IN SITU PROCESS FOR RECOVERY OF CARBONACEOUS MATERIALS FROM SUBTERRANEAN DEPOSITS

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ABSTRACT
Subterranean carbonaceous deposits, such as oil shale, are conditioned for in-situ recovery of carbonaceous values by limited undercutting over a large area to leave an overlying deposit supported by a multiplicity of pillars, if necessary, then removing the pillars and expanding the overlying deposit to fill the entire void with particles of a uniform size, porosity and permeability. Communication is then established with the upper level of the expanded deposit and a high temperature gaseous medium which will liquify or vaporize the carbonaceous values is introduced in a manner which causes the released values to flow downward for collection at the base of the expanded deposit. Convenient media are hot flue gases created by igniting the upper level of the expanded carbonaceous deposit and forcing a flow of hot gases downward through the expanded deposit.

29 Claims, 6 Drawing Figures
IN SITU PROCESS FOR RECOVERY OF CARBONACEOUS MATERIALS FROM SUBTERRANEAN DEPOSITS

BACKGROUND OF THE INVENTION

Immense reserves of subterranean carbonaceous deposits are known to exist throughout the world. In some, the contained values are commercially recoverable. In many, such as oil shale deposits, recovery is not competitive with natural petroleum or gas sources. Over the years, extensive development projects have been conducted to devise economic methods of recovering values from such deposits. One method applied to oil shale generally involves the mining of the oil shale, transporting the shale to the surface, crushing and grinding it to correct size and passing it through a retort to volatilize the oil content, then discarding the remaining shale. This procedure is expensive and has many inherent technical problems and is economically unattractive.

In-situ retorting has been proposed using three general approaches. Conventional fracturing techniques, such as high explosives, have been proposed to establish communication between adjacent wells drilled into a formation. Pressure drop is high and utilization of the complete formation extremely difficult. Nuclear explosions have also been proposed to create a cavity or chimney by vaporization of part of the formation with attendant by breaking of the rock to fill the space created. The resultant chimney serves as a reactor through which reactant gases are circulated. This approach is applicable only to deep formations, namely, formations having at least 1,000 feet of overburden.

The third approach is that described in U.S. Pat. Nos. 3,001,776 and 3,434,757. A tunnel, or cavity, is formed under the oil shale deposit. The resultant roof support is then removed and the overlying shale allowed to cave. Following this initial caving, explosives are detonated in the remaining overlying shale to cause more caving, to yield a large volume of rubble in a loosely filled cavern area. Neither of these two schemes provide control to particle size of the rubble shale and as a consequence gas flow through the rubble is uneven. In addition, U.S. Pat. No. 3,434,757 calls for retort gas flow in a horizontal direction which makes even retort gas distribution virtually impossible. The resultant economics of such schemes are poor and in-situ recovery of oil from shale has not been commercially exploited.

SUMMARY OF THE INVENTION

It has been found that carbonaceous values can be economically recovered from subterranean deposits by a controlled expansion of the deposit over a broad area to form a mass of particulate solids of essentially uniform particle size, porosity, and permeability; establishing communication with the upper level of the expanded deposit and introducing a suitable high temperature gaseous media which will cause the expanded particles to release their carbonaceous values by liquification or vaporization.

This is accomplished by undercutting the deposit to remove only from about 5 to about 25 percent of the deposit and leaving an overlying deposit supported by a multiplicity of supporting pillars, if necessary, for roof support. The pillars are then removed preferably by blasting, to yield an initial mass of particles of uniform particle size. The overlying deposit is then expanded to fill the undercut area with a mass of particulate carbonaceous bearing particles of uniform size, porosity and permeability having a void volume approximately equal to the volume of the deposit removed. Communication is then established with the upper level of the expanded deposit and a suitable high temperature gaseous media is introduced which will cause the expanded deposit to release the carbonaceous values as a liquid and/or vapor by a downward flow of the gaseous media. The liquefied released carbonaceous values are then recovered from the base of the expanded deposit.

