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MODERN PROCESSES OF ECO-GEOMORPHOGENESIS IN THE KOSTANAY REGION UNDER THE INFLUENCE OF ANTHROPOGENIC ACTIVITY

Human economic activity is a key factor shaping the modern landscape. To ensure a high level of environmental well-being, nature conservation, and the rational use of natural resources, it is necessary to comprehensively consider all types of technogenic impacts on the natural environment – both direct and indirect. In this regard, the study of eco-geomorphogenesis under the conditions of anthropogenic pressure and changing climate is especially relevant and becomes one of the priority tasks for maintaining environmental sustainability. This article examines the features of eco-geomorphogenesis in the Kostanay region under the influence of current anthropogenic activities. The processes of landform formation and transformation caused by human activities such as land use, agriculture, forestry, and mineral extraction are analyzed. The consequences of these changes for the natural environment are considered: increased erosion, alteration of the water regime, soil degradation, and disruption of ecosystem stability. Special attention is paid to the interaction between geomorphological and ecological factors in landscape transformation processes. Conclusions are drawn about the current state of geomorphogenetic processes, and measures are proposed to mitigate the negative consequences of anthropogenic impact in the Kostanay region.

Keywords: eco-geomorphogenesis, Kostanay region, geology, geomorphology, geological and lithological features.

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Антропогендік әрекеттің әсерінен Қостанай облысының экзогеоморфогенезінің заманауи процестері

Адамның шаруашылық қызметі қазіргі ландшафтты қалыптастыратын негізгі фактор. Қоршаған ортаның экологиялық тұрақтылығын сақтау, табиғатты қорғау және табиғи ресурстарды ұтымды пайдалану үшін табиғи ортаға техногендік әсердің барлық түрлерін – тікелей және жанама – жан-жақты ескеру қажет. Осыған байланысты өзгермелі климат және антропогендік қысым жағдайында экогеоморфогенез үдерістерін зерттеу аса өзекті болып отыр және қоршаған ортаның тұрақтылығын сақтау жолындағы басым міндеттердің бірі ретінде қарастырылады. Бұл мақалада қазіргі антропогендік әсер жағдайындағы Қостанай облысының экогеоморфогенез ерекшеліктері қарастырылады. Адамның шаруашылық әрекеті, соның ішінде жер пайдалану, ауыл және орман шаруашылығы, пайдалы қазбаларды өндіру сияқты факторлар әсерінен рельефтің қалыптасуы мен өзгеру үдерістері талданады. Бұл өзгерістердің табиғи ортаға әсері: эрозиялық үдерістердің күшеюі, су режимінің өзгеруі, топырақтың деградациясы және экожүйелердің тұрақтылығының бұзылуы сипатталады. Ландшафттардың өзгеру үдерісіндегі геоморфологиялық және экологиялық факторлардың өзара әрекеттестігіне ерекше назар аударылады. Қостанай облысындағы геоморфогенетикалық үдерістердің қазіргі жағдайына қорытынды жасалып, антропогендік әсердің теріс салдарын азайту бойынша ұсыныстар берілген.

Түйін сөздер: экогеоморфогенез, Қостанай облысы, геология, геоморфология, геологиялық-литологиялық ерекшеліктер.

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Современные процессы экогеоморфогенеза Костанайской области под влиянием антропогенной деятельности

Хозяйственная деятельность человека выступает ключевым фактором, формирующим современный ландшафт. Для обеспечения высокого уровня экологического благополучия, охраны природы и рационального использования природных ресурсов необходимо комплексно учитывать все виды техногенных воздействий на природную среду – как прямые, так и опосредованные. В связи с этим изучение экогеоморфогенеза в условиях антропогенного давления и изменяющегося климата приобретает особую актуальность и становится одной из приоритетных задач в деле сохранения устойчивости окружающей среды. В данной статье рассматриваются особенности экогеоморфогенеза Костанайской области в условиях современного антропогенного воздействия. Анализируются процессы формирования и трансформации рельефа, происходящие под влиянием хозяйственной деятельности человека, включая землепользование, сельское и лесное хозяйство, а также разработку полезных ископаемых. Рассматриваются последствия этих изменений для природной среды: ускорение эрозионных процессов, изменение водного режима, деградация почв и нарушение устойчивости экосистем. Особое внимание уделяется взаимодействию геоморфологических и экологических факторов в процессе преобразования ландшафтов. Представлены выводы о текущем состоянии геоморфогенетических процессов и предложены меры по смягчению негативных последствий антропогенного вмешательства Костанайской области.

Ключевые слова: экогеоморфогенез, Костанайская область, геология, геоморфология, геолого-литологические особенности.

