

The use of technology of separating horizontal wells into sections by packers in conjunction with a new geological structure concept of deposits 302-302 of the Romashkino Field

Z.A. Loscheva, I.V. Nigmatzyanova*, A.A. Nazarov, M.K. Bukatov
Modelling Centre, Engineering Center of Tatneft PJSC, Almet'yevsk, Russian Federation

Abstract. The work considers deposits 302-303 of the Kuakbashsky area of the Romashkino oil field. The deposits 302-303 are confined to the carbonate layer of the Bashkirian and Serpukhovian sediments of the Middle and Lower Carboniferous, with various types of voids: intergranular, fractured and cavernous. Based on the analysis of seismic data, aerospace and geophysical data, a new model of the geological structure of deposits 302-303 was created, taking into account faults and lineaments. An analysis was made of the dynamics of horizontal wells operation, depending on the location of decompression zones, which confirmed the geological model of the deposit structure proposed by the authors. Based on the geological structure, solutions are proposed for optimization of deposits development:

- During the establishment and operation of wells, it is necessary to take into account the faults location, their type, strike, predicted locations of high fracturing and cavitation zones to improve well performance;
- The production mode should be developed with the obligatory observance of a balance between the filtration rate of oil from caverns into cracks and the flow of liquid from the production well.

The conducted analysis shows the complete absence of dependence of the development efficiency on the implementation of various technological measures. A comprehensive approach to the deposit blocks (limited by tectonic faults) is required, starting with the selection of the block (the direct drilling site), ending with the selection modes, sequence, type and complex of geological and technical measures, individually for each well of the block.

Keywords: deposits 302-303, Bashkirian and Serpukhovian stages, fracturing, faults, lineaments, oil production, water cut, porosity, permeability

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The study of carbonate deposits is of great importance for the development of the oil and gas industry on the territory of the Volga-Ural oil and gas province. It must be said that the Volga-Ural basin is the most studied of all provinces. In view of the fact that the terrigenous part of the sedimentary cover in the province has long been studied and virtually all the existing oil and gas fields are discovered and developed, and some are already depleted, further production of hydrocarbons in this area is primarily associated with carbonate deposits.

The deposits 302-303 of the Kuakbashsky area of the Romashkino oil field are confined to the carbonate layer of the Bashkirian and Serpukhovian sediments

of the Middle and Lower Carboniferous, with various types of voids: intergranular, fractured and cavernous. Experimental operation of the deposit 303 (represented by Serpukhovian sediments) was started in 1943; the deposit 302 (represented by the Bashkirian sediments) began to be operated from individual wells since 1957.

A large number of studies were carried out on deposits 302 and 303 to determine the causes of differences in production rates and differences in the intensity of water cut in neighboring wells, and methods for intensifying production and increasing oil recovery were tested. All the studies were based on the reservoir model of the deposits structure and by the present time it has not been possible to develop methods for increasing the development efficiency of deposits.

The authors proposed a new model of the structure of deposits 302-303 (Agafonov et al, 2014). According to this model, the Kuakbashsky swell, which controls

* Corresponding author: Irina V. Nigmatzyanova
E-mail: NigmatzyanovaIV@tatneft.ru

deposits 302 and 303, should be divided along the structural-tectonic structure into three separate objects: Oikino-Altuninsky, Sortovodsko-Shugurovsky and Kuakbashsky (Figure 1). All these objects differ in origin and as a consequence in time of their formation. These differences also predetermine the differences in the distribution of fractures, since it is directly related to them. Oikino-Altuninsky uplift is formed by a reef core located in the Lower-Middle Famennian sediments, as it owes its origin to the external near-board zone of the Mukhanovo-Erokhovsky trough of the Kama-Kinel System. In the underlying structural levels this uplift is not manifested. Sortovodsko-Shugurovsky object is of a tectonic type and represents a block bounded from the west by one of the faults of the Altunino-Shunaksky trough, from three other sides by various faults, and the faults have different ages: sublatitudinal – Early Triassic or Jurassic, and submeridional – Kungurian and Kazanian. In this regard, the formation of fractures is completely different from the way diagenetic fractures are formed.

