United States Patent

Redford

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[54] **METHOD FOR EXTRACTING BITUMEN FROM TAR SANDS**

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[52] **U.S. Cl.** **166/272**

[51] **Int. Cl.** **E21b 43/24**

[58] **Field of Search** 166/271, 272

[56] **References Cited**

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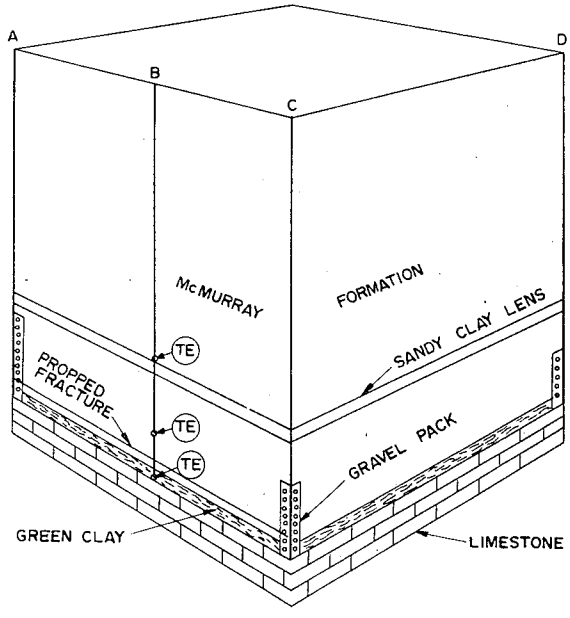
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[57] **ABSTRACT**

Hot caustic solution is injected into an unconsolidated silty lens extending through the Athabasca bitumen reservoir between injection and production wells. Over a period of time part of the lens is rendered movable. The mud is forced to the production well and removed therefrom, leaving a steam-permeable communications zone extending between the wells. Steam can then be injected into the zone to heat the bitumen and form an emulsion which can be forced to the production well. In this way, bitumen is recovered at the surface.

