Project Update

Data-Driven Classification of Canadian Crude Oils

Ryan Bulger
DTSA-5506
University of Colorado Boulder

Problem Definition

Assessing Current Crude Oil Classifications

Grouping Limitations

Existing classifications of crude oils may not accurately reflect the **true similarities** among different types, leading to potential inefficiencies in management and utilization of these resources.

Importance of Reclassifying Crude Oils

Marketing

Improved classifications can enhance **targeted marketing strategies** effectively.

Pricing

Accurate groupings lead to **fair pricing structures** in the market.

Efficiency

Optimized classifications promote **efficient pipeline utilization** and resource management.

Related Work

Overview of traditional and modern methods

Traditional Approaches

Traditional methods like API gravity and sulfur content often fail to capture the complexities of crude oil. These simplistic classifications may overlook significant variations in crude oil characteristics.

Modern ML Studies

Recent machine learning approaches, such as FTIR spectroscopy combined with clustering techniques, have shown promise. However, they often rely on limited datasets, leading to potential inaccuracies in classifications.

Project Steps

Data Collection

Collect data from **CrudeMonitor** for robust analysis.

EDA

Perform exploratory data analysis to understand trends.

Data Cleaning

Prepare the dataset for modeling.

Clustering

Apply clustering algorithms to identify data-driven groups.

Supervised Comparison

Compare clustering results with supervised methods for validation.

COMPLETED →

NEXT STEPS →

Data Collection

CrudeMonitor API

Data was captured using CrudeMonitor’s API endpoints.

