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

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ

Satbayev University

ХАБАРЛАРЫ

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ
НАУК РЕСПУБЛИКИ
КАЗАХСТАН
Satbayev University

NEWS

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

SERIES

OF GEOLOGY AND TECHNICAL SCIENCES

6 (456)

NOVEMBER – DECEMBER 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
ISSN 2224-5278
Volume 6, Number 456 (2022), 261-275
https://doi.org/10.32014/2518-170X.254

UDC 550.98(574

A.S. Zhumagulov[1*], M.T. Manzari[2], S.A. Issayev[1]

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

PETROLEUM PLAYS AND PROSPECTIVITY OF THE SHU-SARYSU BASIN

Abstract. Exploration efforts in the Shu-Sarysu Basin, located in the central-southern part of the Republic of Kazakhstan, started by Soviet geologists in mid-1950's and established a range of petroleum plays in various basin segments: 1 Late Devonian clastic pre-salt play, 2 Early Carboniferous clastic-carbonate play, 3 Early Permian clastic pre-salt play. All these plays attributed to a Middle-Upper Paleozoic single petroleum system, but display significant variation among the basin segments depending on the degree of exploration maturity and tectonostratigraphic units involved.

Nevertheless, despite more than half a century of study, because of the low-resolution geophysical data, opinions about prospective areas are contrasting and ambiguous. Moreover, the Post-Soviet period exploration for new targets has proved potential for gas in the previously located prospects, and has highlighted the prospectivity of unexplored areas and deeper sections. Thus, petroleum plays prospectivity of the Shu-Sarysu Basin needs to be revised, considering more recently obtained data.

This paper investigates characteristics of the petroleum plays of the Shu-Sarysu Basin based on published data concerning both mature producing and underexplored basin segments and clarifies their prospectivity for hydrocarbons. Synthesis and comprehensive analysis of known lithological, structural and production features of the plays and their spatial distributions has highlighted four groups within the Basin: 1 gas-bearing, 2 promising gas-bearing, 3 with unclear prospects, 4 unpromising areas. This will help geologists in the decision making to select the most favorable discovery sites and directions of further explorations, thereby minimizing costs and maximizing profits associated with exploration efforts.

Key words: petroleum play, hydrocarbon prospectivity, Shu-Sarysu Basin, petroleum exploration.

А.С. Жұмағұлов[1*], М.Т. Манзари[2], С.А. Исаев[1]

[1]Satbayev University, Алматы, Қазақстан;
[2]Шариф технологиялық университеті, Тегеран, Иран.
E-mail: a.zhumagulov@satbayev.university

ШУ-САРЫСУ БАССЕЙНІНІҢ МҰНАЙ-ГАЗ КЕШЕНДЕРІ ЖӘНЕ ПЕРСПЕКТИВАЛАРЫ

Аннотация. Орталық және Оңтүстік Қазақстан аумағында орналасқан Шу-Сарысу бассейніндегі барлау жұмыстарын кеңес геологтары 1950 жылдардың ортасында бастады. Бұл бассейіннің әртүрлі сегменттерінде орналасқан бірнеше мұнай-газ кешендерін анықтауға мүмкіндік берді: 1) кейінгі девон кезеңінің терригендік тұз асты кешені, 2) ерте карбон кезенінің терриген-карбонатты кешені, 3) ерте пермь кезенінің терригенді тұз асты кешені. Бұл кешендердің барлығы біртұтас орта-жоғарғы палеозойдың мұнай-газ жүйесіне жатады, бірақ оларда барлау дәрежесіне және тектоностратиграфиялық сипаттамасына байланысты айтарлықтай айырмашылықтар бар.

Алайда, барлау жұмыстарының жарты ғасырдан астам уақытта жүргізілгеніне қарамастан, геофизикалық деректердің төмен сапасына байланысты перспективалық учаскелер туралы пікірлер әртүрлі. Сонымен қатар, кеңес дәуірінен кейінгі кезеңдегі барлау жұмыстары ертеден анықталған алаңдардың газдылығын дәлелдеп, зерттелмеген аумақтар мен тереңірек аймақтардың перспективтілігін көрсетті. Сондықтан, Шу-Сарысу бассейніндегі мұнай және газ кешендерінің перспективтілігін соңғы мәліметтерді ескере отырып қайта қарау қажет.

Бұл мақалада Шу-Сарысу бассейнінің мұнай-газ кешендерінің сипаттамалары бассейннің жетік және нашар зерттелген аумақтары бойынша жарияланған деректер негізінде зерттеліп, олардың көмірсутек перспективалары нақтыланды. Кен орындарының белгілі литологиялық, құрылымдық және эксплуатациялық сипаттамаларын және олардың кеңістікте таралуы бойынша мәліметтерді синтездеу және комплексты түрде талдау бассейн шегіндегі аумақтарды төрт топқа бөлуге мүмкіндік берді: 1) газды, 2) перспективті газды, 3) перспективасы анық емес, 4) перспективасы жоқ. Бұл геологтарға көмірсутек кен орындарын іздестіру кезінде перспективалары ең жоғары аймақтарды және оларды барлау бағыттарын таңдауға, сонымен қатар, барлаумен байланысты шығындарды азайтып, пайданы көбейтуге септігін тигізеді.

Түйін сөздер: мұнай-газ кешені, мұнай-газ перспективалары, Шу-Сарысу бассейні, мұнай-газ барлау жұмыстары.

А.С. Жумагулов[1*], М.Т. Манзари[2], С.А. Исаев[1]

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

НЕФТЕГАЗОНОСНЫЕ КОМПЛЕКСЫ И ПЕРСПЕКТИВЫ ШУ-САРЫСУЙСКОГО БАССЕЙНА

Аннотация. Разведочные работы в Шу-Сарысуйском бассейне, расположенного на территории Центрального и Южного Казахстана, были начаты советскими геологами в середине 1950-х гг. и позволили установить ряд нефтегазоносных комплексов в различных сегментах бассейна: 1) позднедевонский терригенный подсолевой, 2) раннекаменноугольный терригенно-карбонатный, 3) раннепермский терригенный подсолевой. Все эти комплексы относятся к единой средне-верхнепалеозойской нефтегазоносной системе, но имеют значительные различия в отдельных сегментах бассейна в зависимости от степени разведанности и тектоностратиграфических единиц.

