Research and Development of Effective Compositions of Drilling Fluids for Oil and Gas Well Drilling

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**Abstract.** Today, on a global scale, the development and justification of various scientific solutions for using bentonites, palygorskites, hydromicas, and other minerals, as well as chemical reagents, as a base for drilling fluids in oil and gas well drilling, is of great importance. These solutions are focused on the following areas: increasing the stability of drilling fluids; creating effective chemical reagents for drilling processes; developing polymineral compositions based on local clays and preparing effective drilling fluids from them; investigating the physicochemical properties of solutions prepared from polymineral compositions; studying the patterns of heat and salt resistance in drilling fluids obtained from clay compositions; and developing optimal procedures for their application.

**Keywords:** Bentonite, Khaudag, well drilling, rock, palygorskite, hydromica, weighting agent, barite, phosphorite.

# Introduction

Drilling fluid is an integral element of drilling technology and performs a number of important functions, ensuring high technical and economic performance, smooth operation, and reduced drilling costs. Drilling fluids not only remove destructive products from the well and cool the rock cutting tool, but also prevent geological complications and contribute to improving the quality of drilling operations. The use of drilling fluids with properties that do not correspond to the given geological conditions usually leads to various complications and accidents. In this regard, a comprehensive set of complex drilling fluids has been developed in recent years, prepared from high-quality raw materials and treated with various chemical reagents. This research [1] study examines the current state and fundamental physicochemical properties of weighting materials for drilling oil and gas wells, as well as drilling fluids prepared using these materials. New compositions of weighted drilling fluids have been developed utilizing the novel chemical reagent MBR-1 and weighting materials.

During the operation of oil and gas wells, their production is terminated after a certain period due to a sharp decrease in well output, sometimes caused by the cessation of liquid or gas inflow. To restore the normal operation of wells, it is necessary to lift all underground equipment, replace or repair some of its components, clean the sand plug at the bottom of the well, and perform a series of similar operations before lowering the underground equipment back into place. Changing the technological regime of well operation and replacing the pump-compressor pipes or changing the depth of their lowering will depend on replacing the depth pump and performing similar operations [2].

Drilling mud fluids are high-quality drilling fluids with a stable structure. It is precisely the ability of clays to create a strong structure due to their chemical composition, as well as the ability to regulate the physicochemical properties of solutions by adding reagents, that has made them the primary type of drilling fluid. However, due to the increasing complexity of drilling conditions, the term "drilling mud" no longer refers to any type of drilling fluid, but includes several names that differ in the mineralogical composition of the clays used (bentonite, palygorskite, hydromica), and the type of chemical treatment (calcium chloride, limestone, silicate, etc.), the concentration of the solid phase, the degree of mineralization, heat resistance, etc. It is necessary to emphasize the enormous contribution of scientists and engineers who have created the science of drilling mud fluids, developed the technology for their preparation and use, as well as methods for regulating the properties of solutions.

According to the requirements for mixtures used in the oil and gas drilling process, the water separation from the mixtures within 12 hours should not exceed 2.5%. The palygorskite mixture, specifically in a saline environment, becomes saturated with salt and does not release any water at all. Clays are primarily used in mixtures in powder form. Bentonite reserves are found in large quantities in Khaudag, and the obtained samples are used specifically for the production of drilling fluids.

In the [3] research work given physical and chemical properties of chemical reagents, methods of their testing, as well as the development of drilling fluids for drilling oil and gas wells. The result of the research work has been implemented in the wellbore with salt anhydrite layer of Kashkadarya gas deposits

Some reference presents the results of research on the creation of effective composite chemical reagents based on organic and inorganic ingredients for drilling fluids used in drilling oil and gas wells. Comparative descriptions of drilling fluids with drilling fluids used in other countries, such as Russia, USA, are given [4].

Theoretical prerequisites for the development of a complex action reagent, in order to stabilize drilling fluids and the best results in combining the properties of reducing the plastic viscosity index and the filtration index of drilling fluids, are shown by samples of Rodopol-23P and pitchy carbolignosulfonate KLSP. A corresponding scheme for obtaining a reagent of complex action has been developed [5].

# Methods

The research was conducted at Termez State University of Engineering and Agrotechnology. First, a sample was taken from the Khaudag bentonite deposit for experimental purposes. The obtained sample was mixed with water to prepare a suspension, for which we used a flotation machine, model FM-8L, as a diluent.

Initially, we determined the density of the solution formed during the liquefaction process, using the HZMD-2001 laboratory equipment for density measurement. Density is considered a primary property, as it affects processes such as sedimentation, swelling, and the influence of drilling fluid.

