GeoJournal of Tourism and Geosites
ISSN 2065-1198, E-ISSN 2065-0817

Year XIV, vol. 34, no. 1, 2021, p.102-111
DOI 10.30892/gtg.34114-625

CANYONS OF THE CHARYN RIVER (SOUTH-EAST KAZAKHSTAN): GEOLOGICAL HISTORY AND GEOTOURISM

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Citation: Nigmatova, S., Zhamangara, A., Bayshashov, B., Abubakirova, N., Akmagambet S., & Berdenov, Zh. (2021). CANYONS OF THE CHARYN RIVER (SOUTH-EAST KAZAKHSTAN): GEOLOGICAL HISTORY AND GEOTOURISM. *GeoJournal of Tourism and Geosites*, 34(1), 102–111. https://doi.org/10.30892/gtg.34114-625

Abstract: The Charyn River is located in South-East Kazakhstan, 195 km east of Almaty. The river valley cuts through Paleozoic rocks and loose sandy-clay deposits of the Cenozoic and forms amazingly beautiful canyons, the so-called "Valley of Castles". This place is actively visited by tourists from all over the world. However, Charyn canyons have not only tourist but also scientific value. Deposits with fossil fauna and flora are exposed here, and there is evidence of unique tectonic processes that took place in this area. Years of research have made it possible to describe in detail the stratigraphy of the region and outline new tourism routes that open up unknown pages in the history of South-Eastern Kazakhstan.

Key words: Charyn River, Charyn canyons, Kazakhstan, Paleozoic, Cenozoic, paleolandscapes

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INTRODUCTION

As world practice shows, one of the most effective and promising ways to preserve the pristine uniqueness of natural landscapes and geosystems is rational tourism and recreation nature management. In order to optimize the use of natural and recreational resources and with account taken of the anthropogenic load of recreation and tourism, an assessment of the natural and recreational potential of the territory is carried out. Assessment issues were dealt with in different periods by Russian (Dunets, 2019; Kuskov, 2005; Ushakov, 2020) and Kazakhstani scientists (Makashev, 1983; Erdavletov, 2000; Vilesov, 2009; Erdavletov, 2010; Berdenov, 2016; Beketova, 2019; Aktymbayeva, 2020;), and by foreign authors as well (Ilies and Grama, 2010; Wendt, 2020; Ilies, 2017). Due to the physical and geographical location, the peculiarities of the geological and geomorphological structure and landscape diversity, the South Kazakhstan region has sufficient natural resource potential for the development of recreation and such types of tourism as ecotourism, "green" (agritourism), water tourism and other types. The works of the following scientists are devoted to the study of the landscape biodiversity of the geosystems of the South Kazakhstan region: Kulibaev (2006); Ilies and Grama, 2010; Suraganova (2013); Ilies et al. (2017, 2018); Herman et al., 2019; Akbar (2020); Kerimbay (2020); Indrie et al., 2020; Marcu et al., 2020; Suleimenov et al., 2020. Natural and recreational resources as a basis for the development of tourism and recreation are considered in the works of Akhmedenova (2017), Dunets and Zhogova (2019) and others. Landscape refugium are a relief or other natural objects in which, due to the unique combination of landscape-forming factors and low economic development, characteristic and rare relict geosystems for the region have been preserved. The idea of refugiums has long been established in Western and Russian biological science and literally means “shelters” - areas of the earth’s surface where one species, or more often a whole group of living forms, survived an unfavorable period of geological time during which these forms disappeared in other spaces (Kerimbay, 2020). Charyn canyons have not only tourist but also scientific value. Deposits with fossil fauna and flora are exposed here, and there is evidence of unique tectonic processes that took place in this area (Kozhamkulova et al., 1978; Kostenko, 1978; Baybulatova and Kostenko, 1981; Zhilkibaev, 1982; Tyut'kova, 1988; Aubekerov at al., 1990; Bayshashov, 2005). Geological and paleontological studies have made it possible to describe in detail the stratigraphy of the region and outline new tourism routes that open up unknown pages in the geological history of South-Eastern Kazakhstan, which are presented in this article.

MATERIALS AND METHODS

The Charyn River is located in South-Eastern Kazakhstan, approximately 195-200 km from Almaty city, the ex-capital of Kazakhstan.

