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ZOFIA ALEXANDROWICZ

THE OPTIMUM SYSTEM OF TORS PROTECTION IN POLAND

OPTYMALNY SYSTEM OCHRONY SKAŁEK W POLSCE

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Abstract: Tors concentrate in five regions of Southern Poland. They show variation in geologic structure, morphology and origin. The paper gives a description of the morpho-genetic types of tors and summarizes the state of their protection. The proposed system is based on the valuation of the natural, scenic, cultural and utilitarian qualities of tors, and on the assessment of the kind and scope of the means to be applied in compliance with the regulations which are in force in Poland.

Key words: tors, geologic structure, morphology, origin, nature protection, Southern Poland.

Zofia Alexandrowicz: Polska Akademia Nauk, Zakład Ochrony Przyrody i Zasobów Naturalnych, Lubicz 46, 31-512 *Kraków.*

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Treść. Skałki skupiają się w pięciu regionach Polski południowej i są zróżnicowane pod względem budowy geologicznej, morfologii i genezy. Scharakteryzowane zostały ich typy morfogenetyczne i podsumowany stan ochrony. Opracowany optymalny system ochrony skałek opiera się na ich waloryzacji przyrodniczej, krajobrazowej, kulturowej i użytkowej, ocenie rozmieszczenia i rozpoznania możliwości zabezpieczenia obiektów.

I. INTRODUCTION

Single tors or groups of tors are the most spectacular and best known monuments of inanimate nature. Owing to their singular forms, they add variety to the landscape or give it the character all its own. The beauty of such scenery was many a time the prime argument for the protection of certain areas, such as the Grand Canyon National Park in the Colorado Upland, the Paklenica National Park with its karst landscape in Yugoslavia, and several other parks, mainly those situated in mountain regions. The necessity of protection of unique single tors or their picturesque groups was also postulated on account of their high scenic quality. The world famous examples of these singular forms are: the loaf-like Ayers Rocks in Australia, the „Sugar Loaf" in Rio de Janeiro, the granite tors from Dartmoor in England, and the African „Island Mountains". With the latter are connected the first theories of origin of the relief forms of this type (King 1948, Linton 1955).

The unspecified range of motivation concerning the protection of tors in Poland, and the random choice of the means to be applied, make it necessary to work out the general principles of procedure in this field. The individual approach to the groups of monuments of inanimate nature is indispensable for the development of a detailed version of the national strategy for conservation of nature. This applies particularly to the areas characterized by singular natural scenic features. In the physiography of Southern Poland such remarkable features are, for example, the rocky mountain ridges of the Tatra and Pieniny Mountains, and single tors or their groups in the areas devoid of rocks, such as the Outer Carpathians, Sudetes, Cracow-Wieluń Upland, Kielce Upland and Roztocze borderland of the Lublin Upland (fig. 1). The object of the present study are tors occurring in these non-rocky mountain and upland areas of the country. These marvels of nature are under individual protection as monuments of nature, or are preserved as features of national parks, nature reserves, landscape parks and the areas of protected landscape. Up till now, about 50% put of the total number of recorded tors have been protected in this way (according to the state of 1985).

The tors in Poland show remarkable variation in geologic structure, morphology and origin. They are built of limestones, sandstones, conglomerates, granites, gneisses, and a variety of igneous and metamorphic rocks. From the geologic viewpoint, the most diversified forms occur in the Sudetes. The areas remarkable for their exceptional scenic quality are the Table Mountains and the Cracow-Wieluń Upland.

There are two prime arguments for postulating the protection of tors. Firstly, they provide natural and lasting outcrops which, in contrast to artificial exposures which become soon overgrown, retain their scientific, didactic and scenic value. Secondly, tors attract tourists and are accessible to exploitation, whereby they are subject to destruction.

Tors should be the object of many-sided research not only in the field of inanimate but also animate nature. Besides their high natural and scenic qualities, they also represent cultural and utilitarian value. Their aesthetic-

Fig. 1. The areas of occurrence of tors in Poland: 1 — Carpathes, 2 — Sudetes, 3 — Cracow-Wieluń Upland, 4 — Kielce Upland, 5 — Roztocze borderland of the Lublin Upland

Ryc. 1. Obszary występowania skałek w Polsce: 1 — Karpaty, 2 — Sudety, 3 — Wyżyna Krakowsko-Wieluńska, 4 — Wyżyna Kielecka, 5 — Roztocze

scenic and cultural value has been emphasized to-date as the prime motive for their protection. As the research progresses, the really valuable natural features of tors begin to play a more significant part.

The morphological, genetic and environmental diversity of tors widespread throughout various regions of the country, and the frequency of their occurrence served as a basis for a model system of their protection. The system is founded upon the recording of all the tors, their detailed description, valuation, and the assessment of the possibilities of their legal protection.

II. OCCURRENCE OF TORS AND STATE OF THEIR PROTECTION

As in 1985, erratic boulders, mainly found in northern Poland (Alexandrowicz, Drzał, Kozłowski 1975), were the most numerous of all the geological and geomorphological monuments protected in Poland. The second most numerous are tors of various morphology, occurring in mountain and upland areas. 186 sites with single tors or small groups of tors are under protection as monuments of nature, and 9 reserves of inanimate nature were established especially for the protection of tors. Moreover, groups of tors occur within the area of 23 landscape, forest and floral reserves. Vast stretches of rocky land lie within mountain and upland national parks (7) and landscape parks (9) in the Sudetes and in the Cracow-Wieluń Upland (7).

1. Polish Flysch Carpathians

The sandstone and conglomerate tors of the Flysch Carpathians are scattered over a large area. They are often situated off tourist routes in almost inaccessible, and therefore little visited, places. In the Polish part of the Flysch Carpathians, the rocky outcrops are exposed mainly in the Bieszczady Mts. Groups of tors remarkable for their original shapes occur in the Carpathian Foothills. In the Beskidy Mts tors show great diversity, often forming singular groups connected with slumps. In the area of eastern Carpathians lying outside Poland, the most original are tors in Budniszcze, numerous tors and the accompanying block fields in Gorgany, and large groups of tors in the Roumanian Carpathians, e.g., in the Ceahlaul and Bucegi massifs. In the western end of the Carpathian arc, in the territory of Czechoslovakia, the ranges of Javornik and Chřiby are reported to have such forms of relief.

There are only few scientific papers which discuss in detail individual tors or their groups. From the Carpathian Foothills the following tors were described: the mushroom from Bigoszówka, the tor near Szczyrzyc, the mushroom from Tarnawa, Mushroom Rock from Bukowiec, the Lesko Stone, the Stone City from Ciężkowice, the „Spinners" near Krosno, the tors from Wola Komborska (Alexandrowicz 1970, 1987, Klimaszewski 1932, 1935, 1947, Koszarski 1962, Świdziński 1933 a, b). From the Beskidy Mts fairly detailed descriptions were given of the tor on Żar in the Beskid Mały, Kornuty, Devil's Rock near Folusz, and the tors of the Gorce, Beskid Niski and Bieszczady Mountains (Alexandrowicz 1963, 1982, 1987, Lach 1970, Pękala 1969, Świdziński 1933 c, 1936). In addition, the Carpathian tors under protection are discussed in the catalogue of the Polish nature reserves and monuments of inanimate nature (Alexandrowicz, Drzał, Kozłowski 1975). However, a great number of tors are described or mentioned in publications for the general public. The Carpathian tors were also the object of many-sided research, the results of which were presented in a monographic paper (Alexandrowicz 1978 a).

The occurrence of tors in the Beskidy and Bieszczady Mountains and in their foothills is connected with outcrops of very thick-bedded sandstones, conglomerates and sandstone-conglomerates with the sedimentary features of fluxoturbidites. The sediments promoting the formation of tors belong to the flysch formations characterized by coarse-grained complexes. Tors are confined to some beds of the Magura and Silesian nappes, and less commonly, the Dukla nappe. In the Magura nappe, numerous tors appear within the outcrops of thick-bedded sandstones of the Magura Beds and older complexes, particularly those belonging to the Inoceramian-Beloveza Beds (now called

Fig. 2. The distribution of tors in the Flysch Carpathians: 1 — single tors and groups under protection, 2 — tors selected for protection, 3 — national parks: A — Babia Góra N.P., B — Tatra N.P., C — Gorce N.P., D — Pieniny N.P., E — Bieszczady N.P., 4 — planned landscape parks (according to the state of 1985), 5 — South-Beskidy Area of Protected Landscape, 6 — planned areas of protected landscape (according to the state of 1985), 7 — boundaries of voivodships, 8 — state border

Ryc. 2. Rozmieszczenie form skałkowych w Karpatach fliszowych: 1 — pojedyncze i grupowe stanowiska chronione, 2 — proponowane do ochrony, 3 — parki narodowe: A — Babiogórski Park Narodowy, B — Tatrzański Park Narodowy, C — Gorczański Park Narodowy, D — Pieniński Park Narodowy, E — Bieszczadzki Park Narodowy, 4 — parki krajobrazowe projektowane (wg stanu na 1985 r.), 5 — Wschodnio-Beskidzki Obszar Chronionego Krajobrazu, 6 — obszary chronionego krajobrazu projektowane (wg stanu na 1985 r.), 7 — granice województw, 8 — granica państwa.

Ropianka Beds). Tors made up of the Ciężkowice sandstones of this nappe are scarce. Within the Silesian nappe, tor-forming sediments are represented by the Godula sandstones (conglomerates from Malinowska Skała), the Istebna and Ciężkowice sandstones, and also the Krosno sandstones in the Bieszczady Mts. In the Dukla nappe tors are built of the Mszanka sandstones. The limited extent of the Fore-Magura, Sub-Silesian and Skole nappes, as well as the insignificant amount of resistant sandstones in these nappes, did not create suitable geological conditions for the formation of tors.

The varied geologic structure of the respective units of the Flysch Carpathians is responsible for the non-uniform regional distribution of tors. A total of 170 sites where tors occur as single rocks or in groups have been recorded in the whole area in question. They are mostly worth protecting, while only 5 rock reserves and 15 monuments of nature of this type are entered in the register of geologic monuments under legal protection (fig. 2). Taking into consideration the above categories of protection, as well as national parks (3) and reserves of other types (4), it has been estimated that about 30% out of the total number of tors known from this area are under protection (according to the state of 1985).

