Selena Neale, MSc Geology, Fall 2022

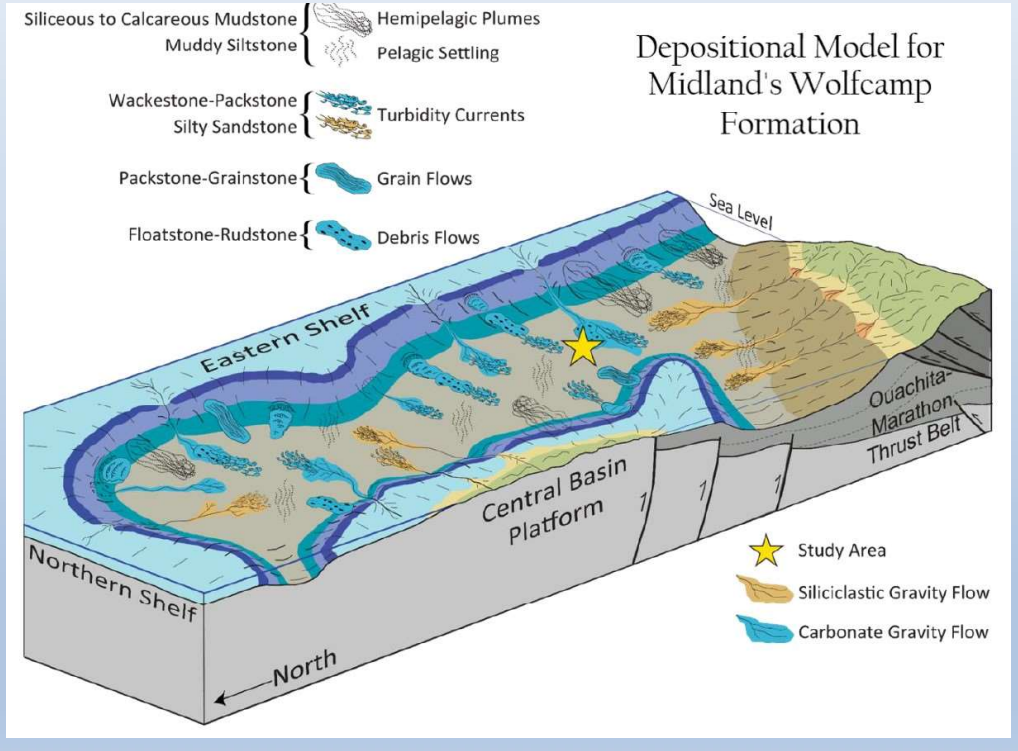
THE IMPORTANCE OF CARBONATE GRAVITY FLOWS IN WOLFCAMP A & B (MIDLAND BASIN, WEST TEXAS, USA) AND MACHINE LEARNING ALGORITHMS TO LITHOLOGICALLY CHARACTERIZE WELL LOGS

Overview

- Wolfcamp A & B Depositional Environment
- Importance of Carbonate Gravity Flows to Petroleum Industry
  - Drilling Hazards, Part of the Petroleum System, Maturing Kerogen
- Carbonate Gravity Flows in Midland Basin
- Lithologically Characterizing Well Logs with ML
  - Unsupervised and Supervised Algorithms
- Continuing & Future Work

