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(54) Title: METHODS FOR FORMING HIGHLY CONDUCTIVE PROPPED FRACTURES

(57) Abstract: Methods of propping subterranean fractures using swellable particulates. Some methods alternate the placement into a fracture of proppant and swellable particulates. Other methods alternate the placement into a fracture of proppant-free fluid and swellable particulates. Still other methods combine proppant and swellable particulates into a single fluid and place that fluid into a subterranean fracture. The methods are useful for treatment of low closure stress formations.



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METHODS FOR FORMING HIGHLY CONDUCTIVE PROPPED FRACTURES

BACKGROUND

5 **[0001]** The present invention relates to methods for enhancing the conductivity of propped fractures in low closure stress subterranean formations.

[0002] Non-traditional sources of hydrocarbons are playing an increasingly important role in the oil and gas industry. Such non-traditional sources include gas hydrates, heavy oil, bitumen, and coal bed methane (CBM).
10 Coal bed methane in particular is becoming an increasingly important energy source, with the total coal bed methane reserves in the United States estimated to be between 400 and 850 trillion cubic feet.

[0003] Typically, CBM can be found unexploited at relatively shallow depths, and because methane is stored in coal by a different means than
15 conventional gas, more gas per unit volume can be recovered at these shallow depths. In order to extract hydrocarbons from the coal seam, the casing and cement sheet are perforated to create production intervals through which hydrocarbons can flow into the wellbore and ultimately to the surface. To enhance hydrocarbon production, the production intervals are often stimulated
20 by a variety of methods that have been developed and used successfully for increasing the production of CBM from coal seams.

[0004] Stimulation operations may involve hydraulic fracturing, acidizing, fracture acidizing, or combinations thereof. Hydraulic fracturing generally includes injecting or pumping a viscous fracturing fluid into a portion of
25 the subterranean formation at a rate and pressure such that fractures are formed or enhanced into the portion of the subterranean formation. The fracture pressure causes the formation to crack which allows the fracturing fluid to enter and extend the crack further into the formation. The fractures tend to propagate as vertical and/or horizontal cracks located radially outward from the
30 well bore.

[0005] In such fracturing treatments once the fracturing pressure is released the fractures tend to close, thereby removing at least a portion of the conductivity gained through the fracturing operation. To at least partially prevent closure proppant is generally disposed into the fractures before the
35 fracturing pressure is released. In this way conductive channels remain between

the proppant particles in the face of the fracture hydrocarbons to produce from the formation into the well bore.

[0006] However, these traditional fracture and propping operations are not specifically suited for use in formations, such as shale and coal bed methane formations wherein the formation itself exhibits a layered structure and fracture "closure" can refer not only to the closure of fracture faces together, but to the closure of individual layers of the formation structure itself.

SUMMARY OF THE INVENTION

[0007] The present invention relates to methods for enhancing the conductivity of propped fractures in low-closure stress subterranean formations.

[0008] Some embodiments of the present invention provide methods comprising: providing a first treatment fluid that comprises proppant; providing a second treatment fluid that comprises swellable particulates; alternating the placement of the first treatment fluid and the second treatment fluid into a fracture within a low closure stress formation.

[0009] Other embodiments of the present invention provide methods comprising: providing a first treatment fluid that is proppant-free; providing a second treatment fluid that comprises swellable particulates; alternating the placement of the first treatment fluid and the second treatment fluid into a fracture within a low closure stress formation.

[0010] Still other embodiments of the present invention provide methods comprising: providing a treatment fluid that comprises proppant and swellable particulates; placing of the treatment fluid into a fracture within a low closure stress formation.

[0011] The features and advantages of the present invention will be readily apparent to those skilled in the art upon a reading of the description of the preferred embodiments that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The following figures are included to illustrate certain aspects of the present invention, and should not be viewed as exclusive embodiments. The

subject matter disclosed is capable of considerable modifications, alterations, combinations, and equivalents in form and function, as will occur to those skilled in the art and having the benefit of this disclosure.

5 **[0013]** Figures 1A-C provide SEM images perpendicular to the bedding planes of tackified shale after exposure to proppant particles.

DETAILED DESCRIPTION

10 **[0014]** The present invention relates to methods for enhancing the conductivity of propped fractures in low closure stress subterranean formations.

[0015] The embodiments of the present invention provide methods of propping fractures in low closure stress subterranean formations. As used herein, the term "low closure stress" refers to formations having closure stresses less than about 2,000 psi. In some embodiments the closure stress of the
15 formation being treated may be less than about 1,750, about 1,500 psi, about 1,250 psi, or less than about 1,000 psi. In some embodiments, the methods comprise using a proppant-containing treatment fluid in alternating stages with a treatment fluid containing swellable particulates. In other embodiments, the methods comprise using a proppant-free treatment fluid in alternating stages
20 with a treatment fluid containing swellable particulates. In still other embodiments, the methods comprise using a treatment fluid comprising both proppant and swellable particulates in a single fluid.

[0016] The use of swellable particulates together with traditional proppant enhances well production when compared to treatments that use
25 traditional proppant alone. Without being constrained by theory, it is believed that as the swellable particulates encounter the formation downhole, they tend to wedge in the crevices between the formation layers. Then, when they expand, they cause the layers to expand as well, further opening the flow paths.

