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ANALYSIS OF DEVELOPMENT PROCESS OPTIMIZATION OF THE OIL AND GAS FIELDS (THE CASE OF SANGACHAL-DENIZ-DUVANNY-DENIZ-XARA-ZIRA FIELD)

(***Представлено членом редакційної колегії д-ром геол. наук, проф. Віктором ОГАРЕМ***)

Background. ***When solving problems aimed at increasing the efficiency of the reservoir development process, it is often necessary to know not only the recoverable oil reserves, but also the degree and nature of the development of balance reserves, balance reserves of oil and gas per well by the area of the deposits. This allows to make correct and reasonable management decisions on regulating and improving development in order to increase the current and final oil recovery factor. In this matter, our target object is the Sangachal-deniz – Duvanny-deniz – Khara-Zira field.***

Methods. ***The article examines the issues of optimal regulation and management of the development processes of the Sangachal-deniz – Duvanny-deniz – Khara-Zira oil and gas-condensate field using Shewhart models and methods, which are relevant for petroleum science and practice. Based on the system analysis, an EOR is proposed to increase oil recovery of the field and recommendations for the rational development of oil and gas-condensate horizons of the field.***

Results. ***The stratigraphy, tectonics, oil and gas potential and current state of development of each field separately are considered. A brief description is shown. Currently, industrially significant residual oil reserves at these exploitation facilities are concentrated in the upper stage of the Productive Series (PS) (Lower Pliocene) deposits. The main development facilities are the V, VII, VIII horizons of the PS.***

Dynamics of technological indicators of development on field were analysed. The annual oil production was 206.9 thousand tons, condensate was 0.864 thousand tons. Annual production of dissolved gas was 83.4 million m^3, and free gas production 35.8 million m^3 are estimated by data of 2022.

Oil and gas of the analyzed area are confined to tectonically screened traps, since it is complicated by numerous longitudinal and transverse faults.

Conclusions. ***Development was carried out with flooding from 1971. Field is at the third development stage. Water-gas mixter and periodic influence methods is appropriate for increasing oil recovery factor.***

Keywords: ***water-gas injection method, Shewhart control charts, oil and gas wells, optimal development, control boundaries.***

Background

Oil and gas production plays a pivotal role in sustaining global economies and ensuring energy security. When that entails significantly improving operational efficiency in gas and oil fields, the choice of technology and methods is an important factor. The tightly interconnected links of the production and value chain require the use of integrated systems and applications that can help reduce the total cost of ownership while increasing asset utilization to enhance oil recovery. The latest technology solutions have also improved the control and analysis of various processes in gas and oil fields. In their study (Cherepovitsyn, Rutenko, & Solovyova, 2021) come to the conclusion that it is a common fact that the development of the oil and gas resources is associated with significant difficulties, which creates fundamentally new requirements for management and makes it necessary to use special approaches to assessing the sustainability of this process.

One of the most important aspects of field development and analysis is control systems and the selection of appropriate EOR methods. By the (Nuranbayeva, Orysgozhix, & Alaguzov, 2021), during the period of depletion of the main oil reserves in fields entering the last stage of development due to the priority development of highly productive highly permeable reservoirs, an increasing proportion of residual reserves become difficult to recover. Therefore, it becomes relevant to use effective methods of increasing oil recovery in existing fields, most of the original volume of geological reserves remains in the deposits. One of these methods is unsteady waterflooding, which has proven its effectiveness.

The latest solutions for advanced process control and optimization cover the entire oil and gas production process, helping to ensure the consistency of its stages and maximize the benefit from side streams, as well as increase the condensate recovery rate.

The general issue of oil field operation is to create the most rational development system in order to achieve the maximum possible oil production. That is, to increase the oil yield of the field or fields, while at the same time keeping the factors affecting the process under control is the most important issue. The concept of oil yield is the ratio of the amount of oil extracted from the formation to the balance oil reserves. It is also necessary to keep in mind the terminology applied to the concept of oil yield. Of these:

- Displacement factor (DF) is the ratio of the volume of oil obtained by displacing it from core samples with a working displacing agent under reservoir conditions to the initial volume of oil.
- Current oil recovery characterizes the oil extraction process and increases over time as oil is extracted from the reservoir.

• Final oil recovery (also known as final oil recovery factor, ORF) is an indicator that shows what proportion of the initially available geological oil reserves can be extracted using a certain reservoir development technology. This indicator reflects the maximum amount of oil that can be extracted from the reservoir upon reaching the technological and economic limit, that is, until the moment when extraction of further reserves becomes unprofitable. When developing fields or deposits, there are a number of factors that affect the final oil recovery, such as the geological properties of the reservoir, for example, porosity, permeability, oil viscosity; reservoir development methods, such as water displacement of oil, gas displacement, thermal methods and economic and technological limitations.

The purpose of the work: to analyze the development process of the Sangachal-deniz – Duvanny-deniz – Khara-Zira island field and to determine methods for increasing oil, gas and condensate recovery, and to determine optimal boundaries for field regulation during development.

Lithological-stratigraphic and tectonic features of the object

The object analyzed in this work is the Sangachal-deniz – Duvanny-deniz – Khara-Zira island field of the Baku archipelago, which is one of the promising tectonic zones of the South Caspian Depression (Nasibova, Mukhtarova, & Ganbarova, 2024; Nasibova et al., 2023).