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The Charyn River basin is located in the territory of 42°40′ - 44°00′ Northing and 78°30′ - 80°35′ Easting . The River Charyn is the left tributary of the Ili River and therefore belongs to the Balkhash lake basin. The Charyn River is about 427 km long, the river basin area is 7,720 km², the average annual water consumption is 37 m³/sec. Within the Kazakhstan territory, it is the longest and most water-rich tributary of the Ili River (Figure 1). Charyn originates in the Ketmen mountains. At the source, it is called Shalkodesu, downstream, opposite the salt lake Tuzkol, it receives the name Kegen and takes on the left its largest tributary Karkara (its source is in the Terskey Alatau mountains) and less significant – Ulken Taldybulak. After merging with another left tributary of the Kensu, it becomes Charyn. Orta Merke and Shet Merke, the first left tributaries of the Charyn, originate in the Kungei Alatau Mountains. The last and only right tributary of the Charyn is the Temirlik River with a length of about 60 km. Its origins are in the Ketmen Mountains. The average annual water consumption in the upper reaches is about 2 m³/s. The Temirlik River is fed by atmospheric precipitation, melted snow and groundwater. The river cuts deep into the Ketmen foothill plain and flows into a canyon for 25 km. It is less deep than the Charyn canyons in the Aktogay and Moyintogay gorges, and the slopes of the Temirlik canyon are not so steep and high.

The unique landscapes of the Charyn canyons are widely known among domestic and foreign tourists. Particularly popular with tourists is a section of a river valley with grandiose canyons, the so-called "Valley of Castles". However, there are no less interesting canyons and gorges along the river, located in the Paleozoic and Cenozoic sediments, which are rarely visited by tourists.

Figure 1. Map of the Charyn River basin (space image Google Earth)

In the Charyn River valley, the "canyon section" changes the appearance of the valley. In the upper part of the section, just above the Shet Merke estuary, the river flows in a deep rocky gorge, reaching a depth of 300 metres in some places. It is located at the junction of the Kuluktau and Kungei Alatau mountains. This gorge is called Moynak ("isthmus" in Kazakh). The canyon in the Jalanasha depression is getting wider and its slopes are smoother, and the riverbed here occupies only part of the canyon bed. This canyon, actually its western part on the left bank, is called Aktogay Canyon. The right bank is called Zhylysay ("warm ravine" in Kazakh). The length of Aktogay-Zhylysay canyon is about 20 km. The canyon has clear river terraces and floodplains. Along the river bed, floodplain forests with a typical arid climate set of plants grow: poplar, ochre and various shrubs. These ribbon groves are called Aktogay ("light forest" in Kazakh).

Down the Aktogay, the Charyn River cuts not only through the Neogene deposits, but also the hard-rocks of the ancient peneplain. In this section, the canyon is very narrow with steep sides. The riverbed takes almost the entire width of the canyon. After steep rocky ravines and chasmy bizarre Neogene-Quaternary canyons of the Kurtogay and Moyintogay gorges, the valley loses its expressiveness and, for about 40 km after its exit from the mountains, its steep slopes (as it approaches the Ili River) come to nothing. In its lower course, the river becomes flat and wide - this place is called Sarytogay (yellow forest). The chain of Charyn canyons ends here. Several manches of the Charyn River flow into the Ili River forming a huge delta which pushes Ili to north for 18 km. In 2004, by decree of the Government of the Republic of Kazakhstan dated February 23, No. 213, on an area of 93,150 hectares (since 2009, 127,050 hectares), the Charyn State National Natural Park was organized. According to the approved and published data, there are three main protected objects and three tourist routes (Charyn ash grove, Charyn canyon "Valley of Castles" and burial grounds and burial mounds). Research materials included geographical maps of the Republic of Kazakhstan, materials of geological and paleontological studies. Based on the

method for assessing the recreational potential of the territory (Stepanova, 2010), the analyzed region is differentiated into Geosites. However, at least six tourist routes can be identified in the valley of the Charyn River.

RESULTS DISCUSSIONS

Geological and geomorphologic structure and paleolandscapes.

The area crossed by the Charyn valley is part of the neotectonic structure of the North Tien Shan, which over the past 1.5 million years formed a complex system of mountains and intermountain basins. These are, from south to north (downstream the Charyn river): the Kungei Alatau mountains, a highly elevated neotectonic block, to north of which is the intermountain Zhalanash depression, then there are the Toraigyr mountains, an elevated neotectonic block, further to north is the Sogety intermountain depression. The Boguty Mountains, an elevated neotectonic block, separate the Sogety depression from the large Ili depression along which flows the Ili River. This sequence of tectonic structural changes is typical for the left bank of the Charyn River. The system is different on the right bank of the Charyn. It is one large negative structure. It is the Ili depression, and the Sogety and Zhalanash depressions are its smaller secondary parts. Both latter intermountain depressions open into the Ili depression, forming a negative structure between the Toraigyr and Boguty mountains and the Ketmen range. The Charyn River paved its way to the western edge of this negative structure, part of the Ili depression.

