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

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫНЫҢ
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

1 (445)

JANUARY – FEBRUARY 2021

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

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

Меншіктенуші: «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 және техникалық ғылымдар бойынша мақалалар жариялау.***

Мерзімділігі: жылына 6 рет.
Тиражы: 300 дана.

Редакцияның мекенжайы: 050010, Алматы қ., Шевченко көш., 28, 219, 220 бөл.,
тел.: 272-13-19, 272-13-18,
http://www.geolog-technical.kz/index.php/en/

Типографияның мекенжайы: «NurNaz GRACE», Алматы қ., Рысқұлов көш., 103.

«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: ***публикация статей по геологии и технических наукам.***

Периодичность: 6 раз в год.
Тираж: 300 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, ком. 219, 220, тел.: 272-13-19, 272-13-18,
http://www.geolog-technical.kz/index.php/en/

Адрес типографии: «NurNaz GRACE», г. Алматы, ул. Рыскулова, 103.

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: ***publication of papers on geology and technical sciences.***

Periodicity: 6 times a year.
Circulation: 300 copies.

Editorial address: 28, Shevchenko str., of. 219, 220, Almaty, 050010, tel. 272-13-19, 272-13-18,
http://www.geolog-technical.kz/index.php/en/

Address of printing house: «NurNaz GRACE», 103, Ryskulov str, Almaty.

N E W S
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224-5278
Volume 1, Number 445 (2021), 177 – 185 **https://doi.org/10.32014/2021.2518-170X.25**

UDC 550.8:553.98; 553.98.048

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CLARIFICATION OF DIRECTIONS OF GEOLOGICAL EXPLORATION WORKS IN KAZAKHSTAN BASED ON FEATURES OF THE OIL AND GAS CONTENT OF SEDIMENTARY BASINS

Abstract. This article presents an assessment of the regional position and clarification of various characteristics of the oil and gas content of the basins of Western Kazakhstan and the Torgai-Syrdarya tectonic belt, which together represent the most active and mobile part of the territory of Kazakhstan. The necessity of further improvement of the existing ideas about the model of the structure and the prospects of oil and gas content of these basins is justified from the standpoint of clarifying the specific features of their oil and gas content and the geochemical environment of the formation of oil and gas deposits in them.

Based on this and considering temporary crisis phenomena in the economy and the oil and gas industry, there is a proposal for rational approaches and the organization of geological exploration works in the most promising areas of the South Torgai, North Torgai and Shu-Sarysu basins. A joint analysis of the available theoretical concepts and new data will allow to clarify the history of the geological development of the regions, the possibilities and routes of hydrocarbon migration, the provisions of the modern theory of the origin of the so-called "deep oil", and based on that justify the forecast of oil and gas content in the bowels of Kazakhstan as a whole.

Considering this, it is proposed to conduct prospecting work in certain areas of this territory, with an emphasis on clarifying the differences in the nature and characteristics of the oil and gas content of individual basins. The formulation of comprehensive scientific research will contribute to further improvement of ideas about the structure and prospects of oil and gas content of this territory, to the choice of the most rational approach to the development of the estimated substantial forecast potential, and to a deeper scientific study of issues related to the nature of specific features of oil and gas content and the geochemical environment of the formation of oil and gas deposits.

Key words: oil and gas content, sedimentary basins, complex researches, geology, geophysics, analysis, geochemistry, forecast, hydrocarbon trap.

Relevance. The systematic sale of raw materials and the reproduction of the mineral resource complex are at all times relevant tasks, regardless of the objective factors that restrain the activity of production facilities. In this process, the key link is the rational study of promising areas and the conduction of exploration works, since the specifics of the geological exploration process assumes the achievement of commercially significant results, providing an advance (10-15 years) preparation of local structures in compliance with its all necessary stages. Of no small importance in this is the state of geological and geophysical study of the regions (basins), as well as taking into account some factors that allow, according to one or another indicator, to differentiate a promising territory of significant area. Significance of the state of geological and geophysical knowledge of the regions (basins) is of no small importance, as well as considering some factors that allow differentiating a promising territory with significant area according to some indicators.

