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DEVELOPMENT OF DRILLING FLUID FORMULATIONS FOR WELLS IN DIFFICULT CONDITIONS BASED ON THE STUDY OF THE COMPOSITION OF CLAYS IN UZBEKISTAN

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Abstract. The article considers the scientific significance of the results of the study is to establish the chemical and mineralogical compositions and physico-chemical properties of bentonite compositions, as well as to identify the composition and properties of Navbakhor bentonites and Palygorskites and Shorsuv hydrosludes. The practical significance of the research results lies in the development of technology for producing clay compositions for drilling fluids based on local bentonites, palygorskites and hydrosludes.

Keywords: drilling mud, chemical and mineralogical composition, physico-chemical properties, composition of bentonites, composition of Navbakhor bentonites, properties of Navbakhor bentonites, palygorskite, hydrosludes, clay composition.

Annotatsiya. Maqolada tadqiqot natijalarining ilmiy ahamiyati bentonit kompozitsiyalarining kimyoviy va mineralogik tarkibi va fizik-kimyoviy xususiyatlarini aniqlash, shuningdek Navbaxor bentonitlari va Palygorskitlari va Shorsuv gidrosludiyalarining tarkibi va xususiyatlarini aniqlashdan iborat. Tadqiqot natijalarining amaliy ahamiyati mahalliy bentonitlar, palygorskitlar va gidroslyudalar asosida burg'ulash suyuqliklari uchun loy kompozitsiyalarini ishlab chiqarish texnologiyasini ishlab chiqishdan iborat.

Kalit so'zlar: burg'ulash loyi, kimyoviy va mineralogik tarkibi, fizik-kimyoviy xossalari, bentonitlarning tarkibi, "Navbahor" bentonitlarining tarkibi, "Navbahor" bentonitlarining xossalari, palygorskit, gidroshlyuzlar, loy tarkibi.

Аннотация. В статье рассматривается научная значимость результатов исследования, заключающаяся в установлении химического и минералогического составов и физико-химических свойств бентонитовых композиций, а также в выявлении состава и свойств навбахорских бентонитов, палыгорскитов и шорсувских гидрошламей. Практическая значимость результатов исследований заключается в разработке

ISSN 3030-3907

технологии получения глинистых композиций для буровых растворов на основе местных бентонитов, палыгорскитов и гидрошламей.

Ключевые слова: буровой раствор, химико-минералогический состав, физико-химические свойства, состав бентонитов, состав навбахорских бентонитов, свойства навбахорских бентонитов, палыгорскит, гидрошламы, глинистый состав.

I. INTRODUCTION.

At the present stage of development of technologies for drilling wells and oil and gas production, the main attention is paid to improving the processes of deep drilling in complicated conditions, where salt formations, rocks of solid minerals, etc. are overcome. Under these conditions, the temperature in wells rises above 200°C and reservoir water contains a lot of salt, especially chloride. Such high mineralization of reservoir water destroys the stability of the drilling fluid, reduces its quality and thereby the efficiency of drilling operations. In addition, the unsatisfactory quality of the drilling mud leads to stoppage and emergency situations, which is more often observed when using clay solutions unstable to high temperatures and highly mineralized aqueous solutions. [1].

When drilling rotationally, a fluid flow constantly circulates in the well, which was previously considered only as a means for removing destruction products (sludge). Currently, it is perceived as one of the main factors ensuring the efficiency of the entire drilling process. When drilling operations are carried out, the liquid circulating in the well is commonly called-drilling mud or washing liquid.

Drilling mud, in addition to sludge removal, must perform other equally important functions aimed at efficient, economical, and safe execution and completion of the drilling process. For this reason, the composition of drilling fluids, the assessment of its properties, becomes the subject of a large volume of scientific and practical research and analysis [2].

During drilling, the equilibrium of the rocks composing the walls of the wells is disturbed. The stability of the walls depends on the initial strength characteristics of the rocks, their change over time under the influence of various factors. A big role here belongs to the flushing process and the flushing agent. The main task of flushing is to ensure an efficient well drilling process, which includes maintaining both the stability of the well walls and the core.

In conditions where the integrity of the rock is violated, mountain pressure plays an important role. In the barrel part of the well, it manifests itself both vertically and horizontally. Lateral pressure is a consequence of vertical pressure

ISSN 3030-3907

and causes tangential directions-contributing to the bulging of rocks, narrowing of the trunk and collapse. The magnitude of tangential stresses depends not only on the rock pressure, but also on the pressure of the washing liquid [3].

