Data Analytics of BOEM Dataset for CO2 Storage in Gulf of Mexico

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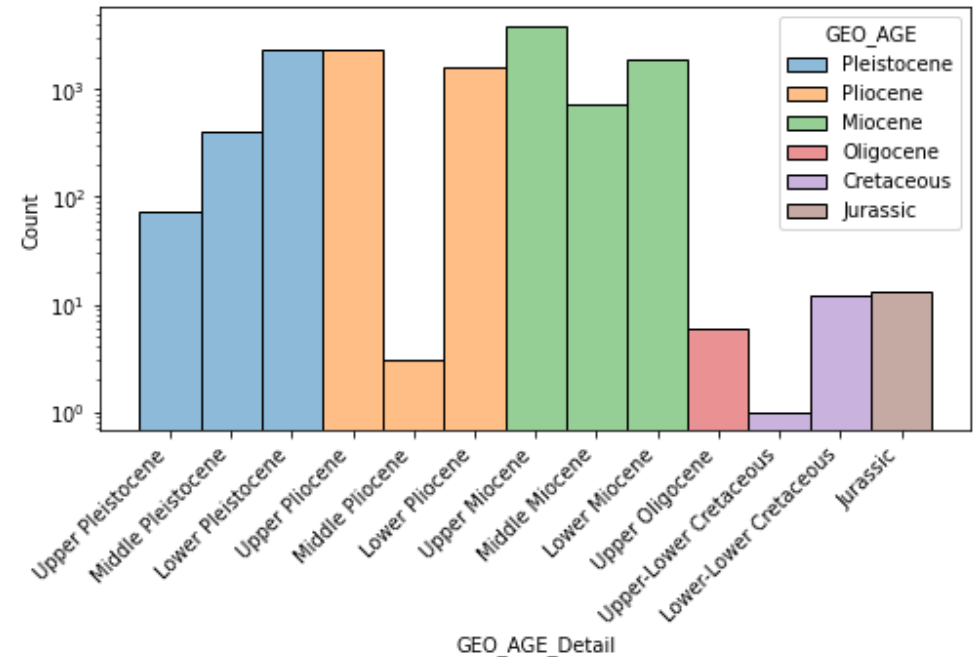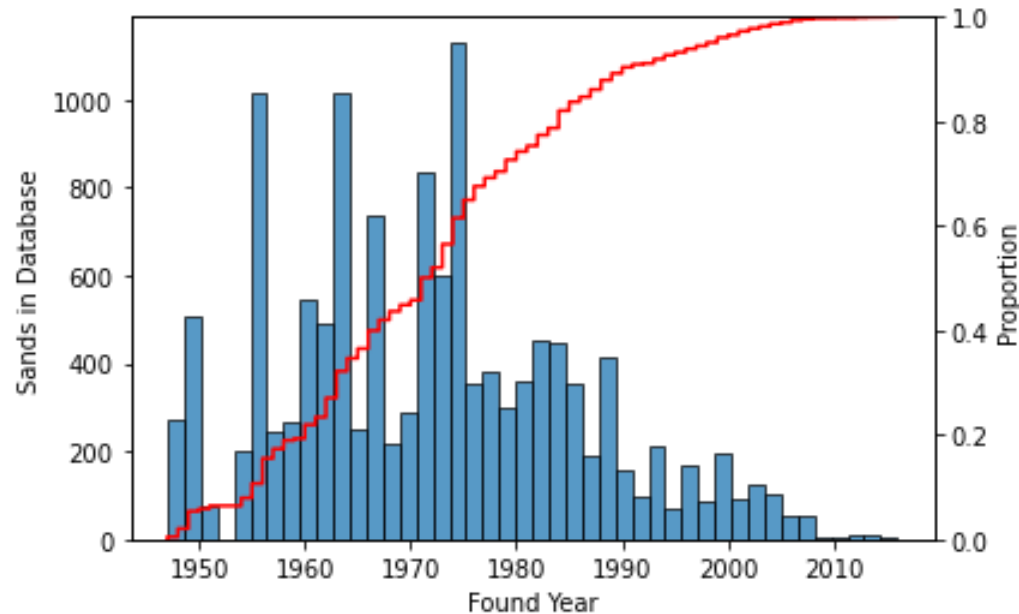(seyyed.hosseini@beg.utexas.edu)

Motivation

- Objective: Evaluation and screening of oil and gas reservoirs for CO2 storage

- Data: 2019 BOEM Database in Gulf of Mexico (Results may be biased toward oil/gas dataset)
  - Over 80 features and 13394 entries of depleted Oil and Gas sands
  - 978 reservoirs (670 reservoirs with detailed well data)
  - Sand discovered year ranges from 1947 to 2015
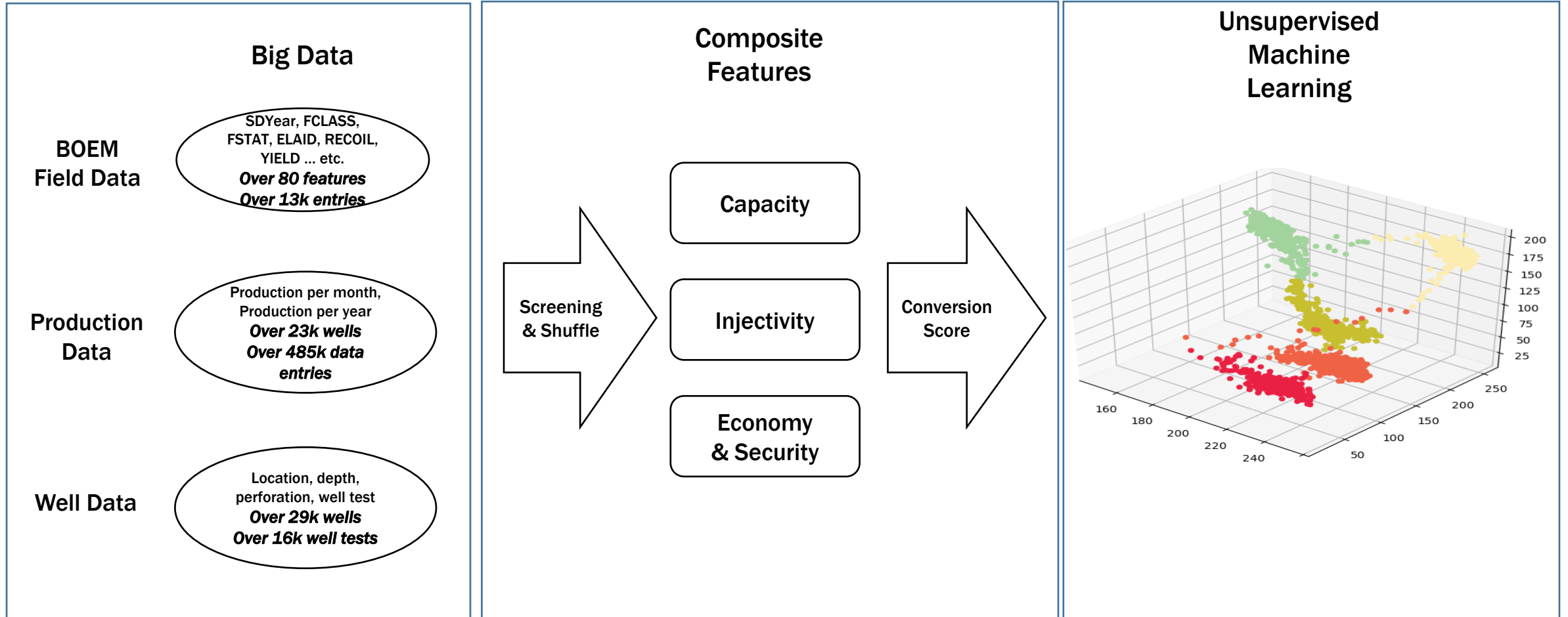 - Sand chronozone ranges from Jurassic to Pleistocene

Methodology

Input

Big Data

BOEM Field Data

SDYear, FCLASS, FSTAT, ELAID, RECOIL, YIELD ... etc.
Over 80 features
Over 13k entries

Production Data

Production per month, Production per year
Over 23k wells
Over 485k data entries

Well Data

Location, depth, perforation, well test
Over 29k wells
Over 16k well tests

Data Mining and Analytics

Composite Features

Screening & Shuffle

- Capacity
- Injectivity
- Economy & Security

Conversion Score

Output

Unsupervised Machine Learning

Composite Factor Description

Capacity

Security & Economy

Injectivity

- CO2 Storage
  - Storage window
  - Fluid replacement

- Well Condition
  - Well completed
  - Well score
  - Perforation safe zone

- Economic Condition
  - Remaining oil/gas
  - Reservoir distance to coast

- Depleted Area Ratio
  - Reservoir area
  - Drainage area

- Production Decline
  - Decline duration
  - Average rate
  - Variation of Decline

