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(54) Title: WELLBORE SURVEYING

(57) Abstract: This invention relates to surveying wellbores. In particular this invention provides methods of correcting magnetic surveys for the effects introduced by magnetic mud. The method of the present invention comprises, in broad terms, measuring gravitational and magnetic fields at least one position in the wellbore; comparing the measured fields with theoretical values, and introducing scale factors to adapt the measured values to equal the theoretical values thus making it possible to cope with the effects of magnetic mud.



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Wellbore Surveying

The present invention relates to wellbore surveying, and more particularly,
5 relates to measurement while drilling surveys using magnetic and gravitational
vectors. The invention particularly relates to measurement while drilling surveys
when the wellbore is being drilled with magnetic mud.

Measurement while drilling (MWD) surveys are carried out by making
downhole measurements of the earth's gravitational and magnetic vector. The earth's
10 magnetic field is generally defined in terms of its components in the coordinate
system of the survey tool. The central axis running longitudinally along the tool is
designated the z-axis. Perpendicular to one another and also to the z-axis are the x-
and y-axes.

In view of the fact that the magnetic field along the axis of the wellbore is
15 frequently corrupted, primarily due to the presence of magnetic materials in the drill
string, MWD surveys commonly take measurements of the earth's gravitational
vector and only the cross-axial components of the magnetic field (US 4,510,696).
This system involves determining the inclination and highside angles by measuring
the gravity vector at the instrument, and determining the magnetic field along the axis
20 of the borehole by minimising the difference between the true value of the earth's
magnetic field and the tool measured value of the earth's magnetic field, resulting in
more accurate azimuth angle calculations.

WO 02/50400 describes a method for determining magnetometer errors during
a wellbore survey, in order to obtain an azimuth relative to true North. The method
25 involves correcting for bias errors in magnetometer measurements of the earth's
magnetic field which may be caused by magnetization of ferromagnetic portions of
the drillstring.

GB 2 158 587 describes a method for the correction of errors in azimuth
determination resulting from variations in the earth's magnetic field, specifically
30 those variations caused by the drillstring.

Magnetization of the collar results in a cross-axial interference, which is
indistinguishable from a cross-axial bias. US 5,806,194 discloses a method to deal
with this type of interference, which involves using a number of measurements and

measuring locations. Variations in the measurements are used to estimate the cross-axial interference, which gives an improved estimate of the azimuth angle.

The above and other prior art methods rely on measurement of geomagnetic field data indicative of the direction and intensity of the geomagnetic field in the area of the borehole. Such methods do not take into account local crustal anomalies and time dependent variations in the earth's geomagnetic field.

US 6,021,577 describes a method whereby spot measurements of the earth's geomagnetic field are taken at local measurement sites in the proximity of the wellbore, during drilling. The sites are sufficiently close for the data to be indicative of the geomagnetic field at the wellbore itself, but sufficiently distant such that the results are not affected by the magnetic interference caused by the drilling machinery and other installations. This method is known as Interpolated In-Field Referencing (IIFR).

The industry has recently started using drilling muds which contain a high content of magnetic materials, such as magnetite, ilmenite with iron impurities, or hematite with iron impurities. It is well known that when a magnetic mud surrounds a surveying tool, the cross-axial component of the magnetic field, as measured by the survey tool, is reduced (see, e.g. Electromagnetic Theory, Julius Adams Stratton, McGraw Hill Book Company, New York, 1941, page 265). The reduction in the cross-axial component of the magnetic field can result in significant surveying errors.

This screening of the field also changes the magnetic dip angle, δ . The magnetic dip angle, δ , is given by:

$$\delta = \sin^{-1} \left(\frac{\vec{B} \cdot \vec{g}}{B \cdot g} \right)$$

25

Where: $\vec{B}$ is the magnetic field vector; $B = |\vec{B}|$;

$\vec{g}$ is the gravitational field vector; $g = |\vec{g}|$;

and where the component of $\vec{B}$ along the tool axis is estimated by using the magnitude of the cross-axial field and the total field magnitude, obtained using either

the standard model to calculate the Earth's magnetic field for a specified location, IFR (in-field referencing) or IIFR (interpolated in-field referencing – US 6,021,577).

