THE GEOLOGICAL RISK OF CHANGING THE PARAMETERS OF THE RESERVOİRS DEPENDING ON THE DEPTH IN A NUMBER OF FIELDS OF THE BAKU ARCHIPELAGO

Gultar Nasibova, Khuraman Mukhtarova, Shura Ganbarova, Sahila Nasibova

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Azerbaijan State Oil and Industry University
Oil and Gas Institute, Azerbaijan
gultar.nasibova18@gmail.com,
mukhtarova.khuraman@mail.ru
qanbarovanicat@mail.ru
sahila_00@mail.ru

Absract

Geological risk belongs to the doubt and variableness of the reservoir characteristics and internal structure, like as porosity, permeability, heterogeneity, thickness, faults, crucks, and seals. These characteristics identify the amount and quality of the hydrocarbons in deposits, as well as the recovery coefficient and the production rate. Geological risk possible to reduce by acquiring and analyzing more data, like as seismic, well logs, core sampling, and producing history. In addition, by using suitable methods and models to assess the range of possible outcomes.

So, this paper discusses the results of studying terrigenous Mesozoic and Cenozoic rocks of the Sangachal-deniz-Duvanny-deniz-Khara-Zira oil and gas bearing region of the Baku archipelago element of the South Caspian depression as possible reservoirs of oil and gas, its characteristics and geological risk in changing of reservoir parameters [1].

To explain the nature of the change in rocks by depth, graphs of the dependence- dependence of porosity on depths were plotted.

The depth of occurrence of these rocks along the well sections varies from several hundred meters (Khara-Zira field) to 5500-6000 m (Sangachal-deniz, Duvanny-deniz fields). The wells uncovered rocks from the Quaternary to the middle Miocene (Chokrak). Well sections are represented by alternation of sands, sandstones, dolomites and clays. The wells completely uncovered the section of the Productive Series (PS). The maximum thickness of the PS in the Sangachal-deniz field and in the north-east part of Khara-Zira is 3950-4000 m. Hypsometrically elevated parts of the Sangachal-deniz and Duvanny-deniz structures, the thickness of the PT varies within 2960-3600 m. The minimum thickness of the PS was discovered by wells in the southwestern limb of the Sangachal-deniz uplift up to 3000 m.

The type of structure is brachianticline, which are associated fields. The arch part is fragmented by faults into blocks that these blocks are oil and gas-condensate. In the oil of the field, the amount of resin is 8-27%, asphaltene mass- 0.2-1.1%, paraffins- 6.0-20.1%. The content of light fractions, which have a boiling point of up to 300° C, varies between 31.4-40.0%, gasoline- 4.5%, naphtha- 12.1%. The hydrocarbon composition of oil is noted in the following order: methane- 52.1-66.8%, aromatic hydrocarbons- 12.2-21.5%, naphthenes- 12.3-35.1%. The density of reservoir oil ranges from 0.729 to 0.780 g/cm^3, and the density of degassed oil is 0.869-0.889 g/cm^3, condensate 0.759-0.797 g/cm^3.

The results of determining the porosity of samples taken from drilled wells were used, in addition, the density and permeability of rocks were studied by mechanical analysis of numerous samples. The porosity of the studied samples varies from 1.5 to 38%, the density in wet samples varies from 1.72 to 2.97 g/cm^3, and in dry samples from 1.72 to 2.97 g/cm^3, permeability - from 0 to 863·10^{-15} m^2. But at some depth, the permeability reaches 1910·10^{-15} m^2.

Keywords: porosity, permeability, mechanical analysis, section, clay, graphs of the dependence, sandy-silty rocks

I. Introduction

The Baku archipelago covers a large water area in the southwest part of the Caspian Sea [2, 3, 14, 18]. Ttectonically, it is the continuation of the South Gobustan and Lower Kura depressions toward the sea. Khara-Zira, Zanbil, Sangi-Mugan, Garasu, Gil, Kurdashi, Daşlı islands and many underwater salses such as Umid, Babek, Yanan Tava, Ateshgah, Mugan-deniz, etc. is known here that formed by the activity of mud volcanoes [11, 22]. Most of the deposits discovered here are related to mud volcanoes, for instance, Khara-Zira, Sangachal-deniz, Sangi-Mugan, Garasu, Duvanni-deniz, Kurdashi, Daşlı and etc. (Fig. 1).

