A Multilateral Case Study in the San Juan Basin: Integrated Geosteering Technology Combined with Near Bit Azimuthal Gamma Tools*

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Abstract

Geosteering technology and interactions with Near Bit Azimuthal Gamma assists optimization of well placement in a multi-lateral CBM project in the San Juan Basin. Despite the complex structure encountered the integrated and dynamic/real-time geo-modelling while drilling helps identify the corridor for drilling.

The examples will illustrate how the near bit gamma directional data is used in conjunction with the geosteering panels to make appropriate decisions and improve recoveries and production at the field or the office. This process provides the framework for the drilling corridor ahead of the bit based on an iterative and interactive data gathering, 3D mapping, characterization and real-time reporting system.

A Multi-lateral Case Study in the San Juan Basin:

Integrated Geosteering Technology Combined with Near Bit Azimuthal Gamma Tools

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Geosteering Horizontals

-Azimuthal gamma used in the remote geo-model based geosteering process helped well placement in thin targets

-Multiple changes to the 3D geo-modeling (pre-drill and while drilling) allowed for forward looking modelling and maximum exposure in the upper and lower Ignacio Coal Seams (~9ft) in the San Juan Basin. The corridor of drilling ahead of the bit was updated over 200 times while drilling.

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Geosteering Horizontals

-The wells had less drilling issues including unnecessary side-tracks and wellbore stability issues (Lower lateral drilled in 36 hours)

-Real time data retrieval using WITSML allows for connection to any rig worldwide for any E&P and service providers

-Real time Reporting, geo-modelling of coal (structures and Gamma characterization) in 3D while drilling, web based system assisted all stakeholders, provided a strong collaboration and communication tool

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Geosteering Horizontals

-Remote geosteering process eliminated HSE issues and costs were lower for the E&P

-System provided a real time virtual platform for multiple wells being drilled worldwide

-Beyond CBM the process is applicable to all unconventional resources such as Shale Gas, Tight Sands, Heavy Oil, Shale oil, etc.

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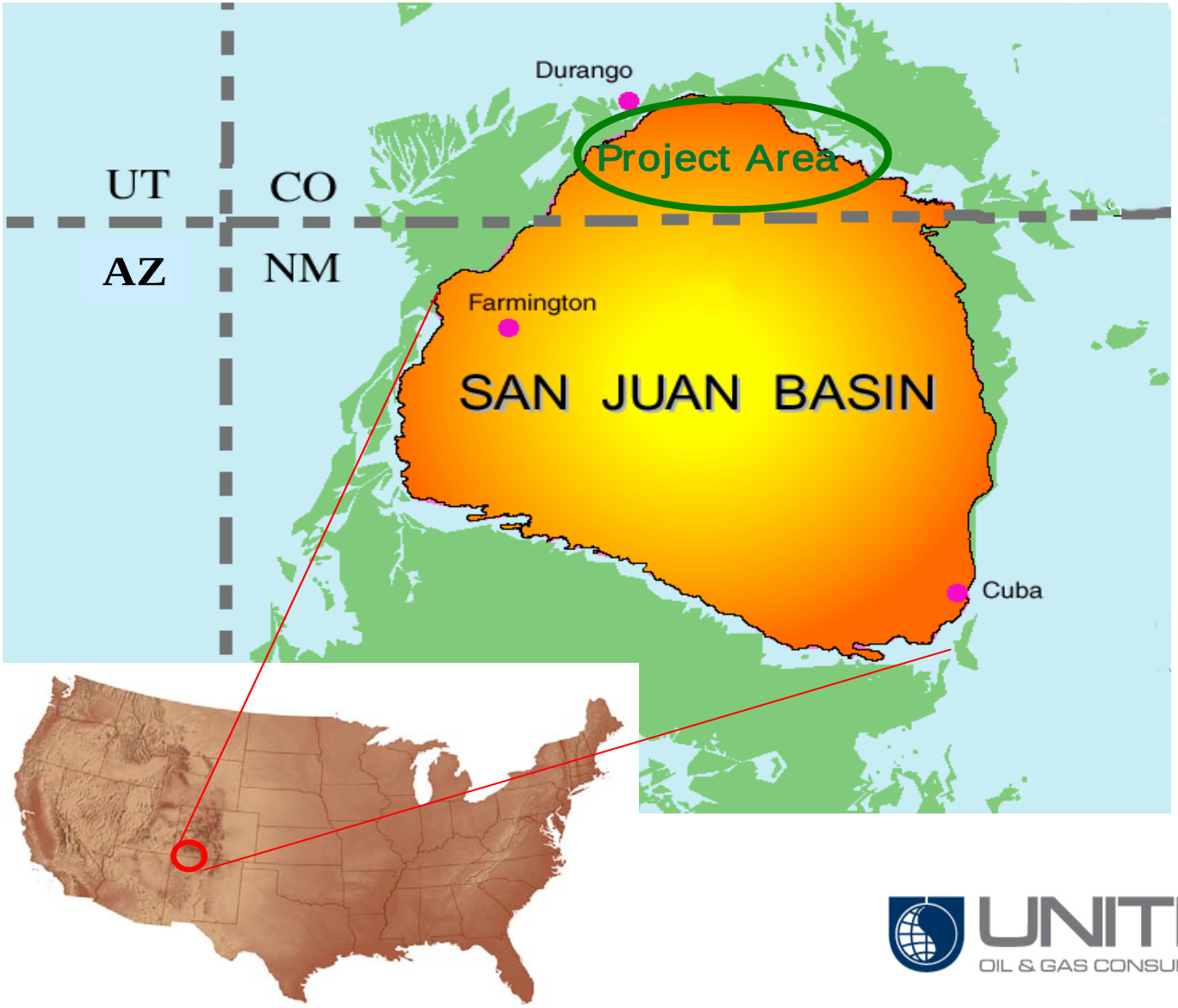
SAN JUAN PROJECT AREA



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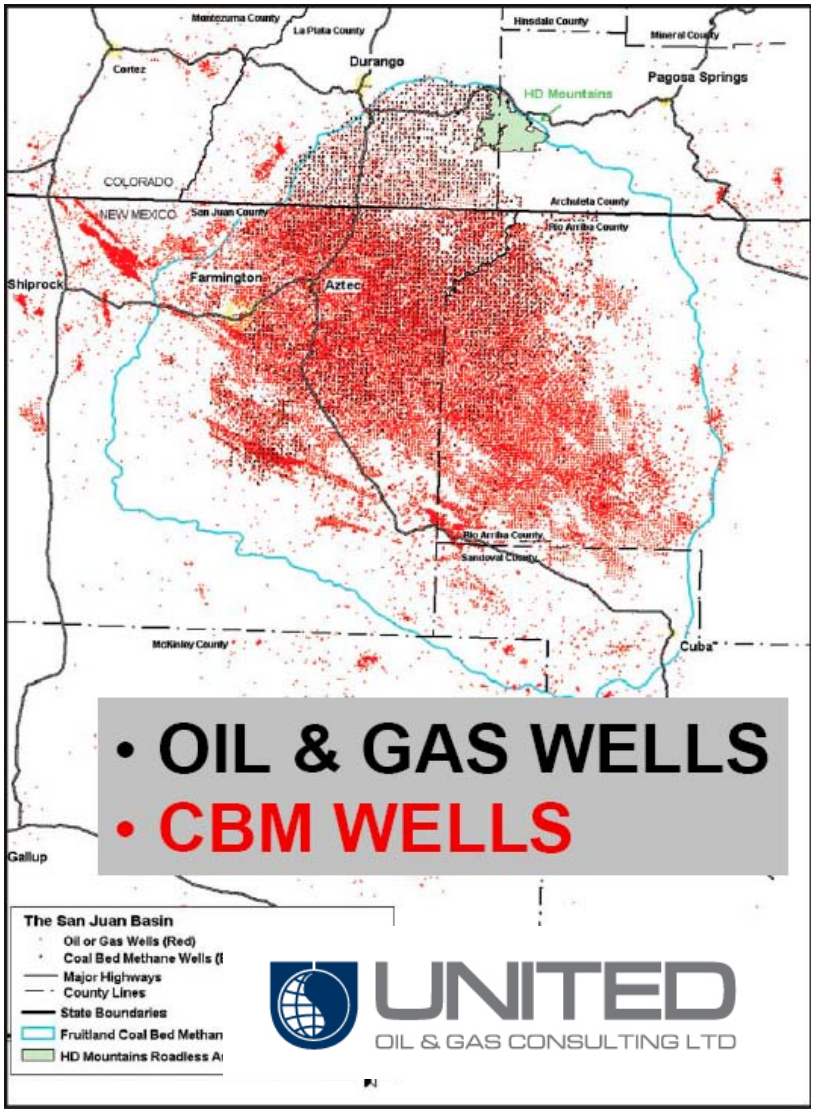
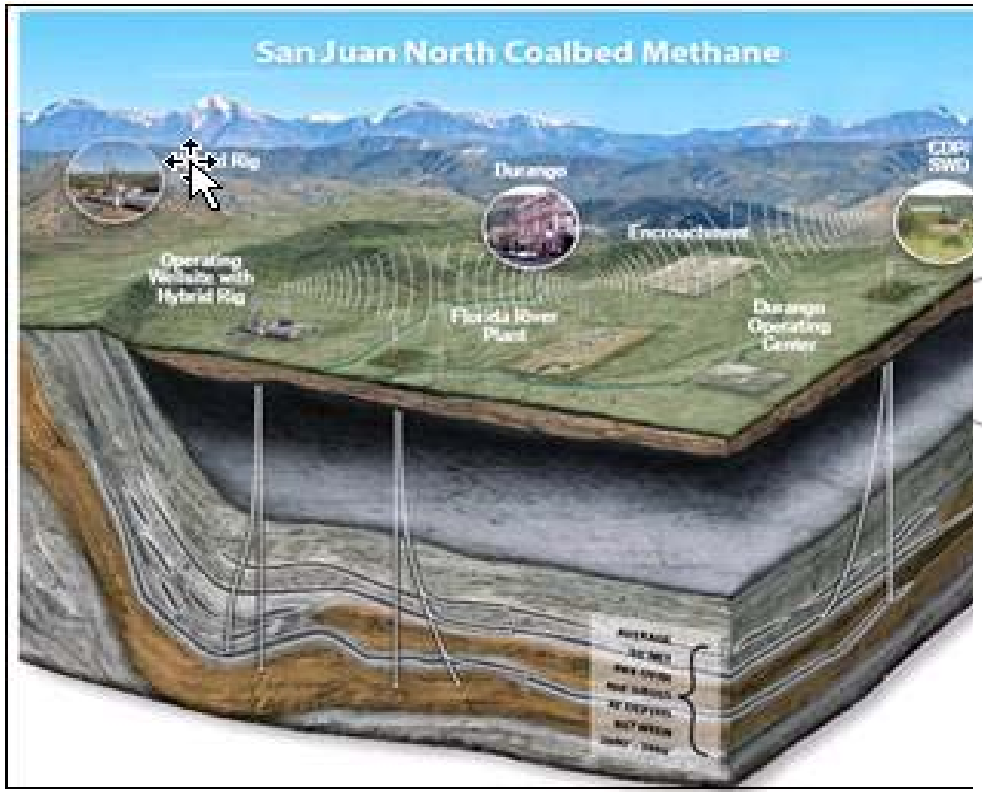
30,000 WELLS IN THE SAN JUAN

