ISSN 2518-170X (Online)
ISSN 2224-5278 (Print)

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ
Satbayev University

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ
НАУК РЕСПУБЛИКИ
КАЗАХСТАН
Satbayev University

N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF
KAZAKHSTAN
Satbayev University

SERIES

OF GEOLOGY AND TECHNICAL SCIENCES

5 (455)

SEPTEMBER – OCTOBER 2022

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

«ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Меншіктеуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).

Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: *геология, мұнай және газды өңдеудің химиялық технологиялары, мұнай химиясы, металдарды алу және олардың қосындыларының технологиясы.*

Мерзімділігі: жылына 6 рет.

Тиражы: 300 дана.

Редакцияның мекен-жайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., тел.: 272-13-19

http://www.geolog-technical.kz/index.php/en/

Типографияның мекен-жайы: «Аруна» ЖК, Алматы қ., Мұратбаев көш., 75.

«Известия НАН РК. Серия геологии и технических наук».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ39VPY00025420,** выданное 29.07.2020 г.

Тематическая направленность: *геология, химические технологии переработки нефти и газа, нефтехимия, технологии извлечения металлов и их соеденений.*

Периодичность: 6 раз в год.

Тираж: 300 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, оф. 219, тел.: 272-13-19
http://www.geolog-technical.kz/index.php/en/

Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75.

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Owner: RPA «National Academy of Sciences of the Republic of Kazakhstan» (Almaty).

The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420,** issued 29.07.2020.

Thematic scope: *geology, chemical technologies for oil and gas processing, petrochemistry, technologies for extracting metals and their connections.*

Periodicity: 6 times a year.

Circulation: 300 copies.

Editorial address: 28, Shevchenko str., of. 219, Almaty, 050010, tel. 272-13-19

http://www.geolog-technical.kz/index.php/en/

Address of printing house: ST «Aruna», 75, Muratbayev str, Almaty.

NEWS *of the National Academy of Sciences of the Republic of Kazakhstan*
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
https://doi.org/10.32014/2518-170X.232

UDC 550.98(574)

A.S. Zhumagulov[1*], M.T. Manzari[2], G.B. Kezembayeva[1], S.M. Nurmakova[1], D.B. Mukanov[1]

[1]Satbayev University, Almaty, Kazakhstan;
[2] Sharif University of Technology, Tehran, Iran.
E-mail: a.zhumagulov@satbayev.university

TECTONIC EVOLUTION AND HYDROCARBON ACCUMULATION CONTROLLING CHARACTERISTICS OF THE SHU-SARYSU BASIN

Abstract. Due to the growth of demand for natural gas, including for environmental reasons, the topical issue of today has become the expansion of its resource base in the Republic of Kazakhstan by involving in the search, exploration and additional exploration of areas, stratigraphic horizons and objects that are promising for its discovery. Among latter, deposits of the Shu-Sarysu depression deserve closest attention, which are characterized by the all necessary geological conditions for the formation and preservation of hydrocarbon accumulations, and productivity of which is confirmed by the discovery of commercial natural gas fields.

Nevertheless, despite a significant number of wells drilled and geophysical studies performed over more than half a century of study the degree of its knowledge as a whole remains low and hinders the exploration and development of its hydrocarbon potential. This is because of uneven distribution of geological and geophysical surveys, focused only on a few individual blocks of the basin, and due to the remoteness of the basin from the necessary facilities and the small size of previously discovered gas fields.

Petroleum potential of any territory mainly depends on its geological and geophysical knowledge and features of the tectonic structure that control hydrocarbon accumulation zones. This article considers the synthesis and system analysis of the results of geological and geophysical studies, including data on seismic, gravity, magnetic, thermal space surveys and drilling, as a tool for solving the tasks set.

Key words: Shu-Sarysu basin, oil and gas potential, tectonic evolution, hydrocarbon accumulation, magnetic exploration, gravity exploration.

А.С. Жумагулов[1]*, М.Т. Манзари[2], Г.Б. Кезембаева[1], С.М. Нурмакова[1], Д.Б. Муканов[1]

[1]Satbayev University, Алматы, Қазақстан;
[2]Технологический университет им. Шарифа, Тегеран, Иран.
E-mail: a.zhumagulov@satbayev.university

ШУ-САРЫСУ БАССЕЙНЫНЫҢ ТЕКТОНИКАЛЫҚ ЭВОЛЮЦИЯСЫ ЖӘНЕ КӨМІРСУТЕКТЕРДІҢ ЖИНАЛУЫН БАҚЫЛАЙТЫН СИПАТТАМАЛАР

Аннотация. Табиғи газға, оның ішінде экологиялық себептерге де байланысты, сұраныстың өсуінің нәтижесінде мұнай-газға перспективті аумақтарда, аудандарда, стратиграфиялық горизонттар мен объектілерде табиғи газды іздеу, барлау және қосымша анықтау жұмыстары Қазақстан Республикасының ресурстық базасын кеңейту мақсатында бүгінгі күннің өзекті мәселесіне айналды. Олардың ішінде перспективтілігі табиғи газ кен орындарының ашылуымен расталған, көмірсутектердің қалыптасуы мен сақталуы үшін қажетті геологиялық жағдайлары бар Шу-Сарысу бассейнінің шөгінді тау жыныстары ерекше назар аударуға лайық.

Дегенмен, бұрғыланған ұңғымалардың айтарлықтай санына және жарты ғасырдан астам жүргізілген геофизикалық зерттеулерге қарамастан, жалпы Шу-Сарысу бассейні туралы білімнің жағдайы төмен болып қалуда және оның көмірсутектік әлеуетін барлау мен игеруге кедергі келтіруде. Бұл геология-геофизикалық жұмыстарының біркелкі бөлінбеуі және ол жұмыстардың бассейннің бірнеше жеке блоктарында ғана жіргізілгендігімен, одан басқа, бассейннің қажетті инфрақұрылымнан қашықтығымен және ашылған газ кен орындарының көлемінің аздығымен түсіндіріледі.