- Heterogeneity
  - Lorenz coefficient

CO2 Storage Estimation

- Static estimation (Agartan et al.)
  - Pore volume

  $$G_{CO_2} = A h_n \phi_e (1 - S_w) B \rho_{CO_2} E_{oil/gas}$$

  - Storage efficiency & Fluid replacement

  $$HCRF = \frac{(Cum.\ Free\ Gas\ Prod. \times B_{gi}) + (Cum.\ Oil\ Prod. \times B_{oi} \times 5.615)}{(OGIP \times B_{gi}) + (OOIP \times B_{oi} \times 5.615)}$$
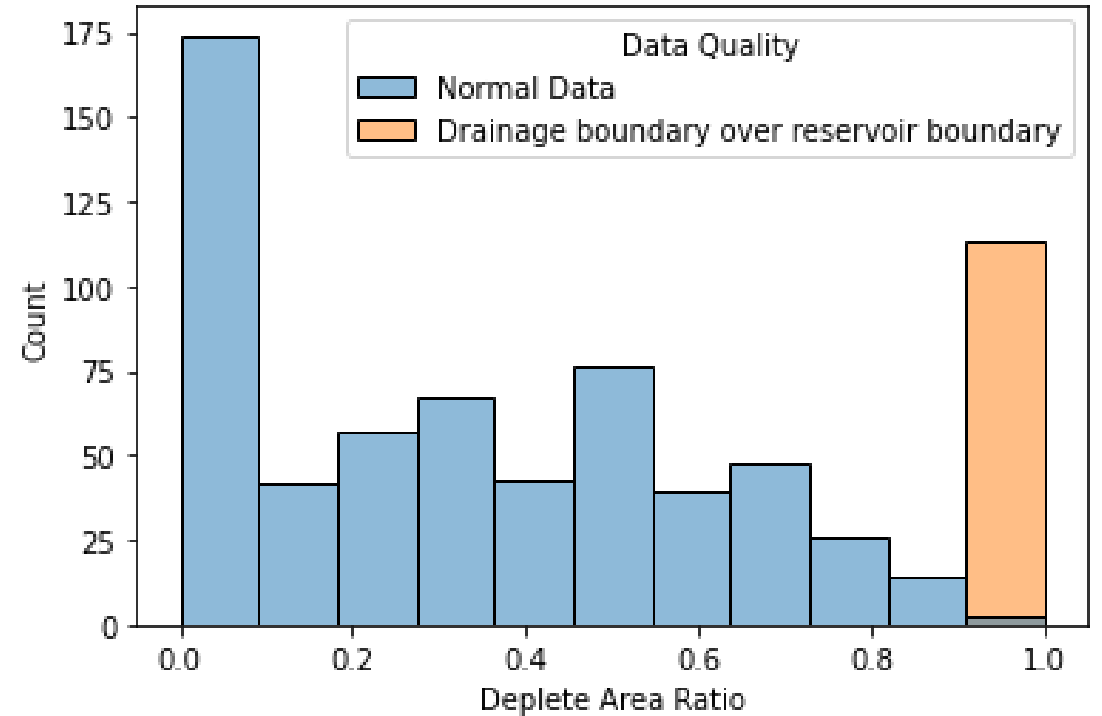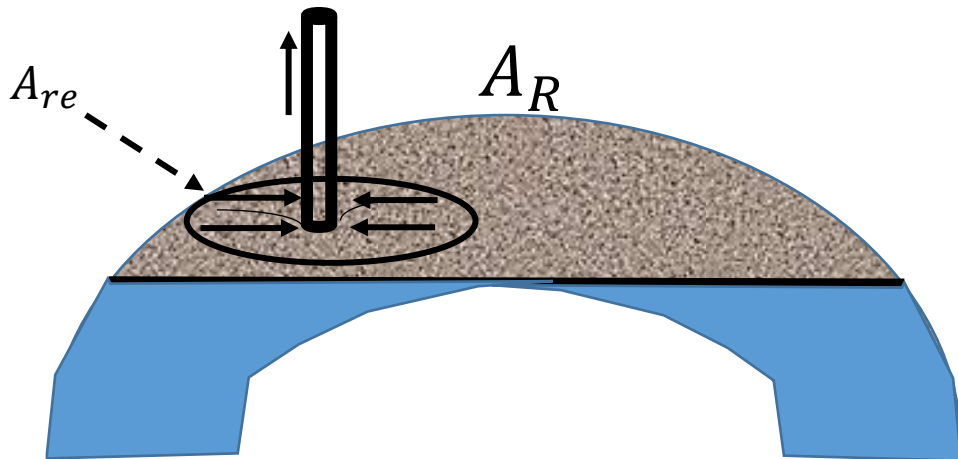

Storage Window

Supercritical Boundary

Overpressure Boundary

Geo Trap/Age Boundary

Sands

Agartan et al.
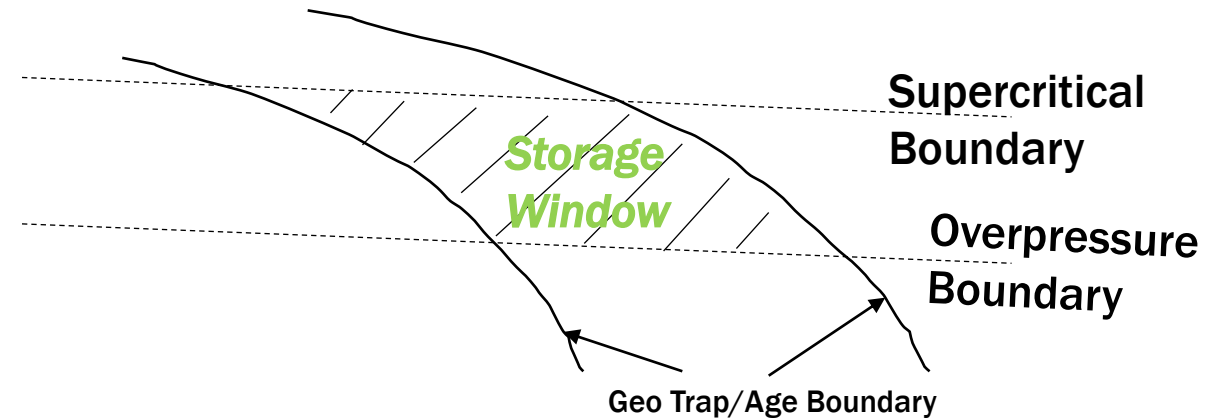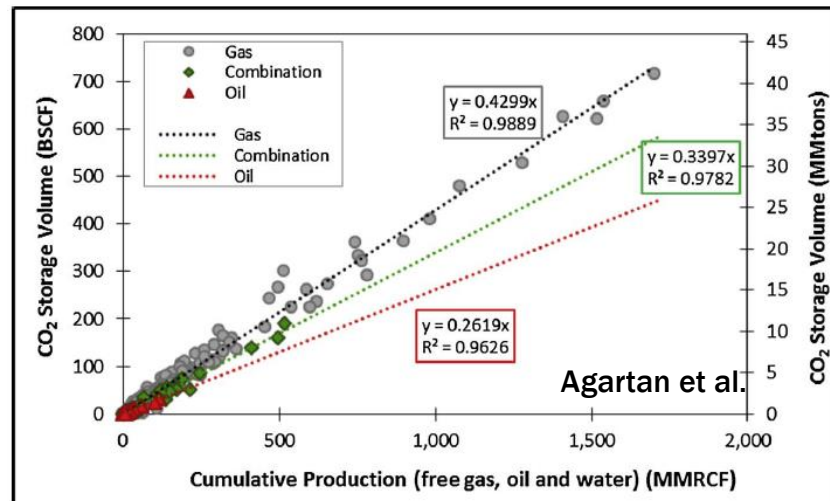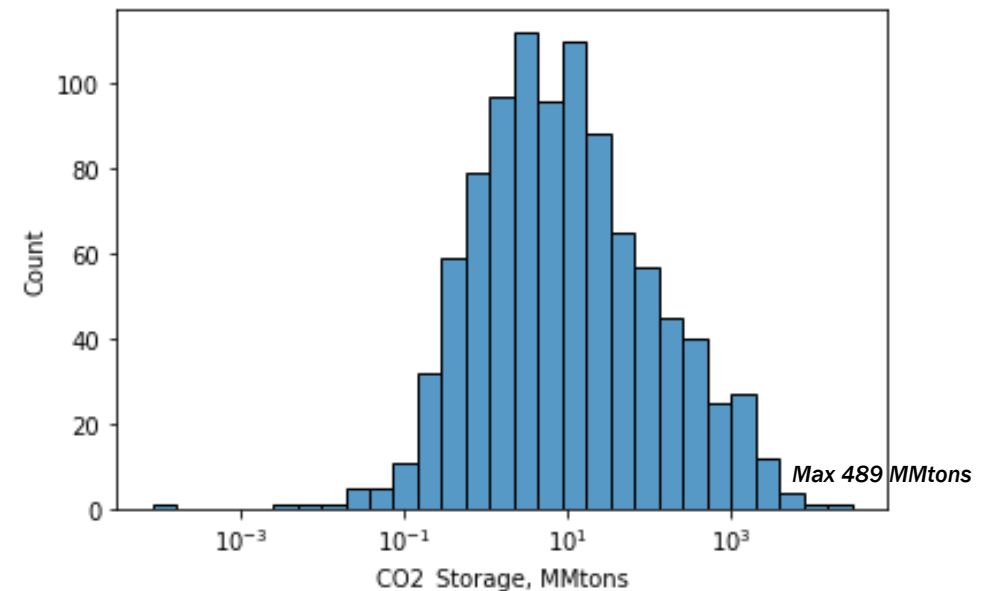
$$V_{CO_2} \times B_{CO_2} = (OGIP \times B_{gi} + OOIP \times B_{oi} \times 5.615) \times E_{Roil/gas}$$

