

LOGGING WHILE TRIPPING - LWT INTRODUCTION



CORDAX

2016

CORDAX EVALUATION TECHNOLOGIES INC.

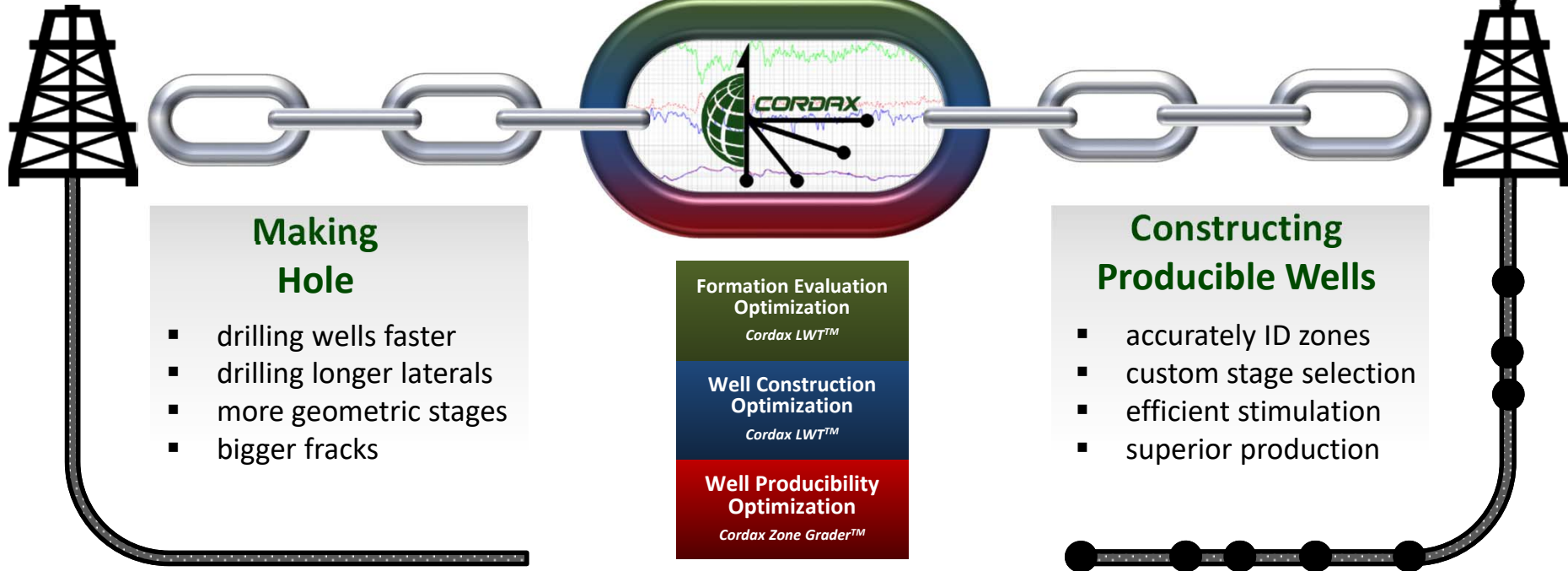
WWW.CORDAX.COM



CORDAX EVALUATION TECHNOLOGIES

Cordax helps clients optimize the producibility of their wells. Utilizing its unique Logging While Tripping™ (LWT™) technology, quality open hole formation evaluation data is economically acquired from vertical, highly deviated, and horizontal well trajectories while reducing operational risks and virtually eliminating lost-in-hole exposure. Petrophysical measurements can be integrated with well information (drilling data, mud logs, pore pressure) using Cordax's proprietary Zone Grader™ software to provide an interpretation that optimizes completion and fracking strategies, improving well producibility.

CORDAX - LINKING DRILLING TO PRODUCTIBILITY





LWT™ - LOGGING WHILE TRIPPING™

Patented and industry proven formation evaluation technique providing cost effective open hole logs with virtually no extra rig time and fewer operational risks (LIH) than alternate logging methods.

- ✓ API calibrated measurements
- ✓ Fully accepted by regulatory agencies

Innovative Deployment & Conveyance

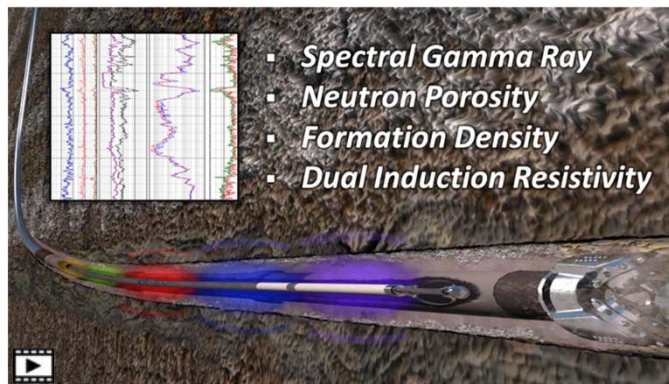
- Tools pumped down for measurement on trip out of well
- Virtually no extra rig time required
- Allows logging of any well trajectory
- No additional trip or hole conditioning required
- Measuring on trip out of well
- Battery/Memory power, no wireline

