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Harness Upstream Geophysical and Petrophysical Data with AI Workflows

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Module 07

Case Studies: Seismic Attributes

LEARNING OBJECTIVES

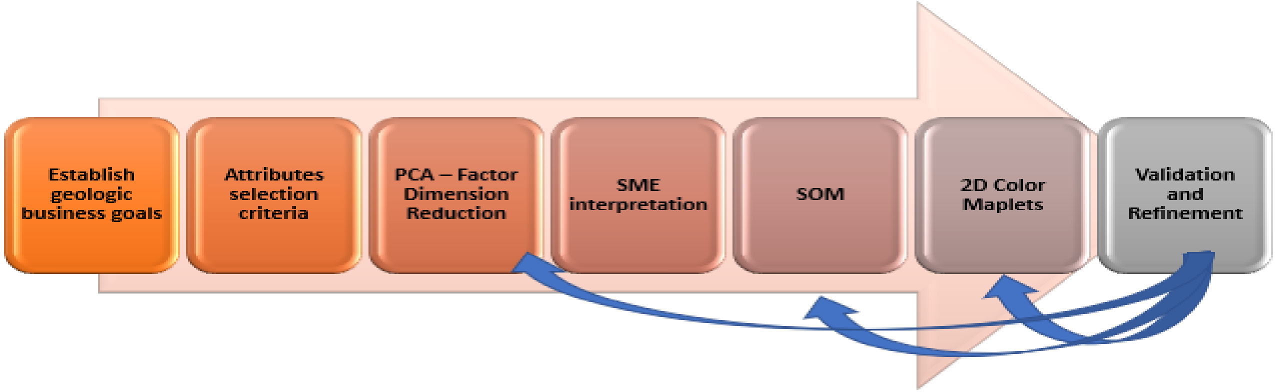
- ➢ GOAL01: Case Studies – Seismic Attributes
- ➢ GOAL02: Self-Organizing Maps (SOMs)
- ➢ GOAL03: Case Studies – Acoustic Impedance

Case Studies

Classifying Multiple Seismic Attributes

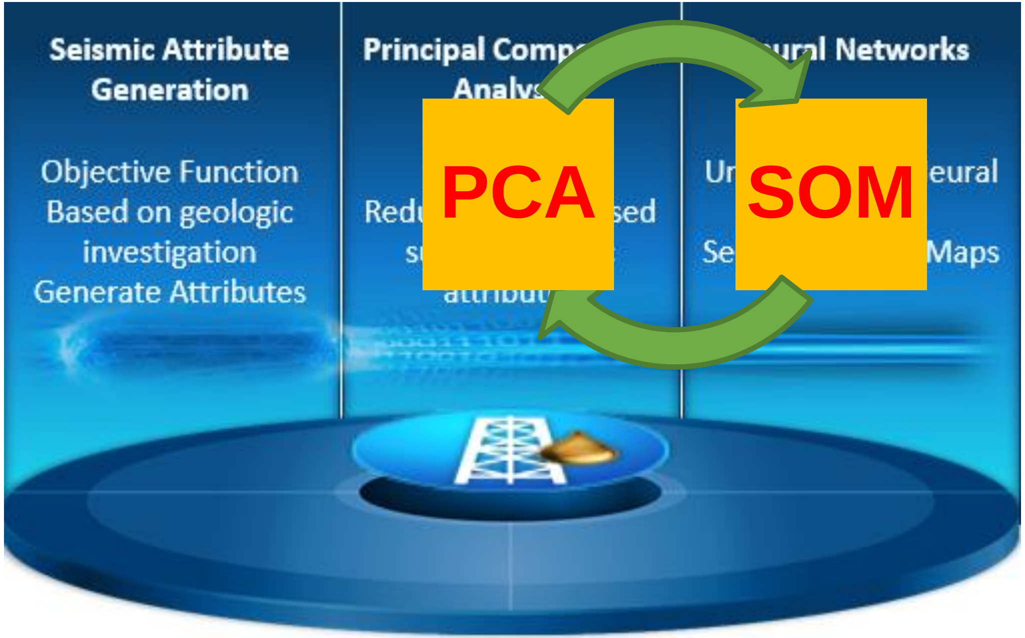
Unsupervised Neural Networks: Self-Organizing Maps

In this research, unsupervised seismic interpretation from multi-attribute data was analyzed by using an ML technique: SOMs.



