

# Chevron: Rate of Penetration

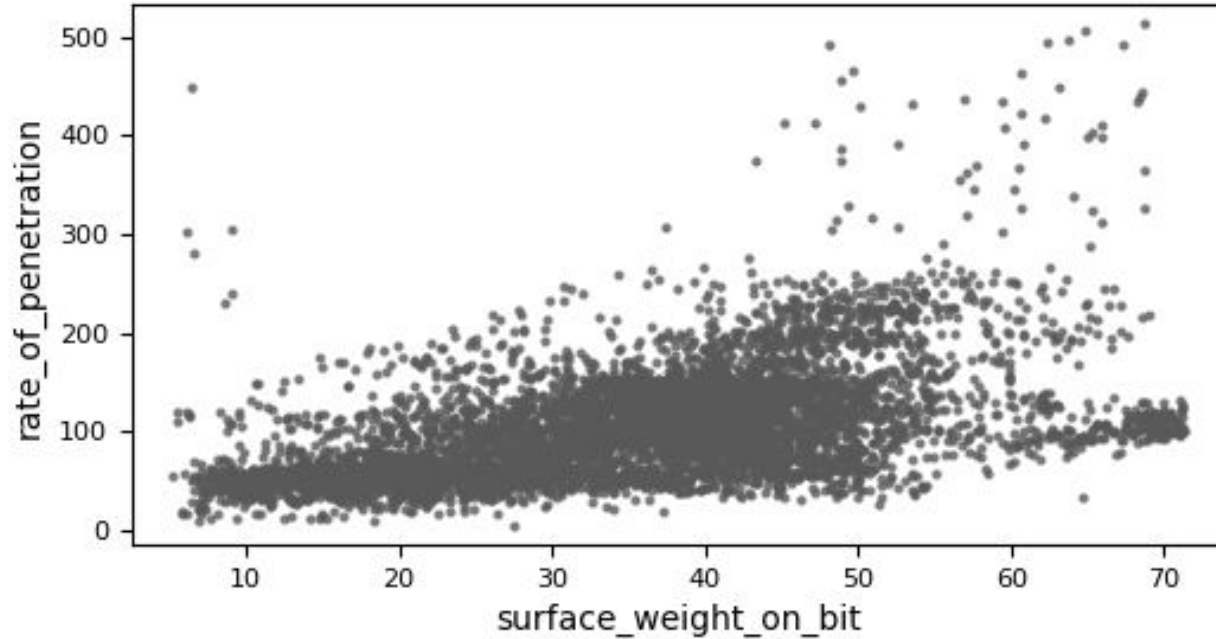
# Data Preprocessing

1. We mapped the following string features into unique integers for input to our models:
  - a. Segmentid
  - b. Wellboreid
  - c. Areaid
  - d. Formation id
  - e. Bit Model id