Тем не менее, несмотря на более чем полувековой период изучения, из-за низкого разрешения геофизических данных мнения о перспективных участках противоречивы и неоднозначны. Более того, разведка новых объектов в постсоветский период доказала потенциал газа на ранее обнаруженных объектах, а также установила перспективность неразведанных площадей и более глубоких участков. Таким образом, перспективность нефтегазовых месторождений Шу-Сарысуского бассейна нуждается в пересмотре с учетом более поздних данных.

В данной статье исследуются характеристики нефтегазоносных комплексов Шу-Сарысуйского бассейна на основе опубликованных данных как по зрелым продуктивным, так и по малоизученным сегментам бассейна и уточняется их перспективность на углеводороды. Синтез и комплексный анализ известных литологических, структурных и эксплуатационных особенностей месторождений и их пространственного распределения позволили выделить в пределах бассейна четыре группы площадей: 1) газоносные, 2) перспективно-газоносные, 3) с неясными перспективами, 4) бесперспективные. Это будет способствовать геологам при выборе наиболее благоприятных для обнаружения углеводородов участков и направлений дальнейших исследований, тем самым минимизируя затраты и максимизируя прибыль, связанную с геологоразведочными работами.

Ключевые слова: нефтегазоносный комплекс, перспективность на углеводороды, бассейн Шу-Сарысу, разведка на нефть и газ.

Introduction. The Shu-Sarysu Basin is located mainly in South Kazakhstan. The basin's north-eastern and eastern boundaries run along the Chu-Ili Mountain range which stretches from north-west to south-east and is formed by a series of low relief mountains. To the west/north-west, the Alatau Range separates Chu-Sarysu from the

Turgay Basin. The Greater and Lesser Karatau ranges to the south-west separate the Chu-Sarysu Basin from the Syr-Darya (Kyzylkum) Basin. The Chu-Sarysu Basin's southern border runs along the foothills of the Tien Shan mountains (Fig. 1). It stretches in the northwest direction for a distance of 840 km, has a width of 300 km and a total area of 160 thousand km^2 (Dikenshteyn et al., 1984; Li and Petlenko, 2017).

From 1941 to the mid-1980's, Shu-Sarysu Basin has been target of extensive exploration for ore and petroleum. However, in spite of this, the degree of our knowledge still remains extremely low. Unfortunately, regional geological surveys of Soviet times mostly resulted in a low-resolution data, while exploration activities during the years of independence, since 1991, focused only on few particular local structures, discovered in Soviet times. Moreover, exploration works conducted since 1991 discovered new insights in prospectivity of the previously explored zones and unexplored deep horizons. As a result, within Shu-Sarysu Basin 12 gas fields were identified, including: 6 in the Moiynkum graben (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). The total number of identified local structures amounted to 150 (Figure 4). Geological conditions of eleven prospective structures are estimated: 6 in Kokpansor Graben (Zholotken, Terekhovskaya, Z. Bulakskaya, S. Pridorozhnoe, Yu. Pridorozhnoe, Kenderlik); 1 in Moiynkum Graben (Karamatau); 3 in Zhezkazgan Graben (S.Kyzylkakskaya, Tala-Zhezdinskoe, Talap); 1 in Sozak-Baikadam Grabben (Ozernaya-Bis). In more than 21 structures geological exploration remained incomplete: in Moiynkum Graben (Sayakpai, Barkhannaya, Zhualy, Kashkynbai, Zhalanash, Besoba, Yu. Zharkum, Sultankuduk etc.); in Tasbulak Graben (Zhatyktau, Izykyr, Karakoin, Kamenistoe, Sokyrtobe, Zhaman-Aibat, S. Izykyr); in Zhezkazgan Graben (Sarysu, Sarydala); in Sozak-Baikadam Graben (Naiman, Borsvaya, Ozernaya) (Daukeyev et al., 2002; Li and Petlenko, 2017).

All fields and structures can be grouped into three petroleum plays: Late Devonian clastic pre-salt play; Early Carboniferous clastic-carbonate play; Early Permian clastic pre-salt play (Li et al., 1982; Tulemissova and Korobkin, 2020). Detailed exploration and rethinking of the geophysical and geological data needs to be carried out additionally for more than 100 promising structures. Thus, our knowledge of prospectivity of established petroleum plays and prospects within Shu-Sarysu Basin is insufficient and requires reinvestigation. Determination the most promising sites for the oil and gas will contribute to reducing costs of the exploration and prospecting for discoveries.

