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ABSTRACT

CONDITIONS OF ACCUMULATION, COLLECTOR FEATURES AND OIL AND GAS PROSPECTS OF MIOCENE SEDIMENTS OF THE WESTERN FRANK OF THE SOUTHERN CASPIAN BASIN

Speciality: 2517.01 – "Litology"

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INTRODUCTION

Relevance and degree of development of the topic: Detailed study of the Pliocene (Productive layer) as the main oil and gas sedimentary complex of Azerbaijan for many years in the territory has allowed for the productive development of hydrocarbon deposits identified in its intersection. However, at the present stage, along with the statistical indicators determined regarding the exploitation indicators of the deposits related to the Pliocene structures located offshore and onshore, especially the forecasts for the near future, necessitate an assessment of the prospects of alternative oil-and-gas objects in terms of potential. From this point of view, the discovery of stratigraphic objects with favorable conditions for the accumulation of industrially significant hydrocarbon deposits in the Miocene intersection, which is considered a secondary oil-and-gas sedimentary complex, is of particular relevance for the development of the oil industry in Azerbaijan.

In recent years, the discovery of some oil and condensate fields (Sangachal, Lokbatan, Garadagh and Umbakı) in connection with Miocene sediments on the western flank (board) of the South Caspian Basin (SCB), as well as oil flows in a number of areas (for example, Hovsan), necessitates more detailed studies to assess the oil and gas potential of the sedimentary complex in question. Although, as a result of geological-geophysical and drilling work carried out on the western flank of the SCB so far, a lot of information has been obtained about the structural-tectonic features of the Miocene and its intersection, from the reservoir point of view, there are shortcomings in studying its oil and gas potential with modern analytical studies, especially in terms of sedimentary accumulation conditions, lithofacies and reservoir properties, and in identifying promising areas based on integrative analyses of the results obtained. In this dissertation, the data obtained from the geological, geophysical and drilling research conducted so far are analyzed, the regional geological features of the research object and the structural structure of different tectonic zones are studied in more detail, and new information is presented on the distribution characteristics of different lithotypes on the western flank of the CPH and the genetic factors determining their collectivity based on modern approaches. It is these data that have allowed us to identify

certain regularities in the distribution of stratigraphic objects with favorable reservoir properties in the Miocene section by area and section, and ultimately to propose promising areas for the direction of exploration and exploration work.

Object and subject of research: The Neogene sedimentary complex of the South Caspian, which is considered a unique basin due to its geodynamic development characteristics and sedimentation conditions, has always been of great interest for research in terms of the distribution of oil and gas resources in terms of area and cross-section. At the present stage, the study of Neogene-Miocene sediments from the point of view of oil and gas resources in Azerbaijan is considered one of the main priorities for directing future exploration and exploration work, so the object of the study presented is the western side of the basin in question, including the study of surface sections and core samples determined by drilling, which are manifested in its numerous areas. In this work, by analyzing the extensive published database on the research object, the geological, structural-tectonic development characteristics of the Western World of the SCB are investigated, as well as the petrographic, mineralogical and reservoir characteristics of numerous samples from surface sections and cores are studied, and the factors controlling the formation conditions of lithotypes belonging to different Miocene regiolevels and their reservoir properties are extensively investigated, which constitute the general subject of the work.

Objectives and tasks of the study: The main objective of the study is to analyze the extensive database of geological, geophysical and drilling works carried out so far, to clarify the structural-tectonic structure of Miocene sediments for the western flank of the SCB, to identify the distribution patterns of reservoir-important sediments by area and sections, and to direct future exploration and exploration works related to oil and gas, based on the results of studying the sedimentation conditions, lithofacies and reservoir properties of Oligocene-Upper Miocene intermediate lithotypes based on modern petrographic, mineralogical and petrophysical analyses of surface sections and core samples, and to determine the distribution patterns of reservoir-important sediments by area and sections, and to direct future exploration and exploration works related to oil and gas. The tasks identified in this regard are as follows:

- Clarification of the regional geological characteristics of the studied areas and the structural structure of individual tectonic zones;

- Study of the petrographic and mineralogical characteristics of surface sections and core samples;

- Restoration of sedimentation conditions based on integrative analyses of petrographic and mineralogical analysis data, along with lithostratigraphic changes, and determination of the field evolution characteristics of lithotypes belonging to individual Miocene regiolevels;

- Study of the temporal and spatial variation characteristics of the collector properties of Miocene sediments;

- Identification of areas and objects with favorable reservoir properties in the Oligocene-Upper Miocene interval based on the results of comprehensive research and proposals for the direction of exploration and exploration works.

Research methods: The problems posed in the research were solved by applying innovative approaches, based on the analysis of numerous cross-sections and well materials, macroscopic and microscopic images of the samples used, petrophysical, mineralogical and chemical analyses using modern equipment. "Coreval 700", "MiniFlex 600" XRD, "S8 TIGER Series 2 WDXRF", "Carl Zeiss Microscopy GmbH", etc. Advanced approaches have been used in the interpretation and analysis of the results of petrographic, petrophysical, mineralogical and geochemical studies conducted on modern analytical devices.

The main provisions put forward for defense:

1. The areal and vertical heterogeneity of lithofacies characteristics and capacity-filtration properties of Miocene sediments on the western flank of the SCB (within the Shamakhi-Gobustan and Absheron depressions);

2. The diversity of feeding (delivery) sources of Miocene sediments and their role in the formation of the quality of collectors;

3. Zoning of the Shamakhi-Gobustan and Absheron depressions according to the degree of prospectivity of Miocene sediments.

Scientific novelty of the research:

1. Based on the results of complex research works, lithofacies maps of Miocene stratigraphic units were compiled, the characteristics of the distribution and thickness of sediments in the area were studied. Within the research area, two facies zones were distinguished: 1) a

shallow-water zone (southern part of the research area) and 2) a deep-water zone, possibly the outer shelf zone (northern part of the research area), and it was determined that the thickness of the sediments significantly increases from the north-northeast of the zone to the south-southwest, as well as from the crests of local uplifts to their flanks and periclinals;

2. For the first time, petrographic analyses of Miocene samples taken from cross-sections and wells in the study area were carried out using SEM, the mineralogical and chemical composition of the rocks was studied in detail, and as a result, it was determined that, in addition to quartz sedimentary sources, rocks of medium and acidic magmatic origin are characteristic of oil-bearing rocks in terms of protolith;

3. Based on the analysis of the results of petrographic and mineralogical analyses, the uniformity of the region fed by detrital materials for the Miocene sediments of the Shamakhi-Gobustan and Absheron depressions and the diversity (multiplicity) of the sources of "terrigens" were determined for the first time. In this regard, it was determined that the main source of detrital material is the Cretaceous sediments of the Greater Caucasus. There were at least two sources of transport of terrigenous materials for sandy silty rocks;

