

PAPER • OPEN ACCESS

## Research of oil-based drilling fluids to improve the quality of wells completion

To cite this article: M.V. Nutskova *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **666** 012065

View the [article online](#) for updates and enhancements.

You may also like

- [Influence of size and surface acidity of silica nanoparticles on inhibition of the formation damage by bentonite-free water-based drilling fluids. Part II: dynamic filtration](#)

Johanna Vargas Clavijo, Leidy J Roldán, Laura Valencia et al.

- [Synthesis and Characterization of a Cationic Micro-crosslinking Polymer and its Application as a Fluid Loss Reducer in Water-based Drilling Fluids](#)

Zhong-yi Wang, Jin-sheng Sun, Shui-xiang Xie et al.

- [A study on the measurement method of a two-component fluid proportion infrared spectrum based on HDC-PSAM](#)

Haibo Liang, Fenglong Luo, Jinhong Guo et al.



**ECS**  
The  
Electrochemical  
Society  
Advancing solid state &  
electrochemical science & technology

**DISCOVER**  
how sustainability  
intersects with  
electrochemistry & solid  
state science research

# Research of oil-based drilling fluids to improve the quality of wells completion

**M.V. Nutskova<sup>1</sup>, K.S. Kupavykh<sup>1</sup>, D.A. Sidorov<sup>1</sup>, V.A. Lundaev<sup>1</sup>**

<sup>1</sup>Saint- Petersburg Mining University, 21-ya Liniya Vasil'yevskogo Ostrova, 2, Saint-Petersburg, 199106, Russian Federation

E-mail: Nutskova\_MV@pers.spmi.ru

**Abstract.** The aim of the work is to increase the well completion efficiency when using oil-based drilling fluids. In this study, the effect of the aqueous phase content on the change in the rheological parameters of the solutions and the effect of the type of asphalt on the structural-rheological and filtration parameters of the oil-based solution was conducted. Studies have shown the effectiveness of various types of asphalt in OBM systems, the obtained dependencies on the effect of the Oil-water ratio can be used in production to select the optimal ratio for the selection of specific properties of solutions.

**Keywords.** Well drilling, flushing, complications, laboratory tests, rheology, plastic viscosity, conditional viscosity, synthetic asphalt, gilsonite, hydrocarbon-based solutions, emulsion solutions, structure formation, reservoir, filtration, density.

## Introduction

The international experience in wells construction shows that there is a dependence of subsequent operations on wells drilling and completion efficiencies. Wells drilling quality is largely dependent not only on a tool used, but also on a drilling technology, which includes washing processes. The washing processes are linked with a type and quality of drilling fluids [10,17,19,26]. The hydrodynamic pressure at the bottom of a well should be maintained at the reservoir level or slightly below it. The latter case there is a likelihood of gas and oil showings occurrence, which must be equipped with a sealed drilling system with wellhead equipment wells rotating preventer. It is done in order to preserve the bottomhole formation zone properties during the initial opening of the productive horizon. When drilling with a hydrodynamic pressure exceeding the reservoir pressure, the probability of contamination of the bottomhole formation zone increases. It especially happens when using solutions with an insoluble finely dispersed solid phase, which can penetrate deep into the formation [1-4].

The reservoir can restore its permeability during well operation by cleaning the near-wellbore zone. This applies only to highly permeable reservoirs. That phenomenon is not observed when using traditional methods with medium or low permeabilities. Hence, in order to avoid the bottomhole formation zone contamination, the choice of a washing fluid for the initial opening of the productive horizon should be done correctly. It can prevent the possibility of deep penetration of its filtrate into the formation at the moment of repression, especially at the cementing stage [11,15,23,33,].

Currently, a number of solutions are used for the initial opening of productive layers with different permeability recovery coefficient [9,27,34]. The clay-based muds with weighting agents (for drilling under conditions of abnormally high reservoir pressures) have the lowest coefficient value - not more than 0.05-0.1; for aluminate solutions - 0.2-0.4; clayless polymer solutions based on salt water have coefficient values of 0.2-0.4. The coefficient of permeability recovery for biopolymer solutions is about 0.3-0.45; for water-based solutions of various mineralization - 0.45-0.85; at the opening of productive layers with foams - around 0.5. Hydrocarbon-based solutions (OBM) have the highest rate. For them, the coefficient value is of the order of 0.6-0.9.

