mainly within the sequence of the Magura Nappe deposits typical for the western marginal Siary subunit (*sensu* Koszarski *et al.*, 1974). The outcropping Siary subunit profile contains the deposits from Late Cretaceous to Early Oligocene. It is possible to distinguish several lithostratigraphic units in the formation rank (see Cieszkowski *et al.*, 2006). The Eocene and Lower Oligocene deposits of the Siary Subunit are different from the other Magura Nappe subunits, in the western segment in Poland also Upper Cretaceous rocks display special characteristics. In the Sucha Beskidzka region, the lithological development of the marginal zone of Magura Nappe differ from the development in Siary near Gorlice in the eastern sector of the Polish Magura marginal Nappe. The classic profile in the Sucha Beskidzka and Zembrzyce area described by Książkiewicz (1966, 1974 a, b) is typical for the whole region west of Dunajec River. Therefore, the name "Zembrzyce zone" was proposed by Cieszkowski *et al.* (2006), for the western sector of the Siary subunit during the lithostratigraphical formalization attempt. Several lithostratigraphic units were distinguished there, some of them formal, some not formal. Informal units would be formalized in the future, now they are proposed to rate in a rank of formation and/or member. The formal lithostratigraphic units are Jaworzynka Formation (Fm.) (Inoceramus beds biotite facies) Senonian–Palaeocene in age (after Oszczypko *et al.*, 2005, next used by Cieszkowski *et al.*, 2006), Ropianka Formation (Inoceramus beds) Senonian–Palaeocene in age (after Oszczypko *et al.*, 2005), and Łabowa Shale Formation, Palaeocene–Middle Eocene in age, including Skawce Sandstone (Mb.) ("Ciężkowice Sandstones" if Magura series) (after Oszczypko 1991, Cieszkowski & Waśkowska-Oliwa, 2002, next used by Cieszkowski *et al.*, 2006). Within the Jaworzynka Formation, Cieszkowski *et al.* (2006) proposed to distinguish Gołynia Shale (Książkiewicz, 1974a, b) and Mutne Sandstone (Sikora & Żytko, 1959) members. The deposits, called by Książkiewicz (1966, 1974a, b) Magura beds, Late Eocene–Early Oligocene in age developed above the Łabowa Shale Formation. They consist of three informal lithostratigraphic units, commonly called Sub-Magura beds (Zembrzyce Shales), Magura glauconite sandstones (Wątkowa Sandstone) and Supra-Magura beds (Budzów Shales). Cieszkowski *et al.* (2006) put forward complete formalization of the Magura Series in the Siary subunit, and proposed to distinguish the Magura beds as Beskid Makowski Formation with Zembrzyce Shale (Submagura beds), Wątkowa Sandstone (Magura Sandstone glauconite facies), and Budzów Shale (Supra-magura beds) members, if formalized.

The distinctive difference between Siary and Rača subunits is clearly visible in the Polish part of the Western Flysch Carpathians. West of Wielka Racza Mountain (Beskid Żywiecki, south of Żywiec town at the Polish-Slovak border) on the territory of Western Slovakia and Moravia, this difference is more obscure. In these regions the thick-bedded sandstones of the muscovite type (Magura Formation *sensu* Oszczypko, 1991), characteristic for the Rača subunit, as well as thick-bedded glauconitic Wątkowa Sandstone characteristic for the Siary subunit are replaced by the deposits similar to those known from the Zembrzyce Shale and Budzów Shale members. These deposits are distinguished in Czech and Slovak republics as Zlin Formation (Matejka & Roth, 1956). The whole area with this Zlin Formation is known there as the Rača zone, sometimes divided into northern and southern zones according to the tectonic features.

The position of the Mutne Sandstone Member (Mb.) within Jaworzynka Formation (Fm.)

Jaworzynka Formation was described recently by Cieszkowski *et al.* (2006) as equivalent of Inoceramus (Ropianka) beds of the northern biotite facies (see e.g. Burtan & Skoczylas-Ciszewska 1966; Książkiewicz, 1974 a, b), and Solan beds of Czech and Slovak geologists (Matejka & Roth 1949; 1956; Pesl 1965). Their similarities to Altenkbach beds in the Rhenodanubian Flysch (Cieszkowski *et al.*, 2002) were also noticed. The formation age is Senonian–Palaeocene. The name Jaworzynka beds was introduced by Burtan (1973a, b; 1978a, b; Burtan *et al.*, 1976) and acknowledged by Golonka and Wójcik (1976; 1978), Cieszkowski (1992) and Oszczypko *et al.*, (2002; 2005) describing the complex of flysch deposits of Senonian age from the northernmost part of the Magura Nappe in the Jaworzynka-Koniaków area. Cieszkowski *et al.*, (2006) defined Jaworzynka Formation as Jaworzynka beds *sensu* Burtan (1973a, b), as well as the other stratigraphic units of Maastrichtian and Palaeocene age, such as Mutne Sandstone Member (Mb.) and Gołynia member (Mb.). Almost all packages of "Inoceramus" or "Ropianka" type of beds present in the Siary Subnit of the Magura Nappe are also included into the Jaworzynka Formation (Fm.). This formation contains all flysch deposits of Senonian–Palaeocene age of the of the Siary Unit between Cretaceous red shales of Cebula Formation (Fm.) (Golonka & Wójcik 1976, 1978; Pivko, 2002), or Malinowa Formation (Fm.) (*sensu* Birkenmajer & Oszczypko 1989; Oszczypko *et al.*, 2005) and Łabowa Formation (Fm.) (Oszczypko, 1991). In the area north of Jeleśnia the upper part of Jaworzynka Formation is represented by the thick sandstone complex of the Mutne Member, sometimes overlain by thin-bedded and medium-bedded flysch somewhat resembling "Ropianka-type" flysch deposits. This flysch deposits are marked on the map as the Jaworzynka Formation undivided. In the Rača Subunit in Beskid Wyspowy Mts. range, the Jaworzynka Formation is overlain by the Ropianka Formation (Oszczypko *et al.*, 2005, cf. Burtan 1978a, b). East of Dunajec River, the Jaworzynka Formation could be completely replaced by the Ropianka Formation (Ślączka & Miziołek, 1985).

Mutne Sandstone Member (a new name)

History. The Mutne sandstones were described for the first time by Sikora and Żytko (1956) from the type section in the vicinity of Mutne village during their presentation of the geological structure of Beskid Wysoki Mountains south of Żywiec. These sandstones were presented as a complex of thick-bedded sandstones located in the lithological section of the northern, marginal zone of the Magura Nappe (Siary zone *sensu* Koszarski *et al.*, 1974) above the Inoceramus beds and below the Eocene variegated shales. In the same period, the mapping work was conducted in the marginal zone of the Magura Nappe between Żywiec and Zwardoń by Burtan, who later distinguished thick-bedded sandstones in the same stratigraphic position as the Łyska sandstones (Burtan *et al.*, 1959). Results of Burtan's mapping in this area were included into temporary map of Lachowice sheet by Nowak (1964). Książkiewicz (1974 a, b) distinguished similar sandstones as one of the "members" of the marginal zone of the Magura Nappe under the name "Ropianka beds with the intercalations of arcose sandstones". This author pointed to the similarities between these deposits and Mutne sandstone described by Sikora and Żytko (1956; 1960). The Mutne Sandstone name was acknowledge among others by: Bieda *et al.* (1963), Geroch *et al.* (1967), Golonka and Wójcik (1978a, b), Golonka *et al.* (1981), Golonka (1981), Malata (1981), Paul and Ryłko (1996), Ryłko (1992) and Unrug (1969). At the beginning of the 21st century the Mutne sandstones became again subject of interest of geologists, who studied their lithology, sedimentological development, stratigraphic and paleogeo-

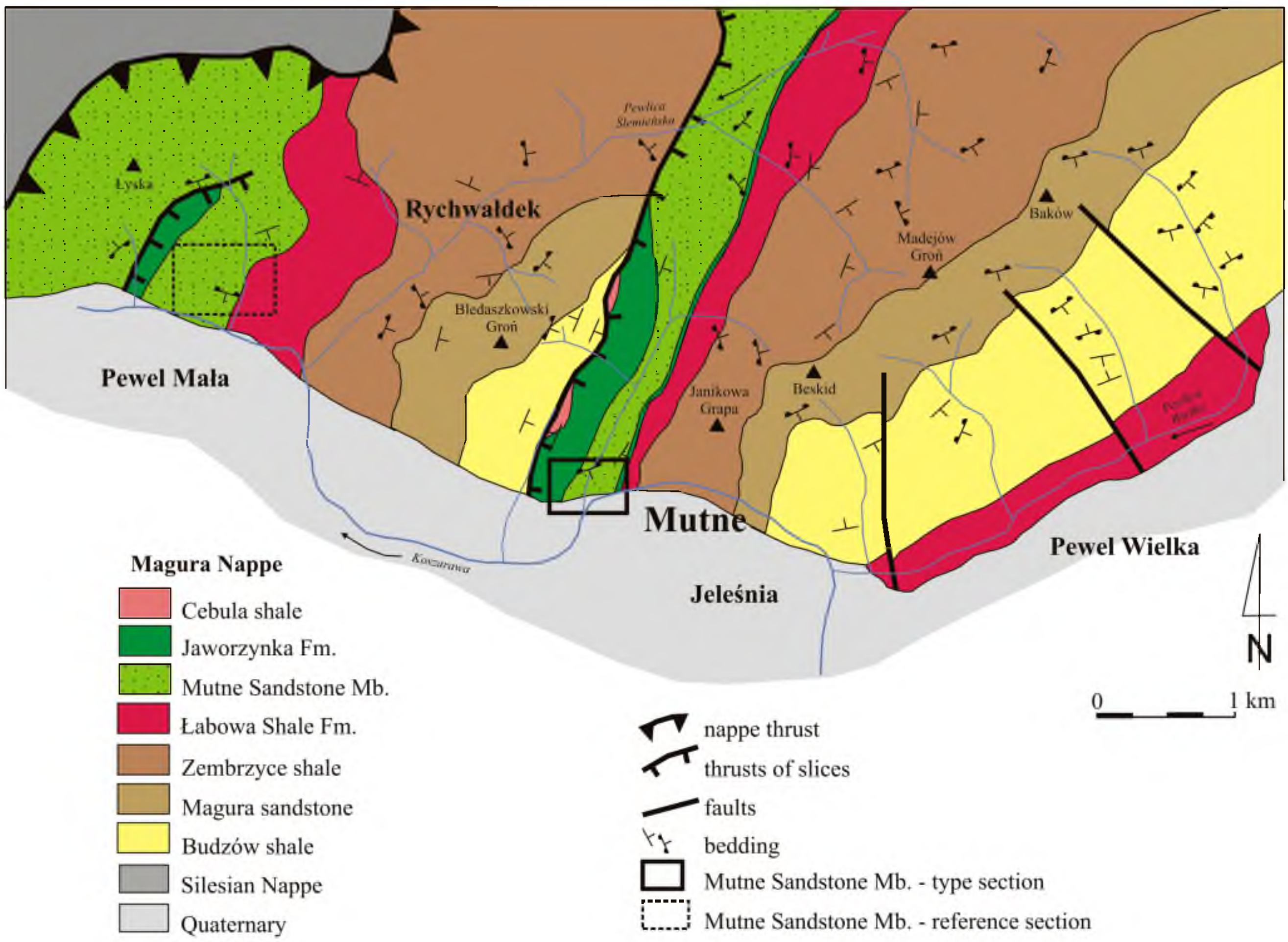

Fig. 2. Localization of the type section and reference section in the Mutne area (map after Chodyń, 2002 – modified)

graphic position, as well as correlation between the Western Flysch Carpathians and Rheno-Danubian Flysch of the Eastern Alps. Publications from this period described the lithological and sedimentological characteristics, heavy minerals, carbonate clasts and olistolith analysis, and the Alps-Carpathians correlation attempts (Cieszkowski *et al.*, 2000, 2002). The modern approach to the lithological development of the sandstones and their position within the frame of the geological structure of the Magura Nappe between Żywiec and Jeleśnia was presented by Chodyń (2002). Because of the occurrence of the submarine slumps with olistoliths and smaller clasts within the Mutne sandstones, these deposits were subject of the specialistic works devoted to the occurrence and position of clasts, olistoliths and olistostromes in the Western Flysch Carpathians (Cieszkowski *et al.*, 2003, 2004a). The lithology and stratigraphic position of the Mutne sandstones were included into the regional description of the Polish Western Flysch Carpathians between Sucha Beskidzka and Świnna Poręba (Cieszkowski *et al.*, 2006). These authors proposed the member lithostratigraphic rank without formal description.