Белгілі болғандай, кез келген аумақтың мұнай-газ әлеуеті оның геология-геофизикалық білу денгейіне және көмірсутектердің жинақталу аймақтарын басқаратын тектоникалық құрылымның ерекшеліктеріне байланысты. Бұл мақалада алға қойылған міндеттерді шешу құралы ретінде геология-геофизикалық зерттеулердің нәтижелерін, оның ішінде сейсмикалық, гравитациялық, магниттік, жылу-ғарыштық зерттеулер мен бұрғылау деректерін, синтездеу және жүйелік талдау әдісі қарастырылады.

Түйін сөздер: Шу-Сарысу бассейні, мұнай-газ потенциалы, тектоникалық эволюция, көмірсутектердің жинақталуы, магниттік барлау, гравитациялық барлау.

А.С. Жумагулов[1]*, М.Т. Манзари[2], Г.Б. Кезембаева[1], С.М. Нурмакова[1], Д.Б. Муканов[1]

[1]Satbayev University, Алматы, Казахстан;
[2]Технологический университет им. Шарифа, Тегеран, Иран.
E-mail: a.zhumagulov@satbayev.university

ТЕКТОНИЧЕСКАЯ ЭВОЛЮЦИЯ И ХАРАКТЕРИСТИКИ, РЕГУЛИРУЮЩИЕ НАКОПЛЕНИЕ УГЛЕВОДОРОДОВ ШУ-САРЫСУЙСКОГО БАССЕЙНА

Аннотация. В связи с ростом спроса на природный газ, в том числе и по экологическим соображениям, актуальным вопросом сегодняшнего дня стало расширение его ресурсной базы в Республике Казахстан за счет вовлечения в поиски, разведку и доразведку перспективных на его обнаружение районов, площадей, стратиграфических горизонтов и объектов. Среди последних самое пристальное внимание заслуживают отложения Шу-Сарысуйской депрессии, которые характеризуются необходимыми геологическими условиями для образования и сохранения скоплений углеводородов, продуктивность которых подтверждена открытием промышленных месторождений природного газа.

Тем не менее, несмотря на значительное количество пробуренных скважин и выполненных геофизических исследований за более чем полвека исследований, состояние изученности Шу-Сарысуйского бассейна в целом остается низким и сдерживает разведку и разработку его углеводородного потенциала. Это вызвано неравномерным распределением геолого-геофизических работ, сосредоточенных только на нескольких отдельных блоках бассейна, отдаленностью бассейна от необходимой инфраструктуры и малыми размерами ранее обнаруженных месторождений газа.

Как известно, нефтегазогеологический потенциал любой территории в значительной степени зависит от ее геолого-геофизической изученности и особенностей тектонического строения, контролирующих зоны скопления углеводородов. В статье в качестве инструмента решения поставленных задач рассматривается синтез и системный анализ результатов геолого-геофизических исследований, в том числе сведения по сейсморазведке, гравиразведке, магниторазведке, данных тепловых космических съемок и бурения.

Ключевые слова: бассейн Шу-Сарысу, потенциал нефтегазоносности, тектоническая эволюция, скопление углеводородов, магниторазведка, гравиразведка.

Introduction. The Shu-Sarysu sedimentary basin is located in the central part of Kazakhstan between the Karatau, Shu-Ili and Kirgiz Alatau ranges. It is extended in a northwestern direction for 840 km with a width of 340 km (Fig. 1) (Bykadorov et al., 2014; Korobkin and Buslov, 2011).

Planned reconnaissance surveys in Shu-Sarysu basin began in the 1941. Works were carried out with the aim of studying geological structure of the area and searching for ore and non-metallic minerals.

From 1941 to 1969 regional and exploratory aeromagnetic surveys using Z-aeromagnetometers in scales 1:500000-1:100000 covered the areas of the western, northwestern and, partially, central parts of Shu-Sarysu basin. Since 1969, up to 70% of the area of Shu-Sarysu basin has been covered with high-precision surveys using proton magnetometer and quantum aeromagnetometers at scales of 1:50000-1:25000, which make it possible to relate measurements to the absolute values of magnetic fields.

Almost entire territory of Shu-Sarysu basin is covered by areal gravimetric surveys of 1:200000 scale, with about 75% of the area surveyed using 1:100000-1:50000. In the West and southeast of this basin some areas were worked out by detailed surveying at a scale of 1:25000 (Urazalin, 1991).

Entire territory of Shu-Sarysu basin has been fully and evenly studied by satellite imagery using Terra, Aqua, Landsat, IRS, Radarsat. Since 1972, an extensive archive of high, medium and low-resolution images has been accumulated, which can be used to solve various cartographic tasks. Landsat satellite images in the visible and thermal ranges are used to solve problems of geotectonic zoning, to identify various geotectonic structures by tracing lineaments and identifying thermal anomalies. The results of surveys by Radarsat system are used to construct the terrain and build its three-dimensional models. This information is of great help in geotectonic zoning, identification and tracking of both fault zones and local structures, including inherited structures. Seismic study of territory of Shu-Sarysu basin by the Seismic Reflection Method began in 1958.

From 1975 to 2002 seismic survey was carried out using the Common Depth Point (CDP) in 2D Method modification. Since 2015 seismic exploration has been carried out by using the CDP-3D method (Korobkin and Buslov, 2011; Li and Petlenko, 2017).

Study of the basin by drilling parametric, prospecting and exploration wells was conducted from 1959 to 1983, and it has continued since 2003 by drilling production wells, in the Amangeldy field. As of today, in total only about 355 parametric, prospecting, exploration and production wells have been drilled in Shu-Sarysu basin.