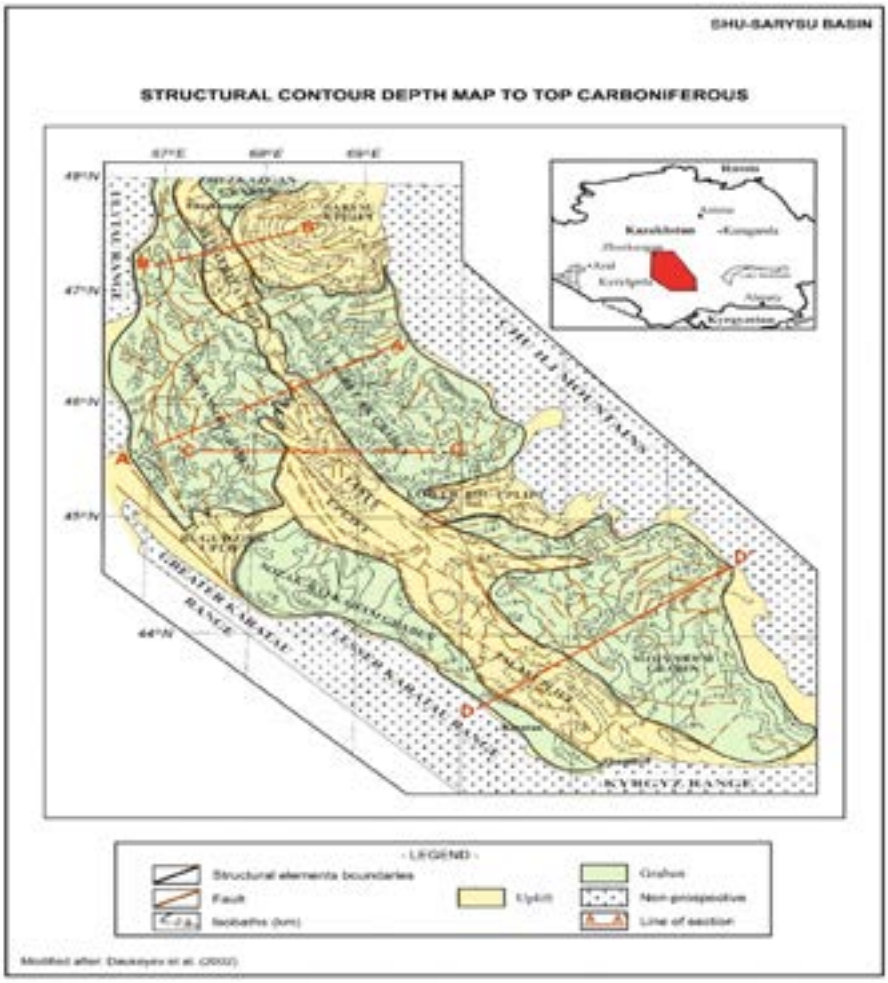

Figure 1. Structural contour depth map of top Carboniferous, Shu-Sarysu Basin

Research materials and methods. The Shu-Sarysu Basin evolved as part of the large Kazakhstan plate. The formation of the main structural elements was mainly influenced by the Caledonian and Hercynian cycles of tectonomagmatic activation. In the Caledonian cycle of tectogenesis, in the Ordovician-Silurian, faults and uplifts of the northwest direction were formed. Also, in the Hercynian cycle of tectogenesis, in the Early Devonian, faults and uplifts of the northeastern direction were formed. The intersection of the northwestern and northeastern faults in the Late Devonian led to fragmentation of the basement. In the Carboniferous-Permian, different-amplitude tectonic activities of the blocks led to the formation of a number of lowered and uplifted blocks, grabens and uplifts. As a result, the Shu-Sarysu Basin is characterized by a blocked structure of different ages as it shown in Figure 1 (Li et al., 1982; Zhang et al., 2020).

The main structural elements of the basin are:

- the Talas-Tasty uplift zone and the Central Betpak-Dala uplift striking from south-east to north-west along the basin's axis. They are believed to be associated with an ancient (Ordovician) suture zone;

- two large depressions in the south-west of the Talas-Tasty zone are the Kokpansor graben and the Sozak-Baikadam graben; they are separated by the Bugudzhil uplift;

- three more grabens exist north-east of the Talas-Tasty zone. They are the Tasbulak graben, the Moiynkum graben and the Zhezkazgan graben separated by the Lower-Shu uplift and the large Sarysu uplift.

Being the southern succession of the Teniz-Shu petroleum province, the Shu-Sarysu Basin is geologically connected with the depression of the same name that stretches in the sub meridional direction. The basin is composed of Devonian-Permian and Meso-Cenozoic sediments of more than 6000 m. The basement consists of Precambrian and Early Paleozoic formations, intensively metamorphosed and widespread along the periphery and uplifts of the basin. The basement with a deep stratigraphic break is overlain by a quasi-platform structural level of a diverse lithological composition of red-coloured terrigenous rocks, carbonates and evaporates. The stratigraphic volume of the rocks covers sequences of deposits from the Early-Middle Devonian to the Permian inclusive. It consists of the following lithological-stratigraphic sequences: carbonate-clastic-halogen of the Late Devonian; clastic-carbonate of Early Carboniferous; continental clastic sediments of Middle-Late Carboniferous, clastic-halogen of Early Permian and clastic-carbonate of Late Permian. The platform cover that combines Mesozoic-Cenozoic formations up to 300 m thick, overlays quasi-platform structural level formations with stratigraphic unconformity (Figures 2 and 3) (Daukeyev et al., 2002; Li et al., 1982; Li and Petlenko, 2017).

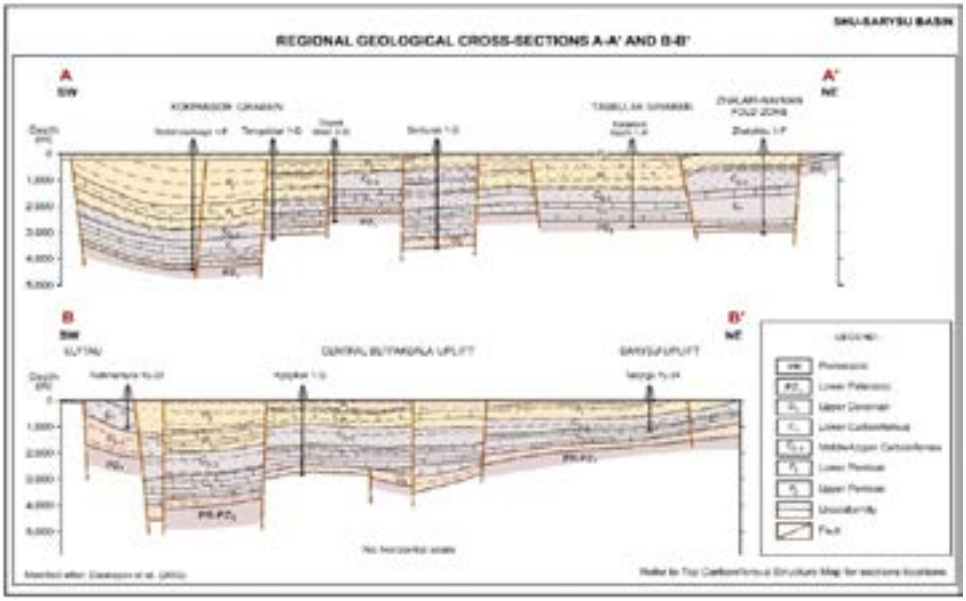

Figure 2. Regional geological cross-sections A-A' and B-B' (Figure 1), Shu-Sarysu Basin

