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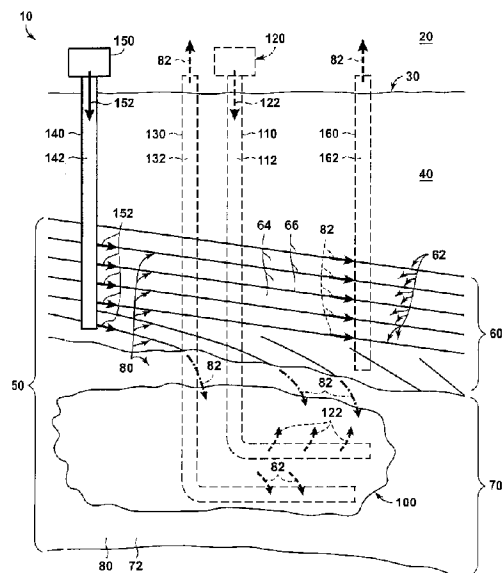
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(54) Title: SYSTEMS AND METHODS FOR PRODUCING VISCOUS HYDROCARBONS FROM A SUBTERRANEAN FORMATION THAT INCLUDES OVERLYING INCLINED HETEROLITHIC STRATA



(57) **Abrégé/Abstract:**

Systems and methods for producing viscous hydrocarbons from a subterranean formation that includes overlying inclined heterolithic strata are disclosed herein. The systems include the subterranean formation, which includes a lower zone and an overlying inclined heterolithic strata (IHS) zone. The systems also include a heated chamber within the lower zone, an IHS injection well extending within the IHS zone, and a mobilizing fluid supply system. The IHS injection well includes an IHS injection well conduit that is in direct fluid communication with the IHS zone, and the mobilizing fluid supply system is configured to provide a mobilizing fluid stream to the IHS injection well. The IHS injection well is configured to inject the mobilizing fluid stream into the IHS zone to facilitate flow of viscous hydrocarbons from the IHS zone. The methods include methods of utilizing the systems.

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Abstract of the Disclosure

Systems and methods for producing viscous hydrocarbons from a subterranean formation that includes overlying inclined heterolithic strata are disclosed herein. The systems include the subterranean formation, which includes a lower zone and an overlying inclined heterolithic strata (IHS) zone. The systems also include a heated chamber within the lower zone, an IHS injection well extending within the IHS zone, and a mobilizing fluid supply system. The IHS injection well includes an IHS injection well conduit that is in direct fluid communication with the IHS zone, and the mobilizing fluid supply system is configured to provide a mobilizing fluid stream to the IHS injection well. The IHS injection well is configured to inject the mobilizing fluid stream into the IHS zone to facilitate flow of viscous hydrocarbons from the IHS zone. The methods include methods of utilizing the systems.

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**SYSTEMS AND METHODS FOR PRODUCING VISCOUS HYDROCARBONS FROM  
A SUBTERRANEAN FORMATION THAT INCLUDES OVERLYING INCLINED  
HETEROLITHIC STRATA**

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Field of the Disclosure

The present disclosure relates generally to systems and methods for producing viscous hydrocarbons from a subterranean formation that includes overlying inclined heterolithic strata.

Background of the Disclosure

10 Certain hydrocarbon reserves may be present within a subterranean formation that includes a lower zone, which includes viscous hydrocarbons dispersed within a porous media, such as sand. The subterranean formation also may include an overlying inclined heterolithic strata (IHS) zone which includes a plurality of fluid-impermeable layers, such as may be formed from rock, interleaved with a plurality of fluid-permeable layers, which also may include viscous hydrocarbons.

15 Production of viscous hydrocarbons from the lower zone may be accomplished utilizing a gravity drainage process, such as steam-assisted gravity drainage (SAGD), solvent-assisted steam-assisted gravity drainage (SA-SAGD), expanding solvent steam-assisted gravity drainage (ES-SAGD), heated Vapor Extraction (H-VAPEX), or a near-azeotropic heated Vapor Extraction (azeotropic H-VAPEX). In the SAGD process, steam may be injected into the lower zone via a  
20 heated chamber injection well that extends within the lower zone. This steam heats the subterranean formation, reduces a viscosity of the viscous hydrocarbons, and generates mobilized viscous hydrocarbons within the lower zone. The mobilized viscous hydrocarbons have a viscosity that is sufficiently low to flow within the lower zone, and the mobilized viscous hydrocarbons may flow to a heated chamber production well, which also extends within the  
25 lower zone. The heated chamber production well may be utilized to produce the mobilized

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viscous hydrocarbons from the lower zone. Heating of the viscous hydrocarbons, via the injected steam, and production of the mobilized viscous hydrocarbons, via the heated chamber production well, forms a heated chamber within the subterranean formation. This heated chamber also may be referred to herein as a viscous hydrocarbon-depleted region and may  
5 expand and/or grow with time as additional steam is injected into the lower zone and/or as additional mobilized viscous hydrocarbons are produced from the lower zone.

Gravity drainage processes, such as SAGD, may be effective at producing viscous hydrocarbons present within the porous media of the lower zone. However, such processes may be ineffective at producing viscous hydrocarbons from the overlying IHS zone for a variety of  
10 reasons. As an example, the fluid-permeable layers of the IHS zone may not be in fluid communication with the heated chamber and/or with the lower zone. As another example, a subset of the fluid-permeable layers may be in fluid communication with the heated chamber and/or with the lower zone. However, a fluid pressure within the heated chamber and/or within the lower zone, such as may be generated by steam injection into the lower zone, may urge  
15 viscous hydrocarbons, which are present within the fluid-permeable layers, away from the heated chamber. Thus, there exists a need for improved systems and methods for producing viscous hydrocarbons from a subterranean formation that includes overlying inclined heterolithic strata.

### Summary of the Disclosure

Systems and methods for producing viscous hydrocarbons from a subterranean formation that includes overlying inclined heterolithic strata are disclosed herein. The systems include the subterranean formation, which includes a lower zone and an overlying inclined heterolithic strata (IHS) zone. The systems also include a heated chamber within the lower zone, an IHS injection well extending within the IHS zone, and a mobilizing fluid supply system. The IHS injection well includes an IHS injection well conduit that is in direct fluid communication with the IHS zone, and the mobilizing fluid supply system is configured to provide a mobilizing fluid stream to the IHS injection well. The IHS injection well is configured to inject the mobilizing fluid stream into the IHS zone to facilitate flow of viscous hydrocarbons from the IHS zone. In some embodiments, an entirety of the IHS injection well is external to the heated chamber. In some embodiments, the hydrocarbon production system further includes an IHS production well that extends within the IHS zone and defines an IHS production well conduit. The IHS production well conduit is in direct fluid communication with the IHS zone.

The methods include receiving, with an IHS zone of a subterranean formation, thermal energy from a heated chamber that extends within a lower zone of the subterranean formation. The methods also include injecting a mobilizing fluid stream into the IHS zone via an IHS injection well that extends within the IHS zone. The methods further include flowing viscous hydrocarbons within the IHS zone and to an IHS production well that extends within the IHS zone. The methods also include producing viscous hydrocarbons from the IHS zone via the IHS production well.

In one exemplary embodiment there is provided a hydrocarbon production system, comprising: a subterranean formation including a lower zone and an overlying inclined heterolithic strata (IHS) zone, wherein both the lower zone and the IHS zone include viscous hydrocarbons; a heated chamber within the lower zone; an IHS injection well extending within  
5 the IHS zone, wherein an entirety of the IHS injection well is external to the heated chamber, and further wherein the IHS injection well includes an IHS injection well conduit that is in direct fluid communication with the IHS zone; an IHS production well extending within the IHS zone, wherein an entirety of the IHS production well is external to the heated chamber, and further wherein the IHS production well includes an IHS production well conduit that is in direct fluid  
10 communication with the IHS zone and the IHS injection well; and a mobilizing fluid supply system configured to provide a mobilizing fluid stream to the IHS injection well, wherein the IHS injection well is configured to inject the mobilizing fluid stream into the IHS zone to facilitate flow of viscous hydrocarbons from the IHS zone to the IHS production well; wherein the IHS injection well and the IHS production well are spaced apart within the IHS zone.

15 In another exemplary embodiment there is provided a method of producing viscous hydrocarbons from a subterranean formation, the method comprising: receiving, with an overlying inclined heterolithic strata (IHS) zone of the subterranean formation, thermal energy from a heated chamber, wherein the heated chamber extends within a lower zone of the subterranean formation that extends vertically below the IHS zone; injecting, via an IHS  
20 injection well that extends within the IHS zone, a mobilizing fluid stream into the IHS zone; flowing viscous hydrocarbons within the IHS zone and to an IHS production well that extends within the IHS zone, wherein the flowing is facilitated by the injecting; and producing, via the IHS production well, the viscous hydrocarbons.

