RUSSIAN OIL WILL INCREMENT AT THE EXPENSE OF BAZHENOV FORMATION

A.T. Panarin, A.V. Fomin
Rus-Oil JSC, Moscow, Russia

Abstract. Depletion of oil and gas resources of conventional fields determines the search for new sources of hydrocarbons. The world's largest oil shale formation – Bazhenov Formation has the greatest long-term production potential in the country. Moreover, the BF is located in regions with developed oil and gas infrastructure and its development is of great social importance for the country. However, despite a fairly significant period of the formation research, many of the issues of the geological structure, allocation of productive zones and cost-effective methods of development remain unsolved.

Therefore, for a comprehensive study of this unique object it is necessary to attract a wide range of geochemical, geophysical and geological field methods. In recent years, the expansion of pilot projects carried out by both large and medium-sized oil and gas companies contribute to the cost-effective development.

Keywords: shale formation, Bazhenov Formation, geological structure, allocation of productive zones, cost-effective methods of development

DOI: 10.18599/grs.18.4.11

For citation: Panarin A.T., Fomin A.V. Russian Oil Will Increment at the Expense of Bazhenov Formation. *Georesursy = Georesources*. 2016. V. 18. No. 4. Part 2. Pp. 325-330. DOI: 10.18599/grs.18.4.11

Russia is one of the recognized world leaders in oil and gas production, but depletion of conventional fields require seeking for a new resource base on scales comparable with the largest developed oil and gas provinces. Development of the Arctic shelf and huge potential of the largest shale formation in the world – the Bazhenov formation (BF) are considered as an equivalent alternatives. If the development of the Arctic shelf is associated with the creation of infrastructure in the severe conditions unfit for human residence, the Bazhenov Formation is developed in areas with existing oil producing infrastructure. Its development in Russia is of great social importance, as the decline in oil and gas production in Western Siberia will affect the economic condition of the country.

Thus, evaluation of the resource base of light oil from the BF ranges from 600 million to 174 billion tons (the middle of this range is greater than the total geological reserves of light oil from all known Russian oil and gas provinces combined). Development of reliable geological model of oil deposits in the BF, on which we can plan cost-effective development, is a major challenge for geologists. But there is no consensus among researchers about its geological structure, especially on the issue of allocation of productive zones. There are more than a dozen of geological models developed. Until recently, the main prevailing theory is that the main conductors of oil in the BF are clays rich in organic matter (OM), foliated and interstratified at the expense of abnormally high reservoir pressures (AHRP). Therefore, mechanized production, which creates a significant depression on the formation, is strictly contraindicated.

In 2007, on the basis of logging data in open hole, single core samples and geophysical studies of gusher wells, specialists of CJSC "MiMGO named after V.A. Dvurechensky" under the leadership of V.S. Slavkin developed a hypothesis that the main conduits of oil in the BF on Sredne-Nazymsky and Galyanovsky fields are dense and carbonized fractured interlayers (Slavkin et al., 2007). In fairness, it should be noted that one of the first, who started associating the BF productivity with dense interlayers, was M.Yu. Zubkov with his colleagues (1999 and 2002). Already since 2007 the BF on Sredne-Nazymsky field has been operated with the use of electric submersible pump and inflows were stimulated by means of hydrochloric acid treatment.

Later on the results of core study with 100 % removal, it was revealed that the main conductors of oil in the BF to the west of Shirotnoye Ob are secondarily transformed layers of radiolarites, which, depending on the nature of these transformations are aporadiolarian limestone, dolomite or aporadiolarian silicite (aporadiolarite). These interlayers are mostly of porous-fractured nature, porosity in some places reach 16 %, permeability – 10 mD. In the logging curves they have the appearance of dense layers.

The uniqueness of the BF as a shale formation lies not only in its size (more than one million km^2), but also in its natural gushers that distinguish it from other shale formations around the world. None of the formations is not characterized by such powerful natural tributaries. Gusher flow rates of the BF can reach hundreds of cubic meters per day, while more than a third of the well inflows were not received at all. The highest flow rate given in the official statistics is 1248 m^3/day for the well No. 141-P of the Salymsky field.