Introduction

The modern stage of society's development is characterized by intensive human intervention in natural processes, which entails significant changes in the structure and dynamics of geomorphological systems. This is especially acute in regions with active agricultural, industrial and infrastructural development, including Kostanay region. In recent decades, there have been significant transformations of natural landscapes caused by human activity – land development, land reclamation, mining, construction and other forms of economic activity [1-2].

Ecogeomorphogenesis, as a scientific field, studies changes in terrain that occur under the influence of both natural and anthropogenic factors. In the context of increasing anthropogenic pressure and global climate change, the relevance of such research is significantly increasing. The analysis of modern processes of exogeomorphogenesis allows not only to assess the current state of the environment, but also to develop scientifically sound approaches to the management of natural resources and the protection of landscapes from degradation [3].

One of the key components of the natural environment is the Earth's surface. In the Paleolithic and Neolithic periods, there was practically no anthropogenic impact on the terrain. However, with the development of civilization and the growth of human industrial, economic and engineering activities, new forms of relief began to form in the geomorphological structure, which were called man-made or anthropogenic. These shapes are the result of an artificial transformation of the Earth's surface that did not previously exist in nature. Their occurrence is not related to natural climatic or tectonic processes. These can be either extended linear or localized spatial formations – embankments, dumps, quarries, and other forms formed as a result of the movement and accumulation of substances of various compositions (organic, chemical, and mineral), ranging in thickness from several meters to hundreds of meters [4-5].

Human economic activity – construction, agriculture, hydraulic engineering and mining – has a significant impact on the geological and geomorphological structure of the Earth's crust. V.I. Vernadsky designated these zones of active technogenic transformation as the technosphere or noosphere (1944) [6].

All anthropogenic landforms can be roughly divided into two main categories: man-made and agrogenic. Technogenic relief arises as a result of industrial and engineering processes related to the processing of minerals, construction and other types

of technical activities. A.E. Fersman coined the term "technogenesis" to denote such a transformation of natural forms. Cryogenic landforms are formed as a result of long-term agricultural exploitation of the territory and, as a rule, have a longer history of development compared to technogenic ones [7-8].

In the process of economic activity, a person exerts both direct and indirect, intentional and unintended influence on natural landscapes, which is designated by the term "anthropogenic impact". It manifests itself both in biotic components (for example, the disappearance or replacement of species of flora and fauna) and in abiotic ones (climate change, pollution of the atmosphere, reservoirs and soils). As a result, destructive changes in natural landscapes are observed, violating their stability and functionality [9].

Man-made landscapes are natural and anthropogenic formations formed under the influence of human activity, especially in the fields of mining, energy, transport and construction. The sources of pollution in such areas are classified as point, linear and areal, while the pollution zones often do not coincide in location with the sources themselves [10].

Thus, human economic activity is the main factor determining the current state of geomorphological systems. To preserve environmental sustainability, it is necessary to take into account and analyze all forms of anthropogenic impact on the natural environment [11-12].

In this regard, the study of exogeomorphogenesis under conditions of increasing anthropogenic pressure and climatic changes is of particular importance. The deterioration of the environmental situation due to these factors is causing increasing concern among scientists and specialists [13].

The purpose of this study is to identify the features of the modern ecogeomorphogenesis of Kostanay region under anthropogenic influence, to identify the main types and directions of terrain transformation, and to assess their consequences for the natural environment of the region.

Materials and methods of research

The data on cartographic and textual material on the geology and morphology of Kostanay region for the modern period of time were used as the research material, geographical and descriptive methods were used.

The geographical method was based on the fact that fieldwork and descriptive work were carried out, during which research materials were obtained. Thanks to the geographical and descriptive method, the main characteristics and the current state of ecogeomorphogenesis are investigated in this work.

Kostanay region is located in the north of the Republic of Kazakhstan and is one of the largest administrative-territorial units of the country. The total area is 196,000 km^2, which makes it one of the most extensive regions in Kazakhstan. The region occupies an important geostrategic position, bordering the Russian Federation (Chelyabinsk, Kurgan and Orenburg regions), as well as neighboring regions of Kazakhstan – Aktobe, Karaganda and North Kazakhstan regions [14-15].

Such a border location has a significant impact on the economic ties of the region, the use of natural resources and the direction of infrastructural development. The large area of the territory and its location in a zone of various natural conditions complicate the geomorphological structure of the region and affect the diversity of the relief [16].

From a coordinate point of view, Kostanay region is located in the range of 52°-55° north latitude and 61°-69° east longitude. The territory of the region occupies a transitional zone between steppe and forest-steppe natural zones, which determines its diverse landscape. This factor has an impact not only on geomorphological features, but also on hydrological processes, the formation of relief and the distribution of soil cover. The differences between the northern and southern parts of the region affect not only the ecosystem characteristics, but also the risks of flooding [17].

