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DRILLING WELLS AND WELL DRILLING FLUID

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8 Claims. (Cl. 255—1)

This invention relates to drilling wells and well drilling fluids; and it comprises an improved method of drilling oil and gas bores or wells through rocky or sandy strata with the aid of a mud fluid circulated around the drill and through the well bore, said mud fluid comprising clay in water suspension, wherein the mud fluid is treated to increase its liquidity with a modicum of caustic alkali solution containing an organic material of feebly acid properties, the mud fluid is pumped into the well, around the drill and up and out of the well through the bore, carrying entrained cuttings, sand and gas, the mud fluid is then freed of entrained matter by passing it through a settling zone where entrained rock particles and sand quickly settle out and gas escapes freely and the fluid is returned to the well for re-use substantially freed of such foreign matter; and it further comprises an improved well drilling fluid comprising clay in water suspension containing a modicum of caustic alkali in solution together with an organic material of feebly acid properties, said fluid allowing even minute rock particles and sand to settle out substantially completely upon being allowed to stand or move in slow current for a short time; all as more fully hereinafter set forth and as claimed.

In drilling wells for oil and gas it is often necessary to sink the well to a depth of several thousand feet through rocky strata, for the most part sedimentary rocks of various kinds. It is customary to circulate a fluid through the well and around the drill during the drilling operation in order to remove and carry to the surface cuttings broken free by the drill and sand working into the bore; to lubricate and cool the drill; and to prevent escape of gas from the well by imposing a high hydrostatic pressure, due to the height of the fluid in the well bore, upon the bottom of the bore. In rotary drilling the lubricating and cooling function of the fluid is particularly important. In rotary drilling the fluid is pumped down the hollow drill stem, across the working face of the drill bit and then upward to the surface in the annular space between the drill stem and the bore wall.

Water is a satisfactory well fluid for accomplishing these purposes; and plain water can be, and often is utilized as the drilling fluid in drilling wells. However, it is usual to employ a mud fluid instead of water, in order to secure certain additional functions: mainly that of plastering the bore walls with solid material, thereby preventing loss of fluid into the formation being drilled and preventing caving of the formation. A further reason for using a mud fluid is that mud, being denser than water, allows a greater hydrostatic head to be maintained in the bore, thereby more effectively preventing escape of gas from high pressure gas strata penetrated by the drill. By using a large proportion of clay, or incorporating a heavy pulverulent material into the mud, high densities can be obtained, and gas-cutting (dispersion of gas bubbles through the fluid) is minimized. Gas-cutting is undesirable. It lowers the effective density and thus the hydrostatic head of the mud fluid in the bore; and the lowering of density due to occluded gas may continue until the hydrostatic head of the mud column over the zone of entrance of gas into the bore is overcome by the pressure of the gas. In this case a blowout is likely to occur, the mud fluid being forcibly blown from the well. Such a blowout not only requires suspension of the drilling operation until more mud fluid can be forced down the well, but may also result in destruction of the drill rig.

A satisfactory drilling fluid represents a number of compromises. It should be as thin and mobile as possible to enable it to be pumped, piped and handled with convenience and with a minimum of power and it should be of high apparent specific gravity; a gallon should weigh as much as possible. In securing this compromise, water is laden with as much clay as possible consistent with making a mixture which can be readily pumped. The use of heavier materials than clay such as barytes, iron oxide, etc., is sometimes practiced; the idea being to obtain a fluid of high weight per gallon which is still mobile enough to permit easy handling and pumping.

Mud fluid issuing from the well is contaminated with drill cuttings, sand, and entrained gas. It is highly important that this foreign matter be removed from the mud as completely as possible, before the mud is pumped back into the well. Cuttings of hard rock and sand are exceedingly abrasive to the liners, pistons and valves of the mud circulating pumps. Furthermore, if cuttings and sand are returned to the well they settle around the drill and the drill may become stuck if circulation is discontinued for a time. Even very small particles of sand and rock will damage the pumps if not removed before the mud is pumped back into the well. Rock and sand particles larger than will pass a 325 mesh screen are injurious to pump parts, and should be removed from the fluid before it is taken into the pumps. Furthermore it is necessary to re-

move as much of this finely divided matter as possible in order to prevent the mud from being thickened in the course of several recirculations.

