

RISK ASSESSMENT OF OIL-GAS PERSPECTIVES OF DEEP-SEATED SEDIMENTS BASED ON GEOCHEMICAL MODELS OF MUD VOLCANOES WITHIN ABSHERON REGION

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Abstract

In the article, in order to identify the variability of the isotopic-chemical composition of mud volcano gases within Absheron oil-gas-bearing region and to grade the oil-gas perspectives of deep-lying sediments, the characteristics of the variability in the composition of methane gases, HHC, CO₂, nitrogen, at the same time isotopic structure of methane gas and carbon dioxide were investigated. The gas emissions of Azerbaijan mud volcanoes contain more than 90% methane. During the analysis of samples taken from the study area of mud volcanoes in the Absheron region, the methane content was determined to be 92-98.53%. At the same time, a regular decrease of methane gas in the gas composition (98.53-83.94%) is noted in the southwestward. Maps were compiled and a comparative analysis was conducted to analyze the characteristics of noted gases changes in gases of mud volcano along the studied area. According to the analyses, it stands to mention the west-southwest part is characteristic with the lowest value of methane, and the high value of HHC and carbon dioxide. In the southwestward, mud volcano gases are expressed with less amount of methane and with high amount of HHC. Carbon dioxide has an average value. According to the analyses, mud volcano gases of the Absheron oil-gas-bearing region are also characterized nitrogen, and compounds of nitrogen. The amount of nitrogen varies between 0.11-10.89%, and the highest amount is observed in the Shorbulag (10.89%) mud volcano situated along the west of the peninsula. Within Absheron oil-gas-bearing area, almost all structures associated with mud volcanoes are prospective with hydrocarbons. Comparison of mud volcanoes and oil field gases is given as the case of the Lokbatan field. The chemical constituent gases of mud volcanoes consists mainly of combustible hydrocarbons and is predominantly associated by the gases of oil, and gas fields. However, it is fact that the violent or weak eruption of mud volcanoes also depends on the underground reserves of these gases and, at the same time, on the plasticity of the rocks. The violent eruption occurs when the gas reserves are high and the plastic rocks are thick, and when they are insignificant, weak eruption occurs. The existing an oil films in the composition of the eruption products that throughout by mud volcanoes shows the accumulation of petroleum along with gas.

Keywords: mud volcanoes, organic carbon, methane, eruption products, nitrogens, distribution.

I. Introduction

The Absheron oil-gas-bearing area, located in the northwest of the South Caspian depression, covers the plunge of depression of the same name. This region includes the Absheron Peninsula and the part of the Azerbaijan sector of the Caspian Sea covering from Absheron-Pre-Balkan zone to the Kapaz structure (Absheron archipelago). Tectonically, corresponds to the southeastern plunge of the Greater Caucasus megaanticlinorium. The maximum thickness of the sedimentary layer of the region is

noted in the southern part of the Peninsula, within shelf zone of sea. It is more than 24 km. 3500-4000 m of the section consist of the Productive series (PS) sediments (Lower Pliocene) [1].

the geological structure of the Absheron oil-gas-bearing region consists of terrigenous-carbonate rocks of the Upper Cretaceous-Cenozoic age. Lower Pliocene sediments (PS) are quite widespread and are represented by alternations of sand, sandstone, siltstone and clay. The maximum oil saturated sediments are PS sediments was determined in the central part of the Absheron Peninsula (Balakhani-Sabunchu-Ramana, Surakhani, Bibiheybat fields), where the number of productive horizons is about 40. The spreading of oil-gas and the location of their deposits in the areas depend on lithological and structural-tectonic factors. An increase in the gas saturation of the layers is observed in the direction of regional subsidence. The oil-gas perspectives of the Miocene-Paleogene, Mesozoic deposits are highly assessed [2,3].

The folds of the Absheron oil and gas-bearing region have a diapir form and are complicated by numerous normal faults and thrusts associated with mud volcanoes.

40 fields have been identified on the Absheron Peninsula and in the water area of the Absheron archipelago. According to the emplacement of the fields, 21 of them are classified as oil, 9 as oil-gas, 3 as gas-condensate, and 7 as oil-gas condensate. Majority of the fields are related to mud volcanoes. Half of them the mud volcanoes are located predominantly within them [4,5].

Mud volcanoes of the Absheron region are located on the Absheron Peninsula and the archipelago of the same name adjoining it from the north, east and south (Fig. 1). There are 69 active, extinct and buried volcanoes. Of these, 39 are located on land and 30 are located offshore [6].

The largest mud volcanoes in the Absheron region are located in its southwestern part: Otmanbozdagh is the highest volcano in Azerbaijan (404 m). Bozdagh-Gobu, Sarinja, Lokbatan and Bozdagh-Guzdak volcanoes are higher than the surrounding area by 105-225 m.

The largest mud volcanoes in the central part of Absheron are Abikh and Keyreki. Height is 95 and 116 m, respectively. In the Absheron archipelago, the largest volcanoes, rising 100-116 m above the bottom of the Caspian Sea, have been identified in the Gunashli and Chirag fields [7].