Reservoirs

Max 489 MMtons

Depleted Area Ratio

- Depleted area ratio (DAR):
  - Calculated drainage re
    - $re = \exp\left(\dfrac{0.0078KH}{J\mu B} + 0.5 + S\right) * rw$
  - Reservoir radius R (from BOEM)
  - $DAR = A_{re} : A_R$

Production Decline

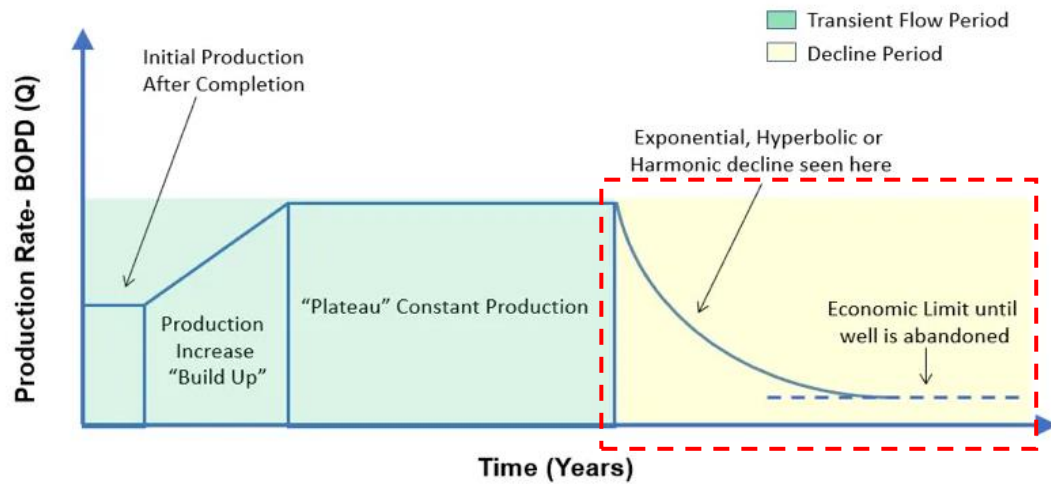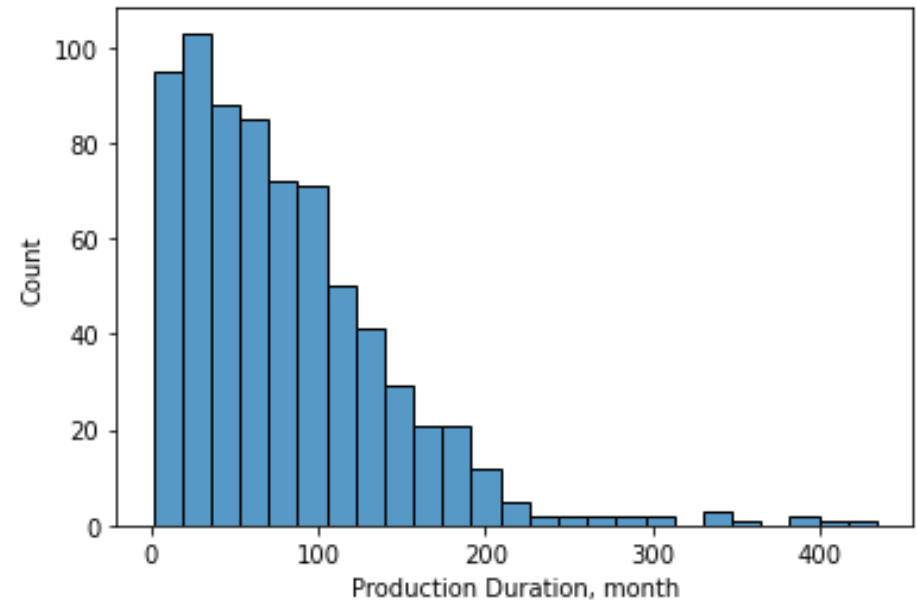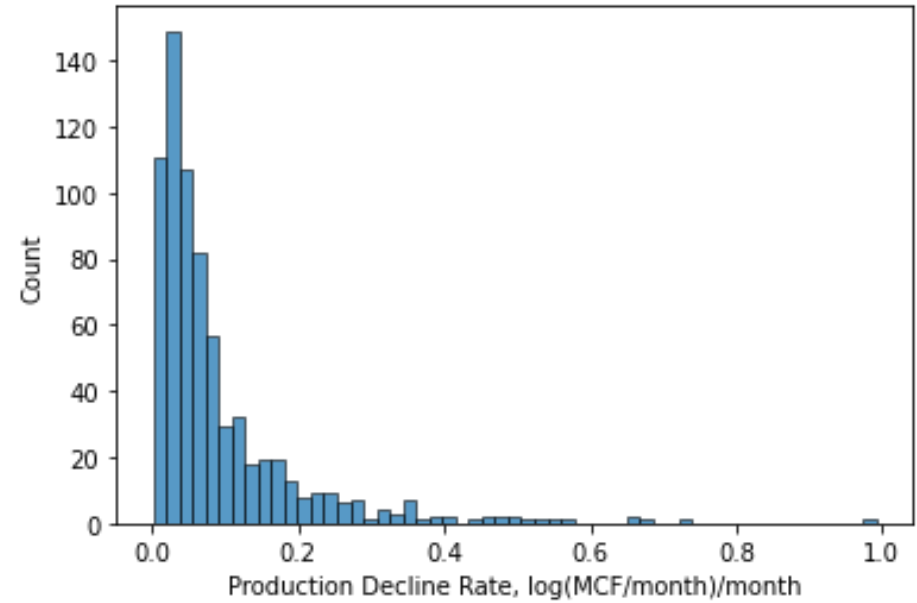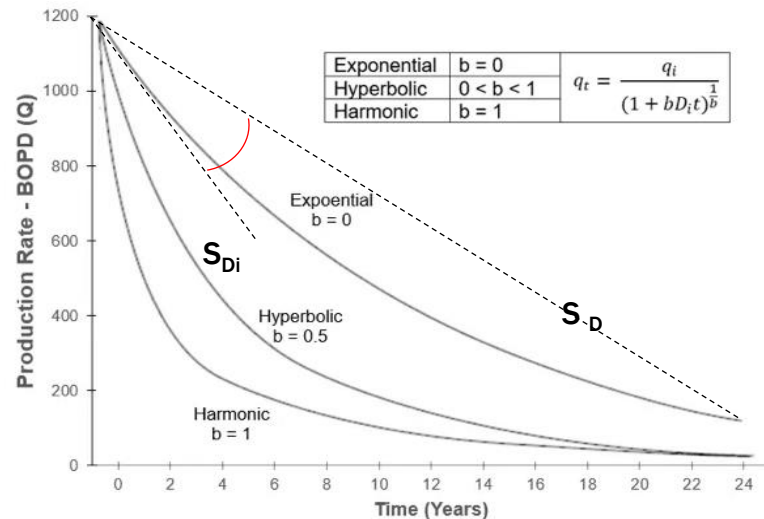- Production decline rate and Period length
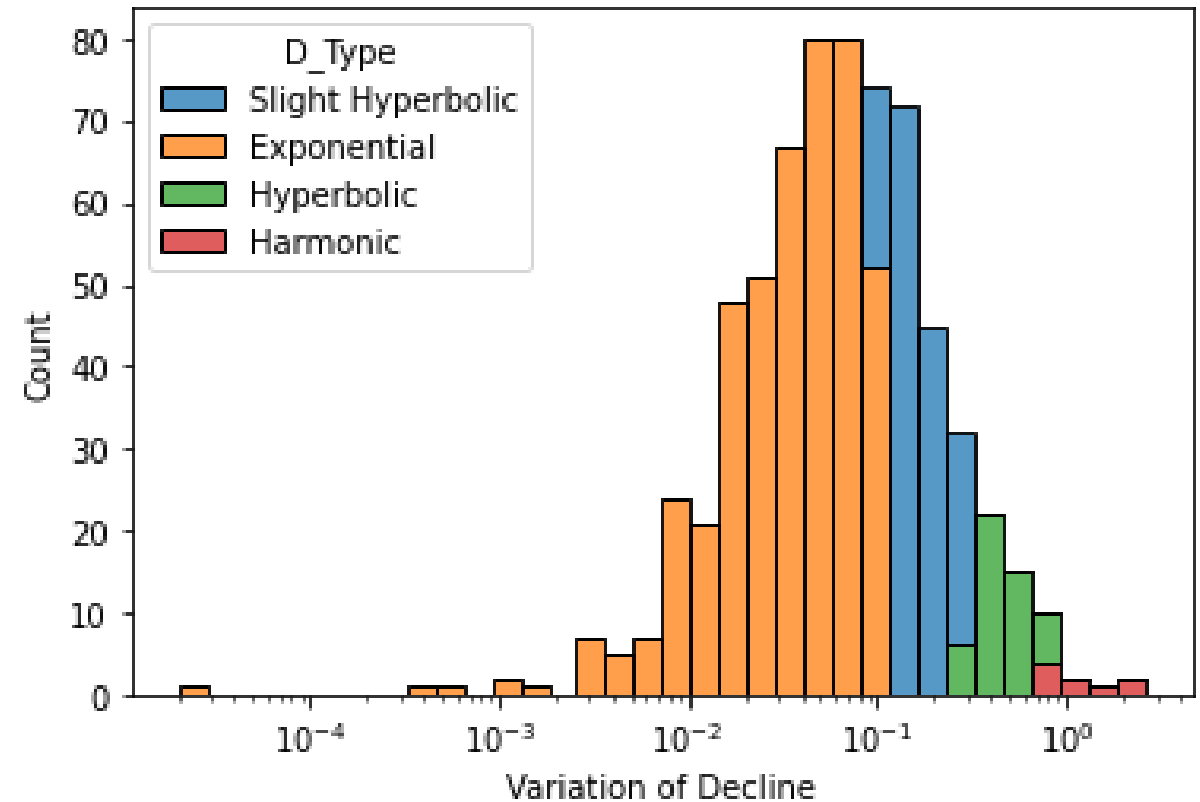 - Average conductivity

