PROCEEDINGS, 13th Indonesia International GEOTHERMAL Convention & Exhibition 2013
Assembly Hall - Jakarta Convention Center Indonesia, June 12 – 14, 2013

OPTIMIZE WELL DESIGN AND REAL TIME STRATIGRAPHIC POSITIONING OF THE WELLBORE IN UNCONVENTIONAL RESERVOIRS

Ilhan Akbar

PT Paradigm Geophysical Indonesia
Sampoena Strategic Square
North Tower, Level 19
Jl. Jend. Sudirman Kav 45-46
Jakarta 12930 - Indonesia
e-mail: ilhan.akbar@pdgm.com

Reservoir complexity drives the need for wellpath and engineering design optimization across all well planning and drilling workflows. Just as designing wells within a 3D geological model can shorten planning cycle times, improve well placement and reduce drilling risk, the ability to make real-time updates to those 3D models, based on LWD responses, enables rapid re-planning and re-engineering while drilling. Such an approach can optimize wellbore placement and maximize production.

This article will share a powerful and flexible planning, engineering and geosteering solution that allow companies to take control of the well design and drilling process.

Featured Products: *Sysdrill® 2012*, *Geolog®* Geosteer 7.0 patch 2.

OPTIMIZE WELL DESIGN AND REAL TIME STRATIGRAPHIC POSITIONING OF THE WELLBORE IN UNCONVENTIONAL RESERVOIRS

By Ilhan Akbar, Paradigm

The challenge of producing hydrocarbons economically from increasingly complex unconventional reservoirs drives the need for wellpath and engineering design optimization at every stage of the planning and drilling process. Just as designing wells within a 3D geological model or seismic volume can shorten well-planning cycle times, improve well placement and reduce drilling risk, the ability to make real-time updates to those 3D models, based on petrophysical log responses, enables rapid and informed re-planning and engineering while drilling.

This article describes an integrated software solution that helps optimize well placement and maximize production.

Collaborative Workflow

The key to the effectiveness of the solution is the use of integrated, multidisciplinary tools operating on a shared data management, and interoperability framework that enables experts from drilling, geology, petrophysics and geophysics to work concurrently and share data.

In order to ensure these goals can be achieved, the use of a geosteering solution in combination with a unified well planning and drilling engineering application delivers a work flow that supports creation of log-scale geosteering models ahead of drilling, facilitates interactive updates to geosteering models while drilling, and enables rapid re-planning of wells using updated models. Based on the real-time data feeds available from the rig site, this work can be carried out in a real-time center, enabling an expert multi-disciplinary team to evaluate operational decisions.

Well Planning

A 3D geological model, defined in industry standard file formats, is shared by the engineering and geosteering applications. In the engineering application, the well is planned and fully engineered within the context of the 3D model, allowing geological validation of the wellbore at every stage of the design process.

Using 3-D pressure volumes, pore and fracture data can be extracted along the well and used to validate casing depths and optimize drilling hydraulics. The final well design is then shared with the geosteering application.

Log-scale Geosteering

Through combining the overall structural framework provided by an existing 3D geological model with the detailed log responses observed in offset well(s) that penetrate the formations of interest, forward modeling in the true stratigraphic thickness domain can be used to produce a detailed pre-drill model along the planned wellbore that reflects predicted changes in log character.

This can include the modeling of tools from any contractor. Typically displayed as a slice or curtain in distance out along the well path, this pre-drill log property model becomes the backdrop upon which new information is displayed as it is received during the drilling operation (**Figure 1**).

In addition to providing predicted log values, a full property map can also be generated (**Figure 2**). By using 3D surfaces, property values can be predicted at any point along the wellbore to produce 3D-modeled image logs. If sufficient changes in log character exist to determine that the well is approaching a given formation, this can be used to geosteer the well to optimize entry and/or avoid early exit from the target reservoir.