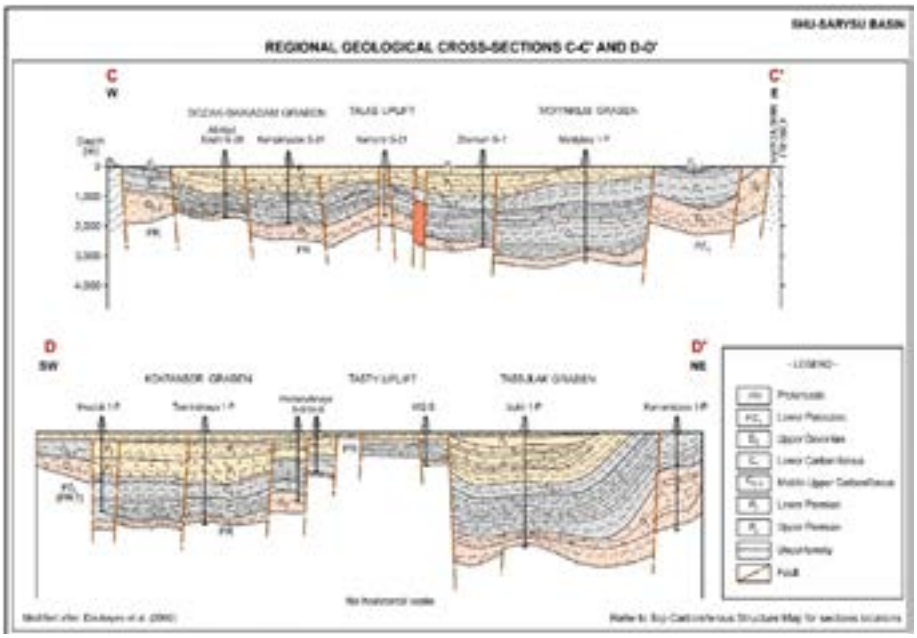

Figure 3. Regional geological cross-sections C-C' and D-D' (Figure 1), Shu-Sarysu Basin

Source rocks. It is understood from the results of the geochemical studies, including the most recent study conducted by ExxonMobil in 2004, that potential oil source formations of the Late Devonian and Early Carboniferous, represented by clastic-carbonate sediments, and gas source rocks of the Early Carboniferous, formed by carbonate-clastic sediments, are characterized by increased content of the original organic matter. In the Middle-Late Carboniferous and Permian, the oil and gas source sequences of the Early Carboniferous in the Kokpansor and Tasbulak grabens were in favor of the generation of liquid and gaseous hydrocarbons thermobaric conditions. However, a hard paleotemperature gradient (2.5-2.9°C/100 m) did not contribute to the generation, accumulation and migration of liquid hydrocarbons. The processes of gas generation have acquired the prevailing influence. Intense sagging of the Permian led to the rapid sinking of oil and gas source rocks into the lower thermal catalytic zone of gas generation. The zones of the most intense dislocations (Talas, Tasty and Lower-Shu uplifts, side parts of the grabens) had the maximum geothermal gradients (Akchulakov et al., 2004; Tulemissova and Buslov, 2019; Zhao, 2017).

Characteristics of gases. Altering the composition of gases based on section and area conclusively supported by geological data (Table 1). According to the composition, gases of the lowest gas-bearing section are dry, with the content of the methane up to 70.4% by volume. The gases composition of the middle gas-bearing section is close to that of the Upper Devonian, however, there is an increase in the proportion of methane to 84.6% and, accordingly, a decrease in the content of nitrogen to 9.52%. A characteristic feature of the gases in the upper gas-bearing section is their high nitrogen content, ranging from 43.8 to 99% (Baspakov, 1979; Li et al., 2018; Wu, 2015).

Reservoir rocks. Overall, conventional (non-fractured), fractured and mixed (non-fractured/fractured) reservoir types are established in the basin. The conventional, non-fractured reservoirs with good properties prevail in clastic red-colored and variegated sandstones of the Late Devonian, Early Carboniferous and Early Permian, characterized by regional and zonal propagation. The mixed (non-fractured/fractured) reservoirs are represented by sandy-siltstone, less often by carbonate rocks, which are characterized by macro- and micro-fracturing. They replace non-fractured reservoirs along the strike and form separate horizons (Permian sediments on the Amangeldy, S. Ucharal fields and Tourne-Visean sediments on the Airakty structures and Amangeldy field). The fractured reservoirs are widespread mostly in the sediments of the Early Carboniferous, represented by crystalline limestones and in sandy-argillaceous rocks. Limestones are characterized by either primary (protogenic) or secondary (exfoliation) fracturing. Primary (protogenic) fracturing is established in the early layers of the Serpukhovian stage (Ucharal structure), where in thin (up to 5 m) limestone interlayers containing small gas fields, meandering fractures filled with detrital material are noted. Also, gas deposits discovered in Proterozoic fractured rocks, overlain by Famennian halogen layers (Ortalyk structure of the Kokpansor Graben) (Minskiy and Sokolova, 1974; Ulmishek and Masters, 1993; Zhang et al., 2018).

