Selena Neale, Geology Masters, Spring 2023

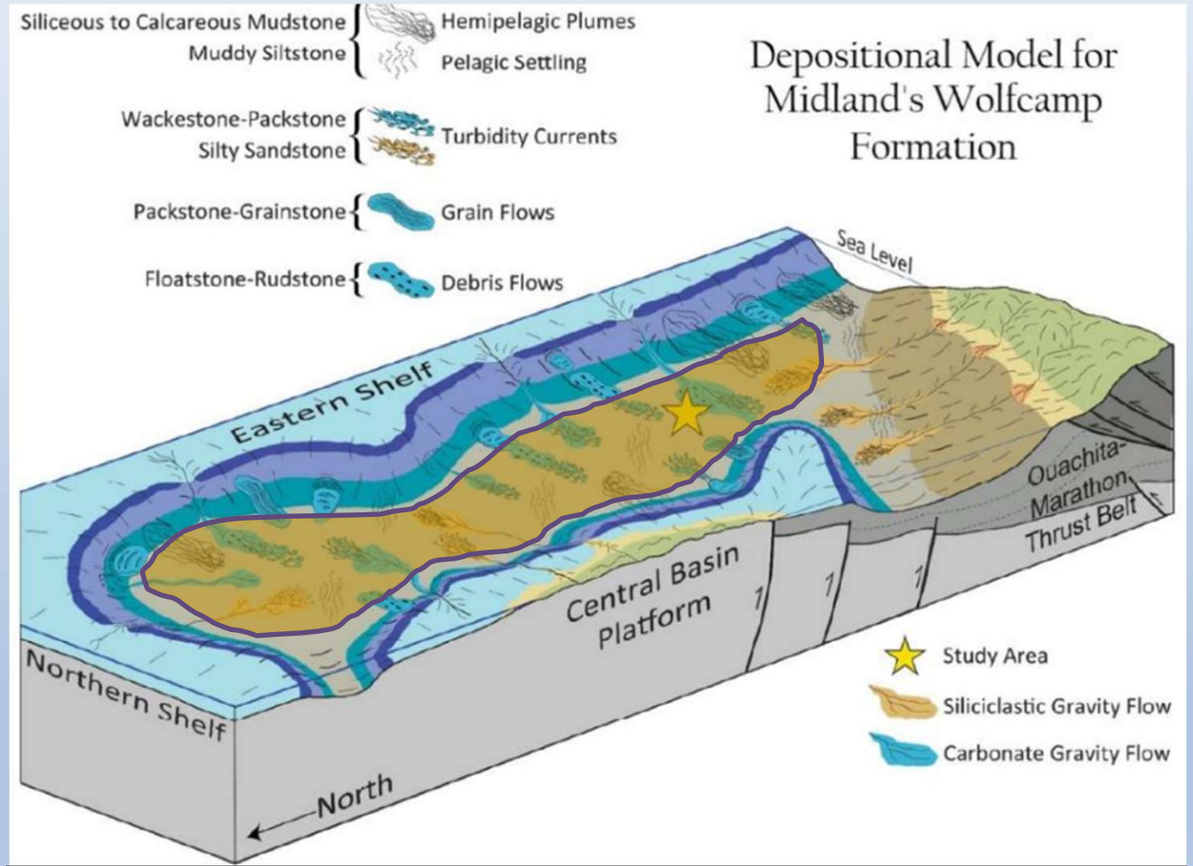
SEDIMENTARY LITHOFACIES CLASSIFICATION USING SUPERVISED MACHINE LEARNING ALGORITHMS

Overview

- Geologic Background
- Importance of Carbonate Gravity Flows in the Hydrocarbon Industry
- Study Area and Data Preparation
- Support Vector Machine Classification & Models
- Decision Tree Classification & Models
- Multilayer Perceptron Classification & Models
- Comparison of Best Models
- Current and Future Work