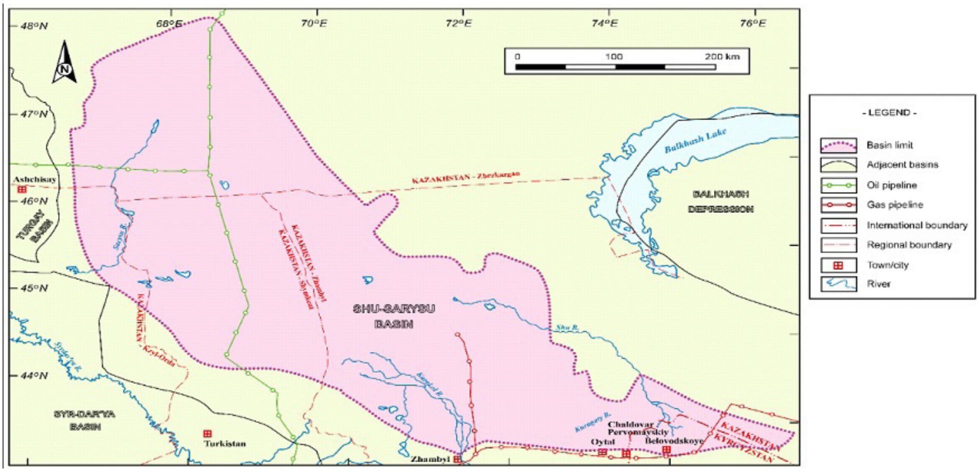

Figure 1 – Shu-Sarysu Basin Location Map

Overall, twelve gas and condensate fields were established in Shu-Sarysu Basin (Fig. 2), including: (Amangeldy, Anabai, Airakty, Zharkum, Kumyrly, Maldybai), 3 in the Kokpansor graben (Pridorozhnoe, Z.Oppak, Ortalyk) and 3 in the Talas uplift (Ucharal, Z.Ucharal, S.Ucharal) (Li and Petlenko, 2017).

Oil and gas potential of the basin is based on the degree of its exploration maturity, characteristics of its tectonic structure and results of oil and gas prospecting. Reducing costs of the exploration and prospecting for accumulations of the hydrocarbons can be achieved by conducting synthesis and systematic analysis of currently available geophysical data. Current research is attempted to systematic examination of the tectonic and hydrocarbon accumulation controlling characteristics on the basis of available geophysical data.

Materials and Methods. Basin evolution. At the end of the Ordovician-Early Silurian, as a result of the collision of a number of microcontinents with Precambrian crust and Lower Paleozoic island arcs, a large Kazakhstan microcontinent was formed. At the same time, as a result of spreading along periphery of the Kazakhstan microcontinent, Ural, Turkestan, and Ob-Zaisan oceanic basins are formed.

During early and partly middle Devonian, Kazakhstan microcontinent had active volcanic margins. Inside continent volcanogenic-sedimentary red-colored sequences accumulated in separate depressions and rifts.

In Famennian geodynamic processes slow down; volcanism is known only on the border with the Turkestan Ocean. Rifting processes with weak volcanism are noted inside continent. In Shu-Sarysu basin along Zhezkazgan-Kokshetau fault, a trough with salt accumulation and alkaline basalt dikes arose. The Kazakhstan continent was located in the Middle-Upper Devonian in low latitudes of the northern hemisphere (8-24° N). In Famennian, a marine transgression began, which reached its maximum in the Visean time, when the western half of the microcontinent, including Shu-Sarysu basin, was covered by the sea (De Pelsmaeker et al., 2015; Korobkin and Buslov, 2011).

By the end of the Middle Carboniferous, oceanic basins surrounding Kazakhstan microcontinent are closed, volcanism subsides. In the Late Carboniferous-Early Permian, collisional processes with granitoid magmatism take place. From the Middle Carboniferous in the Shu-Sarysu basin, lacustrine-alluvial red-colored (C2-3) and predominantly lacustrine salt-bearing red-colored and gray-colored deposits (P1-2) were accumulated.

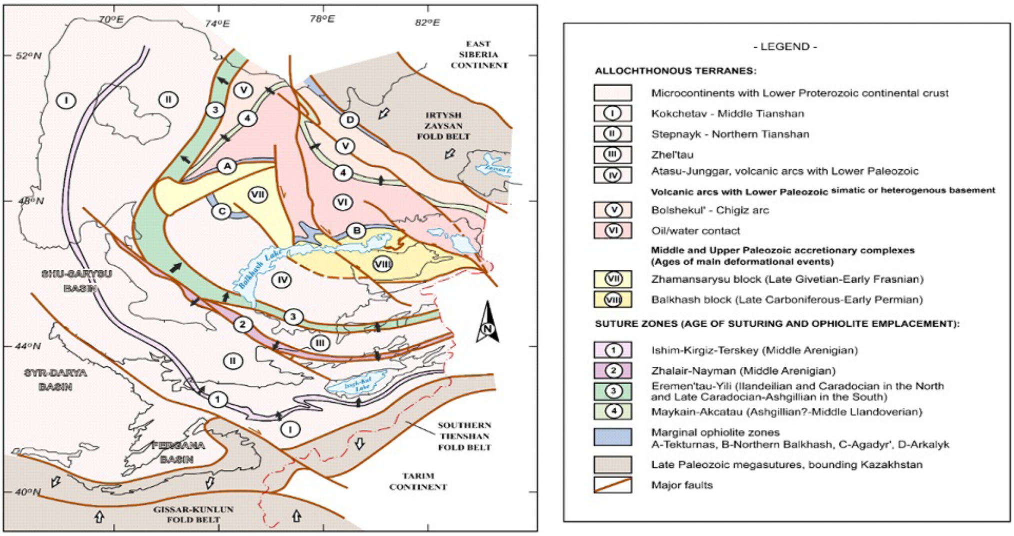

Figure 2 – Main Paleozoic Tectonic Units in Kazakhstan, Shu-Sarysu Basin

At the end of the Permian-Triassic, due to the closure of the Paleo-Tethys, intense compression processes and the development of right-sided strike-slip faults (Main Karatau, Zhezkazgan-Kokshetau, Zhalair-Naiman) with amplitudes of horizontal displacements up to 100-200 km are noted. Main structure of the Shu-Sarysu basin was formed at that time. Some changes in the structure occurred in the Oligocene-Quaternary due to the collision of Hindustan and Eurasia.