Table 1. Composition of the gases of Shu-Sarysu Basin (Li and Petlenko, 2017)

Tectonic zones and deposits	Depth	Age	CO_2	H_2S	N_2	CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_5H_{12}	Condensate,g/m^3
1. Talas Uplift											
Ucharal-Kempirtobe, S. Ucharal, Elemes, Akbii	800-950	P_1nc	-	-	100	-	-	-	-	-	-
	1300-1350	C_1v_3	-	-	16,5	80,77	2,04	0,22	0,15	0,66	99,74
Alimbet	850-1100	C_1v-C_1t	0,35	-	7,4	89,4	2,23	0,30	0,07	сл.	99,4
Kumyrly	950-1100	C_1t-C_1v_1	-	-	25-53	38,6-6,1	5,3-2,5	1,6-2,8	0,5-0,8	0,1-0,4	-
	800-850	C_1v_3	1,0	-	9,8	76,5	9,0	2,3	0,9	0,5	100,1
Kozhekuduk	1600-1650	C_1v_1	0,17	-	50,03	47,78	1,29	0,15	0,07	-	99,49
2. Moiynkum Graben											
Airakty	825-850	P_{1C}	1,60	-	45,29	49,0	2,65	1,07	0,14	0,04	-
	820-950	P_1c	0,33	-	43,8	44,6	4,06	1,31	0,48	0,45	20
	918-953	P_{1C}	-	-	72,95	24,00	1,03	0,47	0,06	-	-
	2070-2180	C_1v_1-C_1t	-	-	15,01	75,23	6,09	2,09	1,07	0,26	31
	2128-2156	C_1v_1-C_1t	0,8-1,0	-	17,90-18,92	73,6-76,0	3,46-4,17	1,26-1,46	0,16-0,21	0,04-0,05	-
	2217-2226	C_1v_1-C_1t	1,2	-	27,92	65,3	2,40	0,72	0,10	-	-
Zharkum	1900-1950	C_1v_1	-	-	12,48	79,16	5,56	1,93	0,58	0,09	51
	1670-1678	C_1v_{2-3}	2,2	-	27,92	75,70	3,60	1,35	0,27	-	-
Amangeldy	850-950	P_1nc	0,38	-	80,2	16,8	1,8	0,47	0,15	0,06	-

	1700-1723	C_1v_{2-3}	0,20	-	2,90	81,45	9,99	3,00	0,54	0,14	-
	2163-2168	C_1v_1	0,30	-	45,47	44,30	6,37	2,04	0,47	0,17	-
	2168-2178	C_1v_1	0,40	-	7,00	75,40	11,43	4,00	0,70	0,18	-
	2187-2198	C_1v_1	0,60	-	7,20	75,45	11,10	3,95	0,70	0,15	-
Zhualy	1100-1200	P_1nc	0,3	-	99,2	0,5	-	-	-	-	-
Anabai	2152-2180	C_1v_{2-3}	0,45	-	3,49	89,3	4,51	1,15	0,30	0,12	-
	3424-3570	D_3	0,75	-	7,43	87,9	3,60	0,37	0,05	0,02	-
Maldybai	1120-1284	C_1v_3	1,15	-	4,98	88,85	4,0	0,74	0,13	0,04	-
	2184-2194	C_1v_1	0,02	-	10,0	89,0	0,92	0,05	0,008	0,03	-
3. Kokpansor Graben											
Pridorozhnoe	2350-2500	D_3nc	0,3	-	25.8-27,9	70,4-71.95	1,2-1.75	0,11-0.12	0,03-0.04	0,01-0.02	-
	1230-1296	C_1v_3	1,35	-	8,0	88,55	1,77	0,18	0,10	0,04	-
	1350-1410	C_1v_3	0,25	-	1,80	89,40	6,0	1,22	0,30	0,10	-
	2233-2260	D_3	1,2	-	32,53	65,00	0,70	0,14	0,20	-	-
	2052-2067	D_3	0,83	-	4,62	90,40	2,44	0,77	0,53	0,07	-
	1350-1410	C_2v_{2-3}	3,6	-	4,65	86,9	3,05	1,0	0,27	0,07	-
	1290-1361	C_1v_3	0,8	-	22,25	75,4	1,0	0,29	0,05	-	-
S.Prido-rozhnoe	2117-2270	C_1v	0,85	-	3,55	91,15	3,28	0,65	0,07	0,01	-
	2478-2635	C_1v_1	0,50	-	2,15	91,60	4,65	0,70	0,10	0,02	-
Ortalyk	2135-2140	C_1v	0,30	0,30	0,11	91,85	1,89	0,10	0,01	0,002	-
	2135-2185	C_1v	0,75	-	0,092	93,50	1,85	0,07	0,01	0,001	-

Cap rocks. Based on gypsum and limestone outcrops as a consequence of manifestations of diapirism, drilling data, CDP seismic and gravimetric data, it is possible to establish the conditions of occurrence and age of impermeable deposits of the Shu-Sarysu Basin. The Early Permian seal has a regional spreading. The exceptions are Tasty and Bugudzhil uplifts, within which the halogenic sediments of the Early Permian reach the surface of the Earth. Lagoon halogen-clastic sediments of the Famenian age (southeastern parts of the Kokpansor and Tasbulak grabens, the Lower-Shu uplift) represent zonal seals. The local seals are represented by halogenic, sulfated, carbonate and clastic rocks of the Early Carboniferous (Bykadorov et al., 2015; Daukeyev et al., 2002; Wu et al., 2015).

Petroleum plays characteristics. In the following, more details about each of these plays, prospects and fields depicted in the Figure 4 are presented.

Late Devonian clastic pre-salt play (first gas-bearing section). First gas-bearing section in terms of petroleum prospects is poorly studied, it has been explored just in a limited number of wells. It spreads in areas geographically combined with the zones of Famennian and Early Tournaisian salt-bearing formations, which serve as a cap rock for it. These are the eastern part of Kokpansor and the northwestern part of Moiynkum Graben as well as Tasbulak one, and Lower-Shu Uplift, where salt formations are replaced by sulfate rocks' facies (gypsum, anhydrite). Subsalt reservoirs are represented by red-brown, quartz-feldspar, petty and medium-grained sandstones. Cement is clay-siliceous, ferruginous, rarely slightly carbonate: the average content of clays is 12.8%, carbonates 10%. Based on the well testing results, the lower limit of Famennian gas reservoirs permeability assumed 0.001 μm^2, effective porosity 7.0-16% (Ageev, 1985; Tulemissova and Korobkin).

