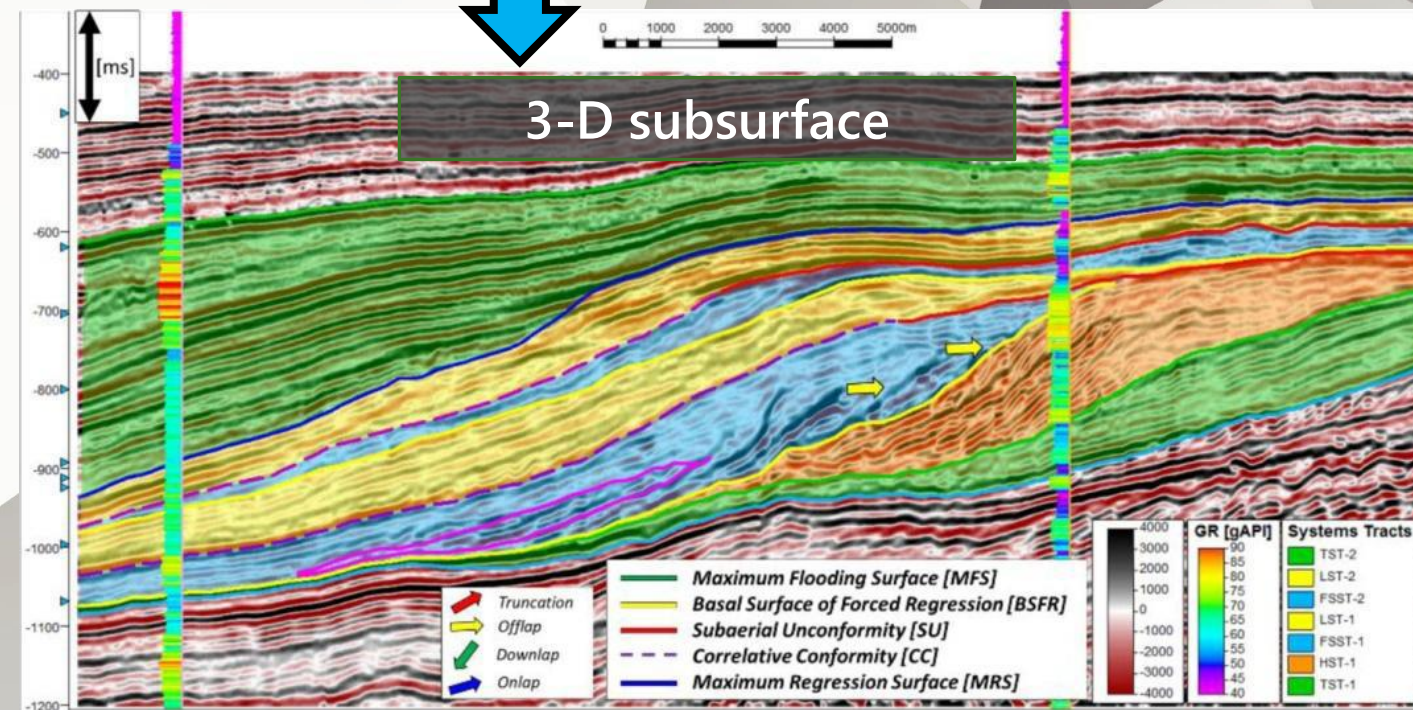
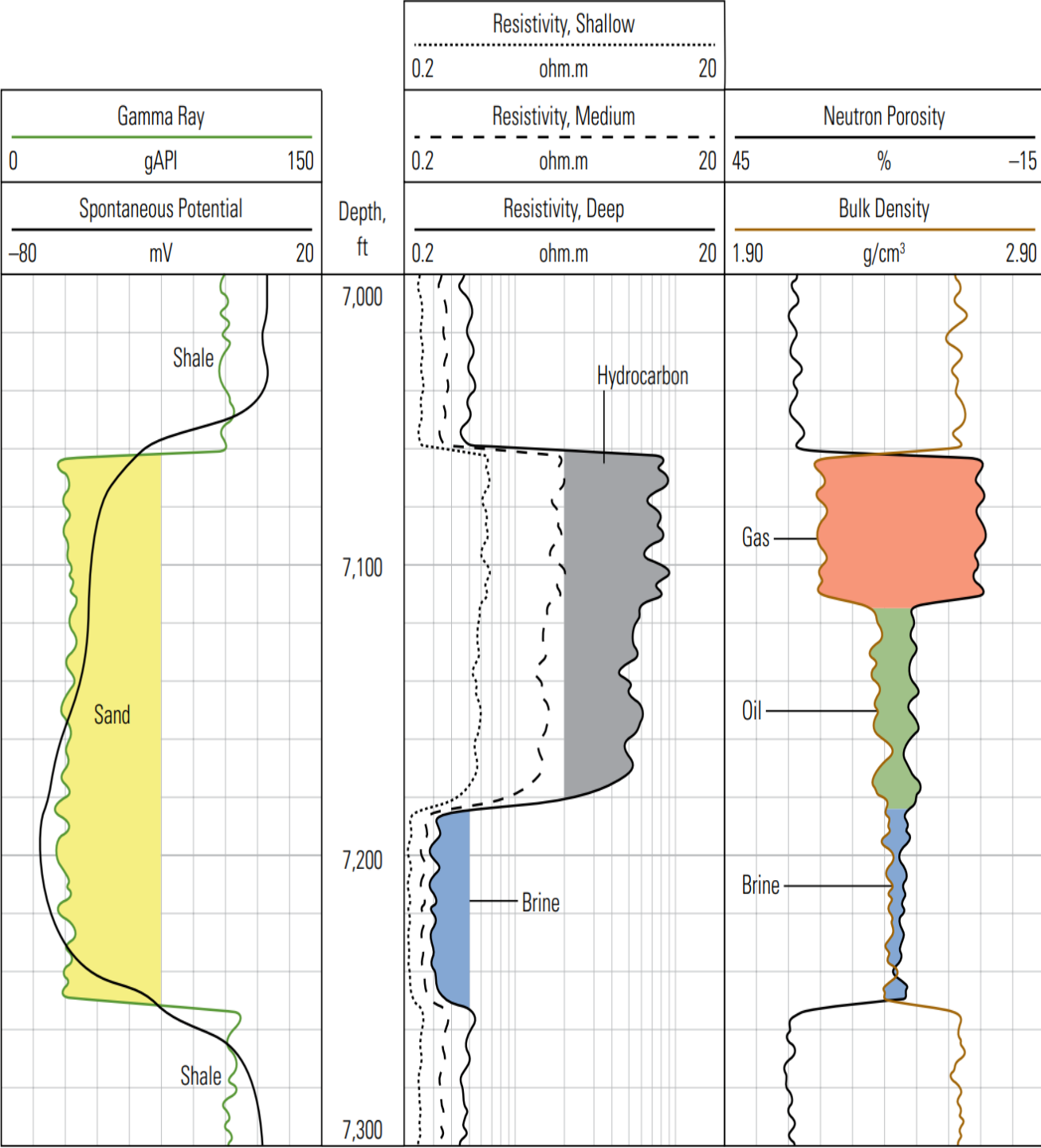


