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A.A. Lukashov

Lomonosov Moscow State University, Moscow, Russia

Evolution of rivers in the arid zone of Kazakhstan (geomorphological aspect)

Geographical location, the variety of relief and climatic conditions of Kazakhstan have caused an uneven distribution of surface waters in its territory. Character of the hydrographic system, regime and flow of the rivers depend essentially on the latitudinal zonation of climate and landscapes. On the most part of the territory evaporation equals to the amount of precipitation. Therefore, there is a shortage of moisture in the soil and aridity roughs in the form of landscapes everywhere. Due to the shortage of moisture, especially sharply expressed in the desert and semi-desert areas, surface runoff is small, river system is sparse, and the rivers are shallow. Many rivers form independent basins of a closed flow and finish in small closed lakes, lost in the sands or its own deposits. Central Kazakhstan applies to the areas with poor hydrographic system. Surface runoff of the Central Kazakhstan is represented by rivers Ishim (upper), Selety, Shiderty, Sarysu, Nura. Modern state of the rivers is aggravated by environmental destabilization of the region.

Keywords: Central Kazakhstan, Ertys, Nura, Lake Kurgalzhin, Tokrau River, Lake Balkhash.

Introduction

Most of the territory of Central Kazakhstan belongs to the internal drainless area, and only the Esil (Ishim) river with tributaries carries its waters to the Ob basin. The rest of the rivers of the northern part of Central Kazakhstan flow towards the Ertys (Irtysh) river, but end in small closed lakes in the extreme south of Western Siberia or are lost in their own sediments. Many rivers form independent closed drainage basins. The largest such river is the Nura, which originates in the Khankashta mountains and flows into Lake Kurgalzhin.

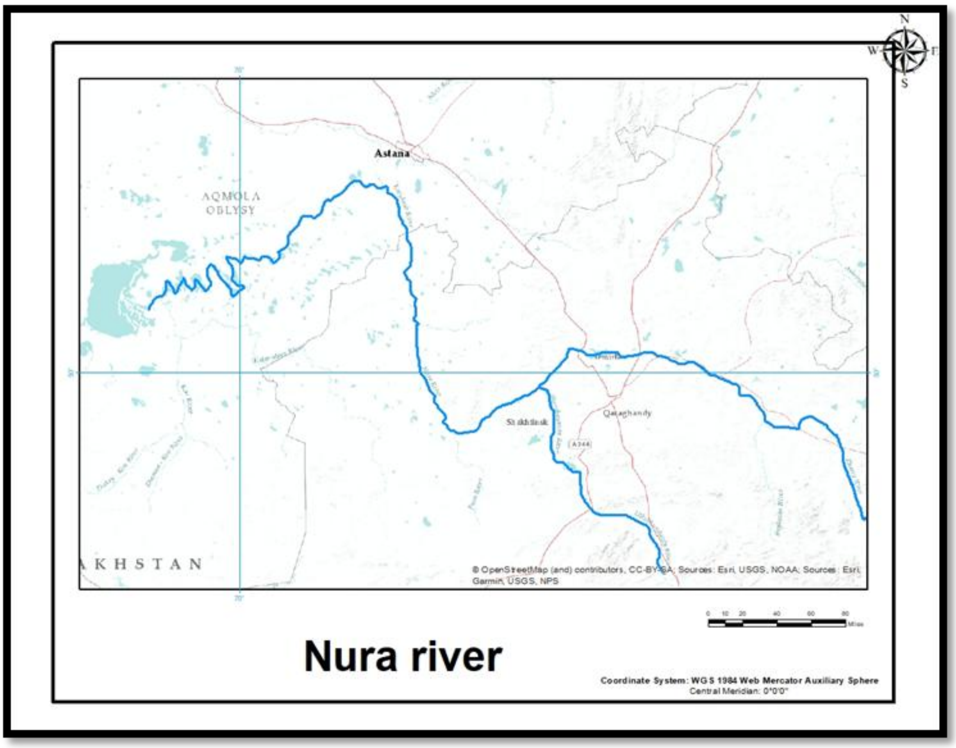

Figure 1. Nura River [9]