Subsequently, the viscosity of the liquid was measured using a laboratory apparatus, specifically the HZYN-1302 model kinematic viscometer. Viscosity is one of the main properties and plays a crucial role during the drilling process. If the viscosity is too high, it causes significant difficulties in excavation.

Let's determine the flammability, that is, heat resistance, of the solution obtained in the experiment. For this purpose, the heat resistance of the solution was determined using the Pensky-Martens B091M laboratory equipment for determining the thermal characteristics of solutions in a closed environment. Only heat-resistant solutions cool the tip of the drill bit, prevent fluid boiling - solutions that meet this requirement provide high efficiency precisely during the drilling process.

# results And analysis

Clay solution is a multicomponent system consisting mainly of clay and water. Clay is the primary structural and shell-forming component of drilling fluids. Clays are complex polydisperse rocks, consisting of mixtures of natural clay minerals. Non-polydisperse components include non-clay minerals (quartz, calcite, feldspar, zeolite, cristobalite, and others).

- organic substances in the form of molecules adsorbed on the surface of particles;

- water-soluble salts added to the clay during its formation.

Chemically, clays are layered aluminosilicates. They are formed as a result of geochemical processes, such as physicochemical decomposition and hydrothermal alterations.

For example, the decomposition of orthoclase can occur according to the following schemes:

**K2Al2Si6O16 + H2O + CO2 → K2CO3 + H2Al2Si4O12 + 2SiO2**

or

**K2Al2Si6O16 + H2O + CO2 → K2CO3 + H4Al2Si2O9 + 4SiO2**

For most clay rocks, formation begins with the state of clay, in which more than 85% of the volume of the solution is filled with water. Over time, sedimentary rocks are compacted by the force of gravity of the upper layers, and their thickness and weight increase during accumulation. Thus, the process of clay rock formation occurs. Along with compression, a process of increasing strength occurs - hardening, which is the result of the merging of particles and the crystallization of salts in solutions, the formation of chemical bonds, recrystallization, etc. [6].

In this research work, a new Khaudag bentonite was used, which is not inferior in chemical composition to the bentonite reserves used for the aforementioned drilling fluids. Currently, exploration work has revealed the presence of 3 reserves of this bentonite: Khaudag alkaline bentonite, Khaudag alkaline-earth bentonite, and Khaudag carbonate palygorskite.

Taking into account the presence of large reserves of this type of bentonite in the Khaudag area of the Jarkurgan district, as well as the proximity of the railway line to this area, it is possible to build a new bentonite deposit and a complex for its processing [7]. Therefore, it is a promising raw material for the production of drilling fluids in terms of supply. It is only necessary to organize the selection and supply of appropriate chemical reagents for them.

Currently, oil and gas wells are being drilled in the saline horizons of the Bukhara-Khiva and Ustyurt regions of Uzbekistan. According to the authors, it is advisable to use such drilling fluids. These drilling fluids are primarily obtained using bentonite clays. Results of sedimentation analysis showed that all clays, depending on their granulometric composition, are fine-dispersed raw materials with bentonite reserves in the Khaudag deposit. In addition, both bentonites have much more delicate fractions than palygorskite.

Chemical reagents are added to drilling fluids to improve their properties. Clay rocks are primarily used in the preparation of drilling fluids. These clays, depending on their mineral composition, are divided into 4 types. These. Montmorillonite (bentonite), kaolin, Hydromicaceous, and Paligorskite minerals. Group 1 montmorillonite for drilling has the formula (OH)4Si8Al4O20 n H2O Silicon in the montmorillonite (bentonite) molecule can be replaced by Al3+, Fe2+,3+, Zn2+, Cu2+, Mg2+, Li+ ions. Montmorrilonite has a grayish white, as well as pink, pinkish-red, and green hues. Montmorrilonite has significant adsorption and ion exchange capacity, as well as absorbing and removing weakly bound water depending on the moisture of the surrounding environment.



**FIGURE 1.** Khaudag bentonite-based montmorillonite

Montmorillonite is a bentonite clay mineral. Bentonite clays are more effective than other types of clays. For example, if 16-24 m3 of a mixture is obtained from bentonite, then 4-6 m3 of a mixture is obtained from hydromica. Therefore, it is advisable to use a bentonite mixture. Hydromica is abundant in terms of quantity and is used only in areas where bentonite is not present. However, when hydromica is used, a sharp increase in the solid phase content is typically observed, and chemical reagents are often used to soften this solid phase. Kaolinite is rarely used in the drilling process.