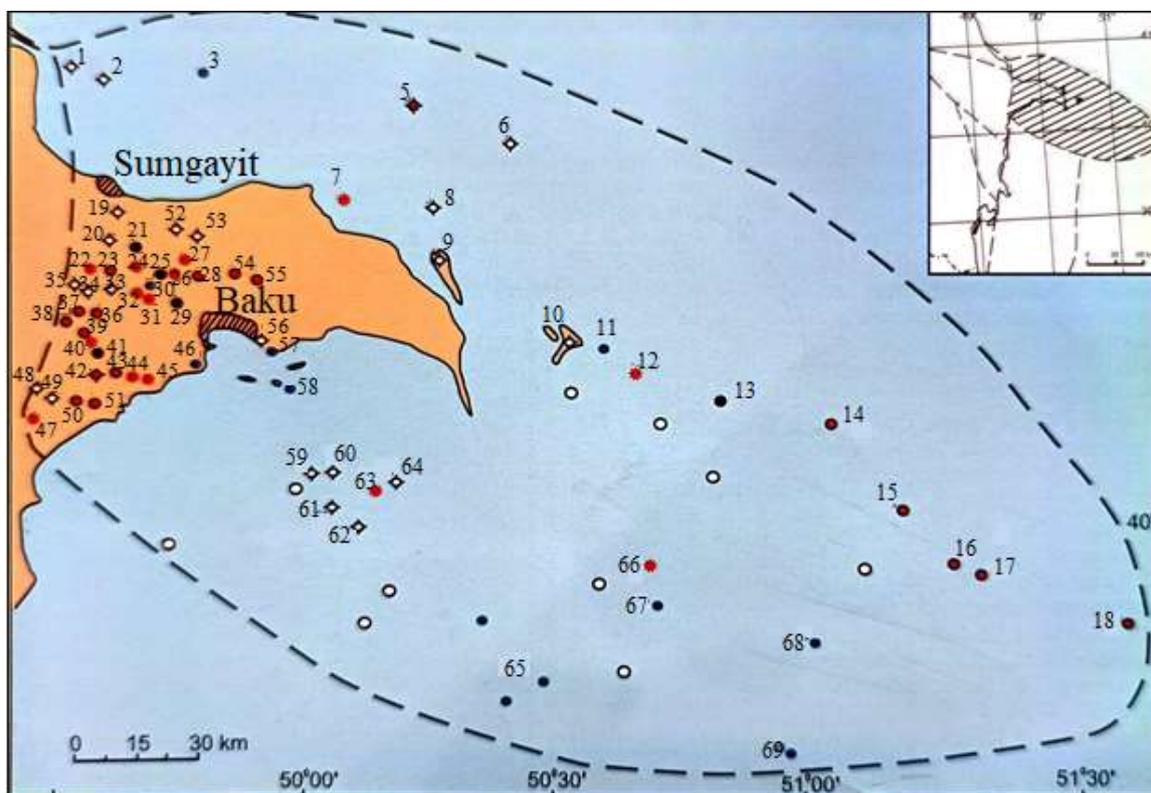


Fig. 1. Location map of mud volcanoes in the Absheron oil and gas-bearing region

Mud volcanoes: 1-Yashma-deniz, 2-Shurabad-deniz, 3-Two brothers, 4-Aghburun-deniz, 5-Absheron Bank, 6-Gilavar, 7-Buzovna Pilpila, 8-Darwin Bank, 9-Pirallahi Island, 10-Chilov Island, 11- Hazi Aslanov, 12-Palchig Pilpila, 13-Neft Dashlari, 14-Gunashli, 15-Chirag, 16-Azeri-west, 17-Azeri-east, 18-Kepez, 19-Giralti, 20-Komuratan, 21-Sengar, 22-Uchtepe, 23-Atbatan, 24-Kecheldagh, 25-Abikh, 26-Keyraki, 27-Boyukdagh, 28-Kichikdagh, 29-Zigilpiri, 30-Sulutepe, 31-Bozdagh-Hokmeli, 32-Bozdagh-Gobu, 33-Agzikhezri, 34-Qaraheybat, 35-Damlamaja, 36-Bozdagh-Guzdek, 37-Deveboynu, 38-Shorbulag group, 39-Gulbakht, 40-Sarinja, 41-Shongar, 42-Giziltepe, 43-Guskhana, 44-Akhtarma-Puta, 45-Lokbatan, 46-Bibiheybat, 47-Otmanbozdagh, 48-Ceyranuchan, 49-Pilpila Garadagh, 50- Torpagli-Akhtarma, 51-Akhtarma-Garadagh, 52-Pilpila-Goradil, 53-Kullutepe, 54-Kirmaki, 55-Bogh-bogha, 56-Pilpila-Zygh, 57-Zygh, 58-Gum-deniz, 59-1906, 60-1960, 61-Seyyar, 62-Saba, 63-Bahar-deniz, 64-1933, 65-Shah-deniz group, 66-1908, 67-Absheron-west, 68- Absheron-east, 69-A.Yagubov

The formation of volcanoes along the oil-gas-bearing areas and closely relation to the processes of formation of folds and faults are significates of the presence of oil-gas fields in these areas. It's a fact that the power sources of mud volcanoes are located in deep-lying reservoir layers which produce hydrocarbon gases. The chemical compound of gases of mud volcanoes is not similar where the mud volcanoes are developed. And change due to the thermo-dynamic medium of the subsoil, as well as the characteristics of the geological structure of these areas. The geochemical properties of mud volcano emissions are the main indicators in identifying the gas and oil-bearing of the subsoil. The mud volcanoes develop onshore and offshore, and determine the world over spacing of hydrocarbons within the Earth's interior. At the present, volcanoes, as a significant component of the ecological system, ensure draining out of gases of deep submerged deposits [8]. During the eruption of mud volcanoes and during the quiet period, enormous gases is emitted from the Earth's interior into the atmosphere [9]. It is fact, the layer of the sediments of the areas where is mud volcano is formed have a very large amount of gas reserves. The focus of gases of mud volcanoes developed in Azerbaijan is the Cretaceous and Paleogene sediments. The learning of gas-bearing is important.

The complication of the folds with longitudinal and transverse faults associated with mud volcanoes located in the Absheron-Pre-Balkan megasaddle and the South Absheron archipelago of the Absheron region, the existing of Paleocene, Cretaceous (K), Eocene age rock fragments in the eruption products, indicates the presence of a crushed area rich in natural gases below the base of volcanoes. This is also confirmed by the occurrence of gas flowing in a number of fields.

In the study region, Upper Cretaceous (K₂), Eocene and Paleocene rock particles are found within erupted wastes of Bozdagp-Gobu, Bozdagp-Guzdek, Sarinja, Gulbakht, Shongar, Lokbatan, Pilpila Garadagh, Torpagli-Akhtarma, Boyukdagh, Kichikdagh, and Ziyilpiri mud volcanoes. The oil and gas-bearing of the fields associated with the noted mud volcanoes varies in a wide range [10].

In preparation for deep exploration drilling, 14 wells were drilled in the Shongar field, which the Shongar mud volcano is associated. Gas flowing was obtained from the horizon VIIa in well 10.

The Post-Kirmaki sandy (PKS) suite (horizon VIII) on the southern limb of the Garadagh fold is highly productive. 250-350 th.m³ of gas and 40-50 tons of condensate were obtained from wells located in the buried part of the southeastern limb of the fold per day. The most productive well was well 130, located in the buried part of the southeast of the fold. During testing 800 th.m³ of gas and 100 tons of condensate per day was obtained [11].

The Shah-deniz mud volcano group is located on the crest and plunge of the fold of the same name, located in the Fatmayi-Garachukhur-Zygh-Gum-adasi anticline zone, which was formed by the Pliocene-Quaternary sediments and became more complicated by thrust faults.

The confirmed (discovered) reserves of the Shah-Deniz field are: more 1 tr.m³ of gas, >300 million tons of condensate.

As of 2007, three wells were in operation in the field. These wells produce 15 million m³ of gas and 4,000 tons of condensate per day. Since 2008, four wells have been in operation in the field, and the average daily production of these wells is 19 million m³ of gas and 4,500 tons of condensate. Since the beginning of operation (2006) to this date, 5.9 billion m³ of gas and 1.6 million tons of condensate have been produced from the field [12].

II. Method

When mud volcanoes activate, significant amounts of liquid, solid, as well as gaseous substances are released onto earth's surface. These substances mainly used for searching of oil-gas accumulations. Drawing on the ends of laboratory studies of these substances of mud volcanoes, it is achievable to get detail data for oil, and gas-bearing of deeply-seated sediments. In this regard, studying of geo-chemical compounds of mud volcanoes of the Absheron oil-gas-bearing area are a main factor for discovering of more and more oil-gas, and gas condensate fields.

In order for studying mud volcano emissions, luminescent-bituminological, and geo-chemical studies of sediment fragments included in the breccias were conducted [6]. Organic carbon, components of bitumen, humus matters are determined by studies. Organic carbon varies most often in the mud volcano product of the Absheron region, ranging from 0.17 to 4.68%.

