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G. D. ETIRMISHLI[1], *Chief Executive Officer, Doctor of Geologo-Mineralogical Sciences*
I. Kh. ARASTUN[2], *Head of Department, PhD*
A. V. SAMEDZADE[3], *Researcher, Candidate for a Doctor's Degree, agazade_afaq@mail.ru*
U. S. SERIKOVA[4], *Associate Professor, Doctor of Engineering Sciences*

[1]*Republican Seysmic Survey Center of Azerbaijan National Academy of Sciences, Baku, Azerbaijan*
[2] *SOCAR, Baku, Azerbaijan*
[3] *Baku State University, Baku, Azerbaijan*
[4]*Sergo Ordzhonikidze Russian State University for Geological Prospecting, Moscow, Russia*

BULLA-DENIZ OIL AND GAS FIELD: GEOLOGICAL FEATURES AND DEVELOPMENT PROSPECTS

The Bulla-Deniz oil and gas field is located in the South Caspian Basin and constitutes a significant part of the energy resources of in Azerbaijan. This article provides detailed information about the oil and gas potential of the Bulla-Deniz field, its geological-geophysical characteristics, and the development possibilities of the field. The Bulla-Deniz area has a complex structure of various layers of different geological periods. These structures are responsible for the abundance of hydrocarbon resources at different depths in the field. The characteristics of the Bulla-Deniz Sea field allow compression and concentration of oil and gas under high pressure, increasing the future production potential of the field. The oil and gas prospects of the field are directly related to the application of modern drilling technologies. Currently, horizontal and vertical drilling, hydrofracking and other advanced technologies are applied to increase the efficiency of production in the field. The research area is of strategic importance in terms of the potential and production of hydrocarbon reserves comprising significant part of the geological structures in the test field. Therefore, in order to assess hydrocarbon production and investigate hydrocarbon potential, the data on oil, gas and water reserves obtained as a result of exploitation of 4 different wells drilled in the area and the fund data of the State Oil Company of Azerbaijan were comprehensively analyzed and compared. The main objective of the research was to collate the analytical results with the oil and gas potential and to evaluate the promising nature of the area. The information on the physical and chemical properties of oil, amount of gas content of wells, as well as on water production and composition assists a more accurate assessment of the promising nature of the area, which, in turn, creates a framework, for the future production appraisal.

Keywords: *Caspian Sea, Bulla-Deniz field, oil and gas field, hydrocarbon resources, water, well, mud volcanoes, earthquake*
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Introduction

The research area is considered one of the strategically important oil, gas and gas condensate fields located in the South Caspian Basin, which provide most of the energy reserves in Azerbaijan. After its discovery in 1950, the offshore Bulla oil and gas field began to form the main part of the country's hydrocarbon industry. The South Caspian Basin is one of the deepest oil and gas systems in the world [1]. In general, the high oil and gas prospects of the Caspian Sea have attracted even more attention to the study of this area. Therefore, the research of lithology, stratigraphy and, in general, the geological and geophysical properties of the area is considered to be important from a geological point of view and is of great interest for improving the economic situation and the use of hydrocarbon resources in the country. The oil and gas system of the South Caspian Depression is characterized by high pressure, high permeability and high heat. It is recommended to conduct more in-depth studies of the oil and gas systems based on new geophysical and geochemical data [2].

In general, increasing hydrocarbon production at the Bulla offshore oil and gas field is of great importance not only for the Azerbaijani sector of the Caspian Sea, but also for strengthening the country's position in the regional energy market (**Fig. 1**). The South Caspian Basin, especially the Azerbaijani sector, has significant unexplored reserves of conventional oil and gas [3]. The purpose of this article is to assess the hydrocarbon reserves of the Bulla offshore oil and gas field and propose various strategic approaches for further fruitful work at the field.

