METHOD FOR LOGGING WELLS

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The present invention is directed to a method for logging wells. More particularly, the invention is concerned with locating the presence of hydrocarbons in subsurface earth formations. In its more specific aspects, the invention is directed to determining the presence of hydrocarbons in subsurface earth formations penetrated by a well bore wherein the subsurface earth formations have been invaded by water or by aqueous filtrate from drilling fluid.

The present invention may be briefly described as a method for determining the presence of hydrocarbons in subsurface formations in which a well is drilled to pierce the subsurface earth formations while circulating drilling fluid through the well. At selected, spaced-apart intervals, a small but sufficient amount of a solution of a surface-active agent consisting of a water soluble cationic salt which causes preferential wetting of the earth formations by hydrocarbons in the pierced earth formations is injected incrementally into the circulating drilling fluid. Thereafter, an electrical log of the pierced earth formations is obtained whereby the presence of any hydrocarbons in the pierced earth formations is indicated.

The electrical log may be obtained by using an electrical resistivity device which may be any of the several well-known electrical resistivity devices available on the market, such as the device described by Doll at the Annual Meeting of the A.I.M.E. February 13-15, 1950, New York, N.Y., or suitably may be a device such as described by Doll at the Fall Meeting of the Petroleum Branch of the A.I.M.E. at Houston, Texas, October 3-1, 1952. While these devices are quite satisfactory, other devices readily available on the market may be used.

The electrical log may be obtained by employing an electrical potential well-logging device such as described in the work entitled "Subsurface Geologic Methods" compiled and edited by L. W. LeRoy and Harry M. Crain, Department of Publications, Colorado School of Mines, Golden, Colorado, 1949, and in U.S. Patent 1,913,293 issued June 6, 1933, to Conrad Schlumberger.

The surface-active agents employed in the practice of the present invention may be selected from a large group of surface-active agents which cause preferential wetting of the earth solids, such as sand, clay, shale, lime, quartz, dolomite, and the like, with hydrocarbons which may be present therein. The earth or rock solids prior to the contacting operation are preferentially wet by the water in the rock solids. After the contacting operation the earth or rock solids are preferentially wet by the hydrocarbons.

Among the surface-active agents which are valuable and operable in the present invention may be mentioned the water soluble amine salts, the ammonium salts, and many others of a similar type. Specifically, the water soluble cationic salts are valuable and useful in the present invention. Exemplary of the compounds which have been found suitable in preferentially wetting rock solids by the hydrocarbons contained therein may be mentioned octadecyl amine acetate, cetyl dimethyl amine acetate, Tetrasol, a cationic surface-active agent sold by Onyx Oil & Chemical Co., Jersey City, N.J., the acetate of Primene JF-T, which is a mixture of primary amines containing branched chains of 15 to 20 carbon atoms, sold by Rohm & Haas, and the amine acetate prepared from Primene 81-R, which is a mixture of primary amines containing branched chains of 12 to 15 carbon atoms, sold by Rohm & Haas, alkyl tolylmethyl trimethyl ammonium chloride, alkyl dimethyl benzyl ammonium chloride, lauryl benzyl dimethyl ammonium chloride, bis quaternary salts such as reaction products of 2-ctyl benzyl chloride with bis dimethyl amino butyne and nonyl benzyl chloride with bis dimethyl amino butene, di-isobutyl cresoxoethyl dimethyl benzyl ammonium chloride and di-isobutyl phenoxoethoxy ethyl dimethyl benzyl ammonium chloride, and the like. Other surface-active cationic surface-active agents may be employed. The amounts of the surface-active agents which cause preferential wetting of the earth formations by any hydrocarbons present therein may range from an amount sufficient to contact the rock solids with from about 0.1 to about 10 volumes of solution containing the solution containing the surface-active agent to about 0.1% by weight of the surface-active agent in the solution in about half the effect of two volumes of flushing solution containing about 1% by weight of the surface-active agent. Solution volume is the volume of aqueous medium contained within the zone of investigation by the particular logging device being used in logging the well. In general, it may be stated that a preferred amount of a surface-active agent in the solution may range from about 0.5% to about 5.0% by weight of surface-active agent in solution contacting the formation. While this is a preferred amount, an upper limit for the surface-active agent is about 10% by weight of the solution and a lower limit is about 0.1% by weight.

The water soluble cationic surface-active agent is suitably dissolved in an aqueous solution such as fresh or salt water although other solutions may be employed. Alcoholic solutions may be used and it is desirable to adjust the pH of the solution depending on the type of surface-active agent which is employed.