Since the measured cross-axial field magnitude is in error, the calculated dip angle is also in error. This leads to surveying errors. As with the magnitude of the magnetic field, the magnetic dip angle, *in situ*, can be estimated using, for example,
5 standard global geomagnetic model, IFR or IIFR.

The prior art methods of overcoming cross axial interference have not been able to cope with the effects of magnetic mud. Accordingly, it is an object of the present invention to provide a method for reducing or overcoming the limitations of the prior art, and specifically, to provide a method of MWD which corrects for the
10 effects introduced by magnetic mud.

In broad terms, the present invention provides a method of correcting magnetic surveys for the effects introduced by magnetic mud. The invention enables the detection and correction of the shielding effect of the magnetic mud.

According to a first aspect of the present invention there is provided a method of surveying a wellbore containing magnetic mud, comprising the steps of: obtaining theoretical data regarding the field strength and dip angle of the earth's magnetic field in the proximity of the wellbore; obtaining measured data from at least one station within the wellbore using at least one set of magnetometers and at least one set of
15 accelerometers positioned in the wellbore; and, applying a correction to the measured data to correct the survey for the shielding effect of the magnetic mud.

The method of the present invention comprises, in broad terms, measuring gravitational and magnetic fields at at least one station in the wellbore; comparing the measured fields with theoretical values, and introducing scale factors to adapt the measured values to equal the theoretical values thus making it possible to cope with
20 the effects of magnetic mud.

Preferably the theoretical values of the earth's magnetic field are obtained from a location remote from the wellbore. Preferably the theoretical values are obtained using IFR or IIFR.

The method comprises the steps of calculating the highside angle and the inclination angle. Preferably, the highside angle is calculated from the accelerometer output using:
30

$$hsg = \tan^{-1} \left(\frac{gy}{-gx} \right)$$

wherein hsg is the highside angle, and gx and gy are the accelerometer outputs on the x and y axis respectively.

- 5 Preferably the inclination angle is calculated from the accelerometer output using:

$$inc = \tan^{-1} \left(\frac{(gx^2 + gy^2)^{0.5}}{gz} \right)$$

- 10 wherein inc is the inclination angle, and gx , gy and gz are the accelerometer outputs on the x, y and z axes respectively.

The invention comprises two important embodiments.

- In a first embodiment the method uses data obtained from multiple stations at varying highside angles to determine the biases and scale factors of the three orthogonal downhole magnetometers, and it uses these errors to correct the tool
15 measurements. This is an iterative technique that models the sensitivity of all the error sources as functions of highside, inclination and azimuth.

- The method of this embodiment comprises obtaining data from a plurality of stations downhole. Preferably data is obtained from at least 5 stations. More preferably, data is obtained from 10 stations. It is to be understood that the higher the
20 number of stations from which data is obtained, the greater the accuracy of the MWD survey. The highside angle at each station will differ.

- At each station data is preferably obtained from at least one set of magnetometers and at least one set of accelerometers. Preferably each set of magnetometers comprises three magnetometers and each set of accelerometers
25 comprises three accelerometers.

The magnetometer output measurements preferably comprise Bx_m , By_m and Bz_m , wherein Bx_m , By_m and Bz_m are the values of the downhole magnetometer on the x, y and z axes respectively.

- Preferably the method further comprises the steps of: correcting the measured
30 magnetometer outputs Bx_m , By_m and Bz_m for magnetic interference/biases and shielding effects of the mud using:

5

$$Bx_c = \frac{Bx_m}{1 - Sx} + \Delta Bx$$

$$By_c = \frac{By_m}{1 - Sy} + \Delta By$$

5

$$Bz_c = Bz_m + \Delta Bz$$

wherein Bx_c , By_c and Bz_c are magnetometer outputs corrected for biases and scaling errors, ΔBx , ΔBy and ΔBz are the magnetometer biases on the x, y and z axes respectively, and Sx , Sy are the magnetometer scaling errors on the x and y axes respectively.