As known, the regional position of the main oil and gas regions is determined, first of all, by the sedimentary basins of Western Kazakhstan that concentrate the bulk of the hydrocarbon potential (the Caspian depression, Ustyurt-Bozashi and Mangyshlak), as well as the South Torgai and Shu-Sarysu basins located to the east (figure 1).

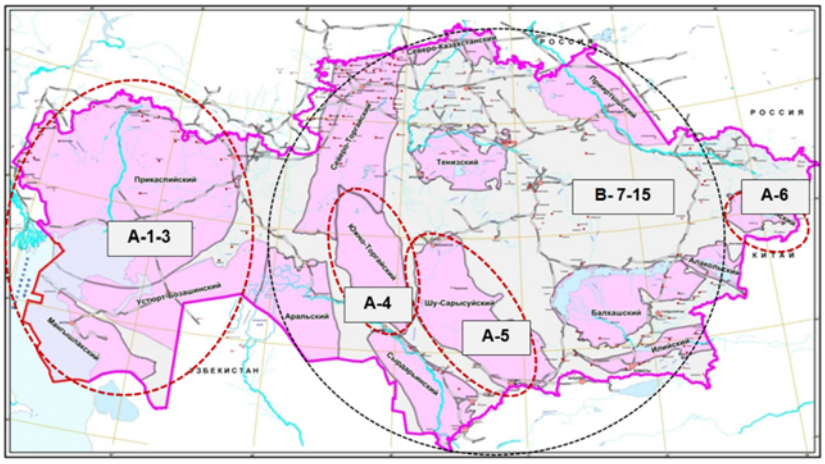

Figure 1 – Oil and gas containing and prospective sedimentary basins of Kazakhstan (Akchulakov U.A. et al.; 2009-2013): A. Oil and gas basins (6): A-1-3 - Caspian, Ustyurt-Bozashi, Mangyshlak, A-4 – South Torgay, A-5 - Shu-Sarysu, A-6 - Zaysan. B. Prospective basins (9): B-7-15 - Aral, Syrdarya, Balkhash, Teniz, Irtysh, Alakol, Ili, North Kazakhstani, North Torgai

These two basins, due to their paleotectonic belonging to the Kazakhstan folded system and the generality of sedimentation environments, along with the North Torgai, Aral and Syrdarya basins, determine the Torgai-Syrdarya tectonic belt (hereinafter referred to as TSTB) stretched in the submeridional orientation [1-3].

The main features of the structure of sedimentary basins. Globally, the territory under consideration is the most tectonically active area of the Earth's crust within Kazakhstan, is a wide zone of interaction between large ancient megastructures of the East European Platform (hereinafter - EEP) and the Kazakhstani lithospheric plate (hereinafter - KLP) [4,5]. In this area, the EEP (Caspian depression) contacts in the east with the western (frontal) edge of the KLP. Taking into account the historically formed appearance and macro-drawing of this area in the plan, clarification of the nature of the phenomena occurring in this entire active tectonic strip (from the point of view of the depth and stratigraphic interval of their manifestation) acquires great practical importance.

The interaction of the eastern margin of the EEP and the active “leading” edge of the KLP at the end of the Paleozoic stage of formation was accompanied by the formation of diverse basins of the back-arc (Torgai, Syrdarya), inter-arc (North Kyzylkum, Aral) and intracontinental (Teniz) types [6,7]. Later, in the Mesozoic (Triassic - Jurassic), a single East European-Kazakhstan plate was formed. From the south, after the closure of the Paleotethis, the ancient Ustyurt block (now the territory of Ustyurt-Bozashi and Mangyshlak) joined it. Presumably, it is the difference in the conditions and time of formation of sedimentary basins that predetermines one or another (individual) specificity of oil and gas content in the section of the Caspian basin, basins of the western Turan plate and TSTB.

