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USE OF KANSAS CLAYS IN DRILLING FLUIDS

by

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USE OF KANSAS CLAYS IN DRILLING FLUIDS

Summary:

Six samples of clay, selected by Mr. Norman Plummer from representative samples obtained from Wallace and Phillips County by geologists of the Kansas Geological Survey were tested for applicability as drilling fluids.

Although designated as bentonites, none of the specimens exhibited the qualities characteristic of high percentage of colloidal material, Aquagel.

Muds of the same viscosity were prepared from each clay and their properties compared with a mud composed of Aquagel and water. They were all found to exhibit properties consistent with low colloidal content (2-4%). Figure I illustrates the relatively low efficiency of the clays as compared with Aquagel.

Based on filtration, settling, and permeability tests, mud No. 3 exhibited the best characteristics and is recommended for test in the field by prospective users. Muds No. 4 and 6 were next in order.

The filter cakes were all compressible; the rate of flow through the cakes declined with increased pressure, and also with time, when the pressure was held constant, indicating that use as "filter-aid" material was not feasible.

No tests were made on the clays as possible bleaching, decolorizing, and neutralizing agents, such as used in the refining of oils and other chemicals. This would require semi-processed stocks not available and would vary with each individual refiner's product. The clays normally used for these purposes are Fullers' Earths from Florida and Southern

California, though some Mid-Continent refiners prefer the poorer quality North Texas clays due to lower shipping rates.

It is questionable whether the clays examined are of good enough quality to be shipped to Oklahoma or Texas where high pressure wells place a premium on good drilling mud. Normally no added clay is required in drilling wells which make their own requirements. A small amount of Aquagel is commonly added during completion and whenever water is encountered. $75 will normally cover the cost of mud for a Kansas well.

Theory:

Drilling fluids are used with rotary drills in order to accomplish the following purposes:

1. Lubricate the bit at its contact with the formation.
2. Lubricate the drill stem from the casing and side of hole.
3. Carry the drill cuttings to the surface.
4. Seal off low-pressure water or gas-bearing horizons, and permit continual drilling without the necessity of setting an additional string of casing.
5. Hold back the flow of gas or water while drilling through a high pressure formation.

In order to perform these functions satisfactorily the mud must also have the following characteristics:

6. It should prevent cuttings from settling around the bit and lower part of the drill stem when drilling operations are temporarily suspended.
7. It should form a nearly impervious cake on the wall of the well which will prevent the loss of water from the drilling fluid (which would alter its properties) into the oil-bearing and other permeable formations. Loss of water to certain types of shale causes them to "heave" or slough into the well-bore, which tends to "freeze" the drill stem. Loss of water to the oil-bearing formation decreases the permeability in the

immediate neighborhood of the well, and hence lowers the productivity for the well.

The cake formed on the walls should also be thin and gelatinous in nature so as to minimize the danger of its being rubbed loose by the drill stem.

8. The mud should contain a minimum quantity of sand, since the latter increases the bulk and permeability of the cake, and increases the wear on the liners in the cylinders of the mud pumps.

9. It should be pumpable. Too high a viscosity or gel strength requires unnecessarily high pump pressures, which, in turn, increase the cost of operations.

10. Occluded gas and drill cuttings should be readily discharged from the mud in the pit at the surface.

To perform the above functions and have the pertinent characteristics, a drilling fluid must be composed of material such that its physical properties may be altered as required to meet the various conditions encountered during drilling. Some of these properties and their contributing influences are as follows:

Viscosity:

Low viscosity makes pumping easier and assists in removal of occluded gas and drill cuttings; high viscosity assists in carrying the drill cuttings to the surface, and retards the settling of these particles when circulation is halted.

Gel Strength:

Low gel strength aids in releasing the suspended drill cuttings in the mud pits; high gel strength aids in keeping the cuttings in suspension, during a shut-down and while setting casing. Abnormally high gel strength (gel strength usually increases with time) may, during a shut down, freeze the bit and result in a twist-off when rotation of the drill-stem is recommenced.