The Sangachal-Deniz – Duvanny-Deniz – Khara-Zira Island field is located on the northwestern border of the Baku archipelago, 50 km southwest of Baku, in the shallow part of the Caspian Sea. Deep exploration drilling has been conducted in the field since 1951. It was discovered in 1963 by well No. 24, which opened the horizon VII at an interval of 2821–2815 m and otained an oil flow of 250 t/day. It has been put into operation since 1967 (Salmanov et al., 2023b).

As a result of the exploration drilling, a gas-rich oil accumulation was discovered in the horizons V, VII of the Productive Series (PS) and a gas-condensate accumulation in the horizon VIII, and their distribution along the areas was determined.

The oldest sediments in the section of the field opened by the wells belong to the Middle Miocene. The upper part of the section consists of PS, Absheron, Aghjagil and Quaternary sediments.

The Chokrak horizon consists of clays characterized by low sand content and is 474 m thick. In the adjacent onshore Duvanny area, Chokrak is represented by alternations of clay, sand, sandstone and dolomite.

The Middle and Upper Miocene-Diatom group (Karagan, Konk, Sarmatian) sediments are represented by clay, sandstone and marl. The maximum thickness of the diatom group sediments is 760 m.

The Pontic stage exposed in the Sangachal-Deniz and Duvanny-Deniz areas, is represented by clays and has a thickness of 70–80 m.

The full thickness of the PS has been uncovered by wells in all areas of the field, and the greatest thickness (3950–4000 m) was discovered in the northeastern part of the Sangachal-Deniz and Khara-Zira Island areas. In the hypsometrically high parts of the Sangachal-Deniz and Duvanny-Deniz structures, the thickness of the Productive Series is 2960–3600 m.

The tectonic structure of the field includes the local structures of Sangachal-Deniz, Duvanny-Deniz and Khara-Zira Island, located on the same anticlinal line from northwest to southeast. The field is represented by a single structure-brachyanticline, extending from northwest to southeastward by the horizon VIII, with dimensions of 30×11 km (Salmanov et al., 2023b).

The transition areas of local areas are manifested by the thickening compression of isohyps (Fig. 1).

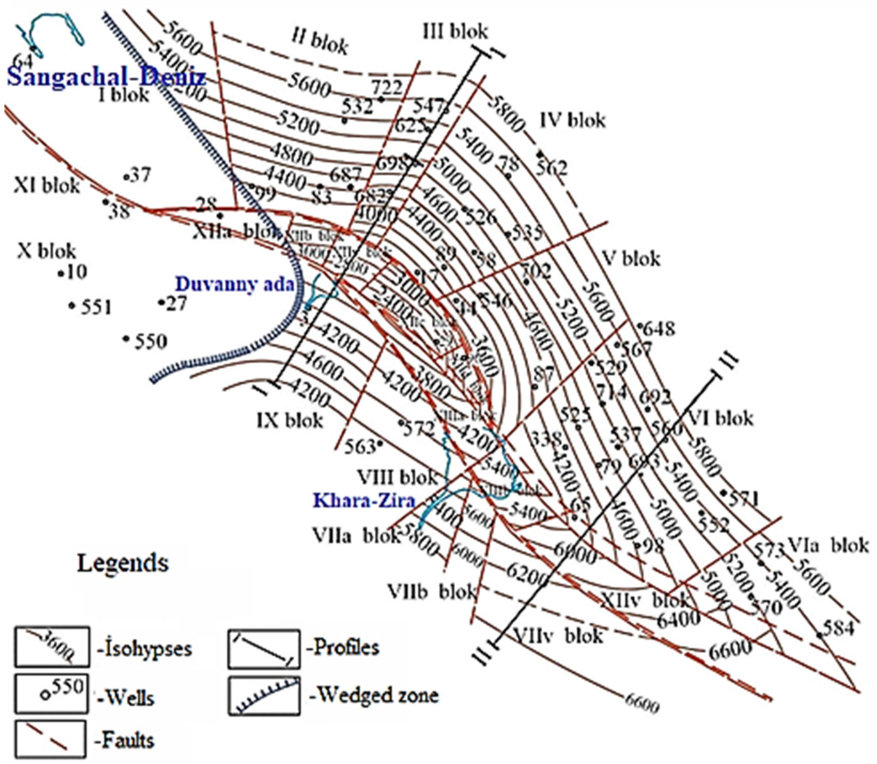

Fig.1. Sangachal-Deniz – Duvanny-Deniz – Khara-Zira Island field.
Structural map by the top of horizon VIII

Characteristics of structures

The Sangachal-Deniz structure is asymmetrical and dome-shaped brachyanticline fold. It is separated from the Kanizedagh structure by a long and shallow saddle, and from the Duvanny-Deniz structure by a short and shallow saddle. The structure is divided into 23 tectonic blocks by longitudinal and transverse faults, oriented northwest-southeastward. The axis of the fold is weakly inclined and convexly curved towards the southwest. Its asymmetry is manifested in the longitudinal section as well as in the transverse section.

The southwestern limb of the fold (20–30°) is more inclined than the northeastern (35–45°) limb.

The Sangachal-Deniz brachyanticline is complicated by three longitudinal faults. These faults are of a stepped nature. In sequence, each northeastern block has subsided relative to the southwestern block. The amplitude of their vertical displacement varies between 100–200 m. With increasing depth, these faults become close to each other, and are assumed to be jointed in a single fault by the lower part of the Productive series and the upper part of the Miocene sediments (Salmanov et al., 2023b).