Dataset Shape

The dataset contains over **8,500 rows and 133 columns**

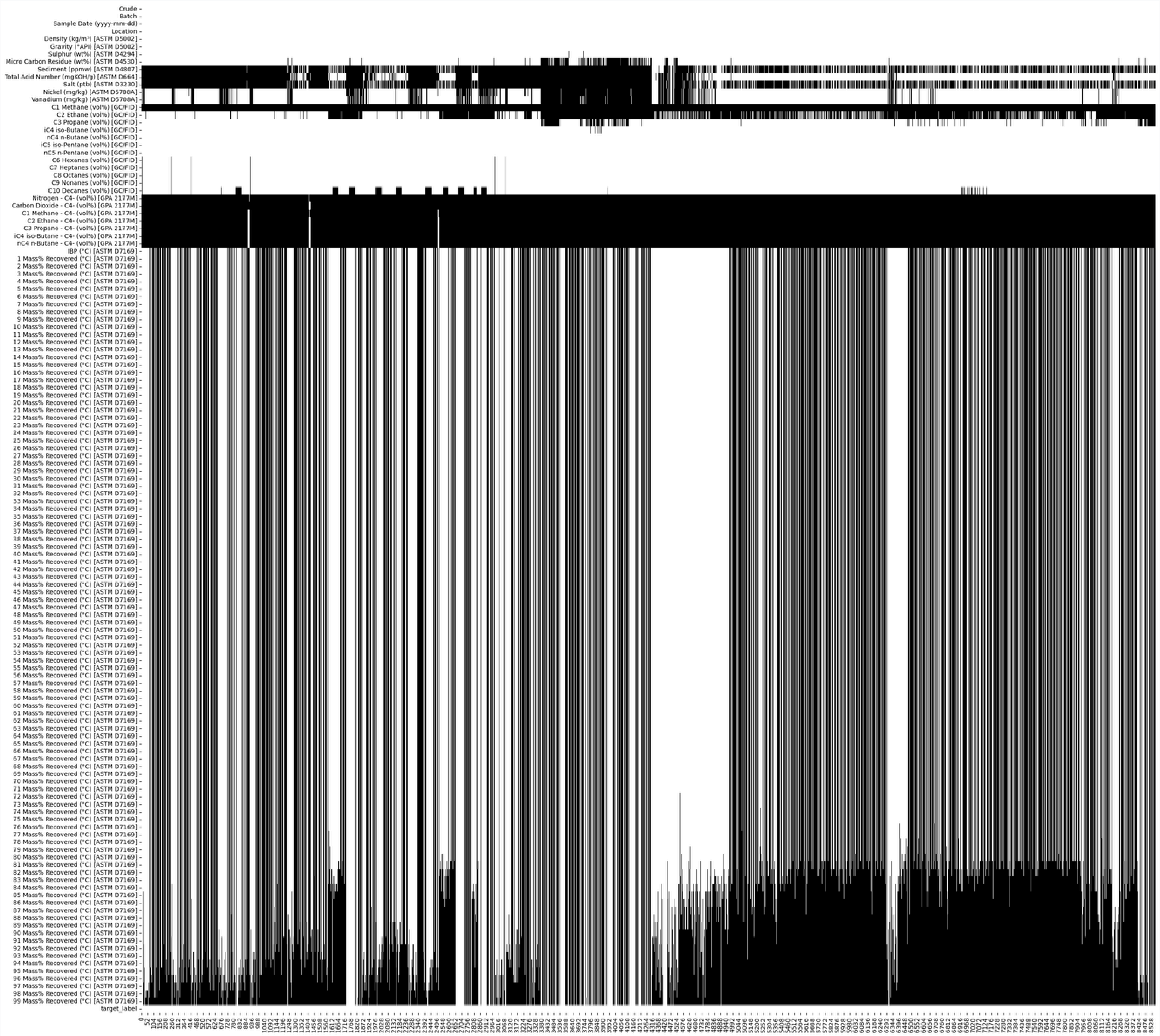
Data Types

The datatypes are 1 datetime, 4 categorical, and 128 numeric columns.