The Kuakbashsky object has a similar structure with Sortovodsko-Shugurovsky object; the difference is that the northern and eastern boundaries of the deposits within it are conditional and not associated with the zones of destruction. Thus, the southern part of the

structure containing 302-303 deposits has sedimentary origin, while the central and the northern parts are of tectonic origin (Agafonov et al., 2014).

There are all kinds of stress sources on deposits 302-303. Tectonic disturbances are represented by several different-age and multidirectional fault systems, which are divided into inter-block and intra-block systems. Submeridional interblock faults were formed during the formation of the Pre-Urals fore deep in the Kungurian time and the Melekess depression in the Kazanian time. Fractures along the submeridional fault are closed. Sublatitudinal interblock faults and fracture zones accompanying them were formed during the deflection of the Caspian depression. Sublatitudinal faults continue to develop, as the deflection of the Caspian depression continues. This means that the fractures formed by these faults are still open and their healing with clay material continues (Figure 2).

At the present time, there is a diagonal system of geodynamic active zones of disturbances (GAZD). GAZD is a multi-rank regularly developed fracturing system formed by the rotational field of the Earth's stresses, caused by the need for periodic discharge of intracrustal stresses (Dragunov, 2011; Dragunov et al., 2017) with a direction of 65-155 degrees (+/-15 degrees), creating its fractured zones. Cavity passes through these

