The regional network of geosites in the Polish Carpathians

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Polish part of the Carpathians represents a region with valuable, diversified geological structures and a wide spectrum of landforms. Nature protection in the Carpathians is regulated by the successive nature conservation acts of 1934, 1949 and 1991. The legal framework of geoconservation of the Inner and Outer Carpathians comprises: 6 national parks, 11 landscape parks, 15 geological reserves, 77 monuments and 14 documentary sites. About 90 individual sites and site-sets of a regional importance are proposed for protection. At present, inventory and documentary work focuses on protection of stratotypes of the flysch sequences and their reference sections, classic sites with fossils, sedimentary and tectonic structures, landforms as well as important sites of Quaternary deposits and evidences of morphological processes. Among the localities that are already protected or proposed to be protected the 25 most valuable sites/objects have been selected for the European List of GEOSITES compiled by IUGS in collaboration with ProGEO Association.

Key words: *Polish Carpathians, geologic sites, conservation, history, legislation, future*

Introduction

In many countries there is observed a growing interest in problems related to Earth science conservation which have been perceived inadequately as an integral part of nature protection (Alexandrowicz, 1994). A need for dissemination of a geoconservation idea and for a social awareness in this field was a fundamental incentive for appointing the European Working Group on Earth Science Conservation — EWGESC in 1988. In 1993 this Group evolved into European Association for the Conservation of the Geological Heritage — ProGEO. The tasks and aims of common endeavour for geoconservation are determined by the International Declaration of the Rights of the Memory of the Earth endorsed during the first international symposium devoted to conservation of geological heritage that was held in Digne, France in 1991 (Actes du Premier Symp., 1994).

At present, an essential task of the discussed activity is the development of the European network of geoconservation sites that are of the highest scientific priority. The GEOSITES programme co-ordinated by IUGS and executed in collaboration with ProGEO is to serve this task. The appointed working groups (i.a. Central European Working Group under the leadership of the Institute of Nature Conservation of Polish Academy of Sciences) foster the co-operation between particular countries finally aiming at selection and conservation of the most representative formations and geo(morpho)logical structures of European continent (Johansson et al., in press; Wimbledon, 1996, 1998). In the current, first stage of the GEOSITES programme domestic networks of geosites for particular countries are under elaboration. The most valuable geosites will be placed on the European list of GEOSITES, and some of them, of the highest scientific value might be included to the List of Sites of Geological Heritage of the World. The first, worlds list of 1990 comprised 90 geological and geomorphological objects, 34 localities from Europe inclusive (Cowie, 1990, 1994). Unfortunately, the list inadequately represents geodiversity of particular continents. In Trondheim, Norway, is being organised a database of international and world geosites and the data are to be accessible in the internet. Moreover, databases of national networks of geosites are being developed (i.a. in Poland) and are intended to be accessible by the same media.

A draft candidate list of geosites distinctive of Central Europe was presented during the workshop held in Cracow, in October 1997. The representatives of Lithuania, Belarus, Ukraine, Slovakia, the Czech Republic, Poland and Austria made a primary selection of about 140 area/sites being usually of a standard importance for particular geological regions (Alexandrowicz — ed., 1998). From the Carpathian region 40 localities were proposed for the list of GEOSITES. Out of this number 25 areas with site-sets or individual sites are within the Polish territory.

The Carpathians are extremely valuable as to their nature, landscape and climate. They should be sustainably used. This is one of the most attractive tourist and recreation region in Central Europe. The whole area of the Carpathians is incorporated into the Pan-European Ecological Network (PEEN) according to the Cracow Declaration of the international conference organised by the European Centre for Nature Conservation (ECNC) in co-operation with the World Conservation Union (IUCN) and the Institute of Nature Conservation of the Polish Academy of Sciences in Cracow (Poland) in February, 1998.

In the nature safeguard strategy for the Carpathians the bedrock and relief play an important role because they decide about the type of landscape and various habitats.

