

CNN on Polyphase Fault Classification on the North Slope, Alaska

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Project Background

- The subsurface geology on the North Slope is complex, affected by multiple episodes of faulting.
- Identify and predict complex faults in 3D seismic data

Data source:

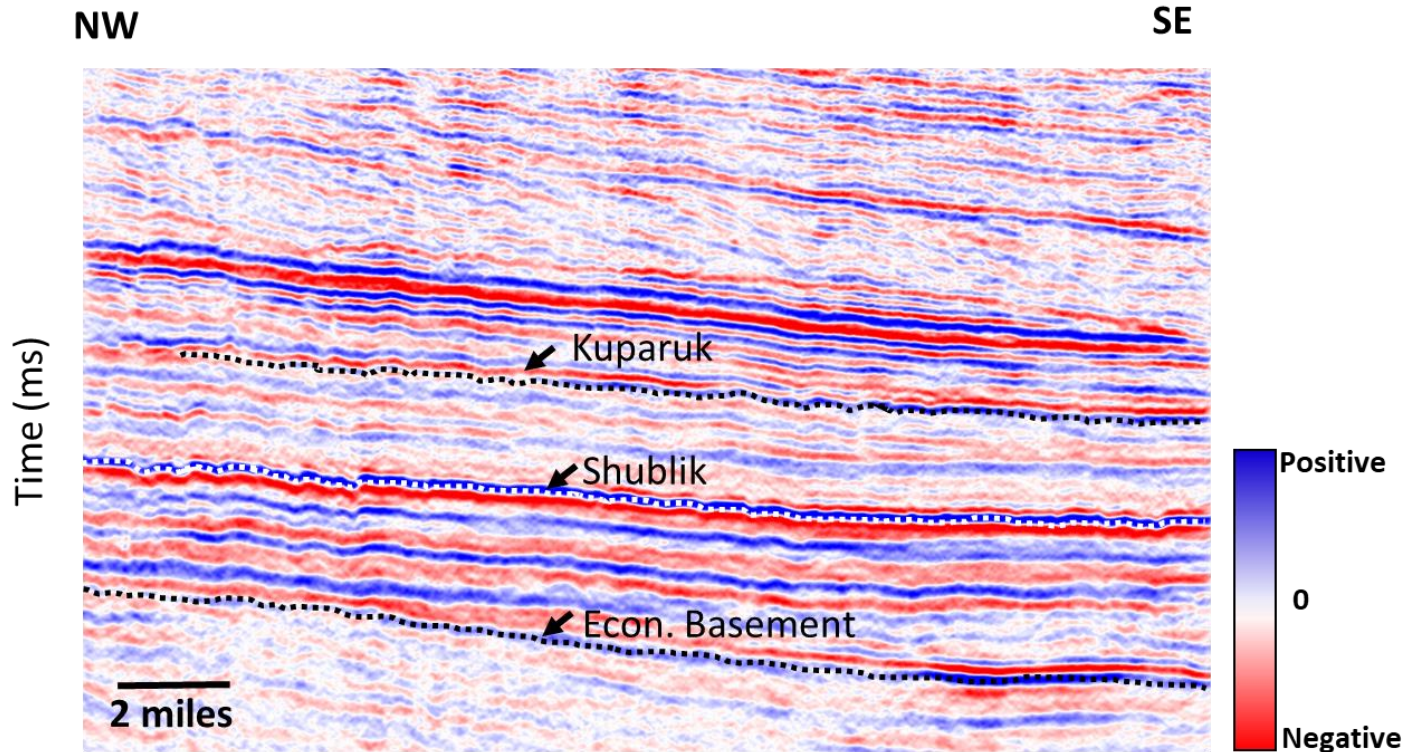
The 3D seismic surveys (Storms 3D and North Shore 3D) are available from the Alaska DNR website through the tax-credit program.

<https://dggg.alaska.gov/gmc/seismic-well-data.php>

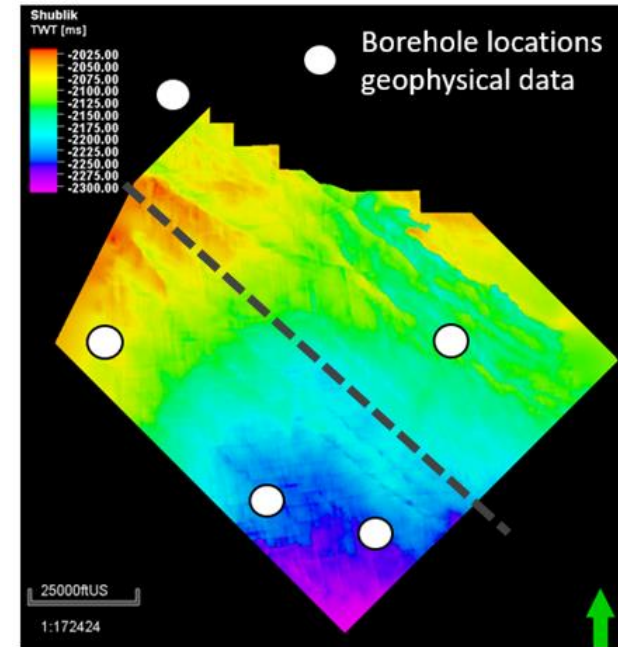


Location of the study area

An Interpreted Seismic Section



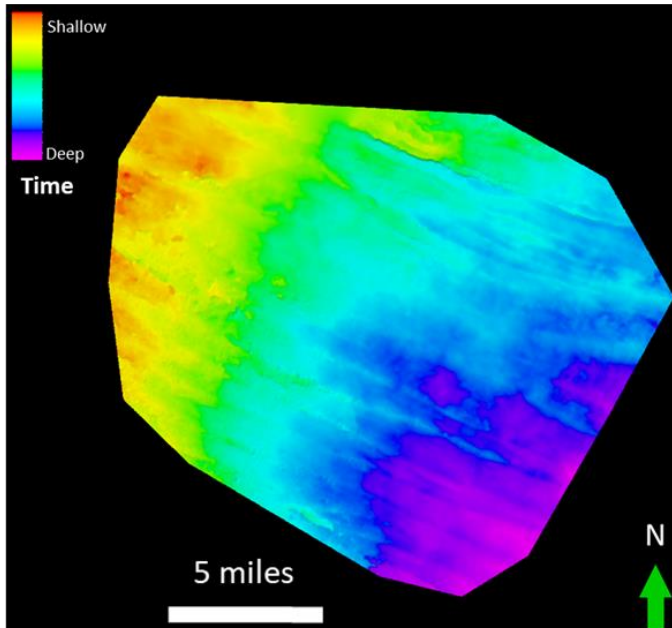
A seismic section along NW-SE (Storms 3D)



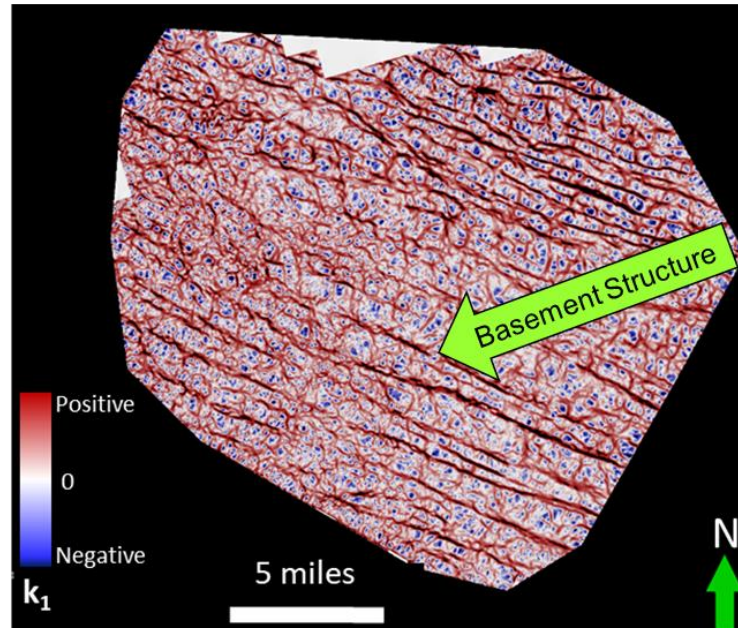
Available wells with required geophysical logs inside the Storms 3D survey