Materials and methods

The Sarysu river valley in the upper reaches is 20 km wide and is composed of red clay on the surface. Expanded areas in the upper reaches are recognized by some researchers (Svarichevskaya Z.A., 1965) as areas of minor local troughs, which were probably filled with lakes at one time. In the Quaternary, a real erosional valley arose, in which the floodplain and the first above floodplain terrace 5-6 m high, composed of sandy loam and gravel-pebble material, were clearly traced.

Figure 2. The bridge across the rivers near Sarysu, destroyed by floods [6].

According to its morphological features, the Mointy River valley is divided into upper and lower parts. In the upper section, the valley is 7–10 km wide. Its bottom, directly from the surface, is composed of red-colored sediments, at the base of which are kaolinized sands with inclusions of pebbles, sometimes cemented by conglomerates. Thickness 6 m, age — Upper Oligocene. The red clays are cut by a relatively narrow young Quaternary Mointy valley and the ancient bottom rises above the modern channel in the form of a terrace, 12–15 m high. Below Zhingil station, a valley bifurcation is noted, and its left branch Minshukur merges with the mouth of the Zhamshi valley. The right branch, or the main valley of Mointa, narrows below the Zhingil station, and there are no red clays in it. Four terraces can be traced here: the first and second terraces are of Quaternary age, and the third and fourth (2 and 10 m heights, respectively) are composed of Upper Oligocene pebbles. Their exposure is associated with the uplift of the ancient bottom of the valley. The fourth terrace received the greatest development on the left bank of the Mointa at the mouth, where it immediately approaches Balkhash [1].

The valley of the Tokrau River and the Kusak tributary, 10–30 km wide, are made of Miocene variegated clays. In the middle part, extensive bottoms are cut by Quaternary valleys with a dry bed. In the upper reaches of the Tokrau River, there is a well-developed floodplain and four alluvial terraces. The channel, filled with pebbles, can be traced to the bottom of the valley and is lost at the end of its vast delta, which in the xerothermal epoch was strongly dispersed and turned into hilly sands 5–7 m high. Near Lake Balkhash, the delta was flooded and then salinized in the Upper Quaternary. Within the Karaganda coal basin, the Nura river appears only over a short stretch to the northwest and northeast. The main rivers of the basin are the Sokyr and Sherubainura rivers. The total length of the Sherubainura River is 270 km, within the basin it flows at a distance of 50 km. The river begins in the Togunbai Mountains, at the watershed of the Nura River and Lake Balkhash basins. For 50 km, Sherubainura flows along a wide (1–10 km) valley, the river bed is meandering, the width in some places reaches 40 m, the bottom is covered with pebbles and sand. The depth of the river is from 0.3 to 4 m. The banks are steep, 4 m and more high, overgrown with willow trees everywhere. The water in the river is fresh, with a constant surface flow along its entire length. Three terraces are well-defined. The right tributaries are the Sokyr and Sarydzhan-Uz ek rivers, the left ones are the Tentek river. Near the village of Molodetskoe, Sherubainura flows into the Nura river.

Figure 3. Mointy River during the flood [7].

The Sokyr river originates in the Itzhan mountains and flows through the basin in the direction from south-east to north-west. The total length of the river from the headwaters to the mouth is 80 km. Throughout its entire length, the river has no constant surface runoff, the water is brackish. The river bed is well expressed, and in some places, it reaches several tens of meters, the height of the coastline is 6 m. The streams in the upper reaches are small, in the lower reaches, they reach lengths from 75 to 200 m and up to 20 m in width with a river depth of 2.5 m. Closer to the mouth, the length of the streams is 1.5 km, the width is 30 m. The river retains its plyosal character up to its mouth. The Elche River is a large tributary. It begins in the Akbastau mountains, flows along a wide valley, the channel is clearly expressed throughout, the water is brackish. The Koktal and Sogurbay (Karasu) rivers are the left tributaries of the Sokyr river. In the upper and middle reaches, these rivers have a well-defined channel, and in the lower, they are lost in the alluvial valley.

