3-D Seismic Attributes for Reservoir Characterization

Coherence and curvature attribute applications

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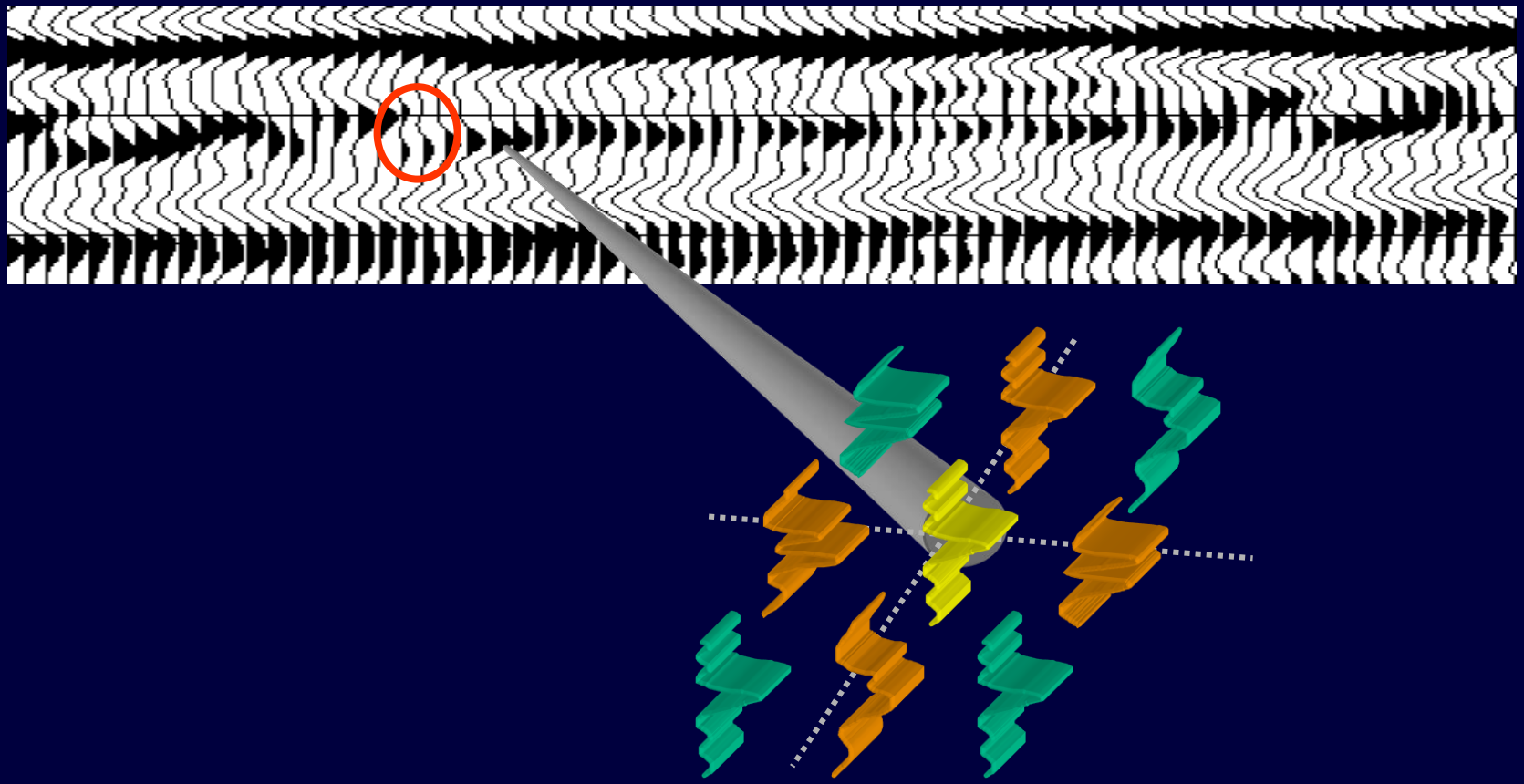
Course conducted on SPG platform

What is coherence?

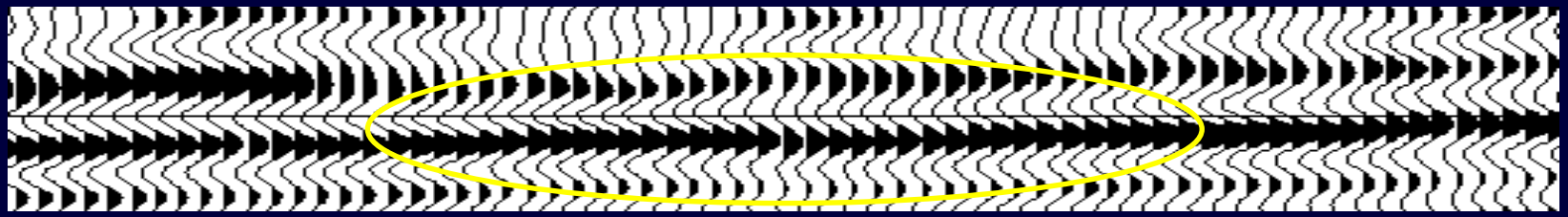
- Measures the similarity of the seismic waveform between adjacent traces.
- Images <u>discontinuities</u> in your seismic data, instead of reflections.
- Reveals structural and stratigraphic changes in your data, such as faults, channels, reef edges

Coherence measures the similarity of the waveform between neighbouring traces.

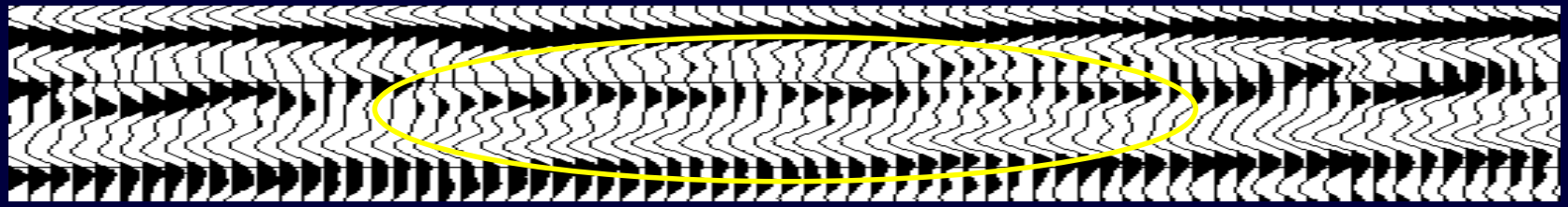


Coherence display convention

measurement of local waveform similarity within a “global” aperture defined in space and time



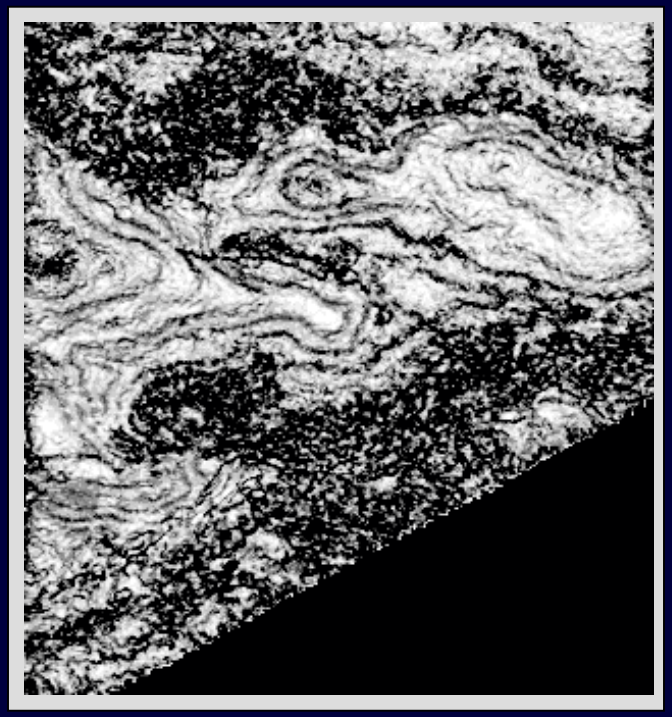
high coherence event ~ high values typically displayed as light colors



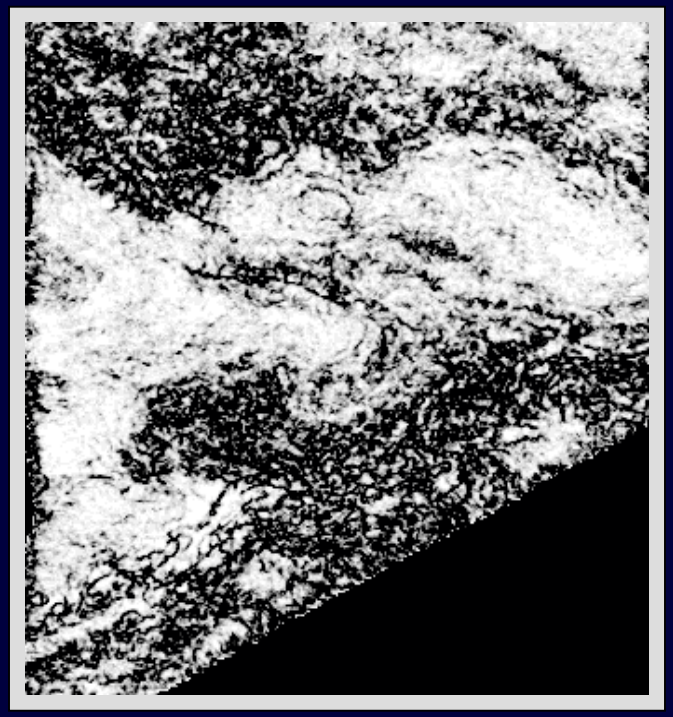
low coherence event ~ low values typically displayed as dark colors

Coherence with dip steering

Coherence without dip steering



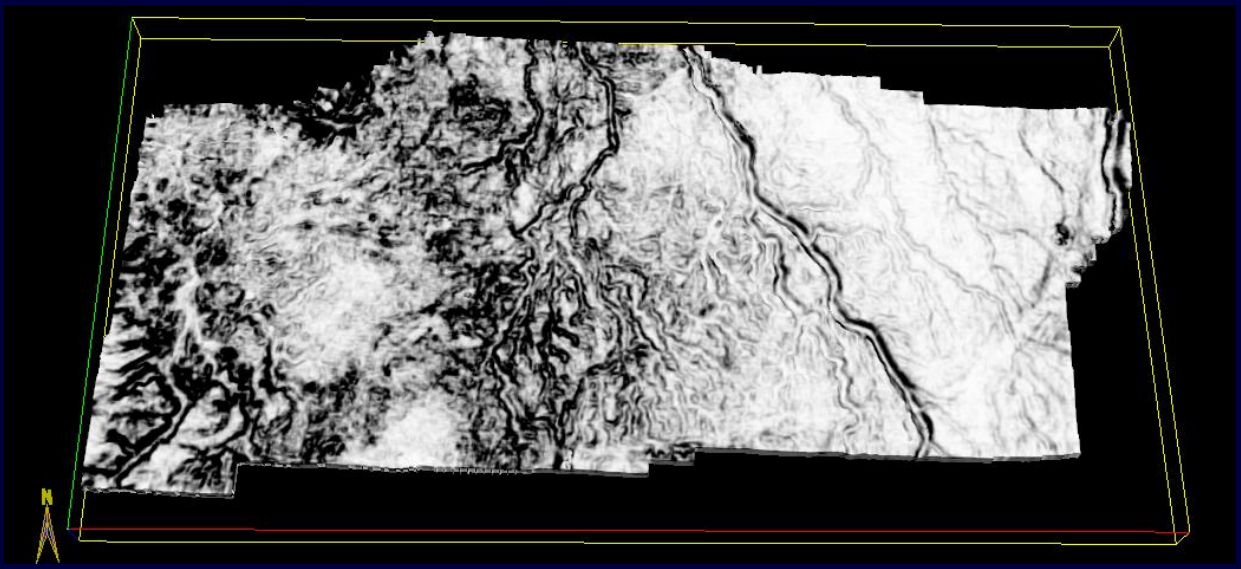
Coherence with dip steering



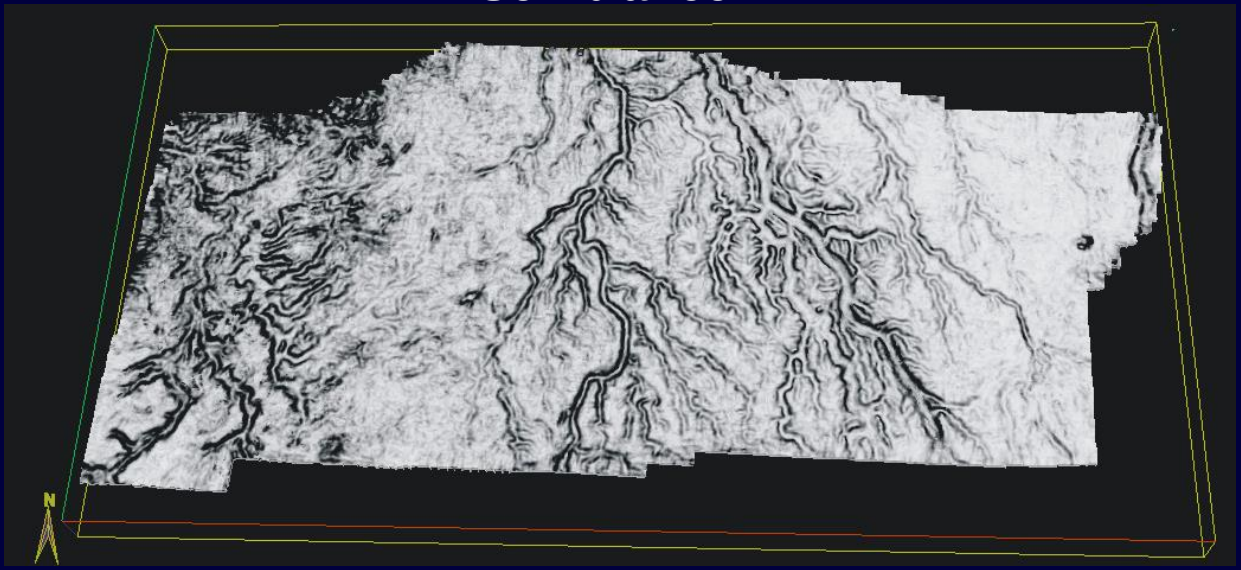
Chopra, 2002

Dip steering minimizes structural artifacts, as shown above.

Coherence with data conditioning

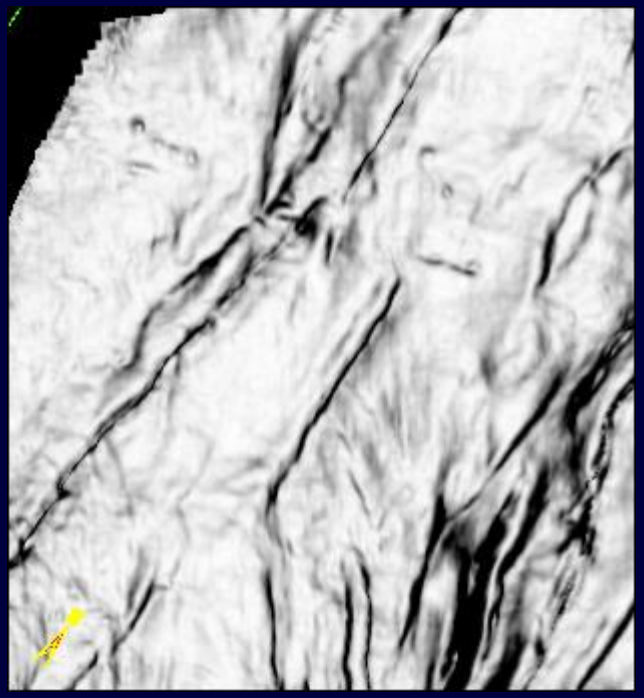


Semblance

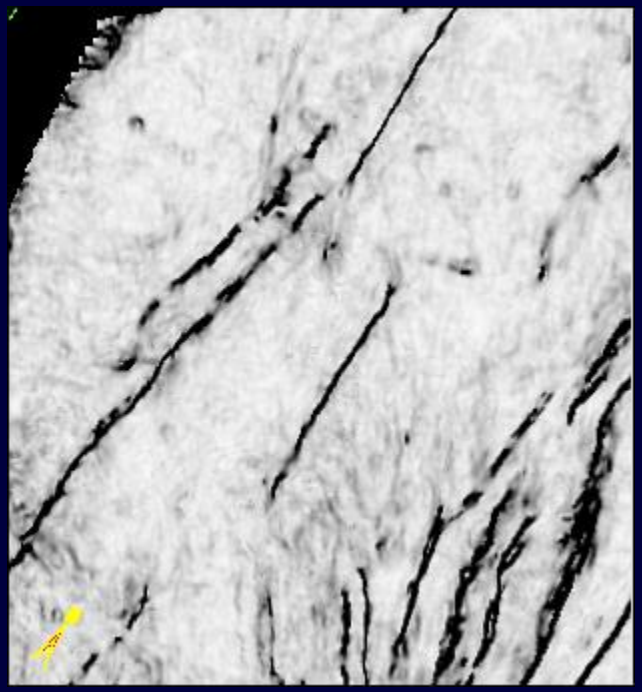


Coherence (Energy-ratio) after pc-filtering

Coherence with data conditioning

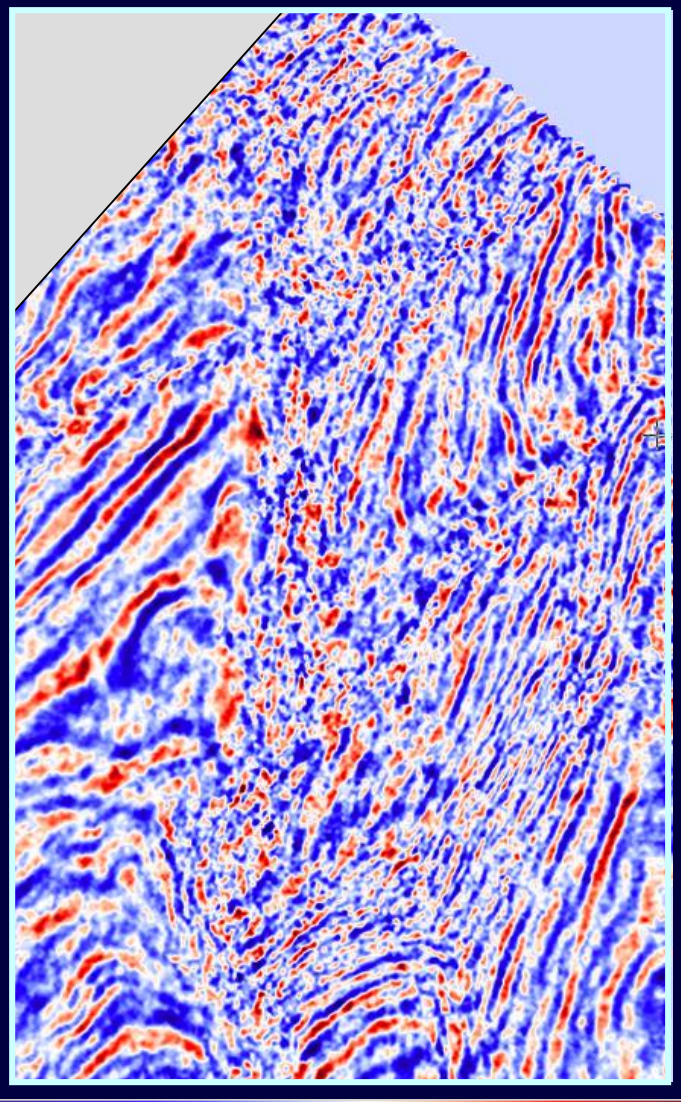


Semblance



Coherence (Energy-ratio) after swtructure-oriented filtering

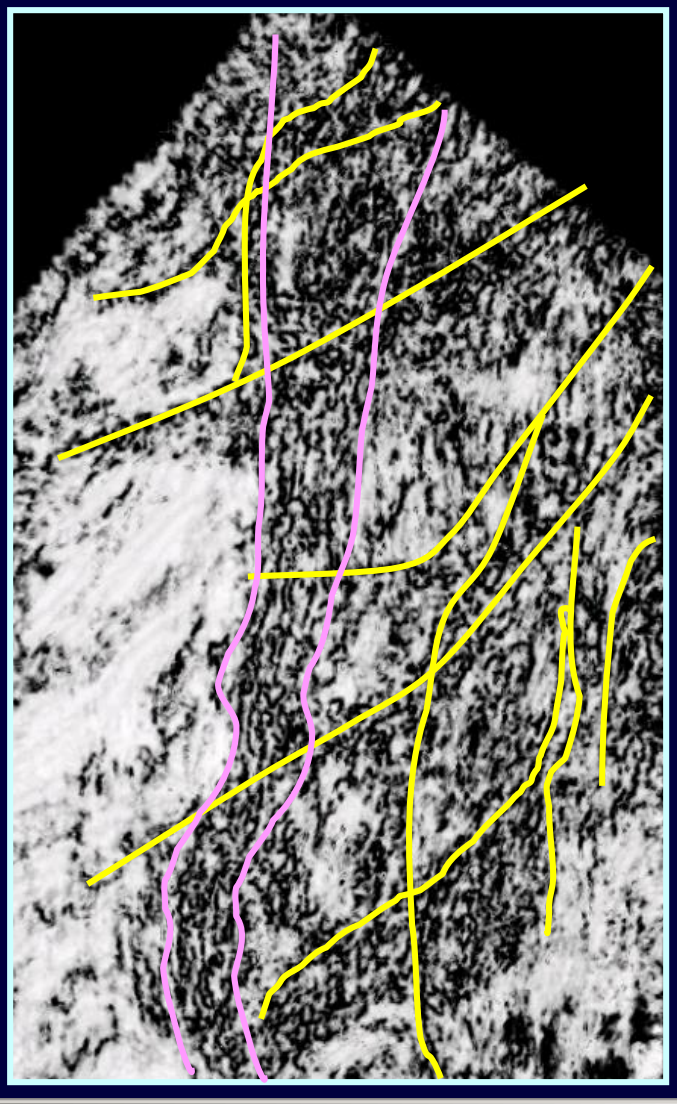
Time slices (676 ms)



Negative

Positive

Seismic

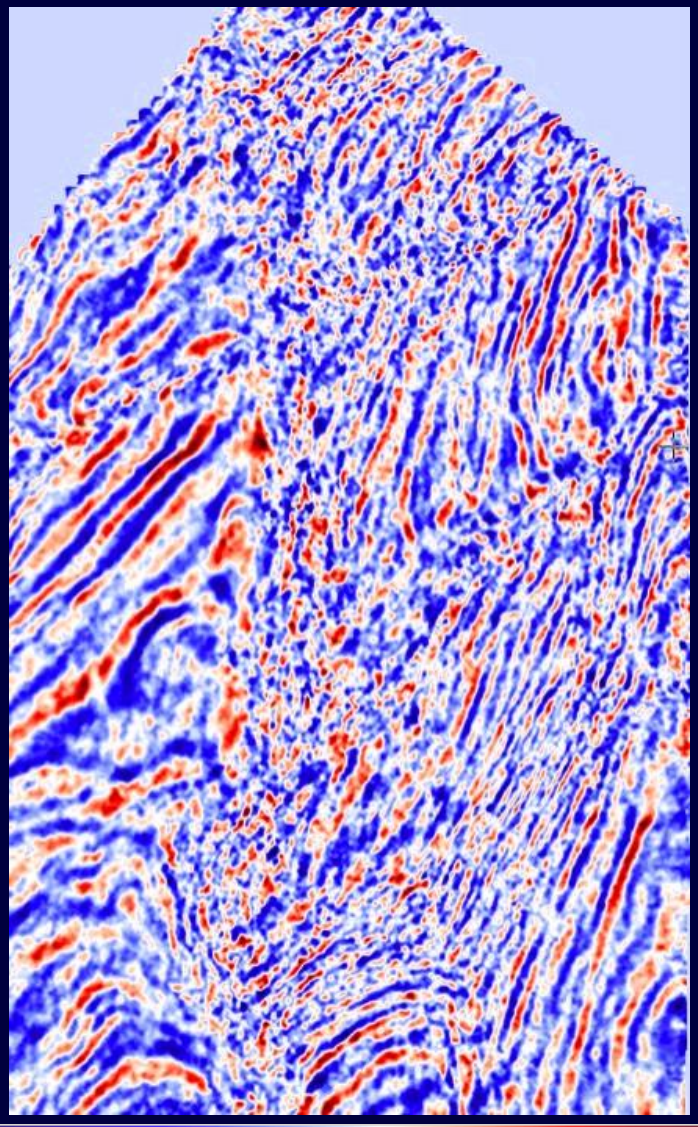


Low

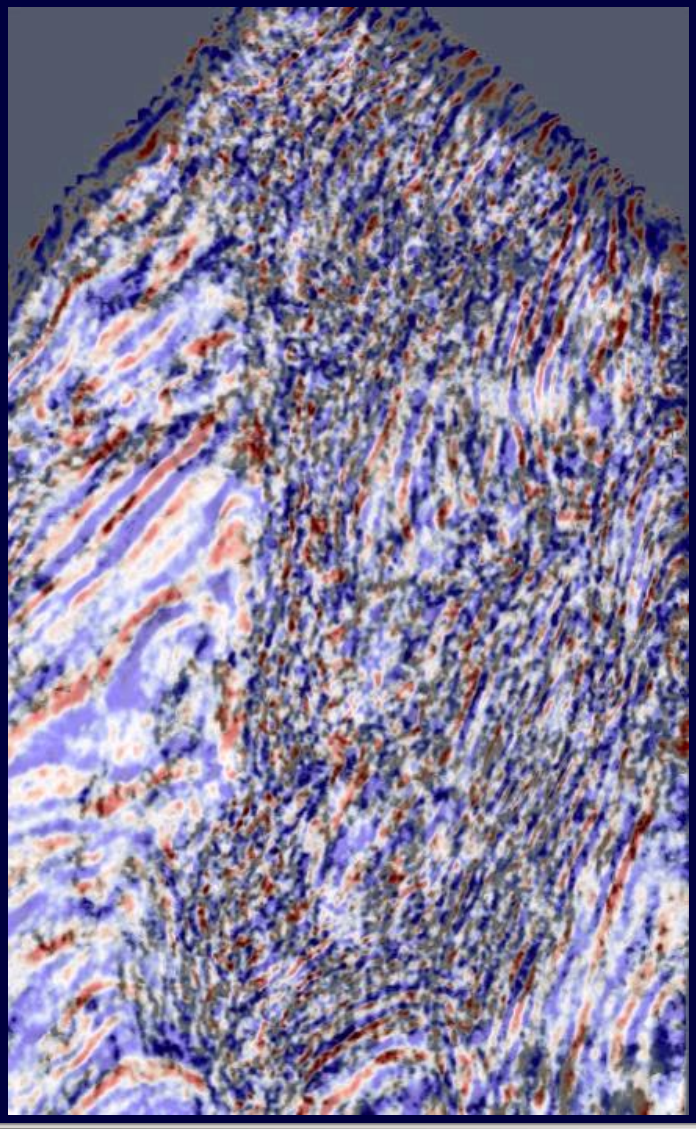
High

Coherence

Time slices (676 ms)

