WELL DRILLING

Application of clayless drilling fluids under conditions of high reservoir pressures and temperatures

УДК 622.24.06.32

Luban Yu.V.,
PJSC «HDIKB BI»

Luban S.V.,

T.O.V. “Geosintezinzhenering”

Dudzych V.V.,

Regal Petroleum Corporation Limited

Boyko A.H.,

Semeniuk V.H.

PJSC «Ukrgazvydobutok»

The paper considers the application clayless drilling fluids under conditions of great depths, high reservoir pressures and temperatures. It was determined that increasing the density of clayless drilling fluids by conventional weighting agents is accompanied by increasing rate of bottomhole filtering. It is shown that the solution of this problem is possible through the use of water-soluble salts. The results of laboratory and field tests for clayless drilling fluids weighted with water-soluble salts are presented.

Recently, for the disclosure of productive horizons are increasingly used clayless rinsing fluids, which provide the highest level of conservation of reservoir properties [1, 2]. This largely is due to the low content of colloidal particle penetration of which to pore space of reservoir is a major factor in the deterioration of their productive characteristics. Moreover, if more recent clayless use was limited by areas of abnormally low or hydrostatic pressure, mow it is increasingly may need to implemente the deep wells with high reservoir pressure and temperature. However, the use of clayless weighted drilling fluid at high temperatures is confronted with a specific problem of uncontrolled growth of filtration rate, which is determined through a special device (tester HPHT or device GrozNDI) under conditions that simulate downhole filtering for reservoir temperature and pressure of 5 MPa (Fig. 1).

Our studies revealed a constant relationship between the content of the weighting as part clayless rinsing fluids and index of its packing filtration (Table 1).

Table 1

Dependence of packing filtration of clayless solution on the content of the fine medium

Solution composition	Solution density, kg/m^3	Solution filtration, cm^3/30 min		
		at standard conditions		at T = 140 °C and P = 5 MPa
		After preparation	After thermostatics at T = 140 °C	
Biokar	1030	2	2	14
Biokar +35 % baritu	1270	2	2,5	19,5
Biokar +70 % baritu	1480	2,5	3	40
Biokar +105 % baritu	1660	2,5	3	85
Biokar +140 % baritu	1820	2,5	3,5	∞

Fig. 1. Tester for determination of packing filtration (tester HPHT)

It is found that, in the result of the introduction of relatively small amounts of barite (35 % to volume), which corresponds to the density of 1270 kg/m3, packing filtration steps up to the limits of the technically acceptable values, and further increase of the density of rinsing fluid its packing filtration continues to grow and rapidly reaches immeasurable quantities in which filtered out almost all the volume of the liquid phase . Of course, such level of packing filtration makes impossible a performance of this type of rinsing fluid in these thermal conditions, since it leads to a deepening of volume filtration peel , which in the interval of bedding permeable can reach sizes capable of creating significant barriers boring tool movement (Fig 2).

It is revealingly that the ultra-high indexes of weighted clayless liquid filtration are almost no decrease with increasing of polysaccharide reagents concentration or with the introduction of additional heat-stabilizers. At the same time, after cooling of pre thermostating washing liquids to room temperature,

their low surface filtration is fully recovered. Thus, the increase in packing filtration of weighted clayless liquids are not associated with irreversible thermal degradation of reagents and of a different nature study which calls for specific research.

In our view, to understand the detected process is important to analyze the mechanism of rinsing fluid filtration.

It is known that the amount of liquid that is filtered under pressure through porous area for a certain period of time (a measure of filtration) is largely determined by the "density packaging material" filtration crust that forms on the surface of the area. When filtering mud in the formation of crust involved filtration of the solid phase particles of different sizes containing large amounts of colloid component. Under pressure from the crust is denser, so that its permeability decreases fairly

rapidly. Accordingly filtering mud tends to decrease over time and after reaching a certain value practically stops [3].