At Kokpansor Graben, gass content of the considered petroleum play is established on Pridorozhnoe and Z. Oppak structures, with porosity 9.04% and permeability 0.012 μm^2, and 11.2% and 0.011 μm^2, respectively. With an absolute permeability of 0.0012 μm^2, the residual gas saturation is about 75%. At Pridorozhnoe structure, the deposit is considered commercially producible, at Z. Oppak structure, gas reserves are insignificant because-of its small size. In Moiynkum Graben at Anabai structure, a gas fountain with a quite high flow rate of more than 200 thousand m^3/day was accessed from Famennian deposits when tested owing to strata tester. At Amangeldy structure, a weak gas inflow was obtained from the same deposits. At Tasbulak Graben, a significant release of gas was noted in saline water that complicated the penetration of salt-bearing strata of Kamenistoe area. In the salt dome zone of Lower-Shu Uplift, short-term gas occurrences were recorded upon drilling of clastic-carbonate interlayers of Famennian salt-bearing strata at Kolkudyk, Bestobe and Koitas structures. Owing to these layers a core containing oil droplets was recovered at Bestobe structure (Well 4G, int. 1727-2280 m) (Lin and Petlenko, 2017; Tulemissova and Korobkin).

In addition, in the inter-salt terrigenous-carbonate interlayers of Famennian formations gas content was detected, with porosity of 26.9% according to single core samples. Reservoir pressures exceed hydrostatic by 11% in Famennian subsalt sedimentations and by 15% in intra salt stratums. Gas flow rates reach 500 thousand m3/day (Pridorozhnaya, well 6G). The play is primarily gas-bearing, gas composition is hydrocarbon and nitrogen-methane with a content of methane homologues up to 3%. Methane content ranges from 54% in Bestobe area (70.4% in Pridorozhnoye area) to 89% in Ortalyk area and respectively nitrogen varies from 46 to 11%. The exception is the gas from Kamenistaya area brine, consisting of 91% nitrogen, inert gases (including helium 0.76%) and methane (Li et al., 2019; Bykadorov et al., 2015).

Early Carboniferous clastic-carbonate play (second gas-bearing section). Second gas-bearing zone is the most studied, about 70% of the proven reserves of Shu-Sarysu Basin hydrocarbon gases (category C1+C2) have been found here. The play is characterized by regional expansion, its producing capabilities and gas content are

controlled by development zones of the cap rocks in the play itself, and Early Permian regional salt layer (the area in which most industrial gas accumulations have been detected). With a certain degree of conditionality, the play divides into the lower and upper subsections (Dikenshteyn, 1983; Minskiy and Sokolova, 1974; Zhao et al., 2017).

The lower sub-section confined to anhydrite and sulfated rocks of small thickness at Tournaisian and Early Visean deposits, which lost their shielding properties under conditions of micro and macro-fracturing (Sayakpai, Maldybai). Anhydrites characterize Early Carboniferous of the northwestern part of Moiynkum Graben and Lower-Shu Uplift. Sulfated dense mudstones lying at the base of Early Visean, shield small gas deposits in Airakty, Amangeldy and Zharkum fields. Gas accumulations at Sayakpai and Maldybai structures are timed to the same gas barrier. The gas barrier under consideration is experiencing a tendency of deterioration related to shielding properties in the areas of fault development in the arched parts of structures. Reservoirs here are fine and medium grained quartz-feldspar sandstones on carbonate-hydro sluidic cement of membranous and regeneration types. In addition, the development of gaping cracks was noted in vaulted and crumbled sections of structures. Value of effective porosity is 4-21.4%, permeability 0.19 μm^2. Dominant position in gas component composition is occupied by methane (75.23%), impurities of heavy methane homologues up to pentane and above reach 10% and paraffin naphthenic gas condensate – 31 g/m^3 (Daukeyev et al., 2002; Tulemissova, 2017; Zhang et al., 2020).

The upper sub-zone confined to the areas of the spread of halite, anhydrites and sulfated carbonate-terrigenous impermeable rocks of the Late Visean and Serpukhovian stage. These formations are installed in all Grabens, as well as on Lower-Shu and Talas uplifts. Reservoirs are represented by calcareous, sometimes fractured, sandstones (with porosity up to 18%) of the Visean-Serpukhovian. Inclusions of rock salt in the form of nests appear at Shu structure of Lower-Shu Uplift in the top of Serpukhovian, and halite layers are marked at Tamgalytar at the given stratigraphic level. At Ortassynyrly and Uvanas structures, there were found interlayers of limestone shells up to 10 m thick, consisting of clusters of large brachiopods with voids between them up to 1.5 cm. Besides, riphogenic limestones with a thickness of 5 m, represented by corals with voids between them, were discovered at Shu structure in the upper part of Serpukhovian. On Tamgalytar area, in the Serpukhovian salt layers a reef formation with a hydrocarbon gas deposit was discovered. A similar formation based on the results of well testing are expected at Katynkamys structure of Early Carboniferous deposits. At Izykyr structure of Tasbulak Graben, at the bottom of Serpukhovian sediments during drilling process, a significant loss of the drilling fluid recorded, which then turned into a water outflow. This loss is presumably associated with reef mass occurrence in the section. Similar mass growth, based on seismic survey, drilling and testing data is also justified by a number of researchers in Terekhovskaya area of Kokpansor Graben (Dikenshteyn et al., 1983; Li and Petlenko, 2017; Zhang et al., 2018).

At Kokpansor Graben, gas deposits were established at Pridorozhnoe and Ortalyk structures in Visean sandstones, at Tamgalytar structure – in sediments of Late Visean sub-layer – Serpukhovian (presumably - a reef mass). At Moiynkum Graben, gas deposits

are identified at Airakty (C1t2-v1), Amangeldy (C1v1), Anabai (C1v2-3), Maldybai (C1v1) structures. Beyond that, gas inflows were obtained at Zharkum, Barkhannaya and Sayakpai structures as well. In Talas anticline zone of the same Graben, small deposits of hydrocarbon gas established in deposits of the Early Carboniferous of Ucharal, Kumyrly and Alimbet structures. Short-term active gas shows were observed while drilling from the same sedimentations in Toguzken and Kozhekuduk, Ozernaya and Bars areas at Sozak-Baikadam Graben and Talap in Zhezkazgan Graben. At Kumyrly, Besoba, Shuskaya, Bestobe, Koitas, Kentaral, Tantai, Kazangap structures, in Mishty kettle of Moiynkum Graben, a core represented by limestone with effusions and inclusions of oil droplets was recovered from Visean sediments (Huang et al., 2015; Li et al., 1982; Ulmishek and Masters, 1993).

