Stochastic Methods for Reservoir Simulation

Project Update 1

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Summary

Initial univariate, spatial analysis for the purpose of formulating an initial subsurface hypotheses.

Work included:

- ► Visualization of data distributions, coverage, sampling and location maps
- ► Sampling bias detection, summary statistics, and outlier detection
- ► Comparison of at-well and mapped acoustic impedance
- ► Initial interpretations of the depositional setting

Results:

- ► The sampling of 271 wells shows some spatial sampling bias
- ► Outlier analysis revealed 10-25 Darcy reservoir rock at the northwestern corner of the reservoir
- ► Reservoir is heterogeneous
- ► Preliminary geological interpretation suggests that the reservoir is sandy channel-fills of a fluvial system

Workflow

The following steps comprised our computational workflow:

1. Loaded csv data files to a DataFrame and ndarray.

2. Checked summary statistics for invalid values, e.g. nulls and negatives.

3. Detected outliers (Tukey method with no distribution assumption)

4. Plotted data distributions and spatial location maps (by-facies and combined).

5. Compared well and map-based seismic data (hypothesis testing)

6. Developed an initial interpretation of reservoir depositional setting and architectural elements.
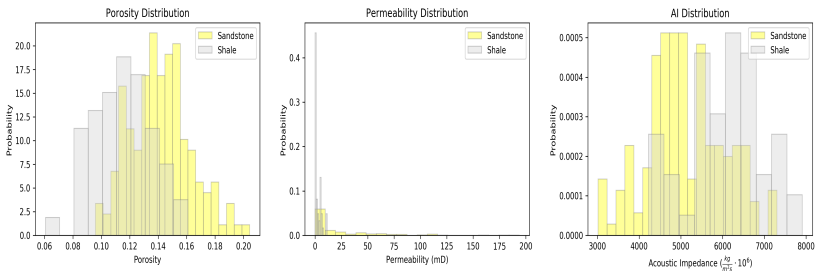
Data Coverage
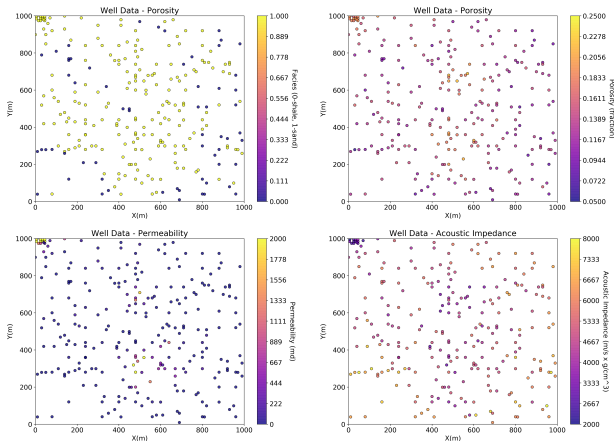
Figure: Location maps for facies, porosity, permeability and acoustic impedance at all 271 wells.

By-well Facies Distribution

Analyses indicate strong porosity, permeability and acoustic impedance dependence on facies. Facies provide good control on reservoir properties and their spatial distribution.

Figure: Univariate binned PDFs by facies for porosity, permeability and acoustic impedance.

Summary Statistics

Sandstone

	count	mean	std	min	25%	50%	75%	max
Facies	164.0	1.000000	0.000000	1.000000	1.000000	1.000000	1.000000	1.000000
Porosity	164.0	0.141945	0.021228	0.095861	0.126620	0.141629	0.153456	0.204388
Perm	164.0	23.033024	34.867885	0.051426	2.321887	7.817239	28.539127	193.746824
AI	164.0	5101.614178	933.384251	3017.611167	4510.886339	5005.947121	5733.632011	7305.189368