In systems of weighted clayless solutions, where the content of colloidal phase is very small compared with the concentration weighting, filtration crust formed mainly barite particles of approximately the same size.

This peel over time is almost sealed and resembles a cage or net, free space is filled with viscous polymer molecule. Under normal conditions of the experiment, corresponding to filtration on the surface, a polymer layer creates a durable and impermeable barrier that provides a low filtration rate cm3/30 2-3 min. However, at high temperatures, when the viscosity of the polymer decreases sharply, they lose their blocking properties. The frame of the particle barita becomes permeable, and filtering can reach 90-100 cm3/30 min and more. Cooled solution viscosity with increasing polymer recovers and low permeability cover filtration.

Thus, the reason for the increase of packing filtration of weighted liquids is an imbalance between the number of colloid and more coarse dispersed phase. This dependence was previously set for mud systems [4]. With decreasing value of the ratio between total and colloidal solid phases (including with increasing density of the solution, due to rising concentrations of weighting) packing filtering of mud solutions increases sharply (Fig. 3). Accordingly, in the weighted clayless systems where the content of the colloidal component is much smaller, this effect should show up even more. Without solving this problem getting of clayless liquids with density over 1270-1300 kg/m³ for drilling at temperatures between 100 ° C and above is out.

In our studies, the level of packing filtration of weighted clayless liquids could slightly reduce by entering their member colloidal barite, bentonite or chalk. But we could not completely solve the problem and achieve an acceptable level of packing filtering technology. In addition, the introduction of additional quantities of colloidal particles in clayless system deprives them of perhaps the most important advantages over the mud. Therefore, this line of research was recognized as false.

To increase the density of clayless rinsing fluid possible by processing with water-soluble salts. By this method of weighting its possible to violate the ratio between the colloidal and solid phases, and thus eliminate the key reason of the packing filtration multiplication.

Figure 2. Filtration cake of clayless solution which is not weighted (1) and weighted by barite up to the density of 1820 kg/m^3 (2), after measuring at T = 140 °C and P = 5 MPa

Besides, the increase of the total environment salinity enhances the inhibitory properties of clayless system and thermal stability of biopolymer reagents [5]. The clayless washing mud weighted by water-soluble salts keeps all the positive characteristics of traditional biopolymer systems: low surface filtration, high level of pseudoplasticity, instant toxitropia, etc. (Table. 2).

Table 2

Parameters of clayless solutions weighted by different water-soluble salts

Solution composition	Density kg/m^3	Relative viscosity (100/200 ml),, c	Фільтрація, cm^3/30 min		ONZ, dPa			Plastic viscosity, mPa *c	DNZ, dPa
			за нормальних умов	за T = 140 °C P = 5 МПа	10 с	1 хв	10 хв		
Biokar	1030	26	2	16–18	18	19	24	33	165
Biokar +27% NaCl	1220	23	2,5	17–19	16	18	22	25	153
Biokar +25% NaCl + 38% $CaCl_2$	1340	25	2	18–20	50	55	68	47	177
Біокар + 25 % NaCl + 69 % $Ca(NO_3)_2$	1480	30	3	16–20	38	44	65	57	195

Table 3

Characteristics of washing mud ‘Biocar-MT’ during drilling of the well 53 Svyridivska

Density kg/m^3	Relative viscosity, c	Filtration, cm^3/30 min		ONZ, dPa		Content, %		Content KCl, %	Total salt content, %	Plastic viscosity, mPa *c	ONZ, dPa	pH
		Standard conditions	at T = 140 °C and P = 5	1 min	10 min	solids	colloids					
1220–1240	40–45	3,5–4	16–17	29–32	34–38	10–12	0,5–0,7	3,5–4	22–24	16–19	148–163	7,5–8

Table 4

Characteristics of washing mud ‘Biocar-MT’ during drilling of the well 62 Ostroverkhivska

