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CRETACEOUS AND PALAEOGENE LITHOSTRATIGRAPHIC UNITS OF THE MAGURA NAPPE, KRYNICA SUBUNIT, CARPATHIANS

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Abstract: The paper presents formal lithostratigraphic standard for the Cretaceous and Palaeogene deposits of the Magura Nappe, Krynica Subunit, Western Carpathians. It includes nine formations belonging to two groups. The Cretaceous through Lower Paleocene marine deposits (deep-water shales, flysch) belong to the Grajcarek Group and include the Hulina Formation, the Malinowa Shale Formation, the Hałuszowa Formation and the Jarmuta Formation. The Middle Paleocene through Lower Oligocene marine deposits (mainly flysch) belong to the Beskid Group which includes the Szczawnica Formation, the Frydman Formation, the Zarzecze Formation, the Magura Formation, and the Malcov Formation, moreover eight members; these are mainly new or redefined units.

Key words: Magura Nappe, Krynica Subunit, Cretaceous, Palaeogene, lithostratigraphy, Carpathians.
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INTRODUCTION

The paper presents a formal lithostratigraphic standard for the Cretaceous through Palaeogene strata of the Krynica Subunit, Magura Nappe, in the Outer (Flysch) Carpathians. A part of formal lithostratigraphic units in this standard has already been in use for the southern part of the Magura Nappe Palaeogene since 1979 (see Birkenmajer *et al.*, 1979; Birkenmajer & Dudziak, 1981), and for the Upper Cretaceous of this nappe since 1977 (Magura Succession of the Grajcarek Unit: Birkenmajer, 1977).

The Magura Nappe is the largest, highest and innermost of the Tertiary thrust-sheets of the Outer West Carpathians. In its northen and middle parts, it is completely uprooted and thrust over more external units, its lowest strata

being represented by variegated shales (Cenomanian–Turonian), sometimes also by spotty shales and marls (Aptian–Albian). Lower Cretaceous and Jurassic deposits of the Magura Basin have been preserved in more or less continuous sequences along the southern margin of the basin, within the Laramian Grajcarek Unit incorporated into the Pieniny Klippen Belt.

Four facies-tectonic subunits have been distinguished in the Tertiary Magura Nappe of the Polish West Carpathians (see Książkiewicz, 1948, 1958a; Świdziński, 1953, 1961a; Sikora, 1960, 1970; Sikora & Żytko, 1959; Węcławik, 1969a; Oszczypko, 1973; Koszarski *et al.*, 1974). These are, from north to south: The Siary (= northern Gorlice) Subunit, the Rača (= southern Gorlice) Subunit, the Bystrica (= Sącz) Subunit, and the Krynica Subunit (see Fig. 1.)

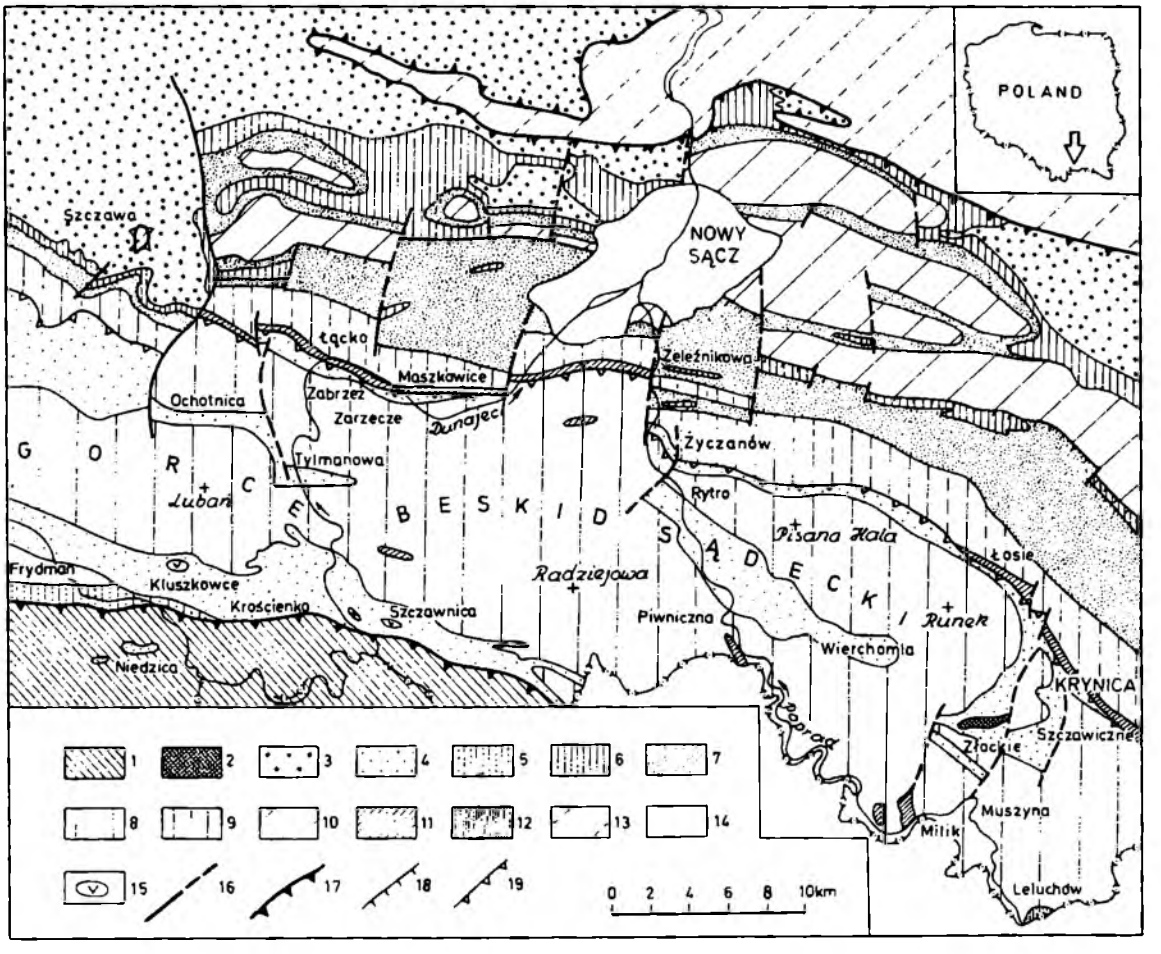


Fig. 1. Geological sketch-map of the Magura Nappe in the Dunajec River and the Poprad River valleys (after Burtan *et. al.*, 1981, simplified and modified). Inset shows position of the area in Poland. *1* – Pieniny Klippen Belt (including Grajcarek Unit); *2–13* – Magura Nappe: *2* – Malinowa Shale Formation; *3* – "inoceramian beds"; *4* – Szczawnica and Zarzecze formations; *5* – Frydman Formation; *6* – Palaeogene variegated shales; *7* – "Beloveza beds", "hieroglyphic beds" and "Łącko beds"; *8* – Magura Formation of the Krynica Subunit; *9* – Magura Formation of the Sącz Subunit ("Maszkowce beds"); *10* – Magura Formation of the Gorlice Subunit; *11* – variegated shales with *Cyclammina amplectens* (Mniszek Shale Member in the Krynica Subunit; „Jazowsko beds" in the Sącz Subunit); *12* – Malcov Formation; *13* – Eocene-Oligocene beds of the Grybów Unit; *14* – Miocene of the Sącz Basin and Miocene-Pliocene of the Nowy Targ Basin; *15* – Miocene andesite intrusions; *16* – main transversal faults; *17* – main overthrusts; *18* – overthrust of the Bystrzyca Subunit; *19* – overthrust of the Krynica Subunit

This scheme is correlatable with that of the Slovak Carpathians. A general tendency to more shaly development towards the north, and increase of sand content towards the south, are recognizable across these units.

The majority of lithostratigraphic units described in this paper have been defined after type localities situated within the Polish territory of the Magura Nappe: Krynica Subunit and the Pieniny Klippen Belt (Grajcarek Unit). For some units whose geographical name derived from the neighbouring area of the Slovak Carpathians, we propose formal designations, bearing however in mind that proper definition according to lithostratigraphical code rules should be coined by our Slovak colleagues.

Formal lithostratigraphic standards introduced for the Pieniny Klippen Belt (Birkenmajer, 1977), and for the Tatra Mountains (Lefeld *et al.*, 1985) proved to be of great help for geologists in promoting uniform, comparable description of particular Mesozoic units in the Western Carpathians. We hope that the new standard presented here for the Krynica Subunit of the Magura Nappe of the Western Outer Carpathians (Flysch Carpathians) will help introduce some order into hitherto quite unruly stratigraphic description of this part of the Flysch Carpathians, and will stimulate similar revisions of lithostratigraphy in other parts of the Magura Nappe both in Poland and abroad, and the remaining parts of the Flysch Carpathians as well.

The present paper is a contribution to the International Geological Correlation Project No. 198: "*Northern Margin of the Tethys*".

LITHOSTRATIGRAPHIC GROUPS, FORMATIONS AND MEMBERS

Three ranks of formal lithostratigraphic units will be used: groups, formations and members. Our formations, as a rule, are mappable units; the same may be said of many members, however difficulties with detailed stratigraphy in some unfossiliferous or poor in fossils flysch strata will often severely limit the practical use of the members in some areas. Only new formal lithostratigraphic units will be described in full. Those already defined and in current use, will be treated briefly and reference will be made for proper publications.

GRAJCAREK GROUP

Remarks. The Grajcarek Group has been defined by Birkenmajer (1977) to include the following Lower and Upper Cretaceous lithostratigraphic units of formation rank, in the area of tectonic contact of the Magura Nappe (southern part of this unit) with the Pieniny Klippen Belt (Grajcarek Unit): (1) the Wronine Formation (Albian); (2) the Hulina Formation (Albian–Ceno-

manian); (3) the Malinowa Shale Formation (Cenomanian–Campanian); (4) the Hałuszowa Formation (Campanian?), and (5) the Jarmuta Formation (Maastrichtian, possibly also highest Campanian). Further work has added more information as to stratigraphic age-ranges of particular formations; this will be mentioned below with respect to those formations which are also distinguishable in the Krynica Subunit of the Magura Nappe, i.e., the Hulina Formation, the Malinowa Formation, the Hałuszowa Formation, and the Jarmuta Formation (Tab. 1).

HULINA FORMATION

Remarks. The Hulina Formation (Birkenmajer, 1977) includes two members: the Groń Radiolarite and the Ubocz Shale Member. The *Groń Radiolarite Member* (lower) consists of black to green radiolarites and radiolaria shales of small thickness (2–6 m). The *Ubocz Shale Member* (upper) consists of black, grey and green argillaceous shales with menilite-type-, bentonitic-, and manganese-oxide-coated shale intercalations of equally small thickness (1.5–5 m). These two members are typically developed in the Grajcarek Unit along the northern border of the Pieniny Klippen Belt where they represent Albian and Cenomanian.

In the Krynica Subunit of the Magura Nappe, the Hulina Formation has been encountered in the Obidowa IG-1 borehole (2453–2510 m, see Cieszkowski & Sikora, 1976): here belong green spotty shales and dark mudstones with infrequent intercalations of thin-bedded, fine-grained micaceous sandstones with T_{bc} Bouma sequences.

In the Sącz Subunit of the Magura Nappe, the only equivalents to the Hulina Formation seem to be represented by green spotty marls known from the southern margin of the Mszana Dolna Tectonic Window (Burtan *et al.*, 1978; Burtan & Łydka, 1978) believed to represent the Albian (?) and Cenomanian.

