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METHODOLOGY FOR IDENTIFYING OPERATING OBJECTS IN OIL FIELD DEVELOPMENT BASED ON MATHEMATICAL AND STATISTICAL INDICATORS (USING THE EXAMPLE OF THE PIRALLAHI (NORTHERN FOLD) FIELD)

(Представлено членом редакційної колегії д-ром геол. наук, доц. О.В. Шабатурою)

Background. ***In this research, a table based on samples taken from wells in each of the two horizons and using the formation parameter values was compiled. As a result of the researches, five formation parameters (geological and technological) were included in the matrix, and parametric criteria were used to determine the degree of similarity or difference between the upper and lower layers of the KS.***

Methods. ***In Pirallahi using the actual data of the wells that opened both layers, (CUS and CLS) calculations were made according to statistical indicators based on the values of the relevant indicators and checked with parametric criteria. Since the calculated prices are lower than the table values and there is a similarity between both objects, it is recommended to combine them and operate them together. Such an approach leads to intensification of development.***

Results. ***Due to the examination of complex geological and operational data, the following proposals are recommended along with the consolidation of similar layers in the north of Pirallahi.***

Conclusions. ***Thus, since the geological and production indicators between the objects KS_{upper} and KS_{lower} are almost similar, it is advisable to combine them into one object and exploit one grid of wells. The allocation of such objects leads to the intensification of exploitation, and the results can be used in drawing up projects for the development of such layers.***

Keywords: ***oil field, horizon, reservoir parameters, mean value, variance, effective thickness, porosity, viscosity, density, reservoir pressure.***

Background

The issue of combining operational objects is constantly studied by researchers, and its results are reflected in the corresponding literature (Bagirov, Narimanov, & Salmanov, 2001). The separation of operational objects should be based on comprehensive research (Bagirov, 1986). As experience shows, the combination of operational objects is of great importance both from the economic and geological point of view. However, it is necessary to justify the corresponding criteria for their allocation and operation as a single object (Bagirov, Mamedov, & Salmanov, 1994). For example, their energy properties, lithological-facial characteristics, physical properties of oil, and natural regimes, which should be close or equal in value, must be taken into account. The solution to the problem can be achieved with the help of geological and mathematical methods, and for a more reliable solution, the method presented by Prof. D. A. Radionov becomes appropriate.

The method of section processing of each productive layer involved in field cutting is favorable from the geological and technological point of view. Thus, each layer has its own network of exploitation and impact wells, which creates conditions for the effective application of appropriate methods in the development process. In this case, it is possible to actively regulate the processing process. However, this option is often not economically viable (Salmanov, & Hasanaliyev, 2000).

If more than two operational objects are separated in the cross-section of an oil and gas field, Bartlett or Cochran criteria are used to determine the degree of difference between them according to any parameter (for example, permeability of reservoir rocks). However, in practice, the comparison of the operating objects separated by any parameter is not based on their complex indicators. In this case, if we denote the number of operating objects by *n*, and the number of their parameters to be compared by *m*, we get an $n*m$ matrix. Then the Rodionov criterion was more effective for checking the degree of similarity between the layers in the field section (Rodionov, 1981). According to this criterion, it is possible to come to an unambiguous conclusion about the joint (or separate) processing of the objects located in the cross section of the layer according to the degree of similarity.

Justified allocation of production facilities in the cross-section of multi-layer deposits is the bases of all scientific and practical work on the development of oil and gas fields. At the stage of geological exploration and work on putting deposits into development, all available geological and geophysical information is brought into consideration to divide the section opened by drilling. A comprehensive study of these data and their comparison with those in adjacent areas makes it possible to divide the section into production facilities. This allocation of the section is the basis for subsequent scientific and practical activities of the enterprise (reserve calculation, preparation of a process flow chart and deposit development projects, etc.). It should be noted that any approaches used in dividing the section into horizons and then into production facilities cannot be considered ideal, since the quality and quantity of information used by researchers at the initial stage of putting the field into development is insufficient, and most importantly, such a very important problem of oil field geology is solved at a qualitative level, without using the appropriate mathematical apparatus. Naturally, under such conditions, the intuition and subjectivity of researchers who put forward the final version of division of a multi-layer oil and gas field come to the fore. Probably, therefore, after putting the field into operation, the scheme for dividing the section into objects is often criticized. However, it should be noted that regardless of how correctly the problem of identifying production facilities in the section of a multi-layer field is solved, it should be periodically updated.