Name. After the Mutne Village, Jeleśnia Common, Żywiec District, Silesian province, Western Outer Carpathians, Poland (Figs 1, 2). **Polish name.** Ogniwo piaskowców z Mutnego formacji z Jaworzynki.

Type section. Slope of the Janikowa Grapa Mountain along the right bank of Koszarawa river in the vicinity of Mutne village, 9 km west of Żywiec, Polish Outer Carpathians, Makowski (Średni) Beskid range, Jeleśnia Common, Żywiec District, Małopolska Province, Poland (Figs 1, 2).

Reference sections. Outcrops in Jaworzynka village: right bank of the Krężelka stream (100 m from its mouth to Czadeczka river) and quarries in the southern slope of the Wawrzaczów Groń Mountain Figs 1, 3); Rychwałdek village – quarries in the eastern slope of the Łyska Mountain (Figs 1, 2), Kuków village – Rzyczki hamlet – outcrop in the stream – left subsidiary of Lachówka river (Figs 1, 4).

Thickness. The member thickness in the type section is 150 m.

Dominant lithology. The Mutne Sandstone Member is characterized by the dominant occurrence of 0.5–1.2 m thick sandstones. Sometimes the sandstone layers are amalgamated and thicker, up to 2.2 m. These sandstones are medium- and coarse-grained, their layers are massive in the lower parts with slightly distinguished parallel lamination in the upper part and cross-bedding in the uppermost part (Figs

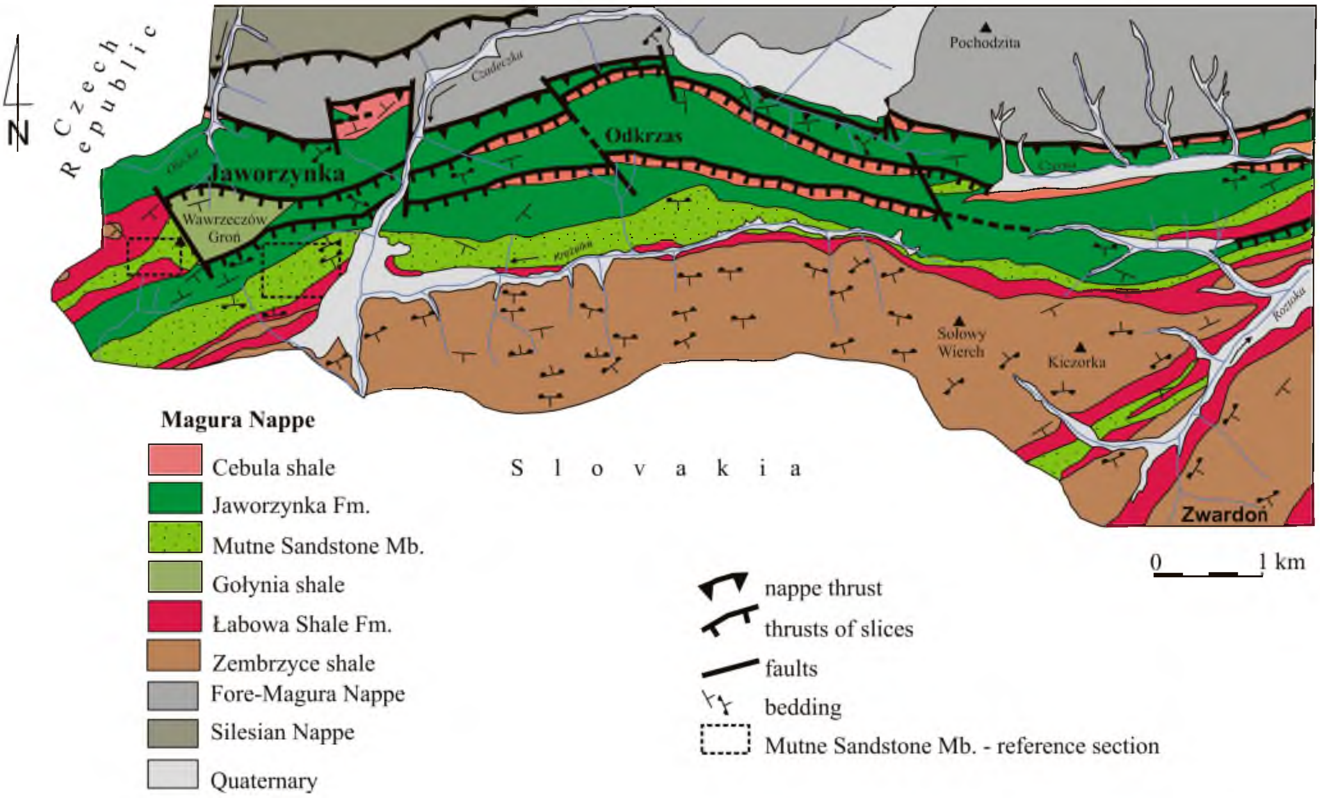

Fig. 3. Localization of the Mutne Sandstone Mb. reference section in the Jaworzynka area (map after Burtan, 1973a – modified)

5, 6). The well preserved flute-casts are rarely present on the bottom surfaces of sandstone layers as well as the trace fossils at the top.

In some thick beds of the Mutne sandstones, large-scale cross-bedding can be observed. In the abandoned quarry above the Jeleśnia–Pewel Mała highway, the large top surfaces of sandstones are exposed displaying the middle-scale ripplemarks (see Unrug, 1969) (Fig. 6). The load-casts are present in the bottom parts of the layers; flame-structures similar to those known from the structures described by Leszczyński (1981) in the Ciężkowice sandstones. The sandstones in the Mutne quarry are steel-grey coloured, grey or light-brown in the weathered parts. The lower parts of layers are often conglomeratic. The fine-grained conglomerates form sometimes separate layers. The inverse gradation was observed within these layers. Sometimes the blue-gray medium-bedded, fine-grained sandstones display parallel lamination (Figs 5, 6).

Quartz is the main builder of the sandstones, with lesser amount of feldspar, fragments of metamorphic rocks, phyllites and clasts or shales and marls. In most layers glauconite is absent, in some layers it occurs in the significant amount. The shale clasts often green in colour occur in the sandstones, sometimes frequently. Sometimes carbonate-silicic matrix cements the sandstones. In the green-beige, brown after weathering, sandstones the matrix is rich in glauconite, the carbonate cement is insignificant.

Conglomerates content is similar to that of sandstones; fragments of carbonate rocks are more frequent. Fragments of crinoid sceletons were also observed sometimes. Limestones, marly limestones, marls, rarely sandy limestones can be distinguished within the carbonate pebbles or clasts. The size of these pebbles and clasts is 2–10 cm, sometimes bigger fragments up to 15–20 cm, rarely to 0.5 m occur. The limestones have massive structure, sometimes with slight content of sands: they display the parallel- or cross-lamination. The rare foraminifers, including *Globotruncana* genus and radiolarians were observed in these limestones. Sometimes, the flat pelitic limestone clasts arranged paralell to the bedding form a kind of sedimentary breccia. The large olistoliths of the carbonate rocks up to dozen or so meters in size occur in the Mutne outcrop (Figs 5, 6). The olistolith of the pelitic marly limestone was inserted there into the sandstone layer described by Unrug (1969) as a submarine slump.

The shales associated with the sandstones are dark-grey, almost black, often muddy, with muscovite pelite and plant detritus. The sandstone–shale/mudstone ratio is always larger than one, sometimes up to 100:1. In the rare 0.6–0.8 m thick packages of shale/sandstone flysch, the Ropianka-type calcareous, laminated, micaceous fine-grained sandstones occur from time to time. Calciturbites are rare within the shale/sandstones packages. These turbiditic limestones are massive in the bottom parts and laminated or cross-bedded toward the top. The fragments of not very well preserved calcareous forams and few siliceous radiolarian shells were observed in the thin sections.

