

RESERVOIR PROPERTIES OF THE MIOCENE DEPOSITS OF THE ABSHERON PENINSULA AND SOUTHEASTERN GOBUSTAN

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Abstract

This study presents a comprehensive evaluation of the reservoir properties of the Miocene deposits in the Absheron Peninsula and the South-Eastern Gobustan region. The porosity and permeability characteristics of sandy–silty lithologies, carbonate reservoirs, and complex fractured–brecciated rocks were analyzed across different stratigraphic levels.

Based on laboratory core data and field observations, regional regularities in the distribution of volumetric and filtration properties within the Chokrak, Karagan–Konk, Sarmatian–Maeotian, and Maykop deposits were identified. The results demonstrate that sandy horizons in Southern Gobustan are characterized by relatively high total porosity (commonly exceeding 20–25%). However, effective porosity and permeability are frequently low and are constrained by clay cementation.

In the central and northern areas, the deterioration of reservoir quality is associated with an increase in carbonate content and intensified cementation processes. The findings indicate that the adequate assessment of the widely distributed complex reservoirs within the Miocene succession requires refinement of conventional evaluation approaches. The results obtained are of considerable importance for forecasting hydrocarbon potential and optimizing geological exploration activities in the region.

Keywords: *Miocene deposits, reservoir properties, porosity, permeability, Maykop Formation, Chokrak horizon, Absheron Peninsula, Gobustan, complex reservoirs, hydrocarbon potential.*

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INTRODUCTION

The study of the reservoir properties of Miocene deposits in the oil- and gas-bearing basins of the

South-Eastern Caucasus is of significant scientific and practical importance for clarifying the mechanisms of hydrocarbon accumulation and assessing their industrial potential. The Absheron Peninsula and the Gobustan region are distinguished by a long geological development history, a complex lithological–facies structure, and the wide distribution of various types of reservoirs.

Recent studies have shown that, in the Miocene section of the region, along with conventional granular reservoirs, so-called “complex reservoirs”—including brecciated dolomites, fractured marls, and shaly clays—are widely developed. Since the pore–filtration properties of these rocks differ significantly from classical terrigenous reservoir models, their proper evaluation requires a specific methodological approach. However, a considerable part of the available data has been obtained using traditional methods, which creates uncertainties in the interpretation of the actual filtration–capacity parameters.

The main objective of this study is to conduct a comprehensive analysis of the reservoir properties of the Miocene deposits within the Absheron Peninsula and South-Eastern Gobustan, to determine the patterns of their regional variation, and to evaluate the oil and gas potential of different lithological–stratigraphic complexes. The results of this research are expected to contribute to the optimization of geological exploration activities in the region and to improve the accuracy of hydrocarbon resource forecasting.

The study of the reservoir properties of the Miocene deposits of the Southeastern Caucasus is of substantial practical importance for understanding the formation of commercial hydrocarbon accumulations, their development, and the assessment of reserves. In this regard, the evaluation of the storage capacity (porosity) and filtration properties (permeability) of reservoir rocks constitutes a critical component of petroleum geological investigations.

At present, the following types of reservoirs have been identified within different stratigraphic subdivisions of the Miocene succession: sand–siltstone rocks, brecciated dolomites, fractured marls, shaly clays, and others. With the exception of sand–siltstone rocks, which represent conventional granular-porous reservoirs, the remaining types are generally classified as complex reservoirs. These differ significantly from traditional intergranular porous systems, and their characterization requires the application of specialized analytical techniques. Unfortunately, such methods remain insufficiently developed, and all definitions and parameters presented below were obtained using conventional methodologies.

Within the Absheron Peninsula, the reservoir properties of the Chokrak Horizon have been investigated in the Fatmai, Zigilpiri, Shabandagh, Damlamaja, and Shorbulag sections. The porosity values range from 16% to 35%, while permeability varies between 9 and 24 mD (Table 1).

Table 1

Number of samples	Areas	Lithology	Porosity, %	Permeability, mD
23	Fatmai	Siltstone	32,7	24
25	"	Sand	30,7	-
28	Zigilpiri	Siltstone	35	-
18	Shabandagh	Sandstone	33,1	13
21	"	Sandstone	33,3	-
23	"	Sand	16,9	9
26	"	Siltstone	35	-
29	"	Siltstone	35	-

33	Damlamaja	Limestone	3,2	at 10 atm
74	Shorbulag	Sandstone	4,5	Impermeable

In the Gobustan region, reservoir properties have been investigated in the Gyrgyshlag, Gichaki, Nardaran–Akhtarma, Cheildag, Umbaki, Arzani–Gilych, and other areas (Table 2). The average total porosity ranges from 19% to 34%, whereas effective porosity varies between 2% and 8.3%.