It is equally essential that entrained gas bubbles be removed before the mud is recirculated, to avoid decreasing the effective density of the column of fluid in the well.

In drilling practice, it is customary to pass the mud pumped from the well through a settling tank or pit, where the mud stream is retarded practically to a standstill for the purpose of allowing rock cuttings and sand to gradually sink out by gravity, and to allow gas bubbles to work their way out of the mud. As stated, the removal of foreign matter from the mud should be as complete as possible. In drilling with ordinary muds, the settling pits and receptacles have been made very large to provide long settling periods. These have the disadvantage that a large supply of mud is required. In any case, with drilling muds at present in use, a certain proportion of the entrained matter fails to separate out, even when the mud is given a prolonged settling period. Various mechanical means and methods have been proposed for accelerating the extrication of entrained cuttings, sand and gas. These include mechanical vibrating screens, riffle tables, centrifugal separators and classifiers. Sometimes the well fluid is diluted in order to assist in the extrication of foreign matter. While such means and methods are more effective than plain settling pits, they are not satisfactory in removing the smallest sized foreign matter. The problem of adequate removal of suspended matter is a serious one in the art.

In order to make possible a more complete settling out of suspended particles and extrication of gas, it has been customary to use special clay fluids of lower viscosity than an ordinary mud fluid; as for example prepared bentonite in 5 to 10 per cent suspension in water. Such fluids may be effective by reason of their gelatinous character in entraining and carrying off cuttings but are not entirely satisfactory because their gelatinous nature tends to prevent extrication of the entrained matter. Small particles are not settled out.

It has been considered that reduction in viscosity is the only essential for improving the ability of a mud fluid to drop suspended matter.

We have discovered that viscosity, as this characteristic is ordinarily indicated and measured: as resistance of a fluid to flow through an opening under pressure or as resistance to motion of a rapidly rotated paddle wheel or the like, is not the only quality which makes for ready extrication of foreign matter. We have found that of two different drilling fluids having equal viscosities measured in these ways, one may gas-cut more than the other, and may have particle-settling properties inferior to the other.

We have discovered that the viscosity of drilling fluids as ordinarily measured is not the chief factor determining the ability of these fluids to free themselves of their burden of cuttings and entrained gas upon emergence from the well bore into the settling receptacle. We have found that fluid muds have definite yield points, that is, relative resistances to shearing stresses too great for the smaller entrained solid particles and entrained gas to overcome; movement of such entrained matter in light particles being substantially prevented. In many cases a large part of the cuttings broken loose by the drill bit are not of sufficient mass to furnish the necessary minimum shearing stresses to enable them to pass through the mud fluid and be settled out. Likewise and for the same reasons gas bubbles are held in suspension.

We have found that bentonite fluids and similar clay fluids behave as plastics, rather than as true viscous liquids. That is, the fluids possess definite yield points; minimum resistance to shearing stress below which no passage of small masses through the fluid occurs. Stresses of a value below this yield point do not set the fluid in motion; for such stresses the fluid behaves in effect like a solid. It possesses insufficient liquidity. In a mud fluid then, having a certain yield point, suspended particles of a mass sufficient to overcome the minimum resistance at which flow occurs, will drop downward through the fluid and settle out. But particles of too small a mass to overcome, under the influence of gravity, the minimum shearing stress yield point will be retained fixed in the fluid, and will not settle out even if given a great length of time for settling. We have discovered that the ability of a mud to release particles and gas by settling is dependent on the minimum yield point of the mud; and not on the apparent viscosity. Both cuttings and gas may be released in a reasonable time from true liquids having greater viscosities than ordinary clay drilling muds; for true liquids have zero yield points. We have found that in ordinary drilling muds and muds of the bentonite type, the minimum yield point is rather high, whatever may be the viscosity of the mud; and hence substantial amounts of small cuttings and of gas are retained in the mud even after a long settling time.