2 Claims, 4 Drawing Figures



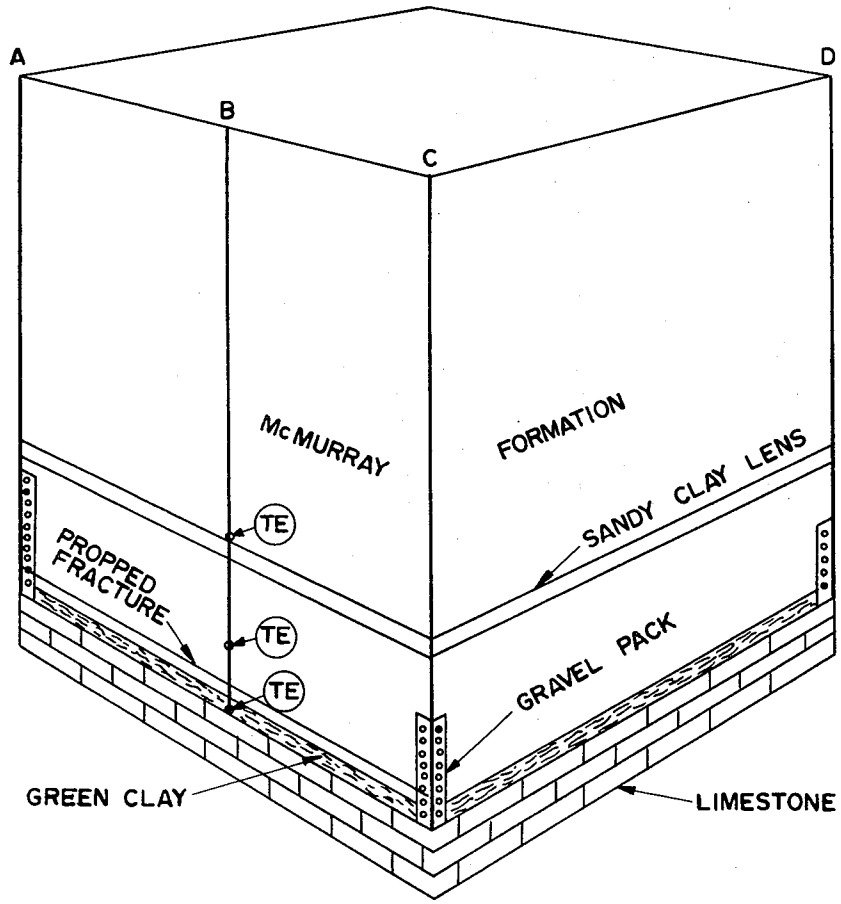
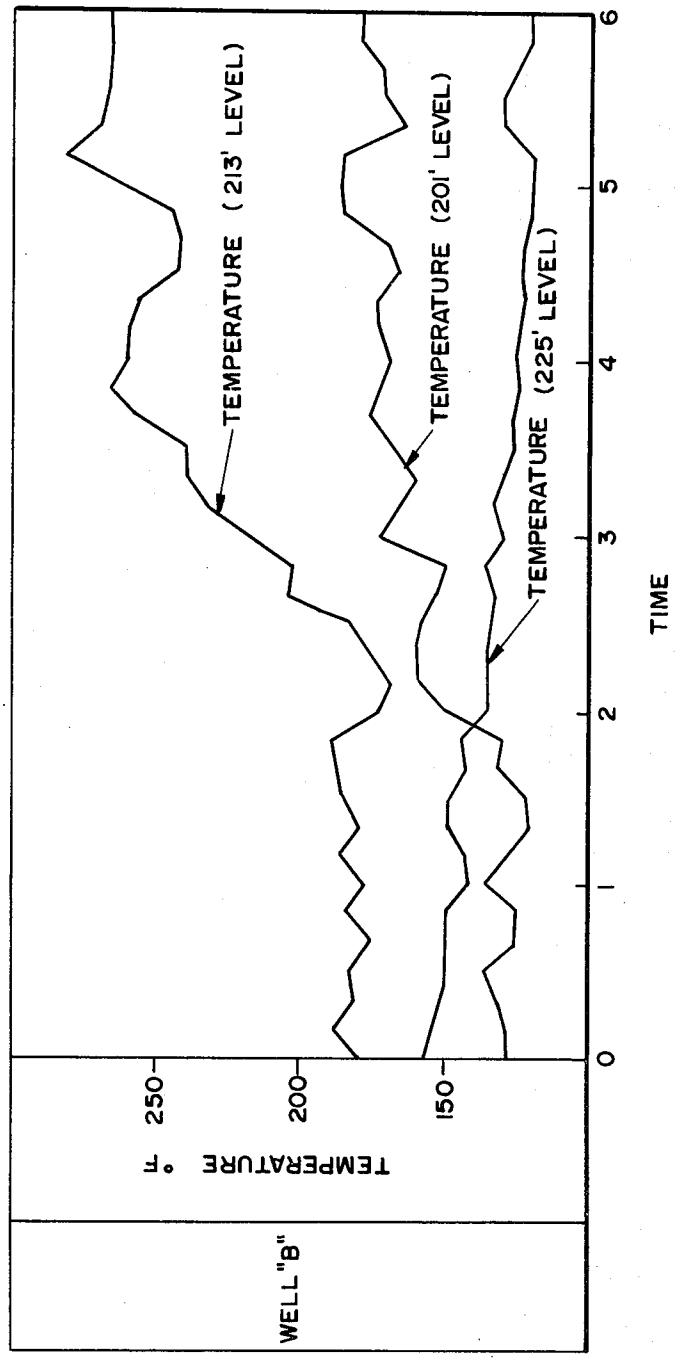


FIG. 1.

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FIG. 2.


