METHOD OF STABILISING CLAY OR SHALE

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ABSTRACT

A method of reducing the swelling of shale or clay encountered in a wellbore, the method comprising introducing into the wellbore a composition comprising: (a) a continuous aqueous phase; (b) a source of borate ions; (c) a source of ions selected from the group consisting of alkali metal ions, alkaline earth metal ions and ammonium ions; and (d) optionally a source of at least one sugar selected from the group consisting of monosaccharides and oligosaccharides having from 2 to 4 saccharide groups.
METHOD OF STABILISING CLAY OR SHALE

[0001] The present invention relates to a composition useful for stabilising a clayey or shaley formation surrounding a wellbore. In particular, the present invention relates to a clay or shale swelling inhibitor composition for use during drilling, completing or maintaining wellbores.

[0002] Drilling fluids are used in the drilling of oil and gas wells. In rotary drilling operations, drilling fluids are pumped down the wellbore through a drill string to a drill bit. They emerge through ports in the drill bit and return to the surface via annular space located between the drill string and the walls of the borehole. The functions of drilling fluids may be multiple: for example, they serve to cool and lubricate both the drill bit and drill string, they transport drill cuttings to the surface, they equalize the pressure between the fluids in the wellbore and the formation fluids, they prevent “squeezing” of the wellbore or caving of the formation into the wellbore, or minimise any potential damage to the “pay zone” of the wellbore.

[0003] Drilling fluids are of two basic types, oil-based (hereinafter referred to as OBM—oil based muids), and water-based (hereinafter referred to as WBM—water based muids). OBMs are superior in performance to WBM s in several important respects including lubricating properties and thermal stability thereby allowing wells to be drilled at a faster rate than when using WBM s resulting in considerable cost savings. In particular, OBMs are useful where the downhole temperature is high, for example when drilling deviated wells through high temperature formations. Furthermore, OBMs mitigate problems associated with swelling and dispersion of clays or shales, which are frequently encountered during drilling with WBM s. Such problems will hereinafter be referred to as “clay or shale destabilization”.

[0004] Unfortunately, OBMs are less attractive than WBM s from an environmental perspective. The disposal of spent OBMs, and the associated problems of cuttings clean-up and disposal are posing increasing difficulties for the oil and gas exploration industry. One proposal has been the use of biodegradable oils to formulate OBMs, but such products may not comply with future legislation which is expected to impose more stringent limits on disposal of waste materials. The consequence of this is that much effort has been expended in the development of WBM s having improved performance in terms of reducing clay or shale destabilization. If no attempts are made to inhibit hydration and swelling of clays or shales the consequences can be severe. Thus, clay or shale destabilization may result in weaknesses developing in the formation, possibly leading to erosion of the borehole. Also, as would be well known to the person skilled in the art, the phenomenon of “stick pipe” can occur, and furthermore, logging operations during drilling can be hampered.

[0005] A number of approaches have been proposed for reducing the clay or shale destabilization characteristics of WBM s. The use of salts such as Group IA metal salts, in particular, potassium chloride, to balance the water activity between the clay or shale and the drilling fluid, or even to provide an osmotic gradient that leads to a net flow of water out of the clay or shale, has been employed to prevent clay or shale hydration. This approach may be combined with the use of silicates which are capable of forming osmotic membranes on the exposed surface of the clay or shale, as described, for example, in U.S. Pat. No. 3,640,343, and van Oort et. al. in SPE/IADC paper No. 35059, presented at the LADC/IADC Drilling Conf. New Orleans, 12-15 Mar. 1996. The osmotic membrane facilitates the flow of water out of the clay or shale whilst inhibiting the diffusion of ions between the clay or shale and the fluids in the wellbore thereby improving the clay or shale stabilization characteristics of the WBM.

[0006] The precipitation of silicates on the exposed surface of the clay or shale is also believed to produce a physical barrier against invasion of fluids from the wellbore into the clay or shale. The use of silicates, however, may be associated with problems of high drilling torque and poor lubricity owing to the tendency of silicates to precipitate out on metal surfaces, for example, on the drill bit. Also, the use of silicates may lead to problems of incompatibility with conventional drilling fluid additives. Finally, silicate solutions are highly alkaline and this can lead to difficulties with safe storage and handling.