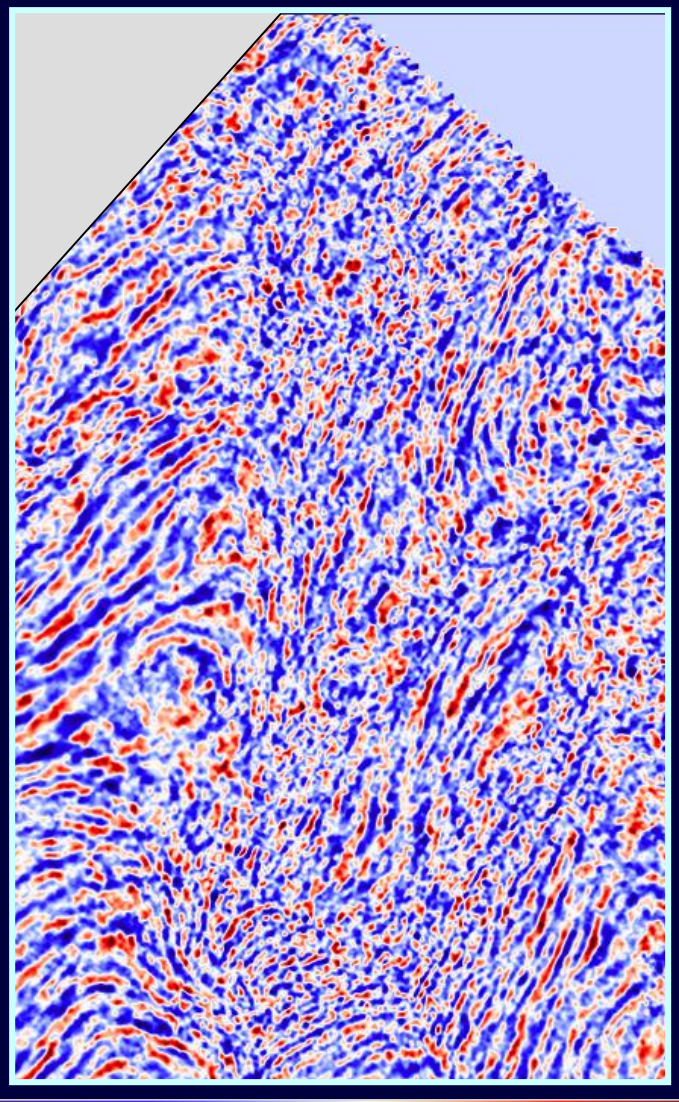


Seismic



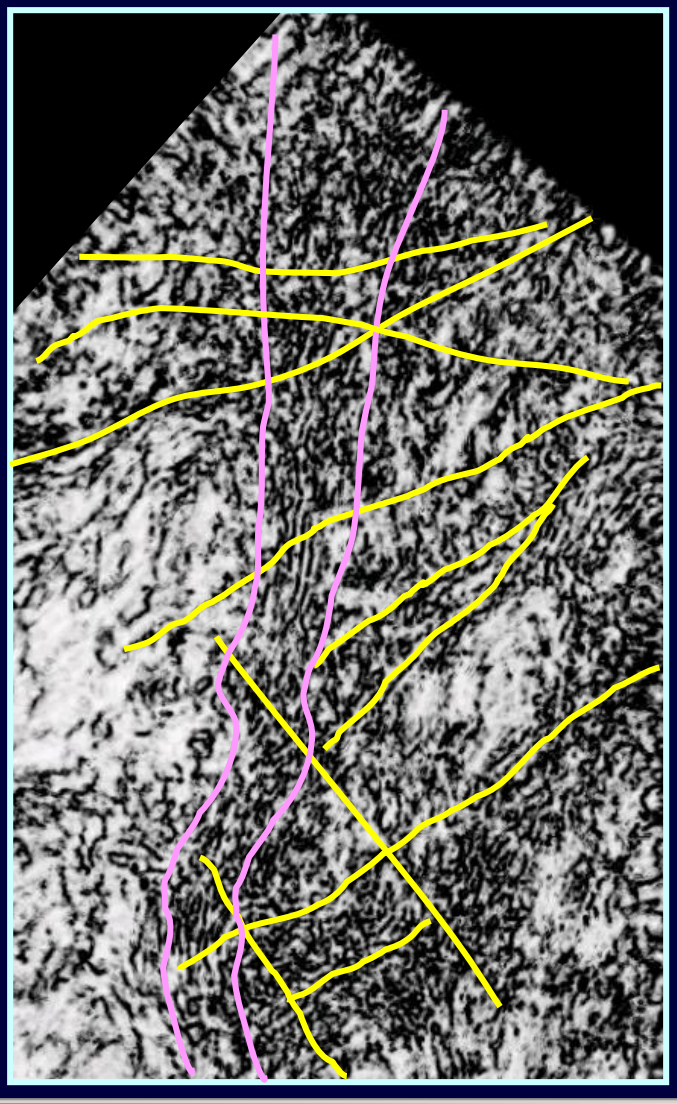
Coherence

Time slices (1176 ms)



Negative — Positive

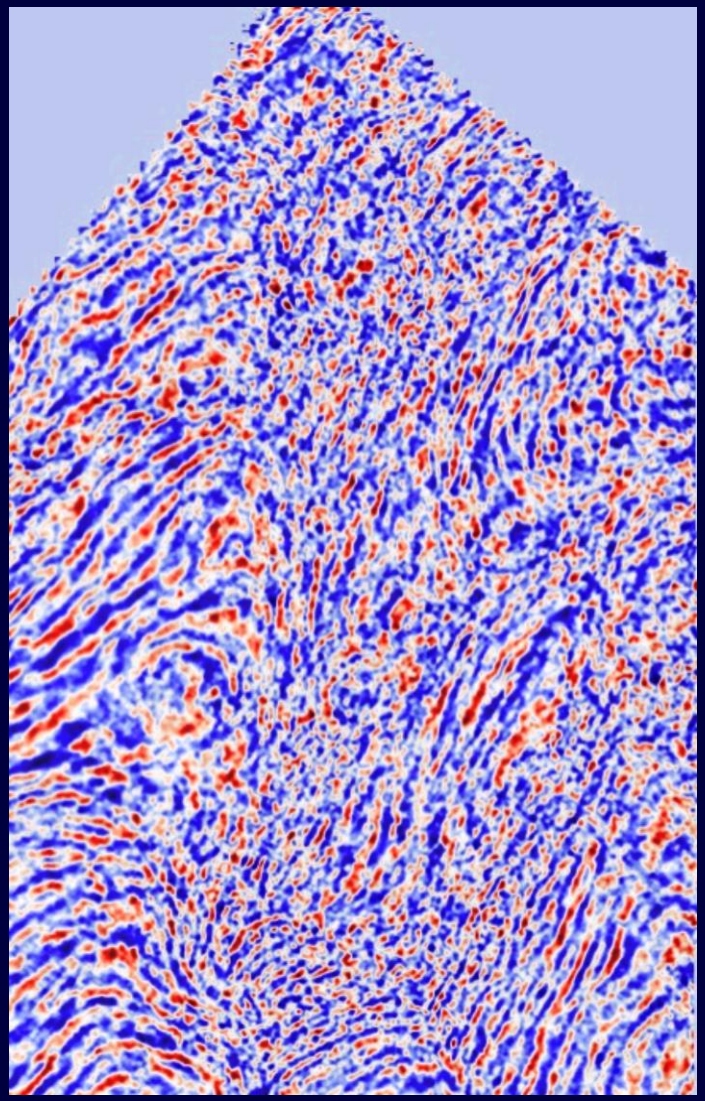
Seismic

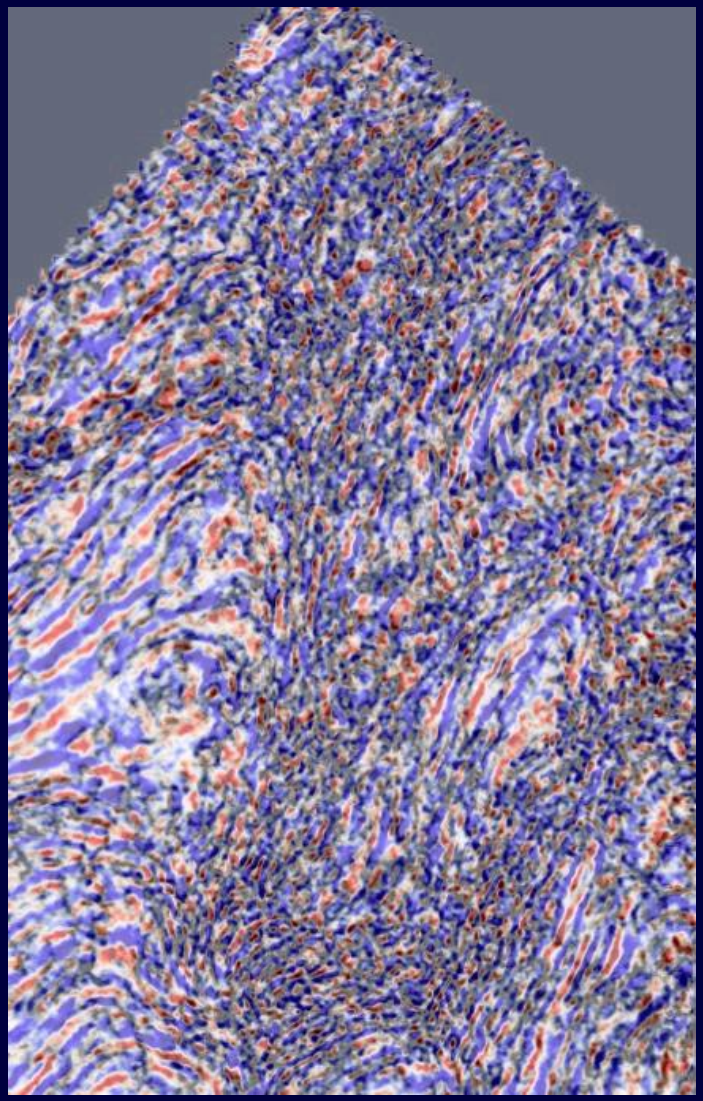


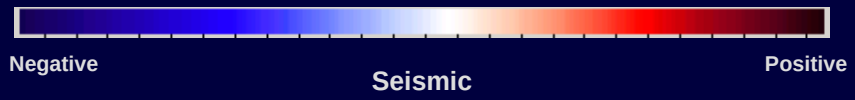
Low — High

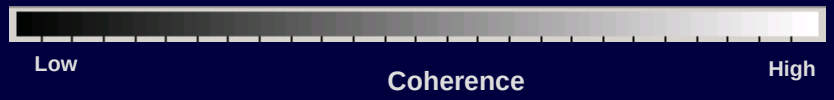
Coherence

Time slices (1176 ms)

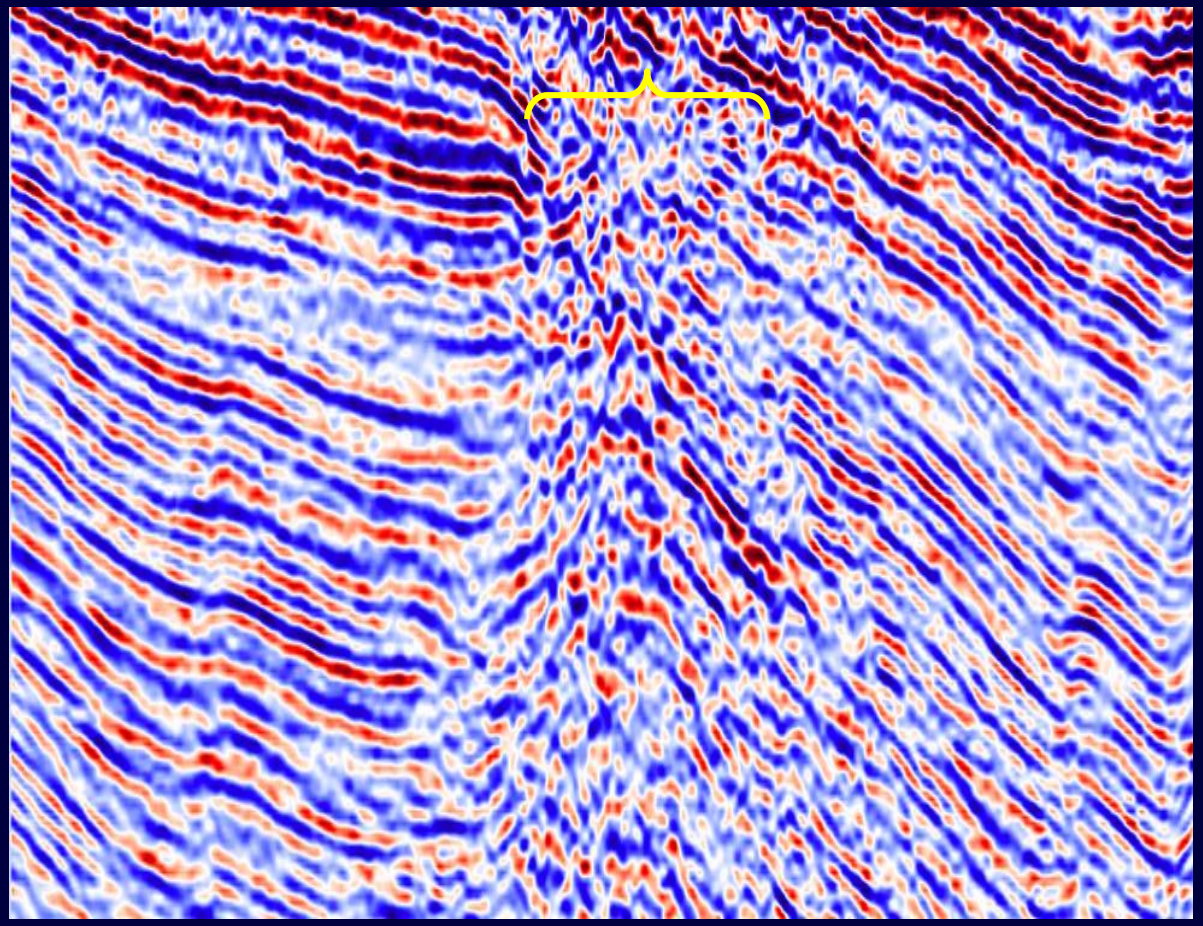


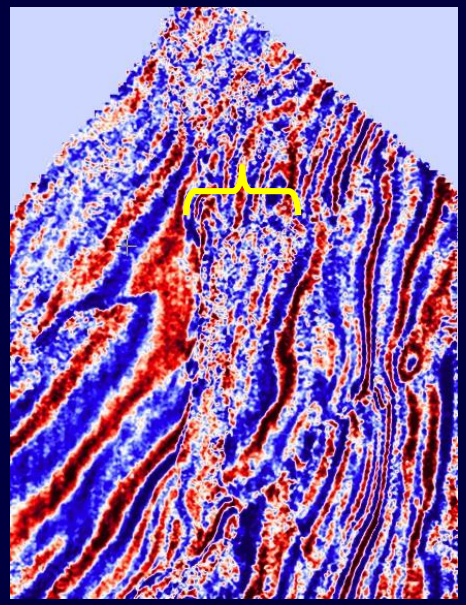


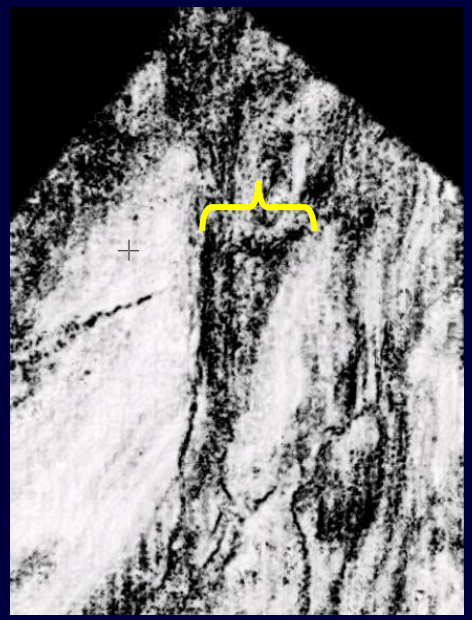




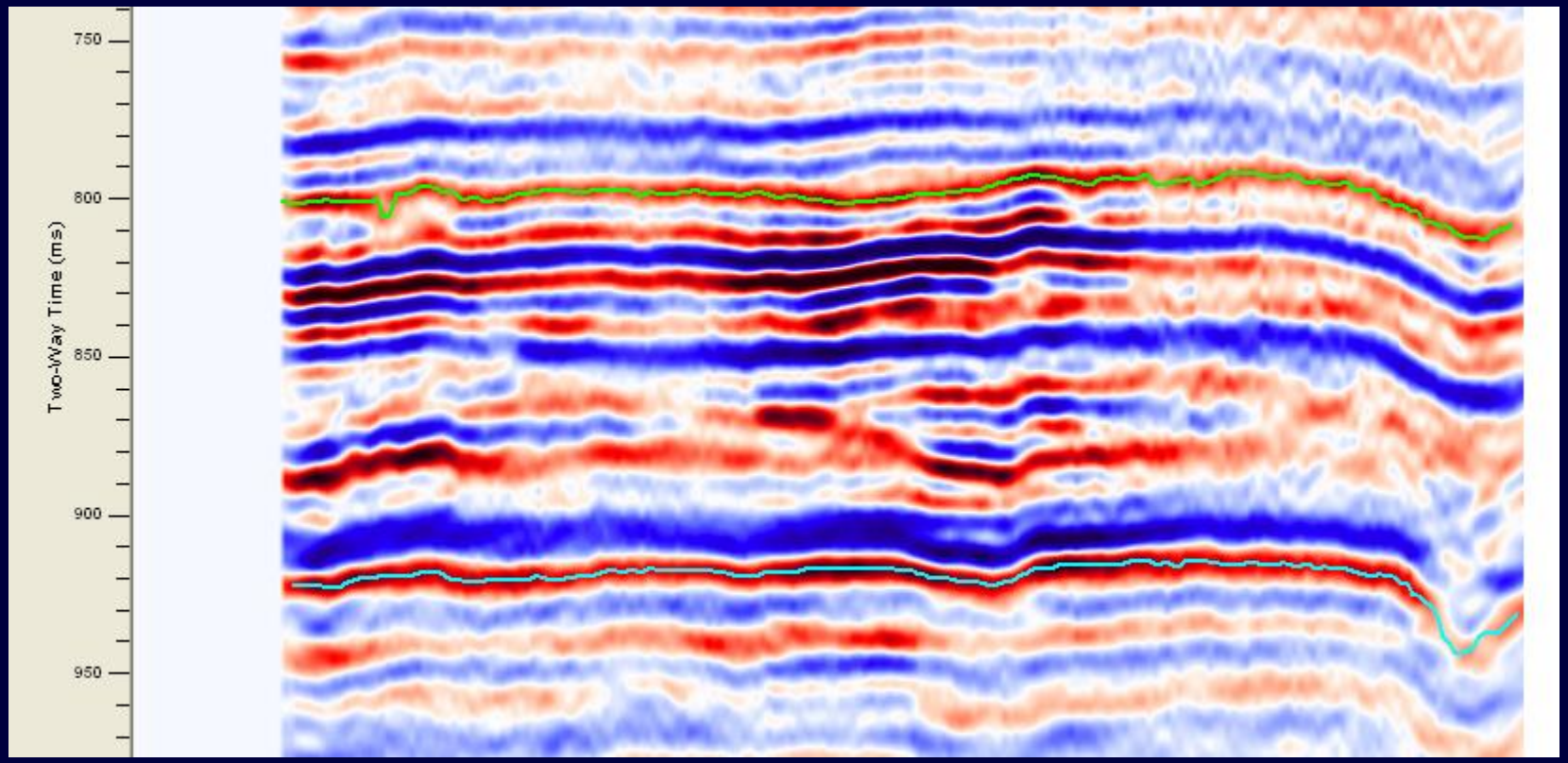
Correlation of coherence signature with seismic



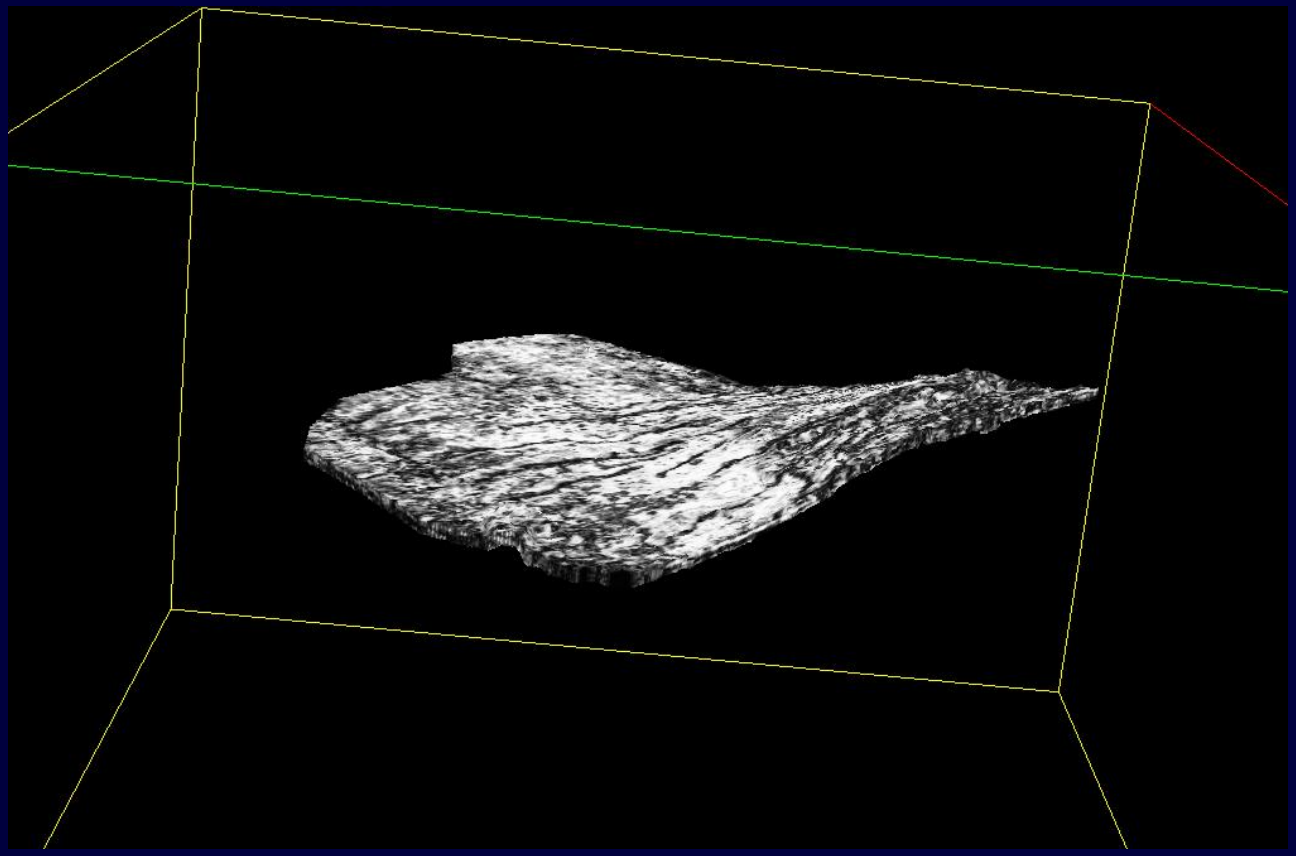




Strat-cubes

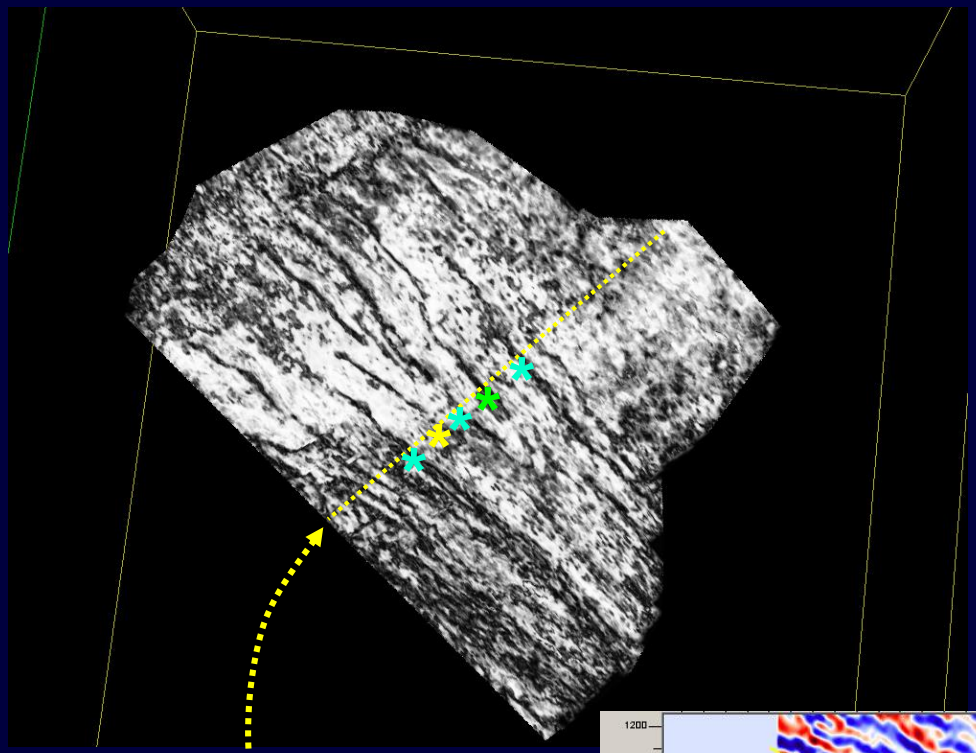


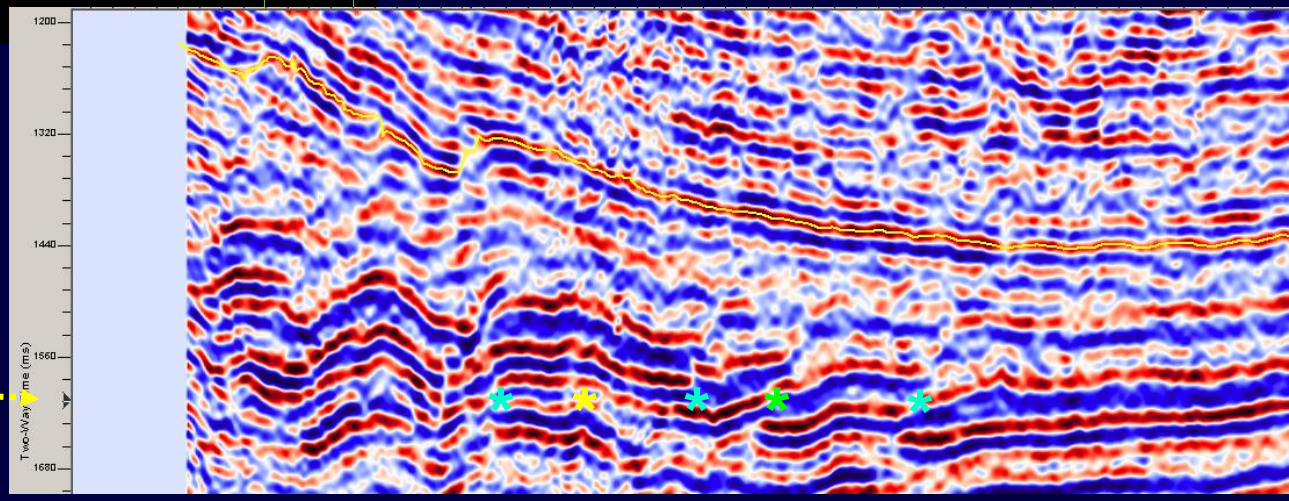
Strat-cube (coherence)



