LITHOLOGICAL AND MINERALOGICAL CHARACTERISTICS AND FORMING CONDITIONS OF THE JURASSIC SEDIMENTS ON THE WEST SIBERIAN BASIN

R.R. Khaziev, E.E. Andreeva, Yu.M. Arefiev, A.G. Baranova, S.E. Valeeva, L.Z. Anisimova, K.Yu. Goryntseva*

Institute for Problems of Ecology and Subsoil Use of Tatarstan Academy of Sciences, Kazan, Russia

Abstract. In the present work, lithological and mineralogical features, granulometric composition, as well as reservoir properties of the formation YuV1-1 of the Ety-Purovsky oil field are considered. It is established that the main rock-forming minerals of the reservoir – quartz, potassium feldspar and mica, also fragments of rocks, including carbonate rocks, are also found. Sandstone is diagnosed as carbonate greywack by the examined thin sections. According to the granulometry data, the formation is characterized as fine-grained sandstone with a dominant fraction of grains of 0.1-0.25 mm (47% of the total mass). According to the petrogenetic Passega diagram it was established that the formation was formed under the conditions of the gradation suspension generated in the lower parts of the fast river streams, directly at the bottom, which agrees with the literature data. Moreover, according to design factors (So, Q3, Q1), it is established that the formation is characterized by a poor degree of sorting of the sand material, as well as low roundness of grains and deteriorated reservoir properties, measured in laboratory conditions. It follows from the analysis that the reservoir is characterized by low productivity, and its development requires the use of hydraulic fracturing at an early stage of development.

Keywords: microscopic description of thin sections, granulometric composition, reservoir properties, hydraulic fracturing, oil-bearing formation, sand reservoir

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The Ety-Purovsky field is the largest of the fields developed by the Muravlenkovskneft-NNG branch of JSC Gazpromneft. According to the size of the initial recoverable oil reserves, the field belongs to the category of large, and by geological structure – to the category of complex fields. The field was discovered in 1978, it was put into industrial development in 2003. Currently it is in the third stage of development.

In the tectonic plan, the Ety-Purovsky field is confined to the Nadym-Tazov syneclise; controlled by a dome-shaped uplift – the Purov megaswell. The geological section of the field is represented by Jurassic, Cretaceous, Oligocene and Quaternary formations. The rocks of the Upper Jurassic and Cretaceous age are productive.

To study the material composition and generation conditions, the YuV1-1 formation was selected, confined to the Vasyuganskian suite of the Callovian stage of the Upper Jurassic. The choice of the development object was made based on the following facts: 1) 20% of the recoverable reserves are concentrated in the YuV1-1 formation; 2) the formation is characterized by considerable thickness (from 8 to 25 m in different parts of the field); 3) an acidic interval-wise fracturing was used on the YuV1-1 formation at the initial stage of field development in order to intensify the inflow of production wells (the average oil flow increased by 2-3 t/d on the wells).

The object of the study was a core material selected from a potentially productive interval. Samples were selected from 2 wells in the field in an amount of 6 pieces (from the roof, middle and bottom parts of the formation).

The study of the selected samples included:

1) Microscopic analysis of thin sections;
2) Granulometric analysis of core samples;
3) Investigation of the reservoir properties.

Microscopic analysis made it possible to establish that the sandstones of the YuV1-1 formation have a polymictic composition. The clastic material is represented by grains of quartz (about 30%), potassium feldspar (35-40%), biotite (5%); in a small amount

