ASPECTS RELATED TO DRILLING THE RESERVOIR SECTIONS WITH ENVIRONMENTAL DRILLING FLUID

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Abstract: *Maximizing productivity of the well is the key objective in the optimal designing of the drilling fluid for crossing productive layers. The first mechanism to minimize the invasion of solid particles or higher aqueous phase in productive reservoir layers involves creating a thin, waterproof, mud cake. This small and thin mud cake will not affect the production rate of the well and will not interfere with well completion operations. The paper aims to present some specific design aspects of drilling fluids used for drilling and crossing productive reservoirs, as certain criteria for selection of the systems in accordance with the nature of productive layers.*
Keywords: *productive layers, environmental drilling fluids, hole cleaning*

1. Introduction

The continuing interest in the development and exploration of new productive perimeters, at higher and higher depths and high temperatures, the increase of environmental regulations imposed on discharge of cuttings and limited performance of water base fluids in harsh and removed environments, have driven the development of high performance ecological drilling fluids and their continued improvement based on data from wellsite. The current paper aims to update and bring its contribution, by bringing new data, to develop an improved ecological drilling fluid which is performant and continuously adapted to the requirements of the wells.

Existing water based mud systems have limited performance when compared to oil based muds or synthetic based systems. Performance is related to:

- inhibition;
- ROP;
- fluid maintenance.

The ultra-inhibitive ecological water-based mud with superior shale inhibition, not only will improve drilling of upper well sections, but also will have applications in the entire drilling operation at higher depths and high temperatures. The improved ecological drilling fluid represents a plus of water based mud technologies, comparative with actual drilling fluids from the market, allowing for improved ecological drilling fluids to be compared with oil based mud systems and/or synthetic mud systems.

The improved ecological drilling fluid system is a highly inhibitive water based mud developed for optimized stability and drillability of reactive and dispersible shale formations. The proposed system can help significantly, also for drilling the reservoirs sections with very good results, sections wich present an maxiumum interest.The improved ecological drilling fluids system it is designed to provide:

- maximum shale inhibition;
- wellbore stability;
- to provide low accretion on bottom hole assembly, drilling string fittings and bit balling tendency;
- to maintain easy the properties of the system and to be stable;
- working density to be very flexibile;
- selection in choosing the potasium or sodium ions;
- huge applications in a variety of sensitive drilling oilfields realtive to environments rules.

2. Component products of improved drilling fluid system

The primary shale inhibitor (figure 1) in the proposed system: improved ecological drilling fluid is a polyamine, followed by a mildly cationic acrylamide polymer together with a alkaline poly glycol, which ensures secondary shale inhibition and cuttings stability.

Secondary shale inhibition can be achieved by cation substitution with formation clays, by using potassium and/or sodium ions in the formulation of improved ecological drilling fluid. The system also contains a product which provides an anti-accretion effect of the cuttings on drill string will help to increase the rate of penetration and will improve the friction factor by obtaining smallest values. This improved ecological system has a multiple inhibition mechanism, provided by the primary and secondary shale inhibitors (two secondary inhibitors).

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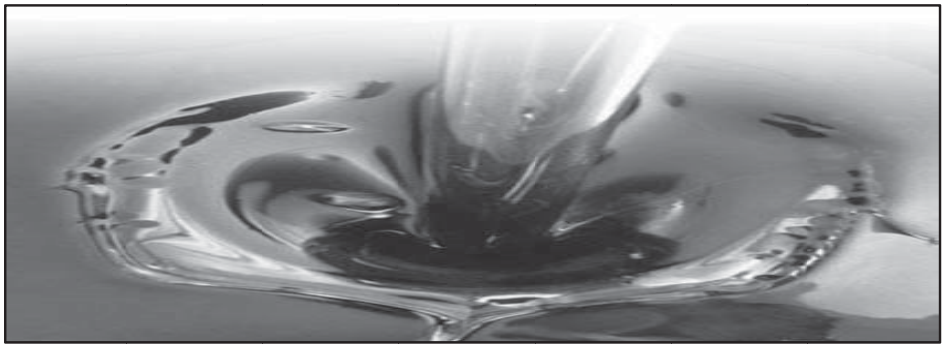