WELL "B"
TEMPERATURE °F
250
200
150
TEMPERATURE (213' LEVEL)
TEMPERATURE (201' LEVEL)
TEMPERATURE (225' LEVEL)
0
1
2
3
4
5
6
TIME

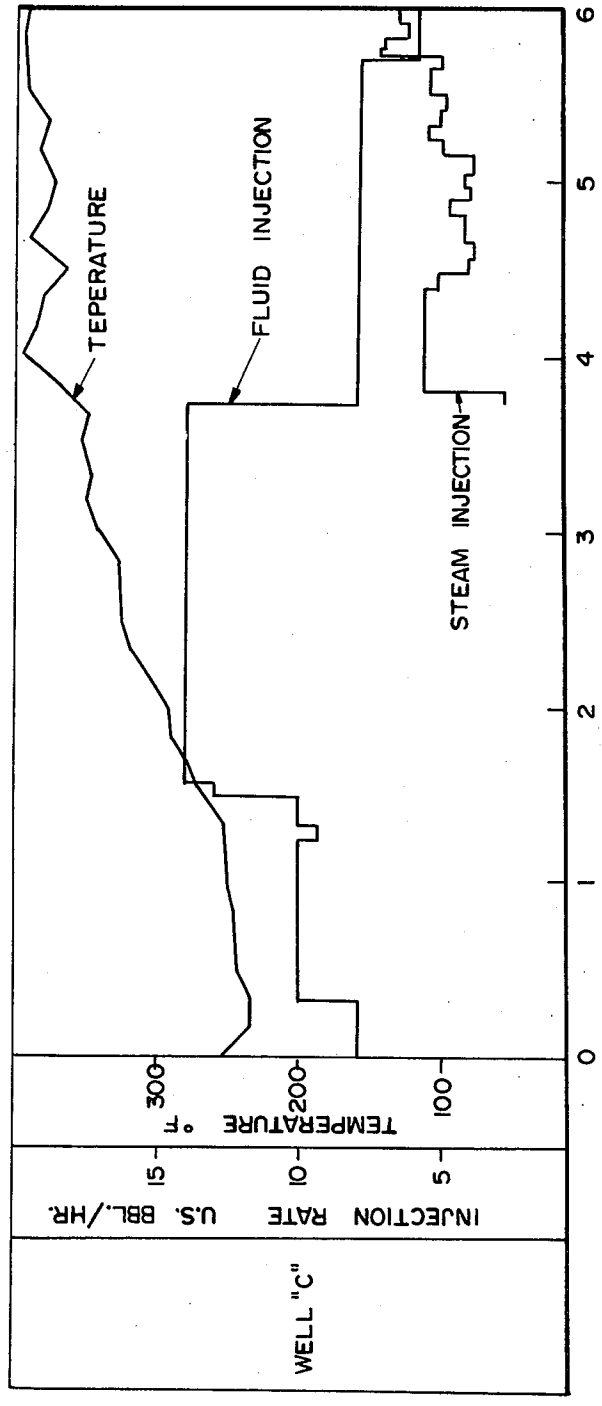

WELL "C"
INJECTION RATE U.S. BBL./HR.
5
10
15
TEMPERATURE °F
100
200
300
0
1
2
3
4
5
6
TIME
TEPERATURE
FLUID INJECTION
STEAM INJECTION

FIG. 3.

