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FORECAST OF OIL AND GAS POTENTIAL OF THE SEDIMENTARY COVER OF THE AFGHAN-TAJIK DEPRESSION

Purpose. Identification of geological structure characteristics and sediment accumulation conditions to improve the regional assessment of hydrocarbon potential in the Mesozoic-Cenozoic deposits of the Afghan-Tajik Depression.

Methodology. The following scientific methods were used: generalization and systematization of available factual data; analysis and validation of geological and geophysical information; identification of the main petroleum-bearing complexes and types of hydrocarbon traps.

Findings. A variety of hydrocarbon traps associated with the platform (anticlinal and non-anticlinal) and orogenic (subthrust with horizontal displacements up to hundreds of meters) stages has been established; the variability of seals (Jurassic evaporites up to 800 m, Cretaceous clays 400–800 m, Paleogene Suzak Formation 10–210 m) with regional differences in mineralogy (montmorillonite, chlorite) has been clarified; high prospects of Paleogene-Cretaceous anticlines and Jurassic deposits throughout the basin have been confirmed. About 20 productive horizons (sandstones, carbonates) have been identified in 30 fields with a predominance of heavy sulfur oils and methane gases.

Originality. A comprehensive synthesis and structural analysis of the geological characteristics of the Mesozoic-Cenozoic deposits in the Afghan-Tajik Depression have been performed. Stratigraphic and tectonic parameters—previously not considered in an integrated manner – have been clarified, including the spatial variability of cap rocks and the influence of neotectonic processes. A comparative analysis of hydrocarbon composition in various types of traps, including sub-thrust and hydrodynamic traps, has revealed patterns of hydrocarbon generation and preservation. These results form the basis for a refined petroleum potential model of the region and provide new guidance for exploration.

Practical value. The practical significance of the research results lies in the justified selection of optimal zones and hydrocarbon-prospective areas for exploration, which enhances the potential for discovering industrially significant oil and gas accumulations, which contributes to strengthening the hydrocarbon resource base of the Afghan-Tajik Depression.

Keywords: *Afghan-Tajik Depression, reservoir, section, oil and gas deposits, geology*

Introduction. Currently, targeted research is being conducted in Uzbekistan aimed at searching for oil and gas deposits in deep-seated horizons of the sedimentary cover, as well as identifying new productive complexes and structures of various types [1]. This is important for expanding the resource base and increasing the efficiency of hydrocarbon production [2, 3]. One of the key areas of such research is the use of new geological exploration and drilling methods for deep horizons of Mesozoic-Cenozoic deposits, such as those found in the Afghan-Tajik Depression [1, 4]. In this regard, special attention is paid to the development of methodological

approaches that are used in geological exploration work at great depths [5, 6]. For the successful operation of the national economy's sectors and their dynamic growth to be ensured, an uninterrupted supply of energy resources and hydrocarbon raw materials is necessary.

One of the most important factors for increasing hydrocarbon production is the development of new targets and new stratigraphic complexes. In particular, considerable attention is being paid to deep-sea horizons of Mesozoic-Cenozoic deposits, which are promising for the discovery of new hydrocarbon deposits. When drilling at great depths, it is important to consider the geological structure and oil and gas potential of these horizons, which requires the use of advanced drilling technologies and approaches [7].

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The drilling process at such depths requires high precision and effective application of geophysical control methods, as well as the development of specialized drilling rigs and equipment [3]. For the successful implementation of geological exploration and prospecting work, methods are needed that allow one to predict with a high degree of certainty the presence of hydrocarbon deposits in the complex geological conditions characteristic of the Afghan-Tajik Depression [8, 9].

An important aspect is also the use of high-quality data obtained during drilling to refine the distribution models of hydrocarbon deposits, analyze lithological and tectonic features, and predict production efficiency at different depths [10, 11]. All of this ultimately contributes to the expansion of the country's raw material base and strengthening its energy security.

In this context, detailed analysis of the geological architecture of the study area, combined with an assessment of the hydrocarbon potential of its Mesozoic–Cenozoic sedimentary complexes, constitutes a key scientific and applied task aimed at substantiating further exploration activities and expanding the resource base [12].

Literature review. The conducted research is aimed at studying the main directions of exploration work, the geological structure and oil and gas potential of the regions of Central Asia. Much attention is paid to the oil and gas regions of Uzbekistan, in particular the Surkhandarya region, in the works [13–15]. Study [16] is based on data from recent years of geological exploration. It presents the geochemical characteristics of hydrocarbon fluids, as well as the commercial parameters of oils, which are key to identifying promising hydrocarbon deposits.

The geological structure and oil and gas potential of the Mesozoic and Cenozoic deposits of the Tajik Depression are analyzed in the work [17]. Productive horizons in Jurassic–Paleogene sedimentary sections were identified, and their lithological and reservoir properties were determined. The work includes characterization of the oil and gas potential of individual territories, which facilitates the assessment of their resource potential.