Secure Logging & Full Well Control

- Tools and radioactive sources safely located inside the drill pipe (LWT collar) during deployment and logging.
- Protected and fully retrievable at any time
- Pipe rotation and circulation at any time during operation
- Limited LIH risk exposure

Well Applications & Hole Conditions:

- First run in well
- Complex trajectory
- Horizontal wells
- Lost Circulation
- Bridged wells
- Underbalanced drilling
- Swelling formations
- Well previews





LWT™ TECHNOLOGY & COMPANY HISTORY

2003-2010

- LWT Technology and patent acquired
- Development and commercialization

2013

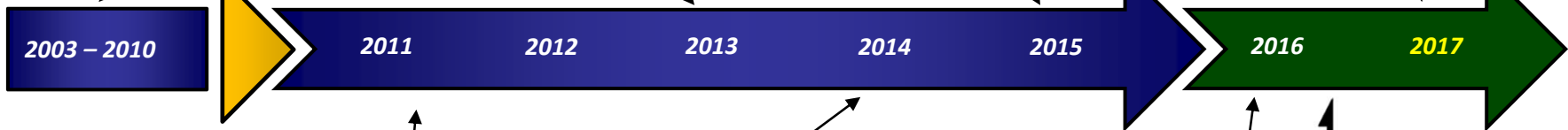
- Expanded in the Bakken (USA)
- Reached job milestone **400** jobs successfully performed

2015

- First job performed in Indonesia
- Reached job milestone **600** jobs successfully performed

2017

- Introduction of new measurements
- Further international expansion



2011-2012

- First full deployment year in Canada including triple-combo measurements
- First job performed in the USA (December 2012)

2014

- Shift in U.S. operations from North Dakota to Oklahoma City.
- Awarded significant work with Indonesian state oil company for 2015.
- First job performed in Australia

2016

- **May 1st** - CORDAX purchases DATALOG
- July first job to be performed in Mexico
- August first job to be performed in Congo
- Q3 introduction of steel collar resistivity





LWT™ - INDUSTRY PROVEN TECHNOLOGY

- Proven field execution with over 650 successful jobs performed as of October 2016.
- Data qualified with successful “log-offs” against conventional wireline
- Industry leading Client List Including:





VALUE APPLICATIONS

Formation Evaluation Optimization

Cordax LWT™

Application

- Formation Evaluation method replacing wireline, LWT, TBL, and pipe conveyed OH logging methods

Benefits

- Wireline quality petrophysical data acquired during routine trip out of well
- Eliminates bridging and lost-in-hole (LIH) exposure versus other methods
- No extra pipe trip or hole conditioning
- Data acquisition in any well trajectory
- Tools pumped into BHA only when required, reducing wear and risk

Well Construction Optimization

Cordax LWT™

Application

- Casing point detection
- Evaluate Multi Laterals
- Kick-off point detection in build section

Benefits

- Deployment at any point during drilling operations
- Virtually invisible to drilling and well construction activities
- Rig time savings by reducing extra trips
- Allows timely completion decisions
- Incorporates well data such as mud logs, gas, ROP, pore pressure

Well Producibility Optimization

Cordax Zone Grader™

Application

- Frack strategy optimization
- Completion design optimization
- Optimal zone selection

Benefits

- Accurately locate and plan frack stages incorporating well parameters with LWT acquired Neutron, Density, Resistivity and Spectral Gamma Ray
- Providing the physical property data necessary for production optimization
- Compete geological model and update reserve calculation in resource plays

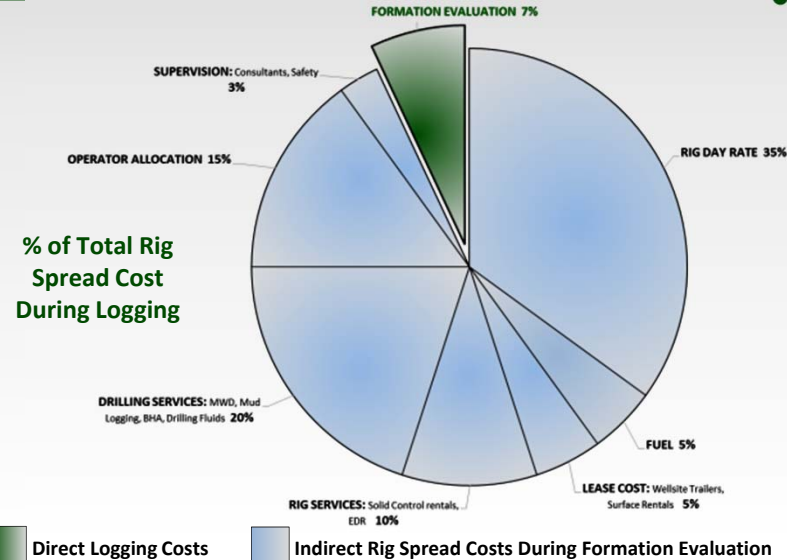


LWT FORMATION EVALUATION OPTIMIZATION

Objective:

LWT™ acquires quality formation evaluation data in vertical, highly deviated, unstable and horizontal well bores by replacing Wireline Logging, Outside-the-Bit Logging, Pipe Conveyed (PCL,TLC) and Logging While Drilling.

