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DIVERSITY OF LANDSLIDE MORPHOLOGY AS A PART OF GEOCONSERVATION PATTERN IN THE POLISH CARPATHIANS

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Abstract. Relief of the Polish Carpathians is strongly transformed by mass movements. Landslides create large-scale landscape elements (typical shapes of slopes) as well as smaller landslide's relief elements (rock walls, tors, debris, lakes, peat bogs). Landslide areas with strongly transformed soils and water conditions, are overgrown by mosaic of plants communities, and create specific biotopes. Carpathian landslides, due to specific relief as well as strong influence on biotopes formation, represent important element of the Polish Carpathians geoconservation, including both European networks: GEOSITES and NATURA 2000.

Key words: landslides morphology, nature protection criteria, Outer Carpathians, Poland.

Abstrakt. Rzeźba polskich Karpat fliszowych jest silnie przekształcona przez ruchy masowe. Z działalnością osuwisk są związane zarówno charakterystyczne kształty stoków, tworzące wielkoskalowe elementy krajobrazu, jak również mniejsze elemeny rzeźby (ściany skalne, skałki, pseudogołoborza, jeziorka, torfowiska). Obszary osuwisk, z silnie przekształconymi glebami i stosunkami wodnymi, są zasiedlane przez charakterystyczną mozaikę zespołów roślinnych, tworzących charakterystyczne biotopy. Osuwiska Karpat, ze względu na swoistą rzeźbę, jak również na ich wpływ na kształtowanie biotopów, stanowią istotny element w geoochronie Karpat Polskich, uwzględniającej zarówno założenia sieci Europejskich Geostanowisk, jak również sieć ekologiczną NATURA 2000 związaną z ochroną siedlisk przyrodniczych.

Słowa kluczowe: rzeźba osuwiskowa, kryteria ochrony przyrody, Karpaty zewnętrzne, Polska.

INTRODUCTION

Flysch formations of the Outer Carpathians are especially favourable for mass movements. These processes were considered until now as catastrophic events for the economy only, usually destroying buildings, roads, railways, arable lands and forests (i.e. Ziętara, 1969; Bober *et al*., 1997; Mrozek *et al*., 2000). It was particularly well visible after strong flood in the Carpathians, during 1997 and 2001 (Mrozek *et al*., 2000; Oszczypko *et al*., 2002). On the other hand, mass movements like all natural catastrophic processes play an essential role in shaping geo- and biodiversity of the mountain natural environment. Landslides strongly transform mountains landscape, and have influence on biotopes formation (Alexandrowicz, Margielewski, 2000; Alexandrowicz *et al*., 2004).

Specific features of landslides were for years not taken into account in the strategy of nature protection. Detail investigations of these landforms carried out in the last ten years have indicated the necessity of their protection as significant elements of the Carpathians geodiversity (Z. Alexandrowicz *et al*., 1996; Alexandrowicz, Poprawa *et al*., 2000). The relationship between patterns of relief and biotops of areas modified by mass movement should be studied in the next years to integrate their geo- and biodiversity. The new proposed criteria for evaluation and selection of landslides for protection represent all kinds of interests: scientific, educational and tourist as well as economic.

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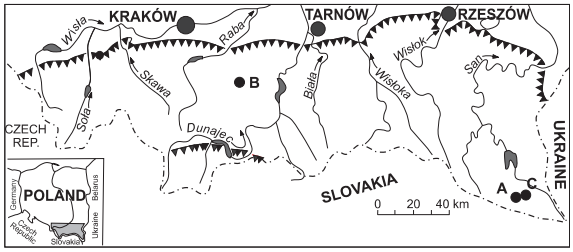
MORPHOLOGICAL FEATURES OF LANDSLIDES

Relief of the Carpathians is strongly transformed by mass movements. The specific type of landslide relief has been distinguished within some ranges of the Polish Carpathians in which mass movements transformed significant part of slopes (Starkel, 1960; Baumgart-Kotarba, 1974; Kotarba, 1986; Ziętara, 1988). Landslides create a characteristic type of Carpathians relief in large scale as well as in local scale.

