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Huseynaga MAMMADOV, PhD (Geol.), Assoc. Prof.
ORCID ID: 0000-0001-6199-3892
e-mail: huseynaqa.mammadov@asoiu.edu.az
Azerbaijan State Oil and Industry University, Baku, Azerbaijan

Murad ABDULLA-ZADA, PhD (Earth sciences)
ORCID ID: 0009-0001-4150-8340
e-mail: murad.abdullazade@asoiu.edu.az
Azerbaijan State Oil and Industry University, Baku, Azerbaijan

Elena POGORELOVA, PhD (Geol.), Assoc. Prof.
ORCID ID: 0000-0002-2412-4441
e-mail: yelena.pogorelova@asoiu.edu.az
Azerbaijan State Oil and Industry University, Baku, Azerbaijan

CASPIAN PIONEER: STRUCTURAL COMPLEXITY AND HYDROCARBON DISTRIBUTION IN THE NEFT DASHLARY OFFSHORE FIELD

(Представлено членом редакційної колегії д-ром геол. наук, проф. Володимиром МИХАЙЛОВИМ)

Background. *The Neft Dashlary (Oil Rocks) oil field is a geologically and historically unique offshore petroleum province, located in the southeastern sector of the Caspian Sea. As the first offshore field in the world to be developed directly on marine platforms, it has played a pioneering role in offshore hydrocarbon exploration and production. Geologically, the field occupies a structurally complex zone within the Absheron–Balakhany tectonic uplift and is situated atop a prominent northwest–southeast-trending brachyanticlinal fold. The reservoir system is primarily hosted within the Lower Pliocene Productive Series, which includes a multilayered assemblage of deltaic, coastal, and shallow-marine facies. Despite decades of production, the field remains a valuable subject for re-evaluation due to its reservoir heterogeneity, fault segmentation, and layered hydrocarbon distribution, which pose both challenges and opportunities for enhanced oil recovery and long-term development planning.*

Methods. *This study is based on a comprehensive analysis of geological, geophysical, petrophysical, and production data from more than 150 wells across the Neft Dashlary field. Core analyses (1,453 samples from 357 wells), well log interpretations, and test data were integrated to characterize reservoir properties and map hydrocarbon-saturated intervals. Reservoir architecture was reconstructed using stratigraphic correlations and structural contouring across tectonic blocks. Oil-in-place and recoverable volumes were estimated using deterministic volumetric methods. Faults and facies pinch-outs were analyzed to define reservoir continuity and trapping mechanisms.*

Results. *The Productive Series at Neft Dashlary comprises a multilayered reservoir system with oil-saturated intervals in 26 distinct stratigraphic objects across eight lithostratigraphic suites, including the Gala, Pre-Kirmaki, Kirmaki, and Post-Kirmaki sandy and clayey units. Reservoirs exhibit porosities of 12–28 % and permeabilities from 0.001 to 3.92 μm², with facies and structural heterogeneity governing hydrocarbon distribution. The most prolific zones are found in the GS-1 and GS-2 horizons (Gala Suite), and in PKS-2a and PKS-2 (Pre-Kirmaki Suite), particularly within Blocks II, III, IV, and V. Block I consistently exhibits low reservoir quality and marginal saturation. Structural closures, lithological seals, and facies transitions control the extent of hydrocarbon accumulations, while free gas is rarely encountered.*

Conclusions. *The Neft Dashlary field demonstrates complex stratigraphic and structural controls on reservoir distribution and productivity. Integrated geological and petrophysical analysis reveals significant heterogeneity both laterally and vertically, requiring block-by-block reservoir management strategies. The identification of key productive intervals and their spatial delineation provides a basis for optimized recovery planning and extended field life.*

Keywords: *Oil field, Productive Series, porosity, permeability, stratigraphy, tectonics, offshore zone, geophysical analysis.*

Background

The Neft Dashlary (Oil Rocks) oil field stands as a historically significant and geologically complex offshore hydrocarbon accumulation located in the south-western sector of the Caspian Sea, approximately 110 kilometers southeast of Baku. Discovered in 1949, Neft Dashlary became the world's first offshore oil production site constructed directly on open sea infrastructure, marking a milestone in petroleum engineering and offshore field development. Spanning an area of approximately 66 km², the field is situated within the Absheron Archipelago system, which includes submerged structural highs and islands such as Chilov, Khali, and Kichik Tava. These features lie along the eastern margin of the Absheron Peninsula and form part of the broader Absheron–Balakhany tectonic uplift zone.

Geologically, Neft Dashlary is located on a northwest–southeast-trending brachyanticlinal fold, bounded and segmented by an array of longitudinal and transverse faults that control reservoir compartmentalization and hydrocarbon migration pathways (Javanshir et al., 2015). The stratigraphic succession spans from Eocene basement units to Holocene marine sediments, with the Lower Pliocene Productive Series forming the principal hydrocarbon-bearing interval. This sequence comprises a complex assemblage of deltaic, coastal, and prodeltaic facies, organized into multiple lithostratigraphic suites including Gala, Pre-Kirmaki, Kirmaki, Post-Kirmaki, Fasila, Balakhany, Sabunchu, and Surakhany (Abdulla-zada, Vahably, 2021). Each suite contains numerous discrete reservoir horizons, many of which exhibit lateral and vertical heterogeneity, compartmentalization, and varied production histories.

Over seventy years of exploration and production have yielded an extensive body of geological, petrophysical, and geophysical data, enabling detailed assessment of structural architecture, reservoir quality, and hydrocarbon distribution across the field's tectonic blocks (Feyzullayev, Mammadova, 2022). Despite its mature development status, Neft Dashlary continues to serve as a key site for methodological advancements in offshore reservoir modeling and layered production strategies. This study presents an integrated geological and petrophysical analysis of the Neft Dashlary field, with a focus on the stratigraphic architecture, fault dynamics, reservoir heterogeneity, and distribution of oil-saturated intervals across major suites. The findings aim to contribute to refined reserve estimation and enhanced recovery planning for this iconic offshore oil province (Fig. 1).

Fig. 1. Neft Dashlary field location map

In Baku archipelago industrial deposits were discovered in the VIII horizon of the Balakhkhany suite, the Fasila suite, and the Postkirmaky sandy suite. Deposits of the stratal type are associated mainly with crestal tectonically shielded deposits. A characteristic feature of the oil and gas content of the Productive Serie section is the regular replacement of oil deposits with gas and gas condensate deposits in the direction of the regional immersion of layers (Ganbarova et al., 2024).

The Sangachal-deniz–Duvanny-deniz–Khara-Zira–Bulla-deniz anticline belt is located within the northern part of the Baku Archipelago oil and gas region. A characteristic feature of the tectonic structure the anticline belt is the presence of large longitudinal faults in the axial parts of the structures. Foci of mud volcanic activity are often associated with longitudinal faults. Numerous transverse faults divide the structures into separate tectonic blocks (Alizade et al., 2018).

