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# CURRENT ECO-GEOMORPHOLOGICAL CONDITION OF THE ZHAIYK RIVER BASIN

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**KEY WORDS**

Zhaiyk river basin
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**ABSTRACT**

Human economic activity plays a key role in shaping the modern landscape. To maintain high environmental quality, protect nature, and ensure the rational use of natural resources, it is essential to comprehensively consider all types of anthropogenic changes, both direct and indirect. In this regard, the study of ecogeomorphogenesis under conditions of climate change and anthropogenic impact is becoming particularly significant, making it one of the most important tasks for maintaining the sustainable state of the natural environment. In this context, the objective of this study was to investigate ecogeomorphogenesis within the basin of the Zhayyk River, specifically analyzing its current state with regard to anthropogenic influence to better understand the processes of formation and transformation of the ecogeomorphological condition of the study area. The Zhayyk River basin is a complex natural system whose formation and development are determined by the interaction of geomorphological, hydrological, and ecological processes. Under the conditions of a changing climate and increasing anthropogenic impact, significant transformations in the relief, riverbed processes, and hydrological characteristics of the river are being observed. This article examines the current ecogeomorphological state of the Zhayyk River basin. Recommendations are provided for the sustainable management of the river basin's natural resources, including measures to mitigate negative environmental impacts and develop strategies for adapting to changing climatic conditions.

## 1. INTRODUCTION

Ecogeomorphogenesis, also known as ecological geomorphology, is one of the branches of applied geomorphology and a relatively young scientific discipline. Its emergence is associated with the need to study problems arising in the process of preserving life on Earth. As early as the mid-1860s, scientists noticed the rapid disappearance of rare species of flora and fauna in various regions of the world, raising concerns about the threat to the future of human civilization. These factors served as a stimulus for the formation and development of the science of ecogeomorphogenesis [1...2].

This field of study examines the structure, formation processes, historical development, and current dynamic state of relief. It is closely related to anthropogenic morphogenesis, which encompasses a set of phenomena and processes resulting from human economic activity that lead to changes in natural landforms. In other words, anthropogenic influence on the environment continues to intensify, affecting an increasing number of aspects of natural systems [3...4].

Many researchers have studied the territory of the Pre-Caspian Tectonic Depression. Numerous monographs, specialized collections, and a large number of scientific articles and conference abstracts have been devoted to these issues.

The study of the geological structure – specifically, the sequence of rock formation, their thickness and spatial arrangement, the development of geological structures, and their changes under the influence of tectonic movements and geological history – has been carried out by scientists from various fields, resulting in numerous collections, books, and monographs.

James Hutton is considered the founder of modern geology, having proposed the principle of actualism. Charles Lyell further developed these ideas and laid the foundations of stratigraphy. Significant contributions to the study of tectonic structures were made by Alexander Kropotkin and

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Vladimir Obruchev, who explored the geology of Siberia and Central Asia. Later, Alfred Wegener proposed the theory of continental drift, which eventually led to the development of plate tectonics. In the 20th century, Harry Hess and John Wilson explained the mechanisms of lithospheric plate movement. Today, geological research continues in leading scientific institutions such as the United States Geological Survey (USGS) and the Russian Academy of Sciences (RAS) [5...7].

The West Kazakhstan region has attracted the attention of many geologists who have made significant contributions to the study of its geological structure and mineral resources. Among them is Muftakh Diarovich, who investigated the geology and geochemistry of halogenic formations in western Kazakhstan, establishing patterns in the formation and distribution of mineral deposits in the Pre-Caspian Depression and the Southern Pre-Ural Trough [8...10].

Specialists from the West Kazakhstan Geological Administration (ZKGU) have played an important role in geological and geophysical research in the region, particularly in the exploration and prospecting of oil and gas fields.

The objective of this study is to analyze the ecogeomorphological state of the Zhayyk River basin and identify the main factors influencing terrain transformation.

The article examines the types of modern processes occurring in the Zhayyk River basin. Exogenous factors play a major role in shaping the contemporary landscape. The most widespread processes within the territory include physical weathering, debris formation, karst processes, takyr (clay flat) formation, and aeolian (wind-driven) processes.

## 2. MATERIALS AND METHODS

As research material, cartographic and textual data on the geology and morphology of the Zhayyk River basin from the modern period were used.

In the study of the ecogeomorphological state of the Zhayyk River basin, the following methods were applied:

Cartographic analysis – the use of topographic and geomorphological maps to identify changes in the relief.

Statistical analysis – processing of long-term data on climate, river flow, and relief dynamics.

Geographical and descriptive methods – conducting fieldwork and descriptive studies, during which research materials were obtained.