The Caspian Sea is considered one of the largest oil and gas basins in the region. Its rich energy resources play a major role in both domestic and foreign markets. In terms of its prospects, the Caspian Sea is divided into 3 parts: South Caspian, Middle Caspian and North Caspian. The offshore oil and gas field Bulla, in turn, is a potential oil and gas field with high prospects, like the fields Babek, Umid, Khara-Zira and others located in the South Caspian Basin. The field has a rather complex geological structure and offers broad prospects. Rocks in the test field are categorized by their age. The field is mainly dominated by Quaternary deposits, and the physical properties of these rocks, namely porosity, density, water capacity, clay content and other properties, were determined as favorable for the accumulation of hydrocarbon resources. It should be noted that the physical and chemical properties of rocks composing the field have a significant impact on the exploitation process and directly affect the hydrocarbon loading. Therefore, a detailed study of the area is considered important. The correct and detailed analysis can have a positive impact on the disclosure of the oil and gas potential of a region. At the same time, as a result of an integrated approach based on modern technologies and modern methods, more effective information is obtained and more serious results are achieved.

In this article, based on all of the above factors, a comparative analysis of data from 4 different wells drilled using different technologies was carried out in terms of assessing the hydrocarbon potential of the Bulla-Deniz oil and gas field. Based on these data, a conclusion can be made about the prospects of the oil and gas field and the presence of suitable conditions for the accumulation of hydrocarbons. Based on the processed well data, the reports of the State Oil Company of Azerbaijan and the history of measurements, we analyzed the liquid flow rate, the percentage of water, the amount of mechanical mixture, the gas flow rate, and the amount of gas supplied. During these analyzes, an important role is played by the amount of air (gas) consumed per ton of oil. During production of hydrocarbons, the regulator was regularly checked and the flow rate was determined. Also, parameters of well drilling using a certain technology are also assumed to be among the factors that influence production. For this reason, when conducting a comparative analysis, we also analyzed the design of the lifting pipes, and as a result of all the information obtained, an assessment was made of the prospects for oil and gas content of the field, which allows us to express the opinion that this is one of the important indicators of a positive change in the hydrocarbon potential of the field during further operation.

The fact that the South Caspian Basin has a unique geological structure for oil and gas deposits further increases the prospects of the studied field and forms an idea of the high potential of the wells drilled in the field. Based

Fig. 1. Bulla offshore oil and gas field

on the above, the article, in addition to the favorability of the study area in terms of hydrocarbon production, sheds light on the possible difficulties that may be encountered during production. For example, difficulties that may arise as a result of the climatic factor.

The main objective of the article is to assess the future hydrocarbon potential by studying the geological and geophysical structure of the study area, as well as by assessing the presence of oil and gas. Based on the well data taken for the comparative analysis, the hydrocarbon prospects of the study area were analyzed and based on all this information, the optimal strategic directions for field exploitation were determined. Attention was also paid to the technologies and systems that can be applied at the production well in the future.

As a result, the main objective of the work is to assess the hydrocarbon reserves of the Bulla-Deniz oil and gas field, and provide the necessary recommendations for the process of further exploitation of the field, making strategic decisions to increase the future potential for oil and gas exploitation at the field.

Based on the selected well data, the geological structure of the field was detailed, and the comparative analysis methods were developed to increase the potential for resource extraction. Based on the comparative analysis method, it is supposed to develop a new approach to field development in accordance with the results obtained on the basis of geological and geophysical data.

Based on the information obtained from SOCAR stock materials, we have interpreted in detail the data on fluid, oil, gas and water production for wells No. 1, 2, 3, 4 as follows:

Well No. 1: According to the well data, the increase of oil and gas levels can be clearly observed during the production period. According to the data from well No. 1, it should be noted that the total hydrocarbon production volume increases every year. This well produces both gas and water. However, special attention was paid to gas production, and significant positive changes in gas production were found. In particular, significant achievements were made in the gas production process (**Table 1**).

Well No. 2: The oil production is even higher, and along with the gas production, the fluids obtained from this well naturally have high-quality oil and gas composition. Water production from the well is also observed, but the amount of water is relatively small (**Table 2**).