The intermountain depressions of the Tien Shan were studied in the work [18]; special attention is paid to Mesozoic–Cenozoic deposits. The study of the basins is described, and their oil and gas potential is briefly characterized. Promising areas for hydrocarbon exploration and prospecting are also identified, which is important for developing a production strategy in these areas. These studies have made a significant contribution to understanding the oil and gas potential of the Central Asian regions, providing a basis for further exploration.

The current state and prospects of the oil and gas potential of the Amu Darya megabasin are studied in the work [19]. As part of these studies, a conceptual model of sedimentary cover formation was developed, which made it possible to clarify the gas-bearing potential of the region and identify promising areas for further work.

Geochemical characteristics of heavy oils and natural bitumens of Central Asia, including the Afghan-Tajik Depression, are analyzed in the works [20, 21]. The research identified three groups of heavy oils and four types of natural bitumen. Patterns of their distribution, geochemical parameters, and deposit forms were established. These data allow for a more accurate assessment of the region's oil and gas potential.

Thus, the summarized research results form the basis for further study and optimization of exploration work, increasing the efficiency of exploration and expanding the hydrocarbon resource base in key oil and gas regions of Central Asia. The goal is to summarize geological and geophysical data and identify features of the geological structure and sedimentation conditions to substantiate a regional forecast of the oil and gas potential of Mesozoic–Cenozoic deposits in the Afghan-Tajik Depression, aimed at strengthening the country's energy security.

The Afghan-Tajik Depression is classified as a post-platform basin of fault-block structure, occupying the south-eastern flank of the Turan plate in the activated zone of the Epi-Hercynian platform; in the current crustal configuration, it strictly correlates with the depression of the same name and is sharply delimited from adjacent tectonic domains as an area of intensive accumulation of molasse series of Neogene–Quaternary age [22].

The northern, eastern, and southeastern boundaries of the basin form high-amplitude (up to 6–7 km) Hercynide orogens of the Hissar, Pamir, Badakhshan, and Hindu Kush fold belts. The southern framework defines a subvertical deep fault along the contour of the North Afghan basement high – a latitudinal-oriented macroblock with a high positive anomaly. The western boundary is less contrasting and is traced along a fault system along the mega-anticline of the southwestern spurs of Hissar with their subsurface continuation [23].

The dominant mesoscale elements are submeridional megasynclines (Surkhandarya, Vakhsh, Kulyab), separated by a pair of similarly oriented megaanticlines (Kafirigan, Obigarm). In the northern sector, perpendicular to them, the sublatitudinal Dushanbe trough is localized [18, 24].

Megaanticlinoria are topographically expressed as ridges and ranges (east about 2,000 m, west about 900 m), exposing Cretaceous and Paleogene lithofacies. Megasynclinoria correspond to relief depressions coinciding with the Vakhsh, Kafirigan, and Surkhandarya river valleys (Fig. 1) and are filled with Neogene–Quaternary molasses.

The basis of the basin is made up of Upper Paleozoic folded-metamorphic complexes, segmented into submeridional blocks [25]. The basement lithology includes crystalline schists, marbles, intensely metamorphosed sandy-conglomerate units and intrusions; the intermediate level is Permian carbonates.

The key tectonic reorganization that determined modern architecture occurred at the turn of the early–middle Anthropogene: on the site of the Neogene depression, the polystructural Kafirigan and Obigarm megaanticlines with intercalating megasynclines superimposed on the Neogene folding were formed [26].

In the sedimentary filling, two structural-facies stages are differentiated [27]: lower (platform) – Jurassic, Cretaceous, Paleogene; upper (orogenic) – Neogene–Quaternary. Thus, the Jurassic–Paleogene series accumulated in a platform regime, when the basin was integrated into the Epi-Hercynian platform as a segment of the Turanian plate, which determines the partial stratigraphic homology of the Mesozoic section with the platform standard.

The formation of the sedimentary basin was determined by cyclical alternations of phases of tectonic acti-

