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DEVELOPMENT REGULATION OF EXPLOITATION OBJECTS BASED ON FIELD DATA OF THE NEFT DASHLARI FIELD

(THE CASE OF X HORIZON OF THE IV BLOK)

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Abstract

The paper is devoted to the current management during the solution of the problems of the increase in the efficiency of development of productive layers at the final stage of the operation within the Neft Dashlari field. The target object is X horizon of the IV block of the Neft Dahslari field. The Neft Dashlari is one of the largest field with huge hydrocarbon reserves in Azerbaijan. The results of the conducted prospecting-exploration work and the development processes of the objects make it possible to obtain extensive geological-field information about the field. The collection and systematization of these data allows reliable description of the geological-technological characteristics of the target objects of the field. So, based on the study of collected data the stratigraphy, tectonics, oil and gas-bearing, reserves, hydrochemistry of fluids was determined. Currently it is at the final stage of development. Development rate is below of regulation limit of the development, and the oil recovery factor is slow down. The solution of the problem of further increase of oil recovery factor leads to the need for extreme regulation of production facilities in reservoir section. Therefore, appropriate methods are identified.

Keywords: oil recovery factor, geological-field information, regulation limit, horizon, development, oil and gas-bearing.

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Introduction:

The Neft Dashlari field is one of the largest fields of Azerbaijan located within the South Caspian basin [3,4], in terms of the volume of oil and gas reserves including other components. About seventy-five years so from 1949 this field was covered by development process and 160 mln. tons of oil and 12.3 billion m^3 of gas were obtained from productive layers of this field. Today, there are 377 wells in operation and an average of 5 tons of oil obtained from each one per day. Every day, 5-6 new wells are drilled in the Neft Dashlari field, and each of them has the ability to produce 15-16 tons of oil per day in the initial period of development. It should be noted that there is a high effect of the Neft Daslari field on the development of the oil industry in Azerbaijan. Geologically the Neft Dashlari is a very interesting field. It is multilayered and consists of 26 productive horizons [4]. In addition, the volume of the remaining recoverable oil reserve over 20 mln. tons are estimated here.

Analysis

The results of the conducted prospecting-exploration work and the development process of the objects made it possible to obtain important geological-field information about the field. The collection and systematization of these data allows for a reliable description of the geological-technological characteristics of the field. Thus, based on this geological-field information the stratigraphy, tectonics, oil-gas-bearing, reserves, hydrochemistry of fluids, etc. of the field was studied. The study of data allowed us to obtain the following information about this structure:

Stratigraphy of the field

Productive series (Middle Pliocene-$₽_2$) - the lithological composition of the PS, as in most structures located in the South Caspian basin, consists of a rhythmic alternation of sand, sandstone, siltstone and clay. The maximum thickness of these sediments is 2400 m and they are divided into two stages: lower stage including Gala (GaS), Pre-Kirmaki (PK), Kirmaki (KS), Post-Kirmaki sandy (PKS), Post-Kirmaki clayey (PKC) suites, and upper stage including Fasila (FaS), Balakhani BaS), Sabunchi (SaS), Surakhani (SuS) suites [2,4].

GaS lithologically consists of clays, alternating with interlayers of aleurite and sand. In some cases, the thickness of sand and aleurite interlayers reaches 20-25 m.

Based on the logging diagram, 8 sandy layers are noted along the section of GaS. It should be noted that the lithological structure of the GaS differs in different blocks. For instance, in block II, along the wells numbers of 229, 256, 1591, 1667, 2072, six sand layers, and in block IV, along the well number of 900 seven sand layers are noted.

The section of the PK consists of gray sand and sandstone deposits layers, as well as thick clay layers. Clay content of suite is 30%. Clay layers are situated in the middle and lower parts of the section. Sands are mainly medium and coarse-grained.

Lithologically KS consists of alternating fine-grained sand and sandstone, clay and clayey sands. The thickness of the sand layers increases downward to the bottom of the section and reaches 10 m.

The lithological composition of the PKS suite sediments consists of medium- and coarse-grained sand (with sandstone) layers; sometimes clay layers are also found. In the sand and sandstone layers, pebbles with a diameter of 1-2 mm are also present. The sand content of the suite is very high; it is 70-90%.