Case Studies

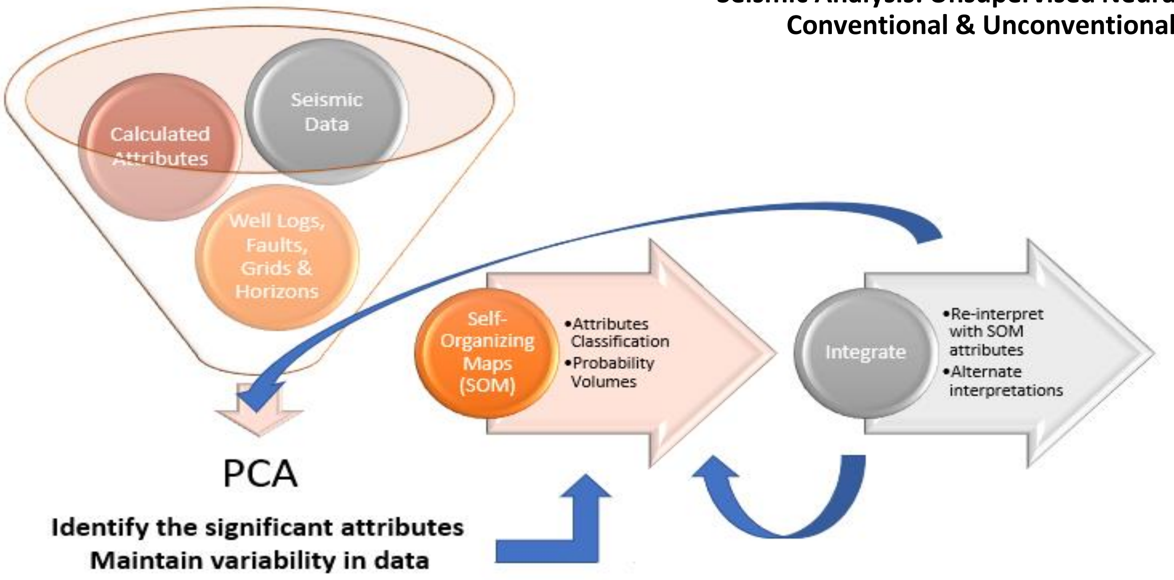
Classifying Multiple Seismic Attributes



Case Studies

Classifying Multiple Seismic Attributes

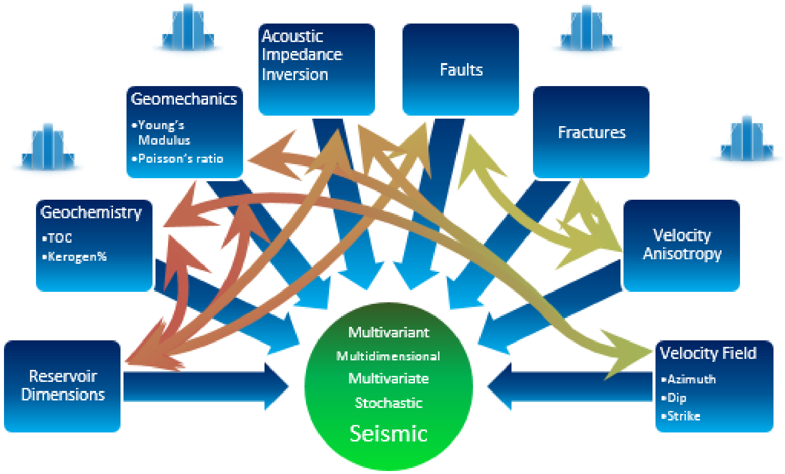
Seismic Analysis: Unsupervised Neural Network & PCA
Conventional & Unconventional Reservoirs



Case Studies

Classifying Multiple Seismic Attributes

- Reservoir geology
  - Thickness and Lateral extent
  - Mineralogy
  - Porosity and Permeability
- Geochemistry
  - Total Organic Content (TOC)
  - Maturity and Kerogen Richness
- Geomechanics
  - Acoustic impedance inversion
  - Young's Modulus
  - Poisson's Ratio (Vp/Vs)
- Faults, Fractures, and Stress regimes
  - Coherency and Curvature
  - Fault Volumes
  - Velocity Anisotropy
  - Stress maps

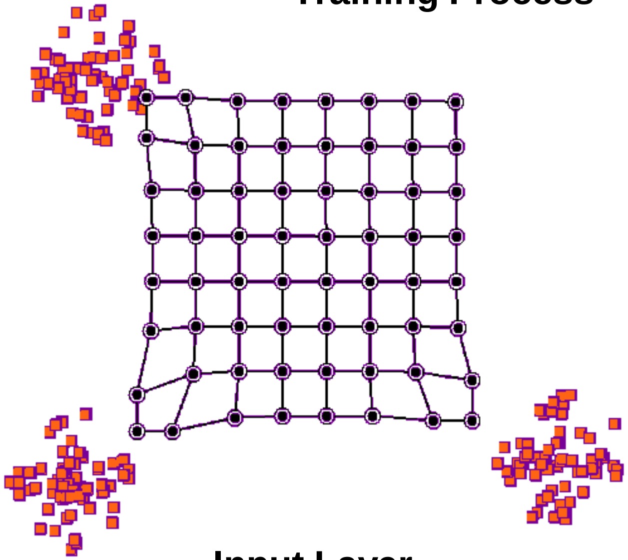


- Pre-Stack Time Migration Traces
  - Attenuation
  - Bandwidth
  - Envelope slope
  - Instantaneous
  - MuRho
  - S-Impedance
  - Trace envelope
  - Young's brittleness
  - Poisson's Ratio
  - Poisson's brittleness
  - Shear Impedance
  - P- impedance
  - Brittleness coefficient
  - Spectral decomposition volumes
  - Instantaneous attributes