It is important to take into consideration, when assessing the quality of solutions of one type or another that are in contact with the reservoir, used for the opening of productive layers, then one should pay attention to the following features (Morenov and Leusheva, 2017):



the presence of an emulsified aqueous phase in a hydrocarbon-based solution and the degree of its mineralization (it characterizes the possible degree of clay particles swelling, when it interacts with the aqueous phase of a hydrophobic emulsion solution if its phases are reversed);

- compliance of the granulometric composition of the solid phase of the washing liquid with the structure of the pore space in order to minimize the deep clogging of the reservoir;
- minimum filtration flow rate of process fluids used in the completion of wells.

Low-permeable formations are mostly polluted during drilling while opening of the repressive layers, especially when using water-based solutions with a fine solid phase. Therefore, for medium-permeable and low-permeable reservoirs, it is preferably to use solutions with a low solids content, foam systems and oil-based solutions [12,14,18,29].

In addition, when drilling directional wells, including those with horizontal ends, as well as during sidetracking, there is an urgent need to maintain the wellbore stability, to bring the load on the rock-breaking tool, and also to reduce the friction of the drill string against the borehole wall [4,13,28,31]. One of the tools that promote trouble-free driving in directional and horizontal sections is the use of drilling fluid systems with minimal friction coefficients [5-7, 21]. The most effective solutions in this are also oil-based solutions.

### **Materials for the preparation of OBM**

Such non-polar liquids as oil and products of its processing, synthetic hydrocarbons can be used as the dispersion medium of the OBM. The suitability of a particular material is assessed both by its physicochemical properties and the technological properties of OBM, which are based on them [16, 20, 36].

When selecting a hydrocarbon phase, it is necessary first of all to check its flash point. In accordance with the Safety Regulations in the oil and gas industry, the flash point of the prepared hydrocarbon-based solution should exceed the maximum expected solution temperature at the wellhead by 50 °C. The flash point temperature of an OBM is significantly higher than that of the original hydrocarbon medium. However, when choosing it, fire safety must also be taken into account at its initial preparation stage. Serious attention is paid to the toxicity of hydrocarbons, and the maximum permissible concentration of their vapors in the area of working personnel should not exceed the established rate [22,23].

Oil is the most affordable and cheap variant of an OBM dispersion medium. At present, oil has a limited use in thickened form as a process fluid for various processes (killing, perforation) in shallow low-temperature wells.

Diesel fuel is a product of oil refining that has received the most widespread use as the hydrocarbon phase of an OBM. The state of the colloidal components of an OBM, the degree of their association is determined by the content of aromatic and paraffin hydrocarbons in the dispersion medium. However, all brands of diesel fuels have approximately the same physico-chemical characteristics: the amount of tar is in the range of 40-50 mg per 100 cm<sup>3</sup> of fuel; density is 0.83-0.85 g/cm<sup>3</sup>; viscosity is 4.0-6.0 centipoise, which allows you to withstand the developed OBM formulations in different regions.

Mineral oils combine a group of refined petroleum products with a low content of aromatic hydrocarbons, which represent the most environmental hazard. The positive quality of mineral oils is their best removability from the surface of drill cuttings particles (residual amount of 5-6% versus 16-17% for diesel fuel) [32].

Synthetic hydrocarbons are a dispersion medium of a new generation of low-toxic solutions on a non-aqueous basis, which are an ecological alternative to OBM, allowing them to realize their advantages in areas with increased requirements for environmental protection.

Organophilic clays are formed as a result of modifying clay materials with organic ammonium salts and are widely used as effective additives to oils, paints and lubricants, as active fillers for plastics and rubbers, as well as for the preparation of OBM.

Highly oxidized oil bitumen is a product of air oil oxidation by air oxygen. The advantage of bitumen as a formative agent is that, being naturally organophilic, it does not require treatment with wetting agents and water repellents.

