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Investigation of Petrophysical Properties in Lower Cretaceous Hizin Zone of Azerbaijan

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Исследование петрофизических свойств нижнего мела в Хизинской зоне Азербайджана

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petrophysics, carbonate content, porosity, permeability, clay content, well, rocks, density, thickness, Mesozoic, oil and gas appearances, synclinore, fault, blocks, drilling, oil.

Investigations of the petrophysical properties of deposits in the Khizin zone have been carried out in several fields.
In the study area, the Lower Cretaceous complex mainly consists of carbonate and clay formations. The lithological composition and sizes of rock fragments vary sharply within a small range of depth. The Lower Cretaceous deposits are exposed at depths of 450–1815 m; with an increase in carbonate and clay content of rocks, the porosity naturally decreases in this interval.
According to petrophysical investigations, it can be concluded that with an increase in depth, a certain change in the reservoir properties of rocks occurs, that is, with a decrease in porosity of rocks, an increase in carbonate and clay content is observed. When predicting the oil-and-gas-bearing capacity of deep-seated strata in the area under consideration, it is advisable to use not only field geophysical techniques, but also a characteristic change in the porosity of rocks with depth revealed by petrophysical investigations.
In the southeastern Khizin tectonic zone, on the eastern flanks of Sitalchay and Shurabad uplifts, Cenomanian deposits are more common. Among the greenish-gray clays in the section, there are widespread calcareous-clayey gravelstones, limestones, sands and sandstones. In the central part of this zone, the section is composed of greenish-gray clays with siltstone interlayers. Gravelite and sandy siltstones reappear in the Senomanian section, south of Atachai. There are also breccia conglomerates in the Bayimdag-Takchay, Sitalchay-Yashma and Shurabad areas. In the Zoratmulda area, the upper part of the Cenomanian is distinguished with the Zoratsky horizon composed of bituminous clays. In the southeastern Khizi tectonic zone, the floor thickness reaches 200 m. According to the data provided, it can be concluded that in the Khizi tectonic zone, oil and gas shows were recorded in all sections of Mesozoic sediments exposed by drilling. The observed oil and gas fountains occurred during the Alba (Shurabad), Valandzhin (Begimdag-Tekchay) and Middle Jura (Keshchay) strata penetration.

Ключевые слова:
петрофизика, карбонатность, пористость, проницаемость, глинистость, скважина, породы, плотность, толща, мезозой, нефтегазопроявления, синклинория, разлом, блоки, бурение, нефть.

Осуществлены исследования петрофизических свойств отложений Хизинской зоны на нескольких месторождениях.
В районе исследований нижнемеловой комплекс в основном состоит из карбонатных и глинистых образований. Литологический состав и размеры обломков пород резко меняются в пределах небольшого диапазона глубины. Нижнемеловые отложения вскрыты на глубинах 450–1815 м; с увеличением карбонатности и глинистости горных пород пористость закономерно уменьшается в данном интервале.
Из результатов петрофизических исследований можно сделать вывод, что с увеличением глубины происходит определенное изменение коллекторских свойств горных пород, то есть с уменьшением пористости горных пород наблюдается увеличение карбонатности и глинистости. При прогнозировании нефтегазоносности глубокозалегающих толщ в рассматриваемой области целесообразным является применение не только полевых геофизических методов, но и использование характерного изменения пористости пород с глубиной, выявленных петрофизическими исследованиями.
В юго-восточной части Хызынской тектонической зоны, на восточных крыльях Ситалчайского и Шурабадского поднятий более распространены сеноманские отложения. Среди зеленовато-серых глин в разрезе широко представлены известково-глинистые гравелиты, известняки, пески и песчаники. В центральной части зоны разрез сложен глинами зеленовато-серого цвета с прослоями алевролитов. Гравелитовые и песчанистые алевролиты вновь появляются в разрезе Сеномана, к югу от Атачай. В районах Байымдаг-Такчай, Ситалчай-Яшма и Шурабад имеются также брекчиевидные конгломераты. В районе Зоратмульды в верхней части сеномана выделяется зоратский горизонт, сложенный битуминозными глинами. В юго-восточной части Хызынской тектонической зоны мощность этажа достигает 200 м. Из приведенных данных можно сделать вывод, что в Хызынской тектонической зоне нефтегазопроявления зафиксированы во всех разрезах мезозойских отложений, вскрытых бурением. Наблюдаемые фонтаны нефти и газа произошли при вскрытии толщ Альба (Шурабад), Валанджина (Бегимдаг-Текчай) и Средней Юры (Кещчай).