In our opinion, it is most appropriate to use the criterion of D. A. Rodionov, which is an unambiguous and justified procedure for finding homogeneous groups of objects with respect to the parameters of both one-dimensional and multidimensional random variables (Salmanov, 2007). The nature of the procedure for considering partitioning options should be determined by the geological problem being solved. For example, as already noted, the position of observation points can be strictly fixed on one line (division of a stratigraphic section by a set of characteristics). In this case, it is sufficient to consider *n*–1 options for partitioning the set of observations into two parts. If the hypothesis of homogeneity of observations located on a plane is considered, then the approach to considering the procedure may be different.

The function $\upsilon(r^2)$ is considered, defined on the set of partitions R^2 of the space T into two parts is considered as a criterion for testing the hypothesis of homogeneity:

$$\upsilon(r^2) = \sum_{j=1}^{m} \frac{n_1 n_2 (x_j^{(1)} - x_j^{(2)})^2}{(n_1 + n_2) S_j^2},$$

where $x_J^{(1)}$ and $x_J^{(2)}$ are the arithmetic means of features with number j, calculated for each of the two sets into which n observations is divided; n_1 and n_2 are the numbers of observations in these sets; S_j^2 is the value of the variance of feature with number j, calculated under the assumption that the variances of both groups into which the set is divided are the same. This value is conveniently calculated by the following formula:

$$S_j^2 = \frac{1}{n_1 + n_2 + 1} \left(\sum_{t \in A_1} x_{tj}^2 + \sum_{t \in A_2} x_{tj}^2 - \frac{1}{n_1 + n_2} \left(\sum_{t \in A_1} x_{tj} + \sum_{t \in A_2} x_{tj} \right)^2 \right),$$

where A_1 and A_2 are the sets into which the space T is divided, and $A_1 \cup A_2 = T$. It is more convenient to calculate the function $\upsilon(r^2)$ using the formula:

$$V(r_0^2) = \frac{n-1}{n(n-k)k} \sum_{j=1}^{m} \frac{\left[(n-k) \sum_{t=1}^{k} X_{tj} - k \sum_{t=k+1}^{n} X_{tj} \right]^2}{\sum_{t=1}^{n} X_{tj}^2 - \frac{1}{n} \left(\sum_{t=1}^{n} X_{tj} \right)^2}$$

If the tested hypothesis is true, then $\upsilon(r^2)$ will be the value of a random variable distributed χ^2 as m with m degrees of freedom. Thus, the hypothesis of homogeneity is accepted if

$$\max_{r \in R} \upsilon(r^2) \le \chi^2_{g,m},$$

and is rejected if

$$\max_{r \in R} \upsilon(r^2) > \chi^2_{g,m}.$$

When there are a large number of oil layers in the field cutting, grouping and joint processing of them significantly reduces the number of wells compared to separate processing of each productive layer and is economically profitable. However, in the grouping option, the final oil production coefficient of the field should be expected to be less than the individual development option of each of them. Since most of the oil fields in our region are multi-layered, it is appropriate to apply the proposed method. Consolidation of operational facilities in the mining division was carried out in several deposits – Neft Dashları, Guneshli, Binagadi, Kirmaku.

Solution of this issue is based on the principle of determining the degree of similarity of layers in the section: geologically similar layers should be exploited together, and different ones should be exploited separately. Solution of the problems of clarifying the division of operational objects at different stages of the development of multi-layered oil and gas fields remains an important problem for all fields. Therefore, it is proposed to apply mathematical methods that provide for the complex use of geological-exploitation indicators of deposits.

Methods

The similarity and differences between layers in the (*V*) of their characteristics are calculated and verified using Student's and Fisher's criteria, as well as compared with critical values taken from a special table. If the condition of the equation is satisfied, where $\upsilon(r^2) \le \chi^2_{g,m}$, then the objects can be combined since they are compatible. However, if $\upsilon(r^2) > \chi^2_{g,m}$, then it is impractical to combine them since there are differences between the layers. In this case, if the number of exploitation objects is denoted by *n* and the number of compared parameters by *m*, a matrix of size *n*m* is obtained. Based on this criterion, a clear conclusion can be drawn about the joint (or separate) development of objects located in the deposit section, based on the degree of their similarity. The article discusses the question of combining the operating objects of the Kirmakinskaya suite (upper and lower) – KS_{upper} and KS_{lower} – at the Pirallahi field (north fold).

