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S. Gahramanli,
E-mail: sevilgahramanli1965@gmail.com;
Institute of Oil and Gas of Azerbaijan National Academy of Sciences,
9, F. Amirov Str., Baku, Azerbaijan

RESULTS OF GEOPHYSICAL MONITORING OF THE DEVELOPMENT OF THE HORIZON PK-2 OF THE PODKIRMAKINSKY SUITE OF THE NEFT DASHLARY FIELD

(представлено членом редакційної колегії д-ром геол. наук, проф. О.М. Карпенком)

The article is devoted to the study of the current state of development of the second horizon of the Podkirmakinsky suite (PK-2) of the Productive stratum (PS) of the Neft Dashlary field, which has been in operation for more than 60 years.

The results of the study by the method of complex areal interpretation of geophysical survey data of wells and geological and field information are presented. Three-dimensional geo models, built on the basis of petrophysical parameters obtained after the interpretation of geophysical and geological data using the DV Seys Geo program are given in the article.

The results of the analysis of the state of water impact are presented, the values of the oil saturation factor during well drilling are summarized, the values of the current oil saturation factor are calculated taking into account the extraction of oil, the results of studying the nature of saturation of reservoirs in the context of production wells by the method of pulsed neutron logging (PNL), as well as a comparative analysis of these values along the horizon PK-2 of the PS of the Neft Dashlary field.

Keywords: field, horizon, reservoir, exploration, development, area, interpretation, porosity, oil saturation, geomodel.

Introduction. In the 1950–1960s, in the oil industry system of Azerbaijan and in the former Soviet Union, taking economic factors as a basis, when developing oil deposits, there was a tendency to combine several interlayers with different hydrodynamic characteristics and reservoir properties into a single object. For this reason, the coverage of the productive section by active development has significantly decreased (*Alizade et al., 1985; Alikhanov, 1964*).

Consequently, science and industry faced the issue of geological and technological solutions, in order to involve the entire productive section in the active development. In this regard, the issue of determining the operational characteristics of interlayers included in a single development object was acute in order to increase their ultimate oil recovery.

The solution of these problems required the creation of an information base on the state of their development for individual wells and for the object as a whole (*Gadzhiev, 2012; Zhemzhurova et al., 2012*).

Against the background of the intensification of the use of an effective development system, methods of intensifying oil production, and methods of influencing the reservoir at various stages of development, a comprehensive areal interpretation of geophysical, hydrodynamic, and geological and field information remained in the shade. In contrast to previous years, in recent years, the volume of studies of wells and reservoirs by geophysical and hydrodynamic methods has significantly increased in order to study the dynamic process taking place in the development object.

However, the effectiveness of such studies should not be limited to the collection of information on wells to create various methods and improve the complexity of well and reservoir studies. Their usefulness is determined by the use of the obtained results of well surveys in the control of the development and during the issuance of sound recommendations for the regulation of this process.

Among such studies, the most important place is occupied by field geophysical and hydrodynamic methods to determine the nature of reservoir saturation, providing tracking of the dynamic process at various stages of oil and gas field development (*Lebedev et al., 1976*).

The complexity of the geological structure, the heterogeneity of productive formations, the multilayer nature of development objects, the change in the modes of oil extraction and water injection into the reservoir, and the underestimation of the structural features and properties of the deposit, lead to incomparability of the calculated and actual development indicators.

In the long-term practice of developing multi-layer oil fields, there has been a certain disproportion between the study of the process and the accumulation of information on wells with graphical constructions reflecting the state of development of the object in which this process takes place, based on a comprehensive areal interpretation of geophysical and geological field data from good studies.

The object of study. All these above-mentioned problems are typical for all multilayer and complex geological structure oil and gas fields, including the Podkirmakinsky (PK) suite, as well as the horizon PK-2 of the Productive stratum (PS) of the Neft Dashlary field in the South Caspian Basin, which is an object of our research.

The Neft Dashlari field was discovered in 1949 and has been developed since 1950. For more than 70 years, the productive facilities of the PK suite of the PS, where the main oil reserves are concentrated, have also been in operation. The PK Formation is represented by four horizons: PK-1v, PK-1, PK-2, and PK-3.

The Neft Dashlari field has a complex geological structure and in tectonic terms this field is an asymmetric brachianticline, complicated by numerous faults, dividing it into 6 tectonic blocks.