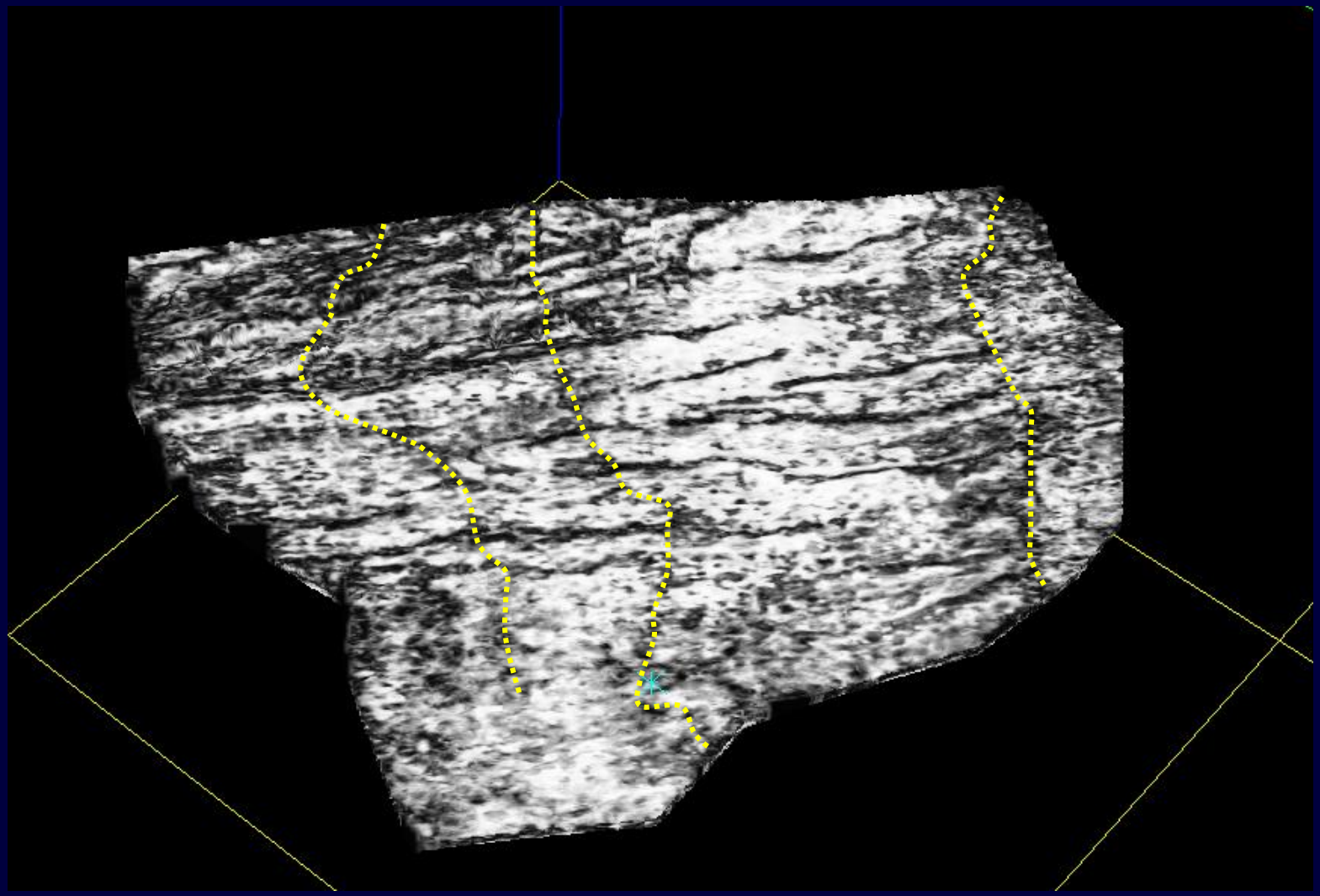
Coherence

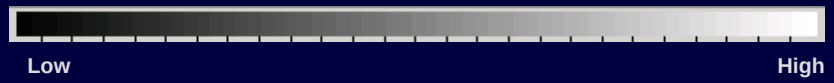
Strat-cube (coherence)





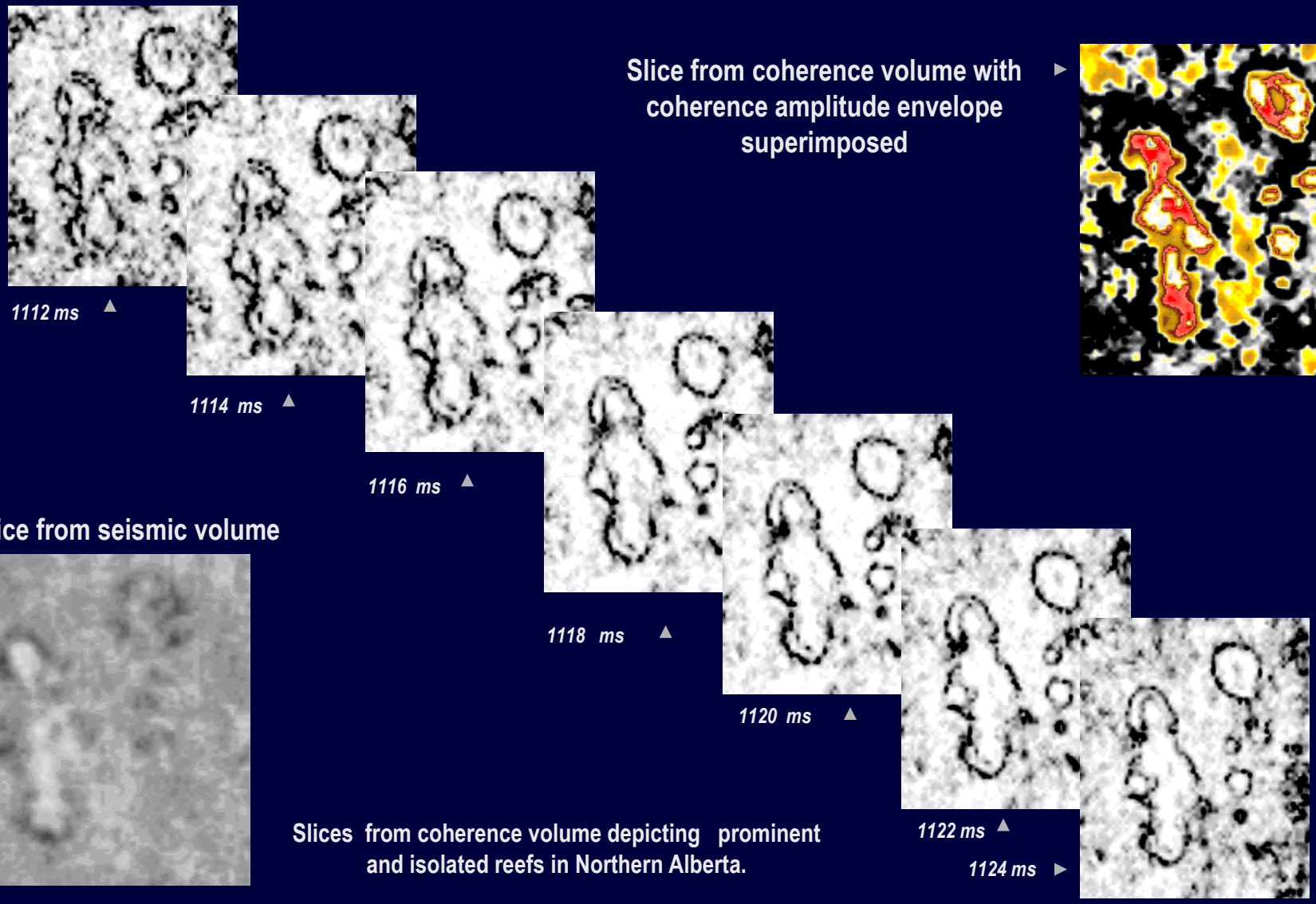
Cross faults on coherence strat-cube





Coherence

Reefs



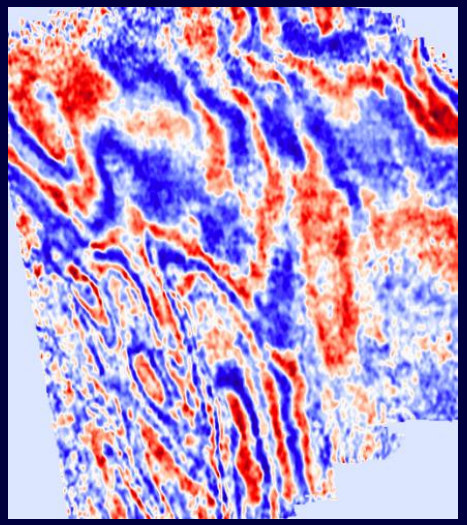
Slice from coherence volume with coherence amplitude envelope superimposed

Slice from seismic volume

Slices from coherence volume depicting prominent and isolated reefs in Northern Alberta.

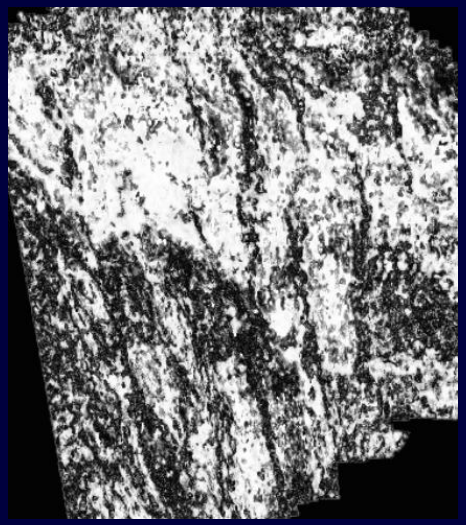
Chopra, 2001

Comparison of time slices (1572 ms)

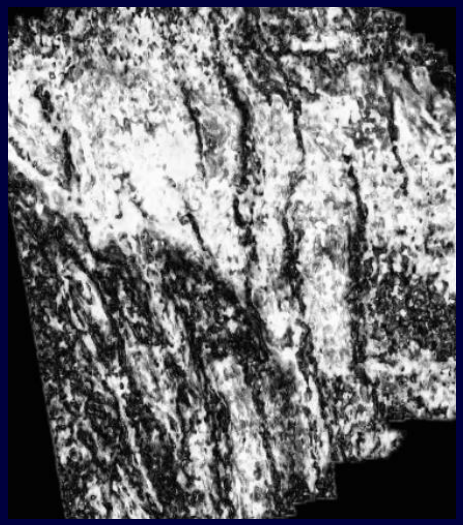


Seismic

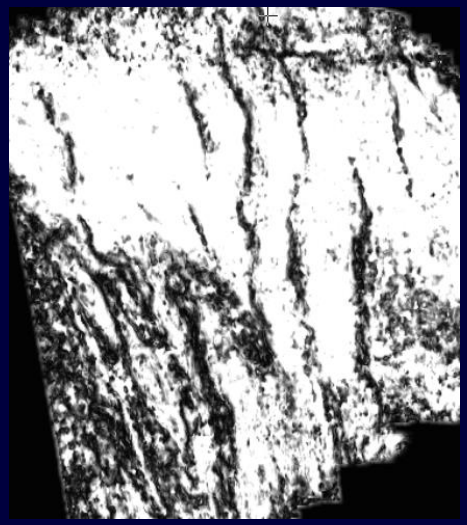
Coherence computation using a semblance algorithm



Parameters 3,3,10ms

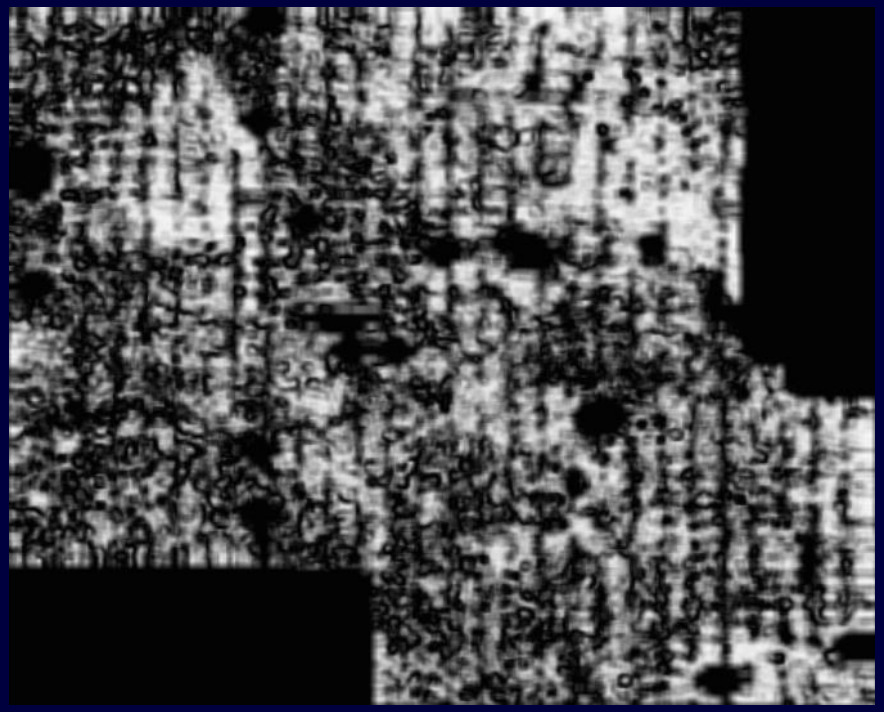


Parameters 5,5,10ms

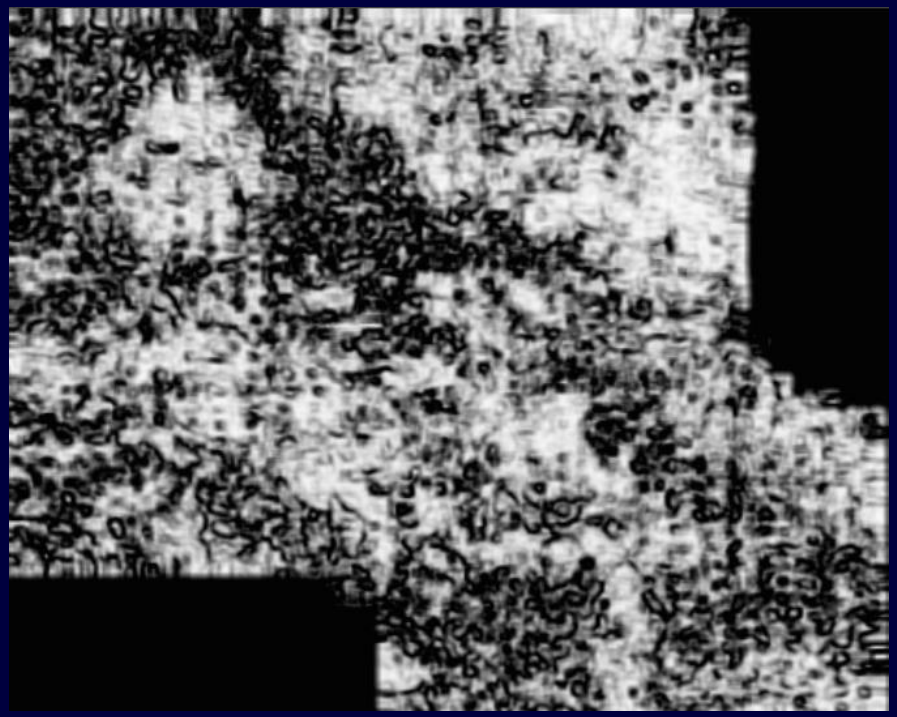


Parameters 7,7,10ms

Time slices (320 ms)



Without AMO

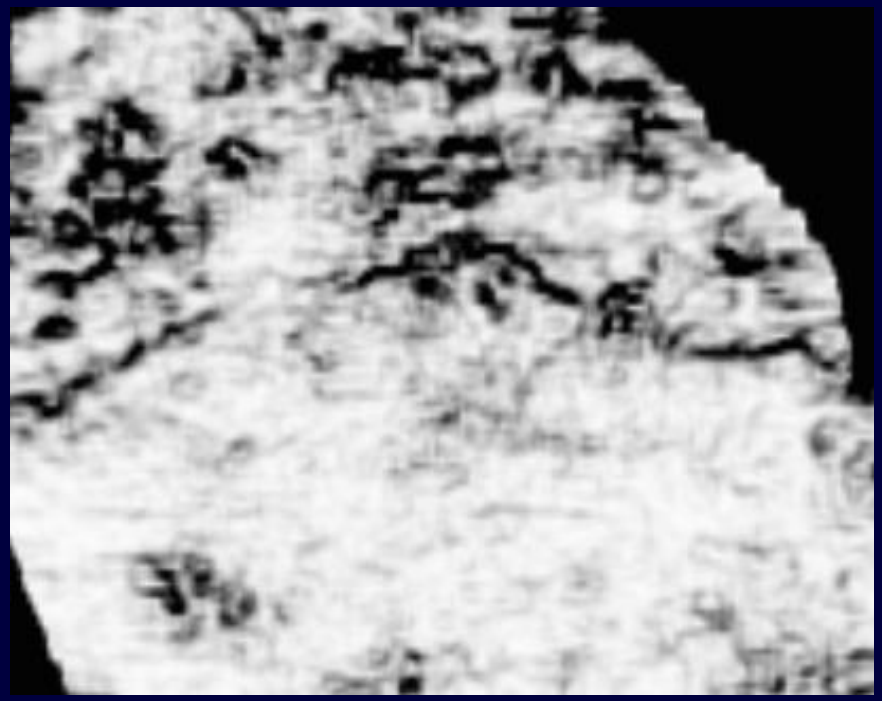


With AMO

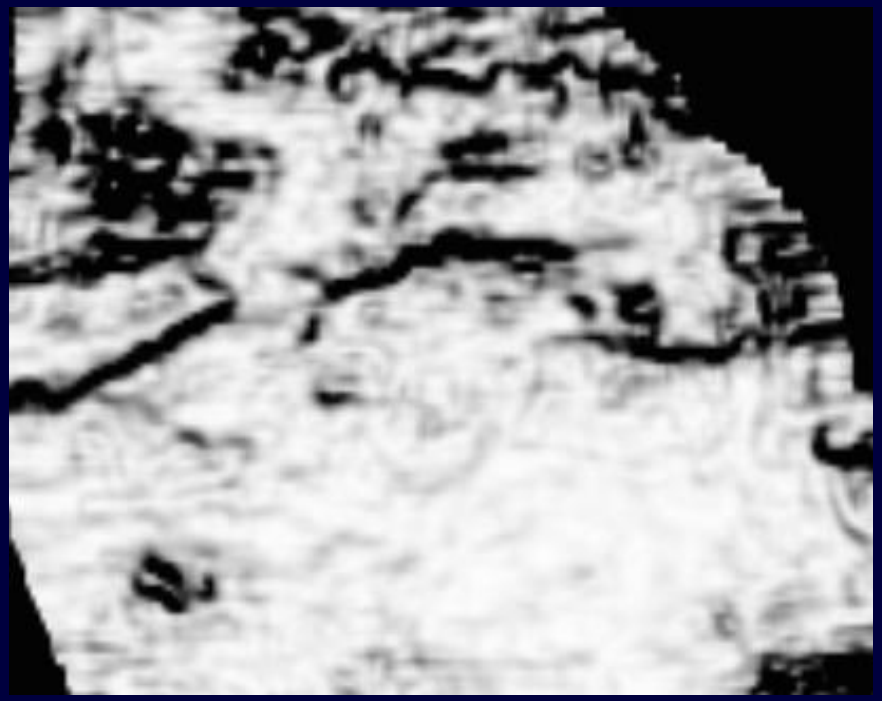
Low High

Coherence

Time slices (1248 ms)



