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PETROPHYSICAL CHARACTERISTIC OF DEEP OIL AND GAS RESERVOIRS IN INLAND AND OFFSHORE FIELDS IN AZERBAIJAN

The article reviews the analytical generalization of lab-scale data on petrophysical parameters of potential hydrocarbon reservoir rocks. The study objects were the known levels in the pay thickness of the Mesozoic–Cenozoic sedimentation basin. The test territory included dynamically and long-term operating inland and offshore oil and gas projects in Azerbaijan. More than a century-long history of these natural hydrocarbon reservoirs shows that the prime oil and gas pools are associated with the South Caspian and Kura depressions subjected to intense subsidence in the Mesozoic–Cenozoic era. Despite the long-term exploitation of the depressions, the deep-level reservoirs are highly commercially promising. At the same time, the challenges of oil and gas extraction in these areas yet remain pending. Currently, high-rate subsoil development in this region is carried out at the depths below 4–4.5 km since the shallow and moderate-depth oil and gas reservoirs are already explored even in difficult ground. The oil industry terms wells longer than 4 km as deep and longer than 6 km as super deep. Aside from engineering difficulties, drilling of such wells involves grand economic problems. For instance, deep and, moreover, super deep drilling cost is very high and ranges from 2–3 to 9–12 million dollars. This fact necessitates improvement of drilling efficiency, which requires high-quality geological validation of promising nature of a deposit and reasoned selection of drilling sites.

Key words: *oil and gas capacity, petrophysical parameters of reservoir rocks, sedimentary rocks, structures, grain size distribution, deep reservoirs, hydrocarbons.*
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Introduction

The relevance of the analytical review of the ample studies into the geological and geophysical characteristics of rocks which determine the reservoir potential as well as oil, gas and gas condensate content in the Meso-Cenozoic formations age is quite obvious. The most important source of knowledge on productivity of oil and gas reservoirs and the whole field as a whole is information on such petrophysical characteristics as carbonate, porosity, permeability, density, grain size distribution, sealing and elastic properties (longitudinal wave velocity) of the rocks. The research also estimated the average values of physical characteristics, the dependence of reservoir properties on the occurrence depth and the relationship of physical parameters [1–4].

The research results over the survey areas are presented in a tabular form and reveal variation in the physical properties of various type reservoirs in time and space, including the patterns of their change across the pay thickness. Preliminary estimates show that the physical properties of homonymous coeval rocks vary significantly as a result of geological and physical processes.

Task description

In recent years, in connection with the study into the oil and gas potential of deep-level sedimentary cover, the comprehensive geological exploration and geophysical survey has been carried out in many well-known oil and gas fields in Azerbaijan. The studies show that the main oil and gas deposits in the region are associated with the deep-lying reservoirs of the South Caspian and Kura Depressions. Accordingly, we analyzed a large amount of data on the geological and geophysical properties of rocks, which govern the reservoir potential as well as the content of oil, gas and gas condensate in the Meso-Cenozoic formations. The studies covered the largest inland deposits in Azerbaijan (Kura Depression), such as the Muradkhanli, Zardob, Tarsdallar, Kursyangya, Jafarly and others, and also the well-known offshore fields of the South Caspian Basin such as Oil Rocks, Sangachaly-Duvanny-Hara-Zira, Guneshli, Gurgan-Deniz, etc.

Geological and geophysical characteristic of oil- and gas-bearing reservoirs

Most of land (onshore) oil deposits are composed of sediments from the Upper Cretaceous to the Quaternary age [5]. In particular, the review of the physical properties of rocks in the geological structure of the Muradkhanli deposit shows that deep-seated oil reservoirs in the area are usually associated with the Upper Cretaceous formations (porosity 11%), Eocene carbonates (marls and limestones with porosity 9.6–10.9%) as well as with the porous Eocene–Maikopean terrigenous rocks (siltstones and sandstones with porosity 15–19.5%) [6]. Rocks exposed by exploration wells in the Zardob area belong to the Meso-Cenozoic era. The Upper Cretaceous volcanogenic and sedimentary rocks were studied in detail here (limestones, calcareous clay and mudstone siltstone). Geologically, the structure of the Dzharly–Saatly oil-and-gas-bearing area of the Middle Kura Depression is composed of Quaternary deposits, Apsheron, Akchagyl series, pay thickness (Upper Pliocene), Sarmat, Chokrak, Maikopean series, as well as Cretaceous and Cretaceous-age volcanic formations. Drilling logs in the areas of Sor-Sor and Karadzhaly in the northwestern Kyurdamir extension prove the identical geological structure of the geological section over the whole tectonic zone. At the same time, the

