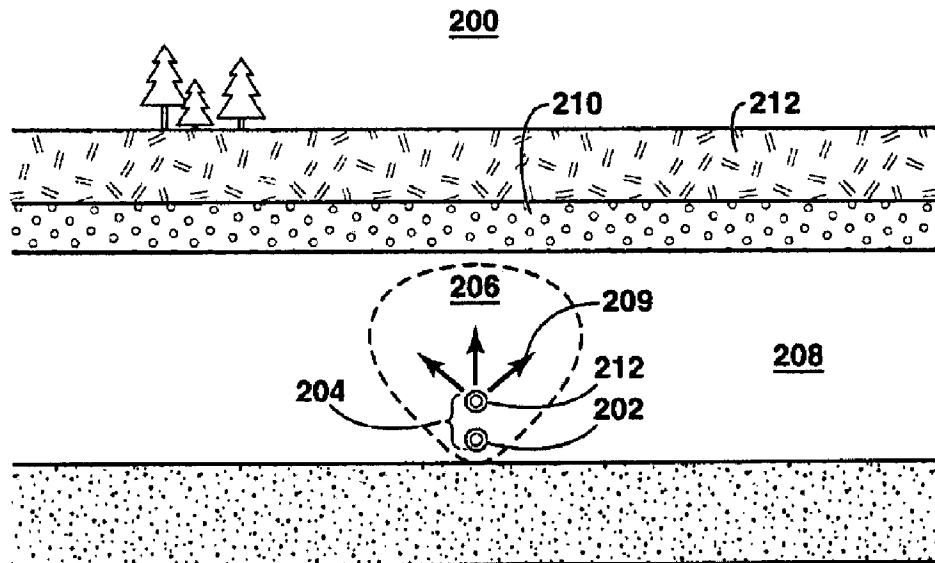




(22) Date de dépôt/Filing Date: 2013/10/22  
(41) Mise à la disp. pub./Open to Public Insp.: 2014/06/19  
(45) Date de délivrance/Issue Date: 2021/03/16  
(30) Priorité/Priority: 2012/12/19 (US61/739,686)

(51) Cl.Int./Int.Cl. *E21B 43/24* (2006.01),  
*E21B 43/30* (2006.01)  
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(54) Titre : PROCÉDES DE RECUPERATION D'HUILE VISQUEUSE A PARTIR DE RESERVOIRS POURVUS DE LIMITES SUPERIEURES PERMEABLES  
(54) Title: METHODS FOR RECOVERY OF VISCOUS OIL FROM RESERVOIRS WITH PERMEABLE UPPER BOUNDARIES



(57) **Abrégé/Abstract:**

Methods for producing a viscous oil such as bitumen from a subsurface reservoir with a permeable upper boundary include injecting a heated vapor into the subsurface reservoir at a pressure below a fracture pressure to reduce the viscosity of the oil and form a vapor chamber within the subsurface reservoir. The vapor injection into the vapor chamber is stopped when the top of the vapor chamber is proximate to the permeable upper boundary. The vapor may include steam or steam plus a hydrocarbon which is soluble in the bitumen. The method may further include evaluating the position of the top of the vapor chamber, wherein evaluating the position of the top of the vapor chamber comprises monitoring subsurface temperatures using temperature sensors placed subsurface. The method may further include forming a flow barrier around a wellbore.

**ABSTRACT**

Methods for producing a viscous oil such as bitumen from a subsurface reservoir with a permeable upper boundary include injecting a heated vapor into the subsurface reservoir at a pressure below a fracture pressure to reduce the viscosity of the oil and form a vapor chamber within the subsurface reservoir. The vapor injection into the vapor chamber is stopped when the top of the vapor chamber is proximate to the permeable upper boundary. The vapor may include steam or steam plus a hydrocarbon which is soluble in the bitumen. The method may further include evaluating the position of the top of the vapor chamber, wherein evaluating the position of the top of the vapor chamber comprises monitoring subsurface temperatures using temperature sensors placed subsurface. The method may further include forming a flow barrier around a wellbore.

## METHODS FOR RECOVERY OF VISCOUS OIL FROM RESERVOIRS WITH PERMEABLE UPPER BOUNDARIES

### FIELD OF THE INVENTION

[0001] Embodiments of the invention relate to methods for recovering viscous oil, such as bitumen, from a subsurface reservoir, such as an oil sand reservoir found in Alberta, Canada. More particularly, embodiments of the invention relate to methods for recovering viscous oil from subsurface reservoirs that have a permeable upper boundary.

### BACKGROUND

[0002] This section is intended to introduce various aspects of the art, which may be associated with exemplary embodiments of the present disclosure. This discussion is believed to assist in providing a framework to facilitate a better understanding of particular aspects of the present disclosure. Accordingly, it should be understood that this section should be read in this light, and not necessarily as admissions of prior art.

[0003] Bitumen is any heavy oil with a viscosity more than 10,000 cP at native in situ conditions found in porous subsurface geologic formations. Bitumen is often entrained in sand, clay, or other porous solids and is resistant to flow at subsurface temperatures and pressures. There are hundreds of billions of barrels of these very heavy oils in the reachable subsurface in the province of Alberta alone and additional hundreds of billions of barrels in other heavy oil areas around the world. Efficiently and effectively recovering these resources for use in the energy market is one of the world's toughest energy challenges.

[0004] Current recovery methods inject heat (typically steam) or viscosity reducing solvents to reduce the viscosity of the bitumen and allow it to flow through the subsurface formations and to the surface through boreholes or wellbores. These methods are referred to as *in situ* recovery methods, a few such methods include steam assisted gravity drainage (SAGD) and cyclic steam stimulation (CSS). Another recovery method involves removing the overburden overlying the oil sand formation and strip mining the underlying oil sand

formation. Mining is usually economic, depending upon the quality of the underlying oil sand formation and its depth and volume, at overburden depths up to approximately 80 meters.