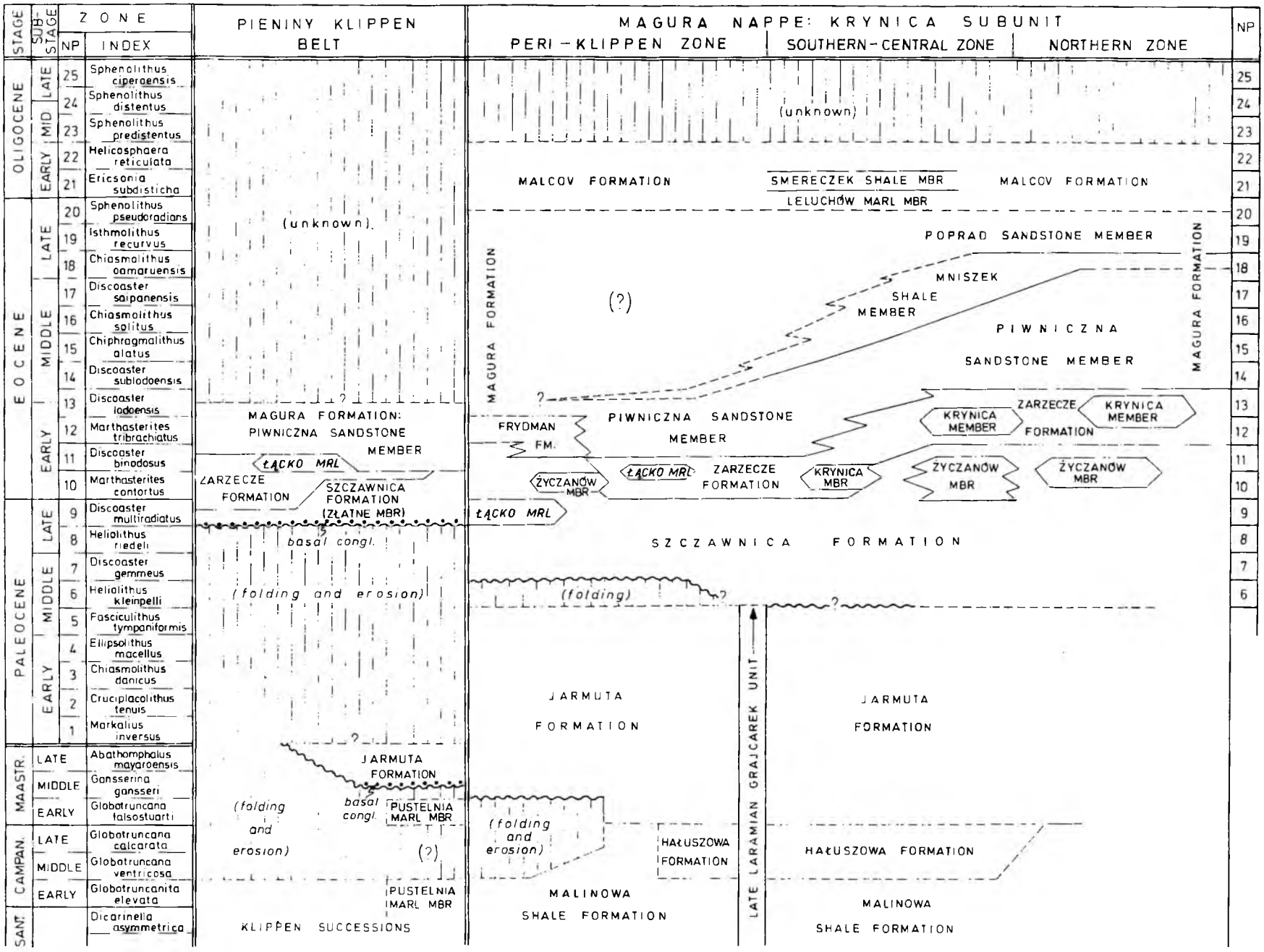
MALINOWA SHALE FORMATION

Remarks. The Malinowa Shale Formation (Birkenmajer, 1977) is represented by red and green, often alternating, argillaceous, sometimes also marly shales, with thin greenish fine-grained turbidite-sandstone intercalations. There occur also, locally, biotite-feldspar tuffite intercalations. The age of the Malinowa Shale Formation is well established on microfauna, mainly arenaceous foraminifera with scarce planktonic ones, in the Grajcarek Unit of the Pieniny Klippen Belt: there it represents the Late Cenomanian through Early Campanian time span (Birkenmajer & Geroch, 1961; Jednorowska, 1980).

Four stratigraphically important successive foraminiferal assemblages have been distinguished (Birkenmajer *et al.*, 1987):

Table 1

Age and distribution of lithostratigraphic units (Upper Cretaceous–Palaeogene) in the Krynica Subunit of the Magura Nappe and the Pieniny Klippen Belt of Poland



Vertical hatching denotes lack of the deposits

(1) Late Cenomanian: the oldest is the *Rotalipora cushmani* Zone with infrequent planktonic foraminifera *Rotalipora cushmani* (Morrow), *Praeglobotruncana delrioensis* (Plummer) and *P. stephani* (Gandolfi), and with more frequent benthic arenaceous foraminifera, among others, *Hippocrepina depressa* (Vašíček), *Haplophragmoides gigas minor* Nauss, *Thalmannammina neocomiensis* Geroch and *Plectorecurvoides irregularis* Geroch, moreover with *Recurvoides godulensis* Hanzliková, *R. primus* Mjatliuk and *R. variabilis* Hanzliková;

(2) Turonian: the next assemblage is characterized by the presence of planktonic foraminifera *Dicarinella hagni* (Scheibnerová) known from the Turonian, and by a mass occurrence of arenaceous benthos with *Uvigerinammina jankoi* Majzon, the latter also characteristic of the Turonian;

(3) Coniacian–Santonian: the foraminiferal assemblage of this age is characterized by the occurrence of scarce calcareous plankton with *Marginotruncana coronata* (Bolli), *M. sinuosa* Porthault and *M. undulata* (Lehmann);

(4) Early Campanian: this is the youngest foraminiferal assemblage of the Malinowa Shale Formation, belonging to the *Globotruncanita elevata* Zone. It includes, besides scarce planktonic zonal index *G. elevata* (Brotzen), numerous arenaceous benthic foraminifera with *Goesella rugosa* Hanzliková and *Hormosina ovulum gigantea* Geroch.

The Malinowa Shale Formation crops out in the Krynica Subunit of the Magura Nappe at several localities, the best exposures recognized between Złockie and Jastrzębik (Fig. 8A, B) where the formation is at least 100 m thick (Oszczypko *et al.*, in press); the maximum thickness of this formation in the Grajcarek Unit of the Pieniny Klippen Belt amounts to 180 m (Birkenmajer, 1977).

At Złockie and Jastrzębik streams, the lower part of the formation yielded Turonian and Early Senonian foraminiferal assemblages, while Late Senonian arenaceous microfauna has been recognized in the Szczawniczek Stream (Oszczypko *et al.*, in press). The Malinowa Shale Formation occurred also in deep borehole Obidowa IG-1 at 2453-2350 m (see Cieszkowski & Sikora, 1976).

HAŁUSZOWA FORMATION

Remarks. The Hałuszowa Formation of the Grajcarek Unit (Birkenmajer, 1977) represents a unit transitional from the Malinowa Shale Formation to the Jarmuta Formation, developed further off the Pieniny Cordillera. It is up to 100 m thick. The formation is represented mainly by grey marly shales alternating with calcareous sandstones (flysch facies); in its upper part, there appear grey-greenish marls, 2–5 m thick.

The Campanian, respectively Middle-Late Campanian age of the formation is based mainly on its stratigraphic position between the Malinowa Shale Formation (Early Campanian *Globotruncanita elevata* Zone is the

youngest zone recognized there) and the Jarmuta Formation (Maastrichthian – Lower Paleocene). The occurrence of scarce coccoliths (Birkenmajer *et al.*, 1979): *Tetralithus pyramidus* Gardet and *T. obscurus* Deflandre, is in agreement with the above conclusion (Birkenmajer *et al.*, 1987).

The Hałuszowa Formation has been recognized above variegated shales of the Malinowa Shale Formation in the Jastrzębik Stream section near Złockie (Fig. 8A, B), in the Krynica Subunit of the MaguraNappe (Oszczypko *et al.*, in press). This is a 100-m thick complex of thin-bedded bluish-grey calcareous sandstones alternating with greenish-grey, usually non-calcareous shales of similar thickness. This complex did not yield any stratigraphically valuable foraminifera or coccoliths thus far. Its Upper Senonian age is suggested by its position between the Malinowa Shale Formation and the Jarmuta Formation.

JARMUTA FORMATION

Remarks. The Jarmuta Formation (Birkenmajer, 1977) in the Grajcarek Unit is developed as flysch deposits up to 500 m thick: thick-, medium to thin-bedded, fine- to coarse-grained calcareous sandstones alternating with marly shales (usually subordinate with respect to sandstones), with conglomerate and sedimentary breccia (olistostrome) intercalations and horizons, with abundant material from Jurassic and Cretaceous rocks of the Pieniny Klippen Belt. The formation often acquires wildflysch character close to the Pieniny Cordillera, becoming more sandy further off it (northwards).

From the flysch of the Jarmuta Formation in the Grajcarek Unit comes a poor assemblage of large foraminifera: *Lepidorbitoides socialis* Leymerie, *Pseudosiderolites vidali* (Douvillé) and *Orbitoides* cf. *media* (d'Archiac) determined by Bieda (1935). It indicates a Maastrichtian or Upper Campanian to Maastrichtian age of the deposit (Birkenmajer, 1977). Late Senonian small foraminifera assemblage includes arenaceous benthos *Hormosina ovulum gigantea* Geroch, *Spiroplectammina dentata* (Alth), *Dorothia trochoides* (Marsson) and *Marssonella oxycona* (Reuss), and very scarce calcareous plankton: *Globotruncana linneiana* (d'Orbigny), ?*Globotruncanita* cf. *stuarti* (Lapparent) and *Rosita fornicata* (Plummer) (Birkenmajer & Geroch, 1963).

From a lower-middle part of the Jarmuta Formation flysch comes a poor assemblage of coccoliths: *Tetralithus obscurus* Deflandre, *T. descriptus* Martini and *Marthasterites inconspicuus* Deflandre (Birkenmajer *et al.*, 1979), indicating a Senonian age (Birkenmajer *et al.*, 1987).

Form the upper part of the Jarmuta Formation flysch with olistostrome intercalations comes an assemblage of coccoliths characteristic of the NP-5 *Fasciculithus tympaniformis* Zone (base Middle Paleocene): *Fasciculithus tympaniformis* Hay et Mohler, *Coccolithus pelagicus* (Wallich), *C.* cf. *pelagicus* (Wallich), *C. cavus* Hay et Mohler, *Chiasmolithus consuetus* (Bramlette et Sullivan), *Markalius astroporus* (Stradner), *Prinsius bisulcus* (Stradner), *Ericsonia* sp., etc., with an admixture of strongly damaged, possibly recycled

Palaeogene forms *Braarudosphaera bigelowi* (Gran et Braarud) and *Micrantholithus* sp., moreover with recycled Late Cretaceous coccoliths: *Watznaueria barnesae* (Black) and *Biscutum supracretaceum* (Reinhardt). This assemblage is associated with single planktonic foraminifera *Globigerina triloculinoides* Plummer (Birkenmajer *et al.*, 1987). The NP-1 through NP-4 zones of Early Paleocene age, have not been recognized so far in the Jarmuta Formation.

The Jarmuta Formation has been distinguished in the Krynica Subunit of the Magura Nappe in the Jastrzębik Stream section near Złockie as a 30-m thick complex of thick-bedded, often conglomeratic calcareous sandstones alternating with grey shale, above the Hałuszowa Formation (Oszczypko *et al.*, in press) (Fig. 8B). Appearance of red shales with Senonian-Paleocene microfauna above these sandstones in the Jastrzębik Stream section may suggest that the Jarmuta Formation wedges out towards the north within deep-water variegated shale complex.

BESKID GROUP
(new group)

Name. After Beskid Sądecki Range, Polish and Slovak Carpathians, where the group is well exposed. Polish name. Grupa beskidzka (gr).

Subdivision. The Beskid Group is subdivided into five formations (Tab. 1): the Szczawnica Formation, the Frydman Formation, the Zarzecze Formation, the Magura Formation, and the Malcov Formation, spanning the time from Mid-Paleocene through Early Oligocene inclusively. Some new formations may be added to this scheme if other subunits of the Magura Nappe, more northern than the Krynica Subunit, will be considered.

Thickness. 3000–3500 m in the Krynica Subunit of the Magura Nappe.

Dominant lithology. Calcareous sandstones and shales (sandy to shaly flysch) with subordinate coarse-grained sandstone and conglomerate intercalations predominate in the lower part of the group; massive sandstones (sandy flysch), with subordinate green and variegated shale horizons predominate in the middle part of the group; shale-sandstone flysch strata with subordinate horizons of marls and menilite-type shales (at the bottom) occur in the upper part of the group.

Boundaries. *Lower boundary* usually tectonic against the Grajcarek Group in the southern part of the Krynica Subunit. Sedimentary contact, possibly with a stratigraphic hiatus, against the Grajcarek Group has been recognized in the northern part of the Krynica Subunit.

A sedimentary hiatus corresponding to the NP-6 Zone (middle Mid-Paleocene) recognized between the Jarmuta Formation and the Szczawnica Formation close to the Pieniny Klippen Belt (Birkenmajer *et al.*, 1987) may be an expression of the Late Laramian folding in the Grajcarek Unit: the original, pre-Miocene, relationships between the Beskid and the Grajcarek lithostratigraphic groups could have been of angular unconformity type.

Lower boundary transgressive in the Pieniny Klippen Belt: angular unconformity against folded and eroded Klippen Successions and the Jarmuta Formation.

Upper boundary erosional: the Malcov Formation is the terminal unit of the flysch succession in the southern part of the Magura Basin.

Age. Middle Paleocene through Lower Oligocene.

Equivalents. None.

SZCZAWNICA FORMATION

History. The Szczawnica Formation has been distinguished as the Szczawnica beds (Birkenmajer, 1956, 1957); it included a southern facies – the Złatne beds in the Pieniny Klippen Belt (Birkenmajer, 1954), and a northern facies – the Kluszkowce beds in the Magura Nappe (Birkenmajer, 1958, 1960a, 1962a). It has been renamed the Szczawnica Formation by Birkenmajer (in Birkenmajer *et al.*, 1979) and known under this name since then (e.g., Birkenmajer, 1970, 1979; Birkenmajer & Dudziak, 1981).

Name. After health-resort Szczawnica, Pieniny Mountains (Figs 1, 2).

Polish name. Formacja szczawnicka (fm).