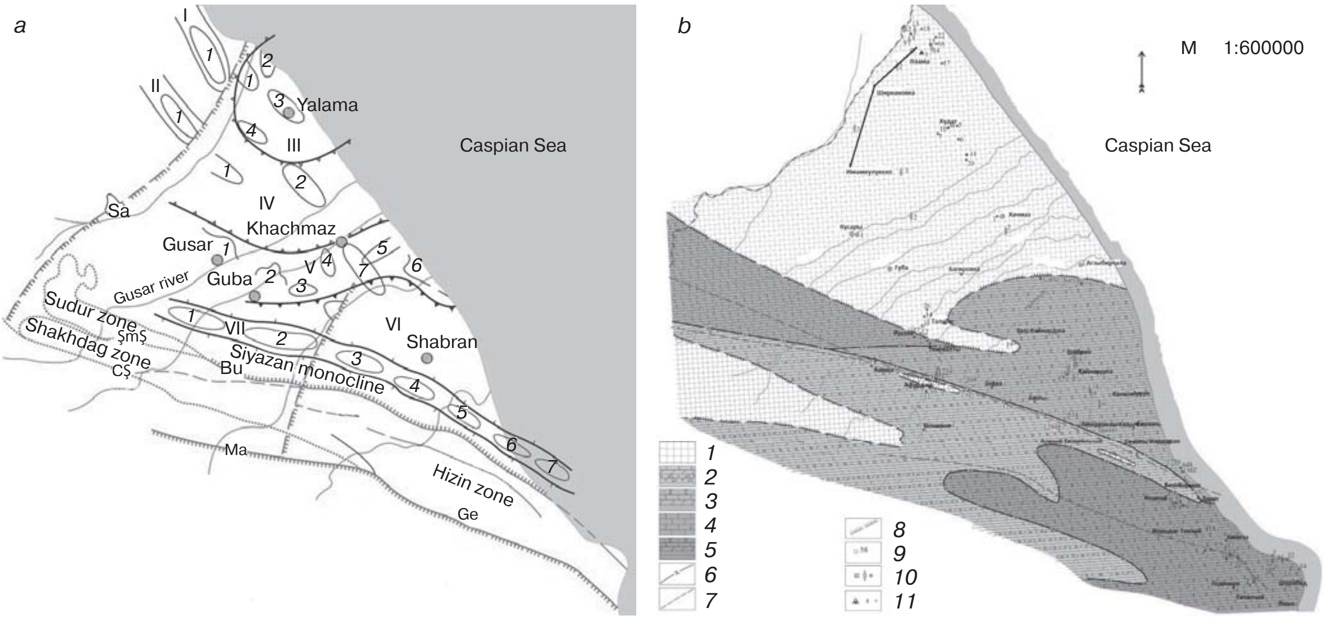

Fig. 1. Tectonic scheme (a) and lithofacial map (b) of the Valanzhin series in the Caspian–Guba oil and gas region [17].
Anticline zones (uplifts):
I — Eastern anticline zonea (*1* — Khoshmenzil); II — Western anticline zone (*1* — Adzhinour); III — Yalama zone (*1* — North Yalama, *2* — East Yalama, *3* — South Yalama, *4* — Shirvanovka); IV — Zeikhur zone (*1* — Imamkulukent, *2* — Khudat); V — Gusar–Khachmaz zone (*1* — Khazri-Kusar, *2* — Zizik, *3* — Guba, *4* — West Khachmaz, *5* — East Khachmaz, *6* — Agzybirchala, *7* — Khachmaz); VI — Divichi depression; VII — Talabi-Kainardzha zone (*1* — Nyugedi, *2* — Talabi, *3* — West Kainardzha, *4* — Kainardzha, *5* — Kyzylburun, *6* — Kyzylburun sea, *7* — sea Zaryat). Deep faults: Sa — Samur, Ma — Malkomud, Ge — Germian. Regional faults: ŞmŞ— North Shakhdag, CŞ — South Shakhdag, Bu — Bulud.
1 — Land areas; *2* — Shallow facies: clay, marl, conglomerates, laminated and block limestone; *3* — Shallow carbonate–terrigenous facies: sandstone, clay, marl, limestone; *4* — Shallow offshore carbonate facies: limestone; *5* — Relatively deep-water carbonate–terrigenous facies: sandstone, clay, marl, limestone; *6* — Boundaries of lithofacies; *7* — Tectonic faults; *8* — Thinning-out surfaces; *9* – Wells; *10* — Stratigraphic and exploration wells; *11* — Key and production wells

Dhzarly–Sor-Sor–Karadzhaly zone has an essentially different geological structure than the Muradkhanly Bock (uplift), and volcanic formations in Dzharly and Sor-Sor have no direct contact with oil and gas source beds of the Paleogene–Neogene system.

This geological feature governs the prospects for the future oil and gas exploration in the northeastern side of the uplift.

It is believed that in case of favorable structure and facies, hydrocarbon reservoirs can be found in the weathered layer and in the wide interval of Meso-Cenozoic sediment cover of the uplift [7].

Another known inland area in Azerbaijan is the Caspian-Guba oil and gas region (**Fig. 1**). The physical and reservoir properties of samples from deep-level strata in the section of deposits and reservoirs under exploitation were investigated.

