Prospects of Reserves Increment in Zavolzhskian Carbonate Sediments of the Romashkino Field

I.S. Karimov[1], I.R. Mukhliev[2], L.R. Sagidullin[2], I.I. Bakirov[3]
[1]PJSC Tatneft, Almetyevsk, Russia
[2]Oil and Gas Production Department «Dzhalilneft» PJSC Tatneft, Dzhalil, Russia
[3]Tatar Oil Research and Design Institute (TatNIPIneft) PJSC Tatneft, Bugulma, Russia

Abstract. This article describes possible ways to search for hydrocarbon reserves in Zavolzhskian horizon of the Upper Devonian within the deposit No. 12 of Romashkino field. In order to study Zavolzhskian horizon we selected 2 sites with 32 wells on the deposit No. 12. Detailed correlation of the geological section was made for sediments of the Lower Carboniferous and Zavolzhskian horizon. On the basis of export correlation data and re-interpretation of logging materials we have built frames and designed three-dimensional geological models of these two sites. We analyzed core material of the studied formations and determined reservoir properties and reservoir saturation. Based on the results obtained we proposed wells for testing Zavolzhskian horizon in the area of the deposit No. 12.

Keywords: Zavolzhskian horizon, carbonate deposits, low productive strata, reserves difficult to recover, core material, reservoir properties, deposit, reserves

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Currently, oil production on the development objects, which are operated in oil and gas production department Dzhalilneft, is conducted mainly in clastic sediments of productive Devonian (71.8%) and Carboniferous (27.6%), as well as in small volumes on the Kizelian horizon of Tournasian tier (0.6%). The depletion in these objects is 87.3% with 85.8% water cut in crude production. Soon available recoverable reserves will be significantly reduced due to the extraction. There is a problem of finding oil reserves in previously not exploited horizons and tiers throughout the geological section.

In the Paleozoic sediments mainly in the southeast of Tatarstan, industrial oil bearing has been proved for Domanic, Famennian, Tulskian, Namurskian and Bashkirian, Vereiskian and Kashirskian, Kungurian-Artinskian deposits. There are various types of oil shows in other parts of the geological section. Thus, the whole complex of Paleozoic deposits of Tatarstan is potentially oil-bearing. However, when prospecting we should not expect well-developed and large reservoirs, rather there will be quite heterogeneous and relatively thin interlayers of lenticular structure.

The heterogeneity of the lithological and petrographic composition of rocks that form the geological section, frequent facies variability indicates unstable hydrodynamic regime of sedimentation and intensive secondary processes.

This paper discusses possible ways to search for hydrocarbon reserves in Zavolzhskian horizon of Upper Devonian within the deposit No.12 of Romashkino field.

On the deposit No. 12 of Romashkino field in the section of the Upper Devonian we allocated Frasnian (D_3^1) and Famennian (D_3^2) tiers, subdivided into lower, middle and upper sub-tiers.

In the Upper Famennian subtier (D_3^23) we allocate Zavolzhskian horizon (D_3zv), which is composed of gray and light gray limestone, mostly fine-grained, irregularly recrystallized and calcitated, interbedded with dolomite strata with uneven stratification, with stylolite seams, uneven areas of oil saturation. The thickness of the horizon is equal to 50-60 m (Abdullin et al., 1982).

Deposits of Zavolzhskian horizon are oil-bearing locally, and their study is insufficient. Allocation of reservoir rocks in carbonate section and their saturation is difficult due to complexity of pore space, changes in reservoir properties of both the area and section. Also penetration of carbonate reservoirs by drilling is often accompanied by the formation of deep penetration of washing liquid filtrate, which, in turn, makes it difficult to determine the resistivity of the reservoir.

On the deposit No. 12 to study Zavolzhskian horizon 2 plots were matched from 32 wells, on which a detailed correlation of the geological section is made in the range of the Lower Carboniferous sediments and Zavolzhskian horizon using the software package of the company Landmark. Benchmark borders are obtained, establishing the nature of bedding in the studied section.

