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The concept of "landscape diversity" and contemporary problems of its research in the mining landscape of Kryvyy Rih region

The content of the concept "landscape diversity" and its identical terms have been considered. The process of formation the general theoretical foundations of the concept of landscape diversity continues in a wide range of direct and related scientific problems. The need to summarize known and to form new provisions on the essence of landscape diversity and various aspects of its importance is topical. The specific features of the landscape diversity manifestation and diversity of the landscape structure of Kryvyy Rih mining landscapes were characterized. Attention is paid to the contemporary problems of landscape diversity research in Kryvyy Rih mining landscapes.
Keywords: anthropogenic landscape, mining landscape, research, Kryvyy Rih region, landscape diversity, landscape territorial structure, problems, technogenesis.

Коптєва Т.С. Поняття «ландшафтне різноманіття» і сучасні проблеми його дослідження у гірничопромислових ландшафтах Криворіжжя Розглянуто зміст поняття «ландшафтне різноманіття» та ідентичних щодо нього термінів. Процес формування загальних теоретичних засад концепції ландшафтного різноманіття триває в широкому колі прямих і супутніх наукових проблем. Актуальними є потреба в узагальненні відомих і формуванні нових положень про сутність ландшафтного різноманіття та різні аспекти його значення. Схарактеризовано специфічні ознаки прояву ландшафтного різноманіття та різноманіття ландшафтної структури гірничопромислових ландшафтів Криворіжжя. Акцентовано увагу на сучасні проблеми дослідження ландшафтного різноманіття у гірничопромислових ландшафтах Криворіжжя.
Ключові слова: антропогенний ландшафт, гірничопромисловий ландшафт, дослідження, Криворіжжя, ландшафтне різноманіття, ландшафтна територіальна структура, проблеми, техногенез.

Essence of the problem. Intensive development of technogenesis on the Kryvyy Rih region from the second half of the 19th century led to the replacement of natural steppe landscapes mainly by industrial and residential landscapes. The processes of technogenesis have affected not only individual geocomponents, but also the landscape as on the whole: a new industrial and residential landscapes, which is not typical for the steppe zone, are being created. The main landscapes in its structure are industrial (mining heaps, dips, quarries and factories).

Significant changes occurs in the landscape diversity and significant differences are characterized in the terrain, climate, soils, flora and fauna. The problem is actual, and covers a wide range of landscape diversity of Kryvyy Rih region. Nowadays, the area of industrial landscapes is being increased rapidly in the Kryvyy Rih landscape-technical system due to active development of the mining industry. It fosters to the enhancement of landscape diversity, stimulates its active exploration and enables the

implementation of recommendations on the landscapes suitability and their subsequent use to meet various economic needs, and organization of tourism and recreational activities.

Analysis of previous research and publications. Mining landscapes are constantly studied by scientists. Only the list of names of famous domestic and foreign geographers whose papers are devoted to the study of landscape diversity, demonstrates the outstanding attention of scientists to solving this problem. Among Ukrainian geographers M.D. Grodzinski, P.G. Shishchenko, V.M. Pashchenko, V.T. Grinevetsky, O.M. Marinich, G.P. Pilipenko, V.P. Palienko, A.O. Kornus, I.M. Voyna, A.O. Domaransky, M.P. Stetsenko, S.I. Kukrudza, M.I. Rutinsky, L.M. Kirilluk and others; D.L. Armand, F.M. Milkov, G.D. Richter, A.G. Isachenko, V.O. Nikolaev are among foreign ones.