However, it should be noted that for an adequate structure model of this unique object it is necessary to attract the widest possible range of geochemical, geophysical, geological and field study techniques. Results of geochemical analyzes carried out under the guidance of M.D. Dakhnova showed an uneven distribution of the different components of organic matter in the section. Also attempts were made to determine the extent of reservoirs and evaluate their fluid connectivity using one of the methods of reservoir geochemistry (Dakhnova et al., 2007).

The BF is oil source strata, in which the conversion process of OM is not yet complete. Some formed hydrocarbons did not lose a genetic link to the original OM and are sealed in pores, which were formed due to the transition of solid organics into a liquid. This oil is also called proto- (micro) oil; in organic chemistry these hydrocarbons are called autochthonous. AHRP is formed in the BF due to them, by the fact that the volume of bitumen generated is more than of the original OM. Besides autochthonous (related) there are mobile hydrocarbons that lost connection with the original OM, but did not leave the oil source strata. They are called paraautochthonous and related oil – macro-oil. Figure 1 shows how we can distinguish paraautochthonous hydrocarbons from autochthonous. At its core, the method developed in the geochemical center VNIGNI under the leadership of M.V. Dakhnova, is an independent geochemical method of reservoir allocation in shale formations.

Currently, on the number of fields in Western Siberia pilot projects are carried out and oil is being extracted. Multanovsky oil field is located in Surgut district of the Khanty-Mansi Autonomous District of the Tyumen region, 85 km southeast from the town of Pyt-Yah and 110 km from the city of Surgut. Multanovsky field was discovered in 1999. Oil and gas bearing is confined to deposits of the Bazhenov, Vasyugan and Tyumen formations of the Upper and Middle Jurassic (layers J_0, J_{1-2}, J_{2-3}).

Exploration stage at the Multanovsky area began in 1971 by drilling of exploration well No. 2 by Pravdinsky oil exploratory expedition in the swell of the north dome of Multanovsky structure. From a depth of 2796 m (approximate roof of the BF) emergency oil and gas shows began. The well was eliminated without lowering the production casing. Exploration well No. 12 was drilled in 1999 in swell part of Multanovsky structure by JSC “Pravdinsky NGRE”. From J_0 reservoir in the interval 2790-2819 m oil flow of 15.6 t/s was obtained. Geological and physical characteristics of formations in Multanovsky field are shown in Table 1.

Geological profile of productive deposits is shown in Figure 2. A comparison of core description, logging set, as well as test results in open hole and in production string for the well No. 12 is shown in Figure 3. It can be said that the BF reservoirs are made of tight interlayers, located deep in less dense rocks.

Formation J_0 on the results of core studies from the well No. 106 of Multanovsky field consists of bituminous mudstone, sometimes with interlayers of siltstone (up to 0.2 m) and sandstones (up to 0.4 m), uneven carbonized, dense, very strong with uneven, staggered, half-shell and crescent fractures with numerous lithoclasts of clay-carbonate material. Numerous fine cracks are traced, open and closed, hollow and made of white calcite.

