

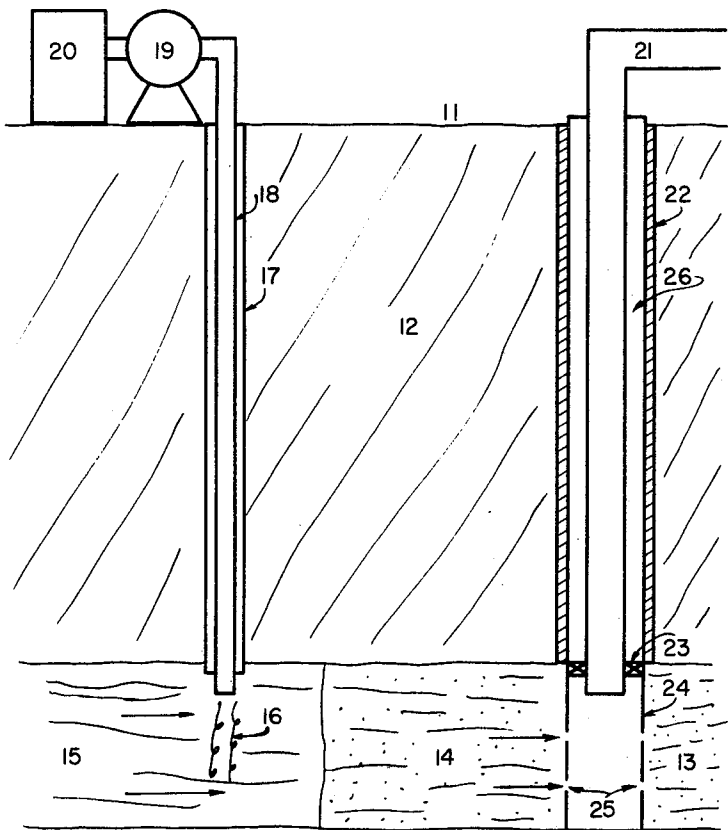
[54] **URANIUM SOLUTION MINING
PROCESS**
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Okla.
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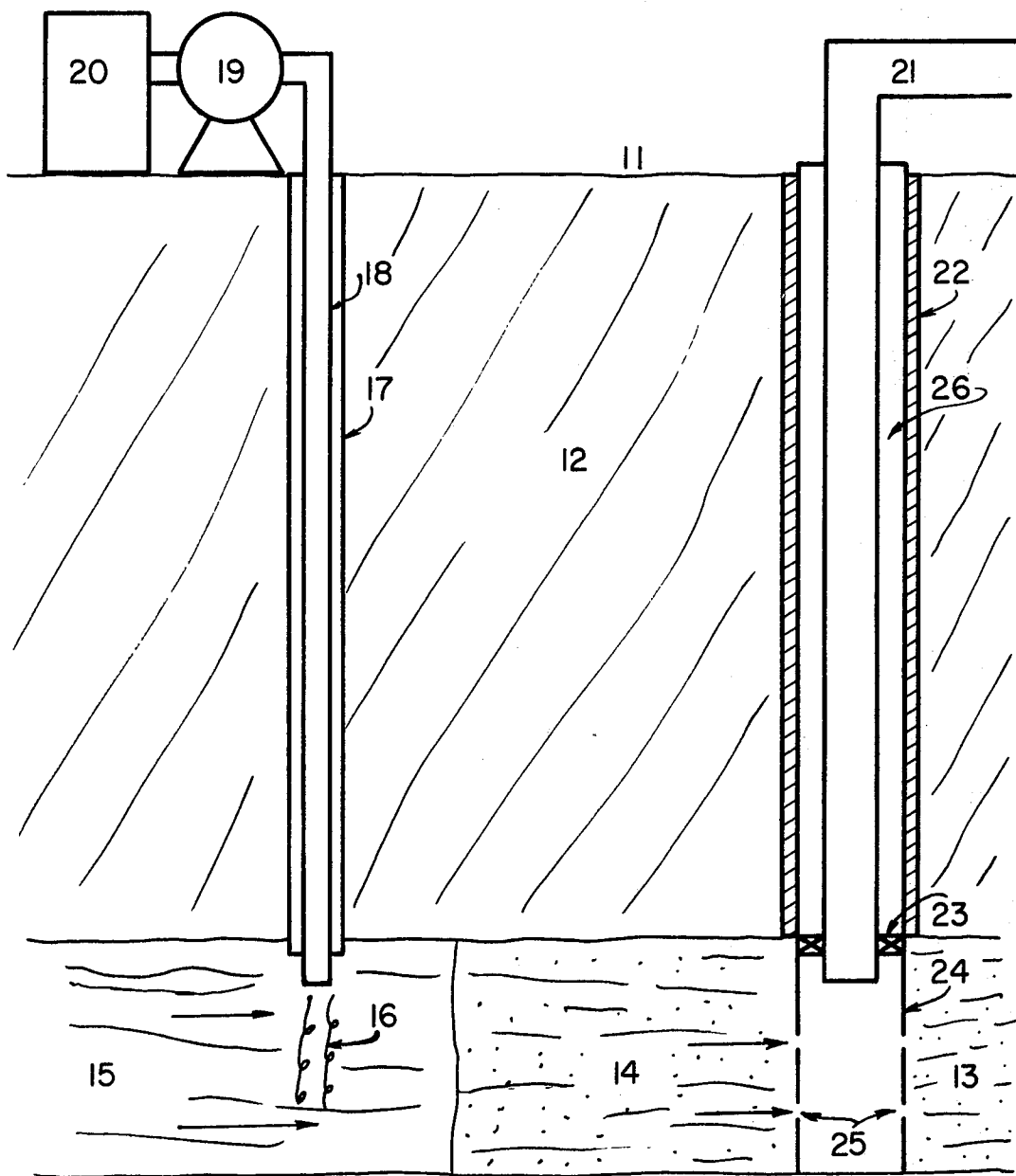
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[57] **ABSTRACT**
One or more production wells are drilled and completed into a uranium bearing formation having a high water saturation. The water saturation is removed from the area within the uranium formation by injecting a slug of an oxidant through the production wells. A series of injection wells is completed in the peripheral edge of the oxidant bank so that a leaching solution is injected into the water bank built up during oxidant injection. The solutions contact and react with the uranium mineral and oxidant to form soluble uranium salts which are produced from the production wells.

