LITHOGENIC BASIS OF MORDOVIAN'S LANDSCAPE: GEO-ECOLOGICAL ASPECT OF RESEARCH

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Abstract: The article describes the results of mapping and typing of the lithogenic basis of the Mordovian forest-steppe landscape. The analysis of the structural components of lithogenic basis is an essential element in the process of designing the region. This facilitates the choice of the most adequate strategy of development within the landscape. The assessment of the landscape's ecological potential, the organization of geo-ecological monitoring, as well as the landscape's territory structure, have a special importance in the process of sustainable usage of the Modrovian natural environment. In this respect it is necessary to design thorough studies of geo-ecological research on the lithogenic structure of Modrovia's geographical region.

Keywords: forest-steppe landscape, geoecology, lithogenic basis, Mordovia

The term of lithogenic basis was proposed for the first time in 1914 by Robert Ivanovich Abolin (1886-1938), a famous Russian geo-botanist and physicist-geographer. He justified theoretically the necessity of studying the small-scale NTC (Natural Territorial Complex) in his work entitled *The Experience of Epigenological Classification of Mires* (Abolin 1914). He distinguished the external formations of lithogenic surface of Earth by the name of epigene (relief, vegetation etc.) and he combined their complex into epigenema, for instance a system of external nature complexes.

The issues of the landscape lithogenic basis were later analyzed in the works of Tutkovsky (1922), Solntsev (1949, 1960), Milkov (1970, 1981), Rodzevich et al. (1974), Galitsky and Zarudny (1983), Mihno (2000). Thus, Solntsev (1949) showed its leading role in the landscape formation and filled this term with the internal meaning.

In Milkov's opinion (1970, 1981) the landscape lithogenic basis should be considered in a narrow and broad sense. In the narrow sense the landscape lithogenic basis means the combination of elementary forms of relief with the peculiarities of composition and structure of near-surface rocks and it is used when mapping *facies*, stows and landscape regions. In the broad sense the lithogenic basis comprises the whole complex of geological and geomorphologic peculiarities of the territory, including the stratigraphy and lithology of the rocks, ancient and newest tectonics, modern tectonic movements, the relief of the earth surface, and hydro-geological peculiarities of the territory. For instance, Rodzevich et al. (1974) include with the landscape lithogenic basis the following:

- tectonic structure of territory;
- character of newest and modern movement of earth crust;

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- lithological composition of primary and quaternary deposits;
- proglacial and modern relief (morphostructure and morphosculpture);
- power of pre-quaternary and quaternary relief-forming rocks (especially of covering deposits);
- hydro-geological peculiarities of territory.

All researchers emphasize at present the most special significance of the lithogenic basis and lithogenic factor in landscape sphere differentiation. At the same time, nowadays there are two polar opposite points of view on the role of the lithogenic basis in landscape formation in the modern landscape science. On the one side, the lithogenic basis is considered as a stronger and more autonomous landscape component (Solntsev 1949, 1960), on the other side, the lithogenic basis is considered as an equivalent landscape component (Milkov 1970, 1981). The lithogenic version is deemed as a derivative of hydroclimatic and biotic landscape components and rocks in the last version. Speaking of the relief-forming role of biota, of vegetation in particular, Milkov (1981) has stated that the vegetation protects the lithogenic basis from wind and water erosion. The processes of carbonaceous rock dissolution are increasing in the forest landscapes due to the excessive acidity of groundwater. It leads to the formation of *karst* relief forms.

Relying on the role of lithogenic basis in the formation of landscapes, Solntsev and Milkov have expressed their opinion on the essence of lithogenic landscapes. Solntsev considers all Earth landscapes as lithogenic, while Milkov refers to this category as comprising only those NTC, in whose formation the lithological composition of external rocks has played a leading role. The evident overestimation of the role of lithogenic basis in the landscapes' formation takes place in the first case, and the underestimation of this occurs in the second case.

