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## GEOMORPHOLOGICAL STRUCTURE OF SOIL COVER RELIEF OF THE VINNYTSIA REGION AS A FACTOR OF THE INTENSITY OF EROSION PROCESSES

**Bronnikova L.**
*senior lecturer*
*Vinnytsia National Agrarian University*

**Abstract**
The results of studying the features of erosion resistance of soils of Vinnytsia region with regard to the features of geomorphological structure of the terrain (slope steepness) based on the results of recent surveys and outlined the main directions of reducing the intensity of erosion processes given the agro-technological features of the region.

**Keywords:** soil, soil cover, water erosion, fertility, erosion processes.

**Introduction.** Most of the territory of Vinnytsia region is located within the Ukrainian Crystal Shield which is part of the Eastern European platform. In the north and northeast, the foundation of the shield rises above the surface by 100-280 m above sea level. The relief of the foundation is complicated by numerous local tectonic uplifts and depressions, which are reflected in its current state.

The foundation of the shield within the Vinnytsia region is composed of igneous and metamorphic crystalline rocks of the Archaea and Lower Proterozoic. On top of the crystalline basement of the region there is a low-thickness sedimentary layer formed of Upper Proterozoic rocks and Cretaceous, Paleogene, Neogene and Quaternary systems of the Phanerozoic, on its southwestern edge. The geological history of the region is complex. It also influenced the formation of relief [1, 2]. The foundation of the territory [3] consists of rocks, the formation of which dates back to Precambrian times. They are mainly granite gneisses. Outcrops of Precambrian rocks on the day surface take place in deep ravines, gullies and in the form of rapids on rivers (especially on the Southern Bug and its tributaries and the Dniester - near Yampol). Reddish and gray granites of Precambrian origin occur in outcrops along the Markivka and Rusava rivers. Most outcrops of crystalline rocks on the day surface are observed in the strip between the lines (conditionally) Kozyatyn-Pogrebyshche and Mohyliv-Podilskyi-Yampil. Part of the Ukrainian Crystal Shield, located within the Vinnytsia region, has a general slope to the west-southwest. Therefore, in the Dnieper, crystalline rocks are covered with a thick layer of sedimentary sediments of Paleozoic and Mesozoic age.

**Formulation of the problem.** Silurian marine sediments are quite common in the Dnieper. They are represented by coarse-grained sandstones, green, gray and purple shales, limestones. Silurian deposits are distributed in the area bounded (conditionally) by a line passing through the village of Zhvan (Murovano-Kurylovetsky district), Nemerchi station to the village of Chernivtsi. Further to the southeast, the Silurian deposits are distributed in the lower reaches of the rivers Rusava and Yalanka, to the confluence of the Markivka and the Dniester. In some places, the Silurian sediments are 250 to 350 m thick. The Cretaceous (Mesozoic) sediments are quite common in Transnistria. Like the Silurian deposits, the Cretaceous rocks stretched in a wide strip along the Dniester, from the Zhvan and Karaets rivers to the Kamyanka river basin. The thickness of the Cretaceous sediments reaches 40, sometimes 60 m. In comparison with the Paleozoic and Mesozoic sediments, Neogene sediments, in particular, the Sarmatian and Baltic tiers, are widespread in a much larger part of the region.

**The purpose of the article.** The eastern boundary of the distribution of Sarmatian tier deposits passes approximately through Vinnytsia, Humenne station, p. Yurkivtsi (Nemyriv district), Dashiv village (Illinetsky district), Kuzmyntsi village (Haisynsky district), Ladyzhyn (Trostyanets district), Sobolivka (Haisynsky district), on the left bank of the Southern Bug to Haivoron (Kirovohrad region). Sarmatian sediments are represented mainly by oolite and shell limestones and have a thickness of 5 to 100 m. These sediments are well preserved in watersheds, and in river valleys they are blurred. Limestone deposits of the Sarmatian Sea are widespread throughout Transnistria. Thus, in the basin of the Rusava River, oolite limestones have a layer thickness of 80-85 m, and along the Kamyanets River - 25 m. lime. Deposits of the Baltic tier are mostly distributed in the left-bank part of the Southern Bug, in the central and southern parts of the region, mainly in watersheds. White loose sands, brittle sandstone, red, brown clays and pebbles alternate in the Baltic deposits. The thickness of the deposits is from 5 to 120 m (the largest in the south-eastern part of the region). Anthropogenic sediments are distributed throughout the region. They are represented by brown clays, forest and forest-like loams, alluvium on river terraces. In the north-eastern part of the region, sand and pebble deposits are very common, which are believed to have brought here the melting glacial waters of the last glaciation (Dnieper).

**Results.** The relief of the territory is heterogeneous, because in its formation a significant role was played by neotectonic movements of the earth's crust, climate and other factors and in the overall assessment in relation to sea level is elevated.

According to the scheme of geomorphological

zoning, the territory of Vinnytsia region is located within two geomorphological regions: Volyn-Podilska and Pridnestrovsko-Pryazovska, in turn within these two regions the following geomorphological subregions are distinguished: Podilska structural-denudation upland, Baltic alluvial-delta plain, Pivna hydroglacial and hewn plain, West Dnieper denudation upland and Central Dnieper denudation upland within two geomorphological provinces - Podil and Dnieper. The Dnieper uplift in the territory of Vinnytsia region gradually turns into Podilsk. The watershed of the Dniester and the Southern Bug, mainly its north-eastern slopes, is a conditional geomorphological boundary between the Dnieper and Podil uplands.