Seeing is Believing

As drilling progresses, timely incorporation of new data into the model is essential. Historically, this data has come in the form of individual files from the contractor or via a proprietary real-time data source. Today, where available, Wellsite Information Transfer Standard Markup Language (WITSML) provides an open standard format for real-time data transmission that can be automatically streamed into both the engineering and geosteering applications via a real time data acquisition system.

By dispensing with the previous practice of manually loading individual files when new data arrive, this automated approach increases efficiency and reduces the chance of transcription errors.
The actual well position and positional uncertainty are calculated and visualized in the 3D model and compared with the planned well. Actual logging-while drilling (LWD) logs are displayed and compared with the predicted logs. Discrepancies between the pre-drill model and actual results can result from a number of sources. Using local knowledge of the reservoir, it is usually possible to reconcile the differences and incorporate this information into the existing model.

In some cases, the original structural framework may be off-depth, while in others the log character of a given formation at a given point may be different from what is expected. By interactively editing the pre-drill model, the geosteering engineer can reconcile differences between predicted and actual responses. The user has the ability to interactively alter the dip of a given bed, alter its thickness or model a geological fault and see instantly how these changes would affect the modeled log properties. Additionally, geological constraints regarding conformability of surfaces from the initial model will be honored during editing operations. Undesirable edits can be removed and an alternative edit made. There are often several possible interpretations of the types of situation we see while geosteering.

Here, the aim is to provide the user with sufficiently flexible tools to try several “what if” scenarios, and apply local knowledge to select the most probable scenario prior to making any decisions.

Changes in the geological structure between the predicted and actual logs, indicate that the model needs to be updated. Updates are achieved through interactive picking of formation intersections and changing formation dip or bed thickness until the log responses match. This updated model then incorporated into the 3D reference model used to update the well path while drilling.

Large discrepancies may be explained by drilling through a fault and can be incorporated into the model. Where model updates result in significant true vertical depth adjustments, the updated 3D surfaces can be used in the engineering application to re-plan and re-engineer the well, during drilling, based on the most recent petrophysical interpretation (**Figure 3**). If required, a sidetrack can be created in the engineering application, a new 3D model produced and the geosteering process repeated for the planned sidetrack. Post-well correlation of existing wells can be performed to update regional scale geological models and optimize the logging program for future wells.

In parallel, the directional driller can use the engineering application to monitor drilling progress against plan, calibrate friction factors based upon real-time surface torque measurements and project ahead of the bit position to ensure that the well can be drilled without exceeding dogleg constraints. Additionally, engineering analysis can be run on the re-planned interval to ensure that the well is drillable from mechanical and hydraulic perspectives, and that the casing or completion string can be installed. Where applicable, the anti-collision scan can be run simultaneously to ensure the well will not collide with any existing wells in the area.

Field Use

The workflows described in this article have been used extensively. Mitra et al (2004) described the use of this workflow in the redevelopment of ONGC's Mumbai High oilfield, which features complex multilayered carbonate reservoirs necessitating high-tech horizontal wells. They noted that, in addition to improving the success of placement of individual wells, they were also able to reduce nonproductive time and the overall cost of the wells.

By bringing together all the data and knowledge gathered during the drilling operations with the updated geological and drilling models, subsequent wells can be more effectively placed in order to optimize production. The workflow has now been used globally in onshore and offshore situations in a variety of reservoirs ranging from deepwater clastic reservoirs to Midcontinent tight-gas plays.

References:
Richard Pelling, Doug Gilmour and Robert Innes, Paradigm
Printed from the March/April 2010 edition of Drilling Contractor magazine
Mitra, P.P., Joshi, T.R. & Thevoux-Chabuel (2004), *"Real Time Geosteering of High Tech Well in Virtual Reality and Prediction Ahead of Drill Bit for Cost Optimization and Risk Reduction in Mumbai High L-III Reservoir,"*
SPE 88531, SPE Asia Pacific Oil and Gas Conference and Exhibition, 18-20 October, Perth, Australia.