Results and discussion

The geomorphological structure of Kostanay region is a combination of flat, elevated and low-lying landforms formed under the influence of tectonic processes, erosion, accumulation and denudation. The regional morphology is determined by the location of the region within the West Siberian Plain and the Turgai plateau, which determines its characteristic features – slight fluctuations in altitude, wide interfluvial spaces and a developed network of drainage basins. According to the geomorphological features, the territory of the region can be divided into three main zones (Table 1):

Table 1 – The main geomorphological zones of Kostanay region

Geomorphological zone	Relief features	Average height above sea level (m)	Characteristic objects
1	2	3	4
West Siberian lowland (northern part of the region)	Flat terrain with small hills, swampy areas	120-180	Ubagan-Ishim watershed, lakes, swamps, salt marshes
Turgai plateau	Undulating plains, sometimes dissected by a ravine-girder network, Aeolian relief forms	200-300	The mountains of Kyzbel tau, Kargalytau, Zhilandytau, Teketau, Tosykkum and Akkum dunes
Turgai hollow	Wide tectonic depression, floodplains, floodplain terraces, salt marshes	150-210	Lake Aksuat, Lake Kushmurun, Turgai and Ubagan rivers
The Trans-Ural plateau (western part of the region)	Hilly terrain, sloping plains, lake-basin areas	250-350	Tributaries of the Tobol, estuaries, river valleys
The cliffs and hills of the southern part of the region	Denudation slopes, elevated ridges, slightly undulating plains	250-300	Watersheds of Turgay-Zhilanchik, Kabyrga-Teke, Zhilanchik-Ulkayak

The Northern plain zone (West Siberian lowland). It consists of poorly dissected plains with altitudes from 120 to 180 m above sea level. This territory is characterized by weakly pronounced slopes, the presence of numerous lake basins (Nazhmuli, Amankaragai) and the spread of hydromorphic soils. These features contribute to seasonal stagnation of water and increase the risk of spring floods.

- The central elevated zone (Turgai plateau). It extends from the northeast to the southwest and includes hilly and rolling landforms with heights of 200-300 m. Ravine-girder systems are developed in this zone, which makes it more susceptible to erosion processes. The Turgai Hollow – an ancient tectonic trough filled with sedimentary rocks, also passes through here. During the spring flood, significant amounts of meltwater flow down this hollow, increasing the burden on the hydrological system of the region.

- Southern arid zone (part of the Turgai depression). It is characterized by the predominance of flat plains with rare residual elevations. There are dry channels of temporary watercourses (sores), as well as large sandy massifs (Aral Karakums), which influence the formation of a local microclimate, increasing the level of evaporation and contributing to the occurrence of dust storms.

The geomorphology of Kostanay region is closely related to its geological structure. The region is composed of sedimentary rocks of Paleozoic, Mesozoic and Cenozoic age, among which sandstones, clays, siltstones, marls and limestones predominate. Quaternary deposits of glacial and alluvial origin are widespread in lowland areas, which determines the high water permeability of soils and contributes to the formation of temporary reservoirs after intense precipitation. The southern part of the region contains denser rocks of the Permian and Carboniferous periods, which reduces the level of precipitation infiltration and leads to the formation of a more stable water regime. These geological differences create significant contrasts in the soil and hydrological conditions of the region and affect economic activity [18-19].

The geological structure of Kostanay region is a complex system formed under the influence of various geological processes over millions of years. The main tectonic elements of the region are the Kostanay megablock, the Turgai depression and the North Kazakhstan region of the Ural Folded system. The Kostanay megablock is a stable platform struc-

ture composed of ancient crystalline rocks of the Archean and Proterozoic, including granites, gneisses and quartzites. These rocks have high strength and are the basis for the placement of large iron ore deposits. In contrast, the Turgai depression is a tectonic trough in which sedimentary rocks accumulated during the Mesozoic and Cenozoic eras. It contains powerful sandstone, limestone and clay strata with high water content and influencing the formation of the region's groundwater resources. The North Kazakhstan region of the Ural folded system is characterized by a complex structure, including fault zones and metamorphosed rocks that have undergone active tectonic processing [20-21].

The lithological composition of the Kostanay region is represented by a variety of rocks, among which sedimentary, igneous and metamorphic formations predominate. In the northern and central regions, sandstones, siltstones and limestones are widespread, which form aquifers and favorable conditions for groundwater accumulation. The southern and western regions are characterized by the presence of basalts, granites and diabases, which have high strength and resistance to weathering. Metamorphic rocks such as gneisses, schists, and quartzites are found mainly in the southern folded zones and are associated with tectonic processes that occurred in the Paleozoic era [22-25].

