GEOLOGICA CARPATHICA, 43, 6, DECEMBER, BRATISLAVA 1992
339 - 346

MARINE MIOCENE DEPOSITS NEAR NOWY TARG, MAGURA NAPPE, FLYSCH CARPATHIANS (SOUTH POLAND)

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(Manuscript received May 7, 1992; accepted in revised form September 16, 1992)

Abstract: New exposures of marine Miocene deposits in the area of Nowy Targ, have recently been discovered. Four new lithostratigraphic units, being younger than both the Magura and Malcov Beds of the Magura Series, have been distinguished there. The lowermost flysch unit is Oligocene - Lower Miocene in age, whilst the overlying flysch and two molassic units represent the Middle Miocene. Their age is documented by assemblages of foraminifers, calcareous nannoplankton and radiolarians. Steeply dipping, marine Miocene beds display tectonic contact with the Pieniny Klippen Belt. The sediments discussed were deposited in a piggy-back basin formed in the southern part of the Magura Basin. Subsequent folding of the Magura Nappe and intensified thrusting at the Badenian/Sarmatian boundary or later led to regression of the Miocene sea and closing of the basin. At the same time, the last tectonic stage, forming the structual contact between the Pieniny Klippen Belt and the Magura Nappe took place. The origin of the Orava-Nowy Targ intramontane basin, controlled by the beginning of freshwater Neogene sedimentation in it, had to take place in, or after the late Middle Miocene.

Key words: marine Miocene deposits, Magura Series, microfauna and nannoplankton, Middle Miocene, piggy-back basin, Orava-Nowy Targ intramontane basin.

Introduction

At the beginning of this century marine Miocene deposits were described from the Nowy Targ area (Podhale region) by Friedberg (1906). He found them south of Nowy Targ, in Szaflary village, in an artificial cross-cut forming the entrance to a quarry. These Miocene deposits were in contact with the Jurassic crinoidal limestones of the Pieniny Klippen Belt. He found that these are marine clays and their Miocene age was based on a few examples of foraminifers and ostracodes. Friedberg (1909, 1912) continued his observations in Szaflary. In 1909 he has suggested the transgression of the Miocene sea and the existence of an active cliff in the Pieniny Klippen Belt. After critical notice of Kužniar (1910), Friedberg (1912) stated that the Miocene age of "Szaflary clays" might be doubtful. Revising old samples taken from Szaflary, Friedberg (1920) found new portions of foraminifers and pieces of molluscs' shells. One of them, *Ervilia pussilia*, unquestionably indicates the Miocene age.

It is important to notice, that on the 1 : 75 000 maps, Uhlig (1889, 1912) has marked in Szaflary the Miocene clays contacting with the Jurassic crinoidal limestone of the Pieniny Klippen Belt to the north. Uhlig made these maps in 1885 - 1890. It means that he stated the occurrence of the Miocene "Szaflary clays" several years before Friedberg found them.

Several geologists have questioned the Miocene age of "Szaflary clays" described by Friedberg. In Kužniar's (Kužniar & Zelichowski 1927) opinion these are Cretaceous clayey rocks, representing the mantle of the Pieniny Klippes. Halicki (1929 - 1930), discussing Friedberg's and Kužniar's polemics, expressed his doubts concerning the connection of the Orava-Nowy Targ Basin and the Miocene sea. Other authors, who accepted Friedberg's idea, tried to apply his information on the occurrence of Miocene in Szaflary to paleogeographic reconstructions. Consequently, the idea of the Miocene marine transgression following from north toward the Pieniny Klippen Belt was postulated. Nowak (1927, 1948) supposed that the Miocene deposits from the Podhale region described by Friedberg transgressively covered the rocks of the Pieniny Klippen Belt and were con-

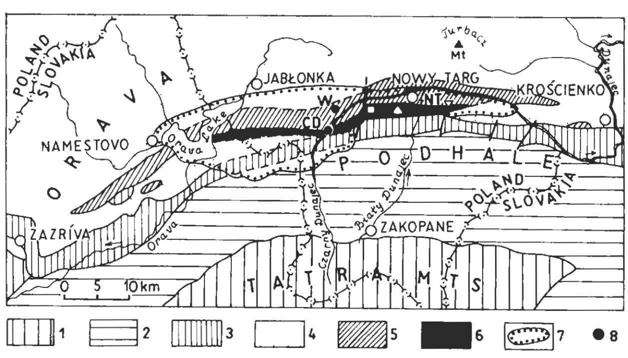

Fig. 1. Geological map ilustrating the occurrence of Miocene deposits in the Podhale and Orava area.
Legend: 1 - Inner Carpathian crystalline and its Mesozoic mantle; 2 - Central Carpathian Flysch (Podhale Flysch); 3 - Pieniny Klippen Belt; 4 - Upper Cretaceous, Paleogene and Eocene deposits of the Magura Nappe (Outer Carpathians); 5 - Malcov Formation and Waksmund Beds - Uppermost Eocene - Lower Micene; 6 - Stare Bystre, Kopaczyska and Pasieka Beds - Middle Miocene; 7 - occurrence of Neogene and Quaternary freshwater deposits filling the Orava - Nowy Targ intramontane basin; 8 - deep boreholes: NT - Nowy Targ PIG-1, CD - Czarny Dunajec IG-1, Wroblowka IG-1, 9 - main outcrops of Waksmund Beds, 10 - main outcrops of Stare Bystre Beds, 11 - main outcrops of Kopaczyska and Pasieka Beds.

nected with areas to the north where patches of transgressive Miocene were found: in the Nowy Sacz intramontane basin as well as in Zegocina and Iwkowa. This connection should be localised along the Dunajec river Valley. He tried to verify the age of marine Miocene from Szaflary, and estimated it as Lower Tortonian. In addition Matějka & Andrusov (1931: fide Birkenmajer 1951) have marked the occurrence of this Miocene in the Nowy Targ area. Discussing Friedberg's and Nowak's opinions, Bieda (1951) has suggested, that the fossil fauna found in Szaflary was too poor to indicate the age very precisely.

