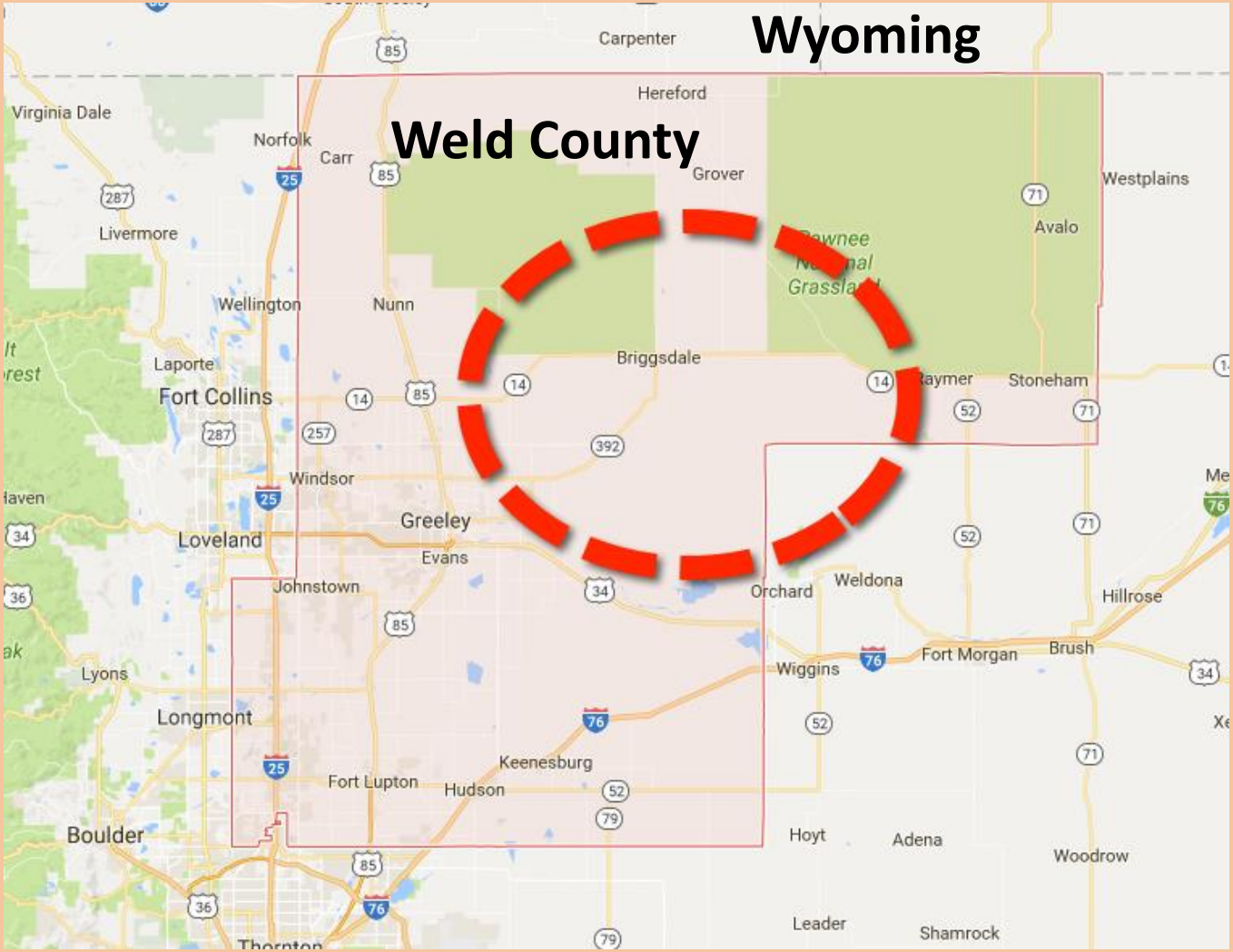
Complex Fault and Fracture Patterns within the Niobrara: How important are they?

Jim Applegate, SeismicUtensils, LLC; **W. Travis Brown**, Travis Energy Group, Inc.; **Doug Paul**, SeisWare, Inc.; & **Filip Soos**, SeismicUtensils, LLC

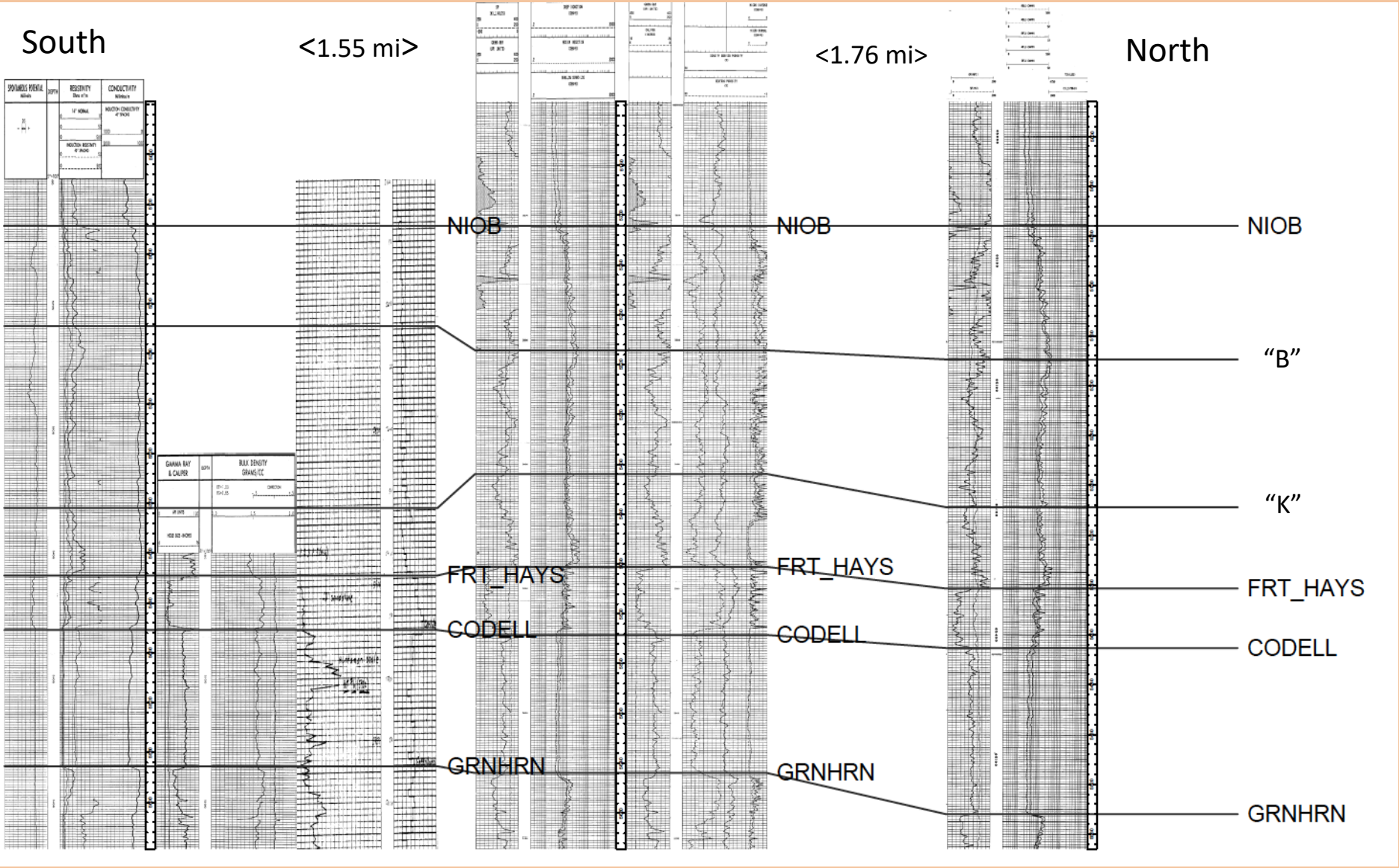
OUTLINE

- **Introduction**
  - Location
  - Geology
- **Observations**
  - Faults/Fractures
  - Pre-Stack & Post-Stack Attributes
- **Summary**

Weld County, CO



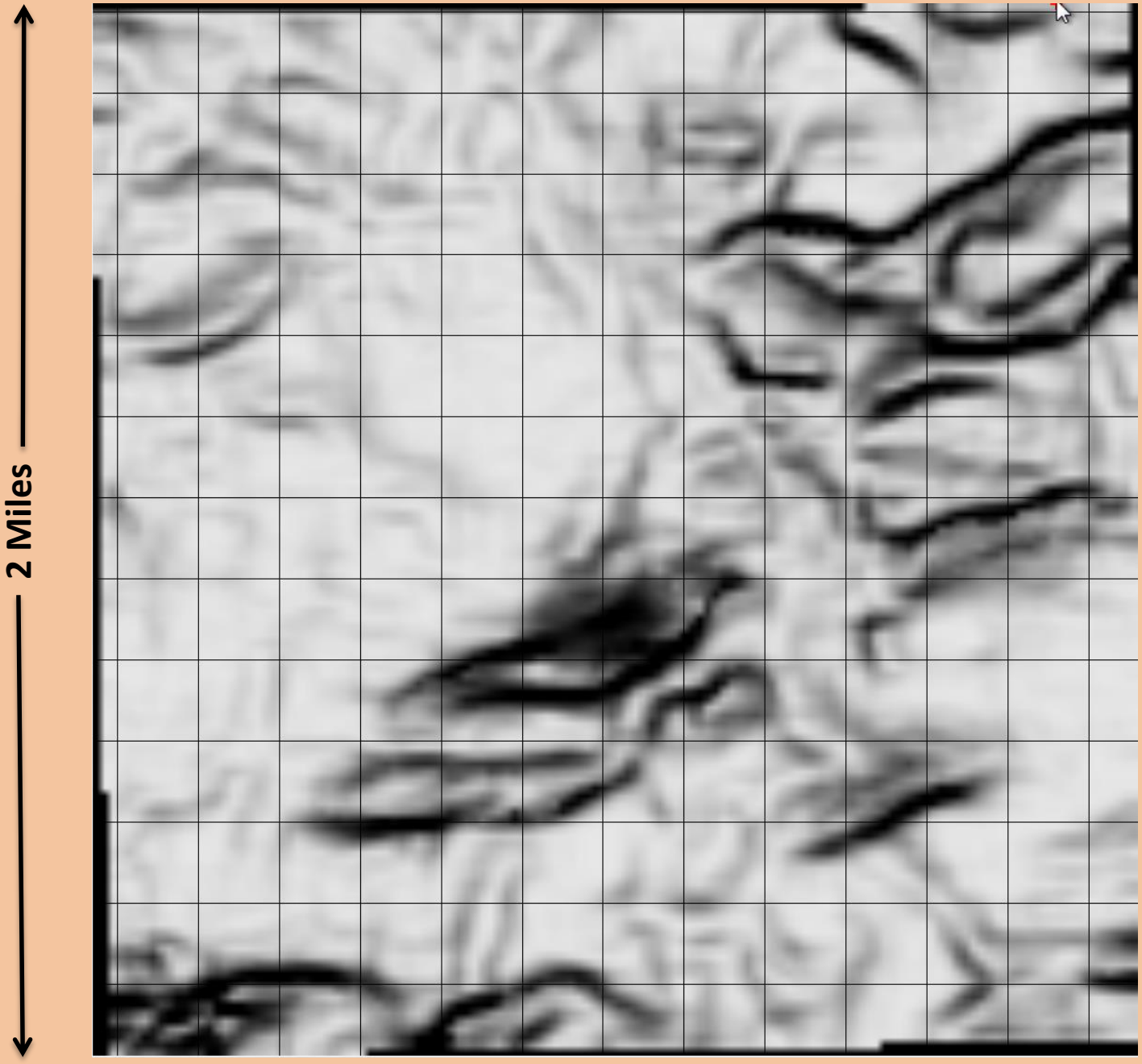
CROSS SECTION



OBSERVATIONS

- Complex Fault Patterns
- Niobrara Wrench Faults
- Flower Structures encompass Wrench Faults
- Possible Shear Fault – Niobrara Level Offsets
- Impact of Deep Structural Feature(s)
- Anomalous Zones from Seismic Attributes
- Fault Character from Seismic Attributes