The oil content is confined to the PS deposits of the Middle Pliocene, among which the object of study PK-3 is lithologically represented by a member of gray sands and sandstones. Clay layers make up to 30% of the object's thickness; clays are highly sandy. The apparent resistivity values reach 100-200 Ohm·m and are characterized by a well-differentiated PS curve (well potential). Sand content is 70% and decreases from the arch to the wings. Oil-bearing horizons are established in all tectonic blocks.

The object of study is the second horizon of the Podkirmakinsky suite (PK-2) of the Productive stratum of the Neft Dashlary field, which has been in operation since 1950 (Fig. 1).

Due to the tectonic pressure that took place in the area of the deposit, it was divided into 6 blocks by longitudinal and transverse faults. Each of them went into active development, ranging from 1-7 to years. With the exception of block 1a, which began operation in 1977.

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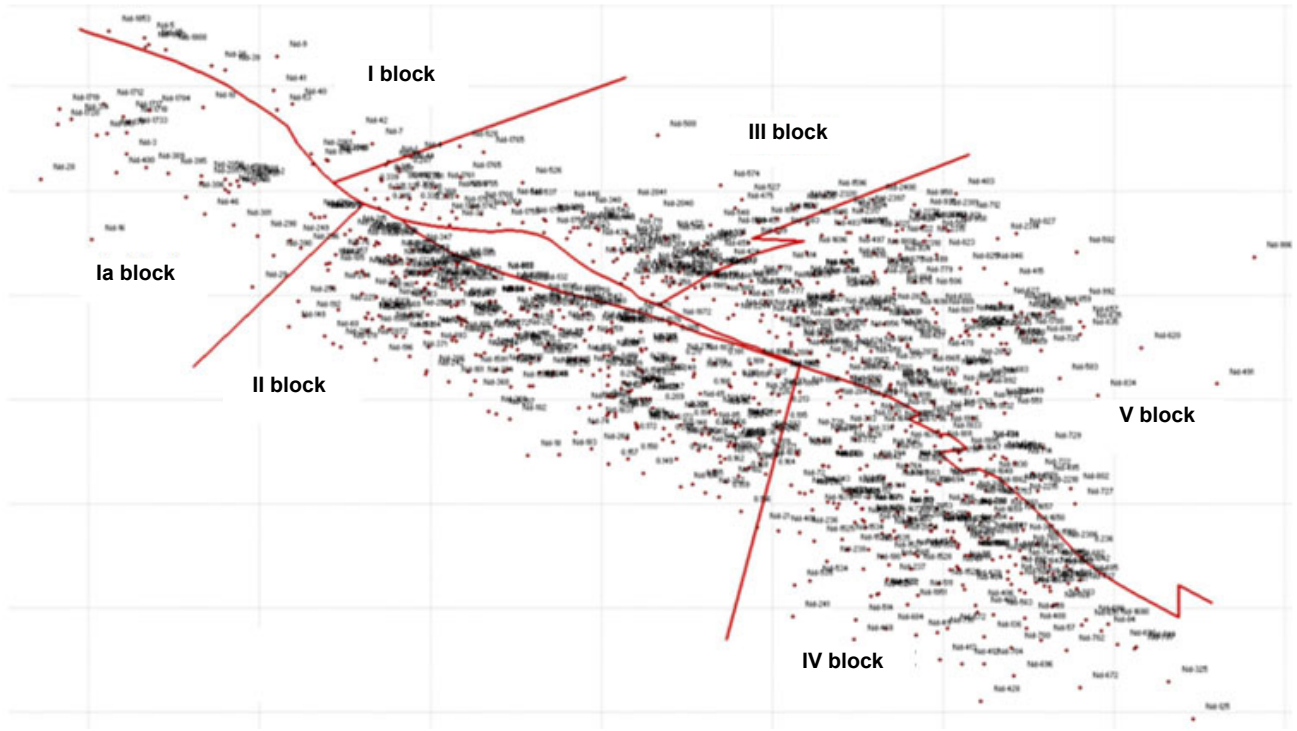

Fig. 1. Development map of the Neft Dashlary field

During operation, in all tectonic blocks out of 841 drilled wells, the horizon PK-2 was penetrated in the section of 465 wells.

Study of the object of research and analysis of the results. The study of the current state of the development of PK-2 by the method of complex areal interpretation and the DV-Seys Geo program was carried out according to the logging data of the values of petrophysical parameters in the section of 465 wells.

The resulting values of porosity and oil saturation of the PK-2 reservoirs are analyzed and generalized for tectonic blocks and their geomodels are built.