As can be seen, the level of interaction of internal processes occurring in the basins determines their global nature and significance in terms of clarifying the genesis of oil, the conditions for the formation of oil and gas accumulation zones (hereinafter referred to as OGAZ), oil and gas generation and etc. In practical terms, relatively more complex mining and geological conditions and, often, the characteristics of the chemical composition of oil and gas in the reservoir state, in comparison with the fields of other oil and gas basins, are characteristic and fair for the OGAZ of the Caspian basin. This means the complex chemical composition of hydrocarbons, the presence of a salt-bearing stratum in the section, the presence of aggressive components (sulfur, hydrogen sulfide, mercaptan) in the oil of the deposits of the subsalt and partially post-salt complex. Accordingly, these features of the Caspian basin deposits and factors determine more difficult conditions for the development of hydrocarbon deposits and a high production cost in comparison with deposits in other sedimentary basins.

In comparison with the Caspian Basin, the nature of oil and gas content and mining and geological conditions of occurrence of deposits in the section of the TSTB basins are more favorable from a practical point of view. The hydrocarbon deposits are characterized by shallow depths, the absence of aggressive

components in the section and deposits. In some cases, oil and gas deposits contain valuable associated components, as exemplified by the unique gas-helium-bearing province of the Shu-Sarysu basin. Also, the well-known factor of an unusually high density of distribution of hydrocarbon volumes over the territory can be noted (in the section and in the area) and in general the uniqueness of oil and gas systems in the Paleozoic and Mesozoic parts in the section of the South Torgai basin.

In Mangyshlak, there is a sharp unevenness in the distribution of HC volumes, ie: about 90% of hydrocarbon reserves in Mangyshlak are concentrated only in 3 nearby Mesozoic fields that are Uzen, Zhetybai and Tenge (out of a total of 55 known deposits of Mangyshlak) [8,9]. In addition, the zoning of deposits with different phase composition is noted, depending on the gypsometry and stepped immersion of blocks (links), which is clearly expressed within the northern side of the South Mangyshlak deflection when it is immersed in the south direction [10].

Research methodology. As you know, the proven volume of recoverable oil reserves in the Republic of Kazakhstan is about 4.525 billion tons [9]. Among the currently active fields, most of which lie in the post-salt deposits of the Caspian depression, have already exhausted their active resource and are at a late stage of development [9,11,12]. At the same time, studies within the framework of the large regional Project "Complex Study of Sedimentary Basins of the Republic of Kazakhstan" (hereinafter - CSSB RK), carried out by the Consortium of leading scientific and research companies in 2009-2013, justified the significant predictive potential of all 15 sedimentary basins of the Republic of Kazakhstan, which is many times higher than the estimate made earlier in previous years and is now 76 billion tons [9].

These results indicate a high oil and gas potential of Kazakhstan's bowels, the implementation of which implies more complex geological conditions for the occurrence of new oil and gas fields, associated both with an increase in the depth of prospecting studies, and with objects occurring at shallow depths, but associated with an unconventional environment and the environment of sedimentation.

Along with the traditional directions of exploration works in the basins of Western Kazakhstan (the post-salt complex of the Caspian basin, etc.), it seems important to carry out prospecting works in the basins of the TSTB, taking into account the currently unfavorable situation on the oil market.

First of all, this concerns the conduct of geochemical studies of oil and gas, which make it possible to identify and clarify potential sources of generation, migration routes and accumulation of hydrocarbons and accordingly study the patterns of formation of traps (natural reservoirs and reservoirs for hydrocarbon).

Thus, in relation to the TSTB in terms of solving the problems of geological prospecting for the discovery of new deposits occurring in relatively favorable geological conditions, certain areas of exploration geology and the zones currently estimated as high prospects in certain areas of the South Torgay, North Torgay and Shu-Sarysu sedimentary basins are of great interest. *An important factor in this regard is that on the territory of these basins, the recently approved State Program for Geological Exploration for the period up to 2025 provides for large-scale exploration work, including research on new and cost-effective technologies (direct methods of exploration) and geochemical research.*

New directions of work and promising areas. Below, in connection with the proposed accents, certain promising areas and directions will be considered according to which it is rational to organize exploration works at present in the opinion of authors.