When drilling wells, the flushing fluid must circulate through a closed hydraulic circuit. Depending on the type of hydraulic circuit, all existing flushing systems are divided into two groups:

1) washing systems with solution output to the surface

2) flushing systems with downhole circulation.

Accordingly, drilling fluids must meet a number of requirements:

– perform the assigned functions;

– do not have a harmful effect on drilling tools and downhole motors (corrosion, abrasive wear, etc.):

– easy to pump and clean from sludge and gas;

– be safe for maintenance personnel and the environment;

– be convenient for cooking and cleaning;

– be affordable, inexpensive, allow for multiple use.

II. METHODS.

The creation of thermo and salt-resistant clay drilling fluids can be carried out in the following areas:

-creation of high-quality compositions of dispersed systems based on thermo and salt-resistant natural mineral raw materials;

-based on thermo salt-resistant reagents of stabilizers obtained by chemical and technological methods.

Of course, the predominant development of the first direction is considered promising and economically justified. Moreover, this does not exclude the need for work in the second direction.

As noted earlier, palygorskite minerals showed higher resistance to the aggression of electrolytes of reservoir waters and salt deposits than montmorillonite minerals. This made it possible to significantly reduce the cost of expensive chemical reagents in obtaining stable drilling fluids [4].

Known heat-resistant reagents-stabilizers (polyelectrolytes) obtained by hydrolysis of polyacrylonitrile and polyacrylamide or their copolymers greatly overestimate the cost of drilling fluids and hydrocarbon production in general. In practice, the following reagents-stabilizers are used to protect clay solutions from the coagulating action of electrolytes: condensed sulfite-alcohol bard (CSAB), carbosimethylcellulose (CMC), starch reagent (SR), cellulose sulfoesters, etc.

A common disadvantage of these stabilizers is their susceptibility to temperature influences. On the contrary, reagents such as HYPAN, RS-2, RS-3, K-

ISSN 3030-3907

4 and others are more resistant to thermal effects on clay solutions. The paper proposes a lignin-containing reagent for the treatment of drilling fluids and water-based buffer fluids [5]. A distinctive feature of this reagent from the known ones is that it contains lignin with a humidity of 20-44%, an alkaline agent is a product of condensation of JK cotton soapstock with silicic acid sodium, etc.

III. Results. From the table. 1 it can be seen that alkaline and alkaline-earth bentonites mainly differ in the contents of TiO_2, MgO, Na_2O, K_2O_2, etc. More significant differences in chemical composition are observed between bentonites and carbonate palygorskite, where the latter has significantly less Al_2O_3, SiO_2, MgO and more CaO. When bentonites are sealed with water, it penetrates into the interlayer space of montmorillonite, hydrates it and causes swelling. When further diluted with water, bentonites form a stable viscous suspension with pronounced thixotropic properties. These bentonites are considered to be good viscous-gelling agents and filtration reducers in the preparation of drilling fluids for drilling wells [6].

Today, formulations have been developed for obtaining padygorskite-containing drilling fluids that have low filtration and resistance to high downhole temperatures and electrolytes. This once again confirms the need for the right choice of mineral raw materials for the preparation of drilling fluids used in difficult drilling conditions.

Carbonate palygorskite of the Navbakhor deposit (Navoi region) is an aqueous magnesium aluminosilicate with the ideal formula R_5 [Si_8 O_2] $(OH)_2$, $(OH_2)_4$, $4H_2O$. The crystal structure of this palygorskite, which has a layered structure, resembles the structure of an amphibole and has zeolite-like channels of 6.4. 3.7 Å In size, two types of water are located in them: molecules that are freely placed and connected to the electronegative surface of the bases of tetrahedra, and molecules that have a connection with octahedral cations on the side walls of the channels. These molecules are removed from the latter at higher temperatures, as are the water molecules of zeolites [7].

Of course, if necessary, the formation of calcium bentonites into sodium ones can be performed by treating them with sodium salts. Today, in the Bukhara-Khiva and Ustyurt regions of Uzbekistan, drilling of oil and gas wells is carried out in saline formations. According to, it is advisable to use solutions for such drilling, mainly obtained using palygorskite clays (atapulgite), which are rich in CaO (Table 1).