3-D subsurface



What in the Hell Well?

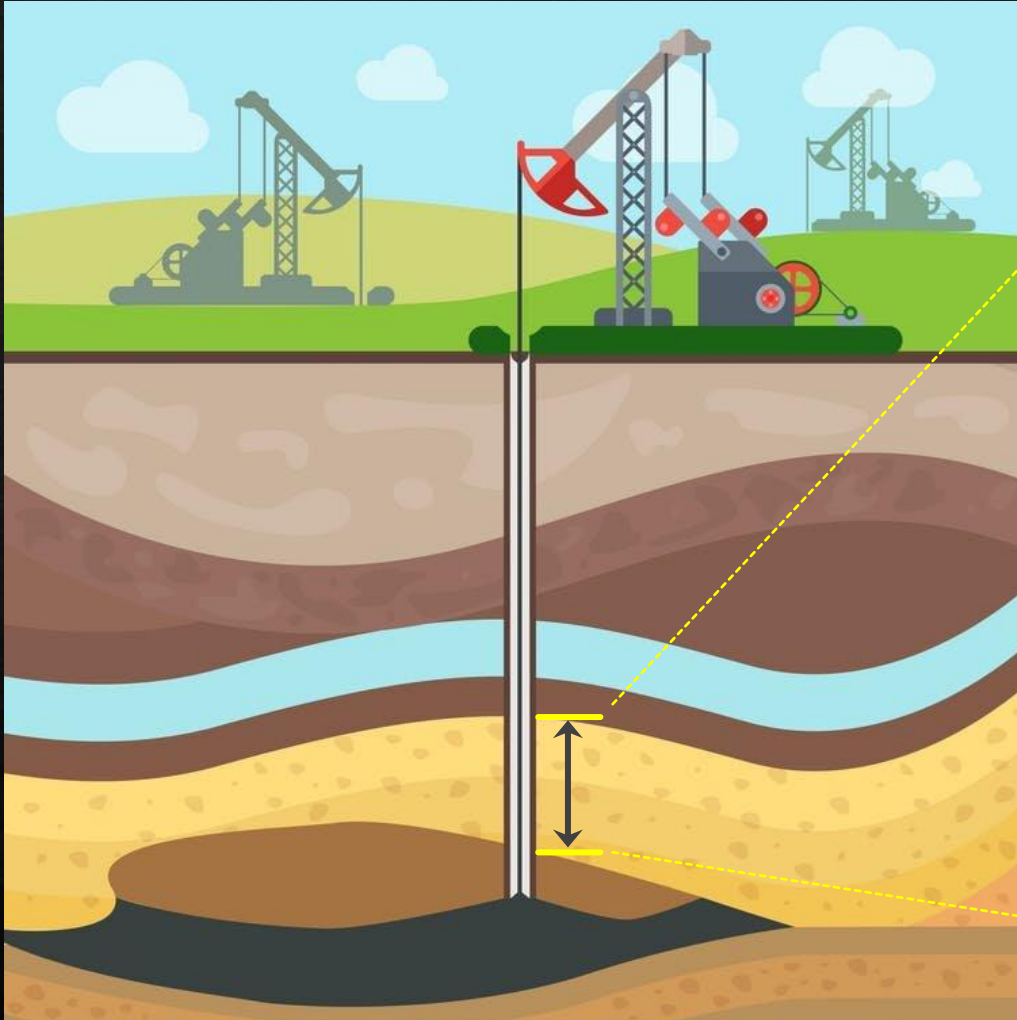
Predicting rock types from drilled oil and gas wells