In the Tulskian horizon we allocated 4 layers – C_1tl-4, C_1tl-3, C_1tl-2, C_1tl-1; in Bobrikovian – C_1bb-4, C_1bb-3, C_1bb-2, C_1bb-1; in Tournaisian – C_1kz (Kizelian horizon), C_1chr (Cherepetskian horizon) and C_1upml (Upinian-Malevskian horizon); 5 productive formations are allocated in Zavolzhskian horizon. When correlations were compared each hole cut with a cut reference wells. 5253.

Using data of detailed correlation from these wells detailed correlation we made reinterpretation of logging data.

The data processing involved the following set of methods: resistivity logging (RL), self-potential logging (PL), caliper logging (CL), gamma-ray logging (GL), induced gamma-ray logging (IGL), lateral logging (LL), induction logging (IL).

The effectiveness of automatic lithological section and assessment of reservoir saturation are high enough, but it is often necessary to manually adjust formation boundaries and clarify the nature of saturation, taking into account the position of oil-water contact.

We used criteria for allocating reservoirs in carbonate section and dividing them into oil-bearing, water-bearing and intermediate.

As can be seen from Table 1, in carbonate section reservoirs are firmly allocated only when porosity is more than 8%.

At lower values it is insufficient to reliably allocate reservoirs knowing only porosity. Therefore, layers with porosity of less than 8% to a certain limit may relate only to possible or dense reservoirs. With porosity less than the limit values layers are attributed to non-reservoirs. We can confidently characterize oil-bearing reservoirs only when they firmly allocated; layers, referred to the possible (or dense) reservoirs are characterized only as possibly oil-bearing with the corresponding parameter values.

Productive horizons	Characteristic of layer		Reservoir bed	
	reservoir	dense reservoirs	possibly oil-bearing	oil-bearing
Alexinsky	K_p > 8 %	K_p = 4-8 %	K_o = 25-70 %	K_o > 70 %
Kizelian, Cherepetskian	K_p > 8 %	K_p = 6-8 %	K_o = 40-60 %	K_o > 60 %
Ypinsky, Malevsky, Zavolzhskian	K_p > 8 %	K_p = 4,5-8 %	K_o = 40-60 %	K_o > 60 %

Table 1. The criteria for allocation of reservoirs in the carbonate section.

However, as stated above, saturation determination of carbonate reservoirs is complicated by deep penetration of washing liquid filtrate. The resistance values in such formations may be highly exaggerated. More efficient methods are required for allocation of oil and water-bearing strata in the carbonate section. Therefore, in determining saturation in reservoirs of Tournasian tier and Zavolzhskian horizon we adopted the so-called 'normalization method': the curves of gamma-ray and induced gamma-ray logging in water-saturated part are the same, and they differ in the intervals of oil reservoirs. During the final determination of oil and water saturation, except processed in logging software, we have to use all other available data.

On the basis of the correlation export data and re-interpretation of the logging results we built frames and designed three-dimensional geological models of two sites.

Plot No.1

For the plot No. 1 we digitized logging materials and performed detailed correlation of the Upper Devonian sediments (Zavolzhskian horizon) and the Lower Carboniferous (Upinian-Malevskian, Cherepetskian, Kizelian, Bobrikovian and Tulskian horizons) by 17 wells. Benchmark borders are obtained, establishing the nature of bedding in the studied section (Fig. 1). In the studied area the following objects are adopted as reference boundaries:

- The roof of Tulskian horizon – C_1tl;
- Carbonate formation – C_1tl-4;
- Carbonate formation – C_1tl-3;
- Roof of Bobrikovian – C_1bb;
- Roof of Tournaisian – C_1tr;
- Roof of Zavolzhskian - D_3zv.

Each horizon was divided into the following layers.