Within Shu-Sarysu basin stratigraphic section and the thickness of sedimentary formations are different. Upper Devonian (Famenian) predominantly terrigenous-saline deposits with a thickness of 500-1000 m are distributed in the Lower Shu and Tasty uplifts, in the southeastern parts of the Kokpansor and Tasbulak grabens, as well as in the northern part of the Moiynkum graben. On salt domes, the thickness of the Upper Devonian is increased to 2-3 km. In other areas, the Upper Devonian is absent or its thickness does not exceed 50-100 m. The formation of the salt-bearing Famennian basin is associated with weak rifting along the Zhezkazgan-Kokshetau fault system with small manifestations of basaltic alkaline magmatism (Tikhomirov, 1959).

During the entire Lower Carboniferous time, sedimentation in the Shu-Sarysu basin and adjacent, later folded, regions of Karatau, Sarysu-Teniz, Shu-Ili occurred mainly in shelf conditions without clear boundaries of the basin. In the greater southwestern part of the basin, the thickness of the Lower Carboniferous is 0.5-0.8 km. On the contrary, in its northeastern half, the thickness of the Lower Carboniferous sediments increases to 1.2–1.4 km in the Tasbulak graben and the Lower Shu uplift, and to 1.8–2.0 km in the northeast of the Moinkum graben. In general, these zones of increased thickness also correspond to hydrocarbon generation areas (primarily the Moinkum graben). It should be emphasized that the maximum thickness of the Lower Carboniferous deposits was established at the eastern boundary of the basin, which indicates its secondary nature and younger age.

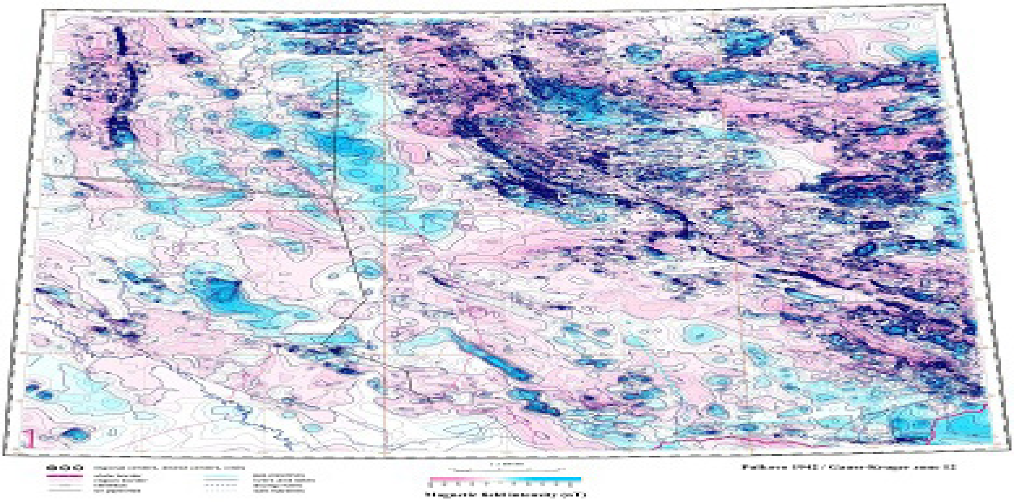

Figure 3 – Magnetic Anomaly Map, Shu-Sarysu Basin

Magnetic field characteristics. In the magnetic field of the Shu-Sarysu basin (Fig. 3), the The thicknesses of the Middle Carboniferous-Permian continental deposits are in good agreement with the modern structural plan of the basin. On large uplifts and in the marginal zones, these deposits are destroyed or reduced in thickness due to subsequent erosion, and in grabens they have maximum values. Deposits of the Middle-Upper Carboniferous in the grabens have a thickness of 500-700 m, at the eastern boundary of the basin from 1000-1500 m to 2000 m (Kyzyltuz trough).

The thickness of the Permian deposits in the grabens reaches 1.5-2 km, and in the Tasbulak graben 2.5 km (Zhang et al., 2020).

closure (and partly deep continuation) of large geological structures of Kazakhstan is quite clearly expressed. In the northwestern corner there are outcrops of the Ulytau (Karsakpai) crystalline basement and the Zhezkazgan mega syncline, in the southwestern part the northern end of the Greater Karatau stands out. To the northeast and east, parts of the Aktau, Shu-Ili and Zhalair-Naiman folding zones are noted.

Increases in the magnetic field, complex and irregular in plan, up to 1000 nT in the South Pre-Atasu region, more often elongated in the northwestern and sub latitudinal directions. They can be interpreted by analogy with the hidden mafic-intermediate intrusions exposed to the north and metasomatic and metamorphic alterations with the introduction of magnetite of host, mostly non-magnetic, rock varieties. Linear positive and reflective anomalies of the northwest direction are interpreted by blocks of ultramafic and effusive rocks of the basic-intermediate composition, located among the non-magnetic rocks of the sedimentary complex (Li et al. 2019).

