Methodological principles of creation of the integrated database of geological and geomorphological monuments of Ukraine

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SUMMARY

The theoretical and methodological principles of the identification and scientific substantiation of the selection of natural monuments are underdeveloped in Ukraine.

The aim of this paper is to introduce an integrated methodological approach: a) to substantiation of selection of geological and geomorphological sites and 2) to elaboration of integrated database of this category of natural monuments in Ukraine. The proposed database can be used both for educational and practical purposes, i.e. spatial planning of nature conservational framework in Ukraine, the eco-network, development of nature science tourism, etc.
Introduction

In Ukraine, natural monuments are considered as prominent sites which also including important and impressive geological and geomorphological features. They are of a particular interest for nature conservation, scientific research, cognitive, aesthetic and cultural issues. According to (Zakon Ukrayiny,1992), the main task is the preservation of these monuments in their natural state. Regarding the classification of the International Union for the Conservation of Nature (IUCN), natural monument are related to the category III of protected areas, which is located between the categories ‘reserve’ and ‘parks’. It should be mentioned that boundaries of the majority of natural monuments in Ukraine are not well defined, and their nature conservational regime remains rather uncertain. Further, the theoretical and methodological principles of the identification and scientific substantiation of the selection of natural monuments are underdeveloped. The large number of factors, which form natural monuments, makes them a common object of study by different natural sciences (geology, geomorphology, palaeogeography, hydrology, biology, geoarchaeology, etc.), As the result, different methodological approaches are applied to interpretation, systematization, and classification of the new nature conservation monuments, as well as to the inventory, certification and cadastre of the monuments, which have already obtained the conservation status (Bondarchuk,1961; Heologicheskie pamiatniki Ukrainy,1985; Wimbledon et al.,1999 a,b; Heolohichni pamiatky Ukrainy: U 3 T, 2006 – 2011; Gritsenko et al., 2012; Geoheritage and Geotourism. A European Perspective (2017); Bortnyk et al., 2018; Bortnyk et al., 2019 Bortnyk and Stetsyuk, 2019; Gozhik et al., 2019).

The aim of this paper is to introduce an integrated methodological approach: a) to substantiation of selection of geological and geomorphological sites and 2) to elaboration of integrated database of this category of natural monuments in Ukraine. The proposed database can be used both for educational and practical purposes, i.g. spatial planning of nature conservational framework in Ukraine, the eco-network, development of nature science tourism, etc.

Materials and Methods

Such main methods for the selection and scientific substantiation of geological and geomorphological monuments are proposed:

- morphological analysis – in order to evaluate hypsometric and lateral organization of the land surface and its prominent morphological features, which frequently control the position of natural monuments; in order to obtain quantitative and qualitative data on these monuments (their sizes, forms of the monuments and their structural elements, angles of slopes, etc.);
- landscape-morphostructural analysis – in order to decipher the geological structure of the site on the basis of indicative features of different landscape components;
- stratigraphical approach – in order to determine the geological age and to reveal the succession of rock formations; to reveal deformations and dislocations);
- palaeogeographic analysis – in order to understand the origin and geological history of studied monuments and their components;
- mineralogical, petrographical and lithological analyses of rocks of the monument;
- perception approach (analysis of educational and aesthetic perception of monuments).
- The main research materials are remote sensing data (satellite images, multispectral data, SRTM), large-scale topographic and thematic maps, geological, geomorphological and landscape sections, field survey data, etc.

Results

Justification of approaches to the establishment of geological and geomorphological monuments