4. The geological structure of the sediments belonging to separate Miocene regiolevels spread on the western flank of the CSH was clarified, structural maps were compiled according to their surface, and it was determined that there are more favorable conditions for the formation of deposits in the uplift or tectonically shielded parts of the anticlinal structures. Based on the results, it was concluded that oil and gas content is higher in the southern-subduction wing and a more detailed study of these areas was proposed;

5. The role of facies and mineralogical composition factors in the formation of the collector properties of Miocene rocks was evaluated, and it was determined that the areas with the best capacity-filtration properties are the Lower Miocene and Chokrak sandy reservoirs in the southeastern part of the study area;

6. For the first time, zoning was carried out by area and section in order to determine the most promising stratigraphic intervals and areas in terms of the presence of collector rocks in Miocene sediments,

and promising directions of exploration and exploration work were proposed;

7. Analytical studies (petrographic, mineralogical and petrophysical) of samples taken from the Miocene section, based on the determination of the time-space distribution patterns of the reservoir properties, revealed that a number of structures of South Gobustan have the best capacity-filtration properties of Lower Miocene and Chokrak and Diatom sediments of South-East Gobustan. In addition, for the first time, highly prospective, medium prospective and weak prospective areas were distinguished from the northwest to the southeast in the Shamakhi-Gobustan and Absheron depressions.

Theoretical and practical significance of the research: Based on the complex analysis of the obtained geological, geophysical, drilling, as well as petrographic-mineralogical and petrophysical data, the directions of future exploration and exploration work have been scientifically substantiated, and the locations, project objects, and depths of the proposed exploration and exploration wells have been determined. The unconventional approaches and methodologies used here, as well as the goals and objectives set for the implementation of the research topic, can generally be used to study the mineralogical and geochemical properties, genesis, and oil and gas prospects of sediments belonging to other research areas.

Approbation and application: The dissertation refers to 12 works of the author, which generally contain the study of lithofacies, geological, mineralogical, petrographic, petrophysical and oil and gas prospects of the research area, of which 8 are articles and 4 theses, which are directly reflected in the scientific results obtained in the work. The results obtained on individual parts of the dissertation work were discussed at scientific conferences of republican and international importance. Thus, the author organized in Azerbaijan “Integrated approach for unlocking hydrocarbon resources – 2012”, “V international conference of young scientists and students – 2013”, Academician A. In addition to the "XII Republican Scientific Conference - 2021" dedicated to the memory of A. Alizadeh, a report was also presented at the conference "Deposit Development Technologies and Process Modeling in Oil and Gas Production" held in Russia in 2024 and dedicated to the memory of A. Mirzajanzadeh.

Name of the organization where the dissertation work was carried out: The dissertation work was carried out at the Institute of Geology and Geophysics, Ministry of Science and Education of the Republic of Azerbaijan.

Total volume of the dissertation: The total volume of the dissertation work is 203903, including its introduction - 9070, Chapter I - 84452, Chapter II - 27127, Chapter III - 31096, Chapter IV - 28995, Chapter V - 23163 and the conclusion - 3684 marks. In addition, 103 references, 62 figures and 12 tables were used in the dissertation work.

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CHAPTER I. GEOLOGICAL FEATURES OF THE RESEARCHED AREAS (STRATIGRAPHY, TECTONICS, LITHOFACIAL FEATURES) AND OIL AND GAS PROPERTIES

This chapter consists of 5 subchapters. In subchapter I, brief information is given on the geological and geophysical research work carried out in the Paleogene-Miocene sediments in the areas located on the western flank of the South Caspian basin. At the same time, D.V.Golyubyatnikov (1903, 1922), M.I.Gubkin (1915-1917), V.V.Weber (1925, 1939, 1947), V.V.Fedinsky (1928-1934, 1947), I.A.Malikov (1938), V.Y.Khain (1950, 1958), I.O.Simelzon (1954), B.M.Garayev (1960, 1968), A.M.Shakinski (1960), H.A.Ahmadov (1966-1968), S.H.Salayev (1961, 1983), K.A.Ismayilov (1961), M.A.Rzayev (1965), A.M.Zeynalov

(1968), A.A.Ali-zadeh (1972, 1975), Kh.B.Yusifzadeh (1987), I.A.Samadov (1993), S.B.Mammadov (1991, 2006), A.M.Suleymanov (2003-2006, 2015), B.I.Maharramov (2008, 2011, 2015), Kh.M. Yusifov (2006, 2009), A.M.Salmanov (2011, 2015), N.P.Yusubov (2011) and others, as well as the results of mapping, geological-geophysical exploration and drilling work carried out in the Oligocene-Miocene sediments on the western flank of the South Caspian basin in 1928-1933, 1954-1960, 1965-1972, 1975-1983, 1986-1988 and 1995-2016, were comprehensively analyzed. In this regard, along with the geological studies conducted, the results obtained from the analysis of the geological and geophysical studies carried out to date allowed for the clarification of the geological structure of individual zones of the western part of the Caspian Sea and, in turn, were used in the work to propose structures and objects related to prospects.

In subchapter II, the data obtained from the wells drilled to date in the study area were extensively analyzed, the cross-sections of the wells were studied, and the changes observed in the cross-sections were traced from the north of the study area (Western Absheron) to the south (Shamakhi-Gobustan). The chronology of the mechanical drilling operations in the Western Absheron area starting from 1913 and in the Shamakhi-Gobustan area starting from 1916 to the present day was examined in detail, and this information was also used in the construction of lithofacies, thickness maps and profiles in the following chapters.

In the third subchapter, stratigraphic and lithofacies analyses of Miocene sediments were carried out, lithofacies maps were compiled for the area and a comparison scheme was established. The studies show that the sediments of the Maykop Formation on the western flank of the SCB mainly consist of clayey lithofacies of great thickness. These sediments, which are widespread in the Gobustan area of the study area, are divided into two sub-sets. The study of core samples and the results of our field work allow us to distinguish two facies zones within the study area in the lithofacies map we have constructed for Maykop (Lower Miocene) (Fig. 1), which are shallow water (southern part of the study area) and northern deeper water, possibly outer shelf zones.

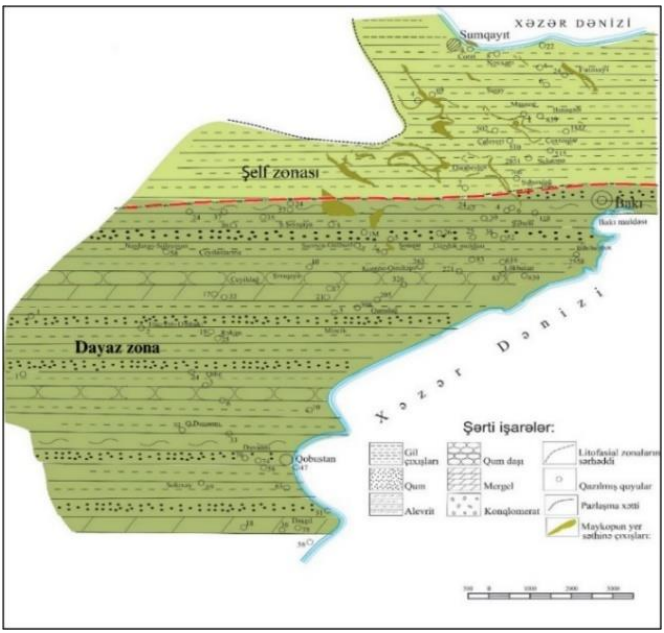


Figure 1. Lithofacies map of the Lower Miocene (Maykop) sediments of Western Absheron and Shamakhi-Gobustan.

