Results of indicator studies on J_1 facility in Kholmistoye field

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Abstract. The hilly gas-oil field is complex by its geological structure. The results of the trace researches on this field, the observation well testing and the application of conformance control methods are presented in the article. According to the results of these researches the channels of low filtration resistance are revealed. The creation of the artificial barrier preventing a water filtration in these channels is necessary. The carried-out injections of the sedimentation systems into the layer have allowed reducing the water cut of wells and rates of oil production decrease. The complex analysis of development condition of an operational object, the research of filtration streams and the application of methods of oil recover increase have allowed to improve the current state of development and to increase the efficiency of oil reserves' development.

1. Introduction

Kholmistoye field is located in the Purovsky section of Yamal-Nenets Autonomous District, 230 km from the city of Noyabrsk. The nearest developed fields are: Ravninnoye, Chatyl'kinskoye, Festivalnoye, etc. [1, 2].

The field is a multi-layer, gas-oil and complex one. It has got a large oil and gas bearing layer. Identified deposits have a complex structure and are controlled by a structural plan, lithological and tectonic fault seals. In terms of oil and gas reserves, the Kholmistoye field is considered to be a small one [1].

To reduce the rate of oil production decline and more complete deposits recovery from heterogeneous and low-permeability productive reservoirs, a comprehensive study of watering sources as well as monitoring and evaluation of the geological and technical measures to be applied is required.

The tracer studies carried out at the field made it possible to clearly establish and assess the presence or absence of a hydrodynamic connection between the injection and production wells and productive interlayers, as well as to reliably determine the volume of the highly productive reservoir part in the inter-well areas This paper presents an investigation of the influence of different content of additives of the pre-treated aluminium oxide powder on the structure of lead-tin-base bronze under formation.

2. Materials and methods

The field was discovered in 1988, but pilot production was only started in 2006.

The technological scheme for the field development provided the implementation at the J_1 facility a single-row development system using horizontal production wells in combination with an in-circuit flooding source system. The distance between the wells is 600×600 m, the wells density grid is 34.5 ha/well. 29 wells were drilled on the J_1 facility, including 16 production wells (10 of which were horizontal ones), and 10 injection wells. In total, 763.4 thousand tons of oil and 3424.6 thousand tons of liquid were extracted from the reservoir, 4365.0 thousand m^3 of water were pumped into the reservoir.

Analysis of the oil reserves production on the J_1 facility allowed making the following conclusions:

- the exploitation of the deposit is characterized by a low rate of recovery from initial recoverable reserves of 1.03% at the achieved recovery of 14.3%, the current index of enhanced oil recovery is 0.052 unit fraction from reserves of the category C_1. Low production values of initial recoverable reserves and current oil recovery are due to the fact that a significant oil reserves area of C_1 category has not been yet drilled;
- based on the results of the field geophysical control over the development, the reservoir coverage in the section is estimated to be high and makes on the whole facility 0.98 unit fraction (including 0.92 for the production well stock and 1.0 for the injection one);
- low development of deposits is due to the low wells density grid;
- based on the results of hydrodynamic studies, parameters of the J_1 facility are determined and given in Table 1.wt.

Table 1. Average hydrodynamic parameters of the J_1

Index	Category of wells	Number of studies, pcs.	Fluid flow rate, m^3 / day	Watercut,%	Effect. reservoir thickness, m	Reservoir pressure at the level of oil water contact, MPa	Bottom hole pressure at the level of oil water contact. MPa	Productivity, m^3/(day*MPa)	Hydraulic conductivity of the reservoir, um^3*cm/cPs	Permeability, μm^2	Piezo conductivity, m^2/s	Skin effect
Average value	production	30	115.8	48.1	6.9	24.3	12.4	23.9	16.2	0.008	0.123	1.9
	injective	24	339.4	100.0	10.4	34.4	44.9	34.2	18.3	0.008	0.245	-5.0

The advantage of indicator studies in comparison with other methods is that they make it possible to obtain parameters characterizing the reservoir properties of the deposit directly in the reservoir conditions. The results of indicator studies should be considered in conjunction with geological and field information as well as hydrodynamic and geophysical data.