The occurrence of marine Miocene in the position described by Friedberg has been questioned by Birkenmajer (1951, 1954, 1958). During very detailed geological investigations in the Szaflary quarry he collected samples of brecciated clays and shales occurring there in the karst pockets formed in the Jurassic crinoidal limestone of the Czorsztyn succesion. Micropaleontological data have shown that these are Cretaceous rocks of the Pieniny Klippen Belt. Birkenmajer suggested, that Friedberg could have mixed the samples and, consequently, the data on the age of the "Szaflary clays" are erroneous. He noticed, that based on geomorphological data as well as on the reconstructed evolution of the Orava-Nowy Targ intramontane basin and the surrounding area, the transgression of the Miocene sea following along the Dunajec Valley to the southern part of the Magura Nappe and the Pieniny Klippen Belt was not possible.

Wožny (1976) questioned the results of Friedberg's studies, and supposed that microfauna described from Szaflary could be redeposited. In the publication concerning the Neogene of the Orava-Nowy Targ intramontane basin Watycha (1976) has mentioned Friedberg's studies (1906, 1909, 1912) but did not present his own opinion on the marine Miocene in Szaflary. He noticed that, although Birkenmajer (1954) was not successful in finding the Miocene deposits in Szaflary, in the last years the idea of Friedberg was not questioned.

During the geological mapping in the northern Podhale area in 1980 - 1981, the present author found new exposures of marine Miocene deposits west of Szaflary, in Rogožnik and Zaskale (Fig. 1). These deposits were marked on the geological map 1 : 50 000 made by Watycha (1978) as a Paleocene - Lower Eocene flysch sequence of the Magura Nappe. On the basis of some lithological similarities, the present author expressed the opinion (Cieszkowski & Olszewska 1986), that these are the Upper Malcov Beds (Malcov Formation - Birkenmajer & Oszczypko 1989). Detailed micropaleontological data on foraminifers obtained by Olszewska and on calcareous nannoplankton obtained by Smagowicz in 1985 - 1991, have indicated an Upper Oligocene - Middle Miocene age for the deposits described in this paper. The first report on this discovery was presented in 1991 (Cieszkowski et al. in print).

Marine Miocene deposits were also found in Nowy Targ PIG-1 borehole which penetrated the Magura Nappe north of its tectonic contact with the Pieniny Klippen Belt (Paul & Poprawa 1992). Several years of study by the present author in the area S and SW of Nowy Targ have shown that the Miocene sequence is associated with the sedimentary Magura Series representing the Magura Nappe. It was found that there is a tectonic contact of the Miocene sequence with the Pieniny Klippen Belt. Unquestionably Birkenmajer's (1951, 1958) opinion, that the marks of the Miocene transgression are not observed in Szaflary quarry's karst pockets, is correct. The present author observed the karst pockets in question in 1974 and 1991, and noticed that the shales filling them are different from those of the Miocene deposits which have been found in Zaskale and Rogožnik. Unfortunately, the outcrop which was found there by Friedberg (1906, 1909) does not exist today.

A few years ago the author was informed by Dr. J. Nemčok from the Geological Institute of D. Štúr in Bratislava, that he had found marine Miocene deposits in Eastern Slovakia. These deposits occur within the area of the Magura Nappe at its tectonic contact with the Pieniny Klippen Belt.

Lithology and stratigraphy

Four new lithostratigraphic units, younger than both the Magura and Malcov Formations (cf. Birkenmajer & Oszczypko 1989), have been distinguished in the Nowy Targ area recently (cf. Cieszkowski et al., in print). These are: Waksmund, Stare Bystre, Kopaczyska and Pasieka Beds.

Waksmund Beds

The Waksmund Beds, poorly represented by outcrops in the field, seem to form a transitional sequence between the uppermost Eocene - Oligocene Malcov Formation (Cieszkowski & Olszewska 1986; Potfaj 1983) and the overlying Miocene series (Fig. 2). These beds are mostly composed of Magura-type Sandstones, interlayered with either sandstone-shaly complexes or shales and soft marls of Malcov Beds - type. Their bottom part is exposed E of Nowy Targ (Fig. 1), in Waksmund village. The upper part has probably been drilled by the Nowy Targ PIG-1 borehole (cf. Paul & Poprawa 1992), but the present author could not examine the core materials, as well as in the Czarny Dunajec IG-1 borehole (microfossils were not examined). In the cross-section of deep borehole Nowy Targ PIG-1, another older lithostratigraphic sequence of the Magura Nappe has been described, below the fresh water Neogene sequence of the Malcov Formation (Paul & Poprawa 1992). However, the present author, on the basis of structural reconstructions and similarities of the drilled flysch deposits described by Paul and Poprawa and those known from outcrops in the area of Nowy Targ, suggests that the whole section of Nowy Targ PIG-1 borehole represents a sequence which is not older than the Uppermost Eocene deposits of the Malcov Beds.

