Abstract:
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Filing International 140
International Branch national
Data:
Language:
States

Figure 2

Title: IN-SITU UPGRADING OF BITUMEN OR HEAVY OIL

Abstract: A method is disclosed for in-situ upgrading bitumen or heavy oils during thermal recovery operations by the use of appropriate catalysts and control of thermal recovery conditions. It is expected that the methods disclosed herein will increase the API density of bitumen by about 2 API degrees to about 10 API degrees. For example, a bitumen with an in-situ API of about 8 API degrees may be upgraded to a heavy oil with a recovered API density in the range of approximately about 10 API degrees to about 18 API degrees. In one embodiment, steam injection for thermal recovery of bitumen in a dolomitic or limestone reservoir matrix material can be carried out at a higher temperature, a higher pressure, a longer dwell time or a combination of all three to allow the mobilized bitumen to remain in contact with the catalytic materials in the dolomitic or limestone reservoir matrix material for longer times at higher temperatures and pressures. In another embodiment, catalytic materials such as for example, oxides or carbonates of calcium, magnesium, potassium, nickel and/or iron can be injected into the reservoir along with steam to further enhance catalytic activity during the heating, mobilization and recovery phases of a thermal recovery operation. In another embodiment applicable to recovery operations conducted from a tunnel or a shaft in or below the hydrocarbon reservoir, a separately excavated upgrading chamber can be used to further upgrade the recovered bitumen or heavy oil.
IN-SITU UPGRADING OF BITUMEN OR HEAVY OIL

CROSS REFERENCE TO RELATED APPLICATION

The present application claims the benefits, under 35 U.S.C.§1 19(e), of U.S. Provisional Application Serial No. 61/560,618 entitled "In-Situ Upgrading of Bitumen or Heavy Oil" filed November 16, 2011, which is incorporated herein by reference.

FIELD

The present disclosure relates to in-situ upgrading of heavy oils and bitumen in general and to upgrading by naturally occurring or injected catalysts in particular.

BACKGROUND

There are an estimated 300 million barrels of recoverable bitumen from Alberta's Athabasca oil sands. There is an approximately equal amount of potentially recoverable bitumen from the carbonates in the Grosmont Carbonates, also in Alberta.

Bitumen does not flow at ambient reservoir temperatures and has an API density of typically less than ~10°. Heavy crude oils also typically do not flow at ambient reservoir temperatures and have API densities in the approximate range of from ~10° to ~20°. In order to mobilize these hydrocarbons so that they can be recovered when they are too deep to mine, thermal methods such as for example Steam Assisted Gravity Drain ("SAGD"), solvent methods such as for example Vapor Extraction ("VAPEX") and combinations of thermal and solvent methods such as for example Solvent Assisted Process "SAP", Steam Alternating Solvent "SAS" and the like are used.

SAGD and other thermal methods are usually carried out by injecting steam into the formation at temperatures typically in the range of 150 to 400 °C and pressures typically in the range of 1 to 15 MPa. These conditions may be maintained in the reservoir for days to months.

In the oil sands such as the Athabasca, the reservoir matrix is formed by weakly cemented sand grains which are primarily quartz. In the carbonates, the reservoir matrix is formed by dolomites which are comprised, in part, by calcium and magnesium.

In catalytic coal gasification, the use of catalytics such as calcium, magnesium, potassium, nickel and iron are used to allow coal gasification to proceed more quickly and efficiently at lower temperatures and pressures. Steam gasification of methane is also known to be enhanced by catalysts such as sodium and calcium at temperatures in the range of 700 to 900 °C and pressures in the range of 0.1 to 5 MPa. The addition of
potassium carbonate in the steam gasification of bituminous coals is known to reduce the optimum temperature and pressure from 980 to 760°C and from 6.7 MPa to 3.35 MPa.

Coal gasification is an upgrading process and there is conjecture that bitumen and heavy oil can be at least partially upgraded by exposure to catalysts during thermal recovery operations. If so, then these thermal recovery processes can be enhanced with little extra effort, resulting in considerable energy savings.