Framework of nature protection

Protection of nature in the Polish Carpathians has a long tradition and outstanding achievements. The attempts in this field, dating back to the previous century, were predominantly focused on protection of large areas, mainly of the Tatras, Pieniny Mts and Babia Góra region. At present, the above mentioned regions are national parks and are significantly larger when compared with the former projects and prototypes developed in the period between WW1 and WW2. The legal system of nature conservation in the Polish Carpathians was formed based on the decrees of an early period of independent Poland (after 1919) and on the subsequent nature conservation acts issued in 1934, 1949 and 1991.

The present nature protection network in the Polish Carpathians comprises: 6 national parks, 11 landscape

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parks, 104 nature reserves and about 1050 of individual forms, and recently established documentary sites of inanimate nature, areas of ecological use, and natural-landscape complexes. The established areas of protected landscape and buffer zones of national and landscape parks only partially contribute to preservation of nature coherence between the parks, reserves and individual protected objects. Because of that the optimum goal in the landscape management is to recognise the whole Polish Carpathians as the area comprising the system of the interrelated, protected landscape zones (Alexandrowicz — ed., 1989). The above concept corresponds to the idea of ecological corridors and the Pan-European Ecological Network. Until now, all the applied nature protection categories of differentiated ranks comprise ca 25% of the total area of the Polish Carpathians amounting to 19,600 km^2. The mountain arc of the entire Carpathians (1300 km long) occupies 209,000 km^2 out of which over 50% of the area lies in Romania, while the remaining fragments are located in Slovakia (17.1%), Ukraine (10.3%), Poland (9.3%), Hungary (4.3%), the Czech Republic (3.2%) and Austria (0.3%) (Warszyńska — ed., 1995). The Polish Carpathians are about 330 km long, their significant portion (87% of the area) is in the northern zone of the Western Carpathians and a small fragment only (13%) is in the Eastern Carpathians. The mountain arc within the Polish territory is located farthest to the north and is characterised by a particularly high diversity of facial-tectonic units. In the Polish Carpathians there are distinguished the Inner Carpathians and widely spread Outer Carpathians separated from the former ones by the Podhale Basin and the Pieniny Klippen Belt.

Overview of the geoconservation network

In the period between WW1 and WW2 the geological and geomorphological sites were selected for protection in agreement with the designers field of interest. However, the basic criterion was the outstanding value of an object together with its rarity and unique character, aesthetic values or conspicuous element of landscape. As early as in the 1920s, a need for protecting the sandstone tors was noticed, and especially their clusters in the Carpathians Foreland. The projects on protection of the above forms were pioneering works and had far-reaching effects in the Carpathians as the motives behind their protection were not only the aesthetic values but also the geological and geomorphological importance (Klimaszewski, 1932, 1935; Świdziński, 1932, 1933a, b, c).

The modern formation of the geosites network in the Carpathians is based on various criteria of evaluation and selection according to features of a region and subjects within its genetic groups: stratotypes and reference sections, characteristic successions, sedimentary structures, fossils, rock types, rare minerals, tectonic structures, forms and processes of weathering, erosion and accumulation of sediments, and other phenomena (Alexandrowicz, 1990; Alexandrowicz — ed. et al., 1996).

Unfortunately, the present-day network of geoconservation of the Polish Carpathians is not adequate as to the diversity of the geological structure and relief of these mountains. As the recognition of nature of the Carpathians and their economic management progress, a wider and wider as well as a more complex protection and evaluation of natural landscape becomes an essential task. The undertaken evaluation has shown that 50% of all the biotic reserves in the Polish Carpathians include also valuable elements of an inanimate nature (Alexandrowicz et al., 1992).