V.M. Pashchenko and V.T. Grinevetsky formulated the definition of landscape diversity. According to them this concept includes all the plurality of natural and anthropogenic (variant and invariant) landscape complexes of any size and hierarchical rank on the earth's surface [15]. The concept of "variants" and "invariants" was considered by F.M. Milkov [13]. He identified three variants in the zonal types of landscapes: climatic, petrogenic and altitude-geomorphological. The last, as the author noted, is "… manifestation of vertical landscapes differentiation" [13]. G.P. Pylypenko notes that landscape diversity is based on a wide range of differences in terrain, climate, soils, flora and fauna. O.M. Marynich pointed out that considerable landscape diversity is inherent in areas with vertical differentiation (mining landscapes). Landscape diversity and vertical differentiation of left-bank Ukraine was investigated by A.O. Kornus [12].

The aim of the study. To analyze the term "landscape diversity"; to characterize the specific features of the landscape diversity manifestation and landscape structure diversity of the mining landscapes of Krivyy Rih; to distinguish current problems of research of landscape diversity in mountain landscapes of Kryvyy Rih region.

Research results. For the first time, the term "landscape diversity" was firstly officially used during the Ministerial Conference on the Environment in Sofia in 1995 [4]. Subsequently it was considered in more details at the conferences in Moscow in 1997, in Florence in 1998, in Kiev in 1999 and 2000 [4]. Dependence of landscape diversity on the geomorphological features of the territory was considered in the O.M. Marinich, G.P. Pilipenko, V.P. Palienko, A.O. Kornus's papers. Determining the landscape complexes diversity in general traits is similar to the definition of biological diversity, i.e. it is based on the determination of the number of classes, families, genera, types of landscapes in a certain area.

An important criterion for the study of landscape diversity is the landscapes systematics, as a basis for the research, mapping and scientific description of landscape diversity. As A.G. Isachenko notes, the number of specific landscapes on the globe should be measured by five or six digits [10]. D.L. Armand, F.M. Milkov, G.D. Richter, A.G. Isachenko, V.O. Nikolaev proposed own systematization of landscapes, which distinguished the following taxa: department, system, subsystem, class, subclass, group, type, subtype, genus, subgenus, species, subspecies. Such taxonomy was developed for the study of natural landscapes.

Despite the active research on landscape diversity have been conducted in recent years, a number of issues related to assessment problems, methods of research of landscape diversity, landscapes systematics, have not yet been resolved, although

attempts to solve them are presented in the publications of O.M. Marinich, A.O. Domaransky, S.I. Kukurudza and M.Y. Rutinsky, V. Hetman, M.P. Stetsenko, A.O. Tkacheva, Zh.I. Buchko, O.M. Petrenko, S.P. Romanchuk and others scientists' publications.

The problems of landscapes systematization and classification of Ukraine were raised in particular by V.M. Pashchenko, O.M. Marinich, L.Yu. Sorokina. O.M. Marynich proposed the creation of landscapes systematics of not only taking into account classes, species, genera, etc., but also with the identification of tracts and landscape areas [3].

The parameters of landscape diversity estimation are given in the A.O. Domaransky, O.M. Marinich, M.D. Grodzynsky, I.M. Voyna's papers. M.D. Grodzynski points out that there are up to 30 indicators assessing landscape diversity. According to O.M. Marynych, "the characteristic of landscape diversity should be based on qualitative and quantitative indicators of different rank" [10]. V.M. Pashchenko described the temporal transformations of landscape diversity and showed that all existing landscape diversity has been formed over the years. Important, but not fully studied, are the issues of methodology, although basic methods of landscape diversity research have already been suggested by A.M. Marinich and V.M. Paschenko. However, this issue requires further development and improvement. Such scientists as O.V. Klimov, V. Hetman, M.P. Stetsenko, A.O. Tkachev, V.I. Oleshchenko focuses on the study, conservation and reproduction of the landscape diversity of natural landscapes, in particular within protected areas. The study of the taxa classification of technogenic landscapes was described in S.M. Smetana's papers by. It was determined in the process of taxa classification of technogenic landscapes that the following landscape-technogenic formations are formed in the conditions of such open-pit and underground ore-mining systems: quarries, dumps, sludge deposits, waste heaps, dip areas, industrial sites.

