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Experimental Evaluation of Effective Chemical Composition on Reservoir Quality of Bottomhole Zone of Low Permeability Terrigenous Reservoirs

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P A P E R I N F O

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A B S T R A C T

During reservoir development process, the permeability of near wellbore zone decreases, and filtration characteristics of productive formations deteriorate due to anthropogenic impact for the primary and secondary improved oil recovery process and other technological operations. To restore and improve the productivity of wells in heterogeneous low-permeability terrigenous reservoirs, classic acid treatments are recommended. Aggressive secondary sedimentation or in other words, precipitation occurs during acid treatments in terrigenous reservoirs, confirming the effectiveness of putting wells into operation through the proposed chemical composition as the cleaning and stimulating operations. Therefore, a comprehensive approach and methods of impact on the near wellbore zone are necessary, as these are multifactorial processes. This research is focused on developing effective technologies to improve technical means or compositions that restore well productivity by decolmatizing the formation and substantiating effective chemical compositions. The results of this work show that the proposed method and chemical reagent highly improved the permeability of near wellbore zone and as a result increased the productivity index of the well.

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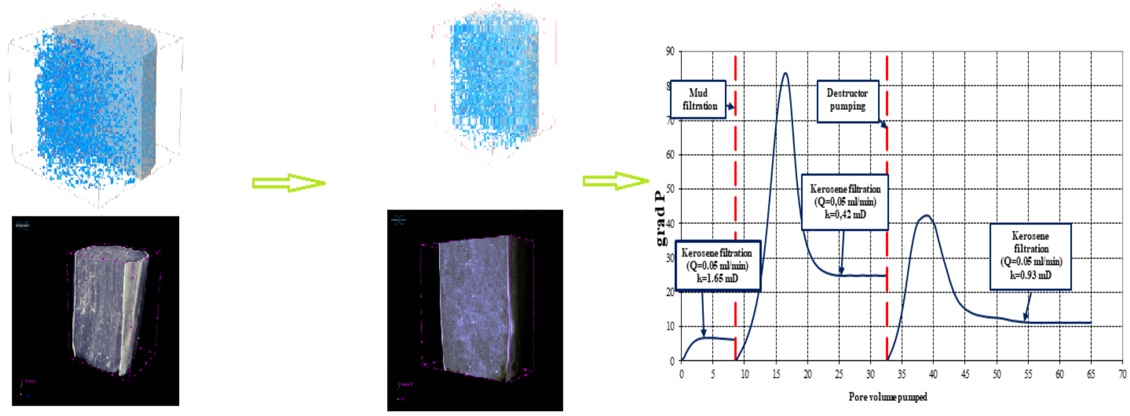
Graphical Abstract



1. Pore volumes containing drilling mud

2. Pore volumes after distruction of drilling mud

NOMENCLATURE

Q	Filtration flow	*PAC LV*	Low viscosity polyanionic cellulose
k	Permeability	*PAC HV*	High viscosity polyanionic cellulose

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1. INTRODUCTION

Today, one of the most important trends in the global oil and gas industry is the decline in the production of conventional hydrocarbon reserves. The decline in conventional oil reserves is forcing oil and gas companies to focus on hard-to-recover hydrocarbon reserves.

British Petroleum estimates that there are approximately 2.621 trillion barrels of recoverable oil reserves. Hard-to-recover reserves account for 39% of the total resource base. More and more oil deposits are being developed in low-permeability reservoirs. As reported Mukhametshin and Andreev (1) that low-permeability reservoirs up to 50.μm^2 are more clayey than high-permeability reservoirs, and have smaller sizes of pore channels. The specific filtration surface of low-permeability reservoirs is several times higher than that of high-permeability reservoirs. In addition to low filtration-capacity properties and complex geological structure of reservoirs, the development of such facilities is adversely affected by anthropogenic impact of primary and secondary stripping, killing and other technological operations, which in turn lead to contamination of the bottom-hole zone of the well discussed in the works of Haustveit et al. (2) and Almukhametova et al. (3).

Li and Liu (4) stated that primary and secondary stripping, at carrying out repair works in the bottom-hole zone in low-permeable reservoirs is damaged 3 to 4 times more than in highly permeable reservoirs in similar conditions as reported by Zhang et al. (5).

Leusheva et al. (6) work has described as in the process of drilling, development and operation of a production well, its bottomhole zone undergoes various types of impacts, which leads to significant changes in well performance. The greatest changes are characteristic of medium- and low-producing formations, and for the latter the changes may be irreversible. The factors of influence on the bottom-hole zone of the formation can be grouped into the following groups:

1. 1. Mechanical Factors They are associated with the process of rock fracture and the creation of excavation - wellbore. In particular, these factors cause changes in the stress state of the rock, which is expressed in the reduction of effective permeability and porosity when the rock is replaced by the washing fluid.