A brief description of the method. Let's accept that in the first stages of working in the field section, the productive layers were combined according to the degree of similarity and turned into n number of exploitation objects. The boundaries that separate them from each other have also been defined. At a certain period of time, the degree of similarity between the processing objects (or the existence of the boundaries separating them) is checked. In this case, it is necessary to solve the problem of determining the boundaries that divide the sedimentary complex into layers of the same type in a certain sequence. A complex of mathematical methods is justified to solve this problem. For this purpose, the indicators that characterize them (for example, the porosity of the reservoir rocks) should be compared with each other. Then the average value (*X*) and dispersion (S^2) of that indicator are calculated for both layers and the values X_1, X_2 and S_1^2, S_2^2 are obtained for the layers, respectively. Then, based on these values, the Student's and Fisher's tests are used to compare the two layers with each other. By comparing the calculated value of both criteria with their critical value it is possible to make a definite opinion about the significant or slight difference of the layers according to the rock porosity. Fisher's criteria were used in the presented work.

Fisher's criterion: $F = \frac{D_{max}}{D}$, where D_{max} – is the maximum variance, D – the variance of the remaining sample.

Student's criterion: $t = \frac{\bar{x}_1 - \bar{x}_2}{D_{\bar{x}_1 - \bar{x}_2}} \sqrt{\frac{n_1 n_2}{n_1 + n_2}}$,

where $\bar{x}_1$ and $\bar{x}_2$ – are the average values of the parameter being studied, n – the amount of data, $D_{\bar{x}_1 - \bar{x}_2}$ – the weighted variance, which is calculated using the formula:

$$D_{\bar{x}_1-\bar{x}_2}=\sqrt{\frac{D_1n_1+D_2n_2}{n_1+n_2-2}}.$$

So if the table value F_0 and t_0 is less than the calculated value F_t and t_t, then the null hypothesis is rejected, but if the table values are greater than the calculated ones, then the null hypothesis (H_0) is not rejected. If the results obtained are ambiguous, the results obtained using the Student's criterion are accepted as true.

Results

In the article, the grouping of exploitation objects was considered on the example of the Pirallahi field. The Pirallahi oil field (marine part) is one of the oldest oil fields in Azerbaijan. It is located in the shelf zone of the Caspian Sea, east of the Absheron Peninsula. The island is separated from the Absheron Peninsula by a narrow water basin 4.5 km wide in the north and 1.5 km in the south. In the narrower southern part, in 1940, the sea was artificially drained and a "Dam" was built in the form of a narrow strip, and the island was connected to the Absheron peninsula. Pirallahi Island is 10-12 km long and is considered the largest island in the Absheron Archipelago. The oil field consists of two uplifted structures: northern and southern.

The first exploration works in the field were started by private owners in 1897. In the same year, the Nobel brothers finished drilling several exploratory wells. In 1902, the potential oil content of the KS-3 horizon was discovered in well number 44. Drilling of exploratory wells was continued and as a result, oil accumulations were discovered in PK and KS reservoirs.

The northern uplift has been under construction since 1902. The length of the northern uplift reaches 6 km. The size of the deposit is 8.3x1.8 km. The oil content of the southern uplift in the field was determined in 1930. Industrial objects located in the northern uplift are the KS_{upper}, KS_{lower}, and PK horizons. Over 1000 production wells have been drilled to develop oil reserves at different stages of development.

Despite the fact that the Pirallahi field was included in development since 1903, the clarification of the tectonic structure began after 1931 with the acquisition of new geological mining-geophysical data. The first structural scheme of the deposit was drawn up by geologist A.A. Kamladze. Structural refinement was continued until 1951, with the acquisition of new geological mining-geophysical and development data.

Despite the fact that the Pirallahi deposit was included in the development since 1903, the clarification of the tectonic structure of the structure began after 1931 with the acquisition of new geological mining-geophysical data. The first structural scheme of the deposit was made by geologist A.A. Kamladze.

Changes in the structural maps mainly covered the area where intensive excavation works were carried out on the field. Later, in 1984 and 2000, due to the recalculation of the deposit's reserves, the structural maps were refined taking into account the obtained geological data.

