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# New compositions of the drilling muds with Kazakhstan clays

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**Abstract**

The experience of the drilling wells shows that at transition from systems of drilling muds with a high content of a solid phase to polymeric-clayey muds technical indicators of drilling dramatically improves. It is caused by decrease in action of hydrostatic pressure towards a bottom-well due to reduction of density of drilling mud and improving of rheological properties of drilling mud and quality of flushing and cleaning of bottom well. In this regard creation of such drilling muds, especially in difficult mining-and-geological conditions was of interest.

*Keywords: Drilling of wells; Drilling mud; Technological properties; Difficult conditions; Bentonite clays; Polymer-clayey mud; Rheological and filtration properties of drilling muds.*

## 1. Introduction

Influence of drilling mud on process of destruction of rocks was studied for a long time but mechanisms governing the effects of drilling mud on strength properties of rocks remained unclear.

Research works of P.A. Rehbinder's (1978; 1979) allowed to explain, from physical and chemical pint of view, the mechanism of loss strength rocks at interaction with various medias of fluids. It showed that mechanical properties of solid bodies including rocks, at their deformation and destruction under the influence of environment, change as a result of

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the physical-chemical processes happening on the surface of transition of a solid body – fluid (Rehbinder, 1978; 1979).

It was proposed to use processes of moisten and an adsorbtion for simplification of mechanical destruction of solid bodies. To simplify destruction, it was decided to apply various superficial active substances as a reducers of hardness which are electrolytes, organic compounds, polyelectrolytes etc. However many reducers of hardness possess selective properties and differently influence on various mineralogical contents. Most of the organic soaps are active hardness reducers for many rocks, and alkaline electrolytes are efficient for carbonate rocks. Each hardness reducer of organic or inorganic structure has the limit of application at which its greatest efficiency is shown.

It is known that resilience of rock to destruction increases with transition to the clayey, weighted mud, and also at saturation of drilling mud by salts of electrolytes. Therefore for drilling wells a special attention should be paid to choose drilling muds which would correspond not only conditions of preservation of a shaft well and provided high technical rates of drilling, but also correspond to requirements of a headway (deepening) well in specific mining-and-geological conditions.

Serious problem for drillers makes drilling in hard clay layers since they generally consist of clay minerals which swelling or are dispersed at contact with water. This reaction leads to violation of stability of layer, caving of shaft well or sticking of drill column. It can also leads to destroying of proper cutting operation of cutting tool. Strongly dispersed formations can promote undesirable expansion of a shaft well, and also fast increasing of solid phase content in a drilling mud and this in its turn complicates and rise in the cost the process of control of characteristics of drilling mud.

Baydyuk & Shreyner (1961), on the basis of experimental evidences, determined critical values of drilling muds density at which clays of various moisture can keep in a steady state at the required depth. According to those data, if clays are poorly moistened or their moisture makes only 2-3%, then they show themselves rather steady against collapses and sloughs on walls of a well and because of this steadiness it is not required to provide high hydrostatic pressure into shaft. As a result, it is possible to control and prevent caving of shaft.

However the increase moisture of clays by 2-4 times causes their sharp seal failure and decrease of stability of shaft well. In this case it is required to increase density of drilling mud to 2.2-2.48 g/cm$^3$.

The prevention of collapses and sloughs of clays by a counter-pressure of drilling mud on well walls doesn't eliminate possible complications during clay drilling. Often counter-pressure of drilling mud doesn't reduce caving process itself, but also can provokes caving in permeable seam where action of high pressure fall causes an increase of filtration speed of a water phase in the mud clay layer along its cracks.

Multiple attempts to decrease water loss filtration of drilling mud by processing with high-molecular protective reagents didn't provide long-lasting stability of walls of the wells in shales.