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Introduction

In the second half of the past century, in order to study the section and oil and gas content of Mesozoic sediments in the Khizin zone, exploratory drilling was carried out at the Shurabad, Keshchay, Sitalchay, Begimdag-Tekchay and Gadisu fields, with the majority of the drilling operations at the Shurabad and Begimdag-Tekchay fields. The relevance of studying the Mesozoic sediments has increased due to industrial flows of oil and gas from the exploration wells drilled in the Shurabad area [1–4].

Materials and Methods

The territory of the Shurabad region is located in the southeastern part of the Caspian-Guba zone, 65 km north-east of Baku. Tectonically, the Shurabad structure is located in the southeast of the Shahdag-Khizi synclinorium and constitues an asymmetric anticlinal fold with a Pan-Caucasian extension and relatively gentle (40–50 °) northeastern and vertical (65–70°) southwestern wings. The structure is 8.7 km long and 1.5 km wide and is divided into the northeastern, central and southwestern tectonic blocks, complicated by two longitudinal tectonic faults. The northeastern and central tectonic blocks are also complicated by longitudinal faults, as well as by a transverse fault passing through the center of the fold (Fig. 1).

During drilling in the Shurabad area, gas shows of varying intensity were observed from Upper and Lower Cretaceous and Middle Jurassic sediments, as well as oil shows from the intervals of the Albian-Barremian and Campanian-Santonian sections. During the tests, inflows of oil and gas were obtained from the Albian sediments [1–8].

In the Shurabad area, an increase in the carbonate content and a decrease in the permeability of the marly-clay group of reservoirs in the base of the Barremian floor were observed. Rather high permeability of carbonate deposits is noted only in exploration well No. 36. For instance, clay mud was absorbed with gas shows in the course of drilling of the lower part of the Barremian floor as well as the upper part of the Hauterivian floor in the well.

Hauterivian and Valanginian sediments in Shurabad are more clayey than in Tekchay. Relatively good reservoirs were found at the bottom of the Valanginian floor in well No. 34 drilled near the arch of the VK pericline [4, 9–11]. Numerous gas shows in this well and a strong gas gusher, formed in the course of drilling the Hauterivian floor at the depth of 2410 m in well No. 31, drilled in the vaulted part of the N – W pericline, demonstrate that the Neocomian strata are gas-prospective (Fig. 2).

The prospects for the Kyulyullyu horizon are mainly associated with a tectonically shielded oil and gas deposit identified by structural exploration wells drilled in the northwestern part of the northeastern limb of the Shurabad fold. 20 tons/day oil production from well No. 4 shows that this deposit, located at a rather shallow depth (250-300 m), is of industrial importance.

As known, the aforementioned prospective sites are in the southeastern part of the Khizin zone. Expansion of the northwestern part of the zone can only be based on positive oil and gas indications from the Afurja region.

During the Albian period, sedimentation in the Gilesi syncline intensified, and the surface of the Aptian sediments sank down to 200 m in the southeastern part of the structure. Begimdag-Tekchay, Sitalchay and Shurabad anticlines increased their amplitudes, maintaining the same dimensions. As can be seen from the above, the tectonic movements that took place in Albian and Cenomanian did not change the structural plan in the Khizi zone.