At the given fields, reservoir gas pressures exceed the conditional hydrostatic pressure by 12-25%. Gas flow rates reach 240 thousand m^3/day (Amangeldy, well 5). The play is initially gas-bearing, whose gas composition is almost universally hydrocarbon from dry to wet, with a helium content of 0.06 to 0.32%. Hydrocarbons content varies from 70 to 96%, including wet hydrocarbons from 12 (Airakty) to 21% (Amangeldy). At Amangeldy, Airakty, Zharkum, Anabai and Barhannaya structures, condensate from dozens to 112 cm^3/m^3 is available in gases (Daukeyev et al., 2002; Zhao et al., 2017).

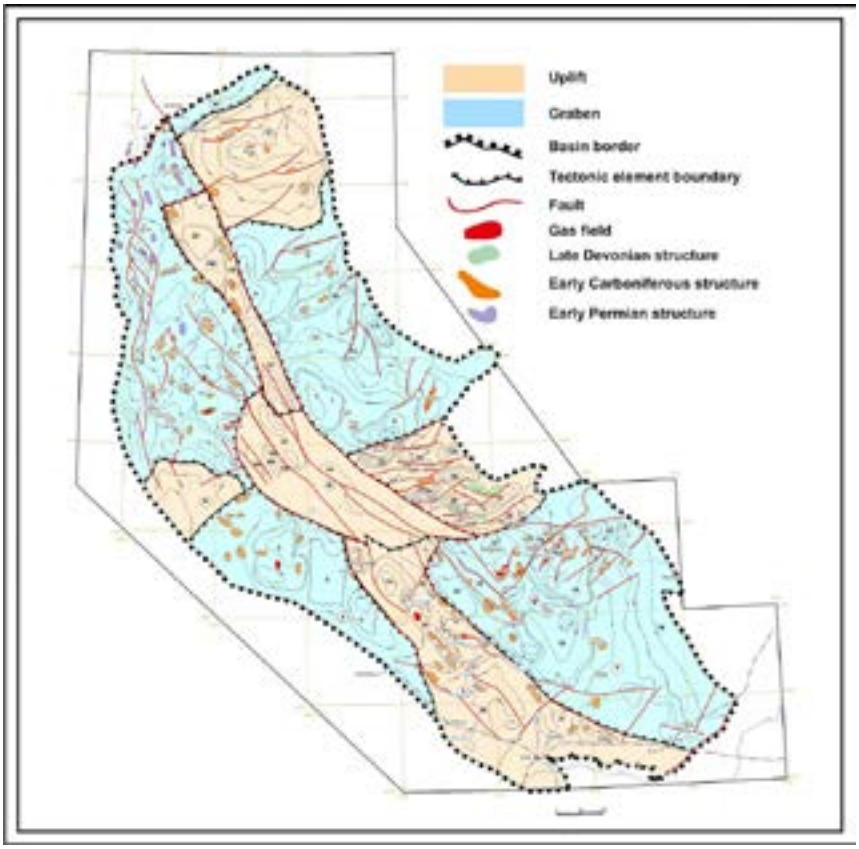

Figure 4. Scheme of the main structural elements, local structures and gas fields, Shu-Sarysu Basin.

Early Permian clastic pre-salt play (third gas-bearing section). Gas-bearing third section as well as the Early Carboniferous, has an average degree of study. Gas occurrences were almost universally recorded when drilling structural exploration wells in Early Permian section. The play stands out in the inner parts of all Grabens within the boundaries of spread of the salt-bearing strata at Early Permian, which serves as a regional cover. Reservoirs studied by anticlinal structures are represented by fine-grained sandstones and siltstones of the subsalt strata at Early Permian, less often by inter-salt terrigenous interlayers. Fractured quartz-feldspar sandstones with siliceous-carbonate and sulfate cement exist on the upper parts of the structures. The values of effective porosity reach 22% while permeability is 0.133 μm^2. In the bottom parts of the gas deposits, collectors often sealed with halite and secondary minerals. This dramatically reduces the permeability of rocks in the gas-water contact zones and creates impermeable barriers between gas and water saturated parts of the deposit (Li and Petlenko, 2017).

Gas deposits at Early Permian clastic rocks identified at Ucharal (the first gas fountain in Shu-Sarysu Basin), Alimbet, S. Ucharal, Z. Ucharal, Kempirtobe and Zharkum structures, as well as at commercially producible Amangeldy and Airakty fields within Ucharal-Kempirtobe group of structures. Short-term low-rate gas inflows were obtained in wells at Elemes, Akbi, Zhualy and Kozhekuduk areas. In addition, within Lower-Shu Uplift and the northern margin of Moiynkum Graben, oil signs were observed in core samples from sections of structural and deep wells in the form of inclusions and effusions (Bestobe area, well 4G, int.1727-2280 m).

Identified gas deposits are gas-cap drive, with the exception of Pridorozhnoe field, which is a water drive. Reservoir drive mechanisms are due to basin's block structure and the sharp deterioration of reservoir properties of the rocks in the zones of gas-water contacts. This substantially defined the hydraulic isolation of individual gas-bearing zones, areas and individual deposits in them, as well as contributed to formation and conservation in AHP deposits created by emigrating hydrocarbons. Reservoir pressures in deposits of Early Permian clastic pre-salt play exceed hydrostatic by 26-28%, and gas flow rates reach 994 thousand m3/day (Amangeldy, well 18).

Early Permian clastic pre-salt play is a secondary gas-containing one. The secondary nature of its gas accumulations is well emphasized by the wide range of transitions of gas compositions noted in them from essentially hydrocarbon in Early Permian clastic pre-salt play through nitrogen-hydrocarbon (Airakty) and hydrocarbon–nitrogen (Amangeldy) to pure nitrogen (Ucharal-Kempirtobe) in Early Permian clastic pre-salt play (Table 1). Hence, hydraulic isolation conditions are apparently characteristic of all plays at Shu-Sarysu Basin, which contributes to formation and conservation in AHP deposits, both created by emigrating hydrocarbons and inherited from elysium paleo hydrodynamic regimes (Dikenshteyn et al., 1983; Wu et al., 2015).

