Sandstone rocky forms in Polish Carpathians attractive for education and tourism

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Rocky forms occurring in the Polish Carpathians are rare but attractive landscape elements, which have been perceived as extraordinary and mysterious landforms. They were associated with various folk tales usually concerning struggles between good and evil, as well as places of religious services and folk ceremonies or they commemorated significant historical events. These long-living traditions have efficiently provided the adequate place of the rocky forms in the local and national culture. These forms have successively become the inspirations for poets and painters, tourist attractions and even places of recreation. They are also important sites of Earth-Sciences education in the Carpathians, used on various stages of the didactic process. The Outer Carpathians (Flysch Carpathians), called Beskidy Mts., except its eastern part (Bieszczady Mts.), are the most extensive area of the occurrence of sandstone rocks and associated rock landforms in Poland. Although the rocky forms usually do not range large sizes and are not very common, they were described many times, especially in popular publications and studied as characteristic elements of the diversity of relief and geological structure of the Carpathians (i.e., Klimaszewski, 1932, 1947; Świdziński, 1932, 1933a; Koszarski, 1962; Alexandrowicz Z., 1970, 1977, 1978; Lach, 1970; Baumgart-Kotarba, 1974; Margielewski, 1997).

The concept and realization of the legal protection of the rocky forms take into account the results of their listing and recording in the scale of the whole Poland (Alexandrowicz, 1990, Alexandrowicz & Urban, 2005). The categories of legal protection adequate for forms under discussion are: nature reserve covering relatively large groups of rocky forms and nature monument carried out for protection of individual forms or small groups of associated forms. In Polish Carpathians the rocky forms were chronologically the first geosites considered as requiring legal protection (Świdziński, 1932, 1933a, b, c). Currently there are 8 nature reserves and 33 nature monuments protecting these excavations (Fig. 1). Moreover, 4 national parks are characterized by rocky relief with natural sandstone outcrops, which determine their landscape and educational values (Fig. 1). Among the nature reserves two which are situated near Krosno and Ciężkowice towns and providing the most picturesque and scientifically interesting rocky landforms have been proposed for the European Network of Geosites (Alexandrowicz, 2006). Some other protected geosites, characterized by relief generated by mass movements have been also proposed for this Network. The significance of rocky forms in the system of the nature protection is principally related to their abiotic values, but they provide also conditions for the development of specific biotopes and plant taxa (Alexandrowicz et al., 2003; Margielewski & Alexandrowicz, 2004; Alexandrowicz & Alexandrowicz, 2006).

The shape of the Carpathian rock landforms is diverse and stimulated by the character of the denudational processes, which generated the uncovering of the rock substratum and exposition of its hardest elements. Among them two main groups can be distinguished. The first group gathers typical weathering forms, most often described and called

