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Cite as: AIP Conference Proceedings **2432**, 050054 (2022); https://doi.org/10.1063/5.0090823
Published Online: 16 June 2022

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# Research of the Properties of Mineral Ingredients and the Possibility of Applying them in Producing the Weighted Drilling Solutions Applicable in Drilling Oil and Gas Wells under High Filled Pressures Conditions

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**Abstract.** Based on a comprehensive study of the physicochemical and physic-mechanical properties of composite chemical reagents and mineral weighting agents, we developed composite chemical reagents and obtained weighted drilling fluids with their use. The results of production and laboratory testing of the composite chemical reagent CCR-WS for producing a weighted drilling fluid during the drilling of saline anhydrite strata of oil and gas wells at high reservoir pressures are presented. Different grades of developed weighted drilling fluids have the following characteristics: density in the range of $\rho$ = 1.34-2.30 g / $cm^3$; viscosity 60-260 $T_{500}$, s; water loss-F 2-6 $cm^2$ / 30 min.; the thickness of the peel is Tk, 0.2-0.5 mm and the pH value is pH 8-10.
The developed composite chemical reagents and weighted drilling fluids based on them were tested during drilling of oil and gas wells, positive results were obtained, regulatory and technical documents and recommendations for the preparation of drilling fluids using weighting agents and their application in the process of drilling oil and gas wells were developed and approved by the relevant authorities.

**Keywords.** Composition, drilling fluids, mineral ingredients, weighting agent, barite, hematite, dolomite, galena, iron powder, magnetite.

## INTRODUCTION

When drilling oil and gas wells in complicated geological conditions with abnormally high reservoir pressure, especially in saline deposits, a number of complications arise that significantly reduce the efficiency of drilling operations and complicate the subsequent operation of wells, which are somehow associated with the used drilling fluid.

In the practice of drilling operations in Uzbekistan, many complications arising from drilling oil and gas wells in complicated geological conditions with abnormally high reservoir pressure, especially in saline deposits, may be the result of a drilling mud mismatch with drilling conditions [1-3].

Under these conditions, one of the ways to improve the technical and economic indicators and environmental safety of well construction is the introduction of resource-saving technologies using new effective flushing fluids of multifunctional action [4-6].

As a rule, the quality of drilling fluids significantly depends on the composition and structure of the chemicals used. It should be noted that the chemical reagents currently used for drilling wells in the complicated geological conditions of Uzbekistan are not effective enough and are very expensive. The applied low-clay solutions, stabilized by chemical reagents, do not always ensure high quality and trouble-free drilling of wells due to the strong salinity of formation waters. In addition, the presence of the aggressive action of

*The 1st International Conference on Problems and Perspectives of Modern Science*
AIP Conf. Proc. 2432, 050054-1–050054-7; https://doi.org/10.1063/5.0090823
Published by AIP Publishing. 978-0-7354-4345-7/$30.00

saline formation waters significantly increases the established rates of consumption of chemical reagents in the preparation of drilling fluids [7-9].

To regulate the rheological and filtration properties of drilling fluids, various chemical reagents, mainly foreign and domestic, are used, such as Na-KMC, GIPAN, K-4, PAA, KSSB, FKhLS, CAS, graphite, chrompik, RV-SM, NaOH, $Na_2CO_3$ others [9-10].

It should be noted that in modern literary sources, studies of the physicochemical properties of chemical reagents and mineral weighting agents based on secondary raw materials and production wastes are not sufficiently sanctified, which make it possible to obtain effective compositions of weighted drilling fluids with a low cost. In this regard, the study of the physicochemical properties of organomineral weighting agents based on local raw materials and industrial wastes of industries and the development of composite weighted drilling fluids that contribute to ensuring an accident-free, stable and environmentally efficient process of drilling oil and gas wells at high reservoir pressures is an urgent problem.

Based on the foregoing, the purpose of this work is to study the physicochemical properties of organomineral weighting agents based on local raw materials and production waste and to develop a resource-saving technology for producing effective weighted drilling fluids using them.