The Paleozoic complex of deposits in the South Torgai basin is substantiated as one of the prioritized areas of research. In the recent past, significant deposits were discovered in it (Kenlik, Kyzylkiya North-West, Kenlik North, Karabulak, Kokbulak, Doschan, Karavanchi, etc.). Oil and gas reservoirs in the Paleozoic are confined to zones of elevated occurrence / protrusions, they are often characterized by a predominantly carbonate composition (Kenlik, Kyzylkiya North-West, etc.). The results of the work and new data indicate a contrasting severity and a large amplitude of traps, which makes it possible to predict their probable non-anticlinal character [13,14]. According to the data from the Kenlik and Kyzylkiya areas, traps in thick carbonates have the character of structures and buildings on seismic materials (the central part of the Aksai horst-anticline) (figure 2). At the same time, very high flow characteristics of Paleozoic deposits, obtained from reservoirs of predominantly carbonate and carbonate-terrigenous composition, "strengthen" the idea of the presence of non-anticlinal traps in these zones (Kenlik North, Kyzylkiya North-West, Karabulak).

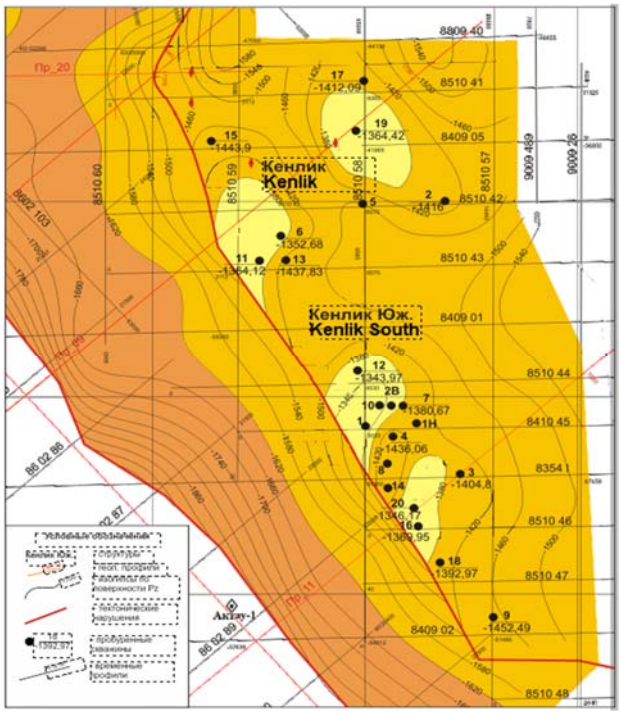

Figure 2 – South Torgai Basin. Structural diagram of the surface of the PZ exhaust gas and non-anticlinal traps of the Kenlik - Kyzylkiya uplift zone: 1 - structures (uplifts), 2 - regional geological profiles, 3 - isohypses along the surface of the PZ OG, 4 - tectonic faults, 5 - drilled wells, 6 - seismic profiles

The range of favorable objects is unusually wide, and along with horst-anticlines, areas of significant subsidence are highly estimated for forecasting promising objects of presumably non-structural type. In this regard the prospects of graben-synclines are highly appreciated, on which the slopes and bands of regional pinching out of pre-Jurassic and Jurassic-Cretaceous deposits, representing areas of distribution of non-structural traps capable of accumulating new hydrocarbon deposits, remain poorly studied.