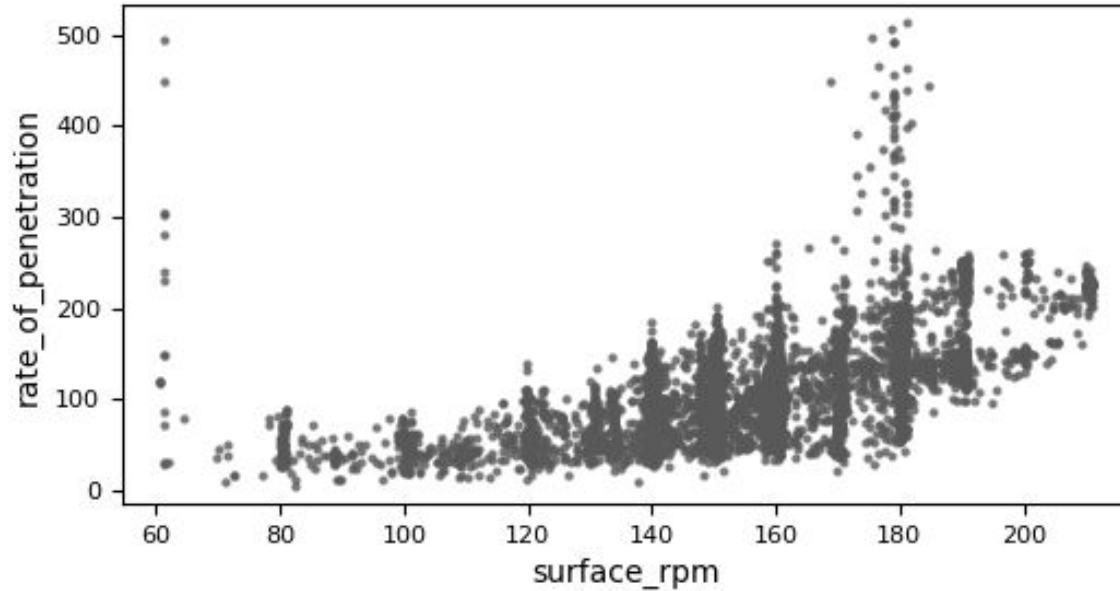
# Data Exploration

- We then sought to understand the features better to see which ones had a big impact on the ROP (Rate of Penetration). We understood this through:
  - Graphical Visualization
  - Correlation Analysis
  - ROP Formula