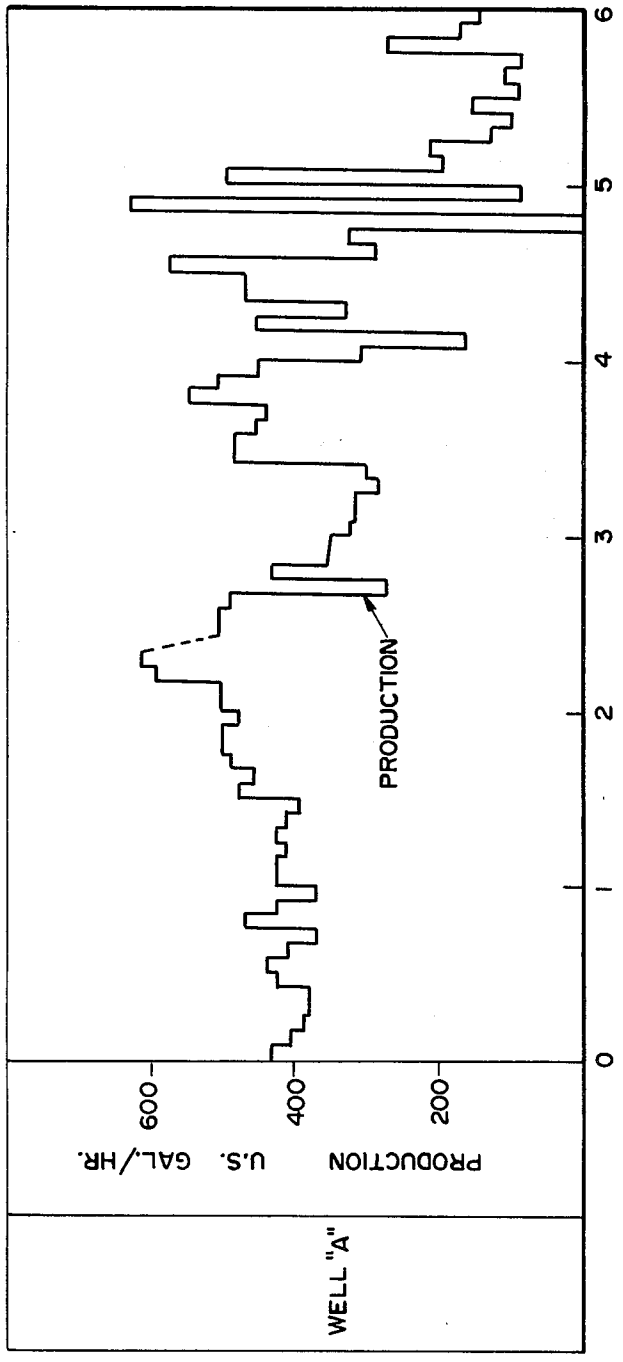

WELL "A"
PRODUCTION U.S. GAL./HR.
600
400
200
0
1
2
3
4
5
6
TIME
PRODUCTION

FIG. 4

METHOD FOR EXTRACTING BITUMEN FROM TAR SANDS

BACKGROUND OF THE INVENTION

This invention relates to a method for developing a hot, steam-permeable communication zone or path within an unconsolidated, bitumen-containing sand reservoir.

When formed, the zone extends between injection and production wells completed in the reservoir. Steam can be injected through the injection well into the zone to thereby gain access to the reservoir across a wide area of contact. In this way, bitumen in the reservoir is heated by the steam and forms an oil-in-water emulsion which is readily driven to the production well and recovered.

The invention is described hereinbelow with regard to the bitumen reservoir located in the McMurray sand formation in the Athabasca region of Alberta, Canada. While the process has particular application to this reservoir, it will be appreciated that it can probably be applied to other reservoirs of the same type.

The Athabasca reservoir contains one of the world's largest known accumulations of bitumen or oil. It has a lateral area of several thousand square miles. In some areas, the bitumen sand is exposed at ground surface; these areas lend themselves to open-pit mining methods (the bitumen is separated from the sand in a plant). The greatest part of the deposit, however, is covered with overburden. In the areas where the overburden is relatively thick, open-pit mining methods are not feasible. The best approach for recovering the bitumen from these areas appears to require an in situ extraction of the bitumen from the sand.

At Athabasca, the bitumen reservoir is located in the lower Cretaceous McMurray formation. The formation is located at relatively shallow depths and is unconsolidated. It is usually comprised of three main types of sedimentary deposits, as follows:

1. massive, cross bedded, coarse-grained sands and conglomerates;
2. massive, medium-grained sands with some cross bedding; and
3. horizontally laminated, fine-grained shaly and clayey micaceous sands (some of which are referred to hereinafter as "silty sands").

The coarse-grained sands are highly porous and irregularly impregnated with bitumen. In many areas of the reservoir these sands are not present adjacent the base of the formation, where they could be used as a steam injection zone.

The medium-grained sands are heavily impregnated with bitumen. As a result they are relatively impermeable to steam injection.

Of the fine-grained sands, those that are interbedded are often impregnated with bitumen and therefore impermeable to steam. However, those that are silty sands are poorly or not at all impregnated with bitumen. These silty sands often occur near the base of the reservoir and have some permeability. They constitute the sands of interest for the present invention.

