

## UNITED STATES PATENT OFFICE

2,617,296

## PROCESS FOR TREATING CORE SAMPLES

John D. Wisenbaker, Dallas, Tex., assignor to  
Core Laboratories, Inc., Dallas, Tex., a corpo-  
ration of Delaware

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This invention relates to oil and gas recovery from subterranean deposits, and more particularly to a method of processing core samples taken from subterranean rock structure to preserve and determine the physical characteristics and fluid contents of such samples as an aid in estimating the value of such rock strata to the oil or gas producer.

Oil and gas in subterranean deposits are held in the interstices of rock strata, commonly referred to as "oil sands" or "gas sands." These sands are in such position with respect to impervious layers of rock structure above and below that their content of oil and gas, or of gas alone, is trapped in the sands by the impervious layers. When a well is drilled to penetrate such sand strata the oil and gas flow through the sand into the well bore and through the bore to the surface. While the well bore is being sunk, core samples are cut from the sand strata through which the well passes. In recent years most of the wells bored have been "cored" in this manner. Such cores or core samples are analyzed for porosity (pore space per unit volume), permeability (fluid-passing ability), oil content, water content, and free gas content; and these determinations have become increasingly important not only in forecasting the producing characteristics of the sands through which the well passes, but also in evaluating the amount of recoverable oil in the reservoir (the sand strata) and in determining the conditions under which the oil or gas should be produced to obtain maximum recovery.

Such core samples, when received at the top of the well, are for the most part "flushed," i. e. during the course of drilling the well and of coring the samples, drilling mud fluids is forced through the core samples so that their fluid content when received at the top of the well is not the same as it was before the sample was flushed by the drilling mud fluid. Also in most instances the oil and water in the sand strata contain dissolved gas under high pressure. As the core sample is brought to the surface and the surrounding pressure is reduced to atmospheric pressure, gas comes out of solution in the oil remaining after the flushing and, as it does so, forces some of the water from the core sample, leaving free gas in its place.

But as disclosed in the United States patents to Lewis et al. 2,225,248, Horner 2,296,852, and Kelton 2,352,638, it is possible from analysis of the percentages of the fluid contents per core space to forecast what fluid the sand will produce and to determine the amount of water (connate)

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present in the strata. But the accuracy of such methods depends upon immediate and accurate determination of the water content and free gas content of the core sample at the time when it is received at the top of the well. Core samples received at the top of the well are covered with mud and have a tendency to absorb water from the mud, and after the mud is scraped from the cores they have a tendency to lose water to the atmosphere or to take on water from the atmosphere. Hence it has been necessary to analyze such core samples at the well site as promptly as possible after cores are received and so guard against errors resulting from variations such as change in water content that would take place with the passage of time. For this reason it has been customary to have at the well site a fully equipped portable laboratory operated by a crew of at least two skilled technicians. In order to assure the presence of such a crew and laboratory at the well site at the time a core sample is taken, it was usually necessary for the laboratory to move onto location well in advance of the core sample arriving at the surface, for it would be too expensive to suspend drilling operations awaiting the arrival of the laboratory. Late arrival of the laboratory, therefore, has resulted in instances of erroneous core analysis, the cores having changed water content during the interval.

But this procedure of arranging for the portable laboratories to be on location well in advance of the core-drilling operation also has the disadvantage of additional expense; holding the laboratory crew idle during waiting time, and limiting their services to one well at a time, even though the core output of the well is insufficient to keep the crew fully occupied.

It is an object of the present invention to overcome the disadvantages of this type of operation and to provide a method for processing core samples which will permit their transportation considerable distances while preserving their fluid contents intact without affecting their physical structures.

Another physical characteristic of the core sample that is important and which must be preserved, is its permeability, for it is the permeability of a sand that determines the rate at which oil and gas can flow through it. Since permeability is closely related to the manner in which the particles making up the sand are physically held together, any procedure that would change this relationship would also change the permeability. The same observation holds true

of the porosity of the core sample, for the porosity shows how much oil a given sand stratum can hold and so how much recoverable oil can be obtained from it.