Without AMO

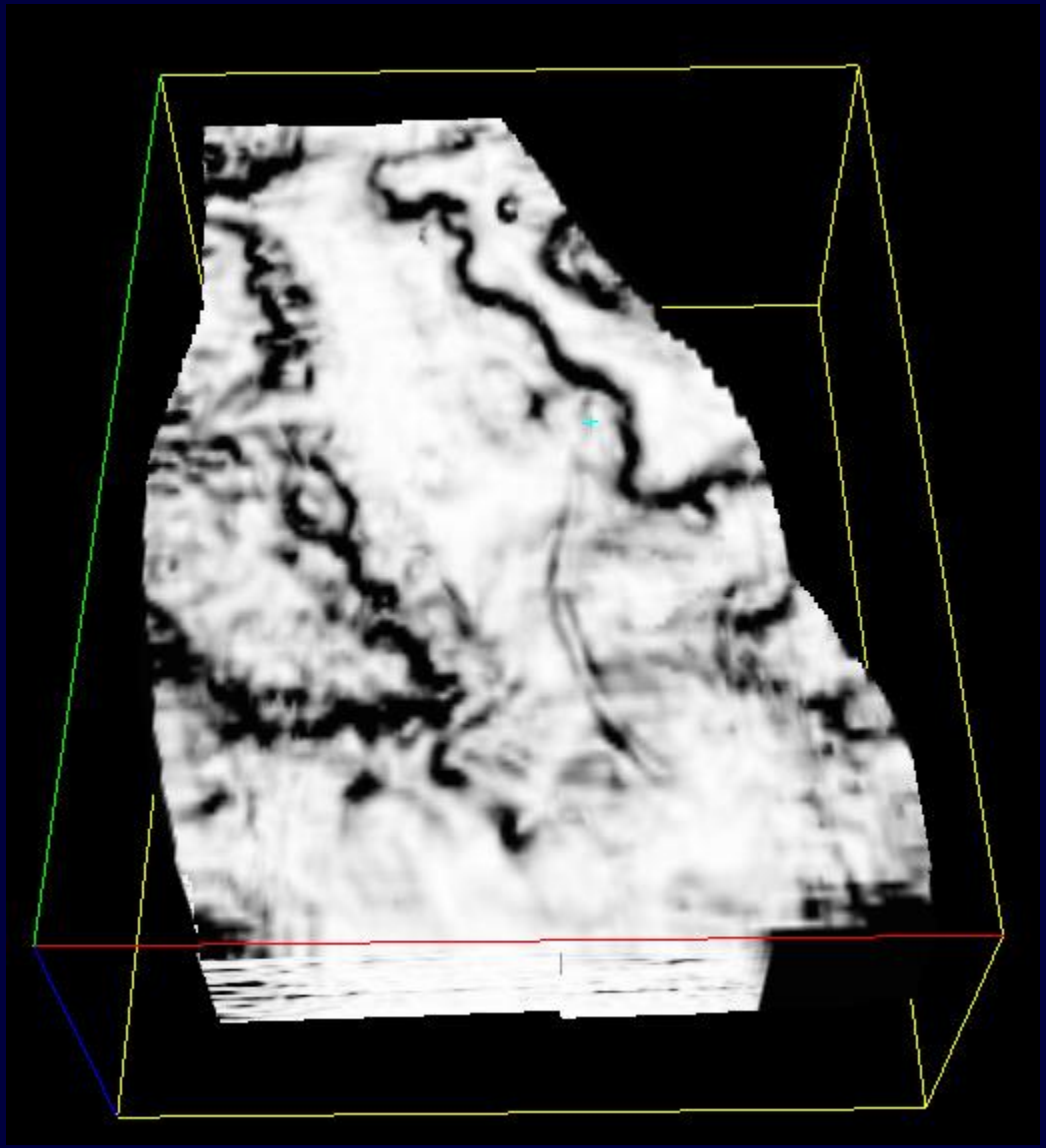


With AMO

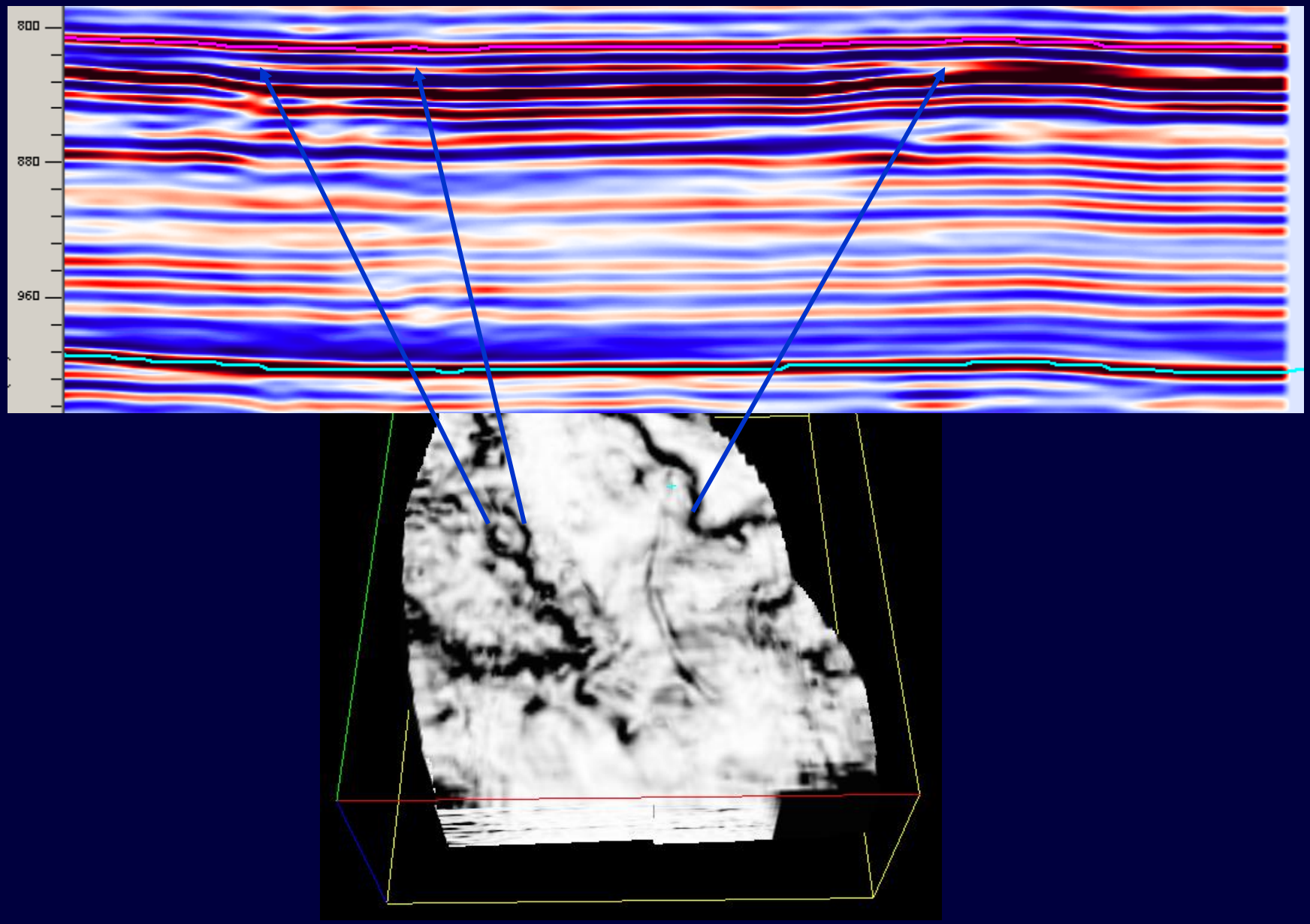
Low High

Coherence

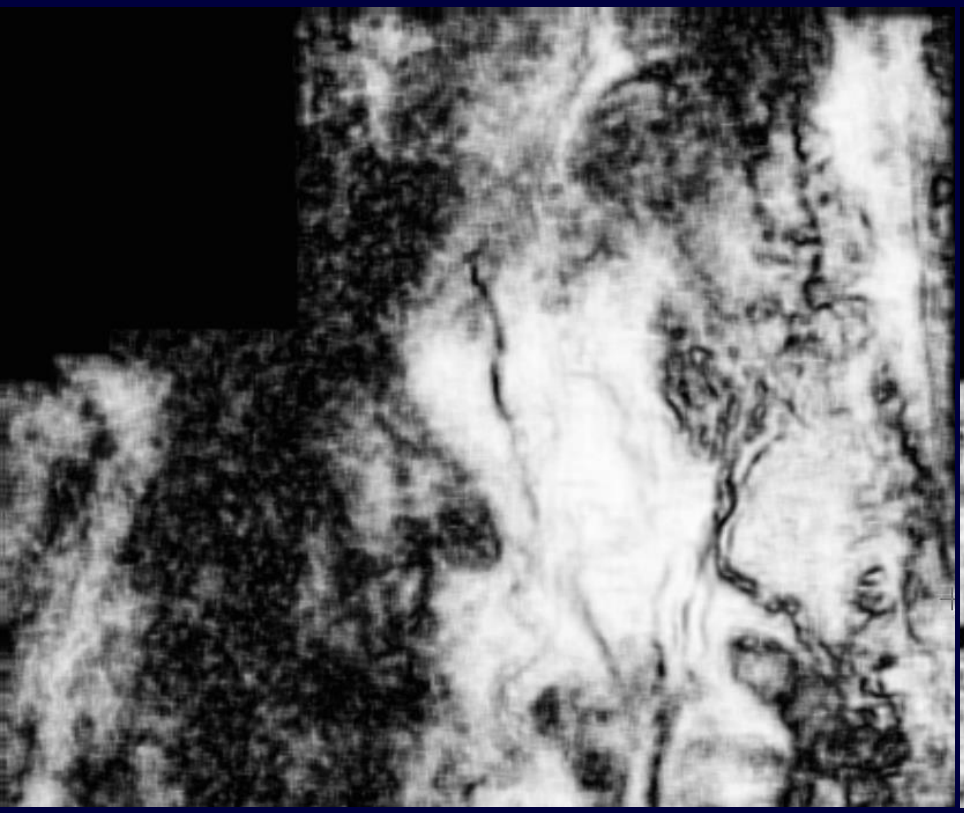
Stratcube (800 – 1000ms)



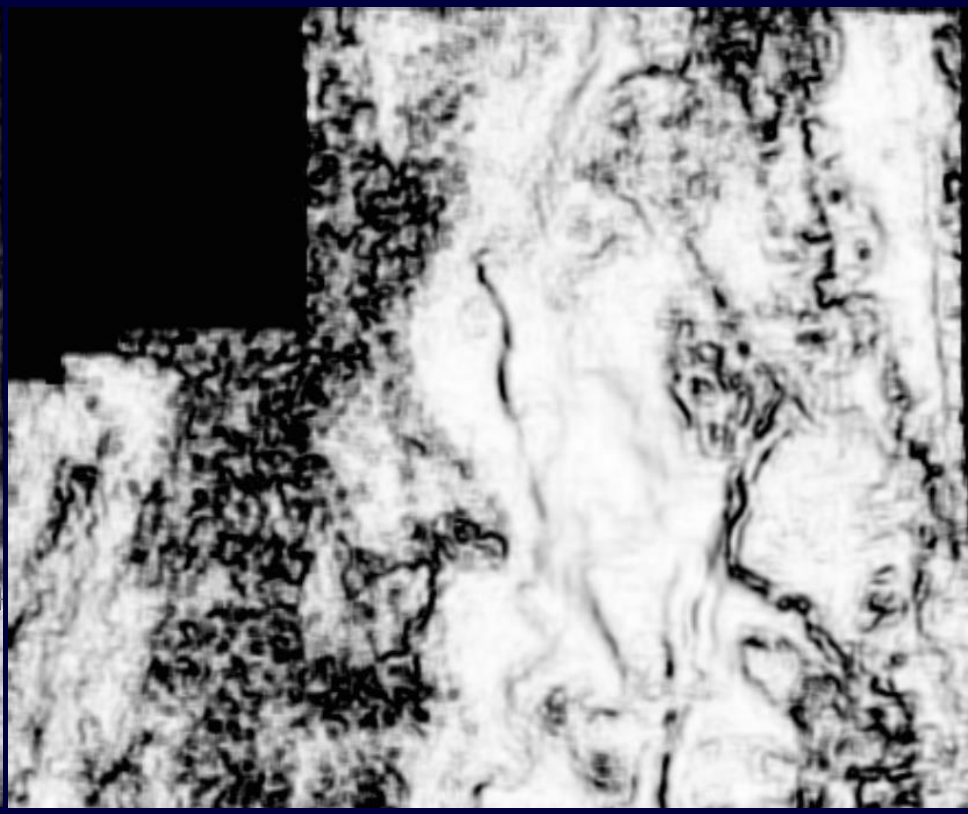
Correlation of channel edges with their seismic signatures



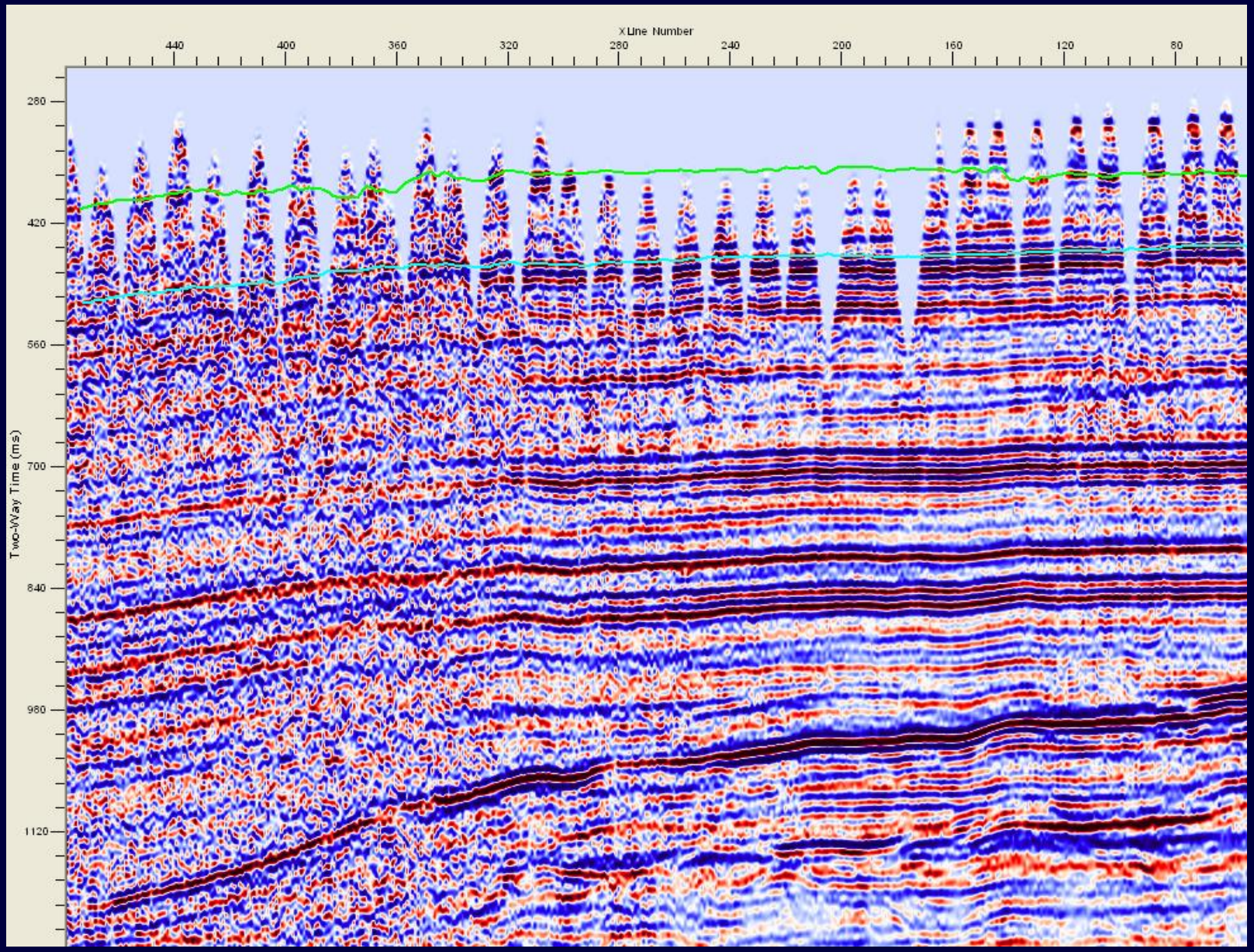
Time slices (1018ms) from coherence volumes before and after AMO



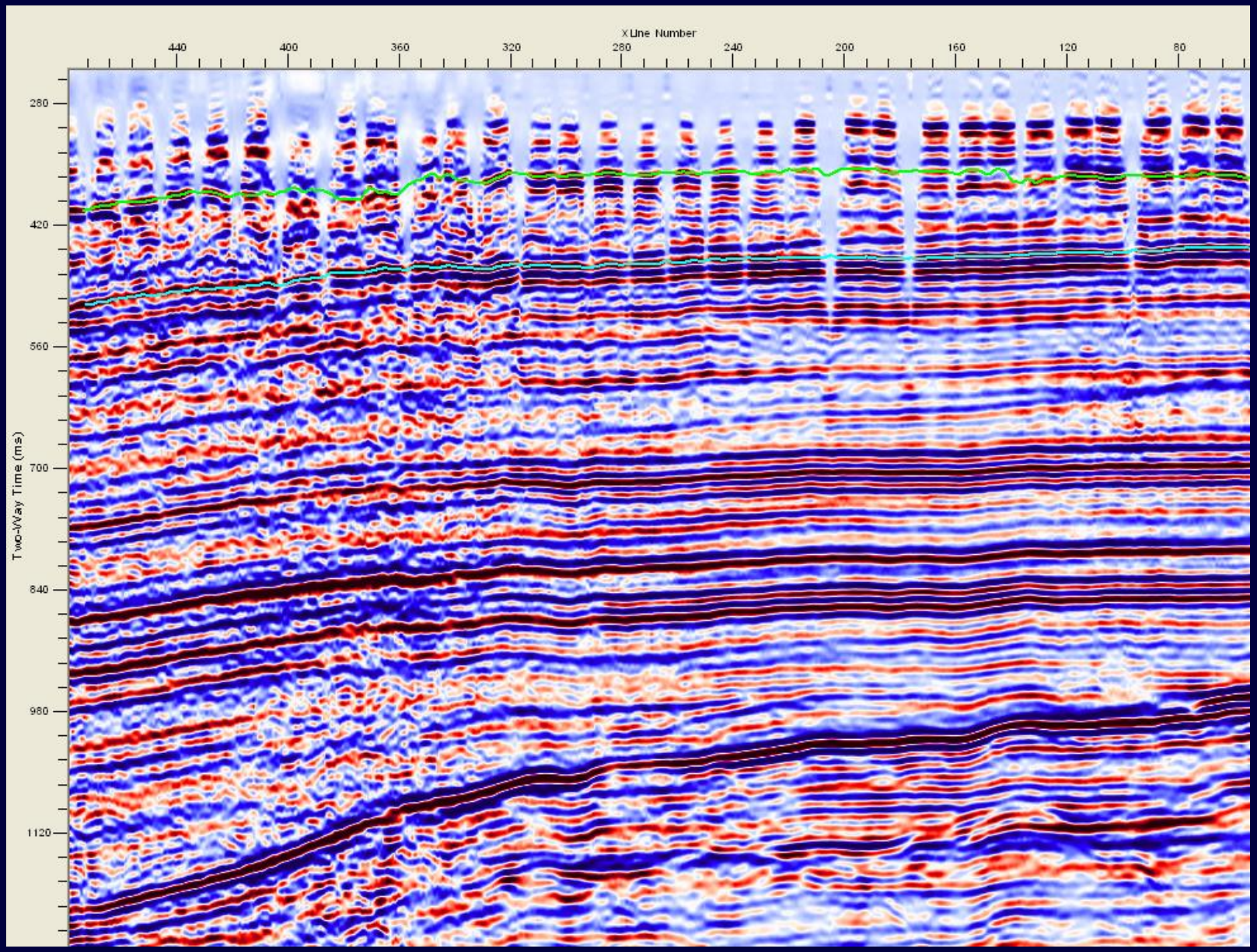
Before AMO



After AMO

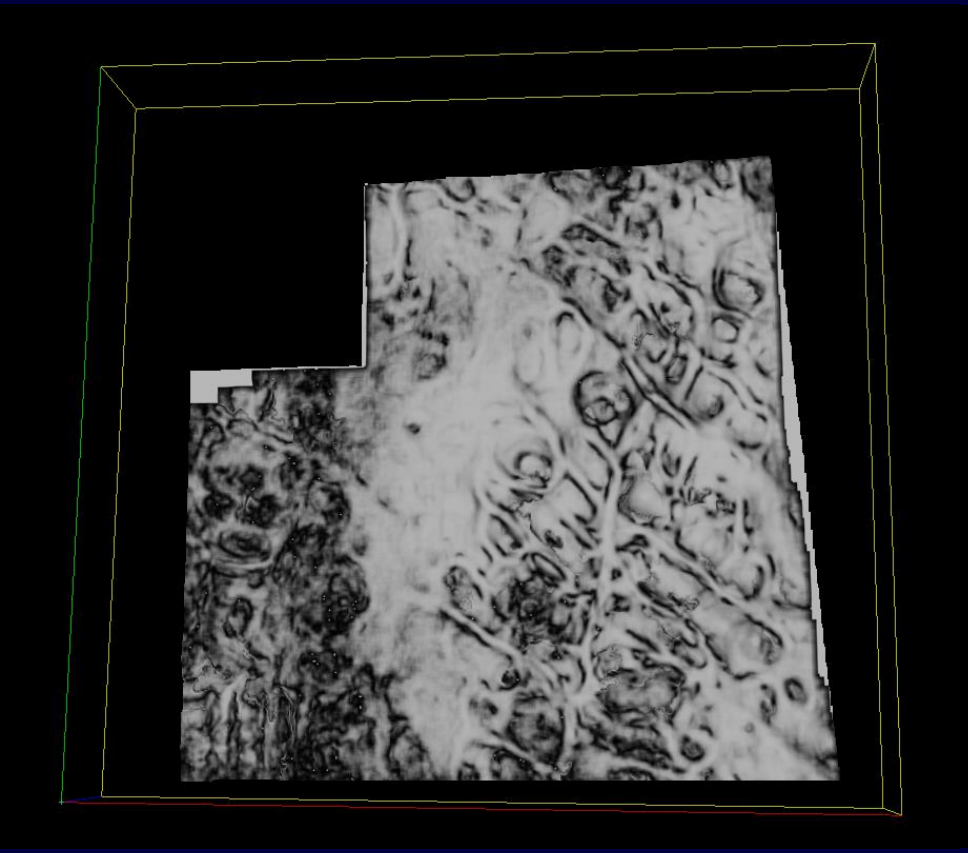


An inline from 3-D seismic volume before AMO

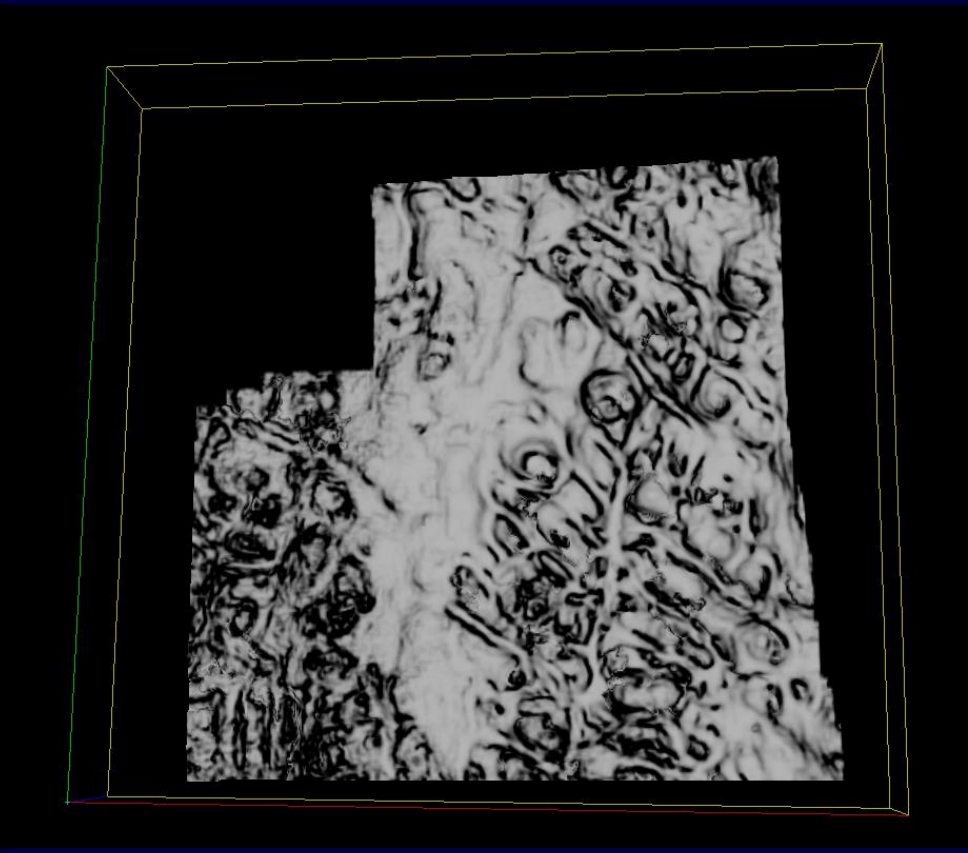


An inline from 3-D seismic volume after AMO

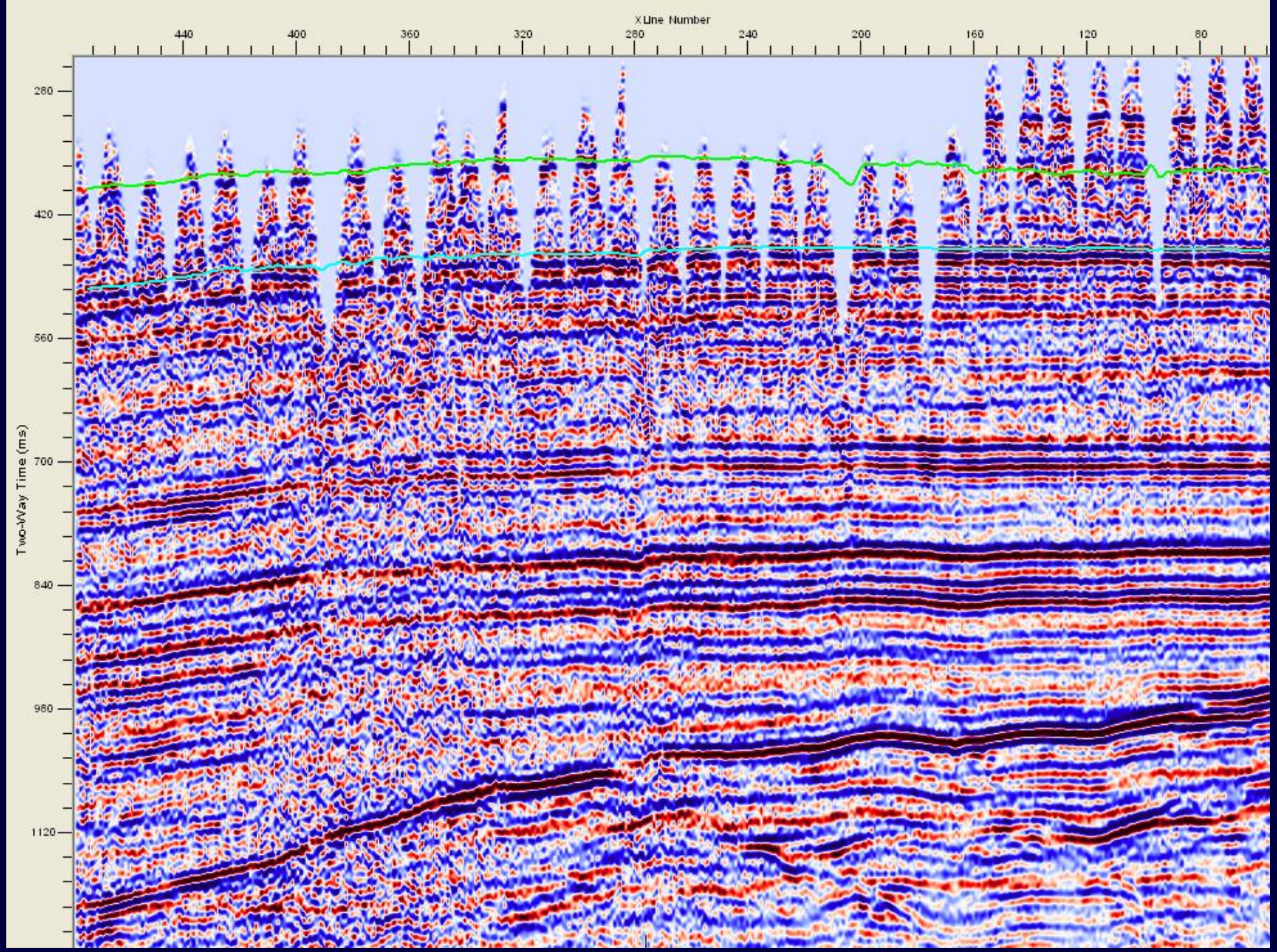
Strat-slices from coherence volumes before and after AMO



