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ATLAS OF LANDSLIDES IN SLOVAKIA

1. Characteristics of the Atlas of landslides

In the period 1997–2006 a geological project of the Ministry of Environment of the Slovak Republic with a title “Atlas of slope stability maps of Slovakia in scale 1:50 000”. was undertaken. The aim of the project was to summarize all previous registrations and surveys of slope deformations (mainly landslides) in Slovakia realized since 1961. The Atlas of landslides was compiled by several professional organizations in Slovakia.

1.1. Methodology of the Atlas compilation

The Atlas of landslides was compiled on the basis of archival engineering geological maps but there were also other data as final reports of landslide investigations and scientific and professional publications (books, magazines and proceedings).

Field mappings were carried out solely for the purpose:

- coherent assessment of landslides — many landslides have been processed by different companies and geologists with different levels of experiences,
- verification of insufficient and/or controversial data on the landslides obtained from the archival material,
- mapping of unexplored territory to find slope deformations, especially those that threaten civil engineering objects.

1.2. Content of the Atlas of landslides

The Atlas of landslides was made for the entire territory of Slovakia and consists of 132 maps sheets in the scale 1:50 000 (Fig. 1.) Each landslide is marked in the map by number

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and is outlined or marked by a point. Expected landslide activity is expressed by color. Type of slope deformations in terms of a simplified classification by Nemčok, Pašek, Rybář [3] is denoted by hatches.



Fig. 1. Cut-sheet of the map (near town Čadca) from the “Atlas of landslides” [2]

For each landslide a passport with basic information was prepared. For example, type of landslide, activity level, geological unit, geological structure, hydrogeological conditions, size, slope, endangered objects, landslide causes, remediation and more. The passports are available in form .xls and .dbf, and the zoning maps of slope stability maps in scale 1:50 000 are available in form .jpg, but also in ArcView shape format.

Online view of the Atlas of landslides is currently available at: www.geology.sk.

2. Results of statistical analyses

In 1982 it was estimated that the number of slope deformations is about 9 200 and that they affect 3.6% of the total territory of Slovakia. However, during the works on the Atlas

(1997–2006) a total of 21 190 slope deformations were recorded that effected a territory area of 257 591.2 ha, which is 5.25% of the total territory of Slovakia [2]. Compared to the data published in 1982 the area of the slope deformation has been increased in the Atlas is over 2%. However, this increase was not caused by the development of new slope deformations, but thank to registration of over 2102 slope deformations not registered yet and more accurate computerized processing of the all registered slope deformation.

For each geological unit located on the territory of Slovakia (Fig. 2) the most effected by slope deformations are the Paleogene and Mesozoic deposits of the Klippen Belt — 14.8% (the percentage of the total area of the unit body) and Paleogene of the external flysch zone — 12.7% [5]. The following are Neogene volcanoes — 9.3% and 7.2% of the Inner Carpathian Paleogene deposits. The least damaged by slope deformations are Mesozoic rocks — 2.4%, Neogene and Quaternary sediments — 1.5% and crystalline rocks (1.5%).

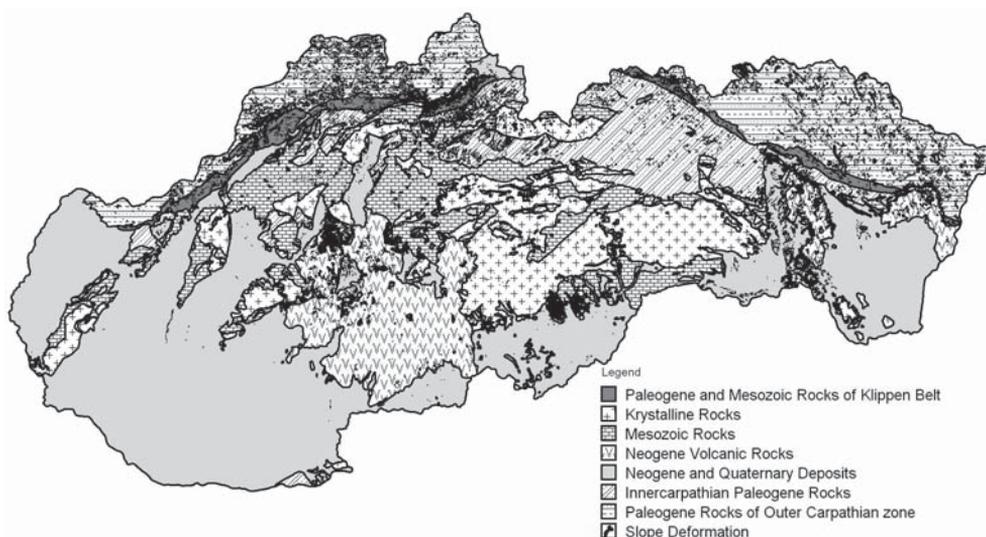


Fig. 2. Schematic geologic map of Slovakia with distribution of registered slope deformations

Of the total number of registered slope deformations up to 94.5% are landslides and land flows. In terms of the evaluation of the degree of activity the greatest number of slope deformations are a potential — 63%. Stabilized slope deformations account for 24.9% and active 11.6%.