ISSN 3030-3907

Table 1

The content of chemical compounds in the composition of bentonites and palygorskite of the Navbakhor deposit (Navoi region)

Name of connections	Compound content, % per absolute dry matter		
	Bentonites		Carbonate palygorskite (attapulgite)
	Alkaline	alkaline earth	
SiO_2	57,91	56,23	46,79
TiO_2	0,35	0,61	-
Al_2O_3	13,69	13,56	8,63
Fe_2O_3	%.10	6,50	-
MgO	1,84	3,76	2,74
CaO	0,48	0,69	10,08
Na_2O	1,53	0,98	-
K_2O	1,75	2,20	1,6
P_2O_3	0,43	0,92	1,99
SO_3	0,75	0,49	-
Fe_2O	-	-	3,41
P.P.P.	16,17	14,06	24,33
∑	99,98	99,95	99,75

The advantage of this reagent is that it is possible to use not only previously used brands of cotton and other types of lignins after pentose hydrolysis, but also more difficult-to-dissolve brands of lignins after hexose brews. Instead of the known stabilizing clay drilling fluids reagents CMC-600, K-4 and K-9, a composite polymer reagent is proposed, which consists mainly of caustic and soda ash and waste from the production of nitrogen fertilizers, which contains polyacrylamide [8].

The carbonate palygorskite of the Navbakhor deposit has more large fractions, compared with the alkaline and alkaline-earth bentonites of the same deposit (Table 2).

The results are presented in table 2.

Table 2

Dispersed composition and specific surface area of alkaline, alkaline-earth bentonites and carbonate palygorskite Navbakhor deposit and hydrosluidic clay Shorsuvskoye field

Name of clay	Content of fractions, %			Specific surface area 10^3 м^2/kg
	less than	less than 0,1 mm	less than 1,0 mm	

ISSN 3030-3907

	0,01 mm			
Alkaline bentonite of the Navbakhor deposit (ABND)	80,2	18,9	0,9	305
Alkaline earth bentonite of the Navbakhor deposit (AEBND)	81,6	17,7	0,7	310
Carbonate palygorskite of the Navbakhor deposit (CPND)	76,5	21,4	2,1	286
Hydrosluidic clay of the Shorsuv deposit (HCSD)	82,7	16,2	1,1	295

Table 2 shows that the largest specific surface area is found in alkaline-earth bentonite (310·103 m^2/kg) and vice versa, the smallest in carbonate palygorskite (286·103 m^2/kg).

In the table 3 the results of the study of the wetting heat and the amount of bound water are presented.

Table 3

Indicators of the heat of wetting and the amount of bound water in the clays of the Navbakhor and Shorsuv deposits

Name of clay	Wetting heat (Q), cal/g	Amount of bound water (A), %
Alkaline bentonite	25,8	33,54
Alkaline-earth bentonite	28,5	37,05
Carbonate palygorskite	19,5	25,35

It can be seen from Table 3 that the greater the value of the wetting heat of the clay, the greater the amount of bound water in it. The greatest heat of wetting and the amount of bound water is observed in alkaline-earth bentonite and vice versa the smallest in carbonate palygorskite at a density of bound water in = 1.3 g/cm^3.

The indicator of the amount of bound water makes it possible to judge the degree of hydrophilicity of the clay under study. Moreover, the alkaline and alkaline-earth bentonites of the Navbakhor deposit are more hydrophilic than the carbonate palygorskite of this object [9].

Palygorskite with a layered-ribbon crystal structure forms angular plank-like crystals with zeolite-like channels. It is known that in bentonite (montmorillonite) clays, water is absorbed not only by the outer surface, but also by the inner

ISSN 3030-3907

(interpackage) space. Therefore, Navbakhor bentonites are characterized by relatively higher values of wetting heat than carbonate palygorskite of this deposit.

The study of the swelling of bentonites and palygorskite of the Navbakhor deposit is important, especially at the stages of well wiring, because the drilled rock, peptising, can lead to an undesirable increase in the viscosity of the drilling mud. Therefore, reducing the amount of swelling of clays is one of the main tasks of obtaining effective drilling fluids. At the same time, the amount of bound water certainly depends on the type of clay, its mineralogical and chemical compositions, specific surface area, dispersion and others [10].

Table 4 presents the results of swelling analyses of selected clays of the Navbakhor deposit.

