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Stratotypes and other important geosites of the Polish Carpathians

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A b s t r a c t . The Carpathians are a part of the Alpine orogen. In the territory of Poland they are characterized by a large diversity of facial-tectonic units and numerous nappes. The relief of the Carpathians is characterized by polygenesis, and developed under influence of denudational, glacial, and fluvial processes. Moreover, the relief clearly reflects the geological structures of the discussed region. The nature conservation in the Carpathians has a long tradition and substantial achievements. Geological/geomorphologic values protected in several areas and objects take a considerable part here. The currently proposed European geologic network of areas/sites representative of the Polish Carpathians consists of four national parks (category II according to IUCN classification) and 21 relatively small areas comprising individual sites or complex-sites out of which 7 are already protected. The standard list should be augmented with geosites typical of the northern zone of Eastern Carpathians and with reference to geosites candidates from the Ukrainian territory. The idea of site system of European geological heritage is to represent type localities of main lithostratigraphic units of the Central Carpathians and Outer Carpathians as well as to represent main relief features.

Key words: geoconservation, network of European geosites, Polish Carpathians.

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S t r e s z c z e n i e. Karpaty polskie, będące częścią orogenu alpejskiego, charakteryzują się dużym zróżnicowaniem jednostek facjalno-tektonicznych i płaszczowinową budową. Rzeźba gór jest poligeniczna i odzwierciedla wyraźnie budowę geologiczną obszaru. Ochrona przyrody Karpat ma długą tradycję i duże osiągnięcia. Geologiczne i geomorfologiczne wartości są tu uwzględniane w ustanawianiu ochrony wielu obszarów i obiektów. Proponowana obecnie sieć geostanowisk o znaczeniu europejskim, reprezentatywnym dla Karpat polskich, składa się z czterech parków narodowych (kategoria II w klasyfikacji IUCN) oraz 21 małych obszarów zawierających pojedyncze stanowiska lub ich zespoły (siedem z nich znajduje się już pod ochroną). Standardowa lista powinna być w przyszłości uzupełniona zwłaszcza o typowe obiekty północnej części Karpat Wschodnich w odniesieniu do ich rozprzestrzenienia na Ukrainę. System stanowisk o randze dziedzictwa geologicznego Europy reprezentuje główne litostratygraficzne jednostki Karpat wewnętrznych i zewnętrznych oraz znaczące elementy ich rzeźby.

Słowa kluczowe: geoochrona, sieć europejskich geostanowisk, Karpaty polskie.

The Carpathians constitute a part of an Alpine orogenic system. The mountain chain extends along the southern boundary of Poland and, as a wide arc, continues westward to surrounding of Vienna and towards south-east to the Danube gap at the Iron Gate. The Carpathians occupy 209,000 km^2, including 19,600 km^2 within the territory of Poland.

The Polish part of the mountain chain reaches farthest to the north and is characterized by a particularly high diversity of facial-tectonic units (S–N cross-section) when compared to other parts of this mountain range.

The Inner and Outer Carpathians are distinguished in the Polish part of the mountain chain. The Tatra Mts., Podhale Basin and Pieniny Klippen Belt belong to the Inner Carpathians.

The Tatra Mts. are built of the metamorphic rocks and the granite massif covered by deposits with a considerable part of Mesozoic limestone formations. Flysch of the Eocene–Oligocene age fills the Podhale Basin. The Pieniny Klippen Belt situated at the northern border of the Inner Carpathians is characterized by a rocky landscape reflecting very complicated structures formed of Jurassic–Cretaceous limestones and marls.

The Outer Carpathians comprise the Beskidy and Bieszczady Mts. as well as the Carpathian Foothills. They are built of the Cretaceous–Lower Miocene flysch formations. Volcanic rocks and deposits of the Miocene and Pliocene age are found sporadically, and the Quaternary cover is discontinuous. During the Upper Cretaceous and Miocene, the flysch deposits were folded, uplifted and as nappes thrust toward the north. In the Polish Outer Carpathians there are six tectonic units thrust one over the other from south to north (Fig. 1). With respect to aerial spreading two units predominate, namely the Magura Unit and the Silesian Unit. Along the northern rim of the Carpathians a

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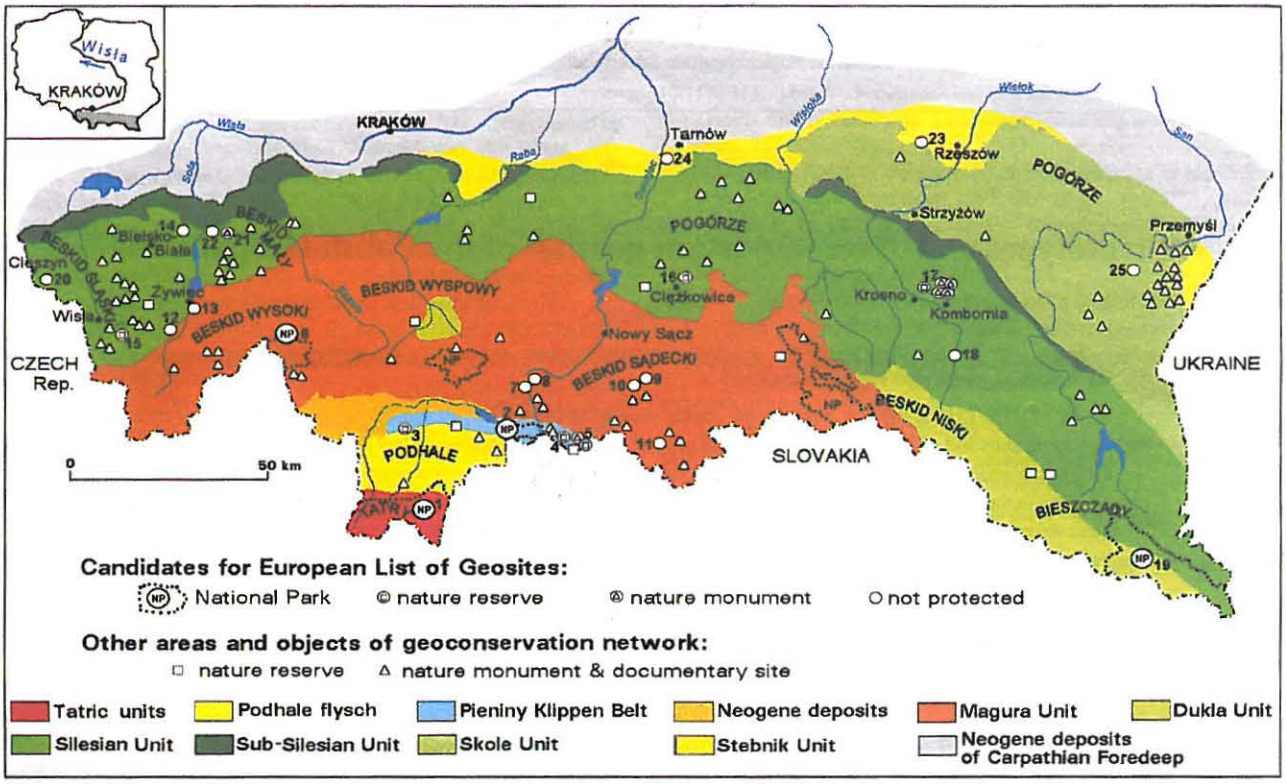


Fig. 1. Distribution of geosites of the Polish Carpathians in relation to main geological structures of the region

Fig. 2. Crystalline core of the High Tatras, the landscape of Pańszczyca Valley in the Tatra National Park — International Biosphere Reserve. Photo by W. P. Alexandrowicz

narrow zone of folded Miocene deposits occurs. The zone delimits (from the south) the Carpathian Foredeep that is filled with the Miocene deposits overlain by the Quaternary.

Characteristic features of the Carpathian landscape are peniplanation surfaces, glacial forms (Tatra Mts.), various types of river valleys and gorges as well as landforms related to mass movements.