Boundaries. Lower boundary with Jaworzynka Forma-

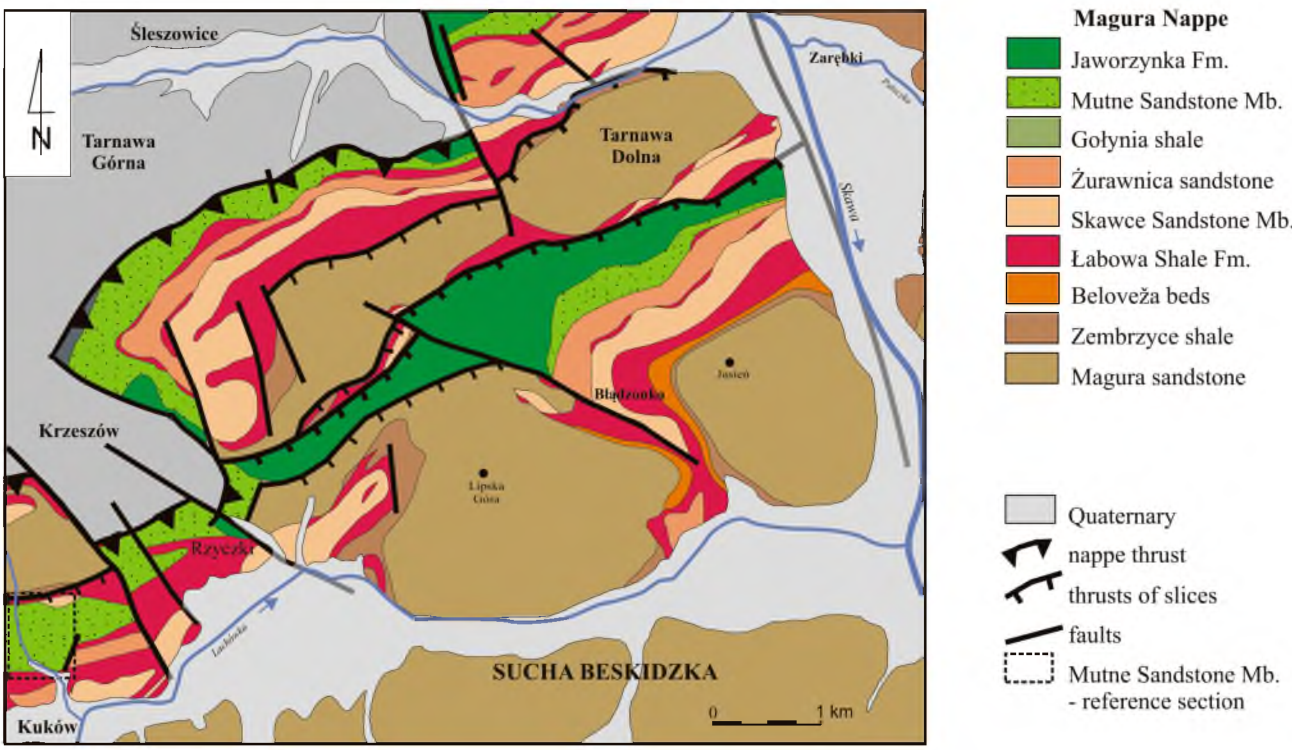

Fig. 4. Localization of the Mutne Sandstone Mb. reference section in the Sucha Beskidzka area (map after Książkiewicz, 1974; modified by Cieszkowski *et al.*, 2006a)

tion *s.s.* is sharp; Mutne Sandstone Member starts with first thick bed of arcose sandstone, upper boundary with rhythmic flysch belonging to the Jaworzynka Formation is more transitional in character. Sometimes, the Mutne Sandstone Member contacts directly with variegated shales of the Łabowa Formation.

Age. The age of the Mutne Sandstone Member corresponds to Late Maastrichtian–Palaeocene. The age was estimated using biostratigraphy – taking into account foraminiferal assemblages (for details see below) and position in the lithostratigraphical log of the Siary subunit (Magura Nappe).

Distribution. The Siary subunit of the Magura Nappe in Poland and adjacent part of Slovak and Czech republics.

Equivalents. The Łyska sandstones (piaskowce z Łyski) of Burtan (Burtan *et al.*, 1959; Nowak, 1964; Burtan, 1973 a, b), Ropianka beds with the thick-bedded arcose-rich sandstones (Książkiewicz, 1974 a, b).

Remarks. The sandstones described by Sikora and Żytko (1956; 1960) as Mutne sandstones are identical under macroscopic and microscopic investigations with sandstones distinguished as Łyska sandstones Burtan *et al.*, (Łyska – mountain between Mutne and Rychwałdek, Żywiec district). This observation was also supported by heavy minerals' research. Cieszkowski *et al.*, (2000, 2002) stated that the Łyska sandstones and Mutne sandstones belong to one lithostratigraphic unit described under the different name. This problem was also highlighted by Chodyń (2002), who conducted detailed observation in Mutne as well as in Łyska localities. Remarks on this subject were also included by Cieszkowski *et al.* (2006), who proposed the preliminary lithostratigraphic division of the Magura Nappe in the Siary zone. The Mutne Sandstone name should be established according to the priority rule.

BIOSTRATIGRAPHY

Six samples were taken for the micropalaeontological investigations from the type locality profile of the Mutne Sandstone Member (no. 96–98, 102–104, Tab. 1, Fig.7). These samples were derived from thin intercalations of grey or olive-grey, non-calcareous mudstone/shales. The Jaworzynka Formation sandstone/shale deposits occurring below the Mutne Sandstone Member of Jaworzynka Formation (3 samples, no. 99–101), as well as variegated shales of the Łabowa Shale Formation positioned above the Mutne Sandstone Member (no. 101a, 105) were also sampled, (Tab. 1, Fig. 7). The sampled shale material was processed by the standard micropalaeontological methods. The samples were dried and disintegrated in solution of sodium carbonate, than washed over the 63 μm mesh sieves. Microfauna was picked and mounted onto cardboard slides for microscopical investigations. The material is hosted at Department of Geology, Geophysics and Environmental Protection, AGH University of Science and Technology, Kraków, Poland. All analyzed samples contained microfauna, in most cases well preserved. The taxonomical contents varied significantly but the positive biostratigraphical results were achieved in most samples. The microfauna assemblages are

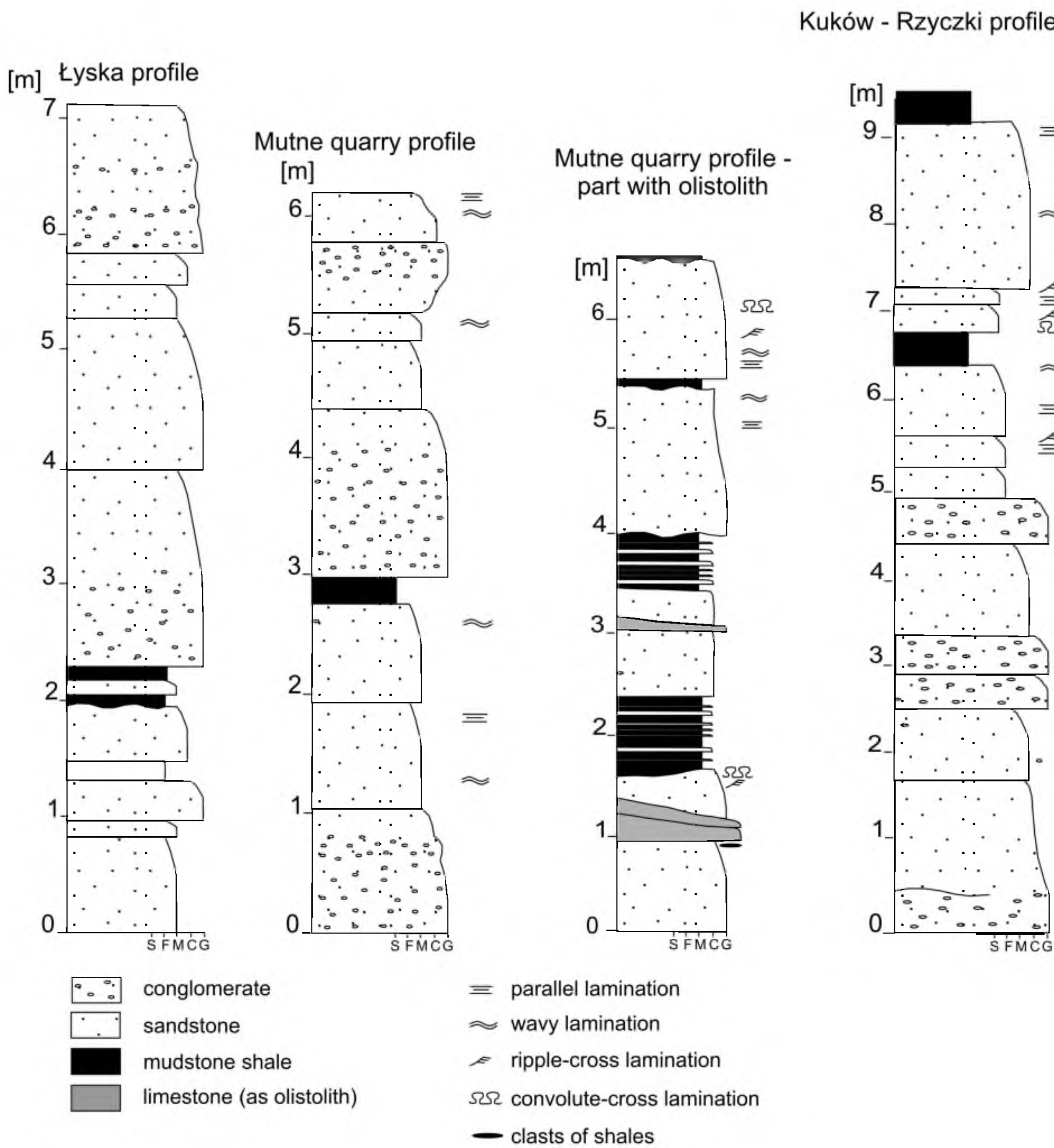

Fig. 5. Partial lithological profiles in the type section and reference sections of the Mutne Sandstone Mb. logs

represented exclusively by deep-water agglutinated foraminifera (Figs 8–11).

The tubular foraminifera (preserved as fragments) from the *Bathisiphon*, *Psammosiphonella* and *Nothia* represent the most frequently encountered group within the analyzed assemblages from the Mutne Sandstone Member deposits. The specimens from the genera *Recurvoides* and *Paratrochamminoides* (represented by 10 species) constitute also important frequent component of the assemblage. The genera *Saccammina*, *Ammodiscus* and in some samples *Gerochammina lenis* (Grzybowski) and *Caudammina excelsa* (Dylążanka) are also numerous and easy to distinguish.

Several taxa are important for biostratigraphy and characteristic for the Late Cretaceous and Palaeocene. *Gerochammina lenis* (Grzybowski), *Caudammina* cf. *gigantea* (Geroch) and single specimens of *Rzehakina inclusa* (Grzybowski) are typical for the Upper Cretaceous Carpathian flysch deposits. The occurrence of *Rzehakina inclusa* (Grzybowski) determine the latest Cretaceous age of the sampled deposits. This is one of the markers commonly utilized in the biostratigraphical determinations of the flysch Carpathians. It is index taxon defining the middle Campanian–end of Maastrichtian age (Olszewska, 1997; Morgiel & Olszewska, 1981). Beside this taxon, several forms

Fig. 6. Mutne Sandstone Mb. in the type locality (Janikowa Grapa Mt.). **A** – thick-bedded sandstones, **B** – middle-scale ripplemarks, **C** – laminated sandstones, **D** – trace-fossils at the top of sandstone layer, **E** – shaly-clasts trace in sandstone, **F** – the olistolith of the pelitic marly limestone

in the investigated assemblages are typical for late Senonian–Palaeocene, namely: *Glomospira diffundens* Cushman et Renz, *Annectina grzybowskii* (Jurkiewicz), *Caudammina ovula* (Grzybowski), *Hormosina velascoensis* (Cushman), *Remesella varians* (Glaessner), *Spiroplectammina spectabilis* (Grzybowski), *Rzehakina epigona* (Rzehak), *Rzehakina minima* Cushamn et Renz. The first occurrence of the most of the above quoted species was reported from Maastrichtian of the deep-water Carpathian basins (Jednorowska, 1975; Morgiel & Olszewska, 1981; Olszewska, 1997; Kaminski & Gradstein, 2005). The species *Remesella varians* (Glaessner) was recently used for the definition of the Late Maastrichtian–Early Palaeocene interval in the Magura Nappe and it became the index talon of the biozone in the Partial Range Zone rank (Malata *et al.*, 1996). Bąk (2004) also utilized this taxon for the definition of the Late Maastrichtian horizon in the Skole Unit.