According to the interpretation, the values of reservoir porosity vary between 16-32%, where the average value is 24%. At the same time, a significant oil-saturated area is characterized by a reservoir porosity value in the range of 20-25%, and a certain part of the area is represented by reservoirs with a porosity of less than 20%. This is well observed in the first constructed geomodels of porosity, shown in Fig. 2.

Of considerable interest are the results of the interpretation of well logging data to determine the values of oil saturation of reservoirs by the time of drilling wells. After summarizing the interpretation results, the oil saturation values were grouped. The first group includes collectors with a value of up to 0.6, the second – with a value from 0.601 to 0.7, and the third – with more than 0.7. For wells with determining oil saturation values, for the first time, a geomodel was built, shown in Fig. 3, which clearly illustrates the changes in values over the area of the object of study.

In the next stage, the study of the current state of the development of oil reserves for PK-2 was carried out. To do this, we used method of complex areal interpretation of geological and field information on oil extraction, taking into account the phased perforation of the object and GWS data (geophysical well survey), accumulated during the control of development in the section of wells, the values of the coefficient of residual oil saturation of reservoirs from the initial one, taking into account oil production at the time of the analysis.

Based on the results of the generalization of the obtained values about the current oil saturation of reservoirs, a geomodel was built for the first time (Fig. 4). In recent years, in the context of a temporarily stopped production well at the horizon PK-2, in order to determine the value of the current oil saturation, studies were carried out using the PNNL method (pulse-neutron-neutron logging).

After interpreting the PNNL materials, the actual values of oil saturation were compared with the values of the current oil saturation, determined by calculation as a result of a comprehensive areal interpretation of well logging data and geological and field information, taking into account oil recovery. The results of these comparisons are presented in Table 1.

As it can be seen from the geomodel and presented in Table 1, compiled on the basis of the actual results of well surveys using the PNL method (pulsed neutron-neutron logging), there is a very good convergence of these values, thus showing the real resolving capabilities of the method of integrated areal interpretation of geophysical and geological and field information for the study of the development process of the object.

Horizon PK-2 of the PS, mainly except the first, is being developed in all tectonic blocks. Active development of the object is observed in the II and V tectonic blocks. The pace is somewhat lower in blocks III and IV. The process is going on passively in the tectonic block Ia.

During the period of water impact on 5 injection wells, a total of 4716 thousand m^3 of water was pumped. Injected water flooded 122 thousand m^3, where the flooding coverage of the entire oil-saturated area is 4%.

Limiting itself to a detailed description of the state of development of the PK-2 of the PS for tectonic block II, the results of the remaining blocks are presented in Table 2. I would like to note that, in general, the methodological approach to studying the current state is presented with more objective information when evaluating the development process based on actual data of petrophysical parameters and

dynamic processes associated with oil recovery, from the applied technological methods of operation and impact.

As a result, the results of the analysis provide more scientifically based information and direction for improving and regulating the development process of the object, achieving a high oil recovery factor of the object when extracting the residual reserve.

The initial balance oil reserve was calculated based on an in-depth analysis of the state of development using updated data on the PK-2 of the PS horizon within the oil-saturated area.