S.M. Smetana used a taxonomic system of typological structures for the classification of such technogenic landscapes. Consideration of the main important characteristics is carried out from the class level to the level of the type according to the facet scheme:

- ✓ Class – it characterizes slopes, bottoms, plateaus, slopes and allows to trace the main types of transport and accumulation of substances and energy, it defines the basic parameters of microclimate.
- ✓ Subclass – it reflects the 4 major groups of granulometric composition of rocks (stone, sand, clay, mixture), which have a significant impact on the accumulation of substances, processes of soil formation and filtration of precipitation.
- ✓ Row – it takes into account the transformation of hydrological and geochemical flows through the transport intensity of substances and energy.
- ✓ Subrow – it records the energetic characteristics of certain habitats, which depend on the slope angle, exposure, surface albedo, condensation precipitation, etc.
- ✓ Genus – it characterizes the major ecologically important differences in the chemical composition of the rocks – acidic, basic, saline, neutral and others.
- ✓ Species – it evaluates the conditions of vegetation cover formation in accordance with the identified characteristics of higher taxa. Its assessment is often complicated by the fact that the vegetation cover has not yet been formed and is undergoing significant changes from year to year.

A species is the most complex taxon, which is more dependent on the characteristics listed in the higher taxa. Thus, the basic characteristics of moisture and nutrient supply are determined at the level of class, subclass and row levels, although microclimatic indicators may level other indicators at the subrow level. The most cases of rocks chemicalization (saline, acidic, basic rocks) are characterized at the genus level. With help of the taxa classification of technogenic origin made by S.M. Smetana, it can be noted that landscape diversity and variability of habitats in the area of Kryvyy Rih region is divided into 5 systems, 10 classes, 29 types, 54 subtypes, 136 classes, and more than 150 subclasses.

Fig. 1. shows the taxonomic system of mining landscapes, which was developed by G.M. Zadorozhnaya [11]. The given classification is functional and genetic, because the varieties of industrial landscapes are caused by a certain type of use of nature by human, which allows to distinguish the type, subtype, specious of landscapes. At the same time, this selection reveals the origin of different types of landscapes. Therefore, based on this classification, it can be noted that the quarry-dump and mine type of landscape complexes are widespread in the area of Kryvyy Rih region.

Quarry-dump landscape complexes are represented by the following basic types of terrain and their variants:

The type of terrain is dumped-monocot. The characteristic feature of such terrains is shallow recesses, their bottom is filled with fragile material, rocks on the sides of the quarries, they are much weathered.