SEMBLANCE – TOP NIOBRARA

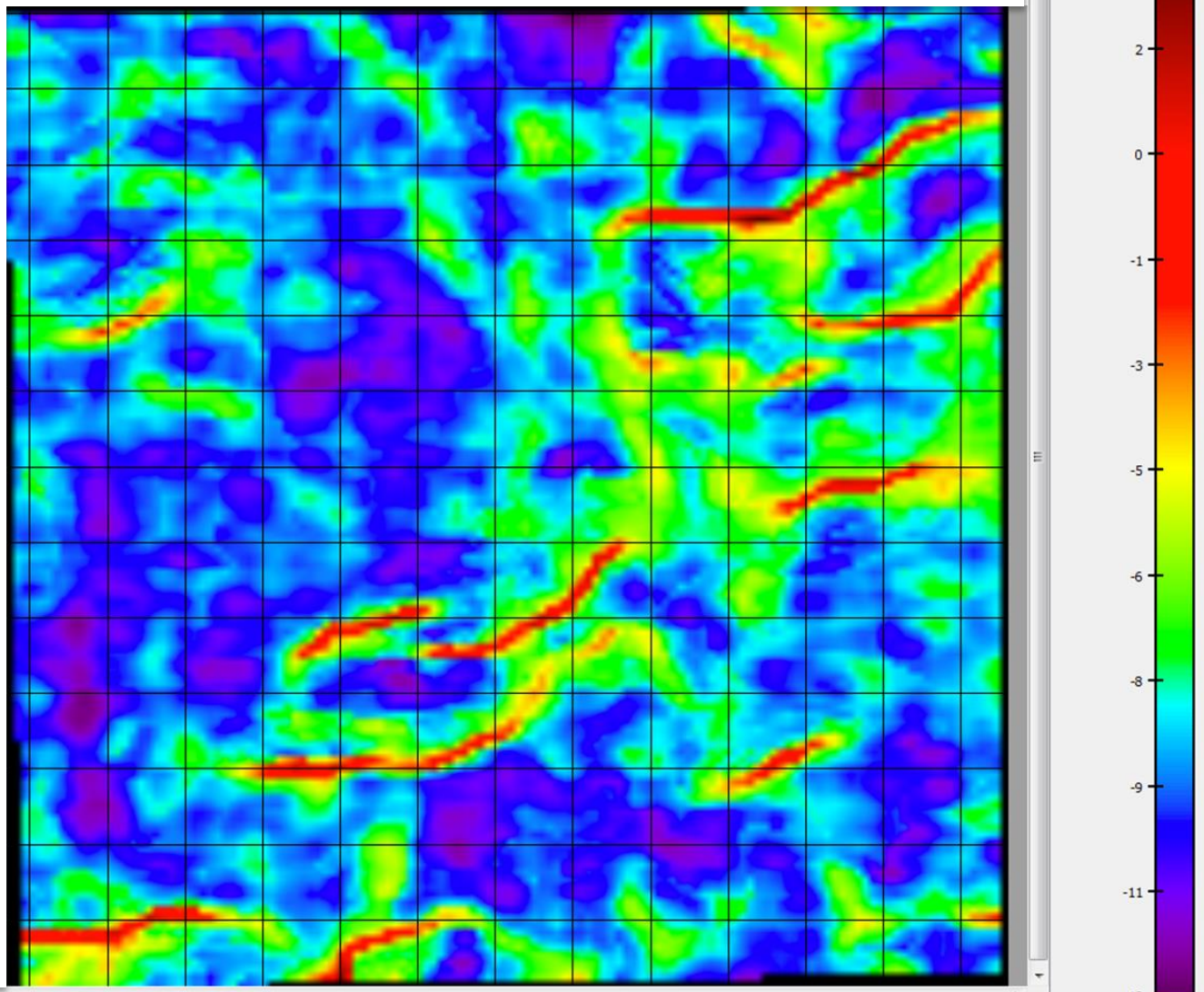


LithF_2x2_1350-1550 @Niobrara 0 ms

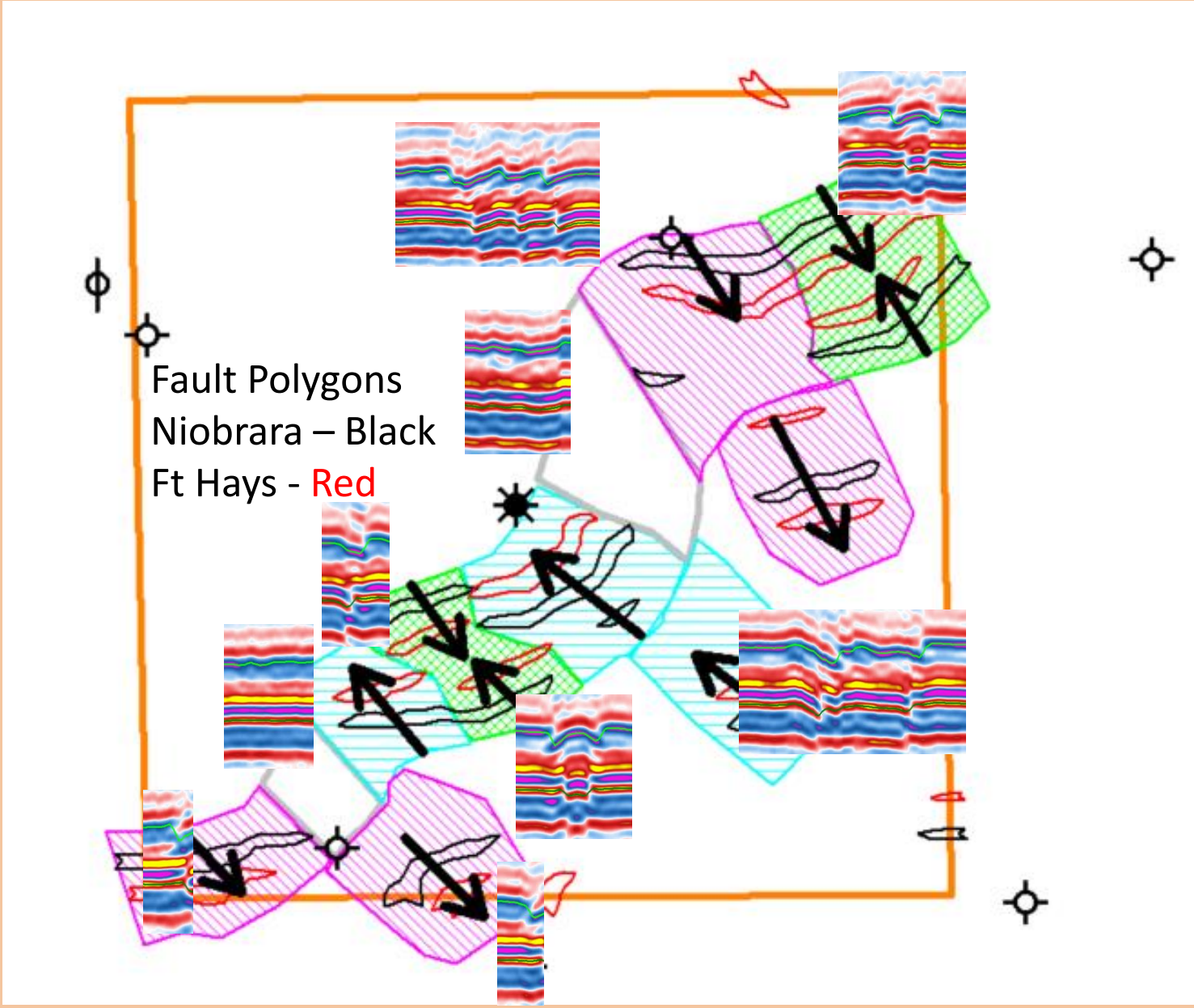
File Scale Display Window Broadcast

Niobrara Relative Time: 0

AVO LITHOLOGY FACTOR –TOP NIOBRARA

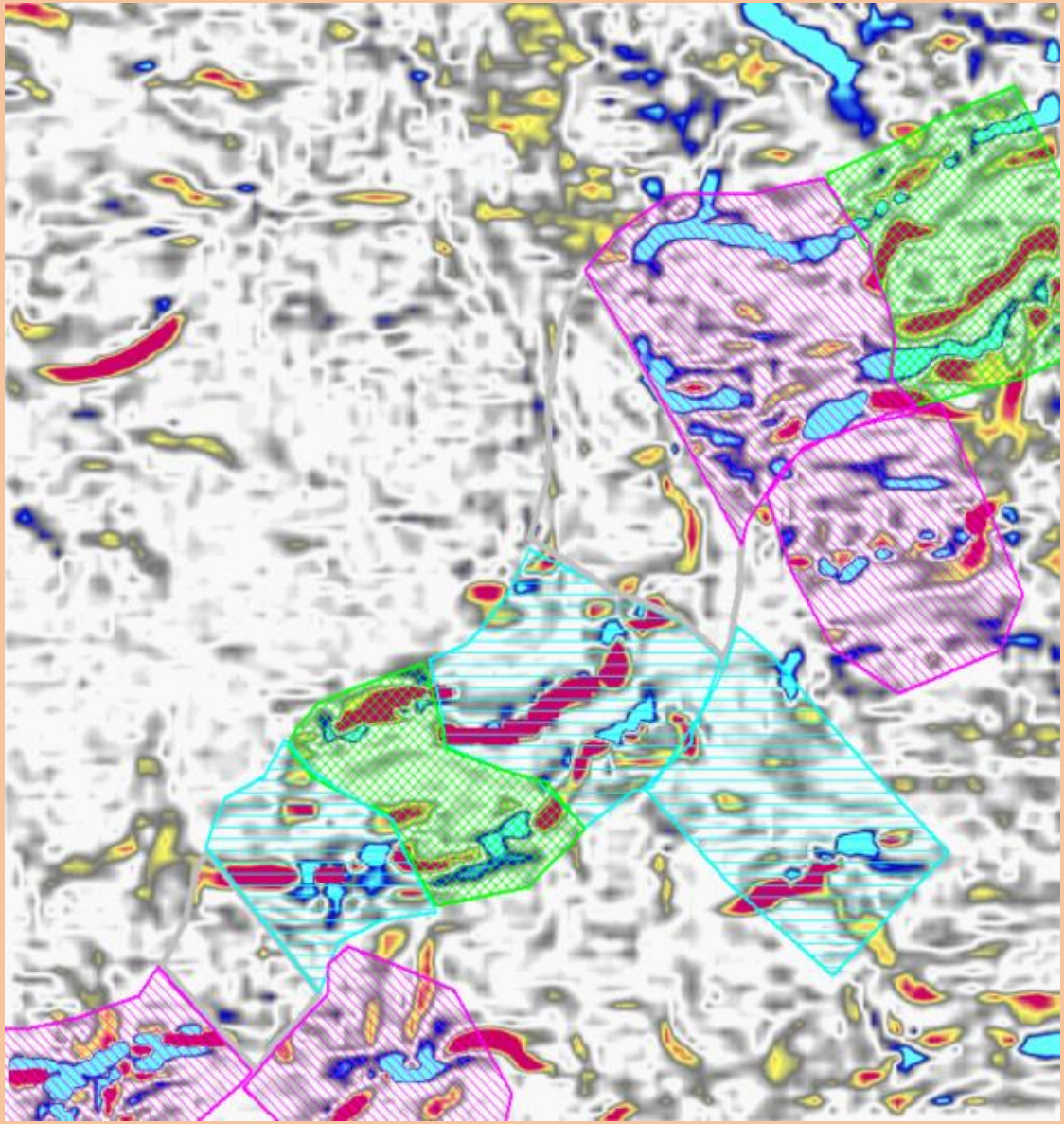


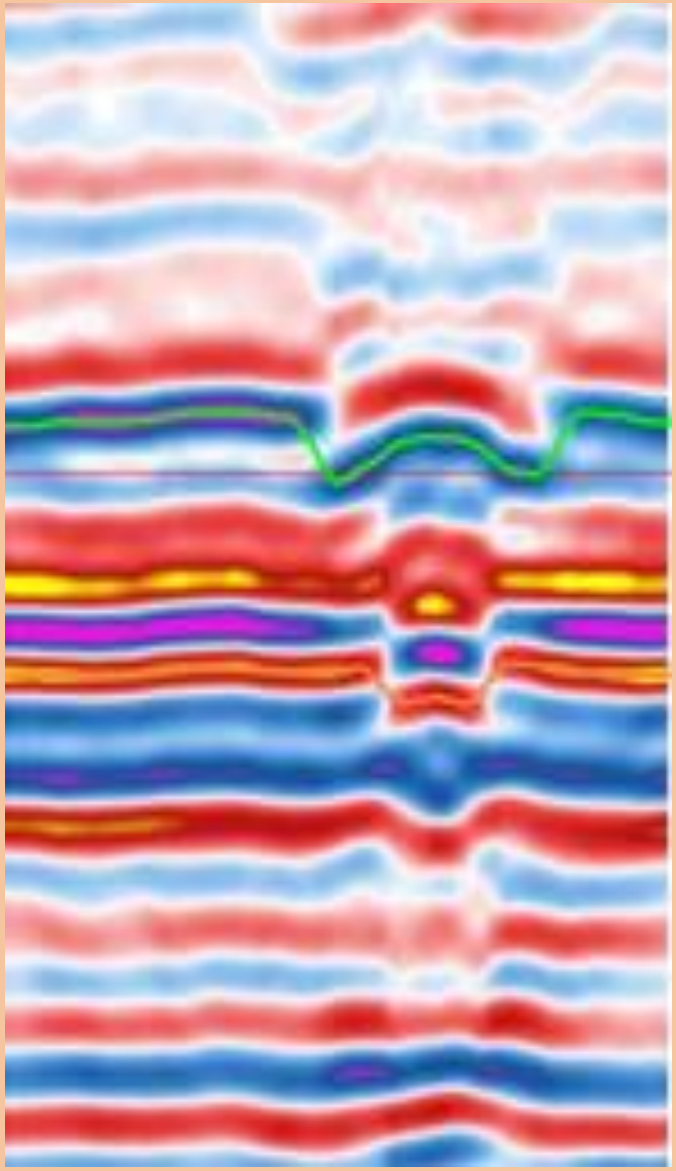
Fault Dip Summary



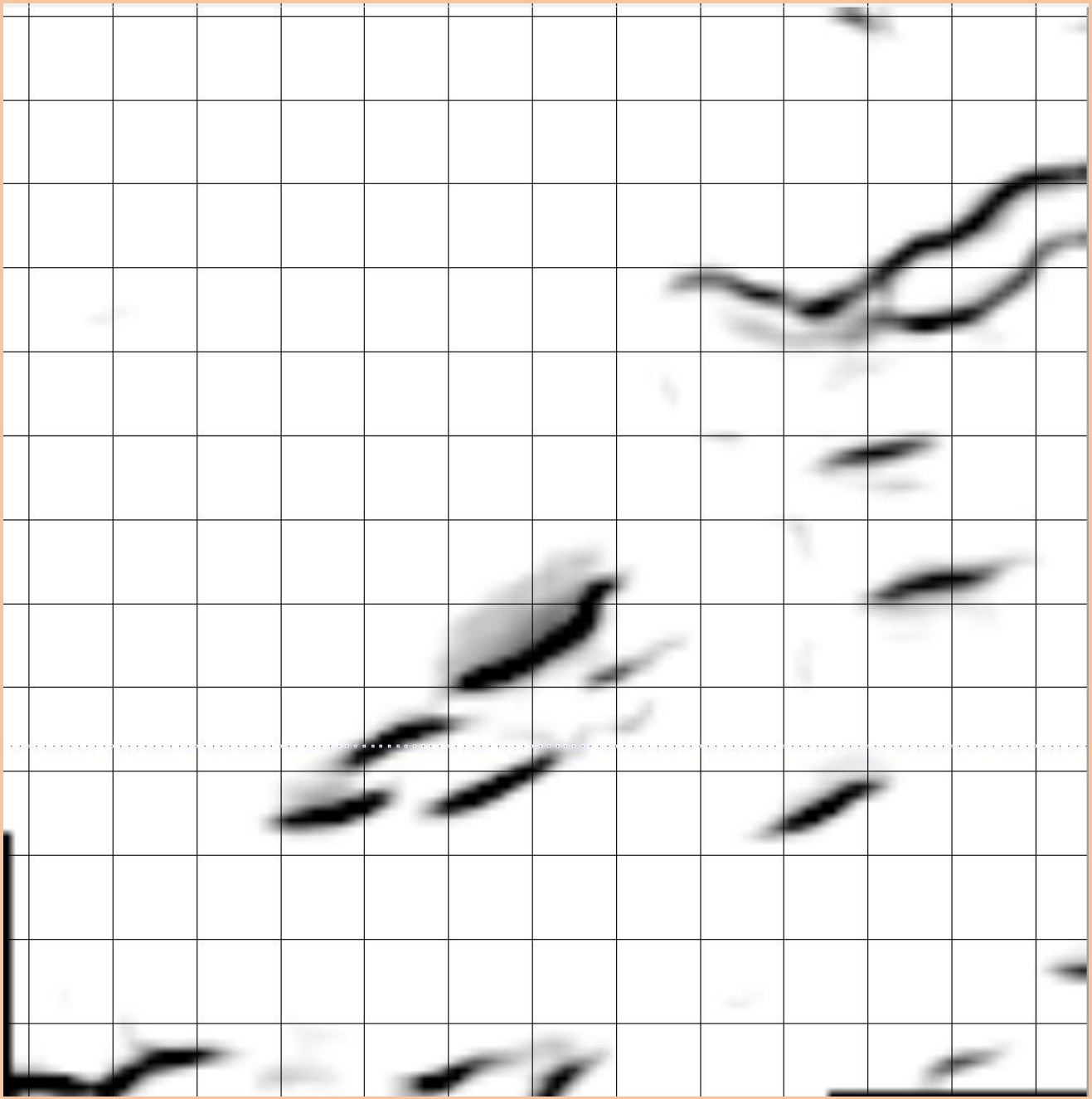
Rock Solid Max Curvature

Red – Positive, Blue – Negative Curvature





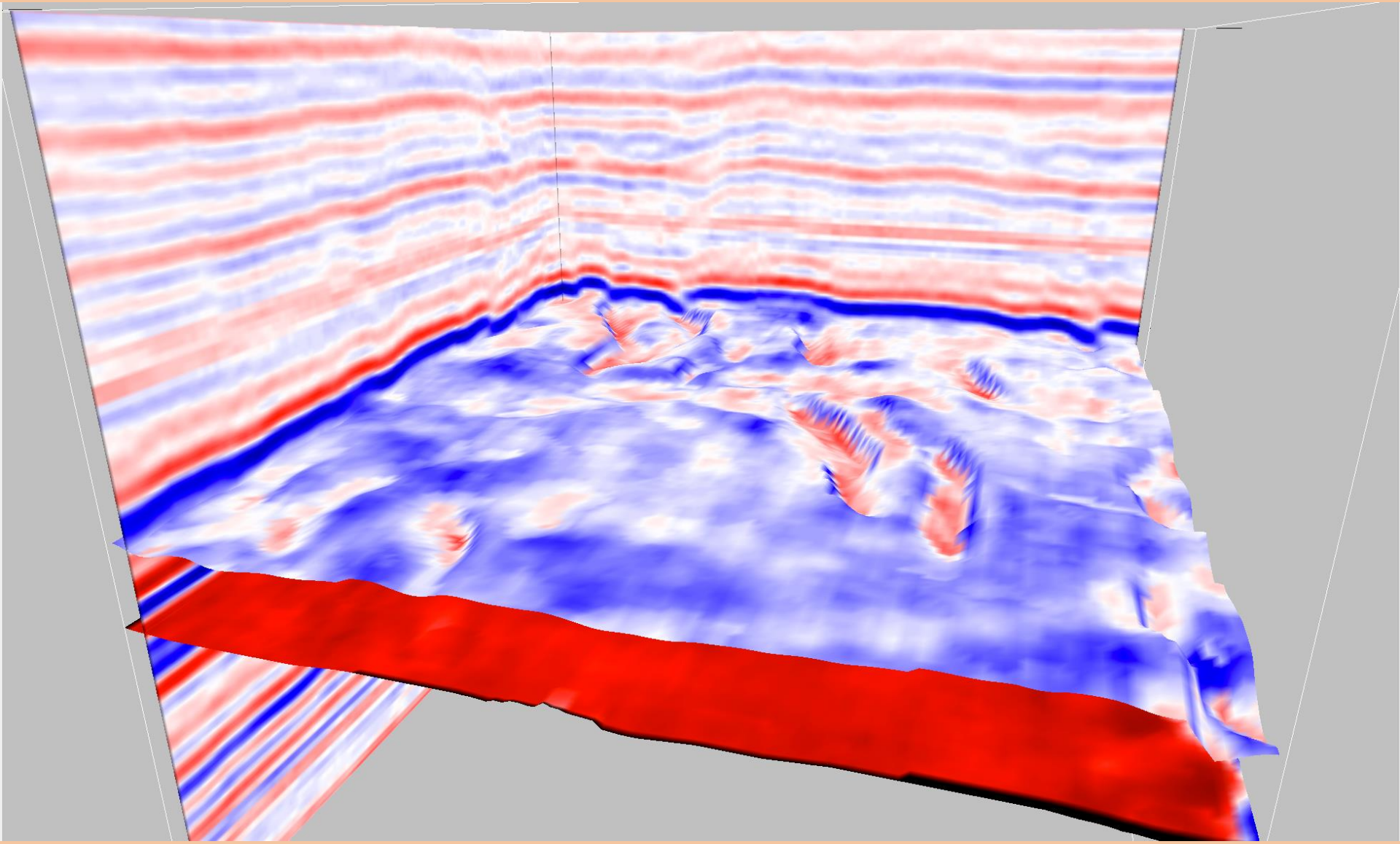