Missing Values

Heatmap

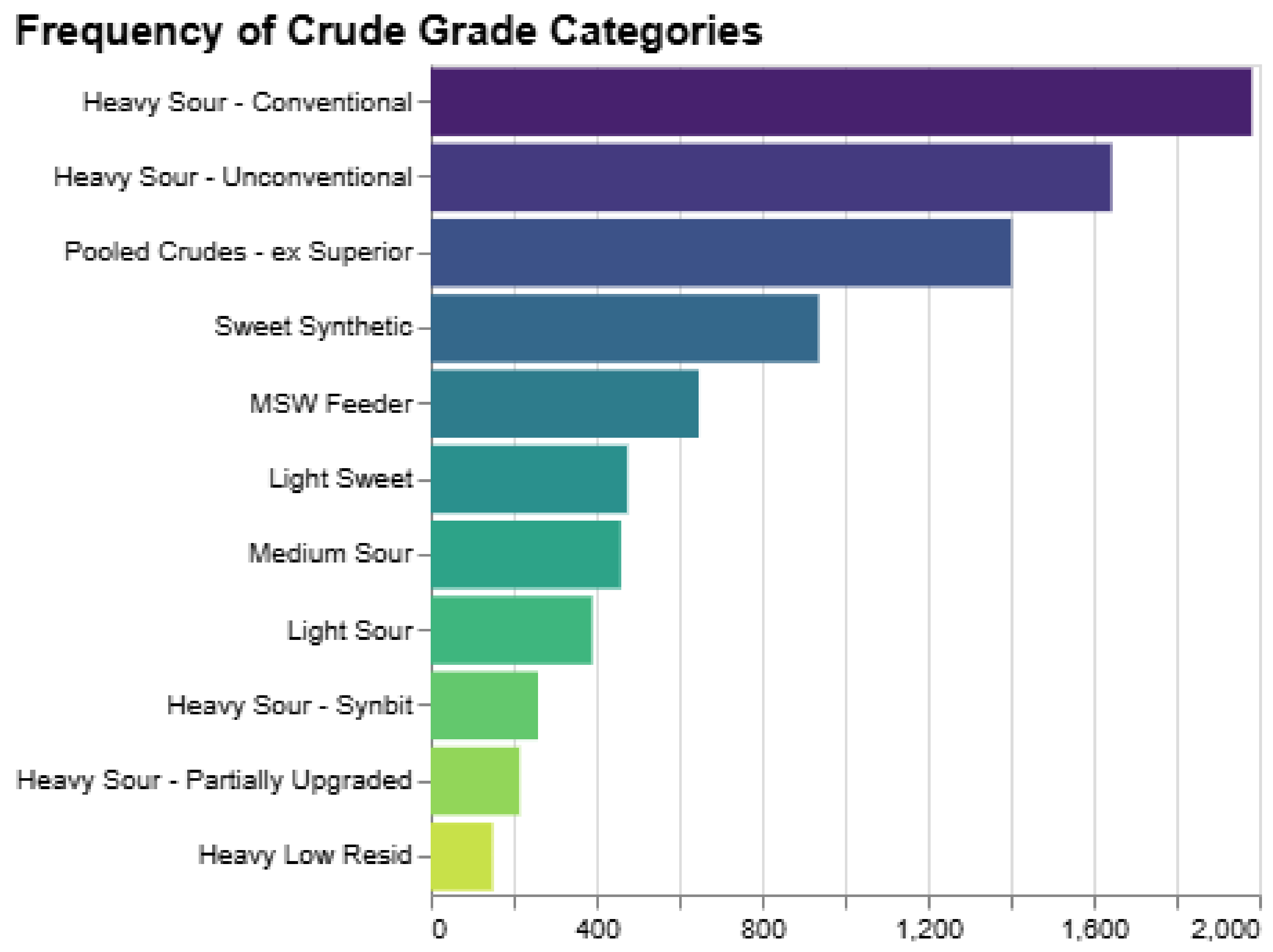
The heatmap color reveals large swaths of data missing throughout the dataset