The aqueous phase is the main component of hydrophobic-emulsion solutions (HES), which determines its viscosity, structural and filtration properties. No less significantly on the properties of HES affects its qualitative composition [33].

Fine-dispersed fillers are mainly intended for stabilizing suspension and emulsion OBMs and regulating filtration.

Calcium oxide is quicklime obtained by burning thin clay limestone. It is used in most OBM formulations as a starting product for the production of active filler  $\text{Ca}(\text{OH})_2$ , which is formed by the interaction of calcium oxide with water.

Calcium carbonate (chalk, marble crumb, calcite) - is used as an active filler and weighting of OBM up to a density of 1.22-1.24 g/cm<sup>3</sup>. Dry fine calcium carbonate is a good adsorbent of surfactant and hydrophobic components of the hydrocarbon environment, acquires oleophilic properties, which ensures its function as a stabilizer and filtration substitute. Calcium carbonate is used in a number of HES formulations in the case of primary, secondary dissection of productive strata and well plugging to increase the recovery coefficient of the bottomhole penetrability zone.

For weighting of OBM, the same materials are mainly used as in water systems: barite weighting compounds (density 4.3-4.7 g/cm<sup>3</sup>), carbonate weighting agents (limestone - 2.7 g/cm<sup>3</sup>; dolomite - 2.8-2.9 g/cm<sup>3</sup>; siderite - 3.8-3.9 g/cm<sup>3</sup>). To increase the density of the solution in the intervals of productive layers, it is advisable to use carbonate weighting agents, since they are acid-soluble, and therefore the harmful effect of clogging of the productive layer can be partially solid eliminate with acid treatments.

When solving various technological problems, OBM can contain various special fillers that have a significant impact on their technological properties. Such additives include materials to reduce the density of OBM and prevent absorption of the solution [35].

The use of OBM when opening highly permeable highly drained fractured productive formations or killing wells under similar conditions with abnormally low reservoir pressures can lead to the absorption of the solution. It is impossible to obtain high-quality OBM with a density below 0.86-0.87 g / cm<sup>3</sup> without special lightening additives. Increasing the number of lightening additives leads to an increase in viscosity and structural indicators of OBM properties [14,24,25].

Surface-active substances (surfactants) include those organic compounds whose molecules contain both a polar group and a non-polar hydrocarbon chain. Surfactants play a huge role in the OBM. Even small additives of special reagents (0.25-0.5%) can completely change the properties of an OBM agent. It is the surfactant complex used in OBM formulations that determines their aggregative and sedimentation stability of the solution, resistance to aggressive factors, controls the processes of solvation of the dispersed solution phase.

As part of the OBM surfactant perform the following functions [8,18,29,30,37].

- Emulsifiers (basic and optional). These are oil-soluble metallic soaps of organic acids, oil-soluble oxyethylated derivatives of organic acids, esters, amines, amides, imido silins, polyamides with an oligomeric structure, esters of fatty acids, amino alcohols, etc.
- Structural builders. This group of surfactants includes compounds that can intensify coagulation structural formation when introduced into a stable reverse emulsion: water-soluble oxyethylated alkyl phenols of type OP-10 and neonol 6-90, disolvan-4411, sulfonol NP-3, etc.
- Water repellents. These surfactants enhance the degree of affinity of the dispersed phase of the OBM to the hydrocarbon dispersion medium, protecting it from hydrophilic flocculation. As part of the HES, these surfactants often complement the action of the main emulsifiers, acting as emulsion stabilizers.
- Viscosity reducers. They allow, due to the adsorption blocking of particles of the dispersed phase, to significantly increase the volumetric filling of its system without damage to the technological properties.