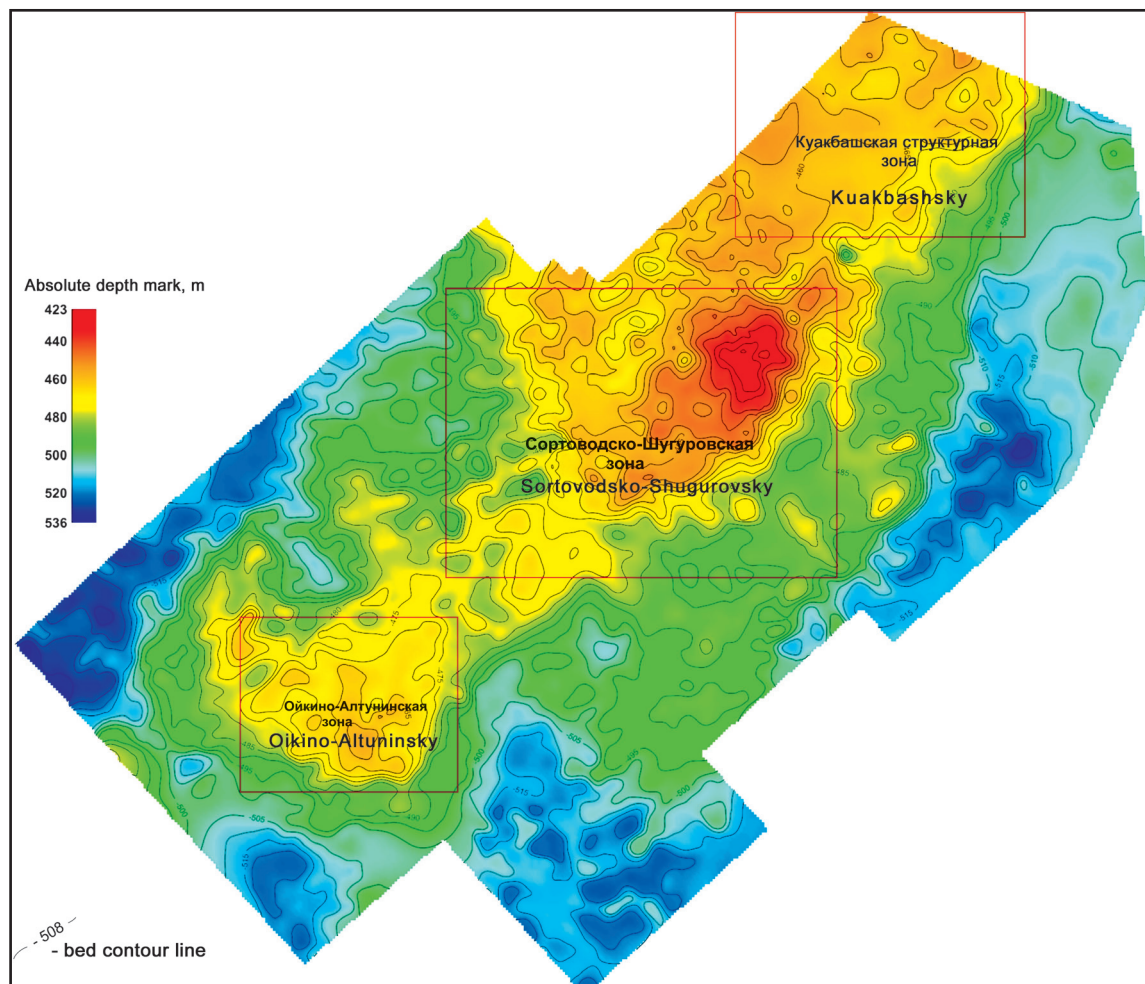


Figure 1. Structural map by the roof of the Middle Carboniferian horizon according to seismic data