From the morphological viewpoint, several types of tors can be distinguished, even within one group (Alexandrowicz 1970, 1978 a, Klimaszewski 1947). Ridge crest tors, jutting above the ridge surface, usually assume the shape of towers, clubs or mushrooms. Such forms are mainly found in the Carpathian Foothills, being less common in the Bieszczady and scarce in the Beskidy Mts. Subridge tors are situated at the edge of the ridge crest and slope, at the breaks of the ridge surface, or in the end and narrow parts of the ridge. Such tors are fairly common in the Beskidy Mts and usually have the form of pulpits and steps. Slope tors occur in the top parts of slopes, often in slump areas and above valley heads. They assume different shapes. Valley tors are the ones situated in river and stream valleys, especially in gorges and within rock terraces. However, they usually form rock walls.

The shape of Carpathian tors is determined by the structural features of sandstones and conglomerates. The general outline of tors reflects primarily the system of joints. The initial angular forms were stripped along joint faces and were subsequently remodelled under the influence of exogenic factors. Now the bounding walls of tors are the structural planes of sandstones and conglomerates transformed to varying degrees. In the Beskidy and Bieszczady Mts tors have generally even walls, changed in an insignificant degree, whereas in the Carpathian Foothills the shapes of tors are diversified, with only some fragments of walls still resembling joint faces. The walls have a strike related to the dominant direction of jointing, and as they meet at different angles, they form specific outlines. Fissures and corridors developed along some joints and subsequently expanded due to the settling and gravitational sliding of tors down the slope. The remodelled walls of tors are covered with a variety of convex and concave weathering structures (Alexandrowicz 1970, 1978a, 1982, 1989, 1990, Świdziński 1933a), the most typical being cellular structures.

The Carpathian tors are polygenic (Alexandrowicz 1978 a, b), owing

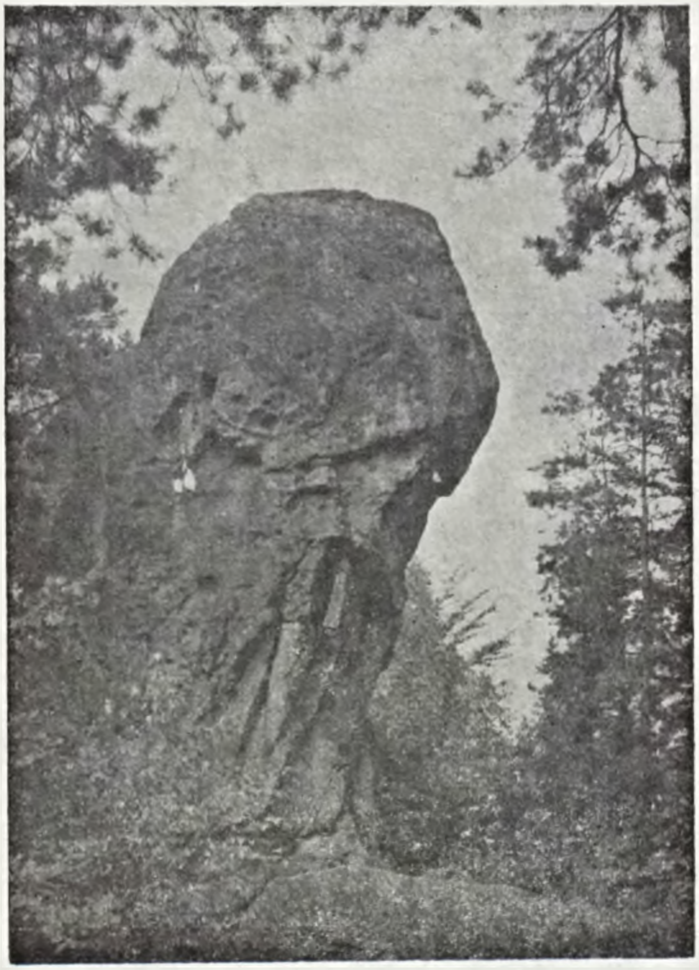

Fig. 3. Sandstone club at Rudnik in the Wieliczka Foreland

Ryc. 3. Maczuga piaskowcowa w Rudniku na Pogórzu Wielickim

their origin to manifold diagenetic and exogenic factors. Diagenetic differentiation in the resistance of flysch sediments, associated with their sedimentary features, predisposed the thick-bedded sandstone and conglomerate complexes to be stripped in the form of rocky elements of resistance in the process of evolution of the Carpathian relief. In the areas of occurrence of large sand-gravel lenses deposited by submarine sand flows (fluxoturbidites), the conditions were particularly suitable for the stripping of tors. A great part of Carpathian tors, especially in the Foothills, are made up of sediments of the fluxoturbidite type. Within the large groups of tors, different sedimentary sequences of fluxoturbidites have been noted, pronounced due to selective weathering. The lenticular lithosomes of different sizes and heterogeneous composition, which formed at the foot of the continental slope as a result of violent sand flows, are characterized by very thick conglomerate-sandstone beds consisting of poorly sorted coarse-grained components (figs. 3, 4). Tors made up of such sediments usually have original shapes, Less typical tors occur within sandstone complexes that do not show the distinct features of fluxoturbidites.

In the Carpathians the stripping of tors from the sandstone and conglomerate beds of the flysch series was affected by a variety of exogenic factors in the processes of denudation, mass movements and erosion. The most typical, single tors owe their origin to denudation, being the result of the recession of slopes, and the lowering and planation of ridge crests. The majority of tors in the Beskidy Mts are directly connected with mass movements. Slump tors are common on slopes above valley heads. They border slump headwalls and jut out from rigde and slope rifts and rigde trenches (Alexandrowicz, Alexandrowicz 1988). They are usually angular, with a poor relief. The rock walls, pulpits and ribs encountered in the Carpathian river and stream valleys owe their origin to erosion, which usually involved the intense lateral cutting of rock terrace socles or steep slopes.

The periglacial conditions of the last Pleistocene glaciation (Würm) were particularly suitable for the formation of tors. The degradation of the bedrock did not proceed uniformly, planating the areas of low structural resistance and forming sharp breaks, called frost-riven cliffs, on the relatively most resistant rocks (Alexandrowicz 1978 a, b, Baumgart-Kotarba 1974, Czudek, Demek, Stehlik 1961, 1965). Frost disintegration of

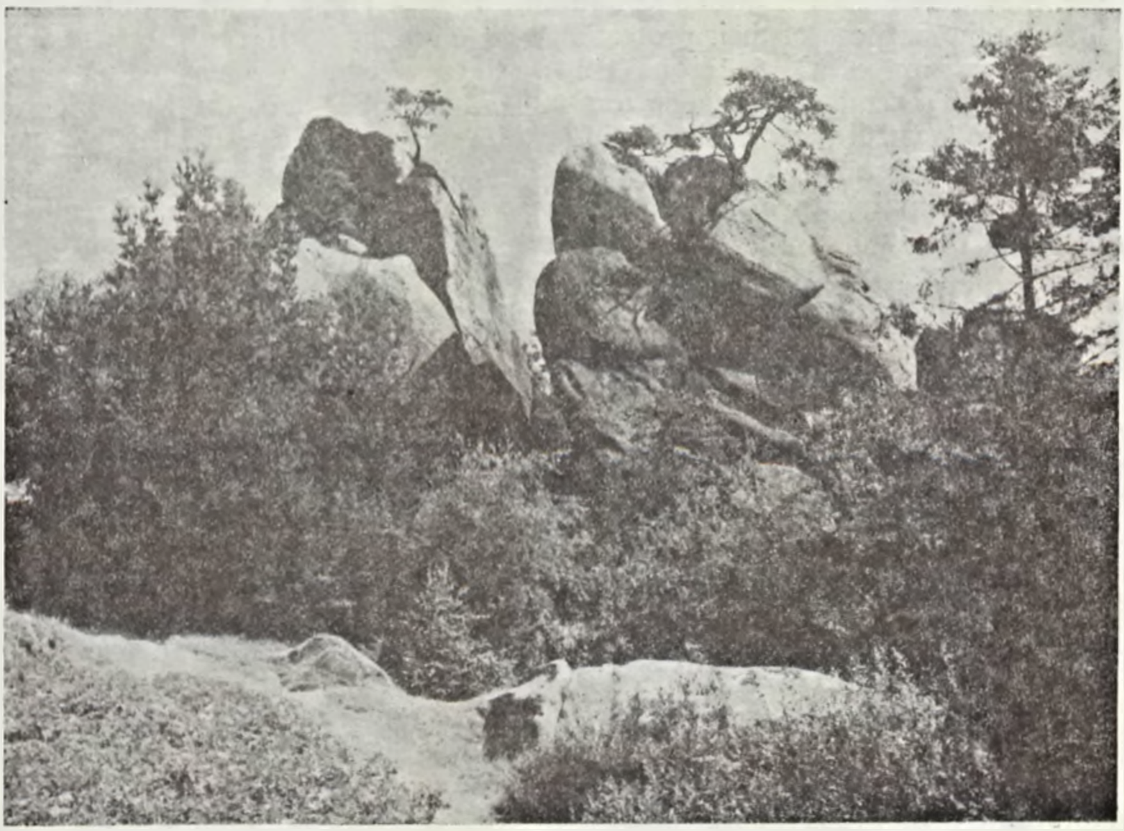

Fig. 4. A group of sandstone tors in the „Prządki" (Spinners) nature reserve

Ryc. 4. Grupa skałek piaskowcowych w rezerwacie przyrody „Prządki" the stripped, resistant sandstone outcrops was directly responsible for the formation of the initial angular tors with even walls corresponding to joint faces.

Mass movements, which could have led to the formation of slump tors, were active in the different periods of the Quaternary, particularly towards the close of the Pleistocene and in the humid phases of the Holocene.

The initial, angular tors of different origin were subsequently subject to modelling by physical and chemical weathering agents aided by aeolian corraison. These processes were attended by the expansion of joints, the formation of corridors, and the disintegration and downslope sliding of rock complexes. The transformation of tors is a continuous process, requiring further studies.

2. Sudetes and their Foreland

Numerous tors of diversified shapes are the characteristic feature of the Sudetic landscape. Because of their location on or near tourist routes, they are widely known and admired. In the descriptions of the relief and geomorphology of the Sudetes, they were discussed as structural elements and as interesting natural outcrops of rocks (Grocholski 1969). Initially, however, they were mostly regarded as natural wonders. The first survey of Sudetic tors for the purpose of their protection was made by K. Hirschberg under the supervision of G. Gürich (1914), who published the results. During the survey, several dozen single tors and groups of tors of the Karkonosze Mts were located and described. Tors to be protected were selected for one of these reasons. 1) they were singular in shape, 2) they were typical of the specific mountain range, 3) they were worthy of note because of the relief features; the best documented structures were numerous weathering bowls, well-developed on the top surfaces of granite tors.

