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OLISTHOSTROMES IN THE KROSNO BEDS (POLISH MIDDLE CARPATHIANS)

(3 Figs.)

Olistostromy z warstw krośnieńskich Karpat Środkowych

(3 fig.)

Abstract. In the Polish Flysch Carpathians, at a certain distance from the front of some nappes, their detached fragments occur, regarded so far to be tectonic outliers or klippes. In the present paper they are interpreted as olisthostromes and olistholiths, which originated in the final phase of flysch sedimentation.

THE HISTORY OF INVESTIGATIONS

Olisthostromes are a geological feature reported from various stratigraphic units of folded mountains. They are associated with rocks formed within eu- and miogeosynclines (G. Flores, 1955, 1959; Righi, 1956; Marchetti, 1956; Righby, 1958; Jacobassi, 1965; E. Abbate et al., 1965, 1970; R. Marschalko, 1968; G. Sestini, 1968; K. Görler, K. J. Reutter, 1969; H. Wilson, 1969).

Before proceeding to the subject proper, some facts need be recalled. Upon folding and uplifting (Tertiary), the Flysch Carpathians were overthrusted northwards. The differences in lithology and spatial distribution of rock complexes permit to distinguish from S to N the following tectonic units: 1) Magura nappe, 2) Dukla folds, 3) Silesian nappe, 4) Subsilesian nappe, and 5) Skole nappe. Within the Magura nappe, the lithostratigraphic units outcropping in the tectonic windows are informally referred to as the „window series" (Fig. 1).

The Flysch Carpathians are made up of sediments from the Lower Cretaceous to Oligocene inclusive. Locally, Miocene rocks overlie discordantly various older Flysch series.

In Polish geological literature olisthostromes in the Middle Flysch Carpathians were first reported in 1963 by F. Szymakowska and