Figure 4: Oil and Gas Well Stages of Life

Deeper Data Mining

- Decline slope change:
  - Near wellbore situation
    - Fractures or vuggies
    - Water channels
  - $(S_D - S_{Di})$ (Wang et al.)
    - <0.1 → Exponential
    - 0.1-0.3 → Slight Hyperbolic
    - 0.3-0.7 → Hyperbolic
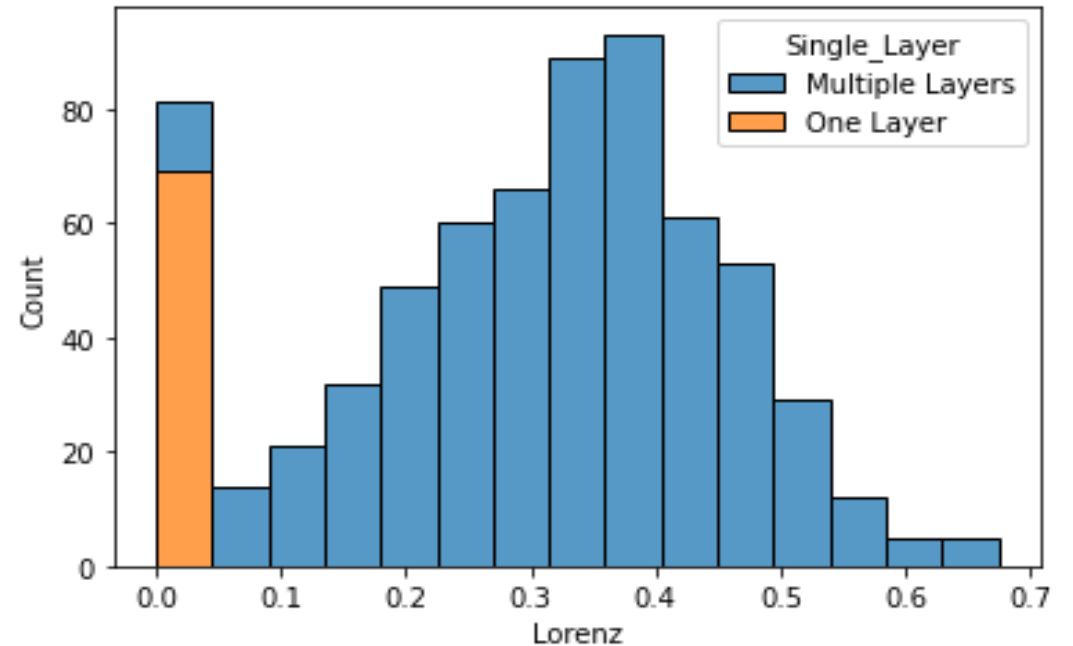   - >0.7 → Harmonic

Reservoirs

Heterogeneity

- Lorenz coefficient
  - Vertical distribution
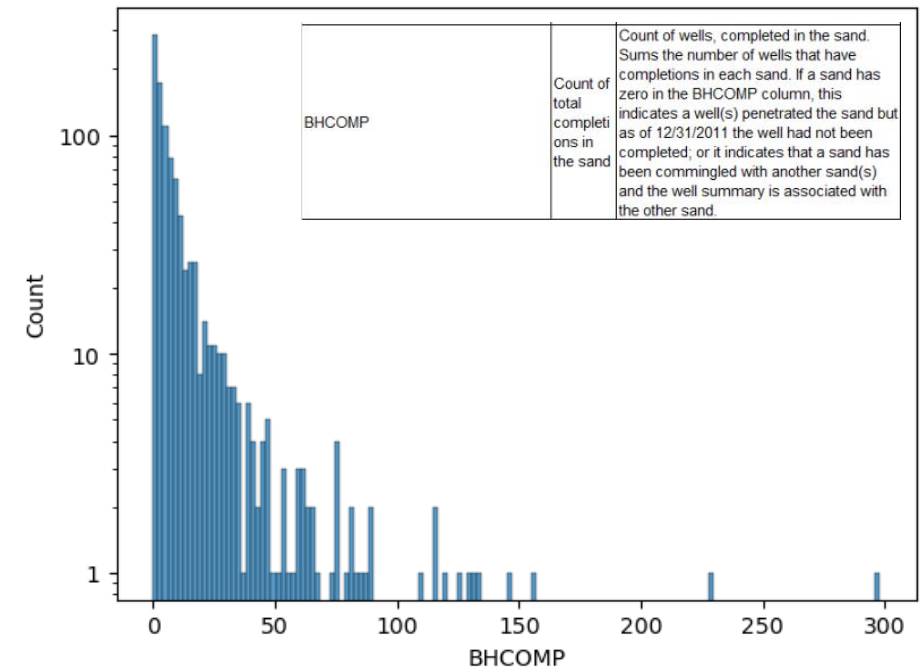   - Permeability (flow capacity)
    - Porosity (pore volume)
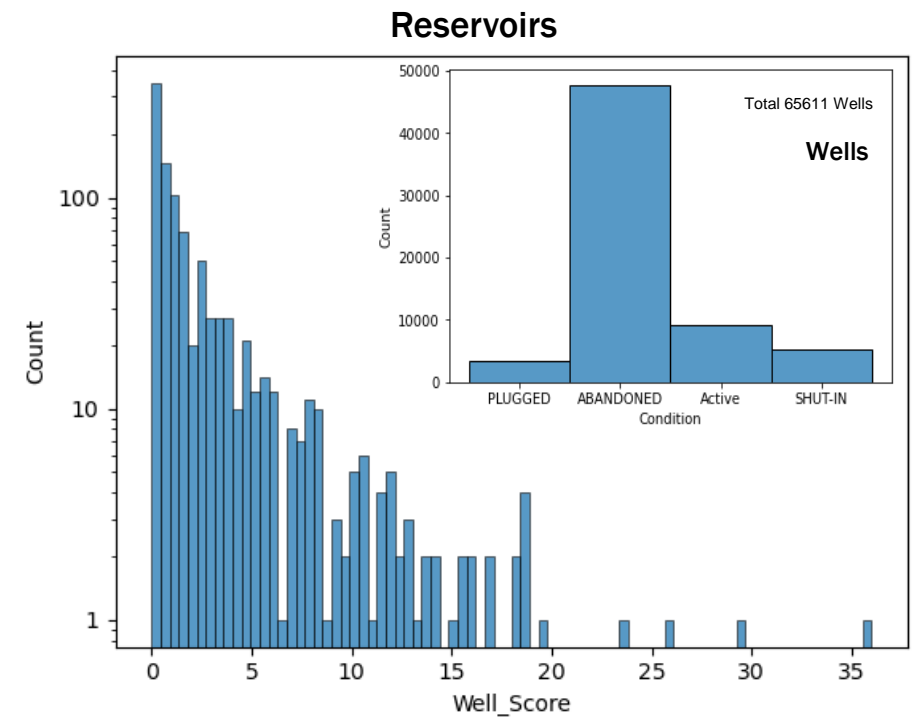