Well No. 3: This well shows stability in gas and oil production. The fluid production is generally moderate, and the amount of water is higher, which may cause some difficulties in the operation of the well (**Table 3**).

Table 1. Data of the well No. 1

Measurement date	Liquid production			percentage of water %	Gas production m^3/day
	Oil	water	total		
04.01.2023	21	4	25	17	60 000
11.01.2023	21	4	25	17	60 000
24.01.2023	21	4	25	17	60 000
Average monthly	21	4	25	16	60 000
04.02.2023	21	4	25	17	60 000
13.02.2023	21	4	25	17	60 000
Average monthly	21	4	25	16	60 000
04.03.2023	21	4	25	17	60 000
13.03.2023	19	4	23	17	60 000
17.03.2023	21	4	25	17	60 000
26.03.2023	21	4	25	17	60 000
Average monthly	21	4	25	16	60 000
04.04.2023	21	4	25	17	60 000
12.04.2023	21	4	25	17	60 000
24.04.2023	21	4	25	17	60 000
Average monthly	21	4	25	16	60 000
04.05.2023	21	4	25	17	60 000
13.05.2023	21	4	25	17	60 000
Average monthly	21	4	25	16	60 000
04.06.2023	21	4	25	17	60 000
13.06.2023	21	4	25	17	60 000
26.06.2023	21	4	25	17	60 000
Average monthly	21	4	25	16	60 000
04.07.2023	21	4	25	17	60 000
14.07.2023	21	4	25	17	60 000
Average monthly	21	4	25	16	60 000
04.08.2023	21	4	25	17	60 000
14.08.2023	21	4	25	17	60 000
26.08.2023	21	4	25	17	60 000
Average monthly	21	4	25	16	60 000
04.09.2023	21	4	25	17	60 000
14.09.2023	21	4	25	17	60 000
25.09.2023	21	4	25	17	60 000
Average monthly	21	4	25	16	60 000
04.10.2023	21	4	25	17	60 000
14.10.2023	21	4	25	17	60 000
23.10.2023	21	4	25	17	60 000
Average monthly	21	4	25	16	60 000
04.11.2023	21	4	25	17	60 000
14.11.2023	23	2	25	7	60 000
23.11.2023	23	2	25	7	60 000
Average monthly	21	4	25	16	60 000
04.12.2023	23	2	25	7	60 000
07.12.2023	23	2	25	7	60 000
12.12.2023	23	2	25	7	60 000
17.12.2023	23	2	25	7	60 000
Average monthly	21	4	25	16	60 000

Well No. 4: This well has recorded high gas production. Liquid production is relatively low (**Table 4**).

We analyzed the liquid production rate of the above wells, and analyzed and presented the current status of each well in terms of liquid, oil, gas and water production rates. The unique characteristics of each well, the trend of increasing or decreasing production rates, and the amount of water may be different, which makes process monitoring and optimization of each well necessary.