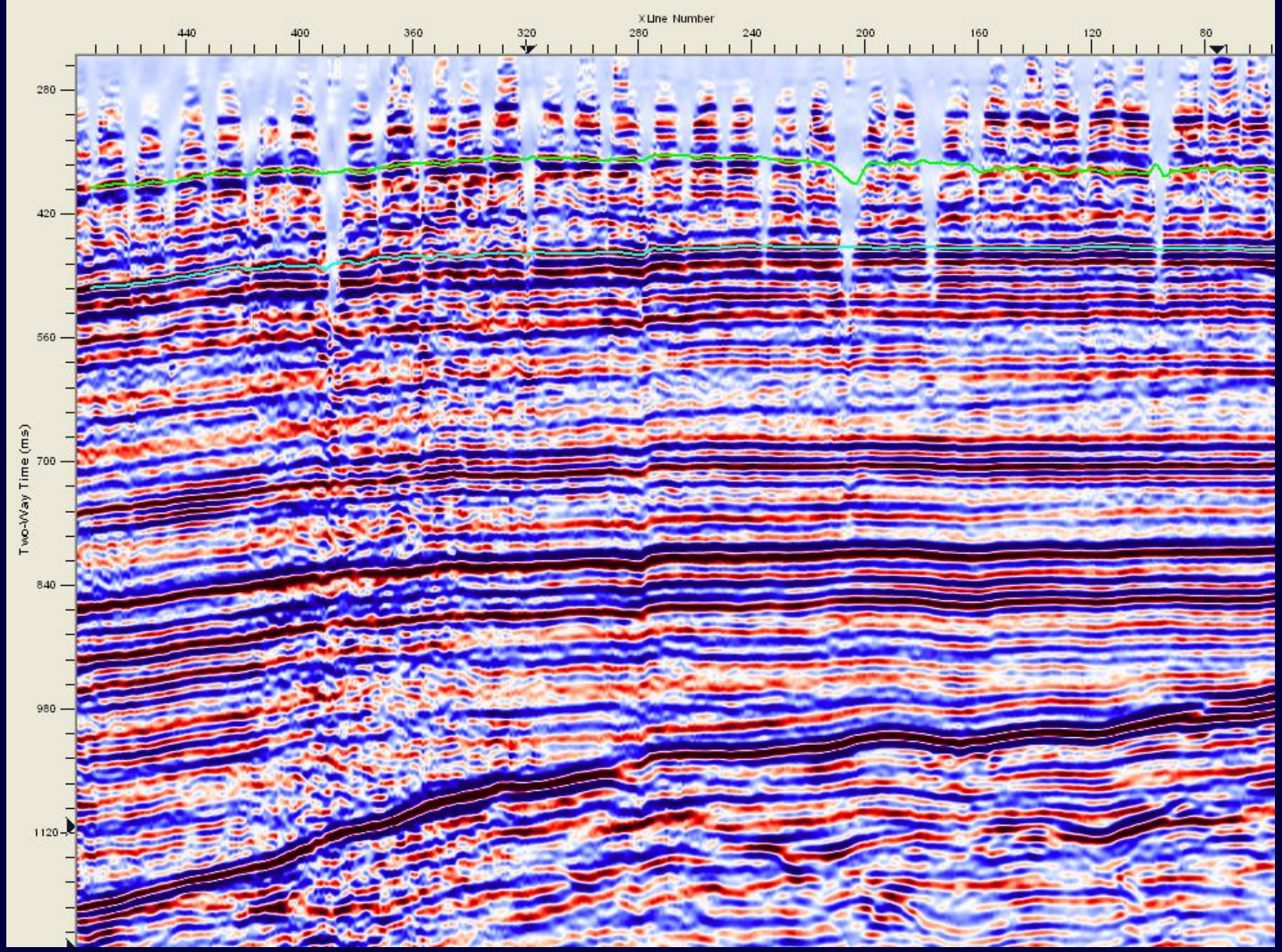
Before AMO



After AMO

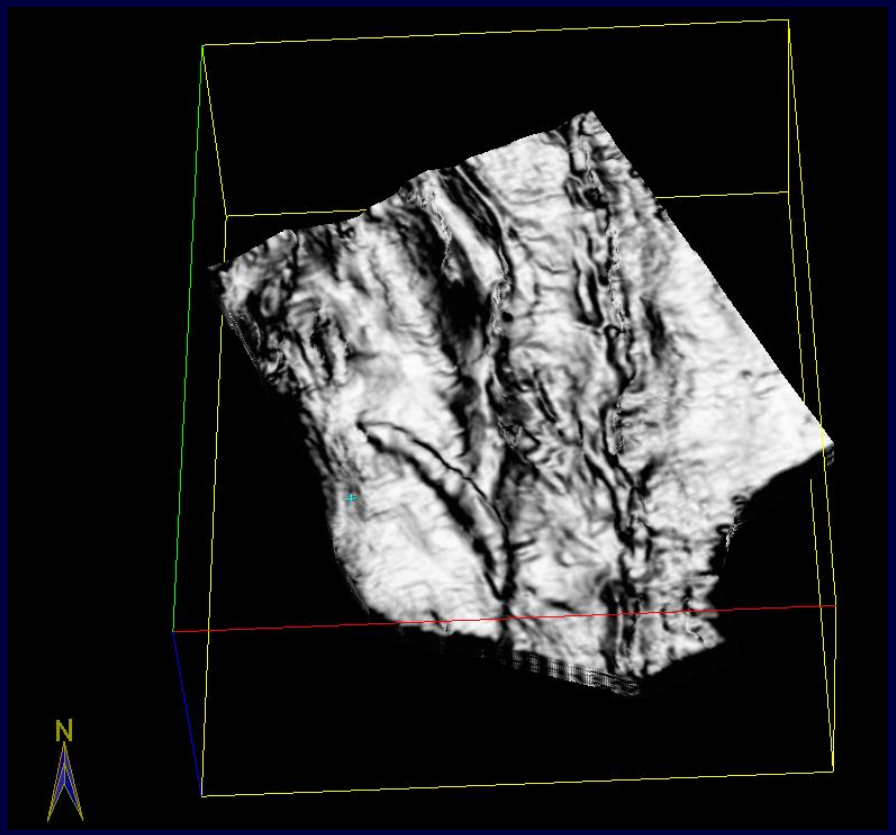


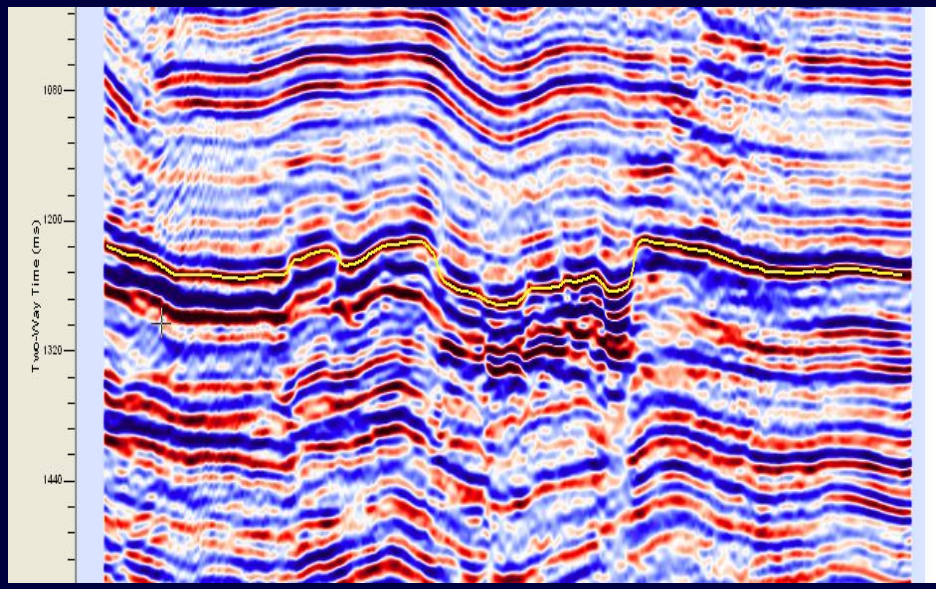
An inline from 3-D seismic volume before AMO

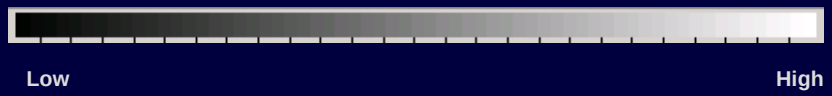


An inline from 3-D seismic volume after AMO

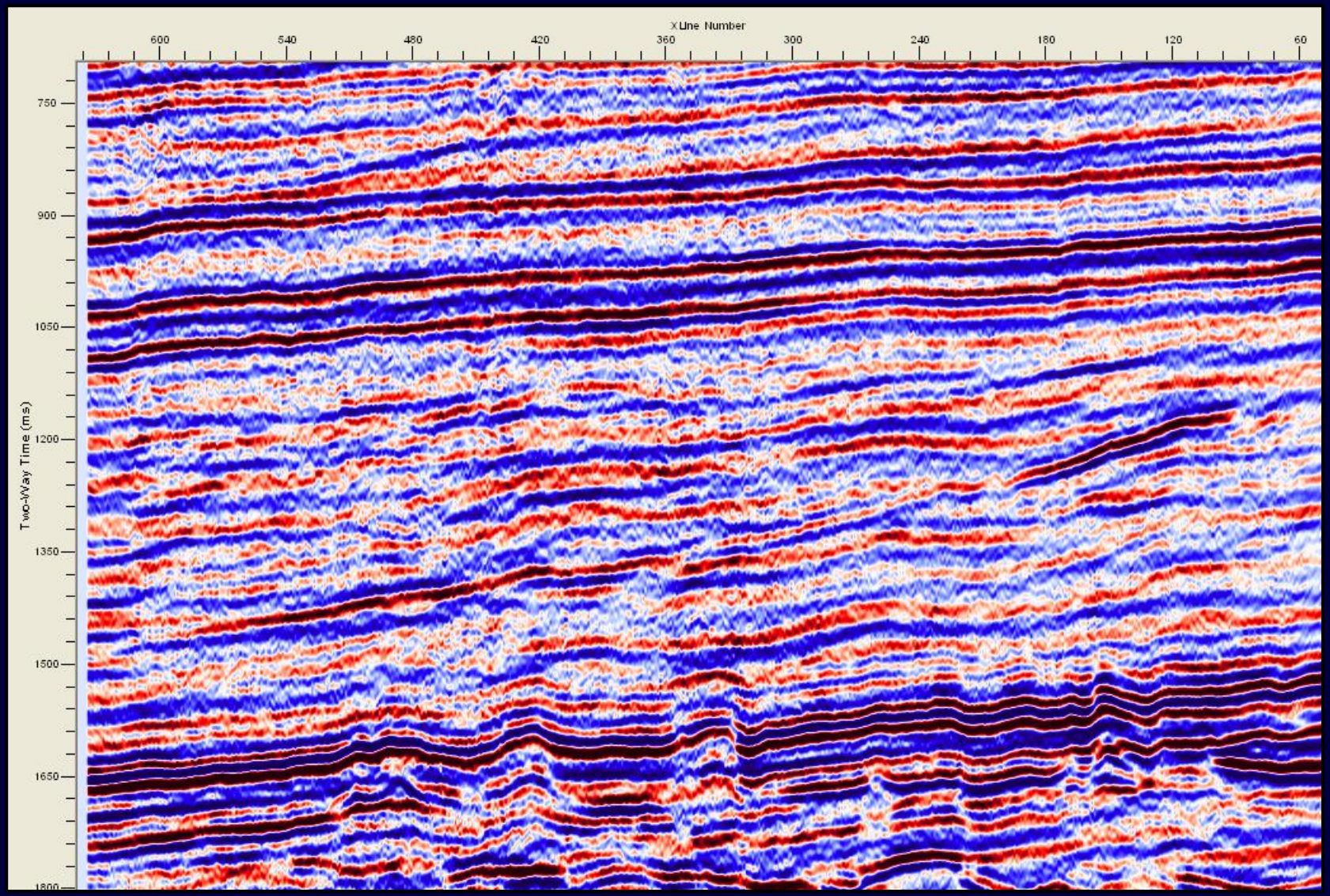
Strat-cube (coherence)



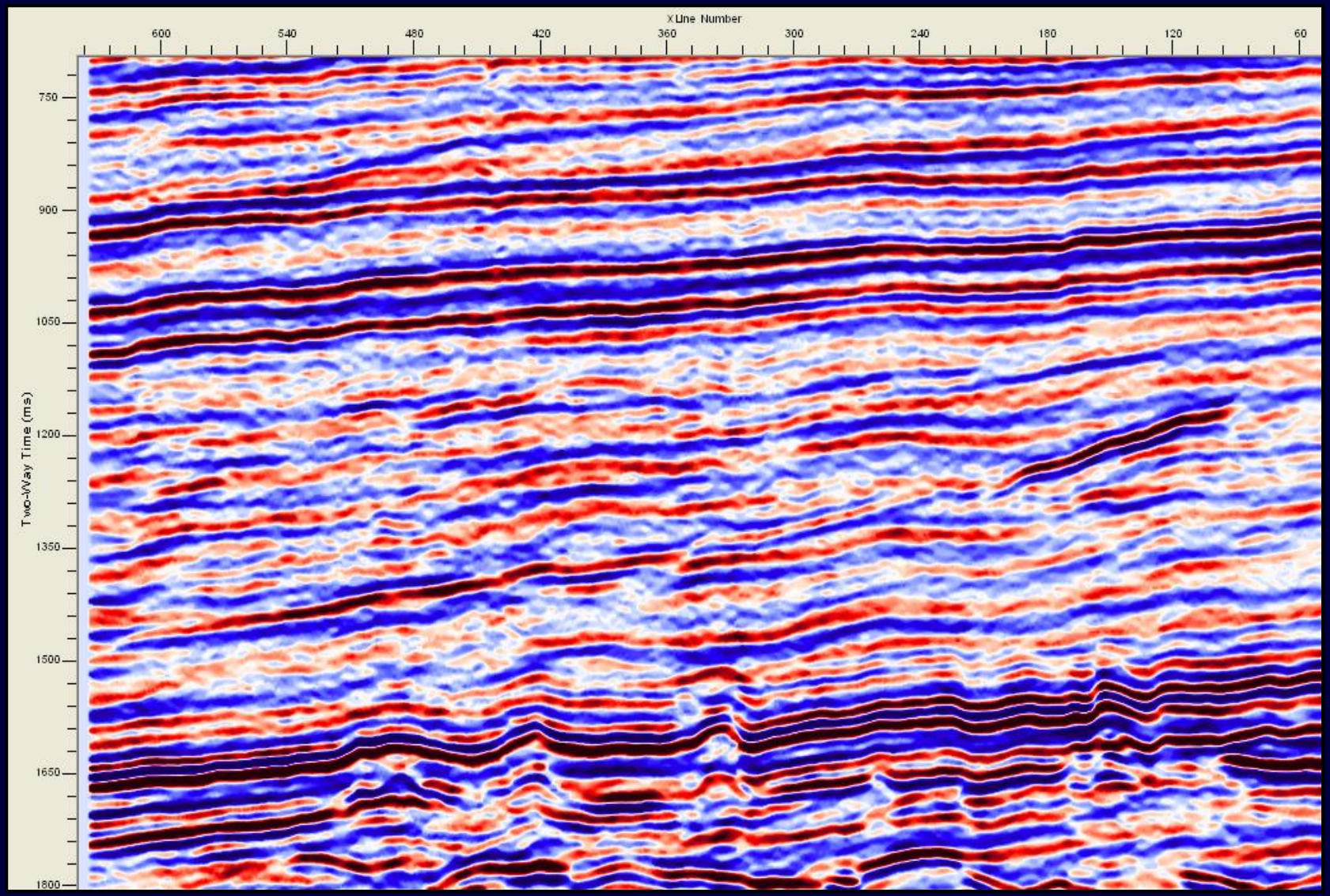




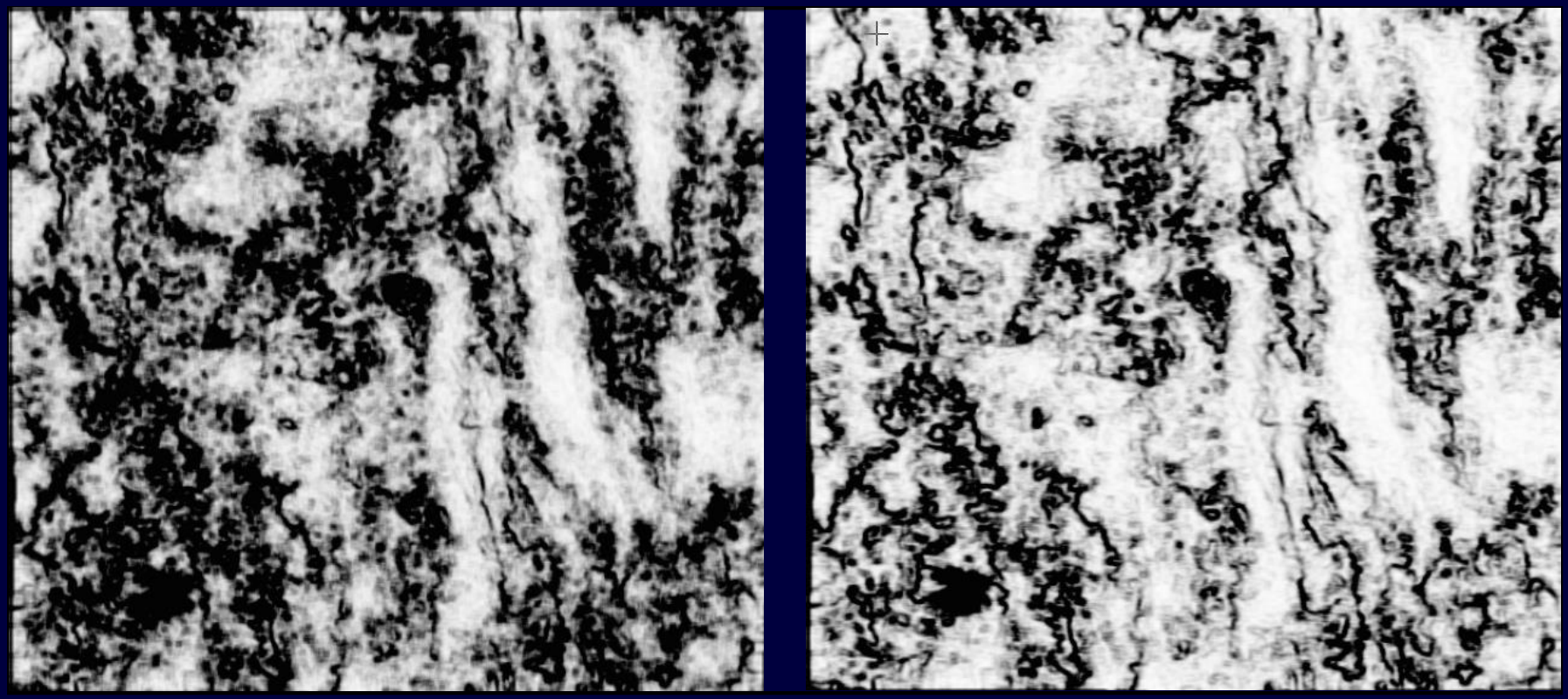
Coherence



An inline from a seismic volume. *(Data courtesy: Arcis Corporation, Calgary*)

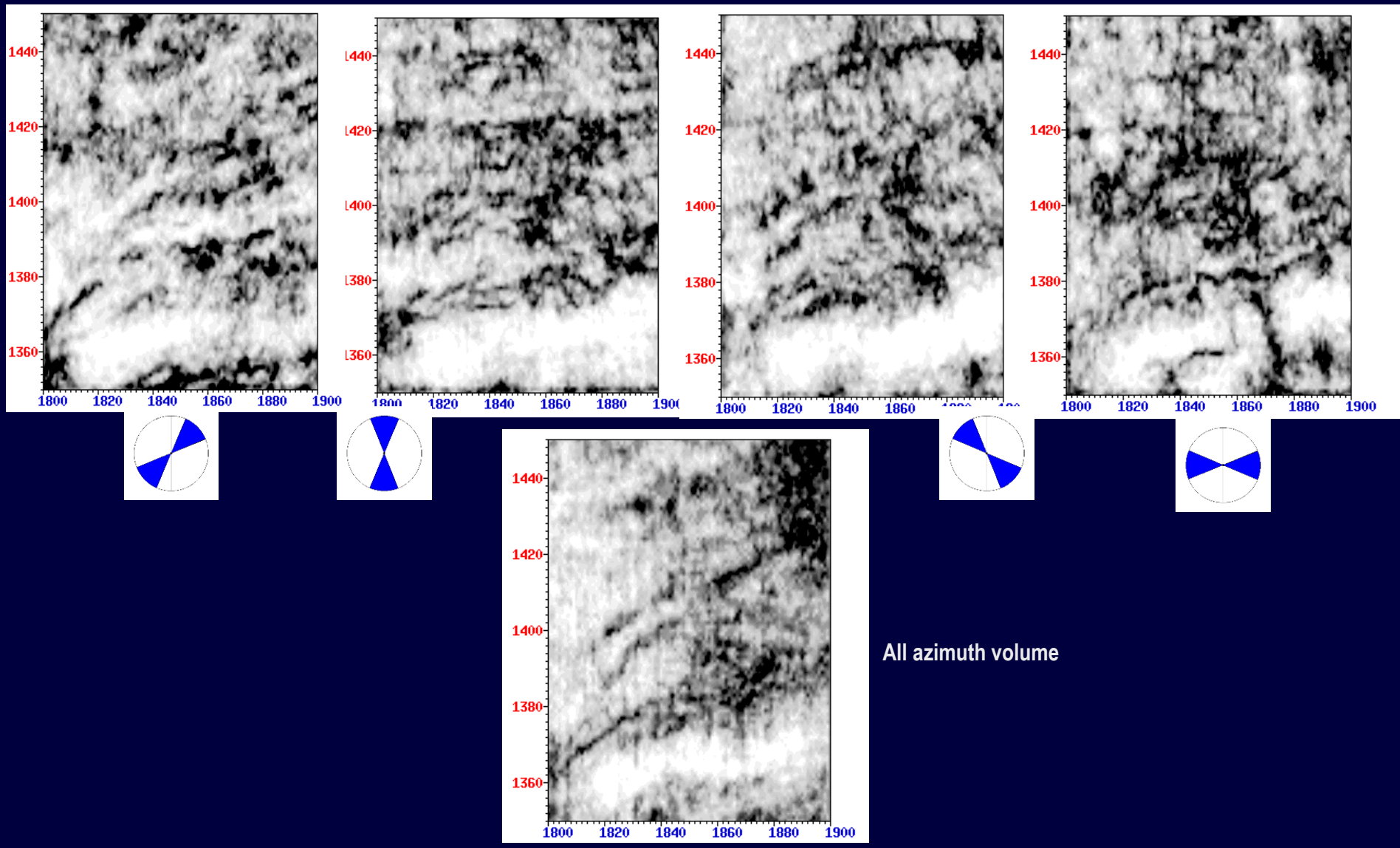


The same inline in (a) after median (5x5) filtering. Notice the cleaner look of the section after median filtering.
(Data courtesy: Arcis Corporation, Calgary)



Time slice at 1130 ms from coherence volume (a) before (b) after median filtering. Notice the clearer definition of the features seen after median filtering. *(Data courtesy: Arcis Corporation, Calgary*)

Comparison of time slices from different azimuth volumes



All azimuth volume

Time slices at 1312 ms from azimuth limited seismic volumes and from the all azimuth seismic volume.

Chopra, 2001

Conclusions

- Adding the coherence dimension to your seismic data enables you to see stratigraphic features, faults and fractures better.

- Subtle faults/fractures can be detected with azimuth based 3D processing and coherence.