Until now, for protection geological and geomorphological features there have been established: 15 reserves of inanimate nature (231.29 ha), 77 nature monuments, and 14 documentary sites (Tab. 1, Fig. 1). Numerous projects aiming at successive optimisation of a current state of geoconservation have been prepared for the Carpathians (Alexandrowicz, 1987a, b, 1997; Alexandrowicz & Denisiuk, 1991; Alexandrowicz — ed. et al., 1996; Gonera, 1991, 1994; Kotlarczyk, 1993; Kotlarczyk & Piórecki, 1988; Margielewski, 1992, 1994, 1997a, b; Poprawa et al., 1995; Urban & Margielewski, 1995). These are areas/sites of various local, regional, and extra-regional importance which makes them adequate to be proposed for the list of GEOSITES. The attached Table 1 and the map (Fig. 1) do not comprise numerous local sites suggested for individual protection and do not comprise other sites, which have been only mentioned. The national parks are particularly valuable areas of protection of the geological heritage of the Polish Carpathians. Out of 6 existing parks the outstanding importance is attributed to: the Tatra National Park (N.P.), Pieniny N.P., Babia Góra N.P., and Bieszczady N.P. They illustrate well the natural diversity of the Polish Carpathians. The landscape parks, amounting to 11, concentrate mainly in the eastern part of the mountains (Fig. 1). The most valuable areas/objects within these parks are subjected to protection as the reserves and individual sites.

Tab. 1. Protected and proposed for protection geo(morho)logical areas/objects in the Polish Carpathians

	Physiographic units	Categories of protection				
		NP	LP	NR	NM	DS
INNER CARPATHIANS	TATRA MOUNTAINS	1	–	–	–	–
	PODHALE BASIN	–	– [2]	–	2	– [7]
	PIENINY KLIPPEN BELT	1	–	5	4	–
OUTER CARPATHIANS	BESKIDY MOUNTAINS	3	4 [4]	4 [12]	47 [4]	– [30]
	BIESZCZADY MOUNTAINS	1	1	2	4	–
	CARPATHIAN FOOTHILLS	– [1]	6	4 [7]	20 [4]	14 [15]
		6 [1]	11 [6]	15 [19]	77 [8]	14 [52]

Legal categories: NP — national park; LP — landscape park; NR — nature reserve; NM — nature monument; DS — documentary site. Numbers in brackets denote regional localities proposed for protection

Geoconservation in the Inner Carpathians

Tatras are the high-mountain massif of the Inner Carpathians with the highest summits of Rysy (2,499 m a.s.l.) on the Polish side and of Gerlach (2,654 m a.s.l.) on the Slovak side. The central element of the Tatras is a crystalline massif consisting of the old Paleozoic metamorphic rocks among which Carboniferous granitoides and tonalites associated with the Variscian orogen occur (Bac-Moszaszwili et al., 1979). The crystalline massif is partially covered with the nappes of the Permian–Lower Cretaceous sediments folded and thrust during the Upper Cretaceous. The core of the High-Tatric Nappe is built of crystalline rocks and is mantled with shallow sea deposits with numerous gaps. The