The Sangachal-deniz-Duvanni-deniz-Khara-Zira island oil-gas-condensate field, which is related to the structures discovered in the northern part of the archipelago, is located 50 km southwest of the Baku city [3] (Fig. 2).

Since 1935, geophysical exploration (gravimetric, electrical exploration, aerial photoplanning, seismic exploration), structural and structural-prospecting drilling has been carried out in the field. Since 1951, the field deep exploration drilling have been involved. As a result of the conducted works, the geological structure of the field was studied, oil-gas-condensate horizons were discovered.

The oil content of the field was confirmed in 1963 by testing in well 24, drilled in the limb of the Duvanni-deniz structure. Here, primarily, an oil gush with a flow rate of 250 t/day was obtained from the VII horizon of the Productive series. In 1965, 150 t/day of oil was obtained from this horizon in the Sangachal-deniz structure, for this year, 300 000 m^3/day of gas was obtained from the VIII horizon in well 29 in the Duvanni-deniz field. İn 1974, 200 t/day of oil was obtained from the V horizon in well 361. Until 1995, 158 exploratory wells were drilled in the field, most of which are [3, 5].The oldest sediments are of middle Miocene age in the well section. The top of well sections are represented by Productive series, Absheron, Aghjagil and Quaternary [3].

This deposit as a whole was formed on the anticlinal belt created by local structures of Sangachal-deniz, Duvanni-deniz and Khare-Zira Island, complicated by the regional fault extending from the northwest to the southeast from the tectonic point of view. The studied deposit is represented by a single structure- brachyanticline, extending in the northwest-southeast direction along the VIII horizon and measuring 30x11 km. Transitional parts of local structures are manifested by densification of isohypses (Fig. 2).

The Sangachal-deniz local structure, which is separated from the Kanizadag structure by a long and shallow saddle, and from the Duvanni-deniz structure by a short and shallow saddle, has an asymmetric structure and a dome shape.

The Duvanni-deniz structure is complicated by a mud volcano. Its northeastern limb bend under the 45-50^0, and the southwest limb inclined under 35-40^0 dip angle.

The arch part of the Khara-Zira island structure is compounded by the mud volcano of the same name.

A longitudinal tectonic fault passes through the arch parts of the structures that make up the deposit as a whole. This fault is revers type in Sangachal-deniz area, and normal fault type in Duvanni-deniz area. This fault, which complicated the field, caused the northeast limb of the Sangachal-deniz structure to rise with an amplitude of 200-600 m, and the limb of the same name of the Duvanny-deniz structure to descend with an amplitude of 500-1400 m. The fault, which complicates the structures along its longitudinal axis, diverges into two tectonic faults with an amplitude varying from 30 to 150 m towards the southeast. As a result, the structure is divided into three parts: the northeast limb, the central part, and the southwest limb [3] (Fig. 2).

Figure 1: *Location scheme of fields and local uplifts of Baku archipelago*

II. Analysis of the problem

Porosity, as well as permeability, are considered to be one of the most significant indicators when determining the reservoir properties of terrigenous sedimentary rocks. The values of these properties are known to depend on a number of factors, such as the substantial and granulometric composition, the degree of sorting, the nature of the location of the clastic particles, the occurrence depth, the degree of compaction, the connection of pore spaces, the size of the particles, the structure and texture, and others.

The main components of the described rocks are sand, sandstone, siltstone, aleurolit, chlidolite and clay. The effect of specified rocks on the values of porosity and permeability is different depending on the size of the grains.

In accordance with this, during studying the relationship between reservoir properties and the composition of rocks, the following components were distinguished, which have different effects on the studied parameters.

