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DRILLING MUDS USEFUL IN DRILLING TRONA BEDS

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This invention pertains to a process of drilling through beds of trona (natural sodium sesquicarbonate) such as encountered in the Green River section of Wyoming, the salt-based drilling mud composition utilized in this process, and the aqueous salt composition used to formulate the drilling mud used in this process.

It is well known that in the rotary drilling of boreholes an aqueous suspension of finely divided solids, commonly referred to as drilling mud, is pumped down the drill stem through the openings in the drill bit and upwardly through the annular space between the drill stem and the walls of the borehole to the surface of the earth. A primary purpose for employing the drilling mud is to pick up the cuttings produced by the drill bit and to transport these cuttings to the surface of the earth. The drilling mud also serves other important functions such as lubricating the bit and the drill stem, cooling the bit, and furnishing a hydrostatic pressure head to prevent flow into the borehole of formation fluid, such as oil, gas and water, from the various strata penetrated by the drill bit. In certain cases it is highly desirable that the mud form a thin, impermeable coating on the walls of the borehole for the purpose of reducing the loss of water from the borehole to the formation and thereby reducing softening of the borehole walls and caving into the drill hole. It is preferable that the filter cake formed on the walls of the borehole be thin rather than thick so as to avoid mechanical difficulties in moving the bit in and out of the hole and in placing casings in the hole.

While the science of drilling mud formulation is well developed for the drilling of the borehole through common rock and shale formations, difficulties are encountered when attempting to drill through water soluble salt formations due to the tendency of the salt to dissolve into aqueous drilling mud. This causes uneven boreholes and considerable caving of the borehole walls.

It is customary when drilling through water-soluble salt formations to utilize a salt based mud formulated with a saturated aqueous solution of the salt compounded with special clays which retain colloidal properties in the high salt concentrations and mixtures of organic colloids such as starch and carboxymethylcellulose. Such salt-based drilling muds are disclosed in U.S. Patent Nos. 2,525,783, 2,571,093 and 2,771,419.

In the process of drilling wells for the solution mining of trona beds, which in the Green River area of Wyoming are situated at various layers up to 12 ft. in thickness under 800 to 1500 feet of overburden, it is customary to drill through the cap-rock and trona bed to the underlying strata. The borehole is then cased with pipe and the casing cemented to the formation. If considerable solution of the trona bed has occurred around the borehole, the amount of cement required to seal the hole is excessive. After the hole is sealed, the cement plug is reamed through. Hydraulic pressure is then applied to the area through the casing to cause hydrofracturing of the strata at the interface of the underlying strata and the trona bed. The pressure forces the trona bed to raise slightly for a

considerable area around the hole. Adjacent wells are thus connected so that water or other solvent can flow from input to output wells, which water or solvent dissolves the trona as it flows underground. If the casing is not firmly cemented to the trona strata before applying hydraulic pressure, the water would flow back up between the casing and the trona bed along the uneven boreholes and when pressure was applied it would either force the water out of the borehole through the annulus outside the casing or if pressure could be maintained, this pressure would not be applied at the strata interface but throughout the entire bed, causing vertical rather than horizontal fracturing with no interconnection of the wells.

I have found that the use of a saturated trona brine formulated with a salt resistant clay of the nature of Florida-Georgia zeolitic clays (floridin), starch and the sodium salt of carboxymethylcellulose, as would be suggested by the prior art, is unsatisfactory for drilling through trona beds. The amount of trona that water can dissolve varies considerably with the temperature of the water. A drilling mud suspension which is saturated with respect to trona at the mud pit undergoes considerable heating during the process of pumping it through the drill stem through heat exchange with ascending mud which has been warmed by removing heat generated by the drill bit. Thus, the solution which is saturated at the surface temperature is not saturated with respect to trona when leaving the drill bit and will dissolve trona from the bed to reach the saturated point.

I have further found that the use of a saturated salt (sodium chloride) drilling mud formulated as above is also disadvantageous in that solution of the trona from the trona beds likewise occurs. The saturated salt solution is not saturated with respect to trona and the amount of trona which such a saturated salt drilling mud will dissolve will likewise increase with an increase in temperature of the mud.

While the use of a trona brine mud is much more advantageous than the use of an aqueous mud or a saturated salt mud, it still suffers the drawback of uneven boreholes and caving of the formation. Excessive cementing is required and it is impossible to obtain cores which do not have partial or complete dissolution of the trona sections.

It is an object of our invention to overcome the above-mentioned defects and obtain a drilling mud composition which will enable the drilling of boreholes through beds containing trona as exemplified by the trona beds in the Green River section of Wyoming without solution of the embedded trona into the drilling mud.

It is a further object of our invention to obtain a borehole through a trona bed which is even in diameter and into which a casing can be cemented without use of more than minimum amounts of cement.

It is still a further object of our invention to obtain cores by core-drilling in trona formations, which cores show no dissolution of the trona contained therein.