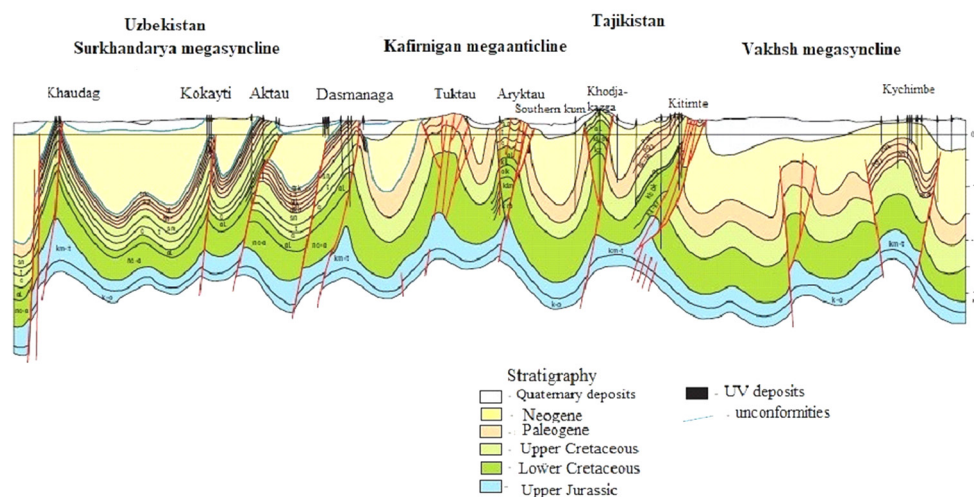


Fig. 1. Sublatitudinal regional profile of the Afghan-Tajik Depression along line II

vation and relaxation, which led to the accumulation of polyfacies series of the Mesozoic-Cenozoic. Five key oil and gas source complexes are differentiated in the stratigraphic section: Lower-Middle Jurassic, Upper Jurassic, Lower Cretaceous, Upper Cretaceous, and Paleocene-Eocene [28].

The Lower-Middle Jurassic complex is poorly characterized; based on the correlation with the southwestern spurs of the Gissar and the Fergana Depression, a coal-bearing profile with an increased contribution of humic OM is assumed.

The Upper Jurassic complex was deposited in a subaqueous environment; the organic matter is dominated by sapropelic and mixed sapropelic-humus types, with local concentrations of up to 25 % in depression facies [4, 18, 29].

The Lower Cretaceous complex is enriched in humic organic matter in its basal part and sapropelic interlayers at the roof. Generation conditions varied: oxidizing regime in anticlinoria; slightly reducing (Neocomian) and reducing (Aptian-Albian) regime in stable troughs (excluding the Kulyab megasyncline with its OM-deficient red beds).

Optimal parameters for hydrocarbon generation were recorded in the marine Upper Cretaceous deposits of the eastern sector of the basin: OM up to 3 %, predominantly of sapropelic genesis [23, 27].

Paleogene deposits demonstrate a uniform generation potential throughout the area; OM is predominantly sapropelic, with peak values of 6.5 % in individual intervals [30].

Unsolved aspects of the problem. The analysis revealed that despite the identified oil and gas horizons and existing exploration of the Afghan-Tajik Depression, unresolved issues remain requiring further study. Specifically, the Afghan-Tajik Depression is characterized by a significant diversity of oil and gas reservoirs, but the level of their exploration remains uneven. Despite the presence of 30 fields, exploration of many productive horizons, particularly in Jurassic and Paleogene deposits, remains low. The spatial variability of reservoir properties, the influence of tectonic factors on the distribution of deposits, seal conditions, and their role in hydrocar-

bon preservation require further investigation. Particular attention should be paid to assessing the properties of oils and gases located in subthrust traps, as they are expected to differ from those identified in other areas of the depression. The need to clarify the conditions under which hydrodynamic traps form and their influence on hydrocarbon accumulation also remains urgent.

The analysis revealed previously undescribed patterns in the spatial variability of seals and their integrity within key structural zones. It was established that in the southern part of the Surkhandarya megasyncline, clay-sulfate deposits exhibit the greatest resistance to tectonic disturbance, making them particularly promising for preserving deposits in complex geodynamic conditions.

Furthermore, for the first time, subthrust traps have been thoroughly characterized within the Afghan-Tajik Depression as an independent type with high hydrocarbon accumulation potential. Analysis of geochemical and structural data has demonstrated that these traps formed under the influence of intense horizontal displacements accompanied by localized sealing, opening a new avenue for predicting underdeveloped productive reservoirs.

Thus, **the purpose** of the article consists in identifying the features of the geological structure and conditions of sediment accumulation for the regional forecast of the oil and gas potential of the Mesozoic-Cenozoic deposits of the Afghan-Tajik Depression.

Objectives of the work are:

1. To assess the degree of study of the productive horizons of the Afghan-Tajik Depression and to identify the shortcomings of existing data.
2. To analyze the influence of tectonic factors on the formation of deposits and distribution of reservoirs.
3. To clarify the characteristics of the seals of various stratigraphic complexes and their role in the preservation of deposits.
4. To determine promising areas for further geological exploration work, taking into account the identified patterns.

Research methodology. The research was carried out using an interdisciplinary approach that combines data and methods from structural geology, tectonics, stratig-

raphy, and mineral resource studies. Attention was focused on the composition and structural features of the Earth's crust, its tectonic evolution, and the factors controlling the formation and localization of mineral accumulations. In addition, published results of studies dealing with the geological structure and hydrocarbon potential of the region were examined, together with recent developments in geological exploration practice.