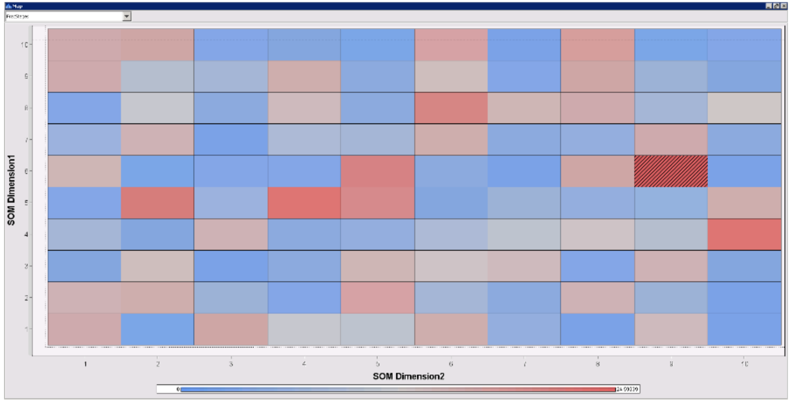
Case Studies

Classifying Multiple Seismic Attributes

Training Process



Input Layer



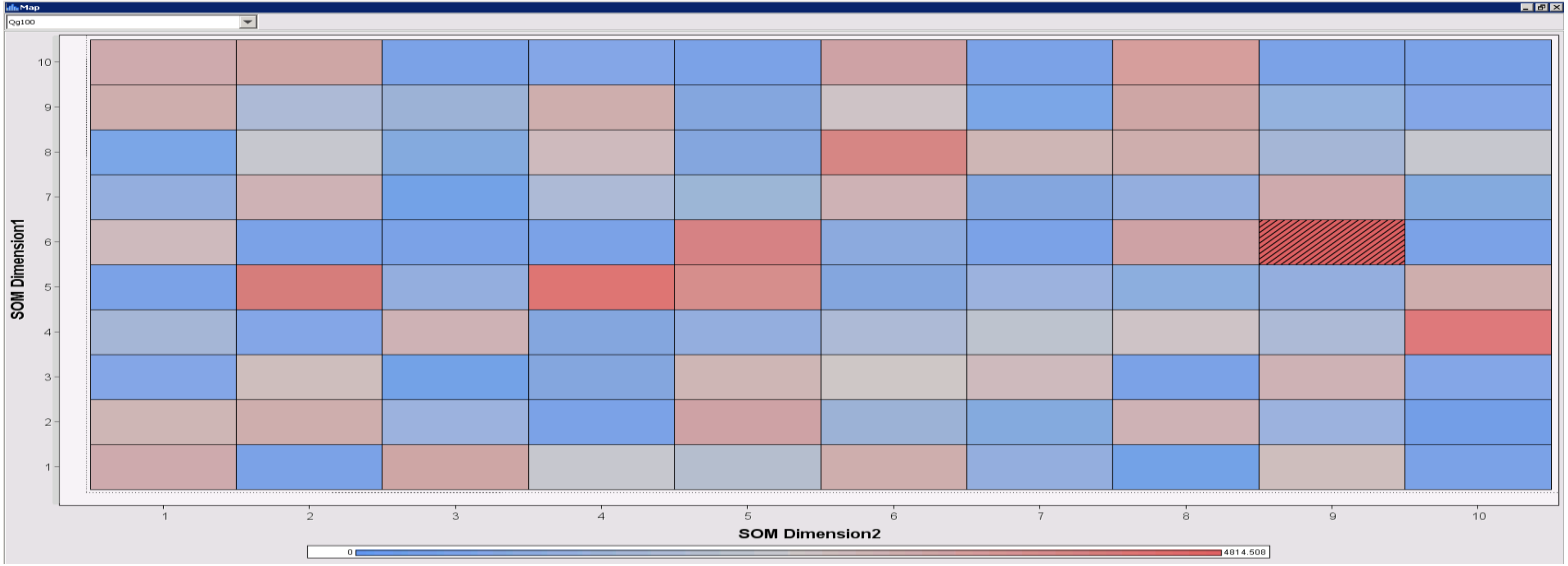
Maplet

Output Layer

Case Studies

Classifying Multiple Seismic Attributes

