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THERMAL RECOVERY METHOD FOR OIL SANDS

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ABSTRACT OF THE DISCLOSURE

This specification discloses:

The thermal recovery of hydrocarbons from subterranean oil sands having thin interbeds of clay, silt and shale, and siltstone lenses. A well, having a conduit cemented in the oil sands, has a circumferential notch formed therein to provide a fluid entry to the oil sands. Fracturing fluids are forced through the notch creating horizontal fractures extending toward an adjacent production well. Thereafter, fluids are passed, via the well, under thermal recovery conditions through the fractures to release hydrocarbons from the oil sands. These hydrocarbons are recovered from an adjacent production well. The notch is of a longitudinal dimension sufficient to accommodate the longitudinal expansion and movement of the conduit within the well when subjected to fracturing and thermal stresses. The notch may be placed adjacent geological discontinuities in the oil sands to control fracture placement at a desired depth. Logging techniques may be employed to facilitate further the placement of the notch.

This invention relates to a method for recovering hydrocarbons from formations within the earth, and more particularly, to a thermal recovery method for winning hydrocarbons from oil sands.

There are vast deposits in the earth which contain large amounts of hydrocarbons and in which, at the present, the hydrocarbons may be classified as unrecoverable for the lack of a practical and efficient producing method. Among these deposits are the oil sands which contain a highly viscous crude hydrocarbon material not recoverable in its natural state through a well by ordinary production methods. The oil sands found in the deposits along the Athabasca River in Alberta Province, Canada, which are commonly known as the Athabasca tar sands, are a prime example of oil sands formations containing hydrocarbons unrecoverable by conventional petroleum producing methods at the present time. Another example is the shallow sandstonelike formations found in California which contain such viscous crude oils that their recovery by conventional well production methods is unsatisfactory. The hydrocarbons in these oil sands have great viscosities at ambient formation temperatures but advantageously undergo a substantial reduction in viscosity when subjected to elevated temperatures. For this reason, thermal recovery procedures appear to bear great promise as a practical and an economical method for winning these hydrocarbons from oil sands.

Thermal recovery methods generally employ a fluid capable of applying heat to the immobile hydrocarbons so as to reduce their viscosity. This fluid is, of course, passed from the earth's surface into the oil sands. These fluids may effect in situ combustion with air being the best known material for this purpose. Alternatively, the fluids may be priorly heated, such as steam, and introduced singly or in combination with chemical additives to foster the movement in the oil sands of the heated hydrocarbons. One problem encountered in thermal recovery methods is the oftentimes low permeability of the

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oil sands to air and other fluids. One solution to this problem is to create a fracture in the oil sands disposed between spaced-apart wells in which the fluid for heating the hydrocarbons may be circulated freely through the oil sands. However, additional problems are encountered in creating a fracture in the oil sands.

The oil sands, such as in the Athabasca deposits, have a plastic nature which results in a hybrid stress behavior resembling that of a liquid hydrocarbon and a solid substratum. Thus, upon subjecting the oil sands to hydrostatic fluid pressure, the oil sands yield to redistribute partially the stresses prior to their initial failure in fracturing. This characteristic can result in rupture of the bond between a well casing, cement, and the adjacent oil sands. As a result, fluids can bypass portions of the oil sands by traveling along the surfaces parted by such bond rupture. Additionally, placing a fracture at a desired depth within the oil sands is complicated by the passage of the fracturing fluids along these surfaces in cased wells. Thus, a fracturing fluid may pass along such surfaces, such as between the cemented well and the presented face of the oil sands, to some depth other than the desired depth until a sufficient weakness in the oil sands is encountered in which the fracture may be generated. Obviously, this problem of creating a fracture at a desired depth within the oil sands is further complicated by a haphazard assortment of materials variable in hydrocarbon content and geological characteristics forming these formations.

For example, the oil sands in deposits along the Athabasca River are very variable along their vertical extent in the amounts of hydrocarbons they contain. In the oil sands thin beds of clay, silt, and shale sections (including shaley sand) as well as lenses of barren siltstone and the like are interbedded. Further, these interbeddings may be continuous or discontinuous in the horizontal depending upon the locality of the deposit.