The Duvanny-Deniz structure is located southeast of the Sangachal-Deniz structure and is separated from this uplift by a slight narrowing of the layers. In appearance, the axis of the layers is weakly bent and turned to the northeast with its convex side. In the southeast, the axis of the fold straightens and turns towards the Khara-Zira island.

Tectonically, the Duvanny-Deniz structure is complicated by mud volcanoes, the dip angle of the northeastern limb is 45–50°, and the southwestern limb is 35–40° (Fig. 2). At the bottom of the sea, the Productive series sediments are concentrated in the arch and northwest plunge of the fold, and the Upper Pliocene and Quaternary sediments are concentrated in the southeast plunge.

The southeast plunge of the fold is sharply elongated in the southeast direction and is four times longer than the northwest one. The fold dips sharply in the direction of the Khara-Zira Island structure.

The arch part of the fold is complicated by longitudinal faults corresponding to the mud volcanoes of Duvanny Island, Khara-Zira Island, and Abikh.

The central longitudinal fault noted in the Sangachal-Deniz fold meets the northern part of the Duvanny-Deniz fold in the southeast, and then is traced by only two faults to the southeast. Along these faults, the central block has descended like a graben to transverse faults. The displacement amplitude of the central block is 100–120 m in the southwestern limb, and 1500 m in the northeastern.

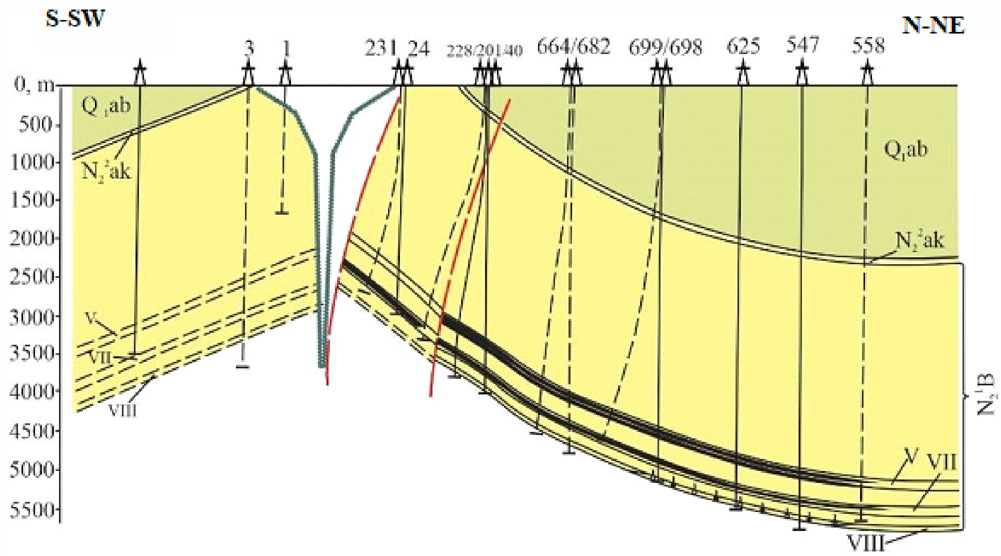

Fig. 2. Duvanny-Deniz. Geological profile on profile I-I

As can be seen from the profile, horizons V and VII of the field are oil-bearing, while horizon VIII is gas-bearing.

The Khara-Zira Island structure is located 25 km southeast of the Sangachal Cape and forms the last fold of the Sangachal-Deniz – Duvanny-Deniz – Khara-Zira Island fold. Khara-Zira Island is a brachianticlinal fold in the northwest-southeast direction based on the upper layers of the Productive series and the Aghjagil stage. The length of the fold is 6 km, and the width is 2 km.

The structure of the Khara-Zira Island structure is asymmetric longitudinally and transversely. The arch part of the fold is complicated by the mud volcano of the same name. Its northeastern limb dips under 15–20º, and the southwestern limb is relatively steep, characterized by a dip angle of 30–40° (Salmanov et al., 2023b).

Methods

When solving tasks aimed at increasing the efficiency of the reservoir development process, it is very often necessary to know not only the extractable oil reserves, but also the degree and nature of production of balance reserves, balance reserves of oil and gas per well on the area of the deposits. This allows to make the correct and justified management decisions on the regulation and improvement of development in order to increase the current and final oil recovery factor (Mukhametshin, 2022).

One of the ways to solve this problem is the geological and industrial analysis (Bagirov, 2011), based on the study of the influence of geological and technological factors on the degree of production of oil reserves, reflected by various indicators.

As research materials, statistical data are used for the development and production of (Urazgaliyeva et al., 2023) Sangachal-Deniz – Duvanny-Deniz – Khara-Zira Island field.

Along the section of the Sangachal-Deniz – Duvanni-Deniz – Khara-Zira Island gas-condensate-oil field, horizons V (V_u, V_m, V_b), VII and VIII have oil and gas-condensate accumulations. Currently, industrially significant residual oil reserves for these exploitation objects are concentrated in the upper stage of the PS sediments. The main development objects are horizons V, VII, VIII of the Productive Series.

In 2022, annual oil production was 206.9 thousand tons, condensate 0.864 thousand tons.