- fraction of sand and coarse-grained siltstone, which is larger in the range of 0.1-0.01 mm. The presence of these fractions is favorable for reservoir properties [14].
- fraction of clay, medium- and fine-grained siltstone, fraction finer than 0.01 mm. They relatively weakly affect the values of porosity, but sharply reduce the permeability of reseroirs.
- the insoluble rock part, represented mainly by chlidolite. It reduces porosity and permeability.

III. Discussion of the problem

In the geological level of connections between porosity and permeability, there are opposite views. Some researchers argue that there is a direct dependence between them, and other researchers, on the contrary, deny this connection. It should be noted that the porosity and permeability of reservoir rocks depend on lithology, on the structure of the pore space, the depth of collection thicknesses and at the same time from cementing materials. To clarify the connections between these properties of rocks, it is necessary to take into account the composition of the latter. Thus, the cross section of the area under the study is mainly consists well-sorted sandstone-aleurolits, clayey-sandy, clayey-aleurolit-sandstones. Didn't consider some depth intervals they have high porosity and permeablity. However, in the depth intervals with low porosity and permeablity the percentage of cement materials is observed in the study area. Thus, by the large content of cement materials (over than 20%) the permeability don't dependence from porosity, while these rocks in most cases practically permeable due to secondary porosity, faults with less scale amplitudes, forming under the influence of over lying rock strata and compressing stresses [10].

