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# DRILLING MUDS

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This invention relates to improvements in drilling mud compositions of the type used in well drilling, and more particularly it pertains to oil-in-water emulsion drilling muds having improved lubricating properties.

A substantial portion of the total time consumed during well drilling operations is taken up in the replacement of drill bits. Inasmuch as changing a bit necessitates pulling the entire string of drill stem, substituting a new bit, and rerunning the entire string of drill stem back into the borehole, it is evident that the time consumed in making bit changes increases roughly in proportion to the depth being drilled. As wells are being drilled to ever increasing depths, the economic losses attendant upon the increasing amount of time lost in making bit changes cannot be ignored. In addition to the loss of time involved in making bit changes, the necessity for making frequent bit changes, particularly when drilling at substantial depths, may create hazards, such as increasing the likelihood of cave-ins, which may arise as a result of stopping the circulation of the drilling mud during the change of bits.

Obviously, the necessity for making a bit change is dictated by the exhaustion of the useful life of the bit. Although much has been done toward improving drill bits and drilling techniques in order to prolong useful life, in the present state of rotary bit development, the most frequent limiting factor of bit life is failure of the bearings, rather than the cutting teeth.

Thus, perhaps the most important factor tending to shorten the useful life of a drill bit is the lack of adequate lubrication of the bearings, In the past, efforts have been made to afford lubrication for the bearings by incorporating self-contained lubricating units in the bits. That such efforts have not been entirely successful is borne out by the fact that conventional bits currently in use are not provided with such self-lubricating units. Consequently, conventional bits receive only such lubrication as may be obtained from the drilling mud being circulated therethrough. Since the bearings of the bit are subjected to high loads, the value of conventional drilling muds as bit lubricants leaves much to be desired.

Although lubricating properties have commonly been attributed to conventional oil-in-water emulsion drilling muds, as far as I am aware, it has not been satisfactorily demonstrated that such muds actually behave as lubricants for the bearings of drill bits under actual field conditions which impose high specific loads on the bearings of the bit. I have investigated some commonly used oil-in-water emulsion drilling muds to which lubricating properties have been attributed, and on the basis of field tests and tests made with the Timken Wear and Lubricant Tester, I have found that the lubricating properties of such muds are of no significance with respect to the specific loads on the bearings under the conditions to which a drill bit is subjected in the field. In other words, under such conditions, such muds have practically no lubricating value for the bearings of drill bits.

I have now discovered that oil-in-water emulsion drilling muds can be made to possess effective lubricating properties and thus prolong the life of drill bits while retaining the normally desirable properties of such muds. In accordance with my invention, I provide a drilling mud which is an emulsion of oil-in-water containing clay solids, and a water-insoluble, preferentially oil-wettable inorganic sulfide selected from the group consisting of the sulfides of lead, arsenic, antimony, bismuth, zinc, iron, cadmium, copper, molybdenum and mercury in an amount sufficient to increase the Timken load-carrying capacity of the mud to at least about 30 pounds. Such drilling mud possess excellent lubricating qualities and prolong the life of the bearings of drill bits, thereby reducing the frequency of bit changes and decreasing the time diverted from actual drilling operations.

The inorganic sulfides utilized in the muds of my invention have the characteristic properties of being insoluble in water and of being preferentially wet by oil. As such, they have the desirable effect of remaining in the oil phase of the oil-in-water emulsion muds where their lubricating properties are best available. The inorganic sulfides themselves are well known in the art and include such materials as lead sulfide, arsenic disulfide, arsenic trisulfide, antimony tri- and penta-sulfides, bismuth trisulfide, zinc sulfide, ferrous sulfide, cadmium sulfide, cuprous and cupric sulfides, molybdenum disulfide and mercuric sulfide.

The sulfides can be used in the form of synthetically prepared products, or as found in nature in the form of minerals, when such mineral sulfides are available. Furthermore, since the sulfides are uniformly blended in the oil phase of my oil-in-water emulsion muds, they are employed in a finely-divided or powdered condition, say finer than about 200 mesh, so that stable and uniform suspensions or dispersions of the sulfides can be obtained.

To assist in obtaining uniform and stable suspensions of the sulfides in the oil phase of the drilling muds of the invention, I prefer to employ an asphalt in the oil phase. The increased viscosity of the oil phase containing an asphalt hinders the settling of the sulfides out of suspension and thus promotes uniform blends of the sulfides in the oil phase. In addition, the asphalt enhances the lubricating properties of oil-in-water emulsion muds containing the above inorganic sulfides, and permits of the use of less inorganic sulfide to obtain the desired lubricating properties.