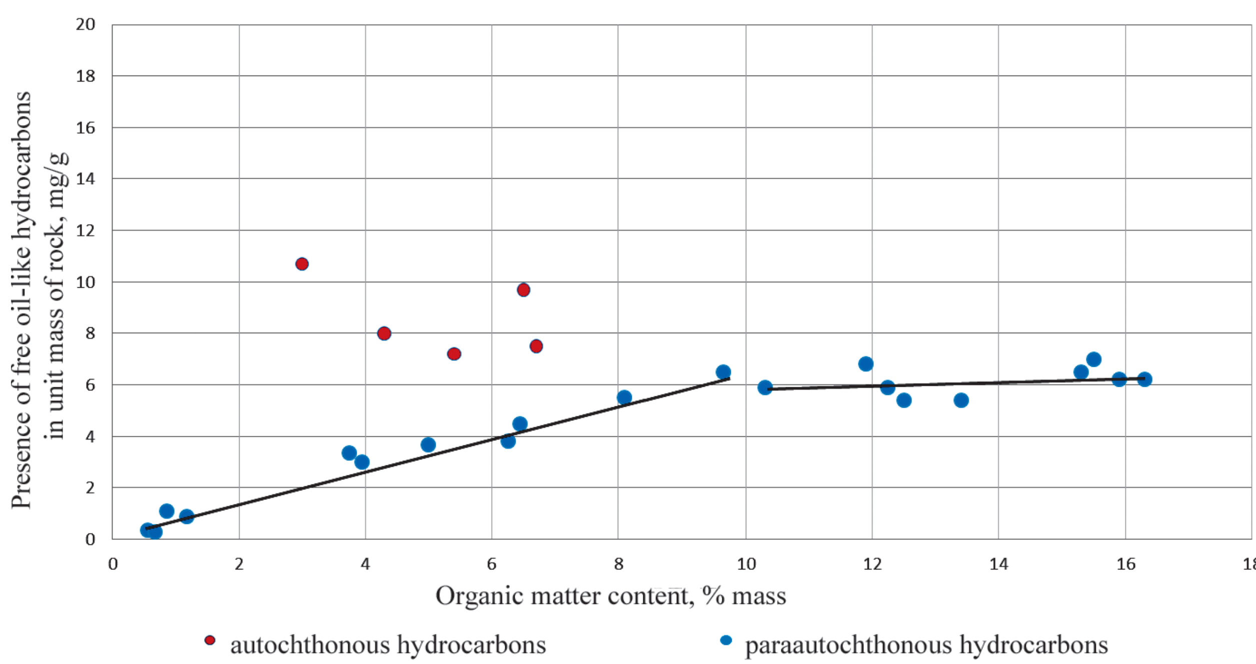

Figure 1. Comparison of the organic matter content and free oil-like hydrocarbons in one unit of the rock mass (according to the method of M.V. Dakhnova).

There are slight gas and oil effusions. According to the results of particle size analysis, sand fraction content in mudstones is 6.68-28.97, silt fraction – 30.21-34.90, politic fraction – 36.13-63.11 %. Sorting is average and good, S_0 = 2.89-5.37, the median diameter of grains – 0.01-0.05 mm.

Currently, two wells No. 25 and No. 33 are operated in oil reservoirs of Bazhenov deposits (J_0). Well No.25 was put into operation in November 2015 with oil flow rate of 17.6 t/s at a buffer pressure of 60 atm. Well No. 33 was put into operation from the drilling in December 2015 with a flow rate of 25.9 t/s. Since the development beginning of J_0 about 14 thousand tons of oil was extracted. Reservoir pressure in well No.25 dropped from 31.0 to 25.3 MPa.

In September 2016 in the process of drilling a project well No.11G when penetrating of the bottom of the Bazhenov deposit, there was a complete absorption of

No.	Characteristics	Formation J_0	Formation J_1^2	Formation J_{2-3}	
				Area of well No.12	Area of well No.9
1	Average depth of occurrence, m	2773-2865	2874,6-2912	2907,2-2927,6	2976-2986
2	Type of deposit	Massive	Layer-uplifted	Lithologically screened	Lithologically screened
3	Type of reservoir	Carbonaceous fractured-cavernous	Terrigenous porous	Terrigenous porous	Terrigenous porous
4	Area of hydrocarbon saturation, thous. m^2	13600	61600	61617	18528
5	Average gross thickness, m	28-30	13-23	26-27	
6	Average oil net pay, m	3,8	5,7	4,8	4,6
7	Porosity, %	10	16	15	15
8	Average hydrocarbon saturation, un. fr.	0,9	0,68	0,64	0,64
9	Permeability, $micron^2*10^{-3}$	5*	32.5	1,6	1,6
10	Net sand coefficient, un. fr.	not determined	0,08-0,63	0,1-0,22	
11	Reservoir compartmentalization, un.	not determined	2-13	3-5	
13	Initial reservoir pressure, MPa	31,0	29,5	30**	30**
14	Reservoir oil viscosity, mPa*s	1,67	0,86	2,14**	2,14**
15	Reservoir oil density, g/cm^3	0,783	0,715	0,825	0,825
16	Oil density at surface, g/cm^3	0,876	0,859	0,88	0,88
17	Absolute depth mark of oil water contact, m	not determined	-2810	-2889	-2919
18	Formation volume factor, un. fr.	1,22	1,4	1,15	1,15
19	Correction factor, un. fr.	0,82	0,714	0,87	0,87
20	Crude sulfur, %	1,51	1,84	1,63-1,7	
21	Oil paraffin content, %	2,39	1,27	2,45-2,62	
22	Saturation pressure, MPa	16,8*	24,7	8**	8**
23	Gas factor, m^3/t	73	133,9	30	30
24	Water density under reservoir conditions, t/m^3	not determined	1,014**	1,004**	1,004**
25	Productivity factor, m^3/day*MPA	not determined	0,86	not determined	0,01
26	Displacement factor, un. fr.		0,478	0,436	0,436