*Corresponding author: Evgenia E. Andreeva
E-mail: aee8277@rambler.ru

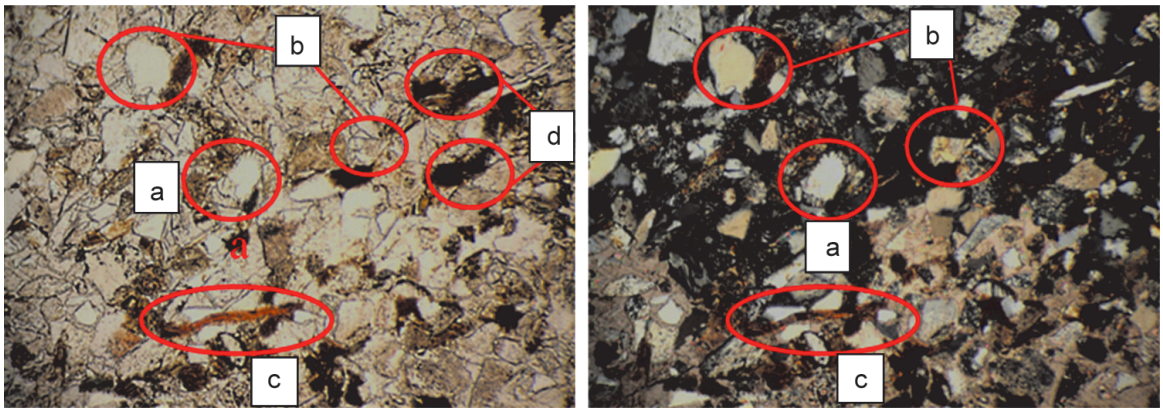

Figure 1. Photo of sample No. 1 thin section (well 1511, sampling depth 3320 m) a-quartz; b – potassium feldspar; c – biotite, d – carbonaceous organic

contains hornblende, muscovite and other minerals. Also there are fragments of carbonates. The shape of most grains is abnormal; the degree of their roundness is weak, the ratio of length to width is close to 1 (Figure 1). Cement is mainly contact-porous; and by the method of formation – cement of pores and voids is corrosive (cementation with partial dissolution of detrital material). The cement content averages 10-15% of the total volume of the thin sections. In all samples, carbonaceous vegetable organics are found everywhere (approximately 15% of the total sample). Thus, in terms of their mineralogical composition, the sandstones of the YuV1-1 formation refer to carbonate greywackes.

According to the granulometry data, the samples are distinguished in the granulometric composition typical for the YuV1-1 formation with the dominant fraction of 0.1-0.25 mm (~ 47% of the clastic part) (Table 1, Figure 2) characterizing the reservoir rocks as fine-grained sandstone.

To determine the transfer mechanism of terrigenous material, Passega genetic diagram was used (Frolov, 1992); the design parameters C and Md were used to determine the mechanism of sediment formation; Q3 and Q1 were used to evaluate the degree of sorting ($S_o = \sqrt{\frac{Q3}{Q1}}$). The values of the parameters are taken from the cumulative curves plotted from the granulometry data (Figure 3, Table 2).

As can be seen from the graph in Figure 4, the cloud of points distribution falls on the P-Q-R area corresponding to the field of the gradation suspension formed in the lower parts of the fast river streams, directly at the bottom. According to the literary data (Dopolnenie k proektu probnoy ekspluatacii..., 2005), the YuV1-1 formation was formed in delta conditions in the territory of the field. As noted in (Frolov, 1992), a good or average degree of sorting is characteristic for sandstones formed under such conditions. The data of the calculated sorting factor confirm this.

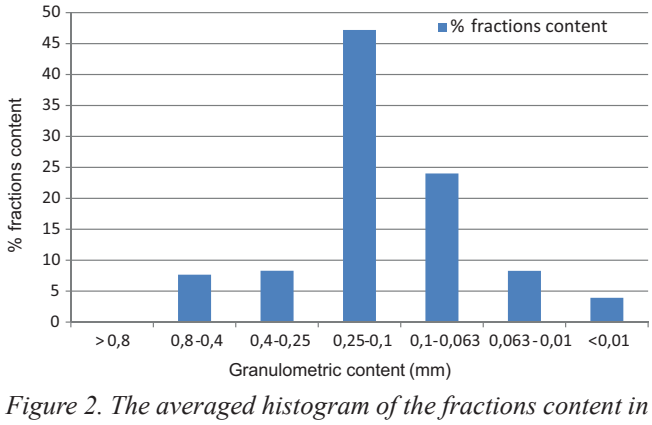

Figure 2. The averaged histogram of the fractions content in the YuV1-1 formation

No. sample	Fraction, mm							
	> 0,8	0,8 - 0,4	0,4 - 0,25	0,25 - 0,1	0,1 - 0,063	0,063 - 0,01	< 0,01	∑ %
1	-	2,28	5,93	45,49	28,78	11,61	5,04	99,13
2	-	8,04	8,59	44,94	24,94	10,29	2,53	99,33
3	-	5,9	7,17	53,1	22,48	6,68	4,51	99,84
4	-	9,1	8,2	44,1	24,9	8,18	5,13	99,61
5	-	14,53	12,04	45,1	19,06	5,79	2,65	99,17
6	-	6,13	7,85	50,49	23,93	7,17	3,66	99,23
Average	0	7,63	8,29	47,2	24,02	8,28	3,2	99,38