As is well known in the art, asphalts range from highly viscous liquids to essentially solid materials and include such materials as natural asphalts, petroleum asphalts, blown asphalts, sulfurized asphalts, the solid petroleum residues or pitches obtained in the vacuum reduction of crude oils, asphalt extract fractions obtained in the solvent refining of residual petroleum oil fractions, the asphaltites, such as gilsonite, manjak or glance pitch, and grahamite, and the like. Any of such materials can be employed in the practice of my invention.

The oil employed in forming my oil-in-water emulsion drilling muds can be obtained from any suitable source. For example, crude petroleum and various petroleum fractions such as topped crudes, reduced crudes, gas oils, kerosene, diesel fuel oils, lubricating oil fractions, the liquid extract fractions obtained in the solvent refining of lubricating oils and mixtures of these materials can be employed in the oil phase. The total oil phase of the drilling muds of the invention ranges from about 2 to 40 percent by volume of the entire drilling mud, preferably from about 5 to 25 percent. The total oil phase comprises an oil, as above described, an inorganic sulfide and an asphalt, if the latter is employed. The emulsifying agents, presently to be described, are also considered to be part of the oil phase for the purpose of determining the amount of total oil phase in the mud.

Any clay can be utilized in the drilling muds of this invention which is commonly employed for this purpose in the art. Such clays, which form dispersions or gels with water, can be native products, such as may be available at the well site, or a relatively pure clay, such as bentonite, or base-exchanged clays, such as lime-treated clays, etc. In general, when using clays such as bentonite, the clay is employed in an amount of from about 2 to 8 percent by weight of the entire composition, more or less, depending upon the yield (barrels of mud of 15 centipoise viscosity per ton of clay) of the clay. When native clays are employed, larger amounts, say as high as 40 percent by weight of the mud composition, can be used because they yield less barrels of mud per ton of clay.

I have found that the relative effectiveness of the inorganic sulfides in conferring lubricating properties on the muds of the invention varies with the nature of the sulfide and the amount employed. Thus, although all of the inorganic sulfides described herein confer lubricating properties, some are more effective than others. For example, 10 percent of arsenic trisulfide by weight of the oil phase will confer a greater gain in the Timken load-carrying capacity of a mud than 10 percent by weight of cadmium sulfide. Similarly, 20 percent by weight of antimony trisulfide results in a greater Timken load-carrying capacity than 10 percent by weight of the same sulfide. While it is therefore difficult to specify the exact numerical amounts of inorganic sulfides to be employed, I have found that in order to obtain the desired increase in lubricating properties of the drilling muds of this invention, the inorganic sulfides should be used in an amount sufficient to increase the Timken load-carrying capacity of the mud to at least about 30 pounds. The exact amount of any individual inorganic sulfide to employ can thus readily be determined through the routine use of the well-known Timken test and will be apparent to those skilled in the art.

While in some instances I can use as little as 1.25 percent of arsenic trisulfide by weight of the oil phase, I generally prefer to employ somewhat larger amounts of the inorganic sulfides, say from 5 to 10 percent. All of the inorganic sulfides are effective in conferring lubricating properties on the muds of the invention in this concentration range, and furthermore the use of larger amounts of the inorganic sulfides provides a reserve to offset depletion thereof as the muds are being used in the drilling of wells. Larger amounts of the inorganic sulfides, for examples, 20 percent by weight of the oil phase, or higher, can also be employed, but it is ordinarily unnecessary to employ such large amounts since no further substantial improvement in lubricating properties of the muds is obtained. Based upon their performance, availability and cost, I prefer to employ the sulfides of arsenic, antimony, lead, zinc and molybdenum.

The amount of asphalt employed will vary with the amount and character of the inorganic sulfide employed, more asphalt being required to suspend more inorganic sulfide of a higher specific gravity. In any event, sufficient asphalt is utilized in the oil phase to stabilize the suspension of inorganic sulfide therein. As little as 5 percent of asphalt by weight of the oil phase is satisfactory in some instances, but amounts as high as 75 percent can successfully be used. I have employed about 20 percent of asphalt by weight of the oil phase to stabilize suspensions of from 5 to 20 percent of inorganic sulfide, and from about 15 to 35 percent of asphalt is ordinarily satisfactory.

Since the drilling muds of my invention are oil-in-water emulsion drilling muds, an emulsifying agent will normally be added during preparation of the muds to facilitate emulsification or dispersion of the oil phase in the water phase and to stabilize the emulsion obtained. Numerous emulsifying agents for preparing oil-in-water emulsions are known in the art and any of such conventional



emulsifying agents can be employed for the above purposes.