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Brief Description of the Drawings

Fig. 1 is a schematic cross-sectional view illustrating examples of hydrocarbon production systems according to the present disclosure.

Fig. 2 is a schematic cross-sectional view illustrating an example of a hydrocarbon  
5 production system according to the present disclosure.

Fig. 3 is a schematic cross-sectional view illustrating an example of a hydrocarbon production system according to the present disclosure.

Fig. 4 is a schematic cross-sectional view illustrating an example of a hydrocarbon production system according to the present disclosure.

10 Fig. 5 is a schematic cross-sectional view illustrating an example of a hydrocarbon production system according to the present disclosure.

Fig. 6 is a flowchart depicting methods, according to the present disclosure, of producing viscous hydrocarbons from a subterranean formation.

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Detailed Description and Best Mode of the Disclosure

Figs. 1-6 provide examples of hydrocarbon production systems 10 and/or of methods 200, according to the present disclosure. Elements that serve a similar, or at least substantially similar, purpose are labeled with like numbers in each of Figs. 1-6, and these elements may not be discussed in detail herein with reference to each of Figs. 1-6. Similarly, all elements may not be labeled in each of Figs. 1-6, but reference numerals associated therewith may be utilized herein for consistency. Elements, components, and/or features that are discussed herein with reference to one or more of Figs. 1-6 may be included in and/or utilized with any of Figs. 1-6 without departing from the scope of the present disclosure. In general, elements that are likely to be included in a particular embodiment are illustrated in solid lines, while elements that are optional are illustrated in dashed lines. However, elements that are shown in solid lines may not be essential and, in some embodiments, may be omitted without departing from the scope of the present disclosure.

Fig. 1 is a schematic cross-sectional view illustrating examples of hydrocarbon production systems 10 according to the present disclosure. Figs. 2-5 are more specific examples of hydrocarbon production systems 10. Hydrocarbon production systems 10 also may be referred to herein as hydrocarbon recovery systems 10, as viscous hydrocarbon production systems 10, and/or as hydrocarbon wells 10.

As illustrated in Figs. 1-5, hydrocarbon production systems 10 include a subterranean formation 50 that includes an overlying inclined heterolithic strata (IHS) zone 60 and a lower zone 70. Both overlying IHS zone 60 and lower zone 70 include viscous hydrocarbons 80. Examples of viscous hydrocarbons 80 include heavy oil, immobile oil, viscous oil, bitumen, and/or any oil, or hydrocarbon, that is at least substantially immobile within subterranean



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formation 50 under naturally occurring conditions but that may flow within and/or from the subterranean formation upon being heated, diluted by a diluent, and/or dissolved within a solvent.

Lower zone 70 may include a porous media 72 that may define an interstitial space, and viscous hydrocarbons 80 may extend within the interstitial space. Stated another way, lower zone 70 may be fluid-permeable in all, or in at least substantially all, directions.

Overlying IHS zone 60, which also may be referred to as IHS zone 60, may include a plurality of IHS layers 62. The plurality of IHS layers may include a plurality of fluid-impermeable, or at least substantially fluid-impermeable, layers 64 and a plurality of fluid-permeable, or at least substantially fluid-permeable, layers 66; and viscous hydrocarbons 80 may extend within the fluid-permeable layers.

Hydrocarbon production systems 10 also include a heated chamber 100 and may include a plurality of heated chambers 100, as illustrated in Figs. 2-5. Heated chamber 100 extends and/or is defined within lower zone 70.

Hydrocarbon production systems 10 further include an IHS injection well 140, which extends within IHS zone 60. IHS injection well 140 includes an IHS injection well conduit 142 that is in direct fluid communication with the IHS zone. Stated another way, IHS injection well 140 is configured such that fluid may flow between IHS injection well conduit 142 and at least a region of IHS zone 60 that is proximal to and/or that physically contacts the IHS injection well without flow, or without the need for flow, of the fluid through another region and/or zone of the subterranean formation. This direct fluid communication is in contrast with fluid communication between IHS injection well conduit 142 and heated chamber 100, which, in the examples of Figs. 1-5, is indirect since IHS zone 60 spatially separates IHS injection well 140

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from the heated chamber. Stated another way, fluid must flow through IHS zone 60 and/or through a portion of lower zone 70 that does not include heated chamber 100 in order for the fluid to flow between the IHS conduit and the heated chamber.

Hydrocarbon production systems 10 also include a mobilizing fluid supply system 150, as illustrated in Fig. 1. Mobilizing fluid supply system 150 is configured to provide a mobilizing fluid stream 152 to IHS injection well 140, and IHS injection well 140 is configured to inject the mobilizing fluid stream into the IHS zone, as illustrated in Figs. 1-5, to facilitate flow of viscous hydrocarbons 80, in the form of mobilized viscous hydrocarbons 82, from the IHS zone.

It is within the scope of the present disclosure that mobilizing fluid stream 152 may facilitate flow of the viscous hydrocarbons from the IHS zone in any suitable manner. As examples, the mobilizing fluid stream may provide a motive force that facilitates flow of the viscous hydrocarbons from the IHS zone, may provide a pressure differential that facilitates flow of the viscous hydrocarbons from the IHS zone, may heat the viscous hydrocarbons to facilitate flow of the viscous hydrocarbons from the subterranean formation, may decrease a viscosity of the viscous hydrocarbons to facilitate flow of the viscous hydrocarbons from the subterranean formation, may dilute the viscous hydrocarbons to facilitate flow of the viscous hydrocarbons from the subterranean formation, and/or may dissolve the viscous hydrocarbons to facilitate flow of the viscous hydrocarbons from the subterranean formation.

As illustrated in dashed lines in Fig. 1 and in solid lines in Figs. 2-3, hydrocarbon production systems 10 also may include an IHS production well 160 that extends within the IHS zone. IHS production well 160, when present, includes an IHS production well conduit 162 that is in direct fluid communication with IHS zone 60.

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During operation of hydrocarbon production systems 10, heated chamber 100 may be heated, such as to decrease a viscosity of, or to mobilize, viscous hydrocarbons 80 that may be present within lower zone 70. This heating may be accomplished via supply of a heated fluid stream 122 to the heated chamber, as illustrated in Fig. 1. Heated chamber 100 may be heated  
5 and/or formed via and/or utilizing one or more of a SAGD process, a solvent-assisted SAGD (SA-SAGD) process, an expanding solvent SAGD (ES-SAGD) process, a heated vapor extraction (H-VAPEX) process, and/or an azotropic H-VAPEX process.

Heating of heated chamber 100 also may indirectly heat regions of subterranean formation 50 that are proximal to and/or that surround the heated chamber, such as IHS zone 60  
10 and/or regions of lower zone 70 that do not include the heated chamber. Heating of IHS zone 60 may decrease a viscosity of viscous hydrocarbons 80, which are contained therein; however, these viscous hydrocarbons may not flow into the heated chamber. As an example, at least a portion of IHS zone 60 may not be in fluid communication with the heated chamber.

To facilitate production of viscous hydrocarbons 80 from IHS zone 60, IHS injection  
15 well 140 may be formed within the IHS zone, may be drilled within the IHS zone, and/or may be utilized to inject mobilizing fluid stream 152 into the IHS zone. Injection of the mobilizing fluid stream may facilitate production of viscous hydrocarbons 80 from fluid-permeable layers 66 of IHS zone 60 as mobilized viscous hydrocarbons 82.

As an example, at least a subset of fluid-permeable layers 66 of IHS zone 60 may be in  
20 fluid communication, or in direct fluid communication, with IHS production well 160, when present. Stated another way, the subset of fluid-permeable layers 66 may extend, and provide fluid communication, between the IHS injection well and the IHS production well. Under these conditions, injection of mobilizing fluid stream 152 may facilitate flow of mobilized viscous

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hydrocarbons 82 toward and/or into IHS production well 160, as illustrated in dashed lines in Fig. 1 and in solid lines in Figs. 2-3.

As another example, at least a subset of fluid-permeable layers 66 of IHS zone 60 may be in fluid communication, or in direct fluid communication, with lower zone 70 and/or with heated chamber 100. Stated another way, the subset of fluid-permeable layers 66 may extend, and provide fluid communication, between the IHS injection well and the lower zone and/or between the IHS injection well and the heated chamber. Under these conditions, injection of mobilizing fluid stream 152 may facilitate flow of mobilized viscous hydrocarbons 82 toward and/or into heated chamber 100, as illustrated in dash-dot lines in Fig. 1 and in solid lines in Figs. 4-5.

