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NEW MUD FOR DRILLING IN CLAY AND SHALE ROCKS WITH CATIONIC KAN-001 POLYMER****

1. INTRODUCTION

Unconventional oil and gas reservoirs have been explored since the beginning of oil and gas industry, however for two hundred years these reservoirs have not played a big role in the oil and gas and energetic industry.

Growing prices of hydrocarbons together with technological progress has led to increased interest in searching for and exploration of unconventional gas reservoirs amongst the Oil and Gas Companies around the world including Poland. Gas from shale formation comes under unconventional gas reservoirs. This gas, bounded in clayish rocks, is called 'shale gas'.

Drilling through clayish rocks is often related to serious technological obstacles, one of which is the swelling of sensitive shale, shale-clayish and clayish rocks. As a result of such acting is annulus collapsing (well collapse), which can cause stuck pipes. In extreme cases big weakening of inter-sheets strengths can occur so that crumbling and pouring can be observed and that leads to well caving. The application of inhibited drilling fluids proved to be a solution for these problems, as it prevents clay and shale minerals from swelling and makes wellbore stabilized and properly protected [1].

Mud type and it's parameters for drilling for hydrocarbons both from conventional and unconventional reservoirs are determined by reservoir-geological conditions (lithology, stratigraphy, mineral composition, depth, reservoirs thickness, temperature) and drilling technology.

The most effective fluids for drilling through clay rocks are synthetic/oil based muds (OBM), which properties let them be used for a big number of wells. Perfect shale stabilizing,

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great resistance against contamination and high lubricity are only a few of its advantages. A negative environmental profile, sophisticated wastes management and economic factors are the main disadvantages. Therefore lab researches are performed to design and apply new water based mud (WBM) systems which properties are close to OBM. Efforts are focused on less environmental impact, mainly on costs-cutting.

This paper presents laboratory researches on KAN-001 cationic polymer application dedicated for drilling fluids used in drilling through sensitive shale formation and also the formulation of a new mud system for drilling in clayish rocks.

KAN-001 polymer was synthesized in the Drilling and Geoengineering Faculty's Laboratory, AGH-UST Krakow, Poland. Polymer is a derivative of polyvinylamine and has got the primary amine groups in the pendant groups.

2. EXPERIMENTAL PART

All surveys were taken in accordance with Polish and international standards (BN, API, OCMA).

As part of the preliminary researches seven WBM samples were prepared, which deferred in terms of composition, and the following surveys were taken: rheological parameters, fluid-loss and lubricity. Swelling tests were also taken on QSE pellets.

Based on the test's results, for the further researches sample no. 7 was chosen (Mud-7), which composition and properties are shown in Table 1.

Table 1

Composition and properties (Mud-7) of the mud sample for further tests

Mud-7 composition [%]		Technological parameters		
Bentonite OCMA	3	PV	19	cP
Starch	1.5	AV	33.5	cP
PAC	0.25	YP	29	lb/100 ft^2
XC-polymer	0.2	Geles	6/11	lb/100 ft^2
Inhibitor 1	5	API filtration	4.1	mL
–	–	Lubricity coef.	0.33	–

In the next step, tests on KAN-001 polymer's influence on technological parameters of Mud-7 and Mud-7 plus 10% calcium carbonate (M-25) were performed. 1% of K-001 polymer was applied. Test results are shown in Table 2 and Figure 1.

Table 2

Composition of mud

Component [%]	Mud-7	Mud-8	Mud-9
Bentonite OCMA	3.0	3.0	3.0
Starch	1.5	1.5	1.5
PAC	0.25	0.25	0.25
XCD	0.2	0.2	0.2
Inhibitor 1	5.0	5.0	5.0
KAN-001 polymer	–	1.0	1.0
Marble M-25	–	–	10

