Automated 3D Seismic Analysis

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New Outline

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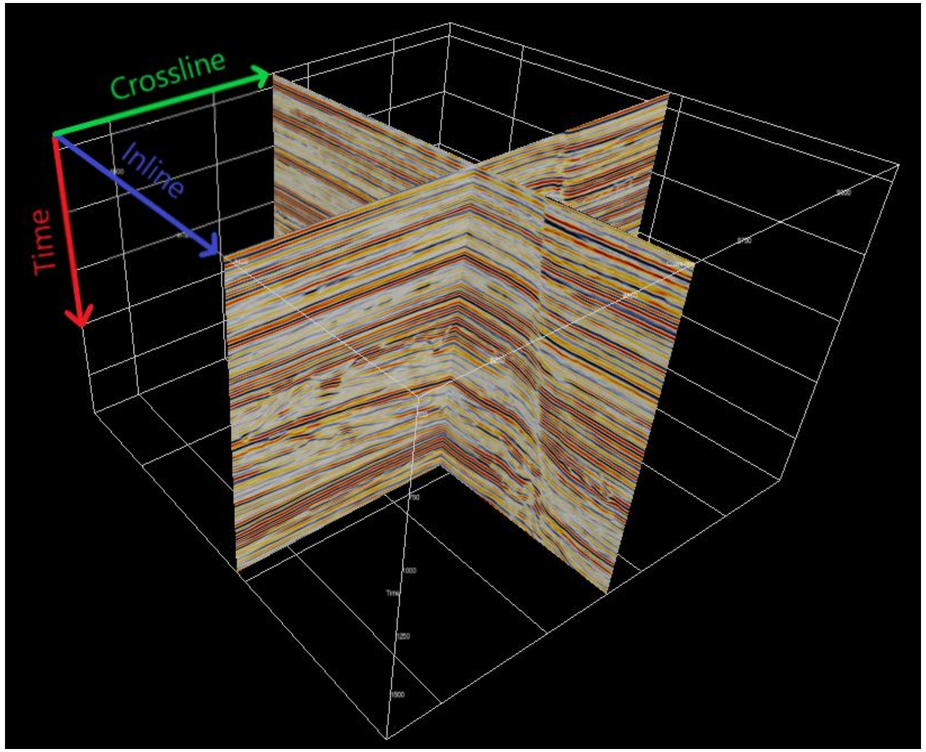
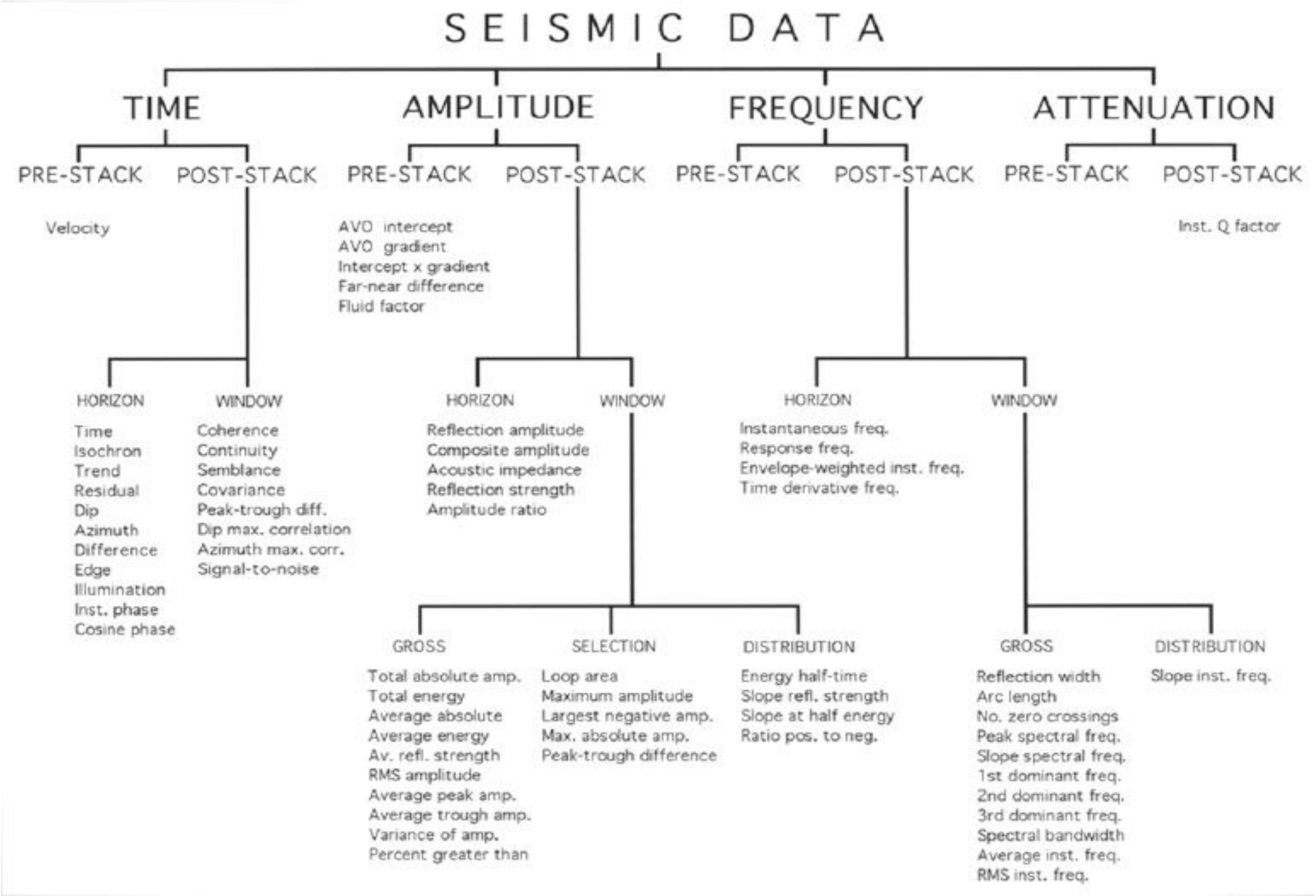
Introduction

- Fundamental to the exploration of oil and gas, seismic data provides structural and geological information of the subsurface.
- Seismic attributes identify structural features, such as faults, channels and even seismic facies.
- Data multi-dimensionality affects the rate of interpreting seismic data
- The analysis and interpretation of raw seismic data is a time consuming and laborious task.
- In addition, the vast majority of software solutions available are designed for analysis of data in a 2D workflow, making 3D interpretation and visualisation difficult.



3D Seismic Data Configuration

Types of Seismic attributes



Classification of seismic attributes by (Brown, 1999)