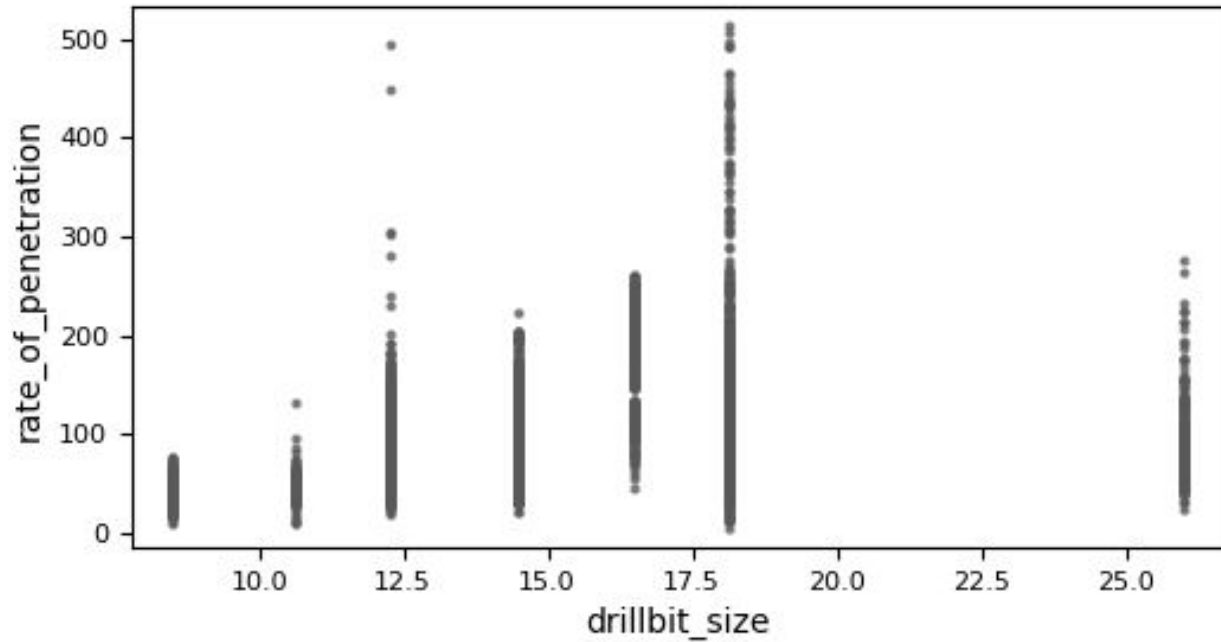
# Visualization: Surface Weight on Bit



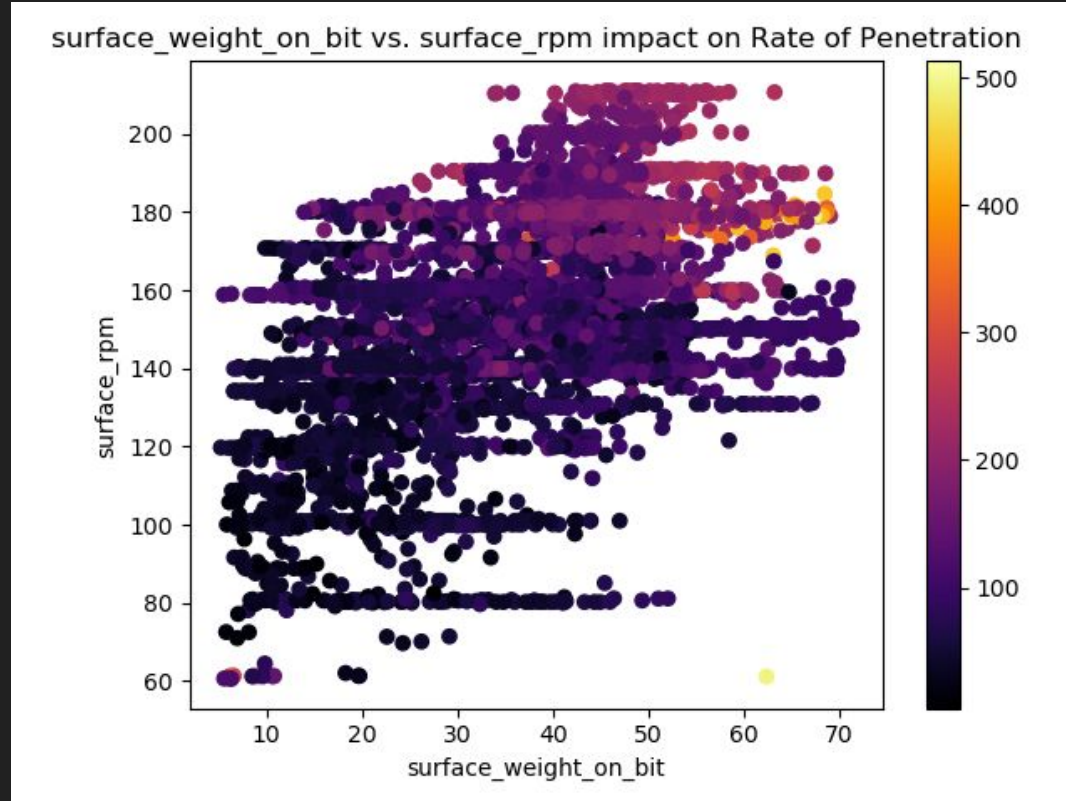
# Visualization: Surface RPM



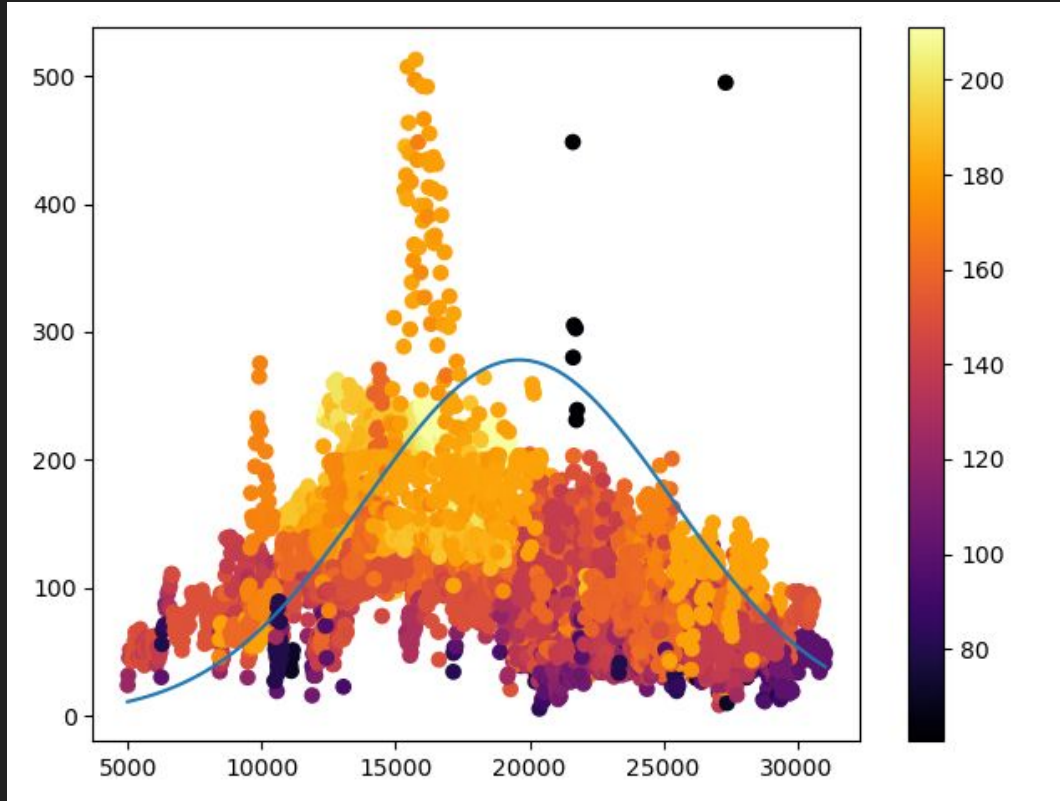
# Visualization: Drillbit Size



# Relations between Variables Visualization

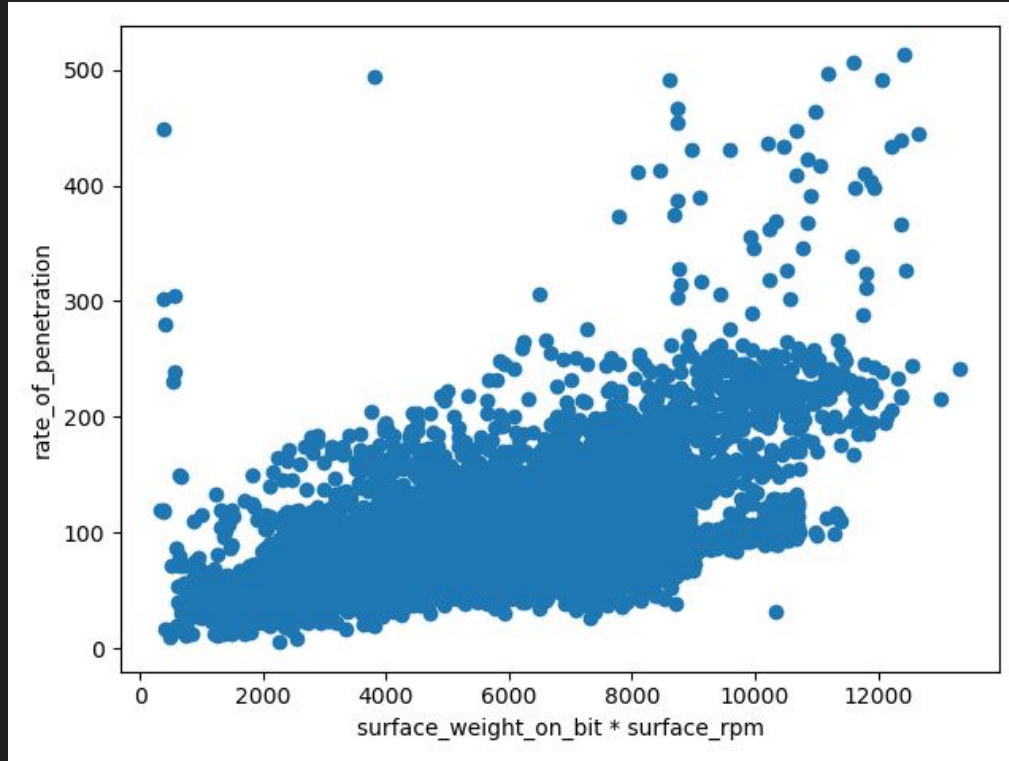