The viscosity of a plastic material such as ordinary mud or mud fluids made from bentonite or other clay is not constant, at a given temperature, but varies with the rate of shear (as for instance the rate at which a paddle is moved through the material) and with the shearing stress (as for instance the force with which the paddle is moved through the material). At low shearing stresses such materials have high effective viscosities; and a viscosity determination of such a material made in the ordinary way by forcibly driving a paddle through the material or by forcing it through an orifice, may be misleading as to the yield point of the material under small stresses, such as the shearing stress exerted by a small solid particle suspended in the material and tending to fall by gravity. For a very small shearing stress such as is exerted by a minute particle of sand pulled downward by the force of gravity, the resistance of the fluid may be so great as to entirely prevent settling of the particle. But this would not be foreseen by considering the viscosity of the fluid under the ordinary conditions of measurement. The fluid may, as stated, have a minimum value of resistance to shearing stress at which the particle would not settle out at all. This is not evident from ordinary viscosity measurements. And merely reducing the viscosity of the fluid may have no effect on the yield point under very small shearing stresses.

An achieved object of the present invention is to reduce the yield point of mud fluids to a degree where even minute entrained particles are enabled to settle out of the fluid by their own weight.

According to the present invention we add to a drilling mud, comprising a slurry of mud or

clay in water suspension, small amounts of certain chemicals which we have found to be particularly effective in depressing the yield point of the mud. We have found that by adding to a drilling mud small proportions of caustic soda or caustic potash together with an acid organic compound such for example as tannic acid, the yield point of the mud is greatly reduced. The mud behaves less like a plastic solid and more like a true viscous liquid. The result is that substantially all the entrained gas and cuttings may be removed by simply allowing the mud to settle as by flowing in retarded current for a short time; and minute particles, which are permanently retained in untreated mud, settle out freely from the treated mud. The added chemicals, in the concentrations we use, do not cause flocculation of the colloidal clay matter in the drilling mud which would cause clay particles to settle. In fact, they cause deflocculation, and decrease in viscosity; both of which are desirable. Colloidal particles of clay are kept in suspension. But the chemicals serve to reduce the yield point to a very low degree, sufficient to allow even minute entrained particles of rock and sand to settle out freely under their own weight, and to allow gas bubbles to freely rise to the surface and escape.

As chemical agents for accomplishing these results we have found satisfactory a solution of caustic alkali such as caustic soda together with an organic acid such as tannic acid, humic acid, ulmic acid, gallic acid, lignic acid and the like. For example a solution of 3 parts caustic soda and 1 part tannic acid, added to an ordinary mud fluid, produces the desired effect. The amount of such salt of an organic acid added to the mud depends on the nature of the mud, but ordinarily amounts to about 0.25 to 1.0 per cent by weight on the solids in the drilling fluid, or about 6 to 25 pounds per 1000 gallons of a drilling fluid weighing 9.5 pounds per gallon. Addition of a greater proportion of chemicals increases the rate at which suspended particles settle out of the fluid, but in general the proportions given are adequate to insure settling in a reasonable time of all particles of size sufficiently great to cause damage. Other alkalis than caustic soda can be used; also the ratio of caustic soda to alkali may be varied to satisfy the requirements of particular muds. A solution of caustic soda combined with certain commercial byproducts of the paper industry containing organic acids of the types mentioned is an advantageous reagent. For example, soda black liquor, a byproduct in the manufacture of wood pulp, may be mixed with a suitable proportion of caustic alkali and employed in our invention. In making paper pulp by the soda process, wood is digested in a caustic soda solution under pressure. About half of the wood remains as cellulose pulp and the rest goes into solution. The dissolved matter comprises the lignin of the wood, together with smaller amounts of other constituents of the wood, including carbohydrates and tannin, if present. The lignin is combined with caustic soda, but there is caustic soda and also some carbonated soda in excess. Chestnut extract, another byproduct of the paper industry, is a suitable addition to an alkali solution, but is not as good as soda black liquor. The latter already contains soda, thereby requiring less caustic soda to be added to bring it to the required alkalinity.