Large-scale landscape elements. Deep-seated, large forms shaping considerable parts of slopes are clearly marked in the landscape as concave slope (Fig. 1A), convex slope (Fig. 1B) or mixed, convex-concave, type slope (Starkel, 1960; Kotarba, 1986). In effect of gravitational displacements of the top parts of mountain ridges, top trenches were created, forming somewhere unique landscape forms called "double ridges" (Alexandrowicz, Alexandrowicz, 1988) (Fig. 1C). Landslides and rock-falls, bordered by large and high walls of head scarps, situated above the timberline, as well as wide ones shaping the whole mountain or even mountain ranges, are particularly spectacular. Within some Carpathians ranges (i.e. Beskid Niski), a special type of landslide's relief was distinguished (Starkel, 1960).



Concave slope. Hnatowe Berdo Mt. (Bieszczady Mts)

Convex slope. Kostrza Mt. (Beskid Wyspowy Mts)

Top trench (double ridge). Połonina Wetlińska Mt. (Bieszczady Mts)

Local-scale landscape elements. In smaller scale, landslides represent a specific set of morphological forms typical for areas shaped by mass movements only. The relief of their surface distinctly differs from the surroundings. It contains the following typical elements (nomenclature after Dikau *et al*., 1996):

— scars bordered by steep, more or less high scarps (head scarp, secondary scarp) or even rocky walls, crowned somewhere with tors (as remnants of rocky head scarp) (Figs. 2B, C);

— trenches above edges of scarps (relaxation, tension cracks) (Fig. 2A), developed somewhere as crevice type caves (Fig. 2D);

— colluvia (displaced rocky material), consisted of block fields, debris fields (Fig. 2E) and big slided rocky massifs dissected by trenches (somewhere representing talus type caves) or colluvial swells with undulated surface, depressions filled by peat bogs (Fig. 2F) or small lakes (Fig. 2G), water-eyes, and springs marking an altered groundwater circulation;

— dam-lakes originated at the bottom of valleys dammed by colluvial masses.

The mentioned above forms have been observed in numerous Polish Carpathians landslides described by several authors (i.e. Ziętara, 1969; S.W. Alexandrowicz, 1978; Z. Alexandrowicz, 1978; Bober, 1984; Bober *et al*., 1997; Alexandrowicz, Alexandrowicz, 1988, 1999; Wójcik, 1997; Bajgier, 1993; Margielewski, 1997; Margielewski, Urban, 2003). Landslides differ in their size, shape and in participation of particular forms and features. The state (expressiveness) of the landslide's relief depends on its age and renewing of sliding, and is connected with geological structures of bedrock, slopes inclination and depth of share-plain.

There are three main types of landslide forms characterised by specific complexes of morphological elements:

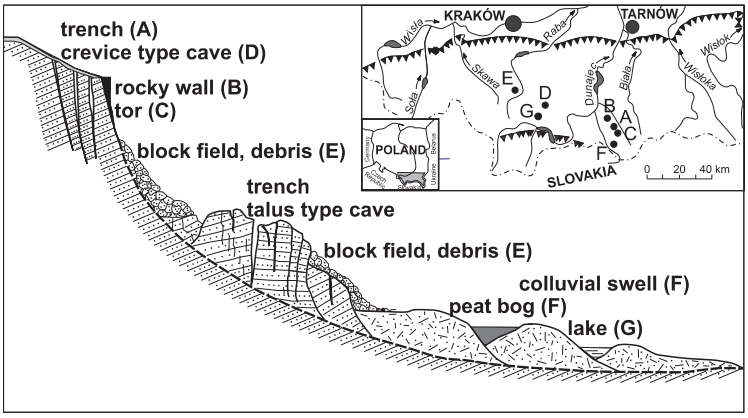
- Landslide with a high rocky head scarp and colluvial package (transformed by trench) and block field representing a complex type (Dikau *et al*., 1996) or packet type

←

Fig. 1. Large-scale landscape elements caused by mass movements

Trench, Wierch nad Kamieniem (Beskid Sądecki Mts)

Rocky head scarp, Zadnie Góry (Beskid Sądecki Mts)



Rocky tor, Diabelskie Ściany (Beskid Sądecki Mts)