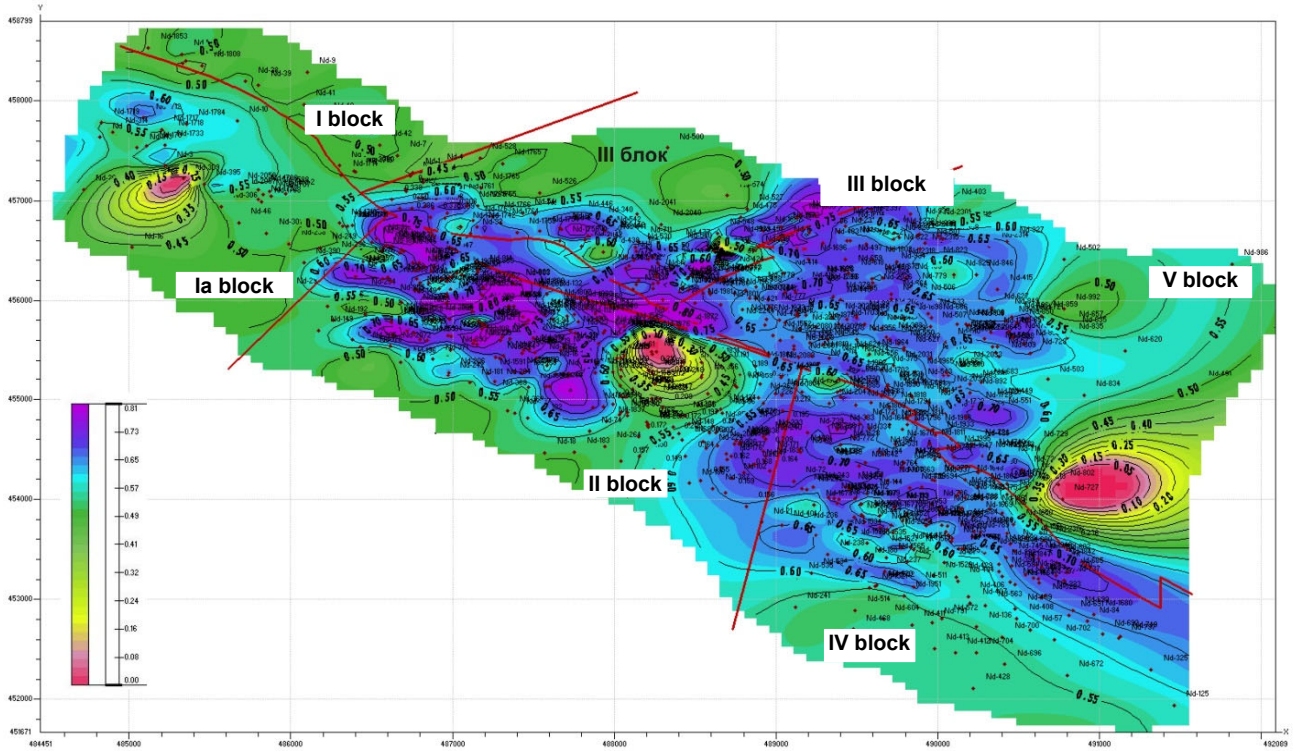

Fig. 2. Porosity change geomodel

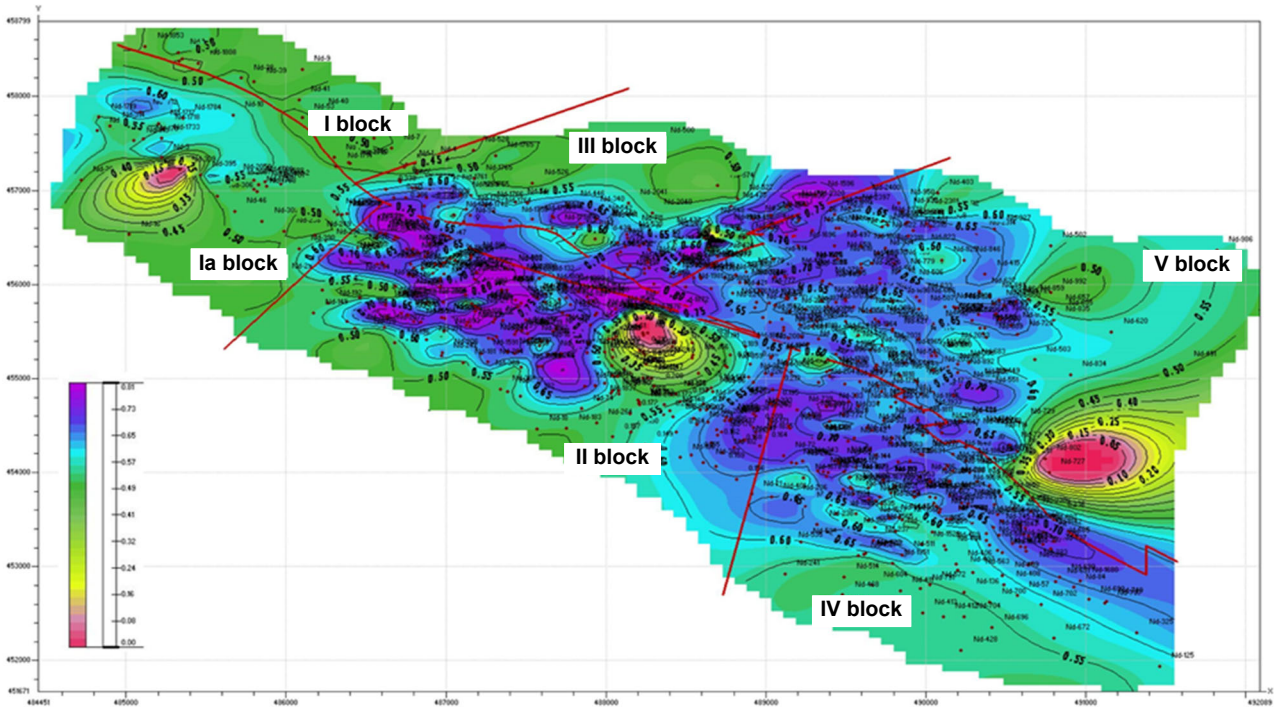

Fig. 3. Geomodel of initial oil saturation change

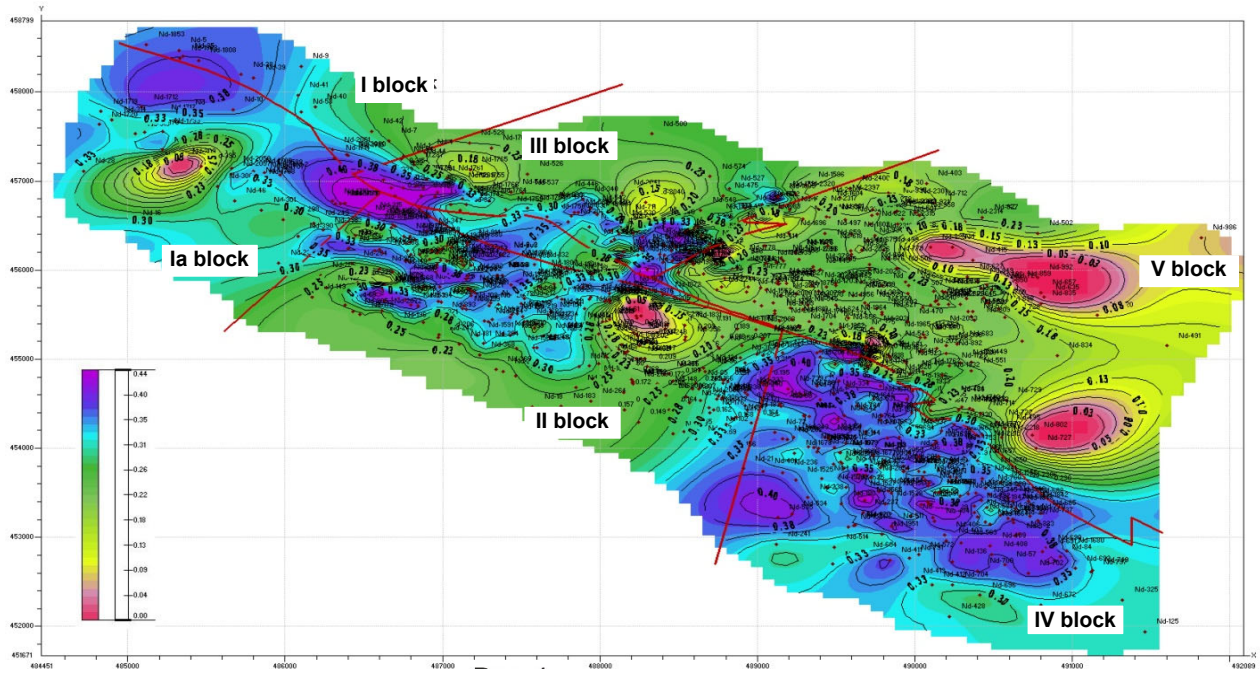

Fig. 4. Geomodel of current oil saturation change

Table 1

Comparison of oil saturation values of reservoirs, the study by the methods of PNNL and integrated areal interpretation of electrical logging data for wells of the PK-2 PT horizon of the Neft Dashlary field

Tectonic block	Well №	Date of the study by the PNNL method	Oil-saturated interval	Intensity in imp/min	Oil saturation values in conditional units	
					By PNNL	By complex areal interpretation of EL data (electrical logging)
If	1715	28/01/1984	473-488	616	0.5	0.48
If	2059	17/02/1984	377-408	849	0.65	0.57