Fig.1 *Primary shale inhibitor of improved ecological drilling fluid*

The first component is a polyamine, is a liquid additive that acts as a clay hydration suppressant, by intercalating and reducing the space between the clay platelets so that water molecules will not penetrate and cause shale swelling. Recommended concentrations are 1.5–3% v/v, depending of reactivity of the drilled shales. This primary component ensure additionally alkalinity for the drilling fluid system, eliminating any additions of caustic soda (NaOH) or potassium hydroxide (KOH). [2,3]

3. Secondary inhibitors for improved ecological drilling fluid

The second component of the system is a mildly cationic acrylamide polymer (figure 2), responsible for cuttings encapsulation and shale stabilization. A system concentration of 1.5 3 - 6 Kg/m3 ensuring a protective covering from polymer, that which gives good shape and integrity of the drilled rocks and also prevent sticking of the cuttings to the screens of the shale shakers and also between them.

Fig.2. *Cationic acrylamide polymer for improved ecological drilling fluid*

The third component is a poly glycol which ensures a very high grade of shale inhibition together with the above mentioned components, stability of the wellbore, reducing the fluid loss in high temperature and high pressures conditions, as well as lubricity of the system. The recommended concentrations are between: 1-2 % v/v. This system together with this product is suit for drilling depleted sand formations, were the risks of differential stuck, also at deep-water operations and highly deviated wells or horizontals which crossing by drilling very reactive shales.

4. Fluid loss control agents of improved ecological drilling fluid

Product PAC (polyanionic cellulose), a high quality component and a water soluble polymer for fluid loss control, this product will slightly increase the viscosity of the drilling fluid system. The polyanionic cellulose product has been very effective in controlling fluid loss in fluids incorporating salts (seawater, NaCl, KCl brines). In applications where hole cleaning is a special concern (ERD, horizontal wells) the polyanionic cellulose together with a modified starch, imparts good fluid loss control and enhances the rheological profile by allowing higher low-shear viscosity for a given yield point value. A concentration of 8-14 Kg/m3 fluid loss agent should insure a low fluid loss (<4.0 ml/30min). The high temperature encountered due to drilling at higher and higher depths, assume optimizing the improved ecological drilling fluid system with temperature stabilizers and synthetic polymer, to prevent degradation of product used and eliminate the risk of creating other contamination.

5. Viscosifier products

The optimum rheology profile of the system is achieved using xanthan gum biopolymers such (figure 3). Concentrations ranging from 0.5 – 3.5 Kg/m3) are required, depending on hole diameter and well profile. Improved ecological drilling fluid will develop a stable rheology in a wide temperature range. Beginning from 15°C up to 200°C, formulation of the system it retains its excellent suspension and hole cleaning of the wellbore. Resulting that the system is suitable for deep wells with high temperatures. [2, 3]

6. Agents for decreasing the coefficient of friction

First product is a blending of surfactants which will minimize the cuttings accumulation effect, the adhesion of clay dislocate to the surface of the metal (bottom hole assembly and/or bit). Also this product will ensure the system lubricity together with the second lubricity component which is a mineral oil. Optimum concentration is 1–1.5% v/v, for first lubricity component and for the second component the optimum concentrations is 0.5-1.0 depending on mud weight and solids content.