Table 2. Data of the well No. 2

Measurement date	Liquid production			percentage of water %	Gas production m³/day
	Oil	water	total		
04.01.2023	13	23	36	65	17 500
12.01.2023	13	23	36	65	17 500
26.01.2023	13	23	36	65	17 500
Average monthly	12.6	23.4	36	65	17 500
04.02.2023	13	23	36	65	17 500
11.02.2023	13	23	36	65	17 500
16.02.2023	10	24	34	70	17000
Average monthly	11.8	23.53	35.33	66.667	17333
18.03.2023	16	36	52	70	24 000
20.03.2023	15	35	50	70	23 000
24.03.2023	14	34	48	70	23 000
29.03.2023	14	34	48	70	23 000
Average monthly	14.65	34.65	49.5	70	23 250
03.04.2023	13	24	37	65	18 000
13.04.2023	11	25	36	70	18 000
19.04.2023	11	25	36	70	18 000
Average monthly	11.52	24.82	36.33	68.333	18 000
03.05.2023	11	26	37	70	18 000
12.05.2023	11	25	36	70	18 000
25.05.2023	11	25	36	70	18 000
Average monthly	10.9	25.43	36.33	70	18 000
03.06.2023	11	26	37	70	18 000
11.06.2023	11	25	36	70	17 000
21.06.2023	11	25	36	70	17 000
Average monthly	10.9	25.43	36.33	70	17 333
03.07.2023	11	26	37	70	17 000
10.07.2023	11	25	36	70	17 000
21.07.2023	11	25	36	70	17 000
Average monthly	10.9	25.43	36.33	70	17 000
03.08.2023	11	25	36	70	17 000
18.08.2023	11	25	36	70	17 000
26.08.2023	11	25	36	70	17 000
Average monthly	10.8	25.2	36	70	17 000
03.09.2023	11	25	36	70	17 000
11.09.2023	11	25	36	70	17 000
19.09.2023	11	25	36	70	17 000
26.09.2023	11	25	36	70	17 000
Average monthly	10.8	25.2	36	70	17 000
03.10.2023	11	25	36	70	17 000
11.10.2023	11	25	36	70	17 000
19.10.2023	11	25	36	70	17 000
Average monthly	10.8	25.2	36	70	17 000
03.11.2023	11	25	36	70	17 000
11.11.2023	11	25	36	70	17 000
20.11.2023	10	25	35	71	16 000
Average monthly	10.58	25.08	35.67	70.333	16 667
03.12.2023	10	24	34	71	17 000
08.12.2023	10	24	34	71	17 000
13.12.2023	10	24	34	71	17 000
18.12.2023	10	24	34	71	17 000
Average monthly	9.86	24.14	34	71	17 000

Table 3. Data of the well No. 3

Measurement date	Liquid production			percentage of water %	Gas production m³/day
	Oil	water	total		
28.01.2023	2.0	2.0	4	50	60 000
Average monthly	2.0	2.0	4	50	60 000
03.02.2023	2.0	2.0	4	50	60 000
15.02.2023	2.0	2.0	4	50	60 000
23.02.2023	2.0	2.0	4	50	60 000
Average monthly	2.0	2.0	4	50	60 000
02.03.2023	2.0	2.0	4	50	60 000
12.03.2023	2.0	2.0	4	50	60 000
20.03.2023	2.0	2.0	4	50	60 000
28.03.2023	2.0	2.0	4	50	60 000
Average monthly	2.0	2.0	4	50	60 000
02.04.2023	2.0	2.0	4	50	60 000
12.04.2023	2.0	2.0	4	50	60 000
Average monthly	2.0	2.0	4	50	60 000
02.05.2023	2.0	2.0	4	50	60 000
12.05.2023	2.0	2.0	4	50	60 000
26.05.2023	2.0	2.0	4	50	60 000
Average monthly	2.0	2.0	4	50	60 000
02.06.2023	2.0	2.0	4	50	60 000
12.06.2023	2.0	2.0	4	50	60 000
24.06.2023	2.0	2.0	4	50	60 000
Average monthly	2.0	2.0	4	50	60 000
02.07.2023	2.0	2.0	4	50	60 000
12.07.2023	2.0	2.0	4	50	60 000
24.07.2023	2.0	2.0	4	50	60 000
Average monthly	2.0	2.0	4	50	60 000
02.08.2023	2.0	2.0	4	50	60 000
11.08.2023	2.0	2.0	4	50	60 000
20.08.2023	2.0	2.0	4	50	60 000
29.08.2023	2.0	2.0	4	50	60 000
Average monthly	2.0	2.0	4	50	60 000
02.09.2023	2.0	2.0	4	50	60 000
10.09.2023	2.0	2.0	4	50	60 000
22.09.2023	2.0	2.0	4	50	60 000
Average monthly	2.0	2.0	4	50	60 000
02.10.2023	2.0	2.0	4	50	60 000
10.10.2023	2.0	2.0	4	50	60 000
20.10.2023	2.0	2.0	4	50	60 000
Average monthly	2.0	2.0	4	50	60 000
02.11.2023	2.0	2.0	4	50	60 000
15.11.2023	2.0	2.0	4	50	60 000
25.11.2023	2.0	2.0	4	50	60 000
Average monthly	2.0	2.0	4	50	60 000
02.12.2023	2.0	2.0	4	50	60 000
14.12.2023	2.0	2.0	4	50	60 000
26.12.2023	2.0	2.0	4	50	60 000
Average monthly	2.0	2.0	4	50	60 000