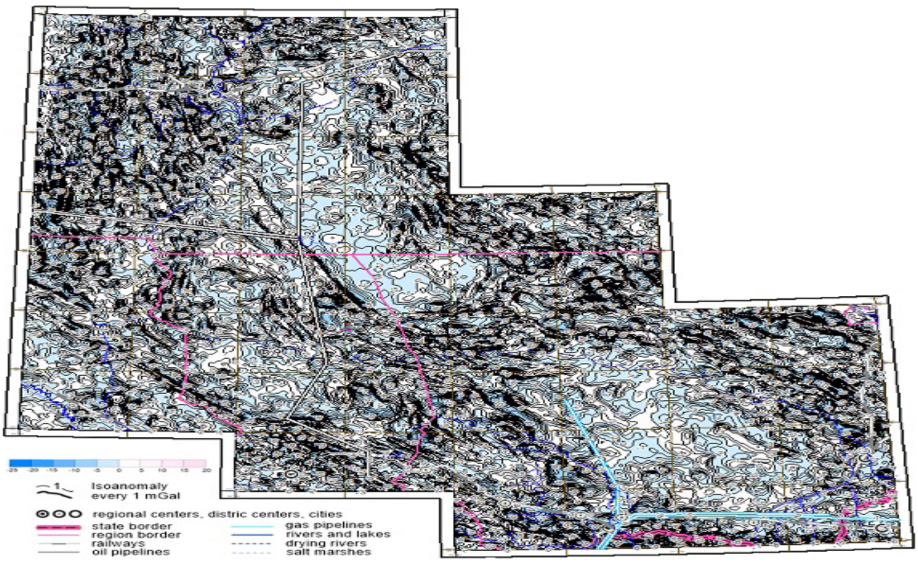

Figure 4 – Gravity anomaly map, Shu-Sarysu Basin

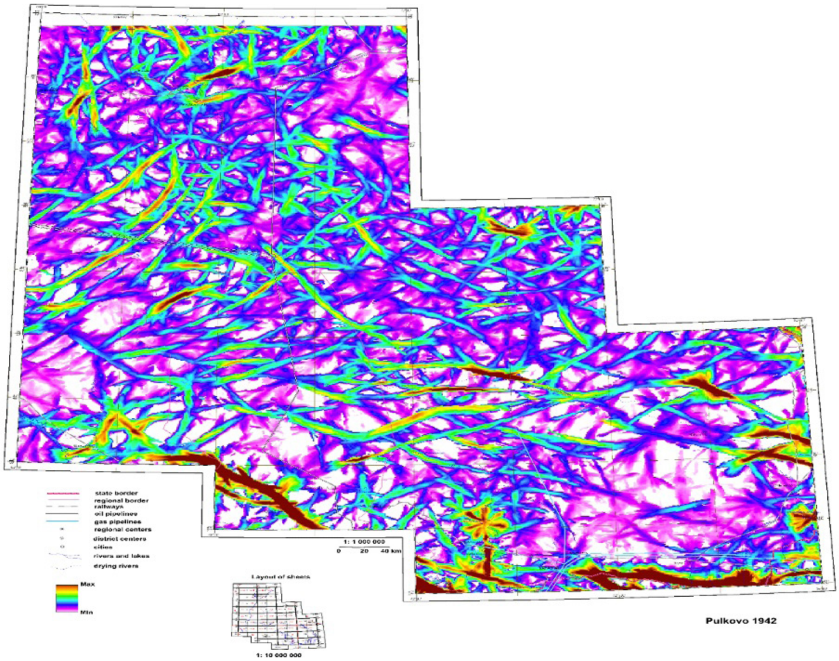

Figure 5 – Thermal Satellite Image, Shu-Sarysu Basin

Gravimetric surveys. The local gravity field of the Shu-Sarysu sedimentary basin is very well differentiated and clearly reflects the tectonic setting of sedimentary complexes and intrusive intrusions at the level of the crystalline basement and the upper part of the earth's crust (Fig. 4). The dominant part of the anomalies is elongated in the northwest direction, obeying the general strike of the tectonic elements of the Karatau and Shu-Sarysu structures and the Shu-Ili folded belt. Only the orientation of the Ulytau structures to the submeridional direction and the Shu block to the sub latitudinal direction change. The most intense minimums of isometric fields, which sometimes represent chains of anomalies, are characteristic of intrusive intrusions of acidic intrusions into the upper and middle parts of the Earth's crust along the Ulytau, Shu-Ili fold system, Shu block and Tasty uplift. Their intensity reaches tens of mGal. Smooth forms of gravity field anomalies with smaller amplitudes of minima are characteristic of areas with a developed thickness of the sedimentary cover - the Moiynkum, Tasbulak, Kokpansor and Sozak-Baikadam grabens. Here, the intensity of the field minima reaches 3–5 mGal. In the southeastern part of the territory, a northwest-trending lineament is pronounced, corresponding to the Karatau structures and the Main Karatau fault, which separate the Shu-Sarysu and Lower Syrdarya sedimentary basins (Turkov, 2020).

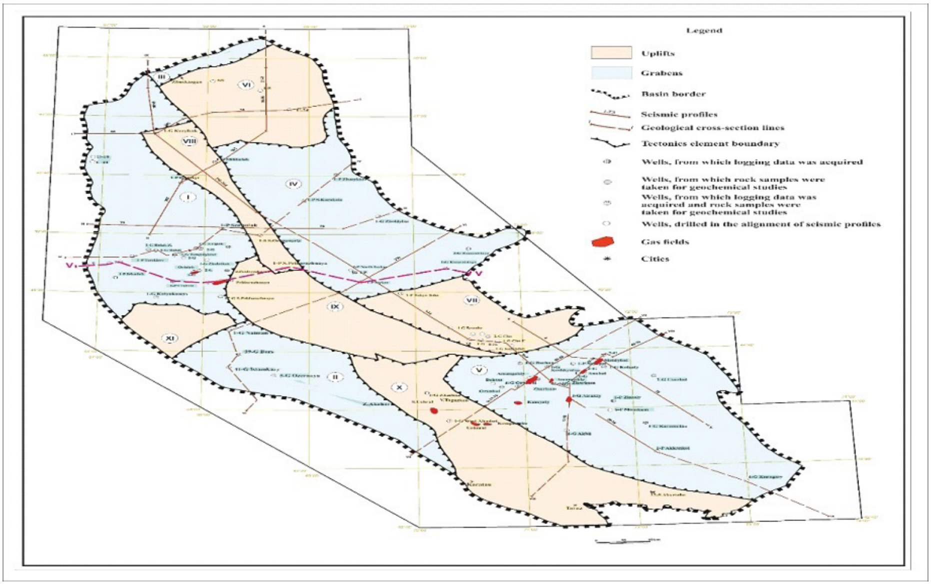

Figure 6 – Structure of the basement, Shu-Sarysu Basin.
Grabens: I - Kokpansor; II – Sozak-Baikadam; III – Zhezkazgan; IV – Tasbulak; V – Moyinkum. Uplifts: VI – Bugudzhil; VII – Sarysu; VIII – Tusty; IX – Talas; X – Betpakdala; XI – Lower-Shu.

Thermal imaging with satellites. Figure 5 shows the result of processing a thermal satellite image of the basin area. The systems of tectonic faults of the northeastern, northwestern, sub meridional and sub latitudinal directions are quite clearly distinguished by extended thermal anomalies. An analysis of the characteristics of the identified anomalies allows us to divide them into two groups. The first group includes anomalies of significant (hundreds of km) extent, which, apparently, reflect deep fault zones in the basement and intermediate structural stage. The second group of faults is distinguished by a relatively shorter extent. These faults are most likely associated with the middle and upper parts of the section (Li and Petlenko, 2017).