Geologic Background

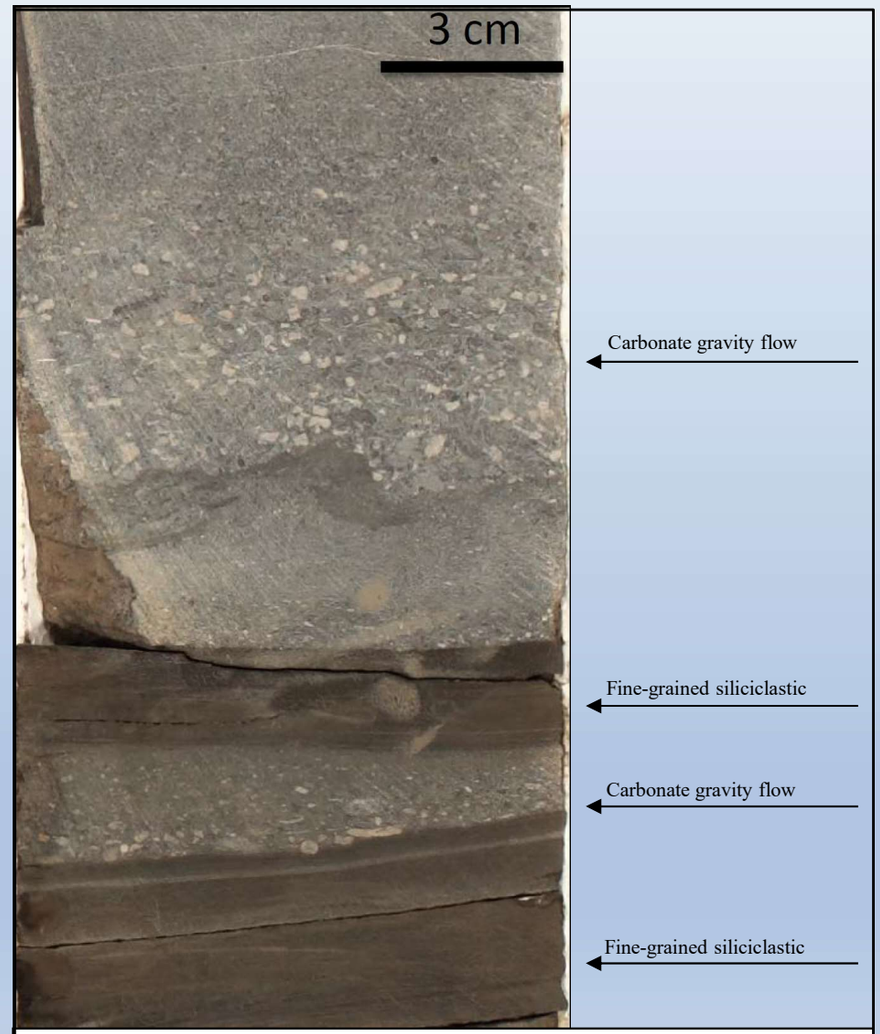
- The A and B upper benches of Midland Basin's Wolfcamp Formation are comprised of organic-rich mudrocks interbedded with carbonate gravity flows
  - The Wolfcamp A typically has a higher percentage of carbonates while the Wolfcamp B bench is more mudrock and siliciclastic rich.
  - The thicknesses and structures of the Wolfcamp A and B also vary across the Midland Basin due to basement tectonic patterns and local depositional conditions



Modified from Ward (2017) and Pioneer Resources (2013).

Importance of Carbonate Gravity Flows

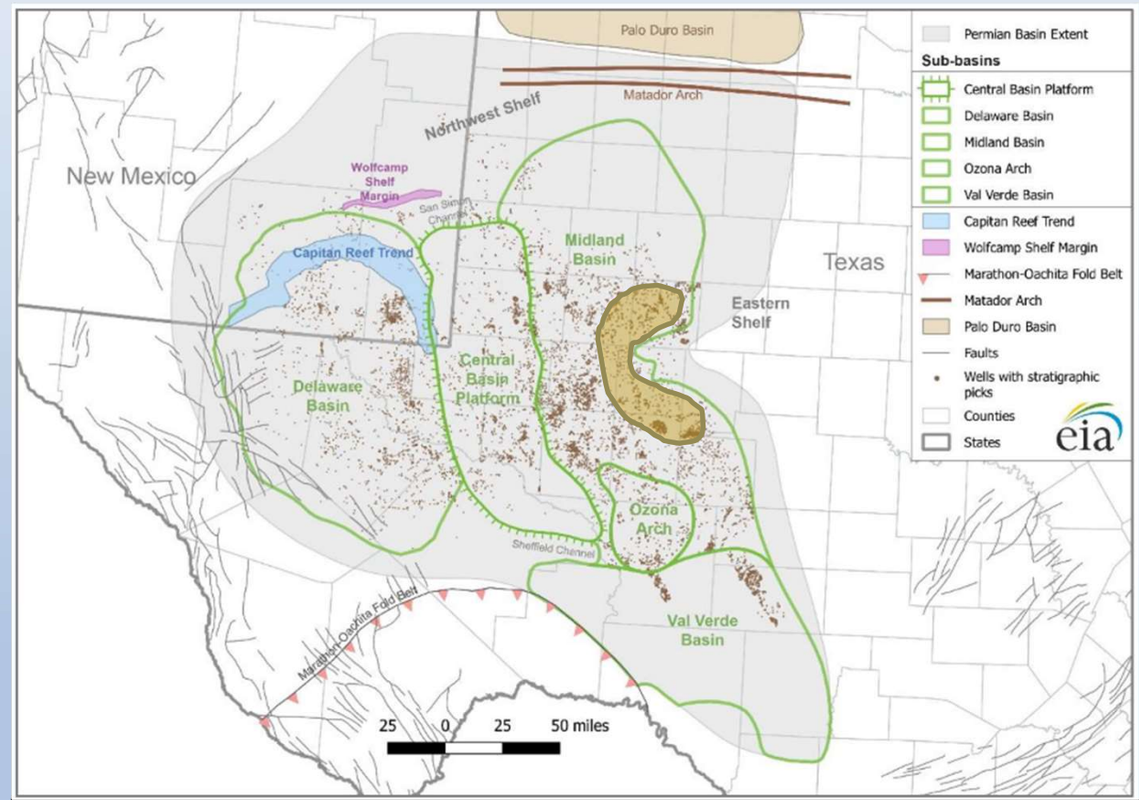
- Carbonate gravity flows in the Wolfcamp A and B benches may variously act as drilling hazards, frac barriers, top or lateral seals for reservoirs, stratigraphic traps, potential reservoirs in rare cases, and have been shown to suppress hydrocarbon expulsion temperatures
- Being able to predict and map where these flows are located would reduce the complexity of picking well targets, planning well paths, and aid completions strategies to improve overall rate of return on wells drilled