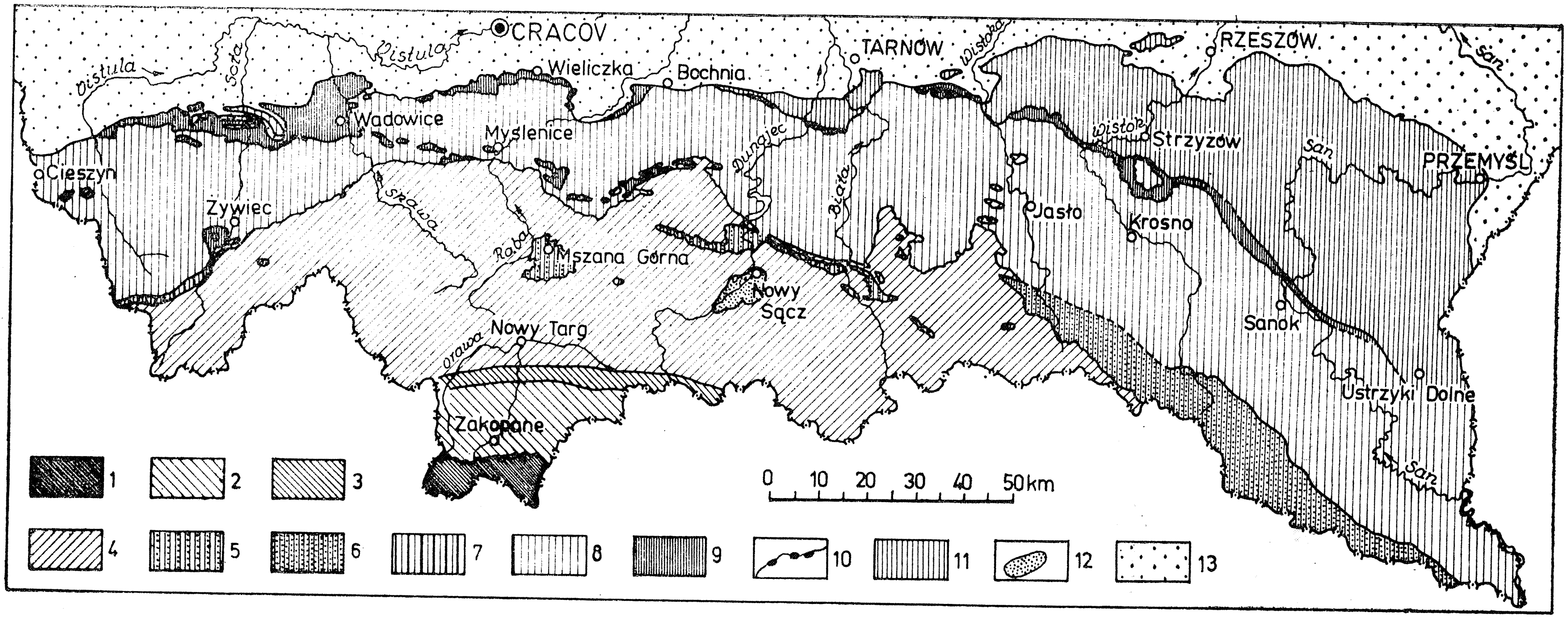

Fig. 1. Tectonic diagram of the Polish Flysch Carpathians 1 — Tatra units; 2 — Podhale Flysch; 3 — Pieniny Klippen belt; 4 — Magura nappe; 5 — window series; 6 — Dukla folds; 7 — Fore-Magura scale; 8 — Silesian nappe; 9 — Subsilesian nappe; 10 — Andrychów Klippen; 11 — Skole nappe; 12 — Miocene Klippes on flysch rocks; 13 — Miocene of the foredeep

Fig. 1. Szkic tektoniczny polskich Karpat fliszowych wg M. Książkiewicza, 1965) 1 — jednostki tatrzańskie; 2 — flisz podhalański; 3 — pieniński pas skałkowy; 4 — płaszczowina magurska; 5 — seria okienna; 6 — fałdy dukielskie; 7 — łuska przedmagurska; 8 — płaszczowina śląska; 9 — płaszczowina podśląska; 10 — skałki Andrychowskie; 11 — płaszczowina skolska; 12 — płaty miocenu na fliszu; 13 — miocen rowu przedgórskiego

