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Engineering Geology in land-use planning and environmental protection in Slovakia

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Abstract: The actual task of engineering geology is to take responsibility for rational use of the geoenvironment and environmental protection against geological hazards. This role calls for new methods of engineering geological maps compilation and for evaluating methods of man's impact on geoenvironment and landscape, as well. To deal with these problems requires an effective monitoring system of environmental geofactors and elaborating of the effective methods of geoenvironment protection against stability failure and pollution.

Key words: geofactor, environment, groundwater, relief, geodynamic phenomena

Introduction

The Slovak engineering geology has fully accepted the International Association of the Engineering Geology (IAEG) declaration to take responsibility for the protection and rational use of the geological environment as well as the environmental protection against geological hazards, approved by the general assembly during the International Geological Congress held in Moscow in the 1980. Results are recorded by series of projects aimed to the geological hazard impact mitigation, geological input data for land-use planning and waste disposal site selection, as well as by numerous papers of Slovak engineering geologists in professional periodicals, proceedings of the IAEG international congresses held in Buenos Aires (1986), Amsterdam (1990), Lisboa (1994), and others.

Terminology and definitions

The trends mentioned above have been followed by a rapid development of the conceptual construction and terminology. It was reflected by the Slovak Geological Society by appointing of terminological commissions. The work of the engineering geological commission resulted issuing the Engineering Geological Terminological Dictionary (ANNON, 1992).

From the point of view of engineering geological projects undertaken in Slovakia, it is useful to explain some important concepts which have started to be used frequently, however, without distinctive definition, or using different definitions.

Geological environment (geoenvironment) is a term we use for the upper part of the lithosphere conditioning the existence and the development of the human society and which, in return, is exploited and changed by man. The geological environment, as a complex dynamic natural system, consists of the following basic components:

1. Rocks (rock environment) - create substancionally as well as structurally the basic constituent of any particular part of the Earth´s crust;
2. Ground water - represents the conjunction of the hydrosphere with lithosphere and creates a favourable condition for the existence of the biota, man included;
3. Topography (relief) - a division between lithosphere and outer Earth´s spheres (atmosphere, hydrosphere, biosphere, etc.) as a result of endogenous, exogenous and antropogeneous geological processes;
4. Soil - the uppermost part of the lithosphere resulting from its conjunction and interaction with atmosphere, hydrosphere and biosphere and conditioning substance and energy exchange between abiotic and biotic part of the nature.
5. Mineral deposits - solid and liquid mineral raw materials accumulated in the lithosphere in an exploitable quantity.
6. Geodynamic phenomena - recent natural and antropogeneous geological processes as well as resulting changes in the geological environment and its relief.

As geofactors (geological factors) we call the properties of the geological environment components facilitating, limiting or affecting the land-use. Factors which, through their character and quality, facilitate or in positive way affect the exploitation of an area in some way (mineral resources, aquifers, foundation ground of high quality, etc.) are called geopotencials (geological potentials). Geological factors which limit or affect in negative way the land-use (landslides, karst phenomena, seismicity of a high intensity, unsuitable foundation ground, etc.) are called geo-barriers (geological barriers).

The most common geobarriers are hazardous geological processes, the probability of which within a particular area and time interval are expressed by the term of geological hazards (VARNES, 1984).

Development of engineering geology for land-use in Slovakia

Engineering geological project development for complex engineering designs resulted in the experience that understanding of geological structure and processes on regional background enables to make the design more effective. It generated a systematic study of engineering geological condition in regional aspects. In this aim Slovak engineering geology utilised results of numerous excellent geologists who worked in Slovakia, first of all results of D. Andrusov and his followers, as well as the methodology of the Russian school of regional engineering geology founded by V. I. Popov. The study results were presented in a monograph of the Regional Engineering Geology of Slovakia by M. MATULA (1969) which was presented at XXIII. International Geological Congress held in Prague in 1968.

Following the regionally oriented research the multipurpose engineering geological maps at a scale of 1:25 000 have been prepared covering the most important Slovak industrial and urban centres. Subsequently, general engineering geological map of Slovakia, at a scale of 1:200 000, was compiled (MATULA, HRAŠNA, ONDRÁŠIK, 1989) creating unified "skeleton" for mosaic of maps at a scale of 1:25 000 and binding urban areas mapped in detail together with their background. It resulted in the comprehensive information system of engineering geological conditions of the whole Slovak territory with more detailed data for economically significant regions. The map involves the data on geofactors affecting in zoning units the environment, as well.