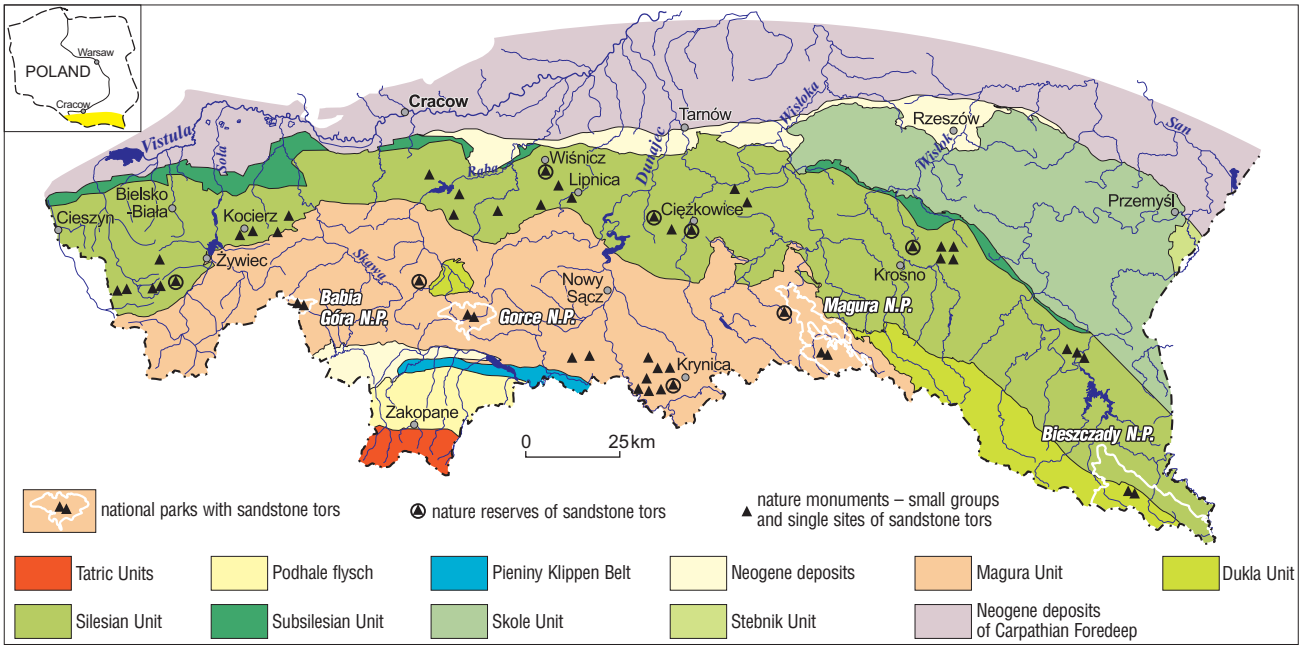

Fig. 1. Distribution of protected sandstone tors in relation to geological structure of the Polish Outer Carpathians

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in literature as *tors*. These are individual rocky forms separated from the slope and other landforms, characterized by walls sculptured mainly by the weathering processes. They occur in the *rock towns* near Ciężkowice and Krosno and as individual forms scattered over the Carpathian Foothills (northern zone of the Carpathians). The second group comprises forms described as *crags*, *pillars* and *cliffs*, occurrence of which is connected with the gravitational mass movements, marginal zones of large landslides or other rock dislocations. Among them the landforms framed by joint surfaces, displaced rock colluvial packets, as well as rock fields predominate. The groups of these landforms are often extensive and hardly accessible as *rock towns* forming ruins or labyrinths. They are predominantly located in the upper parts of the mountain ranges of the Beskidy and Bieszczady Mts. and are usually protected in the forest nature reserves, landscape parks and national parks. Only a few of them are protected in the geological nature reserves and as nature monuments (Margielewski & Alexandrowicz, 2004).

Geological features of rocky forms

The Cretaceous and Paleogene flysch rocks of Polish Outer Carpathians comprise diverse sandstone and conglomerate series, but only part of them crop out directly on ground surface as rock forms in the ridges, highest parts of slopes or even above the terraces of stream and river valleys. The sandstones forming the natural rock landforms represent the particular series (formations, beds), characterized by specific lithological, sedimentological and tectonic features (Alexandrowicz, 1978). These series are thick bedded and display diversified granulometric composition of the sandstones and polymictic conglomerates. Particular layers are rarely separated by thin (several centimeters thick) shale/siltstone or thin-bedded sandstone inserts. Rare (distant each to other) joints representing longitudinal, transversal or diagonal sets, dissect the thick sandstone beds.

Sandstones and conglomerates are composed of poorly sorted sand grains and pebbles of various sizes. They are characterized by low values of the volume weight and high absorption of water. These features are conditioned by poor and heterogeneously distributed cement, usually argillaceous, argillaceous-ferruginous, siliceous, rarely calcareous-argillaceous or calcareous, or matrix comprising fine clastic-clayey material. The poorly sorted sandstones, characterized by the predominance of the coarse grain material, comprise — apart from the quartz grains — admixtures of feldspar, as well as glauconite and muscovite. The conglomerates contain — apart of quartz — pebbles of hornstones, granites, metamorphic schists and other exotics of the pre-Carpathian origin. Somewhere, within the coarse grained beds, clay balls and ferruginous concretions are found. The diverse sedimentary structures observed within the rock beds demonstrate various environments and processes of the deposition of sediments. Generally they are characterized by normally graded bedding (particle size diminishing upward), but the incomplete cycles and cycles with sharp changes of particle sizes or inverted pensymmetric graded bedding are often observed. In some cases the granulometric composition of beds is totally or partially chaotic with randomly distributed particles of different sizes, pebbles or lenses of coarse-grained material. Parallel, cross and convolute laminations of sandstones can be observed on the rock walls. The mode of bedding and sedimentary structures, as well as density and orientation of joints significantly affect the morphology of rocky forms and their morphological evolution, i.e. disintegration and transformation by weathering.

The thick-bedded and coarse-grained complexes and differentiated sedimentary structures are characteristic of the fluxoturbidites deposited by mud/sand/gravel flows and submarine sliding. The lenticular lithosomes of various sizes and heterogenous composition, which formed at the foot of the continental slope as a result of violent detrital flows, are characterized by very thick conglomerate-sandstone layers containing poorly sorted coarse-grained components. The structures specific for this type of rocks are clearly visible and particularly conspicuous on the walls of rocky forms due to the selective weathering. The highest numbers of typical tors are formed of the Istebna Sandstone Fm. and Ciężkowice Sandstone Fm. of the Silesian Unit, particularly those, which occur in the Carpathian Foothills (Fig. 1). Sandstone natural forms in the Beskidy Mts. of Magura Unit and in Bieszczady Mts. within Dukla Nappe (Unit) and Silesian Unit are mostly connected with the areas of landslides (Fig. 1).