In the case of the recovery of hydrocarbon values such as shale oil, the gaseous media preferably used are hot flue gases which pass downward through the expanded deposit. Flue gases can be conveniently generated by ignition of the upper level of the expanded deposit and maintaining a combustion zone which propagates downwardly through the expanded shale by maintaining a supply of a source of oxygen, usually air, to the combustion zone. As the expanded deposit is uniform in character the hot flue gases flow uniformly and result in a maximum conversion of the kerogen to shale oil which collect at the base and is recovered by pumping to the surface. The creation of particles of uniform size, porosity and permeability further prevents the formation of voids and channels which hinder total recovery and provides a uniform pressure drop through the entire mass of particles.

DRAWINGS

FIG. 1 is a side view of an oil bearing shale formation.
FIG. 2 is an illustration of an undercutting of the oil bearing shale formation.
FIG. 3 is a plan view of the undercutting showing numerous support pillars.
FIG. 4 is an illustration of the expanded oil bearing shale formation recovery operation.
FIG. 5 is a plan view of the expanded oil bearing shale formation recovery operation.
FIG. 6 is a plan of a small retorting operation for progressively mining a large deposit.

DESCRIPTION

According to the present invention a subterranean carbonaceous deposit, such as an oil shale deposit, is conditioned for recovery of the carbonaceous values by first undercutting a limited height of the deposit over a broad area, removing the undercut fraction to give porosity to the overlying deposit when uniformly expanded. The expanded fraction will have the desired low pressure drop characteristics needed for an economical retorting operation. The area undercut should be as large as the formation will allow to reduce unit cost, which in favorable locations should be about an acre in area. Formation thickness should be as great as possible, also to reduce unit cost, normally 100 to 200 feet. Pillars should be left in a normal mining pattern although for smaller areas, no pillars, or other roof supporting methods need be employed. The pillars are removed and the overlying deposit progressively, preferably explosively, expanded to form a mass of particulate solids of uniform size, porosity and permeability, having a void volume essentially equal to the volume of the deposit removed.

Communication is then established with the ceiling of the expanded carbonaceous deposit and a gaseous media which will cause the deposit to vaporize the carbonaceous values is forced downwardly through the deposit. The released vapors are condensed on the cooler formation below. The liquid droplets agglomerate on the same formation and most of the total released carbonaceous values are pumped from the base of the formation as liquid. The gaseous media is returned to the surface by its own initial pressure. Additional hydrocarbon recovery from the gaseous media may be made using conventional cooling and collecting equipment. A preferred media are hot flue gases generated by igniting the upper level of the mass of expanded particles and uniformly forced downward through the mass of the particles by a progressive downward burn maintained by the forced supply of a source of oxygen, typically air. The hot flue gases retain the mass of particles and cause the release of the carbonaceous values which collect at the floor for pumping to the surface.

The nature of the high temperature gaseous media is not narrowly critical. It must, however, be sufficiently hot to liquify and/or vaporize the carbonaceous values. In addition to in-situ generated flue gases, there may be employed an externally heated gas stream, steam as well as flue gases recycled from the base of the expanded deposit or supplied from an adjacent retorting operation. Where the hot gases are generated by in-
situ combustion, recycling the flue gases provides a convenient means to modulate combustion temperature by diluting the supplied air.

While the practice of this invention is applicable to the recovery of any carbonaceous values from subterranean deposit, its practice may be conveniently illustrated in terms of the recovery of oil from shale.

Accordingly, and with reference first to FIG. 1, a typical oil shale formation includes an overburden zone 10 typically in order of 200 to 3,000 feet in depth and a mineable grade of oil shale 12 of varying thickness, which most often are in the neighborhood of about 30 to about 500 feet thick, and lower base rock of varied porosity, so, as in the case of a canyon deposit, may allow lateral access to the shale, mineable access to the oil shale is established by the formation of one or more shafts 16 to base rock 14.