As a result of the tendency of fracturing fluids to break the bond between a cemented well and the presented face of the oil sands, and for other reasons, it is desired to have good bonding of cement to the oil sands and metal structures. This leads to additional problems when the cemented wells are used for thermal recovery methods. Using a cemented well for hydraulically fracturing the oil sands places the well conduits under severe tension. This can result in breaking the cemented well bonding to the oil sands, or parting of the conduits cemented in the well. Thermal stress can also create undesired results. For example, operation of heaters in these cemented wells adjacent perforations providing fluid communication to the oil sands results in severe thermal expansion particularly in the metal conduits in the cemented well. This thermal expansion can produce disastrous effects. The liner or metal conduit collapses from thermal distortion and can cause destruction of any equipment contained within the cemented well. Additionally or alternatively, the thermal expansion breaks the cement to oil sands bond with the liner or metal conduit and surrounding cement being extended in the vertical within the well. Even on shallow wells used for in situ combustion, the liner or metal conduit with its surrounding cement may be extended two feet above its initial position relative to the earth's surface as a result of thermal stress.

It is the purpose and principal object of this invention to provide a thermal recovery method employed for recovering hydrocarbons from a subterranean formation, especially oil sands, without suffering the undesired aforementioned results. Another object is to provide a thermal recovery method for employment in oil sands to produce hydrocarbons which resolves the problems heretofore stated. Another object is to create expeditiously, even with cemented wells, a fracture in the oil sands adjacent the

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depth at which it is desired. Another object is to create a fracture in oil sands with the rupturing of the bonding of a cemented well to the oil sand and the traveling of the fracturing fluid vertically adjacent the cemented well reduced to a minimum. Another object is to avoid the thermal expansion problems suffered when cemented wells are employed in thermal recovery methods practiced in oil sands. Another object is to employ the variable geological nature of oil sands to advantage in a thermal recovery method. Another object is to create a fracture at an exact depth in the oil sands. Another object is to provide in a method for the thermal recovery of hydrocarbons the creation of a fracture adjacent a desired depth in the oil sands and avoidance of undesired thermal distortion effects to cemented wells. Another object is the creation of a fracture in oil sands with fracturing pressures less than previously required. These and other objects will be more apparent when read in conjunction with the following detailed description of embodiments of the present invention, the appended claims, and the attached drawings, wherein:

FIGURE 1 is a vertical section taken through the earth illustrating an oil sands formation with the structures employed for carrying out a thermal method for recovering hydrocarbons according to the present invention;

FIGURE 2 is an enlargement of the left-hand portion of FIGURE 1 but with the addition of certain structures for locating initiated fractures; and

FIGURE 3 is an enlarged section of FIGURE 1 like FIGURE 2 but illustrating an application of the present method to oil sands containing shale sections.

In the drawings and the following description, like structures will be designated with like nomenclature and numerals.

Referring to FIGURE 1 of the drawing, a description of the preferred embodiment of the thermal recovery method of this invention will be described in reference to an illustrative subterranean formation. A subterranean formation 11 is shown which contains a deposit of oil sands 12 disposed below the earth's surface 13 beneath an overburden 14. The oil sands 12 rest upon a bedding 16. Assuming the formation 11 to be a portion of the Athabasca River deposit, the overburden 14 usually is a thin layer of soil mantle and glacial drift together with other types of similar strata. Also there may be soft sandstones, siltstones, and shale found in the overburden 14. The overburden 14 is variable in thickness. The bedding 16 in the Athabasca River deposit usually is limestone. The oil sands 12 are variable in thickness, for example, from several feet to several hundred feet in thickness, and in composition, for example in their hydrocarbon content. The oil sands 12 contain thin interbeds of clay 17, silt 18, as well as lenses 19 of barren siltstone and the like. Also interbedded may be one or more stratum of shale which will be identified and discussed hereinafter. It is to be noted that these various interbeds are usually discontinuous. Sometimes they may be considered only to be portions of the oil sands 12 barren of any hydrocarbons. Although the formation 11 has been particularly described with oil sands 12 being within the Athabasca River deposit, it is obvious that other oil sands deposits are similar in structure.