Main Cost of Formation Evaluation is Indirect Rig Expense



LWT™ Reduces Formation Evaluation Risk Exposure

Lost In Hole

- Eliminates LIH risk for tools & radioactive sources
- Inexpensive BHA

Well Control

- Circulation during logging
- Pipe rotation during logging
- Logging tools retrievable at a time during LWT operations

Operational Risk

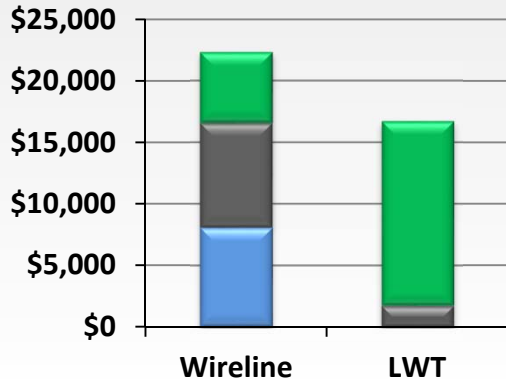
- Eliminates bridging
- Neutralizes most hostile hole conditions
- Reliable tool retrieval if BHA stuck
- Reduces risk of failure to acquire data

TOTAL COST OPTIMIZATION & RISK REDUCTION



Wireline Replacement

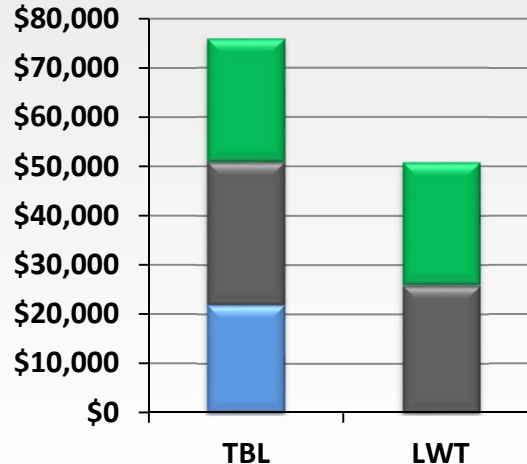
- Up to 25% Total Cost reduction
- Full well control during operations
- Elimination of > **\$400,000** Wireline LIH potential and **radioactive sources**
- Less potential for hole deterioration before casing run



Service Price

Thru-Bit Logging Replacement

- Up to 30% Total Cost reduction
- Better well control during operations
- Less risk of tool damage and LIH
- No dedicated logging trip needed

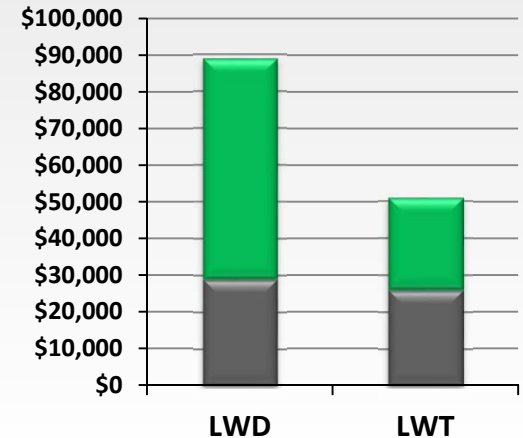


Rig Time Cost (Logging)

Rig Time Cost (Hole Prep)

LWD Logging Replacement

- Up to 40% Total Cost reduction
- Elimination of > **\$1,000,000** LWD LIH potential
- Better data quality, no drilling sliding issues





CASE HISTORY: 36 HOURS OF RIG TIME SAVED

Background

- North America- Horizontal Well
Hole: 77/8 in (200mm)
Depth: 13,238ft (4,035m)
- LWT was mobilized to evaluate the horizontal and vertical sections of the well with one run, prior to running cemented liner
- Wireline considered too risky in vertical section
- Horizontal section considered high risk and rig time too expensive for outside-the-bit and pipe conveyed logging methods

Operation

- The LWT collars were inserted above the MWD gear on the final bit trip
- Final leg of the well was drilled, followed by pumping down the LWT tools and logging the entire well

