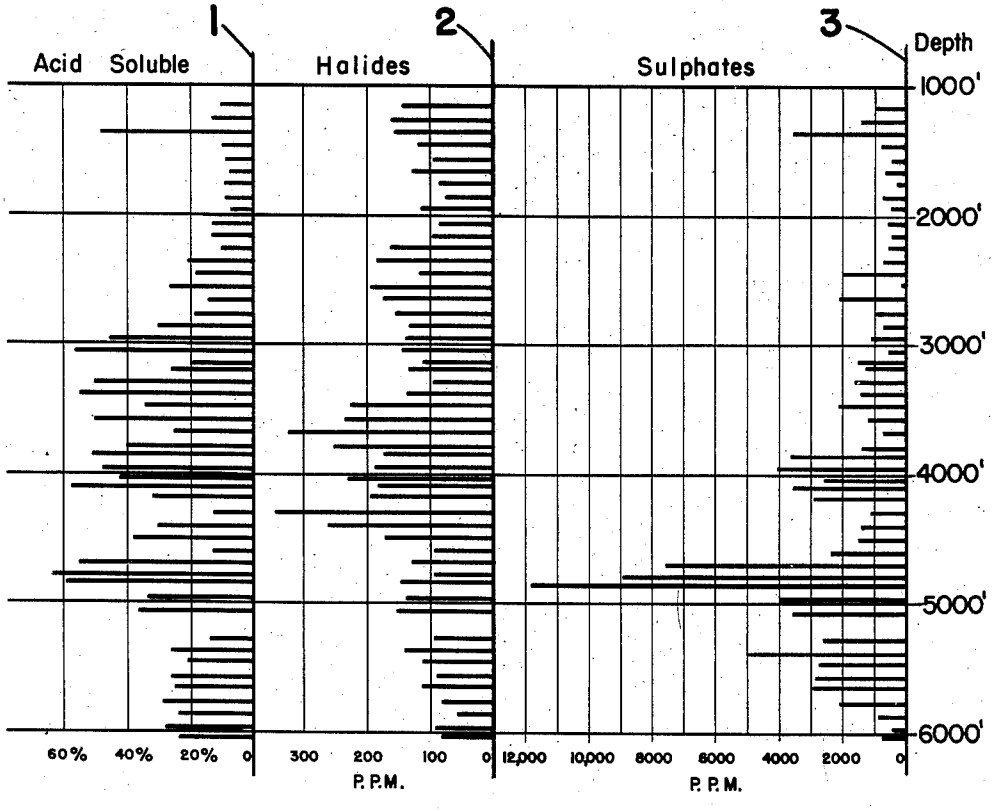
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GEOCHEMICAL WELL-LOGGING

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GEOCHEMICAL WELL-LOGGING

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The present invention is directed to geochemical well-logging. This application is a continuation in part of my co-pending application Serial No. 304,141, filed November 13, 1939.

In my co-pending application referred to, I have disclosed a technique of prospecting for subterranean deposits of a petroleum character by analyzing selected soil samples for inorganic constituents. I have now found that the concentrations of inorganic constituents in soil samples have particular significance in the logging of boreholes.

It has already been proposed to produce geochemical well-logs of a hole drilled for the production of petroleum products by analyzing samples taken at successively greater depths in the borehole for the presence of constituents significant of the existence of subterranean petroleum deposits, particularly for hydrocarbons related to such deposits. It has been found that the concentration of inorganic compounds in soil samples at successively greater depths varies in a significant manner when there is a deeper deposit of petroleum. Logs prepared from concentrations of selected ions or salts in samples taken along a borehole, when the latter is directed toward a petroleum deposit, follow a pattern from which it is possible to make deductions as to the probability that a petroleum deposit is being approached and will also indicate, to a certain extent, the position of the well with respect to the surface area of the petroleum deposit.

In the practice of the present invention, samples are collected at selected depths in a borehole, usually at equally spaced depths, and are subjected to examination in the manner described in my aforesaid co-pending application for the determination of any selected inorganic constituent or ion. The samples used may be those secured by coring either with the conventional vertically arranged core barrel or with a side wall coring device. Time can be saved and uniformity of results better assured by using cuttings from the drill bit which are recovered from the drilling fluid during the circulation of the latter. Knowing the rate of circulation of the drilling fluid and the rate of penetration of the drill bit, these cuttings can be correlated with the depth of the borehole with a fair degree of accuracy. By the use of cuttings, moreover, it is possible to obtain a more or less continuous sample of the structure penetrated by the borehole. That is to say, samples taken during a predetermined distance of penetration can be formed into a composite sample. For example, the cuttings obtained for fifty feet of drilling can be combined into a single sample and analyzed in the manner prescribed. Furthermore, these sections of penetrations can be overlapped, and greater uniformity thus secured. By this is meant that each composite sample may be composed of cuttings of twenty-five feet of drilling, the cuttings from which were used in a previous sample, and twenty-five feet of new drilling.

