Section 4. Earth Sciences

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TECHNOGENIC CHANGE AND ECOLOGICAL STATE OF KARAKALPAK USTYURT

Abstract. The article deals with the issues of studying the state of natural-climatic, geological-hydrogeological and environmental conditions from the point of view of the observed tension of the ecological situation in the Karakalpak Ustyurt. Geoecological zoning of the territory based on the analysis of multidisciplinary information of natural-climatic and geological-hydrogeological conditions to serve for the appropriate use and further development of a regional strategy for sustainable development of the Karakalpak Ustyurt.

Keywords: natural and climatic conditions, geological and hydrogeological conditions, groundwater, environmental conditions, geoecological zoning.

Introduction. The complexity of natural and climatic conditions, the observed tension of the ecological situation in the Karakalpak Ustyurt, is explained by the intense influence of the reduction in the area of the Aral Sea, which leads to an increase in the area of desert ecosystems or is not subject to self-healing after technogenic intervention. Insufficient and uneven study of the environment, subsoil and groundwater is far from a complete list of issues to be analyzed and accounted for in the exploration and development of minerals of the Karakalpak Ustyurt. The purpose of the research was to study the state of climatic, geological, hydrogeological and ecological conditions of the territory of the Karakalpak Ustyurt for geoecological zoning of the territory of the Karakalpak Ustyurt. To achieve this goal, an information base has been systematized and generalized, allowing a retrospective analysis of the geoecological state of the Uzbek part of the Ustyurt plateau, comprehensive studies of the components of the surrounding geological environment – atmospheric air, soils, surface and groundwater, vegetation, wildlife, landscapes, and a cartographic database have been prepared.

On the Ustyurt plateau, within the contract territories, zoning is aimed at identifying objectively existing boundaries by environmental components, studying factors affecting their formation, differentiation and the nature of the relationship of geoecological conditions. The zoning is based on the degree of geoecological stability of the components of the natural environment. An important feature of the research is that it was conducted on the basis of generalization of already available materials and a modern field survey of the components of the natural environment. Of all the variety of natural factors that determine the state of the environment, landscapes, soils, vegetation and wildlife have in the area under consideration.

Discussion of the results. Most of the considered territory of the Karakalpak Ustyurt is located in areas where landscape zones coincide with tectonic structures. In general, it is a flat area with areas of ridge-hilly terrain. Miocene rocks of Neogene-Quaternary deposits are found in the surface occurrence, filling large depressions in the relief of basins such as Barsakelmas, Assakeaudan (Fig. 1).

From a physical and geographical point of view, Karakalpak Ustyurt is an independent district, where Aeolian landforms, clay flat spaces, extensive dry depressions, dry channels of ancient and modern temporary watercourses are widespread. Quaternary deposits are widely developed on the surface in the depressions, and Neogene and Cretaceous deposits are on the plateau. Cretaceous deposits are exposed in outcrops – cliffs of chinks. According to landscape, climatic, soil and geobotanical conditions, Karakalpak Ustyurt can be divided into three districts (Fig. 1).

Northern Ustyurt covers the northern part of the Karakalpak Ustyurt, and it is a gently undulating plain with heights up to 150–200 m. The predominant type is the landscape of the Neogene plateau, which occupies up to 90% of the entire territory of the research area. They are characterized by depressions, with flat basins, sometimes with manifestations of landslides, landslides, fracturing, karst and suffusion.

The central Ustyurt occupies the central, most lowered, part of the studied territory. The absolute marks of the territory range from 61 m at the bottom of the Barsakelmas basin to 150 m in the north. It is a closed, drainless salt-deflationary depression, developed in Meso-Cenozoic rocks and filled with salt layers. In the northwest, there is a continuation of the depression in the form of a lake-accumulative plain composed of sandy deposits (Fig. 1).

Southern Ustyurt occupies the territory to the south of the Karabaur mountain pass and the adjacent hill. The terrain is undulating-flat, dissected by runoff hollows. In the southern part of the Karakalpak Ustyurt there is a large Assakeaudan depression, from the north it is bounded by steep slopes that reach a height of 40–50 m. A hollow wavy relief characterizes the vast bottom of the depression. Here, as in other depressions adjacent to Barsakelmes, semi-fixed bumpy sands with a height of 2–5 m, consisting of fine-grained particles and salt dust, fixed around shrubs and saxauls, are common [2; 3].