Methods

This study is based on an integrated analysis of geological, geophysical, and production data from the Neft Dashlary offshore oil field. Data from more than 150 wells – including log interpretations, core descriptions, and test results – were used to correlate stratigraphic units and define reservoir architecture (Abduev, Alekberli, 2019). Productive horizons within the Gala, Pre-Kirmaki, Kirmaki, Post-Kirmaki, Fasila, Balakhany, Sabunchu, and Surakhany suites were identified and mapped using standard log suites and structural contouring (Abdulla-zada, Vahably, 2021). Reservoir quality was assessed by combining petrophysical parameters (e. g., porosity, resistivity, fluid saturation) with well performance and historical production (Kerimov et al., 2015). Volumetric estimates of oil initially in place and recoverable reserves were calculated using deterministic methods based on net pay, porosity, saturation, and structural closure (Kerimova, 2023). Interpretation uncertainty was reduced by cross-validating log and test data and applying structural consistency checks across blocks.

Tectono-Stratigraphic framework. The Neft Dashlary oil field exhibits a complex tectono-stratigraphic architecture shaped by the interplay of deep structural deformation and extensive sedimentary accumulation (Glumov et al., 2004). Situated in the northwestern sector of the Absheron–Prebalkhan tectonic uplift zone, the field forms a prominent culmination within the Khali–Chilov Island–Neft Dashlary anticline system. The core structural element is a northwest–southeast trending, asymmetric brachyanticlinal fold, measuring approximately 11 km in length and 6 km in width (Novruzov, 2022) (Fig. 2).

The fold is distinctly asymmetric, with variable dip angles on opposing limbs. The crest has undergone significant erosion, exposing Productive Series (PS) deposits at the modern seafloor (Pogorelova, 2019). The northwestern pericline is characterized by steep dips (33–45°), while dips in the southeastern pericline range from 22–29°. The southwestern limb is steeper (35–40°) than the more gently inclined northeastern limb (27–30°), indicating differential deformation.

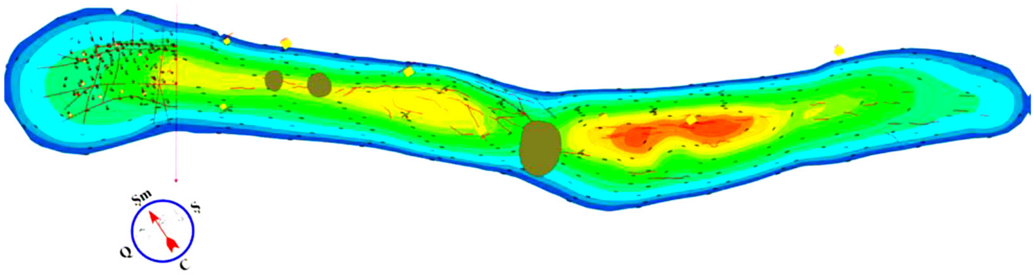

Fig. 2. Structural map of the Neft Dashlary field (based on Novruzov, 2022)

Stratigraphically, the succession at Neft Dashlary spans from the Eocene to modern deposits, reaching a total thickness of over 3350 meters (as documented in Well No.1918, Block V). The Paleogene–Neogene system at the base includes the Koun Suite (Eocene), Maikop Suite (Oligocene–Lower Miocene), and Diatom Suite (Middle–Upper Miocene) (Aliyeva, 2004). These units, composed primarily of brecciated clays, marl-bearing sands, and volcaniclastic materials, are revealed in deep exploratory wells and serve as the structural and stratigraphic basement for overlying productive intervals.

The overlying Productive Series (Lower Pliocene), reaching up to 2400 meters in cumulative thickness, is the principal hydrocarbon-bearing interval. It consists of alternating sequences of sand, sandstone, siltstone, and clay, and is subdivided into several suites: Gala, Pre-Kirmaki, Kirmaki, Post-Kirmaki sandy and clayey suites, followed by the Fasila, Balakhany, Sabunchu, and Surakhany suites (Aliyeva, 2004). Each suite exhibits distinct sedimentological characteristics, internal stratification, and reservoir potential. The Gala Suite alone is subdivided into up to eight sand packages (GS-1 to GS-8), with GS-1 to GS-4 being oil-bearing, and displays a marked vertical increase in sand content from base to top (Katz et al., 2000).

Higher in the section, the Fasila and Balakhany suites represent thick sand-dominated intervals with multiple stacked hydrocarbon reservoirs. For example, the Balakhany Suite includes at least seven productive horizons (X through V), each characterized by varying resistivity, sand content, and log responses. These units are critical targets in field development due to their favorable porosity and permeability (Khalilova, Seyidov, 2023).

Post-Productive Series sediments cap the succession and include the Aghjagil Stage (Upper Pliocene), Absheron Stage (Pleistocene), Ancient Caspian deposits, and Modern Caspian sediments. These strata, composed of clay, sand, and bioclastic materials, reflect continued sedimentation in a shallow marine setting and provide clues to the paleoenvironmental evolution of the basin.

Tectonically, the Neft Dashlary structure is segmented by a network of longitudinal and transverse faults. Six major tectonic blocks are delineated by longitudinal faults (designated 1, 2, and 2a) and transverse dislocations (faults 3 through 7), with displacements ranging from 30 m to over 350 m. Notably, transverse fault I–Ia, inferred from abrupt changes in bedding dips (up to 72° in Wells 1 and 6), reflects significant structural disruption and has been confirmed by drilling. Other major faults, such as II–II and III–III, traverse the structure, altering reservoir continuity and hydrocarbon migration pathways.

Structural mapping indicates that the fold is separated from the adjacent Palchig Pilpilasi uplift by a shallow saddle, further emphasizing its brachyanticlinal geometry. Additionally, a mud volcano has been identified near Site 262, at the Koun–Maikop contact zone. Over 30 exploratory wells were drilled to delineate the spatial extent of the breccia, revealing the field's genetic affiliation with diapiric tectonism (Khuduzade et al., 2016).

Reservoir Properties. The reservoir characteristics of the Neft Dashlary field reflect the diverse lithological composition and sedimentary dynamics of the Lower Pliocene Productive Series, which hosts the majority of hydrocarbon accumulations. A comprehensive assessment based on 1,453 core samples collected from 357 wells provides detailed insights into the petrophysical behavior of the principal reservoir units (Bagirov, Hajiyev, 2019). These include the Gala, Pre-Kirmaki, Kirmaki, Post-Kirmaki sandy, Post-Kirmaki clayey, Fasila, Balakhany, Sabunchu, and Surakhany suites.

Reservoirs within the Gala Suite (GS) are composed primarily of poorly cemented, fine-grained sandstones and siltstones (Duppenbecker et al., 2009). Analysis of 342 samples from 31 wells indicates porosities ranging from 12 % to 49 % (average: 23 %), with permeability values spanning 0.001–1.187 $μm^2$ (average: 0.135 $μm^2$). These reservoirs contain up to 50 % silt and exhibit moderate carbonate content (average: 10 %), underscoring their mixed composition and variable quality.