Palygorskite, primarily due to its linearly fibrous mineral structure, is used to prepare salt-resistant and high-quality mixtures. Palygorskite mixtures yield very good results in the process of drilling salt layers.

Drilling fluids have specific functions, which include: cleaning the wellbore walls, removing rock cuttings from the bottom of the well, cooling the drill bit, and preventing (weighing down) the movement of gas and oil in the reservoir. Water has also been widely used instead of drilling muds. Drilling fluids are prepared based on the liquid phase, clay particles, and chemical reagents.

The gas phase is also used in well cleaning, and air plays a significant role as well. The gas phase is pumped into the well using a compressor. A surfactant (a substance that activates the elastic surface) is added to the gas or air phase pumped into the well.

**TABLE 1.** Types and quantities of surfactants for drilling fluids

|  |  |  |  |
| --- | --- | --- | --- |
| **№** | **Types of surfactants** | **Surfactant content, %** | **Fractured rock: water exiting the layer** |
| 1 | Sulfanol, NP 1 | 0,23 | 1:2 |
| 2 | “Progress”, OP-10 | 0,10 | 1:2 |
| 3 | KAUFE14 | 0,12 | 4:1 |
| 4 | “Azolyat A” | 0,10 | 1:2 |

The product obtained from the Guliob phosphorite reserve in Sariosiyo district primarily consists of calcium sulfate, phosphorus (V) oxide, and a small amount of SiO2. Table 2 presents the chemical composition of the Guliob phosphorite mineral, which is used in the production of drilling fluids possessing the necessary physicochemical, colloidal-chemical, and multifunctional properties.

TABLE 2.The chemical composition of the upper horizon of the Guliob natural phosphorite mineral   
deposit in various fractions.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Chemical composition of components, %** | **Dimensions with different dispersion compositions (mm)** | | | | | | | |
| **+0.5** | **-0,5+0,25** | **-0,25+0,2** | **-0,2+0,16** | **-0,16+0,1** | **-0,1+0,05** | **-0,05** | **Medium** |
| The yield of Guliob phosphorite in various fractions,%. | 6,211 | 34,579 | 10,410 | 7,360 | 10,994 | 25,165 | 5,281 | 100 |
| Total P2O5 | 5,35 | 5,56 | 5,81 | 6,90 | 7,26 | 7,20 | 6,78 | 7,13 |
| Total CaO | 13,10 | 14,70 | 15,23 | 15,50 | 15,79 | 19,83 | 22,80 | 18,62 |
| Total MgO | 1,65 | 1,95 | 2,10 | 1,27 | 0,52 | 2,02 | 1,42 | 1,35 |
| P2O5 assim by Trilon B. | 1,78 | 1,97 | 2,17 | 2,46 | 2,63 | 3,36 | 3,42 | 3,43 |
| P2O5assim. byCitric acid | 2,05 | 1,92 | 2,51 | 2,86 | 4,03 | 3,07 | 3,38 | 3,45 |
| СаО byCitric acid | 8,09 | 10,07 | 11,06 | 10,91 | 10,92 | 13,99 | 16,79 | 13,48 |
| Fe2O3 | 1,84 | 1,79 | 1,64 | 1,50 | 1,49 | 1,77 | 1,82 | 1,68 |
| Al2O3 | 2,38 | 2,56 | 2,54 | 1,8 | 1,98 | 2,37 | 2,39 | 2,38 |
| SO3 | 0,17 | 0,22 | 0,12 | 0,49 | 0,017 | 0,79 | 0,20 | 0,56 |
| CO2 | 6,49 | 6,66 | 6,80 | 6,56 | 5,23 | 8,47 | 11,14 | 7,46 |
| F | 0,295 | 0,329 | 0,392 | 0,449 | 0,489 | 0,50 | 0,488 | 0,42 |
| P2O5ass. : P2O5yield., by Trilon B, % | 33,27 | 35,43 | 37,35 | 35,65 | 36,22 | 46,67 | 50,44 | 48,11 |
| P2O5ass. : P2O5yield., byCitric acid , % | 38,32 | 34,53 | 43,20 | 41,45 | 55,51 | 42,64 | 49,85 | 48,39 |
| CaOass. : CaOyield. byCitric acid, % | 61,76 | 68,50 | 72,62 | 70,45 | 69,16 | 70,55 | 73,64 | 72,40 |

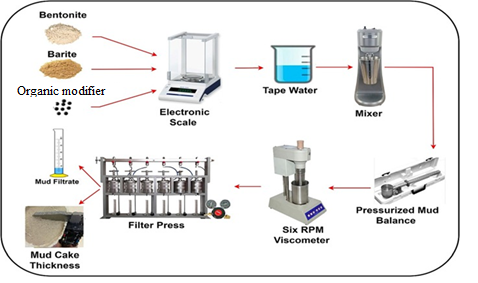
Phosphorite phosphogypsum is characterized by high amounts of SiO2 and P2O5, which is explained by the presence of significant quantities of siliceous rocks in the composition used. It has been determined that the main impurities in phosphogypsum as a current raw material include calcium fluoride, phosphoric acid and its compounds (medium, disubstituted and monosubstituted calcium phosphate), as well as silicofluorides, silica gel, residues of aluminum sulfates, iron, rare earth elements, sulfuric acid, and alkaline salts.