Tulskian horizon (C_1tl – roof of Tulskian horizon; C_1tl-4, C_1tl-3, C_1tl-2, C_1tl-1)

Characteristic features of Tulskian productive horizon are isolation and fragmentation of reservoirs in the section and laterally. The layers are separated by continuous clay and clay-carbonate formations that substantially indicate the absence of hydrodynamic communication between the layers. Oil-saturated reservoirs for industrial development in the wells section are absent for Tulskian horizon.

Bobrikovian horizon (C_1bb of the horizon roof; C_1bb-4, C_1bb-3, C_1bb-2, C_1bb-1)

After re-interpreting 17 wells, in Bobrikovian horizon C_1bb-4 we allocated clay oil saturated siltstones (K_p – 15.3%, K_{gl} = 3.7%, K_o = 78.5%).

Tournaisian tier (C_1tr- roof of tournaisian tier; C_1kz (Kizelian horizon), C_1chr (Cherepetskian horizon) and C_1upml (Upinian-Malevskian horizon);

Oil bearing of Kizelian horizon is proven in the oil-and-gas department Dzhalilneft is proven.

Structurally plot is confined to local uplifts (absolute elevation minus 875-880 m). Oil-saturated carbonates are allocated in 6 wells (K_p – 8.2%, K_{cl} – 0% and K_o – 77%).

It should be noted that when normalizing induction curve on induced gamma-ray curve we could observe increased

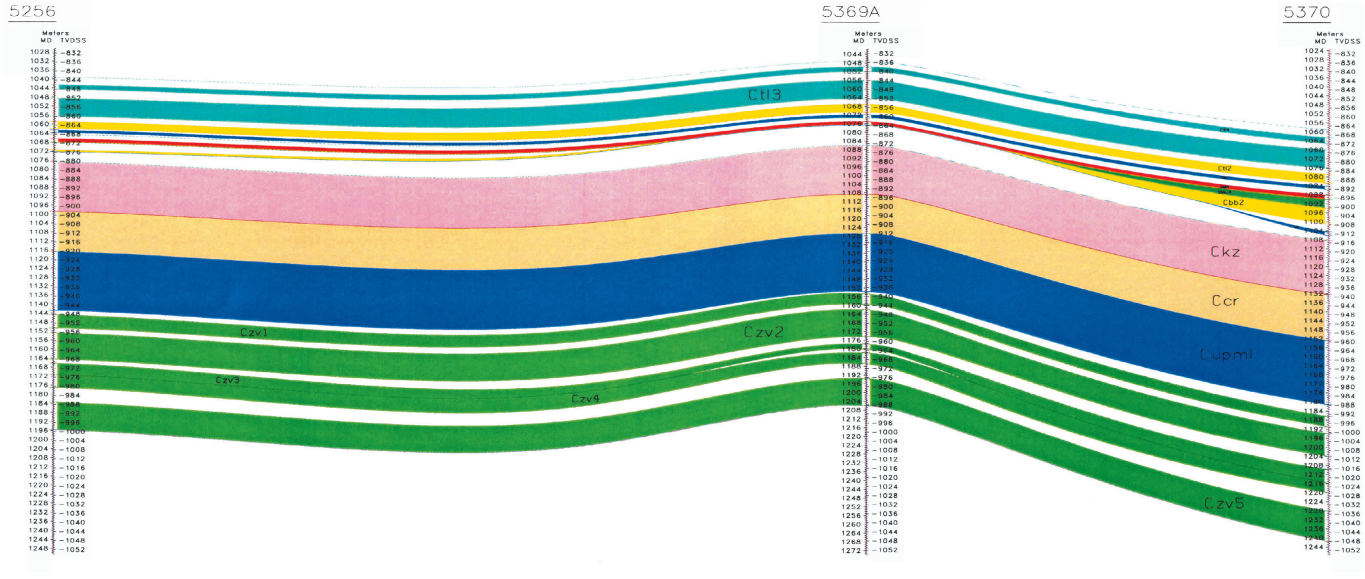

Fig. 1. Allocation of benchmark boundaries and bedding nature in wells of deposit No. 12.

induction curve, which is also one of oil-bearing signs in carbonate rocks.