Geoconservation network

There is a 150 years long tradition of geological studies of the Carpathians. An interest in a natural history of the Carpathians relatively quickly evolved in a conscious efforts to a protect nature, especially in the case of the Tatra Mts., Pieniny Mts. and Babia Góra Mt. — the highest massif in the Polish Outer Carpathians (1725 m a.s.l.). An idea of forming national parks or nature reserves ,dates back to the 19th century and was being implemented since the intra-war period. Nature protection in a broad scale became possible after WW2 based on the Nature Conservation Act of 1949 and the next one of 1991. At present, there are six national parks in the Carpathians and in the near future their number is to increase to seven (Fig. 1). Together with eleven landscape parks and numerous areas of protected landscape they provide an exemplification of major features contributing to diversity of nature and landscape of the Inner and Outer Carpathians as well as to a regional uniqueness of this region when compared to the surrounding.

First achievements in protecting inanimate nature, in forms of a nature reserve or a monument of nature, date back to the intra-war period and were associated with sandstone tors (Motyka, 1927; Klimaszewski, 1932, 1934, 1935; Świdziński, 1932, 1933a, b, c, 1936). Projects of protecting the tors were based on a geological account rather than on an aesthetic or landscape prominence. These were pioneering works creating a scientific background to nature protection according to a contemporary knowledge about geology and relief of the region. A next enumeration and documentation of the Carpathian sandstone tors significantly increased their register and broadened scientific fundamentals of protecting this kind of rocky objects in Poland (Z. Alexandrowicz, 1978, 1989a).

Until now 15 reserves of inanimate nature (231.29 ha), 77 nature monuments and 14 documentary sites have been approved in the Polish Carpathians (Fig. 1). A category — documentary site of inanimate nature — meant to conserve geological outcrops, has been well grounded and introduced to the Nature Conservation Act 1991 (Z. Alexandrowicz, 1991). The first attempt to implement this category was made with respect to the sites with Miocene deposits in the Polish Carpathians (Gonera, 1991). The above geoconservation network comprises also other reserves, mainly forest ones, where valuable geological outcrops and relief features might occur as well. About 30 such reserves, i.e. 50% of all of them, have been distinguished (Z. Alexandrowicz *et al.*, 1989, Z. Alexandrowicz *et al.*, 1992).

As geological and geomorphological studies are progressing in the Carpathians, interesting data about numerous sites are collected. Thus, systematic evaluation and selection of the sites should be performed taking into account a need and possibility of their legal protection. An analysis of the geoconservation network in the Carpathians channelled the conservation efforts on including under protection such elements which are either lacking represented only scantily. That refers mainly to stratotypes and other reference exposures of deposit sequences, fossils, rock types, sedimentary and tectonic structures as well as relief forms and controlling processes.

A worked out principles of the Polish classification, terminology and stratigraphic nomenclature of the pre-Quaternary and Quaternary stratigraphy oblige to disseminate protection of the standard exposures. Numerous projects aiming at successive optimisation of a current state of geoconservation have been prepared for the Carpathians (Z. Alexandrowicz., 1987a, b, 1997; Kotlarczyk & Piórecki, 1988; Z. Alexandrowicz & Denisiuk, 1991; Gonera, 1991, 1994a; Margielewski, 1992, 1994, 1997a, b; Kotlarczyk, 1993; Poprawa *et al.*, 1995; Z. Alexandrowicz *et al.*, 1996; Rajchel, 1996). Some of these projects, although a few of them, have already been executed.

Draft candidate list of geosites

When preparing a draft candidate list of important areas and objects in the Polish Carpathians, a focus was mainly on the spots which document a progress in knowledge about a geological structure of the region as well as about a relief mirroring it. The areas and objects were collectively called geosites. In the research history of the Carpathians, the turning points are achievements of Polish scientists in the following fields:

— micropalaeontology — a method primarily used for seeking after natural oil, and now being a basis of biostratigraphy of flysch deposits,

— sedimentology — used to determine an origin of sediments deposited as turbidites and fluxturbidites in a geosyncline basin,

— trace fossils and mechanoglifs developed at the bottom of sandstone beds,

— sequences of sediments and tectogenesis of the Carpathians,

— relative position of the Carpathian orogen with respect to a platform basement,

— stratigraphy of the Quaternary deposits together with reconstruction of palaeogeographic changes and morphogenesis of the Carpathians during the last glacial.

A leading role in setting up and developing geological research in the Carpathians during the last 40 years was played by Prof. Marian Książkiewicz's school. These are achievements of a global importance, providing background to the current and future studies on the Carpathian orogen, modernized by various methods.

A proposed draft candidate list of geosites in the Carpathians comprises the areas and objects that are already protected in various categories as well as those not yet protected, projected ones and those not documented for legal conservation. Out of six Polish national parks, there are four whose abiotic features, when compared with a whole region, promote them to a priority list. These are: Tatra National Park, Pieniny N.P., Babia Góra N.P. and Bieszczady N.P. These parks are characterized by a diverse geological structure and differentiated relief. Each park also presents an interdependent set of values providing evidence of a high rank of the region with respect to a geological heritage. An international category of geoconservation — lithosphere reserve — has been proposed for such regions (Z. Alexandrowicz & Wimbledon, in press). The lithosphere reserve as international category of geoconservation is an equivalent of the biosphere reserve — the category established by UNESCO-MAB.

The draft list of geosites has been arranged according to occurrence of particular tectonic and stratigraphic units of the Inner Carpathians, and then for the Outer Carpathians from south to north, regardless a state and category of particular geosites. Geosites have been selected according to the requirements for geoconservation networks (Wimbledon *et al.*, in press) and in agreement with the criteria of evaluation and selection worked out on the examples from the Carpathians and other regions of Poland (Z. Alexandrowicz *et al.*, 1996; Z. Alexandrowicz *et al.*, 1992).

1. The Polish Tatra Mts. within the highest massif of the Inner Carpathians (790–2499 m a.s.l.; 49°10'40"–49°16'55"N/19°45'40"–20°08'25"E).

Main features: Variscan crystalline massif, units of alpine nappes, Triassic–Cretaceous sequences, postglacial relief, system of caves.

The central element of the Tatra Mts. is the crystalline massif consisting of a granite Variscan intrusion and its metamorphic mantle (i.a. biotite gneisses, mica schists, chloritic schists and amphibolites). The crystalline massif is partially covered with sedimentary rocks being a main constituent of nappes thrust here from the south to the north (Passendorfer, 1962; Bac-Moszaszwili *et al.*, 1979; Bac-Moszaszwili & Gąsienica-Szostak, 1990). The High-Tatric Nappe in the core of its folds has crystalline rocks and its sedimentary part starts with deposits of the Permian–Lower Triassic age. Younger deposits of the Triassic and Jurassic developed as organogenic limestones and dolomites with shale and sandstone inserts. The Sub-Tatric nappes were thrust over the High-Tatric Nappe. Dolomites, radiolarites and radiolarite limestones are characteristic of the Sub-Tatric Nappe. A mountain massif uplifted in the Upper Cretaceous was then strongly eroded and a part of the sedimentary covered had been wasted. On the northern slopes of the mountains occur locally conglomerates and nummulite limestones related to a sea transgression in the Middle Eocene.

Relief of particular parts of the Tatra Mts. shows marked differences controlled by geologic structures (Fig. 2). In the Quaternary the relief was significantly modified by glaciations and periglacial climate (Kotarba, 1976; Klimaszewski, 1988). An extensive and deep system of karst caves developed in limestone rocks (Grodzicki (ed.), 1991–1996).

The Tatra National Park (21,164 ha) presents a complete geologic structure of the Tatra alpine chain with a typical glacial and periglacial relief (Klimek (ed.), 1996). This park and Tatranski National Park in the Slovak territory, both preserving the nature of the Tatra Mts., were established in 1992 by UNESCO-MAB as the International Biosphere Reserve.

2. The Pieniny Mts. in the northern marginal zone of the Inner Carpathians (425–982 m a.s.l.; 49°23'43"–49°24'42"N /20°19'32"–20°27'36"E).