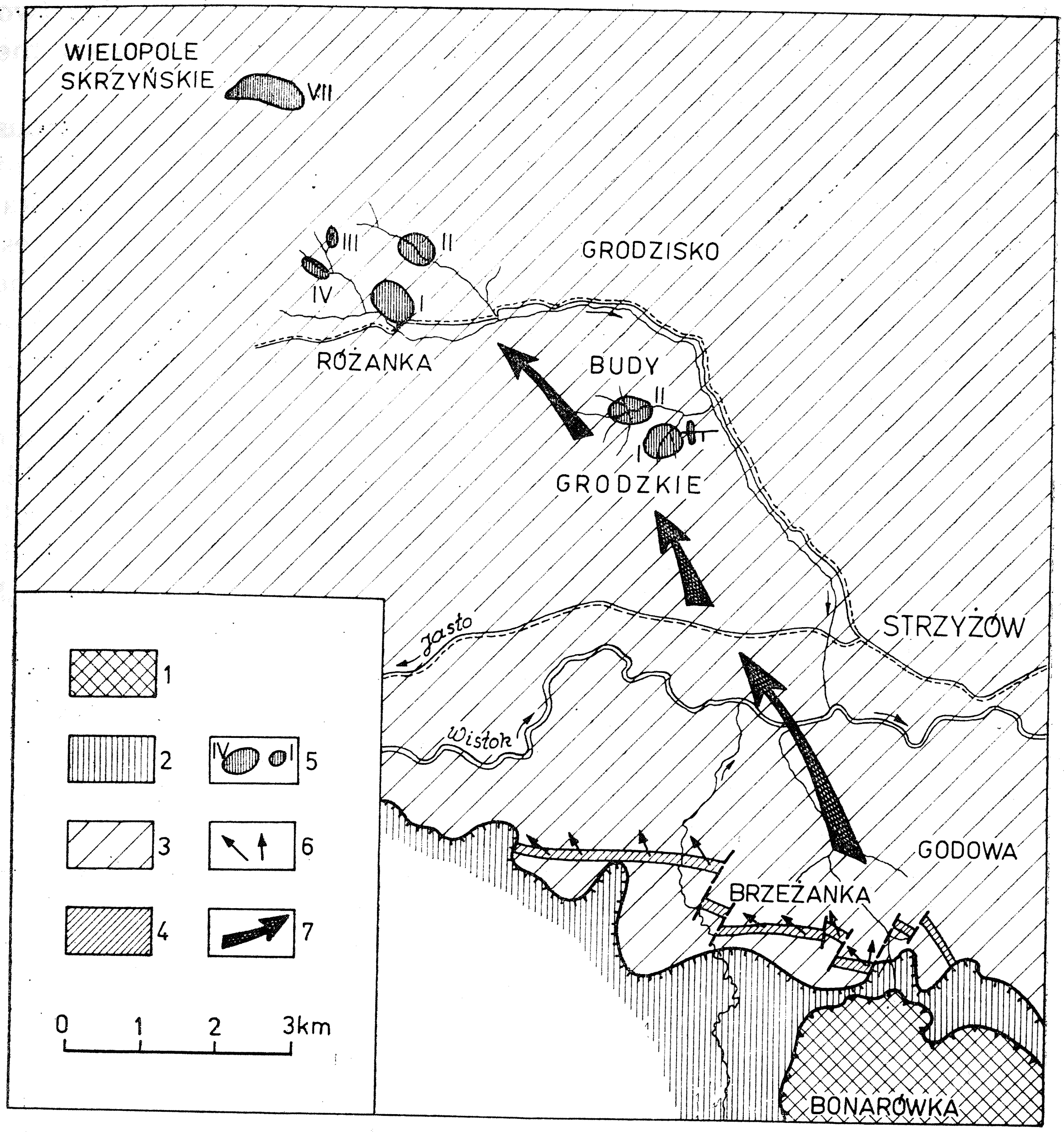

Fig. 2. Distribution of the Subsilesian olisthostromes NW of Strzyżów (Skole nappe). 1 — Silesian nappe; 2 — Subsilesian nappe; 3 — Skole nappe; 4 — series with pebbles from Brzeżanka; 5 — Subsilesian olisthostromes: I — Budy Grodzkie S, II — Budy Grodzkie N; Różanka — I, II, III, IV, Nawsie — VII; 6 — directions of imbrication measurements; 7 — presumable direction of the mud-gravel flow

Fig. 2. Szkic sytuacyjny olistostrom podśląskich na NW od Strzyżowa (płaszczowina skolska). 1 — płaszczowina śląska; 2 — płaszczowina podśląska; 3 — płaszczowina skolska; 4 — seria z otoczakami z Brzeżanki; 5 — olistostromy podśląskie: I — Budy Grodzkie S; II — Budy Grodzkie N, Różanka — I, II, III, IV, Nawsie — VII; 6 — kierunki pomiarów imbrykacji; 7 — przypuszczalny kierunek potoku mułowo-skalnego

J. Jasionowicz. These authors, however, did not use the name „olisthostrome" but defined this phenomenon as a „gravity slide" after J. C. Maxwell (1953, 1959a, 1959b) and G. Merla (1957).

In 1968 J. Jasionowicz described „klippes" of the Subsilesian nappe resting on the Skole nappe, the rise of which he also attributed to a „gravity slide" (J. Jasionowicz, 1968).

The present authoress has found within the Strzyżów depression two further outliers of the Subsilesian nappe (olisthostromes) resting on the Skole nappe (J. Morgiel, F. Szymakowska, 1973).

K. Skoczylas-Ciszewska (1952) described blocks of various flysch rocks of different size in the Miocene sediments in the galleries of a salt mine at Bochnia. They have been also reported from Wieliczka. The blocks in question derive from the Silesian and Subsilesian nappes.

Similar blocks, as well as flysch scales in the Miocene rocks of the Western Carpathians have been noted by W. Nowak (1959) and J. Golonka (1972) in the vicinity of Cieszyn. In both cases the flysch rocks belong to the Subsilesian nappe.

All the above-mentioned blocks and outliers may be regarded, in the authoress's opinion, as olistholiths and/or olisthostromes. It is conceivable that the s. c. „flysch islands" surrounded by the Miocene, e. g. near Pilzno, are olisthostromes (Fig. 1), and so are presumably the Popiele beds occurring in the eastern part of the Skole nappe (S. Dżułyński, J. Kotlarczyk, 1965). Stratigraphically, the Popiele beds lie on the boundary between the Middle Eocene (Hieroglyphic beds) and the Upper Eocene-Oligocene (Menilite beds). They have a similar tectonic position as the olisthostromes recorded within the Macigno formation in the Appenines in the sediments of Late Oligocene-Early Miocene age (V. Bortolotti et al., 1970, pp. 408—412, fig. 44).

Thus, in the external Flysch Carpathians detached blocks of various flysch rocks as well as „tectonic klippes" occur, as a rule, north of the front of the tectonic units to which they belong. They are preserved within the youngest flysch rocks, i. e. within the Krosno beds (Oligocene). Consequently, they have been recorded in the foreland of all the three tectonic units of the Flysch Carpathians, i. e. the Magura, Silesian and Subsilesian nappes. It is probable that they also appear along the front of the Skole nappe within the Carpathian foredeep filled up with Miocene rocks, similarly to the occurrences noted in the Austrian Alps or the North Appenines in Italy.

The formation of olisthostromes in the Flysch Carpathians took place in different stratigraphic units; yet, it became a large-scale phenomenon towards the close of sedimentation in the flysch basin, just like in the Alps and Appenines.

Olisthostromes from the older flysch series are, maybe, represented by the Lower Cretaceous rocks found by S. Gucik and J. Morgiel (1965) in the Maestrichtian sediments of the Skole nappe near Przemyśl. To the older series also belongs the migmatite olistholith in the Silesian nappe (Lower Cretaceous of the Chełm—Czarnorzeki range, Middle Carpathians), associated with a conglomerate composed of exotic rocks (F. Szymakowska, in press).