A plurality of spaced-apart boreholes 23 and 24 are provided extending from the earth's surface 13 downwardly to a desired depth into the oil sands 12. Preferably, the boreholes 23 and 24 extend substantially the entire thickness of the oil sands 12. Within the borehole 23 is disposed a metal casing 26 to provide a conduit for conveying fluids between the earth's surface 13 and the oil sands 12. The casing 26 is cemented within the borehole 23 by a surrounding sheath 27 of cement. The sheath 27 is bonded to the casing 26 and also to the presented face of the oil sands 12. The sheath 27 may be formed in any suitable manner. For example, neat cement may be disposed within the casing 26 and then displaced downward-

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ly by means of a cementing plug 28. The neat cement is forced into the annulus between the borehole 23 and the exterior of the casing 26 as is shown in FIGURE 1.

Additional structures are operably associated with the casing 26 to facilitate the practice of the present method. An inlet 29 for passing fluids is provided in the casing 26. A wellhead 31 is secured at the top of the casing 26. The wellhead 31 is adapted to permit the insertion of various apparatus into the interior of the casing 26. It may be provided with additional inlet connections for passing fluids to the interior of the casing 26, if desired.

The borehole 24 is provided with means for producing formation fluids from the oil sands 12 to the earth's surface 13. Such means may take any form and there are many known structures suited for this purpose. For example, the borehole 24 receives a production casing 36 which is provided with a plurality of perforations 37 along its extent adjacent the oil sands 12. Preferably, the perforations 37 extend to the lowermost extremities of the borehole 24. The casing 36 is sealed above the oil sands 12 to the overburden 14 by any suitable packer means, such as by a cement and packer assembly 38. The casing 36 carries a wellhead 41 on its upper extremity with a tubing 42 concentrically extending through the wellhead 41 down into the lower extremity of the casing 36. If sufficient bottomhole pressure obtains, fluids produced from the formation 12 may be flowed to the surface, or the tubing 42 may be equipped with a suitable downhole pump, not shown. Of course, the borehole 24 can be provided with other types of means for producing formation fluids from the oil sands 12. For example, an inlet 39 may be employed for the fluid lifting of hydrocarbons through the tubing 42 to the earth's surface 13. The produced fluids can be collected at the earth's surface 13 in any suitable type of receiver, which receiver is not shown in FIGURE 1. However, those skilled in the art can provide a suitable receiver for this purpose.

Although the preceding procedural steps have been disclosed in certain order, it is recognized that these steps may be carried out in other sequences as full equivalence within the spirit of the present invention to obtain satisfactory results.

The casing 26 with the surrounding sheath 27, as one unitary and rigid structure, are bonded over an extensive distance to the oil sands 12 and the overburden 14. This bonding, of course, provides a necessary fluid-tight seal to prevent fluids from escaping between the meeting surfaces of the casing 26, the sheath 27, and the oil sands 12. However, vertical movement between the casing 26 and sheath 27 relative to the adjacent oil sands 12 can produce many undesired results, as has been earlier described, during fracturing and in response to thermal expansion.

This bonding of the casing 26 with the sheath 27 and to the oil sands 12 is preserved by this invention during subsequent fracturing of the oil sands 12. A transverse circumferential segment is removed from the casing 26 and the sheath 27 to produce a window 46 through which fluids may easily pass between the casing 26 and the oil sands 12. Preferably, the window 46 is positioned at or adjacent the depth in the oil sands 12 at which a fracture is desired to be produced. It will be apparent that producing the window 46 severs the casing 26 and sheath 27. With the complete separation of the casing 26 and sheath 27, fracturing the oil sands 12 adjacent the depth of the window 46 can produce considerable vertical movements without rupturing the bonding between the oil sands 12, the sheath 27, or the casing 26. Obviously, the casing 26 with the sheath 27 can move with the oil sands 12 above the window 46.

Preferably, the window 46 has a longitudinal or vertical dimension at least equal to the greatest longitudinal dimensional increase of the casing 26 and sheath 27 resulting from subsequent thermal expansion when the oil sands 12 are subjected to the remainder of the thermal recovery method. Any means may be employed for pro-

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ducing the window 46. For example, the notching equipment shown in U.S. Patent 3,050,122 may be used for this purpose. With the window 46 having the stated vertical dimension, it will also be apparent that space is provided in the casing 26 and sheath 27 to accommodate elongations caused by subsequent thermal expansion. Thus, when heated fluids are transmitted via the window 46 between the casing 26 and the oil sands 12, the thermal expansion forces cannot cause the casing 26 with the affixed sheath 27 to buckle, or otherwise impair their operability.