The area of Slovakia damaged by slope deformations is evaluated in the Table 1. The devastation of the land is caused mostly by landslides (90% out of all slope deformations), or by their combination with other types. The devastation of the forested land (46.7%) is also caused by landslides (67.4%), but insignificant part (32.6%) is also damaged by slope deformations resulting from creep, land flow, and rock fall. Other areas, i.e. built-up areas (2.7%) are particularly threatened by landslides. Areas above the tree line are particularly endangered by slope deformation caused by creep, rock fall and land flow. Overview of endangered buildings and structures is shown in Table 2.

TABLE 1
Surface distortion of Slovakia by registered slope deformations

Area	Area	Damaged area	Damage [%]	
	[ha]	[ha]	Related to undamaged area	Related to total damaged area
Total area of Slovakia	4 903 347	257 591.2	5.25	—
Farming land	2 436 876	130 289.9	5.35	50.6
Forested land	2 004 100	120 243.3	6.00	46.7
Other land	462 371	7 058.1	1.53	2.7

TABLE 2
Objects threatened by slope deformations and extent of the threat

Threatened object	Extend of the threat
Roads of I. class and freeways, [m]	98 816
Roads of II. and III. class, [m]	571 408
Railways, [m]	67 210
Electrical wiring, [km]	11 161
Oil pipelines, [m]	3 500
Gas pipelines, [m]	101 350
Water supply, [m]	291 625
Buildings, [pcs]	27 920
Other, [pcs]	600

The statistical processing of the data from the atlas identified 168 sites where the number of buildings at risk (civil engineering — residential, farm and other buildings) is higher than 50. On these sites village communities are threatened, along with city neighborhoods, and cottage gardening areas, which are either wholly or partly situated on slope deformation. The most threatened objects include water reservoirs (38.5%), cemeteries (32%), ski lifts (6.9%), water tanks, ponds, (6.3%), playgrounds (3.8%), landfills (1.8%), bridges (6%) and tunnel portals (0.6%).

3. The Atlas and its possible use

Although the atlas has been available since 2007, public interest in its results only came last year (May–June 2010), after massive occurrence of landslides in Slovakia.

3.1. Urban planning

In our opinion, the Atlas of landslides is a very good tool especially in the design and development of urban plans in Slovakia.

Ignoring this data could result in enormous economic losses. An example can be taken from the village Nižná Myšľa, where in 2010 after the activation of landslides have damaged 45 homes, of which 32 were completely destroyed statics and had to be demolished. 144 people were evacuated [1]. In addition to the destruction of older buildings new objects were also completely destroyed (Fig. 3 and 4) which were built after 2007, when the Atlas of landslides was already available.



Fig. 3. New residential house damaged in the area of the main scarp on the landslide in Nižná Myšľa



Fig. 3. A new house tilting in the main scarp zone of the activated landslides in Nižná Myšľa

The new municipality plan of Nižná Myšľa was drafted in 2008 and allowed for the construction of new buildings on the territory of the landslide, which was activated in 2010. In case of later reactivation of the landslide in Nižná Myšľa, the landslide would have resulted most likely in damage of greater amount of objects.

In addition to Nižná Myšľa in June 2010 large landslides were recorded also in Kapušany Prešov, Vyšná Hutka, Vyšný Čaj, Varhaňovce and other locations where a total of 136 houses were damaged. All these sites were known from the Atlas of landslides and on most of the sites the construction of new buildings continued without appropriate measures.

These facts, raise pressure on law makers to make it a law to have an obligation to respect known occurrences of landslides and landslide areas, when municipality plans are being prepared.

3.2. Routing of traffic constructions

The occurrence of landslides in the path of road constructions (Tab. 2) represents one of the most important factors that significantly influence the process of decision making for routing of traffic constructions. This is mainly because ensuring a slopes stability of construction sites and roads is in itself economically very difficult in such areas.

Based on these experiences the Atlas of landslides is good basis for selection of routes of road constructions. However, the final route selection should be based on mapping and landslides activity verification in the route and on evaluation of the risk on a road based on a landslides survey and monitoring.

4. Summary

The presented article highlights the importance of the Atlas of landslides in the planning and constructions, especially in terms of warnings of the possible occurrence of landslides in the territory concerned. Ignoring the above information may result in large economic losses

On the other hand, however, usage of information from the Atlas, must be made with respecting that:

- the Atlas is compiled with accuracy of the scale 1:50 000,
- the registered landslide activity is being changed in time,
- the landslides have been allocated primarily based on subjective evaluations by different experts. Some of the landslides therefore do not have to be real. In contrary, some of the existing landslides have not been included in to the Atlas.

For the above mentioned reasons, it is necessary to continue updating the current Atlas of landslides database. In the case of real interest to build something in the landslide area it is essential to verify the information from the Atlas by professionals and perform a detailed survey and investigation. Only then the potential risk arising from the landslide can be realistically quantified.

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