*Table 1. Geological and geophysical characteristics of the productive deposits of Multanovsky field. Note: *– by analogy with Salymsky group of fields. ** – by analogy with Ugutsky group of fields.*

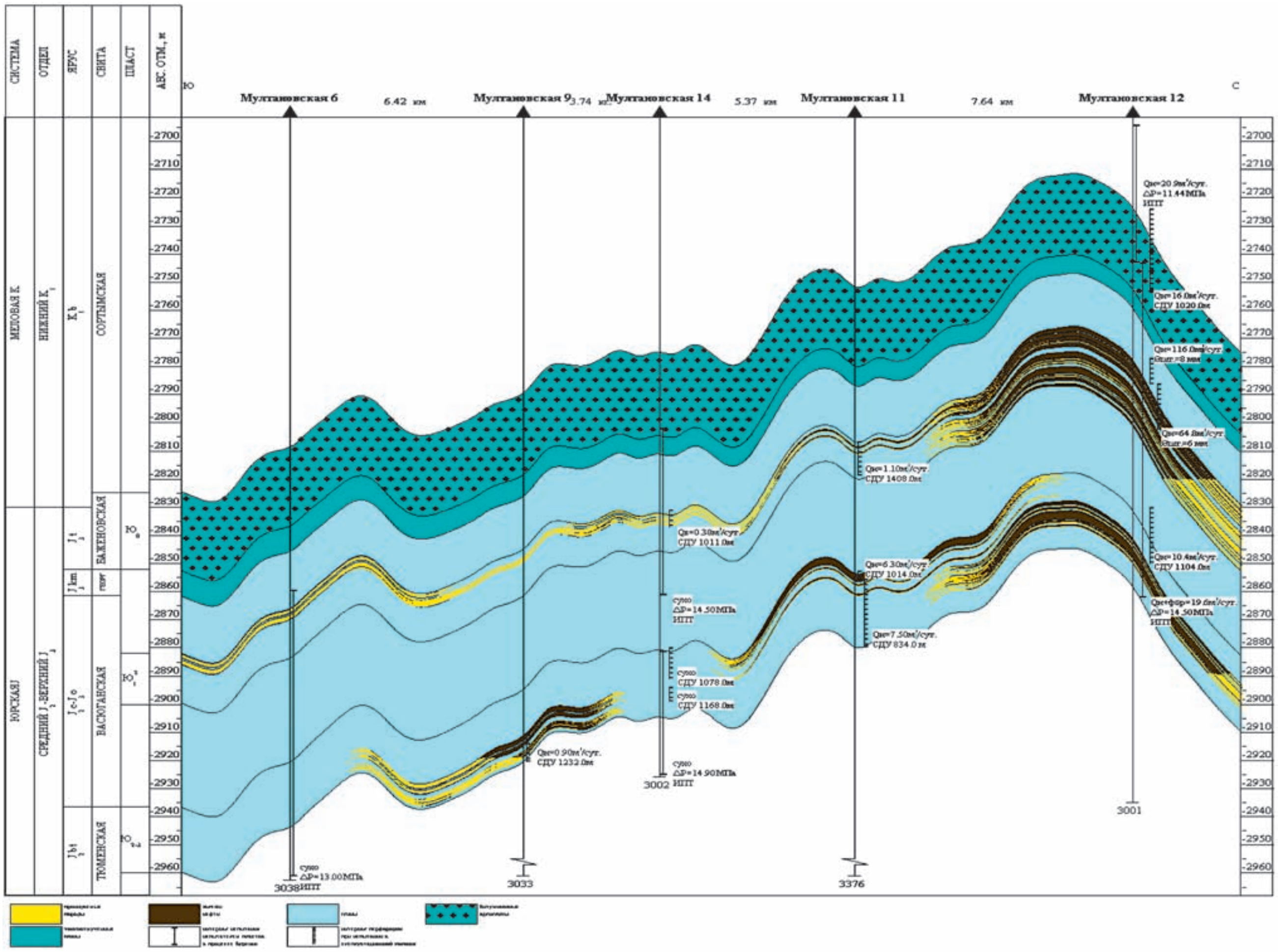