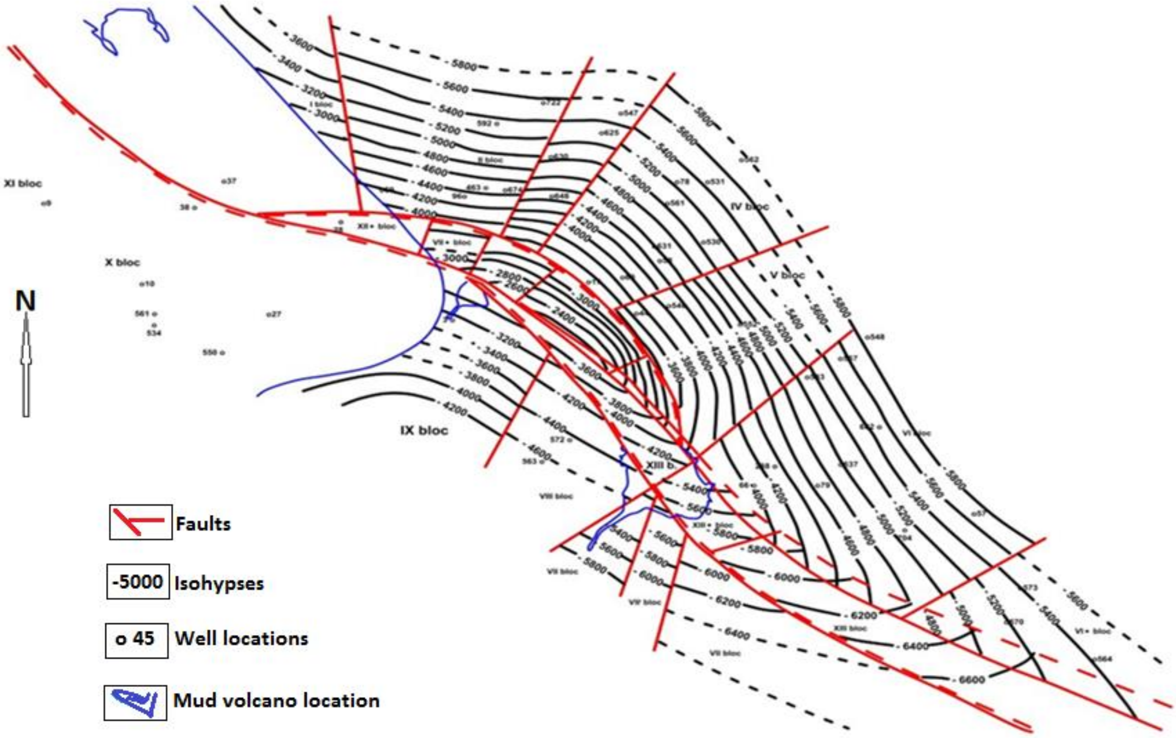

Figure 2: *Structure map of the Sangachal-deniz-Duvanni-deniz-Khara-Zira field*

IV. Methods

One of the structures of the research area is Sangachal-deniz field. In the sections of wells drilled in this field, clayey-silty sandstones, clayey-silty sandy loams, clayey-sandy aleurolits and clayey aleurolits are distinguished by relatively high porosity [3, 17]. The porosity of these deposits varies within the range of 5.5-22.9%, 5.5-33.6%, 2.3-20.4%, 3.8-20.7%, respectively (Fig. 3).

With a higher content of clayey aleurolit particles, porosity decreases to 4-15% with the exception of depths of 3164 and 4140 m. At these depths, rock porosity is 22.9% and 20.7%, respectively. Apparently this is due to the compaction and fracturing of clayey rocks under the load of the overlying ones. Due to present a sufficient percentage of chlidolite by depth, the porosity is reduced to 5.5%, with the exception of rocks with a high degree of sorting of terrigenous material. Along the section from top to bottom, clayey-sandy subaleurolits with a porosity of 11-21% are observed with a higher content of the fraction finer than 0.01 mm in the range of 12.0-20.9%. The carbonate content of rocks varies between 2.3-15.0%, but there are exceptions. At a depth of 4302-4610 m, the carbonate content of chlidolites and aleurolit-clayey sandy loams is expected to increase, reaching values of up to 33.4-35.8%. Such a situation could not affect the porosity and permeability of rocks; they are almost impermeable.