The history of the Zhalanash depression begins in the Neogene or at the end of the Paleogene, when tectonic movements conditioned the sinking of the tectonic block. During the Neogene-Quaternary time, according to geophysical data, more than 1500 m of loose deposits accumulated in the Zhalanash depression. Its geological history proceeded under changing climate and growing altitudes of the watershed relief parts. Initially, there was an accumulation of Miocene and Pliocene deposits in the locked depression, surrounded by relatively sparsely dissected, non-contrast relief. This phase sediments were characterized by a set of lacustrine clays and marls and by sandy and gravel-pebble deposits of relatively small amounts interlaid with lacustrine fine-grained sediments. Lacustrine and lacustrine-alluvial deposits formed the central and northern part of the Zhalanash depression. The cuts in the southern part are composed of boulder and pebble deposits. Accumulation of boulder and pebble thickness of over 300 m is related to the activity of the Kegen River pre-valley, which formed a continental delta in the Zhalanash depression. Whereas in the Miocene and Early Pliocene there was a relative equilibrium between paleo-Zhalanash lake and the continental delta of the theKegen river pre-valley, in Pliocene, with increase of the absolute height of the mountains, the accumulation of coarse-fragmentation material was reinforced, and by the final stage of Neogene sedimentation, the lake ceased to exist, and the boulder-pebble material carried by the Kegen valley became the dominant type in the Zhalanash depression.

This history of sedimentation can be well read from the cuts on sides of the Charyn canyon within the Zhalanash depression. In the south part of the depression, the canyon sides (headstream) are composed of boulder and pebble. In the central and north parts of the Zhalanash depression, the sections' lower and middle parts are filled by lacustrine clays and marls, above they are intertwined with lenses and layers of sand-boulder-gravel deposits, and boulder gravels of the Pleistocene complete the section (Figure 2).

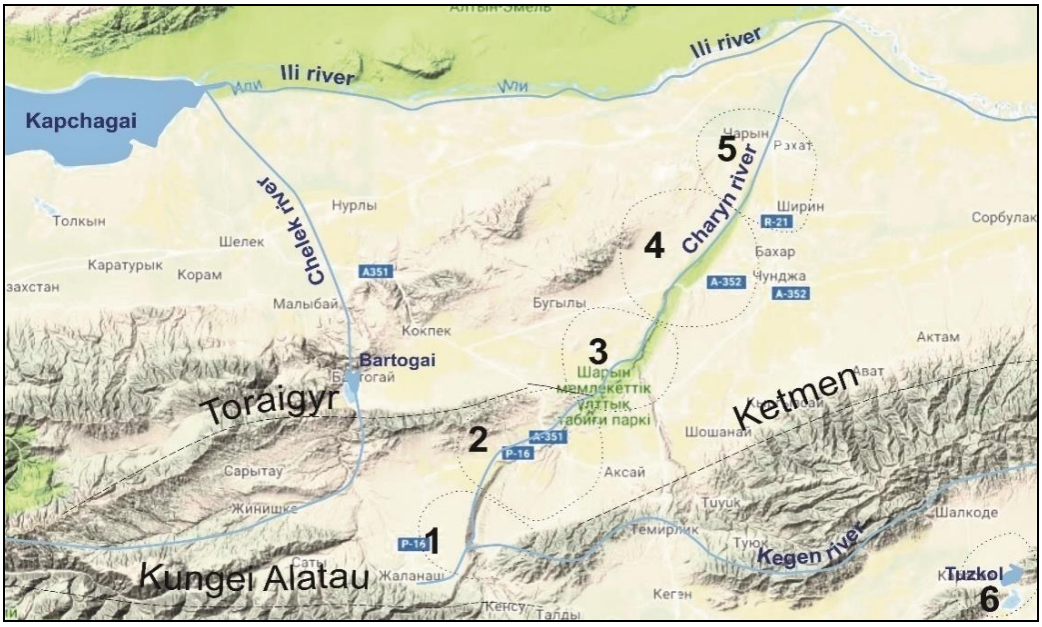


Figure 2. The scheme of geological sites of the Charyn river canyon (Source: SAS Planet)