SEMBLANCE – FT HAYS

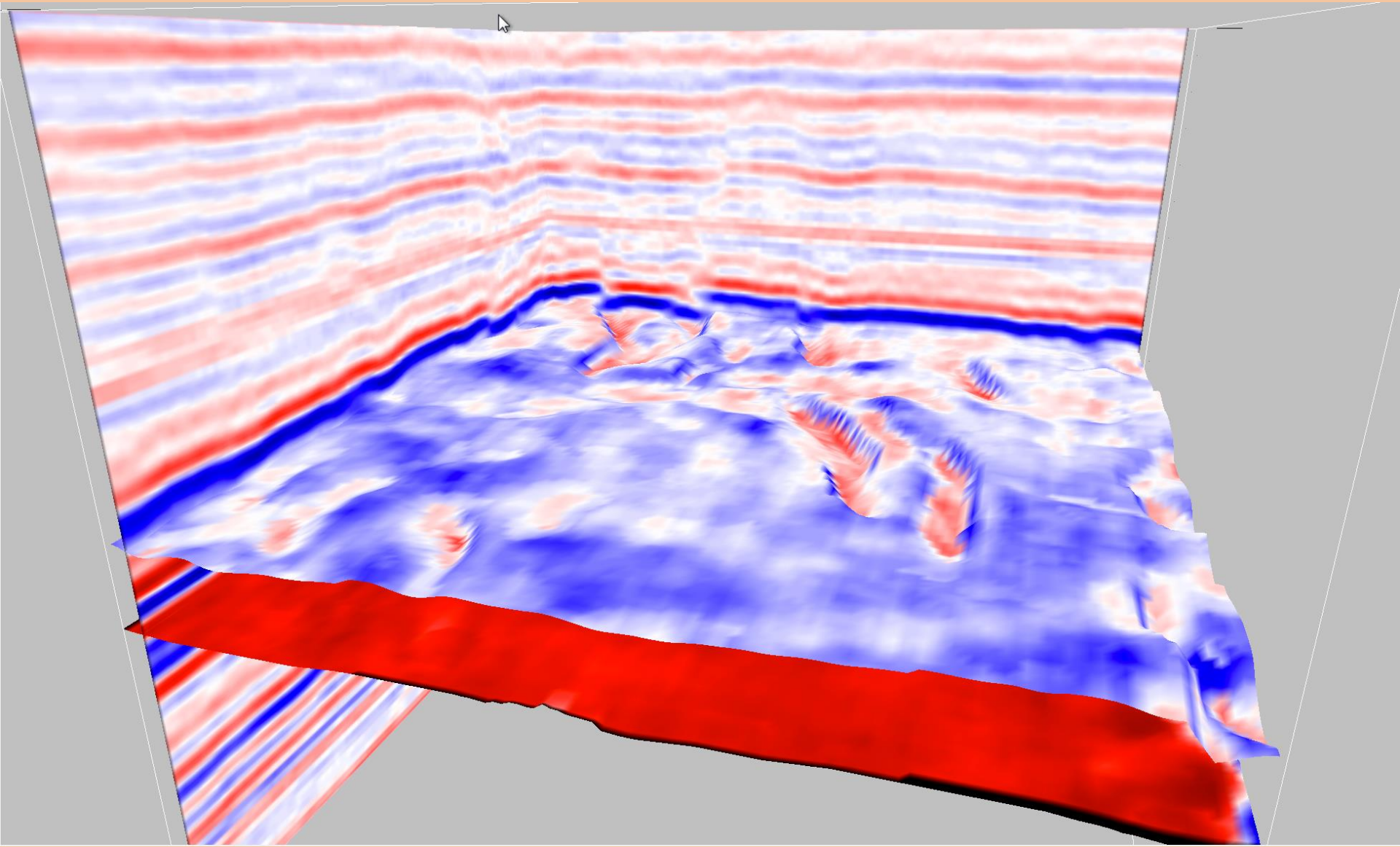


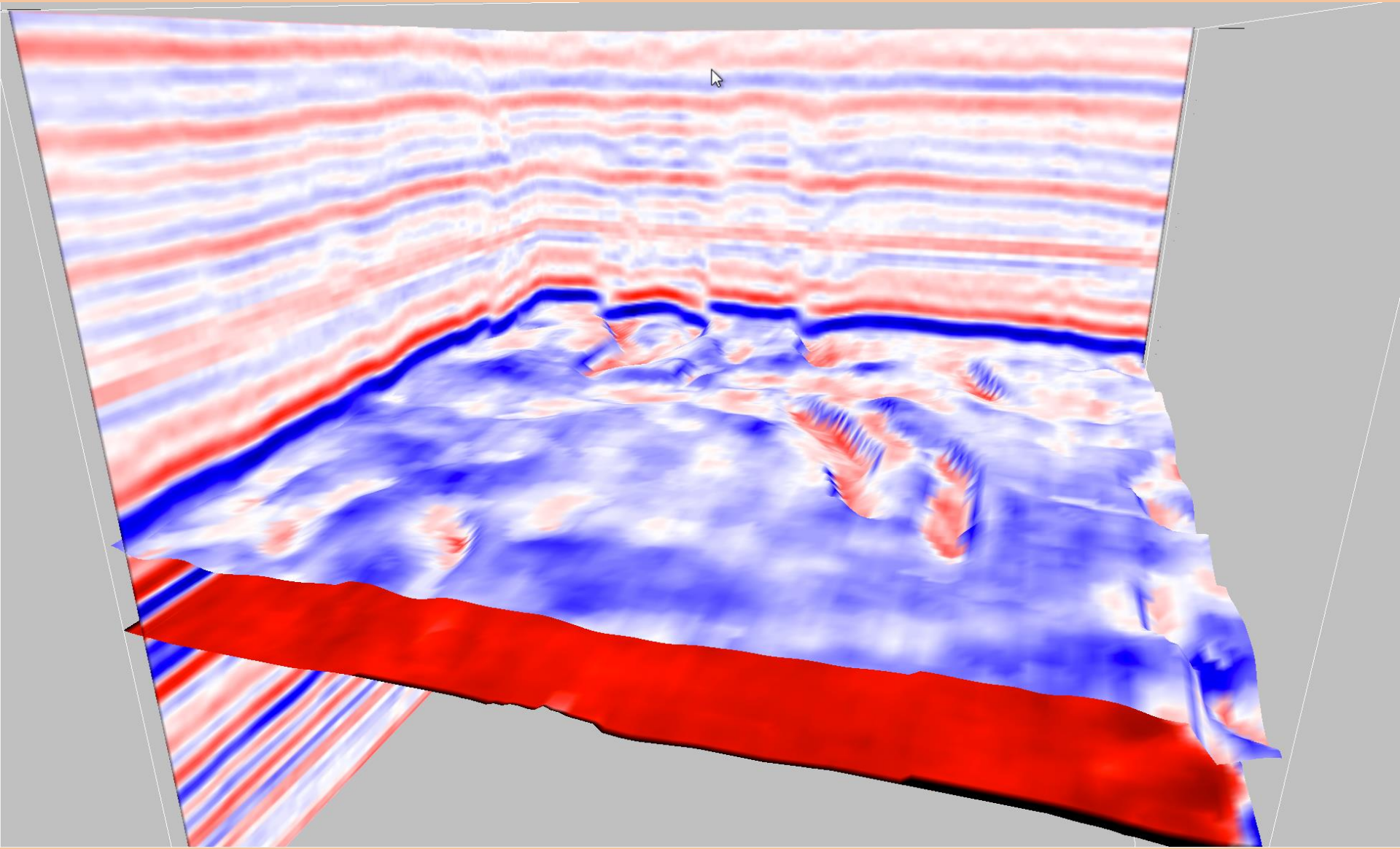
Fault Complexity

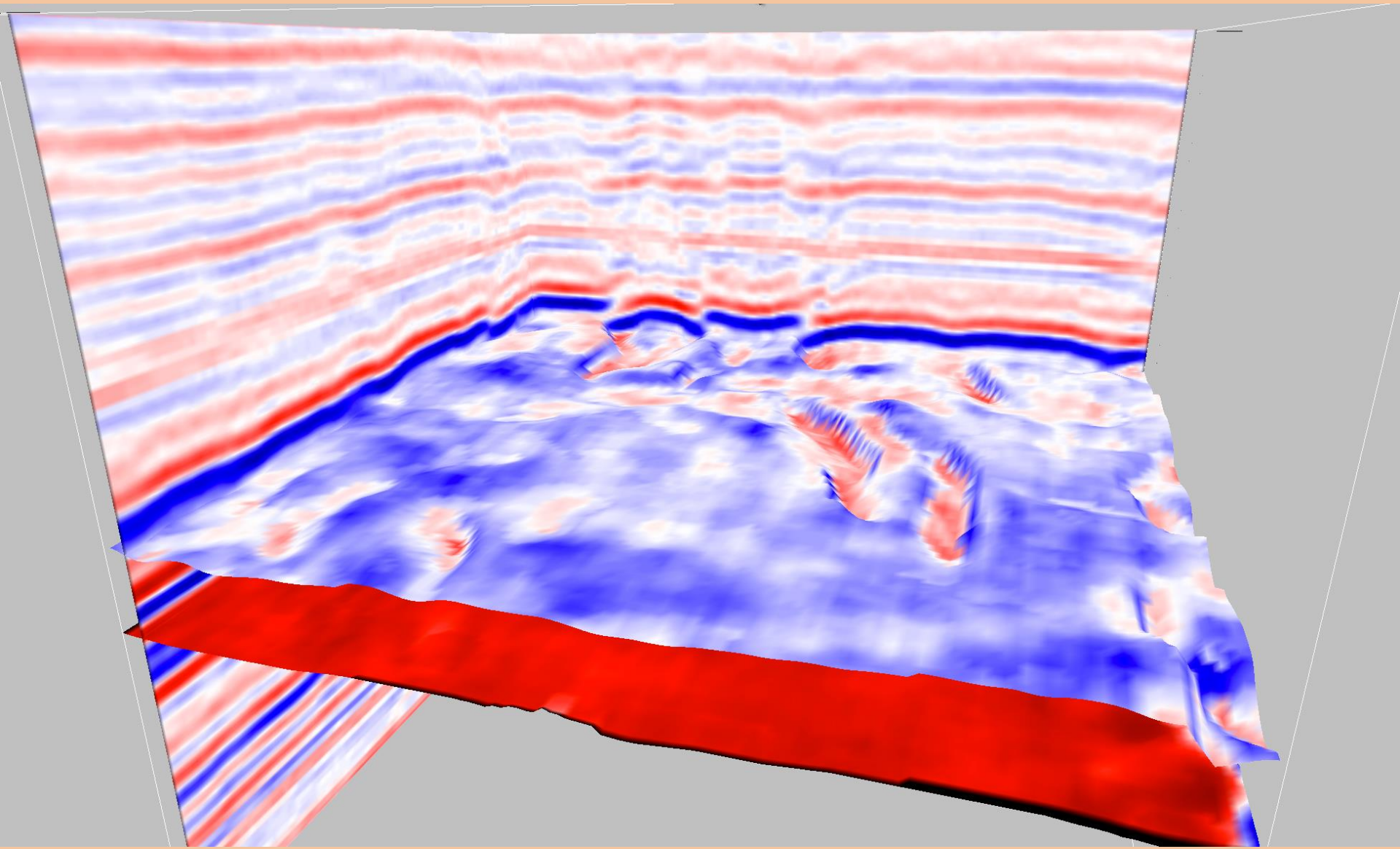
- Illustrate **Spatial Fault Variation**.
- Series of Vertical Slice
- **Inline and Crossline** Displayed
- Two **Horizon** Slices Displayed:
  - Niobrara structure is visible on top
  - Ft Hays below is not very visible, but spacing shows relative thickness.

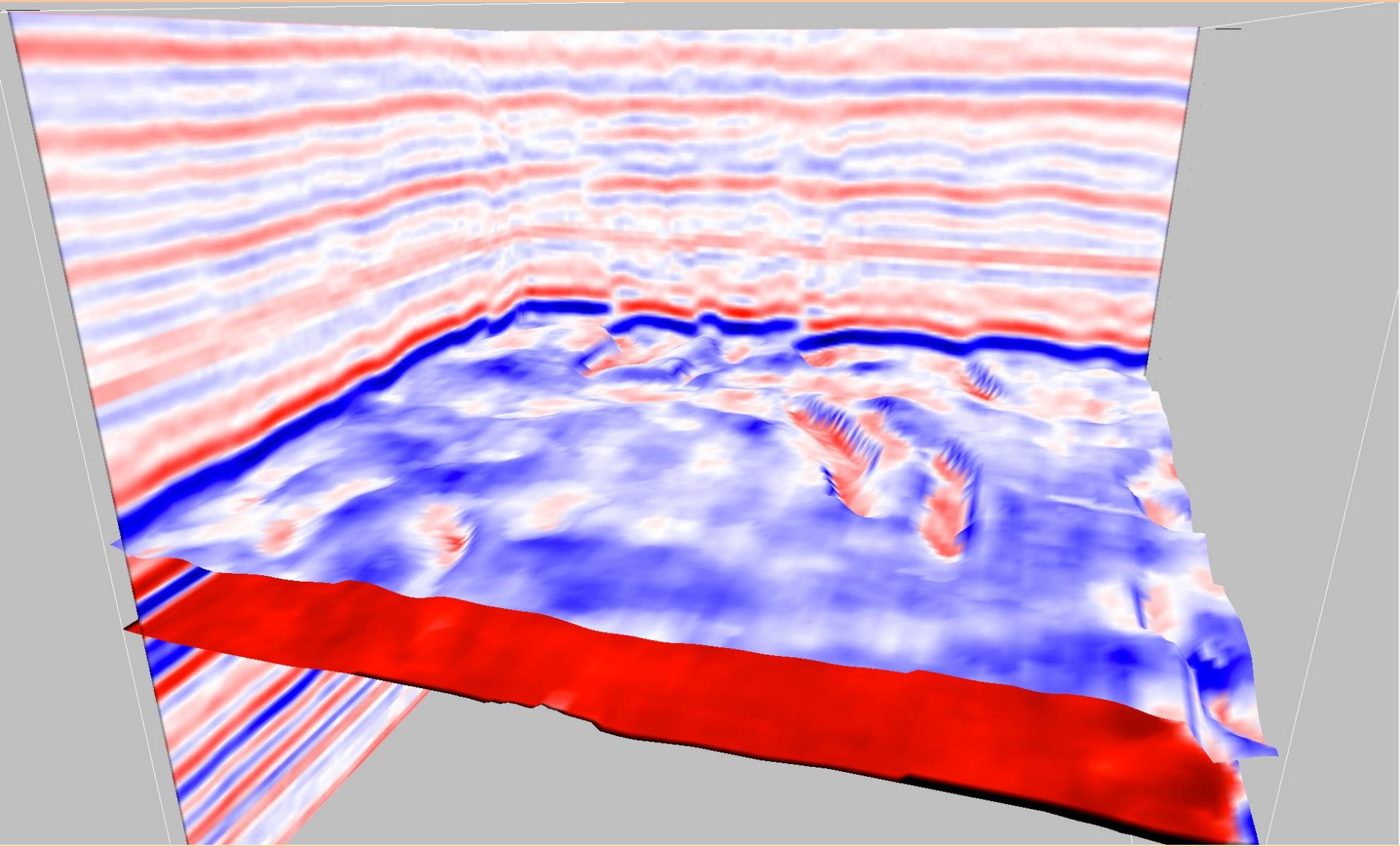
VIEW IS TO THE E-NE.