### Investigation of the properties of hydrocarbon-based solutions

Hydrocarbon based solutions used in the drilling of most wells are expensive systems, usually of foreign manufacture. In this paper, studies were conducted using reagents of domestic production in order to assess the influence of the component composition on the technological properties of the solutions obtained. Experimental studies were conducted in the laboratories of the department of drilling wells at the University of Mines. The composition of the solution includes the following reagents:

- mineral oil - dispersion medium;
- surfactant-emulsifier, water-repellent surface solid phase, reducing the interfacial tension at the interface "oil-water", as well as acting as a coagulation structure-forming agent. As a water repellent, it improves the temperature and rheological stability of the emulsion (Yanovskiy et al., 2018)
- calcium oxide - to regulate alkalinity and as a source of calcium to neutralize carbon dioxide and hydrogen sulfide;
- surfactant - wetting agent, to enhance coagulation structure formation when introduced into hydrocarbon-based solutions;

organophilic bentonite for structure formation and providing the necessary viscosity, high heat resistance, electrical stability, as well as a decrease in filtrational return;

- barite and calcium carbonate of different fractional composition as a plug-in and weighting agent;
- calcium chloride - to increase the stability of the borehole walls in clay sediments;
- gilsonite – as a filtering reducer.

The formulation of the drilling fluid, taken as the base for research, is shown in Table 1.

**Table 1.** Basic component composition

Name of reagent	Appointment in solution	Consumption, g (ml *) / l of solution
Mineral oil	Mineral oil	700*
CaO	Нейтрализатор CO <sub>2</sub> , CO <sub>3</sub>	35
Water	Aqueous phase	583*
CaCl <sub>2</sub>	Inhibitor	82
Surfactant-emulsifier	Emulsifier, water-repellent	29
Surfactant wetting agent	Wetting agent, structurant	12
Gilsonit	Water Loss Reducer	6
Barite	Weighting	350
CaCO <sub>3</sub>	Colmatant	117
Bentonite	Builder	12

To assess the impact of a HC / H ration the technological properties of the solution, 7 solutions with hydrocarbon ratios from 55/45 to 85/15 were studied. Solutions were prepared on a Hamilton Beach laboratory mixer with a stirring speed of 12,000-14,000 rpm. The temperature of measurements of rheological parameters is  $50 \pm 2$  ° C. The results of laboratory measurements of the properties of drilling fluids are presented in table 2.

**Table 2.** The obtained parameters of the solutions

Measured parameter	Units Sequence	Number						
		1	2	3	4	5	6	7
Oil-water ratio	%	55/45	60/40	65/35	70/30	75/25	80/20	85/15
Viscosity	s	33,2	40	80	370	216	152	120
Plastic viscosity	mPa*s	21	33,5	63	68	63	61,5	48,5
Dynamic shear stress	Pa	5	6,5	9,5	29	29	24,5	20,5
Static shear stress 10 s	Pa	4	4	8	18	18	12	9
Static shear stress 10 min	Pa	4	4,5	7	17	18	13	10
Actual density	g/cm <sup>3</sup>	1,17	1,22	1,25	1,28	1,27	1,29	1,29
Estimated density	g/cm <sup>3</sup>	1,22	1,24	1,26	1,28	1,28	1,3	1,32

Analysis of the results of laboratory studies showed that with a decrease in the amount of water, the conditional viscosity, plastic viscosity, dynamic shear stress, static shear stress increase to a certain value, which manifests itself as an obvious maximum (Oil-water ratio = 70/30), with a further increase in the ratio these properties. This can be explained by the chemical nature of the resulting compositions - it is assumed that with a high water content (from a ratio of 55/45 to 65/35), a lack of surfactants for emulsifying free water and wetting the solid phase can be noted; with a decrease in the amount of water (up to a ratio of 70/30) with a constant number of other components, the system goes into an optimum state - the emulsion stabilizes due to the work of the surfactant in an amount sufficient to keep the solid particles in suspension and preserve the emulsion; a further decrease in the amount of water leads to a decrease in the rheological characteristics of the system due to the fact that the hydrocarbon medium, which is less and less “thickened” with water, has the main influence on the rheology. In addition, the same trend is observed in the density of the compositions, but this can be associated with air entrainment when mixing the compositions. However, to obtain an unambiguous confirmation of the hypothesis, it is necessary to conduct additional rheological studies aimed at assessing the effect of the Oil-water ratio on the properties of the system with other component components.

