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(54) **Title:** A METHOD OF CONSOLIDATING A FRACTURE IN A FORMATION

(57) **Abstract:** A method of consolidating a fracture in a formation comprises injecting a solution of an alkali metal silicate into the formation causing the solution to react with the surfaces of the calcium containing inorganic compound deposits, locking the fine material on these surfaces in place and preventing fines generation during production in a well.

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Description

A METHOD OF CONSOLIDATING A FRACTURE IN A FORMATION

Technical Field

[0001] This invention relates to a method of consolidating or reinforcing a fractured formation. More particularly, the invention relates to a method of consolidating fractures in a formation around a wellbore.

Background Art

[0002] Fines are sometimes produced during production in subterranean wells, such as oil or gas wells, or the like, which contain chalk or other calcium carbonates, or which contain sandstone which may or may not include calcium carbonate cementitious material. These fines can cause the fractures in the formation to become blocked and thus decrease the production rate of the well. It is necessary to consolidate these fines in a reliable way so that the fractures do not become blocked and well production is not hampered.

[0003] It is known to use calcium carbonate in a silicate containing solution in sealant compositions. US4762443 describes a fluid composition comprising a sodium metasilicate and a calcium carbonate which is used to make porous material impervious by injecting the composition into the material, which will then harden and set over time.

[0004] In some chalk formations such as, for example, the Valhall field in Norway, the chalk reservoir formation produces fines during production. The first completions in this field were cased-hole gravel stacks, but these were quickly blocked by the chalk fines production, as disclosed in Paper Number 36899-MS entitled "Multiple Proppant Fracturing of a Horizontal Wellbore: an integration of two technologies" 1996 published by the Society of Petroleum Engineers.

[0005] More recently wells have been completed with multiple propped hydraulic fractures. Although these have been very successful, there is still a tendency for the propped fractures to become plugged thus reducing production. The present invention has the advantage of providing a more reliable consolidation of the formation. It also further could be used to limit or prevent lost circulation in fractured carbonate formations.

Disclosure of Invention

[0006] A first aspect of the invention provides a method of consolidating a fracture in the formation around a well comprising:
injecting a solution of an alkali metal silicate into the formation, which causes the solution to react with the surfaces of the calcium containing inorganic compound deposits, locks the fine material on these surfaces in place and substantially prevents fines generation during production in the well.

[0007] Preferably the solution is sodium silicate with a SiO_2 to Na_2O ratio <1.5, such as a sodium metasilicate which has a SiO_2 to Na_2O ratio of 1:1, but other sodium silicates with SiO_2 to Na_2O ratio $\geq$1.5 may be used. Also potassium or lithium silicates may be used.

[0008] A second aspect of the invention provides a method of consolidating a fracture in the formation around a well comprising:
injecting a solution of an alkali metal aluminate into the formation, which causes the solution to react with the surfaces of the calcium containing inorganic compound deposits, locks the fine material on these surfaces in place and substantially prevents fines generation during production in the well.

[0009] Preferably the alkali metal aluminate is sodium aluminate.

[0010] Preferably the calcium containing inorganic compound is calcium carbonate.

[0011] In one form of the invention the solution may be injected into the formation during perforation operations. In another form of the invention the solution may be injected into the formation after perforation. In yet a further form of the invention the solution may be injected into the formation by including it as a pre-pad during a fracturing operation. In another embodiment, the solution may be injected through a hole drilled in the casing which is subsequently plugged.

[0012] The solution may be injected into a plurality of fractures in the formation so as to minimise lost circulation in fractured carbonate formations.

[0013] In one form of the invention the solution of an alkali metal silicate may be added to the drilling fluid. In another form of the invention the solution of an alkali silicate may be in the form of a pill which is placed in front of the area of lost circulation or in regions of a cemented well where the cement has been attacked and degraded.

Mode(s) for Carrying Out the Invention

[0014] The preferred embodiment of the invention is a method of consolidating a fracture in a formation which comprises injecting a solution of sodium silicate or sodium aluminate into the formation around a wellbore of an oil or gas well, or the like. This causes the solution of sodium silicate or sodium aluminate to react with the surfaces of the calcium containing inorganic compound deposits, such as calcium carbonate or chalk in the formation, the fine material is locked in place and the generation of fines is substantially prevented during production oil, gas or the like in the well.

[0015] Potassium or lithium silicates may be used in place of the sodium silicate.

[0016] The solution of sodium silicate reacts with the surface areas of calcium carbonate to form a hard impermeable mass on the surfaces of the calcium carbonate deposits in the fractures. When the calcium carbonate and the silicate solution mix calcium ions react with the silica in the solution to create calcium silicate hydrates. The inorganic compound calcium carbonate is found in rock formations and is also known as chalk, limestone, calcite. Dolomite formations can also be treated in this way.

[0017] The method of the invention can be performed by placing the solution in the wellbore whilst performing perforating operations, by a subsequent injection or by including the sodium silicate solution as a pre-pad during the fracturing operation. If necessary the solution can be pumped post fracture although this is not preferred as the consolidation of any chalk particles that have penetrated into the propped fracture may cause a significant production decrease.