On the basis reasoning from the studies of bitumen, it was identified that oil-series bitumens predominate in the rocks of mud volcano wastes [6]. Prevalently, bitumen is found in the form of spills, proves that this is original with the rocks that contain them. The above shows that the geo-chemical and geological features of rocks where mud volcano associated are similar to these characteristics of the rocks that form oil and gas deposits.

The test report of some analyzes show that the mud volcanoes gases of Azerbaijan don't different than in chemical composition gases from the hydrocarbon deposits and, contain mainly of heavy hydrocarbons, methane, also accompanying carbon dioxide, at the same time nitrogen. Along with this, as a result of these analyzes, carbon oxide, hydrogen-2, hydrogen sulfide, also inert gases were detected in some cases.

III. Results and discussion

In order to clarify changes in the isotopic, chemical compound of mud volcano gases within Absheron area and for assessment of prospect for oil-gas-bearing, distribution maps of CH₄ (Fig.2), HHC, CO₂, N₂, also the isotopic compound of methane and carbon dioxide over the areas have been constructed.

The gas emissions of Azerbaijan mud volcanoes contain more than 90%, in some cases 98% methane. The amount of carbon dioxide in these gases varies from one to 6-7%, the rest percent are heavy hydrocarbons and nitrogen. In some cases, hydrogen, hydrogen sulfide and inert gases are also noted [13].

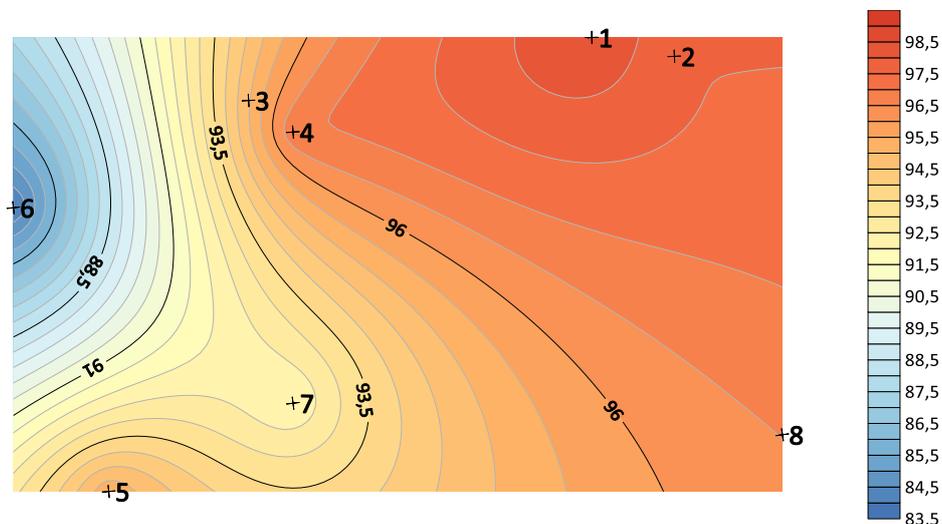


Fig. 2. Distribution map of methane along the Absheron oil and gas-bearing region
Legend: Mud volcanoes: 1-Kirmaki, 2-Bogh-Bogha, 3-Bozdagh-Gobu, 4-Bozdagh-Hokmeli, 5-Akhtarma-Garadagh, 6-Shorbulag, 7-Lokbatan, 8-Otmanbozdagh

In the study area, the methane content in 1 sample taken from the Kirmaki, Bogh-Bogha, Bozdagh-Gobu, Bozdagh-Hokumali, Akhtarma-Garadagh, Lokbatan mud volcanoes and in 6 samples taken from the Shorbulag mud volcano ranged from 92% to 98.53% [6,7]. As we can see from the map, there is a regular decrease in the amount of CH₄ (98.53-83.94%) (Fig. 2).

The value of HHCs along study area varies between 0.09% -0.53%. The value of methane of gas content of mud volcanoes inversely related to the value of HHCs.

In the Absheron oil and gas-bearing region, the highest amount of heavy hydrocarbons was determined in the gases of the Bozdagh-Hokmely mud volcano, is amounted 0.53% (Fig. 3). The value of HHC slightly increases and is associated with the gas flow from oil-gas-condensate deposit to the volcanic crater [14].

Depending on the value of HHCs of gases released from volcanoes, it is possible to determine what type of deposits are they belong, to oil or gas. The value of HHCs in the gases of volcanoes related to oil accumulations is relatively maximum, and the noted maximum amount of HHCs is associated to the oil hydrocarbon accumulations of the individual uplifts whereabouts volcanoes are located. This situation is also affirmed with oil gush in individual well drilled along the Lokbatan fold, whereby the Lokbatan mud volcano is developed.

First exploration well 62 was drilled onto seashore, eastern part of Lokbatan uplift, whereby oil gush was obtained from the horizon II of the PS sediments. In well 45, a strong oil gushes (20 thousand t/day) were got from the VIa horizon of the PS. The sandy layers of both the horizon VII, in addition, the horizon VIIa is more promising. Wells, drilled here put into development with flow rate of 200/300 tons per day.

The well 45 was drilled eastern of the mud volcano conduit (by the recommendation of Sultanov B.I.), which covered breccia from above, gave a strong oil gush of 15000-20000 t/day from the horizon VIa of the PS for three days [15].

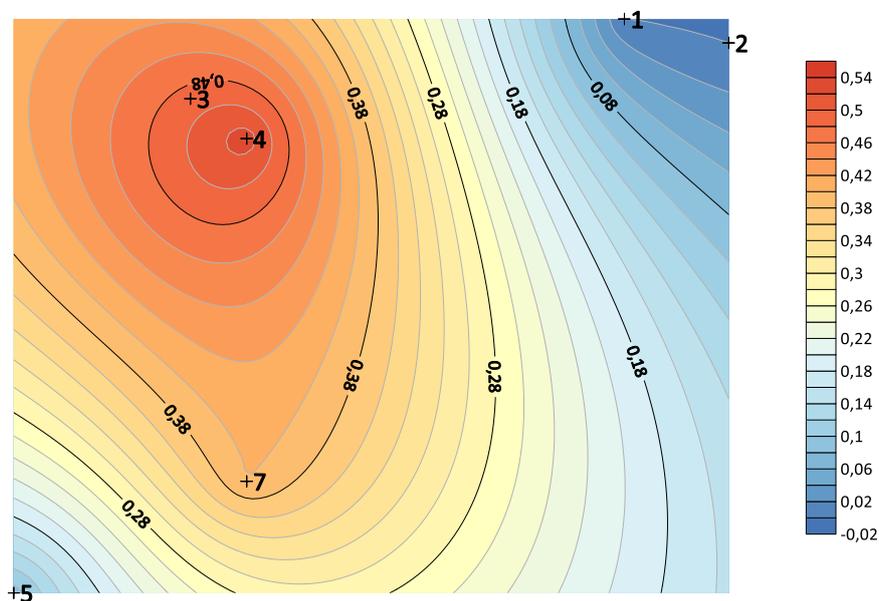


Fig. 3. Heavy hydrocarbons distribution map along the Absheron OGR
 (Legend, see fig.2)

The content of heavy hydrocarbons in the Bozdagh-Hokmeli mud volcano is also 0.56% (Fig. 3). The volcano is located at the junction of two anticlines: one of them is located southeast of Bozdagh (Shabandagh-Lokbatan-Putu anticline), the other (Khirdalan-Binagadi anticline) is located northwest. An exploration well drilled in the southern part of the Shabandagh field yielded 50 tons per day of hydrocarbon along the Kirmaki suite [16].