List of available seismic attributes from Petrel

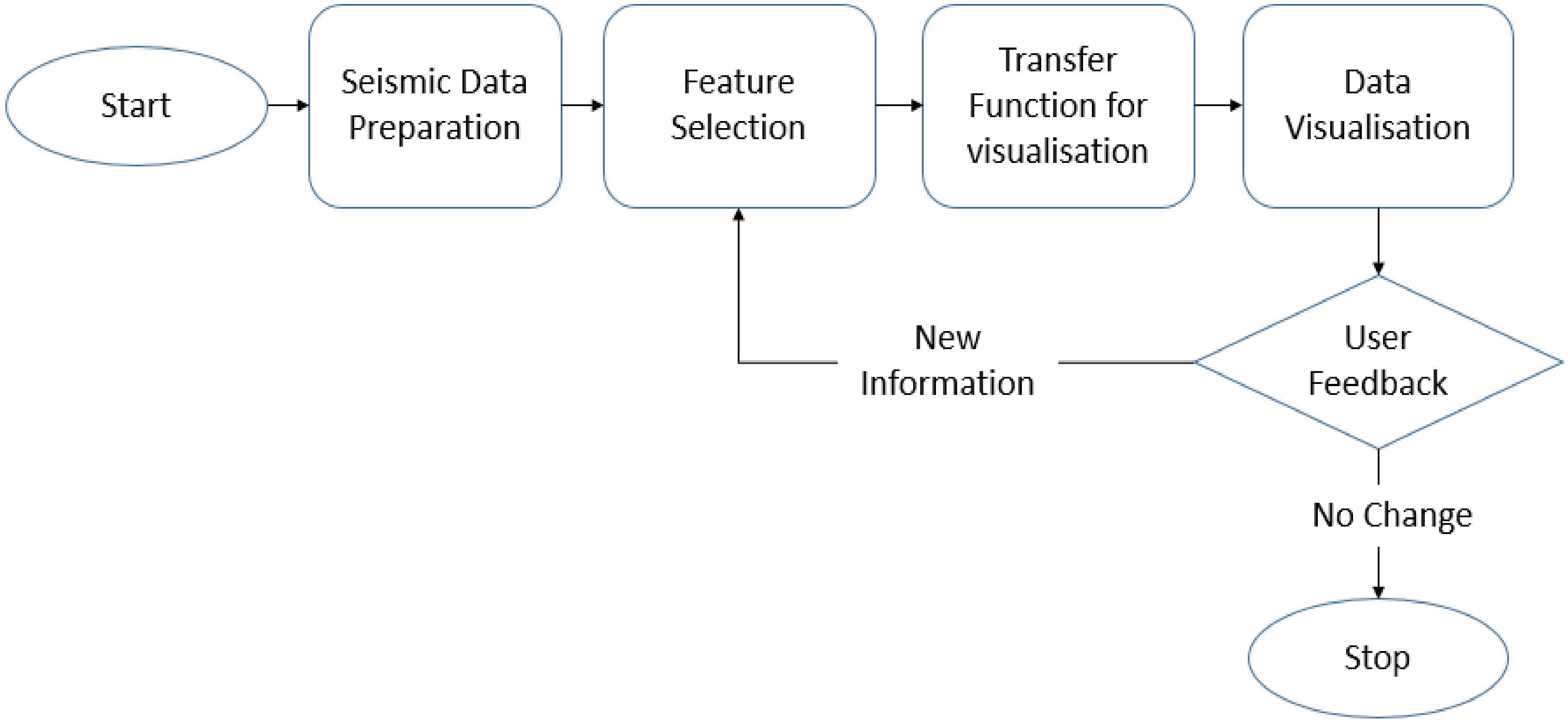
3D Curvature	AVO shear modulus contrast	GLCM	Predictability
3D Edge Enhancement	AVO strength	General depth conversion	Quadrature amplitude
AVO P-wave velocity contrast	AVO uniaxial compressional modulus contrast	Generalized Spectral Decomposition	RMS Amplitude
AVO Poisson's ratio contrast	Amplitude contrast	Genetic inversion	RMS Amplitude (iterative)
AVO S-wave impedance contrast	Ant tracking	Gradient magnitude	RMS Ratio
AVO S-wave velocity contrast	Apparent polarity	Graphic equalizer	Reflection intensity
AVO Shuey 2-term - sign(Intercept) * Gradient	Auto-correlation	Instantaneous bandwidth	Relative acoustic impedance
AVO Vp/Vs ratio contrast	Chaos	Instantaneous frequency	Remove bias
AVO attributes	Colored Inversion	Instantaneous phase	Response attribute
AVO density contrast	Consistent curvature	Instantaneous quality	Second derivative
AVO filtered polarized AB	Consistent dip	Iso-frequency component	Spectrally shaped random noise
AVO fluid angle	Correlation	Isotropic synthetic	Structural smoothing
AVO fluid factor (Gidlow)	Cosine of phase	Isotropic synthetic (grid only)	Sweetness
AVO fluid factor (Shuey)	Cross-correlation	Local flatness	Time gain
AVO fluid strength	Dip deviation	Local structural azimuth	Trace AGC
AVO gas indicator	Dip illumination	Local structural dip	Trace AGC (iterative)
AVO intercept*gradient	Directional blending	Median filter	Trace gradient
AVO linear correlation coefficient	Dominant frequency	NRMS	Variance (Edge method)
AVO polarization angle	Edge evidence	Neural net	Velocity and dix conversion
AVO polarized AB	Envelope	Original Amplitude	Wavelet convolution
AVO reflection coefficient and Poisson's ratio contrast	First derivative	Phase shift	t*Attenuation
AVO reflection coefficient difference	Frequency filter	Pore pressure prediction	

Aims and Objectives

Research Aims

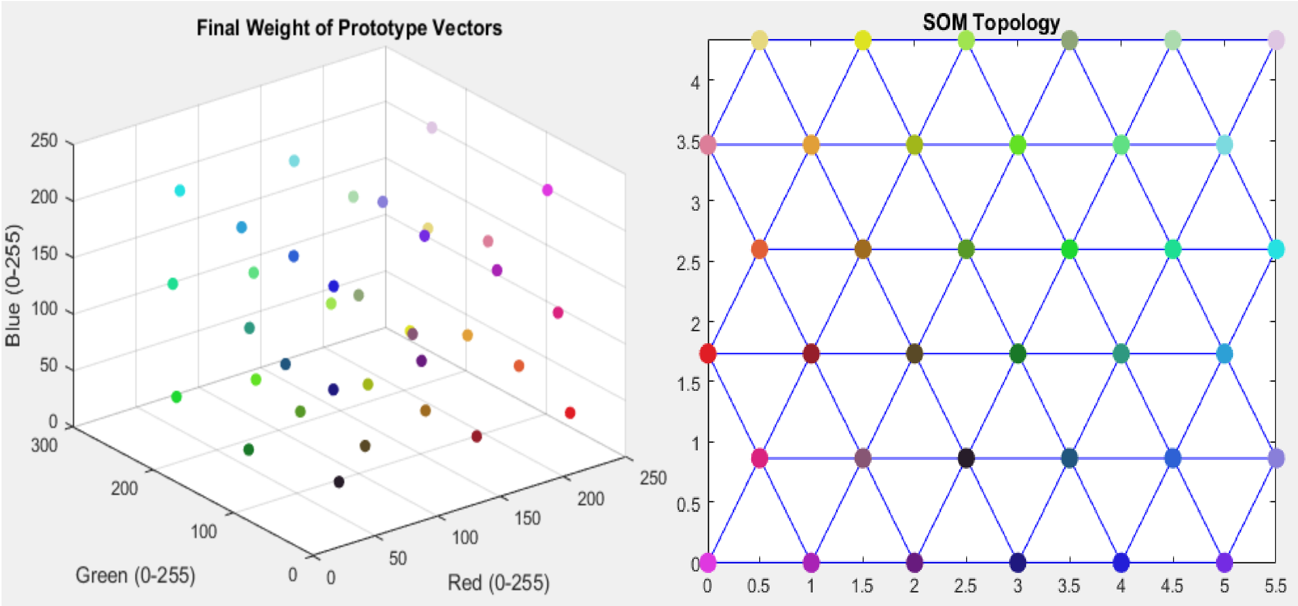
The research is aimed at developing an automated seismic interpretation system, which will reduce the degree of ambiguity of seismic interpretation that also allows the user to view and modify interpretation easily in VR to speed up the process of structural, geometric and reservoir characterisation.

Proposed Workflow

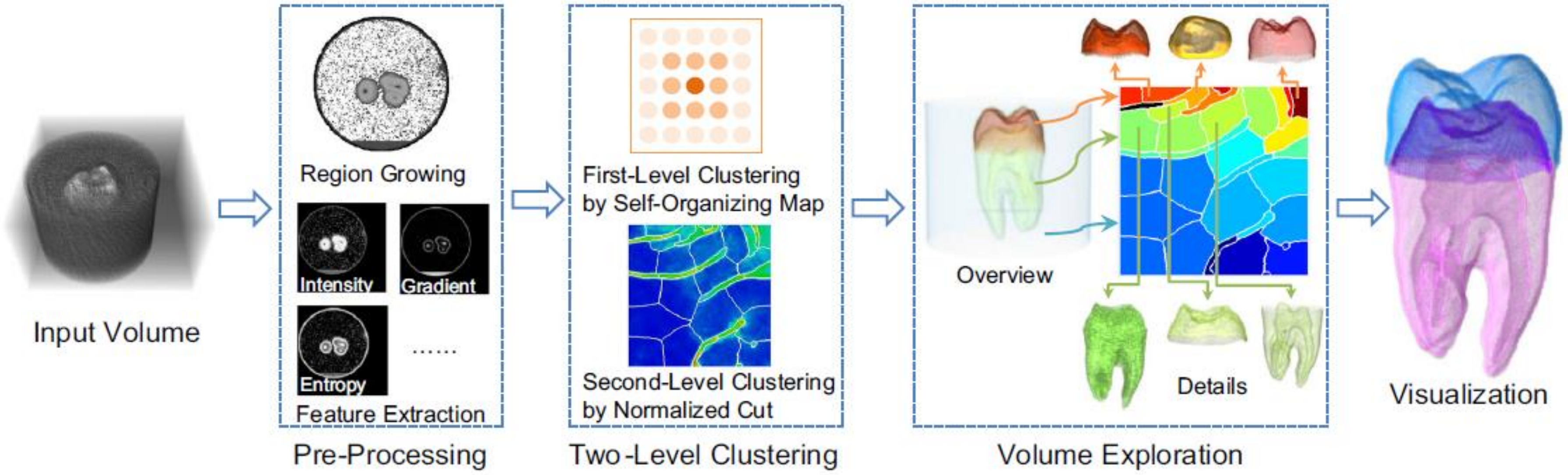


Self-Organising Map (SOM)