According to these studies, the density of dried and wet clayey sandstones sampled from the relatively upper pay thickness was studied. It was confirmed that the density of these rocks changed over a wide range (1.94–2.36 g/cm^3). Porosity ranges as 7–30%, and the ultrasonic wave velocity varies from 2500 to 3000 m/s.

The density of sandstone and mudstone rocks ranges as 1.78–2.29 g/cm^3 in dry condition and as 2.68–2.98 g/cm^3 in wet condition; the porosity is 6.15–30%, and the velocity of ultrasonic waves is 1800–2200 m/s.

At the same time, the reservoir properties of rocks vary sharply depending on the depth. Unlike the above-described inland areas, the Siazan monocline has a rather complex geological structure, which allows the area to be divided with respect to the source-bed and other properties. In particular, the geological structure of the monocline contains the Upper Cretaceous and Paleogene–Miocene formations in the mountainous regions, and the Pliocene sediments in the lowland. The petrographic properties of these deposits were studied in sufficient detail with calculation of the average values of the physical properties and the limits of the reservoir properties, areally and per stratigraphic units [8–19].

For instance, the greatest depth of occurrence of the Sumgait series uncovered by wells in the Zeiva area is 820–2415 m. Here, clayey rocks have the density of 1.90–1.95 g/cm^3 and porosity of 20–25% (up to 30% in some cases), and the velocity of ultrasonic waves is 1200–1300 m/s. The density of the Maikopean age siltstones varies between 2.56 and 2.65 g/cm$^{3.}$ the porosity is 15–30%, and the ultrasonic wave velocity is 2000–2500 m/s. The density of sandstones is 2.07–2.55 g/cm^3 and the porosity is 8.2–22.5%. The velocity of ultrasonic waves in sandstones, as well as in other rocks varies in the range of 950–4000 m/s depending on their lithology. The Paleogene rocks in the geological structure of the monocline, due to the metamorphic changes, have the following physical properties: density 2.05–2.65 g/cm^3 porosity 8.5–30%, ultrasonic wave velocity 2100–4000 m/s. Due to