The significant discrepancy between total and effective porosity can be attributed to the high content of clay fractions within the rock matrix. Despite the relatively low effective porosity, permeability values of these samples are notably high, ranging from 76 to 549 mD, indicating favorable filtration capacity and suggesting considerable reservoir potential under appropriate geological conditions.

Table 2
Average Reservoir Properties of Sandy–Silty Rocks of the Chokrak Horizon in the Gobustan Area

Fields	Number of Analyses	Granulometric Composition			Carbonate Content q, %		Total Porosity, %		Effective Porosity, %		Permeability, mD	
		>0,1 mm	0,1-0,01 mm	<0,01 mm	Number of analyses	Mean value	Number of analyses	Mean value	Number of analyses	Mean value	Number of analyses	Mean value
Girgishlag	-	-	-	-	-	-	5	25,5	5	5,0	4	219,0
Gicaki(Western part)	-	-	-	-	-	-	13	27,5	13	5,9	11	276,0
Gicaki (Eastern part)	-	-	-	-	-	-	10	28,5	10	3,8	6	367,0
Nardaran-Akhtarma	-	-	-	-	-	-	56	22,0	51	3,6	47	145,0
Ilkhichi	-	-	-	-	-	-	5	33,7	5	8,6	5	549,0
Vostochny Sundi	-	-	-	-	-	-	9	25,2	5	2,0	8	76,0
Cheildag	-	-	-	-	-	-	30	24,3	31	8,3	29	241,0
Ajiveli	32	31,9	24,9	33,2	32	17,6	14	22,0	16	4,4	9	270,0
Umbaki	97	35,3	32,4	32,3	97	10,9	18	19,0	13	6,7	7	76,0
Rahim	12	4,8	58,4	36,9	12	8,6	-	-	-	-	-	-
Arzani-Gylych	-	-	-	-	-	-	9	2,6	8	3,0	6	141,0

The reservoir properties of the Karagan–Konk strata, represented by sandy–aleuritic and carbonate deposits in the Absheron region (Orcandag, Fatmai, Zigilpiri, Damlamaja, and Shorbulag), have been studied based on a limited number of samples.

Their overall porosity varies within the range of 9–25%, and in some cases reaches 25–33%. According to the results obtained from two samples, permeability ranges from 1.3 to 3 mD (Table 3).

Table 3.

Results of the determination of porosity and permeability characteristics of the Karagan–Konk rock formations in the Absheron area.

Number of samples	Areas	Lithology	Porosity, %	Permeability, mD
17	Orjandag	Marl	9,30%	-
8	Fatmai	Sand	28	-
12	"	Sand	20,3	-
14	"	Marl	33,3	-
18	"	Sand	26,4	-
17	Zigilpiri	Sand	27,8	-
21	"	Sand	34,6	-
24	"	Sand	33,3	-
31	Damlamaja	Limestone	14,5	3
61	Shorbulag	Sandstone	21,1	1,3

The reservoirs of the Karagan horizon in the southern regions of Gobustan are represented by fine-grained, and in some places medium-grained, sandstones and siltstones. The quartz content locally reaches up to 50%. The average value of total porosity within each interval ranges from 17.1% to 22.7%. The permeability of the rocks varies between 21-55 mD.

Within the Absheron Peninsula (Shabandag, Damlamaca, Zigilpiri, and others), the Sarmatian–Meotian strata are characterized by sandy–silty rocks, fractured marls, and brecciated dolomites. The porosity of these rocks varies around 13.5%, which can be explained by their fractured nature (Table 4).

Table 4.

Results of the determination of porosity and permeability properties of the Sarmatian–Meotian rock layers in the Absheron area.