As mentioned above, one can conclude that the released gases from erupted materials of mud volcanoes gradually become get rich off with HHCs separated from oil-gas fields, while they move via along sedimentary stratum.

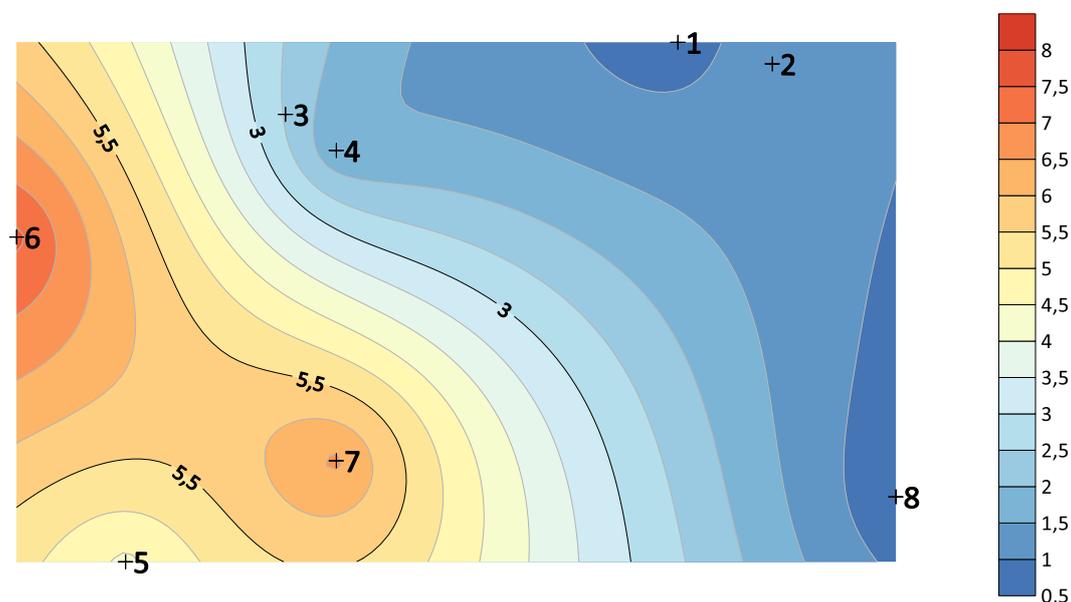


Fig. 4. Carbon dioxide distribution map along the Absheron OGR
 (Legend, see fig.2)

The distribution map explained that the content of carbon dioxide in the composition of gas products released from mud volcanoes in the Absheron OGR, changes in a large diapason (Kirmaki-0.71%, Bogh-Bogha-1.39%, Lokbatan-2.48%, Shorbulag-7.62%) (Fig. 4). It is appreciable that the content of CO₂ in the composition of gases of oil field is mean, consist of 7-8%.

Referring to the comparative analysis of the distribution maps of CH₄, HHCs and CO₂ associated with gases of mud volcanoes of the region, can be noted that the west-southwest part is characterized by the lowest content of methane and the highest content of heavy hydrocarbons and carbon dioxide. Mud volcano gases in the southwestward are characterized with lowest content of CH₂ and high content of HHCs. The content of CO₂ is average. However, calculated gas releasing from mud volcanoes increases from northwest to southeast.

N₂ and nitrogen compounds are also associated with gases and oils of mud volcanoes, although in small quantities. The value of nitrogen related with gases of mud volcanoes different. It is value in mud volcanoes in the Absheron oil and gas-bearing region varies between 0.11-10.89%, and the highest amount is observed in the Shorbulag (10.89%) mud volcano located in the west of the peninsula. The value of N₂ associated with mud volcanoes of the peninsula varies from 2.28% to 23.6% (according on the 6 sample analysis). The average value is 10.89% (Fig. 5).

The generation of N₂ in the field gases is different. Half of it is formed by the exogenous waters infiltrated from atmosphere through the soil, and half of it is formed due to the decomposition of nitrogen-containing organic substances in rocks, waters and oils. Nitrogen is also formed at the depth [7]. Study has shown that the value of HHCs and N₂ increase towards the base of the Mesozoic [14]. The maximum nitrogen value is observed at the Shorbulag mud volcano, and this is most likely due to the decomposition of nitrogen-containing organic matter, at the same time moving via fracture zones, and entry to the top of the section from the surface.

Porphyryns are first decomposition products of the complex nitrogenous compounds, associated with a number of oils. The existing of nitrogenous components in oils are the main factor confirmed that oil is generated from organic components. Be sensible of the fact that C is the basic compoud in hydrocarbons, its isotopic composition is also interested. The both isotopes C₁₂ and C₁₃ of carbon are constant, because the isotope (C₁₃) increases by the carbon oxidation. The isotopic structure of HC gases

and petroleum cut is different. Methane is richer in the C₁₃ isotope. The change in the isotopic composition of gases during emigration is of special interest. Molecules of gases with the isotope C₁₂ exceed the isotope C₁₃ along the migration. The methane isotopic compound depends on the lithofacial content of rocks. However, when methane gas moves via existing faults within areas with high porous and permeable rocks, the isotopic composition does not change. Thus, it can be supposed that when migration occurs in dense and low-porous rocks (clay), the value of isotopes C₁₃ within sediments increase [17].

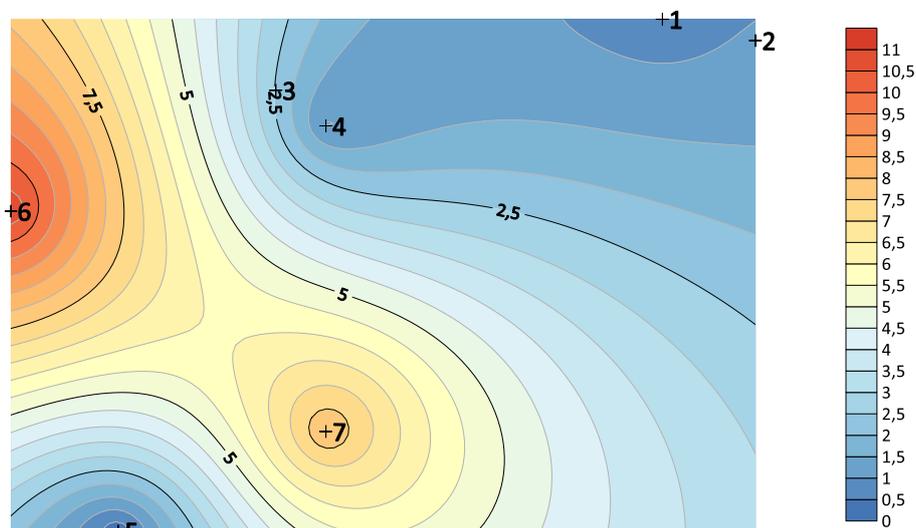


Fig. 5. Nitrogen distribution map along the Absheron OGR
 (Legend, see fig.2)

As can be seen from the maps of changes in carbon isotope composition established for the Absheron OGR, the C isotope of CH₄ fluctuate from 43.4 to 56.8‰ (Fig. 6). This fluctuation is associated to the lithofacial composition of the sedimentary layer of the depression. Thus, since the sedimentary layer made up by dense and low porous carbonate rocks, the value of isotopes C₁₃ in the rocks get larger, while in the west and southwest, since it made up by clayness-carbonate, sandiness rocks, the value of isotopes C₁₃ within rocks does not change enormously (Fig. 6).