Table 4. Data of the well No. 4

Measurement date	Liquid production			percentage of water %	Gas production m³/day
	Oil	water	total		
04.01.2023	3	3	6	50	100 000
11.01.2023	3	3	6	50	100 000
25.01.2023	3	3	6	50	100 000
Average monthly	3	3	6	50	100 000
04.02.2023	3	3	6	50	100 000
15.02.2023	3	3	6	50	100 000
24.02.2023	3	3	6	50	100 000
Average monthly	3	3	6	50	100 000
04.03.2023	3	3	6	50	100 000
16.03.2023	3	3	6	50	100 000
26.03.2023	3	3	6	50	100 000
Average monthly	3	3	6	50	100 000
04.04.2023	3	3	6	50	100 000
19.04.2023	3	3	6	50	100 000
Average monthly	3	3	6	50	100 000
04.05.2023	3	3	6	50	100 000
19.05.2023	3	3	6	50	100 000
Average monthly	3	3	6	50	100 000
04.06.2023	3	3	6	50	100 000
19.06.2023	3	3	6	50	100 000
28.06.2023	3	3	6	50	100 000
Average monthly	3	3	6	50	100 000
04.07.2023	3	3	6	50	100 000
19.07.2023	3	3	6	50	100 000
Average monthly	3	3	6	50	100 000
04.08.2023	3	3	6	50	100 000
14.08.2023	3	3	6	50	100 000
25.08.2023	3	3	6	50	100 000
Average monthly	3	3	6	50	100 000
04.09.2023	3	3	6	50	100 000
14.09.2023	3	3	6	50	100 000
26.09.2023	3	3	6	50	100 000
Average monthly	3	3	6	50	100 000
04.10.2023	3	3	6	50	100 000
14.10.2023	3	3	6	50	100 000
26.10.2023	3	3	6	50	100 000
Average monthly	3	3	6	50	100 000
04.11.2023	3	3	6	50	100 000
14.11.2023	3	3	6	50	100 000
24.11.2023	3	3	6	50	100 000
Average monthly	3	3	6	50	100 000
04.12.2023	3	3	6	50	100 000
14.12.2023	3	3	6	50	100 000
Average monthly	3	3	6	50	100 000

The impact of volcanoes and earthquakes on oil and gas exploration

The nature and depth of mud volcano products in the South Caspian Basin were studied. It was found that mud volcanoes serve as indicators of oil and gas resources [4]. The formation mechanism of mud volcanoes in the South Caspian Basin was studied using 2D and 3D seismic data. Oligocene (Late Oligocene–Early Miocene) and productive series (Upper Miocene–Upper Pliocene) were identified as the main source rocks of mud volcanoes [5]. According to the volcanic eruption data near the Bulla Marine Structure, there were no volcanic eruptions near the structure or adjacent structures in 2023. However, in 2021, in addition to Gushchu and Dashly volcanoes, Shikhzahirli volcano erupted 3 times at an interval of about 5 minutes, and in 2022, since Lokbatan volcano is located near the study area, its impact on hydrocarbon production was investigated, but no changes were found. The formation time, duration, depth and coordinates of these volcanoes were picked out by us and the corresponding analysis was carried out (**Table 5**).