Main features: Jurassic–Cretaceous sequences of facial-tectonic units with main stratotypes of the Pieniny Klippen Belt, picturesque rocky landscape reflecting geologic structures, famous Dunajec gorge.

The Pieniny Mts. embody a mosaic of well recognized, diversified lithostratigraphic units consisting of the Jurassic–Cretaceous deposits with complicated structures such as steep folds, thrust faults and overthrust nappes, strongly dislocated (Birkenmajer, 1958, 1963, 1977, 1979, 1986). Steep, upright limestones of the Upper Jurassic and Lower Cretaceous separate in places inserts of soft rocks (shales and marls). The Lower and Middle Jurassic and the Upper Cretaceous are mainly represented by shales and marls. The Upper Cretaceous sediments contain numerous foraminifera of *Globotruncana* species (S. W. Alexandrowicz, 1966).

Many stratotypes of the Pieniny Klippen Belt are represented in the referred area. Deposits belonging to the Pieniny and Branisko successions are most important here. The thickest (100–200 m) are white limestones with cherts known as the Pieniny Limestone Formation (Tithonian–Berriasian). These limestones, very resistant to erosion, build major summits, including the highest peaks — Trzy Korony Mt. (Three Crowns; 982 m a.s.l.) being a symbolic element of the Pieniny landscape and a viewpoint located above the deeply incised Dunajec valley (Fig. 3). Another characteristic feature of the Pieniny geologic structure is a narrow belt of steep, upright outcrops of the resistant, Middle Jurassic crinoid limestones of the Czertezik Unit. The extent of the outcrops of the resistant crinoid limestones of the Czorsztyn Unit and of the Niedzica Unit is limited.

Particular successions of the units comprise sediments differing as to resistance that is clearly reflected in the Pieniny Mts. relief. Hills with steep slopes, klippes, and deep rocky gorges developed in hard limestones. Depressions and passes among limestone klippes formed where complexes with predominating shales, shales and marls occur. A very peculiar element of the Pieniny Mts. relief is the antecedent gorge of the Dunajec river (Zuchiewicz, 1988). In the main range of the Pieniny Mts. there is a dense network of springs which are sometimes accompanied by Holocene calc-sinter (Kostrakiewicz, 1982; S. W. Alexandrowicz, 1988).

The Pieniny Mts. represent an area of the highest tectonic and lithostratigraphic rank in the Pieniny Klippen Belt. Moreover, they form the most typical landscape reflecting tectogenesis of the Pieniny Klippen Belt. The Pieniny Mts. are located within the Pieniny National Park (2346 ha).

The Pieniny Klippen Belt is well represented in geoconservation network which is a large accomplishment of Prof. Krzysztof Birkenmajer. Numerous nature reserves make a very important supplement of geological and geomorphological values of the Pieniny Klippen Belt situated outside of the Pieniny National Park. Three of them should be emphasized.

3. The Klippes in Rogoźnik in the Pieniny Klippen Belt (680 m a.s.l.; 49°26'00"N/19°57'32"E).

Main features: the Czorsztyn Succession within the Pieniny Klippen Belt, type locality of the Tithonian and Lower Berriasian sequences, biostratigraphic ammonite level of the Tithonian Rogoźnik Coquina Member.

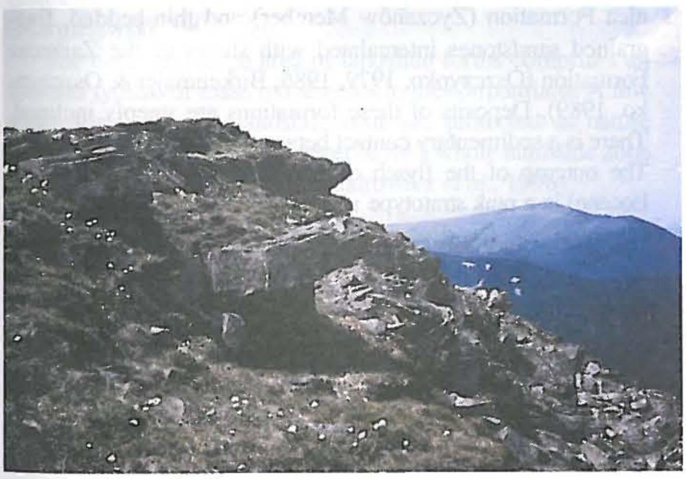
The site comprises a natural outcrop and two inactive quarries located nearby (Fig. 4). The Czorsztyn Succession with stratotype facies of Tithonian–Lower Berriasian outcrops in this area (Birkenmajer, 1977). Fossils found in the coquina limestone, which occurs there, were a subject of classic studies during the last two centuries. Middle Tithonian fauna from the coquina limestone is the standard of the ammonite Zone *Semiformis semiforme* in the Alpine–Carpathian area (Kutek & Wierzbowski, 1979, 1986; Wierzbowski & Remane, 1992). The brachiopod and crinoids fossils from Rogoźnik are well recognized as to their stratigraphic and palaeontologic importance (Pisera & Dzik, 1979; Barczyk, 1991; Krobicki, 1994).

The Rogoźnik Klippes formed of limestones rich in fossils are the most important site of the Tithonian–Berriasian deposits in the Alpine–Carpathian region as a standard stratigraphic sequence of the Jurassic–Cretaceous border.

The geosite is protected as a nature reserve called "Skałka Rogoźnicka" and occupies 3.06 ha including suggested enlargement of the area (Birkenmajer, 1962; Z. Alexandrowicz *et al.*, 1997). The reserve is placed on the UNESCO list of World Geological Heritage.

4. The Homole Gorge near Szczawnica in the Pieniny Klippen Belt (550–718 m a.s.l.; 49°24'00"N/19°33'15"E).

Main features: unique rocky scenery of the gorge within the area of the Pieniny Klippen Belt, the tectonic contact of calcare-



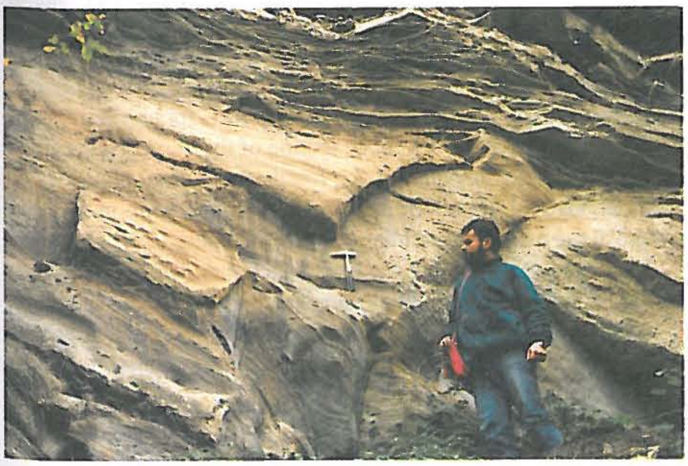


Fig. 3. Pieniny National Park. The highest limestone peaks — Trzy KoronyMt. (Three Crowns) above the Dunajec river. Photo by Z. Denisiuk

Fig. 4. Skałka Rogoźnicka (Rogoźnik Klippe) Nature Reserve in the Pieniny Klippen Belt. Stratotype of the Rogoźnik Coquina Member. The site placed on the UNESCO *List of World Geological Heritage*. Photo by Z. Alexandrowicz

Fig. 5. Babia Góra National Park (Biosphere Reserve). Block field and rocky edge of the ridge crest. Photo by S.W. Alexandrowicz

Fig. 6. Outcrop of Krosno Beds in the Fore-Magura zone near Żywiec (Przybędza). Sedimentary structures well exposed by weathering. Photo by W. Rączkowski

ous formations of Czorsztyn and Niedzica successions, stratotype of Czajakowa Radiolarite Formation, Holocene landslide.

The Homole Gorge is a classic example of a trench morphology, which originated as the result of uprising, cracking and dividing of calcareous plate into blocks and their irregular subsidence in softy, shale substratum (Birkenmajer, 1958, 1971, 1979). These processes have determined the unique gorge which is characterised by threshold-like and narrow bottom and by unusual rocky scenery of its fringe. A large landslide dated at the beginning of the Holocene damming the valley and forming a huge block field is another value of this gorge (S. W. Alexandrowicz, 1996).