Animated activities connected with listing of the monuments of inanimate nature in Lower Silesia were resumed after the Second World War. They were initiated by review papers in which special emphasis was laid on natural tors (Klimaszewski 1948, 1949, Łaszkiewicz 1946, Wojciechowski 1951). Then, following a few programmatic papers and critical compilations (Alexandrowicz, Drzał, Kozłowski, 1975, Gunia, Śliwa 1960, Jońca 1962, Wójcik 1966), there appeared publications giving more detailed descriptions of rock monuments of a specified type or from a specified area. They mostly dealt with the sandstone tors of the Table Mountains (Czeppe 1949, Dumanowski 1961 a, b, Walczak 1963, Wilczkiewicz 1983), granite tors (Jahn 1962, Dumanowski 1963), and basalt and porphyry tors (Birkenmajer 1967; Grocholski, Jerzmański 1975). Recently Złonkiewicz (1984) compiled on a map all the tors recorded to-date in the Sudetes (basing on a car index prepared by M. Jahn) and summarized the state of their protection. About 150 sites comprising a total of 450 single tors and their groups were located (fig. 5). Tors are non-uniformly distributed, concentrating in ten areas extending concordantly with the strike of mountain ranges. The areas abounding in tors are the Karkonosze Moun-

Fig. 5. The distribution of tors in the Sudetes and their foreland (partly after Z. Złonkiewicz 1984): 1 — single tors and groups under protection, 2 — tors selected for protection, 3 — Karkonosze National Park, 4 — authorized landscape parks, (according to the state of 1985), 5 — authorized areas of protected landscape, (according to the state of 1985), 6 — planned areas of protected landscape, 7 — boundaries of voivodships, 8 — state border. Lithologic types of rocks: G — granite, D — diabase, gabbro, serpentinite, P — porphyry, porphyroid, rhyolite, keratophyre, B — basalt, nepheline, trachybasalt, latite, Z — greenstone, spilite, Gn — gneiss and its varieties, Ł — metamorphic schist, M — rare contact-metamorphic and other rocks, W — crystalline limestone, Pz — sandstone, conglomerate, greywacke

Ryc. 5. Rozmieszczenie skałek w Sudetach i na ich pogórzu (częściowo wg Z. Złonkiewicza 1984): 1 — pojedyncze i grupowe skałki zatwierdzone, 2 — proponowane do ochrony, 3 — Karkonoski Park Narodowy, 4 — parki krajobrazowe zatwierdzone, (wg stanu na 1985 r.), 5 — obszary chronionego krajobrazu zatwierdzone, (wg stanu na 1985 r.), 6 — obszary chronionego krajobrazu projektowane, 7 — granice województw, 8 — granica państwa. Typy litologiczne skał: G — granit, D — diabaz, gabro, serpentynit, P — porfir, porfiroid, riolit, keratofir, B — bazalt, nefelinit, trachybazalt, latyt, Z — zieleniec, spillit, Gn — gnejs i jego odmiany, Ł — łupek metamorficzny, M — rzadko występujące skały kontaktowo-metamorficzne i inne, W — wapień krystaliczny, Pz — piaskowiec, zlepieniec, szarogłazy.

tains, the Table Mountains and the Izera Mountains. Relatively poor in tors are the Wałbrzych, Bystrzyckie and Bardzkie Mountains.

The formal steps taken so far to protect the Sudetic tors have been unsatisfactory, as only 7 geological and landscape reserves have been established, and 7 tor sites are under protection as monuments of nature (fig. 5). These are tors made up mainly of Upper Cretaceous sandstones, less commonly of Permian porphyries, and sporadically of Palaeozoic igneous plutonic and metamorphic rocks. Furthermore, some tors are under protection in a few forest reserves, and numerous granite tors are within the area of the Karkonosze National Park. The recent projects for the conservation of nature by establishing landscape parks and areas of protected landscape will amend considerably the state of protection of tors, provided that precise principles and practical rules are formulated and strictly observed, particularly in areas which attract the tourist trade. This does not mean, however, that there is no need for establishing special rock reserves. On the contrary, many tors should have the status of monuments on account of their different, not only scenic, qualities. Taking into consideration all the forms of legal protection, it has been roughly estimated that 50% of tors are under formal protection (according to the state of 1985). Only 3.5% in this number are protected as reserves and monuments of inanimate nature.

The Sudetic tors owe their remarkable diversity and originality of shape to their geologic structure and morphological position. The Sudetes, an old massif with a complex structure and the relief rejuvenated in the Tertiary, are built of a variety of metamorphic, igneous and sedimentary rocks. In the relief, reflecting today the resistance of these rock varieties, the elements of resistance are primarily preserved within the mountain ranges. These elements could have been the initial zones where side-ridge rocks, walls, steps, pulpits, old towers, mushrooms, tables, etc. were formed. Tors showing such petrographic variation as those in the Sudetes occur nowhere else in Poland. They are made up of a variety of rocks: granites, diabases, gabbros, different varieties of porphyries, basalts, gneisses and metamorphic schists, greenstones, rare rocks of contact-metamorphic (hornfels), metamorphic (amphibolites) and other origin (kersantites), crystalline schists, and sandstone-conglomerate sedimentary rocks (fig. 5).

The petrographic variety of the Sudetic rocks is responsible for the individual character of tors in respect of their shape and distribution. The several mountain ranges differ in the morphological types of tors, depending on their geologic structure. The most common granite, gneiss and sandstone tors provide fine examples of this variety.

The majority of granite tors concentrate within the Variscan (Carboniferous) intrusion of the Karkonosze granite. In the Izera Mountains tors are less numerous. They are built of Rumburg granites, much older then the Carboniferous. The granite tors occurring in the Karkonosze Mts and the Jelenia Góra Depression lend singular character to the landscape. Tors of varying size (up to 25 m in height) are made up of large matress-shaped blocks standing one on top of another (fig. 6). This singular shape of tors is due to horizontal sheet jointing imitating the bedding, parallel to the ground surface, and the system of two fracture directions perpendicular to the join-

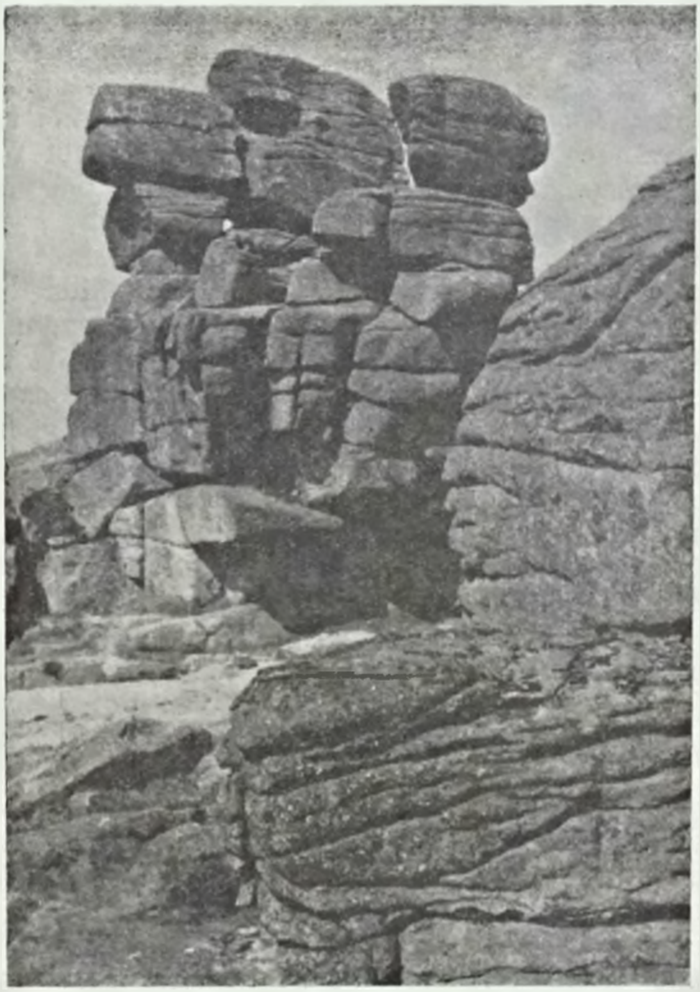

Fig. 6. A granite tor in the Karkonosze Mountains
Rys. 6. Skałka granitowa w Karkonoszach
Phot. Z. Zieliński

ting. Along the joint, horizontal and vertical dissection of rock massifs took place and is still in progress. The granite tors belong to three morphological types (Jahn 1962) (fig. 7). The first type (I) is represented by tors with angular outlines, perpendicular walls and a tabular top. The second type (II) is characterized by the angular base and the top part in the form of spires made up of blocks with usually rounded corners. The third type (III) represents irregular accumulations of ellipsoidal blocks. All these tors form long and narrow walls, tables, and square or irregular towers. The names of particular tors, such as Pilgrims, Horse Heads, Stag, Monk, etc., give a clue to their eccentric shapes.

The position of granite tors in relation to the geomorphological features is somewhat different in individual areas. They are situated on ridges within the ridge crests, or on the convex breaks of slopes near the ridge crests. In the Karkonosze Mts, tors stretch on the ridge crests of ridges running northwards from the main, highest mountain range. Their strike is usually