The key aspects of the study were:

1. The analysis of previously published geological and geophysical materials on the Afghan-Tajik Depression. Their interpretation made it possible to clarify the main structural features of the region, outline its tectonic evolution, and assess the conditions that may favor the presence of hydrocarbon accumulations, including the identification of areas of increased exploration interest.

2. The core of the study was actual data obtained during deep drilling in various areas of the Afghan-Tajik Depression. This data formed the basis for forecasting and assessing the region's oil and gas potential at various levels. New geological exploration, including modern methods and technologies, provides a reliable basis for predicting the success of exploration efforts.

The use of geological exploration data and methods significantly improves the efficiency of hydrocarbon exploration and accelerates production processes. Advanced technologies, such as new drilling techniques and geochemical analysis methods, ensure the accuracy and reliability of exploration results.

Thus, the comprehensive analysis of the geological and economic situation in the Afghan-Tajik Depression, taking into account both scientific and practical aspects, will contribute to more effective forecasting and development of the region's oil and gas resources.

To achieve the goals of the research, a range of general scientific research methods was used, each of which played a key role in the analysis, generalization, and synthesis of geological and geophysical data aimed at predicting the oil and gas potential of the Afghan-Tajik Depression. The main methods were as follows.

1. Analytical interpretation was applied to characterize the spatial setting of the Afghan-Tajik Depression and to clarify the internal structure of the region with regard to hydrocarbon accumulations of different geological ages. This approach made it possible to examine the main tectonic and geomorphological features and to distinguish structural elements reflecting variations in different parts of the basin, which is important for forecasting oil and gas potential and further geological exploration.

2. The generalization method was used to systematize the scientific data and assumptions obtained during the study, as well as to establish the theoretical aspects and characteristics of geological exploration for the oil and gas potential of promising areas. This method was used to develop a theoretical approach for forecasting the future development of the country's fuel and energy sector, which allowed for the formulation of recommendations for the efficient use of the region's hydrocarbon resources.

3. The method of analogies and comparisons served as the basis for substantiating and analyzing the geological and geophysical characteristics of the Afghan-Tajik Depression in different periods (late 20th

and early 21st centuries). This method allowed for comparing changes in the geological environment and tectonic activity over the specified period, as well as identifying features of modern paleotemperatures and sedimentary depths, which is critical for understanding the dynamics of oil and gas field formation and forecasting their development.

4. The synthesis method was used to identify the main sediment types in different directions of the Afghan-Tajik Depression and to characterize them in detail. This method allowed for the generalization of sediment accumulation data throughout the entire depression zone, which was initially characterized by stable, compensated subsidence. Synthesizing various sediment types and their characteristics helped create a complete picture of the region's geological history, which is important for further research and hydrocarbon resource exploration.

5. The abstract-logical method was used to clarify and formulate key concepts, definitions, and categories used in the study of all phases of deposits within the context of their stratigraphic and tectonic context. This method also played a key role in data synthesis and drawing conclusions necessary for further petroleum potential forecasting and developing recommendations for improving exploration and production operations.

6. The combined application of these approaches provided a coherent understanding of the geological and geophysical features of the Afghan-Tajik Depression and served as a basis for a more reliable assessment of its hydrocarbon potential and the rational planning of further resource utilization.

Presentation of the main material. In the Lower-Middle Jurassic section of the Afghan-Tajik Depression, the reservoirs are thick sandstone units with siltstone interlayers (horizons XX–XVII). In the Upper Jurassic deposits, Callovian–Oxfordian fractured and fracture-porous carbonates (horizons XVI–XV) exhibit high-quality filtration and capacity properties; reefogenic carbonate facies also offer additional potential.

The Lower and Upper Cretaceous complexes contain more than 10 productive horizons (XIV–V), including 7 commercial gas-bearing and 1 oil and gas-bearing (Lyalmikar); lithology – Neocomian red sandstones, Cenomanian sandstones/calcareous sandstones, Maastrichtian sandstones.

Paleogene reservoirs are Paleocene organogenic-detrital limestones, Eocene-Alai shell rocks and sandstones (horizons IV–I).

Lower-Middle Jurassic deposits lack consistent regional seals; exploration is low.

The Upper Jurassic complex is marked by a thick Kimmeridgian–Tithonian evaporite (salt-gypsum) sequence (Gaurdak Formation) serving as a reliable regional seal: thickness from 80–100 m (north) to 800 m (south). In the Dushanbe Trough, the formation pinches out; the Oxfordian–Kimmeridgian sequence consists of alternating fissure carbonates and anhydrites; bitumen data indicate partial permeability of the anhydrite/dolomite-anhydrite interlayers hydraulically linking the intervals of Horizon XV; the main seal here is the Lower Cretaceous red-colored clays of the Karabil Formation.