Though decrease of water loss filtration of drilling mud improved a working condition of a shaft and also the period of hydration of clays till the point of critical loss of strength, has been prolonged, however after a long flushing of an open shaft of well there were observed collapses and sloughs. Thus the period of initiation of collapses and sloughs didn't depend on the amount of water loss filtration of drilling muds. It testifies that the water loss filtration parameter cannot be revising as quality criteria of drilling mud. Here quality criteria is the compatibility of drilling mud with drilling-out clayey rocks. Our experience in drilling wells with polymer-clayey drilling muds using biopolymers and other polymers showed that for keeping the stability of walls of the wells formed it is necessary to form, on well walls, polymer-clayey semipermeable membranes which would prevent rock filtration. Use of such drilling muds would allow to keep considerably stability of walls of wells and to provide their long durability in time.

In connection with that for drilling-out of powerful deposits of shales we had developed and introduced compounding of drilling muds for the Kazakhstan deposits.

## 2. Materials & methods

In this study we report new compositions of drilling muds developed especially for difficult conditions of drilling on Kazakhstan clay deposits using high-quality bentonite clays and ecological clean polymeric reagents. Polymeric reagents produced in Germany (Antisol, Walocel), France (Policol S), USA (Drispac) and Kazakhstan (SOP) were used.

To investigate on the mechanism of interaction of polymeric reagents with clays, component structural characteristics of polymeric reagents were studied by IR spectroscopy.

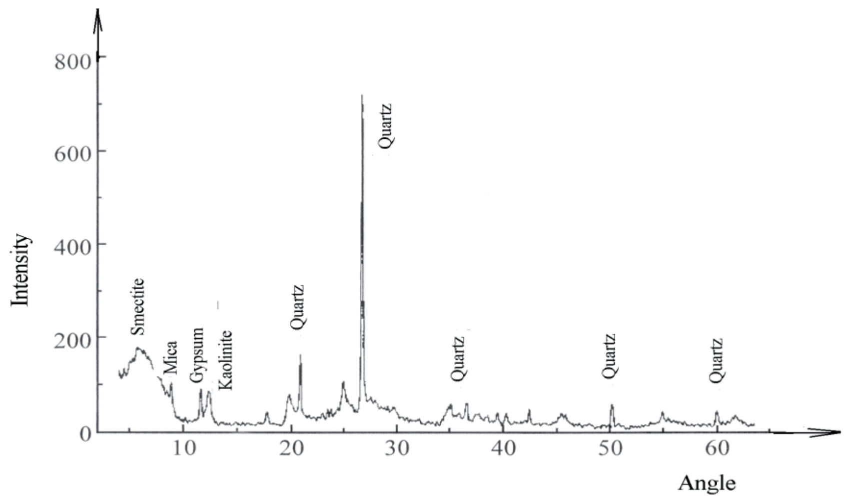
Bentonite clays (from Urangaiskaya and Akzhrskaya deposits) were characterized by mineralogical, chemical, granulometric and physico-mechanical point of view.

Technological parameters of drilling muds were measured by a FANN viscometer, rotational viscometer of VSN-3, FANN- filter press and the aerometer.

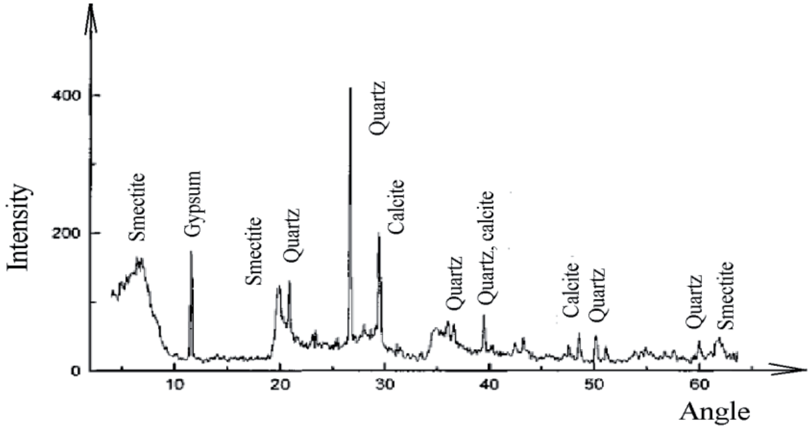
Drilling in clay deposits was carried out by equipment Boart Longyear LF-70 with use drilling pipes, tools and accessories of the Boart Longyear standard.