As can be seen from the comparison scheme (Fig. 2), Miocene sediments in the Western Absheron area have undergone serious lithofacies changes. In some cases, the upper parts of Miocene sediments are accompanied by Pliocene washout. In many areas of the study area, as a result of Chokrak front washout, the thin sediments of the Tarkhan horizon do not participate in the arch parts of the anticlines. The lower part of the Tarkhan horizon, which occurs in very few areas, is composed of marls, and the upper part is composed of dark-colored clays. The Chokrak horizon is distributed in clayey and sandy-clayey facies in the study area. In the northwestern, northern and northeastern parts of the region, it is represented by a clayey facies consisting of clays with dolomite and marl interlayers, and in the southwestern, southern and southeastern parts, it is represented by a sandy-clayey facies with sand, sandstones, and a small amount of dolomite and marl interlayers (Figure 3).

The total thickness of the Chokrak sediments in most areas varies between 50-400 m.

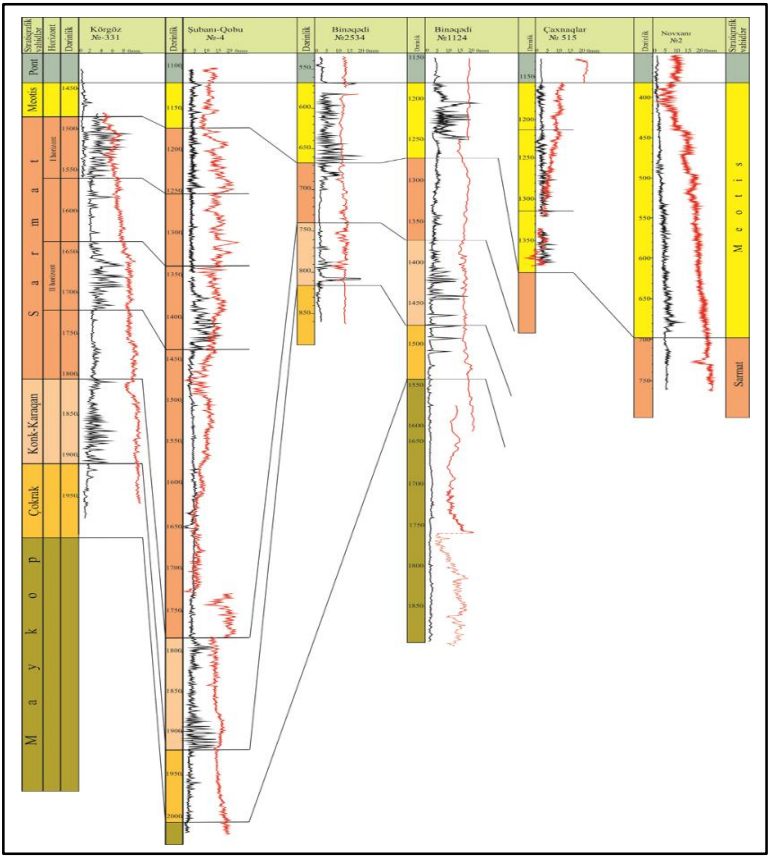


Figure 2. Comparison scheme of lithostratigraphic features of Miocene sediments of Western Absheron in different areas.

The Diatom Formation sediments covering the Karagan, Konk, Sarmat, and Meotis stratigraphic intervals of the Miocene have been studied using well data [6]. This formation is mainly composed of clays and limestone, marl, and sandstone layers, with thicknesses ranging from 0 to 1800 m.

The thickness of the sandy layers gradually increases towards the southwest in the Diatom section. In many areas of the study area, the thickness of the Diatom varies between 50-1000 m. In the Chalayeri-Guzdek troughs and the Kolani-Hajiveli-Umbaki areas of South Gobustan, it

is 1000-1400 m, in the center of the Jeyrankechmez depression and towards the Caspian Sea it exceeds 1600-1800 m.

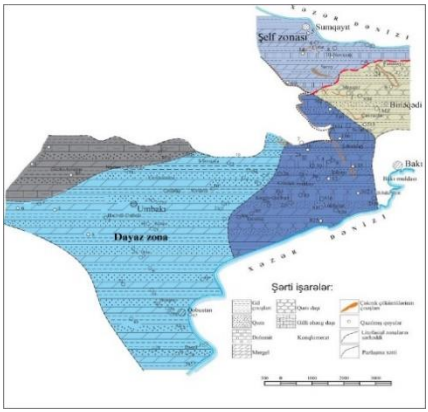


Figure 3. Lithofacies map of Chokrak sediments.

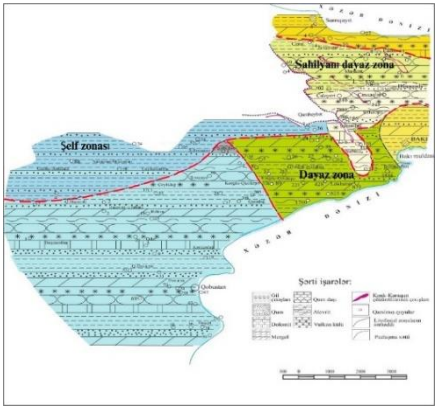


Figure 4. Lithofacies map of Konk-Karagan sediments.

Karagan-Kong sediments consist of fine-grained sand and silt-stone, dolomite, breccia-like dolomite, marl, dolomitic marl, brown and greenish-gray clays with layers (Fig. 4). Karagan sediments differ from Chokrak in the absence of spirals. Their thickness varies between 400-600 m in the central part of the Jeyrankechmez depression and in the Baku trough. In the arch and near-arch areas of the anticline uplifts, the thickness is 50-200 m, and in the synclines - 250-300 m.

The Sarmatian floor sediments consist of clays with greenish-gray and greenish-brown fish remains and occasionally marl layers in the northwestern, northern and central parts of Western Absheron. In the north and northwest of the study area, the thickness of the Sarmatian sediments varies between 100-300 m. In the southward section, the amount of sandy, carbonate (dolomite and marl) rocks increases and the thickness reaches 700-800 m

In the IV subchapter, the complex tectonic features of the study area, which covers the southeastern basin of the Greater Caucasus megaticlinorium and the southern foot of its southeastern part, were investigated.

