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(54) **Titre:** Logging method.

(57) **Abrégé:**

The invention relates to a method of operating a logging tool in a wellbore formed in an earth formation, the wellbore having at least a section which is to be provided with a wellbore component. The method comprises arranging the logging tool in a selected relationship relative to said component so that the logging tool is guided by the component through the wellbore during lowering of the component into the wellbore, and lowering the component with the logging tool in said selected relationship through the wellbore to said section of the wellbore. The logging tool is operated so as to provide logging data of the earth formation surrounding the wellbore, the logging data are transferred to surface, and the logging tool is retrieved.

LOGGING METHOD

The present invention relates to a method of operating a logging tool in a wellbore formed in an earth formation, which wellbore has at least a section which is to be provided with a wellbore component, for example a casing.

In conventional wellbore drilling a plurality of casing sections of stepwise decreasing diameter are installed in the wellbore to prevent the wellbore from collapsing and to protect drilling equipment. The wellbore is deepened by rotating a drill string which extends to the bottom of the wellbore through previously installed casing sections. Before installing casing in the newly drilled wellbore section, a logging tool is lowered via a wireline into the un-cased wellbore section and operated in order to obtain logging data representing characteristics such as porosity or oil/water content of the earth formation surrounding the un-cased wellbore section. A drawback of such wireline logging method is the required additional drilling rig time during lowering and operating the logging tool. A further drawback is that there is a danger that the logging tool gets blocked in the open wellbore section. Moreover, it may not be possible to operate the logging tool over a significant part of the newly drilled wellbore section, as a consequence of which valuable information on the surrounding formation cannot be obtained.

Another proposed logging method is disclosed in Oil & Gas Journal, June 10 1996, pp. 65-66, whereby a logging tool is pumped down a drill string and operated during tripping of the drill string. Such method has several drawbacks, for example the diameter of the logging tool is limited to the inner diameter of the drill string, and the presence of a downhole motor obstructs further pumping of the tool. Furthermore, drilling of a further wellbore section before the string is tripped is precluded once the tool is positioned in the drill string. Also, positioning of the tool in the drill string at the desired location requires special technical measures to be taken which make the system rather complicated.

Thus, there is a need to provide an improved logging method which is reliable and which results in a significant reduction of drilling rig time.

In accordance with the invention there is provided a method of operating a logging tool in a wellbore formed in an earth formation, the wellbore having at least a section which is to be provided with a wellbore component, the method comprising arranging the logging tool in a selected relationship relative to said component so that the logging tool is guided by the component through the wellbore during lowering of the component into the wellbore, lowering the component with the logging tool in said selected relationship, through the wellbore to said section of the wellbore, operating the logging tool so as to provide logging data of the earth formation surrounding the wellbore, and transferring the logging data to surface.

It is to be understood that the term wellbore component refers to any component which is to be arranged in the wellbore to form a structural part thereof, and relative to which the logging tool can be arranged in said selected relationship.

By applying the method of the invention it is achieved that drilling rig time is reduced since the logging tool is lowered together with the wellbore component, thereby obviating the need for wireline logging. Furthermore, wellbore components generally have high mechanical strength so that such wellbore components are capable of protecting the logging tool in the wellbore. Also, the risk that the logging tool becomes blocked in the wellbore, or cannot be moved through highly inclined or horizontal wellbore sections, is reduced because of the wellbore component guides the logging tool through the wellbore.

A further reduction of drilling rig time is achieved if the logging tool is operated simultaneously with the step of lowering the wellbore component into the well-bore.

Suitably the wellbore component forms a tubular element and the logging tool is at least partly arranged within the tubular element.

To obtain logging data from a selected side of the wellbore, suitably the logging tool is attached to the inner surface of the tubular element at a selected side thereof in correspondence with a section of the earth formation to be logged.

Suitably the wellbore component is selected from a wellbore casing, a wellbore liner, a slotted wellbore liner, an expandable slotted liner, a pre-perforated liner, a wellbore screen, a wire-wrapped screen, and a gravel pack screen.