In addition, 40 earthquakes with coordinates close to the study area were selected from the 2023 catalog. It is noticed that the processes in the centers of stress activity in the areas of the Gobustan and Nizhne-Kura depressions, close to the Bulla marine structure, can cause geodynamic changes in the oil reservoirs in the study area.

The histogram of the distribution of seismic energy corresponding to the seismic activity around the areas of the Bulla marine structure of the South Caspian Basin shows its change with characteristic values in 2003–2024 (**Fig. 2**).

The distribution of seismic energy for 2003–2024 was plotted depending on the number of earthquakes. The graph shows that the dynamics of seismic activity in 2010–2024 has increased significantly compared to previous years (see Fig. 2). Looking at the graph, it is clear that seismic activity is high in 2023. Based on the obtained data, a comparative analysis of seismic activity with hydrocarbon production was conducted to determine the impact of earthquakes on hydrocarbon production.

Well data analysis. Based on the data from wells Nos. 1, 2, 3 and 4, the volume of oil, gas and gas condensate production at the Bulla offshore oil and gas field was analyzed. The main objective of the comparative analysis was to identify the oil and gas potential of the Bulla offshore oil and gas field. All this was analyzed in terms of gas composition, physicochemical characteristics of oil and water content, as well as its composition. The gas content of the field is considered to be very rich. To improve the efficiency of operation, it is necessary to take into account both geological analysis and technological optimization [6]. A comparative analysis was made of the main components of the gas produced here, namely, methane, ethane, propane and other elements, as well as their content. An analysis of the lithofacies characteristics of the productive series on the northwestern flank of the field was carried out. The distribution of gas condensate in the formations is directly related to lithological heterogeneity [7]. In addition to the physical properties of oil, its chemical properties were also studied, mainly taking into account density factors. The amount of liquid water obtained from the well was also determined, as well as the minerals that make up the water and its

Table 5. Time of formation, duration, depth and coordinates of volcanoes

Date	Time	Lat	Lon	H, km	Duration of eruption	Volcano name
09.01.2021	13:48:36	40.49	49.03	2	3 min 28 s	Shikhzahirli
09.01.2021	13:53:59	40.49	49.03	2	2 min 18 s	Shikhzahirli
09.01.2021	13:58:17	40.49	49.03	2	7 min	Shikhzahirli
23.01.2021	15:23:21	40.44	48.74	2	2 min 48 s	Gushchu
04.07.2021	21:51:00	39.62	49.71	1.48	8 min	Dashli
11.08.2022	05:36:47.06	40.30	49.71	3	5 min 12 s	Lokbatan

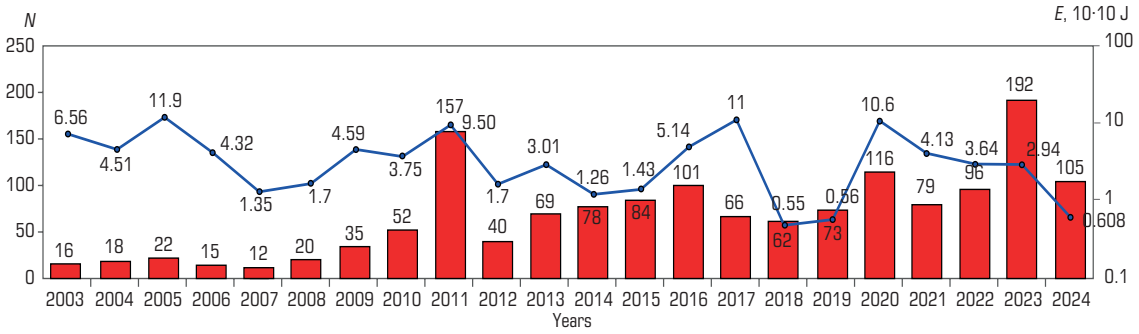

Fig. 2. Histogram of seismic energy distribution by the number of earthquakes in Azerbaijan in 2003–2024

ionic composition. The reason all this information is important is that it allows us to estimate the future prospects of the field.