A B

Figure 4. The destroyed bridge across the Sokyr river (A), liquidation of overflow on the river (B) [8].

Since false history evolution has the Balkhash-Alakol parameter lakes group, which and hitherto object disputed. From the point of view of L.S. Berg (1904), Z.A. Svarichevskaya (1952) Lake Balkhash is young, the nature of the shores is ingression. According to research by B.F. Meffert (1912), M.P. Rusakova (1933), K.V. Kurdyukov (1952), the nature of the shores is regression. Research by Z.A. Svarichevskaya revealed: a) the pebble terraces of Balkhash are the fourth Upper Oligocene terrace of the Mointy valley; b) the coastal zone of Balkhash is characterized by youth; c) the coast is bay, ingression, in places discharge. The forms of the shores of the Northern Balkhash are determined by the dissection of the land flooded by the lake. The

Saryshagan Bay is located on the site of the flooded mouth of the Mointy River. The absence of a deeply protruding bay at the mouths of the Minshukur and Zhamshi is explained by the powerful accumulations of alluvium in the valleys, which compensated for the flooding of the mouth. In the northwestern part of the Saryshagan Bay, flooded rocky granite hills have caused a kind of island relief, similar to the skerry coast of Finland. From time to time, the lake floods the denudation plain sinking under its level, and in some places the plain breaks off with a sharp ledge, and the coast bears traces of abrasion. However, the steepness of the shores is of tectonic origin. This is evidenced by the ancient lacustrine sediments at the foot of Targyl at an altitude of 9–12 m, the distinct straightness of the western shores of the lake, as well as the limitation of the shore of the Kashkanteniz Bay by young faults and the high height of coastal ramparts (up to 20 m). Along the coast stretches a narrow strip of beach and coastal embankments, well-developed and of considerable width and height (3-4 m). An ancient wall of the Upper Quaternary age is occasionally observed. It is very wide, overgrown with vegetation. In the estuarine parts of the valleys, only modern ramparts are found. They are small in width and height. On the coast at the mouth of the Zhamshi River and on the southern bank of the Balkhash, the Aral type of coast is observed, characterized by flooding of the hilly desert aeolian relief. The flooding took place during the Upper Quaternary flooding epoch. Now the shore of the lake has receded, and the ancient coastline of the Aral type characterizes the winding edge of the saline plain [3].