However, in the use under drilling conditions of oil-in-water emulsion drilling muds, it is desirable that the mud filtrate have a low surface tension, say on the order of 40 dynes per centimeter or below. Since emulsifying agents are surface-active compounds, they will also act to reduce the surface tension of the filtrate, although not all emulsifying agents are of equal effect for this purpose. In a preferred embodiment of my invention, my drilling muds therefore contain an emulsifying agent which not only serves to assist in the emulsification of the oil and to stabilize the emulsions formed, but substantially to reduce the surface tension of the filtrate as well. I have found that emulsifying agents which are particularly suitable for the latter purpose include preferentially oil-soluble alkyl-aryl sulfonic acids, e. g., "wax" benzene sulfonic acids and mahogany acids, and metal salts thereof, e. g., the alkali metal, ammonium and alkaline earth metal, including calcium and magnesium, salts. Other suitable emulsifying agents include the sodium soaps of tall oil and the fatty acid esters of the anhydroalkitols, for example, sorbitan, mono-, di-, or tri-oleate, sorbitan mono-stearate, etc. Of the above emulsifying agents, I prefer to employ the sodium salt of mahogany acids, because not only is it more effective in achieving the desired reduction in surface tension of the filtrate, but it can be used in smaller amounts for this purpose than other emulsifying agents. Substantial economies can therefore be achieved.

In general, satisfactory results with respect to reducing the surface tension of the filtrate and stabilizing the emulsion can be obtained by the use of from about 1 to 4 pounds of emulsifying agent per barrel of the entire drilling mud composition, sufficient to reduce the surface tension of the filtrate substantially below that of water and preferably to about 40 dynes per centimeter or less. However, when using the preferred emulsifying agent, namely, the sodium salt of mahogany acids, it is highly advantageous to employ not more than about 2 pounds per barrel in order to avoid excessive oil loss in the filtrate, as fully set forth in my copending application Serial No. 350,460, filed April 22, 1953, now U. S. Patent No. 2,713,032.

It is characteristic of the drilling muds of this invention that they are sensitive to the presence of alkali metal hydroxides. By this I mean that the addition of substantial quantities of alkali metal hydroxide to these muds results in a loss of the lubricating properties otherwise obtained through the use of the inorganic sulfide.

Similarly, a drilling mud which has already been treated with substantial amounts of alkali metal hydroxide does not respond beneficially to later treatment with the inorganic sulfide. In other words, notwithstanding the fact that oil-in-water emulsion drilling muds contain an inorganic sulfide, such muds will not have enhanced lubricating properties in the presence of alkali metal hydroxide. This phenomenon is unexpected and cannot be satisfactorily explained at present, particularly since the lubricating properties of the muds of this invention are not detrimentally affected by admixture with such materials as calcium hydroxide or sodium chloride.

The sensitivity of the drilling muds to alkali metal hydroxide imposes certain precautions in the use of clay deflocculants to reduce the viscosity and fluid loss of the muds. For example, one of the most widely used clay deflocculants is quebracho which is generally employed with caustic soda. If the drilling muds of this invention are treated in the usual manner with the conventional quebracho-caustic soda mixture, there results a loss of the enhanced lubricating properties, although the otherwise normal properties of the muds are retained. It is to be noted, however, that the muds of the invention will tolerate a limited amount of caustic soda without losing their load-carrying capacities. The limits of such tolerance are difficult to specify exactly since they will vary

with the nature and amount of the clay in the drilling mud and the nature of the inorganic sulfide. For example, with a drilling mud made in accordance with this invention, containing arsenic trisulfide and pure bentonite as the clay in an amount of 6 percent by weight of the entire mud and having a relatively high tolerance to alkali metal hydroxides, I have found that the use of 1.0 pound of caustic soda per barrel of drilling mud, although reducing the load-carrying capacity considerably, does not render the mud worthless from a lubricating standpoint. However, when the caustic soda is increased to larger amounts, the lubricating properties of the mud are substantially eliminated. With other clays, lesser amounts of clay, or other inorganic sulfides, the caustic soda tolerance is substantially less.