It is therefore an object of the present invention to provide a method for processing core samples in such a way as to preserve their fluid contents without affecting their permeability or porosity values.

In analyzing core samples, it is desirable to clean them thoroughly to remove the mud that covers them. Frequently core samples are cut from sand strata in which the sand is relatively soft, i. e., can be distorted or pushed out of shape. Under such circumstances, properly cleaning the core sample is difficult because the physical characteristics of the core may be changed by the cleaning operation.

It is an object of the present invention to provide a method for processing core samples which permit soft core samples to be handled and cleaned with the same facility as hard ones, and without materially altering their physical characteristics.

Other objects will be in part obvious and in part pointed out hereinafter.

The invention accordingly consists in the steps and sequences of steps exemplified in the method hereinafter described, and the scope of the application of which will be indicated in the following claims.

When core samples are brought to the top of a well they are run into an open trough from which excess drilling mud water flows off. The samples are then promptly taken from the trough and, if desired, cleaned with a wire brush or cloth to remove the major portion of the mud, whereupon they are placed in containers suitably marked as to the depth at which each core sample is taken. In the past it has been necessary (if accurate results were to be obtained) to analyze these core samples promptly, preferably within one-half hour after removal from the coring barrel, before material change of water content could take place. It has now been discovered, particularly as to core samples taken from non-depleted fields, that if each such core sample is promptly removed from the trough, wrapped in paper, and placed in a container having a temperature so low that the outside mud coating and the surface of the core are quickly frozen, the liquid content of the sample no longer changes. Further, when the core sample is subsequently removed from the paper in its frozen condition it may be thoroughly freed from mud while still frozen without change of water content due either to absorbing water from its mud coating or to absorbing water from the atmosphere or losing water to the atmosphere. Frost that may collect on the core sample during the cleaning process is easily wiped off with a cloth and does not penetrate to the interior of the sample.

It has been found, for example, that by placing each sample, after it has been cleaned (with a wire brush for hard cores or with a knife for soft cores), in a paper bag which is then placed in a quantity of Dry Ice (frozen carbon dioxide) in such a way that the major surface area of each paper bag is in contact with the Dry Ice, the sample freezes with sufficient rapidity to prevent any change of the water content, and that such core sample may be preserved indefinitely by keeping the Dry Ice replenished.

To prepare each core for analysis, it is taken from the paper bag while frozen and may be

cleaned of any remaining frozen mud by a rotating wire brush or other suitable means. It may then be broken into three parts, one for permeability determination, one for oil and water content determination, and one for free gas content determination. The part used to determine permeability may be placed in a solvent such as carbon tetrachloride, thawed and extracted, and thereafter tested for permeability in the usual manner. The part used to determine liquid content is preferably wiped clean of frost which may collect during the cleaning operation, is weighed and immediately put into a retort that distills off and measures the oil and water content of the pores as disclosed in Horner Patent 2,361,844. The part used for the determination of free gas content is likewise wiped free of frost and weighed. It may then either be placed in a sealed container and permitted to thaw out, or may be placed directly in a chamber containing mercury such as is described in the Horner Patent 2,327,642, and its bulk volume determined by mercury displacement and its free gas content determined by the amount of mercury that can be forced into the pores under high pressure as described in the last mentioned Horner patent. Then as described in Horner Patent 2,345,535, the density of the core sample is obtained from the volume-weight measurements, and the porosity is determined by adding the percent of free gas, water and oil determinations corrected to a unit volume of the core sample.

It has been discovered that frozen core samples do not lose moisture or hydrocarbon to the atmosphere, nor take on moisture from the atmosphere, because such moisture as reaches the sample condenses and freezes on its outside in the form of frost which is readily detected and wiped off. Thus the present method eliminates errors, due to such water gain or loss, which in the past have commonly occurred unless elaborate precautions were taken.