The geological setting of sandstone-conglomerate rocky forms in the Carpathian flysch is not comparable with other sandstone landscapes. Resistant for weathering/erosion complexes of thick-bedded and coarse-grained sandstones and conglomerates occur within the sequences of less hard flysch formations. Owing to this kind of geological structure, this region is unique regarding the genesis of rocky forms composed of fluxoturbidite deposits and other rocky forms connected with the mass movements active during the Late Pleistocene and Holocene.

Origin of rocky forms

The genesis of the rocky forms — tors, crags, cliffs and others — should be always considered regarding the geological structure of the area of their occurrence, as well as exogenic processes generating the relief transformation. Both the geological and geomorphic factors control the development and differentiation of the rocky forms. In case of the Flysch Carpathians the following aspects and stages of the development and transformation of the described forms can be distinguished (Alexandrowicz, 1977, 1978):

1. zones with the local concentrations of cement in sandstones were the most suitable for the development of rocky forms; these zones are usually large diagenetic concretions occurring among less compact and less resistant surrounding series; they develop within lithosomes represented by fluxoturbidites comprising very thick beds of sandstone/conglomerate characterized by the heterogeneous and poorly sorted coarse-grained components; other rocky forms in the Carpathians, distributed within the areas of the gravitational mass movements, mainly in the Beskidy Mts., are genetically related to the occurrence of the thick sandstone complexes underlying the thin-bedded shale-sandstone flysch;

2. the complexes of hard rocks have been exposed in the relief by active processes of the erosion and weathering; these processes were extremely intensive in the periglacial climate predominating in the Carpathians during the several glacial periods of the Pleistocene, especially in the last glaciation (Würm); the mechanical weathering, slope wash, washout, cryoplanation, creeping and sliding were the common processes affecting the relief evolution

in that time, respectively to the resistance of the rocks (Baumgart-Kotarba, 1974); these factors generated the deepening of valleys, recession of slopes, lowering of mountain ranges and gravitational displacement of rock packets; successively, also during the Holocene, the fragmentation of rock substratum along the progressively widened joints has developed; it has been reflected within the rock massifs, especially underground, by the formation of crevice-type caves (Margielewski & Urban, 2003); it also stimulated the angular shapes of the initial rocky forms and their flat wall surfaces (Alexandrowicz, 1978);

3. the modeling of the sandstone outcrops was more or less intensive, depending on the dominant destructive agents and the difference in the resistance of the exposed rocks; the chemical-mechanical weathering, ablation, falling and gravitational sliding of rock fragments have been processes shaping the natural rock relief; the shapes of rocky forms depend on their lithologic features, bedding and lamination of the rocks, orientation and density of joints as well as the situation of the rock excavations in relation to the morphological elements.

The development of the weathered relief exposed on rock walls is slow and hardly effective in the case of the rocky forms built of the sandstones characterized by little differentiation of the grain size and uniform distribution of the cement. The rocky forms built of the sandstones/conglomerates displaying diversity of structures and various distribution of the cement, are characterized by unique, specific shape and microrelief. These features and joint density are responsible for the progress of the rock surface weathering. The effects of this process, especially of chemical weathering, are marked on the rock surfaces by differentiated microforms of relief (Świdziński, 1933a; Alexandrowicz, 1978, 1989). The morphology and microrelief of tors are permanently transformed under impact of the thermo-humidity climatic conditions and at present also by the air-pollution (Alexandrowicz & Brzeźniak, 1989; Lach & Wilczyńska-Michalik, 1996).

The formation of mineral crust on rock surfaces is the remarkable effect of the process of water diffusion within the rock massif, the dissolution and remobilization of the elements of its cement and secondary mineralization (Alexandrowicz & Pawlikowski, 1982). This duricrust protect the rock surface zone against the weathering and for some length of time it is exfoliated by natural or antropogenic processes. The freshly stripped rock surface, soft, deprived of cement, gradually undergoes to the secondary cementation forming new crust. The repeated cycles of the decomposition of the surface rock zone, dissolution and precipitation, as well as various concentrations of the secondary minerals are the essential processes of the continuous chemical weathering, as factors of the transformation of shape of the rocky forms in various climatic environments.

Selected examples

In Polish Outer (Flysch) Carpathians some 200 more or less recognized sites of the natural sandstone/conglomerate landforms are known (Alexandrowicz, 1978, 1987a, b; Alexandrowicz & Poprawa, eds., 2000). Their occurrence was often an indication for speleological explorations and archaeological investigations. The activity of the regional speleoclubs resulted in the registration of 874 pseudokarst caves of total length 15209 m till 2006 (Klassek & Mleczek, 2006). They are situated mainly within groups of rocky forms connected with the gravitational mass movements or in their vicinity.