[0005] The *in situ* methods rely on an impermeable topseal above the oil sand formation, often a continuous shale layer, to contain the injected steam and/or solvent within the underlying oil sand formation. Without the impermeable topseal, applying conventional *in situ* methods which utilize steam or solvent injection tends to be unacceptably inefficient and expensive due to losses to the overburden. However, large amounts of viscous oil, such as bitumen, are known to occur, primarily in Canada, at depths below economic mining depths, i.e., the overburden is greater than approximately 80 m, in reservoirs with semi-permeable or no top seals (e.g., without a continuous shale layer). See, for example: L.L. Schramm et al., "Saskatchewan's Place in the Canadian Oil Sands", Paper 2009-116, Canadian International Petroleum Conference, 2009. In general, such resources are not commercially viable due to a lack of a practical, efficient method for recovery.

[0006] If a method was available for producing viscous oil (e.g., >1000 cp or >10000 cp at original *in situ* conditions) from reservoirs with poor or no topseals, the method may also be applicable to bitumen at mineable depths. Although bitumen mining is a well-established industry, it disturbs the local environment due to surface removal and the formation of tailing ponds. Although reclamation of the environment is performed, temporary environmental impacts may be unacceptable to the public under certain conditions. Additionally, bitumen mining generally requires huge upfront capital expenditures for massive facilities and equipment. If oil could be extracted using an *in situ* technique suited for shallow, poorly sealed bitumen zones, the environmental and capital expenditure issues may be greatly reduced.

[0007] Hence, an *in situ* viscous oil recovery method is desired which is suitable for reservoirs with permeable upper boundaries. In particular, a variation on SAGD is desired which is suitable and economic for reservoirs with permeable upper boundaries. Conventional SAGD is a proven, effective method for recovering high viscosity oil. However, as currently practiced SAGD is operated so that much of the oil produced occurs during the so-called "spreading phase" where injected steam spreads laterally along an

*impermeable* upper boundary after it rises up to the boundary. This allows well spacings of greater than 100 m between SAGD horizontal wells. If the upper boundary of a reservoir is permeable, however, a spreading phase may not be possible or may be much reduced in extent. Moreover, conventional SAGD requires separate injector and producer wells to be drilled, which adds to the capital cost. If an equally effective method could be devised which used only a single wellbore, the economics could be significantly improved and closer well spacing could be economic. Closer well spacing might be desirable if there is no, or only a weak, spreading phase of the injected steam.

### **SUMMARY OF THE INVENTION**

[0008] In one embodiment of the present disclosure, a method for producing a viscous oil such as bitumen from a subsurface reservoir with a permeable upper boundary include injecting a heated vapor into the subsurface reservoir at a pressure below a fracture pressure to reduce the viscosity of the oil and form a vapor chamber within the subsurface reservoir. The vapor injection into the vapor chamber is stopped when the top of the vapor chamber is proximate to the permeable upper boundary. The vapor may include steam or steam plus a hydrocarbon which is soluble in the bitumen. The method may further include evaluating the position of the top of the vapor chamber, wherein evaluating the position of the top of the vapor chamber comprises monitoring subsurface temperatures using temperature sensors placed subsurface.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

[0009] The foregoing and other advantages of the present invention may become apparent upon reviewing the following detailed description and drawings of non-limiting examples of embodiments in which:

[0010] FIG. 1 is an illustration of a conventional steam assisted gravity drainage (SAGD) bitumen production method;

[0011] FIG. 2 is an illustration of one exemplary embodiment of a viscous oil production system according to the present disclosure;

[0012] FIGS. 3A and 3b are illustrations of another exemplary embodiment of a viscous oil production system according to the present disclosure;

[0013] FIG. 4 is an illustration of an exemplary embodiment of a viscous oil production system with the injection of a noncondensable gas according to the present disclosure;

[0014] FIG. 5 is an illustration of an exemplary embodiment of a viscous oil production system utilizing interacting vapor chambers;

[0015] FIG. 6 is an illustration of one exemplary embodiment of a viscous oil production system with a cooling system;

[0016] FIG. 7 is an illustration of one exemplary embodiment of a flow barrier for a viscous oil production system according to the present disclosure;

[0017] FIG. 8 is an illustration of another exemplary embodiment of a flow barrier for a viscous oil production system according to the present disclosure.

### **DETAILED DESCRIPTION OF THE INVENTION**

[0018] In the following detailed description section, the specific embodiments of the present disclosure are described in connection with preferred embodiments. However, to the extent that the following description is specific to a particular embodiment or a particular use of the present disclosure, this is intended to be for exemplary purposes only and simply provides a description of the exemplary embodiments. Accordingly, the disclosure is not limited to the specific embodiments described below, but rather, it includes all alternatives, modifications, and equivalents falling within the scope of the appended claims.

### **DEFINITIONS**

[0019] Various terms as used herein are defined below. To the extent a term used in a claim is not defined below, it should be given the broadest definition persons in the pertinent art have given that term as reflected in at least one printed publication or issued patent.

[0020] The terms "a" and "an," as used herein, mean one or more when applied to any feature in embodiments of the present inventions described in the specification and claims. The use of "a" and "an" does not limit the meaning to a single feature unless such a limit is specifically stated.

[0021] The term "about" is intended to allow some leeway in mathematical exactness to account for tolerances that are acceptable in the trade. Accordingly, any deviations upward or downward from the value modified by the term "about" in the range of 1% to 10% or less should be considered to be explicitly within the scope of the stated value.

[0022] In the claims, as well as in the specification above, all transitional phrases such as "comprising," "including," "carrying," "having," "containing," "involving," "holding," "composed of," and the like are to be understood to be open-ended, i.e., to mean including but not limited to. Only the transitional phrases "consisting of" and "consisting essentially of" shall be closed or semi-closed transitional phrases, respectively, as set forth in the United States Patent Office Manual of Patent Examining Procedures, Section 2111.03.