Seismic survey. Based on gathered seismic data, a number of reflecting horizons have been established. According to drilling data, these reflecting horizons are stratified as follows: top of Paleozoic (Regional unconformity above Paleozoic); top of Permian salt (P_1); base of Permian salt (P_1); top of carbonate formation of Carboniferous (C_1v_{2-3}-s); base of Carboniferous (C_1); top of the basement (PR-D_3).

The basement of the basin was formed at the end of the Ordovician. In its structure, Precambrian blocks (Moinkum, Tasbulak, etc.) and zones of Caledonian folding (Shu-Ili, Baikonur-Karatau, Tastinskaya) are distinguished. The sedimentary cover of the basin includes deposits from the Middle-Upper

Devonian to the Neogene and forms two structural levels separated by large stratigraphic and angular unconformities: Paleozoic (Middle-Upper Devonian-Permian) and Mesozoic-Cenozoic (Upper Cretaceous-Neogene).

Basement of the Shu-Sarysu sedimentary basin is composed of Precambrian and Lower Paleozoic formations. Basement rocks are intensively dislocated, metamorphosed and intruded by intrusions of various composition and age, which are widely developed in the side frames of the Shu-Sarysu sedimentary basin in Ulytau, Karatau, Kirgiz Alatau, on Kendyktas, Shu block, Ergenekty-Zhuantobe anticlinorium and in separate areas of the Sarysu-Teniz uplift. In addition, the rock associations of the basement were also exposed by boreholes in a number of interior areas of the basin. Basement of the Shu-Sarysu depression is characterized by a block structure of different ages. It contains a number of subsided (Kokpansor, Sozak-Baikadam, Zhezkazgan, Tasbulak, Moiynkum grabens) and uplifted blocks (Bugudzhil, Sarysu, Tasty, Talas, Betpakdala, Lower-Shu) (Fig. 6) (Madenova et al., 2018).

The main structural element of the Shu-Sarysu basin, dividing it into the northwestern and southeastern parts, is the central system of uplifts stretching from the northwest to the southeast and consisting of the Betpakdala, Tasty and Talas uplifts. The Kokpansor and Sozak-Baikadam grabens, separated by the Bugudzhil uplift, stand out to the southwest of this system of uplifts (Fig. 6). On the northeastern side of this system of uplifts, Zhezkazgan graben, Sarysu uplift, Tasbulak graben, Lower-Shu uplift and Moiynkum graben are located successively from northwest to southeast. Table 1 presents a description of the structural and morphological characteristics of the main tectonic elements of the Shu-Sarysu sedimentary basin along the top of the basement. Overall, conformity of structural plans for different horizons of the quasi platform structural level displays itself well in geological and seismic sections (Fig. 7) (Tulemissova, 2017).

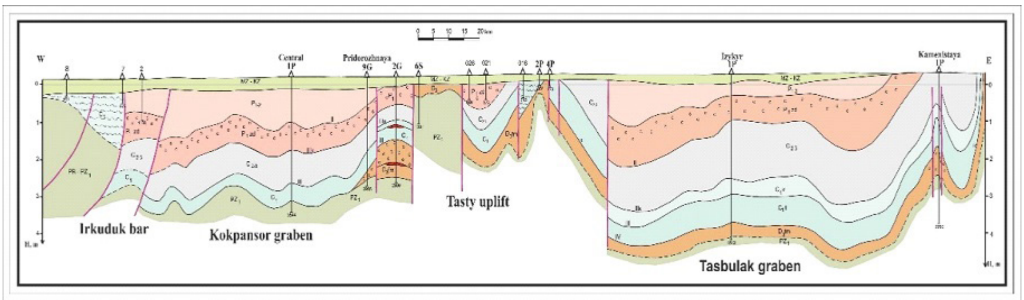

Figure 7 – Geological sub-latitudinal section along the V-V line

Along the base of the Mesozoic-Cenozoic structural level, Shu-Sarysu basin is not distinguished as a single structure. Most of it is the southwestern end of the Central Kazakhstan Shield. Within the Shu-Sarysu basin, the only clear-cut post-Paleozoic large structure is distinguished tectonic element is Sozak graben. The Mesozoic-Cenozoic formations of the platform structural level, according to the lithological and stratigraphic features of sedimentary filling, the nature of areal development, the degree of dislocation, the presence of various types of unconformities, are confidently differentiated into two structural layers: the lower one, which includes the Triassic-Jurassic formations, and the upper one, that represents the rest of the deposits of the platform structural level.

Types of the traps of the discovered gas fields within Middle-Upper Paleozoic sediments of the Shu-Sarysu Basin. As a result of the geological and geophysical studies, including the drilling of parametric and exploration wells in various geotectonic conditions, commercial accumulations of gas and gas condensate were discovered in the basin, and no surface oil and gas manifestations were observed (Figure 6). In total, twelve gas fields have been discovered in the Shu-Sarysu basin: six (Amangeldy, Anabay, Airakty, Zharkum, Kumyrly, Maldybay) in the Moyinkum graben, three (Pridorozhnoe, Western Oppak, Ortalyk) in the Kokpansor graben and three on the Talas uplift (Usharal-Kempirtobe, Northern Usharal, Alimbet). All identified fields belong to the reservoir-arch type with elements of tectonic and lithological shielding (Figure 8). For some gas fields (such as Maldybay etc.), there is an incomplete coincidence of structural plans with the displacement of arches with depth at various stratigraphic levels (Zhang et al., 2018).