Economic Basement (Kekiktuk) Structure

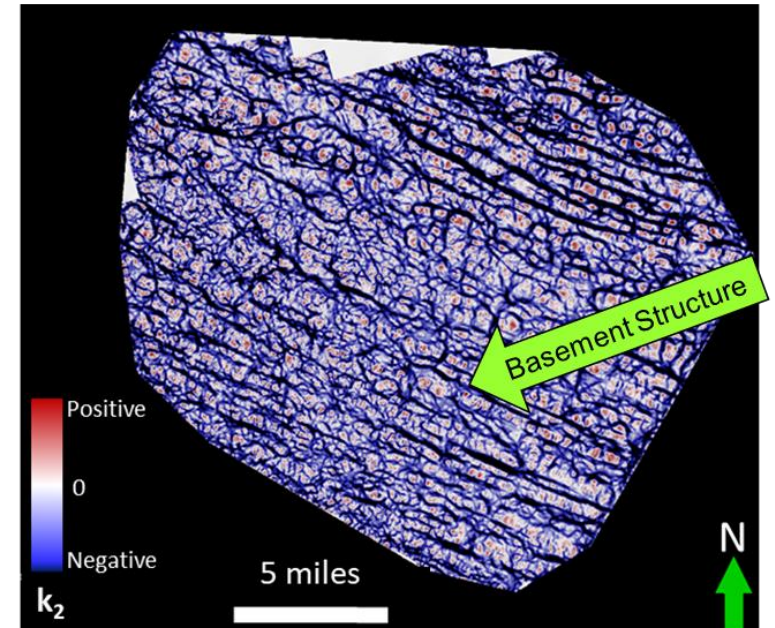
Kekiktuk Time Structure



Most Positive Curvature (long)

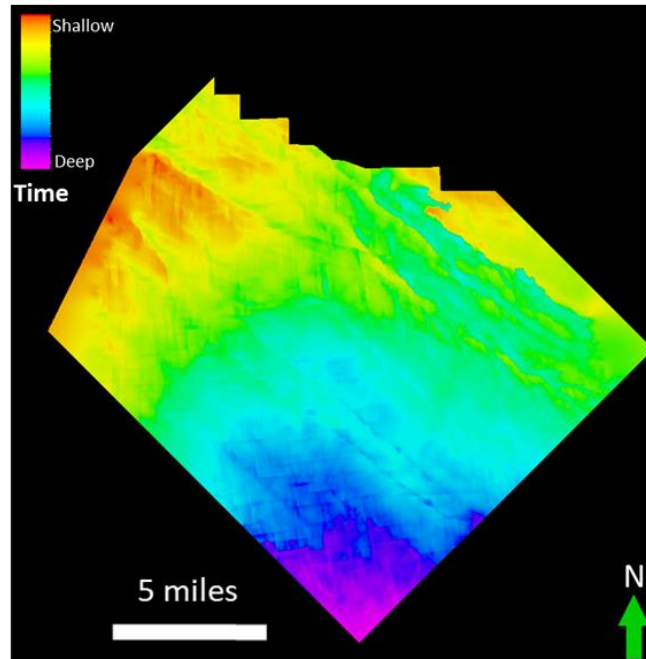


Most Negative Curvature (long)