## MATERIALS AND METHODS

The objects of study are the composite chemical reagent CCR-WS, consisting of CCR-1, composite water-soluble gossypol resin, calcined, caustic soda and alumac, which are waste products for the processing of lump non-ferrous metals [9, 11, 12], as well as sodium chlorine, oil , Na-CMC, barite, hematite, dolomite, limestone, clay, marl, hematite, iron, etc. The structure and physicochemical properties of the weighting agents were determined by standard methods and instruments adopted for the study of drilling fluids in the CIS countries.

## RESULTS AND DISCUSSION

In order to develop effective compositions of weighted drilling fluids, we investigated the physicochemical properties of organomineral ingredients and weighting agents based on local raw materials and industrial waste.

Weighted drilling fluids are expensive, multi-component systems with a high content of various chemicals and materials. The most common such systems are solutions weighted with solid additives - weighting agents. Despite the variety of weighting agents, barite is the most used and frequently encountered in drilling. Barite weighting agent can be divided into gravity and flotation.

Depending on the base of the mineral, weighting agents from natural ores are divided into several types: barite, ferruginous, carbonate and galena. Therefore, we further investigated the physicochemical properties of mineral weighting agents - barite, hematite, dolomite, scale, marble powder, red clay and carbonate-polymer sludge (CPS). Table 1 shows comparative data of the results of studies of the physicochemical properties of the studied organomineral raw materials as weighting agents for drilling fluids.

**TABLE 1.** Physicochemical and mechanical properties various weighting materials

| **Name of weighting materials** | **Physio-chemical properties** | | | | |
|---|---|---|---|---|---|
| | Density, g /cm$^3$ | Mohs hardness | The remainder sieves, 0071% | Humidity,% | **pH** |
| Redclay | 2.55-2.65 | 2.0-3.0 | 5 | 2 | 7.5 |
| Marbleflour | 2.30-2.60 | 2.5-3.0 | 6 | 1.5 | 7-8 |
| KPSh | 2.50-2.70 | 2.5-3.0 | 6 | 2.5 | 11-12 |
| Dolomite | 2.8-2.9 | 3.5-4.0 | 6.5 | 1.2 | 7-8 |
| Barite (Uz) | 3.85-4.1 | 3.0-3.5 | 10 | 1.9 | 7-7.5 |
| Barite (Kz) | 4.1-4.2 | 3.0-3.5 | 8 | 1.3 | 7 |
| Barite (R) | 4.15-4.25 | 3.0-3.5 | 7 | 1.1 | 7-8 |
| Scale | 4.3-4.5 | 5.5-6.5 | 8 | 0.9 | 7-7.5 |
| Hematite | 4.9-5.3 | 5.5-6.5 | 6 | 008 | 7-7.5 |

Analysis of the data given in Table 1 shows that the true density of hematite, scale and barite concentrates with the indicated density 4.90-5.30 g/cm$^3$, 4.30-4.50 g/cm$^3$, 3.85-4,10 g/cm$^3$, respectively, selected for testing as weighting agents, is close to the density of imported class B barite concentrate according to GOST 4682-84 for use in the oil and gas industry as a weighting agent and is 4.0-4.20 g/cm$^3$. In this regard, the specified raw materials available in the Republic of Uzbekistan can be successfully used as weighting agents for drilling fluids.

Further, for the development of composite chemical reagents for weighted drilling fluids, the main parameters of weighted drilling fluids were investigated using the selected reagents and organomineral ingredients of weighting agents such as density, viscosity, filtration index, static shear stress, stability, sedimentation index, pH value. For this, we preliminarily selected a composite chemical reagent CCR-1 as a base, consisting, as noted above, of a water-soluble powdery modified gossypol resin, Na-CMC, soda ash and caustic soda and alumac [7, 10 - 12].

The following are the dependences of the physicochemical properties based on the composite chemical reagent on the content of hematite and barite.

Considering that hematite and barite have a high density, to obtain superheavy drilling fluids, we carried out experimental studies to study the physicochemical properties of drilling fluids based on the composite chemical reagent CCR-1 as a base using hematite and barite. The results of the dependence of the physical and chemical properties of drilling fluids on the content of hematite and barite are shown in Figure 1.