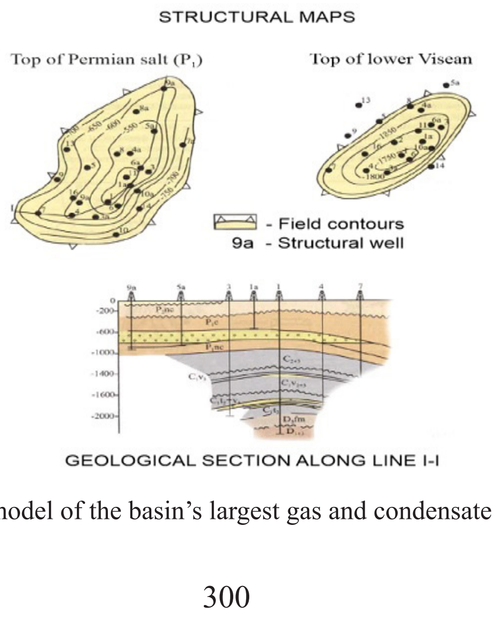

Figure 8 – Trap model of the basin's largest gas and condensate field Amangeldy

Methods. Systematic examination of the tectonic and hydrocarbon accumulation controlling characteristics was carried out on the basis of structural maps built from seismic surveys, in conjunction with magnetometric and gravimetric studies and their various transformations. It aims to identify and summarize the key findings related to tectonic structure of the basin and to evaluate it effects on formation of the hydrocarbon accumulations.

Results and discussion. The Shu-Sarysu Basin is characterized by low exploration maturity. To date, only the southern margin of the Kokpansor graben and the northern margin of the Moiynkum graben have been studied quite well. Most likely, this explains the discovery of commercial gas accumulations within the Kokpansor and Moiynkum grabens and only gas shows and signs of hydrocarbons in the Tasbulak, Zhezkazgan and Sozak-Baikadam grabens.

The lows of the gravity field, as a rule, characterize the thickness of the development of depositional sequence. Here, in contrast to the South Torgai depression, correlation coefficient between intensity of the gravity field lows and the depth to the top of the basement is not clearly traced. There are two reasons for this: firstly, there are no sufficient number of wells that have exposed the basement, and, secondly, field lows are additionally caused by the development of Permian and Devonian salts here.

According to the seismic material, the junction of uplifts with grabens occurs along high-amplitude faults of thrust and shear-thrust nature. Structural plans of the Paleozoic deposits are in good agreement with the different horizons. All the main tectonic elements are well shown on the map of the local gravity field, but at the same time, on the magnetometric maps, the main tectonic elements of the Paleozoic deposits are not clearly observed.

The appearance of thermal anomalies in tectonic faults according to the data of thermal satellite surveys, especially regional ones, indicates that geological conditions for heat migration have been created in these zones. Such anomalies may be associated with regional geodynamic zones, which, in turn, may be a subject to fluid-dynamic systems of the regional level. This can be an important prospecting criterion. For example, the analysis of the spatial distribution of the largest hydrocarbon fields in the South Torgai basin shows that the vast majority of them are located in the areas of identified anomalies or are located near them, and the largest of them, Kumkol, tend towards the area of intersection of anomalies of the northwestern and northeastern directions. Similar situation is observed in other basins, in connection with which this fact is proposed to be considered during planning of exploration works.

Features of the regional structure indicate sufficient isolation of the grabens from each other, which as a whole creates a characteristic, relatively closed system. The differentiation of the grabens is also quite contrasting both in terms of hypsometry and the number of faults of the sedimentary section, especially in the northern regions of the Moinkum and western regions of the Kokpansor grabens. We can conclude that the specified features of the hydrogeological environment have determined the stagnant hydrodynamic regime and the passive nature of the marginal waters in gas fields, which are considered as a favorable factor contributing to the conservation of hydrocarbon accumulations. Hydrocarbons migrated along faults in different periods of geological history, upon encountering structural, combined, and other types of traps, could filled them and formed accumulations of hydrocarbons. At the same time, the Zhezkazgan, Kokpansor, Tasbulak, Moiynkum and Sozak-Baikadam grabens were autonomous sources of hydrocarbon generation, and their edge zones, complicated by local structures, were oil and gas accumulation zones.

Almost all of the identified grabens are asymmetric and do not have a clearly defined internal axial linearity close to their general regional orientation. The grabens are characterized by relatively small submerged areas and larger flattened side zones. Such most submerged areas for the Moinkum and Tasbulak grabens are spatially confined to the near-contact zones with the Shu ledge and individual elements at the contact with the Talas-Tasty system of uplifts. Submerged areas of the Kokpansor graben tend mainly to its axial zone. Multi-vector orientation is also characteristic of structural elements of a lower rank within grabens, which indirectly indicates the influence of various tectonic factors at different times on the formation and subsequent reshaping of a number of structural elements, including local structures. These are mainly anticlines and brachyanticlines folds with varying levels of tectonic dislocations, including fault folds. The faulting of the grabens by local anticlinal structures is quite high, while any strictly defined orientation is practically not traced in the location of the structures. This also indicates a multifactorial tectonic impact on the sedimentary cover in various parts of the grabens.

Table 1 – Structural and morphological characteristics of the main tectonic elements within Shu-Sarysu basin

Name of tectonic elements	Strike	Borders	Dimensions, km	Depth, m		Dislocation	Local anticlinal structures
				From	To		
Kokpansor graben	Subme-ridional	Between Betpakdala, Tasty, Bugudzhil uplifts and the Ulytau anticlinorium. In the southwest with the Itmurun step, in the south with the Akkol step, in the northwest with the Bugudzhil and in the northeast with the Tasty uplift.	310 x 20-120	-2500	-4500	Mosaic appearance and increased number of rifts	Oppak uplift