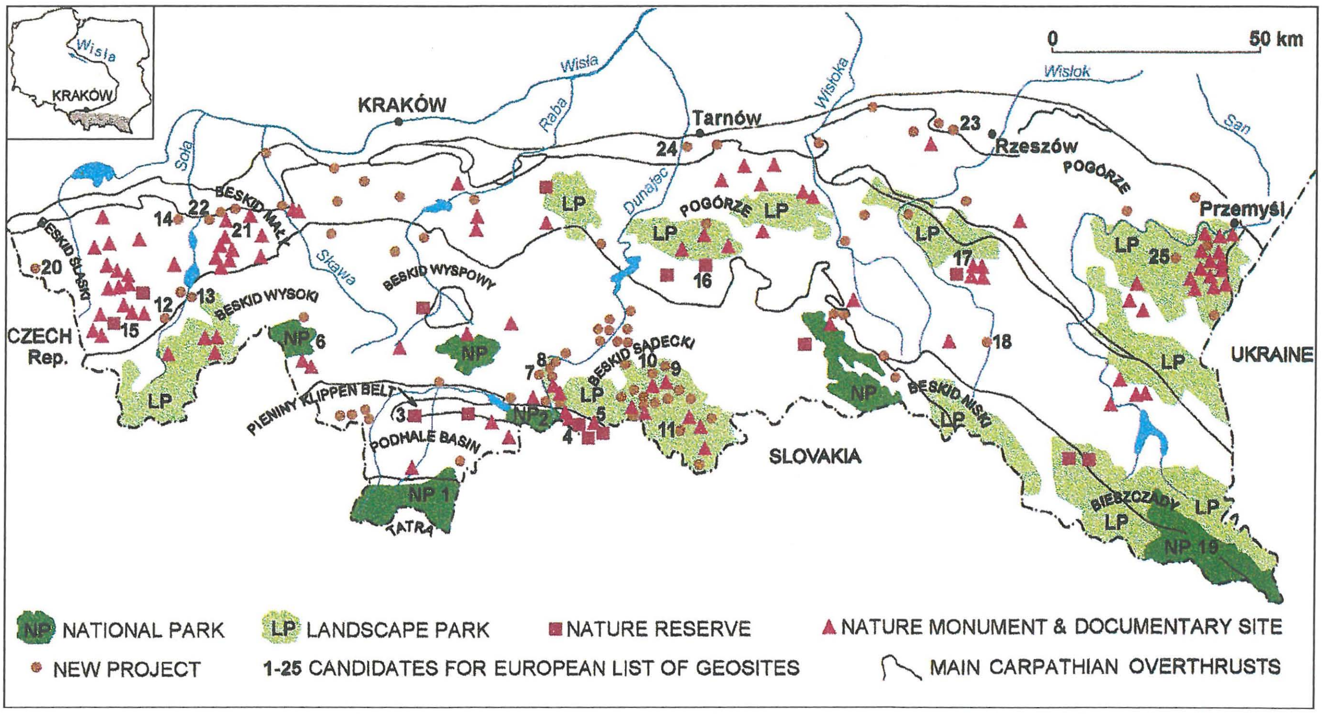

Fig. 1. Geoconservation system of the Polish Carpathians

organogenic limestones and dolomites with shale and sandstone inserts are characteristic here. The Sub-Tatric nappes differ from the High-Tatric Nappe by the Jurassic and Lower Cretaceous sequences which show deep-sea features that are evidenced by radiolarites and radiolarite limestones. After the uplift, the Tatras were intensively eroded, and subjected to a sea transgression in the Middle Eocene. Conglomerates and nummulite limestones of this age have fragmentarily been preserved on the northern slopes of the mountains.

The Tatras, being young mountains belonging to an alpine system, have a very diversified relief formed by the end of the Tertiary and remodelled by Pleistocene glaciers and periglacial climate (Klimaszewski, 1988).

The Tatra National Park, established in 1955, in its vast area (21,164 ha), comprises the whole mountain massif located within the Polish territory, all its structures and geological formations as well as relief forms. In the classification of large protected forms the Park in question is assigned to category II (in the 6 category scale) by IUCN. The Tatra N.P. and Tatransky N.P. in the Slovak territory, both preserving the nature of the Tatra mountains were established as the International Biosphere Reserve by UNESCO-MAB in 1992. The Tatra N.P. has been selected for the list of GEOSITES (Tab. 2).

The Podhale Basin of a tectonic origin, located at the foot of the Polish Tatras, is filled up with the Eocene–Oligocene deposits that are more significantly deformed in the contact zone of the Pieniny Klippen Belt. The complex of shale-sandstone sediments, known as the Podhale flysch, is relatively thick (over 2,500 m). Interesting elements in the geological structure are the Neogene, mollase, gravel-sandy cones and fine-grained terrestrial deposits with flora.

