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GEODYNAMIC PREREQUISITES FOR ASSESSING THE HYDROCARBON POTENTIAL OF THE BALKHASH BASIN

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Abstract. The Balkhash sedimentary basin is one of the largest geostructural elements in the southeast of Kazakhstan and remains poorly studied in terms of its oil and gas potential. The fundamental research problem lies in the ambiguity of existing concepts regarding the nature, structure, and hydrocarbon potential of the basin, particularly in its central subsided part. The relevance of the topic is driven by the need to diversify sources of hydrocarbon raw materials, as well as the socio-economic importance of potentially discovering new fields for the southern regions of the country. The study employs methods of comprehensive analysis of geological and geophysical data, including gravimetry, magnetometry, electrical exploration, heat flow data, and the interpretation of structural-tectonic information. Based on the reconstruction of the geodynamic evolution of the region, a new model of the structure of the Balkhash basin is proposed, which includes the identification of graben-synclines and tectonic steps. The key hypothesis is the presence of slightly deformed Upper Paleozoic and Jurassic sedimentary and volcanogenic-sedimentary complexes in the central part of the basin, which show signs of hydrocarbon generation. Drawing on analogies with hydrocarbon-bearing basins of the Junggar zone (China) and the geochemical characteristics of coal-bearing and bituminous strata, the author substantiates the area's prospectivity for oil and gas. As a practical conclusion, a three-stage program of exploration work is proposed, involving regional seismic surveys, refinement of potential structures, and drilling of exploratory wells. The results of the study can be used in planning geological exploration activities, selecting priority areas for further investment, and developing regional energy security programs.

Keywords: basin, graben-synclines, anticlines, facies, hydrocarbon-bearing sequences

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БАЛҚАШ БАССЕЙНІНІҢ МҰНАЙ-ГАЗ ӘЛЕУЕТІН БАҒАЛАУДЫҢ ГЕОДИНАМИКАЛЫҚ АЛҒЫШАРТТАРЫ

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Аннотация. Балқаш шөгінді бассейні Қазақстанның оңтүстік-шығысындағы ең ірі геоқұрылымдық элементтердің бірі болып табылады, бірақ ол мұнай потенциалы бойынша әлі де аз зерттелген. Бұл зерттеудің негізгі мақсаты бассейннің табиғаты, құрылымы және мұнай әлеуеті, әсіресе оның орталық су астында қалған бөлігі туралы бар түсініктердің екіұштылығында жатыр. Бұл тақырыптың өзектілігі көмірсутек көздерін әртараптандыру қажеттілігінен, сондай-ақ елдің оңтүстік өңірлері үшін жаңа кен орындарын ашудың әлеуетті әлеуметтік-экономикалық маңыздылығынан туындап отыр. Бұл зерттеу гравиметрияны, магнитометрияны, электр барлауды, жылу ағынын және құрылымдық және тектоникалық интерпретацияны қоса алғанда, геологиялық және геофизикалық деректерді жан-жақты талдауды пайдаланады. Аймақтың геодинамикалық эволюциясын қайта құру негізінде грабен-синклиналдар мен тектоникалық сатыларды анықтауды қамтитын Балқаш ойпатының жаңа құрылымдық моделі ұсынылады. Негізгі гипотеза – алаптың орталық бөлігінде мұнай мен газдың пайда болу белгілерін көрсететін әлсіз дислокацияланған жоғарғы палеозой және юра шөгінді және вулканогенді-шөгінді кешендердің болуы. Жоңғар аймағының (Қытай) мұнайлы-газды бассейндерімен ұқсастықтары мен көмірлі және битумды қабаттардың геохимиялық сипаттамаларын ескере отырып, автор аймақтың мұнай-газ әлеуетін негіздейді. Практикалық қорытынды ретінде аймақтық сейсмикалық зерттеулерді, әлеуетті құрылымдарды нақтылауды және барлау ұңғымаларын бұрғылауды қамтитын үш кезеңді барлау бағдарламасы ұсынылды. Бұл жұмыстың нәтижелері геологиялық барлау жұмыстарын

жоспарлауда, одан әрі инвестициялау үшін басым бағыттарды таңдауда және аймақтық энергетикалық қауіпсіздік бағдарламаларын әзірлеуде пайдаланылуы мүмкін.

Түйін сөздер: алап, грабен-синклинальдар, антиклинальдар, фациялар, мұнай-газ түзуші қабаттар

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ГЕОДИНАМИЧЕСКИЕ ПРЕДПОСЫЛКИ ОЦЕНКИ ПЕРСПЕКТИВ НЕФТЕГАЗОНОСНОСТИ БАЛХАШСКОГО БАССЕЙНА