[0017] Treatment Fluids

[0018] Any suitable treatment fluid that may be employed in subterranean operations may be used in accordance with the present invention, including aqueous gels, oil-based fluids, viscoelastic surfactant gels, and emulsions. While non-aqueous fluids can be used, one of skill in the art will recognize that some low closure stress formations, such as coal bed methane formations, are unsuitable for oil-based fluids because they tend to block the water exiting the formation thereby trapping the gas. Where desirable, the selected carrier fluid may be foamed by the addition of a gas, such as carbon dioxide or nitrogen. Where the methods describe the use of alternating treatment fluids, the treatment fluid containing swellable particulates may be the same or different than the proppant-containing treatment fluid or the proppant-free treatment fluid.

[0019] Suitable aqueous gels are generally comprised of water and one or more gelling agents. Suitable aqueous-based fluids may include fresh water, saltwater (e.g., water containing one or more salts dissolved therein), brine (e.g., saturated salt water), seawater, and any combination thereof. Suitable aqueous-miscible fluids may include, but not be limited to, alcohols, e.g., methanol, ethanol, n-propanol, isopropanol, n-butanol, sec-butanol, isobutanol, and t-butanol; glycerins; glycols, e.g., polyglycols, propylene glycol, and ethylene glycol; polyglycol amines; polyols; any derivative thereof; any in combination with salts, e.g., sodium chloride, calcium chloride, calcium bromide, zinc bromide, potassium carbonate, sodium formate, potassium formate, cesium formate, sodium acetate, potassium acetate, calcium acetate, ammonium acetate, ammonium chloride, ammonium bromide, sodium nitrate, potassium nitrate, ammonium nitrate, ammonium sulfate, calcium nitrate, sodium carbonate, and potassium carbonate; any in combination with an aqueous-based fluid; and any combination thereof. In some embodiments of the present invention, the carrier fluids are aqueous gels comprised of water, a gelling agent for gelling the water and increasing its viscosity, and, optionally, a crosslinking agent for crosslinking the gel and further increasing the viscosity of the fluid. The increased viscosity of the gelled, or gelled and cross-linked, carrier fluid, *inter alia*, reduces fluid loss and allows the carrier fluid to transport proppants.

[0020] Suitable oil-based fluids may include alkanes, olefins, aromatic organic compounds, cyclic alkanes, paraffins, diesel fluids, mineral oils,

desulfurized hydrogenated kerosenes, and any combination thereof. Suitable emulsions can be comprised of two immiscible liquids such as an aqueous liquid or gelled liquid and a hydrocarbon.

[0021] Suitable viscoelastic surfactant gels include an aqueous base fluid and a suitable surfactant that is capable of imparting viscoelastic properties to an aqueous fluid. Example of suitable surfactants can be found in U.S. Patent No. 8,012,914, the entire disclosure of which is hereby incorporated by reference. The surfactants may be zwitterionic, cationic, anionic, or amphoteric in nature, and comprise any number of different compounds, including methyl ester sulfonates (as described in U.S. Patent Publication Nos. 2006/0180308, 2006/0180309, 2006/0181310 and 2006/0183646, the entire disclosures of which are hereby incorporated by reference), betaines, modified betaines, sulfosuccinates, taurates, amine oxides, ethoxylated fatty amines, quaternary ammonium compounds, derivatives thereof, and combinations thereof. The term "derivative" is defined herein to include any compound that is formed, for example, by replacing one atom in one of the listed compounds with another atom or group of atoms, ionizing one of the listed compounds, or creating a salt of one of the listed compounds. The surfactant should be present in a surfactant gel of the present invention in an amount sufficient to provide the desired viscosity (e.g., sufficient viscosity to divert flow, reduce fluid loss, suspend particulates, etc.) therein through formation of viscosifying micelles. In certain embodiments, the surfactant may be present in an amount in the range of from about 0.1% to about 20% (or from 2% to 10%) by volume of the surfactant gel.

[0022] Suitable water-in-oil emulsions, also known as invert emulsions, may have an oil-to-water ratio from a lower limit of greater than about 50:50, 55:45, 60:40, 65:35, 70:30, 75:25, or 80:20 to an upper limit of less than about 100:0, 95:5, 90:10, 85:15, 80:20, 75:25, 70:30, or 65:35 by volume in the base fluid, where the amount may range from any lower limit to any upper limit and encompass any subset there between. Examples of suitable invert emulsions include those disclosed in U.S. Patent Nos. 5,905,061, 5,977,031, 6,828,279, 7,534,745, 7,645,723, and 7,696,131, the entire disclosures of which are hereby incorporated by reference. It should be noted that for water-in-oil and oil-in-water emulsions, any mixture of the above may be used including the water being and/or comprising an aqueous-miscible fluid

