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	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2022 **Issue:** 11 **Volume:** 115

Published: 20.11.2022 **http://T-Science.org**

Issue Article

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DETERMINATION OF SATURATION AND PHYSICAL PROPERTIES OF RESERVOIR FLUIDS, GAS AND PHYSICO-LITHOLOGICAL CHARACTERISTICS OF PRODUCTIVE HORIZONS FOR DUAL COMPLETION OPERATION OF WELLS

Abstract*: the article provides a detailed analysis of determining the saturation and physical properties of reservoir fluids and gas for simultaneous separate operation at the Altyguyi field.*

The research data are given for simultaneous-separate oil and gas exploitation with two elevators in one well. The positive effect of the use of the technology of dual completion operation (hereinafter referred to as DC) is expressed in a reduction in capital investments for the construction of wells for each of the operational facilities, in reducing operating costs and the development period of a multi-layer field, in increasing hydrocarbon production and the term of final oil recovery with cost-effective operation of wells.

The article describes the results of the analyses carried out from the cores and slurries taken (samples) to determine the open porosity, density, granulometric composition, corbonateness, absolute permeability, residual water saturation, effective porosity, relative resistivity, as well as the determination of the average values of oil and gas saturation and filtration capacity indicators of siltstone-sand rocks.

This work can be used for the purpose of accelerated development of multilayer deposits by the DC method.

Key words*: block, horizon, porosity, gas-water contact, shielded, dome, core.*

Language*: English*

Citation: Deryaev, A. R. (2022). Determination of saturation and physical properties of reservoir fluids, gas and physico-lithological characteristics of productive horizons for dual completion operation of wells. *ISJ Theoretical & Applied Science, 11 (115),* 605-609.

Soi: http://s-o-i.org/1.1/TAS-11-115-43 ***Doi***: https://dx.doi.org/10.15863/TAS.2022.11.115.43

Scopus ASCC*: 2209.*

Introduction

Productive strata combined into one object for development by the method of simultaneous and separate exploitation should have similar lithological characteristics and reservoir properties of rocks of productive strata, physico-chemical properties and composition of the fluids saturating them

The productive horizons NK_{7d}, NK_8, NK_9 were taken into account in the Altyguyi deposit I, II, and III blocks of the red-colored strata. Below the productive horizon of NK_9 there is a deposit of NK_{10}, which has been uncovered only on the consolidated part and is not estimated in oil and gas potential.

The uncovered power of the NK_9 horizon varies from 21 to 44 meters. The total effective saturated power varies from 2 to 15 meters. In block II, a feature of the increase in clay rocks is traced. In the context of all three productive horizons (NK_9, NK_8, NK_{7d}), a fascial change in places was noted. When testing this horizon, an inflow of water was obtained from the developed wells.

The tectonic shielded and lithological limited oil reservoir is marked in the I block. A gas deposit with a small size has been discovered in block IIIa.

The total size of the horizon varies from 47 to 79 meters. In wells, the total effective saturated power along the length of the axis of the depression is from

2 to 12 meters, and in the northwest it varies from 8-12 meters. The horizon is gas condensate, tectonic shielded and is located in the I block. Block I is bounded from the east by the first fault, from the west by the third fault, from the northwest by a partial GWC (gas-water contact), from the northeast and from the southwest with conditional violations.

In block III, during the study, a gas reservoir was identified in the NK_8 horizon, and an oil reservoir was detected in block IIIa and a section was traced.

The section of the NK_{7d} horizon has been opened for all drilled wells. The power of the horizon varies from 27 to 50 meters, and the lowest power is located at the top of the curved part of the dome, and the highest is noted in the north-western wing of the structure. The total effective saturated capacity of the field varies from 2 to 4 meters and from 13 to 14 meters, and also has a large degree of increase in the north-west wing. The horizon is gas-condensate, with a dome shape, bounded from the southwest and northeast with conditional violations, from the west by a partial GWC (gas-water contact).

In the future, when drilling new wells at the field, in order to ensure full coverage of the drainage of the horizon section by capacity and to determine the value of the oil saturation limit, as well as to obtain industrial oil inflow and possible operation of wells, it will be acceptable, according to geophysical well surveys, to conduct tests in all saturated capacity intervals [1].

Table 1 provides information on the characteristics of oil and gas horizons, the average value of saturated capacities.