The fact that the Upper Turanian sediments overlie older sediments with sharp angles and inconsistent azimuths shows that tectonic movements in the Upper Turonian were more important during folding. At the beginning of the Upper Turonian, the southeastern pericline of the Beshbarmag anticline shifted 1.5 km to the west and southwest relative to its position in the Cenomanian. The mismatch between the

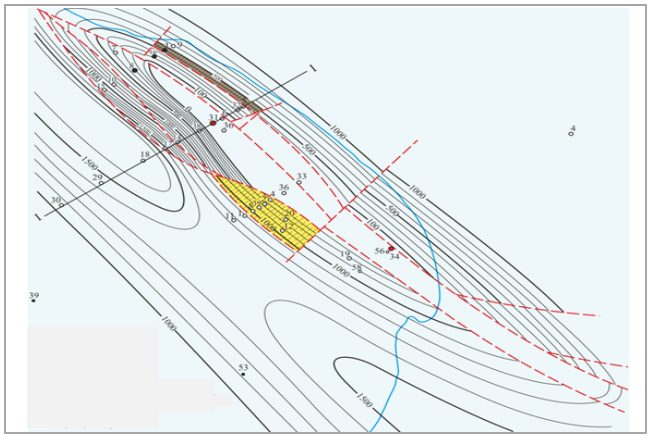

Fig. 1. Structural map of the Shurabad area according to the arch of the Aptian deposits (author H. Yusifov, A. Suleimanov)

axial azimuths of the Upper Turonian structure, which extends in a more meridional direction, reached 25° [12–15].

Paleostructural analysis reveals that, as a result of the Upper Turonian movement, the Shurabad anticline tilted more to the southeast. As in previous geological periods, this structure was located in the anticlinal belt with the Beshbarmag and Gilazi structures, and not with the Bagimdag-Tekchay structure. Along the 60 m isohypsum, the structure was 8 km long, 3 km wide, and 100 m high. This anticlinal structure is separated from the Begimdag-Tekchay uplift by the already formed relatively wide and deep Shurabad syncline [12, 16, 17].

Sediments of the Lower Cretaceous in the Keshchay and Shurabad regions of the Caspian-Guba oil and gas field, the Lower Cretaceous (Valanginian, Hauterivian), the Upper Cretaceous in the northeastern limb of Sitalchay, the Lower Cretaceous (Valanginian) and the Upper Cretaceous in Yashma and Begimdag are considered prospective.

The oil and gas content of the Albian floor is due to the Kyulyullyu sandstone horizon in its upper half. Its oil content has been confirmed in Shurabad and other regions.

In the southeastern Khizin tectonic zone, on the eastern flanks of Sitalchay and Shurabad uplifts, Cenomanian deposits are more common. Among the greenish-gray clays in the section, there are widespread calcareous-clayey gravelstones, limestones, sands and sandstones. In the central part of this zone, the section is composed of greenish-gray clays with siltstone interlayers. Gravelite and sandy siltstones reappear in the Cenomanian section, south of Atachay. There are also brecciate conglomerates in the Bayimdag-Takchay, Sitalchay-Yashma and Shurabad areas. In the Zoratmulda area, the upper part of the Cenomanian is distinguished with the Zoratsky horizon composed of bituminous clays. In the southeastern Khizin tectonic zone, the floor thickness reaches 200 m [1–9]. According to the data provided, it can be concluded that in the Khizin tectonic zone, oil and gas shows were recorded in all sections of the Mesozoic sediments exposed by drilling. The observed oil and gas gushes occurred during the Albian (Shurabad), Valanginian (Begimdag-Tekchay) and Middle Jura (Keshchay) strata penetration.

Laboratory Test Results

The Table shows the values of the petrophysical properties of core samples taken from well No. 38 drilled in the Shurabad area. From the data in the Table, it follows that the reservoir properties of the Lower Cretaceous rocks weaken with increasing depths. The Lower Cretaceous complex along the section consists mainly of carbonate and carbonate-clayey rocks. The lithological composition and size of the fragments change sharply in small intervals of the section depth.