A suitable logging tool in application of the invention includes at least one of a gamma ray logging device, a density logging device, a neutron logging device, an NMR logging device, a resistivity logging device, a micro resistivity/calliper logging device, a sonic logging device and any other suitable logging device. If a plurality of such logging devices is applied, the logging devices are preferably arranged in a stacked manner.

To improve communication of the tool with the surrounding formation the tubular element can be provided with a window opposite a selected one of said logging devices, which window is optionally filled with a material suitably transparent to the logging tool signal. Examples of such materials are fibre reinforced plastic, glass fibre reinforced epoxy and fibre reinforced cement.

In case said logging device forms a pad type device, such device suitably extends through the window so as to contact the wellbore wall.

The invention will be described hereinafter in more detail and by way of example with reference to the appended drawings, in which

Fig. 1 schematically shows a system for carrying out the method according to the invention; and

Fig. 2 shows a cross-section of a wellbore in which the method according to the invention is applied, wherein a logging tool is placed eccentrically in a casing shoe track.

Referring to Figs. 1 and 2 there is shown a wellbore 1 which is being created by drilling into an earth formation 3 from a drilling rig 5 at the earth surface 7. An upper part of the wellbore 1 has been provided with tubular casing to prevent the wellbore from collapsing. As is common practice in wellbore drilling, the casing includes a plurality of casing sections of stepwise decreasing diameter in downward direction. The wellbore 1 is further deepened by drilling a new, inclined, wellbore section 8 through previously installed casing sections (not shown), and lowering a casing section 9 of smaller diameter than the previously installed wellbore sections into the new wellbore section 8. In this manner casing sections of stepwise decreasing diameter are positioned in the wellbore.

The lower end part of the casing section 9, named the casing shoe track 11, is internally provided with a logging tool 15 composed of a gamma ray logging device 17, a neutron logging device 19, a density logging device 21, and a power/memory cartridge 23 which includes a suitable energy source for the tool 15. The casing section 9 is provided with a window 25 which can be in the form of an opening or an opening filled with fibre reinforced plastic material such as fibre reinforced epoxy, the window 25 being located opposite the density logging device 17. Some sections of the shoe track 11 can be made entirely of glass fibre reinforced epoxy, fibre reinforced cement or other suitable material, in order to optimise log response of tools affected by steel (e.g. Resistivity / Induction and Nuclear Magnetic Resonance type tools). In all cases the shoe track 11 will be designed to allow through-pumping of mud to the shoe track nose. The materials used are selected so as to be able to be drilled out in case further deepening of the well is required. The logging tool 15 is retrievably located within an open ended retaining tube 27 made of glass fibre reinforced epoxy by means of arms 29, which retaining tube 27 is fixedly attached to the lower side of the inner surface of the casing section 9. The lower side of the casing is defined as the side that is pushed against the formation, either by casing eccentralisers (in vertical sections) or by the tools ex- centred weight, using a casing swivel (for example in horizontal sections).

A guide funnel 31 is located at the upper end of the retaining tube 27, which guide funnel 31 has a large diameter end remote from the retaining tube 27 and a small diameter end adjacent the retaining tube 27. The large diameter end corresponds to the inner diameter of the casing section 9 and the small diameter end corresponds to the inner diameter of the retaining tube 27.

During lowering of the casing section 9 into the new wellbore section 8, the logging devices 17, 19, 21 of the logging tool 15 are operated and the logging data representing information on the earth formation surrounding the new wellbore section 8 are stored in the power/memory cartridge 23 (i.e. the tool is operated in memory mode). Since the logging tool 15 is located inside the casing shoe track 11, the latter protects the logging tool 15 from mechanical damage due to collision with the wellbore wall. Furthermore, by the arrangement of the logging tool 15 in the casing section 9 it is ensured that lowering of the logging tool 15 is not hampered by the irregularly shaped wellbore wall. Especially in case of horizontal or nearly horizontal wellbore sections which are to be logged, the method of the invention is of particular advantage since moving a logging tool through such newly drilled sections would be difficult, if not impossible, if the logging tool would be lowered by wireline.