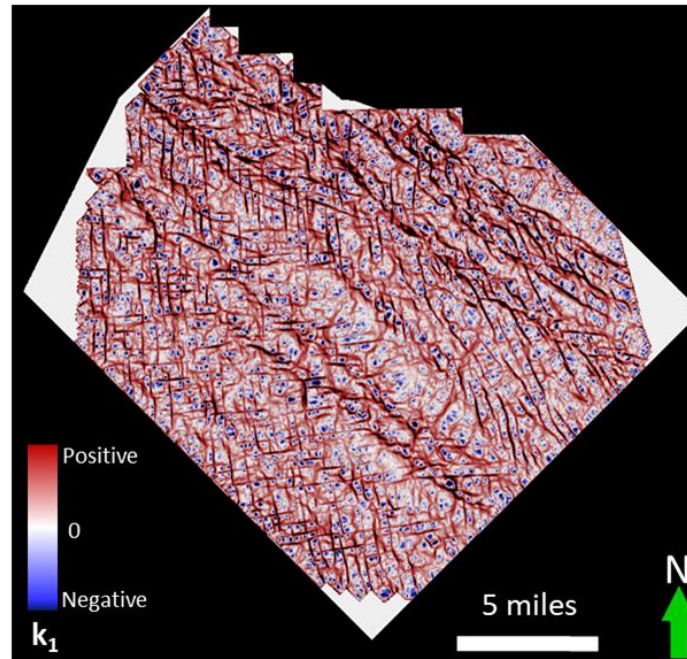


Shublik Shale Structure

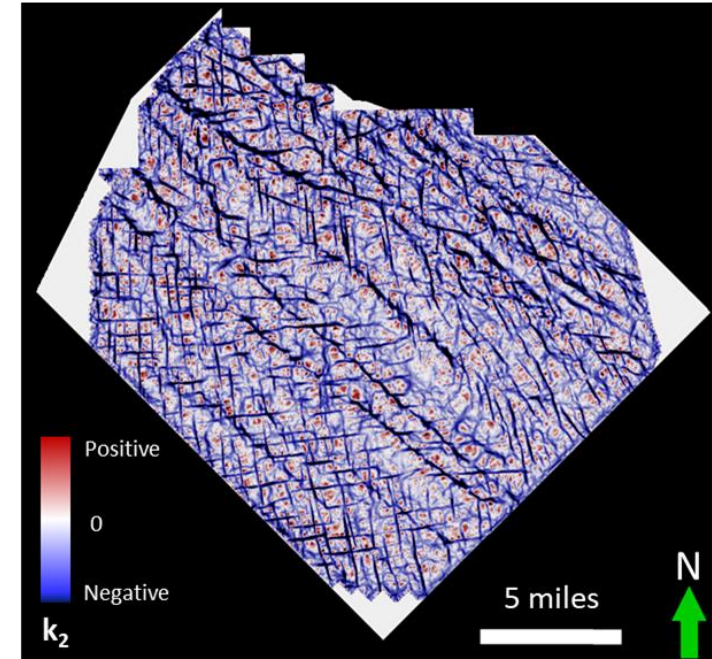
Shublik Time Structure



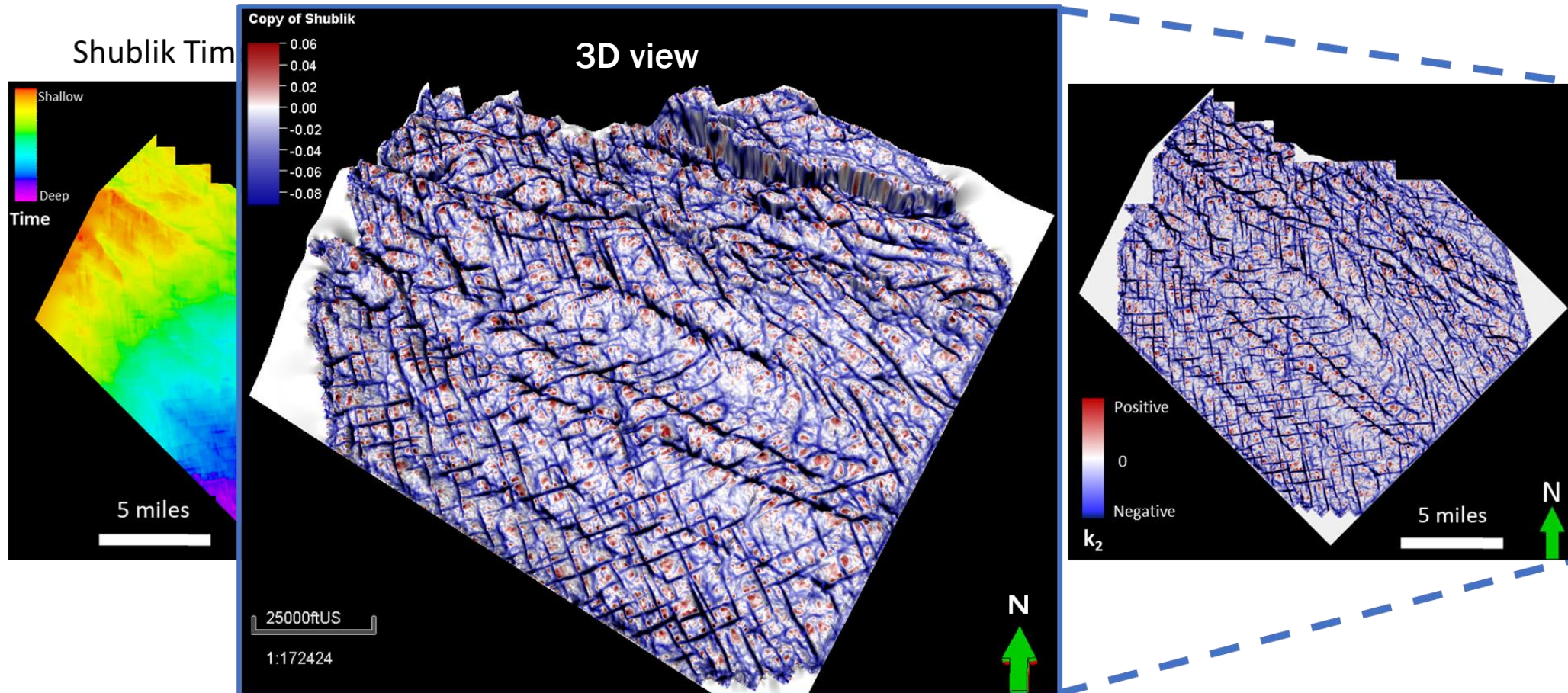
Most Positive Curvature (long)



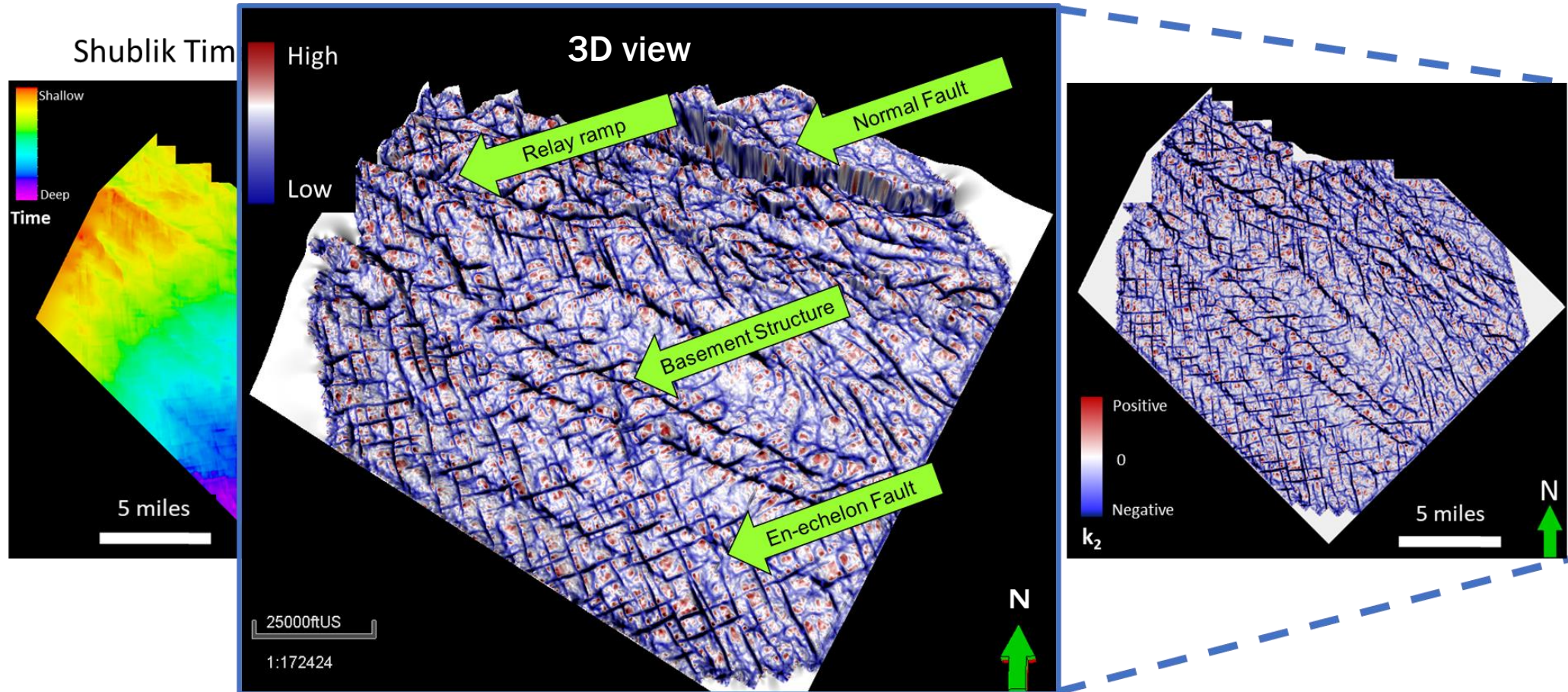
Most Negative Curvature (long)



