Significance of real-time petro-physical data for an optimal remote geosteering operation in complex geological reservoirs

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Abstract: In the last decade, the oil industry has transitioned from primarily drilling vertical wells to a majority of extended reach complex horizontal wells with help of geosteering techniques for better reservoir and production efficiencies. The overall objective of geosteering and well placement has helped to maximize reservoir contact by the keeping well trajectory in the pay zone with the help of quality real-time data, especially in these uncertain times of pandemic due to COVID-19. This paper illustrates the immense impact of real-time data feeds (special logging tools/images) at operation centers with the full remote expert support of multidisciplinary teams. The proper data communication mechanism is also helpful to share the information across asset teams in a timely manner to drill complex wells remotely. To achieve the desired geosteering objectives, experts monitor and evaluate the real-time data in a landing well accurately in the pay horizon by designing the well path which considers geological variables like (reservoir architecture, permeability and porosity distribution, and fluid contacts) which further helps update the reservoir models in real-time based on the latest subsurface information for better reservoir management and timely decision making.

Keywords: remote geosteering, integrated real-time data, logging while drilling, collaborative decision making, reservoir management

INTRODUCTION

Managing contemporary oil and gas drilling (both conventional and unconventional) has become increasingly complex, especially when challenged by mature fields, thin bed reservoirs, remote geographies, globally disbursed infrastructure and the utilization of different drilling tools/services. As a result, the demand for real-time and digitally streaming data continues to grow, helping to improve collaborative decision making and operational performance. This real-time technology enhances the overall data collection, communication, collaboration and control as the real-time data enables companies to simultaneously monitor, visualize, analyze and optimize the geosteering and well placement operation.

Geosteering is the process that allows experts to perform real-time adjustments in the well bore geometry and to drill the well in the sweet zones of the reservoir, utilizing petro-physical data and directional drilling techniques (Fjellheim et al. 2010).

It is used to steer the borehole position (inclination and azimuth angles) to reach more than one geological target while drilling safely. Operators consider this operation the most critical as it sums up the overall rig operational cost due to the involvement of advanced logging tools from service contractors. Equipped with real-time data from these logging tools, geologists can interpret the formation and guide the logging company with the right directions, aiding them in placing the wellbore in the desired pay zone. Any interruption in data transmission or any issue with the tools can delay the decision making during geosteering and consequently impact the cost of the well or even lead to its complete loss.

MATERIALS AND METHODS

This methodology demonstrates the immense impact of real-time and digital data feeds (M/LWD, images, and special logging tools) and collaborative work done at a remote operation center with the full remote expert support of multidisciplinary teams. The proper communication mechanism is also helpful to share timely information across the asset teams which is also possible to securely access from any "portable or mobile devices" anywhere and anytime with just the use of an internet connection.

Integrated real-time data

As technologies evolve, the oil and gas industry has increasingly turned to the WITS/WITSML (Wellsite Information Transfer Standards Markup Language) protocol for real-time streaming data for petro-physical, logging while drilling, and directional tools through satellite systems (Fig. 1). This figure shows that rig sensors and petro-physical data is being recorded by a data acquisition system (DAQ) which goes to the town based server via satellite communication protocol for monitoring purpose. It is a tremendous help in decision making based on diverse data feeds, helping to optimize the drilling, geosteering process and reduce operational costs (Sapkal et al. 2011).

Web based real-time displays for monitoring

This WITSML feed is displayed on a web-based system for visualization and provides customizable displays for monitoring the required data anytime, anywhere (Fig. 2).