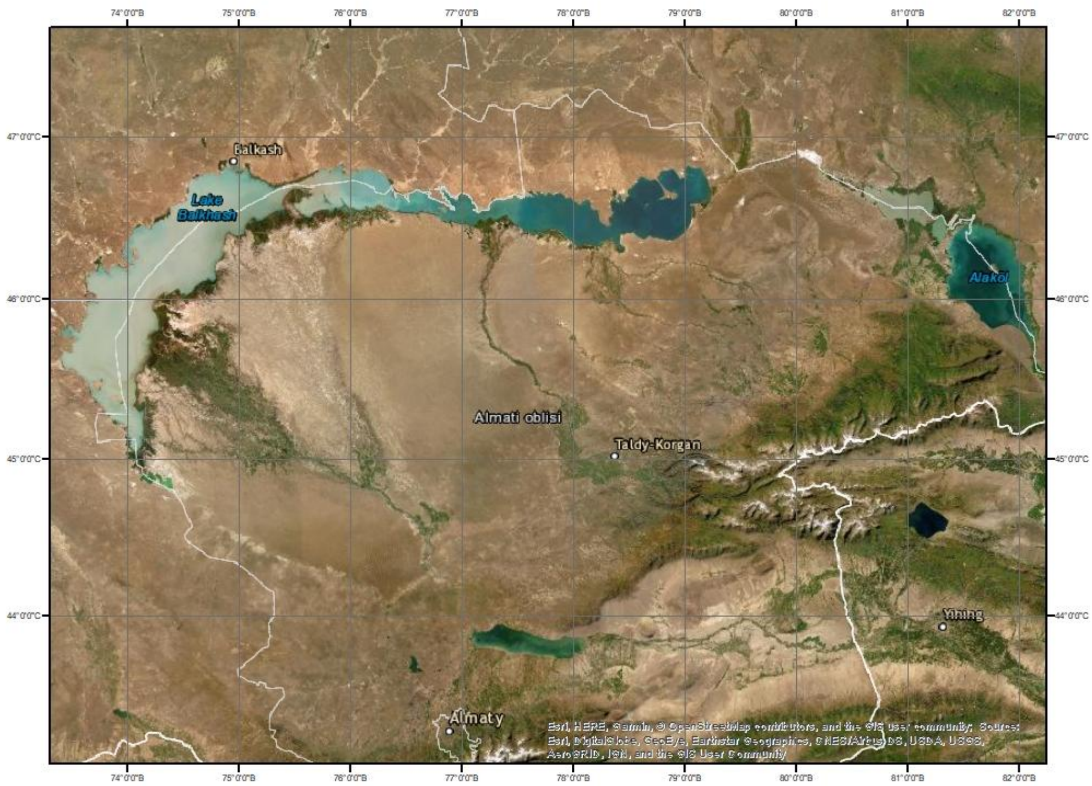

Figure 5. Balkhash-Alakol group of lakes (satellite image).

Fluctuations in the level of Lake Balkhash have occurred and are occurring constantly. It periodically increases and decreases in area. The lake reached its lowest level in the late 40s. From 1952, a sharp rise began, which continued until 1962, after which a decline began again. The decline in the level of the lake from 1990–1993 corresponds to the mark of 32 cm, from 1993 to 1995 there was a rise in the level to 28 cm. From the end of 1995 to 1998, the lake level began to decrease and reached 21 cm. Short-term rhythms occur against the background of intrasecular fluctuations in the level of the Lake Balkhash (45–60 years).

On the territory of Central Kazakhstan, there are lakes with fresh, salt, and brackish water. They are shallow depressions with flat shores. Some lakes exist only in spring: in the summer, the water either disappears completely and the bottom is a rough surface or some of it remains and turns into swamps.

According to the words of formation, the lakes are divided into lakes formed on the site of the stretches of former rivers; dam lakes, formed by blocking river valleys with sediments, brought by their temporary channels and lakes, which owe their origin to deflation.

The largest lake Sasykkol has an area of about 7 km^2, the depth does not exceed 3 m. By origin, Sasykkol belongs to the type of dam lakes of the river. In the southeastern part of the basin, there are a number of drying up lakes under the general name Sarykol or Bala-Sarykol. In places where groundwater flows out, there are swampy areas.

Results and Discussion

The evolution of rivers has influenced the current state and distribution of underground waters in Central Kazakhstan, which are formed due to the filtration of water from transit rivers and underground runoff from the surrounding mountain systems. Reservoir waters associated with weakly dislocated sedimentary rocks of various ages predominate. Fissure waters occur under Paleozoic and more ancient rocks at a depth of 100 meters or more. Groundwater outlets through cracks are available in the low mountains of the Kazakh Upland, at the foot of the Chu-Ili Mountains. The identified basins of fresh and slightly saline artesian waters lie at a depth of 100–400 to 500–800 m [4]. In the northern parts of the region and in areas of low mountains, characterized by an increased amount of atmospheric precipitation, at the foot of hills and mountain ranges, along the sides of the valleys, natural outflows of groundwater in the form of springs and hollows are recorded.