There is an economic benefit to achieving a partial upgrade of bitumen and heavy oil during thermal recovery operations since, once recovered, these hydrocarbons must be upgraded either for transportation to a refinery and/or for upgrading into marketable products at a refinery.

**SUMMARY**

These and other needs are addressed by the various embodiments and configurations of the present disclosure which are directed generally to means of upgrading bitumen or heavy oils during thermal recovery operations by the use of appropriate catalysts and control of thermal recovery conditions.

A method can include the steps:

(a) injecting a catalytic material and steam into a bitumen-containing dolomitic or limestone reservoir matrix material to form upgraded bitumen, wherein the catalytic material is an oxide, carbonate, and/or chloride of an alkali and alkaline earth metal; and

(b) recovering the upgraded bitumen.

The catalytic material can be one or more of oxides and/or carbonates of calcium, magnesium, potassium, nickel, and/or iron.

A recovered API density of upgraded bitumen can be at least about 125% of an in situ API density of bitumen.

A recovered API density of upgraded bitumen can be from about 2 to about 10 API degrees greater than an in situ API density of bitumen.

A method can include the steps of:

(a) fracturing a bitumen-containing dolomitic or limestone reservoir matrix material to increase a permeability and exposed surface area of the matrix material; and

(b) injecting steam into the fractured matrix material to form an upgraded bitumen, wherein the matrix material comprises a catalytic material having a catalytic effect on bitumen; and

(b) injecting steam into the fractured reservoir matrix material to form an upgraded bitumen.
The fracturing can be performed by one or more of hydro-fracturing, explosive fracturing, and block caving.

The catalytic material can be an alkali and/or alkaline earth metal carbonate or bicarbonate.

A method can include the steps of:

(a) recovering, by steam injection, bitumen from a bitumen-containing material;
(b) in an underground excavation, contacting the recovered bitumen with excavated limestone and/or dolomite to upgrade the bitumen; and
(c) recovering the upgraded bitumen.

The excavated limestone and/or dolomite can include a catalytic material having a catalytic effect on bitumen.

The catalytic material can be one or more of an oxide, chloride, and/or carbonate of an alkali, alkaline earth, and transition metal.

The underground excavation can include an underground working area and an underground chamber containing the excavated limestone and/or dolomite and injector and producer wells for injecting recovered bitumen into the underground chamber and removing upgraded bitumen from the underground chamber, respectively.

The excavated limestone and/or dolomite could have been used in carbon dioxide scrubbing operations to remove carbon dioxide from refinery flue gas.

A thermal or thermal plus solvent process can be applied to the recovered bitumen in the underground excavation.

The contacting step can be performed by one or more of SAGD, CSS, and steam flooding.

The catalytic material can be contained within the at least one of limestone and dolomite.

The catalytic material can be added to the at least one of limestone and dolomite.

A recovered API density of the upgraded bitumen can be at least about 125% of an in situ API density of the bitumen, before recovery.

An upgraded API density of the upgraded bitumen can be from about 2 to about 10 API degrees greater than an in situ API density of bitumen, before recovery.

The upgraded API density of the upgraded bitumen can range from about 10 to about 18 API degrees.
The underground excavation can be heated to a temperature in the range of about 150 to about 200 degrees Celsius in the contacting step.

The various methods disclosed herein can increase the API density of bitumen typically by about 1 to about 20 API degrees, more typically by about 2 to about 15 degrees, and more typically by about 2 API degrees to about 10 API degrees. For example, a bitumen with an in-situ API of about 8 API degrees may be upgraded to a heavy oil with a recovered API density in the range of approximately about 10 API degrees to about 18 API degrees. In another example, a heavy oil has a recovered API density that is typically at least about 125%, more typically at least about 135%, more typically at least about 145%, and even more typically at least about 150% of an in situ API density of a bitumen prior to upgrading.

In one embodiment, steam injection for thermal recovery of bitumen in a dolomitic or limestone reservoir matrix material can be carried out at a higher temperature, a higher pressure, a longer dwell time or a combination of all three in order to allow the mobilized bitumen to remain in contact with the catalytic materials in the dolomitic or limestone reservoir matrix material for longer times at higher temperatures and pressures.

