FAULT DETECTION USING ATTENTION MODELS BASED ON VISUAL SALIENCY

Muhammad Amir Shafiq*, **Zhiling Long***, **Haibin Di***, **Ghassan AlRegib***, and **Mohammed Deriche**†

{amirshafiq, zhiling.long, haibin.di, alregib}@gatech.edu, mderiche@kfupm.edu.sa

Center for Energy and Geo Processing (CeGP)

* Georgia Institute of Technology, Atlanta, GA, 30332, USA

† King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia
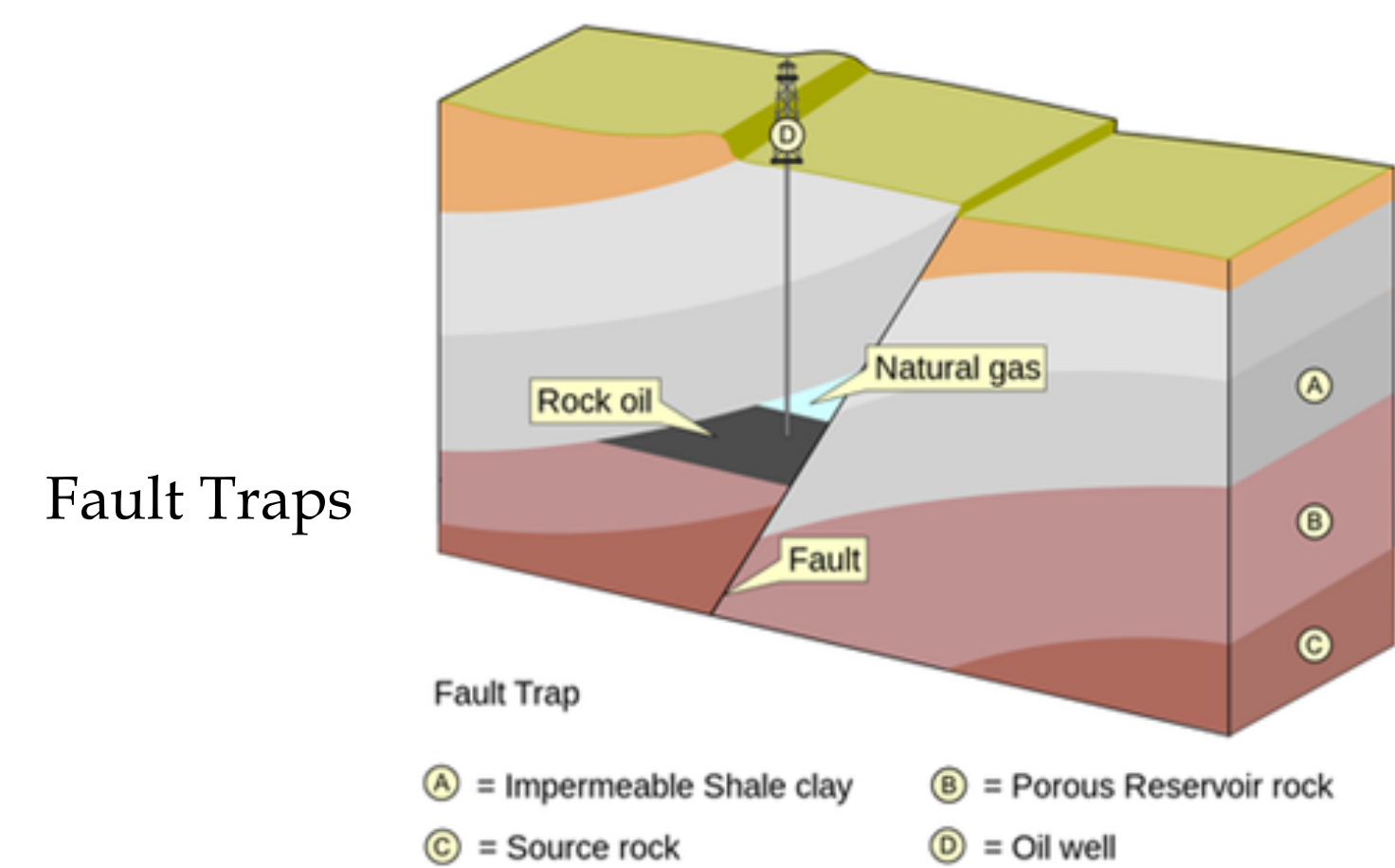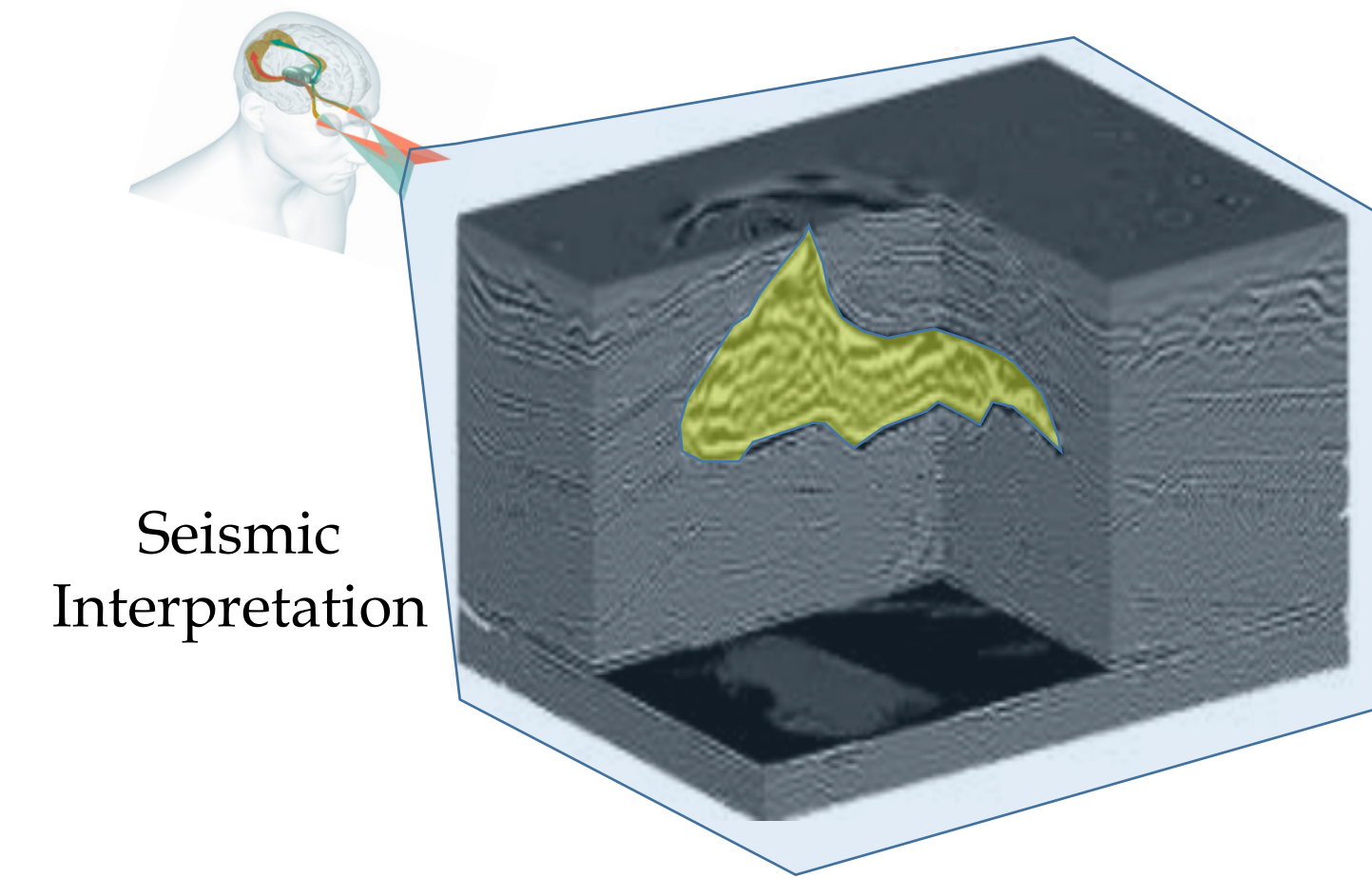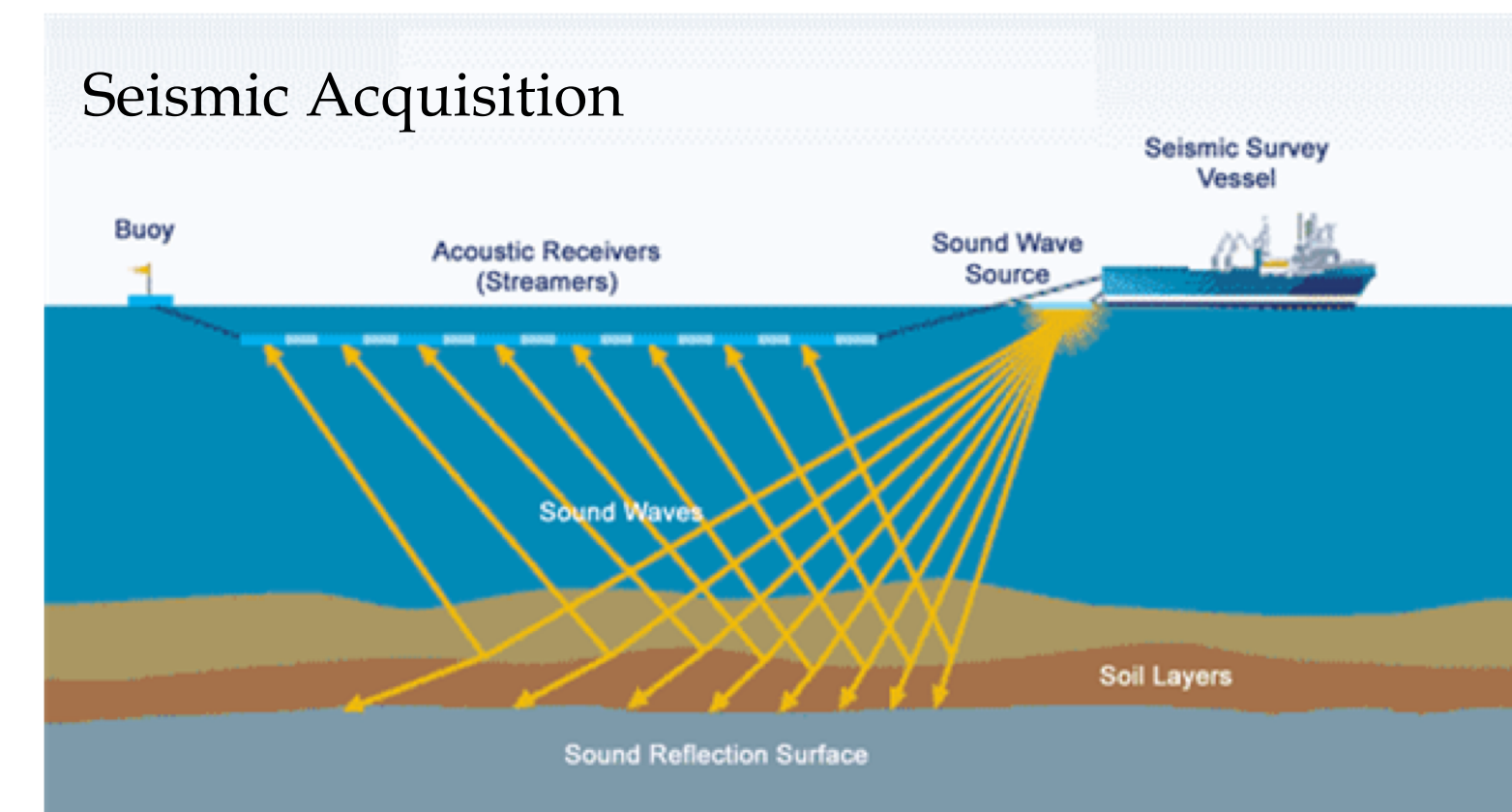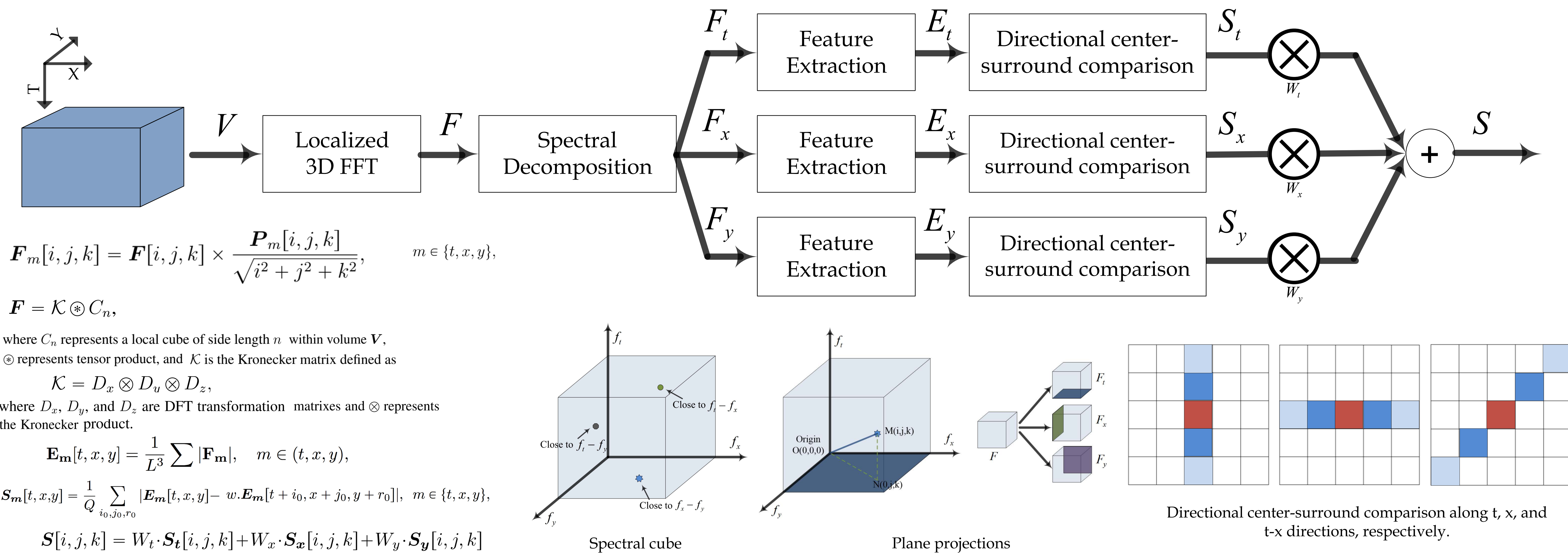
www.ghassanalregib.com