The oil sands 12 are fractured by introducing a fluid under pressure from the casing 26 through the window 46 into the oil sands 12. Generally, the fluid must be under a pressure initially much greater than required merely to raise the overburden 14 and the superimposed part of the oil sands 12 as a result of the plasticlike nature of the oil sands 12. After a fracture 47 is initiated in the oil sands 12, a lesser fracturing pressure will extend this fracture 47 from the borehole 23 toward, and, preferably, to the borehole 24. This pressure is about that amount required to lift the overburden 14 and superimposed oil sands 12. Any fluid may be used under pressures suitable for creating the fracture 47. Many known fluids are employed in conventional fracturing procedures and these fluids may be used for producing the fracture 47. For example, the fracturing fluid may be water with various additives such as agents to correct for undesired fluid-loss and non-Newtonian behavior. Also, the fracturing fluid may include various propping agents. For example, it has been found useful in a water-based fracturing fluid to add several pounds per gallon of frac sand, preferably in the 20-40 mesh size. The fracture 47 obviously provides a permeable channel through which the fluids employed for the thermal recovery of hydrocarbons from the oil sands 12 may readily pass between the boreholes 23 and 24.

It is desirable in many instances that the fracture 47 be disposed substantially in a horizontal plane. For this purpose, there is formed through the window 46 a continuous circumferential V-shaped notch 48 into the oil sands 12. The equipment described for producing the window 46 may also be used to produce the notch 48. The notch 48 is oriented in a substantially horizontal plane and needs to penetrate the oil sands 12 only a short distance. It has been found that employment of the notch 48 with the above-described hydraulic fracturing step produces the fracture 47 in a substantially horizontal plane between the boreholes 23 and 24. It is found that less pressure is required for the fracturing fluid to initiate the fracture 47 where the notch 48 is present in the oil sands 12. The advantages of such a horizontal fracture 47 are self-evident and include increased horizontal sweep efficiency for the thermal recovery of hydrocarbons from the oil sands 12. Also, a horizontal fracture 47 allows freer vertical movement of the superimposed oil sands 12 and overburden 14. Of course, the notch 48 is placed most nearly adjacent the depth at which the fracture 47 is desired.

In many instances it will be found that the fracture 47 is not initiated at a desired depth as a result of the variable nature of the hydrocarbon content and composition of the oil sands 12. With reference to FIGURE 2, such fracture initiations at undesired depths are illustrated. The fracturing fluid can break the bond between the sheath 27 and the presented face of the oil sands 12 to travel to a depth at which a structural weakness of one nature or another exists in the oil sands 12. For example, upon introduction of fracturing fluid through the window 46, a fracture 47' is initiated at a lesser depth than desired for the fracture 47. Continued injection of the fracturing fluid under these circumstances would result in extension of the fracture 47' at a depth other than the one desired. Under such conditions, a fracture can be created at a desired depth by the following steps of the

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present method. First, the depth at which the fracture 47' is initiated is determined. Any suitable means may be employed for this determination. One means found well suited for this purpose is to provide in the fracturing fluid a radioactive isotope which emits radiation detectable by a suitable gamma-ray detector 51 moved coaxially within the casing 26 by a suitable mechanism. In conjunction with the detector 51 is used a surface read-out means 52 for displaying radiation intensities. Movement of the detector 51 within the casing 26 will detect a peak radiation intensity at the depth containing the initiated fracture 47'. Obviously, the casing 26 is cleared of fracturing fluid. Hydraulic cement or other fracture sealing material is injected through the window 46 to fill the initiated fracture 47'. After sealing the fracture 47', fracturing fluid is again injected through the window 46. Assuming formation of another initiated fracture 47'' to be at a depth other than desired, the steps of detection and sealing are repeated. Thus, initiated fractures at depths in the oil sands 12 other than that depth desired for the fracture 47 are sealed. The fracture 47 will now be initiated either exactly at, or acceptably close to, the depth desired for the fracture 47 in carrying out the thermal recovery of hydrocarbons from the oil sands 12. The advantages of such fracture placement can be appreciated when the conditions surrounding the thermal recovery of hydrocarbons are examined. One particular advantage is in the employment of a fracture disposed within the lower third of the oil sands 12 for improving the vertical extent of formation heating. Other advantages will be apparent to those skilled in the art.