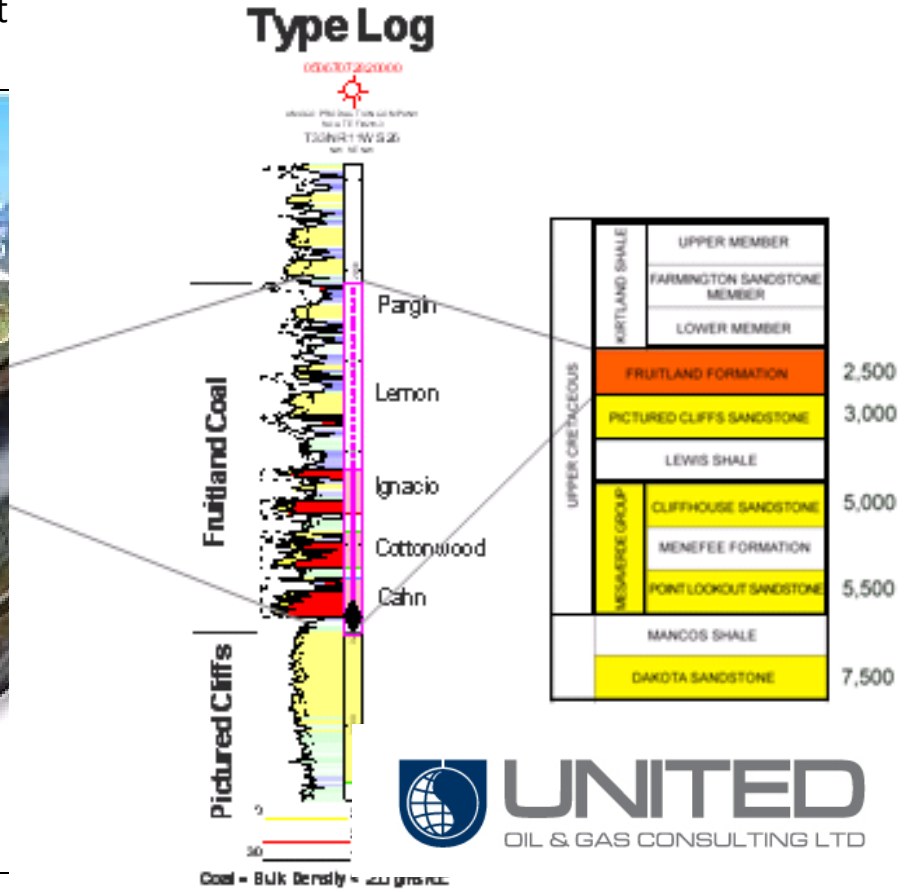
- FOCUS IS ON RECOVERY
- REDUCED WELL SPACING BELOW GROUND NOT AT SURFACE (PAD DRILLING)
- HORIZONTAL DRILLING & VERTICAL WORKS
- CONSIDERABLE GAS STILL IN PLACE



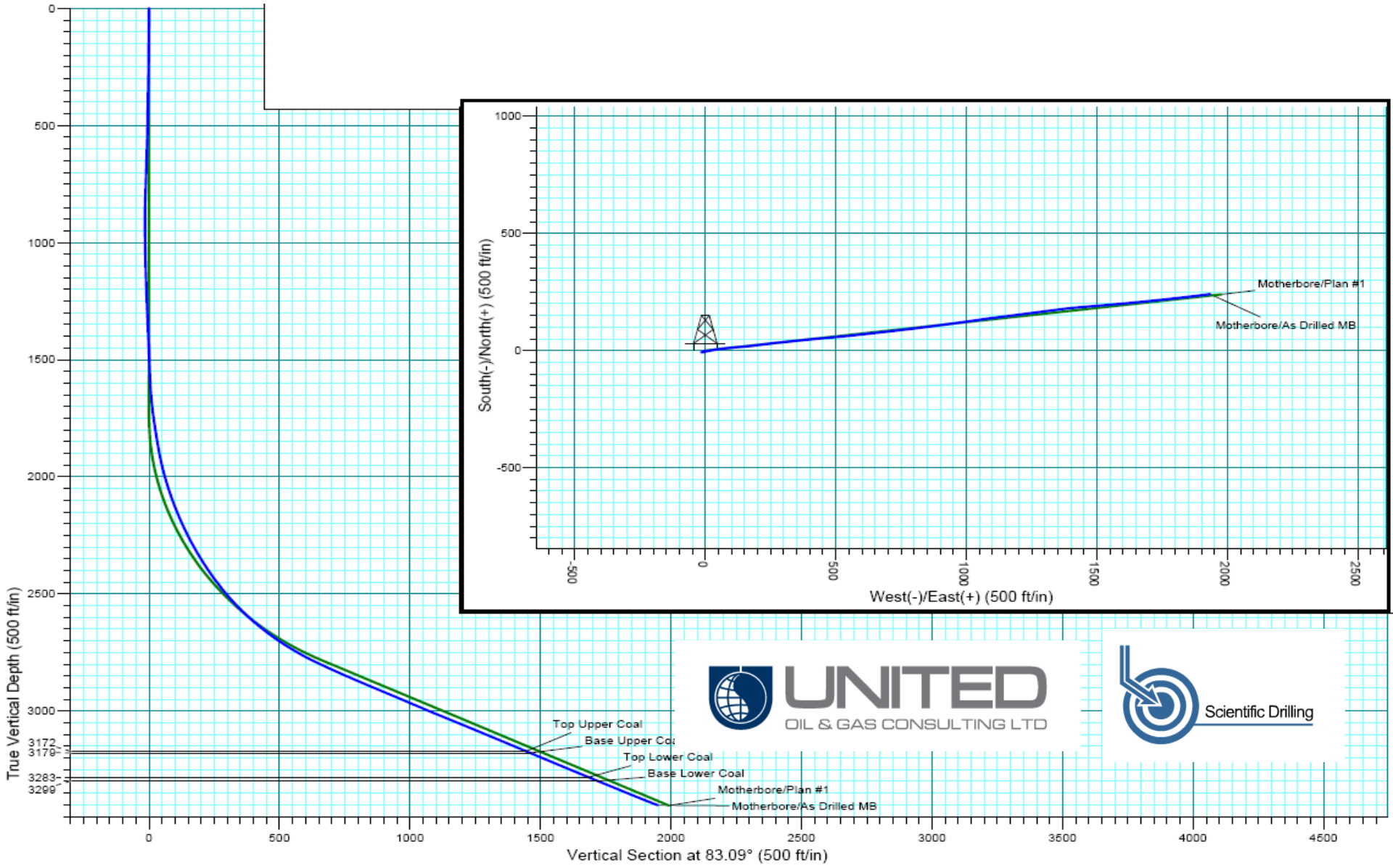
SAN JUAN BASIN OVERVIEW

- Fruitland Formation: MultiSeam Coal Interbedded with Sand / Shale
- 2500’ TVD ~ Net Pay Over 400’ Interval; 2-5 Seams Typical
- Permeability variations driven by cleating & natural fracture density
- High Continuity Well-to-Well; Discontinuous Across Sections
- Hydraulically Fractured Wel Completions in this Project

