



(86) Date de dépôt PCT/PCT Filing Date: 2002/01/15  
(87) Date publication PCT/PCT Publication Date: 2002/07/25  
(45) Date de délivrance/Issue Date: 2009/08/25  
(85) Entrée phase nationale/National Entry: 2003/07/17  
(86) N° demande PCT/PCT Application No.: EP 2002/000442  
(87) N° publication PCT/PCT Publication No.: 2002/057595  
(30) Priorités/Priorities: 2001/01/18 (EP01200179.8);  
2001/07/03 (US60/302,982)

(51) Cl.Int./Int.Cl. *E21B 47/06* (2006.01),  
*G01N 33/24* (2006.01), *G01N 33/28* (2006.01)  
(72) Inventeur/Inventor:  
HASHEM, MOHAMED NAGUIB, US  
(73) Propriétaire/Owner:  
SHELL CANADA LIMITED, CA  
(74) Agent: SMART & BIGGAR

(54) Titre : MESURE DE LA TEMPERATURE STATIQUE D'UNE FORMATION IN SITU  
(54) Title: MEASURING THE IN SITU STATIC FORMATION TEMPERATURE

(57) **Abrégé/Abstract:**

Measuring the in situ temperature of a formation traversed by a borehole comprising lowering to a predetermined position in the borehole a tool that comprises a central conduit having an inlet an dbeing provided with a temperature sensor in contact with the fluid, means for analysing the fluid, and means for discharging fluid; allowing only formation fluid to pass through the central conduit; analysing the formation fluid; and measuring the temperature when the formation fluid is substantially uncontaminated.

## (12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
25 July 2002 (25.07.2002)

PCT

(10) International Publication Number  
**WO 02/057595 A1**

- (51) International Patent Classification<sup>7</sup>: **E21B 47/06**, 49/10
- (74) Agent: **SHELL INTERNATIONAL B.V.**; Intellectual Property Services, P.O. Box 384, NL-2501 CJ The Hague (NL).
- (21) International Application Number: PCT/EP02/00442
- (81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.
- (22) International Filing Date: 15 January 2002 (15.01.2002)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
01200179.8 18 January 2001 (18.01.2001) EP  
60/302,982 3 July 2001 (03.07.2001) US
- (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- (71) Applicant (*for all designated States except CA, US*): **SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V.** [NL/NL]; Carel van Bylandtlaan 30, NL-2596 HR The Hague (NL).
- Published:**  
— *with international search report*  
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*
- (71) Applicant (*for CA only*): **SHELL CANADA LIMITED** [CA/CA]; 400 - 4th Avenue S.W., Calgary, Alberta T2P 2H5 (CA).
- (72) Inventor; and
- (75) Inventor/Applicant (*for US only*): **HASHEM, Mohamed, Naguib** [US/US]; One Shell Square, 701 Poydras Street, New Orleans, LA 70139 (US).
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

(54) Title: MEASURING THE IN SITU STATIC FORMATION TEMPERATURE

(57) Abstract: Measuring the in situ temperature of a formation traversed by a borehole comprising lowering to a predetermined position in the borehole a tool that comprises a central conduit having an inlet and being provided with a temperature sensor in contact with the fluid, means for analysing the fluid, and means for discharging fluid; allowing only formation fluid to pass through the central conduit; analysing the formation fluid; and measuring the temperature when the formation fluid is substantially uncontaminated.



**WO 02/057595 A1**

63293-3943

-1-

## MEASURING THE IN SITU STATIC FORMATION TEMPERATURE

## Field of Invention

The present invention relates to measuring the in situ static formation temperature in a well during a drilling stage.

## Background

Ceasing circulation also refers to shutting-in the borehole. Ceasing circulation leaves the borehole filled with drilling mud, and the temperature of the drilling mud will in general differ from the temperature of the undisturbed formation.

One way of measuring this temperature is lowering a thermometer into the borehole filled with drilling mud and recording the temperature at a predetermined depth as a function of time ( $\Delta t$ ) after ceasing circulation. The thermometer can be a self-contained recording temperature or a surface-recording thermometer. When the temperature is constant with time, one assumes that this constant temperature is the in situ static formation temperature. However, this method is time consuming.

An improvement of the above-described method is the following method. In this method the temperature is plotted versus  $\log ((t_k + \Delta t) / \Delta t)$ , wherein  $t_k$  is the circulation time and  $\Delta t$  is the time after ceasing circulation. The result is extrapolated to  $\log ((t_k + \Delta t) / \Delta t)$  is substantially equal to zero, which means that the circulation time is negligible compared to the time after ceasing circulation. The extrapolated temperature is then assumed to be the in situ static formation temperature.



63293-3943

-2-

However, mistakes in the circulation time could make a large effect on the extrapolated temperature. Such a mistake is easily made, for example when after completing a drilling stage the driller pulls the drill bit up a couple  
5 of hundreds of meters, and continues circulation for several hours to clean the bit before shutting in the borehole. In which case he will report a circulation time that is the sum of the circulation time needed to drill the particular stage and the time required for cleaning the drill bit. Whereas in  
10 order to evaluate the temperature record, the circulation time should be the circulation time needed to drill the particular stage.

#### Summary

It is an object of some embodiments of the present  
15 invention to provide a more accurate measurement of the in situ static temperature.

To this end according to the present invention, there is provided a method of measuring the in situ static temperature of a formation traversed by a borehole according  
20 to the present invention comprises the steps of a) lowering to a predetermined position in the borehole a tool that comprises a central conduit having an inlet and being provided with a temperature sensor in contact with a fluid, means for analysing the fluid, and means for discharging  
25 fluid; b) making an exclusive fluid communication between the formation and the inlet of the central conduit; c) allowing formation fluid to pass through the central conduit; d) analysing the formation fluid; and e) measuring the temperature continuously until when the formation fluid

63293-3943

-2a-

is substantially uncontaminated, and determining the in situ static temperature of the formation as the temperature of the substantially uncontaminated formation fluid.