The method of this embodiment may further comprise the step of calculating the measured dip angle. Preferably the measured dip angle is calculated using the vertical and horizontal components of the earth's field as follows:

$$Bv = -Bx_c \cdot \cos(hsg) \cdot \sin(inc) + By_c \cdot \sin(hsg) \cdot \sin(inc) + Bz_c \cdot \cos(inc)$$

$$Bn = \sqrt{(Bx_c^2 + By_c^2 + Bz_c^2)^{1/2} - Bv^2}$$

$$dip = \tan^{-1} \left(\frac{Bv}{Bn} \right)$$

20

wherein Bv is the vertical component of the earth's magnetic field; Bn is the horizontal component of the earth's magnetic field; dip is the tool measured dip angle.

The method may further comprise the step of calculating the total field, Bt . Preferably Bt is calculated using:

25

$$Bt = \sqrt{Bx^2 + By^2 + Bz^2}$$

The method may further comprise the step of using the calculated values of Bt and dip to minimise S . This step may be performed by the "least squares method". This step preferably comprises inputting Be , Bt , $dipe$ and dip into the following algorithm:

30

$$S = \sum_n \left[\left(\frac{Be - Bt}{Be} \right)^2 + \left(\frac{dipe - dip}{dipe} \right)^2 \right]$$

wherein Be and $dipe$ are theoretical values of the earth's magnetic field strength and dip angle respectively, and Bt and dip are as hereinbefore defined; and, varying Sx , Sy , ΔBx , ΔBy and ΔBz in order to minimise S .

5 In the second embodiment of the present invention, it is assumed that the scale factor errors for both of the components of the cross-axial magnetic field (i.e. on the x- and y- axes) are the same. This method is particularly useful where there is a limited amount of data, and it allows for the scale factor error to change at different survey stations.

10 In one embodiment, this method effectively uses the "short collar corrections method" (SCC, US 4,510,696) to determine axial interference. The difference between the magnetic dip angle corrected for axial interference and the theoretical dip angle is minimized by modifying the cross-axial field components (Bx and By) by a common scale factor.

15 The method of this embodiment comprises obtaining accelerometer output and magnetometer output measurements from at least 1 position in the wellbore.

The highside and inclination angles are then calculated as heretofore described, and the azimuth is calculated, preferably by the short collar correction method (azSCC).

20 The method may further comprise the step of calculating Bz_c . Preferably Bz_c is calculated using:

$$Bz_c = Be \cdot \cos(dipe) \cdot \sin(inc) \cdot \cos(azSCC) + Be \cdot \sin(dipe) \cdot \cos(inc)$$

25 wherein Be and $dipe$ are theoretical values of the earth's magnetic field strength and dip angle respectively, and $azSCC$ is the azimuth, as calculated by the short collar correction method.

The method may further comprise the step of correcting Bx and By for biases, and may further comprise the step of calculating Bt and dip . Preferably Bt is calculated using:

30

$$Bt = \sqrt{Bx^2 + By^2 + Bz_c^2}$$

Preferably dip is calculated using:

$$dip = \tan^{-1} \left(\frac{B_v}{B_n} \right)$$

The method may further comprises calculating the value of Δdip . Preferably Δdip is
 5 calculated using:

$$\Delta dip = dipe - dip$$

wherein Δdip is the dip angle bias, and $dipe$ and dip are theoretical values of the
 10 earth's dip angle and the tool measured dip angle respectively.

Preferably the method further comprises the step of minimising Δdip by
 modifying the magnetometer measurements Bx_m and By_m by a shielding factor S . The
 step of minimising Δdip preferably comprises varying S according to the following
 algorithms:

15

$$Bx_c = \frac{Bx_m}{1 - S} \quad By = \frac{By_m}{1 - S}$$

Accordingly the present invention is capable of calculating the magnetometer
 scale factor errors, thereby overcoming or minimising the effects of magnetic mud or
 20 other magnetic materials which exert an effect upon the magnetometers of an MWD
 system downhole.

A theoretical example will now be described, with reference now made to the
 accompanying figures, in which:

FIGURE 1 is a chart depicting the assumed well trajectory (azimuth and
 25 inclination) of a theoretical model for a North Sea location;

FIGURE 2 is a chart depicting the raw (long and short) azimuths and the
 azimuth corrected by the method of the present invention; and

FIGURE 3 is a chart comparing the long and short collar azimuth errors.