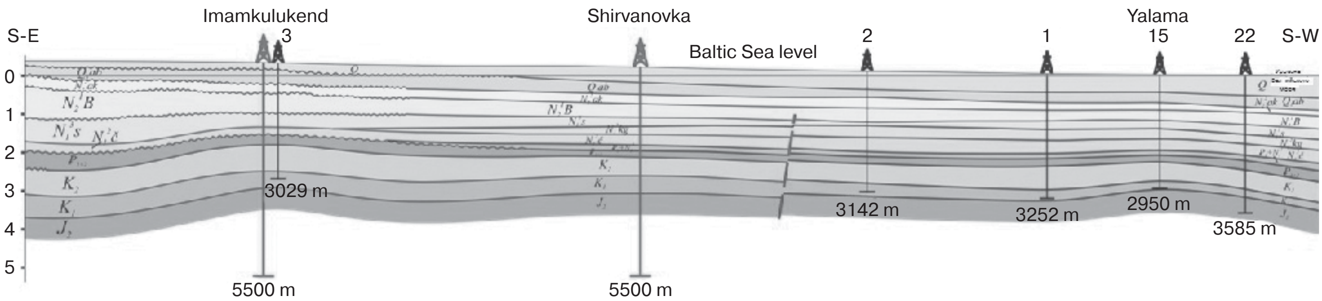

Fig. 2. Geological section along the line Imamkulukend–Shirvanovka–Yalama line [18]. 3, 2, 1,15, 22 — Production wells

structural and tectonic features of the South-East subsidence of the Greater Caucasus, along with local uplifts of the pan-Caucasian direction, some anti-Caucasian strike-type structures also develop sometimes.

The main structures of the Caspian–Guba oil and gas region are the Yalama, Khudat and Agzybirchala uplifts, which are separated from the Gusar structure and the Talabi–Gaiynardzhia anticline zone by a wide syncline. In the depression composed of two parts, the thickness of the Paleogene deposits increases from 1000 to 1500 meters from the northwest to the southeast. The basin expands southeastward and continues in the Caspian Sea. The thickness of the Paleogene sediments on the uplifts of Yalama and Khudat varies from 100 to 370 m (**Fig. 2**). Despite the fact that the Khudat structure is enclosed in a 200-meter paleo-terrain contour, no closed-loop structure is observed on the Yalama site [5, 6, 12].

Despite the highly promising nature of the Upper Cretaceous, Paleocene, Eocene, Oligocene–Miocene sediments in the center of the study area and in the deep-seated formations, this forecast is yet unproved. Inside the considered areas, the Mesozoic sediments were completely uncovered by deep drilling (2600–3700 m, refer to Fig. 2). It should be noted that the density, particle size distribution, carbonate content, ultrasonic wave velocity, magnetic susceptibility, porosity, and permeability of rocks sampled in deep exploratory wells in the Yalama and Khudat uplifts were studied on a laboratory scale. The data base is composed of hundreds of core measurements, and the actual values are averaged using the minimum and maximum values typical of the certain lithological varieties and occurrence depths. For example, within the considered areas, carbonate content, reservoir properties, density and velocity of elastic waves were studied from the Lower Pliocene pay thickness down to the Jurassic formations. The pay thickness at the occurrence depth 955–1235 m is represented mainly by clayey sandstones with low carbonate content (11.6%). Its porosity is 20.2%, permeability is $1837 \cdot 10^{-15}$ μm^2 and the density is 2.1–2.5 g/cm^3. The average velocity of ultrasonic waves in these strata is 2800 m/s.

The Sarmatian sediments are topped in the depth interval of 1236–1460 m and are represented by the alternation of sandstones, mudstones and clays with a carbonate content of more than 15%, porosity of up to 20%, permeability of more than $25 \cdot 10^{-15}$ μm^2 and density of 2.15–2.57 g/cm^3. The velocity of ultrasonic waves is 2000 m/s. A decrease in the velocity ultrasonic waves in the Sarmatian series at almost the same density as the pay thickness has can be associated with increased clay content in the section. Deposits of the Karagan series occur at depths of 1462–1864 m and are represented by clays with a carbonate content of more than 14%, porosity of more than 20%, permeability of $730.5 \cdot 10^{-15}$ μm^2 and a density of 2.11–2.67 g/cm^3. The ultrasonic wave velocity is 1900 m/s. In this case, the decreased velocity of ultrasonic waves is possibly associated with poor cementation of sandstones.

