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Dependence of calculation parameters on the detail of exploration works

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SUMMARY

Inaccurate determination and substantiation of calculated parameters performed based on the results of exploration works leads to overestimation or underestimation of the value of oil and gas reserves of the field. The article analyzes the calculated parameters and their change during the entire period of study and development of the field.

Introduction. The calculation of hydrocarbon reserves is considered as a comprehensive analysis and generalization of all: geological, geophysical, industrial and other factual data obtained in the process of exploration. Based on the results of the calculation of reserves, the geological-industrial model of the deposit is substantiated, which should reflect the qualitative and quantitative characteristics of the object and the degree of detail of its study. This model is the basis for further economic evaluation of the deposit and therefore the completion of each stage of geological study should ensure the reliability of determining the value of mineral reserves and related components in the subsoil.

Theory. However, each calculation of hydrocarbon reserves is complicated by the problems of determining the accuracy and reliability of these calculations, which are always performed with certain errors. This is due to the selective method of obtaining geological information, the variability of the filtration-capacity properties of reservoirs and the physicochemical properties of formation fluids. The accuracy of the measurement or determination, as the main characteristic of the quality of this measurement, reflects the approximation of the measurement results to the true value of the measured value. Whereas reliability is a property of information to be correctly perceived, it is the probability of the absence of errors. Reliability is a broader concept than accuracy and is defined as the degree of conformity of the obtained parameters to the valid ones that characterize natural objects. The accuracy of reserves is essentially the accuracy of establishing numerical values of geological and industrial parameters of the deposit, which determine its size, conditions, qualitative characteristics of minerals and industrial assessment in general (Ampilov and Hert, 2006; Rudko et al., 2011). In general, it is impossible to determine the calculated parameters with high accuracy, but as the degree of subsoil study increases, the reliability of such estimates increases. The main factors influencing the definition of each calculation parameter are technical, geological and methodological (Korzhnev et al., 2006).

Method. The technical factors that determine the accuracy of all calculation parameters include methods of obtaining and analyzing samples, taking into account the curvature of wellbore, which affect the determination of deposit areas, the reliability of data on filtration-capacity characteristics of reservoirs and physicochemical properties of formation fluids. Geological factors include the type and size of deposits, their mutual location, the degree of uneven distribution of reservoirs; they are due to the limited possibilities of using methods of interpolation and extrapolation of geological data, which causes a simplified idea of the structure and changes in the properties of reservoirs in different parts of the field.

Methodological factors include the method of conducting exploration work and, accordingly, the density of the network of wells, which characterizes the reliability of information. Methodological and geological factors have the greatest influence on the degree of determination of the accuracy and reliability of the calculated parameters.

Results. Let's analyze the degree of change in the reliability of such calculated parameters as oil bearing area, effective oil saturation thickness, open porosity and oil saturation on the examples of the Boryslavsko-Pokutska oil field of the Precarpathian foredeep. According to the administrative division, it is located on the territory of Bohorodchany and Nadvirna districts of Ivano-Frankivsk region. Tectonically it belongs to the III structural-tectonic tier of the central part of the zone. The deposit is associated with a narrow anticline fold of the north-western extension, which is overturned in the north-eastern direction and is broken by transverse tectonic faults into three blocks. The north-eastern wing of the fold is steep, with angles of incidence of rocks 65-85° and complicated by a longitudinal disjunctive violation of the sliding nature. The discovered geological section of the deposit is represented by Cretaceous, Paleogene, Neogene and Quaternary deposits. The industrial oil and gas potential of the field is associated with deposits of the Upper, Middle, and Lower Menilithic backgrounds of the Oligocene and the Vyhodska and partially Manyavian suites of the Eocene within the second block of folds. The life cycle of the field covers a long period of time, starting in 1963, when well 35 established the industrial oil potential of Menilithic deposits. Later, in 1964, well 100 discovered oil deposits in Eocene deposits.

The study of the geological structure of the field was carried out by drilling exploratory, exploration and production wells, selection and analysis of core material, samples of formation fluids, geophysical and hydrodynamic studies of wells, their testing and actual operation.

The exploration period of the field lasted until 1967, during which time 23 exploration wells were drilled, the total area of which was 59,311 l.m. Simultaneously with the exploration, trial operation of wells was carried out. Beginning in 1967, the field was put into commercial development in accordance with the approved technological scheme. The operational fund consists of 16 wells, the total area of which is 32048 m.

Currently, the field is in the final stages of development, a flooding system is being implemented and it is planned to achieve a recovery factor of 0.367. Further drilling works at the field are not planned.

Of the total number of wells drilled within the field: 9 units were eliminated for geological reasons, 7 units - for technical reasons, 10 units were eliminated without testing.