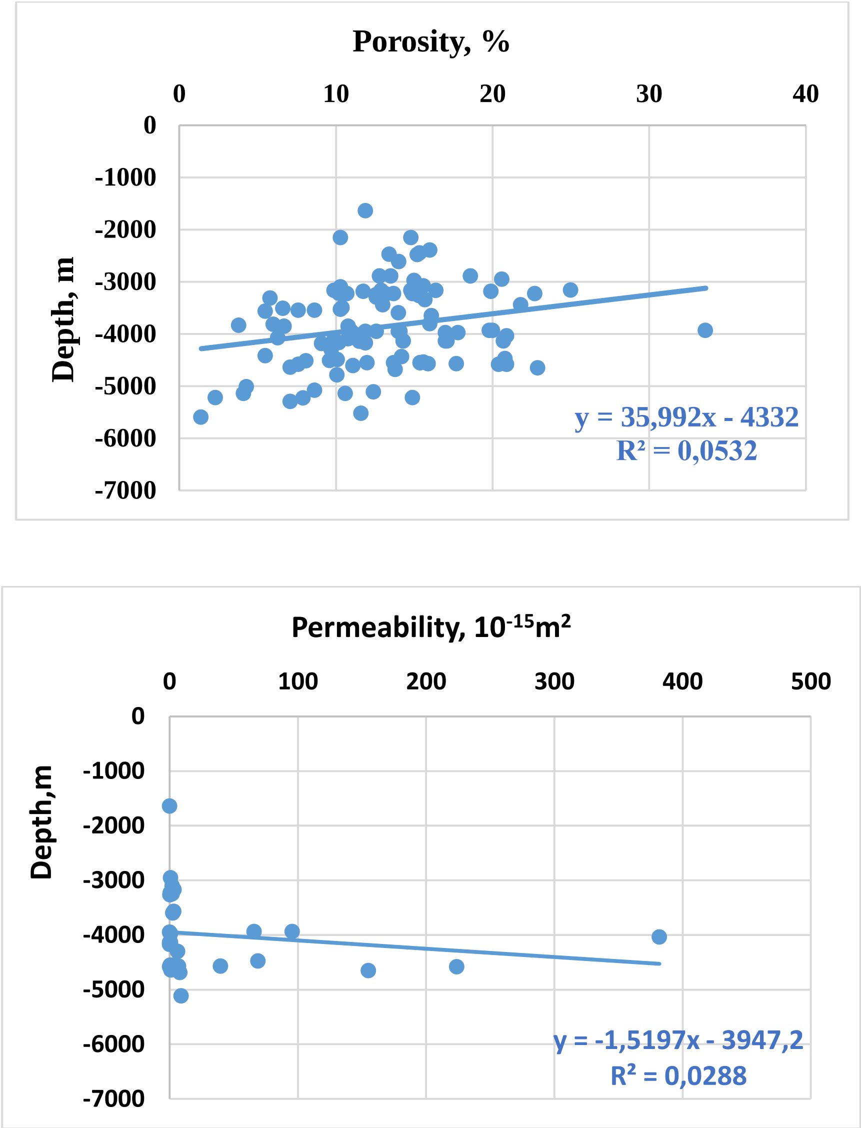

Figure 3: *Graph of the dependence of rock porosity and permeability on the occurrence depth in the Sangachal-deniz field*

In the Duvanny-deniz field, the rocks that make up the section, with the exception of some occurrences, are highly porous. The porosity of clayey-silty sandstones varies within 17-34%, while the porosity of clayey-silty sandy loams, clayey-sandy aleurolits and clayey aleurolits varies within 16-25%, 18.0-30.0% and 30.3-23. 0% accordingly. Despite the fact that the content of the fraction finer than 0.01 mm is 63%, the porosity in most cases is over 17%. The distinctive nature of the field section is noted at a depth of 3632 m, where porosity and permeability are higher (23% and $541 \cdot 10^{-15}$ m^2, respectively) (Fig.4). As noted above, this depends on the degree of fracturing of the rocks composing the field section. It should be noted that under this condition, the permeability of the rock is higher and amounts to $166\text{-}167 \cdot 10^{-15}$ m^2; in some cases, the permeability value reaches up to $266\text{-}294 \cdot 10^{-15}$ m^2 due to the appearance of additional cracks with depth in the rocks.

Manifestations of the chlidolite fraction smaller than 0.01 mm negatively affect the permeability of rocks, so that the permeability decreases to $42 \cdot 10^{-15}$m^2, even in some cases to $2.2 \cdot 10^{-15}$m^2. The distinctive character of the Duvanny-deniz field section is the presence of silty-sandy loams (fractions finer than 0.01 mm are 45.3%), which has a bad effect on the permeability of rocks.