Motivation

Large geological structures such as salt domes, faults, and anticlines form structural traps for oil and gas as a result of structural deformation (a bend or dip) of rocks, which takes place over elongated periods of time. Therefore, accurate localization and delineation of such structures is one of the important steps in seismic data interpretation.
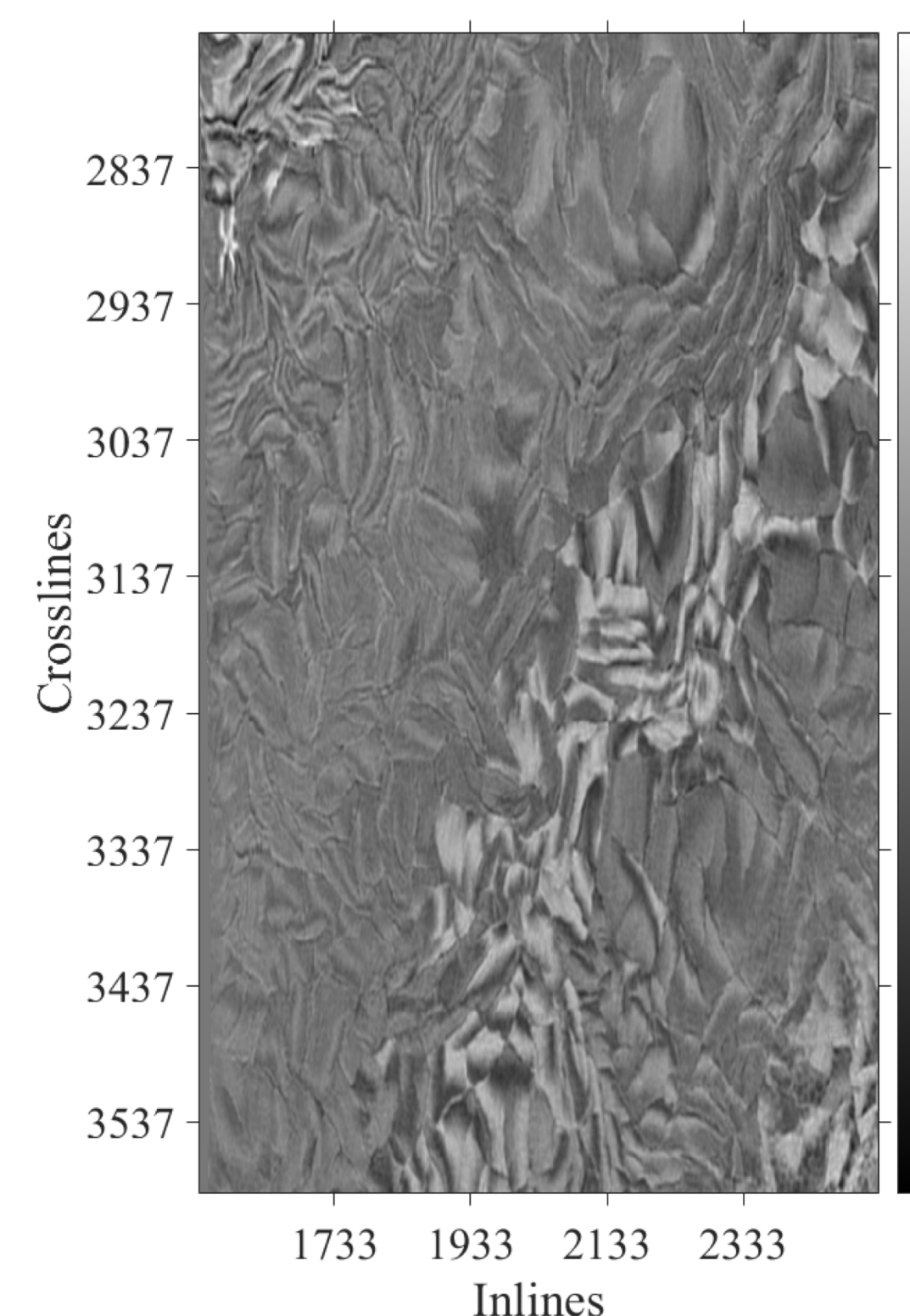