The thickness of the Paleogene-Miocene sediments participating in

the geological structure of Western Absheron increases from northwest to southeast from 150-500 m to 2500-3500 m, and in the Jeyrankechmez depression it even reaches 4000-5000 m. These sediments, which are more common in the clayey-sandy facies, somewhat reflect the regional-tectonic features of the Southeast Caucasus in the study area[1]. The arch and subarc parts of most of the subduction-oriented tectonic units are complicated by longitudinal depth faults of the superimposed type. This has led to the formation of large-scale anticline zones. Many transverse faults directed opposite to the general Caucasian direction are also regional in some cases.

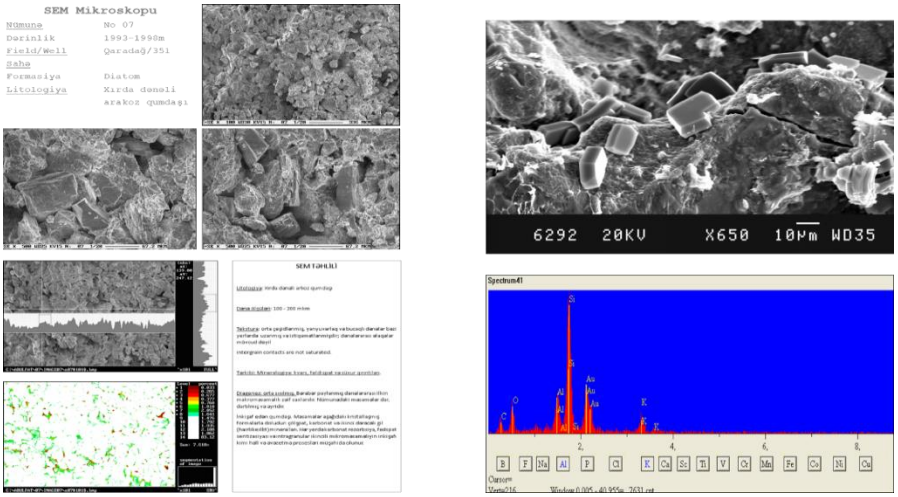
From the analyses related to the V subchapter, which investigated the oil and gas content of Miocene sediments, it is known that there are favorable reservoirs with regional oil and gas content in the intersection of this complex on the western flank of the SCB. In most areas of the study region, both surface natural oil and gas outcrops have been observed in connection with these sediments, and intensive oil and gas manifestations have been recorded in drilled wells. At the same time, industrially significant oil and gas flows were observed in many areas of the research region (Binagadi, Zigilpiri-Masazir, Sulutepe, Shubani-Ateshgah, Korgoz-Giziltepe, Garadagh, Umbakı, East Hajivelı and Kilinj).

CHAPTER II. PETROGRAPHIC CHARACTERISTICS OF MIOCENE SEDIMENTS

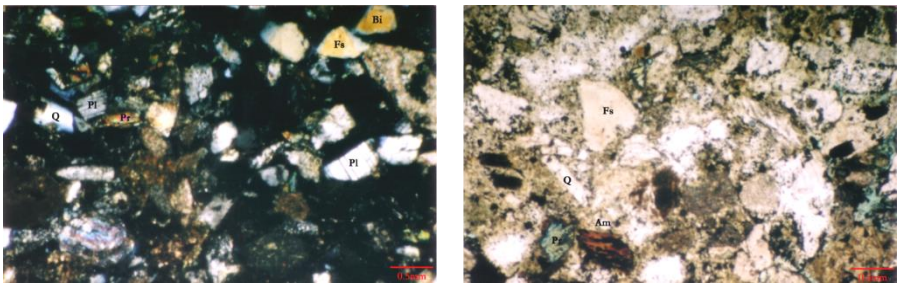
In this chapter, dedicated to the petrographic characteristics of Miocene sediments, 150 micrographs (thin sections) were prepared from samples taken from wells drilled in different areas of the research region and from surface sections, their extensive analysis was given with reference to SEM analyses, and the most important results were reflected in the work (Figure 5, 6). Petrographic analyses show that the amount of quartz in the light fraction of minerals in the section of the Upper Maikop

[1] Suleymanov A.M., Zeynalov R.L., Maharramov B.I., Regional and local tectonic features of the Paleogene-Miocene sedimentary complex in Western Absheron. Collection of scientific works of AzNSDETLI, 2004, No. 3, pp. 55-62.

III horizon of Shamakhi-Gobustan is on average 67%. The amount of sandy-silty rocks in the section of the II, IV, V and VI horizons is 40-42% [2, 7]. Sands and siltstones are distinguished by a high content of quartz (70-85%) and weak carbonation. The lithophysical characteristics of the sandy horizons of the Upper Maikop are given in Table 1. While the light fraction in the Upper Maikop sediments in Western Absheron consists mainly of feldspar and quartz, the heavy fraction consists of up to 20 mineral residues.



Figur 5. SEM images



Q-quarts, Fs-feldspar, Bi-biotite, Pl-plagioklose, Pr-Pyroxene, Am-Amphibole

Figur 6. Petrographic images

According to the results of granulometric analysis of Chokrak sediments in Western Absheron, the degree of sorting of clays increases from north to south and west. The amount of quartz in the sections is 69.8% in Sumgayitchay, 18% in Orjundagh. The amount of feldspars in Orjundagh is 1.2%. Pyrite, limonite, magnetite and ilmenite predominate from heavy fractions in the sediments. Small amounts of chloride, picotite, epidote, glauconite, etc. are found.

In Western Absheron, the Miocene sediments are characterized by a high percentage of clay content in the section. In the Masazir area, the clay content of the sediments reaches 98%. The average amount of clay fraction in the area is 88%, the sand fraction is about 3%, and the carbonation is 66%. Such a high concentration of carbonation is due to the presence of calcareous clays in the section of Miocene sediments.

Diatom sediments account for up to 85.2% of the terrigenous material in the section. The light fraction consists mainly of quartz and feldspars, and the heavy fraction minerals consist mainly of pyrite and iron oxide. Relatively small amounts of magnetite, ilmenite, chlorite, muscovite, garnet, and amphibole, pyroxene, and anhydrite are found in the form of grains. The heavy fraction is characterized by the presence of pyrite (up to 40%) and altered minerals (up to 44%). The content of feldspar and quartz in the clays varies between 3.0-12.0%.

The paleotectonic conditions of the Middle and Upper Miocene basins were in many respects a continuation of the conditions of the early Miocene. In a number of regions of the study area, a short-term regression of the sea occurred at the end of the Tarkhan age and the beginning of the Chokrak age, as a result of which the Tarkhan sediments were completely washed out in many regions, and the Upper Maykop sediments were partially washed out. The fact that the Tarkhan horizon sediments in Northern Gobustan and the western part of the Absheron Peninsula are composed of thin marls and clays is explained by the remote location of the washing zones or the fact that the relief is not much higher than sea level.

Studies show that most structures of Western Absheron were consolidative structures with amplitudes reaching 100 m. From the paleostructural state of the Chokrak surface at the end of the Diatom it is clear that no serious changes occurred in the structural plan of Western Absheron at the end of the Miocene. The change in thicknesses between 100-600 m indicates that the structures continued to develop consolidatively.