Annual production of dissolved gas was 83.4 million m^3, and free gas production was 35.8 million m^3.

Oil and gas in the analyzed area are confined to tectonically screened traps, as it is complicated by numerous longitudinal and transverse faults. The area is divided into separate blocks. Oil and gas of separate blocks are exploited by a separate network of wells, since the faults are impermeable, the physical parameters of the reservoirs of the blocks are expressed by different moderate values: the permeability of the V, VII and VIII horizons is respectively 31, 67 and 68·10^{-3} μm^2, porosity is 20, 19 and 20 % and carbonate content is 13, 10.5 and 8.6 % respectively.

The lithology of the reservoirs is expressed by sands and sandstones. The clayiness of the horizons is variable and amounts to 18.4, 21 and 26.9 %, and sand content is 46, 44 and 41 % respectively.

The search for the best option for the development of an oil or gas field is usually carried out based on the selection of a certain number of options. It is obvious that the optimal development option will be found as a result of such a search.

To regulate the development of the research object, the dynamics of development indicators were used: annual production of oil, gas and condensate, the number of oil and gas wells drilled by year, daily production of oil and gas per well.

The goals of regulating the development of the researched object are to maintain the pace of development within the limits of the optimal development and eliminate the causes of going beyond the optimal limits when developing the horizons during the next years. To solve this task, the capabilities of "Control maps" of Shewhart dynamic models are used, which will allow rational development of products from horizons during development (Fig. 3 (a), 3 (b); Fig. 4).

The methodology allows to reliably determine the optimal zones for the development of the dynamics of oil extraction of a separate object, in the case of transition of the annual production below or above the limits of the optimal regulation of the process, to clearly determine the time of disruption of the process, to clarify the causes of this phenomenon and to recommend measures to return it to this zone. At the same time, it is expedient to consider the estimates of the dynamic series both for the entire period of oil extraction of a specific object and for individual stages.

According to the method, the number of measurements of the parameter X, in our case – the volume of annual production of oil, gas and condensate, the volume of annual dissolved gas in oil, the volume of water injected into the reservoir, the amount of daily extraction of oil and gas per one well, the amount of drilled oil and gas wells during development, is equal to n, the average value is determined by the formula

$$\bar{X} = \sum_{i=1}^{n} x1/n.$$

Deviation (R) in turn will be determined by the formula

$$\bar{R} = \sum_{i=1}^{n-1} \frac{R1}{n-1}.$$

Then the optimal zone of development of the development process or the upper and lower limits of regulation (X_{upper}. и X_{bottom} are determined by the formula

$$X_{lower} = \overline{X} - \frac{3\overline{R}}{d}; \quad X_{upper} = \overline{X} + \frac{3\overline{R}}{d}$$

where d is a factor, it is taken from a special table compiled by Shewhart.

If the analyzed parameters run beyond the established limits of regulation, then this indicates that the optimality of the development process is violated and it is necessary to take measures that will allow the process to return to the optimal course.

This requires an adjustment and optimization of the development plan to achieve the goal of improving gas, oil and water drive control and balanced displacement (Yang, Kim, & Choe, 2017; Zhang et al., 2023).

Advanced oil production technologies and regulation methods are actively introduced and improved in order to increase the efficiency of development and extraction of reserves from deposits. The most optimal method of Shewhard's control maps is already mentioned above. This method will be used for optimization of the Sangachal-Deniz – Duvanni-Deniz – Khara-Zira Island gas-condensate-oil field.

The field is in industrial development since 1967. Along the section, there are 5 productive objects that are under exploitation: V_u, V_m, V_l, VII, VIII. oil and gas condensate development horizons. The type of oil deposits is layered, tectonically and lithologically screened. The reservoir type is terrigenous, consisting of sands and sandstones. The permeability of layer-reservoirs varies from 67·10^{-3} to 31·10^{-3} μm^2. As we can see, the field has been under development for 58 years, and it is in the final stage of development. However, the application of positive measures for optimization of the development system is required and recommended. For this purpose, Shewhard models were built, taking into account the dynamics of development from 1963 to 2023. The data includes: free gas in mln.m^3, water injection in thousand tons, oil production in th.t., dissolved gas in oil in million m^3, condensate in thousands of tons, at the same time, a number of drilled oil and gas wells and oil and gas production per one well (Fig. 3 (a), (b), (c), (d), (e); 4 (a), (b)).

Objects were developed in natural mode until 1971. Starting from this year, the development was carried out with water injection. The water injection process was mainly carried out in horizons V and VII of the field. A total of 73842 thousand m^3 of water was injected into the layers, resulting in the production of 11 million tons of additional oil. Seawater was mainly injected into the wells.

The maximum level of oil production was reached in 1975, estimated 4640 thousand tons, gas production reached 2988 million m^3 in 1997. The maximum production level of dissolved gas reached 2369 million m^3 and 245.8 tons of condensate was developed from the horizons of the facility in 1978. At the same time, the field was at the second stage of development.

As we can see from the models, the established boundaries for regulating the development process are symmetrical relative to the center. However, the deviation in development process is observed. Production of oil, gas and condensate runs beyond the regulation limits. The reason for the expansion was the water-pressure mode (injection of water into the productive layer), which led to the flooding of objects. Water-logged production in the horizons V and VII was 56.8 % and 31.9 %, respectively, and in the horizon VIII it was only 8 %. The initial reservoir pressure was 30.0–60.2 MPa in the horizon V, 30.5–53.4 MPa in the horizon VII, and 49.5–57.9 MPa in the horizon VIII.