The above mentioned foraminiferal assemblages occur in the Mutne type locality, but the investigations conducted in the other localities of the Mutne Sandstone Member (publications in preparation), that is in Jaworzynka, Kuków–Rzyczki, encountered assemblages of the similar taxonomical composition with *Rzehakina inclusa* (Grzybowski) and *Remesella varians* (Glaessner).

Very similar taxonomical composition of foraminiferal assemblages represent samples of the Jaworzynka Formation, directly below the Mutne Sandstone Member. They point to a late Maastrichtian age of the sampled sediments. Samples from the bottom part of the Łabowa Shale Formation contain a typical Palaeocene assemblage of agglutinated foraminifera, with *Caudammina ovula* (Grzybowski), *Hormosina velascoensis* (Cushman), *Rzehakina fissistomata* (Grzybowski), *Haplophragmoides mjatliukae* Maslakova, and relatively numerous *Spiroplectammina spectabilis* (Grzybowski) (Tab. 1). Usually, lot of *Spiroplectammina spectabilis* (Grzybowski) specimens in Palaeocene assemblages refer to late part of this time interval (Geroch & Nowak, 1984). The next sample (50 cm above in lithological profile) display many features characteristic for the Early Eocene assemblages. It contains numerous but only slightly taxonomically differentiated assemblage of small in size forams, with domination of *Glomospira charoides* (Jones et Parker) species and specimens from genera *Recurvoides* and *Thalmannammina, Ammodiscus*, *Paratrochamminoides* and *Ammosphaeroidina pseudopauciloculata* (Mjatliuk) are also relatively frequent.

Also typical Palaeocene species *Rzehakina fissistomata* (Grzybowski) and *Haplophragmoides* cf. *mjatliukae* Maslakova are present. The latest occurrence of these species is linked in papers on the Carpathian biostratigraphy with the end of the Palaeocene (Jednorowska, 1975; Morgiel & Olszewska, 1981; Geroch & Nowak, 1984; Olszewska, 1997) (Tab. 1). The *Hormosina velascoensis* (Cushman) was also encountered in this assemblage. This species is common in Senonian and Palaeocene of the Outer Carpathian deposits (Olszewska, 1997), in Eocene is very rare (Jednorowska, 1975). Similar foraminiferal assemblages were observed in micropalaeontological samples (publications in preparation) from the other localities of the Łabowa Shale Formation overlying the Jaworzynka Formation.

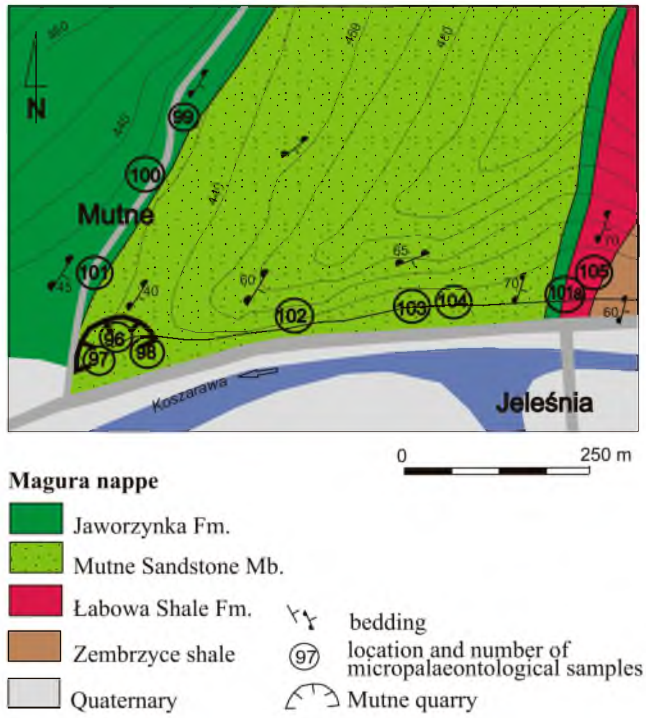

Fig. 7. Localization of micropalaeontological samples in the type section (Mutne area)

The time of deposition of the sampled sequence of the Mutne Sandstone Member rocks was determined as Maastrichtian on the basis of investigated foraminiferal assemblages. It represents the upper part of the *Rzehakina inclusa* zone *sensu* Olszewska (1997). Unfortunately the lack of the planktonic forams, which are the precise stratigraphic markers precludes the more detail age determination. The variegated shales occurring above the top of the Mutne Sandstone Member rocks indicate the late Palaeocene age of these deposits with the foraminiferal assemblages characteristic for the upper part of the *Rzehakina fissistomata* zone *sensu* Olszewska (1997). A Palaeocene age of the uppermost part of the Mutne Sandstone Member is possible, but there is still lack of the explicit palaeontological supporting data. The paper by Paul and Ryłko (1996) mentions the palaeontological data supporting the Palaeocene age of the Mutne Sandstone Member rocks in the Rychwałdek, but is not quoting the taxonomical lists. The Palaeocene age of the uppermost part of the Mutne Sandstone Member is based on superposition and the quoted above paper.

Discussion

The age of the sedimentation of Mutne Sandstone Member rocks from the type locality was determined as Senonian–Palaeocene (Sikora & Żytko, 1956; Sikora & Żytko, 1960), or latest Cretaceous–Palaeocene (Golonka & Wójcik, 1978a, b; Malata, 1981). The Mutne Sandstone Member rocks were described as the Palaeocene lithosom

Table 1

Distribution of the deep-water foraminifera in Mutne section

Number of sample ›	99	100	101	96	97	98	102	103	104	101 A	105
	Jaworzynka Fm.			Mutne Sandstone Member						Łabowa Shale Fm.	
Ammodiscus cretaceus (Reuss)	I	I	II		I	I	I		I		I
Ammodiscus pennyi Cushman et Jarvis		I					I				
Ammodiscus cf. *pennyi* Cushman et Jarvis		I	I			I					
Ammodiscus peruvianus Berry	I	I	III		III	I	I				I
Ammodiscus planus Loeblich	IV	III	IV				IV		V		IV
Ammodiscus sp.			I				I				
Ammodiscus tenuissimus Grzybowski	I	I	I				I				
Ammolagena clavata (Jones et Parker)		I								IV	
Ammosphaeroidina pseudopauciloculata (Mjatliuk)	I		II			I	I			II	IV
Annectina biedai Gradstein et Kaminski										I	
Annectina grzybowskii (Jurkiewicz)							I		I	I	
Aschemocella grandis Grzybowski)			II			II				I	
Aschemocella sp.	I	I				I					
Bathysiphon div. sp. and *Nothia* div. sp. (fragments)	VI	VI	VI	IV	VI	VI	VI	VI	VV	IV	
Budashevaella multicamerata Voloshinova										II	
Caudammina excelsa (Dylążanka) (fragments)		I	VI		I	IV	III				
Caudammina gigantea Geroch		I									
Caudammina cf. *gigantea* Geroch						I					
Caudammina ovula (Grzybowski)	V	II	III		I		I			I	I
Caudammina sp.	II										
Cribrostomoides trinitatensis (Cushamn et Renz)									I		
Cribrostomoides sp.		I				I					
Cribrostomoides subglobosus (Cushamn)		I	II		II	II	I		I		
Cribrostomoides cf. *subglobosus* (Cushamn)							I				
Cystammina sp.										I	
Gerochammina conversa (Grzybowski)							II				II
Gerochammina lenis (Grzybowski)					VI	IV	V				
Glomospira diffundens Cushman et Renz		I	III		I	I					
Glomospira charoides (Jones et Parker)	II	I	I			III	III			I	VI
Glomospira glomerata (Grzybowski)			I		I		I			II	I
Glomospira gordialis (Jones et Parker)	IV	I	III			I	II			I	IV
Glomospira irregularis (Grzybowski)	I		IV		II		II			I	III
Glomospira cf. *irregularis* (Grzybowski)		1	I			I					
Glomospira serpens (Grzybowski)			I		I				I		
Glomospira sp.			I							I	I
Glomospirella cf. *grzybowskii* (Jurkiewicz)		I	I								I
Haplophragmoides eggeri Cushamn		I	I		II	II				I	
Haplophragmoides horridus (Grzybowski)							I				
Haplophragmoides kirki Wickenden											I
Haplophragmoides mjatliukae Maslakova		I								I	
Haplophragmoides cf. *mjatliukae* Maslakova											I
Haplophragmoides porrectus Maslakova		I	I								
Haplophragmoides stomatus (Grzybowski)											I
Haplophragmoides sp.	II	I	I								I
Hormosina trinatinensis (Cushman et Renz)		II	III			II	I				
Hormosina velascoensis (Cushman)		I	I				I		I	I	I
Hormosina cf. velascoensis (Cushman)			I							I	
Hyperammina elongata Brady			I								
Hyperammina sp.			I								
Kalamopsis grzybowskii (Dylążanka)					I	I			I	II	
Karrerulina coniformis (Grzybowski)					I	I			I		

Table 1 continued

Number of sample ›	99	100	101	96	97	98	102	103	104	101 A	105
	Jaworzynka Fm.			Mutne Sandstone Member						Łabowa Shale Fm.	
Karrerulina horrida (Mjatliuk)					V	V	V		I		II
Paratrochamminoides heteromorphus (Grzybowski)			I				I		I	I	I
Paratrochamminoides irregularis (White)	IV	III	IV		I	III	III		IV	I	IV
Paratrochamminoides acervulatus (Grzybowski)		I	II		III	I				I	
Paratrochamminoides deflexiformis (Noth)										I	
Paratrochamminoides gorayskii (Grzybowski			II		I		I				III
Paratrochamminoides mitratus (Grzybowski			II		I					I	I
Paratrochamminoides multilobus (Dylążanka)		I									
Paratrochamminoides cf. *multilobus* (Dylążanka)		I	I								
Paratrochamminoides olszewskii (Grzybowski)			IV			I	I			I	II
Paratrochamminoides sp.	I	II	III		I	II	II			II	
Paratrochamminoides spp.			IV			III	I				IV
Paratrochamminoides uviformis (Grzybowski)							1				1
Psamosphaera sp.	I	I	I				I				
Recurvoides div. sp. and *Thalmannammina subturbinata* (Grzybowski)	VI	III	IV	I	VI	VI	VI		IV	IV	VI
Remesella varians (Glaessner)					II		I				
Reophax duplex Grzybowski	I	I	III			I				I	I
Reophax globosus Sliter			IV			III			I		
Reophax pilulifer Brady										I	I
Reophax sp.			I			I					
Psammosiphonella div. sp. (mainly), *P. cylindrica* Glaessner (in fragments)	VI	VI	VI	II	VI	VI	VI		VI	VI	III
Rhizammina sp. (fragments)						I				I	
Rzehakina epigona (Rzehak)			I			I				I	
Rzehakina fissistomata (Grzybowski)										I	I
Rzehakina inclusa (Grzybowski)		I				III	I				
Rzehakina cf. *inclusa* (Grzybowski)							I				
Rzehakina minima Cushman et Renz	II	1	I		I	I	I				
Rzehakina spp.			I								
Saccammina grzybowskii (Schubert)	V	III	V		II	IV	IV		IV	II	I
Saccammina placenta (Grzybowski)	III	I	VI		II	I	III		II	I	
Saccammina scabrosa Mjatliuk		I	I			I				I	I
Saccammina sp.	III		III							I	I
Spiroplectammina spectabilis (Grzybowski)					I					II	
Spiroplectinella dentata (Alth)		1									
Spiroplectammina sp.											
Subreophax scalaris (Grzybowski)		I								I	
Subreophax splendidus (Grzybowski)		II									
Subreophax pseudoscalaris (Samuel)	II	I	III		II	I	II			I	
Trochammina bulloidiformis (Grzybowki)			I				1				I
Trochammina cf. *altiformis* Cushamn et Renz							I				I
Trochammina globigeriniformis (Jones et Parker)			I							I	I
Trochammina cf. *globigeriniformis* (Jones et Parker)										1	
Trochammina quadriloba (Grzybowski)										I	
Trochammina sp.		I	I			I				I	
Trochamminoides variolarius (Grzybowski)			IV		I	I	II			I	IV
Trochamminoides grzybowskii Kamiński et Geroch	I		II		I	I			I	I	I
Trochamminoides proteus (Karrer)		I	I							I	
Trochamminoides subcoronatus (Grzybowski) and *Trochamminoides coronatus* Brady	I	I	III		II	II	III		II	II	IV
Trochamminoides sp.	I										

