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METHOD OF DRILLING WITH AIR

William A. Freeman, Jr., and Victor G. Meadors, Tulsa, Okla., assignors to Esso Research and Engineering Company, a corporation of Delaware

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This invention concerns a novel technique for drilling bore holes in the earth using the so-called "air drilling" procedure. In the method of this invention air or another gas is used as the circulating fluid for drilling operations. This gas, in accordance with this invention, carries a small amount of an organohalosilane. The presence of the organohalosilane in the drilling fluid permits advantageous results to be obtained in this drilling procedure.

The present invention generally relates to a rotary drilling technique for drilling bore holes in the earth. In drilling by the rotary drilling technique, a liquid which is ordinarily called "drilling mud" is circulated through a drill string into the bore hole. The drilling fluid gains access to the bore hole through orifices or nozzles positioned in a drill bit as the bottom of the drill string. The drilling mud washing out of these nozzles serves to lubricate the drill bit and serves to bring cuttings to the surface of the earth in the annulus of the bore hole about the drill string. In addition to these functions, the drilling mud ordinarily provides a number of other functions such as conditioning the bore hole, providing a high hydrostatic pressure to prevent loss of high pressure fluids which may be encountered in drilling, and other functions. As stated, conventionally a fairly high density liquid is employed as the drilling fluid in rotary drilling.

For a number of applications it has been appreciated that the use of air or another gas in place of a liquid drilling mud would be desirable. Attempts have been made to employ a gas as a drilling fluid. It is known that in some cases use of a gas as a drilling fluid is highly advantageous. For example, drilling with air is desirable in the case of drilling bore holes of relatively shallow depth for seismic prospecting. Drilling of shot holes for seismic prospecting by the air drilling technique is particularly desirable since lighter weight, more compact drilling apparatus can be used without necessity for the usual complicated drilling mud preparation and conditioning equipment. It has also been appreciated that drilling with air would be desirable in the case of certain formations which otherwise may break down or rupture under the hydrostatic head of any liquid drilling fluid. In these and other applications it is considered important to secure an attractive air drilling method.

However in using the air drilling procedure it has been found that a number of problems are encountered. Probably the most serious limitation in the use of gaseous circulating fluids for drilling lies in the fact that difficulties are encountered when drilling in the presence of water. When a water bearing stratum is encountered water enters the bore hole causing the cuttings in the bore hole to become gummy. In general the cuttings tend to coagulate so as to plaster together on the bore hole walls, the bit and the drill pipe. This causes a sharp reduction in the rate of drilling and in aggravated cases will cause complete plugging of the borehole annulus with consequent loss of any circulation. Consequently heretofore in attempting to drill with gas, in general, when water

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has been encountered in the bore hole the drilling has become uneconomic and undesirable or even completely inoperable.

It is the primary purpose of this invention to overcome this limitation of the air drilling technique by providing a means for overcoming the problems caused by water entry into a bore hole during drilling. In accordance with this invention, this objective is attained by the injection of certain particular organic silicon compounds into the gas used as a drilling fluid. The presence of these compounds in vaporized form in the gas makes it possible to minimize or prevent the problems of water entry in the bore hole during drilling. The silicon compound or compounds function in two ways to minimize these problems. First these compounds tend to prevent water entry into the bore hole by establishing a surface condition at the wall of the bore hole which materially cuts down water entry into the bore hole. Secondly, the organic silicon compound tends to provide a surface condition on the cuttings formed during drilling so as to prevent their coagulation in the bore hole.

The particular compounds to be employed in the present invention are monomers of organohalosilanes having the general formula R_nSiX_{4-n} and polymers of such monomers. In this formula R is an aliphatic radical having from one to three carbon atoms. The radical is specifically chosen from the group consisting of methyl, ethyl, vinyl and allyl radicals. X is a halogen and preferably chlorine or bromine, and n is an integer which may vary from one to three. The preferred organohalosilanes compounds falling within the scope of this invention are trimethylchlorosilane, trimethylbromosilane, dimethyldichlorosilane, diallyldichlorosilane, methyltrichlorosilane, ethyltrichlorosilane and vinyltrichlorosilane.