Modified from Zoeten and Goldstein (2017).

Study Area and Data

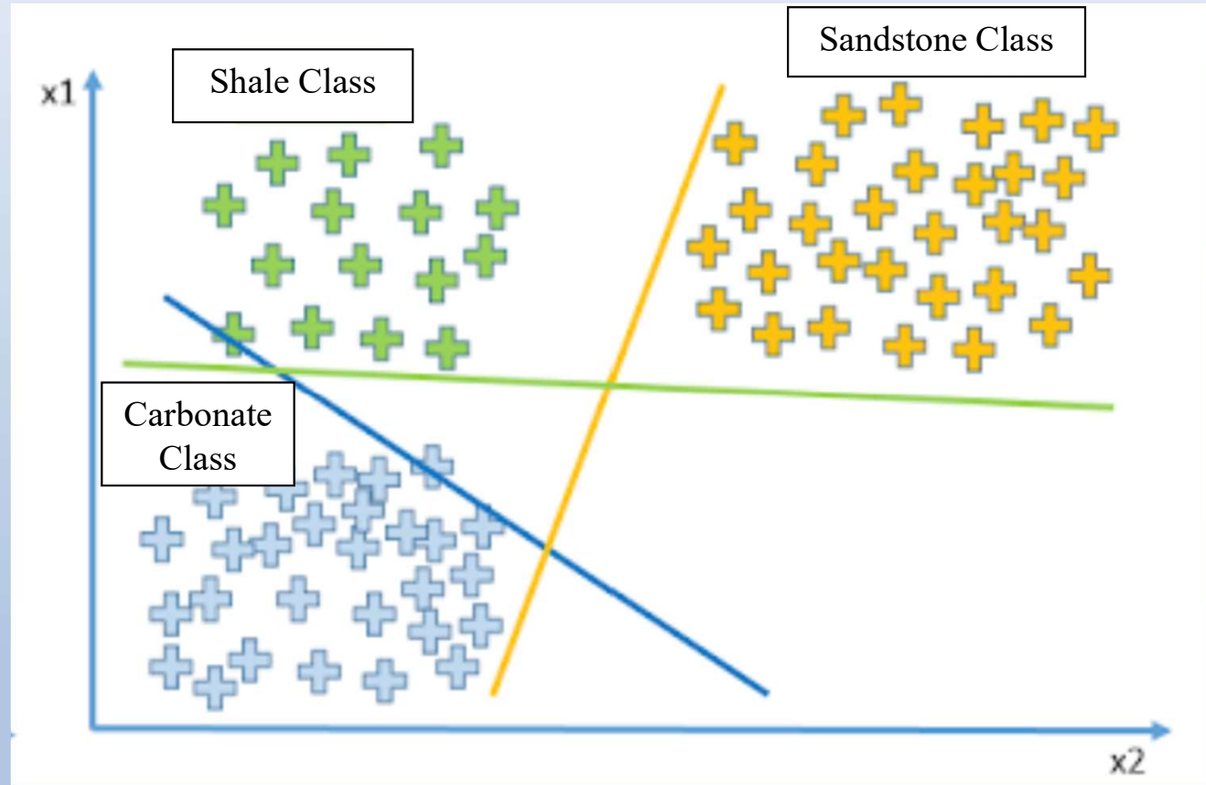
- My study area covers the eastern Midland Basin – the gold shaded area on the map shows that general area
- The results shown in this presentation use data from a vertical well within that shaded area, but the well's exact location can't be shown due to a data confidentiality agreement
- The vertical well is depth-limited to the Wolfcamp A and B and has quad-combo and XRD from core mineralogy
- The XRD mineralogy and gamma ray were used to calculate sandstone, shale, and carbonate labels



Modified from the EIA (2020).