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Аннотация. Балхашский осадочный бассейн — один из крупнейших геоструктурных элементов юго-востока Казахстана, остающийся слабоизученным в аспекте нефтегазоносности. Основная проблема исследования заключается в неоднозначности существующих представлений о природе, строении и потенциале нефтегазоносности бассейна, особенно в его центральной погруженной части. Актуальность темы обусловлена необходимостью диверсификации источников углеводородного сырья, а также социально-экономическим значением возможного открытия новых месторождений для южных регионов страны. В работе применены методы комплексного анализа геолого-геофизических данных, включая данные гравиметрии, магнитометрии, электроразведки, теплового потока и интерпретации структурно-тектонической информации. На основе реконструкции геодинамической эволюции региона предложена новая модель строения Балхашского бассейна, включающая выделение грабен-синклинальных структур и тектонических ступеней. Ключевая гипотеза заключается в существовании слабодислоцированных верхнепалеозойских и юрских осадочных и вулканогенно-осадочных комплексов в центральной части бассейна, обладающих признаками нефтегазогенерации. С учетом аналогий с нефтегазоносными бассейнами Жонгарской зоны (КНР) и геохимических характеристик угленосных и битуминозных отложений автор обосновывает перспективность нефтегазоносности района. В качестве практического вывода предложена трехэтапная программа поисково-разведочных работ, включающая проведение региональной сейсморазведки, уточнение потенциальных структур и бурение поисковых скважин. Результаты исследования могут быть использованы при планировании геологоразведочных мероприятий, выборе приоритетных участков для дальнейших инвестиций и разработке региональных программ энергобезопасности.

Ключевые слова: бассейн, грабен-синклинали, антиклинарии, фации, нефтегазпроизводящие толщи

Introduction. The Balkhash sedimentary basin, covering an area of more than 90,000 km² and overlain by Quaternary barchan sands, is a major structural element in southeastern Kazakhstan. On its western margin, i.e., the eastern slope of the Chu-Ili anticlinorium, ancient metamorphosed rocks—exposed by hydrogeological boreholes No. 131–133, 308, 311 and gradually dipping toward the center of the basin—host lead-zinc, molybdenum, and gold deposits such as Vostok-1, 2, and 3, Zhideli, Kaskyrmys, Semizkol, and brown coal enriched with uranium (Nizhneili, Balatopar, Orta-Bakanas, Kertobe). Gold occurrences are also known in the Malaisary anticlinorium, which forms the southern margin of the basin. In the central subsided part of the basin lies an artesian basin of fresh groundwater. The Junggar-Balkhash fold region to the east is separated from the Balkhash basin by the Main Junggar Fault, along which volcanic eruptions occurred in the Late Permian and Early Triassic, such as the Ushmola volcanic massif and others. In the northern part of this fold region lies the Sayak polymetallic deposit, associated with reef limestones that have undergone metamorphism, indicating the existence of a marine sedimentation regime in the region and possibly in the adjacent Balkhash basin.

The Mointy mega-anticlinorium and the Tokrau synclinorium, which bound the basin from the north, are likely to dip stepwise toward the center of the basin. The rock formations are similar; in the Tokrau zone, they have been encountered by hydrogeological boreholes Nos. 6, 10, 77, and 215 on the southern shore of the lake and further south, where the surface of the Paleozoic deposits dips toward the basin center (Smolyar et al., 2007).

Historically, the potential for discovering oil and gas deposits in the Mesozoic and Paleozoic formations at significant depths (more than 3–6 km) in the central part of the basin has remained a subject of debate. Most researchers have assessed the hydrocarbon prospects negatively, citing the limited thickness of the Meso-Cenozoic sediments and assuming that the Paleozoic formations are heavily deformed. Only in recent years have some researchers begun to support the basin’s potential for oil and gas, allowing for the possible presence of so-called quasi-platform complexes of Upper Paleozoic age, although this view has been advanced without substantial supporting evidence.

In this article, by analyzing not only the geological and geophysical data from the basin's marginal zones and central part, but also the opinions of various researchers, the logic of their conclusions, and literature from both proponents and opponents of oil and gas exploration, we present our views on the tectonic nature and internal structure of the basin. We also discuss the conditions under which sedimentary and coeval formations may have accumulated—by analogy with the Junggar-Balkhash region—and assess the potential hydrocarbon prospects of the Upper Paleozoic sedimentary and volcanogenic-sedimentary sequences and Mesozoic (Jurassic) deposits. Recommendations are provided regarding the methodology and phased approach to oil and gas exploration and prospecting (Figure 1).

There are conflicting views among researchers regarding the nature of the Balkhash Basin. One of the first, N.G. Kassine, identified the Balkhash-Alakol Depression as a region resting on ancient basement blocks, where platform-type sedimentation occurred throughout the Paleozoic. He later clarified that the Balkhash and Alakol basins represent Middle Paleozoic platforms on a Precambrian foundation (Kassine, 1934).

Most researchers describe the Balkhash Basin territory as part of the "Devonian volcanic belt" (Bogdanov et al., 1963), while some avoid discussing the nature of the basin altogether, labeling it as a "region with an unknown sedimentation character" (Seitmuratova, 2011). The concept of the "Devonian volcanic belt," introduced by A.A. Bogdanov (1959) for the Aktau-Mointy zone, structurally represents a "morphologically expressed uplift… whose internal structure is characterized by block tectonics complicated by the emergence of localized volcano-tectonic structures, grabens, and horsts" (Seitmuratova, 2011).

Similar theoretical assumptions are found in the works of R.A. Borukaev, O.A. Seydalin (Azbel et al., 1971; Map, 1971; Shcherba, 1973), Yu.A. Zaitsev (Bogdanov, 1963; Ozdoev et al., 2020; Ozdoev et al., 2021), and others. This diversity of opinion among researchers is largely due to the lack of factual data on the Paleozoic section of the basin, which is mostly covered by Cenozoic sediments.