Each of the compounds has a boiling point at atmospheric pressure of no more than 100° C. Consequently the vapor pressure of these particular silane compounds is sufficiently high at the temperatures encountered in drilling so as to make their use practical. It should be observed that use of silane compounds of substantially higher boiling point or lower vapor pressures is not practicable for the purposes of this invention. The attempt to use high boiling liquid silane compounds, for example, is unsuccessful due to the fact that improper distribution of the silane compounds over the cuttings formed during drilling will occur so that satisfactory results cannot be obtained without using prohibitive quantities of liquid silanes. For this reason it is an important feature of this invention to employ silane compounds of the character specifically identified in order that these compounds may be used in vaporized form in the gas employed as a drilling fluid.

Sufficient organohalosilane is to be injected with the gaseous drilling fluid so as to more or less cover the surface of all cuttings. In general this requires injection of about 0.01 to 0.10 lbs. of halosilane per thousand cu. ft. of drilling gas. It is apparent that larger amounts may be used, although for economic purposes the quantities of halosilane employed should be chosen within the ranges stated. The particular proportion of silane to be employed is of course selected with a view to the actual drilling conditions encountered. When a bore hole is relatively dry the proportions of the halosilane near the lower range stated may be employed while for wet bore holes greater amounts are to be used.

The injection of the halosilane may be carried out in a number of ways. Thus any desired technique may be used so as to incorporate the approximate proportion of the halosilane indicated in the drilling fluid prior to pumping the drilling fluid into the drill string in the bore hole. However, the preferred technique for incorporating the halosilane in the drilling fluid is to make up a dilute solu-

tion of the halosilane in a suitable inert organic solvent. The solvent must be inert to the halosilane so as to prevent decomposition of the halosilane. Suitable solvents which may be used for example, are toluene, benzene, ether, etc. By making up a dilute solution of the halosilane in such a solvent it is convenient to add the solution of halosilane to the drilling fluid by means of a conventional metering pump. Since the drilling fluid is pumped at a high velocity into the drill string for drilling purposes, incorporation of the halosilane in the drilling fluid is ensured without difficulty by the rapid vaporization of the halosilane solution.

In all other respects the drilling procedure will be carried out in the conventional manner. In the initial portion of the drilling procedure the halosilane content of the drilling fluid will be somewhat depleted while passing through the drill string. Thus for a portion of initial operation some percentage of the halosilanes will be adsorbed on the drill string itself as the drilling fluid is pumped downwardly through the drill string toward the drill bit in the formation actually being drilled. However, this effect is not serious. The drilling gas containing the entrained halosilane will be injected into the cuttings and into the borehole at the bottom of the drill string through the fluid openings provided in the drill bit employed. The halosilane will be forced with the drilling gas into and through the drill cuttings so as to form a water repelling surface on the drill cuttings. Passage of the drilling fluid containing residual halosilane will then occur upwardly to the surface of the earth together with the drill cuttings in the annulus of the bore hole about the drill string. In the upward passage of the drilling fluid containing the entrained and vaporized halosilane, the halosilane will then contact the wall of the bore hole itself, forming an additional water repellent surface on the wall of the bore hole. This water repellent surface on the bore hole wall will tend to minimize entry of water into the bore hole. This occurs primarily by formation of a hydrolyzed form of the halosilane resulting in the formation of an insoluble hydroxysilane which tends to prevent the passage of water from the formation into the bore hole. In this manner the present invention serves to greatly improve drilling with gas by making the cuttings themselves water repellent so as to prevent their coagulation and to prevent their gumming up in the borehole. Secondly, as pointed out, use of halosilane in the procedure of this invention tends to reduce water entry into a bore hole. By these mechanisms drilling with gas in accordance with this invention is greatly improved.

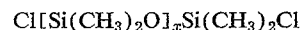
While, as stated, the preferred compounds for use are organohalosilane compounds, compounds of a second class may be employed if desired. These compounds are silicon compounds which are organo-aminosilane compounds. Such compounds may be represented by the generic formula R_3SiNH_2 or $(R_3Si)_2NH$, where R is a hydrocarbon radical having from 1 to 3 carbon atoms, e. g. trimethylaminosilane. Use of these aminosilane compounds is particularly advantageous since hydrolysis of these compounds causes the liberation of ammonia or an amine. The presence of the ammonia or an amine in the bore hole is advantageous in providing a corrosion retardant acting to prevent corrosion of the drilling equipment due to water in the bore hole. At the same time the aminosilane compounds provide the same advantages indicated for use of halosilane compounds in a drilling with gas procedure.