#### Detailed Description

5           The invention will now be described in more detail. The first step of the method of measuring the in situ static temperature of a formation traversed by a borehole according to the present invention is lowering to a predetermined position in the borehole a tool that comprises  
10 a central conduit having an inlet and being provided with a temperature sensor in contact with the fluid, means for analysing the fluid, and means for discharging fluid. The predetermined position can be the bottom of the borehole, or a position in a formation

- 3 -

layer of which the in situ static formation temperature is to be measured. The tool is lowered into the borehole by means of for example a wireline.

5 Then an exclusive fluid communication is made between the formation and the inlet of the central conduit. In order to make the exclusive fluid communication, a probe is extended into the formation, wherein the outlet of the probe is in direct fluid communication with the inlet of the central conduit of the tool. Because the inlet of the  
10 probe is located in the formation, drilling mud present in the borehole cannot enter into the central conduit, an exclusive fluid communication is made between the formation and the inlet of the central conduit and thus the wellbore fluids are isolated.

15 Then formation fluid is allowed to pass through the central conduit. This is done with the aid of a pump, sucking the formation fluid via the probe into the central conduit and discharging the formation fluid from the central conduit. It will be understood that during  
20 drilling of the borehole, drilling mud will invade the formation. Therefore, when formation fluid is withdrawn, first drilling mud will be withdrawn, then a mixture of drilling mud and original formation fluid and finally uncontaminated formation fluid.

25 As it passes through the central conduit, the formation fluid is analysed to determine its composition.

Then the temperature is measured continuously until the formation fluid is substantially uncontaminated. Applicant had found that the temperature of the  
30 uncontaminated formation fluid is not just a temperature of a liquid, but it is precisely the in situ static formation temperature.

In practice both the temperature and the composition will be recorded, and the in situ static formation



- 4 -

temperature is the temperature that belongs to the substantially uncontaminated formation fluid.

Because in the method of the present invention the temperature of the uncontaminated formation fluid is measured, this method is more accurate than the known methods.

Moreover, the method according to the present invention can be carried out with a tool that is used to take samples of the formation fluids. Such a tool is for example the Modular Dynamics Formation Tester tool from Schlumberger. This tool also contains an accurate thermometer used to calibrate a pressure sensor, and the output of the accurate thermometer can be used in the method of the present invention. Other suitable tools known in the art are the repeat dynamic tester from Halliburton and the reservoir characterization instrument from Western Atlas.

In case the hydrocarbon reservoir fluid is a so-called heavy oil that is relatively viscous, it will be difficult to acquire a representative sample of the reservoir fluid. In order to obtain a representative sample, the step of making an exclusive fluid communication further includes activating a heating device arranged near the probe to heat the formation fluid.

Suitably, the probe is associated with a packer pad in an assembly, and the heating device is placed in the packer pad. Alternatively the heating device is arranged on the tool. The heating device may be a device generating microwaves, light waves or infrared waves. The heating device may also be an electrical heater, a chemical heater or a nuclear heater.

The method of the present invention can as well be applied in a cased borehole. In this case the step of lowering the tool into the borehole comprises two steps.

- 5 -

At first a perforation set is made through the casing wall into the formation at a location where the temperature needs to be established, wherein the perforation set comprises at least one perforation extending into the formation layer. Then the tool is lowered into the cased borehole. The tool is further provided with an upper and a lower packer arranged at either side of the inlet of the central conduit, wherein the central conduit opens below the lower packer or above the upper packer, and wherein the distance between the upper and the lower packer is larger than the height of a perforation set.

Making an exclusive fluid communication then comprises setting the packers so that the perforation set is straddled between the packers.



63293-3943

-6-

CLAIMS:

1. A method of measuring the in situ static temperature of a formation traversed by a borehole, which method comprises the steps of

5 a) lowering to a predetermined position in the borehole a tool that comprises a central conduit having an inlet and being provided with a temperature sensor in contact with a fluid, means for analysing the fluid, and means for discharging fluid;

10 b) making an exclusive fluid communication between the formation and the inlet of the central conduit;

c) allowing formation fluid to pass through the central conduit;

d) analysing the formation fluid; and

15 e) measuring the temperature continuously until when the formation fluid is substantially uncontaminated, and determining the in situ static temperature of the formation as the temperature of the substantially uncontaminated formation fluid.

20 2. The method according to claim 1, wherein making an exclusive fluid communication between the formation and the inlet of the central conduit comprises extending into the formation a probe having an outlet that is in direct fluid communication with the inlet of the central conduit of the  
25 tool.

3. The method according to claim 2, wherein making an exclusive fluid communication further includes activating a

63293-3943

-7-

heating device arranged near the probe to heat the formation fluid.

4. The method according to claim 1, wherein the formation is traversed by a cased borehole, wherein step a)  
5 comprises:

a1) making a perforation set through the casing wall into the formation at a location where the temperature needs to be established;

a2) lowering the tool into the borehole to the  
10 perforation set, which tool is further provided with an upper and a lower packer arranged at either side of the inlet of the central conduit, wherein the central conduit opens below the lower packer or above the upper packer, and wherein the distance between the upper and the lower packer  
15 is larger than the height of a perforation set, and wherein step b) comprises setting the packers so that the perforation set is straddled between the packers.

SMART &amp; BIGGAR

OTTAWA, CANADA

PATENT AGENTS