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OIL SHALE MINING METHOD

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8 Claims

ABSTRACT OF THE DISCLOSURE

A method for mining underground oil shale formations by drilling a series of small diameter shot holes from the earth's surface substantially vertically downwardly to near or into the roof of a room previously dug out and mined from the formation, and lowering explosive charges to the same depth in each hole and simultaneously exploding these charges to bring down into the room an appropriate thickness of roof. Withdrawable automatic conveying equipment is arranged in the room for hauling rubbleized shale from the formation to the earth's surface. After the automatic conveyors have hauled away the rubbleized shale, additional explosive charges are lowered in each of the shot holes to an appropriately lesser depth and exploded simultaneously to bring down additional roof material. This sequence is repeated to extend the room vertically upward maintaining the same gauge to the desired height (usually to the top of the shale formation). The shot holes are arranged in a closed pattern or configuration which defines an area of roof span sufficiently large to cause the inner portions of the area to collapse because of roof instability when only moderate charges are used to knock down the periphery of the area. A preferred configuration is a circle. To dispose of retorted spent shale, one or more of the shot holes may be enlarged, or a new hole may be drilled at any desired location, from the surface of the earth to the top of the shale oil formation after the vertical room (or corridor) has been completed to the top of the oil shale section and spent shale may be dumped into the room through the hole until the room has been filled.

BACKGROUND OF THE INVENTION

The present invention concerns a method of mining underground formations of carbonaceous material such as oil shale, coal, and the like, and particularly thick oil shale sections. More particularly, this invention concerns a method for mining oil shale sections in which maximum shale rubble is created with a minimum amount of explosive.

This result is accomplished by utilizing the fact that if the roof span of a mined room is sufficiently large, but not too large, the roof approximates an unstable situation. Consequently, properly placed explosive charges of small size will bring down a desired thickness of roof.

SUMMARY OF THE INVENTION

A method for mining a thick oil shale formation which comprises the steps of forming a shaft extending generally horizontally in the bottom of the oil shale formation; by conventional mining, forming a room or corridor of appropriate horizontal dimension and moderate height on or extending from the horizontal shaft; drilling a series of small diameter holes in a particular pattern or configuration from the earth's surface in a generally vertical direction to the level of the roof of the room, said pattern or configuration of the holes defining an enclosed area within the periphery of said pattern or configuration; lowering to the same depth in each hole a charge of explosive, the size of said explosive charges being only large enough to sufficiently weaken the periphery of said defined area upon

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simultaneous detonation of said charges, so that the roof area within said periphery collapses into said room because of inherent roof span instability once the periphery has been weakened; simultaneously detonating said explosive charges to collapse the desired thickness of said oil shale formation defined by said pattern and to raise the roof of said room and form a vertical room in said oil shale formation of the configuration of said pattern; substantially rubbleizing the collapsed shale upon impact on the room floor; hauling away from said room through said shaft the accumulated fallen rubbleized oil shale; repeating the steps of lowering explosive charges in each of the drill holes to successively lesser heights above the roof of the room being formed, and exploding said charges simultaneously to again raise the roof of said room by collapse of the periphery of said pattern and collapse of the area within said periphery of said pattern; again hauling away the fallen rubbleized oil shale from said room through said shaft; and repeating the steps of placing explosives in the drill holes and simultaneously discharging them, and hauling away debris formed thereby from beneath the lengthened corridor until the top of the oil shale section has been reached.

Where the oil shale section is located in a mountain, the shaft may be initially dug into the mountain in a horizontal direction. However, in other cases, it will be necessary first to dig out a vertically extending shaft either directly perpendicular to a horizontal shaft that is later dug out, or a sloping shaft may be dug from the earth's surface at an angle to such horizontal shaft. Several shafts or tunnels may extend horizontally from one vertically extending shaft. Several shot hole patterns spaced suitable distances from each other are preferably located along each of the horizontally extending shafts. The pattern or configuration of the series of shot holes or drill holes is preferably along the periphery or circumference of a circle. The spacing and arrangement of the drill holes is such to create maximum roof instability with minimum power spent. The mining method may be completed by disposing of spent shale retorted at the surface after being broken down and hauled from the mine shafts. Once the room has been completed from the bottom to the top of the oil shale section, one or more of the drill holes is enlarged by drilling from the earth's surface into the room opening and the spent shale is then dumped into the enlarged drill holes and into the cavity until it has been filled. If desired, the amount of conventional mining required to form the initial room may be reduced by forming a room slightly smaller than the shot hole patterns and using an initial round or rounds of larger explosive charges to "bell out" the room.

