Geological Geomorphological Analysis of the Town of Belgorod

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Abstract. The article presents the analysis of the condition and use of the terrain of the town of Belgorod and a geological geomorphological analysis of the town's territory. The terrain of the Belgorodskaya oblast was studied and analyzed as a whole, the geomorphological regions were listed based on absolute heights and erosive breakdown of the surface in the Belgorodskaya oblast. Environmental and geomorphological research of the terrain in Belgorod helped to identify types of morphosculture that have been represented in the present article. Problems that arise in the town's territory because of negative terrain were studied, causes of man-made impact on the town's territory were represented and erosion forms from the first to the fifth order were identified. Solutions to these problems were also given that were associated with the organization of the urban space in the terrain of the town of Belgorod.

1. Introduction

The major features of the modern terrain of the Belgorodskaya oblast had started to form in the late Neogene, when it was freed from the Paleogene sea, the last one that covered its territory.

Figure 1. Belgorodskaya oblast’s terrain.
The Belgorodskaya oblast has many rivers that had been formed well before a glacier covered the territory of the East European Plain. Different directions of river valleys is a distinctive feature of the region. Vorskla, Severky Donets and Korocha go from north-east to south-west, the Oskol river has a meridian direction, and the rivers Tikhaya sosna and Chernaya Kalitva has a latitudinal direction. The largest rivers’ valleys have clear dextrality. The majority of the valleys are broad, well developed and deeply cut into primary rocks with a number of bottomland terraces and terraces located above flood lands on their slopes.

Natural processes that create the terrain in the Belgorodskaya oblast are quite diverse. Lineal erosion, rainsheet, landslides, sink holes, suffosion, wind-borne and man-made processes are among the most common ones.

Figure 2. Ravine division on the slopes of the river Nezhegol.

Lineal erosion is predominant and as a whole determines the exposure of the area to exogenous geological processes (EGPs). It affects river valleys, ravines, gullies and smaller erosion forms. The density of erosion division of the terrain (the spread of erosion forms per unit of land area) in the Belgorodskaya oblast is between 0.2 and 2.0 km/km². It reaches its minimum in the north part (0.2 - 0.6). Medium level of erosion division (0.6-1.2) can be found on the larger part of the terrain in the region. The left bank of the Severky Donets, the basin of the river Oskol (in its medium flow), the north-east and the eastern part that is characterized by a high level of density of erosion division (1.5-2.0).

2. Main part
Landslides in the region are frequent.

The eastern and central parts of the region have been hit by erosion the hardest, and the south-west has been affected less.

Landslide system are formed mostly on chalk and Paleogenic substratum, mostly with deformations of Quaternary Period rocks.

They differ by size, morphological features, displacement mechanism, age and rock cutting depth.

The slopes in river valleys and ravine systems are affected by landslides most of all with paleogenic waters in the water-bearing horizon wedging out there (the left bank of the river Potudan, the upstream of the rivers Chernaya Kalitva, Tikhaya sosna, Korochi).

Landslides along roads are quite frequent.

They develop in places where slopes with loess loam and clays have been cut [1...5].
Six relatively distinct areas called geomorphological regions were identified on the basis of their absolute height, the nature of erosion division and specific features of the terrain in the Belgorodskaya oblast:

Seimsky, Pselsko-Vorsklinsky, Sosninsko-Oskolsky, Oskolsko-Severodonetsky, Pravoberezhny Donskoy, Kalitvinsko-Bogucharsky (Fig. 3).

I. Seimsky geomorphological region occupies the north-western part of the region.
Deeply cut gently undulating planes with the depth of the wedge of up to 60 m and that of the Quaternary Period deposits up to 68 m cover the majority of the surface.
Ravines and gullies are narrow and poorly developed, symmetrical in the largest part of the region with slopes being cut with a big number of washaways.
Interstream areas are broad and flattened.
The river valleys are well-developed.

II. The Pselsko-Vorskinsky geomorphological region occupies the western and south-western parts of the region.
They are characterized by the development of moderately divided gently undulating and hilly planes.
Landslides among other current relief-forming processes plays the main role.
The interstream areas are narrow and very winding.