Support Vector Machine Classification

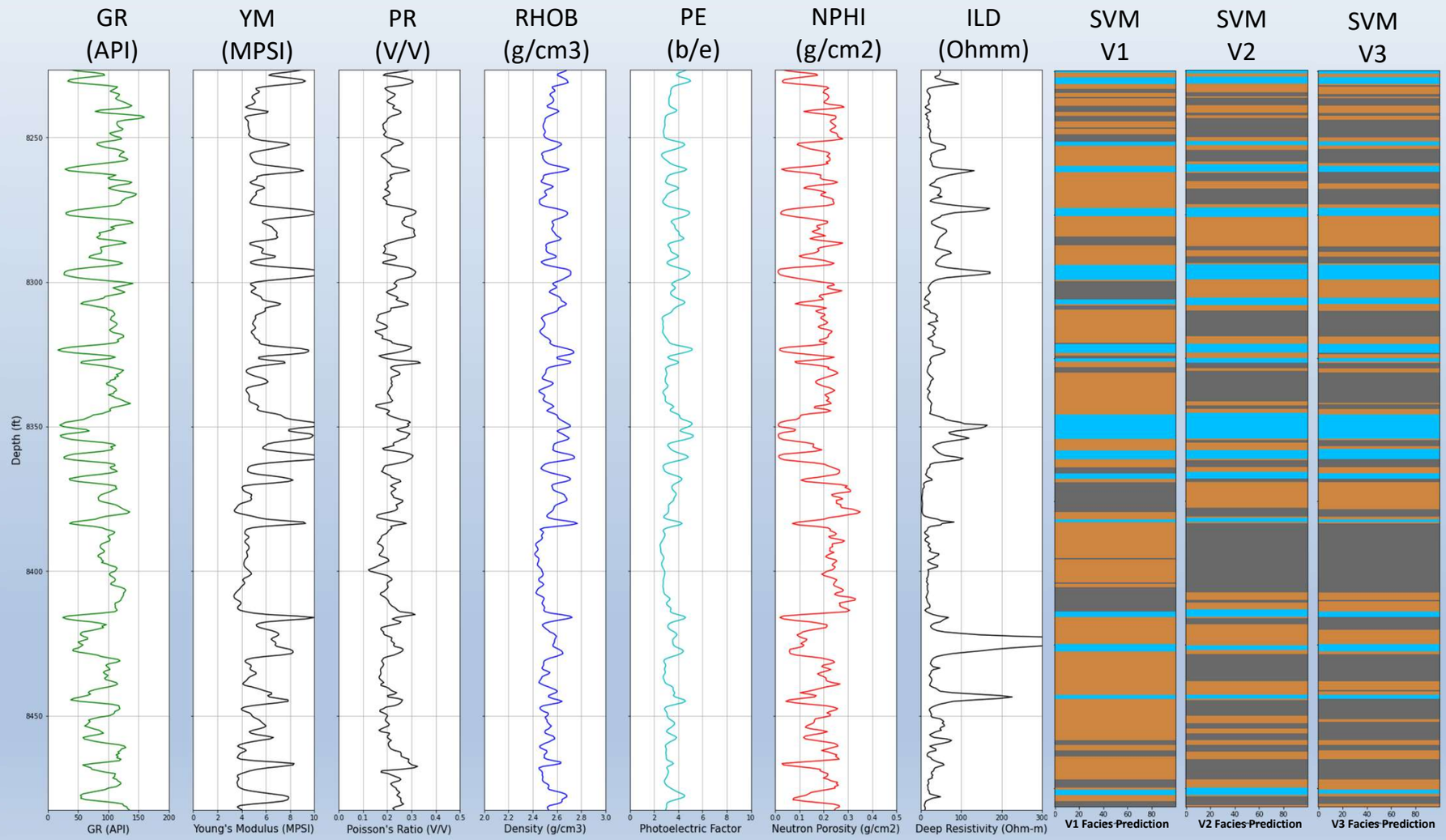
- Support vector machines are supervised algorithms which find hyperplanes in N-dimensional space that distinctly classifies the data points, where N is the number of features
- Three support vector machine models were created using different hyperparameter values for code size
- All three models were validated using classification accuracy scores



Modified from ReachItEasily.com (2020).

