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Environmental and Geomorphological Analysis of Exomorphogenesis of the Territory of the Region of Belgorod.

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ABSTRACT

Differentiated recent and modern tectonic movements in combination with various landscape and climatic conditions of the region of Belgorod determine various manifestations of modern exogenous relief-forming processes, the whole variety of which consists in weathering, denudation, accumulation, and their anthropogenic modification. However, the denudation processes (erosion, landslide processes, karst, abrasion) prevail, but occur with different intensity over the territory of the region. This is determined by territorial differences in display of neotectonics, landscape and climatic conditions, and by the main types and level of anthropogenic impacts.

Keywords: Erosion, formation of landslides, aeolian processes, karst processes, suffosion processes, abrasion processes, environmental and geomorphological situation.

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INTRODUCTION

The purpose of this paper is to give scientific justification to the contents of exomorphogenesis and to make an environmental and geomorphological analysis thereof using the example of the region of Belgorod.

The issue of development of a broad spectrum of exogenous geomorphological processes in the region of Belgorod is of vital importance. The territory of the region of Belgorod equals to 27.1 thousand square kilometres and is characterized by a wide variety of natural, climatic and geological conditions. Some of them adversely affect human living conditions and economic activities. This category includes erosion, landsliding, aeolian, karst, suffosion, abrasion processes. Along with natural exogenous processes, there are technogenic processes which occur widely on the territory of the region of Belgorod.

Joint occurrences of various types of exogenous geomorphological processes annually increase areas of unusable lands with high probability of occurrence of extreme environmental and geomorphological situations in the region. Reduction of –these hazards and prediction thereof requires availability of valid data concerning development of exogenous geomorphological processes. These include dynamics of the factors which affect the said processes intensity. The region of The region of Belgorodneeds an up-to-date system to monitor exogenous geomorphological processes. This will allow for timely minimisation of the negative impact of all the exogenous geomorphological processes (Barsch, 1990; Belousova, 2011).

METHODS AND METHODOLOGY

This work is based on the results of the field research carried out during 2000-2015. The following methods were used during investigation of exomorphogenesis of the region: system analysis in geomorphology (the concept of a geomorphological system, its elements and properties), morphometric study of the relief, remote survey methods (space remote survey technology and aerial photography), geomorphological mapping (Barsch, 1990; Belousova, 2011; Belousova *et al.*, 2015).

Ecological orientation of geomorphological studies becomes evident and involves researchers of the leading geomorphological centres. At the same time, other countries also start to take an active part in the environmental and geomorphological studies (Geomorphology and Geoecology: Geomorphological approaches in applied geography, 1991; Geomorphology and Geoecology: Geomorphological mapping, remote sensing and terrain models, 1990; Global Mega-Geomorphology, 1985; Kornilov *et al.*, 2005).

Abroad, especially in the USA (Kornilov *et al.,* 2005), environmental and geomorphological studies mainly address the global issues. Regional environmental and geomorphological studies and thematic environmental and geomorphological mapping gained attention among the Hungarian researchers (Pecsi, 1986; Second International conference on Geomorphology, 1989).

RESULTS

The conducted environmental and geomorphological analysis of the exomorphogenesis has shown that the typical set of exogenous geomorphological processes in the old-cultivated areas, like the region of Belgorod, include erosion, landslide formation, karst, suffosion, deflation, abrasion, and formation of marshes (Fig. 1).

However, a real threat to human life and economic activity is represented mainly by erosion, landslide, and karst-suffosion processes. Their intensity is given in Table 1.

As can be seen from the Table, erosion processes are the most widespread – about 60% of the region of Belgorod territory. The proportion of areas affected by the landslide processes accounts for more than 9 % of the region's territory, while suffosion processes cover about 7 % and karst processes about 6 % thereof. The rest of exogenous geomorphological processes account for more than 1 % of the region's territory (Belousova, 2011; Belousova *et al.,* 2013).