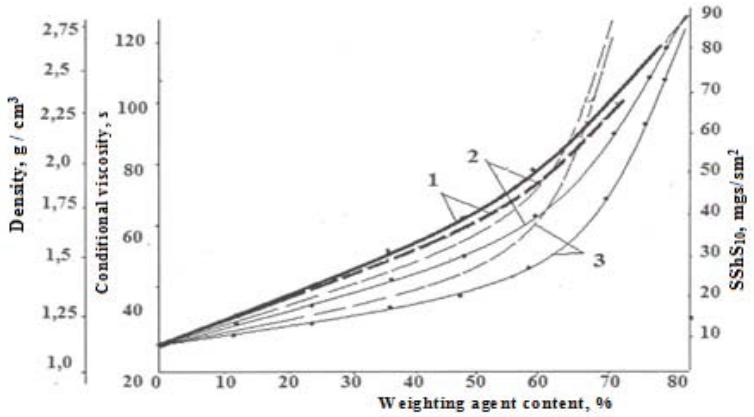


**FIGURE 1.** Dependence of density (1), viscosity (2) and $SShS_{10}$ (3) of drilling fluids based on composite chemical reagents on the content of hematite and barite

Figure 1 shows that when the drilling mud is weighted with hematite to 70-72%, the density of the mud increases to 2.4-2.50 g/cm$^3$, and the SShS is in the range of 55-60 mgc / cm$^2$. The fluid loss values are almost unchanged and amount to 5-6 cm$^3$ / 30 min, the pH is 10-11.

When barite weighting agents are added in an amount of 60-65%, the density of the solution is 2.1-2.2 g / cm$^3$, while the conditional viscosity of the drilling fluid is 100-110 sec and the SShC of the solution is 62-64 mgs /cm$^2$ in 10 minutes. The fluid loss of the solution is 5-6 cm$^3$ / 30 min, the pH value is 10-11.

Figure 2 shows the results of studies of the dependence of the conditional viscosity of drilling fluids based on composite chemicals and various weighting agents on their density.

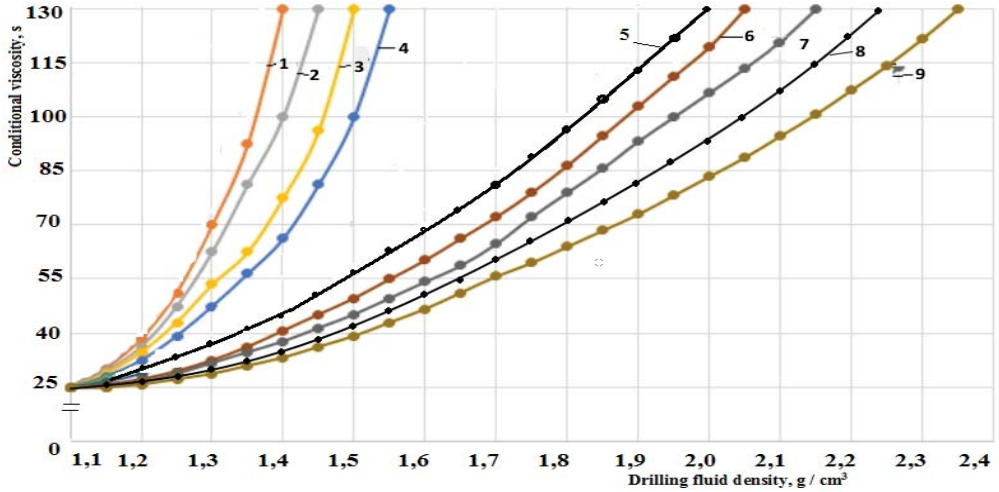


**FIGURE 2.** Dependence of the conditional viscosity of drilling fluids on their density: 1- red clay, 2-K-feldspar, 3-marble flour, 4-dolomite, 5-barite Saribulak, 6- barite Zheiremky, 7-barite Salair, 8-scale, 9-hematite

As can be seen from Figure 2, when using various weighting agents in drilling fluids prepared on the basis of a composite chemical reagent, it is possible to obtain drilling fluids with a density of red clay - up to 1.40 g / $cm^3$, carbonate-polymer sludge - up to 1.43 g / $cm^3$, marble flour - up to 1.48 g / $cm^3$, dolomite - up to 1.55 g / $cm^3$, Uzbek barite - up to 1.9 g / $cm^3$, Kazakh barite - up to 2.05 g/$cm^3$, Russian barite - up to 2,1 g/$cm^3$, scale - up to 2.25 and hematite - up to 2.35 g/$cm^3$.