It has been found that in many oil sands 12, besides the interbedded clays 17, silts 18, lenses of siltstone 19, and the like, there are intrastratified shale sections 56 as shown in FIGURE 3. The shale sections 56, including shaley sand sections, are varied in nature and of random distribution like the other described structures in the oil sands 12. For example, in one deposit of oil sands 12, the shale sections 56 are found varied in spacings from one another of 1 foot up to 50 feet with a thickness between a few inches and 10 feet. It has been found to be of great advantage in placing the window 46, and the notch 48, adjacent to the shale section 56 nearest to the depth at which the fracture is desired. Subsequent introduction of fracturing fluid under pressure through the window 46 will result in the fracture 47 being formed along the upper boundary of the lowermost illustrated shale section 56. Reference to FIGURE 3 will make clear such structure. Although the window 46, and the notch 48, may be somewhat spaced from the nearest shale section 56, the fracture usually will be initiated along the upper boundary of the shale section 56. If not, then the initiated fracture may be detected and sealed as previously described. Then the fracture 47 can be formed where desired.

Preferably, the apex of the notch 48 is placed in horizontal alignment with the upper boundary of the shale section 56 nearest to the depth at which the fracture is desired. As a result, the fracture 47 is initiated along the upper boundary of the shale section 56. If the shale section 56 extends between the boreholes 23 and 24, the fracture 47 will follow such upper boundary to the borehole 24. However, the shale section 56 need not be continuous between the boreholes 23 and 24. It is sufficient when it extends only a short distance from the borehole 23 in order that the initiation of the fracture 47 occurs in the manner described. Once the fracture 47 is initiated, it may be extended in the horizontal as has been described without a continuous upper boundary of the shale section 56 to follow.

Each shale section 56 may be located in any suitable manner. For example, the borehole 23 may be continuously cored through its entirety while being drilled into the oil sands 12. The resulting cores disclose the presence, depth and thickness of each shale section 56 within the oil sands 12. If desired, a conventional resistivity log may

be taken after completion of the borehole 23 to disclose the occurrence of each shale section 56 with a correlation to their depths within the oil sands 12. Other logging methods applicable to open boreholes, of course, may be used. The casing 26 and sheath 27 may be secured within the borehole 23 and a cemented well logging method can be used. In this situation, the location of each shale section 56 may be determined by natural gamma ray logging. For this purpose, a detector 57 is disposed within the casing 26 and arranged for vertical movement therein with a connection to a readout apparatus 58 where each shale section 56 is indicated by an increase in natural gamma ray radiation. Thus, the borehole 23 may be logged by any one of several methods for the presence of one or more of the shale section 56 within the oil sands 12.

With the fracture 47 extending between the boreholes 23 and 24, thermal recovery of the hydrocarbons from the oil sands 12 may be effected. Any suitable thermal recovery procedure may now be employed to effect the release and recovery of the hydrocarbons. For example, such procedure may include the passing of a fluid under thermal recovery conditions into the fracture 47 via the window 46. As a result of heating the hydrocarbons within the oil sands 12, fluids are produced through perforations 37 into the production casing 36. Thereafter, these fluids are lifted through the tubing 42 to the earth's surface 13. Hydrocarbons are then recovered from such fluids by a suitable means which may be selected from means well known to those skilled in the art.

The fluid employed in the thermal recovery procedure, which fluid passes through the window 46 into the fracture 47, is preferably a fluid which obtains in situ combustion in the oil sands 12 when introduced under combustion conditions into the fracture 47. As an illustration, air, or other combustion-supporting fluids, is forced into the casing 26 through the inlet 29. An electric heater 61 is positioned within the casing 26, preferably with its lower extremity slightly above the window 46. The heater 61 is energized by any suitable means such as by connection through an electrical conductor 62 which extends through the wellhead 31 to a surface-disposed generator 63. The generator 63 powered by any suitable prime mover produces electrical energy which the heater 61 converts into heat energy. The heat energy is transferred from the heater 61 to the air flowing into the fracture 47. After a suitable period of time, the air has heated the oil sands 12 adjacent the borehole 23 sufficiently to initiate combustion along the fracture 47. At this time the heater 61 may be deenergized since combustion within the fracture 47 is self-sustaining upon the continued injection of air. The injection of air into the fracture 47 is continued until a suitable production of hydrocarbons has been recovered from the oil sands 12.

A heated fluid, which is passed through the window 46 into the fracture 47, may be used in the thermal recovery procedure, if desired. Preferably, the heated fluid is steam, with or without various additives, such as caustic. Of course, the borehole 23 is provided with suitable equipment to facilitate the injection of the heated fluid.