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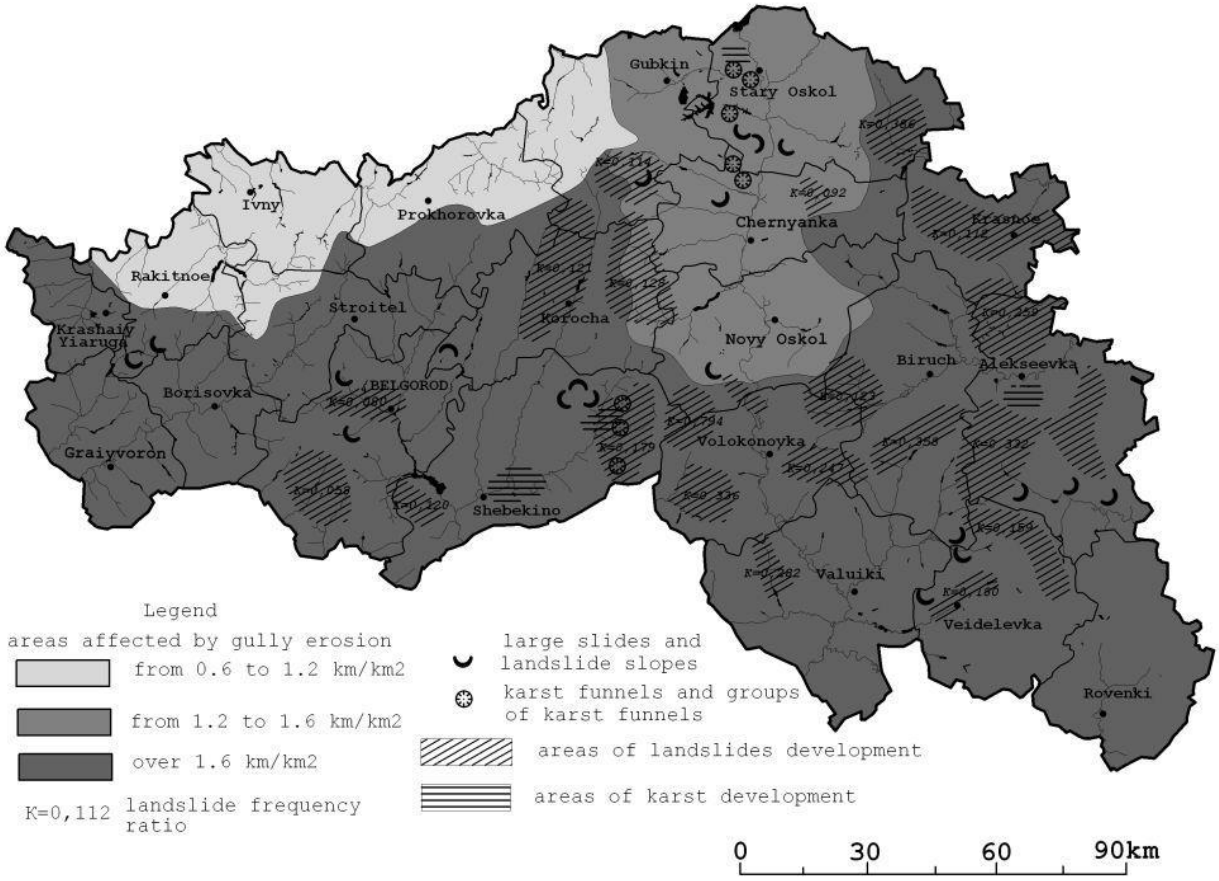

Figure 1. Map of the region of Belgorod showing areas affected by the main types of exogenous geomorphological processes

Table 1. General data about the intensity of exogenous geomorphological processes (EGP) on the territory of the region of Belgorod

No.	EGP type	Surface area (extension of linear areas) of EGP propagation, km^2	Percentage of affected area (%)	Number of identified EGP	Density of EGP, elements/km^2
1	Landslide	2,500	9.2	270	0.01
2	Karst	1,500	5.5	210	0.008
3	Erosion processes (gully erosion)	16,200	59.8	4,800	0.177
4	Suffosion	1,900	7.0	350	0.013
5	Erosion processes (sheet erosion)	600	2.2	90	0.003
6	Aeolian accumulation	300	1.1	30	0.001
7	Formation of marshes	100	0.4	10	0.0004

Diversity of the natural climatic conditions, vertical neotectonic movements, and composition of rocks subject to erosion, as well as various technogenic (anthropogenic) impacts on the region's environment have determined its spatial nonuniformity and different intensity of exogenous geomorphological processes (Table 2).