1. 2. Hydrodynamic Factors This group combines the effects of excessive pressures at the bottom of wells, which are created during the opening, treatment and killing of formations. As a result of repression on the formation in the process of downhole operations, large volumes of perforating fluid (PF), well killing fluid (WHF) or other used compositions of process fluids and their filtrates are squeezed into the bottomhole cavity. At the same time, mechanical and chemical colmatants (clay particles, CMC, etc.) penetrate into the bottomhole cavity, as well as watering of the bottomhole cavity with filtrate, a significant increase in water saturation of the reservoir in it, accompanied by displacement of hydrocarbon fluid to remote areas and, as a result, the formation's water content.

1. 3. Physicochemical Factors The impact of these factors is caused by different composition and properties of fluids and reagents penetrating into the bottomhole cavity. Most PF and WHF have an aqueous phase in their composition. As a rule, the composition and properties of the aqueous phase differ from those of formation water. Therefore, penetration of foreign water into the formation leads to numerous changes in reservoir characteristics of oil and gas saturated rocks. The intensity of manifestation of hydrodynamic forces at opening and killing of formations is determined by the volume and density of applied fluids and compositions. Documented permissible values of repressions on the reservoir are regulated by the "Safety Rules in the oil and gas industry". However, as the practice of such works shows, the actual value of repression usually exceeds the permissible one. This leads to irreversible consequences and causes deterioration of reservoir characteristics of productive rocks. Attempts to estimate the volume and depth of penetration into the reservoir of filtrate of PF or WHF show that they can reach significant values. In a number of cases the volumes of absorption of several dozens of cubic meters, the depth of penetration of which reached tens and even hundreds of meters from the bottom of the well were noted. Especially severe consequences from penetration of various compositions and fluids into formations are observed for low-permeable, highly heterogeneous by composition of rock-forming minerals and reservoir properties productive horizons.

The greater the volume of filtrate penetration into the formation, the stronger are the results of physicochemical processes of interaction of formation fluids and setting fluids with oil and gas saturated formation. Taking into account small size of filtration channels and huge area of contact surface, the nature and dynamics of capillary and hydrodynamic forces manifestation in the bottomhole formation changes. This results in deterioration of technological parameters of wells and bottomhole zone. Analysis of the results of hydrodynamic studies of wells and reservoirs showed that a significant part of the stock of producing wells is operated at the values of perfection coefficients at the level of 0.2 to 0.5. It means that wells work at 20 to 50% of their production capabilities. Restoration of reservoir characteristics of the formation usually does not occur and is possible only by carrying out expensive works to increase well productivity (6).

The purpose of bottomhole treatment is to break up the filtration crust and prevent completion equipment from becoming clogged with residuals from the cleaning fluid reactions.

The use of water-soluble reagents which are described in the work of Litvinenko et al. (7) in combination with chemical treatment allows to remove the products of interaction products of drilling mud filtrate and formation fluids and physical cleaning of rock pore space. To improve well productivity, it is often necessary to perform chemical treatment of the bottomhole zone.

Chemical reagents can react with polymers that bind solid particles to destroy both the polymers and the structure formed by the solid phase of the cake (8). Drill cuttings particles in the cake structure reduce the effectiveness of specialty reagent solutions. Treatment effectiveness is often determined by the reaction time required for cake breakthrough and fluid loss. Rapid cake breakthrough may be ineffective because the chemical treatment solution can rapidly percolate through highly permeable zones without disrupting the filtration crust across the entire wellbore surface in the pay zone. In these works, solution with a long reaction time can help achieve subsequent high well production rates by uniformly treating the entire interval, including areas of varying permeability (9-11). The most important element in improving the efficiency of well operation is preserving the reservoir properties of the bottomhole zone of the pay zone. In most cases, primary stripping fails to achieve the well's design flow rate. Thus, it is necessary to carry out works on intensification of hydrocarbon inflow to wells, which consist in cleaning of bottomhole zone contaminated during drilling and cementing or after prolonged operation and workover (killing) of the well (12, 13).

Reservoir treatment refers to chemical methods of impact on the formation. During its treatment chemical agents react with formation rock, as well as with materials and substances that have penetrated into the bottomhole zone and changed reservoir properties. and changed reservoir properties of the formation in the radial filtration interval.