The lithological composition of the PKC consists of clays, aleurite, sand and sandstone interlayers are also found. Compared to other fields of the South Caspian basin, the sand content here is relatively high (up to 40%). The PKC suite is oil-bearing in blocks II, III, IV and V of the field. The thickness of the suite is varying in the range of 90-220 m, while on average is 135 m thick.

FaS consists of medium- and coarse-grained quartz sands and sandstones, rarely thin clay interlayers are found along the section. There are pebbles with a diameter of 8 mm in the sands; sand content of suite is 65-70% and increases toward crest of the structure.

BaS suite consists of medium- to coarse-grained quartz sands and sandstones with clay interlayers. Sand content of the suite varies in the range of 50-60%. X, IX, VIII, VIIa, VII, VI, V sandy horizons are found along the BaS section.

The horizon X is composed of fine-medium-grained sands and sandstones. The horizon is oil-bearing in blocks II, III, IV, V of the structure. It varies 30-70 m thick, on average is 50 m.

The horizon IX consists of sand and sandstone with clay interlayers. Sands are fine- and medium-grained, consists up to 60%. Horizon is oil-bearing in the III, IV, V blocks; the thickness of its of 38-70 m, on average is 55 m.

The horizon VIII consists of medium- and fine-grained sand, sandstones and clays. It varies from 35 to 70 m thick, on average it is 55 m, in addition, it is oil-bearing only in blocks III, IV, V.

The lithological composition of the horizon VII consists of an alternation of sand and clay; sands are abundant. At the bottom of the horizon, a sand layer with a thickness of 30-75 m (VIIa) is found. In the III, IV, V blocks of the field, the horizon VII is oil-bearing, and in the II, III, IV, V blocks, the VIIa oil is found. The total thickness of the VII + VIIa horizon is 110-120 m.

The horizon VI consists of alternating sand-clay layers. It varies from of 100 to 150 m thick, while on average is 125 m, and it is oil-bearing in blocks IV and V of the field.

Lithologically horizon V consists of alternating sand-clay layers. The thickness of the horizon varies between of 70-100 m, while on average is 80 m and.

The lithological composition of SaS consists of alternating sand and clay layers, the amount of sand is 50%. These sediments are found on the limbs of the fold and in the south-east periclinal. The thickness of the suite is 250 m, there are IV, III and II sand horizons are found along the section.

The thickness of the IV horizon varies from 110 to 155 m; on average it is 140 m thick. it is oil-bearing in the III and V blocks of the field [1,4].

The III horizon consists of an alternation of sand and clay layers according to the lithological composition; sands are prevailing. The thickness of the horizon on average is 30 m, it varies in the range of 20-45 m.

The horizon II consists of an alternation of sand and clay in lithological composition; sands are prevailing. The thickness of the horizon on average is 35 m, it varies in the range of 30-55 m. This is oil-bearing in blocks III and IV of the field.

SuS consists of an alternation of sand and clay in lithological composition; clay layers are prevailing. Sand horizons I and I^1 are found in the bottom part of the suite, which lithologically consists of fine-grained sands. These sediments cover the limbs of the structure and the far southeast periclinal. The thicknesses of I and I' horizons are 30 and 35 m, respectively, and vary in intervals of 25-40 and 30-40 m. According to geophysical data, it is assumed that these horizons are oil-bearing in block III of the field.

The interpretation of the stratigraphy of the field allowed to singled out 26 development objects along its section.

Field tectonics

The Neft Dashlari field is a brachyanticlinal structure. It is asymmetric and extended from the north-west to the south-east with a length of 11 km and 6 km width. The field is complicated with longitudinal and latitudinal faults and divided into 6 tectonic blocks. Conducted studies show that tectonic faults are screen type. Anyway all blocks are isolated from each other by fault plains. So, each blocks are developed individually.

Oil-bearing and water charachteristics of the field

The suites and horizons of the Neft Daslari field are mainly oil-bearing and exploited for a long time. The data characterizing the potential of the field were determined. Using these information, it is possible to regulate of development process of the target objects.

The initial balance, recoverable reserves, cumulated reserves, as well as the volume of remaining reserves of individual objects were collected and systematized. Preliminary studies show that the current potential of the field is mainly related to the V and IV blocks, where we will analyze.