Table 1. Data of the granulometric composition of samples No 1-6 of the YuV1-1 formation

No. sample	C, μm	Md, μm	Q3,μm	Q1, μm	So	Degree of sorting
1	300	110	180	60	1,73	Average
2	530	120	240	75	1,78	Average
3	410	140	220	75	1,71	Average
4	560	140	240	70	1,85	Average
5	680	160	260	90	1,69	Average
6	460	140	220	70	1,77	Average

Table 2. Calculation parameters for determining the mechanism of sediment formation and grain sorting

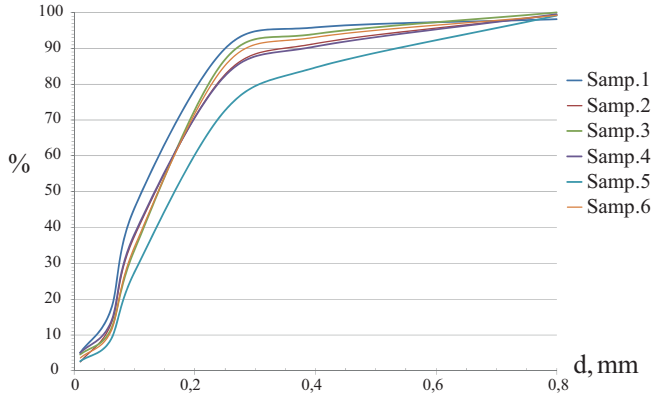

Figure 3. Cumulative curves of samples No.1-6 of the YuV1-1 formation

No. sample	Kpor(%)	Kper(mD)	Category of reservoir (According Khanin)
1	11	7,3	4
2	8	1,2	5
3	12	10,7	4
4	16	2,4	5
5	15	10,5	4
6	5	0,9	6

Table 3. Reservoir properties of the YuV1-1 formation

Under laboratory conditions, reservoir properties were measured for all 6 samples: porosity and permeability coefficients. The results are shown in Table 3.

As can be seen from Table 3, according to the Khanin's classification of reservoirs (Burlin, 1976; Gimatutdinov et al., 1982), sandstones belong to the 4-6 categories and are estimated as "low productive". Obviously, in view of the deteriorated reservoir properties, the productive formation already at the initial stage of development was characterized by a small amount of recoverable reserves and, as a consequence, a low rate of oil extraction. This circumstance, most likely, was one of the main reasons for applying the mechanical method for intensifying production at the initial stage of development.

Conclusions

Based on the above data, the authors draw the following conclusions:

1) Polymictic carbonate greywackes, fine-grained, medium-sorted are the main type of reservoir rocks. Experience of works (Shvanov, 1987; Frolov, 1992; Yezhov, 2009; Nedolivko et al., 2011) shows that feldspars are subject to the process of pelitization, which,

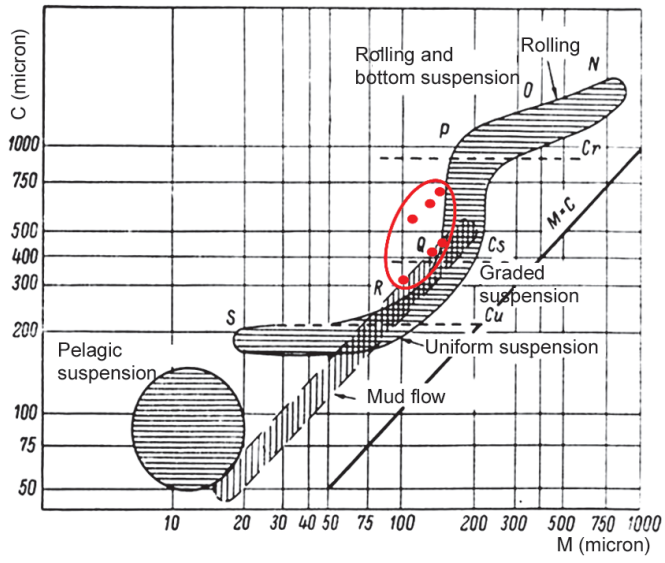

Figure 4. Passega diagram (Frolov, 1992) for determining the mechanism of sediment formation

in turn, is accompanied by a deterioration of reservoir properties (reduced open porosity and permeability).