Although several examples of fluids to effect the thermal recovery of hydrocarbons have been described, other fluids may be employed. For example, liquids may be passed through the fracture 47 under thermal recovery conditions for making mobile the hydrocarbons contained in the oil sands 12.

It has been found that the notch 48 at the window 46 produces in the oil sands 12 not only fractures oriented in the horizontal but fractures which have a predominant directional characteristic of propagation in the horizontal. Thus, once this characteristic is known for any oil sands 12, it is preferred to orient the boreholes 23 and 24 from one another in alignment with the predominant direction of propagation of the hydraulically induced fracture 47 in the oil sands 12. By this means, greater horizontal

extension of the fracture 47 may be obtained with the expectations that the amount of energy for effecting hydraulic fracturing is at a minimum for each unit area of the fracture 47 induced into the oil sands 12.

It will be obvious that the steps for providing the fracture 47 in the foregoing embodiments of the present method are of great utility in and of themselves. Also, these steps can be utilized in any method for thermally recovering hydrocarbons from a subterranean formation by the placement of the fracture 47 at a desired depth. As one example, these steps can be utilized to great advantage where only the borehole 23 is employed, as has been described, without using the borehole 24 as the means for producing formation fluids. For this purpose, the injection of the fluid used in the thermal recovery procedure through the window 46 is interrupted while the resultant formation fluids are produced from the oil sands 12 via the fracture 47 into the casing 26 and then, from which fluids, are recovered hydrocarbons.

From the foregoing it will be apparent that a method is disclosed which accomplishes all of the stated objects of this invention. Various modifications of the disclosed method may be made by those skilled in the art without departing from the spirit of this invention. Similarly, the disclosed steps of this method when employed both in combination and in sub-combination are of utility. For this and other reasons, the present description is intended to be illustrative of this invention, and only the appended claims are to be considered as limitative of the invention.

What is claimed is:

1. A method for the thermal recovery of hydrocarbons from a deposit of oil sands residing in a subterranean formation, said oil sands having thin interbeds of clay and silt, shale sections and siltstone lenses, comprising the steps:

- (a) providing a plurality of spaced-apart boreholes in the formation which extend into the oil sands,
- (b) cementing to the surrounding formation and oil sands, within a first borehole, a conduit for conveying fluids,
- (c) providing a second borehole with means for producing formation fluids therefrom,
- (d) removing from the conduit and surrounding cement a transverse circumferential segment producing a window therein having a vertical dimension at least equal to the longitudinal dimensional increase of the conduit and surrounding cement resulting from subsequent thermal expansion, said window produced at about the depth in the oil sands where a fracture is to be initiated,
- (e) introducing a fluid under pressure into the oil sands from the conduit via the window to create a fracture in the oil sands extending from the first borehole in the direction of the second borehole,
- (f) passing a fluid under thermal recovery conditions into the fracture via the window,
- (g) producing fluids from the second borehole, and
- (h) recovering hydrocarbons from such fluids.

2. The method of claim 1 wherein the first and second boreholes are aligned with the direction of preferential propagation of the induced fractures in the oil sands.

3. A method for the thermal recovery of hydrocarbons from a deposit of oil sands residing in a subterranean formation, said oil sands having thin interbeds of clay and silt, shale sections and siltstone lenses, comprising the steps:

- (a) providing a plurality of spaced-apart boreholes in the formation which extend into the oil sands,
- (b) cementing to the surrounding formation and oil sands, within a first borehole, a conduit for conveying fluids,
- (c) providing a second borehole with means for producing formation fluids therefrom,
- (d) removing from the conduit and surrounding cement a transverse circumferential segment producing a

window therein having a vertical dimension at least equal to the longitudinal dimensional increase of the conduit and surrounding cement resulting from subsequent thermal expansion, said window produced at about the depth in the oil sands where a fracture is to be initiated,

- (e) forming into the oil sands at the window a continuous circumferential V-shaped notch with such notch oriented in a substantially horizontal plane,
- (f) introducing a fluid under pressure into the oil sands from the conduit via the window to create a fracture in the oil sands extending from the first borehole in the direction of the second borehole,
- (g) passing a fluid under thermal recovery conditions into the fracture via the window,
- (h) producing fluids from the second borehole, and
- (i) recovering hydrocarbons from such fluids.