In another embodiment, catalytic materials such as for example, oxides or carbonates of calcium, magnesium, potassium, nickel and/or iron can be injected into the reservoir along with steam to further enhance catalytic activity during the heating, mobilization and recovery phases of a thermal recovery operation.

In another embodiment, methods such as hydro-fracturing, explosive fracturing and the like may be used to increase the permeability and surface area of the reservoir matrix material so as to enhance the contact between the catalytic elements in the dolomitic or limestone reservoir matrix material.

In another embodiment applicable to recovery operations conducted from a tunnel or a shaft in or below the hydrocarbon reservoir, block caving methods and the like may be used to increase the permeability and surface area of the reservoir matrix material so as to enhance the contact between the catalytic elements in the dolomitic or limestone reservoir matrix material.

The above-described embodiments and configurations are neither complete nor exhaustive. As will be appreciated, other embodiments of the disclosure are possible utilizing, alone or in combination, one or more of the features set forth above or described in detail below.
As noted above, the hybrid transmission configurations all utilize a one-way clutch to prevent reverse power flow from the drive train to a free power turbine.

These and other advantages will be apparent from the disclosures contained herein.

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" means A alone, B alone, C alone, A and B together, A and C together, B and C together, or A, B and C together.

The following definitions are used herein:

*Acid-producing gases* as used herein are gases such as carbon dioxide, sulfur dioxide, nitrogen dioxide and the like when combined with water provided by steam to form carbonic acid, sulfuric acid, nitric acid and the like.

*A diluent* as used herein is a light hydrocarbon that both dilutes and partially dissolves in heavy hydrocarbons. In a thermal or non-thermal heavy oil or bitumen production method, a solvent liquid or vapor is used to reduce viscosity of the heavy oil. An injected solvent vapor expands and dilutes the heavy oil by contact. The diluted heavy oil is then produced via horizontal or vertical producer wells. *Diluent* and solvent are often used interchangeably in the production of heavy oil and bitumen.

*A mobilized* hydrocarbon is a hydrocarbon that has been made flowable by some means. For example, some heavy oils and bitumen may be mobilized by heating them or mixing them with a diluent to reduce their viscosities and allow them to flow under the prevailing drive pressure. Most liquid hydrocarbons may be mobilized by increasing the drive pressure on them, for example by water or gas floods, so that they can overcome interfacial and/or surface tensions and begin to flow.

*Primary production* or recovery is the first stage of hydrocarbon production, in which natural reservoir energy, such as gasdrive, waterdrive or gravity drainage, displaces hydrocarbons from the reservoir, into the wellbore and up to surface. Production using an artificial lift system, such as a rod pump, an electrical submersible pump or a gas-lift installation is considered primary recovery. *Secondary production* or recovery methods frequently involve an artificial-lift system and/or reservoir injection for pressure maintenance. The purpose of secondary recovery is to maintain reservoir pressure and to displace hydrocarbons toward the wellbore. *Tertiary production* or recovery is the third stage of hydrocarbon production during which sophisticated techniques that alter the
original properties of the oil are used. Enhanced oil recovery can begin after a secondary recovery process or at any time during the productive life of an oil reservoir. Its purpose is not only to restore formation pressure, but also to improve oil displacement or fluid flow in the reservoir. The three major types of enhanced oil recovery operations are chemical flooding, miscible displacement and thermal recovery.

A producer is a any producer of natural gas, oil, heavy oil, bitumen, peat or coal from a hydrocarbon reservoir.

The following in-situ process acronyms are used herein:

CSS means Cyclic Steam Stimulation. In the CSS process, steam is injected into the reservoir at rates of the order of 1000 B/d for a period of weeks; the well is then allowed to flow back and is later pumped. In suitable applications, the production of oil is rapid and the process is efficient, at least in the early cycles. If the steam pressure is high enough to fracture the reservoir and thus allow injection, it can also be used to produce the very viscous oil of the oil sands at an economic rate. The main drawback of the cyclic steam stimulation process is that it often allows only about 15% to 25% of the oil to be recovered before the oil-to-steam ratio becomes prohibitively low.