Mihno (2000) has suggested the term of landscape genesis. It is defined as a process predetermining the origin and development of landscape complexes under the influence of lithogenic factors. In his opinion, the lithosphere type of landscape genesis can be divided into three subtypes depending on the methods (processes) predetermining the origin and development of landscapes. These subtypes are tectonic landscape genesis, petrolandscape genesis and litholandscape genesis. The last type is specific to those territories, where the sedimentary rocks are widespread.

When defining the lithogenic basis Mihno (2000) pays special attention to the recording of the physical and chemical properties of the substratum and structural peculiarities of the lithogenic basis. It is impossible to get an overview of the landscape forming role of the lithogenic basis without such kind of information. In his opinion, the physical and chemical properties of the substratum establish the specific character of energy and mass and the energy exchange which forms the basis of landscape formation.

The interest in the examination of lithogenic basis is nowadays determined by the fact that the lithogenic basis, which represents the aggregate of abiotic conditions of a territory, predetermines to a large extent the morphological structure and numerous processes of landscape functioning. The structural elements of the lithogenic basis (power and lithological composition of aeration and water saturation zones, position of groundwater level, fields of groundwater supply, transit and discharge, position and character of landscape bottom boundary) settle such important geo-ecological characteristics of geosystems as the type of water regime, natural drainage condition and character of watering, conditions of accumulation and chemical composition of underwater, potential of self-purification, activity of geodynamic and geochemical processes etc. In this context, in our opinion, the experience of the examination of lithogenic basis of the Mordovian forest-

steppe landscape performed by us is of great interest.

Before commencing to classify the lithogenic basis, the bottom boundary of the geosystems has been determined. There is still no uniform methodological approach to determine the geosystem bottom boundary (Beruchashvili 1990; M.A. Glazovskaya 1964; Dyakonov 1971). The seasonal of the soil manifests itself up to 20-30 m depth within the boundaries of Mordovia, the limits of penetration of free oxygen into the lithogenic basis coinciding generally with the upper flow of underwater. The main mass of the living matter is concentrated within the limits of some tens of centimeters of the weathering crust; the main biogeochemical processes take place within the same zone. Thus, the bottom limits of the functioning processes in the Mordovian geosystems are comparatively close; however, they do not coincide.

In our opinion, the bottom boundary for the geosystems of various taxonomic ranks can be determined in the following way: by the first regional confining layer for the landscape, by the lower part of the underwater flow (or by the first local confining layer, which conventionally coincides with the basis of erosion of local erosion channels) for the area and stows, also by the critical depth level of groundwater for the *facies*.

We have distinguished four types of bottom boundaries of the area ranked in the republic (Maslyaev 1994). The type characterized by the existence of the regional confining layer, occurring beneath the layer of comparatively uniform water-permeable rocks is the most widely spread. The well-defined groundwater surface is formed in these conditions as a rule. There is no connection of the landscape water with the artesian water or it is highly hindered. The bottom boundary is determined by the lithological sign and is mapped by the first regional overlying confining bed, which as a rule represents the surface of the primary rocks of Cretaceous and Jurassic periods. If the surface of pre-quaternary rocks is represented by the mass of interstratified sands and clays, then it is very difficult to establish the overlying confining bed according to the lithological sign. The bottom boundary of geosystem is determined by the value (depth) of the local erosion basis. Such a type of bottom boundary is specific to the types of areas of lower and medium landscape elevations of erosion and denudation plains, dividing interfluve areas of landscapes of secondary till plains.

The second type of bottom boundary of geosystems is similar to the first one to a large extent. Its peculiar feature is the existence of a deep aeration zone and of dead horizon of high power. The hydraulic connection of soil and ground waters is completely absent. The bottom boundary is marked according to the lithological sign – depth of considerable attenuation of rock fracturing. The ground waters are highly mineralized. The connection of landscape waters with the artesian ones is hindered. Such a type of boundary is peculiar to the landscapes of erosion and denudation plains of the well-drained area of outlier and dividing type.