## 3. Results and discussion

Results of X-ray diffraction analyses performed on the two bentonite clays are given in Fig. 1.




(a)




(b)

Fig. 1. Diffractograms of Urangaiskaya (a) and Akzhrskaya (b) bentonite clays.

Data on a chemical composition of the bentonite clays are provided in Table 1.

Table 1. Chemical content of bentonite clays.

| Content, % | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $Na_2O$ | $K_2O$ | Loss on ignition |
|---|---|---|---|---|---|---|---|---|---|
| Urangaiskaya | 62.07 | 0.90 | 13.33 | 5.32 | 0.85 | 1.89 | 0.17 | 2.36 | 13.07 |
| Akzharskaya | 51.77 | 0.51 | 10.18 | 5.04 | 6.98 | 2.90 | 1.11 | 0.65 | 20.93 |

For receiving the qualitative clay suspension used at drilling operations, the main role is played by mineralogical composition of clay and quantity of fine-dispersed particles, i.e. colloidal fraction. It is well known that clays are active colloids because of their morphology and their surficial charges (negative basal surfaces and positive on edges). Interaction between these opposite charges strongly influences viscosity of clay drilling muds and it is the reason of reversible assemblage when mud is the equilibrium state. According to Lityeva & Ryabchenko (1992) the content of fine particles with sizes of 1.0-5.0 microns is more than 90% in alkaline bentonites.

Data of the granulometric analysis are provided in Table 2.

Table 2. Granulometric content of bentonite clays.

| **Sample of clay** | **Content of fraction to absolutely dry sample, % ( size of fraction, mm)** | | | | | |
|---|---|---|---|---|---|---|
| | 1.0 – 0.5 | 0.5 –0.063 | 0.063 – 0.01 | 0.01 –0.005 | 0.005 – 0.001 | Less 0.001 |
| Urangaiskaya | – | 0.50 | 0.10 | 7.40 | 45.50 | 46.50 |
| Akzharskaya | 0.01 | 0.20 | 4.30 | 5.80 | 1.40 | 78.30 |

As an important condition of interaction of clay with reagents represents an optimum moisture of a clay powder which gives increase clay suspension yield of drilling mud at the increased moisture.

The plasticity of the clay material is characterized as a property that allows it to deform under the influence of stress without breaking the continuity and preserve the acquired shape after stress relieving.

During swelling of clays the essential factor to consider should be a pore volume, which provides availability and transport of the reacting molecules. Having information of pores volume of this substance, it is possible to describe a mechanism of interaction of various molecules with a surface of porous disperse system.

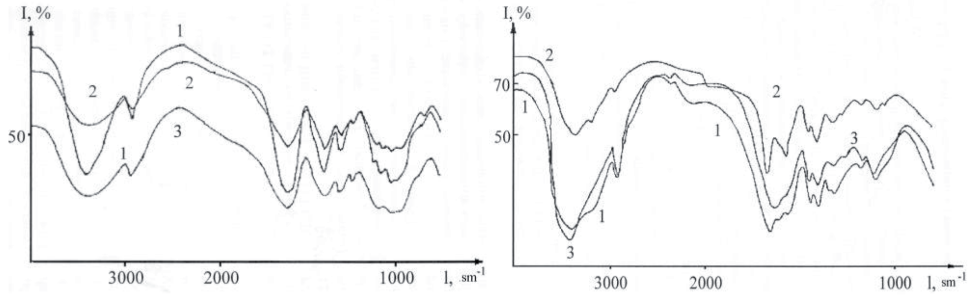
Physicomechanical properties of clays are presented in Table 3.