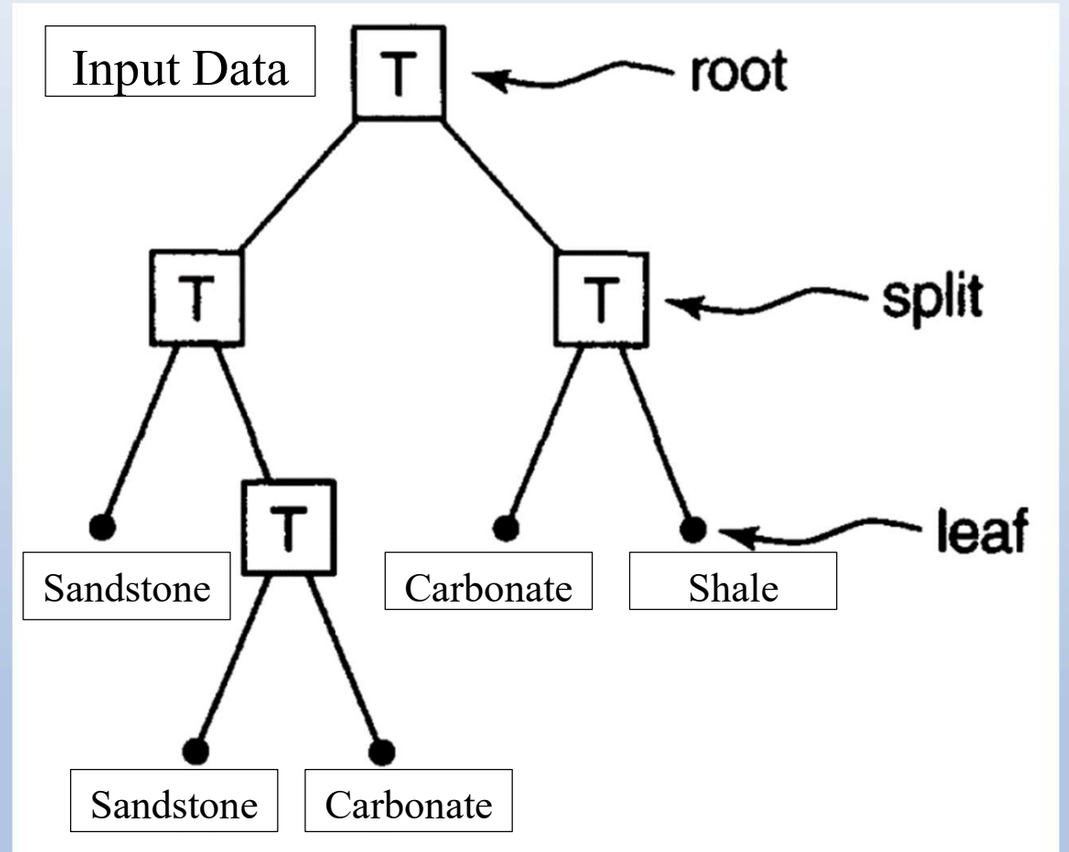
Support Vector Machine Models

SVM Iteration	Code Size	Accuracy Score
SVM_V1	1	0.729
SVM_V2	5	0.895
SVM_V3	10	0.916