Objects of the invention include (1) providing a mining method less costly than existing mining methods by utilizing minimum amounts of explosives and minimum total shot hole footage; (2) providing a mining method which permits the recovery of rock from naturally fractured or weak sections of the shale formation where poor, unstable rock conditions make "conventional-type mining" excessively hazardous; (3) providing a mining method that maximizes safety by the complete absence of personnel from the active mining area after completion of the initial tunnel network; (4) providing a mining method that reduces the amount of surface crushing of the rock required because of the high degree of shattering of the fallen rock that occurs; (5) providing a mining method that greatly reduces the cost of returning spent shale to mined-out cavities; and (6) providing a mining method that makes it possible to dispose of a much higher fraction of the spent shale back into the mine to improve conservation and aesthetic values because of the relationship of the height of the cavity to the diameter of the

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cavity formed. The greater percentage arises through (a) the configuration of the cavity permits a larger fraction thereof to be filled, and (b) the heavy weight of the high column of spent shale will substantially compact the low strength spent shale.

The above objects and other objects and advantages of the invention will be apparent from a more detailed description thereof when taken with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional side elevation of a subterranean oil shale field being mined in accordance with the method of the present invention; and

FIG. 2 is a top view of a section of the oil shale field of FIG. 1 illustrating directions of the shafts mined in the section and shot hole configurations or patterns arranged along the shafts.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1 and 2, a sloping shaft 10 has been mined from the earth's surface through a thick oil shale formation or section 12, the top of which is indicated at 13 and the bottom of which is indicated at 13A. A system of horizontal tunnels or shafts 14 extend outwardly from the lower end of surface shaft 10. Rooms of appropriate size and moderate height are formed by conventional mining along these shafts. A series of small diameter shot holes 15 are then drilled from the earth's surface to the bottom of oil shale section 12 to adjacent and just above or into the roof of one of the rooms as indicated at 16 in FIG. 1. The shot holes 15 are arranged in a distinctive pattern or configuration 17 which may be circular, square, rectangular, etc. The preferred configuration, as shown in FIG. 2, is circular. Small explosive charges are then lowered into each hole 15 to the same depth or level just above the roof of room 14 as indicated at 20 in FIG. 1 on suitable conductor cables 18 connected at the surface to a firing or shot control device indicated at 19. All of the charges are then fired simultaneously to bring down a desired thickness of roof indicated by the dashed line 21. As will be explained in more detail later herein, the size of the charges is only sufficient to bring down the periphery or boundary of the pattern which, when collapsed, causes the area within the boundary of the pattern to collapse because of the inherent instability of the roof span within the periphery. In this manner the roof of room 14 beneath the area defined by pattern 17 is raised and the formation of a vertical corridor or room 30 is begun which, with continued excavation, eventually extends to the top of oil section 12 as indicated by the dashed lines 30A. Previously installed automatic mechanical loading equipment, such as conveyors 25, 26, loads the rubbleized shale oil and moves it to the earth's surface where it is sent as indicated at 27 in FIG. 1 to a shale crusher. The automatic conveyors are withdrawn at the time the explosives are fired. After the rock fall has been cleared, another round of charges is lowered into holes 15 to above the existing roof of room 30 as indicated at 22. These charges are then exploded simultaneously to bring down another thickness of roof designated by the dashed line 23. The fallen rock is again cleared by the automatic loading equipment as described above. This sequence of operation is repeated until the top of oil shale section 12 is reached.