Parallel to the systematic regional engineering geological research in the 60-ties a systematic research of hazardous geological phenomena (landslides, suffusion, erosion, sagging of loesses, etc.) has developed. The landslide disaster in Handlová at the turn of the years 1960-1961 triggered a systematic landslide inventory on the whole territory of previous Czecho-Slovakia. During the years 1962-1963 there were registered 123 594 slope deformations in Slovakia, with the total extent of 11 615 km^2, representing 3,3 % of the total state territory. However, slope deformations locally represent 20 up to 30 % of the area. Slope deformations maps of various types and scales have been systematically prepared for the exposed portions of the country (MALGOT & BALIAK, 1993). Subsequently, some landslides endangering engineering structures or urban areas have been reclaimed.

Recent state and trends in engineering geological research in Slovakia

While multipurpose maps of engineering geological conditions and zoning compilation prevailed in the last decade, special purpose maps of engineering geological valorization compilation predominate in Slovakia recently (HRAŠNA & VLČKO, 1994). These may be prepared as suitability maps, as optimization maps compiled on the base of multicriterial analysis or in the form of prognostic maps expressing the expected changes in geological environment due to man interferences.

The more extensive project of this type was to prepare the suitability maps for the waste disposal sitting compiled for the whole territory of the Slovakia, at a scale of 1:200 000 at the beginning (1990-1991) followed (1992-1993) by maps at a scale of 1:50 000 (HRAŠNA, 1993). The degree of the danger of ground water pollution and geo-dynamic phenomena impact are the main criteria from geological suitability aspects in these maps. Apart of them, protected areas of various kinds (including protected areas of mineral resources and aquifers) and other important phenomena (flood-lands, protective forests, etc.) affecting the intended land-use were presented in the maps.

Optimization maps are compiled for land-use planning aimed to choose the most suitable land-use of various parts of the particular area (MATULA, HRAŠNA, VLČKO, 1986) or with the aim to select the most suitable site for particular investment decision. The last ones are compiled especially for the sitting of complex or ecologically dangerous development (HRAŠNA & SZABO, 1994, HRAŠNA, 1995). A specific program for waste disposal deals with the selection of suitable geological structures for toxic and radioactive wastes, as well as suitable waste disposal sites for some urban agglomerations.

The compilation of prognostic maps calls for the elaboration of classification systems both the character and intensity of man interferences, and the expected changes of the geoenvironment due to man's interference, as well. The example of such a map was introduced by HRAŠNA & VLČKO (1986).

The other significant program is the monitoring of environmental geofactors, realised on the request of Geological Section of the Ministry of Environment of the Slovak Republic, similarly as the above mentioned maps. The program involves monitoring of the following phenomena: landslides, erosion, weathering, subsidence of undermined areas, antropogeneous deposits and seismotectonic activity of the Slovak territory.

At present, the State Geological Service in cooperation with the Department of Engineering Geology of the Faculty of Natural Sciences elaborate the draft of recommendation for the geological investigation and compilation of special purpose maps for urban development in accordance with the new urbanization program of the Slovak Republic and expected innovation of the law on land-use planning.

Slovak engineering geology and hydrogeology have also played a significant role in environmental protection in accordance with recently (1994) adopted law for environmental impact assessment (EIA). The law specifies all kinds of environmental interferences at which the EIA method is to be accepted and gives a succession of particular steps to be done. Related and acute task of geology is to specify methods of geoenvironment assessment from the point of view of its stability failure or pollution and to quantify the extent of possible deterioration and the cost needed for the prevention, as well.

Conclusion

While the engineering geological research and investigation were concentrated on the close construction site surroundings and endeavour for the most economically effective structure realisation and safe utilization predominated in the past, modern engineering geology is characterised by the extent regional background and an endeavour for optimal sitting of engineering designs in the geoenvironment and landscape as well as with respect to the environmental protection. The stress is laid upon a rational use of the geological environment based on a complex assessment of a terrain potentials and relations in the system: engineering structure - geoenvironment - landscape.

To accomplish the above mentioned tasks the development of the assessment methods of the whole system and particular components of engineering geological conditions is required, and the assessment methods of engineering interferences with geoenvironment, as well. In relation to it, an improvement of rock mass and territorial units typology, as well as the methodology of special purpose maps compilation for various kinds of land-use is required. At the same time, there is a necessity to be directed in a larger scale at compilation of optimization and prognostic maps of geoenvironment changes due to man`s interferences.

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