The bottom boundary for the third type has been marked along the bottom of the river's valley, whose boundary conventionally coincides with the overlying confining bed of primary rocks overlaid with the mass of permeable rocks. In this case a well-seasoned and shallow horizon of ground waters is formed. There is a constant and regular hydraulic connection of soil and ground waters in such geosystems. A peculiar feature is that there is a permanent hydraulic connection of landscape and artesian waters in the hydro-geological oceans, consisting of permeable rocks. This type is specific to the meadow alluvial areas of valley landscapes.

The fourth type of bottom boundary is distinguished in the geosystems, which lie on the carbonate rocks, in the landscapes of glaciofluvial valleys, terraces above the flood plain and flood plain meadows of valley landscapes. The fractured limestone and dolomites cannot serve the impermeable

horizon as the mix of landscape and artesian waters takes place. In this case the bottom boundary of geosystems has been marked according to the hydrodynamic indices. Thus, the bottom boundary of geosystems determines the character of water exchange between the landscape and artesian waters. The geosystems, which have additional watering by artesian waters, can be a source of their pollution.

The power of lithogenic basis of geosystems within the boundaries of the Mordovian forest-steppe landscapes is not uniform. The maximum power is specific to the landscapes of erosion and denudation valleys of the remnant and dividing area (to 50.0 m). In this case the geosystems, which have been formed on the chalk, have greater power than the drained geosystems, which lie on the terrigenous rocks. The general decrease of power of lithogenic basis from the water-dividing to near-valley area types is specific (from 7.5 to 15.0 m).

The decrease of the lithogenic basis power from the water-dividing to the near-valley area types is typical of landscapes of the secondary till plain. The lithological and hydrogeological peculiarities of the structure of lithogenic basis of glaciofluvial valley landscapes determine the special differences in the distribution of the power of the lithogenic geosystem basis. The depth of the bottom boundary is quite different. The general regular decrease of the power of the lithogenic geosystem basis from the water-dividing to the near-valley area types is typical.

The depth of the bottom boundary of valley geosystems is also irregular. Its values increase as a rule in the valleys of large and middle-size rivers of the republic and decrease in the valleys of small and very small rivers. The general tendency of increase in the geosystem's power from the flood plain meadow geosystems to the ones of terraces above the flood-plain is preserved.

The power of the aeration zone within the boundaries of the Mordovian landscape is changed from 0.1 m to 43.5 m. The decrease in the aeration zone power takes place from the dividing range to the river and creek valleys. The lithological composition of aeration zone rocks is various and facially different. Five lithological types of aeration zone can be distinguished in the republic. These are:

- sand (sands, sand clay);
- argillo-arenaceous (clay-loams with clay bands);
- stratified (stratification of sand, clay-loam, clay and other rocks);
- peat-lite (peat, undecomposed vegetation remnants);
- fracture-rubble (break marl stone, gaize, rotten-stone with clay-loam strata).

The sand type is most widely spread in the landscapes of glaciofluvial valleys, the clay-loam type is widespread in the landscapes of near-valley areas of secondary till plains and erosion-denudation plains. The stratified type of aeration zone is also widely spread. More often it is met in the valley landscapes. The peat-lite type has a local distribution in the mire geosystems. The fracture-rubble type of aeration zone is quite developed in the remnant and dividing areas of landscapes of erosion and denudation valleys.

The power of the lithology of aeration zone rocks, the level of erosive relief roughness determines the character of natural landscape drainage. We have distinguished four categories of geosystem according to this index. They are intensively drained, drained, poorly drained and very poorly drained.

The comparative analysis of the mechanical soil composition, of the lithology of aeration zone rocks, of the position of groundwater level, of the drainage degree, of landscape and geochemical conditions, of the power of the water saturation zone has allowed us to distinguish five types of water regime of the Mordovian geosystems: permacidous, semi-permacidous, impermacidous, periodically water-saturated and water-saturated. Each type has its peculiar water supply of landscape and

character of substances' water migration. The geo-ecological analysis of different types of water migration of chemical substances in the republic's geosystems has revealed that the highest danger of accumulation of technogenesis products in the landscape is typical of impermacidous geochemical landscapes. The accumulation of polluting substances in the soil's upper level takes place here as a result of low water permeability. The favourable conditions for accumulation of toxic substances are also met in the flood meadow landscapes with the periodically water-saturated and water-saturated regimes. The highest danger of possible accumulation of technogenesis products has been established in the water-permeable sandy and clay soils of glaciofluvial valley landscapes.