4. The method of claim 3 wherein the apex of said V-shaped notch is disposed in the oil sands adjacent a shale section nearest to the depth at which a fracture is desired to be initiated.

5. The method of claim 3 wherein the apex of said V-shaped notch is positioned in horizontal alignment with the upper boundary of a shale section, which boundary is nearest to the depth at which a fracture is desired.

6. A method for the thermal recovery of hydrocarbons from a deposit of oil sands residing in a subterranean formation, said oil sands having thin interbeds of clay and silt, shale sections and siltstone lenses, comprising the steps:

- (a) providing a plurality of spaced-apart boreholes in the formation which extend into the oil sands,
- (b) cementing to the surrounding formation and oil sands, within a first borehole, a conduit for conveying fluids,
- (c) providing a second borehole with means for producing formation fluids therefrom,
- (d) removing from the conduit and surrounding cement a transverse circumferential segment producing a window therein having a vertical dimension at least equal to the longitudinal dimensional increase of the conduit and surrounding cement resulting from subsequent thermal expansion, said window positioned at about the depth in the oil sands where a fracture is to be initiated,
- (e) introducing a fluid under pressure into the oil sands via the window to initiate a fracture,
- (f) determining the depth in the oil sands at which the fracture is initiated,
- (g) sealing each initiated fracture at a depth other than at the desired depth,
- (h) repeating steps (e), (f), and (g) until a fracture is initiated in the oil sands at the desired depth,
- (i) continuing the introduction of a fluid under pressure to extend the fracture in the oil sands at the desired depth from the first borehole in the direction of the second borehole,
- (j) passing a fluid under thermal recovery conditions into the fracture via the window,
- (k) producing fluids from the second borehole, and
- (l) recovering hydrocarbons from such fluids.

7. A method for the thermal recovery of hydrocarbons from a deposit of oil sands residing in a subterranean formation, said oil sands having thin interbeds of clay and silt, shale sections and siltstone lenses, comprising the steps:

- (a) providing a plurality of spaced-apart boreholes in the formation which extend into the oil sands,
- (b) cementing to the surrounding formation and oil sands, within a first borehole, a conduit for conveying fluids,
- (c) providing a second borehole with means for producing formation fluids therefrom,
- (d) removing from the conduit and surrounding cement a transverse circumferential segment produc-

ing a window therein having a vertical dimension at least equal to the longitudinal dimensional increase of the conduit and surrounding cement resulting from subsequent thermal expansion, said window positioned in the oil sands at about the depth at which a fracture is to be initiated,

- (e) forming into the oil sands at the window a continuous circumferential V-shaped notch with such notch oriented in a substantially horizontal plane,
- (f) introducing a fluid under pressure into the oil sands via the window to initiate a fracture,
- (g) determining the depth in the oil sands at which the fracture is initiated,
- (h) sealing each initiated fracture at a depth other than the desired depth,
- (i) repeating steps (f), (g), and (h) until a fracture is initiated in the oil sands at the desired depth,
- (j) continuing the introduction of a fluid under pressure to extend the fracture in the oil sands at the desired depth from the first borehole in the direction of the second borehole,
- (k) passing a fluid under thermal recovery conditions into the fracture via the window,
- (l) producing fluids from the second borehole, and
- (m) recovering hydrocarbons from such fluids.

8. A method for the thermal recovery of hydrocarbons from a deposit of oil sands residing in a subterranean formation, said oil sands having thin interbeds of clay and silt, shale sections and siltstone lenses, comprising the steps:

- (a) providing a plurality of spaced-apart boreholes in the formation which extend into the oil sands,
- (b) logging a first borehole to determine the depth of shale sections in the vicinity of the depth in the oil sands at which a fracture is desired to be initiated,
- (c) cementing to the surrounding formation and oil sands, within a first borehole, a conduit for conveying fluids,
- (d) providing a second borehole with means for producing formation fluids therefrom,
- (e) removing from the conduit and surrounding cement a transverse circumferential segment producing a window therein having a vertical dimension at least equal to the longitudinal dimensional increase of the conduit and surrounding cement resulting from subsequent thermal expansion, said window provided at about the depth in the oil sands of a shale section nearest to the depth where a fracture is to be initiated,
- (f) forming into the oil sands at the window a continuous circumferential V-shaped notch with such notch oriented in a substantially horizontal plane and with the apex of the notch positioned adjacent the shale section nearest to the depth at which a fracture is desired to be initiated,
- (g) introducing a fluid under pressure into the oil sands from the conduit via the window to create a fracture in the oil sands extending from the first borehole in the direction of the second borehole,
- (h) passing a fluid under thermal recovery conditions into the fracture via the window,
- (i) producing fluids from the second borehole, and
- (j) recovering hydrocarbons from such fluids.