In Podhale the exposure of spherosiderites in the flysch as well as an exclusive to this area large waterfall (on the Kacwiński Stream) are protected as nature monuments. Formation of the Orawa Landscape Park (a prospective national park), Spisz Landscape Park, and of documentary sites of Quaternary deposits is planned. Some sites of terrigenic deposits and fossil Neogene flora are also selected for protection (Gonera, 1994).

Pieniny Klippen Belt forms in Poland a narrow zone, maximum up to 3 km wide and about 60 km long. Its geological structure is extremely complicated and characterised by steep folds, thrust faults and strongly dislocated diversified lithostratigraphic units consisting of Jurassic–Cretaceous deposits (Birkenmajer, 1977, 1979, 1986). Many stratotypes of the Pieniny Klippen Belt are represented in this area. Particular successions of geological units comprise deposits of various resistance that is reflected in the landscape very well. Hills with steep slopes, klippes and deep rocky gorges developed in limestones. Depressions and passes are formed in the complexes where shales and marls predominate. In the contrastive landscape of the limestone summits reaching up to 982 m a.s.l. (Trzy Korony — Three Crowns) deeply incised antecedent gorge of the Dunajec River (Zuchiewicz, 1988) is winding. This gorge belongs to the most spectacular forms in Europe.

In the period of 1955–1965 the Pieniny Klippen Belt was subjected to geoconservation and the developed network of that time requires only fine adjustments. The main range of the Pieniny is within the Pieniny N.P. (2,346 ha). This area represents the highest tectonic and lithostratigraphic rank as well as the most typical rocky landscape in the Pieniny Klippen Belt. Five nature reserves and 4 monuments make a very important supplement to geological and geomorphological values of this region (Fig. 1). Besides the Pieniny N.P., three nature reserves that have minutely been documented, are proposed for the European list of GEOSITES. These are: Klippes in Rogoźnik (Birkenmajer, 1962, 1963; Kutek & Wierzbowski, 1979, 1986; Wierzchowki & Remane, 1992; Barczyk, 1991; Korbicki, 1994; Pisera & Dzik, 1979), the Homole Gorge (Alexandrowicz S.W., 1996; Bir-

Tab. 2. Representative areas/sites in the Polish Carpathians — candidates for the European List of GEOSITES (after Alexandrowicz et al., 1998)