Seismic Acquisition

Seismic Interpretation

Fault Traps

Fault in Peru

Proposed Method

$$\boldsymbol{F}_m[i,j,k] = \boldsymbol{F}[i,j,k] \times \frac{\boldsymbol{P}_m[i,j,k]}{\sqrt{i^2 + j^2 + k^2}}, \qquad m \in \{t,x,y\},$$

$$\boldsymbol{F} = \mathcal{K} \circledast C_n,$$

where C_n represents a local cube of side length n within volume $\boldsymbol{V}$, $\circledast$ represents tensor product, and $\mathcal{K}$ is the Kronecker matrix defined as

$$\mathcal{K} = D_x \otimes D_y \otimes D_z,$$

where D_x, D_y, and D_z are DFT transformation matrixes and $\otimes$ represents the Kronecker product.

$$\boldsymbol{E}_m[t,x,y] = \frac{1}{L^3} \sum |\boldsymbol{F}_m|, \qquad m \in (t,x,y),$$

$$\boldsymbol{S}_m[t,x,y] = \frac{1}{Q} \sum_{i_0, j_0, r_0} |\boldsymbol{E}_m[t,x,y] - w \cdot \boldsymbol{E}_m[t+i_0, x+j_0, y+r_0]|, \quad m \in \{t,x,y\},$$

$$\boldsymbol{S}[i,j,k] = W_t \cdot \boldsymbol{S}_t[i,j,k] + W_x \cdot \boldsymbol{S}_x[i,j,k] + W_y \cdot \boldsymbol{S}_y[i,j,k]$$