Sources flow rates range from hundredths to 5 dm 3/s. Granite massifs of low mountains (Kokshetau, Bayanauyl, etc.) are most favourable for the formation of fractured waters. Fissure-karst waters are associated with the Famen and Tourne carbonate rocks. The largest water cut is characteristic of the cores and wings of anticlinal folds composed of karst limestones (Zhezkazgan-Ulytau, Kengir districts). The thickness of the flooded zone is 100–200 m, the karst content is established to a depth of 280 m. Pore-type waters are associated with sediments of gray-colored coal-bearing formation (J).

The Karaganda artesian basin covers an area of more than 1100 km^2. With the thickness of the watered conglomerate-sandstones of the order of 200–250 m, the natural reserves of the basin are 3.8 billion m^3. The exploitable groundwater resources of the Jurassic rocks of the basin are estimated at 1.5 m^3/s. The existing water intakes, taking into account the mine drainage, give about 1 m^3/s. Long-term exploitation of the artesian basin (over 40 years) has led to a decrease in water levels by 30–70 m and the formation of a depression funnel with an area of 300 km^2. Pore water is accumulated by loose clastic deposits of the surface formation. Of greatest practical interest are aquifers of alluvial and alluvial-proluvial deposits. Sand-gravel-pebble deposits in the valleys of large rivers of the region contain flows and horizons of groundwater everywhere. The increase in pore water reserves occurs due to the infiltration of flood runoff, atmospheric precipitation, and inflow of fractured waters. Long-term hydrometric observations have established that up to 95 % of the annual surface waterfalls on the spring flood. In vast areas of clayey and sandy-clayey plains, groundwater flows through deep confined aquifers at great depths. These areas include the western part of the Betpakdala plateau.

The underground waters of the study area are subdivided by V.A. Kurdyukov (1936) into two main types: waters filling cracks and voids of solid Paleozoic rocks, and waters trapped in the pores of loose post-Paleozoic formations. Taking into account the variety of conditions of occurrence and circulation of waters, depending on the differences in lithological composition and structure of rocks, V.A. Kurdyukov identified the following types of groundwater within the above types:

1-fractured effusive waters; 2-fractured, fractured-stratal, and karst waters of the sedimentary strata of the Devonian and Lower Carboniferous; 3-reservoir fractured waters of the productive strata (first type).

4-bed waters of Mesozoic sediments; 5-bed waters of ancient alluvial valleys; 6-stratal waters of post-Tertiary sediments: alluvial flows and localized free horizons (second type) [5].

Other researchers (A.P. Vykhodtsev, I.S. Rusanov, etc.) identify basically the same types, but either combine some types, or identify subtypes of groundwater, but in general, adhere to the classification of V.A. Kurdyukov. When considering each type of groundwater, we note that they have their own characteristics and specificity. Fissured waters of effusive rocks, due to the large area of development of fractured rocks, are of great importance in the hydrogeology of the basin. These waters serve as the base for water supply to branches and farms. The waters of tectonic zones are associated with tectonic contacts of rocks of the effusive suite and sedimentary formations of the Upper Devonian-Lower Carboniferous or with faults within each of the formations. The strongest manifestations of these waters were studied by

V.A. Kurdyukov in the area of Maikuduk (Karaganda) and the Zhalair hills. The Maikuduk tectonic aquifer, confined to the contact of the Middle Devonian porphyritic lavas and the Carboniferous strata, was traced along the outcrops of sources and swampy areas at a distance of more than 4 km. Fractured and karst waters are confined to the fractured and karst limestones of the Rusakov and Kassinsky layers. The general synclinal bedding of limestones with good water confinement conditions generally favorable conditions for the accumulation of a significant amount of water. The waters are exposed by wells. Wells located north of Karaganda in the area of the village. Tikhonovka and Kompaneisky, showed flow rates from 5 to 30 l/s. Fractured waters of the coal-bearing strata are exposed by mines, wells, pits, and boreholes. The degree of water content depends on the lithological composition of the formations, rock fractures, and the presence of tectonic faults. The waters of the coal-bearing strata are characterized by a variegated composition: below the weathering zone, it is with deer and hard waters, not suitable for drinking and technical purposes. The content of sulfates is 400–1600 mg/l, chlorine — 34–5300 mg/l. Water consumption from tens of a liter to 6-7 l/s. Aquifers are confined to coal seams and sandstones. The formation waters of ancient alluvial valleys were discovered in the river valley. Sherubainury, near the village. Zhartas and in the valley of the river. Nury. The formation waters of post-Tertiary sediments are in most cases fresh, with a chlorine content of 50–200 mg/l and sulfates — 20–150 mg/l.