Petrophysics (2016)
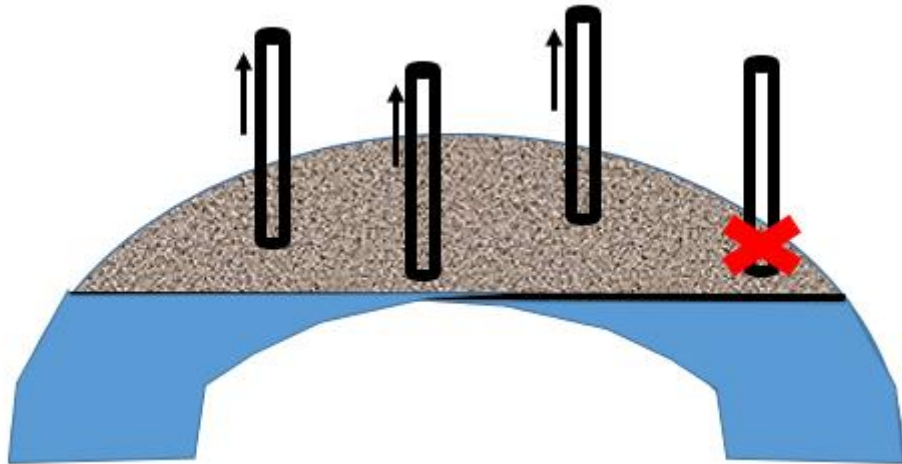
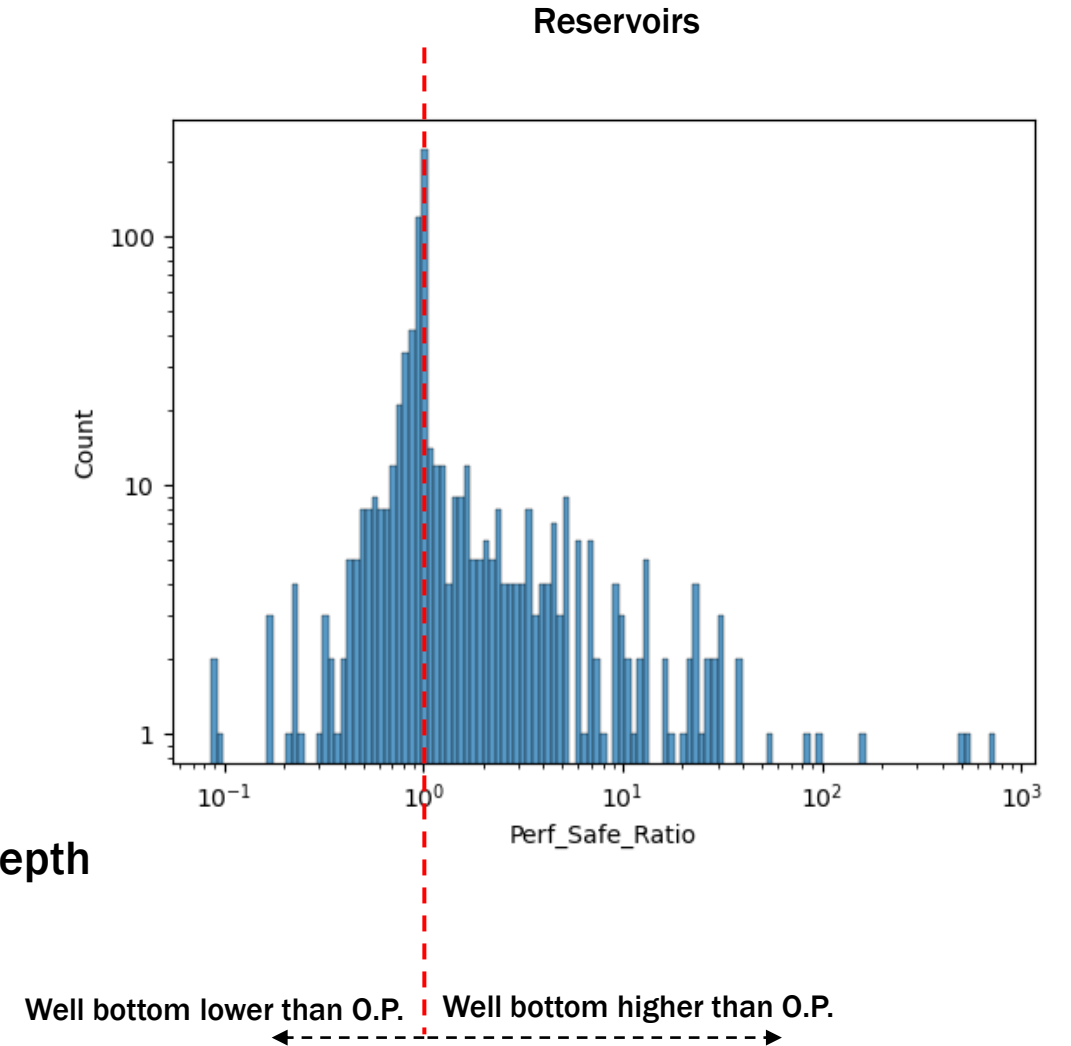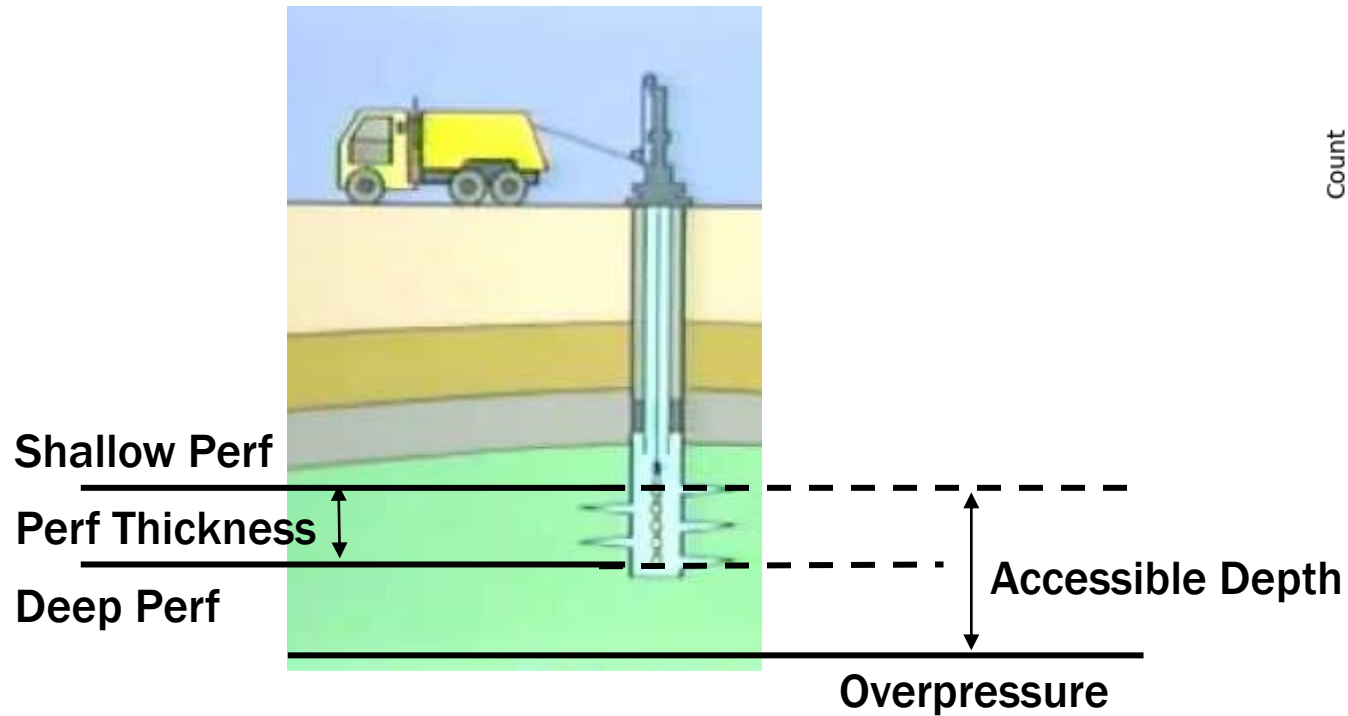$$L_K = \frac{\text{Area ABCA}}{\text{Area ADCA}}$$
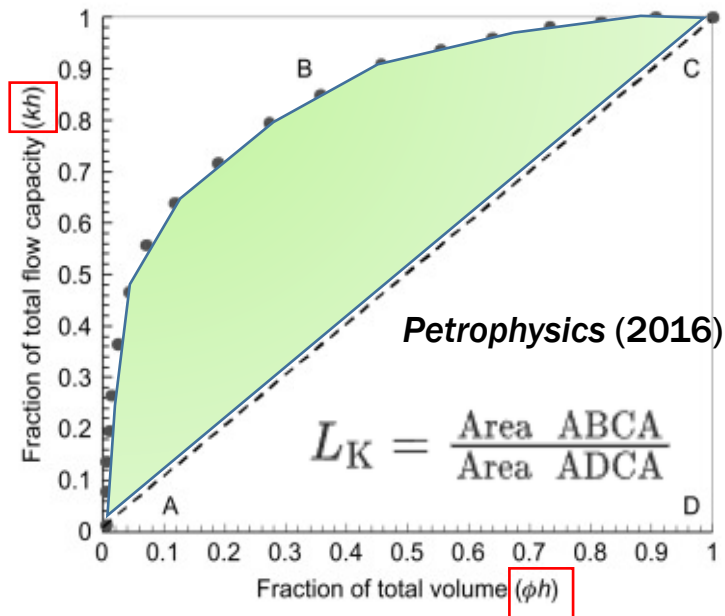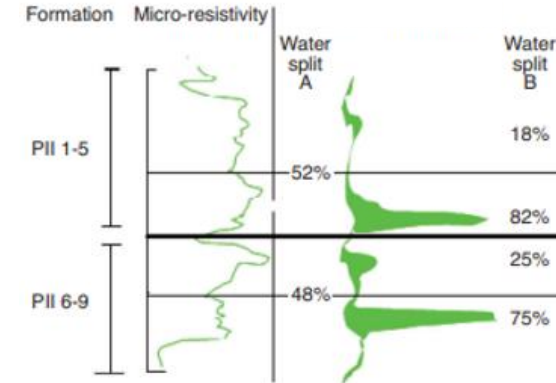
Well Condition in Reservoir