Podil and Prydniprovska uplands stand out in the relief of Vinnytsia region. The border between them is conditionally drawn along the valley of the Southern Bug River. Most of the territory of Vinnytsia region is occupied by Podil structural-denudation upland. The maximum height of the Podil Upland is located in the area of Zhmerynsky elevation near the village of Borschi-Chemeryske and is 370 m above sea level.

The geological development of the territory of Vinnytsia region has undergone a corresponding evolution with the formation of a corresponding modern geological structure [4]. In the late Mesozoic and Cenozoic, the Ukrainian crystal shield was influenced by differentiated block movements. As a result, the raised plain of the shield is divided into five geomorphological stages. Within the boundaries of Vinnytsia region there is the Bug-Dnieper geomorphological stage. Its structural basis is tectonic blocks: Vinnytsia, Berdychiv, Haisyn, Yampil.

The Bug-Dnieper geomorphological stage has absolute heights of 200-300 meters. The surface is a slightly undulating plain. Of the rocks most common here are granites, granite gneisses and others. Maximum absolute heights are found in the extreme southwestern part of the region, where they reach 330 - 340 meters; on the watersheds of the rivers Snyvoda, Gnilopyat, Rostavytsia, Rossi, the height is slightly less than 280-300 meters. Southwest of Khmilnyk near the village of Pedosy is the highest point of the Dnieper Upland - 340 meters.

From the north-west to the south-east there is not only a general slope of the elevation surface, but also its greater length (more than 200 kilometers, with an average width of 60 - 80 kilometers).

The relief of the Dnieper Upland is not entirely homogeneous. In the western part it is calmer: the river-beam system is relatively dense, the river incisions are shallow; but in the east and especially in the south-east the nature of the relief changes greatly: there are many ravines, the number of beams and slopes increases.

The Podil upland (upland plain) has a geostructural basis of the south-western part of the Ukrainian Crystal Shield and the Podil plate, which within the Vinnytsia region is only their eastern outskirt [5].

The basic basis for modern relief is the Sarmatian-Pontic surface with the development of ancient alluvial, deltaic and typical marine Sarmatian Pontic plains. The period of continental rupture here began after the retreat of the Sarmatian Sea.

Podolsk Upland is inclined from north and northeast to south and southwest, has a submeridional direction. This location, as well as the significant slope of the surface in the southern direction determined the meridional and parallel tributaries of the Dniester River, the valley of which is an essential element of the relief of the Podolsk Upland. The second, no less important feature of the southern slopes of the elevation is a kind of asymmetry of its interfluves. The deep incision of the rivers of the Podil Upland into the earth's surface, their narrow, in places canyon-like valleys, stretching from north to south - is the third common feature of this area. Also, a significant role in the structure of the relief of the region is played by the river valleys of the Southern Bug basin, the Dniester and partly the Dnieper.

The Dniester washes the extreme southern and part of the south-western border of the region. Within the Vinnytsia region it flows through a narrow, very winding and deep valley with highly elevated shores, especially steep left bank. Characteristic is the presence of terraces, of which there are four near the city of Mogilev-Podolsk. The river flows along the territory of the region with the middle course and the Dniester valley forms six large incised meanders (river bends). Water level at the entrance of the Dniester to the borders of Vinnytsia region near the village Bernashivka is 69 meters, near Kozlov - 66 meters, in Mohyliv-Podilskyi - 60 meters. The farther to the south-east, the greater the slope and the greater the speed of flow: in the ravine the water level is - 56 meters, in Yampol only 48 meters. Outside the region, the water level does not exceed 38 meters above sea level.

The valley of the Southern Bug and its tributaries are cut to a depth of 100-200 meters and has a beautiful bottom. The general direction of the Southern Bug to the southeast, but in some areas the river significantly changes direction, forming a kind of meandering. In some places the river is blocked by rapids [6].

The structure of the Southern Bug valley is different in different parts. The left bank of the Bug near Ladyzhyn is covered with a narrow strip of sand.

Characterizing the relief of the surface there are two types of valleys: sewage and bypass. Bypass valleys occupy the area from northwest to southeast. They inherited early Quaternary erosion depressions. Sewage - formed as a result of erosion of water-glacial flows. In the Vinnytsia region, mainly waste valleys are common, although sometimes they are found in combination with bypasses. One of these valleys, very wide in size, is called Letychiv-Lityn plain.

A significant role in the structure of the relief of Vinnytsia region is played by ravine-beam forms. The southern and south-eastern parts of the region are mainly exposed to dismemberment by beams and ravines. The ravines here are highly developed and occupy a large area.

Also widespread within the region are landforms formed by gravitational processes (landslides). These processes, which cause great damage, are widely developed in the south of the region and require the application of appropriate measures to combat these dangerous natural phenomena.

Forms of technogenic relief, represented by numerous quarries for the production of various building materials, reclamation and drainage canals, etc., have become of great importance in the Vinnytsia region.

Geomorphologically, the territory of Vinnytsia region is located within the Right Bank Upland, which is represented mainly by the Podolsk Plateau, Prydniprovska Upland and Southern Pobuzhye, or two geomorphological regions - Azov-Prydniprovska and Volyn-Podilska, respectively, subregions of Prydniprovschyna and Podil.