The object of study is the Zhayyk River basin, as it is an important natural entity influenced by both natural and anthropogenic factors. In recent decades, significant changes in geomorphological processes have been observed, caused by climate change, anthropogenic impact, and intensive economic development of the territory.

Through the application of the above-mentioned methods, this study has examined the main characteristics and the current state of the ecogeomorphogenesis of the Zhayyk River basin.

## 3. RESULTS AND DISCUSSION

In tectonic terms, the West Kazakhstan region is associated with the northern part of the Pre-Caspian Depression, which is located in the southeast of the East European Platform. Due to its spatial position, morphology, and development history, it is classified as a syneclise. The northern boundary of the Pre-Caspian Depression is marked by the Zhadyovsky Escarpment, which is geologically defined by the Tokarev regional fault. The Pre-Caspian Depression represents a depression of the Russian Platform, filled with Paleozoic, Mesozoic, and Cenozoic deposits and complicated by numerous salt domes. It is one of the world’s largest salt-bearing basins, characterized by extensively developed salt-dome tectonics. The depression is expressed in the relief as a lowland area. The crystalline basement dates back to the Precambrian [11].

The sedimentary cover of the depression is divided into three complexes:

Subsalt complex, which includes rocks older than the Kungurian stage of the Lower Permian.

Salt-bearing complex, containing extensive halogenic deposits.

Supersalt complex, consisting of Upper Permian, Mesozoic, and Cenozoic formations.

The geomorphological and tectonic features of the Pre-Caspian Depression are interconnected. The study area is characterized by recent tectonic uplifts and subsidence, which are

expressed in the relief (e.g., the Zhanybek-Urda and Malouzensk uplifts, the Ashiozek Depression, and the Furmanov-Zhangalin subsidence zone).

Salt tectonics is one of the most distinctive features of the geological structure of the depression. In 1953, Yu.A. Meshcheryakov conducted research that provided data on the mobility of salt-dome structures in the northern Pre-Caspian region, leading to the creation of a scheme of recent tectonics for this area [12].

In the study region, the intensity of vertical movements of the Earth's crust increases both westward and eastward from the Zhayyk River valley. In the Pre-Caspian Lowland, within the valleys of the Bolshoy and Maly Uzen rivers and the Ashiozek River, the uplift rate of the Earth's crust reaches 2 mm per year. In the western part of the Podural Plateau, vertical movements also range from 0 to 2 mm per year, while in the eastern part, subsidence of up to 2 mm per year is observed. In the Obshchy Syrt area, crustal uplift increases from 2 mm per year to 4 mm per year. North of the Kushum River, the Zhayyk River valley experiences uplift up to 4 mm per year, whereas south of this section, crustal subsidence reaches 2 mm per year [13].

The oldest deposits penetrated by drilling are from the Devonian period. Paleozoic (PZ) deposits correspond to Devonian, Carboniferous, and Permian formations.

Devonian (D) deposits are found only in the marginal zones of the Pre-Caspian Depression at depths exceeding 3,000 meters, consisting mainly of carbonate formations with interbeds of terrigenous deposits in the lower sections.

Carboniferous (C) deposits are found in the marginal zones of the Pre-Caspian Depression and consist of limestones with interbeds of dolomites and argillites. The total thickness of Carboniferous deposits reaches 2,200 meters or more.

Permian (P) deposits outcrop on breached salt domes but generally occur at great depths (up to 5 km). In the northern Pre-Caspian region, they are found at depths of 2.5 km, whereas in the central part, geophysical data indicate burial depths of up to 8 km.

Permian deposits are divided into two sequences:

Lower Permian (P1) includes Asselian, Sakmarian, Artinskian, and Kungurian stages, represented by limestones with interbeds of anhydrite, gypsum, calcite, dolomite, and argillites. The maximum thickness of the Lower Permian pre-Kungurian deposits does not exceed 270 meters.

Upper Permian (P2) deposits are rarely exposed at the surface and are widespread in the southern part of the region. The lower part consists of marine and lagoonal clay-carbonate rocks, while the upper section is predominantly composed of red and variegated continental sand-clay sediments [14].

Mesozoic (MZ) deposits include Triassic, Jurassic, and Cretaceous formations. In the region, Lower Triassic deposits are exposed at the surface.

Lower Triassic deposits are represented by red-colored sand-clay formations, found in the Chagan River basin and in the crests of some salt domes. They primarily consist of red-colored siltstones, argillites, clays, sandstones, limestones, and marls, with a thickness ranging from 560 to 1,000 meters.

Jurassic deposits are exposed in small areas of the Podural Plateau and the Pre-Caspian Lowland, where they are mainly associated with salt domes. Borehole data indicate their widespread distribution across the Pre-Caspian Depression. These formations consist of alternating sand and clay layers, with thicknesses reaching up to 1,040 meters.