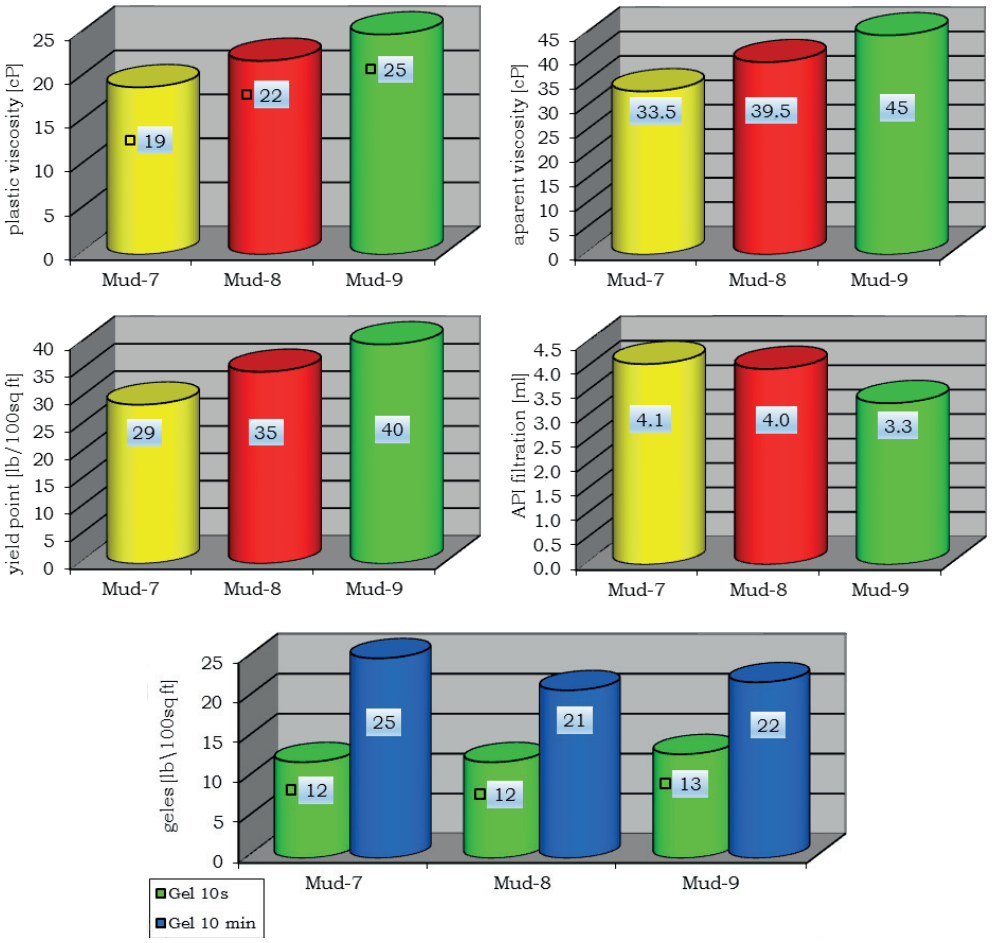

Fig. 1. Technological parameters of examined mud samples

Results of tests showed that designed muds have got proper technological parameters.

Swelling tests using QSE pellets were also taken on designed muds, depending on Inhibitor 1 concentration. Tests were run for concentration 2–4% (weight) for Inhibitor 1. Tests results are listed in Figure 2. Additional tests indicated that the increase of Inhibitor 1 concentration has got no influence on the technological parameters of the designed muds.