Such a rapid pace of studying the geological structure and oil and gas potential of the field in the process of both exploration and its development, led to repeated counts of oil and gas reserves, starting with the operational in 1965. The following were performed in 1971, 1980 and 2011. As the main method of determining the amount of initial total and production reserves of hydrocarbons in all cases used bulk. The calculation of oil and gas reserves and justification of all calculation parameters was regulated by the requirements of the current at the time of assessment "Instructions for the application of the Classification of reserves and resources of minerals" (Klasyfikaciya zapasov mestorozhdeniy (zalegey) nefi i goryuchego gaza, 1959; Klasyfikacii zapasiv i resursiv..., 1998).

As of January 1, 1965, 16 wells were drilled within the field, of which four received industrial oil inflows, and 5 wells were being tested at that time. Thus, the substantiation of such calculation parameters as effective oil saturation thickness, open porosity and oil saturation coefficients is based on research materials of 9 wells. Exploration of the field at that time was still ongoing.

The degree of geological study of the field at that time allowed to calculate the reserves of oil and dissolved gas in the sediments of the Menilitic, Vyhoda and Manyava suites within the first (pre-explored) and second (explored) blocks. Structural map, which was the basis of the calculation plan.

The study of the field at the stage of exploratory drilling was planned to be carried out by transverse profiles, the distance between which is from 700 to 1300 m, and between the wells on the profiles - 600 - 1000 m.

The profile system of exploration wells is only partially observed, so the south-western wing of the fold turned out to be unexplored and drilled two production wells did not give positive results. There is also a deviation of the actual location of individual wells from the design, caused by unfavorable terrain conditions or the presence of various structures in the area.

Further drilling of the field by exploration wells and analysis of the material available at that time also allowed to identify a number of significant shortcomings in relation to the exploration work carried out at the field:

1. The area was not sufficiently prepared for exploratory drilling, so 16 units of wells were not brought to the design depth for geological or technical reasons. Only 4 wells received industrial oil inflows during the test.
2. The industrial oil and gas potential of the fold in the first block is not set.
3. The oil and gas potential of the south-eastern extension of the fold is unsatisfactorily studied.
4. Extremely low core removal from oil-saturated intervals: the core illumination of Middle Menilite deposits is 5.8% of Lower Menilite deposits - 4.6% and Eocene deposits - 3.2%.

It should be noted that sand-siltstone varieties of rocks are characterized only by individual wells, which led to insufficient study of the reservoir properties of productive horizons in the field area.

5. The low quality of industrial and geophysical research in a number of wells, due to their poor preparation, led to poor recording of AR and SP curves and made it impossible to determine such calculation parameters as effective thickness, porosity and oil saturation.

6. Insufficiently substantiated position of OWC due to the lack of induction logging in wells.

The combination of all these factors led on the one hand to the destruction of the field, on the other hand - to its unexplored. Only the vaulted part of the structure was explored, its south-western part in the first block and the second block turned out to be completely unexplored.

Since 1967, the field has been in industrial development, and the details of its geological structure and oil potential have been met by increasing the volume of production drilling.

Thus, as of 01.01.1971 for the field:

1. The geological structure of the south-western wing of the structure within the first two blocks has been specified, for which, according to drilling data, the presence of longitudinal tectonic faults of a sliding nature has been established. Also, it was found that the structure of the folds in the first and second blocks are morphologically significantly different: in the first block it is narrower and has a steeper northeast wing, while the southwest is truncated.
2. As a result of the expansion of the GWL complex, testing and operation of wells, the position of OWC for each of the deposits was clarified, which also led to a change in the area of oil bearing capacity.
3. During the GWL, the above-mentioned shortcomings were not allowed, which allowed to obtain additional information about the physical properties of the collectors, including according to the drill sample.

The nature of the distribution of oil-saturated thicknesses by area and section of the field is detailed.

Lithological dismemberment of well sections, their correlation, selection of reservoirs, assessment of their productivity and reservoir properties were performed based on the interpretation of a set of industrial geophysical surveys, which included standard logging, lateral logging, radioactive logging, cavernometry and thermometry. In some wells the complex was supplemented by micro-logging, lateral, induction logging and gas-dynamic research (Trubenko et al., 2019). In the process of exploration of the field with the selection of the core drilled 1713.3 m, which is 2.97% of the total penetration. The removal of the core was 551.4 m or 32.2% of the penetration of the column bit. The selection of the core in the production wells was carried out in the productive part of the section and amounted to 398.5 m or 12.4% of the total penetration. The removal of the core is much lower than in exploration wells and is 93.1 m or 23.4% of the drill bit. The reservoir properties of productive horizons were studied on 145 samples, of which 31 were analyzed: in Middle Menilitic sediments, 70 - in Lower Menilitic sediments and 44 samples in Eocene sediments (study parameters: porosity, permeability, oil saturation, carbonate content, particle size distribution).