The Pre-Kirmaki Suite (PKS), evaluated from 220 samples across 69 wells, is characterized by high sand content (67 %) and moderate porosity (12–40 %; average: 24 %). Permeability ranges widely, reaching up to 3.920 $μm^2$, with an average of 0.138 $μm^2$. These intervals exhibit favorable reservoir properties, enhanced by relatively low clay content (25 %) and modest carbonate concentrations (average: 9.4 %).

In contrast, the Kirmaki Suite (KS), based on 100 samples from 42 wells, presents more heterogenous reservoir properties. Average porosity remains comparable (24 %), but permeability varies significantly across its sub-units. The KS-1 interval shows the lowest permeability (0.036 $μm^2$), while KS-2 exhibits more favorable values (up to 0.207 $μm^2$), linked to its improved sorting and coarser texture (Mammadov, 2010).

The Post-Kirmaki sandy Suite (PKsS), represented by 44 samples from 18 wells, contains high-quality reservoirs.

These sands exhibit porosities averaging 25 % and permeability values up to 0.257 μm². The relatively low clay fraction (~25 %) and consistent petrophysical behavior make UKSS an attractive development target.

The overlying Post-Kirmaki clayey Suite (PKcS), though dominated by clayey siltstones, retains moderate reservoir quality. Based on 36 samples, porosity and permeability average 25 % and 0.085 μm², respectively. Carbonate content ranges from 3.4 % to 26 %, indicating a diverse diagenetic history (Abrams, Narimanov, 1997).

The Fasila Suite (FS), derived from 115 samples across 46 wells, offers some of the most favorable properties in the field. With porosities up to 37 % (average: 27 %) and permeability reaching 2.0 μm², this unit represents a key reservoir horizon. Sand content exceeds 65 %, while carbonate content remains moderate (average: 10 %).

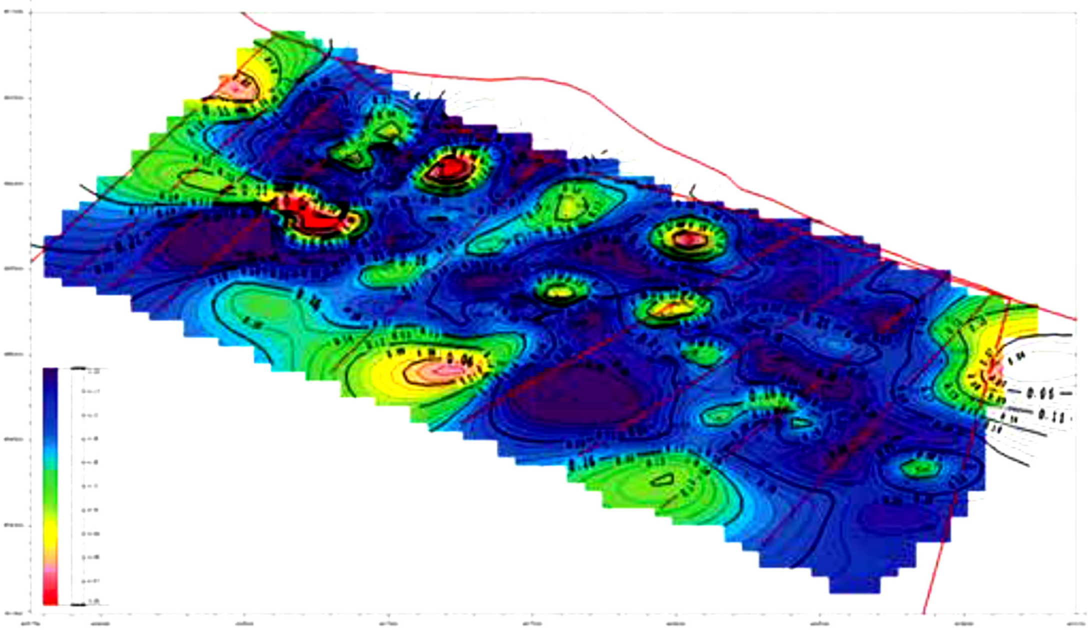

Fig. 3. Decline in porosity values from the structural crest toward the periclinal zones, as well as across the areal extent of the reservoir

Reservoirs in the Balakhany Suite (BalS), examined through 207 samples from 59 wells, are consistently porous (up to 40 %) and moderately permeable (Javanshir et al., 2015). The average carbonate content is approximately 10 %, and internal horizons (e. g., X, IX, VIII) show variable but often high flow capacity, supporting their long-standing role in field production.

Statistical analysis of the full sample set reveals the following:

- Granulometric composition was determined for 1,236 samples. Clay content varies from 1.8 % to 50 %, averaging 24–30 %. Maximum values occur in the KS Suite, while the PKS, PKsS, and BalS exhibit the lowest clay contents.
- Carbonate content, based on 1,373 measurements, ranges from 1 % to 30 %, with localized spikes up to 40 %. The average across all productive units lies between 10 % and 15 %, with higher values in GS and KS.
- Porosity was measured in 1,030 samples, ranging from 2 % to 45 %, with suite averages between 18 % and 28 % (Fig. 3).
- Permeability, assessed from 504 samples, ranges from 0.0001 to 3.920 μm². PKS-2a exhibits the highest values, while KS-1 is the least permeable.

A permeability threshold of 0.001 μm² is adopted to distinguish reservoir from non-reservoir intervals. Empirical porosity-permeability plots show that effective reservoir behavior is maintained when:

- Porosity exceeds 10 % for the PKS, PKsS, and FS suites.
- Porosity exceeds 12 % for GS, KS, and PKcS suites.

Accordingly, the following petrophysical criteria are recommended for defining reservoir quality in the Neft Dashlary field:

- For PKS, KS, PKsS, FS, and BalS: porosity >10 %, permeability >0.001 μm², carbonate <25 %, and clay content <48 %.
- For GS, KS, and PKcS: porosity >12 %, permeability >0.001 μm², carbonate <27 %, and clay content <48 %.

Distribution characteristics of hydrocarbon accumulations. The Neft Dashlary field is multilayered, with hydrocarbons occurring in as many as 26 stratigraphic intervals within the Productive Series. The thickness of oil-bearing formations varies significantly across the structure, with minimum values observed in the northwestern blocks (e. g., 67.7 m in Block I) and maximum values in the southeastern blocks (e. g., 348.6 m in Block III).

Hydrocarbon-bearing intervals have been identified in nearly all productive suites and horizons:

- Surakhany Suite: 2 horizons (I and II)
- Sabunchu Suite: 3 horizons (II, III, IV)
- Balakhany Suite: 7 horizons (V, VI, VII, VIIa, VIII, IX, X)
- Fasila, Post-Kirmaki clayey, and Post-Kirmaki sandy Suites: 1 object each
- Kirmaki Suite: 3 horizons (KS, KS-1, KS-2)
- Pre-Kirmaki Suite: 4 objects (PKS-1, PKS-1a, PKS-2, PKS-2a)
- Gala Suite: 4 productive sand packages (GS-1 through GS-4)

These reservoirs are often confined by lithological and tectonic seals, with several exhibiting stratigraphic pinch-outs or lateral lithofacies transitions. The nature of these traps reflects a combination of structural and lithological controls on hydrocarbon entrapment.