[0023] Proppant Particulates

[0024] Proppants suitable for use in the present invention may comprise any material suitable for use in subterranean operations. Suitable materials for these particulates include, but are not limited to, sand, bauxite, ceramic materials, glass materials, polymer materials, polytetrafluoroethylene materials, nut shell pieces, cured resinous particulates comprising nut shell pieces, seed shell pieces, cured resinous particulates comprising seed shell pieces, fruit pit pieces, cured resinous particulates comprising fruit pit pieces, wood, composite particulates, and combinations thereof. Suitable composite particulates may comprise a binder and a filler material wherein suitable filler materials include silica, alumina, fumed carbon, carbon black, graphite, mica, titanium dioxide, meta-silicate, calcium silicate, kaolin, talc, zirconia, boron, fly ash, hollow glass microspheres, solid glass, and combinations thereof. The mean particulate size generally may range from about 2 mesh to about 400 mesh on the U.S. Sieve Series; however, in certain circumstances, other mean particulate sizes may be desired and will be entirely suitable for practice of the present invention. In particular embodiments, preferred mean particulates size distribution ranges are one or more of 6/12, 8/16, 12/20, 16/30, 20/40, 30/50, 40/60, 40/70, or 50/70 mesh. In some embodiments, the proppant particulates range from about 10 to about 70 mesh with preferred size distributions being 10-20 mesh, 20-40 mesh, 40-60 mesh, or 50-70 mesh. It should be understood that the term "particulate," as used in this disclosure, includes all known shapes of materials, including substantially spherical materials, fibrous materials, polygonal materials (such as cubic materials), and combinations thereof. Moreover, fibrous materials, that may or may not be used to bear the pressure of a closed fracture, may be included in certain embodiments of the present invention. In certain embodiments, the particulates may be present in the first treatment fluids of the present invention in an amount in the range of from about 0.5 pounds per gallon ("ppg") to about 30 ppg by volume of the treatment fluid

[0025] Swellable Particulates

[0026] Swellable particulates suitable for use in the present invention may be placed in the treatment fluid placed into a fracture and then contacted with a swelling fluid so the swellable particulates swell or expand once in the fracture. Suitable swellable particulates comprise swellable elastomer

compositions. In some embodiments, the swellable particulates may comprise a swellable elastomer in combination with a filler material.

[0027] Examples of suitable swellable elastomer can be found in U.S., Patent Publication No. 2008/0017376, the entire disclosure of which is hereby incorporated by reference. Typical examples of swellable elastomer materials include: natural rubber, acrylate butadiene rubber, polyacrylate rubber, isoprene rubber, chloroprene rubber, butyl rubber, brominated butyl rubber, chlorinated butyl rubber, chlorinated polyethylene, neoprene rubber, styrene butadiene copolymer rubber, sulfonated polyethylene, ethylene acrylate rubber, epichlorohydrin ethylene oxide copolymer, ethylene propylene rubber, ethylene propylene diene terpolymer rubber, ethylene vinyl acetate copolymer, fluoroelastomers, silicone rubbers, fluoro rubber, and combinations thereof.

[0028] The mean particulate size of the swellable elastomer (before swelling occurs) generally may range from about 2 mesh to about 400 mesh on the U.S. Sieve Series; however, in certain circumstances, other mean particulate sizes may be desired and will be entirely suitable for practice of the present invention. In particular embodiments, preferred mean particulates size distribution ranges are one or more of 6/12, 8/16, 12/20, 16/30, 20/40, 30/50, 40/60, 40/70, or 50/70 mesh. It should be understood that the term "particulate," as used in this disclosure, includes all known shapes of materials, including substantially spherical materials, fibrous materials, polygonal materials (such as cubic materials), and combinations thereof. Moreover, fibrous materials, that may or may not be used to bear the pressure of a closed fracture, may be included in certain embodiments of the present invention.

[0029] While particulates made solely from the elastomers described above may be used, in some embodiments, the methods of the present invention comprise a solid particulate that has been coated with a swellable elastomer. Unless particularly called out here, where the methods refer to "swellable particles," the disclosure should be read as referring to a particle made solely from the elastomer, a solid particle coated with elastomer, or a combination thereof.

[0030] Where coated particulates are used, the size and shape characteristics remain as described above for swellable elastomer particulates. As used herein the term coated does not imply any particular coverage of the solid particulate with a swellable elastomer composition. Moreover, the

swellable elastomer may be coated with the swellable elastomer using any suitable method. For example they may be coated on-the-fly at the well site. In embodiments in which the swellable elastomer is placed onto a solid particulate, the elastomer is generally present in an amount ranging from about 0.1% to about 10% by weight solid particulates. Where swellable elastomer coatings are used, the underlying particulate may be any particulate known for use as a proppant particulate, as described above.

[0031] Consolidating Agents

[0032] In some embodiments, the swellable particulates, the proppant particulates, or both may be coated with a consolidating agent.