The bitumen contained in the formation is extremely viscous at reservoir conditions. In fact, it is a brittle solid at the reservoir temperature of 40° F. If the bitumen is to be recovered by in situ methods, it is clear that it has to have its viscosity decreased so that it can

be driven to and recovered from production wells completed in the reservoir.

It is known to drill injection and production wells to the base of the McMurray reservoir and develop a hot, steam-permeable communication zone or path through the formation to connect the wells. Steam is then injected into the zone; it rises through the reservoir and contacts and heats the bitumen. The heated bitumen and condensed steam combine to form a low-viscosity oil-in-water emulsion which runs back down into the communication zone. The emulsion is then forced to the producer wells by the drive force of the injected steam.

The most difficult operation in this scheme is the development of the hot communications zone. Prior art efforts have usually been directed toward horizontally fracturing the impermeable, bitumen-bearing sand and injecting steam or some other fluid through the fracture system, at a pressure above the fracture propping pressure, to heat the system and widen it by removal of adjoining bitumen.

One problem with this approach is that vertical fracturing often occurs when the formation is fractured. Another problem is that, once created, the permeable fracture system often becomes blocked. This can occur due to slumping of the formation as it is heated or by solidification of emulsion which becomes cooled as it is driven through the system away from the injection well. The injection pressure rises when blockage occurs — this leads to vertical fracturing. If vertical fracturing occurs, there is a good possibility that the injected steam will be diverted to a thief zone or will break out at the ground surface. The whole venture may then have to be abandoned.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a novel method for establishing a hot, steam-permeable communications path or zone through a bitumen reservoir between wells;

It is another object to provide such a method for use in the McMurray reservoir in a manner which takes advantage of the geology of the reservoir to effectively guarantee that the communications zone will extend in a generally horizontal plane between the wells;

It is another object to provide such a method whereby the location of the communication path between the wells can be predicted with reasonable certainty.

The present invention finds application in those areas of a bitumen-containing reservoir wherein one or more unconsolidated, silty sand lens are located adjacent the base of the reservoir and extend between injection and production wells.

In accordance with the invention, a hot, basic aqueous solution, such as a caustic solution, is injected through the injection well into the lens for a prolonged period of time at a pressure substantially less than the formation fracturing pressure. In due course, the contained clay in the lens becomes hydrated and movable or thixotropic. At least part of the bed material is fluidized to form mud which is driven to the production well by the differential pressure acting between the injection and production wells. The mud is removed at the production well and a hot, steam-permeable com-

munications path between the wells through the lens is thereby obtained. This path is generally horizontal and its locations can be accurately predicted since it coincides with the location of the lens.

DESCRIPTION OF THE DRAWING

In the drawing:

FIG. 1 is a fanciful representation showing four wells completed at the base of the McMurray formation;

FIG. 2 is a chart showing the changes in temperature over a period of time at three thermocouples positioned in well B of FIG. 1;

FIG. 3 is a chart showing the injection rate and temperature at well C of FIG. 1 for the same period of time;

FIG. 4 is a chart showing the production rate at well A of FIG. 1 for the same period of time.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention will be more clearly understood in conjunction with the following example.

EXAMPLE 1

Three wells A, B and C were completed in the McMurray formation. The wells were spaced 50 feet apart and aligned in a straight line. A fourth well D was spaced 100 feet from C at a right angle to the three-well line.

In this area, the McMurray formation consisted of about 65 feet of varying grades of bitumen-impregnated sand with a silty sand lens intersecting the wells between the 205- and 210- foot levels.

Production well A was bottomed in 3 feet of green clay and limestone at a total depth of 221 feet. The well was cased from surface to 209 feet, leaving an open interval of 12 feet.

Temperature monitoring well B was bottomed in 1 foot of green clay and limestone at a total depth of 225 feet. It was cased and cemented to total depth and perforated at 223 feet.

Injection well C was bottomed in 2 feet of green clay and limestone at a total depth of 226 feet. It was cased from surface to 213 feet, leaving an open interval of 13 feet.

Production well D was bottomed in 2 feet of green clay and limestone at a total depth of 226 feet and cased from surface to 214 feet, leaving an open interval of 12 feet.