2) It has been established that all samples are characterized by an average degree of sorting by granulometric analysis and comparison with a general sampling of data from literature sources; taking into account the fact that roundness of grains is characterized as low according to the study of thin sections, the YuV1-1 formation should be considered low-productive.

3) According to Khanin's classification, the formation is characterized as low-productive. This entails certain difficulties in the development of recoverable reserves by conventional methods. Development of such formations is carried out using hydraulic fracturing. Hydraulic fracturing is most often used at later stages of development of oil fields (Zhdanov, 2008) with the aim of increasing the inflow of production wells or increasing injectivity of injection wells. However, as the results of the studies showed, the application of hydraulic fracturing may be justified at the early stages of oil field development due to lithological features, degraded reservoir properties and, as a result, low productivity of the reservoir.

References

Burlin Y.K. Natural reservoirs of oil and gas. Moscow: Mosc. University Publ. 1976. 135 p. (In Russ.)

Gimatutdinov S. K., Shirokovsky A. I. Physics of oil strata. Moscow: Nedra. 1982. 311 p. (In Russ.)

Ezhova A.V. Lithology. Tomsk: Tomsk Polytechnic University Publ. 2009. 336 p. (In Russ.)

Zhdanov S.A. Experience of enchanced oil recovery methods application in Russia. *Oil industry*. 2008. No. 1. Pp. 58-61. (In Russ.)

Nedolivko N.M, Ezhova A.V. Petrographic studies of terrigenous and carbonate reservoir rocks. Tomsk: Tomsk Polytechnic University Publ. 2011. 172 p. (In Russ.)

Dopolnenie k proektu probnoy ekspluatacii Ety-Purovskogo gazoneftyanogo mestorozhdeniya [Supplement to the pilot project of Yety-Purovsky oil and gas field development]. Research report. GeoNATs OAO «Sibneft-Noyabrskneftegaz». Ed. Talipova I.M. Noyabrsk. 2005. (In Russ.)

Frolov V.T. Lithology. B.1. Moscow: MSU Publ. 1992. 336 p. (In Russ.)

Shvanov V.N. Petrography of sand rocks (composition, classification and description of mineral types. Leningrad. 1987. 269 p. (In Russ.)

About the Authors

Radmir R. Khaziev – Researcher, Laboratory of Geological and Environmental Modeling, Institute for Problems of Ecology and Subsoil Use of Tatarstan Academy of Sciences
28 Daurskaya St., Kazan, 420087, Russia

Evgenia E. Andreeva – Senior Researcher, Laboratory of Geological and Environmental Modeling, Institute for Problems of Ecology and Subsoil Use of Tatarstan Academy of Sciences
28 Daurskaya St., Kazan, 420087, Russia
Phone: +7 843 298 59 65, e-mail: aee8277@rambler.ru

Yuri M. Arefiev – Senior Resercher, Laboratory of Geological and Environmental Modeling, Institute for Problems of Ecology and Subsoil Use of Tatarstan Academy of Sciences
28 Daurskaya St., Kazan, 420087, Russia

Anna G. Baranova – Senior Resercher, Laboratory of Geological and Environmental Modeling, Institute for Problems of Ecology and Subsoil Use of Tatarstan Academy of Sciences
28 Daurskaya St., Kazan, 420087, Russia

Svetlana E. Valeeva – Reserchers, Laboratory of Geological and Environmental Modeling, Institute for Problems of Ecology and Subsoil Use of Tatarstan Academy of Sciences
28 Daurskaya St., Kazan, 420087, Russia

Lilia Z. Anisimova – Reserchers, Laboratory of Geological and Environmental Modeling, Institute for Problems of Ecology and Subsoil Use of Tatarstan Academy of Sciences
28 Daurskaya St., Kazan, 420087, Russia

Ksenia G. Goryntseva – Junior Reserchers, Laboratory of Geological and Environmental Modeling, Institute for Problems of Ecology and Subsoil Use of Tatarstan Academy of Sciences
28 Daurskaya St., Kazan, 420087, Russia

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