Flow of mobilized viscous hydrocarbons 82 into IHS production well 160 and/or into heated chamber 100 may permit production of the mobilized viscous hydrocarbons from the subterranean formation. As an example, and as illustrated in Fig. 1-3, IHS production well 160 may extend between IHS zone 60 and a surface region 20, thereby permitting production of the mobilized viscous hydrocarbons from the IHS zone and/or to the surface region. As another example, and as illustrated in Figs. 1-5, a heated chamber production well 130 may extend within the heated chamber and/or between the heated chamber and the surface region, thereby permitting production of the mobilized viscous hydrocarbons from the IHS zone and/or to the surface region.

IHS injection well 140 may include any suitable structure that may include and/or define IHS injection well conduit 142, which is in direct fluid communication with IHS zone 60. Examples of such structures include a wellbore, one or more downhole tubulars, which may extend within the wellbore, one or more perforations and/or completions within the downhole tubulars, and/or one or more isolation devices. The isolation devices, when present, may be

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utilized to fluidly isolate various regions of the wellbore and/or of IHS injection well conduit 142 from various other regions of the wellbore, from various other regions of the IHS injection well conduit, and/or from various regions of the subterranean formation.

As illustrated in Figs. 1-5, and although not required of all embodiments, the IHS injection well, or an entirety of the IHS injection well, may be, or may extend, external to heated chamber 100 and/or external to lower zone 70. Stated another way, IHS injection well 140 may terminate external to, may not extend into, may not extend within, and/or may be spaced-apart from heated chamber 100 and/or lower zone 70. Stated yet another way, an entirety of a length of the IHS injection well may be external to the heated chamber and/or may be external to the lower zone. Stated another way, IHS injection well 140 may be configured to inject mobilizing fluid stream 152 into a region of subterranean formation 50 that is external to lower zone 70 and/or that is external to heated chamber 100.

It is within the scope of the present disclosure that IHS injection well 140 may have any suitable orientation within subterranean formation 50 and/or within a subsurface region 30 that includes the subterranean formation. As examples, the IHS injection well may include one or more of a vertical injection well region, as illustrated in Figs. 1-2 and 4, a horizontal injection well region, and/or a deviated injection well region, as illustrated in Figs. 3 and 5. It is also within the scope of the present disclosure that hydrocarbon production system 10 may include any suitable number of IHS injection wells 140, including 1 or a plurality of IHS injection wells, including 2, 3, 4, or more IHS injection wells, that extend within the IHS zone.

IHS production well 160, when present, may include any suitable structure that may include and/or define IHS production well conduit 162; and the IHS production well conduit may

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be in direct fluid communication with IHS zone 60. Examples of such structures are disclosed herein with reference to IHS injection well 140.

As illustrated in Figs. 1 and 3, and although not required of all embodiments, the IHS production well, or an entirety of the IHS production well, may be, or may extend, external to heated chamber 100 and/or to external to lower zone 70. Stated another way, IHS production well 160 may terminate external to, may not extend into, may not extend within, and/or may be spaced-apart from heated chamber 100 and/or lower zone 70. Stated yet another way, an entirety of a length of the IHS production well may be external to the heated chamber and/or may be external to the lower zone. Stated another way, IHS production well 160 may be configured to receive mobilized viscous hydrocarbons 82 from a region of subterranean formation 50 that is external to lower zone 70, may be configured to receive the mobilized viscous hydrocarbons solely from a region of the subterranean formation that is external to heated chamber 100, and/or may be configured to receive the mobilized viscous hydrocarbons solely from the IHS zone.

It is within the scope of the present disclosure that IHS production well 160 may have any suitable orientation within subterranean formation 50 and/or within a subsurface region 30 that includes the subterranean formation. As examples, the IHS production well may include one or more of a vertical production well region, as illustrated in Figs. 1-2, a horizontal injection well region, and/or a deviated injection well region, as illustrated in Fig. 3. It is also within the scope of the present disclosure that hydrocarbon production system 10 may include any suitable number of IHS production wells 160, including 1 or a plurality of IHS production wells, including 2, 3, 4 or more IHS production wells, that extend within the IHS zone. In addition, the plurality of IHS injection and production wells may have and/or define any suitable pattern, examples of which include a five-spot pattern, a half five-spot pattern, and/or a nine-spot pattern.

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As discussed, heated chamber 100 may be formed, defined, and/or heated utilizing a suitable gravity drainage process, examples of which are disclosed herein. As also discussed, hydrocarbon production system 10 may include heated chamber production well 130, which may be configured to produce mobilized viscous hydrocarbons 82 from lower zone 70, such as via a  
5 heated chamber production well conduit 132 thereof.

As illustrated in dashed lines in Fig. 1 and in solid lines in Figs. 2-5, hydrocarbon production system 10 also may include a heated chamber injection well 110, which may extend within the heated chamber and may define a heated chamber injection well conduit 112 that is in direct fluid communication with the heated chamber. As also illustrated in dashed lines in Fig. 1,  
10 hydrocarbon production system 10 may include a heated fluid supply system 120, which may be configured to provide a heated fluid stream 122 to the heated chamber injection well. Heated chamber injection well 110 may be configured to inject the heated fluid stream into the heated chamber. This injection may heat the heated chamber, may dilute the viscous hydrocarbons, may decrease the viscosity of the viscous hydrocarbons, and/or may mobilize the viscous  
15 hydrocarbons, thereby producing and/or generated mobilized viscous hydrocarbons 82 within lower zone 70. The mobilized viscous hydrocarbons may flow into heated chamber production well 130 and thereby may be produced from the lower zone and/or from the subterranean formation.

As perhaps illustrated most clearly in Fig. 1, heated chamber injection well 110 may  
20 include a horizontal, or at least substantially horizontal, heated chamber injection well region. Similarly, heated chamber production well 130 may include a horizontal, or at least substantially horizontal, heated chamber production well region, which may extend vertically below the

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horizontal heated chamber injection well region. Such a configuration may facilitate production of the mobilized viscous hydrocarbons via the heated chamber production well.

It is within the scope of the present disclosure that, as illustrated in Fig. 1, IHS injection well 140 and/or IHS production well 160 may be spaced-apart and/or distinct from both heated chamber injection well 110 and heated chamber production well 130. Alternatively, it is also within the scope of the present disclosure that IHS injection well 140 may be an injection well lateral that is a re-drilled and re-completed extension of the heated chamber injection well and/or may be a re-completed and perforated region of an existing heated chamber injection well. Similarly, IHS production well 160 may be a production well lateral that is a re-drilled and re-completed extension of the heated chamber production well and/or may be a re-completed and perforated region of an existing heated chamber production well. The re-completion of the IHS injection and IHS production wells may include any design configuration that allows for controlled delivery of injected mobilizing fluid into the IHS injection well and or production from the IHS production well. Subterranean formation 50 may include and/or be any suitable subterranean formation that includes both overlying IHS zone 60 and lower zone 70. Subterranean formation 50 may extend within subsurface region 30, and an overburden 40 may separate, or spatially separate, subterranean formation 50 from surface region 20.

As discussed, IHS zone 60 may include a plurality of IHS layers 62. IHS layers 62 may include the plurality of fluid-impermeable, or at least substantially fluid-impermeable, layers 64 interleaved with the plurality of fluid-permeable layers 66, and viscous hydrocarbons 80 may extend within the fluid-permeable layers. Examples of fluid-impermeable layers 64 include one or more of shale layers, clay layers, silt layers, and/or siltstone layers. An example of fluid-permeable layers 66 includes sand layers.



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The combination of fluid-impermeable layers 64 and fluid-permeable layers 66 within IHS zone 60 may cause the IHS zone to exhibit directionally dependent fluid permeability. As an example, the IHS zone may permit fluid flow therethrough, via fluid-permeable layers 66, in a direction that is parallel, or at least substantially parallel, to the fluid permeable layers and/or to the fluid-impermeable layers. However, the IHS zone may restrict, resist, and/or block fluid flow therethrough, or at least bulk and/or large-scale fluid flow therethrough, in a direction that is perpendicular to the fluid-permeable layers, that is perpendicular to the fluid-impermeable layers, and/or that is directed between two distinct fluid-permeable layers.

It is within the scope of the present disclosure that the individual IHS layers 62 may be relatively thin layers, at least when compared to a thickness, or vertical extent, of lower zone 70. As examples, an average distance between a given fluid-impermeable layer 64 and a closest other fluid-impermeable layer 64 may be at least 0.5 centimeter (cm), at least 1 cm, at least 2 cm, at least 3 cm, at least 4 cm, at least 5 cm, at least 6 cm, at least 8 cm, at least 10 cm, at most 200 cm, at most 100 cm, at most 50 cm, at most 40 cm, at most 30 cm, at most 20 cm, at most 15 cm, and/or at most 10 cm. This “average distance” for the individual IHS layers 62 should be measured in a core sample between the inside faces of the fluid-impermeable layer 64 and the closest other fluid-impermeable layer 64, and is calculated as the average distance between these two impermeable layers within the core sample.