Geological and geomorphological monuments in Ukraine are diverse in their age, origin, morphology, and dynamic processes. Nevertheless, it is possible to trace a clear correlation between the types of natural monuments and the features of morphostructure, relief, tectonics, stratigraphy, palaeogeogrphahy, hydrology etc., which are also reflected in the landscape morphology. The starting point of the study is a morphological analysis of the land surface, aimed on the revealing of its lateral
and vertical organization. The former shows differentiation of the area into the sites with development of denudation or accumulation processes, directions of mass movement the latter impacts the energy of relief-forming processes. Denudational and erosional processes are particularly significant in the formation of geomorphological and geological sites as they "excavate" exposures of geological rocks which might have a great scientific and educational value (Relief Ukrainy, 2010; Bortnyk et al., 2018; Gozhik et al., 2019). For example, the sections of the Vendian, Cambrian, Ordovician, and Silurian deposits (the Kytaihorod village, the Khmelnytskyi region) is the geological site of the national value, which was formed by the intensive incision of the Ternava River. This incision, in its turn, was caused by the involvement of this area in the uplift of the Carpathians. The other impact of this uplift is reflected in the formation of the unique incised meanders of the Dniester River. In the mountain regions of Ukraine (Lavruk et al., 2019), tectonic processes created much more diverse geological and geomorphological monuments than in the plain area. Due to the high relief energy here, there are also much more exposures of geological structures, rocks of different composition and properties, and the great variety of morphological and morphometric features of relief. Genetic types of relief are completely different even at close distances, as well as their ages.

Landscape-morphostructural approach to the studies of formation of geological-geomorphological monuments is based on the principle of geological-geomorphological and landscape-geomorphological conformity: each relief form is connected with a geological structure, on one side, and transfer the corresponding features into the landscape structure, on the other side. The aim of landscape-morphostructural approach is to decipher a geological structure of the area on the basis of the characteristic features of relief and other components of its landscape. The close connections between geological and geomorphological components of the natural monuments are clearly demonstrated when geological structures are exposed through the action of geomorphological processes. Under appropriate structural-denudation conditions, almost all types of geological structures can be distinctly reflected in the relief (Bortnyk and Stetsyuk, 2019).

Stratigraphical approach is a primary requirement in dating geological and geomorphological monuments. It allows to establish the geological age of rocks and also the age of erosional or denudational processes which produced exposures of these rocks and, thus, made them accessible for research, conservation and geotourism. For instance, the Vendian bioherms and Palaeozoic reef deposits would have never been accessible without "excavation" of them by the incised meanders in the lower part of the coastal cliffs of the Dniester River and its tributaries. On the other hand, the uplift of the Neogene sea bed in Podillia area formed the Tovtry geological-geomorphological monuments, the uplift in the Kharkiv region led to the formation of the Chalk Mountains site. Palaeogeographic analysis, based on stratigraphy, palaeontology and palaeogeomorphology, allows to reconstruct the developmental stages in the formation of geological and geomorphological sites. For instance, multidisciplinary palaeogeographical studies of the Vyazivok site (the parastratotype of the Ukrainian Quaternary), including the study of facies and palaeosol catena in different relief forms of different age, enabled the reconstruction of short-period environmental changes during the Neopleistocene. They are temporal and spatial changes in sedimentation and pedogenesis, depending on transformation of palaeorelief; changes in intensity of erosional and accumulation processes; the cyclic development of cryogenic phenomena; vegetational, faunal and climatic changes.

Palaeogeomorphological processes are clearly reflected in the morphosculptural features of the relief. They are: strong deformations of the surface by the ancient glacial or other catastrophic processes; cases of prolonged and intense weathering of crystalline rocks (e.g. in the valley of the Mertvovod River, or “The Stone village” in Polissia); strong and long-lasting chemical leaching of carbonate and gypsum rocks (the numerous karst cavities in Crimea and Podillia); the coastal processes (e.g. abrasive wave-breaking niches on the Zmiinyi Island, accumulative forms of the Tuzla Spit).

Dynamic geomorphological processes are represented in geological and geomorphological monuments as relief forms, characterized by a significant speed of their formation, e.g. the ravine and gully complex of the Kaniv dislocations, the dune fields of the Oleshia, the rock landforms of the Svidovets Ridge in the Carpathians, the abrasive cliffs of the Black Sea shore near the Odessa City, the accumulative islands in the Kremenchuk reservoir.
The rocks composition and properties are important for formation of geomorphological monuments due to their different resistence to denudation processes. Very special and picturesque relief (and landscape) forms appear because of difference in the speed of weathering processes, e.g. the bizarre form of the erosion remnant at the mouth of the Bohovychka River (Podillia).

