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(54) **Title:** METHOD AND APPARATUS FOR PRODUCING UNCONVENTIONAL OIL AT SHALLOW DEPTHS

(57) **Abstract:** An oil production well is drilled into a kerogenous chalk source rock comprising (i) type IIs kerogen and (ii) shallow naturally-occurring unconventional oil derived from the type IIs kerogen that is resident within pore space of the source rock. In some embodiments, the production well is drilled at a location where the geothermal gradient is at least 3 degrees C per 100 m is present at or near the production well. It is believed that the presence of this geothermal gradient accelerated maturation of the type IIs kerogen of the source rock to convert a portion of the type IIs kerogen into the unconventional oil. In some embodiments, the shallow production well is non-vertical. In some embodiments, at depths that are shallow and within the source rock, the production well is cased and perforated. Oil from the source rock may be produced via the production well and the shallow-depth perforated locations thereof.



METHOD AND APPARATUS FOR PRODUCING UNCONVENTIONAL OIL AT SHALLOW DEPTHS

BACKGROUND AND RELATED ART

5 In the last few years, the oil industry in the United States has developed methods for producing unconventional gas and oil from very low permeability source rocks. In these unconventional gas and oil plays, the gas and oil is still contained within the original source rock and has not migrated to a reservoir and trap.

For example, the Bakken shale in North Dakota has been extensively produced
10 using long horizontal wells which are stimulated with multiple propped hydraulic fractures. These Bakken wells are typically at depths greater than about 3000 m in order for the Type I kerogen to have matured over geological time sufficiently to generate oil and gas. Even though the Bakken oil produced is low viscosity and rich in NGL (natural gas liquids), because of the depth of the wells and the many stages of hydraulic
15 stimulation that are required, these unconventional wells are very expensive and only a very small percentage of the unconventional oil and gas in place is actually produced.

SUMMARY OF EMBODIMENTS

Instead of relying on artificial heat to pyrolyze kerogen of a kerogenous chalk into
20 pyrolysis fluids (i.e. as is common in in-situ conversion processes (ICP)), it is possible to drill for oil in a kerogenous chalk where natural events (e.g. historical volcanic or other geothermal activities) supplied sufficient thermal energy to convert kerogen of the source rock into naturally-occurring oil. In particular, the present invention relates to techniques where production wells (e.g. shallow wells) are drilled into a kerogenous chalk that is
25 characterized by Type II kerogen, a porosity of at least 30% and at a location where the geothermal gradient is at least 3 degrees Celsius per 100 meters.

In contrast with the aforementioned ICP techniques where (i) oil is only created within the subsurface after an extended period of time (e.g. at least months or years) and where (ii) there is a need to invest significant thermal energy in order to pyrolyze
30 kerogen, according to the presently-disclosed techniques, it is possible to produce naturally-occurring oil with little or no subsurface heating required.

One salient feature of the present invention is that the production well is shallow - i.e. having a maximum depth of at most 2 kilometers. This is in contrast to conventional techniques where significantly deeper production wells are required to access naturally occurring oil. Advantageously, the shallow production wells of the present invention can be provided at a much lower cost than would be required for deeper production wells.

Surprisingly, it is now disclosed for the first time that it is possible to find naturally-occurring oil at these relatively shallow depths in coastal/marine formations and/or in locations where there was no significant uplift to the source rock or sediment and/or in locations lacking significant non-conformities.

Furthermore, by selecting kerogenous chalk having a porosity of at least 30%, it is possible to access locations where a greater quantity of naturally-occurring oil is located in pore space of the source rock.

In some embodiments, the geothermal gradient is at least 3.5 degrees Celsius per 100 meters or at least 4 Celsius per 100 meters.

It is now disclosed a method of unconventional oil production comprising:

- a. drilling a production well into a kerogenous chalk source rock comprising (i) type IIs kerogen and (ii) shallow naturally-occurring unconventional oil derived from the type IIs kerogen that is resident within pore space of the source rock;
- b. at shallow depths of at most 2 kilometers and within the source rock, casing and perforating the production well; and
- c. producing the shallow naturally-occurring unconventional oil from the source rock via the production well.

In some embodiments, a location at which the production well is drilled is selected in accordance with a geothermal gradient.

In some embodiments, the production well is drilled at a location where the geothermal gradient is at least 3.0 degrees Celsius per 100 meters, or at least 3.5 degrees Celsius per 100 meters, or at least 4.0 degrees Celsius per 100 meters.

In some embodiments, the unconventional oil and at least some of the perforations of the production well are located at depths of at most 1.5 kilometers, or at most 1200 meters, or at most 1 kilometer or at most 800 meters.

In some embodiments, the source rock is below an overburden comprising a basalt layer. In some embodiments, the overburden further comprises a sedimentary portion situated below the basalt layer so that horizontal stresses of the sedimentary portion were locked in at or before a time of deposition of the lava flow which formed the basalt layer.

- 5 In some embodiments, a porosity of the source rock is at least 30% or at least 35% or at least 40%.

In some embodiments, a permeability of the source rock matrix is at most 1 mD or at most 0.1 mD or at most 0.01 mD.

- 10 In some embodiments, an oil saturation of pore space of the source rock is at least 50% or at least 60% or at least 70%.

In some embodiments, the source rock is stimulated at the shallow depths to increase a permeability of the source rock.

In some embodiments the stimulation of the source rock occurs at a depth that is less than that of all aquifers thereof.

- 15 In some embodiments the source rock is stimulated by means other than by hydraulic stimulation.

In some embodiments, a total organic content (TOC) of the source rock is at least 10%.

In some embodiments, the source rock is stimulated at the shallow depths by high pressure acid stimulation of the source rock.

- 20 In some embodiments, the source rock is hydraulic stimulated.

In some embodiments, the source rock thermally stimulated.

In some embodiments thermal energy is effective to significantly increase the mobility of the naturally-occurring oil by at least a factor of 10.

- 25 In some embodiments thermal energy is effective to significantly decrease the viscosity of the naturally-occurring oil by at least a factor of 10.

In some embodiments the thermal energy is effective to vaporize liquid water and light hydrocarbons within the pore space of the source rock.

- 30 In some embodiments, pressurized steam is injected into the source rock at the shallow depths so as to thermally stimulate the source rock to increase a mobility of the unconventional oil.

In some embodiments the steam is injected according to a huff-and-puff technique.

In some embodiments the steam enters the source rock at a temperature of at most 200 degrees Celsius.

In some embodiments, the production well is non-vertical.

5 In some embodiments the non-vertical production well is substantially horizontally-oriented.

In some embodiments the stimulation forms a plurality of parallel, thin flow channels within the source rock that are each substantially vertically oriented, a thickness direction of the flow channels being along a central axis of the production well, and with each flow channel leading to the production well.

10 In some embodiments, the production well is substantially horizontal, a central axis thereof being substantially parallel to a minimum stress vector of the kerogenous chalk source rock.

In some embodiments, a total organic content (TOC) of the source rock is at least 15%.

15 In some embodiments, a sulfur content of the unconventional oil is at least 2.5% wt/wt or at least 3% wt/wt or at least 3.5% wt/wt or at least 4% wt/wt.

In some embodiments, an API gravity of the unconventional oil is at least 20⁰ and/or at most 30⁰.

20 In some embodiments, a maximum depth of the production well is at most 2 km or at most 1.5 kilometers, or at most 1200 meters, or at most 1 kilometer or at most 800 meters.

In some embodiments, oil produced via the production wells is never heated within the source rock to a temperature exceeding 200 degrees Celsius

In some embodiments carried out so that bulk source rock is never heated to a temperature exceeding 200 degrees Celsius.

25 In some embodiments, the method is carried out without significantly pyrolyzing the source rock.

In some embodiments, a majority of hydrocarbon liquids produced via the production wells is the naturally-occurring oil.

30 In some embodiments the producing includes drawing naturally-occurring oil residing in pore space of the kerogenous chalk source rock into the production well.

In some embodiments the producing includes drawing naturally occurring oil residing in the pore space of the kerogenous chalk source rock into the production well via perforations thereof.

In some embodiments comprising subjecting the produced oil to a distillation process.

- 5 It is now disclosed an apparatus for unconventional oil production comprising:
- a production well drilled into a kerogenous chalk source rock comprising (i) type IIs kerogen and (ii) shallow naturally-occurring unconventional oil derived from the type IIs kerogen that is resident within pore space of the source rock,
 - wherein the production well is cased and perforated at shallow depths of at most 2
 - 10 kilometers and within the source rock so that the shallow naturally-occurring unconventional oil is recovered by the production well via the shallow-depth perforations of the production well.

In some embodiments the production well is non-vertical.

In some embodiments the production well is horizontal.

- 15 In some embodiments further comprising a series of thin parallel flow channels that are all vertically oriented and transverse to a central axis of the production well.

In some embodiments wherein the production well is substantially horizontal, a central axis thereof being substantially parallel to a minimum stress vector of the kerogenous chalk.

- 20 In some embodiments wherein at a location of the production well, a local geothermal gradient is at least 3.0 degrees Celsius per 100 meters, or at least 3.5 degrees Celsius per 100 meters, or at least 4.0 degrees Celsius per 100 meters.

- In some embodiments the unconventional oil and at least some of the perforations of the production well are located at depths of at most 1.5 kilometers, or at most 1200 meters, or
- 25 at most 1 kilometer or at most 800 meters.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1, 3, 5, and 10 are flow charts of methods of producing naturally-occurring oil that resides in pore space of a kerogenous chalk.

FIGS. 2, 4, and 6-9 illustrate subsurface production wells.

FIGS. 11 illustrates a geothermal gradient from a well log.

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DETAILED DESCRIPTION OF EMBODIMENTS

The invention is herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the exemplary system only and are presented in the cause of providing what is believed to be a useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how several forms of the invention may be embodied in practice and how to make and use the embodiments.

For brevity, some explicit combinations of various features are not explicitly illustrated in the figures and/or described. It is now disclosed that any combination of the method or device features disclosed herein can be combined in any manner – including any combination of features – any combination of features can be included in any embodiment and/or omitted from any embodiments.

FIG. 1A-1C are flow charts of a method of producing naturally-occurring oil that resides in pore space of a kerogenous chalk optionally at a location where there is a significant geothermal gradient. For the present disclosure, a 'significant' geothermal gradient is at least 3 degrees Celsius/100 meters. In some embodiments, the geothermal gradient is at least 3.5 degrees Celsius/100 meters or at least 4.0 degrees Celsius/100 meters or about 4.5 degrees Celsius/100 meters.

The kerogenous chalk is characterized by Type IIs kerogen and may have a porosity of at least 30% (in some embodiments, at least 35% or at least 40% or at least 45% or at least 50%). Because of the relatively large porosity, a large amount of naturally-occurring oil may be stored therein.

In step **S101** a shallow production well (i.e. see **224** of any of FIGS. 2, 4, 6 or 8-10) is drilled into the kerogenous chalk source rock (i.e. see **800** of FIGS. 2, 4 or 6) that is characterized by type II_s kerogen and optionally at a location where there is a geothermal gradient of at least 3 degrees Celsius per 100 meters.

5 For the present disclosure, a depth (e.g. a depth 'within the source rock') is measured relative to the surface and not relative to the highest location in the source rock. For the present disclosure, the term 'shallow' refers to a maximum depth of at most 2 kilometers - in some embodiments, at most 1.5 kilometers, or at most 1200 meters, or at most 1 kilometer, or at most 800 meters, or at most 750 meters.

10 The production well of step **S101** is 'shallow' - i.e. has a maximum depth that is 'shallow.' In step **S105**, at depths that are (i) shallow, (ii) optionally above the aquifer and (iii) within the source rock **800**, the production well is cased and perforated. The 'shallow depth' of the casing and perforating may be less than the maximum depth of the production well which is also 'shallow.' For example, the well may be cased or perforated
15 at a maximum depth of about 1.5 kilometers, or at most 1200 meters, or at most 1 kilometer or at most 800 meters.

In step **S109**, naturally-occurring oil from the source rock may be produced via the shallow-depth perforations of the production well. For example, the producing may include drawing naturally occurring oil residing in pore space of the kerogenous chalk
20 source rock into the production well. As noted above, the high porosity means that larger quantities of naturally-occurring oil may be stored than would be possible if the porosity of the source rock was lower.

In the examples of FIG. 1B, 3B, 5B and 10B, the drilling of the production well is contingent upon geothermal conditions being satisfied - e.g. a minimal temperature
25 gradient.

In the examples of FIG. 1C, 3C, 5C and 10C, the drilling of the production well is contingent upon a basalt overburden condition being satisfied - e.g. a minimum thickness or a greater thickness than that in neighboring locations.

In one non-limiting example, magnetotelluric techniques may be employed to
30 measure a thickness of the basalt overburden.

FIG. 2 illustrates an apparatus related to the method of FIG. 1. Illustrated in FIG. 2 are the overburden **820** (e.g. a basalt overburden), the kerogenous chalk **800**, the aquifer **830**, a production well **224**.

In the example of FIG. 2B, a stimulated zone **870** is formed within the kerogenous chalk source rock **800**. In the example of FIG. 2C, multiple stimulated zones **870** at different depths are formed within the kerogenous chalk source rock **800**.