The Podil plateau occupies most of the region and lies to the west of the conditional line: the upper reaches of the Snyvoda River - the town of Kalynivka - the upper reaches of the Sob River and further along its valley and the Southern Bug Valley to the regional boundary. This is the most elevated, dismembered and eroded territory, especially its part, which is inclined to the Dniester. Researchers believe (Bondarchuk VG, 1949) that the relatively rapid rise of this area, which was observed in anthropogenic times, led to increased erosion of the southwestern slopes of the Podolsk plateau. The eastern and northeastern parts of the plateau are much less dissected. The Dnieper Upland extends from the upper reaches of the Snyvoda River to the Tikich Mountain (northeastern part of the region). Their slopes are also cut by numerous river valleys, but the general dismemberment of the surface is much smaller and the area has the appearance of a gently undulating plain.

According to the structure and shape of the relief and river valleys, the subregion of the Dnieper Upland is divided into a number of geomorphological areas.

Kozyatyn structural-denudation watershed upland. As a geomorphological area, these are the watersheds of the interfluve of the Southern Bug and the Dnieper, their numerous tributaries: the rivers Snyvoda, Desna, Gnilopyata, Guyva, Rostavytsia, Rosi, Rosky, and Soba [7].

Kozyatyn watershed is one of the largest in the region in terms of area. The southern border in the extreme north-western part coincides with the well-defined valley of the river Khvos and runs along the line of villages Tessa - Ivanivtsi - Shevchenkovo - Kozhukhiv - Bruslin and further east through the villages Bruslinov - Penkivka - Mizyakiv, where it coincides with the valleys of Pivden Bug; from the top of the Desna the southern border coincides with the direction of the riverbed and from Turbov along the valley of the river Vilshanka it is directed to Vakhnivka - Zoziv - Lypovets - Dashiv, along the valley of the river Sob to the confluence of the stream Soroka.

Kozyatyn Upland is the quietest territory of Vinnytsia region. Although it is quite elevated above sea level - the absolute heights here are 290-305 meters, but the division of the territory is insignificant, the valleys of gullies and rivers have shallow incisions and gentle slopes. Watershed plateaus here are relatively wide, slightly undulating and predominate in the area of the slopes [8].

On the territory of the hill there is a well-defined relief valley between the headwaters of the rivers Gnilopyata and Rostavica. The valley is composed of water-glacial deposits. Its depth does not exceed 30 meters. In addition to the passage valley, in the northern part of the Kozyatyn Upland on the border with Zhytomyr and Kyiv regions there is a whole system of passage valleys between the rivers Teterev and Snivoda, Glylopyat and Postolova, Gnilopyat and Guyva, Guyva and Rostavytsya, Rostavytsya and Desna, Rostavytsya and Rostsy. etc. They are not always well expressed in relief and do not always attract the attention of researchers.

Vinnytsia denudation-accumulative undulating plain. Occupies the central part of the region from the valley of the Southern Bug in the west to the valley of the river Sob in the east; in the north it passes into the Kozyatyn watershed, and in the south, where its boundary is not clearly traced, it borders the northern slopes of the Podil Upland.

A detailed analysis of the relief and geological structure of the area makes it possible to identify differences in the geomorphological structure of the left and right bank parts and therefore can be divided within this area two geomorphological subdistricts: left bank (main) and right bank.

The left-bank subdistrict is relatively less elevated and dissected. The average height above sea level is 280-300 meters, reaching 310 meters in the extreme west near the village of Yaryshivka and decreasing in the eastern part to 235-240 meters. The right-bank territory is slightly higher than 290-323 meters.

The left bank is sloping in the southern and southeastern directions, the right bank - more to the north. The left-bank part is weakly dissected by river valleys, except for the Southern Bug and the Sob, there are almost no significant rivers. Thus, only one Voronka stream flows through Voronovytsia towards the Southern Bug, and only in the villages of Korzhivka, Raigorod, and Nizhnyaya Kropivnya small streams flow into the Southern Bug.

The hydrographic grid of the Sobu basin is slightly thicker. The floodplain of the Sob River in the middle course (from Illintsi to Bubnivka) is relatively wide, swampy in places, and well terraced. The right bank is less terraced compared to the left and terraces are found only in the area of the villages of Dzvonykha, Kolyukhiv, Rogozna, Pechera, Markovo, Bratslav.

The relief is associated with the widespread distribution in the past in the area of forests and, accordingly, podzolic soils. The general branching of the surface caused the formation of eroded soils in the region of varying degrees.

Letychevsko-Litynska water-glacial-alluvial plain. This is a kind of geomorphological area of the Dnieper Upland. Geologically, the Lityn Plain consists of a small layer of water-glacial sand and sandy deposits on forest-like loams. The plain is a valley-like terraced depression between Letychev (upper reaches of the Southern Bug) and Lityn (Zhar river valley).

The total length of the plain does not exceed 75-80 kilometers, with a width of 12-16 kilometers, although within the region the plain itself is clearly expressed only on the meridian Lityn - Settlement, and then to the east turns into a wavy depression, which is divided into two bands: one of them stretches along the

valley of the river Zgar to its connection with the Southern Bug and further in the direction of Lavrivka - Strizhavka; the second, much wider in area and better expressed in relief, is located in the direction of the rivers Riv and Rivets, forming between the valley of the latter and the valley of the Southern Bug a kind of intermediate valley.