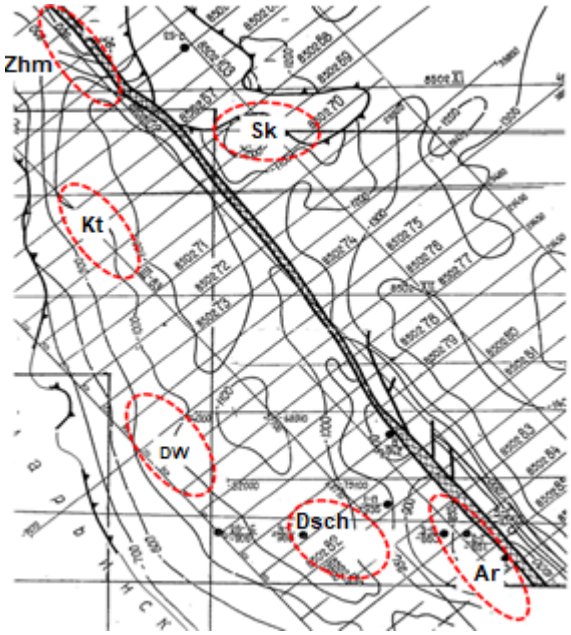

Figure 3 – Forecast NAL in the Doschan zone of uplifts. Block diagram for reflecting horizon No. III (upper Jurassic roof). According to Geotex JSC, 1993-1995: NAT contours: Kt - Kitpay, Sk - Sakpay, DW - Doschan Western, Dsch - Doschan, Ar – Aryskum

It is believed that a more detailed level of study of objects in graben synclines is far from complete. In another case, in the southwestern part of the Aryskum graben-syncline, structures associated with possible "paleo-incisions" of river channels and deltaic sediments (Nuraly, Doschan, etc.) are substantiated as priority objects in non-anticlinal traps (hereinafter - NAT) (figure 3 and 4). In this regard, the zones of depressions in deep troughs (Aryskum, Akshabulak, Sarylan, Bozingen troughs) are promising for discovering new deposits in traps associated with faults [15]. In the side parts of the troughs, the pre-Mesozoic strata is complicated by the active manifestation of faults of various orientations. Historically, large faults contributed to greater expansion of space and the formation of deep depressions.

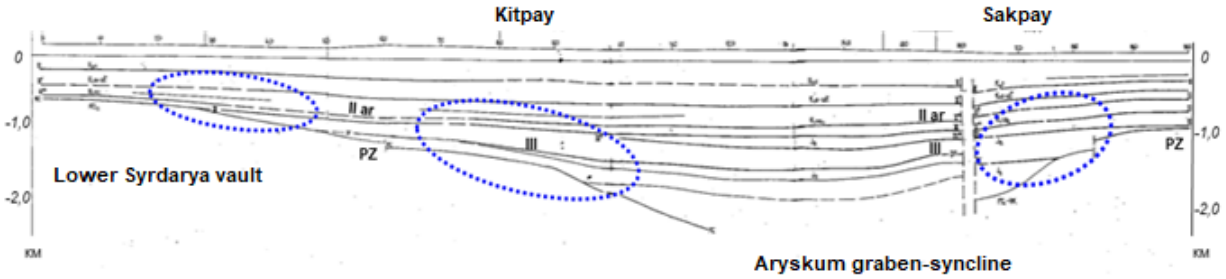

Figure 4 – Areas of paleo-incisions in the section of the Doschanskaya uplift zone:
Geological and seismic profile 850269 (Filipyev G.P., Alpayev A.A. et al., 1990)

The Amangeldy group is in the Moyinkum trough of the Shu-Sarysu basin, includes the Amangeldy, Zharkum, Kumyrly, Maldybai, Airakty, Anabai deposits, which is the object of close attention of researchers in search terms. The potential for identifying shallow objects with favorable commercial characteristics of fluid components is far from being exhausted here and, in the authors' opinion, the study of objects of this category is at a beginning stage. It is believed that a full-fledged concept and the development on its basis of a promising exploration program in the Shu-Sarysu basin (after the discovery of the Amangeldy gas accumulation zone) at one time were left without due attention.