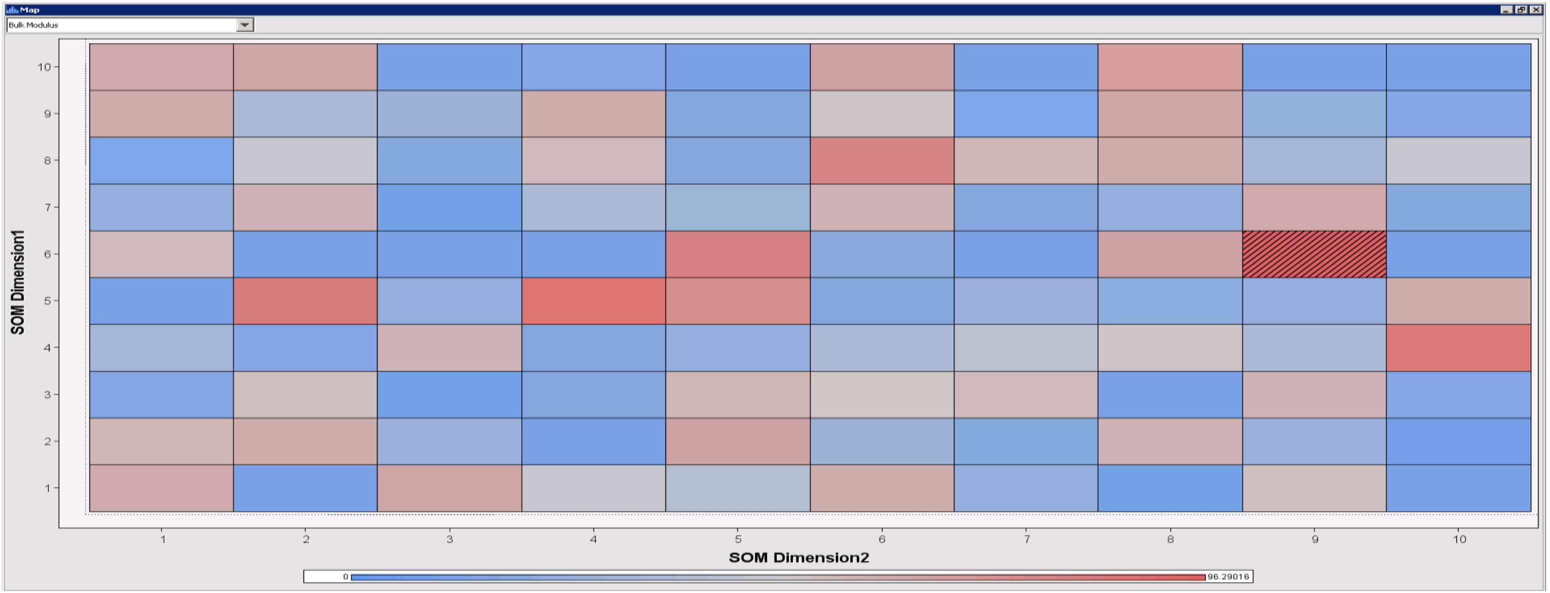
Self-Organizing Maps: Unsupervised NN: Qg100 Maplet



Case Studies

Classifying Multiple Seismic Attributes

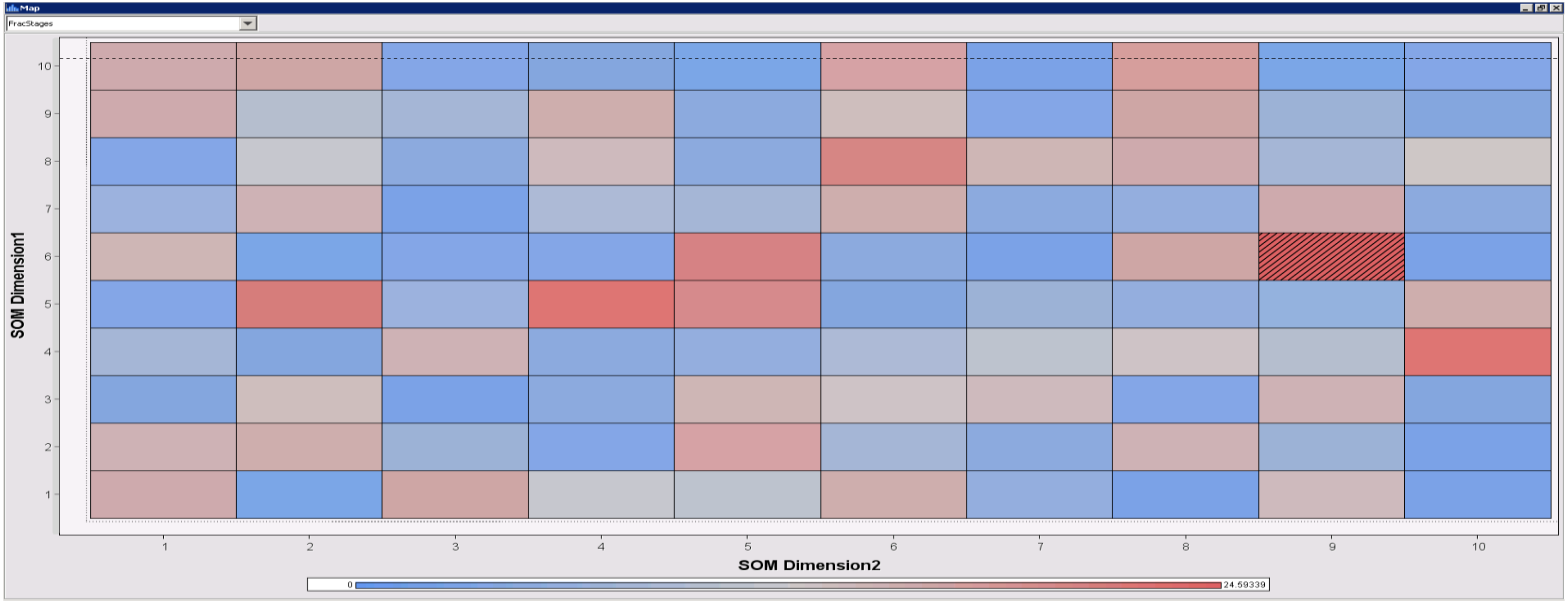
Self-Organizing Maps: Unsupervised NN: Bulk Modulus Maplet