9. The method of claim 8 wherein the apex of the notch is positioned in horizontal alignment with the upper boundary of the shale section.

10. A method for the thermal recovery of hydrocarbons from a deposit of oil sands residing in a subterranean formation, said oil sands having thin interbeds of clay and silt, shale sections and siltstone lenses, comprising the steps:

- (a) providing a plurality of spaced-apart boreholes in the formation which extend into the oil sands,
- (b) logging a first borehole to determine the depth of

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- shale sections in the vicinity of the depth in the oil sands at which a fracture is desired to be initiated,
- (c) cementing to the surrounding formation and oil sands, within a first borehole, a conduit for conveying fluids,
- (d) providing a second borehole with means for producing formation fluids therefrom,
- (e) removing from the conduit and surrounding cement a transverse circumferential segment producing a window therein having a vertical dimension at least equal to the longitudinal dimensional increase of the conduit and surrounding cement resulting from subsequent thermal expansion, said window provided at about the depth in the oil sands adjacent a shale section nearest to the depth at which a fracture is to be initiated,
- (f) introducing a fluid under pressure into the oil sands from the conduit via the window to create a fracture extending from the first borehole in the direction of the second borehole,
- (g) passing a fluid under thermal recovery conditions into the fracture via the window,
- (h) producing fluids from the second borehole, and
- (i) recovering hydrocarbons from such fluids.
11. The method of claim 10 wherein the window is positioned in horizontal alignment with the upper boundary of the shale section.
12. A method for creating a fracture at about a desired depth in a deposit of oil sands residing in a subterranean formation from a borehole subject to thermal expansion, said oil sands having thin interbeds of clay and silt, shale sections and siltstone lenses, comprising the steps:
- (a) providing in the formation to extend into the oil sands a borehole and therein surrounding cementing a conduit for conveying fluids between the oil sands and the earth's surface,
- (b) removing from the conduit and surrounding cement a transverse circumferential segment producing a window therein having a vertical dimension at least equal to the longitudinal dimensional increase of the conduit and surrounding cement resulting from subsequent thermal expansion, said window positioned at about the depth in the oil sands where a fracture is to be initiated,
- (c) introducing a fluid under pressure into the oil sands via the window to initiate a fracture,
- (d) determining the depth in the oil sands at which the fracture is initiated,
- (e) sealing each initiated fracture at a depth other than at the desired depth,

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- (f) repeating steps (c), (d), and (e) until a fracture is initiated in the oil sands at the desired depth, and
- (g) continuing the introduction of a fluid under pressure to extend the fracture at the desired depth from the borehole into the oil sands.
13. A method for creating a fracture at about a desired depth in a deposit of oil sands residing in a subterranean formation from a borehole subject to thermal expansion, said oil sands having thin interbeds of clay and silt, shale sections and siltstone lenses, comprising the steps:
- (a) providing in the formation to extend into the oil sands a borehole and therein surrounding cementing a conduit for conveying fluids between the oil sands and the earth's surface,
- (b) removing from the conduit and surrounding cement a transverse circumferential segment producing a window therein having a vertical dimension at least equal to the longitudinal dimensional increase of the conduit and surrounding cement resulting from subsequent thermal expansion, said window positioned at about the depth in the oil sands at which a fracture is to be initiated,
- (c) forming into the oil sands at the window a continuous circumferential V-shaped notch with such notch oriented in a substantially horizontal plane,
- (d) introducing a fluid under pressure into the oil sands via the window to initiate a fracture,
- (e) determining the depth in the oil sands at which the fracture is initiated,
- (f) sealing each initiated fracture at a depth in the oil sands other than the desired depth,
- (g) repeating steps (d), (e), and (f) until a fracture is initiated in the oil sands at the desired depth, and
- (h) continuing the introduction of a fluid under pressure to extend the fracture at the desired depth from the borehole into the oil sands.

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