The Neogene deposits are underlain by a flysch series. In Czarny Dunajec they are represented by a more shaly facies and in Nowy Targ we observe a prevalence of thick bedded sandstones, the age of which - on the basis of calcareous nannoplankton studies - could be related to the Upper Oligocene and Lower Miocene. The transition between Malcov Beds and Waksmund Beds is covered by fluvial Quaternary deposits and has not been documented in the outcrops up to now. The stratigraphic position of these beds is interpreted on the basis of their structural setting, lithological analogies to Malcov or/and Magura Formations and the micropaleontological data.

Stare Bystre Beds

The main outcrops of the Stare Bystre Beds occur in the river bed and banks of Rogožnik Wielki creek, at a strong curve situated in western part of Rogožnik village at the boundary with Stare Bystre (Fig. 1). There are also smaller outcrops in southern tributaries of Rogožnik Wielki between Stare Bystre and Zaskale villages. The Stare Bystre Beds consist of flysch deposits (Figs. 2, 3) which are represented by soft marls or marly shales, similar to those of the Zlin (Lacko) Beds (Bystrica Formation),

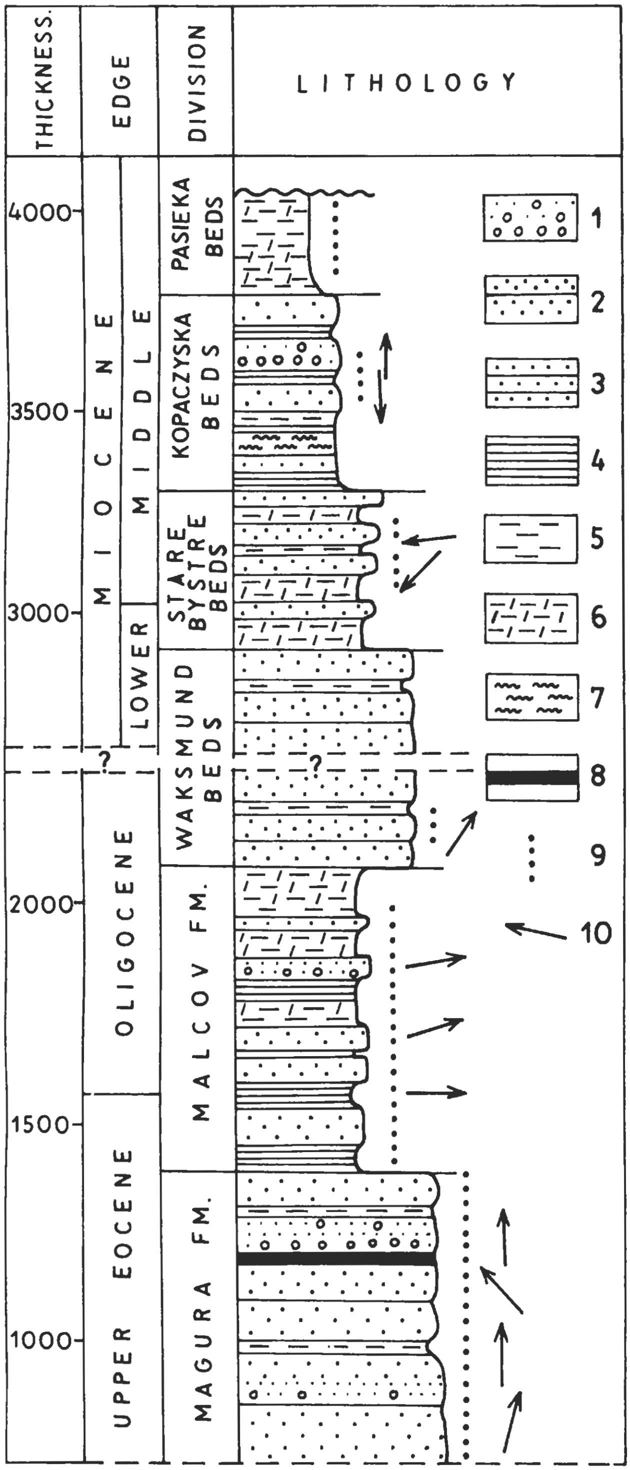

Fig. 2. Lithostratigraphic profile of the youngest deposits of the Magura Series.
Legend: 1 - fine conglomerates and conglomeratic sandstones; 2 - thick bedded sandstones; 3 - medium- and thin-bedded sandstones; 4 - thin-bedded sandstones and shales; 5 - shales; 6 - soft marls and marly shales; 7 - mudstones; 8 - variegated shales; 9 - parts of section outcropping in the field; 10 - main paleocurrent directions.

intercalated by medium and thin-bedded calcareous sandstones as well as thick bedded Magura-type Sandstones. The petrographic composition of the Magura-type Sandstones is almost the same as of sandstones of the Magura Formation. They consist of monocrystalline or metamorphic mosaic quartz, fragments of quartzites, plagioclase and less common alkali feldspars grains, muscovite, biotite, chlorites and locally pyrite. The rocks are cemented by carbonates. The heavy mineral assemblage consists of (according to Dr. W. Schnabel from Geologische Bundesanstalt in Vienna, Austria) garnet (84%), zircon (1%), tourmaline (3%), rutile (2%), apatite (3%), staurolite (6%), chloritoid and spinel (one grain only). Quartz grains are usually poorly rounded. Besides, thick-bedded sandstones contain also often clasts of shales. One layer, rich in plant detritus, contains larger fragments up to 20 *cm* long. The marls and marly shales are rich in microfossils. They contain skeletal sponge fragments, foraminifers, radiolarians, diatoms, dinocysts, and calcareous nannoplankton. The age of the Stare Bystre Beds was found to be Middle Miocene.