According to the presented hydrochemical information, the mineralization of formation waters changes from 720.2 mg-eq/100g (Absheron stage) to 48.0 mg-eq/100g (GaS). The degree of mineralization of waters gradually decreases with depth. If chloride-magnesium and chloride-potassium waters are found in the upper horizons of the PS, starting from the PKS to the bottom of the GaS there are hydrocarbonate-sodium type waters in the lower stage. According to the genetic characteristics the "transitional" waters in the Fasila suite of PS are found. Alkaline waters along the sections of GaS, PK, KS and PKS are also found.

Characterizing the regimes of individual deposits under development is based on the changes of the parameters of these deposits during exploitation, as well as the nature of the edge water zone energy. For this purpose, the absence of a gas cap, initial layer pressure exceeding the dissolution pressure, the amount of the gas factor, the rate of drop of the layer pressure, the movement intensity of the contour waters, the waterflooding characteristics of the marginal wells, etc. factors are taken into account. Due to the fact that the specified factors and parameters do not remain constant during processing, the layer regime is also changed.

Method

An integrated approach to field development involves not only predicting fluid behavior in reservoirs but also continuously monitoring reservoir conditions in real time. Modern digital technologies and machine learning algorithms enable the analysis of large volumes of data and the development of optimal operating strategies [6,7]. Therefore, the primary goal of this article is to analyze modern field development management methods and identify factors influencing oil recovery. One such method, the Shewhard map, is a statistical tool in the form of a graph that helps visually track and monitor process stability over time, identifying points of uncontrollability and enabling prompt corrective action.

Thus, the oil production process was controlled by the Shewhard method using field data. The middle, upper and lower limits of the regulation for the X horizon of the IV block of the Neft Dashlari field were determined. $X_{av.}$=21, X_u=37, X_l=5 (Fig.1).

As can be seen from the map, the upper and lower limits are symmetrical with the middle limit. From 1966 to 1974, production exceeded the upper regulatory limit. The maximum production was in 1972 and amounted to 84 thousand tons. In the period 1974-1985, the oil extracted from the horizon was between the upper and middle limits, and in the period 1985-2017, it was within the lower and middle limits, except for 1988. In 1988, production fell sharply. It exceeded the lower limit and amounted to 5 thousand tons. The development of the horizon continues in modern times, being below the regulation limit.

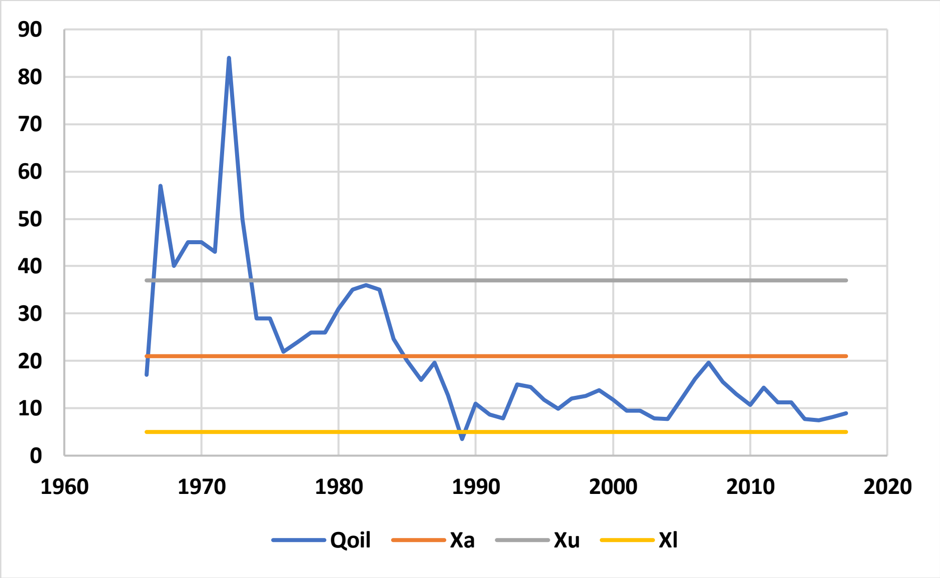

Fig.1. Regulation map of the oil production by X horizon

Water is extracted from productive formations as a byproduct of oil and gas production. This water is called formation water. If formation pressure is low, water can be reinjected into the formation to maintain pressure, a secondary method of enhanced oil recovery known as waterflooding. The average, upper and lower limits of the regulation for the fluid extracted from the X horizon were determined. $X_{av.}$=39, X_u=53, X_l=15 (Fig.2).