Route 1 - The Moinak gorge

This is picturesque place with deep rock canyons. They are composed of volcanic rocks of the Paleozoic (Lower Carboniferous) (Figure 3 (B). The age of the rocks is about 350 million years. In the upper reaches of the Charyn River, in 2012, the Moinak hydroelectric station was put into operation, with the regulating Bestyube reservoir (Figure 3 (A)). This is the highest hydroelectric power station in Kazakhstan and Central Asia. Below the reservoir, the river flows into a rocky gorge. In the canyon crevasses, the spruce -*Picea schrenkiana* subsp. *tianschanica* (Rupr.) Bykov, finds refuge, feeling very comfortable on slopes shaded and wetted by water splashes. Vacationers, who love mountain scenery and turbulent mountain rivers, are heading here. The uppermost part of the section is composed of loess laid in the piedmonts of the Kungei Alatau Mountains. The loess surface bears traces of erosive fragmentation in the form of troughs of north-west flow (across the Zhalanash depression). These ancient troughs have no channels and do not coincide with the direction of the modern Charyn river valley, which cuts through this drainage system. Probably, accumulation and subsequent erosion of loess occurred in the final stage of the first half of the alluvial cone (continental delta) of the Kegen River, discharging its waters in the north-west direction. A chain of river cuts begins from the mouth of the Kensu River (left tributary of the Charyn River) and extends for about 80 km to a point of 17 km below the Charyn bridge on the Almaty-Shonzha motorway. The absolute height of the valley floor at the beginning of the canyon chain is 1,700 m while at the end it is 650 m. Consequently, the height difference between them is just over 1000 m.

Route 2 - The Kopaly (Aktogay) gorge

Down the Shet Merke estuary, the Charyn River overlooks the expanse of the intermountain Zhalanash depression (Figure 4 (A, B). It cuts into the Cenozoic loose clastic thickness 150-200 m deep. It consists mainly of the Neogene proluvial alluviation interlaid with lacustrine sediments. The Neogene thickness is covered by alluvial (riverine) Lower Quaternary sediments of boulders and gravels. The largest boulders reach 0.5 m in diameter. Lower Quaternary conglomerates from the surface are overlapped by loess of the same age (Tyut'kova, 1988; Aubekerov at al., 1990). The Cenozoic sediments of the Zhalanash depression contain numerous remains of ancient animals, among which notable are rodents, bones of ancient elephant, horse and antelope (Kozhamkulova et al., 1978; Bayshashov, 2005). The bone remains were first discovered here in 1977 by the team of the Paleozoology Laboratory at the Institute of Zoology (Almaty, Kazakhstan). This location is also known in literature as Kopaly or Aktogai (Figure 5, 6). In 1990, a group of geologists and palaeontologists analysed and described the site section using known palaeontological and geological data (Aubekerov at al., 1990).

A) Bestyube reservoir

B) The deep rocky canyons of the Moynak Gorge, formed by lower Carboniferous volcanic rocks

Figure 3. Scenic views of Moinak gorge (foto authors)

A) The alluvial sediments of the Zhalanash depression

B) The Zhalanash depression

Figure 4. Scenic views of the Zhalanash depression (Photos of authors)

The main paleontological artefacts have been found in the Zhalanash depression. According to paleontologists, they are located in the section formations described from bottom to top as per deposition stages (Tyut'kova, 1988; Baybulatova et al., 1981; Kozhamkulova et al., 1987; Aubekerov et al., 1990; Jamangaraeva,1993).

Formation 1. Identified here are: rodents and lagomorphs *Hypolagus sp., Ochotona aktogaiensis, Ellobius sp., Villanya patenyi, Mimomys haplodentatus;* mollusks *Planorbis;* stoneworts *Chara molassica var. Kirgizensis.*

Formation 2. Identified here are: rodents and lagomorphs *Ellobius sp., Cricetulus sp., Meriones sp., Clethrionomys mirus, Prologurus pannonicus, Allophajomys pliocaenious, Mimomys haplodentatus, Pachycrocuta brevirostris;* predators *Canis etruscus*; rhinoceros *Dicerorhinus sp.;* odd-toed *Equus cf. stenonis;* artiodactyl *Leptobos cf. etruscus, Gazella sp., Gazellaspira sp.;* proboscidean *Archidiscodon sp., A. gromovi*; fish *Carassius sp., Rutillus sp.;*molluscs *Subzebrinus costatus, Macrochlamys kasnakowi*; stoneworts *Chara molassica var.kirgisensis, Chara cf. vulgaris* L. f. *lata* Krassav., *Hornichara narinensis*.