The purpose of present study is to examine the effect of the disruptor composition on the filtration crust of a model biopolymer solution used for penetration of productive formations and the restoration of filtration-capacitance properties of reservoir rock from the complex effect of the proposed technology.

2. MATERIALS METHOD

2. 1. Drilling Mud Preparation

To conduct the present study, it is initially necessary to prepare a model biopolymer drilling fluid used in the initial opening of productive formations. The composition of the solution is summarized in Table 1.

TABLE 1. Composition of model mud system

No.	Component	Purpose
1	Xanthan biopolymer	Rheology modifier
2	Lubricante	Lubricante additive
3	PAC LV	Filtration reducer
4	PAC HV	Viscosity regulator
5	Bactericide	Bactericide additive
6	Caustic soda	pH adjuster
7	Foaming agent	Foaming agent
8	Potassium chloride	Mineralizer

Xanthan is used as a stabilizer for a wide range of suspensions, emulsions and foams. It is highly effective over a wide range of temperature and pH. In addition, this exopolysaccharide is pseudoplastic, i.e., its viscosity decreases with increasing shear stress, which makes it widely used in applications where high viscosity at rest and low viscosity required under high shear operating conditions. In the oil industry, xanthan is used to thicken drilling fluids. Such muds are used to extract solids by drill bit to the surface.

Xanthan biopolymer provides the necessary rheological properties in a wide pH range, while solids remain suspended when the circulation of the mud stops.

According to the provided recipe, a model mud is prepared in the drilling fluids laboratory. Preparation is carried out with the help of high-speed agitator, with the number of revolutions up to 6000 revolutions per minute. Drilling mud parameters are measured according to ISO 10414-1:2008 standards "Oil and Gas Industry. Control of drilling fluids in field conditions. Part 1: Water-based muds", API 13B-1 "Oil and Gas Industry. Field testing of drilling fluids. Part 1. Water-based muds".

2. 2. Filtration Experiment

For further research it is necessary to form a filtration cake on the basis of the above model drilling mud, the formation of filtration caket is made by hot filtration of the mud on the device High Pressure High Temperature (HPHT) according to the standard technique at a temperature close to the formation values t=85 ° C and a pressure drop of 500 psi (3.5 MPa).

TABLE 2. Parameters of model mud system

No	Parameter	Model drilling mud, units
1	Density	1,025, g/cm^3
2	Filtration capacity (API)	9,8, cm^3/30 min
3	Filtration (HPHT)	24, cm^3/30 min.
4	Gels10'/10'	9/10 (45/50), lbs/100 ft^2 (dPa)
5	Dynamic shear stress	26(127), lbs/100 ft^2(dPa)
6	Plastic viscosity	13, mPa-s

The standard filtration test time of 30 minutes is taken and the cake are formed on ceramic disks with permeability below 50 mD (Figure 1). Jaffar et al. (14) said that after formation of filtration cake we proceed to preparation of the chemical treatment of bottomhole zone - destruction fluid. On the basis of patent and literature review we took into account the data and practical experience of application of breaker systems at Russian fields. The formulations of the compositions used by different service solution companies are almost identical in composition and include: organic acid to remove marble crumbs, selectively directed enzymes to destroy the polymer group, surfactants to ensure the affinity of the breaker composition with formation fluid (15).

The disadvantages of the studied chemical compositions are: low effectiveness on high-temperature (>80°C) (16) sandstone formations containing carbonates as cementitious material, since the presence of solvent in the composition insignificantly reduces the rate of reaction of acids with rock at high formation temperatures; low sediment-holding capacity in relation to calcium fluorides ($CaF2\downarrow$), which will lead to clogging of filtration channels with insoluble precipitates of fluorides formed by interaction of fluoric acids with carbonate component of sandstone formation; high corrosive activity at high temperatures; insoluble precipitates occur, which colmatize the formation (17-19).

On this basis, the chemical composition of the destruction fluid was selected (Figure 2), which to a greater extent satisfies our conditions and the physical and chemical composition of the filtration cake of the drilling fluid.

The composition of the destruction fluid included potassium fluoride peroxosolvate, chelating agent and non-ionogenic surfactant. The addition of the surfactant provides an opportunity to reduce the dissolution rate of the reservoir rock and also increases the washing properties.

Figure 1. Formed filter cake after high-pressure and high-temperature filter press

Figure 2. Composition of the destruction fluid

After selecting the composition of the destruction fluid, we proceed to test the washing ability on ceramic disks. We place the prepared filtration cake in a glass vessel. Carefully pour the disk with filtration cake prepared composition of the liquid of destruction, in the volume of 200 milliliters, hermetically close the lid and leave for 24 hours at room temperature (22 °C). The test is followed by visual inspection and photofixation.

