In-Field Referencing Service

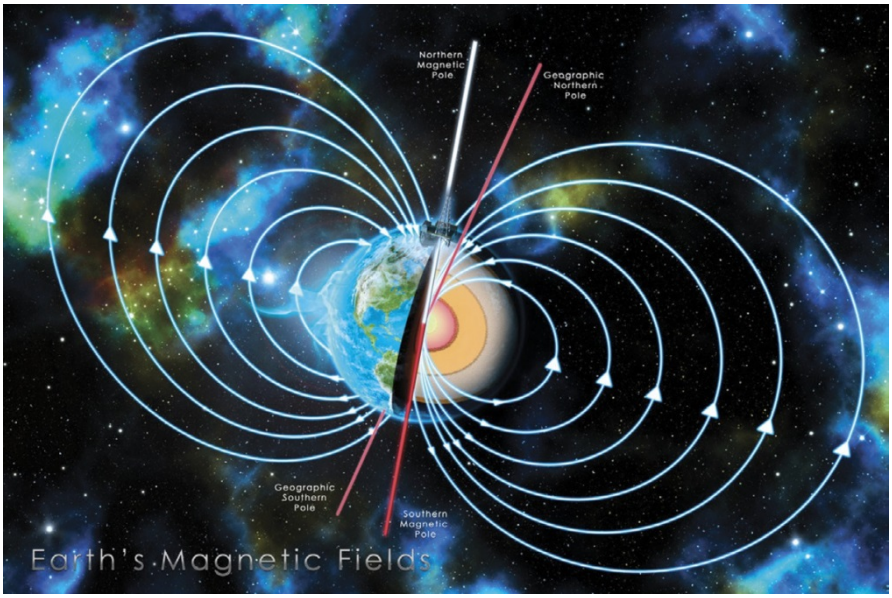
Evaluates the influence of the Earth's magnetic field on local geology at the wellsite

Applications

- Determining the strength, declination angle, and dip angle of Earth's magnetic field over the oil field to improve accuracy of measurement-while-drilling (MWD) surveys
- Serves as a prerequisite for multistation analysis

Features and Benefits

- Delivers precise geomagnetic data that improves the accuracy of MWD surveys by 20 to 30% compared to conventional methods
- Enhances reservoir modeling, helps to optimize reservoir drainage, informs well contingency planning, and mitigates the risk of well collisions
- Reduces the need for gyroscopic surveying
- Provides a geophysical in-field referencing (IFR) report and an electronic IFR map of the entire field that become the full property of the client. Subsequent corrections based on existing and future wells can be made by third-party companies, and there are no per-well charges.
- Provides accompanying software that enables the client to access the survey data, including reference values, at the wellhead. By applying reference values to MWD data, the user can produce an IFR correction to the wellbore positional survey measurements.



The IFR service provides precise measurements of the Earth's magnetic field that improve the accuracy of MWD surveys by up to 30%.

Tool Description

The Weatherford IFR service improves the accuracy of borehole surveys compared to conventional methods by taking precise, direct-vector measurements of Earth's magnetic field from the oil field. Unlike the global magnetic models commonly used as the basis for downhole MWD surveys, the IFR service characterizes the local magnetic effects of Earth's crustal field. By providing precise data on the strength and direction of Earth's magnetic field around the oil field, the IFR service reduces uncertainty and eliminates a major source of errors in downhole MWD surveys.

Weatherford magnetic survey specialists measure the strength, declination angle, and dip angle of Earth's magnetic field over the oil field. By measuring declination and dip directly, rather than inferring the values from total-field values, the IFR service provides more accurate data than an aeromagnetic survey with a smaller footprint.

When deploying the IFR service in onshore fields, Weatherford transports the necessary equipment—a theodolite, a total-field magnetometer, a precision GPS survey, and associated power and computers—in a truck and hand-carries it to the wellsite.

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Tool Description (continued)

For fields that have rough terrain or are otherwise difficult to survey accurately from the ground, Weatherford deploys the MAGMA™ air data acquisition system. The MAGMA air system includes a specially designed pod that carries a rigid chassis to support the magnetometers and a GPS internal-attitude reference system. The pod is suspended below a helicopter and flown over the survey area.

The MAGMA system can also be deployed offshore. The MAGMA marine system includes a catamaran tail buoy that carries the same rigid sensor chassis used in the MAGMA air system. The MAGMA marine system can be operated from a standard survey or field-supply vessel.

Specifications

IFR Corrections*

Total field	±100 nT
Declination angle	±0.15º
Dip angle	±0.10º

* Survey accuracy may be reduced in very magnetically anomalous areas. Figures are at 1 standard deviation.