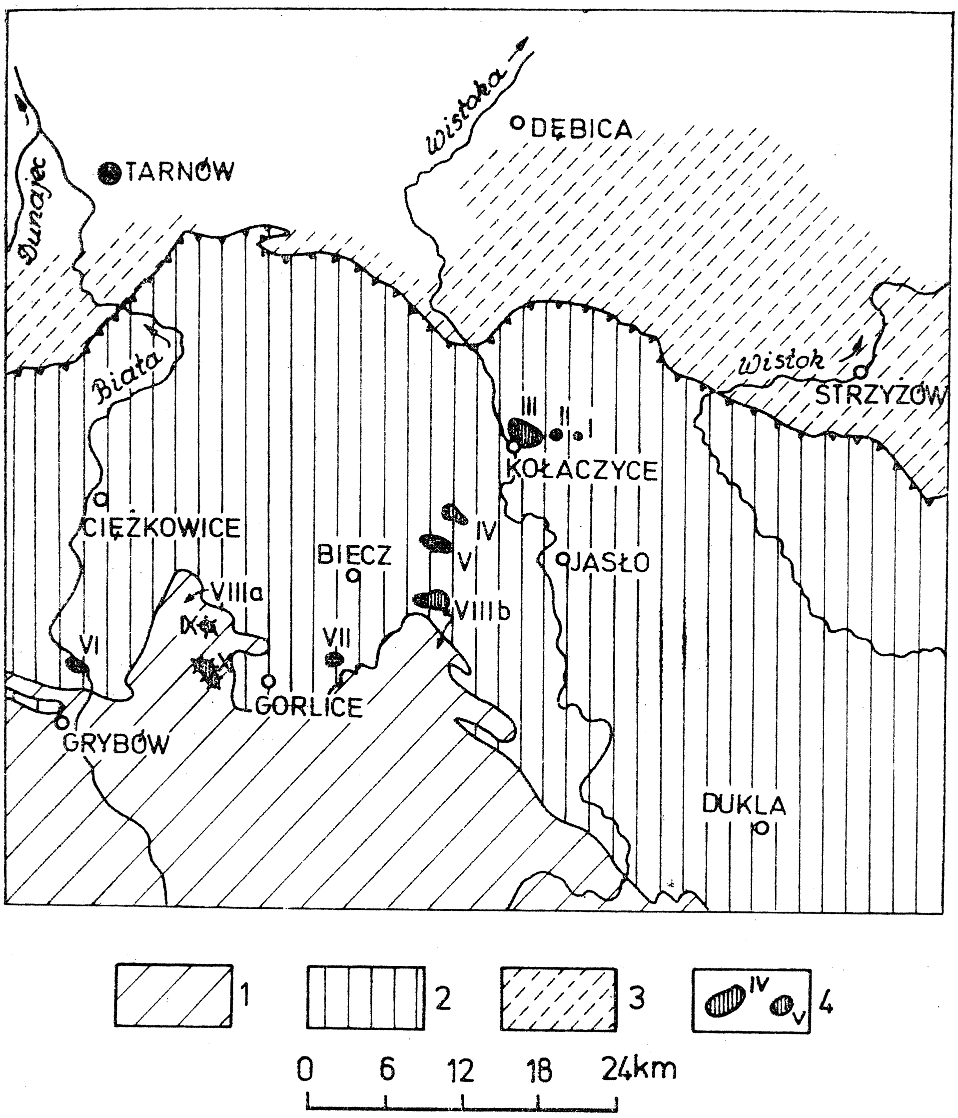

Fig. 3. Distribution of the Magura olisthostromes in the region Harklowa—Jasło—Kołaczyce (Silesian nappe). 1 — Magura nappe; 2 — Silesian nappe and Subsilesian nappe; 3 — Skole nappe; 4 — olisthostromes: I — west Sieklówka, II — Sowina, III — Kołaczyce, IV — Lipnica, V — Skołoszyn, VI — Miłkowa, VII — Kryg, VIIIa — Wola Łużańska promontory; VIIIb — Harklowa promontory; IX — window of Mszanka, X window of Bystra

Fig. 3. Szkic sytuacyjny olistostrom magurskich w rejonie Harklowa—Jasło—Kołaczyce (płaszczowina śląska). 1 — płaszczowina magurska; 2 — płaszczowina śląska i podśląska; 3 — płaszczowina skolska; 4 — olistostromy: I — zachodnia Sieklówka, II — Sowina, III — Kołaczyce, IV — Lipnica, V — Skołyszyn, VI — Miłkowa, VII — Kryg, VIIIa — półwysep Woli Łużańskiej, VIIIb — półwysep Harklowej, IX — okno Mszanki, X — okno Bystrej

The mechanism of olisthostrome formation was fairly complex. Apart from the uplifting movements, seismic tremor seems to have played a significant role in this process. The two phenomena caused the whole rock complexes to be detached from the front of the uplifted, folded and northwards-moving nappes and then to roll down in the form of gigantic slides.