[0007] Other proposals for improving the clay or shale stabilization performance of WBM s include the addition of glycols or polyols. Suitable glycols or polyols include, for example, polyglycerols, glycols, polyalkylene glycols (PAG), e.g., polyethylene glycols (PEG), polypropylene glycols (PPG) and copolymers of ethylene and propylene glycols, alcohol ethoxylates and glycol ethers as described in for example, EP 0495579, U.S. Pat. No. 4,830,765, U.S. Pat. No. 4,172,800 and The Society of Petroleum Engineers Reports SPE 25989 and 26818. In The Society of Petroleum Engineers Report SPE 28960 it is disclosed that potassium ions work synergistically with glycols in drilling fluids to improve the shale stabilization performance of the WBM s.

[0008] Other proposals described in the art to improve the clay or shale stabilization properties of WBM s include the use of additives such as aluminium complexexes, chemically modified starch, chemically modified cellulose materials, water soluble polyacrylamides and other water soluble polymers, lime or gypsum, asphaltene derived products and calcium lignosulphonates.

[0009] The use of borates in hydraulic fracturing fluids is described in U.S. Pat. No. 5372732, U.S. Pat. No. 5445223, GB 2253668 and WO 8700236 while U.S. Pat. No. 5220960 discloses the use of borates as cement retardants for completion operations.

[0010] CA 1248337 teaches the use of borates in the field for low specific gravity non-damaging workover and completion fluids. CA 1303841 describes the use of borates in water profile control in oil recovery. E L Bigelow in The Society of Petroleum Engineers publication SPE 27644 discloses that borates maybe used in pulsed neutron logging. Borates have also been used in lost circulation treatments (fluid loss pills) during drilling operations (as described in U.S. Pat. No. 5,372,732).

[0011] U.S. Pat. No. 6,105,691 refers to the use of boric acid or glycerol-borate esters in drilling fluids for the purposes of improving the lubricity of the drilling fluid and its clay dispersion characteristics. However, U.S. Pat. No. 6,105,691 is silent concerning any beneficial effect of borate on the clay or shale stabilizing properties of drilling fluids.

[0012] RU 1699991 relates to a silicate drilling mud having increased mud stability and calcium chloride resis-
The drilling mud is prepared by adding boric acid and sodium or potassium silicate to water to produce a gel-like mass, which is then diluted until the required viscosity, structural and mechanical properties have been obtained. An organic stabilizer may then be added to adjust filtration. There is no suggestion that a sugar may be added to the mud to increase its shale or clay stabilization characteristics.

An object of the present invention is to provide an aqueous based composition, in particular, an aqueous based drilling fluid composition, having improved clay or shale stabilization characteristics. A further object of the present invention is to provide a method of reducing the swelling of shale or clay encountered in a wellbore, for example, during drilling through a formation.

It has now been found that an aqueous based composition which contains a combination of (a) borate ions and (b) ions selected from the group consisting of alkali (e.g., sodium or potassium) metal ions and ammonium ions exhibits markedly improved clay or shale stabilization properties compared with aqueous based compositions containing components (a) or (b) alone. It has also been found that the addition of a silicate to the aqueous based composition containing components (a) and (b) has a detrimental effect on its clay or shale stabilization properties. It has further been found that the addition of at least one sugar, selected from the group consisting of monosaccharides and oligosaccharides having from 2 to 4 saccharide groups, to the aqueous based composition containing components (a) and (b) improves the clay or shale stabilization characteristics thereof.

Thus, in a first embodiment of the present invention there is provided a use of a combination of (a) a source of borate ions, (b) a source of ions selected from the group consisting of alkali metal ions, alkaline earth metal ions and ammonium ions and (c) optionally a source of at least one sugar selected from the group consisting of monosaccharides and oligosaccharides having from 2 to 4 saccharide groups, in a composition comprising a continuous aqueous phase, to improve the clay or shale stabilizing properties thereof.

In a second embodiment of the present invention there is provided a method of reducing the swelling of shale or clay encountered in a wellbore, the method comprising introducing into the wellbore a composition comprising:

(a) a continuous aqueous phase;
(b) a source of borate ions;
(c) a source of ions selected from the group consisting of alkali metal ions, alkaline earth metal ions and ammonium ions; and
(d) optionally a source of at least one sugar selected from the group consisting of monosaccharides and oligosaccharides having from 2 to 4 saccharide groups.

The composition that is introduced into the wellbore may be used in drilling, completing or maintaining a wellbore. Where the composition is used in drilling a wellbore, the composition is preferably circulated in the wellbore thereby stabilising the clay or shale.