With reference now to FIG. 2, after communication with base rock 14 has been established, a tunnel 18 from each shaft to the deposit is established and an underfoot 20 excavated to the length of the area to be mined and, with reference now to FIG. 3, broadened to the width of the area to be mined leaving a plurality of small support pillars 22. The area mined should be conveniently large, sometimes in the order of an acre or more. Care should be taken to generally provide that the floor of the mined-out area will be flat or inclined in the direction of tunnel 18 to assure no impediment to the flow of oil in the direction of shaft 16 during the subsequent retorting operation. Only a limited height of the deposit is excavated, generally only 5 to about 25 percent, preferably from about 5 to about 15 percent, of the total deposit volume.

The removed shale may be treated, where desired, for recovery of its oil at the surface in conventional retorts, or in underground retorts such as might be prepared in mined-out areas. It may also be conveniently pumped as an expanded particulate mass, in a convenient canyon or like depression, covered with a suitable thin overburden layer, the values extracted in a manner similar to that set forth herein for the original deposit. Alternatively, the removed shale can be deposited in a mined-out chamber underground. After retorting the mined-out chamber may be emptied or simply closed. By such means, although mining costs are incurred in the initial creation of the mined-out area, the values recovered from the removed shale will substantially offset the mining costs but without the costs of grinding, crushing and disposing as is the current common practice.

After the area has been suitably mined, there is preferably placed, again with reference to FIGS. 2 and 3, explosive charges 24 in columns 22 and charges 26 in the shale overlay.

The charges are programmed to fire explosively to destroy column 22 followed by progressive explosive expansion of the overlay by employing charges 26, generally, in a progressively sequential manner from the bottom up. A barricade 28 is then placed at the entrance to the mined-out area to seal the mined-out area from tunnel 18 and shaft 16. With reference now to FIGS. 2, 3, 4 and 5, once the tunnel is sealed the pillars are explosively broken to yield a uniform rubble. Charges 26 are progressively exploded to expand the overlaying shale to fill the void created by the undercut to establish, thereby, a mass of particles of uniform size, porosity and permeability, having a total void volume approximately equal to the amount of shale removed in the undercut.

Explosion is preferably accomplished by a slight doming of the overburden 10 to create dome 30, which serves to improve the support provided by the overburden.

As illustrated in FIGS. 4 and 5, the net deposit is a plurality of uniform particles spread throughout the mined-out area and overlaying deposit area. Following explosive expansion of the shale, communication is established with the top of the expanded oil shale deposit by drilling at least one and preferably a plurality of communicating conduits 32 to the top of the expanded shale.

Alternatively, and easily convenient, a tunnel (not shown) may be established at the top of the expanded shale, for introduction of the media used for recovery of carbonaceous values in the deposit.

Following expansion of the shale, the exhaust barrier 28 is removed and exhaust conduit 34, and oil flow conduit 36 are installed, preferably by employing fishback 16 as a source of oxygen, typically air, from compressor 38 is then provided to conduits 32. To establish a flow of oil, from the shale, the upper level of expanded shale deposit is ignited using an initial supply of fuel and air to the top of the shale deposit through conduits 32. The source of oxygen, typically air, is supplied at a pressure sufficient to overcome the inherent pressure drop through the conduits and the shale deposit, to establish a positive downward flow of hot gases. Once the upper level of the shale is ignited, the supply fuel may be discontinued as the shale deposit will inherently provide a sufficient source of fuel to generate the hot flue gases for retorting. The flue gases generated by combustion flow downwardly through the shale and serve to retort the oil from the expanded mass of particles. As they are of a uniform size, porosity and permeability, uniform flow of flue gases will be obtained as channels which would normally preclude flue gases from reaching certain areas of the shale prematurely are avoided. In passing through the shale, the flue gases cause the shale to release its oil as a carbonaceous value which drains to the floor and is conveniently pumped out through conduit 36. Depending on point in time, the cross-sectional appearance of the expanded shale deposit will generally have a burning zone 40, a burning zone 42, and a retort zone 46, where oil is released from the shale. As previously mentioned, the released oil flows downwardly concurrently with the flow of hot flue gases and collects at the floor 48 for recovery through conduit 36, with flue gases exiting through conduit 34.