Table 4

Indicators of swelling of bentonites and carbonate palygorskite Navbakhor deposit and hydrosluidic clay Shorsuvskoye field (ShF)

Name of the swelling index	Bentonite		carbonate palygorskite	hydrosluidic clay ShF
	alkaline	alkaline-earth		
Degree of swelling (h), cm^3/g	1,398	1,425	1,235	1,321
Swelling time (τ), hour	762	776	675	689
Average swelling rate (ω_{cp}. 10^{-3}), cm^3/g. hour	1,720	1,735	1,689	1,578
Limiting shear stress (Pm), $g.s/cm^2$	125	121	127	122

From the table 4 it can be seen that the greatest water swelling is observed in alkaline-earth bentonite and vice versa, the least in carbonate palygorskite (atapulgite). Moreover, the average swelling is observed in the alkaline bentonite of the Navbakhor deposit [4].

Palygorskite-magnesium aluminosilicate forms the strongest suspension when replacing the exchange complex with magnesium cation, the most. Completely filling vacancies of broken bonds in places of crystal structure violations, especially in areas of destruction of zeolite-like channels.

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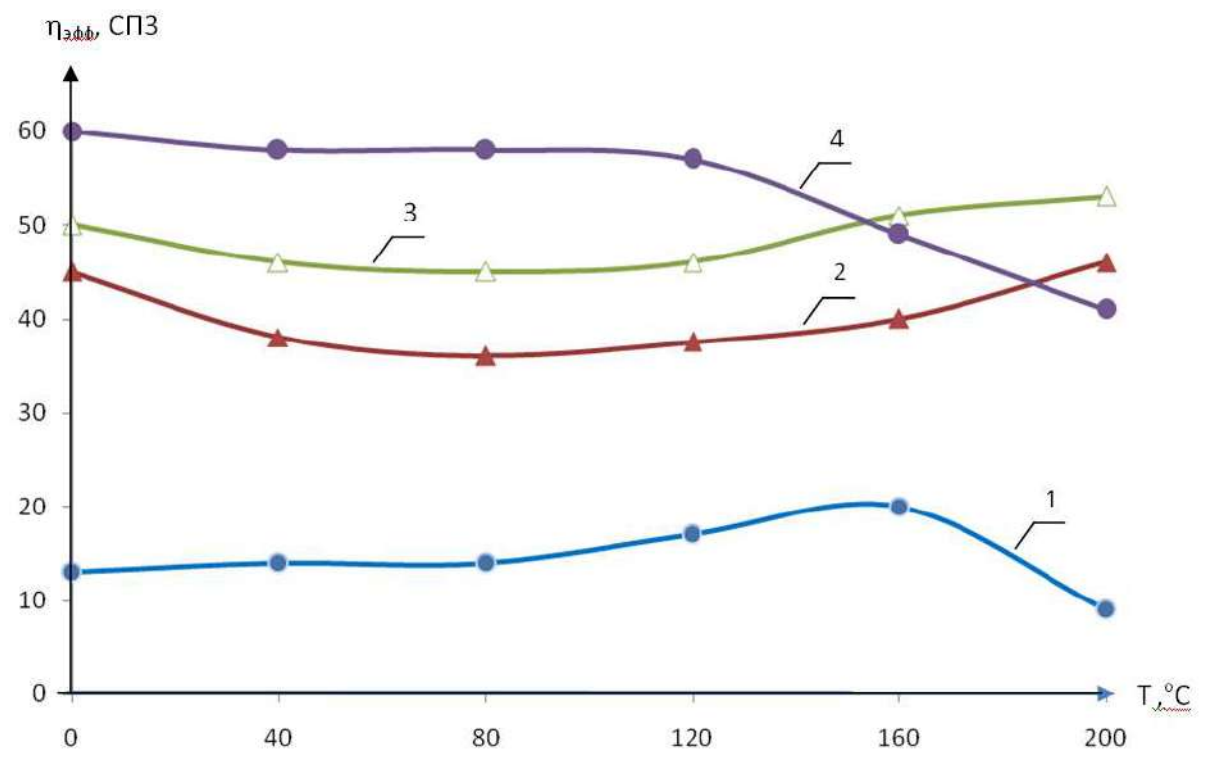


Figure 1. Change in the effective viscosity (η eff) of a 10% aqueous solution of CP NM depending on the temperature of its hydrothermal treatment: 1-without electrolyte; 2-with the addition of 10% NaCl; 3-with the addition of 20% NaCl; 4-with the addition of 30% NaCl.

When using a 50:50 ratio of the above-mentioned clays, the effective viscosity of the solution is higher than when they are used individually, and its decrease is observed after 170°C-180°C. This once again confirms the advantage of using a clay composition with the addition of palygorskite in producing a suspension for drilling deep, high-temperature wells.

