An application for real-time lithofacies identification using artificial intelligence and machine learning

Julia McElgunn, M. Sc., P. Geo,, Vermilion Energy
Ian Theunissen, P. Geo., Vermilion Energy
Brett Montague, AI Geoscience

Summary

Artificial intelligence (AI) and machine learning enhances data analytics with completely new capabilities. The integration of AI and machine learning with fundamental geological techniques allows oil and gas operators to design applications for real time geosteering and drilling operations in challenging and complex formations, such as the Ellerslie Formation.

The Ellerslie Formation in West Central Alberta, Canada is situated along the extensive Pembina Paleo-Jurassic uplands. The formation is heterogeneous with a complex architecture of tidal flats and channel sands. Subsequent regional uplift, subaerial exposure, and discontinuous diagenesis of meteoric waters further increases the complexity. Despite drilling more than 100 wells to date in the Ellerslie Formation around Drayton Valley, Alberta, Canada, uncertainty arises in the accurate distinction of the upper unconformable bounding shales and the lower conformable to disconformable bounding shales.

Most recently wells drilled in 2019 and 2020 proved wellsite petrographic distinction between these two shales can been ambiguous and resulted in misidentification of the shales with increased out of zone meterage drilled. The remaining inventory exhibits increased complexity targeting thinner and riskier net pay closer to the upper and lower shale contacts, therefore, well placement is critical not only for expected ultimate recovery but to ensure maximized capital efficiency during drilling and completions operations.

Even with the great advances in conventional geosteering applications, they often do not work in the Ellerslie due to its internal complexity. This paper describes a novel attempt in using AI and machine learning to fingerprint Ellerslie lithofacies and the upper and lower bounding shales, in real time to optimize wellbore placement through confident geosteering decisions.

Theory / Method / Workflow

In 2017, Cabra Consulting partnered with AI Geoscience to create an artificial intelligence geosteering software. The software incorporates all available real-time drilling parameters, including LWD and mud gas data, using them as features in an ensembled, gradient boosting decision tree and neural network-based machine learning model which originally used to produce a real-time statistically optimized well path.

Vermilion's geological model of the Ellerslie Formation has been refined through petrography from core and drill cuttings in vertical and horizontal wells. By combining lookback studies of wells drilled with the functionality of Cabra's AI supported geosteering, the application was modified to create a new and unprecedented lithofacies class identification software. Three stages were used to create this software: training/testing, confirmation and implementation. 19 horizontal wells were used to train, validate and test the model. All drilling parameters and a reservoir breakdown of the lithofacies encountered horizontally from each well were fed into the model. The AI initially identified 6 lithofacies including the upper and lower bounding shales. This was later increased to 8 lithofacies . Secondly, 12 wells were "post-steered" to confirm the accuracy of the lithofacies identification. All results were displayed on a dashboard highlighting the actual lithofacies vs the AI interpreted lithofacies along the wellbore in 0.2m increments (Figure 1). The final results plotted in a confusion matrix quantifying the actual vs predicted counts for each lithofacies (Figure 2). The modelled results averaged 83% identification accuracy providing enough confidence to test live.

Results, Observations, Conclusions

In January 2021, preliminary live results identified potential errors that were absent in the training and testing sets. Furthermore, a limited amount of reservoir lithofacies were identified, and only one of the two bounding shales even though both bounding shales were drilled. The AI and model were re-trained and a scaling factor was applied. In two subsequent wells, the AI identified additional lithofacies including both the upper and lower bounding shales.

Common to all AI and machine learning applications, this tool is designed to learn through repeated exposure and will thereby refine its classification capabilities. Final results indicated that further deployment of the AI and model is required to refine its accuracy.

Acknowledgements

Gary Bugden, P. Geol., Cabra Consulting Ltd.