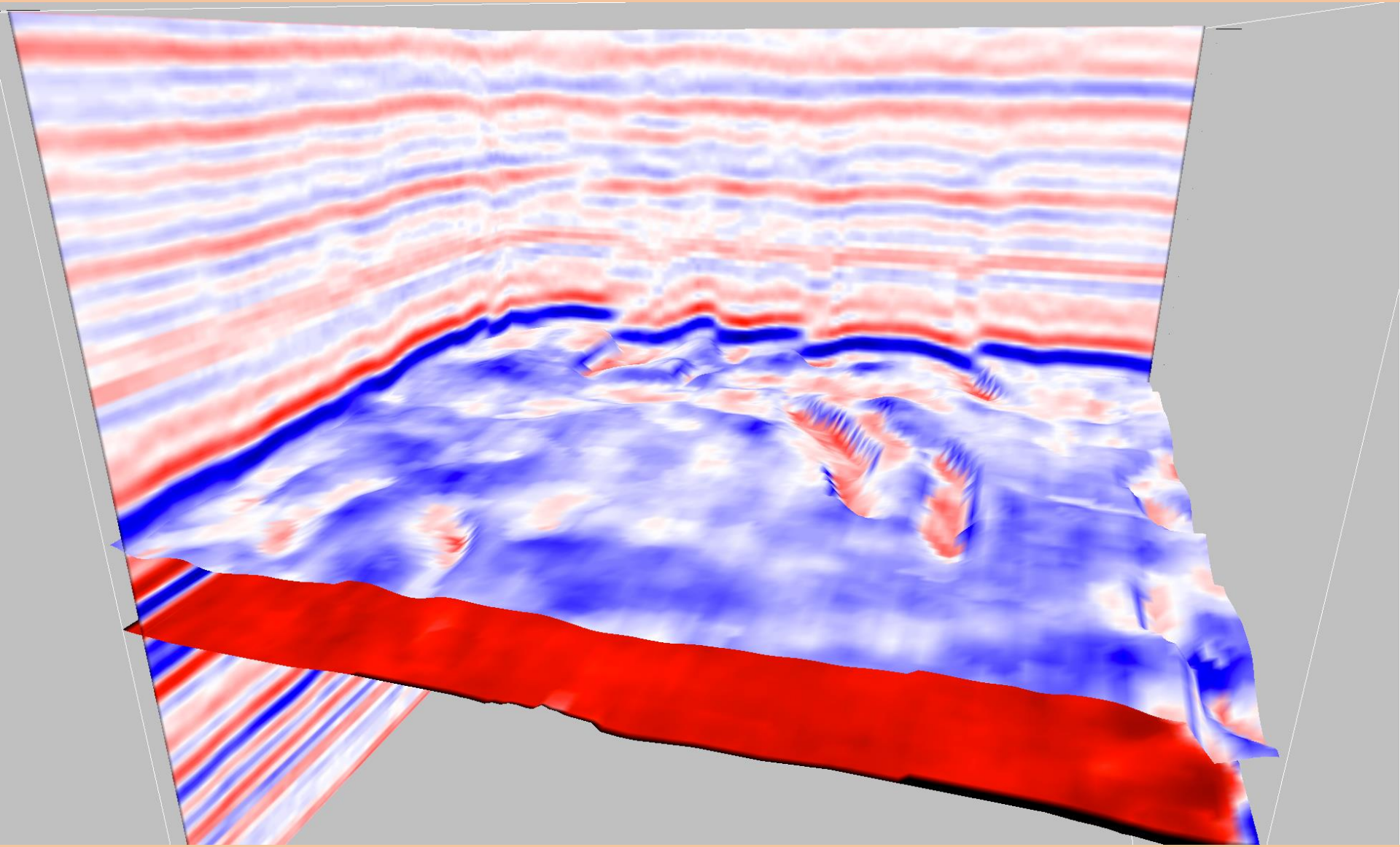


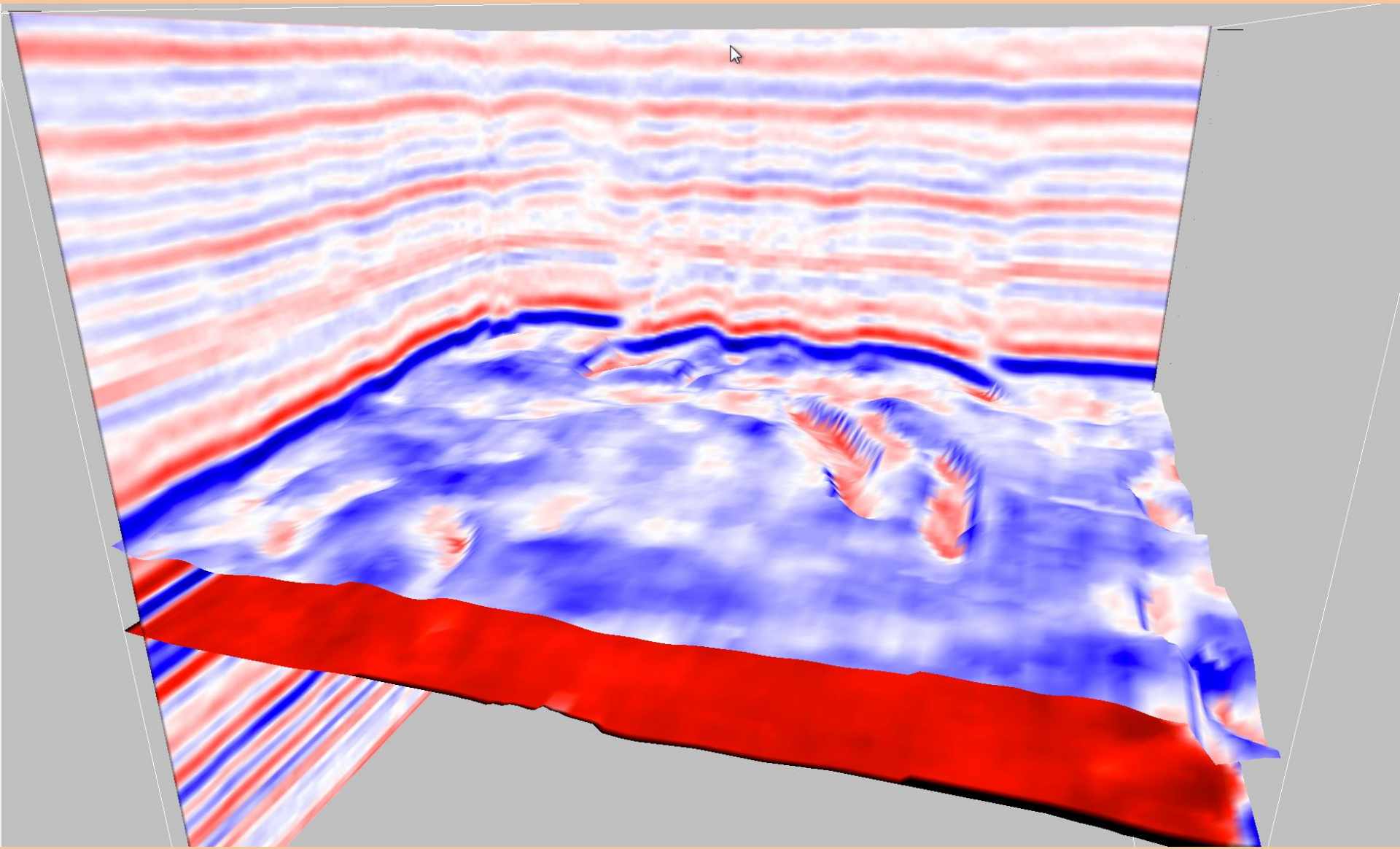


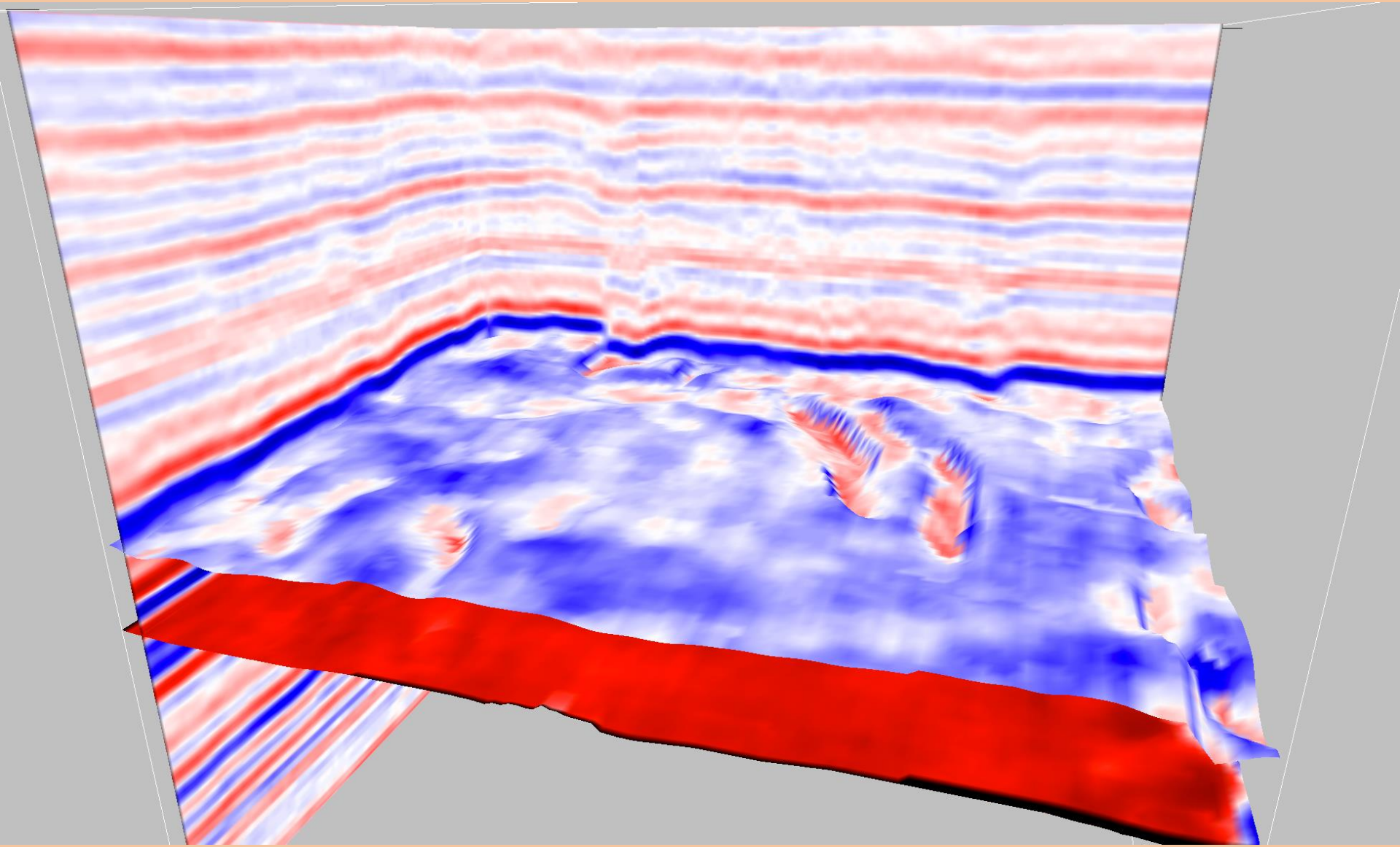


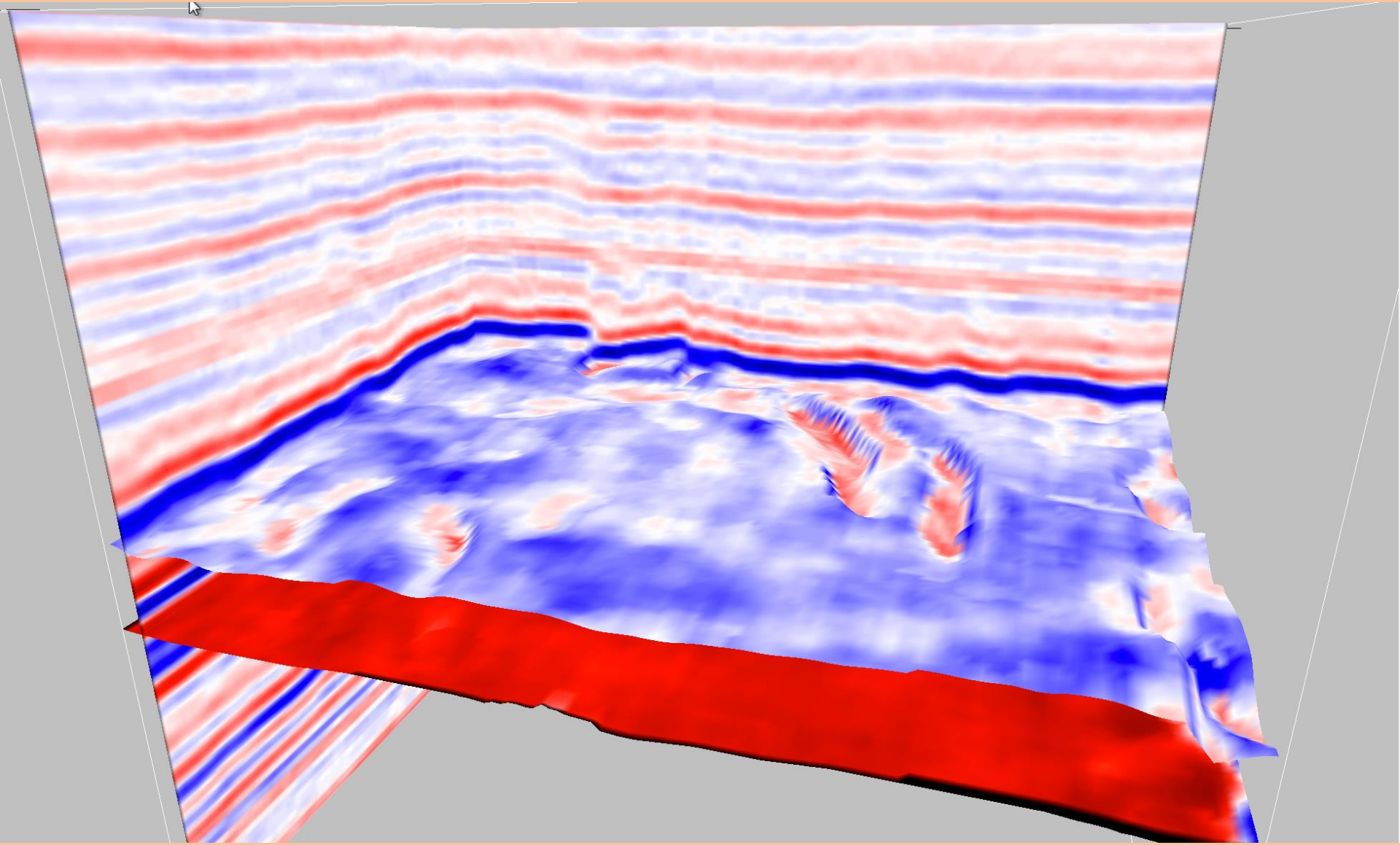


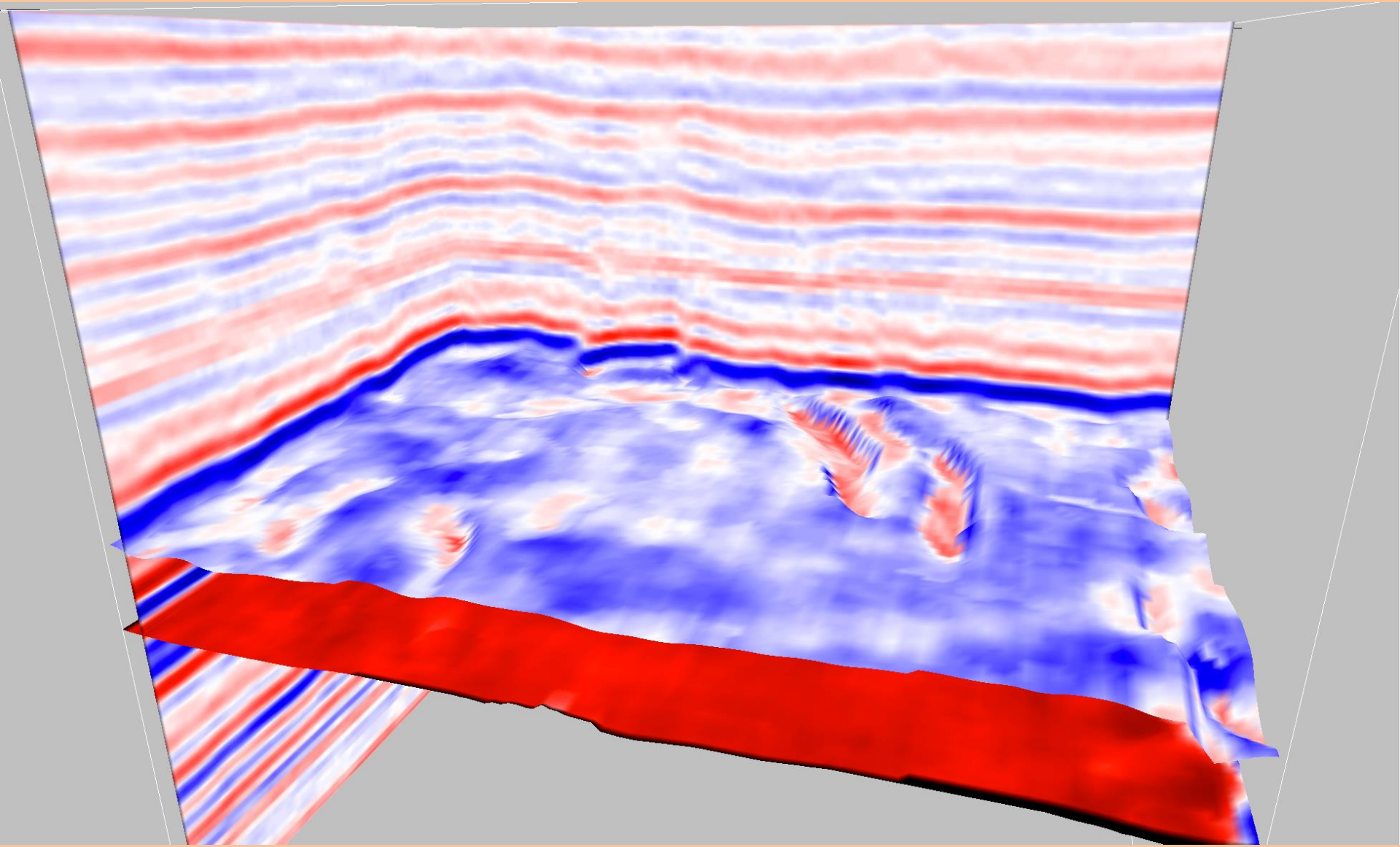


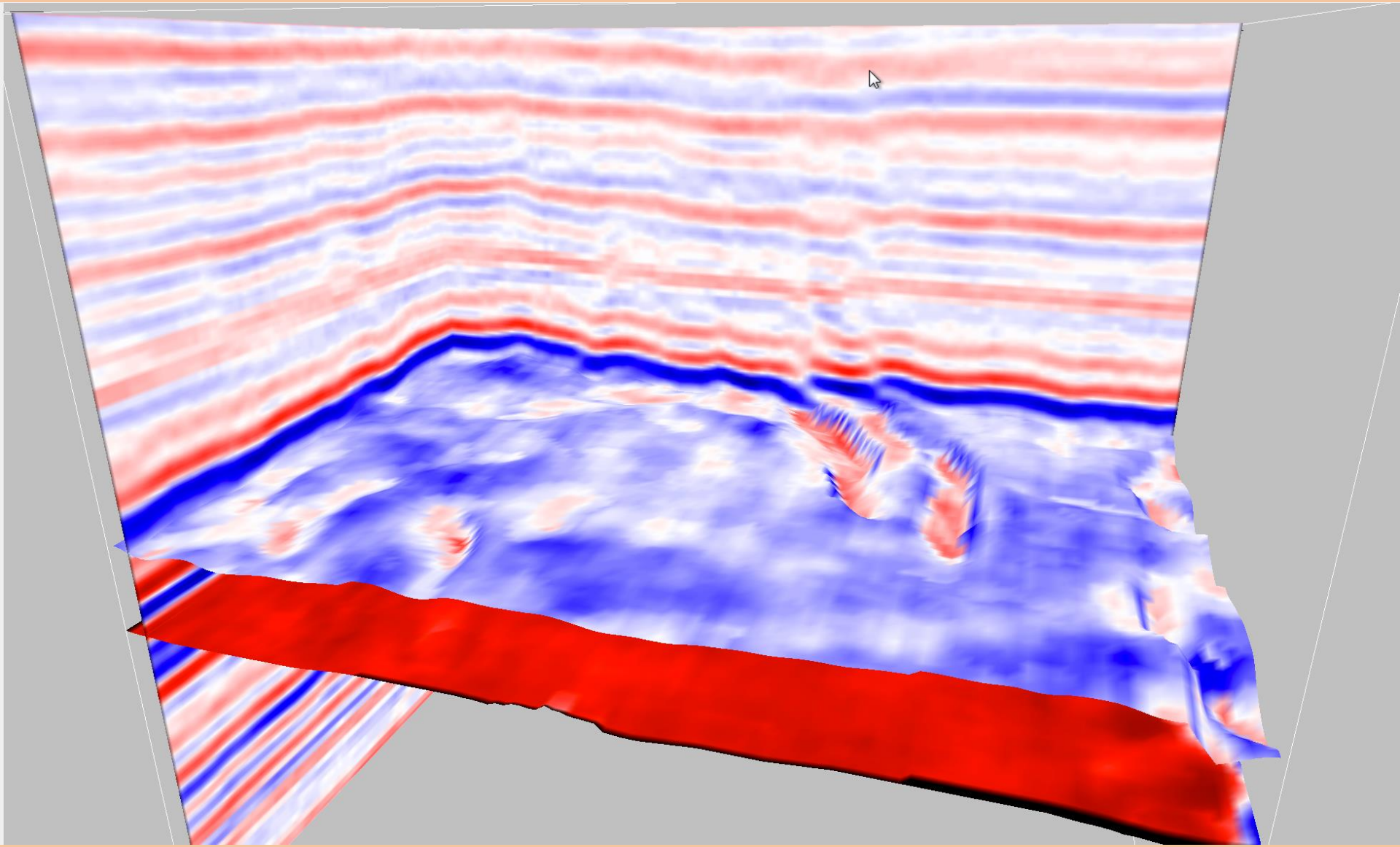


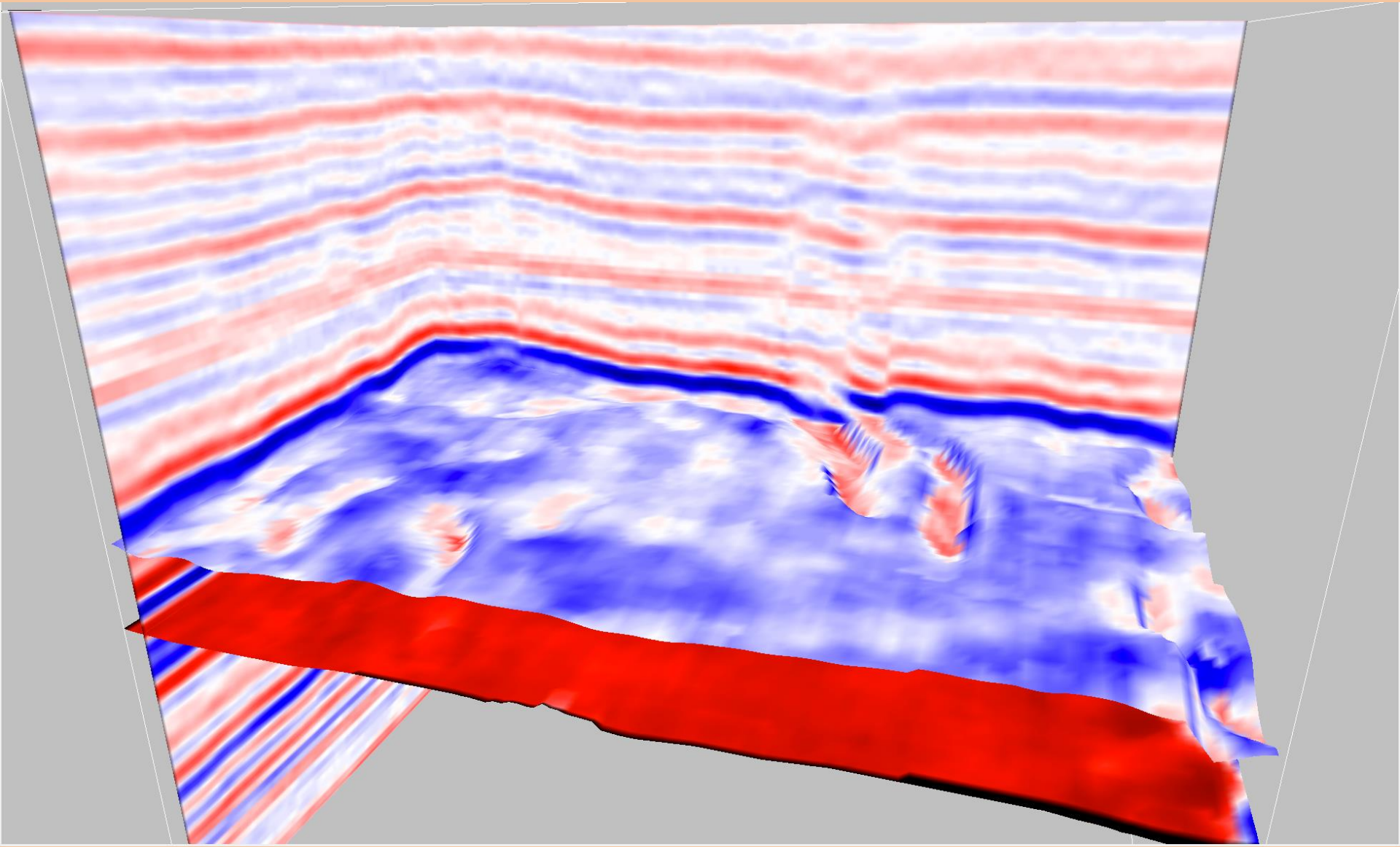


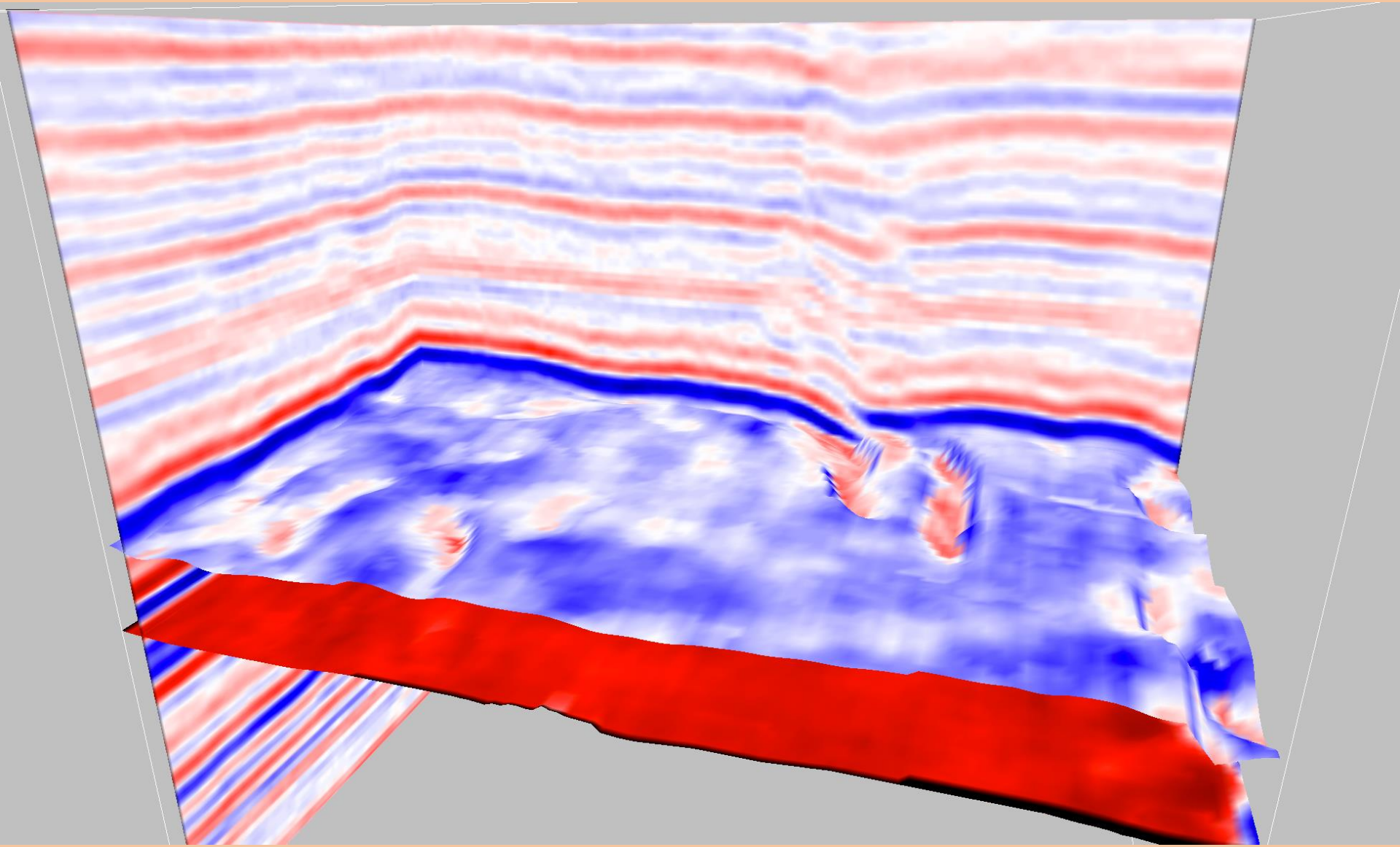


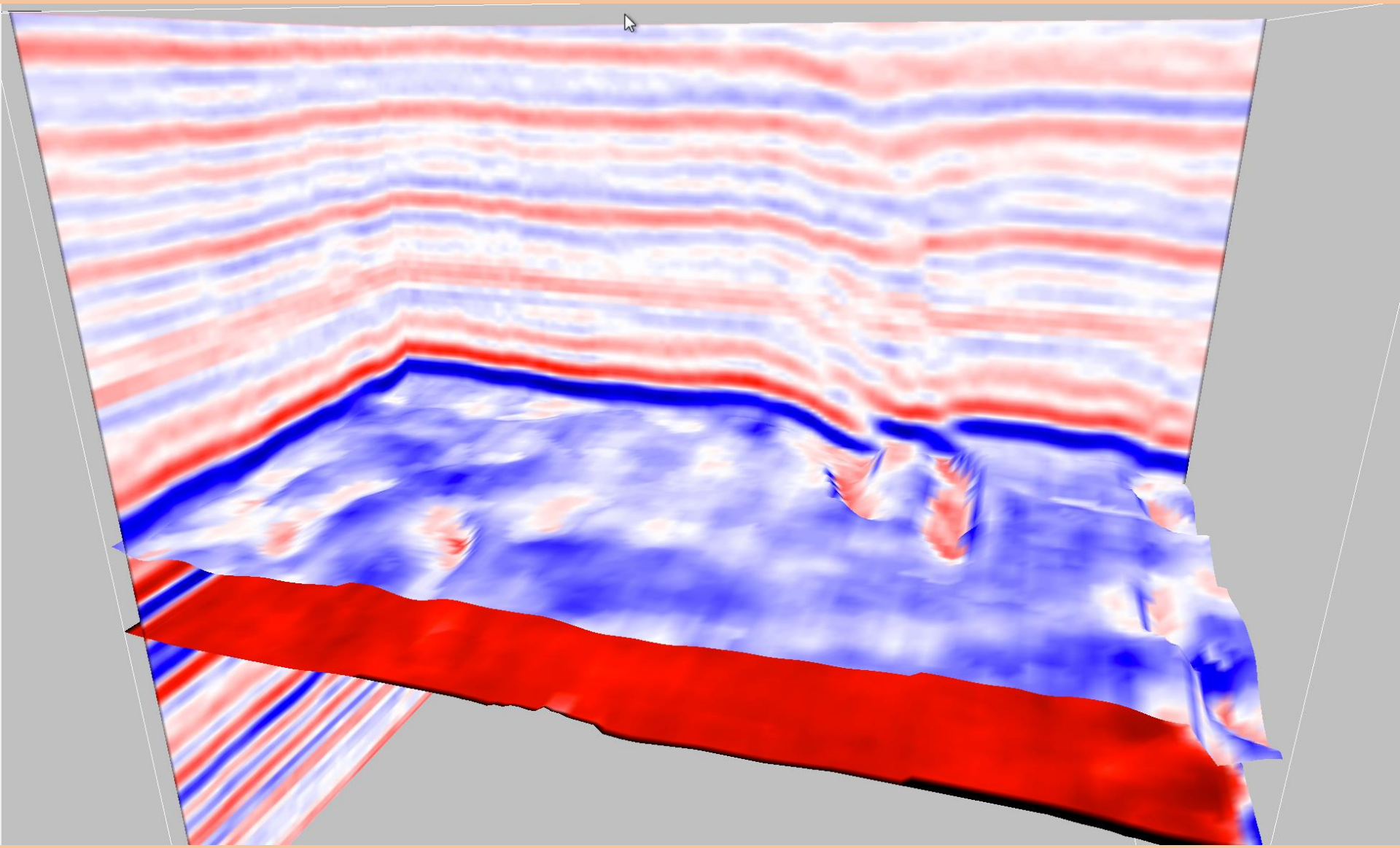


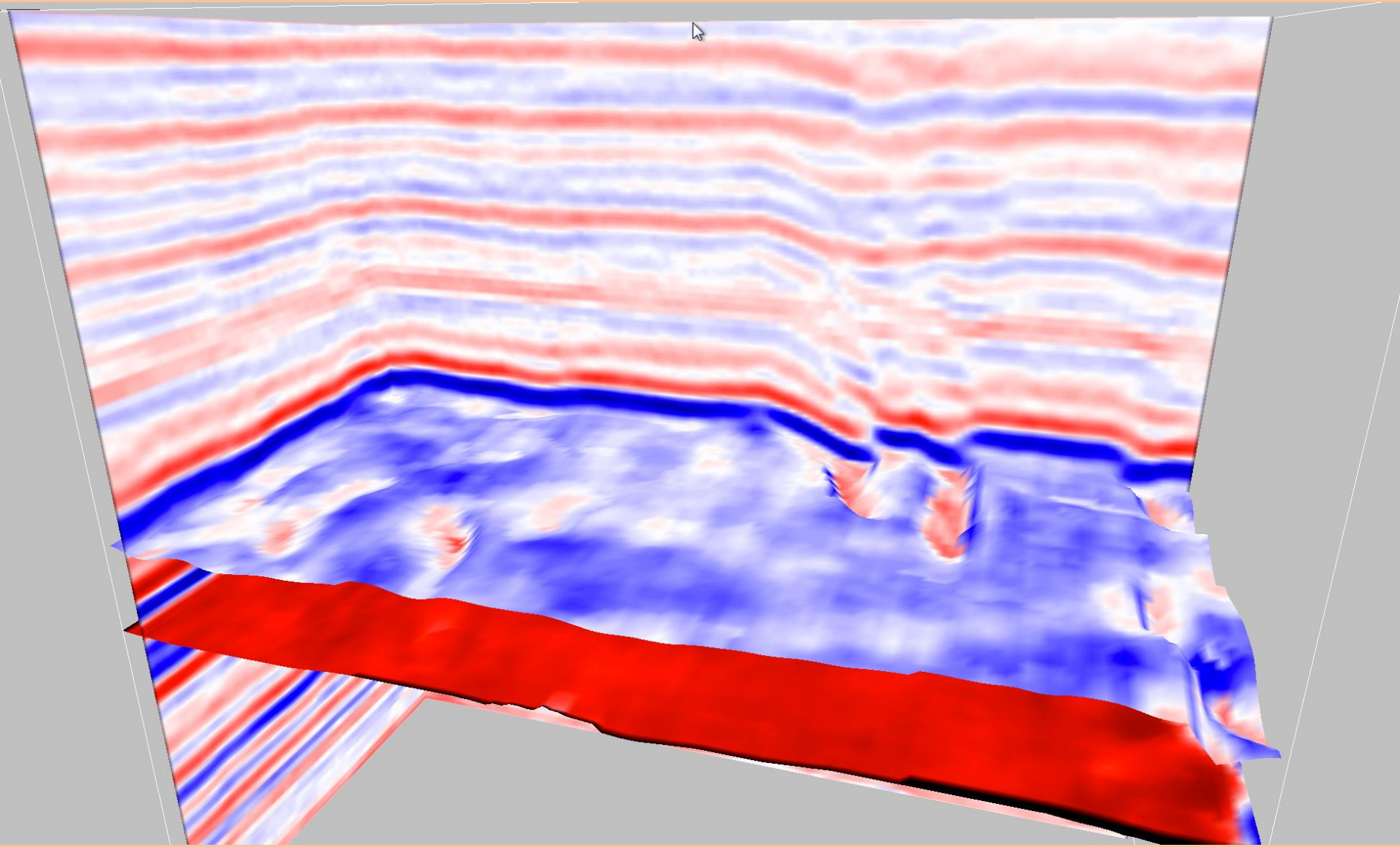