This section examines the accuracy of the two embodiments of the invention
 30 used to determine the presence of magnetic shielding.

The first embodiment calculates axial magnetic interference and the individual cross axial biases and scale factor errors by minimising the difference between IFR/IIFR data and tool measured data.

The second embodiment uses an extension of the SCC algorithms to determine a single cross axial scaling error. It assumes that the B_x and B_y magnetometers have identical scale factor errors and constrains the SCC *dip* and B_{total} (B_t) to equal the IFR/IIFR data. This technique has the advantage that data from fewer survey stations are required. However this method can be sensitive to cross axial biases if there is less data or there is insufficient highside variation. Again the accuracy of this technique relies on IFR, or ideally IIFR, data being available.

A theoretical example will now be described. In this theoretical example a North Sea location was assumed, together with magnetometer biases of 140nT, -80nT and 2000nT on B_x , B_y and B_z respectively. A cross axial magnetic shielding value of 2% was modelled. Random noise of +/-0.5milli g and +/-50nT was added to the accelerometer and magnetometer outputs respectively. The assumed well trajectory in shown in Figure 1.

The following error values were calculated:

Error source	Calculated error	
	mean	Std. dev.
ΔB_x (nT)	131	12
ΔB_y (nT)	-85	21
ΔB_z (nT)	1997	35
S_x (%)	-2.048	0.152
S_y (%)	-2.065	0.183
S_{xy} (%)	-1.962	0.382

20

Note that the calculated value of S_{xy} is slightly less accurate and noisier. This is a consequence of the cross axial biases affecting the accuracy of the extended SCC technique. However the accuracy of S_{xy} could be improved by correcting for the cross axial biases.

The raw (long and short collar) azimuths and the corrected azimuth are shown in Figure 2. The azimuth error is illustrated in Figure 3.

It will be appreciated that the invention can be modified.

Claims

1. A method of surveying a wellbore containing magnetic mud, comprising the steps of: obtaining theoretical data regarding the field strength and dip angle of the earth's magnetic field in the proximity of the wellbore; obtaining measured data from at least one position from within the wellbore using at least one set of magnetometers and at least one set of accelerometers positioned in the wellbore; and, applying a correction to the measured data to correct the survey for the shielding effect of the magnetic mud.

10

2. A method according to claim 1, comprising the steps of calculating the highside angle and the inclination angle.

3. A method according to claim 2, wherein the highside angle is calculating from the accelerometer output using the following algorithm:

15

$$hsg = \tan^{-1} \left(\frac{gy}{-gx} \right)$$

wherein: hsg is the highside angle, and

gx and gy are the accelerometer outputs on the x and y axis

20 respectively.

4. A method according to claim 2 or 3, wherein the inclination angle is calculated from the accelerometer output using the following algorithm:

$$inc = \tan^{-1} \left(\frac{(gx^2 + gy^2)^{0.5}}{gz} \right)$$

25 wherein: inc is the highside angle, and

gx , gy and gz are the accelerometer outputs on the x, y and z axes respectively.

5. A method according to claim 1, 2, 3 or 4, comprising the step of obtaining accelerometer output and magnetometer output measurements from at least 5 stations in the wellbore.

30

6. A method according to claim 1, 2, 3, 4 or 5, comprising the step of obtaining accelerometer output and magnetometer output measurements from 10 stations in the wellbore.

5 7. A method according to claim 5 or 6, wherein said magnetometer output measurements comprise Bx_m , By_m and Bz_m .

8. A method according to claim 7, further comprising the steps of: correcting the measured magnetometer outputs Bx_m , By_m and Bz_m for magnetic interference/biases
10 and shielding effects of the mud using the following algorithms:

$$Bx_c = \frac{Bx_m}{1 - Sx} + \Delta Bx$$

$$By_c = \frac{By_m}{1 - Sy} + \Delta By$$

15

$$Bz_c = Bz_m + \Delta Bz$$

wherein: Bx_c , By_c and Bz_c are magnetometer outputs corrected for biases
20 and scaling errors,
 ΔBx , ΔBy and ΔBz are the magnetometer biases on the x, y and z axes respectively, and
 Sx , Sy are the magnetometer scaling errors on the x and y axes respectively.