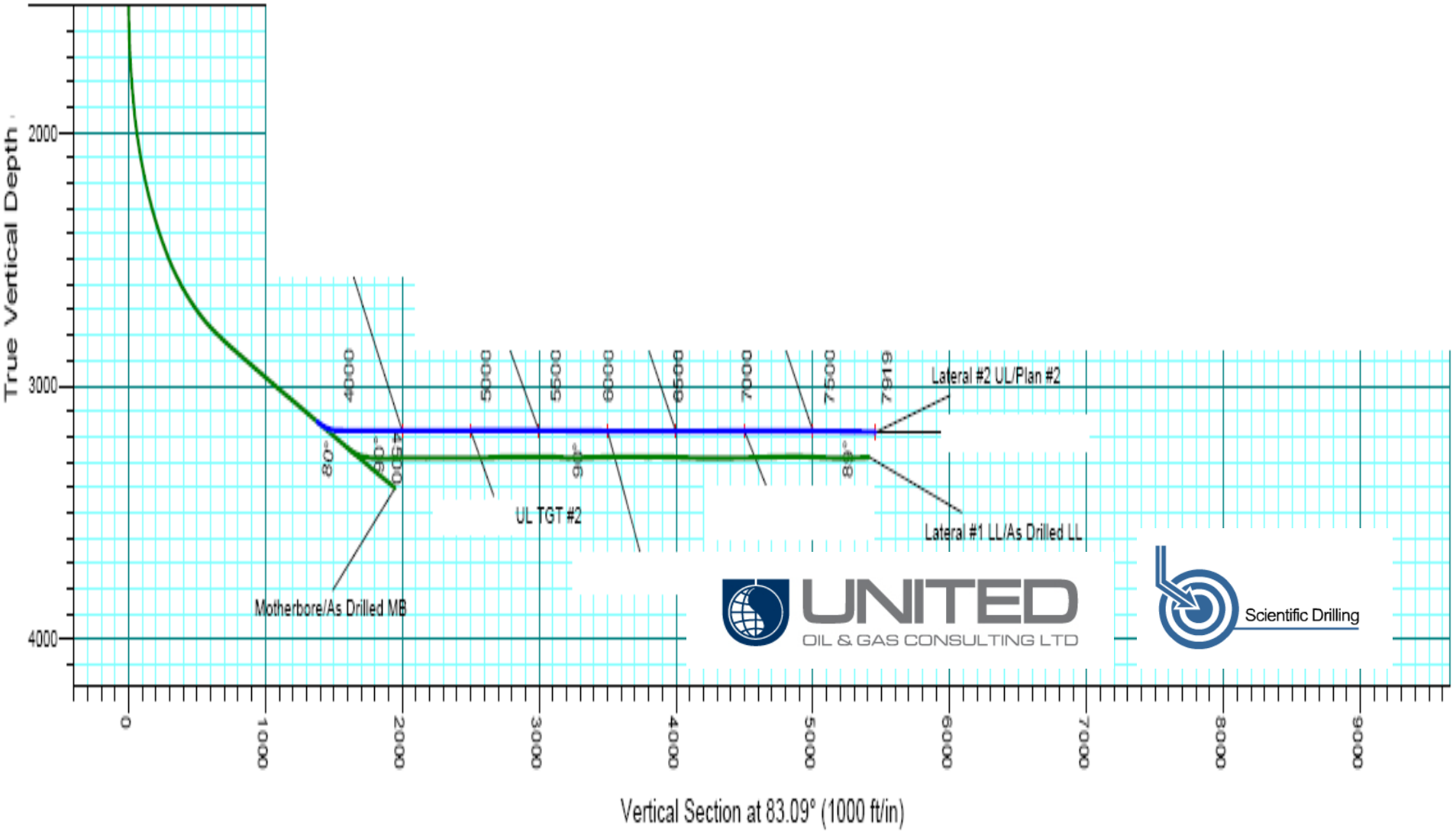




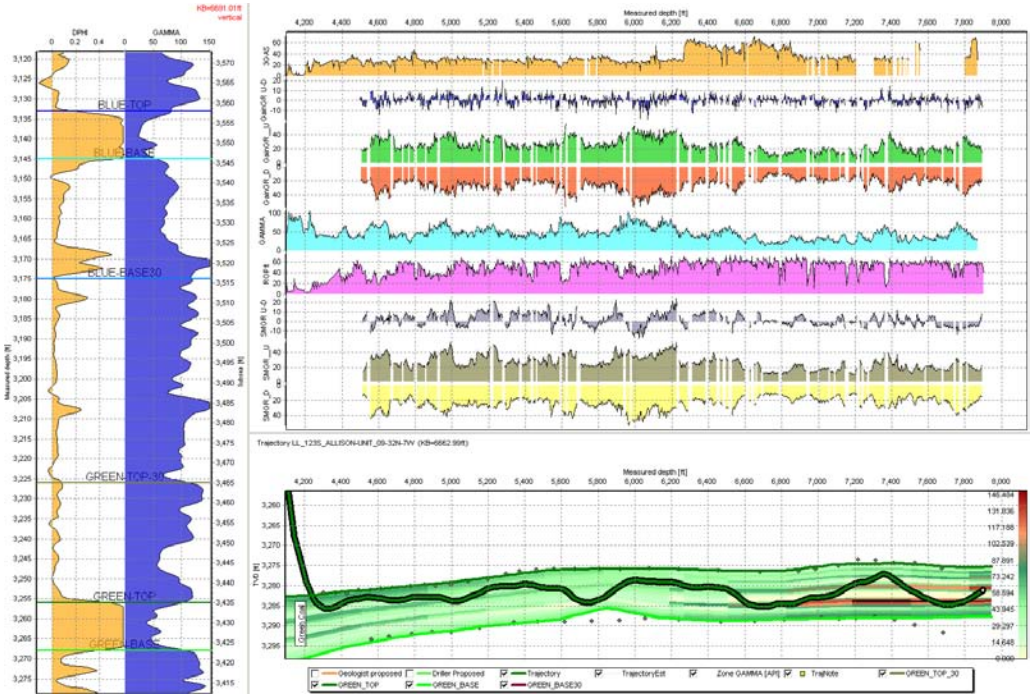
MOTHERBORE WELL DESIGN WITH TWO CSG LATERALS

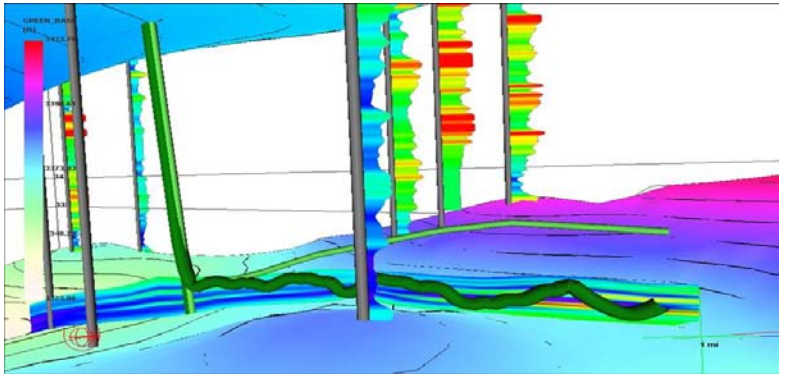


TWO LATERALS TO BE DRILLED IN THE COAL FROM A 60 DEG. SLANT MOTHERBORE

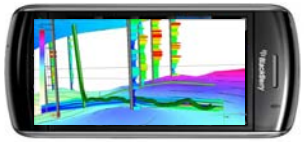


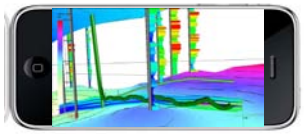
SMART4D Profile and 3D Visualization Applications and Viewed While Drilling





Typical Reporting is a 10 minute frequency from a website accessible by E&P and other stakeholders such as DD's and well site personnel.





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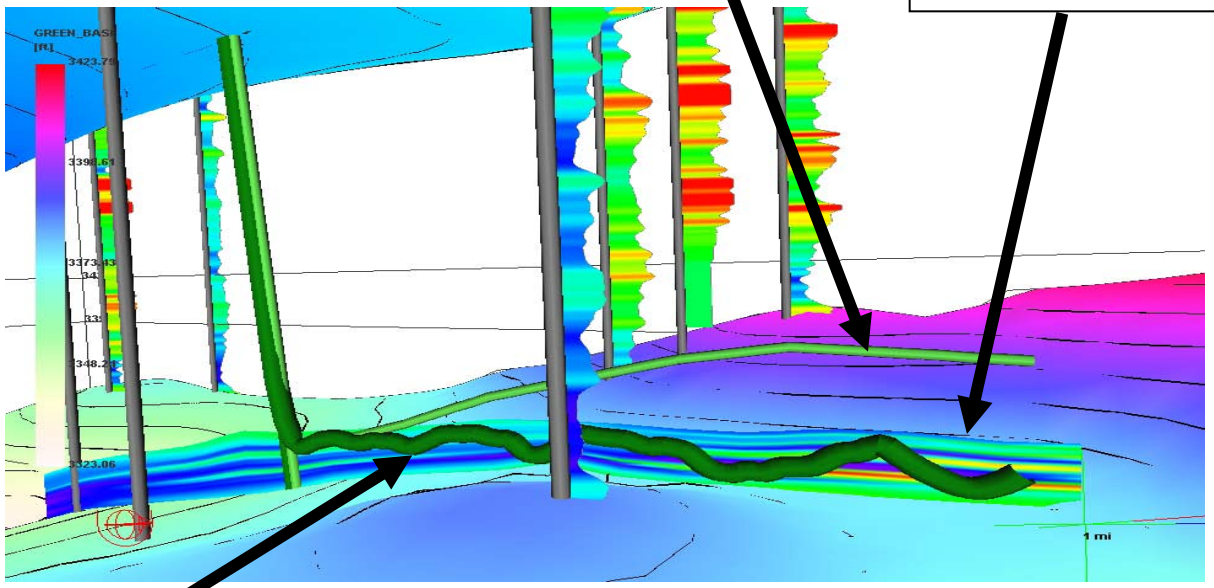
3D Views Available While Drilling