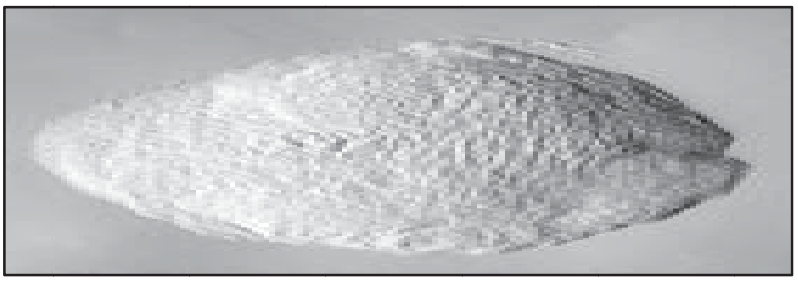

Fig.3. *Biopolymer xanthan gum superior grade*

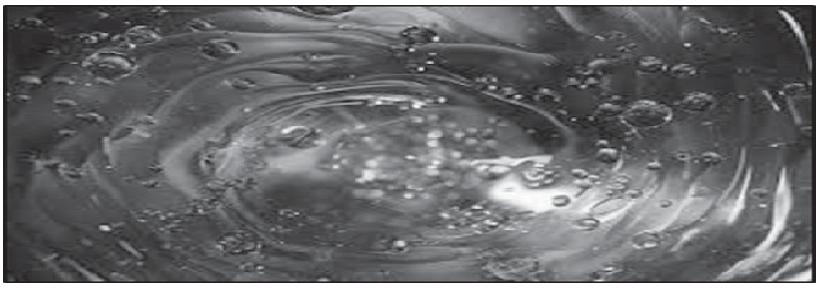

Fig.4. *Lubricity agents for our system*

The formulation of improved ecological drilling fluid is presented in table 1.

Table 1. *The usual concentrations and product functions*

Product	Function	Concentration
Fresh water	Base fluid	
Soda Ash	Hardness control	0.5-1.5 kg/m^3
Potassium Chloride	Inhibition	95-100 kg/m^3
Polyamine	Shale inhibition	1.5 – 3.0% (v/v)
Acrylamide polymer	Shale encapsulate	3-6 kg/m^3
Cellulose polymer	Fluid loss control agent	8-14 kg/m^3
Poly glycol	Shale encapsulate/ inhibition	2-3 % v/v
Modified Starches	Fluid loss control agent	2-4 kg/m^3
Biopolymer xanthan gum superior grade	Rheology control/LSRV	0.5 – 3.5 kg/m^3
Mix Surfactant	Anti-accretion/ Lubricity	1.0 – 1.5% (v/v)
Biodegradable synthetic oil	Lubricant	0.5-1.0 % (v/v)
Micro Barite	Density control	Function of density
Polymeric alkaline materials PTS 200 (MI)	Temperature stabilizer / Reducer of polymer degradation	6-10 kg/m^3
Micro calcium carbonate	Density control /Bridging agent	Function of project

Table 2. *Proprieties of improved ecological drilling fluid*

Proprieties	**Values**	**Proprieties**	**Values**
Densities, SG	1.50 – 1.75	HTHP Filtrate, cc/30min	<3.0
Funnel viscosity, sec/liter	55 – 80	MBT, kg/m^3	< 42
R3/R6	3-5 / 5-7	pH	9.0-9.5
PV, cP	< 42	Pm	3.0 - 6.0
YP, lb/100 ft^2	5 – 15	Pf/Mf	2.5-4.5 / 3.0-6.0
Gels, 10s/10m, lb/100ft^2	3-5 / 8-10	Chlorides, mg/L	>90 000
		Hardness (Ca^{++})	250 – 450

The improved ecological drilling fluid may be prepared by a variety of brines and also with a wide range in choosing and using the density. The table 2 develops the properties of improved ecological drilling fluid system in a range: min-max with a concentration of potassium chloride: 9-10% in the proposed system for analysis. [2, 3].

7. Building and maintaining improved ecological drilling fluids system

One of the main advantages of the proposed system is the simplicity of the mixing process. The products can be added relatively quickly, and the fact that two products are liquids saves even more time.