Density:

The density or specific gravity (control) enables the operator to place a higher pressure against the formation than its normal pressure which is equivalent to a static water head.

Colloidal Content:

Indeterminable. May be estimated relatively by the settling rate and filtration tests. Increased amounts of colloids increase the viscosity and gel strength, and thereby retarding the settling of cuttings, aid in the formation of a thin, gelatinous, impervious filter cake, and make chemical adjustment of the physical properties easier.

The properties of the mud may be varied by adjusting the concentration of clay, colloidal material, and inert weighing material, and by the addition of certain chemicals.

Permeability of Filter Cake:

Low permeability of the filter cake prevents loss of water to permeable formations and thus tends to preserve the properties of the mud. In the case of oil or gas-bearing formations, loss of water would cause a decrease of the permeability of the producing formation to oil or gas, and result in a lower productivity for the well. In the case of certain shales, the addition water causes them to swell and slough into the hole.

Hydrogen-ion concentration (pH value):

The hydrogen-ion concentration governs the dissociation of the colloidal clay particles. There is an optimum value for each clay, which varies with the presence of other chemicals. Below this optimum point the colloid is only partially dispersed, above this point, flocculation occurs.

Procedure:

The tests used in the control and evaluation of drilling fluids consisted of the following:

1. Specific Gravity, expressed as gm./cc, #/Gal., #/Cu. Ft., or #/Sq. In./100 Ft.; It was measured by means of a specific gravity bottle, and by a special mudwate hydrometer.

2. Viscosity was measured by the Stormer Viscosimeter at 600 r.p.m.

3. Temperature was maintained constant at 25° C. (77° F.)

4. Settling Rate was measured periodically and the results plotted as the volume % of free water separated from a 100 cc. sample during the time shown.

5. pH was measured by a Beckman pH meter with glass electrode.

6. Filtration rate was measured with a Baroid 100#/in² filter press.

7. Permeability of cake was calculated from data obtained from filtration tests with a Baroid 100#/in² filter operated for 150 minutes at 100#/in² and at 50#/in² pressures, by measuring the volume and viscosity of filtrate, the volume and per cent water, and the thickness of cake.

8. Permeability calculations were made by graphical extrapolation according to the method of Williams and Gannon, Oil Weekly, V. 90, No. 2, P. 25. Data were obtained at 50 and 100#/in² differential pressures. The constants of the equations were determined from log-log charts, Figures 11 and 12, and the permeability coefficients calculated and plotted on Figures 13 and 14.

Evaluation Procedure:

Series A:

Each of the six clays and a sample of Aquagel were ground in a ball mill until approximately 90% of the sample passed through a 200-mesh screen. Only that portion passing through the screen was used. Utilizing an Aquagel-water mud as a control, muds with a viscosity of 50 millipoise were prepared from each clay. A portion of each mud was then evaporated to dryness, allowed to stand in a drying oven at 105-110°C. overnight, cooled and weighed, in order to determine the per cent solids. A 100-cc graduate was also filled with the mud and the settling rate determined.

Series B:

Omitted. Originally, it was planned to conduct tests on samples of constant viscosity, constant pH, measuring the settling rate and filtration characteristics.

Series C:

2 liters of 9#/ gal. mud were prepared from each clay. Settling rate, viscosity, pH, and filtration rate, and permeability of filter cake were determined.

Series D:

The same procedure was repeated, but with the pH of all the muds adjusted to 9.5 by means of addition of required amount of NaOH. This was an arbitrarily assumed figure, the optimum pH was not determined.

Data and calculations:

Identification of Clays Used

1. S-2, Bed 5, Saline Co., Sec. 30, Twp. 12, R. 7 W.
2. Phillips Co. Bentonite, Ph-1.
3. Kl-53, Bed 6.
4. Wallace Co., Bentonite, Loc. 6.
5. Phillips Co. Bentonite, Loc. 2, Trench 2.
6. Wallace Co. Bentonite, Sec. 19, Twp. 12, R. 41 W.