Zavolzhskian horizon (D_3zv – top of Zavolzhskian horizon; D_3zv-1; D_3zv-2; D_3zv-3; D_3zv-4; D_3zv-5)

As can be seen from Fig. 2, there are two uplifts in the central (well 5369A) and northwestern (well 5256) parts of the plot.

On the basis of detailed correlations and logging data reinterpretation we calculated oil saturation, porosity, clay content in order to separate reservoirs in the Upper Devonian Zavolzhskian horizon. As mentioned above, in Zavolzhskian horizon we allocate 5 interlayers that are different in thickness, reservoir properties and saturation character. According to interpretation of geophysical data well 5369A, which is located in the dome, reservoirs D_3zv-2; D_3zv-3; D_3zv-4 are allocated.

Characteristics of the reservoirs from well 5369A are presented in Table 2.

Horizon	Layer	Thickness, m	K_p, %	Resistance, Om·m	K_o, %	Lithology	Saturation
Zavolzhskian	D_3zv-2	8,5	5,5	78,1	73,8	carbonate reservoir	oil
Zavolzhskian	D_3zv-3	1,8	5,8	61,5	70,4	carbonate reservoir	possibly oil
Zavolzhskian	D_3zv-4	4,9	7,2	103,9	81,8	carbonate reservoir	oil

Table 2. Characteristics of the reservoirs from well 5369A.

Horizon	Layer	Thickness, m	K_p, %	Resistance, Om·m	K_o, %	Lithology	Saturation
Zavolzhskian	D_3zv-2	10	7,1	76	56,5	carbonate reservoir	possibly oil
Zavolzhskian	D_3zv-4	7	7,2	82	53,9	carbonate reservoir	possibly oil
Zavolzhskian	D_3zv-5	7,3	7,4	70	54,3	carbonate reservoir	possibly oil

Table 3. Characteristics of the reservoirs from wells 5254.

According to logging reinterpretation on the considered structure reservoirs are allocated in carbonate rocks in well 5254 (D_3zv-2; D_3zv-4; D_3zv-5).

The maximum oil saturation coefficient is 56.5. Characteristics of the reservoirs from well 5254 are presented in Table 3.

Fig. 3 shows a grid pattern on the distribution of oil saturation. It is seen that the maximum values of oil saturation are confined to the dome local structure.

Thus, on the plot No. 1 oil reserves were discovered in Zavolzhskian horizon in wells 5369A and 5254, which are offered for testing.

Plot No.2

For plot No.2 we digitized logging materials, performed detailed correlation of the Upper Devonian (Zavolzhskian horizon) and the Lower Carboniferous (Upinian-Malevskian, Cherepetskian, Kizelian, Bobrikovian and Tulskian horizons) in 15 wells.

Analysis of reinterpreted geophysical data indicated the presence of reservoirs in Bobrikovian and Kizelian horizons similar to the plot No. 1.

Let us consider the geological and geophysical information according to re-interpretation and simulation of Upper Devonian Zavolzhskian horizon.

Analysis of the structural roof shows that in the northeastern part uplift is allocated in the area of well 1285 (absolute elevation – minus 948 m). In the central part of the plot (in the area of well 1376) through area is allocated (absolute elevation – minus 970 m).

On the basis of detailed correlation and logging data reinterpretation we calculated oil saturation factor, porosity, clay content in order to separate reservoirs in the Upper Devonian Zavolzhskian horizon.