From the foregoing, it will be apparent to those skilled in the art that no substantial amount of caustic soda should be added to the muds of this invention; in no event should such amount be sufficient to destroy the enhanced lubricating properties of the muds. Since in normal field practice, the amounts of caustic soda usually employed, particularly in connection with quebracho treatment, are in substantial excess of the amounts deleteriously affecting the lubricating properties of the muds of the invention, when it becomes desirable to use an alkaline treating agent with or without a clay deflocculant, it is preferred to employ such alkaline materials as ammonia, amines, such as mono-, di- and tri-ethanolamine, etc., which do not have any deleterious effect on the lubricating properties of the muds. In treating the muds of my invention with quebracho, it is possible to use this material alone, that is, without the conjoint use of caustic soda, although in such case more of the quebracho will usually be required to obtain the desired deflocculating effect.

In the actual practice of my invention, it is permissible to conduct the entire drilling operation with the drilling muds above described. However, initial drilling operations can be started with a conventional straight water-base mud because the soft formations and the absence of high specific loads on the drill bit at the shallower depths do not require greater lubricating properties than can be obtained with a water-base mud. Thereafter, as dictated by the requirements of drilling and the formations encountered, the water-base mud is converted to the mud of my invention. This conversion can readily be accomplished during circulation of the water-base drilling mud in the well by adding to the mud in the mud pit, either separately or preferably in admixture, an oil, an inorganic sulfide as disclosed herein, an emulsifying agent, and an asphalt if desired. These materials are added in an amount dependent upon the total amount of the drilling mud already in the system and preferably at a rate dependent upon the rate of drilling mud circulation, so as to effect a substantially uniform dispersion of the oily materials, including the preferentially oil-wettable inorganic sulfide, as an oil phase throughout the drilling mud system. Conventional methods can be employed for whatever mechanical agitation is necessary to achieve the proper mixing. It is highly desirable to add the emulsifying agent to the water-base drilling mud in admixture with the oil, but if added separately, it is advisable that it be added after the oil has been added or simultaneously with the addition of the oil. If the emulsifying agent is added prior to addition of the oil phase, there is a tendency for the mud to foam excessively and this entails the risk of a blowout.

In the practice of my invention, it is also possible to convert an existing conventional oil-in-water emulsion drilling mud to a drilling mud in accordance with my invention. This is also accomplished during circulation of the drilling mud in the well by adding thereto, with agitation with the drilling mud in the usual mud pit, an inorganic sulfide or a concentrate thereof in oil and an emulsifying agent. An asphalt can also be added if desired. The amounts of the components added are such that the concentration of the components of the resulting drilling mud composition being prepared, taking into account the composition of the conventional oil-in-water emulsion drilling mud being converted, will result in an oil-in-water emulsion drilling mud having the composition of the muds of my invention, as set forth in detail above.

It will be understood that the drilling muds of my invention which have become depleted in one or more components during use, can be treated with the depleted components or oil concentrates thereof to restore the desired concentration of such components.

As an example of the preparation and use of one of the preferred embodiments of my invention in drilling a well, about the first two thousand feet of hole are drilled using as the drilling mud the mud formed from water and the natural clays incorporated therein from the formations during the drilling. In case such formations are deficient in natural clays, it is permissible to add a small quantity of bentonite to the drilling mud to increase the viscosity and thixotropic and wall building properties thereof. Up to this point, the procedure is identical with normal drilling operations where straight water-base drilling muds are employed. At this stage, the water-base drilling mud in the system totals about 500 barrels (barrel throughout the specification and claims is 42 standard U. S. gallons). It having been determined that conversion to an oil-in-water emulsion drilling mud is now desirable, an oil phase is prepared as follows. Into a suitable mixing vessel, there is placed 20 barrels of a Diesel fuel oil and 4 barrels of an oil concentrate of the sodium salts of mahogany acids (the concentrate being available commerically as Petronate HL, containing 60 percent by weight of the salts dissolved in a lubricating oil). To this mixture there is added 3500 pounds of a granulated petroleum asphalt having a melting point of about 325° to 335° F. and a penetration of 2 to 3 at 115° F. (100 gm., 5 sec.) and 1750 pounds of arsenic trisulfide. The mixture is stirred until all of the components are uniformly blended. There is then added with stirring a sufficient amount of the same Diesel fuel oil to bring the volume to about 50 barrels, the entire oily composition being stirred until uniformly blended. The oily composition thus prepared, which is to constitute the oil phase of the drilling mud, is a moderately viscous, black liquid that can be pumped readily at ordinary temperatures and emulsifies readily in the mud to form an oil-in-water emulsion. The oily composition is then added to the straight water-base drilling mud by circulating the mud through the well while pouring the oily composition into the mud ditch through which drilling mud returns to the mud pits from the well and agitating the pits with mud guns. Drilling need not be discontinued during the change from a water-base mud to the oil-in-water emulsion mud of my invention. After all of the oily composition has been added to the pre-existing drilling mud and after the mixture has been circulated through the well about two or three times, the entire drilling mud in the system is a uniform oil-in-water emulsion mud of my invention. Continued drilling with the new mud results in the benefits and advantages heretofore dscribed.