[0033] Suitable consolidating agents may include, but are not limited to, non-aqueous tackifying agents, aqueous tackifying agents, emulsified tackifying agents, silyl-modified polyamide compounds, resins, crosslinkable aqueous polymer compositions, polymerizable organic monomer compositions, consolidating agent emulsions, zeta-potential modifying aggregating compositions, silicone-based resins, and binders. Combinations and/or derivatives of these also may be suitable. Nonlimiting examples of suitable non-aqueous tackifying agents may be found in U.S. Patent Nos. 5,853,048; 5,839,510; and 5,833,000 as well as U.S. Patent Application Publication Nos. 2007/0131425 and 2007/0131422 the entire disclosures of which are herein incorporated by reference. Nonlimiting examples of suitable aqueous tackifying agents may be found in U.S. Patent Nos. 5,249,627 and 4,670,501 as well as U.S. Patent Application Publication Nos. 2005/0277554 and 2005/0274517, the entire disclosures of which are herein incorporated by reference. Nonlimiting examples of suitable crosslinkable aqueous polymer compositions may be found in U.S. Patent Application Publication Nos. 2010/0160187 and 2011/0030950 the entire disclosures of which are herein incorporated by reference. Nonlimiting examples of suitable silyl-modified polyamide compounds may be found in U.S. Patent No. 6,439,309, the entire disclosure of which is herein incorporated by reference. Nonlimiting examples of suitable resins may be found in U.S. Patent Nos. 7,673,686; 7,153,575; 6,677,426; 6,582,819; 6,311,773; and 4,585,064 as well as U.S. Patent Application Publication Nos. 2010/0212898 and 2008/0006405, the entire disclosures of which are herein incorporated by reference. Nonlimiting examples of suitable polymerizable organic monomer compositions may be found in U.S. Patent Nos. 7,819,192, the entire disclosure

of which is herein incorporated by reference. Nonlimiting examples of suitable consolidating agent emulsions may be found in U.S. Patent Application Publication No. 2007/0289781 the entire disclosure of which is herein incorporated by reference. Nonlimiting examples of suitable zeta-potential
5 modifying aggregating compositions may be found in U.S. Patent Nos. 7,956,017 and 7,392,847, the entire disclosures of which are herein incorporated by reference. Nonlimiting examples of suitable silicon-based resins may be found in Application Publication Nos. 2011/0098394, 2010/0280210, 2010/0179281, and 2010/0212898 the entire disclosures of which are herein incorporated by
10 reference. Nonlimiting examples of suitable binders may be found in U.S. Patent Nos. 8,003,579; 7,825,074; and 6,287,639 as well as U.S. Patent Application Publication No. 2011/0039737, the entire disclosures of which are herein incorporated by reference. It is within the ability of one skilled in the art, with the benefit of this disclosure, to determine the type and amount of consolidating
15 agent to include in the methods of the present invention to achieve the desired results.

[0034] Methods of the Present Invention

[0035] In some embodiments, proppant particles may be present in a treatment fluid for use in the present invention in an amount in the range of
20 from about 0.1 pounds per gallon ("ppg") to about 15 ppg by volume of the treatment fluid. In some embodiments, swellable elastomers may be present in a treatment fluid for use in the present invention in an amount in the range of from about 0.1 ppg to about 15 ppg by volume of the treatment fluid. In other embodiments, the combination of proppant particulates and swellable
25 elastomers may be present in a treatment fluid for use in the present invention in an amount in the range of from about 0.1 ppg to about 15 ppg by volume of the treatment fluid.

[0036] Some embodiments of the present invention provide methods of propping a subterranean fracture comprising: providing a first treatment fluid
30 that comprises proppant and a second treatment fluid that comprises swellable particulates; alternating the placement of the first treatment fluid and the second treatment fluid into a fracture within a low closure stress formation. In some embodiments the second (swellable) treatment fluid may be placed into the fracture before the first (proppant) treatment fluid, or vice versa. In these
35 embodiments, the first (proppant) and second (swellable) fluids may be placed

into the formation alternating only once (that is placement of the first once and then the second once) or may be alternated multiple times (that is, placement of, for example, second – first – second – first- second – first). One of skill in the art will recognize that the number of alterations may be selected based on the needs of the individual treatment being performed. Moreover, while the treatment fluids are alternated, they need not be equal in volume. That is, the treatment may include the placement of a volume of the first treatment fluid followed by the placement of only half the volume of the second treatment fluid, or vice versa.

[0037] Other embodiments of the present invention provide methods of propping a subterranean fracture comprising: providing a first treatment fluid that comprises no proppant and a second treatment fluid that comprises swellable particulates; alternating the placement of the first treatment fluid and the second treatment fluid into a fracture within a low closure stress formation. In some embodiments the second (swellable) treatment fluid may be placed into the fracture before the first (no proppant) treatment fluid, or vice versa. In these embodiments, the first (no proppant) and second (swellable) fluids may be placed into the formation alternating only once (that is placement of the first once and then the second once) or may be alternated multiple times (that is, placement of, for example, second – first – second – first- second – first). One of skill in the art will recognize that the number of alterations may be selected based on the needs of the individual treatment being performed. Moreover, just as above, while the treatment fluids are alternated, they need not be equal in volume.

[0038] Other embodiments of the present invention provide methods of propping a subterranean fracture comprising: providing a first treatment fluid that is proppant-free and a second treatment fluid that comprises swellable particulates; alternating the placement of the first treatment fluid and the second treatment fluid into a fracture within a low closure stress formation. In some embodiments the second (swellable) treatment fluid may be placed into the fracture before the first (proppant-free) treatment fluid, or vice versa. In these embodiments, the first (proppant-free) and second (swellable) fluids may be placed into the formation alternating only once (that is placement of the first once and then the second once) or may be alternated multiple times (that is, placement of, for example, second – first – second – first- second – first). One

of skill in the art will recognize that the number of alterations may be selected based on the needs of the individual treatment being performed. Just as above, while the treatment fluids are alternated, they need not be equal in volume.