The conducted studies show that the development of the individual local uplifts noted in the study area did not proceed evenly until the beginning of different periods. The uplifts located in some zones of the region have an earlier development than others, and their geological structure was complicated by tectonic disturbances earlier. At the beginning of Pontun and Agcagil, almost all uplifts acquired their modern forms, and the amplitudes of the faults reached their maximum values.

According to the ratio of quartz-feldspar-rock fragments, four zones are distinguished in the sandy-silty sediments of the III sandy horizon of the lower Miocene. The first zone includes areas with a high content (40%-60%) of quartz and feldspar (14%-70%). The second zone includes areas with a high content of quartz (more than 60%-80%) and a low content of feldspar (less than 40%). The amount of quartz in the sandstone sediments of the mentioned areas is highest in the Hajiveli area, and less in the Cheyildag and Kurdemiç areas. For the rocks of the third zone, a high content of quartz 40-60% and a low content of feldspar are characteristic. Here, the second zone, by analogy, includes all areas, except for the Hajiveli area. Finally, in zone 4, the average feldspar content is 30-50%, and the low quartz content is 20-40%. Only the Shaytanud area is located in this zone. Figure 7 shows the ratio of feldspar and rock fragments in the III sandy horizon of the Lower Miocene. Zone I is distinguished by the high content of both components. In this zone, feldspar constitutes 30-50%, and rock fragments 30-40%. Analogous to zone IV, in figure 9a, the Shaytanud area is mainly distinguished by the small amount of rock fragments belonging to zones III and IV. However, in zone IV, the Hajiveli area is located, where feldspar is rarely found (less than 30%). In zone III, there are areas rich in high amounts of feldspar (30-50%). However, the percentage of feldspar in the samples taken from the Cheyildag area is lower than in zone IV. Thus, the Cheyildag area is characterized by a low content of both feldspar and rock fragments, which is typical for the Hajiveli area in terms of the lower Miocene III sandy horizon[2].

[2] Alieva E.G., Mustafaev K.F. Mineralogy of drift sources and paleogeography of Miocene sediments of Gobustan (South Caspian basin). Works of the Institute of Gcology of the Dagestan Scientific Center. RAN. No. (172), 2018, 4-160).

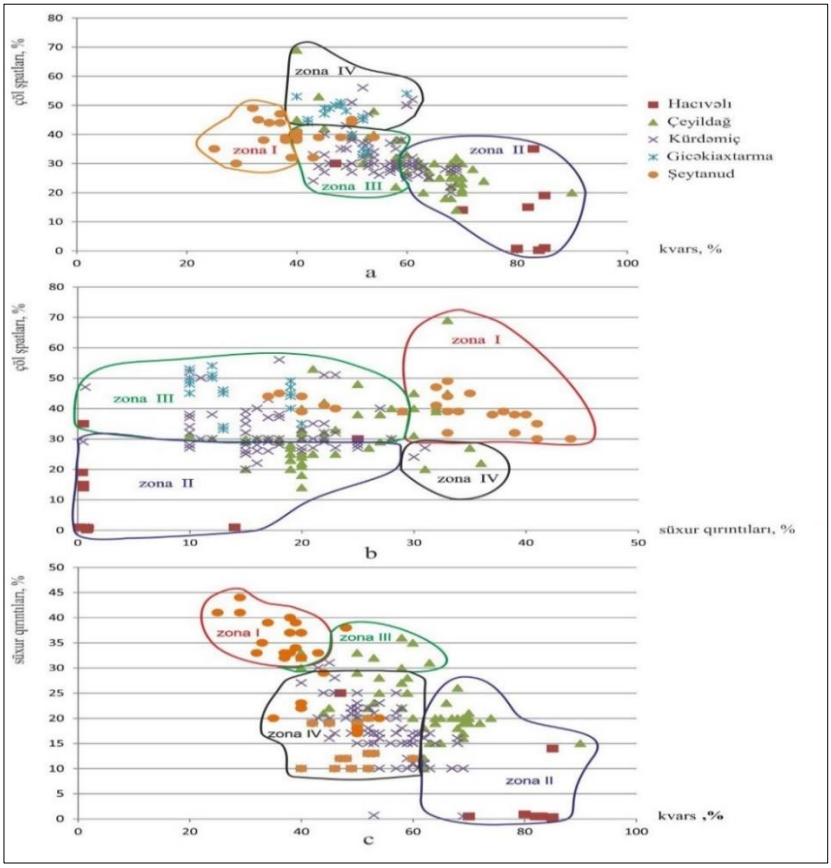


Figure 7. Zoning of the Shamakhi-Gobustan depression areas according to the composition of light fraction components associated with the sandy horizon of the Lower Miocene.

In the sandy horizon III of the Lower Miocene, two zones with opposite mineralogical characteristics are distinguished according to the distribution of quartz and rock fragments. The first zone is represented by the 90% Shaytanud area, characterized by rock fragments - more than 45% and quartz - less than 45%. The second opposite zone is represented by a high content of quartz (more than 80%) and a small amount of rock fragments (0-27%). This zone includes practically all samples from the Hajivel area (with the exception of the majority from

the Cheyildag area and a small amount of rocks from the Kurdemiç area). Zones III and IV are represented by rocks with an average content of quartz and rock fragments. Rock fragments are more common in zone III [5].

The analysis of the composition of light fraction components shows that the sediments of the III sandy horizon in the lower Miocene sediments of the Shamakhi-Gobustan area are divided into two completely opposite zones (zone I and zone II) according to their mineralogical characteristics. Zone I is characterized by a high amount of rock fragments, feldspar and a small amount of quartz. Zone II is characterized by a high amount of quartz and a small amount of rock fragments and feldspar.

Based on the above analyses and the results of the conducted studies, the regularity of temporal and spatial changes in the mineralogical composition of Miocene rocks was traced. These changes are mainly determined by changes in the sources of nutrition (delivery) (except for paleofacial and diagenetic factors). According to the map of the mineralogical composition of light fractions of horizon III, in the collectors of the Lower Miocene sediments (Upper Maykop semilayer) of separate areas of North, Central and South Gobustan, a general trend of increasing quartz content from north to south is observed. Thus, as a result of the conducted studies, it can be concluded that there were at least two sources of transport of terrigenous material for the Lower Miocene and sandy siltstone rocks of Chokrak in South, Central and North Gobustan. One is characterized by a high content of quartz, and a low content of feldspar and rock fragments. Such mineralogical composition has been identified in some lower Miocene and Chokrak sandy rocks of the Hajiveli, Cheyildag, and Umbakı areas. The intrusion of quartz-rich detrital material from the source occurred only briefly in separate stages of the Miocene.