The eastern border of the Letychiv-Lityn plain is the valley of the Southern Bug. In general, the Lityn plain has a slightly undulating flat surface with depressions. Podolsk Upland is also divided into a number of geomorphological districts and subdistricts. Zhmerynka dismembered forest upland. Occupies the most elevated part of the region. Absolute marks are 364-370 meters (near Bar). This is the territory of Barsky, Zhmerynsky, part of Tyvrivsky, Shargorodsky and Tulchynsky administrative districts [9].

In the north and northeast, the hill borders the Letychevsko-Litynska plain and Vinnytsia denudation-accumulative plain, in the south with Mohyliv-Podilsky Transnistria. The total length of the height is over 110 kilometers and its eastern edge it reaches Vapnyarka. The width in the western and central parts is 40-50 kilometers. Zhmerynska Upland has the shape of a triangle with a base of 50 kilometers in the western part on the border with Khmelnytsky region and sides 110-115 kilometers long. In geomorphological terms, the Zhmerynska Upland is an interfluve of the massifs of the Southern Bug and Dniester rivers.

The territory is densely and deeply dissected by a ravine-beam system. Wet narrow sometimes swampy floodplains are found only in the valleys of large tributaries of the Dniester - the rivers Lyadov and Muraf. In general, the height is inclined from north-west to south-east, decreasing near Vapnyarka to 298 meters.

Zhmerynska Upland is a center of active modern water plane and deep erosion, where the entire surface is constantly washed away, and 20% -30% of cases - strong, which leads to an annual loss of 45-50 tons of fertile fine soil per hectare of arable land. Mohyliv-Podilska is a dismembered raised plain. Geomorphological area occupies the southern part of the region. This area is sometimes called Vinnytsia or Mohyliv-Podilskyi Transnistria. It stretches in a narrow strip along the entire course of the Dniester from the western border of the region. The geological basis of Transnistria is (partially) the southwestern outskirts of the Ukrainian Crystal Shield.

The water part of the district is calmer and less dissected by relatively wide beams; the Transnistrian part is very complex in relief, cut by canyon-like deep river valleys into a system of narrow, sloping from north to south sections. Therefore, there are four geomorphological subdistricts: Kopaygorod erosion-denudation low-wave plain, Limestone erosion-denudation undulating plain, Dniester over-canyon terraces and Dniester canyon.

Kopaygorod erosion-denudation weakly undulating plain covers the mouth and middle reaches of the rivers Zhvan, Lyadova, Nemia, Murafa and a narrow strip of 15-20 kilometers stretches from the western border of the region to the strip of the Sarmatian tier, crossing Transnistria in Transnistria in Transnistria .

This is a watershed of Transnistria with heights of 300-310 meters and a relatively calm slightly undulating relatively flat terrain.

The headwaters are slightly curved to the northwest. They acquired a meridional direction after the formation of the river network and the rapid geological uplift of the terrain.

The plain consists of crystalline rocks of the Podolsk Black Whale Formation. Above them lies a sedimentary complex of sandy-limestone rocks of the Lower Sarmatian. Sometimes the slopes are composed of crystalline rocks and partly Sarmatian limestone.

The limestone erosion-denudation undulating plain is an integral part of the Baltic Pliocene plain. It covers the interfluve of the Markovka, Vilshanka, Kamyanka rivers and lies to the east of the Kamenskaya reef ridge, which is weakly expressed in the relief near Tomashpol. The river valleys are sparsely terraced here. The ravine-beam network, due to the large slope of the area to the southwest towards the Dniester, is more developed than on the Kopaygorod plain. At the base of this plain lie crystalline rocks - pygmatites.

Quaternary deposits are represented mainly by deluvial loams, sometimes with admixtures of Carpathian pebbles. They occur mainly on the slopes of the beams, on the watersheds are absent. Floodplains in the upper reaches are wider than in the lower reaches, sometimes slightly swampy.

The relief of the northern part of this subregion to the latitude of Gorodkivka - Kryzhopil is relatively calm. The area is raised an average of 300 meters above sea level. Although the southern half of the subarea, the eastern boundary of which is the watershed between the rivers of the Lower Bug and the rivers of the Dniester, is very complex: in relief most narrow watersheds and sloping lands are very complex. This area is most affected by water erosion from all geomorphological areas of the region.

The area of the Dniester canyon terraces stretches up to 30 kilometers along the Dniester riverbed from northwest to southeast. There are two parts of the subarea: the outer, which borders on the Kopaygorod erosion-denudation weakly undulating plain, and the inner, border subarea of the Dniester canyon.

The outer part is an area with absolute heights of 250-270 meters and deepening (incision) of riverbeds into the surface up to 150-200 meters. The geomorphological structure is the territory of the fourth and fifth terraces, raised above the level of the Dniester riverbed by 50-60 and 90-100 meters. The slopes of the valleys are steep, and the rivers have the character of mountain streams.

The inner part is mainly the territory of the first, second and third floodplain terraces of the Dniester. Rapid currents, river regimes, the structure of valleys resemble real mountain rivers. In the upper part of the slopes of the canyons on the rivers Zhvan, Karaets, Lyadova, cornices formed on both sides of the valleys are formed, formed by weathered limestones. Cenomanian flint marls, Cambrian sandstones and shales are exposed on the slopes below. Floodplains are very narrow, sometimes completely absent.

