SIMULTANEOUS PIPELINE TRANSPORTATION AND RECOVERY
OF OIL FROM OIL SHALE
Filed Feb. 16, 1968

REMOTE REFINING AREA

RECOVERED HEAT

REFINED HYDROCARBONS

WASTE ROCK

HEAT

PIPELINE

SOLVENT IN

SOLVENT IN

SLURRY

CRUSHED OIL SHALE

CRUSHING PLANT

MINED OIL SHALE FRAGMENTS

LOCATION OF OIL SHALE FORMATION

INVENTOR:
P A U L E. T I T U S

BY:

Louis J. Bovard

HIS ATTORNEY
SMULTANEOUS PIPELINE TRANSPORTATION AND RECOVERY OF OIL FROM OIL SHALE

Paul E. Titus, Houston, Tex., assignor to Shell Oil Company, New York, N.Y., a corporation of Delaware
Filed Feb. 16, 1968, Ser. No. 706,014
Int. Cl. C10g 1/00
U.S. Cl. 208—11

ABSTRACT OF THE DISCLOSURE

A method for the simultaneous transportation and recovery of shale oil from oil shale flowing as a slurry within a pipeline. Oil shale is taken from a subterranean formation, crushed and transported to a remote area as an oil shale/solvent slurry in a pipeline under heating conditions sufficient to extract shale oil from the oil shale while in transit. Rates of extraction are accelerated by the addition of $\text{H}_2\text{S}$ to the solvent.

BACKGROUND OF THE INVENTION

Field of the invention
This invention relates to the recovery of hydrocarbons from oil shale while transporting crushed oil shale in slurry form in a pipeline which is used as a high-temperature reactor to affect the separation of hydrocarbons from the oil shale while recovering oil therefrom.

Description of the prior art
Vast quantities of hydrocarbons are contained in oil shale formations which are found in several parts of the world and particularly in the Green River Formation of the Piceance Creek Basin of Colorado. In these formations, the oil shale is not a true shale nor does it contain oil in the common usage of that term. The oil shale is a fine-grained, compact sedimentary rock which is generally highly laminated in the horizontal by bedding planes. It is more in the nature of marl-stone. It contains an organic matter, kerogen, which is an amorphous organic solid. Kerogen, particularly, is defined as an organic high molecular weight mineraloid of indefinite composition. It is not soluble in conventional solvents but will decompose by pyrolysis upon being heated to temperature above 500° F. to provide fluid hydrocarbons commonly termed "shale oil." Generally, the decomposition is undertaken at temperatures about 900° F. However, excessive temperatures are usually avoided in the pyrolysis of kerogen to avoid heat consumption by the decomposition of the mineral carbonate constituents in the oil shale. Thus, oil shale must be heated in a process of pyrolysis, which process is usually termed "retorting" in order to obtain the desired recovery of hydrocarbons. For this purpose, it is necessary to either mine the oil shale and then retort it at the earth's surface, or to retort it in-place.

The relatively low natural permeability to fluids or subterranean oil shale deposits prevents ready application of in situ retorting processes. The desired permeability for in situ processes may be created artificially, such as by hydraulic fracturing. However, in such deposits, especially in oil shales, artificially produced fractures tend to close by swelling or the like during in situ combustion so that fluid permeability is lost and then combustion operation is restricted severely or even terminated. This increases the costs for recovering the desired hydrocarbons.

One in situ process for recovering oil from oil shale formations is to extensively thermally crack the oil shale formation so as to provide a more pumpable fluid. However, in this process, and in other mining and retorting practices, the oil recovered has been cracked at temperatures of 800° F. and higher. Such high-temperature retorting of oil shale is unfavorable since it creates undesirable byproducts and is difficult to control.