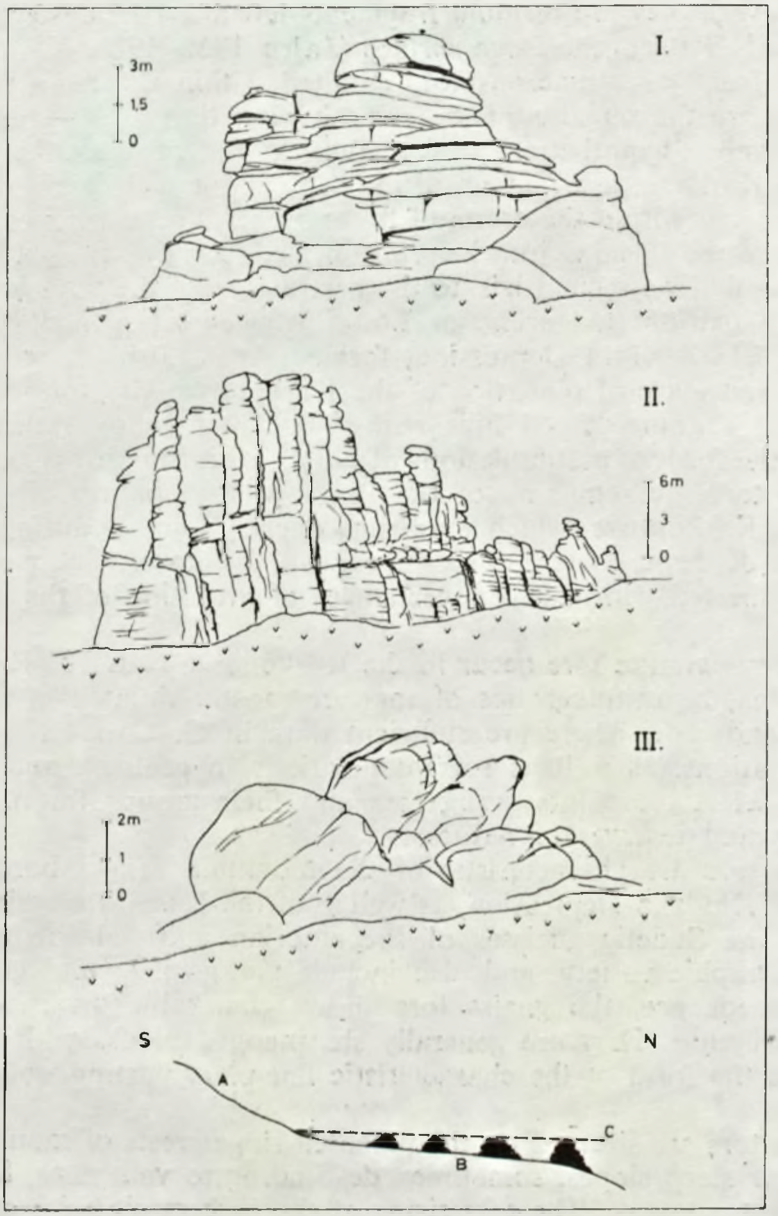

Fig. 7. Morphological types of granite tors in the Karkonosze Mts (I, II) and in the Jelenia Góra Depression (III). The distribution of tors in the Karkonosze Mts, taking „Kukułcze Skały" (Cuckoo Rocks) as an example (after A. Jahn 1962): A — main slope of the Karkonosze, B — long axis of the ridge, C — top surface of tors

Ryc. 7. Typy morfologiczne skałek granitowych w Karkonoszach (I, II) i w Kotlinie Jeleniogórskiej (III). Rozmieszczenie skałek w Karkonoszach na przykładzie „Kukułczych Skał" (wg A. Jahna 1962): A — stok główny Karkonoszy, B — oś podłużna grzbietu, C — powierzchnia szczytowa skałek

concordant with the long axis of the ridge, sometimes oblique or transverse with respect to this axis. The lowest tors are located at the base of the ridge, and the highest at its end (fig. 7). Tors stretching along the ridge edge rise from a flat surface which is broken below them, passing into a steep slope. Ridge tors in the Karkonosze Mts occur mainly at altitudes of 1000—1200 m above sea level. They are residual fragments left after the destruction of the planated Early Palaeogene ridge surface (Jahn 1962, 1980, Klimaszewski 1972). Relatively less numerous tors situated within the main ridge of the Karkonosze are the remains of the summit planation (1320—1420 m above sea level), whose hypothetical surface falls to the north. Other groups of tors in the Karkonosze lie at an altitude of about 600 m above sea level. They are located within the crests of lower ridges, and on slopes descending to the level of the Jelenia Góra Depression, i.e. 400 m above sea level. These tors presumably owe their origin to the destruction of the younger, Neogene, surface of planation (Oligocene or Lower Miocene) (Jahn 1980).

In the Jelenia Góra Depression, formed, in A. Jahn's opinion (1980), after the oldest cycle of planation of the Karkonosze Mts, tors occur on the ridge crests of dome-shaped hills rising 400-550 m above sea level. They often have the form of accumulations of blocks with rounded corners (fig. 7—III). These tors are remnants of the Palaeogene planation of the summit parts of the Karkonosze, which were subsequently lowered during the formation of the depression. Tors also appear on the lower, flat morphological surfaces connected with the younger stages of evolution of the relief (Jahn 1962).

Numerous granite tors occur in the Karkonosze National Park. Outside the park area, beautiful groups of tors are mostly situated in the areas of protected landscape. There are sufficient data in G. Gürich's (1914) and later publications, as well as several mentions in geologic and geographic papers, to select more interesting tors and their groups for protection as monuments and reserves of nature.

Gneiss tors are characteristic of the mountain ranges bordering from the east the Kłodzko Depression, as well as of the Izera Mountains and their Foreland. The Sudetic gneisses of Precambrian and Palaeozoic age show great petrographic variety, and also include paragneisses and granite gneisses. In consequence, the gneiss tors show remarkable diversity of shape, size and structure. They are generally sharp-edged blocks with the gneissic structure in the form of the characteristic fine-platy parting well-marked on their walls.

Gneiss tors are situated on the planated ridge crests of mountain ranges and on their steep slopes, sometimes descending to valleys as, for example, in the Bystrzyca gorge. The tors rising at the highest altitudes are probably the remnants of the Palaeogene surface of planation (Klimaszewski 1972).

Very few of the numerous and diversified gneiss tors are under individual protection. However, single tors or their groups often stand in the existing or planned landscape parks and areas of protected landscape, especially in the Izera, Sowie, Bardzkie, Złote and Bialskie Mountains. This state of affairs is mainly due to the fact that little is known about the tors except their general location. Scanty information can only be found in guidebooks and in geologic and geographic papers. It is postulated that the gneiss tors should be the object of extensive studies for the purpose of their protection as monuments of inanimate nature.

Sandstone tors appear in the areas of occurrence of Upper Cretaceous sandstones in the North-Sudetic trough in the foreland of the Western Sudetes (Izera Foreland, Kaczawa Foreland), in the Intra-Sudetic trough stretching from Kamienna Góra to the Kłodzko Depression, and in the trough of the upper Nysa Kłodzka river. The North-Sudetic trough and the Nysa Kłodzka valley are areas poor in tors. In the public park in Lwówek Śląski (North-Sudetic trough), a picturesque rocky edge extends along the valley side. It is dissected by wide, perpendicular rifts into individual tors up to 30 m in height (Wojciechowski 1951, Milewicz 1973). This area is referred to as „Lwówek Switzerland". A few tors made up of Lower Triassic fine-grained sandstones also appear on a nearby hill near the village of Mojesz (Grocholski 1969). In the Nysa valley east of Bystrzyca Kłodzka, near Idzików, protected as monuments of nature are the Shepherd Rocks (Five Sisters) stretching in a row on the crest of a hill (about 600 m above sea level). They are built of Upper Cretaceous, s.c. Idzików, conglomerates.

The Intra-Sudetic trough abounds in tors, both in its Polish and Czech parts. The only rock massif in this area is the Table Mountains, which are a classic example, unique in Poland and one of the few in Europe, of platy mountains. They rise about 900 m above sea level, striking NW—SE. Along the margin the tableland is bounded by rocky scarps rising 300 m above the neighbouring depressions. In places the scarps are stripped, forming craggy walls, pulpits and isolated tors. (fig. 8). In the foreland of the

Fig. 8. Sandstone tors in the Table Mountains
Ryc. 8. Skałki piaskowcowe w Górach Stołowych

Phot. J. Hereźniak

Stołowe (Table) Mountains, e.g. near Radków, jut out inselbergs, which are the remnants of the destruction and recession of the tableland. The tableland surface, lying at an altitude of 500—900 m above sea level, is the lower surface of denudation planation and descends in a gentle slope to the Kłodzko Depression. Four rock massifs of a relative height of 150 m jut above the planated lower tableland. They are Szczeliniec Wielki and Mały, Narożnik, Błędne Skały and Skalniak. They are the remnants left after the destruction of the upper tableland — the oldest, Palaeogene surface of planation in the Table Mountains, lying 890 m above sea level (Czeppe 1952, Klimaszewski 1972), and delimited by the summit flatissements of the Szczeliniec massif and the highest part of Skalniak.

The vast „rock town" of the upper level of the Table Mountains offers scenery of concentrated diversity and singularity. Tors of different shapes are separated by a labyrinth of narrow corridors. The attitude of individual tors and their stripping are determined by jointing of the sandstone massif. This dependence is particularly conspicuous in the Błędne Skały massif (Czeppe 1952). The open joints are evidence of stress-relieving movements of the massif caused by the loosening and subsidence of the plate and by the slow gravitational displacement of sandstone blocks.

The profile of the Table Mountains reflects their geologic structure. They consist of flat or slightly inclined thick beds of cross-laminated joint sandstones representing the Turonian and Coniacian stages of the Upper Cretaceous (Jerzykiewicz 1966; Radwański 1973). The complexes of sandstone beds are separated by marls. These marls, called lower „plener marls", are underlain by Cenomanian sandstones and appear below marginal tors in the basement of the massif. Such sequence of beds had a determinant effect on the process of denudation leading to the stripping and preservation of sandstone complexes, their disintegration along the planes concordant with joint faces, and their settling on the marly, impermeable basement. Because of the extreme differences in resistance of the sediments making up the Table Mountains, both the lowering of ridge crests effected by denudation and the recession of marginal slopes were a non-uniform process, giving rise to a contrasted landscape of planated structural surfaces and marginal rocky hills.

In the Polish part of the Table Mountains, two large areas with tors — Szczeliniec Wielki and Błędne Skały — are under protection as landscape reserves. The sandstone massif of the Table Mountains extends to the north-west, passing into the territory of Czechoslovakia, where it forms the famous rock towns (Teplice, Adršpach). The Table Mountains end in Poland, forming some original tors near Gorzeszów. These are: a single tor called Devil's Club (monument of nature) and the Dwarves' Stones (nature reserve).

The Table Mountains with their unique rocky relief are in the highest degree worthy of protection. Recently a landscape park was established, but the postulate of protecting this area within the framework of a national park is still being considered.

Fig. 9. The distribution of tors in the Cracow-Wieluń Upland (partly after K. Pawłowska 1972): 1 — single tors or small groups, 2 — large groups of tors, 3 — Ojców National Park, 4 — landscape parks — Complex of Jurassic Landscape Parks, 5 — planned landscape parks, 6 — authorized areas of protected landscape, 7 — planned areas of protected landscape, 8 — boundaries of voivodships; numbers next to tor groups give their amount

Ryc. 9. Rozmieszczenie skałek na Wyżynie Krakowsko-Wieluńskiej (częściowo wg K. Pawłowskiej 1972): 1 — pojedyncze lub małe grupy skałek, 2 — duże skupienia, 3 — Ojcowski Park Narodowy, 4 — parki krajobrazowe — Zespół Jurajskich Parków Krajobrazowych, 5 — parki krajobrazowe projektowane, 6 — obszary chronionego krajobrazu zatwierdzone, 7 — obszary chronionego krajobrazu projektowane, 8 — granice województw; liczby przy skupieniach skałek wyrażają ich ilości

3. Cracow—Wieluń Upland

The Cracow—Wieluń Upland, generally referred to as the Jura or Polish Jura, is distinguished by its typical karst relief and abounds in tors built of Upper Jurassic (Oxfordian) limestones developed in two coeval facies: rocky limestones and platy or bedded limestones (Dżułyński 1951). The majority of tors of original shapes have been stripped within rocky limestones. Being the natural and picturesque features of the relief, tors give the landscape of the Upland its unique character. They generally form large groups in the surroundings more or less changed by man. Of all the types of landscape distinguished by Bogdanowski (1972) in the Cracow—Wieluń Upland, the landscape of hills and valleys with tors is considered to be the most typical of this region and the most spectacular. Since these areas have the highest scenic quality, they should not be built up or subject to any exploitation, except for carrying on farming and forestry on a limited scale. In the Cracow and Częstochowa Uplands rocky landscapes are widespread and dominant, whereas in the Wieluń Upland they have a small extent (fig. 9). Other types of landscape of lower scenic quality are: the landscape of hills and valleys without tors, rolling country and flat country.