Number of samples	Areas	Lithology	Porosity, %	Permeability, mD
28	Fatmai	Sand	35,2	-
33	"	Sandstone	23,7	-
34	"	Silt	16,7	-
36	"	Sand	19,4	14
14	Jeyranbatan	Marl	9,7	-
17	Damlamaja	Marl	8,1	-
19	"	Clay	28	-
23	"	Marl	5,8	-
24	Shorbulag	Sandstone	8,9	at 10 atm Impermeable

32	"	Marl	8,9	"
48	"	Marl	13,2	"

The following points should be added to the materials describing reservoir properties:

1. In highly clayey reservoirs, such as the Miocene–Oligocene deposits, particularly during the interpretation of geophysical well logging (GIS) data, corrections for clay content are required. Apparently, for this reason, in some cases (Table 4) the difference between total and effective porosity reaches 5–10 times, which is difficult to explain. In turn, at low values of effective porosity (1.5–2%), the reported extremely high permeability values (150–200 mD) also appear unreliable.

2. The Miocene sedimentary sequences contain brecciated dolomites, fractured marls, thinly laminated “book-like” shales, and clays (for example, the Bazhenov-type deposits of West Siberia). By their nature, these are classified as “complex reservoirs” and should be studied using specialized techniques. Due to the absence of appropriate methodologies, these reservoirs have been investigated as conventional terrigenous reservoirs, which has not ensured the acquisition of objective and reliable data.

3. The migration and accumulation of hydrocarbons within the plastic clayey Paleogene–Miocene sediments are governed by specific conditions, primarily arising from the low reservoir properties of these rocks. Due to the absence of effective intra-formational migration pathways and the unfavorable conditions for hydrocarbon preservation, large accumulations cannot develop, resulting instead in the formation of numerous localized accumulations.

Regional Variation of Reservoir Properties

The study of samples taken from different sections across various fields for analyzing the porosity-permeability characteristics of the Maykop formations indicates that, in all structures, the overall porosity of sandy layers is relatively high, ranging between 15–30%. However, the highest volumetric properties are observed in the Sheytanud, Gicekiakhtarma, and Cheyildag structures. In other areas, these values are relatively stable, ranging from 15–25%.

Unlike porosity, permeability in sandy layers is higher within the III horizon of the Maykop formations. The distribution of total porosity in the sandy and siltstone layers of the Maykop deposits across the Gobustan fields demonstrates that the rocks possess significant volumetric properties, according to data obtained from outcrops (Figure 1).

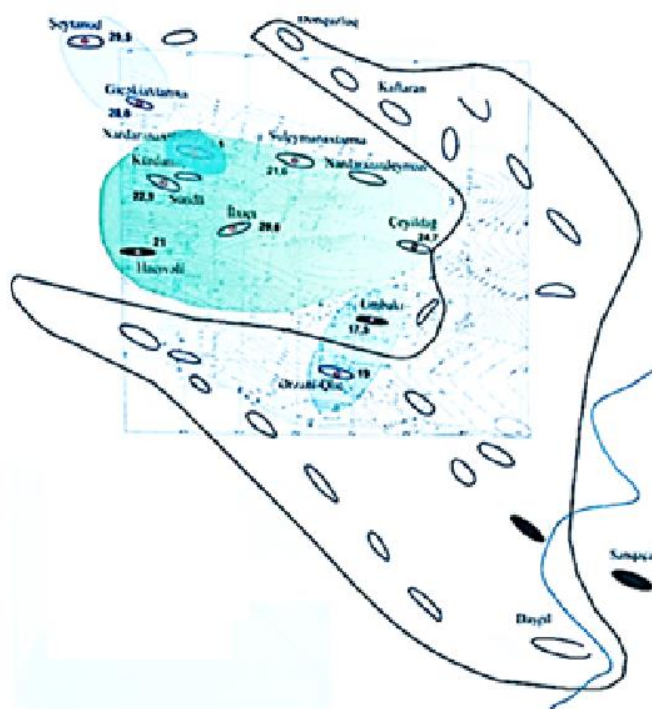


Figure 1. Variation of total porosity (%) of Maykop deposits across the Gobustan areas.

In the Sheytanud and Gicekiakhtarma fields, the porosity of the Maykop deposits exceeds 25%. Across the entire study area, porosity varies within the range of 20–25%. A general decrease in porosity from northwest to southeast is observed in the Maykop sediments. In the Umbaki, Arzani, and Qlic structures, porosity is less than 20%, indicating that these rocks possess favorable volumetric characteristics.