In practicing the invention we usually find it convenient to add the chemical solution to the drilling mud at a point near the intake of the circulating pumps, which makes for thorough intermixing of the solution and the mud in the pumps and during circulation. The mud itself may be formed from clays present in the bore, as by circulating plain water through the well for a sufficient time to form a mud; or it may be made up outside the bore from bentonite or other clays. Weighting material such as hematite or barytes may be incorporated into the mud if desired. The amount of chemicals added is, as stated, adjusted according to the qualities of the mud; and also according to the nature of the strata being drilled. In drilling through soft clay or "gumbo" only enough of the chemical reagent need be added to insure the release of any sand particles and gas brought up in the fluid. In drilling through rock formations sufficient of the chemical should be added to insure the settling out of all rock particles larger than 325 mesh, for these are injurious to the pumping equipment. In such drilling we usually add the chemical reagent in proportions of 0.5 to 1.0 per cent on the weight of solids in the mud.

In the following specific examples we show the results of treating ordinary drilling muds according to our invention. In each case the untreated mud, and the mud after treatment, were allowed to settle out suspended matter, and the proportions of different sized solid particles retained in the mud after settling were determined.

The following table shows the sieve analysis of an untreated drilling mud from Pierce Junction (Texas) as obtained from the settling ditch; and of the same mud after being treated on its way to the settling ditch according to the present invention with a mixture of caustic soda 80 per cent and tannic acid 20 per cent totaling 1.0 per cent by weight of solids in the mud. The time of settling in both cases was 15 minutes.

Sieve analysis of Pierce Junction (Texas) drilling fluid before and after chemical treatment

Mesh	Before treatment	After treatment
40–70	3.09% of total solids	0.00% of total solids.
70–100	3.43	0.00
100–140	4.12	0.06
140–200	4.41	0.41
200–325	5.97	2.18
Through 325	79.95	97.40
Total solids in mud	25.60 percent	20.00 percent

It will be noted that the large non-colloidal particles (cuttings) had been almost entirely removed by settling as a result of the chemical treatment, and that the remaining fluid solids consisted mostly of fines smaller than 325 mesh, thus reclaiming the colloidal solid content of the drilling fluid. The untreated mud retained 25.6 per cent of total solid matter after settling as compared with 20 per cent for the treated mud. The particles injurious to mud-pump liners, and those liable to settle in the drill hole and cause freezing of the drill stem were entirely removed by settling the treated mud. Greater or less separation of large particles may be obtained by using more or less concentration of chemical; that is, as stated, the concentration may be adjusted to the particular requirements of drilling conditions.

A second example is the treatment of drilling

fluid from Oficina well (Venezuela). This drilling fluid weighed 9.2 pounds per gallon and untreated with chemical settled only 0.3 per cent solids as cuttings in 24 hours. When treated with 0.25 per cent (by weight of solids) of 75 per cent caustic soda and 25 per cent tannic acid in solution, 14.5 per cent of solids separated in 15 minutes; the solids separating were larger than 325 mash and therefore represented the cuttings, the finer colloidal clay particles remaining in suspension.

Clay drilling fluids containing weighting materials may also be treated according to the present invention, with beneficial results. For example, a weighted drilling fluid having a solid content consisting of 21 per cent clay and 79 per cent colloidal barytes and weighing 12 pounds per gallon showed no settling of cuttings even when left standing for 24 hours. This fluid was treated with about 0.6 per cent of its volume of a solution containing about 2 pounds caustic soda (NaOH) per gallon to which had been added about 0.67 pound tannic acid per gallon (one part tannic acid to 3 parts caustic soda). The treatment caused 9.8 per cent of solid matter to settle from the treated mud fluid, this being substantially all of the cuttings; 95 per cent of the solid matter settled out being larger than would pass a 100 mesh screen, which would be very destructive to pumping equipment.