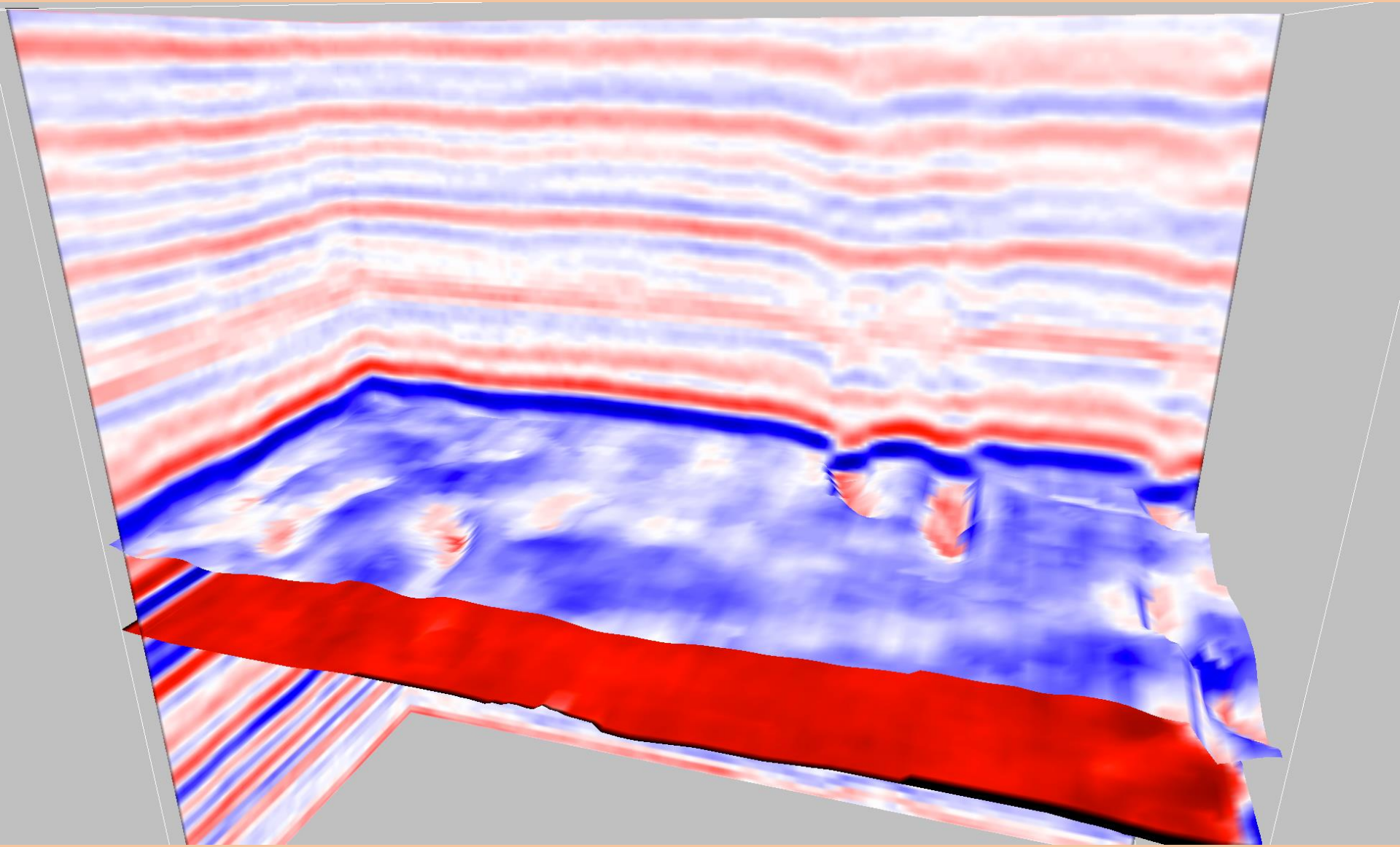


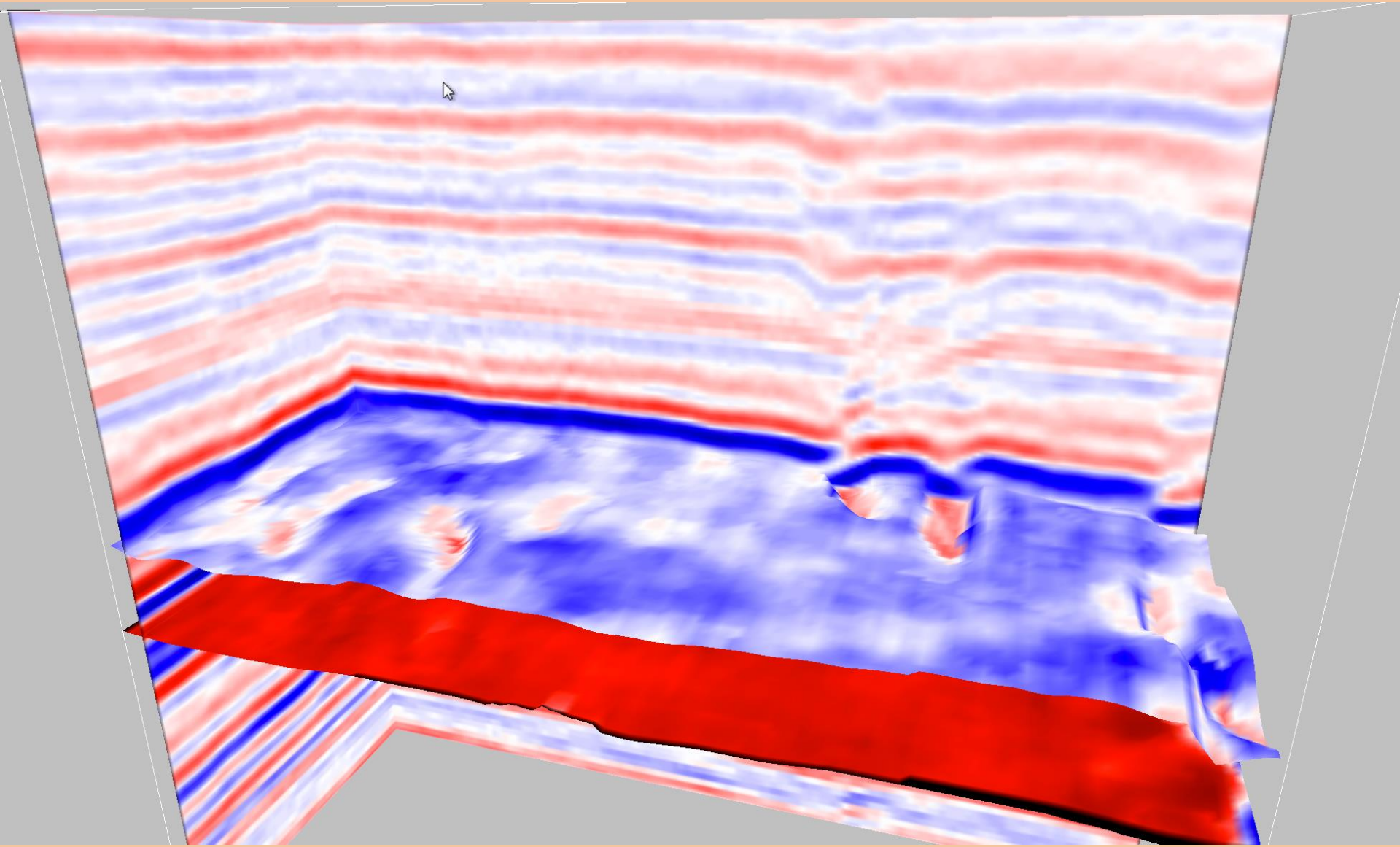


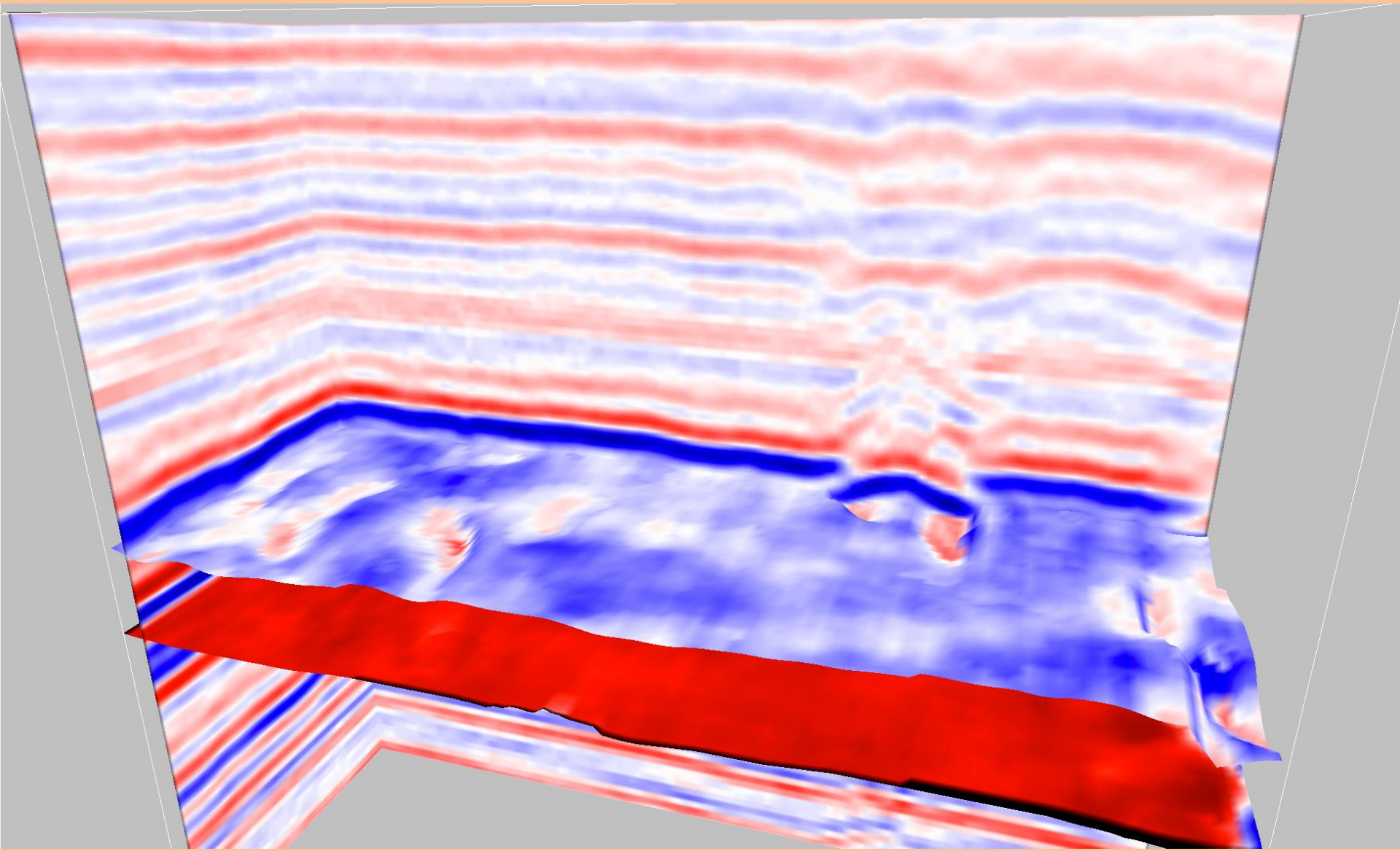


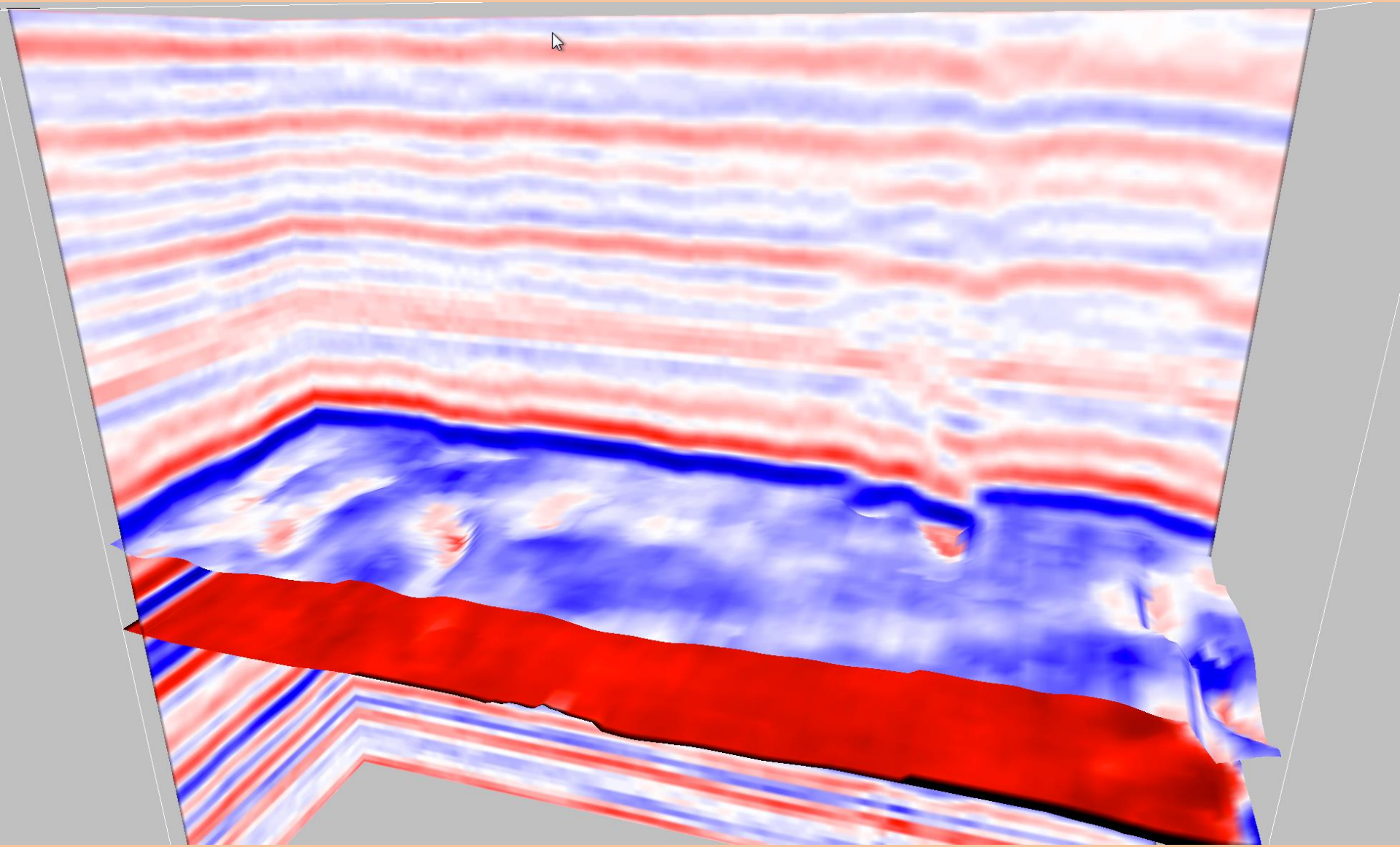


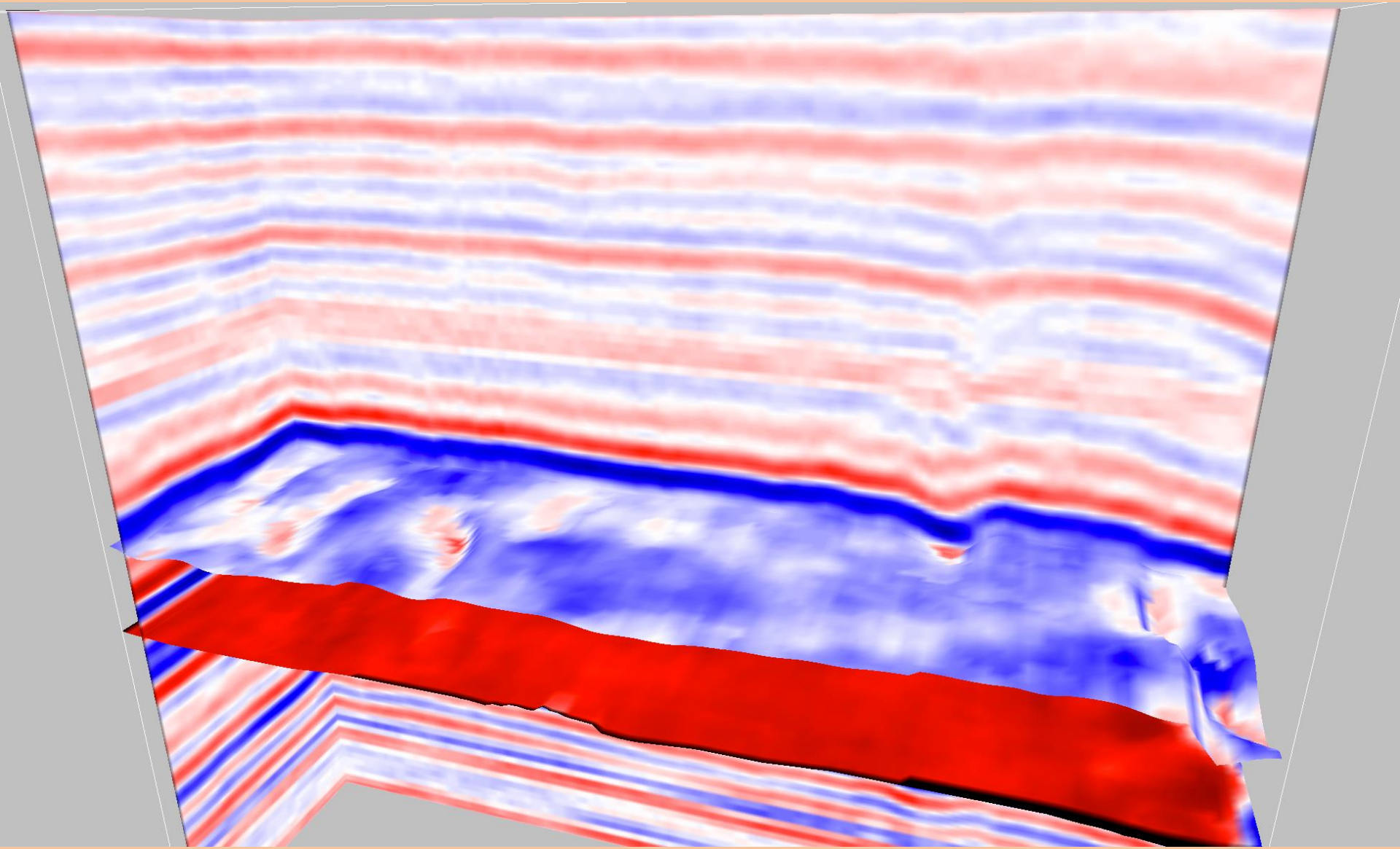


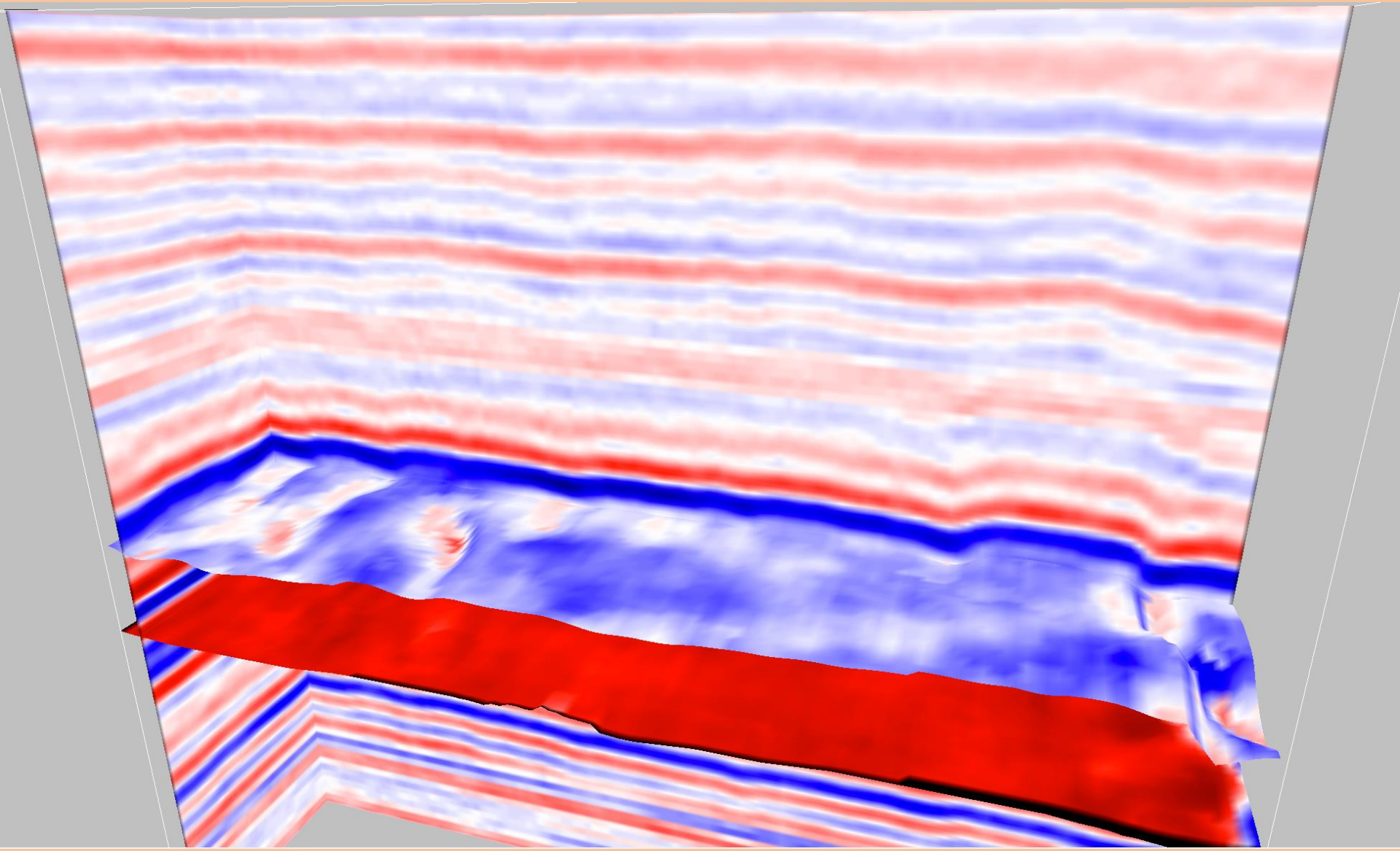


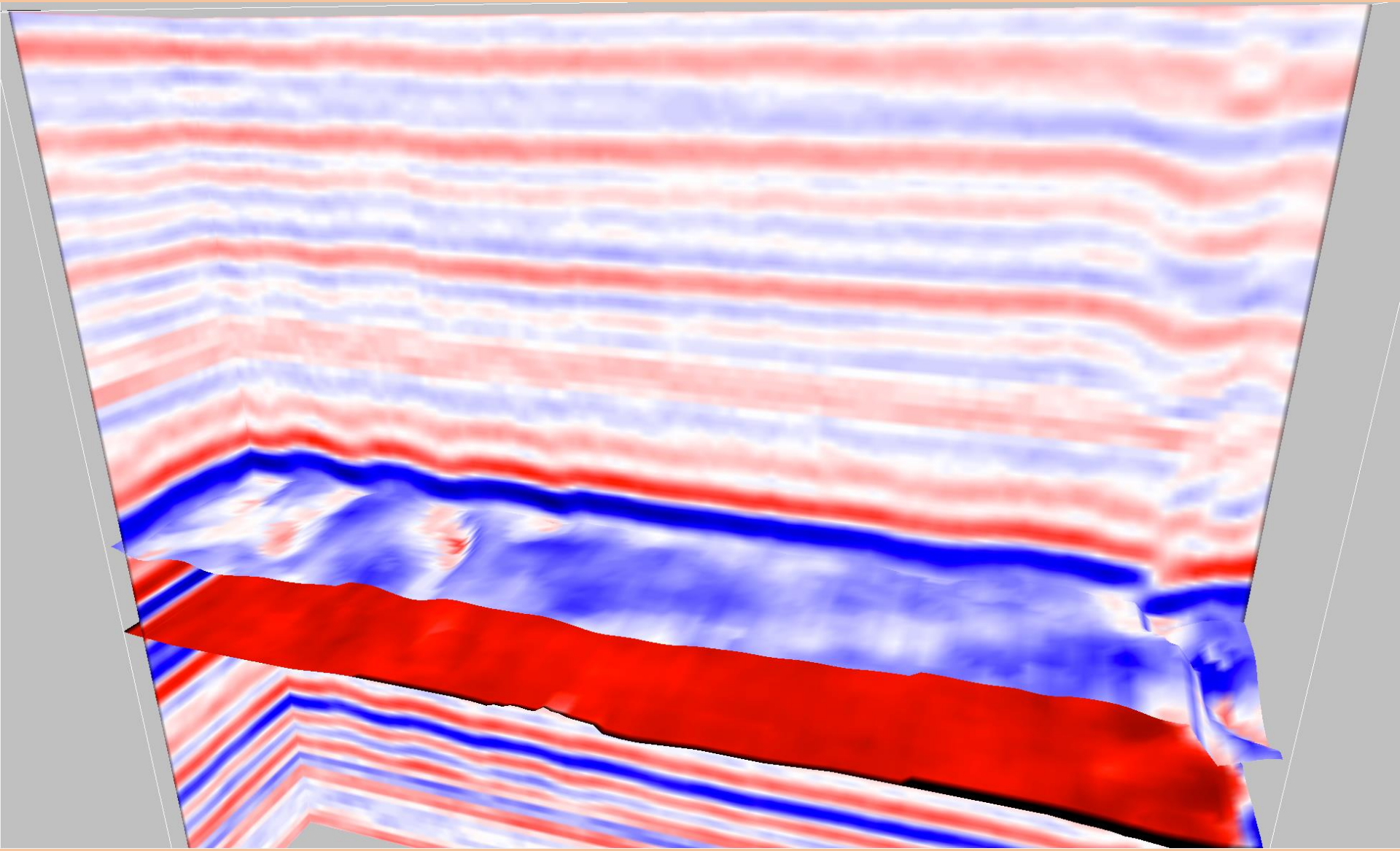


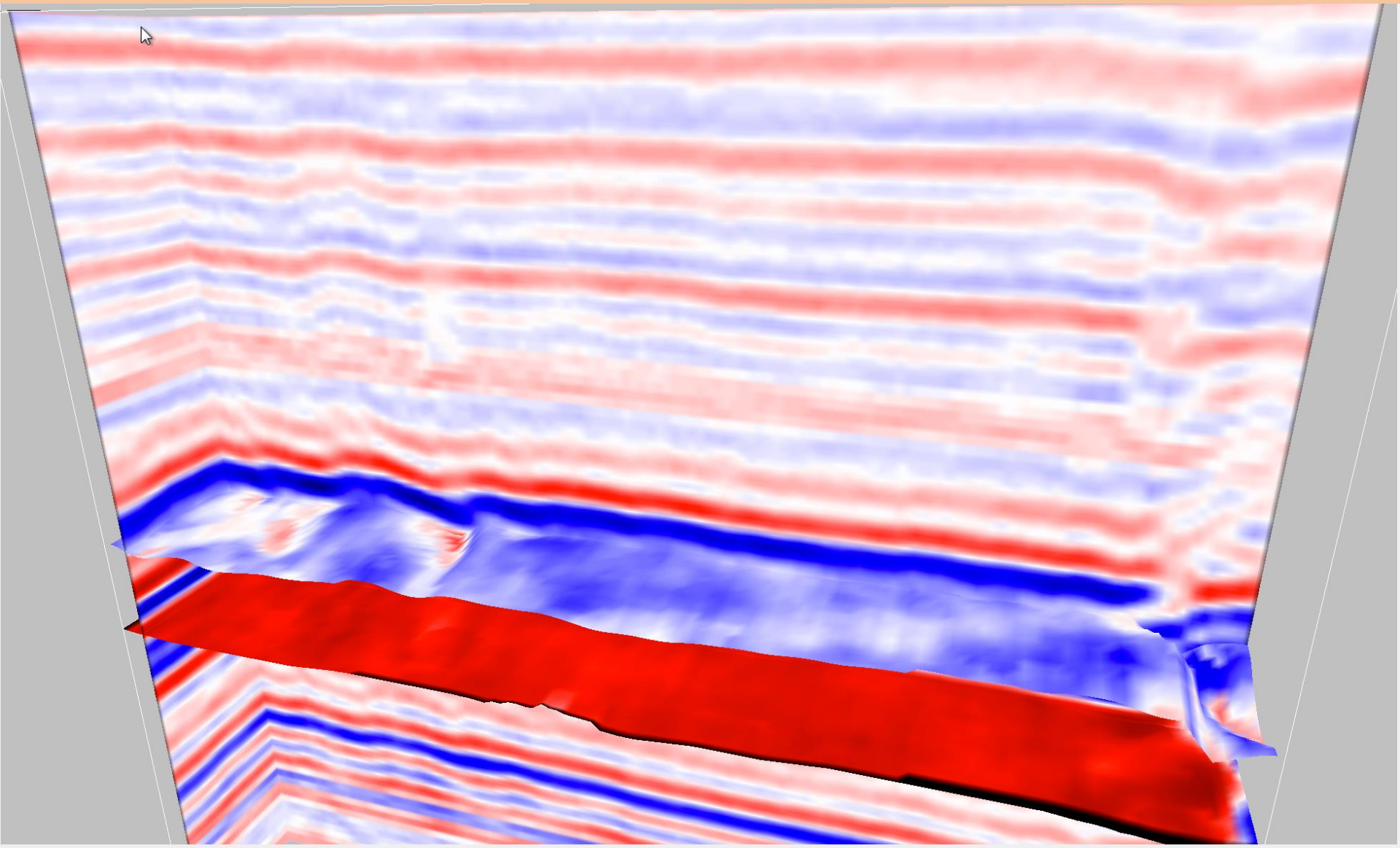


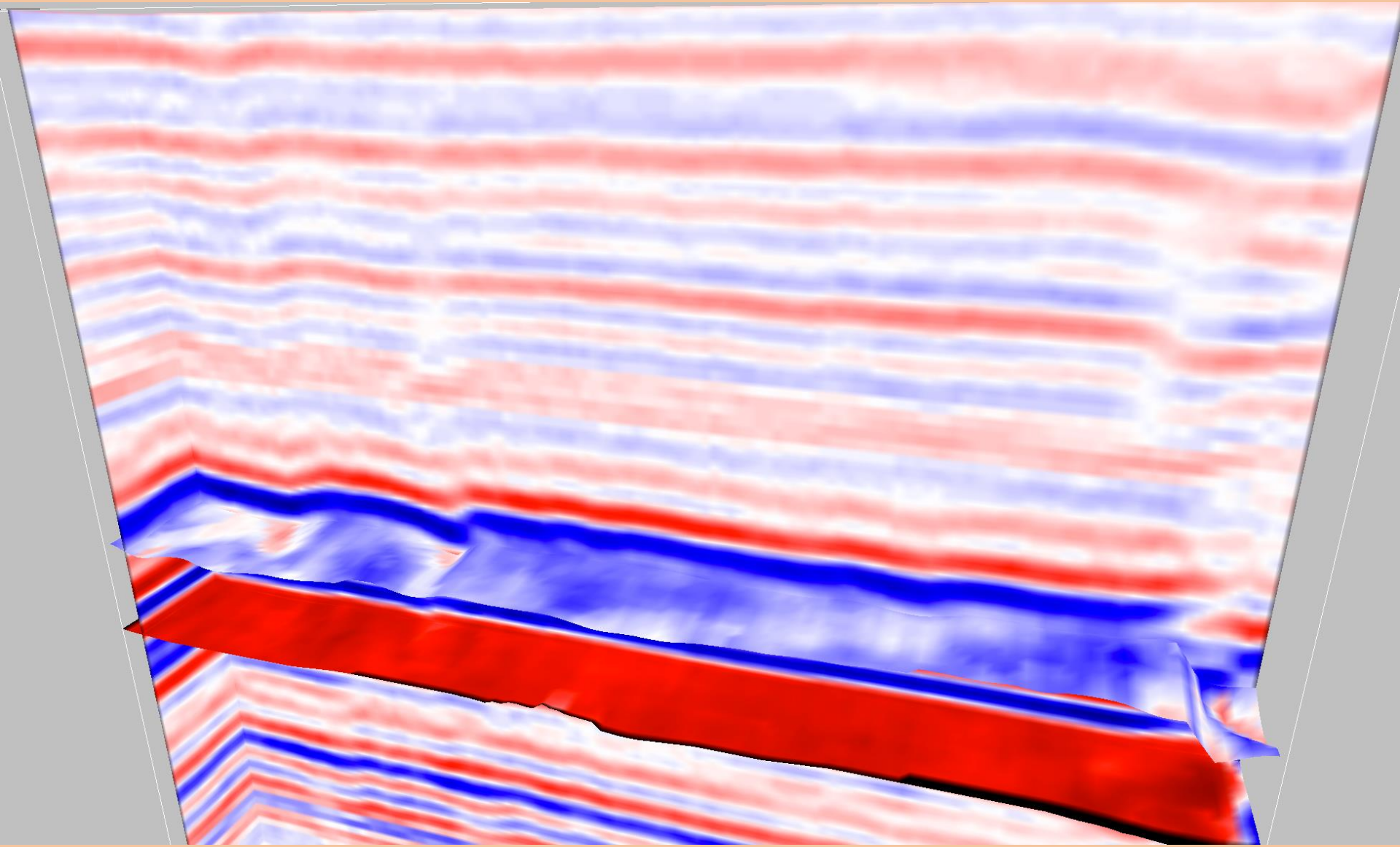






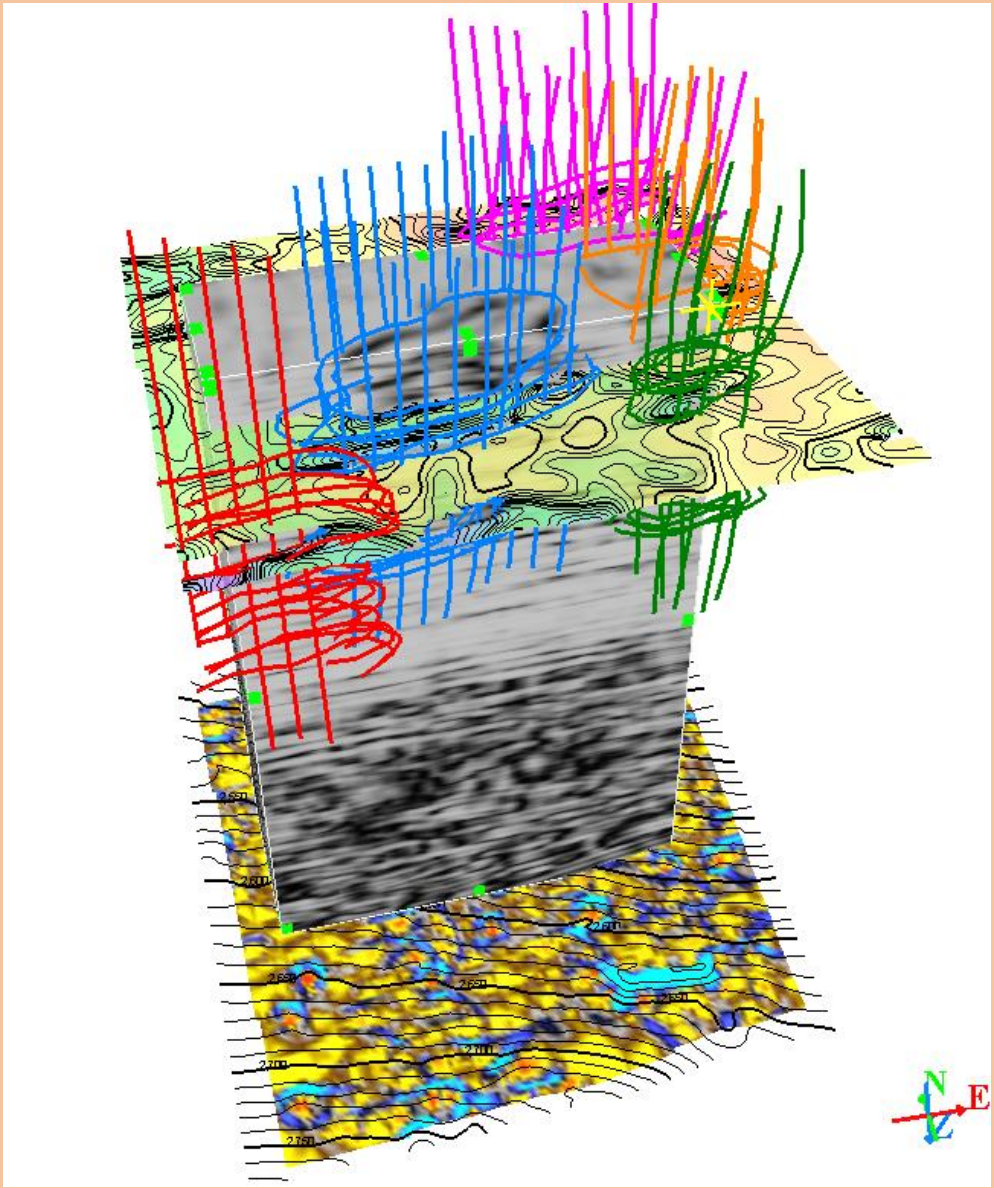