SMART4D Briefcase Geo-model was available in Real-Time from Geosteering website

Pre-Drill Trajectory Plan

Gamma Ray Fence from Geo-model



Post-Drill Trajectory Path After Geosteering

SMART4D MODELLING

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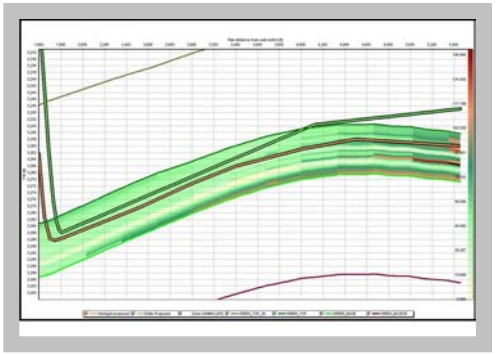
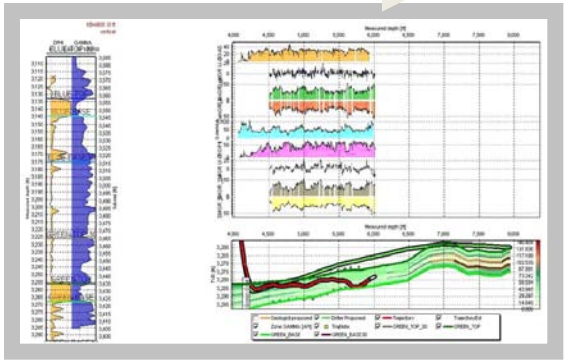
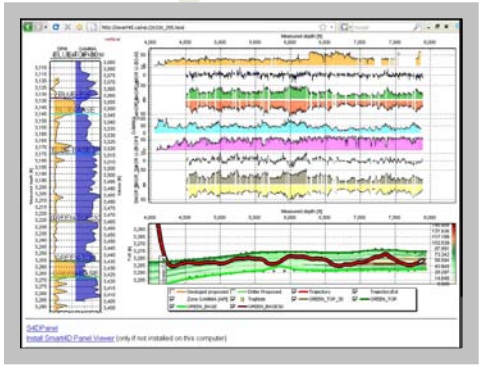
3D Geo-model Changes While Drilling (WD)

Pre-Drill

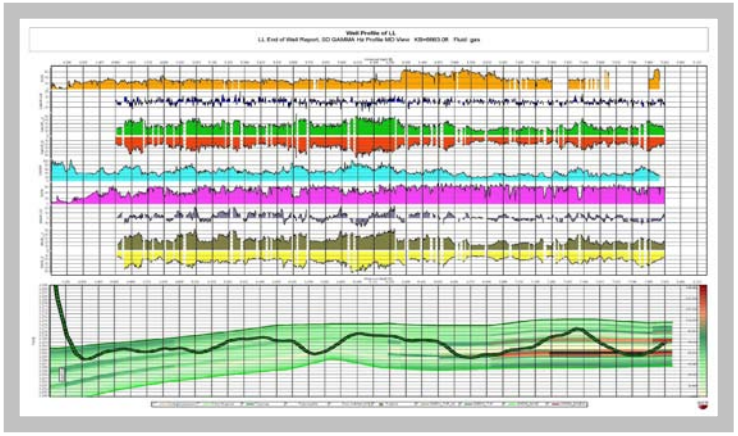


WD



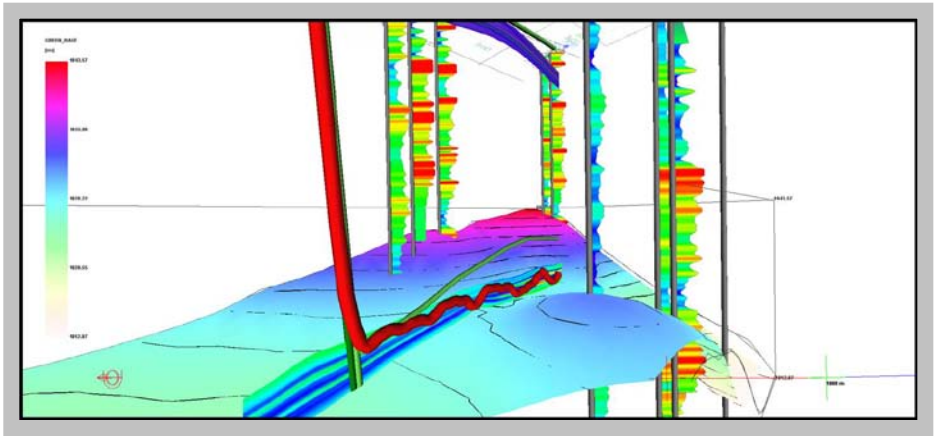


End Of Well (EOW)



SMART4D Panel WD

EOW



SMART4D Visualization WD

SMART4D MODELLING

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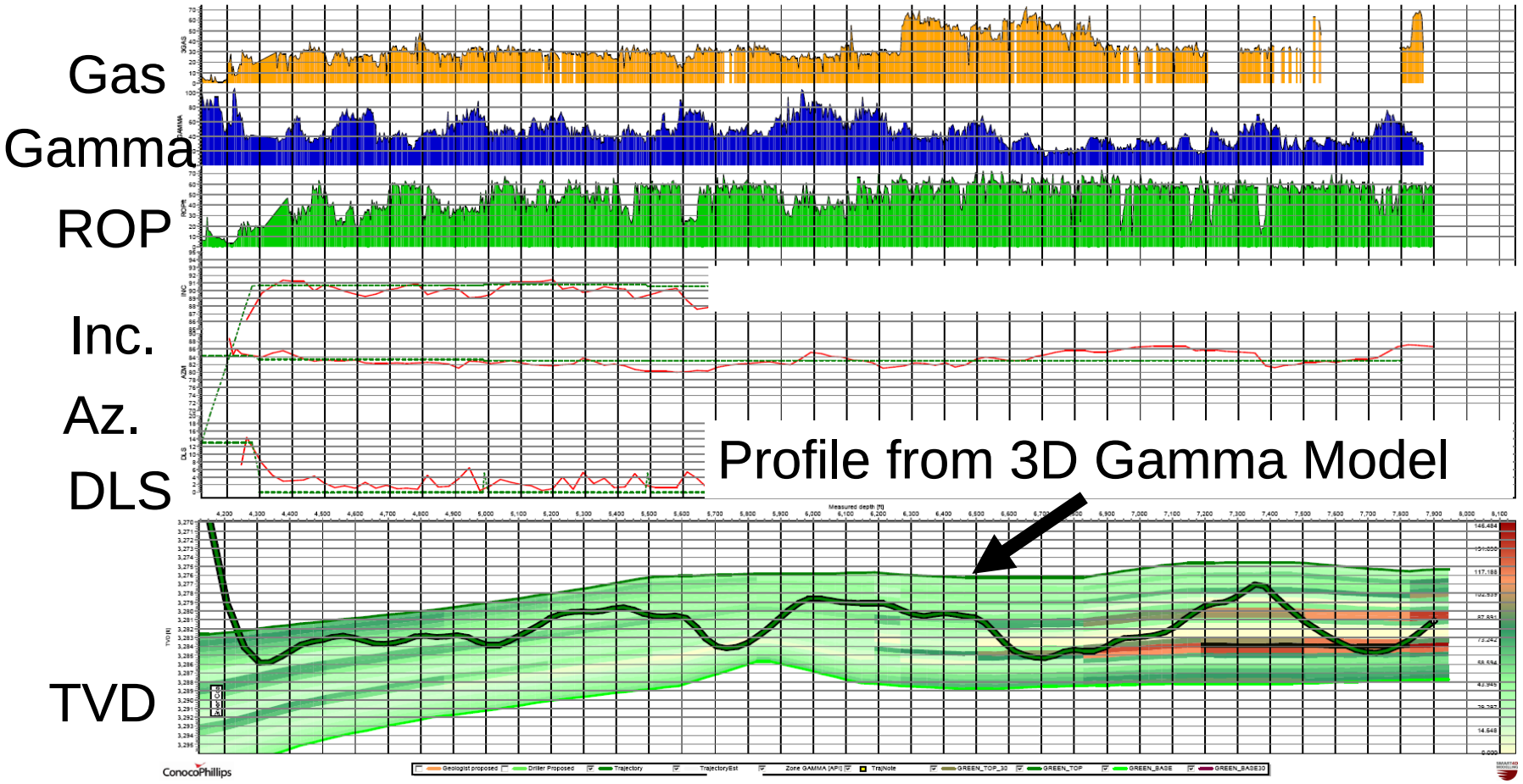
Typical SMART4D Panel While Drilling for Lower Coal