Case Studies

Classifying Multiple Seismic Attributes

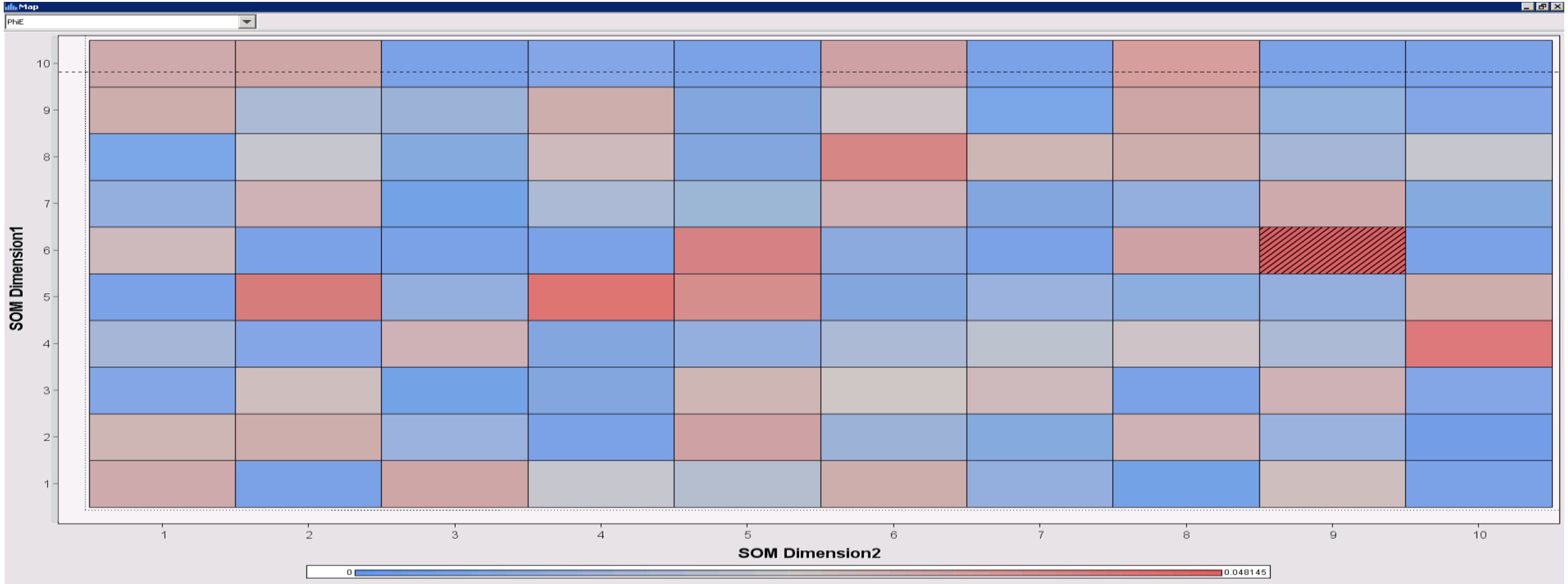
Self-Organizing Maps: Unsupervised NN: Instantaneous Phase Maplet