References

Reference Style (use Arial 9pt normal)

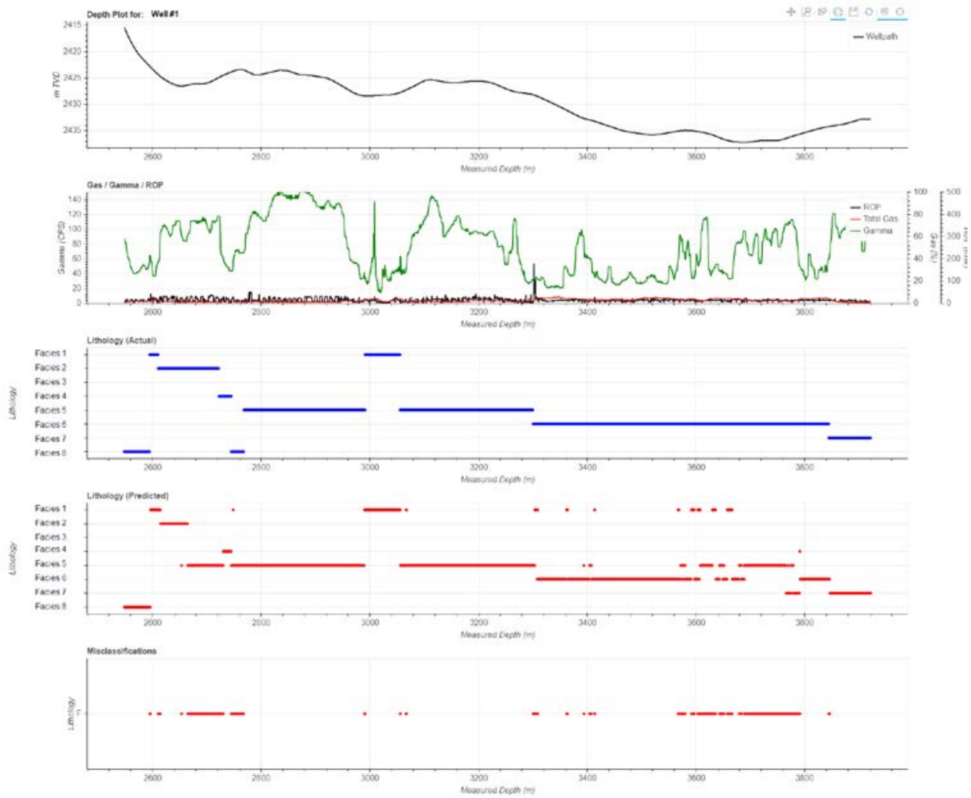

Figure 1: Dashboard displaying from top to bottom: the well path, gamma/gas/ROP data, Actual (blue) vs AI Predicted (red) lithofacies and misclassification

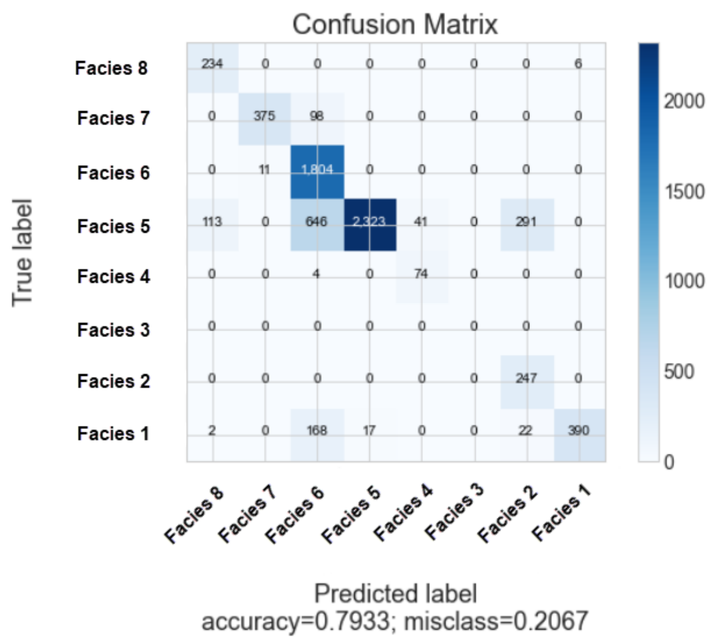

Figure 2: Each count represents a 0.2m interval for the well presented in Figure 1