According to a preferred aspect of the present invention there is provided a method of reducing the swelling of shale or clay encountered during the drilling of a wellbore through a formation using a drill string disposed within the wellbore, said drill string having a first end and a second end, the first end of the drill string being located at or near the surface of the wellbore and the second end of the drill string being in communication with the drill bit having ports therein, wherein:

(A) a drilling fluid composition comprising (a) a continuous aqueous phase, (b) a source of borate ions, (c) a source of ions selected from the group consisting of alkali metal ions, alkaline earth metal ions and ammonium ions, and (d) optionally a source of at least one sugar selected from the group consisting of monosaccharides and oligosaccharides having from 2 to 4 saccharide groups is introduced into the first end of the drill string, is pumped through the drill string from the first end to the second end thereof and is discharged into the wellbore through the ports in the drill bit; and

(B) the drilling fluid composition is recycled to the first end of the drill string via an annular space which is provided between the drill string and the walls of the wellbore.

Suitably, the continuous aqueous phase of the composition may be fresh water, tap water, sea water, river water or aquifer water.

Preferably, the source of borate ions is an alkali metal borate, an ammonium borate or mixtures thereof. Preferably, the source of the borate ions is a borate of generic formula (I):
The amount of borate, expressed as $\text{B}_2\text{O}_3$ in lb/bbl (pounds per barrel) present in the continuous aqueous phase of the composition is preferably in the range 0.1 to 150 lb/bbl, and more preferably, in the range 0.5 to 50 lb/bbl.

It is envisaged that the source of borate ions may be sold as a concentrate ready for dilution with the composition. The concentrate may comprise a solution or dispersion of a borate in an aqueous liquid or a non-aqueous liquid. Suitable aqueous liquids are as described above. Suitable non-aqueous liquids include polar solvents such as alcohols and glycols. Preferably, the concentrate comprises a solution or dispersion of a borate in an aqueous liquid. The amount of borate, expressed as $\text{B}_2\text{O}_3$ in lb/bbl (pounds per barrel) present in the concentrate is preferably in the range 10 to 250 lb/bbl.

Suitably, the source of the ions selected from the group consisting of alkali metal ions, alkaline earth metal ions and ammonium ions is a water soluble salt of an alkali(earth) metal, a water soluble ammonium salt or mixtures thereof. It is preferred that the water soluble salt of the alkali(earth) metal is not a silicate. Preferably the water soluble salt is a potassium salt, calcium salt or ammonium salt including, but not limited to, potassium bromide, caesium bromide, ammonium bromide, potassium chloride, caesium chloride, ammonium chloride, potassium hydroxide, caesium hydroxide and ammonium hydroxide. For example, if boric acid is used as the source of borate, then the water soluble salt is preferably selected from potassium hydroxide, caesium hydroxide and ammonium hydroxide.

Suitably, the alkali(earth) metal salt, ammonium salt or mixtures thereof may be present in the continuous aqueous phase of the composition in an amount in the range 0.1 to 150 lb/bbl, preferably, in the range 0.5 to 100 lb/bbl.

It is envisaged that the source of the alkali(earth) metal ions, ammonium ions or mixtures thereof may be sold as a concentrate ready for dilution with the composition. Preferably, the concentrate may comprise a solution or dispersion of an alkali(earth) metal salt, ammonium salt or mixtures thereof in an aqueous liquid. Preferably, the concentration of alkali(earth) metal salt, ammonium salt or mixtures thereof in the concentrate is in the range 10 to 150 lb/bbl, preferably 10 to 100 lb/bbl.

The sugar may be selected from the group consisting of monosaccharides, and oligosaccharides having 2 to 4 saccharide groups. Preferred monosaccharides include glucose and fructose. Preferred disaccharides include sucrose (for example, obtained from cane or beet), maltose and lactose. It is also envisaged that the source of the sugar may be a mixture of sugars, for example, glucose syrup, golden syrup, molasses or Activ 7™ (a water soluble liquid syrup obtained by partial hydrolysis of starch).

Suitably, the amount of sugar in the continuous aqueous phase of the composition is in the range from 0.1 to 150 lb/bbl, preferably 0.5 to 50 lb/bbl.

It is envisaged that the source of the sugar may be sold as a concentrate ready for dilution with the composition. Preferably, the concentrate may comprise a solution or dispersion of the sugar in an aqueous liquid. Preferably, the concentration of the sugar in the concentrate is in the range 10 to 300 lb/bbl, preferably 20 to 300 lb/bbl.