Clarification of the mineralogical composition of the caprock revealed previously undescribed differences in the tightness of the western and eastern regions. Compositional features (variations in montmorillonite, chlorite, and kaolinite) directly impact the insulating properties of the rocks and the potential productivity of the deposits, which has significant predictive value.

Lower Cretaceous seals – Barremian–Lower Albian clays (isolate XIV–XI); regional – Cenomanian–Turonian–Lower Campanian impermeable clays (sulfates, to a lesser extent), separating the Paleogene–Maastrichtian, Middle Albian, Neocomian–Aptian and Jurassic; total thickness 400–800 m, with embedded permeable carbonate-terrigenous units (more than 100 m), forming an anomalous Upper Cretaceous complex (horizons XIV–V).

The Suzak Formation (Lower Eocene) is a regional oil-sealing aquifer for Paleocene horizons (IV–I): thickness from 10–38 to 130–210 m (west/southwest); complete isolation requires the inclusion of the Upper Bukhara and Lower Alai low-permeability layers; sand deposits increase to the north/east. Mineralogical domains: montmorillonite disappears in the east (0%), in the west there is 10–50% clay fraction.

A thick regional seal, reaching 300–400 m in places, is formed mainly by the Paleogene Turkestan–Rishtan clay-rich strata, which overlie the fractured carbonate formations of the Alai sequence. Together with the clays, the sealing interval also incorporates sulfate rocks as well as terrigenous and carbonate units. The proportion and total thickness of these components increase markedly toward the northeastern part of the Afghan-Tajik Basin, where they may reach 80–100 m or more.

The productive intervals with appreciable porosity and permeability – corresponding to horizons Ia and Ib – typically range from 10 to 40 m in thickness. Across most of the basin, the clay facies consist predominantly

of hydromica and montmorillonite. In the northeastern areas, mixed-layer minerals and chlorite become common, while in the far eastern sector kaolinite in association with chlorite is characteristic.

Thus, within the Afghan-Tajik intermontane basin, approximately 20 horizons with good reservoir properties are identified in the Jurassic to Paleogene interval. This identification is somewhat arbitrary, as the horizons are sometimes subdivided into smaller layers in certain areas of the basin.

The Afghan-Tajik oil and gas basin comprises approximately 30 commercial fields with proven Paleogene oil and gas potential and Mesozoic gas potential. Tajikistan has 14 of these fields (10 oil fields, 4 gas/gas condensate fields). The highest concentrations are found in the Kulyab megasyncline: the Sulduzy and Beshtentyak oil and gas condensate fields; the Pushion-Yuzhny, Pushion-Severny, and Uzunkhor oil fields; and the Khodja-Sartis gas condensate field. There are 3 fields each in the Vakhsh megasyncline (the Kyzyltumshuk, Kichikbel, and Akbash-Adyr oil fields) and the Dushanbe trough (the Shaambary, Komsomolskoye, and Andygen oil/gas fields). One oil field each in the Kafirnigan (Kum-Yuzhny) and Tajik Surkhandarya (Kurgancha-Severny) megasynclines.

Uzbek Surkhandarya megasyncline: 14 fields (Fig. 2) – Gadzhak gas field, Lyalmikar oil and gas field, 12 oil fields (Khaudag, Uchkizyl, Amu Darya, Kokayty, Koshtar, Mirshadi, Yuzh. Mirshadi, Dzheyranhana, Aktau, Dosmanaga-Korsagly, Akjarsay, Zhalaïr).

Jurassic-Lower Cretaceous horizons are mostly unexposed; Mesozoic gas content has been confirmed at Shaambary (XV), Komsomolskoye (XV, XIV, XII, XI, Xa, b), Andygen (XV, XIV, XIII, XII, XI, Xa, b, IX), Gadzhak (M-25), Kagnisay (XV, XVa, XIV).

The largest reserves are in the Paleogene Akdzhär (IV, III), Bukhara (II, I), Alai (Ia) layers: Shaambary, Komsomolskoye, Andygen, Beshtentyak, Sulduzy,