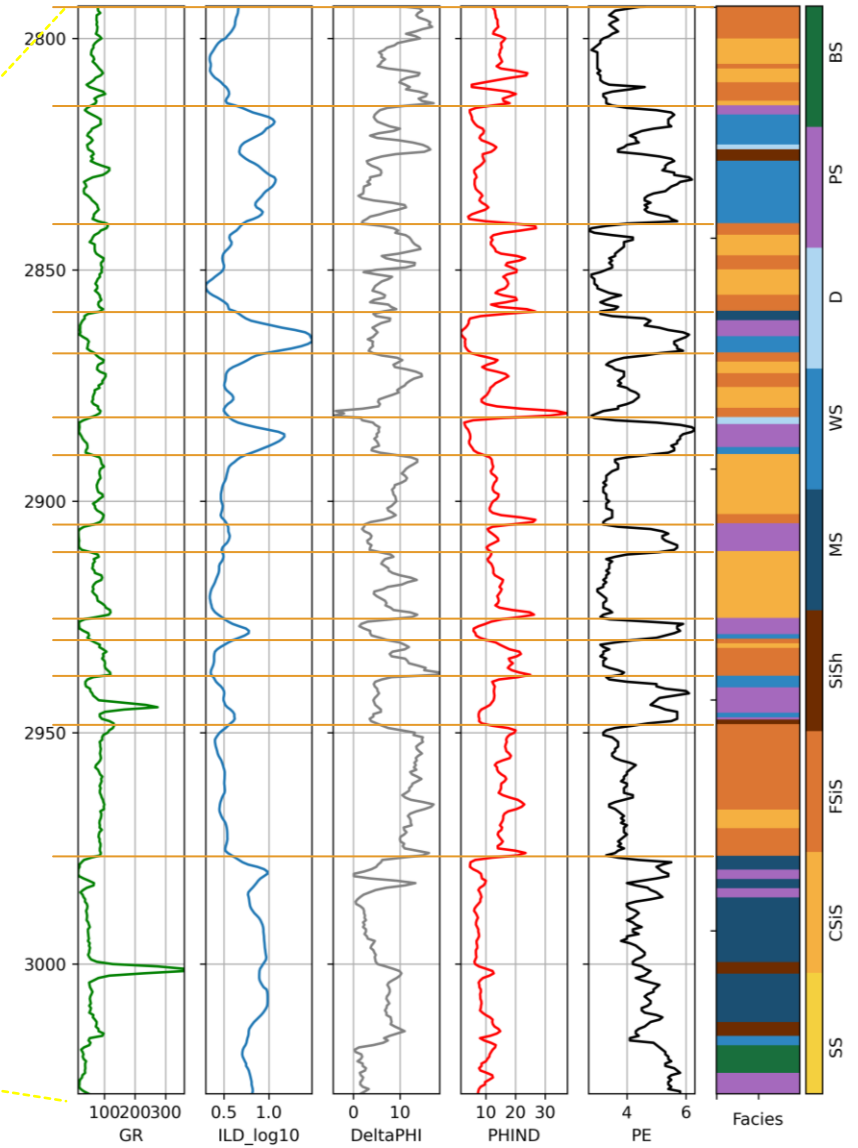
Lithology prediction saves time and money

Conventional log analysis:

- ❖ Subjective, manual, and error prone
- ❖ Always limited to very specific zones of interest (oil and gas)
- ❖ Can often take > 1 yr to confirm against advanced (core) analysis