Geological analysis. The Bulla-Deniz field was chosen because of its unique geological structure and the abundance of rocks with oil and gas potential since its discovery. For this reason, the researchers conducted structural and stratigraphic analyses to explore the geological features of the area more accurately. The location of hydrocarbon reserves in the field can be determined based on the analysis of rocks of different ages that make up the field and the location of these rocks using stratigraphic analysis. The importance of structural analysis was that the structural change of the area was studied based on the tectonic characteristics of the area and the influence of all these factors on the accumulation of hydrocarbons was investigated. The hydrocarbon reserves of the field and the exploitation of these reserves, as well as the production potential were determined as a result of the geological analysis. Also, as a result of geological studies, both structural and stratigraphic, conducted at the Bulla-Deniz oil and gas field, drilling points were determined in accordance with the purpose of exploitation. A comprehensive analysis of logging and GIS data was carried out using the Techlog software package. An analysis of geophysical and lithological data was carried out, zones with a high content of gas condensate were identified and drilling of new wells in the southwestern part of the structure, where the highest productivity is observed, is recommended [8, 9].

Hydrodynamic analysis. Based on geological and geophysical data obtained from wells Nos. 1, 2, 3 and 4, taken during research work, data on pressure, temperature of the reservoir and fluid flow here were analyzed. The study of these parameters helps determine the technologies and methods that will be involved in the extraction of hydrocarbon resources. As a result of the hydrodynamic study of the reservoir, a model of fluid and gas flow was built, and drilling and production methods were analyzed to improve the efficiency of hydrocarbon exploitation. Hydrodynamic analysis was used to select production technologies. In some fields of the South Caspian Basin, natural renewal of oil and gas reserves is observed. This renewal is associated with active hydrodynamic processes, such as hydrocarbon migration from deeper layers [10]. Geochemical features of hydrocarbon systems of the South Caspian Basin are described. The processes of hydrocarbon migration and their accumulation in various geological structures of the region are considered [11].

Potential production. Models have been created to increase the various production potentials based on geological, geophysical and hydrogeological information obtained from the four wells shown above. The general methods calculate the volume of geological reserves of the deposits and the total volume of reserves using the internal structure. There is also a gradation of the method set by the manufacturer, which can be included with regard to all technical and economic factors. The assessment of total reserves, the maximum carbon potential of the deposit, the amount and composition of minerals extracted from the wells depends on the production process. In the process of extracting hydrocarbon resources, the relationship between technical and economic factors plays an important role. The geological structure of deposits, their depth and the reservoir properties of rocks determine the choice of technological solutions, which directly affects the costs and efficiency of extraction. The use of such technical methods as hydraulic fracturing, water and gas injection has a significant impact on the increase in production, but the choice and implementation of these methods should be accompanied by a comprehensive economic risk analysis. Electrification of production facilities and the introduction of alternative energy sources are also considered as factors that have a positive effect on the technical and economic indicators of field development [12].

Statistical methods. Statistical methods were used to increase the carbon potential of the offshore Bulla oil and gas field. As a result, the long-term carbon potential was estimated. Using various statistical methods (Monte Carlo simulation and sensitivity analysis), the future development of the Bulla-Deniz oil and gas field was determined. Based on all these data and with the help of modern technologies, various methods for operating new wells in the future exploration field will be developed. Modern research shows that at the initial stage of field development, it is possible to achieve high productivity through the use of natural energy sources (primary recovery), but for long-term operation, technological and economic optimizations are necessary [13, 14].

Economic efficiency

The oil and gas condensate fields located in the study area are at the final stage of development and are complicated by mud volcanoes, and are also subject to active tectonic processes. The impact of the earthquakes on this study area was assessed, although its economic and practical efficiency is not manifested to a significant extent. The results obtained can be used to determine the locations of new wells, as well as to control the dynamics of the exploitation of oil and gas horizons under development.