Figure 2. The geological profile of productive strata of Multanovsky field.

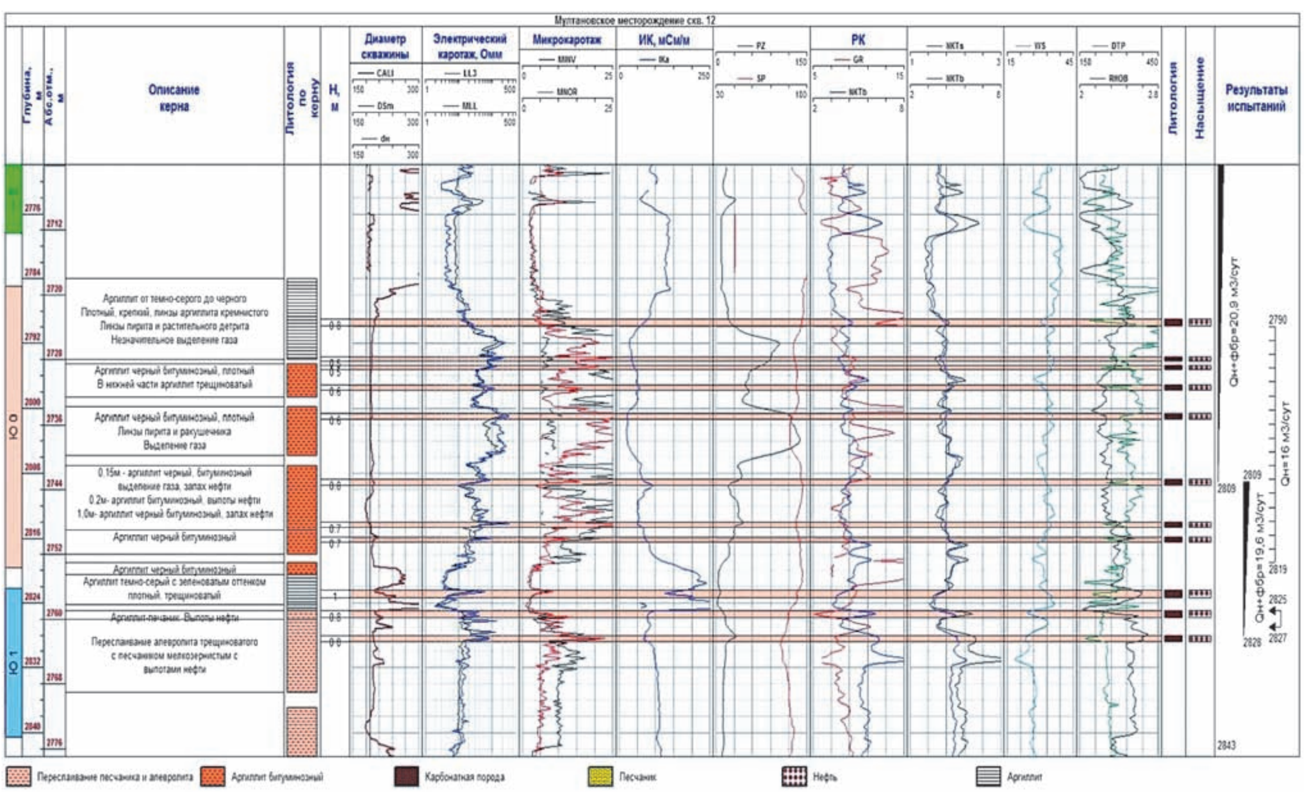

Figure 3. A comparison of core samples, logging, test results in open hole and in production string for the well No.12 of Multanovsky field.