The study of the mineral-petrographic composition of the strata was carried out by describing more than 800 sections under a microscope. As of January 1, 1971, 27 wells were drilled within the field, 10 of which received industrial oil inflows. The results of drilling, research and operation of wells are the basis for substantiating the effective oil saturation thickness, open porosity and oil saturation coefficients. The reserves according to the degree of geological study are referred within the first block to the previously explored, within the second - to the explored.

After the calculation of reserves, the drilling and operation of the field continues, the fund of drilled wells increases to 32 units. The complex of works allowed to specify the geological structure of the field and the features of its oil and gas potential, namely:

1. It is established that the structure within the second block is divided by transverse tectonic faults into three blocks.
2. The non-industrial nature of the productivity of Manyava deposits, which contain small accumulations of oil, has been established.
3. Previously explored oil reserves of the first unit have been written off as unconfirmed.

Thus, calculated as of 01.01.1980, oil reserves are classified as explored.

Since 1983, the field has entered a phase of declining production, but its drilling by production wells lasts until 1994 and the fund of drilled wells reaches 39 units.

For the field, which is in the final stage of development (during the period of operation 94.7% of the initial oil reserves were extracted from the average menilitic deposit, 96% from the lower menilitic deposit and 65.1% from the Eocene deposit) the oil and dissolved gas reserves were calculated again. .

As of 01.01.2011, all reserves calculated within the second block are classified as explored, for which:

1. Accurately established shape and size of deposits.
2. The nature of inhomogeneity in area and section of reservoir properties (porosity, permeability, oil saturation) is studied, the effective oil-saturated thickness is determined.

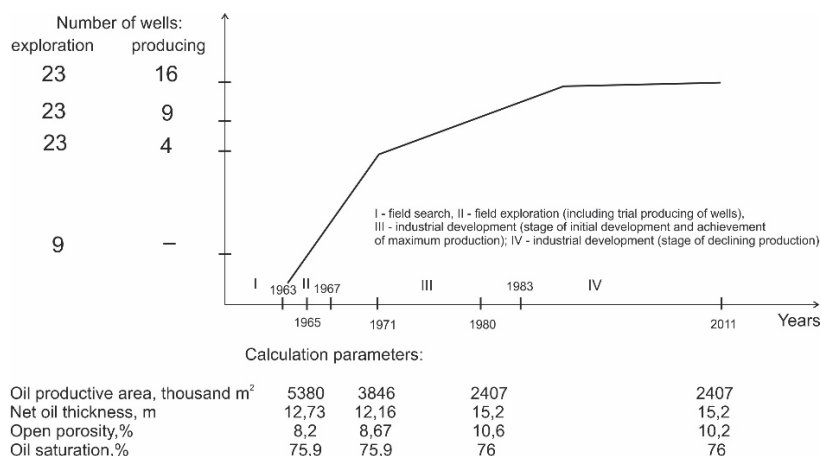


Figure 1 Changing of the calculated parameters of the Middle Menilit oil deposit

Conclusions. Given the history of prospecting, exploration and development of the Hvizdetsky field, increasing the degree of its study and obtaining new facts, significantly changed the perception of the geological structure and oil and gas potential of the object, which, in turn, affected the determination of both calculated parameters and reserves of hydrocarbon deposits. In Figure 1 shows the change of the calculated parameters depending on the stage of study of the field. As can be seen from Figure 1, of all the calculated parameters of the most significant changes for the entire period of exploration and development of the field underwent an idea of the area of oil, which for the average menilitic deposit decreased by 2.2 times compared to the initial value. The effective oil-saturated thickness and open porosity changed to a much lesser extent, and increased in comparison with the initial values, respectively by 1.19 and 1.24 times. The value of oil saturation has hardly changed. Thus, we can conclude that the study of the geological structure and characteristics of oil and gas field lasted a long time, covering not only the period of exploration but also industrial development, until the field enters the stage of declining production. That is, in this case, a significant number of drilled exploration wells still did not fulfill its main purpose and the features of the geological structure and oil and gas field were not definitively established. Therefore, it can be argued that the degree of reliability of such calculated parameters as oil area, effective oil saturation thickness, open porosity and oil saturation did not increase in the process of increasing exploration of the field, but was achieved only in the process of its industrial development. In this case, a significant influence on the reliability of the parameters was played by methodological factors, which consisted in non-compliance with the system of location of exploration wells.

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