Spectral cube

Plane projections

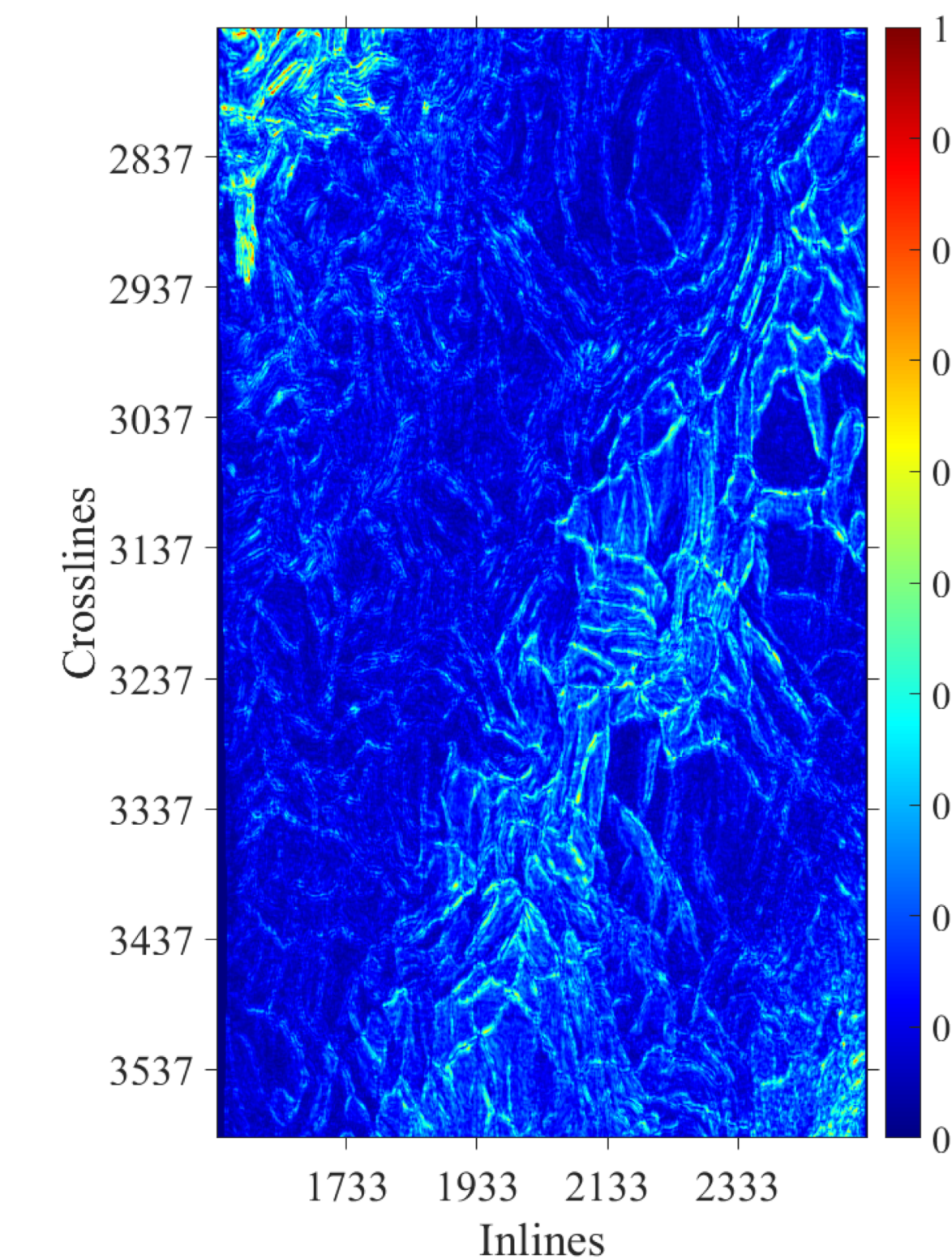Directional center-surround comparison along t, x, and t-x