ESEIEH means Solvent Extraction Incorporating Electromagnetic Heating

HAGD is an acronym for Heat Assisted Gravity Drain. In the US oil shales, one recovery method being implemented in pilot projects involves the use of resistance heaters and heating elements to raise the temperature of the oil shales so that oil is produced. These methods are being considered for application to both oil sand and carbonate deposits in Alberta. These methods are designed to heat heavy oil and bitumen deposits to mobilize these hydrocarbons for production. Heating of oil sands by electrodes, often referred to as a form of HAGD. Direct heating of oil sands by electrically-powered heating elements is another form of HAGD.

LASER means Liquid Addition to Steam for Enhancing Recovery

LASER-CSS means Liquid Addition to Steam for Enhancing Recovery of Cyclic Steam Stimulation

N-Solv means thermal solvent process

PHARM means Passive Heat Assisted Recovery Methods

SAGD means Steam Assisted Gravity Drain. Typically, SAGD wells or well pairs are drilled from the earth's surface down to the bottom of the oil sand deposit and then
horizontally along the bottom of the deposit and then used to inject steam and collect mobilized bitumen.

SAGP means Steam Gas Push.
SA-SAGD means Solvent Assisted SAGD
SC-SAGD means Solvent-Cyclic SAGD
ES-SAGD means Expanding Solvent-SAGD
SAP means Solvent Assisted Process
SAS means Steam Alternating Solvent
SA VES means Solvent Assisted Vapour Extraction with Steam
SA VEX means Steam and Vapour Extraction process
SGS means Steam Gas Solvent.

In a steamflooding process, steam is forced continuously into specific injection wells and oil is driven to separate production wells. The zones around the injection wells become heated to the saturation temperature of the steam, and these zones expand toward the production wells. Oil and water from the condensation of steam are removed from the producers. With viscous oil there is a considerable tendency for the steam to override the reservoir, and this tends to limit the downward penetration of the heat and hence the recovery. Steamflooding can allow higher steam injection rates than steam stimulation; this advantage often offsets the rather lower thermal efficiency.

VAPEX means Vapour Extraction process and is a process which uses a diluent as the fluid injected into the hydrocarbon formation as a mobilizing fluid

It is to be understood that a reference to solvent herein is intended to include diluent and a reference to diluent herein is intended to include solvent.

It is to be understood that a reference to oil herein is intended to include low API hydrocarbons such as bitumen (API less than about 10 degrees) and heavy crude oils (API from about 10 degrees to about 20 degrees) as well as higher API hydrocarbons such as medium crude oils (API from about 20 degrees to about 35 degrees) and light crude oils (API higher than about 35 degrees). A reference to bitumen is also taken to mean a reference to low API heavy oils.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The present disclosure may take form in various components and arrangements of components, and in various steps and arrangements of steps. The drawings are only for purposes of illustrating the preferred embodiments and are not to be construed as limiting
the disclosure. In the drawings, like reference numerals refer to like or analogous components throughout the several views.

Figure 1 is a schematic of a flow process for in-situ upgrading of bitumen or heavy oil.

Figure 2 is a schematic of an underground recovery operation including is-situ upgrading.

DETAILED DESCRIPTION

In-Situ Upgrading

Known catalysts for steam gasification are oxides and chlorides of alkali and alkaline-earth metals and transition metals, separately or in combination. For example, sodium chloride and potassium chloride are known catalysts while the carbonates of sodium and potassium are known to have higher catalytic activity. Also, oxides of calcium, iron, magnesium and zinc are known to have catalytic effect on steam gasification of coal. Calcium carbonate and magnesium carbonates are known to occur naturally in dolomitic and limestone formations.

In one embodiment, steam injection for thermal recovery of bitumen in a dolomitic or limestone reservoir matrix material can be carried out at a higher temperature, a higher pressure, a longer dwell time or a combination of all three in order to allow the mobilized bitumen to remain in contact with the catalytic materials in the dolomitic or limestone reservoir matrix material for longer times at higher temperatures and pressures.

In another embodiment, catalytic materials such as for example, oxides or carbonates of calcium, magnesium, potassium, nickel and/or iron can be injected into the reservoir along with steam to further enhance catalytic activity during the heating, mobilization and recovery phases of a thermal recovery operation.