THE DISTRIBUTION OF OLISTHOSTROMES AND THEIR RELATION TO THE ENCLOSING ROCKS

In all the cases reported from the Polish Flysch Carpathians (fig. 1), the olisthostromes that originated towards the close of the Oligocene appear within the Krosno beds, which are the youngest lithostratigraphic units of the Silesian, Subsilesian and Skole nappes.

In the area of the Skole nappe (Strzyżów depression) olisthostromes (Fig. 2) are built of rocks that belong to the Subsilesian nappe, comprising sediments from the Senonian to Eocene (J. Jasionowicz, J. Morgiel, 1962; J. Jasionowicz, F. Szymakowska, 1963; J. Morgiel, F. Szymakowska, 1973).

Olisthostromes have been also noted in the southern part of the Silesian nappe, in the synclines filled with the Krosno beds. In this area, olisthostromes follow the direction SW—NE, occurring NE of the Magura nappe border in the region of Harklowa—Jasło—Kołaczyce (Fig. 3). This direction indicates the original course of the mud-gravel flow that left the present-day slide blocks on its way. It is feasible that the mud-gravel flow used an earlier trough in the basement. Facially, the material making up the olisthostromes belongs to the marginal (northern) part of the Magura nappe, which is referred to in this region as the Harklowa zone (H. Świdziński, 1953, 1958, 1961) (Fig. 3).

All the described Magura and Subsilesian olisthostromes are made up of randomly arranged blocks of different sizes. The blocks are embedded in the matrix, which is sedimentary breccia consisting of clayey-mudstone sediment and angular fragments of different size and shape of the same rocks that make up the blocks (olistholiths).

The amount of sedimentary breccia inside the olisthostromes is rather insignificant; in most cases it is missing altogether. It is present, on the other hand, under all the olisthostromes. Only in some sections at Kluczowa the occurrence of a zone with breccia composed of sharp-edged and poorly rounded fragments ranging from 10 to 20 cm in diameter has been noted between two different blocks. When the matrix is missing, the arrangement of blocks is still more random as, e. g. at Bystra. In such cases, the blocks that make up the olisthostrome contact directly one another, each of them preserving its original sequence of strata.

The internal structure of the olisthostromes under study indicates that they are sedimentary bodies which owe their origin to creeping and transport in a mud-gravel flow, e. g. of the „frane" type, recorded at present in the Appenines (A. Jacobacci, 1965; K. Görler, K. J. Reutter, 1968), rather than tectonic „klippes" or breccias as frequently defined in literature. The rock mass detached from the nappe front became fractured during transport and then disintegrated into smaller blocks that were transported together with clayey and/or marly sediment.

A feature supporting the statement that the flow carrying the material of olisthostromes could be of the „frane" type is the lack of erosion directly below the olisthostrome.

In some places a contact of the underlying layered sediment with the olisthostrome may be observed, e. g. at Kluczowa (J. Jasionowicz, F. Szymakowska, 1963, p. 372, fig. 8). Another contact may be traced along the northern border of the olisthostrome of Skołyszyn. In both cases, there are no visible traces of erosion of the basement, and the exposed contact forms a smooth surface. Slightly below, in the clayey-marly sediment that underlies the olisthostromes, there are deformational structures and load casts resulting from pressure exerted on incompletely consolidated sediment.

All the olisthostromes under study have a sharp lateral boundary with the enclosing layered sediment, i. e. with the Krosno beds. The boundary is particularly well visible at Kluczowa, where the northern edge of the olisthostrome ends with a steep wall towering above the surrounding area. The wall is made up of sandstone of the Magura type (the youngest unit of the Harklowa zone).

Similar relationship between olisthostromes and the enclosing rocks have been reported by J. K. Righby (1958) and E. Abbate et al. (1970).

Beneath the olisthostromes, intercalations of coarse material have been found in the underlying sediment. The material consists of pebbles and fragments of flysch rocks of the same type as those building the overlying olisthostrome. Thus, e. g. in the Skole nappe the intercalations contain fragments of red marls and shales of the Subsilesian nappe; in the Silesian nappe — fragments of shales and sandstones of the Harklowa facies. The occurrences of such intercalations have been reported from other regions by several authors (K. J. Reutter, 1969; E. Abbate et al., 1970).

The discussed intercalations represent the first phase of the movement which ultimately gave rise to the olisthostrome proper. The olisthostromes formed in several stratigraphic units, which is indicated by the presence of microfauna from different Miocene biostratigraphic horizons in the matrix of the olisthostromes.