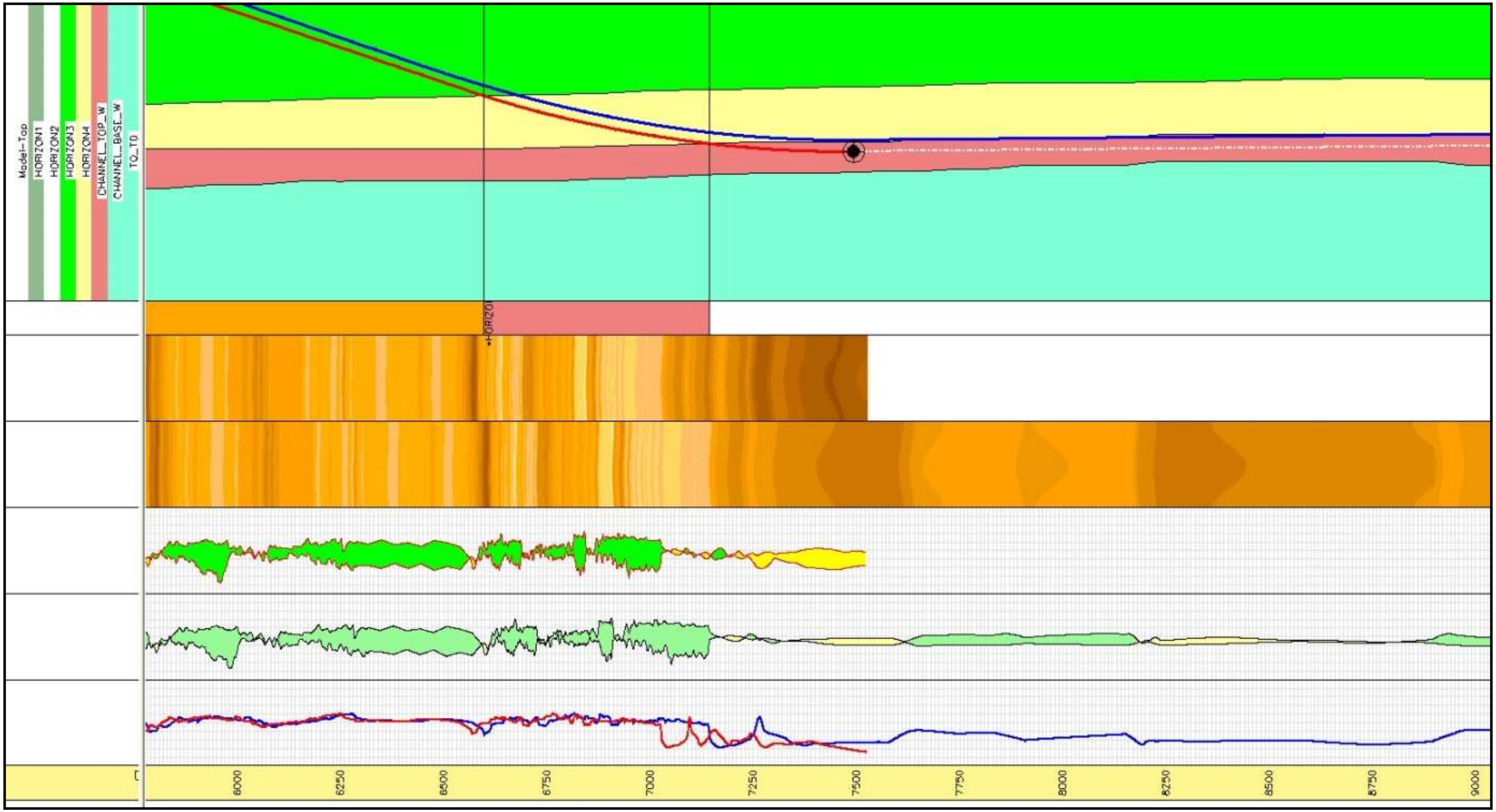

***Figure 1**: Using an integrated software system, correlation of the pre-drill log property model can be achieved while drilling using multiple logs, including an image log.*