Land Survey System Specifications

Magnetic total-field measurement system	Proton or Overhauser magnetometer
Magnetic vector measurement system	Specifically modified WILDT1 steel-free theodolite
Position and orientation system	Trimble R6000 RTK or client-sourced survey
Maximum operating temperature	122°F (50°C)
Minimum operating temperature	5°F (−15°C)

MAGMA Air and Marine System Specifications

Magnetometers		Bartington Mag-03 Triaxial
Attitude and positioning system		Applanix POS MV
IFR support chassis		Glass-fiber tube
Umbilical		Integrated multicore with MIL spec. connectors
Acquisition system		Beckhoff Industrial PC
Acquisition and processing software		Tech21 Bespoke
Power		Variable, 110 to 220 Vac or 28 Vdc
Umbilical length	air	98 ft (30 m)
	marine	525 ft (160 m)
MAGMA marine tail buoy deployment		Crane or A-frame
MAGMA marine system tail buoy dimensions		11.5 × 4.3 × 2.5 ft (3.5 × 1.3 × 0.75 m)
MAGMA marine system buoy weight		9,705 lb (321 kg)
MAGMA air system pod dimensions		13.1 × 3.3 × 2.6 ft (4 × 1 × 0.8 m)
MAGMA air system pod weight		1,014 lb (460 kg)
Personnel requirements		3 engineers
Survey speed	air	50 knots
	marine	2 to 6 knots
Maximum operating temperature		122˚F (50˚C)
Minimum operating temperature		5˚F (−15˚C)
Maximum sea state		4

In-Field Referencing Service

Weatherford provides IFR service on land, from the air, and at sea.

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A member of the Weatherford service team calibrates the sensors on the rigid chassis of the MAGMA air system pod.

A helicopter prepares to take off with the MAGMA air system pod.

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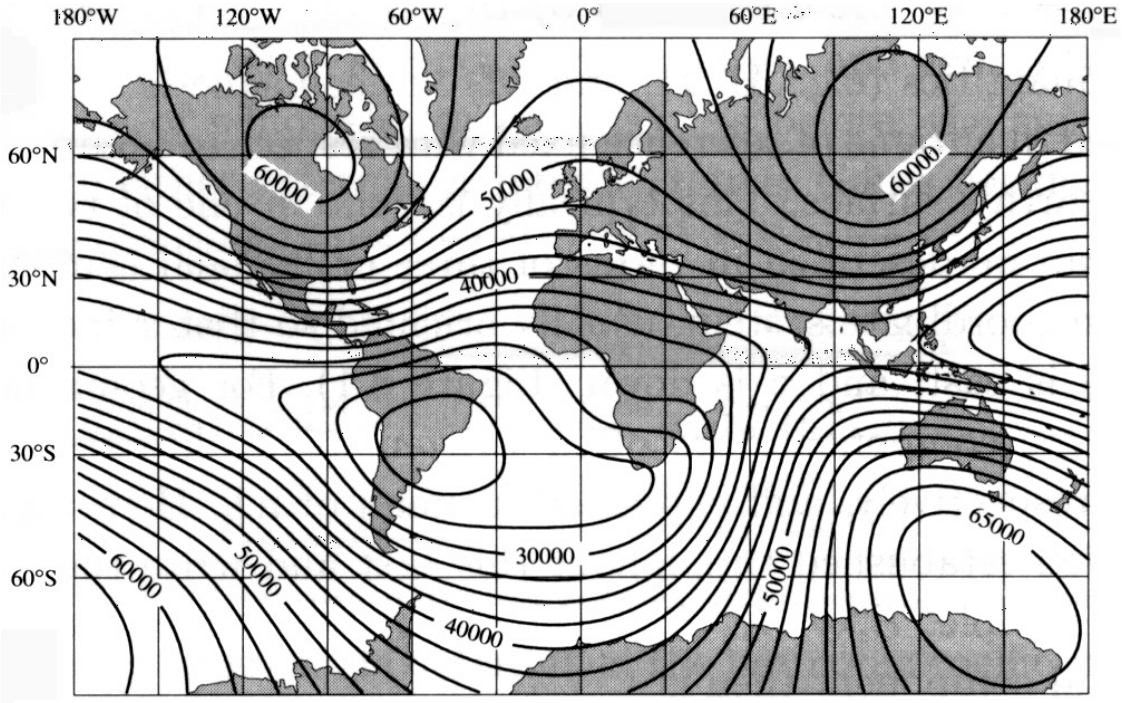

The Earth's magnetic field is subject to three sources of variation. Slow changes in the Earth's core cause secular variations of fractions of a degree per year. Rapid daily variations caused by solar winds and the Earth's rotation are known as diurnal variation and shift the field by about 0.2 degrees. The third, and by far the largest, is crustal variation: permanent local effects caused by deep, magnetic basement rock that can offset the magnetic field by 1 degree or more. IFR service corrections account for crustal variation.