Case Studies

Classifying Multiple Seismic Attributes

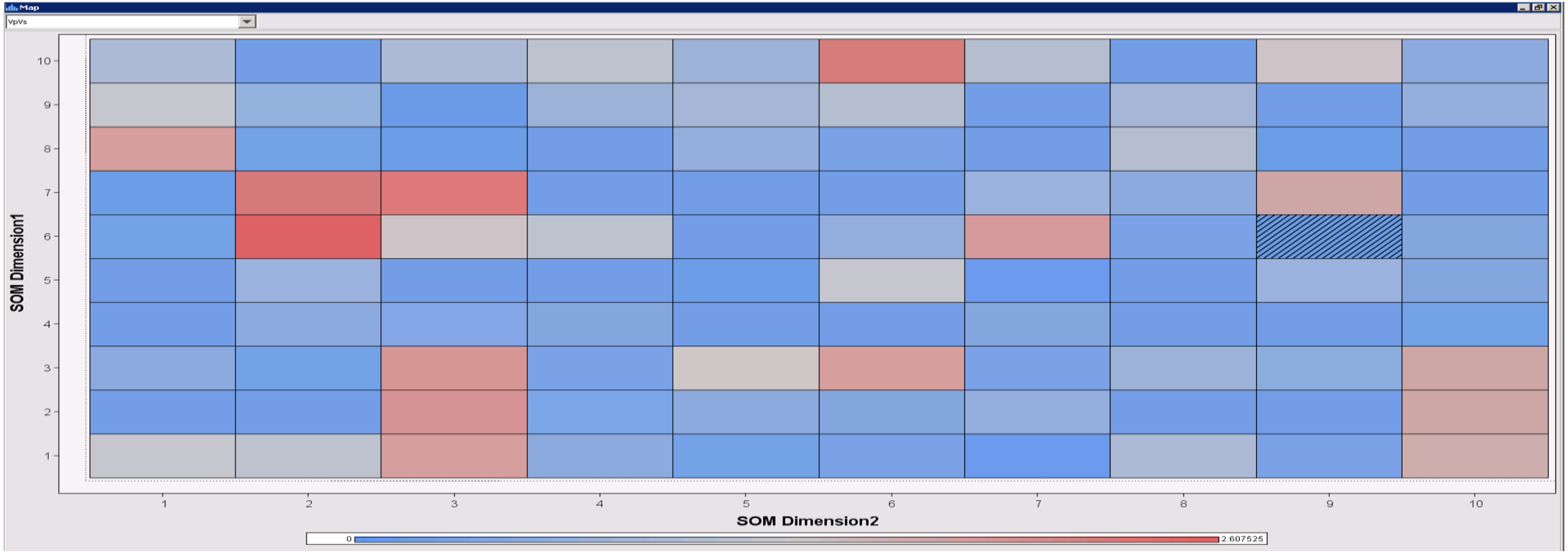
Self-Organizing Maps: Unsupervised NN: Instantaneous Frequency Maplet



Case Studies

Classifying Multiple Seismic Attributes

Self-Organizing Maps: Unsupervised NN: VpVs Maplet

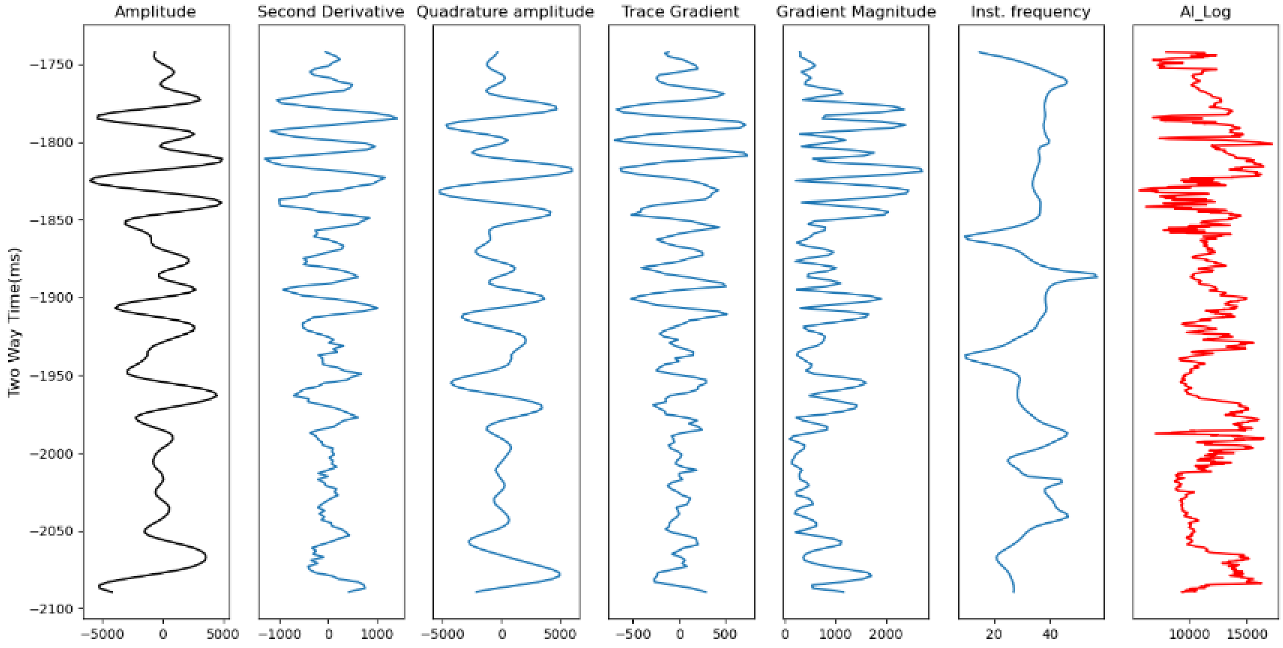


Acoustic Impedance Estimation from Seismic Data Using ML in Well-Log Resolution

Variable/Feature	Description
Depth	Depth in well (m)
Amplitude	Seismic Trace Amplitude
AI_Log	Acoustic Impedance calculated from Sonic and Density logs
Derivative2	Second time derivative of the input seismic volume
QuadrA	Quadrature Amplitude attribute; imaginary part of the analytic signal calculated by phase shifting original trace by 90 degrees
TraceGrad	Gradient along the trace is generated.
GradMag	Magnitude of the instantaneous gradient.
IFreq	Instantaneous frequency, time derivative of phase angle
AI_Inv	Acoustic Impedance Inversion determined from 50 well logs and 3D seismic cube at well locations