When the inorganic constituent selected for observation is one which is not likely to be contained in the drilling fluid, direct analysis of the cuttings or cores for this constituent yields satisfactory information. It is preferable, however, to subject the sample to a treatment which will insure that the inorganic constituent thereof determined actually existed in the sample in place in the earth. In this preferred embodiment of the present invention, therefore, the samples selected are first subjected to a thorough washing with water for the removal therefrom of all water-soluble salts which might be present in the drilling fluid. This washing step will also remove any finely divided insoluble inorganic particles which have been deposited on the sample by the drilling fluid. When the sample is a relatively hard piece of earth, it is best to first rinse it thoroughly with water to remove any loosely deposited particles and then crush it in water to dissolve out any soluble inorganic materials contained therein.

After the washing step the sample is dried, pulverized and weighed. The weighed, dry sample is then treated with an acid which is capable of decomposing carbonates but which does not contain the ion which is being sought for. After the acid treatment, or concurrently therewith, if desired, an aqueous extract of the sought constituent is made and the extract is analyzed for this constituent, the content of which is then related to the weight of the sample.

It will be understood, as pointed out in the parent case, that any desired inorganic constituent or ion may be selected as the indicator. For example, the samples can be examined for chloride content, sulphate content, carbonate content, nitrate content, bi-carbonate content, hydrogen-ion concentration or the concentration of other cations. A special advantage of the method of the present invention is that it is applicable to old samples, that is, samples taken from wells long since abandoned, so as to make possible a reexamination of the potentialities of such wells. It is often found that previously abandoned wells would have been producers had they been drilled deeper and it is one of the prin-

cipal objects of the present invention to make possible the reclamation of such abandoned wells.

The nature of the information which may be obtained by the practice of the present invention will appear from the accompanying drawing in which the single figure is a chart containing logs of the same well obtained by examination of borehole samples for different inorganic constituents.

Referring to the drawing in detail, lines 1, 2, and 3 are zero lines to the left of which the concentrations of the inorganic constituent named at the top of each line is plotted. Under acid soluble, the concentration is given as percent of total weight of sample, while under chlorides and sulphates the concentration is given as parts per million by weight. The spacing of the horizontal lines of the log indicates different depths.

In determining the acid soluble content of samples each sample was treated with a fifty percent nitric acid solution in water by volume. The extract so recovered was evaporated to dryness and weighed. In examining the samples for halides the samples were first thoroughly lixiviated with water and the extracts so obtained were discarded. The samples were then dried and weighed and then treated with sufficient acid to decompose carbonates followed or accompanied by the addition of water to form an aqueous extract. The acid employed for this treatment was nitric acid. The extract so obtained was then neutralized. This neutralization resulted in the precipitation of some hydroxides, such as aluminum and iron, the extract being filtered off from these precipitates. The neutral extract was then slightly acidified with nitric acid and titrated with silver nitrate using potassium chromate as an indicator.

In carrying out these analyses only aliquot portions of the neutral extracts were used so that other portions thereof could be examined for other inorganic ions. For example, in the case of these particular samples other aliquot parts of the neutral extracts were examined for sulphates by titration with barium chloride using tetra-hydroquinone as an indicator. If desired, the determinations of various ions can be made on the acid soluble extract used for the preparation of the acid soluble log.

In all cases in the procedure above described, the cuttings obtained at the well were well rinsed before being forwarded to the laboratory.

It has already been postulated that the variation in concentration of these inorganic constituents may be accounted for by the fact that gases emanating from the petroleum deposit exert an upward pressure on flowing streams of water and bring about the deposition of inorganic salts at some distance above the petroleum deposit, the distance to be determined to some extent by the lateral position of the point inspected with respect to the surface area of the petroleum deposit, the higher concentrations being closer to the deposit near the edges thereof. On the basis of this theory can also be explained the different levels at which the highest concentrations of different ions are found in boreholes.

A reference to the drawing shows that the highest concentrations of acid soluble constituents occurred at about 4750 feet. The highest concentration of halides, on the other hand, occurred at about 4600 feet. The highest concentration of sulphates occurred at about 4800 feet.

The higher solubility of the halides would lead one to expect that they would be deposited at a higher level above the petroleum deposit than the less soluble inorganic compounds, such as barium sulphate, calcium sulphate, calcium carbonate, magnesium carbonate and the like. It is for this reason that the acid soluble constitutents show their peak concentration at the levels where the concentrations of the water-insoluble constituents is greatest. Of course, this is not necessarily so in every well, but in the particular well from which the logs shown in the drawing were prepared this happened to be the case.

In all three of the logs it is found that the concentration of these inorganic constituents decreases after reaching a maximum at a level quite considerably above that at which production was to be expected. The occurrence of a peak in these logs at such substantial depths is a uniform indication of the presence of a gas or oil bearing formation below the depth at which the peak occurs. The particular well represented by the logs in the drawing produced at about 6040 feet. This well was near the edge of production which accounts for the fact that a substantial concentration of inorganic constituents persisted to the producing level. Were the well closer to the center of the deposit the concentration of inorganic constituents would pass its maximum at a greater distance above the producing level.