25

9. A method according to claim 8, further comprising the step of: calculating the measured dip angle using the vertical and horizontal components of the earth's field using the following algorithms:

$$Bv = -Bx_c \cdot \cos(hsg) \cdot \sin(inc) + By_c \cdot \sin(hsg) \cdot \sin(inc) + Bz_c \cdot \cos(inc)$$

30

$$Bn = \sqrt{(Bx_c^2 + By_c^2 + Bz_c^2)^{1/2} - Bv^2}$$

$$dip = \tan^{-1} \left(\frac{Bv}{Bn} \right)$$

wherein: B_v is the vertical component of the earth's magnetic field;
 B_n is the horizontal component of the earth's magnetic field;
 dip is the tool measured dip angle.

5

10. A method according to claim 9, further comprising the step of calculating the total, B_t .

11. A method according to claim 10, wherein B_t is calculated using the following
 10 algorithm:

$$B_t = \sqrt{B_x^2 + B_y^2 + B_z^2}$$

12. A method according to claim 10 or 11, further comprising the step of using the
 15 calculated values of B_t and dip to minimise S .

13. A method according to claim 12, wherein the step of using the calculated values of B_t and dip to minimise S comprises inputting B_e , B_t , $dipe$ and dip into the following algorithm:

20

$$S = \sum_n \left[\left(\frac{B_e - B_t}{B_e} \right)^2 + \left(\frac{dipe - dip}{dipe} \right)^2 \right]$$

wherein: B_e and $dipe$ are theoretical values of the earth's magnetic field strength and dip angle respectively, and
 25 B_t and dip are as hereinbefore defined,

and varying S_x , S_y , ΔB_x , ΔB_y and ΔB_z in order to minimise S .

14. A method according to any preceding claim, wherein each set of
 30 magnetometers comprises three magnetometers, and each set of accelerometers comprises three accelerometers.

15. A method according to claim 1, 2, 3 or 4, comprising the step of obtaining accelerometer output and magnetometer output measurements from at least 1 position in the wellbore.

5 16. A method according to claim 15, further comprising the step of calculating Azimuth (azACC) by the short collar correction method.

17. A method according to claim 16, further comprising the step of calculating Bz_c .

10

18. A method according to claim 17, wherein Bz_c is calculated using:

$$Bz_c = Be \cdot \cos(dipe) \cdot \sin(inc) \cdot \cos(azSCC) + Be \cdot \sin(dipe) \cdot \cos(inc)$$

15 wherein: Be and $dipe$ are theoretical values of the earth's magnetic field strength and dip angle respectively, and
 $azSCC$ is the azimuth, as calculated by the short collar correction method.

20 19. A method according to claim 17 or 18, further comprising the step of correcting Bx and By for bias errors.

20. A method according to claim 17, 18 or 19, further comprising the step of calculating Bt and dip .

25

21. A method according to claim 20, wherein Bt is calculated using the following algorithm:

$$Bt = \sqrt{Bx^2 + By^2 + Bz_c^2}$$

30

22. A method according to claim 20 or 21, wherein dip is calculated using the following algorithm:

$$dip = \tan^{-1} \left(\frac{B_v}{B_n} \right)$$

23. A method according to claim 20, 21 or 22, further comprising calculating the value of Δdip .

5

24. A method according to claim 23, wherein Δdip is calculated using:

$$\Delta dip = dipe - dip$$

10

wherein: Δdip is the dip angle bias, and
 $dipe$ and dip are theoretical values of the earth's dip angle and
the tool measured dip angle respectively.

25. A method according to claim 23 or 24, further comprising the step of
15 minimising Δdip by modifying the magnetometer measurements Bx_m and By_m by a
shielding factor S.

26. A method according to claim 25, wherein the step of minimising Δdip
comprises varying S according to the following algorithms:

20

$$Bx_c = \frac{Bx_m}{1 - S} \quad By = \frac{By_m}{1 - S}$$

27. A method according to any preceding claim, wherein the theoretical data
regarding the earth's magnetic field is obtained from a location remote from the
wellbore.