Perception approach. Frequently natural monuments form the basis of the unique cultural landscapes, e.g. the Urytsk Rocks historical and architectural complex in the Skole Beskydy National Nature Park (the Carpathians), where the Tustan’ fortress was built in the 11th-13th centuries. Some of geological and geomorphological sites attracted the ancient Man and, thus, became archaeological (later on, geoarchaeological) monuments. For instance, the exposures of flint-carrying Cretaceous chalk rocks in the coastal cliffs of the Desna River form ‘knots’ of the Upper Palaeolitic sites which provided valuable geological and palaeoenvironmental data (e.g. the Mezin National Natural Park with many well-stratified and reliably dated sections).

The geological and geomorphological monuments in Ukraine have a strong potential for research, geotouristic and naturalistic activities, recreational, sport and adventure tourism, like caving, rafting, jumping, trekking, etc. (Stetsyuk and Popovych, 2001). Geoattractions that reflect the intense natural processes of endogenous (ancient volcanism, earthquakes) and exogenous origin (catastrophic floods, landslides, screes, mudslides, catastrophic subsidence) have a great educational value, as well as man-made geological and geomorphological sites (the ancient mines and quarries).

Thus, the patterns of morphological organization of the land surface, the modern and ancient relief, exposures of geological structures and rocks, made by exogenous processes, the outstanding landscape features with a strong geological content were pre-conditioned by tectonics, geological structure, the unique mineral-petrographic associations and rocks properties, history of the biosphere and climate. All of these shows the methodological unity of the studies of geological and geomorphological sites, and it should form the basis for the elaboration of integrated database of geological-geomorphological monuments – both for scientific and educational purposes. The assessment of these environmental components should produce valuable synergistic results which are important for practicalities, e.g. substantiation of a conservational status of the newly discovered monuments, the expansion of the nature conservational fund and the eco-network in Ukraine, popularization of geoscience, development of geotourism, etc.

Educational and environmental institutions should join the elaboration of the integrated database of geological-geomorphological sites. For instance, students and lecturers of Department of Earth Science and Geomorphology (Geography Faculty of Taras Shevchenko National University of Kyiv) have implemented the project on the scientific substantiation of the landscape reserve "Boremelske Nadstyrya" (the Rivne region), within their course "Management of ecological projects and environmental co-operation". Geological and geomorphological components played an important role in the selection of this area as a reserve. The Quaternary studies in the Boremelske Nadstyrya are important for understanding of the Pleistocene nature history of this region within the heart of the Volyn’ Upland. The exposures of the Mid-Pleistocene deposits in the basin of the Styr River (Fig. 1b) is unique for the southern Volyn’.

The slopes of the Styr River terraces (Fig. 1a) are valuable for the study of a wide range of geomorphological processes (abrasion, landslides, scree, suffosion, erosion, etc.), many of which are typical for the Volyn’ Upland but they rarely occur in one and the same place, as they do at Boremel. Many relic relief forms (palaeolandslides, ancient erosional, cryogenic, thermokarstic, eolian-alluvial forms) form the natural museum of the ancient relief. The area also has historical and archeological monuments harmoniously joined with the landscape features (e.g. the settlement of X-XII cent., the castle of XVI-XVII cent., the Prince Chatsky’s Palace of XVIII–XIX cent., the Bronze Age burial ground). Detailed information on the nature conservational objects of the landscape reserve “Boremelske Nadstyrya” is presented in (Bonchkovskyi et al., 2016).
Figure 1: a - general view on the abrasion cliffs within the landscape reserve 'Boremelske Nadstyrya'; Foto: O. Bonchkovskyi
b - the outcrop of the Upper and Middle Pleistocene deposits in the Styr River terrace; Foto: O. Bonchkovskyi

Conclusions

The category ‘geological monument’ is the carrier of geological, and as well of geomorphological, palaeogeographic and generally geosystem, ethnocultural, aesthetic, and naturalistis content.

As almost all geological sites are a part of the Earth's surface, they are inherently both geological and geomorphological. This kind of trivial postulate reveals a deep connection between the relief and the geological structure.

This statement has a fundamental methodological importance for the creation of an integrated database of geological and geomorphological sites, which can be used for their classification, systematization, certification, inventory and cadastre, granting them the appropriate legal (environmental) status. The formation of such a database extends the possibilities for the complex (environmental, recreational, geotouristic, naturalistic) usage of natural monuments of the geological-geomorphological category.

References