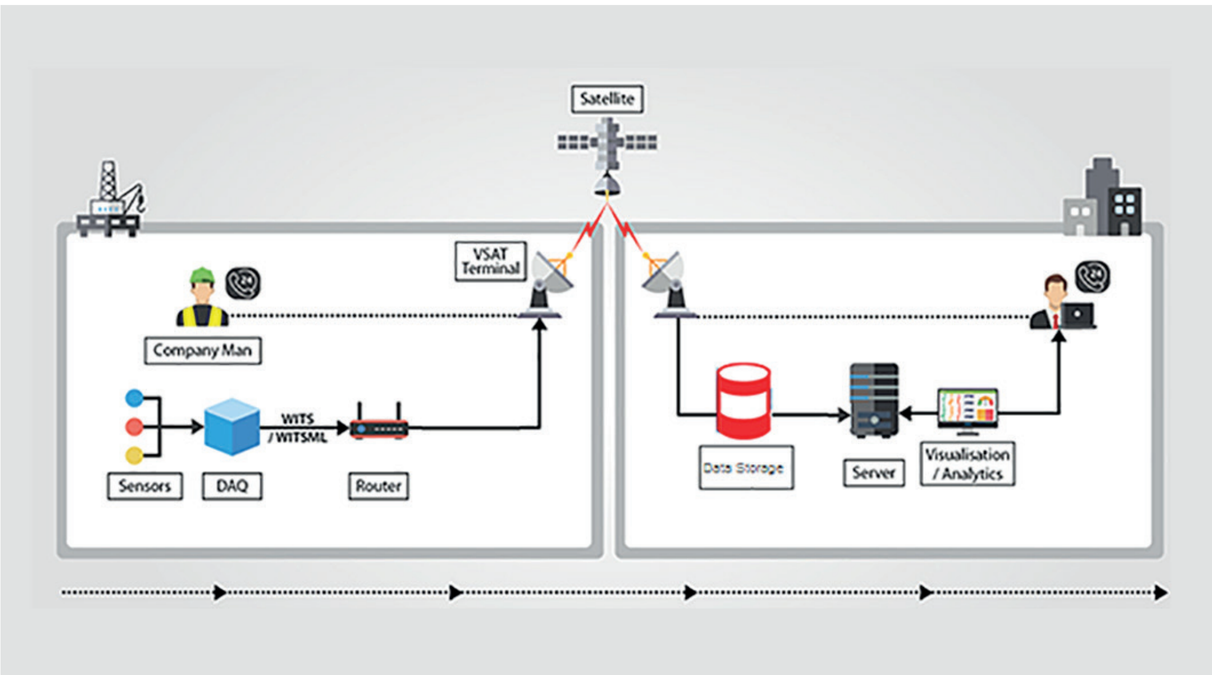

Fig. 1. *Simple sketch of infrastructure for real-time data communication from rig to base (modified after Khudiri et al. 2014)*

Fig. 2. *WITSML real-time data visualization of drilling and geosteering display and data pulling for 3rd party applications any detailed interpretation (modified after Khudiri et al. 2014)*

The viewer enables collective, collaborative knowledge sharing of the whole well site data in real-time on the user's desktop and, thanks to this information, the user can make timely and more informed decisions regarding the reservoirs. This real-time data feeds (L/MWD with high quality images and special tools NMR, Mud Logging, Coil Tubing, Wireline etc.) can also be pulled from the WITSML server to load and visualize in other 3rd party applications for detailed interpretation and analysis (Fig. 3).