Further, in order to practice in situ combustion in a hydrocarbon-containing formation, such as an oil shale, it is of prime importance to have means for transporting oxygen to the combustion zone and means for the removal of liquids and gases. Finally, large quantities of dawsonite, naphcolite, halite, and minor amounts of other sodium minerals have been discovered in oil shale, especially in the rich oil shales of the aforementioned Eocene Green River Formation. These discoveries are of economic importance because dawsonite, a dihydroxy sodium aluminum carbonate, and naphcolite, a sodium bicarbonate, constitute potentially valuable sources of alumina and soda ash. As of this time, however, economically proven extraction processes for recovering these minerals have not been demonstrated. Further, such a process must be compatible with the recovery of the shale oil from the oil shale. If these commodities can be recovered along with the shale oil, development of mineral industry in the Piceance Creek, and of course other oil shale formations, may be expedited.

SUMMARY OF THE INVENTION

It is an object of this invention to provide an economic process for simultaneously transporting and recovering oil from oil shale.

It is a further object to recover oil from oil shale which is not thermally cracked and having relatively high hydrocarbon content.

It is another object to recover heat and waste rock as byproducts of an economic oil shale extraction process wherein the waste rock constitutes valuable mineral sources and is recovered in a process compatible with the recovery of oil from oil shale.

It is a still further object to provide a process for recovering oil from oil shale which may be used in conjunction with the conventional thermal processing, including in situ processing, of oil shale wherein the heat and shale oil recovered therefrom is used in the process of the invention.

The objects of this invention are carried out by extracting oil shale from a subterranean formation, crushing the oil shale and transporting the crushed oil shale to a remote area as an oil shale/solvent slurry while heating the slurry until shale oil is extracted therefrom.

BRIEF DESCRIPTION OF THE DRAWING

The drawing is a schematic illustration of a preferred arrangement in accordance with the process of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

According to the present invention, hydrocarbons are recovered from an oil shale formation by fragmenting oil shale and forming a slurry of the fragmented oil shale which is injected into a pipeline and maintained at a sufficiently high temperature to aid in extracting hydrocarbons from the in situ oil shale at the terminal end of the line. The oil shale can be obtained from a subterranean formation by any known means, such as mining, to produce appreciable quantities of large fragments of oil shale. The fragments of oil shale can be passed to a crusher to reduce the fragments to a size sufficient to be flowed, when mixed with a solvent, within a pipeline. For example, about 15 percent fines have been produced in crushing Green River shales, this size being sufficient for the operations to be discussed hereinbelow. However, power requirements increase as the size of the
oil shale particles decrease; accordingly, for purposes of this invention, a preferred particle size distribution should consist of a range of particle sizes from 1/4 inch to fine passing a 325 mesh sieve.

The crushed oil shale may be preheated if desired. However, preheating is merely a way to conserve the heat energy latent in a shale and to counteract the low rate of heat transfer. It does not increase the oil yield or improve its quality. This preheating involves increased operating costs thus limiting any advantages to be gained therewith.

Preferably, as illustrated in the drawing, the mined oil shale fragments are passed into the crushing plant where the fragments are crushed and the crushed oil shale is mixed with a solvent to form an oil shale/solvent slurry.

The oil formation may, for example, be located in the Green River Formation of the Piceance Creek Basin of Colorado. The solvent is preferably crude oil, retorted shale oil as will be discussed further hereinbelow, or some appropriate fraction of these. It has been found that oil shale bitumen solubility is favored by the presence of aromatics, both cyclics, such as benzene, and heterocyclics, such as pyridine. Therefore, while any fraction of crude oil containing some aromatics would act as a solvent, those fractions rich in aromatics, either cyclics or heterocyclics, are preferred as the most efficient for extraction. It is also preferable to add small quantities of H₂S, as in the order of about 2.2 mole percent, to the solvent. This has been found to accelerate the rates of extraction of the kerogen in the oil shale into the solvent as will be discussed further hereinbelow.

The slurry is then heated and passed into a pipeline where it is transported, to a remote refinery area, as for example, to the west coast or to the Gulf coast refineries. The slurry is periodically heated by means well known in the art to replace heat lost in transit and to maintain the desired temperature range. The pipeline is preferably insulated to minimize heat loss. The slurry may be removed from the pipeline to effect the heating, if desired.