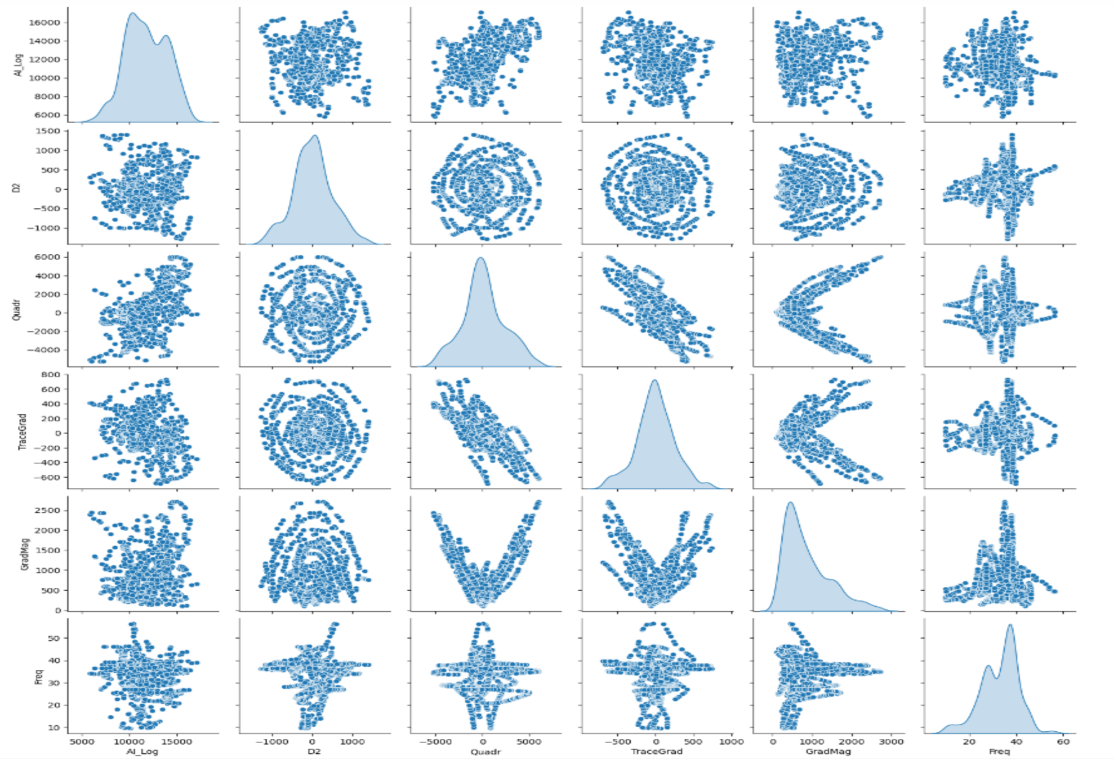
Case Studies

Seismic Attributes



Case Studies

Seismic Attributes: Pair plot



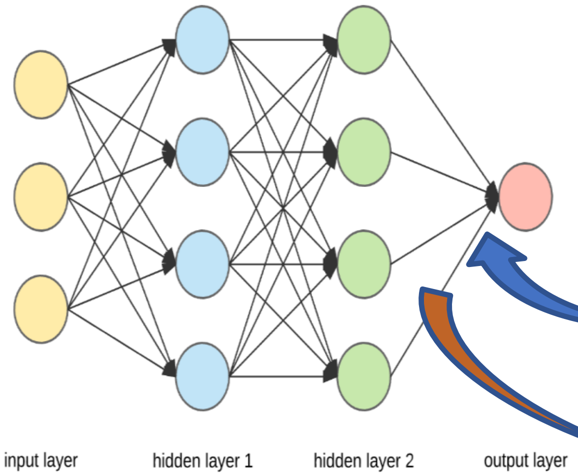
Case Studies

Seismic Attributes: Descriptive + Normalization/Scaling + Neural Network

	count	mean	std	min	25%	50%	75%	max
D2	4154.0	6.233901	483.644848	-1301.850220	-269.884384	0.937068	287.638557	1426.181519
Quadr	4154.0	68.946043	2222.350184	-5258.812012	-1135.513886	-83.835155	1076.680450	6001.270996
TraceGrad	4154.0	-1.895277	261.936301	-692.938904	-146.534729	-10.918543	157.479198	737.373962
GradMag	4154.0	852.799978	580.266098	104.631599	417.605415	653.331024	1130.101135	2719.670166
Freq	4154.0	33.217643	8.299750	9.398151	28.239159	35.046831	38.467464	56.897087