[0039] Still other embodiments of the present invention provide methods of propping a subterranean fracture comprising: providing a treatment fluid that comprises both proppant and swellable particulates; and placing the treatment fluid into a fracture within a low closure stress formation. In these embodiments, the amount of proppant may be the same, less than, or greater than the amount of swellable particulates.

[0040] To facilitate a better understanding of the present invention, the following examples of preferred or representative embodiments are given. In no way should the following examples be read to limit, or to define, the scope of the invention.

EXAMPLES

[0041] A treatment solution was prepared by diluting 5% v/v of aqueous-based tackifier SANDWEDGE[®] ABC (commercially available from Halliburton Energy Services, Inc. of Houston, Texas) and fresh water containing 2% v/v CLA-WEB[®] clay stabilizer (commercially available from Halliburton Energy Services, Inc. of Houston, Texas).

[0042] A shale sample was immersed in a stirred beaker of the treatment solution for 5 minutes, which simulates the exposure of fracture faces to a treatment fluid comprising a tackifier. The shale sample was removed and immersed in a beaker of tap water containing 0.2% v/v CLA-WEB[®] clay stabilizer and 5% w/v OK#1 sand (proppant). This suspension was stirred enough to cause the proppant particles to circulate, which stimulates the introduction of proppant particles into a tackifier treated formation. The shale sample was removed for SEM imaging.

[0043] Figures 1A-C provide SEM images perpendicular to the bedding planes of the shale after exposure to the proppant particles. Specifically, Figures 1A-C show, at increasing magnifications respectively, the adhesion of larger proppant particles to the sides of the bedding planes without, in some instances, support from a lower bedding plane. Further, some of the smaller proppant particles are between bedding planes and appear to be adhered, in some instances, to the upper bedding plane. These figures demonstrate that the

particles can be placed not only into the fracture faces but also the layers (*i.e.*, bedding planes) of the formation, as best illustrated in Figure 1C.

[0044] It should be noted that when "about" is provided at the beginning of a numerical list, "about" modifies each number of the numerical list. It should be noted that in some numerical listings of ranges, some lower limits listed may be greater than some upper limits listed. One skilled in the art will recognize that the selected subset will require the selection of an upper limit in excess of the selected lower limit.

[0045] Therefore, the present invention is well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular embodiments disclosed above are illustrative only, as the present invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular illustrative embodiments disclosed above may be altered, combined, or modified and all such variations are considered within the scope and spirit of the present invention. The invention illustratively disclosed herein suitably may be practiced in the absence of any element that is not specifically disclosed herein and/or any optional element disclosed herein. While compositions and methods are described in terms of "comprising," "containing," or "including" various components or steps, the compositions and methods can also "consist essentially of" or "consist of" the various components and steps. All numbers and ranges disclosed above may vary by some amount. Whenever a numerical range with a lower limit and an upper limit is disclosed, any number and any included range falling within the range is specifically disclosed. In particular, every range of values (of the form, "from about a to about b," or, equivalently, "from approximately a to b," or, equivalently, "from approximately a-b") disclosed herein is to be understood to set forth every number and range encompassed within the broader range of values. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. Moreover, the indefinite articles "a" or "an," as used in the claims, are defined herein to mean one or more than one of the element that it introduces. If there is any conflict in the usages of a word or term in this

specification and one or more patent or other documents that may be incorporated herein by reference, the definitions that are consistent with this specification should be adopted.

CLAIMS

The invention claimed is:

1. A method comprising:
providing a first treatment fluid, wherein the first treatment fluid either comprises proppant or is proppant-free;
providing a second treatment fluid that comprises swellable particulates;
alternating the placement of the first treatment fluid and the second treatment fluid into a fracture within a low closure stress formation.
2. The method of claim 1 wherein the first treatment fluid is placed into the fracture before the second treatment fluid.
3. The method of any of the preceding claims, wherein the second treatment fluid is placed into the fracture before the first treatment fluid.
4. The method of any of the preceding claims, wherein the proppant, the swellable particulates, or both are coated with a consolidating agent.
5. The method of any of the preceding claims, wherein the swellable particulates are selected from the group consisting of: swellable elastomer particles, proppant coated with swellable elastomer, or a combination thereof.
6. The method of claim 5, wherein the swellable elastomer is selected from the group consisting of: natural rubber, acrylate butadiene rubber, polyacrylate rubber, isoprene rubber, chloroprene rubber, butyl rubber, brominated butyl rubber, chlorinated butyl rubber, chlorinated polyethylene, neoprene rubber, styrene butadiene copolymer rubber, sulfonated polyethylene, ethylene acrylate rubber, epichlorohydrin ethylene oxide copolymer, ethylene propylene rubber, ethylene propylene diene terpolymer rubber, ethylene vinyl acetate copolymer, fluoroelastomers, silicone rubbers, fluoro rubber, and combinations thereof.
7. A method comprising:
providing a treatment fluid that comprises proppant and swellable particulates;
placing of the treatment fluid into a fracture within a low closure stress formation.
8. The method of claim 7, wherein the proppant, the swellable particulates, or both are coated with a consolidating agent.