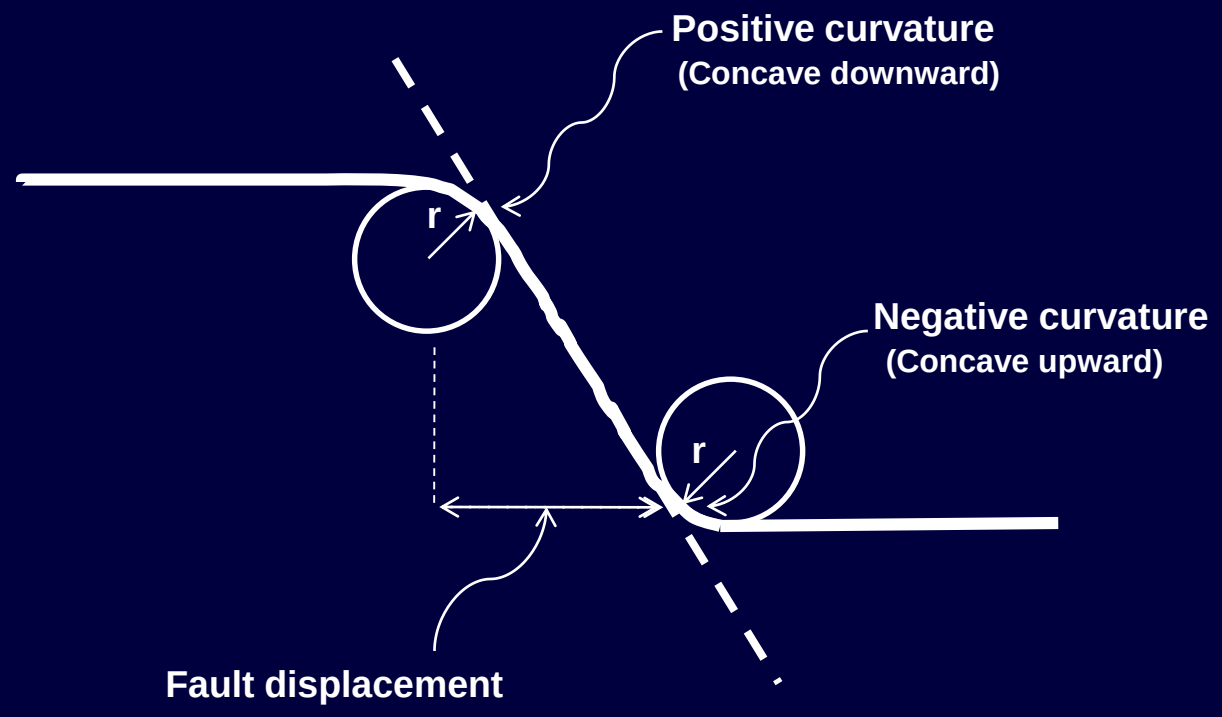
To add more value to your interpretation,

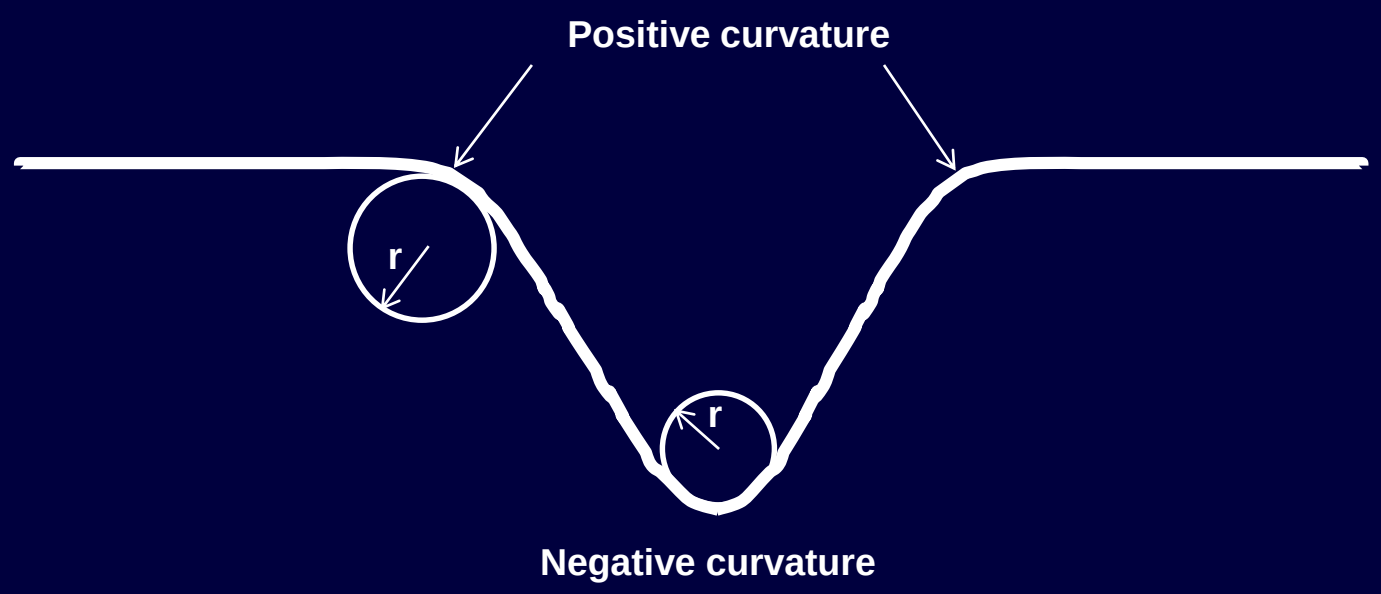
'Add the coherence dimension to your 3D seismic data'

We should remember

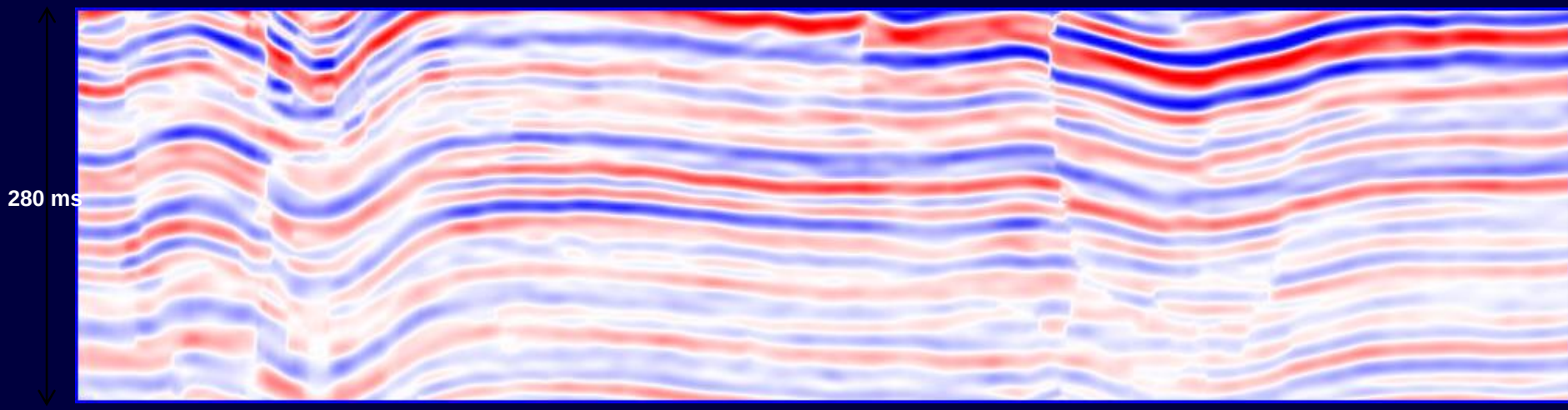
If it's worth doing well, it's worth doing coherently

Curvature

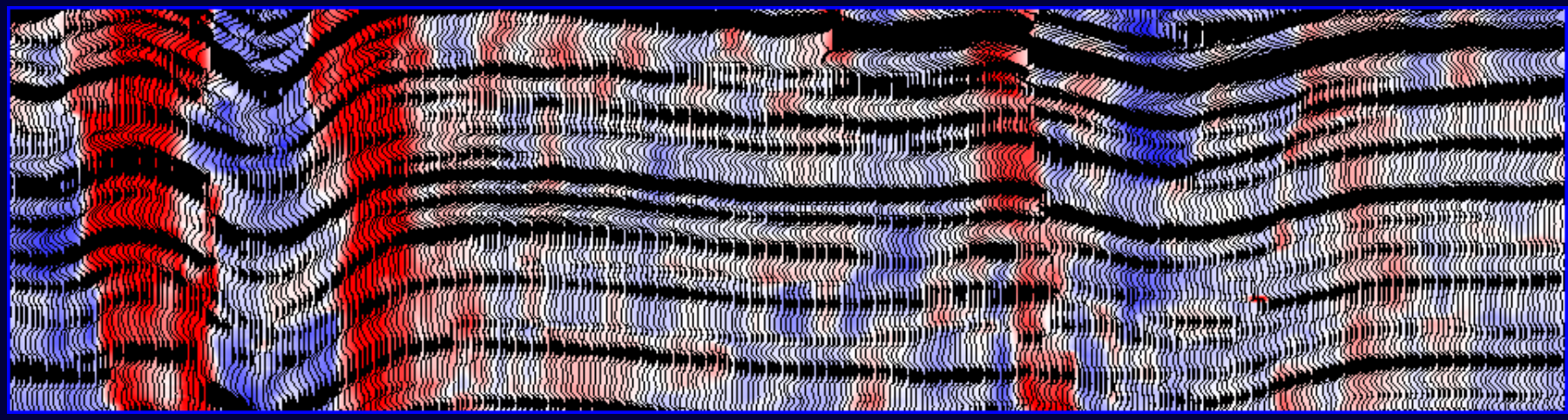

Positive curvature
(Concave downward)
r
Negative curvature
(Concave upward)
r
Fault displacement


Positive curvature
r
r
Negative curvature

Curvature

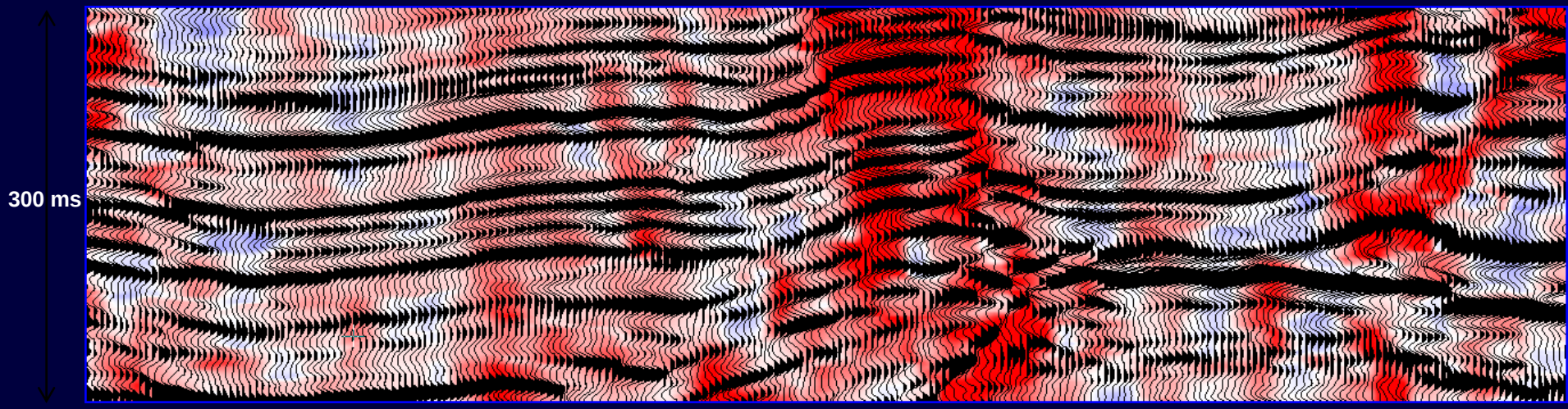


Segment of a seismic section after structure-oriented filtering

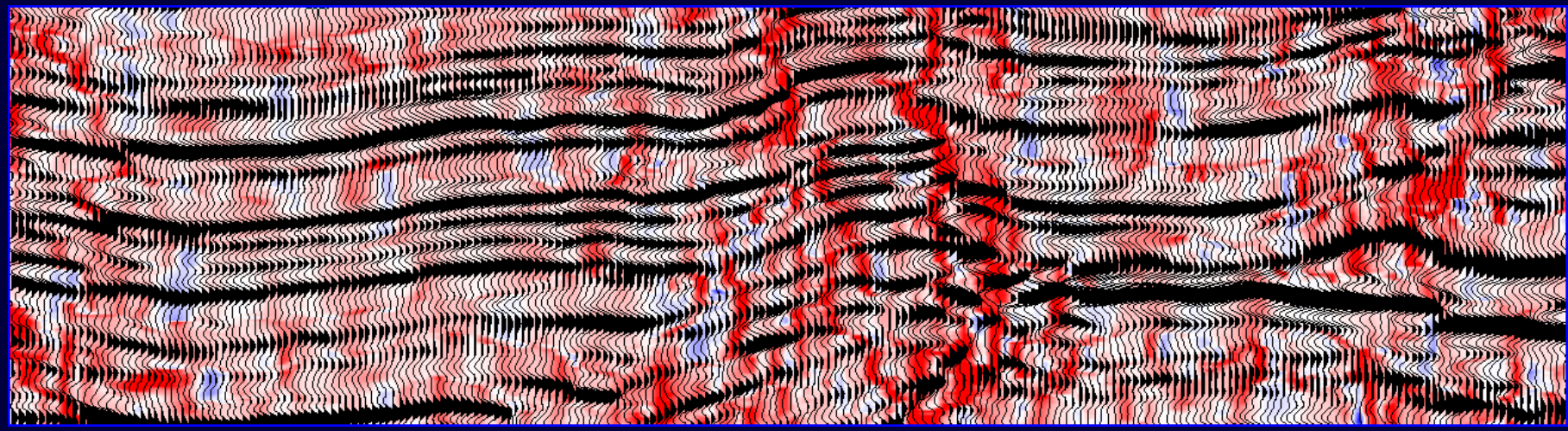


Seismic section with most-positive curvature overlaid on it.

Curvature

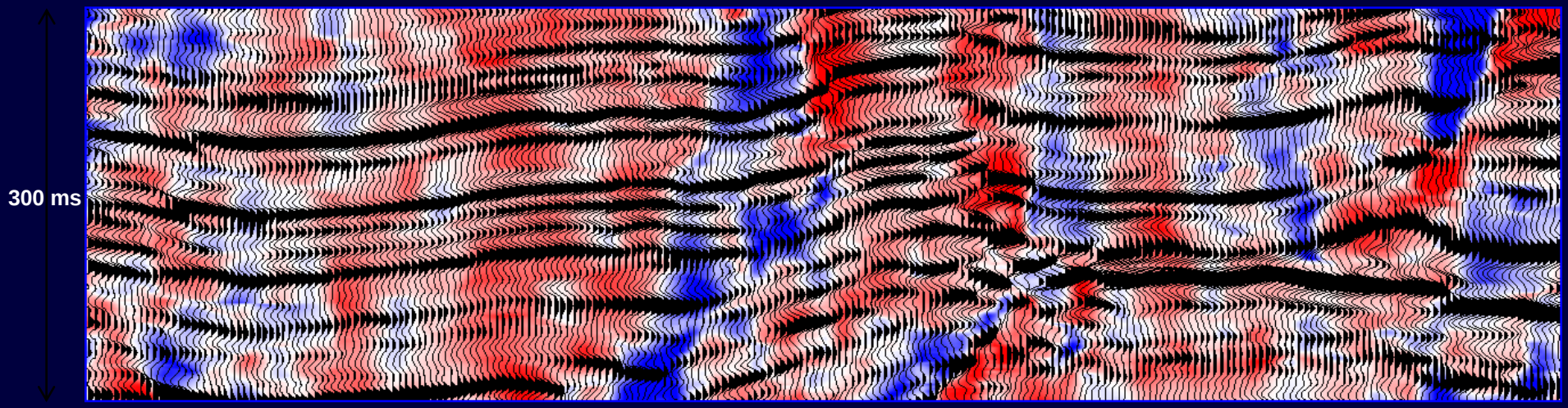


Seismic section with most-positive curvature (long-wavelength) overlaid on it.

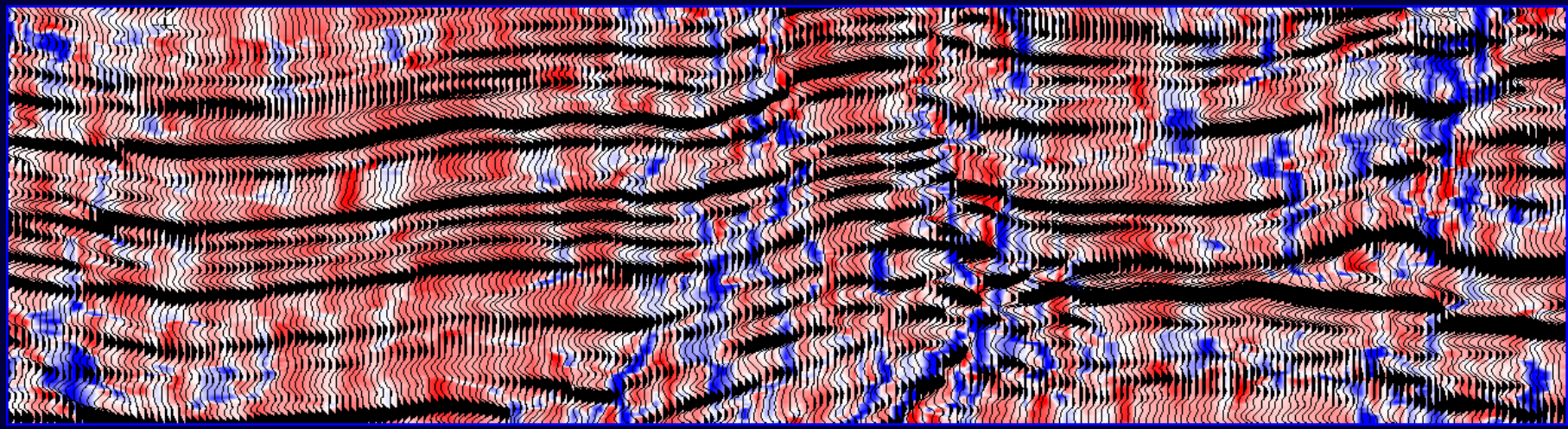


Seismic section with most-positive curvature (short-wavelength) overlaid on it.

Curvature

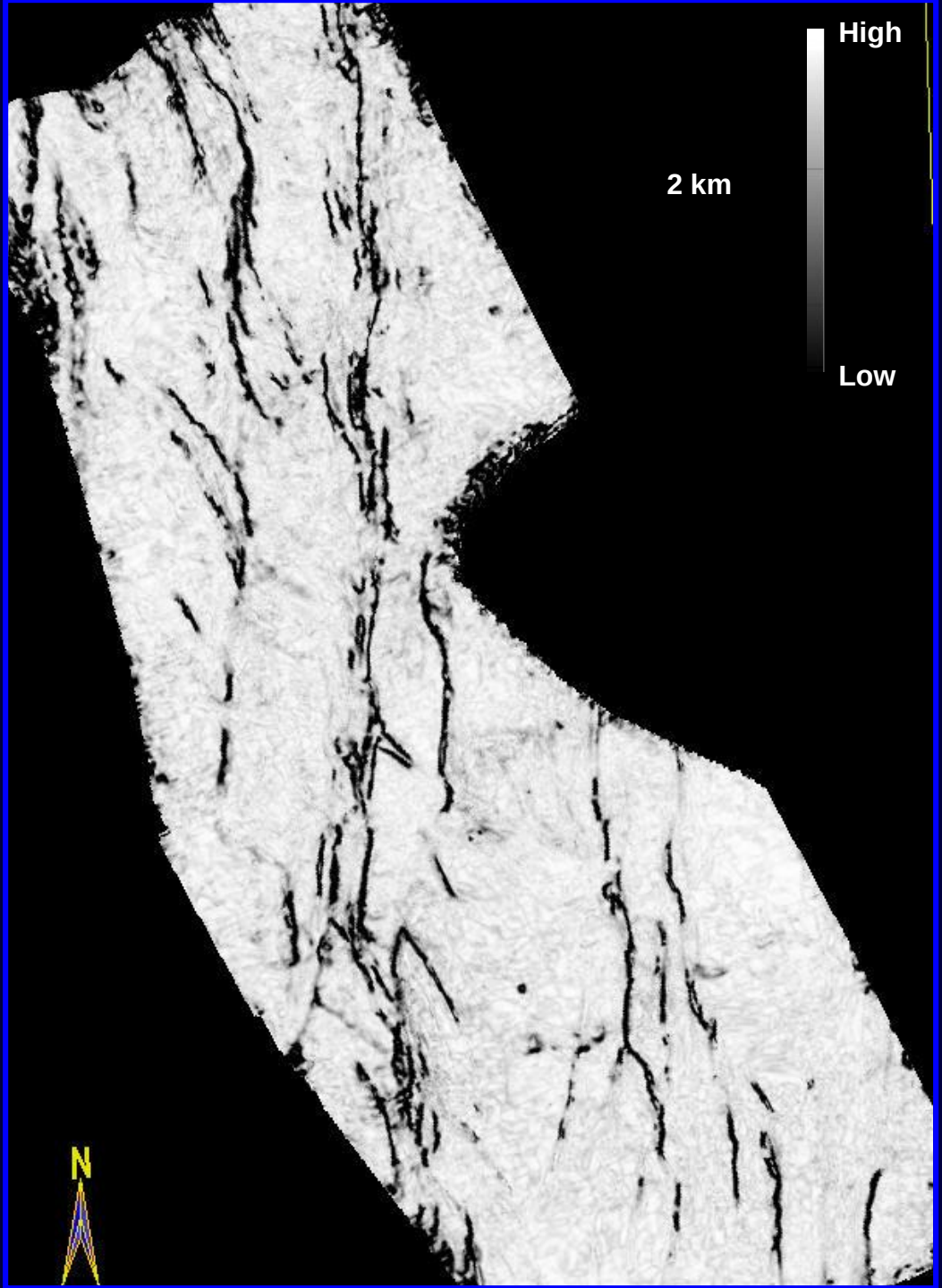


Seismic section with most-negative curvature (long-wavelength) overlaid on it.



Seismic section with most-negative curvature (short-wavelength) overlaid on it.