- It is an unsupervised clustering algorithm inspired by biological neural networks, which are capable of self-organising without external supervision.
- To illustrate the SOM, if we consider the a 3D RGB colour space, where each axis has a range of 0-255. The expected outcome of the SOM is a 2D map which shows gradation of colours which represents their property of topological preservation.



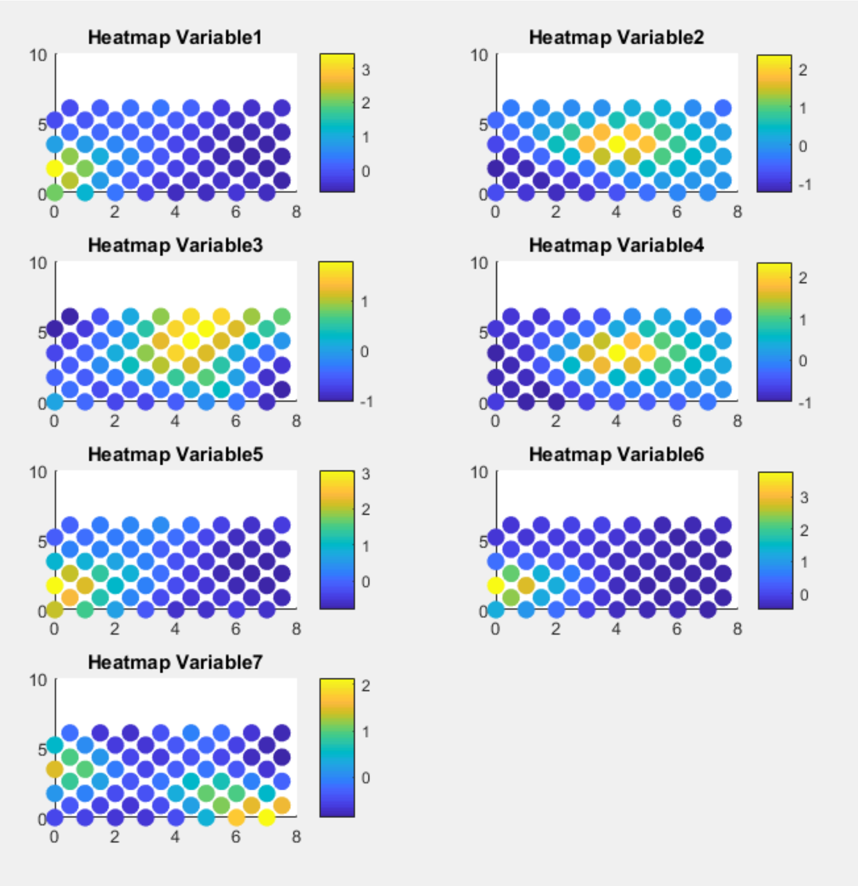
SOM as transfer function



The flow process of the method proposed by Cai et al., 2017.