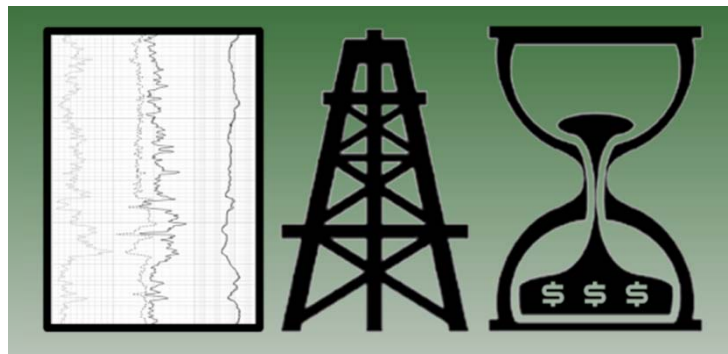
Achievements

- Providing formation evaluation on the bit trip, rather than dedicated run, allowed the operator to save over 36 hours (**est. \$108,000**) in rig time compared to other logging methods

Client Statement

- “The LWT system negated the need for separate vertical and horizontal logging runs saving significant rig time.”

- Drilling Lead



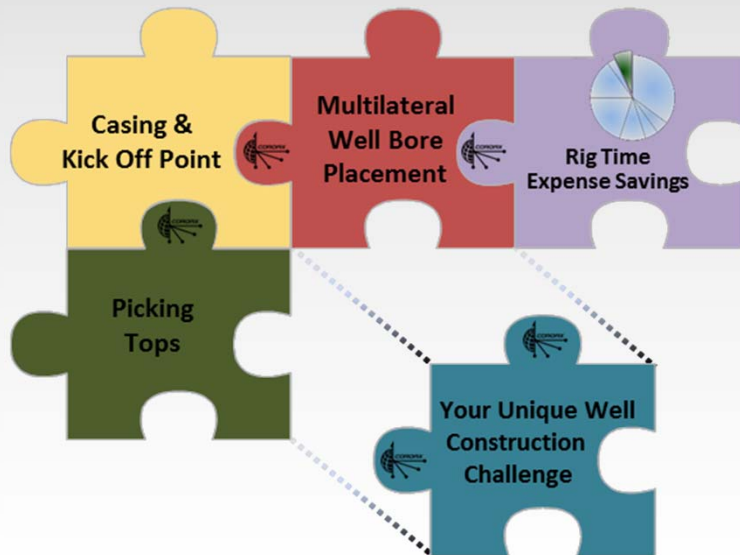


WELL CONSTRUCTION OPTIMIZATION

Objective:

Reduce total well construction cost with LWT™ by being able to make informed decisions.

LWT™ Helps Piece Together Your Well Construction Solution



LWT™ Reduces Formation Evaluation Risk Exposure

Lost In Hole

- Eliminates LIH risk for tools & radioactive sources
- Inexpensive BHA

Well Control

- Circulation during logging
- Pipe rotation during logging
- Logging tools retrievable at a time during LWT operations

Operational Risk

- Eliminates bridging
- Neutralizes most hostile hole conditions
- Reliable tool retrieval if BHA stuck
- Reduces risk of failure to acquire data



CASE HISTORY: LOGGING MULTI-LEG LATERAL WELL

Well Construction
Optimization
Cordax LWT™

Background

- 3 leg multi-lateral well drilled in July 2013
- Operator was expecting to return to surface in order to gather well logs through each leg
- LWT was mobilized to gather data in the 2 most porous legs on a single run, without returning to surface
- Other outside-the-bit horizontal logging methods unable to allow two consecutive runs in separate legs

Operation

- The final leg was drilled with the LWT composite collar
- LWT tools were pumped down into leg #3 and logged to the leg intersections
- BHA was re-orientated, run into leg #2, and logged to surface

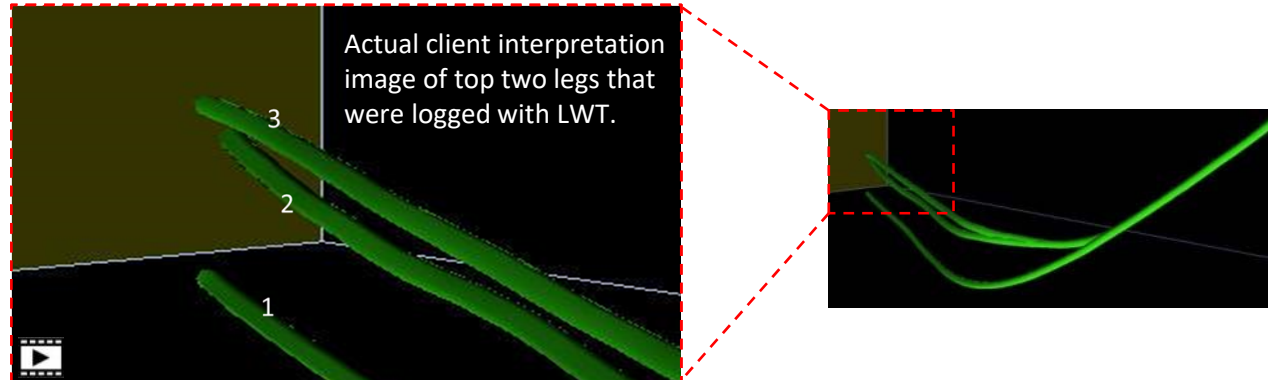
Achievements

- No additional trip to surface between every logging runs was required
- Estimated rig time savings was 24 hours, which equated to \$40,000 to the client