Studies have shown that the system used for water injection was ineffective, and the process was stopped due to high product waterlogging in the productive blocks, and its continuation is considered inefficient because it is not technologically and economically feasible (due to the high cost).

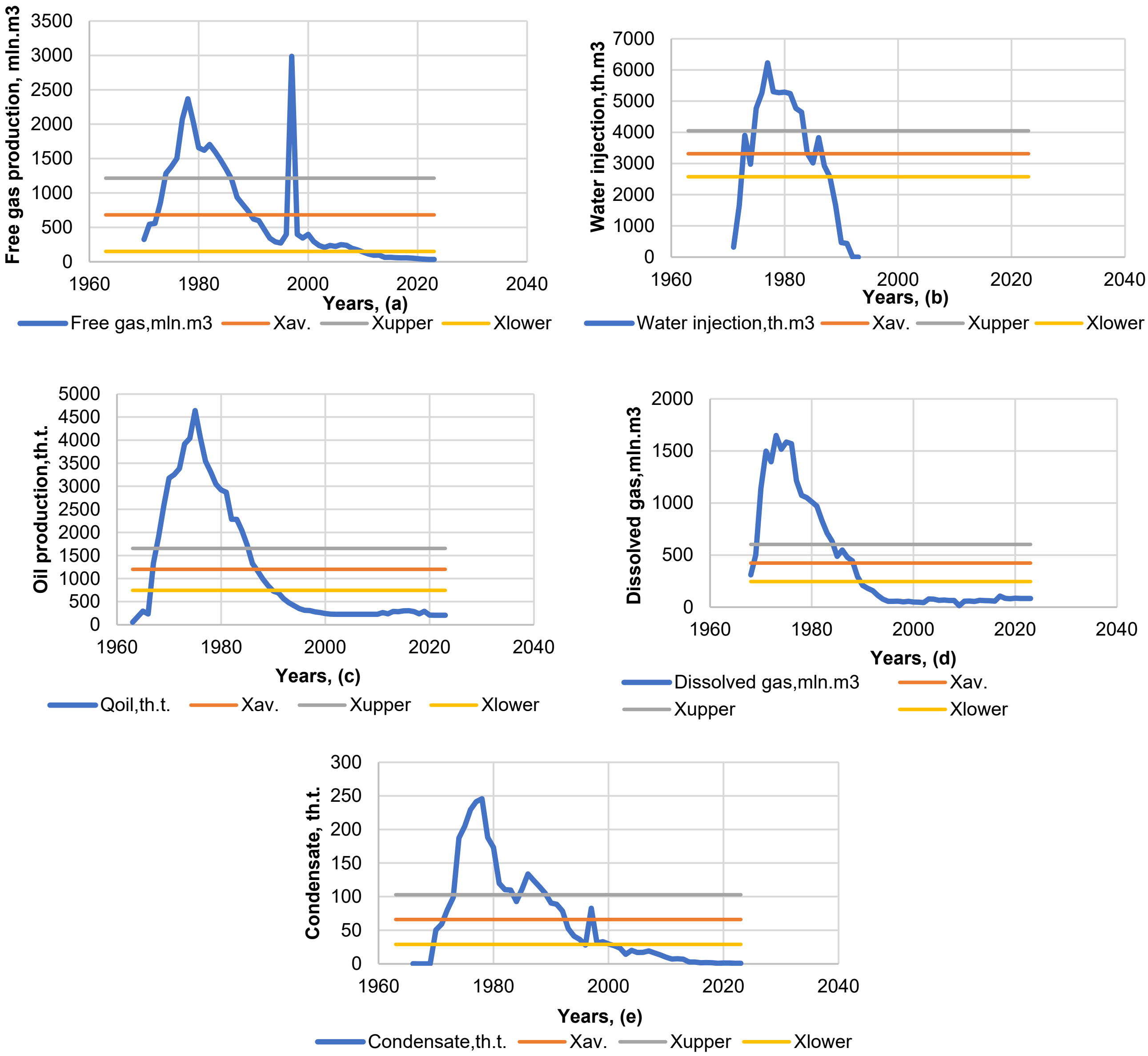

Fig. 3. Control maps of Shewhard for adjustment of the development process
Adjustment control maps: free gas production (a); water injection (b); oil production (c); dissolved gas production (d); condensate production (e)

As can be seen from the models, in the third period of development, there was a sharp decrease in gas production, it fell from 2988 million m^3 to 399 million m^3, and in 2010 it was 152 million m^3, below the limit of optimization of development. The decrease in oil production is naturally observed since 1975, gradually decreasing to 746 thousand tons. It is below the lower limit of regulation. A decrease is observed in the production of dissolved gas in oil from 1973 (from 1648.5 million m^3) to 1990 (to 246 million m^3), as it is below the regulation limit. Production condensate decreased from 245.8 t to 29 t. Of course, it fell below the optimal limit of regulation.

Many optimization schemes have been proposed to simultaneously optimize various variables such as well locations, well operation schedules, well types, and the number of wells (Yang, Kim, & Choe, 2017).

The task of ensuring the effective operation of the well fund is one of the urgent tasks of the oil field development process. This task is solved by improving and managing oil and gas extraction technology (Aliyev, 1983) by studying wells.