To determine the efficiency of drilling fluid filtrate removal from the pore space, the filtration-capacity properties of the core material are determined. For the filtration experiment the RPS-812 filtration unit is used and thermobaric conditions are created as close as possible to formation conditions. Scheme of the RPS-812 core holder is shown in Figure 3.

The proposed unit allows to qualitatively estimate the depth of drilling fluid filtrate penetration into the productive formation and optimize the drilling fluid formulation for specific mining and geological conditions. Filtration studies which describes at works are carried out in the conditions of the productive horizon of the well while modeling the process of primary penetration (20, 21).

The direction of injection and filtration of working fluids in the studied core samples corresponds to the real direction of movement of formation fluids and process fluids in producing wells: direct filtration corresponds to the process of fluid inflow from the formation into the

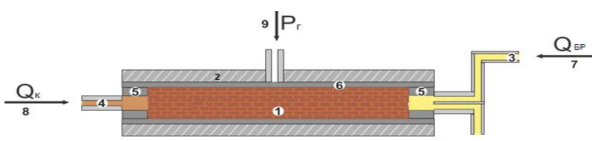

Figure 3. Scheme of the RPS-812 core holder: 1. Natural core sample; 2. Core holder body; 3. Working solutions; 4. Formation fluid; 5. Buffer metal rings; 6. Rubber cuff for core crimping; 7. Solution filtration direction; 8. Formation fluid filtration direction; 9. Fluid supply direction for creating crimping pressure

well and, subsequently, to the process of "development" of the well; reverse filtration modeled the process of primary opening of the well, which consists in creating a constant pressure drop (22).

Before each filtration experiment in the samples of core material, saturation was created by filtration of the hydrocarbon phase model in the core holder of the filtration unit (23, 24). Kerosene was used as a hydrocarbon phase model (25-27).

2. 3. Micro-CT Process After data acquisition and interpretation, tomographic imaging of the core material is performed on the SkyScan 1173 microtomography system.

SkyScan 1173 is a tomograph based on a new microfocus high power X-ray source of 130 kV. Thus, the design allows the examination of large size and high density samples.

This instrument is used to obtain highly accurate geometric data of small to medium sized samples in a non-destructive manner. Inside the scanning chamber, hundreds of X-ray projections are taken from the sample. Based on these, a reconstruction algorithm can create a three-dimensional volumetric representation of the sample.

3. RESULTS

The following results were obtained during a set of laboratory tests.

The results were obtained during the degradation fluid corrosivity test: at the time the crust was placed in the degradation fluid, the solution changed color from cloudy white to grayish. No further visible changes were observed. After 24 hours, 90% of the crust was washed off the surface of the disk, the liquid became dirty gray with a dense sediment at the bottom.

A test for the presence of carbonate inclusions in the remaining filtration crust was also performed. This is done by applying a few drops of a 12% hydrochloric acid solution to the crust. When added, a violent reaction occurs with the release of gas, indicating the residual presence of carbonate inclusions. On visual inspection, particles of marble chips on the surface of the filter cake are noticeable (Figure 4).

To determine the convergence of the results of filtration experiments and to evaluate the efficiency of process fluids, permeability measurements were carried out using the hydrocarbon phase model (kerosene). The results are calculated according to Equation 1 arising from the Darcy-Weisbach formula and the related data for kerosene permeability are presented in Table 3.

$$k = \frac{Q\mu L}{\Delta P F} \quad (1)$$

TABLE 3. Results of kerosene permeability measurements in the filtration unit

№	ΔP	k
1	0,34	1,65
2	0,38	1,11
3	0,31	1,36
4	0,39	1,24
5	0,42	1,17

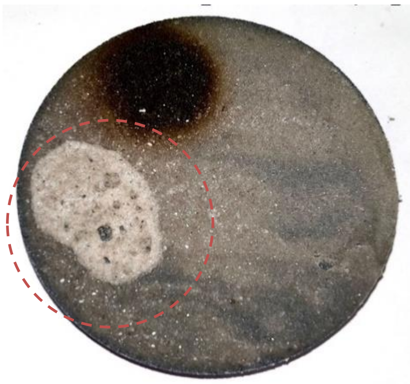

Figure 4. Carbonate test result (white bubbles)

After determination of initial phase permeability, modeling of the process of primary formation opening was carried out.