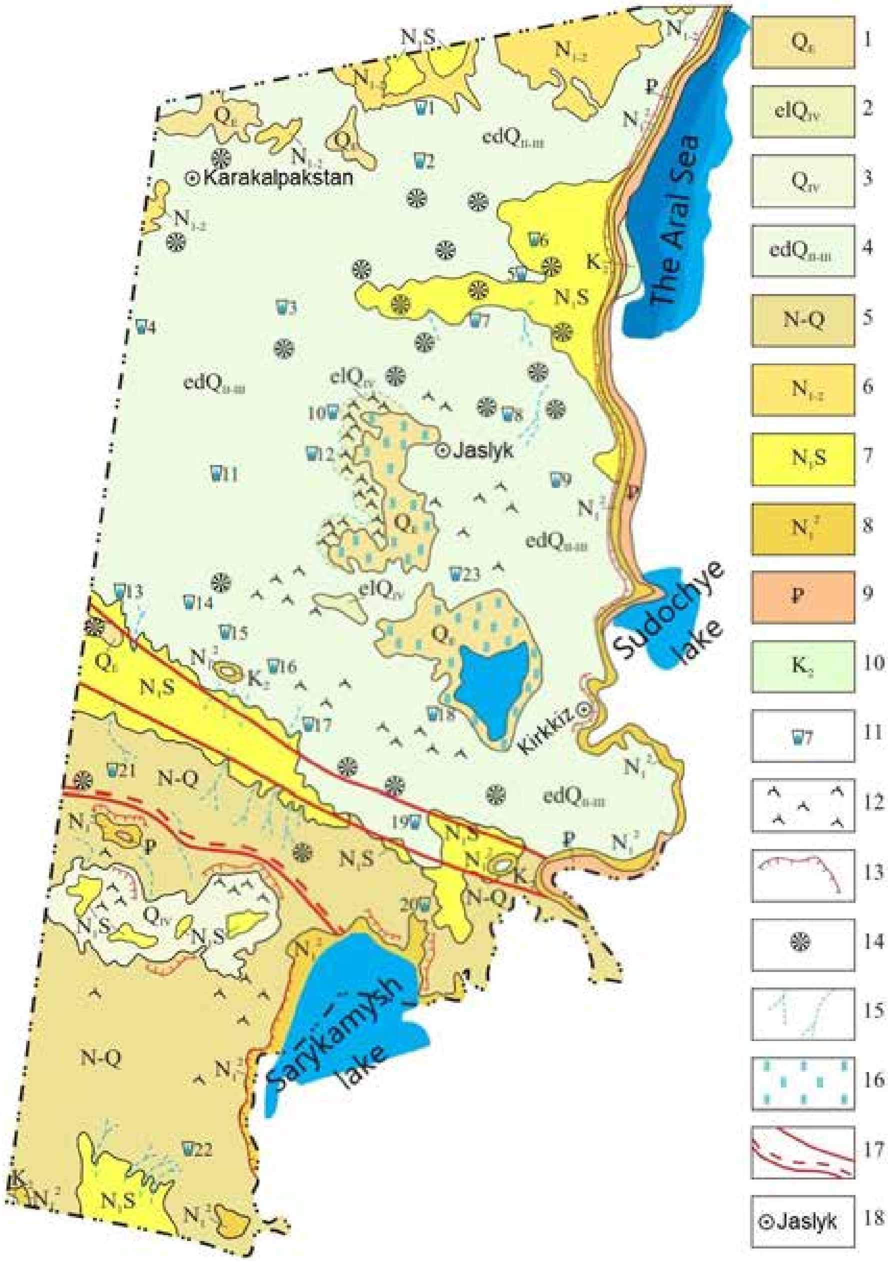

Figure 1. Schematic geological and lithological map of the Karakalpak Ustyurt

Symbols. Age – related: 1-Eopleistocene deposits (sands, gypsum, halite and chemical rocks); 2-Aeolian deposits (dusty and fine-grained sands); 3-Holocene deposits (wetlands with medium and coarse-grained sands, stratification of gypsum, halite and other chemical rocks); 4-eluvial-deluvial deposits (coarse-grained and medium-grained sands, powdery sandy loam and loam, lumpy in places); 5-undifferentiated neogene-quaternary deposits (coarse-grained and medium-grained sands, with the inclusion of gravel, limestone and marl sediments); 6-Miocene-Pliocene deposits (sands, marls, limestones, clays); 7-Miocene deposits of the Sarmatian tier (limestones, marls and clays with gypsum interlayers); 8-Middle Miocene (marl clays with gypsum nests and interlayers of marl limestones); 9-undifferentiated Paleogene deposits (clays, marls); 10-Upper Cretaceous deposits (clays, siltstones with layers of sandstones and sands). Other: 11-wells (1-Urdebai; 2-Riapai; 3-Terenkuduk; 4-Ushbent;