An expert in the geology of sedimentary basins in eastern Kazakhstan, Kh.Kh. Paragulgov, together with co-authors, in one of their recent articles (Paragulgov et al., 2002), after an extensive and thorough review of scientific opinions in recent publications, made, in his words, “an important assumption for assessing hydrocarbon potential: the formation of sediments in all modern sedimentary basins (SB) of Eastern Kazakhstan began in the Devonian and is of a quasi-platform nature…” (Paragulgov et al., 2002). This significantly alters the approach of those who view the Paleozoic deposits as Hercynides that have undergone strong deformation and are therefore considered unfavorable for oil and gas accumulation.

U.A. Akchulakov and A.B. Bigaraev classify the Balkhash sedimentary basin as a rift-type basin, initiated in the early Paleozoic era and actively developing during the Late Devonian (Akchulakov et al., 2014).

Data on the Balkhash Basin have been obtained through gravimetric, aeromagnetic, electrical prospecting methods, as well as helium and satellite surveys. These methods provide fundamental information about the state (thermodynamic conditions) and deep structure of the subsurface, i.e., quantitative and qualitative characteristics of the physical heterogeneities of the geological environment. The geological interpretation of the results from each method (gravimetry, magnetometry, electrical prospecting, heat flow studies, and others), or even from their combined use, is complicated by the diversity of physical fields and the subjective opinions of researchers. These factors lead to multiple possible interpretations and ambiguities, resulting in the development of various hypothetical and alternative geological models.

To construct reliable models of the basin's structure, in addition to a comprehensive analysis of the maximum amount of information from various interpretative results, data from seismic prospecting using the CMP (Common mind point) method are needed. This method has significant informational content and resolution capabilities to illuminate the deep structure of the basin's cross-section and the drilling of wells.

Research materials and methods.

Considering the currently available geological and geophysical data for the basin area, along with published information on the geological structure and nature of geostructural elements that are relatively well studied—such as the Shu-Ile anticlinorium to the west, the Tokrau synclinorium to the north, the North Zhetysu anticlinorium to the east, and the Tasmurun and Malaisary anticlinoria to the south (composed of Permian and Triassic volcanic complexes)—the following geodynamic model of the basin's structure can be proposed (Figure 1).

Based on the analysis of the geodynamic evolution of the region and materials from the marginal outcrops of the basin, the most acceptable and well-substantiated version of its tectonic nature and structural position is presented in the Tectonic Map of Eastern Kazakhstan and described in the book Tectonics of Kazakhstan (Kassine, 1934; Tectonic Map, 1982), edited by A.V. Peive and A.A. Mossakovsky.

Like the authors of these important documents, we believe that the Balkhash sedimentary basin is located in the southeast of the Kazakh continent, where the continental crust of Caledonian age expanded due to the Hercynian formations of the Junggar-Balkhash region. Therefore, we consider that during the Late Paleozoic, the Balkhash Basin existed in a marginal continental sea regime, similar to the Sea of Okhotsk adjacent to the Kamchatka-Kuril volcanic zone. The basement of the Balkhash sedimentary basin is most likely of Early Paleozoic age and composed of deformed Lower Paleozoic deposits, as well as partially volcanic-plutonic rocks of the Lower and Middle Devonian. Under the influence of tectonic and volcanic processes occurring in the adjacent young Junggar-Balkhash geosynclinal system to the east, the basement surface of the Balkhash Basin underwent stepwise subsidence, and the basin was filled with volcanogenic-sedimentary formations. Judging by the depth of the magnetoactive surface in the inner part of the basin, gravity data, and the anisotropic heat flow transformation map, horsts, grabens, and numerous faults were formed—along some of which volcanic activity may also have occurred.

In the newly compiled tectonic scheme, which for the first time incorporates updated geological and geodynamic (magnetometric) information, the Naryn and Akzhar tectonic steps are identified. These are separated in the west by the deep Balkhash Fault from the Mointy and Anrakay synclinoria, which are part of the ancient Precambrian Chu-Ili mega-anticlinorium.

In the central part of the Balkhash sedimentary basin, geophysical data indicate that the basement surface plunges to a depth of 4–6 km or more, forming the Bakanas graben-syncline, which extends from the southeast to the north, then northeastward, spanning approximately 220 km in length and 40 to 90 km in width, with two major depressions — the Akkol and Karamergen depressions — named after the village of Akkol and the ancient Karamergen fortress along the Silk Road.

These depressions are likely filled with Upper Paleozoic sedimentary rocks, with the presence of volcanogenic-sedimentary formations, especially within coeval strata associated with a phase of volcanic activity in the Junggar-Balkhash zone. The accumulation of sedimentary sequences in the Balkhash Basin is believed to have begun in the Late Devonian and concluded in the Permian period.