3. 1. Modeling of Process Primary Formation Opening and Drilling Fluid Filtration into Bottomhole Zone of the Well During 2 hours with the maximum pressure drop of 1MPa the slurry mud (with X-ray contrast agent - potassium iodide 5% wt. %) was held at the core face. The direction of filtration was "reverse" (modeling the impact on the formation from the side of the well). The X-ray contrast agent is used to facilitate visual inspection by means of microtomographic imaging.

Microtomography of the samples was carried out after the drilling mud exposure at the core face. The results of tomographic studies determined the porosity coefficient, as well as the volume of pores occupied by drilling mud. Figure 5 shows the results of reconstruction of the image of the core with X-ray contrast agent, after exposure to mud. Core segment reconstruction was performed to determine the depth of mud penetration.

3. 2. Filtration of Hydrocarbon Phase Model and Measurement of Permeability Coefficient of Core Samples The order of work is similar to the determination of relative phase permeability of samples by hydrocarbon phase model. Permeability coefficients were determined at a constant fluid flow rate of 0.05 ml/min.

After estimating the coefficient of relative permeability change, modeling of bottomhole zone treatment with the destructor was performed. The technique was as follows:

1) Washing the core face with the destructor at a flow rate of 1 ml/min for 3-5 minutes;
2) Exposure of the destructor at a constant repression of 0.5 MPa for 4 hours.
3) After holding the destructor, the inflow call was simulated and the change in relative permeability change coefficient was measured.

After pumping with the destructor, tomographic imaging was performed. The results of segmental reconstruction are presented in Figure 6.

Based on obtained reconstruction of the segment after the destructor treatment it can be observed that the drilling fluid particles were washed out and the number of pores increased.

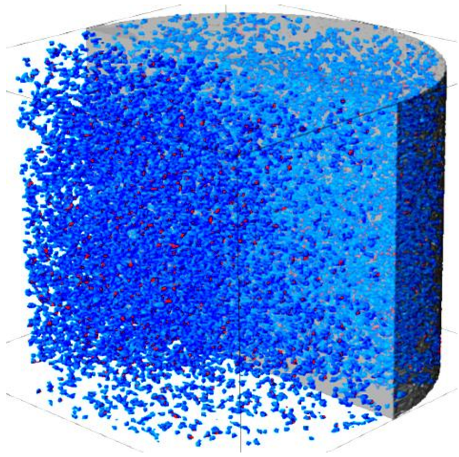

Figure 5. Results of reconstruction of internal pore volume of core sample (blue color - pore space, red color - drilling mud in these pores)

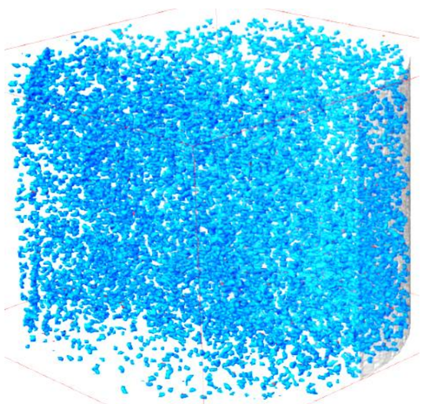

Figure 6. Results of reconstruction of internal pore volume of core sample after the destructor (blue color - pore space)

The results of change in the relative permeability change coefficient and an example of graphs-results for determining the filtration-capacitance properties of core samples after treatment with the destructor are presented in Figures 7-9.

3. 3. Interpretation of Microtomograph Imaging

To evaluate the effectiveness of the destructor, tomographic studies were performed on core samples after modeling the flow inducement.

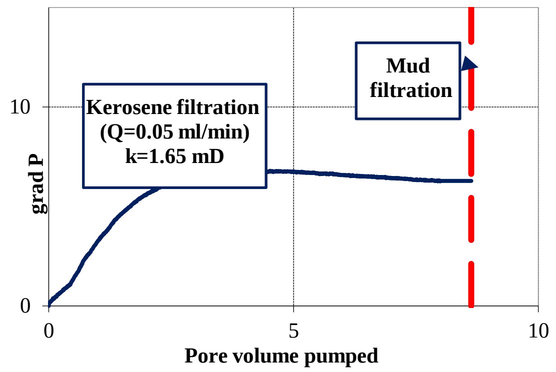

Figure 7. Determination of permeability of sample by formation hydracarbone model before mud impact