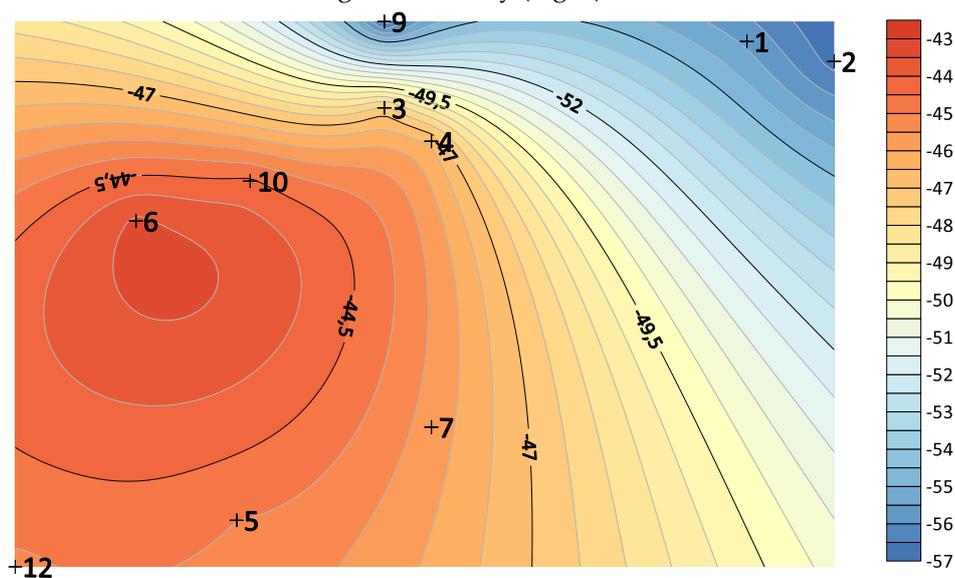


Fig.6. Change map of methane isotope composition along the Absheron OGR

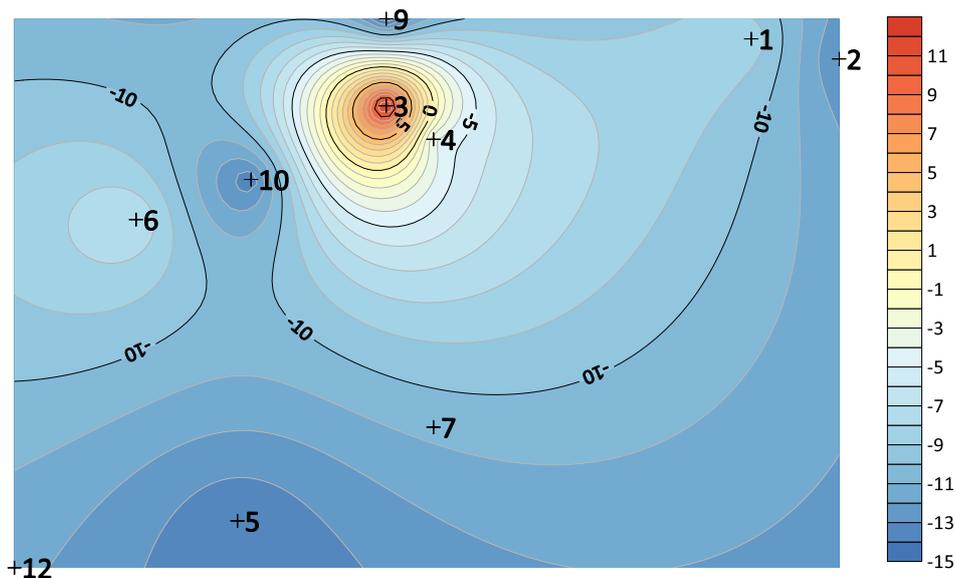


Fig.7. Change map of carbon dioxide isotope composition along the Absheron OGR

The carbon isotope of CO₂ within research region changes from -3.9‰ to 13.1‰. The high content of the carbon isotope is observed mainly in the center of the peninsula (13.1‰) (Fig. 7), whether concurs with the zone where the maximum content of CO₂ is distributed. It is most likely related to the fact that in the studied region, the amount of the isotope C13 is larger in CO₂ and carbonates [8].

Within Absheron OGR, almost all mud volcano structures are prospective with hydrocarbons. One of the richest oil-gas field of the Absheron Peninsula is the Lokbatan field. Conducted exploration works cover along the area covered by mud volcano breccia.

Memories of the history of oil production in Azerbaijan are associated with the Lokbatan mud volcano. For a long time, areas with mud volcanoes were considered unpromising for the search for industrial hydrocarbon resources. Mud volcanism was considered a factor in the collapse of oil and gas fields. However, many geologists disagreed with this idea and accepted the opposite. Some even suggested drilling oil wells in volcanic areas. In this regard, well 45 drilled in the Lokbatan mud volcano erupted with a flow of 20 thousand tons, thereby proving that volcanoes do not destroy deposits. However, initially in the Lokbatan volcano, the genetic links of mud volcanoes-oil deposits were established, and the need to search for mud volcanoes arose. It is interesting that during the exploitation of the Lokbatan field, over 27 mil.t. of hydrocarbons and 1 bil.m³ of gases were extracted from the subsoil. The famous well 45 is still being exploited.

The gases of the Lokbatan mud volcano consist of hydrocarbons by their chemical composition. According to gas analyses taken from the volcano, it consists of 92% methane, 2% heavy hydrocarbons, and up to 2.5% carbon dioxide.

During the eruption of Lokbatan volcano, the volume of gas released in the first phase was 300,000 m³. The gas released in the second phase was 2,500,000 m³, and in the third phase was 4,200 m³. As can be seen, a large volume of gas was released into the atmosphere with one eruption. When we compare this volume with the gas extracted from the field during the development process, it can be seen that it is a very small amount less than the half-yearly production of this enterprise. Taking into account the intensity of the gases released in previous eruption, ground that there is an extremely large gas reserve in the interior of the area.

If we examine the chemical compound of oil field gases, especially gas fields, we see that they, like the composition of mud volcano gases, consist mainly of methane, with a few content of HHCs, carbon dioxide, and a few content of nitrogen gas. A comparison of mud volcano and oil field gases is given in Figure 8.