# Fitting Gaussian to Min Depth vs.ROP

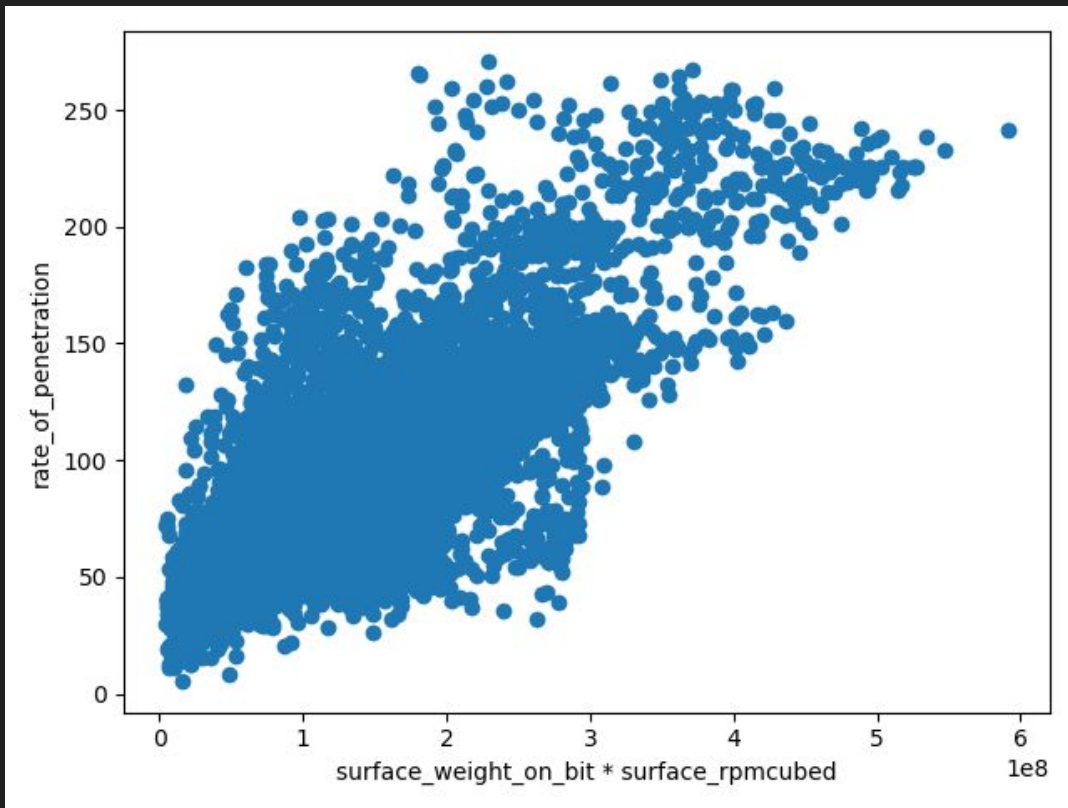




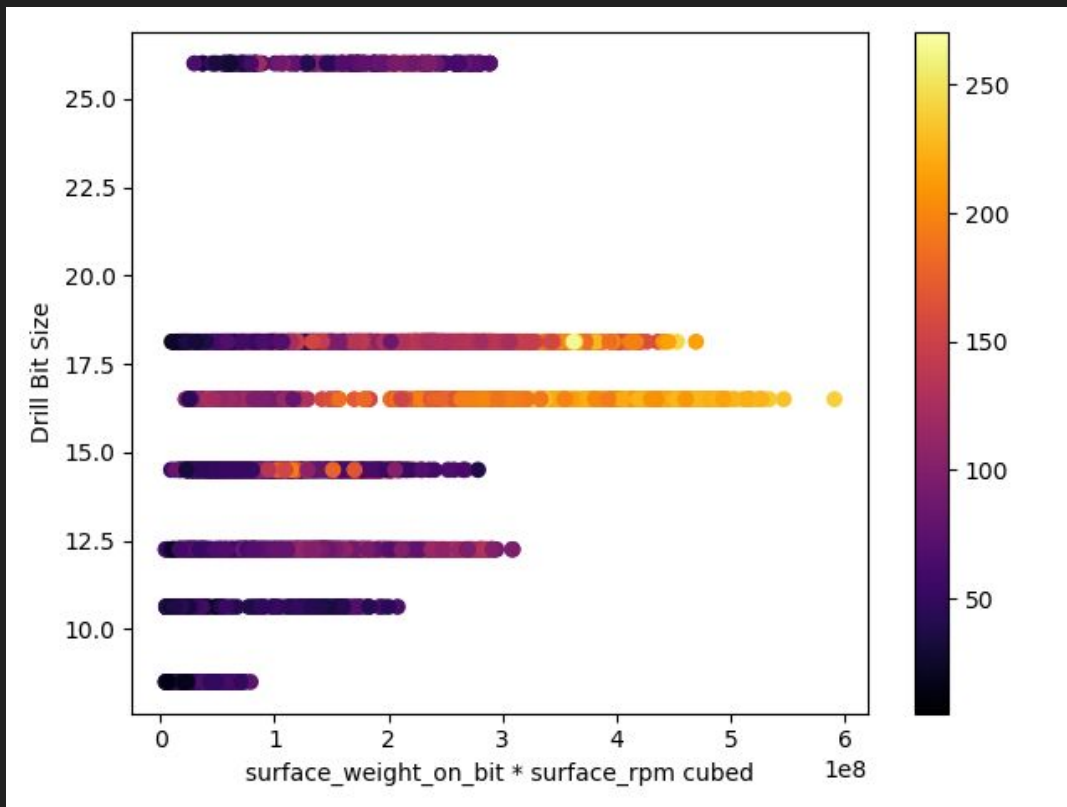
# Relation between ROP and WOB \* RPM



# After Removing Outliers



# Attempt to Combine with Drill Bit Size



# ROP Formulas used for Feature Engineering

## Mechanical Specific Energy Equation

SPE 92194, 2005



$$MSE = 0.35 * \left( \frac{WOB}{A_B} + \frac{120 * \pi * RPM * T}{A_B * ROP} \right)$$

Where:

MSE = Energy Input, psi

WOB = WOB (lbs)

AB = Bit Area, sq. inches

RPM = Rotary Speed

T = Torque, ft-lbs

ROP = Rate of Penetration, ft/hr

Factor = 0.35 (Efficiency factor)



## Drilling Rate as a Pore Pressure Predictor

➤ Penetration rate depends on a number of different parameters.

$$R = K(P_1)^{a_1} (P_2)^{a_2} (P_3)^{a_3} \dots (P_n)^{a_n}$$

### D - Exponent

The  
drilling rate  
equation:

$$R = KN^E \left( \frac{W}{D_B} \right)^D$$

Where

R = drilling rate, ft/hr

K = drillability constant

N = rotary speed, RPM

E = rotary speed expon.