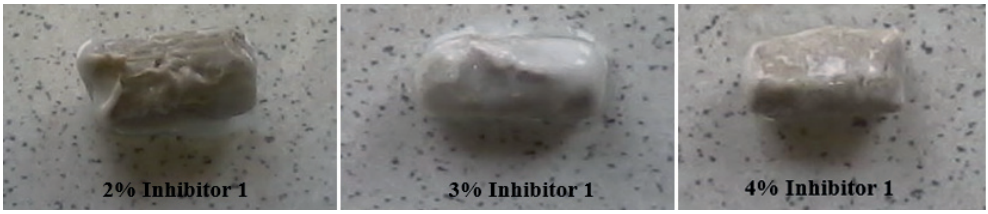

Fig. 2. Swelling tests on QSE pellets depending on Inhibitor 1 concentration

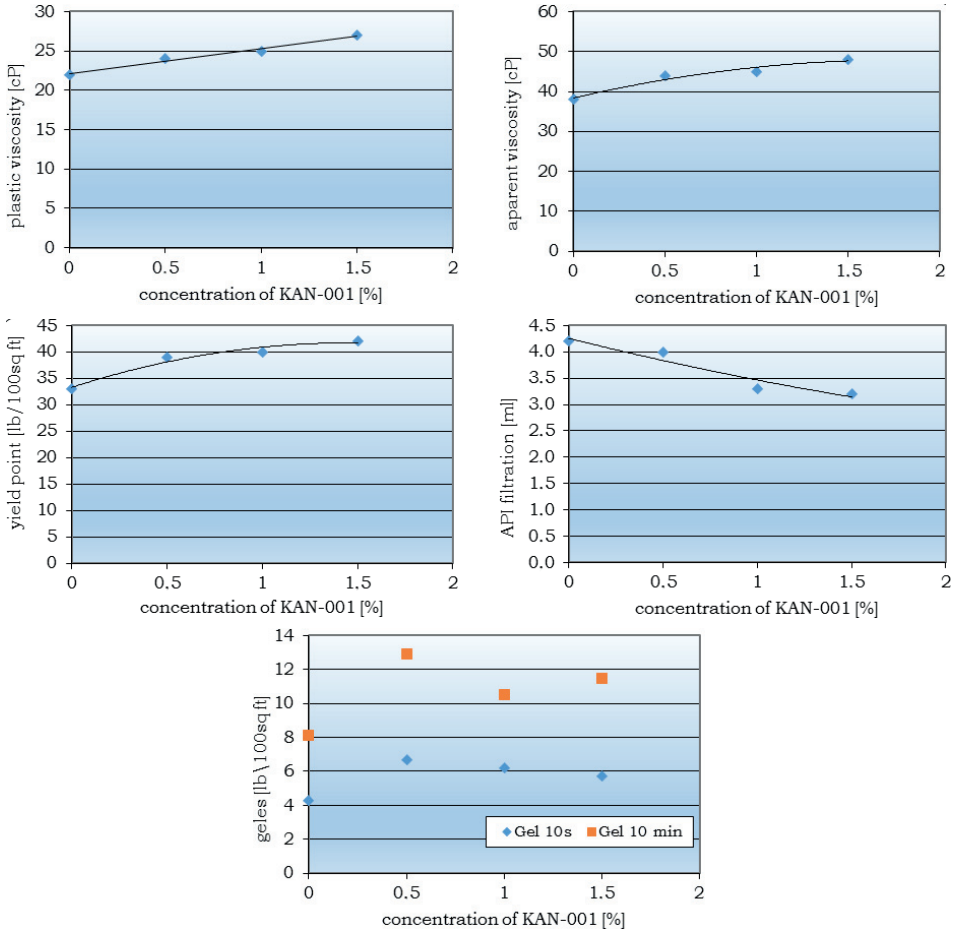

Fig. 3. Dependence of developed mud technological parameters on KAN-001 polymer concentration

The results have exhibited great hydration inhibition of clay rocks caused by the examined muds.

In the subsequent phase test of KAN-001 polymer concentration influence on developed drilling fluids technological parameters was performed. The test range of weight concentration was between 0% and 1.5%. The results are presented in Figure 3.

Based on the test, it can be observed that an increase of KAN-001 polymer concentration slightly affects the technological parameters of studied mud. Filtrate loss decrease and rheological properties increase have been noticed as well.

In order to improve the inhibition properties of developed drilling fluid, it was decided to replace Inhibitor 1 with potassium carbonate. The QSE Pellets swelling test was conducted and developed muds technological parameters were measured. Drilling fluid compositions are shown in Table 3. The test outcome is summarized in Figure 4.

Table 3

Mud compositions

Mud component [%]	Mud-15	Mud-16	Mud-17
Bentonit OCMA	3.0	3.0	3.0
Starch	1.5	1.5	1.5
PAC UV	0.25	0.25	0.25
XC-polymer	0.2	0.2	0.2
KAN-001	–	1.0	1.0
K_2CO_3	3.0	3.0	3.0
Marble M-25	–	–	10.0

Mud-15 Mud-16 Mud-17

Fig. 4. Test of QSE Pellets swelling in muds with potassium carbonate

Findings of QSE Pellets swelling test indicate that developed muds effectively inhibit the swelling of the clay. Occurrence of cracks has been observed on the pellet conditioned in mud without the addition of KAN-001 polymer (Mud-15). However, it does not appear on the pellet conditioned in mud with the addition of above mentioned polymer. Technological parameters measured for drilling fluids with Inhibitor 1 and potassium carbonate are alike. Therefore, mud marked as Mud-17, with composition presented in Table 3, was selected for the following studies.