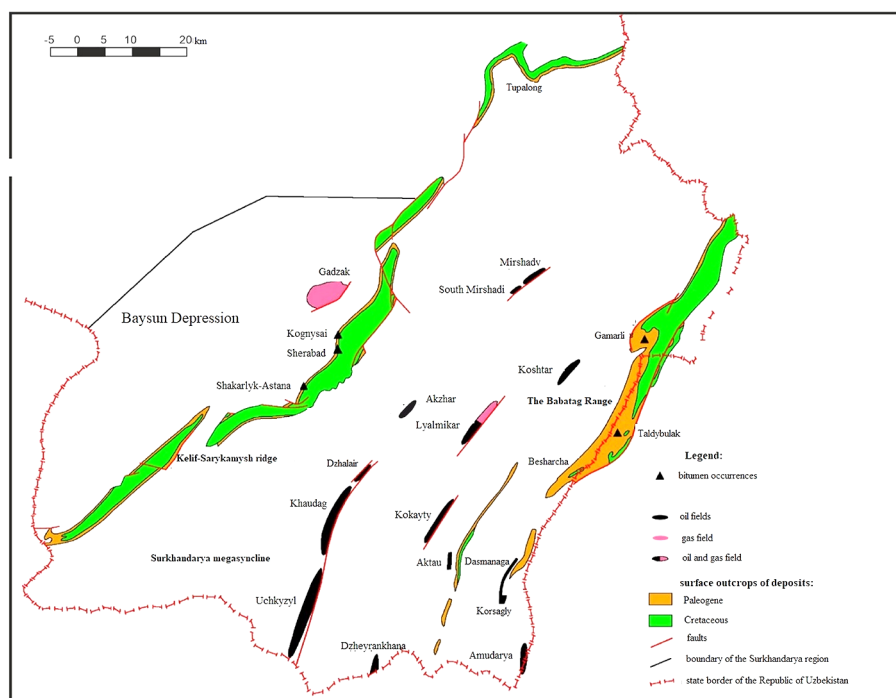


Fig. 2. The layout of oil and gas fields and bitumen occurrences of the Surkhandarya megasyncline

Pushion-Northern, Uzunkhor, Pushion-Southern, Khoja-Sartis, Kyzyltumshuk, Kichikbel, Akbash-Adyr, Kurgancha-Northern, Khaudag, Uchkizil, Lyalmikar, Amudarya, Kokaity, Koshtar, Mirshadi, South Mirshadi, Jeyrankhana, Aktau, Dosmanaga-Korsagly, Akjar-sai, Zhalair.

From the standpoint of the genetic classification of hydrocarbon traps, the oil and gas accumulations within the Afghan-Tajik Basin are predominantly associated with structural types of reservoirs. These accumulations are confined to anticline-related traps whose crest geometry varies from gently domed to distinctly wedge-shaped configurations. Within this group, three subtypes can be distinguished: crest-type reservoirs, hydrodynamically controlled hanging traps, and traps sealed by tectonic discontinuities. Hydrodynamic traps are the most widespread in the basin; they represent closed, low-permeability structural highs underlain by an inclined oil-water or gas-water contact. Preservation of hydrocarbons within these permeable formations requires that the dip of the reservoir beds along the flanks exceed the dip of the corresponding fluid-contact surface, preventing displacement of the accumulated hydrocarbons by formation water.

Most oils known from the Afghan-Tajik depression are heavy, viscous, resin- and asphaltene-rich, and contain elevated amounts of sulfur and paraffinic components, resulting in a low yield of gasoline-kerosene fractions. The distillate portion of these oils corresponds to the methane-naphthene-aromatic class. Lighter and higher-quality crude oils are mainly associated with the Middle Eocene (Alai) deposits of the Dushanbe trough (Shaambary area) and the northern part of the Western Babatag region (Northern Kurgancha), as well as with the Paleocene (Bukhar) formations of the Kulyab zone (Beshtentyak). These oils contain significantly smaller amounts of resins, asphaltenes, and sulfur-bearing compounds, produce a higher proportion of gasoline-kerosene fractions, and exhibit an aromatic-methane-naphthene composition in their distillate segment.

Free gases Mesozoic-Paleogene: $\text{CH}_4 + \text{C}_2\text{H}_6^+$, CO_2 , N_2 , $\text{Ar}(\text{+Kr} + \text{Xe})$, $\text{He}(\text{+Ne})$. Dushanbe Trough (Jurassic/Cretaceous): $\text{CH}_4 \leq 93.5 \text{ vol}\%$; $\text{C}_2^+ 1.7\text{--}7.0 \%$; $\text{N}_2 1.0\text{--}16.0 \%$ (up to $33.5\text{--}58.5 \%$ in Andygen-IX, Komsomolskaya-II); $\text{He} 0.043\text{--}0.885 \%$, $\text{Ar} 0.014\text{--}0.121 \%$ (max. in the Cenomanian Andygen X-IX); H_2S usually 0 ($\leq 0.01 \%$ in Andygen XV). Vakhsh (Paleocene-Maastrichtian, Kyzyltumshuk): $\text{CH}_4 88.7\text{--}92.3 \%$; $\text{C}_2^+ 0.3\text{--}2.7 \%$; $\text{N}_2 5.6\text{--}8.0 \%$; $\text{Ar} 0.029\text{--}0.37 \%$; $\text{He} 0.046\text{--}0.079 \%$; $\text{H}_2\text{S} \approx 0$.