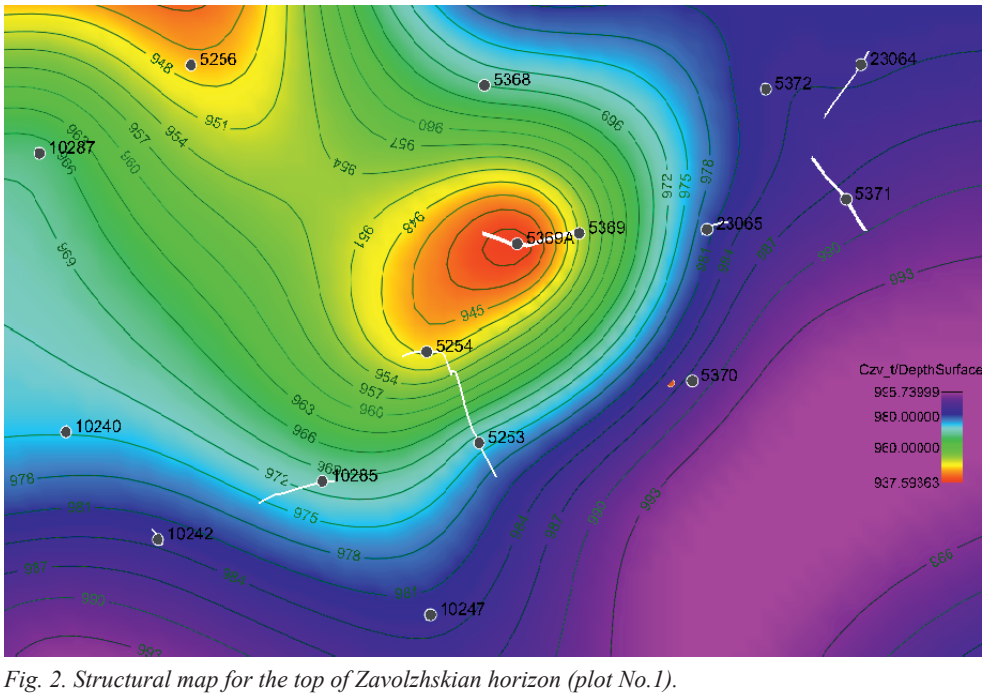

Fig. 2. Structural map for the top of Zavolzhskian horizon (plot No.1).

Analysis of the core material

We produced core sampling from the intervals of Zavolzhskian horizon in order to obtain improved values of reservoir properties and saturation character in neighboring drilled wells drilled in the considered area. Analysis of core samples showed that mostly formations are composed of limestone and dolomite with a few thin layers of marl, clay, siltstone, clay and anhydrite lenses, less – gypsum. Carbonate reservoir rocks lithologically are presented against with organogenic-detrital