In practice, "Uzbekneftegaz" JSC mainly uses bentonite clays from local deposits for the production of drilling fluids. These include Kattakurgan bentonite (Samarkand region), Shorsuy bentonite (Fergana region), and Navbahor bentonite (Navoi region).

This requires the selection of appropriate additives to obtain stable drilling fluids with controlled density and thixotropy.

In this process, a solution is prepared using bentonite, barite, magnetite, and water. All components are precisely measured on electronic scales and mixed according to the specified weights. Subsequently, the density is measured, the viscosity level is determined, and the mixture is filtered to obtain the finished product.

The results obtained from the aforementioned experiments indicate that the Khaudag bentonite solutions prepared during the experimental process demonstrate high efficiency when used in drilling operations.

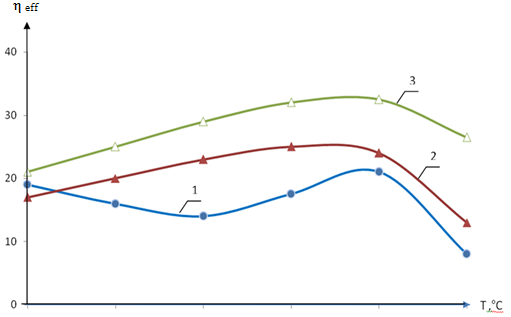


**FIGURE 2.** A scheme for obtaining drilling fluid by mixing minerals such as bentonite and weighting barite for use in the drilling process.

**TABLE 3.**Chemical parameters of bentonite

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Indicators** | **Flow rate (with SPV-5), S** | **Density of the mixture, g/sm3** | **Volume of mixture production, m3/t** | **Water retention, sm3 30min** | **Shell thickness,mm** |
| **Navbahor bentonite** | 25 | 1.04 | 15 | 16 | 2 |
| **Kasantau bentonite** | 25 | 1.06 | 10 | 18 | 2 |
| **Shorsuy clay** | 25 | 1.30 | 2 | 30 | 3 |
| **Konstantin bentonite** | 25 | 1.06 | 10 | 12 | 2 |
| **Khaudag bentonite** | 25 | 1.05 | 15 | 17 | 2 |

If the reagent is mixed in various molar ratios and used as a drilling fluid, the efficiency and scope of application are significantly expanded. High efficiency was achieved when we used the prepared solution during the drilling process of oil and gas wells. Using solutions made from local Khaudag bentonite and Guliob phosphogypsum products helps to prevent high costs.



**FIGURE 3.** Change in effective viscosity (η eff) of clay solution depending on the temperature of hydrothermal treatment.

The figure shows the change in effective viscosity of aqueous solutions of Khaudag bentonite clays and their composition. In this case, the effective viscosity of the solutions was measured using the VSN-2 high-temperature rotary viscometer-plastometer developed by the Oil and Gas industry. The solution composition includes bentonite, clay, sand, phosphorus compounds, and water.

Based on these results, the study of the developed technology for producing heat-and salt-resistant drilling fluids based on Khaudag bentonite clays using MCD at a speed of 2100 rpm showed high efficiency compared to the traditional method.

# CONCLUSION

Thus, considering the requirements for drilling fluids, several experiments were conducted. These experiments analyzed solutions containing montmorillonite-based bentonite. To address specific issues in the drilling process, research was carried out, and the physicochemical properties of bentonite were studied. Several experiments on bentonite have been conducted and are being applied in industry. We experimentally studied Khaudag bentonite and Guliob phosphogypsum, and determined their high effectiveness by using the obtained solutions in the drilling process. This is essential for producing drilling clays used in oil and gas extraction from local raw materials and for the efficient utilization of local resources. Based on the above results, samples obtained from bentonite clays are being widely used in drilling fluids. The main characteristics of Khaudag bentonite also correspond to the drilling fluids obtained from Navbahor bentonite and other regions. Based on these characteristics, the use of bentonite from the new deposit is considered a solution to several problems in obtaining and using drilling fluids.

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