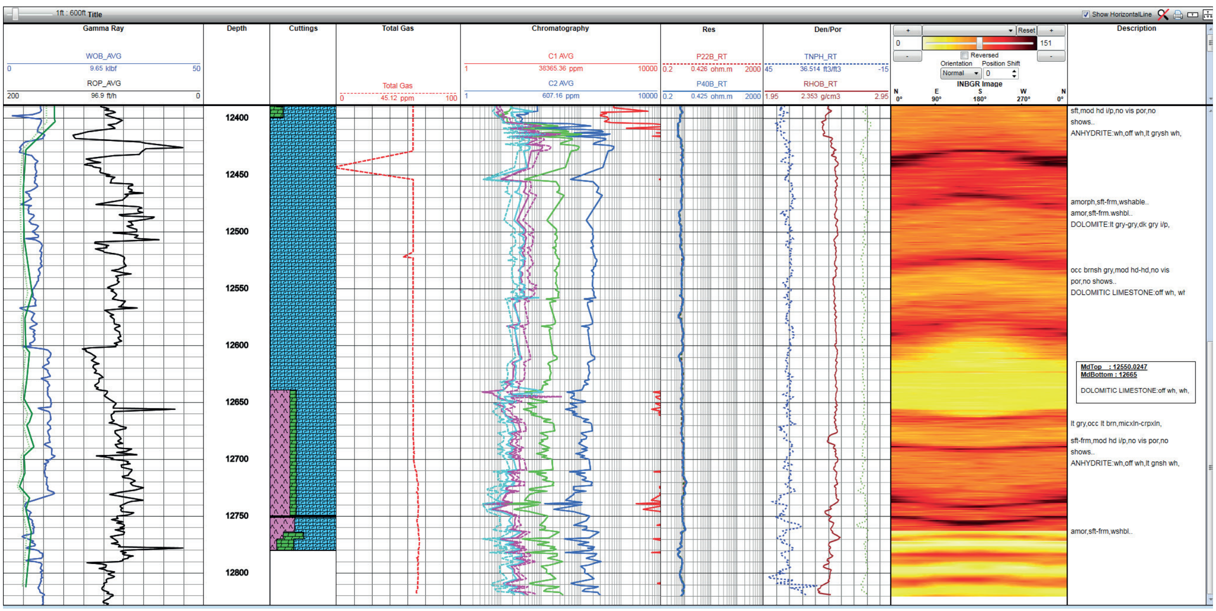

Fig. 3. *A composite display showing integrated real-time and live well logging data, in the 1st track (Gamma, Weight on Bit – WOB, Rate of Penetration – ROP), 2nd track (depth), 3rd track (cuttings lithology), 4th track (mudlog total gas), 5th track (mud gas chromatograph), 6th rack (resistivity), 7th track (density, neutron), 8th track (density image) and mud logger comments in the last track (Petrolink, n.d.)*

RESULTS

Recent advances in IT capabilities and data acquisition in this digital era have led to many users adopting real-time well placement and geosteering in different types of complex geological reservoirs throughout the world. To achieve the desired geosteering objectives, experts monitor and evaluate the real-time data in the deviated section to land accurately on top of the pay horizon followed by optimum placement by designing the well. The asset team has to keep in view the optimal geological variables like (reservoir architecture, permeability and porosity distribution, and fluid contacts, etc.) and at the same time minimize the drilling uncertainties during the operation (Kullawan et al. 2014).

Once the geosteerers and asset team have all the integrated information on their desktops, their main focus will be drilling a borehole in complex geology with continued adjustment in order to reach one or more reservoir targets. Here, we propose a collaborative approach where the Geologist, Geosteerer, Reservoir Engineer and Drilling Engineer etc., can monitor the real-time data and use their technical expertise to keep the critical geosteering well in the desired zone and target. In these remote centers, specialists of drilling and geological expertise can make informed decisions for executing the ideal well trajectory in a safe, secure and optimized drilling practice by communicating between the rigsite and the office with ease.

This workflow is followed by a series of forward modeling along the planned trajectory based on real-time data and log responses for properties like GR, resistivity, density and neutron, etc. The response of the real-time images is critical in determining whether the trajectory has cut the structure stratigraphically up or down, or maintained it in parallel with the reservoir (Fig. 4).