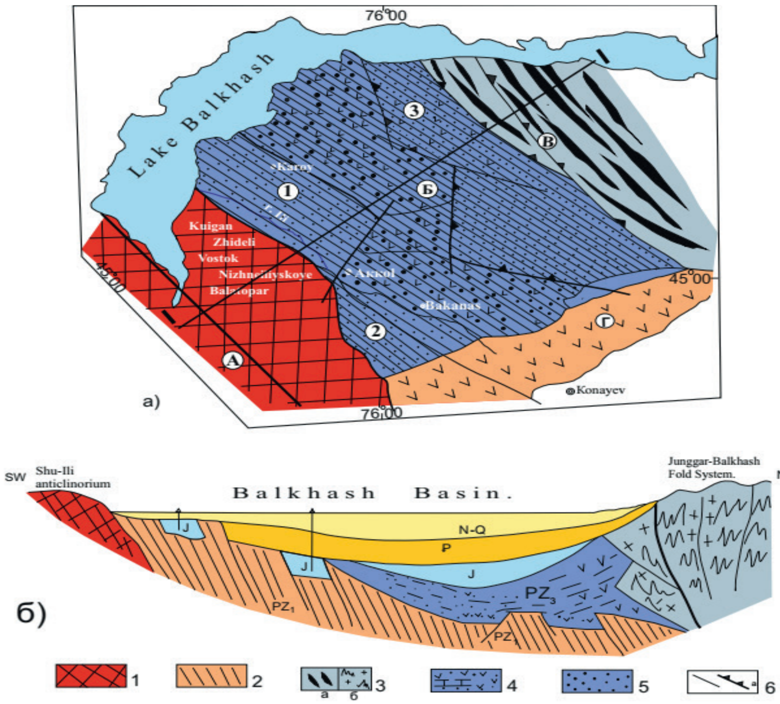

Figure 1 – Geodynamic model of the Balkhash Basin
a – tectonic scheme; b – geological cross-section along line I–I. A – Chu-Ili Anticlinorium; B – Balkhash Basin; C – Junggar-Balkhash Folded Area; D – Malaisary Anticlinorium. Tectonic steps (numbers): 1 – Naryn Step, 2 – Akzhar Step, 3 – Zhetysu Step.
Age of the basin basement: 1 – Riphean, 2 – Caledonides, 3 – Hercynides (marked as a on the scheme and b on the section). 4–5 – Sedimentary and volcanogenic-sedimentary formations: 4 – on tectonic steps, 5 – in the deep central part of the basin within the Bakanas graben-syncline.
6 – Faults; a – Main Junggar Deep Fault.

In the Late Devonian and Carboniferous, simultaneous with the formation of the Junggar-Balkhash volcano-plutonic belt in a marginal continental environment of Caledonian age, on which the Balkhash sedimentary basin is located, predominantly terrigenous-carbonate sedimentation occurred, interlayered with volcanic rocks corresponding to periods of intensified volcanism in the east.

In the central part of the Balkhash Basin, faults are clearly identified on the anomalous magnetic field map, predominantly trending northeastward—parallel to the Junggar-Balkhash system—and likely of earlier origin. Northwest-trending faults, influenced by tectonic processes within the Malaisary Anticlinorium, are distinguished in the southern part of the basin. These tectonic dislocations are characterized by high gradients of magnetic anomalies and considerable length; on the map, they are marked by a sharp reversal in the sign of the magnetic field.

The characteristics of the anomalous magnetic field of the Balkhash sedimentary basin reflect its structural-tectonic and geological features. The local gravitational field of the basin is well differentiated and clearly reflects the tectonic setting of sedimentary complexes, intrusive bodies, and the position of the folded foundation surface. It is assumed that the gravitational field minima generally correspond to zones with sedimentary complexes of considerable thickness. Within the Balkhash sedimentary basin, according to calculations by geophysics specialists, the correlation coefficient between the intensity of the minima and the depth to the roof of the foundation can be quite high, reaching values of approximately 0.7-0.8, by analogy with neighboring basins.

In the history of the formation of the Balkhash sedimentary basin (OB), three stages should be highlighted: Late Paleozoic, Mesozoic, and Cenozoic.

The Late Paleozoic stage, beginning with rifting and volcanism in the Middle and Late Devonian, occurred in the setting of a marginal continental sea. It was characterized, as in the region as a whole, by the dominance of volcanic and intrusive processes at the start, resulting in the predominance of volcanic-plutonic formations in the stratigraphic section, which were later replaced by volcanogenic-sedimentary and sedimentary complexes of terrigenous-carbonate composition during the Famennian and Frasnian stages.

Based on the results of detailed studies of the stratigraphic sections (Bespalov, 1954; Seitemuratova, 2011; Azbel, 1971; Afoničev, 1967) in the Zhetysu-Balkhash area, starting from the Famennian, there was a large-scale marine transgression and accumulation of marine terrigenous-carbonate sediments. It is likely that similar geodynamic and paleogeographic conditions existed over the area of the adjacent Balkhash basin. The possible correlations of the Upper Paleozoic sections in the neighboring Zhetysu-Balkhash area and the Balkhash basin are shown in Figure 2.

The forecast of sedimentary accumulation and the geological history of the basin in the Late Paleozoic can be reconstructed taking into account the history and influence of the concurrently developing neighboring Zhetysu-Balkhash fold area, which now limits the Balkhash basin to the east and is separated from it by the Main Zhetysu deep fault with an overthrust character. The Devonian, Carboniferous, and Permian sections, studied in detail due to good exposures in the Zhetysu-Balkhash area and in the Zhetysu (Malaysarin) mountains, have been taken as the basis for the forecast Paleogeographic conditions of sedimentation, as well as potential magmatic and volcanogenic processes in the interior of the basin.