Fine rock material was also supplied in the final phase of the uplifting movements. The rocks cropping out between the northern part of the Wola Łużańska „promontory" (Pustki Mt. made up of Middle Cretaceous sandstones) and the main margin of the Magura nappe (Fig. 1) are most likely the remainder of a disappearing mud-gravel flow. The zone in question is narrow, having about 10 km in the N—S direction. It is filled with sediments containing heterogeneous flysch material derived mainly from the Dukla folds or narrow anticlines of the Silesian nappe (Eocene-Oligocene) as well as from the marginal part of the Magura nappe (mainly Eocene). Moreover, material from the littoral zone (Lithothamnium-limestones with Nummulites, the s. c. Łużna limestones) and feebly consolidated sands and quartz gravels have been recorded.

In earlier publications (V. Uhlig, 1886; H. Świdziński, 1936, 1946 a, 1946 b, 1950) the Łużna limestones were regarded to be intercalations in the Hieroglyphic beds. The authoress's investigations in the area of Mszanka and Bystra (Fig. 1) have shown that these limestones are detached blocks inside the Early Tortonian sedimentary breccia (F. Szymakowska, 1966) which underlies the whole promontory of Wola Łużańska, appearing only sporadically in the tectonic windows of Mszanka and Bystra (Fig. 1). Fragments of those limestones are present in coarse--material intercalations in the sediments cropping out south of a block of Cretaceous rocks that form the front of the Wola Łużańska promontory. Here, too, the contact of the olisthostrome with the surrounding rocks is sharp. There are no sedimentary transitions or interfingering with the enclosing sediment (i. e. with the rocks of the Silesian nappe).

Similar sedimentary breccia occurs in the southern and eastern part of the olisthostrome of Sowina. Its composition has been discussed by J. Jasionowicz (1961, pp. 687—688).

Clayey-marly sediments with pebbles and fragments of various flysch rocks outcrop as well at the southern border of the olisthostrome of Kluczowa. The outcrop is situated some metres below the sole of the olisthostrome. It has been described by J. Jasionowicz nad F. Szymakowska (1963, pp. 367—373). The sediments reported by these authors are very similar to those mentioned by E. Abbate et al. (1970, p. 533, fig. 8).

A clayey-marly rock with flysch fragments of different size and shapes has been found in shallow boreholes at Skołyszyn, on the contact of the olisthostrome with the underlying layered sediments. Here, as in other places, fragments of the Jasło shales and globigerine marls coming from the Silesian nappe have been identified apart from the other flysch material.

Within the Skole nappe or, strictly speaking, in the southern part of the Strzyżów depression adjoining the border of the Subsilesian nappe (Figs. 1, 2), the authoress has found a lens-shaped sedimentary body with flysch pebbles occurring in the upper Krosno beds (F. Szymakowska, 1961).

Microfaunal studies performed within the lower part of the Krosno shales which overlie the lenticle with pebbles have revealed the presence of reworked Upper Cretaceous (Senonian) microfauna (Globotruncana). The microfauna comes from the eroded Węglówka marls (Subsilesian nappe), which were transported by turbidity currents over considerable distances. A similar phenomenon has been observed by T. Birecki (personal information) in the Krosno beds of the Bobowa syncline, which lies west of the Wola Łużańska promontory.

The reworked Cretaceous microfauna permits to approximately determine the sourceland of the mud-gravel flow that gave rise to the olisthostromes in the Skole nappe (7 olisthostromes) and the Silesian nappe (8 olisthostromes) (Figs. 1, 2, 3).

At Brzeżanka (F. Szymakowska, 1961), additional data indicating the source area on one hand, and the direction of the mud-gravel flow on the other, were yielded by measurements of pebble imbrication (F. Szymakowska, 1961, p. 591). The material was transported from the border of the Subsilesian nappe towards the north and north-west in the form of a broad tongue that reached the sedimentary basin of the Skole nappe. Another tongue of this kind was moving towards NE (from Brzeziny to Nawsie).

The reworked Senonian microfauna in the Krosno beds of the Bobowa syncline was transported from the south, presumably from the zone of pelagic sediments adjoining the border of the Magura nappe (Fig. 1). The olisthostrome of Miłkowa described by A. Ślączka (1963), which is made up of variegated clay sediments, came very likely from the same source. It is probable that still farther to the south, but already under the Magura overthrust, there is a facies of red Cretaceous marls of the Subsilesian type. These sediments may be the source of reworked Globotruncana in the Krosno beds of the Bobowa syncline.

Microfaunal investigations of sedimentary breccias occurring in the vicinity of the discussed olisthostromes have revealed the presence of two assemblages. One assemblage consists of microfauna derived from various older reworked flysch rock units, ranging in age from Late Cretaceous to Oligocene. The other contains Miocene microfauna, the age of which points to the period that witnessed the rise of slide blocks (olisthostromes). The Miocene microfauna may be further divided into two assemblages: the older (Helvetian) and the younger (Lower Opolian = lowermost Tortonian).