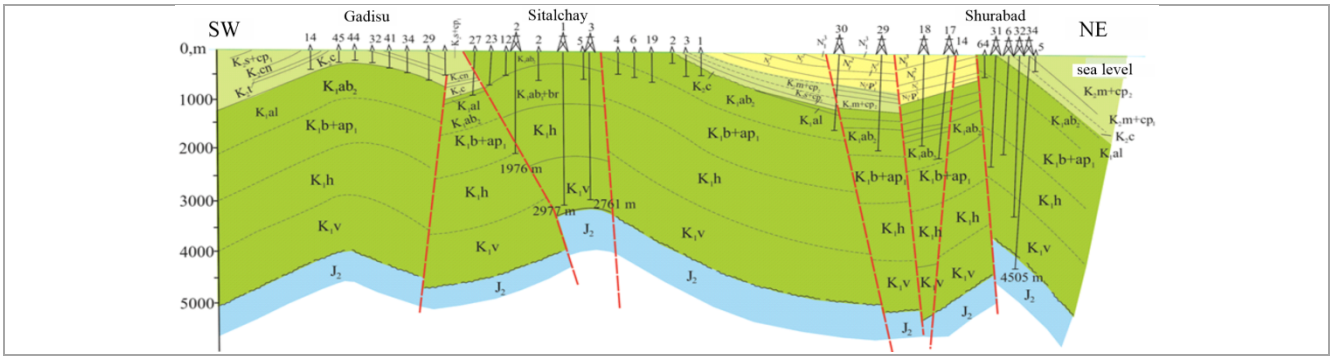

Fig. 2. Geological profile in the direction of Gadisu – Sitalchay – Shurabad (author H. Yusifov, A. Suleimanov)

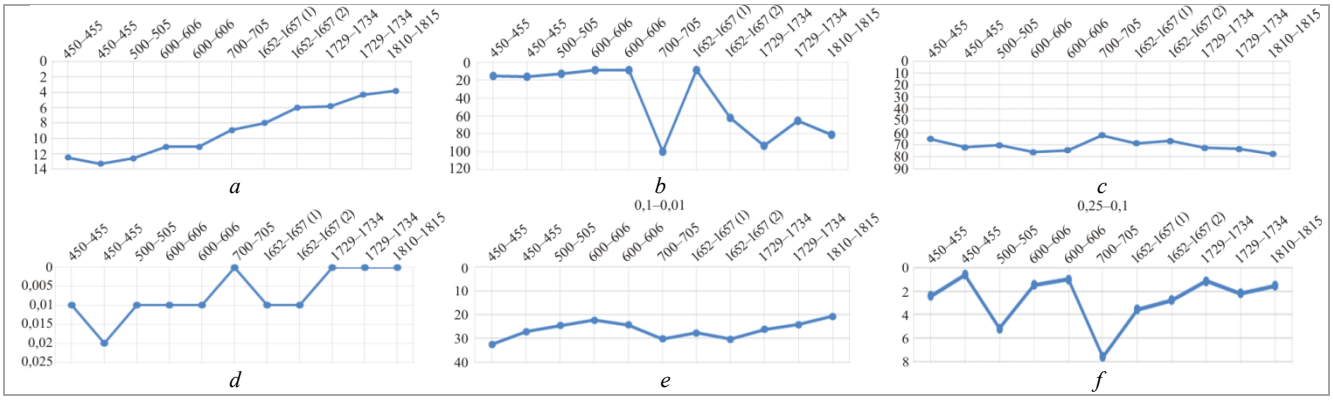

Fig. 3. Graphs of changes in carbonate content (*a*), porosity (*b*), clay content (*c*), electrical conductivity (*d*), variations in particle-size fractions 0.1–0.01 (*e*) and 0.25–0.1 mm (*f*) in the depth range 450-1815 m