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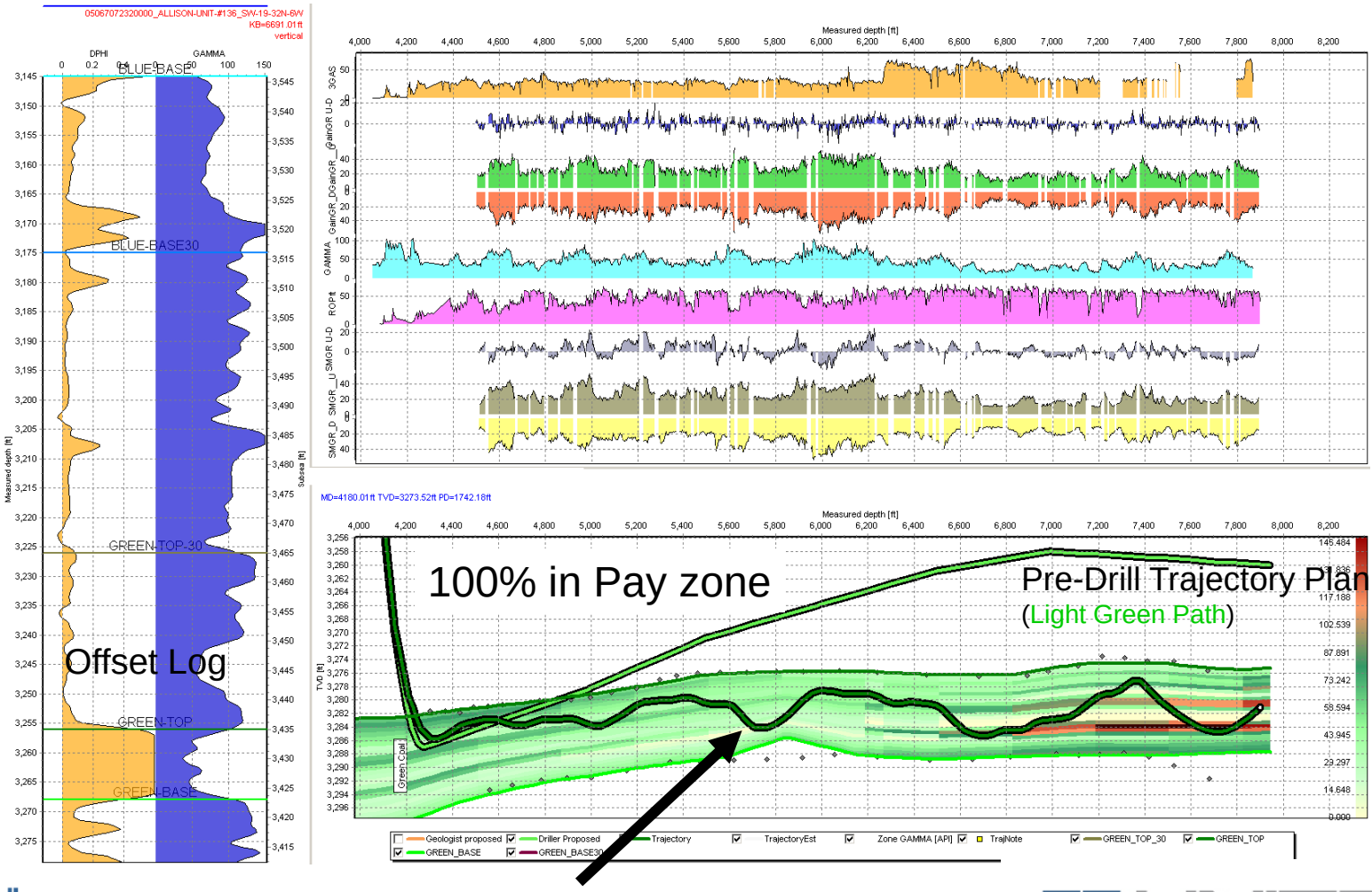
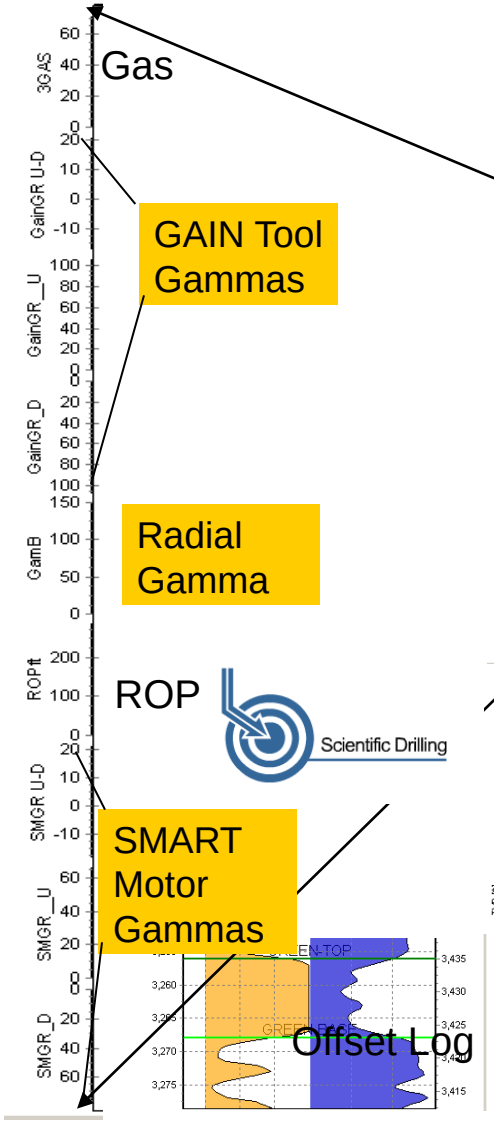
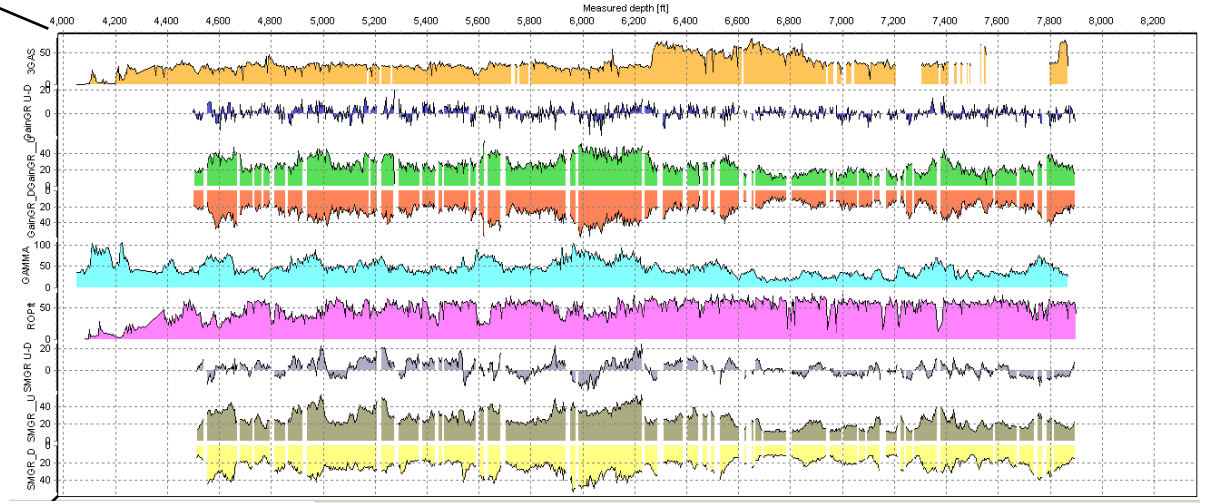
Integrated Gamma Presentation: CBM Project San Juan Basin

