Diversified Well Logging

The Surface Measurement While Drilling[™] Company

Wellbore Surveillance Service





All wells experience problems while drilling, problems that will cause unexpected hazards and increased cost. Offshore, and especially in deepwater environments the control and mitigation of hazards and the extra direct and indirect cost will seriously affect the ROI of any company.

At the height of drilling activity, in the early 2000's, at least 40% of operating cost was due to non-productive and invisible lost time and around 40% of this lost time was associated with wellbore stability and pressure issues. This represented an estimated **\$26BN per year**.

Today, the old challenges still exist but are further complicated by more complex well paths into structures that have changed significantly over the years due to reservoir depletion and structural stress change.

DWL combats these challenges with its **Surface Measurement While Drilling™** services and **Realtime Wellbore Surveillance**.



Wellbore Surveillance Overview



Pressure Management Wellbore Stability Drilling Dysfunction

The Realtime Wellbore Surveillance

service includes:

- Cuttings evaluation visual & elemental using HML-XRF
- Gas evaluation organic and inorganic with Mass Spectrometry
- Trend evaluation drilling, tripping, hydraulics, pits, torque & drag
- Wellsite consultants 24/7 onsite for rapid analysis and solutions
- Onshore consultants 24/7 backup and analytic expertise
- A.I. data solutions drill efficiency and production forecasting
- Remote data transmission to client geologists and engineers





Realtime Responsibilities



- Verify the communications protocol that informs all key drilling personnel in a timely manner of any condition that may have a bearing on operations.
- Track, confirm and correct the execution of client specific drilling, connection & tripping best-practices. Capture lessons learned for feedback.
- Continuous monitoring and prompt reaction to drilling trends. Providing proactive advice and recommendations to the key drilling personnel.
- Continuous monitoring and prompt reaction to pressure related trends. Providing proactive analysis and recommendations to the key drilling personnel.
- Torque and drag modeling of BHA and monitor actual field data against model and advise remedial actions to client rep where appropriate
- Hydraulics modeling of all BHAs and monitor actual field data against this model and advise remedial actions to client rep where appropriate.
- Collation and interpretation of all relevant surface and downhole data using appropriate software and hardware to mitigate drilling problems.
- Prepare and deliver daily reports with application specific graphs. Provide an annotated realtime log to highlight key events / actions taken / trend explanation.
- Make realtime recommendations for continuous performance improvement.

Wellsite Consultants Onshore SME Team



Wellbore Surveillance - Geology



Cuttings visual inspection

- Formation type and visual properties with photographs
- Show indications/fluorescence (with gas shows)
- Cavings type, quantity, and source
- Cuttings return volume hole cleaning
- · Correlation of cuttings, gas and drilling trends

Cuttings elemental XRF analysis

- · Clay type identification
- Grain size indication
- Matrix density estimation
- TOC proxy determination
- H2S indicators
- Elemental gamma ray depth verification
- Chemostratigraphic certainty

Formation gas measurements

- Background, trip, and gas anomaly evaluation
- · Chromatography and formation fluid changes
- Reservoir identification and compartmentalization
- Gas ratios and pore pressure evaluation
- Mass spectrometry for fault/fracture indication
- · Water saturation indicators aromatics



Formation Gas



Wellbore Surveillance - Operations



Drilling Trends

Hydraulics & Fluids Trip & Connection Trends

Drilling parameter trends

- Rate of penetration compared with geology
- Rate of penetration compared with WOB, RPM/Torque
- Rate of penetration compared to hydraulics
- MSE evaluation and drilling efficiency
- DXC evaluation for formation pressure estimates
- · Drillstring compared with geology and wellbore geometry

Hydraulics and fluid monitoring

- Mud weight monitoring in and out
- · ECD and ESD compared with gas and geologic anomalies
- ECD and ESD compared with drill/trip trends
- · Hole cleaning indications with cuttings volume
- Pit monitoring for gains and losses

Trip and connection trends

- Hookload and drag evaluation
- · Swab effects, trip and connection gas evaluation
- Surge effects, gas evaluation, mud losses
- Mud volume fill and gain during trips
- Mud volume flowback trends during connections





Wellbore Surveillance - Workflow



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Pressure Management - Workflow



Offset well data - rock and fluid properties *Pre-well prognosis – seismic – water-depth – etc.* Cuttings - XRF - EGR for sample depth verification Cuttings type - interval bulk density estimation Cuttings – XRF – matrix density Gas ratios - fluid indication - fluid density Mass spectrometry – aromatics – fluid density