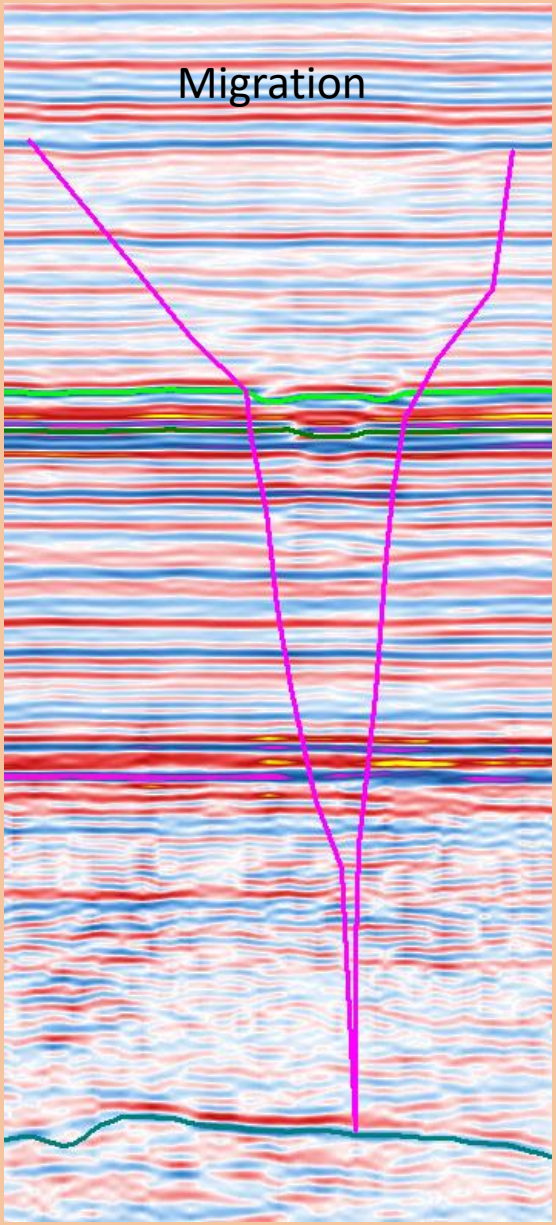


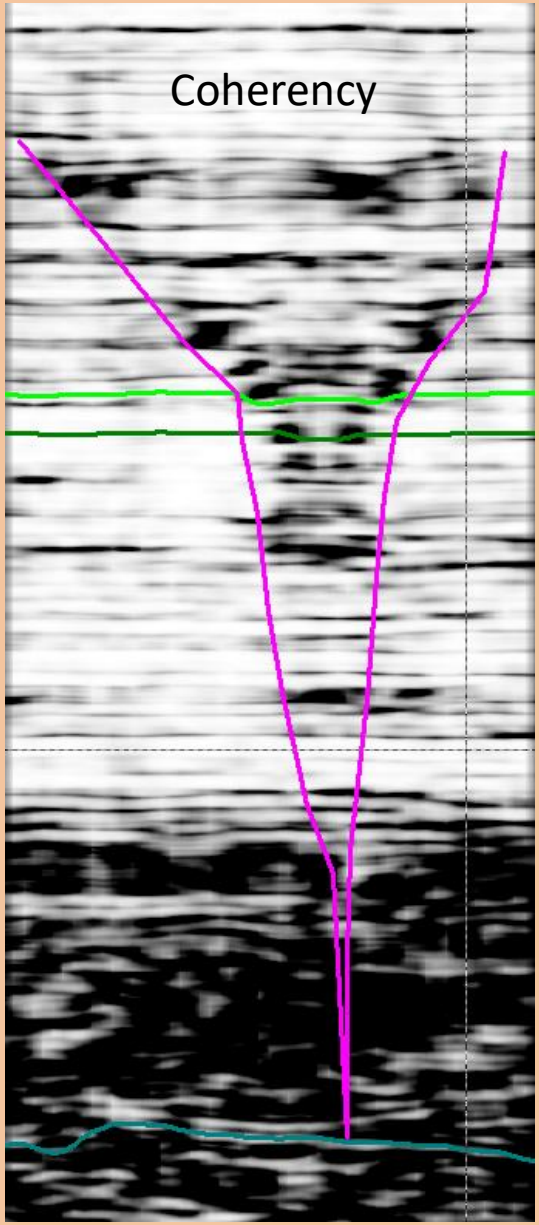
3D Viz Fault Zone

Structure & Coherency

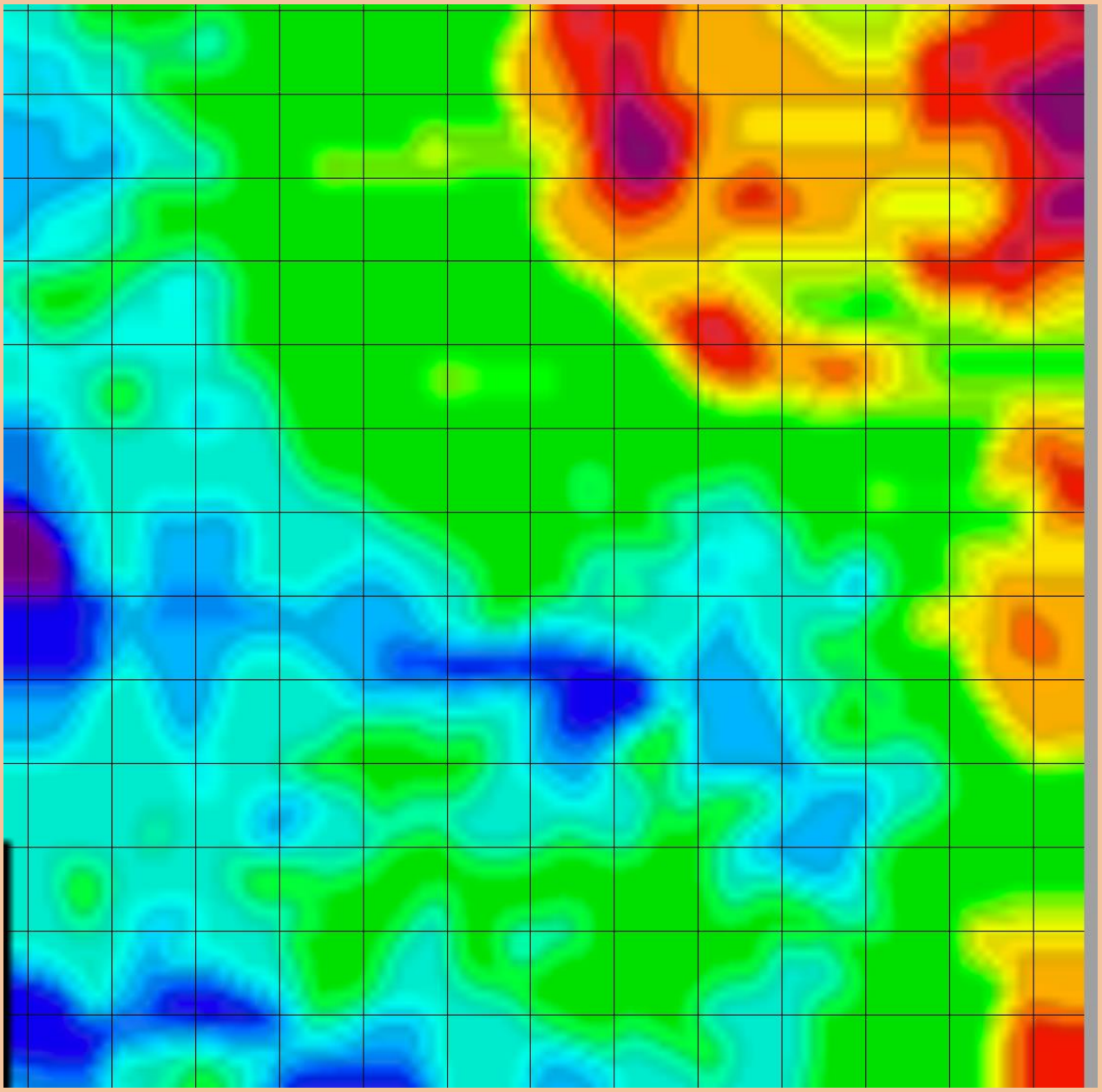


Fault Zone Complexity





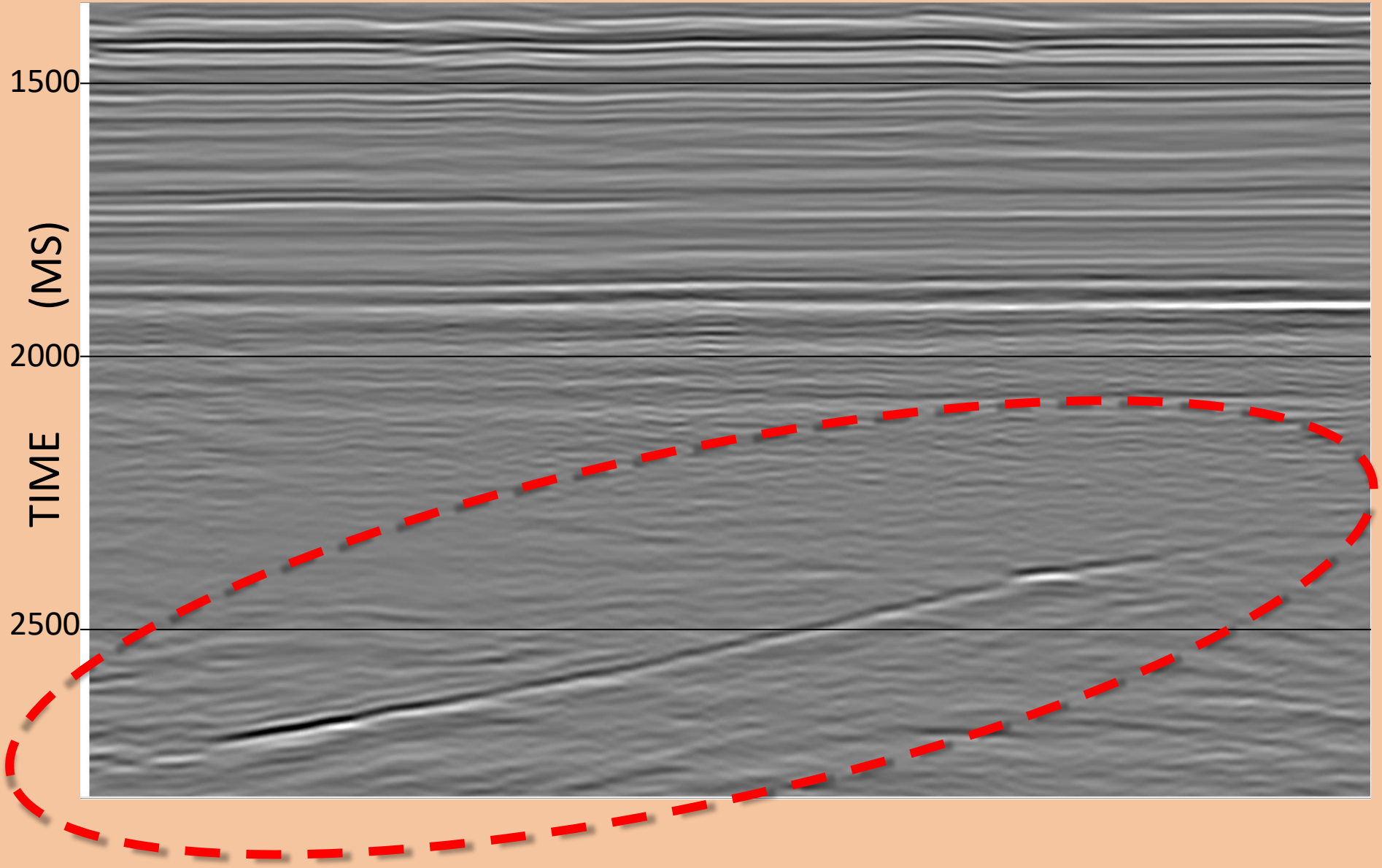
STRUCTURE – NEAR GREENHORN



THE ROLE OF THE BASEMENT

- Very prominent structure in the basement
- Strongly dipping **WSW**
- Dip varies and/or is broken by faulting