5-Sengir; 6-Turlibai; 7-Boiterek; 8-Kuvonishkazgan; 9-Boschuvok; 10-Tezenkazgan; 11-Okboytol; 12-Borishjon; 13-Tuzelbai; 14-Kiziltom; 15-Uchkuduk; 16-Okshukir; 17-Boychagir; 18-Lutibai; 19-Uru; 20-Surzha; 21-Toshoek; 22-Uzunkuyi; 23-Alpizkazgan); 12-Saxauls and thickets of saxauls; 13-canions ravines and chinks; 14-salt marshes; 15-temporary watercourses;16-chemical deposits, salt marshes, sands, sandy loam rocks, salt layers and accumulations (mirobilite and halite); 17-faults: a) Karabaursky; b) Shakhpakhtinsky; 18-settlements.

In accordance with the structural features of the hydrogeological section, two hydrogeological floors are distinguished. The upper floor covers deposits of Quaternary and Miocene age. They form non-pressure and low-pressure waters of the free water exchange zone with a mineralization of 1.8–10 g/l. The lower hydrogeological floor is associated with relatively isolated water-pressure complexes of Cretaceous, Jurassic and Permian-Triassic deposits.

Groundwater developed in Miocene sediments, as well as in a small part of Quaternary formations, have a close hydraulic connection with each other and form a single aquifer. They have a free mirror surface and are of the nature of groundwater. The area of their nutrition coincides with the area of distribution. In most cases, atmospheric precipitation is the main source of the formation of underground waters of Miocene formations. In the conditions of the Karakalpak Ustyurt, a small amount of precipitation (90–120 mm per year), a significant part of it goes to feed groundwater. This is facilitated by the high permeability of Quaternary sediments and Neogene deposits, represented by fractured and quarried limestones and marls. Based on the common geological and geomorphological structure and conditions of formation, movement and discharge of groundwater within the Karakalpak Ustyurt, the selected groups of groundwater flows have a certain orientation due to the general bias of the regional water barrier. The geological and structural plan of the Karakalpak Ustyurt is mostly quite clearly reflected in the relief, groundwater moves from areas of maximum surface marks to areas with minimum marks.

Intensive infiltration of atmospheric precipitation, due to the high permeability of rocks, had a noticeable desalination effect on the groundwater of Miocene sediments. During this long period, due to repeated changes in the basis of groundwater drainage, the hydrodynamic conditions of the aquifer also changed. The basins of underground and surface runoff determine important features and boundary conditions of geochemical migration. In general, they can be considered as one of the main hydrogeological and geomorphological units, within which many important natural and anthropogenic factors and processes that determine the state of the geological environment are integrated.

Based on the above, the spatial relationship between the zonality of groundwater flows and landscapes is clearly determined within the Karakalpak Ustyurt [1–6]. Ecological zoning of landscapes and groundwater flows was carried out according to the system of assessment points. The evaluation criteria were arranged in the order of the expected reduction of the environmental effect of the zoned object. Where a maximum of 3 points is determined for the initial sections of the movement of ground flows within the watersheds, these are *ecologically less stressful areas*.

The slopes of groundwater flows are *more intense areas* within which geodynamic processes and mass transfer in the form of water-soluble substances, including groundwater pollutants, are carried out – it is estimated as 2 points.

Within the confines of the drainless depressions, *the condition of groundwater is significantly deteriorating*, and therefore, these areas were evaluated at a minimum of one point.