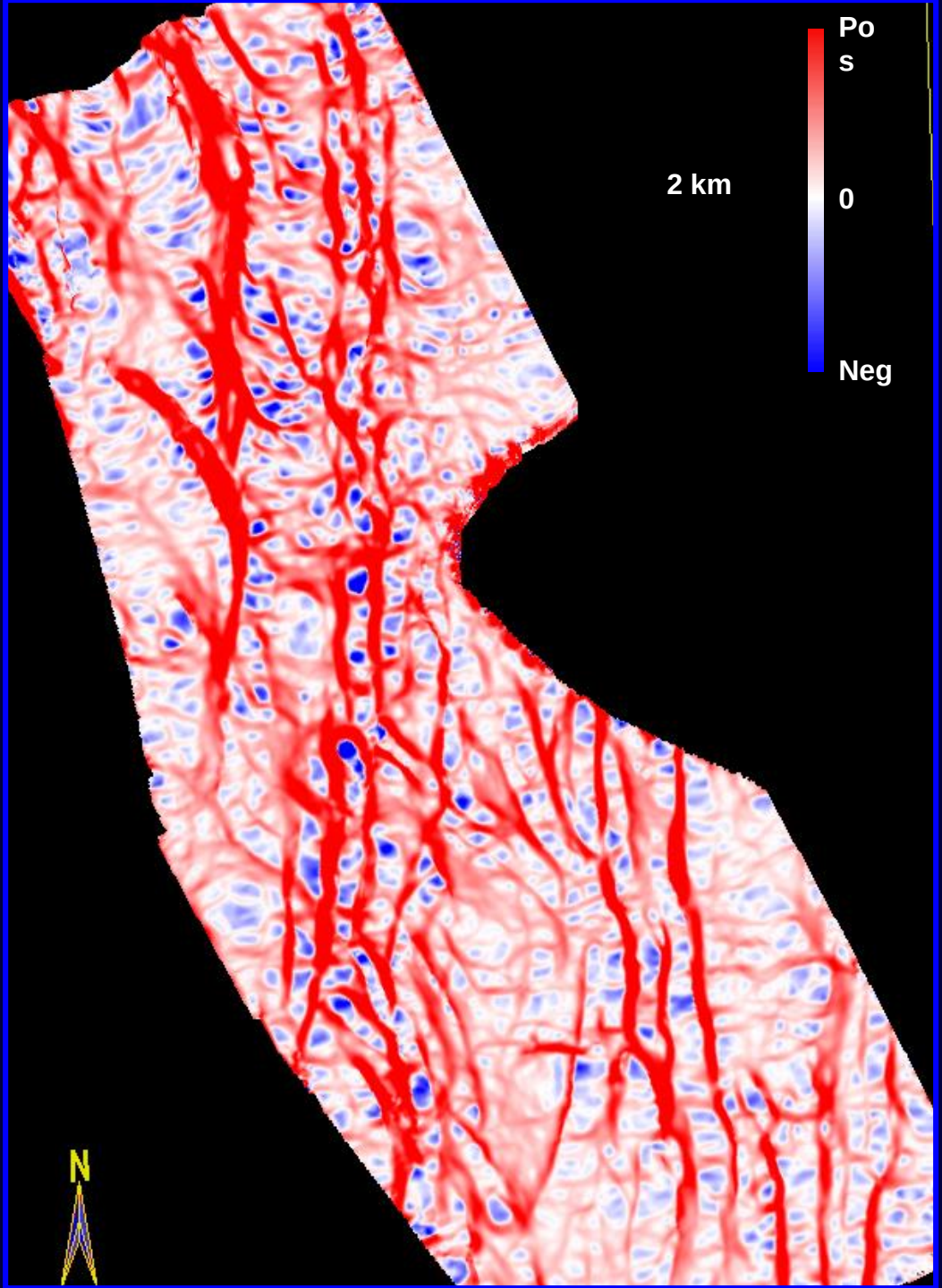
Coherence



Horizon slice through the coherence volume

Data courtesy: Arcis Corporation, Calgary

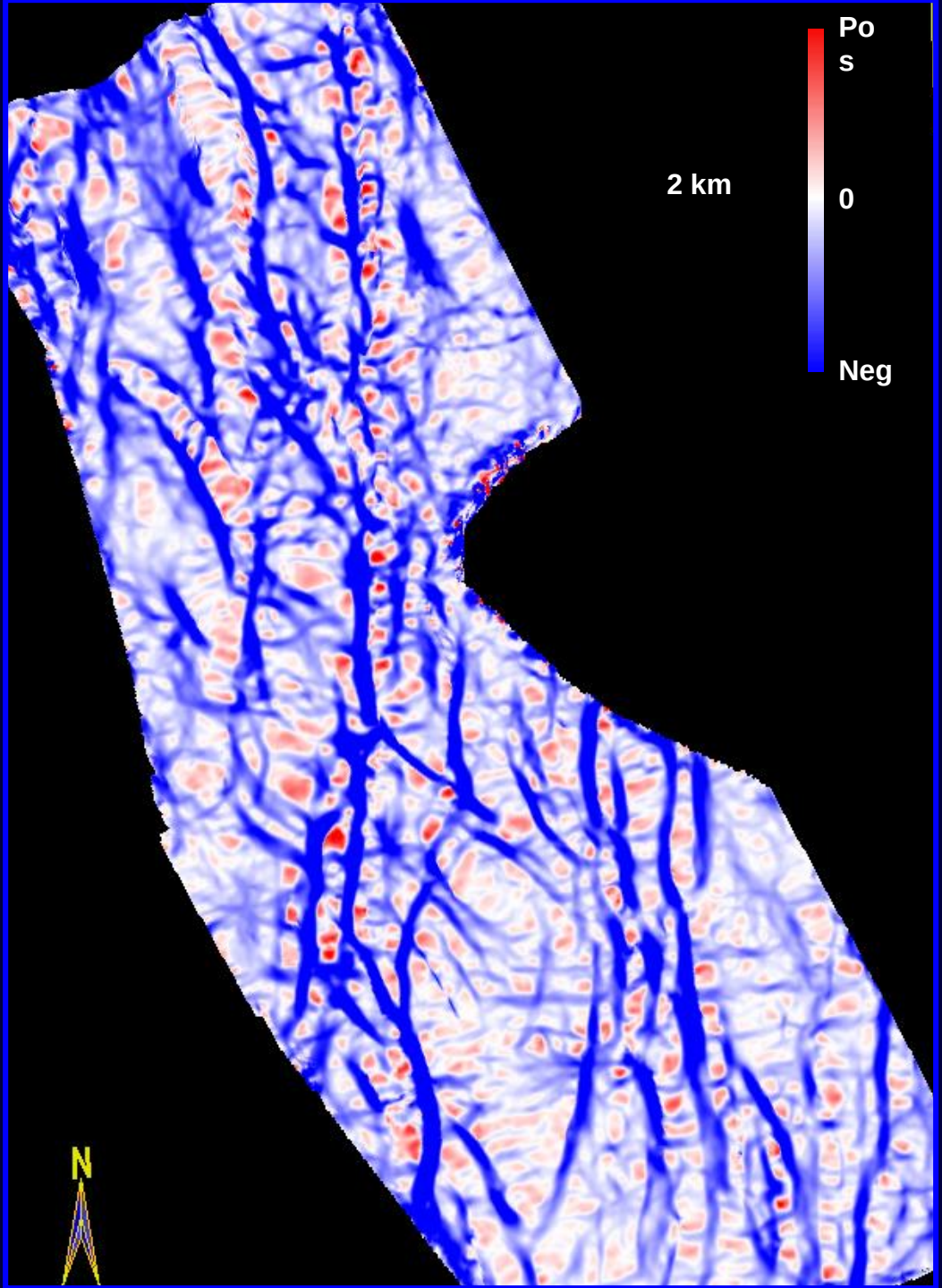
Curvature



Horizon slice through the most-positive curvature volume

Data courtesy: Arcis Corporation, Calgary

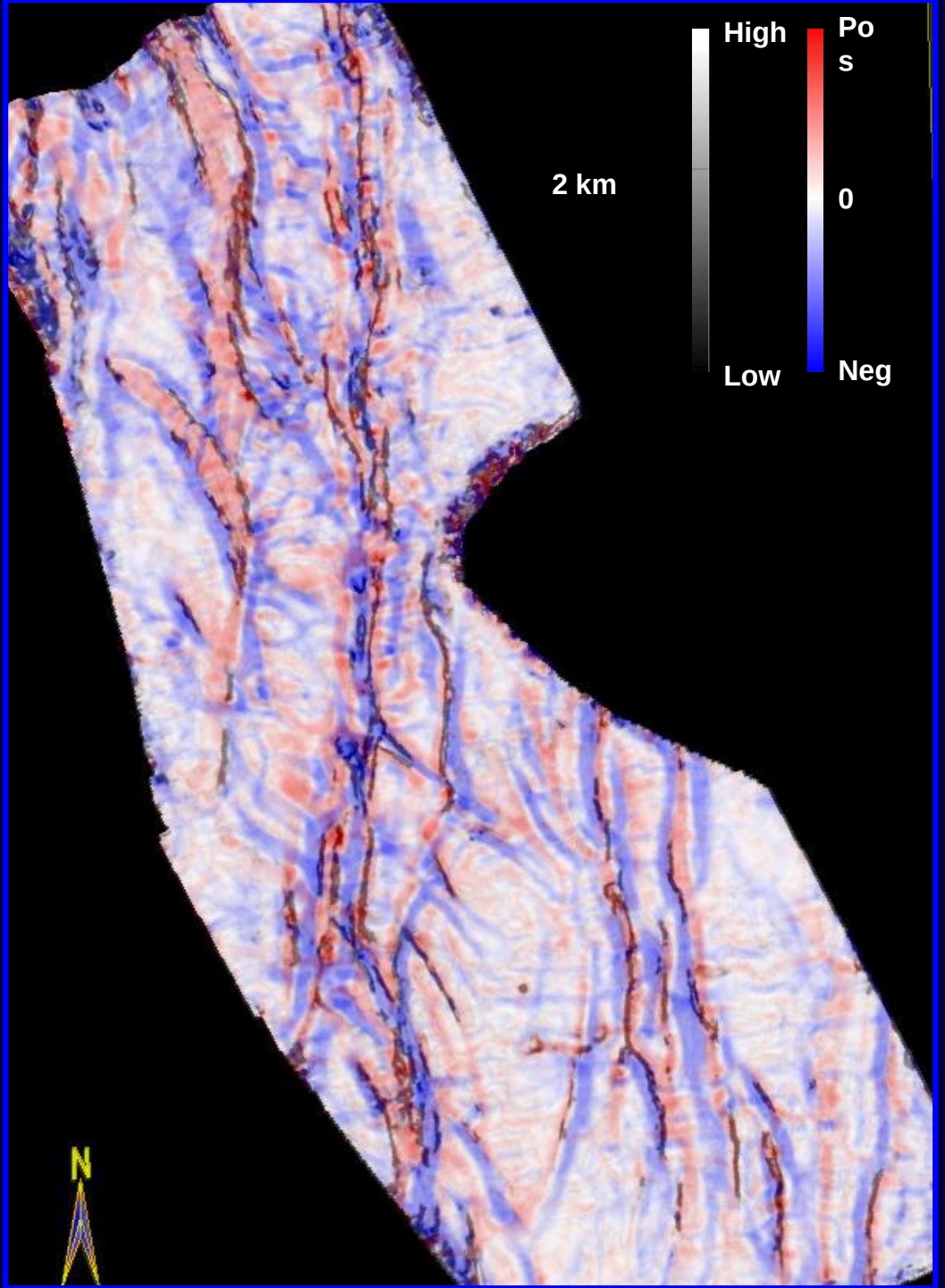
Curvature



Horizon slice through the most-negative curvature volume

Data courtesy: Arcis Corporation, Calgary

Coherence and Curvature

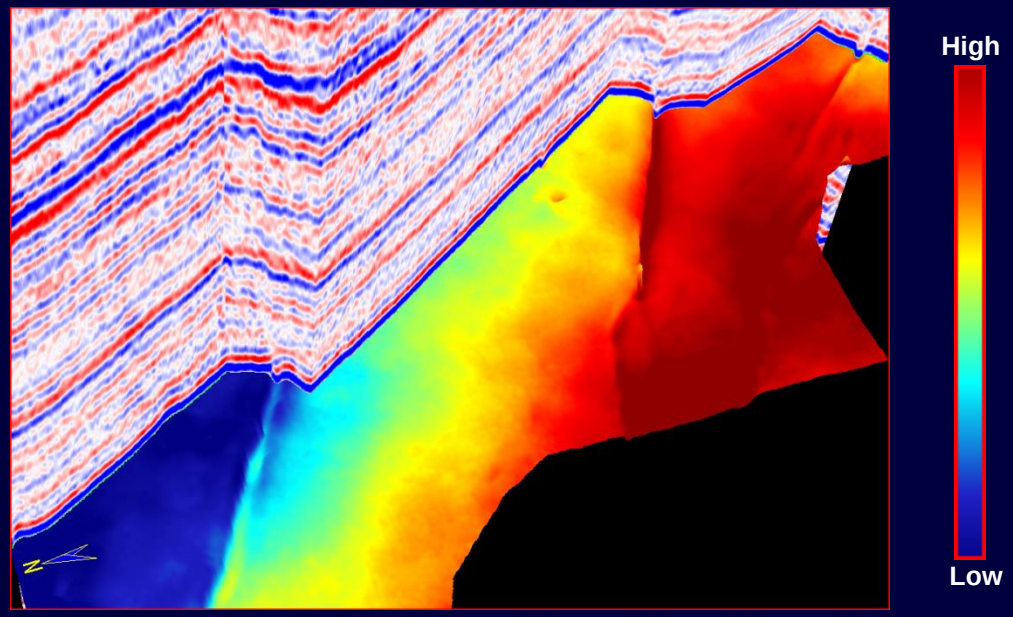


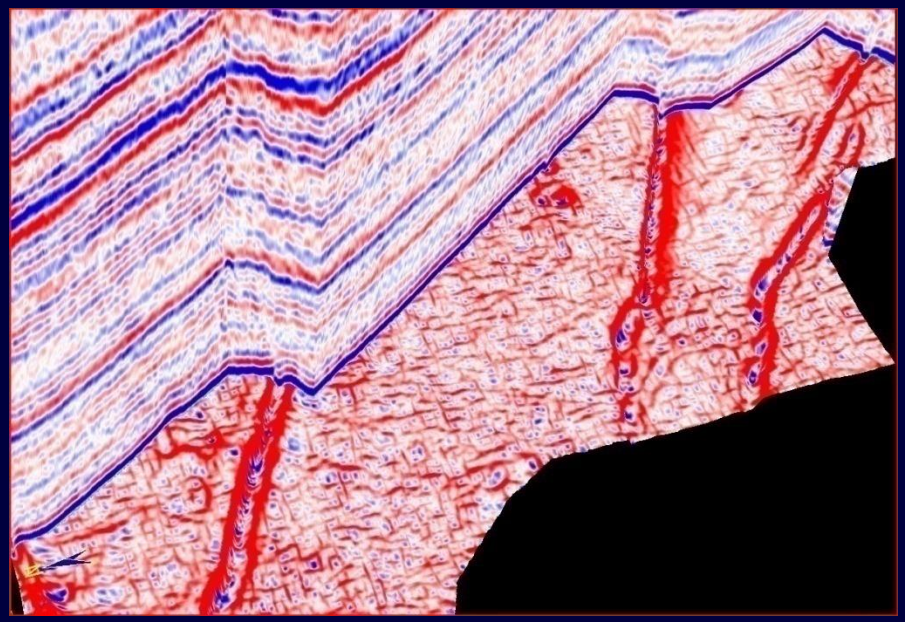
Color stack of coherence, most-positive curvature, and most negative curvature

Data courtesy: Arcis Corporation, Calgary

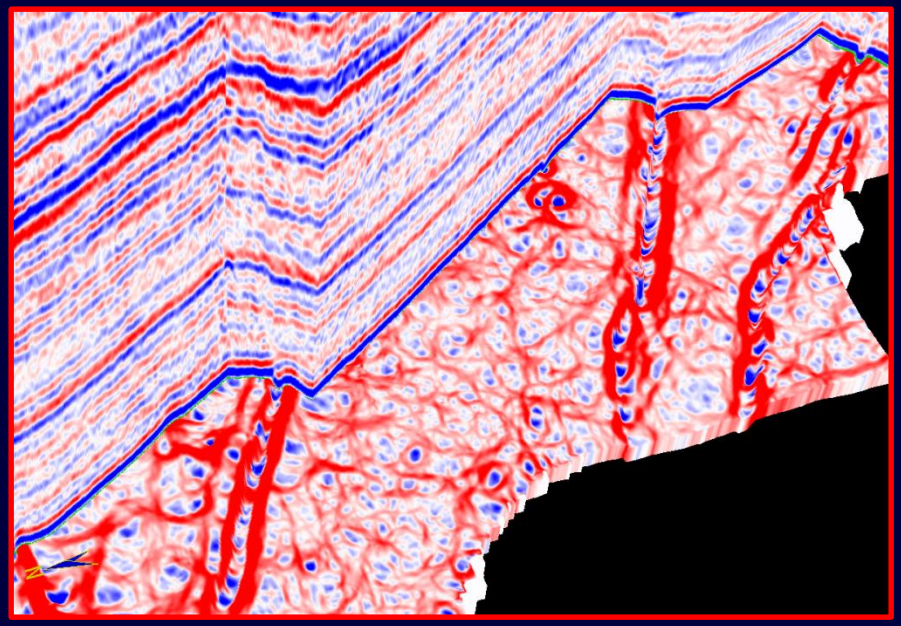
Curvature

Time surface through the seismic volume



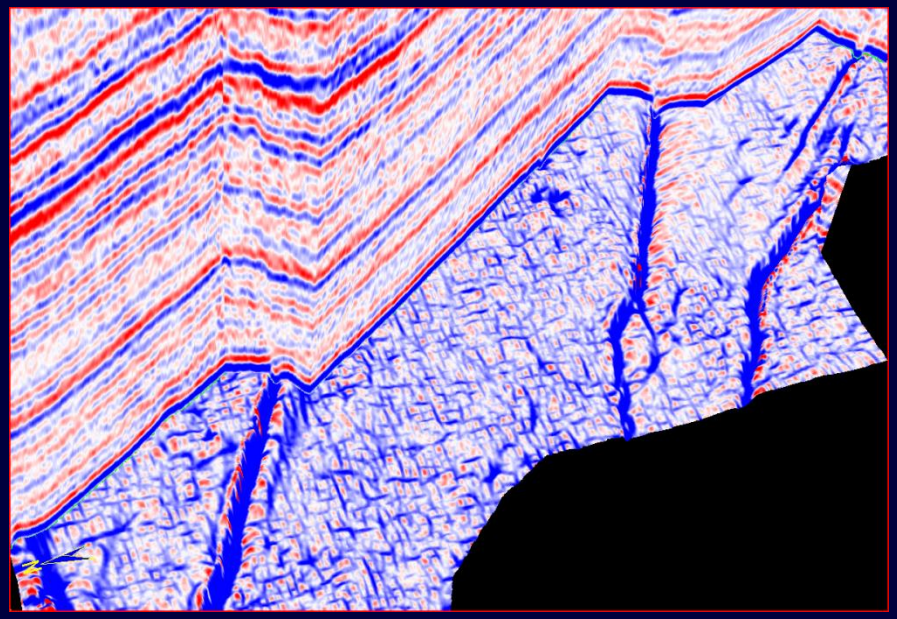


Most-positive curvature computed along the time surface

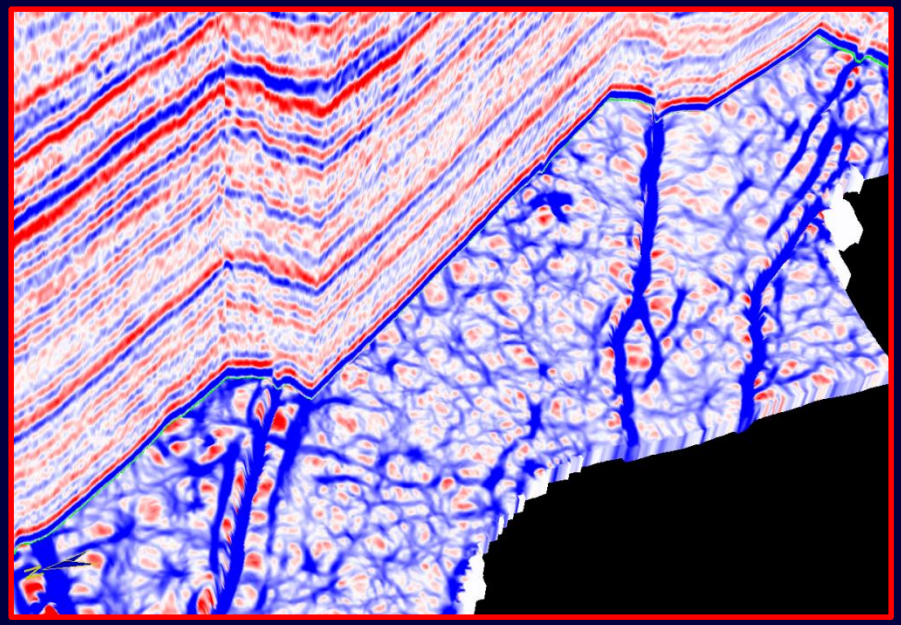


Most-positive curvature extracted along the time surface from the volume

Curvature

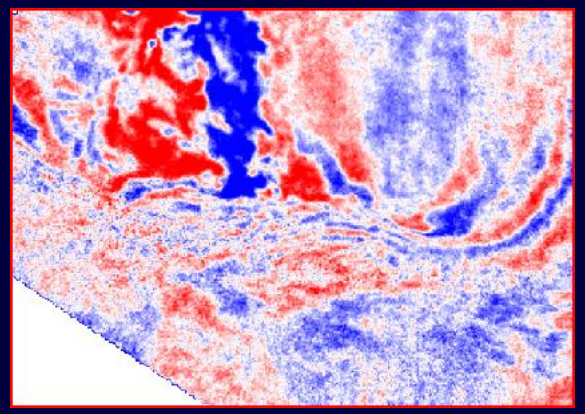


Most-negative curvature computed along the time surface

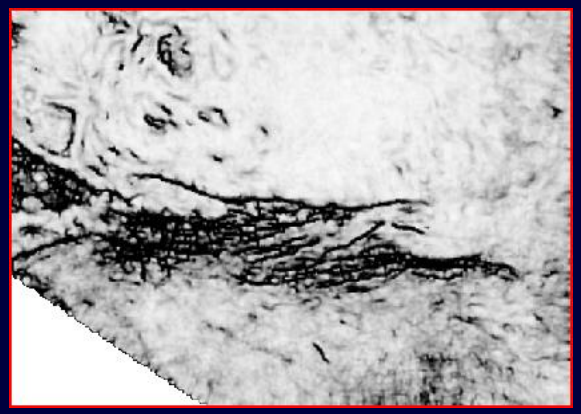


Most-negative curvature extracted along the time surface from the volume

Curvature

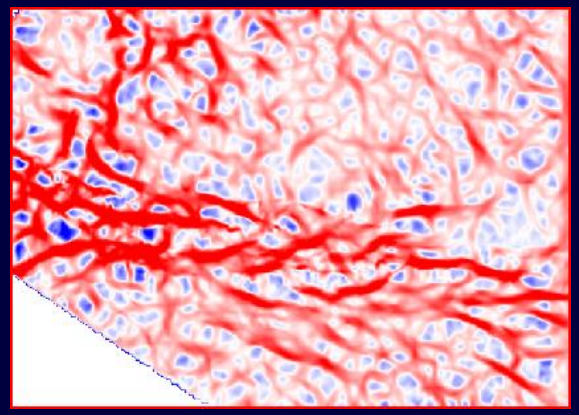


Seismic

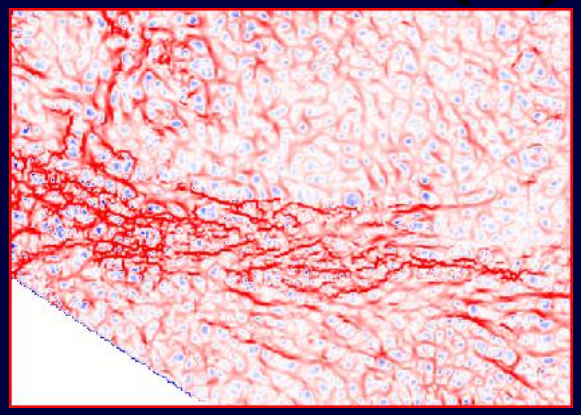


Coherence

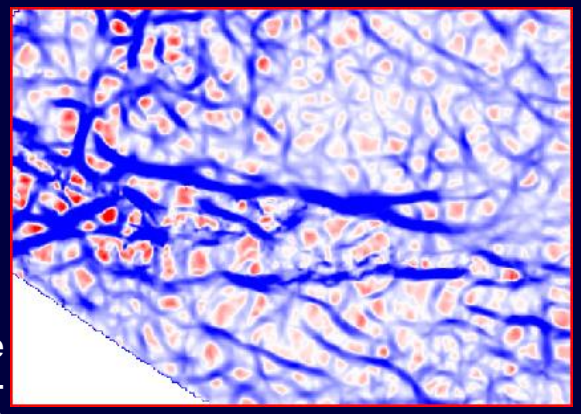
3 km



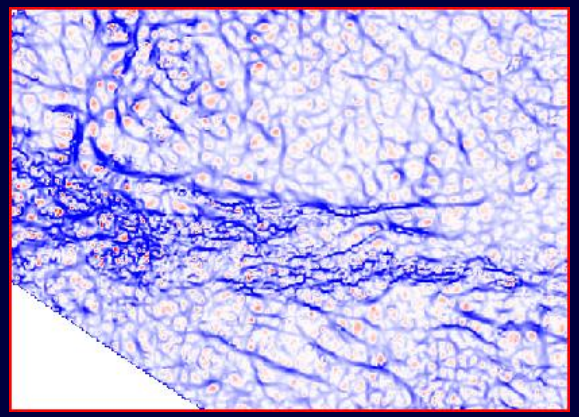
Most-positive curvature (long-wavelength)



Most-positive curvature (short-wavelength)



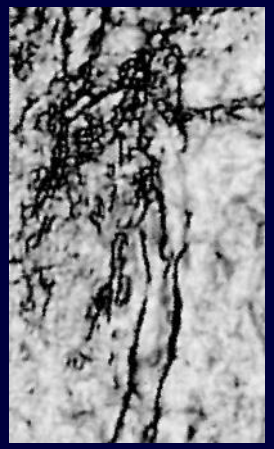
Most-negative curvature (long-wavelength)



Most-negative curvature (short-wavelength)

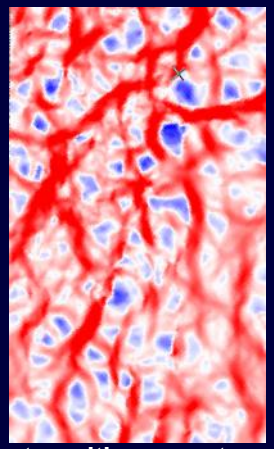
Notice the clear set of faults/fractures generated from coherence and curvature attributes.

Curvature

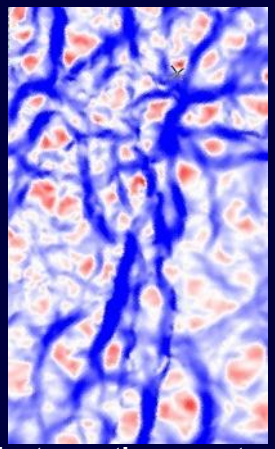


1.5 km

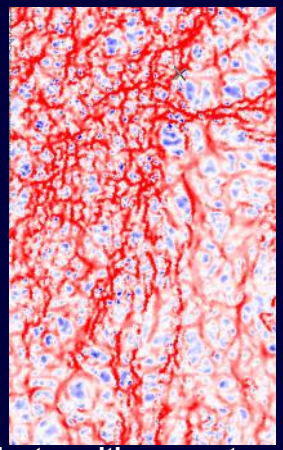
Coherence



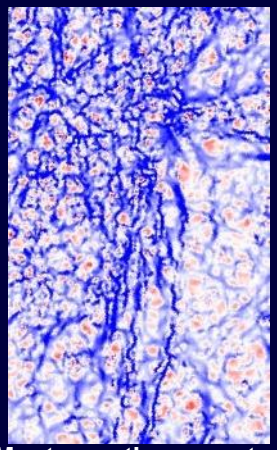
Most-positive curvature (long-wavelength)



Most-negative curvature (long-wavelength)



Most-positive curvature (short-wavelength)

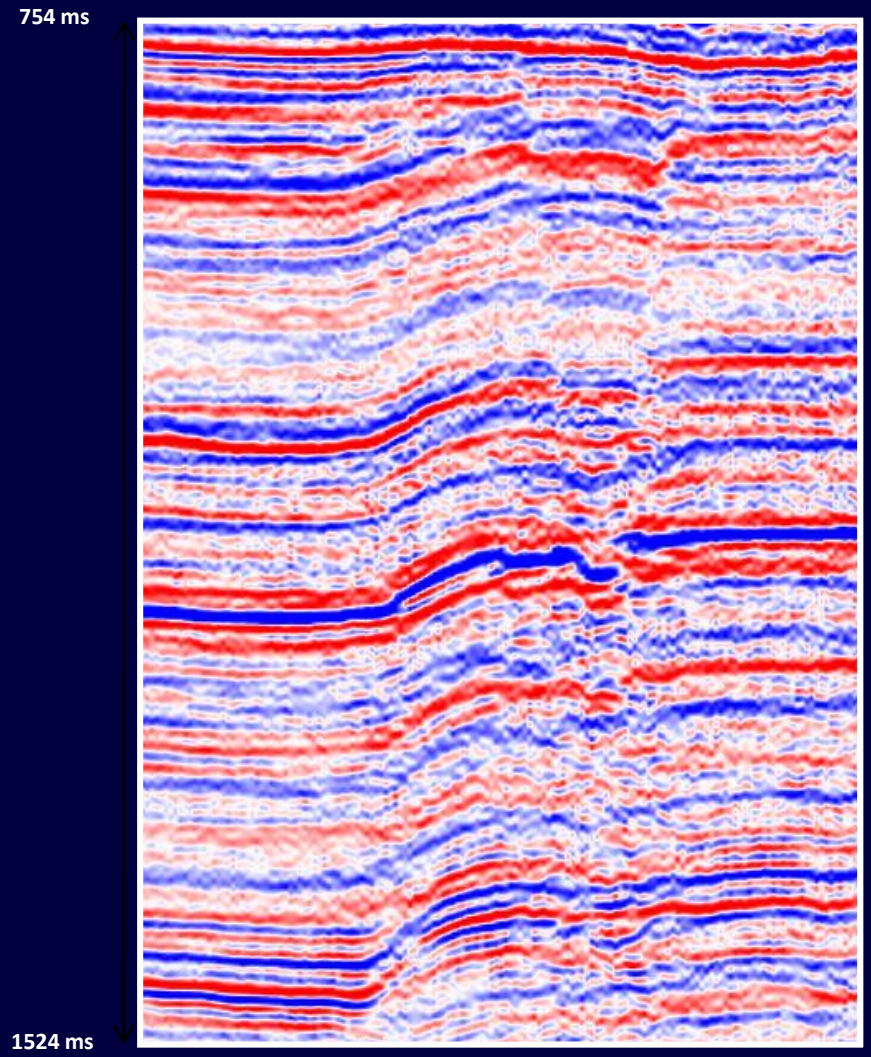


Most-negative curvature (short-wavelength)