Condensate fluids within the Afghan-Tajik Basin are primarily associated with gas-bearing intervals of Cretaceous and Jurassic age at the Shaambary, Komsomolskoye, and Andygen fields in the Dushanbe trough. They are also documented in Paleocene reservoirs at the Beshtentyak field located within the Kulyab syncline. These condensates typically exhibit low densities – generally not exceeding 0.80 g/cm^3 – and display a wide boiling range, from about 61 to $353 \text{ }^\circ\text{C}$. Many samples contain elevated sulfur concentrations, including highly sulfurous varieties.

Nitrogen is present in most condensates at levels up to 0.05% , and condensates from the Upper Jurassic sec-

tion (Horizon XV) at the Shaambary and Komsomolskoye fields contain silica-gel resins. In terms of hydrocarbon group composition, methane-naphthene components dominate, giving these condensates a predominantly aromatic-naphthene-methane character. In the Lower Cretaceous and Cenomanian intervals of the Andygen field, condensates exhibit a more strongly naphthenic signature, corresponding to an aromatic-methane type.

Within the Surkhandarya megasyncline, commercial gas deposits have been identified in the Gadzhak field (M-25) in Upper Jurassic limestones (horizon XV) and Lower Cretaceous sandstones (horizon XIV), as well as in the Lyalmikar field in Paleogene terrigenous-carbonate beds. A gas manifestation was obtained in the Khaudag field (well No. 1001, int. 960–967 m) in Upper Cretaceous sandstones (K_2t) with a flow rate of 20–29 thousand m^3/day .

The gas of the subsalt productive horizons of the Gadzhak field is dry, carbonic, high-sulfur, low-nitrogen. The molar fraction of the components was (%): methane 83.8; ethane 0.27; propane 0.06; isobutane 0.03; carbon dioxide 8.30; nitrogen 1.71; sulfur 4.28. The relative density of the gas is $0.5847\text{--}0.6994 \text{ g/cm}^3$.

The analyzed gases of the Lower Cretaceous consist exclusively of methane (96.28–96.33 %) with an insignificant content of methane homologues ($\text{C}_2\text{H}_6 + \text{higher} - 0.28\text{--}0.34 \%$) and hydrogen sulfide (0.001–0.007 %). At the same time, the concentration of carbon dioxide is $0.1\text{--}1.16 \%$, nitrogen – $2.2\text{--}3.22 \%$. The gases of the Cretaceous deposits of Khaudag, Lalmikara and Kokaity are characterized by the same composition.

In the Lalmikar field gas deposits are found in the Alai and Bukhara layers of the Paleogene and Senonian of the Upper Cretaceous. The gases of the Alai layers are methane-rich in hydrocarbon composition, semi-fat ($\text{C}_2 + \text{higher} - 13.7 \%$). Of the non-hydrocarbon components, the gases contain 0.04% hydrogen sulfide, 1.4% carbon dioxide and 3.6% nitrogen.

The gases of the Bukhara layers of horizons I and IV are characterized by a high content of methane (96.1–98.4 %), low heavy hydrocarbons $\text{C}_2 + \text{higher}$ (the sum of methane homologues is $1.6\text{--}2.5 \%$) and virtually no hydrogen sulfide. The Senon gases are close in composition to the gases of the Bukhara layers of horizons I and VI. It should be noted that the gases of the Lalmikara chalk are characterized by a relatively high content of helium.

The identified oils are located in the Surkhandarya megasyncline (Paleocene, Eocene I-IV horizons) heavy, low-gasoline with a density from $0.945\text{--}0.951$ to $0.962\text{--}0.970 \text{ g/cm}^3$. High-sulfur oils (up to 5% total sulfur), relatively enriched with aromatic hydrocarbons (on average 28% per fraction of NK – $300 \text{ }^\circ\text{C}$), gases – containing up to 25% nitrogen, 15% carbon dioxide. Such oils occur in carbonate-sulfate deposits and their formation is explained by the influence of neotectonic movements occurring in the Neogene-Quaternary period, when aggressive hydrocarbonate and sulfate waters began to actively affect the already formed deposits, with the subsequent impact of negative factors. These factors stimulated secondary hypergene changes (sulfurization, oxidation, degassing, evaporation, biodehydration, etc.). The heaviest, highly viscous ($\rho_4^2 -$

0.987–0.992 g/cm³), high-sulfur (6.2–22.1 %), highly resinous (23.7–62.6 %) and asphaltene (20.3–22.1 %) oils were found in the Dzheyranhana (I horizon), Amu Darya and Dosmanaga-Korsagli (II, III horizons) fields. In some samples from the II, III horizons, the oil density reaches 1.006–1.027 g/cm³, the paraffin content is up to 9.6 %. These data indicate that the oils have undergone significant hypergene changes, which led to the formation of semi-liquid bitumens (malta).