I have discovered that a salt-based drilling mud in which the major salt constituent is sodium chloride with minor amounts of sodium carbonate and sodium bicarbonate, does not dissolve trona present in the formation over a wide range of temperature, thus enabling one to drill through natural trona beds without solution of the bed and allowing one to obtain a borehole having practically uniform diameter as shown by a caliper log of the borehole.

Any of the customary salt-based drilling mud formulations can be used in the operation of our invention. In place of concentrated sodium chloride brine usually used as a liquid base in these formulations, I substitute a brine comprising 20 to 24% of sodium chloride, 3 to 7% of sodium carbonate and 0.6 to 3% of sodium bicarbonate. In the presence of a brine of the above composition, natu-

ral trona is insoluble over a wide range of temperatures from 0° C. to 90° C. and only slightly soluble at temperatures above this. The above composition is compatible with the ingredients customarily utilized in salt-based drilling muds.

To our chloride-carbonate-bicarbonate brine can be added various clays which retain their colloidal properties in the presence of sodium ions. Such clays are well-known in the art, a commercial clay of this type is "Zeogel" sold by the National Lead Company. Natural clays such as the Florida-Georgia zeolitic clays known as floridin can also be used. If the clay does not add sufficient colloidal properties to cut down on water-loss to the formation, organic colloids can be added in addition. Such organic colloids are, for example: water-soluble starch and the sodium salt of carboxymethylcellulose. Weighting agents can also be added, although these are not necessary in the drilling muds utilized in the Green River area of Wyoming. When using starch, bactericides such as formaldehyde may also be used.

I have found that an excellent mud can be formulated from "Zeogel," water-soluble starch, sodium carboxymethylcellulose, and the dissolved salt-solution, which has a density of 10.7 lbs./gal., a water loss of 3 cc. in 30 minutes (API), a pH of 10.5 and a viscosity of 58 seconds (API). Use of this mud enables one to drill through trona formations and produce a hole diameter of approximately the same size as the bit diameter. The cores obtained utilizing this drilling mud show no evidence of dissolution of the trona.

Example

A drilling mud was prepared having the following composition:

	Pounds/bbl.
"Zeogel"	30.5
Water soluble starch	9
Sodium carboxymethylcellulose	0.5
Sodium chloride	110
Sodium carbonate	20
Sodium bicarbonate (per 55 gal. barrel)	4

As the mud is fairly expensive, a plain water mud was used to drill down to the sandstone (800 ft.). Then the special mud was used for the remainder of the drilling, core drilling and reaming. The cores obtained from the various trona formations showed no dissolving of trona whatever, whereas all previous cores had partial or complete dissolution of the trona, depending upon whether trona liquors or water had been used in the drilling mud.

In addition to furnishing an ideal drill core, the finished hole was exceptionally good. Practically no sluffing of the various formations into the drill hole had taken place. Caliper logs of the wells drilled with this drilling mud composition were made, which show the actual hole diameter versus depth. In general these logs show that during the coring the hole diameter is exactly the same as the bit diameter throughout the cored section. In drilling with ordinary mud above the 800 ft. level, the hole diameter is often more than 2 inches and generally at least 1 inch larger than the bit diameter. When the special mud was used, seldom was the hole diameter more than 1 inch larger than the bit diameter and most of the time they coincided. It is desirable to have a uniform drill hole for two reasons. Less cement is needed when cementing the casing and the cement will be much stronger. If there are large cavities where sluffing of the formation has occured the mud will not be replaced by cement during the cementing and the casing will have a weakened cement job as a result.

While we have given specific embodiments of our invention, we wish it to be understood that the invention is not limited to these embodiments and that various changes and modifications can be made therein without departing from the spirit of the invention or the scope of the appended claims.

I claim:

1. A salt-based drilling mud for use as a circulating fluid in a well in drilling through rock formations containing trona, said mud containing colloids selected from the group consisting of clay and organic colloids, and a salt-based aqueous brine comprising about 20% to 24% of sodium chloride, about 3% to 7% of sodium carbonate, about 0.6% to 3% of sodium bicarbonate, and the remainder water.

2. A salt-based aqueous brine for use as a base in the formulation of drilling muds useful as circulating fluids in a well in drilling through formations containing trona deposits comprising about 20% to about 24% of sodium chloride, about 3% to about 7% of sodium carbonate, about 0.6% to 3% of sodium bicarbonate, and the remainder water.

3. In a process for drilling a well through formations containing trona deposits with well drilling tools wherein there is circulated in a well a salt-based drilling mud containing colloids selected form the group consisting of clay and organic colloids, the improvement which consists in circulating in said well a salt-based drilling mud compounded with a salt-based aqueous brine comprising about 20% to about 24% of sodium chloride, about 3% to about 7% of sodium carbonate, about 0.6% to about 3% of sodium bicarbonate, and the remainder water.

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