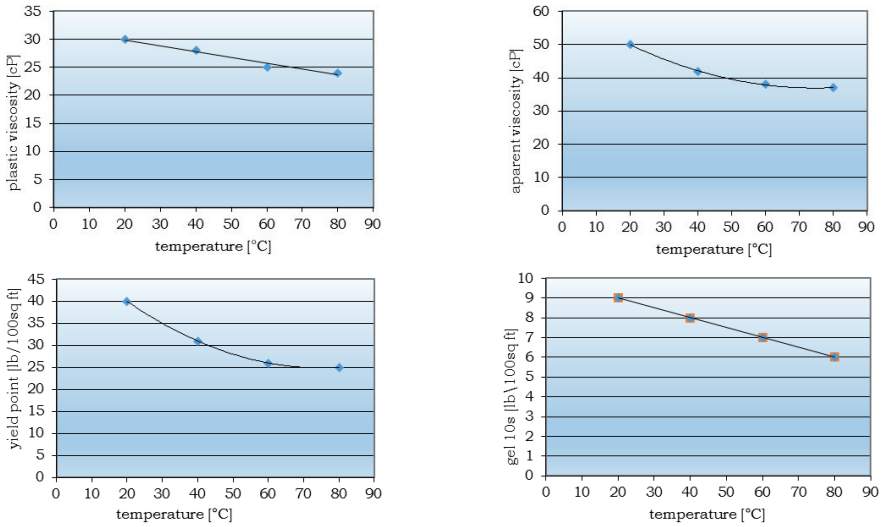

Fig. 5. Temperature resistance test of developed mud

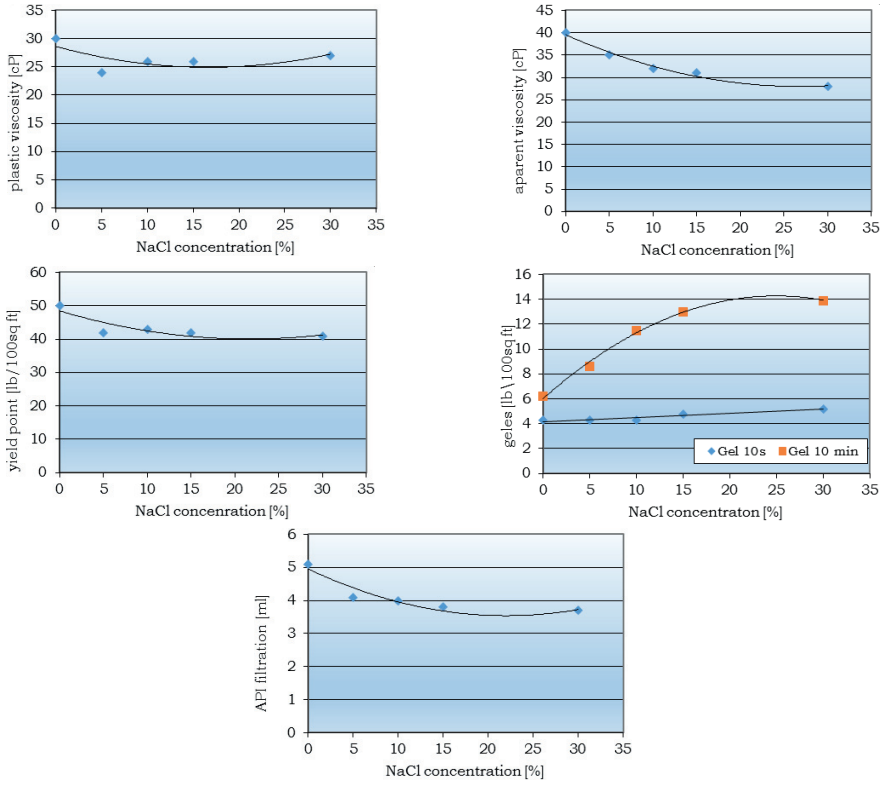

Fig. 6. Test of sodium chloride contamination resistance of developed mud

For the developed drilling fluid (Mud-17) a temperature resistance test was conducted using a rotary viscometer with a temperature attachment (temperature range of 20–80°C). Test results are illustrated in Figure 5. It has been found that technological parameters of the mud marginally diminish with temperature increase.

Next, a test of resistance to monovalent salt contamination of developed mud was performed. In this test sodium chloride with 0–30% weight concentration was used. Findings are presented in Figure 6.

The outcomes indicate that the studied mud is resistant to sodium chloride contamination. As the sodium chloride contamination increases, the gel strength value also increases, yet filtrate loss diminishes. Satisfying technological parameters prove that the mud may be used as a salinized to saturation. Further phase contained of test of muds resistance to divalent salt contamination. In this test calcium chloride and magnesium chloride with 0,5% weight concentration was used. Test results are presented in Figure 7.