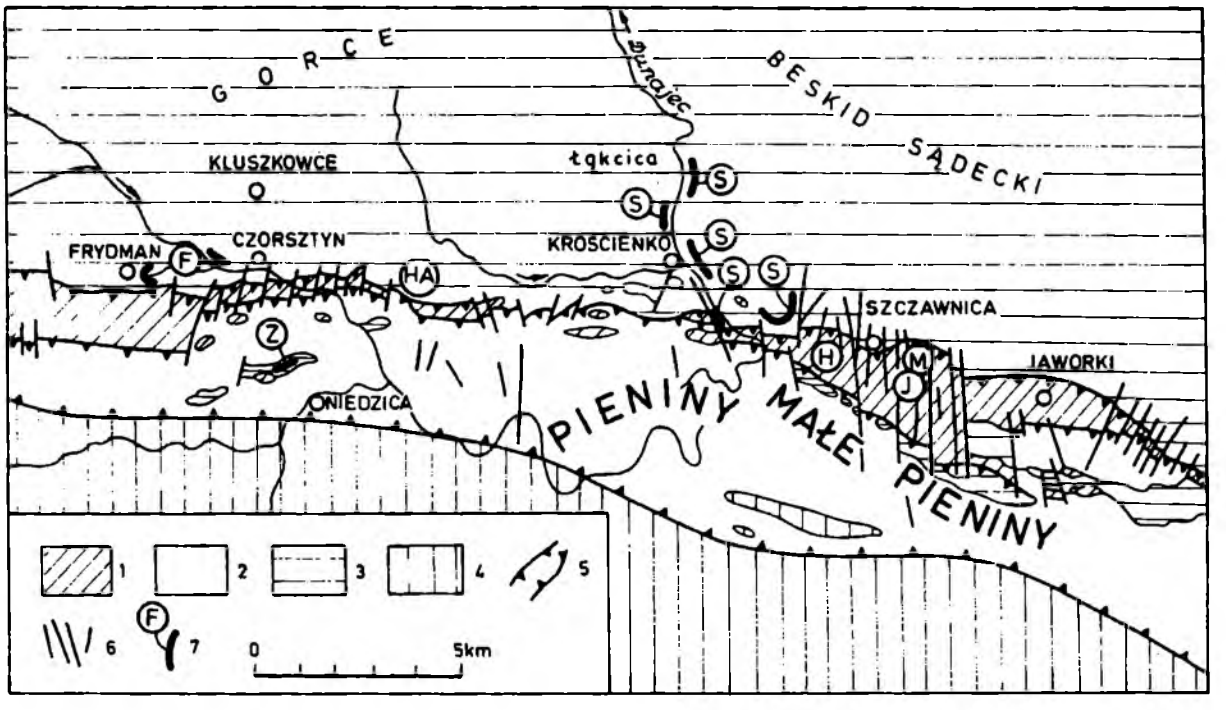


Fig. 2. Location of type exposures of Upper Cretaceous and Palaeogene lithostratigraphic units dealt with in the present paper, within the Pieniny Klippen Belt and the peri-Pieniny zone of the Magura Nappe. *1* – Grajcarek Unit; *2* – Klippen Successions; *3* – Magura Palaeogene of the Magura Nappe and the Pieniny Klippen Belt; *4* – Podhale Palaeogene of the Podhale Depression and the Pieniny Klippen Belt; *5* – Main Tertiary overthrusts in the Pieniny Klippen Belt; *6* – Main Tertiary transversal faults; *7* – location of type exposures; *F* – Frydman Formation; *H* – Hulina Formation; *HA* – Hałuszowa Formation; *J* – Jarmuta Formation; *M* – Malinowa Shale Formation; *S* – Szczawnica Formation; *Z* – Złatne Member

Type area. The type area of occurrence of the formation is between Szczawnica and Krościenko (Fig. 2).

Reference sections. Krościenko-Łąkcica, section of the right bank of the Dunajec River exposes an upper part of the formation (Fig. 2); the section at Życzanowski (Rzeczanowski) Stream, tributary to the Poprad River, exposes middle part of the formation (Fig. 3); the section in the Biała Woda

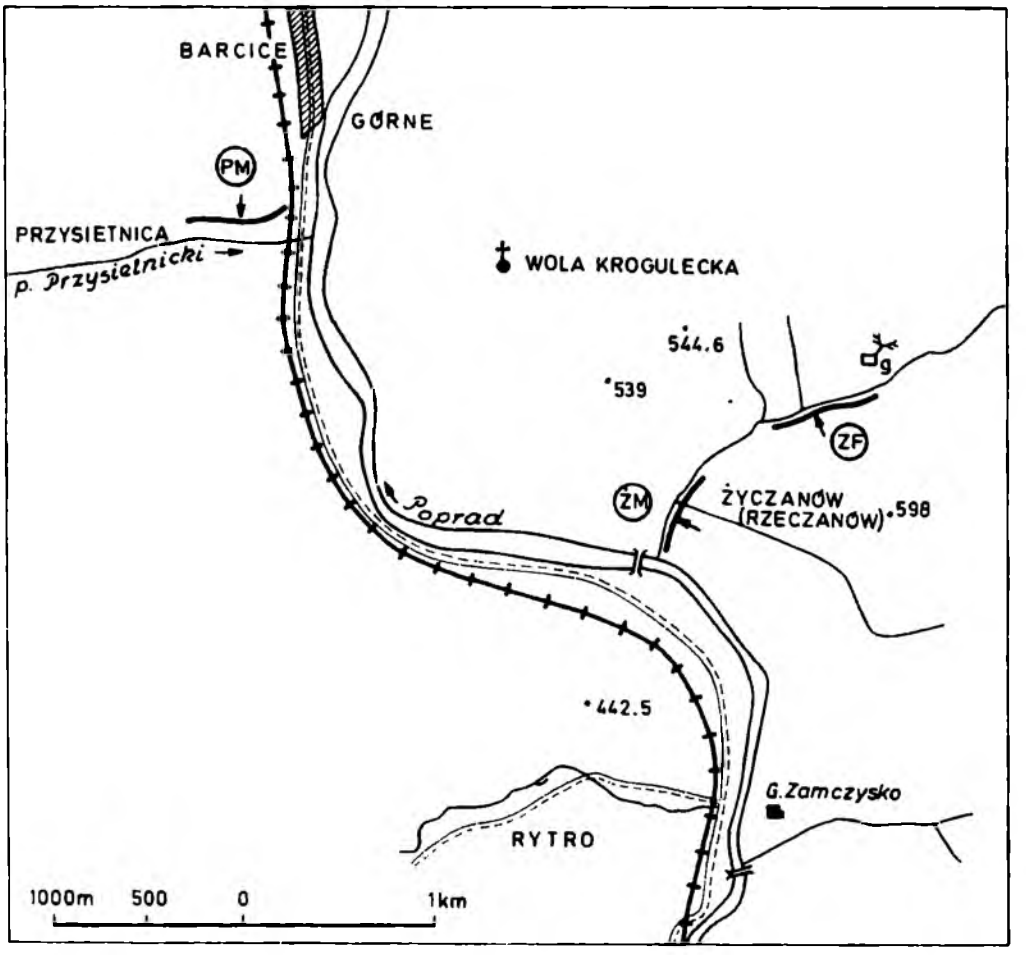


Fig. 3. Type and reference sections of the Piwniczna Sandstone Member (*PM*), Zarzecze Formation (*ZF*) and Życzanów Member (*ŻM*) in the Poprad Valley near Rytro

Stream near Jaworki exposes a lower part of the formation (Fig. 2). For comparison see Birkenmajer (1979, Figs 78, 79, 87), Birkenmajer & Jednorowska (1979), Birkenmajer & Dudziak (1981), Oszczypko (1973, Fig. 4; 1979, Fig. 5), Oszczypko *et al.* (in press, Figs 2, 4).

Subdivision. The southern condensed facies of the Szczawnica Formation within the Pieniny Klippen Belt has long been separated as the Złatne Member. The northern facies of great thickness has been treated as the Kluszkowce member; for this the name Szczawnica Formation applies in its full extent.

The Życzanów Member see p. 157 is distinguished as a formal unit in the Szczawnica Formation of the Krynica Subunit in the Magura Nappe (Fig.

8B-E). Intercalations and lenses of marls commonly known as the Łącko marls will be distinguished as local lithosomes without formal designation (Tab. 1).

Thickness. 20–70 m in the Pieniny Klippen Belt (Złatne Member), more than 500 m in the Krynica Subunit of the Magura Nappe along the northern boundary of the Pieniny Klippen Belt between Krościenko, Szczawnica and Jaworki; more than 1200 m in the PD-9 borehole at Szczawnica (Birkenmajer *et al.*, 1979).

Dominant lithology. In the Krynica Subunit of the Magura Nappe along the Pieniny Klippen Belt, this is a fine-rhythmical flysch consisting of calcareous sandstones alternating with carbonate-free or slightly calcareous (marly) shales, grey, bluish or black. The sandstones are usually fine-grained, fine- to medium-bedded turbidites rich in current markings and trace fossils. Intercalations of fine-grained conglomerates and coarse-grained sandstones contain *Lithothamnium* detritus, Mesozoic rock fragments from the Pieniny Klippen Belt, and exotic elements (Alexandrowicz *et al.*, 1965, 1966). A characteristic feature of the lower and middle parts of the formation close to the contact with the Pieniny Klippen Belt is its strong folding and brecciation resulting in a tectofacies rich in calcite veins.

In the Pieniny Klippen Belt, the thickness of the formation is strongly condensed: the shale intercalations become subordinate with respect to nummulite-bearing medium- to coarse-grained calcareous sandstones (Złatne Member). The contact with the folded units of the Pieniny Klippen Belt (Klippen Successions) is transgressive, often with coarse to fine conglomerate consisting mainly of local material, 1.5 to 5 m thick, at the base (Birkenmajer, 1954, 1958, 1970).

Boundaries. *Lower boundary* – transgressive contact and angular unconformity at the base of the Złatne Member of the Szczawnica Formation against folded and eroded Klippen successions and the Jarmuta Formation in the Pieniny Klippen Belt. Lower boundary usually tectonic due to Early Miocene folding in the northern boundary zone of the Pieniny Klippen Belt: originally, there could be an angular unconformity and a stratigraphic hiatus corresponding to the NP-6 Zone (middle Mid-Paleocene – see Birkenmajer *et al.*, 1987). Similar unconformity probably occurs between the Szczawnica Formation and the Jarmuta Formation in the northern part of the Krynica Subunit near Złockie (Oszczypko *et al.*, in press).

Upper boundary – transition to the Zarzecze Formation both in the Pieniny Klippen Belt and the Krynica Subunit of the Magura Nappe. Transition to the Frydman Formation in the Krynica Subunit between Czorsztyn and Frydman.

Fossils and age. In the Pieniny Klippen Belt, the formation yielded numerous large foraminifera collected from fine conglomerates and coarse-grained sandstones of the Złatne Member: *Operculina ammonea* Leymerie, *Nummulites planulatus* Lamarck, *N. irregularis* de la Harpe, *N. nitida* de la Harpe, and *Assilina granulosa* d'Archiac, indicating a Lower Eocene age of

these beds (Bieda, 1929, 1946; see also Birkenmajer & Dudziak, 1981). The coccolith assemblages indicate the presence of the NP-9 Zone (upper Late Paleocene) and the NP-10 Zone (lowest Early Eocene). The coccolith assemblage of the NP-9 Zone includes: *Discoaster gemmeus* Stradner (most numerous), *D. multiradiatus* Bramlette et Riedel, *D. barbadiensis* Tan Sin Hok, *D. binodosus* Martini, *D. ornatus* Stradner, *D. salisburgensis* Stradner, *Coccolithus eopelagicus* (Bramlette et Riedel), *C. pelagicus* (Wallich), *Chiasmolithus bidens* Bramlette et Sullivan, *Ch. grandis* Bramlette et Riedel and *Heliolithus kleinpelli* Sullivan. The assemblage of the NP-10 Zone includes *Marthasterites contortus* (Stradner), *Discoaster barbadiensis* Tan Sin Hok, *D. multiradiatus* Bramlette et Riedel, *D. ornatus* Stradner and *Coccolithus pelagicus* (Wallich) – Birkenmajer & Dudziak (1988b).

In the Krynica Subunit of the Magura Nappe, the best palaeontological-stratigraphical characteristics based on large and small foraminifera and on coccoliths comes from the area between Kluszkowce and Jaworki, along the northern border of the Pieniny Klippen Belt (Bieda, 1946, Birkenmajer, 1958; Birkenmajer & Jednorowska, 1979; Birkenmajer *et al.*, 1979; Birkenmajer & Dudziak, 1981). The age-range of the Szczawnica Formation is there from the NP-7 Zone (upper Mid-Paleocene) through the NP-11 Zone (middle Early Eocene).

The NP-7-8 zones yielded at Czarna Woda the following coccolith assemblage: *Coccolithus pelagicus* (Wallich), *Cyclococcolithus formosus* Kamptner, *Discoaster gemmeus* Stradner, *Heliolithus riedeli* Bramlette et Sullivan, etc. (Birkenmajer & Dudziak, 1981), moreover small foraminifera (mainly calcareous benthos) with planktonic forms *Globigerina triloculinoides* Plummer and *G. linaperta* Finlay (Birkenmajer & Jednorowska, 1979), and large foraminifera *Nummulites* cf. *fraasi* de la Harpe (Bieda, 1929, 1935).

The NP-9 Zone (upper Late Paleocene) has been recognized on the basis of poor coccolith assemblage from the Łącko marl intercalations in the middle part of the Szczawnica Formation near Hałuszowa: *Discoaster multiradiatus* Bramlette et Riedel and *D. salisburgensis* Stradner (Birkenmajer & Dudziak, 1988b). To this zone probably belongs also an assemblage of large foraminifera collected from coarse- and medium-grained sandstone intercalations, determined by Bieda (in Birkenmajer, 1958; see also Birkenmajer, 1960a, 1963a, 1965, 1979) as: *Nummulites exilis* Douvillé, *N. subplanulatus* Hantken et Madaras, *N. praelucasi* Douvillé, *N. solitarius* de la Harpe, *N. pernotus* Schaub, *Operculina couizaensis* Doncieux etc.