As Gregory King noted in his lesson "Introduction to Petroleum and Natural Gas Engineering", in the development stage, all of the wells required for initial Field Development Plan are drilled, completed, and tied back to the production facilities. During this period, multiple drilling rigs may be running simultaneously in order to drill and complete all of production wells, injection wells, and, possibly, observation wells required by the development plan in a timely manner.

In this regards, for the specified horizons of the Sangachal-Deniz – Duvanni-Deniz – Khara-Zira Island, the limits are established in the following order, in pieces: for oil wells – $X_{av.}$=120.8, $X_{up.}$=144.8, $X_{low.}$=96.8, the range in drilling wells by year R=9.1 (see, Fig. 4(a)).; for gas wells – $X_{av.}$=9, $X_{up.}$=13, $X_{low.}$=5, the range in drilling wells by year R=1.5 (see, Fig. 4(b)).

The regulation limits for daily oil production per well are established in the following order – $X_{av.}$=44, $X_{up.}$=59.4, $X_{low.}$=28.6, the range in production by year R=5.8 (see, Fig. 4 (c)).

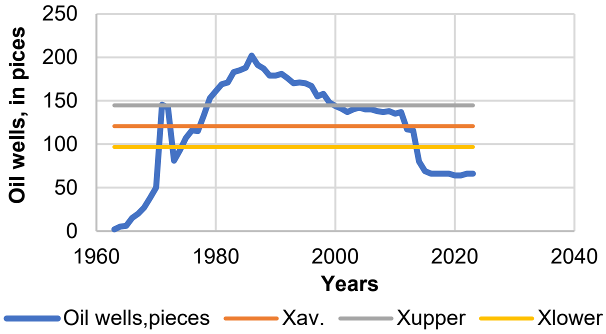

Fig. 4 (a). Regulation map of oil wells

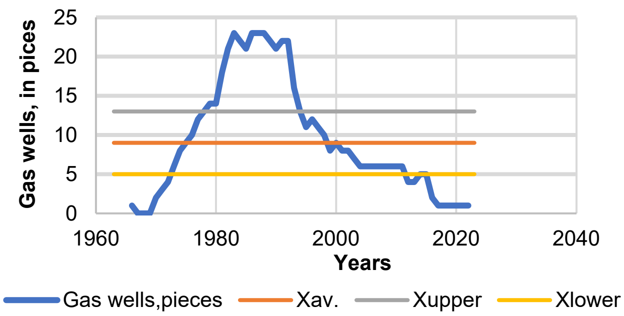

Fig. 4 (b). Regulation map of gas wells

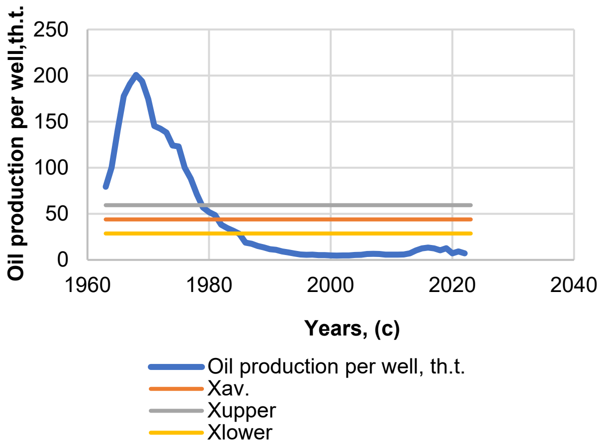

Fig. 4 (c). Regulation map of oil production per well

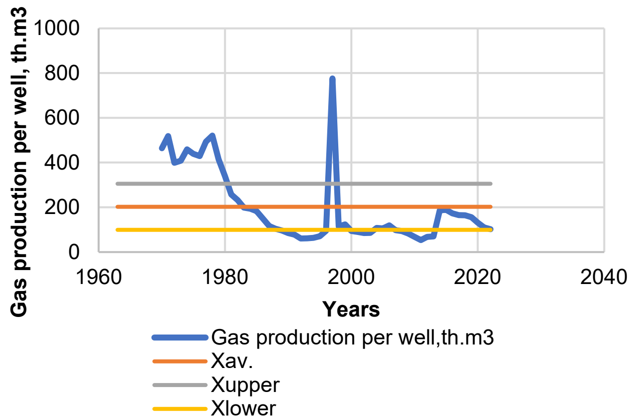

Fig. 4 (d). Regulation map of gas production per well

From the model it is obvious that upper and lower regulation limits are symmetric to average limit. 1963 to 1979 oil production per well is beyond the upper limit, and from 1963 to 1969 there is an increase in oil production, then gradually decreasing is noted. Subsequent decreasing between (1979–1985) regulation limits and oil production amounted from 59.4 to 28.6 th.t. Starting from 1985 oil production is beyond lower limit. There is decreasing in oil production from 28.6 to 7 th.t. that below 2 % of production. As we see the target object entered a late stage of development, its recoverable reserves can be specified directly based on the exploitation data for the period of work at this stage and new development methods and ways to intensify oil production and other factors are required.

The regulation limits for daily gas production per well are established in the following order – $X_{av.}$=202.6535, $X_{up.}$=305.8535, $X_{low.}$=99.4535, the range in production by year R=38.8002 (see, Fig. 4 (d)).