In certain embodiments herein, at least a portion of the IHS zone contains at least 4, or optionally, at least 6, or optionally, at least 8 fluid-impermeable layers, such as may be formed from rock, to form at least 3, or optionally at least 5, or optionally at least 7 interleaved fluid-permeable layers, which also may include viscous hydrocarbons.

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In contrast with IHS zone 60, lower zone 70 may be fluid-permeable in all, or in at least substantially all, directions. As an example, and as discussed, lower zone 70 may include a porous media, such as sand. In addition, a vertical extent, or thickness, of lower zone 70 may be significantly larger than a vertical extent, or thickness, of individual IHS layers 62 within IHS zone 60. As examples, the vertical extent of lower zone 70 may be at least 1 meter (m), at least 2 m, at least 3 m, at least 4 m, at least 5 m, at least 6 m, at least 8 m, and/or at least 10 m.

Fig. 6 is a flowchart depicting methods 200, according to the present disclosure, of producing viscous hydrocarbons from a subterranean formation that includes a lower zone and an overlying IHS zone. Methods 200 may be performed utilizing any suitable hydrocarbon production system, such as hydrocarbon production systems 10 of Figs. 1-5, and any of the structures, features, functions, and/or steps disclosed herein with reference to methods 200 may be included in and/or utilized with hydrocarbon production systems 10 without departing from the scope of the present disclosure. Similarly, any of the structures, features, functions, and/or steps disclosed herein with reference to hydrocarbon production systems 10 may be included in and/or utilized with methods 200 without departing from the scope of the present disclosure.

Methods 200 may include heating a heated chamber at 210 and/or producing viscous hydrocarbons from the lower zone at 220. Methods 200 include receiving thermal energy at 230 and may include determining a distribution of viscous hydrocarbons within the IHS zone at 240 and/or drilling and completing IHS wells at 250. Methods 200 further include injecting a mobilizing fluid stream at 260 and may include fracturing the IHS zone at 270. Methods 200 further include flowing viscous hydrocarbons within the IHS zone at 280 and producing viscous hydrocarbons from the IHS zone at 290.

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Heating the heated chamber at 210 may include heating any suitable heated chamber, such as heated chamber 100 of Figs. 1-5, in any suitable manner. It is within the scope of the present disclosure that the heating at 210 may facilitate, or provide thermal energy for, the receiving at 230. Examples of the heating at 210 include heating via one or more of a SAGD  
5 process, a SA-SAGD process, an ES-SAGD process, an H-VAPEX process, and/or an azeotropic H-VAPEX process.

The heating at 210 may include injecting a heated fluid stream into the lower zone of the subterranean formation. The injecting may be performed via and/or utilizing a heated chamber injection well, such as heated chamber injection well 110 of Figs. 1-5, that extends within the  
10 lower zone of the subterranean formation. The heating at 210 may include mobilizing viscous hydrocarbons, which may be present within the lower zone of the subterranean formation, such as to produce and/or generate mobilized viscous hydrocarbons.

Producing viscous hydrocarbons from the lower zone at 220 may include producing any suitable viscous hydrocarbons from the lower zone of the subterranean formation in any suitable  
15 manner. As an example, the producing at 220 may be subsequent to the heating at 210 and may include producing mobilized viscous hydrocarbons that were mobilized during and/or via the heating at 210. This may include producing with, via, and/or utilizing a heated chamber production well, such as heated chamber production well 130 of Figs. 1-5, that extends within the lower zone of the subterranean formation and/or that extends within the heated chamber.

20 Receiving thermal energy at 230 may include receiving the thermal energy with, or into, the IHS zone of the subterranean formation. This may include receiving the thermal energy from the heated chamber. The heated chamber may extend within the lower zone and/or vertically below the IHS zone. The receiving at 230 may include receiving thermal energy in any suitable

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manner. As an example, the receiving at 230 may include receiving thermal energy via conduction, or thermal conduction, through the subterranean formation and from the heated chamber to the IHS zone. The receiving at 230 further may include heating viscous hydrocarbons contained within the IHS zone and/or decreasing a viscosity of the viscous hydrocarbons.

Determining the distribution of viscous hydrocarbons within the IHS zone at 240 may include determining any suitable distribution, concentration, concentration distribution, spatial distribution, and/or spatial concentration of viscous hydrocarbons within the IHS zone and may be performed in any suitable manner. As examples, the determining at 240 may include determining utilizing a well logging method, utilizing a subsurface surveillance method, utilizing a seismic surveillance method, and/or utilizing temperature logging.

Drilling and completing IHS wells at 250 may include drilling and completing an IHS injection well and/or an IHS production well within the IHS zone. It is within the scope of the present disclosure that the drilling and completing at 250 may include drilling and completing based, at least in part, on the determining at 240. As an example, the drilling and completing at 250 may include drilling and completing within a region of the IHS zone that includes viscous hydrocarbons, as determined and/or established by the determining at 240.

It is also within the scope of the present disclosure that, subsequent to the drilling and completing at 250, the IHS production well and/or the IHS injection well may be external, or entirely external, to the lower zone. With this in mind, the drilling and completing at 250 may include ceasing the drilling and completing prior to the IHS injection well entering the lower zone, prior to the IHS injection well entering the heated chamber, prior to the IHS production

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well entering the lower zone, and/or prior to the IHS production well entering the heated chamber.

Injecting the mobilizing fluid stream at 260 may include injecting the mobilizing fluid stream into the IHS zone. This may include injecting with, via, and/or utilizing the IHS injection well that extends within the IHS zone; and examples of the IHS injection well are disclosed herein with reference to IHS injection well 140 of Figs. 1-5. The injecting at 260 may include generating, or injecting to generate, a pressure differential within the IHS zone, heating, or injecting to heat, viscous hydrocarbons that extend within the IHS zone, diluting, or injecting to dilute, the viscous hydrocarbons, and/or dissolving, or injecting to dissolve, the viscous hydrocarbons. Stated another way, the injecting at 260 may include injecting to produce and/or facilitate the flowing at 280. With this in mind, the injecting at 260 may include injecting one or more of steam, water, hot water, a solvent for the viscous hydrocarbons, a diluent for the viscous hydrocarbons, propane, carbon dioxide, a non-condensable gas, methane, a gas plant condensate, a flue gas, air, an l/or a mixture of some of them.

The injecting at 260 further may include injecting the mobilizing fluid stream at any suitable temperature, or injection temperature. Examples of the injection temperature include injection temperatures of at least 50 °C, at least 60 °C, at least 70 °C, at least 80 °C, at least 90 °C, at least 100 °C, at least 110 °C, at least 120 °C, at most 350 °C, at most 340 °C, at most 330 °C, at most 320 °C, at most 310 °C, at most 300 °C, at most 290 °C, at most 280 °C, at most 270 °C, at most 260 °C, at most 250 °C, at most 240 °C, at most 230 °C, at most 220 °C, at most 210 °C, at most 200 °C, at most 190 °C, at most 180 °C, at most 170 °C, at most 160 °C, at most 150 °C, at most 140 °C, at most 130 °C, at most 120 °C, at most 110 °C, at most 100 °C, at most 90 °C, and/or at most 80 °C.

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Fracturing the IHS zone at 270 may include fracturing, or creating one or more fractures within, the IHS zone in any suitable manner. This may include fracturing to increase a fluid permeability of the IHS zone, fracturing to increase fluid conductivity among a plurality of IHS layers of the IHS zone, fracturing to facilitate the injecting at 260, and/or fracturing responsive to the injecting at 260.

As an example, the fracturing at 270 may include fracturing a region of the IHS zone that is proximal to and/or that extends from the IHS injection well. As another example, the fracturing at 270 may include performing at least a portion of the injecting at 260 at an injection pressure that is greater than a fracture pressure of the IHS zone.

Flowing viscous hydrocarbons within the IHS zone at 280 may include flowing the viscous hydrocarbons to the IHS production well and/or flowing the viscous hydrocarbons from the IHS zone via the IHS production well. The viscous hydrocarbons that flow within the IHS zone also may be referred to herein as mobilized viscous hydrocarbons, as discussed herein. As also discussed herein, the flowing at 280 may be facilitated by and/or may be responsive to the injecting at 260. The flowing at 280 may include flowing within a plurality of spaced-apart fluid-permeable layers of the IHS zone.