The Chokrak stage in the studied areas is stricken at the depths of 1870–2080 m and is represented by clays with a density of 2.08–2.68 g/cm^3 carbonate content of 38% , porosity of more than 21.7% and permeability of $9.2 \cdot 10^{-15}$ μm^2. The velocity of ultrasonic waves is 1750 m/s. As follows from these data, there is a distinct inverse relationship between the carbonate content and the velocity of ultrasonic waves in the section as of the Chokrak stage as in the previous stratigraphic intervals, i.e., the increase in the carbonate content leads to a decrease in the ultrasonic wave velocity. The Maikopean series in the test area is topped in the depth interval of 2080–2585 m. The series is lithologically composed of alternating clays and sandstones with a carbonate content of more than 76.3%, porosity of 15.7%, zero permeability, relatively high density of 2.29–2.72 g/cm^3 and an increased velocity of ultrasonic waves (2500 m/s).

The Mesozoic section in the considered areas begins from the Maastrikht stage identified in the depth interval of 2596–2598 m and represented by clay limestone with a density of 2.63–2.72 g/cm^3 carbonate content of more than 32.8%, porosity of 5.0% and zero permeability. The velocity of ultrasonic waves here jumps 4700 m/s. Obviously, more clayey limestone and high compaction killed permeability and accelerated ultrasonic waves. The Cognac stage lies at the depths of 2610–2633 m and is represented by clay limestone with a carbonate content of more than 66%, porosity of more than 5% and permeability up to $0.01 \cdot 10^{-15}$ μm^2. The density of rocks is more than 2.6 g/cm^3 and the velocity of ultrasonic waves is 4700 m/s as in the previous formations of the same composition.

The Turonian sediments stricken at at depths of 2633–2735 m are represented by marls and clay limestones with a carbonate content of more than 84%, porosity of more than 4% and permeability of $1.45 \cdot 10^{-15}$ μm^2. The density of these rocks is 2.60–2.67 g/cm^3 and the velocity of ultrasonic waves is slightly lower than in the Cognac stage and is 4350 m/s. It can be assumed that the decrease in the velocity of ultrasonic waves in these rocks is associated with a multifold increase in porosity in the Turonian deposits.

The Albian stage within the study areas is topped at the depths of 3061–3074 m and is represented by sandstones with a carbonate content of 22%, porosity of more than 7%

Table. Ranges and averaged reservoir and physical properties of pay thickness sediments in the section of the Oil Rocks deposit.