The appearance of tracer fluid in production wells indicates their water cut by water injected into the reservoir. The indicator type shows the specific injection well, which is a source of water trouble.

For this purpose, tracer studies were conducted on the J_1^{1+2} facility in 6 injection wells with injection of indicators (uranyl, urea, ammonium nitrate), which allowed one:

- to establish a hydrodynamic connection between injection and production wells;
- to determine the direction, speed and performance of filtration flows;
- to evaluate the filtration-capacitive parameters of the test portion of the reservoir;
- to identify the sources of flooding.

In Fig. 1, 2 the rose of directions of the filtration flows of injected water as well as the scheme for the advancement of the flood front slug along the sections of the J_1 facility are shown. Table 2 presents a generalized characteristic of tracer studies for injection well areas.

As a result of the conducted indicator studies on the J_1 facility in Kholmistoye field, the following was revealed:

1. The productive reservoir section is characterized as heterogeneous, dissected by channels of high conductivity.
2. The established hydrodynamic connection between injection and neighboring producing wells along the sections indicated the presence in the western zone of the developed system of high-conductivity channels with low filtration resistance and an underdeveloped channels system within the eastern zone on the facility.

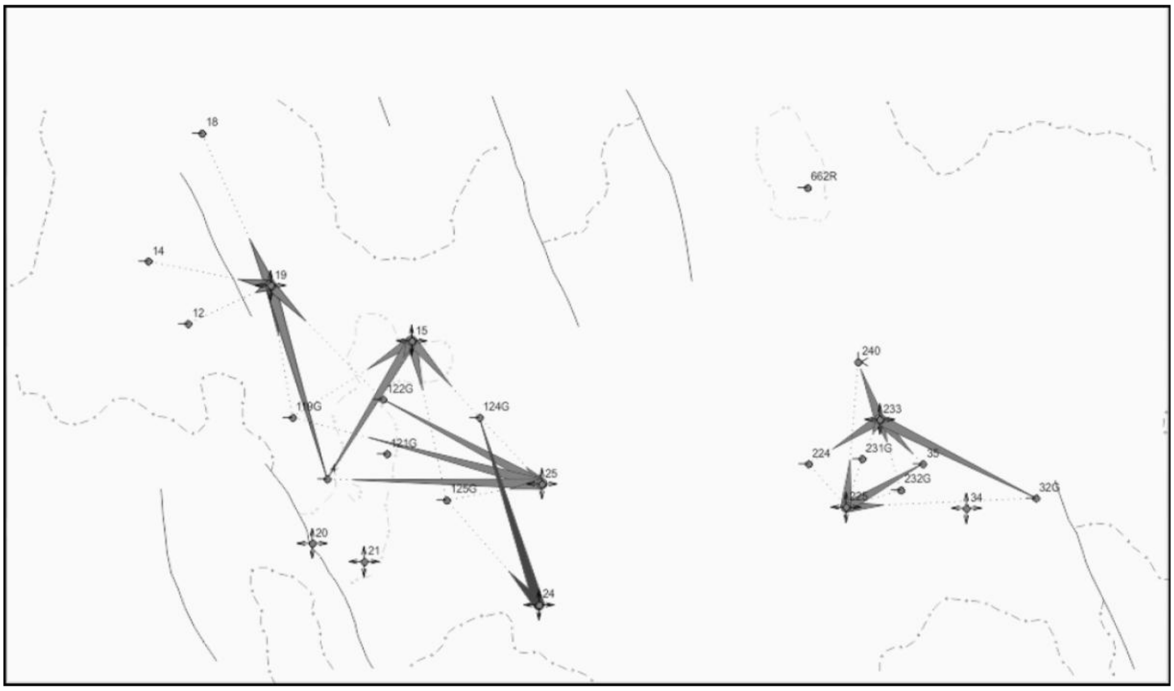

Figure 1. Map of direction vectors and filtration flow rates of injected water along sections on J_1 facility.