Lower Cretaceous (K1) deposits are divided into two main sequences: a predominantly clay-rich layer and a predominantly sandy layer. These deposits consist of clays, quartz-glauconitic sands, siltstones, argillites, and sandstones. Their thickness reaches up to 100 meters [15].

Cenozoic (KZ) deposits are widespread throughout the region and include formations from the Paleogene, Neogene, and Quaternary periods.

Paleogene deposits are widely distributed in the Pre-Caspian Depression, found in the Obshchy Syrt, the Podural Plateau, and the eastern part of the Pre-Caspian Lowland. These formations include deposits from the Paleocene, Eocene, and Oligocene. Paleocene sediments are entirely marine, whereas Eocene and Oligocene deposits contain both marine and continental facies. The total thickness reaches 200 meters.

**Figure 1.** *The Cretaceous remnant and the slopes of the Cretaceous remnant*

Geomorphological features:

The geomorphology of the West Kazakhstan region is diverse. Studies by Veselovoy and Geldeeva (1992) classified the region's horizontal and vertical dissection. The Pre-Caspian Lowland is characterized by a weakly dissected accumulative plain with low relief intensity. The average horizontal dissection is 25 km, increasing in the western lowland near salt domes.

The terrain includes five major geomorphological regions:

The western part of the Podural Plateau.

The southern part of the Obshchy Syrt upland.

The Pre-Syrt Escarpment.

The northern part of the Pre-Caspian Lowland.

The middle course of the Zhayyk River valley.

The highest point in the northeast of the region is 279 meters, while elevations decrease southwestward to -15 meters.

In the Pre-Caspian Lowland, the interfluve between the Zhayyk and Volga rivers has a general northwest-southeast inclination, while the left bank of the Zhayyk slopes northeast-southwest, leading to the river valley.

The Obshchy Syrt extends into the region only with its southern spurs, forming a structurally elevated plateau. Absolute elevations reach 80...150 meters, with isolated hills exceeding 200...250 meters. The largest valleys include those of the Chagan and Derkul rivers.

To the east of the region, sand massifs are found in the lower reaches of the Kaldygayty and Zhaksibay rivers. The landscape is dissected by meandering, shallow channels and ancient depressions, varying in depth from 1 to 3 meters with gently sloping sides. The key elements of the interfluve terrain are depressions and elevated areas between them.

## 4. CONCLUSION

The Late Khvalynian Plain is located below zero elevation marks, where weakly expressed shoreline ridges and dry deltas are partially preserved, with less dissection than the Early Khvalynian Plain, particularly in areas where the deposits have a clayey composition. In sections with sandy deposits, the surface has undergone and continues to undergo significant aeolian reworking. A rather narrow, northernmost part of the plain extends into the region.

To the west, the Urda Sand Massif borders a vast erosion-tectonic depression known as Khaki. Further east, almost reaching the Zhayyk River, stretch the Volga-Ural sand massifs. The northern part of the Volga-Ural Sands is interrupted by the erosion-tectonic depression of the Kamysh-Samara Lakes, which serves as a discharge area for floodwaters from the Uzen rivers. This depression is a vast lowland, complicated by a system of lakes of varying size and shape, interconnected by channels. In summer, most of these lakes dry up, leaving salt deposits on their surface. On the left bank of the Late Khvalynian Plain, a massif of sharply defined ridges and hummocks with relative heights of 10...20 meters stands out.

The Zhayyk River valley in the northern part of the area is quite wide. Between the villages of Kushum and Chapaevo, where the Kushum River branches off from the Zhayyk, the valley reaches a width of 45 km. South of Chapaevo, as it approaches the Inder Uplift, the Zhayyk valley narrows from 20 km to 10 km. North of the village of Antonovo, another deltaic branching occurs, with the main channel being the Bagyrday River.

Terrace formations are developed on the slopes of the Zhayyk River valley. Upstream from the mouth of the Utva River tributary, a series of four terraces of the Zhayyk River can be observed, while downstream, only two terraces remain. The first terrace (relative height of 6...12 meters) and the second terrace (relative height of 12...14 meters) are well-defined and wide on the right bank of the Zhayyk. The first terrace is dissected by a sparse network of abandoned channels, while the second terrace has a smoother surface, particularly near the river, becoming sandier and, in some places, loamier as it extends further away. The slopes of the Zhayyk valley are shaped by erosion. In the northern section, ravines are deeply incised, often reaching groundwater levels, and are covered with forest. The terrace surfaces, especially the upper one, exhibit microrelief features such as burrow mounds, micro-slopes, micro-depressions, and steppe depressions.