With this in mind, we studied the change in the effective viscosity (η_{eff}) of a 10% aqueous solution of KP NM depending on its thermal treatment temperature and the addition of electrolyte with varying concentrations.

The results are presented in Figure 1.

Figure 1 shows that aqueous solutions of KP NM exhibit uniform changes in their effective viscosity curves up to 160°C. With further increases in temperature, the effect of NaCl concentration becomes more pronounced.

However, mixtures i.e. compositions of these types of clays of the Navbakhor field for obtaining drilling fluids have not been studied enough. In order to fill this gap, we studied a number of compositions obtained on the basis of clays from the Navbakhor deposit and others [11].

Thus, the conducted studies show that from these clays, depending on the purpose of the drilling fluids obtained, various compositions of them can be made. At the same time, it should be noted that the resulting compositions serve as the

ISSN 3030-3907

basis of clay drilling fluids and their treatment with chemical reagents allows to stabilize the quality indicators of the latter.

It is known that bentonites contain more than 70% of montmorillonite-a highly dispersed layered aluminosilicate, the crystal-chemical structure of which causes the presence of ion-exchange cations on its surface, which determine its chemical and physical properties as a mineral. The excessive negative charge compensating the exchange cations of the interlayer space of montmorillonite causes the high hydrophilicity of bentonites. When bentonites are sealed with water, it penetrates into the interlayer space of montmorillonite, hydrates it and causes swelling. Upon further dilution with water, bentonite forms a stable viscous suspension with pronounced thixotropic properties [12], These bentonites are considered good visco-gelling agents and filtration reducers in the preparation of drilling fluids for drilling wells.

IV. DISCUSSION.

Ca-clays bind water more strongly than Na-clays, in terms of the binding energy, i.e. by the heat of wetting, being more hydrophilic. However, they do not form diffuse double layers as thick as Na-clays, and therefore do not detect peptization of particles and give compact coagulation through the thinnest layers of water [13].

Carbonate palygorskite of the Navbakhor deposit has more large fractions, compared with alkaline and alkaline-earth bentonites of the same deposit (Table 2).

This means that the entire possible clay surface also interacts with water in this case, but this interaction is not accompanied by the release of particles and, consequently, a significant increase in their number per unit volume, as is observed in Na-clays. In the latter case, they are partially connected at the contact points much weaker, but their number, and therefore the number of contacts, is much greater [14]. In the limit, when the cation-exchange complex is completely replaced by a sodium ion, the diffuse ion forces are so developed that the peptization of particles and their stabilization in dilute suspensions are complete.

The results of the sedimentation analysis using the Sabanin-Robinson method showed that, according to their granulometric composition, all the clays of the Navbakhor deposit belong to fine-dispersed raw materials. Moreover, both bentonites have more small fractions than palygorskite [15].

The creation of thermo- and salt-resistant drilling fluids can be carried out in two main directions, partially complementing each other;

– creation of high-quality dispersed systems based on thermo- and salt-resistant natural mineral raw materials;

– based on thermo and salt-resistant reagents-stabilizers.

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Of course, it is advisable to preferentially develop the first direction as the most promising and economically profitable. Moreover, this does not exclude the possibility of carrying out work in the second direction, especially in the case of the use of washing fluids when drilling in salt deposits alternating with clay layers, where it is required to reduce the filtration of clay solutions to minimum values [16]. Of course, this can be achieved only by combining heat-resistant mineral raw materials and surfactants, i.e. by combining the two above-mentioned directions.

V. CONCLUSION.

It is known that the use of even high-quality montmorillonites (bentonites) does not allow efficient drilling in mineralized media without treatment with chemical reagents, which is many times higher than the cost of drilling fluids, and often leads to the impossibility of their operation due to coagulation of clay suspension by electrolytes. The use of palygorskite clays when drilling solid salt-bearing strata allows in some cases to do without expensive chemicals, which reduces the cost of drilling mud tenfold.

Long-term practice shows that ordinary clay minerals, even with chemical treatment, are not able to form dispersed systems stable in the presence of electrolytes in the hydrothermal regime. In this case, the use of padygorskite-containing drilling fluids allows for further drilling of difficult wells Such solutions have low filtration and are suitable for drilling salt deposits interspersed with clay layers. As can be seen, salt-resistant clay minerals do not significantly change the course of the deformation process in their dispersions when exposed to various electrolytes. Moreover, this is confirmed both with and without surfactant additives.

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