#### Experimental study of the effect of using asphalt as a filtering reducer in an OBM

To assess the effect of the asphalt type (the appearance is shown in Fig. 1) on the technological characteristics of the OBM, a base solution was studied with the types of asphalt:

- Solution 1. TDM natural (natural) asphalt;  
 Solution 2. Synthetic asphalt grade B (SinAsfalt B)  
 Solution 3. Synthetic asphalt (SinAsfalt)  
 Solution 4. Sulfonated asphalt;  
 Solution 5. Base solution without asphalt.



**Figure 1.** The appearance of the investigated asphalt

This paper presents the results of laboratory studies (Table 3) of the rheological properties of hydrocarbon-based solutions, measurements of rheological parameters were carried out before heating (at 25 ° C) and after heating to 90 ° C (melting point of synthetic asphalt - 80-85 ° C).

Entering gilsonite leads to an increase in conditional and plastic viscosity, but after heating these raststor to 90 ° C, natural asphalts (natural and sulphated) increase the conditional viscosity of the solution (compared to the base solution), since they begin to create a structure, and synthetic (synasphalt and synasphalt B) show a decrease in viscosity due to their melting.

Enter gilsonita leads to the fall of the Dynamic shear stress (DSS). At the same time, after heating to 90 ° C, a solution with a natural asphalt of the TDM brand shows an increase in the dynamic shift compared to tests at room temperature. The introduction of asphalt has no significant effect on static shear stress.

**Table 3.** The results of studies of the properties of drilling fluids depending on the type of asphalt

Measured parameter	Units of measurement	Natural Asphalt		SinAsfalt grade B		SinAsfalt		Sulfated asphalt		Without asphalt	
		before heating	after heating	before heating	after heating	before heating	after heating	before heating	after heating	before heating	after heating
Viscosity	s	108	98	128	70	80	57	80	112	60	85
Plastic viscosity	mPa s	49	67	56	49	63	48	59	42	55	42
Dynamic shear stress	Pa	2	11	6	2	9	2	9	3	15	10
Static shear stress 10 s	Pa	4	4	2	2.5	4	4	4	2	4	4
Static shear stress 10 min	Pa	4	2.5	2	2.5	4	4	4	2	3.5	4
Filtration	cm <sup>3</sup>	3.9	4.6	3.6	2.4	4	3.6	4.1	6.4	3.2	3.2
Peel thickness	mm	1.6	2.5	1.7	2	1.7	1.3	1.5	1.7	1.28	1.2

The introduction of asphalt without heating leads to an increase in the volume of the filtrate (Table 4), but after heating these solutions to 90 ° C, the volume of the filtrate decreases significantly, as a physical bond with permeable rocks is formed, creating an effective crust to prevent penetration of the drilling mud and its filtrate in reservoir.

**Table 4.** Results of filtration studies of solutions

Type of asphalt in the composition of the solution	Time, min					
	1	5	7,5	10	15	30
	The volume of filtrate, ml					
TDM natural asphalt	0.7	1.6	2.0	2.3	2.8	3.9
Sinasfalt, mark B	1.8	1.5	1.8	2.1	2.5	3.6
Sinasfalt	1.9	1.5	1.8	2.1	2.5	3.6
Sulfonated asphalt	2.2	1.7	2.1	2.4	3.0	4.2
Without asphalt	1.6	1.3	1.6	1.8	2.3	3.2

The rate of filter recovery is often the most important property of the drilling fluid, especially when drilling permeable formations where the hydrostatic pressure exceeds the formation pressure. Proper filtering control can prevent or minimize sticking of drill pipes, and in some areas improve wellbore stability. As a rule, large volumes of filtrate are associated with a thick filtration cake, because the sediment is formed by the deposition of clay particles on the walls of the well during the loss of filtrate into the formation. Thus, the higher the filtrate volume, the thicker the filter cake and the less effective the drilling mud. Studies have shown that at high temperatures and pressures, an OBM without asphalt has the highest instant filtration compared with other compounds. In general, studies have shown that the use of synthetic asphalt as a fluid loss reducer is appropriate.

### Conclusions and recommendations

Analysis of the laboratory studies results has shown that the effect of the Oil-water ratio has a significant impact on the technological parameters of OBM. However, a significant set of experimental studies with various reagents is advisable to be conducted in order to obtain such dependencies, which can make an unambiguous decision on the component composition.