[0023] The term "exemplary" is used exclusively herein to mean "serving as an example, instance, or illustration." Any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments.

[0024] The term "formation" refers to a body of rock or other subsurface solids that is sufficiently distinctive and continuous that it can be mapped. A "formation" can be a body of rock of predominantly one type or a combination of types. A formation can contain one or more hydrocarbon-bearing zones. Note that the terms "formation," "reservoir," and "interval" may be used interchangeably, but will generally be used to denote progressively smaller subsurface regions, zones or volumes. More specifically, a "formation" will generally be the largest subsurface region, a "reservoir" will generally be a region within the "formation" and will generally be a hydrocarbon-bearing zone (a formation, reservoir, or interval having oil, gas, heavy oil, and any combination thereof), and an "interval" will generally refer to a sub-region or portion of a "reservoir."

**[0025]** The term "heavy oil" refers to hydrocarbons having an API gravity less than about 22°, such as bitumen.

**[0026]** The term "hydrocarbon-bearing zone," as used herein, means a portion of a formation that contains hydrocarbons. One hydrocarbon zone can be separated from another hydrocarbon-bearing zone by zones of lower permeability such as mudstones, shales, or shaley (highly compacted) sands. In one or more embodiments, a hydrocarbon-bearing zone includes heavy oil in addition to sand, clay, or other porous solids.

**[0027]** The term "overburden" refers to the sediments or earth materials overlying the formation containing one or more hydrocarbon-bearing zones. The term "overburden stress" refers to the load per unit area or stress overlying an area or point of interest in the subsurface from the weight of the overlying sediments and fluids. In one or more embodiments, the "overburden stress" is the load per unit area or stress overlying the hydrocarbon-bearing zone that is being conditioned and/or produced according to the embodiments described.

**[0028]** The terms "preferred" and "preferably" refer to embodiments of the inventions that afford certain benefits under certain circumstances. However, other embodiments may also be preferred, under the same or other circumstances. Furthermore, the recitation of one or more preferred embodiments does not imply that other embodiments are not useful, and is not intended to exclude other embodiments from the scope of the inventions.

**[0029]** The terms "substantial" or "substantially," as used herein, mean a relative amount of a material or characteristic that is sufficient to provide the intended effect. The exact degree of deviation allowable may in some cases depend on the specific context.

**[0030]** The definite article "the" preceding singular or plural nouns or noun phrases denotes a particular specified feature or particular specified features and may have a singular or plural connotation depending upon the context in which it is used.

## DESCRIPTION OF EMBODIMENTS

[0031] Typical impermeable upper boundaries for oil sand formations, those that form high quality topseals, are continuous shale layers, which may be tens of centimeters thick to many meters thick. As mentioned in the Background section, there are many oil sand formations that do not have a high quality topseal, but rather have permeable upper boundaries. Examples of permeable upper boundaries may include, fractured shales, faulted shales, unfractured shales with limited lateral continuity, shales penetrated by injection sands, glacial till, low permeability sands, sandstones, silts, siltstones, or mudstones (which may or may not contain viscous oil). Low permeability sands may reflect a presence of a wide distribution of grain sizes or of significant clay content.

[0032] In SAGD, leakage of heated vapor into a permeable upper boundary significantly reduces efficiency of the process since the overburden becomes heated but does not produce oil or is only poorly productive. As illustrated in Fig. 1, SAGD 100 is operated so that much of the oil which is produced occurs during a so-called "spreading phase" where injected steam 102 forms vapor chambers 107 that spread laterally through the oil sand formation 103 along an *impermeable* upper boundary 104 after the vapor chambers rise up to the boundary. The impermeable upper boundary 104 is positioned below additional overburden 108. Because of the impermeable upper boundary 104, the vapor chambers 107 are confined vertically and then spread laterally through the oil sand formation 103. This typically allows well spacings of greater than 100 m between SAGD horizontal well pairs 106. However if the upper boundary of a reservoir is permeable, a spreading phase may not be possible or may be much reduced in extent. In the modified SAGD embodiments disclosed herein, vapor injection is not, or is not significantly, continued into the so-called "spreading phase."

[0033] To effectively recover viscous oil, especially bitumen, from reservoirs with permeable upper boundaries it is proposed that a modified version of steam assisted gravity drainage (SAGD) be applied. Referring to Fig. 2, as mobilized oil is produced through producer well 202 in well pair 204, a vapor chamber 206 is formed within the reservoir 208 in the region drained of oil. In some embodiments, heated vapor injection 209 from injection well 212 is permanently halted, and optionally the vapor chamber is then blown down, when

the vapor chamber is proximate to the top of the reservoir zone 208. This halting may occur somewhat prior to the vapor chamber reaching the upper permeable boundary 210, soon afterwards, or even after the vapor chamber has partially penetrated the upper permeable boundary 210. However, it is preferred that the vapor chamber not substantially extend into the upper permeable boundary (*e.g.*, <10% to <25% of the distance from the injection depth to the bottom of the upper permeable boundary). The permeable upper boundary 210 is positioned below additional overburden 212.

[0034] In one embodiment of the invention, horizontal wells are used to inject a heated vapor into a reservoir zone with a permeable upper boundary. The heated vapor is preferably steam but may also be a steam/hydrocarbon solvent mixture or vaporized hydrocarbon solvent. Injection of heated vapor is performed through a flowpath in a horizontal well. In some embodiments, the injection is distributed over the horizontal section of a horizontal well.