The natural rocky relief of the Upland is in danger of being destroyed by strip mines which have been constructed here to extract raw materials for the manufacture of lime, cement, moulding sand, fire-clay, white clay and aggregate (Kozłowski 1972). The exploitation of natural resources in the Upland has a tradition of long standing. The first raw material extracted by man was siliceous concretions (flints) embedded in limestones. Today quarries, mines, and processing plants based on a variety of local materials are in many localities, concentrating mainly near Częstochowa, Ogrodzieniec and between Olkusz and Cracow. Not long ago, illegal exploitation of limestones in numerous small quarries was a common practice (Kubicz 1964), which, needless to say, spoiled the beauty of the landscape. As they were easy of access, tors sometimes were also the object of exploitation. The economic activities in this region have been under legal restraint since the Complex of Jurassic Landscape Parks was established in the Upland in 1980—1982.

Descriptions of tors as geological-morphological features and suggestions for their protection can mainly be found in scientific publications for the general public (Leńkowa 1960, Otęska-Budzyn 1976, 1977, 1978, Szaflarski 1955). The problems connected with the protection of tors were discussed more comprehensively in several papers dealing with specific areas (Błaszak 1973, Drzał 1954, Otęska-Budzyn 1987, Polichtówna 1962).

The rocky morphology of the Upland attracted a great many naturalists, chiefly on account of its high scenic quality. Such an approach to tors led to the postulate of their protection as landscape monuments. In consequence, only two reserves of inanimate nature (Góra Zborów and Węże) were expressly established in this area to protect the tors and karst features. In the Węże reserve, with the limestone hill of Zelce lying within its area, the fossil Pliocene fauna preserved in caves is also under protection. However, the postulates of protection of the rocky hills and valleys of the Upland usually empha-

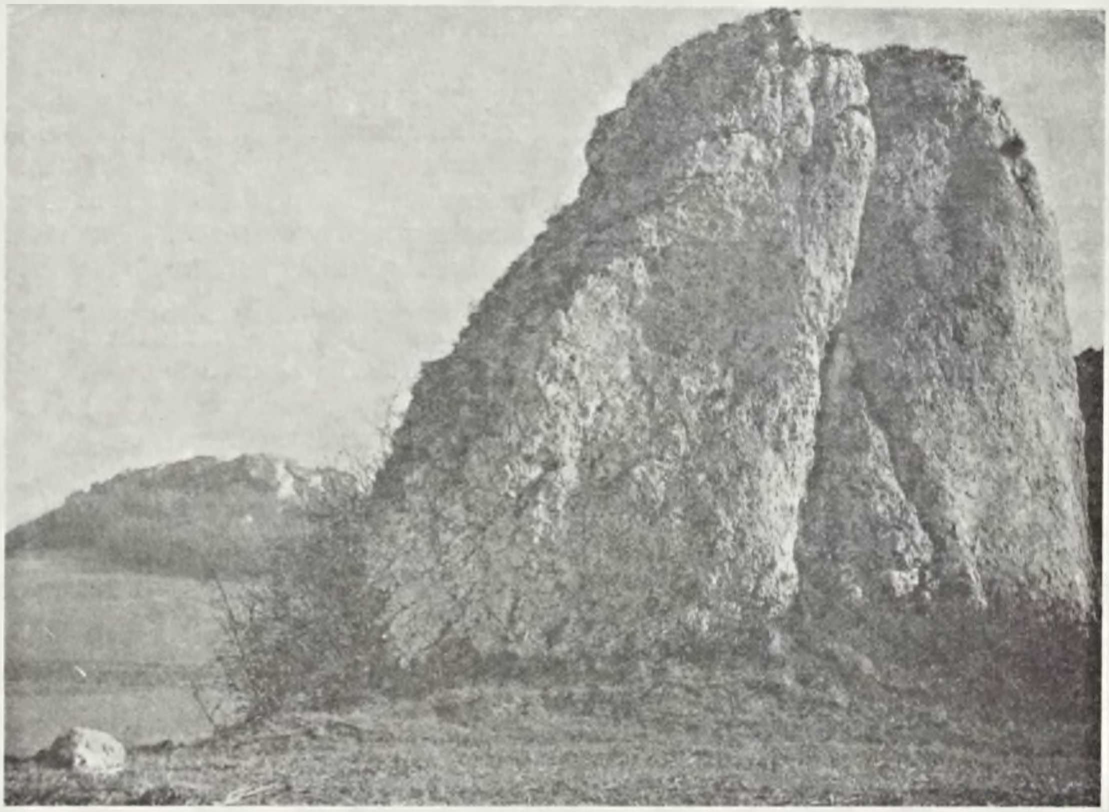

Fig. 10. Limestone tors near Jerzmanowice in the Cracow Upland
Ryc. 10. Wapienne skałki w okolicy Jerzmanowic na Wyżynie Krakowskiej

sized their other qualities and features, such as forests, the characteristic species of rock plants, and picturesque scenery. With this end in view, 23 reserves of inanimate nature and landscape were established. In most of them (13) groups of original tors crown the hilltops or border the valleys. The principal form of individual protection of limestone tors is their qualification as monuments of nature. The singular shapes of these tors, and caves preserved in them, were essentially the prime arguments for giving them the status of monuments of inanimate nature. Other considerations, e. g. their flora, were regarded in this case to be of minor importance. About 90 tors out of the total number of ridge crest tors occurring in the Częstochowa and Cracow Uplands have been protected in this way near Smoleń, Złożeniec, Strzegowa, Pomorzany, Bogucin Mały, Rabsztyn, Jerzmanowice and Bębło (Alexandrowicz, Drzał, Kozłowski 1975). About 50 sites with valley tors are under protection as monuments in the Prądnik valley outside the area of the Ojców National Park, and in the Vistula gorge between Tyniec and Piekary. It appears, therefore, that a total of 140 tors out of 1000 recorded have the status of monuments of nature (Drzał 1972, Pawłowska 1972) (fig. 9). Tors are particularly widespread on the Ojców Plateau and throughout the Częstochowa Upland. Most of them (about 700) have their individual, local names which usually tell their fantastic shape.

From the formal point of view, the protection of tors in the Cracow—Wieluń Upland seems to be satisfactory if all the forms of protection, viz. the national park, nature reserve, monument of nature, landscape park, area of protected landscape, are taken into account. Nearly all the tors are under legal protection (Otęska-Budzyn 1985). However, several objections can be raised as to the carrying of this protection into effect, particularly in the areas which attract tourists, e.g. the Eagles' Nests route, and climbers. It is to be hoped that the administration of the Jurassic Landscape Parks will soon settle the matter of tourist traffic in this area.

The existing state of protection of inanimate nature in the Polish Jura can be improved in the first place by establishing new reserves that would serve scientific and educational purposes, and by extending some of the existing ones. Moreover, larger groups of tors protected until now as monuments of nature should be revalued and given the status of reserves, while new monuments are selected. There are some documented but unrealized projects for tor reserves, such as Straszykowa Góra near Ryczów (Polichtówna 1962) and Ogrodzieniec (Otęska-Budzyn 1987), as well as a large number of postulates concerning primarily the protection of tors in the Cracow Upland, e.g. the Gaudynowskie Tors near Brodła, numerous tors in the Vistula valley, etc. (Gradziński 1960).

The preparation of the optimum system of tor reserves and monuments of inanimate nature requires more purposeful and concentrated studies than those carried out to-date. Up till now, only two areas of tor occurrence have

Fig. 11. Limestone tors near Ogrodzieniec in the Częstochowa Upland

Ryc. 11. Wapienne skałki w okolicy Ogrodzieńca na Wyżynie Częstochowskiej

Phot. J. Otęska-Budzyn

been the object of extensive studies: the area between Ryczów and Strzegowa (Polichtówna 1962) and the area of Ogrodzieniec (Otęska-Budzyn 1987). The documentation of other tor sites is mostly very general.

In the Cracow—Wieluń Upland there are two major types of tors, ridge crest and valley tors, differing in the mode of occurrence and origin. Ridge crest tors are usually represented by typical isolated monadnocks of diversified shapes. Their groups, or sometimes single tors, crown the hills or rise directly from the gently undulating ground surface of the plataeu (400—460 m above sea level), and are surrounded by forests or fields. The white steep-walled ridge crest tors stand out in relief, towering above the surroundings (fig. 10). On some larger, lofty hills, fortified castles were built among the tors (the Eagles' Nests route). Their ruins in different states of repair now blend with the Jurassic landscape into a harmonious whole (fig. 11). Owing to the diversity of shape and the spatial distribution, the individual groups of ridge crest tors are distinguished from one another by peculiar morphology. They assume the shape of broad towers and pulpits, long walls and side-ridge rocks, high pinnacles and clubs, ruins and large, irregular slumped blocks, as well as a variety of other forms with massive bases and fancifully carved walls.

Valley tors are less spectacular than ridge crest forms. They border valleys, being particularly picturesque in gorges (S. Alexandrowicz 1955, Z. Alexandrowicz 1960, Przyroda Ojcowskiego P.N. 1977). Valley tors usually form pulpits, ribs and walls, seldom appearing as isolated rocks. Typical tors of this type can be found in the Cracow Upland in the Prądnik valley (Ojców National Park), the Cracow Valleys, and in the gorge of the Vistula, called the Cracow Gate (fig. 12).

The tors of the Cracow—Wieluń Upland, especially ridge crest tors are intensely karstified. Their walls are covered with a variety of structures typical of limestone karst (Otęska-Budzyn 1987). Inside the tors, numerous caves and corridors were produced by karst (Kowalski 1951). They form specific horizontal systems which, together with the other morphological elements of the Upland, served as a basis for the reconstruction of the stages of its formation (Dżułyński, Henkiel, Klimek, Pokorny 1966; Gradziński 1962).