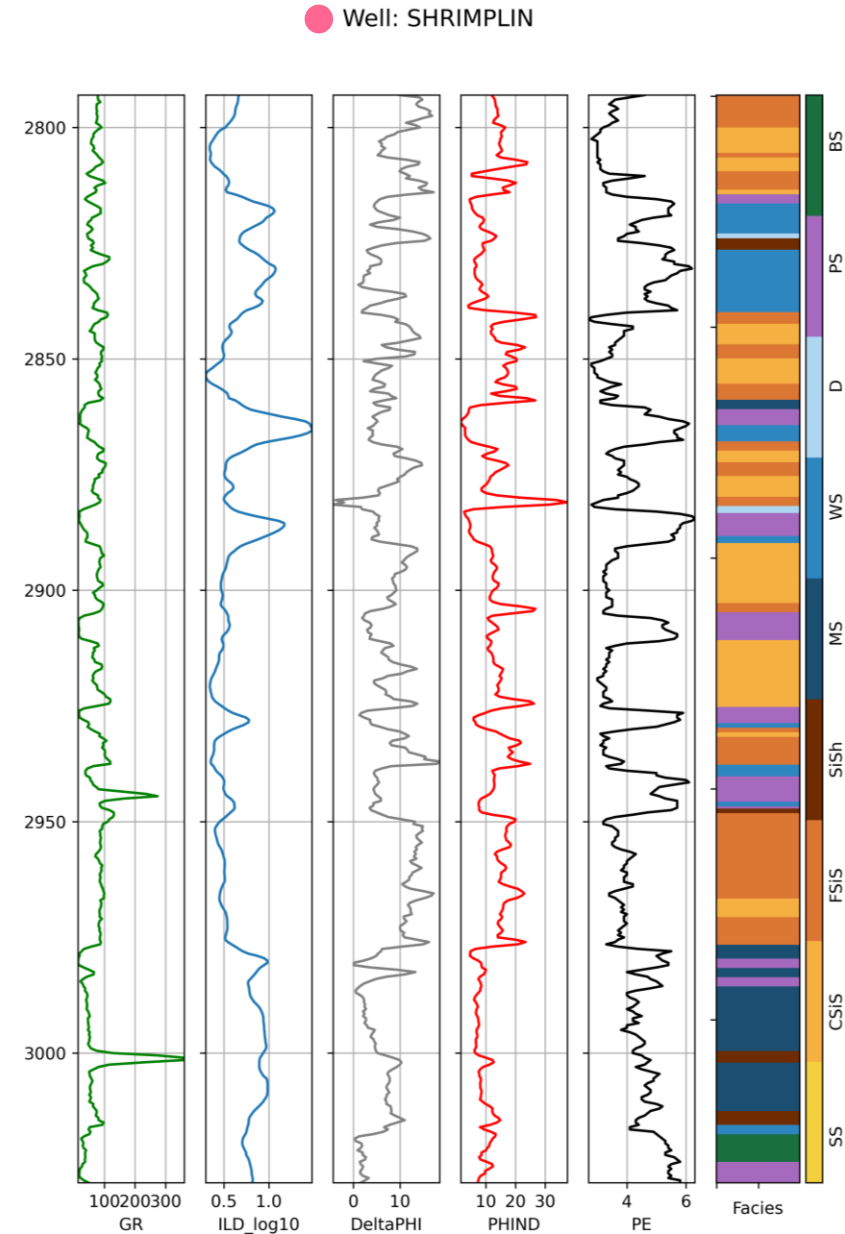
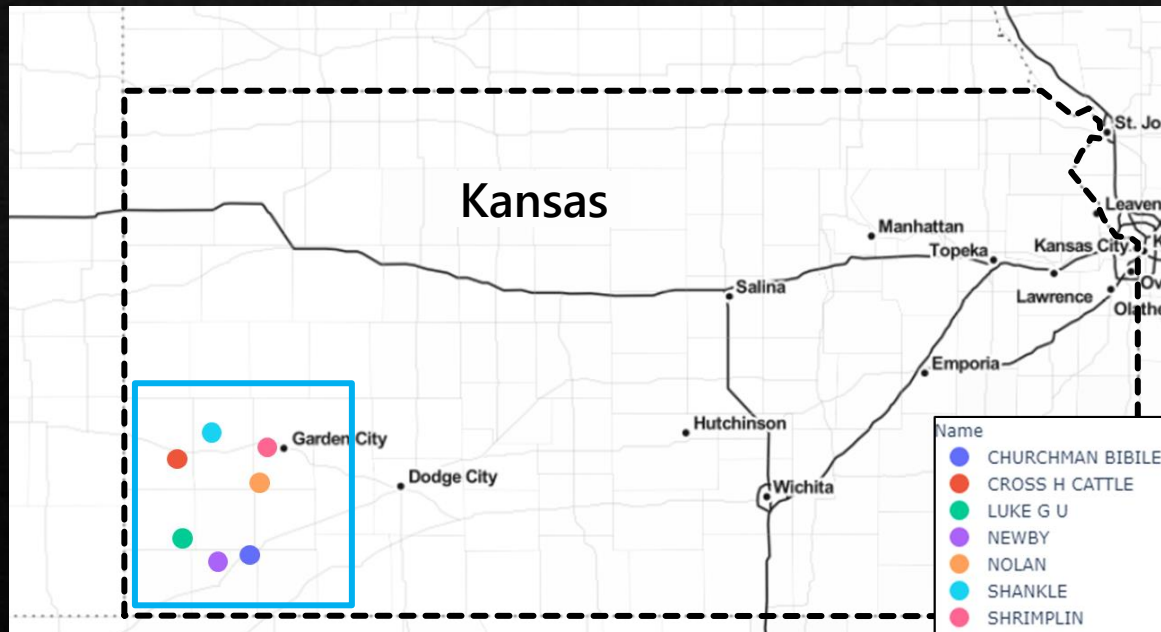


Well: SHRIMPLIN



Hugoton Gas Field

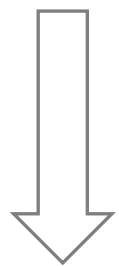
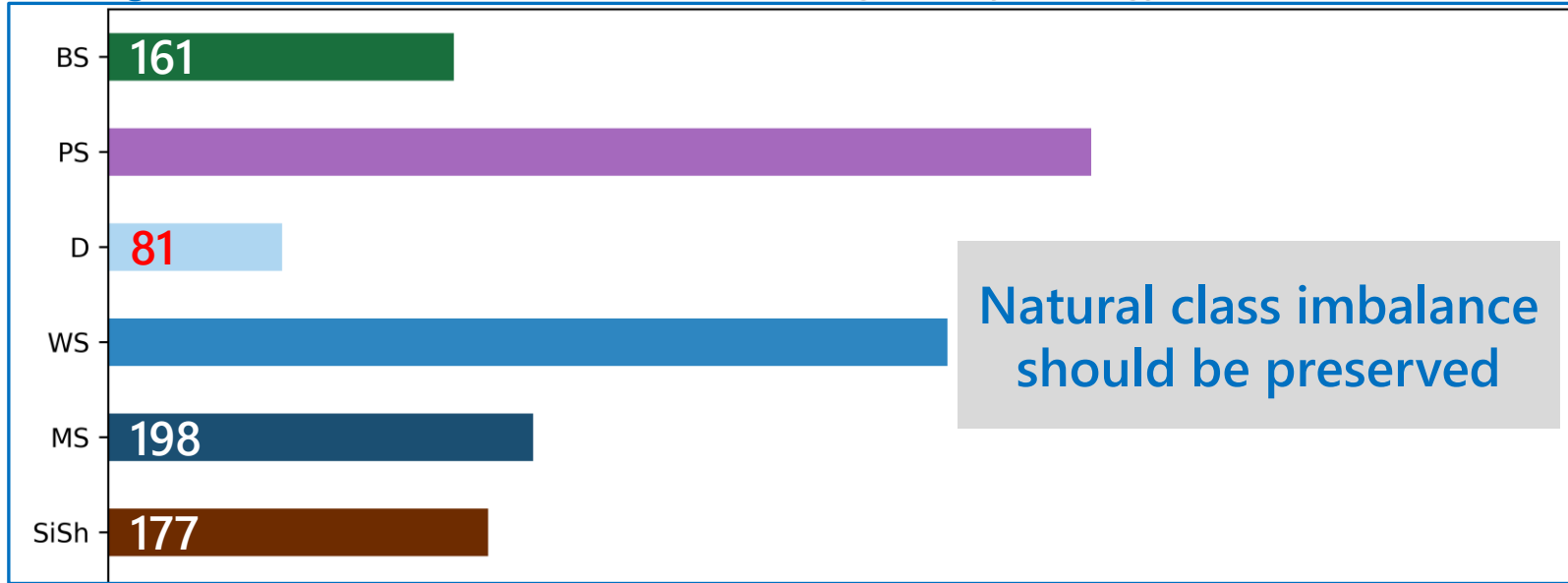
- ◇ Largest producing gas area in the US
- ◇ First well-log dataset for ML (2016)