It has been found that heating a slurry of crushed oil shale and solvent for a relatively long period of time, such as periods of up to eighteen to twenty days, and at a temperature of approximately 550° to 600° F., results in the extraction of oil shale having 80% wt. of Fischer assay with benzene and 90% wt. Fischer assay with benzene-H₂S mixtures. This relatively low temperature process breaks the kerogen within the oil shale down into bitumen, which is then dissolved in the appropriate solvent. Thus, at approximately 550° F. to 600° F., the insoluble kerogen in the oil shale decomposes to soluble bitumen very similar to conventional crude oils. The material recovered is more like typical refinery crudestocks (i.e., not thermally cracked) with relatively high hydrocarbon content (i.e., relatively low ash, nitrogen, oxygen).

Since the refinery area is generally far enough away from the location of the oil shale formation, as for example, from the oil shale formations in Colorado to west or Gulf coast refineries, efficient utilization is taken of the relatively long processing time required (approximately 18 to 20 days) to decompose the kerogen to bitumen and extract oil therefrom. Thus, the shale oil delivered to the refinery is recovered en route. At the refinery, the extracted shale oil is continuously processed and the waste material is removed following appropriate heat recovery. The heat put into the slurry may be partially recoverable at the refinery during the distillation process furthering the efficiency of the overall process.

The waste rock which is recovered may be delivered to a smelter location, as for example, a smeltery in Washington or Texas. This rock is then used as a raw material (i.e., dawsonite, aluminum, sodium carbonates) thereby economically recovering valuable minerals while extracting oil from oil shale. Alternatively, the waste rock may be harmlessly disposed of, such as by dumping it into the ocean, if desired.

The process of this invention may be used in conjunction with a known retorting process, such as in situ thermal recovery. The shale oil recovered therefrom may then be used as the solvent in the process of this invention, and the initial heat for the solvent/shale slurry may be obtained from the thermal process. In other words, one of the advantages of this invention is to remove the economic necessity of recovering shale oil by retorting at a mine location. However, since shale oil is a good solvent for bitumen, any shale oil available obtained by conventional means, including in situ recovery, may be advantageously used to effect additional recovery while in transit to a refinery. In this case, the shale oil would contain significant quantities of heat as the result of the thermal recovery. This heat may be utilized to heat initially the slurry.

While in the foregoing a preferred embodiment is presented, the present invention has been shown and described, it is to be understood that minor changes in details of the invention may be resorted to without departing from the spirit and scope of the invention as claimed.

I claim as my invention:

1. A method for the simultaneous transportation and recovery of shale oil flowing as a slurry within a pipeline, the method comprising the steps of:
   obtaining oil shale from a subterranean formation;
   crushing said oil shale;
   combining said crushed oil shale with a quantity of a liquid solvent selected from the group consisting of crude oil and shale oil fractions; said liquid solvent having added thereto about 2.2 mole percent of H₂S sufficient to make a pumpable oil shale/solvent slurry;
   transporting said slurry to a remote area within a pipeline for approximately eighteen to twenty days; and heating said slurry at a temperature of approximately 550° F. to 600° F., within said pipeline while transporting said slurry until the kerogen within the oil shale contained in the slurry is converted to shale oil.

References Cited

UNITED STATES PATENTS

1,016,958 2/1912 Roberts et al. 137—13
1,672,231 6/1928 Ryan 208—11
2,431,677 12/1947 Brown 208—11
2,601,237 6/1952 Buchman 208—11
3,129,164 4/1964 Cameron 208—11
3,459,502 8/1969 Van Nordstrand 23—143

PATRICK P. GARVIN, Primary Examiner
P. E. KONOPKA, Assistant Examiner

U.S. Cl. X.R.

23—63, 143; 137—13; 208—370; 302—66