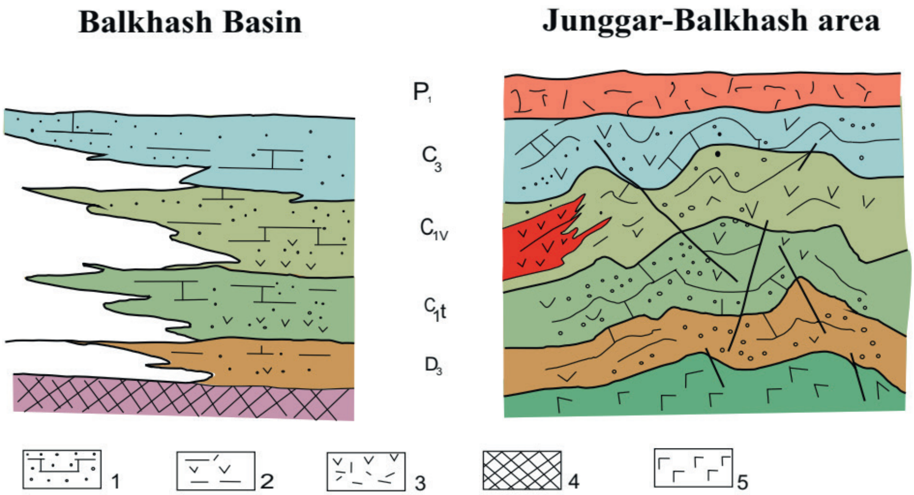

Figure 2 – Prognostic correlation of the Upper Paleozoic sections in the Balkhash Basin and in the Zhetysu-Balkhash fold region
1 - Terrigenous-carbonate complexes, 2 - Volcanogenic-sedimentary complexes,
3 - Volcanogenic-plutonic complexes, 4 - Caledonian continental crust 5 - Oceanic crust

Most of the basin's territory lies on a Caledonian basement, formed during the Silurian–Early Devonian period. In the Zhetysu-Balkhash region, beginning in the Famennian, a large-scale marine transgression took place, resulting in the accumulation of marine terrigenous-carbonate sediments. In the Early Carboniferous, shallow marine conditions persisted, leading to the deposition of terrigenous, carbonate-terrigenous, and volcanogenic-sedimentary formations. Active volcanic activity occurred along deep faults. The marine transgression continued during the Visean, covering vast areas and forming thick sedimentary sequences. The Visean transgression is distinguished by persistent horizons of limestones, calcareous sandstones, and siltstones, interbedded with tuffs and rich in marine fauna (Afonichev, 1967; Shuzhanov, 1968).

During the Late Visean–Moscovian period, volcanic activity was particularly intense. In coastal marine environments, volcanogenic-sedimentary sequences and volcanic rocks of andesite–basalt–rhyolite formations were formed. In several stratigraphic sections, co-burials of flora and marine ostracods were observed, indicating periodic marine transgressions in the Zhetysu-Balkhash region during this time (Tectonic Map, 1982; Bogdanov et al., 1963; Seitemuratova, 2011; Azbel et al., 1971; Peive et al., 1976).

In the Late Carboniferous, alongside continental volcanic deposition, shallow water basins existed across vast areas of the Zhetysu-Balkhash Basin. These basins saw the accumulation of thin-layered reworked tuff horizons, composed of well-sorted material. In some deeper areas, organogenic and chemogenic deposits, such as limestone beds, bituminous siltstones, and sandstones with algal imprints, were deposited along with terrigenous materials.

The early Permian period is known for active destructive processes, accompanied by basalt and andesite volcanism. Volcanic eruptions likely occurred over large areas of the Balhash-Ili region. In the southern part of the Balhash Basin, in the Malaisary ridges, numerous small volcanic structures and a single large volcanic massif are known. The Ushmola volcanic structure has been studied in detail on the eastern shore of the basin.

The well-argued geodynamic conditions of the Junggar -Balhash region in the late Paleozoic likely had a significant impact on sedimentation conditions, and naturally, on the formation of internal faults, horsts, and grabens with varying rates and characteristics of geological history. The formed grabens and subsiding areas of the central part of the basin, as evidenced by the depths (from 3 to 6 km) of the magnetically active surface (the roof of the Caledonides), were filled with sedimentary deposits of the same age, including volcanic-sedimentary layers. These sedimentary and volcanic-sedimentary sequences, forming in the conditions of marginal seas, could have possessed the properties of hydrocarbon-producing formations, and the high thermal regime, created by volcanic and magmatic processes, contributed to the formation of hydrocarbons.

Results and discussion

By analogy with the Meso-Cenozoic oil and gas-bearing basins (Shcherba, 1973; Khain et al., 1978) in the northwest Pacific region (Sakhalin and others), a significant feature of the structure of sedimentary layers in the Balhash basin is related to the influence of volcanic processes that occurred in the adjacent Junggar-Balhash region. Volcanism affected the composition and structure of the sedimentary layers in the basin in two ways. First, the ash material became part of the rocks, possibly in large quantities, sometimes forming well-defined layers. Second, the waters of the volcanic zone, rich in silica, contributed to the development of organisms that used silica to build their skeletons, which led to the rapid development of diatoms and silica-containing organisms. Clay-silica formations in Sakhalin are known as rich oil-mother rocks (Burlyn, 1976).

Based on the results of the reconstruction of the geodynamic evolution of the basin in the late Paleozoic, using data from detailed surveys of the basin's periphery and geophysical research materials on the deep structure, we consider the Upper Paleozoic deposits in the submerged parts of the basin to be prospective for oil and gas.

In the Mesozoic, the considered territory, like the entire Kazakh continent, occupied an elevated position and represented an area of erosion. Along the regional South-Junggar fault, a system of depressions formed, the largest of which is the Balkhash sedimentary basin. During the period of active volcanism in the late Permian and early Triassic, there were possible accumulations of coeval volcanogenic-sedimentary continental deposits in the basin. In the Jurassic, sedimentation of terrigenous coal-bearing and terrigenous-carbonate shallow water deposits occurred; in the west, on the Naryn tectonic step, small grabens were formed, mainly filled with terrigenous coal-bearing sediments. One of these grabens is the Lower Ili, which has been studied in detail and is filled with coal-bearing terrigenous sediments enriched with uranium.