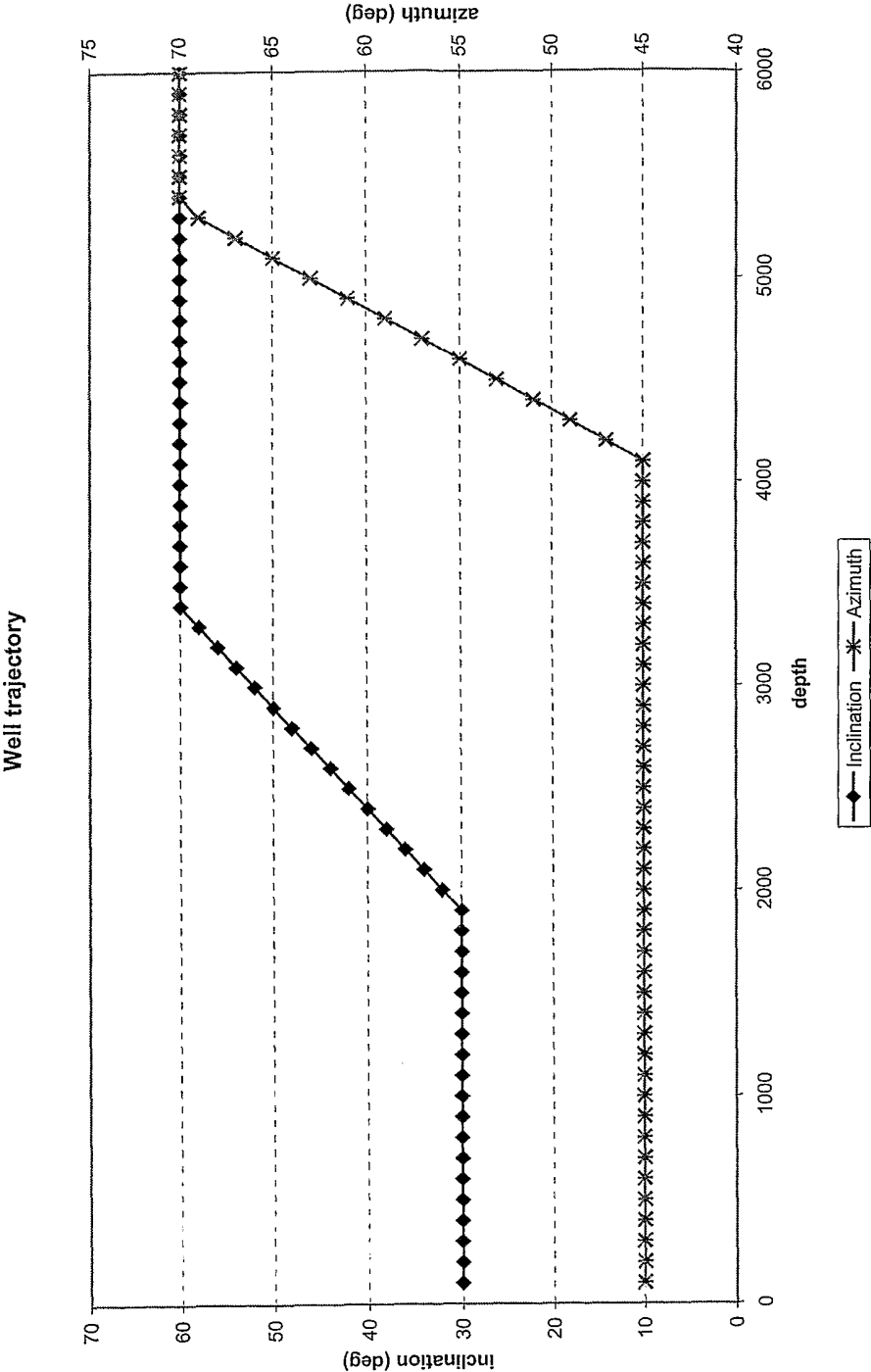
25

28. A method according to any preceding claim, wherein the theoretical data
regarding the earth's magnetic field is obtained by IFR or IIFR.

