Improved Geomagnetic Referencing in the Arctic Environment

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Challenges of Wellbore Positioning in the Arctic

• Challenges include:
  – Smaller horizontal magnetic field values at high latitudes
  – High inclination limitations
  – Time and expense considerations of gyroscopic surveys

Advances in Geomagnetic Referencing provide a viable alternative.
Geomagnetic Referencing at High Latitudes

• Smaller horizontal component in the Arctic means increased impact from crustal and drillstring magnetic interference

• Geomagnetic field consists of three components:
  – Main Field
  – Crustal Field
  – Disturbance Field

Knowledge of crustal field and real-time data on disturbance field are crucial.
Crustal Field Model

• Important to cover entire wavelength spectrum:
  – Satellite data for long wavelengths, ≥ 250 km
  – Local aeromagnetic surveys for shorter wavelengths

• Strong emphasis on quality control and validation
Crustal Field Model

- Data from various sources are merged
- 3-D magnetic model is generated, showing total field strength
- Laplace’s differential equation is used to estimate field vector
Crustal Field Model

• Data are used to produce 3D maps of crustal residuals starting at mean sea level to maximum drilling TVD for:
  – Declination
  – Dip
  – Total magnetic intensity
Magnetic Observatory Data

• Deadhorse Observatory:
  – Established March 2010 at Prudhoe Bay
  – Collaboration with USGS
  – Certified as INTERMAGNET Observatory in 2012
Magnetic Observatory Data

• Additional real-time data:
  – USGS observatories in Barrow and College
  – Provide unique visualization of geomagnetic field during active periods
  – High level of spatial resolution
  – Identical low noise, high resolution instrumentation
Characterizing Maximum Magnetic Disturbance Field

- Solar Maximum characterization (11 years cycle)
- Based on 1-minute averaged measurements from two observatories from 1995 to present
- Residual values transformed into declination, dip, total field
Declination During Magnetic Storms

- Large magnetic storm occurred June 1, 2013
- Declination differs significantly over small geographic separation of observatories.
Applying Higher Frequency Observatory Data

• Higher frequency data are more useful in describing disturbance fields

• Maximum change exceeds 0.02°/second at all three sites

• Rapid changes can significantly impact drilling operations.
DED versus MWD Reading Comparisons

• Raw MWD measurements of field strength and dip are compared to main field model (green line)

• Erratic nature of points and crossed FAC lines could indicate:
  – MWD tool failure
  – Interference from nearby wellbores
  – Magnetic minerals in mud, magnetic sediments, etc.

Based on comparison with model, drilling ahead would be prohibited.
DED versus MWD Reading
Comparisons

- MDW measurements are compared to DED observatory data
- Close match in data indicates MWD tool is accurate
- DED data is shown to be more accurate than main field model predictions

Based on comparison, drilling ahead would be permitted
Case History—Nikaitchuq Field Exploitation

- Development in two primary surface locations:
  - Coastal Oliktok Point
  - Spy Island offshore

- Drilling program based on alternating producer/injector wells

- Approx. 1,200 ft between each producer and injector to optimize production

Faulting taken into consideration during well planning.
Case History–Nikaitchuq Field Exploitation

- Well lengths and density make minimizing collision risk a challenge
- Incorporating DED observatory data and the North Slope geomagnetic reference model has enabled meeting well placement and anticollision objectives.
Case History–Nikaitchuq Field
Exploitation
Beyond MWD: Applications for Space Weather

- Observatory data can also play a role in diagnosis of space weather conditions
- Large magnetic storms can cause loss of communication, affect GPS accuracy, damage satellite electronics, etc
- One-second observatory data can help compute auroral electrojet index
Summary and Conclusions

• Challenges to MWD in Arctic:
  – Escalating level of solar activity
  – Unmodeled crustal anomalies
  – Complex reservoirs requiring great surveying precision
  – Increased impact of drillstring magnetic interference

• Advanced geomagnetic referencing can meet the challenge:
  – Precise real-time wellbore positioning with MWD
  – Nikaitchuq experience as blueprint for success in other challenging environments
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