According to new data for 2019-2020 in the Paleozoic part of the basin section various genetic types of deposits are distinguished. An analysis of the sedimentation conditions allows us to preliminarily make a river / lacustrine-boggy genesis of sediments, indicating a rather diverse and probably very complex pattern of sedimentation (PGS-Kazakhstan, 2020). Considering the new ideas in 2020 (figure 5) in the section, it is possible to predict the distribution of objects of non-structural type. Objects associated with NAT, considering the specifics and features of sedimentation of the basin and the probable genesis of structures, can have different sizes and scales of manifestation over the area.

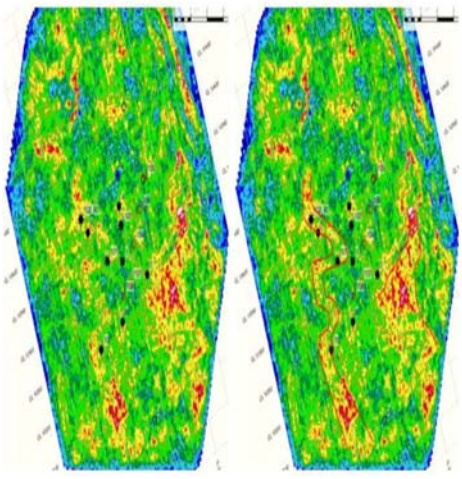

Figure 5 – Forecast of the productive complex associated with NAT in terrigenous sediments of the Lower Visean age. Slice of the Vp / Vs attribute (according to PGS - Kazakhstan; 2020)

Many researchers rightly note the need to consider the South Torgai and North Torgai basins in a unified manner, as large geostructures formed at the leading edge of the TSTB (KLP) [1,3,16].

Further to the north, within the North Torgai basin, according to the results of geological exploration works in the early years many oil and gas shows were encountered during drilling of structural and exploratory wells (Karasor, Novonezhinskaya, etc.). Direct signs of hydrocarbons are noted in the deposits of the Upper Paleozoic (D_3-C_1). The Jurassic-Cretaceous deposits covering the Paleozoic complex are not of interest in terms of oil and gas due to insufficient development and strong tectonic disturbance. When assessing the prospects, the Triassic period of the formation of this territory is of interest, with which the activity of rifting in the Torgai megabasin is associated. The sharp difference in the hydrocarbon saturation of sedimentary strata along the strike of the TSTB is associated with the sliding and weakening of the amplitude and thickness of rifting in the direction from south to north [17, 18, 19]. In the South Torgai section, Triassic sediments have not been exposed and their development at the most submerged points of the graben-synclines seems to be ambiguous, and the Upper Triassic Turin Group developed in the North Torgai section.

The Ubagano-Kushmurun zone, together with the Priishimsky district in the south, borders on the Zhilanshik trough of the South Torgai basin. The extended grabens that developed in the North Torgai basin are a source of initial material that could participate in the formation of hydrocarbon deposits. Deposits in their location, in turn, may not coincide in plan with grabens. Despite the fact that until now hydrocarbon deposits with commercial conditions have not yet been identified, this region is of significant prospecting interest due to the favorable conditions for the occurrence of Paleozoic deposits within the Kushmurun trough and in the west of the Valeryanov zone (central part of the North Torgai basin).

One of the directions of work in this complex are thrust and underthrust sections, the probability of which is high, considering the peculiarities of geodynamic development and paleotectonic reconstructions. Along with the objects of thrust-nappe nature, the likelihood of forecasting objects associated with NAT is also not excluded. According to Zholtayev G.Zh. et al. (2015) in the carbonate strata of carbon it is assumed the formation of objects of sedimentation origin [20]. It is supposed that the main generation potential of the North Torgai basin is associated with the OGSS in the Upper Devonian-Lower Carboniferous strata. The distribution of reservoir rocks in the Upper Devonian and Lower Carboniferous carbonate-terrigenous strata may have a regional character. At the areal level, the development and distribution of reservoir rocks is associated with zones of disintegration of Proterozoic-Lower Paleozoic folded-metamorphic complexes of rocks and basement protrusions.