Decision Trees Classification

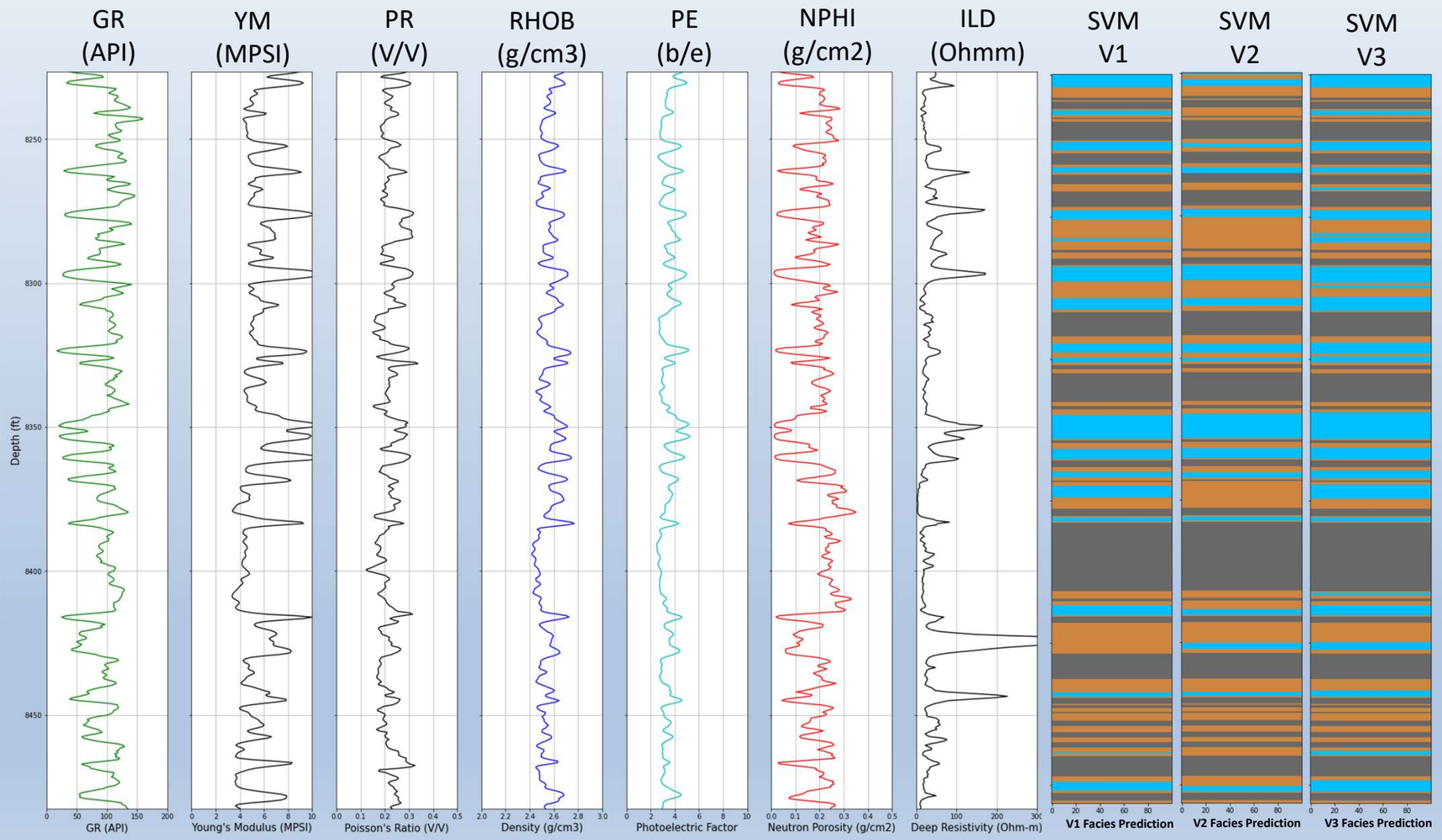
- A decision tree is constructed in an approach that identifies ways to split a data set based on different conditions
- Each internal node represents a test on a feature, each leaf node represents a class label, and branches represent conjunctions of features that lead to those class labels
- Three decision tree models were created using the hyperparameters criterion, max depth, and min samples leaf
- The three models were verified using a classification accuracy score



Modified from Friedl and Brodley (1997).