9. The method of claim 7 or 8 wherein the swellable particulates are selected from the group consisting of: swellable elastomer particles, proppant coated with swellable elastomer, or a combination thereof.

10. The method of claim 7, 8, or 9 wherein the swellable elastomer is selected from the group consisting of: natural rubber, acrylate butadiene rubber, polyacrylate rubber, isoprene rubber, chloroprene rubber, butyl rubber, brominated butyl rubber, chlorinated butyl rubber, chlorinated polyethylene, neoprene rubber, styrene butadiene copolymer rubber, sulfonated polyethylene, ethylene acrylate rubber, epichlorohydrin ethylene oxide copolymer, ethylene propylene rubber, ethylene propylene diene terpolymer rubber, ethylene vinyl acetate copolymer, flourosilicone rubbers, silicone rubbers, fluoro rubber, and combinations thereof.

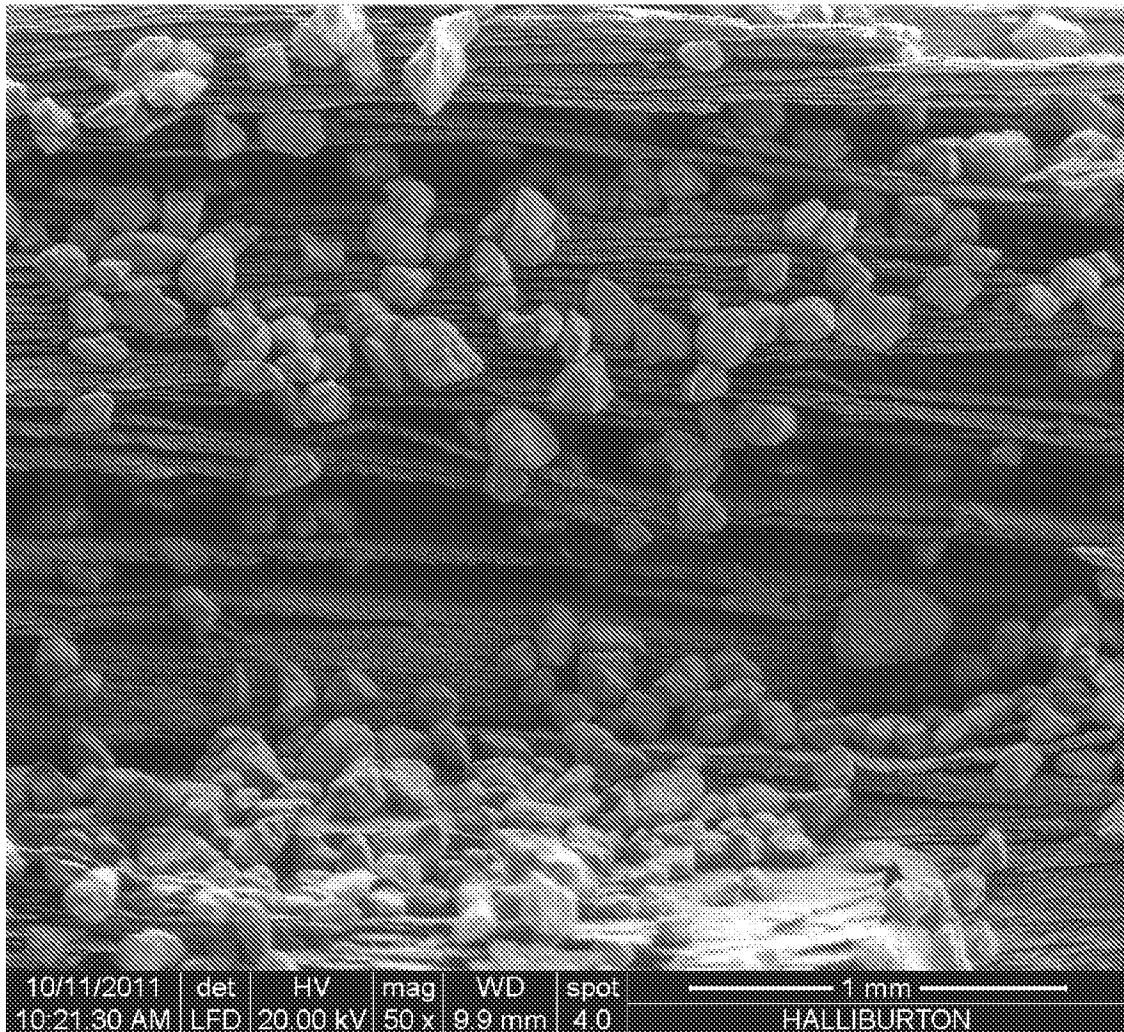
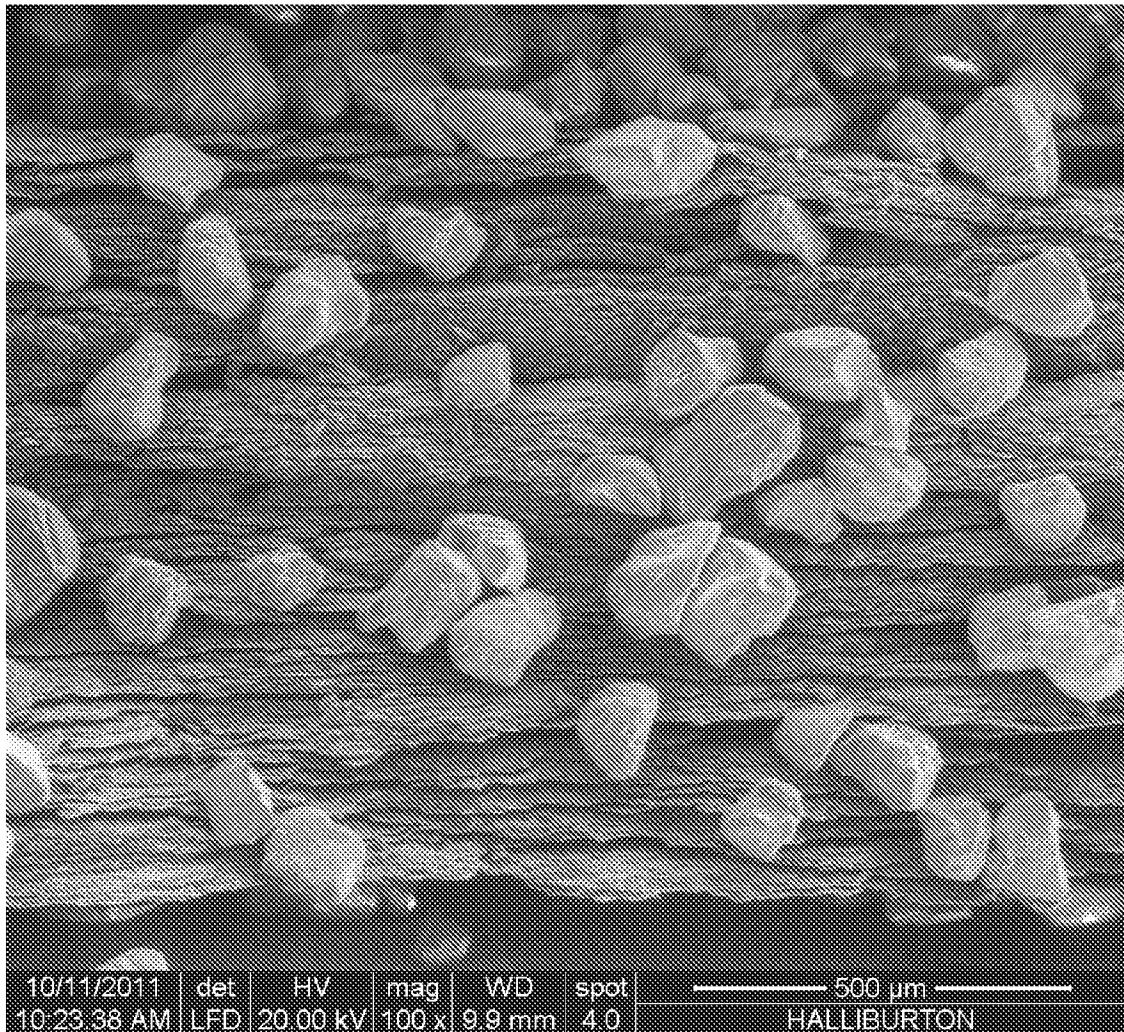
1/3