Because deposit is uniformly expanded, to a desired, predetermined porosity, the air pressure required will be generally low and as a consequence only a thin overburden is required to contain the pressure. This offers, the advantage, as previously indicated, in that the shale removed during the tunneling and mining operations, can be deposited in a canyon or other depression as an expanded particulate mass covered with only a thin overburden and processed for recovery of the oil in the manner set forth herein. It offers the additional economic advantage of minimum compression costs.

Once recovery is complete, air may be blown through the formation may be continued to both cool the deposit and to heat the air which can be pumped as the retorting hot gas stream by compressors to adjacent areas being mined in a similar manner. Any gases generated during retorting may be discarded, used to pre-heat an adjacent area being processed, or the values contained therein, such as methane and hydrocarbons, recovered. Where hydrogen is generated it may be used directly for hydrogenation or stabilization of recovered oil.

Although in situ generated flue gases are a most convenient media for use in extracting hydrocarbons, such as oil, it will be appreciated that other generated hot gases, such as those generated in adjacent mined-out areas may be pumped through the shale, with or without combustion, to force the deposit to release its carbonaceous values.

In the alternative, and depending upon the carbonaceous material to be recovered, there may also be used as the media oxygen, steam, water and the like, which can be forced through the expanded deposit under positive pressure to cause the release of carbonaceous values contained therein.

Although the process of this invention has been generally described in terms of recovery of oil from shale it will be readily appreciated that it is fully adaptive to the recovery of values from other subterranean carbonaceous deposits. For instance, many petroleum and gas bearing reserves are known in which porosity is too low to allow a reasonable flow of the contained values to a producing well or the like, in that the source has been extracted to its commercial limit or in the alternative low recovery has resulted because of the high viscosity of contained values.
Examples of such deposits include among others oil sands such as Athabasca tar sands, gilsonite, lignite, low rank coal, bituminous coal and like carbonaceous materials which, at present, are generally uneconomically recoverable.

The carbonaceous bearing deposit may be mined in the manner set forth above if the nature of the deposit is not unduly hazardous to excavation. If it is, the undercut may be conveniently made in the base rock slightly below the formation and the base rock perforated to connect with the deposit. Any free carbonaceous fluids or gaseous materials may then be allowed to flow through the perforations for recovery and the formation then expanded in the manner described above by breaking the interlayer between the undercut and expanding the overlying deposit to allow in-situ retorting. In the alternative, the same result may be accomplished by undercutting directly into formation using casements to protect workers during the excavation operations. Perforations could then be used to allow withdrawal of any free fluid carbonaceous values or gases followed by expansion in the manner set forth above, for recovery of carbonaceous values.

In some instances, a deposit may be operating a gas producer by employing limited air, or an alternating with steam or other as the extracting medium.

In other instances, the expanded deposit may be first treated pyrolytically in the manner set forth above for the production of hydrocarbon values and residual coke treated as a gas producer by the introduction of a source of oxygen, such as air.

In some instances, where deposit has some porosity, the amount of undercutting required would be minimal as the amount of expansion necessary for suitable processing would not be as great.

In each instance, as in the case of oil shale, the mined out material can be retorted at the surfaces or deposited in a canyon or mined out area covered with a thin mantle, and treated in the manner described above.

With some deposits, maximum recovery of contained values can also be realized by finally leaching the processed deposit for any remaining values using media such as percolating water, acids, bases and the like, to form an enriched solution which collects at the floor and which can be pumped to the surface for recovery of extracted ore values.

With reference to FIG. 6, the following example will serve to illustrate this invention by describing the formation and re-torting of a single, relatively small, oil shale zone which may be operated in successive stages in mining a large shale deposit.