To study the vertical structure of the lithogenic geosystem basis we have used three information blocks:

- air and satellite images;
- graphic maps (a series of meso-scale maps);
- fund material in geological and geomorphologic, hydro-geological conditions.

The method of mapping the vertical structure of the lithogenic basis is quite simple. The data concerning the drill holes has been applied to the republic landscape map with the scale of 1:200000 (Yamashkin 1998). The analysis of fund material according to the vertical structure of lithogenic basis has been carried out for each landscape area. There have been established the mean values of the lithogenic basis power, the depth of ground water level, a set of structural geological horizons etc. The horizontal boundaries of lithogenic basis have been adjusted according to the maps of the primary and quaternary deposits, the depth of groundwater level, engineering and geological map, according to the materials of deciphering air and satellite images. A sketch map of the main types of the lithogenic basis of the Mordovian geosystems has been drawn up basing on the mapping results.

The classification of the types of lithogenic basis has been performed for the explored territory. The largest unit of this classification is a group of types of lithogenic basis. The orographical sign, which the exogenetic processes are subject to, has been set as a basis of their classification. Five groups of lithogenic basis types can be distinguished in space according to five forms of landscape areas, of which each being characterized by its peculiar features of matter and energy exchange both vertically and horizontally.

The boundaries of the subgroups of the types of lithogenic basis have been marked taking into account the peculiarities of primary rocks, which represent the regional confining bed and determine the character of engineering and geological processes, position and interconnection of ground and artesian waters. The subgroups of the types of lithogenic basis can be distinguished within each group. These subgroups are:

- subgroup on the carbonate rocks of the Upper Cretaceous period;
- on the terrigenous rocks of the Lower Cretaceous and Jurassic period;
- on the carbonate rocks of the Carbonic period.

The ranges of the types of lithogenic basis are distinguished within the subgroups according to the character and intensiveness of the geosystem's water regime. These are the types with the permacidous, periodic permacidous, impermacidous, periodically water-saturated and water-saturated regimes.

The smallest subdivision of the vertical structure of the geosystem lithogenic basis is the type of lithogenic basis. The main criteria of its definition are as follows:

- lithological and genetic structure and engineering-geological properties of rocks;
- geomorphologic conditions;
- natural drainage level and position of groundwater;
- hydro-chemical conditions of groundwater. The various combinations of enumerated factors

determine the variety of types of the lithogenic geosystem basis.

We have distinguished 64 types in the territory of Mordovia. It is possible to distinguish one dominating type or some associated with the types of lithogenic basis within the landscape areas according to the division of areas into dominant and subdominant stows.

Conclusions:

The geo-ecological stability of the lithogenic basis of forest-steppe landscapes is determined by the interrelation of a whole complex of exogenic geomorphologic processes: gully erosion, *karst*, subsoil erosion, formation of landslides, mire formation, sheet flood, submergence, silting of water bodies. Three types of geosystems have been distinguished according to the stability of lithogenic basis.

- Relatively stable – there are no massive deformations of lithogenic basis. These have been agriculturally developed lands since the ancient times (developed before the first half of the 19th century) with poorly developed destructive processes. The geosystems of near-valley spaces of secondary till plains and erosion-denudation valleys, geosystems of terraces above the flood plain with the dark grey forest soils, *podzolized* chernozems and leached valley landscapes refer to this group.
- Poorly stable – there are considerable deformations of the lithogenic basis as a result of the activation of erosion, landslide and other exogenic geo-morphological processes. The landscapes of glaciofluvial valleys, geosystems of middle slopes of landscapes of secondary till plains and erosion-denudation plains, practically all valley landscapes refer to this group.
- Unstable – there are large and massive deformations of lithogenic basis, intensive landslide formation and gullying, *karst* and subsoil erosion processes, which lead to inevitable modifications or deformations of geosystems. As these landscapes have been engaged in agricultural development since the second half of the last century, their further development should be directed to the extension of forestlands and meadowlands, used as specially protected natural areas (geosystems of remnant and divide and near the water divide areas of landscapes of erosion-denudation plains, geosystems of water divide areas of landscapes of secondary till plains).