After the casing section 9 has been installed and prior to cementing of the casing section in the wellbore, a latching device 33 provided with suitable discs 35 (so-called swab cups) for pumping the latching device 33 through the wellbore 1 is inserted into the wellbore 1. The latching device 33 is connectable to the logging tool 15 and is connected to a wireline 37 or a coiled tubing (not shown) extending from surface into the wellbore 1. The wireline 37 or coiled tubing is provided with electric conducting means for transferring electric signals representing the logging data to surface, the conducting means at surface being connected to suitable data reading equipment at a logging truck 39. The latching device 33 is pumped down the wellbore 1 to the retaining tube 27. Upon arrival of the latching device 33 at the retaining tube 27, the guide funnel 31 guides the latching device 33 to the open upper end of the retaining tube 27 until the latching device becomes connected to the logging tool 15.

In a next step the logging data stored in the power/memory cartridge 23 are transferred to the data reading equipment via the electric conductor. Subsequently the logging tool is retrieved to surface 7 using the wireline 37 or the coiled tubing. Alternatively the logging data could be read from the logging tool 15 after the logging tool 15 has been retrieved to surface 7 or during retrieval of the tool to surface. Such wireline or coiled tubing can also be used to check the depth of the logging tool. The optimum method for depth control would be to leave the tool on during retrieval while measuring cable (or coiled tubing) depth at surface thus creating an optimal depth match curve.

The casing is then cemented, including the retaining tube 27 which can be drilled out of the casing section 9 using a conventional drill string if the wellbore is to be further deepened.

In case of temporary latching of the latching device to the logging tool, for example during taking of pressure testing measurements or logging while allowing full interactive data acquisition, the latching system 33 can be controlled from surface to either retrieve the tool 15 or to dis-latch from the tool.

Instead of the logging tool being arranged entirely eccentrically in the casing shoe track, the tool can be positioned partly eccentrically and partly centralised, depending on the type of tool and tool sensor or pad geometry applied.

In the above described procedure the logging data are stored in the power/memory cartridge and transferred to surface thereafter. However in an alternative mode of operation the logging data can be transferred to surface in a real-time mode using full interactive connection with a logging unit, for example during formation pressure testing at selected depths.

To establish a real time check that the logging tool is functioning properly while in memory mode, without the tool being connected to surface by a wireline, an internal check system providing intermittent pulses (e.g. pressure or electromagnetic) can be included in the tool string. The intermittent pulses can also be used to obtain real time data while running the wellbore component into the wellbore.

In the event of a tool failure, the tool can be retrieved by the pump down latch on a cable and be replaced by a back-up tool, whereafter logging operations can be resumed. If the logging tool is to be placed in the shoe track of an open liner (e.g. a slotted liner, a pre-drilled liner or a wire-wrapped screen) a wash pipe can be positioned in the open liner to close off the openings in the liner so as to allow the latching device to be pumped through the open liner, or alternatively the tool can be connected to the wash pipe and retrieved together with the wash pipe.

AMENDED CLAIMS

1. A method of operating a logging tool in a wellbore formed in an earth formation, the wellbore having at least a section which is to be provided with a wellbore component, the method comprising:

- arranging the logging tool (15) in a selected relationship relative to said component (9) so that the logging tool is guided by the component (9) through the wellbore (1) during lowering of the component into the wellbore;
- lowering the component (9) with the logging tool (15) in said selected relationship, through the wellbore (1) to said section of the wellbore;
- operating the logging tool (15) so as to provide logging data of the earth formation (3) surrounding the wellbore; and
- transferring the logging data to surface,

characterized in that the logging tool (15) is retrievably arranged relative to said component (9), and that after operating the logging tool, the logging tool is retrieved to surface while the wellbore component is left downhole.

2. The method of claim 1, wherein the logging tool (15) is connected to said component (9) in said selected relationship.

3. The method of claim 1 or 2, wherein the logging tool (15) is operated during lowering of the component (9) with the logging tool in said selected relationship, through the wellbore (1) to said section of the wellbore.

4. The method of any one of claims 1-3, wherein the logging tool (15) is operated when the logging tool is located in said section of the wellbore (1).

5. The method of any one of claims 1-4, wherein said component (9) forms a tubular element and the logging tool (15) is at least partly arranged within the tubular element.

6. The method of claim 5, wherein the logging tool (15) is connected to the inner surface of the element (9) at a selected side thereof, said side corresponding to a section of the earth formation (3) to be logged.