Further, the operational and technological characteristics of the developed weighted drilling fluids based on composite chemical reagents using formation waters were investigated - the dependence of the conditional viscosity on their density, stability and sedimentation stability on their concentration.

With a further increase in the density of drilling fluids with the help of weighting materials, the viscosity of the drilling fluids increases, which leads to an increase in the resistance force on the movement of the fluids.

Figure 3a shows the dependence of the stability of weighted drilling fluids on the concentration of composite chemical reagents for various weighting agents, and Figure 3b shows the dependence of stability on the particle size of the weighting agent.

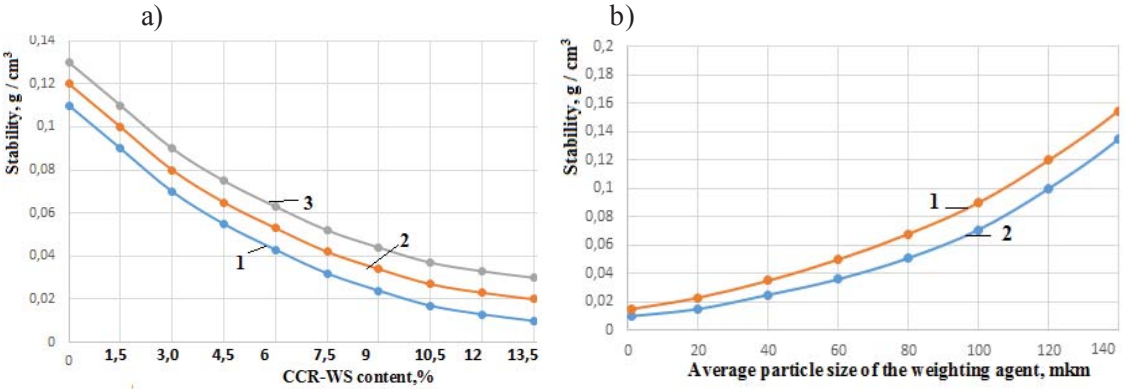


**FIGURE 3.** a) Dependence of the stability of weighted drilling fluids on the concentration of the composite chemical reagent CCR-WS; 1-barite, 2-scale, 3-hematite. b) Dependence of the stability of weighted drilling fluids on the average particle size of the weighting agents; 1 - existing; 2- obtained on the basis of CCR-WS

Figure 3a shows that the composite chemical reagent has a positive effect on the stabilizing ability of weighted drilling fluids. With an increase in the content of the composite chemical reagent to 13.5%, the stability of hematite-weighted drilling fluids decreased from 0.13 to 0.03 g/cm$^3$, scale from 0.12 to 0.02 g/cm$^3$, and barite from 0.11 to 0.01 g/cm$^3$.

Fig. 3b, it can be seen that the stabilization process of weighted drilling fluids is influenced by the dispersion of solid phases, and with a decrease in the particle size in the drilling fluid, the stability index also decreases from 0.2 to 0.01 g/cm$^3$. Studies have shown that the average particle size of the weighting agent should be in the range of 10-40 microns in order to maintain the stability of weighted drilling fluids.

Next, we investigated the sedimentation rate of weighted drilling fluids. Figure 4 shows the dependence of the sedimentation index of solutions with various weighting agents on the content of the composite chemical reagent.