The amount of roof to be knocked down by each sequence of explosive charges may be in the 20 to 40-foot vertical range. The optimum height above the roof at which to place the charges will be determined by experience. A flat roof of oil shale starts to become unstable when the span exceeds about 60 feet, with increasing instability as the span increases. Flat spans approaching 100 feet are completely unstable with spontaneous fall to form a domed roof. The present invention utilizes this characteristic of oil shale formations. The area of

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the roof defined by pattern 17 is sufficiently large that only enough explosive to weaken the periphery of the domed roof, as for example at 22, 23, is needed to cause the inner portion of the domed roof to fall through instability. Consequently, because of the high degree of instability of the oil shale roof spans in accordance with the magnitudes discussed above, only a limited number of shot holes 15 and limited amounts of explosive are necessary. The width of room 14 should approximate the width of the pattern and be of adequate height to conduct the debris removal operations. The fall of the rock provides a substantial amount of breakage of the ore, particularly as the height of room 30 increases, which minimizes the amount of surface crushing of the oil shale required, particularly when the distance of fall reaches several hundred feet. In addition, since the explosive charges are placed in the holes from the earth's surface and since the fall of rock is loaded mechanically, no personnel are required in danger areas once the tunnels and rooms 14 have been completed, which contributes to a maximum of safety of operation.

As an example of the dimensions of an operation in accordance with the present invention, room 30 might be 100 feet in diameter formed in a 1500-foot thick section of oil shale which would yield approximately one million-tons of shale oil. Ten to fifteen shot holes of approximately 2000-foot depth would be sufficient. The total length and cost shot holes per ton of shale oil produced would thus be very low, and the cost of explosives would be far less than the explosive cost for conventional mining.

Any appropriate number of shafts 14 and rooms 30 can be mined at the same time, which permits continuous production of oil shale and the full utilization of equipment and manpower.

To dispose of spent retorted shale at the earth's surface and to provide additional stability for the subterranean honeycomb of shafts, holes and rooms, once one of the rooms 30 has been depleted, a relatively large diameter hole 31, as shown in FIG. 1, about 12 inches in diameter, is drilled from the earth's surface to the top of the mined out room 30. Then, spent shale is dumped into room 30 through hole 31 until room 30 has been filled. Instead of drilling a separate independent hole 31, one or more of the shot holes 15 could be enlarged.

It will be understood that various changes and modifications may be made in the preferred embodiments of the invention which have been described herein without departing from the spirit and scope thereof.

Having fully described the method, objects, and advantages of my invention, I claim:

1. A method for mining a thick oil shale formation having a shaft formed in the bottom thereof comprising the steps of:

drilling a series of small holes in a predetermined pattern from the earth's surface in a generally vertical direction to adjacent said shaft, said pattern defining an enclosed area within the periphery of said pattern;

lowering to substantially the same depth in each hole a charge of explosive;

detonating said explosives to rubbleize thereby a portion of said oil shale formation, said portion of said oil shale formation so rubbleized being dependent upon the size and depth of said explosive charges, the size of said explosive charges being only sufficient and the depth of said explosive charges being such as to bring down into said shaft only the periphery of said enclosed area, said area within said periphery being sufficiently large to collapse into said shaft because of inherent roof instability once said peripheral portion of said area has been broken down whereby the roof of said shaft is raised to form a vertical room in said oil shale formation which conforms to the configuration of said pattern;

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lowering explosive charges in each of the drill holes to substantially the same height above the roof of the room being formed;

detonating said explosive charges to raise the roof of said room by collapse of the peripheral portion of said pattern and collapse of the area within said peripheral portion of said pattern in the same manner that the roof of the room was initially formed;

repeating the steps of lowering explosive charges in each of the drill holes to substantially the same height above the roof of the room being formed and exploding said charges to raise thereby the roof of said room in the same manner the roof of said room was initially formed and later raised; and

hauling away from the bottom of said room through said shaft the accumulated fallen rubbleized oil shale following each detonation of said explosive charges.

2. A method as recited in claim 1 in which said pattern is a circle.

3. A method as recited in claim 2 including repeating the steps of lowering explosive charges in each of the drill holes to substantially the same height above the roof of the room being formed, exploding said charges and hauling away the fallen rubbleized oil shale until the top of the shale oil formation is reached.

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4. A method as recited in claim 3 including exploding said charges simultaneously.

5. A method as recited in claim 3 including mining said shaft to the earth's surface.

6. A method as recited in claim 5 in which said shaft includes a horizontally extending shaft and a vertically extending shaft.

7. A method as recited in claim 6 in which said rubbleized oil shale is automatically and mechanically conveyed to the earth's surface through said shaft.

8. A method as recited in claim 7 including drilling an enlarged hole from the earth's surface into said room; and depositing spent oil shale into said room through said enlarged hole.

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