According to the soil-geographical zoning, the territory of the Karakalpak Ustyurt belongs to the zone of deserts and semi-deserts. The following soil varieties are represented on the territory: gray-brown desert, takyr, gypsum soils, desert-sandy, desert salt marshes, salt marshes. Salinity and low humus content are characteristic features of the soils of the Karakalpak Ustyurt [12]. Ecological zoning of soils – the upper biogenic layer of the daytime surface, is necessary to predict the ecological situation and assess the consequences of man-made impacts. Soil zoning is based on generalized information about the stability of the soil cover to chemical pollution during geological exploration and industrial construction of linear structures – gas pipelines. When zoning soils, such parameters as granulometric composition, humus reserves, humus content in the upper horizon, the reaction of the soil environment (degree of acidity), and the power of the upper horizon were taken into account. Indicators of soil acidity, redox potential, etc. which are functional and depend on the genesis of the breeds. The content and reserves of humus in the soils of the Karakalpak Ustyurt are initially low, at the level of 0.3 1.0%, which entails instability of the main properties, primarily the ability of soils to sorb and activate pollutants entering it (a pollutant is any natural or anthropogenic agent entering the surrounding geological environment in quantities exceeding background values and causing thereby polluting it). With a pronounced effect, the rate of humification processes and nitrogen accumulation are further reduced. The loss of humus is primarily associated with its natural mineralization, erosion processes, as well as with a violation of the structure of soil aggregates, for example, during the passage of machinery and the formation of a "puffy" in the rut or when the soil is "knocked out" during sheep grazing.

The functional parameter of soil stability is dynamic, changing in space and time. Variability is associated with climatic conditions: precipitation and temperature, as well as with the influence of internal factors. Soil acidity is an indicator that changes due to the release of carbon dioxide during the decomposition of organic residues and the functioning of biota, the course of chemical and biochemical reactions within the liquid and solid phases of the soil. The level of activity of the soil microbiota, mobility and availability of not only biophilic elements, but also heavy metals depend on the amount of soil acidity. In the soils of natural biogeocenoses of Ustyurt, under anthropogenic influence, a change in soil acidity is often observed, mainly in the direction of acidification. A sharply alkaline reaction is characteristic of the takyr crust – up to 9.5 pH, and the crust itself is usually not saline – the concentration of easily soluble salts is observed under it. Takyrs are extremely poor in humus (0.2 0.5%) and easily digestible nutrients for plants, they periodically actively undergo the processes of silting and salting. The capacity of the bio-accumulative horizon (humus horizon) plays an essential role in the formation of soil stability. The humus horizon has an increased absorption capacity in relation to various kinds of pollutants, due to the formation of organomineral complexes. This horizon plays the role of the first sorption-geochemical barrier on the path of pollutants. Having increased moisture capacity, it reduces the level of leaching and migration of elements in the soil profile. The assessment of the level of soil stability in points was carried out according to the method of A. S. Fedorov et al. [3, 10–12]. With the general vulnerability of desert soils to undesirable influences, the soil varieties of Karakalpak Ustyurt can be divided as follows: 1) gray–brown soils – moderate level of stability (20–15 points); 2) takyr soils – low level of stability (15–10 points); 3) salt marshes and cortical salt flats – very low level of stability (less than 10 points). Based on the information received, ecological zoning of the soils of the Karakalpak Ustyurt was carried out (Fig. 2). Areas with very low soil stability are mainly confined to the lowering of the Barsakelmas in Central Ustyurt. In the rest of the territory under consideration, they are represented only in a limited way, within the Assakeaudan-Southern Ustyurt depression and in the extreme northwest of the Karakalpak Ustyurt. Salt marshes, cortical salt marshes, and their variations are included in this category of lands. Mechanical disturbance of the salt crust can lead to a sharp activation of salt removal and the development of secondary salinization and salinization processes, up to complete degradation of the soils of the adjacent territory.

