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DRILLING OF WELLS AND DRILLING MUD THEREFOR

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This invention relates to the drilling of wells, and to a drilling mud therefor.

More specifically, my invention relates to a method of drilling wells into and through porous and unconsolidated formations where difficulty is normally experienced due to sticking of the drill stem and/or casing, which may be due to excessive build-up of mud cake on the bore hole of the well, or to other causes such as swelling and heaving of the shale.

Drilling muds are almost universally used in the drilling of wells employed for tapping underground collections of oil, gas, brines and water. These muds fulfill various functions, the most important of which are to assist in the removal of the cuttings from the wells, to lubricate the drill tools and the drill pipes which carry the tools, and to assist in the sealing of formations from gas, oil and water which may be encountered at various levels by the formation on the wall of the bore hole of a filter cake consisting of the solid constituents of the drilling mud. In customary practice, a drilling mud, which generally is an aqueous clay suspension that may or may not contain an additional weighting material, such as barytes, is circulated down the hollow drill stem to the locus of drilling and is then returned up through the annular channel between the drill stem and the well bore or well casing to the head of the well.

During the course of drilling, which involves lowering and raising of the drill stem and pit, and lowering of the casing, difficulty may be encountered, particularly in certain formations, due to sticking or jamming of the drill stem or casing when employing the conventional drilling mud. This is particularly noticeable when drilling through porous or unconsolidated strata which are of such a character that the water of the drilling mud is permitted to enter the porous strata while the solids of the mud are filtered out and form a mud cake on the wall of the bore opposite the porous strata. With the conventional drilling muds, the cake so formed may be sufficiently porous to permit this infiltration of water to take place over a considerable period of drilling, thereby building up a ring of deposited mud of substantial thickness opposite the porous strata, which is termed "mud ringing."

In the course of drilling wells, the bores may encounter certain geological formations which are termed "heaving shale formations," or more simply "heaving shale." The term denotes shale strata which do not remain consolidated during the drilling operation. In some cases, the shale heaves or caves into the hole during the course of actual drilling, and in other cases the shale may heave when the drilling tools are removed therefrom. Certain shales are of such character that they absorb water from the circulating drilling mud or by reason of infiltration of well water along fracture planes cause swelling and caving. Even where heaving shale difficulties may not be encountered during the actual progress of drilling, occasions arise where it is necessary to discontinue drilling operations for a period of time, leaving the bore hole filled with the aqueous drilling mud to prevent blowouts, such as in fishing jobs; and in such cases, the continued exposure of the shale to the aqueous mud will cause swelling and crumbling of the weak spots of the wall of the well.

In accordance with my invention, the drilling mud is treated with a small proportion of an alkaline caseinate solution, which has been found to successfully counteract the objectionable build-up of mud cakes opposite porous strata or mud ringing, and to prevent heaving or caving of the shale into the well bore, and to permit satisfactory and unimpeded drilling through such difficult formations without sticking or jamming of the drill pipe and casing. It is believed that the small proportion of alkaline caseinate in the drilling mud produces a thin coating for the shales which effectively resist their water absorption, crumbling and heaving tendencies, and the thin cakes so formed opposite porous strata are waterproof and prevent further infiltration of the water of the drilling mud through the cakes into the porous formation with resultant build-up of thicker cakes or mud ringing.

In the co-pending application of Sterling P. Hart, Serial No. 220,507, filed July 21, 1938, now Patent No. 2,248,457, dated July 8, 1941, there is disclosed and claimed a method of preventing the heaving of shale in the drilling of a well by first circulating through the well a slug of drilling mud containing dispersed casein, and following this with a separate slug of drilling mud containing a hardening reagent for the casein sheath, such as formaldehyde. I have found that it is unnecessary to employ the two-step procedure of first depositing the casein containing coating, and then treating with a hardening reagent, which of course involves entirely changing certain portions of the circulating mud stream. In accordance with my process, an appreciably smaller quantity of the caseinate is added to the entire circulating mud stream and is employed throughout the course of drilling

through the porous or unconsolidated formation.

I am also aware that the Harth U. S. Patent No. 1,991,637 has proposed the addition of about 2–5% by weight of casein glue based on the weight of the total solids to a weighted drilling mud as a substitute for bentonite to maintain the weighting material, or clay plus weighting material, in suspension in the aqueous medium. My invention is distinguished by the use of a proportion of alkaline caseinate substantially less than 0.4% by weight on the weight of the total solids in the mud stream for the purpose of preventing the sticking of the drill stem and casing due to mud ringing or the swelling and heaving of shale during the course of drilling, which proportion of caseinate is substantially below that which affords any appreciable suspending action. Furthermore, the use of higher proportions of the order set forth in the said patent of alkaline caseinate with the continuous circulation of the mud stream during the progress of drilling is fraught with such difficulty due to foaming of the mud stream and gas cutting as to make the use thereof impractical in a continuous drilling operation with continuous mud recirculation. I have found that the above mentioned smaller proportion, which may more conveniently be expressed as less than 1% by volume of a sodium caseinate solution of a dilute concentration of the order of 10—20%, based on the total volume of the mud stream, gives the further advantages of avoiding objectionable foaming and gas cutting of the mud stream, and does not alter physical tests of the drilling mud.