Wolfcamp A & B Depositional Environment

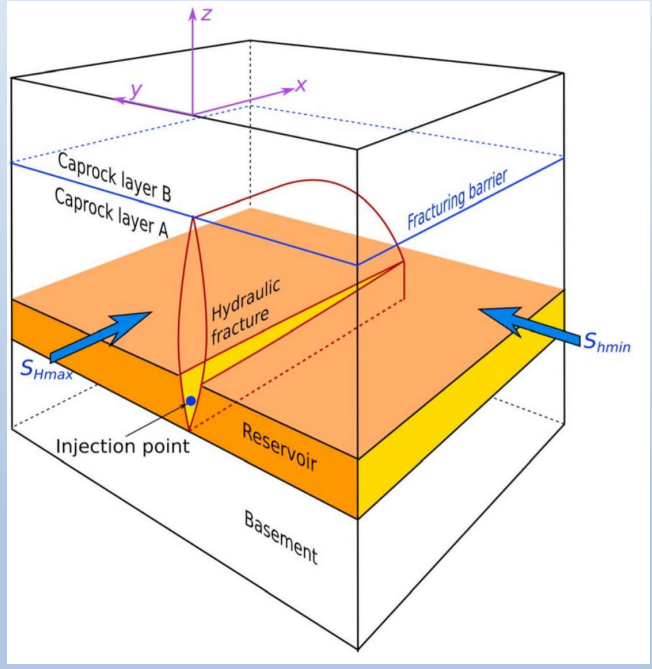
- Sea levels rose and fell during Wolfcampian deposition due to glacioeustatic sea-level fluctuations and episodic tectonic pulses
- This led to the interlayering of siliciclastic shales and carbonate-rich gravity flows sourced from the basin margins
- Midland Basin's Wolfcamp A & B is characterized by organic-rich calcareous shales and siliciclastic mudstones and allocthonous shallow-water carbonate gravity flows



Depositional model of Midland's Wolfcamp Formation. Modified from Ward, 2013; Pioneer Natural Resources, 2013.

Carbonate Gravity Flows: Drilling Hazards

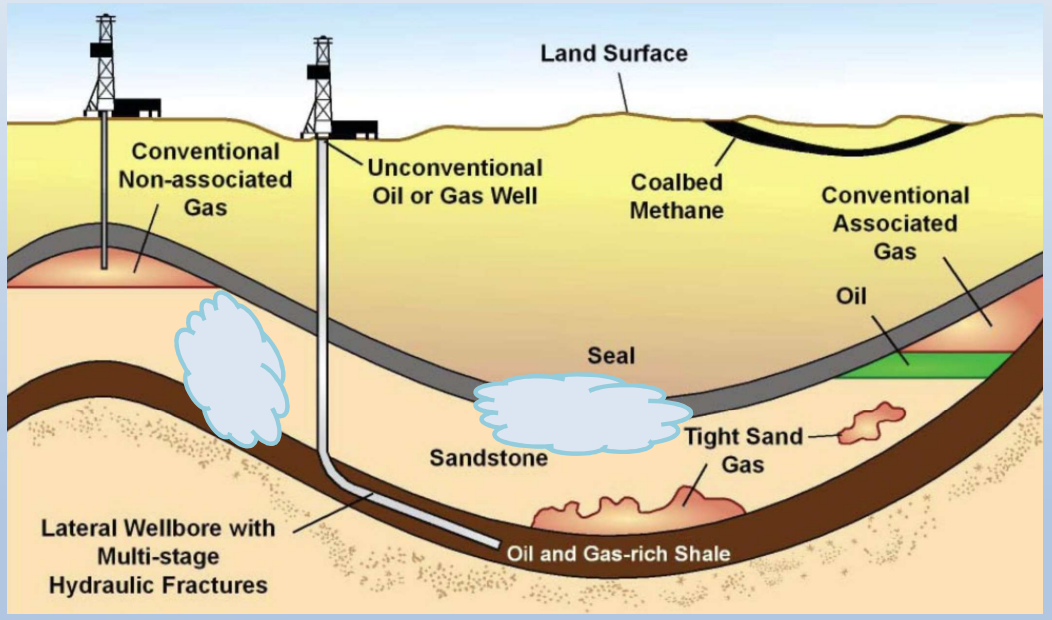
- Negatively impact horizontal drilling
- Act as fracture barriers during hydraulic stimulation
- Make wells more expensive



Model depicting the geometric relationships between the storage reservoir, caprock, basement, hydraulic fractures, frac barriers, and in-situ stress (Fu et al, 2017).