Accounting for geodynamic abnormal changes, mud volcanoes and changes caused by earthquakes plays an important role in preventing emergency situations when drilling new wells, and also affects the efficiency of oil production.

Discussion

The data obtained from 4 wells at the Bulla-Deniz field are very important for clarifying the structural characteristics of the field and the availability of resources. The composition of the gas obtained from the wells, especially methane and other alkanes, plays an important role in determining the quantity and quality of gas reserves in the field. At the same time, the amount and composition of water observed in the wells indicate possible difficulties that will be encountered during the production process. High water content can create difficulties for the long-term operation and efficiency of the field production, especially technical problems associated with the separation and processing of water.

The physicochemical properties of oil (viscosity, density) obtained from these wells are important indicators for assessing the production potential of the field. The corresponding properties of oil affect the choice of the most suitable methods for its production, and this is especially important in the case of high viscosity oil [15–18].

Considering the fact that earthquakes cause tectonic changes, the relationship between hydrocarbon production and earthquakes was assessed in terms of the effect of seismicity on changes in the physicochemical properties of rocks and the accumulation of hydrocarbons. It is determined that earthquakes cause changes in the volume of production. The geological structure of the field directly affects the location of reserves and the possibility of its production. The stratigraphic and structural characteristics of the Bulla-Deniz field are characterized by the presence of rocks representing different geological periods. The composition of these rocks, especially carbonate and non-carbonate structures, plays an important role in determining the presence and volume of oil and gas reserves in a field. The presence of highly productive rocks indicates that the field has high production potential, but geological complexity and structural variations may complicate the drilling and production processes. At the same time, it is possible to estimate the location of reserves and the volume that can be naturally produced based on the structural characteristics of the field and stratigraphic analysis based on well data. This also helps to make more accurate predictions about the development of the field. The production potential of the Bulla-Deniz field was determined based on both gas and oil reserves. Volumetric and calibration methods were used to determine the total reserves of the field and estimate the recoverable reserves. These results indicate that the field is technically and economically viable, but high water content and some geological risks may complicate the production processes. Difficulties in drilling operations and water treatment problems may affect the long-term exploitation and economic viability of this field.

In particular, to improve the productivity of the field, it is necessary to reduce water consumption and apply modern technologies. These issues are important considerations when making decisions about optimizing production and developing the field. The economic viability of the Bulla-Deniz field was determined as a result of an analysis carried out on the basis of the obtained well data. The data obtained from the wells were assessed taking into account the expected revenues from the production of the field and the operating costs of these processes. The application of technologies necessary for the production of oil and gas, as well as the economic efficiency of these technologies, were considered. In particular, the large volume of water and the environmental impact of the production processes are important issues to consider for the sustainable development of the field.

Conclusions

The Bulla-Deniz oil and gas field is considered to be an area with rich hydrocarbon resources in the South Caspian Basin, and the selected wells in the study area were identified as highly promising. As a result of the comparative analysis, it is found that despite the complex geological structure of the field, high water cut, as well as the difficulties identified in the production process, the hydrocarbon reserves here are high. It is shown that in order to increase the hydrocarbon potential at the Bulla-Deniz field, the study of new technologies for well operation is considered mandatory. The work also examined the factors that can affect hydrocarbon production. As a result of the study, it is noticed that volcanoes do not affect hydrocarbon production. The relationship between earthquakes during the period of high seismic activity and hydrocarbon production is assessed, and it is found that earthquakes have a high impact on the production process in terms of its flow rate.

In order to improve the efficiency of oil production at the studied field, additional geological and geophysical studies are needed. Although the Bulla-Deniz oil and gas field has high productivity, in order to increase the prospects of oil and gas production, in addition to geological and geophysical factors, environmental and technical factors that may cause difficulties in the production process should also be taken into account. To prevent these difficulties, new technologies and modern methods should be applied. Conducting more extensive and in-depth studies and making appropriate decisions on the development of the Bulla-Deniz oil and gas field will enable the hydrocarbon resources in this area to be effectively extracted in the future.

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