Kopaczyska Beds

The Kopaczyska Beds outcrop in the center of Zaskale village, west of Kopaczyska hamlet, in the high, right orographic bank of Rogożnik Mały (Skrzypny) creek (Fig. 1). These beds (Figs. 2, 3), first called Zaskale Beds (Cieszkowski el al., in print), are composed of yellowish, poorly cemented, fine and medium-grained, rarely coarse-grained and conglomeratic sandstones, frequently containing shale and mudstone clasts. These sandstones display parallel or large scale cross lamination, showing paleocurrent directions generally oriented from the S as well as from the N (Fig. 3). Their petrographic composition include monocrystalline or mosaic quartz, feldspars, muscovite, chloritised biotite, plagioclase and chlorites, cemented with siliceous-clayey matrix, rarely accompanied by small amount of carbonates. The grains are usually poorly rounded. These sandstones are accompanied by thin-bedded mudstones, interlayered with fine- or very fine-grained sandstones and greenish claystones (Figs. 3, 4, 5). In general, the Kopaczyska Beds contain no carbonates. Small fragments of mollusc shells and pteropods can be found sporadically. The samples examined usually contain poor assemblages of microfauna, mainly represented by agglutinated *Rhabdammina*-type foraminifers. Richer assemblages, similar to those of the Pasieka Beds, were found but only in one or two cases. The Kopaczyska Beds are of Middle Miocene age.

Pasieka Beds

The Pasieka Beds were observed in several artificial outcrops close to the church in the center of Zaskale (Fig. 1), east of Las Pasieka (Pasieka Forest). The upper part of these beds has probably been describęd by Friedberg (1906, 1909) from Szaflary, and called "Szaflary Clays". The Pasieka Beds (Fig. 2) consist of light-beige, greenish, yellowish, sometimes brown chiefly marly claystones or clays, containing intercalations of yellowish soft mudstones and rare, very fine-grained, thin-bedded sandstones. There are marly claystone beds rich in microfauna and nannoplankton as well as poor in microfossils. These deposits are subjected to strong weathering. The Pasieka Beds are of Middle Miocene age.

Type of sediments

Both the Waksmund and Stare Bystre Beds represent flysh deposits. Their thick-bedded sandstones are fairly similar to those of the Magura Formation. The marly claystones and soft