Formation 3. Identified are: rodents and lagomorphs *Clethrionomys kretzoi, C. miricus, Prolagurus pannonicus, Allophajomys pliocaenicus, Microtus cf. hintoni; Gastrocopta theeli, Vertigo alpestris, Ponsadensis semenovi, Diacus ex. gr. ruderatus, Pupilla cf. bigranata, Pseudonapaeus sp.;* predator *Canis sp.*

This is one of the largest paleontological locations of the Late Pliocene Ili Formation. The Neogene sections in the northern part of the Jalanasca depression are an inexhaustible source of information on Neogene fauna and flora. Dozens of sites with bone remains of ancient

elephants, horses, antelopes and numerous large and small mammals have given scientists decades of research into fossil fauna and flora. The organisation of the open-air museum will make it possible to organise an excursion for tourists. Traces of seismotectonic cataclysms are also interesting. Tectonically induced faults in the rocks, their movement and, in some cases, the inversion of the layer, have a great influence when viewing the Kopaly area. Changed climatic conditions and desertification in the area lead to the accumulation of early Pleistocene loesses, which cover the thickness of boulder and pebbles and are clearly visible in cuts along the canyon sides. Only in the Middle Pleistocene does the situation in the Zhalanash depression change. The increase in the height of the mountains and the neotectonic movements that led to even greater relief contrast have caused the valley to break out towards the Ili Depression. The valley cuts deep into the Quaternary and Neogene sediments, and erosion processes lead to the formation of several erosion levels-steps, typical not only of the Zhalanash depression but also of the eastern periphery of the Toraigyr mountains. A floodplain and two floodplain terraces are observed in a deep canyon along the river banks. They are composed of mountain alluvium - boulder and pebble deposits interspersed with layers of sand and loams. In the instrumental parts of the canyon there are powerful removal cones of periodically acting valleys. In total, they form three levels of nested removal cones. This feature of the canyon structure is characteristic of the entire deep-cut Charyn River valley.

A. General view of The Kopaly (Aktogay) gorge

B. The valley of the Charyn River in the Aktogay tract, a view of the Neogene-Quaternary deposits

C. The contact of Paleozoic rocks with the Cenozoic loose-detrital stratum on the right side of the canyon

D. Neogene Quaternary sediments in the Kopaly

Figure 5. The Kopaly (Aktogay) gorge (Photos of authors)

Our own palinological studies of loess sections has shown that loess contains quite complete spores-pollens spectra of both steppe and forest-steppe types. This has led to the belief that in the early Pleistocene, quite a rich vegetation cover was restored here, and the vertical belt existed in the mountains. There are pollen grains of coniferous (spruce, pine), broad-leaved (linden, maple, oak, elm) and small-leaved species and shrubs (birch, alder, willow). Participants of plant groups at the time were also shrubs: barberry, jujuba (Oleaster, Wild Olive. - *Eleagnus angustifolia L.*), rosehip. The presence of juniper (*Juniperus*) and fir (*Abies*) was also noted. Such a set of plants, where broad-leaved plants (linden, maple, oak, elm) and conifers (juniper, fir) could co-exist with the togai desert vegetation, is unlikely and requires further study of the section, in order to separate redeposited, inwashed and autochthonous pollen in the spectrum. Charyn Canyon in this section was well explored by man. Parking sites of the ancient man of the Ashelian and Mousterian epochs, Bronze Age and Early Iron Age have been preserved in the Jalanash Canyon and may be an object for tourist visits. Piedmonts of the Trans-Ili Alatau were always the place of human settlement. Traces of human activity here have survived to this day in the form of remnants of dwellings, burial structures, kurgans, etc. The Charyn canyon was well mastered by humans. Stations of Ashelian and Mousterian ancient man of the Bronze and the Early Iron Ages were preserved in the Zhalanash depression and can be used for tourist visits. Primitive stone tools by the Stone Age ancient

man were found here dated 500-700 thousand BP. These are the oldest findings of its kind in the territory of Kazakhstan. The Paleozoic foundation uncovered by the Charyn River is represented by effusive carbonaceous rocks. They are opened on sides of the Zhalanash depression.