- Well scoring:
  - Well number X Well condition
  - Active: 1
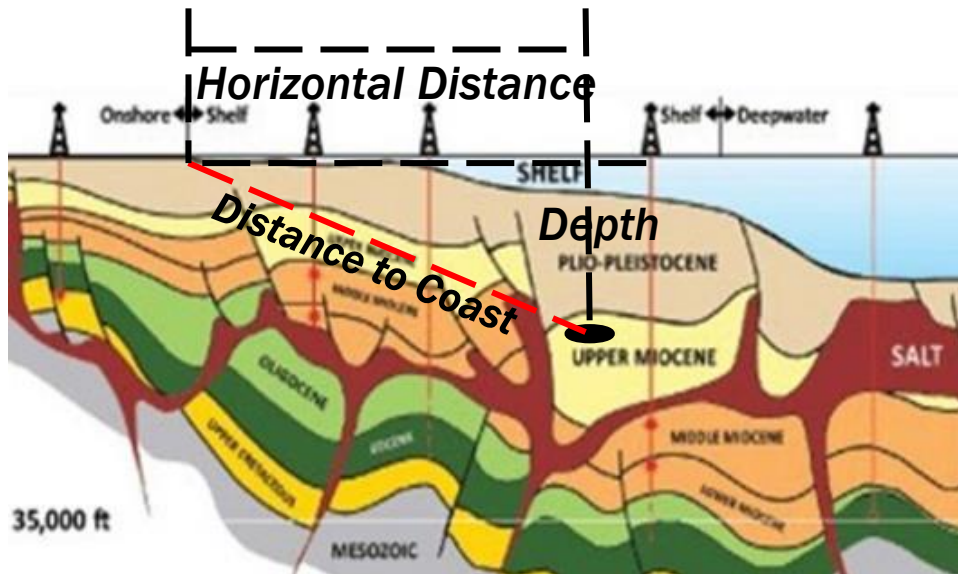 - Shut-in: 0.75
  - Abandon: 0.25
  - Plugged abandon: 0

Perforation Safe Ratio

- **Perforation Safe Ratio**

  =Accessible Depth/Perf Thickness

Shallow Perf

Perf Thickness

Deep Perf

Accessible Depth

Overpressure

Reservoirs

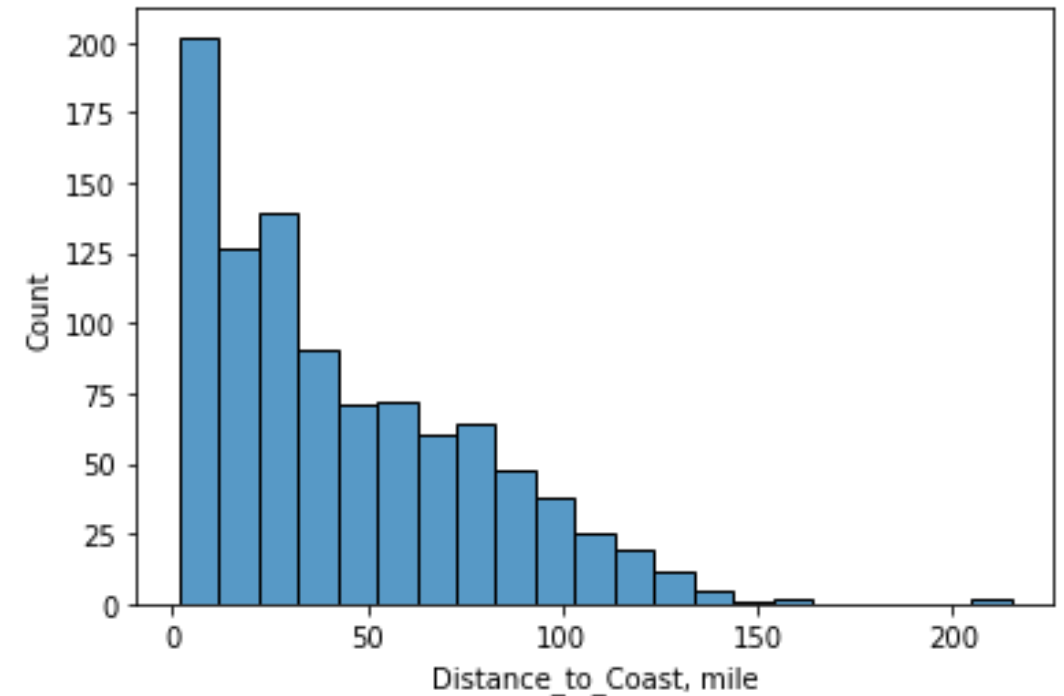Well bottom lower than O.P.   Well bottom higher than O.P.