directions, respectively.
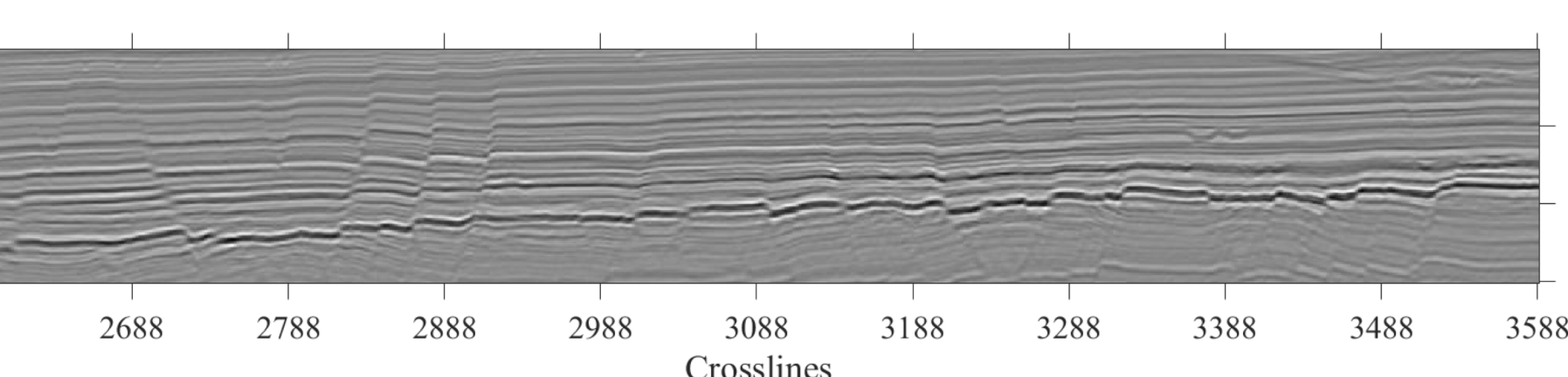
Intermediate Results
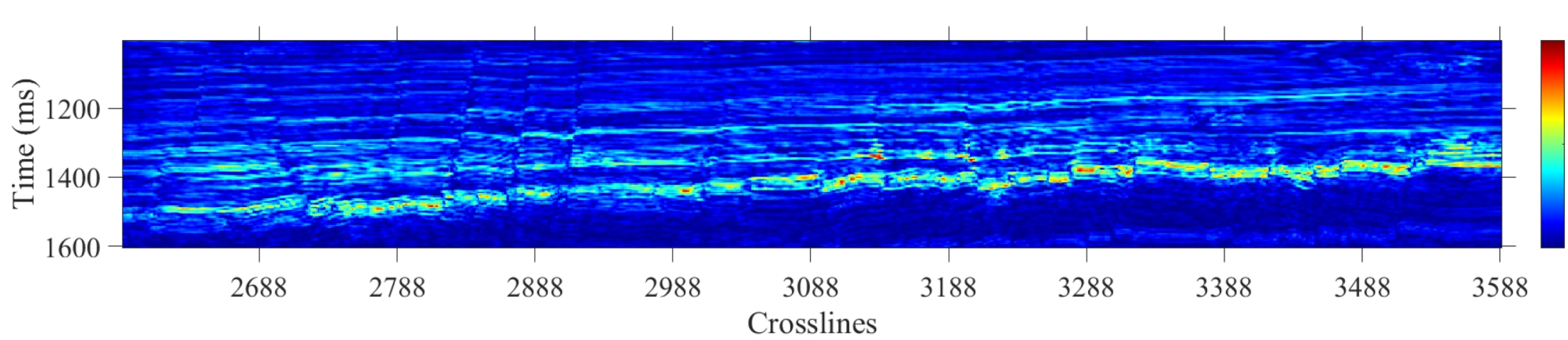