There are solution losses occur in the reservoir during drilling with OBM. The losses occur in cavernous rocks, and in natural or in artificially formed fractures in permeable and low permeable horizons. However, it is possible to solve the problem by using of asphalt (including synthetic), which is currently not widely used in drilling.

### References

- [1] Ashcheulov A, Nikitin S & Khoroshanskay A 2015. Statistical research of drilling rig's top drive stress loading. *International Journal of Applied Engineering Research*, 10(19), 40021-40026.
- [2] Ashcheulov A. V, Shestopalov A A, Khoroshansky A E & Kochetkov A V 2015. Performance characteristics of drill rigs with a top-drive system. *Chemical and Petroleum Engineering*, 51(1), 94-99. doi:10.1007/s10556-015-0006-3
- [3] Ashcheulov A V, Shestopalov A A & Lobachev A A 2016 Analysis of dynamic load capacity of the top drive of drilling rigs. *Chemical and Petroleum Engineering*, 52(3-4), 167-173. doi:10.1007/s10556-016-0169-6
- [4] Bakirov D L, Babushkin E V, Fattakhov M M, Malyutin D V 2016 Povysheniye effektivnosti bureniya mnogoazaboynykh skvazhin za schet primeneniya rastvorov na uglevodorodnoy osnove [Improving the efficiency of drilling multilateral wells due to the use of hydrocarbon-based solutions]. *Neftyanoye khozyaystvo*, no. 8, 28-30.
- [5] Blinov P A, Dvoynikov M V 2016 The process of hardening loose rock by Mud Filtrat. *International Journal of Applied Engineering Research*, 11 (9), 6630-6632.
- [6] Blinov P A, Dvoynikov M V 2018 Rheological and filtration parameters of the polymer salt drilling fluids based on xanthan gum. *Journal of Engineering and Applied Sciences*, 13 (14).
- [7] Blinov P A, Dvoynikov M V, Sergeevich K M, Rustamovna A E 2017 Influence of mud filtrate on the stress distribution in the row zone of the well. *International Journal of Applied Engineering Research*, 12 (15), 5214-5217.
- [8] Blinov P A, Podoliak A V 2016 The method of determining the effects of drilling fluid on the stability of loose rocks. *International Journal of Applied Engineering Research*, 11 (9), 6627-



6629.