The South Pirallahi structure differs significantly from the anticlinal structures of the Absheron Archipelago. Tectonically, the South Pirallahi structure forms the southern part of the North Pirallahi structure and is characterized by a large-amplitude uplift fault. The plane of the uplift broke the crestal part of South Pirallahi in the direction of the axis line, and as a result, the NE limb (III block) was superimposed on the SW limb (IV block). The amplitude of the fault is 800 m.

The KS formation consists of gray and greyish fine-grained sands. Gray dense or scattered layers of sandstone are often found in the section, and the sandiness of the layer increases as it goes down. In the electric log diagram, sandy layers are observed in the section, and the value of the assumed specific resistivity curve is more than 2550 Ohm m. In this regard, the KS formation is divided into 7 operational objects: I, II, III, IV, IVa, V, Va, and recently it is divided into 2 objects. The KS_{upper} horizon includes groups I, II, and III, and the KS_{lower} includes groups IV, IVa, V, and Va. The thickness of the KS formation varies in a small range from 240 to 280 m (Fig. 1). Thus, the thickness of the layer increases gradually from the crest to the edges of the fold. The sandiness of the horizon varies in the range of 20–40 %.

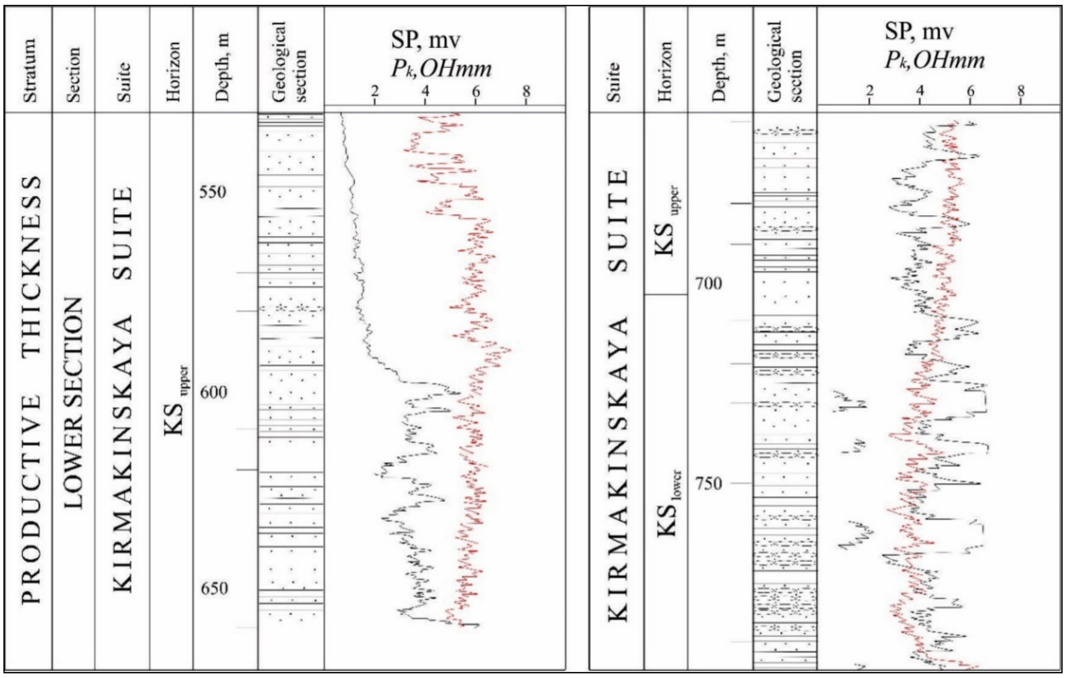

Fig. 1. Section of the KS horizon of the Pirallahi field

Waterflooding in Pirallahi field. In order to maintain formation pressure in the field, the contour waterflooding process was started in 1947 in the southern uplift of the field. From 1947 to 1949, the waterflooding of the formations covered a distance of 200–250 m from the wells. Since 1949, the waterflooding process has been expanded by injecting sea water into the eastern part of the northern fold with new wells. The analysis of the initial and current production of the wells shows that the effectiveness of the waterflooding process in the northern fold was not high.

In 1948, water was pumped from two injection wells (600–800 m deep) in the western zone of the dry area, and in 1950–1951 from 6 more injection wells to study the effect on operational wells located at a distance of 150–200 m. Due to the flow of sand into the wells and the ingress of formation water, the waterflooding process was stopped in 1986, and since 2012, the waterflooding process has been started again in the SW KS_{upper} horizon of the northern fold. During the waterflooding, 19828.8 thousand m^3 of water was pumped into the bed.