FIG. 3 is a flow chart of a method where the production well is non-vertical - e.g. horizontal. Although well perforations **860** at shallow depths are not illustrated in any of FIGS. 4, 6, 8-10, it is appreciated that the well perforations **860** may be provided in any embodiment, and not just that of FIG. 2. FIG. 4 illustrates an apparatus related to the method of FIG. 3.

As illustrated in FIG. 5, optionally, it is possible to stimulate the source rock at the shallow depths (e.g. above all aquifers) so as to mobilize naturally-occurring oil within the kerogenous chalk source rock **800**. In some embodiments, this creates a series of parallel flow conduits towards the production well **224** through which the naturally-occurring oil may flow. In this sense, the stimulation of the kerogenous chalk source rock **800** may increase the ability of the naturally-occurring oil to flow to production well **224**, and thus may be said to 'mobilize' the naturally-occurring oil.

FIGS. 6 and 9 illustrate a series of thin flow channels, for example, shaped like discs. Each flow channel leads to production well **224** and is vertically oriented. Each flow channel is a transverse fracture.

In contrast, in the example of FIGS. 7-8, longitudinal fractures are illustrated. It is noted that transverse fractures are significantly more efficient for transporting oil within the chalk formation to the production well - thus, the transverse fractures of FIGS. 6 and 9 are preferred to the longitudinal fractures of FIGS. 7-8.

In all of FIGS. 7-9, the production well **224** is horizontal so that a central axis thereof is in the horizontal plane. In the example of FIG. 7, the minimum stress direction is vertically-oriented - i.e in the z direction. In the example of FIG. 8-9, the minimum stress direction is horizontally-oriented - however, in the example of FIG. 9, the central axis of the production well **224** is substantially co-linear with a stress axis of the formation.

As noted earlier, in order to attain the geometry of FIGS. 6 and 9, it may be preferred that the minimum stress axis is in the horizontal plane. Thus, it may be preferred to locate the horizontal production well where there is significant vertical stress. A presence of dense basalt in the overburden, and preferably an existence of a relatively thick basalt overburden, increases the vertical stress within the formation, and allows the deployment of horizontal production wells together with vertical transverse fractures at a depth less than what would be possible in the absence of the basalt.

Because of the relatively large density of basalt (i.e. over 70% greater than that of chalk), a presence of the basalt overburden increases a vertical stress/pressure in the kerogenous chalk. During deposition of the sediments, the resulting horizontal stresses, contained within stiff lateral boundaries, are locked in place. Basalt flows, resulting from volcanic eruptions, are added on top of the sedimentary deposits. As such, a ratio between the vertical stress and horizontal stresses is concomitantly increased by the basalt accumulations, and for relatively shallow depths (i.e. significantly shallower than would be observed in the absence of the basalt overburden), the vector of minimum stress is in the horizontal plane. As will be discussed below, this is useful for situations where it is desired to stimulate the kerogenous chalk source rock so as to form a series of vertical flow channels which each lead to production well **224** and which are transverse fractures relative central axis of the production well **224**. The fracture direction in shallow formations may not necessarily be vertical. If during stimulation a confined fracture leads to an additional net pressure, then the hydrofracture may start vertical and then turn horizontal. These complex “T”-shaped hydrofractures are usually bad for oil production because the width of the horizontal branch may be very small resulting in screenouts where the slurry fails to transport the proppant because the proppant cannot be transported beyond the point where the fracture width is smaller than three proppant diameters. The thin horizontal branches may lead to an excessive pressure increase that prevents further lateral fracture growth.

Thus, it is desirable to have a shallow location where the vertical stress is sufficiently greater than the horizontal stresses to assure that the hydrofractures are vertical. Thus it is desirable to have sufficient overburden of high density basalt. Basalt has a high density of about 3 gm/cc, and a basalt flow on top of the sedimentary cover

adds significant vertical stress. For example, 100 m of basalt on the surface adds over 400 psi of vertical stress, thus assuring that a hydrofracture will be oriented vertically.

In the example of FIG. 9, a thickness direction **890** of each flow channel is along the central axis of the production well **224**.

5 In the examples of FIG. 5-9 the source rock is stimulated to mobilize naturally-occurring oil. This is not a requirement.

Alternatively or additionally, it is possible to introduce thermal energy into the kerogenous source rock as to increase the mobility of naturally occurring oil therein - e.g. by reducing the viscosity thereof or by facilitating the removal of water or brine from the pore space of the kerogenous chalk so as to increase the relatively permeability of the naturally-occurring oil therein.

As noted above, in some embodiments, there is a geothermal gradient of at least 3 degrees Celsius per 100 meter. Fig. 11 illustrates data from a well log where the geothermal gradient is about 4.4 degrees Celsius per 100 meter.

15 Additional Discussion

Some embodiments of the present invention relate to a method of oil production comprising: a. drilling a shallow production well having a maximum depth of at most 2 kilometers into a kerogenous chalk source rock that is characterized by a. type IIs kerogen; at a location where there is a geothermal gradient of at least 3 degrees Celsius per 100 meters ; and b. at depths that are shallow, above the aquifer and within the source rock, casing and perforating the production well; c. producing naturally-occurring oil from the source rock via the production well and the shallow-depth perforated locations thereof.

Some embodiments of the present invention relate to a method of oil production comprising: a. drilling a shallow non-vertical production well having a maximum depth of at most 2 kilometers into a kerogenous chalk source rock that is characterized by: i. type IIs kerogen; and ii. a geothermal gradient of at least 4 degrees Celsius per 100 meters and c. producing naturally-occurring oil from the source rock via the non-vertical production well.

30 In some embodiments, the non-vertical production well is substantially horizontally-oriented.

Some embodiments of the present invention relate to a method of oil production comprising: a. drilling a shallow production well having a maximum depth of at most 2 kilometers into a kerogenous chalk source rock that is characterized by: i. type II_s kerogen; and ii. a geothermal gradient of at least 4 degrees Celsius per 100 meters and b. stimulating the source rock at the shallow depths so as to mobilize naturally-occurring oil therein; and c. producing from the source rock, via the production well, the mobilized naturally-occurring oil.

In some embodiments, the production well is non-vertical.

In some embodiments, the non-vertical production well is substantially horizontally-oriented.

In some embodiments, the stimulation forms a plurality of parallel, thin flow channels within the source rock that are each substantially vertically oriented, a thickness direction of the flow channels being along a central axis of the production well, and with each flow channel leading to the production well.

In some embodiments, the stimulation of the source rock occurs at a depth that is less than that all aquifers thereof.

Some embodiments of the present invention relate to a method of oil production comprising: a. drilling a shallow production well having a maximum depth of at most 2 kilometers into a kerogenous chalk source rock that is characterized by: i. type II_s kerogen; and ii. a geothermal gradient of at least 4 degrees Celsius per 100 meters and b. introducing thermal energy into the source rock so as to increase a mobility of naturally-occurring oil in the source rock; and c. producing, via the production wells, the increased-mobility naturally-occurring oil from the dried portions of the oil shale source rock.

In some embodiments, thermal energy is effective to significantly increase a mobility of the naturally-occurring oil by at least a factor of 10.

In some embodiments, the thermal energy is effective to significantly decrease the viscosity of the naturally-occurring oil by at least a factor of 10.

In some embodiments, the thermal energy is effective to vaporize liquid water within the pore space of the source rock so as to increase the relative permeability of the naturally-occurring oil within the source rock.

In some embodiments, oil produced via the production wells is never heated within the source rock to a temperature exceeding 200 degrees Celsius.

In some embodiments, the method is carried out so that the bulk source rock is never heated to a temperature exceeding 200 degrees Celsius.

5 In some embodiments, the method is carried out without significantly pyrolyzing the source rock.

In some embodiments, a majority of hydrocarbon liquids produced via the production wells is naturally occurring.

10 In some embodiments, the geothermal gradient is at least 3.5 degrees Celsius per 100 meters.

In some embodiments, the geothermal gradient is at least 4.0 degrees Celsius per 100 meters.

In some embodiments, the geothermal gradient is at about 4.5 degrees Celsius per 100 meters.

15 In some embodiments, the production well is substantially horizontal, a central axis thereof being substantially parallel to a minimum stress vector of the kerogenous chalk.

In some embodiments, the producing includes drawing naturally-occurring oil residing in pore space of the kerogenous chalk source rock into the production well.

20 In some embodiments, the producing includes drawing naturally-occurring oil residing in the pore space of the kerogenous chalk source rock into the production well via perforations thereof.

In some embodiments, the method further comprises (i) subjecting the produced oil to a distillation process and/or (ii) desulfurizing the produced oil or a derivative thereof and/or (iii) refining the produced oil into at least one of naphtha, gasoline, diesel fuel, asphalt base, heating oil, kerosene, and liquefied petroleum gas.

25 Some embodiments of the present invention relate to an apparatus for oil production comprising: a shallow production well having a maximum depth of at most 2 kilometers drilled into a kerogenous chalk source rock that is characterized by: i. type IIs
30 kerogen; and ii. a geothermal gradient of at least 4 degrees Celsius per 100 meters

wherein at depths that are shallow, above the aquifer and within the source rock, the production well is cased and perforated.

In some embodiments, the production well is non-vertical.

In some embodiments, the production well is horizontal.

5 In some embodiments, the apparatus further comprises a series of thin parallel flow channels each of which leads to the production well and a thickness direction of each flow channel being oriented along the production well central axis.

In some embodiments, the production well is substantially horizontal, a central axis thereof being substantially parallel to a minimum stress vector of the kerogenous
10 chalk.

The present invention has been described using detailed descriptions of embodiments thereof that are provided by way of example and are not intended to limit the scope of the invention. The described embodiments comprise different features, not
15 all of which are required in all embodiments of the invention. Some embodiments of the present invention utilize only some of the features or possible combinations of the features. Variations of embodiments of the present invention that are described and embodiments of the present invention comprising different combinations of features noted in the described embodiments will occur to persons of the art.

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WHAT IS CLAIMED:

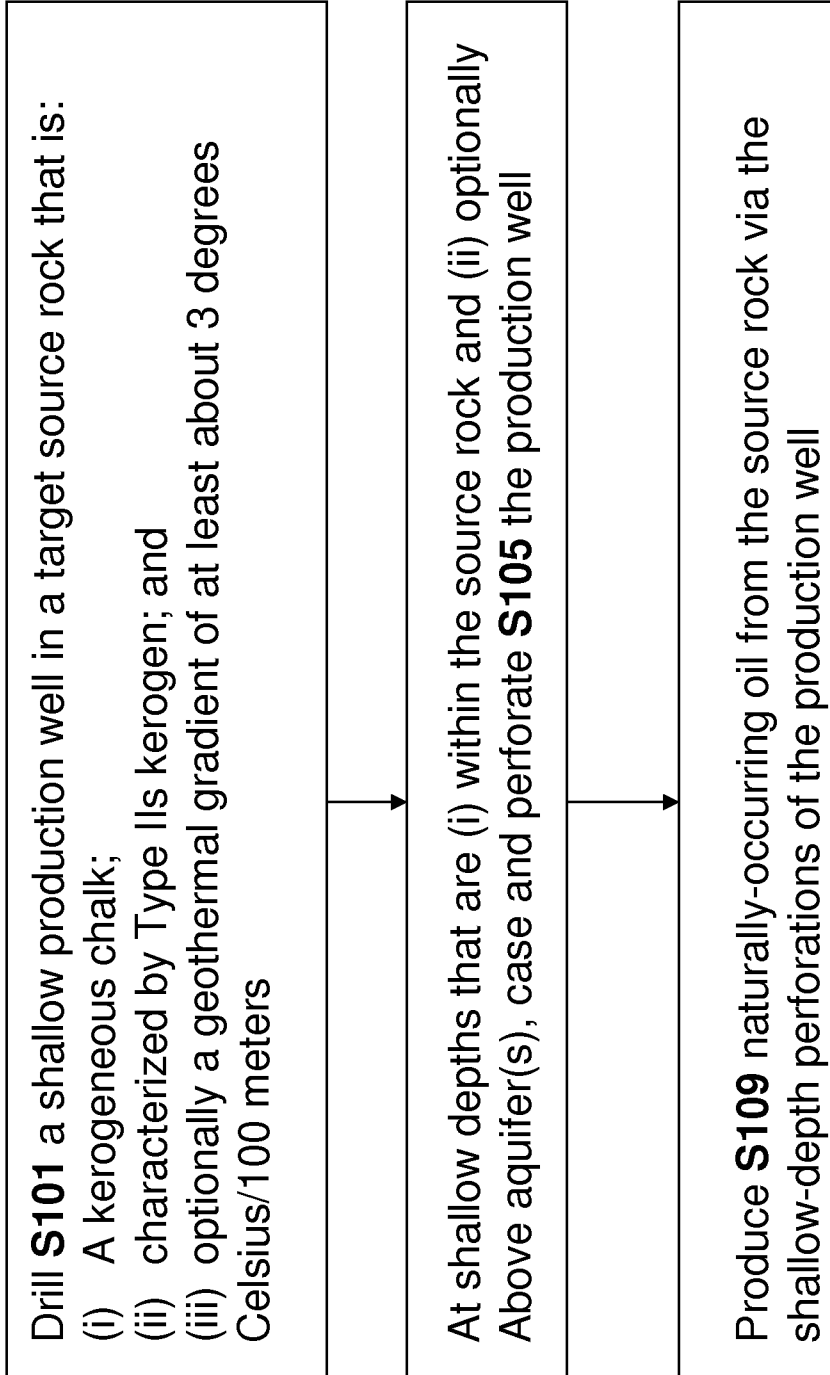
1. A method of unconventional oil production comprising:
 - a. drilling a production well into a kerogenous chalk source rock comprising (i) type IIs kerogen and (ii) shallow naturally-occurring unconventional oil derived from the type IIs kerogen that is resident within pore space of the source rock;
 - b. at shallow depths of at most 2 kilometers and within the source rock, casing and perforating the production well; and
 - c. producing the shallow naturally-occurring unconventional oil from the source rock via the production well.
2. The method of claim 1 wherein a location at which the production well is drilled is selected in accordance with a geothermal gradient.
3. The method of any preceding claim wherein the production well is drilled at a location where the geothermal gradient is at least 3.0 degrees Celsius per 100 meters, or at least 3.5 degrees Celsius per 100 meters, or at least 4.0 degrees Celsius per 100 meters.
4. The method of any preceding claim wherein the unconventional oil and at least some of the perforations of the production well are located at depths of at most 1.5 kilometers, or at most 1200 meters, or at most 1 kilometer or at most 800 meters.
5. The method of any preceding claim wherein the source rock is below an overburden comprising a basalt layer.
6. The method of claim 5 wherein the overburden further comprises a sedimentary portion situated below the basalt layer so that horizontal stresses of the sedimentary portion were locked in at or before a time of deposition of the lava flow which formed the basalt layer.
7. The method of any preceding claim wherein a porosity of the source rock is at least 30% or at least 35% or at least 40%.
8. The method of any preceding claim wherein a permeability of the source rock matrix is at most 1 mD or at most 0.1 mD or at most 0.01 mD.
9. The method of any preceding claim wherein an oil saturation of pore space of the source rock is at least 50% or at least 60% or at least 70%.
10. The method of any preceding claim wherein the source rock is stimulated at the shallow depths to increase a permeability of the source rock.