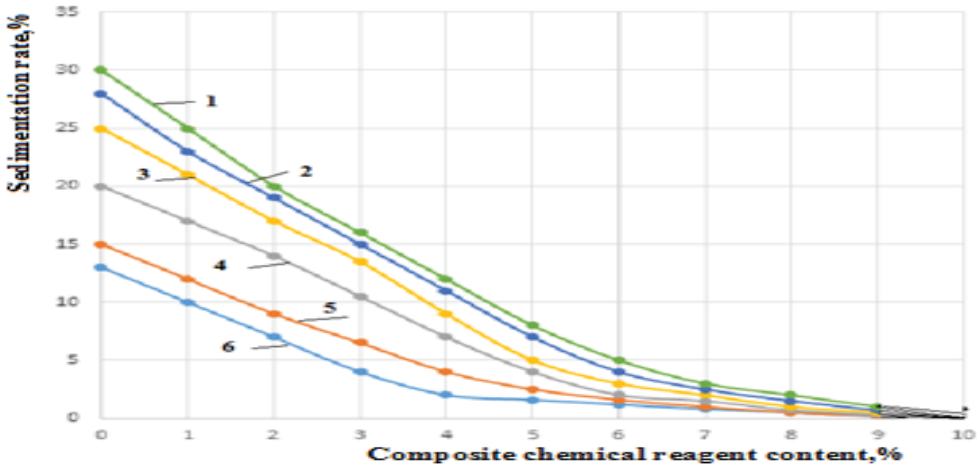


**FIGURE 4.** Dependence of the sedimentation index of drilling fluids weighted with various weighting agents on the content of the composite chemical reagent. 1-hematite; 2-scale; 3-barite; 4-dolomite; 5-PCS; 6-tap clay

Figure 4, shows that the sedimentation index in solutions with various weighting agents decreases with an increase in the content of the composite chemical reagent.

The sedimentation index of weighted drilling fluids with barite decreases from 25 to 1.4 cm$^3$, hematite from 30 to 2 cm$^3$, scale from 28 to 1.6 cm$^3$, dolomite from 20 to 1.3 cm$^3$, carbonate-polymer sludge from 15 to 1, 2 cm$^3$, clay from 14 to 0.5 cm$^3$ with an increase in the content of the composite chemical reagent from 1 to 13.5%.

Studies show that the most stable weighting agent is clay, but its weighting capacity is negligible: -1.3-1.4 g/cm$^3$. Therefore, for the further production of heavier drilling fluids, weighting agents were selected according to the maximum weighting capacity - hematite up to 2.3 g/cm$^3$, scale 2.25 g/cm$^3$, barite 2.15 g/cm$^3$, dolomite 1.55 g / cm$^3$, carbonate polymer sludge 1.45 g / cm$^3$.

To create weighted drilling fluids using barite and hematite, an optimal composition of composite chemical reagents was developed, conventionally called CCR-WS, which have high lubricity due to the content of about 35-40% of polymerized fatty acids, pigment, glycerin and other components in their composition, serving for the emulsification of oil with water. Na-CMC of Namangan production "Carbonam" was used as a stabilizer. To obtain salt-saturated weighted drilling fluids, from 15 to 25% technical salt of sodium chloride was added from the total volume of the solution and weighting agents.

The results of the tests carried out to obtain weighted clayless drilling fluids based on the CCR-WS composite chemical reagent are shown in Table 2.

**TABLE 2.** Technological parameters of CCR-WSweighted drilling mud.

| Reagent brands | Composition of weighted drilling mud | Technological parameters | | | | |
|---|---|---|---|---|---|---|
| | | ρ, g/cm$^3$ | $T_{500}$, s | F, cm$^3$/30 min | $T_к$, mm | pH |
| CCR-WS-1 | 1000 ml working solution Chulkuvar 39 based on CCR-1 | 1,92 | 52,0 | 10,0 | 1,2 | 9,0 |
| CCR-WS-2 | No. 1 solution + 10% NaCl | 2,11 | 64,0 | 12,0 | 1,5 | 7,0 |
| CCR-WS-3 | No. 2 solution + 6% CCR-WS | 2,18 | 69,0 | 8,0 | 1,0 | 9,0 |
| CCR-WS-4 | No. 3 solution + 10% oil | 2,33 | 72,0 | 8,0 | 1,0 | 9,0 |

From the data in Table 2, it follows that on the basis of the developed composite chemical reagent CCR-WS it is possible to obtain effective high-density drilling fluids.

## CONCLUSIONS

Based on the results of complex studies, a scientifically grounded approach to the creation of effective composite compositions of chemical reagents using organomineral ingredients from secondary raw materials has been developed to obtain weighted drilling fluids with a density of up to 2.30 g/cm$^3$.

As a result of the development of the composition by selecting the type, content, ratio and properties of the studied weighting agents, the possibility of regulating the physicochemical properties and technological parameters of weighted drilling fluids was shown, the regularities of the influence of the ratio of the components on the properties of the system were revealed.

Optimal compositions of CCR-WS composite chemical reagents have been developed, which ensure the preservation of the regulated rheological and filtration properties of drilling fluids and are recommended for drilling oil and gas wells in difficult geological and technical conditions.

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