Against the background of total porosity, effective porosity is less remarkable. However, Horizon III is an exception, where the average value does not exceed 7%. In certain areas, effective porosity in sand layers reaches up to 12%. Nevertheless, the quantity and thickness of these layers are relatively small compared to the total thickness of the sand intervals.

Horizon III sands exhibit the best effective volumetric properties (Figure 2). In the Umbaki and Cheyildakh fields, effective porosity is low, whereas in the Khacivali structure, it is moderate.



Figure 3. Variation of permeability values of Maykop deposits in different areas of Gobustan, mD

structures adjacent to the Caspian Sea in southeastern Gobustan—specifically the Duvanni, Duvanni-Sea, and Sangchal-Sea areas—oil- and gas-bearing rocks were identified within Diatomaceous deposits.

According to the map of total porosity distribution of the Chokrak sandstones across the study area, the sandy deposits of South Gobustan exhibit relatively better volumetric properties, with total porosity exceeding 25% (Figure 5). In contrast, this parameter significantly deteriorates in the Chokrak deposits of East Gobustan, reaching 9.5% in the Dashgil field and 6.6% in the Sangachal-Sea area. Overall, the sandstones of the Chokrak stage in these structures can be characterized as rocks with poor to very poor volumetric properties. It should be noted that in the Dashgil structure, the Miocene deposits are not subdivided into stages and occur below 3400 m, corresponding to the Middle Miocene.

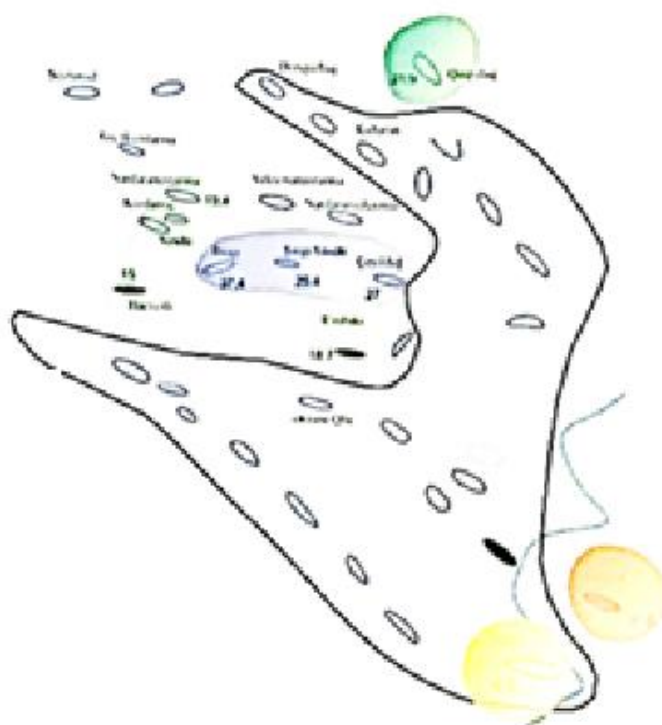


Figure 5. Distribution of total porosity (%) in sandy-silty deposits of the Chokrak Formation in Southeastern and Central Gobustan.

The permeability of the Chokrak deposits in the structures of South Gobustan decreases from south-east to north, indicating a deterioration in the filtration properties of the rocks. Overall, the sandy rocks of the Chokrak horizon in South Gobustan exhibit moderate to poor filtration characteristics. Clay cementation predominates within the Chokrak deposits, reaching 25–30% in some areas (e.g., Girgishlag, East-Sundu).

Based on effective porosity values, the Chokrak deposits of South Gobustan are characterized by very poor and ineffective volumetric properties. In Central Gobustan, effective porosity has been identified only in the Qırqışlaq area, where it exhibits negative values.

CONCLUSION

The sandy lithologies of the Maykop deposits in Central and Southern Gobustan exhibit well-defined zones of reservoir properties. Based on rock samples obtained from natural outcrops and core materials, despite generally good porosity, permeability and effective porosity decrease significantly in Central Gobustan. In the Umbakı, Çeyildağ, and Hacivəli structures of Southern Gobustan, the Maykop deposits can be characterized as rocks with low permeability.

The sandy-silty lithologies of the Çokrak formation in Southern Gobustan structures demonstrate adequate reservoir properties, with porosity values exceeding 15% and permeability characterized as weak to moderate. In Southeastern Gobustan, reservoir property indicators decrease, and these deposits can be classified as rocks with very poor to poor volumetric and permeability characteristics.

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