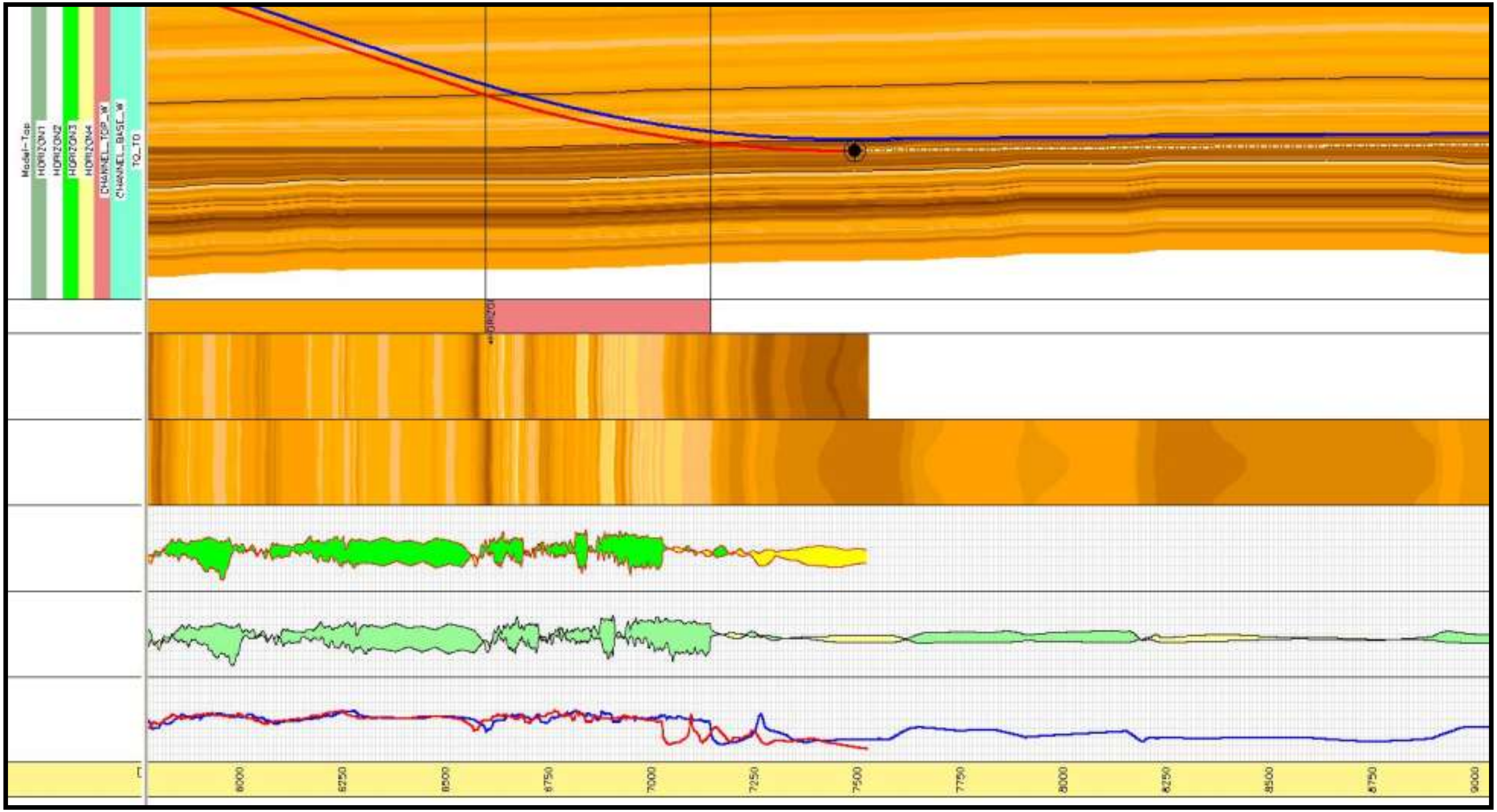

***Figure 2**: Any modeled property can be displayed in the structural section to help determine appropriate edits.