- **Colorado Mineral Belt** also traverses the area trending **NE**
- ***How do these features impact the Niobrara faulting?***

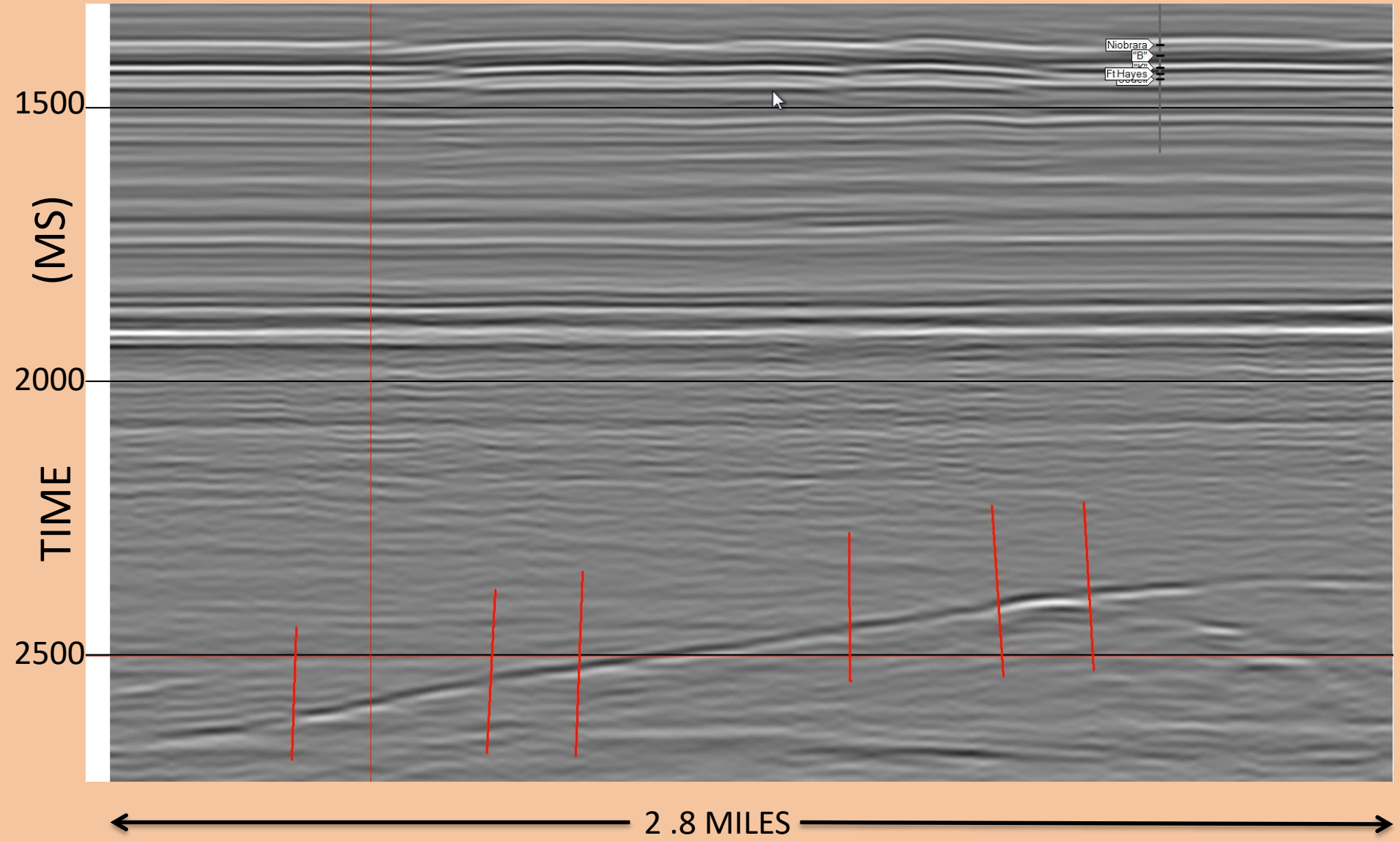
BASEMENT FEATURE



BASEMENT FEATURE

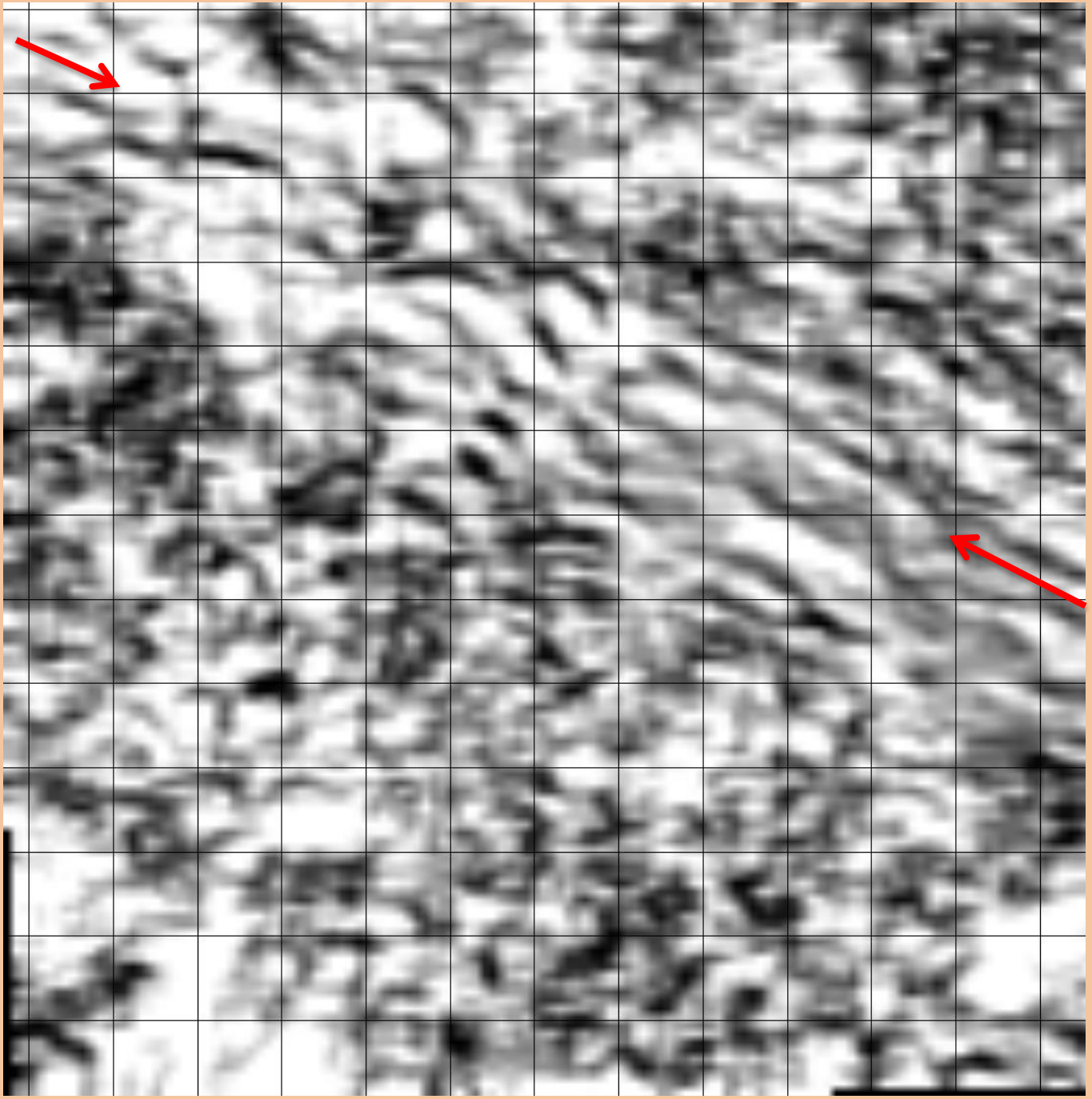
with possible breaks/dip variations

SW NW



SEMBLANCE 2480 ms.

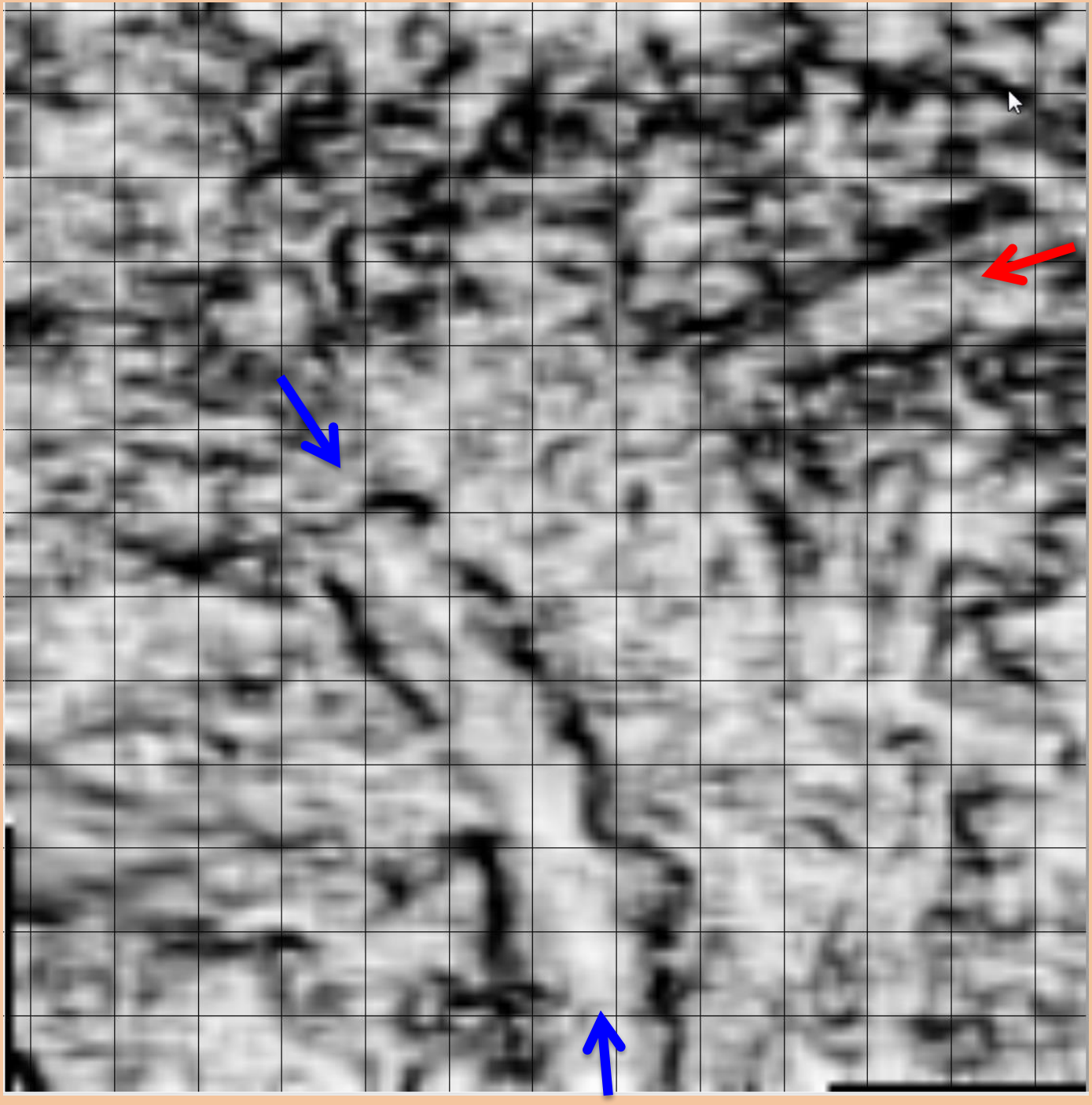
NW trend (**red**) aligns with the offset of Niobrara wrench faults.