The legal protection of the most valuable and spectacular Carpathian rocky forms has been successively developed along the progress of their investigation. Therefore the current network of the legally protected rock geosites is almost adequate to the state of their scientific evaluation (Fig. 1). It should be emphasized that in Polish Carpathians the legally protected rocky forms represent the most numerous group of the protected geosites, whereas number of other ones ought to be increased (Alexandrowicz, Poprawa, eds., 2000). The *rock towns* belong to the most scenic and interesting rocky groups in the Carpathians. They are not comparable with the extensive „sandstone districts" occurring in the Bohemian Paradise (Česky Raj) in the Czech Republic or Saxonian Switzerland in Germany, but represent features typical for the „sandstone landscape", in which the occurrence of the thick complexes of siliciclastic rocks constructively influences the relief and whole environment (Adamovič et al., 2006).

The geological formations stimulating the occurrence of the rocky forms in the Carpathian Foothill, within the area of the Silesian Unit (Nappe) are the Ciężkowice Sandstone (Upper Paleocene-Lower Eocene) and Istebna Beds (Upper Cretaceous). The most picturesque groups of rocky forms deserving the name *rock towns* are there: Skamieniałe Miasto (Stone Town) Nature Reserve and Prządki (Spinners) Nature Reserve in Memory of Prof. Henryk Świdziński.

Stone Town Nature Reserve near Ciężkowice has been protected at the begining of 1930s (its protection act was renovated in 1974 on the surface of 15.01 ha). Within the reserve, there are 11 groups composed of individual rocky forms ranging in height from 6 m to 17 m and numerous smaller forms of 3–5 m in height (Alexandrowicz, 1970). They are distributed in the hill slope of the relative altitude of 100 m, spanned from the flood terrace of the Biała Dunajcowa river to the extensive hill culmination (plateau, ca 360 m a.s.l.). The spatial distribution of the rocky forms in this area is the unique example of their development controlled by various geomorphic factors. The rocky forms situated just above the lower river terrace were exposed mainly due to the fluvial erosion (Fig. 2). Forms located on the slope have been formed by denudation supported by the gravitational mass movements and weathering. In few places traces of stone exploitation may be observed. Tors distributed within the hill culmination rises above the planation surface (Carpathian Foothill planation level) as high as isolated towers (Figs. 3, 4).

The area of the Stone Town near Ciężkowice is a stratotype locality of the Ciężkowice Sandstone Formation (Upper Paleocene-Lower Eocene) in the Silesian Unit. This formation, outcropped in the nature reserve, is underlain by the variegated shales and overlain by the thin-bedded, shale-sandstone Hieroglyphic Beds or younger shale series (Alexandrowicz, 1970). The Ciężkowice Sandstone represents classical fluxoturbidite deposit (Koszarski, 1956, Leszczyński, 1981, 1989). The differentiated bedding of these deposits, predomination of coarse-grained material and structures of the submarine erosion, characteristic of fluxoturbidites, are accurately visible on the rocky walls surfaces subjected to the selective weathering. The modelling of rock surfaces of beds differing in resistance is demonstrated by the rich microrelief (Alexandrowicz, 1970). The Stone Town Nature Reserve is proposed for the

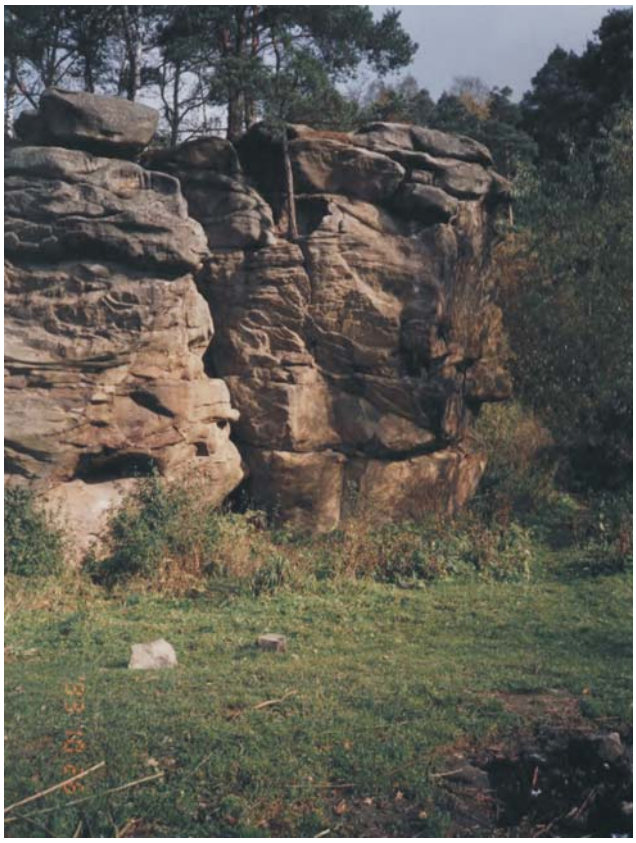

Fig. 2. The Stone Town Nature Reserve in Ciężkowice, rocky form above the terrace of the Biała Dunajcowa river. Figs. 2, 3, 4 photo by Z. Alexandrowicz