Block field, Luboń Wielki nature reserve (Beskid Wyspowy Mts)

Colluvial swell with peat bog, Wierchomla (Beskid Sądecki Mts)

Crevice type cave, Jaskinia Zbójecka Jama (Gorce Mts)

Landslide's lake, Jeziorko Zawadowskie (Gorce Mts)

Fig. 2. Typical elements of the landslide relief

(see Ziętara, 1969). Sometime this type of landslides creates top trench (double ridge) caused by blocky displacement of large part of the massif (Alexandrowicz, Alexandrowicz, 1988);

- Landslide with a high rocky or creeped head scarp (sometime with depression at the bottom, usually filled up by peat bog) and with packet-detrital colluvial area, representing usually complex (or rotational) landslide (Dikau *et al*., 1996) of the packet-detrital type (Ziętara, 1969);
- Landslide with distinct head scarp and detrital colluvial area. Its surface is very diversified: within the rampart are swamps, peat bogs, springs, small lakes. Such landslides represent a rocky-weathering, detrital type (Ziętara, 1969; Dikau *et al*., 1996).

Several landslides have profile formed in steps following either rotation heads or colluvial swells. They are flattened on the top and bordered by ridges or steep scarps passing downward to the next flat surface. Inclined parts of colluvial fields diversified by rock debris, big blocks and rocky packets are mainly overgrown by virgin forest of old Carpathians. These forms with rich landslide relief (see Fig. 2) represent patches of forest seclusion — place of wildlife.

Landslide's peat bogs (usually of fen type) occur in various part of landslide (see Fig. 2F). Their sediments analysed by palynological (also by macro-fossil) and malacological methods, and dated by radiocarbon method, enabled reconstruction of the Carpathian palaeoenvironmental changes during the Late Glacial and the Holocene (Alexandrowicz, 1996; Starkel, 1997; Margielewski, 2002).

RELATIONSHIP: GEODIVERSITY–BIODIVERSITY

Landslides have strong influence on biotops formation. The diversified relief and water relation of down slided slopes are the main factors determining specific character of environments existing there. Extremely various habitats: dry, humid and wet, with poor and fertile soils are close to each other and even situated side by side on differently inclined and shaped slopes. Swamps and marches in depressions without outflows are biotops particularly favourable for higrophile plants, mainly for several species of Bryophytes. Different lichens cover rocky walls and tors as well as old trees.

Distribution of forest communities (dominating within landslide areas) is related to bedrock changes controlled by mass movements. Usually rocky head scarp and debris with strong degraded habitats are overgrown by transitional forest communities with mountain ash (*Sorbus* sp.) and birch (*Betula* sp.), locally by unique forest communities Phyllitido--Aceretum with mountain mapple (*Acer pseudoplatanus*) (S.W. Alexandrowicz *et al*., 1989; Alexandrowicz *et al*., 2004). Colluvial areas with strongly disturbed water relations and poorly developed soils (lithosoils and regosoils) are recently covered by Luzulo-luzuloides-Fagetum while places with brown-acid soils (cambisoils) are favourable for the succession of Dentario-glandulosae-Fagetum. Trees on steep slopes are shaped irregularly with warped trunks bent towards the slid, especially within the renewing landslides.

PROTECTION OF LANDSLIDES

Only a few landslide areas in the Polish Carpathians are up to now under protection for their geomorphological values. Kornuty Nature Reserve in the Beskid Niski Range was proposed before the Second World War and nominated at 1953 as the first one protecting a large landslide. Duszatyn Lakes in Bieszczady Mts., formed within the landslide after heavy rainfall in 1907, was established at 1957 as the next to nature reserve Zwiezło (Alexandrowicz *et al*., 1989).

Only 7 nature reserves have been established for landslides protection, so far. A few landslide areas overgrown with old Carpathian virgin forest (rich relief caused that forest exploitation in these places was impossible) are protected in nature biological reserves (Fig. 3). These landslides are protected indirectly; usually forest nature reserves were established without clarification of the unique forest communities connection with ground. Data on the geological bedrock and geomorphological features are in general not included in documentation of floristic (forest) reserves, in which landforms caused by mass movements occur.

