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METHOD OF DETERMINING THE MOVEMENT OF HEAT IN A SUBTERRANEAN FORMATION USING BACTERIA ANALYSIS

Ralph E. Gilchrist, Houston, Tex., assignor to Tenneco Oil Company, Houston, Tex., a corporation of Delaware

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ABSTRACT OF THE DISCLOSURE

A method of determining the movement of heat in a subterranean hydrocarbon bearing formation, such as during a thermal recovery process. It includes the steps of instituting a lateral heat movement in the formation. This heat movement generally causes the percolation upward of hydrocarbon gases, such as methane. Thereafter, samples of soil from a plurality of spaced apart points on the overburden are collected and analyzed to determine the relative bacteria count of hydrocarbon gas feeding bacteria as indications of the extent of movement of the heat front.

This invention relates to a method of detecting the movement of heat in the subterranean hydrocarbon bearing formation, as for example during a thermal recovery process. It contemplates the use of bacteria analysis to detect the presence of a hydrocarbon gas in the overburden, which hydrocarbon gas is found to exist in greater quantities in the overburden where the heat has progressed.

The use of heat or a heat movement, such as the injection of steam, or an in-situ combustion, as a recovery agent in oil production provides the opportunity to produce heavy crudes, heretofore considered unrecoverable. In many instances, it is difficult to determine the areal invasion of the heat movement, particularly if it does not manifest itself in some of the producing wells of a pattern.

Heretofore, other methods have been developed for determining this areal invasion and such methods include the drilling of observation wells between the injection and production bore holes, and the use of various seismic techniques.

Still another method is taught in copending application Ser. No. 647,710 filed June 21, 1967 by the applicant. The method of that application utilizes thermocouples.

None of these processes are fully satisfactory in all situations. For example, the drilling of observation holes is quite expensive. With respect to the use of thermocouples, certain overburdens may provide insulation means which prevents uniform transmission of heat through the overburden. Further, seismic data is often very difficult to interpret.

It is therefore an object of this invention to provide an improved method for detecting the movement of heat in a subterranean hydrocarbon bearing formation, as for example during a thermal recovery process, and which is not subject to some of the limitations of the prior art methods.

Briefly stated, this invention is for a method of determining the extent of areal invasion of heat in a subterranean hydrocarbon bearing formation, as for example during a thermal recovery operation. The method comprises instituting or initiating a lateral heat movement in the hydrocarbon bearing formation. It is to be understood that the heat movement can be in the form of steam injection from one injection well to another production well, or it may be in a "huff and puff" cyclical

injection system. Further, it may be an in-situ combustion type wherein the heat front is initiated in the hydrocarbon bearing formation. In any event, once the heat movement is commenced, samples of soil from a plurality of spaced apart points on the overburden are collected. These samples are then tested to determine the relative amount of hydrocarbon gas feeding bacteria in the samples as indications of the extent of areal movement of the heat front. It is to be understood that as the heat front advances in a formation, hydrocarbon gases, such as methane, are found to percolate upward through the overburden thereby stimulating the growth of bacteria feeding on such hydrocarbon gases.

In certain embodiments of the invention, the aforesaid testing is carried out by adding a culture medium to the soil sample, after which the samples are contacted with an atmosphere containing a substantial amount of hydrocarbon gas, such as methane. Thereafter, the amount of hydrocarbon gas consumed by the bacteria in the sample is then measured to determine the relative quantity or bacteria count for the samples, as a measure of the extent of areal movement of the heat front. The testing can be repeated at intervals of one or more days, with those samples showing the earliest and greatest amount of loss of the hydrocarbon gas from the sample indicating the sample having the highest bacteria count.

The method of the present invention is particularly useful in fields such as the Chetopa field of Labette County, Kansas, where the hydrocarbon bearing formation, was at a relatively shallow depth on the order of 82–100 feet.

In carrying out the invention, stream is injected through an injection bore hole in conventional manner and caused to move laterally in the hydrocarbon bearing formation, which will sometimes hereinafter be referred to as instituting a lateral heat movement therein. It is to be understood that an in-situ combustion following conventional methods could also be used as a means for instituting a lateral heat movement.

As the heat movement progresses, it has been found that there is a tendency for hydrocarbon gases, such as methane, to percolate upwardly through the overburden to the surface thereabove. This added presence of the hydrocarbon gas stimulates the growth of hydrocarbon gas feeding type bacteria in the soil above the heated hydrocarbon formation.