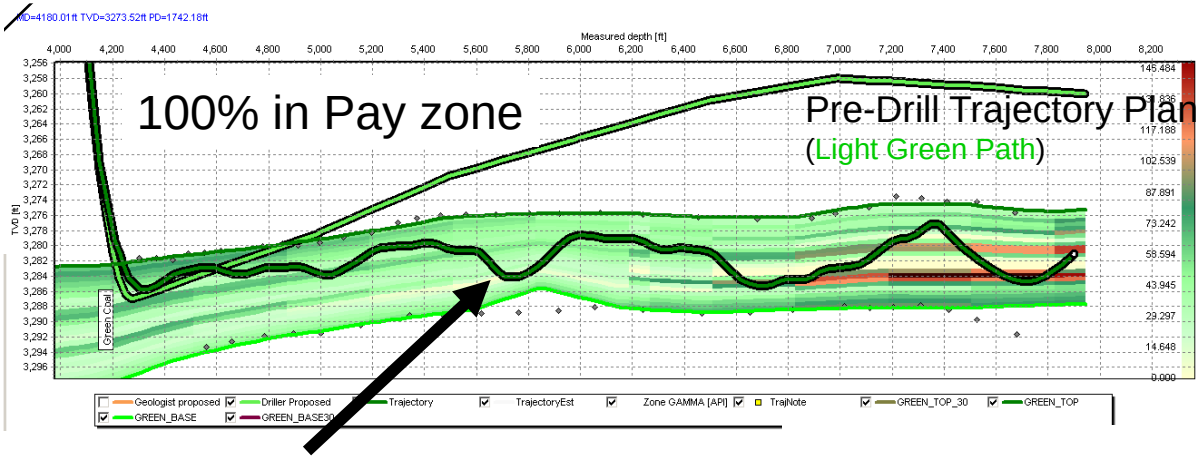


Post-Drill Trajectory Path and Structure Map after Geosteering

Integrated Gamma Presentation: Lower Coal Horizontal Profile







Post-Drill Trajectory Path and Structure Map after Geosteering

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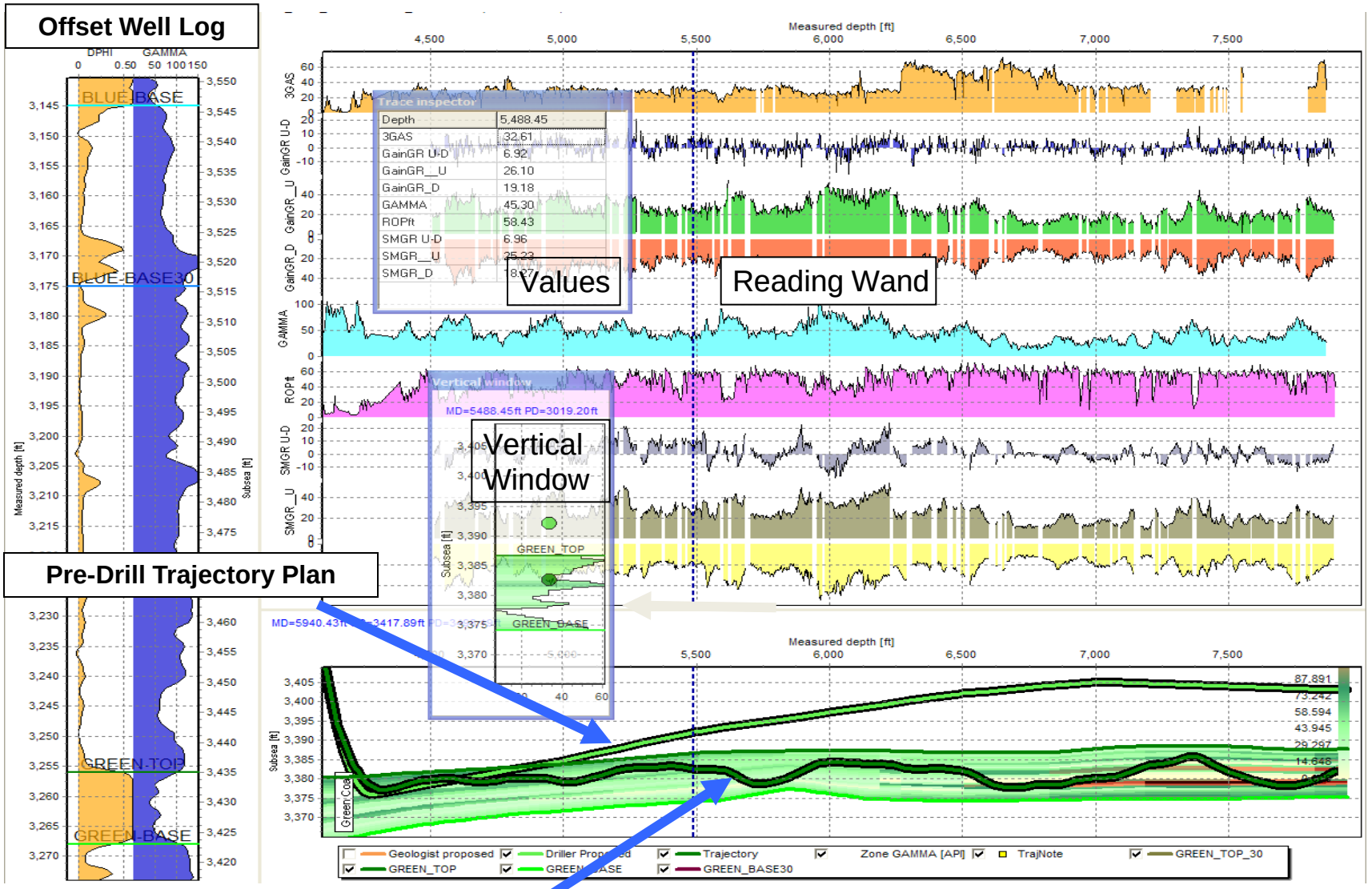
While Drilling 3D Views and SMART4D Horizontal Profile tool



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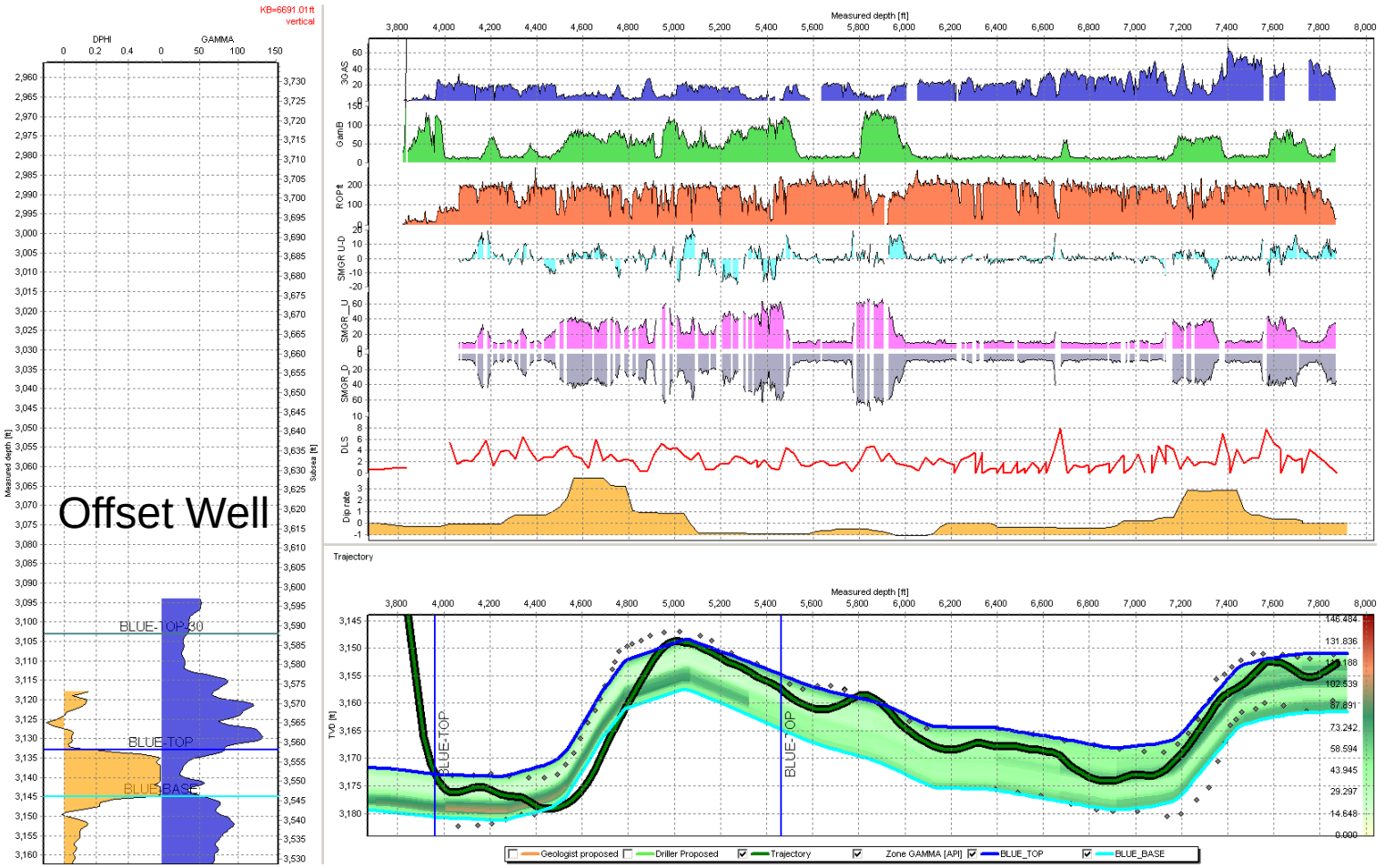
SMART4D Panel
Upper Lateral Horizontal Profile



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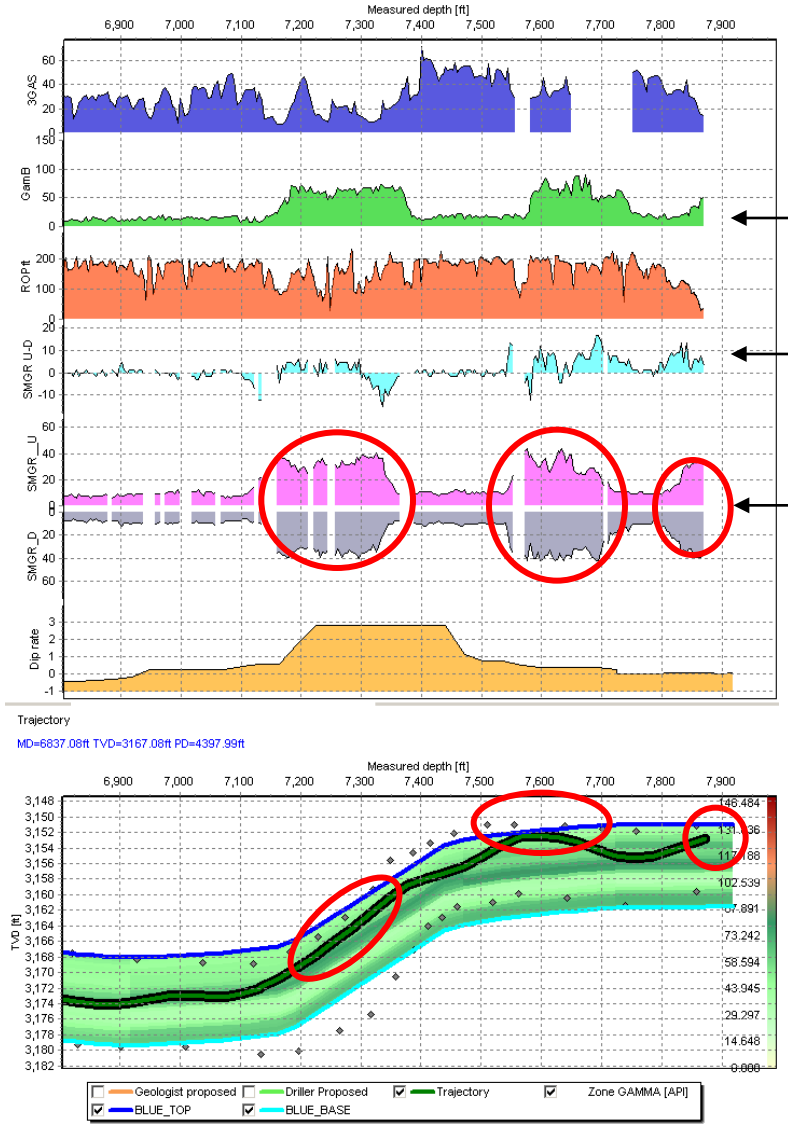
SMART4D Profile Upper Lateral