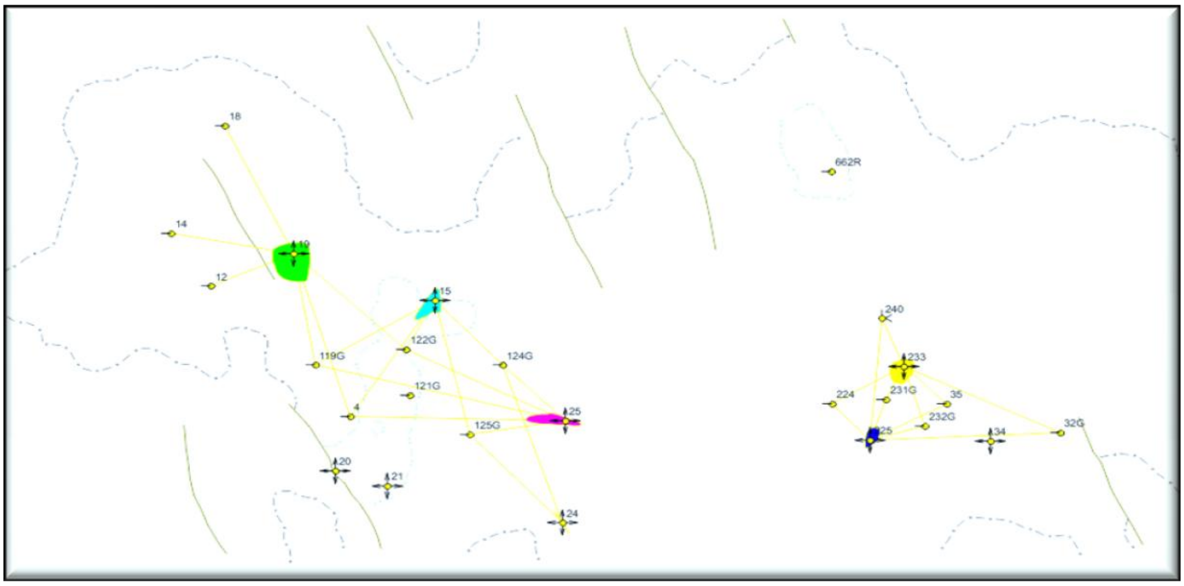

Figure 2. Scheme of advancement of flood front slug along sections on J_1 facility.

3. There was a traced liquid transfer to production wells in channels with a permeability of 0.42 ÷ 34 μm^2.

4. The average velocity of moving the traced fluid varied in the eastern part of the deposit from 25 to 85 m/day, in the center — from 43 to 51 m/day and in the western part — up to 25 m/day. Anomalous advancement of water pumped into the reservoir at maximum rates was not detected.

5. Average calculated channels permeability in the west of the deposit was 7.0 μm^2, in the center – 8.0-11.0 μm^2 and in the east – 3.0-11.0 μm^2, which was many times higher than the matrix permeability.

Table 2. Results of tracer studies along injection wells areas on J_1 facility in Kholmistoye field