Within the boundaries of Mohyliv-Podilskyi

Transnistria, where the edge of the shield caused the change of direction of the Dniester valley from east to southeast, the fourth geomorphological subdistrict stands out - Vinnytsia Dniester canyon. It differs from Khmelnytsky Transnistria. First of all, there is a different climate that promotes the development of viticulture and horticulture, as well as balneology. Within the canyon there are four above-canyon terraces. Lower terraces - erosion-accumulative, upper - mostly erosion. The first terrace is covered with pebble alluvium and loam; the second - pebbles and woody loams. On the third and especially the fourth - Cenomanian marls and Middle Sarmatian limestones are deposited.

Baltic erosion-denudation dissected plain. The geomorphological region occupies the southern edge of the lowest and narrowest part of the Podolsk Upland.

In general, this slightly sloping territory is elongated in the south-eastern direction and is represented by a very narrow Dniester-Bug watershed within the south-eastern part of Kryzhopil and Pishchansky districts, as well as Chechelnytsky. The general slope of the territory is mainly to the east and south-east, and partly to the south. The highest mark of the surface near Vapnyarka - Kryzhopil - Yavorivka - Rudnytsia is 308-303 meters. The lowest - on the eastern outskirts of the district near Kidrasovka - Goldashivka - Berezok Chechelnytsky - 218-224 meters; in the southern direction the slope is insignificant, the heights do not fall below 259-243 meters (Britavky - Lubomyrka); in the northern part of the territory 277-265 meters (Chinatown - Buda). The difference in height from west to east does not exceed 60 meters, and the rivers are relatively calm, their valleys are wide, usually having wet, swampy, and sometimes peat floodplains, although the terraced is almost absent.

Depth of local bases of erosion within 100 meters (250 meters of height on plateaus, 130-160 meters in valleys of the rivers and beams). This area corresponds to the Tulchyn-Bershad type of eroded areas (erosion is 30-40%). The most erosive-dissected relief by the criterion of the sum of areas with steep slopes more than 50 was determined for the areas of Barsky (15.8% of the surveyed area), Zhmerynsky (15.68%), Kryzhopilsky (18.73%), Pohrebyshchensky (16.15). %), Chechelnytsky (28.23%), Shargorodsky (11.06%).

Water soil erosion as a natural and anthropogenic degradation process causes enormous environmental and economic damage in many countries around the world. In Ukraine, erosion occurs on an area of 12.5 million hectares. In the Vinnytsia region, water damage to agricultural lands, mainly arable land, is caused by water erosion of soils, as a result of which 39% of arable land is to some extent affected by planar erosion. The main reasons for this are well known: excessive plowing of the territory, heavy rainfall, sloping terrain, unfavorable structure of sown areas stimulates the development of erosion processes [10]. Currently, natural and anthropogenic factors that cause erosion are well studied. In particular, there are detailed quantitative assessments of storm danger in the region, determined the anti-erosion efficiency of agricultural vegetation, studied the erosion properties of the terrain, etc. [11]. Among the components of the landscape, the soil plays a significant role in assessing the resilience of landscape systems, especially its characteristics such as the thickness of the humus horizon, morphological structure of the profile, nutrient reserves that suffer most from anthropogenic impacts, including erosion [12].

To assess the erosion resistance of the agro-landscape and the effectiveness of anti-erosion measures, the only criterion may be the ratio of the rate of soil formation and soil erosion. Effective erosion control is possible if the current rates of erosion is equal to or lower than a predetermined level, which theoretically allows maintaining a balance between the rate of erosion losses and the rate of soil formation. Today it is proved that erosion processes directly depend on the steepness of the slopes. The steepness of the slopes primarily determines the degree of soil erosion (Table 1).

*Table 1*

**The degree of soil erosion depending on the slope**

| Characteristics of slopes | Steepness, degree | The degree of possible erosion |
|---|---|---|
| Even areas | Less than 1 | – |
| Gentle slopes | 1-2 | weak |
| Descending | 2-5 | medium |
| Steep | 5-10 | strong |

The steepness of the slopes determines the system of erosion control measures and the method of use of the territory. Approximately the dependence of the degree of erosion and the method of using the area on the steepness of the slopes can be characterized as follows: up to 1 ° the soil is not washed away, its areas do not require any anti-erosion measures; you can use them for any culture; 1-3 ° - possible weak washing away of soils, for their protection against erosion plowing should be carried out across slopes, and under steam and chills - shelfless cultivation; 3-5 ° - there is an average soil washout; it is expedient to introduce soil-protective forage crop rotations with high saturation with perennial grasses; from 5 to 8 ° - strong washing away of soils is possible; such areas are of limited use in agriculture, it is necessary to cover the edges of beams and ravines; more than 8 ° - soils are strongly washed away, they are considered unworn, they are subject to siltation and fixing in some places by artificial structures; more than 15 ° - not used in agriculture without special measures. Thus, the structure of the slope of the sloping lands of a certain area is a reliable criterion for its erosion resistance. This is confirmed by the results of our groupings in terms of areas of the region (Table 2).