III. The Sosnensko-Oskolsky geomorphological region is situated on a deeply cut eroded gently undulating plane with narrow flattened interstream areas.
The ravine and gully network is very dense and is situated on the slopes of river valleys.
Landslides, ravines, sink holes, and sagging depressions among other exogenous forms are common.

IV. Oskolsko-Severskodonetsky geomorphological region occupies the south part of the oblast.
It is situated on a gently undulating plane that goes slightly down from north to south.
River valleys are well developed, their slopes are asymmetrical and divided by ravines and washaways.
Sink holes and sagging reliefs are common on watersheds.

V. The Right-bank Donskoy geomorphological region is situated on the north-east of the oblast.
This area is the most heavily divided and is situated on plain covered with glacier deposits.
The slopes of watersheds are heavily cut with ravines and gullies with landslides.
Sink holes can be found in some places.

VI. The Kalitvinsko-Bogucharsky geomorphological area occupies the south-east part of the region.
The area is characterized by uneven erosion division of the terrain.
Landslides and sink holes are very common here [6].
Belgorod is situated in two geomorphological regions, namely in Pselsko-Vorsklinsky and Oskolsko-Severskodonetsky ones. The terrain of the town of Belgorod involves gently undulating planes with flat plateau-like watersheds, flat terraced valleys and widespread ravine and gully network. The altitude is between 230-240 m on the watersheds and up to 114-116 m in river valleys. River valleys are quite broad, well-developed and U-shaped. As a rule, the right bank is steep, while the left one is not. Well-defined first and the second accumulative terraces are situated above the flood lands in the river valley of the Seversky Donets, and the third and the forth ones that are rock-defended terraces are not so well-developed, with a platform terrace wedging out in some places.
Figure 3. Geomorphological zoning and relief-forming process in the Belgorodskaya oblast.

The level of environmental and geomorphological danger in an area is defined based on the intensity of dangerous geological and geomorphological processes that depend on the following terrain characteristics: earth surface slope angle, density of horizontal division of the terrain, the indicator of the vertical division of the terrain [7...13]. The density of horizontal division of the terrain shows the impact of the erosion network, activity and the direction of fluvial processes. The intensity of erosion division on the urban territory is high, from 0.1 km/km² to 4 km/km². The average level of terrain division (from 1.1 to 2.4 km/km²) is the most common. Places with most ravine and gully division (from 2.5 to 4 km/km²) are situated in the right bank area of the Seversky Donets river and in the western part of the city; they have distinct borders. Weak division (from 0.1 to 1.5 km/km²) can be found in river valleys and watersheds.

Erosion forms become more dynamic towards the upstream parts of the river, and the most dynamic forms are found in erosion form basins of the third grade with the division coefficient being from 1.5 and higher. Exogenous geological processes with geological and geomorphological factors are mostly influenced by climate, by precipitation in particular.

Belgorod is situated on the south-western slopes of the Central Russian Upland in the zone heavily affected by air masses from the Atlantic Ocean with high percentage of water. The annual average precipitation is 660 mm. The precipitation level fluctuates in different years and seasons. April and October account for 65% of the annual precipitation in the town. In summer, precipitation chiefly takes the form of heavy rains that contribute to the washing off of the lightest soil particles and the destruction of the top soil and the deeper bed rock.

Solid precipitation account for about 30% of the annual level and are represented mainly by rain. Seasonal snow cover as a rule can be seen in December, however, there are winters with unstable snow cover. The average perennial depth of soil freezing is 78 cm. The soil usually fully thaws in April. On average the period of snow thawing takes about 18-20 days. A sharp rise of temperature in spring results in fast melting of snow and encourages landslide processes on the slopes.

Environmental and geomorphological research of the urban terrain in Belgorod helped to identify the following types of morphosculpture:

1) fluvial one represented by erosion forms;
2) fluvial-gravitational one represented by landslides and mud slides on the slopes;
3) wind-borne one in the flood lands and the left bank of the Belgorod water storage basin;
4) man-made one caused by economic activities (mining, road and pipeline construction, industrial
and public construction, etc.) that can be found throughout Belgorod.