Sozak-Baikadam graben	Northwest	In the northwest with the Shu block and the Lower-Shu uplift, in the northeast with the Kendyktas massif and the Shu-Ili anticlinorium, in the southwest and northwest with the Talas uplift	240 × 75	-2500	-3500	The inner part has a simple structure and is broken only by low-amplitude discontinuities	
Moiynkum graben	Northwest	In the east with the Tasty and Baikadam uplifts and in the south with the Lower-Shu uplift, in the east-northeast with the Shu-Ili fold belt	310 x 70-150	-1200	-2500	The southwestern part is complicated by low-amplitude northeast-trending faults, the northeast part is complicated by high-amplitude northeast-trending faults	In the southwestern part: Amangeldy, Airakty, Karamatau, Barkhannaya, Akkankol, Kashkynbay, Zharum, etc. In the northeastern part: Anabay, Maldybay, Sayakbay, Besoba, Kolgaly, Merkesh, Usurbay, etc.
Tasbulak graben	Northwest	In the east with the Tasty and Baikadam uplifts and in the south with the Lower-Shu uplift, in the east-northeast with the Shu-Ili folded belt	190-210 × 90-110	-2000	-5500	Weak dislocation and weak faulting of the sedimentary cover, a small number of local anticlines, with the exception of the northeastern, southwestern and southern parts	Zhaman-Aybatskaya, Dautbayskaya, Karakoinskaya
Zhezkazgan graben	Latitudinal	In the south with Sarysu uplift and in the north with the Teniz-Sarysu watershed	90 x 20	-1500	-4000		
Tasty uplift	Northwest		220 × 50-70	-1500	-2500	It is bounded by large longitudinal tectonic faults of north-northwest strike and is broken up by transverse faults into separate blocks	
Betpakdala uplift	Northwest	In the southeast with the Tasty uplift	210 x 20-40	-500	-2500	Limited by large faults	Ortasynyrli and Milibulak swells, Central Betpakdala step
Sarysu uplift	Northwest	In the south with the Tasbulak graben	90-130 x 90-110	0	-1500	Complicated by northeast-trending faults	Northeast-trending brachianticlines
Talas uplift	Northwest	In the east with the Moiynkum graben, in the southwest with the Lesser Karatau	250 × 90	-1500	-3000	The faults have a northwestern orientation and small amplitudes (the first hundreds of meters)	Northern Usharal, Zhaiylma, Koskuduk, Akbii, Dreams, Western Mishty, etc.

Lower-Shu uplift	Northwest	In the northeast with the Shu block, in the southwest with the Tasty uplift	110 × 60-70	-1500	-3500	It is complicated by high-amplitude (many hundreds of meters) sublatitudinal faults and northeast-trending faults cutting them.	
Bugudzhil uplift	Northwest	In the northeast with the Tasty uplift	80 x 65-20	-1500	-5000		

Conclusions. The low degree of geological and geophysical certainty of the Shu-Sarysu basin does not provide an opportunity to fully assess its oil and gas potential. The data on the tectonics and structure of individual blocks of the basin are undoubtedly subject to research as a more detailed study of less explored areas appears.

Tectonics has had a multifactorial tectonic impact on the sedimentary cover in different parts of the grabens. The multi-vector orientation of local structures, potential hydrocarbon accumulation zones, inside the grabens indicates the multifactorial and multidirectional impact of tectonic processes on their formation. The presence of tectonically active zones at the boundaries of the basin and within it led to the development of a wide network of faults in sedimentary cover, which, on the one hand, provided conditions for the formation of structures of various ranks, and, on the other hand, increased the degree of isolation during the formation of zonal and local traps.

While planning prospecting works, it is recommended to consider the location of thermal anomalies in regional faults according to thermal satellite imagery.

Structural differentiation of the Shu-Sarysu basin indicates the isolation of grabens separated by dynamically active zones of uplifts, and indicates the prospects for the marginal parts of the grabens.

Acknowledgements. *We express our gratitude to the Republican State Institution «Yuzhkaznedra» for permission to search, obtain and use geological and geophysical data related to the Shu-Sarysu Basin in the database of geological information.*

Information about authors:

Zhumagulov Almas Serikbaevich – PhD student in Oil-gas and ore geophysics (MSc in Reservoir Engineering), 1-st level Reservoir Engineer at International Centre for Deposit Analysis and Development, Satbayev University, Almaty, Kazakhstan, a.zhumagulov@satbayev.university, https://orcid.org/0000-0001-5851-5750;

Manzari Mehrdad Taghizadeh – PhD in Engineering, Professor of School of Mechanical Engineering, Sharif University of Technology, Tehran, Iran, mtmanzari@sharif.edu, https://orcid.org/0000-0003-0297-7053;

Kezembayeva Gulmira Bulatovna – DBA, Chief ecologist at International Centre for Deposit Analysis and Development, Satbayev University, Almaty, Kazakhstan, g.kezembayeva@satbayev.university, https://orcid.org/0000-0002-2298-2987;

Nurmakova Saule Mukanovna – к.т.н., Professor of the Department of Chemical Processes and Industrial Ecology Satbayev University, Almaty, Kazakhstan, mnurma@mail.ru, https://orcid.org/0000-0002-2896-4261;

Mukanov Daulet Bekbulatovich – MSc in Oil-gas and ore geophysics, 1-st level Geologist at International Centre for Deposit Analysis and Development, Satbayev University, Almaty, Kazakhstan, d.mukanov@satbayev.university, https://orcid.org/0000-0002-9628-2588.

CONTENTS

Publication Ethics and Publication Malpractice in the journals of the National Academy of Sciences of the Republic of Kazakhstan

For information on Ethics in publishing and Ethical guidelines for journal publication see http://www.elsevier.com/publishingethics and http://www.elsevier.com/journal-authors/ethics.

Submission of an article to the National Academy of Sciences of the Republic of Kazakhstan implies that the described work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see http://www.elsevier.com/postingpolicy), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The National Academy of Sciences of the Republic of Kazakhstan follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the Cross Check originality detection service http://www.elsevier.com/editors/plagdetect.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will only accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the National Academy of Sciences of the Republic of Kazakhstan.

The Editorial Board of the National Academy of Sciences of the Republic of Kazakhstan will monitor and safeguard publishing ethics.

Правила оформления статьи для публикации в журнале смотреть на сайтах:
www:nauka-nanrk.kz
http://www.geolog-technical.kz/index.php/en/
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Директор отдела издания научных журналов НАН РК *А. Ботанқызы*
Заместитель директор отдела издания научных журналов НАН РК *Р. Жәлиқызы*
Редакторы: *М.С. Ахметова, Д.С. Аленов*
Верстка на компьютере *Г.Д.Жадыранова*

Подписано в печать 14.10.2022.
Формат 70x90$^{1}/_{16}$. Бумага офсетная. Печать – ризограф.
20,0 п.л. Тираж 300. Заказ 5.

Национальная академия наук РК
050010, Алматы, ул. Шевченко, 28, т. 272-13-19