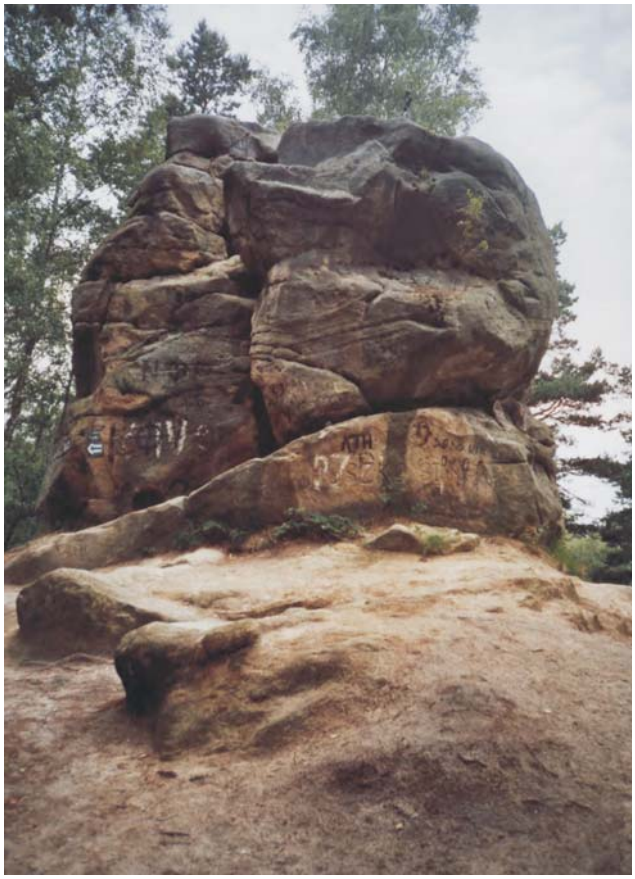

Fig. 3. *Tower with Cross*, Nature Reserve in Ciężkowice

Fig. 4. *Ignacy Paderewski Tower,* Nature Reserve in Ciężkowice

European Network of Geosites as the stratotype area of the Ciężkowice Sandstone Fm. as well as the easily accessible centre for investigation and education of morphological and geological setting of tors, well exposed sedimentary structures typical of fluxoturbidites and differentiated rocky microrelief (Alexandrowicz, 2006).

In the vicinity of the town of Ciężkowice other groups of rocky forms are located. The Diable Skały na Bukowcu (Devil Rocks on the Bukowiec Hill) Nature Reserve (16.07 ha), situated ca 15 km south-west of Ciężkowice, should be mentioned, as the most scenic among them (Alexandrowicz & Poprawa, eds., 2000). Three tors (7 m, 10 m and 13 m high) characterized by specific shape and microrelief, are situated within the hill ridge (ca 500 m. a.s.l.), formed of the Cieżkowice Sandstone Fm. with the significant participation of conglomerates. The hill ridge, elongated in the west-east direction, is framed from the north by the distinct escarpment 600 m long, composed of the rock cliffs 15 m high. In the western part of the hill the Diabla Dziura (Devil Hole) pseudokarst cave developed on the vertical system of joints widened due to the gravitational shift of the rock massif. It is 365 m long and belongs to the deepest caves in the region (42.5 m) (Margielewski & Urban, 2004). It is a hibernaculum of bats and a living place for numerous insects and spiders.

The Krosno town area in the Carpathian Foothill is the next region of the occurrence of numerous and various rocky forms and group of forms, which are usually legally protected (Alexandrowicz 1987a, b; Alexandrowicz & Poprawa, eds., 2000) (Fig. 1). These landforms are distributed in the northern, marginal zone of the Silesian Unit (Nappe), on the hills formed of complexes of the thick-bedded and coarse-grained sandstones with fluxoturbidite structures, which belong to the Istebna Beds and Ciężkowice Sandstone (Upper Cretaceous-Lower Eocene).

The Spinners Nature Reserve in Memory of Prof. Henryk Świdziński covers the largest group of the spectacular tors formed of the Ciężkowice Sandstone (13.62 ha). They are situated in the ridge zone (ca 500 m a.s.l.) striking west-east, about 1 km long and 100–300 m wide. Apart from numerous individual rocky forms, ten clusters of them occur there. Each cluster comprises several rocky forms separated by passageways along the fissures founded on the diagonal joint system. The largest rocky forms, ranging of 20 m in height, are characterized by the most variable shape and weathering microrelief, thus they are called