No	Location	Geological sitting	Main features	State of protection
1	Tatra Mountains	Tatras	The highest mountains of Poland; Variscian crystalline massif with Triassic–Cretaceous units of alpine nappes; postglacial relief; systems of caves	national park — international biosphere reserve
2	Pieniny Mountains	Pieniny Klippen Belt	Jurassic–Cretaceous sequences of facial-tectonic units with main stratotypes, rocky landscape well reflecting geological structure; Dunajec valley gorge	national park
3	Rogoźnik	Pieniny Klippen Belt	Type locality of Tithonian and Lower Berrasian sequences of Czorsztyn Succession; biostratigraphic ammonite level of Tithonian Rogoźnik Coquina Member	nature reserve of World Geological Heritage
4	Homole Gorge	Pieniny Klippen Belt	Classic example of a trench morphology, rocky scenary; tectonic contact of calcacerous formations of Czorsztyn and Niedzica successions; stratotype of Czajakowa Skała Radiolarite Formation (Oxfordian); Holocene landslide	nature reserve
5	Biała Woda valley	Pieniny Klippen Belt	Type locality of Smolegowa Skała Limestone Formation (Jurassic); zone of tectonic contact of different units; rocky gorge; Tertiary basalt tor	nature reserve and monument
6	Babia Góra range	Magura Nappe	The highest range in the Western Polish Outer Carpathians (Beskidy); European watershed; typical thick-bedded Magura Sandstones (Eocene); the largest rock slump and block fields in the Polish Carpathians	national park — international biosphere reserve
7	Tylmanowa (Beskid Sądecki Mts)	Magura Nappe	Stratotype of Magura Formation (Eocene) within the Krynica Subunit; rocky slopes in the Dunajec river valley	planned nature monument
8	Zarzecze (Dunajec river valley)	Magura Nappe	Stratotype of the Zarzecze Formation (Early Eocene); contact of two lithostratigraphic formations	planned documentary site
9	Uhryń stream valley (Beskid Sądecki Mts)	Magura Nappe	Stratotype of Łabowa Shale Formation (lower part of Early Eocene); reference section of the Beloveza Formation; deposits rich in trace fossils and current markings; deep and narrow valley	planned nature reserve
10	Wierch nad Kamieniem (Beskid Sądecki Mts)	Magura Nappe	Large area of landslide forms; dated phase of mass movement activity; pseudokarstic caves; block fields	nature monument; planned nature reserve
11	Złockie stream valley (Beskid Sądecki Mts)	Magura Nappe	Natural exhalations of carbon dioxide; mineral water springs; dated tufa and peat; Magura Unit Succession with the oldest Upper Cretaceous deposits rich in formainifera	planned nature reserve and 2 monuments
12	Przybędza (Żywiec Basin)	Dukla Nappe	Sedimentary structures of Krosno Beds (Oligocene)	planned documentary site
13	Soła river valley (Żywiec Basin)	Silesian Nappe	Lower Cretaceous deposits of Cieszyn Limestones, shales and teschinite sills; river gorge	planned nature reserve
14	Kozy (Beskid Śląski Mts)	Silesian Nappe	Lgota Sandstones (Albian–Lowest Cenomanian); high variability of bedding and types of turbidity currents; large old quarry	planned documentary site
15	Wisła (Vistula) river valley (Beskid Śląski Mts)	Silesian Nappe	Head-water streams of Vistula; numerous waterfalls and other types of erosional forms; transitional section of the flysch Godula Beds to the thick-bedded sandstones of the Lower Istebna Beds (Upper Cretaceous)	nature reserve
16	Ciężkowice (Carpathian Foothills)	Silesian Nappe	Rocky town; type locality of Ciężkowice Sandstones (Eocene); typical sedimentary structures of fluxoturbidites; weathering forms	nature reserve
17	Vicinity of Krosno (Carpathian Foothills)	Silesian Nappe	Hills with the large group of tors („Spinners") of Ciężkowice Sandstones (Eocene) and numerous ones of Istebna Sandstones (Paleocene); sedimentary structures of fluxoturbidites; weathering forms; ruins of a medieval castle	nature reserve, 4 monuments and a planned reserve
18	Wisłok river valley (Beskid Niski Mts)	Silesian Nappe	Sequence of Oligocene deposits — Krosno Beds with Jasło Shales; tectonic and sedimentary structures; river valley gorge	planned nature reserve
19	Bieszczady Mts	Silesian Nappe; Dukla Nappe	Highest part of the Polish Eastern Outer Carpathians; contact zone of two facial-tectonic units; diversified structural landscape	national park — international biosphere reserve
20	Goleszów (Carpathian Foothills)	Silesian Nappe	Oldest deposits of the Polish Outer Carpathians — Cieszyn Limestones and Lower Cieszyn Shales (Jurassic/Cretaceous); old quarry	planned documentary site
21	Targanice (Beskid Mały Mts)	Sub-Silesian; Silesian Nappe	Limestone olistholite of Andrychów Klippen Succession (Oxfordian–Tithonian); tectonic contact with flysch units	nature monument
22	Domaczka stream (Beskid Mały Mts)	Sub-Silesian Nappe	Olistostrome of different members of the Carpathian flysch among the Lower Miocene shales	planned documentary site
23	Olimpów (Carpathian Foothills)	Skole Nappe	Patch of Miocene sediments on the flysch; stratotypes of the Badenian lithotamnia facies	planned documentary site
24	Zbylitowska Góra (Dunajec river valley)	Zone of folded Miocene in the front of Flysch Carpathians	Badenian clays covered with Quaternary fluvial deposits and moraine blocks	planned documentary site
25	Krzeczkowski stream valley (Carpathian Foothills)	Skole Nappe	Pleistocene terrace sequence of Early–Late Vistulian deposits with molluscs fauna	planned documentary site

kenmajer, 1971, 1979) and the Biała Woda Valley with the monument of a basalt tor (Birkenmajer, 1977; Birkenmajer & Nairn, 1969), (Tab. 2). The first of the listed reserves has already the highest rank as it is the Site of the World Geological Heritage. Recently enlargement of the park has been projected as well as educational accessibility has been planned (Alexandrowicz et al., 1997).