Client Statement

- "Very impressed with the ease of operation"
- "Data was used for future well placement to ensure they were producing from the most porous zone"

- Engineering Lead





CASE HISTORY: LOGGING IN DIFFICULT HOLE CONDITIONS

Background

- Fractured reservoirs result in an unstable borehole, making them a high risk for typical open hole logging techniques
- Operator wasn't expecting to be able to acquire logs to accurately locate the high porosity zone due to hole conditions
- LWT was mobilized to gather data triple combo data through the heel of the well

Operation

- The tectonically stressed area was conditioned for a total of 10 hrs with the LWT collars in the BHA
- Once on TD the tools were deployed and rotation was necessary while logs were gathered on the trip out of the well

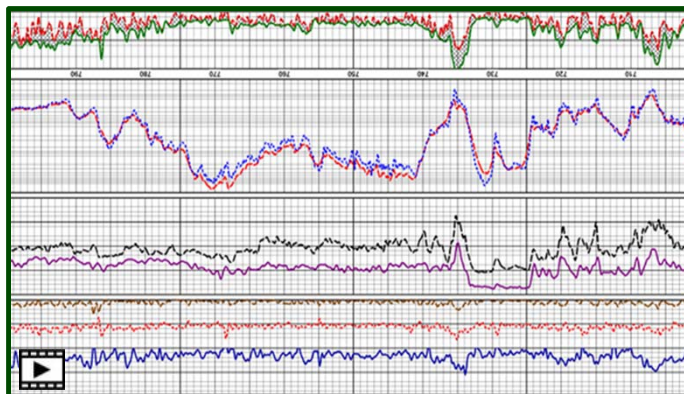
Achievements

- Logs were generated while the operator safely rotated the drill pipe through the stressed area
- With tools safely inside pipe the operator risk for bridging or losing tools in the stressed area was eliminated

Client Statement

- "We were able to confirm well placement in the high porosity streak and accurately set casing as planned with out lost in hole risk."

- Team Lead





WELL PRODUCIBILITY OPTIMIZATION

Objective:

Increase well producibility by enhancing completion effectiveness through optimized Frac and Completion designs. Invest in data to make informed decisions to increase well producibility and lower the well construction cost per barrel produced

ZoneGrader™ Analysis of LWT™ Data

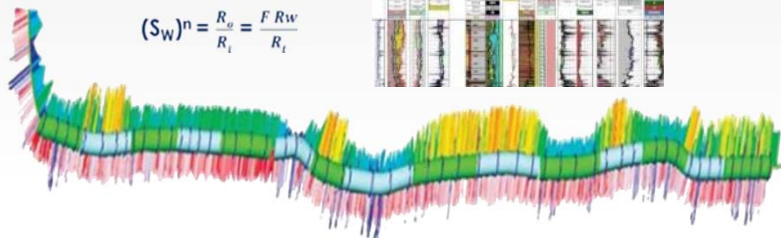
Geomechanical

- Rock Mechanical Properties
- Lithology
- Brittleness / Stress
- Natural Fractures

Producibility

- Lithology
- TOC
- Porosity / Permeability
- Saturation
- Stimulation Analysis

$$(S_W)^n = \frac{R_o}{R_i} = \frac{F R_w}{R_i}$$



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- Inexpensive BHA

Well Control

- Circulation during logging
- Pipe rotation during logging
- Logging tools retrievable at a time during LWT operations

Operational Risk

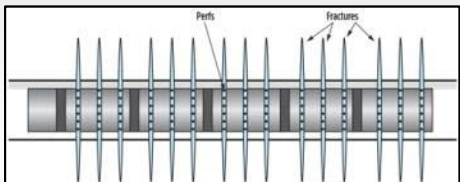
- Eliminates bridging
- Neutralizes most hostile hole conditions
- Reliable tool retrieval if BHA stuck
- Reduces risk of failure to acquire data

Status Quo – Geometrical Completion Design

- Geometrically spaced clusters without regard to heterogeneity of the formation
 - Clusters may not be fractured adequately
 - Increased probability of screen-outs
 - Uneven proppant distribution
 - Not prioritizing the sweet spots
 - Increased fracture initiation time from fracturing more ductile rock

“Production logs indicate that, due to sub-optimized completions, 30%–40% of perforation clusters contributed no production whatsoever, leaving considerable reserves in place.”