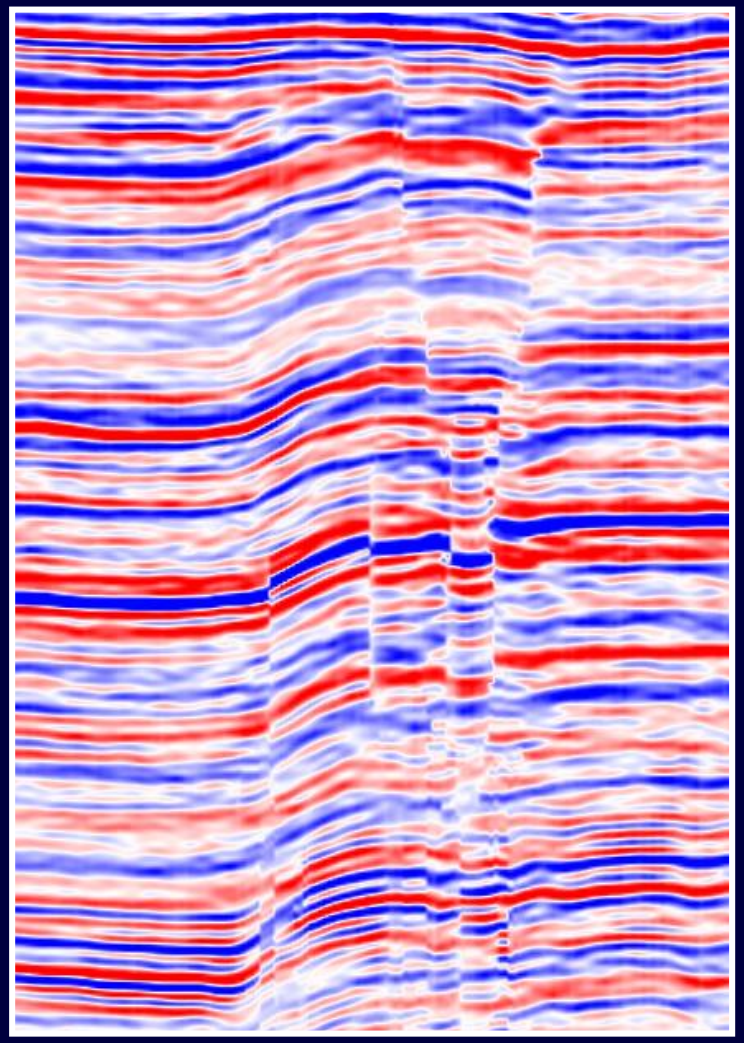
Time slices (1978 ms)

(Images courtesy: POGC & FX Energy)

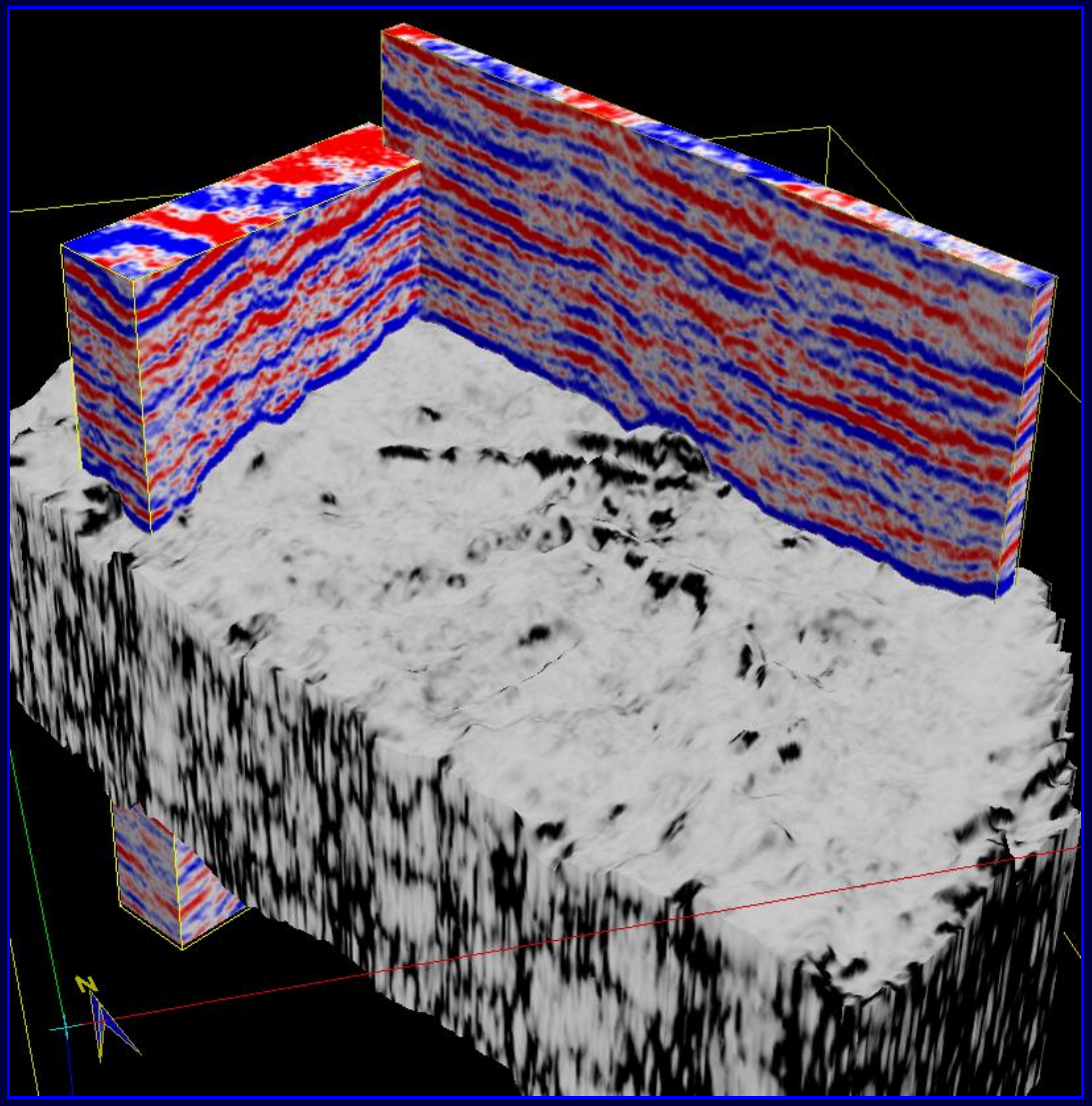
Pre-conditioning of seismic data



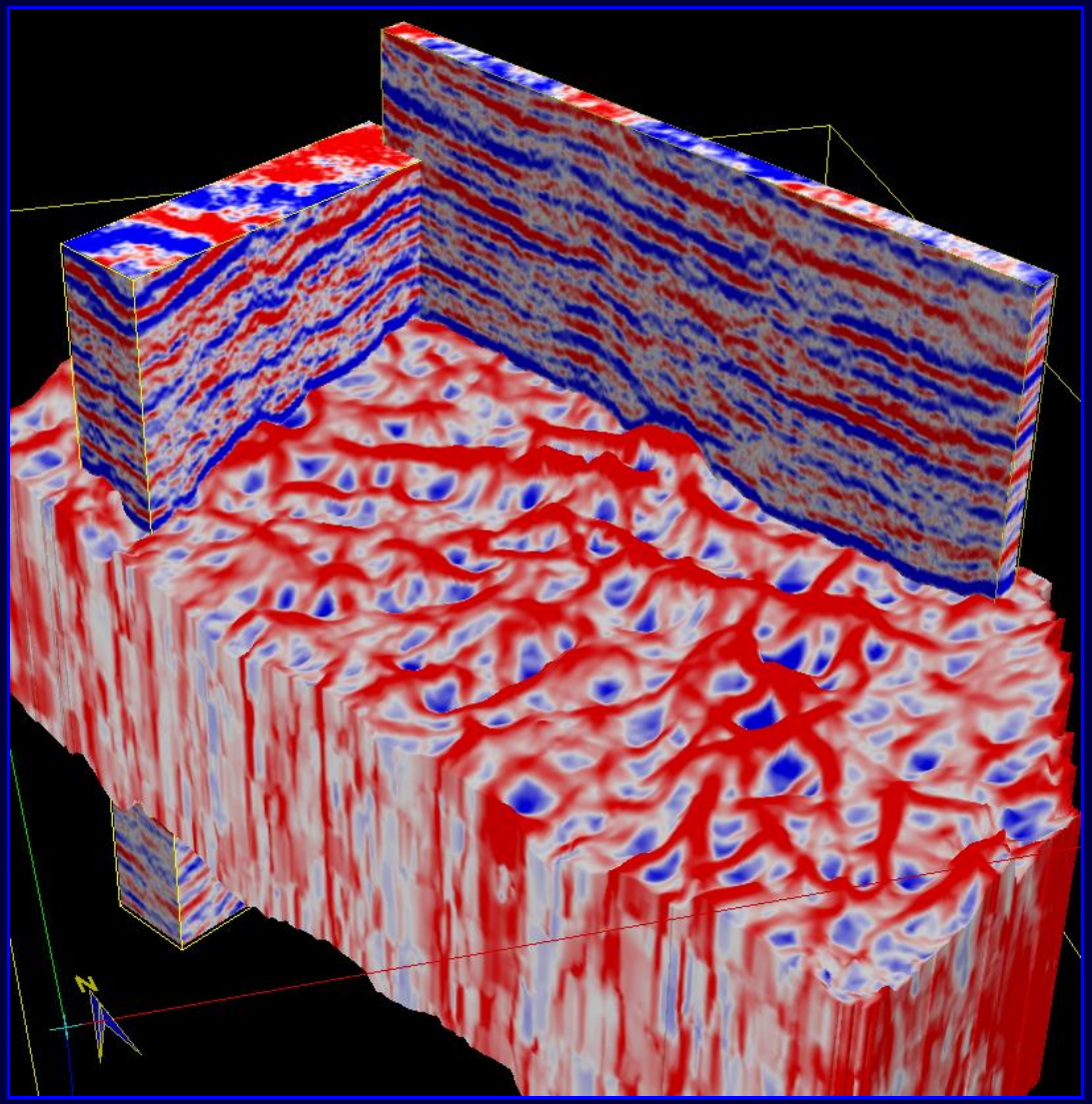
An inline through the input data volume



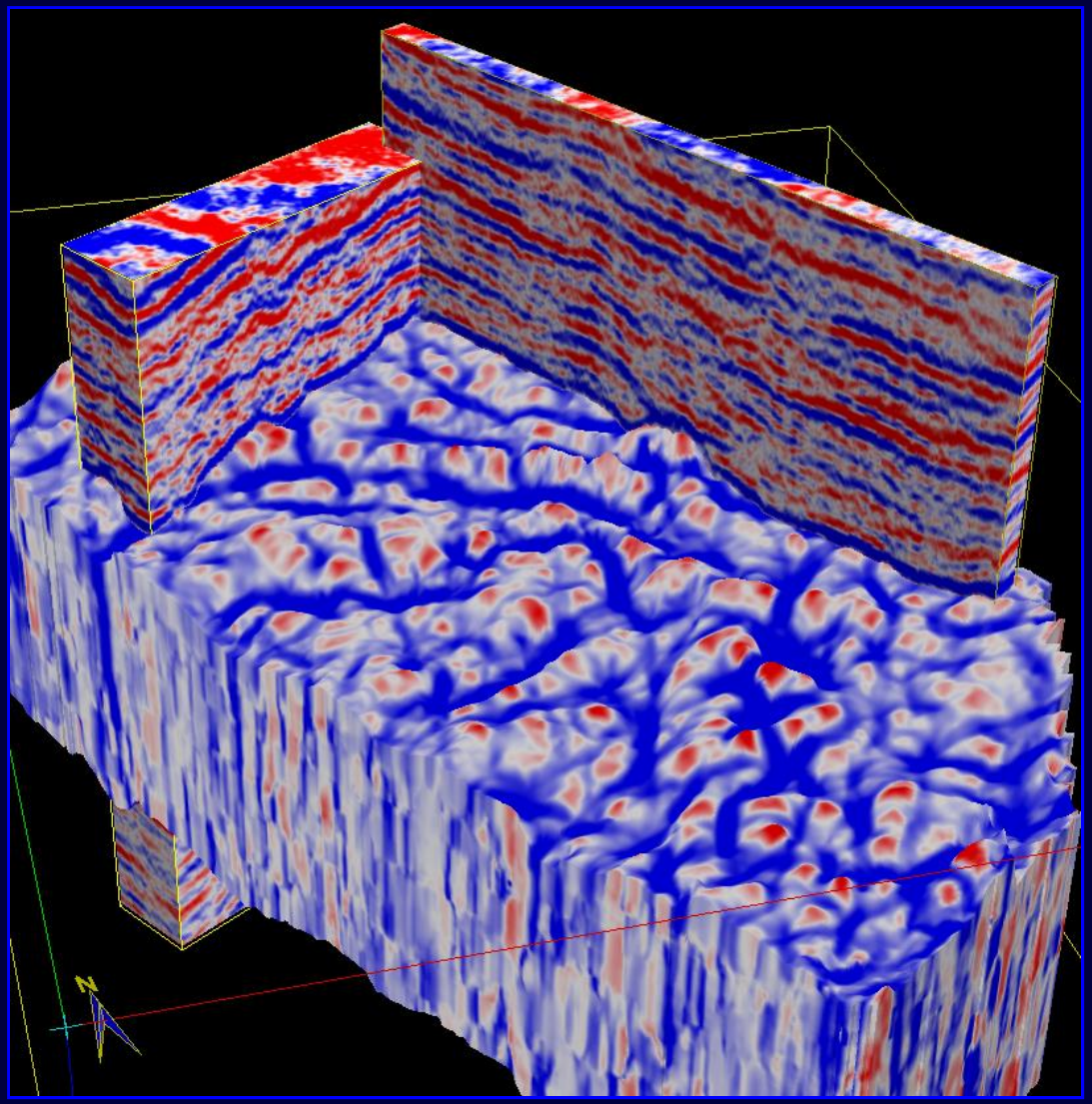
The same inline in (a) but after running pc-filtering on the input data volume



A seismic sub-cube intersecting the coherence strat-cube

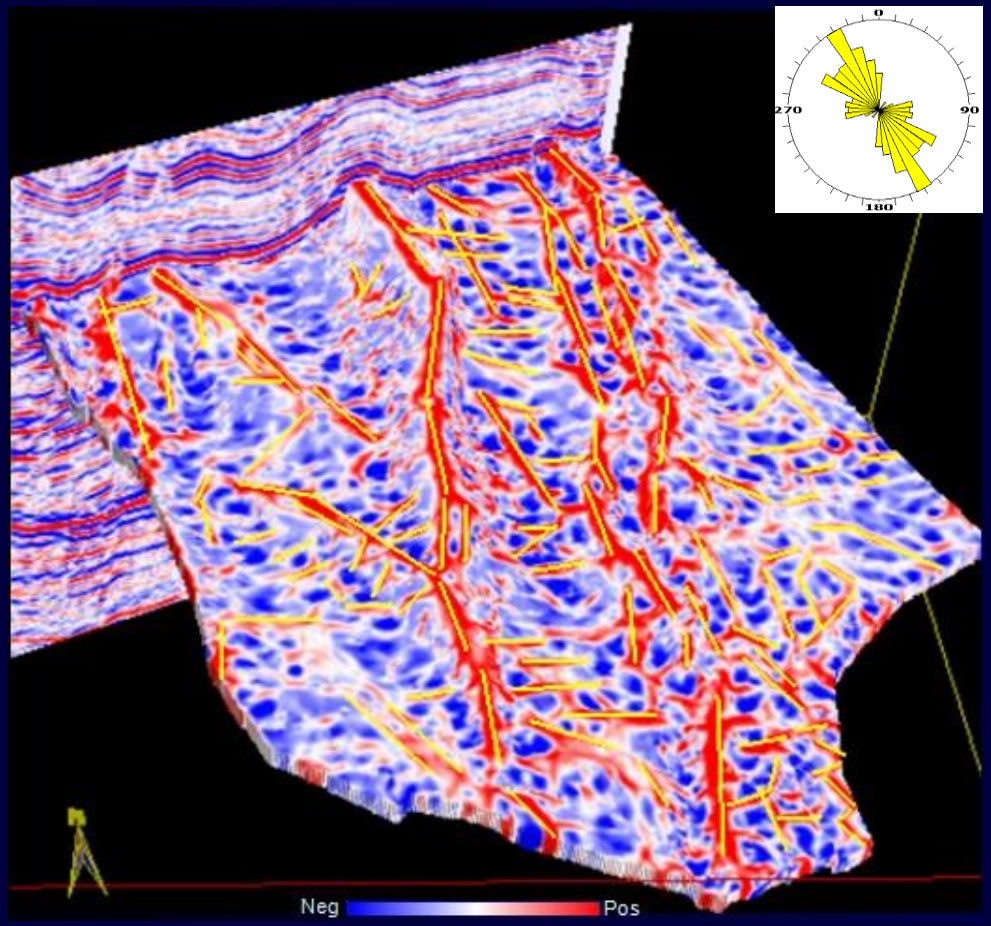


A seismic sub-cube intersecting the most-positive curvature strat-cube



A seismic sub-cube intersecting the most-negative curvature strat-cube

Interpretation of lineaments on curvature displays

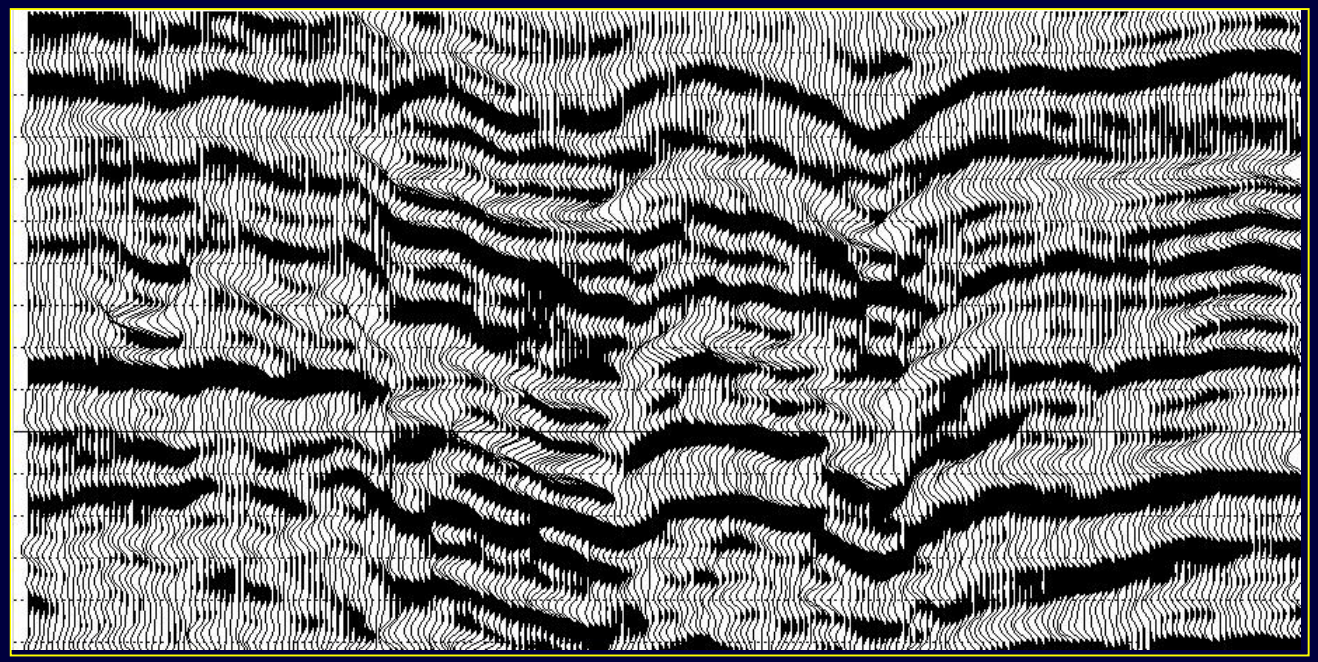


Lineaments on most-positive curvature horizon slice interpreted as yellow line segments and transformed into a rose diagram shown in the inset.

Curvature attributes and bandwidth of the input seismic

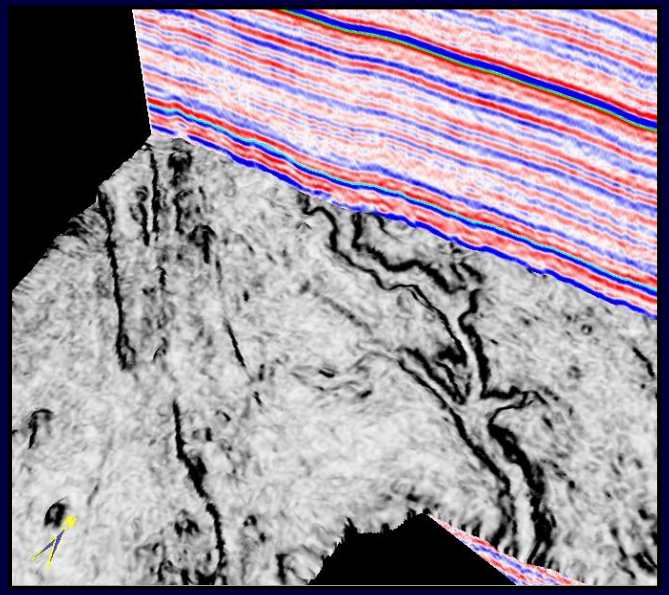
Input seismic

Curvature attributes and bandwidth of the input seismic

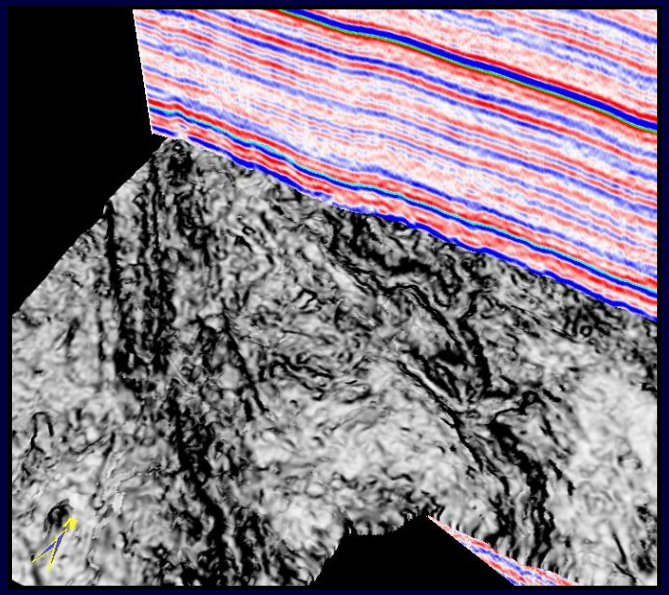


Reflectivity convolved with bandpass wavelet

Attributes on frequency-enhanced data



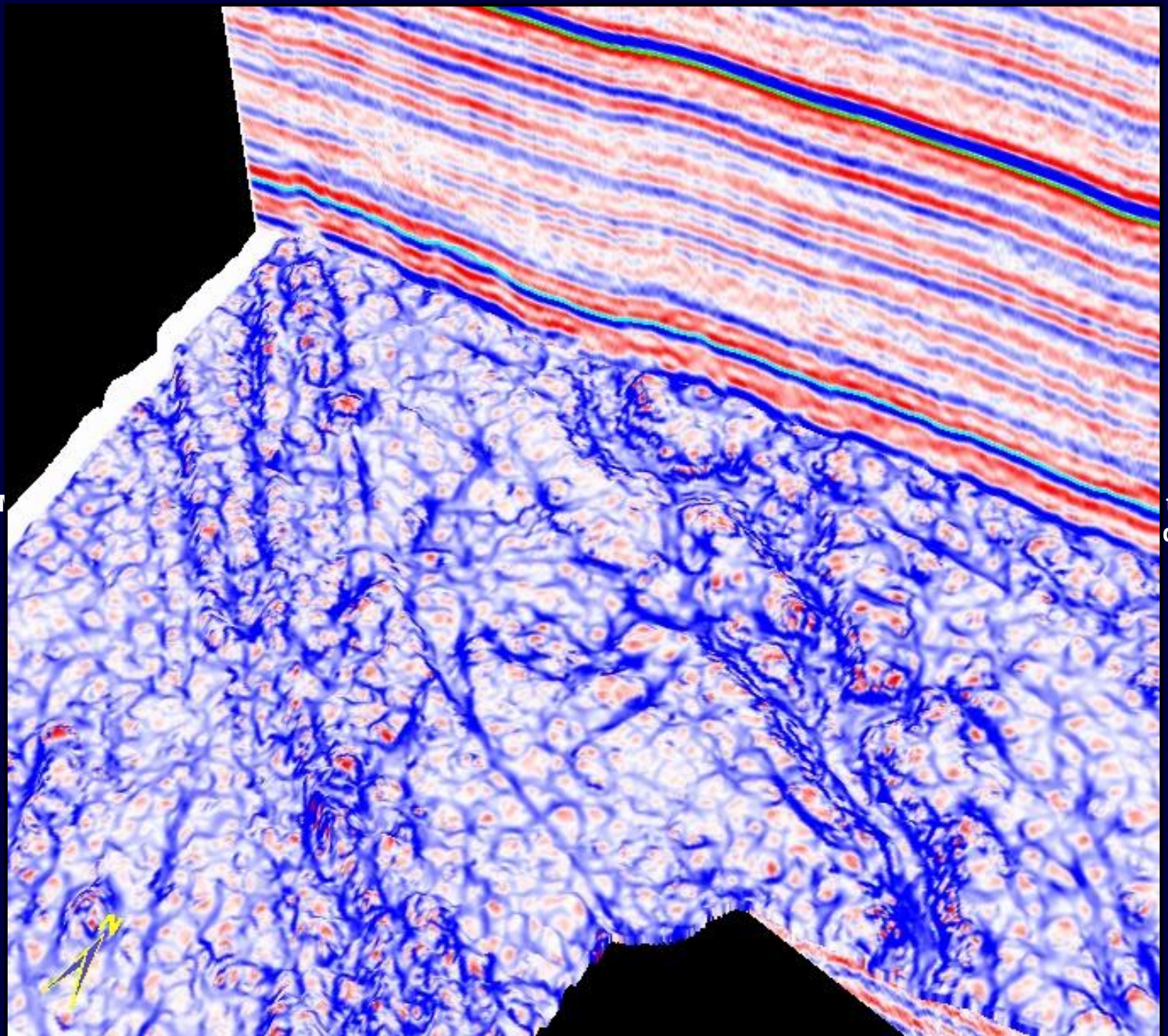
Coherence on the input volume



Coherence on the frequency-enhanced volume

Data courtesy: Arcis Corporation,

Attributes on frequency-enhanced data



the input
d then
of 120 hz

Conclusions

- Use of curvature attributes enables you to see the faults and fractures much better

- Subtle faults/fractures that cannot be detected with coherence can be detected with curvature attributes

To add more value to your interpretation,

'Add the curvature dimension to your 3D seismic data'

We should remember

If it's worth doing accurately, it's worth doing with the use of curvatures

THANK YOU