The northern uplift. Since 1947, the process of waterflooding was started in the uplift, in 1986, this process was stopped, and since 2012, the process of waterflooding has been started again. In the northern uplift, the process of linear waterflooding on the field was started in 1951. Currently, 12 injection wells are in the inactive fund in the northern fold. From the beginning of the process until now, 14384.2 thousand m^3 of water has been pumped into the uplift.

The southern uplift. Since 1952, the waterflooding process was started in the uplift, in 1984, the efficiency of waterflooding decreased and as a result, this process was stopped. From the beginning of the process until now, 5447 thousand m^3 of water has been pumped into the uplift zone.

Physico-chemical properties of oil. In the Pirallahi field, oil samples were analyzed in order to study the physical and chemical properties of oil in reservoir conditions. As a result of the conducted research, density, viscosity, volume coefficient, gas solubility in oil, etc. parameters are set.

The formation oil parameter on KS_{upper} was studied based on 72 samples. As it can be seen, the average value of gas capacity of oil is 18 m^3/t, density is 0.899 g/cm^3, viscosity is 24 mPa.s.

Production dynamics of the deposit. As can be seen from the dynamics, the Pirallahi field was in the I stage of development until 1949. Thus, performance indicators increased dynamically. In 1949–1953, the indicators remained stable at the highest point. In the subsequent period, the production indicators began to decrease gradually. Currently, the field is in the final IV stage. In recent years, due to the new wells drilled in the onshore and offshore part of the field, the indicators have started to rise relatively (Fig. 2). In 2021, 4 wells were drilled and put into operation. In particular, 18 wells were drilled from core samples No. 1140, 16; No. 1150, and 16 wells from core sample No. 1220 built in the shallow water part of the dam. In addition, restoration works are being carried out for the wells that were flooded due to the rise of the sea level. Since 2013, 25 wells have been decommissioned and returned to the operating fund.

At present, the construction of earth foundations in the shallow part of the sea is being continued. Construction of 16-well land foundation No. 1240 continues.

Research works on the application of influence methods are being conducted. The vibroresonance method was used in wells No. 1024 and 1025. In wells No. 1072 and 1080, special reagents were used to increase the temperature at the bottom of the well.

Based on the results of the analysis of 42 samples taken from KS_{lower}, the average value of gas capacity is 46 m^3/t, density is 0.890 g/cm^3, and viscosity is 16 mPa.s.

The objects of the Kirmakinskaya suite that were studied were developed simultaneously. They operate in the dissolved gas mode and are in the final stage of development. The last time oil reserves were estimated at the field was in 2018. The reserves of each of the two objects were estimated separately, and the average values of the geological and production data of the horizons are presented in Tab. 1.

As can be seen from Tab. 1, the average values of many parameters (effective thickness, porosity, viscosity, density, temperature, reservoir pressure, etc.) and the daily well productivity are very close to each other (in the range of 0.5–0.7 tons per day). Both objects operate in the dissolved gas mode, as already noted earlier.

In this study, based on samples taken from wells of each of the two horizons and using the values of reservoir parameters, a table (Tab. 2) was compiled. As a result of the research, five reservoir parameters (geological and technological): oil viscosity, density, rock permeability, current reservoir pressure, reservoir temperature, reservoir water type were included in the matrix using parametric criteria to determine the degree of similarity and the difference between the upper and lower KS horizons.