Table 1 summarizes the gross and net effective oil-saturated thicknesses of the principal reservoir units. The net oil-bearing thickness generally correlates inversely with increasing clay content. Cumulatively, net thicknesses are greatest in the downthrown southeastern flanks of the structure.

Each hydrocarbon-bearing unit consists of rhythmically alternating sandy siltstones, clays, and silty mudstones, with individual sand bodies ranging from 1–2 meters to as much as 18 meters in thickness. Interbedded shale barriers range from 2–4 meters within productive zones, increasing to 8–20 meters between separate reservoir bodies (Fig. 4).

The distribution of oil-bearing objects by block reveals the highest concentration in Block III (24 objects), followed by Blocks IV and V (21 objects each), Block II (15), Block Ia (12), and Block I (8).

Notably, deeper sequences beneath the Productive Series – including the Koun, Maikop, Diatom, and Pontian deposits – were penetrated by 25 wells. While these older formations were fully characterized, they did not demonstrate significant hydrocarbon potential in this field (Mammadov, 2015).

Hydrocarbons within the Neft Dashlary field occur primarily in solution gas form. However, minor accumulations of free gas have been reported in a few wells, particularly within GS-1 (Blocks Ia and IV) and GS-2 (Blocks III and IV), where limited gas production has been documented.

Table 1

Variation in thickness and effective oil saturation of productive intervals

Horizon/Suite	Gross Thickness (m)	Avg. Gross	Net Effective Thickness (m)	Avg. Net
GS	193–380[x]	274	29,0–101,8	64.9
PKS	72–135	110	39,3–78,1	63.9
KS	165–350	286	22,0–35,2	27.9
PKsS	18–46	31	10–19	18.2
PKcS	90–220	147	6–8	6.3
FS	56–105	78	18–34	28.7
X	30–70	50	9–26	24.3
IX	38–71	55	11–14	11.5
VIII	35–70	55	15–20	15.6
VIIa	30–76	50	5,8–12,5	11.5
VII	32–70	57	16–20	17.0
VI	95–153	124	14–21	19.0
V	70–105	84	10–14	12.6
IV	111–155	141	6–11	11.0
III	20–43	30	6,0	6.0
II	30–55	35	5,0	5.0
I	11–55	30	4,0	4.0
I^{I} (SurS)	30–45	33	4,0	4.1

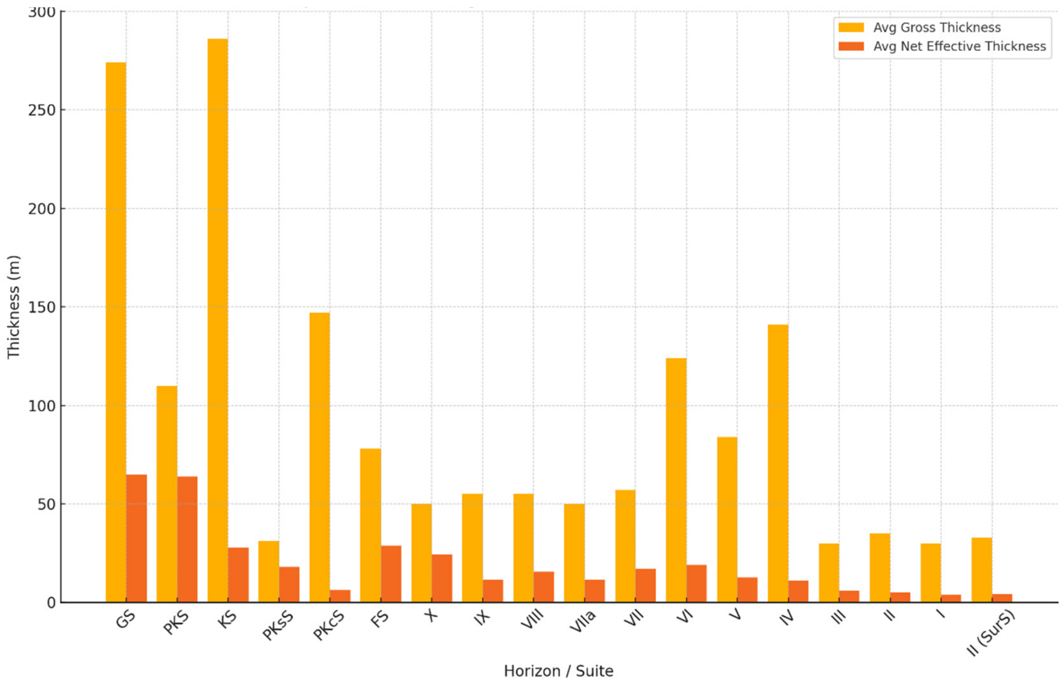

Fig. 4. Comparison of average gross and net effective thicknesses

Results

The stratigraphic succession of Lower Productive Serie sediments of the Neft Dashlary field includes a wide range of reservoir types, from shallow-marine sands to deltaic and prodelta facies, each demonstrating varying degrees of lateral continuity, vertical heterogeneity, and hydrocarbon saturation.

The Gala Suite (GS) is stratigraphically divided into four distinct horizons: GS-1 through GS-4. Industrially significant oil accumulations have been identified across all tectonic blocks of the field, with the most productive intervals associated with horizons GS-1 and GS-2.

The lithological and reservoir properties of GS deposits exhibit considerable heterogeneity across the structure. Detailed correlation of well log data from wells in Block V (e. g., Wells 1778, 1967, 2078, 1749, 2032, 1728, and 845) revealed lateral facies variability. In the northwestern portion of Block Ia (e. g., Well 1716), only GS-2 is oil-saturated, while GS-1 and GS-3 are composed predominantly of clay-rich facies. Conversely, in the southeastern area (e. g., Well 1501), all four GS horizons are productive.

GS-4 was the initial oil-bearing horizon discovered in the Neft Dashlary field, delineating a productive zone primarily along the southeastern (Blocks Ia, II, and IV) and partially the north-northeastern flanks of the structure. The initial producing wells reported oil flow rates of 40–150 tons/day. The oil-bearing zone associated with GS-4 extends approximately 3,750 meters southeastward and 2,200 meters northwestward.

In the southeastern crestal region (Block IV), particularly near Wells 262, 1835, and 1836, GS-4 transitions into non-reservoir clayey facies, resulting in an unproductive central zone (Fig. 5).