The periphery 50 shown is a desired boundary or retort wall left intact when the oil shale inside the zone is undercut and explosively broken. The four small pillars 22 comprising approximately 15 percent of the cross-sectional area of the retort represent pillars left standing at the bottom of the oil shale bed. Drifts 52, at the same depth as the pillars, allow access for mining and ventilation during the mining operation. The bottom 15 feet of a 100 foot thick shale oil formation is mined through access drifts 52. Mined material is removed to a main shaft and dumped in a below-ground cavity near the outcrop for additional retorting. Mining is complete when the only remaining structure in the resulting cavern consists of the pillars 22, as shown and when the retort floor is graded sufficiently to allow drainage toward drifts 52. A small entry retorting air tunnel, and distribution tunnels (not shown) are also formed above the shale bed.

Drill holes are next placed in the shale in a detailed firing pattern through the pillars to obtain the desired particle size distribution and permeability upon blasting. Explosives are loaded into these holes, and barricades are placed in drifts 52. Blasting is initiated by first exploding the pillars and then, sequentially from the bottom up, detonating the explosives within the shale bed. While the time interval between the detonations may vary from one shale bed to another, it is kept short enough to eliminate free collapse of the roof. In this manner the particle size and subsequent permeability are controlled by the specific detonations and the formation of large unbroken blocks of oil shale is minimized. The result of this caving technique is a retort uniformly packed, not loosely filled, with relatively small oil shale particles or rubble, and with a controlled porosity based upon the amount of undercutting.

Following the explosive caving, both product recovery and air feeding facilities are installed. This may include repairing the seals at the drifts. For the small retort of this example, a single tunnel is sufficient to handle the total gas flow into the retort, using flue gas from an adjacent older retort to pre-heat the formation.

Gas flow through the retort is initiated by forcing compressed air with or without flue gas through the central air tunnel through the retort and out through heat and product recovery systems. If preheating is not sufficient, start-up fuel is injected into the inlet air and ignited. The resultant flue gases heat the top of the bed and initiate the retorting process. When the top shale reaches 300°F to 400°F, it will sustain combustion without the start-up fuel which is then discontinued. Retorting proceeds as the heat front descends through the bed causing decomposition of the kerogen to yield the oil shale oil which is carried down through the bed with the moving gases. Residual carbon left on the shale is burned with the incoming oxygen, providing the heat for continued retorting. Retorting is completed when the bottom of the bed reaches around 900°F, usually with a total gas flow of less than 20,000 SCF/ton of oil shale. Only the amount of air necessary for the heat balance is used, usually less than 10,000 SCF/ton dependent upon efficiency of heat recovery. Gas velocity during the retort is 1 to 4 SCF/min./ft. retort cross-sectional area. Oil recovery from the total formation, excluding the loss in the barrier walls has been found to be from 75 to 85 percent for oil greater than 15 gal/ton.

While the Example is illustrative for oil shale operation, other carbonaceous deposits such as the thick seams of subbituminous coals can be similarly explosively caved to give controlled particle size and permeability. Gasification or liquefaction of the resulting rubble may be by various techniques such as reaction with air and steam, oxygen and steam, and the like.

What is claimed is:

1. A process for the recovery of carbonaceous values from subterranean deposits which comprises the steps of:
   a. establishing communication with the base of the subterranean carbonaceous deposit;
   b. undercutting at least at the base of said carbonaceous deposit to remove from about 5 to about 25 percent of the volume of said deposit, to provide an overlaying deposit supported by a plurality of pillars;
   c. removing said pillars;
   d. expanding said overlaying carbonaceous deposit to provide particulate mass of uniform particle size, porosity and permeability, said particulate mass having a void volume approximately equal to the volume of the carbonaceous deposit removed;
   e. providing at least one communicating conduit to the upper level of said expanded deposit;
   f. heating said expanded deposit to liquify and vaporize said carbonaceous values by introducing and maintaining a downward pressure positive of a high temperature gaseous media therethrough;
   g. collecting liquified carbonaceous values at the base of said deposit for recovery.