The further development of the geoconservation network in the Pieniny Klippen Belt should refer to its western part where individual limestone klippes occur as well as to the exposures found in the contact zone of the belt in question with the flysch of the Outer Carpathians. The project of geoconservation comprises also andesites of Wżar Mt. at the northern border of the Pieniny Klippen Belt (Urban & Margielewski, 1995).

Geoconservation in the Outer Carpathians

In the Western Polish Carpathians the ranges of the Beskidy Mts are distinguished. They represent medium–high mountains with the highest elevation of Babia Góra (1,725 m a.s.l.). The Bieszczady Mts, belonging to the Eastern Carpathians, are characterised by a medium–high mountain landscape with the highest summit of Tarnica (1,346 m a.s.l.). In the Carpathians there are intra-mountain basins (250–400 m a.s.l.) while the mountain foreland (400–500 m a.s.l. hilly terrain) forms the northern margin of the Carpathians delimited by the Carpathian Foredeep. The Outer Carpathians are built of thick flysch complexes characterised by the presence of alternated beds of sandstones, conglomerates, claystones, mudstones, and locally marls and limestones. The sequences of Cretaceous–Tertiary deposits were accumulated by turbidity currents. Their sedimentation took place in a geosynclinal basin where the zones of deep sea were separated by shallows or sometimes islands. Such pattern of the basin resulted in lithological-facial differentiation of its deposits. Due to particular phases of the Tertiary tectonic movements these deposits had been folded and overthrown northward loosing the contact with their original substratum and forming a complex of nappes (Książkiewicz, 1972). The largest and the innermost (southern) unit in the western and central part of the Polish Carpathians is the Magura Nappe, while in the eastern part — steeply arranged scales of the Dukla Unit. The latter is fragmentally exposed westward and is known as the Fore-Magura Unit. The Silesian Nappe is also widely spread in the whole Carpathians and is exposed north of the overthrusts of the internal units. The Sub-Silesian Unit forms a narrow belt along its front. Along the northern margin of the Carpathians there is a narrow zone of the folded Miocene (Stebnik Unit) and then the Carpathian Foredeep filled up with Miocene overlain with the Quaternary.

The diversified geological and hipsometric structure of the nappe tectonics of the Outer Carpathians affected different stages of the relief development. The oldest preserved elements are the planation surfaces. An intensive modelling of the mountain relief during the Quaternary is evidenced by numerous features, especially by a dense network of the valleys with a complex system of terraces, weathering covers, landslides and block fields (Starkel, 1960).

In the Polish Outer Carpathians there have been formed: 4 national parks, two of which are classified as biosphere reserves (Babia Góra N.P., Bieszczady N.P.), and 11 landscape parks (Fig. 1). Major mountain ranges of the Beskidy and Bieszczady Mts are within the national parks while the forelands of these mountains are not protected under the highest rank. Only in the case of the Przemyśl Upland (north-eastern part of the Carpathians) the project of the Turnicki National Park, located in the zone of the Skole Nappe, has been prepared. The three of the existing national parks: Babia Góra N.P., Gorce N.P. and Magura N.P. are situated within the range of the Magura Nappe while the Bieszczady N.P. — in the zone of the Dukla and Silesian Nappes. Among the national parks mentioned above two areas, representing different structural landscapes, have been selected for the Euro-list of GEOSITES. These are: the Babia Góra N.P. — the highest range in the Western Outer Carpathians, and the Bieszczady N.P. — the highest part of the Eastern Polish Outer Carpathians (Tab. 2) (Alexandrowicz et al., 1998). In the future, the projected Turnicki N.P. will be also classified this way because it is the area of a large, stratigraphic, sedimentological, paleontological and tectonic diversity (Kotlarczyk, 1993).