Density, kg/m^3	Relative viscosity, c	Filtration, cm^3/30 min		ONZ, dPa		Content of colloids, %	Total salt content, %	Content KCl, %	Content Ca^{2+}, %	Plastic viscosity, MPa*c	ONZ, dPa	pH
		Standard conditions	at T = 120 °C and P =	1 min	10 min							
1340–1360	134–195	4–4,5	17–18	48–55	61–63	0,5–0,66	25–27	7–8	4,8–5	54–57	267–285	6,9–7,1

Depending on the type of salinity machine it is possible to have clayless washing mud with different density. Thus, in the case of sodium chloride the drilling mud density will be 1250 kg/m3, calcium chloride - 1380 kg/m3, calcium nitrate - about 1500 kg/m3. The use of relatively cheap salt allows having the drilling mud which density corresponds to formational pressure of most deposits of Ukraine. To obtain clayless liquids with higher density, you can use the more expensive salts - calcium bromide, zinc chloride, etc.

The industrial tests of developed drilling fluid "Biocar-MT" which is weighted by sodium chloride, held at Svyrydivske deposit at reservoir temperature of 136°C. The selected trial place results from unsuccessful experience of use of barite weighted clayless solution ‘Baradrill’ (developer – ‘Vahoisi’), so the performance of most drilled wells was lower than planned.

In our opinion, the main cause of the problem was underestimating the importance of high factor of packing filtration inherent to clayless liquids during their weighting by barite. Another reason was the increase of the density of the drilling fluid, which was explained by the low resistance of rocks and shattering during drilling. The solution weighting led to the creation of ultra-

high ranges of repression within dive horizons, which reached 15-20 MPa.

Uncovering of layers of high repression and packing filtration naturally leads to pollution and low flow rates because of the formation of large areas of penetration. The indirect confirmation of this conclusion: the flow rates of wells drilled in Soviet times using the old clay mud is significantly higher. This paradox can be explained by the fact that even the limited filtration by "bad" mud leads to less pollution of layers than the excessive packing filtration by "modern" weighted clayless liquids.

The washing mud "Biocar-MT" weighted by sodium chloride to the density of 1220-1240 kg/m3, was introduced during the drilling of the interval for the production string (4800-5450m) in well 53. The interval drilling was carried out with the speed for this deposit. Drifting was close to 50 meters per day, and the entire interval was drilled in less than a month.

The increase of mineralization of drilling mud ensured the high level of clay rock inhibition to keep its density at lower level than during the drilling at the deposit (1320-1360 kg/m3 and more). The rigidity of rock was high, caving was not observed. The parameters of washing mud were stable and almost unchangeable during drilling (Table 3).

The absence of weighting coarse particles in the solution made it possible to use effectively such cleaning means as hydrocyclone and centrifuge installations. Regardless the disclosure of strong clay roof of productive layers, the concentration of colloidal particles in solution was minimal. The absence of contaminating components allowed the efficient use of reagents-colmatants that had been introduced into solution immediately before the opening of the first productive facility. It ensured to provide high-quality disclosure of layers; and avoid possible differential tacking. During handling operations in the intervals of permeable layers the tool moved freely, indicating the absence of increase of filter cake and restriction zones.

The absence of contamination of productive reservoir during drilling in low layer pressure is proven by data of industrial and geophysical studies. In particular, the results of electrometric methods of GDS it was found the absence of zone of the filter agent penetration to the productive layer with porosity ratio of 11% within 5,194-5,200 m. During the test of wells we received the industrial flows of gas and condensate exceeding the flow rates of deposit adjacent wells.

Other example of successful use of clayless biopolymer liquids weighed by water-soluble salts is the well 62 of Ostroverkhivsky Deposit, where there was gas show during the opening of the reservoir depth at 4,368 m. The density of clayless liquid ‘Biocar-MT’ reduced from 1220 to 910 kg/m3 as resulted from gas. There were signs of intensive argillite caving accompanied by pressure fluctuations during washing and tools pulling. To overcome the complexity it needed to increase the density of the drilling fluid to 1,360 kg/m3. But downhole temperature was about 120°C, it prevented the use of traditional weighting system within the system of clayless drilling mud. There was used calcium chloride (Table 4).