Producing viscous hydrocarbons from the IHS zone at 290 may include producing the viscous hydrocarbons with, via, and/or utilizing the IHS production well. This may include flowing the viscous hydrocarbons, within and/or via the IHS production well, to a surface region.

In the present disclosure, several of the illustrative, non-exclusive examples have been discussed and/or presented in the context of flow diagrams, or flow charts, in which the methods are shown and described as a series of blocks, or steps. Unless specifically set forth in the accompanying description, it is within the scope of the present disclosure that the order of the

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blocks may vary from the illustrated order in the flow diagram, including with two or more of the blocks (or steps) occurring in a different order and/or concurrently.

As used herein, the term “and/or” placed between a first entity and a second entity means one of (1) the first entity, (2) the second entity, and (3) the first entity and the second entity.

5 Multiple entities listed with “and/or” should be construed in the same manner, i.e., “one or more” of the entities so conjoined. Other entities may optionally be present other than the entities specifically identified by the “and/or” clause, whether related or unrelated to those entities specifically identified. Thus, as a non-limiting example, a reference to “A and/or B,” when used in conjunction with open-ended language such as “comprising” may refer, in one embodiment, to  
 10 A only (optionally including entities other than B); in another embodiment, to B only (optionally including entities other than A); in yet another embodiment, to both A and B (optionally including other entities). These entities may refer to elements, actions, structures, steps, operations, values, and the like.

As used herein, the phrase “at least one,” in reference to a list of one or more entities  
 15 should be understood to mean at least one entity selected from any one or more of the entity in the list of entities, but not necessarily including at least one of each and every entity specifically listed within the list of entities and not excluding any combinations of entities in the list of entities. This definition also allows that entities may optionally be present other than the entities specifically identified within the list of entities to which the phrase “at least one” refers, whether  
 20 related or unrelated to those entities specifically identified. Thus, as a non-limiting example, “at least one of A and B” (or, equivalently, “at least one of A or B,” or, equivalently “at least one of A and/or B”) may refer, in one embodiment, to at least one, optionally including more than one, A, with no B present (and optionally including entities other than B); in another embodiment, to

at least one, optionally including more than one, B, with no A present (and optionally including entities other than A); in yet another embodiment, to at least one, optionally including more than one, A, and at least one, optionally including more than one, B (and optionally including other entities). In other words, the phrases “at least one,” “one or more,” and “and/or” are open-ended expressions that are both conjunctive and disjunctive in operation. For example, each of the expressions “at least one of A, B and C,” “at least one of A, B, or C,” “one or more of A, B, and C,” “one or more of A, B, or C” and “A, B, and/or C” may mean A alone, B alone, C alone, A and B together, A and C together, B and C together, A, B and C together, and optionally any of the above in combination with at least one other entity.

In the event that any patents, patent applications, or other references referenced herein (1) define a term in a manner that is inconsistent with and/or (2) are otherwise inconsistent with, either the present disclosure or any of the documents referenced, the present disclosure shall control, and the term therein shall only control with respect to the reference in which the term is defined and/or was present originally.

As used herein the terms “adapted” and “configured” mean that the element, component, or other subject matter is designed and/or intended to perform a given function. Thus, the use of the terms “adapted” and “configured” should not be construed to mean that a given element, component, or other subject matter is simply “capable of” performing a given function but that the element, component, and/or other subject matter is specifically selected, created, implemented, utilized, programmed, and/or designed for the purpose of performing the function. It is also within the scope of the present disclosure that elements, components, and/or other recited subject matter that is recited as being adapted to perform a particular function may



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additionally or alternatively be described as being configured to perform that function, and vice versa.

As used herein, the phrase, “for example,” the phrase, “as an example,” and/or simply the term “example,” when used with reference to one or more components, features, details, structures, embodiments, and/or methods according to the present disclosure, are intended to convey that the described component, feature, detail, structure, embodiment, and/or method is an illustrative, non-exclusive example of components, features, details, structures, embodiments, and/or methods according to the present disclosure. Thus, the described component, feature, detail, structure, embodiment, and/or method is not intended to be limiting, required, or exclusive/exhaustive; and other components, features, details, structures, embodiments, and/or methods, including structurally and/or functionally similar and/or equivalent components, features, details, structures, embodiments, and/or methods, are also within the scope of the present disclosure.

#### Industrial Applicability

The systems and methods disclosed herein are applicable to the oil and gas industries.

It is believed that the disclosure set forth above encompasses multiple distinct inventions with independent utility. While each of these inventions has been disclosed in its preferred form, the specific embodiments thereof as disclosed and illustrated herein are not to be considered in a limiting sense as numerous variations are possible. The subject matter of the inventions includes all novel and non-obvious combinations and subcombinations of the various elements, features, functions and/or properties disclosed herein. Similarly, where the claims recite “a” or “a first” element or the equivalent thereof, such claims should be understood to include incorporation of one or more such elements, neither requiring nor excluding two or more such elements.

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It is believed that the following claims particularly point out certain combinations and subcombinations that are directed to one of the disclosed inventions and are novel and non-obvious. Inventions embodied in other combinations and subcombinations of features, functions, elements and/or properties may be claimed through amendment of the present claims or  
5 presentation of new claims in this or a related application. Such amended or new claims, whether they are directed to a different invention or directed to the same invention, whether different, broader, narrower, or equal in scope to the original claims, are also regarded as included within the subject matter of the inventions of the present disclosure.

10

## CLAIMS

1. A hydrocarbon production system, comprising:

a subterranean formation including a lower zone and an overlying inclined heterolithic strata (IHS) zone, wherein both the lower zone and the IHS zone include viscous hydrocarbons;

5 a heated chamber within the lower zone;

an IHS injection well extending within the IHS zone, wherein an entirety of the IHS injection well is external to the heated chamber, and further wherein the IHS injection well includes an IHS injection well conduit that is in direct fluid communication with the IHS zone;

10 an IHS production well extending within the IHS zone, wherein an entirety of the IHS production well is external to the heated chamber, and further wherein the IHS production well includes an IHS production well conduit that is in direct fluid communication with the IHS zone and the IHS injection well; and

15 a mobilizing fluid supply system configured to provide a mobilizing fluid stream to the IHS injection well, wherein the IHS injection well is configured to inject the mobilizing fluid stream into the IHS zone to facilitate flow of viscous hydrocarbons from the IHS zone to the IHS production well;

wherein the IHS injection well and the IHS production well are spaced apart within the IHS zone.

20 2. The system of claim 1, wherein the IHS zone includes a plurality of IHS layers, wherein at least a fraction of the plurality of IHS layers extends, and provides fluid communication, between the IHS injection well and the heated chamber, and further wherein the viscous hydrocarbons flow from the IHS zone into the heated chamber responsive to injection of the mobilizing fluid stream into the IHS zone.

3. A hydrocarbon production system, comprising:

a subterranean formation including a lower zone and an overlying inclined heterolithic strata (IHS) zone, wherein both the lower zone and the IHS zone include viscous hydrocarbons;

a heated chamber extending within the lower zone;

5 an IHS injection well extending within the IHS zone, wherein an entirety of the IHS injection well is external to the heated chamber, and the IHS injection well includes an IHS injection well conduit that is in direct fluid communication with the IHS zone;

an IHS production well extending within the IHS zone, which is spaced apart from the IHS injection well in the IHS zone, wherein an entirety of the IHS production well is external to the heated chamber, and the IHS production well includes an IHS production well conduit that is in direct fluid communication with the IHS zone and the IHS injection well; and

10

a mobilizing fluid supply system configured to provide a mobilizing fluid stream to the IHS injection well, wherein the IHS injection well is configured to inject the mobilizing fluid stream into the IHS zone to facilitate flow of viscous hydrocarbons from the IHS zone via the IHS production well.

15

4. The system of any one of claims 1-3, wherein the heated chamber is formed via at least one of:

- (i) a steam assisted gravity drainage (SAGD) process;
- 20 (ii) a solvent-assisted SAGD (SA-SAGD) process;
- (iii) an expanding solvent SAGD (ES-SAGD) process;
- (iv) a heated vapor extraction (H-VAPEX) process; and
- (v) an azeotropic H-VAPEX process.