The NP-10 Zone (base of Early Eocene), higher part, has been recognized on poor coccolith assemblages from Szczawnica and Krościenko: *Discoaster multiradiatus* Bramlette et Riedel, *D. barbadiensis* Tan Sin Hok, *D. binodosus* Martini, *Marthasterites tribrachiatus* (Bramlette et Riedel), *M. contortus* (Stradner), etc. (Birkenmajer & Dudziak, 1981).

The NP-11 Zone (middle Early Eocene) has been recognized at Biała Woda (Rogacz Stream near Obidza, below Radziejowa Mount), at the contact with

the Piwniczna Sandstone Member of the Magura Formation: *Coccolithus pelagicus* (Wallich), *Discoaster multiradiatus* Bramlette et Riedel, *Marthasterites tribrachiatus* (Bramlette et Riedel), etc. (Birkenmajer & Dudziak, 1981).

Distribution. The Szczawnica Formation is a common basal member (Złatne Member) of the Magura-type Palaeogene in the Pieniny Klippen Belt of Poland. In the Krynica Subunit of the Magura Nappe, it is well distributed along the northern border of the Pieniny Klippen Belt in Poland, between Biała Woda-Jaworki in the east, through Szczawnica and Krościenko, to Czorsztyn-Kluszkowce and Huba in the west (see, e.g., Birkenmajer, 1963b, c, 1970, 1979).

In the northern part of the Krynica Subunit of the Magura Nappe, the formation crops out in the lower course of the Poprad River valley (Życzanów, Złockie) – see Oszczypko (1973, 1979), Oszczypko *et al.* (in press).

Equivalents. Szczawnica beds (Formation), Kluszkowce beds (Member), Złatne beds (Member) of Birkenmajer (papers published between 1954 and 1979), Birkenmajer *et al.* (1979, 1987), Birkenmajer & Dudziak (1981) are exact equivalents of the Szczawnica Formation as described in the present paper. Nördliche Grenzbildungen of Uhlig (1890) and equivalent terms of S. Małkowski and L. Horwitz (see discussion by Birkenmajer, 1954, 1956, 1957) correspond partly to the Szczawnica Formation. A part of the "Beloveza beds", "sub-Magura beds" and "inoceramian beds" of Bogacz and Węcławik (1962; in Birkenmajer *et al.*, 1965; in Unrug *et al.*, 1979) correlate with the Szczawnica Formation of the present paper.

Złatne Member

History. See Szczawnica Formation.

Name. After Złatne Mount (known also as Mount Cisówka) near Niedzica, Pieniny Klippen Belt (Fig. 2). Polish name: Ogniwo złatniańskie (og).

Type area. Mountain ridge between Mt Cisówka (Złatne Mount on older topographic maps) and Tobór, near the Niedzica village (see Birkenmajer, 1960b).

Reference sections. None specified. The member is poorly exposed in the Pieniny Klippen Belt. The most representative areas outside Niedzica are: Szlachtowski Wierch south of Szlachtowa, Stachurówka and Durbaszka mounts near Jaworki (Birkenmajer & Pazdro, 1968; Birkenmajer, 1970).

Thickness. 20–70 m.

Dominant lithology. See under Szczawnica Formation, Pieniny Klippen Belt.

Boundaries. See under Szczawnica Formation, Pieniny Klippen Belt.

Fossils and age. See under Szczawnica Formation, Pieniny Klippen Belt.

Distribution. Pieniny Klippen Belt. The member is well distributed, but generally poorly exposed, between Niedzica and Cisówka in Polish Spisz (see

Birkenmajer, 1960b), then between Szafranówka and Wierchliczka in the Małe Pieniny (Little Pieniny) Range (see Birkenmajer & Pazdro, 1968; Birkenmajer, 1970, 1979).

Equivalents. Złatne beds (Member) of Birkenmajer (1954–1979). Złatne Member (Birkenmajer & Dudziak, 1988b).

Życzanów Member
(new name)

History. The term "sandstones and conglomerates of Życzanów" was used by Oszczypko (1979) for thick-bedded sandstones and conglomerates which appear within the Szczawnica Formation of the Krynica Subunit. The same rocks were previously distinguished as "thick-bedded sandstones" within the "inoceramian beds" (= Ropianka beds) of the Krynica Subunit (Oszczypko, 1973). These rocks were distinguished near Piwniczna and Łomnica as "sandstones and conglomerates of Krynica" within the "Beloveza beds" (Chrząstowski & Ostrowicka, 1978; Ostrowicka, 1979) and as the "Krynica sandstones" within the "Ropianka beds" (Alexandrowicz *et al.*, 1984).

Name. After Życzanów (or Rzeczanów) village and stream near Rytro on the Poprad River (Figs 1, 3). The Życzanów Stream is a right tributary to the Poprad River. Polish name. Ogniwo życzanowskie (og).

Type section. Życzanów, canyon in the lower course of the Życzanów Stream (Oszczypko, 1973, fig. 4; Oszczypko & Porębski, 1985, fig. 88; 1986, fig. 50).

Reference sections. Łomnica Stream at Łomnica Zdrój and Wierchomla Stream at Wierchomla (Ostrowicka, 1979); right bank of the Dunajec River at Łącko, above boat-crossing (Oszczypko, 1979, fig. 2).

Thickness. From about 80 m at Życzanów Stream (Oszczypko, 1973; Oszczypko & Porębski, 1985, 1986) to about 300 m on the southern slopes of Radziejowa (according to Alexandrowicz *et al.*, 1984).

Dominant lithology. The member is formed of conglomerate-sandstone complexes of the Magura Formation sandstone lithotype separated by thin- to medium-bedded turbidite complexes of the Szczawnica Formation lithotype. The thickness of the sandstone-conglomerate complexes is up to 40 m, the intervening Szczawnica Formation-type turbidite complexes are maximum 20 m thick. Individual layers of conglomerate-sandstone sets are up to 5 m thick, their bases are sharp, with large flute and groove casts indicating sediment supply from E and SE. Bouma sequences T_{ab} dominante, more seldom are T_{abc}, the grain size varies from fine gravel down to medium sand. Clay clasts, sometimes "armoured", up to a dozen or so centimetres in diameter occur. Quartz is the dominant mineral, lithoclasts and feldspar are second in frequency, the matrix is calcareous.

Boundaries. *Lower boundary* sharp, placed at the bottom of a conglomeratic sandstone several metres thick, above thin- to medium-bedded

turbidites of the Szczawnica Formation lithotype. *Upper boundary* – transition from conglomeratic sandstone to thin- and medium-bedded turbidites of the Szczawnica Formation lithotype (Fig. 8D).

Age. Paleocene, after microfaunal assemblages (Oszczypko, 1973; Ostrowicka, 1979; Malata in Oszczypko *et al.*, in press); Lower Eocene, NP-10/11 Zone (Dudziak in Oszczypko *et al.*, in press).

Distribution. Mainly in the northern part of the Krynica Subunit, but traceable also in some areas of the southern part of this unit close to the Pieniny Klippen Belt.

Equivalents. "Krynica conglomerates and sandstones" *sensu lato* (Chrząstowski & Ostrowicka, 1978; Ostrowicka, 1979; Alexandrowicz *et al.*, 1984). In the Ochotnica Górna area, Gorce Range, a probable equivalent is represented by thick-bedded micaceous sandstones distinguished within the "inoceramian beds" by Sikora and Żytko (1968). In the Sącz (= Bystrica) Subunit and the Gorlice (= Rača) Subunit, the Życzanów Member finds its equivalents in thick-bedded sandstones of a higher part of the "inoceramian beds" (Ropianka beds). In the Bardejov area, Eastern Slovakia (Bystrica Subunit), our member may find an equivalent in the Tvarožec sandstone (Nemčok, 1980).

Remarks. Lenticular form of occurrence of the Życzanów Member (sandstone and conglomerate complexes) may be interpreted in terms of distributary channel sediment heralding the first appearance of coarse-clastic sedimentation of the Magura Formation-type sandstones (Oszczypko & Porębski, 1985, 1986).

ZARZECZE FORMATION

(new name)

History. The term "Zarzecze beds" has been introduced by Oszczypko (1979) for the flysch strata in the Krynica Subunit previously distinguished as the "upper *Paleodictyon* beds" (Nowak, 1924), "Beloveža beds" (Świdziński, 1953, 1972), "hieroglyphic beds" (Bogacz & Węcławik, 1969; Węcławik, 1969a,b; Oszczypko, 1973) or "sub-Magura beds" in the peri-Pieniny zone (Birkenmajer, 1960a, 1962b, 1963b,c; Birkenmajer & Dudziak, 1981; sheet Krościenko, 1965) and in the Pieniny Klippen Belt (Birkenmajer, 1960a,b, 1970, 1979; Birkenmajer & Pazdro, 1968).

Name. After Zarzecze village near Łącko on the Dunajec River where one of the best sections of this formation is exposed (Figs. 1, 4). Polish name. Formacja z Zarzecza (fm).

Type section. Steep right bank of the Dunajec River valley between Łącko and Zarzecze village (Oszczypko, 1979, Fig. 2).

Reference sections. Middle course of the Życzanów Stream near Rytro (Fig. 3), "Pod Skocznią" (below ski-jump) Stream at Krynica (Fig. 5A).

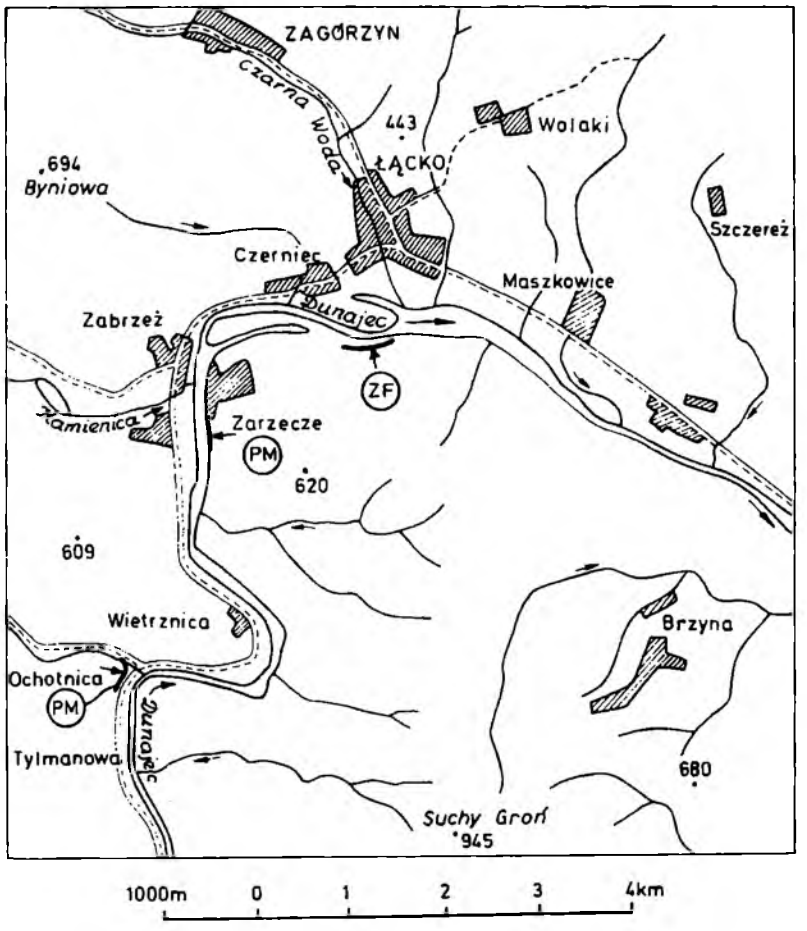


Fig. 4. Type and reference sections of the Piwniczna Sandstone Member (*PM*) and the Zarzecze Formation (*ZF*) in the Dunajec River Valley between Łącko and Ochotnica

Subdivision. The Krynica Member may be locally distinguished within the Zarzecze Formation (Fig. 8D-F, Tab. 1).

Dominant lithology. Alternating calcareous sandstones, siltstones and marly shales, grey-greenish, weathered to yellow-orange. The sandstone to shale ratio is 1:2 or 1:1. The sandstones are thin- and medium-bedded, fine- and very-fine-grained, with T_{abc} and T_{bc} Bouma sequences in the lower part of the unit, being replaced in the upper part by thin and very thin turbidites with T_c or, more seldom, T_{bc} types. The shales are silty, often resembling soft marls. Current markings and trace fossils are abundant, the clastic supply was from SE.

Conglomerates, pebbly mudstones and thick-bedded sandstones (Krynica Member) appear locally in the upper part of the formation.

Thickness. 10–80 m in the Pieniny Klippen Belt, 100–200 m in the peri-Pieniny zone of the Krynica Subunit on the west (Czorsztyn–Dębno), 20–30 m near Krościenko, completely disappearing near Jaworki–Biała Woda; growing to 600 m in the northern part of the Krynica Subunit (Fig. 8E).