9 Claims, 1 Drawing Figure





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URANIUM SOLUTION MINING PROCESS

BACKGROUND OF THE INVENTION

The present invention is related to a process for the solution mining of uranium from subterranean formations. More particularly, the process of the present invention utilizes one or more injection and production wells and the natural water saturation of the uranium bearing formation for the reaction, solution and production of uranium salts therefrom.

Conventional solution mining processes for the dissolution of the uranium deposits normally utilize an acid or alkaline leaching solution which is added to the uranium deposit through an injection well. Simultaneously injected with the leaching solution is an oxidant, for example hydrogen peroxide, such that the acid or alkaline leaching solution utilized in conjunction with the oxidant transforms the uranium mineral deposit into a soluble salt. The uranium mineral is leached from the formation, dissolved in the leaching solution and subsequently produced from an offsetting production well. The production fluid is then processed for the extraction of the uranium therefrom, with the spent leaching solution and oxidant being either reconstituted for reinjection into the formation or discarded.

An inherent problem in the solution mining of uranium is the requirement of numerous completed wells for the development of small acreages of uranium deposit. Therefore, it is necessary to drill and complete injection and production wells within the formation on close spacings to achieve reasonable areal sweep efficiencies in the leaching operation. These spacing restrictions often require wells to be completed within 50 feet of each other for efficient solution mining of the uranium deposit.

What is required is a process for the solution mining of uranium deposits from subterranean formations, through utilization of inexpensive injection wells and by utilizing the natural energies of a formation so that a simple and economic solution mining process is derived.

It is an object of the present invention to provide a process for the solution mining of uranium in subterranean formations.

It is a further object of the present invention to provide a process for the solution mining of uranium through the use of uncompleted injection wells and utilizing the formation water saturation of uranium bearing formations as one of the constituents of the leaching solution.

It is still a further object of the present invention to provide a process for the solution mining of uranium deposits by using the natural driving tendencies of the water contained within uranium bearing formations as the drive energy for the solution mining process.