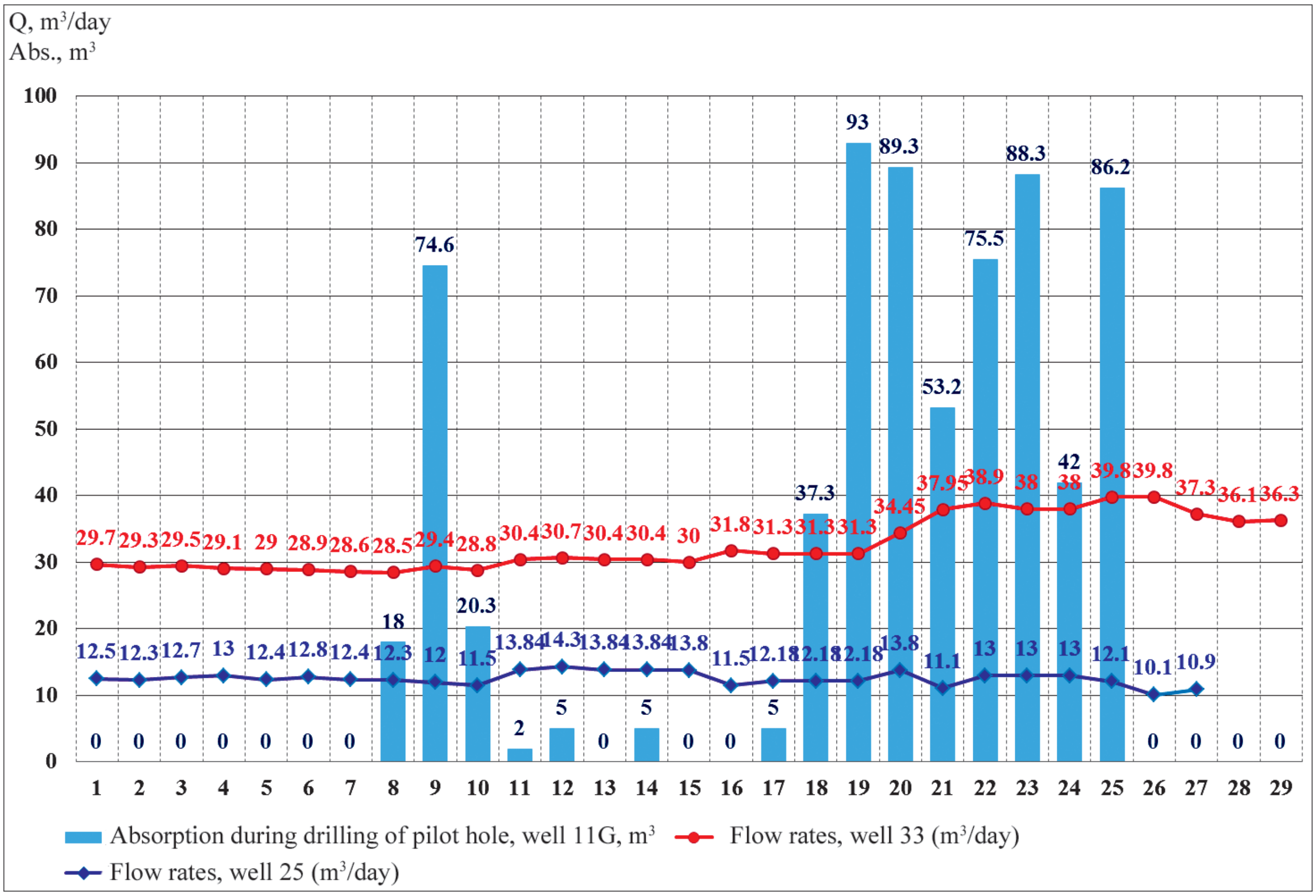

Figure 4. Analysis of the dynamics of production wells No. 25 and 33 depending on the absorption volume in the well 11G.