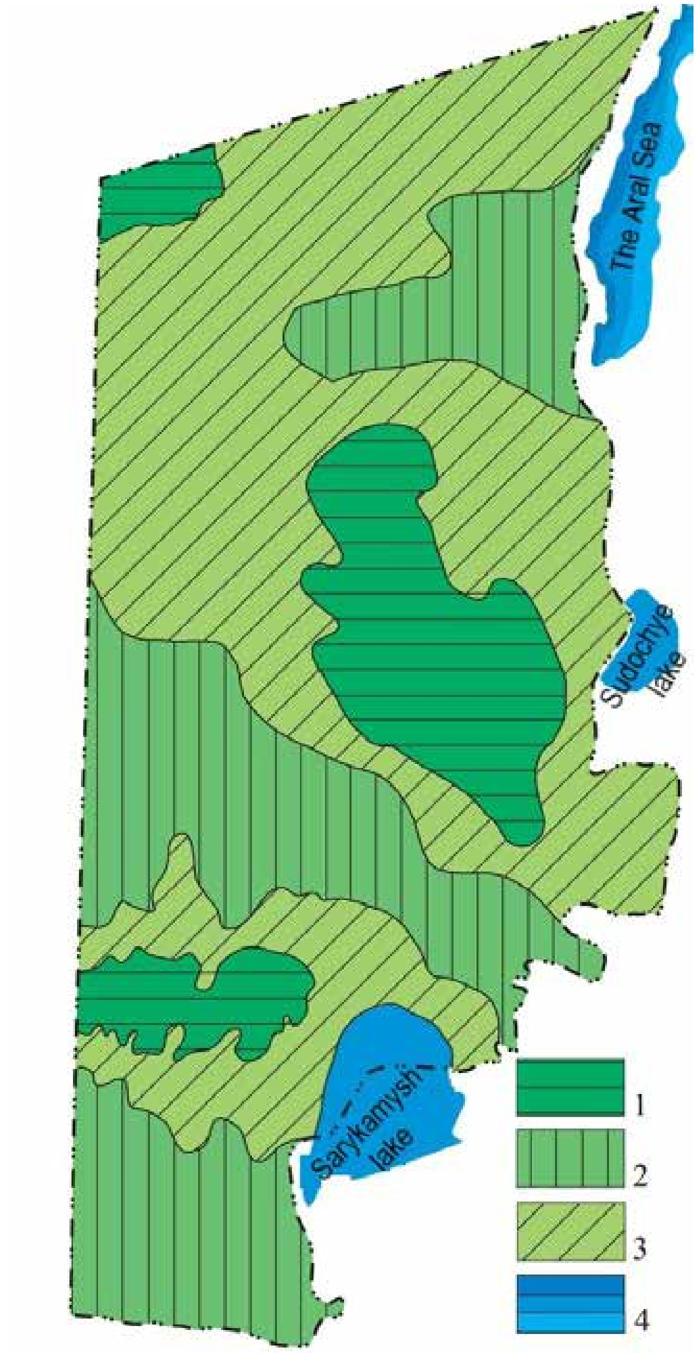

Figure 2. Schematic geoecological zoning of the Karakalpak Ustyurt: 1 –very low level of stability (less than 10 points); 2 – low level of stability (15–10 points); 3 – moderate level of stability (20–15 points); 4 – water surface

Areas with a low level of stability are mainly represented by takyrs and takyr-like soils. Low humus content, unfavorable physico-chemical properties, low intensity of flow and incompleteness of soil processes with contrasting natural and climatic conditions worsen their ecological stability. Soil arrays with low ecological stability are noted in all landscape areas. Gray-brown desert soils and various variations of underdeveloped soils have moderate stability. The assignment of gray-brown soils to this category is due to their lack of negative properties, with the activation of which a sharp deterioration of the ecological situation is possible. They occur mainly in the southwestern and southeastern parts of the Karakalpak Ustyurt. A significant area of moderately stable soils was formed in the northwestern part of Central Ustyurt.

The nature of plant communities is determined by natural and climatic factors: intense solar insolation and high summer temperatures, severe frosts combined with weak snow cover in winter, lack of moisture in the soil and air in summer and pronounced daily and annual temperature fluctuations [1–4]. The flora includes about 600 species of higher vascular plants, the basis of which are hazy (20%): biyurgun, boyalych, keireuk, kyrgyzbugush, black saxaul, sarsazan. As the data of I. I. Granitov show, on the Karakalpak Ustyurt "there are plant species that are rare in Central Asia in general, known so far only in a few places, and the Khiva solyanka (Salsola chivensis) is an "Ustyurt endemic" [6–9]. Protected species are more than 30 species of rare and endemic plants. The modern fauna of the region includes 2 species of amphibians, about 35 species of reptiles, 200 species of birds, 44 species of mammals.

Conclusions. The current state of the biological resources of the territory under consideration, their high value, the presence of sites with the status of specially protected natural territories, as well as the presence of areas of growth or habitat of rare and protected species of flora and fauna, additionally impose a number of environmental restrictions on the implementation of geological exploration and design and survey work. Zoning based on the analysis of multidisciplinary information is advisable to use for further development of a regional strategy for sustainable development of the Karakalpak Ustyurt. In particular, the analysis of the materials has already made it possible to prepare a number of measures to reduce and eliminate the negative impact on the unique ecosystems of the Karakalpak Ustyurt. Ecological zoning is the final part of ecological research and serves as a fundamental basis for making management decisions in the field of rational nature management.

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