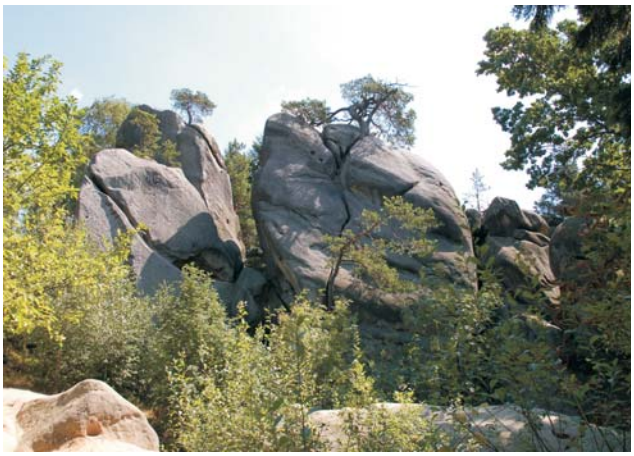

Fig. 5. The Spinners Nature Reserve near Krosno. Photo by K. Miśkiewicz

Fig. 7. The tor *Ship* in the Brodziński Stones Nature Monument near Lipnica

Spinners. This group of forms is accurately exposed in the landscape, whereas other ones are hidden in the forest (Figs. 5, 6). On the southern slope of the hill, the rocky forms of shapes resembling pulpits and towers are separated by passageways widened upslope, being an instructive example of the gravitational spreading and toppling of packages of the Ciężkowice Sandstones on the substratum of the plastic Czarnorzeki Shales, representing the Upper Istebna Beds.

The Spinners Nature Reserve was proposed for the European Network of Geosites, for the particularly differentiated shapes of the rocky forms, sedimentary structures typical for fluxoturbidites and — first of all — abundant surface microstructures related to the weathering processes, as furrows, honeycombs, pseudokarrens, pits, arcade-like forms, cementation covers and mineral crusts, exfoliation forms, etc. These microforms were described in details by H. Świdziński (1933a) — for the first time in the Carpathians — and compared with the classic microreliefs described in the *rock districts* in the Cretaceous sandstones of the Bohemian Massif. According to this author, the act of legal protection of the Spinners Rocky Forms was carried out in 1932. In order to commemorate the contribution of Prof. H. Świdziński to the investigation and protection of the Spinners and other rocky forms in the Carpathians, his name has been recently included to the name of this nature reserve (Spinners Nature Reserve in Memory of Prof. Henryk Świdziński).

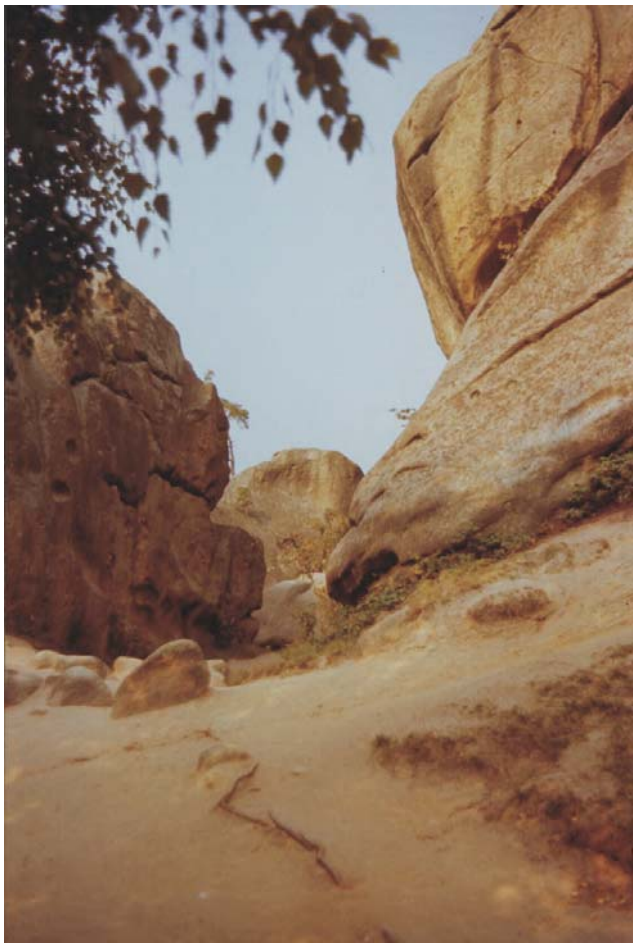

Fig. 6. Rocky corridor in the Spinners Nature Reserve near Krosno. Figs. 6, 7 photo by Z. Alexandrowicz

In the same hill range, in which the Spinners are situated, 2 km west of them, on the next hill summit, Kamieniec Mt., also formed of the Ciężkowice Sandstone, the group of similar rocky forms was incorporated into the fortifications of two castles built in the 17th century (Alexandrowicz, 1987a, b; Ślączka & Thompson, 1981).

The hill ranges situated northeast of the Spinners Rocky Forms are formed of the Lower Istebna Beds with significant participation of the thick-bedded sandstones (of the fluxoturbidite structures), which crop out in numerous places as scenic rock forms, fortunately not destroyed by quarrying (Koszarski, 1962).