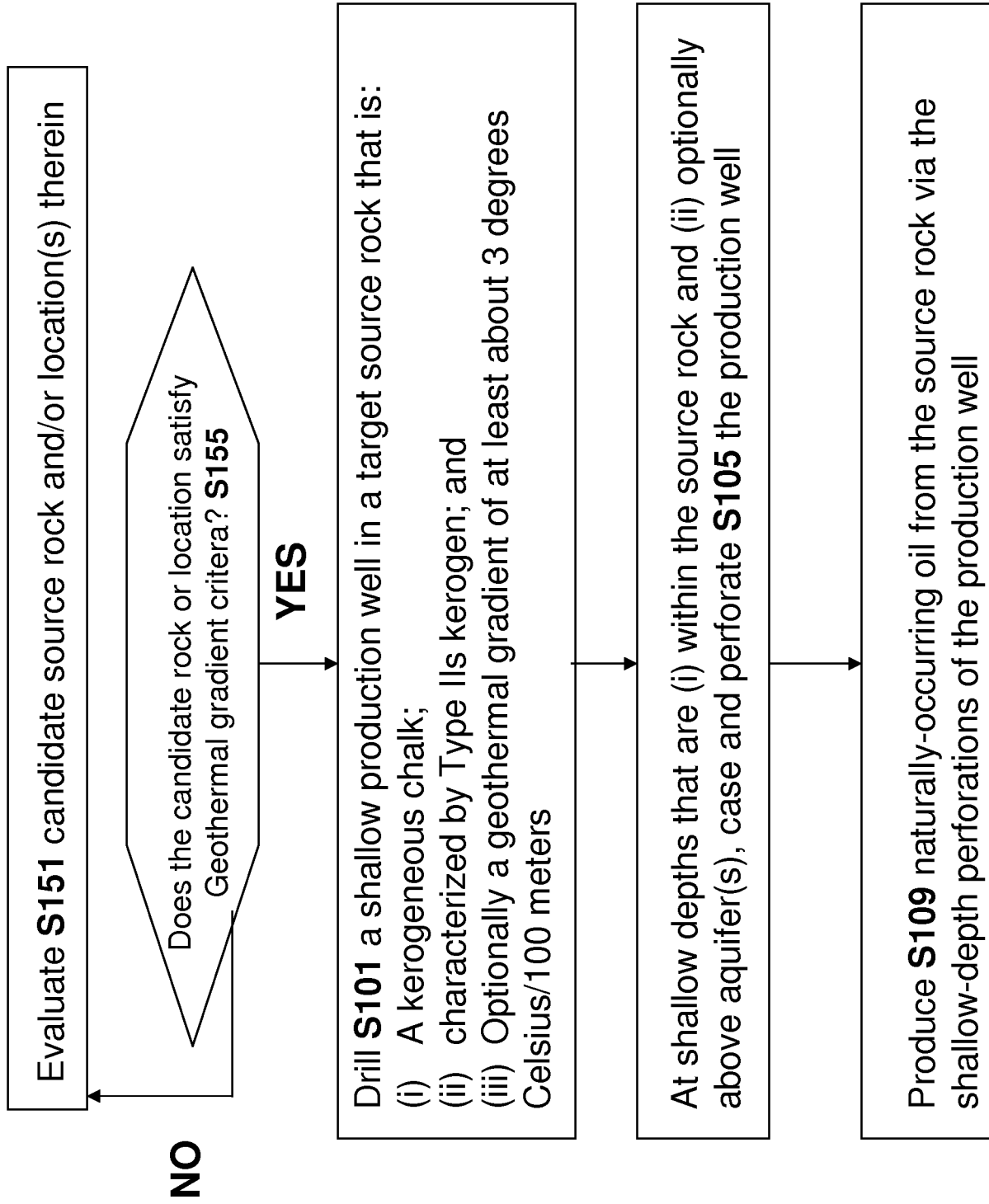
11. The method of claim 10 wherein the stimulation of the source rock occurs at a depth that is less than that of all aquifers thereof.
12. The method of any of claims 10-11 wherein the source rock is stimulated by means other than by hydraulic stimulation.
13. The method of any preceding claim wherein a total organic content (TOC) of the source rock is at least 10%.
14. The method of any preceding claim wherein the source rock is stimulated at the shallow depths by high pressure acid stimulation of the source rock.
15. The method of any preceding claim wherein the source rock is hydraulic stimulated.
16. The method of any preceding claim wherein the source rock thermally stimulated.
17. The method of claim 16 wherein thermal energy is effective to significantly increase the mobility of the naturally-occurring oil by at least a factor of 10.
18. The method of any of claims 16-17 wherein thermal energy is effective to significantly decrease the viscosity of the naturally-occurring oil by at least a factor of 10.
19. The method of any of claims 16-18 wherein the thermal energy is effective to vaporize liquid water and light hydrocarbons within the pore space of the source rock.
20. The method of any preceding claim wherein pressurized steam is injected into the source rock at the shallow depths so as to thermally stimulate the source rock to increase a mobility of the unconventional oil.
21. The method of claim 20 wherein the steam is injected according to a huff-and-puff technique.
22. The method of any of claims 20-21 wherein the steam enters the source rock at a temperature of at most 200 degrees Celsius.
23. The method of any preceding claim wherein the production well is non-vertical.
24. The method of claim 23 wherein the non-vertical production well is substantially horizontally-oriented.
25. The method of any of claims 23-24 wherein the stimulation forms a plurality of parallel, thin flow channels within the source rock that are each substantially vertically oriented, a thickness direction of the flow channels being along a central axis of the production well, and with each flow channel leading to the production well.

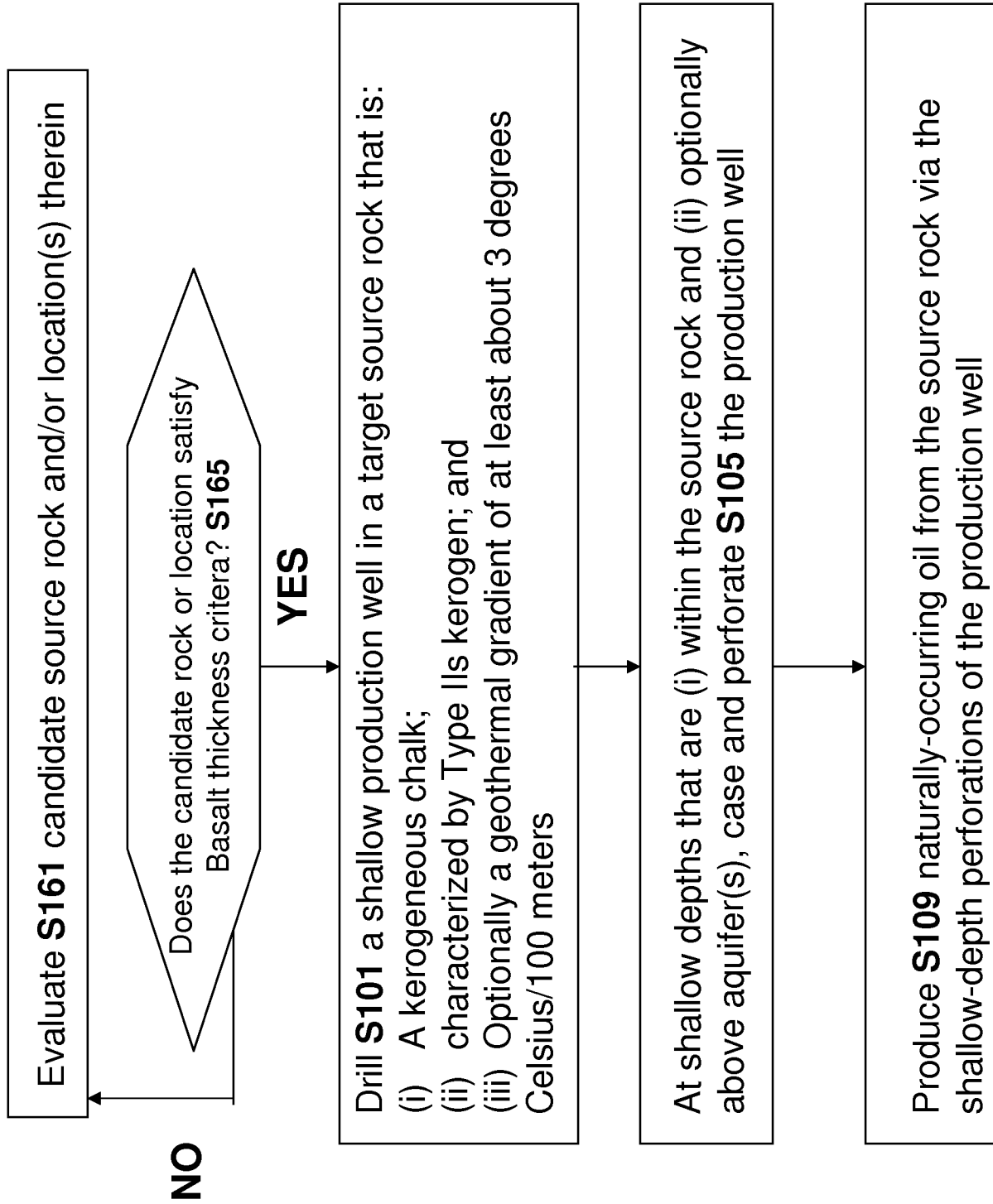
26. The method of any preceding claim wherein the production well is substantially horizontal, a central axis thereof being substantially parallel to a minimum stress vector of the kerogenous chalk source rock.
27. The method of any preceding claim wherein a total organic content (TOC) of the source rock is at least 15%.
28. The method of any preceding claim wherein a sulfur content of the unconventional oil is at least 2.5% wt/wt or at least 3% wt/wt or at least 3.5% wt/wt or at least 4% wt/wt.
29. The method of any preceding claim wherein an API gravity of the unconventional oil is at least 20⁰ and/or at most 30⁰.
30. The method of any preceding claim wherein a maximum depth of the production well is at most 2 km or at most 1.5 kilometers, or at most 1200 meters, or at most 1 kilometer or at most 800 meters.
31. The method of any preceding claim wherein oil produced via the production wells is never heated within the source rock to a temperature exceeding 200 degrees Celsius
32. The method of any preceding claim, carried out so that bulk source rock is never heated to a temperature exceeding 200 degrees Celsius.
33. The method of any preceding claim wherein the method is carried out without significantly pyrolyzing the source rock.
34. The method of any preceding claim wherein a majority of hydrocarbon liquids produced via the production wells is the naturally-occurring oil.
35. The method of any previous claim, wherein the producing includes drawing naturally-occurring oil residing in pore space of the kerogenous chalk source rock into the production well.
36. The method of any previous claim, wherein the producing includes drawing naturally occurring oil residing in the pore space of the kerogenous chalk source rock into the production well via perforations thereof.
37. The method of any previous claim, further comprising subjecting the produced oil to a distillation process.
38. The method of any previous claim, further comprising desulfurizing the produced oil or a derivative thereof.