Optimum shearing of the drilling fluid has demonstrated that a shearing unit such as a powerful hopper is beneficial for proper polymer hydration and maximum fluid performance, Screen ability to take the work flow is greatly enhanced also by rheological properties. In table 3, is illustrated how to prepare a sample of the fluid at the density of 1560 kg/m^3 (350 ml laboratory equivalent to 1 bbl.).

Table 3. *Example how to prepare improved environmental drilling fluid having density 1560 kg/m^3 respectively 13.0 ppg.*

Recommended Order of Mixing (for building a 350 ml sample)	**Notifications**
1. Add freshwater/drill water in metallic sample cup (volume 350 ml). Add Soda ash if is require to control the hardness.	Minor foaming may develop. Will be treat with antifoaming agent.
2. Add KCl brine to blend with the water	
3.Poliamina	
4. Adding **ACRILAMIDA POLYMER** *trough Hamilton B mixer*	
5. Adding POLYANIONIC CELLULOSE	
6.Poly glycol	
6. Add XANTHAN GUM DE GRAD SUPERIOR	
7. Mixing Surfactants& Lubricants	.
8. Temperature stabilizer	
9. Increasing the mud weight of drilling fluid at density:1560 kg/m^{3}with aditions of micro liquid barite	Shearing time of the products is a function of maximum flow trough the preapration mixer.
10. Circulate the new drilling fluid through Hamilton B mixer ,up to 30 - 45	

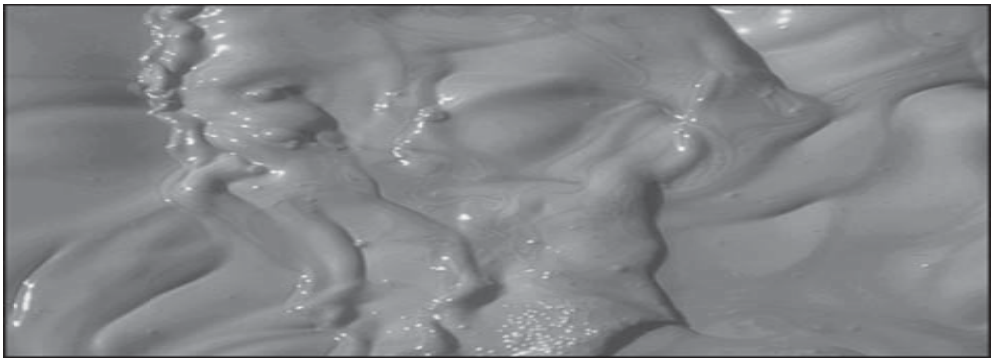

Fig.5. *System based on improved polymers*

8. Performance of improved ecological drilling fluid enhanced with poly glycol

The improved ecological drilling fluid is a system based on improved polymers (figure 5), using poly glycols technology to achieve a high degree of shale inhibition, wellbore stability, the reduction of the fluid loss under conditions of high temperature, high pressure and lubricity.

It is also very suitable for drilling trough depleted sand formations, were is a risk for differential sticking, also can have good results in deep-water, highly deviated or horizontal wells which crossing trough drilling very reactive shales. The drilling fluid system provides firmer and sharper cuttings, a thinner and more resistant wall cake, reducing rates of daily dilution daily, improved tolerance for incorporated solids, improvement performance for PDC bits, reducing the effects of bit balling of bottom assembly and increase the rate of penetration. In addition, this system does not affect the environment due to very low toxicity. This system has a plus of inhibition provided by the third inhibitor through two mechanisms: by chemical adsorption and the formation of a micro emulsion.

Poly glycols adsorption on shale surfaces lead to form a protective barrier against water and its undesirable effects. The second mechanism appears when is reach a certain temperature ("Cloud Point") to whom the poly glycols become insoluble from total soluble, formed colloidal droplets or micelles (disturbance). At temperatures above this point, colloidal droplets or micelles resulting in appearance of micro emulsion. This micro emulsion provides wellbore stability through bridging the micro cracks and micro porosity and creating a small, thin cakes and less permeable. The improved ecological drilling fluid system formulated with different salinities in order to adjusting the forming temperature of the micro emulsion and growing inhibition character.