5. The system of any one of claims 1-4, wherein the hydrocarbon production system further includes:

a heated chamber injection well extending within the heated chamber and including a heated chamber injection well conduit that is in direct fluid communication with the heated chamber;

a heated fluid supply system configured to provide a heated fluid stream to the heated chamber injection well, wherein the heated chamber injection well is configured to inject the heated fluid stream into the heated chamber to heat the heated chamber and to decrease a viscosity of viscous hydrocarbons within the lower zone to generate mobilized viscous hydrocarbons within the lower zone; and

a heated chamber production well extending within the heated chamber and including a heated chamber production well conduit that is in direct fluid communication with the heated chamber, wherein the heated chamber production well is configured to receive the mobilized viscous hydrocarbons from the heated chamber and to produce the mobilized viscous hydrocarbons from the subterranean formation.

6. The system of claim 5, wherein the heated chamber injection well includes a horizontal heated chamber injection well region, wherein the heated chamber production well includes a horizontal heated chamber production well region, and further wherein the horizontal heated chamber production well region extends vertically below the horizontal heated chamber injection well region.

7. The system of claim 5 or 6, wherein the IHS injection well is at least one of:

(i) an injection well lateral that extends from the heated chamber injection well;

(ii) distinct from both the heated chamber injection well and the heated chamber production well; and

5 (iii) a re-completed and perforated region of an existing heated chamber injection well.

8. The system of any one of claims 5-7 when dependent from any one of claims 1 and 3, wherein the IHS production well is at least one of:

10 (i) a production well lateral that extends from the heated chamber production well;

(ii) distinct from both the heated chamber injection well and the heated chamber production well; and

(iii) a re-completed and perforated region of an existing heated chamber production well.

15

9. The system of any one of claims 1-8, wherein the overlying IHS zone includes the plurality of IHS layers, wherein the plurality of IHS layers includes a plurality of at least substantially fluid-impermeable layers interleaved with a plurality of fluid-permeable layers, wherein the viscous hydrocarbons extend within the plurality of fluid-permeable layers.

20

10. The system of claim 9, wherein the plurality of at least substantially fluid-impermeable layers includes at least one of:

(i) a plurality of shale layers;

- (ii) a plurality of clay layers;
- (iii) a plurality of silt layers; and
- (iv) a plurality of siltstone layers.

5           11.    The system of claim 9 or 10, wherein the plurality of fluid-permeable layers includes a plurality of sand layers.

          12.    The system of any one of claims 9-11, wherein an average distance between a given fluid-permeable layer of the plurality of fluid-permeable layers and a closest other fluid-  
10 permeable layer of the plurality of fluid-permeable layers is at least 1 centimeter and at most 200 centimeters.

          13.    The system of any one of claims 9-12, wherein the overlying IHS zone permits fluid flow therethrough, via the plurality of fluid-permeable layers, in a direction that is parallel  
15 to the plurality of fluid-permeable layers and resists fluid flow therethrough in a direction that is perpendicular to the plurality of fluid-permeable layers.

          14.    The system of any one of claims 1-13, wherein the lower zone is fluid-permeable in substantially all directions.

20

          15.    The system of any one of claims 1-14, wherein the lower zone includes a porous medium that defines an interstitial space, and further wherein viscous hydrocarbons extend within the interstitial space.

16. The system of claim 15, wherein the porous media includes sand.

17. The system of any one of claims 1-16, wherein a vertical extent of the lower zone is at least 5 meters.

5

18. The system of any one of claims 1-17, wherein the IHS injection well includes at least one of a vertical injection well region, a horizontal injection well region, and a deviated injection well region.

10 19. The system of any one of claims 1-18, wherein the IHS injection well is a first IHS injection well of a plurality of IHS injection wells that extends within the IHS zone.

15 20. The system of any one of claims 1-19, wherein the IHS injection well is configured to inject the mobilizing fluid stream solely into a region of the subterranean formation that is external to at least one of:

- (i) the lower zone; and
- (ii) the heated chamber.

20 21. The system of any one of claims 1-20, wherein the IHS production well includes at least one of a vertical production well region, a horizontal production well region, and a deviated production well region.



22. The system of any one of claims 1-21, wherein the IHS production well is a first IHS production well of a plurality of IHS production wells that extends within the IHS zone.

23. The system of any one of claims 1-22, wherein the IHS zone includes the plurality of IHS layers, and further wherein at least a fraction of the plurality of IHS layers extends, and provides fluid communication, between the IHS injection well and a/the IHS production well such that the viscous hydrocarbons flow from the IHS zone and into the IHS production well.

24. The system of any one of claims 1-23, wherein an entirety of the IHS production well at least one of:

- (i) extends external to the heated chamber; and
- (ii) extends external to the lower zone.

25. The system of any one of claims 1-24, wherein the IHS production well at least one of:

- (i) is configured to receive the viscous hydrocarbons solely from a region of the subterranean formation that is external to the lower zone;
- (ii) is configured to receive the viscous hydrocarbons solely from a region of the subterranean formation that is external to the heated chamber; and
- (iii) is configured to receive the viscous hydrocarbons solely from the IHS zone.

26. A method of producing viscous hydrocarbons from a subterranean formation, the method comprising:

receiving, with an overlying inclined heterolithic strata (IHS) zone of the subterranean formation, thermal energy from a heated chamber, wherein the heated chamber extends within a lower zone of the subterranean formation that extends vertically below the IHS zone;

5 injecting, via an IHS injection well that extends within the IHS zone, a mobilizing fluid stream into the IHS zone;

flowing viscous hydrocarbons within the IHS zone and to an IHS production well that extends within the IHS zone, wherein the flowing is facilitated by the injecting, and wherein the IHS injection well and the IHS production well are spaced apart within the IHS zone; and

producing, via the IHS production well, the viscous hydrocarbons.

10 27. The method of claim 26, wherein the receiving thermal energy includes receiving thermal energy via thermal conduction, through the subterranean formation, from the heated chamber and to the IHS zone.

28. The method of claim 26 or 27, wherein the receiving includes at least one of:

- 15 (i) heating viscous hydrocarbons within the IHS zone; and  
(ii) decreasing a viscosity of viscous hydrocarbons within the IHS zone.

29. The method of any one of claims 26-28, wherein the injecting includes at least one of:

- 20 (i) generating a pressure differential within the IHS zone;  
(ii) heating the viscous hydrocarbons;  
(iii) diluting the viscous hydrocarbons; and  
(iv) dissolving the viscous hydrocarbons.

30. The method of any one of claims 26-29, wherein the injecting includes injecting  
at least one of:

- (i) steam;
- (ii) water;
- 5 (iii) hot water;
- (iv) a solvent for the viscous hydrocarbons;
- (v) a diluent for the viscous hydrocarbons;
- (vi) propane;
- (vii) carbon dioxide;
- 10 (viii) a non-condensable gas;
- (ix) methane;
- (x) a gas plant condensate;
- (xi) a flue gas; and
- (xii) air.

15

31. The method of any one of claims 26-30, wherein the flowing includes flowing  
within a plurality of spaced-apart, fluid-permeable layers of the IHS zone.

32. The method of any one of claims 26-31, wherein the producing includes flowing  
20 the viscous hydrocarbons, within the IHS production well, to a surface region.

33. The method of any one of claims 26-32, wherein, prior to the injecting, the method further includes drilling and completion of both the IHS injection well and the IHS production well within the IHS zone.

5           34. The method of claim 33, wherein the drilling and completion includes:

(i) ceasing the drilling and completion prior to the IHS injection well entering the lower zone;

(ii) ceasing the drilling and completion prior to the IHS injection well entering the heated chamber;

10           (iii) ceasing the drilling and completion prior to the IHS production well entering the lower zone; and

(iv) ceasing the drilling and completion prior to the IHS production well entering the heated chamber.

15           35. The method of claim 33 or 34, wherein the method further includes determining a distribution of viscous hydrocarbons within the IHS zone, and further wherein the drilling and completion includes drilling within a region of the IHS zone that includes viscous hydrocarbons, as determined by the determining.

20           36. The method of claim 35, wherein the determining the distribution includes utilizing at least one of:

(i) a subsurface surveillance method;

(ii) a seismic surveillance method; and

(iii) temperature logging.

37. The method of any one of claims 26-36, wherein, prior to the producing, the method further includes fracturing the IHS zone.

5

38. The method of claim 37, wherein the fracturing includes fracturing a region of the IHS zone that is proximal to, and extends from, the IHS injection well.

39. The method of claim 38, wherein the heated chamber is heated by at least one of:

10 (i) performing a steam assisted gravity drainage (SAGD) process within the heated chamber;

(ii) performing a solvent-assisted SAGD (SA-SAGD) process within the heated chamber;

15 (iii) performing an expanding solvent SAGD (ES-SAGD) process within the heated chamber;

(iv) performing a heated vapor extraction (H-VAPEX) process within the heated chamber; and

(v) performing an azeotropic H-VAPEX process within the heated chamber.