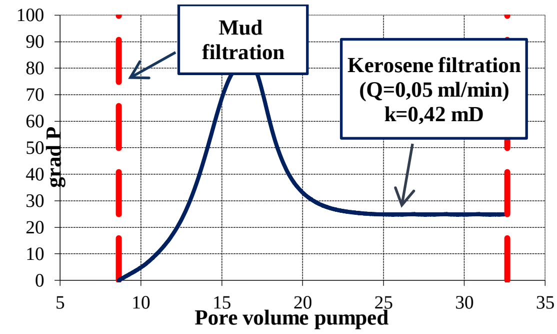

Figure 8. Determination of permeability by formation hydrocarbon model after mud

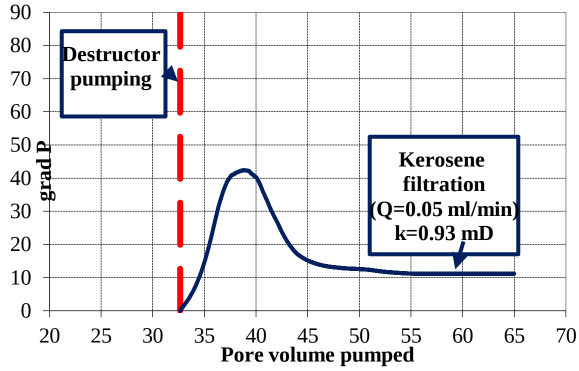

Figure 9. Determination of sample permeability by hydrocarbon phase model after destructor exposure

Figure 10 shows the results of image reconstruction of the core with X-ray contrast agent, after exposure to mud. White clear lines on the image data are lines showing traces of drilling mud penetration into the core.

Based on presented image in Figure 11 the result of reconstruction can be seen with the naked eye, the number of white wormholes and spots has decreased, which means that the drilling fluid filtrate (with X-RAY agent) has been washed out. In order to make sure that the pore space was completely cleaned from the drilling fluid degradation products.

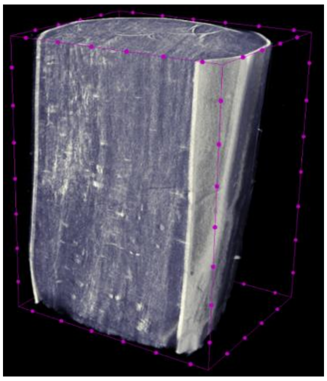

Figure 10. Reconstruction after microtomography of core sample with drilling mud

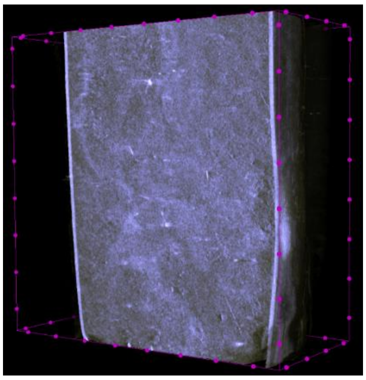

Figure 11. Reconstruction after microtomography of core after exposure to the destructor

4. CONCLUSIONS

At contact of potassium fluoride peroxosolvate with filter cake an oxidizing agent is released, which promotes dissolution of acid-soluble colmatants, as well as destruction of polysaccharides. The concentration of the oxidizing agent is constant throughout the reaction, which contributes to the uniform removal of the filter cake. Ammonium nitrate is used to control the reaction start time, reaction rate, as well as to prevent the formation of secondary insoluble precipitates, which increases the rate of the limiting stage of the reaction as a consequence of the hydrolysis process. The process of ammonium nitrate hydrolysis is started by potassium fluoride peroxosolvate. By changing the concentration of ammonium nitrate, it is possible to regulate the time of reaction start, as well as the reaction rate of dissolution of acid-soluble colmatants and destruction of polysaccharides, while the action of the composition is not based on exothermic reaction.

To improve relative permeability by kerosene after exposure to drilling mud and to improve cleaning of bottomhole zone from drilling mud filtrate, a special composition of the destructor was developed.

According to the results of filtration experiment, the average kerosene permeability of the core was 1.65 mD. After modeling of primary stripping processes, the phase permeability by kerosene decreased from 1.65 mD to 0.42 mD (permeability after drilling mud), and the coefficient of relative permeability change was 74.7%. Accordingly, it shows that the proposed method and chemical reagent highly improved the permeability of near wellbore zone and as a result increased the productivity index of the well.