39. The method of any previous claim, further comprising refining the produced oil into at least one of naphtha, gasoline, diesel fuel, asphalt base, heating oil, kerosene, and liquefied petroleum gas.
40. The method of any previous claim wherein a geothermal gradient at one or more candidate locations is analyzed, and the drilling of the production well at its location is contingent upon the results of the analysis.
41. The method of any previous claim wherein the kerogenous chalk is situated beneath a basalt overburden.
42. The method of claim 41 wherein a thickness of the basalt overburden at one or more candidate locations is analyzed, and the drilling of the production well at its location is contingent upon the results of the analysis.
43. The produced oil, or any derivative thereof, produced by the method of any of preceding claim.
44. An apparatus for unconventional oil production comprising:
a production well drilled into a kerogenous chalk source rock comprising (i) type IIs kerogen and (ii) shallow naturally-occurring unconventional oil derived from the type IIs kerogen that is resident within pore space of the source rock,
wherein the production well is cased and perforated at shallow depths of at most 2 kilometers and within the source rock so that the shallow naturally-occurring unconventional oil is recovered by the production well via the shallow-depth perforations of the production well.
45. The apparatus of claim 44 wherein the production well is non-vertical.
46. The apparatus of claim 44 wherein the production well is horizontal.
47. The apparatus of any of claims 44-46 further comprising a series of thin parallel flow channels that are all vertically oriented and transverse to a central axis of the production well.
48. The apparatus of any of claims 44-47 wherein the production well is substantially horizontal, a central axis thereof being substantially parallel to a minimum stress vector of the kerogenous chalk.

49. The apparatus of any of claims 44-48 wherein at a location of the production well, a local geothermal gradient is at least 3.0 degrees Celsius per 100 meters, or at least 3.5 degrees Celsius per 100 meters, or at least 4.0 degrees Celsius per 100 meters.
50. The apparatus of any of claims 44-49 wherein the unconventional oil and at least some of the perforations of the production well are located at depths of at most 1.5 kilometers, or at most 1200 meters, or at most 1 kilometer or at most 800 meters.
51. The apparatus of any of claims 44-50 wherein the source rock is below an overburden comprising a basalt layer.
52. The apparatus of any of claims 44-51 wherein the overburden further comprises a sedimentary portion situated below the basalt layer so that horizontal stresses of the sedimentary portion were locked in at or before a time of deposition of the lava flow which formed the basalt layer.
53. The apparatus of any of claims 44-52 wherein a porosity of the source rock is at least 30% or at least 35% or at least 40%.
54. The apparatus of any of claims 44-53 wherein a permeability of the source rock matrix at most 1 mD or is at most 0.1 mD or at most 0.01 mD.
55. The apparatus of any of claims 44-54 wherein an oil saturation of pore space of the source rock is at least 50% or at least 60% or at least 70%.
56. The apparatus of any of claims 44-55 wherein a total organic content (TOC) of the source rock is at least 15%.
57. The apparatus of any of claims 44-56 wherein a sulfur content of the unconventional oil is at least 2.5% wt/wt or at least 3% wt/wt or at least 3.5% wt/wt or at least 4% wt/wt.
58. The apparatus of any of claims 44-57 wherein an API gravity of the unconventional oil is at least 25⁰ and/or at most 30⁰.

