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PROCESS FOR MAKING A WELL LOG WITH RADIOACTIVE TRACERS

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1 Claim. (Cl. 250—43.5)

This invention relates to the art of geophysical prospecting and more particularly to the art of radioactivity well logging in which a radioactive tracer material is employed.

Numerous methods have heretofore been devised for locating porous or permeable formations that have been penetrated by a drill hole such as an oil well. Among these are those methods which employ a fluid that has been rendered radioactive by the addition thereto of substances such as radium oleate radon, ground carnotite, and others in suspensions, colloidal or otherwise, after which pressure is applied to the fluid to cause it to enter the formations carrying with it the radioactive material, to thereby mark the porous zones. In some instances the contaminated fluid is removed from the well and a log made of the retained radioactivity, and in others a log is made without removing the contaminated fluid. In each instance it is expected that the pourous zones would show a higher intensity of radioactivity. These methods, however, have not met with success, for in some instances the radioactive contaminant was not suitably chosen, and therefore it usually adhered to every substance with which it came in contact. On the other hand, the contaminant or tracer material is forced back into the formations with its carrier fluid so far that it cannot be detected with certainty. In other cases when trying to make a log without first bailing the fluid from the hole, the concentrated radioactivity of the entire fluid in the well exhibits such a strong effect that it would tend to mask any small change in radioactivity exhibited by a porous zone into which the fluid has been forced. Still in other cases, when attempts have been made to introduce the radioactive contaminant in particle size sufficiently large that the particles do not enter the pore spaces of the zones of interest but be deposited on the face of the porous zones, they would settle out, causing complete loss of control of the tracer material before any log could be made, or when the pressure was removed from the fluid carrying the suspended radioactive particles the backflow of the carrier fluid into the well would cause any deposited particles to be washed off the formations of interest.

The present invention provides a novel tracer method of logging a drill hole which overcomes all the objectionable features of the prior art processes that have been enumerated above. The present invention comprises broadly the steps of first making a log of the natural radioactivity of the formations, then a carrier fluid having suspended particles of a radioactive contaminant is introduced into the drill hole while agitating the carrier fluid. Pressure is then applied to the fluid to force the carrier fluid into the permeable or porous formations leaving the particles of radioactive contaminant disposed on the face of those formations. A neutral carrier fluid, one which has no radioactive contaminant suspended therein, is then introduced into the drill hole while continuing to apply pressure and enough additional pressure applied to the fluid to cause that fluid which carries the radioactive contaminant to be completely displaced from the well out into the porous formations. While maintaining the fluid under sufficient pressure that no backflow into the well can occur, a second log is then made to measure the intensity of the radiation emitted by the formations. Permeable or porous zones would then be indicated on the second log by a marked increase in the intensity of the radiations detected adjacent the permeable or porous zones.