*

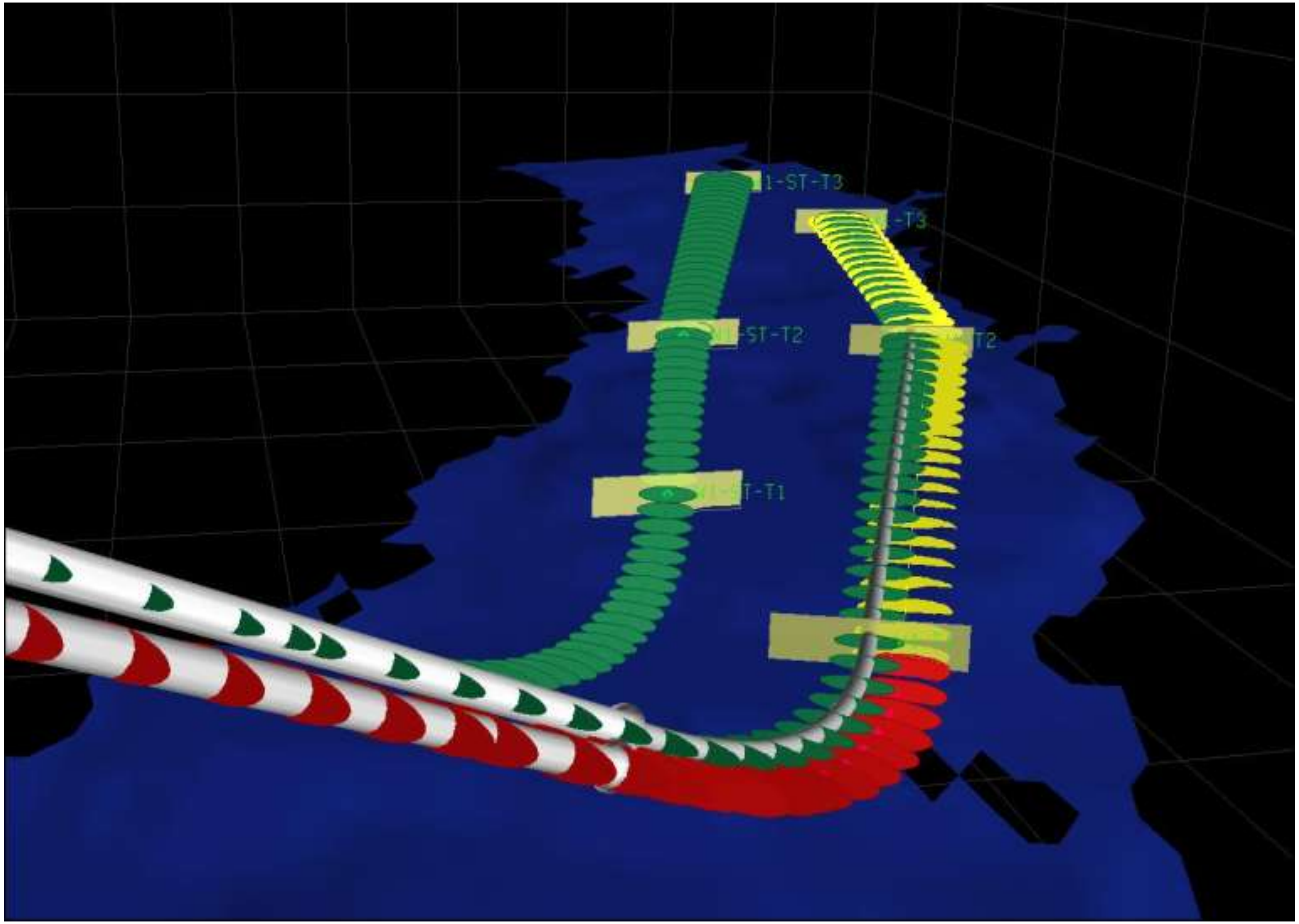

Figure 3*: Re-planning and re-engineering within an updated 3D model can be done during drilling based on new petrophysical interpretation.*