In practicing the present invention, a tank which may have a capacity of about 500 barrels of the surface-active agent is made up in a solution in water. For example, 2% to 4% by weight of Corexit-40, which is a water soluble cationic surface-active agent, in the water available on the drilling rig, is a satisfactory solution to be employed. Corexit-40 has a composition as follows:

Material: Percent by weight
VR-1 acids—Rohm & Haas (Dibasic acids, mol wt—1000) 28.7
Diethylene triamine 10.3
Isopropyl alcohol 19.0
Dispersing agent (Alkylene oxide product, mol wt—5000) 3.0
Tapwater 33.7
Acetic acid 5.3


Small quantities of this solution, which may range from about 1 to about 10 barrels, are injected periodically into the drill pipe or drill string while drilling. The time of injection may be determined in any of several ways. For example, it may be desirable to inject the aqueous solution for about every 5 feet of the formation drilled, or it may be desirable to inject the solution at the discretion of the driller—for example, at a...
drilling break from one formation to another. When the increment or slug of the solution containing the surface-active agent reaches the drill bit, the drill bit uncovers the formation and for the period of time when the solution is being employed, the bit penetrates into the formation in the presence of the solution. Thus, the drilling fluid and the surface-active agent alternately contact said earth formations during the drilling operations. In other words, the solution contacts the formation directly and in the absence of solids.

The present invention is quite advantageous and useful in that the solution contacts directly the formation, foaming difficulties are not encountered, and the presence of hydrocarbons is indicated by obtaining a single electrical log by virtue of the fact that the presence of hydrocarbons causes an increase in the value of the recorded electrical resistivity as shown on a sheet.

The present invention will be further illustrated by reference to the drawing in which:

FIG. 1 illustrates the injection of the aqueous solution during drilling operations with increments of the solution being injected;

FIG. 2 shows the withdrawal of the drill string and the running of an electrical log; and

FIG. 3 is a typical electrical resistivity log indicating the presence of hydrocarbons at particular depths in a well.

Referring now to the drawing for illustrating a preferred mode, numeral 11 designates a well bore being drilled to penetrate earth formations 12, 13, 14, and 15, some of which may be productive of hydrocarbons and others of which may be non-productive of hydrocarbons.

A drill string 16 depending from the rotary table 17 on the derrick floor 18 of the derrick 19 carries on its lower end a drill bit 20, which may be a rock bit or one of the fish-tailed type having an eye or eyes 21 for circulation of drilling fluid down the hollow drill string 16 out the eyes 21 and up the annular space 22 to the earth's surface 23 where the drilling fluid flows through a mud return ditch 24 to the usual mud pit 25. A pump suction line 26 controlled by a valve 27 draws the mud returns from the pit 25. The discharge of the pump is connected to the drill pipe through a stand pipe, a flexible hose and a swivel 28.

Connected to the suction line 26 between the valve 27 and the pump is a conduit 30 controlled by valve 31, which connects the line 26 to a tank 32 containing a solution of the surface-active agent.

Increments of the solution in tank 32 are drawn periodically into the suction line 26 such that the solution will contact the several formations pierced by the well 11 as the drill bit 20 makes hole and drills through the several formations.

When it is desired to determine whether or not hydrocarbons are present in the several pierced formations 12, 13, and 14, the drill string 16 is withdrawn from the well 11 and an electrical logging device 33, which may be of the electrical resistivity or electrical potential type, is lowered and run on an electrical cable 34 suspended from a sheave 35. The electrical cable 34 leads to a service truck provided with a tape recorder, computer, and printer. The electrical logging device 33 is provided with centralizers 36 which carry electrodes 37 which conduct signals by electrical leads 38 through the cable 34 to the service truck and its equipment, not shown, for recording and displaying the electrical log such as shown clearly in FIG. 3.

Referring now to FIG. 3, an electrical resistivity log 40, preferably a Microlaterolog or a Microlog, is shown plotted against the depth of the well. Between 3,000 and 3,050 feet a formation such as sandstone, limestone, dolomite, sandy shale, and the like, is indicated by the deflection 41 while a formation between 3,100 and 3,163 feet is indicated by the deflection 42. A solution of surface-active agent of the type described is injected into the drilling fluid while drilling between 3,000 and 3,050 feet, but hydrocarbons are not indicated to be present. However, surface-active agent is again injected into the drilling fluid between 3,100 and 3,137 feet and the presence thereof causes the presence of hydrocarbons to be indicated at about 3,137 feet by the deflection 43.