Petrophysical properties of the Lower Cretaceous core samples in the Shurabad area

Item No.	Interval, m (number of samples is given in parenthesis)	Lithological composition	Grain-size composition, % fraction, mm				Carbonate content, %	Porosity, %	Permeability, 10^{-15} m²
			>0.25	0.25–0.1	0.1–0.01	<0.001			
1	450–455 (1)	Silty, calcareous clays with layered texture	–	2.40	32.45	65.15	15.3	12.5	0.01
2	450–455 (2)	Silty, calcareous clays with layered texture		0.61	27.18	72.21	16.2	13.3	0.02
3	500–505	Calcareous silty clay	–	5.17	24.58	70.25	12.7	12.6	0.01
4	600–606 (1)	Low-silt clay	–	1.46	22.36	76.18	8.5	11.1	0.01
5	600–606 (2)	Low-silt calcareous clay	–	1.02	24.32	74.66	8.5	11.1	0.01
6	700–705	Marbleized limestone	–	7.56	30.26	62.18	99.9	8.9	–
7	1652–1657 (1)	Silt clay	–	3.56	27.71	68.70	8.5	8.0	0.01
8	1652–1657 (2)	Organogenic pelitomorphic limestone	–	2.76	30.42	66.82	62.2	6.0	0.01
9	1729–1734 (1)	Limestone	–	1.17	26.18	72.65	93.1	5.8	–
10	1729–1734 (2)	Clayey marl	–	2.18	24.27	73.55	65.5	4.3	–
11	1810–1815	Clayey limestone	–	1.55	20.72	77.73	80.7	3.8	–

The carbonate content of the Lower Cretaceous rocks increases with increasing stratigraphic depth, while porosity and permeability decrease. In the depth interval 450–1815 m, porosity decreases from 15.5 to 80.7 %, clay content increases from 65.15 to 77.3 %, porosity decreases from 12.5 to 3.8 %. Graphs of changes in carbonate content, porosity, clay content, permeability, particle size fractions 0.1–0.01 and 0.25–0.1 mm in the depth range of 450–1815 m are shown in Fig. 3.

Conclusion

In general, noting the oil and gas content of the Lower Cretaceous sediments in the Caspian-Guba oil region, one should not overlook the increase in the carbonate content and terrigenous composition towards large-amplitude anticlinal folds in the Khizin zone (Shurabad, Sitalchay, Begimdag, Tekchay, etc.). As is well known, the prospects for the oil and gas content of the Khizin tectonic zone are associated with Middle Jurassic and Lower Cretaceous sediments. The maximum Middle Jurassic layer thickness (according to well data 1850 m) was registered in the Keshchay area. The most promising are the Afurjin and Keshchay uplifts, from which industrial flows of oil, gas and condensate have been obtained. In this regard, the Khizin zone is of particular importance, where Lower Cretaceous and Middle Jurassic sediments are widespread. There is a sharp change in the thickness of the Lower Cretaceous deposits and the lithological composition of rocks (in the vertical and lateral directions) in the southeast of the Khizin zone. This variability can be explained by the breaks in the sedimentation process and tectonic movements that induce folds [3–8, 18–26].

The coverage of the Neocomian terrigenous-carbonate deposits in the Khizin zone, consisting mainly of clays, by the Aptian-Barremian deposits, an increase in the bituminous content of the rocks, oil and gas manifestations and inflows in wells at the Begimdag-Tekchay and Keshchay fields, as well as the discovery of the Shurabad field, indicate the industrial oil and gas content of Mesozoic deposits in this area. To open oil and gas fields associated with lithological and stratigraphic traps, however, it is necessary to drill exploratory wells in the submerged part of the Shirvanovka, Imamgulukand, and Khudat uplifts, and in the periclinal part of the Khachmaz, Agzibirchala, Gusar and Talabi uplifts [27–45].

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