**FIG. 1A**

**FIG. 1B**

**FIG. 1C**

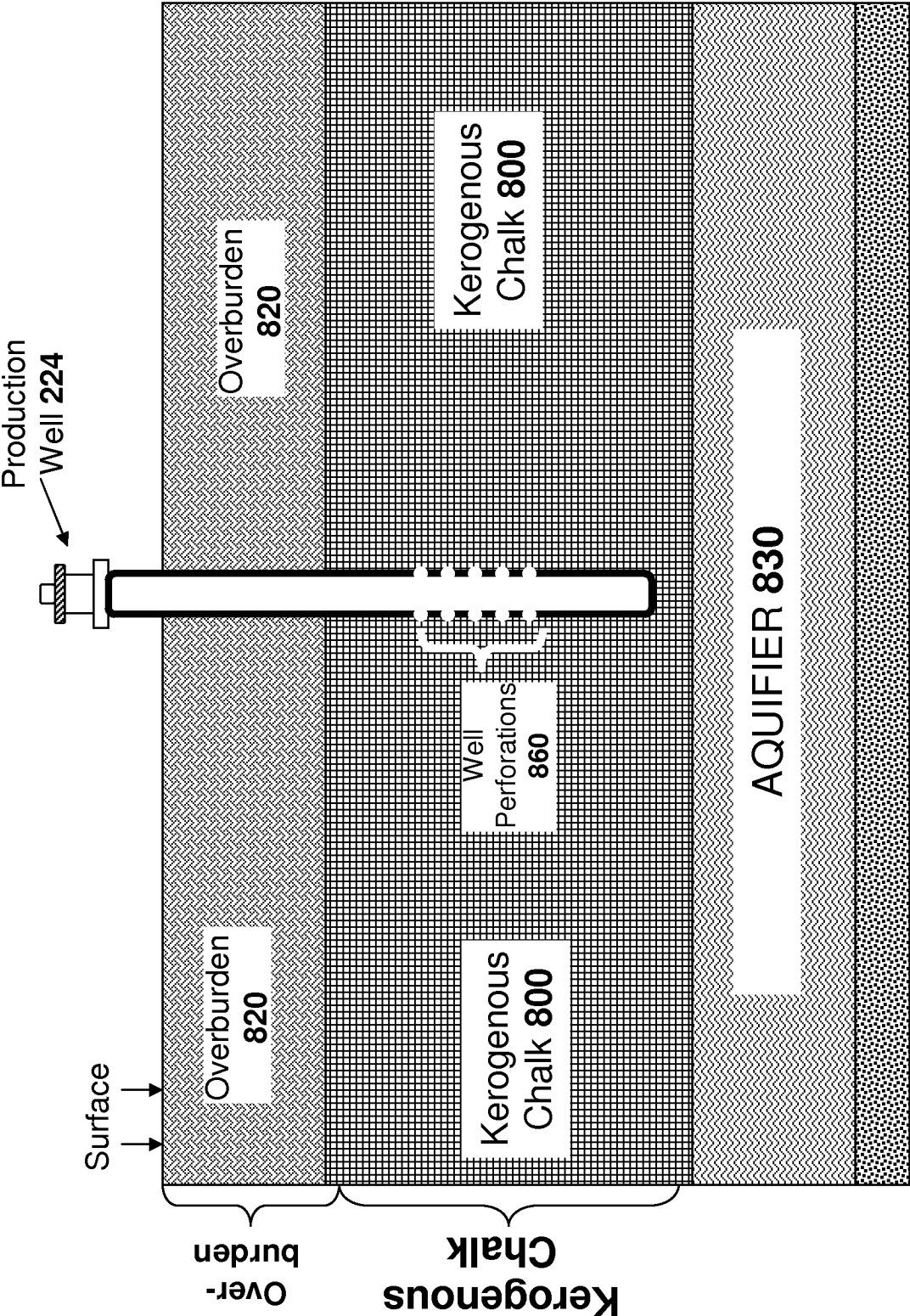


FIG. 2a

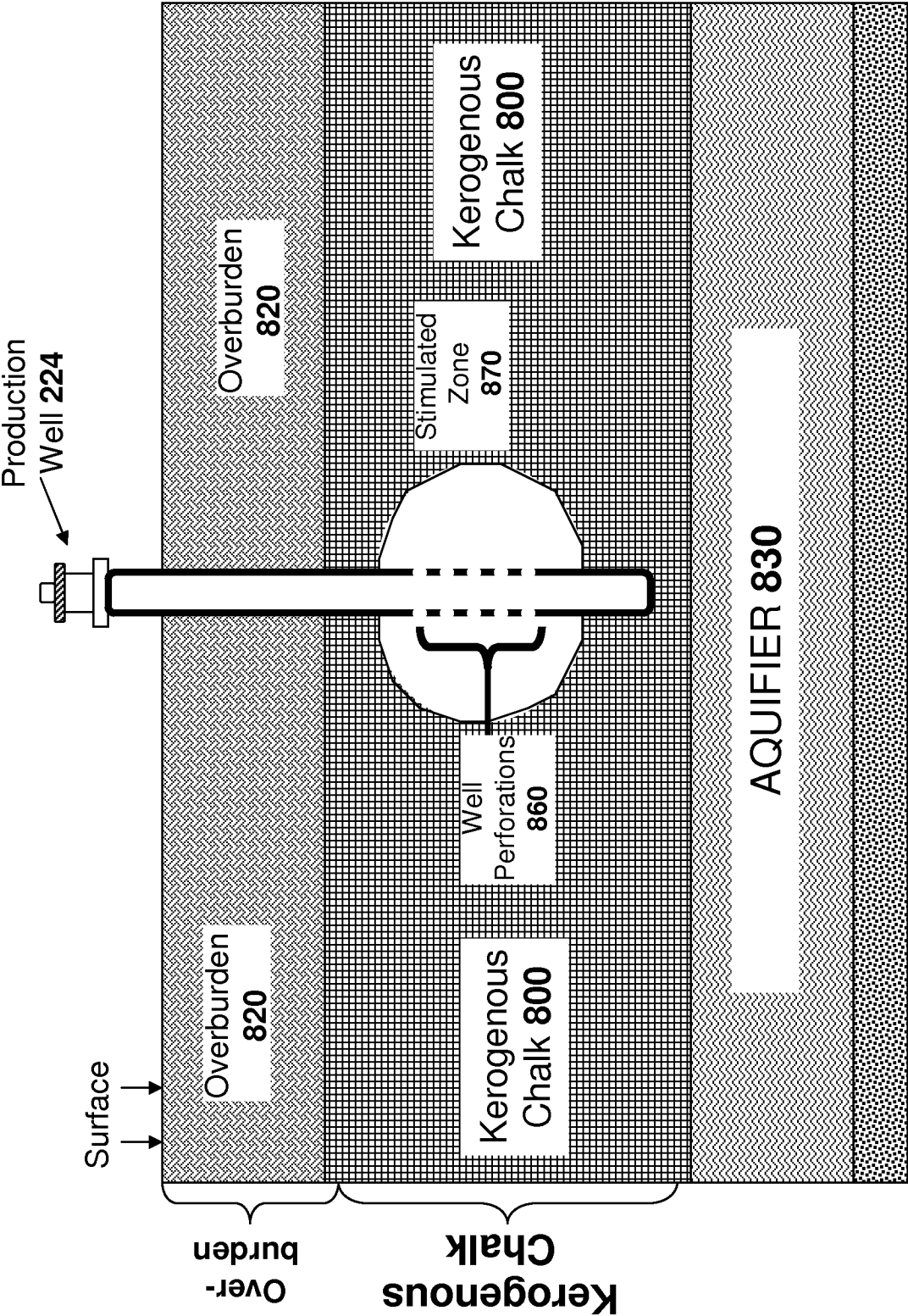


FIG. 2b

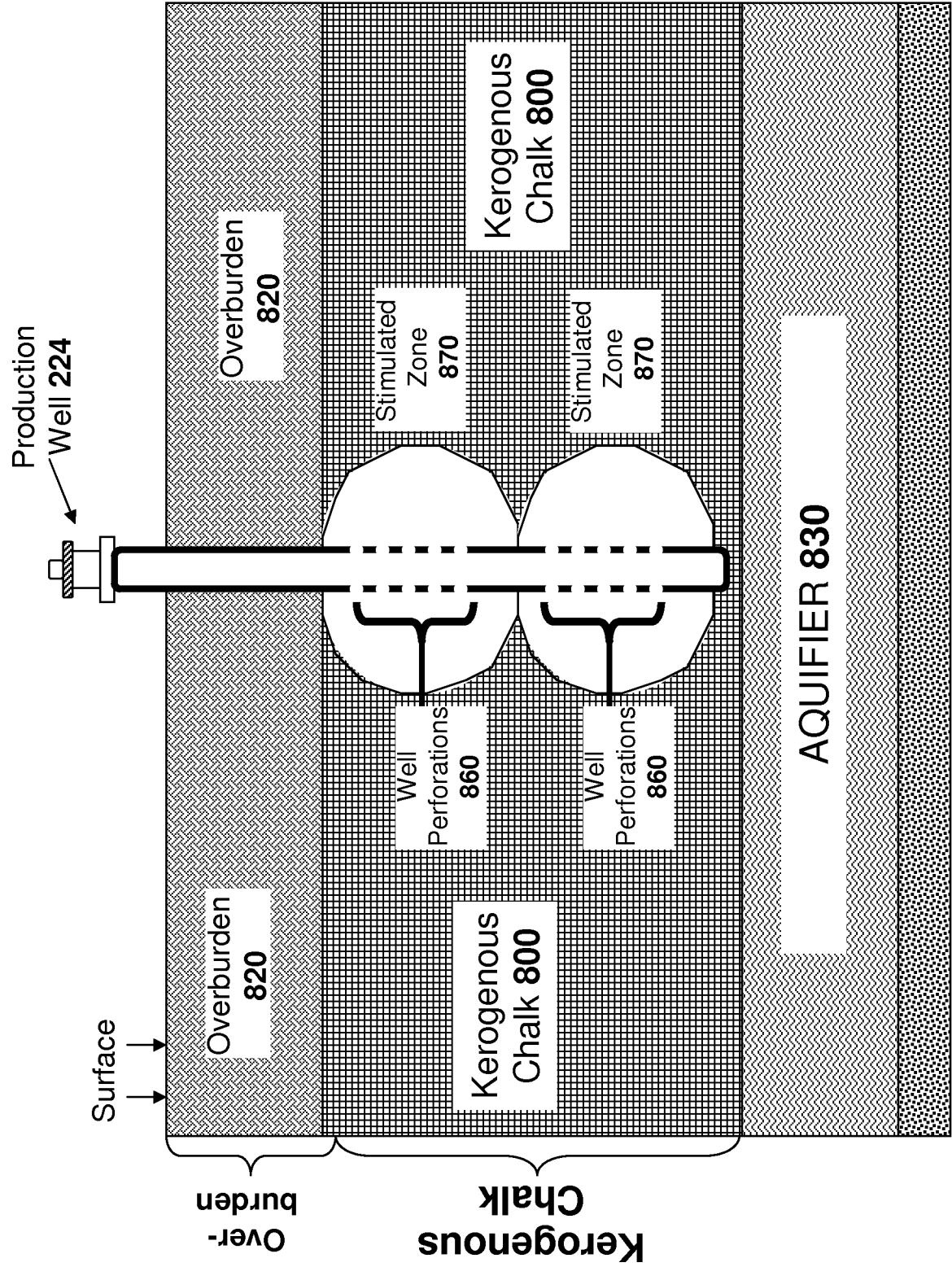
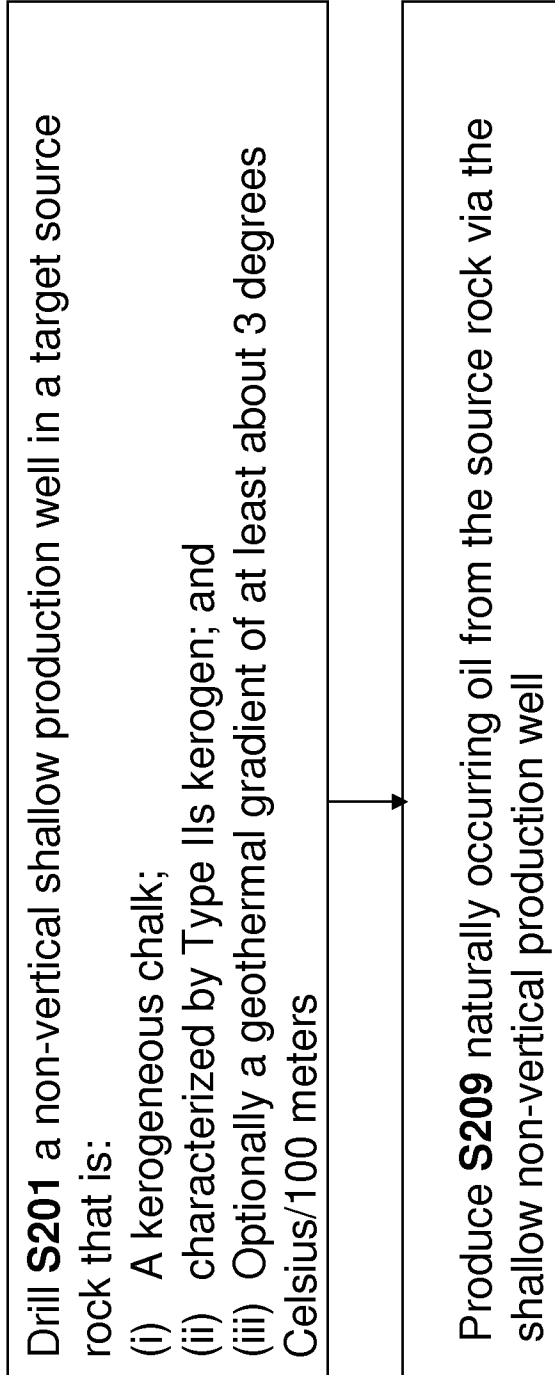