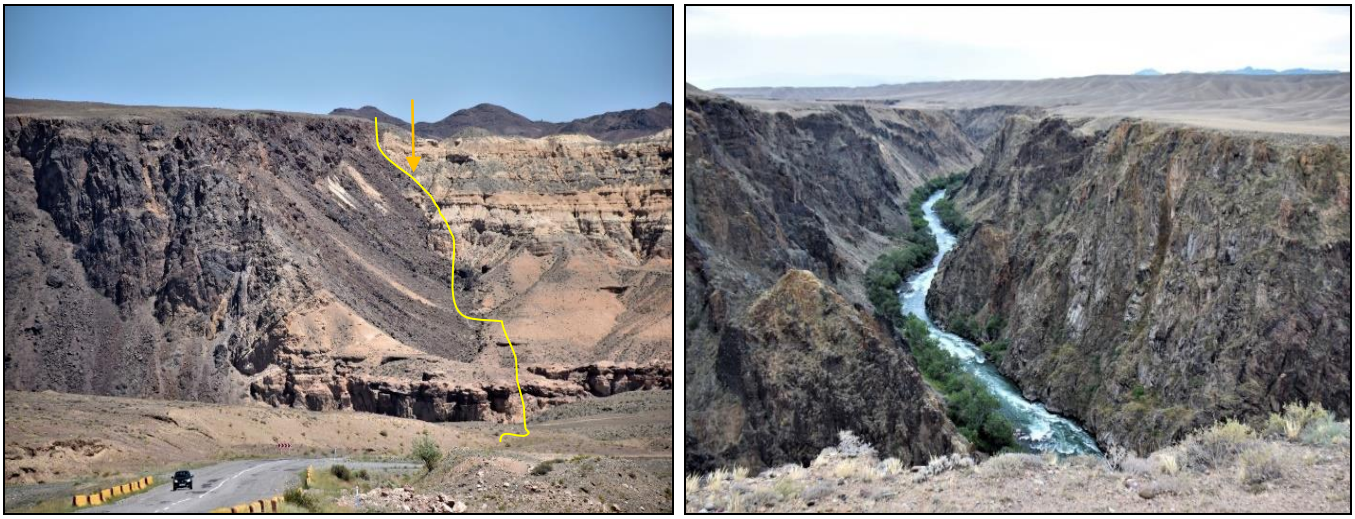
A. Late Pliocene deposits in the Aktogay Gorge

B. Palaeontological finds of a tooth of *Equus cf. stenonis* from Late Pliocene deposits in the Aktogay Gorge

Figure 6. Late Pliocene deposits in the Aktogay Gorge and palaeontological finds of a tooth of *Equus cf. stenonis* (Photos of authors)

Route 3 – the Kurtogai gorge

North of the Zhalanash depression, downstream, the valley paved its way to the periphery of the Toraigyr Mountains. Separated from the Zhalanash depression by a fault, the Toraigyr Mountains in this site are losing their height and along the eastern periphery are connected to the ancient surface of peneplain, elevated in separate blocks to different heights but still located near the modern day surface, while in the Zhalanash, Sogety and Ili depressions the peneplain surface sunk to a depth of several hundred meters to 1.5 km. The canyon sides are mainly composed of Carboniferous effusives and Ordovician granites broken by faults that can be clearly seen from lightened colouring of the rocks and different heights at which the tectonic blocks (key-driven tectonics) were elevated. And only the section's uppermost part on elevated blocks is composed of loose Neogene and Quaternary deposits (Aubekerov et al., 2007). On the right bank of this section, seen is a vast sloping foothill plain developed on a thick loose cover functioning as intermountain depression. The sloping surface of the plain has been paved with numerous dry valleys cutting through Quaternary loess sediments as well as Neogene clays and patums (the rock is a typical sedimentary unsorted breccia or conglomerate breccia). Below the bridge over Charyn, on the motorway between Almaty and Narynkol (Raimbek), the canyon is called Kurtogai gorge (Figure 7). It has some remarkable features. At the base of its left side, beneath the Cenozoic thickness, dark grey limestone of the Paleozoic Carboniferous period is exposed. The limestone is saturated with petrified brachiopod shells (bottom sea molluscs). The visible horizon is only few metres thick. Rested on ancient limestones is a Neogene Formation represented by lacustrine deposits (limestone, marl, clay) and proluvial unsorted cemented clay, sandy and crushed rock deposition. The entire Neogene thickness has reddish and yellowish tones. Its thickness is a few tens of meters. The uppermost cover horizon is represented by grey cemented pebbles (conglomerates) of the Lower Quaternary age (Aubekerov et al., 1990; Aubekerov et al., 2007).