Depth interval, m	Lithology	Carbonate content, % max–min average	Density σ, g/cm^3 max–min average	P-wave velocity *Vp*, m/s max–min average	Porosity, % max–min average	Permeability, ·10^{-15} μm^2 max–min average	Permeability capacity
430–480	Sandy-clayey siltstone	8.3–12.8 9.7	2.42–2.50 2.45	2200–2600 2400	11.6– 20.1 16.3	28.5–79.4 59.7	Good
480–600	Slit clay	4.9–26.8 19.14	2.36–2.56 2.50	2000–3100 2650	12.4–17,0 11.0	2.6–8.1 5.35	Very weak
640–690	Clayey-sandy siltstone	5.8–12.4 7,53	1.6–2.34 2.20	1700–2400 1980	11.0–33.6 16.92	0.1–95.7 40.68	Good
690–930	Clayey-sandy siltstone	8.9–9.9 9.37	2.01–2.10 2.05	2400–2600 2500	19.5–22.9 21.4	0.1–95.7 2.20	Very weak
930–940	Sandy-clayey siltstone	8.2–9.4 8.8	2.01–2.47 2.37	2300–3200 3000	9.9–25.7 15.5	1–3.5 2.3	Very weak
940–1130	Clayey siltstone	4.5–6.0 5.27	2.37–2.67 2.56	2500–3000 2800	6.0–16.0 9.57	214.9	High
1130–1400	Clayey-sandy siltstone	23.4–25.8 24.6	2.38–2.53 2.44	2100–3200 2580	9.7–11.1 10.40	2.25–6.23 4.24	Very weak
1500–1550	Clayey siltstone	3.0–11.0 7	2.40–2.47 2.44	2300–2400 2350	12.6–14.9 13.75	0.6–2.0 1.3	Zero
1600–2050	Clayey siltstone	3.8–15.7 11.8	2.47–2.56 2.51	3500–3600 3550	7.6–10.8 9.02	56.9	Good
2050–2200	Sandy-clayey siltstone	4.1–14.6 9.79	2.36–2.43 2.40	3150	13.6–17.9 14.8	12.5	Moderate
2200–2500	Clayey siltstone	3.8–15.7 11.8	2.47–2.56 2.51	3500–3600 3550	7.6–10.8 9.02	56.9	Good
2550–3550	Clayey siltstone	7.8–8.7 8.1	2.43–2.60 2.56	3600	8.5–10.0 9.9	66.9	Good
3550–4600	Clayey-sandy siltstone	2.8–10.8 6.8	2.58–2.64 2.61	4000	5.3–14.2 9.57	60.5	Good
Comment: numerator — minimal and maximal values, denominator – average value.							

and no permeability. The density of the Albian sandstones is 2.62–2.75 g/cm$^{3.}$ and the longitudinal wave velocity in these rocks increases to 4500 m/s. Obviously, the primary cause of the higher ultrasonic wave velocity in the Albian sandstones is their relatively high density and low porosity.

The Aptian formations are uncovered in the depth interval of 3074–3229 m as clay limestones and mudstones with a carbonate content of more than 23% and no permeability. The density of these rocks is 2.48–2.63 g/cm^3. The ultrasonic wave velocity drops to 3850 m/s, which is apparently associated with lower density and higher porosity of these rocks.

The Barremian stage composed of sandstones is stricken in the depth interval of 3605–3696 m. The carbonate content of rocks here is about 4% with porosity up to 11%, permeability of 0.45·10^{-15} μm^2 and density of 2.50–2.62 g/cm^3. The velocity of ultrasonic waves is 3000 m/s. A significant decrease in the ultrasonic wave velocity as compared with the Aptian formations, at almost the same density and insignificant difference in other parameters, may be due to a sharp decrease in the carbonate content of sandstones in the Barremian stage.

The Jurassic sediments within the studied areas are uncovered at the depths of 3441–3608 m. Lithologically, they are mainly represented by siltstones and sandstones with a carbonate content of about 56%, which is many times higher than in the Barremian sandstones. The Jurassic formations have the porosity 0.65% higher than in the Barrem but are nevertheless impermeable at a density of 2.53–2.62 g/cm$^{3.}$ i.e. the same as in the Barrem sandstones. However, the velocity of ultrasonic waves in the Jurassic sediments is 450 m/s higher than in the Barremian stage [7, 11].

It follows from the review of data on the offshore deposits in Azerbaijan that the Oil Rocks deposit occurs within the Apsheron archipelago, in the near-axis zone of the Apsheron–Balkhan structural mega-saddle, and is oriented in the general Caucasian direction. The deposit structure is complicated by two longitudinal and many transverse faults. The longitudinal faults form a wide zone of disjunctive dislocations, composed of strongly deformed breccia sediments of the Oligocene–Miocene age. In the southeast of the structure, at intersection of the longitudinal and transverse discontinuous faults, a mud volcano is located. Here, at the bottom of the sea, there are numerous griffins that continuously spread out oil and gas. The Oil Rocks deposit is characterized by bedded, lithological and tectonic types of oil traps. The density of clay rocks here is 2.20–2.48 g/cm^3 porosity is 8.3–17% (in some cases 25%), and the ultrasonic wave velocity is 2150–2200 m/s. The density of siltstones varies between 2.13 and 2.60 g/cm^3, the porosity ranges as 15–28%, and the ultrasonic wave velocity varies as 1300–2200 m/s. The density of sandstones is from 2.00 to 2.50 g/cm^3, ane the porosity varies between 7.2 and 22.0%.