Conclusion. Clarification of the structural features and nature of oil and gas content in connection with the regional geotectonic position of the sedimentary basins of Western Kazakhstan and TSTB allows to outline and clarify promising areas of exploration works. Based on the following conclusions and provisions, for this and considering the specific features of sedimentary basins, favorable and economically optimal options are proposed:

- Emphasis is made on the choice of promising and priority areas of prospecting, considering the specifics of oil and gas content of sedimentary basins and the state of individual components in the composition of fluid hydrocarbon systems;
- It is rational to strengthen initiatives in the direction of improving the quality of geochemical research of oil in order to clarify the genesis of oil and the features of the formation of hydrocarbon systems, to predict probable oil and gas accumulation zone and oil and gas generation;
- The basis for the widespread implementation of the recommendations should be the methodological "approaches" proposed by the authors in the integration of data of various directions for forecasting and clarifying the genesis of oil and gas deposits, characterized by shallow depths of occurrence and not containing aggressive components in the composition of formation fluids.
- The results of prospecting works in the recommended version and available generalizations on geochemical studies, as well as methodological recommendations for forecasting promising objects in the South Torgai, North Torgai and Shu-Sarysu basins will help to clarify the guidelines in exploration geology and expand the possibilities of geological exploration in general.
- Implementation of the practical recommendations proposed by the authors, which are based on new objects of unconventional type, will make it possible to concretize the directions of prospecting research in Kazakhstan for the coming years and contribute to improving the quality of forecasting potentially oil and gas objects.

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ШӨГІНДІ БАССЕЙНДЕРДІҢ МҰНАЙГАЗДЫЛЫҚ ЕРЕКШЕЛІКТЕРІ НЕГІЗІНДЕ ҚАЗАҚСТАНДАҒЫ ГЕОЛОГИЯЛЫҚ БАРЛАУ ЖҰМЫСТАРЫНЫҢ БАҒЫТТАРЫН НАҚТЫЛАУ

Аннотация. Мақалада жиынтығында Қазақстан аумағының неғұрлым белсенді және жылжымалы бөлігін білдіретін Батыс Қазақстан бассейндері мен Торғай-Сырдария тектоникалық белдеуінің мұнайгаздылығының өңірлік жағдайына баға беріліп, олардың түрлі сипаттамаларын нақтылау ұсынылды. Осы бассейндердің мұнайгаздылығының құрылымын көрсететін модельдер мен перспективалары туралы белгілі түсініктерді олардың мұнайгаздылығы мен мұнай және газ кен орындары қалыптасуының геохомиялық жағдайының өзіндік ерекшеліктерін нақтылау тұрғысынан одан әрі жетілдіру қажеттілігі негізделеді.

Осының негізінде және экономика мен мұнай-газ саласындағы уақытша дағдарыс құбылыстарын ескере отырып, Оңтүстік Торғай, Солтүстік Торғай және Шу-Сарысу бассейнінің перспективалы учаскелерінде геологиялық барлау жұмыстарын ұтымды жүргізу тәсілдері ұсынылды. Теориялық түсініктер мен жаңа деректерді бірлесіп талдау өңірлердің геологиялық даму тарихын, көмірсутек көші-қонының мүмкіндіктері мен жолдарын, сондай ақ «терең мұнайдың» пайда болуының қазіргі заманғы теориялық ережелерін нақтылауға және осының негізінде тұтастай алғанда Қазақстан жер қойнауының мұнайгаздылық болжамын негіздеуге мүмкіндік береді.

Аталған аумақтың кейбір учаскелерінде жекелеген бассейндердің мұнайгаздылығының сипаты мен ерекшеліктеріндегі айырмашылықтарды анықтауға назар аудара отырып, іздеу жұмыстарын жүргізу ұсынылады.