Categorical Frequencies

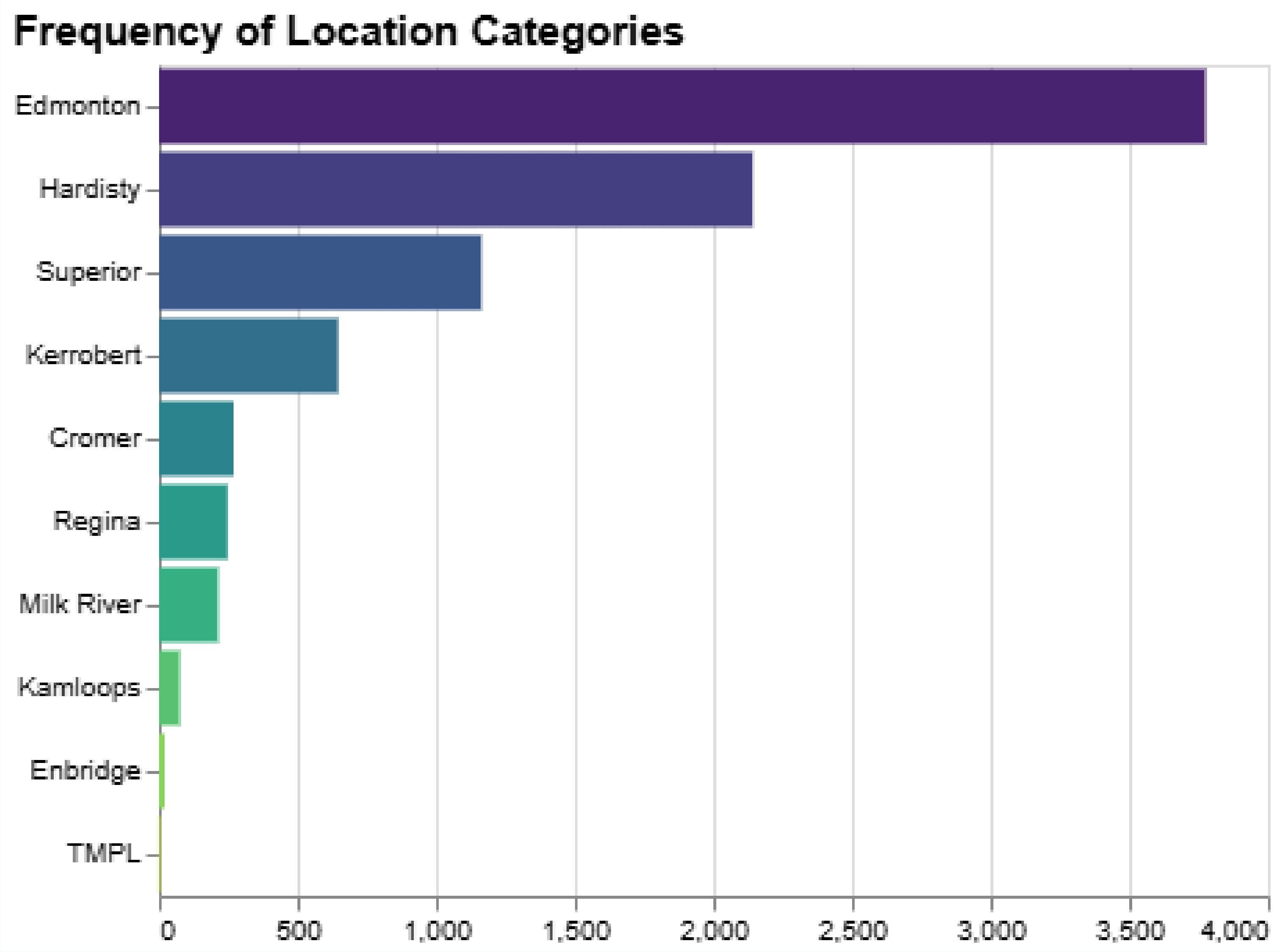
Crude Grades

Majority of the dataset's rows are related to the production of heavy oils and their by-products



Sample Locations

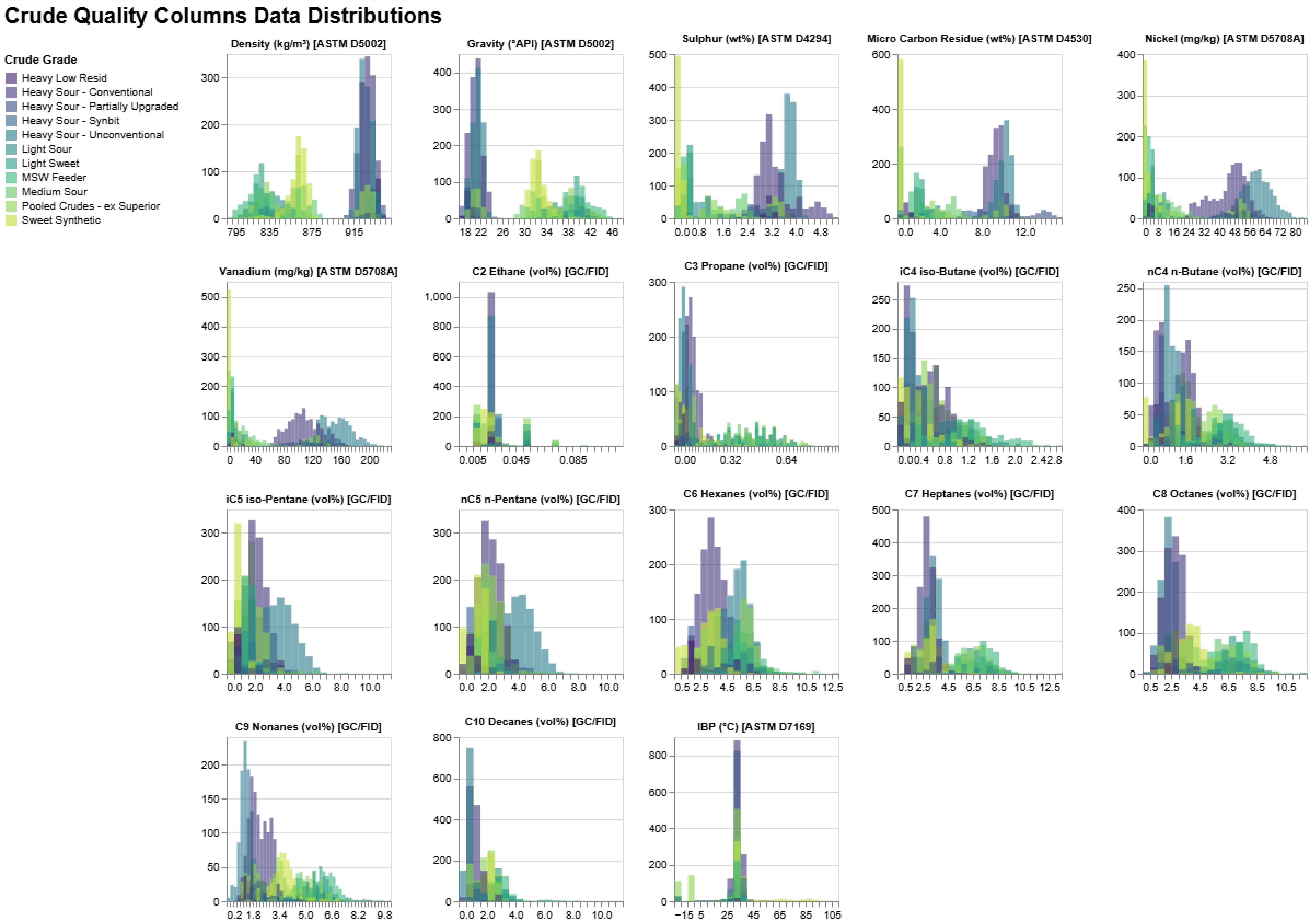
Oil production typically flows from northern Alberta, through Edmonton, and onto Hardisty