Casein is a member of the group of proteins, exhibits colloidal properties, and is amphoteric in that it can act either as an acid or a base. It does not dissolve in water, but upon soaking therein it rapidly swells. Solution of the casein is conveniently effected by treating swelled casein with a water solution of an alkaline material, such as borax, ammonia, an alkali metal bicarbonate, an alkali metal carbonate, lime, sodium metasilicate, sodium silicate, or any equivalent alkaline material. It is advantageous to heat the casein in water for a period of time, and then mix therewith a previously formed alkaline solution, and agitate the mixture until a clear solution of the alkaline caseinate is obtained. For most purposes, a solution of a sodium salt, such as sodium borate, is preferred which produces a sodium caseinate when admixed with the swelled casein. Where the casein solution is to be stored or used in a circulating drilling mud for any length of time, it is desirable to incorporate therein a small proportion of a preservative, such as phenol, cresol, camphor, pine oil and the like, for retarding the growth of bacteria or mold. A solution of sodium caseinate in water of a concentration of about 10—20% is preferred, although more dilute or stronger solutions of alkali metal caseinate may be employed.

The resulting alkaline caseinate solution is then added to a drilling mud, such as an aqueous clay suspension, in the desired amount to give a proportion of about 0.1—0.8% by volume of solution on the total volume of the mud stream, equivalent to about 0.0066—0.1056% by weight of casein on the total weight of the mud stream, and preferably about 0.3—0.5% by volume. This may conveniently be accomplished by injecting the alkaline caseinate solution into the circulating mud stream as it circulates through the mud ditch on its way from the well head to the settling pit, where the drilling mud is subjected to agitation and time is permitted for the casein solution to become homogeneously dispersed in the mud stream. In the flow of the mud from the well through the usual screen and mud ditch to the settling pit, the cuttings settle out and the resulting settled drilling mud is then returned for recirculation through the well. However, it is to be understood that the casein solution can be added to the mud stream at any other suitable location as long as it is adequately mixed therewith in the desired proportion and uniformly distributed throughout the entire circulating mud stream.

The following is a preferred example of the method of preparing the drilling mud of this invention, although it is to be understood that the invention is not limited thereto:

For each 50-gallon barrel of sodium caseinate solution, 61.25 pounds of casein were added to 13 gallons of water heated to 150° F. and allowed to soak for twenty minutes. Eleven pounds of granular borax were dissolved in 2.75 gallons of water heated to 150° F. The casein suspension and borax solution were then mixed and stirred until clear. Enough water heated to 150° F. was then added to make 50 gallons of the solution, having a concentration of sodium caseinate of approximately 17.3%. One pint of 96% phenol was then mixed with the solution as a preservative.

The resulting sodium caseinate solution was then injected into a circulating drilling mud to give a proportion of about .5% by volume of the solution on the total volume of the circulating mud.

This invention was applied to the drilling of a well in the North Belridge, California, field where caving tendencies had been encountered and to facilitate a fishing job. The mud stream was composed of a 75-pound per cubic foot Mojave clay suspension weighted with barytes to 80 pounds per cubic foot and containing two sacks of bentonite for each 120 barrels of mud. The circulating mud stream totaled approximately 700 barrels (50 gallons each), and 3.5 barrels (50 gallons each) of the above described sodium caseinate solution were gradually added to the circulating mud stream over a period of about 1½ hours which approximated the time for one complete recirculation or round trip of the mud stream. As described above, this was equivalent to about 0.5% by volume of the solution on the volume of the total mud stream including the aqueous phase. Calculation of the casein content thereof shows that the drilling mud contained approximately 0.057% casein by weight based on the weight of the total mud stream, or approximately 0.26% casein by weight based on the weight of the total solids of the mud stream. Employing this treated mud, it was found possible to complete the fishing job and to resume drilling without the difficulty which had previously been experienced when employing an untreated conventional mud due to swelling and caving of the shale.