In the following illustrative examples, there are set forth certain specific embodiments of the drilling mud compositions of the invention. It will be understood that these specific embodiments are given by way of illustration only and are not intended to limit the invention. It will be noted that, in determining the improvement in lubricating properties of the drilling muds, I have employed the well-known Timken wear and lubricant tester. This machine is employed in the lubricating oil art to determine the load-carrying capacity of lubricants. It was obviously impractical to test the lubricating properties of all the drilling muds set forth in each of the specific examples in an actual well drilling operation, but I have found that the load-carrying capacities of drilling muds, as deter-

mined by the Timken machine, are a measure of the prolongation of bit life and other advantages obtained through the use of my drilling muds in actual drilling operations in the field. Since the load-carrying capacities of drilling muds as obtained by the Timken machine correlate well with actual field tests, it is thus possible to test the efficacy of drilling muds in the laboratory to determine their suitability for use in the field.

It is characteristic of the drilling muds of this invention that they have load-carrying capacities, as measured by the Timken machine, of not less than 30 pounds, as compared to load-carrying capacities of 15 pounds and below for conventional oil-in-water emulsion drilling muds which have substantially no lubricating properties.

There are set forth in the following table illustrative examples of drilling muds made in accordance with the invention. The table also includes for purposes of comparison a mud (Example 18) which represents the conventional oil-in-water muds of the prior art. All of the muds of the examples were prepared by the following general procedure. The oil, inorganic sulfide, asphalt, when employed, and emulsifying agent were mixed and the mixture was heated to 180° F. and stirred for 15 minutes to obtain a uniform blend of the various constituents. The oily mixture was then added to a suspension of 6 percent by weight of bentonite in water, and the entire mixture was heated in an open vessel at 140° F. with sufficient stirring to insure complete emulsification. Prior to testing in the Timken machine, the oil-in-water emulsion muds thus prepared were placed in a sealed container and aged overnight.

The asphalt employed in the examples was granular petroleum asphalt having a melting point of 325° to 335° F. and penetrations of 0 at 77° F. and 2 to 3 at 115° F., both penetrations being measured under loads of 100 grams after 5 seconds. The inorganic sulfides were finely-divided materials of 200 mesh or finer.

The "naphthenic extract No. 1" employed in the oil phase was the oily material obtained as the extract fraction in the solvent extraction of a 400 Texas lubricating oil distillate with furfural. The extract had a gravity of 14.5° API and a viscosity of 1170 S. U. S. at 100 F. The "Petronate" employed was an oil concentrate containing about 60 percent by weight of the sodium salts of mahogany acids, said sodium salts having an average molecular weight of from about 445 to 460.

| Example | Asphalt, Percent by Wt. of Oil Phase | Inorganic Sulfide | | Oil, Naphthenic Extract No. 1, Total Oil Phase, Percent by Vol. of Drilling Mud | Petronate, Lb./Bbl. of Mud | Timken Load-Carrying Capacity (Pounds) |
|---|---|---|---|---|---|---|
| | | Type | Percent by Wt. of Oil Phase | | | |
| 1 | 20 | FeS | 20 | 10 | 3 | 55 |
| 2 | 20 | $Sb_2S_3$ | 20 | 10 | 3 | >100 |
| 3 | 20 | $Sb_2S_3$ | 10 | 10 | 3 | 90 |
| 4 | 20 | $Sb_2S_3$ | 5 | 10 | 3 | 70 |
| 5 | 20 | $Bi_2S_3$ | 10 | 10 | 3 | >100 |
| 6 | 20 | CdS | 10 | 10 | 3 | 80 |
| 7 | 20 | $MoS_2$ | 10 | 10 | 3 | 100 |
| 8 | 20 | ZnS | 10 | 10 | 3 | 90 |
| 9 | 20 | HgS | 10 | 10 | 3 | 80 |
| 10 | 20 | CuS | 20 | 10 | 3 | 85 |
| 11 | 20 | $Cu_2S$ | 20 | 10 | 3 | 55 |
| 12 | 20 | $As_2S_3$ | 10 | 10 | 3 | >100 |
| 13 | 20 | $As_2S_3$ | 10 | 10 | 3 | 60* |
| 14 | 20 | $As_2S_3$ | 5 | 10 | 3 | >100 |
| 15 | 20 | $As_2S_3$ | 1.25 | 10 | 3 | 60 |
| 16 | 20 | PbS | 20 | 10 | 3 | 95 |
| 17 | 0 | PbS | 20 | 10 | 3 | 80 |
| 18 | 0 | ---------- | 0 | 10 | 3 | 10 |