In all rocks, the ultrasonic wave velocity varies as 850–2800 m/s depending on the lithological composition. The density of carbonate clays in the pay thicknes is 2.02–2.59 g/cm^3, porosity is 8.5–30%, and the velocity of ultrasonic waves is 2100–3500 m/s.

The granulometric content of the pay thicknes in the Oil Rocks area is mainly represented by aleuritic facies, i.e., particle sizes from 0.1 to 0.01 mm. This indicates the prevalence of siltstone in the section over other facies. In order to find out the nature of the change in the reservoir properties in the pay thickness with depth, the ranges of physical parameters were identified. In particular, the carbonate content of rocks varies from 5.27 to 24.6%, and the permeability ranges from 1.3 до 214.9·10^{-15} μm^2 with porosity of 9.02–21.4% (**table**) [12]. According to the generalized data, it can be assumed that the changes in the physical characteristics of the pay thickness rocks in trhe Oil Rocks deposit associated with the quantitative intensity of lithological differences, variety of rocks, their mineralogical composition and tectonics.

The obtained variation patterns of the petrophysical characteristics in the reservoirs in depth (**Fig. 3**) were compared with the neighboring areas, in case of similarity of their paleogeography, structure and tectonics.

Within the Baku archipelago, the petrophysical characteristics of rocks in the northern structures such as Sangachaly-deniz, Duvanni-deniz and Bulla-deniz, with the mature pay thicknes were considered [7]. The total pay thickness (3950–4000 m) was topped in the Sangachaly-deniz area and in the northeast of the other areas. On the dome and near the dome of local uplifts in Sangachaly-deniz and Duvani-deniz, the pay thickness is 2960–3600 m. Tectonically, the Sangachaly-deniz uplift is an asymmetric brachy-fold separated by a long but shallow saddle from the Kanizadag uplift located northwest. In the pay thickness, in the southeast, the pericline of the fold is expressed in the relief by a shallow and short saddle, which separates it from the Duvanni uplift.

The Sangachaly-deniz and Duvani-deniz rock masses have been studied by deep drilling from modern sediments down to the Mesozoic formations. The pay thickness is exposed in the north of the uplift but is breached to a depth of 750–800 m in the near-axis part. The lithological section of rocks is represented mainly by the alternation of sand, sandstone and clay. The maximum pay thickness uncovered by wells is 3950–4000 m, and the minimum is 3000 m. The geological structure of the area involves the pay thickness, Akchagyl, Apsheron and Quaternary formations. The pay thickness is topped to the upper Kirmaki series. The pay thickness section is composed of clays, sandstones and siltstones. The density of clay rocks is 1.95–2.20 g/cm^3, porosity is 7.5–25.5% and the ultrasonic wave velocity varies between 1950 and 2300 m/s. Unlike clays, the density of sandstones is 2.15–2.50 g/cm^3, and the ultrasonic wave velocity is 1200–3000 m/s. The density of siltstones is 2.06–2.56 g/cm^3, porosity is 5.5–30%, and the ultrasonic wave velocity varies as 1950–2800 m/s.

The permeability determined from core samples is relatively small. To determine the permeability as a function of porosity, a special study was carried out, and the correlation interdependence $K_{perm}=f(K_{por})$, where K_{perm} is the permeability factor; K_{por} is the porosity factor [20, 21]. However, the dependence is conditional as any permeable rock is known to have porosity, but not every rock with porosity is permeable.