The richness of minerals is one of the key geological features of the region. Kostanay region has the largest iron ore deposits in Kazakhstan, concentrated in the Sokolovsko-Sarbaysky, Kacharsky and Lisakovsky basins. These ores are of sedimentary-metamorphic origin and have a high iron content, reaching 50-60%. In addition, there are significant reserves of bauxite used in the production of aluminum in the Lisakovsk area. The Zhitikarinsky phosphorite deposit is of marine origin and is actively used in the agricultural sector for the production of fertilizers. Lignite deposits have been discovered within the Turgai basin, but their development is limited due to difficult hydrogeological conditions. Exploration work is also underway in the southwestern part of the region to find oil and gas deposits in the carbonate strata of the Lower Paleozoic [26].

The geological structure of the region has a significant impact on the hydrogeological conditions and the distribution of water resources. There are three main aquifers in the region: deep artesian basins lying at a depth of 300-800 meters and containing mineralized waters; medium-depth horizons (30-150 meters) used for drinking and domestic water supply; as well as shallow groundwater located at a depth of 0.5-10 meters and playing a key role in irrigation of agricultural lands. The most significant underground water resources are concentrated in the Turgai basin, where powerful sand and limestone strata contribute to the active accumulation and filtration of waters. However, in the northern regions of the region, where dense clay rocks predominate, precipitation infiltration is limited, which leads to the accumulation of surface water and increases the likelihood of floods in the spring [27].

The geology of the region also influences economic activity, determining the specifics of the location of industrial enterprises, agricultural land and transport infrastructure. The mining industry is concentrated in the areas of iron ore deposits, while the agricultural sector is developing mainly in the central and northern parts of the region, where the lithological composition of the soils is more favorable for agriculture. In areas where clay deposits are common, increased soil salinity is observed, which requires the use of special land reclamation measures. The construction of roads and engineering structures also depends on the geological structure, since additional fortification work is required in areas with loose sedimentary rocks.

Conclusion

In general, the geographical location and relief of Kostanay region determine its climatic conditions, water balance and risk level of natural disasters, including floods and erosion processes. The northern regions of the region, belonging to the West Siberian Lowlands, are characterized by a weak surface slope, high moisture storage capacity and increased susceptibility to flooding, especially during the spring snowmelt.

The central part, represented by the hills of the Turgai plateau, is characterized by more active runoff, which reduces the likelihood of prolonged floods, but leads to increased soil erosion and landscape degradation. In the southern regions of the region, located within the Turgai basin, the water regime depends on the composition of the underlying rocks, in particular sandstones and limestones, which contribute to the active filtration and accumulation of groundwater, providing nutrition to aquifers. The geological structure of the region

forms heterogeneous water exchange conditions, where the presence of clay deposits in some areas leads to moisture stagnation, while in others, precipitation infiltration contributes to the formation of deep-lying water reservoirs. In recent decades, due to climate change, there has been an increase in extreme meteorological events, which increases the likelihood of severe floods and exacerbates the problem of water scarcity in the southern regions. In this context, the study of the relief and geological features of the region acquires strategic importance, allowing not only to predict hydrological risks, but also to develop effective measures to protect territories from floods, optimize water use and preserve soil fertility.

Thus, the geographical location, geomorphological and geological features of Kostanay region have a significant impact on the formation of hydrological conditions, the nature of landscape dynamics and the manifestation of natural hazards. In conditions of a complex and mosaic relief structure – from the plains of the northern part to the elevated areas of the central plateau and depressions of the southern regions – different types of regimes of surface and underground runoff, water exchange and moisture accumulation are formed. This determines the uneven distribution of hydrological risks across the region and requires an integrated approach to their assessment.

The study of spatial variability of anthropogenic impact on the natural environment is of particular relevance, since landscape changes due to economic activity exacerbate natural risks, including floods, erosion, soil degradation and a decrease in the water-holding capacity of landscapes. Active land development, land reclamation, deforestation, construction of dams and other engineering structures disrupt the natural mechanisms of regulating moisture circulation, which leads to an aggravation of hydroecological problems in the region.

Taking into account the increasing consequences of global climate change, including an increase in extreme precipitation, temperature anomalies and changes in seasonal water regimes, the need for a systematic study of ecogeomorphological processes is becoming a strategic task. Modern approaches to monitoring, modeling, and forecasting the geomorphodynamics of the region make it possible to identify the most vulnerable areas, develop risk scenarios, and make sound recommendations for environmental management.

In addition, understanding the interrelationships between relief, geological structure, climatic conditions and human activity allows us to move from fragmented responses to the consequences of natural disasters to their long-term prevention. In this regard, it is particularly important to develop programs for sustainable water use, protection of soil resources, restoration of degraded landscapes and improvement of the territorial planning system taking into account geoecological risks.

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