I – 1–5 specimens; II – 6–10; III – 11–20; IV – 21–50; V – 51–100; VI < 101

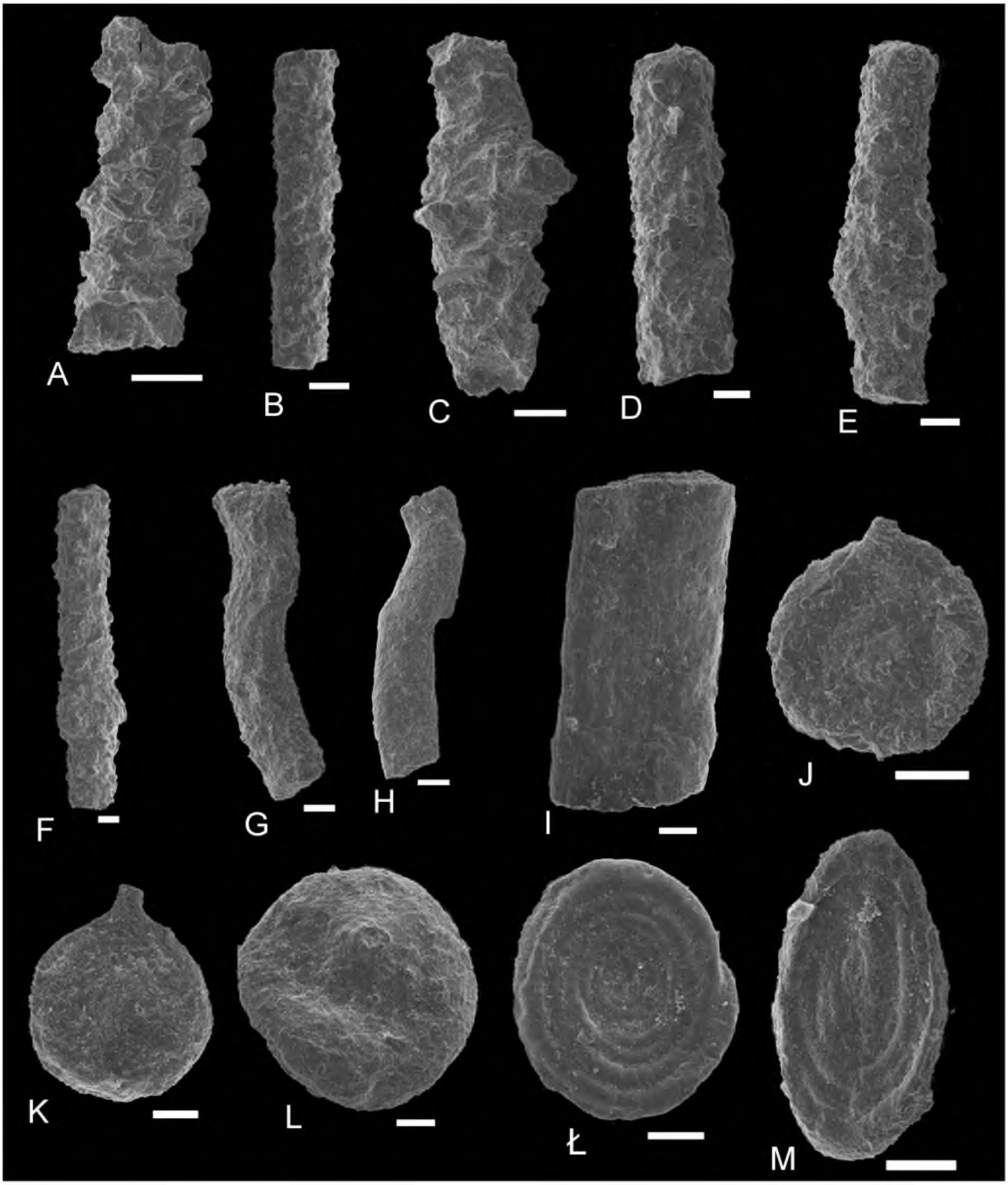

Fig. 8. SEM-photos of foraminifera from the Mutne locality. **A** – *Psammosiphonella cylindrica* Glaessner (sample 97), **B**, **D** – *Psammosiphonella cylindrica* Glaessner (s. 99), **C** – *Psammosiphonella* sp. (s. 97), **E**, **F** – *Psammosiphonella linearis* Brady (s. 99), **G** – *Nothia* sp. (s. 96), **H** – *Nothia* sp. (s. 100), **I** – *Nothia* sp. (s. 99), **J** – *Saccammina placenta* (Grzybowski) (s. 99), **K**, **L** – *Saccammina placenta* (Grzybowski) (s. 100), **Ł** – *Ammodiscus cretaceus* (Reuss) (s. 97), **M** – *Ammodiscus* sp. (s. 102). Scale bar = 100 μm

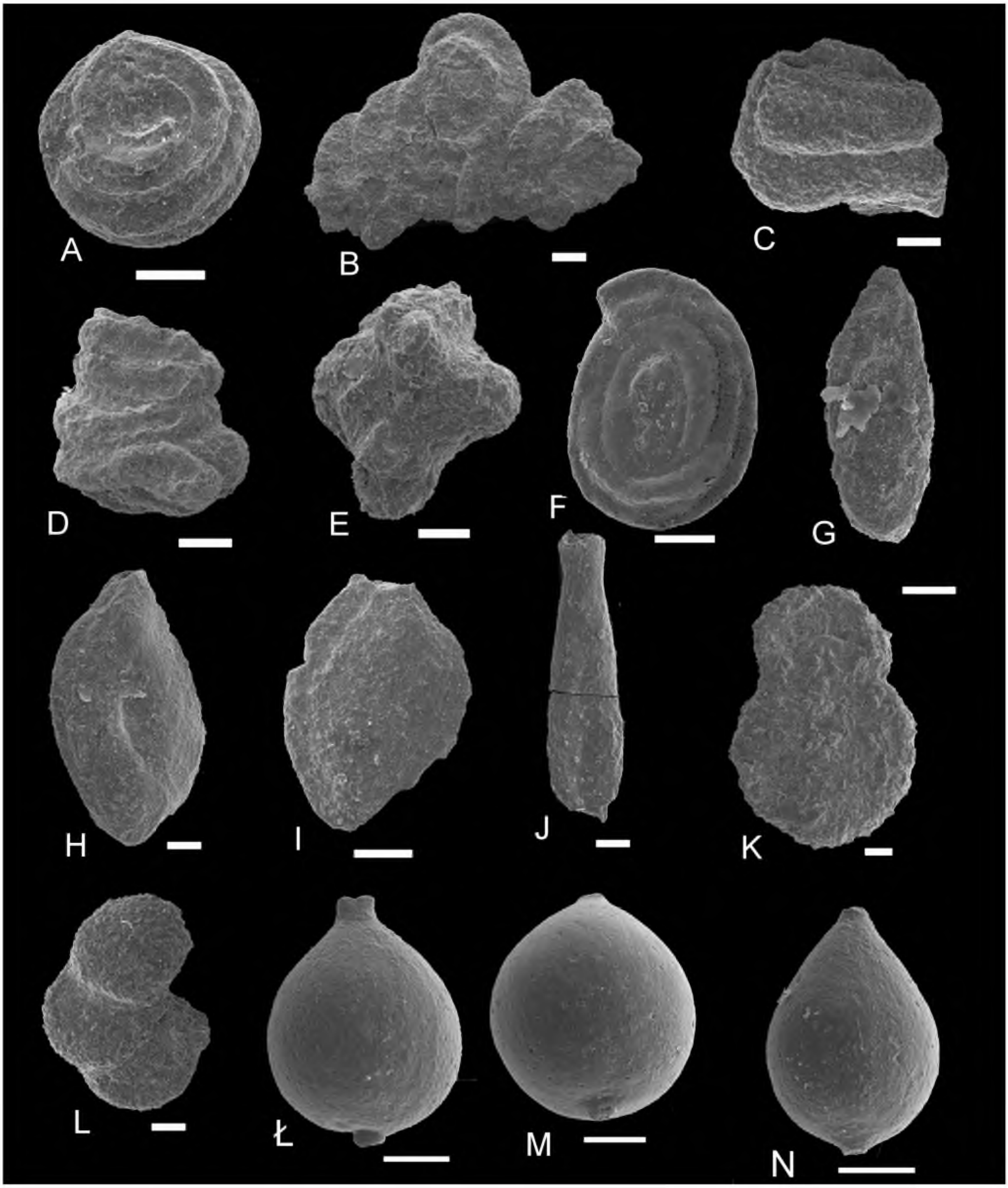

Fig. 9. SEM-photos of foraminifera from the Mutne locality. **A** – *Glomospira charoides* (Jones et Parker) (sample 102), **B**, **D** – *Glomospira glomerata* (Grzybowski) (s. 97), **C** – *Glomospira irregularis* (Grzybowski) (102), **E** – *Glomospira* cf. *irregularis* (Grzybowski) (s. 100), **F** – *Annectina grzybowskii* (Jurkiewicz) (s. 102), **G** – *Rzehakina minima* Cushman et Renz (s. 100), **H** – *Rzehakina epigona* (Rzehak) (s. 97), **I** – *Rzehakina inclusa* (Grzybowski) (s. 102), **J** – *Kalamopsis grzybowskii* (Dylążanka) (s. 97), **K** – *Reophax duplex* Grzybowski (s. 99), **L** – *Subreophax scalaris* (Grzybowski) (s. 100), **Ł** – *Caudammina ovula* (Grzybowski) (s. 99), **M**, **N** – *Caudammina ovula* (Grzybowski) (s. 100). Scale bar = 100 μm