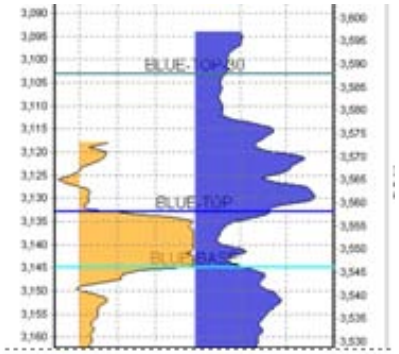


Conventional/Radial Gamma (lagged in time)

Positive Displacement indicates close to roof

Smart Motor Azimuthal Gamma 2m from bit

Offset Well



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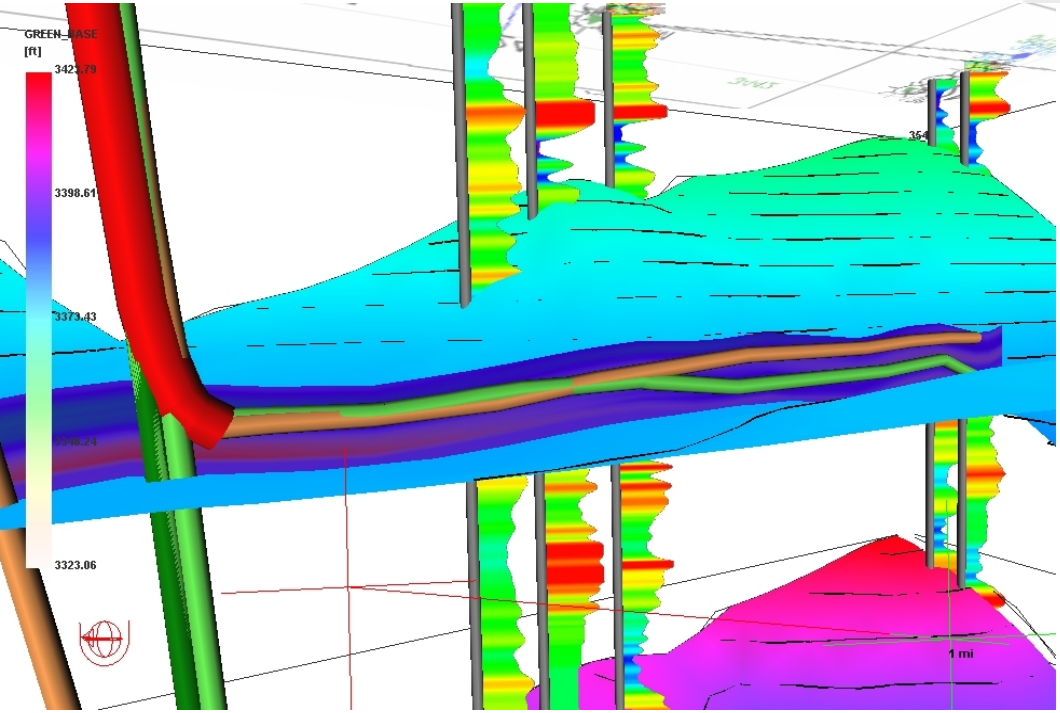
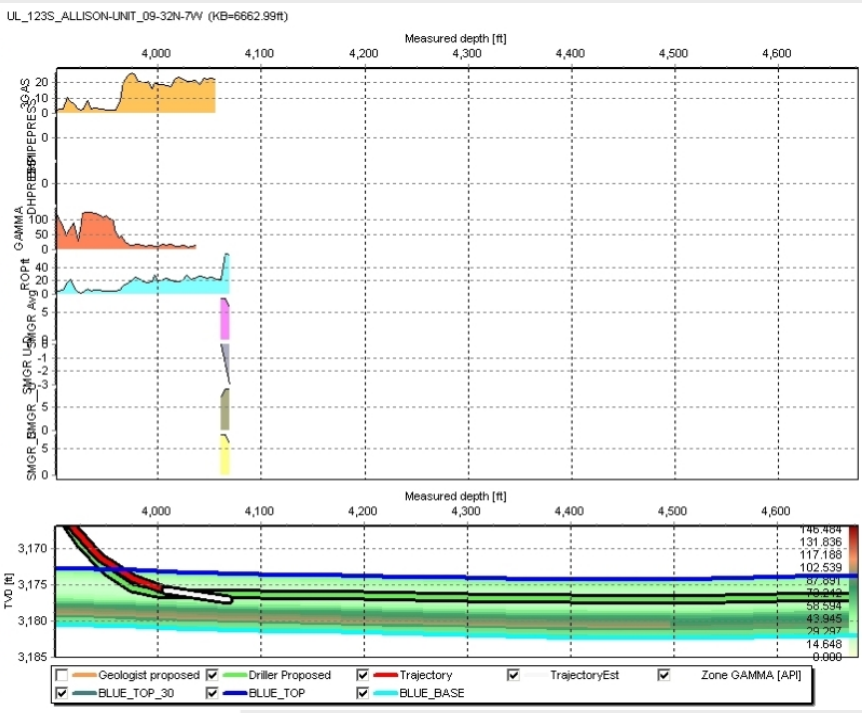
Real time SMART4D Geo-modelling and Characterization While Drilling





Geosteering example in San Juan Basin

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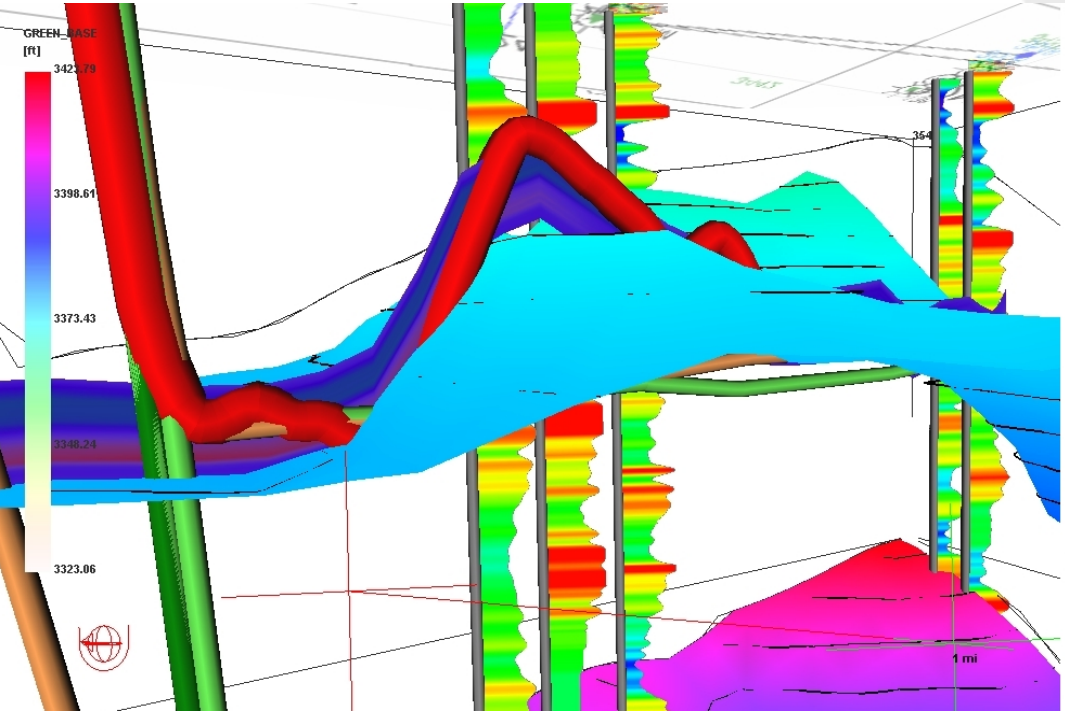
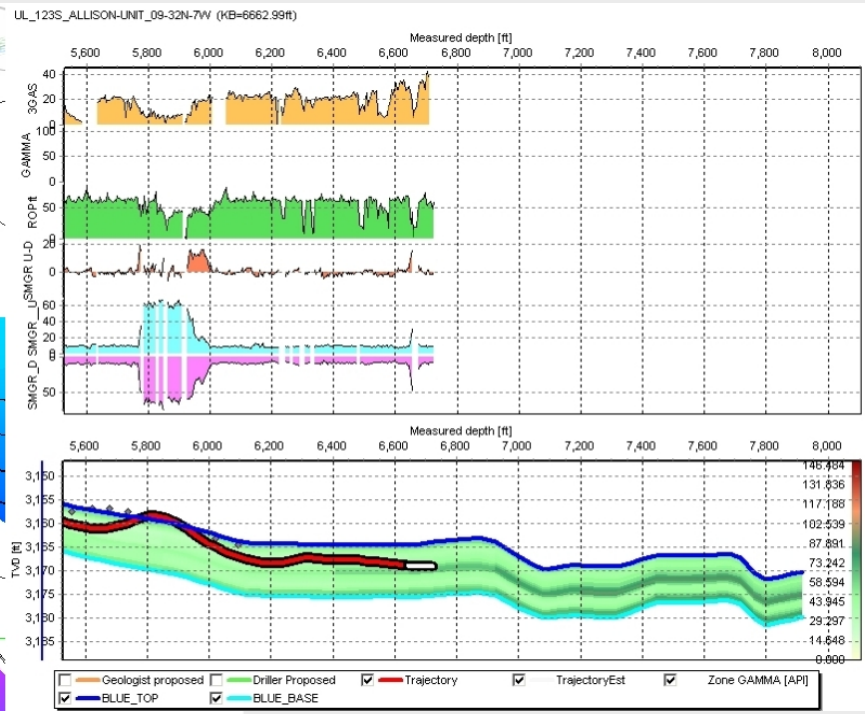
Real time SMART4D Geo-modelling and Characterization While Drilling