With these and other objects in mind, the present invention may be more fully understood from the following description and drawing:

SUMMARY OF THE INVENTION

The objects of the present invention are accomplished through the use of a process for the solution mining of subterranean uranium formations having a water saturation. The process comprises the drilling and completing of one or more production wells into the uranium formation. One or more injection wells are

drilled offsetting the production wells into the uranium formation. An oxidant is injected into the uranium formation through the production wells so that the water contained therein is driven away from the vicinity of the production wells. Subsequent to the oxidant injection, a concentrated leaching solution is injected into the injection wells while dissolved uranium salts, formed from the reaction of the leaching solution and oxidant contacting the uranium in the formation, are produced from the production wells.

Generally, the oxidant utilized in the process of the present invention is air. Although the production injection wells may take any configuration of drilled patterns of wells, it is preferred that the patterns be formed of production wells drilled in concentric patterns about injection wells with a single production well contained in the center of the pattern, or production and injection wells being drilled in offsetting line patterns so as to form a line drive for the uranium solution mining. It is also preferred that the leaching solution be an acid or alkaline solution and that it not be injected into the formation until the water bank formed by the injection of an oxidant passes the injection wells. The injection wells are generally drilled with sufficient diameter to receive a length of small diameter tubing requiring no elaborate completion other than the hanging of the tubing therein.

BRIEF DESCRIPTION OF THE DRAWING

The present invention may be more fully understood by referral to the accompanying FIGURE in which typical injection and production wells utilized in practicing the process of the present invention are depicted drilled into a uranium formation in which the process of the present invention is being utilized.

DETAILED DESCRIPTION OF THE INVENTION

The process of the present invention comprises a solution mining process in which an oxidant, for example air, is injected into one or more production wells in a uranium containing formation. It is preferred that the uranium containing formation have a considerable water saturation. Through the introduction of air into the formation, the water saturation is pushed or driven from the vicinity of the uranium solution mining production well and driven a predetermined distance from the well to form a water bank. Generally, the water bank formed is driven past the offsetting injection wells. Subsequent to this water drive the injection wells have introduced therein a leaching solution, for example an acid or alkaline solution, which is injected in concentrated form at the bottom of each injection well, while the production wells are put on a production cycle. This production causes the water bank, which was previously pushed past the injection well, to begin to traverse the injection wells and be driven by the natural energy drive of the reservoir towards the production wells. The solution acid or alkaline materials are introduced in the water bank to form the dilute treatment solutions required in the uranium solution mining process. These treating solutions contact the uranium mineral and the air or oxidant contained within the formation. These reactants cause reaction with the uranium mineral to form a soluble uranium salt which is leached from the formation and dissolved

in the treating solution. The treating solution is then subsequently produced from the formation through the production wells for ultimate recovery of the uranium salts.

It is a preferred embodiment of the present invention to utilize the process for the solution mining of the uranium from subterranean formations in a particular pattern design of injection and production wells. It is preferred that the injection and production wells either be drilled in concentric patterns about each other with a single production well contained within the center of the pattern, for example a five-spot, or that the injection and production wells be drilled in offsetting line patterns so as to form a line drive mechanism within the uranium formation. Generally, the distance between the injection and production wells will be from 20 to 100 feet, with particular depth, thickness, permeability, porosity, water saturation of the formation, and economic value of the uranium mineral contained therein being the engineering constraints upon which the design of the solution mining patterns are based. Therefore, through patterned well completion in the uranium formation, the process may be used sequentially across the uranium deposit through a series of line drive wells or concentric pattern wells so that the entire uranium deposit may be acid or alkaline leached.

The process of the present invention is unique in that, although the production wells are cased and completed in conventional solution mining design, the injection wells need not be completed and may comprise an unconventional or small diameter well drilled into the formation containing therein a one-eighth to two-inch injection tubing. This tubing may consist of plastic tubing such as polyvinyl chloride pipe extended to the bottom of the injection well. Through use of this tubing, the slow rates of injection of leaching solution required for comingling with the water bank contacting the bottom of the injection well may be derived to form the leaching solutions of the present invention. Therefore, the leaching solution injected into the water bank creates one of the reactants utilized with the oxidant or air bank as the reaction materials. The driving power of the solution mining operation is provided by the natural energy buildup within the formation formed by the initial injection of the oxidant. Generally, the formation must have a considerable water saturation. By considerable it is meant that the water saturation is greater than 30 percent of the total pore volume of the formation.