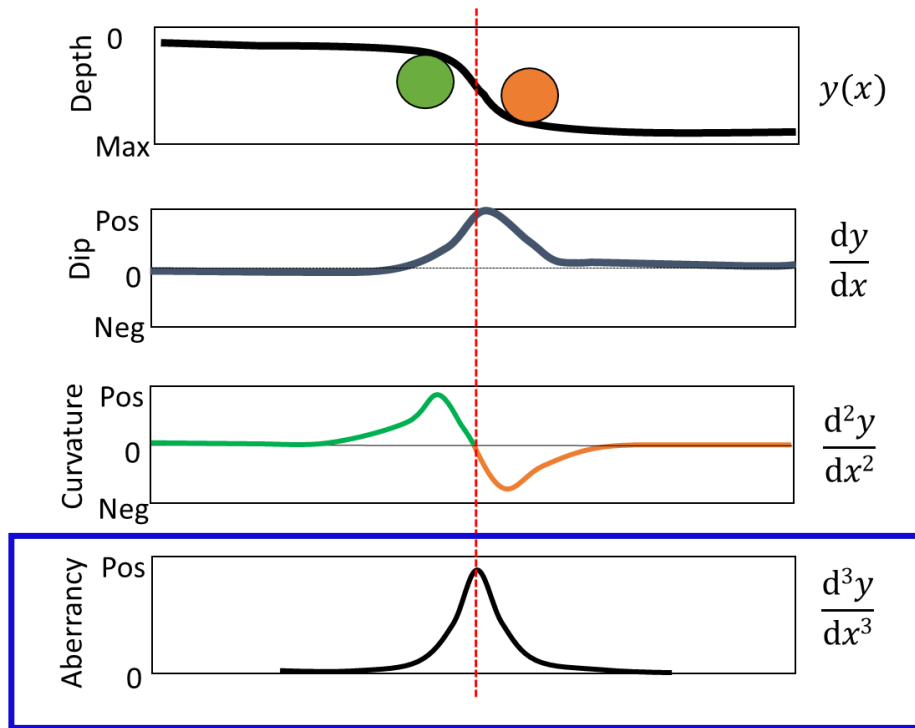
Shublik Shale Structure



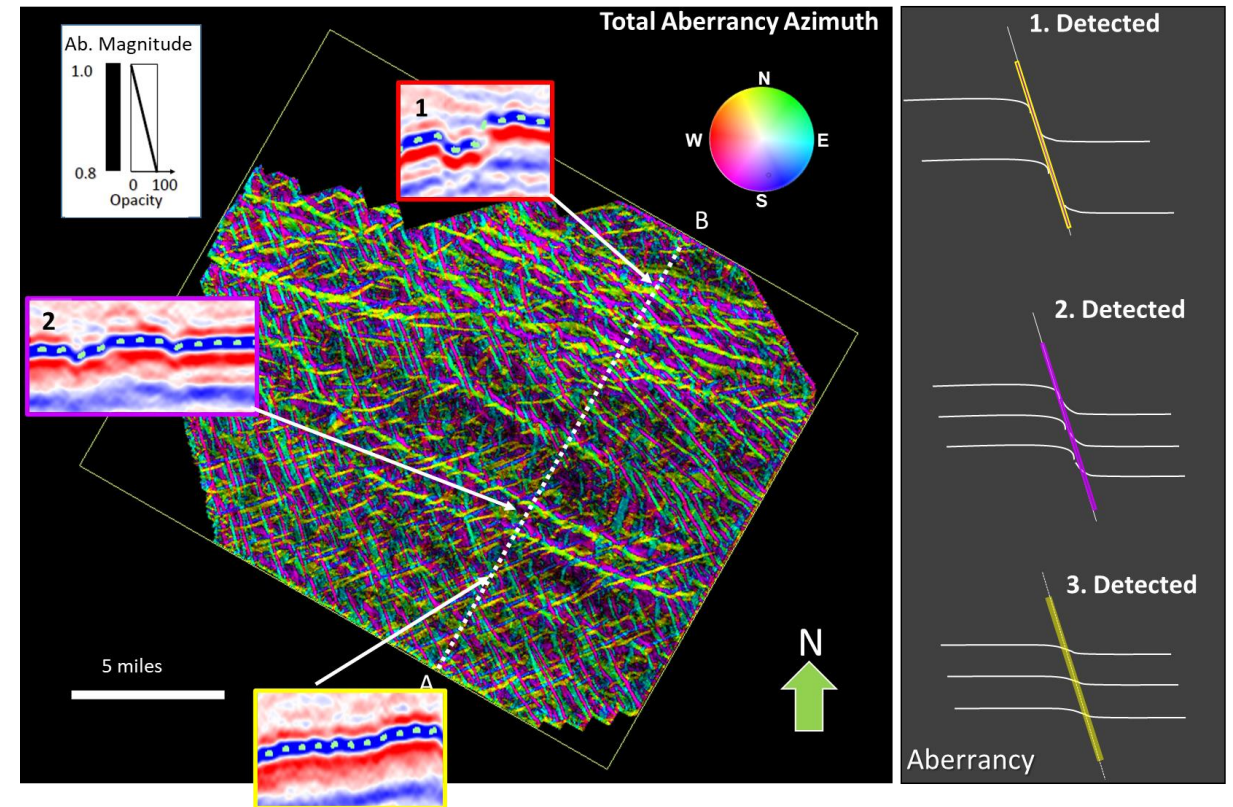
Shublik Shale Structure



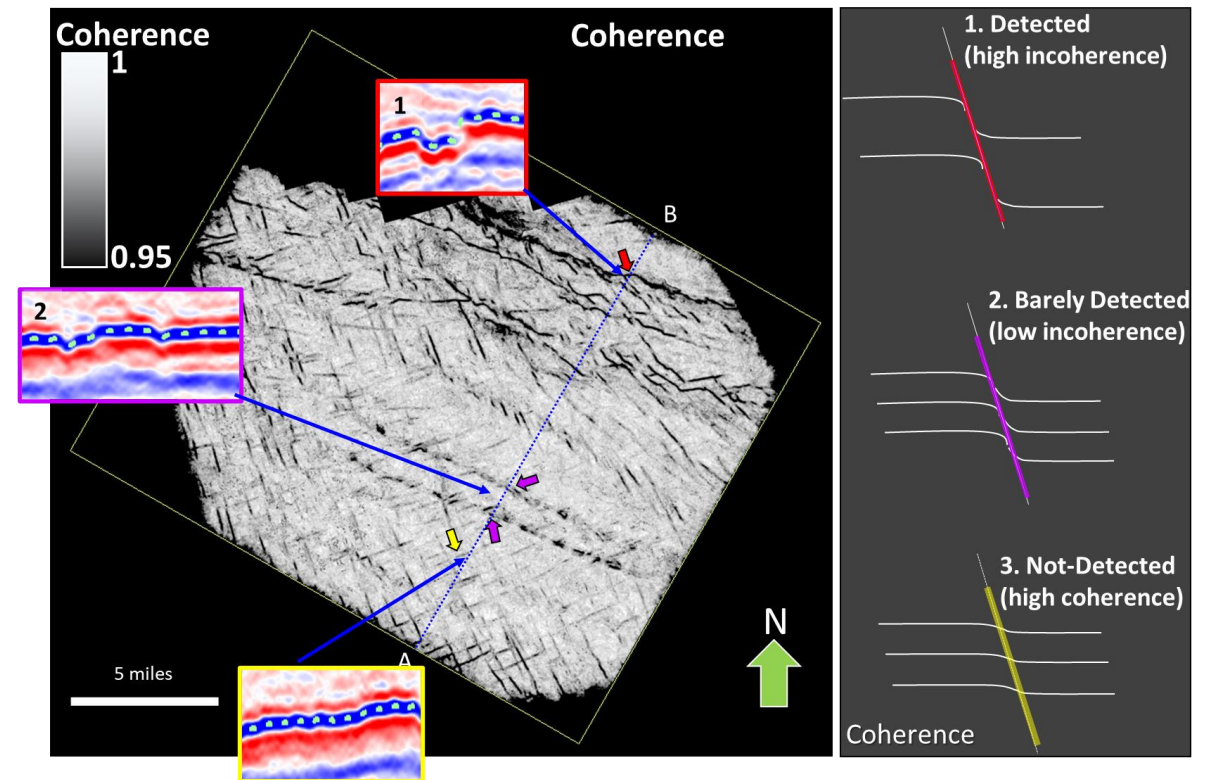
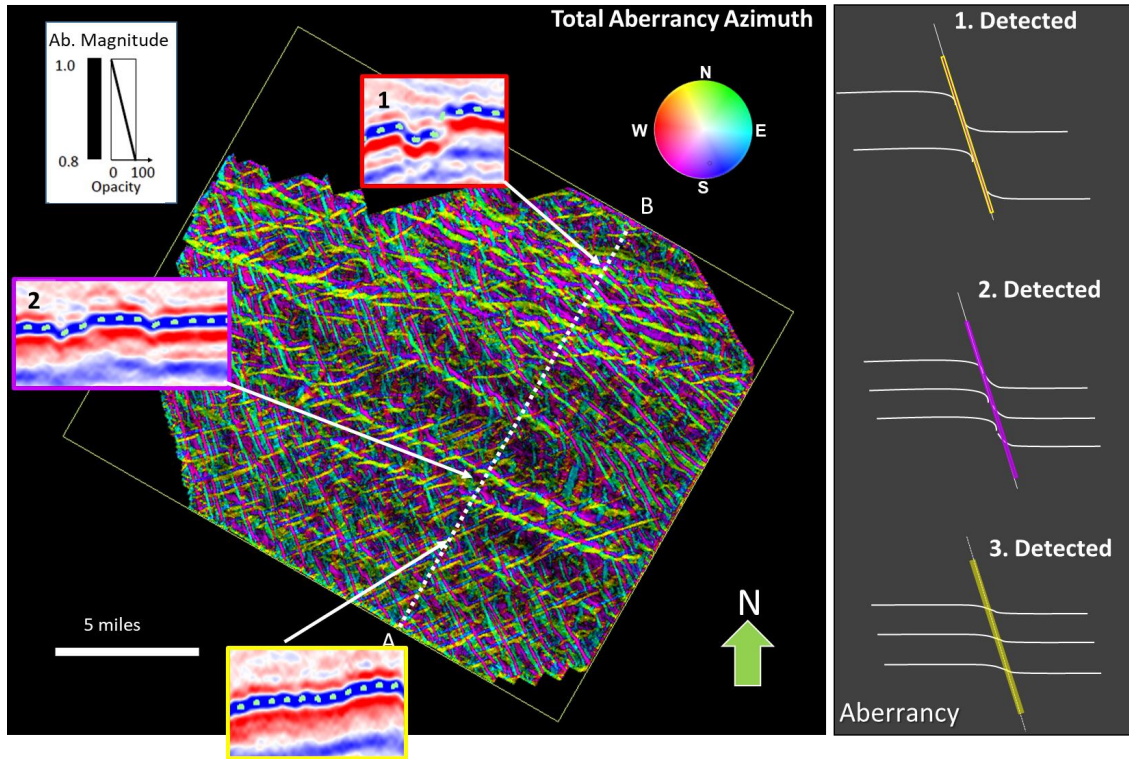
Aberrancy Attribute on the Shublik Shale