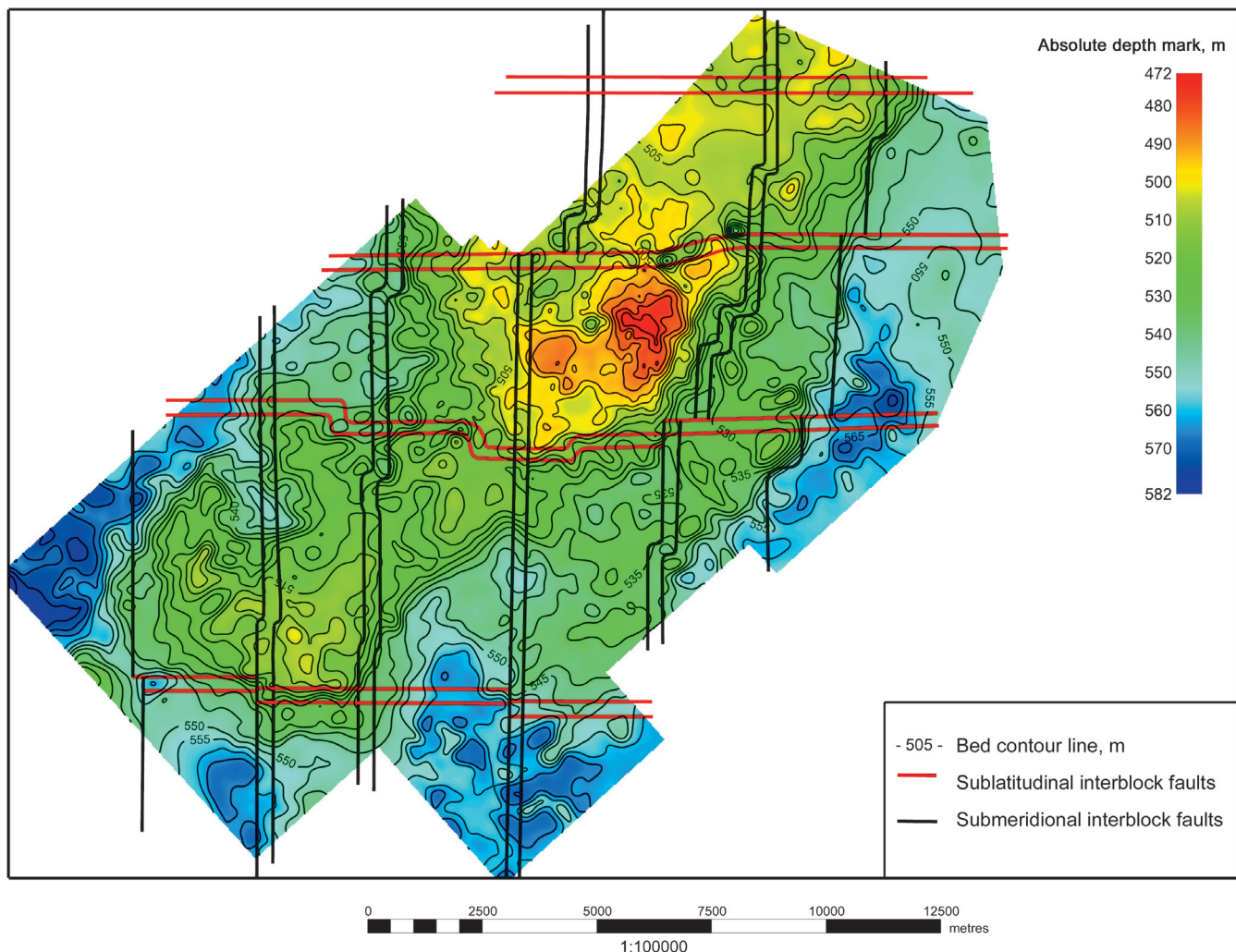


Figure 2. Structural map by the roof of Sбsh₂

fractures. Within the limits of all GAZD, and primarily of the zones of fluid flow (NW direction), tectonic fracturing is constantly in the active state.

In 2016 GPS and geological survey was carried out in the system-geodynamic modification over the entire area of deposits 302-303 with the purpose of distinguishing GAZD of different ranks (Figure 3). GAZD of the North-Western direction are the most active – distributive, and of the North-Eastern direction – cumulative¹.

The authors of the article have created a geological model of deposits 302-303 of the Romashkino field, taking into account tectonic faults and gas turbines, using the ROXAR software package (a package for geological modeling Irap RMS), which reflects the structure of the deposits as much as possible (Figure 4).

In most cases drilled wells on deposits 302-303 are quickly watered or enter into development with a high percentage of watercut.

In this paper, the geological structure of the deposits and horizontal wells is analyzed. The location of the

well in relation to tectonic faults, lineaments (GAZD), as well as packers installed in the trunk is considered. The analysis was carried out in conjunction with development data to identify factors that affect the dynamics of horizontal wells.

A detailed analysis of two wells is given below, similar to the analysis of 25 horizontal wells drilled on these deposits.

Well No. 35387G is cased with a 114 mm shank equipped with packers “Kvart” in the intervals 951-952 m, 1034.5-1035.5 m, 1057.5-1058.5 m and a filter with magnesium plugs in the interval 1076-1096 m. The trunk of the well is directed to the marginal part of the GAZD of 7th rank with the NW direction. The sock of the borehole is closer to the bottom of Upper Bashkirian deposits. There are nine meters till oil-water contact; the formation is well cavernous with small densified areas (Figure 5).

There is a stable drop in oil production and a gradual increase in water cut. The rate of oil production falls for 20 months from 5.9 t/day to 2.2 t/day. The percentage of water logging for the first six months did not exceed 10%, gradually increasing – over the next 26 months it reached 30% (Figure 6).

¹Dragunov A.A. (2016). Provedenie AKGI v sistemno-geodinamicheskoy modifikatsii po vsey ploshchadi rasprostraneniya zalezhey 302-303. Report. Kazan: TNG-Kazangeofizika LLC.