FIG. 2c

**FIG. 3A**

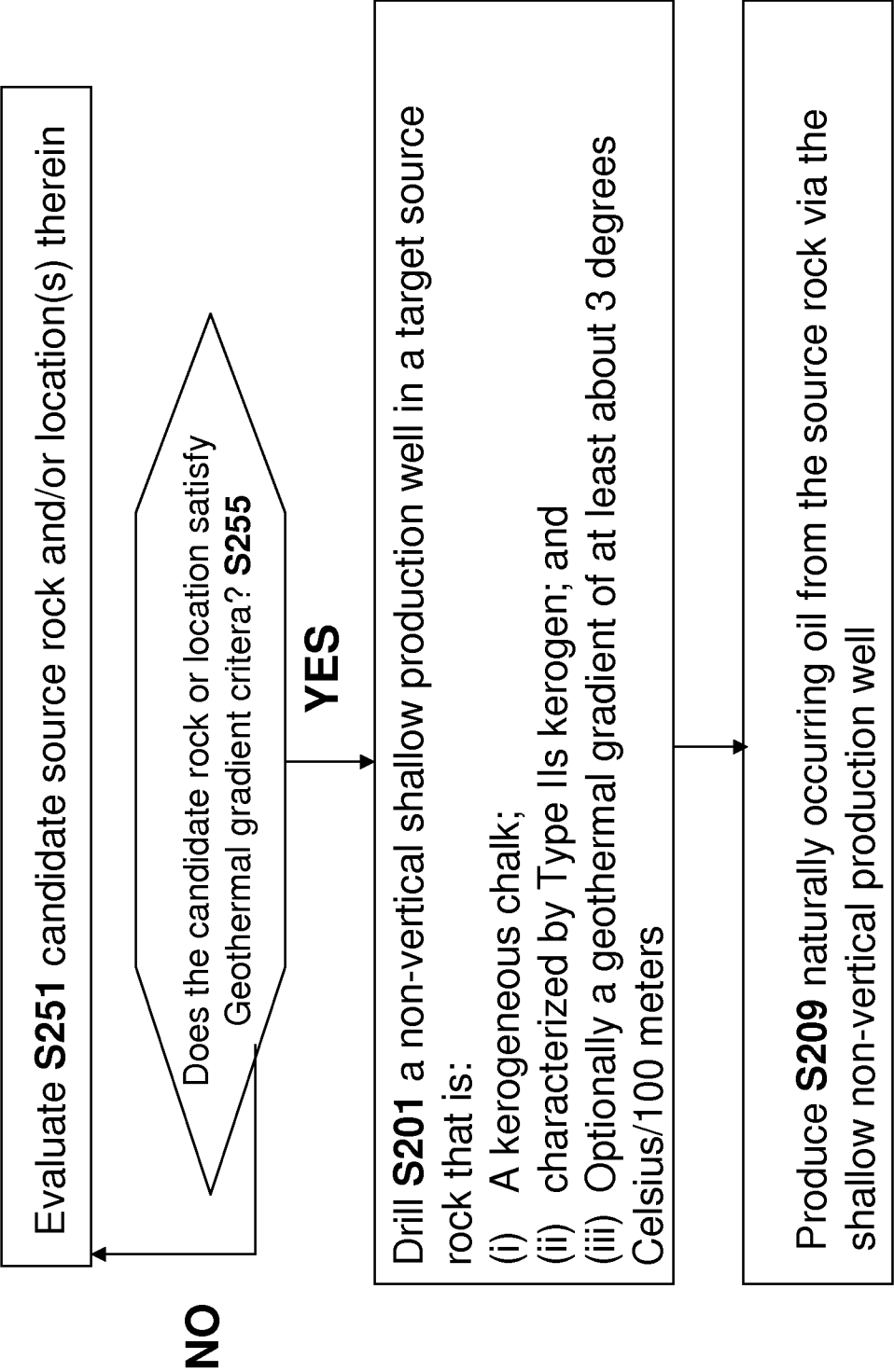


FIG. 3B

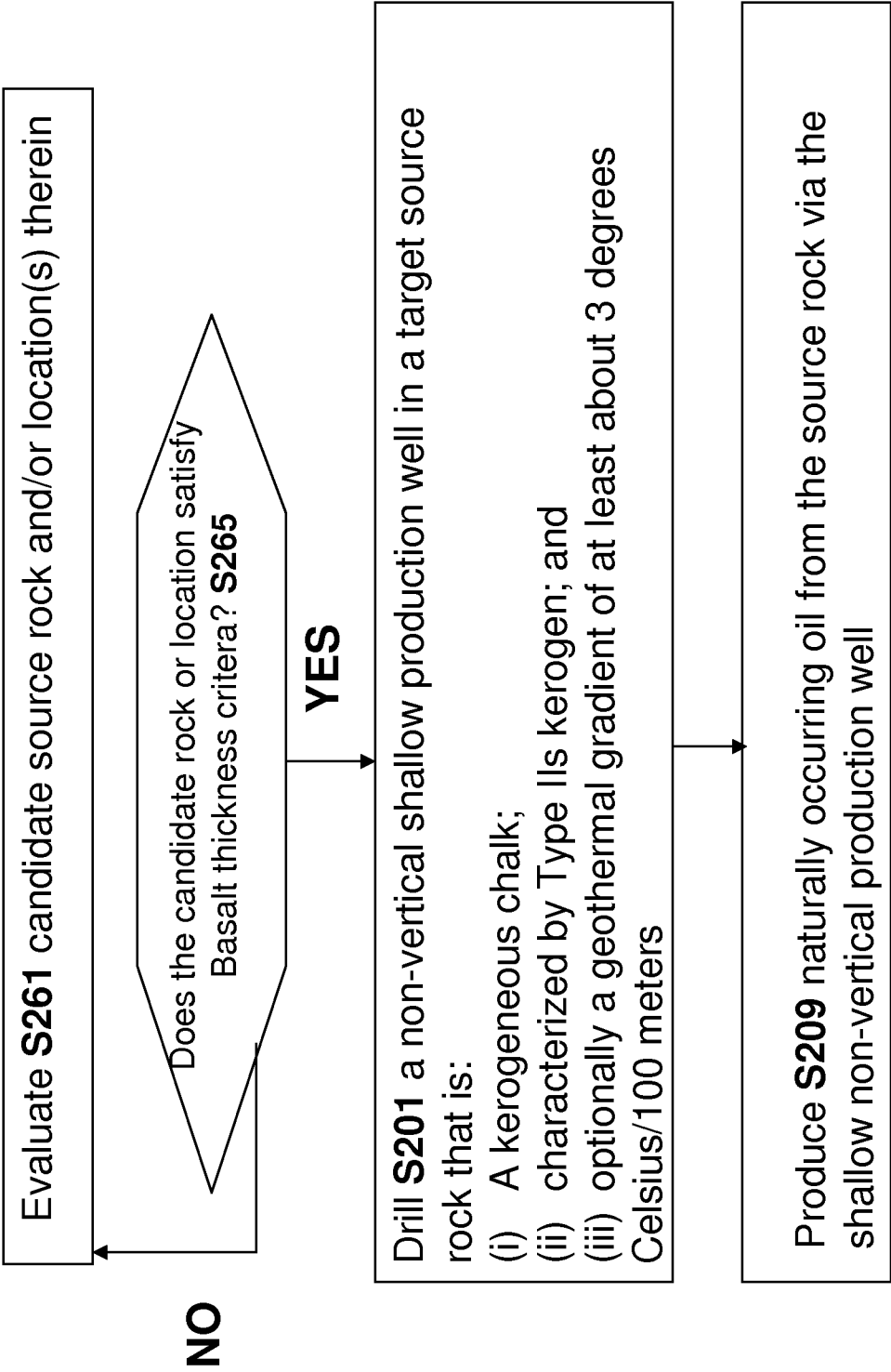


FIG. 3C

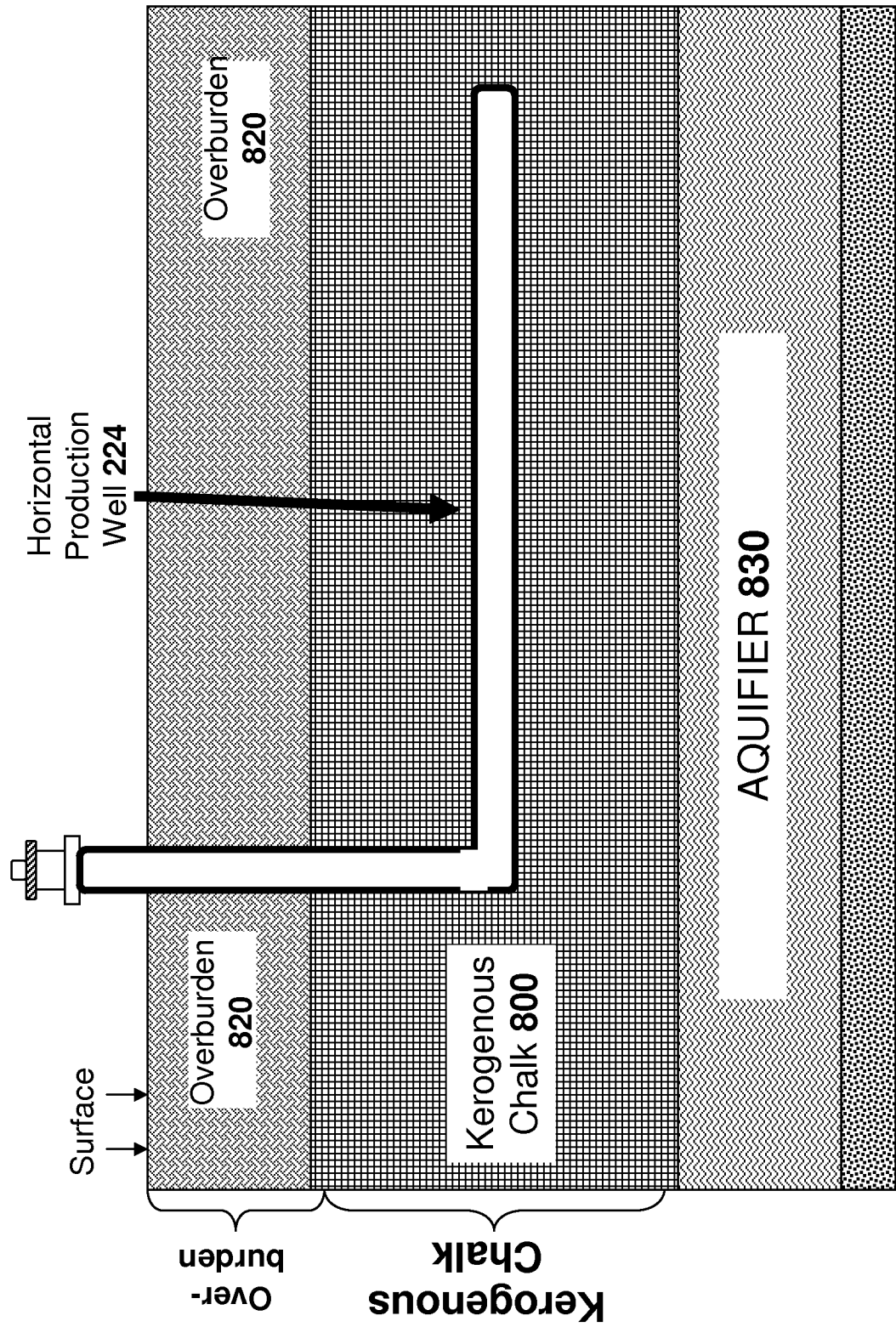


FIG. 4

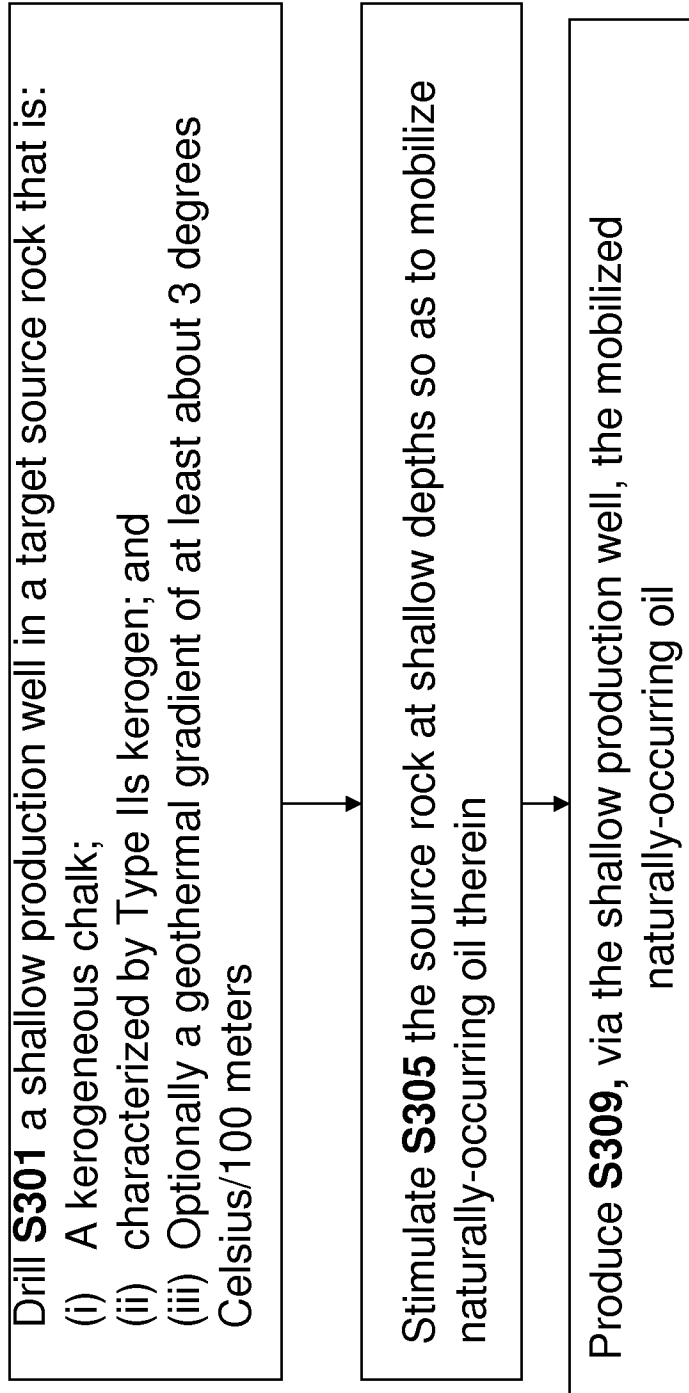


FIG. 5A

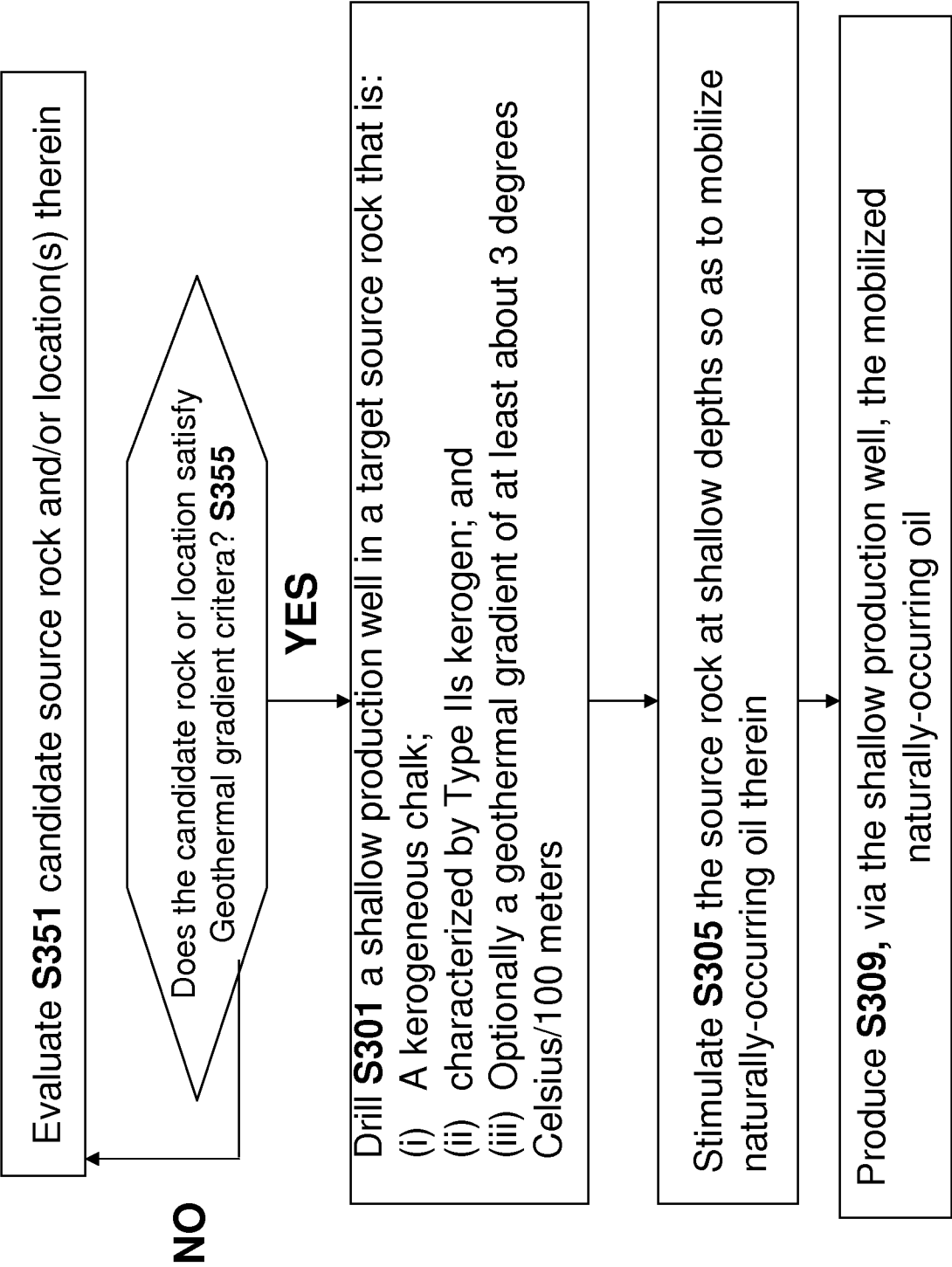