Calcareous formations of the Czorsztyn and Niedzica successions crop out along the gorge (Birkenmajer, 1977). Characteristic features of the Czorsztyn Succession are crinoids and calpionella limestones belonging to different formations of the Jurassic age. The Niedzica Succession comprises a stratigraphic profile from the Upper Liassic to Lower Cretaceous. The outstanding feature here is a stratotype of the Czajakowa Radiolarite Formation (Oxfordian). The tectonic contact of the low dipping limestones of first mentioned succession with the strongly folded deposits of the other one is clearly visible. The origin of the Homole Gorge and its geological setting characterized by tectonic contact of different standard successions are exceptional values in the whole area of Pieniny Klippen Belt.

The Homole Gorge is protected as the nature reserve called "Wąwóz Homole" (58.64 ha).

5. The Biała Woda valley in the Pieniny Klippen Belt (620–675 m a.s.l., 49°24'18"N/20°34'45"E).

Main features: the rocky gorge, type locality of the Smolegowa Limestone Formation, tectonic contact zone of different units, the basalt tor.

The gorge section of this valley is incised in Jurassic white crinoidal limestones of the Czorsztyn Succession. The latter produce high klippes and are exposed in the valley bottom where they form steps. A protruding Smolegowa Skała (Smolegowa Rock) is a stratotype of the Smolegowa Limestone Formation (Birkenmajer, 1977). From the south this succession is covered with Upper Cretaceous deposits of the Niedzica Succession. Along the right bank of the gorge the Czorsztyn Succession is thrust north-ward over the Upper Cretaceous–Palaeogene flysch of the Grajcarek Succession.

The discussed site is very interesting not only as the picturesque gorge but especially due to the tectonic contact of three units, the type locality of the thickest limestone formation of Czorsztyn Succession as well as the occurrence of the basalt intrusions.

Two fragments of the Biała Woda valley are protected in one nature reserve called "Biała Woda" (33.70 ha). Close to the northern border of the reserve there is a basalt tor which is a trace of a Tertiary intrusion (Birkenmajer & Nairn, 1969). The tor is protected as a nature monument.

6. The Babia Góra range in the Beskid Wysoki Mts. (830–1725 m a.s.l.; 49°32'52"–49°36'42"N/18°28'20"–19°35'22"E).

Main features: the highest range in the Polish Outer Carpathians, the European watershed, typical thick-bedded Magura Sandstones, largest rock slump and block field of the Polish Carpathians.

The Babia Góra range is situated within the asymmetric synclinal structure of the Magura Unit formed mainly of the thick-bedded Magura Sandstones (Książkiewicz, 1966, 1983; Aleksandrowski, 1985, 1989). The northern limb of the syncline plunges normally while the southern limb is overturned and limited by two narrow and steep folds.

The Babia Góra range follows the orientation of a parallel of latitude (about 12 km). The upper part of the range rises above the timberline and is shaped by periglacial processes (Jahn, 1958; Baumgart-Kotarba, 1972). In the summit area there are flattening and steps formed at the outcrops of the resistant Magura Sandstones (Fig. 5). Asymmetrical slopes are characteristic features in the range morphology. The northern slope is very steep and in the prevailing part covered with sandstone blocks. It developed as a result of a huge rock-fall (100–300 m high) which dates back to the Early Holocene (Ziętarowie, 1958; S. W. Alexandrowicz, 1978). Some under-summit depressions were interpreted as glacial kars (Sawicki, 1913). The northern slope is gently inclined in agreement with the Magura Sandstone bedding. The Babia Góra range is a watershed delimiting the Baltic Sea drainage basin in the north and the Black Sea drainage basin in the south. This range is also characterized by a dense network of springs of high outflow (Łajczak, 1981).

The Babia Góra is the highest mountain range in the Polish Outer Carpathians. This massif is built of typical thick-bedded Magura Sandstones. Its relief is unique because of a clear asymmetry of slopes related to syncline structure of the substratum as well as to mass movements which caused formation of a huge rock slump with a large block field covering the northern slope of the range.

The Babia Góra range is entirely protected within the framework of the Babia Góra National Park (3392 ha), which was later recognized by UNESCO as a MAB Biosphere Reserve in 1977.

7. The Baszta (Basset) hill near Tylmanowa in the Beskid Sądecki Mts. (400 m a.s.l.; 49°30'55"N/20°24'02"E).

Main features: the stratotype of the Magura Formation.

On the left slope of the Dunajec river valley there are well exposed deposits of the Magura Formation (Eocene) within the Magura Unit of the Krynica Subunit. A 130 m long exposure rising to 35 m is mainly a wall of an old quarry. This is the exposure of 50 m thick sequence of deposits. These are mainly complexes of thick-bedded and coarse-grained conglomerate sandstones among which thin-bedded sandstones, shales and mudstones occur. The site is thoroughly examined with respect to lithostratigraphy, sedimentary structures, microtectonics and fossil traces (Tokarski, 1975a; Oszczypko & Porębski, 1985, 1986; Oszczypko *et al.*, 1992b). From this exposure deposits and sedimentary structures of a submarine slide, which was identified for the first time by Książkiewicz (1958), were described and interpreted. The discussed site has a high value as a type locality of the Magura Formation and due to well recognised sandstones with characteristic sedimentary structures. The Magura Sandstones widespread in the Outer Carpathians are the main ridge-forming rocks. The site called Baszta (Basset) is a candidate for protection (Z. Alexandrowicz *et al.*,), 1996). This site is valuable due to its landscape and didactic aspects.

8. The outcrop along the Dunajec river valley near Zarzecze in the Beskid Sądecki Mts. (400 m a.s.l.; 49°32'21"N/20°24'56"E).

Main features: stratotype of the Zarzecze Formation, contact of two lithostratigraphic formations within the Magura Unit (Krynica Subunit).

The profile is well exposed in the river bottom and on its right bank over the distance of 350 m. This is a contact zone of the thick-bedded and coarse-grained sandstones of the Szczawnica Formation (Życzanów Member) and thin-bedded, fine-grained sandstones intercalated with shales of the Zarzecze Formation (Oszczypko, 1979, 1986; Birkenmajer & Oszczypko, 1989). Deposits of these formations are steeply inclined. There is a sedimentary contact between lithological formations. The outcrop of the flysch of the Zarzecze Formation (Early Eocene) is a rank stratotype within the Krynica Subunit of the Magura Unit. The discussed site is documented for protection (Z. Alexandrowicz *et al.,* 1989).

9. The Uhryń stream valley near Łabowa in the Beskid Sądecki Mts. (500 m a.s.l.; 49°30'50"N/20°52'08"E).

Main features: the stratotype of the Łabowa Shale Formation, reference section of the Beloveza Formation within the Magura Unit, deep and narrow valley.

The site is of a standard importance for litho- and biostratigraphy of a lower part of the Early Eocene deposits in the Bystrica Subunit of the Magura Unit. Both the type locality of Łabowa Shale Formation (rich in fossils — foraminifera, nannoplankton) and the reference section of the variegated argillosilty deposits abundant in trace fossils and current markings of the Beloveza Formation are accessible in many spots in the floor and at the banks of the stream valley (Dudziak, 1991; Oszczypko, 1991; Oszczypko *et al.*, 1992a; Uchman, 1992). The Łabowa Shale (about 50 m thick) are steeply folded. The sequence consists of alternated, differing in colour, layers of shales and marly mudstones. At the bottom of this sequence there are

Inoceramus Beds (with prevailing thick-bedded sandstones interlaminated with clayey shales) and at the top — deposits of the Beloveza Formation.

The Łabowa Shale Formation, abundant in foraminifera and nannoplankton, is an important stratigraphic level of Early Eocene in the Outer Carpathians. The landscape of a deep, narrow and winding valley contributes to the value of this area, proposed as a geological reserve comprising ca 40 ha (Z. Alexandrowicz *et al.*, 1996).