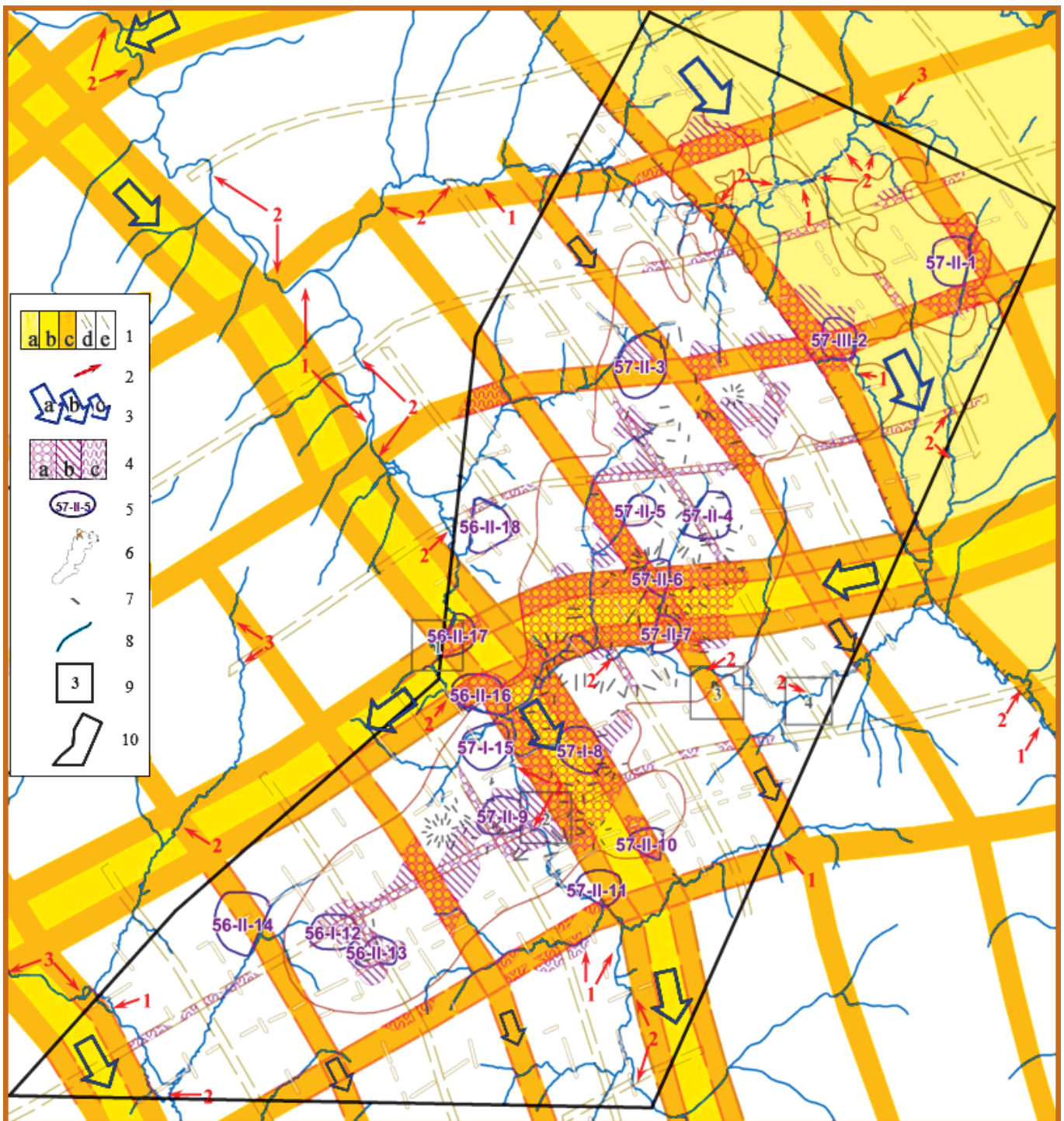


Figure 3. Map of the results of system-geodynamic modeling for the distribution area of deposits 302-303. Scale 1: 150 000.
 1 – geodynamically active zone of disturbances (GAZD): a – 1-3d ranks, b – 4th rank, c – 5th rank, d – 6th rank, d – 7th rank;
 2 – hydrological anomaly associated: 1 – with the gravitation of the water flow to the marginal parts of the GAZD, 2 – with the “II”-like “waste” of the river bed at its intersection with the GAZD, 3 – with a varied “refraction” of the river bed; 4 – with the bifurcation and wandering of the river bed at the site of its intersection with the GAZD and downstream;
 3 – the expected flow of reservoir waters along the Serpukhovian-Bashkirian and lower-lying sediments, incl. on the basement: a – primary, b – secondary, c – third-rate;
 4 – perspective object, associated with the multi-ranked framework of GAZD: a – within the GAZD, intersecting the geodynamically active uplift, b – on the periclinal of the large uplift, shielded by the GAZD; c – complicated, at the intersection point of the GAZD;
 5 – cosmotectonic object, identified with the HC of the structural type and its number;
 6 – the outline of the Kuakbashsky swell (based on the materials of Lukyanova R.G.);
 7 – horizontal well;
 8 – channel of a constant watercourse;
 9 – reference section of system-geodynamic interpretation and its number;
 10 – boundary of the distribution area of deposits 302-303.