Table 1. Characteristics of oil and gas horizons, the average value of saturated capacities

Well number	Intervals for geophysical surveys of wells	Power	Oil saturation coefficient	Results of geophysical surveys of wells	Filter
3	3732-3738	6	-	Oil+Gas	3732-3738
	3746-3754	8	-	Gas+Oil	
10	36534-3662,4	9	0,61	Oil+Gas	3653-3662
	3663,4-3665	1,6	0,34	Water+Oil +Gas	
11	3832,2-3840	7,8	0,65	Oil+Water	3833-3839
	3842-3844	2	0,39	Water+Oil	
	3858-3861,2	3,2	0,40	Water+Oil	
	3863,4-3865	1,6	0,40	Water+Oil	
16	3850,6-3856	5,4	0,53	Oil+Water	3850-3857
	3856,4-3863	6,6	0,42	Water+Oil	
	3866-3869	3	0,48	Water+Oil	
18	3890,8-3897,4	6,6	0,87	Oil	3890-3896
	3898,8-3901	2,2	0,69	Oil	
105	3836-3842	6	0,73	Oil	3838-3844
	3846-3850	4	0,57	Oil+Water	
	3861-3865	4	0,60	Oil+Water	
107	3862,4-3869	6,6	0,64	Oil+Water	3864-3869
	3871-3873	2	0,55	Oil+Water	
	3875,4-3878	2,6	0,36	Water+Oil	
108	3879-3798,4	9,4	0,65	Oil	3790-3796
	3801-3806,4	5,4	0,75	Oil	

The average value of the oil-saturated capacity of the NK_9 horizon is 8,6 meters, and the volume of oil-saturated rocks is 55,04 million m^3. The average value of the gas-saturated capacity of the NK_8 horizon is from 1,0 to 20 meters, and the volume of gas-saturated rocks varies between 100,55-106,99 million m^3.

The total value of the gas-saturated capacity of the rocks of the red-colored horizons is 207,54 million m^3.

According to the information, geophysical surveys of wells for the field, the total capacity of oil and gas storage facilities (horizon NK_{7d} -135 m, horizon NK_8 -172 m, NK_9-118 m) is 425 meters.

In the operational analysis of geological and geophysical materials and the calculation of oil and gas reserves, as well as in assessing the saturation of reservoir rocks, one of the important tasks is the interpretation of field geophysics data.

Evaluation of the saturation properties of separated reservoirs is carried out at the expense of

critical indicators, which are minimal for conventional reservoirs. According to the test results, oil and gas are obtained from these formations. However, insufficient information on the tests carried out, especially in aquifers, reservoir productivity is assessed by determining the resistivity (P_o) and by the results of high-quality interpretation of geophysical studies of wells [2].

At the Altyguyi field in the NK_{7d} horizon, the effective capacity of oil and gas reservoirs varies from 2 to 15 meters and the average capacity of productive reservoirs is 9,2 meters. In the NK_8 horizon, the effective capacity of productive layers varies from 1.5 to 20 meters, and the average value of the capacity of productive layers is 10.4 meters. The effective capacity in the horizon of NK_9 varies from 6 to 15 meters, the average value of the capacity of productive layers is 10,5 meters.

The porosity coefficient (K_p) at the core deposit ranges from 14,1% to 21,5%, the arithmetic mean is 18,1%, according to geophysical studies it varies from 14% to 28%, the average value is 20,2%.

The lowest limit of the oil and gas saturation coefficient in all fields of Southwestern Turkmenistan is 0,50.

For this reason, in calculations, the value of the oil and gas saturation coefficient ($K_{o.g.}$) is not accepted below 0,50.

Proposals for comparative average values of the coefficients of productive formations determined by different methods are given in Tables 2 and 3.

Table 2. Proposals of comparative average values of productive reservoir coefficients determined by various methods

Hori-zons	Number of wells	$\Sigma h_{o.g}$ m	$H_{o.g}^{av}$ m	K_l^c % (specific number)	K_l^f % (specific number)	$K_{o.g.}^c$ % (specific number)	$K_{o.g.}^1$ specific power		
							$h_{o.g.}^1$ m	$h_{o.g.}^2$ m	$h_{o.g.}^3$ m
NK_{7d}	27	249	9,2	18,3(39)	19,1(32)	0,664(24)	236	191	249
NK_8	27	271	10,4	17,8(63)	19,7(19)	0,626(18)	235,5	154	216,5
NK_9	26	229	8,8	-	20,3(34)	-	217	90	143,5
NK_{7d+} NK_9	80	749	9,5	18,1(58)	19,7(129)	0,65(42)	688,5	435	609

Table 3. Proposals of comparative average values of productive reservoir coefficients determined by various methods

Horizons	Number of wells	$K_{o.g.}^1$ n=1,8	$K_{o.g.}^1$ n=1,46	$K_{o.g.}^2$ m	$K_{o.g.}^3$ m	Suggested coefficients		
						K_l	$K_{o.g.}$	$W_{o.g} = K_l x K_{o.g.}$
NK_{7d}	27	0,69	0,76	0,80	0,76	0,191	0,76	0,145
NK_8	27	0,67	0,74	0,815	0,75	0,197	0,75	0,148
NK_9	26	0,67	0,74	0,815	0,835	0,203	0,74	0,150
$NK_{7d}+NK_9$	80	0,68	0,75	0,81	0,77	0,197	0,75	0,148

Based on the surveys, the K_l – saturation coefficient of the layers is proposed along the horizons of NK_{7d} and NK_8, respectively, 0,76, 0,75 and 0,74 along the horizon of NK_9.