10. The range of Wierch nad Kamieniem (Summit over Stone) in the Beskid Sądecki Mts. (820–1070 m a.s.l.; 49°28'57"N/20°48'08"E).

Main features: large area of landslide forms, dated phase of mass movement activity.

Mass movements resulting in diversified landslide forms contribute to shaping the Outer Carpathian relief. Landslide age, determined mainly by the radiocarbon method points to different climatic phases of the Holocene. A broad landslide zone, occurring on high-elevated slopes of the ridge running northward from a culmination called Wierch nad Kamieniem, is a best example of relief associated with head an lateral erosion of a stream. Among various forms, outstanding features are high niches with sandstone tors, narrow trenches and colluvial block fields (Baumgart-Kotarba, 1974; Z. Alexandrowicz, 1978; Margielewski, 1992, 1997c, d). There are also here pseudokarst caves including Niedźwiedzia Cave — one of the longest (340 m) in the Beskidy Mts. The landslide developed gradually in the thick-bedded sandstones and conglomerates of the Magura Unit. One period of the landslide activity is dated at 770±100 BP (Margielewski, 1997c, d).

The described large area of landslide forms comprises all features typical of mass movements in the Carpathians. A few rocky elements of a landslide zone are protected as nature monuments. Setting a nature reserve for a whole landslide zone (ca 12 ha) is proposed (Z. Alexandrowicz *et al.*, 1996).

11. The Złockie stream valley in the Beskid Sądecki Mts. (560–600 m a.s.l.; 49°23'18"N/20°54'25"E).

Main features: natural exhalations of carbon dioxide, mineral water springs, dated tufa and peat, the Magura Unit Succession with the oldest Upper Cretaceous deposits.

The Beskid Sądecki Mts. is an exceptional zone of mineral water resources in the Outer Carpathians. The surrounding of the Złockie stream deserves particular interest due to mineral water springs with dissolved CO_2 and exhalation of CO_2 as mofettes. They occur within a very complicated and interesting geological structure of the Krynica Subunit of the Magura Unit (Świdziński, 1965; Chrząstowski, 1992). Outcrops of red shales of the Upper Cretaceous are of a considerable stratigraphic value as the oldest deposits of the Magura Unit (Birkenmajer & Oszczypko, 1989; Oszczypko *et al.*, 1990). The unique locality of the Late Holocene calcareous tufa and peat associated with mineral waters and dated by radiocarbon method at 630±80 BP is a supplementary value of this area. The discussed sites occur over the area of ca 25 ha. The nature reserve — Mofette in the Złockie stream — and two documentary site are proposed (Z. Alexandrowicz *et al.*, 1996).

12. Outcrop in Przybędza near Żywiec (400–420 m a.s.l.; 49°37'40"N/19°08'50"E).

Main features: stratigraphy and lithology of the Krosno Beds in the Fore-Magura zone (Dukla Series), sedimentary structures.

In the quarry in Przybędza (15a) there are outcrops of thick-bedded, medium- and fine-grained mica sandstones. These sandstones are laminated which is emphasised by accumulation of muscovite and carbonized plant detritus on lamina planes. Thicker beds of sandstones contain numerous shale fragments occurring at the bottom. The top surfaces of the sandstone beds are not very clear; the sandstones gradually change into mudstones, and then in sandy shales. The site is very valuable due to sedimentary structures (Fig. 6) which are to be protected here.

13. Outcrops along the profile of the Soła river near Żywiec (365 m a.s.l.; 49°40'20"–49°40'30"N/19°12'00"E)

Main features: the Lower Cretaceous deposits of the Silesian Unit.

The area of Grojec hill in Żywiec is one of the most interesting and controversial geologic elements in the Żywiec Basin. On the right bank of the Soła river, upstream the Koszarawa mouth, a 200 m long, continuous profile of the Lower Cretaceous deposits of the Silesian Unit is visible. Because of numerous scales and strong folding of shale deposits of the Cieszyn–Grodzisko series geologic pattern is disputable. Here, the oldest deposits of the Silesian Unit are the Cieszyn Limestones, representing the upper — Cretaceous — part of this member (Nowak, 1970a, b). Limestones are the main constituents of the first outcrop. They comprise about 400 calciturbidites of various thickness (Malik, 1994). Between the limestones, forming here a small anticline, two teschenite sills occur which are a subject of palaeomagnetic studies (Grabowski *et al.*, 1996) (Fig. 7). Further, about 800 m south of the Koszarawa mouth there is an outcrop of a thick rock complex

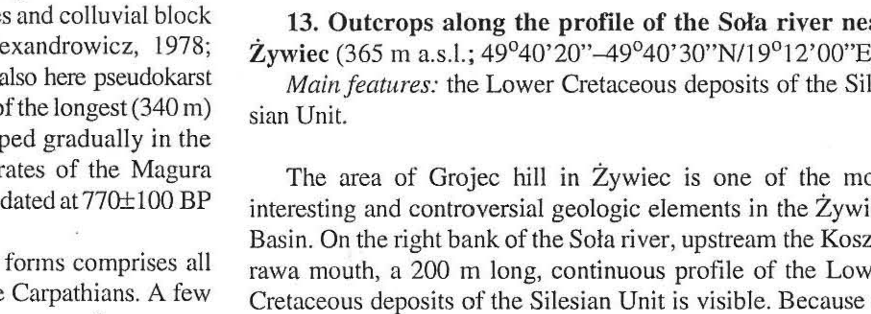


Fig. 7. Outcrop of the Cieszyn Beds on the right bank of the Soła river near Żywiec (after J. Grabowski *et al.*, 1996)