Within the Naryn tectonic step, deposits of brown coal, including the Lower Ili, Balatopar, Orta-Bakanas, and Kertobel, have been discovered, with the largest being the Nizhneili field (Figure 3).

The Nizhneili field deposit is located in the Balkhash district of the Almaty region, approximately 160 km west-northwest of the district center, the village of Bakanas, at the mouth of the Ili River where it flows into Lake Balkhash. It was discovered in 1973 by the geological survey organization "Volkovgeologia." From 1981 to 1987, detailed exploration was conducted, including the calculation of coal reserves.

At the Balatopar deposit, the coal seam has a thickness of 21.8 meters, with the roof of the seam lying at a depth of 180-230 meters. At the Kertobel deposit, the seam thickness is 22.4 meters, with the roof located at a depth of 400-430 meters. At the Orta-Bakanas deposit, the coal seam is 14.1 meters thick and lies at a depth of 540-560 meters (Figure 3).

The Nizhneili field deposit contains coal-bearing strata of Lower to Middle Jurassic age with a thickness ranging from 50 to 200 meters, subdivided into 4 cycles (Figure 4). Within these cycles, the coal layers range from 1-2 to 7-10 seams of brown coal. The main coal seam is located at the top of the IV cycle, which extends across the entire basin area (approximately 560 km²). The thickness of the seam varies from 1-2 meters to 58.3 meters, with an average thickness of about 17 meters. The depth of the seam varies from 160 to 330 meters.

In the central and southeastern parts of the subsidence, where the Jurassic strata are exposed in borehole 313, the coal-bearing strata are relatively simple in structure over an area of 240 km². On the remaining area, the seam splits, and the coal deposit is divided into two major packages: the lower (I) and upper (II). The coal-bearing sequence is overlain by a coal-bearing layer of Middle Jurassic age, with a thickness of up to 60-80 meters, consisting primarily of sand-gravel rocks with rare clay interlayers (Bekzhanov, 2000).

The brown coals (grades B1 - B3) are primarily of the fusain type and are prone to spontaneous combustion. The average moisture content is 37.8% (ranging from 23.8% to 44%), while the ash content fluctuates from 10-12% to 20-25%, and sometimes even up to 35%, with an average of 15.94%. The lowest ash content (10-12%) is found in the axial parts of the contiguous coal seam areas, while the highest ash content is in the splitting and wedging zones, as well as in the roof and soil of the coal seam. The calorific value of the coal on a combustible mass basis is 6.7 kcal/kg. The coals are sulfurous (up to 2%).

In the section of Jurassic deposits, combustible shales are present, lying at the bottom of the coal seam and on the kaolinite weathering crust. The reserves of combustible shales (forecasted) are estimated at 57 million tons. Their ash content ranges from 14% to 60%, moisture content is 2.45%, sulfur content is 0.9%, and the calorific value of the dry shale is on average 3.5 kcal/kg. The carbon content is 52-73%, hydrogen content is 7.5-10% (average 9.8%), and nitrogen and oxygen content is 18-24% (average 22%). When partially coked, the yield is 13.7-24.2% (average 20.4%) tar, 65% semicoke, and 7.5% gas (mainly nitrogen, carbon dioxide, and hydrogen sulfide). The ash content of the shales is characterized by an increased content of titanium dioxide (1.31%).

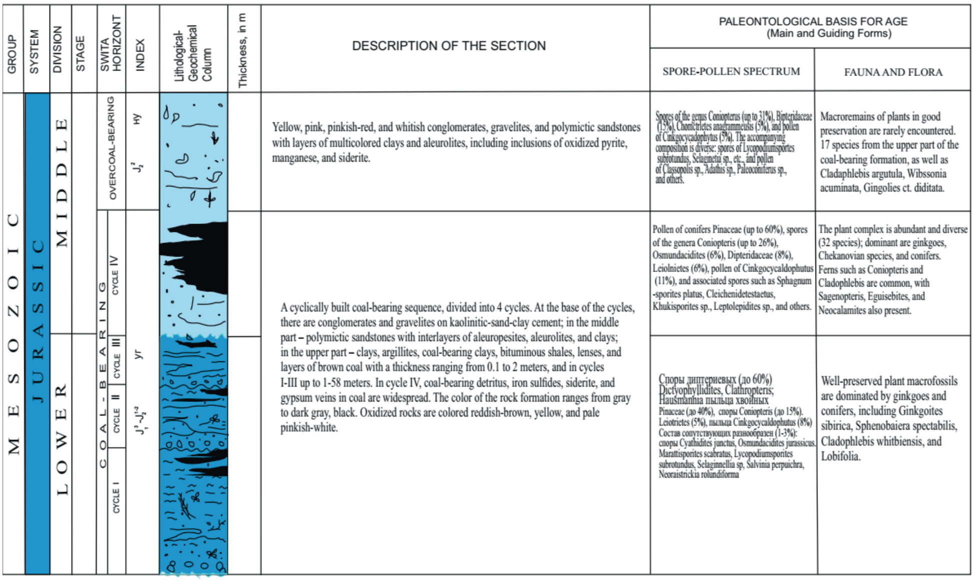

Figure 3 – Cross-section of the Jurassic deposits of the Nizhneili field lignite deposit

The Jurassic deposits in the Nizhneiliyskoye field coalfield are characterized by an increase in thickness as one moves from the periphery of the basin towards its central part. In the same direction, there is a replacement of coal horizons with coal-bearing clayey rocks. The total depth of burial in the down-warped areas can reach 1.5 km or more. The paleogeographic conditions of sedimentation are primarily lacustrine and shallow-water, which occupied a large portion of the basin area. Geochemically, the deposits are predominantly composed of humic coals, with a smaller proportion of sapropelic-humic coals.