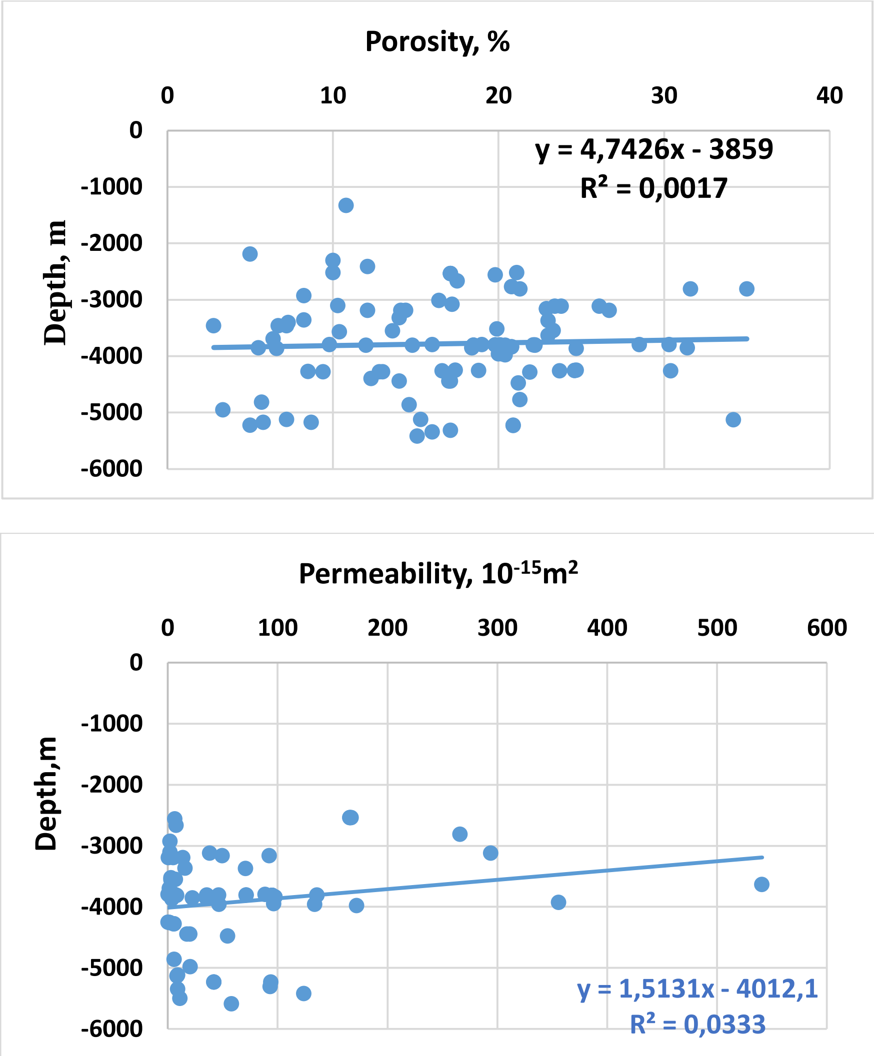

Figure 4: *Graph of the dependence of rock porosity and permeability on the occurrence depth in the Duvanny-deniz field*

With the exception of some depths along the section from top to bottom, clayey-sandy subaleurolits with a porosity of 12.0-20.8% are observed with a higher content of the fraction finer than 0.01 mm (35.5%) in the range of 5.0-9.0%.

The carbonate content of sediments along the section of the field varies from 4.2% to 25.4%.

Deposits of the Productive series, deposits of the Absheron and Gadim Khazar stages are wide spread along the Khara-Zira field [3, 16]. The section of the structure consists of rocks similar to previous fields.

In all cases, terrigenous rocks are permeable. The permeability of rocks along the section of the area varies between of 0.1-267·10^{-15} m^2 with the exception of some depth intervals. Analysis of core materials taken from great depths (4982-4988 m) showed that despite the presence of clay fractions, the permeability of reservoirs (sands and sandstones) varies in a wide range of 132-1910·10^{-15} m^2, which is an indicator of a high degree of sorting of reservoir rocks, as well as fracturing of clayey deposits. In this case, the porosity of the rocks is 16.2-23.1%. The porosity of clayey-silty sandstones and clayey aleurolites along the field section ranges from 23-34% and 28-38%, respectively (Fig.5).

From the above it follows that the amount of clayey-sandy aleutolites and clayey rocks varies for different fields. At the same time, the physical properties of these rocks vary in a wide range [15]. This difference is shown to be due to varying degrees of compaction and occurrence depth of the sediments. Lithological differences in sediments are compacted to varying degrees under the same geological conditions. With depth, the clays compact at first very quickly, then slowly. It should be noted that in some places this pattern is violate; compaction accelerates and then slows down. Sandstones and coarse-grained aleurolites containing other small fragments are compacted to a lesser extent, and their porosity is reduced by an average of 2-3% for every 700-800 m.