Calcium chloride is traditional inhibitor of deconsolidation of clay rocks; it was widely used for drilling mud in 70-80s of the 20th century. But inhibiting properties of such solutions were restricted by rather low concentration of ion Ca2+ that was caused by problems with their stabilization by lingosulfonate agents. The polysaccharidic base of ‘Biocar’ ensures the stabilization of even saturated calcium chloride brine, and it ensures to increase considerably the inhibiting characteristics of the washing liquids on its basis.

The same situation is with other polyvalent salts, including magnesium chloride and calcium nitrate which show better results than calcium chloride (3-5%) due to their high concentrated brines with inhibiting effect for clay rocks (Fig. 4).

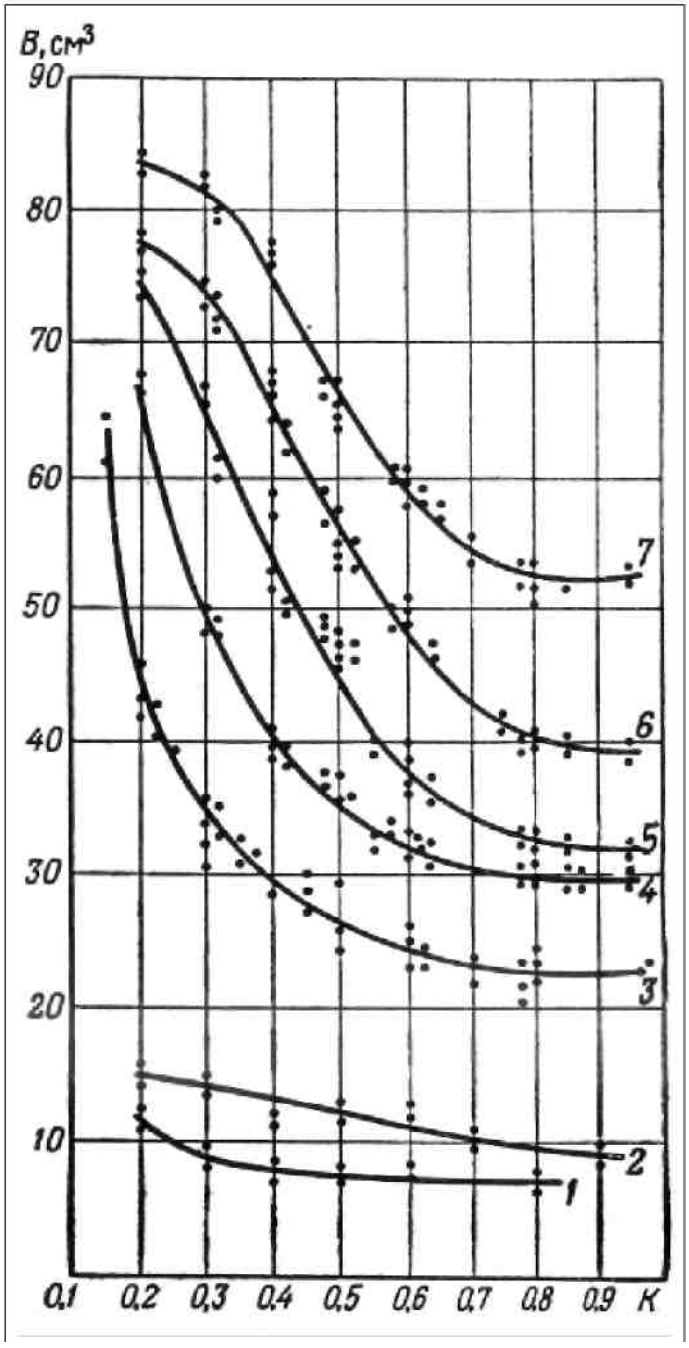

Figure 3. Dependence of filtration of VLR-stabilized drilling mud, on rate of clay colloid characteristics (K) [4]: 1/2-filtration in normal conditions of solutions with density 1,4 and 2,0 g/cm^3; 3-filtration at T = 140 °C and P= 5 Mpa of unweighed solution; 4-7-filtration of solutions with density 1,4; 1,6; 1,8; 2,0 g/cm^3 respectively in similar conditions

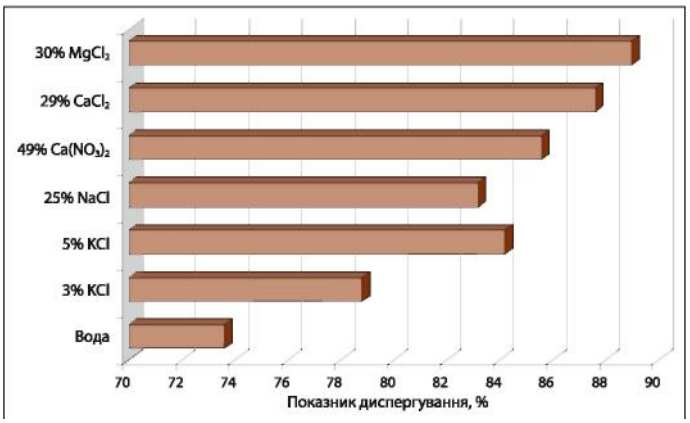

Figure 4. Claystone Water and Salt Solutions Dispersibility Index (Rolling Test). Density of Ca^{2+} and Mg^{2+} salts solutions was 1270 kg/m^3. Dispersibility Index is defined as the percentage ratio of claystone residue after the test to its initial weight

The increase of inhibiting properties of solution 'Biocar MT' because of insertion of calcium chloride simultaneously with increase of its density helped to eliminate the complications at well 62 and lower the casing well within a short period of time.