Results on New Zealand Dataset

Results on NZ Seismic Dataset



Variable 1 = Dip Illumination

Variable 2 = GLCM Inline

Variable 3 = GLCM Time

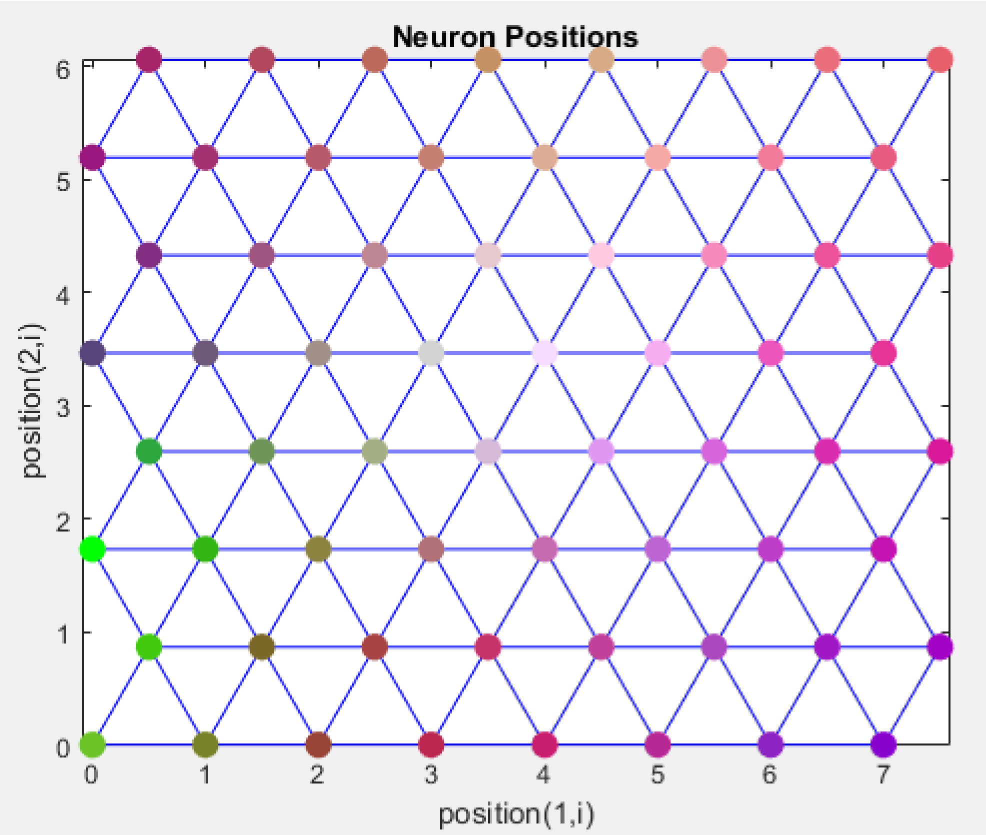
Variable 4 = GLCM X-Line

Variable 5 = Local Structural Dip PCA

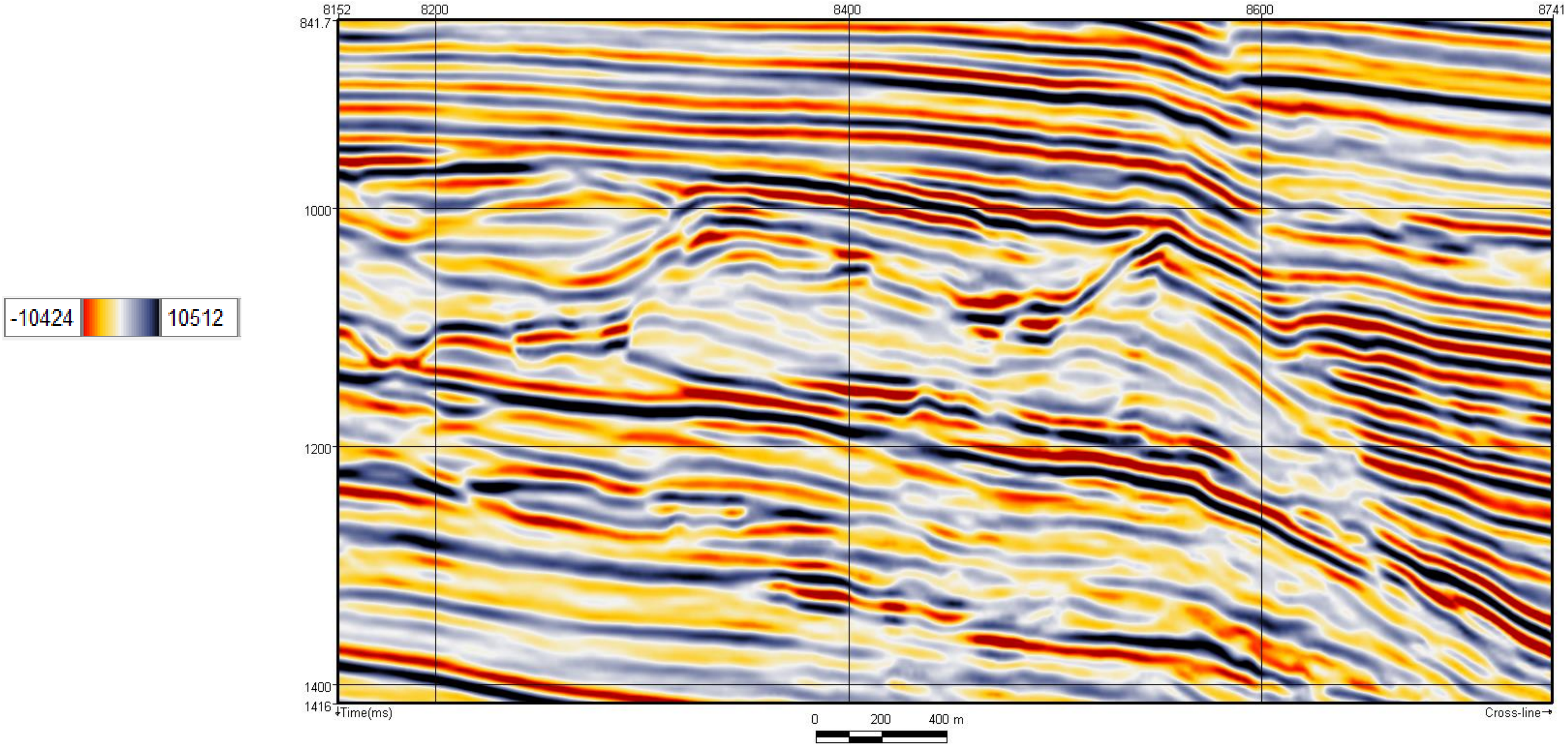
Variable 6 = Variance

Variable 7 = Gradient Magnitude

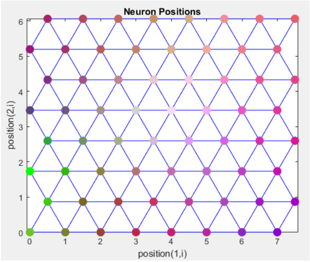