Distance to Coast

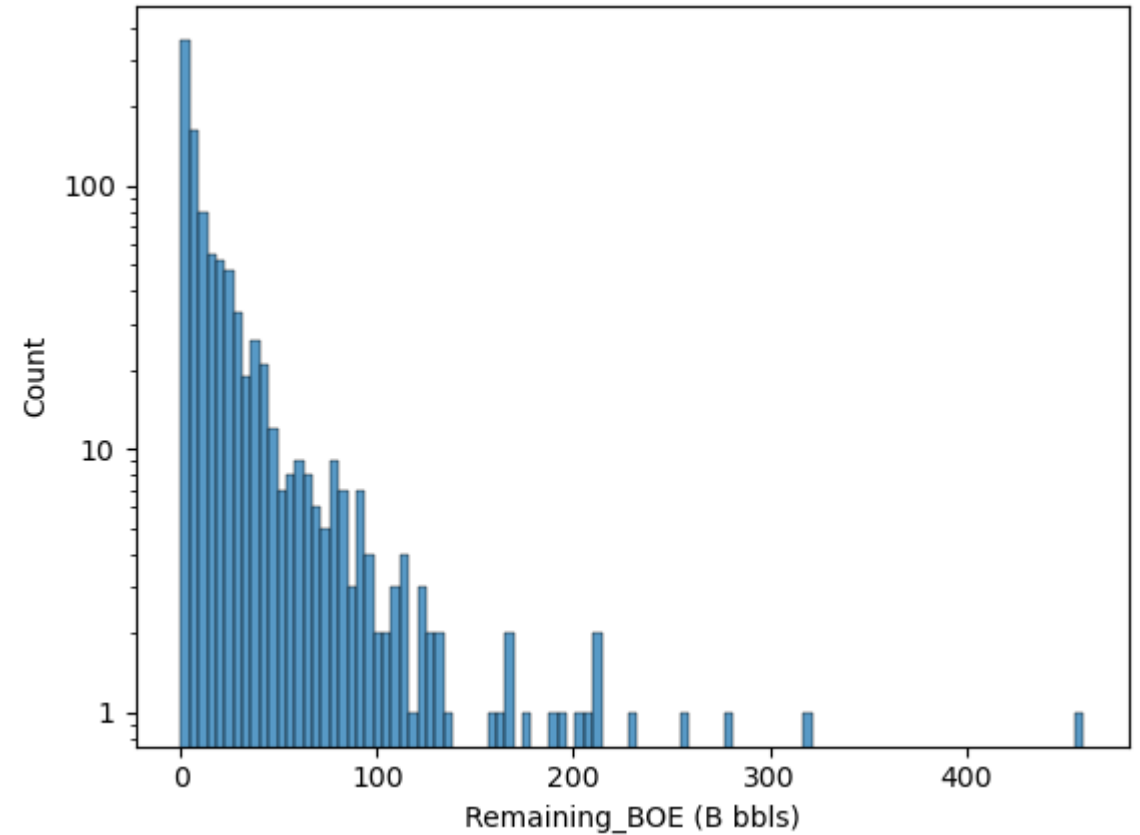- From reservoir center to coast line
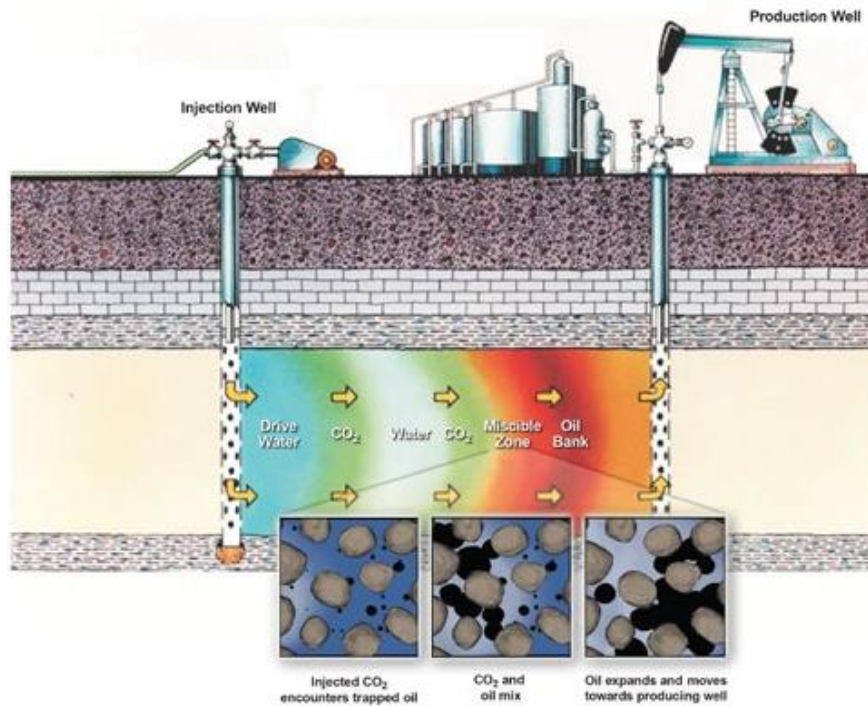 - Economic concern

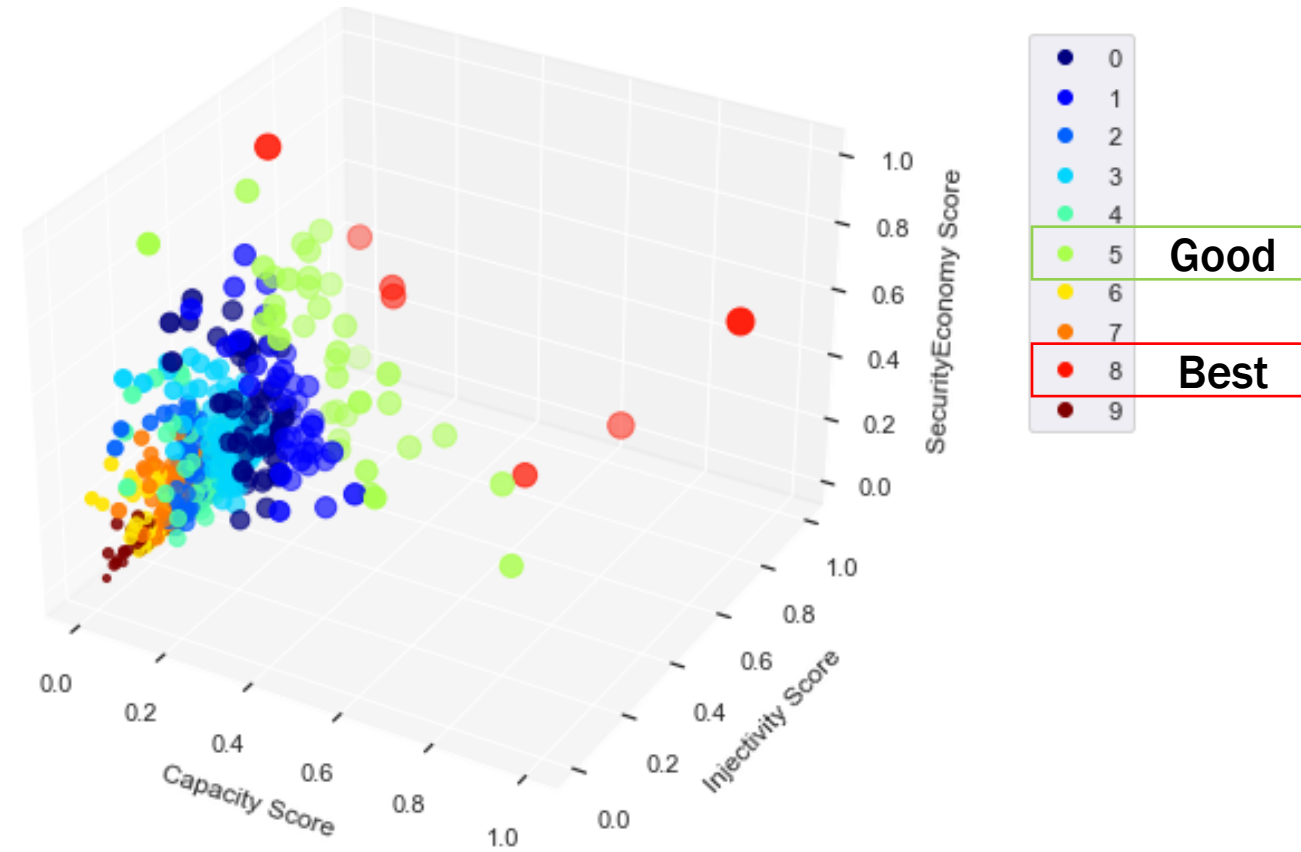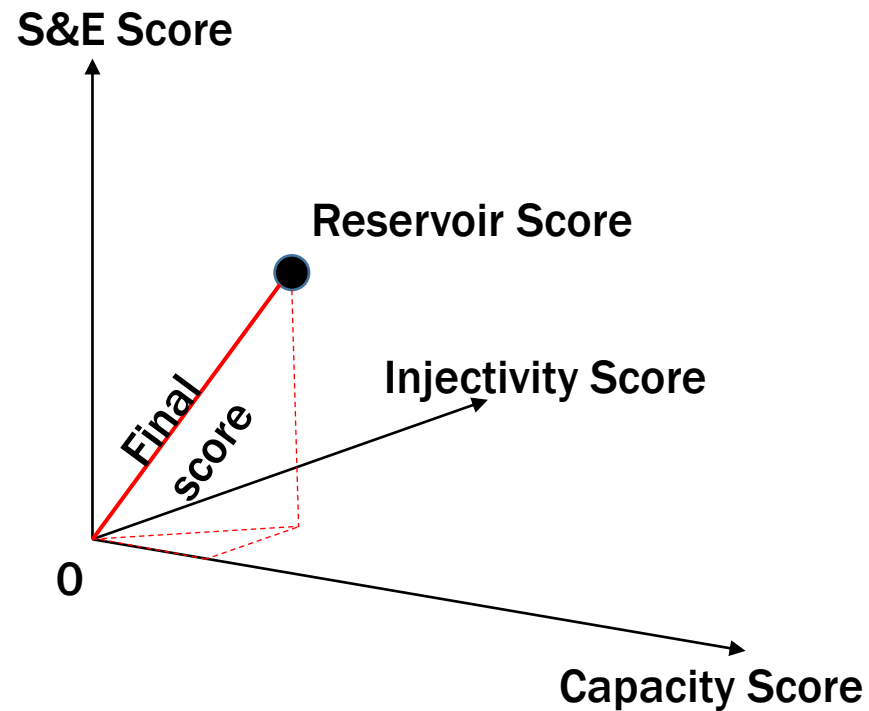Reservoirs