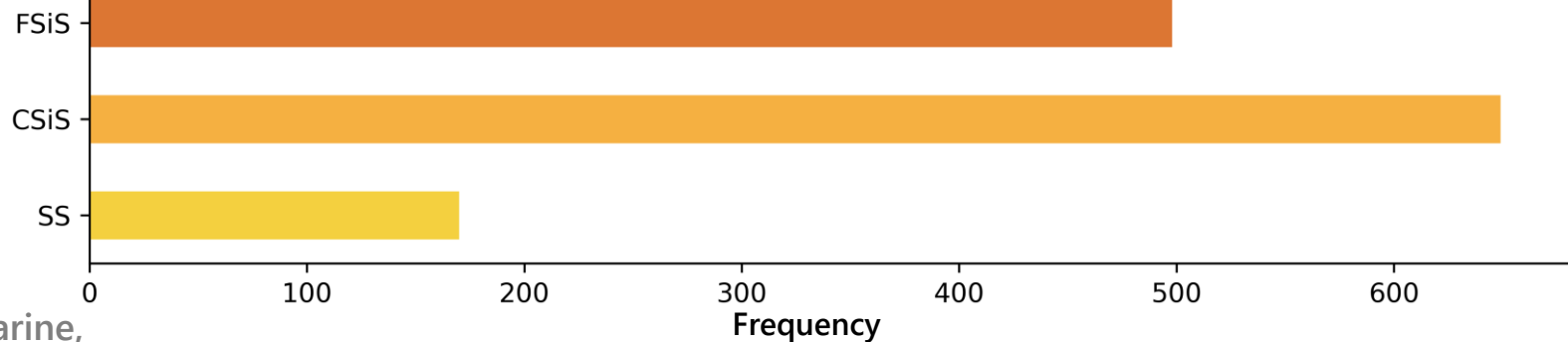
Anomalies (class imbalances) drive Exploration