Numeric Distributions

Crude Quality Columns

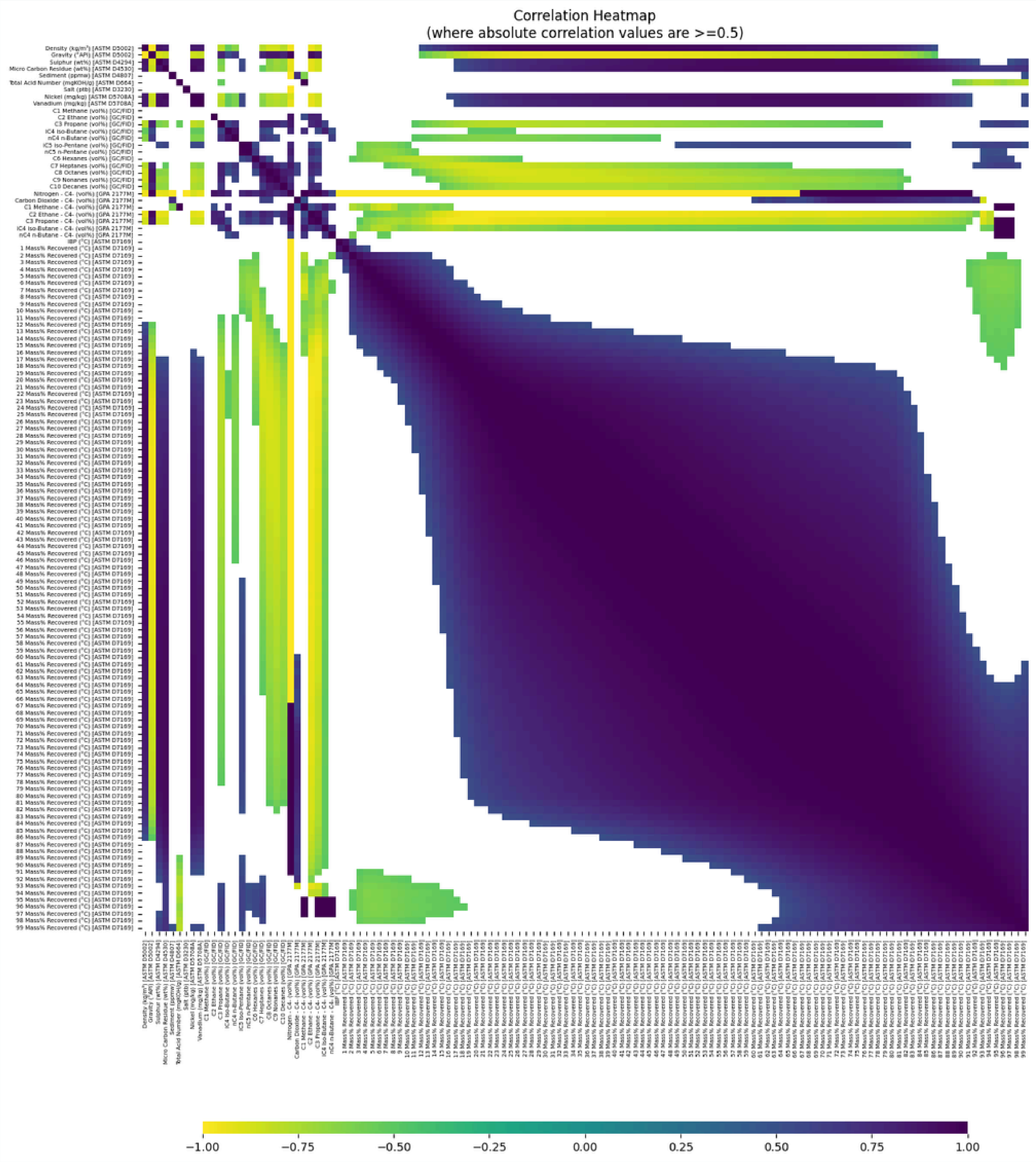
Noticeable patterns in the distributions suggest that many groups of crudes share similar properties



