Machine Learning to Predict Geological Facies in Complex Carbonate Reservoirs

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Extended abstract

Extended Summary

Automatic Facies prediction for complex reservoirs is an important step in characterising reservoir heterogeneity, understand reservoir productivity and performance. In this study decision tree algorithm approach was utilised to automatically classify and define facies on a field scale by using standard logs and calibrated reservoir properties data, such as porosity and permeability. The steps in the workflow include data preparation, data scaling, data identification, gaps correction in data, log processing, training data sets and testing on the validation data sets.

The technique was generated and tested on more than 1000 wells in a giant oil field in Southeast Iraq. This giant field contains multiple reservoir intervals, including the Upper Cretaceous Mishrif carbonate complex reservoir, one of the major reservoirs in the world, that has been producing at considerable oil rates for more than 50 years. With billions of barrels yet to be recovered it is expected to play a significant role in sustaining production for decades.

One of the key subsurface challenges in carbonate reservoirs is to understand the geological setting, characterise reservoir heterogeneity and productivity, with facies properties and lateral continuity being one of the key factors in understanding the large-scale sweep behavior.
This paper presents a workflow that utilises machine learning algorithm that accepts a set of well standard logs as an input and generates a distinct facies type as an output. The approach isfocussed on distinguishing between different facies types from its petrophysical properties and log responses.

The improvement in geological facies prediction has been reflected in better geological modelling and dynamic simulation. It has improved understanding of sweep behaviour and planning for new wells, leading to more optimal management of reservoir performance. Moreover, at the well level, the new model has resulted in enhanced completion decisions for newly drilled wells, as well as ongoing well-work operations (additional perforation and re-perforation campaigns) on existing producers and injectors, with a commensurate positive impact on economic outcomes.

Business Value

The traditional workflow of manual well log facies interpretation was revisited using a machine learning approach. A prototype model and algorithm based on decision trees was applied to automate the classification of facies across more than 1,000 wells. The proposed approach

satisfied our three main required criteria for success:

1 - ***Geographically representative data sets:*** The prototype model and the algorithm were developed using a representative dataset containing 19 training wells of which 10 wells were cored and 5 validation wells of which 2 wells were cored and was successfully applied fieldwide containing approximately 1000 wells.

2 - ***High model performance:*** Ancor C value score of 98% was achieved for training datasets and 60.4% for blind test wells. This is a very good performance given the reservoir heterogeneity.

The overall prediction success of good reservoir quality facies (Back shoal and Shoal facies which represent 62% of the total interval thickness in the blind test wells) is even better with 71-74% correctly predicted.

3 - ***Time saving:*** Significant time saving (5-6 months) compared to the traditional manual approach.

The automated facies prediction workflow has demonstrated an ability to predict distinct facies types as an output, away from controlled training data, based on facies features defined by geology and well log responses defined by Petrophysics. This automated machine-learning-based workflow was tested on more than 1000 wells, delivering a very good prediction accuracy and does not suffer from overfitting.

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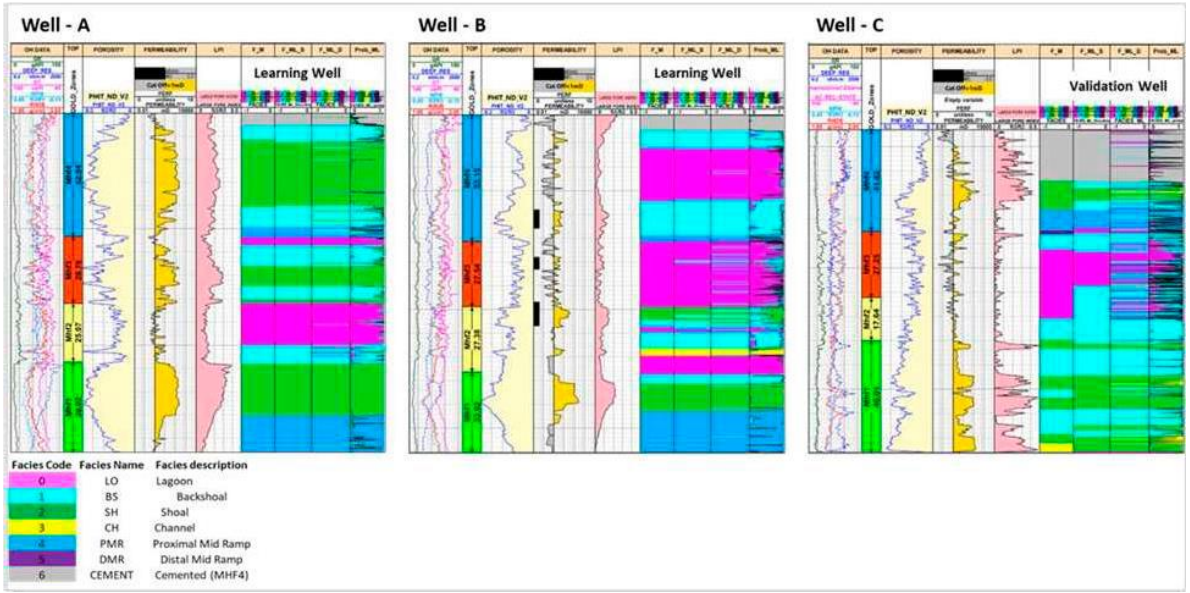

A comparison of manual (first facies track) and machine learning (second facies track) facies logs