In another embodiment, methods such as hydro-fracturing, explosive fracturing and the like may be used to increase the permeability and surface area of the reservoir matrix material so as to enhance the contact between the catalytic elements in the dolomitic or limestone reservoir matrix material.

In another embodiment applicable to recovery operations conducted from a tunnel or a shaft in or below the hydrocarbon reservoir, block caving methods and the like may be used to increase the permeability and surface area of the reservoir matrix material so as to enhance the contact between the catalytic elements in the dolomitic or limestone reservoir matrix material.
Formation of an Upgrading Chamber

Much of the Athabasca is underlain by a competent, thick limestone basement formation. These formations are well-suited to excavating tunnels or caverns by a variety of well-known methods such as for example, drill&blast, roadheaders, tunnel boring machines and the like.

The limestone removed from these excavations has many uses in a comprehensive thermal recovery operation in an overlying or near-by bitumen resource, especially after the bitumen has been recovered and de-watered. In the upgrading and refining processes, these uses include but are not limited to: water purification, removal of sulfur dioxide and carbon dioxide from recovered gases and flue gases from on-site or near-by refineries, for aggregate in road construction etcetera and for various agricultural uses where transportation distances are not to great.

One of the principal uses for this limestone is to form calcium oxide (quick lime) which can be hydrated to form slaked lime and used to remove carbon dioxide from flue gases. In the production of quick lime, carbon dioxide is generated. This carbon dioxide is "clean" (uncontaminated by sulfur dioxide and NOXs for example) and can be readily captured for various uses or it can be sold.

When used to remove carbon dioxide from flue gases, a "dirty" limestone sludge is formed (contaminated by sulfur dioxide and NOXs for example). One option is to take this dirty limestone and return it to the underground excavations previously formed in the aforementioned limestone formation. In effect, clean carbon dioxide (produced by turning limestone into calcium oxide) which has been captured and has some value, is exchanged for dirty limestone which can be sequestered in the underground excavations previously formed in the limestone formation.

In well-known thermal recovery operations of bitumen, a hot, dirty bitumen/water mixture is recovered. It is possible to effect a partial upgrade of this by storing it in a catalytic matrix. Such a matrix can be provided by the dirty limestone that has been returned to the underground excavations previously formed in the limestone formation.

If this is anticipated, then the following method can be envisioned:

1. Form an excavation in a competent limestone or dolomite formation under or near a natural bitumen deposit.
2. Utilize the excavated limestone or dolomite for a variety of purposes including usage as gravel and removal of carbon dioxide from refinery flue gases to provide a source of clean carbon dioxide.

3. In the excavation in the competent limestone or dolomite formation, install injector and producer wells suitable for a thermal stimulation operation such as SAGD, CSS or steam flooding.

4. Backfill the excavation in the limestone or dolomite formation with dirty limestone or dolomite sludge from carbon dioxide scrubbing operations.

5. Inject the hot, dirty bitumen/water mixture from a conventional thermal recovery operation into the excavation that now contains injector and producer wells and is backfilled with dirty limestone or dolomite sludge.

6. Steam the "man-made" reservoir and recover partially upgraded bitumen.

In effect, a new thermal recovery operation can be applied to the bitumen now in a limestone or dolomite matrix or reservoir. It is expected that there will be some upgrading of the bitumen as the bitumen is further heated and recovered for a second time.

It is noted that the installation of injector and producer wells will be far less expensive than installation by surface-based horizontal drilling since they need not be drilled from the surface or even a near-by tunnel or shaft but can be installed directly in an open tunnel or cavern. The cost of recovering the bitumen a second time can be more than offset by the upgrading action of the bitumen being heated while in contact with the catalytic limestone backfill. This second recovery operation is expected to be very efficient because the injector and producer wells can be installed accurately with optimal separation. Alternately, heating elements or electrodes can be installed to assist or replace heating by steam.