*Table 2*

**Characteristics of Vinnytsia region by land slopes and technological groups (own grouping), %**

| Region/ district | Slope, $^0$ | | | | | | | | Technological groups | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $<1^0$ | $1\text{-}2^0$ | $2\text{-}3^0$ | $3\text{-}5^0$ | $5\text{-}7^0$ | $7\text{-}10^0$ | $10\text{-}15^0$ | $>15^0$ | I $< 3^0$ | II $3\text{-}7^0$ | III $>7^0$ |
| Barsky | 4,57 | 25,38 | 24,24 | 30,01 | 12,78 | 2,81 | 0,21 | 0,00 | 54,20 | 42,78 | 3,02 |
| Bershadsky | 39,63 | 25,14 | 13,38 | 12,99 | 6,04 | 2,72 | 0,10 | 0,00 | 78,16 | 19,02 | 2,82 |
| Vinnytsia | 65,63 | 17,94 | 6,01 | 6,46 | 2,70 | 1,15 | 0,11 | 0,01 | 89,58 | 9,15 | 1,27 |
| Gaisinsky | 43,13 | 28,06 | 10,46 | 11,36 | 4,46 | 2,12 | 0,38 | 0,04 | 81,65 | 15,81 | 2,54 |
| Zhmerynsky | 17,26 | 22,95 | 17,51 | 26,60 | 11,17 | 3,97 | 0,49 | 0,04 | 57,72 | 37,76 | 4,51 |
| Illinetsky | 48,81 | 32,74 | 3,10 | 10,29 | 3,51 | 1,37 | 0,18 | 0,01 | 85,49 | 13,03 | 1,47 |
| Kalinovsky | 62,95 | 24,28 | 4,30 | 4,69 | 2,55 | 1,18 | 0,06 | 0,00 | 91,53 | 7,23 | 1,24 |
| Kozyatynsky | 46,16 | 24,03 | 6,12 | 10,14 | 8,15 | 5,06 | 0,34 | 0,00 | 76,31 | 18,29 | 5,39 |
| Kryzhopilsky | 16,12 | 19,01 | 17,88 | 28,25 | 13,12 | 4,86 | 0,75 | 0,01 | 53,54 | 40,78 | 5,68 |
| Lipovetsky | 61,03 | 23,31 | 6,02 | 4,89 | 2,78 | 1,59 | 0,37 | 0,00 | 90,35 | 7,68 | 1,97 |
| Litynsky | 43,75 | 25,42 | 6,17 | 13,00 | 7,37 | 3,61 | 0,68 | 0,00 | 75,34 | 20,37 | 4,29 |
| Mohyliv-Podilskyi | 20,09 | 33,23 | 15,38 | 23,19 | 5,67 | 1,83 | 0,53 | 0,07 | 68,72 | 28,85 | 2,43 |
| Murovano-Kurylovetsky | 7,70 | 25,46 | 24,40 | 29,60 | 10,31 | 2,33 | 0,19 | 0,00 | 57,56 | 39,91 | 2,53 |
| Nemyrivsky | 44,52 | 26,01 | 11,64 | 10,12 | 5,00 | 2,47 | 0,23 | 0,01 | 82,17 | 15,12 | 2,71 |
| Orativsky | 34,26 | 20,06 | 12,57 | 16,55 | 9,24 | 6,26 | 1,05 | 0,02 | 66,89 | 25,77 | 7,34 |
| Pischansky | 8,88 | 17,50 | 21,25 | 31,31 | 16,23 | 4,46 | 0,35 | 0,03 | 47,61 | 47,55 | 4,84 |
| Pohrebyshchensky | 26,51 | 27,74 | 8,52 | 21,09 | 8,42 | 4,60 | 3,08 | 0,05 | 61,23 | 28,78 | 9,99 |
| Teplytsky | 42,34 | 25,37 | 14,65 | 12,06 | 4,00 | 1,43 | 0,15 | 0,00 | 82,36 | 16,06 | 1,58 |
| Tyvrivsky | 32,76 | 27,89 | 15,48 | 14,52 | 7,09 | 2,06 | 0,20 | 0,00 | 76,13 | 21,61 | 2,26 |
| Tomashpilsky | 13,15 | 29,74 | 13,87 | 32,68 | 7,39 | 2,69 | 0,32 | 0,17 | 56,77 | 40,05 | 3,18 |
| Trostyanetsky | 28,62 | 27,31 | 17,91 | 15,51 | 6,68 | 3,53 | 0,43 | 0,02 | 73,83 | 22,19 | 3,98 |
| Tulchinsky | 30,85 | 29,76 | 15,01 | 13,92 | 7,24 | 2,80 | 0,41 | 0,02 | 75,62 | 21,16 | 3,22 |
| Khmelnytsky | 50,84 | 26,15 | 7,43 | 6,90 | 5,35 | 2,88 | 0,46 | 0,00 | 84,42 | 12,24 | 3,34 |
| Chernivtsi | 23,44 | 38,72 | 17,91 | 10,48 | 6,60 | 2,15 | 0,62 | 0,08 | 68,71 | 28,85 | 2,43 |
| Chechelnytsky | 13,45 | 16,27 | 15,79 | 26,26 | 16,15 | 10,52 | 1,46 | 0,09 | 45,53 | 42,41 | 12,06 |
| Shargorodsky | 10,09 | 25,11 | 28,26 | 25,48 | 7,96 | 2,80 | 0,24 | 0,07 | 63,51 | 33,45 | 3,04 |
| Yampilsky | 24,09 | 34,91 | 13,98 | 20,93 | 4,29 | 1,53 | 0,22 | 0,05 | 72,98 | 25,21 | 1,80 |

Given the area of the surveyed lands for the last round (18.73%), Pohrebyshchensky (16.15%), Chechelnytsky (28.23%), Shargorodsky (11.06%).