Кешенді ғылыми зерттеу жүргізу аталған аумақтың мұнайгаздылығының құрылымы мен перспективалары туралы түсініктерді одан әрі жетілдіруге, бағаланатын болжамды әлеуетті игеруге неғұрлым ұтымды тәсілді таңдауға, сондай-ақ, мұнай мен газ кен шоғырларын қалыптастырудың геохимиялық жағдайы мен мұнайгаздылығының өзіндік ерекшеліктерінің табиғатына байланысты мәселелерді неғұрлым терең ғылыми түрде пысықтауға ықпал ететін болады.

Мақала ҚР Білім және ғылым министрлігі Ғылым комитетінің 2018-2020 жылдарға арналған мақсатты қаржыландыру бағдарламасы (МҚБ) бойынша «Қазақстан Республикасындағы мұнай мен газдың антиклинальды емес тұзақтарын кешенді зерттеу» тақырыбындағы жобаны орындау аясында жүргізілген зерттеу нәтижелері бойынша дайындалды (18.03.2018 ж., №231 келісімшарт).

Түйін сөздер: мұнайгаздылық, шөгінді бассейндер, кешенді зерттеулер, геология, геофизика, талдау, геохимия, болжам, көмірсутектер тұзағы

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УТОЧНЕНИЕ НАПРАВЛЕНИЙ ГЕОЛОГОРАЗВЕДОЧНЫХ РАБОТ В КАЗАХСТАНЕ НА ОСНОВЕ ОСОБЕННОСТЕЙ НЕФТЕГАЗОНОСНОСТИ ОСАДОЧНЫХ БАССЕЙНОВ

Аннотация. В статье дана оценка региональному положению и уточнение различных характеристик нефтегазоносности бассейнов Западного Казахстана и Торгайско-Сырдарьинского тектонического пояса, представляющих в совокупности наиболее активную и подвижную часть территории Казахстана. Обосновывается необходимость дальнейшего совершенствования имеющихся представлений о модели строении и перспективах нефтегазоносности данных бассейнов с позиции уточнения специфических особенностей их нефтегазоносности и геохимической обстановки формирования в них залежей нефти и газа.

На основе этого и с учетом временных кризисных явлений в экономике и нефтегазовой отрасли предложены рациональные подходы и постановка геологоразведочных работ на наиболее перспективных участках Южно-Торгайского, Северо-Торгайского и Шу-Сарысуского бассейна. Совместный анализ имеющихся теоретических представлений и новых данных позволит уточнить историю геологического развития регионов, возможности и пути миграции углеводородов (УВ), положения современной теории происхождения «глубинной нефти», и на основании этого обосновать прогноз нефтегазоносности недр Казахстана в целом.

С учетом этого предлагается проведение на некоторых участках данной территории поисковых работ, с акцентом на выяснение различий в характере и особенностях нефтегазоносности отдельных бассейнов. Постановка комплексных научных исследований будет способствовать дальнейшему совершенствованию представлений о строении и перспективах нефтегазоносности данной территории, выбору наиболее рационального подхода к освоению оцениваемого значительного прогнозного потенциала, а также более глубокой научной проработке вопросов, связанных с природой специфических особенностей нефтегазоносности и геохимической обстановки формирования залежей нефти и газа.

Статья подготовлена по результатам исследований, проведенных в рамках выполнения проекта на тему «Комплексные исследования неантиклинальных ловушек нефти и газа в Республике Казахстан» по программе целевого финансирования (ПЦФ) Комитета науки Министерства образования и науки РК на 2018-2020 гг. (договор №231 от 18.03.2018г.).

Ключевые слова: нефтегазоносность, осадочные бассейны, комплексные исследования, геология, геофизика, анализ, геохимия, прогноз, ловушка углеводородов.

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

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

Редакторы *М. С. Ахметова, Д. С. Аленов, А. Ахметова*
Верстка *Д. А. Абдрахимовой*

Подписано в печать 01.02.2021.
Формат 70x881/8. Бумага офсетная. Печать – ризограф.
12,75 п.л. Тираж 300. Заказ 1.

Национальная академия наук РК
050010, Алматы, ул. Шевченко 28, т. 272-13-19, 272-13-18