In drilling a well with muds treated according to the invention we are able to dispense with the large settling pits, mechanical screens and classifiers, etc. heretofore considered necessary. A short settling trough, through which the pumped-out mud is passed before being taken up by the circulating pumps, gives ample opportunity for suspended rock and sand particles to settle out from the mud, and for entrained gas to escape.

In our experiments on treating drilling muds to improve their action in releasing cuttings, we have obtained satisfactory results in using the following classes of organic materials, their alkaline extracts and salts:

Compounds and their salts: Humic acid, lignic acid, ulmic acid, tannic acid, quercitannic acid, gallic acid, and pyrogallic acid.

Extracts, solutions and dispersions of sap brown dyes, lignins, humins, tannins, ulmins; extracts of wood (oak, chestnut, sumac, and cork) and of peat, straw, and cellulose.

By-products of the paper and cereal industries: Soda black liquor, sulfite liquor, chestnut extract, and spent liquor from the alkaline extraction of rice hulls.

Of the above chemicals that may be used in the practice of our invention, certain ones have been found to be more effective than others in settling cuttings from the muds without settling out the clay particles smaller than 325 mesh. In general, we have found that the humins, lignins, and tannins from sources that offer the purer compounds are more suitable than those contaminated by foreign matter. Certain commercially available extracts, by-products of the wood and cereal industries, are applicable, as they contain lignins or humins. As stated, soda black liquor, a by-product of the paper industry is an excellent reagent for our purposes. Chestnut extract is also good. Tannin and humin, as represented by sap brown dye, are valuable in the same way.

In our experiments we have measured the reduction in viscosity effected by the described treatment of drilling mud. While the reduction of viscosity is always great, being often as much as 80 per cent, it is, as we have found, incidental to reduction in yield point. Low viscosity accelerates the rate of settling. Lowering the minimum resistance to shearing stress makes possible the settling out of particles which otherwise would not be able to settle at all. We are able to form an aqueous clay suspension of high clay content giving a high density without sacrifice of liquidity.

This application is a continuation of our prior application Serial No. 571,672, filed October 28, 1931.

What we claim is:—

1. An improved method of drilling wells through rocky or sandy strata by means of a drill wherein a mud fluid is admixed with a modicum of caustic alkali solution containing an organic material of feebly acid properties, is pumped down the well, around the drill and up out of the well so as to carry up entrained cuttings, sand and gas, the mud fluid is then freed of entrained matter by settling, and is returned to the well substantially freed of the entrained material.

2. An improved will drilling fluid adapted to allow entrained matter to separate out rapidly upon standing, said fluid comprising an aqueous clay suspension containing a modicum of caustic alkali in solution together with an organic material of feebly acid properties enhancing the liquidity of the fluid.

3. The fluid of claim 2 wherein the aqueous suspension contains a modicum of caustic soda in solution together with a minor proportion of a material selected from the class consisting of humic, gallic, tannic, ulmic and lignic acids.

4. The fluid of claim 2 wherein the aqueous suspension contains a modicum of soda black liquor and caustic alkali.

5. The fluid of claim 2 wherein the aqueous suspension contains a modicum of a solution of 3 parts of caustic soda and about 1 part of tannic acid by weight.

6. The fluid of claim 2 wherein the aqueous clay suspension contains in solution a modicum amounting to about 0.1 to 0.8 per cent of caustic soda by weight of the clay solids and about 0.05 to 0.5 per cent by weight of the clay solids of a material selected from the class consisting of humic, gallic, tannic, ulmic and lignic acids.

7. The fluid of claim 2 weighted with a substantial proportion of a solid weighting agent.

8. In drilling wells with the aid of an aqueous mud fluid circulated down the well around the drill and up out of the well, the process improvement which comprises enabling the mud to release entrained matter in small particles by adding to the mud a modicum of caustic alkali together with a smaller modicum of a feeble organic acid selected from the class consisting of humic, gallic, tannic, ulmic and lignic acids.

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