Cuttings – visual estimation of type/porosity Cuttings - XRF - EGR for sample depth verification Cuttings type – interval bulk density estimation Cuttings – XRF – matrix density Gas ratios - fluid indication - fluid density Mass spectrometry – aromatics – fluid density XRF – clay type: kaolinite – porosity/permeability inhibitor – seals XRF – grain size – deposition/compaction trends Total gas – background, connection, trip gas – pressure trends Gas ratio – porosity/permeability indication – compaction trends Gas ratio – pore pressure trend indicators Mass spectrometry – helium – porosity/permeability indication Mass spectrometry – hydrogen – pore pressure indication Drilling, tripping, hydraulics trends – pore pressure indication

* All data listed in black is collected, collated and added to the drilling-model by DWL in realtime







Pre-well modelling by DWL and Client teams is built upon by full realtime monitoring and measurement by wellsite consultants and ongoing modification of the pre-well model to predict, mitigate and manage formation pressure issues. DWL used proprietary and industry software for data analysis along with cloud-based A.I. machine learning data solutions from Enovate Upstream.

More Data - More Oversight - More Control - Less Cost and NPT





Wellbore Stability - Workflow



Offset well data - rock and fluid properties Logs – sonic, resistivity, density, porosity, VClay, Caliper Pre-well prognosis – hydrostatic gradient All realtime data collected for Pressure Management will be used in wellbore stability analyses.

Cuttings - visual estimation of type Cuttings volume – indication of hole stability/cleaning Cavings – identification and percentage of type Cavings – XRF – precise identification of cavings origin Total gas - behavior of connection, trip and pump-off gas Gas ratios – fault and fracture indication Mass spectrometry – fault and fracture indication Drilling hydraulics – mud properties, pump pressure, flow Drilling hydraulics – ECD/ESD calculated or from LWD Drilling trends – rop vs wob vs rpm/torque vs pump pressure Trip and connection trends – calculated vs actual torque & drag Trip and connections – swab and surge pressure Trip and connection trends – cuttings fill indication

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Wellbore Stability - geomechanical - surveillance and analysis uses all of the data also required for geopressure. Of importance is the pre-well modelling with comprehensive offset data. In realtime information collected from cuttings, gas, and drilling data is key to improving the rock model, drilling efficiency, and mitigation of NPT. DWL and the client will work hand in hand with 24/7 communications.



Drilling Dysfunction - Workflow



All data collected by DWL in realtime for pressure management and wellbore stability evaluation will serve to limit or eliminate much drilling dysfunction and resultant NPT due to inefficient operations or equipment failure. Most drilling dysfunction (and other issues) can be traced back to geology ...

 A. Common challenges Shallow formation hazards Wellbore mechanical stress failure Thermal induced effects Physical-chemical interaction and effects Surge and swab pressure changes 	 B. Direct consequences Stuck pipe and loss of BHA Influx/kicks oversize hole Wellbore collapse Formation fracture and damage Under-gauge hole – swelling, squeezing or spalling Excessive circulating and reaming Excessive volumes of cavings and cuttings Difficulty circulating cavings to surface Hole fill after connections and trips Losses - excess mud volumes and additives 	 C. Indirect consequences High torque and drag friction Excessive doglegs and poor directional control Stuck pipe Cuttings beds and key seating Ledging hang up due to erosion/washout Annular gas leakage Increased circulating pressures Poor log runs or inability to run logs Excessive drill string vibration Drill string failure Induced kicks and loss of well control
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More Data - More Oversight - More Control - Less Cost and NPT



Hardware and Software



Data measurement

- Independent drill and fluid monitoring sensors
- Remote hazardous gas sensors
- · State of the art total gas and FID chromatographs
- WITS capture capability for rig and 3rd party equipment

Data measurement +

- X-ray fluorescence
- Mass spectrometry
- Cuttings size/shape imaging
- Micropaleontology marker classification
- MPD hardware capability (with SafeKick®)

Software solutions

- SafeVision[™] realtime wellbore pressure management
- A.I. Machine learning solutions from Enovate Upstream
- Synthetic log creation
- Geochemical analysis with Isologica applications
- Geosteering with Rogii StarSteer
- Formation pressure analysis DrillWorks, JewelSuite etc.
- Data transmission Kongsberg OnSite™



Realtime

Independent Measurements

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Diversified Well Logging thanks you for your attention and hopes that this short presentation has illustrated our commitment to improving efficiency and return on investment for our customers.

We would also like to take this opportunity to state our commitment to safety by celebrating zero recordable incidents in 2019. A record that continues into 2020.

Z019 ZERRO

Celebrating this number is a big thing. Zero recordable incidents for every day of last year. DWL employee's making the workplace safer one careful step at a time.



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