[0035] The injected heated vapor mobilizes the viscous oil in the reservoir allowing it to gravity drain to a production flowpath in a horizontal well. In some embodiments, the production is distributed over the horizontal section of the horizontal well. In some embodiments, as shown in Fig. 2, the injection and production flowpaths are in separate horizontal wells which are vertically separated from each other in the reservoir, as is the case in conventional SAGD. However in some embodiments, as illustrated in Figs. 3A and B, injection and production flowpath pairs are contained in common wellbores 302. In such embodiments, the flowpaths may comprise separate, adjacent injection 304 and production flowlines 306 as shown in Fig. 3A, or a single flowline 308 which is alternately used for injection and then production, as shown in Fig. 3B. In the case where the injection and production flowlines are within a common wellbore, the injection and production may be performed alternately in cycles. In some embodiments, temperature sensors 310 at the surface 312 and/or in shallow wells 314 may be used to directly or indirectly detect vapor chamber 316 position. In other embodiments, the steam chamber location may be estimated using pressure sensing in the permeable overburden, seismic methods, or monitoring for biodegradation chemical species in production fluids indicative of fluids being produced near

a top-water contact. In still other embodiments, the top of the chamber position may be estimated based on reservoir production modeling, metering of oil production, metering of fluid injection, or metering of fluid production.

[0036] Referring to Fig. 4, in some embodiments, a noncondensable gas 402, such as nitrogen or natural gas, may be added to injected steam 403, particularly when the vapor chamber approaches or just reaches the upper boundary. The noncondensable gas will concentrate near the top of the vapor chamber 416 as the steam condenses and drains downward. The noncondensable will form a buffer zone 404 of noncondensable gas 402 which will help divert steam 403 and heat from the permeable upper boundary 406 and promote lateral growth of the vapor chamber 416.

[0037] Blowing down (*i.e.*, producing vapors from) a chamber may be done to aid final recovery of oil by providing a strong, but temporary, pressure drive. Furthermore, blowing down a chamber can improve the halting of the vapor chamber growth by removing remaining steam and its associated latent heat or by removing injected solvents. In some embodiments, the chamber may be purged with nitrogen, natural gas, or carbon dioxide to remove hot steam and vapors.

[0038] Referring to Fig. 5, wells 502 may be laterally spaced so that groups of vapor chambers 504, for example consisting of 3 to 8 chambers, interact or coalesce prior to the vapor chambers reaching the upper boundary 506. However, interacting groups are isolated from other interacting groups so that pressure blowdowns can be performed locally and as needed. By "isolated", it is meant that a gap 508, for example 20-100 m, of undrained viscous oil exists between adjacent vapor chamber groups so that pressures in adjacent vapor chamber groups are essentially independent.

[0039] In some embodiments, pressure within a vapor chamber or group of vapor chambers is controlled so that the pressure at the chamber top is near to or below hydrostatic pressure. By controlling pressure in this way the chance of vapor leakage into or beyond the upper permeable boundary is minimized. In some embodiments, the pressure is controlled so that the pressure at the top of the vapor chamber is kept within 25% of the hydrostatic pressure at

the top of the vapor chamber. Steam-only may be used for injection (*i.e.*, no solvent addition) in order to minimize environmental impact due to any unexpected leakage to the near-surface or atmosphere.

**[0040]** In some embodiments, as previously mentioned, the invention utilizes a single-well, cyclic injection-production, gravity drainage concept. In some embodiments, the injector and producer line may be the same line. In another embodiment, separate injector and producer lines are used. The lines may or may not be of equal diameter. Moreover, in an embodiment, the wellbore has a long, substantially horizontal section where the injection into and production from the reservoir is performed. "Substantially horizontal" may be understood to mean within  $\pm 10^\circ$  of true horizontal. The injector well may have limited-entry perforations along its length to allow steam to be relatively evenly injected along its length, which may be several hundred meters. Likewise, the production line may have limited-entry perforations to allow suction of fluids relatively evenly along its length. The wellbore itself may, in some embodiments, be lined with a screen. Limited-entry perforations, known to one of ordinary skill in the art, are holes through the walls of tubing which permit inflow or outflow but keep flow rates relatively constant despite pressure variations along the length of the tubing. Various limited entry perforations are known in the art and practiced in the field. Some utilize the principle of critical flow through an orifice so that the rate of flow is relatively insensitive to pressure difference across a perforation if the pressure difference is greater than a certain amount.

**[0041]** For the single-well embodiment, the injection and production may be performed cyclically; that is, inject heated vapor then stop injection and, optionally after a soak period, produce oil and condensed injectant then repeat. A soak period may occur between the injection and production periods. Several control schemes may be applied. For example, for each cycle, the amount of vapor injected may be controlled to be a predetermined volume, such as, for example, 10-25% of the total produced oil, *i.e.*, voided space, where the vapor volume is calculated on a condensed liquid basis. Injection may be done at constant pressure, such as, for example, approximately 60-90% of lithostatic pressure, and then production of liquids performed until a vapor production rate becomes unacceptably high or a liquids

production rate becomes unacceptably low. Alternatively the control scheme may be that the end of an injection, production, or soak period occurs when an estimated or measured pressure or temperature which is representative of the formation reaches a predetermined value.

**[0042]** It is preferred that pressure be kept below a fracturing pressure and even a dilation pressure, for example, keep the pressure below approximately 90% of the fracturing pressure, except perhaps for start-up. In certain embodiments, cycle times may be several hours (e.g., 1 to 24) to several days (e.g., 1 to 30). Start-up may be accomplished by cycling steam between the injector and producer lines if they are separate lines.

**[0043]** In some embodiments, a barrier may be placed over the surface to control vapor and/or odor leakage. The barrier may be a geotextile, plastic sheeting, or mining material, such as, for example, tailings or removed overburden comprising granular or clay materials. This may be particularly useful for very shallow reservoirs; for example, bitumen zones which are potentially mineable. Indeed, embodiments of the invention may be used in a region adjacent to an oil sands mining pit. This may be advantageous if adjacent resources exist deeper than is economically feasible for continued expansion of a mining pit. In some embodiments, injection and/or production may be performed via wells connected to the floor or walls of an oil sands mining pit.