- [9] Brunman V E, Vataev A S, Volkov A N, Volkov E A, Petkova A P, Kochanzhi F I & Plotnikov D G 2017 Energy-efficient oil extraction by sucker rod borehole pumps in low-yield fields. *Russian Engineering Research*, 37(5), pp. 378-382. doi:10.3103/S1068798X17050082
- [10] Dvoynikov M V 2017 Issledovaniya tekhniko-tekhnologicheskikh parametrov bureniya naklonnykh skvazhin [Studies of technical and technological parameters of drilling of inclined wells]. *Zapiski Mining Institute*, Vol. 223, pp. 86-92.
- [11] Dvoynikov M V, Blinov P A 2016 Analysis of incident causes while directional and horizontal wells drilling. *International Journal of Applied Engineering Research*, 11 (20), 10039-10042.
- [12] Dvoynikov M V, Blinov P A 2016 Survey results of series-produced downhole drilling motors and technical solutions in motor design improvement. *International Journal of Applied Engineering Research*, 11 (10), pp. 7034-7039.
- [13] Dvoynikov M, Syzrantsev V, Syzrantseva K 2017 Designing a high resistant, high-torque downhole drilling motor. *International Journal of Engineering, Transactions A: Basics*, 30 (10), pp. 1615-1621.
- [14] Garshina O V, Khvoshchin P A, Kuznetsova O G, Kudimov I A, Okromelidze G V 2011 Razrabotka, opyt primeneniya i perspektivy povtornogo ispol'zovaniya invertno-emul'sionnykh burovnykh rastvorov [Development, application experience and prospects for reuse of invert-emulsion drilling fluids]. *Neftyanoye khozyaystvo*, no. 10, pp. 56-59.
- [15] Kamenskih S, Ulyasheva N, Buslaev G, Voronik A & Rudnitskiy N 2018 Research and Development of the Lightweight Corrosion-Resistant Cement Blend for Well Cementing in Complex Geological Conditions. *Society of Petroleum Engineers*. doi:10.2118/191509-18RPTC-MS
- [16] Konesev V G, Khomutov A YU 2016 Rezul'taty primeneniya rastvorov na uglevodorodnoy osnove pri vskrytii produktivnykh plastov na mestorozhdeniyakh OAO "Gazpromneft" - Noyabr'skneftegaz" [Results of application of hydrocarbon-based solutions when opening productive strata in the fields of Gazpromneft' - Noyabr'skneftegaz]. *Neftyanoye khozyaystvo*, no. 5, pp. 44-45.
- [17] Kozhevnikov Ye V, Nikolayev N I, Melekhin A A, Turbakov M S 2015 Issledovaniye svoystv tamponazhnykh rastvorov dlya krepleniya neftnykh skvazhin s protyazhennym gorizontaln'ym uchastkom, proburenykh s ispol'zovaniyem rotornykh upravlyayemykh sistem [Investigation of the properties of cement slurries for fixing oil wells with an extended horizontal section drilled using rotary controlled systems]. *Neftyanoye khozyaystvo*, no. 9, pp. 58-60.
- [18] Kozhevnikov Ye V, Nikolayev N I, Ozhgibesov O A, Dvoretzkyas RV 2014 Issledovaniye vliyaniya sedimentatsii tamponazhnogo rastvora na svoystva poluchayemogo tsementnogo kamnya [Investigation of the effect of sedimentation of cement slurry on the properties of the resulting cement stone]. *Neftyanoye khozyaystvo*, no. 6, pp. 23-25.
- [19] Kupavikh K S, Nutskova M V 2016 Ecological features of oil well repair at low-permeability reservoir. *International Journal of Applied Engineering Research*, 11 (11), pp. 7505-7508.
- [20] Leusheva E, Morenov V 2017 Research of clayless drilling fluid influence on the rocks destruction efficiency. *International Journal of Applied Engineering Research*, 12 (6), pp. 945-949.
- [21] Melekhin A.A, Chernyshov S Ye, Blinov P A, Nutskova M V 2016 Issledovaniye smazyvayushchikh dobavok k burovym rastvoram dlya snizheniya koeffitsiyenta treniya pri stroitel'stve skvazhin rotornymi upravlyayemyimi sistemami [Investigation of lubricant additives to drilling fluids to reduce the coefficient of friction in the construction of wells with rotary controlled systems]. *Neftyanoye khozyaystvo*, no. 10, pp. 52-55.
- [22] Merkulov V 2018 Analysis of advanced nuclear technologies applicable in the russian arctic. Paper presented at the IOP Conference Series: Earth and Environmental Science, 180(1) doi:10.1088/1755-1315/180/1/012020
- [23] Moradi S ST, Ghasem, M F, Nikolaev N I, Lykov Y V 2016 Effect of fault stress regime on the mechanical stability of horizontal boreholes. *GeoBaikal. 4th International Conference: From East Siberia to the Pacific. Geology, Exploration and Development*.
- [24] Moradi S ST, Nikolaev N I 2016 Considerations of cementing directional wells in high-pressure, high-temperature conditions. *7th EAGE Saint Petersburg International Conference and Exhibition: Understanding the Harmony of the Earth's Resources Through Integration of Geosciences*, 11-15.