Descriptive Analysis

Sequential Neural Network



Normalization

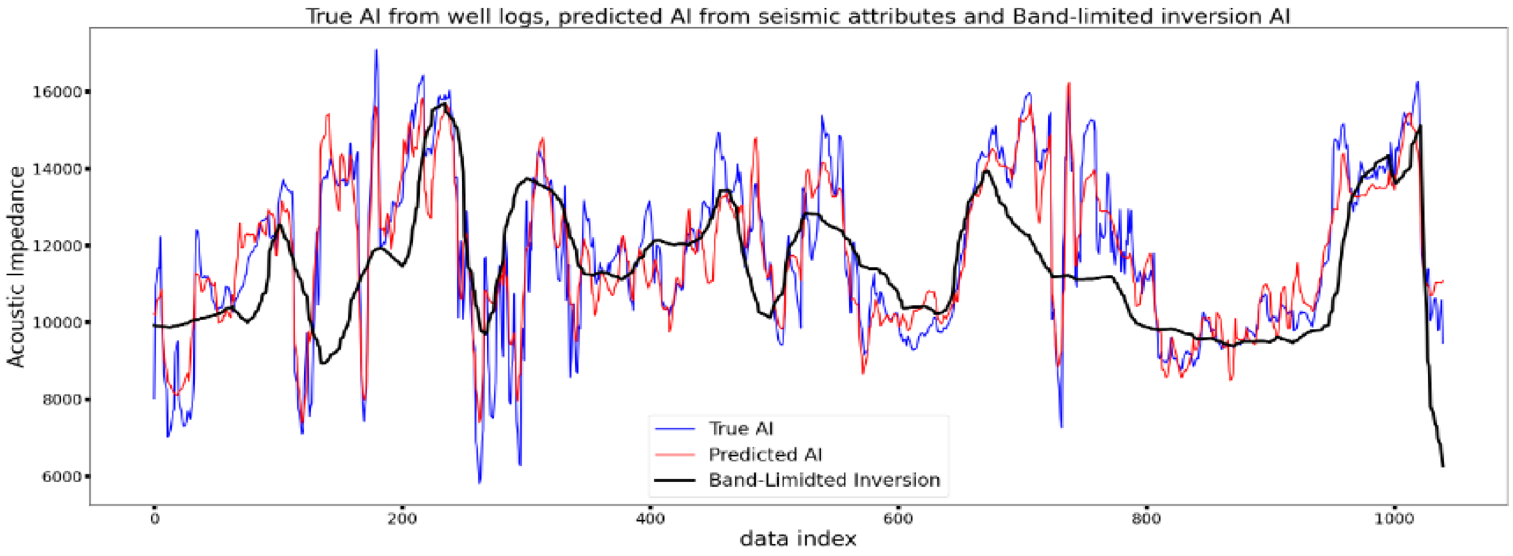
	D2	Quadr	TraceGrad	GradMag	Freq
7127	-0.110911	-0.186294	-0.423878	-0.951503	-2.239415
7134	-0.033997	-0.197319	-0.512131	-0.936389	-2.139127
7148	0.116923	-0.237370	-0.536117	-0.929738	-1.854823
7151	0.148651	-0.248342	-0.521002	-0.931481	-1.782884
7152	0.159211	-0.251999	-0.515962	-0.932060	-1.758911

	loss	mae	mse	val_loss	val_mae	val_mse	epoch
795	79123.000000	207.771271	79123.000000	91841.007812	223.593536	91841.007812	795
796	80983.390625	205.555542	80983.390625	180168.718750	354.522369	180168.718750	796
797	78248.476562	202.256042	78248.476562	142529.468750	289.698700	142529.468750	797
798	80460.343750	205.290558	80460.343750	79298.562500	174.930710	79298.562500	798
799	79822.710938	207.968369	79822.710938	87984.718750	203.654663	87984.718750	799

Model Training Progress

Case Studies

Seismic Attributes: Descriptive + Normalization/Scaling + Neural Network



Module 08
Case Studies: Drilling Program & Completion Study & Virtual Assistant for Fluids and Lithology

MODULE 08

This Module introduces two case studies based on a data-driven analytical methodology to address a business value proposition to optimize drilling and completions and identify fluids and petrophysical properties in an onshore field. We shall follow the SEMMA process introduced in Module 02 under Process and Methodology.

The first case study details a repeatable and scalable data-driven analytical process to optimize drilling and completion strategies in a brownfield with upstream historical datasets.

The second case study under investigation in this Module is Lithology-Fluids and Rocks pattern recognition. We shall discuss an automated workflow with domain input to identify important historical datasets that can predict an African asset's rocks and fluid contents. The analytical workflow follows a SEMMA process to cleanse data, perform Exploratory Data Analysis, and generate Tukey diagrams to understand feature relationships and feature engineering for derived variables and statistical predictive power.

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