Geosteering example in San Juan Basin

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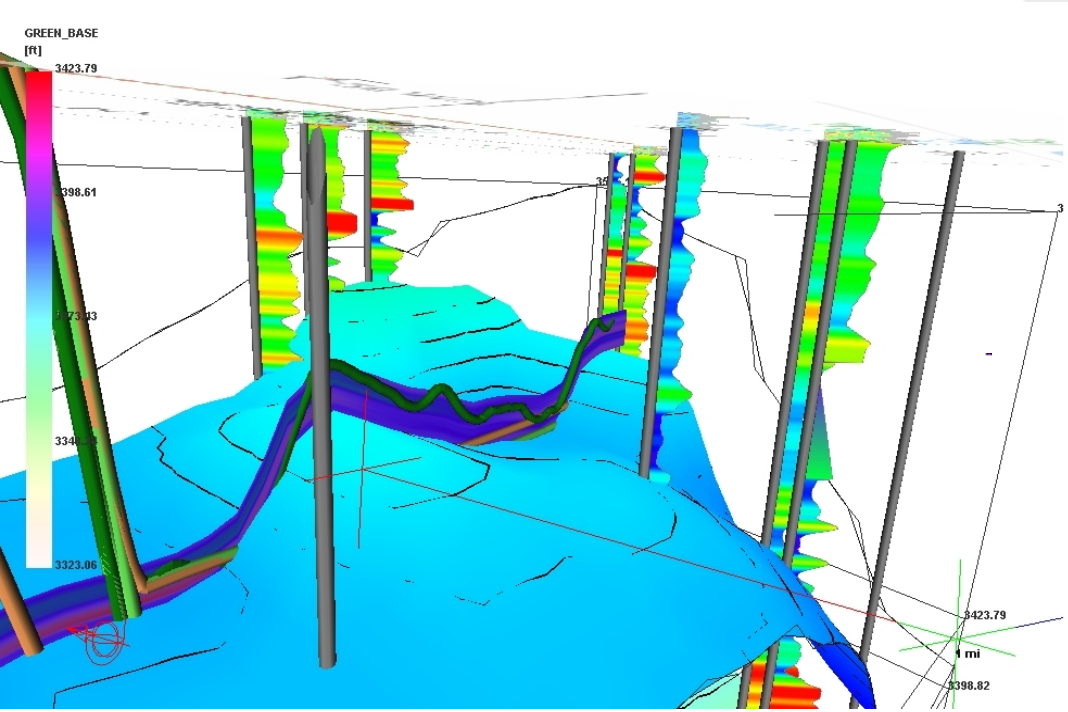
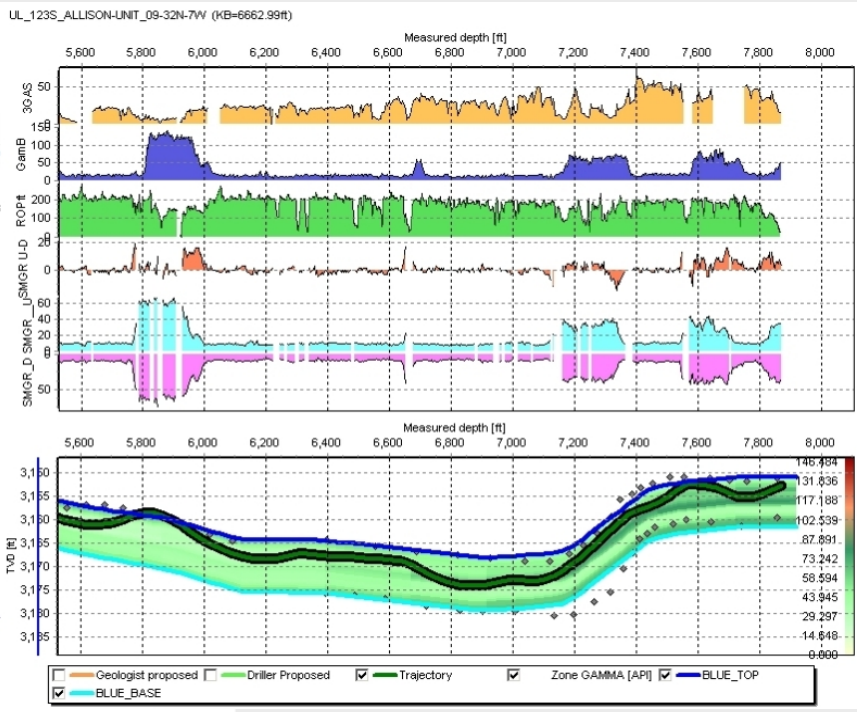
Real time SMART4D Geo-modelling and Characterization While Drilling





Geosteering example in San Juan Basin

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Geosteering and Impact on Horizontal Well Completions

- Completions cost (Multi-stage Fracs) $1-8MM
- Fracs are a huge cost to E&Ps. Focused application is required to reduce costs. Bigger frac seems to be better but there are other issues to consider.
- Geosteering allows for engineered and focused well placement in the sweet spots of pay intervals.
- 2 things are achieved by applying geosteering
  - Expensive fracs don't dissipate into non-productive intervals
  - Additional opportunity intervals for multi-staged fracs become a possibility
  - Frac intervals and spacing of horizontals are optimized resulting in capital optimization.

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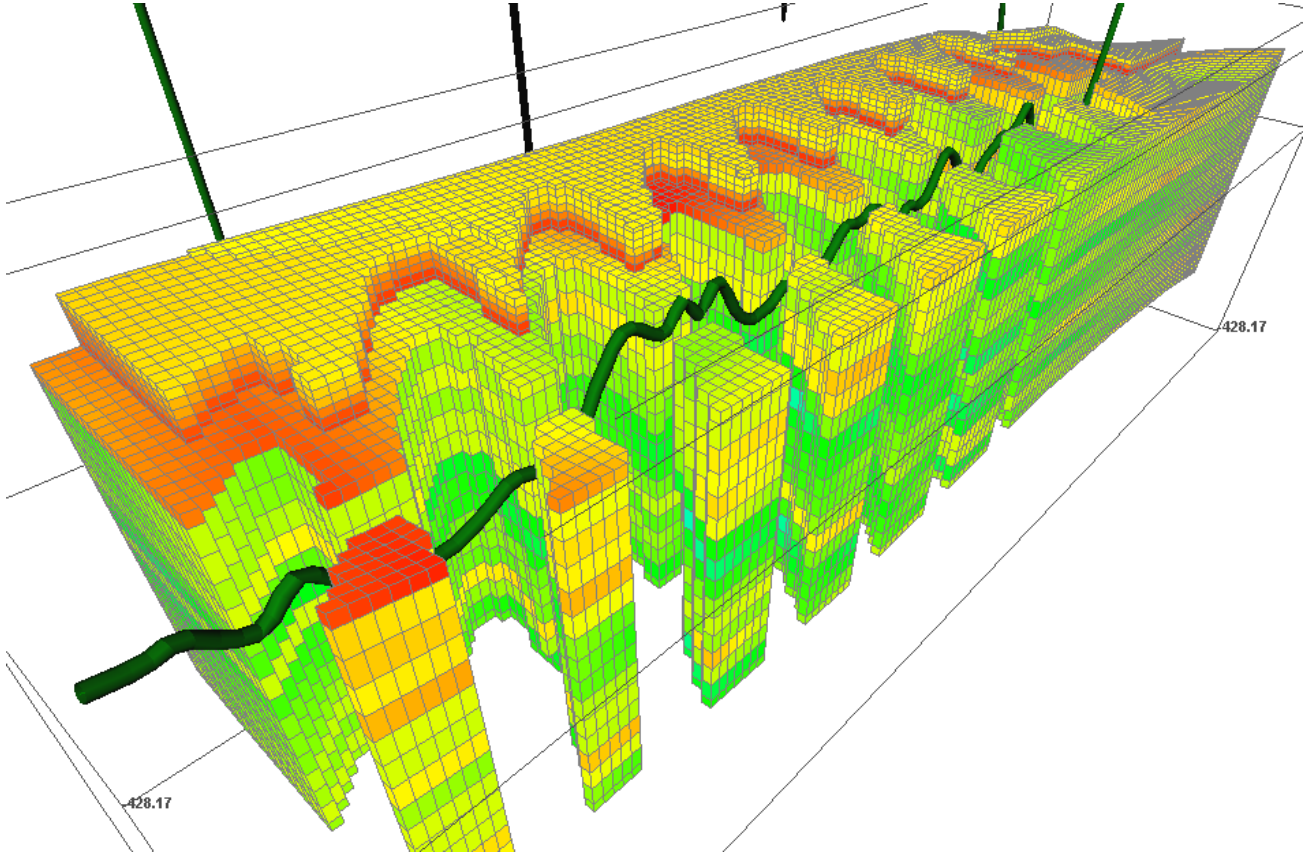
Volumetric Sweep Mapping (VSM) Simulation for Optimizing well placement and Multi-staged Fracs



SMART4D MODELLING

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In Conclusion

Geosteering technologies allow you to:

- Stay on the sweet spots of your pay in horizontal wells
- Reduce drilling issues by being proactive about where we are and where we are going.
- Manage your drilling through technologies that inform you and provide visual targets for all involved in geosteering
- Collaborate to maximize value for the E&P
- Drill anywhere, be informed anywhere and anytime
- Make a difference when it counts for in-zone penetration and optimizing production and recovery
- Reduce HSE and cost issues
- Helps optimize the next step which is well completion

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