Certain elements of landslides, mainly rocky walls, tors, caves, trenches and lakes have gained the status of nature monuments. About 26 of such objects (i.e. tors, caves, lakes) are protected until now, and further 46 ones are proposed for protection (Fig. 3) (Z. Alexandrowicz *et al*.,1996, 1999, 2000).

Landslide's relief shaping a whole mountain massif is characteristic for some ranges protected as national parks and landscape parks. In particular Baba Góra National Park, Bieszczady National Park, and Żywiec and Poprad Landscape parks (S.W. Alexandrowicz, 1978; Alexandrowicz *et al.*, 1996). Other Carpathian national parks (i.e. Gorce National Park and Beskid Niski National Park) and several landscape parks have relief more or less transformed by mass movements. Forms of this type of relief were recognised and described there and in some nature reserves or areas proposed for protection.

In the geoconservation project of the Beskid Sądecki range, which is a model for the Outer Carpathians, several values and features of landslides have been exposed for the first time as important elements of the mountain geodiversity (Alexandrowicz

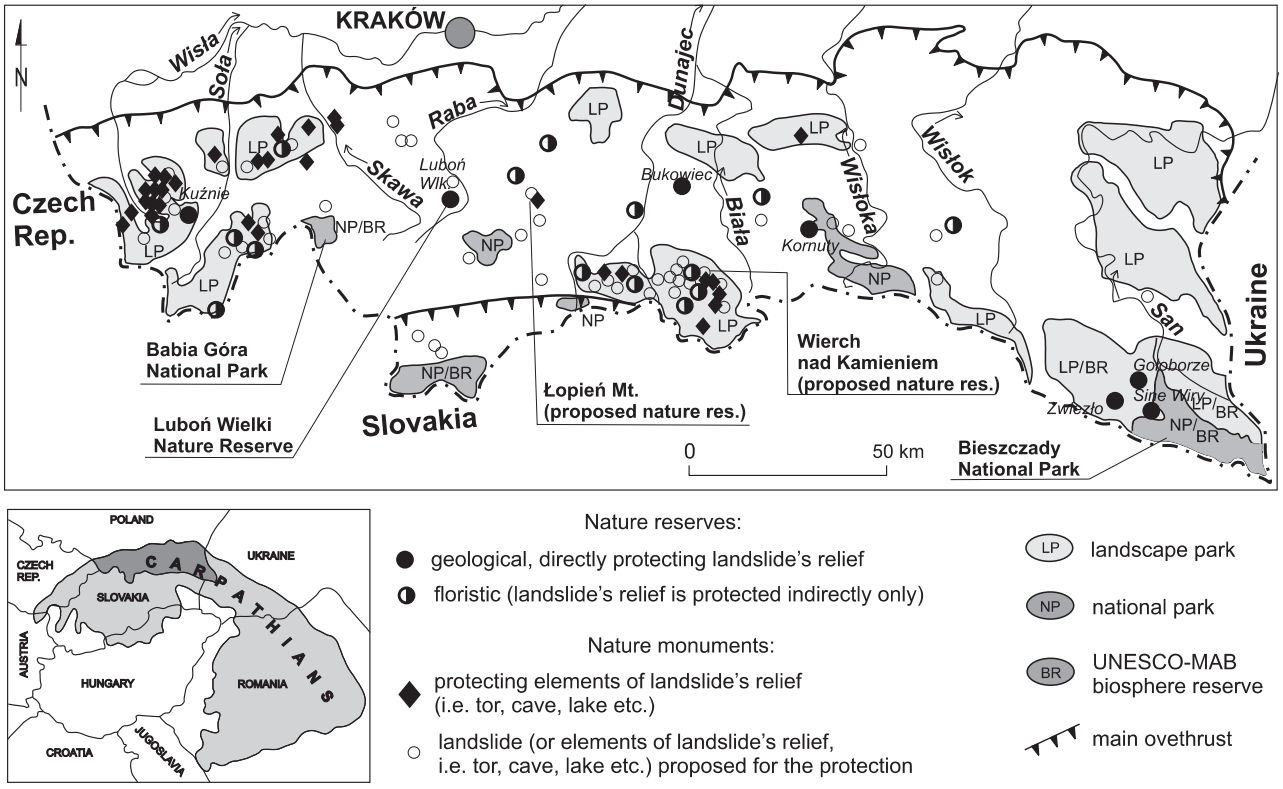


Fig. 3. Protection of landslide areas as part of geoconservation pattern in the Carpathians (after: Alexandrowicz *et al*., 1996; Alexandrowicz *et al*., 2000)