The origin of the Jurassic tors has been discussed by many investigators of the Upland (Gilewska 1972). Their hypotheses rest on the common assumption that there exists a planated, slightly undulating surface from which rise monadnocks that have the nature of elements of resistance. As was ascertained in the Cracow Upland, between these tors lie depressions without outflow, filled up with weathering waste and loess (Pokorny 1963). There is, however, a divergence in opinions concerning the origin of this surface and, thereby, the genesis of tors. It was thought that it is the abrasion surface of the Cretaceous sea (Smoleński 1924), the structural surface of Jurassic limestones (Małecki 1958), an erosion-denudation surface (Walczak 1956), or a karst surface (Klimaszewski 1958, Pokorny 1963, Różycki 1972). According to the recent hypothesis, the tors are of karstic origin, preserved as the most resistant parts of limestones. They can be regarded as mogots of Palaeogene age (Pokorny 1963). Despite the periglacial trans-

Fig. 12. Limestone valley tors in the Ojców National Park
Ryc. 12. Wapienne skałki dolinne w Ojcowskim Parku Narodowym
Phot. S. Michalik

formation during the Pleistocene, mogots retained their karst relief. A detailed study of the development of tors in the area between Ryczów and Strzegowa was carried out by Polichtówna (1962), who proved the existence of two surfaces of planation above which jut out monadnocks of the type of mogots — elements of resistance.

The scientific basis on which should be founded a concept for protection of limestone tors in the Cracow—Wieluń Upland is a complex issue, the more so as the origin of tors is still a matter of dispute. Nevertheless, the present state of knowledge can provide a starting point for preliminary valuation of at least some, carefully selected, tors.

4. Kielce Upland

We owe the earliest information on the occurrence of natural tors in this area to Jan Czarnocki (1932), an eminent geologist and investigator of the Kielce region, who also formulated definite postulates of their protec-

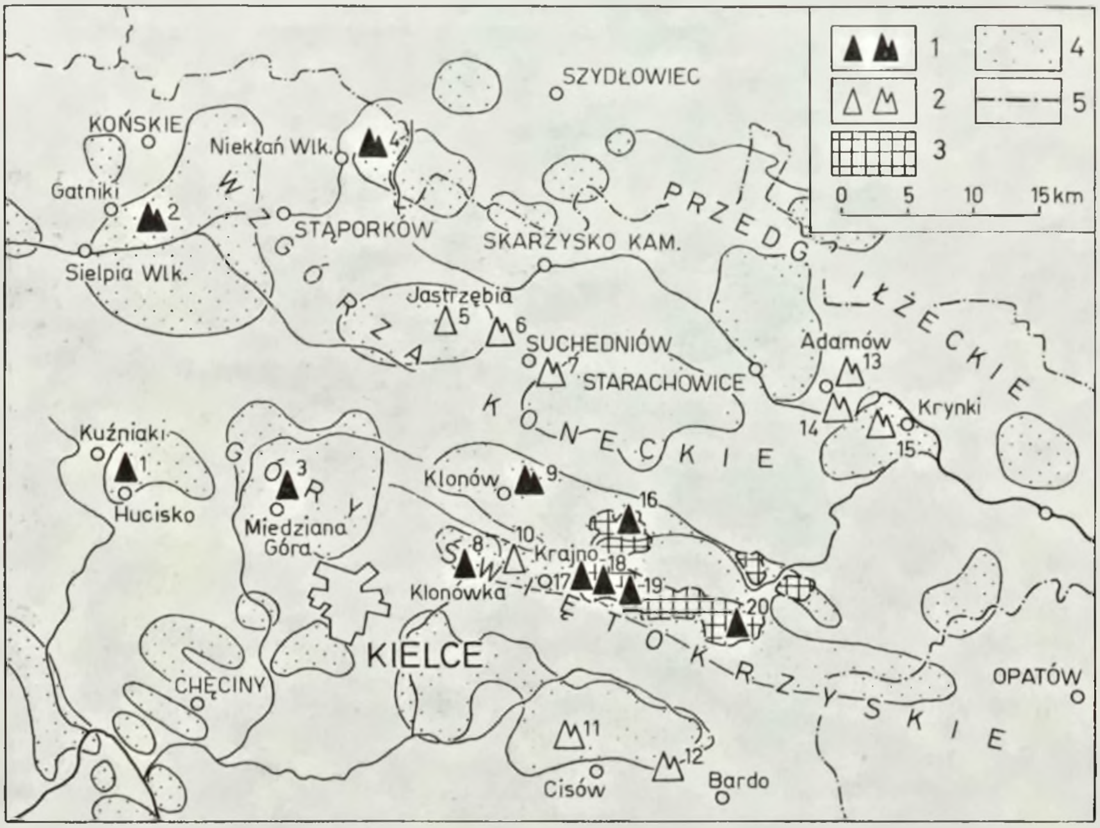

Fig. 13. The distribution of tors in the Kielce Upland: 1 — single tors and groups under protection, 2 — tors selected for protection, 3 — Świętokrzyski National Park, 4 — areas of protected landscape, (according to the state of 1985), 5 — boundaries of voivodships. Numbers next to tor signatures designate the site number

Ryc. 13. Rozmieszczenie form skałkowych na Wyżynie Kieleckiej: 1 — pojedyncze i grupowe stanowiska chronione, 2 — proponowane do ochrony, 3 — Świętokrzyski Park Narodowy, 4 — obszary ochrony krajobrazowej (wg stanu na 1985 r.), 5 — granice województw. Liczby przy sygnaturach skałek oznaczają numery ich stanowisk

tion against the progressing exploitation. A number of tors selected by Czarnocki (1932) are under protection as reserves and monuments of nature, or within the area of the Świętokrzyski National Park, but 5 out of 13 tors indicated by this investigator have not gained recognition. These unrealized postulates must now be verified, but this presents considerable difficulties as the location of tors is not very precise. It is probable that some of these tors no longer exist having been worked out, as foreseen by J. Czarnocki, for whom it was the chief argument for their immediate protection. J. Czarnocki was mainly interested in tors occurring in the Holy Cross Mountains and their southern margin. Some brief pieces of information about these tors were then complemented in later papers (Massalski 1951, Kotański 1959), which also gave data on other tors worthy of protection.

To obtain reliable data on the occurrence of tors in the Kielce Upland, field checks had to be made and basic descriptions of tors provided (fig. 13). On this basis it was estimated that about 50% of tors are not under indivi-

Fig. 14. Sandstone tors in the „Skałki Piekło" (Hell Rocks) reserve near Niekłań
Ryc. 14. Skałki piaskowcowe w rezerwacie „Skałki Piekło pod Niekłaniem".

dual protection (according to the state of 1985). This situation is soon going to change because a few documented projects will be realized.

Up till now, six monuments of nature for the protection of single tors or their groups have been established in the Kielce Upland. The most beautiful group of tors on Piekło (Hell) hill near Niekłań is under protection as a reserve (fig. 14). Tors and the accompanying block fields in the Łysa Góra range lie within the area of the Świętokrzyski National Park. To be approved as a reserve is the area with tors near Adamów. The remaining tors, 9 in all, require detailed documentation, but this number may yet increase as a result of further surveys. Of the eleven tor sites under protection, the „Hell Tors" reserve near Niekłań is the only one with complete documentation (Alexandrowicz, Drzał, Kozłowski 1975; Lindner 1972; Massalski, Kazanowski 1928). The quartzite tors of the Łysa Góra range were described incidentally during the detailed investigation of block fields (Klatka 1962). The other tors under protection are only mentioned in some geological publications (Budowa geologiczna Polski 1973) and in a geological guidebook (Kotański 1959).

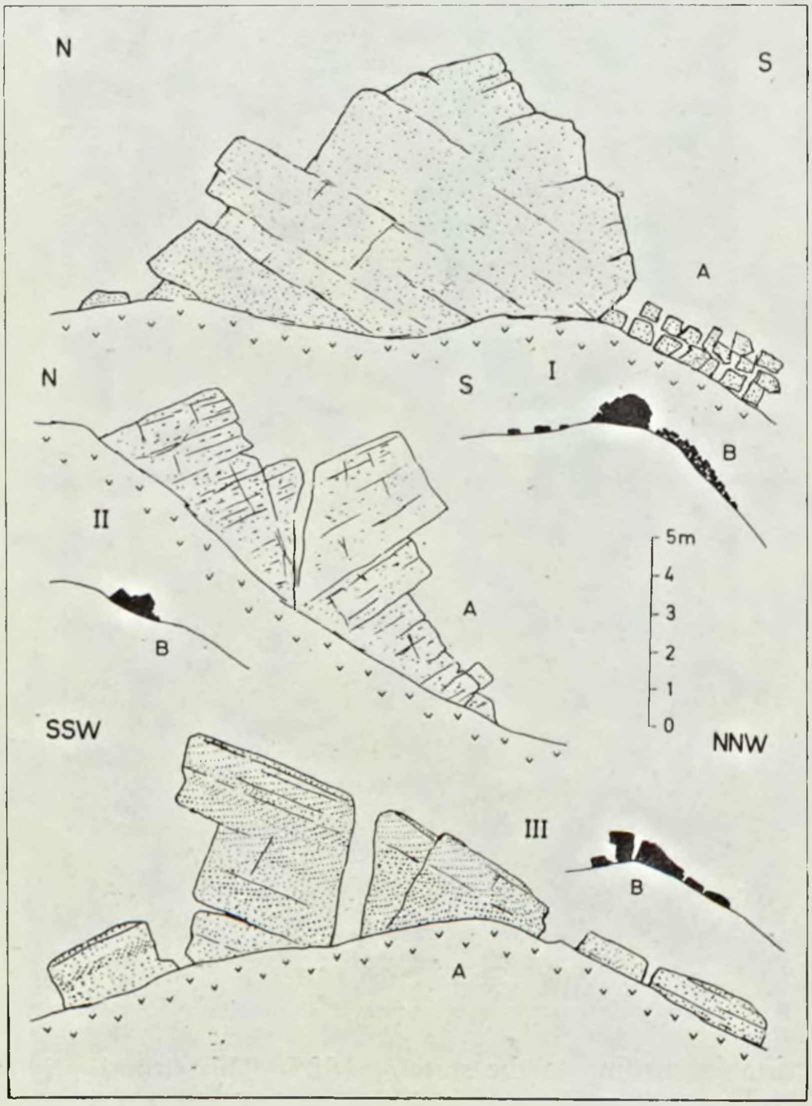

Fig. 15. Morphological types of tors in the Kielce Upland (A) and their position in relation to the elements of relief (B): I — protected tor „Wielki Kamień" (Great Stone) on Klonówka hill (No 8 in fig. 13) — Middle Cambrian quartzite sandstones, II — protected tors near Miedziana Góra (No 3) — Lower Devonian quartzite sandstones, III — protected tors on Bukowa Góra in the Klonów range (No 9) — Lower Devonian sandstones