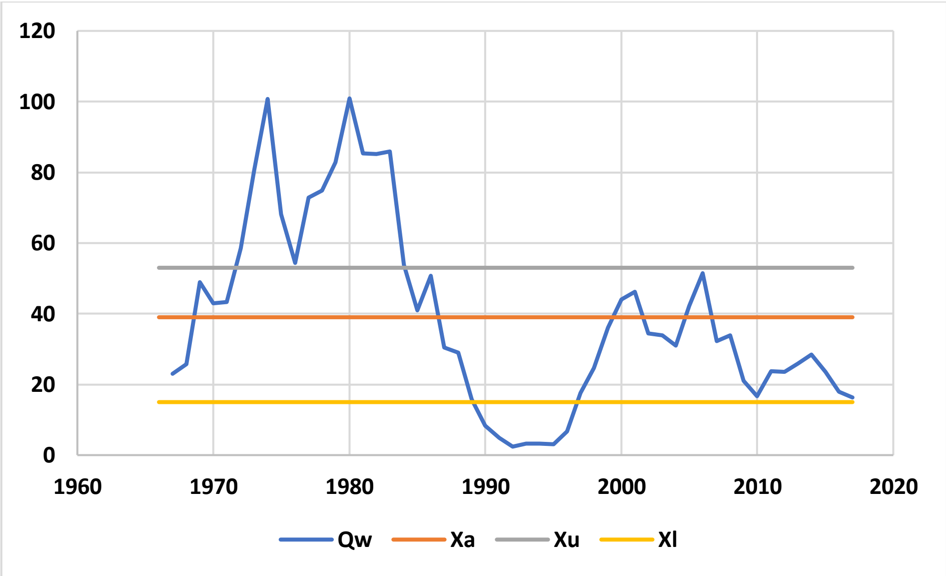

Fig.2. Regulation map of the water production by X horizon

The map shows that, with the exception of 1972-1984 (above the regulation limit) and 1989-1997 (below the regulation limit), water extraction from the horizon is within the regulation limit (Fig. 2).

Managing the number of wells during productive formation development is based on the principles of optimizing production, increasing oil recovery, and economic efficiency, through varying well spacing and using different well placement systems. The design takes into account the reservoir depth, the nature of the productive formation, and its properties, as well as measures to maintain pressure and monitor the development process.

The middle, upper and lower limits of the regulation for wells drilled in the X horizon have been determined. $X_{av.}=11$, $X_u=16$, $X_l=6$ (Fig. 3).

As can be seen from the map, the upper and lower limits are symmetrical with the middle limit.