The rocky forms built of the sandstones of the Istebna Beds are relatively abundant in the western part of the Carpathian Foothill, especially in the vicinity of the Lipnica Murowana and Wiśnicz towns (Klimaszewski, 1932). The most interesting and picturesque among them are: Kamienie Brodzińskiego (Brodziński Stones) — a cluster of rocky forms, protected as nature monument (proposed nature reserve) (Figs. 7, 8), as well as Kamień Grzyb (Mushroom Stone) in the Nature Reserve of the same name (Fig. 9). In the same region, but farther to the west, 25 km south of Cracow, the unforgettable objective of the excursion can be the scenic Diabelski Kamień (Devil Stone) near Rudnik. It is a rock bar of 9 m in height with adjoining rock wall 30 m long (Fig. 10). The same sandstones of the Istebna Beds crop out in many sites in the western part of the Beskidy Mts. (Klimaszewski, 1947) (Figs. 11, 12).

Fig. 8. *Big Rock* in the Brodziński Stones Nature Monument near Lipnica. Figs. 8, 9, 10 photo by Z. Alexandrowicz

Fig. 9. *Mushroom Stone* in the Nature Reserve near Wiśnicz

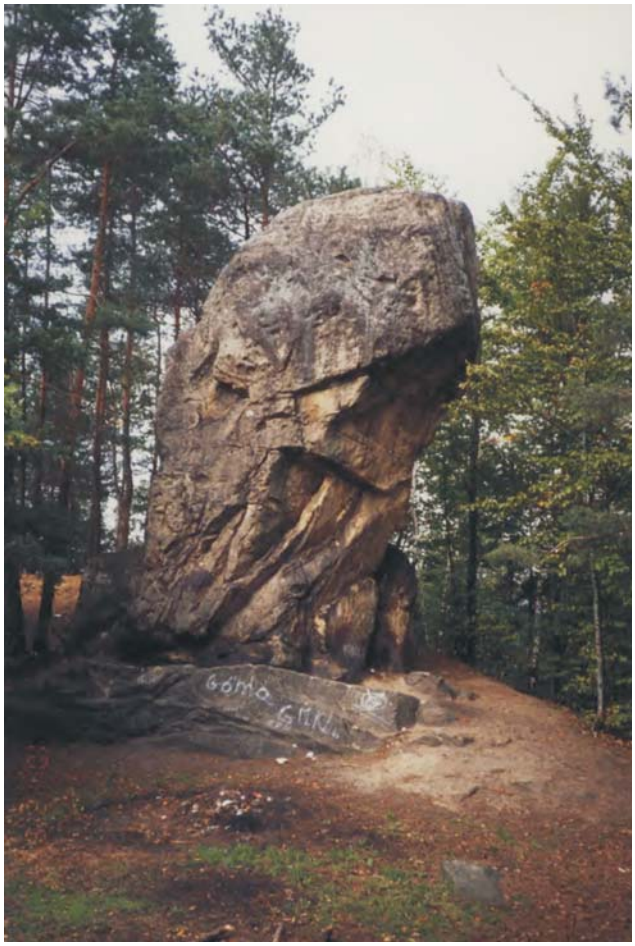

Fig. 10. *Devil Stone* near Rudnik, 25 km southward of Cracow

Magura and Dukla Units are characterized by the thick sandstone complexes, which are often outcropped in the landslide zones as groups of rocky forms: cliffs, pulpits, rock trenches and block fields. The single rocky forms of the specific shape are rather rare there (Fig. 13). In the Magura Unit zone, the Babia Góra National Park (Fig. 14), as well as two other sites: near Krynica town and next to the boundary of the Magura National Park (Lach, 1970; Alexandrowicz S.W., 1978; Alexandrowicz & Alexandrowicz, 1988; Margielewski 1997) have been proposed for the European Network of Geosites. Also the Bieszczady National Park, situated in the area of the Dukla and Silesian Units, has been proposed for this Network.

Educational and geotourist aspects

Natural rocky outcrops are elements presenting various scientific aspects ranging from the geology and geomorphology to the biology. They are often connected with the cultural and economical traditions of the region and their aesthetic-landscape features were in many cases first values, which aroused the interest of the local people and tourists, before the rocky forms became the geosites, important for the geological and geomorphological studies. Subsequently the scientific, educational and aesthetic significance of these unique and rare landforms resulted in their legal protection against the devastation and even quarrying.

The tourist trails in the Outer Carpathians reach some, easily accessible groups of rocky forms or single forms. If these landforms are situated out of the tourist trails, they are marked on the tourist maps or described in guidebooks. But some of them situated in the hardly accessible places, as steep slopes of valley heads or extensive landslides, are difficult to access, which requires the tourist-nature competence of people. The access to the selected hardly accessible but attractive rocky forms ought to be provided.

The famous and popular rocky forms, as unique and spectacular landscape elements are often the essential objectives of excursions, owing to their natural features, as well as cultural traditions, legends and historical events or folk ceremonies. The arrangement of educational trails has created the favorable occasion for their tourist propagation. Their practical educational importance depends on the proper planning of trails and panels and adequate interpretative provision. Apart from the trails, to the most important elements of educational promotion belong guide-books, booklets and guide-leaflets providing interpretation of the visited sites adequate to the common education. These publications should be available in the sites. The panels can be also used, but they must be renewed frequently.