Ryc. 15. Typy morfologiczne skałek Wyżyny Kieleckiej (A) i ich położenie względem elementów rzeźby terenu (B): I — chroniony „Wielki Kamień" na wzgórzu Klonówka (nr 8 na ryc. 13) — piaskowce kwarcytowe środkowego kambru, II — chronione skałki w okolicy Miedzianej Góry (nr 3) — piaskowce kwarcytowe dolnego dewonu, III — chronione skałki na Bukowej Górze w Paśmie Klonowskim (nr 9) — piaskowce dolnego dewonu

In many localities of the Kielce region not only tors but also craggy faces of steep slopes, natural outcrops on the walls of valleys and gullies, and rocky hill ridges are under protection. They represent a variety of features connected with the geologic structure and the processes of karst and mineralization, as well as being geomorphological elements of high scenic quality. Such reserves of inanimate nature are, for example, Góra Zelejowa and Góra Miedzianka, and the monuments of nature are caves — the Piekło

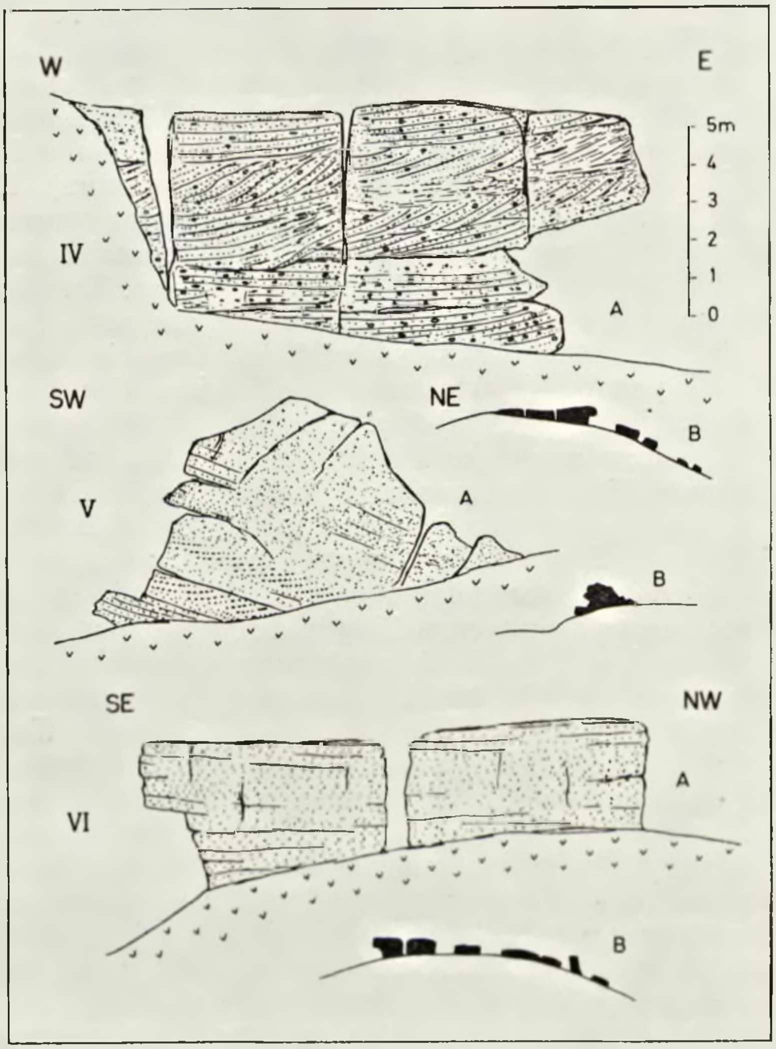

Fig. 16. Morphological types of tors in the Kielce Upland (A) and their position in relation to the elements of relief (B): IV — protected tors on Perzowa Góra near Hucisko (No 1 on fig. 13) — Lower Triassic sandstones (Buntsandstein), V — tors near Adamów (No 13) to be protected as a reserve — Lower Triassic sandstones (Upper Rhaetian), VI — protected „Gatniki" tors near Sielpia Wielka (No 2) — Lower Jurassic sandstones (Liassic — Gielniów series)

Ryc. 16. Typy morfologiczne skałek Wyżyny Kieleckiej (A) i ich położenie względem elementów rzeźby terenu (B): IV — chronione skałki na Perzowej Górze koło Huciska (nr 1 na ryc. 13) — piaskowce dolnego triasu (pstry piaskowiec), V — proponowane do ochrony rezerwatowej skałki w okolicy Adamowa (nr 13) — piaskowce dolnego triasu (ret górny), VI — chronione skałki „Gatniki" koło Sielpi Wielkiej (nr 2) — piaskowce dolnej jury (lias — seria gielniowska)

(Hell) cave near Małogoszcz, for example, with its opening situated in a sheer cliff wall (Kowalski 1954).

The tors of the Kielce Upland fall into two major morphological types related to the geologic structure. One type is represented by tors with angular outlines, little diversified wall relief, and well-defined joint faces (fig. 15). They are made up of Middle Cambrian compact quartzite sandstones (referred to as the Łysogórski quartzite) showing macroscopically insignificant lithologic variation. The other type is represented by well-modelled tors of cylindrical shapes and with the diversified wall relief (fig. 16). The sandstones that make up these tors vary in their grain-size composition from conglomeratic to fine-grained. They show horizontal and cross-lamination, accentuated by the selective weathering of the rock. The sandstones are of Lower Triassic (Lower-Middle Buntsandstein, Rhaetian) and Lower Jurassic age (Liassic — the Ostrowiec series, the Gielniów series). The outcrops of Triassic and Jurassic sandstones in the form of tors concentrate in the northern and western margin of the Holy Cross Mountains, in the area of the Końskie Hills, Iłża Foreland and Oblęgorek Range. Tors built of Cambrian and Devonian sandstones are found within the several ranges of the Holy Cross Mts. The lithologically varied Lower Devonian sandstones form tors of unmodelled shapes (Piekło tor near Miedziana Góra), as well as cylindrical in shape (Bukowa Góra) (fig. 15).

Tor outcrops form pulpits or long side-ridge rocks and steps dissected by expanded joints. They are never more than 8 m in height, averaging 3—5 m, whereas their length varies from 5 m in the case of isolated pulpits to several dozen metres. Sporadically they may even attain a length of several hundred metres (700 m near Adamów), when the sandstone beds outcrop in a step dissected into pulpits stretching in a row, isolated slumped towers, and blocks of detached beds. Rock mushrooms are scarce, the most beautiful being reported from the Niekłań reserve. Most characteristic are vast debris flows at the foot of tors. They consist of blocks of different sizes derived from shattered tors. They are often large bed complexes, particularly in the vicinity of tors made up of Triassic and Jurassic sandstones. Block accumulations at the foot of tors built of quartzitic sandstones are different in nature. They are a jumble of angular blocks, forming thick covers. Sometimes they also cover the lower parts of tors. In the main range of Łysogóry they form typical block fields.

The majority of tors in the Kielce Upland are situated along the morphological edges, in breaks of slopes just below the ridge crest or above the local slope flatissements (figs. 15, 16). Sometimes tors rise from flat ridge crests. From the mode of occurrence of tors it can be inferred that they were stripped in the course of lowering of ridge crests, effected by denudation, and during the recession of slopes. The large accumulation of blocks at the foot of many tors testify to the intense destruction of stripped rocks. The block fields of the Łysogóry range originated from the congelifluction block and debris covers formed under the periglacial conditions of the Pleistocene (Klatka 1962). Quartzite tors preserved in the vicinity of some block fields are the residual forms of this period. If the congelifraction process operated, as is assumed, on a large scale in the Holy Cross Mountains, it must have led to the formation of initial tors in the form of frost-riven cliffs also in other areas of the Kielce Upland. The subsequent modelling of angular tors, effected by weathering and corraison, was a successive stage in the process of their shaping. A hypothesis on the origin of sandstone tors occurring in the northern and western margin of the Holy Cross Mountains was advanced by Lindner (1972). On the basis of the distribution and extent of loesses, this author assumed that during the last loess-forming period in the Würm, the area in question was a vast deflation field, in which quartz material was being deflated from the poorly silicified sandstones. According to this hypothesis, the tors of the Holy Cross Mountains foreland owe their origin to the corraison and deflation processes.

The present state of knowledge of the Kielce Upland tors is far from satisfactory, and further studies are required not only to obtain new data on their origin, which is important for their scientific valuation, but also to prepare the lists and documentation of tors which should be under protection.

5. Roztocze borderland of the Lublin Upland

The rock forms of the Roztocze hills were recently listed and described by Złonkiewicz (1990), only their characteristic features will be discussed in this paper. Because of their small size (generally up to 2 m in height), the tors have no scenic quality. They are important, however, as the natural outcrops of organodetrital Miocene limestones and sandstones, and as the sites of well-developed karst structures. Therefore, most of them should be under protection as geologic outcrops, the more so as they generally are not shaped like typical tors but form low steps and ledges, or appear as single blocks or accumulations of loose, displaced blocks. Only 5 out of 20 recorded sites show the morphology of typical tors. Their detailed description is given by Złonkiewicz (1990). From a comparison of the actual number of tors with the earlier lists it appears that part of them have already been worked out. There is still a danger of further destruction, especially at the sites situated amidst fields. Tors are under formal protection in the Roztocze National Park and in its enclosure, and only sporadically outside these areas. About 40% of the known tors are under protection at the most (vide the map — Złonkiewicz 1990). The rock forms of the Roztocze hills are usually situated along the edges of ridge crest flatissements and in breaks of slopes, less commonly within the morphological surfaces of planation. They owe their origin to karst weathering in the Tertiary period, the planation of ridge crests, and to the intense denudation under the periglacial conditions of the Pleistocene.

III. PRINCIPLES OF THE CONCEPT FOR PROTECTION OF TORS

If the concept for protection of tors occurring in different regions is to be founded upon a solid basis, some criteria must be set out whereby their specific qualities may be assessed. The assessment should be based on the following indicators: 1) the valuation of tors, 2) the mode of their occurrence, 3) the possibility of their protection in compliance with the binding legal regulations.

1. The valuation of individual tors involves the study of all their features. Tors can have different value: scientific and didactic, aesthetic (scenic), cultural, and utilitarian (fig. 17). The weighing of these qualities for each tor determines its rank.