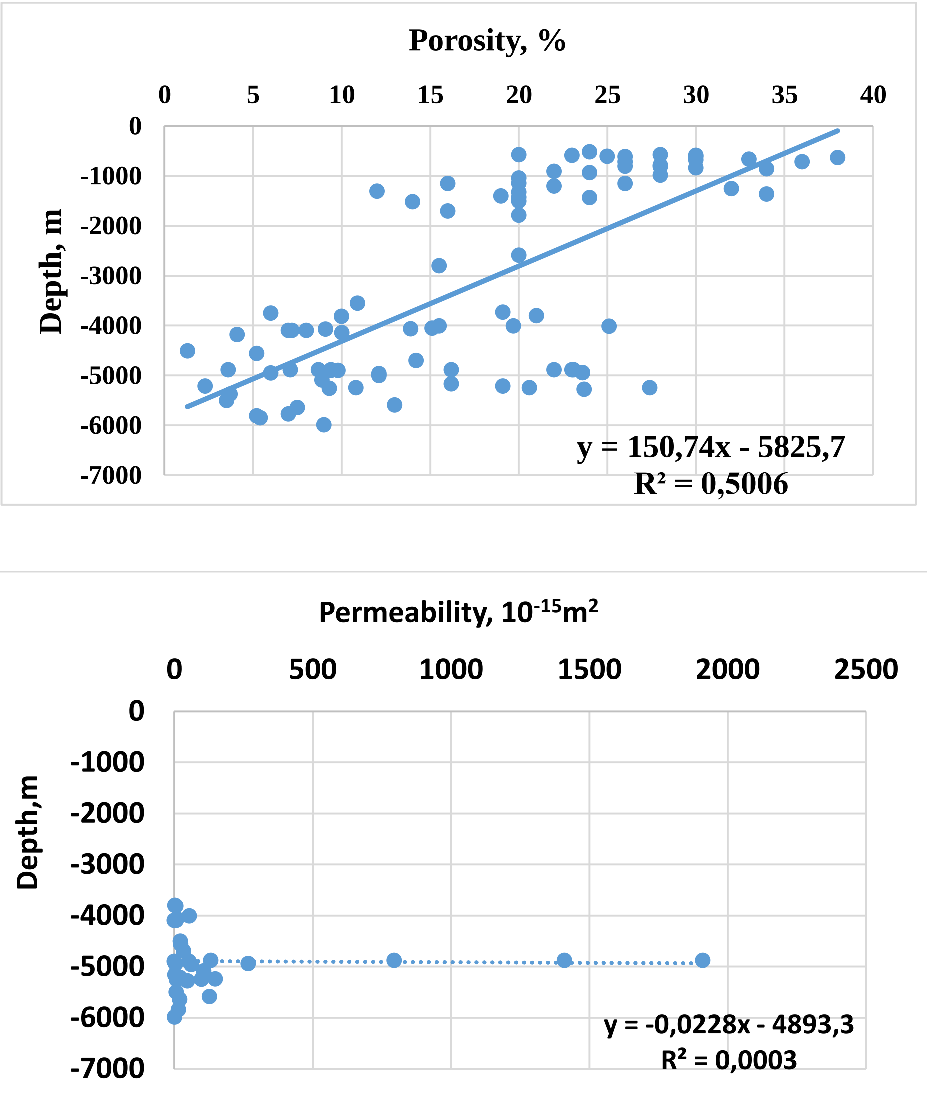

Figure 5: *Graph of the dependence of rock porosity and permeability on the occurrence depth in the Khara-Zira field*

As can be seen from the plotted graphs, the relationship between rock permeability and burial depth is less clear, but in general the pattern remains the same- the greater the burial depth, the lower the permeability of terrigenous rocks (see, Fig. 2, 3, 4).

V. Conclusions

1. Depending on the depth, the increase in the density of rocks under the influence of geostatic pressure leads to a decrease in their porosity and permeability. Compaction of different types of rocks occurs with unequal intensity.

3. At great depths (over 4900 m), due to subsidence in sands, sandstones and clayey sandstones, a very wide range of changes in porosity and permeability is observed in the Khara-Zira deposits. This circumstance is an indicator of industrial accumulation and must be taken into account when assessing the prospects for oil and gas potential.

4. There is no regulation in changes in porosity and permeability with depth, which is associated with the lithology of the rocks.

5. With increasing burial depth, porosity increases in places. This is due to the fracturing of rocks under the load of overlying rocks.

6. The cementing material (carbonate content, chlidolite fraction, tiny particles, loam, sandy loam) greatly affects the permeability and porosity of terrigenous rocks, and at different depths it varies. The greater the depth of the rocks, the less cement they must contain in order for them to be permeable.

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