A. The contact between Paleozoic rocks and the Cenozoic friable strata

B. The Kurtogai gorge

Figure 7. View of The Kurtogai gorge (Photos of authors)

Paleozoic limestone with brachiopod shells (Figure 8) indicates that the sea was warm about 300 million years ago (Chabdarov et.al. 1971; Krasnoborodkin, 1985). For about 23 million years, the Neogene was dominated by arid subtropical climate and landscapes reminiscent of modern savannahs. Early Neogene, in the Miocene, lakes were widespread here. At the end of the Neogene and in the Lower Quaternary, the climate sharply cooled down, and glaciers began to appear in the mountains. Full-flowing rivers began to carry sandy rocky

material into the Zhalanash depression and form the abovementioned conglomerates. The downstream Kurtogai gorge changed dramatically: the river leaves the Zhalanash depression and crashes into the eastern spur of the Toraigyr range. Here it flows in a wild rocky gorge 300 m deep. Paleozoic (Carboniferous) volcanic rocks are exposed along the slopes, and the gorge bottom is fully filled by the water current. At the point where the river enters the Toraigyr rocky massif, the contact of Paleozoic rocks with the Cenozoic loose clastic thickness is clearly visible on the right side of the canyon. The tectonic structure is impressive: the rock block rises above the Cenozoic sediments, horizontal layers of which bend upwards at the contact, indicating the active rise of the Toraigyr. In Toraigyr, the rocky gorge stretches for about 8 km. From there, Charyn enters the expanses of the Ili depression and again cuts deep into the Cenozoic and Paleozoic deposits. Here is another section of the canyon, Moyintogai, which stretches from the northern foot of the Toraigyr to the place where its last right tributary Temirlik flows into Charyn.

A. General view of Paleozoic limestone of Charyn region B. Paleozoic limestone with brachiopod shells of Charyn canyon

Figure 8. Paleozoic limestone with brachiopod shells (Photos of authors)

Figure 9. Charyn The "Valley of the Castles" of of Charyn canyons (zen.yandex, 2019)

Route 4 - Valley of the Castles

At the point where the Charyn emerges from the deep rocky gorge that cuts through the Toraigyr, a deep sai, the “Valley of Castles”, opens into it from the left, from the west, which is most frequently visited by tourists (Figure 9). Along the sides of this deepest gully, weathering processes, temporary water currents and strong winds have sculpted fanciful rocks resembling castle ruins, human and animal figures. The Neogene pattum of this bay contains significant quantities of crushed rock - a product of the destruction of the northern macro-slope of Toraygyr. Also noteworthy are whitewashed lenses of lacustrine deposits, represented mainly by marls (clay-lime rock). In the "Valley of the Castles", Neogene deposits overlay a rocky shallow bed formed by effusives (volcanic rocks) of the upper Paleozoic (Carboniferous) period (Chabdarov et.al. 1971; Krasnoborodkin 1985). These dark rocks are clearly visible on the right side of the valley, especially at the outlet to the Charyn where it is 200 m deep. Desert trees and shrubs - saxaul (sexeuil), chingil (shengel), karagan (karagan), turpentine (tuyesinir), ephedra (kylsha) - grow on the bottom of the Say. Curlew is a prickly, stunted shrub with small leaves. In spring, its white-pink flowers exude a strong honey scent Along the banks of the Charyn, there are turanga or poplar multifoliate, willow, oleaster (jida), Along the banks of the Charyn River one can meet: turanga (poplar), multifoliage poplar (oak, tobylgy), honeysuckle (ushkat), tamarisk (zhingyl), wild rose (ytmuryn), and others. "The Valley of Castles" descends to the Charyn River. On the riverbank there is a camping with guest houses, yurts (nomadic houses) and places for tents (Figure 10).

Route 5 – The Sarytogai gorge

Downstream, after the Sugety depression, the valley rounds the Mount Boguty from the east. The valley becomes wider and cut into the relief decreases. The valley acquires a transverse chest-shaped profile. The slopes of the valley are smoothed out. Several channels

appear in the floodplain. There are many remnants of ancient fauna. It is in this section of the valley that the remains of ancient elephant, primitive horse, antelope, bull and other large and small animals were collected and studied for the first time; the remains of ostrich shells were found. The valley is cut into sediments of the Ili and Khorgos Formations, composed of clays, loams, lenses of sandstone and fine pebbles. In the valley, Quaternary sediments formed a floodplain, the first and second terraces above the floodplain. The sides of the valley cut through numerous dry valleys and ravines. The floodplain and its terraces are composed of clays, loams, layers of sand with gravel and pebble (Kostenko, 1978). Alluvial cones of dry valleys can be seen everywhere in the valley's sides.