As can be seen from the models, the established limits are symmetrical relative to the center. But in the number of the wells beyond the optimal limits is noted. According to the model, it is established that 48 oil wells and 8 gas wells are completely moderate for optimal development of horizons of the field. Starting from 2014, the number of oil wells decreases from 96 to 66. To eliminate fluctuations in the development process, it is necessary to return 30 oil and 4 gas wells along the horizons of the field.

Discussion and conclusions

However, it should be noted that regardless of how correctly the task of identifying operational objects in the section of a deposit is solved before the start of development, it should be periodically refined. This is due to the fact that the differences in the values of the parameters of operational objects are decreasing more and more during the development process and after a certain period they may turn out to be insignificant. And since the discovery of the identity of the geological and industrial conditions of adjacent layers (Abduallayeva, & Abdullayev, 2022), their separate exploitation should be stopped, as an irrational oil extraction system. These measures, as it is known, allow to optimize the development of oil and gas fields due to the effective use of wells.

As of 01.01.2023, 669 wells were drilled at the field facilities. There were 71 wells in the active production fund, of which 67 are active and 4 are inactive. The drilling of 2 wells has not been completed. Due to certain geological and technical reasons, 408 wells (120 wells for geological reasons and 288 wells for technical reasons) were canceled. 77 wells are awaiting cancellation, and 111 wells are under repair due to the breakdown of hydraulic structures.

Since the beginning of development, 72,418.7 thousand tons of oil, 3,586.8 thousand tons of condensate, 23,864.3 million m^3 of dissolved gas have been produced from the field; free gas extracted from gas-condensate accumulations is 36,021.3 million m^3.

In 2022, annual oil production was 206.9 thousand tons, condensate was 0.864 thousand tons. Annual production of dissolved gas was 83.4 million m^3, and free gas production was 35.8 million m^3.

The long history of field development has led to depletion of the field facilities. Despite this field has substantial remaining reserves. The activity level on the producing field will remain high in the years ahead, and this field will account for the bulk of production in the coming years. Moreover, the resource base for existing facilities increases when small, neighbouring discoveries are tied-in to the existing infrastructure.

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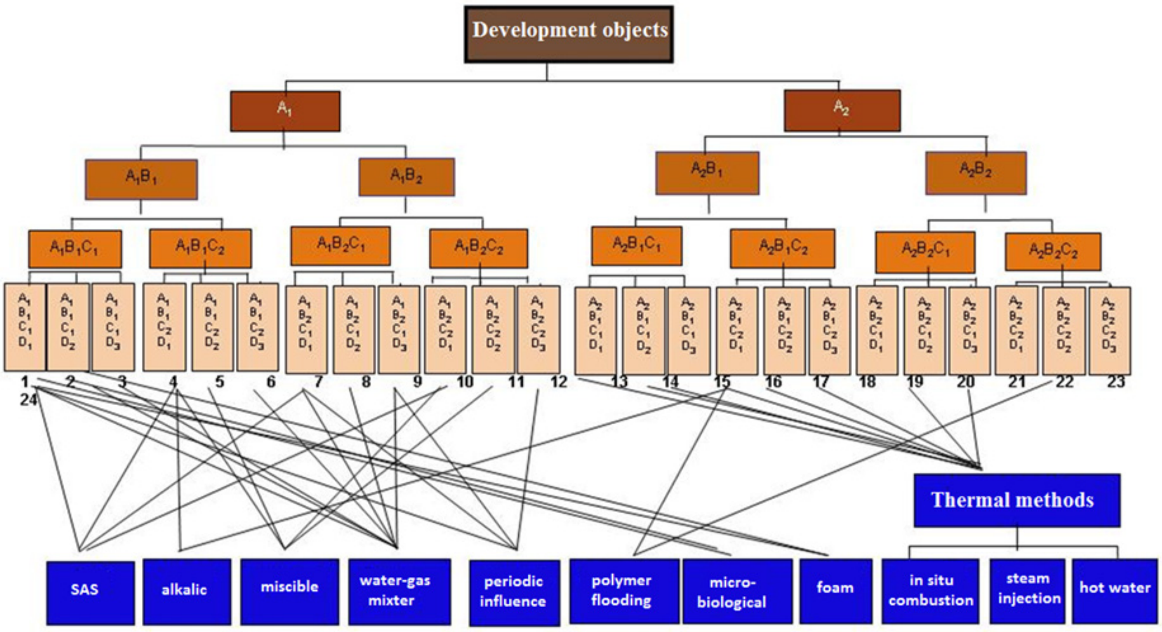
As the reserves are declining, there's more and more interest to use new technologies to investigate old fields potential and consider redeveloping them, reduce drilling days by optimized use of modern drilling equipment, fluids and hydraulics to drive down development drilling costs. A variety of technologies and approaches to extend the life of old fields that were initially developed are used. These include: New infill wells beneath old fields to access deeper targets or the ones that were previously deemed uneconomic to develop; drill multilateral wells to minimize surface footprint, as well as reduce construction and production facility costs; geosteer within thin oil bands to increase hydrocarbon section length; reduce drilling days by optimized use of modern drilling equipment, fluids and hydraulics to drive down development drilling costs. (Field development, Oil & gas solutions). As is known, the modern technology of oil production provides for the use of methods of increasing oil production (EOR). These methods allow to increase oil production by 3–10% and more compared to the amount achieved when using the natural mode of dependence and waterlogging.