Numeric Correlations

Correlation Heatmap

Strong correlations are found throughout the crude quality and distillation temperature columns



Clustering Algorithms

K-Means

K-Means is a **baseline clustering** method that partitions data into K distinct clusters by minimizing intra-cluster variance, allowing for efficient and straightforward classification of crude oil samples.

Agglomerative

Agglomerative clustering is a **hierarchical approach** that builds clusters by merging similar data points iteratively, resulting in a tree-like structure that captures the relationships among crude oils.

GMM

Gaussian Mixture Models (GMM) utilize a **probabilistic framework** to model data as a mixture of multiple Gaussian distributions, providing flexibility and capturing complex data distributions in crude oil classification.

Model Evaluation Metrics

Internal Metrics

Internal metrics will be used to assess clustering quality using statistical measures.

External Metrics

External metrics will be used to compare cluster assignments to known labels.

Visualization Plots

Visualization plots will be used to illustrate clustering results and distribution patterns.

Supervised Benchmarking

Comparing key machine learning methods

Logistic Regression

Logistic Regression serves as a fundamental method, modeling the **probability of class membership** using a linear approach, effective for binary classification problems in crude oil analysis.

Support Vector Classifier

SVC utilizes hyperplane separation to classify data points, **excelling in high-dimensional spaces**, providing robust classification through kernel trick adaptations tailored for complex crude oil datasets.

Gradient Boosting Classifier

Gradient Boosting Classifier builds an ensemble of decision trees where each model corrects the errors of the previous one, producing an **accurate and flexible classifier** that captures nonlinear relationships in complex crude oil data.

Project Timeline

WEEK 1

COMPLETED

- Data Extraction
- Data Cleaning
- EDA

WEEK 2

NEXT STEPS

- Modeling
- Evaluation
- Final Presentation

Potential Challenges

Data Quality

Ensuring high data quality is crucial for accurate clustering results.

Cluster Selection

Choosing the right method for cluster selection impacts the project's effectiveness.

Scaling

Efficient scaling is necessary to handle larger datasets effectively and swiftly.

Computation

Computation resources must be allocated properly to support the algorithms used.