The present invention may be more fully understood by referral to the accompanying FIGURE in which a production well, comprising casing 26, which extends from the earth's surface 11 through overburden rock 12 and into the uranium containing formation 13, is cased and completed by cement 22 within the earth. A production tubing string 21 is hung in the casing 26 and is isolated from the uranium containing formation 13 by isolation means, for example hydraulic packer 23. The well further comprises a slotted liner 24 having slots 25 contained therein through which oxidant may be injected during the initial steps of the process and from which production fluid may be produced during subsequent solution mining of the formation. Offsetting the production well is an injection well comprising a well 17 drilled from the earth's sur-

face 11 through overburden rock 12 into the uranium containing formation 13. The well 17 has a relatively small diameter as compared to the conventionally drilled production well, and has tubing 18 hung therein. The tubing 18 is openholed to the bottom of the injection well and connected at the earth's surface 11 to a pump 19 which is fed with a concentrated leaching solution from storage tank 20.

Therefore, during the operation of the process of the present invention for uranium solution mining, an oxidant, for example air, is injected through production tubing string 21, through slotted liner 24 and slots 25 contained therein, into the uranium containing formation 13. The oxidant injection forms a bank of oxidant 14 and a bank of water 15 within the formation. The oxidant is generally introduced until the water bank 15, formed by its injection, is pushed past the bottom of the injection well. Thereafter, the production well is placed in a production cycle so that fluid is produced through production tubing 21 and the water bank 15 moves past the injection well. At this time a concentrated leaching solution is fed from storage tank 20, through pump 19 and tubing 18, and introduced at the bottom of the injection well. This leaching solution comingles in a mixing zone 16 with the water bank 15 and forms the leaching solution utilized in the present invention. Through continuous production, the water bank moves throughout the uranium containing formation 13, contacting the oxidant bank 14, thereby dissolving the soluble uranium salts formed. These salts are picked up and dissolved within the leaching solution and subsequently produced through production tubing 21 in the production well.

A similar arrangement as depicted in the FIGURE may be utilized with either the line drive or concentric patterns or other preferred patterns, depending upon the formation characteristics and economic constraints upon the process. Generally, the leaching solution, as mentioned, will comprise an acid, for example sulfuric acid, or an alkaline solution, for example sodium carbonate, depending upon the formation rock. As mentioned, the oxidant may be any conventional oxidant, for example hydrogen peroxide, although air is preferred, as large quantities are required and this is a cheap source of oxidant material.

Therefore, through the utilization of the process of the present invention, a process for the solution mining of uranium is derived in which the natural formation energy of the earth may be concentrated and then utilized for the comingling of a concentrated leaching solution with a water bank formed within the formation; thus leaching areal sweep efficiency for the solution and production of uranium deposits. The process provides an economic and easily utilized method for the production of uranium salts from uranium containing formations.

The present invention has been described herein with reference to particular embodiments thereof. It will be appreciated by those skilled in the art, however, that various changes and modifications can be made therein without departing from the scope of the invention as presented.

Therefore, I claim:

1. A process for the solution mining of subterranean uranium containing formations having a considerable water saturation, which comprises:

- a. drilling and completing one or more production wells into the uranium formation;
 - b. drilling one or more injection wells offset from the production wells;
 - c. injecting an oxidant into the uranium formation through the production wells so that the water contained therein is driven away from the vicinity of the production wells;
 - d. injecting a concentrated leaching solution into the injection wells; and
 - e. producing the dissolved uranium salts, formed from the reaction of the leaching solution and oxidant contacting the uranium contained within the formation, from the production wells.
2. The process of claim 1 in which the oxidant is air.
3. The process of claim 2 in which the production and injection wells are drilled in concentric patterns about each other with a single production well con-

- tained in the center of the pattern.
4. The process of claim 3 in which the leaching solution is an acid.
5. The process of claim 4 in which the air is injected until the water bank formed by its injection passes the injection wells.
6. The process of claim 2 in which the production and injection wells are drilled in offsetting line patterns.
7. The process of claim 6 in which the leaching solution is an acid.
8. The process of claim 7 in which the air is injected until the water bank formed by its injection passes the injection wells.
9. The process of claim 2 in which the injection wells are drilled with a sufficient diameter to receive a length of small diameter tubing.

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