– OILPRO, January 8, 2016



New Optimized Completion Design

- Design based on Geomechanical and Productivity criteria for perforation placement and Frac design

Geomechanical	Productivity
<ul style="list-style-type: none"> ▪ Rock Mechanical Properties ▪ Lithology ▪ Brittleness / Stress ▪ Natural Fractures 	<ul style="list-style-type: none"> ▪ Lithology ▪ TOC ▪ Porosity / Permeability ▪ Saturation ▪ Stimulation Analysis

- Only an indication of geomechanical formation properties can be derived from drilling and mud logging data
- Proper grading of the well requires additional data: resistivity, density, porosity, spectral gamma ray

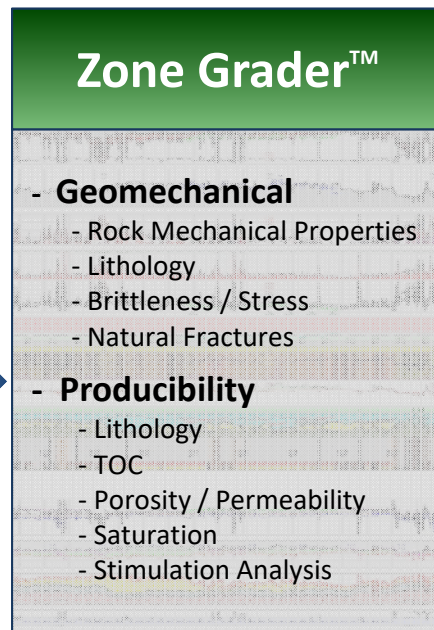
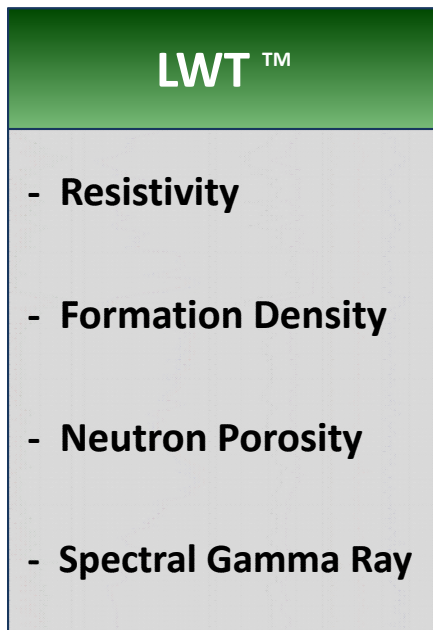


LWT™ & ZONE GRADER™

Well Productivity
Optimization
Cordax Zone Grader™

While Drilling.....During Trip Out.....Immediate Evaluation.....Optimized Producing Well

(Invisible to drilling operations)





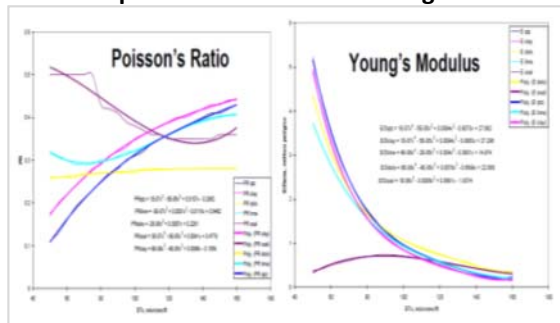
SPE CASE STUDIES: LOG OPTIMIZED COMPLETIONS

Well Productivity
Optimization
Cordax Zone Grader™



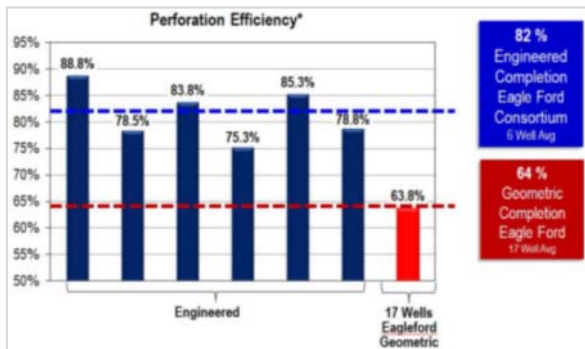
SPE 108139

A Composite Determination of Mechanical Rock Properties for Stimulation Design



SPE 138427

Perf Cluster Contribution to Production

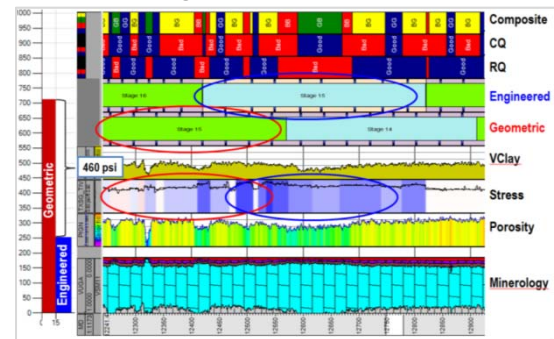


SPE 120591

Measurement Techniques for US Land Shale HydroCarbon Plays

SPE 166242

Eagle Ford Completion Optimization Using Horizontal Log Data





Background

- Indonesia – High Angle Well
Hole: 216mm (8 1/2 in)
Depth: 1,550m (5,085ft)
- LWT was mobilized to log the well to acquire additional data to complete an engineered completion design
- Wireline not run due to unstable borehole conditions