In general, the soil cover of Vinnytsia region by erosion degradation can be divided into three main zones, of which the most eroded are the North-East and South-West. It should also be noted (Table 3) that for the conditions of the studied region in the composition of eroded soils weakly eroded lands predominate - 4.71-36.6% (in terms of districts of the region), and the smallest share - strongly eroded 0.01-4.24%. The situation is especially threatening for the conditions of Chechelnytsky (4.24% of heavily eroded lands), Pohrebyshche (3.35%), Bershad (1.93%), Kryzhopilsky (1.52%) districts, etc.

According to the defined gradation of erosion, the recommended option of grouping lands into three technological groups according to the CMOT system with the dominance of land variants of the first technological group and most of the lands of the third technological group for areas marked with a high proportion of heavily eroded soils. In numerical terms, the erosive degradation of the soil cover of Vinnytsia region, according to the latest observations and records, has the following statement: the area of unproductive and degraded lands of the region is about 741 thousand hectares, arable land, of which lightly washed soils - 511 thousand hectares, medium washed soils - 82 thousand .ha, heavily washed soils - 5.7 thousand hectares of the total area of lands subject to erosion, 256.3 thousand hectares of arable land with a slope of 2-30. The location of arable land on the slopes from 2 to 7 degrees is 575.7 thousand hectares, more than 70 - 20.5 thousand hectares.

*Table* 3

**Characteristics of Vinnytsia region on land erosion (own grouping)**

| Region/ district | Total surveyed lands, thousand hectares | Total eroded lands,% | Including by eroded (washed away),% | | |
|---|---|---|---|---|---|
| | | | weakly | medium | strongly |
| Barsky | 94,71 | 38,18 | 31,25 | 6,50 | 0,39 |
| Bershadsky | 115,4 | 21,78 | 15,36 | 4,49 | 1,93 |
| Vinnytsia | 73,31 | 6,82 | 5,54 | 1,15 | 0,01 |
| Gaisinsky | 92,52 | 14,33 | 9,66 | 4,28 | 0,39 |
| Zhmerynsky | 101,82 | 38,02 | 31,43 | 6,30 | 0,30 |
| Illinetsky | 76,28 | 8,48 | 6,88 | 1,44 | 0,16 |
| Kalinovsky | 91,64 | 5,53 | 4,69 | 0,79 | 0,05 |
| Kozyatynsky | 106,34 | 14,48 | 11,38 | 2,78 | 0,36 |
| Kryzhopilsky | 78,90 | 35,61 | 27,28 | 6,87 | 1,52 |
| Lipovetsky | 91,54 | 5,99 | 4,71 | 1,09 | 0,19 |
| Litynsky | 84,04 | 15,68 | 12,01 | 3,58 | 0,09 |
| Mohyliv-Podilskyi | 79,79 | 29,62 | 26,32 | 2,87 | 0,43 |
| Murovano-Kurylovetsky | 78,83 | 45,81 | 38,63 | 6,85 | 0,33 |
| Nemyrivsky | 111,76 | 17,46 | 13,12 | 3,92 | 0,42 |
| Orativsky | 82,97 | 21,75 | 15,01 | 5,51 | 1,24 |
| Pischansky | 48,35 | 41,76 | 33,75 | 6,54 | 1,47 |
| Pohrebyshchensky | 111,26 | 42,71 | 29,07 | 10,29 | 3,35 |
| Teplytsky | 76,81 | 28,93 | 24,58 | 4,07 | 0,29 |
| Tyvrivsky | 79,81 | 25,03 | 18,74 | 5,59 | 0,69 |
| Tomashpilsky | 71,15 | 37,68 | 32,99 | 4,44 | 0,25 |
| Trostyanetsky | 77,35 | 26,14 | 18,60 | 5,44 | 2,11 |
| Tulchinsky | 91,64 | 26,42 | 21,02 | 4,20 | 1,21 |
| Khmelnytsky | 11,08 | 15,09 | 11,51 | 3,27 | 0,24 |
| Chernivtsi | 61,18 | 29,62 | 26,32 | 2,86 | 0,42 |
| Chechelnytsky | 56,08 | 48,77 | 34,29 | 10,24 | 4,24 |
| Shargorodsky | 99,27 | 42,63 | 36,60 | 5,81 | 0,22 |
| Yampilsky | 69,18 | 32,93 | 28,64 | 3,76 | 0,53 |

Thus, Vinnytsia region is characterized by a rather complex from the agro technological point of view relief, which is reflected, with a close force of connection, in the gradation of eroded soils. In our opinion, our analysis indicates the need to restore the system of agriculture on the basic principles of contour and reclamation organization of the territory. In particular, such approaches in the organization of agro-technological groups of lands require first of all agro-formation of the most eroded districts of Barsky, Zhmerynsky, Kryzhopilsky, Mohyliv-Podilsky, Murovano-Kurylovetsky, Pischansky, Pohrebyshchensky, Tomashpilsky, Chechelnytsky, Shargorodsky, Yampilsky. In addition, for the conditions of the region it is important to clarify and map the bases of erosion and to assess the intensity of the division of the territory by the ravine-beam system.