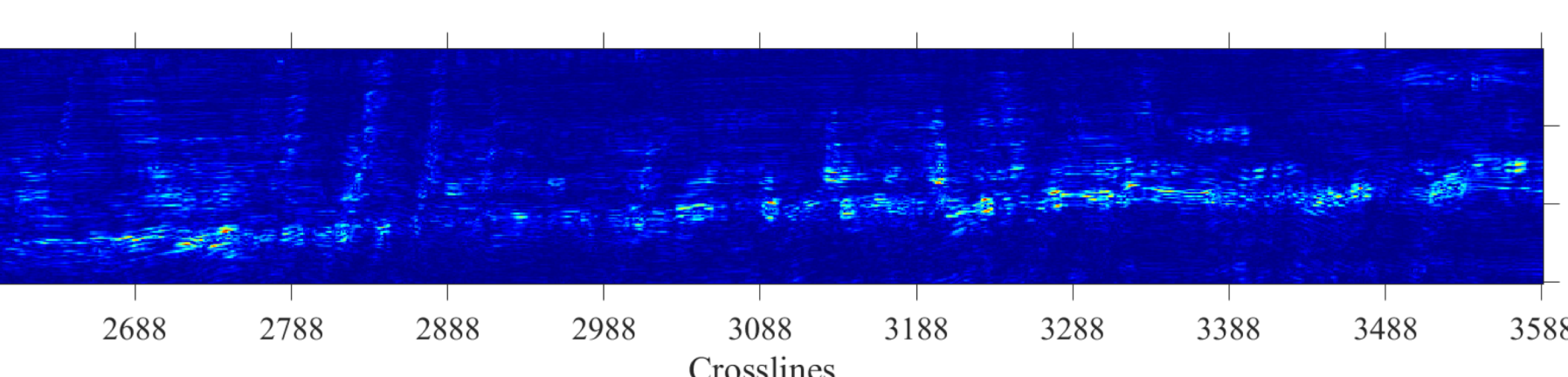The Great South Basin, New Zealand

Time Section
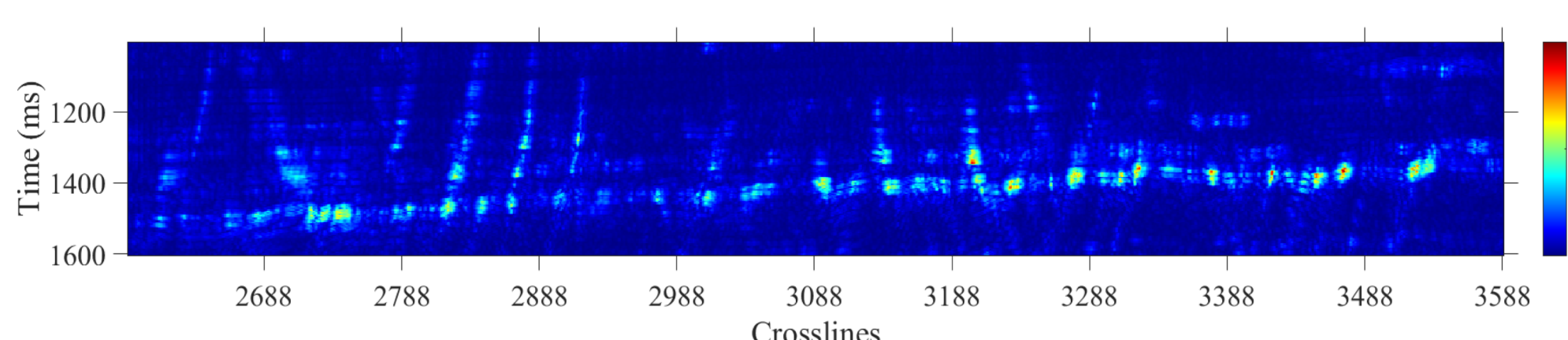
Saliency Map – Faults Network
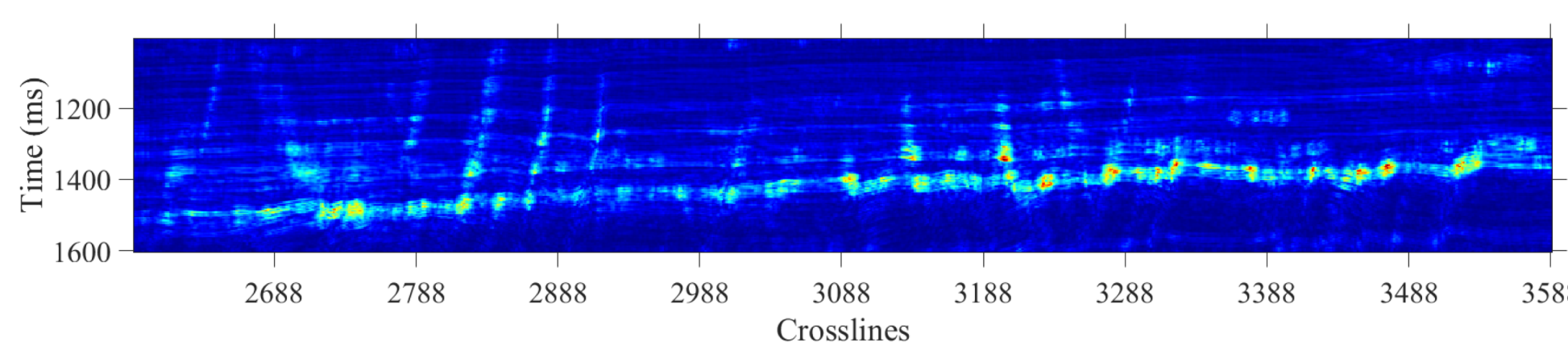
A Typical Seismic Inline Section

Saliency - Sx

Saliency - Sy

Saliency - St

Combined Saliency - S

Experimental Results and Comparison with State-of-the-art Algorithms

A Typical Seismic Inline

Reference Section Manually Labelled

Zhang et al. (2008)

Hou and Zhang (2007)

Schauerte and Stiefelhagen (2012)

Long and AlRegib (2015)

Achanta et al. (2008)

Fang et al. (2014)

Alaudah and AlRegib (2016)

Bahorich and Farmer (1995)

Proposed Method (Equal Weights)

Proposed Method (Faults)