- **Aberrancy (Flexure)** measures the lateral change in curvature along a surface.
- Related to the 3rd order derivative.

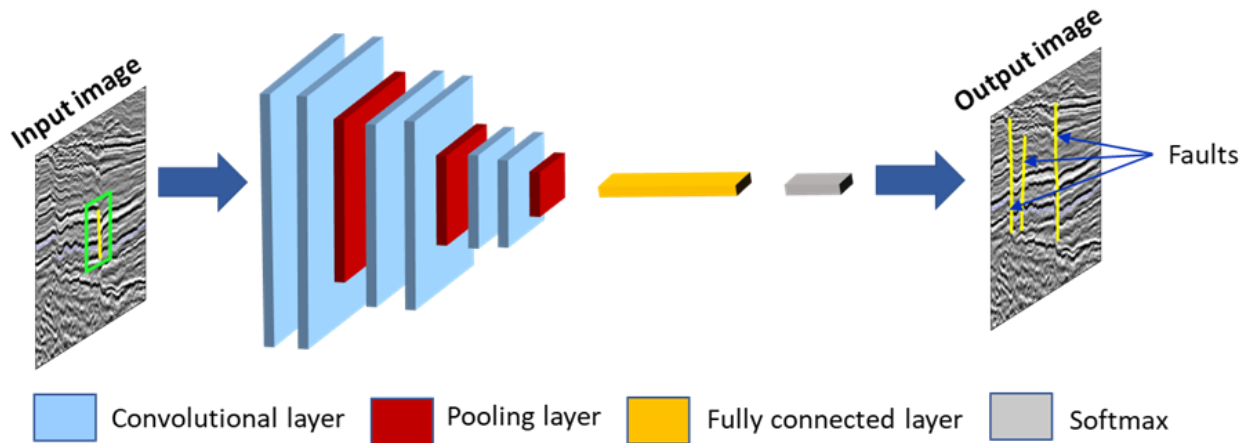


Aberrancy versus Coherence Results

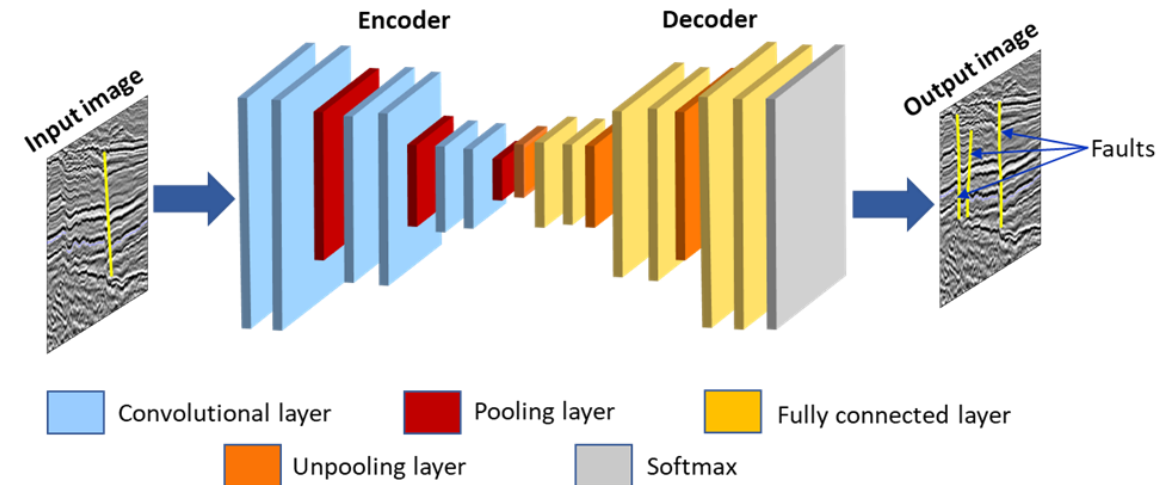


Convolutional Neural Network

- One of the most advanced machine learning algorithms for image analysis
- Growing applications in geosciences