Colour Scheme using Sammon Mapping

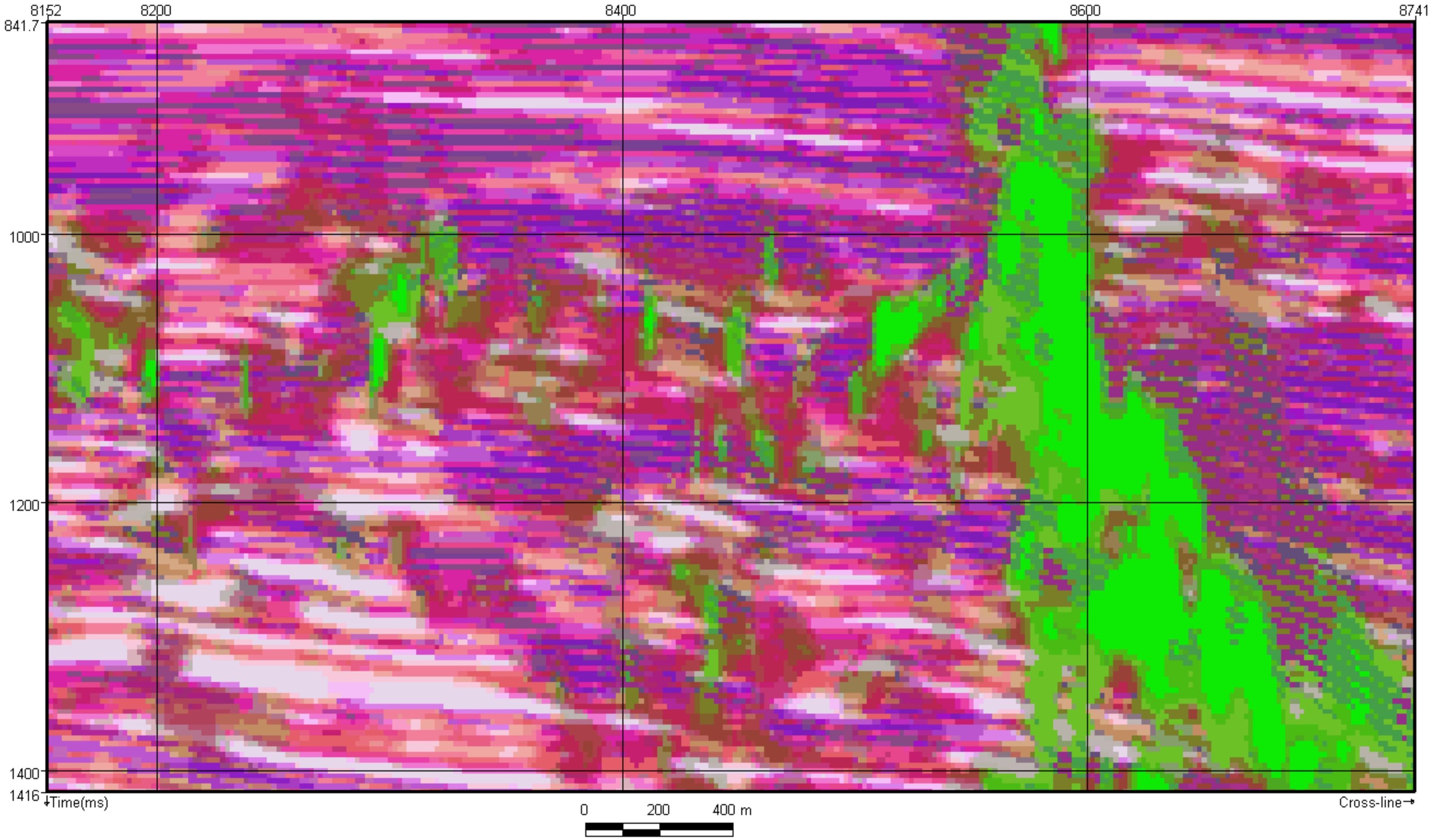


Raw Amplitude Data at IL 4300

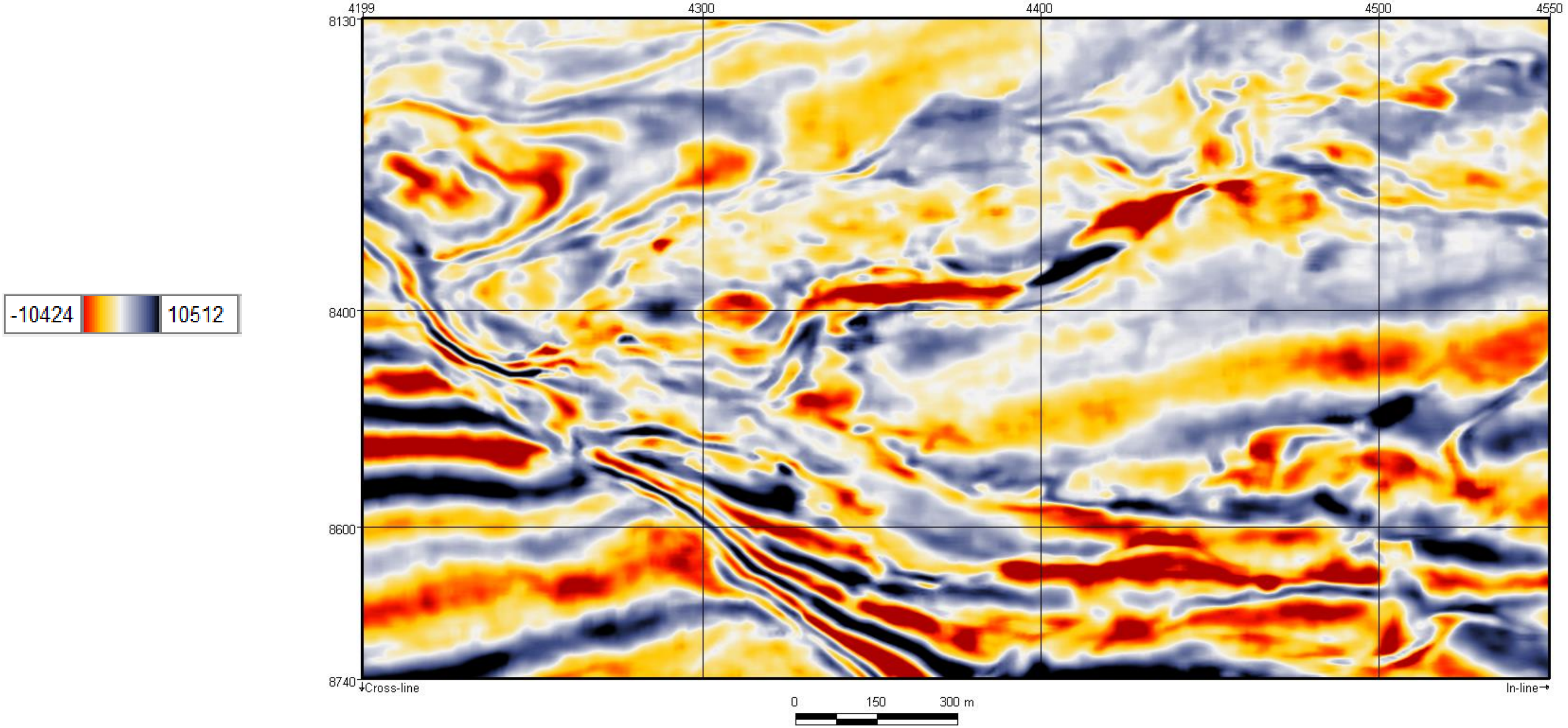


SOM Classification Result at IL 4300

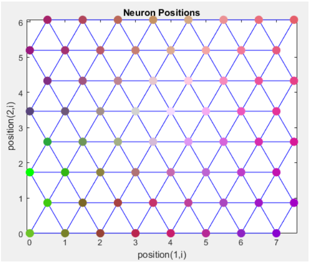


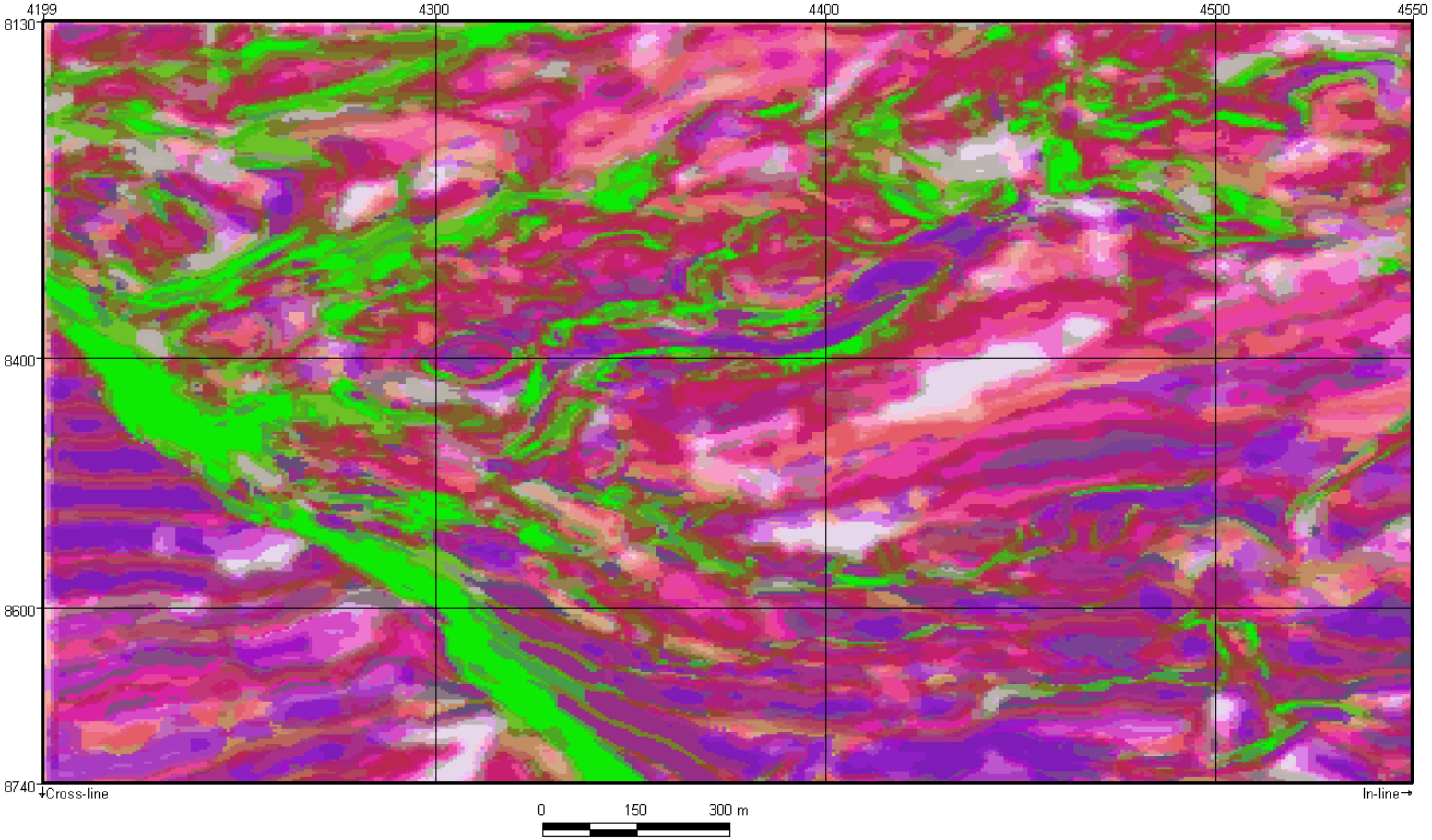


Raw Amplitude Data at 1060ms



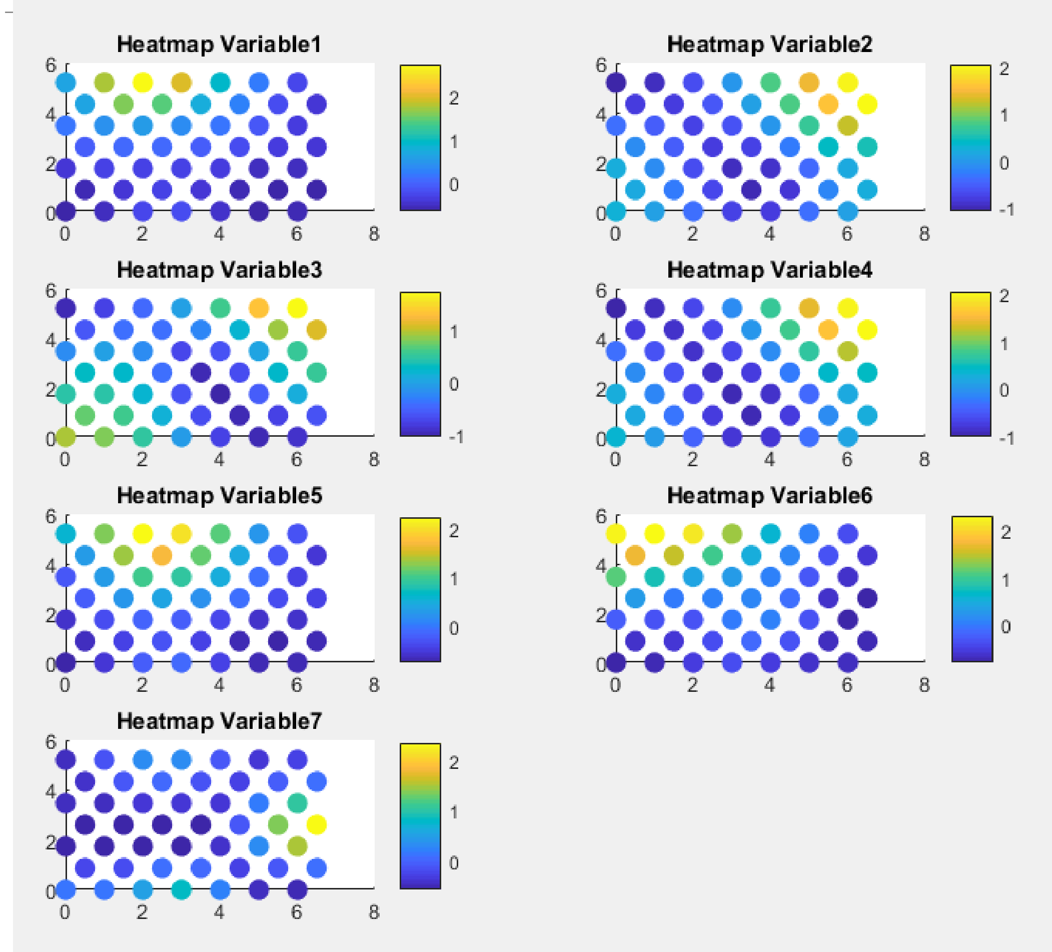