Marine lithologies

Distribution of Training Data by Lithology

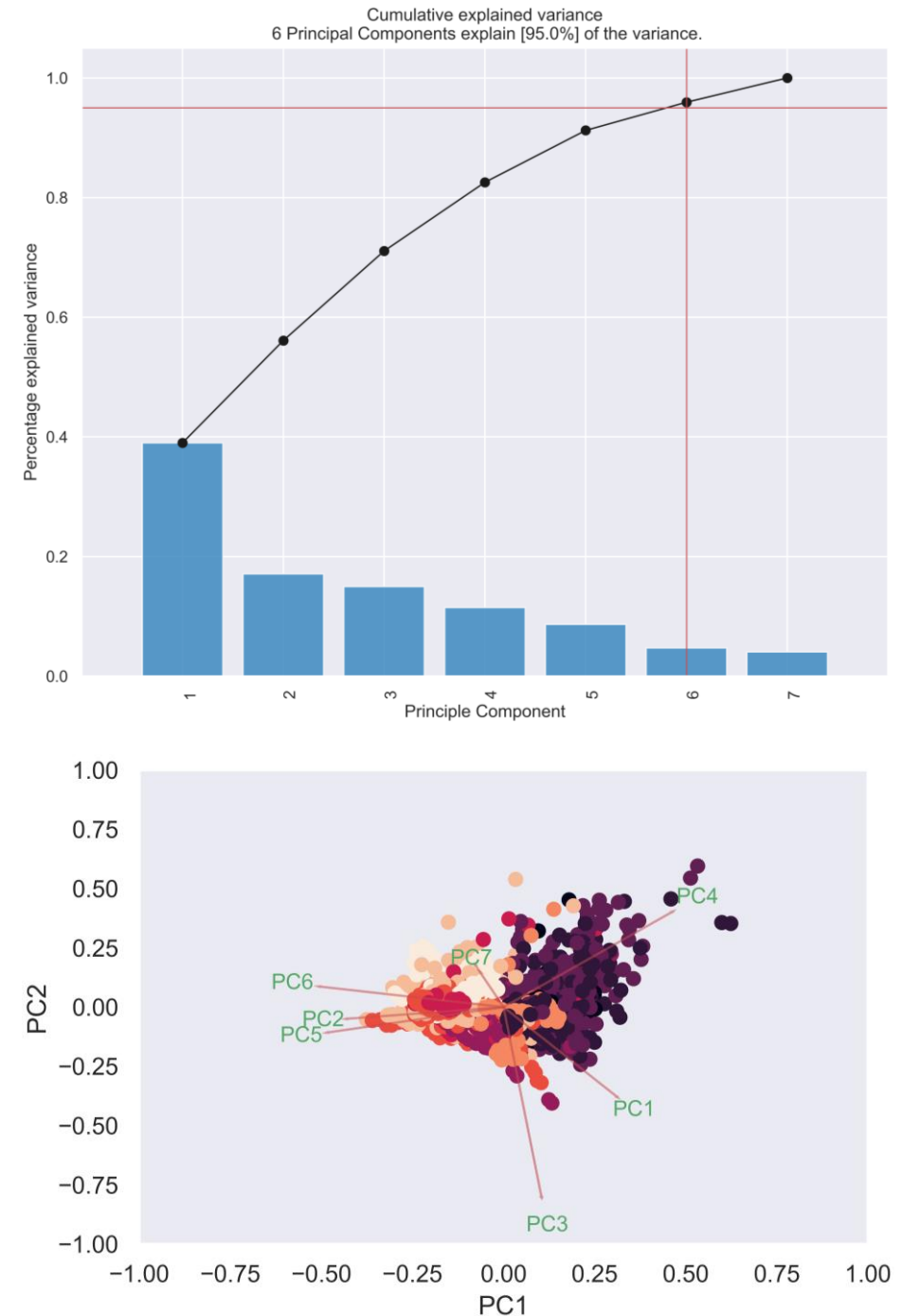


Non-marine,
non-reservoir lithologies



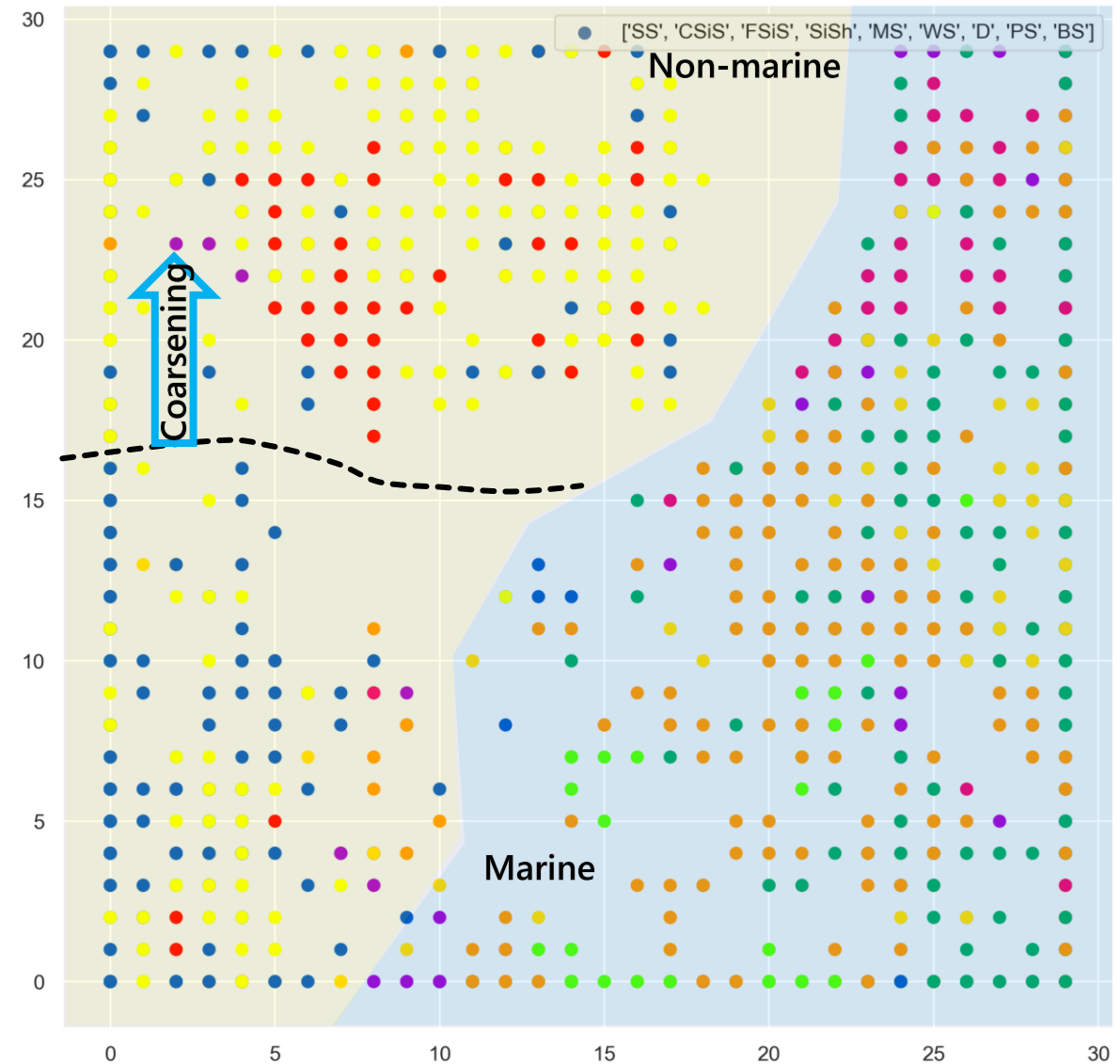
Data Analysis

- ◇ Goal is to feed predictive models robust data to mitigate costly mis-predictions
- ◇ 6 out of 7 features explain 95% of the total variance; little to no multicollinearity
- ◇ Principal Component Analysis identifies the Non-marine/Marine categorical variable as the most important feature