In the Krosno shales (Skole nappe), enclosing the olistrostromes that lie in the southern part of the Strzyżów depression and are made up of variegated marls of the Subsilesian nappe, *Ammonia beccari* (Linné) and *Elphidium* sp. have been found. These species are indicative of a shallow-water or brackish Miocene facies (J. Morgiel, F. Szymakowska, 1973).

At the southern border of the olisthostrome of Sowina, poor Miocene microfauna has been noted so far in sediments that, on the basis of their lithology, were assigned to the Miocene already by K. Tołwiński (1921, p. 29).

A series with pebbles and fragments of flysch rocks crops out at the southern border of the olisthostrome of Kluczowa. Its age has been tentatively determined as Oligocene/Miocene (J. Jasionowicz, F. Szymakowska, 1963, p. 382). A revision of the microfauna present in these rocks permitted to define their age accurately as Early Miocene (Helvetian), considering the occurrence of *Globigerinoides trilobus* (Reuss) and *Cassigerinella* sp. (E. Łuczkowska-Schiller — personal inf.).

There are two other blocks south of Kluczowa: the northern block of Lipnica and the southern one of Skołyszyn (Fig. 3). Shallow boreholes passed through the olisthostrome of Skołyszyn, reaching a series with pebbles embedded in grey clayey sediment. The latter contains microfauna consisting mainly of small globigerines, as well as of *Uvigerina costata* Bieda, *Trifarina bradyi* Cush., *Marginulina hirsuta* d'Orb. and *Stilostomella adolphina* (d'Orb.). This microfauna is Miocene in age.

Another investigated point is the window of Mszanka on the Wola Łużańska promontory (Fig. 1), situated in the zone with flysch olistholiths. The outcropping rocks form the basement of the promontory; their position is then similar to that at Kluczowa.

The outcropping sedimentary breccia is developed as a dark clayey-marly sediment with an admixture of quartz gravel and sand. The sediment shows no distinct bedding. In the clayey-marly matrix heterogeneous flysch material of different size and shape is embedded. The dark sediment of the lower part of the outcrop passes upwards into pure blue-grey clays containing crushed macrofauna (F. Szymakowska, 1966, 1967).

Microfaunal investigations were carried out in the whole above-described profile. In its lower part, in the dark clayey sediment, microfauna of Miocene age has been noted besides abundant reworked older microfauna. The latter comes from flysch fragments ranging in age from the Senonian to Late Eocene. The young microfauna is associated with the matrix, i. e. with the dark clays, being coeval with it. According to W. Szotowa's determinations, this microfaunal assemblage consists of *Cibicides conspiciendus* Pischv., *Marginulina hirsuta* d'Orb. *Stilostomella adolphina* (d'Orb.), *Trifarina bradyi* Cush. and small globigerines. Microfauna from blue-grey clays with macrofauna detritus constitutes the other assemblage, which, according to S. Alexandrowicz (vide F. Szymakowska, 1966, pp. 224—226), is Early Opolian in age.

The Wola Łużańska promontory is another area in which Miocene microfauna has been recorded (Figs. 1, 3). There are two tectonic windows in this zone: Mszanka and Bystra. Each of the shallow boreholes that were made here passed through several flysch olistholiths of different size and shape, reaching the underlying sediments, i. e. grey shales or mudstones. As in the previously discussed areas, microfauna recorded here is of two types: older from reworked flysch sediments and younger from the matrix. Microfauna from the matrix is Early Tortonian. According to W. Szotowa it consists of the following species: *Cibicides conspiciendus* Pischv., *Marginulina hirsuta* d'Orb., *Stilostomella consobrina* (d' Orb.), *S. adolphina* (d' Orb.), *Trifarina bradyi* Cush., *Siphonia fimbriata* Reuss, *Ehrenbergina serrata* Reuss, *Valvulina pennatula* (Batsch.), *Robulus cultratus* Montf., *R. calcar* (Linné), *Asterigerina planorbis* d' Orb., *Trifarina angulosa* (Will.), *Uvigerina asperula* Czjzek, *U. acuminata* Hosius and *Globigerinoides trilobus* (Reuss).

The above-cited microfaunal assemblage comes both from the matrix in which olistholiths are embedded and from the underlying shales and mudstones.

The last investigated site with Miocene sediments is the tectonic window and slide block of Bystra (F. Szymakowska, 1972). At Bystra, grey and blue-grey shales with fine flysch fragments have been noted. The rocks in question contain Eocene and Oligocene microfauna originating from reworked older sediments, as well as Miocene microfauna represented by *Globigerina bulloides* d'Orb., *G. dutertrei* d'Orb., *G. concinna* Reuss and *G. apertura* Cush.