Figure 1 is a schematic of a flow process for in-situ upgrading of bitumen or heavy oil. A thermal or thermal plus solvent process 102 is applied to a bitumen or heavy oil reservoir 101. A catalyst 103 may also be injected to enhance the catalytic reactions occurring during the in-situ thermal or thermal plus solvent operations to produce an upgraded bitumen 111 which is recovered. This upgraded bitumen may then be combined with excavated and crushed limestone or dolomite in a cavern 104 excavated in the basement limestone or dolomite rock. A second thermal or thermal plus solvent process 105 is applied to the bitumen or heavy oil in cavern 104. A catalyst 106 may also be injected to enhance the catalytic reactions occurring during the thermal or thermal plus
solvent operation in the cavern to produce a further upgraded bitumen 112 which is then recovered and prepared for on-site refining or for transport to market.

Figure 2 is a schematic of a possible underground recovery operation including is-situ upgrading. A bitumen or heavy oil reservoir formation 201 is shown over basement rock 202 and overlain by an overburden layer 203. An underground working area 203 has been excavated in the basement rock 202. A number of horizontal well pairs 205 have been installed from the underground work space 203 into reservoir 201 with wellheads 206 installed for operating well pairs 205. As described above, steam or steam plus solvent and catalysts can be injected at the well head through the injector well of well pair 205. Mobilized bitumen or heavy oil is recovered through the producer well of well pair 205.

Bitumen recovery operations have been demonstrated in this manner by the Underground Test Facility ("UTF"). The Alberta Oil Sands Technology and Research Authority ("AOSTRA"), a government organization responsible for funding research in oil sands, was the key link in the transformation from concept to implementation. AOSTRA constructed the Underground Test Facility (UTF) in the Athabasca Oil Sands, in the 1980's to specifically test the SAGD hypothesis. Using directional drilling techniques, the original SAGD wells were drilled upwards and then horizontally from a tunnel in the limestone basement rock such as shown in Figure 2.

As also shown in Figure 2, another underground chamber 204 is also excavated and serves as an upgrading chamber. The chamber is filled with bitumen or heavy oil recovered from reservoir 201 and mixed with catalytic material such as limestone and/or dolomite rubble which may or may not be recovered from the material excavated to form either the work space 203 or the upgrading chamber 204. As shown in Figure 2, Upgrading chamber 204 is separated from working space 203 and connected by one or more passage ways 207. Passage ways 207 can be blocked of by gates or barriers.

The bitumen or heavy oil recovered and catalytic material can then be steamed and heated up to temperatures in the range of about 150 °C to about 200°C for additional upgrading. It is also possible to incorporate mechanical mixing apparatuses in the upgrading chamber to increase the catalytic action.

The disclosure has been described with reference to the preferred embodiments. Modifications and alterations will occur to others upon a reading and understanding of the preceding detailed description. It is intended that the disclosure be construed as including
all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

A number of variations and modifications of the disclosures can be used. As will be appreciated, it would be possible to provide for some features of the disclosures without providing others. For example, the same slow fill system can be applied to filling any vehicle powered by gaseous fuels such as CNG, propane, hydrogen etcetera. These slow fill systems could be located, for example, at malls, parking garages, factory outlets and the like. A similar strategy, which is known, is charging electric cars overnight. The present disclosure differs in that a slow fill CNG location is based on a central storage and metering facility serving a number of fueling posts.

The present disclosure, in various embodiments, includes components, methods, processes, systems and/or apparatus substantially as depicted and described herein, including various embodiments, sub-combinations, and subsets thereof. Those of skill in the art will understand how to make and use the present disclosure after understanding the present disclosure. The present disclosure, in various embodiments, includes providing devices and processes in the absence of items not depicted and/or described herein or in various embodiments hereof, including in the absence of such items as may have been used in previous devices or processes, for example for improving performance, achieving ease and/or reducing cost of implementation.

The foregoing discussion of the disclosure has been presented for purposes of illustration and description. The foregoing is not intended to limit the disclosure to the form or forms disclosed herein. In the foregoing Detailed Description for example, various features of the disclosure are grouped together in one or more embodiments for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed disclosure requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment. Thus, the following claims are hereby incorporated into this Detailed Description, with each claim standing on its own as a separate preferred embodiment of the disclosure.

