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DRILLING FLUID FOR HEAVING SHALE

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This invention relates to a drilling fluid which will effect a minimum of disintegration of heaving shale.

In the rotary drilling of oil and gas wells fluid is pumped down the drill stem to the drill at the working face in the bottom of the bore. The stream of drilling fluid passes across the working face of the drill and escapes upwardly through the annular space between the drill stem and the borehole walls. In some areas, as for example parts of the Gulf Coast of Texas and Louisiana, formations known as heaving or sloughing shales must be penetrated before the oil or gas reservoirs are reached. It has frequently been difficult or impossible to penetrate these formations successfully by the ordinary rotary drilling methods when using common mud fluids. These shales have a tendency to disintegrate by swelling or cracking or both so that the walls of the hole are unstable and material sloughs into the hole or moves into the hole by swelling. The caving or sloughing of material into the hole may frequently result from the unequal swelling and resulting cracking caused by the presence of seams or thin layers of readily hydratable and swellable material closely interbedded with harder and less readily hydratable shale materials. In many cases in the past filling of the borehole, or parts of it, have resulted in stuck drill pipe and abandonment of further efforts to make additional hole. It is common in drilling shale sections which do not swell or slough severely enough to stop drilling operations or even to cause extreme difficulty to observe extensive enlargements of the borehole or even the formation of subterranean cavities. In these cases although the materials which swell, slough or cave into the hole are removed by the drilling fluid, the enlarged holes and cavities which are formed interfere to various degrees with operations involved in drilling and completing the well. When such enlargements and cavities are formed the rate of flow of the mud is greatly reduced and the carrying capacity thereof is diminished. To increase the rate of flow, pumps having a large excess capacity must be employed. Furthermore, when it becomes necessary to seal casing, large quantities of cement are required in order to obtain a proper sealing.

It is generally believed that the cause of disintegration of heaving shale is the hydration of shale adjacent the borehole by water contained in the ordinary drilling mud. Thus, a heaving shale may be defined as one which in contact with the usual water base drilling fluids swells or

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disintegrates continuously to such an extent as to interfere with drilling operations.

The rates of disintegration of sloughing and heaving shales may be decreased when using conventional drilling muds by adding materials which reduce the rate of filtration loss and improve other mud properties. But with even the best of such conventional drilling muds extreme difficulties from shale disintegration are encountered occasionally and serious hole enlargement in shale sections is the rule rather than the exception.

While disintegration of shales has been overcome to a large extent by the use of certain specially prepared drilling fluids, such for example as sodium silicate base drilling fluids and oil base drilling fluids, the methods heretofore practiced have not been entirely satisfactory. Not the least of the disadvantages of such methods is the high cost of materials required in their practice.

It is an object of this invention to provide a drilling fluid for the drilling of boreholes into subsurface formations by the rotary drilling method through heaving shale without causing the disintegration thereof.

In accordance with the present invention the disintegration of heaving shale is prevented by employing a drilling fluid consisting of water, clay, alkali metal hydroxide, salt, and materials for promoting the effectiveness of the hydroxide in preventing disintegration of shale. Instead of adding the alkali metal hydroxide, salt and a material for promoting the effectiveness of the hydroxide to a mixture of water and clay, these materials may be added to ordinary drilling mud provided the drilling mud contains a suitable amount of clay to give a fluid having the desired yield point and viscosity after the above mentioned constituents have been added. Finely divided material such as barytes, iron oxide, and the like, may be used to supplement the clay in forming the drilling mud.

A number of different materials may be used for promoting the effectiveness of the alkali metal hydroxide employed and I have found that the alkali metal salts of weak inorganic acids are particularly suitable. Of these sodium carbonate is not only an effective promoter but it is also readily available commercially at reasonable cost. Sodium sulphite and trisodium phosphate have been found to give good results for promoting the effectiveness of alkali metal hydroxide in the drilling of heaving shale formations. Of course, the potassium or lithium salts of weak inorganic acids may be employed although they are somewhat

more expensive than the corresponding sodium salt.

It is known that when shales are immersed in suitably strong solutions of alkali metal hydroxides they do not swell. Tests made by placing samples of shales in solutions of sodium hydroxide showed that when substantially less than the optimum concentration of sodium hydroxide was used, swelling and sloughing still occurred and little advantage was gained. It was also observed that when substantially more than the optimum concentration of sodium hydroxide was used swelling did not occur but cracking was observed which weakened some of the shales. Shale samples differed among themselves in the optimum concentration of sodium hydroxide solutions required for their preservation. These optimum concentrations for the different shale samples tested varied within the limits of 15% and 30% by weight of sodium hydroxide. It was further observed that the amount of sodium hydroxide required to preserve a particular shale could be decreased by adding sodium chloride, a much less expensive material, to the solution. With concentrations of sodium hydroxide and sodium chloride above the optimum, as with the sodium hydroxide solutions, cracking of some of the shales occurred. It was still further observed that the addition of small amounts of certain salts to the caustic alkali solutions or to the solutions of sodium chloride and caustic alkali, of more than sufficient concentration to prevent swelling, served to prevent cracking of the shales and thus adapted the solutions to preserving a wider range of shale types. For example, I have found that a fluid consisting of 70.3 weight percent water, 8.25 weight percent sodium hydroxide, 4.15 weight percent sodium carbonate, and 17.3 weight percent sodium chloride is substantially equivalent to a 20 weight percent solution of sodium hydroxide from the standpoint of preventing the swelling of clay and shale samples and superior to such a solution from the standpoint of cracking of some of the shale samples. Thus, the use of a material such as sodium carbonate greatly reduces the cracking of shales contacted by alkali hydroxide solutions. It has further been found that the use of sodium carbonate makes any given caustic-brine solution effective over a wider range of shale types than is the case when no such promoter material is used.