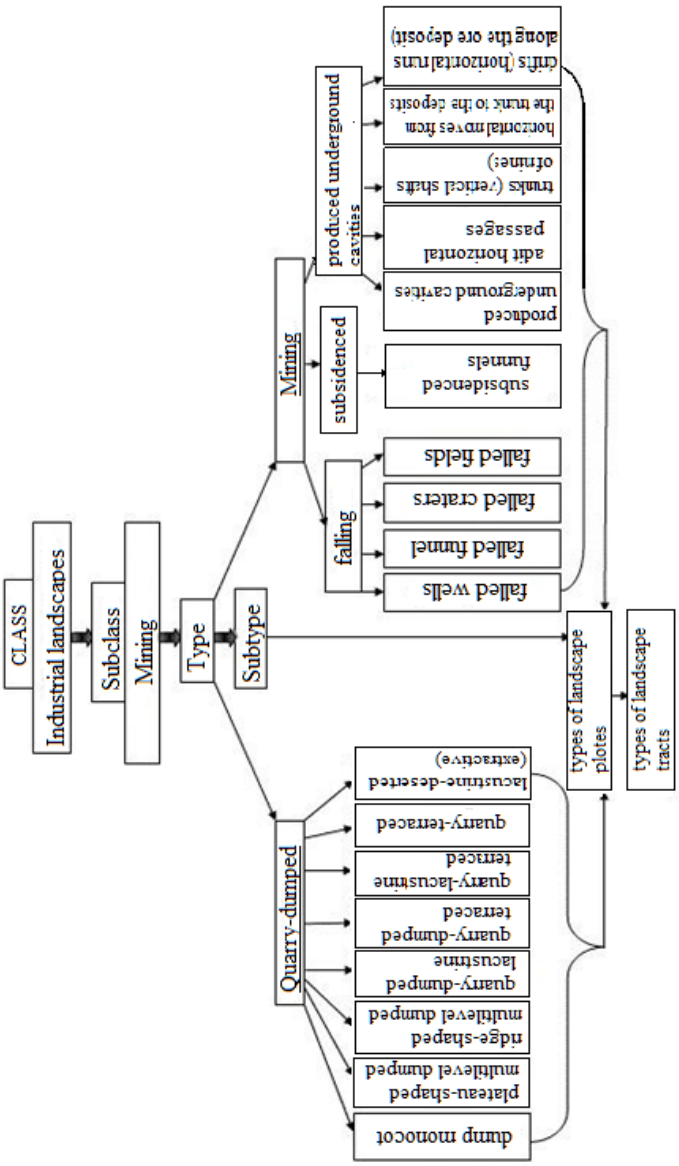

Figure 1. Taxonomic system of mining landscapes. By G.M. Zadorozhnaya [11]

1. *Plateau multilayer dump type of terrains.* The characteristic forms of anthropogenic relief are formed at railway or automobile dump of rocks – multilevel dumps with the leveled plateau-shaped surface. They are represented by three variants in Kryvbas: rocky (represented by hard rough rubble rocks, mainly friable rocks – limestone, marl, clay, loam – quartzite, shale, brown iron, granite), friable (glass, sand), mixed (contain as friable and rocky rocks).
2. *The ridge-shaped multilevel dump type of terrains.* Such complexes were formed as a result of cyclically current technology of dump dumping.

3. *Quarry - dumped - lake type terrains.* Increasing the depth of quarries has led to the formation of a reservoir and filling the water after working out and quarries recesses.
4. *Quarry - dumped - terraced type of terrains.* The use of mining equipment for mining operations, as well as certain technological features of extraction causes to the formation of significant quarry recess (more than 200 m) with a characteristic terrace structure.
5. *Quarry-lake-terrace type of terrains.* Such areas are typical for terrains where, the quarry was flooded and formed deep (up to 30 m) reservoirs as a result of the cessation of mining operations.
6. *Quarry-terraced type of terrain.* This type is typical for modern areas of development.

There are 7 powerful quarries in Kryvbas now: depths ranging from 250 to 500 m and length exceeds 4 km. Landslides, scree are actively developed on the slopes of existing quarries and waste heaps. The development of soil-biotic processes and phenomena is suppressed. At the end of the quarry and dump complexes life, processes and phenomena become active and act as landscape factors, which leads to the formation of a new landscape structure. An example of the consequences of the long term development of landscape formation processes can be the contamporary status of the spent quarry and dump complex of the RU named after K. Liebknecht and the dump of the Ternovskaya mine. Quarry-dump complex of RU named after K. Liebknecht was operated in the 1950s-1960s of the last century. Quarry is one of the few no-flooded quarries of Kryvbas today, as it is located in the area of the modern underground development of the Rodina mine, where groundwater is pumped.

Mine type of mining landscapes are represented by the following subtypes: falling, subsidenced, produced underground space.