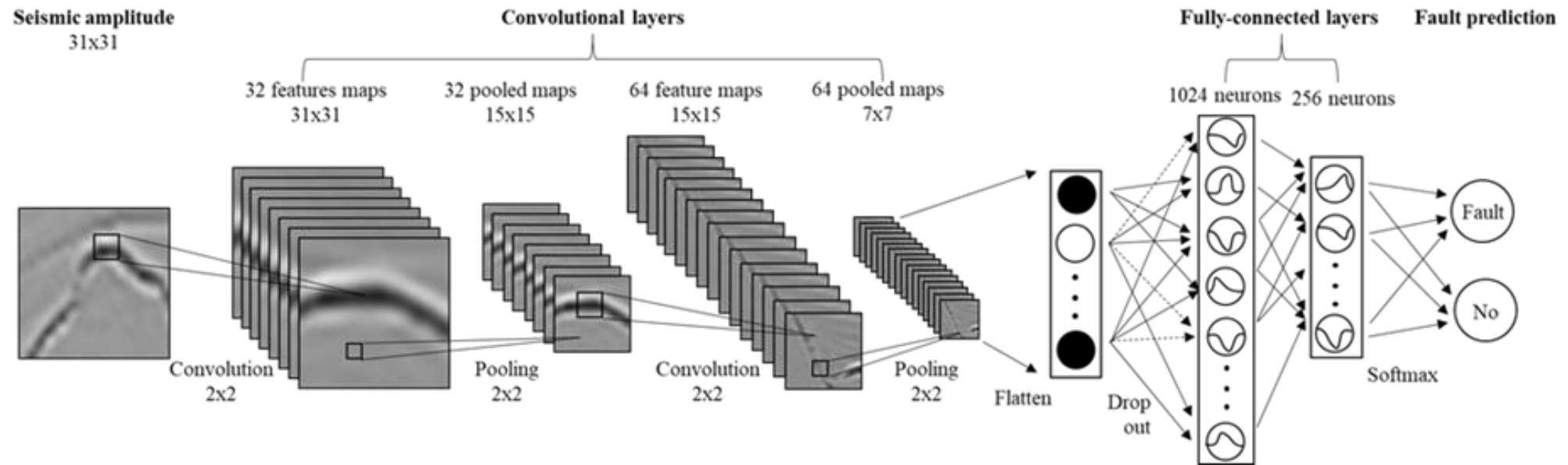


Fully connected CNN



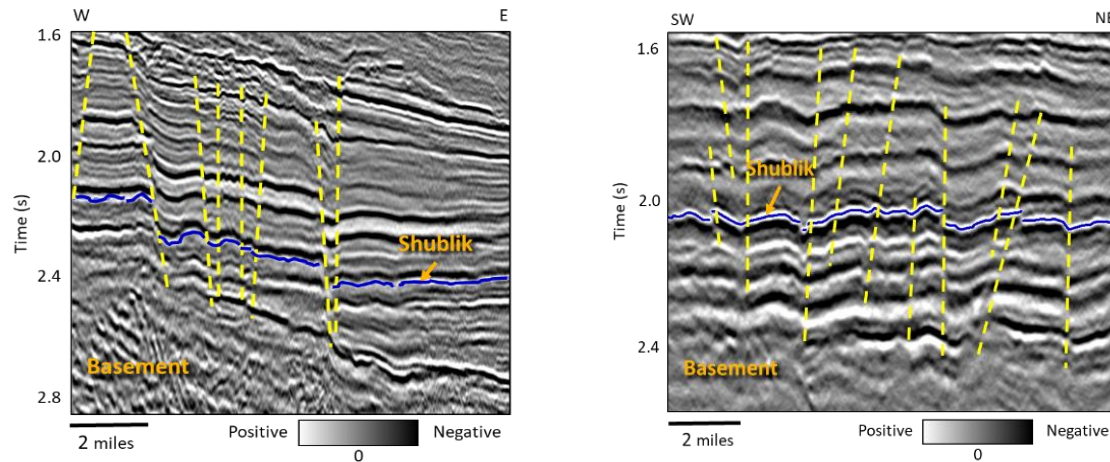
Encoder-decoder CNN

Convolutional Neural Network Architecture

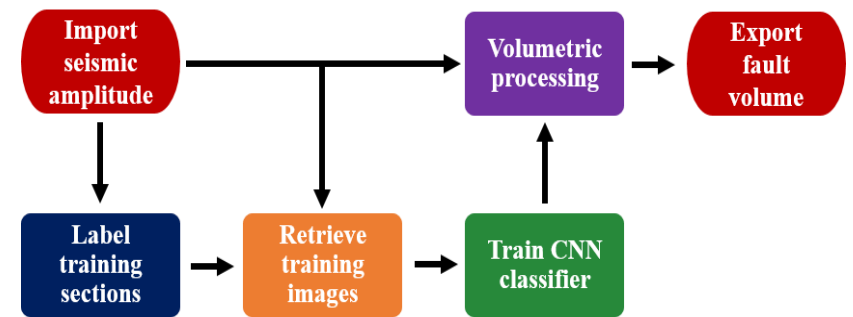


CNN architecture in this study

CNN Workflow



Interpreted seismic sections

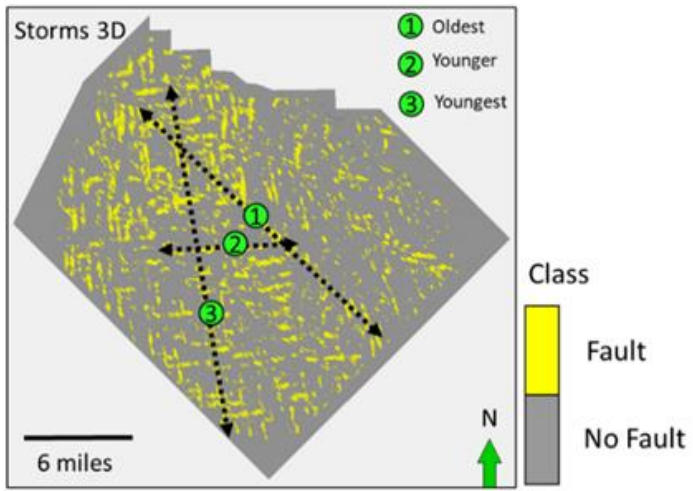
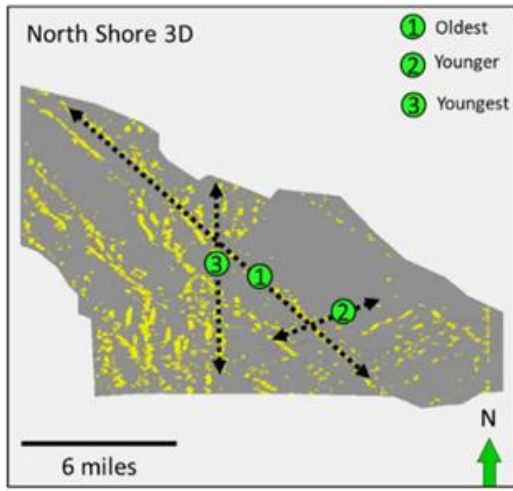


CNN Workflow

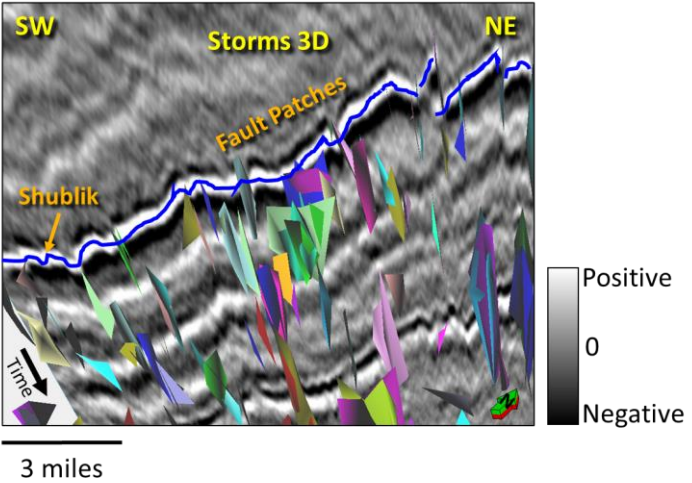
- Fault labeling:** Interpreted 20-30 lines out of 1000s in both 3D surveys
- CNN model training:** two convolutional layers and two fully-connected layers, used drop-out technique
- CNN model test:** Used three seismic section to test the model performance.
- Application of the model throughout full 3D volumes