It is to be understood that the amount of material for promoting the effectiveness of the hydroxide to be employed in the drilling fluid may vary within a substantial range depending largely on the character of the shale encountered. The minimum concentration of the electrolytes which will be effective in any particular case may be determined by experimentation, that is, by obtaining a sample of the shale through which drilling is to be accomplished and observing its rate or degree of disintegration by the action of water-containing various concentrations of the materials. When optimum amounts are incorporated in the drilling mud, the rate of disintegration of the shale sample will be negligible. In general, the amount of alkali metal hydroxide may be varied from about 6% to about 15% by weight of the total fluid, and when such concentrations are utilized, the amount of the material for promoting the effectiveness of the alkali metal hydroxide may vary from about 1% to about 10% based on the total fluid, the preferable range of the latter being from about 2% to about 6%.

The concentration of the alkali metal hydroxide required will generally increase as the drier shales are encountered in deep, high temperature formations. Salt is added to the fluid in quantities sufficient to substantially saturate the fluid after the alkali metal hydroxide and the promoter material have been dissolved therein.

Although any alkali metal hydroxide may be employed, it is preferable to use sodium hydroxide largely because of its commercial availability and cheapness. Although any of the previously mentioned materials for promoting the effectiveness of the hydroxide may be employed, I prefer to use sodium carbonate not only because it is slightly superior but also because of its ready availability. Either commercial salt or pure sodium chloride may be employed.

A solution representative of those effective in preserving a wide variety of shales contains 70.3 weight percent water, 8.25 weight percent sodium hydroxide, 4.15 weight percent sodium carbonate and 17.3 weight percent sodium chloride. This solution at about 75° F. has a specific gravity of 1.25 and a viscosity of about 4.7 centipoises. While clays do not disperse readily into solutions of this kind, it is easily possible to prepare muds having suitable viscosity and gel properties by dispersing clay into water before adding the electrolytes to provide an aqueous phase of the desired composition. The following are examples of muds so prepared in which the aqueous phase contained 70.3 weight percent water, 8.25 weight percent sodium hydroxide, 4.15 weight percent sodium carbonate and 17.3 weight percent sodium chloride:

	17 C. P. S. Vis. Mud	25 C. P. S. Vis. Mud
Per cent of Fluid	95	93
Per cent of El Paso Clay	4	5
Per cent Wy. Bentonite Clay	1	2

The mud referred to above as having 17 centipoises viscosity (at 600 rpm Stormer) had an extrapolated yield value of 18 grams Stormer while the 25 centipoise viscosity mud had an extrapolated yield value of 24 grams Stormer. The filtration rate of the 25 centipoise viscosity mud was 66 ccs. in 30 minutes at 100 pounds as tested on the standard API low pressure mud tester. Additions of small amounts of starch to muds of this type decrease the filtration rate greatly. For example, addition of 1.2% of pearl starch to a mud prepared in the same way as those described above but which contained 4% of El Paso clay as the only clay component provided a mud fluid of the following properties: Viscosity, 41 centipoises; extrapolated yield value, 23 grams Stormer; API filtration rate, 6 ccs. (30 minutes at 100 pounds).

Gelation rates of the caustic-brine-promoter muds are high making it desirable to keep the yield values of such mud fluids as low as possible while holding the desired solids in suspension. By so doing, gas or air cutting of the mud are avoided and at the same time sand and cuttings may easily be separated from the mud at the surface.

It will be apparent from the above data that drilling fluids having desirable viscosities and yield values may be prepared from clay with water containing sodium hydroxide, brine, and sodium carbonate. Viscosity and yield value may, of course, be controlled by controlling the amount

of clay in the drilling fluid. These values will be influenced by the type of clay used and normally it will be desirable to use the clay produced from the borehole. In general, the clay content of the fluid will not be less than 2% nor exceed about 10% although in some instances it will be understood that the clay content may be somewhat less or somewhat greater than these values.

It will be further understood that in the practice of my invention other materials may also be added to form the drilling mud. For example, if a heavily weighted mud is required it may be necessary to add weighting materials such as barytes, iron oxide and the like. In addition, treating agents such as sodium-hexametaphosphate, tannin, and the like, may also be included in the drilling fluid.

The nature and objects of the present invention having been thus described, what is claimed as new and useful and is desired to be secured by Letters Patent is:

1. A drilling fluid for preventing the hydrous disintegration of shales comprising clay, water, 6 to 15% sodium hydroxide by weight based on the fluid, 1 to 10% by weight based on the fluid of an alkali metal salt of a weak inorganic acid for promoting the effectiveness of the sodium hydroxide in preventing disintegration of shale, and sodium chloride in an amount substantially to saturate the said fluid.

2. A composition in accordance with claim 1 in which the alkali metal salt of a weak inorganic acid for promoting the effectiveness of the sodium hydroxide is an alkali metal carbonate.

3. A composition in accordance with claim 1 in which the alkali metal salt of a weak inorganic acid for promoting the effectivness of the sodium hydroxide is an alkali metal sulphite.

4. A composition in accordance with claim 1 in which the alkali metal salt of a weak inorganic acid for promoting the effectiveness of the sodium hydroxide is a tri-alkali metal phosphate.

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