Boundaries. *Lower boundary* – gradual transition to the Szczawnica Formation, placed within colour change from bluish and steel-grey (calcareous medium-bedded turbidites of the Szczawnica Formation) to grey-green

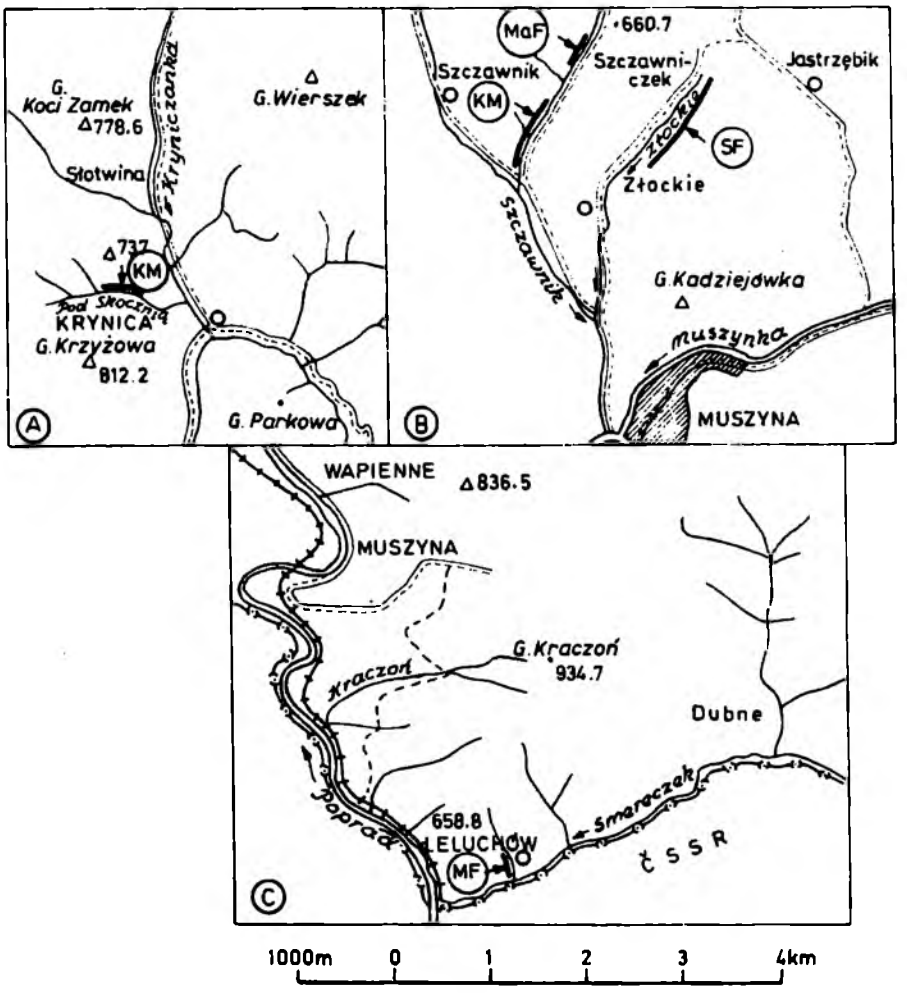


Fig. 5. Type and reference sections of the Krynica Member (*KM*), Malinowa Shale Formation (*MaF*), Malcov Formation (*MF*) and Szczawnica Formation (*SF*) in the Poprad River Valley

(thin-bedded turbidites of the Zarzecze Formation). *Upper boundary* — passage to the Magura Formation, placed at the transition from thin-bedded green-grey flysch to thick-bedded muscovite sandstones (Magura Formation).

Age. In the northern part of the Krynica Subunit the formation represents Lower Eocene, as based on foraminifera (Oszczypko, 1979; Malata, in Oszczypko *et al.*, in press); nannoplankton zones NP-10 through NP-13/14 (Dudziak, in Oszczypko *et al.*, in press). In the southern part of the Krynica Subunit, in the peri-Pieniny zone, the formation represents the Lower Eocene, NP-10 to NP-11 zones (Birkenmajer, & Dudziak, 1981). In the Pieniny Klippen Belt, the formation belongs to a lower part of Lower Eocene, NP-9/10 to NP-11 (lower part) zones (Birkenmajer & Dudziak, 1988b).

Distribution. The most extensive occurrence of the formation is in the northern part of the Krynica Subunit. To the south, in the southern part of the Krynica Subunit, in the peri-Pieniny zone, and the Pieniny Klippen Belt, the formation is strongly reduced in thickness and may altogether disappear, being replaced by the Piwniczna Sandstone Member of the Magura Formation.

In the Sącz (= Bystrica) Subunit, the Zarzecze Formation is replaced by variegated shales from Łabowa, and by thin-bedded flysch of the "Beloveža beds".

Equivalents. In the Krynica Subunit, northern and central parts – "Zarzecze beds", "hieroglyphic beds", "Beloveža beds", *pars* (see the History); in the Krynica Subunit, peri-Pieniny zone – "sub-Magura beds". The Frydman Formation is a partial age equivalent of the Zarzecze Formation, developed close to the Pieniny Klippen Belt between Czorsztyn and Frydman. In the Pieniny Klippen Belt – "sub-Magura beds". In Eastern Slovakia (Čerhov and Kochanovce zones), the "Beloveža beds" (Bystrická *et al.*, 1970) are a partial equivalent to the Zarzecze Formation of the northern part of the Krynica Subunit.

Remarks. The Zarzecze Formation is represented by thin-bedded distal turbidites interpreted as sediments of outer submarine fan (Oszczypko, 1979; Oszczypko, 1985, 1986); they are being replaced to the south by thick-bedded turbidites of the Magura Formation (deposits of middle fan and its lobes). To the north, in the Sącz Subunit, the Zarzecze Formation is being replaced by the "Beloveža beds", its lithofacies analogue, and by variegated shales from Łabowa, representing hemipelagic sediment of basin plain.

Krynica Member
(new name)

History. The "sandstones and conglomerates of Krynica" have been distinguished by Świdziński (1953, 1972) within the "Beloveža beds" of the Krynica Subunit. Analogous deposits have also been distinguished within the "hieroglyphic beds" by Mochnacka and Węcławik (1967) and Węcławik (1969a,b), and within the "transitional beds" by Oszczypko (1973).

A thick complex of the Krynica-type sandstones near Łącko has been included to the "Piwniczna beds" by Oszczypko (1979), and distinguished as the "Tylicz conglomerate" by Węcławik (1986). These units have been distinguished not only within various lithostratigraphic units of higher rank ("beds"), but also in various tectonic-facies subunits of the Magura Nappe. Węcławik (1969a,b) initially attributed them to the "transitional Tylicz subunit", and recently – to the southern part of the Sącz Subunit (Węcławik, 1986; Mochnacka & Węcławik, 1986), while Świdziński (1953, 1972), Oszczypko (1975, 1979), Alexandrowicz *et al.* (1984) and Cieszkowski and Oszczypko (1986) – to the Krynica Subunit.

Taking into account that the "Krynica conglomerates" occur within the Zarzecze Formation lithofacies but not within the Szczawnica Formation lithofacies, the Krynica Member has been distinguished in the Zarzecze Formation only (Oszczypko *et al.*, in press).

Name. After Krynica health-resort where this unit has been first distinguished and named, and is known from several good sections. Polish name. Ogniwo krynickie (og).

Type section. Krynica, right bank of the "Pod Skocznią" Stream, being the right tributary of the Kryniczanka Stream (Fig. 5A; see Świdziński, 1972, figs. 3, 5).

Reference sections. Łosie village, Łosiański Stream (Mochnacka & Węcławik, 1986); Tylicz, left bank of the Muszynianka Stream (Węcławik, 1969b); Zarzecze near Łącko (Oszczypko, 1979, Fig. 2).

Thickness. From a score or so metres near Słotwina, Krynica area, to 200 m at Zarzecze, and 400–500 m near Złockie and Jastrzębik.

Dominant lithology. Thick-bedded conglomerates, pebbly mudstones and thick-bedded sandstones alternating with thin complexes of thin-bedded green-grey turbidites. Individual pebbly mudstone beds, from 1 to 5–6 m thick, are often disturbed by submarine slumping. They consist of exotic pebbles, usually 1–10 cm in diameter, well rounded, discoidal or spherical, scattered in blue-grey sandy-silty-marly matrix.

The conglomeratic sandstones and coarse-grained sandstones occur usually as layers from one to several metres thick. Bouma's sequences T_{ab}, more seldom T_{abc}, are predominant. Maximum size of granules and fine pebbles does not exceed 1 cm. Medium- to fine-grained sand grades prevail in top parts of the layers, the matrix is of calcareous-silty type. The exotic material consists mainly of milky quartz, plutonic, effusive and metamorphic rocks, with a considerable admixture of carbonate Mesozoic rock fragments (Oszczypko, 1975). Current markings and imbrication of pebbles indicate clastic supply from SE.

Boundaries. *Lower boundary* sharp, placed at the base of coarse-clastic complex (often at the base of pebbly mudstone bed), above thin-bedded turbidites. *Upper boundary* – gradual transition from thick-bedded sandstones to thin-bedded turbidites (with a variegated shale intercalation at Zarzecze).

Age. Lower Eocene, as based on small foraminifera (Malata, in Oszczypko *et al.*, in press) and on calcareous nannoplankton: from the NP-10/11 Zone at Zarzecze, to the NP-13/14 Zone at Krynica (Dudziak, in Oszczypko *et al.*, in press).

Distribution. The Krynica Member is characteristic of the northern area of the Krynica Subunit. Towards the south, it probably interfingers with the Magura Formation (Piwniczna Sandstone Member). In the Sącz Subunit, the Krynica Member wedges out completely.

Equivalents. see History.

Remarks. The conglomerates and sandstones of the Krynica Member probably represent deposits of distributary channels within middle submarine fan which intermittently supplied coarser material to the outer fan deposits of thin-bedded turbidites.

FRYDMAN FORMATION

History. The unit has been distinguished by Birkenmajer (1954) as the "flysch beds of Frydman" (see also Birkenmajer, 1963c), later distinguished as the Frydman Formation (Birkenmajer, 1979; Birkenmajer & Dudziak, 1981), between Czorsztyn-Ciechorzyn and Frydman, along the Dunajec River Valley.

Name. After Frydman village on Polish Spisz (Figs. 2, 6). Polish name. Formacja frydmańska (fm).

Type section. Abandoned quarry near the road from Frydman to Falsztyn.

Reference sections. Exposures along the right bank of the Dunajec River between Frydman and Falsztyn (Błahuty), and along the left bank of this river between Ciechorzyn and Brzeziny near Czorsztyn (see Birkenmajer, 1963b, 1979; Birkenmajer & Dudziak, 1981, Figs. 2B, 3A).

Thickness. About 400 m.

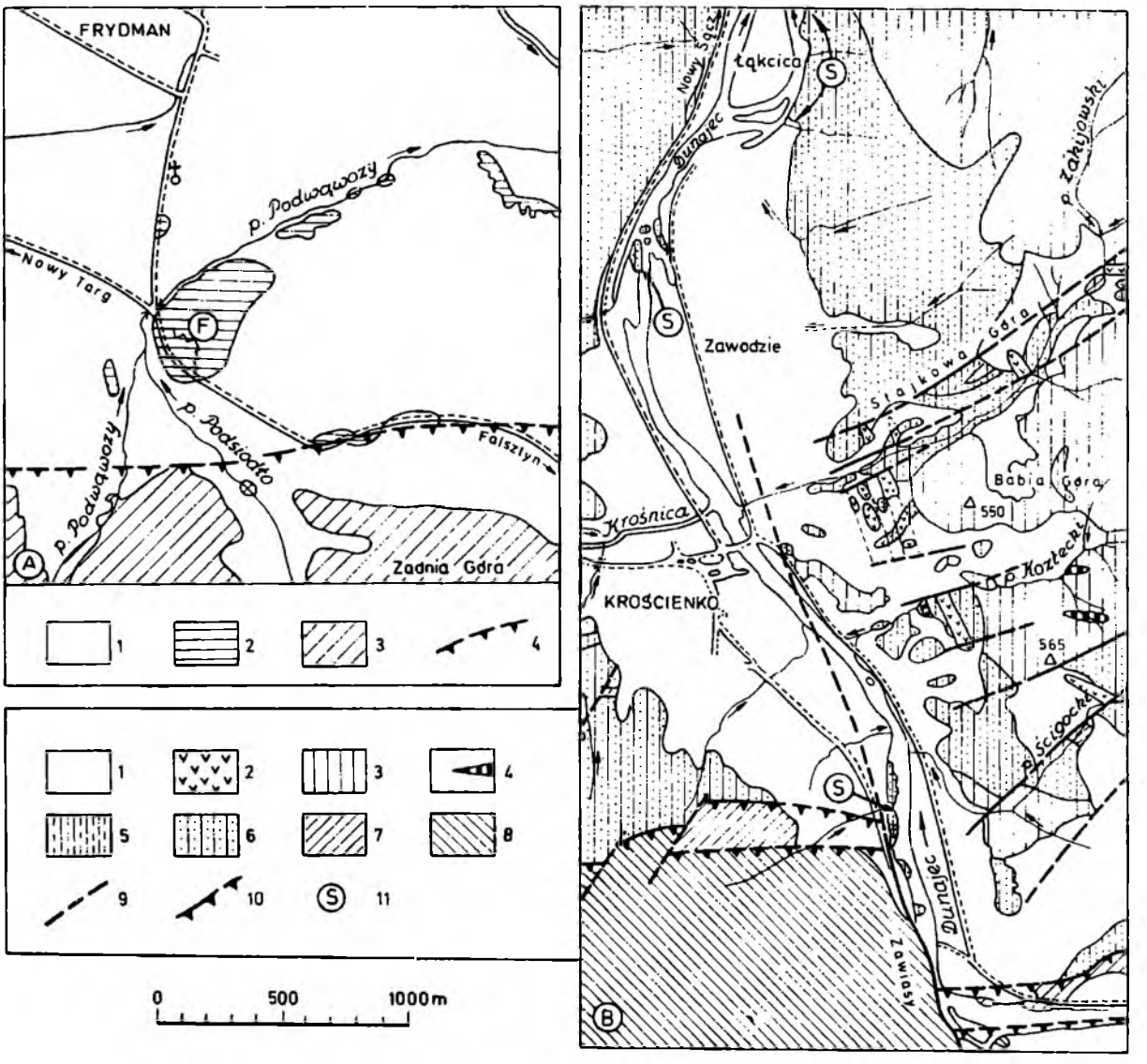


Fig. 6. A. Type section of the Frydman Formation (*F*) near Frydman. *1* — Quaternary cover. *2* — Frydman Formation; *3* — Grajcarek Unit of the Pieniny Klippen Belt; *4* — overthrust. **B.** Location of reference sections of the Szczawnica Formation in geological map of Krościenko (based on Birkenmajer, 1979). *1* — Quaternary cover; *2* — Miocene andesite intrusions; *3* — Magura Formation, Piwniczna Sandstone Member; *4* — Łącko marl intercalations; *5* — Zarzecze Formation-type intercalations within the Piwniczna Sandstone Member and Zarzecze Formation; *6* — Szczawnica Formation; *7* — Grajcarek Unit; *8* — Klippen Successions; *9* — main Tertiary faults; *10* — main Tertiary overthrusts; *11* — reference sections of the Szczawnica Formation