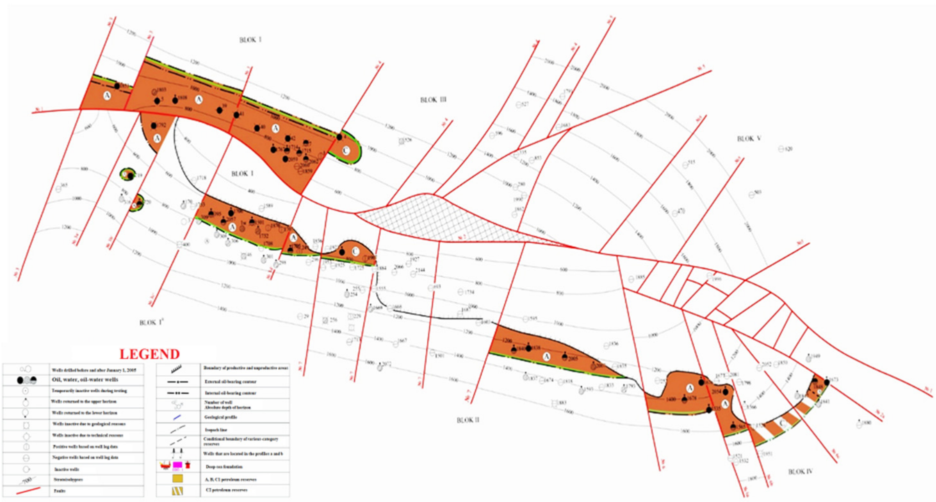

Fig. 5. Oil saturation distribution map for the GS-4 horizon

Oil production from GS-3 has proven variable. While test results from some wells (e. g., Wells 35 and 515) have indicated the presence of formation water, geophysical analyses confirm that Blocks I and V are largely non-productive in this interval. Notably, on 17 February 1955, Well 203 (Block III) produced oil from GS-3 at a rate of 53 tons/day with a wellhead pressure of 4.8 MPa. Subsequent development (e. g., Wells 255, 296, and 467) delineated the productive limits of the reservoir in Blocks Ia, II, and IV. The oil-bearing trend of GS-3 spans approximately 7,100 meters southeastward and 900 meters northwestward.

The lateral extent of oil saturation in GS-3 is largely determined by lithological constraints. In the southeastern flank, sand-rich intervals pinch out into impermeable clay, creating a distinct boundary between productive and non-productive zones (Fig. 6). The width of this non-productive zone varies from 100–150 meters in the central area to 600–850 meters toward the east and west.

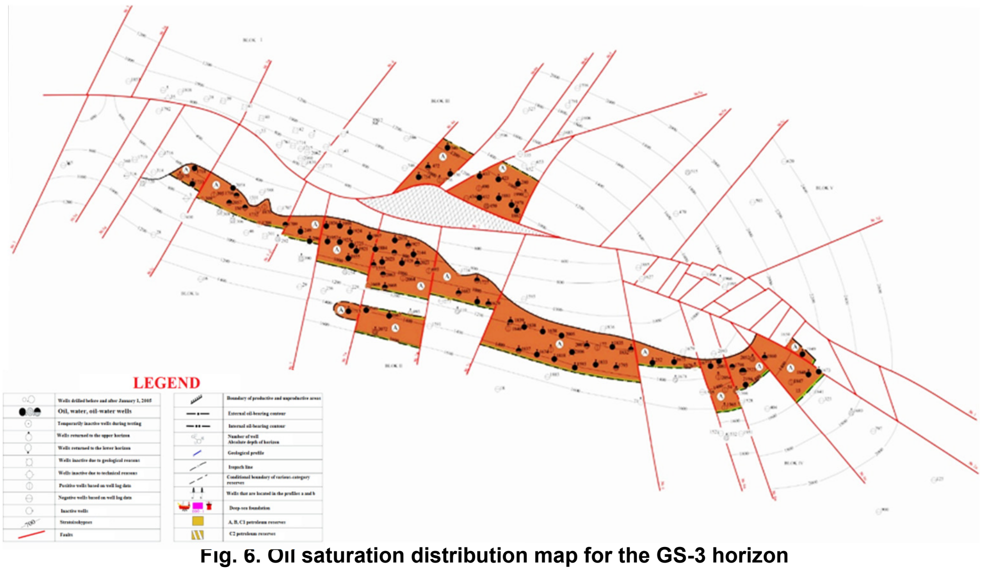

Fig. 6. Oil saturation distribution map for the GS-3 horizon

In the north-northeastern flank, GS-3 is productive only within Block III. Well log and production data from Wells 430 and 434 indicate a narrow water-bearing zone.

GS-2 is oil-bearing across the southeastern flank (Blocks Ia, II, and IV) and partially in the north-northeastern flank (Blocks I and III). Commercial oil production was first recorded from Well 51 on 16 September 1951 at a rate of 50 tons/day. Follow-up production from multiple wells (e. g., Wells 3, 41, 53, 90, 243, and 350) confirmed the lateral continuity of this reservoir. The productive zone in GS-2 spans approximately 7,800 meters southeastward and 3,600 meters northwestward. Minor quantities of free gas were encountered in several wells (e. g., Wells 17, 197, 199, and 201 in Block IV and Well 711 in Block III).

The majority of reserves in GS-2 are concentrated in Block II, which features a vertical closure of up to 1,000 meters (Fig. 7).

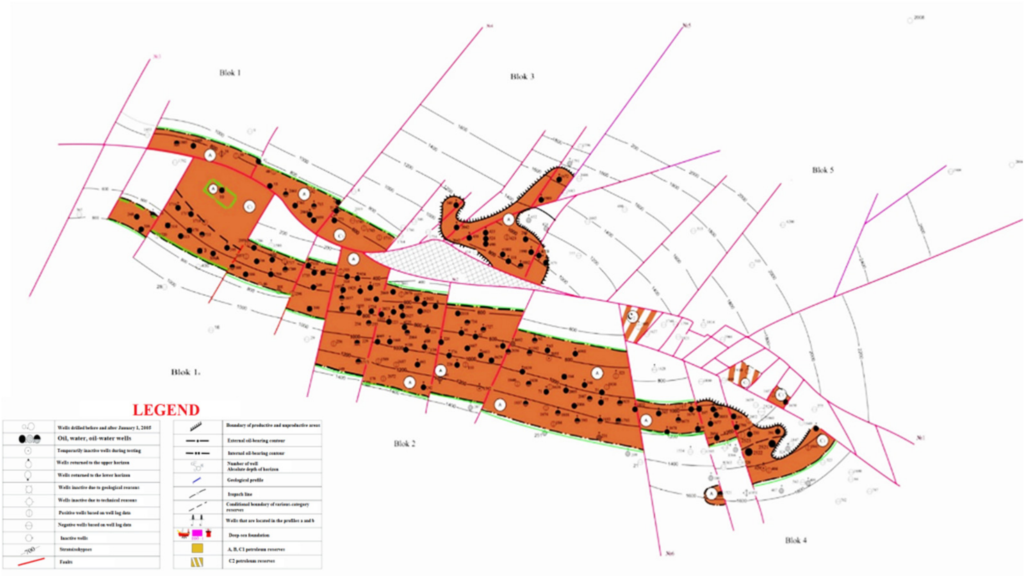

Fig. 7. Oil saturation distribution map for the GS-24 horizon

GS-1 is oil-bearing in all blocks except Block I. Initial production was established on 21 January 1952 from Well 15 (Block II), yielding 50 tons/day at a wellhead pressure of 2.7 MPa.

Block I exhibits low apparent resistivity values (below 4.5 Ohm·m), and testing in Well 1808 yielded formation water. In Block Ia, Wells 1710 and 2051 produced oil, while Wells 1710 and 1718 produced mixed oil and water. Minor gas occurrences were documented in Wells 1784 (Block Ia), 243, and 267 (Block IV).