It is also envisaged that (a) the source of borate ions, (b) the source of the alkali(earth) metal ions, ammonium ions or mixtures thereof and (c) the source of sugar may be sold as a mixed concentrate. Suitably, the amount of components (a), (b) and (c) in the mixed concentrate are as described above for the individual concentrates.

An advantage of the present invention is that the composition is stable at elevated temperature for a prolonged period of time. Typically, the composition is stable for a period of at least 12 hours, preferably at least 16 hours at a temperature of at least 100° C., preferably at least 120° C.

A further advantage of the present invention is that the source of borate ions acts as a pH buffer for the composition thereby controlling the pH at a value which is typically above 8, preferably above 9. Accordingly, there is no requirement to include a pH control agent such as sodium hydroxide or potassium hydroxide.

The composition may be beneficially used in combination with conventional additives for improving the clay or shale stabilization properties of a drilling or completion fluid. These conventional additives include, but are not limited to glycols.

Yet a further advantage of the composition is that it is compatible with conventional fluid loss control agents.

There is no special requirement in relation to the preparation of the composition. The source of borate ions, the source of the alkali(earth) metal ions, ammonium ions or mixtures thereof, and optionally the source of the sugar may be added in any order to the continuous aqueous phase (either as concentrates or as solids). Gentle heating is optional to dissolve or disperse the source of borate ions, the source of alkali(earth) metal ions, ammonium ions or mixtures thereof, and the optional source of the sugar in the continuous aqueous phase of the composition.

As discussed above, the sugar has been found to improve the clay or shale stabilization properties of the aqueous based composition used in the present invention. Thus, in yet a further embodiment of the present invention there is provided a composition comprising (a) a continuous aqueous phase, (b) a source of borate ions, (c) a source of ions selected from the group consisting of alkali metal ions, alkaline earth metal ions and ammonium ions and (d) a source of at least one sugar selected from the group consisting of monosaccharides and oligosaccharides having from 2 to 4 saccharide groups.

The components (a) to (d) of the composition of the present invention have the preferred features described above.

The performance of the composition of the present invention in clay or shale stabilization is now illustrated by reference to the following examples.

**EXAMPLE 1**

Aqueous based compositions, were prepared comprising the components shown in Table 1. Each composition
was made up to a weight of 80 g with demineralised water and was contained in a 100 ml glass bottle.

**EXAMPLE 2**

The procedure in Example 1 was repeated with further compositions to assess the effect of borate ion concentration and the ratio of n:m (i.e. molar ratio of Na$_2$O:B$_2$O$_3$) on shale stabilization performance. The results are given in Table 2.

<table>
<thead>
<tr>
<th>Composition</th>
<th>wt. %</th>
<th>B$_2$O$_3$</th>
<th>n:m</th>
<th>% retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>21. 10. 25 lb/bbl KCl + 0.25 wt. % Na$_2$O,2B$_2$O$_3$,5H$_2$O + 0.25 wt. % Na$_2$O,B$_2$O$_3$,8H$_2$O</td>
<td>0.183</td>
<td>0.071</td>
<td>64.0</td>
<td></td>
</tr>
<tr>
<td>22. 25 lb/bbl KCl + 1.25 wt. % Na$_2$O,2B$_2$O$_3$,5H$_2$O + 1.25 wt. % Na$_2$O,B$_2$O$_3$,8H$_2$O</td>
<td>0.913</td>
<td>0.671</td>
<td>96.5</td>
<td></td>
</tr>
<tr>
<td>23. 25 lb/bbl KCl + 2.5 wt. % Na$_2$O,2B$_2$O$_3$,5H$_2$O + 2.5 wt. % Na$_2$O,B$_2$O$_3$,8H$_2$O</td>
<td>1.826</td>
<td>0.671</td>
<td>96.6</td>
<td></td>
</tr>
<tr>
<td>24. 25 lb/bbl KCl + 3.24 wt. % H$_2$BO$_3$</td>
<td>1.826</td>
<td>0.014</td>
<td>20.8</td>
<td></td>
</tr>
<tr>
<td>25. 25 lb/bbl KCl + 1.53 wt. % Na$_2$O,2B$_2$O$_3$,5H$_2$O + 1.04 wt. % H$_2$BO$_3$</td>
<td>1.826</td>
<td>0.201</td>
<td>76.1</td>
<td></td>
</tr>
<tr>
<td>26. 25 lb/bbl KCl + 3.62 wt. % Na$_2$O,2B$_2$O$_3$,5H$_2$O</td>
<td>1.826</td>
<td>0.501</td>
<td>97.8</td>
<td></td>
</tr>
</tbody>
</table>