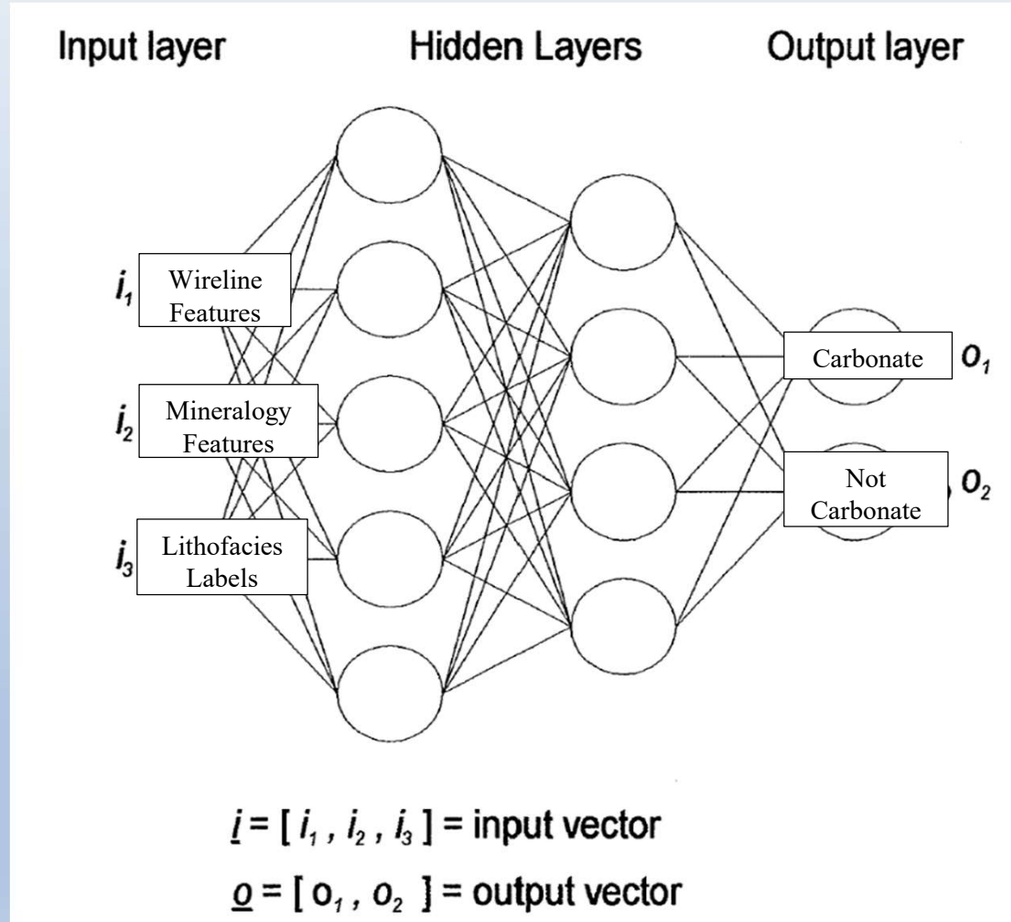
Decision Tree Models

DT Iteration	Max Depth	Min Samples Leaf	Accuracy Score
DT_V1	200	100	0.918
DT_V2	100	50	0.998
DT_V3	100	125	0.881



Multilayer Perceptron Classification

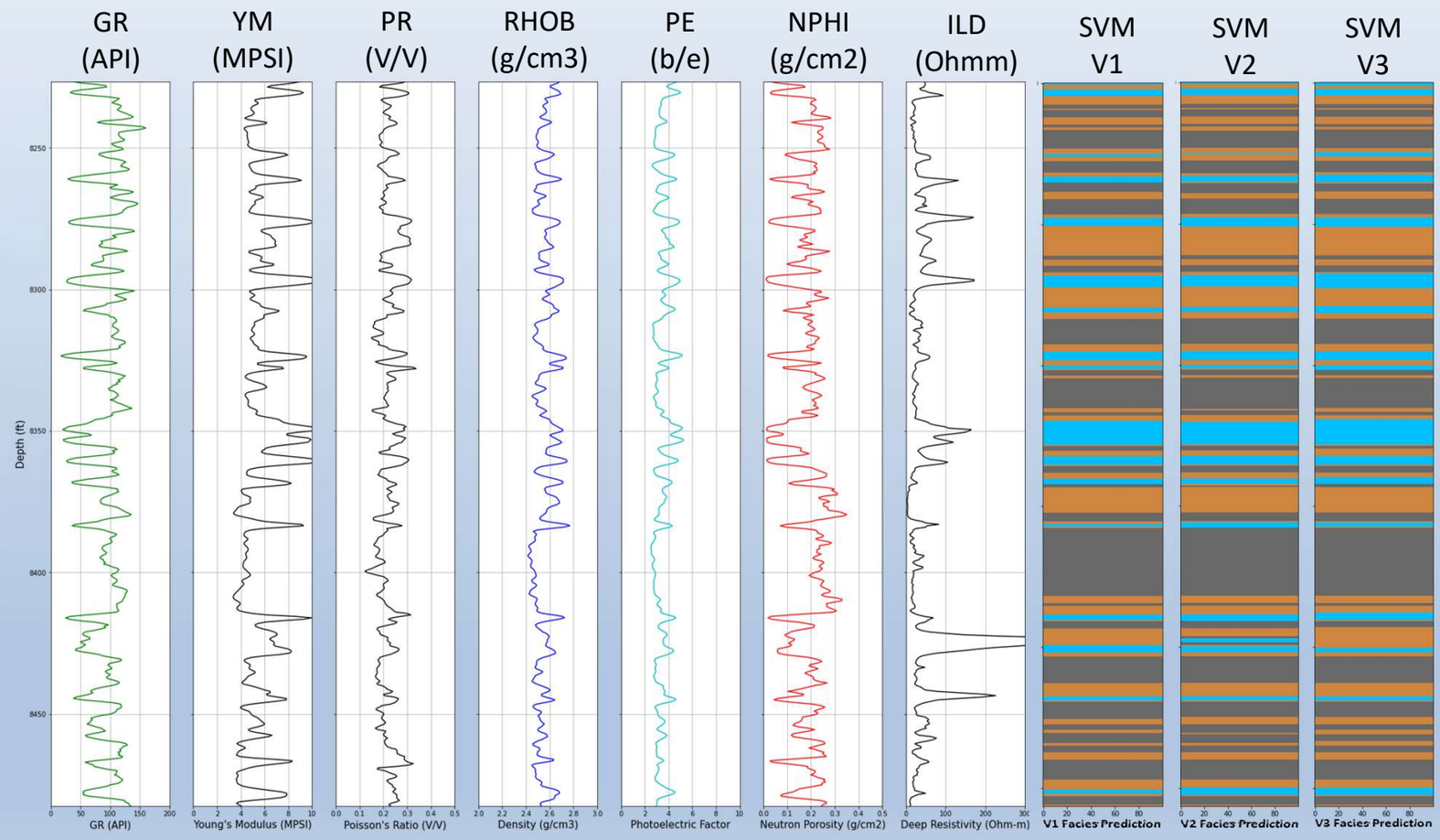
- A multilayer perceptron is a class of feedforward artificial neural network information in the network moves forward from the input nodes, through the hidden nodes, and to the output nodes
- Three multilayer perceptron models were created using the hyperparameters of solver, hidden layer sizes, batch size, and max iteration
- The validity of the three models was evaluated with classification accuracy scores