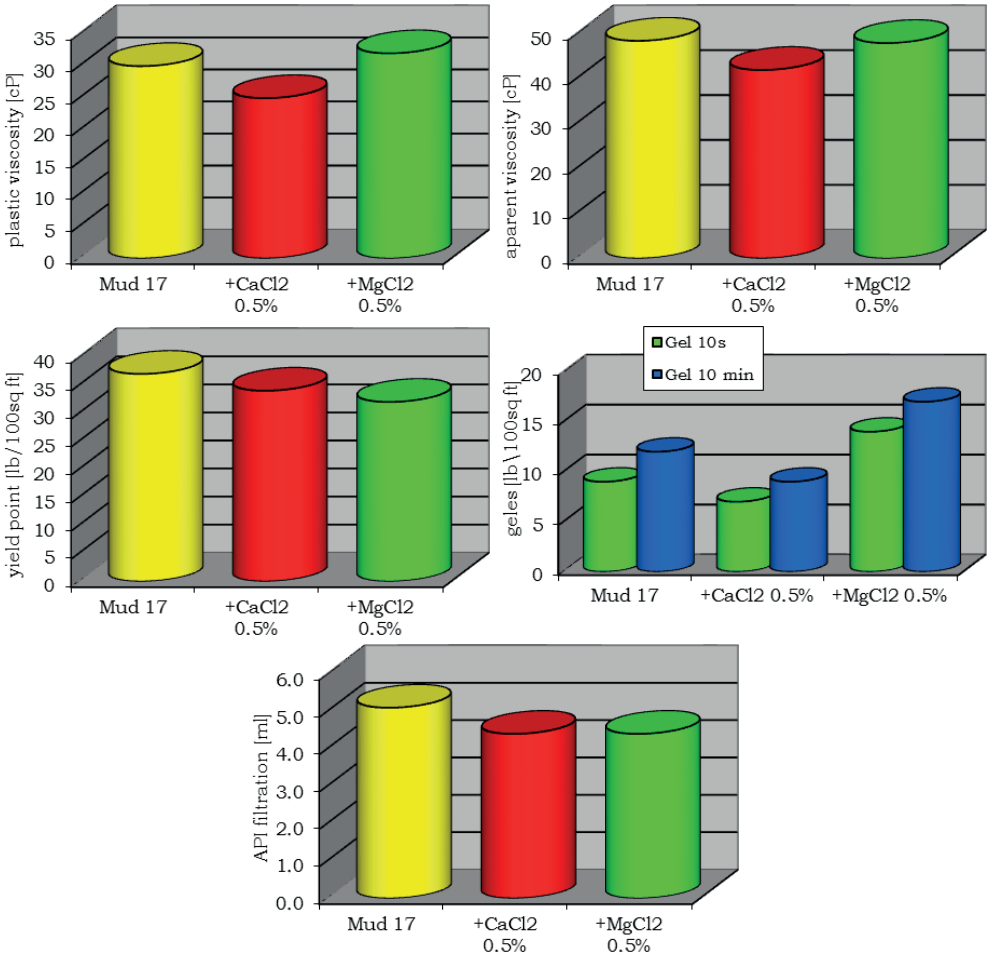

Fig. 7. Test of divalent salt contamination resistance of developed mud

The results show that developed mud is resistant to divalent salt contamination. Rheological properties are stable, whereas filtration is favourable reduced.

In order to confirm the practical utility of the developed mud Mud-17 with KAN-001 polymer for clay drilling, a swelling test of Eocene age shale was conducted. Test was carried out with a HPHT Swell Meter apparatus in standard conditions for 6 hours. Outcome is illustrated in Figure 8.

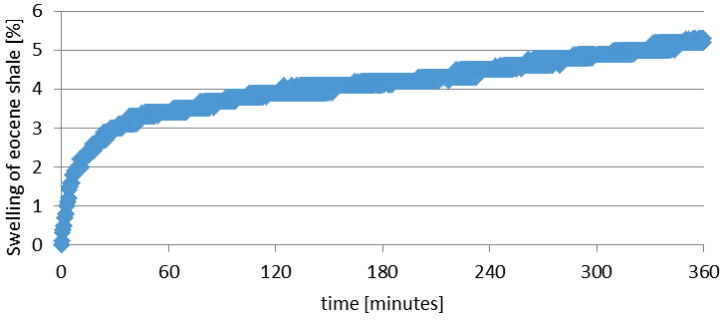

Fig. 8. Swelling of Eocene age shale in studied mud

The performed test of Eocene shale swelling verified the inhibitive activity of the developed drilling fluid.

3. CONCLUSIONS

As was previously stated the research confirmed the practical utility of KAN-001, synthesized at the Drilling, Oil and Gas Faculty AGH-UST, in the drilling fluid for clay drilling.

Developed mud Mud-17 with addition of KAN-001 polymer has satisfying technological parameters. It is resistant to monovalent and divalent salt contamination. Thus it can be used as a mud salinized to saturation. Drilling fluid Mud-17 is resistant to temperature as well, what allows for the use of it in deep boreholes.

Furthermore, hydration inhibition properties of developed drilling fluid with KAN-001 are effective. For this reason this polymer can be applied in the oil and gas industry during shale gas drilling.

REFERENCES

[1] Bielewicz D.: *Płyny wiertnicze*. Wydawnictwa AGH, Kraków 2009.