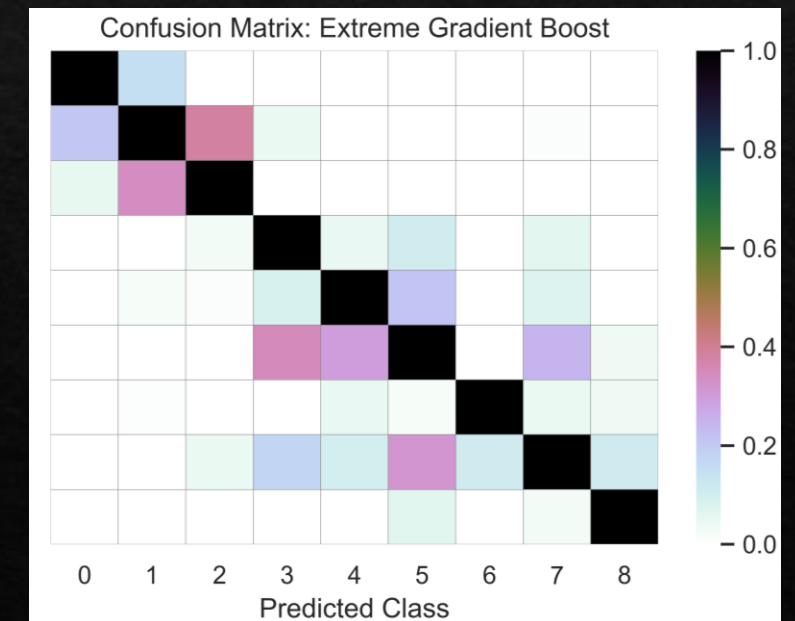
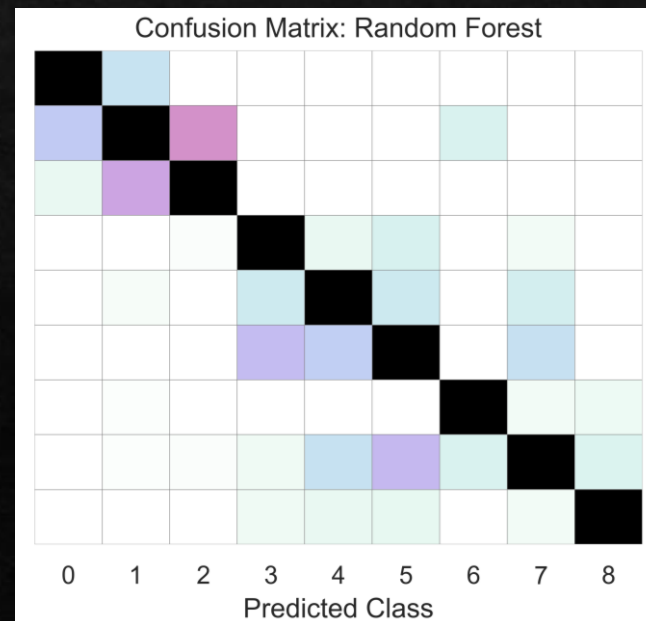
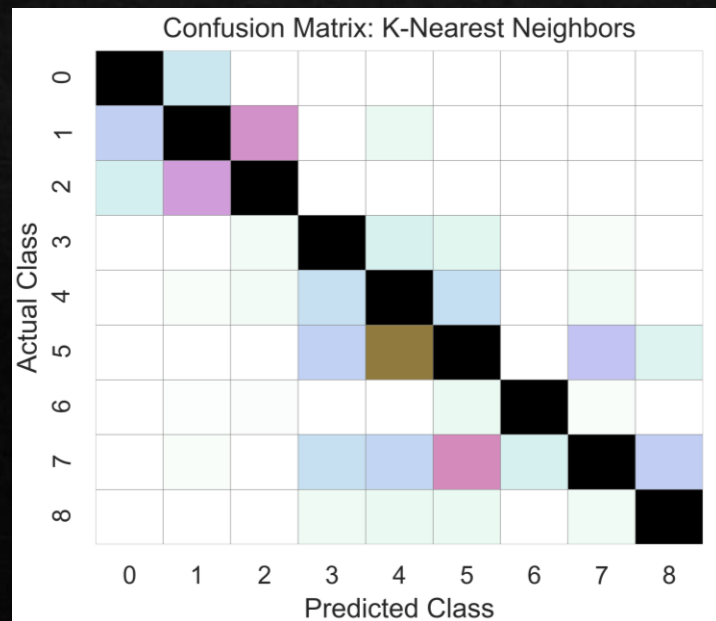
More Data Analysis

- ◆ The value of a self-organizing map is identifying unforeseen patterns
- ◆ SOMs naturally demonstrate lithology break-out without any supervision
 - ◆ marine (blue) vs. non-marine (yellow)
 - ◆ Grain-size: fine vs. coarse