Dominant lithology. There is an alternation of lithotypes, one corresponding to the Szczawnica Formation lithotype, and the other to the Zarzecze Formation lithotype: greenish, medium- to thin-bedded, coarse, medium- to fine-grained sandstones alternate with greenish to bluish marly shales, with intercalations of bluish calcareous, medium- to fine-grained sandstones. There is a wealth of current markings indicating clastic supply from NE (in greenish sandstoness of the Zarzecze Formation lithotype) and from S (in bluish sandstones of the Szczawnica Formation lithotype), and of trace fossils. Graded layers are common, sometimes with large foraminifera at fine-conglomeratic soles, submarine slumping and convolutions may often be found.

Boundaries. *Lower boundary* against the Szczawnica Formation is transitional, but not well defined due to insufficient exposures. *Upper boundary* – tectonic against the northern boundary fault of the Pieniny Klippen Belt: originally probably transition to the Magura Formation.

Age. Middle part of the Lower Eocene, NP-11/12 and NP-12 zones (Birkenmajer & Dudziak, 1981). This age is also supported by large foraminifera determined by Bieda (in Birkenmajer, 1954): *Nummulites pernotus paraburdigalensis* Schaub, *Operculina couizaensis* Doncieux, *Discocyclina* sp. etc.

Distribution. The Frydman Formation occurs between Frydman and Czorsztyn along the northern border of the Pieniny Klippen Belt (see Birkenmajer, 1963b).

Equivalents. "Flysch beds of Frydman" (Birkenmajer 1954, 1963b).

Remarks. The Frydman Formation is a regional, peri-Pieniny sandstone-shale flysch corresponding to a peripheral zone of two overlapping fans: the Piwniczna Sandstone Member (southern part of the Krynica Subunit; Pieniny Klippen Belt) fed from the NE or E sources, and the Szczawnica Formation fan fed from the southern sources.

MAGURA FORMATION

(new name)

History. The name "Magura Sandstein" has been introduced by Paul (1868) for thick-bedded sandstone complex of the Oravská Magura Range (West Slovakia), and attributed to the Oligocene (Paul, 1869). As a result, many thick-bedded sandstones of supposedly Oligocene age were subsequently termed the "Magura sandstones" in the Outer (Flysch) Carpathians, e.g. those later distinguished as the "Krosno sandstones", "Istebna sandstones", "Czarnohora sandstones", etc., notwithstanding the fact that they differed from Paul's "Magura Sandstein" not only in lithology and petrographic characters, but also in age. Uhlig (1888) restricted the use of Paul's term to the inner part of the Western Flysch Carpathians ("Bergland"). Later, after the separation of the Magura Nappe by Limanowski (1905), the term "Magura sandstone" was

restricted to the youngest lithostratigraphic unit of this nappe only. Another term, based on the original denomination, but taking into account various subordinate lithologies, was the "Magura beds" (Świdziński, 1934a; Książkiewicz, 1935).

Two mutually intertonguing lithofacies have been distinguished within the "Magura sandstone" of the Polish Western Carpathians by Książkiewicz (1953, 1958a): a northern one – glauconitic, and a southern one – muscovite-bearing. The glauconitic facies of the "Magura sandstone" has also been recognized to the east of the Dunajec River valley (Sikora, 1960).

Since Nowak's (1924) geological studies in the Krynica area, it was apparent that considerable facies changes take place in the Magura Nappe, including the "Magura sandstone" as well. Four facies zones have been distinguished (Książkiewicz, 1948, 1958a; Świdziński, 1953, 1961a; Sikora, 1960, 1970; Sikora & Żytko, 1959; Węcławik, 1969a; Oszczypko, 1973), comparable to those recognized in Czechoslovak Carpathians (Matějka & Roth, 1950; Fusán *et al.*, 1963) and in Transcarpathian Ukraine (Čalyj, 1965), and shown in the tectonic map of the Carpatho-Balkan area (see Koszarski *et al.*, 1974). These are, from north to south: the Siary (= northern Gorlice) Subunit; the Rača (= southern Gorlice) Subunit; the Bystrica (= Sącz) Subunit, and the Krynica Subunit.

In the Siary Subunit, the "Magura sandstone" is developed in glauconitic facies (eastern part) or as a mixed glauconitic-muscovite facies (western unit). In the remaining subunits of the Magura Nappe the muscovite facies occurs. The base of the sandstone unit is diachronous, being the oldest in the Krynica Subunit and the youngest in the Gorlice Subunit (Bieda *et al.*, 1963, 1967; Sikora, 1970; Oszczypko, 1973, 1979). The muscovite facies was fed from a source situated on SE, while the glauconite facies – from the NE and N sources (Książkiewicz, ed., 1962). The "Magura sandstones" of the Krynica Subunit and the southern part of the Sącz Subunit, belong to the same facies zone, and were fed by the same sources; their relation to the "Magura sandstone" (muscovite facies) of the Rača Subunit has not been solved: it is possible that these two lithosomes were separated in the northern part of the Sącz Subunit by the Łącko marl lithofacies (see Oszczypko *et al.*, in press). This was one of the reasons to restrict our lithostratigraphic standard to the Krynica Subunit, at the present state of investigation.

Name. After Oravská Magura in West Slovakia (cf. Paul, 1869; Potfaj, 1983, fig. 2). Polish name: Formacja magurska (fm).

Type area. Oravská Magura (Czechoslovakia), Gorce and Beskid Sądecki ranges (Poland) – Fig. 1.

Type section (Poland). "Baszta" Crag, at the outlet of the Ochotnica Stream to the Dunajec River, at Tylmanowa (Figs 1, 4). See Oszczypko and Porębski (1985, figs 89, 90; 1986, figs 53, 54).

Reference sections. Zabrzeź on the Dunajec River (Oszczypko, 1979), middle part of the Życzanów Stream (Oszczypko, 1973, fig. 4).

Thickness. 2000–2500 m (Cieszkowski & Oszczypko, 1986).

Subdivision. In the Krynica Subunit, the Magura Formation is subdivided into the Piwniczna Sandstone Member, the Mniszek Shale Member and the Poprad Sandstone Member (Fig. 8).

Dominant lithology. Massive, thick-bedded muscovite sandstones predominate (Piwniczna Sandstone Member, Poprad Sandstone Member), with subordinate intercalations of thin-bedded turbidites (resembling the Zarzecze Formation facies), Łącko marls, conglomerates (pebbly mudstones), and variegated shales (Mniszek Shale Member).

The thick-bedded sandstones usually form layers 0.7–2.0 m thick, less frequently they amalgamate into 5–7-m thick units or form even thicker massive zones 15–20 m thick. These sandstones are either devoid of, or alternate with, thin shale intercalations: the ratio of sandstone to shale being in the latter case 10 : 1. The sandstones are often separated by thin-bedded flysch complexes up to 5 m thick, with sandstone: shale ratio 1 : 1. The sandstones grades vary from fine gravel to very fine sand. The thick-bedded sandstone sets consist mainly of the T_{abc} or T_{ab} turbidites, while T_{bc} type is dominating in thin-bedded flysch intercalations.

The sandstones consist of quartz, feldspar, lithoclasts, muscovite and chlorite, their matrix is calcareous-illitic or illitic. Current markings present mainly in or nearby thin-bedded flysch intercalations, indicate clastic supply from SE and S. Submarine slumps and pebbly mudstones often occur (see Książkiewicz 1958b; Oszczypko, 1975).

Boundaries. *Lower boundary* – transition to underlying thin-bedded flysch (Fig. 8D-F) of the Zarzecze Formation (northern part of the Krynica Subunit and some parts of the peri-Pieniny zone of this subunit, moreover Pieniny Klippen Belt), or to the Szczawnica Formation (peri-Pieniny zone), placed at the bottom of the first massive sandstone complex. *Upper boundary* sharp against variegated marls of the Leluchów Marl Member, or transitive to the flysch development of the Malcov Formation.

Age. Lower Eocene in the Pieniny Klippen Belt and the peri-Pieniny area of the Krynica Subunit, NP-10/11 Zone (Birkenmajer & Dudziak, 1981); higher Lower Eocene (Oszczypko *et al.*, in press), in the north-eastern part of the Krynica Subunit, up to Upper Eocene (NP-20 Zone) at the top of the Formation.

Distribution. In Poland – mainly Beskid Sądecki, Gorce and Beskid Wysoki ranges, moreover Beskid Wyspowy Range. Distinguishable, moreover, in the West and East Slovak, Transcarpathian Ukraine and Romanian parts of the Outer Carpathians.

Equivalents: In Poland – see History (mainly muscovite sandstone facies of the "Magura sandstone"). In East Slovakia – "Zborov beds" in the Rača Subzone (Stránik & Hanzliková, in Mahel & Buday, ed., 1968); "Makovica sandstone", Rača Subzone (Nemčok, 1961); "Strihov beds", Čerhov or Kochanovce Subunit (Leško & Samuel, 1968; Bystrická, *et al.*, 1970).

Piwniczna Sandstone Member

(new name)

History. The term "sandstones from Piwniczna" has been introduced by Ostrowicka (1966, 1979) for thick-bedded Magura-type sandstones below Mid-Eocene variegated shales with *Cyclammina amplectens* (Grzybowski).

Name. After Piwniczna health-resort in the Poprad River valley (Figs 1, 7).

Polish name. Ogniwo piaskowca z Piwnicznej (og).

Type locality and area. Abandoned quarry at right bank of the Łomnicki Stream at Łomnica-Zdrój near Piwniczna, and slope exposures along left bank of the Poprad River above railway bridge at Hanuszów (Fig. 7; see Ostrowicka, 1979).

Reference sections. Right bank of the Dunajec River at Zabrzeż (Oszczypko, 1979); "Baszta" Crag at Tylmanowa, at the outlet of the Ochotnica Stream to the Dunajec River (Oszczypko & Porębski, 1985, 1986); Krupianka-Ubocz hills near Jaworki, Pieniny Klippen Belt (Birkenmajer & Pazdro, 1968; Birkenmajer, 1970, 1979; Birkenmajer & Dudziak, 1981).

Thickness. 800–1500 m in the Krynica Subunit (Cieszkowski & Oszczypko, 1986); about 400 m in the Pieniny Klippen Belt (Birkenmajer & Pazdro, 1986; Birkenmajer, 1970, 1979).

Dominant lithology. In the Poprad River valley, the member typically begins with conglomerates, thick-bedded sandstones and pebbly mudstones.