7. The method of claim 5 or 6, wherein the logging tool (15) is arranged within a retaining device attached to the inner surface of the tubular element.

8. The method of claim 7, wherein the retaining device (27) is a tube made of a fibre-reinforced material.

9. The method of claim 8, wherein the fibre-reinforced material is selected from glass fibre-reinforced epoxy and fibre-reinforced cement.

10. The method of any of claims 1-9, wherein the logging tool (15) includes at least one of a gamma ray logging device (17), a density logging device (21), a neutron logging device (19), an NMR logging device, a resistivity logging device, a micro resistivity/calliper logging device, a sonic logging device and any other suitable logging device.

11. The method of claim 10, wherein the logging tool (15) includes a plurality of said logging devices arranged in a stacked manner.

12. The method of claim 10 or 11, wherein the component (9) is provided with a window (25) opposite a selected one of said logging devices.

13. The method of claim 12, wherein said window (25) is filled with a material suitably transparent to the logging tool signal.

14. The method of claim 13 wherein said material is selected from fibre reinforced plastic, glass fibre reinforced epoxy and fibre reinforced cement.

15. The method of claim 12, wherein said logging device forms a pad type device extending though the window so as to contact the wellbore wall.

16. The method of any of claims 1-15, wherein the logging data are stored in the logging tool (15) and are transferred to surface by lowering a pump-down latching device (33) into the wellbore (1), the latching device being connectable to the logging tool (15) and being provided with logging data retrieving means (37), pumping the latching device (33) through the wellbore until the latching device is connected to the logging tool, and transferring the logging data via the logging data retrieving means (37) to surface.

17. The method of claim 16, wherein the tubular element (9) is provided with a guide funnel so as to guide the latching device to the logging tool during connecting the latching device (33) to the logging tool.

18. The method of claim 16 or 17, wherein the latching device (33) is provided with logging tool retrieving means, and wherein the logging tool is retrieved to surface using said logging tool retrieving means after measuring said parameter.

19. The method of any of claims 1-18, wherein the wellbore component (9) is selected from a wellbore casing, a wellbore liner, a slotted wellbore liner, an expandable slotted liner, a pre-perforated liner, a wellbore screen, a wire-wrapped screen, and a gravel pack screen.

20. The method of claim 19, wherein the wellbore component (9) forms a wellbore casing having a casing shoe track (11), and wherein the logging (15) tool is at least partly arranged in said casing shoe track.

21. A system for operating a logging tool in a wellbore formed in an earth formation, the wellbore having at least a section which is to be provided with a wellbore component, the system comprising:

- means (27) for arranging the logging tool (15) in a selected relationship relative to said component (9) so that the logging tool is guided by the component through the wellbore during lowering of the component into the wellbore;
- means (5) for lowering the component with the logging tool (15) in said selected relationship, through the wellbore (1) to said section of the wellbore;
- means (23) for operating the logging tool so as to provide logging data of the earth formation surrounding the wellbore; and
- means (37) for transferring the logging data to surface, characterized in that the means for arranging the logging tool (15) relative to said component (9) includes means for retrievably arranging the logging tool relative to said component, and that the system further comprises means (33) for retrieving the logging tool to surface while the wellbore component is left downhole.