In practicing the present invention the walls of the drill hole are first conditioned by washing, scraping, or otherwise removing the mud sheath that has been disposed on the walls of the well during the drilling operation. The fluid in the well is then bailed or displaced by a neutral carrier fluid, the selection of which is determined by the condition of the walls of the well, and whether or not any of the formations penetrated are producing gas or tend to cave. The density of the displacing fluid should be such that it would exert a pressure on the formations adequate to prevent flow of gas from the formations. A tracer fluid is then prepared by selecting a carrier fluid such as water, brine, or petroleum, a quantity at least sufficient to fill the drill hole. To this carrier fluid is then added, by dispersion therein, particles of radioactive tracer material. Suitable materials have been found to be radium 224, in the form of radium sulfate, radioactive barium, barium 140, in the form of barium sulfate, or radium-barium sulfate. Enough of the selected tracer substance is used to obtain an activity of approximately 0.6 microcurie per linear foot. The amount added to obtain this activity, of course, depends upon the diameter of the particular well and upon the number of permeable or porous zones that are encountered in the well. The radioactive tracer material is introduced into the carrier fluid while in the form of finely divided dry particles which are of a size ranging from 20 to 120 microns depending on the pore sizes in the formations that it is desired to mark. The particles must be chosen of a size that is large enough that they cannot be forced back into the formations that it is desired to mark but be plated out on the face thereof. On the other hand, the largeness of the particle is determined by that size of particle which will not settle out of the carrier solution while it is being injected into the well. In order to enable the use of as large a particle size as possible, the carrier fluid with the dispersed particles therein is continuously agitated while it is being injected into the well. Pressure is then applied to the fluid to cause the carrier fluid to be forced into the permeable or porous zones that it is desired to mark, and this fluid in passing into these permeable or porous zones leaves the tracer particles plated on the face of the formations. This pressure may be as high as 1500 pounds per square inch. While pressure is continuously maintained on the fluid to prevent any backflow into the well of fluid which has been forced out into the formations a neutral fluid which may be water, brine, or oil, having no radioactive tracer dispersed therein, is injected into the well to completely displace all of the tracer-carrying fluid into the formations. Sufficient pressure is maintained on the fluid in the well that no backflow can occur which would wash the tracer particles, which have been disposed on the faces of the formations, back into the well. While maintaining this pressure a log is made of the well by measuring along the walls thereof the intensity of the radiation emitted by the formations. Those permeable or porous zones having the tracer material deposited on the faces thereof will exhibit a relatively high intensity of radiation in contrast to other formations penetrated by the well that are less porous or permeable.

It is extremely important in practicing this process that the tracer-carrying fluid, injected into the well while agitating, be completely displaced out into the formations by a neutral fluid and that pressure be maintained on the neutral fluid to prevent any backflow into the well. First,

if the tracer-carrying fluid is not completely displaced out into the formations from the well, the high concentration of radioactive material in the fluid would preclude the making of a log which would indicate with certainty the desired permeable or porous formations, since this high concentration of radioactive material surrounding the radioactivity detector would tend to mask any increase in radioactivity that would be exhibited by the marked formation. Second, if pressure is at any time removed from the fluid during or before the second log has been made, loss of control of the tracer substance would result due to backflow of the carrier fluid from the formations into the well. This backflow would obviously wash the particles which have been plated on the faces of the formations off into the well and the radioactive particles would settle to the bottom of the well.

Radium 224 and barium 140 are selected as suitable radioactive tracers for the following reasons: First, they have half lives of 3.64 days and 12.8 days, respectively; this is important since the use of short half-life tracers will not permanently contaminate the well. Second, at least one daughter product of these elements emits intense gamma radiation that is readily detectable with conventional surveying instruments.

Obviously, in order to maintain a pressure on the fluid while making a log of the drill hole, it is necessary that some means be provided whereby the detector can be introduced into the mouth of the well and whereby the cable which supports the detector in the well can extend outside to some form of hoisting equipment. One form of apparatus which has been found to be satisfactory for this purpose is known commercially in the field as a lubricator having an oil-saver seal. Since this device is well-known in the art, it is not thought that a detailed description of the device or its operation is necessary.

It is to be understood that this invention is not to be limited to the specific modifications described but is to be limited only by the following claim.

I claim:

A process for determining the permeability and porosity of selected formations that have been penetrated by a drill hole that comprises the steps of making a log of the natural radioactivity of the formations, introducing into the drill hole a carrier liquid carrying suspended radioactive particles while agitating the liquid, said particles being at least 20 microns in size and yet small enough to remain in suspension in the carrier liquid, applying hydraulic pressure to force the carrier liquid into the permeable and porous formations to deposit the radioactive particles on the face thereof, displacing all of the carrier liquid from the well into the formations by introducing a neutral liquid, continuously maintaining sufficient hydraulic pressure on the face of the formations to prevent backflow of liquid from the formations, and making a second radioactivity log of the drill hole while maintaining said pressure.

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