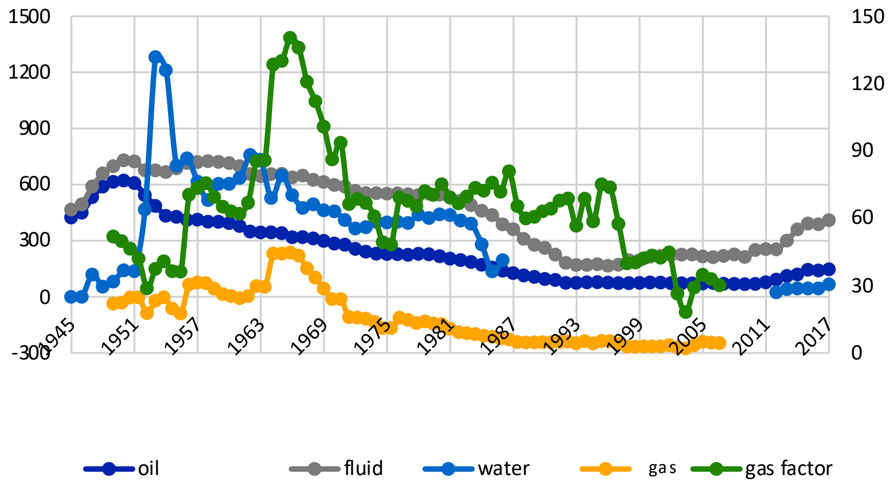

Fig. 2. Dynamics of development indicators of the Pirallahi field

Table 1

Geological and production indicators of the horizons of the Pirallahi field

Indicators	Horizons	
	KS_{upper}	KS_{lower}
Year of commissioning	1902	1902
Reservoir depth, m	270	420
Oil-bearing area, ha	818	114
Effective reservoir thickness, m	12,8	11,5
Rock porosity coefficient, %	24	26
Rock permeability, mkm^2	0,075	0,123
Oil saturation coefficient of the reservoir	0,74	0,68
Density of reservoir oil, kg/m^3	899	890
Oil viscosity under reservoir conditions, mPa.s	24	16
Type of reservoir water	Sodium bicarbonate	Sodium bicarbonate
Mineralization of reservoir water, g/L	33,2	49,8
Reservoir temperature, °C	21,5	23,1
Reservoir pressure, MPa	17,2	18,8
Reservoir water cut, %	68,7	74,5
Current well density, ha/well	3,8	1,2
Well fund	95	57
Oil recovery factor: ultimate current	0,310 0,270	0,340 0,310
Daily production rate: oil, t/day water, m^3/day	0,5 1,2	0,7 2,2

Table 2

Well data for the KS_{upper} and KS_{lower} horizons

Well	Horizons	Blok	Oil viscosity, mPa	Oil density, g/sm^3	Rock permeability, $0.001 mkm^2$	Current reservoir pressure, MPa	Reservoir temperature, °C	Type of reservoir water
411	KS_{upper}	I	35	0,916	69	15	23	S_1A_2-Sodium bicarbonate
849	KS_{upper}	I	33	0,913	78	13	21	S_1A_2-Sodium bicarbonate
1168	KS_{upper}	II	39	0,914	64	12	19	S_1A_2-Sodium bicarbonate
946	KS_{upper}	II	40	0,910	75	11	18	S_1A_2-Sodium bicarbonate
1080	KS_{lower}	I	43	0,922	117	19	24	S_1A_2-Sodium bicarbonate
295	KS_{lower}	I	39	0,920	132	17	25	S_1A_2-Sodium bicarbonate
431	KS_{lower}	II	41	0,914	127	22	22	S_1A_2-Sodium bicarbonate
438	KS_{lower}	II	40	0,911	110	25	21,4	S_1A_2-Sodium bicarbonate

Conclusions

The analysis of the obtained results shows that the layer parameters of both horizons do not differ significantly from each other according to their average values (Tab. 3).

The calculation results were as follows: with a critical value of the Student's criterion of 3.18 and Fisher's criterion of 15.98, the calculated values were lower than the tabular values: $T_{calc.} < T_{tab.}$ and $F_{calc.} < F_{tab.}$ This situation once again confirms the similarity between these parameters.

Table 3

Distribution of reservoir parameters by wells and statistical indicators

Parameters	Horizon	Statistical indicators				Parametric criteria, α=0,05			
		Average value $\overline{X}$	Dispersion (D)	Mean square bias (σ)	Coefficient of variation (V,%)	Calculated value (T_{calc})	Table value (T_{tab})	Calculated value (F_{calc})	Table value (F_{tab})
Oil viscosity, mPa	KS_{upper}	37	6.5	2.5	6.75	1.4	3.18	2.6	15.98
	KS_{lower}	41	2.5	1.5	3.65				
Rock permeability, 0.001 mkm^2	KS_{upper}	71	32.5	5.7	8.02	1.5	3.18	2.4	15.98
	KS_{lower}	121	78.5	8.86	7.32				
Oil density, g/sm^3	KS_{upper}	913	3.5	1.8	0.19	0.29	3.18	6.4	15.98
	KS_{lower}	917	22.5	4.7	0.51				
Current reservoir pressure, MPa	KS_{upper}	13	2.5	1.5	11.53	2.24	3.18	3	15.98
	KS_{lower}	21	7.5	2.7	12.8				
Reservoir temperature, °C	KS_{upper}	20	5	2.2	11	1.12	3.18	1.5	15.98
	KS_{lower}	22	7.5	2.7	12				

Thus, since the geological and production indicators between the KC_{upper} and KC_{lower} objects are practically identical, it is expedient to combine them into one object and operate them with a single well grid. The identification of such objects leads to the intensification of production (Bagirov, Gismetov, & Aliye, 1989), and the results can be used in the development of projects for oil reservoirs (Velieva, 2005).