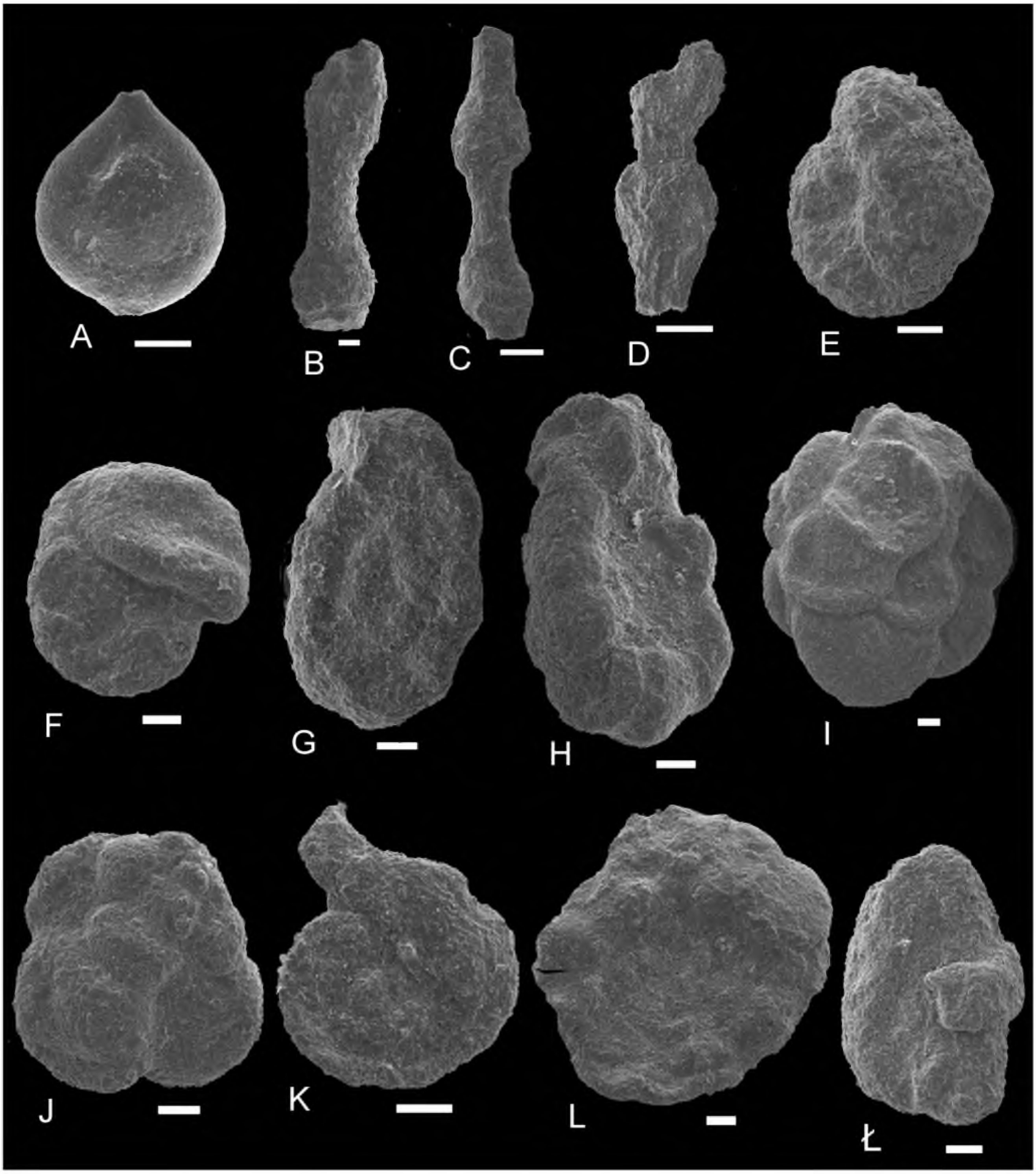

Fig. 10. SEM-photos of foraminifera from the Mutne locality. **A** – *Caudammina ovula* (Grzybowski) (s. 100), **B**, **C** – *Caudammina excelsa* (Dylążanka) (s. 100), **D** – *Caudammina excelsa* (Dylążanka) (s. 98), **E** – *Haplophragmoides eggeri* Cushaman (s. 97), **F** – *Haplophragmmoides horridus* (Grzybowski) (s. 102), **G**, **H** – *Trochamminoides proteus* (Karrer) (s. 100), **I** – *Paratrochamminoides mitratus* (Grzybowwki) (s. 97), **J** – *Paratrochamminoides* sp.(s. 97), **K** – *Trochamminoides* sp. (s. 99), **L** – *Trochamminoides grzybowskii* Kaminski et Geroch (s. 99), **Ł** – *Paratrochamminoides heteromorphus* (Grzybowski) (s. 102). Scale bar = 100 μm

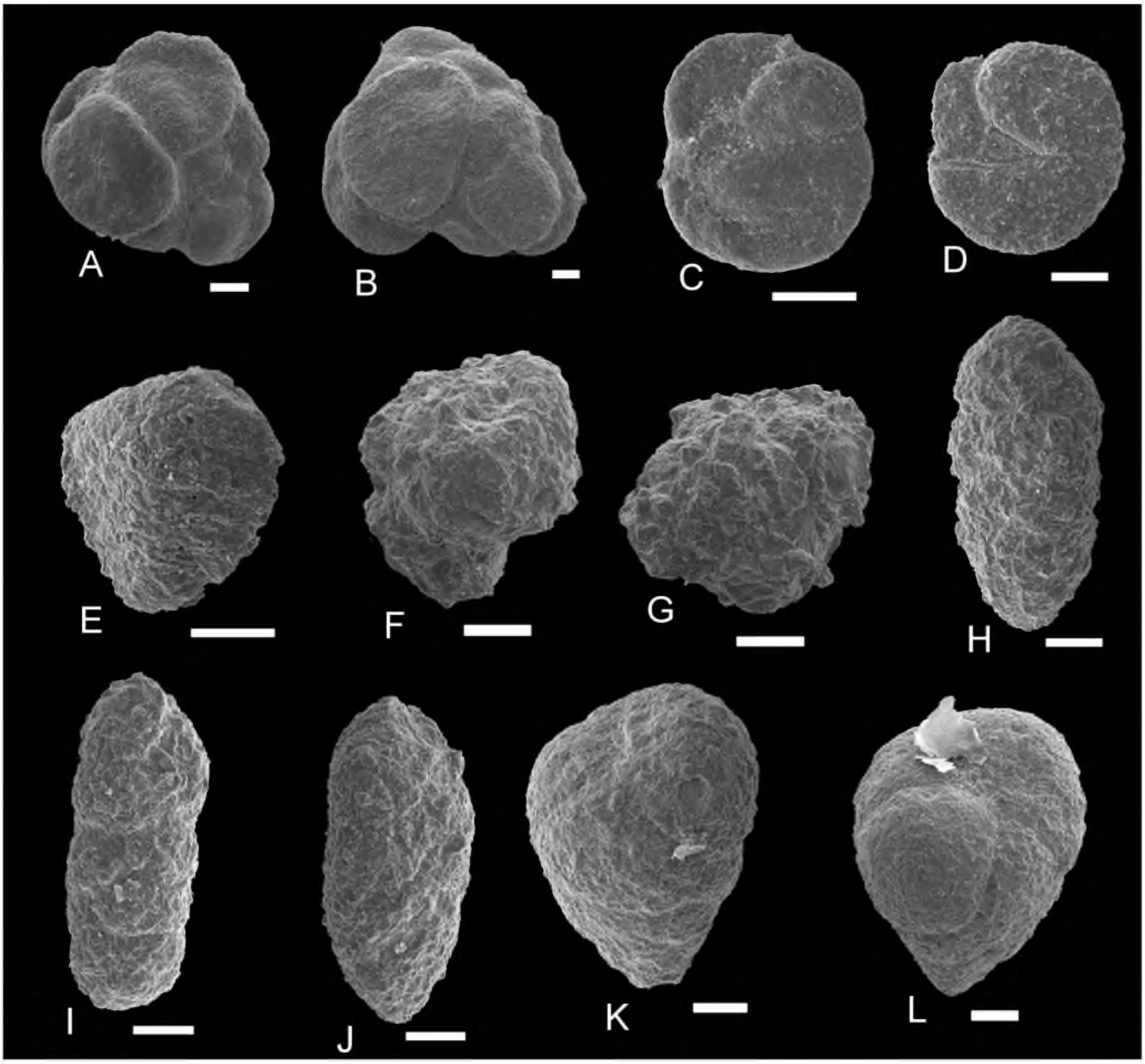

Fig. 11. SEM-photos of foraminifera from the Mutne locality. **A** – *Paratrochamminoides irregularis* (White) (s. 99), **B** – *Paratrochamminoides irregularis* (White) (s. 97), **C** – *Ammosphaeroidina pseudopauciloculata* (Mjatliuk) (s. 102), **D** – *Ammosphaeroidina pseudopauciloculata* (Mjatliuk) (s. 101), **E** – *Spiroplectinella dentata* (Alth) (s. 100), **F** – *Recurvoides walteri* (Grzybowski) (s. 97), **G** – *Recurvoides walteri* (Grzybowski) (s. 102), **H**, **I**, **J** – *Gerochammina lenis* (Grzybowski) (s. 102), **K**, **L** – *Remesella varians* (Glaessner) (s. 102). Scale bar = 100 μm

based on the lithostratigraphic position within sedimentary series of the Magura Nappe profile (Bieda *et al.*, 1963; Cieszkowski *et al.*, 2000; Chodyń, 2002; Geroch *et al.*, 1967; Oszczypko, 1992 a, b; Paul & Ryłko, 1996; Ryłko, 2004; Unrug, 1969). The cited foraminiferal assemblages (Geroch *et al.*, 1967; Sikora & Żytko, 1960; Golonka & Wójcik, 1978) were described as taxonomically poor, containing *Dorothia crassa* (Marsson), *Remesella varians* (Glaessner), *Gerochammina lenis* (Grzybowski), *Caudammina excelsa* (Dylążanka), species characteristic for the Senonian–Paleocene interval. The presence of the *Rzehakina inclusa* (Grzybowski) form in the sampled sequence in the type locality of Mutne Sandstone Member) explicitly indicates sedimentation in the Late Cretaceous. Generally, the species *Rzehakina inclusa* (Grzybowski) is rare and represented by limited number of specimens in the assemblage. This happened also in the Mutne Sandstone Member deposits, where *Rzehakina inclusa* (Grzybowski) occurred as single specimens within the assemblage extracted from the 0.5 kg sample of dry muddy material. Only two samples (no. 98 – quarry and no 102, Tab 1, Fig. 9) among seven analyzed do contain this species.