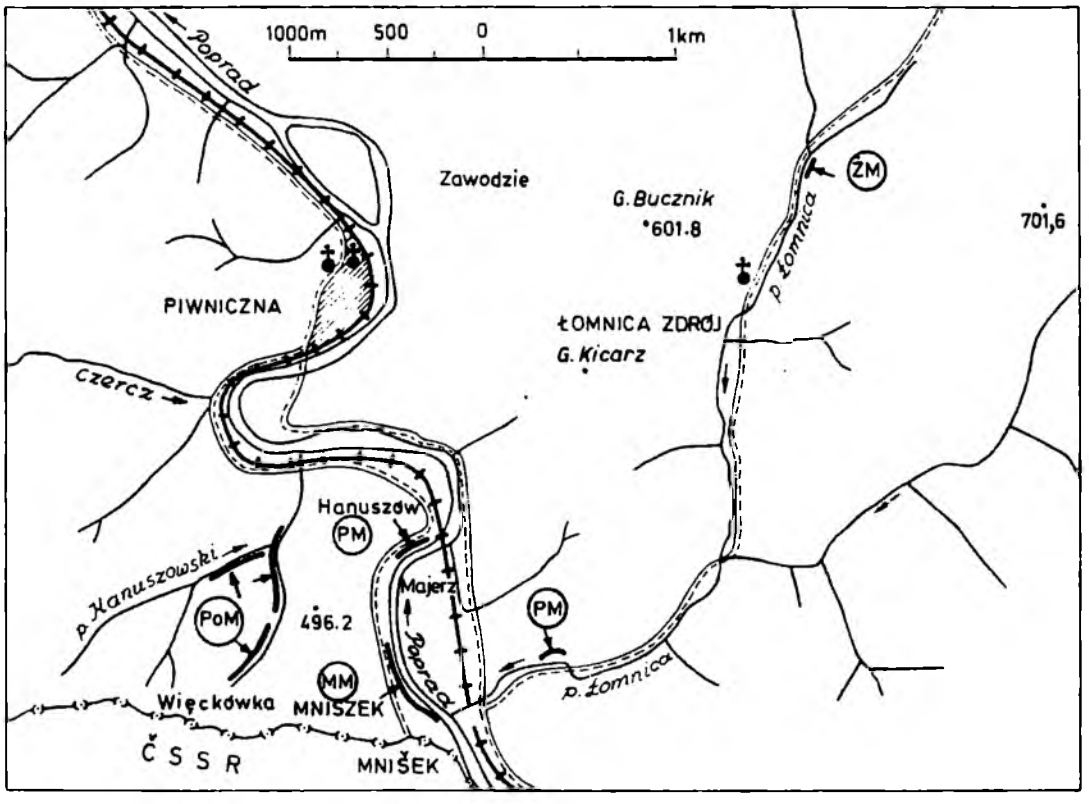


Fig. 7. Type and reference sections of the Piwniczna Sandstone Member (*PM*), Poprad Sandstone Member (*PoM*), Mniszek Shale Member (*MM*) and the Życzanów Member (*ŻM*) in the Poprad River Valley near Piwniczna

They are weathering-resistant ("Marszałek bed" of Alexandrowicz & Kutyba, 1979; Alexandrowicz *et al.*, 1984). There follow sets of thick-bedded sandstones 20–25 m thick, usually separated with 5–8-m thick sets of thin-bedded turbidites lithologically resembling the Zarzecze Formation. The thick-bedded sets consist of sandstone layers 0.7–1.5 m thick, sometimes conglomeratic, usually fine- to medium-grained, often massive, structureless (homogenous). Graded bedding is marked usually only in the bottom part of the layers, while parallel lamination and ripple cross-lamination – in the top part. Large-scale traction current structures are sporadic (Oszczypko & Porębski, 1985, 1986). Thicker layers are usually amalgamated sandstones; intraclasts and large load-casts are often observed. Lower boundaries of sandstone layers are sharp, their soles being covered with large current markings (flute and drag casts). The clastic material was supplied from S and SE. Petrographic composition of the sandstones includes quartz (dominant), feldspar, lithoclasts, muscovite and illite, the matrix is calcareous-illitic or illitic. Conglomerate and pebbly mudstone intercalations with exotic pebbles (Jaksa-Bykowski, 1925; Oszczypko, 1975) occur sometimes. The sandstone : shale ratio is 15 : 1 in thick-bedded sandstone sets, and 1.5 : 1 to 3 : 1 in thin-bedded flysch intercalations (Oszczypko & Porębski, 1985, 1986).

Boundaries. *Lower boundary* – transition to thin-bedded flysch of the Zarzecze Formation or the Szczawnica Formation, placed at the base of the first massive sandstone complex. *Upper boundary* – placed at the first appearance of variegated shale of the Mniszek Shale Member.

Age. Lower Eocene in the Pieniny Klippen Belt and the peri-Pieniny area of the Krynica Subunit, NP-10/11 Zone (Birkenmajer & Dudziak, 1981); higher Lower Eocene in the Dunajec River valley, NP-12 Zone (Birkenmajer & Dudziak, 1981); highest Lower Eocene in the north-eastern part of the Krynica Subunit, about NP-13/14 Zone, up to lower part of the Upper Eocene (Zone NP-18). (Oszczypko *et al.*, in press).

Distribution. Gorce and Beskid Sądecki ranges; Pieniny Klippen Belt (Małe Pieniny Range) in Poland; Oravská Magura Range in West Slovakia (Potfaj, 1983); Čerhovské Pohorie Range in Eastern Slovakia (Leško & Samuel, 1968; Bystrická *et al.*, 1970).

Equivalents. "Magura sandstone" in the Pieniny Klippen Belt and the peri-Pieniny zone in Poland (Birkenmajer & Pazdro, 1968; Birkenmajer, 1963b, c, 1970, 1979; Birkenmajer & Dudziak, 1981), "Piwniczna sandstone" in the peri-Pieniny zone (Birkenmajer, 1985, 1986); "Čerhov sandstone" (Nemčok, 1970) and "Strihov beds" (Leško & Samuel, 1968; Nemčok, Koráb & Ďurkovič, 1968) in East Slovakia; a part of the "Magura sandstone" (or "beds") in the literature pertaining to the Krynica Subunit of the Magura Nappe.

The sandstones and marls of the "Maszkowice beds" occupy a stratigraphically similar position in the Sącz Subunit (see Oszczypko *et al.*, in press).

Remarks. The Piwniczna Sandstone Member is interpreted as deposited in distributary channels and lobes of a middle submarine fan (Oszczypko & Porębski, 1985, 1986).

Mniszek Shale Member

(new name)

History. Ostrowicka (1966) has distinguished variegated shales with *Cyclammina amplectens* (Grzybowski) within the "Magura beds" of the Piwniczna area. This allowed to separate the lower "Piwniczna sandstone" (see above) from the upper "Magura sandstone" (see also Ostrowicka, 1979; Alexandrowicz *et al.*, 1984) – now the Poprad Sandstone Member (this paper). The variegated shales have also been distinguished in an upper part of the Krynica Subunit (Čerhov or Kochanovce Subunits) of Eastern Slovakia by Bystrická *et al.* (1970).

Name. From Mniszek (Mnišek) on the Poprad River near Piwniczna (see Ostrowicka, 1979). Polish name. Ogniwo łupków z Mniszka (og).

Type locality. Exposure in steep left bank of the Poprad River at Mniszek (Mnišek) – Fig. 1, 7.

Reference sections: Piwniczna-Hanuszów, left bank of the Poprad River above railway bridge; Hanuszów Stream at Piwniczna (see Ostrowicka, 1979).

Thickness. About 80 m (Ostrowicka, 1979).

Boundaries. *Lower boundary* accepted at the base of the first red shale intercalation, above massive thick-bedded sandstones of the Piwniczna Sandstone Member. *Upper boundary* – above the last intercalation of variegated shale, at the bottom of thick-bedded sandstones of the Poprad Sandstone Member (Fig. 8A,C).

Age. Middle Eocene, as based on foraminifera (Ostrowicka, 1979). The shales yielded a characteristic small foraminifera association with *Cyclammina amplectens* (Grzybowski), generally regarded as Middle Eocene in age (Bieda *et al.*, 1963, 1967). The nannoplankton obtained from the topmost part of the Piwniczna Sandstone Member, just below variegated shale, at Milik, indicates a lower part of Upper Eocene, NP-18 Zone (Dudziak, in Oszczypko *et al.*, in press).

Dominant lithology. Red and green, usually non-calcareous argillaceous shales, forming stripes and beds up to 1.5 m thick within thick-bedded, variably grained sandstones (with clay interaclasts), with sporadic medium-bedded sandstone layers.

Distribution. The Mniszek Shale Member occurs locally in the Krynica Subunit of the Beskid Sądecki and Gorce ranges, moreover in equivalent zones of Eastern and Western Slovakia.

Equivalents. Variegated shales with *Cyclammina amplectens* (Oszczypko, 1973, 1979; Alexandrowicz *et al.*, 1984), "higher variegated shales" with *C. amplectens* (Ostrowicka, 1979); a part of "transitional beds" in the Oravská Magura Range (Potfaj, 1983).

An age equivalent of the Mniszek Shale Member may be represented in the western part of the Gorce Range by the "shale beds (member) of Kowaniec" (Cieszkowski, 1979; Alexandrowicz *et al.*, 1984).

In the Sącz Subunit, the Mniszek Shale Member includes variegated shales with *Cyclammina amplectens* (Bogacz & Węcławik, 1969; Węcławik, 1969a,b; Oszczypko, 1973) known also as the "Jazowsko beds (member)" – see Oszczypko (1979).

Remarks. The variegated shale sedimentation corresponds to hemipelagic conditions below CCD with lowered rate of turbidite influx, in the central part of the Magura Basin.

Poprad Sandstone Member

(new name)

History. Since the discovery of variegated shales with *Cyclammina amplectens* (presently, the Mniszek Shale Member) within the "Magura beds" by Ostrowicka (1966), the sandstone complex above the shales was known as the "Magura sandstone *s.s.*" (Ostrowicka, 1979; Oszczypko, 1979; Alexandrowicz *et al.*, 1984; Cieszkowski & Oszczypko, 1986). Another informal name proposed for this lithostratigraphic unit in the Gorce Range was the "Lubań sandstone member" (Oszczypko & Węcławik, 1987). However, as no variegated shales with *Cyclammina amplectens* are known from the Mount Lubań section, it is not certain whether these sandstones really belong to an upper part of the Magura Formation or still represent the Piwniczna Sandstone Member. The "Lubań sandstone member" is thus treated as an informal name, not taken into account in the present standard.

Name. After Poprad River. Polish name. Ogniwo piaskowca popradzkiego (og).

Type locality. Więckówka hamlet at Hanuszów near Piwniczna on the Poprad River (see Ostrowicka, 1979, Fig. 1).

Reference sections. Upper part of the Hanuszów Stream near Piwniczna (Fig. 7).

Thickness. 200–300 m (see Ostrowicka, 1979; Bystrická *et al.*, 1970; Oszczypko *et al.*, in press).

Dominant lithology. Thick-bedded, variably grained sandstones, sometimes conglomeratic, light-grey, weathering yellowish. Graded bedding T_a dominates, higher members of the Bouma sequence occur more seldom. The sandstone layers, up to 3 m thick, alternate with olive-green shales 5–15 cm thick, wedging-out within amalgamated sandstone beds. Sets of thick-bedded sandstones up to a dozen or so metres thick alternate with sets of thin-bedded turbidites about 5 m thick.

The sandstones consist mainly of quartz, with subordinate feldspars, lithoclasts and muscovite flakes (Ostrowicka, 1979). Some layers are disturbed by submarine slumping. The clastic material was supplied from S and SE sources.

Age. Upper Eocene (see Oszczypko *et al.*, in press).

Boundaries. *Lower boundary* sharp, placed at the last variegated shale

intercalation of the Mniszek Shale Member. Upper boundary sharp against variegated marls of the Leluchów Marl Member (Fig. 8A).

Distribution. The Poprad Sandstone Member has been recognized best in the Krynica Subunit of the Magura Nappe. Its equivalents could be recognized also in more northern subunits of the Magura Nappe.

Equivalents. Upper part of the "Magura sandstones" of the Krynica Subunit in various publications; higher part of "Strihov beds" in Eastern Slovakia (Bystrická *et al.*, 1970). In the Gorlice (= Rača) Subunit, the Poprad Sandstone Member is represented by the "Magura sandstones (beds) of muscovite facies".