Authors' contribution: Vafa Suleymanova – setting of the problem, conducting of mathematical-statistical analysis, analysis of results; Samira Mansurova – data collection and processing, mathematical-statistical analysis; Nazile Mammadova – drafting of the article.

References

Bagirov, B. A., Narimanov, A. A., & Salmanov, A. M. (2001). *Methods of separation of operational objects in the cutting of multi-layered oil fields*. ASOA Publishing House [in Azerbaijan]. [Bağırov, B. A., Nərimanov, A. A., & Salmanov, A. M. (2001). Çoxlaylı neft mədənlərinin kəsilməsində istismar obyektlərinin ayrılması üsulları. ADNA nəşriyyatı].

Bagirov, B. A. (1986). *Geological basis for the development of oil deposits*. Elm [in Azerbaijan]. [Bağırov, B. A. (1986). Neft yataqlarının əlavə işlənməsi üçün geoloji əsaslar. Elm].

Bagirov, B. A., Gismetov, T. V., & Aliyev, R. M. (1989). Identification of local zones by the area of deposits for the application of thermal methods of reservoir stimulation. *Azerbaijan Oil Industry*, 2, 8–16 [in Azerbaijan]. [Bağırov, B. A., Xismətov, T. V., & Əliyev, R. M. (1989). Formalara təsir edən istilik üsullarının tətbiqi məqsədilə yataqların ərazisi üzrə yerli zonaların müəyyən edilməsi. *Azərbaycan neft sənayesi*, 2, 16–18].

Bagirov, B. A., Bagirov, E. B., & Salmanov, A. M. (1992). Classification of oil deposits of Azerbaijan with hard-to-recover reserves to determine the order of their development. *Proceedings of the IX International Symposium Non-traditional sources of hydrocarbon raw materials and problems of their development, Petersburg,* p. 119–120 [in Russian]. [Багиров, Б. А., Багиров, Е. Б., & Салманов, А. М. (1992). Классификация нефтяных залежей Азербайджана с трудноизвлекаемыми запасами для определения очередности их освоения. *Материалы IX Международного симпозиума Нетрадиционные источники углеводородного сырья и проблемы его освоения, Петербург*, с. 119–120].

Bagirov, B. A., Mamedov, T. M., & Salmanov, A. M. (1994). Geological basis for the choice of oil deposits in Azerbaijan for development by horizontal wells. *Azerbaijan Oil Industry*, 6, 33-36 [in Azerbaijan]. [Bağırov, B. A., Məmmədov, T. M., & Salmanov, A. M. (1994). Azərbaycan yataqlarında horizontal quyularla işlənmək üçün neft yataqlarının seçilməsinin geoloji əsasları. *Azərbaycan neft sənayesi*, 6, 33–36].

Bagirov, B. A., Salmanov, A. M., & Hasanaliyev, M. G. (1998). On determining the quality of oil reserves. *Oil and Gas Geology*, 1, 22–25 [in Russian]. [Багиров, Б. А., Салманов, А. М., & Гасаналиев, М. Г. (1998). Об определении качества запасов нефти. *Геология нефти и газа,* 1, 22–25].

Velieva, E. B. (2005). On the classification of hydrocarbon reserves and resources. *Azerbaijan Oil Industry*, 5, 5–13 [in Azerbaijan]. [Vəliyeva, E. B. (2005). Karbohidrogen ehtiyatlarının və ehtiyatlarının təsnifatı məsələsinə dair. *Azərbaycan neft sənayesi,* 5, 5–13].

Narimanov, A. A., Gasymov, A. A., & Akperov, N. A. (1996). Features of the development of offshore oil and gas fields. *Azerbaijan Oil Industry,* 1–2, 6–11 [in Azerbaijan]. [Nərimanov, A. A., Qasımov, A. A., & Əkbərov, N. A. (1996). Dənizdə neft və qaz yataqlarının işlənməsinin xüsusiyyətləri. *Azərbaycan neft sənayesi,* 1–2, 6–11].