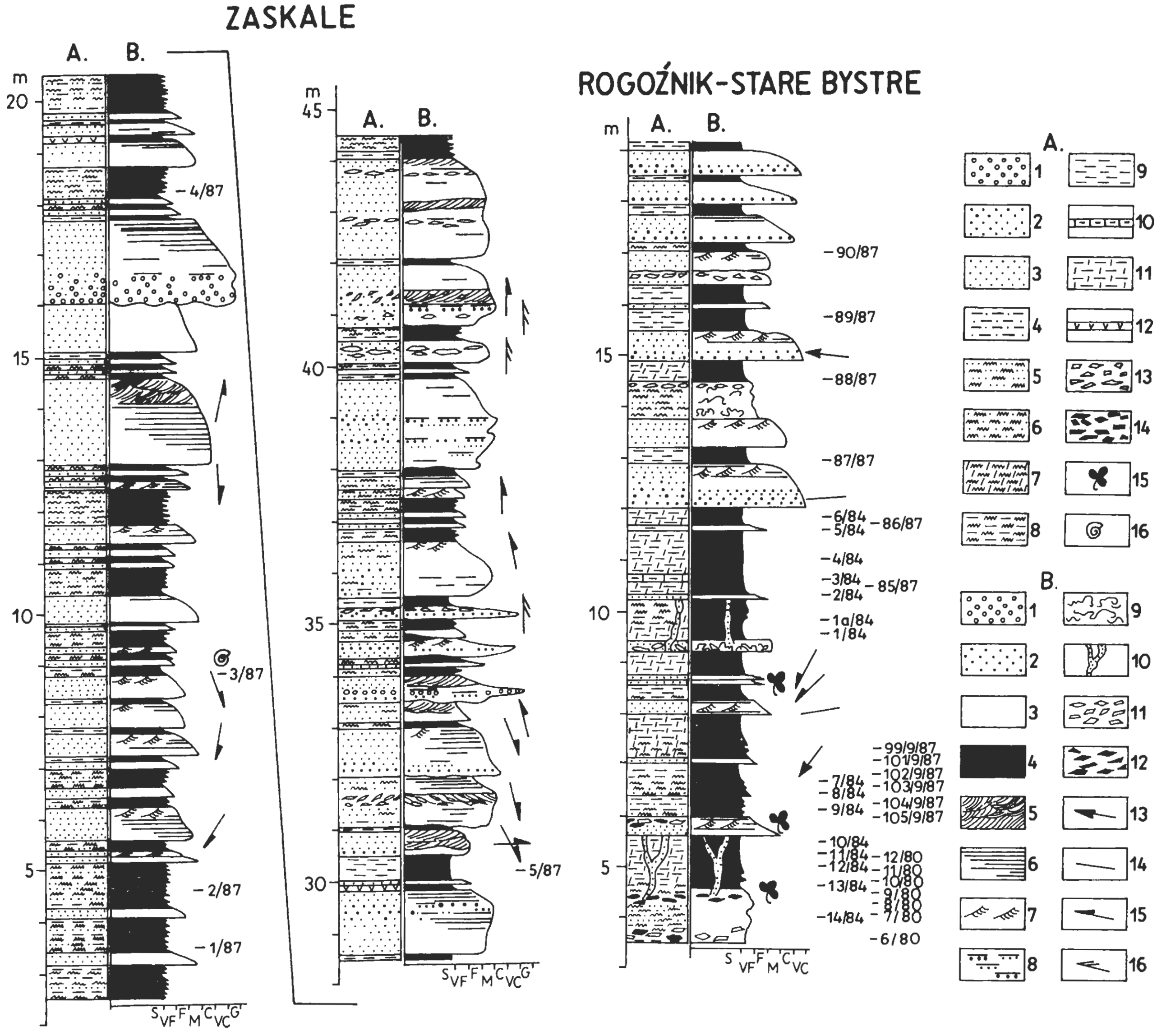

Fig. 3. Profiles of the Stare Bystre Beds outcropping in Rogoźnik and Stare Bystre, and of the Kopaczyska Beds exposed in Zaskale.
A. Lithological profiles: 1 - fine conglomerates and conglomeratic sandstones; 2 - coarse-grained sandstones; 3 - medium- and fine-grained sandstones; 4 - shales intercalated with sandstone laminae; 5 - sandstones intercalated with mudstone laminae; 6 - sandy mudstones; 7 - marly mudstones; 8 - muddy shales; 9 - clayey shales; 10 - marls; 11 - soft marls and marly shales; 12 - tuffites; 13 - clasts of shales; 14 - fragments of detrital plants; 15 - larger remnants of fossil flora; 16 - remnants of macrofauna.
B. Sedimentological profiles: 1 - conglomerates; 2 - coarse-grained sandstones; 3 - fine- and medium-grained sandstones; 4 - claystones, mudstones and marls; 5 - big-scale cross lamination; 6 - parallel lamination; 7 - ripple-cross lamination; 8 - inverse gradation; 9 - submarine slumps; 10 - sandy clastic dikes; 11 - clasts of shales; 12 - fragments of detrital plants; paleocurrent-directions based on: 13 - flute-casts, 14 - groove-casts, 15 - cross lamination, 16 - imbrication of clasts. Numbers show places where the micropaleontological samples were collected.

marls, as well as thin-bedded sandstone and shale complexes are partly similar to those of the Malcov Formation. The Kopaczyska Beds (Fig. 3) and Pasieka Beds, in turn, are typical marine molasses.

Structural position of marine Miocene deposits

Marine Miocene beds at Zaskale and Rogoźnik show a WSW - ENE strike (Fig. 1), and dip steeply 70 - 90° to the S (normal position) or 60 - 90° to the N (overturned beds). At Zaskale, they display a tectonic contact with both the Jarmuta and Malinowa Formations of the Pieniny Klippen Belt (Fig. 6). Marine Miocene rocks are unconformably overlain by flat-laying fresh-water Neogene and fluvial Quaternary deposits filling the Orava-Nowy Targ intramontane trough.

Micropaleontological data

The samples of. Waksmund Beds' deposits, that have been taken from outcrops and boreholes, contain only foraminiferal assemblages of wide stratigraphic extent, representing mainly the Paleogene or Eocene. The age of these beds was determined

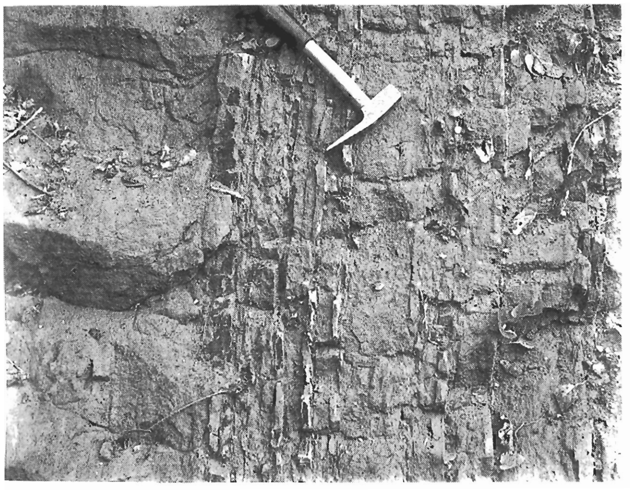

Fig. 4. Outcrop of Kopaczyska Beds in the right bank of Maly Rogožnik (Skrzypny) Creek in Zaskale. Mudstones with intercalations of thin bedded sandstones iterlyerd with medium- and thick-bedded sandstones.

Fig. 5. Kopaczyska Beds in Zaskale.
Thick-bedded sandstone layer and mudstones intercalated with very thin-bedded sandstones.

as the Upper Oligocene - Lower Miocene, on the basis of testing of calcareous nannoplankton assemblages including *Sphenolithus conicus* Bukry, *Sph. heteromorphus* Deflandre, *Sph. pseudoradians* Bramlette et Wilcoxon, *Helicosphaera* cf. *ampliaperta* Bramlette et Wilcoxon, *Reticulofenestra minuta* Roth, accompanied by redeposited Cretaceous and Paleogene forms (cf. Paul & Poprawa 1992).