SOM Classification Result at 1060ms





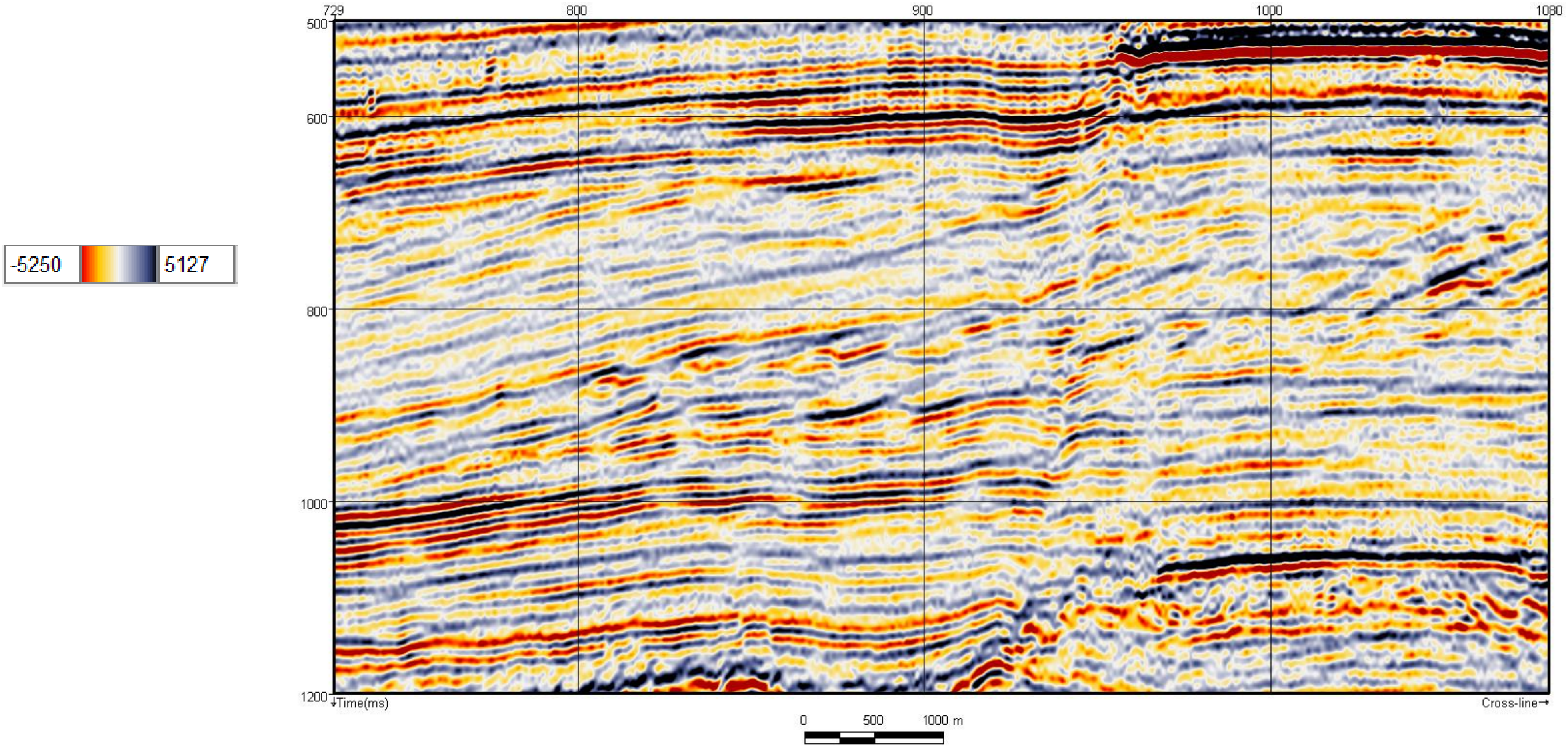
Results on F3 Netherland Seismic Dataset

Results on Netherland Dataset

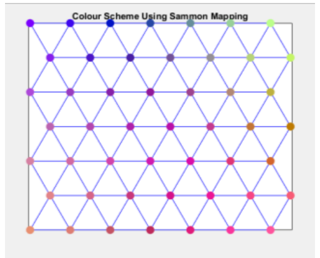


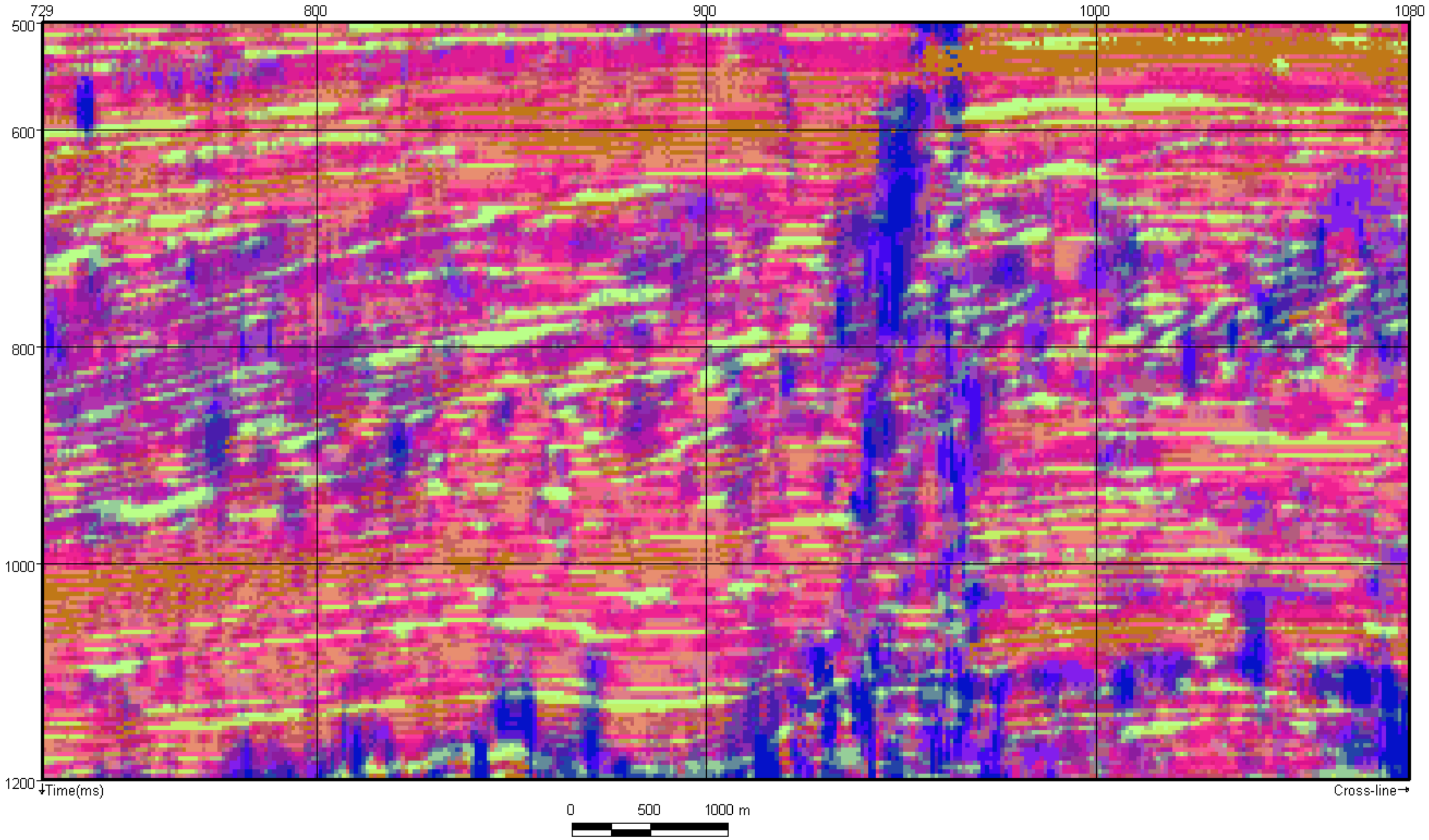
Var 1 = Dip Illumination
Var 2 = GLCM Inline
Var 3 = GLCM Time
Var 4 = GLCM X-Line
Var 5 = Local Structural Dip PCA
Var 6 = Variance
Var 7 = Gradient Magnitude