Identification	Density #/ gal.	Viscosity (Stormer) (600 RPM) cps	Temp. C	S	f	v	$R' \times 10^6$	K_2 (10^{-4})	K_4 (10^{-4})	K_8 (10^{-4})	K_{16} (10^{-4})	K_{32} (10^{-4})
#1 Gulf Coast Mud (unweighted)	13.43	11.0	25	.800	.894	0.160	0.904	6.36	3.65	2.10	1.21	0.690
with weighting mtl. (unweighted)	13.43	11.0	60	.900	.469	.160	1.36	3.93	2.12	1.14	0.614	0.328
with weighting mtl. #2	14.07	11.0	25	.847	.894	.240	.690	9.90	4.50	2.47	1.45	0.876
#3	13.43	10.0	25	.810	.894	.163	.331	17.10	9.90	5.62	3.20	1.83
#4	13.26	8.0	25	.858	.894	.143	.662	8.26	4.53	2.48	1.48	.740
#1-3.0% Bentonite (% on basis total mud weight)	11.83	2.0	25	.778	.894	.023	3.92	1.49	.870	.504	.294	.187
#1-4.0% Bentonite	11.93	3.0	25	.778	.894	.033	4.25	1.37	.800	.465	.272	.174
#1-5.0% "	12.04	9.0	25	.778	.894	.043	5.34	1.09	.637	.370	.216	.140
#1-6.0% "	12.12	14.0	25	.778	.894	.052	5.40	1.07	.624	.364	.212	.139

Discussion of Results:

Figure 1 compares the efficiency of the Kansas clays with Aquagel and 5 other clays reported by Baroid Sales Company in their trade publication, Drilling Mud, V. 1, No. 1, May, 1931. The price, delivered at the well, that an operator would be willing to pay for the clay is proportional to its efficiency. It may be seen that none of the clays correspond to Aquagel, though several (notably numbers 2, 3, 4, 5, 6) are relatively efficient as base clays.

Figures 2, 3, and 4 show the rate of settling of the clays, when compared under three different sets of conditions. Since this test is a measure of gel strength, and to some extent of colloidal content, the fact that Mud No. 3 is highest under each condition would cause one to give it favorable consideration.

The filtration tests show that muds 4, 5, and 6 compare favorably with the Gulf Coast muds, Figure 13, reported by Williams and Cannon, Oil Weekly, V. 90, No. 2, P. 25, 1939. All three lost not only relatively small amounts of water in the Baroid 100# filter test, Figures 5-10, but they also show the best (lowest) permeability curves, Figure 14. Mud, C-1, which had a relatively high permeability at low pressure differentials showed the least permeability above a differential of 300#/□".

It should be noted that series C shows these muds in their natural state at 9#/ gal. density, and Series D, after their pH had been adjusted to 9.5. This is a relatively high pH, arbitrarily selected for comparative purposes. Most light-weight muds have an optimum pH of 7-8, but it becomes necessary to increase the pH in order to hold weighting materials in suspension. Baroid Sales Co. recommends 11-11.5 when "Baroid," barite, is added.

A pH of 9.5 was evidently too high for mud No. 6, since it resulted in flocculation of whatever colloidal material was present.

The tests reported, although extensive, are far from complete. Before recommending a mud for usage, the following examinations should also be made:

Sand content

Gel strength, viscosity and filtration tests of the mud at densities of 11 and 12#/gal.

The effect of addition of various quantities of colloidal material, sodium tannate or quebracho, lime, barite, hematite, pyro and meta-phosphates and similar standard treating agents.

The optimum pH under each condition.

The effect of temperature increase under each condition.

With such data at hand, recommendations for the usage of a clay can be correctly made, and the results predicted.

From figure 13, it may be seen that for the Gulf Coast mud in question, increasing the temperature to 60°C. (140°F) or approximately that of bottom-hole conditions, the permeability was considerably decreased. Addition of bentonitic material (colloidal bentonites) decreased the permeability greatly. The effects of other chemicals are given in the reference.

On the basis of the above tests made, mud No. 3 can be recommended <u>for testing</u> by a prospective user with muds 4 and 6 are next in order. We cannot recommend any of them for general usage, however, without a much more complete analysis.

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