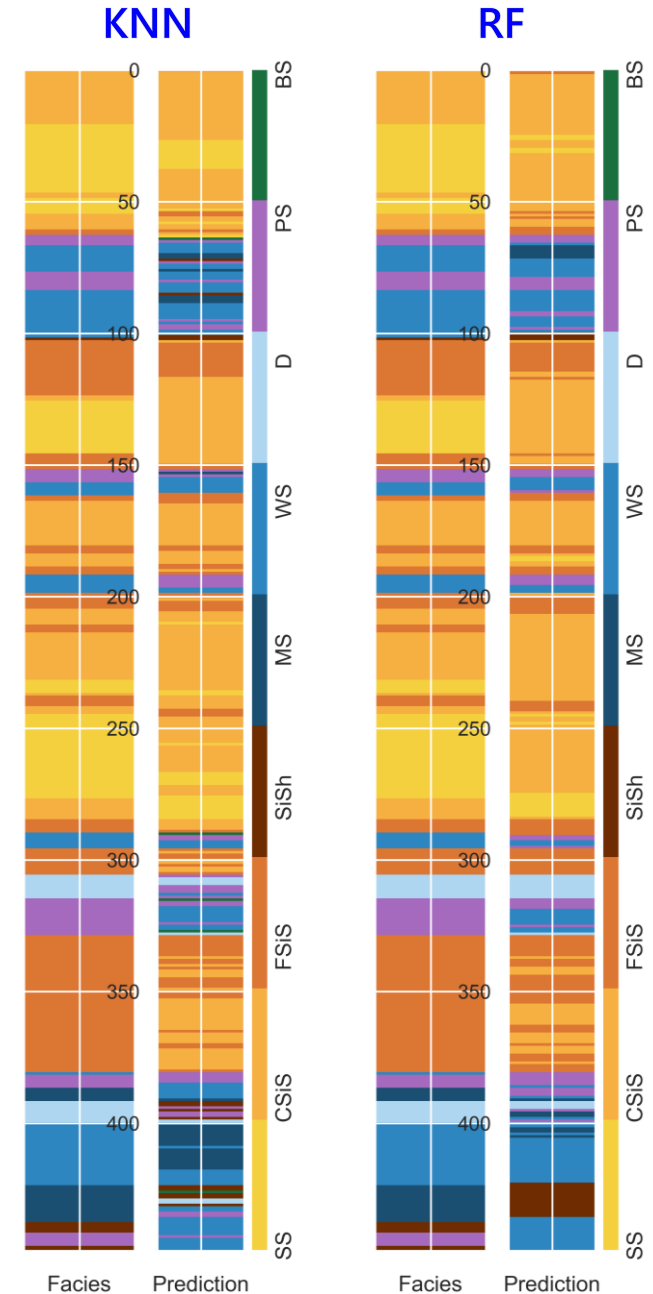
Best in Classifiers

	LogR	KNN	DT	RF	GBT	XGB	LSVM	SVM	BerNB
Precision	0.60	0.70	0.64	0.72	0.68	0.73	0.58	0.63	0.46
Recall	0.60	0.69	0.64	0.71	0.67	0.72	0.60	0.61	0.50
F-1 score	0.58	0.69	0.63	0.71	0.67	0.72	0.58	0.60	0.46



Blind Well Test (validation)

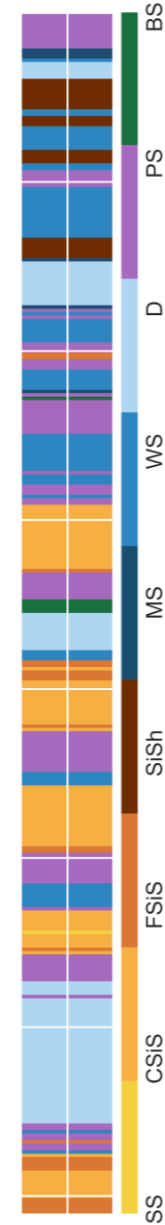
- ◇ KNN captures less of the gas reservoir section than Random Forests
- ◇ KNN predicts a lithology not present in the holdout well
- ◇ Random Forest & XGBoost very similar in metrics and predictions
 - ◇ XGBoost adds more granularity



Prediction on new wells

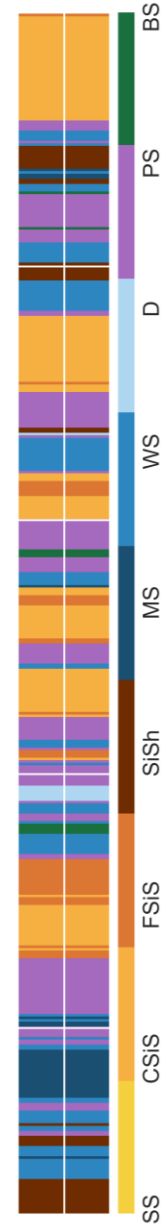
- ◇ Random Forests provides a good layer-cake prediction for each well (more blocky, less stratifications)
- ◇ Both predicted wells show the expected alternating (cyclic) depositional patterns between marine and non-marine typical of sea-level changes.

Crawford Well



Facies

Stuart Well



Facies

Implications

Cost of mis-predicting a single reservoir sample

Scenarios:

[Modest] 10 million barrel field, 5m thick:

- ◇ 10 x (0.1524m interval / 5m)
x \$40/barrel of oil = **\$12,192,000**

[Large] 100 million barrel field, 30m thick:

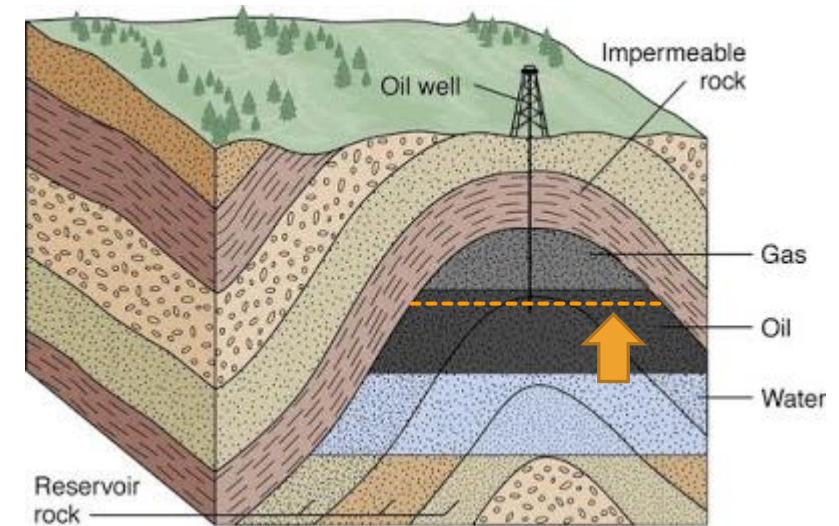
- ◇ **\$20,320,000**

[Very large] 1 billion barrel set of fields, 100m thick:

- ◇ **\$60,960,000**

[Giant] 10 billion barrel aggregate of fields, 25m thick:

- ◇ **\$1,219,200,000**



Thank you



METIS