Raw Amplitude Data at IL 250

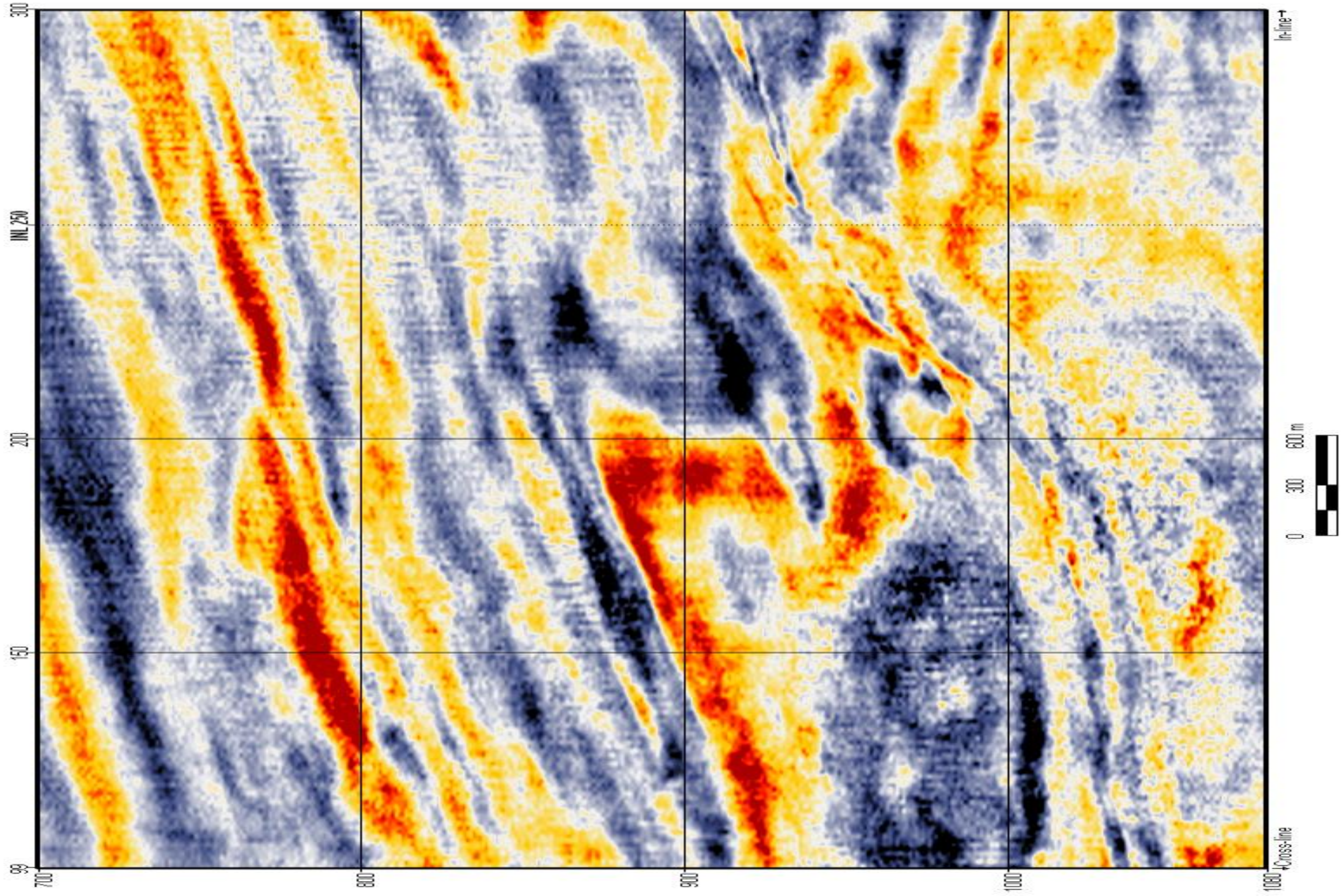


SOM Classification Result at IL 250

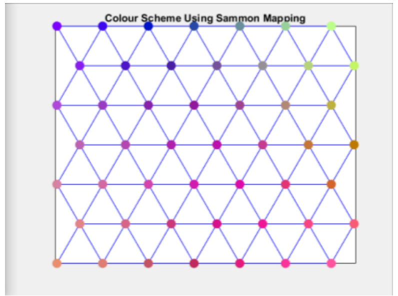


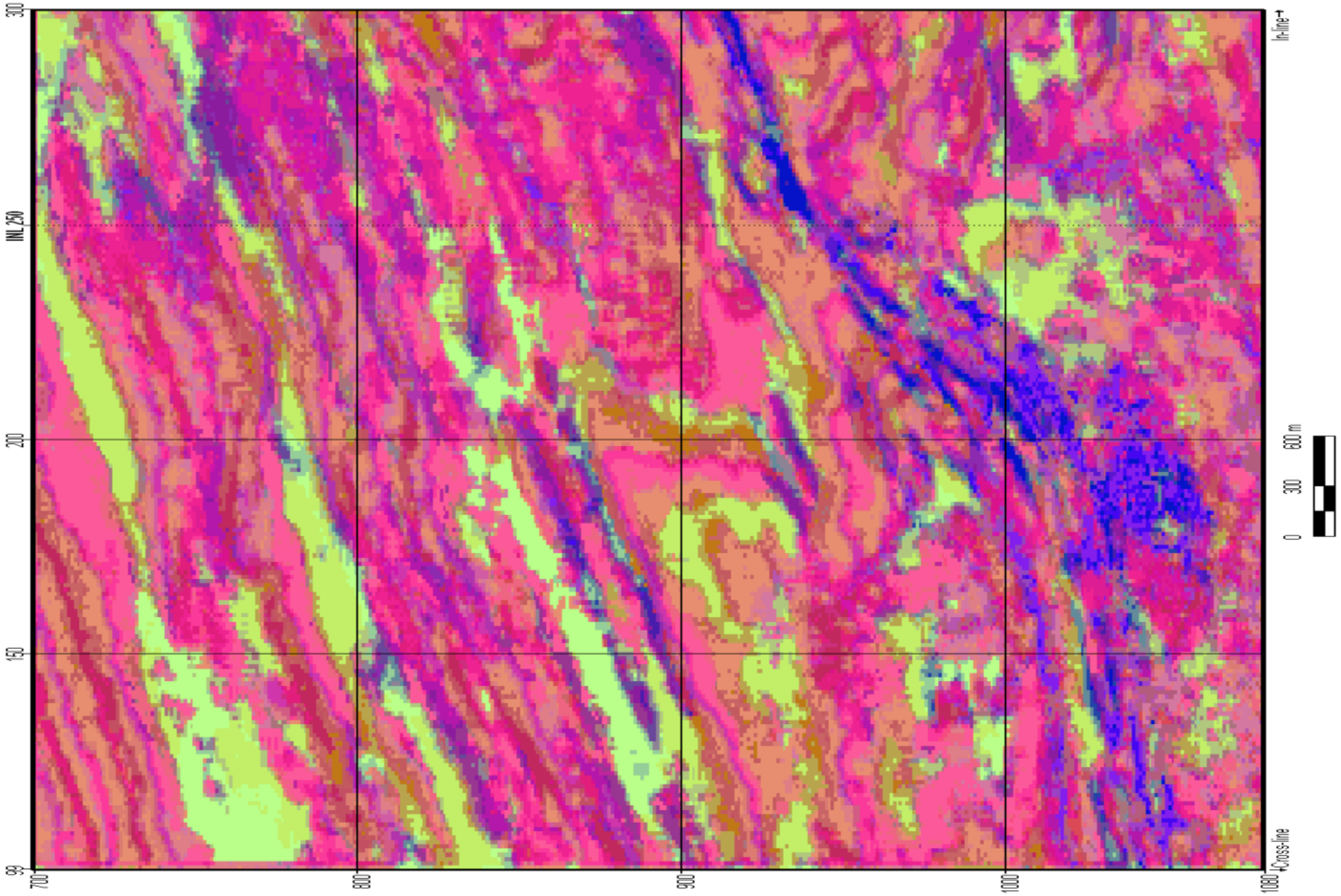


Raw Amplitude Data at 968ms

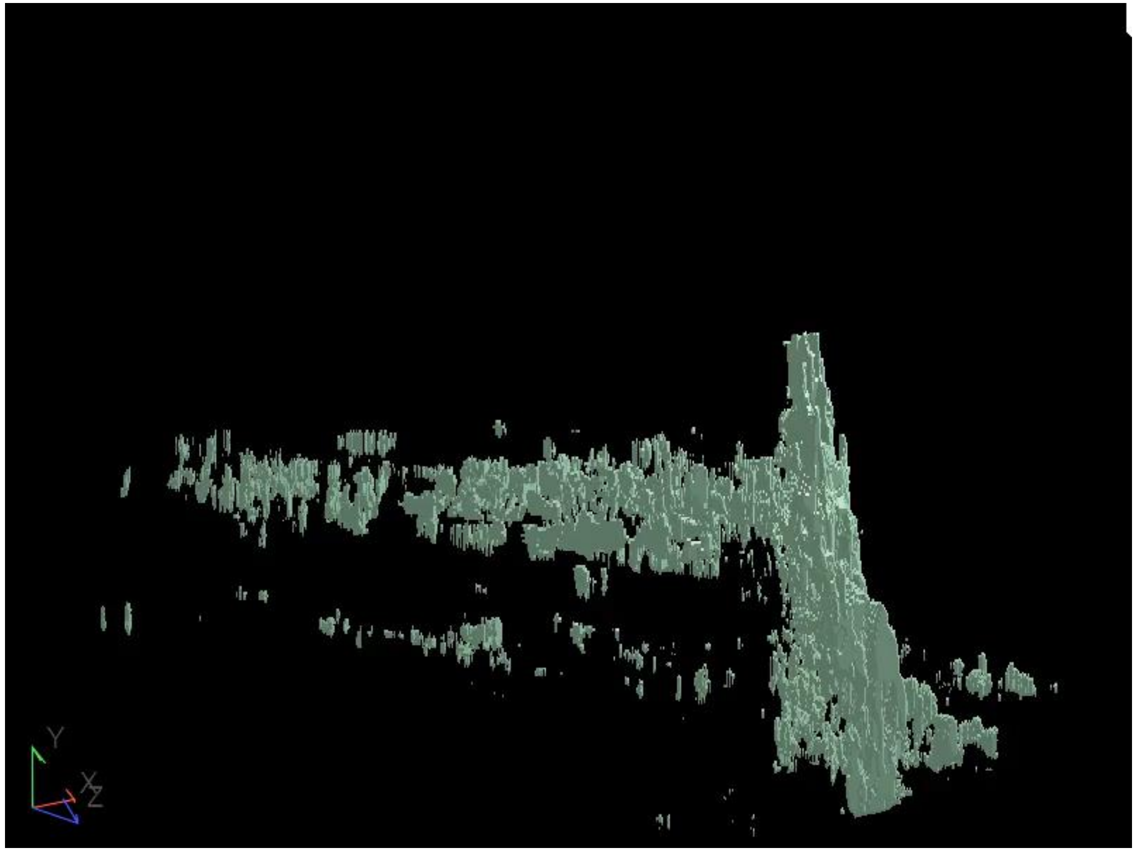


SOM Classification Result at 968ms

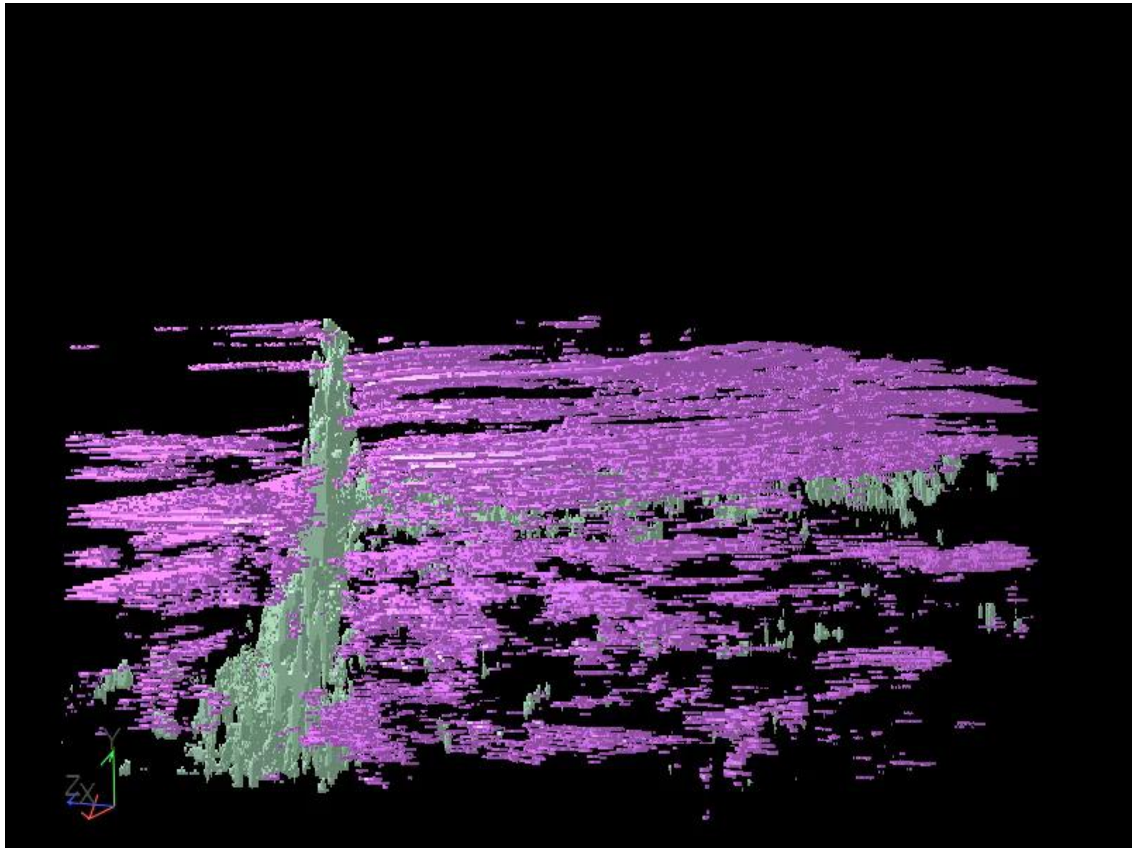




Visualisation in VR



Visualisation in VR



Conclusions

- The rapidly growing field of seismic attributes makes it difficult for effective and efficient interpretation.
- Therefore, there is a significant benefit in having an automated 3D seismic interpretation pipeline, which are capable to elucidate the relevant geological features, based on the given seismic attributes.
- A preliminary test of using SOM shows a promising potential for the application of transfer function.
- This gives the capability of viewing the underlying seismic data in Virtual Reality
- Further works will focus more on the automatic feature selection scheme and VR user interface.