drilling fluid with loss of circulation. Total absorption was about 700 m^3 of drilling fluid and viscoelastic composition with different colmatants. As a result of this absorption, reaction was observed from wells No. 25 and 33. Dynamics of absorption volumes and flow rates is shown in Figure 4.

This experiment clearly shows that the production of oil from J_0 formation can be carried out with the maintenance of reservoir pressure, with possible injection of not only water, but also the alternation rims of viscoelastic compositions, polymer, fiber-dispersed systems and other physical and chemical methods of enhanced oil recovery. Fluid injection pressure and volumes into the reservoir, the impact technology and parameters definition of injecting viscous compositions, taking into account thin reservoirs-inductors capable of almost instantaneous transmission of the impact impulse through the formation, require further study and clarification.

However, the fact of a quick response of wells by flow rates, on the first cycle of drilling fluid leaving with total volume of 100 m^3 within less than two days, indicates the minimum relaxation time of the environment to the applied impact. It should also be noted that at the extraction of about 14 thousand tons of substantially anhydrous oil, reservoir pressure in the system dropped to 5.7 MPa, which confirmed by a small volume of drained reservoirs, along which the movement of fluids was carried out.

In the US, more than 150 thousand wells are drilled on hydrocarbon deposits in shale formations, the process of studying these deposits continues for more than 60 years, and only in 2010 the rapid growth of shale oil began (Panarin, 2015). In Russia, the issue is only being given due attention in recent years. Of course, that under favorable economic conditions (especially the price of oil) and certain tax benefits, share of shale oil in the total production of the country will steadily increase.

References

Dakhnova M.V., Nazarova E.S., Slavkin V.S., Koloskov V.N., Alekseev A.D. Geokhimicheskie metody v reshenii zadach, svyazannykh s osvoeniem zalezhey nefti v bazhenovskoy svite na zapade Shirotnogo Priob'ya [Geochemical methods in solving problems related to the development of oil deposits of Bazhenov Formation on the West Ob River Region]. *Geologiya nefti i gaza = Geology of oil and gas*. 2007. No. 6. Pp. 39-43. (In Russ.)

Panarin A.T. Skoro l' v Rossii gryanet slantsevaya revolyutsiya? [How Soon in Russia shale revolution will start?] *Materialy Mezhdunarodnoy nauchno-prakticheskoy konferentsii «Osobennosti razvedki i razrabotki mestorozhdeniy netraditsionnykh uglevodorodov»* [International scientific-practical conference «Peculiarities of exploration and development of unconventional hydrocarbons»]. Kazan: Ikhlas Publ. Pp. 38-40. (In Russ.)

Slavkin V.S., Alekseev A.D., Koloskov V.N. Nekotorye aspekty geologicheskogo stroeniya i perspektiv neftenosnosti bazhenovskoy svity na zapade Shirotnogo Priob'ya [Some aspects of the geological structure and prospects of oil-bearing Bazhenov Formation on the West Ob River Region]. *Neftyanoe khozyaystvo = Oil Industry*. 2007. No. 8. Pp. 100-105. (In Russ.)

Information about authors

Aleksandr T. Panarin – PhD in Geology and Mineralogy, Chief geologist, Rus-Oil JSC

Russia, 111033, Moscow, Zolotorozhskiy val str., 32

Phone: +7 (499) 258-57-05 (33205)

E-mail: a.panarin@Rus-Oil.com

Anatoliy V. Fomin – PhD in Engineering, First Deputy Director General, Rus-Oil JSC

Russia, 111033, Moscow, Zolotorozhskiy val str., 32

Phone: +7 (499) 258-57-05 (33157)

E-mail: AFomin@Rus-Oil.com

Manuscript received October 07, 2016