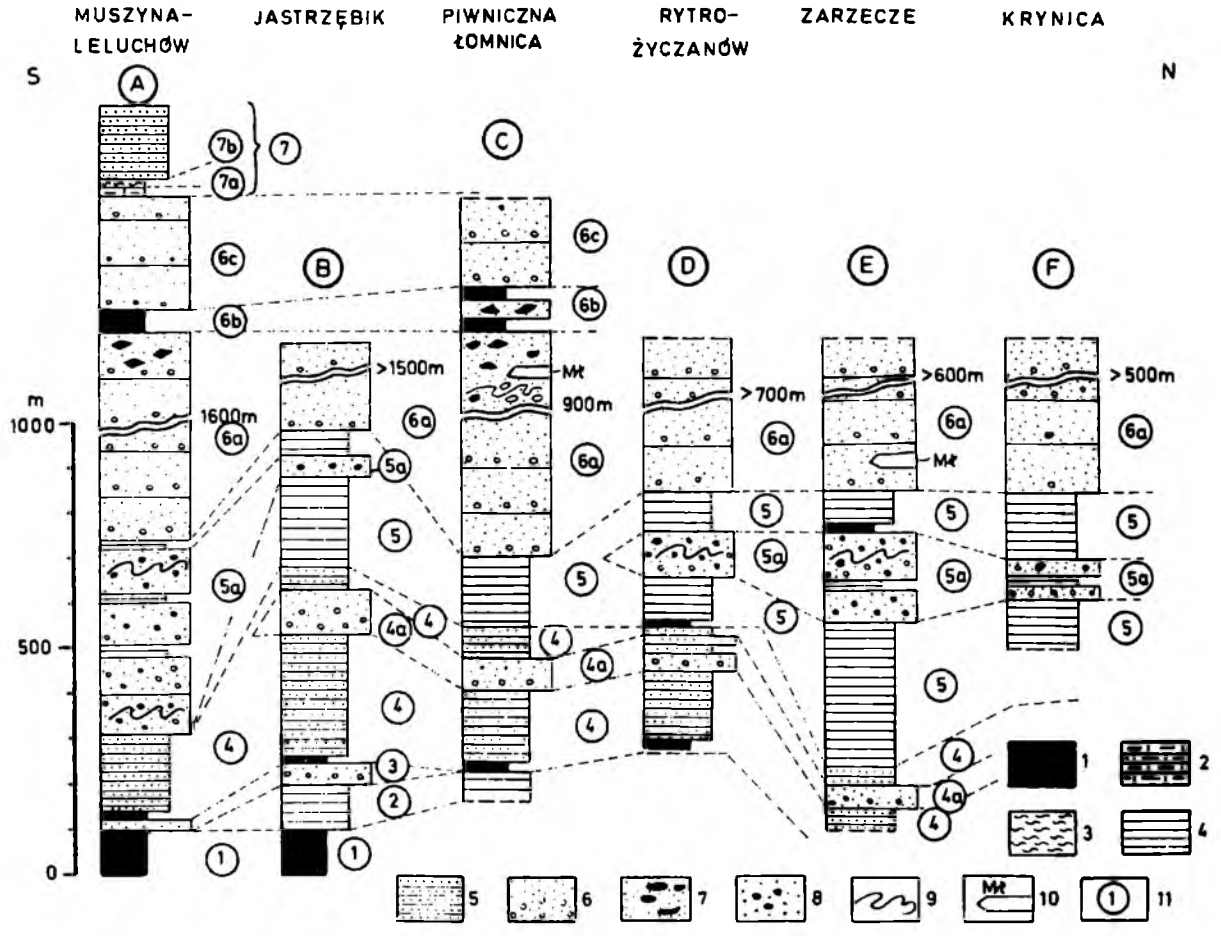


Fig. 8. Lithostratigraphical columns of the Krynica Subunit of the Magura Nappe in the Beskid Sądecki Range. Lithology: *1* — variegated shales; *2* — variegated marls; *3* — menilite shales with cherts; *4* — thin- and very thin-bedded turbidites; *5* — thin- and medium-bedded turbidites: *6* — thick-bedded turbidites (thick-bedded sandstones, variably grained, sometimes conglomeratic); *7* — thick-bedded sandstones with clayshale intraclasts; *8* — pebbly mudstones with exotic rock fragments; *9* — submarine slumps; *10* — Łącko marl intercalations; *11* — Lithostratigraphic units distinguished (*1* — Malinowa Shale Formation; *2* — Hałuszowa Formation; *3* — Jarmuta Formation; *4* — Szczawnica Formation; *4a* — Życzanów Member; *5* — Zarzecze Formation; *5a* — Krynica Member; *6* — Magura Formation; *6a* — Piwniczna Sandstone Member; *6b* — Mniszek Shale Member; *6c* — Poprad Sandstone Member; *7* — Malcov Formation; *7a* — Leluchów Marl Member; *7b* — Smereczek Shale Member)

MALCOV FORMATION

(redefined unit)

History. Świdziński (1934) has distinguished near Bardejov, Eastern Slovakia, variegated marls, menilite shales and Krosno-type beds, later (Świdziński, 1961a,b) attributed to the newly-created "Richvald series" or "Leluchów series" believed to represent tectonic windows (Bardejov, Malcov, Plaveč and Leluchów) in the Magura Nappe. Another opinion was expressed by Książkiewicz and Leško (1959) and Nemčok (1961) who attributed the above complex to the youngest elements of the Magura Nappe succession. As follows from further investigations in East Slovakia and in Poland (Oszczypko, 1973; Blaicher & Oszczypko, 1974), the variegated *Globigerina* marls and overlying flysch complex of the "Malcov beds", represent a stratigraphic superstratum of the "Magura sandstone" (i.e. of the Poprad Sandstone Member of the present paper). This is also supported by recent investigations by Potfaj (1983), Cieszkowski (in Birkenmajer, ed., 1985, 1986) and Cieszkowski and Olszewska (1986).

Name. After Malcov on the Toplá River, East Slovakia. Polish name. Formacja malcowska (fm).

Type area. Malcov on the Toplá River, East Slovakia.

Reference sections: In Poland – exposure in road cutting at Leluchów above orthodox-church (Figs. 1, 5C); left bank of the Dunajec River at Samorody near Nowy Targ (Cieszkowski, 1985, 1986; Cieszkowski & Olszewska, 1986); Biegonice near Nowy Sącz (Oszczypko, 1973).

Thickness. About 400–500 m (Świdziński, 1961b; Nemčok, 1961; Bystrická, *et al.*, 1970); 600–800 m (Cieszkowski & Olszewska, 1986).

Subdivision. The Leluchów Marl Member is locally distinguishable at the base of the Malcov Formation; the Smereczek Shale Member is locally distinguishable in the lower part of the Malcov Formation, above the Leluchów Marl Member (Figs. 8A, 9).

Dominant lithology. Thin- and medium-bedded, fine- and medium-grained muscovite sandstones, grey and blue-grey, alternating with grey marly shales. Horizontal and ripple cross-lamination dominate in the sandstones, carbonized plant detritus often appears in top parts of sandstone layers. Ankerite concretions may occur in the shales. The sandstone to shale ratio is 1:3. Locally, there appear intercalations of thick-bedded Magura-type sandstones, especially near Nowy Targ (see Cieszkowski & Olszewska, 1986). Variegated marls (Leluchów Marl Member) and menilite-type shales (Smereczek Shale Member) appear locally in the Malcov Formation in the Krynica Subunit.

Boundaries. *Lower boundary* sharp in case of appearance of basal variegated marls and shales (Leluchów Marl Member) and menilite-type shales (Smereczek Shale Member). *Upper boundary* erosional.

Age. Lower Oligocene according to foraminiferal assemblages from the

Krynica Subunit (Malata, in Oszczypko *et al.*, in press); uppermost Eocene and Lower Oligocene (?) as based on foraminifera in the area of Nowy Targ (Cieszkowski & Olszewska, 1986). Probably NP-21 Zone (Lower Oligocene) (Birkenmajer & Dudziak, 1988a); uppermost Upper Eocene, NP-19/20 Zone at Nowy Sącz (Dudziak, in Oszczypko *et al.*, in press). A considerable share of recycled Cretaceous and Palaeogene foraminifera (Cieszkowski & Olszewska, 1986) and of calcareous nannoplankton (Paleocene and Eocene forms – see Birkenmajer & Dudziak, 1988a) in these strata, makes age determination difficult: the youngest taxa are the only reliable age indicators.

The base of the Malcov Formation has been determined as the Eocene-Oligocene boundary, based on planktonic foraminifera of the Leluchów Marl Member and as Lower Oligocene, based on foraminiferal assemblage from menilite-type shales of the Smereczek Shale Member.

Distribution. Krynica Subunit of the Magura Nappe in the vicinity of Leluchów and Nowy Targ in Poland; Oravská Magura Range (Orava Subunit)

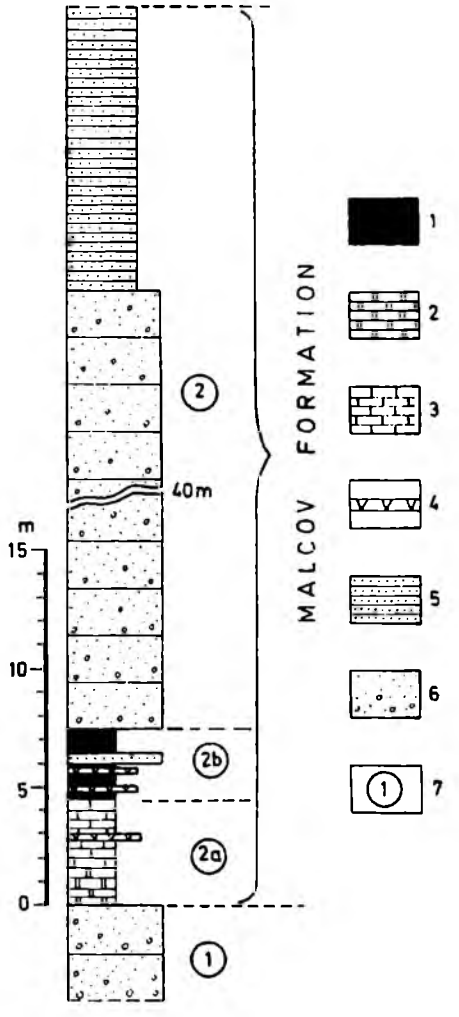


Fig. 9. Lithostratigraphic column of the Krynica Subunit of the Magura Nappe at Leluchów on Poprad. Lithology: *1* – menilite shales with cherts; *2* – red marls; *3* – olive-grey marls; *4* – tuffite intercalations; *5* – thin- and medium-bedded turbidites; *6* – thick-bedded sandstones; *7* – lithostratigraphic units distinguished (*1* – Poprad Sandstone Member; *2* – Malcov Formation; *2a* – Leluchów Marl Member; *2b* – Smereczek Shale Member)

in West Slovakia (Potfaj, 1983); Sącz Subunit near Bardejov in East Slovakia (Nemčok, 1961, 1980); Gorlice Subunit near Nowy Sącz (Oszczypko, 1973).

Equivalents. The age equivalents in the western part of the Gorlice (= Rača) Subunit are represented by the "supra-Magura beds" (lower part of Lower Oligocene, NP-21 Zone – Birkenmajer & Dudziak, 1988a). The age, and partly facies equivalents in other areas of the Outer (Flysch) Carpathians are represented by the "Krosno-menilite series", and in Central Carpathians – by a part of the Podhale Flysch (Upper Eocene – Lower Oligocene).

Leluchów Marl Member

(new name)

History. See the Malcov Formation.

Name. After Leluchów on the Poprad River (Fig. 5C). Polish name. Ogniwo margli leluchowskich (og).

Type locality. Road-cutting above orthodox-church at Leluchów on the Poprad River (Świdziński, 1961a, Fig. 1).

Reference sections. Richvald near Bardejov, East Slovakia (Świdziński, 1961b); Malá Domasa near Humenné, East Slovakia (Bystrická *et al.*, 1970).

Thickness. 4 m (Fig. 9).

Dominant lithology. Marls, red at the bottom, grey-green (sometimes with red streaks) in the upper part, moreover grey and olive-green marls.

Boundaries. *Lower boundary* sharp against massive sandstones of the Poprad Sandstone Member. *Upper boundary* sharp against menilite-type shales of the Smereczek Shale Member.

Age. Uppermost Eocene–Oligocene (Malata, in Oszczypko *et al*, in press), based on very rich planktonic foraminifera characteristic of the so-called "submenilitic *Globigerina* marls" in the Outer Carpathians (Blaicher & Sikora, 1967; Olszewska 1983).

Distribution. Krynica Subunit (Čerhov or Kochanovce Subunit) in Eastern Slovakia, and Leluchów on the Poprad River in Poland; Sącz (Bystrica) Subunit near Bardejov, East Slovakia (Świdziński, 1961b; Nemčok, 1961); Gorlice (= Rača) Subunit near Nowy Sącz (Oszczypko, 1973; Oszczypko, 1985).

Equivalents. In the Polish Outer Carpathians: "submenilite *Globigerina* marls" (Bieda *et al.*, 1963; Olszewska, 1984); "variegated shales of Niemcowa" near Piwniczna (Alexandrowicz *et al.*, 1984) in the Krynica Subunit of the Magura Nappe. This is a characteristic chronostratigraphic correlation horizon of pelagic sediments in the Outer Carpathians (see Van Couvering *et al.*, 1981).

Smereczek Shale Member

(new name)

History. These menilite-type shales have been known within the Malcov Formation of the Magura Nappe since investigations by Świdziński (1934b,

1961a,b), Książkiewicz and Leško (1959), Nemčok (1961) and Bystrická *et al.* (1970).

Name. After Smereczek Stream at Leluchów, right tributary of the Poprad River. Polish name. Ogniwo łupków ze Smereczka (og).

Type locality. Road-cutting at Leluchów, above orthodox-church (Figs 1, 5C).

Reference sections. Bardejov area in East Slovakia.

Thickness. 3 m (Fig. 9).

Dominant lithology. Black or brownish bituminous, sometimes siliceous, shales, with thin (up to 1.5 cm) chert bands and with two tuffite intercalations (Blaicher & Sikora, 1967), moreover with a 50-cm thick graded sandstone intercalation (Fig. 9).

Boundaries. *Lower boundary* sharp against olive-green marls of the Leluchów Marl Member. *Upper boundary* sharp against thick-bedded sandstones of the Malcov Formation (Fig. 9).

Age. Lower Oligocene as based on foraminiferal assemblages (Malata, in Oszczypko *et al.*, in press).

Distribution. As the Malcov Formation, especially in the areas of Leluchów, Malcov, Bardejov, Raslavice, Giraltovce (see Świdziński, 1961a,b; Nemčok, 1961; Bystrická *et al.*, 1970).

Equivalents: Menilite shales of Outer Carpathians (cf. Bieda *et al.*, 1963).

Remarks. The sedimentation of the menilite-type shales in the Carpathians is related to euxinic conditions within the flysch basin.

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Streszczenie

JEDNOSTKI LITOSTRATYGRAFICZNE KREDY I PALEOGENU PODJEDNOSTKI KRYNICKIEJ PŁASZCZOWINY MAGURSKIEJ, KARPATY

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W pracy przedstawiono formalny schemat litostratygraficzny utworów kredy i paleogenu podjednostki krynickiej płaszczowiny magurskiej w Karpatach Zachodnich. Utwory kredowe i dolnopaleogeńskie należą do grupy Grajcarka (gr) i składają się z następujących formacji: hulińskiej (fm), łupków z Malinowej (fm), hałuszowskiej (fm) i jarmuckiej (fm), (por. Birkenmajer, 1977). Osady przypadające na okres od środkowego paleocenu po wczesny oligocen włącznie (głównie utwory fliszowe) reprezentują grupę beskidzką (gr), która składa się z następujących formacji: szczawnickiej (fm), z Zarzecza (fm), frydmańskiej (fm), magurskiej (fm) i malcowskiej (fm); w grupie tej wyróżniono osiem formalnych ogniw litostratygraficznych. Jednostki litostratygraficzne grupy beskidzkiej (gr) są jednostkami nowymi lub redefiniowanymi.