The present invention can be practiced by examining borehole samples for a single inorganic ion or salt. This type of logging is particularly useful for correlation purposes where the end to be achieved is the location of a known substratum over a given producing area. The log on the single constituent is also indicative in the manner illustrated of the presence or absence of an oil producing formation. For more complete information, however, it is preferable to analyze the samples for a plurality of different ions or salts, particularly the water soluble ions on the one hand, and the water insoluble constituents on the other hand. The greater the number of inorganic constituents which are determined the more complete the picture will become.

It will be apparent that no attempt has been made to describe all types of sampling which may be practiced, or all types of inorganic analyses which may be applied to the samples. It will be understood that the present invention is not limited to the particular methods of sampling or analysis described, but contemplates broadly any procedure according to which borehole samples of any description are collected and analyzed for inorganic constituents, the concentrations of which are correlated with depth.

In addition to the species claimed in the present application, there are claimed in Ser. No. 451,631, filed July 20, 1942, the determination of the hydrogen ion concentration of the soil samples, in Ser. No. 451,632, filed July 20, 1942, the determination of the total water soluble content of the soil samples, and in Ser. No. 451,633, filed July 20, 1942, the determination of the total acid soluble content of the soil samples.

The nature and objects of the present invention having been thus described and illustrated, what is claimed as new and useful and is desired to be secured by Letters Patent is:

1. A method of logging a borehole which comprises collecting samples of soil at spaced intervals along the borehole, analyzing each sample for its content per unit weight of at least one substance selected from the group consisting of

ionizable inorganic salts and the component ions thereof, the substance selected being the same for all samples, and correlating the concentrations of said substance so determined in the respective samples with the depths from which the samples were taken, the samples collected being sufficient in number to yield data showing the variation in concentration of the selected substance with depth whereby such correlation may be interpreted to predict the possible approach of the borehole to a petroleum deposit.

2. A method of logging a borehole which comprises collecting samples of soil at spaced points along the borehole, analyzing each sample for its content per unit weight of at least one selected inorganic acid radical, the radical selected being the same for all samples, and correlating the concentrations of said radical so determined in the respective samples with the depths from which the samples were taken, the samples collected being sufficient in number to yield data showing the variation in concentration of the selected radical with depth whereby such correlation may be interpreted to predict the possible approach of the borehole to a petroleum deposit.

3. A method of logging a borehole which comprises collecting samples of soil at spaced points along the borehole for the purpose of analyzing said samples individually for their content per unit weight of at least one substance selected from the group consisting of ionizable inorganic salts and the component ions thereof, washing and drying each sample, treating each sample with an acid free from said selected substance to thereby decompose water insoluble carbonates contained in the samples to liberate any of such selected substance which may be entrapped in such carbonate, analyzing each acid treated sample for its content per unit weight of said selected substance and correlating the concentrations of said substance so determined in the respective samples with the depth from which the samples were taken, the samples collected being sufficient in number to yield data showing the variation in concentration of the selected substance with depth, whereby such correlation may be interpreted to predict the possible approach of the borehole to a petroleum deposit.

4. A method of logging a borehole which comprises collecting samples of soil at spaced intervals along the borehole, washing each sample with water, treating each sample with an acid capable of decomposing water insoluble carbonates whereby an extract is obtained, neutralizing said extract whereby certain substances thereof are precipitated, removing the precipitate from the neutralized extract, analyzing the residual extract for its content of an inorganic acid radical other than that contained in the aforesaid acid, the acid treatment and the analysis being so conducted as to give the content of the inorganic acid radical per unit weight of sample, and correlating the concentrations of said acid radical so determined in the respective samples with the depths from which the samples were taken, the samples collected being sufficient in number to yield data showing the variation in concentration of the selected inorganic acid radical with the depth, whereby such correlation may be interpreted to predict the possible approach of the borehole to a petroleum deposit.

5. A method for logging a borehole which comprises collecting samples of soil at spaced points along the borehole, analyzing each sample for its content per unit weight of a plurality of different selected inorganic acid radicals and correlating the concentrations of the individual radicals so determined in the respective samples with the depths from which the samples were taken, the samples collected being sufficient in number to yield data showing the variation in concentration of the selected radicals with depth, whereby such correlation may be interpreted to predict the possible approach of the borehole to a petroleum deposit.

6. A method of preparing a well log which comprises collecting samples of soil at spaced points along the well, analyzing each sample for its content per unit weight of at least one inorganic acid radical, the samples being sufficient in number to yield data showing the variations in concentration of the selected inorganic acid radical with depth, and plotting the contents of the selected inorganic acid radical so determined in the respective samples on a chart against the depths from which the respective samples were taken whereby such chart may be interpreted to predict the possible approach of the well to a petroleum deposit.

7. A method according to claim 1 in which the samples of soil are cuttings obtained during the drilling operation.

8. A method according to claim 3 in which the samples of soil are cuttings obtained during the drilling operation.

9. A method according to claim 5 in which the samples of soil are cuttings obtained during the drilling operation.

10. A method according to claim 2 in which the selected substance is a halogen.

11. A method according to claim 2 in which the selected substance is the carbonate radical.

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