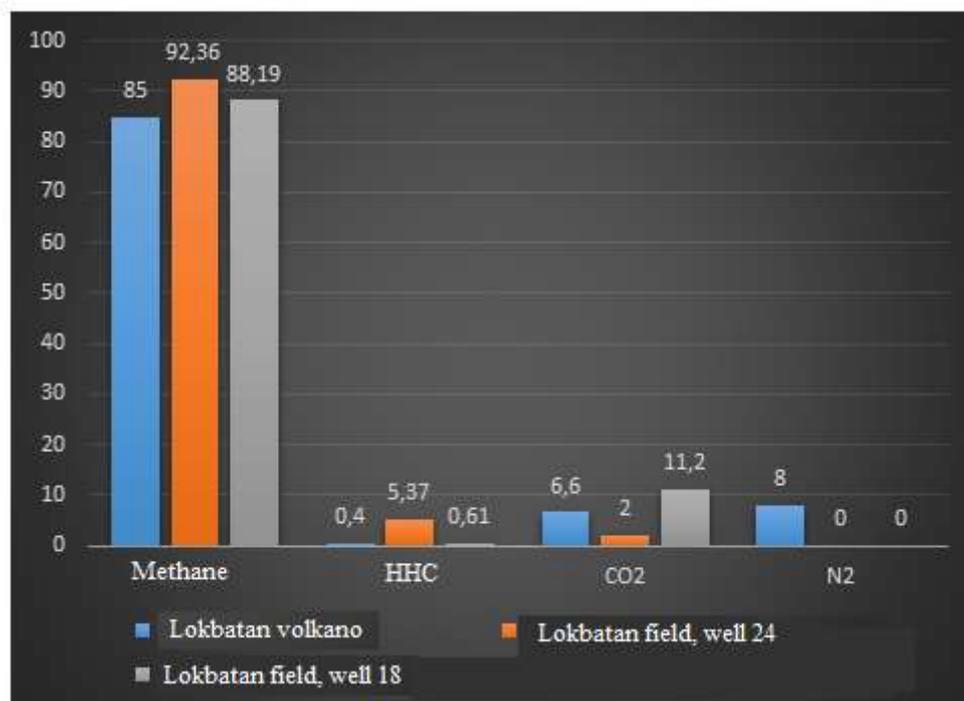


Fig. 8. Comparison histogram of gases of the Lokbatan ...

As show the histogram, the chemical compound gases of mud volcanoes consists mainly of combustible hydrocarbons and are close associated to the gases of oil and gas fields. If there were no natural gas deposits in the deep layers of the areas where mud volcanoes are located, then mud volcanoes would not have formed. The violent or weak eruption of mud volcanoes also depends on the underground reserves of these gases and, at the same time, on the plasticity of the rocks. When the gas reserves are high and the plastic rocks are thick, violent eruptions occur, and when they are low, weak eruptions occur.

Underground waters also have a great influence on the eruption of mud volcanoes. Analysis of the chemical features of water samples collected from mud volcanoes show that the compound of these waters is the same as the waters of oil fields located in the mud volcano area or in the neighborhood. Mud volcano waters contain chlorine, sodium, potassium, bicarbonates, etc., as in oil field waters. Elements such as naphthenic acid, iodine, boron, bromine, which are characteristic of oil field waters, are distributed in all mud volcano waters in greater or lesser amounts. Mud volcano waters are divided into alkali and hard water types. The degree of mineralization of mud volcano waters varies according to the degree of mineralization of oil field waters nearby. So, mud volcano waters are also related to oil field waters.

24 samples were taken from the Paleogene-Miocene sediment complexes for determination the organic substances dispersed in the solid waste of Lokbatan mud volcano [6]. These samples consist of sandstone, siltstone, clay, marl, limestone and dolomite. The amount of bitumen and organic carbon in them was determined.

Bitumen in the noted rocks increases from 0.03 to 0.8%, in rare cases increases up to 1.56%. The high content of bitumen (0.8-1.56%) is not due to the presence of bitumen in a dispersed state, but is due to the enrichment of rocks with epigenetic bitumens as a result of migration. High content of bitumen is noted in oil-saturated limestone samples (sample 3, 70,71,72,73). Bitumen content is 2.3, 4.69, 1.56, 2.34, 6.25 respectively.

The content of organic carbon (C_{org}) varies from 0.01-1.05%. In a sample No.70 its content increases to 1.83%, which are also strongly saturated with oil (Fig. 9).