The main aspects to be considered for proper maintenance of the system are:

- maintain the inhibitor concentration in the system at an appropriate level;
- maintain the potassium chloride in the plan ;
- keep the low gravity solids at a minim level;
- the methylene blue test values should be below 42 kg/m^3;
- the use of micro barite in the form of liquid barite;
- the bridging process will be realized with micro calcium carbonate;

Particular attention should be paid to the degree of the drilling fluid cleaning process, maintaining the value of solids concentration in the project range represent an elemental conditions designed to preserve the rheology's values projected. Solids contamination from the cuttings leads to an increasing potassium chloride consumption, as well as reduction of inhibition capacity of the drilling fluid.

To keep the concentration of solids at a lower level is recommended to dress the shale shakers with finest screens possible and even using a centrifugal separation system. In this case with this fluid, the situation becomes more acute and is necessary of using centrifuges to minimize the dilution rate. The daily treatment will be made with premix, the concentrations of inhibitor and the potassium chloride to be slightly larger, to compensate for their consumption during drilling. Increasing the rheological parameters can be made through addition of biopolymer xanthan gum superior grade, and them reduction by adding premix and also use of all solids equipment with maximum efficiency for mechanical cleaning of solids. Also, in order to avoid increases in plastic viscosity and yield point, low gravity solids content must not exceed 6%. Two very important rheological parameters are zero-gel strength and 10 seconds gel strength, greatly helping with the suspension and transport of cuttings at very low shear rates. Increasing the 10 minutes is an indication of the incorporation of ultrafine solids in the system and for reducing this solids is recommended to replace a part of the system with a fresh drilling fluid.

Inhibition must continuously monitor so that it does not fall during drilling (especially at high rate of penetration). A well shaped and dried cuttings inside is a good indicator of inhibitions [3].

9. Hole cleaning with the proposed system

Running dedicated hydraulics software's (figure 6) prior to drilling a new interval, will allow optimizing the drilling parameters and the procedures for drilling each section. Rheology and the low-shear rheology should be adjusted accordingly with biopolymer xanthan gum superior grade. Cuttings should be circulated up above the bottom hole assembly prior to connections. Reaming each connection should also be considered.

Fig.6. *Image form simulation drilling*

This will minimize the potential of cuttings settling during connections, avoiding causing packing off and stuck pipe. Prior to trips the hole should be circulated for at least 1 ½ x bottoms-up. This will prevent tight hole on the way out and bridges.

Due to the highly inhibitive character, the improved ecological drilling fluid can generates cuttings larger than typical water based muds, even larger than invert-emulsion cuttings. This has to be taken into account when:

- recommending the rheology;
- flow rate;
- drill string rotation;
- Higher annular velocities and higher 6 and 3-rpm readings are required to carry these cuttings to surface.

Usage of hydraulics software's and the next recommendations, will significantly impact the drilling process:

- Bit selection is also very important;
- Rate of penetration, with the proposes drilling fluid system can achieve the performance of the synthetic drilling fluids systems.

Increasing excessive rheology can reduce wellbore cleaning. The first step when is encounter problems relative to hole cleaning, is to increase system rheology and pumping high viscous pills. Both procedures can have a decisive impact on hole cleaning, especially in deviated wells by allowing the flow model to sneak over agglomeration of cuttings and thus worsening the problem. It was noted that the rheology must be maintained in an optimal area to allow the cuttings during drilling to be effectively removed. The improved ecological system, through the rheology results, suggest a value between: 5 to 7 lbs. /100ft^2 for the Fann 35/A readings, at a yield point: 5-15 lbs./100 ft^2, depending on the diameter of the borehole, drilling fluid density and drilling conditions [3]

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