2. A process as claimed in claim 1 in which from about 5 to 15 percent of the volume of said deposit is removed.

3. A process as claimed in claim 1 in which the pillars are explosively removed.

4. A process as claimed in claim 1 in which the overlaying carbonaceous deposit is explosively expanded.

5. A process as claimed in claim 1 in which the carbonaceous deposit is selected from the group consisting of oil shale, oil tars, oil sands, tar sands, gilsonite, lignite, low rank coal, and bituminous coal.
6. A process as claimed in claim 1 in which the undercutting is below the base of the carbonaceous deposit to provide a thin intermediate overlaver and an intermediate layer is perforated to allow the drainage of free carbonaceous values from said deposit and the deposit expanded to provide a particular mass of uniform size, porosity and permeability for introduction of a high temperature gaseous media through a communicating conduit.

7. A process as claimed in claim 1 in which the deposit provides gaseous, carbonaceous values which are collected by an upward flow to the conduit communicating with the upper level of the expanded deposit.

8. A process as claimed in claim 1 in which the high temperature gaseous media is selected from the group consisting of hot gases and steam.

9. A process as claimed in claim 8 in which the hot gases are generated by steps of igniting the upper level of the expanded deposit and maintaining a uniform zone of combustion across the expanded deposit said combustion zone propagating downward through said deposit by maintaining a positive pressure supply of at least a source of oxygen.

10. A process as claimed in claim 9 in which the source of oxygen is air.

11. A process as claimed in claim 9 in which the residual deposit is subsequently leached with a leachant selected from the group consisting of water, acids, and bases and the enriched solution withdrawn at the base for recovery of mineral content.

12. A process as claimed in claim 9 in which the residual carbonaceous materials resulting from the combustion of a portion of the deposit are utilized for the production of carbonaceous gaseous values.

13. A process as claimed in claim 1 in combination with the additional steps of:
   a. accumulating the removed carbonaceous deposit in an underground mined-out chamber until full;
   b. continuously introducing to the filled mined-out area a high temperature gaseous media to liquify and vaporize the contained carbonaceous values;
   c. collecting the liquified carbonaceous values at the base of the mined-out chamber for recovery.

14. A process as claimed in claim 13 in which the exhausted mined-out chamber is then emptied.

15. A process for the production of oil shale which comprises steps of:
   a. establishing communication with the base of a subterranean shale deposit;
   b. undercutting at the base of the shale deposit to remove 5 to about 25 percent of the volume of said deposit to provide an overlying deposit supported by a plurality of pillars;
   c. removing said pillars;
   d. expanding the overlying shale deposit to a particular mass of uniform size, porosity and permeability, said particulate mass having a void volume approximately equal to the amount of shale deposit removed;
   e. providing at least one connecting conduit through the upper level of said expanded deposit;
   f. igniting the upper level of said shale deposit and maintaining a flow of a source of oxygen and deposited pressure to cause a flow of flue gas downwardly through said expanded mass of particles to release the oil contained therein for downward flow to the base of said deposit;
   g. collecting the shale oil at the base of said deposit for recovery.

16. A process as claimed in claim 15 in which from about 5 to about 15 percent of the volume of the shale deposit is removed.

17. A process as claimed in claim 15 in which the deposit is subsequently leached with a leachant selected from the group consisting of water, acids and bases to form an enriched solution which is withdrawn at the base for recovery of mineral content.