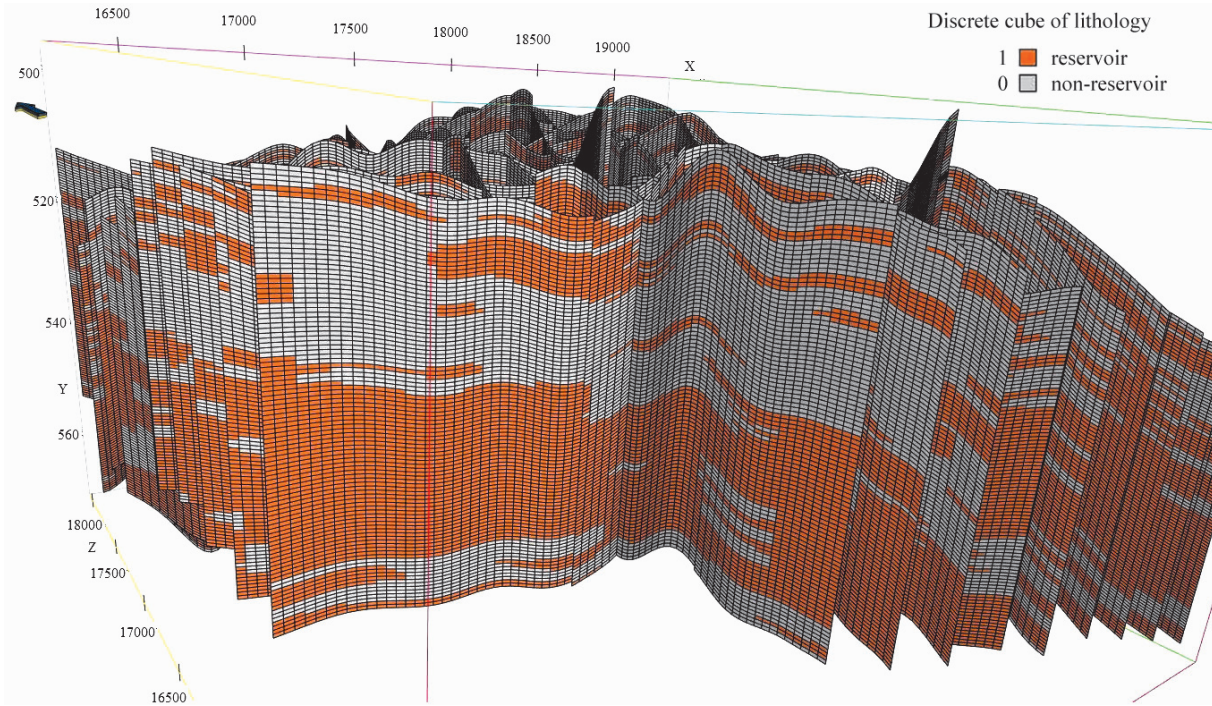


Figure 4. Distribution of the discrete lithological parameter of the geological model along the northern section