According to B. D. Panasenko and on the basis of his analysis [3] within the field landscapes of Vinnytsia region the following forms of microrelief and corresponding geotopes are distinguished: 1) beam-shaped basins and semi-closed depressions; 2) the foothills of terraces and ledges with a smooth transverse profile: 3) flat sections of the slope (in the longitudinal and transverse directions), including subhorizontal surfaces; 4) curbs of terraces and ledges with a smooth cross profile; 5) ridges with a smooth longitudinal profile; 6) ridges with a convex profile, including hills and peaks. The selected geotopes in their territorial combinations form the next, higher hierarchical level of local geosystems - part of the catchment in watercourses of the 1st order (according to the Horton-Straler classification). This part of the catchment corresponds to a complex of slope tracts. The elementary watershed consists of several slopes with different solar exposures. Elementary types of locations are evaluated primarily by their place in the system of local conjugations (paragenesis) characteristic of the region.

For this purpose, these geotopes are distributed according to certain categories of paragenetic units of the paragenetic series. The paragenetic series includes the following elementary landscapes: eluvial, or autonomous, transeluvial, transaccumulative, accumulative and superaqual, or surface. Field landscapes of watersheds, hill tops belong to eluvial, edges of terraces and ledges, as well as upper parts of slopes - to transeluvial, middle and lower sloping parts of slopes - to transaccumulative, and the foothills of terraces and bottoms of basins - to accumulative. There are also accumulative-eluvial landscapes, confined to closed and semi-closed depressions in local watersheds and transaqual-superaqual (floodplain) complexes, which are distinguished by sharp seasonal changes in water regime. Each type of elementary landscape is divided into subtypes and species based on the height of the terrain, exposure and slope slope, the position of the geotope in the system of different watercourses, lithology and mechanical composition of soil-forming rocks. All these features are crucial in the territorial differentiation of field landscapes. Regional elementary field landscapes of Podillya correspond to three main groups of types of relief: 1) eluvial - positive morphostructures, in particular placors, hills and high plains; 2) accumulative - lowlands, valleys, etc.; 3) transeluvial and transaccumulative occupy the slopes of hills and valleys. All types of landscapes form groups by type of location - from eluvial watershed to accumulative valley. Such factorial-dynamic series within the Vinnytsia region have a certain feature, because here one of the upper links of the landscape conjugation (eluvial or transeluvial) often falls out, and the two lower links (transaccumulative and accumulative) in the conditions of plain relief are often difficult to distinguish, because they just overlap.

Within the Vinnytsia region, usually the most diverse types of field landscapes are characteristic of weakly undulating and hilly watersheds with erosive and erosive-denudation relief. Significant, although significantly less landscape-species diversity is inherent in the middle sections of the gently undulating slopes of the interfluves, which occupy a transit location. Transaccumulative and accumulative elementary landscapes are primarily formed by the peculiarities of the lithological composition of genetic types of soil-forming rocks and features of relief. The region is characterized by a long-term manifestation of erosion-denudation processes with the formation on the interfluves of various landforms of the "reservoir" type and different in mechanical composition and thickness of the slope slope. Within the Vinnytsia region, three territories are distinguished by the predominance of field landscapes by type of location: 1) northeastern erosion-denudation with predominance of eluvial-transeluvial (52% of the area) and transaccumulative (26%) elementary landscapes within the lowlands; 2) internal (valley of the Southern Bug) with the development of fluvial processes, accumulation and valley complexes; within its limits transaccumulative and accumulative elementary landscapes (42% of the area) which together with transeluvial occupy 82% of the territory prevail; 3) south-western with a predominance of transeluvial (58% of the area) and transaccumulative (28%) elementary landscapes within the Podil Upland. The north-eastern part is almost homogeneous in terms of soil types - 60% of arable land is occupied by typical and strongly degraded chernozems, 24% - podzolic and slightly degraded chernozems. Accumulative and transaccumulative elementary landscapes are more in the northwest of this part, and eluvial and transeluvial - in the northeast. The valley of the Southern Bug is distinguished by the dominance of gray podzolic soils with low humus reserves. Transeluvial elementary landscapes predominate on the outskirts of the valley. The south-western part of the region is characterized by a significant combination of typical and podzolic chernozems, as well as dark gray podzolic soils. The area of transeluvial elementary landscapes decreases here from west to east, and transaccumulative increases in the same direction.

**Conclusions.** The types of locations are directly related to such an important feature of field landscapes, which they acquired as a result of anthropogenic development. It defines such a property as the degree of hydromorphism. It is important to change the content in the upper soil horizons of silty-dusty fractions, which come with lateral-material flows from neighboring relatively higher areas. Increasing such fractions makes the mechanical composition heavier and at the same time increases the moisture content of the arable layer due to the content of bound water. At the same time, however, the water-air regime of the arable layer significantly deteriorates and soil fertility decreases. The removal of small particles is noticeable on well-drained, especially dissected hills, so hydromorphization is characteristic of lowland-valley geotopes, where there is an accumulation of fine material. For multidimensional landscape-ecological analysis, the species of field landscapes of Vinnytsia region were grouped into species groups taking into account the types of location, genetic unity of species, lithology and mechanical composition of the arable layer and edaphic moisture, which determine the potential soil fertility. Also, the relief is associated with the widespread distribution of forests in the past in the region, resulting in the formation of podzolic soils.

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