Rodionov, D. A. (1981). Statistical solutions in geology. Nedra [in Russian]. [Родионов, Д. А. (1981). Статистические решения в геологии. Недра].

Salmanov, A. M. (2004). On the problem of developing Azerbaijani deposits with horizontal wells. *Oil and Gas Geology,* 6, 41–43 [in Russian]. [Салманов, А. М. (2004). О проблеме доразработки месторождений Азербайджана горизонтальными скважинами. *Геология нефти и газа,* 6, 41–43].

Salmanov, A. M. (2007). Geological and mathematical aspects of a new approach to identifying operational objects in multilayer fields. *Azerbaijan Oil Industry,* 3, 23–26 [in Azerbaijan]. [Salmanov, A. M. (2007). Çoxlaylı yataqlarda istehsal müəssisələrinin müəyyənləşdirilməsinə yeni yanaşmanın geoloji-riyazi aspektləri. *Azərbaycan neft sənayesi*, 3, 23–26].

Salmanov, A. M. (2005). Geological and production aspects of drilling and operation of horizontal wells in onshore fields of Azerbaijan. *Proceedings of ANAS. Earth Sciences Series*, 3, 64–70 [in Azerbaijan]. [Salmanov, A. M. (2005). Azərbaycanın quru yataqlarında horizontal quyuların qazılması və istismarının geoloji və çöl aspektləri. *Azərbaycan Milli Elmlər Akademiyasının Xəbərləri. Yer Elmləri Seriyası*, 3, 64–70].

Salmanov, A. M., Hasanaliyev, M. G. (2000). Identification of Azerbaijan's deposits with hard-to-recover oil reserves and recommendations for their rational development. *Scientific conference dedicated to the 80th anniversary of ASOA,* p. 16–17 [in Azerbaijan]. [Salmanov, A. M., Həsənəliyev, M. Q. (2000). Çətin çıxarılan neft ehtiyatlarına malik Azərbaycan yataqlarının müəyyən edilməsi və onların səmərəli işlənməsi üçün tövsiyələr. *AMEA-nın 80 illik yubileyinə həsr olunmuş elmi konfrans*, c. 16–17].

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МЕТОДИКА ВИЗНАЧЕННЯ ДІЮЧИХ ОБ'ЄКТІВ ПРИ РОЗРОБЦІ НАФТОВОГО РОДОВИЩА ЗА МАТЕМАТИКО-СТАТИСТИЧНИМИ ПОКАЗНИКАМИ (НА ПРИКЛАДІ РОДОВИЩА ПІРАЛЛАХІ (ПІВНІЧНА СКЛАДКА))

В с т у п . ***У цьому дослідженні було складено таблицю на основі проб, відібраних зі свердловин кожного з двох горизонтів і з використанням значень параметрів пласта. В результаті досліджень до матриці було включено п'ять параметрів пласта (геологічних і технологічних), а за параметричними критеріями визначено ступінь подібності або відмінності між верхнім і нижнім шарами КС.***

М е т о д и . ***На родовищі Піраллахі з використанням фактичних даних свердловин, які розкрили обидва пласти, (CUS і CLS) було зроблено розрахунки за статистичними показниками на основі значень відповідних показників і перевірено параметричними критеріями. Оскільки розраховані ціни нижчі за табличні та є схожість між обома об'єктами, рекомендовано об'єднати їх та експлуатувати разом. Такий підхід приводить до інтенсифікації розвитку.***

Р е з у л ь т а т и . ***Завдяки вивченню складних геологічних та експлуатаційних даних, наступні пропозиції рекомендуються разом із консолідацією подібних шарів на північ Піраллахі.***

В и с н о в к и . ***Таким чином, оскільки геолого-видобувні показники між об'єктами KS_{upper} і KS_{lower} практично схожі, їх доцільно об'єднати в один об'єкт і експлуатувати одну сітку свердловин. Виділення таких об'єктів приводить до інтенсифікації експлуатації, а результати можуть бути використані при складанні проєктів розробки таких пластів.***

К л ю ч о в і с л о в а : ***нафтове родовище, горизонт, параметри пласта, середнє значення, дисперсія, ефективна товщина, пористість, в'язкість, щільність, пластовий тиск.***

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