Operation

- LWT collars were inserted into the BHA and the hole was conditioned while tripping in
- The LWT tools were pumped down and logged out while tripping to surface

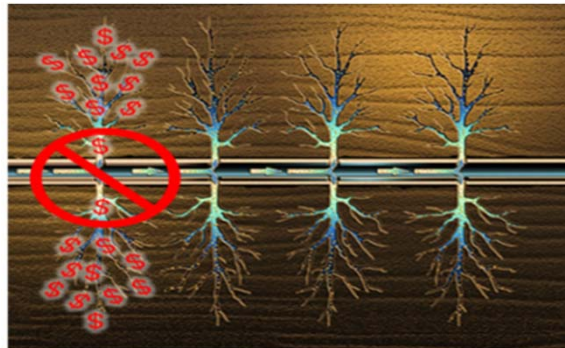
Achievements

- No additional rig time was required as the operator was conditioning the well during this trip
- Completed the analysis on the target formation based on both producibility and reservoir quality
- Eliminated risk of lost logging tools using LWT method

Client Statement

- “The final results, an engineered completions analysis, allowed us to increase well production from 900bbl/d to 1200 bbl/d when comparing to offset wells”

- Engineering Lead





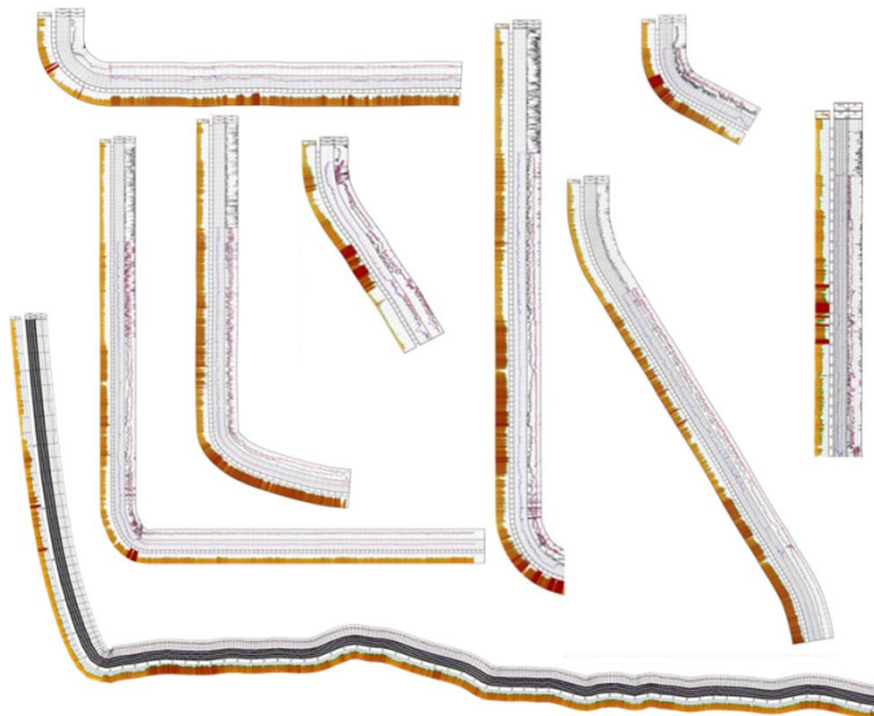
OPEN HOLE LOGS IN ANY WELL

■ Well Geometry

- horizontal
- deviated
- vertical

■ Tough Logging Conditions

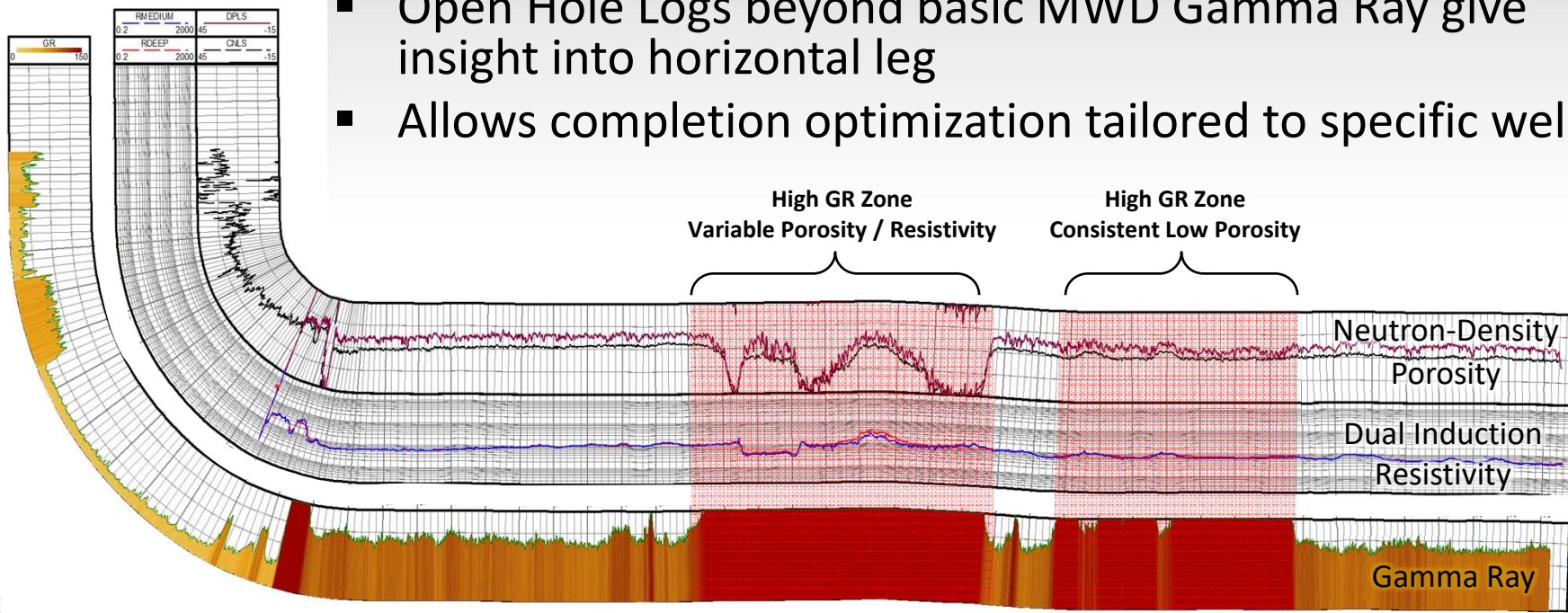
- complex trajectory
- horizontal wells
- lost circulation
- swelling formations
- bridged wells
- underbalanced drilling





FULLY UNDERSTAND YOUR LATERAL

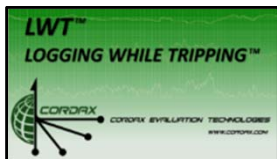
- Open Hole Logs beyond basic MWD Gamma Ray give insight into horizontal leg
