Welcome

IADD Topical Forum, featuring 10K+ ERD Wells
Date: February 15 - 16, 2017  Where: OXY; Greenway Plaza; Houston
Speaker Information

- Katie Mills
- Micro Dogleg Detection with Continuous Inclination Measurements and Advanced BHA Modeling (SPE 184074-MS)
- February 16th, 2017
- DrillScan US Inc.
Speaker Bio

- Introduction
  - DrillScan US
  - Experience
    - DrillScan
      - 2 years as Drilling Optimization Engineer
    - SLB Drilling and Measurements
      - 3 years as MWD/DD Mexico Land
      - 1 year as Drilling Engineer GOM Mexico
  - Colorado School of Mines
    - BSc Petroleum Engineering 2011
  - Based in Houston, TX
  - Specialized in drilling mechanics
Outline

- What are micro doglegs?
- Where do micro doglegs come from?
- How do we detect or measure micro doglegs?
- Case Study
- Trajectory Prediction
- Doglegs and Ledges
- Bending Stress
- Conclusion
What are Micro Doglegs?

Tortuosity on a smaller scale which we are not able to detect with standard surveys

Source: SPE-84449
What are Micro Doglegs?

- **Doglegs**
  - Large scale
    - 10-30ft interval
    - Measured over 90ft+ survey interval

- **Micro doglegs**
  - Small Scale
    - 1-5ft interval
    - Must be detected with smaller survey increments
Where do micro doglegs come from?

They are a natural consequence of directional wells.
Where do micro doglegs come from?

They are a natural consequence of directional wells. Even drilling with an RSS, though usually to a lesser extent.
How do we measure or identify micro doglegs?

Two Methods

Continuous Surveying

Computer Modeling

Micro Dogleg Identification
How do we measure or identify micro doglegs?

**Continuous Surveying**

- MWD tools equipped with continuous inclination and azimuth
- Tool used is accurate to ±0.1° after 12° inc
- See the wellpath forming in real-time between surveys
How do we measure or identify micro doglegs?

Trajectory Prediction Model

- Step by step calculation of the BHA propagating through the formation
- Analysis performed post-run or stand by stand

STEP = 3 ft
How do we measure or identify micro doglegs?

**Continuous Surveying**
- Real-time during drilling measurement and evaluation
- Requires pre-planning
- MWD tool with capability must be used

**Computer Modeling**
- Post-drilling analysis or after each stand is drilled
- No pre-planning required
- Post-run data used
Case Study

- Typical Eagle Ford shale well
  - 9 5/8” Shoe at ~4000ft
  - 8 ½” Section
    - Curve with planned DLS ~10deg/100ft
    - 6,000ft+ lateral
    - MD = 16,426ft
    - TVD ~ 9,850ft
  - 7” Motor w/ 2.0° Bend
Trajectory Prediction Model

- Rock-Bit-BHA model using:
  - Drilling parameters
    - Weight on bit (WOB)
  - Slide Sheet
    - Toolface orientation (TFO)
    - Slide/rotate intervals
  - BHA specifications
    - Motor bend angle and position
    - Stabilizer gauge and placement
  - Bit details
Trajectory Comparisons

[Graph showing trajectory comparisons with axes labeled MD (ft) on the x-axis and Inclination (deg) on the y-axis. Legend: Yellow line - Standard Surveys, Green line - Continuous Inclination, Red line - Calculated Survey (Tool).]
Doglegs and Ledges

Standard Survey Points

- TF = HS
- TF = 30°
Doglegs and Ledges

Sliding intervals
Doglegs and Ledges

- Continuous Inc. Rotating Build Rate = -0.94 deg/100ft
- Continuous Inc. Sliding Build Rate = 16.55 deg/100ft
- Survey Build Rate = 6 deg/100ft

Survey Build Rate = 6 deg/100ft

Continuous Inc. Rotating Build Rate = -0.94 deg/100ft

Continuous Inc. Sliding Build Rate = 16.55 deg/100ft

TF = HS

TF = 30°
Ledge (step up) from initiation of sliding phase

TF = 30°
TF = HS
TF = HS

Doglegs and Ledges
Doglegs and Ledges

Source: SPE-151248
Bending Stress

- Calculated Bending Stress - Continuous Inclination
- MWD Measured Bending Stress
- Continuous Surveys
- Calculated Bending Stress - Standard Survey
- Standard Surveys

Measured Depth (ft)

Inclination (deg)
Bending Stress 3D
Conclusions

- Micro doglegs are always present and inherent to the drilling process
- BHA modeling is able to reproduce measured micro doglegs

Consequences of micro doglegs
- Bending stress → Fatigue → Failure
- Torque and Drag
  - Difficulty running casing to TD
- Wellbore Placement
  - Differences in TVD
Thank You