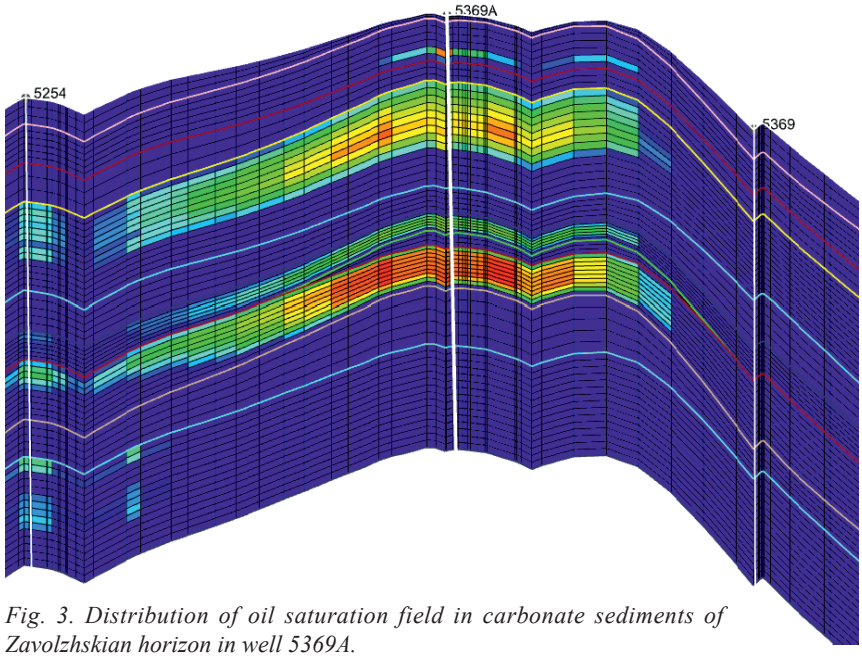

Fig. 3. Distribution of oil saturation field in carbonate sediments of Zavolzhskian horizon in well 5369A.

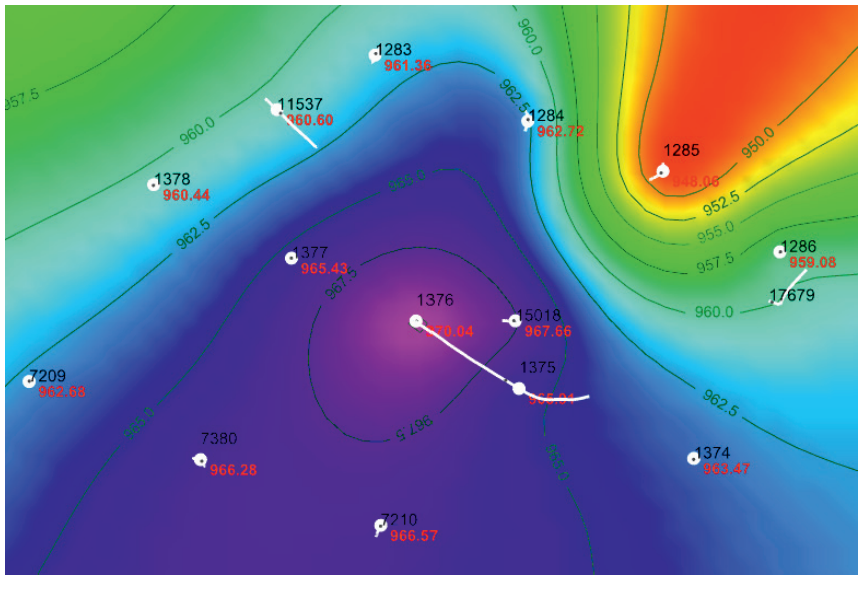

Fig. 4. Structural map for the top of Zavolzhskian horizon (plot No.2).

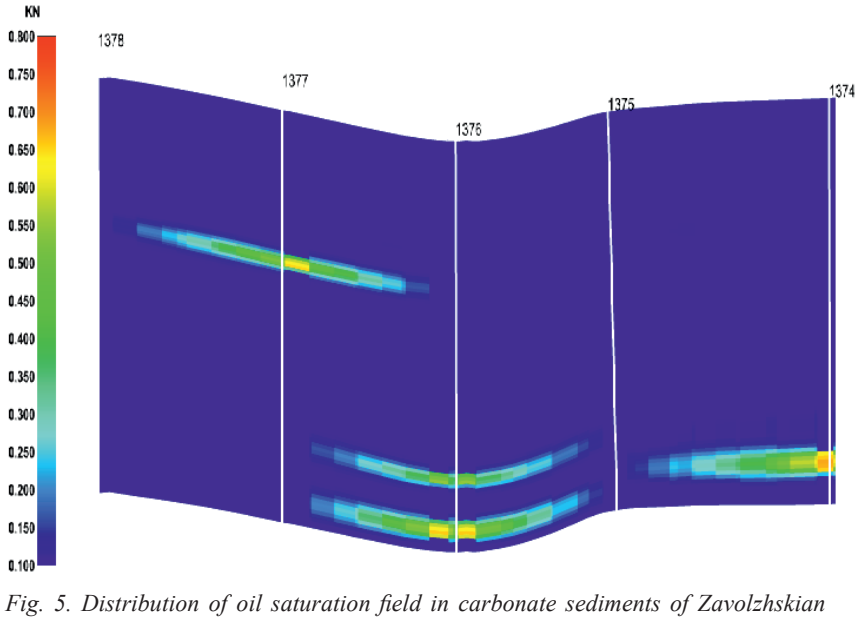

Fig. 5. Distribution of oil saturation field in carbonate sediments of Zavolzhskian horizon in well 1377.

limestone. The pore space structure is complex; there are all kinds of pores: recrystallized, leached, often with small cavern.