Intensive erosion dissection is one of the main indicators of unfavourable environmental and geomorphological state of the region territory. Erosion of soils is one of the most powerful processes of displacement of hard and chemical substances down the slopes of the cultivated territories. Annually, as a result of soil erosion, from 7 to 14.5 million tons of soil being washed away from arable lands. This corresponds to the extent of soil washout from 0.5 to 1.2 mm annually that is 2 to 7 times more than natural soil-forming

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processes. In the cropland structure, a large proportion (exceeding 40%) is occupied by arable crops which are cultivated by the majority of farms situated on erosion hazard slopes. Therefore, washout of soil from slopes with steepness of more than 30 increases to 30-50 t/ha (Belousova, 2011; Chendev *et al.*, 2006).

Table 2. Degree of erosion per administrative districts

Administrative district	District area, km^2	Degree of the territory erosion (numerator – km^2 affected, denominator – the same in % of the district area)			
		Total	High	Medium	Low
Alexeyevka	1,765.1	1,150 65	230 13	575 32	345 20
Belgorod	1,627.8	986 61	246 15	493 30	247 15
Borisovka	650.4	371 57	111 17	111 17	149 23
Valuyki	1,709.6	1,192 70	179 10	715 42	298 18
Veydelevka	1,356.3	888 65	178 13	444 32	266 20
Volokonovka	1,287.7	1,037 80	207 16	674 52	156 12
Grayvoron	853.8	524 61	183 21	157 18	184 22
Gubkin	1,526.6	845 55	211 14	296 19	338 22
Ivnya	871.1	708 81	177 20	425 49	106 12
Korocha	1,464.1	650 44	130 9	195 13	325 22
Krasnoe	851.9	651 76	391 46	130 15	130 15
Biryuch	1,762.6	882 50	88 5	397 22	397 23
Krasnaya Yaruga)	479.2	449 94	202 42	202 42	45 10
Novy Oskol	1,401.6	707 50	141 10	247 18	319 22
Prokhorovka	1,378.7	904 66	316 23	316 23	272 20
Rakitnoe	900.9	769 85	308 34	384 43	77 8
Rovenki	1,369.2	692 50	173 12	208 15	311 23
Stary Oskol	1,693.5	923 55	277 16	277 16	369 23
Chernyanka	1,227.5	438 36	88 7	88 7	262 22
Shebekino	1,865.9	1,043 56	156 8	469 25	418 23
Stroitel	1,089.8	391 36	78 7	78 7	235 22
Total in Belgorod Region	27,133.5	16,200 60	4,070 15	6,881 25	5,249 20

High degree of erosion – more than 25 % of the territory is affected. Medium degree – from 5 to 25 %, and low degree corresponds to less than 5 % of the territory.

Out of 2,145.8 thousand hectares of the region farmlands, 1,597.6 thousand hectares (60 %) are affected by erosion, of which 26.2 thousand hectares are under gullies; of which 50% have active gully heads. There are 7 active gullies per one farm on average. While in some farms of the region south east, their number amounts up to 100-150. The total length of gully-ravine system equals to 50 thousand kilometres. Considering

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the fact that each active gully increases annually by 20 m^2 on average, the region loses more than 30 ha of agriculturally used lands annually.

Soils affected by erosion in a greater degree are in the east and south-east districts: Krasnogvardeyskoye, Alexeevka, Valuyki, Rovenki, and Novy Oskol where the eroded lands occupy 60-73 % of agriculturally used lands.