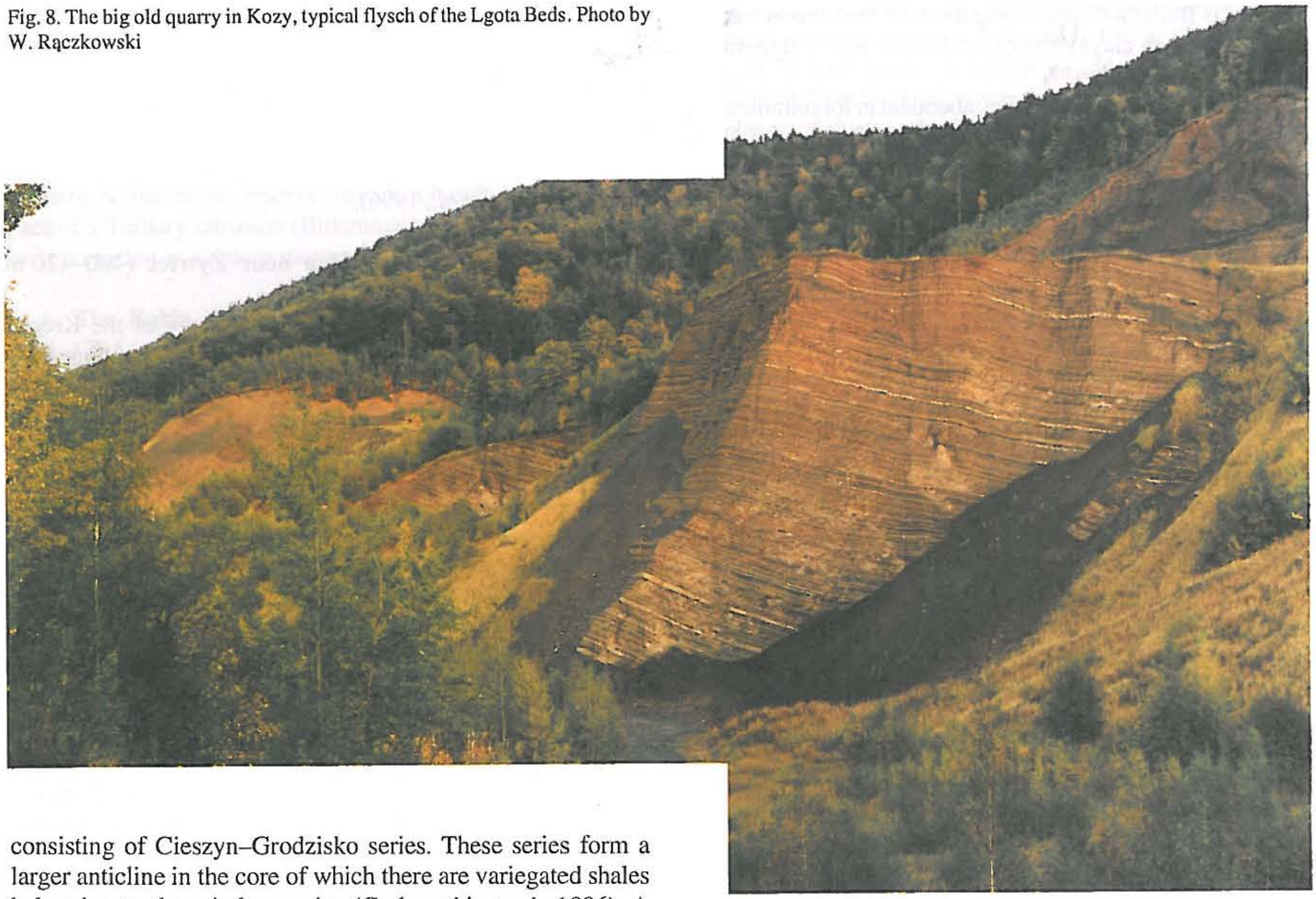


Fig. 8. The big old quarry in Kozy, typical flysch of the Lgota Beds. Photo by W. Rączkowski

consisting of Cieszyn–Grodzisko series. These series form a larger anticline in the core of which there are variegated shales belonging to the window series (Grabowski *et. al.*, 1996). A layer of a sedimentary breccia, 21 m thick (Malik, 1994), as a megaturbidite is a characteristic element of the discussed exposure. This breccia layer contains, besides size-differentiated clasts representing all members of the Cieszyn Series, larger patches reaching up to 3 m in length. They represent, among others, dark grey, almost black, clayey shales with fine-grained siderite sandstone lamina resembling Wierzowa Shales. There are also visible patches of Cieszyn Limestones. Among these rocks, strongly weathered teschenite blocks and fine- and medium-bedded sandstones with carbon chunks, representing the Grodzisko Beds occur.

The fully developed profile of the Lower Cretaceous deposits of the Silesian Unit is to be protected in this site.

14. Abandoned quarry in Kozy near Bielsko (500–600 m a.s.l.; 49°49'40"N/19°09'30"E).

Main features: Lgota Sandstones of the Silesian Unit, sedimentary structures.

The quarry in Kozy is one of the largest exposures of the Lgota Beds of the Silesian Unit (Fig. 8). They represent deposits of the Albian–the Lowest Cenomanian. The thickness of the Lgota Beds in the quarry profile is 220 m (Unrug, 1959), and in the excavation site the 150 m thick complex is exposed. The sandstones showing up in the quarry are characterized by a high variability of bedding and amount to about 66% of rocks occurring here. The shales add to the remaining 34%. The thickness of the sandstone beds measured in the quarry varies from 1 to 100 cm (Peszat, 1971) with 7cm on the average. Very thin- and thin-bedded sandstones are most abundant and amount to 82%. The beds of sandstones occurring here are structurally and texturally highly differentiated. These sandstones are: fractionally bedded, horizontally laminated as well as cross-bedded, and were formed in various sedimentary environments related to different types of turbidity currents.

The sandstones in the Kozy quarry have been exploited as building and road stones for over 80 years. After processing they were also used as brick-stones of various sizes. Having environment protection in mind, the quarry was closed down at the beginning of the 1980s.

15. The head-water of the Vistula river valley (830–1100 m a.s.l.; 49°36'51"–49°38'04"N/18°56'24" – 19°00'50"E).

Main features: waterfalls, contact zone of two formations.

The area is situated within the Silesian Unit section of transition of the Upper Cretaceous flysch of the Godula Beds to the coarse-grained and thick-bedded sandstones, conglomerates and mudstones of the Lower Istebna Beds (Burtanówna *et al.*, 1937). The Istebna Beds represent the typical sediment of fluxoturbidites (Unrug, 1963). The Vistula streams in the western slopes of Barania Góra range are a particular example of a great concentration of erosional forms, especially fall steps in the Outer Carpathians (Z. Alexandrowicz, 1976, 1994, 1997; Ziętara & Lis, 1986). The cascades and other types of erosional forms are in different stages of development, depending on lithology and on various strikes related to streamflow direction. The largest sets of 5 m high fall steps were formed in the bottom thick layers of sandstones and conglomerates of the Istebna Beds. The contact of two different flysch formations is an important factor controlling the origin of waterfalls in the described valley. The area is of primary hydrographic importance due to occurrence of headwater streams of the Vistula — the main Polish river. The Vistula head streams are protected as a nature reserve (17.61 ha).

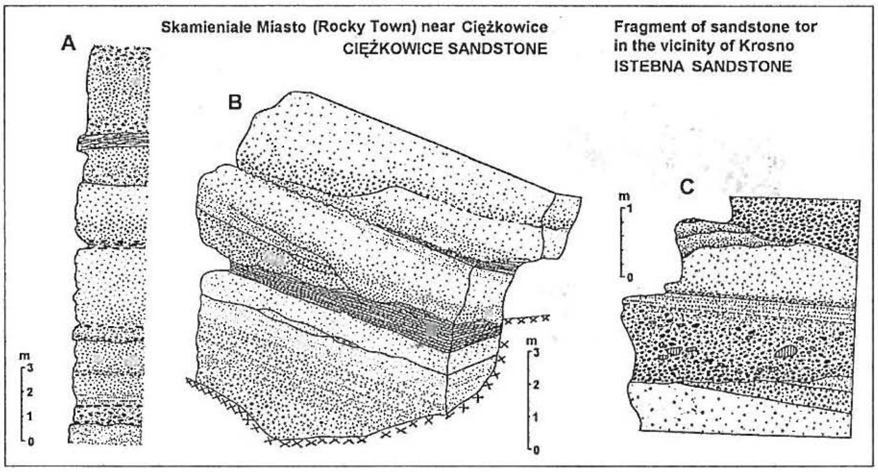


Fig. 9. Examples of different sequences of fluxoturbidites from the Carpathian Foothills (after Z. Alexandrowicz, 1970 — fig. A; Koszarski, 1956, modified by Ślączka & Thompson, 1981 — fig. B; Koszarski, 1962 — fig. C)

16. Ciężkowice tors in the western part of the Carpathian Foothills (255–355 m a.s.l.; 49°46'32"N/ 20°58'20"E).

Main features: type locality of Ciężkowice Sandstones, tors, typical sedimentary structures of fluxoturbidites, weathering forms.

At the beginning of the 1920s, the Ciężkowice Sandstones were distinguished in lithostratigraphy of the Carpathian flysch, basing on the outcrops from Ciężkowice surroundings (Grzybowski, 1921; Zerndt, 1924). Now, it is well studied and its best outcrops are in the Skamieniałe Miasto (Rocky Town) Nature Reserve in Ciężkowice. Considering the above mentioned reasons, the reserve area could be recognized as the Lower Eocene stratotype of Ciężkowice Sandstones of the Silesian Unit. A scenic, large group of sandstone tors has been protected here since 1931. The differentiated bedding, domination of coarse-grained material and traces of submarine erosion characterize fluxoturbidites accumulated by high density turbidite current and debris flows (Koszarski, 1956; Z. Alexandrowicz, 1970, 1978; Leszczyński, 1981, 1989) (Fig. 9A, B). Features of these sediments are particularly well visible on tors walls subjected to selective weathering (Alexandrowicz & Brzeźniak, 1989).

The area is a classic study site and has high didactic value especially, for demonstrating rock relief, sedimentary structures typical of fluxoturbidites, and geological setting of tors in the zone of Ciężkowice Sandstones as well as lithostratigraphic position in the deposit succession of the Silesian Unit.