More than 50 samples were collected from the Stare Bystre, Kopaczyska and Pasieka Beds for micropaleontological studies. These samples contain sixty foraminiferal species, including thirty planktonic species of the genera *Globigerina, Globoquadrina, Globigerinella, Catapsydrax, Turborotalia*, and *Globigerinoides*. Among Miocene forms, several groups of foraminifers, showing different temporal extents can be distinguished. The most numerous are species of maximum development being associated with the Early Miocene or Late Oligocene through Early Miocene. Some of these forms were reworked. A smaller amount of foraminifer tests, usually those of small size, belong to Middle Miocene species. They occur quite frequently, although their number is limited. These are, usually, represented by the groups *Globorotalia (Truncorotalia) miocena* Finlay and *G.* ex gr. *foshi* Cushman, as well as *G. praemenardi* Cushman, *Globigerina bolli* Citta et Premoli Silva, *G. druryi* Akkers, *G. diplostoma* Reuss. The Middle Miocene (B. Olszewska suggests Langhian, even Serravallian age) may be represented by *Globorotalia explicationis* Jenkins and *G.* ex gr. *languaensis* Bolli. Moreover, there occur long term foraminifers like, among others, *Globoquadrina dehiscens* Chapman, Parr et Collins, and *Globierinoides immaturus* Leroy. The materials studied represent oceanic-type Miocene deposits that also contain redeposited Middle and Late Cretaceous microfauna as well as in the Stare Bystre Beds, also that of older Paleogene age. Some of the reworked forms must have been derived from red marls or shales. Among radiolarians, a Miocene species *Eurycyrtidium inflatum* Kling was determined.

The numerous, well-preserved and diversified assemblages of calcareous nannoplankton of the Stare Bystre Beds are composed of more than 60 species belonging to 33 genera. A Middle Miocene age is suggested by the presence of *Reticulofenestra pseudoumbilica* (Gartner), and *Discoaster kugleri* Martini et Bramlette. The occurrence of *Sphenolithus* cf. *abies* Deflandre seems to indicate Upper Middle Miocene. The samples examined also contain Lower Miocene, probably redeposited, species including *Discoaster druggii* Bramlette et Wilcoxon, *Sphenolithus ciperoensis* Bramlette et Wilcoxon, *S. heteromorphus* Deflandre, *Helicosphaera ampliaperta* Bramlette et Wilcoxon, *H. recta* Haq and, extending up to Pleistocene, *Calcidiscus leptoporus* (Murray et Blackman) Loeblich et Tappan. In addition, the forms extending from Upper Paleogene through Miocene have been found, including those of *Coronocyclus nitescens* (Camptner) Bramlette et Wilcoxon, and *Coccolithus miopelagicus* Bukry, as well as redeposited forms of Middle through Upper Cretaceous and Paleogene age.

Paleogeographic position and structural evolution

The marine Miocene deposits were laid down in a piggy-back basin which was formed in the southern part of the Magura Basin after partial folding of its deposits during latest Oligocene and Early Miocene times (Fig. 7). At that time, the newly-formed, active front of the Magura Nappe underwent a gradual uplift in the north, and the emerged areas began to supply material into a new basin in the south, feeding mostly the present Kopaczyska Beds. This deposition was preceded by the activity of a southern alimentary source, that was responsible for the formation of muscovitic facies of the Magura Sandstones*. Uninterrupted sedimentation of the Malcov Beds and overlying marine Miocene deposits took place, most probably, in the Nowy Targ area, although the contact cannot be directly examined due to the presence of a thick cover of freshwater Neogene and Quaternary sediments. Subsequent folding of the Magura Nappe and intensified thrusting at the Badenian - Sarmatian boundary or later (cf. Cieszkowski et al. 1988; Cieszkowski 1992) led to regression of the Miocene sea and closing of the basin. The infilling deposits were then folded together with older complexes of the Magura Series. At the same time, the Pieniny Klippen Belt was thrusted over the Magura Nappe, and sub-

* in sense of Kiažkiewicz 1972

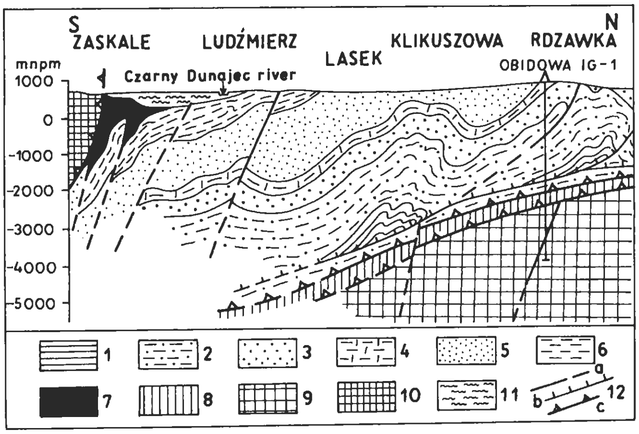

Fig. 6. Geological cross-section between Zaskale and Rdzawka. Magura Nappe (Krynica zone):
Legend: 1 - green spotted shales (Albian - Cenomanian) and variegated shales (Turonian); 2 - Inoceramian Beds (Senonian - Paleocene); Magura Formation: 3 - Jaszcze Beds (Lower Eocene); 4 - Kowaniec Beds (Middle and Upper Eocene); 5 - Magura Beds (Upper Eocene); 6 - Malcov Formation and Waksmund Beds (Uppermost Eocene - Lower Miocene); 7 - Stare Bystre, Kopaczyska and Pasieka Beds (Middle Miocene); 8 - Grybow Unit; 9 - Dukla Unit (Obidowa-Slopnice zone); 10 - Pieniny Klippen Belt; 11 - fresh water deposits of the Neogene and Quaternary filling of the Orava-Nowy Targ Basin; 12 - dislocations: a - faults, b - thrusts of scales, c - thrusts of nappes.

sequently, the last stage of intensive tectonic movements forming the recent shape of the tectonic boundary of the Pieniny Klippen Belt and the Magura Nappe took place. Following these events, the intramontane Orava-Nowy Targ Basin began to form, being filled with freshwater Neogene sediments that unconformably overlie folded marine Neogene and Paleogene rocks of the Magura Nappe (Figs. 1, 7). Their present-day occurrence results from their location in a tectonic depression that survived post-orogenic erosion.