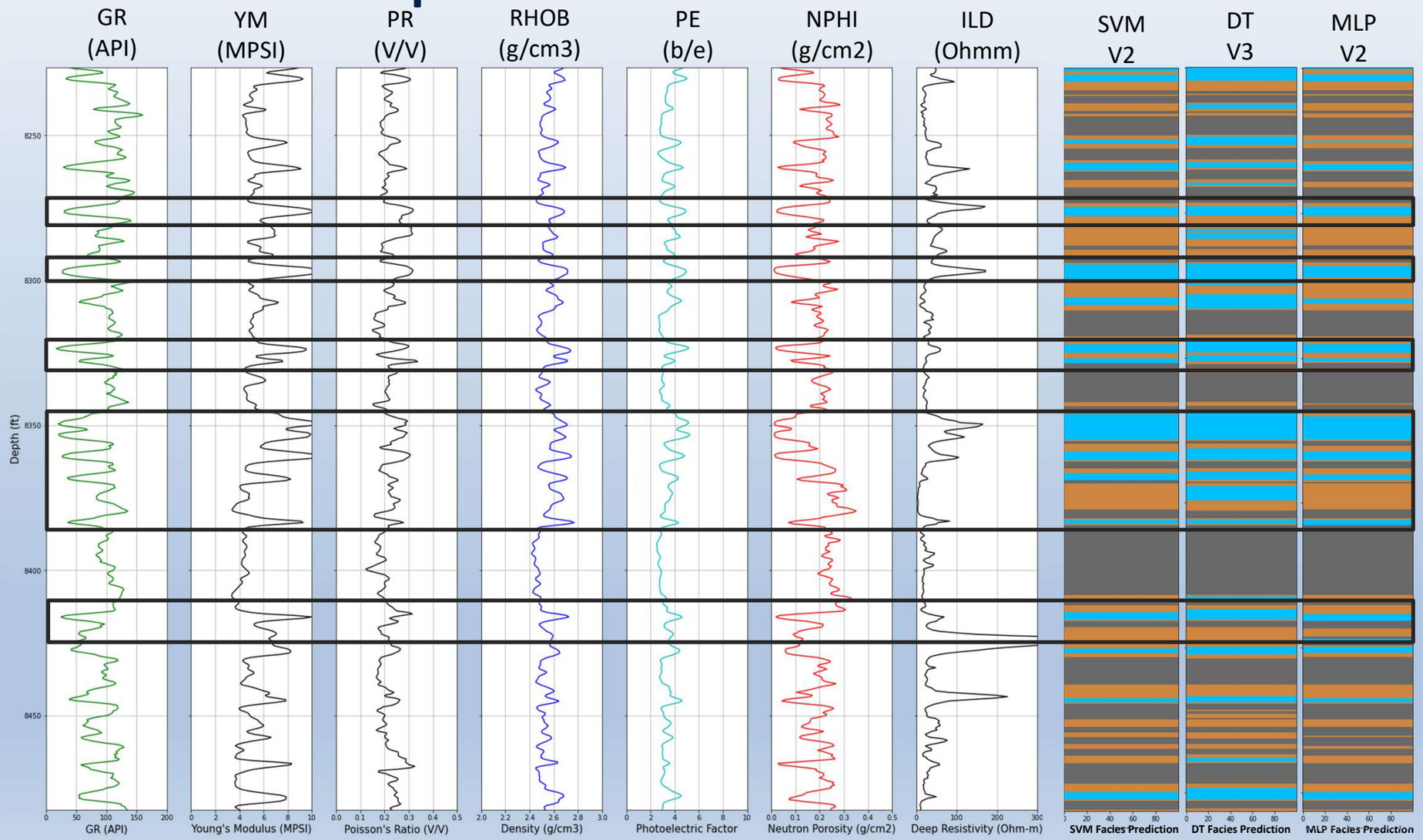
Modified from Gardner and Dorling (1998).

Multilayer Perceptron Models

MLP Iteration	Hidden Layer Sizes	Batch Size	Max Iteration	Accuracy Score
MLP_V1	10	100	100	0.936
MLP_V2	50	500	1000	0.908
MLP_V3	100	1000	10000	0.945



Comparison of Best Models



Current and Future Work

- Improving how facies labels are generated by creating labels from core description
- Expanding data sets to include horizontal wells and more vertical wells
- Creating lobe and fan gravity flow geometry shape files in Petra
- Using predicted carbonate facies, stratigraphically map the extents and locations of carbonate gravity flows between vertical wells and between horizontal wells

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