Tors are of high scientific value as distinct structural elements of the relief, as geologic features suitable for studying exogenic processes and phenomena, and above all, as representative and permanent rock outcrops. Moreover, they are specific plant and animal habitats, as well as sometimes being interesting archaeological sites.

The aesthetic (scenic) value of tors is due to their original shapes and to their position, often prominent, in the landscape, owing to which they provide excellent vantage-points.

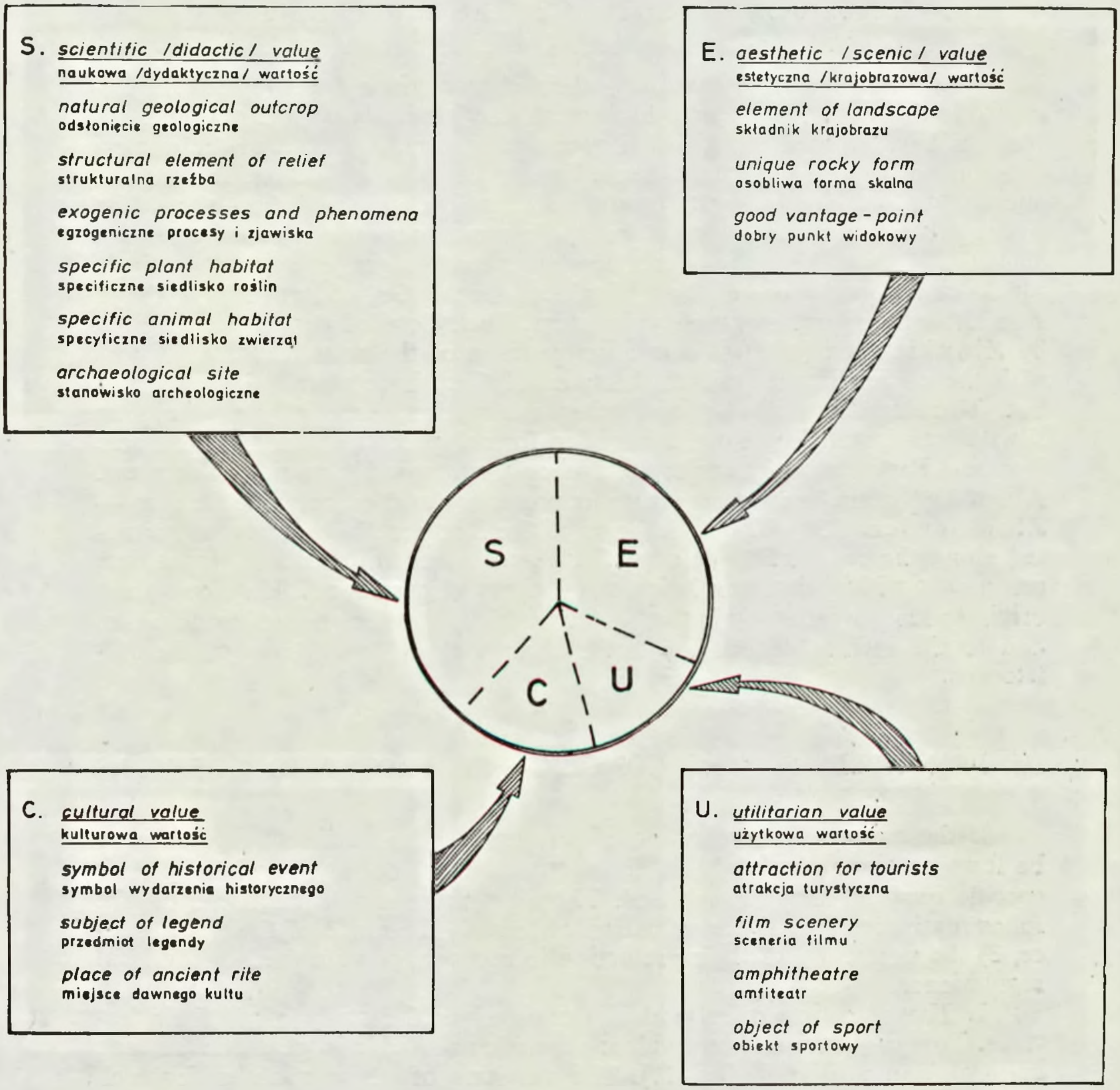

Fig. 17. Criteria of valuation of tors. The circular diagram reflects the hierarchy of the mentioned criteria

Ryc. 17. Kryteria waloryzacji skałek. Diagram kołowy przedstawia hierarchię wymienionych kryteriów

Tors connected with important historical events, legends or ancient rites have cultural value.

The utilitarian value of tors lies mainly in their attraction for tourists. They also provide excellent locations for films, amphitheatres for all sorts of performances, and training grounds for sportsmen.

2. The mode of occurrence of tors varies from one area to another. It depends on the geologic structure of the bedrock and on the evolution of relief. From the viewpoint of the frequency of occurrence of tors, the following distinction can be made:

A. An area where tors are widespread and numerous,
B. A large concentration of tors in a relatively small area,
C. Small groups of tors or scattered single tors,
D. A single tor or a small, isolated group of tors.

TABLE I

Protection of tors
Ochrona skałek

Occurrence of tors Występowanie skałek	Form of protection Forma ochrony					
	Integral protection (subordinate) Ochrona kompleksowa (podporządkowana)			Specific protection (major) Ochrona specyficzna (główna) rank of tors ranga skałek		
				h		l
A — widespread and numerous concentrations rozległe i liczne zgrupowania	PN	[RP]		PN		RP
B — large concentration duże skupienie	PN	RP		RP		[RP)
C — small groups or scattered single tors małe grupy lub pojedyncze skałki rozproszone	[PN]	RP	PK	RP		PP
D — single tor or small, isolated group samotna skałka lub izolowana mała grupa	[RP]	PP	PK	[RP]	PP	PP

Explanation (objaśnienie): PN — national park (park narodowy), RP — nature reserve (rezerwat przyrody), PP — nature monument (pomnik przyrody), PK — landscape park (park krajobrazowy); h — high rank (wysoka ranga), l — low rank (niska ranga).
Symbols in brackets designate possible but untypical forms of protection.
Symbole w kwadratowych nawiasach oznaczają możliwe, ale nietypowe formy ochrony.

3. The valuation of tors, and the assessment of their number and concentration provide a solid basis for the choice of the best form of protection (table I). It falls into two categories: integral protection and specific protection. In the former case, tors are subordinate elements in the assemblage of other features of the natural environment, irrespective of their value. In

the latter case, tors are the major elements, and the form of their individual protection depends on their value.

The scope of protection is determined in compliance with the existing regulations. In the absence of such regulations, or in the case of their imperfection, new solutions are suggested. In Poland, the statutory forms of nature protection are: the national park, nature reserve, and monument of nature. The optimum form of protection suggested for each tor or group of tors is chosen from among these categories. Landscape protection alone (landscape park) is possible only when small groups of tors (C) or single, isolated tors (D) occur as minor components of the landscape under protection.

The presented system of protection of tors has methodological value and may be utilized for the protection of different monuments of inanimate nature. Such a system ensures the optimum distribution of features and objects under protection, at the same time taking into consideration their value and different functions.

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STRESZCZENIE

Obiektami opracowania są skupienia i pojedyncze skałki występujące w obszarach nieskalistych w całości, jakimi są: Karpaty zewnętrzne, Sudety, Wyżyna Krakowsko-Wieluńska, Wyżyna Kielecka i Roztocze (ryc. 1). W wymienionych regionach górskich i wyżynnych Polski skałki charakteryzują się dużą różnorodnością pod względem budowy geologicznej, morfologii i genezy (ryc. 3, 4, 6—8, 10—12, 14—16). Najbardziej zróżnicowane formy występują w Sudetach. Do obszarów skałkowych o wybitnych walorach krajobrazowych należy zaliczyć Góry Stołowe i Wyżynę Krakowsko-Częstochowską.

Potrzeba stosowania ochrony skałek wynika z dwóch głównych przyczyn. Po pierwsze obiekty te są naturalnymi, dobrymi i długotrwałymi odsłonięciami geologicznymi, które — w przeciwieństwie do stosunkowo szybko zarastających sztucznych odkrywek — zachowują swoje wartości naukowe, dydaktyczne i krajobrazowe. Po drugie są one atrakcyjne turystycznie, a także łatwo dostępne do eksploatacji, przez co w dużym stopniu narażone na zniszczenie. W Polsce chroni się je indywidualnie jako pomniki przyrody lub na obszarach parków narodowych, rezerwatów przyrody, a także licznie w parkach krajobrazowych i obszarach chronionego krajobrazu. W tych kategoriach ochrony do 1986 r. zabezpieczonych zostało około 50% z ogólnej ilości zarejestrowanych i przebadanych skałek. Ich rozmieszczenie i status ochronny ilustrują mapy poszczególnych regionów (ryc. 2, 5, 9, 13; 1 — patrz Z. Złonkiewicz 1990).

Problematyka badawcza skałek jest szeroka przede wszystkim w zakresie przyrody nieożywionej, ale także i przyrody ożywionej. W dotychczasowej motywacji ochrony skałek dominowały względy estetyczno-krajobrazowe i kulturowe. W miarę postępu badań istotnie wartościowe cechy przyrodnicze skałek odgrywają coraz większą rolę w staraniach ich ochrony. Opracowany model prawidłowego systemu ochrony skałek opiera się na wielokierunkowej waloryzacji poszczególnych form, zbadaniu sposobu ich występowania w terenie oraz rozpoznaniu możliwości ochrony w dostosowaniu do obowiązujących kategorii prawnych. O randze wartości poszczególnych pojedynczych lub grupowych obiektów skałkowych decyduje ich znaczenie naukowe i dydaktyczne, estetyczne i krajobrazowe, kulturowe, a także użytkowe (ryc. 17). Zwaloryzowanie form i rozpoznanie ich rozmieszczenia w danym obszarze, stwarzają właściwą podstawę dla dokonania optymalnego wyboru formalnego zabezpieczenia, czynnej ochrony i wykorzystania dydaktyczno-krajoznawczego skalnych obiektów (tab. I). Ochrona może być kompleksowa lub specyficzna (przedmiotowa). W pierwszym przypadku skałki są elementami podporządkowanymi, niezależnie od ich wartości, w zespole innych składników środowiska przyrodniczego. W drugim przypadku są one elementami głównymi i ich przedmiotowa kategoria ochrony jest uzależniona od rangi wartości.

Praca została wykonana w ramach problemu międzyresortowego MR II/15, w grupie tematycznej 06.