Conclusions

The discovery of Marine Miocene deposits in the area of Nowy Targ and their connections with the Magura Series implicate important data for the evolution of the Magura sedimentary basin and the origin of the Orava-Nowy Targ intramontane basin.

1 - The marine Miocene deposits were sedimented continuously after those of the Malcov Formation, known recently as the youngest deposits of the Magura Series. Although the whole sequence of the Oligocene, Lower and Middle Miocene sequence of deposits is not exposed, there are no sedimentological features showing discordance or distinct shallowing of the marine basin during the Late Oligocene and Early Miocene. Both, the Waksmund and Stare Bystre Beds showing many similarities to the Malcov Formation, represent deep sea flysch sedimentation as well as the Kopaczyska and Pasieka Beds representing molassic sedimentation. It is possible that during deposition of the Kopaczyska and Pasieka Beds, the Miocene piggy-back basin started to decrease steeply. In consequence, it is possible that shallow-water deposits closed marine sedimentation in the basin discussed, but they were eroded during the last stage of the folding and uplifting movements of the Magura Nappe. Even, if they are partly preserved, they are actually covered beneath the fresh water Neogene and Quaternary deposits.

2 - The above conclusions show that the marine Miocene deposits are associated with the Magura Group and are not transgressive. Friedberg's supposition on the existence of Miocene cliff in the Pieniny Klippen Belt was based, most probably, on the occurrence of fragments of crinoid limestones in Quaternary weathered cover overlaying the Miocene clays. Unquestionably Birkenmajer's (1951, 1954, 1958) opinion that the evidence of the Miocene transgression marks are not observed in Szaflary quarry's karst pockets is correct. The deposits examined by Birkenmajer filling karst pockets, were not of Miocen age. Unfortunately, the outcrop, which was found by Friedberg there, no longer exists. Probably his description of its localization (Friedberg 1906, 1909) is not quite precise, and the Miocene deposits did not occur in karst pockets (as it might be supposed), but in tectonic contact with the crinoid limestone (cf. Uhlig 1912), north of the places penetrated by Birkenmajer (1951, 1958). Recent authors do not suppose that Friedberg (1920) mixed his samples as it was suggested by Birkenmajer (1951), although it may be possible. It is not strange, that Friedberg found only one example of *Ervilia pussilia*, since during very detailed layer by layer observations (cf. Fig. 3), of outcrops, it was possible to find only one intercalation, several milimeters thick, with poorly preserved remnants of macrofauna in the Kopaczyska Beds.

Obviously, Birkenmajer (1951, 1958) was right in his critical opinion that the Miocene transgression did not reach the Pieniny Klippen Belt, while Friedberg supposed that it progressed along the Dunajec river Valley from the Nowy Sacz area. Such an interpretation (Halicki 1929 - 1930; Nowak 1927, 1948) is based on Friedberg's descriptions and supposition that the Miocene deposits in the area of Nowy Targ are transgressive.

3 - It was supposed, that the end of sedimentation in the Magura Basin took place in the Late Oligocene, and before the Early Miocene, the Magura Nappe were completely folded, uplifted and partly thrusted over units of the Flysch Carpathians lying further out (Nowak 1948; Watycha 1976; Książkiewicz 1977; Pescatore & Slaczka 1984; Birkenmajer 1986; Oszczypko & Zytko 1987 and othrers). The structural reconstructions, based on this statement, should be partly reinterpreted. It is concluded above, in the light of the present author's studies, that after the Late Oligocene the sedimentation of deposits was not finished in the Magura Basin. This basin was only partly folded and uplifted by that time. In the southern, and probably also the southeastern part, deep sea sedimentation continued during the whole of the Oligocene and Early Miocene up to the Middle Miocene. The piggy-back basin, which existed there, was closed in the Serravallian (Late Badenian or Early Sarmatian). Then it was folded, and consequently the last stage of intensive tectonic movements, forming the structural contact between the Pieniny Klippen Belt and the Magura Nappe took place, i.e. later than was postulated by (Birkenmajer 1986, 1988).

4 - The Miocene piggy-back basin discussed was formed as result of a modification of the Magura Basin, in its south and southeastern part, during the Late Oligocene - Middle Miocene period. During all this time deep sea sedimentation continued there, although in this period the sediments filling the Magura Basin were partly folded (Fig. 7), and the Magura Nappe began to form. Then northward thrusting of this nappe started and its western part as well as the frontal zone were uplifted. The uplifted, folded and eroded Magura flysch on the west was transgraded by the Early Miocene sea that progressed from the Vienna Basin. It was marked by the sedimentation of the Early