Conclusion

Great importance has always been attached to the study and search of underground waters in Central Kazakhstan, since surface waters are unevenly distributed over the territory of the republic, and underground waters are the main source of water supply for many regions. Significant reserves of fresh water have been identified in carbonate structures, ancient and modern valleys, sandy massifs, granitoid and metamorphic rocks.

Thus, along with geological, climatic, hydrogeological conditions, geomorphological factors also influenced the evolution of genetic types of surface and ground waters, their distribution, and accumulation.

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А.А. Лукашов

Қазақстанның құрғақ аймағы өзендерінің эволюциясы (геоморфологиялық аспект)

Қазақстанның географиялық орналасуы, жер бедері мен климаттық жағдайларының әртүрлілігі оның аумағында жерүсті суларының біркелкі бөлінбеуіне әкелді. Гидрографиялық жүйенің табиғаты, өзендердің режимі мен ағыны климат пен ландшафттардың ендік белдеулеріне байланысты. Аумақтың көп бөлігінде булану жауын-шашынға сәйкес келеді. Сондықтан барлық жерде топырақта ылғал жетіспейді және ландшафттардың құрғақтығы байқалады. Әсіресе бұл тапшылық жерүсті ағыны аз, өзен жүйесі сирек, өзендері таяз, шөлді және шөлейт аймақтарда айқын көрінеді. Көптеген өзендер дербес тұйық ағынды бассейндерді құрайды және құмдарда немесе өз шөгінділерінде жоғалған шағын ағынсыз көлдерге айналады. Орталық Қазақстан гидрографиялық жүйесі төмен аумаққа жатады. Орталық Қазақстанның жерүсті ағыны Есіл, Сілеті, Шідерті, Сарысу, Нұра өзендері арқылы көрсетілген. Өзендердің қазіргі жағдайы аймақтың экологиялық тұрақсыздануына байланысты қиындауда.

Кілт сөздер: Орталық Қазақстан, Ертіс, Нұра, Қорғалжын көлі, Тоқырауын өзені, Балқаш көлі.

А.А. Лукашов

Эволюция рек аридной зоны Казахстана (геоморфологический аспект)

Географическое положение, разнообразие рельефа и климатических условий Казахстана обуславливают неравномерное распределение поверхностных вод на его территории. Характер гидрографической системы, режим и сток рек во многом зависят от широтной зональности климата и ландшафтов. На большей части территории испаряемость соответствует количеству осадков. Поэтому повсюду наблюдается недостаток влаги в почве и засушливость ландшафтов, особенно остро этот дефицит выражен в пустынных и полупустынных районах, где поверхностный сток невелик, речная система разрежена, реки мелководны. Многие реки образуют самостоятельные бассейны замкнутого течения и заканчиваются небольшими бессточными озерами, затерянными в песках или собственных отложениях. Центральный Казахстан относится к территории со слабой гидрографической системой. Поверхностный сток Центрального Казахстана представлен реками Ишим (Есиль), Селеты, Шидерты, Сарысу, Нура. Современное состояние рек усугубляется экологической дестабилизацией региона.

Ключевые слова: Центральный Казахстан, Ертыс, Нура, озеро Кургалжин, река Токрау, озеро Балхаш.

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Information about the author

Lukashov Andrey Aleksandrovich — Doctor of Geographical Sciences, Professor, Lomonosov Moscow State University, Moscow, Russia.