5. REFERENCES

1. Mukhametshin V, Andreev V, editors. Search and argumentation of decisions aimed at increasing the efficiency of bottom-hole zone stimulation in oil accumulations with challenged reserves. SPE Russian Petroleum Technology Conference?; 2017: SPE. 10.2118/187785-MS
2. Haustveit K, Elliott B, Roberts J, editors. Empirical Meets Analytical-Novel Case Study Quantifies Fracture Stress Shadowing and Net Pressure Using Bottom Hole Pressure and Optical Fiber. SPE Hydraulic Fracturing Technology Conference and Exhibition; 2022: SPE. 10.2118/209128-MS
3. Almukhametova E, Zakirov A, Fattakhov D, Faizullin A, editors. Analysis of enhanced recovery by treatment of bottom-hole zone of Potochnoye field. IOP Conference Series: Earth and Environmental Science; 2018: IOP Publishing. 10.1088/1755-1315/194/8/082003
4. Li M, Liu X. Effect of thermal treatment on the physical and mechanical properties of sandstone: insights from experiments and simulations. Rock Mechanics and Rock Engineering. 2022;55(6):3171-94. 10.1007/s00603-022-02791-1
5. Zhang H, Sun Q, Jia H, Dong Z, Luo T. Effects of high-temperature thermal treatment on the porosity of red sandstone: an NMR analysis. Acta Geophysica. 2021;69:113-24. 10.1007/s11600-020-00526-w
6. Leusheva E, Alikhanov N, Morenov V. Barite-free muds for drilling-in the formations with abnormally high pressure. Fluids. 2022;7(8):268. 10.3390/fluids7080268
7. Litvinenko VS, Dvoynikov MV, Trushko VL. Elaboration of a conceptual solution for the development of the Arctic shelf from seasonally flooded coastal areas. International Journal of Mining Science and Technology. 2022;32(1):113-9. https://doi.org/10.1016/j.ijmst.2021.09.010
8. Folomeev A, Davidenko I, Vakhrushev S, Mingalishev F, Sharifullin A, Faizov R, et al. Adaptation of the technology for bottom-hole zones treatment under conditions of scaling at the

Sorovskoye field (Russian). Oil Industry Journal. 2019;2019(11):124-9. 10.24887/0028-2448-2019-11-124-129