FIG. 5B

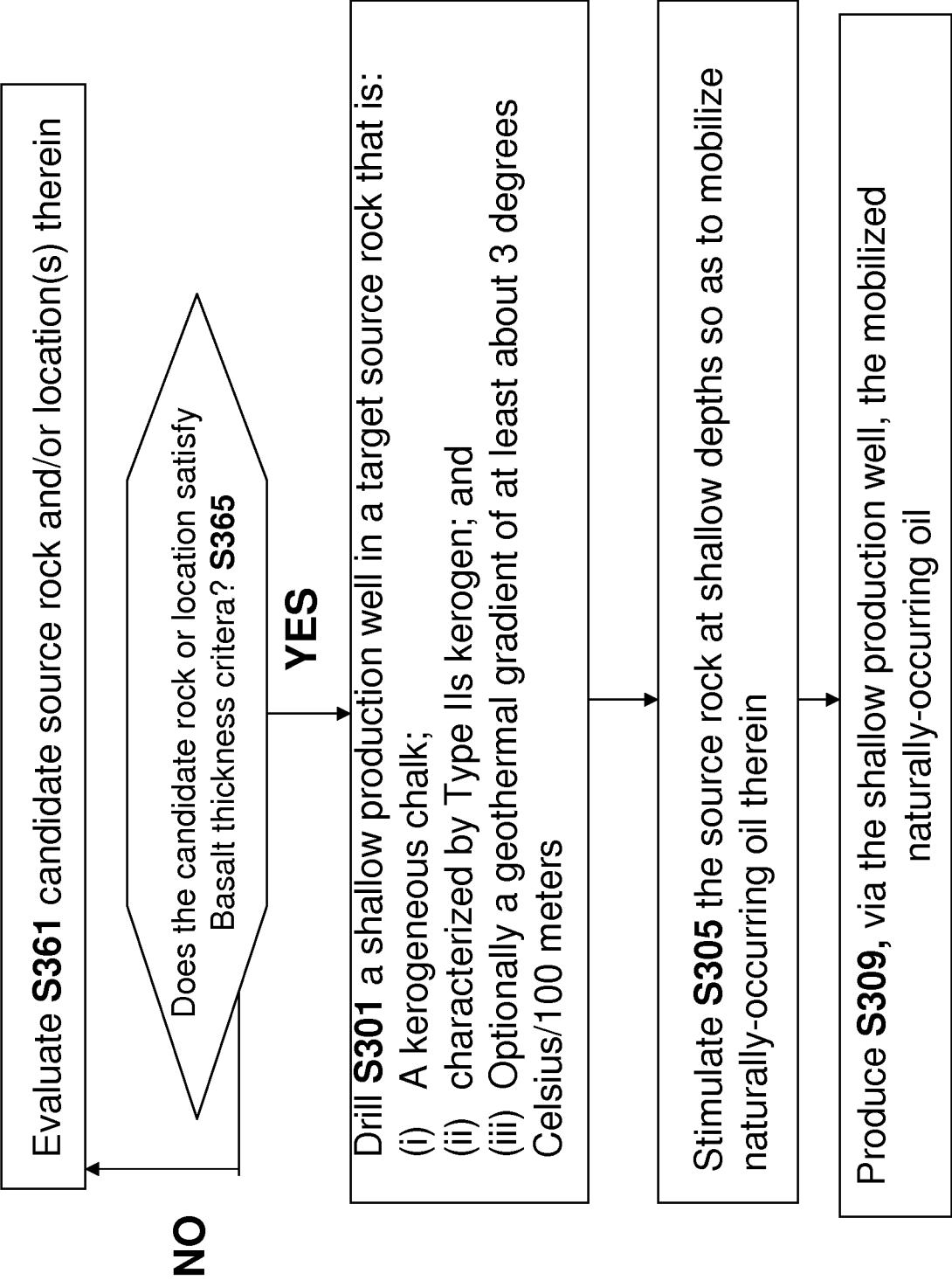


FIG. 5C

Discs 850 are longitudinally oriented

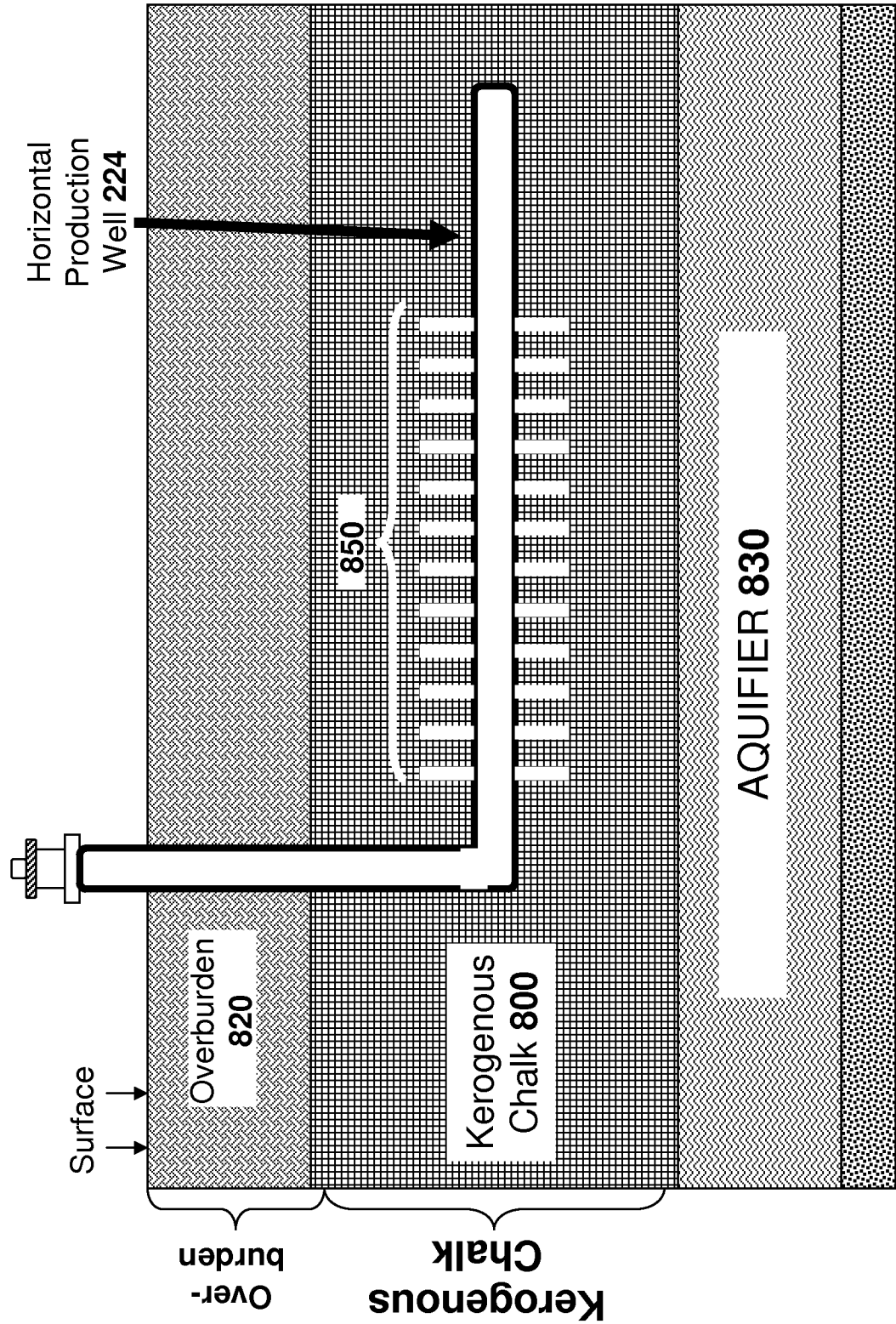


FIG. 6

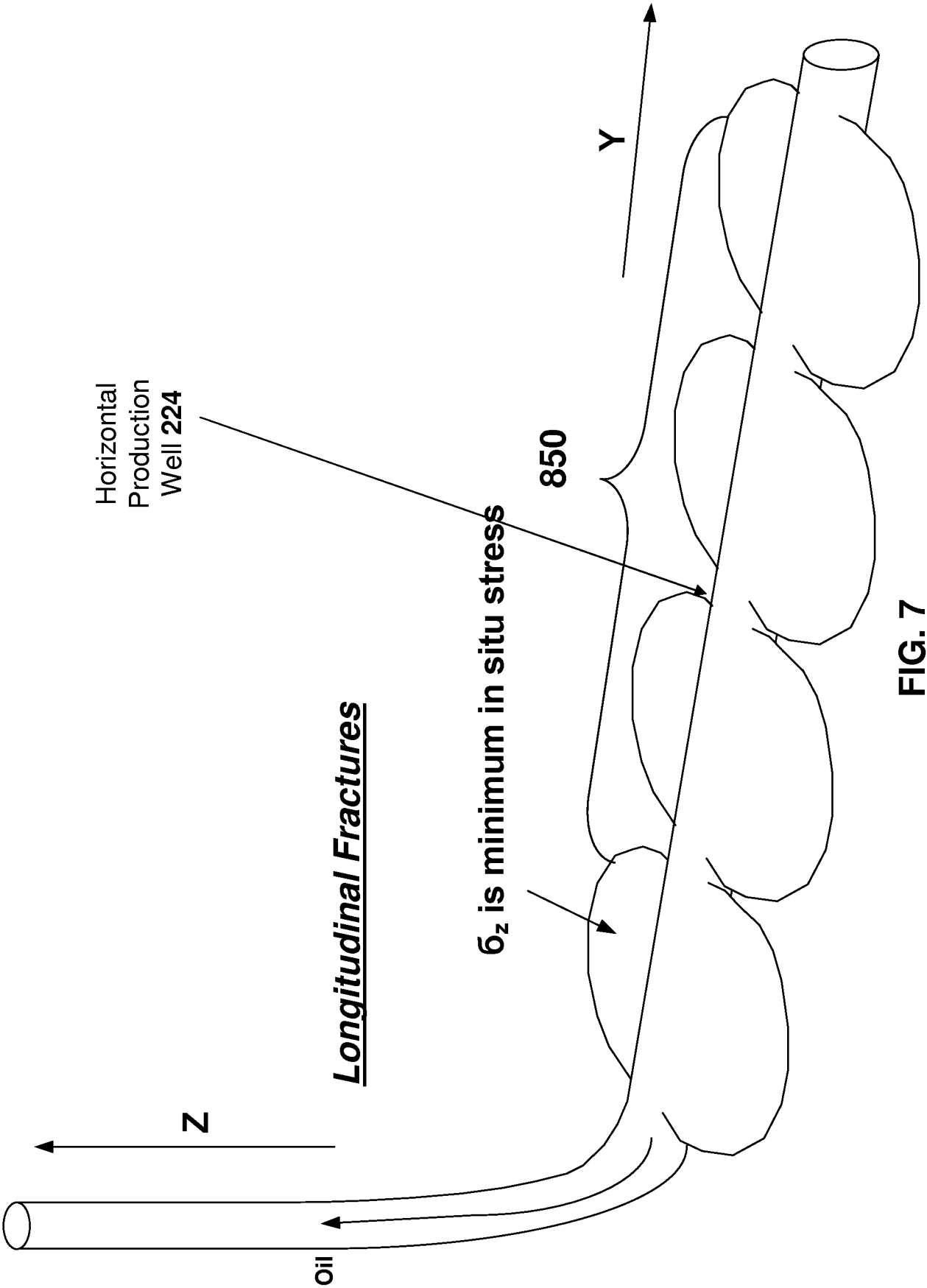


FIG. 7

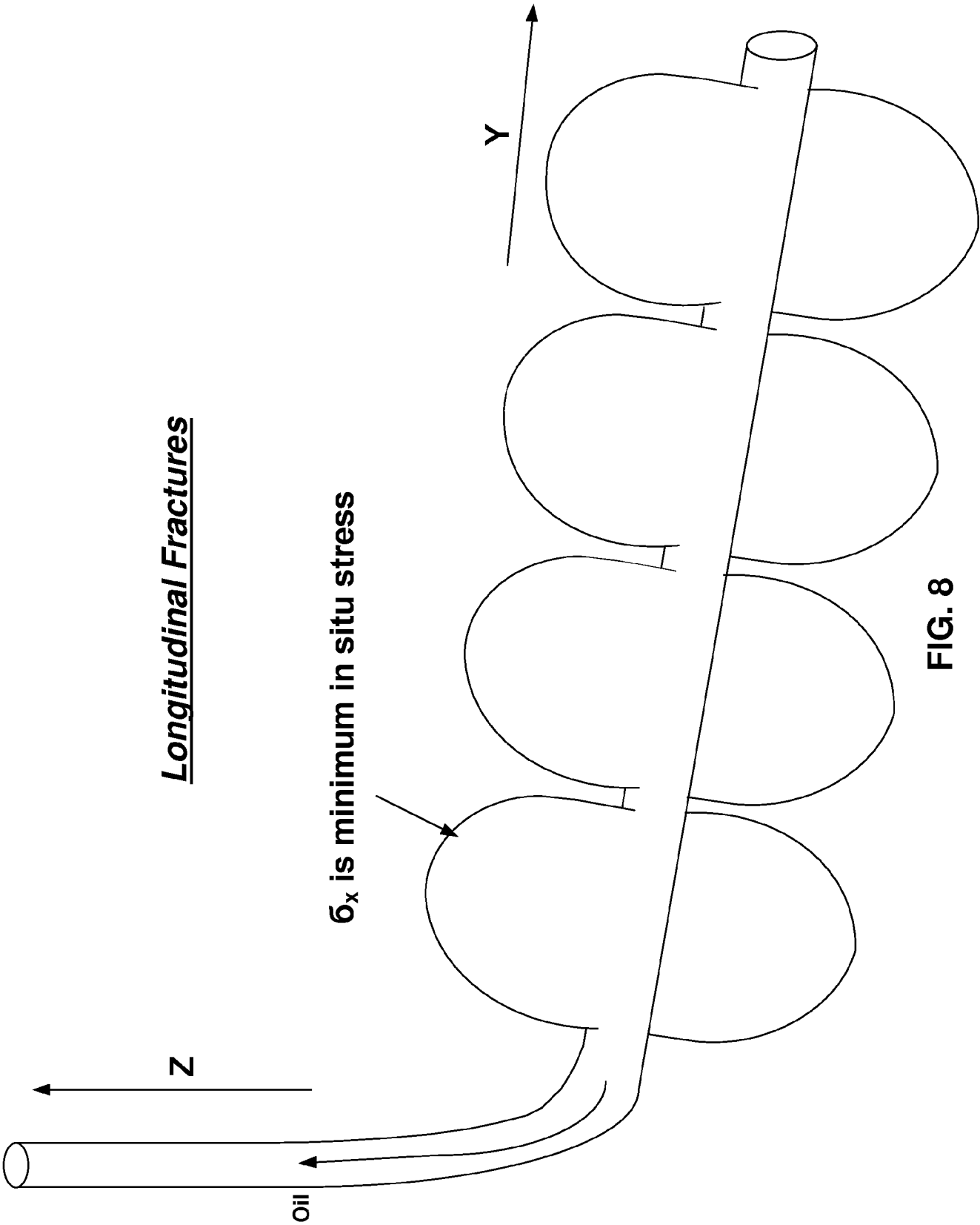