Carbonate Gravity Flows: Part of the Petroleum System

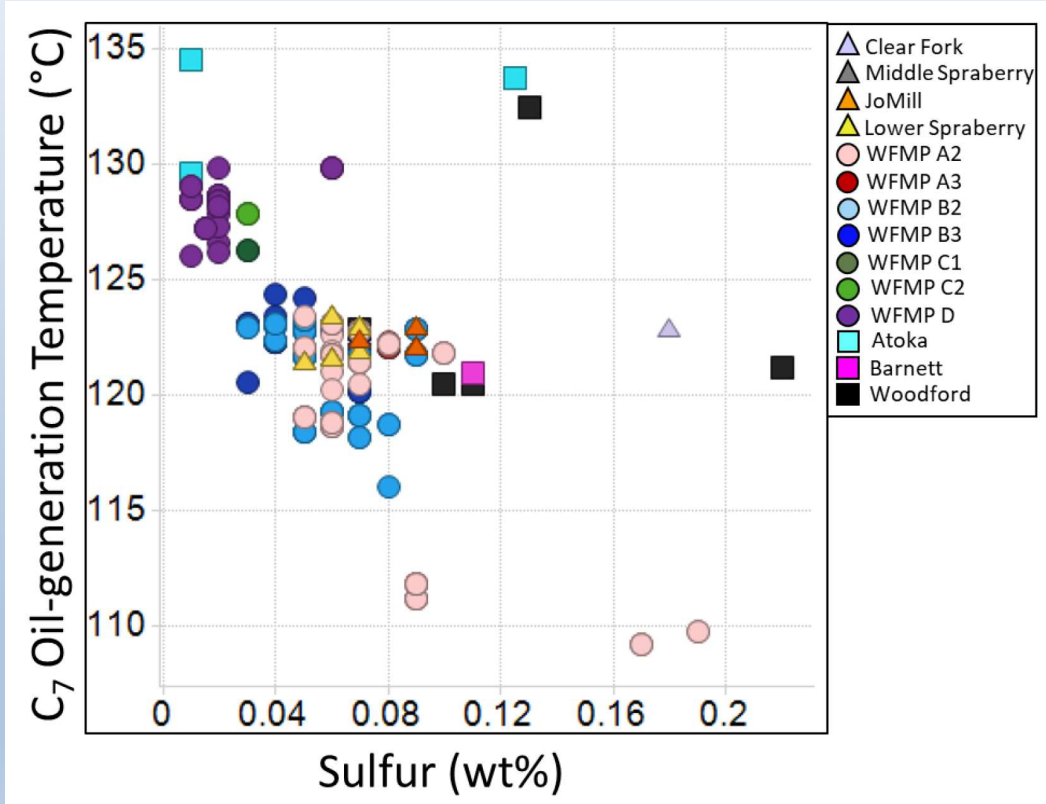
- Carbonate gravity flows are integral parts of the Permian Basin Petroleum System:
  - Act as top and lateral seals
  - Can be stratigraphic traps
  - Are even reservoirs themselves



Modified from EIA.

Carbonate Gravity Flows: Maturing Kerogen

- Oil samples taken from Wolfcamp A2 and B2 payzones were generated at a lower temperature than most of the oil in those reservoirs
- These lower temperature oils were produced where carbonate gravity flows are present in those pay zones



C_7 oil-generation temperature (°C) plotted against wt. %S concentrations of Midland Basin oils and condensates. Modified from Prosser et al. (2020).

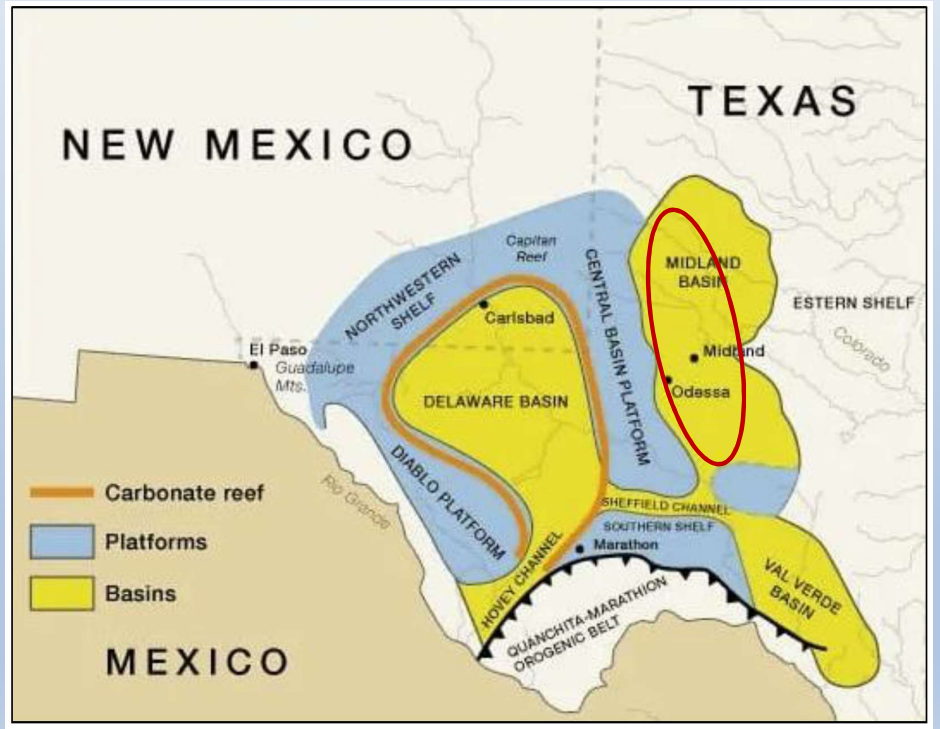
Carbonate Gravity Flows in Midland's Upper Wolfcamp