The presence of Miocene sediments, i. e. from the Lower Miocene (Kluczowa) to the Lower Opolian (Mszanka), in the basement of the olisthostromes or in their immediate vicinity evidences that there were several phases in which olisthostromes were formed. The mechanism of their formation was presumably identical in each phase. We can distinguish the initial phase, in which the uplifting movements began to be active (intercalations with flysch gravel); the proper phase of greatest intensity, which gave rise to the olisthostromes under study, and the final phase, in which the movements were quenched and calmed. Intercalations with flysch gravel come from that period, too. After the final phase sedimentation could have continued in the areas in which the sea remained.

It may be inferred from the microfauna present in the matrix of the olisthostromes that the first uplifting movements in the area of the present-day Magura nappe occurred in the Lower Miocene (Helvetian). The movements in the Subsilesian nappe became active at a somewhat later period; here olisthostromes began to detach in the upper stage of the Miocene.

CONCLUSIONS

The above studies have shown that the so-called „klippes" of the Magura and Subsilesian nappes are olisthostromes. The olisthostromes in question formed towards the close of sedimentation in the flysch basin under marine conditions as a result of sliding of rock complexes of different sizes and their subsequent transportation in mud-gravel flows. The mechanism responsible for their rise involved uplifting and folding movements and the accompanying seismic tremor.

The dating of the olisthostromes is based on the microfauna recorded both in the layered sediments underlying each olisthostrome and in the matrix. It appears from these microfaunal studies that the olisthostromes resting on the Silesian nappe were formed earlier, i. e. in the Lower Miocene (Helvetian), whereas all the others originated in the upper stages of the Miocene to the Lower Opolian inclusive.

The microfauna present in the sediments underlying the olisthostromes and in their matrix dates the uplifting movements. The movements first began in the area of the Magura nappe (Helvetian), which is the southermost Flysch unit within the Polish Flysch Carpathians. They progressed gradually northwards, comprising successively the Silesian and Subsilesian nappes and reaching finally the northernmost Skole nappe.

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STRESZCZENIE

W pracy przedstawiono zagadnienie czapek tektonicznych płaszczowiny magurskiej z okolicy Jasła (zachodnia Sieklówka, Sowina, Kluczowa, Lipnica, Skołyszyn, Miłkowa, Kryg oraz półwysep Woli Łużańskiej z oknem Mszanki i Bystrej), a także płatów jednostki podśląskiej (Nawsie, Różanka i Budy Grodzkie) w obrębie depresji strzyżowskiej. Wymienione powyżej płaty i czapki powstały, w świetle nowo uzyskanych danych, głównie w wyniku podmorskich ruchów masowych jako olistostromy.

Przy końcu sedymentacji w basenie fliszowym, gdy doszły do głosu ruchy wynurzające i nasuwawcze, od czoła formujących się płaszczowin pod ich wpływem jak i drgań sejsmicznych odrywały się różnej wielkości pakiety skalne, które następnie w potokach mułowo-skalnych być może typu „frane" były transportowane na znaczne odległości.

Poszczególne olistostromy złożone są z szeregu mniejszych bloków (olistolitów) połączonych brekcją sedymentacyjną w jedną całość. Wszystkie omawiane olistostromy usytuowane są w obrębie warstw krośnieńskich (oligocen) różnych jednostek tektonicznych Karpat. W okresie późniejszym zostały one zafałdowane w te warstwy w czasie ostatecznego dofałdowania i wynurzenia całego łuku karpackiego.

Czy w okresie po ich osadzeniu a przed ostatecznym wynurzeniem trwała nadal jeszcze sedymentacja morska, trudno jest powiedzieć, ponieważ, jak wiadomo, Karpaty po wynurzeniu zostały poddane bardzo silnej denudacji i masa osadów skalnych została usunięta. Niemniej jednak należy przypuszczać, że przez pewien okres czasu po osadzeniu olistostrom a przed ostatecznym wynurzeniem łuku karpackiego nadal trwała jeszcze sedymentacja typu fliszowego lub molasowego.

Badania mikrofaunistyczne wykazały obecność mikrofauny starszej, która pochodzi z rozmytych osadów fliszowych wchodzących w skład poszczególnych olistostrom oraz mikrofauny młodszej występującej w spoiwie brekcji i będącej jej równowiekową.

Wstępne opracowanie tej mikrofauny przez doc. dr E. Łuczkowską-Schiller wskazuje na wiek dolnego miocenu. Stąd wniosek, że tworzenie się olistostrom i początkowa faza wynurzania poszczególnych płaszczowin tektonicznych rozpoczęła się w dolnym miocenie (helwecie).

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