Advances in Geosteering

SMART4D
While Drilling Geosteering

Marcellus Case Study

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Advances in Geosteering

Examining Advances that have Minimized Costs Incurred by Going Out of the Zone and Enabled the Drilling of Longer Laterals
Agenda

1. Acknowledgement & Introduction
2. What is Geosteering?
3. What is the role of Geology?
4. Marcellus Shale Case Study
Extensive Experience with many resource types
Providing solutions to complex geological, geosteering, and engineering challenges

Unconventional Resources
- Tight Oil, Shale oil/Tight Gas
- Resource Plays, Heavy Oil, In-situ Oil Sands
- Footprint modelling of Tight Plays

Conventional Resources
- Sandstone & Carbonate Reservoirs
- Oil & Gas Reservoirs, Gas Storage
- Heavy Oil Development
- Waterflood Design & Optimization
- Simulation Studies
Our Geosteering Experience

• Over 12 years of Geosteering
• Extensive worldwide experience
• Worked in all major reservoir types & basins
• Longer laterals
• Complex projects
WHAT IS GEOSTEERING?
Our Definition of Geosteering
Improved work flow through Dynamic Intelligence®

• Addition of Geological Information to Drilling Data to optimize well placement and maximize well length within target interval
• Automated data links (WITSML)
• Adjustment of 3D geo-models while-drilling
• Live interactive updating and reporting via Panels and 3D views
• Delivery through a secure website

RESULTS IN:
All 3D geo-model learning is re-used in real-time for one or more rigs drilling concurrently or for upcoming wells.

Proactive & forward modelling of drilling corridor while drilling
Why does well placement matter?

• Optimal production of Hydrocarbons/economics
• Staying within the zone of interest longer
• Less cost per well
• Less complications with drilling including reducing DLS, Tortuosity and sidetracks
• Happy Clients & better results
Fields that contribute to better Well Placement

• Geology/Petrophysics/Geophysics
• Well planning
• Engineering
• Geosteering
• Drilling & Completion
• Data Aggregators
• What kind of Data do these give us (??)
  – Survey data, TVD, WITSML etc.
Benefits of Geosteering

• Proactive Decision Making
• Increased well length in the sweet spot
  – Increased production & recovery
  – Increased success of fracs
• Reduce dogleg severity and tortuosity
  – Increase ability to reach planned TD
  – Improve conditions for completions
• Mitigate risk from geo-hazards such as faults, thief zones, water legs
• Opportunity to drill in areas with complex structure
• Collision avoidance
ROLE OF GEOLOGY IN WELL PLACEMENT
Role of Geology in Well Placement

- What Geology tells us about the subsurface
- Logs, seismic and other data
- Correlation of traces
- Geo-Modelling: 2D vs 3D vs 4D
- Benefits of 3D & 4D
Why we model

To Optimize placement of well bore within the zone of interest
To Map Geological variability affecting the placement

We start modelling the reservoir by:
– Import vertical and horizontal logs and trajectories
– Import seismic surfaces
– General well data
– Formation (Structure) Tops
– Directional drillers plans
UNITED’S REMOTE GEO STEERING PROCESS & CAPABILITIES
SMART4D GEOSTEERING PROCESS - FLOW OF INFORMATION

OFFICE

FIELD INFORMATION

RIG DATA TRANSMISSION

LIVE DATA STREAM VIEWABLE ON SECURED WEBSITE

WITSML SERVICES

LIVE MODEL MAPPING AND VISUALIZATION

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GEOSTEERING CASE STUDY
Marcellus Shale Case Study

• 2 Horizontal wells were geosteered by United in the Marcellus Shale

• The wells were at 7200ft TVD, laterals: 3500ft & 5000ft

• The Marcellus was 40 ft thick with a 9 ft sweet spot in the middle

• Wells were drilling using:
  – Gas detector
  – Conventional gamma tool 40 ft behind the bit
Marcellus Shale Case Study

2 wells geosteered in this Case Study

Presented with Permission from Client
3D Visualization While Drilling

Cross section of the subsurface showing the 2 wells geosteered in this Case Study

Fence through Gamma characterization on the path of the well (darker color is the sweet spot)
Real-time 3D Top View of model

2 wells geosteered in this Case Study
Illustration of the flow of data throughout drill

- Gas
- Gamma
- ROP

Apparent Dip from Geo-model

5000 ft Lateral, 100% in 9’ Sweet Spot
Staying in the Sweet Spot

Percentage Drilled within Target Interval (9ft)

- Based on 8 wells
- Based on 2 wells

- Without SMART
- With SMART
Cumulative DLS study

Cumulative DLS vs Distance from ICP

Offset wells

2 Geosteered wells

SMART w/ continuous monitoring
SMART w/ 2 daily updates

Distance from ICP (ft)
Cumulative Tortuosity Study

Cumulative Tortuosity vs Distance from ICP

Offset wells

2 Geosteered wells
Results of the case study

• 100% placement within the sweet spot vs 80% offset horizontals

• Lower DLS compared to other wells in the same area

• Lower tortuosity than wells in same area
How did we do this?

• Continuous mapping of the drilling corridor ahead of the bit
• Proactive decision-making using SMART4D Real-time Panels
• Collaborative environment for Driller & Op. Team
• Real-time understanding of well bore position
• Extensive understanding of geological environment
  
  Ability to see top and bottom of target intervals
  
  Improved Correlation methods for landing and staying in zone of interest
• Team of skilled geologist monitoring 24/7, reporting & geosteering within an Operations Team.
SMART4D GEOSTEERING
REAL-TIME PANELS
Benefits of SMART4D Panels

• Easy and intuitive (Web based for smart phones and browsers and a user friendly Windows Application.)
• Interactive
• Shows WD data and relation to geology
• Allows many users to view Correlations simultaneously
Live & Interactive SMART4D Panel System

Real-Time Data

Gamma Profile

9 ft Target
SMART4D Panel System

Automated Real-Time Data Integration Using WITSML
Sweet spot is a 9 ft High Gamma (dark brown color)
StartCORR Real-Time Correlation

Offset Well Log

Dynamic Profile

StratCORR Application

A

Apparent Dip

A’

A

A’
Imaging While Drilling

Offset Well Gamma

Gas

Gamma

Apparent Dip from Geo-model

ROP

Dynamic Vertical Profile from 3D Gamma model

Azimuthal Gamma Imaging

Highly exaggerated vertical scale: Doglegs <3
Imaging detail

High Gamma Readings (Near a boundary above)

Low Readings in Target

Highly exaggerated vertical scale
Conclusions

We have shown in this Case Study that recent advancements in geosteering can help to accurately place extended horizontals in thin target intervals. Using advanced software such as SMART4D to enhance the ability of Operators & Drillers to proactively steer to stay in the sweet spots longer, reducing risk and enhancing economics.
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