It has also been discovered that in the case of core samples having a gas saturation of ten per cent of the pore space or greater, the physical structure of the samples is not disturbed or disrupted by the freezing, as well as that the permeability and porosity characteristics of such samples remain unchanged by the freezing. Therefore the present method has the advantage of permitting core samples to be correctly analyzed at any time after they are taken. This method has the further advantage that it permits a single portable laboratory to move into an area where several wells are drilling and coring, collect core samples by messenger from a number of different wells within reach, and analyze them at the laboratory, working on a 24-hour basis. Thus one laboratory may be used to service more than one well at a time and the drilling operations need never be stopped to await its arrival, for the drilling operators can remove the cores from the open trough, clean them, and put them in freezing containers previously supplied to the operators by the personnel from a laboratory some distance away, to await collection by the laboratory messenger. Thus the over-all cost of core analyses to the operators is reduced and the over-all efficiency of the laboratories is increased.

Another advantage of the present method is that, where a well is being drilled in a location inaccessible to a portable laboratory, the core samples may be placed in a freezing containers by the operators and transported to any desired

point for analysis. This has made core analysis studies available to wells which heretofore had to be completed without the aid of such studies.

As many embodiments of the above invention are possible without departing from its scope, it is to be understood that all matter herein set forth is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. A stabilized core sample comprising a porous permeable oil-sand structure substantially the same as the structure of said core sample as removed from the ground and containing in the pores thereof water and oil in substantially the same quantities as when removed from the ground, the water content of said structure at least in the portion of said sample adjacent to the outer surface thereof being in the form of ice, and the oil content of said structure at least in the portion of said sample adjacent to the outer surface thereof being at a temperature substantially below 0° C., whereby said oil is substantially non-volatile and its viscosity is so high as to render said oil substantially immobile in the pores of said structure.

2. A stabilized core sample comprising a porous permeable oil-sand structure substantially the same as the structure of said core sample as removed from the ground and containing in the pores thereof water and oil in substantially the same quantities as when removed from the ground, all of the water content of said structure being in the form of ice and all of the oil content of said structure being at a temperature substantially below 0° C., whereby said oil is substantially non-volatile and its viscosity is so high as to render said oil substantially immobile in the pores of said structure, and a substantially impervious coating of frozen drilling mud encasing said structure.

3. A stabilized core sample comprising a porous permeable oil-sand structure substantially the same as the structure of said core sample as removed from the ground and containing in the pores thereof water and oil in substantially the same quantities as when removed from the ground, all of the water content of said structure being in the form of ice and all of the oil content of said structure being at a temperature substantially below 0° C., whereby said oil is substantially non-volatile and its viscosity is so high as to render said oil substantially immobile in the pores of said structure, and a substantially impervious coating of ice encasing said structure.

4. In the preparation for analysis for fluid con-

tent and original porosity and permeability of oil-well core samples of consolidated oil sands, the step of immediately upon emergence of a core sample from the well rapidly lowering the temperature of the core sample to freeze the water content of the interstices between the sand grains of the sample, to render the oil in said interstices practically non-volatile, and to cause atmospheric moisture to deposit on the surface of the core to form a coating of ice substantially impervious to the passage of further atmospheric moisture to the interior of said core, and maintaining the sample in frozen condition until ready for analysis.

5. In the preparation for analysis for fluid content and original permeability and porosity of oil-well core samples of consolidated sand containing at least 10% free pore space, the steps of cleaning excess drilling mud from the samples immediately upon their emergence from the well, immediately thereafter rapidly lowering the temperature of the sample to freeze the water content contained in the interstices between the sand grains of the sample, to render oil in said interstices practically non-volatile, and to cause moisture from the surrounding atmosphere to condense and freeze on the surface of said sample to form a coating substantially impervious to the passage of further atmospheric moisture there-through, maintaining the sample in frozen condition until ready for analysis, and cutting and cleaning the sample for analysis while thus frozen.

6. The method of handling and/or preserving oil well core samples for study that comprises subjecting a core sample to deep freezing promptly after extraction from the well, and maintaining the sample in said frozen condition until study of the sample can be undertaken.

7. An oil well core sample containing substantially all the solids and fluids, forming part of the sample when it was extracted from the well, in deep frozen form.

JOHN D. WISENBAKER.

#### REFERENCES CITED

The following references are of record in the file of this patent:

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