18. A process for the recovery of carbonaceous values from subterranean deposits which comprises the steps of:
   a. establishing communication with the base of the portion of a subterranean carbonaceous deposit to be retorted;
   b. undercutting at least at said base of said carbonaceous deposit to remove from about 5 to about 25 percent of the volume of said deposit, to provide an overlying deposit supported by a plurality of pillars;
   c. removing said pillars;
   d. explosively expanding at least a portion of said overlying carbonaceous deposit to a height predetermined by placement of explosive charges to provide a mass of packed carbonaceous solids filling the undercut volume and extending to the predetermined height so as to provide a mass of carbonaceous solids of desired permeability and having a void volume approximately equal to the volume of the deposit removed;
   e. providing at least one communicating conduit to the upper level of said expanded deposit;
   f. heating said expanded deposit to liquify and vaporize said carbonaceous values by introducing and maintaining a downward positive pressure of a high temperature gaseous media therethrough;
   g. collecting liquified carbonaceous values at said base of said deposit for recovery;
   h. accumulating the removed carbonaceous deposit in an earthen depression as an expanded particulate mass;
   i. covering said expanded deposit with a mantle;
   j. continuously introducing to the mantled deposit a high temperature gaseous media to liquify and vaporize the contained carbonaceous values;
   k. collecting the liquified carbonaceous values at the base of the depression for recovery.

19. A process for the recovery of carbonaceous values from subterranean deposits which comprises the steps of:
   a. establishing communication with the base of the portion of a subterranean carbonaceous deposit to be retorted;
   b. undercutting at least at said base of said carbonaceous deposit to remove from about 5 to about 25 percent of the volume of said deposit, to provide an overlying deposit supported by a plurality of pillars;
   c. removing said pillars;
   d. explosively expanding at least a portion of said overlying carbonaceous deposit to a height predetermined by placement of explosive charges to provide a mass of packed carbonaceous solids filling the undercut volume and extending to the predetermined height so as to provide a mass of carbonaceous solids of desired permeability and having a void volume approximately equal to the volume of the deposit removed;
   e. providing at least one communicating conduit to the upper level of said expanded deposit;
   f. heating said expanded deposit to liquify and vaporize said carbonaceous values by introducing and maintaining a downward positive pressure of a high temperature gaseous media therethrough;
   g. collecting liquified carbonaceous values at the base of said deposit for recovery.

20. A process as claimed in claim 19 in which from about 5 to 15 percent of the volume of said deposit is removed.

21. A process as claimed in claim 20 in which the pillars are explosively removed.

22. A process as claimed in claim 19 in which the overlying carbonaceous deposit is explosively expanded.

23. A process as claimed in claim 19 in which the carbonaceous deposit is selected from the group consisting of oil shale, oil tars, oil sands, tar sands, gilsonite, lignite, low rank coal, and bituminous coal.

24. A process as claimed in claim 19 in which the high temperature gaseous media is selected from the group consisting of hot gases and steam.

25. A process as claimed in claim 24 in which the hot gases are generated by steps of igniting the upper level of the ex-
panded deposit and maintaining a uniform zone of combustion across the expanded deposit said combustion zone propagating downward through said deposit by maintaining a positive pressure supply of at least a source of oxygen.

26. A process as claimed in claim 25 in which the source of oxygen is air.

27. A process as claimed in claim 19 in which the undercutting is below the base of the carbonaceous deposit to provide a thin intermediate overlayer and an intermediate layer is perforated to allow the drainage of free carbonaceous values from said expanded deposit by introduction of a high temperature gaseous media through a communicating conduit.

28. A process as claimed in claim 19 in which the deposit provides gaseous media through a communicating conduit.

29. A process as claimed in claim 19 in which the deposit provides gaseous, carbonaceous values which are collected by an upward flow to the conduit communicating with the upper level of the expanded deposit.
CERTIFICATE OF CORRECTION

Patent No. 3,661,423 Dated May 9, 1972

Inventor(s) Donald E. Garrett

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Cover page, Item [72] correct spelling of inventor's name from "Garret" to --Garrett--

Column 1, line 27, after "attendant" omit "by"

Signed and sealed this 2nd day of January 1973.

(Seal)

Attest:

EDWARD M. FLETCHER, JR. ROBERT GOTTSCHALK
Attesting Officer Commissioner of Patents
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