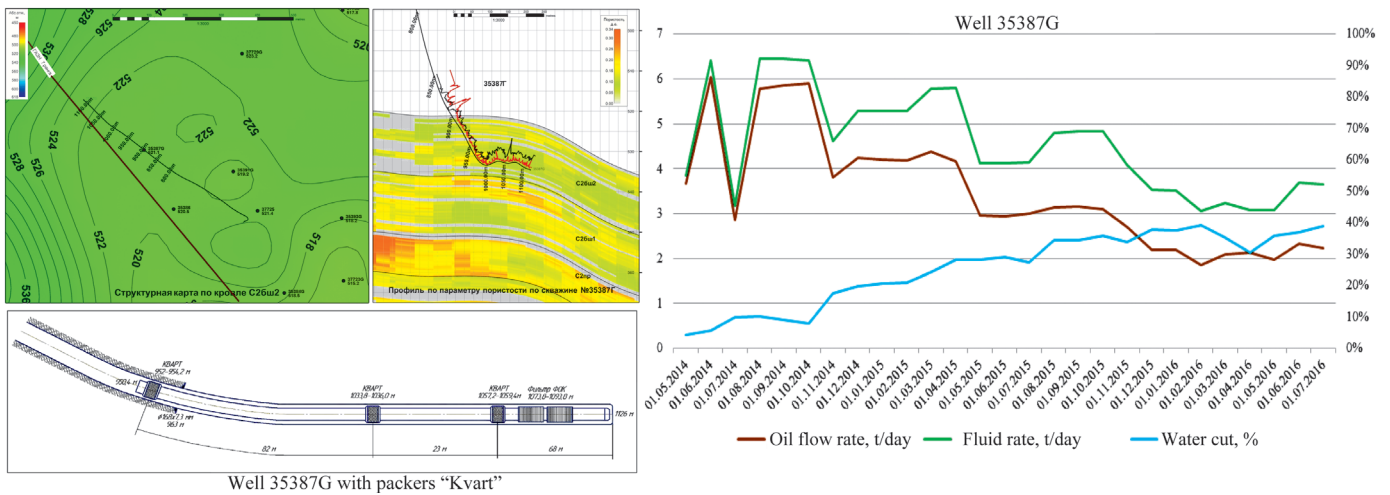


Figure 5. Well No. 35387G

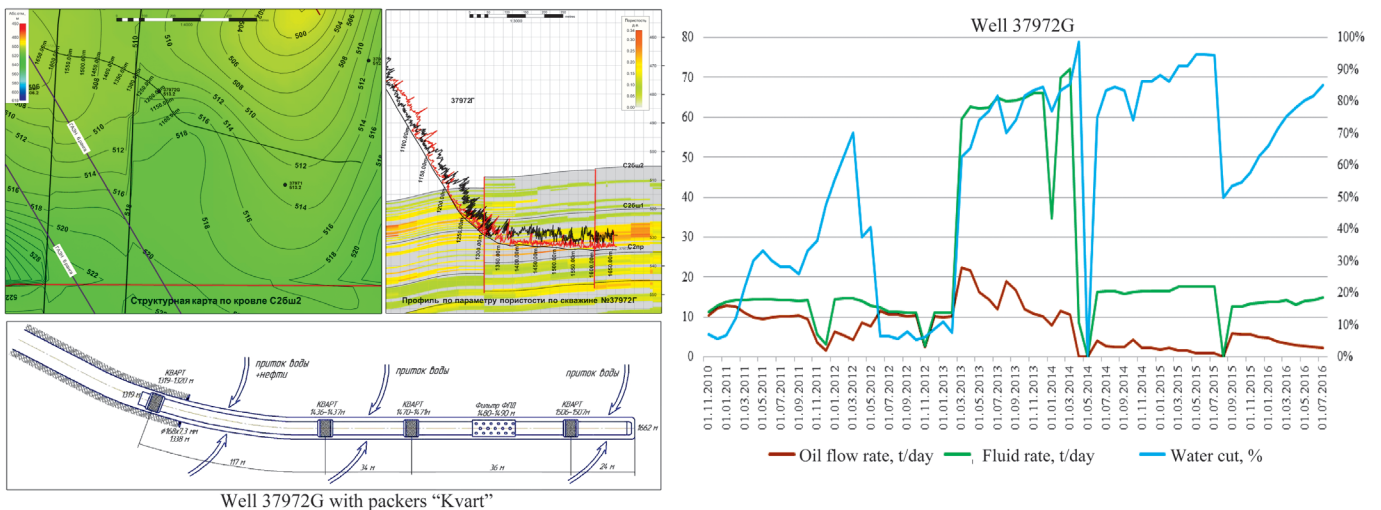


Figure 6. Well No. 37972G

Watering is low and slowly growing, possibly due to the fact that the well does not cross the sublatitudinal interblock fault with open fractures and does not cross the GAZD. The extraction is conducted not from fractures, but from caverns, which feed GAZD of the seventh rank with the NW direction, the border zone of which is located 40 meters from the perforation interval.

From the packer in the interval 1057.5-1058.5 m the effect was minimal; there was no need to cover this interval.