- Allows completion optimization tailored to specific well





LWT OPERATIONAL ANIMATIONS

You  Channel: **cordaxLWT**



LWT Overview Animation: <https://youtu.be/rWITGsktV2Q>



LWT Horizontal Logging Animation: <https://youtu.be/rWITGsktV2Q>



LWT vs Wireline Animation: <https://youtu.be/mLcNYkvnac0>

Animations also available on website: www.cordax.com

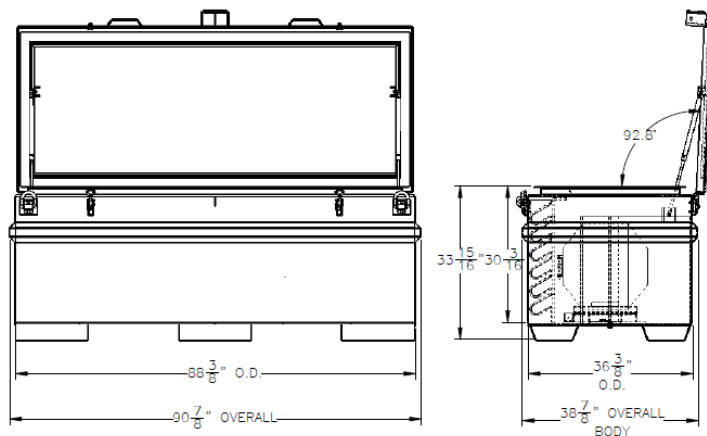


INTERNATIONAL LWT OPERATIONAL UNITS



MWD style field transport container:

- uphole equipment
- redundant downhole tools
- nuclear sources
- land or offshore operations
- LWT collars transported separately





NORTH AMERICA LWT FIELD UNITS



Customized Ford F-450 4x4 HD

- redundant uphole equipment
- redundant downhole tools
- nuclear sources
- LWT collars transported on heavy duty roof racks
- DOT approved sleeper bunk
- integrated processing office with second sleeper bunk
- legal for all seasonal road bans
- small rig site footprint



Cordax Evaluation Technologies

Cost effective **Formation Evaluation**

Lowering the well construction cost per barrel produced

Informed decisions to increase well **Productivity**

Google Search

I'm Feeling Lucky