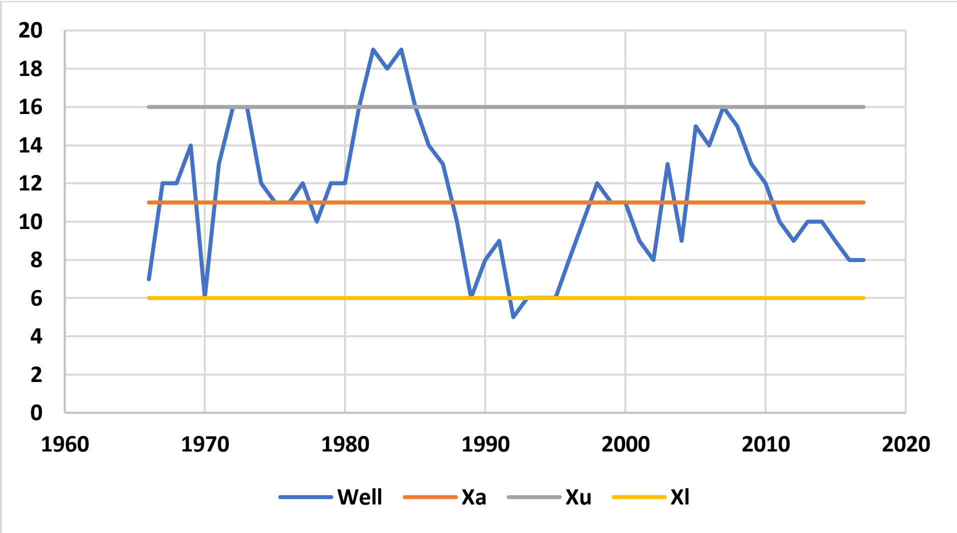

Fig.3. Regulation map of the wells drilled in the X horizon

The map shows that, with the exception of 1981-1985 (above the regulation limit) and 1992-1995 (below the regulation limit), wells drilled in the years 1981-1985 are within the regulation limit (Fig. 3).

Regulation of reservoir development rates is achieved through the design of development systems, which determine the number and location of wells, reservoir stimulation methods, and operating modes to optimize oil and hydrocarbon production, taking into account reservoir hydrodynamic conditions and field development stages.

Since the target (horizon X) is in the final stage of development, the development rate is below the regulation limit. The middle, upper and lower limits of regulation are determined. $X_{av.}=1.2$, $X_u=2$, $X_l=0.8$ (Fig. 4). As can be seen from the map, the upper and lower limits are asymmetrical with the middle limit.

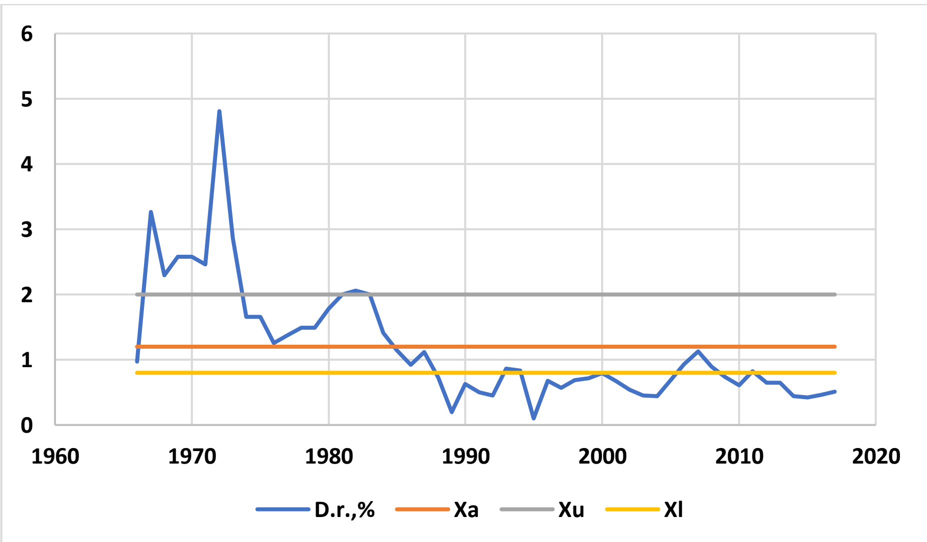

Fig.4. Regulation map of the development rate of the X horizon

In older fields, in the final stages of development, when they are no longer producing the required amount of oil, forced recovery measures are used instead of fluid extraction. Secondary and tertiary methods are employed to enhance oil recovery and increase production rates. Therefore, an important aspect of field development is maintaining optimal reservoir pressure using various methods, such as gas, water, or chemical injection. This increases reservoir pressure, forcing oil to the bottom of the wellbore.

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.

Thus, according to geological and field data we know that:

- oil viscosity of X horizon 3 MPa s;

- the occurrence depth of X horizon 1450 m;

- permeability of X horizon $470 \cdot 10^{-3}$ μm^2;

- 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 $A_1B_1C_2D_3$ ratio. According to Bagirov's method (Bagirov B.A. (2011), water-gas mixter influence methods is appropriate for increasing oil recovery factor.

Conclusion:

The use of such methods for regulating oil field development to enhance oil recovery is becoming a key area for the efficient and economically viable development of hydrocarbon resources. With the development of modeling using field data, drilling technologies, and reservoir stimulation, a significant increase in oil recovery can be expected.

Thus, the introduction of innovative methods into field development contributes to the improvement of not only economic indicators but also environmental sustainability, which is becoming an important factor for the future development of the oil industry.

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