Again, surface-active agent is injected into the drilling fluid while drilling between 3,200 and 3,263 feet where a deflection 44 is obtained which indicates the presence of hydrocarbons by virtue of the deflection 45.

Again, between 3,300 and 3,350 feet a surface-active agent is injected into the drilling fluid during the drilling of the well to the depths reflected by the deflection 46 with the presence of hydrocarbons being indicated by the deflection 47 between about 3,310 and 3,335 feet, which may indicate a hydrocarbon productive stratum, the greater width of the deflection 47 being due to continued injection of the solution.

In short, by virtue of the present invention, it is unnecessary to compare electrical logs to obtain a direct indication of the presence of hydrocarbons, the presence of hydrocarbons being indicated positively and directly from the single log by virtue of the effect of the surface-active agent injected incrementally during drilling to cause any hydrocarbons present in the pierced formations, strata, horizons, zone, sands, to wet preferentially the rock or sand and to indicate the presence thereof by the increased deflection in the recorded and displayed log of resistivity.

It will be apparent that the present invention is of considerable value and utility.

The nature and objects of the present invention having been completely described and illustrated, what I wish to claim as new and useful and secure by Letters Patent is:

1. A method for determining the presence of hydrocarbons in subsurface earth formations which comprises drilling a well in the earth to pierce said earth formations while circulating a drilling fluid through said well, injecting incrementally into said circulating drilling mud at selected spaced-apart intervals a small but sufficient amount of a solution of a surface-active agent consisting of a water soluble cationic salt which causes preferential wetting of said pierced earth formations by any hydrocarbons in said pierced earth formations, alternately contacting said earth formations during said drilling with said drilling fluid and said solution, and then running and obtaining a single electrical log of said pierced earth formations whereby the presence of any hydrocarbons in said pierced earth formations is indicated by increased deflection in the recording and displaying of said log over that normally obtained.

2. A method in accordance with claim 1 in which the electrical log is an electrical resistivity log.

3. A method in accordance with claim 1 in which the electrical log is an electrical potential log.

4. A method for determining the presence of hydrocarbons in subsurface earth formations which comprises drilling a well in the earth to pierce said earth formations while circulating a drilling fluid through said well, injecting incrementally into said circulating drilling fluid at selected spaced-apart intervals a surface-active agent of sufficient amount from about 1 to about 10 barrels of a solution of a surface-active agent consisting of a water soluble cationic salt which causes preferential wetting of said pierced earth formations by any hydrocarbons in said pierced earth formations, alternately contacting said earth formations during said drilling with said drilling fluid and said solution, and then running and obtaining a single electrical log of said pierced earth formations whereby the presence of any hydrocarbons in said pierced earth formations is indicated by increased deflection in the recording and displaying of said log over that normally obtained.

5. A method for determining the presence of hydro-
5 carbons in subsurface earth formations which comprises drilling a well in the earth to pierce said earth formations while circulating a drilling fluid through said well, injecting incrementally into said circulating drilling fluid at selected spaced-apart intervals a small but sufficient amount of an aqueous solution containing from about 0.01% to about 10% by weight of a surface-active agent consisting of a water soluble cationic salt which causes preferential wetting of said pierced earth formations by any hydrocarbons in said pierced earth formations, alternately contacting said earth formations during said drilling with said drilling fluid and said solution, and then running and obtaining a single electrical log of said pierced earth formations whereby the presence of any hydrocarbons in said pierced earth formations is indicated by increased deflection in the recording and displaying of said log over that normally obtained.

6. A method for determining the presence of hydrocarbons in subsurface earth formations which comprises drilling a well in the earth to pierce said earth formations while circulating a drilling fluid through said well, injecting incrementally into said circulating drilling fluid at selected spaced-apart intervals for about every 50 feet of said formations drilled, a small but sufficient amount from about 1 to about 10 barrels of an aqueous solution containing from about 0.01% to about 10% by weight of a surface-active agent consisting of a water soluble cationic salt which causes preferential wetting of said pierced earth formations by any hydrocarbons in said pierced earth formations, alternately containing said earth formations during said drilling with said drilling fluid and said solution, and then running and obtaining a single electrical log of said pierced earth formations whereby the presence of any hydrocarbons in said pierced earth formations is indicated by increased deflection in the recording and displaying of said log over that normally obtained.

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