[0018] The chemical reaction caused by injecting or pumping the solution can also be used to control lost circulation in fractured carbonates. Either a drilling fluid based on sodium metasilicate can be used or a pill of sodium metasilicate can be placed in front of the area of lost circulation. As the fluid penetrates the fractures it will start to react with the calcium carbonate along the fracture faces leading to gelation of the solution and consequent reduction in the lost circulation in the well fractures. The solution can also be used to consolidate sandstone formations containing some calcium carbonate and this can be used to control sand production. Treatment of sandstone formations can be done before or after initial production.

[0019] The preferred embodiment of the invention will now be described with reference to specific examples.

[0001] Calcium carbonate:
Socal® 31 (Solvay): a rhombohedral calcite (a precipitated calcium carbonate) with a mean particle size of 70nm

[0002] The calcium carbonate is formed by precipitation from a lime solution. The hydrophobically modified calcium carbonate is reacted with fatty acids in suspension.

[0003] Sodium metasilicate:
Sodium metasilicate (anhydrous) (available from Van Eyck Chimie). In the examples the sodium metasilicate is used as a solution containing 30g of sodium metasilicate and 70g of distilled water.

[0004] **Example 1 showing consolidation with sodium aluminate**

[0005] 50g of fine calcium carbonate (Socal 31 from Solvay) was mixed with 150g of Wata Floc (a 38% sodium aluminate solution from Eaglebrook Inc., Canada) and left to set for 1 week at room temperature. Subsequently, the set material was cored and cut into a cylinder 1 inch in diameter and 2 inches long. A compressive strength measurement showed that the sample had a compressive strength of 0.6 MPa.

[0006] **Example 1 showing consolidation with sodium metasilicate**

[0007] To demonstrate that the method of the invention leads to the setting of a solid, 30g of calcium carbonate with a mean particle size of 70nm (Socal® 31) is mixed in a Waring blender with 100g of the sodium metasilicate solution, which contains 30g sodium metasilicate and 70g distilled water. The solids disperse easily in the solution and the resulting suspension is poured into a container. After 3 hours at room temperature the suspension had set into a solid homogenous mass. No excess fluid is present on the top of the solid.

[0008] Other changes can be made while staying within the scope of the invention.

Claims

1. A method of consolidating or reinforcing a formation around a well that contains calcium-containing inorganic compound deposits, the method comprising: injecting a solution of an alkali metal silicate or alkali metal aluminate into the formation, so as to cause the solution to react with the surfaces of the calcium containing inorganic compound deposits and lock the fine material on these surfaces in place and substantially prevent fines generation during production in the well.
2. A method as claimed in claim 1, wherein the alkali metal silicate is sodium metasilicate.
3. A method as claimed in claim 1, wherein the alkali metal aluminate is sodium aluminate.
4. A method as claimed in claim 1, 2 or 3, wherein the calcium containing inorganic compound is calcium carbonate.
5. A method as claimed in any of the preceding claims, wherein the solution is injected into the formation during perforation operations.
6. A method as claimed in any of claims 1-4, wherein the solution is injected into the formation after perforation.
7. A method as claimed in any of claims 1 to 4, wherein the solution is injected into the formation by including it as a pre-pad during a fracturing operation.
8. A method as claimed in any one of the preceding claims, wherein the solution is injected into a plurality of fractures in the formation so as to minimise a lost circulation zone in fractured carbonate formations.
9. A method as claimed in any preceding claim, comprising positioning a tool containing the solution adjacent a formation to be treated and using the tool to inject the solution into the formation.
10. A method as claimed in claim any of the preceding claims, wherein the solution of an alkali metal silicate is added to a drilling fluid.
11. A method as claimed in claim any of the preceding claims, wherein the solution of an alkali silicate is in the form of a pill which is placed in front of the area of lost circulation.
12. A method as claimed in any preceding claim, wherein the formation to be treated comprises a cement layer around the well.

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. C09K8/56 C09K8/57 C04B28/18

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 C04B

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 practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 101 901 A (SHU PAUL [US] ET AL) 7 April 1992 (1992-04-07) column 2, line 32 - line 48 column 4, line 1 - line 25	1-12
X	US 5 211 233 A (SHU PAUL [US]) 18 May 1993 (1993-05-18) column 2, line 13 - line 62 column 3, line 24 - line 62	1-12
A	US 4 762 443 A (GOUVENOT DANIEL [FR]) 9 August 1988 (1988-08-09) cited in the application column 1, line 34 - line 57	1-12

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5101901 A	07-04-1992	CA 2056885 A1	04-06-1992
US 5211233 A	18-05-1993	US 5362318 A	08-11-1994
US 4762443 A	09-08-1988	CA 1261609 A1	26-09-1989
		CS 8605803 A2	15-03-1988
		CY 1712 A	06-05-1994
		DE 3674510 D1	31-10-1990
		DE 213030 T1	03-09-1987
		DK 364886 A	02-02-1987
		EP 0213030 A1	04-03-1987
		ES 2000609 A6	01-03-1988
		FR 2585698 A1	06-02-1987
		HK 88893 A	03-09-1993
		JP 1723023 C	24-12-1992
		JP 4006753 B	06-02-1992
		JP 62089791 A	24-04-1987
		NO 863107 A	02-02-1987
		SG 48493 G	09-07-1993