IId	108	22/04/1985	915-920	886	0.67	0.61
IId	141	10/07/1987	1009-1029	445	0.36	0.42
IId	1563	15/08/1984	589-639	1617	0.78	0.69
IId	1589	23/08/1986	1110-1141	976	0.69	0.64
IId	2027	10/04/1985	625-640	568	0.46	0.48
IIe	61	22/03/1987	641-658	597	0.49	0.42
IIf	1837	07/07/1984	1136-1161	1068	0.82	0.79
IIf	1839	18/06/1985	985-1000	802	0.71	0.65
IIf	1840	07/06/1984	1050-1086	1392	0.75	0.71
IIg	2257	05/03/1984	474-486	1760	0.8	0.76
IIh	2007	18/04/1984	997-1032	1455	0.76	0.68
IIk	1832	04/11/1988	1058-1075	1921	0.82	0.74
IIk	1833	13/09/1984	1139-1159	1607	0.78	0.7
IIk	1836	03/10/1984	919-934	1603	0.78	0.75
Va	2313	15/04/1990	1864-1910	1030	0.7	0.65
Vd	1736	22/08/1985	1066-1104	1964	0.83	0.8
Vd	1810	13/10/1987	1110-1139	396	0.32	0.36
Vd	2274	13/08/1986	1314-1360	795	0.71	0.72
Vn	2172	30/07/1987	1711-1730	898	0.67	0.67