The red-colored strata has not been fully uncovered for the deposit, some sections of the deposit have not been clearly defined by drilling. In the unopened sections of the sedimentary rock section, no assessment was carried out for future oil and gas resources [3, 4].

In order to clarify the boundaries of the horizons of the western wing, to determine the location of the water-oil contact and gas-water contact in the NK_9 oil horizon or for the purpose of searching and industrial evaluation of oil rims in the NK_{7d} and NK_8 gas condensate horizons, it is necessary to lay exploration drilling.

Determination of the physico-lithological characteristics of rocks at the Altyguyi deposit was carried out by studying the section of 15 wells. 34

cores were obtained from the NK_{7d}, NK_8 and NK_9 horizons.

More than 320 rock samples were taken from the remaining productive horizons for laboratory studies. From these samples, analyses were carried out to determine the following physico-lithological characteristics of productive horizons;

- 298 samples for determination of open porosity and density;
- 327 samples for determination of granulimetric composition and carbonate content;
- 53 samples to determine absolute permeability;
- 51 samples for determination of residual water saturation and effective porosity;
- 101 samples to determine the relative resistivity;

The complex of sedimentary rocks of the productive zone (horizons NK_{7g}, HK_8, HK_9) does not differ from each other in lithology, they mainly consist of alternations of siltstone rocks with sandstones [5].

Clay in the section is about 1.6%.

Siltstones are widespread and make up about 78.8% and 18% sandstones.

Siltstone-sand productive sedimentary rocks of the Altyguyi deposit belong to an industrially productive reservoir and are characterized by more than 14% open porosity, more than 3-5 md permeability; no more than 45-50% water saturation.

In connection with the above, from the distribution of lithological indicators and a detailed analysis of the relationship between them, it makes it possible to divide siltstone-sand rock reservoirs into two types: industrial and non-industrial [6].

The conditioned values of reservoir and metophysical indicators of reservoirs of productive zones are given in Table 4.

From the depth intervals of productive horizons, the penetration with core bits for the selection of cores of insufficient degree of removal is 31,3%. This can be explained by the fact that when the core is brought to the surface, there are weakly cemented and crumbly loose types of rocks in their composition [7]. This is due to the fact that such rocks are characterized by high K_p indicators, but the average permeability indicators according to core analyses may be slightly less important.

Table 4. Conditioned values of collector and metaphysical indicators of collectors of productive zones

№	Indicators of collectors	Conditioned value	
		Types of collectors	
		industrial	not industrial
1	Open porosity, %	more 14	less than 14
2	Effective porosity, %	more 7-8	less than 7-8
3	Absolute permeability, md	more 3-5	less than 3-5
4	Carbonate content, %	less than 20	more 20
5	Clay, %	less than 28-30	more 30
6	Relative clay content , %	less than 0,55	more 0,55
7	Residual water saturation , %	less than 45	more 45

All types of the listed laboratory works are entirely given from the selected rock samples of 15 wells located in different places of the field [8, 9].

Industrial accumulation of hydrocarbons accompanies the types of collectors of silt-sand rocks of the lower part of the red-colored strata of the NK_{7d}, NK_8 and NK_9 horizons. The horizon of NK_9, compared with the horizons of NK_{7d}, NK_8, has little information based on the core analysis materials [10].

The section of the productive zone consists of alternating weakly cemented rocks of some loose sandstones and clays, as well as strongly cemented siltstone rocks.

Table 5. Average indicators of filtration-capacity and oil saturation of silt-sand rocks

Horizons	Open porosity, %		
	Average values	Number of definitions	Limit of change
NK_{7d}	18,3	39	14,1-21,5
NK_8	17,8	19	16,9-19,7
NK_9	-	-	-

Table 6. Average indicators of filtration-capacity and oil saturation of silt-sand rocks

Horizons	Absolute permeability, %		
	Average values	Number of definitions	Limit of change
NK_{7d}	71,4	25	13,0-210,0
NK_8	51,0	18	5,6-87,1
NK_9	-	-	-

Table 7. Average indicators of filtration-capacity and oil saturation of silt-sand rocks

Horizons	Oil and gas saturation, %		
	Average values	Number of definitions	Limit of change
NK_{7d}	66,4	24	60,7-78,6
NK_8	62,6	18	57,0-69,0
NK_9	-	-	-

Basically, the layers of granular reservoirs with different capacities are located in the horizons of NK_{7d} and NK_8. The values of the porosity coefficient K_p and the permeability coefficient K_{per} (granular reservoirs) vary in wide ranges [6].

The reservoir capacity of silt-sand rocks in the NK_{7d} horizon ranges from 14,1% to 21,5%, the permeability is 5-6 md. In the NK_8 horizon, the permeability changes to 210 md. The average porosity of industrial reservoirs for the NK_{7d} horizon is 18,3%, the NK_8 horizon is 17,8% and, respectively, the permeability is 71,4 md and 51,0 md. Tables 5,6 and 7 show the average values of filtration capacity and oil and gas saturation of silt-sand rocks.

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