- They are horizontal drilling hazards, part of the basin's petroleum system, mature kerogen, and are widespread in Midland's Wolfcamp A & B
- What kind of data could be used to identify carbonate gravity flows?
- Could carbonate gravity flows be stratigraphically mapped?
- If they could, what would be the implications of knowing where carbonate gravity flows are located in Midland's Wolfcamp A & B?

Core from a Midland Wolfcamp A well showing carbonate sediment gravity flows and fine-grained siliciclastic deposits. Image from Zoeten & Goldstein, (2017).

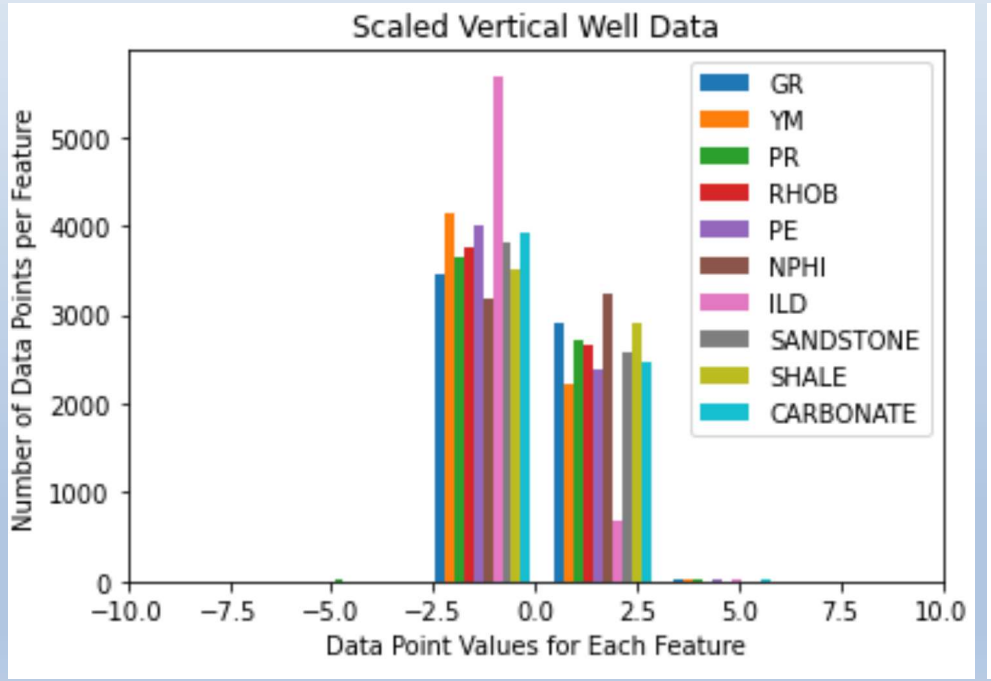
Lithofacies Identification in Well Logs Using ML Algorithms: Data Acquisition