It is expedient to rely on the well-known method created by Professor B. A. Bagirov (Fig. 5) for the use of EOR methods (Bagirov, 2011, Bazhenova et al., 2004, 2012; Aliyev, 1983). According to this method, four main factors of the developed operational object have a significant influence on the effectiveness of the application of EOR methods: oil viscosity in reservoir conditions, reservoir depth, rock permeability and the degree of utilization of oil balance reserves. Based on this model, which allows to reliably classify all horizons of the field without exception, it became possible to determine the scale of application of certain types of EOR methods on these objects.



Where: A- oil viscosity, A_1- < 10 mPa×s, A_2 > 10mPa×s
B- occurrence depth of the reservoir, B_1 < 2000 m, B_2 > 2000 m
C- permeability of the reservoirs, C_1 < 0.1 mkm², C_2 > 0.1 mkm²
D- use level of geological reserves, D_1 < 20%, D_2-20-40%, D_3 > 40%

Fig. 5. "Tree" model for application of types of EOR methods (by B. A. Bagirov)

Thus, according to geological and field data we know:

• oil viscosity of horizons V, VII and VIII is 1.2, 1.2 and 1.0 MPa s, respectively;

• the occurrence depth of horizons V, VII and VIII is 3700, 2500 and 5780 m, respectively;

• permeability of horizons V, VII and VIII is 31 10–3, 67 10–3 and 68 10–3 μm^2, respectively;

• use level of reserves is 70.7 %.

Taking into account these parameters, we will find a suitable method for increasing oil and gas recovery from reservoirs. Thus, we find the $A_1B_2C_1D_3$ ratio. According to Bagirov's method (Bagirov, 2011), water-gas mixter and periodic influence methods are appropriate for increasing oil recovery factor.

• For the purpose of efficient development and exploitation of horizons of the Sangachal-Deniz – Duvanni-Deniz – Khara-Zira Island field, it is advisable to drill and commission production wells. At the same time, exploitation should be justified by returning wells from lower horizons, as well as geological, technical and technological measures application is required.

• Four main factors of the developed operational object have a significant influence on the effectiveness of the application of EOR methods: oil viscosity in reservoir conditions, reservoir depth, rock permeability and the degree of utilization of oil balance reserves. Based on this factors we found that water-gas mixter and periodic influence methods is appropriate for increasing oil recovery factor.

• To eliminate fluctuations in the development process, it is necessary to return 30 oil and 4 gas wells along the horizons of the field.

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АНАЛІЗ ОПТИМІЗАЦІЇ ПРОЦЕСУ РОЗРОБКИ НАФТОГАЗОВИХ РОДОВИЩ (НА ПРИКЛАДІ РОДОВИЩА САНГАЧАЛ-ДЕНІЗ – ДУВАННИЙ-ДЕНІЗ – ХАРА-ЗІРА)

В с т у п . ***При вирішенні завдань, спрямованих на підвищення ефективності процесу розробки покладу, часто необхідно знати не лише видобувні запаси нафти, а й ступінь і характер вироблення балансових запасів, а також розподіл балансових запасів нафти та газу на одну свердловину по площі покладів. Це дає змогу приймати правильні та обґрунтовані управлінські рішення щодо регулювання та вдосконалення розробки з метою підвищення поточного та кінцевого коефіцієнта вилучення нафти. У цьому контексті об'єктом нашого дослідження є родовище Сангачал-деніз – Дуванний-деніз – Хара-Зіра.***

М е т о д и . ***Розглядаються питання оптимального регулювання та управління процесами розробки нафтогазоконденсатного родовища Сангачал-деніз – Дуванний-деніз – Хара-Зіра з використанням моделей і методів Шухарта, які є актуальними для нафтової науки та практики. На основі системного аналізу запропоновано методи підвищення нафтовіддачі для збільшення вилучення нафти з родовища та надано рекомендації щодо раціональної розробки нафтогазоконденсатних горизонтів родовища.***

Р е з у л ь т а т и . ***Розглянуто стратиграфію, тектоніку, нафтогазоносність та поточний стан розробки кожного родовища окремо. Наведено їх стислий опис. Нині промислово значущі залишкові запаси нафти на цих об'єктах експлуатації зосереджені у відкладах верхнього ярусу Продуктивної товщі (нижній пліоцен). Основними об'єктами розробки є горизонти V, VII, VIII ПТ.***

Проаналізовано динаміку технологічних показників розробки родовища. За даними 2022 р., річний видобуток нафти становив 206,9 тис. т, конденсату – 0,864 тис. т. Річний видобуток розчиненого газу становив 83,4 млн м³, а вільного газу – 35,8 млн м³.

Поклади нафти і газу досліджуваної ділянки приурочені до тектонічно екранованих пасток, оскільки структура ускладнена численними поздовжніми та поперечними розломами.

В и с н о в к и . ***Розробка здійснювалася із застосуванням заводнення з 1971 р. Родовище перебуває на третій стадії розробки. Для підвищення коефіцієнта нафтовіддачі доцільно використовувати методи закачування водогазових сумішей та методи періодичного впливу.***

К л ю ч о в і с л о в а : ***метод закачування водогазової суміші, контрольні карти Шухарта, нафтові та газові свердловини, оптимальна розробка, контрольні межі.***

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