The performed geo-ecological analysis and evaluation of stability of lithogenic basis of the Mordovian forest-steppe landscapes is a component of general evaluation of stability of geo-ecosystems of the Republic of Mordovia and it allows estimating the territorial-differential approach to their development and forecasting of unfavorable geo-ecological processes even today, at this stage of research.

Rezumat:

LITOGENIA DE BAZĂ A REGIUNII GEOGRAFICE MORDOVIENE: ASPECTE GEO-ECOLOGICE ALE CERCETĂRII

Articolul descrie rezultatele cartografierii şi tipăririi litogenicului bazal din regiunea de stepă-pădure a Mordoviei. Analiza componentelor structurale ale litogenicului bazal reprezintă un element esenţial în procesul de proiectare a regiunii. Ea facilitează alegerea celei mai adecvate strategii de dezvoltare în cadrul regiunii geografice. Evaluarea potenţialului ecologic al regiunii, organizarea monitorizării geo-ecologice, precum şi structura teritorială a regiunii au o importanţă deosebită în procesul de utilizare durabilă a mediului

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natural Mordovian. În acest sens este necesară realizarea de studii amănunțite de cercetare geo-ecologică a structurii litogene a regiunii geografice din Mordovia.

References:

ABOLIN R.I. (1914), The experience of epigenological classification of Mires, *Science of Mires*, 3: 231-239.

BERUCHASHVILI N.L. (1990), *The landscape geophysics: Study guide*, Vyschaya Shcola, p. 278.

GALITSKY V.I., ZARUDNY R.F. (1983), The lithogenic basis and its role in formation of territorial natural complexes*, The landscapes of Kiev suburban area and their rational use*, Kiev, p. 51-77.

GLAZOVSKAYA M.A. (1964), *The geochemical fundamentals of typology and methodology of research of natural landscapes*, Publishing House of Moscow Univeristy, p. 230.

DYAKONOV K.N. (1971), *The study of vertical structure of landscape, The methodology of landscape research*, p. 67-73.

MASLYAEV V.N. (1994), The structure of Mordovian geosystems and its analysis for the purpose of water amelioration: author's abstract, *Cand. Sc. (Geography)*, p. 24.

MILKOV F.N. (1970), *The landscape sphere of the Earth*, Mysl, p. 207.

MILKOV F.N. (1981), *Physical geography: actual situation, regularities, issues*, Voronezh University Publishing House, p. 395.

MIHNO V.B. (2000), The new insights in the landscape lithogenic basis, *Newsletter of Voronezh University. Series Geography and Geo-Ecology*, 4: 15-19.

RODZEVICH N.N., LYUBUSHKINA S.G., VASILIEVA I.V. (1974), The history of formation of landscapes of marginal zone of Moscow glacial area, *Landscape Science*., p. 4-32.

SOLNTSEV N.A. (1949), About morphology of natural geographical landscape, *Landscape Science*, p. 61-86.

SOLNTSEV N.A. (1960), The diurnal cycle in the landscape dynamics, *Newsletter of Moscow University. Series 5. Geography*, 6: 70-73.

TUTKOVSKY P.A. (1922), *The natural zoning of Ukraine. The genetic classification and division of physical and geographical zones of Ukraine on the basis of their geological evolution*, Kiev, p. 79.

YAMASHKIN A.A. (1998), *The physical and geographical conditions and landscapes of Mordovia*, Saransk, p. 156.