Due to their specific characteristics and geochemical indicators, the strata may be classified as potential petroleum and gas-generating formations. When coal-bearing layers with a high content of uranium are buried, they undergo natural methanogenesis, resulting in the generation of methane gas. Indirect evidence of the potential for hydrocarbon gas (methane) formation is provided by the results of laboratory analyses of the coals, confirming the possibility of methane generation under certain conditions.

The volatile component yield when heated to 850°C under normal conditions, based on the dry mass, ranges from 44% to 47%. The carbon (C) content in the combustible mass varies from 7% to 76%. The hydrogen (H) content ranges from 5.21% to 5.26%, and nitrogen and oxygen make up 18-20%. The coal has reached the late brown coal stage of coalification.

Uranium ore deposits are distributed in the upper part of the coal horizon and contain ore concentrations of U, Mo, Se, Re, and Ge. The uranium mineralization is represented by asturian (80%) and coffinite (20%).

The yield of semi-coking tar (heating to 500-550°C without air access) is relatively high, reaching 9.3-10.5%. The yield of gasoline-ligroin and kerosene-diesel fractions is 5.6% and 49.6%, respectively.

Geochemically, the deposits are predominantly composed of humic coals, with a lesser proportion of uranium-rich sapropelic-humic coals.

Coal reserves: total (balance) reserves amount to 10.9 billion tons, with 9.975 billion tons in the Nizhneili field. The forecasted reserves in the region are estimated at 7.1 billion tons. The Nizhneili field is prepared for development both by underground and open-pit mining methods.

With such coal reserves, trillions of cubic meters of combustible natural gas can be expected, which would be essential for the gas supply to the cities of Taldykorgan, Almaty, and Balkhash, as well as for the entire region.

By the Cenozoic era, the Balkhash Basin has undergone relatively uniform subsidence, filling with terrigenous sediments, which are confidently dated to the Paleogene, Neogene, and Quaternary periods. The total thickness of the sediments in the wells exceeds 600 meters, and according to rare seismic profiles, it may exceed 1000 meters. The greatest thickness of these sediments is observed in the Bakanas graben-syncline.

Conclusion

The prospects for oil and gas potential in the Balkhash Basin, as noted, are evaluated differently and ambiguously by researchers. We believe that in the subsiding zones of the basin, weakly dislocated Upper Paleozoic, Triassic, and Jurassic deposits enriched with organic components may be present, which can be considered as potential source rocks for oil and gas production. Age-equivalent terrigenous-carbonate and volcaniclastic sediments in the Zhaosu Basin in China, which are in similar tectonic conditions, are commercially oil- and gas-bearing. Oil and gas-bearing horizons have been identified in the Zaysan Basin, while bitumens "A" in quantities of 0.19-0.39% have been observed in Permian and Triassic deposits in the Ili Basin. Bituminous shales of Upper Paleozoic age are present in the Kendyrlyk Syncline, and bituminous limestones of Viséan age have been discovered in the eastern part of the Ketmen Range.

Taking into account the information on oil and gas manifestations in the region, the paleogeographic conditions of sediment accumulation, and the geodynamic settings conducive to hydrocarbon generation, we consider the Balkhash sedimentary basin to be promising for oil and gas. It is viewed as an object of important social and economic significance for the country and for improving the socio-economic living conditions of people in the densely populated southern and southeastern regions of Kazakhstan.

To assess the oil and gas potential of the Balkhash sedimentary basin, it is recommended to carry out geological exploration in three stages.

At the first stage, regional 2D seismic surveys should be conducted.

Based on the processing and interpretation of regional profiles, the most promising areas should be selected for detailed seismic studies and for preparing potential targets for exploratory drilling.

In the event that promising targets are identified, the third and final stage of exploration should include the drilling of 3–4 independent wells with depths ranging from 2,000 to 4,000 meters.

Based on the available geological and geophysical data, as well as the overall geodynamic evolution of the Balkhash sedimentary basin, there is reason to expect a positive and significant outcome from geological exploration in the area.

References

Akchulakov U.A., Bigaraev A.B. (2014) Osobennosti geologicheskogo stroenija i perspektivy neftegazonosnosti Balhashskogo riftovogo osadochnogo bassejna [Geological Structure Features and Hydrocarbon Prospects of the Balkhash Rift Sedimentary Basin]. Oil and Gas. — No. 2. (in Russ.).

Afonichev N.A. Osnovnye jetapy razvitija Dzhungaro-Balhashskoj geosinklinal'noj sistemy [Main Stages in the Development of the Dzhungaro-Balkhash Geosynclinal System], Soviet Geology, 1967. — No. 2. (in Russ.).