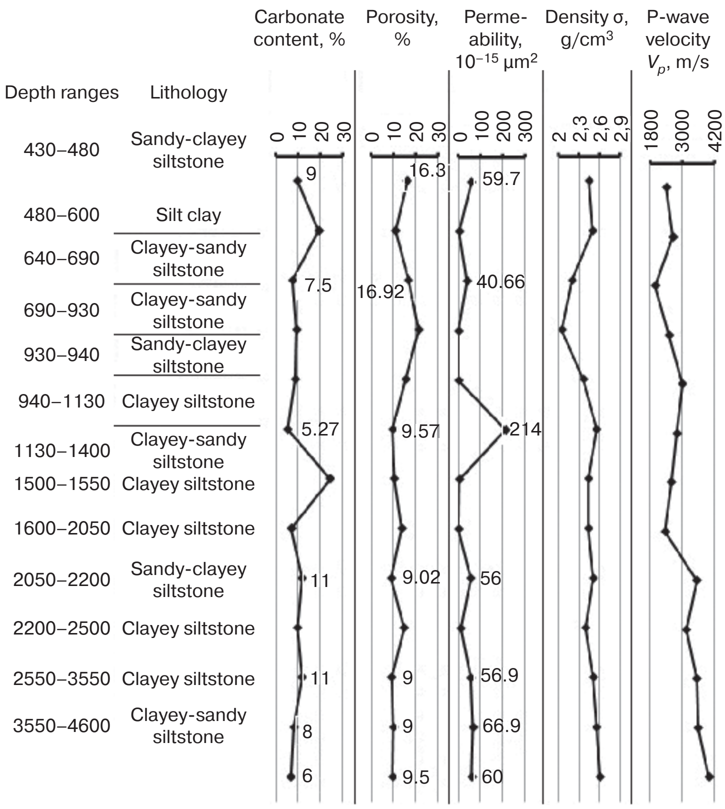

Fig. 3. Ranges of average values of physical parameters in sedimentary rocks of pay thickness in the Oil Rocks deposit

It follows from the above analysis that in the considered granular reservoirs of the study areas, the porosity and, in particular, the permeability of rocks are controlled mainly by the quantitative content of psammitic–aleurolitic and, in particular, psammite facies. Such dependence of the reservoir properties is reflective of low or zero secondary porosity associated with fracturing, cavernousness, etc. In turn, low carbon content eliminates possibility of leaching meant to imporve reservoir properties mainly in carbonate rocks. The absence of this process in the reservoirs under consideration is evidenced not only by their low carbonate content, but also by low reservoir properties.

Due to the direct relationship between changes in rock density and ultrasonic wave velocity, these properties correlate well with each other. However, between the lithofacial, reservoir and studied physical properties of rocks in the case under discussion, there is no more or less clearly expressed dependence.

It follows from the foregoing that in order to clarify oil-and gas-bearing potential of certain structures of the Baku archipelago, it is necessary to carry out additional geological exploration and geophysical survey (gravimagnetometric, electrometric, seismic exploration and petrophysical studies) followed by deep drilling. Such investiation will make it possible to more effectively study the reservoir properties of deep oil-and gas-bearing strata, as well as the structure and tectonics of the considered areas.

Conclusions

Based on the accomplished review of the generalized petrophysical and reservoir studies, the comparative analysis of deep-seated formations in the South Caspian and Kura depressions, as well as in the Caspian–Guba oil and gas region has been performed. It follows from the analysis that the wide-range variation in the properties of the studied objects is mainly due to the lithological heterogeneity of the sediments, variety of rock properties and tectonic conditions. In addition, there is a certain pattern between the factors of porosity and permeability. The gathering and interpretation of petrophysical and oilfield data reveals oil-bearing capacity of some reservoirs.

In particular, it should be noted that:

– firstly, the wide-range variation in reservoir properties of oil-bearing formations over the area of the inland (onshore) deposits is mainly associated with lithogenesis, heterogeneous lithology of sediments, occurrence depths and with peculiar structure of local uplifts;

– secondly, the velocity of ultrasonic waves increases in dense limestone and less often in rocks with high carbonate content, at some deviations with stratigraphic depth;

– thirdly, when predicting oil and gas potential in deep reservoirs in the territories under consideration, along with the exploration and geophysical survey methods, it is advisable to use the depth-wise change patterns of permeability, porosity and other characteristics of prodctive reservoirs.

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