22. The method substantially as described hereinbefore with reference to the drawings.

23. The system substantially as described hereinbefore with reference to the drawings.

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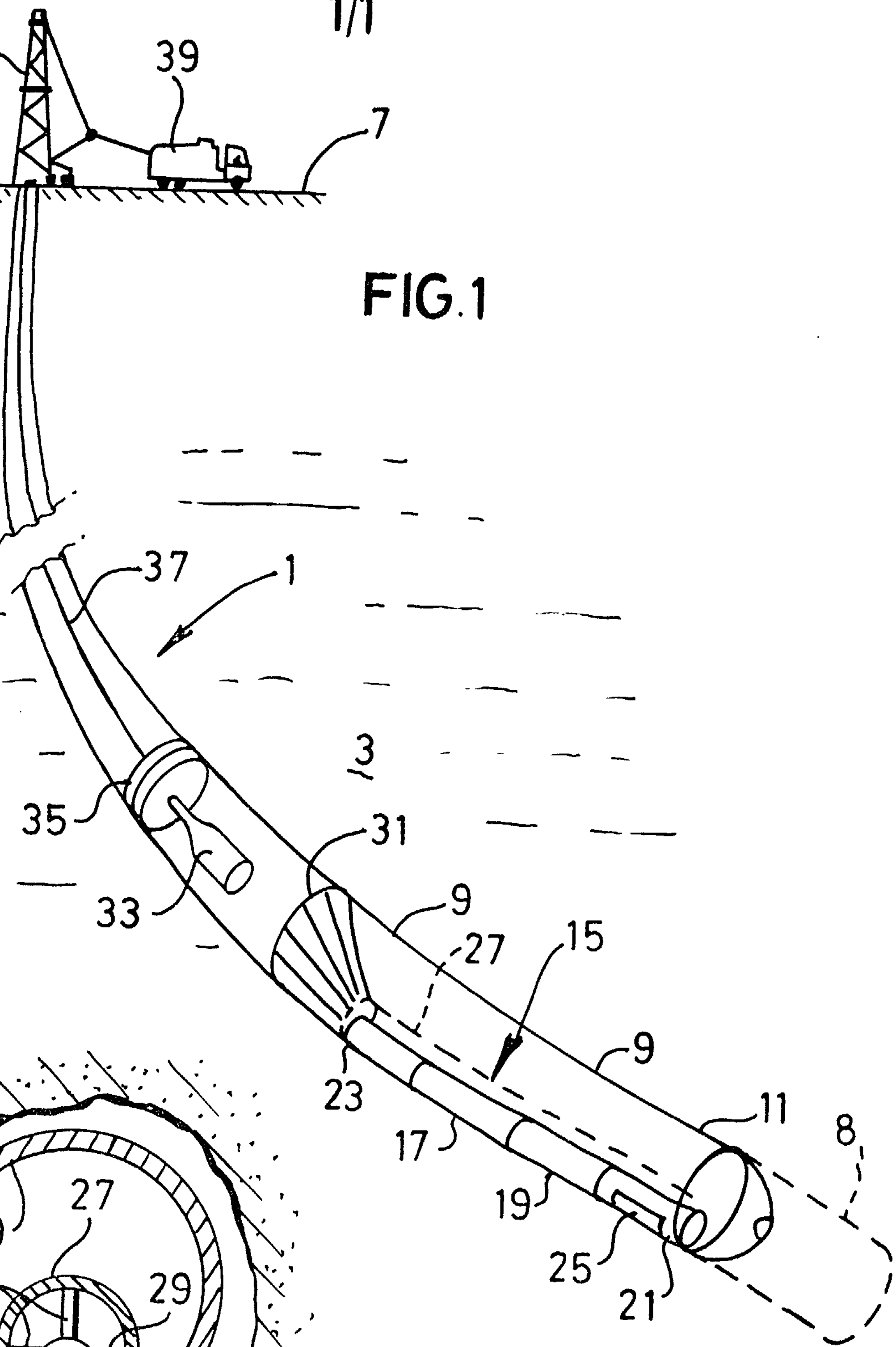

FIG.1

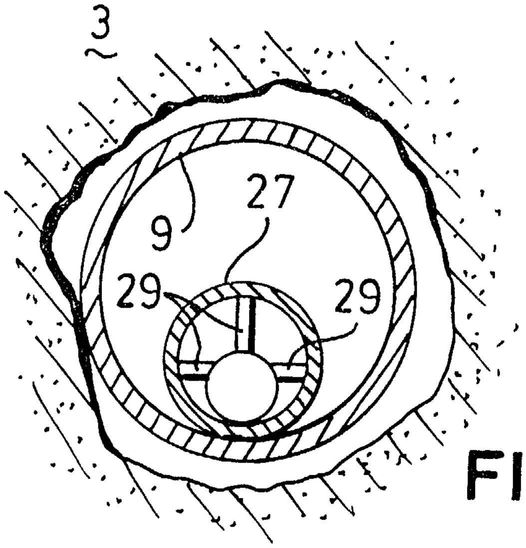

FIG.2