Figure 1A

2/3**Figure 1B**

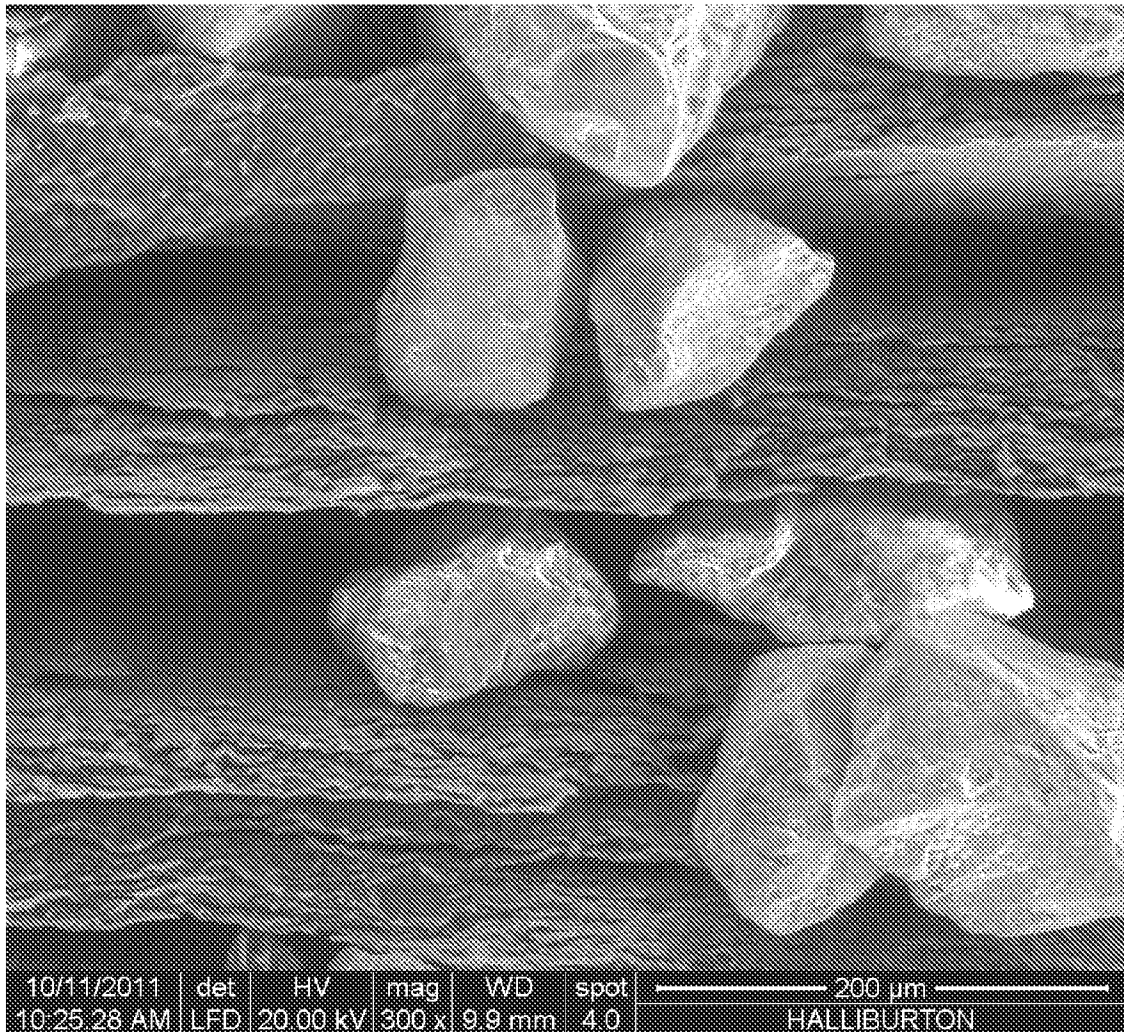
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Figure 1C

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/055720

A. CLASSIFICATION OF SUBJECT MATTER

INV. C09K8/80 C09K8/88 C09K8/92
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C09K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	WO 2013/070082 A1 (RUMA PRODUCTS HOLDING B V [NL]) 16 May 2013 (2013-05-16) page 1, line 28 - page 2, line 5 page 5, line 14 - line 27 -----	1,2,5,6
X	US 2010/089581 A1 (NGUYEN PHILIP D [US] ET AL) 15 April 2010 (2010-04-15)	7,8
Y	claims paragraph [0062] - paragraph [0063] -----	9,10
X	US 2008/142222 A1 (HOWARD PAUL [US] ET AL) 19 June 2008 (2008-06-19)	7,8
Y	paragraph [0026] paragraph [0029] - paragraph [0034] paragraph [0045] - paragraph [0046] claims ----- -/--	9,10



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

8 November 2013

Date of mailing of the international search report

20/11/2013

Name and mailing address of the ISA/

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/176667 A1 (NGUYEN PHILIP D [US]) 9 July 2009 (2009-07-09)	1-6
Y	claims paragraph [0034] - paragraph [0036] -----	9,10
A	US 2005/274523 A1 (BRANNON HAROLD D [US] ET AL) 15 December 2005 (2005-12-15) claims -----	1-10
A	US 2008/066910 A1 (ALARY JEAN ANDRE [FR] ET AL) 20 March 2008 (2008-03-20) claims 1, 40, 41 -----	1-10
A	EP 2 418 263 A1 (WEATHERFORD LAMB [US]) 15 February 2012 (2012-02-15) claims paragraph [0035] - paragraph [0039] -----	1-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2013/055720

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 2013070082	A1	16-05-2013	NONE	

US 2010089581	A1	15-04-2010	AU 2009305258 A1	22-04-2010
			CA 2739383 A1	22-04-2010
			EP 2337827 A1	29-06-2011
			US 2010089581 A1	15-04-2010
			WO 2010043852 A1	22-04-2010

US 2008142222	A1	19-06-2008	AR 064382 A1	01-04-2009
			AU 2007335838 A1	26-06-2008
			CA 2671944 A1	26-06-2008
			CO 6190628 A2	19-08-2010
			DE 112007003060 T5	29-10-2009
			GB 2457197 A	12-08-2009
			RU 2009127803 A	27-01-2011
			US 2008142222 A1	19-06-2008
			WO 2008075237 A2	26-06-2008

US 2009176667	A1	09-07-2009	NONE	

US 2005274523	A1	15-12-2005	CA 2509130 A1	10-12-2005
			US 2005274523 A1	15-12-2005

US 2008066910	A1	20-03-2008	US 2008066910 A1	20-03-2008
			US 2010087342 A1	08-04-2010

EP 2418263	A1	15-02-2012	CA 2747178 A1	09-02-2012
			EP 2418263 A1	15-02-2012
			US 2012031612 A1	09-02-2012