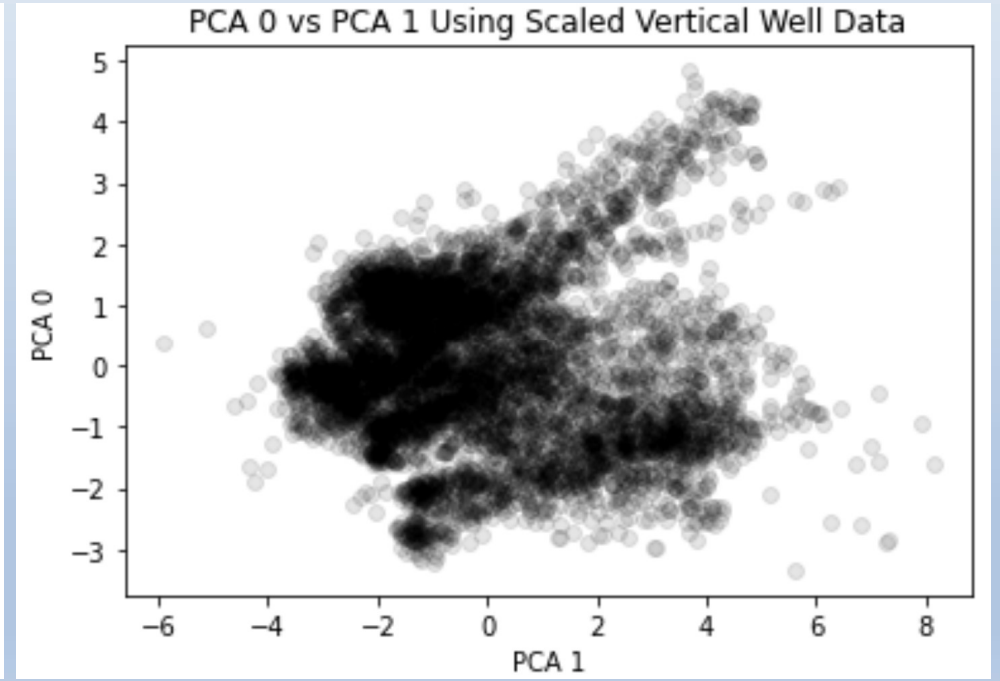
- Seven vertical wells located in eastern Midland Basin through Wolfcamp A and B
- GR, YM, PR, RHOB, PE, NPHI, ILD, & XRD from core
- Data imported into Python and wrangled for ML work



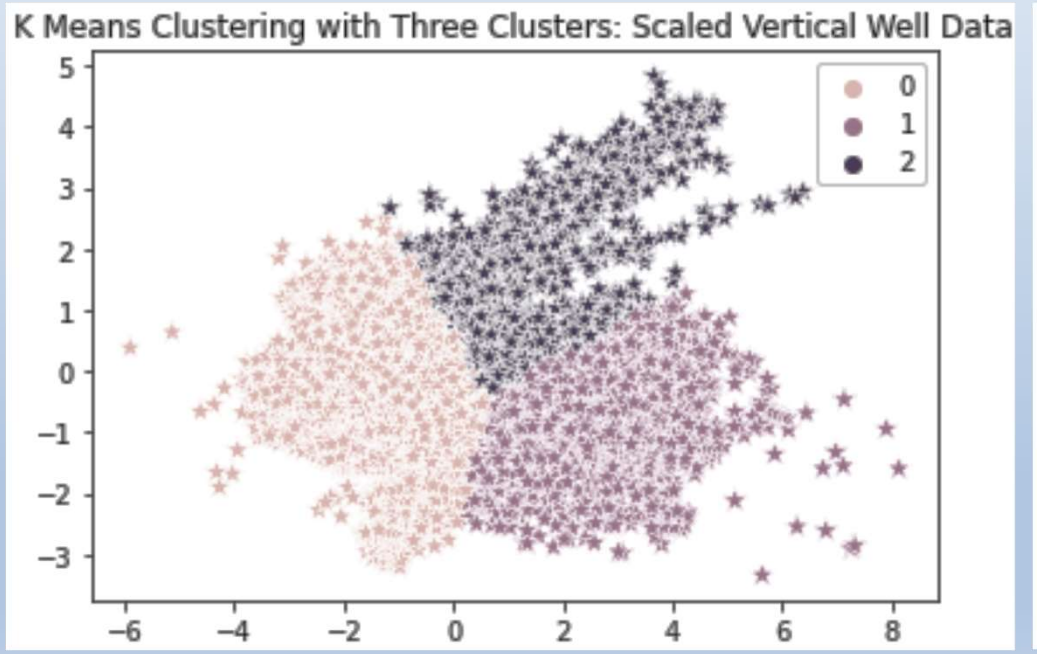
Major structural and tectonic features of the Permian Basin. The approximate location of the seven vertical wells is within the red oval. Modified from Sansal et al. (2021).