A petroleum play is an exploration concept that groups fields and prospects together based on similar characteristics, generally structural, lithological and geochemical, that can be applied at regional or local scales. Petroleum plays are distinguished according to style of trap and target formation. Re-examination of known play characteristics and their

spatial distributions may highlight areas and zones that may contain new discoveries. In this paper, currently available results of scientific studies and field reports, relevant to each of the petroleum system elements, are synthesized and comprehensively evaluated to determine the most promising areas for the oil and gas accumulations.

Results and discussion. Based on the conducted geological and geophysical study, the territory of the Shu-Sarysu sedimentary Basin can be subdivided into lands of medium and poor exploration. The first includes the lands of the Talas Uplift, Kokpansor and Moiynkum Grabens, the second includes Zhezkazgan Graben, Tasbulak Graben and Sozak-Baikadam Graben.

The Shu-Sarysu Basin can be considered as a large tectonic structure, whose evolution at various stages of the geological history of the Middle and Late Paleozoic predetermined the accumulation of oil and gas source rocks, and followed by generation, migration and conservation of the hydrocarbons, up to the formation of the commercial gas fields. Concurrently, there is a strict stratigraphic relationship between gas composition, the age of the host rocks as well as basin's geological and structural features.

The generalization of the results of the geochemical studies makes it possible to determine the Late Devonian and Early Carboniferous clastic-carbonate sediments of marine genesis as the most likely oil source formations, and the Early Carboniferous carbonate-clastic and coaly sediments of lacustrine genesis as the gas source formations.

Gases of all the identified sections correspond, apparently, to one cycle of hydrocarbon generation associated with Famennian-Early Carboniferous time, within which the accumulation of mainly marine carbonate and carbonate-terrigenous-halogen formations took place. Two lower gas-bearing sections correspond to different epochs of one hydrocarbon generation cycle. Gas-bearing upper section is formed by virtue of vertical migration of gases as the red-colored sediments of Early Permian comprising it are characterized by a low content of organic substances that exclude their participation in generation of hydrocarbon compounds. Accordingly, the variability of the gas composition within the two lower sections is mainly due to lateral and local vertical (within Late Devonian clastic pre-salt play and Early Carboniferous clastic-carbonate play) migration and possible thermal catalytic or geochemical transformations. No oil accumulations have been established within its borders, only in the core samples from deep oil and gas prospecting and structural wells of the Lower-Shu Uplift and the northern margin of the Moiynkum Graben signs of oil were noted in the form of inclusions and effusions.

The main gas reserves of the basin are concentrated in the Tournaisian, Early Visean and Early Permian (Moiynkum Graben) as well as in the Famennian-Early Tournasian (Kokpansor Graben) clastic deposits with good reservoir rock properties. The Late Visean and Serpukhovian carbonate deposits are have relatively poor porosity and low permeability. In addition, of particular interest are the Proterozoic fractured rocks of the basement (Kokpansor Graben).

Location of the promising productive strata within Shu-Sarysu Basin is predominantly defined by the seal development zones, represented substantially by Early Permian (Regional), Famenian (zonal) and Early Carboniferous (local) halogen formations. Absence of the given cap rocks in the section resulted in deposit destruction, gas flew

to higher stratigraphic horizons and, in the presence of seals in them, secondary gas accumulations formation (Amangeldy, Airakty fields).

In the Middle-Late Paleozoic quasi-platform structural level of the Shu-Sarysu Basin, three gas plays, and accordingly three gas-bearing sections, are distinguishable: 1) Late Devonian clastic pre-salt play; 2) Early Carboniferous clastic-carbonate play; 3) Early Permian clastic pre-salt play. The Early Carboniferous clastic-carbonate play is a primary gas-bearing section, the Late Devonian clastic pre-salt play is a mixed one and the Early Permian clastic pre-salt play is a secondary gas-bearing section. Their gas contents are due to the presence of the Early Carboniferous clastic-carbonate play in the section and controlled by the zones of development of the Famennian, Serpukhovian and Early Permian salt-bearing stratas, respectively.

Conclusions. Uneven exploration of the Shu-Sarysu Basin explains the discovery of commercial gas accumulations within the Moiynkum and Kokpansor Grabens, and only signs of oil and gas in Tasbulak, Zhezkazgan and Sozak-Baikadam Grabens.

The results of oil and gas prospecting and laboratory analysis of formation fluids carried out in the Moiynkum, Kokpansor, Tasbulak, Sozak-Baikadam and Zhezkazgan Grabens show that the territory of the Shu-Sarysu Basin is predominantly gas-bearing.

In accordance with comprehensive study of the tectonic structure, together with direct hydrocarbons signs, the territory of the Shu-Sarysu Basin can be subdivided into four categories according to its prospectivity for hydrocarbons: gas-bearing, promising gas-bearing, with unclear prospects and unpromising. The territories of the Kokpansor and Moiynkum Grabens may be classified as gas-bearing; territories of the Tasbulak, Zhezkazgan and Sozak-Baikadam Grabens as promising gas-bearing; territories of the Lower-Shu and Sarysu uplifts, as well as thrust zones of the western and northern half of the eastern sides of the Shu-Sarysu Basin as zones with unclear prospects; the teriitories of the Tasty uplift and the entire far south of the Basin may be classified as unpromising

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 candidate in Oil-gas and ore geophysics (Satbayev University) and Master of Science in Reservoir Engineering (University of Aberdeen), 1-st level Reservoir Engineer at International Centre for Deposit Analysis and Development of 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;

Issayev Syrdan Adilkhanovich – Technical Head for Geology and Field Development at International Center for Deposit Analysis and Development of Satbayev University, Almaty, Kazakhstan, s.issayev@satbayev.university, https://orcid.org/0000-0002-0156-1745.

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 06.12.2022.
Формат 70x90$^{1}/_{16}$. Бумага офсетная. Печать – ризограф.
20,0 п.л. Тираж 300. Заказ 6.

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