W = bit weight, lbs

D<sub>B</sub> = bit diameter, in

D = bit wt. Exponent

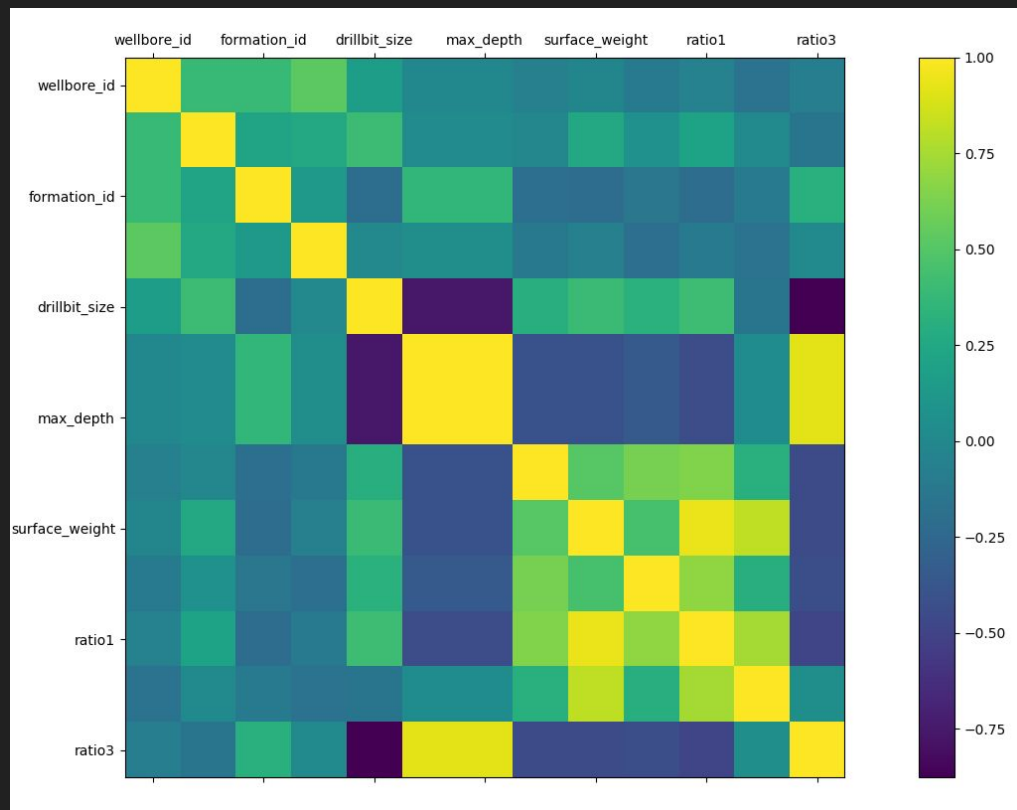
or D - exponent

# Correlation

1. Surface weight, surface RPM, and Drill Bit Size all had large positive correlation coefficients (proportional)
2. Min and max depth both had large negative correlation coefficients (inversely proportional)

Unnamed: 0	-0.089781
wellbore_chev_no_id	-0.060850
area_id	-0.005844
formation_id	-0.191339
bit_model_id	-0.121953
drillbit_size	0.309222
min_depth	-0.402306
max_depth	-0.402290
rate_of_penetration	1.000000
surface_weight_on_bit	0.508618
surface_rpm	0.611703
ratio1	0.643477
ratio2	0.317429
ratio3	-0.463423
ratio4	0.247433

# Correlation Matrix



ROP

## Legend:

1. Wellbore
2. Area
3. Formation
4. Bit\_model
5. Drill bit Size
6. Min Depth
7. Max Depth
8. ROP
9. Surface Weight
10. Surface RPM
11. Surface RPM / Surface WOB (Ratio 1)
12. Surface WOB / Drill Bit Size (Ratio 2)
13. Min Depth / Drill Bit Size (Ratio 3)

# We Implemented Five Different Models

- Elastic Net
- Xgboost
- Random Forest Regression
- LASSO
- Ridge Regression

# Cross Validation RMSE Results

- Mean Squared Error of:
  - XGBoost: \_\_\_\_\_
  - Elastic Net Model:
  - Random Forest Regressor: 18.68
  - LASSO: 38.90
  - Ridge: 40.64