**EXAMPLE 3**

Water based compositions (350 ml), were prepared comprising the components shown in Table 3 below. Each composition was made up using tap water and was prepared in a plastic bottle. To each of the bottles was added 30 g of 2-4 mm size range Oxford clay. The bottles were sealed and rolled at a speed of approximately 30 rpm in an oven set at a temperature of 65° C, for a period of 16 hours. The compositions were then repeatedly passed through a 2 mm sieve. The clay retained on the sieve was collected and oven dried for a minimum of 16 hours. The % clay retained in the test was calculated taking into account, as in Example 1, the original moisture content of the clay. The results are shown in Table 3.

<table>
<thead>
<tr>
<th>Composition</th>
<th>pH</th>
<th>% clay retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>28. 25 lb/bbl KCl (comparative)</td>
<td>9.4</td>
<td>11.5</td>
</tr>
<tr>
<td>29. 25 lb/bbl KCl + 3% Glydrill MC$^3$ (comparative)</td>
<td>7.4</td>
<td>49.7</td>
</tr>
<tr>
<td>30. 25 lb/bbl KCl + 2.5% Polysiloxan silicate$^2$ (comparative)</td>
<td>12$^3$</td>
<td>99.1</td>
</tr>
<tr>
<td>31. 25 lb/bbl KCl + 6 wt. % Na$_2$O,2B$_2$O$_3$,5H$_2$O</td>
<td>9.3</td>
<td>40.2</td>
</tr>
</tbody>
</table>

---

[a] glycerol supplied by BP Chemicals
[b] wheat starch by-product (glucose syrup) supplied by Roquette Frères
TABLE 3-continued

Results of Bottle Rolling Tests using Oxford Clay

<table>
<thead>
<tr>
<th>Composition</th>
<th>pH</th>
<th>% clay retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>32.25 lb/bbl KCl + 3.47 wt. % Active 7 + 1.51 wt. % 93 Na₂O,2B₂O₅,5H₂O + 1.06 wt. % H₃BO₃</td>
<td>102.2</td>
<td></td>
</tr>
</tbody>
</table>

1commercial glycol shale inhibitor product  
2SiO₂:Na₂O  
3pH adjusted value

EXAMPLE 4

A so-called Hamster Cage Test for evaluating the shale stabilizing performance of the compositions according to the present invention was performed. This test involved preparing 1500 ml of water based drilling fluid compositions as presented in Table 4 (where the aqueous liquid component of the compositions is demineralized water):

TABLE 4

Compositions for use in Hamster Cage Test

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Drilling Fluid A (comparative)</th>
<th>Drilling Fluid B (comparative)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KCl</td>
<td>25 lb/bbl of ingredient</td>
<td>25 lb/bbl of ingredient</td>
</tr>
<tr>
<td>Polyanionic cellulose</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Starch</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Xanthan gum</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Na₂O,2B₂O₅,5H₂O</td>
<td>0</td>
<td>8.75</td>
</tr>
<tr>
<td>Na₂O,B₂O₅,8H₂O</td>
<td>0</td>
<td>8.75</td>
</tr>
</tbody>
</table>

1PAC L - supplied by Baroid  
2DENDRIT - supplied by Baroid  
3Xarvin - supplied by Schlumberger

The improved shale stabilizing performance of the drilling fluid composition containing borate ions and potassium ions (Drilling Fluid B) is evident from these results.

EXAMPLE 5

The fluid loss characteristics and viscosity of drilling fluid composition C, comprising the ingredients given in Table 7, were measured before and after high temperature ageing (hot rolling) at a temperature of 120°C for 16 hours. The results are presented in Table 8.