Fluvial morphosculture is caused by constant and temporary waterways. The analysis of maps and
charts of engineering and geological assessment and the creation of natural and environmental
framework of the Belgorodsky region (Fig. 4 and 5) allowed to identify erosion forms of the first-fifth
grade [14, 15].

Water-erosion terrain forms are the most common ones establishing the basis of the hydrographic
network (ridge-top ravines, gullies, rain channels) and falling under the first and second grades. They
appear on long slopes that are not steep with the incline not exceeding 50. These are whole systems of
parallel fallings that are oriented towards the main form at a straight angle. These systems account for
about 80% of all the erosion forms of the terrain. The third range is represented by slope and valleys
ravines as well as by dry gullies and gullies with temporary water flows. They account for more than
15%. There are big gullies in Belgorod, for example Saprykin Log, Krutoy Log, Western, Shevelev
Yar, etc. Water courses of these gullies as a rule are marshy and covered with marsh vegetation. There
are also a couple of big ravines. The fourth and fifth grades are represented by the river valleys of the
Seversky Donets and its tributaries: Vezelka, Gostenka, Razumnaya, and Nizhegorodki. They account
for about 5% of all the erosion terrain forms.

![Figure 4. The plan of the engineering and geological assessment in the Belgorodsky region.](image)

Large exposed slopes are caused by side erosion. Material that is carried away when ravines or
washaways are being formed settles in orifices of gullies, creating as a result alluvial cones. Erosion
forms are caused both by natural factors and human activities. For example, a washaway appeared in
proximity to the town power plant as a result of waters eroding the soil; its width is 3-5 m, and the
length is approximately 20 meters (Fig.6). The size of the washaway is constantly growing. The washaway poses a threat to the garages situated in close proximity.

Figure 5. The map of the natural and environmental framework of the Belgorodsky region.

Figure 6. The washaway near the town power plant.
Intensive and deeply cut valley and gully network is aggravated by small landslide deformations and mud slides that are localized in ravines and gullies with steep slopes. Landslide processes develop due to two groups of factors: natural and man-made ones. As for man-made factors, soil erosion resulting from sewage waters and traffic affecting the soil play the decisive role.

The simultaneous impact of both man-made and natural factors causes more frequent landslides. For example, there is an area in the suburbs of Belgorod with a landslide in a gully (Fig. 7). It is associated with Paleogenic clays wedging out. The size of the gully is 150 meters with the displacement range of 15-20 meters. The body of one of the micro landslides near the car market is 18 m in width, 25 m in height, and it is constantly growing. This landslide poses a serious threat to the nearby buildings.

![Landslide near the car market.](image)

There have been two micro landslides near the Belgorodsky Technological University. One of them is old with partly grass covered slopes. It is 14 m wide and 30 m long. The second landslide is in a couple of meters from the first one; it is fresh and growing. It is approximately 15.5 m wide and 28 m high. The landslides have still been developing because of gradual spreading of the university campus and the sewage pipelines nearby. There is a landslide on the far side of Esenin street that is a significant threat to the development of the area and garages situated nearby (Fig. 8). This landslide is 19 m wide and 40 m long.

Its body's size is growing by 1 m every year. This is caused by sewage washing of the soil. Human activities impact the condition and sustainability of geological environment of the urban regions and natural and man-made systems.

The sources of man-made impact in Belgorod:
1) construction of various buildings in the town;
2) use of housing and water-bearing infrastructure;
3) water leakage from water-bearing infrastructure;
4) slope surcharging resulting from construction in landslide hazard areas;
5) dynamic pressures from moving vehicles on the soil;
6) man-made flooding of the area.
3. Conclusions
The urban area is not very suitable for the development of heavy industry facilities. The larger part of Belgorod is situated on slopes and ravines with active engineering and geological processes. Territory resources for housing construction in the old town are depleted with all the flat and low-inclined areas being occupied. Today new housing is constructed in the suburbs, such as the Novy, Esenina, South-Western neighborhoods and frequently beyond the city limits. Shabby buildings in the old town are being pulled down and multi-story buildings are constructed, and quite often the terrain is changed too (the sites are flattened and protected against flooding). Based on the analysis of the condition today, I managed to conclude that as a whole engineering and geological conditions for construction in Belgorod are difficult, however it is feasible to organize recreation zones [16].

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