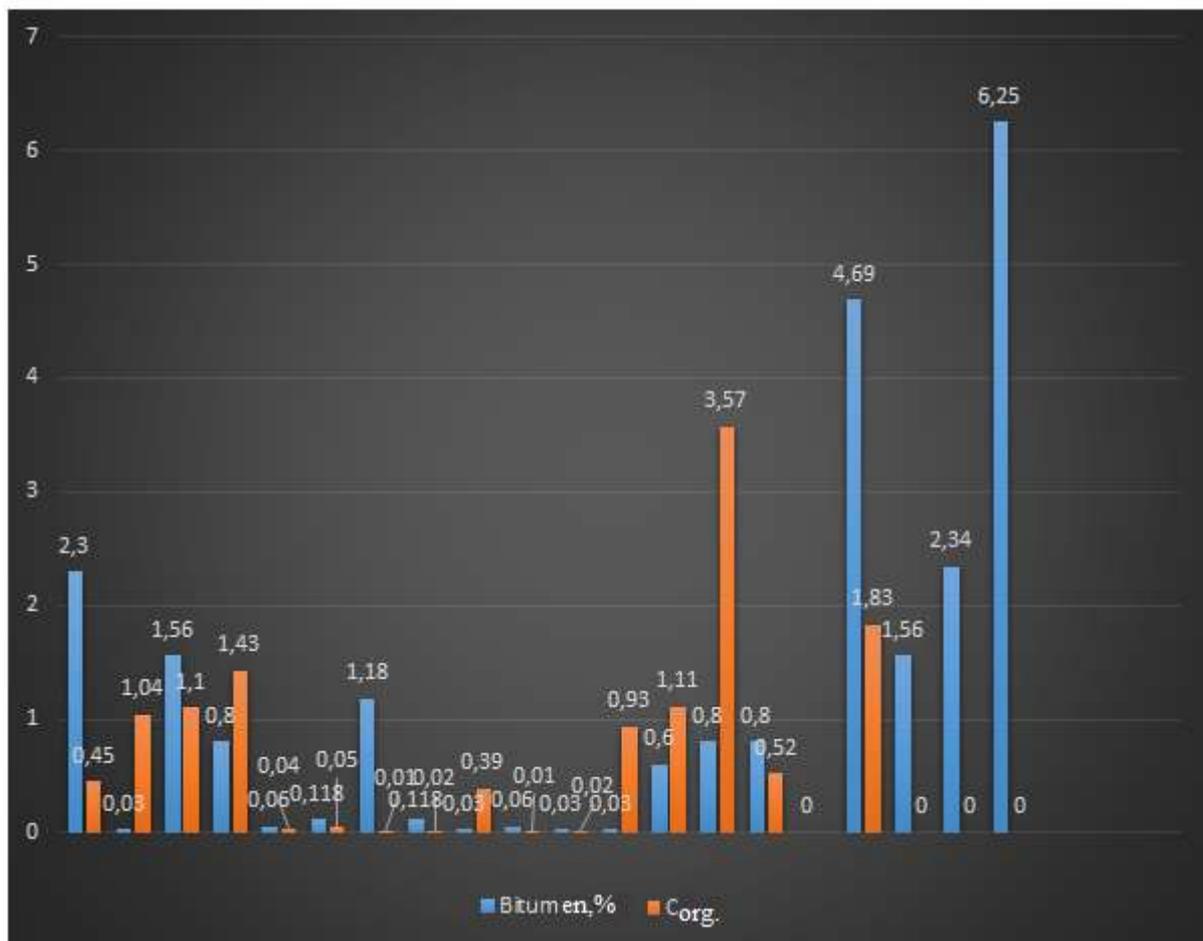


Fig.9. The content of bitumen and organic matter in the solid waste of the Lokbatan mud volcano

The oil-gas-bearing all fields is associated with upper and lower stages of the PS. One of the largest hydrocarbon deposit depending on the size and volume of oil reserves is the sandiness layer of the horizon VI of the PS.

The oil and gas-bearing of the Kirmaki field, where the mud volcano of the same name is located, is mainly related to the sediments of the lower section of the PS. Currently, all horizons of the Kirmaki (KS) and Pre-Kirmaki (PK) suites of the PS have been put into operation.

The Qum-deniz fold forms the southern edge plunge of the Fatmai-Garachukhur-Zygh anticline line, which is considered the main anticline line of Absheron region.

21 objects are in operation in the Qum-deniz field. Initially, Ga and PK suites were put into operation in the II block. Later, Xa, IXa, IXo, VIy and others are developed. 27,083 thousand tons of oil, 15,375 mln. m³ of dissolved gas, 10397 mln. m³ of free gas and 832 th.t. of condensate was exploited from objects by wells [1].

A comprehensive study of mud volcano products of the Absheron oil-gas-bearing region allows us to distinguish zones suitable for collecting of hydrocarbon and gases.

The degree of development of diapir and local folds and mud volcanoes complicating them along the three tectonic zones of the area is related to the tectonic conditions of these zones and the intense of compressional stresses affecting them. According to the results of the analysis, the least intensity of compressional stress is noted on the north slope of the Absheron-Pre-Balkan megasaddle. It is explained by the weakening of compressional stresses in the direction of the Scythian-Turanian plate to the north. For this reason, diapir folds (Goshadash, Aghburun-deniz, Absheron Bank) and their cryptodiapiric types (Khazri, Dan Ulduzu, Arzu, Gilavar, Ashrafi, Garabagh, Hamdam, North Absheron) have developed here. Mud volcanoes have not developed in the northern zone. Only in the Absheron Bank

the griffon with natural gas manifestations along the longitudinal fault, which complicates the arch part of the fold, mud volcano manifestations in the Gilavar structure, and a buried mud volcano in the Goshadash structure are observed [9].

The test results of exploration wells drilled in the Khazri, Garabagh, Ashrafi folds of North Absheron confirmed the presence of industrially significant hydrocarbon accumulations in separate layers of the lower section of the PS.

In the exploration well 2 drilled in the Garabagh field 770,000 m³ per day of gas from the Pre-Kirmaki suite (PK), 707,000 m³/day of gas from the Post-Kirmaki sandy suite (PKS) and 82 m³ per day of condensate flow was obtained.

In the Hamdam fold, from well 3, 798,000 m³ per day of gas and 27 m³ per day of condensate from the PK suite, while 300 m³/day of oil flow from the PKS suite was obtained.

Exploration well 1 in the Ashrafi area produced 640,000 m³/day of gas and 70 m³/day of condensate from the PK suite, and 556 t/day of oil and 27,000 m³/day of gas from the PKS suite was gotten.

During the test work of well 4 in the Khazri area, the gasbearing of the lower Cretaceous deposits was determined and 6-7,000 m³ per day of gasflow was gotten at the 4327-4319 m interval. The gas obtained from the Hauterivian stage of the Lower Cretaceous in the Khazri-4 prospecting well, drilled in the hypsometrically higher area of the North Absheron fold zone, show that these sediments will be industrially important oil and gas in the parts of the noted fold zone with suitable lithofacies and structural-tectonic conditions.

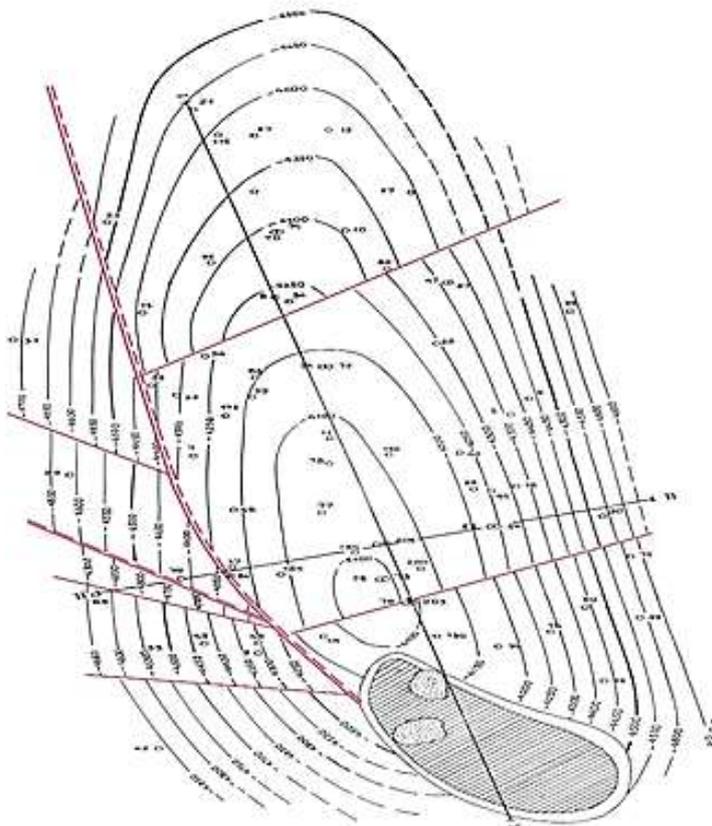


Fig.10. Bahar field. Structural map on the horizon IX of the Productive series (Lower Pliocene)

During drilling from well 1 in the Goshadash area, a strong gas gush was obtained from Miocene sediments. During drilling from exploration well 4 drilled in the Absheron Bank, 150-200,000 m³ per day of gases and 15-20 m³ per day of condensate were gotten via the PK suite. Gases also was gotten from the Gala suite in exploration well 42 with a production rate of 82,000 m³/day. 10 t of oil from PK suite in exploration well 48, and 7 t of oil from KS in exploration well 49 was obtained [11].