Well No. 35387G is an example of a well that has been successfully drilled. The trunk does not cross faults; it is drilled in the Upper Bashkirian deposits (denser carbonates). The well works stably with a small oil production rate, without a rapid increase in water supply, the barrel is directed to the border zone of GAZD of the 7th rank with the NW direction, from which the solution for cavity formation was given (Figure 6).

A 114 mm casing liner with packers “Kvart” was installed in the horizontal well trunk No. 37972G in the intervals 1507-1506 m, 1471-1470 m, 1437-1436 m, 1319-1320 m and a filter in the interval 1480-1490 m.

The well trunk is located at some distance from the sublatitudinal interblock fault with open fractures and crosses two interblock submeridional faults with closed fractures. Also, the sock of the well is located in the immediate vicinity of the marginal zone of GAZD of the 6th rank with the NW direction. The sock is located in the Lower Bashkirian sediments. There are nine meters to the oil-water contact; the reservoir is medium-sized in the Upper Bashkirian sediments, mediumly cavernous with compacted areas in the Lower Bashkirian sediments (Figure 6).

In the first eight months, the percentage of water cut reached a value of 68%, after the remedial cementing the percentage of water cut sharply drops first to 47%, after – up to 6%. After the next two months, the flow rate of the liquid increases sharply to 60 m³/day, and within six months the percentage of water cut reaches 98%. In May 2014, the shank with packers is lowered, the interval is 1481.6-1491.7 m, a filter (1480-1490 m) is installed and extraction is conducted. Reducing the selection of liquids to 17 m³/day, watering is reduced to 81%, for eight months the water supply reaches 93%. In August 2015, waterproofing works are carried out and the extraction of liquids was reduced to 12 m³/day, which allowed reducing the water supply to 52% (Figure 6).

A good interval for perforation is chosen – it is located 270 meters from the GASD boundary of the 6th rank

with the NW direction. From below (1506-1507 m) and from above (1470-1471 m), the perforation interval was isolated by packers. The effect of the packer established in the interval (1470-1471 m) is absent, and in the lower interval it is expedient to install the packer, since in the toe the well trunk and the GASD practically intersect. The packer in the range of 1506-1507 m is installed in an insufficiently dense part and therefore the water has come quickly, waterproofing works allow closing the washed fractures and lowering the water cut, due to the activation of the unwashed ones, but the effect lasts not for long for two reasons: first, the gel breaks and closed fractures again become permeable, and secondly, new cavern fractures are washed to already flooded vertical fractures

As a result of the work, a new geological model was created and the dynamics of the operation of horizontal wells was analyzed in coordination with geology, on the basis of which the following conclusions were made:

- During the establishment and operation of wells, it is necessary to take into account the faults location, their type, strike, predicted locations of high fracturing and cavitation zones to improve well performance.

- The production mode should be developed with the obligatory observance of a balance between the filtration rate of oil from caverns into cracks and the flow of liquid from the production well.

- The conducted analysis shows the complete absence of dependence of the development efficiency on the implementation of various technological measures: the location of the well relative to the faults, the placement of packers, plugs and filters, perforation intervals, water shutoff treatment, change in extractions and depressions. A comprehensive approach to the deposit blocks (limited by tectonic faults) is required, starting with the selection of the block (the direct drilling site), ending with the selection modes, sequence, type and complex of geological and technical measures, individually for each well of the block.

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About the Authors

Zoya A. Loscheva – Head, Modelling Centre, Engineering Center of Tatneft PJSC
30, K. Zetkin St., Almet'yevsk, 423452, Russian Federation

Irina V. Nigmatzyanova – Sector Manager, Modelling Centre, Engineering Center of Tatneft PJSC
30, K. Zetkin St., Almet'yevsk, 423452, Russian Federation

Azamat A. Nazarov – Sector Manager, Modelling Centre, Engineering Center of Tatneft PJSC
30, K. Zetkin St., Almet'yevsk, 423452, Russian Federation

Maxim K. Bukatov – Sector Manager, Modelling Centre, Engineering Center of Tatneft PJSC
30, K. Zetkin St., Almet'yevsk, 423452, Russian Federation

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