20 40. The method of claim 38 or 39, wherein the heating includes injecting, via a heated chamber injection well that extends within the lower zone of the subterranean formation, a heated fluid stream into the lower zone of the subterranean formation.

41. The method of any one of claims 38-40, wherein the heating includes mobilizing viscous hydrocarbons within the lower zone of the subterranean formation.

42. The method of any one of claims 38-40, wherein the method further includes  
5 producing, via a heated chamber production well that extends within the lower zone of the subterranean formation, mobilized viscous hydrocarbons from the lower zone of the subterranean formation.

43. The method of any one of claims 26-43, wherein the method further includes  
10 utilizing the hydrocarbon production system of any of claims 1-25 to perform the method.

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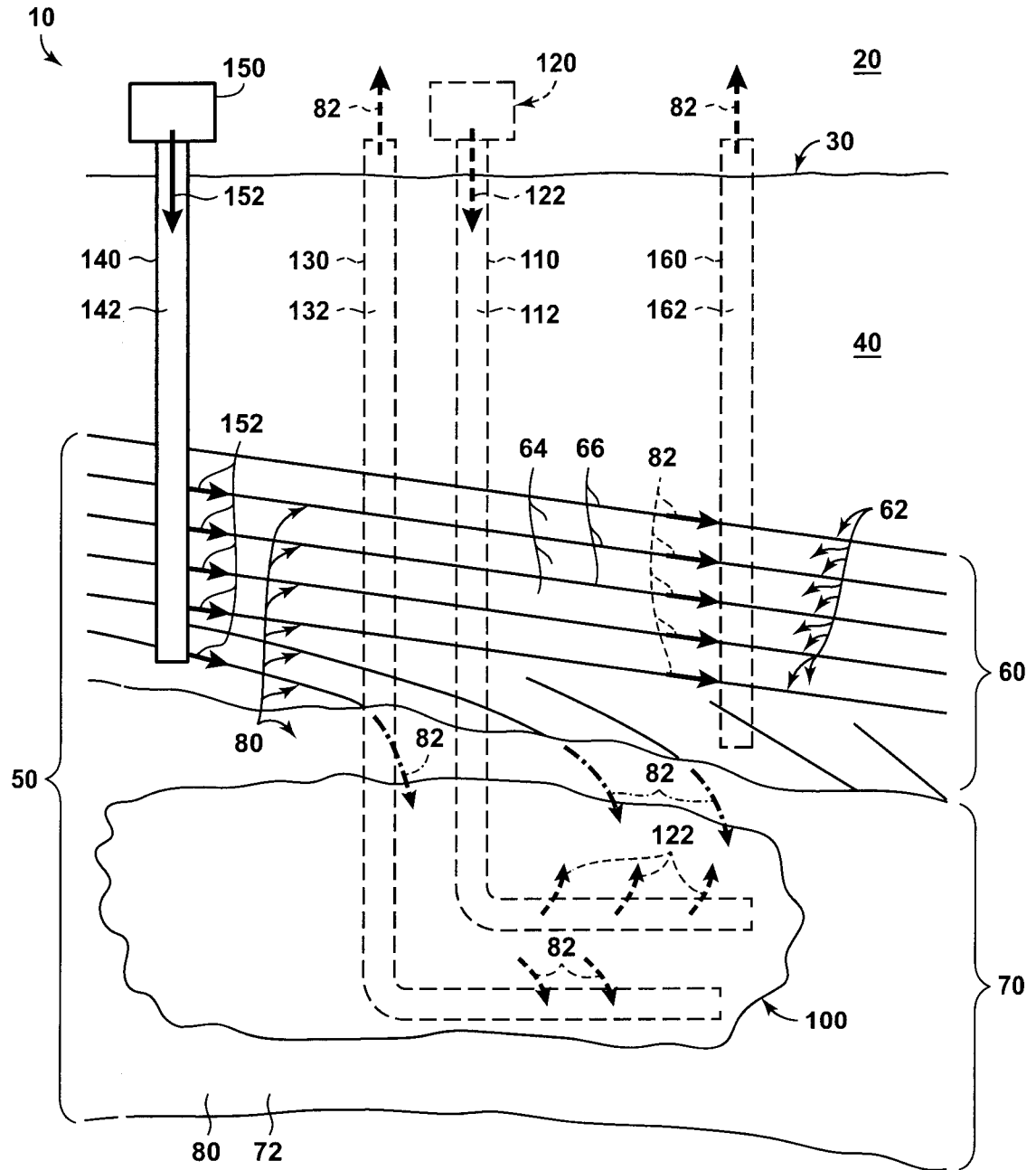


FIG. 1

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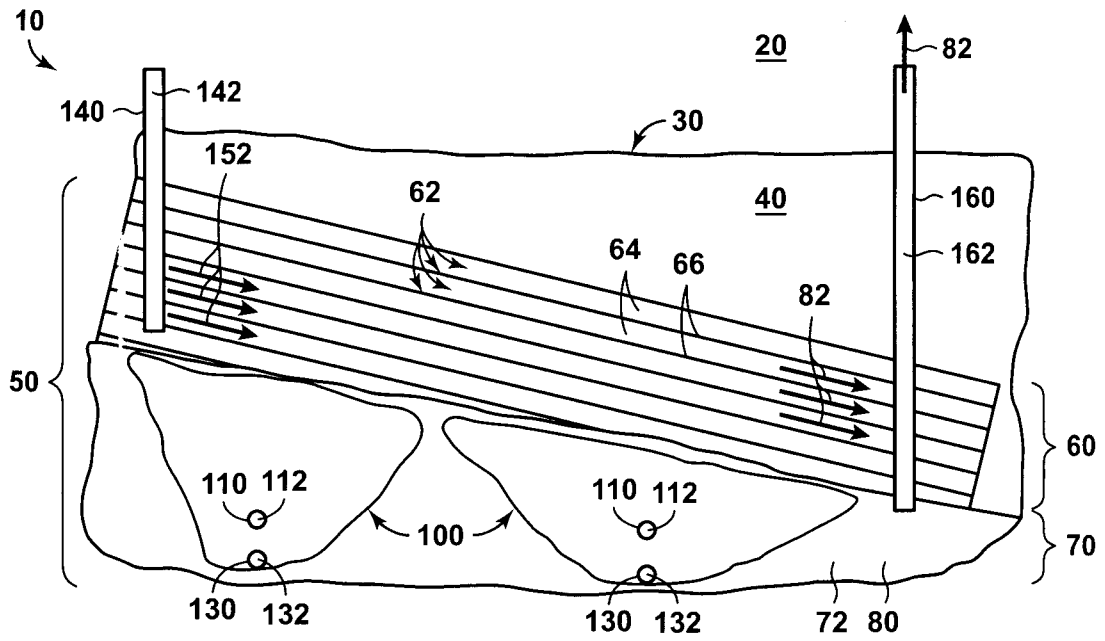