It will be noted from the above table that conventional oil-in-water emulsion drilling muds had substantially no lubricating properties. This is shown in Example 18, wherein the load-carrying capacity of a drilling mud containing 10 percent by volume of oil was 10 pounds. A mud of this type is substantially identical with oil-in-water emulsion muds commonly employed in the field. The addition of the inorganic sulfides, with or without asphalt, in accordance with the invention resulted in substantial increases in load-carrying capacity ranging from the 55 pound figure shown in Example 1 to more than 100 pounds shown in the other examples.

Examples 12 and 13, taken together, show the effect of alkali metal hydroxides on the drilling muds of the invention. The asterisk adjacent the value of load-carrying capacity shown in Example 13 indicates that this mud has been treated with alkali metal hydroxide. Example 12 is a mud of the invention without having been treated with caustic soda and has a load-carrying capacity in excess of 100 pounds. As shown in Example 13, when the mud of Example 12 is treated with one pound per barrel each of caustic soda and quebracho, the load-carrying capacity was reduced to 60 pounds. Treatment with still larger amounts of caustic soda, as is common in field practice, would result in a loss of substantially all lubricating properties. It is to be noted that although quebracho was used in this test to simulate the conventional caustic soda-quebracho treatment in the field, the use of quebracho alone without caustic soda will not result in a reduction of the load-carrying capacity of the muds of the invention.

It is obvious from the foregoing detailed description of the invention that I have provided superior oil-in-water emulsion drilling muds of improved lubricating properties, which prolong the useful life of drill bits by substantially retarding failure of the bearings thereof. It is therefore now possible to reduce the number of round trips required for replacing drill bits, to educe the time lost in making bit changes, and thereby to achieve substantial economies in well drilling operations. Furthermore, since fewer bits are required to drill a well, there will be less wear and tear on the drilling rig, and a relatively small, but nevertheless significant savings in the cost of bits. Also, more time will be made available to the drilling crew for performing other essential tasks. When employing the drilling muds of my invention, the limiting factor of bit life is not the bearings, as in the past, but the cutting teeth of the bit. The use of the drilling muds of the invention therefore confers the additional advantage of imparting a safety factor in drilling operations because a bearing failure may not be expected until after the teeth of the bit have been substantially worn out. Since bit changes will be accomplished because of tooth wear prior to the bearings approaching a dangerous condition of wear, the likelihood of cone-fishing jobs is substantially reduced.

It is a further important advantage of the oil-in-water emulsion drilling muds of this invention that the oil phase thereof is capable of preferentially wetting metal surfaces. This ability of the oil phase, including the inorganic sulfide, preferentially to wet metals results in the formation of a continuous film of oil phase on the surfaces of the drill bit and the bearings thereof to the virtual exclusion of water. Accordingly, only relatively small amounts of oil phase, such as are customarily used in oil-in-water emulsion drilling muds, are necessary to obtain the desired lubrication of the bearings of a drill bit in accordance with the invention. When it is considered that the main lubricating function desired of the drilling mud is directed to the small area of metal surface which constitutes the bearings of a drill bit, it will be appreciated that substantial economies are achieved by using the oil-in-water emulsion muds of the invention, particularly since the additives conferring the desired lubricating properties need be based only on the oil phase and not on the entire mud.

As will be apparent to those skilled in the art, conventional modifying agents can be added to my drilling muds without departing from the spirit of the invention, provided that the muds remain substantially free of alkali metal hydroxide. Thus, there can be added the usual weighting agents, viscosity modifiers, agents for reducing fluid loss, etc.

Furthermore, I can add to the muds of this invention containing the inorganic sulfides set forth herein other materials which have a contributory effect on the lubricating properties of the resulting muds. For example, as described and claimed in my copending application Serial No. 465,418, now Patent No. 2,773,031, filed on even date herewith, sulfur-containing asphaltic materials containing at least about 1.5 percent by weight of combined sulfur are effective in conferring improved lubricating properties on oil-in-water emulsion drilling muds. Such sulfur-containing asphaltic materials can be the asphalt constituent of the present drilling muds, but this is not necessary because other asphaltic materials regardless of sulfur content can also be employed. Also, as described and claimed in my copending application Serial No. 465,417, now Patent No. 2,773,030, filed on even date herewith, water-insoluble, oil-soluble sulfurized organic compounds are effective in conferring improved lubricating properties on oil-in-water emulsion drilling muds.