The floodplain of the Zhayyk within the Pre-Syrt Escarpment reaches a width of 4...6 km, while in the Pre-Caspian Lowland, its width varies from 2...3 km to 8...10 km. As with the valley as a whole, the floodplain narrows southward. It is separated from the upper terraces by a ledge 4...6 meters high. The floodplain surface is deeply dissected by a network of narrow channels and is dotted with oxbow lakes and small floodplain lakes.

The Zhayyk River is the second-largest river to enter the Caspian Sea after the Volga. In its northern section, it flows in a sublatitudinal direction, while south of Uralsk, it follows a meridional course. The river flows through loose Pliocene and Quaternary deposits, originating from the Obshchy Syrt and Podural Plateau, passing through the Pre-Syrt Escarpment, and finally entering the young Pre-Caspian Lowland.

## DATA AVAILABILITY

The data used in this study were obtained by the authors from open and paid sources.

## AUTHORS' CONTRIBUTIONS

Development of the concept and methodology, creating software, conducting statistical analysis, conducting a research, resources, preparing and editing the text, visualization – TS

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# ЖАЙЫҚ ӨЗЕНІ АЛАБЫНЫҢ ҚАЗІРГІ ЭКОГЕОМОРФОЛОГИЯЛЫҚ ЖАҒДАЙЫ

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**ТҮЙІН СӨЗДЕР**

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**АБСТРАКТ**

Адамның шаруашылық қызметі қазіргі ландшафттың қалыптасуында маңызды рөл атқарады. Қоршаған ортаның жоғары экологиялық сапасын сақтау, табиғатты қорғау және табиғи ресурстарды ұтымды пайдалану үшін барлық техногендік өзгерістерді, тікелей және жанама әсерлерін кешенді түрде ескеру қажет. Осыған байланысты климаттық өзгерістер мен антропогендік ықпал жағдайында экогеоморфогенезді зерттеу ерекше маңызға ие болып, табиғи ортаның тұрақты жағдайын сақтау бойынша ең маңызды міндеттердің біріне айналуда. Осы зерттеудің мақсаты – Жайық өзені алабындағы экогеоморфогенезді зерттеу, атап айтқанда, антропогендік әсерді ескере отырып, қазіргі жағдайды талдау және зерттелетін аумақтағы экогеоморфологиялық жағдайдың қалыптасу және трансформациялану процестерін толығырақ ашу. Жайық өзенінің алабы – геоморфологиялық, гидрологиялық және экологиялық үдерістердің өзара әрекеттесуі нәтижесінде қалыптасқан күрделі табиғи жүйе. Өзгеріп жатқан климат және өсіп келе жатқан антропогендік әсер жағдайында жер бедері, арналық процестер және өзеннің гидрологиялық сипаттамалары айтарлықтай трансформацияға ұшырауда. Мақалада Жайық өзені алабының қазіргі экогеоморфологиялық жағдайы қарастырылады. Жайық өзені алабындағы табиғи ресурстарды тұрақты басқару бойынша ұсыныстар беріліп, экожүйеге теріс әсерді азайту және климаттық өзгерістерге бейімделу стратегияларын әзірлеу шаралары ұсынылады.

# СОВРЕМЕННОЕ ЭКОГЕОМОРФОЛОГИЧЕСКОЕ СОСТОЯНИЕ БАССЕЙНА РЕКИ ЖАЙЫК

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**КЛЮЧЕВЫЕ СЛОВА**

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антропогенное воздействие
изменение климата
геолого-литологические особенности

**АБСТРАКТ**

Хозяйственная деятельность человека играет ключевую роль в формировании современного ландшафта. Для сохранения высокого экологического качества окружающей среды, защиты природы и рационального использования природных ресурсов необходимо комплексно учитывать все виды техногенных изменений, как прямые, так и косвенные. В связи с этим изучение экогеоморфогенеза в условиях климатических изменений и антропогенного влияния приобретает особую значимость, становясь одной из важнейших задач для поддержания устойчивого состояния природной среды. В этой связи целью данной работы стало исследование экогеоморфогенеза в пределах бассейна реки Жайык, а именно анализ текущего состояния с учетом антропогенного воздействия для более полного раскрытия процессов формирования и трансформации экогеоморфологического состояния исследуемой территории. Бассейн реки Жайык представляет собой сложную природную систему, формирование и развитие которой обусловлены взаимодействием геоморфологических,

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гидрологических и экологических процессов. В условиях изменяющегося климата и нарастающего антропогенного воздействия наблюдаются значительные трансформации рельефа, русловых процессов и гидрологических характеристик реки. В статье рассматриваются современное экогеоморфологическое состояния бассейна реки Жайык. Приводятся рекомендации по устойчивому управлению природными ресурсами бассейна реки Жайык, включая меры по снижению негативного воздействия на экосистему и разработку стратегий адаптации к изменяющимся климатическим условиям.