Candidates to the European GEOSITES are located on the map

et al., 1996). This developing progress of investigations enables to evaluate and select the most important landslide's forms which should be protected within various categories.

Significant reasons for protection of an old landslide are its morphology, age and sediments deposited in a peat-bog or in a lake. Palaeoecological and palaeoclimatic reconstruction of environment are based on plant and animal remains, thus localities with such investigated material (profiles) could be preserved (Birks, 1996). The relationship between abiotic pattern and recent biocenose of landslide is another important motive for the protection.

The new proposed evaluation criteria join all principal features. At first, relationship between geo- and biodiversty has been analysed taking into account a few landslides studied separately in details by botanists, geologists and geomorphologists (Alexandrowicz *et al*., 2004). Within the documented landslide's areas, 16 types of natural habitats were identified in accordance with the Habitats Directive for European Ecological Network NATURA 2000 (see Makomaska-Juchiewicz *et al*., 2003). The specificity of the natural habitats connected with some fixed topographical features of landslides should be more extensively included into both European networks NATURA 2000 and GEOSITES (Alexandrowicz, 2003; Alexandrowicz *et al*., 2004). Abiotic environments of slided areas are favourable for many endangered species as well. They are listed in the Polish Plant Red Data Book and Polish Red Data Book of Animals.

The above mentioned new evaluation and selection criteria have been split into three groups: scientific, educational–tourist and economic.

1. Scientific criteria including geological, geomorphological and biotic values:
   — geological structure of the bedrock and its predisposition for sliding,
   — outcrops of geological formations within the landslide and its close surrounding,
   — morphological features of landforms and their differentiation,
   — current development of slopes and weathering processes,
   — mineral and organogenic sediments deposited within landslide with special attention to ones suitable for ^{14}C dating,
   — changes of the water regime (springs, water-eyes, swamps and outflows),
   — forest and plant communities,
   — mosaic pattern of biotops and their relation to the abiotic environment,
   — endangered and protected species of plants and animals; refuges of wildlife.
2. Educational and tourist criteria:
   — accessibility of the landslide,
   — diversity and distinctiveness of landforms,

— instructive outcrops of geological formations and structures as well as sediments deposited within the landslide,
— diversity of biocenoses,
— possibility of adaptation for sightseeing, didactic and tourist trails, guidebooks, maps,
— attractiveness of the landscape.

3. Economical criteria:
— traces of ancient farming, pasturelands and settlements,
— forestry, exploitation of wood and clearings,
— limiting of plant and forest succession to preserve mountain glades, meadows and small settlements.

Five areas rich in the most representative landslides are indicated as candidates to the European GEOSITES Network (Alexandrowicz, 2003). They are: Babia Góra National Park, Bieszczady National Park, Luboń Wielki Nature Reserve, as well as landslide group proposed for the protection as nature reserve: Wierch nad Kamieniem in the Poprad Landscape Park and Łopień Mt. in Beskid Wyspowy Mts. (Fig. 3) (Alexandrowicz ed.,1996; Margielewski, 1997; Margielewski, Urban, 2003). Additionally, few other nature reserves in different part of the Carpathians should be taken into consideration (Fig. 3).

CONCLUSIONS

The landslide morphology have strong influence on the Carpathian landscape rich in unique morphological forms connected with mass movements. Thus protection of landslide areas represent an important part of the geoconservation policy carried out in the Polish Carpathians. Landslides are specific geotopes connected with relief typical for mass movement processes only. Specific plants communities overgrowing the mosaic of habitats within the landslides create the unique biotopes which development is controlled by mass movements. In landslide areas, dependence between geo- and biodiversity (relation: geotopes–biotopes) is particularly well marked.

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