The Skamieniałe Miasto (Rocky Town) near Ciężkowice is protected in 15 ha area of the nature reserve (Z. Alexandrowicz, 1970).

17. The vicinity of Krosno in the eastern part of the Carpathian Foothills (390–504 m a.s.l.; 49°46'06"–49°46'44"N/21°48'26"–21°51'40"E).

Main features: tors of Ciężkowice and Istebna sandstones, fluxoturbidites, weathering structures.

The marginal zone of the Silesian Nappe to the north of Krosno is characterized by a series of hills with sandstone tors having original shape among which a group called Prządki (Spinners) is remarkable in landscape (Fig. 10). The tors were formed within the thick-bedded and coarse-grained sandstones and conglomerates of the Ciężkowice Sandstones (Eocene) as well as Istebna Beds (Palaeocene) of the Silesian Unit. A characteristic feature of tor grouping are labyrinths of narrow corridors formed by splitting along bedding planes, gravitational slip and subsiding of particular rock pockets. On Kamieniec hill the tors of Ciężkowice Sandstones form picturesque surrounding of a ruin of a medieval castle. Numerous tors of the Istebna Sandstones occur in the surrounding of Kombornia.

Geological setting of tors near Krosno is a key to understanding the origin of such phenomena developed as hard rocks within fluxoturbidite lithosomes (Z. Alexandrowicz, 1987b). The groups of tors present various sequences of fluxoturbidites very characteristic for Ciężkowice and Istebna sandstones (Koszarski, 1962; Ślączka & Thompson, 1981) (Fig. 9C). The Prządki (Spinners) tors of Ciężkowice Sandstones have been the first rocky objects minutely documented as nature reserve (Świdziński, 1932, 1933a). It is a classic site of occurrence of various types of weathering structures of the Carpathian sandstones firstly described here.

Numerous tors in the vicinity of Krosno are protected as a reserve (Prządki) and nature monuments in the Ciężkowice–Strzyżów Landscape Park (Z. Alexandrowicz, 1987a, b). The most gorgeous group of tors occupies an area of 23 ha.

18. Outcrops in the Wisłok river valley (300–350 m a.s.l.; 49°31'00"–49°32'10"N/21°55'40"–21°56'20"E and 49°34'50"–49°35'40"N/21°55'50"–21°56'40"E)

Main features: sequence of the Oligocene deposits (Silesian Unit), tectonic and sedimentary structures, gorge river valley.

The profile of the Wisłok river valley might be observed in two localities, 1.2 km and 1.0 km long sections, upstream and downstream of the Sieniawa reservoir, respectively. Here, there are good exposures of the Lower Krosno Beds with the Jasło Shales and the underlying Passage Beds. The Jasło Shales are important correlation elements. These exposures are particularly valuable for sedimentological studies and tectonic research as in particular bed complexes or packets there are visible various forms of lamination as well as tectonic structure

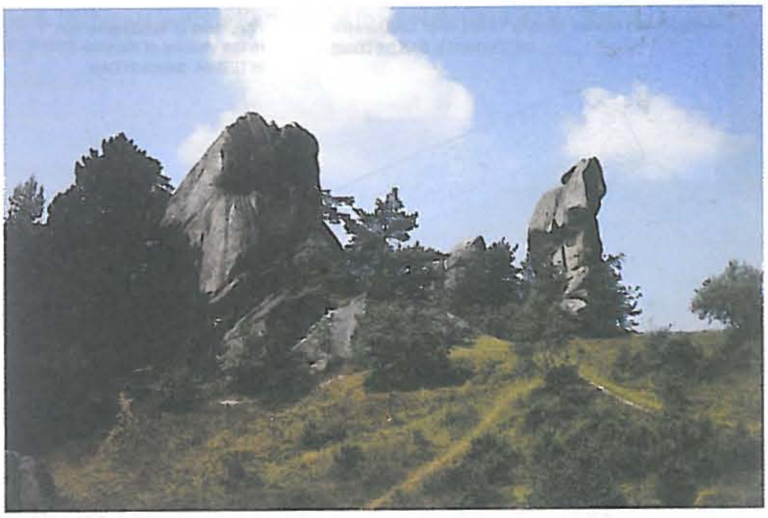


Fig. 10. The Prządki (Spinners) Nature Reserve near Krosno. Ciężkowice Sandstones of the Carpathian Foothill. Photo by Z. Alexandrowicz

Fig. 11. The Bieszczady National Park — International Biosphere Reserve. A typical structural relief formed on resistant sandstones of the Krosno Beds.Photo by S. Michalik

(Dżułyński *et al.*, 1956). Moreover, a picturesque river gorge with continuing outcrops of bed complexes is an additional value of this site.

The exposures are proposed for protection as a geological reserve (Z. Alexandrowicz, 1987a).

19. Bieszczady Mts. — a highest part of the Polish Eastern Outer Carpathians (650–1346 m a.s.l.; 49°00'07"–49°14'11"N/22°26'30"–22°53'52"E).

Main features: the highest part of the Polish Eastern Outer Carpathians, contact of two facial-tectonic units, diversified structural landscape.

In the area of the Bieszczady Mts. there is a contact of two large facial-tectonic units. The Dukla Unit is thrust over the Silesian Unit from the south-west (Ślączka, 1971; Żytko (ed.), 1973). The Bieszczady Mts. are mainly formed of the Oligocene–Lower Miocene Krosno Beds of the Silesian Unit characterized by thick-bedded sandstones alternating with shales. This is the youngest formation of the Carpathian flysch. Relief of the mountains reflects geological pattern (Starkel, 1965; Tokarski, 1970, 1975b; Baumgart-Kotarba, 1974). Ranges built of resistant sandstones are arranged parallel from the north-west to south-east. Slopes of these ranges are dissected by deep gorge valleys. The highest mountain range reaches above the timberline situated at 1150 m a.s.l. In the summit parts there are numerous sandstone outcrops with broad block fields beneath (Pękala, 1969).

The Bieszczady Mts. are the classic area of a structural landscape of the Eastern Outer Carpathians (Fig. 11). The Bieszczady National Park (27,834 ha) comprises the largest mountain massifs of the Polish territory and is a part of the International Eastern Carpathian Biosphere Reserve that was established in 1992. The other part of this reserve is in Slovakia.

20. Abandoned quarry in Goleszów near Cieszyn (450–460 m a.s.l.; 49°44'30"N/18°43'50"E).

Main features: Lower Cieszyn Shales, the oldest deposits of the Carpathian flysch.

The extent of the Lower Cieszyn Shales is limited to the Silesian Beskid and the Żywiec Basin. These shales form the bottom part of the flysch series. As to their age, they represent the Lower Tithonian (Gąsiorowski, 1961; Książkiewicz, 1972) and in the lowest part also the Kimmeridgian. According to the most recent studies, they represent the time interval the Upper Kimmeridgian–Middle Portland (Malik, 1994). The Lower Cieszyn Shales were formed by various gravitational processes in marine environment. The discussed rocks are exposed in the quarry Nowa Marglownia. The quarry has been closed down since the end of the 1970s.

21. Targanice in the Beskid Mały Mts. (340 m a.s.l.; 49°50'08"N/19°20'05"E).

Main features: Andrychów Klippen Succession surrounded by flysch.

The exposure along the stream is a unique site belonging to the Andrychów Klippen Succession and its tectonic contact with lithostratigraphic flysch units. The Klippen Succession is represented by olistholites of limestones with cherts of Oxfordian and Tithonian age, Upper Cretaceous limestones and marls rich in foraminifera and by Palaeocene limestones with lithothamnium with black shales (Książkiewicz, 1951; Książkiewicz & Liszkowa, 1972). Deposits mentioned above rest on the Upper Cretaceous marls of the Sub-Silesian Unit on which a complex of Lgota Layers of the Silesian Unit is thrust from the south. Shallow marine carbonate deposits of the Andrychów Klippen Succession evidence an important palaeogeographic element of the Carpathian Baška–Inwałd Cordillera (Książkiewicz, 1951, 1972; Unrug, 1969). The profile along the stream bank over a 200 m long section is protected as a nature monument (Z. Alexandrowicz *et al.*, 1975).