29. A method of surveying a wellbore substantially as herein described.

30

Figure 1



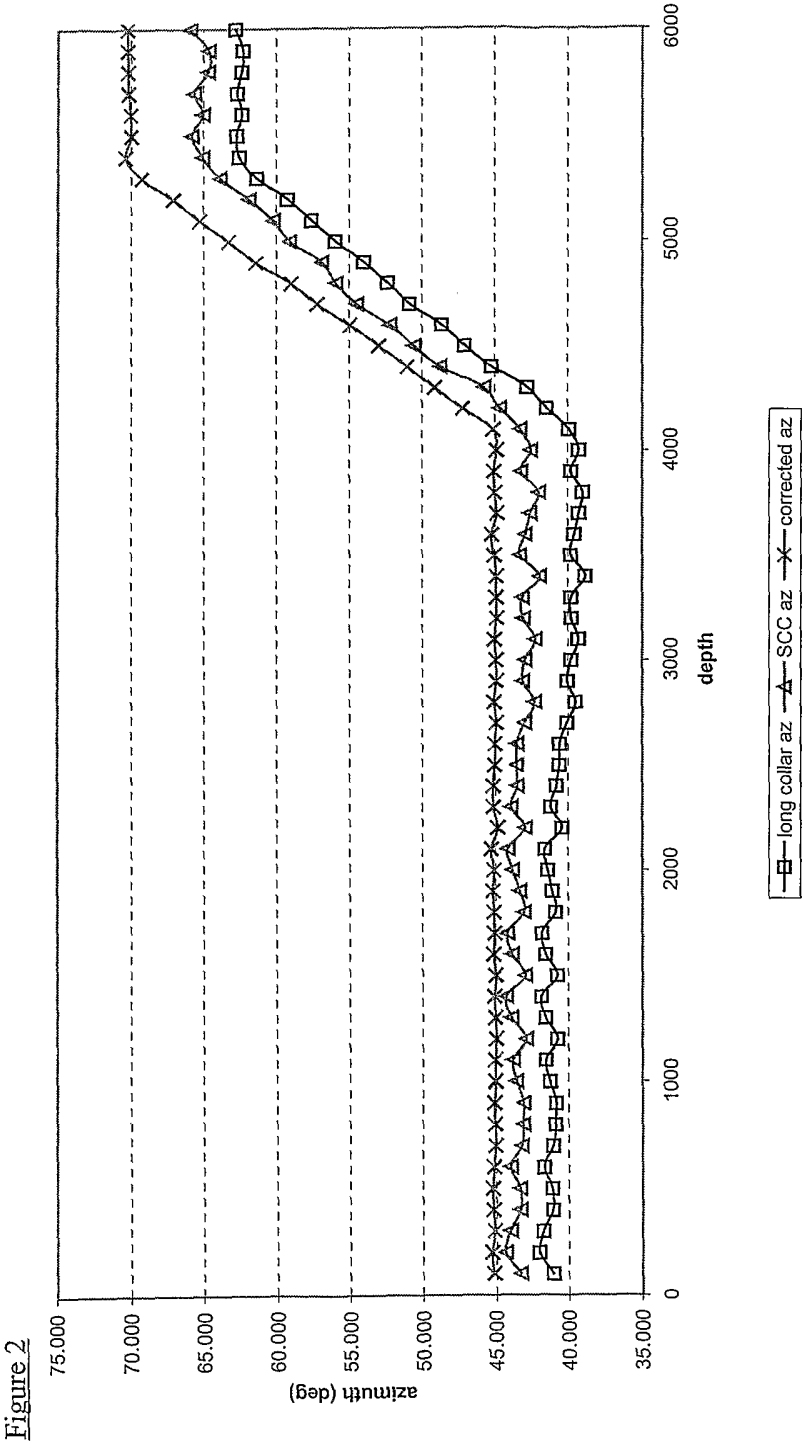
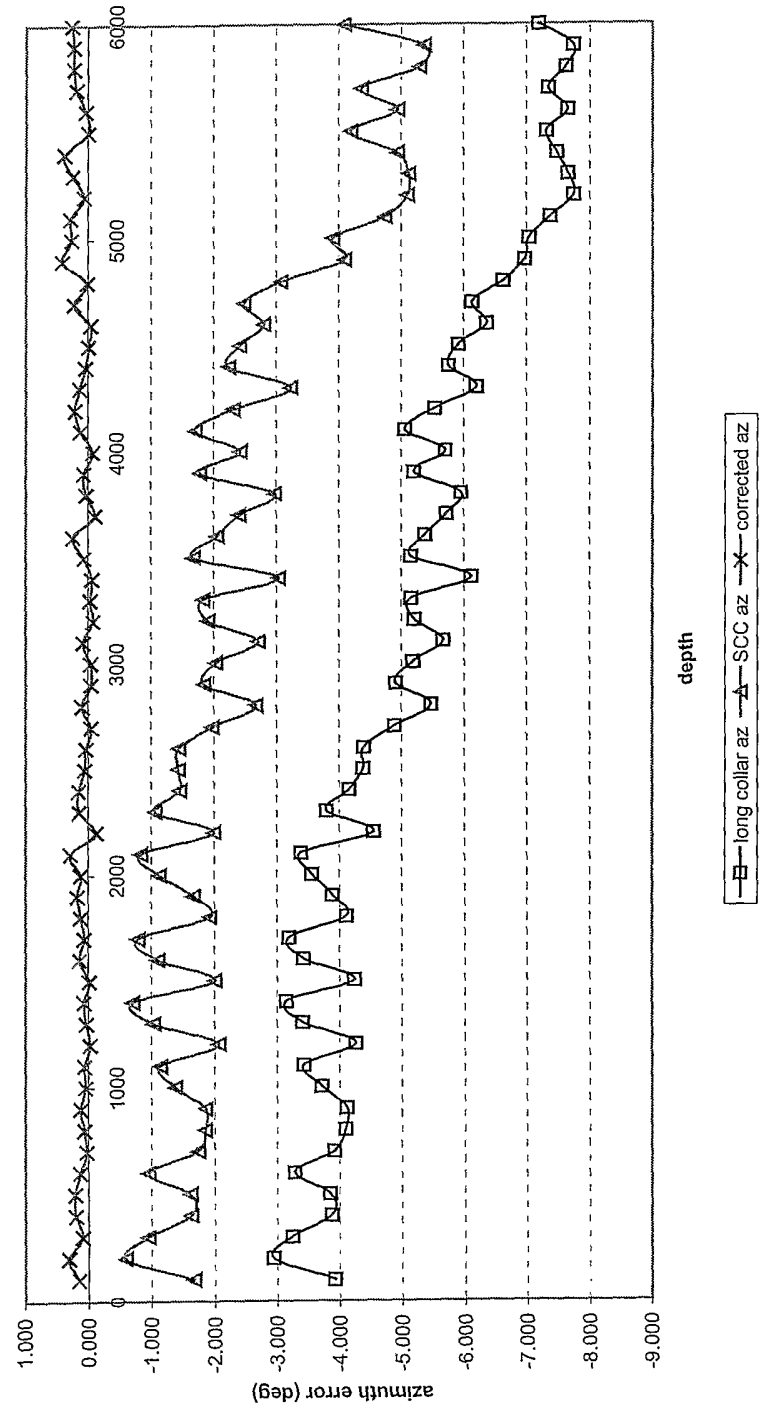


Figure3



INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 E21B47/022

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, TULSA, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	HARRY WILSON ET AL: "Wellbore Position Errors Caused by Drilling Fluid Contamination" SPE 71400, 30 September 2001 (2001-09-30), pages 1-8, XP002339637 the whole document	1
A	EP 0 793 000 A (HALLIBURTON COMPANY; HALLIBURTON ENERGY SERVICES, INC) 3 September 1997 (1997-09-03) page 7, lines 1-3 claim 1	1
A	TORGEIR TORKILDSEN ET AL: "Drilling Fluid affects MWD Magnetic Azimuth and Wellbore Position" SPE 87169, 2 March 2004 (2004-03-02), pages 1-8, XP002339638 the whole document	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0793000	A	03-09-1997	GB 2301438 A	04-12-1996
			EP 0793000 A2	03-09-1997
			NO 961966 A	18-11-1996