Shale

	count	mean	std	min	25%	50%	75%	max
Facies	53.0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Porosity	53.0	0.115015	0.020962	0.060693	0.100367	0.114894	0.128914	0.160937
Perm	53.0	2.573466	3.058961	0.018054	0.268076	0.888961	4.979026	11.605383
AI	53.0	6099.268353	886.103245	4227.070196	5574.433666	6174.244316	6684.167663	7911.757046

Outlier Detection
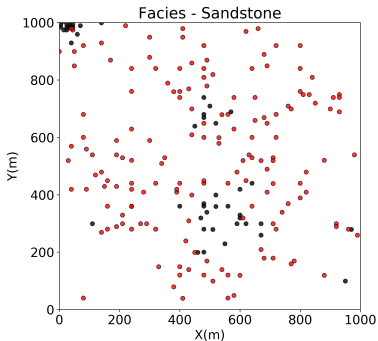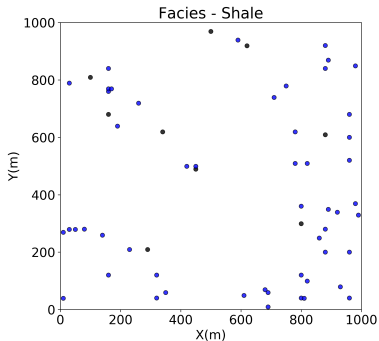
Figure: Location map for shale (left) and sandstone (right) facies. Black dots indicate **outliers** in the dataset.

Acoustic Impedance

▶ Comparing acoustic
impedance over the map
and at the wells

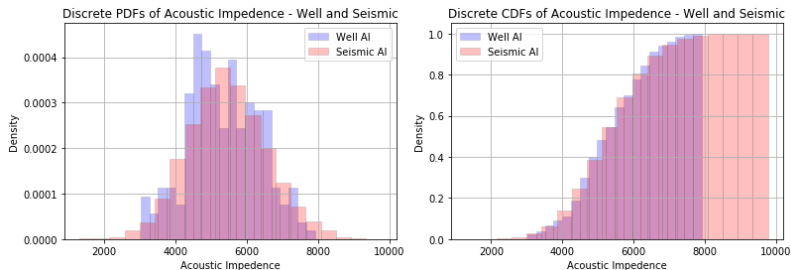| Hypothesis Test	p-value
T-test	0.1858
Rank-Sum	0.2075
ANOVA	0.1858
Kruskal-Wallace	0.2075

Figure: PDF and CDF of Acoustic Impedance from wells and seismic

Initial Interpretation

- ▶ Preliminary interpretation: fluvial system
- ▶ Alternative interpretation: deltaic or submarine fan system
- ▶ Recommendation: a more comprehensive geological analysis to reduce the uncertainty of the interpretation
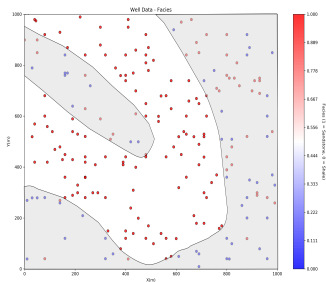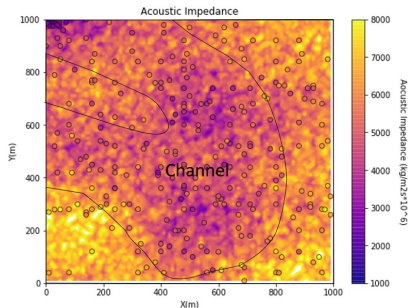
Conclusions

- ▶ The sampling of 271 wells shows some bias according to the facies location

- ▶ Outlier analysis account for 54/271 of the data set and reveal 10-25 Darcy reservoir rock at the northwestern corner of the reservoir

- ▶ Preliminary geological interpretation suggests that the reservoir is sandy channel-fills of a fluvial system

- ▶ Directionality and trends consistent with the geological interpretation should be included in the model

- ▶ Future analyses should include observations from recovered core, namely in search of cross bed features in wells near the interpreted point bar location