CNN Results

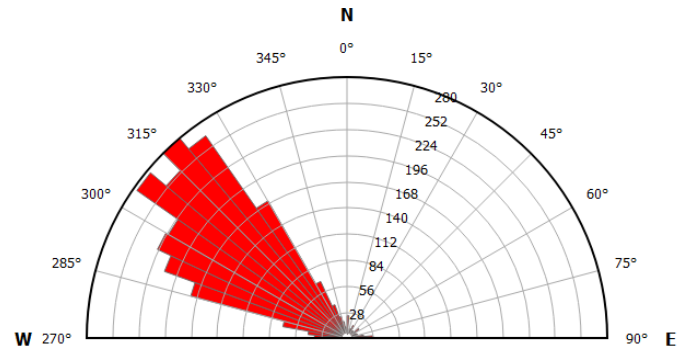
Map view of the faults on the Shublik surface



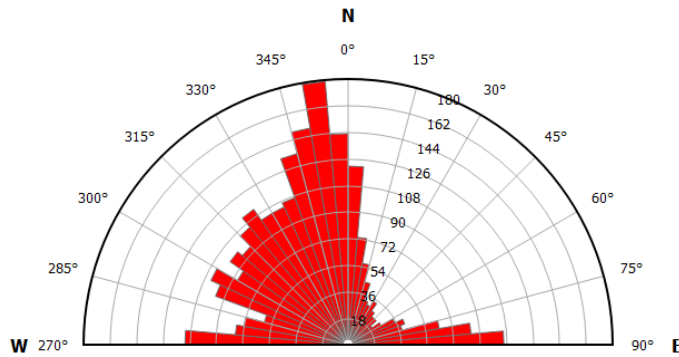
A 3D view of fault patches extracted from CNN



Fault Orientations

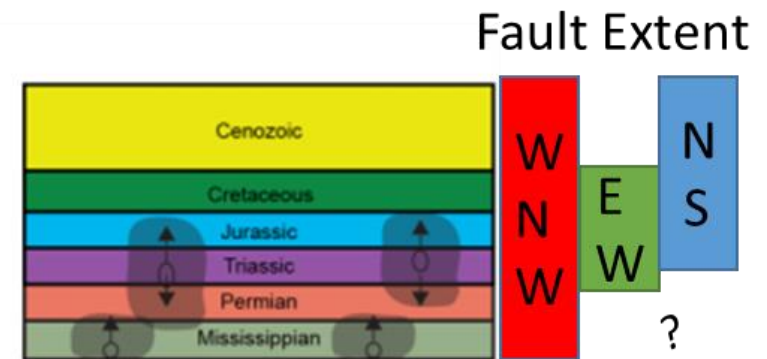


Economic Basement (Kekiktuk)



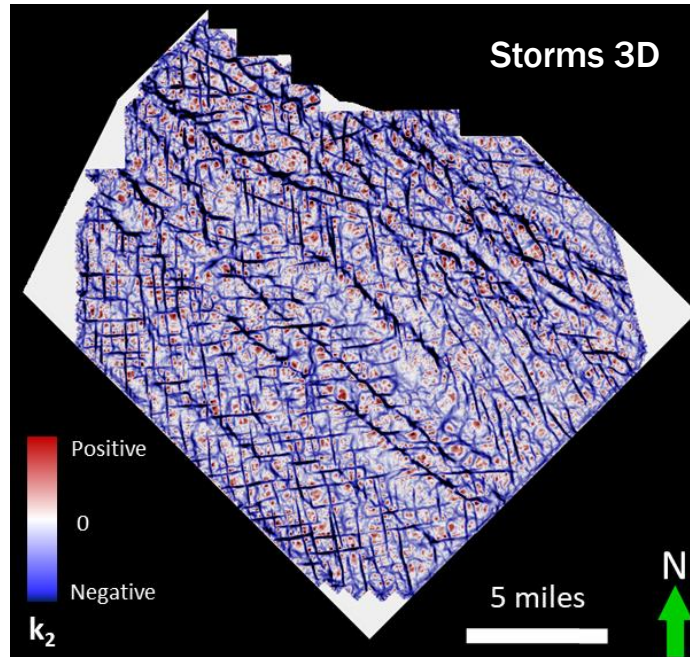
Shublik

Bhattacharya and Verma, 2019

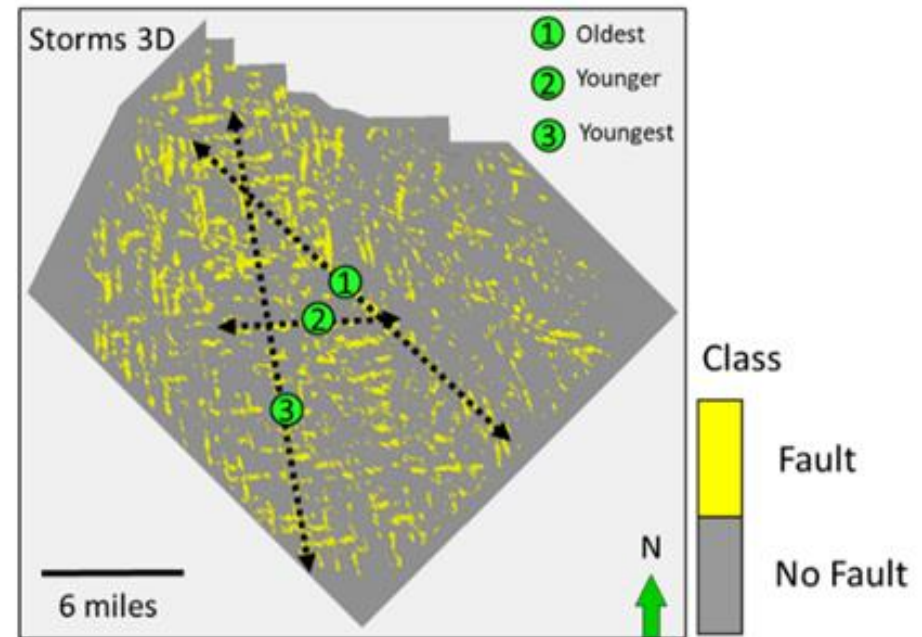


Modified after Tatarin, 2019

New Research?



Curvature Attribute Result

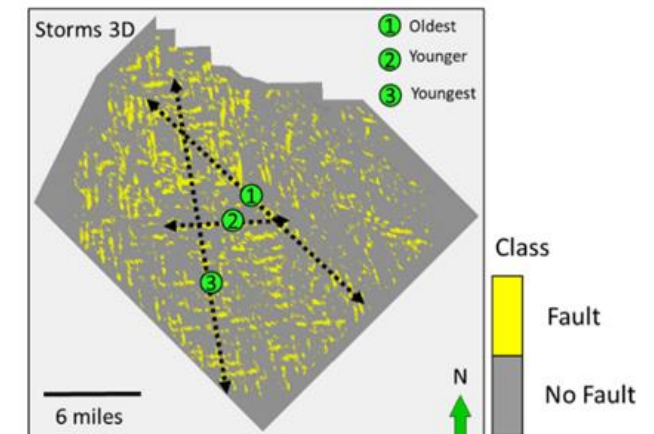
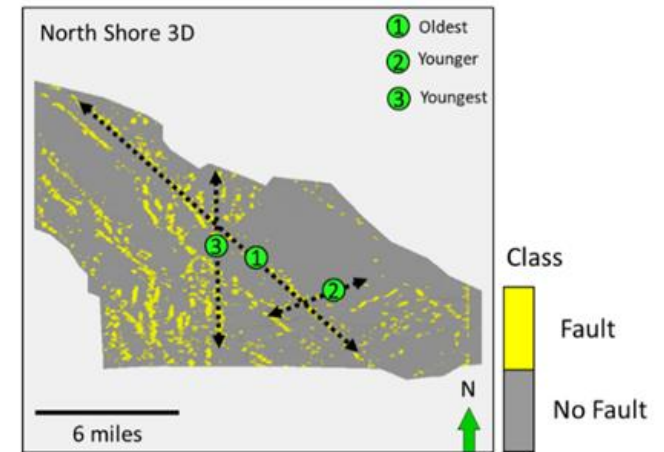


CNN Result

Curved fault segments, including relay ramps are not visible on the CNN. Why?