**[0044]** In some embodiments the method may be applied adjacent to an oil sands mining operation with heat, steam, water, or fluid processing shared with the mining operation to improve economics. The targeted bitumen may be of lower quality than is economic for mining, for example low bitumen saturation or too deep below the overburden.

**[0045]** Passing a well carrying a hot fluid through a permeable upper boundary may promote vapor leakage through the boundary. In particular if the permeable upper boundary contains highly viscous oil at ambient temperatures, a heated well passing through the upper boundary may sufficiently raise the temperature and reduce the viscosity of the oil near the well to allow the oil to drain down. This in turn would increase the effective permeability of the drained region near the well since it would no longer be filled with largely immobile oil.

Vapor from the underlying vapor chamber may then readily channel along the outside of the well up through the permeable upper boundary. This would reduce recovery efficiency and may cause unacceptable leakage of injectant into groundwater or the atmosphere.

[0046] To guard against such issues, in some embodiments a barrier to flow along the outside of the well is constructed. Referring to Fig. 6, in an embodiment, a portion of a well 602 passing through the permeable upper boundary 604 is cooled through the use of refrigeration or cooling system 606 and coolant lines 608. The cooling system keeps the cooled permeable upper boundary zone 610 from heating up and draining or losing oil and/or other fluids that could be mobilized from the heat of the well. In an embodiment, well 602 may also include insulation 612 to decrease the amount of heat transmitted to the permeable upper boundary 604. In an embodiment, the cooling system 606 may include circulating refrigerated fluid down a string in the well and back up to the surface. In some embodiments, the cooling comprises a thermosyphon where a liquid flows down a first cooling string, at least partially boils within the first cooling string, returns up a second cooling string in at least a partially vaporized state, and is recondensed at the surface. In some embodiments, the cooling lines may be insulated in certain locations to localize the cooling of the permeable upper boundary to a desired depth range and to not pick up heat from the injection and/or production lines.

[0047] Referring to Fig. 7, as an alternative to, or in conjunction with, cooling of the permeable upper boundary, a flow barrier 702 may be constructed adjacent to a wellbore 704 passing through the permeable upper boundary 706 such that injected vapor 708 largely cannot travel along the exterior of the wellbore and through the permeable upper boundary. The flow barrier 702 may comprise a physical impermeable barrier constructed via a hydraulic fracture 705 filled with an impermeable substance such as clay or grout 710. In some cases, one may be able to position the vertical portions of wells to penetrate through and take advantage of local, but non-extensive, shale barriers (not shown) to act as the flow barrier rather than constructing artificial ones. Alternatively, referring to Fig. 8, a flow barrier 802 may comprise a pressure barrier consisting of a local high pressure zone 804 formed by injection of a fluid 806, such as gas or water through an injection line 808.

[0048] While the present disclosure may be susceptible to various modifications and alternative forms, the exemplary embodiments discussed above have been shown only by way of example. However, it should again be understood that the disclosure is not intended to be limited to the particular embodiments disclosed herein. Indeed, the present disclosure includes all alternatives, modifications, and equivalents falling within the scope of the appended claims.

**CLAIMS:**

1. A method of producing a viscous oil from a subsurface reservoir with a permeable upper boundary, the method comprising:
  - injecting a heated vapor into the subsurface reservoir via an injection wellbore at a pressure below a fracture pressure to reduce the viscosity of the oil;
  - forming a vapor chamber within the subsurface reservoir;
  - halting vapor injection into the vapor chamber when the top of the vapor chamber is proximate to the permeable upper boundary and prior to the top of the vapor chamber reaching the permeable upper boundary;
  - producing fluids via a production wellbore to the surface, wherein the fluids comprise the reduced viscosity oil; and
  - blowing down the vapor chamber prior to the top of the vapor chamber reaching the permeable upper boundary.
2. The method of Claim 1, wherein the injected heated vapor comprises steam.
3. The method of Claim 1, wherein the injected heated vapor comprises a hydrocarbon which is soluble in the viscous oil.
4. The method of Claim 1, further comprising evaluating the position of the top of the vapor chamber, wherein evaluating the position of the top of the vapor chamber comprises monitoring subsurface temperatures using temperature sensors placed subsurface.
5. The method of Claim 1, further comprising controlling the vapor chamber pressure such that the pressure within the chamber at the top of the vapor chamber is near-to or below the hydrostatic pressure at the top of the vapor chamber.
6. The method of Claim 1, further comprising halting injection into the vapor chamber prior to the top of the vapor chamber extending into the permeable upper boundary by more than 25% of the distance from an injection depth to the bottom of the permeable upper boundary.

7. The method of Claim 1, wherein three or more horizontally adjacent and intersecting vapor chambers are formed.
8. The method of Claim 6, further comprising blowing down the vapor chamber prior to the top of the vapor chamber extending into the permeable upper boundary by more than 25% of the distance from an injection depth to the bottom of the permeable upper boundary.
9. The method of Claim 5, wherein the pressure at the top of the vapor chamber is controlled to be within 25% of hydrostatic pressure at the top of the vapor chamber.
10. The method of Claim 1, wherein the injecting and producing are performed through one or more flowpaths in a common wellbore comprising the injection flowpath and the production flowpath.
11. The method of Claim 10, wherein the common wellbore comprises a substantially horizontal section with separate injection and production flowpaths.
12. The method of Claim 10, wherein the common wellbore comprises a substantially horizontal section with common injection and production flowpaths.
13. The method of Claim 10, wherein the injection and production flowpaths both comprise limited entry perforations.
14. The method of Claim 10, wherein the injection flowpath comprises limited entry perforations.
15. The method of Claim 8, wherein the injecting and producing are performed in cycles comprising an injection phase and a subsequent production phase.
16. The method of Claim 15, wherein the injection or production phase within a cycle of the cycles is ended when an estimated or measured pressure or temperature within the reservoir, wellbore, or surface reaches a predetermined value.
17. The method of Claim 1, further comprising cooling a portion of at least one wellbore passing through the permeable upper boundary.