Thus, the use of water soluble salts ensures to exclude from clayless washing mud the standard weighting agents which increase the packing filtration and makes them unsuitable for use at high packing pressures and temperatures. A side effect of water-soluble salts weighting are to increase the thermal stability of biopolymer systems and growth of their inhibitory properties

The successful conduction of industrial tests of clayless biopolymer solutions weighted by water-soluble salts is a successful evidence of theory consideration on which a new concept of use of clayless solutions at deep water where the majority of effective objects of Ukraine are located.

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NEWS

Gas Deposit was put in production in Israel

First cubic meters of natural gas were supplied to Israeli clients from the newly-found of offshore gas deposit 'Tamar'. The deposit located in the Mediterranean Sea was found in 2009. After construction of the gas pipeline the gas was distributed to the terminal in the Ashdod Port.

According to the Ministry of Energy of this country the deposit will satisfy 50-80% of Israel needs in natural gas for at least 10 years. The half of Israeli power is generated with use of gas. The discovery of the second important offshore gas deposit in the area of the Northern Israel, known as Leviathan, can make Israel the gas exporter.

Pipeline & Gas Journal/ May/ www.pgjonline.com, p.18

New record high of drilling depth in Indian waters

'Transocean Ltd and Oil&Natural Gas Corp.' declares the new record high of offshore depth achieved by the well drilled in Eastern Part of Indian water surface.

From the driller 'Dhirubhai Deepwater KG1', the drilling of the extension well 'ONGC NA7-1' at the sea depth of 3,407 m was completed on January 23, 2013. The estimated well depth is 5,367m.

This company achieved the earlier record high – 9,727 m in the Eastern Part of the Indian water surface in 2011 p.

http://www.ogj.com/content/ogj/en/articles/2013/02/