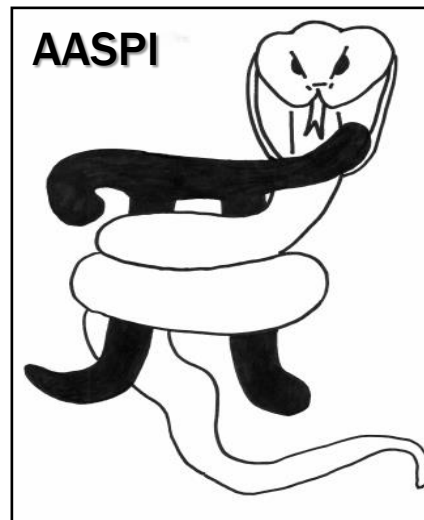
Summary

- The Shublik Shale affected by at least three different faults along WNW, EW, and NS.
- CNN helped to automate the process of fault interpretation in two large 3D surveys.
- Use ML with caution! A lot to learn about our data yet...

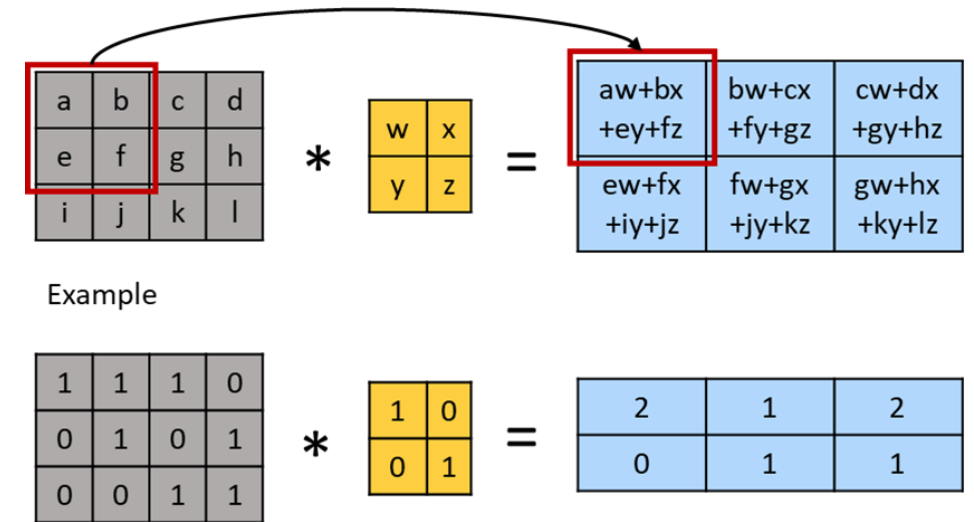
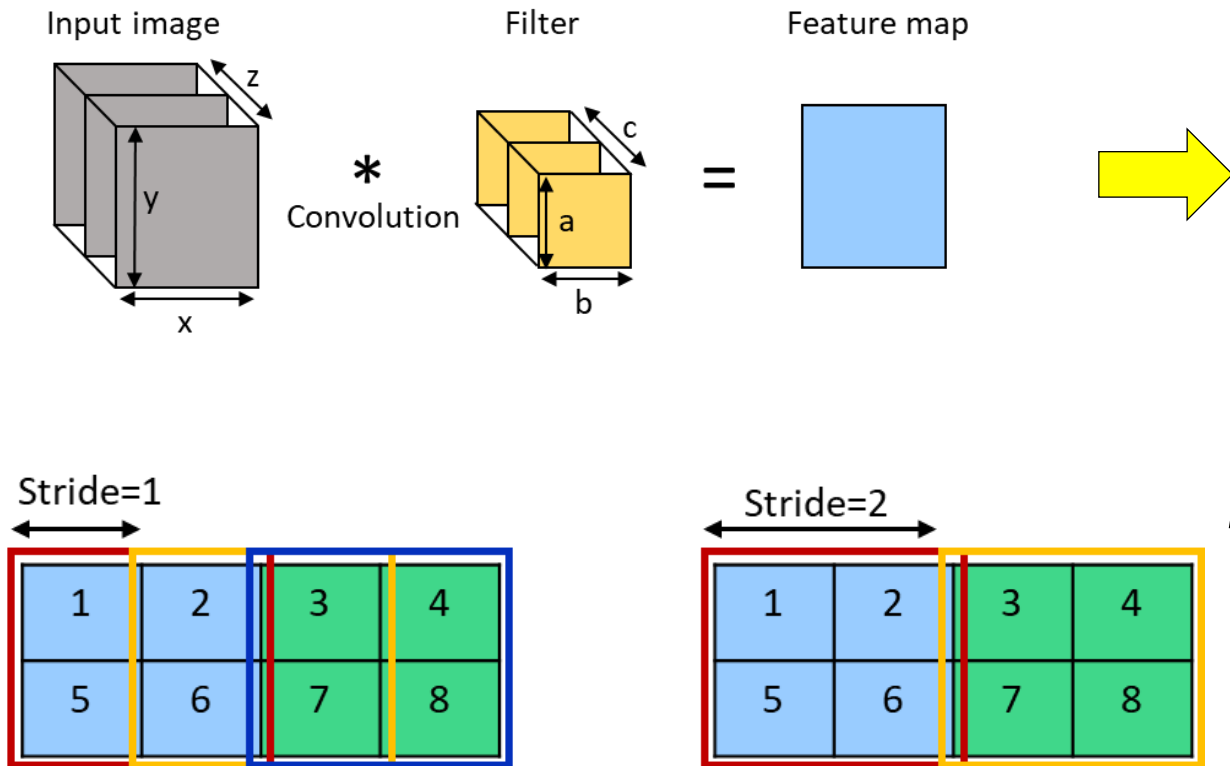


CNN fault results

Thanks to sponsors for your support

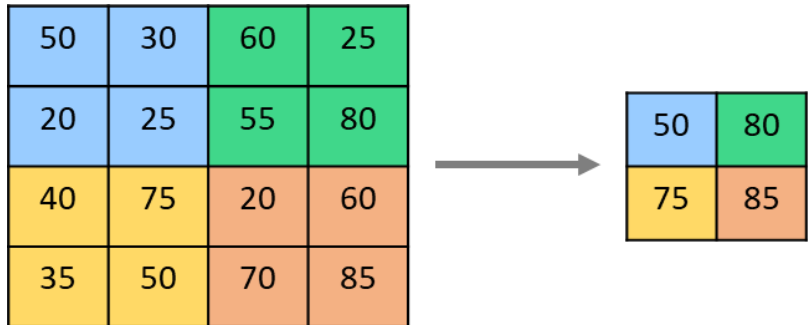


How does convolution work in CNN?



An example of convolutional operation in CNN

Downsampling and Fully Connected Layers



The concept of pooling (downsampling) layers