The research portion (injection well)	The degree of hydrodynamic coupling between injection and production wells	Homogeneity degree of reservoir	The average velocity of the tracer fluid movement, m^3 / day	Conducting the main channels for moving the tracer fluid to the production well, m / day	Permeability of the main channels of tracer fluid, μm^2	The average calculated permeability for the injection well, μm^2	Frontal displacement velocity of injected water, m / day	The nature of the established fracturing
Well 233	Low	Uniform cross section, minimally dissected by high conductivity channels	25	6÷26	0.42÷1.41	2.95	0.9-2.2	Underdeveloped cracks system
Well 19	Medium	Inhomogeneous cross section	37	11÷161	0.95÷28	7.12	2.4-3.9	Fractured channel systems
Well 15	Low	Inhomogeneous, the presence of a low-performance channels system of high conductivity in the cross section	51	412÷422	1.10÷159	8.3	1÷ 2.9	Fractured channel systems with anomalously low filtration resistance
Well 25	Medium	The cross section is relatively homogeneous, weakly dissected	43	207÷1366	2.76÷284	9.5	0.9÷ 4.4	Exclusively through channels with low filtration resistance
Well 225	Low	Section with an underdeveloped cracks system	85	4÷37	0.49÷0.92	11.0	0.6÷ 1.4	Exclusively through low-capacity fractured systems

6. The largest total water displacement rock volume in the facility was identified in the western part equal to 1212 m^3, and the smallest one was in the eastern zone – from 24 to 322 m^3.

7. The front loading velocity of the injected fluid along the matrix in the western part was 2.4 ÷ 3.9 m/day, in the center - 1.9 ÷ 6 m/day, in the east – in the range from 0.6 ÷ 1.4 m/day to 0.9 ÷ 2,2 m/day.
8. During the research period, the slug of the main volumes of injected water from the injection wells along the rock matrix has advanced to a distance of 220-395 m.
9. Results of the indicator studies indicated that the main oil displacement from injection wells occurred in the sub-meridional direction. The sub-latitude direction was less affected by the water-flooding process.
10. The established fracturing at the facility was sufficiently developed, which led to an increase in the water cut of production wells on average by 5-9 % per year.

As a result of the performed work, the filtration-capacitive reservoir parameters were obtained, the low-filtration channels, their volumes and permeability, the filtration direction as well as velocity of the injected water were determined.

It was decided to conduct well interference testing to clarify the geological structure of the studied area, quantify the hydrodynamic connection between the wells and determine the filtration parameters of the inter-well space.

Injection well 19 was chosen as a perturbing one, with a capacity of 975 m^3/day, enough to create a powerful pulse signal. The fountain well No. 14 was used as a reactive one. The reaction wells did not stop during the study, the reaction to the perturbing was monitored by changing the value of the bottom hole pressure.

The mode change of disturbing injection well No. 19 was carried out by completely injection stopping, and then starting up again. Perturbing was created by two equal impulse signals.

The well interference testing curve in borehole No.14G had got a clearly expressed maximum and a point, where the pressure change, had the maximum value for the given study, relatively to the background bottom hole pressure. On the graph, the bottom hole pressure, responded to the series of perturbing pulses, created in the reservoir, was clearly visible.

3. Conclusion

Study results reliably established the presence of hydrodynamic connection across the reservoir between wells No. 19 and No. 14G. Based on the results of the research, the following conclusions were drawn:

- the tectonic fracture supposed by geological data did not exert a shadow effect on the process of pressure propagation in the area between the studied wells;
- long-term monitoring the change in bottom hole pressure in well No. 14G suggested that the well operated in a quasi-steady-state filtration mode, despite the impact of the injection well. This was the result of the isolation of the developing area, which probably had got a tectonic nature;
- during the operation of the injection well, there was a tendency of decreasing the bottom hole pressure, which did not contradict the assumption of quasi-stationary filtration;
- during the processing of well interference testing data, the permeability coefficient was 0.109 μm^2, the hydraulic conductivity coefficient was $120 \cdot 10^9 m^3/s*Pa$, the piezoelectric conductivity coefficient was $72.5*10^{-6} m^2/s$.

Due to the negative influence of low filtration resistance channels on the production process, it becomes necessary to create an artificial filtration resistance in these channels. Sludge-forming systems injected into the reservoir allowed one to reduce the water cut of wells and reduce the rate of decline in oil production.

Thus, a comprehensive analysis of the development state of the operational facility, the study of filtration flows and the application of methods for oil recovery enhance allow improving the current state of development and increasing the efficiency of oil reserves production.

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