Moreover though the description of the disclosure has included description of one or more embodiments and certain variations and modifications, other variations and modifications are within the scope of the disclosure, e.g., as may be within the skill and knowledge of those in the art, after understanding the present disclosure. It is intended to
obtain rights which include alternative embodiments to the extent permitted, including alternate, interchangeable and/or equivalent structures, functions, ranges or steps to those claimed, whether or not such alternate, interchangeable and/or equivalent structures, functions, ranges or steps are disclosed herein, and without intending to publicly dedicate any patentable subject matter.
What is claimed is:

1. A method, comprising:
   injecting a catalytic material and steam into a bitumen-containing dolomitic or limestone reservoir matrix material to form upgraded bitumen, wherein the catalytic material is an oxide, carbonate, and/or chloride of an alkali and alkaline earth metal; and recovering the upgraded bitumen.

2. The method of claim 1, wherein the catalytic material is one or more of oxides and/or carbonates of calcium, magnesium, potassium, nickel, and/or iron.

3. The method of claim 1, wherein a recovered API density of upgraded bitumen is at least about 125% of an in situ API density of bitumen.

4. The method of claim 1, wherein a recovered API density of upgraded bitumen is from about 2 to about 10 API degrees greater than an in situ API density of bitumen.

5. A method, comprising:
   fracturing a bitumen-containing dolomitic or limestone reservoir matrix material to increase a permeability and exposed surface area of the matrix material; and injecting steam into the fractured matrix material to form an upgraded bitumen, wherein the matrix material comprises a catalytic material having a catalytic effect on bitumen; and injecting steam into the fractured reservoir matrix material to form an upgraded bitumen.

6. The method of claim 5, wherein the fracturing is performed by one or more of hydro-fracturing, explosive fracturing, and block caving.

7. The method of claim 5, wherein the catalytic material is an alkali and/or alkaline earth metal carbonate or bicarbonate.

8. A method, comprising:
   recovering, by steam injection, bitumen from a bitumen-containing material; in an underground excavation, contacting the recovered bitumen with at least one of excavated limestone and dolomite to upgrade the bitumen; and recovering the upgraded bitumen.

9. The method of claim 8, wherein the at least one of excavated limestone and dolomite comprises a catalytic material having a catalytic effect on bitumen.

10. The method of claim 9, wherein the catalytic material is one or more of an oxide, chloride, and/or carbonate of an alkali, alkaline earth, and transition metal.
11. The method of claim 8, wherein the underground excavation comprises an underground working area and an underground chamber containing the at least one of excavated limestone and dolomite and injector and producer wells for injecting recovered bitumen into the underground chamber and removing upgraded bitumen from the underground chamber, respectively.

12. The method of claim 8, wherein the at least one of excavated limestone and dolomite has been used in carbon dioxide scrubbing operations to remove carbon dioxide from refinery flue gas.

13. The method of claim 8, wherein a thermal or thermal plus solvent process is applied to the recovered bitumen in the underground excavation.

14. The method of claim 8, wherein the contacting step is performed by one or more of SAGD, CSS, and steam flooding.

15. The method of claim 8, wherein the catalytic material is contained within the at least one of limestone and dolomite.

16. The method of claim 8, wherein the catalytic material is added to the at least one of limestone and dolomite.

17. The method of claim 8, wherein a recovered API density of the upgraded bitumen is at least about 125% of an in situ API density of the bitumen, before recovery.

18. The method of claim 8, wherein a upgraded API density of the upgraded bitumen is from about 2 to about 10 API degrees greater than an in situ API density of bitumen, before recovery.

19. The method of claim 8, wherein the upgraded API density of the upgraded bitumen ranges from about 10 to about 18 API degrees.

20. The method of claim 8, wherein the underground excavation is heated to a temperature in the range of about 150 to about 200 degrees Celsius in the contacting step.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8): BOU 38/06; E21B 43/24; C10G 11/00 (2013.01)
USPC: 166/272.1, 272.2; 208/46, 106, 108, 121, 122

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8): BOU 38/06; E21B 43/24; C10G 11/00 (2013.01)
USPC: 166/272.1, 272.2; 208/46, 106, 108, 121, 122; 502/55, 174, 34, 20, 100; 44/551, 569, 550

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)