9. Yaskin S, Mukhametshin V, Kuleshova L, editors. Geological and technological justification of the bottom-hole zone treatment of wells and formations of the Langepas group of fields. IOP Conference Series: Materials Science and Engineering; 2021: IOP Publishing. 10.1088/1757-899X/1064/1/012073
10. Irawan S, Khaleeda S, Shakeel M, Fathaddin MT. Maximizing well productivity by using filter cake breaker for synthetic-based mud drill-in fluid (SBMDIF) system. Upstream Oil and Gas Technology. 2022;9:100075. 100075. 10.1016/j.upstre.2022.100075
11. Eyaa Allogo C-M, Allias B, Tayebi R, Baraque A, Lansot JY, Diogo J, editors. Reversible Fluids and Mud Breaker Technology Outperforms Productivity and Injectivity in West Africa–Fit to Purpose and Designed for Success. SPE International Conference and Exhibition on Formation Damage Control; 2022: SPE. 10.2118/208861-MS
12. Byrne M, Djayapertapa L, Watson K, editors. Breaker Placement in Sand Control Lower Completions–New Challenges and Potential Solutions. SPE International Conference and Exhibition on Formation Damage Control; 2024: SPE. 10.2118/217914-MS
13. Wayo D. Primary Evaluation of Filter Cake Breaker in Biodegradable Synthetic-Based Drill-In-Fluid: Nazarbayev University School of Mining and Geosciences; 2022.
14. Jaffar NA, Luan N, Arisandi E, editors. Novel Microemulsion Breaker System Remove Drill-in-Fluids Filter Cake and Remediate Near Wellbore Damage to Enhance Productivity of Horizontal Wells of Offshore Sabah, Malaysia. Offshore Technology Conference Asia; 2022: OTC. 10.4043/31684-MS
15. Eliasson C, Braadland O, Kaarigstad H, Mathisen A-M, Ibragimova Z, Salmelid B, editors. Reservoir Drilling, Completion and Breaker Fluid Qualification for Direct Injection Wells on the Johan Castberg Field–A Multi-Disciplinary Study to Secure Injectivity. SPE/IADC Drilling Conference and Exhibition; 2021: SPE. 10.2118/204042-MS
16. Baimukhametov GF, Dengaev AV, Safiullina EU, Kayumov AA, Drozdov IM, Shishulin V, et al. Relaxation Process in Crude Oil after Ultrasonic Treatment. International Journal of Engineering, Transactions B: Applications. 2024;37(5):896-903. 10.5829/IJE.2024.37.05B.08
17. Rozhkova Y, Lekomtsev A, Lisin V, Poilov V, Safiullina E, Efremenko D, et al. Comprehensive Review of Demulsifiers based on Magnetic Nanoparticles for Oil-water and Water-oil Separation. International Journal of Engineering, Transactions B: Applications. 2024;37(5):904-19. 10.5829/IJE.2024.37.05B.09
18. Jafarpour H, Moghadasi J, Khormali A, Petrakov D, Ashena R. Increasing the stimulation efficiency of heterogeneous carbonate reservoirs by developing a multi-bached acid system. Journal of Petroleum Science and Engineering. 2019;172:50-9. https://doi.org/10.1016/j.petrol.2018.09.034
19. Jafarpour H, Aghaei H, Litvin V, Ashena R. Experimental optimization of a recently developed matrix acid stimulation technology in heterogeneous carbonate reservoirs. Journal of Petroleum Science and Engineering. 2021;196:108100. https://doi.org/10.1016/j.petrol.2020.108100
20. Li Q. Effects of Drilling Mud Properties on Hydrate Dissociation Around Wellbore during Drilling Operation in Hydrate Reservoir. International Journal of Engineering. 2022;35(1):142-9. 10.5829/IJE.2022.35.01A.13
21. Duryagin V, Nguyen Van T, Onegov N, Shamsutdinova G. Investigation of the selectivity of the water shutoff technology. Energies. 2022;16(1):366. 10.3390/en16010366
22. Blinov PA, Sadykov MI. Evaluation of elastic-strength properties of cement-epoxy systems. OF THE TOMSK POLYTECHNIC UNIVERSITY GEO ASSETS ENGINEERING. 2023:104.
23. Smirnova E, Saychenko L. Hydrodynamic Modeling and Evaluation of Partial Substitution of Cushion Gas During Creation of Temporary Underground Gas Storage in an Aquifer. International Journal of Engineering, Transactions A: Basics. 2024;37(7):1221-30. https://doi.org/10.5829/ije.2024.37.07a.02
24. Petrakov D, Loseva A, Alikhanov N, Jafarpour H. Standards for selection of surfactant compositions used in completion and stimulation fluids. International Journal of Engineering, Transactions C: Aspects. 2023;36(9):1605-10. https://doi.org/10.5829/ije.2023.36.09c.03
25. Блинов ПА, Шаньшеров АВ, Черемшанцев ДМ, Кузнецова НЮ, Никишин ВВ. Анализ и выбор тампонажной смеси, устойчивой к динамическим нагрузкам, с целью повышения качества герметичности крепи в затрубном пространстве. Известия Томского политехнического университета Инжиниринг георесурсов. 2022;333(11):115-23. 10.18799/24131830/2022/11/3726
26. Galkin VI, Martyushev DA, Ponomareva IN, Chernykh IA. Developing features of the near-bottomhole zones in productive formations at fields with high gas saturation of formation oil. Записки Горного института. 2021;249:386-92. 10.31897/PMI.2021.3.7
27. Grishchenko AI, Semenov AS, Melnikov BE. Modeling the processes of deformation and destruction of the rock sample during its extraction from great depths. Записки Горного института. 2021;248:243-52. 10.31897/PMI.2021.2.8

Persian Abstract

چکیده

در فرآیند توسعه و تولید، نفوذپذیری ناحیه نزدیک چاه کاهش می یابد و ویژگی های فیلتراسیون سازندهای تولیدی بدتر می شود. امروزه بیشتر میدان های سیبری غربی در آخرین مراحل توسعه هستند و خواص ظرفیت فیلتراسیون سازندهای تولیدی به دلیل تأثیرات انسانی در مراحل تولید اولیه و ثانویه و سایر عملیات تکنولوژیکی بدتر می شود. روش های اسیدکاری کلاسیک برای بازیابی و بهبود بهره وری چاه درمخازن ناهمگن با نفوذپذیری پایین استفاده می شود. اما درعملیات اسیدکاری در مخازنی که تولید ماسه دارند، رسوب ثانویه تهاجمی رخ می دهد که اثربخشی راه اندازی چاه ها را کاهش میدهد. در این راستا، لازم است رویکرد و روش‌های تاثیرگذاری جامع که به نوبه خود فرآیندهای چند عاملی هستند، ایجاد شود. بنابراین، هدف اصلی این تحقیق مربوط به توسعه فناوری‌های مؤثر با بهبود ابزارها یا ترکیبات فنی، فراهم کردن احیای بهره‌وری چاه و ایجاد ترکیبات شیمیایی مؤثر است. روش و ترکیبات شیمیایی ارایه شده در این مقاله به خوبی باعث افزایش تراوایی سازند شدند و در نتیجه ضریب بهره وری چاه را افزایش دادند.