The degree of the development of network of tourist-educational trails in Polish Carpathians is insufficient and only rarely concerns geological-geomorphological aspects. Lack of the abiotic elements in the nature education network in Polish Carpathians motivates activity in the new tourist field such as geotourism, based on the network of the geotourist objects (Słomka & Kicińska-Świderska, 2004; Słomka et al., 2006). These objects

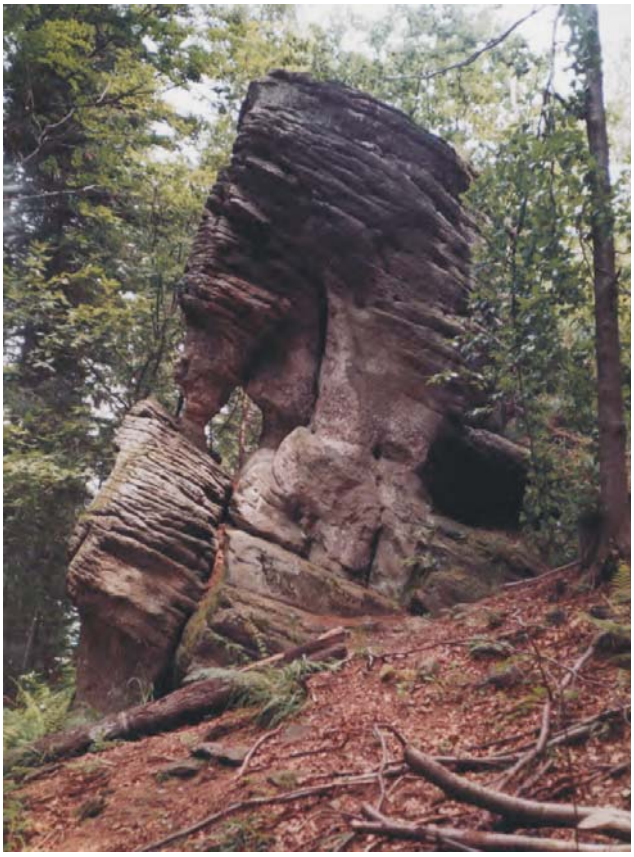

Fig. 11. The *Brigant Window* Nature Monument near Kocierz, Western Beskidy Mts. Figs. 11, 12 photo by Z. Alexandrowicz

Fig. 12. Sandstone wall of the rock-slump near Kocierz, Western Beskidy Mts.

assume the abiotic values in the context of the changes and threads of the natural and cultural environment. The Carpathian rocky forms are important elements of the network of geotourist sites. As attractive elements of this network, they are promoted not only due to their aesthetic-landscape importance. On the basis of the evaluation criteria elaborated for this kind of sites, the scientific values conditioning their educational use, as well as landscape, cultural and practical values have been determined (Alexandrowicz, 1990). This evaluation ought to be taken into account in the development of the geotourist network. In the Outer Carpathians the following features of the rocky forms should be evaluated for the education and geotourism:

- ❏ lithological types of sandstones and conglomerates, the differentiation of particle sizes and bedding, especially characteristic of the fluxoturbidites;
- ❏ specific landforms generated by geomorphological processes such as erosion, denudation, cryoplanation, weathering and mass movements;
- ❏ joint system and its role in the shaping of the rocky forms;
- ❏ diversity of the sedimentary structures exposed on the surfaces of rocky forms due to the selective weathering;
- ❏ forms and phenomena of the chemical and mechanical weathering;
- ❏ unique, scenic shapes of the rocky forms, as aesthetic elements of landscape;
- ❏ rocky forms as viewpoints;
- ❏ rocky forms as specific environments of rock flora and fauna assemblages;
- ❏ archaeological sites in the pseudokarst caves;
- ❏ historical events and traditions connected with the rocky forms, as well as legends and folk ceremonies;
- ❏ rocky forms as specific scenery for film shooting and other open-air spectacles.

The educational and geotourist use of the rocky forms is limited by the articles concerning the legally protected sites, which should be also applied for the sites proposed for protection. To the frequently observed negative anthropogenic impact on the geosites belong: littering, putting inscriptions and scratching the rock surfaces. The natural rock walls are also threatened by climbing, especially where the rock surfaces display diversified microrelief and are covered by mineral crusts. The observance of the preven-

Fig. 13. *Mushroom Stone*, Nature Monument in the Western Beskidy Mts. near Krynica. Photo by W. Margielewski

Fgi. 14. *Sokolica Rock* in the Babia Góra Natural Park. Photo by Z. Alexandrowicz

ting articles is difficult for realization, especially due to the tourist attractiveness of these forms. In the geotourist aspect, the rocky forms should be principally used for the Earth-Sciences education, as natural laboratories of the development and transformation of the hard rock elements controlled by various factors of the weathering, denudation and mass movements in the past and currently.

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