Azbel K.A., Borukaev M.R., Kovalevsky A.F., Sterkin V.D. (1971) Osnovnye cherty orogennogo magmatizma Pribalhashsko-Ilijskogo vulkanicheskogo pojasa (na primere Severo-Vostochnogo Pribalhash'ja i Juzhnoj Dzhungarii) [Main Features of Orogenic Magmatism of the Pre-Balkhash-Ile Volcanic Belt (Based on the Example of Northeastern Pre-Balkhash and Southern Dzungaria)], In: Materials on the Geology and Mineral Resources of Southern Kazakhstan. Alma-Ata. — Issue 4 (20). (in Russ.).

Bekzhanov G.R., Koshkin V.Ya., Nikitchenko N.I., et al. (2000) Geologicheskoe stroenie Kazahstana [Geological Structure of Kazakhstan], Almaty. (in Russ.).

Bespalov V.F. (1954) Dzhungaro-Balhashskaja gercinskaja geologicheskaja provincija [The Dzhungaro-Balkhash Hercynian Geological Province], In: Problems of the Geology of Asia. Moscow. (in Russ.).

Bespalov V.F. (1971) Geologicheskoe stroenie Kazahskoj SSR [Geological Structure of the Kazakh SSR], Alma-Ata. (in Russ.).

Bogdanov A.A., Zaytsev Yu.A., Mazarovich O.A., et al. (1963) Tektonicheskie rajonirovanie paleozojskogo massiva Central'nogo Kazahstana [Tectonic Zoning of the Paleozoic Massif of Central Kazakhstan], Vestnik of Moscow State University, Geology Series. — No. 5. (in Russ.).

Burlin Yu.K. (1976) O svjazi neftegazonosnosti s tektonikoj i formacijam na severo-zapade Tihookeanskogo tektonicheskogo pojasa [On the Relationship Between Hydrocarbon Potential and Tectonics and Formations in the Northwest Pacific Tectonic Belt]. Geotectonics. — No. 7. (in Russ.).

Karta geologicheskih formacii Vostochnogo Kazahstana [Geological Formation Map of Eastern Kazakhstan], Scale 1:1 500 000. Explanatory Note. Moscow: Nedra, 1971. (in Russ.).

Kassin N.G. (1934) Materialy po paleogeografii Kazahstana [Materials on the Paleogeography of Kazakhstan], Alma-Ata (in Russ.).

Khain V.E., Levin L.E. Tektonicheskie tipy okrainnyh i vnutrennih morej s okeanicheskoj i subokeanicheskoj koroj [Tectonic Types of Marginal and Inland Seas with Oceanic and Suboceanic Crust], Vestnik of Moscow State University, Geology Series, 1978. — No. 6. (in Russ.).

Ozdoyev, S., Popov, V., Tileuberdi, N., Huadong, M. The Balkhash Depression Sediment Paleogeology and Oil-Gas Prospects. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, 2020, August (1.2). — P. 799–804. doi: 10.5593/sgem2020/1.2/s06.102. (in Eng.).

Ozdoev S.M., Popov V.A., Tleuberdi N. (2020) Geologija i perspektivy neftegazonosnosti vostochnyh i jugo-vostochnyh vpadin Kazahstana [Geology and Oil and Gas Potential of the Eastern and Southeastern Depressions of Kazakhstan], Almaty. (in Russ.).

Paragulgov Kh.Kh., Paragulgov T.Kh., Poleshchikov V.E. Osadochnye bassejny Vostochnogo Kazahstana. Jevoljucija i perspektivy neftegazonosnosti [Sedimentary Basins of Eastern Kazakhstan: Evolution and Hydrocarbon Prospects]. Geology and Subsoil Protection. — No. 4/2002 (5). (in Russ.).

Peive A.V., Yanshin A.L., Zonenshain L.P., et al. (1976) Stanovlenie kontinental'noj zemnoj kory Severnoj Evrazii (v svjazi s sostavleniem novoj tektonicheskoj karty) [Formation of the Continental Crust of Northern Eurasia (in Connection with the Compilation of a New Tectonic Map)], Geotectonics. — No. 5. (in Russ.).

Seitmuratova E.Yu. (2011) Pozdnij paleozoj Zhongaro-Balhashskoj skladchatoj oblasti (Kazahstan) [Late Paleozoic of the Dzhungaro-Balkhash Folded Area (Kazakhstan)], Almaty. (in Russ.).

Smolyar V.A., Mustafayev S.T. (2007) Gidrogeologija bassejna ozera Balhash [Hydrogeology of the Lake Balkhash Basin], Almaty (in Russ.).

Tectonics of Kazakhstan [Tektonika Kazahstana] (Explanatory Note to the Tectonic Map of Eastern Kazakhstan, scale 1:2 500 000), Moscow: Nauka, 1982. (in Russ.).

Shcherba N.G. Gercinskaja struktura Severnogo Pribalhash'ja [Hercynian Structure of Northern Pre-Balkhash], Transactions of the Geological Institute of the USSR Academy of Sciences. Moscow, 1973. — Issue 249. (in Russ.).

Shuzhanov V.M. Strukturno-tektonicheskoe polozhenija vulkanogennyh obrazovanij devona juzhnoj i zapadnoj chastej Central'nogo Kazahstana [Structural-Tectonic Position of Devonian Volcanic Formations in the Southern and Western Parts of Central Kazakhstan], Materials of the First Scientific Conference of Young Scientists of the Academy of Sciences of the Kazakh SSR, Alma-Ata, 1968. (in Russ.).

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