Well B was fractured to establish a fracture system connecting wells A, B and C. Standard gravel packs and slotted liners were installed in the open hole intervals of wells A and D. A pre-pack sand-exclusion liner consisting of concentric slotted liners with a gravel filling was installed in well C. Thermocouples were installed at the 225- foot, 216- foot and 205- foot levels in well B.

A horizontal communications path, intersecting B at about 223 foot level, was developed between C and A. This was accomplished by slowly injecting water containing between 0.2 and 0.1 percent by weight sodium hydroxide and between 0.4 and 0.1 percent by weight octylphenoxypolyethyleneoxy ethanol at increasing temperature through well C and producing oil-in-water emulsion at well A. There was no production at well D.

When the communications path between wells A and C had been developed to the point where 14 bbl/hr of 300° F. water containing 0.1 percent sodium hydroxide were being injected into well C and 12 bbl/hr of 250° F. fluid were being produced from well A, sharp fluctuations were noted in the temperature at well B. More particularly, the temperature at the fracture level thermocouple (225- feet) decreased while the temperature at the silty lens thermocouples (213- feet and 201- feet) increased (see FIG. 2). At the same time, the production at well A began to drop steadily. These phenomena indicated that the flow of injected hot fluid had risen in the formation and was now entering a relatively permeable zone between the 205- foot and 216- foot levels, i.e., the silty lens.

Hot sodium hydroxide was then injected for two days into well C at about 200 p.s.i.g. bottom hole pressure. Following this, a mixture of hot caustic solution (at about 4 bbl/hr.) and steam (at about 8–9 bbl/hr.) was injected for 32 days into well C at about 200 p.s.i.g. bottom hole pressure.

At this point in time, well D, which had previously not produced any appreciable amount of fluid, suddenly began to produce mud and steam at a very high rate (estimated at up to 40 bbl/hr.). When D had produced 250 bbl, injection at C was terminated and the site was shut in for 3 days.

Injection of a mixture of steam (9 bbl/hr.), hot water (4 bbl/hr.) and sufficient sodium hydroxide to provide a concentration of 0.1 percent by weight was resumed into well C. The temperature of the mixture was about 380° C. and the injection pressure about 200 p.s.i.g. Well D again produced highly fluid mud. These conditions continued for 6 days, with a total production at D of 390 bbl. The pressure drop between C and D was calculated at less than 20 p.s.i.g. during this 6-day period. Steam production at D was minimized by maintaining a wellhead back pressure on D, thus limiting the production rate and temperature.

Production during the 6-day period gradually changed from a fine sand and clay mixture containing little bitumen, to a mixture of sand, water and bitumen. This latter production separated in the collection pits: the aerated bitumen rose to the surface and the relatively bitumen-free sand fell to the bottom.

The sudden production of fluid at D was preceded by fluctuations in the temperature as monitored at B, and was followed by a sharp drop in pressure at C. These observations indicated that good communications existed between B and D between the 216- foot and 205- foot levels.

These observations would indicate that the silty lens which existed throughout the area between the 205- foot and 210- foot levels started to accept hot caustic solution sometime after a hot communications path had been established between A and C at a lower level. Movement of steam and hot fluids into this zone continued for 34 days with a marked reduction in fluid production at A. This solution and steam apparently swelled the clays in the silty lens to such an extent that the lens became movable and, under the influence of pressure drop between C and D, began to act as a fluid and was produced at D. A hot communications path between C and D was eventually developed which was permeable to fluid. Since its location coincided with the silty sand lens, its location was known.

What is claimed is:

1. A method for developing a hot, steam-permeable communications zone between injection and production wells completed in a bitumen - containing sand reservoir having at least one silty sand lens located adjacent the base of the reservoir, which lens extends between the wells, comprising:

injecting a hot basic aqueous solution into the lens for a prolonged period of time to render at least part of the lens movable;

applying differential pressure to the lens whereby at least part of the lens material is fluidized and driven to the production well; and

removing fluidized material from the production well whereby a hot, steam-permeable communications zone connecting the production and injection wells is gradually developed.

2. The method of claim 1 wherein the solution is a caustic solution.

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