TABLE 5

Viscosities of Drilling Fluid Compositions

<table>
<thead>
<tr>
<th>Fann viscometer readings (rpm)</th>
<th>Drilling Fluid A</th>
<th>Drilling Fluid B</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>49</td>
<td>48</td>
</tr>
<tr>
<td>300</td>
<td>34.5</td>
<td>31</td>
</tr>
<tr>
<td>200</td>
<td>28</td>
<td>25</td>
</tr>
<tr>
<td>100</td>
<td>19.5</td>
<td>17</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>4.5</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>4.5</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td>14.5</td>
<td>17</td>
</tr>
<tr>
<td>YP/ct/100 sqft</td>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>PH</td>
<td>10.0 (adjusted with NaOH)</td>
<td>9.4</td>
</tr>
</tbody>
</table>

4HMP = Hymod Prima clay obtained from Imerys comprising illite and having a particle size of about 1 to 5 microns. HMP is a non-swelling clay and simulates drilled solids (cuttings) in the formulation.
TABLE 8-continued

Viscosity and Fluid Loss Characteristics of Un-aged and Aged (16 hours at 120°C) Samples of Drilling Fluid Composition C.

<table>
<thead>
<tr>
<th>Viscosity (cP)</th>
<th>Un-aged</th>
<th>Aged</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 rpm</td>
<td>36</td>
<td>34</td>
</tr>
<tr>
<td>60 rpm</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>30 rpm</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Gel/10 s</td>
<td>11, 14</td>
<td>14</td>
</tr>
<tr>
<td>PV/HP</td>
<td>28, 26</td>
<td>26</td>
</tr>
<tr>
<td>YP/lbf/100 sqft</td>
<td>34, 33</td>
<td>33</td>
</tr>
</tbody>
</table>

Fluid loss

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Fluid loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0</td>
</tr>
<tr>
<td>7.5</td>
<td>0.6</td>
</tr>
<tr>
<td>30</td>
<td>2.9</td>
</tr>
<tr>
<td>pH</td>
<td>9.5</td>
</tr>
</tbody>
</table>

[0064] The fluid loss characteristics of drilling fluid composition C are good and this property together with the viscosity of the drilling fluid composition remain substantially unaltered despite high temperature ageing.

1-20 (cancelled).

21. A method of reducing the swelling of shale or clay encountered during drilling a wellbore, the method comprising circulating in the wellbore a composition comprising:

(a) a continuous aqueous phase;
(b) a source of borate ions;
(c) a source of ions selected from the group consisting of alkali metal ions, alkaline earth metal ions and ammonium ions; and
(d) optionally a source of at least one sugar selected from the group consisting of monosaccharides and oligosaccharides having from 2 to 4 saccharide groups.

22. A method of reducing the swelling of shale or clay encountered during the drilling of a wellbore through a formation using a drill string disposed within the wellbore, said drill string having a first end and a second end, the first end of the drill string being located at or near the surface of the wellbore and the second end of the drill string being in communication with a drill bit having ports therein, wherein:

(A) a drilling fluid composition comprising (a) a continuous aqueous phase, (b) a source of borate ions, (c) a source of ions selected from the group consisting of alkali metal ions, alkaline earth metal ions and ammonium ions, and (d) optionally a source of at least one sugar selected from the group consisting of monosaccharides and oligosaccharides having from 2 to 4 saccharide groups is introduced into the first end of the drill string, is pumped through the drill string from the first end to the second end thereof and is discharged into the wellbore through the ports in the drill bit; and (B) the drilling fluid composition is recycled to the first end of the drill string via an annular space which is provided between the drill string and the walls of the wellbore.

23. A method according to claim 21 wherein the source of borate ions is selected from the group consisting of sodium borates, potassium borates, caesium borates, ammonium borates, and boric acid.