The advantageous features of this invention may be demonstrated by simple experiments. In one such experiment ten grams of a bentonitic clay were mixed with 30 grams of water. It was found that this proportion of water mixed with the clay resulted in a jelly-like, gummy material which swelled to a volume tenfold the original volume of the clay. This gummy material was completely immobile and could not be fluidized or transported by passage of air through the material. In a

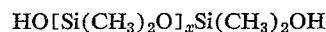
comparative experiment the clay was first exposed to air saturated with the vapor of a commercial mixture of methylchlorosilanes and was then mixed with water in the same proportions. In this case conglomeration of clay was completely prevented and the clay remained in a sufficiently mobile state, so that it could be transported by passage of gas through the clay. This experiment shows that earth formation or drill cuttings can be treated with silane compounds so as to retain suitable mobility for successful circulation with a drilling gas even though substantial water or moisture may be present.

To establish the second mechanism on which the present invention depends, experiments were conducted in an actual borehole during air drilling tests. In a particular bore hole employed the surface casing was placed in a bore hole for a length of 57 ft. in order to prevent surface formation water from entering the bore hole during air drilling tests. The bore hole was then drilled to a depth of 80 ft. providing 23 ft. of exposed walls below the casing in the bore hole. Under these conditions it was found that the bore hole soon filled with water.

In order to obtain significant data, air was circulated in the bore hole for a period of time until the well was completely cleared of all water and cuttings. It was then found that in a period of 24 hours sufficient water had entered the bore hole so as to provide a depth of 43 ft. of water. The well was then again cleaned by circulating air through the bore hole until completely clean and dry. At this time a gallon of a silicon compound was introduced into the well down the drill stem. The silicon compound employed was a polymeric silicon compound which consists essentially of molecules of the following nature:



which upon hydrolysis reacts to form



where x is an integer which may range from one to one hundred. In order to insure vaporization of the silicon compound, the well was sealed off and 120 lbs. per sq. in. air pressure was held on the formation by the use of an air compressor for one hour. Thereafter pressure was released from the well, and the rate of water encroachment into the well was determined. It was found that the rate of water entry into the well was greatly below the rate of water entry when no silicon compound was employed. The rate of water entry was less than 1/5 of that in which no silicon compound was used. As a result, at the end of 24 hours it was found that only eight feet of water had entered the well. This and other tests conclusively establish that the presence of a silicon compound in a well bore hole can and does substantially shut off the entry of water into a bore hole.

What is claimed is:

1. The method of overcoming coagulation of drill cuttings in drilling a bore hole by gas circulation in which about 0.01 to 0.10 lb. of a vaporized organosilane compound per thousand cubic feet of gas is mixed with the drilling gas during circulation of the gaseous drilling fluid, said organosilane compound being selected from the group consisting of organohalosilanes and organo-aminosilanes having boiling points of less than 100° C. at atmospheric pressure.

2. In the drilling of a bore hole in the earth the improvement which comprises removing cuttings from the bore hole during drilling by circulating in the bore hole a gas to which has been added, at the rate of about 0.01 to about 0.1 lb. per thousand cubic feet of gas, a vaporized organosilane compound selected from the group consisting of organohalosilanes and organoaminosilanes having boiling points of less than 100° C. at atmospheric pressure.

3. The method defined by claim 2 in which the said

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organosilane compound is an organohalosilane selected from the group consisting of trimethylchlorosilane, trimethylbromosilane, dimethyldichlorosilane, diallyldichlorosilane, methyltrichlorosilane, ethyltrichlorosilane and vinyltrichlorosilane.

4. An improved drilling method defined by claim 2 in which the said organosilane has the generic formula R_nSiX_{4-n} where R is a hydrocarbon radical of from 1 to 3 carbon atoms selected from the group consisting of methyl, ethyl, vinyl and allyl radicals, X is a halogen and n is an integer which may vary from 1 to 3.

5. An improved drilling method as defined by claim 2 in which said organosilane is an organoaminosilane selected from the group consisting of compounds of the

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formula R_3SiNH_2 and $(R_3Si)_2NH$ where R is a hydrocarbon radical having from 1 to 3 carbon atoms.

References Cited in the file of this patent

UNITED STATES PATENTS

1,065,409	Van Sickle	June 24, 1913
1,401,488	Nolan	Dec. 27, 1921
2,259,875	Bent et al.	Oct. 21, 1941
2,265,962	Bent et al.	Dec. 9, 1941
2,306,222	Patrode	Dec. 22, 1942
2,469,354	Bond	May 10, 1949
2,583,606	Sirianni	Jan. 29, 1952