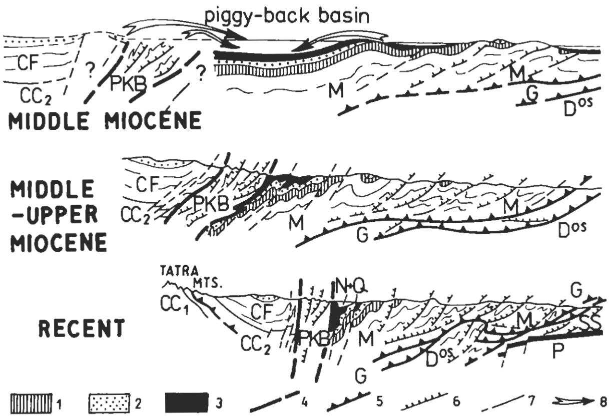

Fig. 7. Structural evolution of the piggy-back basin and of the Magura Nappe along the meridian of Nowy Targ.
Legend: 1 - Malcov Formation (Uppermost Eocene - Lower Oligocene); 2 - Waksmund Beds in the Magura Nappe, uppermost Chocholow Beds and Ostrysz Beds in the Podhale Flysch (Upper Oligocene - Lower Miocene); 3 - Stare Bystre, Kopaczyska and Pasieka Beds (Middle Miocene); 4 - dislocations limited Pieniny Klippen Belt; 5 - thrusts of nappes; 6 - thrusts of scales; 7 - faults; 8 - clastic material's paleocurrent directions.
Central Carpathians: CC - Tatric crystalline, CC - Mesozoic deposits of Tatric and Veporic, CF - Central Carpathian Flysch (Podhale Flysch); PKB - Pieniny Klippen Belt; Inner Carpathians: N+Q - Neogene and Quaternary of Orava-Nowy Targ Basin, M - Magura Nappe, G - Grybow Unit, D - Dukla Unit (Obidowa-Slopnice zone), SS - Silesian and Sub-Silesian Nappes; P - European Platform.

Miocene transgressive molassic deposits (cf. Kováč et al. 1989; Nemčok & Poprawa coord. 1988 - 1989).

During the events in the western part of the Magura Basin described above, the continuous deep sea sedimentation, in its southern and south-eastern part, was in the Middle Miocene, changed only in facies from flysch to molasse. Later the basin was closed, probably before the Late Miocene. During the Early Miocene rapid folding and emergence took place in the outer part of the Flysch Carpathians and the Dukla, Silesian, Sub-Silesian and Skole Nappes were formed. These uplifted structures separated the Miocene sea (piggy-back basin) still existing in part of the area of the Magura Basin from the Para-Tethyan sea filling the new forming foredeep of the Polish Carpathians.

The deep sea sedimentation of the Waksmund and Stare Bystre Beds, as well as of the Kopaczyska and Pasieka Beds, is marked not only by the sedimentological features of flysch and molassic sediments, but also by an oceanic type of foraminiferal assemblages, different from those usually known from the Para-Tethys deposits, and not easy to compare with them. During the sedimentation of the Kopaczyska and Pasieka Beds, the depth of the Miocene piggy-back basin began to decrease rapidly, it became shallow and finally closed. Consequently we can observe the rotation of tectonic movements during the last period of the evolution of the Magura Basin. The folding and shortening of the basin as well as the uplifting and thrusting movements of the Magura Nappe began in the west in the Latest Oligocene and/or Early Miocene and advanced towards the east during the Early and Middle Miocene. These processes were accompanied in the Magura Basin by the displacement of the depocenter from west to east.

5 - There is a problem of the southern extent of the piggy-back basin and of the southern source area feeding Miocene deposits, and, especially displaying features of the Magura Sandstone muscovitic-type. It is possible, that in the Early Miocene it was partly connected with the Inner Carpathian Flysch (Podhale Basin). Consequently, the opinion that sedimentation of the Podhale Flysch was terminated in the Oligocene (cf. Birkenmajer 1986, 1988; Książkiewicz 1977; Watycha 1976) should also be revised, especially in the light of recently found Lower Miocene foraminiferal assemblages (Westfalewicz-Mogilska 1986) and nannofossils (Smagowicz - unpubl. materials), occurring in the youngest deposits of the Podhale Flysch. A part of the Cretaceous foraminifers, occurring in the Stare Bystre and Pasieka Beds, which are redeposited from red sediments, may come from the Pieniny Klippes, partly lifted above sea level and subjected to weathering. The type of Magura Sandstones of muscovitic facies which intercalate the Waksmund and Stare Bystre Beds suggest continuation of the activity of a southern alimentary source, which was also feeding the sedimentation of all thick bedded sandstones of the Magura Formation in the southern and central part of the Magura Basin during the whole Eocene.

6 - In the light of the data presented, on the age and structural position of marine Miocene deposits, the fresh water Neogene molassic deposits covering them in the Orava-Nowy Targ intramontane basin are younger than it was previously supposed (Watycha 1976; Wožny 1976), and must have been deposited later than in the Langhian or Earliest Serravallian (Late and Middle Badenian). It also indicates the age of origin of the Orava-Nowy Targ intramontane basin, filled with these freshwater molasses. The begining of subsidence tectonic movements, initiating the origin of the Orava-Nowy Targ tectonic depression, was approximated to the Chattian/Aquitanian (Watycha 1976; Książkiewicz 1977). This data was based on studies of fresh-water and continental gastropods fauna (Wožny 1976), occurring in the oldest deposits filling the Orava-Nowy Targ Basin. The parallel palynologic data (Oszast & Stuchlik 1977) showed a Middle Miocene (Badenian and Sarmatian) age for the oldest fresh-water deposits representing the Neogene. These data correspond better to the conclusions of the present author. It shows, that begining of the subsiding tectonic movements, which formed the Orava-Nowy Targ Basin should been start in the Middle Miocene, and might be of Upper Serravallian - Tortonian age (Uppermost Badenian - Saramatian).

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