I can add to or substitute for part of the inorganic sulfides of the present invention the sulfurized organic compounds or the sulfur-containing asphaltic materials of the above copending applications, or mixtures of these materials, as may be dictated by considerations of cost and availability.

Resort may be had to such other modifications and variations as fall within the spirit of the invention and the scope of the appended claims.

I claim:

1. A drilling mud of enhanced lubricating properties comprising an oil-in-water emulsion containing clay solids, an oil phase of from 2 to 40 percent by volume of said mud, and a water-insoluble, preferentially oil-wettable inorganic sulfide selected from the group consisting of the sulfides of arsenic, antimony, bismuth, lead, zinc, iron, cadmium, copper, molybdenum and mercury in an amount, from about 1.25 to 20 percent by weight of the oil phase, sufficient to increase the Timken load-carrying capacity of the mud to at least about 30 pounds, said mud containing no amount of alkali metal hydroxide sufficient to destroy the enhanced lubricating properties of the mud.

2. The drilling mud of claim 1, containing an emulsifying agent selected from the group consisting of preferentially oil-soluble alkylaryl sulfonic acids and metal salts thereof, the sodium soaps of tall oil, and the higher fatty acid esters of the anhydroalkitols.

3. The drilling mud of claim 2, wherein the emulsifying agent comprises the sodium salts of mahogany acids.

4. The drilling mud of claim 2, wherein the emulsifying agent comprises the sodium soaps of tall oil.

5. The drilling mud of claim 2, wherein the emulsifying agent comprises sorbitan monooleate.

6. A drilling mud of enhanced lubricating properties comprising an oil-in-water emulsion containing clay solids, an oil phase of from 2 to 40 percent by volume of said mud, an asphalt as part of said oil phase, and a water-insoluble, preferentially oil-wettable inorganic sulfide selected from the group consisting of the sulfides of arsenic, antimony, bismuth, lead, zinc, iron, cadmium, copper, molybdenum and mercury in an amount, from about 1.25 to 20 percent by weight of the oil phase, sufficient to increase the Timken load-carrying capacity of the mud to at least about 30 pounds, said mud containing no amount of alkali metal hydroxide sufficient to destroy the enhanced lubricating properties of the mud.

7. The drilling mud of claim 6, wherein said asphalt is present in an amount of from about 5 to 75 percent by weight of the oil phase and the mud contains an emulsifying agent selected from the group consisting of preferentially oil-soluble alkylaryl sulfonic acids and metal salts thereof, the sodium soaps of tall oil, and the higher fatty acid esters of the anhydroalkitols.

8. The drilling mud of claim 6, wherein the inorganic sulfide is arsenic trisulfide.

9. The drilling mud of claim 6, wherein the inorganic sulfide is lead sulfide.

10. The drilling mud of claim 6, wherein the inorganic sulfide is antimony trisulfide.

11. The drilling mud of claim 6, wherein the inorganic sulfide is zinc sulfide.

12. The drilling mud of claim 6, wherein the inorganic sulfide is molybdenum disulfide.

13. A drilling mud of enhanced lubricating properties comprising an oil-in-water emulsion containing clay solids, an oil phase of from 5 to 25 percent by volume of said mud, arsenic trisulfide in an amount, from about 1.25 to 10 percent by weight of the oil phase, sufficient to increase the Timken load-carrying capacity of the mud to at least about 30 pounds, and an emulsifying agent selected from the group consisting of preferentially oil-soluble alkylaryl sulfonic acids and metal salts thereof, the sodium soaps of tall oil, and the higher fatty acid esters of the anhydroalkitols, the amount of emulsifying agent being sufficient to reduce the surface tension of the filtrate substantially below that of water, said mud containing no amount of alkali metal hydroxide sufficient to destroy the enhanced lubricating properties of the mud.

14. The drilling mud of claim 13, containing from about 15 to 35 percent of asphalt by weight of the oil phase.

15. The drilling mud of claim 14, wherein the emulsifying agent comprises the sodium salts of mahogany acids.

16. A drilling mud of enhanced lubricating properties comprising an oil-in-water emulsion containing clay solids, an oil phase of from 5 to 25 percent by volume of said mud comprising an extract fraction of a solvent refined lubricating oil distillate, lead sulfide in an amount, from 5 to 10 percent by weight of said oil phase, sufficient to increase the Timken load-carrying capacity of the mud to at least about 30 pounds, and an emulsifying agent selected from the group consisting of preferentially oil-soluble alkylaryl sulfonic acids, the sodium soaps of tall oil, and the higher fatty acid esters of the anhydroalkitols, the amount of emulsifying agent being sufficient to reduce the surface tension of the filtrate substantially below that of water, said mud containing no amount of alkali metal hydroxide sufficient to destroy the enhanced lubricating properties of the mud.