Figure 10. The camping area on the Charyn riverbank (Photos of authors)

A. Neogene and Quaternary sediments of Charyn canyons (Photos of authors)

B. General view of the ash-tree grove of Charyn region (zen.yandex, 2019)

C. Sogdian ash trees (Photos of authors)

Figure 11. The Sarytogai gorge and the Ash-tree grove of Charyn region

The river bed gets shallow. Down the Temirlik mouth, the Charyn canyon is called Sarytogai. It becomes wider and cuts into Neogene and Quaternary sediments to a depth of about 100 metres. The Sarytogai canyon is known for its relict ash-tree grove, which

covers about 800 hectares (Figure 11). The relict Sogdian ash-tree grove covers approximately 800 ha. The Sogdian, or potamophilous, ash-tree grove exists since the Neogene when the climate in these places was warmer than it is today. At the time the canyon did not exist, and the ash-tree grew under subtropical climate, along the banks of small rivers throughout the south of Kazakhstan. And when it cooled down in the Quaternary, it settled on the shelter of the Charyn canyon, which began to form at the beginning of the Middle Pleistocene, about 350,000 BP. The Ash-tree grove is a cherished nature haven of the Almaty region.

Across the Boguty Mountains and down, the valley has a similar geological but varying geomorphological structure. On this basis, the sections of the valley crossing the eastern tip of the Boguty Mountains and the Charyn valley itself within the Ili depression are identified as independent sections. Passing the Boguty Mountains, the Charyn River paves its way on the southern part of the Ili depression. The river formed a land delta composed of sandy clay alluvium, then it flows into the Ili River. In the place where the Charyn River enters the Ili River valley, the Ili depression has a section that is characteristic to the entire depression. The top of the section is composed of alluvial deposits of the Ili river valley, its floodplain and two terraces.

The alluvium consists mainly of fine sand, loam and clay. Influenced by arid climate, with weak vegetation cover, the terraces and floodplains are constantly exposed to aeolian processing, which shaped the aeolian relief - dunes, bumpy and heapy terrain - observed on their surface and along sides of the Ili depression. The aeolian sand is fine, well breezed, composed mainly of quartz and quartz-fieldspar. Below the Pleistocene sediments in the Ili depression lie the Khorgos (Eopleistocene), Ili, Santash and Shol-adyr deposits. The following tectonic stages are distinguished in the Pleistocene when occurred maximal block movements (Kostenko, 1978): Khorgos, Koiba, Baky and Almaty. These tectonic stages define important milestones in the history of Semirechie geological development. During the Quaternary period, intensity of tectonic movements, which had both continuous and intermittent character, caused quickening of vertical movements. Rising, the Alpine massifs gradually involved the adjacent parts of plains, therefore the Quaternary and older Neogene and Paleogene deposits of the foothills are sloping, not horizontal. All these morphologically different relief macroforms are linked by the largest rivers valleys of the Semirechie: Ayagoz, Lepsy, Karatal, Aksu, Koksu, Ili, and Chu.

Route 6 - the Tuzkol lake

It is one of the gems of the Charyn basin. The lake is located about 10 km southeast of the Karasaz settlement, between the mountains of Yelshin Buirek and Tizgen Karatau, at an absolute height of 1,950 m. Its area of about 6.6 km² varies by seasons and years. The lake stretches from northeast to southwest for about 5 km. Its depth is only a few tens of centimeters. The years are remembered when the lake was nearly all dry. The shores are murshy and sludgy with stains of salts. Alkaline soils stretch along the coast.

They are the highest ones in our region. The lake is unusually salty, the most salty in the mountains of Kazakhstan. Its salinity is extremely variable depending on the water inflow. It can reach 225 g/l, that is, almost the same as in the Dead Sea of the Arabian Peninsula. The salt deposition is continued in the lake; in the past, the salt was extracted and carried to the surrounding villages and even to the Issyk-kul region. The shoreline Tuzkol muds have curative properties (Figure 12).

A. North side B. South side

Figure 12. The Tuzkol lake of Charyn canyons (authors)

CONCLUSION

Thus, by studying the geological formations of the canyons of the Charyn River, it is possible to visually reconstruct the geological and paleontological chronicle of this unique territory. Furthermore, it is possible to trace the entire long history from the moment the first land islands appeared in the Paleozoic to the formation of arid mountains in the Neogene and Quarter, with their unique flora and fauna. The Charyn canyons can be classified as monuments of geological history: they are national treasures that require special attention, protection, and study. Well-developed infrastructure (including modern roads, equipped campsites and guest houses), close to the large city of Almaty (where there is an international airport), increases the attractiveness of this National Park for scientific tourism, and also makes it possible to use these unique natural and geological sites for scientific and educational purposes.

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Article history: Received: 15.10.2020 Revised: 07.01.2021 Accepted: 20.01.2021 Available online: 09.02.2021