PALAEOGEOGRAPHY AND SEQUENCE STRATIGRAPHY

The Mesozoic and Cenozoic palaeogeography of the Outer Carpathians reflects the series of continental break-ups, rifts and collisions (Golonka *et al.*, 2000; 2003; 2005; 2006; Golonka, 2004). The Magura Basin originated as part of the Penninic-Pieniny Klippen created during Mesozoic time between Tethyan terranes and Eurasia. During the Cenomanian and Turonian, compression embraced the Inner Carpathians and several nappes with northward polarity developed. Subduction consumed the major part of the Pieniny Klippen Belt Ocean. As an effect of these movements the Inner Carpathians and Alps jointed with the Adria plate and the Alcapa terrane was created. In the Cenomanian period, subsidence was faster than the sedimentation rate (Poprawa *et al.*, 2006a, b) and uniform, deep-water pelagic sedimentation of radiolarites, green and red shales embraced a greater part of the Outer Carpathians basins. In the Outer Carpathians during this stage, several ridges were uplifted as an effect of the orogenic process. These ridges distinctly separated several subbasins, namely Magura, Dukla-Fore-Magura, Silesian, Chernahora-Audia, Skole-Tarcau subbasins (Golonka *et al.*, 2006). More outer subbasins (Skole, Silesian, Dukla-Fore Magura) reached diagonally the northern margin of the Outer Carpathians and successively terminated towards the west. From uplifted areas, situated within the Outer Carpathian realm as well as along its northern margin, enormous amount of clastic material was transported by various turbidity currents. This material filled the Outer Carpathian basins. Each basin had the specific type of clastic deposits, and sedimentation commenced in different time. In the western part of the area these turbidites were terminated during late Turonian/Coniacian time by slump deposits. In the Silesian basin sedimentation started during the Late Turonian–Early Coniacian and lasted up to the Early Eocene, being mainly represented by thick bedded, coarse-grained turbidites and fluxoturbidites (Godula beds, Istebna beds and Ciężkowice Sandstone). The supply of clastic material into the outer part of the Magura basin, which included the deposits in the Siary subunit, was traditionally related to the uplift of Silesian ridge (e.g. Oszczypko, 1992a, b, c, 1999; Oszczypko *et al.*, 2003; Poprawa *et al.*, 2006 a, b). This approach does not take into consideration the origin of several new basins. In the Western Carpathians, north of the Magura Nappe, there are several units, which are characterized by the occurrence of the Upper Cretaceous–Eocene sediments similar to those of the Magura Nappe and the Oligocene deposits similar to those from the Silesian unit. From the West, there are: the Fore-Magura *sensu stricto*, Obidowa-Słopnice, Jasło, Grybów and Dukla units. The relation between these units is not clear but it is supposed that the Grybów Unit was located in the more internal position than the Dukla Unit or represents a prolongation of the southern part of the Dukla Unit. During the Late Cretaceous–Eocene, these units were separated from the Silesian Basin by the Silesian ridge, reorganized by the tectonic movements. The separation from the Magura basin is more enigmatic. Similarities of the deposits developed during the Late Cretaceous–Palaeocene time suggest then existing connection between Magura and Dukla (Dukla–Fore-Magura) basins (Cieszkowski, 1992, 2003; Ślączka, 2000). The development of the Palaeogene carbonate platform, which supplied the material to the basins, where the *Lithothamnium* sandstones within the flysch deposits were formed, indicates the existence of the ridge in this area. Its existence was supposed by Cieszkowski (1992: p. 85, fig 13; p. 87. fig. 14), later named the Grybów ridge (Cieszkowski, 2001). The variety of flysch facies developed in the partly separated subbasins indicated the en-echelon arrangement of these subbasins. The Late Cretaceous reorganization of the Silesian ridge and adjacent basinal areas was perhaps caused by the large strike-slip faults. The origin of these faults is related with the orogenic process in the East Carpathians. The Fore-Magura group of subbasins was formed in the transtensional regime. The en-echelon arrangement of these subbasins is a result of pull-apart process caused by major strike-slip faults of NW–SE orientation. The Fore-Magura ridge (cordillera), called also the Grybów ridge (Cieszkowski, 1992, 2001) (Figs 12, 13), originated during the Late Cretaceous reorganization (Golonka *et al.*, 2005). This ridge was responsible for the supply of the proximal turbidites of the Mutne Sandstone Member. The measured transport directions (e. g., Książkiewicz, 1962;

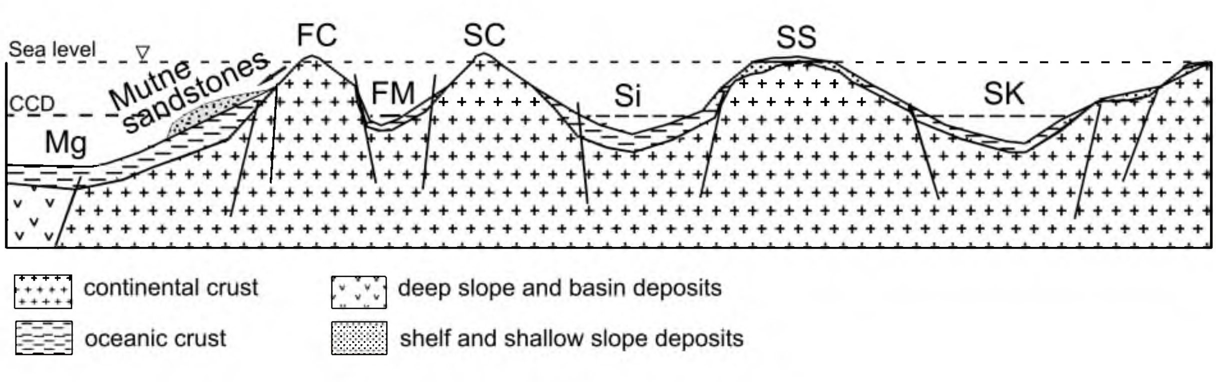

Fig. 12. Palinspastic cross-section showing the Outer Carpathian basins during Late Cretaceous–Palaeogene. Abbreviations: FC – Fore-Magura ridge (cordillera), FM – Fore-Magura basin, Mg – Magura basin, Si – Silesian basin, SK – Skole basin, SC – Silesian ridge (cordillera), SS – Sub-Silesian ridge (from Cieszkowski *et al.*, 2006a; modified)

Ryłko, 1992) are perpendicular to the ridge that is generally from the North. Exact direction is obscured by the rotation during the final orogenic processes in the Outer Carpathians (Golonka *et al.*, 2006). Uplift of the Fore-Magura ridge resulted in deposition of the fluxoturbidites during the Maastrichtian–Early Palaeocene. Then, on the southern slope of this ridge, on its lower slope and toward the basin, carbonate sedimentation of marls and limestones, partly calciturbidites, took place. Some of them slided to the basin and formed clasts, olistoliths or debrites described from the Mutne Sandstone. Observations of them suggests that flysch rich of calciturbidites, more similar to Altenkbach beds than Jaworzynka Formation, could have been deposited, at slope base. The destruction of ridges and rising subsidence caused the replacement during Late Palaeocene–Early Eocene of the Mutne Sandstone Member turbidites by distal "normal" flysch of Ropianka (Inoceramus) type, and successively by hemipelagic deposits of the Łabowa Formation.

The Upper Cretaceous–Palaeogene deposits of the Magura Nappe may be subdivided into three turbidite complexes. Each of them begins with pelitic basinal deposits (variegated shales) which pass into thin-and medium-bedded turbidites with intercalations of allodapic limestones/marls, and then into thick-bedded ones. Finally, there are thin-bedded turbidites (Oszczypko, 1992c; Golonka *et al.*, 2005). The Campanian/Maastrichtian–Palaeocene is one of these complexes. It reflects the geodynamic development of the basin, that is reorganization of ridges. Increasing amount of clastic material to the Siary depositional area can be related to the uplift and destruction of the Fore-Magura ridge. The significant destruction of the ridge was leading to the beginning of a new complex. In the Siary subunit it starts with the hemipelagic deposits of the Łabowa Formation. The Campanian/Maastrichtian–Palaeocene complex corresponds very well with the global time slice 26 – Upper Zuni IV, one of the 32 supersequences, distinguished during the Phanerozoic times (Golonka & Kiesling, 2002). This supersequence began with a high sea-level, which slowly lowered, than dropped dramatically at the Selandian–Thanetian boundary. The lower Thanetian unconformity is related to the inversion in Europe and convergence in Tethys (Golonka 2002; Golonka & Kiesling, 2002). The development of the Magura series deposits indicates a possibility of application of sequence stratigraphy in the Western Flysch Carpathian Flysch basins.

GEOTURISTIC AND CONSERVATION ASPECTS

Geotourism emerged recently as an applied science integrating tourism and Earth sciences, especially geology. According to Słomka and Kicińska-Świderska (2004), a geotourist object is a geological object that is or may become a subject of tourism. The scientific value, educational value and accessibility are important aspects of the potential geotouristical object. The type locality of the Mutne Sandstone Member provides high scientific and educational

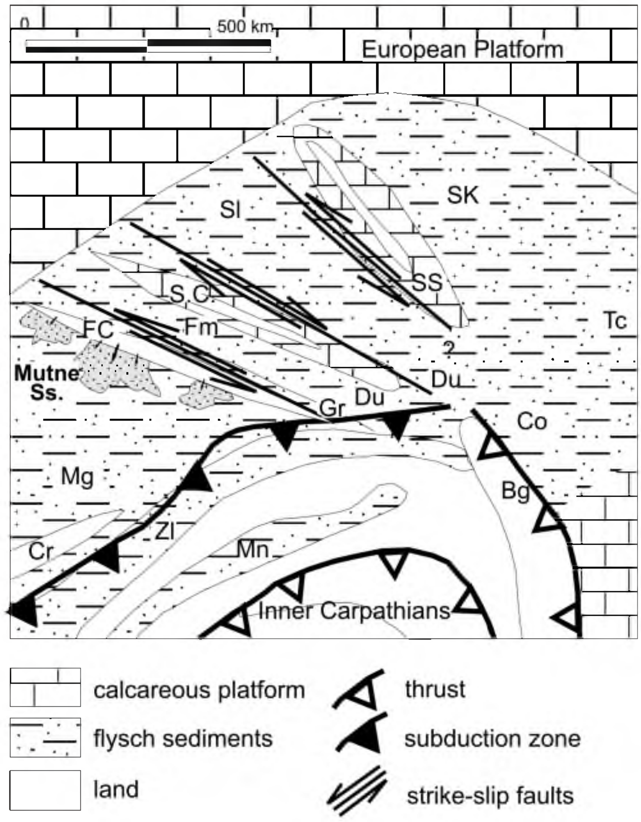

Fig. 13. Palaeogeography of the Outer Carpathian basins during the Late Cretaceous. BG – Bucovinian-Getic, Co – Chernohora, Porkulec, Audia, Teleajen, Cr – Czorsztyn ridge, Du – Dukla, FC – Fore-Magura ridge (cordillera), FM – Fore-Magura basin, Gr – Grybów, Mg – Magura, Mn – Manin, Si – Silesian basin, SK – Skole, SC – Silesian ridge (cordillera), SS – Sub-Silesian ridge, Tc – Tarcau, Zl – Zlatna (from Cieszkowski *et al.*, 2006a – modified)

valours. It was a subject of intensive integrated studies including geological, sedimentological, petrological, structural, micropalaeontological and stratigraphic observations. The rocks are well exposed allowing interesting educational field lectures and exercises for students and tourists interested in sedimentary conditions of fluxoturbiditic sandstones in the deep-water flysch basins. It contains the large amount of sedimentological features, including hieroglyphs, ripplemarks and olistoliths. The Mutne locality was among the 26 best areas in Polish Western Flysch Carpathians chosen by the authors of geological guide edited by Unrug (1969). It was also mentioned as one of the localities proposed for protection by Alexandrowicz and Poprawa (2000). The outcrops are located at the main highway from Silesia to the Beskid Wysoki recreational and ski areas in Korbielów vicinity, as well as to Slovak Orava and Tatra Mountains. Tourist traffic is heavy here and will increase after implementation of Schengen Agreement, when the road will provide the most convenient route from industrial areas in Silesia to Zakopane and High Tatras. The cliffs at Mutne serve also as a rock climbing exercise area. The infrastructure is relatively well developed in the vicinity of

Mutne, including many hotels, boarding houses and famous Stara Karczma in Jeleśnia. The main quarry is easily accessible and safe, the cliffs along the highway require cleaning and establishing of walking trail. It is also highly desirable to protest this area as abiotic nature monument. The Mutne type locality will became one of the main geoturist attractions in the planned cross-boarder Beskidy geopark.