Remaining Oil and Gas

- **Remaining BOE:**
  - $BOE_r = OIP * (1 - ORF) + GIP * (1 - GRF) * C$
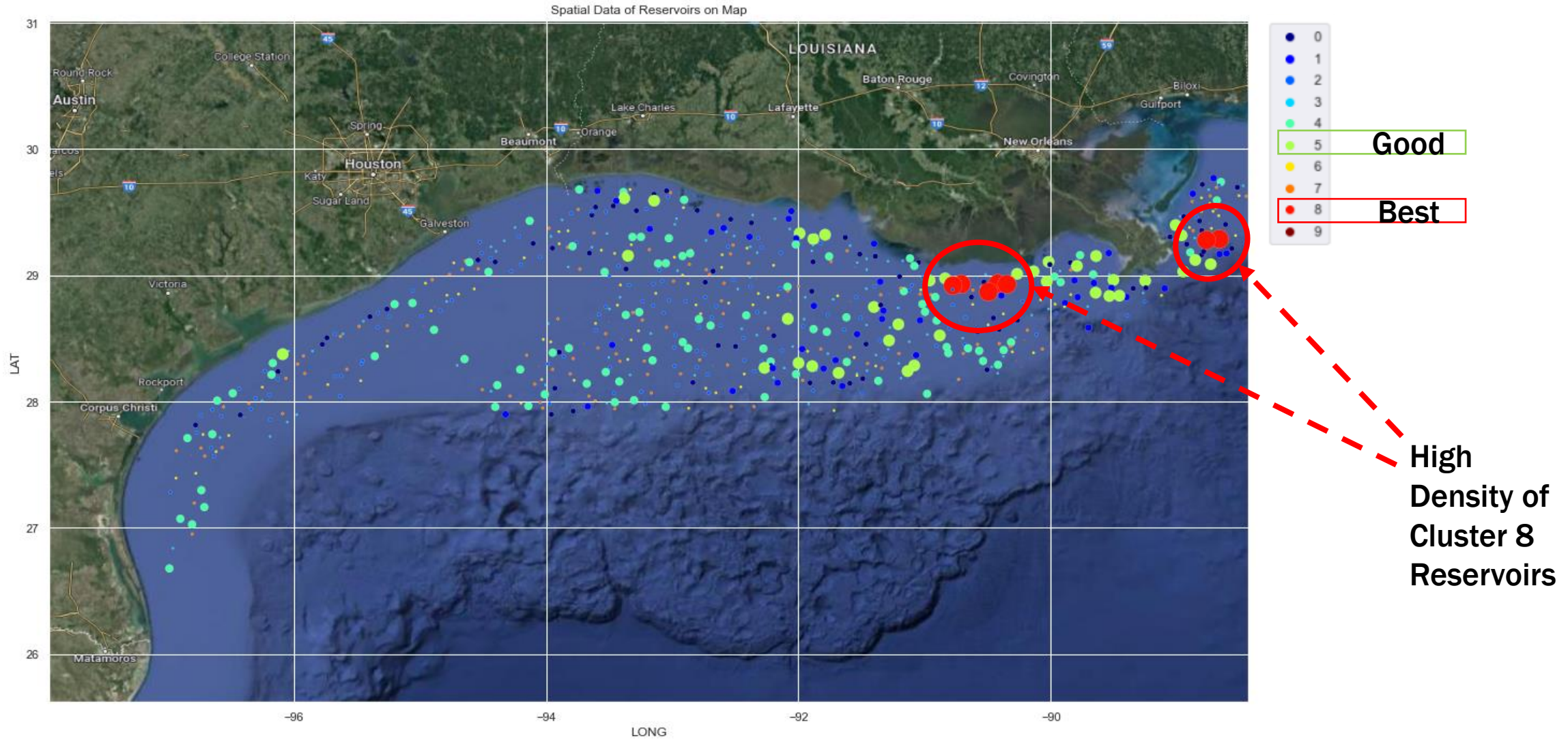 - **EOR profit during CO2 injection**

K-means based on Score

- Final score = 3D distance to 0
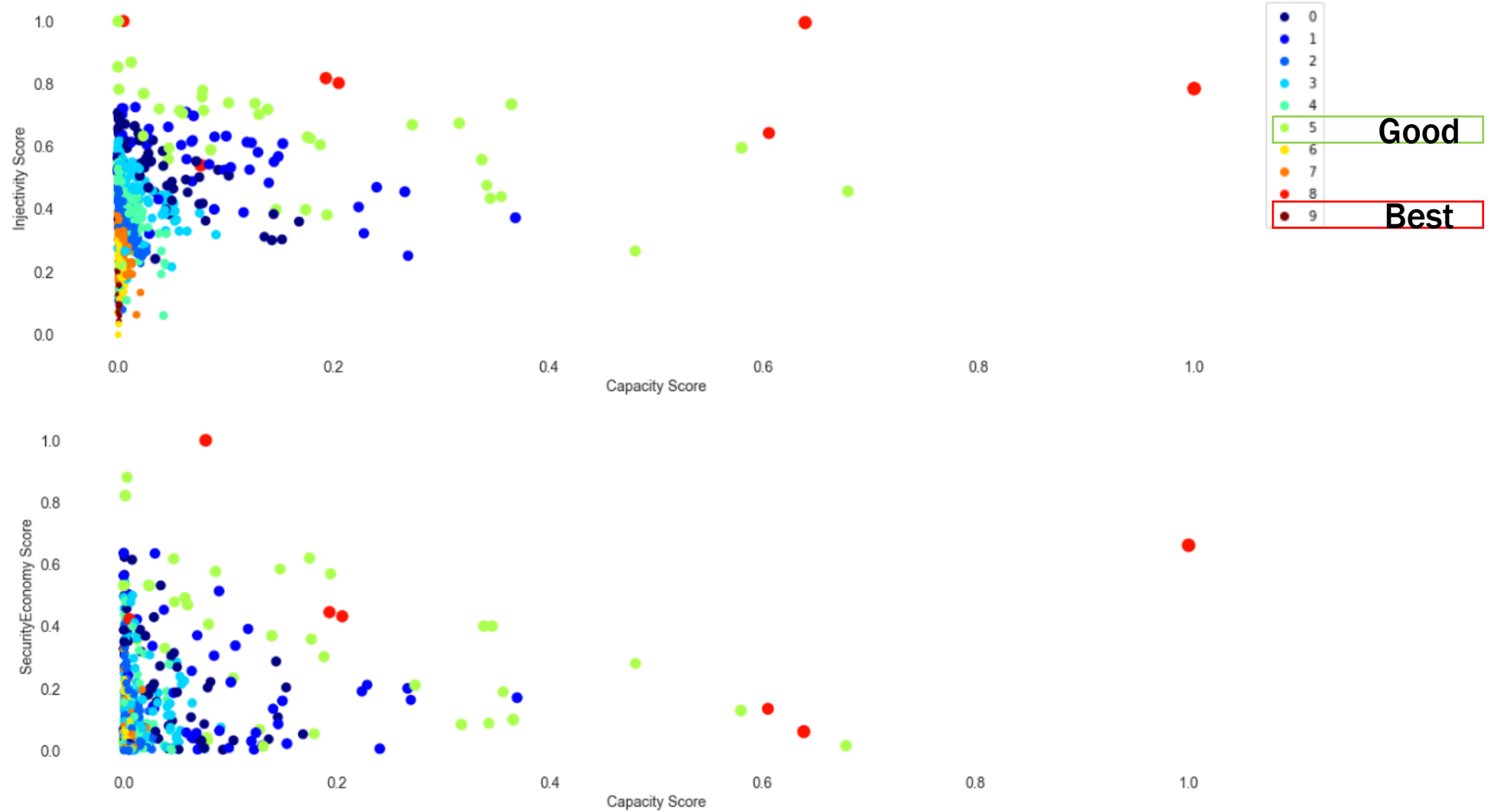 - Comprehensive score of three aspects

Location of Clusters on Map

Spatial Data of Reservoirs on Map

Novelty

- **Comprehensive score**
  - 13 factors
  - Geo/Petro

- **Balanced score**
  - Storage
  - Injectivity
  - Safety

Next Step

- Collection of more data to avoid bias toward BOEM dataset

- Analysis of characterization of each cluster based on safety score, injectivity score, and storage score separately

- Analysis of geological factors' impact on the clustering

- Report results on CCUS conference

- Implementation of the method to saline aquifer dataset

Thank you