Heavy oils of the Afghan-Tajik Depression differ from heavy Neogene and Paleogene oils of the Fergana region in their sulfur, asphalt-resinous components, and paraffin content. The former contains less paraffin (1.0–9.7 %), comparatively many asphalt-resinous components (2.1–83.8 %), and an order of magnitude more sulfur (2.5–10.6 %). In the latter case, the amount of sulfur does not exceed 0.6 % (the average sulfur content by world standards is 0.7 %), asphalt-resinous components are present in the amount of 8.0–34.6 %, and paraffin 2.1–22.8 %.

Conclusions and prospects for further development in this direction. The Afghan-Tajik Depression is marked by polygenetic hydrocarbon reservoirs in the Jurassic-Cretaceous-Paleogene interval. Lower-Middle Jurassic: thick sandstone units and siltstones (XX–XVII). Upper Jurassic: fissure-pore carbonates of the Callovian-Oxfordian (XVI–XV); reefoids are highly capacious.

Cretaceous: about 10 productive horizons (XIV–V) – 7 gas, 1 oil and gas (Lyalmikar); lithology: Cenomanian/Maastrichtian sandstones/calcareous, Neocomian redstones. Paleogene: Paleocene organogenic-detrital limestones and Eocene-Alai shell rocks/sandstones (IV–I).

The seals vary laterally: Jurassic – Kimmeridgian-Tithonian evaporites no more than 800 m; Lower Cretaceous – Barremian-Lower Albian clays; Upper Cretaceous – Cenomanian-Turonian impermeable clays; Paleogene-Suzak Formation 10–210 m.

About 20 reservoir horizons; low exploration. about 30 fields (14 in Tajikistan); focus: Kulyab megasyncline and Dushanbe trough (oil and gas/gas condensate).

The deposits are structurally diverse in anticlines; hydrodynamic deposits predominate. The oils are predominantly heavy/viscous/resinous/sulfurous; light/high-quality – Middle Eocene Alai and Paleocene Bukhara.

Mesozoic–Paleogene gases: CH₄ no more than 93.5 %. Condensates (Cretaceous/Jurassic/Paleocene): density no more than 0.80 g/cm³, boiling point 61–353 °C. The depression is highly promising for geological exploration.

The work refines strati-tectonic models; the identified reservoir/traps/seal patterns motivate the reprioritization of exploration in underexplored Jurassic/sub-thrust zones.

Geochemistry of Mesozoic oils (stagnation hydrodynamics, especially underthrust): “normal” type – light, low-viscosity, low-resin/sulfur, with high gas-oil ratio due to large-scale hydrocarbon generation.

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Прогноз нафтогазоносності осадового чохла Афгано-Таджицької западини

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Мета. Виявлення особливостей геологічної будови та умов накопичення осадових порід для регіонального прогнозу нафтогазоносності мезозойсько-кайнозойських відкладів Афгано-Таджицької западини.

Методика. Були використані такі наукові методи: узагальнення й систематизація наявних фактичних матеріалів; аналіз та обґрунтування геолого-геофізичних даних; виділення основних нафтогазоносних комплексів і типів вуглеводневих пасток.

Результати. Встановлена різноманітність пасток вуглеводнів, пов'язаних із платформним (антиклінальними й неантиклінальними) та орогенним (піднасувними з горизонтальними переміщеннями до сотень метрів) етапами; уточнена мінливість покришок (євапорити юри до 800 м, глини крейди 400–800 м, сузакська світа палеогену 10–210 м) із регіональними відмінностями в мінералогії (монтморилоніт, хлорит); підтверджена висока перспективність палеоген-крейдианих антикліналей та юрських відкладень по всій западині. Виявлено близько 20 продуктивних горизонтів (пісковики, карбонати) у 30 родовищах із переважанням важких сірчистих нафт і метанових газів.

Наукова новизна. Проведені узагальнення й структурний аналіз геологічних характеристик мезозойсько-кайнозойських відкладень Афгано-Таджицької западини. Уточнені стратиграфічні й тектонічні параметри, що раніше не розглядалися комплексно, у тому числі просторова мінливість покришок і вплив неотектоніки. Виконано порівняльний аналіз вуглеводневого складу покладів у різних пастках, включаючи піднасувні й гідродинамічні, із виявленням закономірностей генерації та збереження вуглеводнів. Ці результати дозволяють запропонувати уточнену модель нафтогазоносності регіону та нові орієнтири для пошукових робіт.

Практична значимість. Полягає в обґрунтованому виборі оптимальних зон і нафтогазоперспективних ділянок з метою пошуків промислово значущих покладів вуглеводневої сировини, що сприятиме нарощуванню ресурсної бази Афгано-Таджицької западини.

Ключові слова: Афгано-Таджицька западина, колектор, розріз, родовища нафти й газу, геологія

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