In the North Absheron fold zone, hydrocarbon fields are replaced with oil-gas, gas fields with gas condensate, with the weakening of the degree of deformation and dislocation of structures in the northwest-southeast direction along anticlinal lines. Along the southern slope of the Absheron-Pre-Balkan megasaddle, majorly diapir structures have developed and are complicated by mud volcanoes. In the southern zone, Sulutepe, Shubani diapir folds, Surakhani, Hovsan, Turkan, Gala, Buzovna-Mashtagha cryptodiapir folds have developed. Along the Absheron Peninsula, 11 active, 11 periodically erupting, 4 extinct, 4 buried mud volcanoes and Lokbatan, Guzdek, Garadagh, and in the aquatorium, Bahar, Gum-deniz gas-mud volcanoes have developed [6].

According to the results of deep drilling, the Bahar field is represented by a brachyantoclinal fold, has an asymmetric structure, dimensions 10x4.5 km (on the top of the horizon IX), and a height of up to 450 m. The structure is complicated by faults and tectonic faults and is divided into 8 tectonic blocks. There is a mud volcano in the southwestern part of the transverse longitudinal fault along the entire western limb.

As mentioned above the field is divided into 8 tectonic blocks, blocks I, II, III are considered the major according to the amount of hydrocarbons.

15 hydrocarbons (gas, condensate, oil) objects have been identified in the Bahar field through exploration and prospecting [13].

During the development of a number of wells in the lower part of the section of the Gala suite in the Turkan area, industrial oil was obtained, and well 1216 operated with a production of 100 tons per day.

In the areas noted in the South Absheron zone, oil deposits are spread across the entire section of the PS.

The deep dislocation extending on the axis of the Absheron-Pre-Balkan megasaddle is specified by the formation of cryptodiapir, diapir-type structures, mud and gas-mud volcanoes. Diapir folds such as Janub, Janub-2, Gunashli cryptodiapir, Gurgan-deniz have developed here. The remaining structures are complicated by mud volcanoes and gas-mud volcanoes (Neft-Dashlari, Azeri, Chirag).

The Gunashli structure is situated within Absheron-Pre-Balkan tectonic zone to the south-east of the Neft Dashlari field, and the oil and gas content of the fold is associated with PS sediments. As a result of test work from well 4, an oil gush was obtained with a production of 230 t/day from the horizon X of the Balakhani suite, and 320 t/day from the Fasila suite from well 6. The lower suites of the PS (PKS, PK, GaS) are gas condensate. Oil and gas-condensate deposits are related with tubular and tectonic screened types of traps.

The Neft-Dashlari fold is formed by the crushed clayey sediments of Miocene-Upper Paleogene age, complicated by large longitudinal faults and numerous transverse faults. In the southeastern part of the fold, where transverse and radial faults intersect with longitudinal faults, there is a mud volcano and numerous griffons that regularly emit oil and gas. The mentioned mud volcano is a gas mud volcano. The base of the mud volcano is made up of Oligocene-Miocene sediments, and Eocene and Upper Cretaceous rock fragments are found in the volcanic breccia. Here, 26 oil objects covering all its series and horizons have been identified along of the PS section. Oil-bearing layers are thick within the tectonic blocks has a minimum value in the northwest of the structure, and a maximum value in the southeast, while the mud volcanoes are replaced. The oil-bearing of the GaS, which forms the base of the PS, has been determined in all blocks of the field. The GaS-4, GaS-3 horizons are oil-bearing, while the GaS-2, GaS-1 horizons contain oil with gas gap. The fact that the entire section of the PS is oil-bearing and the fault is complicated by a gas-mud volcano gives reason to say that the sediments underlying the PS are oil-bearing.

The Chirag gas-mud volcano is located on the southeastern plunge of the fold of the same name, above the crushed zone at the intersection of longitudinal and transverse faults.

During testing, 154-355 t/day of oil and 201000 m³/day of gas flow were obtained from 2 objects from the Fasila suite of the PS and 1 object from the Balakhani suite (horizon X) of the Chirag field. Later, gas-condensate was obtained from horizons IX, VI, V and IV of the PK, PKS and Balakhani suites, and oil from horizons VII, VIII.

The Azeri gas-mud volcano is situated along the south limb of the structure of the same name. Later, another volcano was identified in the central part of the northern wing. 9 objects of the MG were opened in the southwestern wing of the structure. Oil-gas mixture was obtained from horizons X, IX, VIII, VI and V of the QUQ, FLD (2 objects) and Balakhani formations. Hydrocarbon flow rate up to 155-300 t/day, and gas flow rate was 12-75 m³ per day. Gas condensate was gotten via PKS, from horizons VI, V, the output of which was 245-300 th. m³ per day and 30-70 tons per day, correspondingly [1].

The morphological characteristics of the folds and the analysis of the relationships of the structural-formational complexes of different ages show that mud volcanoes are associated with structures complicated by faults in a thick sedimentary layer and subjected to sharp folding.

A comparison of the tectonic structure of depressions located in the mobile belts of the earth's crust shows that since separate subsidence areas complicated by large faults and subjected to sharp folding are noted only in the eastern part of Azerbaijan and the adjacent South Caspian water area, most mud and gas-mud volcanoes are concentrated here. The basic point for the development of the latter in the mentioned zone is the significant increase in the thickness of the rock layer, the content of clayness along intersection and the oil and gas-bearing in the southeast direction within folds of the South-Caspian mega-depression [18].

The compressional stresses arising along the area is a main factor for formation of its structural tectonic plan, the dispersion of fluid, and reformation of different type of accumulations, the collection, also storage of sediments and OM in them, which are subsequently turned to oils, by the environment of non-compensated intense sinking floor of the South Caspian depression, and the development of diapirism and mud volcanism.

In areas with appropriate quality distribution of compressional stresses and in the absence of large-scale research in areas where mud volcanism develops, it is possible to predict the oil-gas bearing of the area.

IV. Conclusion

1. The focusing of HHCs into mud volcano gases within Absheron OGR is inverse proportional to the content of methane in them.

2. Increasing of the content of methane in mud volcanoes along the northeast-west direction on the Absheron Peninsula, also decreasing of the content of CO₂, HHCs, gives grounds to say that there are significant oil-gas, gas-condensate reserves in this zone.

3. The sediments building up of the mud volcanoes root of in the Absheron OGR are Maykop and Pliocene age, but the presence of rock fragments of Upper Cretaceous, Paleocene, Eocene ages in the erupted materials of 16 mud volcanoes gives grounds to say that there are crushed zones enriched in natural gases under the roots of the volcano.

4. According to isotope analysis, the mud volcano gases in the Absheron OGR are characterized by a lighter isotope composition of carbon.

5. Separate subsidence areas, complicated by large faults and subjected to sharp folding, is noted along the east part of Azerbaijan and adjacent South Caspian water area. Therefore, a significant increase in the thickness of the sedimentary layer, the percentage of clay content of the section and oil and gas-bearing in the southeastward has led to the development of most mud and gas-mud volcanoes here.

CONFLICT OF INTEREST

Authors declare that they do not have any conflict of interest.

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