CHAPTER III. SEDIMENTATION CONDITIONS OF MIOCENE OIL AND GAS COMPLEXES

This chapter has extensively studied the sedimentation conditions of the oil-gas complexes of the Miocene sediments. The paleotectonic and paleogeographic conditions of the Middle and Lower Miocene basins in many respects existed as a continuation of the conditions of the Lower

Miocene. This geological time interval is characterized by the dominance of folding and orogenic movements for the Azerbaijani part of the Greater Caucasus. Accumulation processes continue in the sedimentary basins that existed in the Lower Miocene. However, instead of sediments mainly composed of clayey rocks, molasse sediments composed of sandy clays and variously grained sandstones, marls, and dolomites accumulate in these basins. In a number of regions of the SE Caucasus, the process of washing out sediments accumulated at the end of the Lower Miocene and the beginning of the Middle Miocene is not recorded. It is assumed that the limited distribution of Tarkhan horizon sediments is associated with the Chokrakonu washing. One of the main reasons why the Tarkhan horizon sediments in North Gobustan and the western part of the Absheron Peninsula are composed of thin marls and clays is that the relief is not very high above sea level and the washing zones are located far away.

At the end of the Tarkhanian and the beginning of the Chokrakian, a short-term regression of the sea occurred, as a result of which the Tarkhan sediments were completely washed away, and the Lower Miocene sediments were partially washed away in many regions of the Southeastern Caucasus. The marine transgression that began a little later rapidly expanded and was able to occupy the areas covered by the Lower Miocene sea. It should be noted that the formation of developed local structures and paleotectonic development are of great importance as the main criteria for the study of the oil and gas prospects of the region. For this purpose, the paleodevelopmental nature of individual uplifts at the beginning of different periods was clarified on the basis of regional geological profiles passing through the southwest-northeast direction of the SW Gobustan. The Dashmardan, Ilkhichi and Nardaranakhtarma uplifts had different amplitudes at the beginning of the Oligocene[3].

Here, the thickness of the Upper Cretaceous, Paleocene, Eocene sediments increases from the arch part to the wings, which led to the consolidation development of these structures and the complication of the arch parts with disjunctive dislocations. At the beginning of the Middle Miocene, the dip angle of the northeastern wings of these uplifts and the amplitude of the mentioned faults show a slight increase.

[3] Maharramov B.I. Paleotectonic development of the Middle and Upper Miocene uplifts of the Western Absheron and Shamakhi-Gobustan OGR and their oil and gas prospects // Baku: ANT, 2006. No. 11, pp. 15-21.

Thus, the paleotectonic studies conducted show that the development of the individual local uplifts noted in the territory of South-Western Gobustan at the beginning of different periods was not at all uniform. The uplifts located in the south and southeast of the region (Dashmardan, East Hajiveli, Durandag, Arzani-Gilic uplifts) have an earlier development compared to the uplifts noted in the north and northwest (Ilkhidag, Nardaran-Akhtarma, Umbakı, Cheyildag, etc.), and their geological structure was complicated by tectonic disturbances earlier. At the beginning of Pontun and Agcagil, almost all uplifts acquired their modern forms, and the amplitudes of the faults reached their maximum values[4].

CHAPTER IV. COLLECTOR PROPERTIES OF MIOCENE SEDIMENTS AND FACIAL CONTROL ON THE FORMATION OF COLLECTOR ROCKS

In this chapter, the collector properties of Miocene sediments have been extensively and comprehensively investigated and the formation of collector rocks has been analyzed. In the study area, both the thickness of Miocene sediments increases from the north, northwest to the south, southeast, and the collector properties improve. The fact that these sediments have collector properties for oil and gas collection has been proven by the receipt of industrially important oil flows mentioned in the previous section. As a result of exploration drilling in the Shamakhi-Gobustan region, 6 (I, II, III, IV, V and VI) (Umbaki and other fields) were recorded in the Upper Maykop section, and one sandy reservoir was recorded in Chokrak. The thickness of the sandy layers increases from 2.0-2.5 m to 8-10 m from north to south. These layers merge at various intervals, forming thick (20-60 m) horizons. Horizon III has been better studied by drilling and is more oil-gas-rich. This horizon, which is distinguished by its high collector properties and is 50-60 m thick, has a total porosity of 14-32%, an average effective porosity of 6%, and a permeability of 245 mD.

[4] Salmanov A.M., Magerramov B.I., Huseynov R.M. 2016. Justification of directions of exploration work on the Oligocene-Miocene complex of the western Apsheron based on geological and geophysical studies. Logger, scientific and technical bulletin, Tver, RU, issue 5, p. 3-17.

The amount of sandy-silty rocks at the intersection of horizons II, IV, V and VI is 40-42%. Porosity varies between 16-30%, and permeability varies between 25-270 md (Table 1).

Table 1

Collector properties of sandy horizons of the Upper Maykop

Field	Total porosity, %	Effektive porosty, %	Permeability, mD
Sheytanud	5,9-36,1	1,0-6,5	10-400
Nardaranakhtarma	3,4-36,6	1,0-11,0	10-800
Gicakiakhtarma	10,0-36,4	1,0-11,0	10-700
Sundu	2,8-34,0	1,0-10,0	15-700
Cheildag	3,7-31,1	1,0-12,0	10-600
Umbaki	9,4-32,0	1,5-7,0	10-145
Hajiveli	10,5-31,9	1,0-12,0	10-900
Arzani- Kılınc	10,0-27,5	1,0-5,2	10-125
İlkhıci	9,9-28,2	1,0-6,5	10-234
Kurdemich	6,4-24,2	24,6	202

In the Western Absheron region, the Chokrak horizon sediments are distributed in a very variable composition. The porosity of sandy-silty rocks varies between 4.5-35%, and the permeability varies between 0.9 - 2 mD. In the Masazir area, the total porosity of Chokrak rocks varies between 19.6-39.7%, the average porosity is 27.8%, and the permeability is within the range of 0.2-28.8 mD. The amount of carbonation in the sediments varies between 9.3-35.5%. In the Sulutepe area, the porosity of the rocks is 12.8-16.7% (average value - 15.1%), and the permeability is within the range of 1.9-10.8 mD. The amount of carbonation in the sediments varies between 21.5-29.3

Diatom sediments have been studied in the Masazir, Binagadi, Sulutepe, Shabandag, Shubany, Shorbulag, Garadagh, etc. areas using well data [1,4]. In the Masazir area, the total porosity of the rocks in the Diatom sediments varies between 9.9-39.7% (average value - 28.9%), and the permeability varies within the range of 0.1-4.3 mD. The amount of carbonation in the sediments is 1.5-66.5%.

In the Garadagh area, the total porosity of the rocks in the diatom sediments is 4.0-18.5% (average value - 8.9%) - and the permeability is within the range of 0.04-17.0 mD. The amount of carbonation in the

sediments varies between 10.0-31.3%.

In order to identify areas in the study area where the Miocene complex has better reservoir properties in terms of oil and gas content, reservoir property distribution diagrams were constructed based on values obtained from laboratory analyses conducted on rock samples (Figures 8, 9, 10 and 11).