- [25] Moradi S ST, Nikolaev N I, Chudinova I V, Martel A S 2018 Geomechanical study of well stability in high-pressure, high-temperature conditions. *Geomechanics and Engineering*, 16 (3), pp. 331-339.
- [26] Morenov V, Leusheva E 2017 Development of drilling mud solution for drilling in hard rocks. *International Journal of Engineering, Transactions A: Basics*, 30 (4), pp. 620-626.
- [27] Morenov V, Leusheva E, Martel A 2018 Investigation of the fractional composition effect of the carbonate weighting agents on the rheology of the clayless drilling mud. *International Journal of Engineering, Transactions A: Basics*, 31 (7), pp. 1152-1158.
- [28] Nikolayev N I, Leusheva Ye L 2016 Povysheniye effektivnosti bureniya tverdykh gornykh porod [Improving the efficiency of drilling solid rocks]. *Neftyanoye khozyaystvo*, no. 3, pp. 68-71.
- [29] Nutskova M V, Dvoynikov M V, Kuchin V N 2017 Improving the quality of well completion in order to limit water inflows. *Journal of Engineering and Applied Sciences*, 12 (22), pp. 5985-5989.
- [30] Nutskova M V, Kupavyh K S 2016 Improving the quality of well completion in deposits with abnormally low formation pressure. *International Journal of Applied Engineering Research*, 11 (11), pp. 7298-7300.
- [31] Oshibkov A V, Vodorezov D D, Syzrantseva K V, Frolov S A, Dvoynikov M V, Bakirov D L 2015 Vliyaniye tekhnicheskikh kharakteristik klina-otklonitelya i obsadnykh trub na nadezhnost' soyedineniya stvolov mnogostvol'nykh skvazhin [Influence of the technical characteristics of the wedge-diverter and casing on the reliability of the connection of the trunks of multilateral wells]. *Neftyanoye khozyaystvo*, no. 11, pp. 121-123.
- [32] Sholukha V, Panda J, Salvia P, Beyer B, Rooze M & Jan S V S 2017 Prediction of the drilling path to surgically pin the femoral neck from the spatial location of pelvic and femoral anatomical landmarks: A cadaver validation study. *Medical Engineering and Physics*, 40, pp. 117-121. doi:10.1016/j.medengphy.2016.11.008
- [33] Turitsyna M V, Chernobrovin Ye V, Morozov V A, Teleyev G YU, Kovalev A V, Ryabokon Ye P 2012 Gazozhidkostnyye promyvochnyye smesi dlya zakanchivaniya skvazhin v usloviyakh anomal'no nizkikh plastovykh davleniy [EP Gas-liquid flushing mixtures for well completion under conditions of abnormally low reservoir pressure]. *Neftyanoye khozyaystvo*, no. 8, pp. 111-113.
- [34] Turitsyna M V, Kovalev A V, Morozov V A, Teleyev G YU, Chernobrovin Ye V, Shcherbakov A A 2012 Gazozhidkostnyye promyvochnyye smesi dlya pervichnogo vskrytiya plastov v usloviyakh anomal'no nizkikh plastovykh davleniy [Gas-liquid flushing mixtures for primary reservoir opening under conditions of abnormally low formation pressures]. *Neftyanoye khozyaystvo*, no. 9, pp. 58-59.
- [35] Yushkov A, Nudner I, Semenov K, Ivanov K, Geidarov N, Stukolov S & Zakharov Y 2017 Computational investigation of turbulent flow impact on non-cohesive soil erosion near foundations of gravity type oil platforms. Paper presented at the CEUR Workshop Proceedings, 1839 524-534.
- [36] Yanovskiy V A, Andropov M O, Churkin R A, Fakhrislamova R S, Fenzel' A D, Minayev K M 2018 Vliyaniye khimicheskoy prirody emul'gatorov ryada proizvodnykh zhirnykh kisloti etanolaminov na svoystva gidrofobno-emul'sionnykh burovyykh rastvorov [The influence of the chemical nature of emulsifiers of a number of fatty acid derivatives and ethanolamines on the properties of hydrophobic-emulsion drilling fluids]. *Neftyanoye khozyaystvo*, no. 1, pp. 42-47.
- [37] Yanovskiy V A, Fenzel' A D, Andropov M O, Fakhrislamova R S, Zakharov A S, Churkin R A, Minayev K M 2018 Vliyaniye usloviy sinteza emul'gatora na svoystva gidrofobno-emul'sionnogo burovogo rastvora [Influence of conditions for the synthesis of an emulsifier on the properties of a hydrophobic-emulsion drilling mud]. *Neftyanoye khozyaystvo*, no. 6, pp. 93-97.