Similar to GS-2, the primary reserves of GS-1 are concentrated in Block II, which displays significant structural closure and reservoir continuity (Fig. 8).

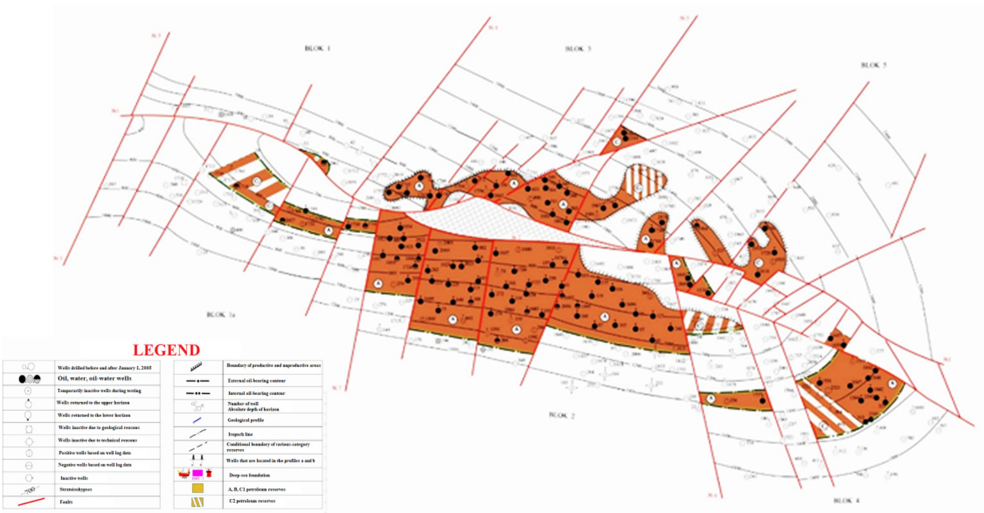

Fig. 8. Oil saturation distribution map for the GS-1 horizon

The Pre-Kirmaki Suite (PKS) is stratigraphically subdivided into four productive horizons: PKS-2a, PKS-2, PKS-1a, and PKS-1. Commercial oil accumulations have been identified in all tectonic blocks except Block I (Fig. 4.1.2.1–4.1.2.4). The apparent resistivity of these horizons generally ranges from 10 to 20 Ohm·m, whereas in Block I it ranges from 4 to 7 Ohm·m. As a result, exploitation was long delayed, and only in 1984 were two wells (1714 and 1715) tested in PKS-1, yielding oil-stained water. In the remaining blocks, extensive well testing has confirmed oil

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saturation throughout the suite, with minimal variation in hydrocarbon contact contours.

In Blocks II, IV, and V, a non-productive zone has been identified in the southeastern crestal areas. This is attributed to facies pinch-outs of PKS-2a or substitution by non-reservoir rocks (PKS-2). The relatively dense well distribution in these zones has enabled precise delineation of reservoir limits.

PKS-2a is oil-bearing in Blocks II, III*, IV, V, and partially in Block Ia. Initial commercial oil flow was recorded on 5 July 1951 from Well 17 (Block IV) at 80 tons/day with a 7 mm choke and 9.5 MPa wellhead pressure. Subsequent development (e. g., Wells 23, 55, 67, 62, 69, and 70) defined oil-bearing areas in Blocks II through V. In the southeastern flank, the productive zone extends 6,000 meters longitudinally, with a width of 200–1,100 meters and vertical closure of 150–1,000 meters. Later, Wells 1711, 1712, 1716, and 1717 confirmed a smaller oil-bearing area in Block Ia.

The PKS-2a reservoir is bounded by an oil-water contact in the deeper parts of the structure and by tectonic faults elsewhere. In Block V, the reservoir is partially truncated by a non-productive zone along the crest. In some wells, PKS-2a is not present in the well section. The boundary between productive and non-productive zones is defined by interpolating between producing wells and those considered non-productive based on well logs. The dense well network in Block V has facilitated detailed mapping of the reservoir extent (Fig. 9).

Fig. 9. Oil saturation distribution map for the PKS-2a horizon

PKS-2 has been in commercial production since 1952 and is productive in Blocks II, III, IV, and V. In Block I, poor reservoir quality (low resistivity) has precluded successful development. In Block Ia, testing in Well 1711 yielded clean formation water (Fig. 10). The main reserves of PKS-2 are concentrated in Blocks II through V, with oil-bearing zones extending 5,000 meters southeastward and 4,000 meters northwestward.

Fig. 10. Oil saturation distribution map for the PKS-2 horizon

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PKS-1a first yielded oil on 14 December 1951 from Well 32 (Block III), producing 70 tons/day with a 9 mm choke and 2.6 MPa wellhead pressure. Subsequent testing of Wells 73, 116, 153, 236, 260, and 424 delineated productive zones in Blocks II through V. Limited oil-bearing zones were also detected in Block I (e. g., Wells 1714, 1715, 2059) and Block Ia (e. g., Wells 1712, 1716, 1710, 1711, 1739, 1884), based on test results and log interpretations (Fig. 11). The principal reserves of PKS-1 are located in Blocks II through V, where the oil-bearing zones span 5,000 meters and reach up to 900 meters in vertical closure.

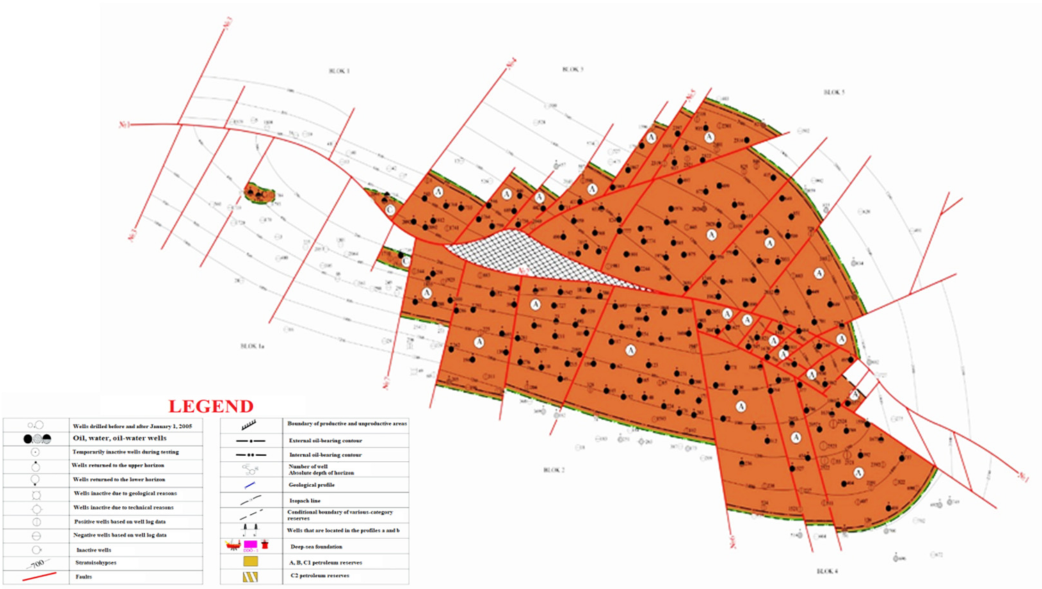

Fig. 11. Oil saturation distribution map for the PKS-1a horizon

PKS-1 is a thin oil-saturated layer located near the top of the Pre-Kirmaki Suite and has only been identified in Block II. In other blocks, due to the absence of a separating shale bed, this horizon merges with PKS-1 (Fig. 12). The first production was achieved on 10 February 1957 from Well 274 (Block II), which produced 62 tons/day through a 6 mm choke at a pressure of 2.4 MPa. Wells 266 and 282 further delineated the PKS-1 reservoir, which was subsequently put into commercial development. The productive area in Block II measures approximately 3,200 by 1,100 meters, with a structural closure of up to 1,000 meters.