SEMBLANCE 2784 ms.

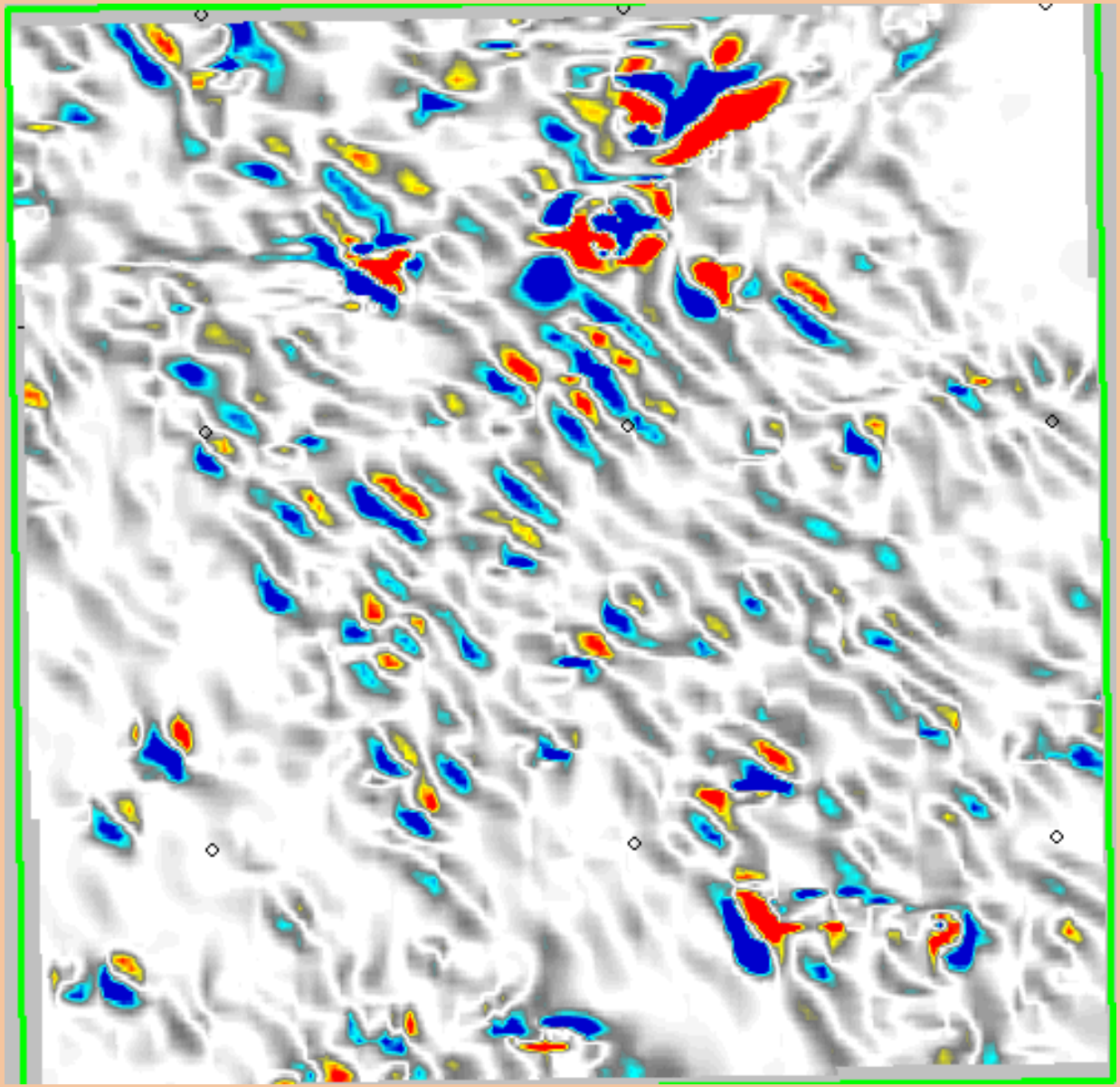
Slightly different NW trend of deep feature (**blue**).

NE trend (**red**) aligns with Niobrara wrench faults.



CURVATURE – Strike

DEEP FEATURE



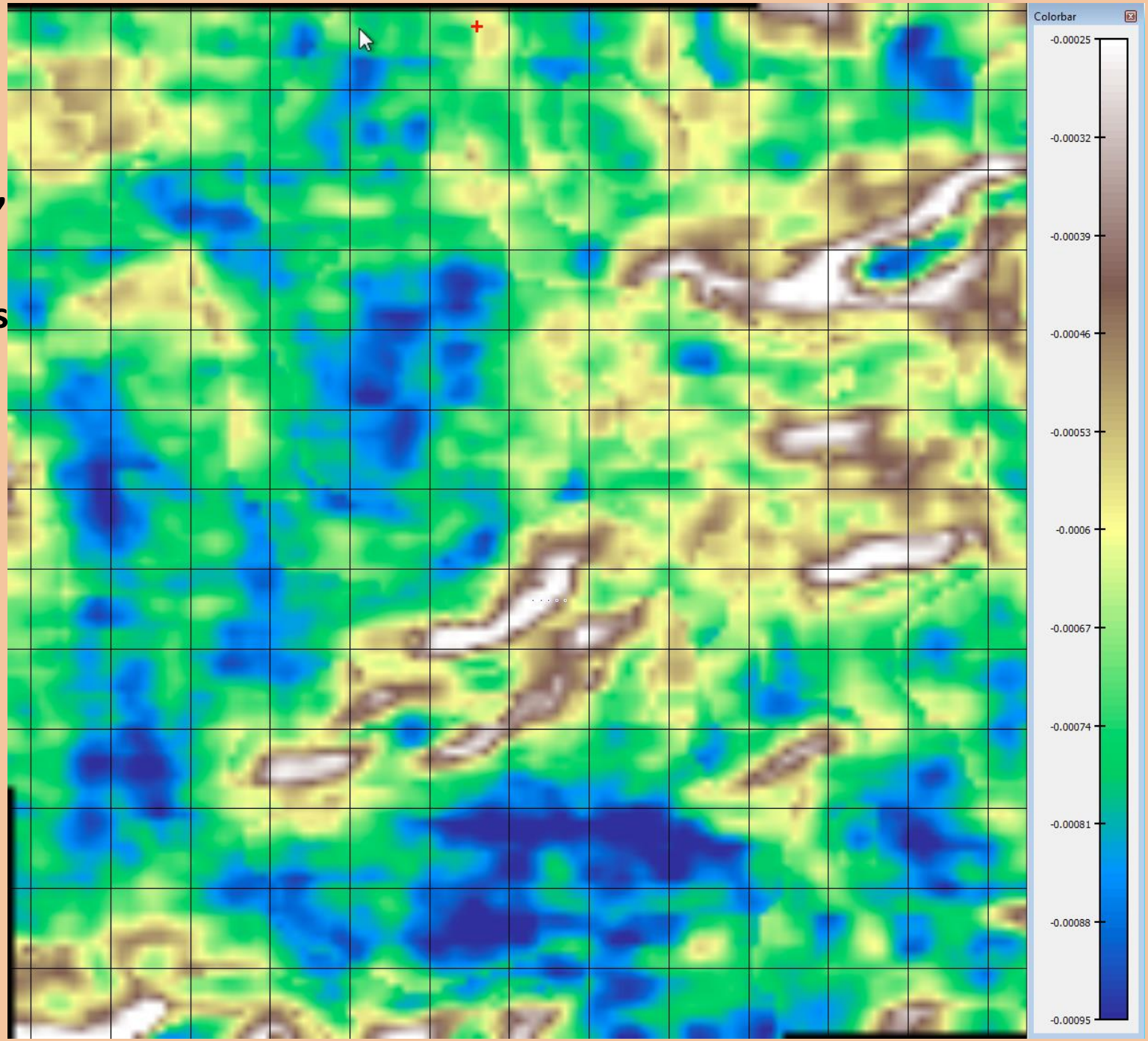
ATTRIBUTES

- Earlier slides showed attribute responses that may indicate rock property variations.
- Next slides focus on the ***Niobrara "K"*** unit
  - Variations in AVO properties.

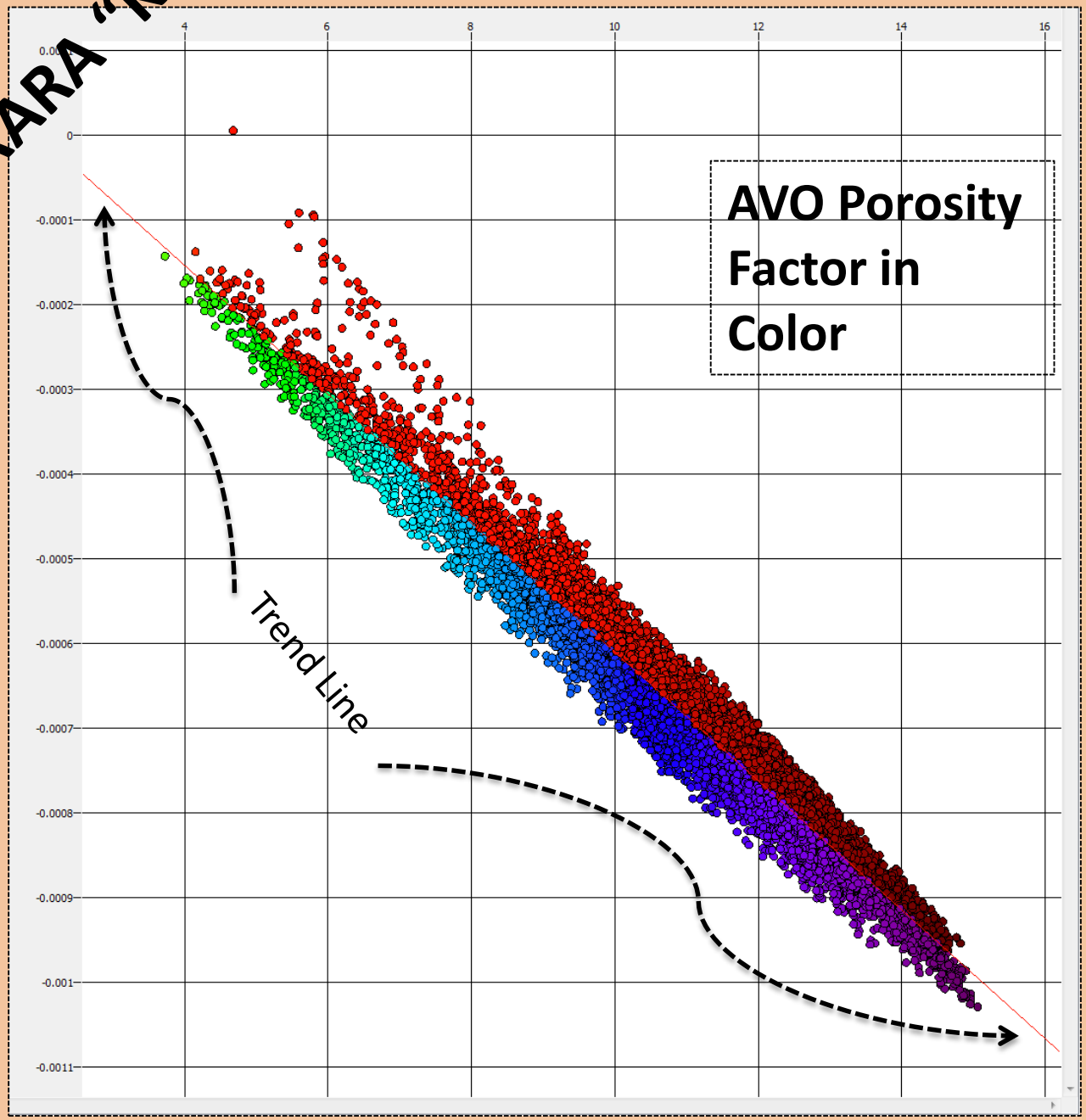
AVO Gradient Niobrara “K”

Note variations in gradient.

What do they mean?



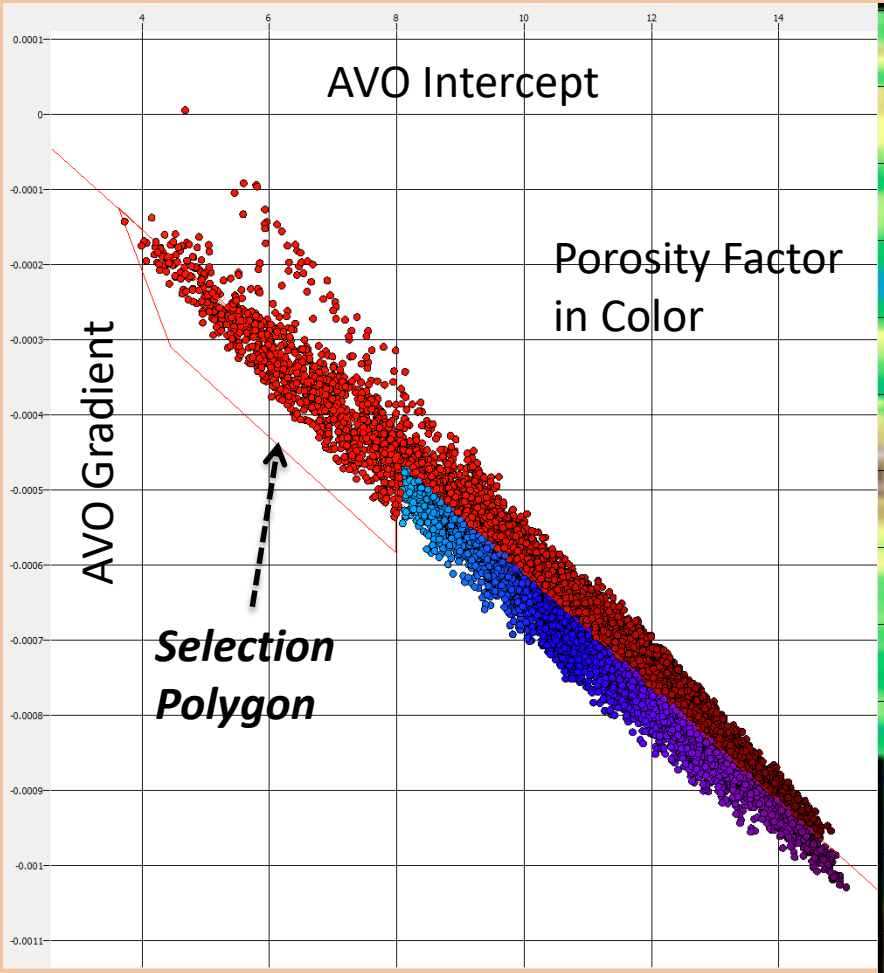
NIOBRARA "K"

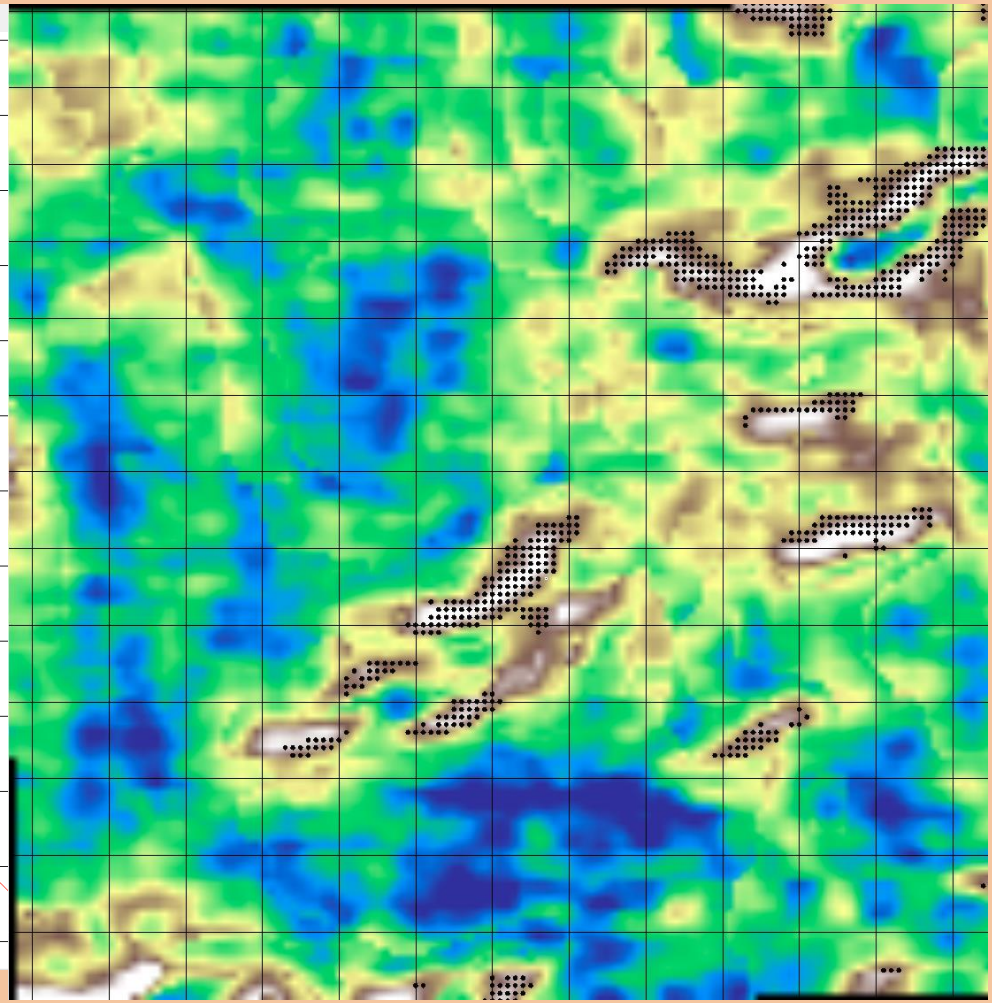

AVO Intercept
AVO Gradient
AVO Porosity Factor in Color
Trend Line
4
6
8
10
12
14
16
0
-0.0001
-0.0002
-0.0003
-0.0004
-0.0005
-0.0006
-0.0007
-0.0008
-0.0009
-0.001
-0.0011

RELATING THE CROSSPLOT TO THE MAP

NIOBRARA "K"

Black points on map projected from crossplot ***Selection Polygon***



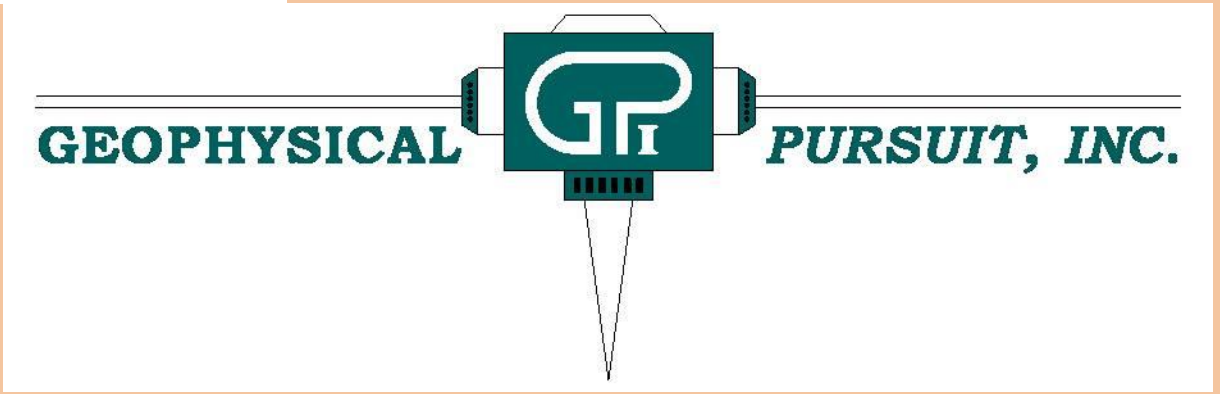


AVO Gradient

SUMMARY

- **Niobrara Faulting is Complex**
  - **Wrench Faults** Predominant
  - Strong **Shear** Component
  - **Flower** Structure
- **Attributes are Useful for:**
  - **Fault** Analysis
  - **Rock Property** Variations

DATA PROVIDED BY:



ALSO THANKS TO THREE ANONYMOUS DENVER GEOPHYSICISTS FOR HELPFUL DISCUSSIONS & THOUGHTS

SOFTWARE PROVIDED BY:

THANKS TO MY CO-AUTHORS

- ***W. TRAVIS BROWN*** – Geological input & discussions
- ***DOUG PAUL*** – Attribute & fault analysis
- ***FILIP SOOS*** – Programming changes on the fly