FIG. 8

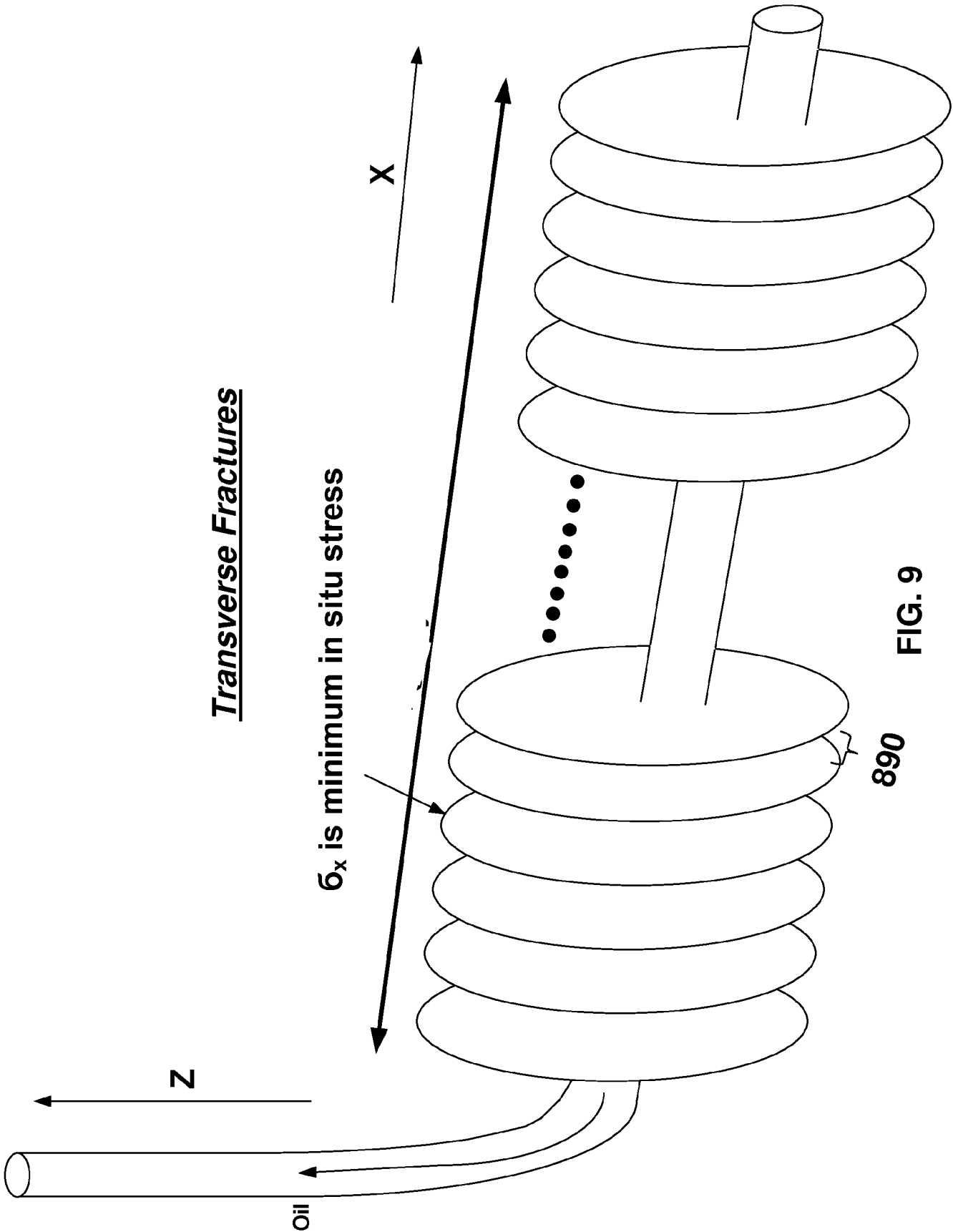


FIG. 9

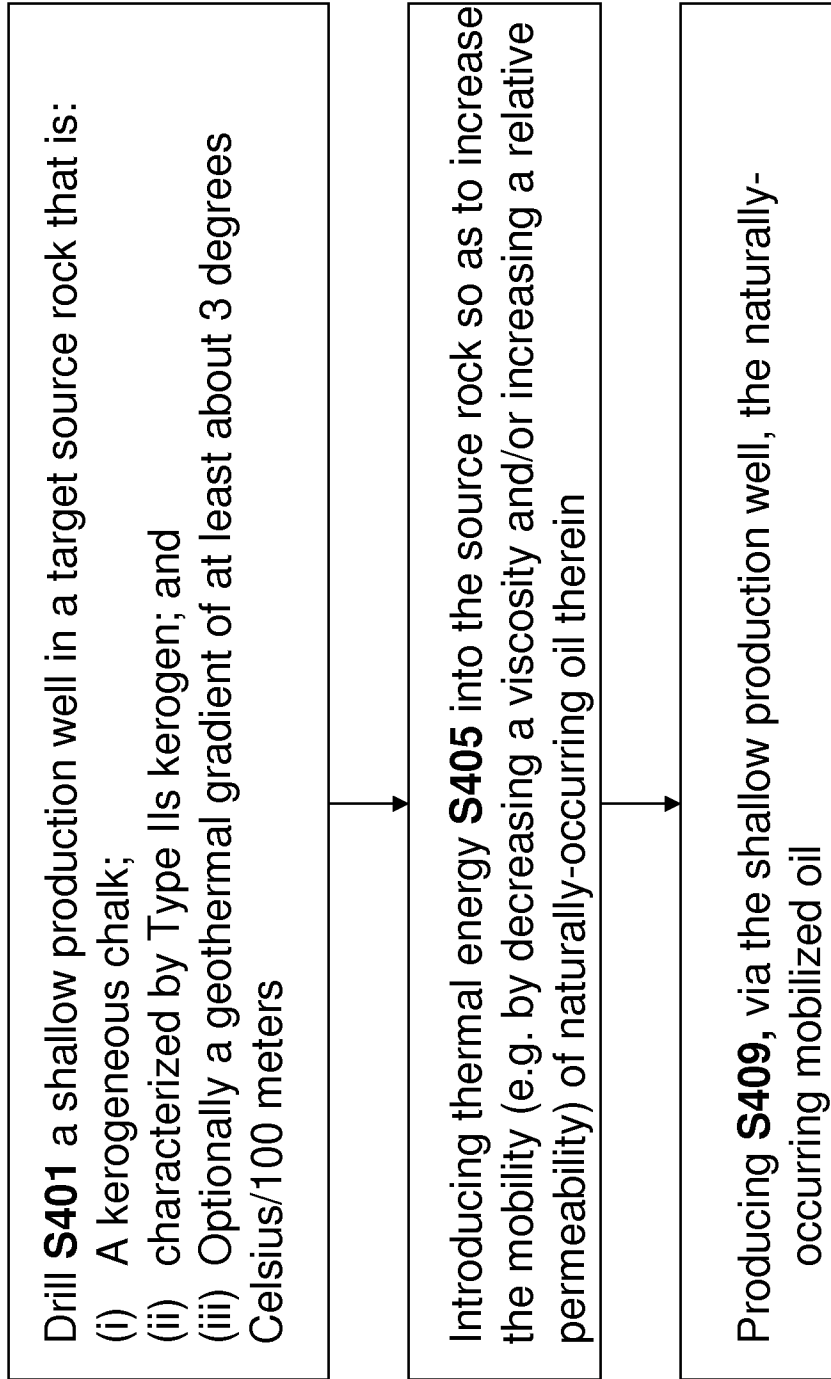
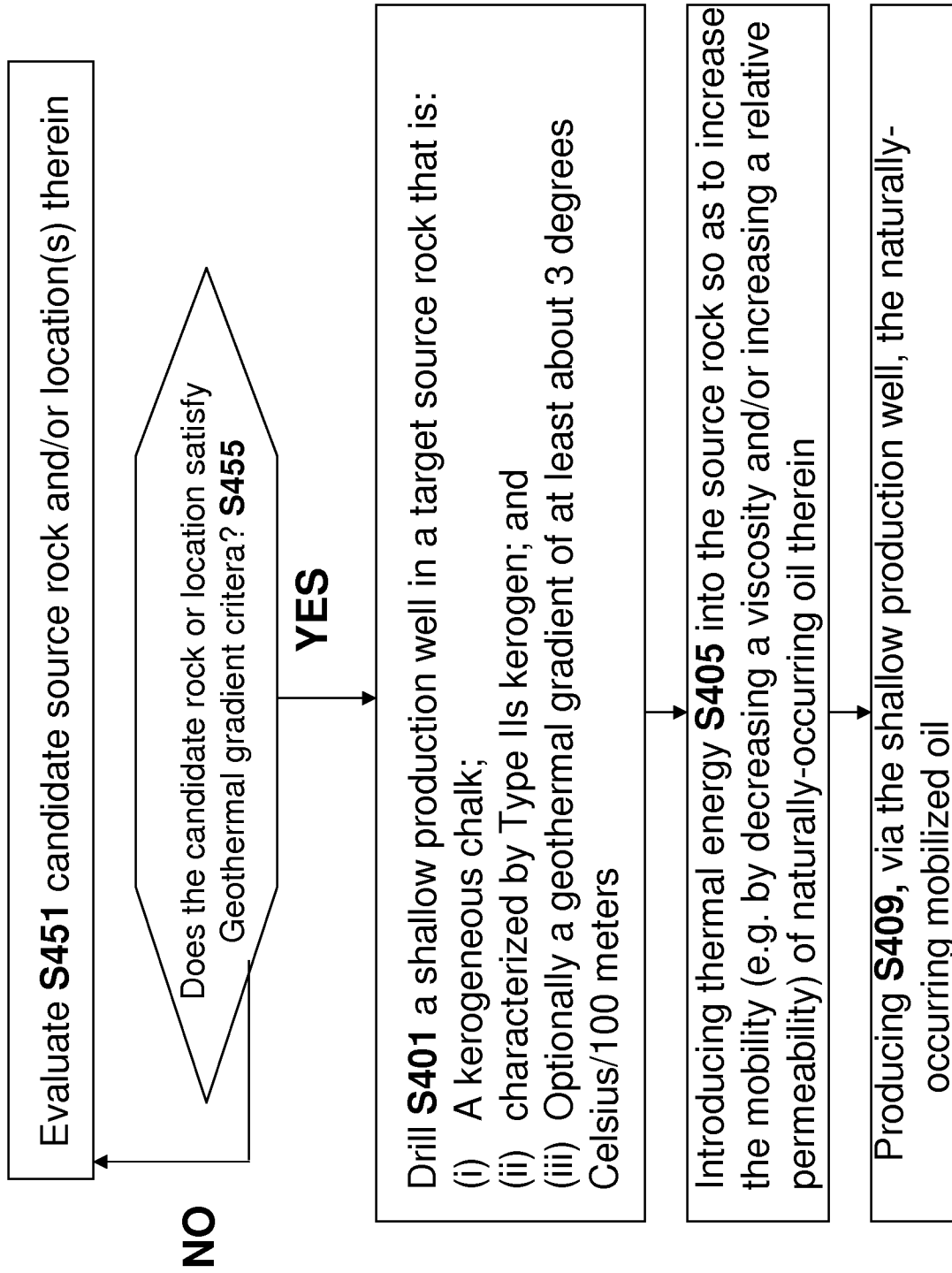
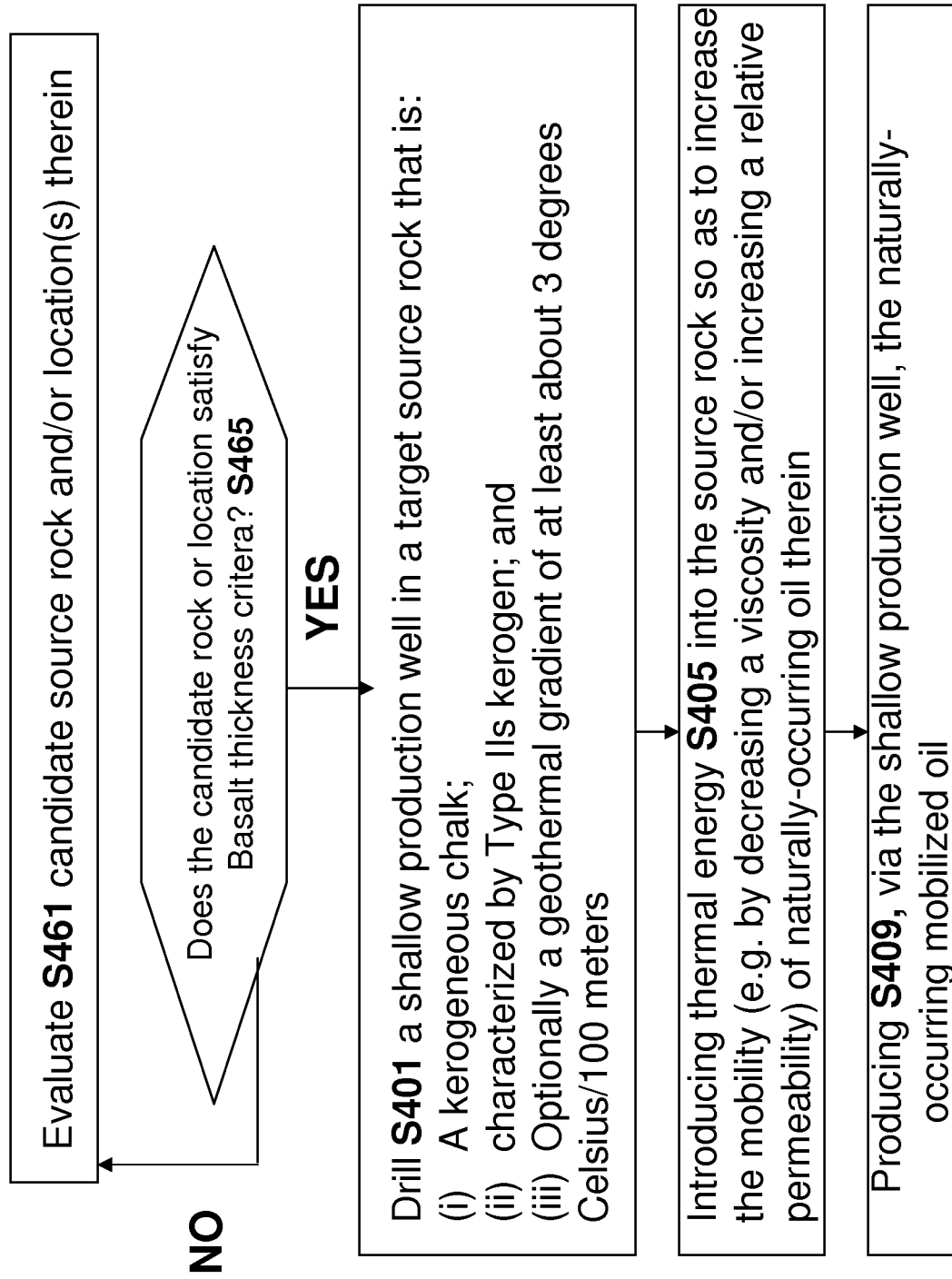


FIG. 10A

**FIG. 10B**

**FIG. 10C**

Example of Geothermal Gradient