Table 3. Physicomechanical properties of clays.

| Sample | Moisture, % | Swelling, % | Total porosity, % | Volume-bulk mass, g/m$^3$ | Number of ductility |
|---|---|---|---|---|---|
| Urangaiskaya | 8.04 | 40.00 | 71.16 | 0.77 | 44.49 |
| Akzharskaya | 12.26 | 32.00 | 57.94 | 1.06 | 50.29 |

In order to better control of filtration and rheological properties of drilling muds based on clays, there various polymers are added.

Polymeric liquid additives represent non-Newtonian liquids reduce friction forces at the state of turbulent mode of a stream leading to reduction of viscosity of drilling mud when increasing the speed of its current. Other distinctive property of polymers is their ability to be adsorbed on the surface of clay particles, preventing process of dispersion of drill cuttings and providing stability of water-sensitive shales. Such properties depend on shape and number of functional groups and also on polymer structure.
IR-spectrums of some studied polymers are given in Fig. 2.




(a) (b)

Fig. 2. IR – spectra of some samples Antisol (a) and Polycol 60S (b).

It is important to study structural properties of polymers not only due to influence of functional group on solubility of polymers but also to determine their reactivity and ability to adsorption and formation of structure in the reagent. For example, the reactionary ability of Antisol rather worse than such ability reagent Polycol. It is because of Policol's structure. Comparing to Antisol, Policol has an active center, it is placed on group =C=O, where electronic density is shifted to atom of oxygen. It leads to strong intramolecular interaction in the alkaline media and absence of such interaction into the acid media. Then those long molecules of Policol twist in a spiral, shape into packs, i.e forming unique mesh structure that is absent in other polymers.

Thus studying structural characteristics of polymers is necessary for understanding of the mechanism of their interaction with a clay component of drilling muds.
In the Table 4 it is given the technological parameters of the developed drilling muds (DM).

Table 4.

| Drill mud | ρ, g/sm$^3$ | Yield Point, mPa·s | PlasticViscosity, mPa·s | Water loss filtration, sm$^3$ | Nonlinearity indicator |
|---|---|---|---|---|---|
| 1 | 1.05 | 27.30 | 24 | 6.0 | 0.27 |
| 2 | 1.07 | 24.90 | 26 | 6.2 | 0.27 |
| 3 | 1.06 | 31.60 | 11 | 8.1 | 0.17 |
| 4 | 1.05 | 20.60 | 19 | 7.5 | 0.30 |
| 5 | 1.05 | 20.16 | 30 | 7.9 | 0.15 |

Formulations of the developed drilling muds (DM) are given below:

1. 10 – 15 % Akzharsky clay + 0.08 % Antisol + water
2. 5 – 7 % Akzharsky clay + + 0.10 % Walocel + water
3. 5 – 7 % Akzharsky clay + 0.04 % Pol.60S + 0.08 % Antisol + water
4. 10 – 15 % Urangaysky clay + 0.04 – 0.08 % Drispac + 0.08 % Antisol + water
5. 10 – 15 % Urangaysky clay + 0.04 % SOP + 0.04 % Antisol + water

We managed to elaborate recipes of drilling muds which represents pseudo-plastic fluid with $N< 0.3$ which can provide uniform distribution of hydrogen durability force of in the structure of water of drilling mud. Combinations of reagent allowed us to get compounds with improved rheological characteristics which in practice facilitate the process of cleaning of a well.

## 4. Conclusion

In this study we developed ecologically clean polymer-clay drilling muds. The polymer concentration does not represent a hazard to the environment and at the same time minimize drilling waste.

There were developed combinations of polymeric reagents in polymer-clay drilling muds with the size of an indicator of nonlinearity less than 0.3. Those reagents able to provide even distribution of hydrogen bonds in the structure of a drilling mud and, as a result,

- the holding and taking out abilities of drilling mud significantly improves,
- liquid filtration speed in productive layer reduces,
- collection properties of drilling mud better preserves.

The obtained data documented that the drilling muds have technological indicators allowing to use them in specific mining-and-geological conditions that provides efficiency of cleaning process of drilling well.

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