FIG. 2

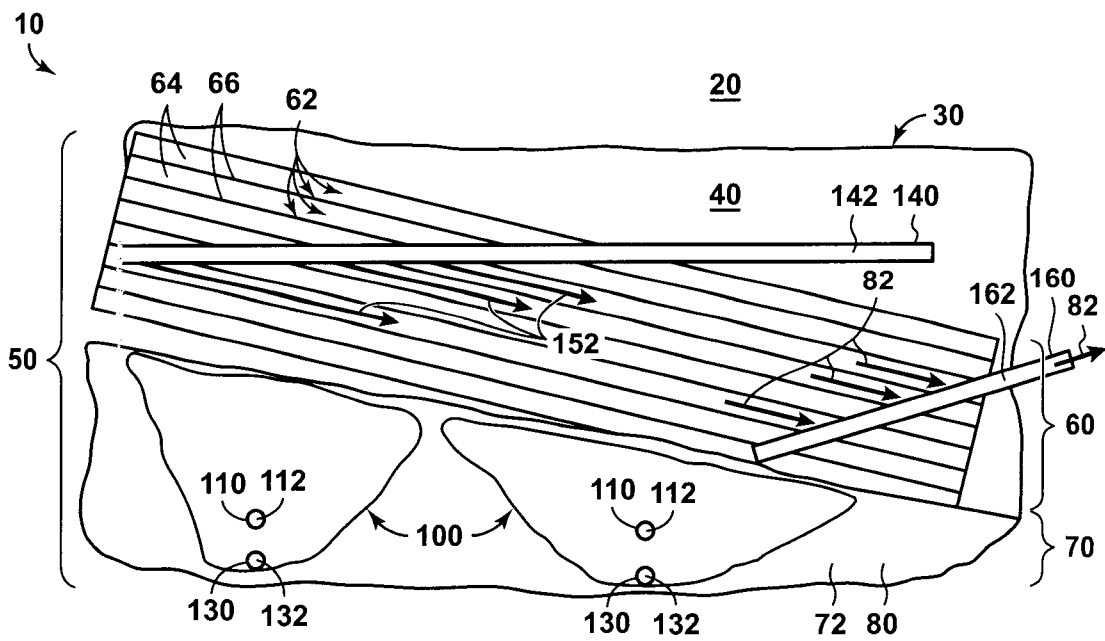


FIG. 3



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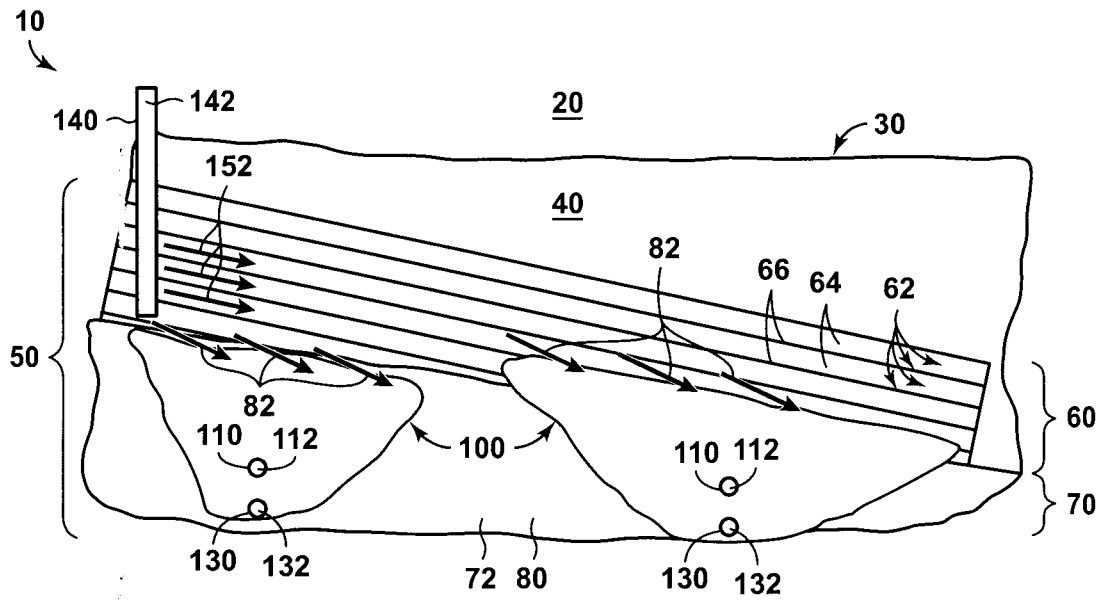


FIG. 4

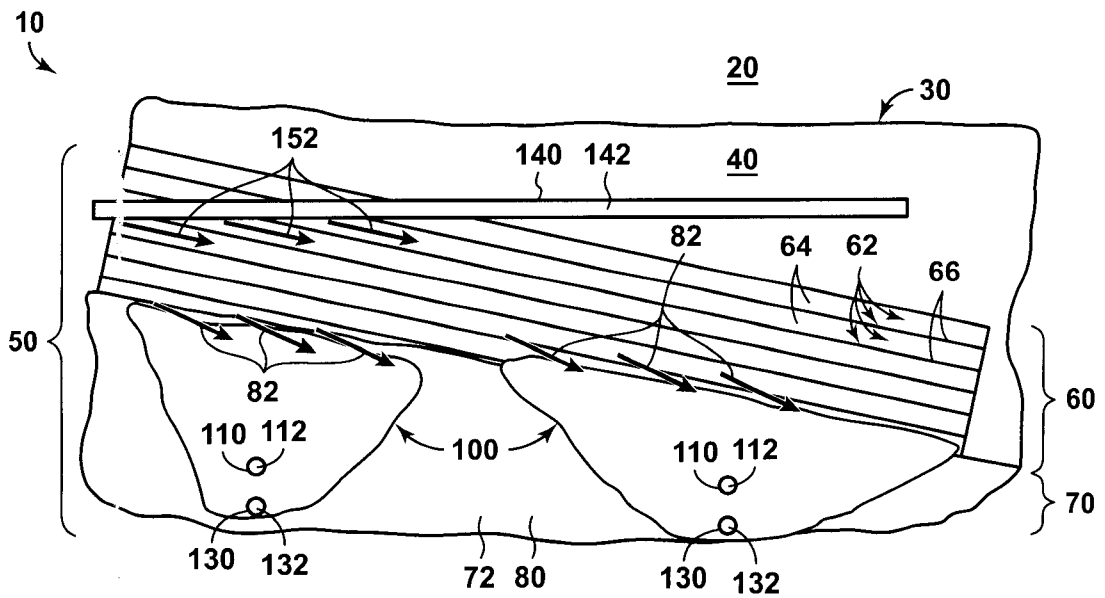
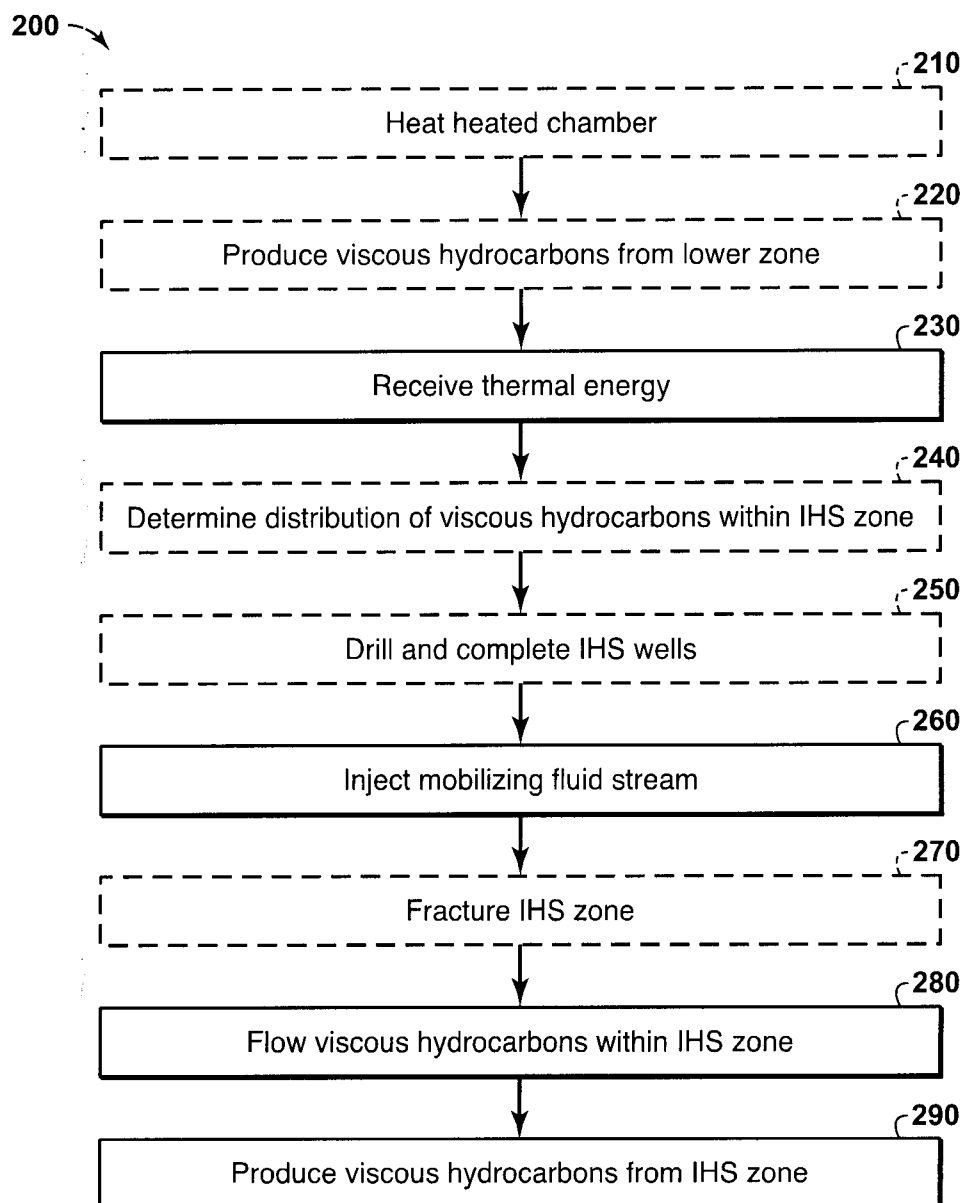


FIG. 5

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**FIG. 6**