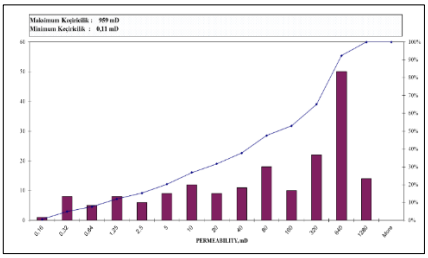


Figure 8. Diagram showing the permeability of Miocene sediments (for the northeastern part of the study area)

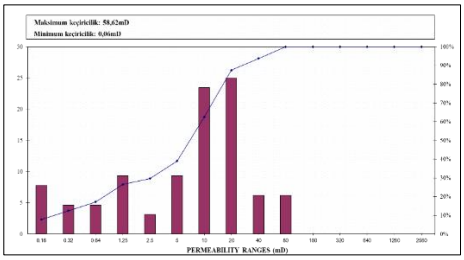


Figure 9. Diagram showing the permeability of Miocene sediments (for the southwestern part of the study area)

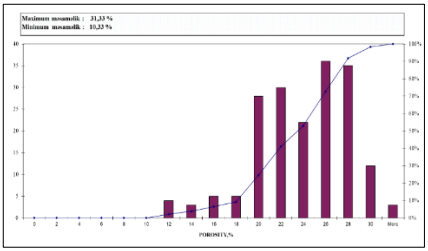


Figure 10. Diagram showing the porosity of Miocene sediments (for the northeastern part of the study area)

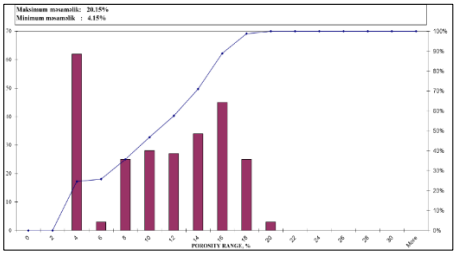
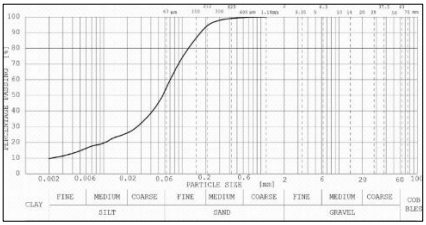
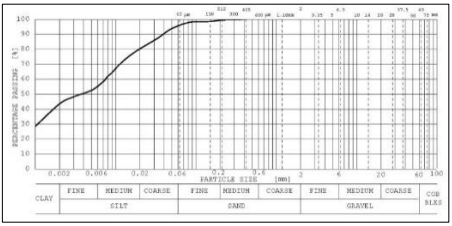


Figure 11. Diagram showing the porosity of Miocene sediments (for the southwestern part of the study area)

The diagrams show that the collector properties of Miocene sediments improve both from north to south and from west to east. As a result of the complex studies carried out, diagrams of the change in granulometric composition from northeast to southwest in the study area were constructed (Figure. 13 and 14).



Figur 12. Diagram showing granulometric composition (for the northern, northeastern part)



Figur 13. Diagram showing granulometric composition (for the south, southeastern part)

CHAPTER V. ZONING OF THE MIOCENE SEDIMENTS OF THE SOUTH CASPIAN BASIN ACCORDING TO THE DEGREE OF PROSPECTIVITY

Chapter V provides geological justification for prospective directions of exploration and prospecting in the western flank of the South Caspian basin. The conducted research shows that during the Paleogene-Miocene period, favorable regenerative geochemical conditions existed for the formation of hydrocarbons in the Western Absheron and in the southern and southeastern parts of Gobustan. Analysis of geotectonic development shows that the South Caspian depression, which had mainly favorable conditions for the formation of hydrocarbons, functioned both in the Palegene-Miocene period and in the subsequent Pliocene-Anthropogenic period[5]

At the same time, favorable conditions for the generation of hydrocarbons also existed in the Baku, Chuvaldagh, Gozdek depressions and the Jeyrankechmez depression, which are intensive sedimentation zones.

The results of a comprehensive study of the conducted geological-geophysical and drilling data show that the prospects of Miocene (Lower Miocene, Chokrak, Diatom) sediments are higher in the southwestern and southeastern zones of the Shamakhi-Gobustan region and in Southwestern Absheron. According to studies, the migration of oil and gas in these zones and their accumulation went in parallel with the formation of anticlinal

[5] Aliyeva E.G., Safarli K.G., Aslan-zade F.B., Imanov A.D., Ismailova S.M. Collector properties of deposits of Nadkirmakin sand suite of Absheron oil and gas district // Baku: Proceedings OilGasScientificResearchProject Institute, -2010. No. 2, p. 6-157

traps. Since these anticlines are complicated by numerous deep faults, it is highly likely that the Lower Miocene reservoirs are filled with hydrocarbons from the Paleogene and Mesozoic through these dislocations.

According to studies, the oil and gas prospects of the lower Miocene (Maykop) stratum increase in the south and southwest direction. In this direction, in the lower Miocene section, medium and fine-grained sand, sandstone and siltstone layers with porosity ranging from 10-36% and permeability ranging from 10-900 mD, reaching a thickness of several cm, characterize the reservoir properties of these sediments.

The lower Miocene strata with rich organic residues are characterized by a high genetic potential for oil and gas in the sandy-clay lithofacies of South-West and South-East Gobustan. The amount of organic matter in the section reaches 0.6-0.65%. The high content of siderite and dolomite, pyrite (15.90-95.0%) in the Upper Maykop indicates that the basin in which they were accumulated was closed, which is an indicator of the accumulation of sandy-clay sediments of the lower Miocene under favorable geochemical conditions. That is why the lower Miocene strata in South Gobustan can be attributed to the main oil-producing sediments. The formation of oil and gas deposits in this strata is directly related to the conversion of organic matter into hydrocarbons in its own section [3,7].

The Chokrak horizon is one of the most promising objects in the Miocene section. In Central and South-Western Absheron, the Chokrak horizon is distributed in sandy-clayey facies. Its oil and gas content is associated with the sands and sandstones in the section. These sediments account for more than 5% of the total thickness of the Chokrak horizon. In some areas, the porosity of sandstones and siltstones reaches 35%, and their permeability reaches 13 mD.

In South Gobustan, the oil and gas content of Chokrak is associated with the sandy layers, breccia-like dolomites and fractured marls noted in its upper section. Industrial oil flows have been recorded from these reservoirs in the Umbaki and East Hajiveli areas. The results of the conducted studies show that the oil in these rocks is also syngenetic and was formed due to the conversion of organic matter into oil in the Chokrak horizon itself. According to geochemical data, the rocks of the Chokrak horizon are characterized by a high content of organic matter (0.67%). The average value of bitumens dispersed in its clayey rocks reaches

0.033%. All this suggests that the accumulation of sediments during the Chokrak period occurred under restorative geochemical conditions.