Lithofacies Identification in Well Logs Using Unsupervised Algorithms: Data Preparation

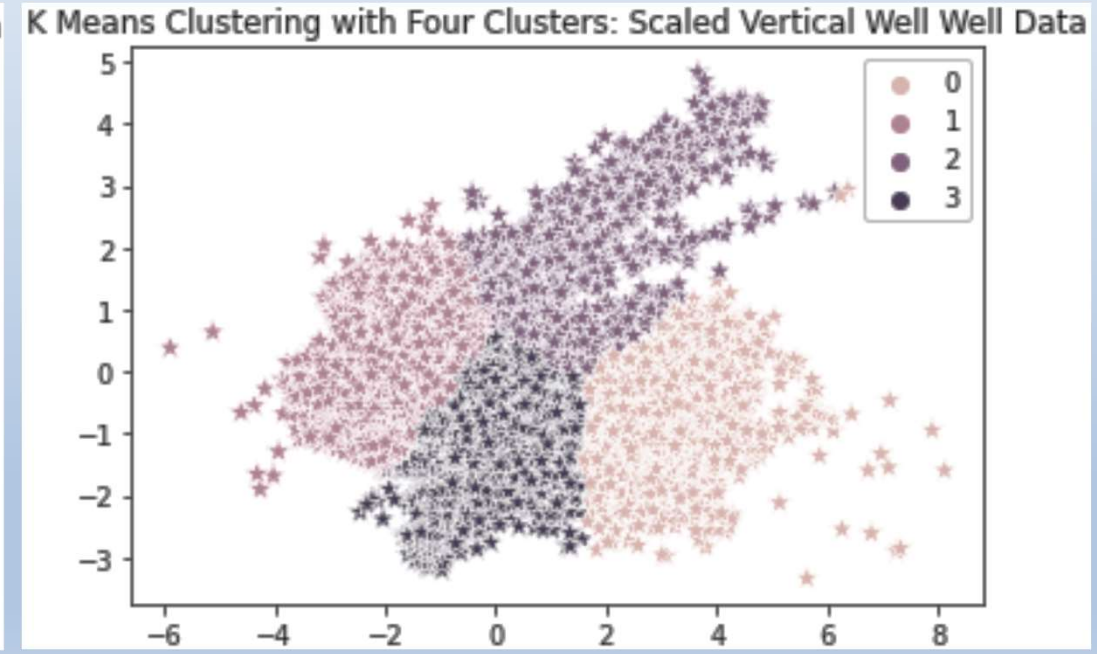




Lithofacies Identification in Well Logs Using Unsupervised Algorithms: K Means Clustering