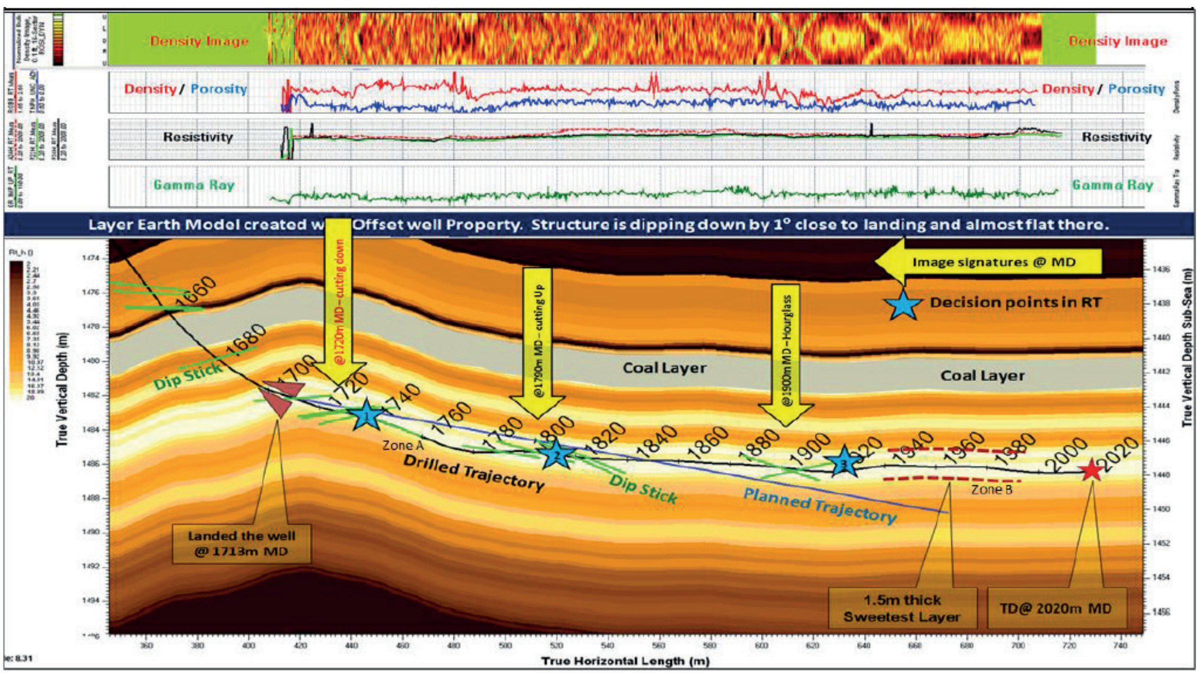

Fig. 4. Cross section plan vs. actual trajectory and decision point in real-time. The curves description is marked on the upper part whereas the density image is scaled in between 1.75 to 2.75 g/cc. The lower part has the subsurface model of the reservoir zone, where drilling trajectory and planned trajectory are also displayed for decision making in terms of optimal well placement (modified after Sapkal et al. 2011)

A few steps in the geosteering and well placement are usually followed:
- Land the well just after entering the desired formation and reservoir.
- Drill the wellbore trajectory in the most resistive and porous part.
- Maintain distance from undesired zones (no go formations) i.e., coal seam or shale etc.
- Correlate log signatures in real-time with offset well logs to update the model.
- Pick structural dips in real-time logging while drilling azimuthal density/resistivity image accordingly.
- Calculate structural dipping trend with a high degree of accuracy to update the 2/3D model.
- Correlate log signatures with drill cuttings while drilling for a greater degree of certainty.
- Keep the well trajectory and placement in the sweet zone with real-time information.

Significance of remote geosteering with integrated real-time petro-physical data

This collaborative and modern geosteering approach with integrated real-time data has a key significance to better understand and characterize the reservoir by helping operators maximize the horizontal wellbore exposure through proper well placement. This integrated approach primarily helps to identify the geological uncertainties during the well drilling phases (Dawoud et al. 2010):
- depth uncertainties: fluid contacts, bed boundaries,
- structural uncertainties: dip angle, faults,
- lateral variation in petro-physical properties.

Therefore, this collaborative remote geosteering approach helps in both strat-based and model-based geosteering, leading to the optimization of the well placement operation, lowering the costs and enhancing the well production life cycle (Raja et al. 2011). Some business returns of remote and collaborative geosteering are following:
- remote operation surveillance and full expert support for optimal well placement,
- comprehensive data management and monitoring the geosteering process collaboratively,
- communication between directional driller, geologists, engineers for timely and informed decisions,
- cost reduction through remote monitoring and increased efficiency in complex well placement operations,
- maximize the reservoir contact and enhanced the hydrocarbon production,
- improved drilling and geosteering efficiency and workflows for proper wellbore assurance,
- ease to manage multiple geosteering wells at the same time while sitting in the office,
- timely and collaborative decisions of asset teams for improving the rate of penetration and saving rig time,
- minimize the wellbore hazards by predicting them with the help of real-time data in complex formations,
- maintaining the good and desired borehole conditions with real-time information/ knowledge,
- reduce travel, logistical cost and physical exposure to avoid potential health, safety and environment concerns,
- real-time data accessible for surveillance at anytime, anywhere,
- maximize the productive time and minimize the non-productive time/ invisible lost time during the operation,
- hence, saving the time and costs, improving safety and boosting business return on investment.

DISCUSSION

Recently, initiatives have been taken by the industry to utilize real-time data to better understand reservoirs in safely drilling complex wells and minimizing the non-productive time during the operation. Moreover, operators are also using this real-time data compliance to identify the key performance indicators across all phases of drilling and geosteering to seek critical insights that can lead to the successful delivery of the well as well as reducing invisible lost time and non-productive time. Therefore, it is necessary to share the lessons learned to fill the gaps to improve operational efficiency and save costs, especially during the current downturn of the oil and gas industry.

CONCLUSIONS

It is concluded that this collaborative and modern geosteering approach not only helps in better characterizing complex reservoirs but also helps operators maximize the horizontal wellbore exposure through proper well placement in the most efficient reservoir zones and also in the drilling domain to overall increase the rate of penetration, maintaining good hole conditions, avoiding non-productive time, invisible lost time and drilling uncertainties to eventually optimize the operational costs for appropriate and successful well delivery.

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