The main oil and gas objects in the intersection of the Diatom sediments of Central and South-Western Absheron are associated with the collectors of the Karagan horizon, the Sarmatian and Meotis layers. The noted natural oil outcrops, the receipt of industrially significant oil flows from drilled wells and signs of oiliness indicate that these deposits are promising objects. In the intersection of the Meotis and Sarmatian layer deposits spread over a wide area, the increase in the number and thickness of sand and sandstone layers (in the wing parts of the structures) and the wedging of a number of sandy layers in the parts close to the arch of the structures led to the formation of lithological traps favorable for the accumulation and storage of hydrocarbons. Such favorable conditions exist in the wings of the anticline uplifts surrounding the Guzdek, Baku and Chuvaldagh troughs directed towards the troughs.

Comprehensive studies show that favorable geological and geochemical conditions existed for the formation, accumulation and storage of hydrocarbons in the Diatom sediments, which are mainly characterized by clayey facies, in South Gobustan and the Jeyrankechmez depression. The clays of this layer differ from the Maykop clays in the abundance of organic matter, and the organic matter dispersed in the sediments is characterized by syngeneticity. Taking into account the above, the potential of the Diatom layer in South Gobustan is highly estimated in terms of oil and gas.

Results

1. The lithofacies composition of the Lower, Middle and Upper Miocene sediments varies along the section. Terrigenous rocks dominate in the Lower Miocene section. Although the amount of carbonate rocks increases in Chokrak, they are more developed in Diatom.
2. Deeper sedimentation conditions in the study area occurred in the Lower Miocene basin (except for the Pontic basin). The northern Absheron part was covered by the outer shelf area. In other zones, coastal-shallow conditions and inner shelf facies were dominant. In Chokrak, coastal-shallow conditions prevailed. These conditions transitioned to deeper shelf facies in the Baku archipelago region.

In Konk-Karagan, the proximal coastal-shallow conditions of sedimentation shifted towards western Absheron. The Sarmatian basin was shallower. In this basin, coarse-grained rocks developed in the coastal facies of the basin in the South-West and Central Gobustan. There was a transition to shallow conditions in the Meotis.

3. Although the increase in clay content in the Miocene sediments in the northeast direction is generally observed, there is no general regularity in the change in clay content across the section. In the northern and northeastern part of Absheron, Miocene sediments are distributed in clayey facies, and in the southwestern part - in clayey-sandy facies. The Chokrak and Karagan horizons, the upper parts of the Sarmatian layer and the lower parts of the Meotis layer have higher sand content. The thickness distribution of Miocene sediments indicates that most structures of Western Absheron underwent consolidation development during the Miocene.
4. The feeder province for the Miocene sediments of the study area was the Greater Caucasus, but the sources of input were related to different parts of the Shamakhi-Gobustan and Absheron depressions over time. The detrital material to the Shamakhi-Gobustan depressions was brought as a result of the washing of the Cretaceous sediments of the Greater Caucasus. The terrigenous material to the Absheron depression was brought from the Paleogene sediments of the Greater Caucasus.
5. The reservoir properties of Miocene sediments have changed significantly throughout the study area. The best capacity-filtration properties are possessed by the Lower Miocene-Chokrak rocks of a number of structures of southern Gobustan and the Diatom sediments of southeastern Gobustan. Taking into account the thickness of the sandstone layers corresponding to the reservoir properties, promising, medium-promising and weakly promising areas have been distinguished in the Shamakhi-Gobustan and Absheron depressions.
6. The capacity filtration properties of Miocene sediments were controlled by the facies conditions of the basin. The mineralogical composition of the rock (more precisely, the high content of quartz) played a decisive role in the formation of reservoir properties. The

mineralogical composition indicates a change in the sources of supply over time in the Shamakhi-Gobustan and Absheron sediments.
7. In the Binagadi, Chakhnaglar, Sulutepe, Gara-Heybat, Shabandag, Korgoz-Giziltepe and Garadagh areas located in the central and southwestern parts of Western Absheron, Meotis, Sarmatian, Karagan and Chokrak sediments form lithostratigraphic and tectonically shielded deposits where they are wedged in the upthrust parts of anticlinal structures or tectonically shielded.
8. According to Miocene sediments, a zone of uplifts and a number of large anticlinal folds are noted in South Gobustan. These folds extending in the latitudinal direction are complicated by large-amplitude axial-type faults. On the surface of these faults, the northern wings of local uplifts cover the southern wings.
9. Since exploration wells are mainly drilled in the northern-superimposed wings of the structures, the oil and gas potential of the Miocene sediments in the southern-superimposed wing remains unexplored. The prospects of the Lower Miocene and Chokrak sandy reservoirs are almost certainly related to the southern wings of the folds.

Published scientific articles related to the dissertation topic:

1. Mustafayev, K.F. Changes in the reservoir properties of Miocene sediments in the Garadagh area and oil and gas prospects // Azerbaijan Oil Industry, 2017. No. 11, pp. 20-25.
2. Mustafayev K.F. Comparative analysis of lithological and petrographic characteristics of the Miocene deposits in the South Caspian basin western flank// Stratigraphy and sedimentology of oil-gas basins. 2017. No. 2, p. 62-67.
3. Mustafayev, K.F. Conditions for the formation of hydrocarbons in the Miocene sediments of the SCB and their oil and gas prospects // Azerbaijan Oil Industry. 2018. No. 07-08, pp. 72-77.
4. Mustafayev, K.F. Reservoir properties of Miocene sediments in Western Absheron and lithofacies characteristics of reservoir rocks // Azerbaijan Oil Industry. 2018. No. 11, pp. 62-66.
5. Alieva E.G., Mustafayev K.F. Mineralogy, provenances and paleogeography of Miocene deposits of Gobustan (South Caspian Basin)

// Proceedings of the Institute of Geology of the Dagestan Scientific Center. RAS. No. (172), 2018, 4-16.
6. Mustafayev, K.F. Stratigraphic and lithofacies peculiarities of the Miocene deposits of western Absheron and Shamakhi-Gobustan region, South-Caspian basin // Stratigraphy and sedimentology of oil-gas basins, 2018, №1, 45-49
7. Aliyeva E., K. Mustafayev. Petrographic and capacitive-filtration features of Miocene deposits of the western edge of the South Caspian Basin // ANAS Transactions, Earth Sciences 1 /2021, 3-15.
8. Aliyeva E., K. Mustafayev. Geochemistry of Miocene sediments of the Middle and South Caspian basins (within Azerbaijan): climate, chemical maturity and provenance sources // SOCAR proceedings, 2023, Special issue №2, 49-65.
9. Mustafayev K.F. İnternational Conference " İntegrated Approach for Unlocking Hydrocarbon Resources" Miocene deposits thickness distribution laws at Absheron peninsular and adjacentares. 3-5 October 2012, Page 174.
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12. Mustafayev, K.F. Technologies of field development and modeling of processes in oil and gas production. Collection of abstracts of the international scientific-practical conference, dedicated to the memory of academician A.Kh.Mirzajanzade. UFA, "Publishing House of UGNTU", August 24-27, 2023, Page 154-156

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