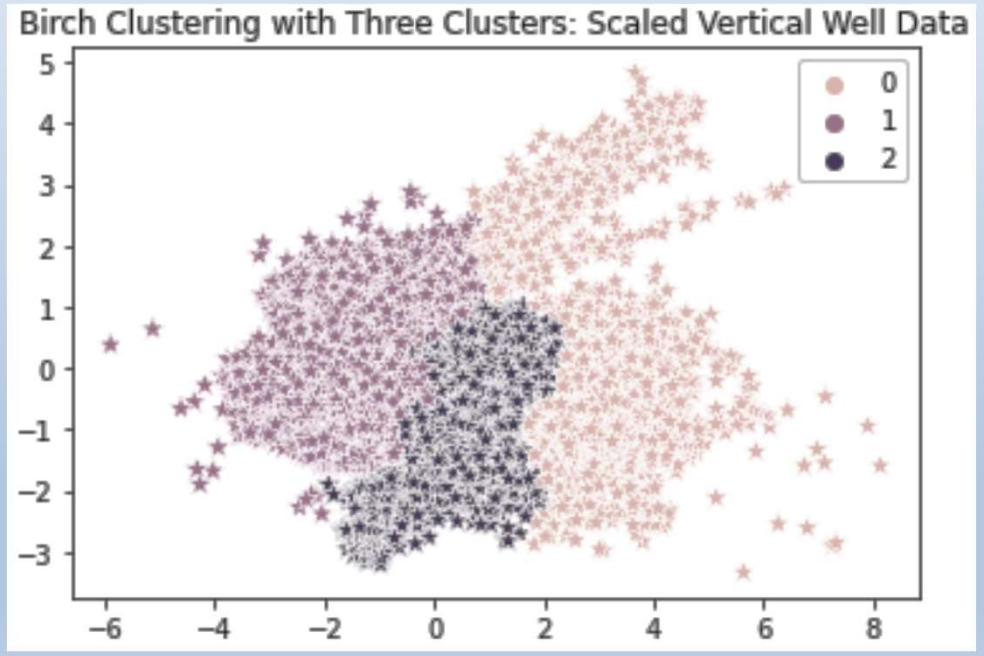


The average silhouette score for K Means clustering with three clusters is 0.425

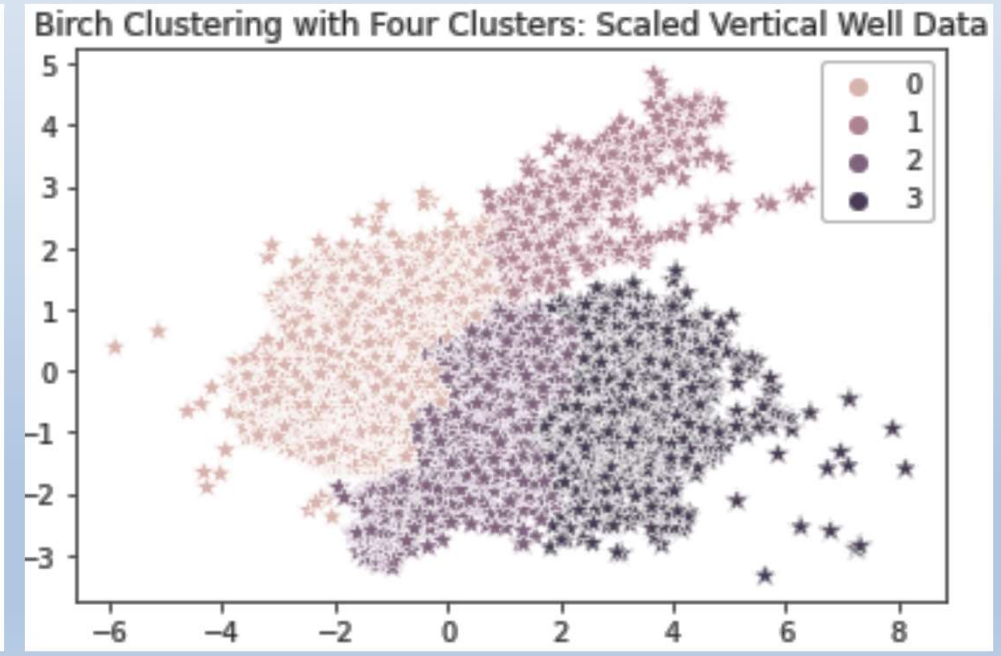


The average silhouette score for K Means clustering with three clusters is 0.388

Lithofacies Identification in Well Logs Using Unsupervised Algorithms: Birch Clustering



The average silhouette score for Birch clustering with three clusters is 0.332



The average silhouette score for Birch clustering with three clusters is 0.374

Lithofacies Identification in Well Logs Using Supervised Algorithms

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- Supervised algorithms utilize labeled data with the goal of classifying the input features and their associated labels
  - Convolutional Neural Nets
  - Random Forest Classifiers
  - Support Vector Machines
  - XGBoost

Continuing & Future Work

- Continue supervised algorithm selection to lithologically characterize well logs
- Extract carbonate gravity flow data from well logs
- Select, train, and test an algorithm using that carbonate gravity flow data and typical gravity flow geometry shape files
- Stratigraphically/geographically map carbonate gravity flows in Wolfcamp A & B wells

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