17. The drilling mud of claim 16, containing from about 15 to 35 percent of asphalt by weight of the oil phase.

18. The drilling mud of claim 17, wherein the emulsifying agent comprises the sodium salts of mahogany acids.

19. A uniform blend of materials, useful in the oil phase of an oil-in-water emulsion drilling mud of enhanced lubricating properties, comprising an oil, an asphalt, and a water-insoluble preferentially oil-wettable inorganic sulfide selected from the group consisting of the sulfides of arsenic, antimony, bismuth, lead, zinc, iron, cadmium, copper, molybdenum and mercury in an amount, from about 1.25 to 20 percent by weight of the oil phase, sufficient to increase the Timken load-carrying capacity of a mud prepared from said blend to at least about 30 pounds, said blend containing no amount of alkali metal hydroxide sufficient to destroy the enhanced lubricating properties of the mud.

20. The blend of claim 19, containing additionally an emulsifying agent selected from the group consisting of preferentially oil-soluble alkylaryl sulfonic acids and metal salts thereof, the sodium soaps of tall oil, and the higher fatty acid esters of the anhydroalkitols.

21. A process for enhancing the lubricating properties of a drilling fluid during the drilling of a well, drilling of said well having been begun with a water-base drilling mud, which comprises adding to said water-base

drilling mud in the drilling fluid system of said well an oil phase in an amount of from 2 to 40 percent by volume of said mud, said oil phase containing an emulsifying agent, and a water-insoluble, preferentially oil-wettable inorganic sulfide selected from the group consisting of the sulfides of arsenic, antimony, bismuth, lead, zinc, iron, cadmium, copper, molybdenum and mercury in an amount, from about 1.25 to 20 percent by weight of the oil phase, the whole being effective to convert said water-base drilling mud to an oil-in-water emulsion drilling mud having a Timken load-carrying capacity of at least about 30 pounds, said mud containing no amount of alkali metal hydroxide sufficient to destroy the enhanced lubricating properties of the mud, circulating the resulting mixture through said drilling mud system, and continuing drilling of the well.

22. The process of claim 21, wherein there is also added to the water-base drilling mud an asphalt.

23. The process of claim 21, wherein the emulsifying agent is selected from the group consisting of preferentially oil-soluble alkylaryl sulfonic acids and metal salts thereof, the sodium soaps of tall oil, and the higher fatty acid esters of the anhydroalkitols.

24. A process of drilling a well with a rotary bit which comprises forming a borehole with said bit while circulating a drilling mud of enhanced lubricating properties through said borehole, said drilling mud comprising an oil-in-water emulsion containing clay solids, an oil phase of from 2 to 40 percent by volume of said mud, and a water-insoluble, preferentially oil-wettable inorganic sulfide selected from the group consisting of the sulfides



of arsenic, antimony, bismuth, lead, zinc, iron, cadmium, copper, molybdenum and mercury in an amount, from about 1.25 to 20 percent by weight of the oil phase, sufficient to increase the Timken load-carrying capacity of the mud to at least about 30 pounds, said mud containing no amount of alkali metal hydroxide sufficient to destroy the enhanced lubricating properties of the mud, whereby the life of the bit is prolonged.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 2,156,803 | Cooper et al. | May 2, 1939 |
| 2,476,845 | Dawson | July 19, 1949 |
| 2,497,398 | Dawson | Feb. 14, 1950 |
| 2,509,588 | Dawson | May 30, 1950 |
| 2,686,156 | Arntzen et al. | Aug. 10, 1954 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 476,310 | Canada | Aug. 21, 1951 |

OTHER REFERENCES

Davey: The Mechanism of Action of Extreme Pressure Lubricants, article in Scientific Lubrication, September 1949, pages 7, 8, 11 and 14.

Van Dyke: Oil Emulsion Drilling Mud, article in World Oil, November 1950, drilling section, pages 101, 102, 103, 104 and 106.

Rogers: Composition and Properties of Oil Well Drilling Fluids, revised edition, pub. 1953 by Gulf Publishing Co. of Houston, Texas, pages 511, 513, and 514.