In the drilling of another well employing a weighted drilling mud having a weight of 110 pounds per cubic foot, the addition of approximately 0.16% by volume of the above described sodium caseinate solution on the volume of the total drilling mud was found effective in controlling mud loss due to lost circulation and in combating heaving shale conditions. In the case

of another well where 300 feet of drill pipe had been dropped down a 10,000-foot hole, requiring a subsequent plugging and sidetracking job, the addition of 0.5% by volume of the above described sodium caseinate solution to a 71-pound native clay drilling mud was found successful in cleaning up the shale in the hole and enabling the plugging and sidetracking job to be completed without difficulty from heaving shale.

It is pointed out that in the practical application of this invention in the field, a number of shales and clays have been encountered, such as in the San Joaquin Valley of California, which were of the mildly hydratable type, that could not be controlled by the addition of bentonite to the drilling mud, but which were effectively controlled against hydration, swelling and caving by the use of the drilling mud of this invention.

While I have given above preferred examples of the invention, it is to be understood that the invention is not limited to the use of solutions of the alkali metal caseinate of the concentration range set forth but that the drilling mud may be treated with any suitable caseinate solution so as to mix with the entire circulating mud a controlled and critical proportion of caseinate which is effective to give a thin water-impervious mud cake on the bore hole without objectionable mud ringing opposite porous formations, and to prevent the swelling and heaving of shale, but which is below that amount that causes objectionable foaming and gas cutting of the drilling mud. In general, a proportion of alkali metal caseinate of the order of less than 0.4% by weight and in excess of about 0.001% by weight on the dry weight of the total solids of the drilling mud may be employed, and preferably about 0.10 to 0.25% by weight. This extremely small percentage of the caseinate is believed effective to form a waterproofing thin or molecular coating on the shales being penetrated such as to resist their tendency to hydration, swelling and caving, and to quickly form a thin water-impervious cake opposite porous strata without excessive build-up or mud ringing, while at the same time the drilling mud is not thickened or rendered gummy and the physical properties thereof are not altered.

Obviously many modifications and variations of the invention, as hereinbefore set forth, may be made without departing from the spirit and scope thereof, and therefore only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. In the drilling of a well wherein a drilling mud comprising an aqueous clay suspension is circulated through the well during the course of drilling, and wherein difficulty is normally experienced due to sticking of the drill stem or casing due to mud ringing or swelling and heaving of shale, the method of inhibiting sticking of the drill stem or casing which comprises adding a small proportion of an alkaline caseinate to the circulating aqueous mud stream, the proportion added being such as to provide about 0.0066—0.1056% by weight of casein based on the total weight of the drilling mud and such as to avoid objectionable foaming and gas cutting of the treated mud but sufficient to counteract the tendency toward mud ringing opposite porous strata or the heaving of the penetrated shale, and continuing drilling with the circulation of the treated mud containing the dispersed alkaline caseinate.

2. The method of combating mud ringing and/or heaving of shale in the drilling of a well, which comprises circulating through the well during the course of drilling a drilling mud comprising an aqueous clay suspension containing a small proportion of alkali metal caseinate sufficient to provide about 0.0066—0.1056% by weight of casein based on the total weight of the drilling mud, the proportion of alkali metal caseinate being such as to avoid objectionable foaming and gas cutting of the treated mud but sufficient to counteract the tendency toward mud ringing opposite porous strata or the heaving of penetrated shale.

3. The method of combating mud ringing and/or heaving of shale in the drilling of a well, which comprises circulating through the well during the course of drilling an aqueous clay suspension having added thereto an aqueous alkaline solution of casein of a concentration of about 10—20%, the alkaline solution of casein being added in a proportion of less than 1% by volume based on the total volume of the mud stream such as to provide about 0.0066—0.1056% by weight of casein on the total weight of the mud stream, the proportion of alkaline solution of casein added to the mud stream being below that producing objectionable foaming and gas cutting of the treated mud but sufficient to counteract the tendency toward mud ringing opposite porous strata or the heaving of the penetrated shale, and then continuing drilling with the circulation of the treated mud containing the added alkaline solution of casein.

4. In the drilling of a well wherein a drilling mud comprising an aqueous clay suspension is circulated through the well during the course of drilling, and wherein difficulty is normally experienced due to sticking of the drill stem or casing due to mud ringing or swelling and heaving of shale, the method of inhibiting sticking of the drill stem or casing which comprises adding to the circulating aqueous drilling mud a water solution of sodium caseinate of about 10—20% strength in a proportion of about 0.1—0.8% by volume based on the total volume of the mud stream, such as to provide about 0.0066—0.1056% by weight of casein based on the total weight of the drilling mud, the proportion of added sodium caseinate solution being insufficient to cause objectionable foaming and gas cutting of the treated mud but sufficient to counteract the tendency toward mud ringing opposite porous strata or the heaving of the penetrated shale, and then drilling with the circulation of the treated mud containing the sodium caseinate.

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