1. *Mine-falling type of terrains* is formed as a result of underground mining of iron ore with the use of surface shift technology in Kryvbas. Such areas are typical for the northern and central part of Kryvbas. Contemporary Kryvbas's subsidenced zones are areas of alienation where the original landscape is developed. They are characterized by a significant difference in altitudes (depth of falling funnels is up to 200 m), harsh environmental conditions for vegetation development. The landscape structure of the faling zones is characterized by a considerable diversity of landscape complexes.
2. *Mine-subsidenced type of terrain*. It is characterized for the southern part of Kryvbas and is of limited distribution. The formation is caused by the geological and geomorphological features of the territory of the southern part of Kryvbas, as well as the method of brown iron extraction.
3. A special place in the structure of mining landscapes is occupied by *underground cavities*. Such formations include adits (horizontal passages), shafts of mines (vertical passages), kvershlags (horizontal passages from the trunk to the deposit), drifts (horizontal passages along the ore deposit), hezzenki with sections, horizons, transitional wells (vertically - stepways for ore downstairs), extraction chambers (large rounded ones). Self-development processes occur in underground cavities after working out, but due to extreme

risk, experimental and scientific studies of such landscapes are extremely dangerous.

The territory of Kryvyy Rih region is dominated by a quarry-terraced type of terrain, which includes landslides have formed in the areas of: western dumps of the Gleuvatsky quarry, the dumps of the Kirov RU, Burschitsky dump, the dump of the Soviet quarry, Skelyuvatsky dump, the dump of the Ingulets quarry, the Nikolaevske sludge depository, the United sludge depository, the Mirolyubivske sludge deposit.

The mine-falling type of terrains is characterized by a complex geomorphological structure, differed by high dynamics of landscape formation processes and phenomena. The subsidensed zones Kryvbas were created there: they are areas of alienation where the original landscape is developed. They are characterized by a significant difference in altitudes (depth of falling funnels is up to 200 m), harsh environmental conditions for vegetation development. The landscape structure of the falling zones is characterized by a considerable diversity of landscape complexes.

Falling zones were formed on the territory of Kryvyy Rih region, namely the Turnovskaya RU, RU named after R. Luxembourg, OJSC “Sukha Balka”, RU named after Kirov, mine named after ZOT, RU named after Illich, the Komsomolsk mine.

Now 12 sludge deposits are located in Kryvyy Rih region. Strong winds causes blow up of hundreds of tons of dust from the surface of the sludge deposits, which is carried up to a distance of 3 - 5 km, polluting air, soils, reservoirs. a lake-desert landscape is formed on the surface of these waste heaps, which sometimes resembles a "lunar surface". Sludge deposits are located along the whole territory of Kryvbas [11].

The total area of mining landscapes of the Kryvyy Rih region is 17.1 thousand hectares. These are:

- area of the quarries is more than 4.2 thousand hectares;
- area of waste heaps – 7.0 thousand hectares;
- area of extractive landscapes (sludge deposits) – 5.5 thousand hectares;
- area of mine dips and displacement zones – 3.4 thousand hectares.

The above figures are constantly changing, due to the continuous continuation and expansion of mining operations and dumping.

In the future, the scale of landscape diversity of mining landscapes will increase due to the increase of the area of quarries and waste heaps, expansion of the falling zones, activation of karst processes, development of vegetation, biota settlement.

Conclusions. Landscape diversity has become manifested in the territory of Kryvyy Rih region due to the intensive development of technogenesis. It caused replacement of natural landscapes to industrial-residential ones. Landscape factors play an important role in shaping landscape diversity, which leads to the formation of a new landscape structure. The scale of activation and development of various processes and phenomena in the territory of Kryvyy Rih cause the formation of landscape complexes of different rank from tracts and sites to terrains. In general, quarry-dump and mine type of landscape complexes were mostly developed in the territory of Kryvyy Rih region, which in turn is divided into a large number of subtypes. The pronounced subtypes of landscape terrains in the territory of Kryvyy Rih region are mines, adits, drifts, quarries, sludge deposits, dumps, waste heaps. Modern problems of research of landscape diversity of mountain landscape in the Kryvyy Rih region are the following: a new geosystem is being formed due to technogenic landscape-forming processes. The active development of technogenesis on the area of Kryvyy Rih region leads to complete

transformation of individual geocomponents and landscape complexes and change of their structure into new geotechnosystems.

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