22. Profile of the Domaczka stream near Czaniec in the Beskid Mały Mts. (400 m a.s.l.; 49°49'47"N/19°12'05"E).

Main features: Miocene deposits altered with those of the Sub-Silesian Unit, a large olistostrome consisting of different members of the Carpathian flysch.

In the longitudinal profile of the Domaczka stream there are exposures of marls and shales, containing *Globotruncana,* and belonging to the Sub-Silesian series. Here, the marls separate variegated deposits of the Cretaceous, Palaeocene and Eocene from the Miocene shales. The profile of the referred deposits is situated directly west of the Roczyn Klippe that belongs to the Andrychów Klippen Belt. In the Domaczka profile, chaotically arranged Miocene Krosno Shales containing blocks of limestone, marls, gneiss, granites and other crystalline rocks rest on the folded marls of the Sub-Silesian Unit (Koszarski, 1992). According to Koszarski (1992) both the Andrychów Klippen Belt as well as the blocks and gravels occurring in the Domaczka stream likely originate from a ridge delimiting the Sub-Silesian zone from the north.

In the Domaczka profile there are also exposures of shales and mudstones with singular inserts of sandstones. The most interesting outcrops of these deposits (grey and dark grey shales with thin, singular beds of sandstones) are upstream of the road from Czaniec. The poorly preserved and inter-mixed fauna, identified in various shales, represents a wide age interval from the Palaeocene (or even the Cretaceous) to the Upper Eocene likely with some Miocene species. Yet, the foraminifera sampled point to the Upper Senonian while the calcareous nannoplankton consists of badly preserved Palaeogene forms. Moreover, in the Domaczka profile there are outcrops of grey marly shales (claystones and mudstones) with singular, thin inserts of fine-grained sandstones. Here, the assemblages of foraminifera of the Barremian and Upper Senonian were identified while the calcareous nannoplankton comprised the age interval from the Palaeocene to the Recent.

Based on sedimentological and micropalaeontological studies, it is believed that the deposits identified in the Domaczka stream profile constitute an olistostrome, consisting of material originating from various members of the Carpathian flysch among the deposits of the Lower Miocene. Sedimentation of these deposits should be referred to an internal Miocene basin.

As the site locality is important in stratigraphy and tectogenesis of the Carpathians it is a candidate documentary site for the list of the European Geosites.

23. Olimpów — 18 km west of Rzeszów, in the eastern part of the Carpathian Foothills (250 m a.s.l.; 49°50'18"N/-21°45'22"E).

Main features: stratotype of the Badenian lithotamnia facies.

In the Olimpów quarry (0.2 ha) there are exposures of organodetritic limestones of the Middle Miocene (Badenian) which are of a rank of stratotype of lithotamnia facies (Golonka, 1981; Gonera, 1991). The limestones very rich in fauna present a unique geotop of the fragment of carbonate build-up connected with sublithoral zone of the Miocene Paratethys. The bedrock of Miocene deposits near Rzeszów is formed of flysch of the Skole Unit. The patches of the Miocene sediments covering the flysch were folded during the latest tectonic movements of the Carpathians (Gonera, 1994b).

The locality is proposed to be protected as a documentary site (Gonera, 1991).

24. Zbylitowska Góra in the Dunajec river valley (200–250 m a.s.l.; 49°58'00"N/20°56'12"E).

Main features: Badenian clays covered with Quaternary fluvial deposits and moraine blocks.

A landform is built of Miocene clays with well preserved assemblage of molluscs, representing the Badenian fauna (Urbaniak, 1974). The landform, rising above the level of the Dunajec river, is mantled with Dunajec deposits, and forms a plain extending at an altitude of 240–242 m, sloping along a steep slumping wall into the Dunajec valley.

The exposure at Zbylitowska Góra comprises quartzite and weathered sandstone gravels varying in size (2–25 cm in diameter). Severely weathered granite pebbles occur sporadically at the depths of 0–3.40 m and 4.80–5.95 below the ground. The pedestal, ca 38 m high is built of Miocene clays. Here, the Scandinavian ice-sheet accumulated a moraine above the thick series of the Dunajec deposits. However, during the recession of the Cracovian ice-sheet the plain of Zbylitowska Góra has been cut by the Dunajec water flowing eastward over a level of some 240 m. Therefore, only large blocks survived the destruction of the moraine.

The site deserves protection as it is a unique outcrop of the Quaternary deposits in the Carpathian Foothills.

25. Krzeczkowski Stream valley — 15 km SW of Przemyśl in the Eastern Carpathian Foothills (235 m a.s.l.; 49°44'22"N/22°36'42"E).

Main features: Early–Late Vistulian mollusc-bearing deposits.

Deposits forming a 12 m high Pleistocene terrace crop out along the left bank of the Krzeczkowski Stream over the distance of about 100 m. The sequence comprises from the bottom upward: gravels, sandy muds, loess and loams with sandstone lumps generated by solifluction. The Brørup evidenced by a rich molluscs fauna and thermoluminiscence data has been distinguished in the lower part of the outcrop. It is followed by loess abounding in cold-tolerant snails representing the interpleniglacial and the last pleniglacial of Vistulian. This is the unique locality of well documented Early–Late Vistulian sediments in the Carpathians (S. W. Alexandrowicz & Łanczont, 1995). Flysch of the marginal Skole Unit forms the bedrock of Quaternary deposits.

Final remarks

The Polish Carpathians are a mountain region comprising various vertical zones that are characterized by distinctive landscapes and relief excellently reflecting the bedrock structure. Because of its unquestionable value and numerous tourist trails the area is particularly important in environmental education. In the national parks and in some landscape parks of the region there are well functioning didactic centres committed to nature museums. The presented listing of 25 sites are very important in developing didactic and in promoting geology and geomorphology of the Carpathians. However, their usefulness depends on a scope of information available and sustained accessibility. Moreover, meaningful characteristics of the proposed sites are their natural, unaltered features.

The identified individual geosites and geosite sets represent main values of the Carpathians such as: stratotypes of litho- and biostratigraphic formal units, borders of geological facial-tectonic units, deposits with fossils of stratigraphic and palaeoecologic importance, sedimentary and tectonic structures, rock types, well documented successions of flysch and Quaternary deposits, as well as various relief forms and related processes. In the proposed list of the most valuable localities there are 11 items that are already protected under categories of national parks, reserves or monuments of inanimate nature (Fig. 1). The remaining 14 geosites are well documented for protection and following the accepted optimisation strategy for geoconservation in the Carpathians should be given the top priority in legislation procedure.

Taking into account geodiversity of the Carpathians, the presented list of geosites is not complete yet. First of all, the geosites representing the marginal zone of the Eastern Carpathians south-west of Przemyśl (Fig. 1) are lacking in this list. The occurring there numerous exposures of a rank of stratotype of the Skole and Stebnik units, sites with deposits reach in fossils, outcrops of interesting sedimentary structures as well as relief forms and a deeply incised Wiar valley cause this area to be outstanding when compared with other regions of the Carpathians. Fourteen exposures in the discussed area have recently been approved as documentary sites (Kotlarczyk & Piórecki, 1988; Kotlarczyk, 1993). Formation of a national park in the marginal zone of the Eastern Carpathians will cause the entire area as well as some remaining objects to be included in the list of the European Geosite Candidates. The final selection of geosites requires a thorough examination with reference to geosites in the Ukrainian territory. The geoconservation system of the Polish Carpathians proposed for the European Geoconservation Network comprises now four large areas of a rank of national parks. They are assigned to the second category according to IUCN (there are six categories). Three national parks are accepted by UNESCO as MAB biosphere reserves (Babia Góra N.P., Tatra N.P., and Bieszczady N.P.). Two out of them are international biosphere reserves (Tatra N.P. and Bieszczady N.P.). The national parks are the most representative centres in the geoconservation network in the Carpathians and they must be complemented by relatively smaller localities and individual geosites selected as standard localities of geological heritage and structural landscape.

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