The Kirmaki Suite (KS) is stratigraphically subdivided into three horizons: KS-2, KS-1, and KS. Commercially significant oil accumulations have been identified in all tectonic blocks except Block I. Hydrocarbon saturation is more prominent in the lower, sandier units of the suite, while the upper part comprises thicker intervals of non-reservoir lithologies.

KS-2 is oil-bearing in Blocks Ia, II, III, IV, and V. Reservoirs in Block I are water-saturated according to borehole geophysical surveys, and no testing has been conducted in this block. In the southeastern flank, the productive area extends approximately 6,600 meters, and in the northwestern flank about 4,900 meters. The width varies from 180 to 2,000 meters in the southeast and 300 to 1,750 meters in the northwest, with a structural closure reaching up to 1,200 meters (Fig. 13).

KS-1 is productive in all blocks except Block I. In recent years, the oil-bearing limits in Blocks III, IV, and V have been significantly expanded based on new well data (Fig. 14).

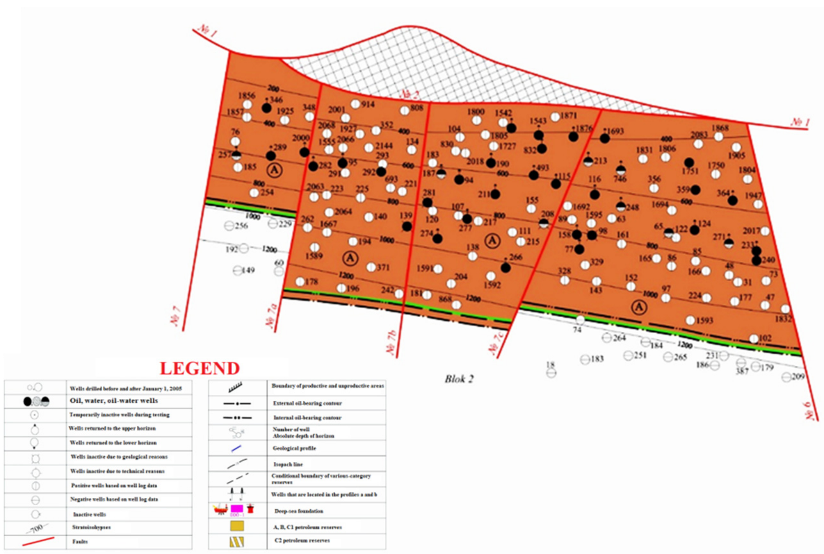

Fig. 12. Oil saturation distribution map for the PKS-1 horizon

KS – is primarily productive in Block II, where it forms a monolithic reservoir with a vertical extent of up to 800 meters. In other blocks, limited oil shows were encountered in a few wells, suggesting residual hydrocarbon presence. In Block Ia, only Well 1733 was tested and yielded formation water. Well log interpretations from Wells 3, 313, 316, 380, 1712, 1720, 1588, and 1710 did not indicate productive intervals (Fig. 15).

In Block III, seven wells (345, 438, 569, 583, 1742, 1745, and 1789) were successfully tested, all yielding clean oil without water. In Blocks IV and V, wells such as 1570, 1966 (Block IV) and 645, 823, 843 (Block V) have also been tested. While two wells (645 and 843) produced oil with minor water, the others yielded clean oil.

These results, along with geophysical interpretations, confirm the presence of a small isolated reservoir in Block III (approximately 1,300×300 meters) and local accumulations in Blocks IV and V.

Fig. 13. Oil saturation distribution map for the KS-2 horizon

Fig. 14. Oil saturation distribution map for the KS-1 horizon

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Fig. 15. Oil saturation distribution map for the KS horizon

The Post-Kirmaki Sandy Suite (PKsS) represents a single productive interval with a thickness ranging from 20 to 50 meters. In Blocks I and Ia, the PKsS deposits have been eroded and exposed on the seabed; the associated reservoirs are water-saturated, and no testing has been performed. However, log data from Well 184 (Block Ia) suggests potential oil saturation.

In Block II, the PKsS has been tested in 37 wells. Of these, eight wells (30, 49, 95, 103, 122, 279, 280, and 281) produced oil, two wells (48 and 758) yielded oil with water, and the remainder produced only formation water. This irregular distribution of hydrocarbon saturation in Block II suggests disintegration of a once-unified reservoir. In contrast, testing in Blocks III, IV, and V confirms that the oil saturation is consistently distributed throughout the suite. The most prolific oil-bearing area is in Block V, where the structural closure reaches up to 1,000 meters.

Initial oil production from the PKsS was recorded on July 30, 1955, in Well 342 (Block III), which yielded 60 tonnes per day through a 6 mm choke under a buffer pressure of 4 MPa. Subsequent testing in Wells 134, 135, 275, 297, 473, 475, and others delineated discrete oil accumulations across Blocks III, IV, and V (Fig. 16).

Fig. 16. Oil saturation distribution map for the PKsS

The Post-Kirmaki Clayey Suite (PKcS) has a thickness ranging from 158 to 220 meters, with an average of 147 meters. In Blocks Ia and II, these deposits are exposed at the seabed and have been eroded along the structural crest.

Industrial-scale reservoirs have been confirmed through multiple wells in Blocks III, IV, V, and to a lesser extent, Block I. The reservoir in Block II is lithologically restricted and localized around Wells 95, 282, 286, 154, and others. The lateral distribution of oil in the PKcS is largely governed by lithological controls. Oil accumulations are primarily associated with sandy layers at the base of the suite, enclosed within dominant clayey facies. As Blocks I and Ia are composed predominantly of clays, they are considered non-prospective (Fig. 17).