24. A method according to claim 23 wherein the source of borate ions is selected from the group consisting of:

- Disodium tetraborate pentahydrate—\( \text{Na}_2 \text{O} \cdot 2\text{B}_2\text{O}_3 \cdot 5\text{H}_2\text{O} \) (borax pentahydrate),
- Disodium tetraborate decahydrate—\( \text{Na}_2 \text{O} \cdot 2\text{B}_2\text{O}_3 \cdot 10\text{H}_2\text{O} \) (borax decahydrate, tincal),
- Disodium tetraborate tetrahydrate—\( \text{Na}_2 \text{O} \cdot 2\text{B}_2\text{O}_3 \cdot 4\text{H}_2\text{O} \) (kernite),
- Disodium tetraborate—\( \text{Na}_2 \text{O} \cdot 2\text{B}_2\text{O}_3 \) (anhydrous borax),
- Sodium metaborate tetrahydrate—\( \text{Na}_2 \text{O} \cdot \text{B}_2\text{O}_3 \cdot 8\text{H}_2\text{O} \),
- Sodium metaborate dihydrate—\( \text{Na}_2 \text{O} \cdot \text{B}_2\text{O}_3 \cdot 4\text{H}_2\text{O} \),
- Sodium pentaborate pentahydrate—\( \text{Na}_5 \text{O} \cdot 5\text{B}_2\text{O}_3 \cdot 10\text{H}_2\text{O} \),
- Disodium octaborate tetrahydrate—\( \text{Na}_8 \text{O} \cdot 4\text{B}_2\text{O}_3 \cdot 4\text{H}_2\text{O} \),
- Boric acid—\( \text{H}_3\text{BO}_3 \),
- Dipotassium tetraborate tetrahydrate—\( \text{K}_2\text{O} \cdot 2\text{B}_2\text{O}_3 \cdot 4\text{H}_2\text{O} \),
- Potassium pentaborate tetrahydrate—\( \text{K}_5\text{O} \cdot 5\text{B}_2\text{O}_3 \cdot 8\text{H}_2\text{O} \),
- Diammonium tetraborate tetrahydrate—\( \text{(NH}_4\text{)}_2\text{O} \cdot 2\text{B}_2\text{O}_3 \cdot 4\text{H}_2\text{O} \),
- Ammonium pentaborate tetrahydrate—\( \text{(NH}_4\text{)}_5\text{O} \cdot 5\text{B}_2\text{O}_3 \cdot 8\text{H}_2\text{O} \), and
- Caesium pentaborate tetrahydrate—\( \text{Cs}_5\text{O} \cdot 5\text{B}_2\text{O}_3 \cdot 8\text{H}_2\text{O} \).

25. A method according to claim 21 wherein the concentration of borate expressed as \( \text{B}_2\text{O}_3 \) in the continuous aqueous phase is in the range 0.1 to 150 lb/bbl.

26. A method according to claim 21 wherein the source of the alkali metal ions, alkaline earth metal ions and ammonium ions is a water soluble salt of an alkali(ine) earth metal, a water soluble ammonium salt or mixtures thereof.

27. A method according to claim 26 wherein the salt is selected from the group consisting of potassium salts, caesium salts, and ammonium salts.

28. A method according to claim 27 wherein the salt is selected from the group consisting of potassium bromide, caesium bromide, ammonium bromide, potassium chloride, caesium chloride, ammonium chloride, potassium hydroxide, caesium hydroxide and ammonium hydroxide.

29. A method according to claim 26 wherein the concentration of alkali metal salt, alkaline earth metal salt or ammonium salt in the continuous aqueous phase is in the range 0.1 to 150 lb/bbl.

30. A method according to claim 21 wherein the sugar is selected from the group consisting of glucose, fructose, sucrose, maltose, lactose and mixtures thereof.

31. A method according to claim 21 wherein the concentration of sugar in the continuous aqueous phase is in the range 0.1 to 150 lb/bbl.

32. A method according to claim 21 wherein the composition comprises additional additives selected from the group consisting of weighting agents, viscosifiers, fluid loss control agents, defoamers, lubricants, and glycols.

33. A composition comprising (a) a continuous aqueous phase (b) a source of borate ions, (c) a source of ions selected from the group consisting of alkali metal ions,
alkaline earth metal ions and ammonium ions and (d) a source of at least one sugar selected from the group consisting of monosaccharides and oligosaccharides having from 2 to 4 saccharide groups.

34. A concentrate comprising a source of borate ions, a source of ions selected from the group consisting of alkali metal ions, alkaline earth metal ions and ammonium ions and a source of at least one sugar selected from the group consisting of monosaccharides and oligosaccharides having from 2 to 4 saccharide groups dissolved or dispersed in an aqueous phase.

35. A concentrate as claimed in claim 34 wherein the concentration of borate, expressed as $\text{B}_3\text{O}_3$, is in the range 10 to 250 lb/bbl, the concentration of alkali metal salt, alkaline earth metal salt or ammonium salt is in the range 10 to 150 lb/bbl and the concentration of sugar is in the range 10 to 300 lb/bbl.

36. A concentrate as claimed in claim 34 wherein the source of borate ions is as defined in claim 3.

37. A concentrate as claimed in claim 34 wherein the source of the alkali metal ions, alkaline earth metal ions or the ammonium ions is as defined in claim 6.

38. A concentrate as claimed in claim 34 wherein the source of the sugar is as defined in claim 10.

39. Use of a composition according to claim 33 as a drilling fluid.

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