Table 2

Summary indicators of summarizing the results of the study by the method of integrated areal interpretation of geophysical data from wells of the state of development of the horizon PK-2 of the Neft Dashlary field

Tectonic block	Horizon	Oil-saturated area (thousand m^2)	Number of wells				Thickness (m)		Porosity, fractions of units	Initial oil saturation, fractions of units	Oil density g/cm^3	Balance oil reserve, thousand m^3	Total oil production thousand m^3	Total water injection, thousand m^3	Current oil recovery	Conversion coefficient	Remaining oil reserves, thousand m^3	Flooding area, thousand m^2	Injection water flood coverage, %
			With effective thickness	Operating	Not operating	Injection	Effective	Perforated											
Ia	ПК-2	120	5	1	1	–	13.8	16	0.21	0.686	0.9	213	12	–	0,056	0.85	201	–	–
II	ПК-2	3020	151	50	2	5	10.5	13	0.27	0.776	0.9	5823	3657	4716	0,628	0.89	2166	122	4
III	ПК-2	1050	65	47	1	2	23.4	26	0.24	0.738	0.9	3894	1696	3499	0,436	0.89	2198	350	33
IV	ПК-2	3000	106	48	–	12	14.3	16	0.24	0.73	0.9	6607	1954	4388	0,296	0.88	4653	1057	35
V	ПК-2	2970	138	82	2	13	21.4	22	0.26	0.734	0.9	10480	7323	9975	0,699	0.91	3157	650	22

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Conclusions. Summarizing the results of studying the state of development, we can draw the following conclusions:

• Not in all tectonic blocks, the horizon PK-2 is involved in active development, where the oil recovery factor is: in I^a – 0.5%, in IV – 29.6%, in block V – 69.9%. Block I does not participate in the selection at all.

• Low flood coverage from injected water, where in II tectonic block is 4%, in III and IV blocks, respectively, 33% and 35%.

• For the first time, geomodels were built for the horizon PK-2 of the PS using petrophysical parameters: porosity, initial and current oil saturation.

• Based on the obtained data on the horizon PK-2 of the PS within the oil-saturated area, the balance oil reserve was adjusted.

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С. Гахраманли,
E-mail: sevilgahramanli1965@gmail.com.
Інститут нафти і газу Національної академії наук Азербайджану,
вул. Ф. Амірова, 9, Баку, Азербайджан

РЕЗУЛЬТАТИ ГЕОФІЗИЧНОГО МОНІТОРИНГУ РОЗРОБЛЕННЯ ГОРИЗОНТУ ПК-2 ПІДКИРМАКІНСЬКОЇ СВІТИ РОДОВИЩА НАФТИ ДАШЛАРИ

Присвячено вивченню поточного стану розроблення другого горизонту Підкирмакінської світи (ПК-2) продуктивної товщі (ПТ) родовища нафти Дашлари, що перебуває більш ніж у 60-річній експлуатації.

Наведено результати вивчення методом комплексної площинної інтерпретації даних геофізичних досліджень свердловин та геолого-промислової інформації. Описано тривимірні геомоделі, побудовані за петрофізичними параметрами, отриманими після інтерпретації матеріалів геофізичних і геолого-промислових даних за програмою DV Seys Geo. Представлено результати аналізу стану водного впливу, узагальнено значення коефіцієнта нафтонасиченості при бурінні свердловин, розраховано значення коефіцієнта поточної нафтонасиченості з урахуванням відбору нафти, наведено результати вивчення методом імпульсного нейтрон-нейтронного каротажу характеру насичення колекторів у розрізі видобувних свердловин по горизонту ПК-2 ПТ родовища Дашлари.

Ключові слова: родовище, горизонт, колектор, дослідження, розроблення, площа, інтерпретація, пористість, нафтонасиченість, геомодель.