CONCLUSIONS

The Mutne Sandstone Member is the lithostratigraphic unit characteristic for the Siary tectono-facies subunit of the Magura Nappe, best developed in the region between Jaworzynka and Sucha Beskidzka, where the most representative profiles are located. The micropalaeontological analysis of assemblages of the agglutinated deep-water forams documents the Late Maastrichtian age of the Mutne Sandstone Member in the type locality near the Mutne village, Żywiec District, Silesian province, Poland. The variegated shales of the Łabowa Shale Formation contain the Late Palaeocene assemblage of agglutinated forams. So the age of the Mutne Sandstone Member was determined as Maastrichtian–Palaeocene; its Palaeocene age coming from the position of this lithosom within the Magura Nappe profile. The supply of clastic material into the Mutne Sandstone Member was related to the Late Cretaceous emergence of the Fore-Magura Ridge, which separated Magura and Fore-Magura basins. The turbidity currents transported the material from the ridge into the outer part of the Magura basin. The Campanian/Maastrichtian–Palaeocene complex of the Siary Subunit deposits provides the perfect example for application of supersequences into the Western Flysch Carpa- thian basin. It fits the Upper Zuni IV supersequence and global time slice. The Mutne type locality is also a prime geotourist attraction and object of inanimated nature proposed for protection.

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Streszczenie

LOCUS TYPICUS OGNIWA PIASKOWCÓW Z MUTNEGO FORMACJI Z JAWORZYNKI W POLSKICH KARPATACH ZEWNĘTRZNYCH

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Piaskowce z Mutnego występują przede wszystkim w sekwencji utworów serii magurskiej, typowej dla zachodniego sektora brzeżnej (północnej), facjalno-tektonicznej strefy płaszczowiny magurskiej, zwanej strefą Siar (*sensu* Koszarski *et al.* 1974) (Fig. 1). Profil serii magurskiej obejmuje tu utwory od późnej kredy po wczesny oligocen. Strefę Siar wyróżniają spośród innych stref przede wszystkim utwory eocenu i wczesnego oligocenu, ale w jej zachodnim sektorze na terenie Polski bardzo charakterystyczne są także utwory późnej kredy. W sekwencji osadowej tego rejonu wydziela się kilka jednostek litostratygraficznych o randze formacji i ogniw (por. Cieszkowski *et al.* 2006a).

Nazwa – ogniwo piaskowców z Mutnego (og.) formacji z Jaworzynki (fm.) *sensu* Oszczypko *et al.* (2006) pochodzi od wsi Mutne koło Jeleśni (woj. śląskie, zachodnie Karpaty fliszowe). Profil stratotypowy znajduje się na S stoku Janikowej Grapy i rozciąga się wzdłuż prawego brzegu Koszarawy we wsi Mutne (Fig. 1, 2). Typowe profile obejmują: wychodnie w Jaworzynce, w prawym brzegu potoku Krężelka; kamieniołomy i łomy w górze Wawrzeczów-Groń (Jaworzynka); kamieniołomy i łomy w górze Łyska (Rychwałdek) oraz odsłonięcia w Kukowie lewym dopływie Lachówki (przysiółek Rzyczki) (Fig. 2, 3, 4). Miąższość ogniwa w obszarze stratotypowym 150 m.

W profilu litologicznym dominują średnio- i gruboziarniste, niekiedy zlepieńcowate piaskowce gruboławicowe, często amalgamowane. Obecne są również ławice zlepieńcowate. Piaskowce są barwy stalowoszarej, po zwietrzeniu stają się jasnobrunatne lub szare. Zwykle dolne części ławic są masywne, a w górnych widoczne są laminacje równoległe, faliste oraz przekątne. Często obserwowana jest gradacja ziaren, notowane są również obecności klastów łupkowych, toczeńców uzbrojonych, jak również mechanoglify (ślady wleczeniowe, jamki wirowe) na powierzchniach spągowch oraz na stropach ślady organiczne. W petrograficznym składzie szkieletu ziarnowego piaskowców dominuje kwarc, w mniejszej ilości występują skalenie, okruchy wapieni, oraz łupków mikowych, fyllitów i innych skał metamorficznych, a także klasty łupków lub margli. Zwykle obecny jest w skale muskowit, niekiedy biotyt, a miejscami pojawia się też glaukonit. Twarde margle, podobne do tych, które występują w drobniejszych klastach, w piaskowcach tworzą klasty znacznych rozmiarów, a nawet olistolity (Cieszkowski *et al.*, 2000; Chodyń, 2002). Piaskowcom towarzyszą łupki ciemnoszare lub prawie czarne, często mułowcowe z muskowitowym pelitem i detrytusem roślinnym, tworzące wkładki od kilku do kilkudziesięciu centymetrów (Fig. 5, 6). Od spągu piaskowce z Mutnego graniczą z utworami cienko- i średnioławicowego fliszu formacji z Jaworzynki, natomiast od stropu z pstrymi łupkami formacji z Łabowej lub z kilkunastometrowej miąższości kompleksem formacji z Jaworzynki. Wiek ogniwa określony został na późny mastrycht–paleocen. Do ogniwa piaskowców z Mutnego (og.) zostały włączone piaskowce z Łyski wyróżnione przez Burtan w rejonie Pewli Małej i Jaworzynki (Burtan *et al.*, 1959; Nowak, 1964; Burtan, 1973a, b) oraz piaskowce arkozowe wyróżnione przez Książkiewicza (1974a, b) w rejonie Suchej Beskidzkiej.

W celu ustalenia wieku sedymentacji piaskowców z Mutnego zostały wykonane badania biostratygraficzne w oparciu o zespoły małych otwornic (Fig. 7). Z taksonów istotnych biostratygraficznie występował szereg gatunków charakterystycznych dla senonu i paleocenu. Gatunkami typowymi dla karpackich osadów późnokredowych były: *Gerochammina lenis* (Grzybowski), *Caudammina gigantea* (Geroch) oraz reprezentowane przez pojedyncze egzemplarze *Rzehakina inclusa* (Grzybowski). Obecność *Rzehakina inclusa* (Grzybowski) przesądza o późnokredowym wieku opróbowanych osadów (Tab. 1). Ponadto, w zespole reprezentowany jest szereg form typowych dla najpóźniejszej kredy–paleocenu. W analizowanym materiale są to *Glomospira diffundens* Cushman et Renz, *Annectina grzybowskii* (Jurkiewicz), *Caudammina ovula* (Grzybowski), *Caudammina excelsa* (Dylążanka), *Hormosina velascoensis* (Cushman), *Remesella varians* (Glaessner), *Spiroplectammina spectabilis* (Grzybowski), *Rzehakina epigona* (Rzehak), *Rzehakina minima* Cushamn et Renz (Tab. 1, Fig. 8–11). Pojawienia większości wymienionych powyżej gatunków w głębokomorskich zbiornikach karpackich podawane są z mastrychtu (Olszewska, 1997; Kamiński & Gradstein, 2005; Morgiel & Olszewska, 1981; Jednorowska, 1975). Zespoły o bardzo zbliżonym składzie taksonomicznym zostały stwierdzone w osadach formacji z Jaworzynki, tuż pod spągiem piaskowców z Mutnego (og.). W osadach formacji z Łabowej, w pstrych łupkach (strefa spągowa tego wydzielenia) występują zespoły o charakterze paleoceńskim gatunkami indeksowymi, tj. *Rzehakina fissistomata* (Grzybowski) i *Haplophragmoides mjatliukae* Maslakova. Liczna obecność *Spiroplectammina spectabilis* (Grzybowski) w próbce pobranej z najniższej części formacji z Łabowej oraz masowe wystąpienie otwornic z rodzajów *Glomospira* oraz *Recurvoides* w próbce pobranej 1 m powyżej w profilu sugeruje, iż to są zespoły późnopaleoceńskie. Wiek piaskowców z Mutnego został określony na mastrycht–paleocen, przy czym udokumentowany paleontologicznie jest tylko wiek mastrychcki, natomiast paleoceński w dalszym ciągu wynika z położenia tego litosomu w obrębie profilu jednostki magurskiej strefy Siar.

Górnokredowo-paleogeńskie osady jednostki magurskiej są rozdzielone na 3 kompleksy turbidytowe. Jednym z nich jest kompleks kampańsko-paleoceński. W nim zapisane jest stadium geodynamicznego rozwoju basenu, które głównie dotyczy reorganizacji grzbietów dzielących baseny. Wzrost ilości materiału klastycznego dostarczanego do obszaru depozycyjnego jednostki Siar może być wiązany z destrukcją grzbietu przedmagurskiego (grybowskiego), który dostarczał materiał do tej części zbiornika karpackiego (Fig. 12, 13). Jest to jeden z końcowych etapów cyklu turbidytowego, gdyż nowy zaczyna się w późnym paleocenie sedymentacją osadów hemipelagicznych formacji z Łabowej. Kampańsko-mastrychcko-paleoceński kompleks jest korelowany z supersekwencją 26 – Upper Zuni IV, jedną z 32 supersekwencji wyróżnionych w fanerozoiku (Golonka & Kiesling, 2002).

Istotnym aspektem, w świetle dynamicznie rozwijającej się obecnie geoturystyki, jest promowanie stanowisk geologicznych, które niosą wiele wartości poznawczych z zakresu nauk o ziemi. Stratotyp piaskowców z Mutnego, znajdujący się na Janikowej Grapie jest miejscem, które spełnia wszystkie kryteria obiektu geoturystycznego. Należy podkreślić wartość naukową tego odsłonięcia (gdyż jest to miejsce w którym od lat sześćdziesiątych prowadzone są analizy geologiczne), historyczną, jak również edukacyjną.