18. The method of Claim 1, further comprising insulating at least a portion of at least one wellbore passing through the permeable upper boundary.
19. The method of Claim 17, wherein the cooling comprises a thermosyphon.
20. The method of Claim 1, further comprising constructing a flow barrier adjacent at least one wellbore in the permeable upper boundary.
21. The method of Claim 20, wherein the flow barrier comprises a hydraulic fracture filled with an impermeable substance.
22. The method of Claim 20, wherein the flow barrier comprises a local high pressure zone formed by injection of a fluid.
23. The method of Claim 1, wherein the reservoir is adjacent an oil sands mining pit and wherein the injecting and/or producing is performed via wells connected to the mining pit.
24. The method of Claim 1, wherein a low permeability barrier is placed over an area undergoing heated vapor injection.
25. The method of Claim 24, wherein the barrier primarily comprises geotextile or plastic sheeting.
26. The method of Claim 24, wherein the barrier primarily comprises a granular or clay material.
27. The method of Claim 26, wherein the granular material comprises tailings or mined material from an oil sands mining operation.
28. The method of Claim 1, further comprising injecting a noncondensable gas with the heated vapor.

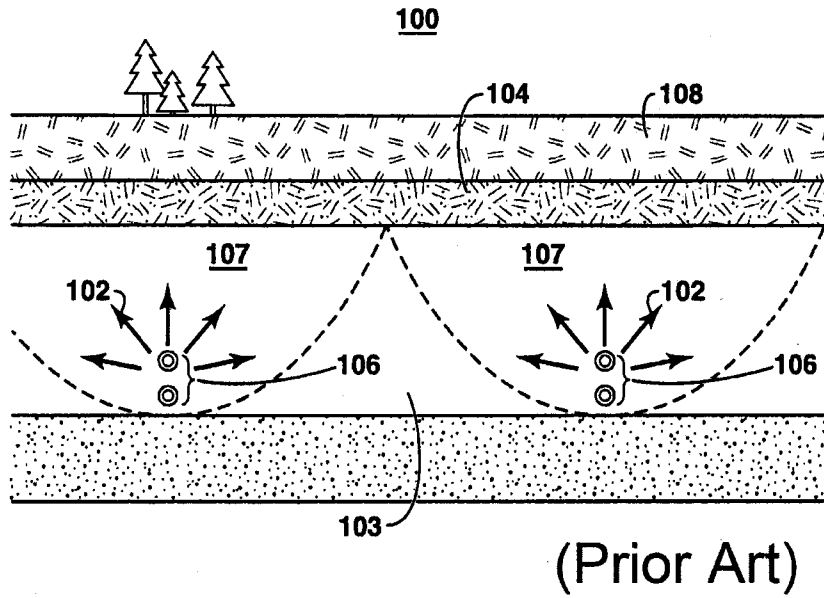


FIG. 1

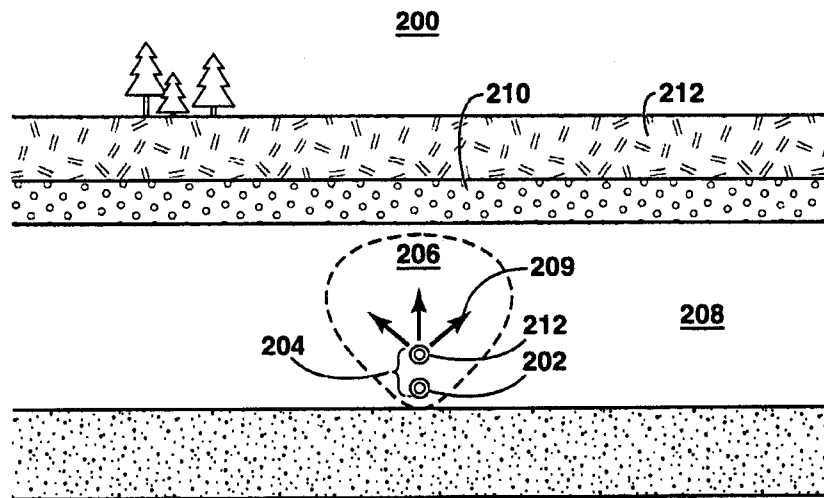


FIG. 2

2/5

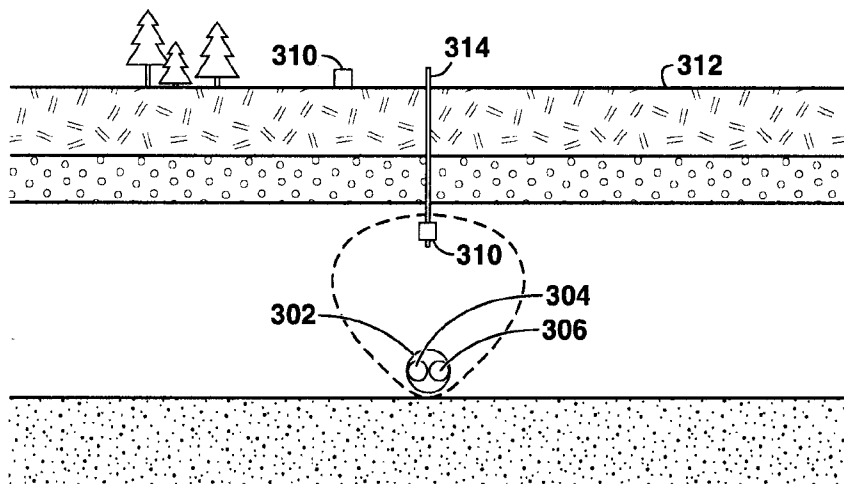


FIG. 3A

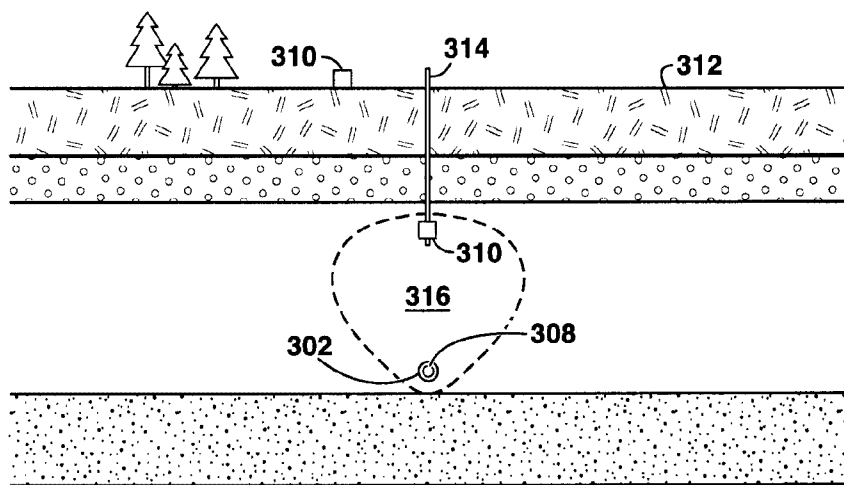


FIG. 3B

3/5

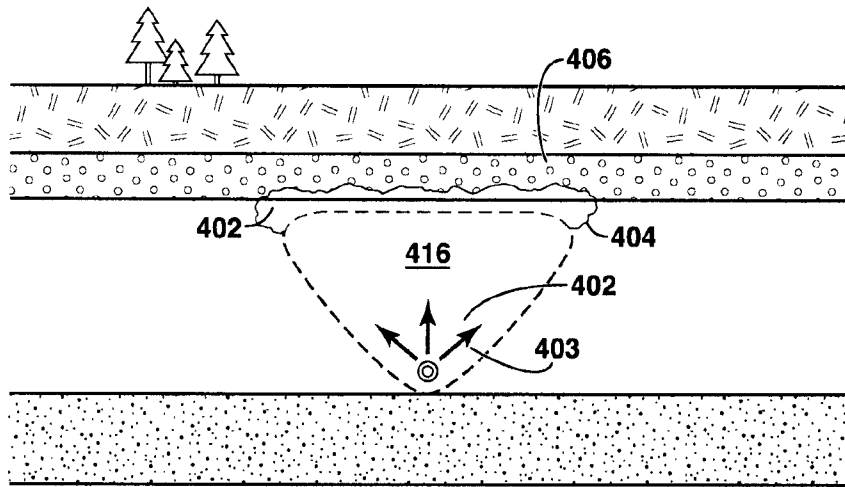


FIG. 4

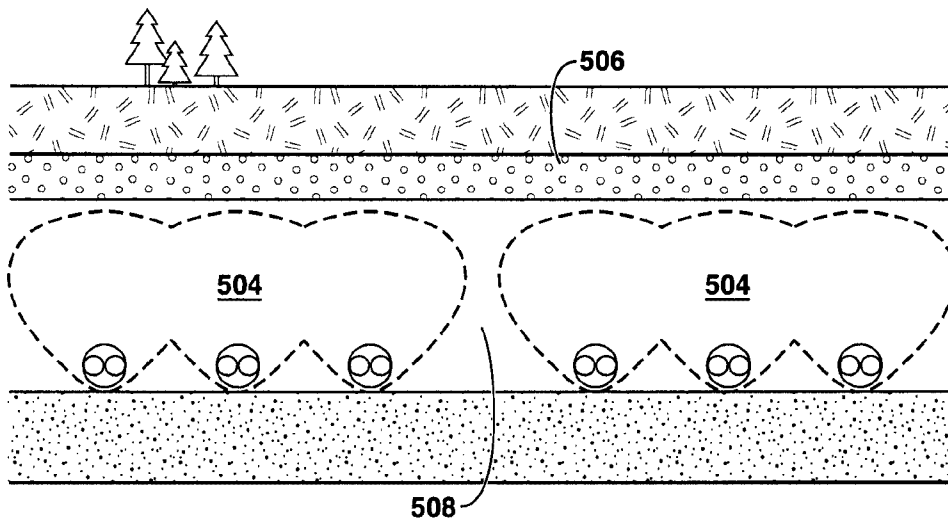


FIG. 5

4/5

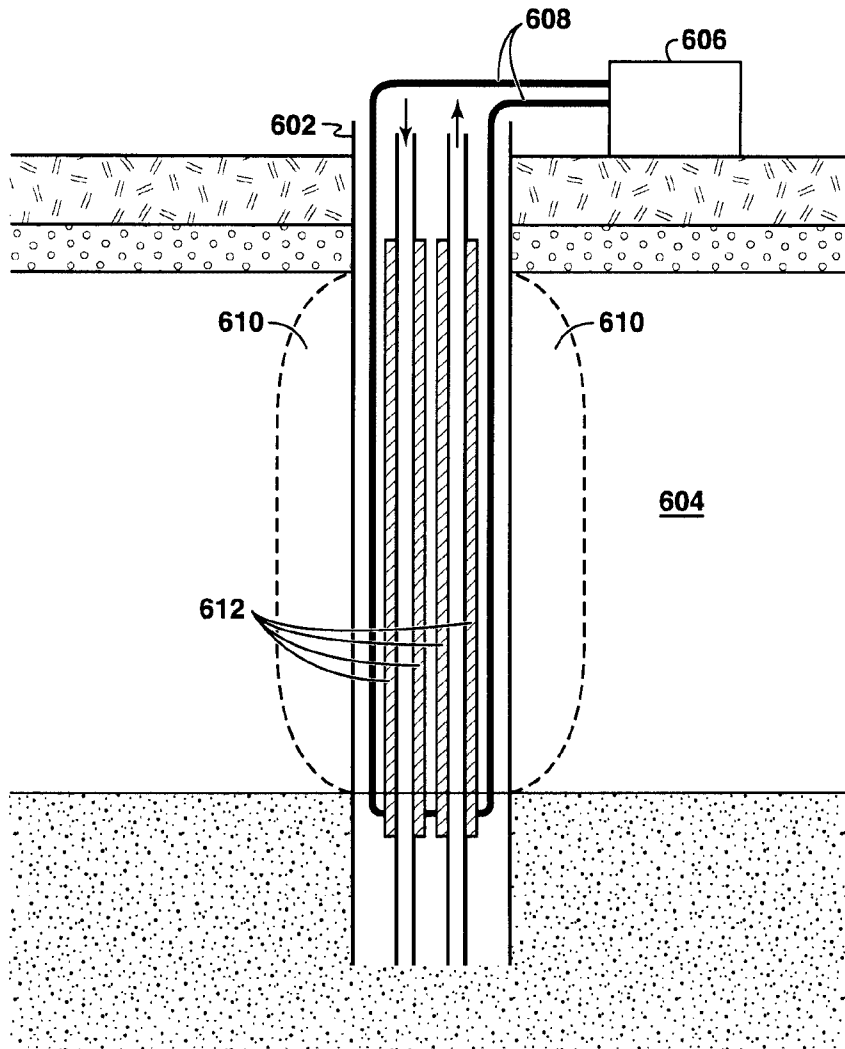


FIG. 6

5/5

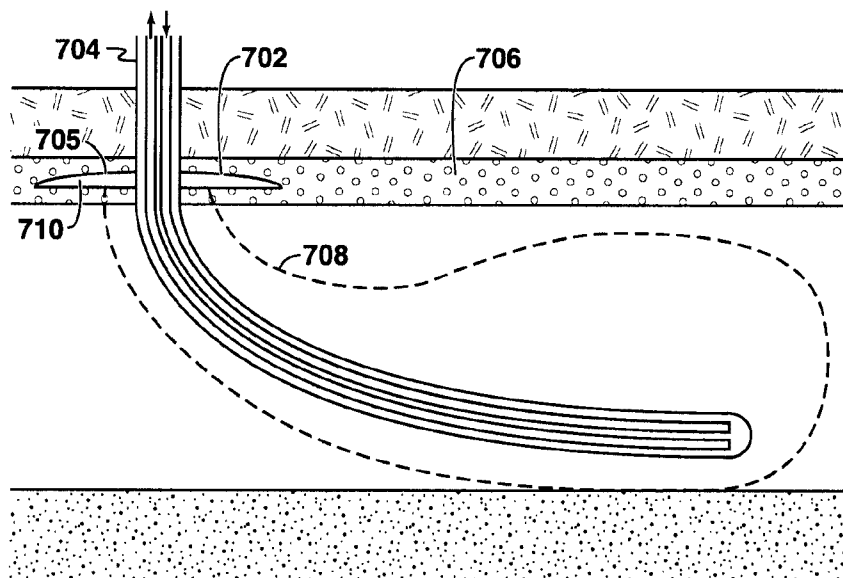


FIG. 7

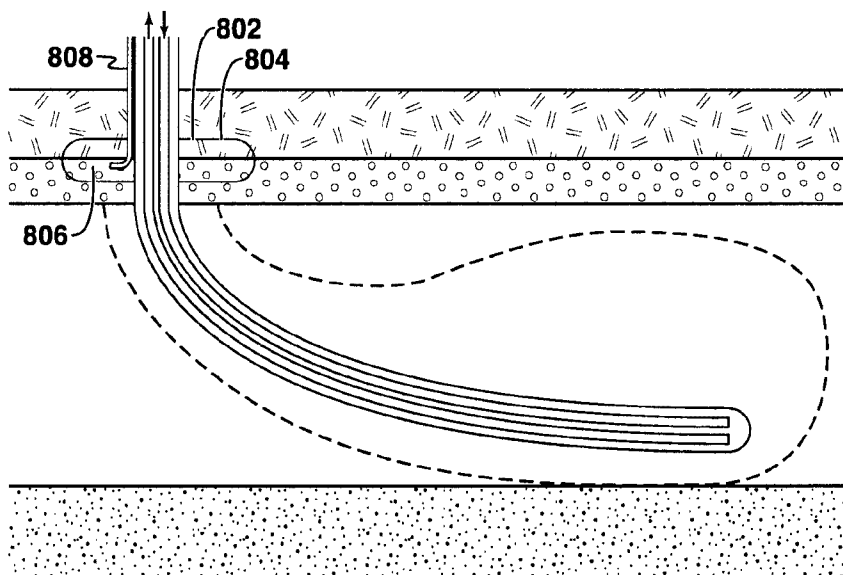
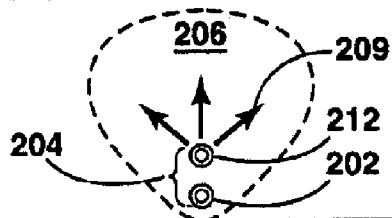
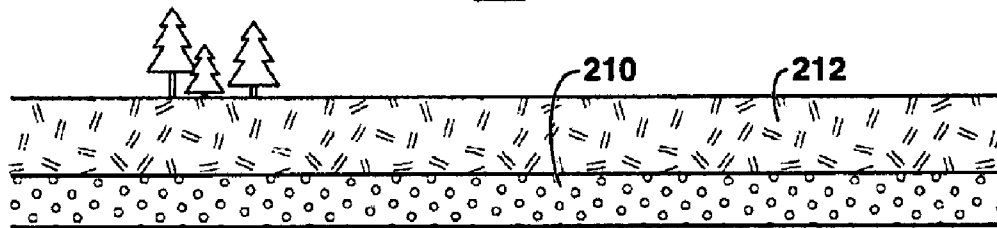


FIG. 8

200



208