Study of microcracks on large thin sections revealed that openness of microcracks is not more than 20 microns, and the density of cracks is 10-100 t/m, increasing for separate interlayers to 300 t/m. Fracture permeability of Zavolzhskian deposits is up to 0.014 square microns. Fracture porosity is characterized by low values – 0.35%, for Zavolzhskian – 0.17%, and the average is 0.005-0.07%.

The average values of reservoir properties in the whole horizon is equal by porosity – 6.5%, permeability – 0.001 mm^2, oil saturation – 0.468.

In general by the results of detailed correlation, construction of geological models and analysis of core material we can make the following conclusions.

1. From the bottom up five reservoirs (D_3zv-1; D_3zv-2; D_3zv-3; D_3zv-4; D_3zv-5) are allocated in Zavolzhskian horizon.

2. Zavolzhskian horizon as a whole is alternation of permeable and dense varieties of carbonate rocks.

3. Carbonate reservoir rocks lithologically are presented with organogenic-detrital limestone.

4. Major oil deposits in carbonate sediments of Zavolzhskian horizon of the Upper Devonian Famennian stage are related to local structures.

5. Deposits of Zavolzhskian horizon are attributed to stratum-arched type.

To conclude the above stated, on a range of studies performed the authors suggested wells to test Zavolzhskian horizon in the territory of the deposit No. 12.

The nature of identified prospective formations is scattered and probably depends on the degree of exploration. To determine the distribution and nature of their occurrence it is necessary to further explore geological structure; the prospects of this direction is obvious.

Integrated interpretation of logging data and study of core material can significantly improve the efficiency of exploration tasks on the following well data:

- Allocation of reservoirs;
- Assessment of inflow from these wells;
- Forecast of yield opportunities;
- Calculation of oil and gas reserves.

References

Abdullin N.G., Badamshin E.Z., Muslimov R.Kh. Perspektivy poiskov nefti v karbonatnykh otlozheniyakh Tatarskogo svoda [Pospects for oil search in the carbonate sediments of the Tatar arch]. Kazan: Kazan Univer. Publ. 1982. 135 p.

Information about authors

Ildar S. Karimov – Deputy Head of Drilling and Well Productivity Increase Department, Reservoir Engineering Directorate, PJSC Tatneft

Russia, 423400, Almetyevsk, Lenin str. 75

Phone: +7(8553)307-032, e-mail: karimovis@mail.ru

Ilnur R. Mukhliev – Head of Geology Department

Oil and Gas Production Department «Dzhalilneft» PJSC Tatneft. Russia, 423368, Tatarstan Republic, Dzhalil, Lenin str. 2. Phone: +7(85559)60-273, e-mail: dn_ro@tatneft.ru

Lenar R. Sagidullin – Deputy Head of Geology Department.

Phone: +7(85559) 60-259, e-mail: dn_geo@tatneft.ru

Oil and Gas Production Department «Dzhalilneft» PJSC Tatneft. Russia, 423368, Tatarstan Republic, Dzhalil, Lenin str. 2

Ildar I. Bakirov – Head of Geological Modeling Sector, IT and Reservoir Simulation Department

Tatar Oil Research and Design Institute (TatNIPIneft) PJSC Tatneft

Russia, 423230, Tatarstan Republic, Bugulma, M.Jalil str. 32. Phone: +7(85594)789-41, e-mail: tanz@tatnipi.ru

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