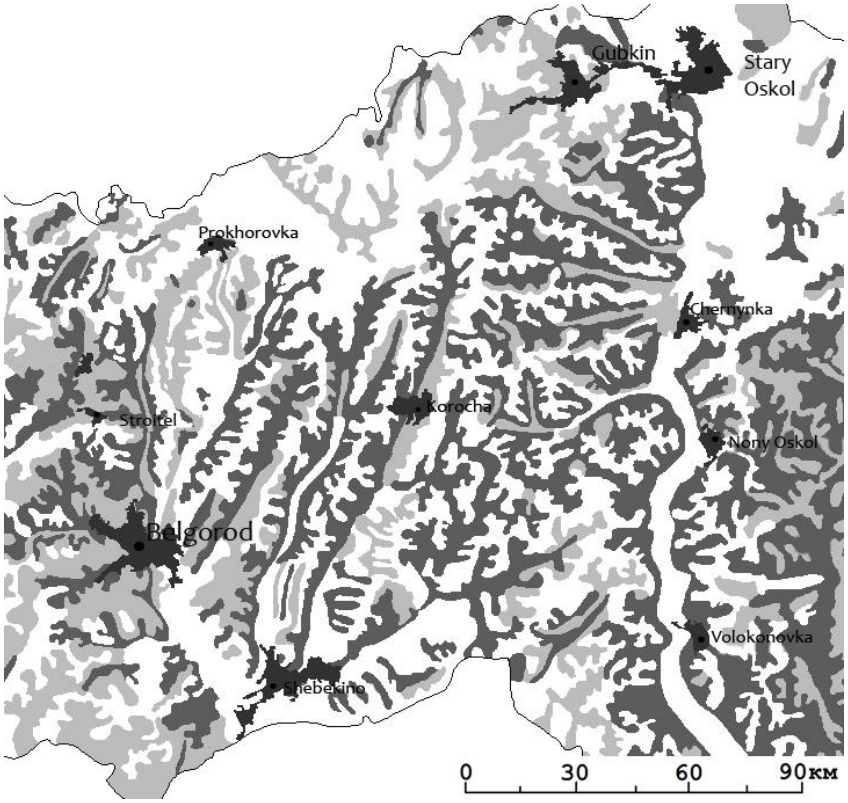
Erosion constitutes a special hazard to natural economic infrastructure components and facilities. Indirect adverse impacts of erosion appear in the form of: a) reduction of pastures and haylands on floodplains, and on the bottoms of ravine systems due to the soft soils brought from actively developing ravines; b) contamination of water basins by fertilizers, toxic chemicals, pesticides, and heavy metals brought from fields by meltwaters; c) increase of expenses on waterworks for road and pipeline laying and for other communication lines in the erosion hazard areas (Belousova, 2011; Chendev *et al*., 2008).

DISCUSSION

Analysis of the natural climatic conditions, specific distribution of engineering-geological complexes, relief morphometric parameters (surface slopes and vertical dissection of land surface), as well as various economic activities and degree of anthropogenic load made it possible to generate a map of expected activation of exogenous processes and of geomorphological risks on the territory of the region of Belgorod (Fig. 2).

The map shows three marked area groups with different risk levels (Barsch, 1990):

1) Low geomorphological risk (water-dividing ranges and gentle slopes with gradient of land surface up to 2-3^0);
2) Medium geomorphological risk (near-the-water divide slopes with gradient up to 5^0);
3) High geomorphological risk (slopes of river valleys and large gully-ravine systems with gradient from 5^0-10^0 and more), as well as water reservoir cliffs;
4) Very high geomorphological risk (settlement and mining territories).



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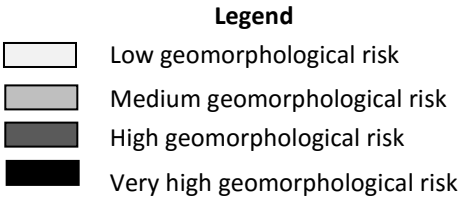

Figure 2. Fragment map of expected activation of exogenous processes or geomorphological risks on the territory of the region of Belgorod

Therefore, development of unfavourable ecological situations can be caused by extreme intensities of both separate environmentally hazardous exogenous processes, and their synergetic effect. Additionally, grave ecological situation can be created by long-time impacts of exogenous processes of medium intensity. In this case, a conflict ecological situation is caused by an overall result of exogenous processes display. Environmental and geomorphological situations of different gravity, on the territory of Belgorod Region, as one of the old-developed regions, are caused mainly by development of erosion, landslide, abrasion, and technogenic processes (Coates, 1990).

CONCLUSION

Environmental and geomorphological analysis of exomorphogenesis made during the work carried out in Belgorod Region was based on a system approach. It was aimed at solving a number of problems relating to assessment of environmental and geomorphological condition of the regional geomorphosystem. This system consists of the following interacting elements: relief of land surface, relief-forming processes of the regional geomorphological system and external geomorphological system with its surrounding natural and socioeconomic systems (Furmanova *et al*., 2015).

Morphometric analysis of relief that was made with the use of GIS technologies forms a base for identifying natural preconditions for development and propagation of present-day exogenous relief-forming processes in the region.

Natural factors, determining development and extensional propagation of exogenous geomorphological processes, include vertical non-tectonic movements, composition of rocks, and climatic conditions. Technogenic (anthropogenic) factor is of great impact on development of processes of exogenous geodynamics.

Ecology and geomorphological analysis has made possible to identify the role of exogenous geomorphological processes in forming environmental and geomorphological situation and to evaluate the regional specific character of geomorphological risks within the territory under study.

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