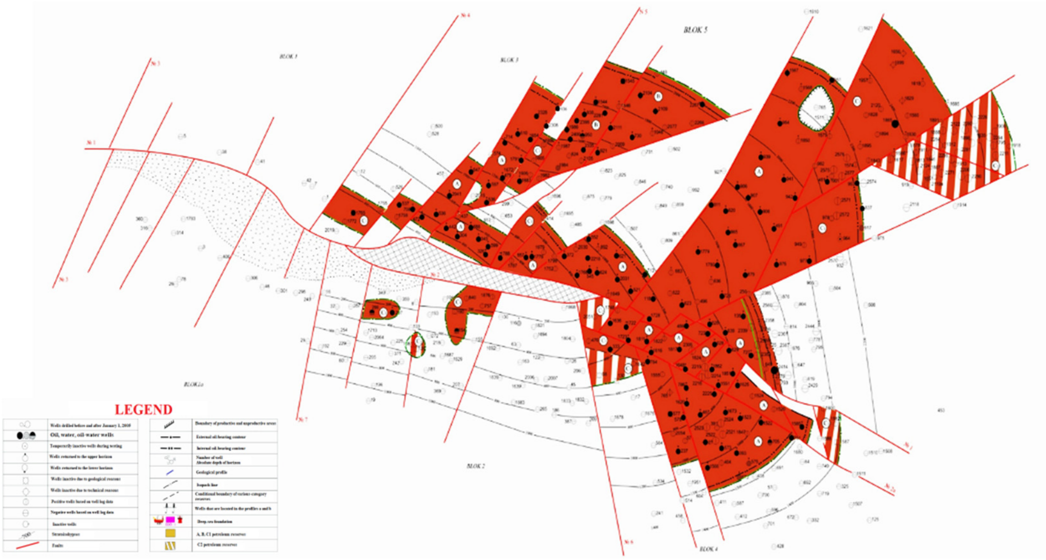

Fig. 17. Oil saturation distribution map for the PKcS

The first oil discovery in the PKcS occurred on March 19, 1962, in Well 342 (Block III), which produced 30 tonnes per day through a 5 mm choke under 2.8 MPa buffer pressure. Wells 473, 527, 552, 557, and others later confirmed the productivity in Blocks IV and V. Initial production rates were generally low, ranging from 3 to 30 tonnes per day.

The distribution of reserves reflects structural and stratigraphic architecture. Block V contains over half of the field's total recoverable reserves, owing to its large closure, multiple stacked reservoirs, and high net-to-gross ratios. The central blocks (II, III) also contribute significantly, while Block I consistently shows poor saturation and marginal reservoir development. These findings underscore the importance of integrating geological and geophysical data to define stratigraphic traps and improve recovery efficiency.

Discussion and conclusions

The geological and petrophysical evaluation of the Neft Dashlary offshore oil field has revealed several key insights essential for optimizing development and managing remaining reserves. The field's hydrocarbon potential is primarily hosted within a multilayered Pliocene Productive Series, comprising more than 25 oil-bearing intervals whose distribution is governed by both structural dislocations and lithofacies variations.

The most productive horizons are found within the Gala and Pre-Kirmaki suites, particularly in structurally favorable Blocks II, III, IV, and V. In contrast, Block I consistently exhibits low porosity, low permeability, and reduced resistivity, resulting in poor hydrocarbon saturation. The spatial distribution of reserves strongly correlates with structural closures, net oil-bearing thickness, and the proportion of sandy versus clay-rich facies.

Structural segmentation by longitudinal and transverse faults significantly influences reservoir compartmentalization and the formation of localized traps. Stratigraphic pinch-outs, lithological transitions, and facies wedge-outs are common within multiple productive horizons and play a critical role in controlling hydrocarbon entrapment and vertical reservoir continuity.

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Гусейнага МАМЕДОВ, канд. геол. наук, доц.
ORCID ID: 0000-0001-6199-3892
e-mail: huseynaqa.mammadov@asoiu.edu.az
Азербайджанський державний університет нафти та промисловості, Баку, Азербайджан

Мурад АБДУЛЛА-ЗАДЕ, д-р філософії (науки про Землю)
ORCID ID: 0009-0001-4150-8340
e-mail: murad.abdullazade@asoiu.edu.az
Азербайджанський державний університет нафти та промисловості, Баку, Азербайджан

Олена ПОГОРЄЛОВА канд. геол. наук, доц.
ORCID ID: 0000-0002-2412-4441
e-mail: yelena.pogorelova@asoiu.edu.az
Азербайджанський державний університет нафти та промисловості, Баку, Азербайджан

КАСПІЙСЬКИЙ ПІОНЕР: СТРУКТУРНА СКЛАДНІСТЬ І РОЗПОДІЛ ВУГЛЕВОДНІВ У ШЕЛЬФОВОМУ РОДОВИЩІ НАФТОВІ КАМЕНІ

Вступ. ***Нафтогазове родовище Нафтові Камені (Neft Dashlary), розташоване у південно-східному секторі Каспійського моря, є унікальним як з геологічного, так і з історичного погляду. Це перше у світі шельфове родовище, освоєне шляхом буріння зі спеціально побудованих морських платформ. Геологічно воно приурочене до Абшеронсько-Балаханської тектонічної зони підняття та розташоване на брекчіантиклінальній складці північно-західно-південно-східного простягання. Основна нафтогазонасичена товща – це нижньопліоценова Продуктивна серія, представлена багатошаровими дельтовими, прибережними та мілководно-морськими фаціями. Незважаючи на тривалу історію розробки, родовище залишається актуальним об'єктом для переоцінки в контексті вивчення різнотипних колекторів, тектонічної сегментації та стратиграфічної складності, що відкриває перспективи для підвищення нафтовіддачі.***

Методи. ***У дослідженні використано комплексний підхід, що включає геологічний, геофізичний та петрофізичний аналіз даних понад 150 свердловин. Узагальнено результати інтерпретації геофізичних каротажів, описів кернів та результатів випробувань. Колекторські властивості визначались за даними понад 1450 зразків керну. Стратиграфічне зіставлення та побудова структурних карт дали змогу відобразити архітектоніку покладів і межі нафтонасичених товщ. Ресурси визначались за детерміністичними методами з урахуванням ефективної товщини, пористості, насичення та площі пастки.***

Результати. ***У межах Продуктивної серії виділено 26 нафтонасичених об'єктів у восьми стратиграфічних пачках (світах), зокрема в горизонтах Gala, Pre-Kirmaki, Kirmaki, Post-Kirmaki тощо. Пористість порід варіює в межах 12–28 %, проникність – від 0.001 до 3.92 мкм². Найбільш продуктивними є горизонти GS-1, GS-2 (свита Gala) та PKS-2a, PKS-2 (свита Pre-Kirmaki), особливо в блоках II, III, IV і V. У блоці I колекторські властивості слабко розвинені. Розподіл вуглеводнів зумовлений поєднанням тектонічних пасток, літологічних ущільнень та фаціальних змін.***

Висновки. ***Родовище Нафтові Камені характеризується складною стратиграфічною будовою та значною тектонічною дислокованістю, що зумовлює неоднорідність колекторів як по площі, так і по розрізу. Інтеграція даних буріння, каротажу та петрофізики дала змогу визначити просторові межі продуктивних інтервалів і сформулювати критерії їх ефективності.***

Ключові слова: ***Нафтове родовище, Продуктивна серія, пористість, проникність, стратиграфія, тектоніка, шельфова зона, геофізичний аналіз.***

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