Soil samples are taken from a few inches below the soil surface at spaced apart intervals extending away from the injection bore hole and in the general direction or directions of the anticipated heat movement. These soil samples are then analyzed for the relative presence of bacteria of the hydrocarbon gas feeding type according to known methods. For example, the article entitled Comparison of Geomicrobiological Prospecting Methods Used by Various Investigators by D. O. Hitzman and carried in the book entitled Developments in Industrial Microbiology, volume 2 published by Plenum Press Incorporated, 227 W. 17th St., New York 11, N.Y., and the articles referred to therein discuss various testing and analyzing procedures to test for the relative presence of hydrocarbon consuming bacteria in soil samples.

The method which the applicant used in testing for the presence of hydrocarbon gas feeding bacteria was to place the soil samples in stoppered serum bottles with 15 ml. of a culture medium per 7.5 grams of soil. Thereafter the serum bottles were connected to a manometer and the bottles flushed with a gas comprising approximately ⅓ methane and ⅔ air. It is to be understood that this ratio could be on the order of 50% methane and 50% air. The manometer was used to measure gas uptake by the bacteria present in the bottle.

The particular manometer used was the U-tube type

and the pressure change was read and multiplied by two to give the reading of the decrease in pressure caused by the consumption of the hydrocarbon gas in the atmosphere contacting the sample.

The bottles with the fastest and most gas uptake would of course reflect those containing the most hydrocarbon gas consuming bacteria. These readings can be taken at intervals of one or more days over a period of several days, such as a month.

In some instances it may be desirable to use a control sample with each test sample, where in the control sample is flushed with an atmosphere containing approximately ⅓ nitrogen and ⅔ air or some other non-hydrocarbon type gas. Thus, if the reduction in pressure on the manometer were caused by some other factor than the bacteria being tested for, it would become apparent.

It was found that those soil samples overlying the hydrocarbon formation through which the heat had advanced generally had a reading indicating a higher hydrocarbon gas feeding bacteria count, than those samples taken from areas overlying the formation through which the heat front had not advanced.

It will thus be apparent that this invention provides an improved means for determining the areal invasion of heat in a reservoir. The present invention is simple and inexpensive as compared with prior art methods requiring observation wells that are costly to drill and/or seismic records which are difficult to interpret.

During recovery processes utilizing steam drive or cyclical injection, a great amount of heat is required to raise the temperature of the portion of the reservoir containing the hydrocarbon material. In many instances, the reservoir is overheated because it is difficult to predict the size of the steam stimulation treatment. By the use of this invention, the movement of the heat can be detected to determine the areal invasion thereby eliminating possible overheating of the formation.

It is to be understood that the foregoing description is generally illustrative of the invention, which will admit of the many different embodiments.

What is claimed is:

1. In a method of detecting the movement of heat in a subterranean hydrocarbon bearing formation, the combination of steps comprising:
instituting a lateral heat movement in said hydrocarbon bearing formation;
collecting samples of soil from a plurality of spaced apart points on the overburden generally above said heat movement;
and analyzing said samples to determine the relative bacteria count of hydrocarbon gas feeding bacteria therein as indications of the extent of movement of said heat.

2. The method for determining the extent of areal invasion of heat in a subterranean hydrocarbon bearing formation during a thermal recovery operation, said method comprising the steps of:
initiating a lateral heat movement in said hydrocarbon bearing formation;
collecting samples of soil from a plurality of spaced apart points on the overburden above said formation;
and testing said samples to determine the relative amount of hydrocarbon gas feeding bacteria in said samples as indications of the extent of areal movement of said heat.

3. The invention as claimed in claim 2 wherein:
said bacteria is of the methane feeding type.

4. In a method detecting the movement of heat in a subterranean hydrocarbon bearing formation during a thermal recovery operation, the combination of steps comprising:
initiating a lateral heat movement in said formation;
collecting samples of soil from a plurality of spaced apart points on the overburden above said formation;
adding a culture medium to said samples;
subjecting said samples to an atmosphere containing a substantial amount of a hydrocarbon gas;
and measuring the amount of said hydrocarbon gas consumed by bacteria contained in each of said samples as indications of the extent of areal movement of said heat.

5. The invention as claimed in claim 4 wherein:
said hydrocarbon gas includes methane and said bacteria is of the methane consuming type.

6. The invention as claimed in claim 4 wherein:
said measuring step is performed by connecting a manometer to each of said samples, and the change in pressure caused by the consumption of hydrocarbon gas in each of said samples is read therefrom.

7. The invention as claimed in claim 4 wherein:
said measuring step for each of said samples is at least one day subsequent to said first measuring step.

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NILE C. BYERS, JR., Primary Examiner
I. A. CALVERT, Assistant Examiner

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