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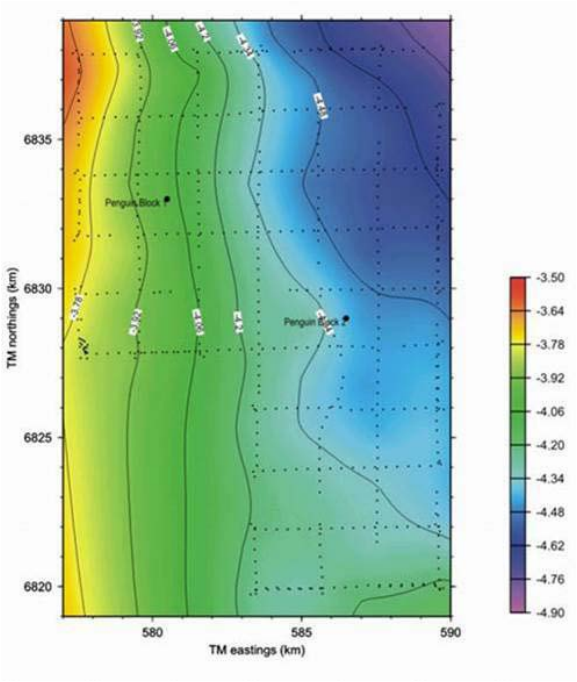
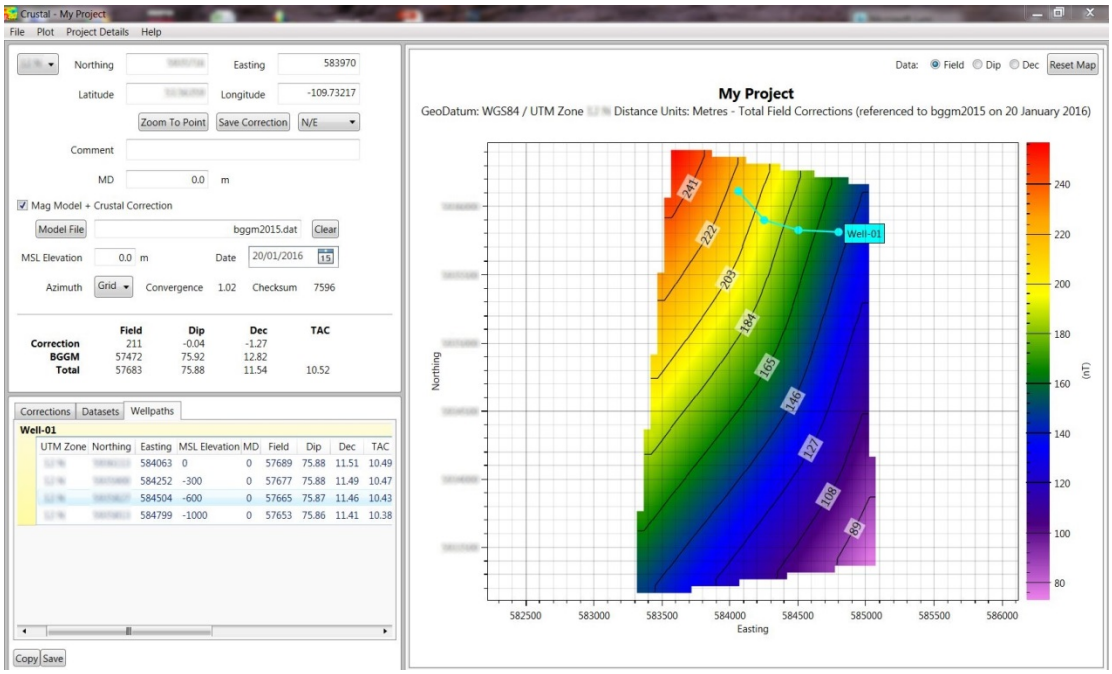


The IFR service produces a map of crustal corrections to the global magnetic model.



The IFR service interprets borehole surveys using the crustal application, which provides corrected values for direct use with well planning software, such as the Weatherford 5D application.