Within the areas and outside the landscape parks 10 geological reserves, 71 geological monuments and 14 documentary sites have been located until now (Tab. 1). These objects are mainly clustered in the western part of the Silesian Nappe and in the eastern part of the Skole Nappe (Fig. 1). Recently, numerous projects have been worked out in the area of at the Magura Unit (Alexandrowicz — ed., 1996). The proposal comprising over 60 documented projects from the Beskid Sądecki and the Sącz Basin is very important as a standard for geoconservation of the Polish Carpathian, based on evaluation and selection criteria adopted to regional and local features of a given territory. The projected, most valuable geosites from various parts of the Carpathians provide the rationale behind the supplementing the regional network of geoconservation (Tab. 1, Fig. 1). Among the localities that have been already protected and those suggested for protection 18 sites/areas from the Outer Carpathians are proposed as the candidates for a Euro-list of Geosites (Tab. 2).

The present-day network of geosites in the Outer Carpathians does not represent well an actual differentiation in geology and relief of the discussed region. Groups and individual sandstone tors, as examples of characteristic elements of the relief, well exposed sedimentary structures of the sandstones and their weathering forms, are protected most numerously (Alexandrowicz, 1978, 1987, 1989). Their register requires only slight modification, mainly as to the foreland region. Erratic boulders are the objects which are almost fully protected. These boulders belong to the category of geological monuments of a prominent value as the indicators of the maximum advance of the Scandinavian ice-sheets (Dudziak, 1961).

A fairly numerous group of protected geosites is formed by pseudo-karst caves in the region of rock-slides. Their number increasing due to the ongoing inventory of these objects (Pulina — ed., 1997). Prevention against channellisation of certain sections of mountain streams with interesting rocky erosional forms, i.a. waterfall steps (Alexandrowicz, 1997), is still insufficient. Various types of springs, protected only sporadically, deserve a systematic inventory and evaluation with respect to safeguard their natural character and water quality.

The present-day network of geoconservation is particularly scare as to exposures of the deposit sequences of a stratotype rank and reference sections, classic localities of fossil occurrence, sedimentary and tectonic structures as well as landslide relief typical of the Flysch Carpathians.

The need for their protection currently focuses the ongoing inventory works of the Institute of Nature Conservation of the Polish Academy of Sciences and of the Carpathian Branch of the Polish Geological Institute. The executed programme comprises also important exposures of Quaternary deposits and forms and morphological processes related to them. The current Nature Conservation Act which admitted a new category — a documentary site — significantly facilitated the protection of various geological exposures (Alexandrowicz, 1991).

Final remarks

The Carpathians, the region of very valuable nature and landscape, have a growing system of areas protected under different legal and customary categories. This is a typical recreation region. The restrictions imposed on unsustainable utilisation of natural resources are to be ordained on activities associated with an expanding recreation and tourism. The latter concentrates in particularly attractive landscape which, at the same time, mostly deserves protection as national parks or some nature reserves. Development of tourist-educational centres outside such regions is an urgent need which should be fulfilled by the landscape parks in a wider range than it is now. The landscape parks occupy a larger area when compared with national parks and as sightseeing spots they usually offer diversified elements of geological environment available for direct observation. Thus, the entire network of geosites should be designed and documented bearing in mind the above. If possessing adequately marked and described (in guides, leaflets, folders, maps) trails they will play an important role in education and protection of the geological heritage. Some sites of a unique scientific concern, especially those with fossils or minerals that might be easily dragged out, if are not effectively safeguarded, should not be included into the system of education trails.

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