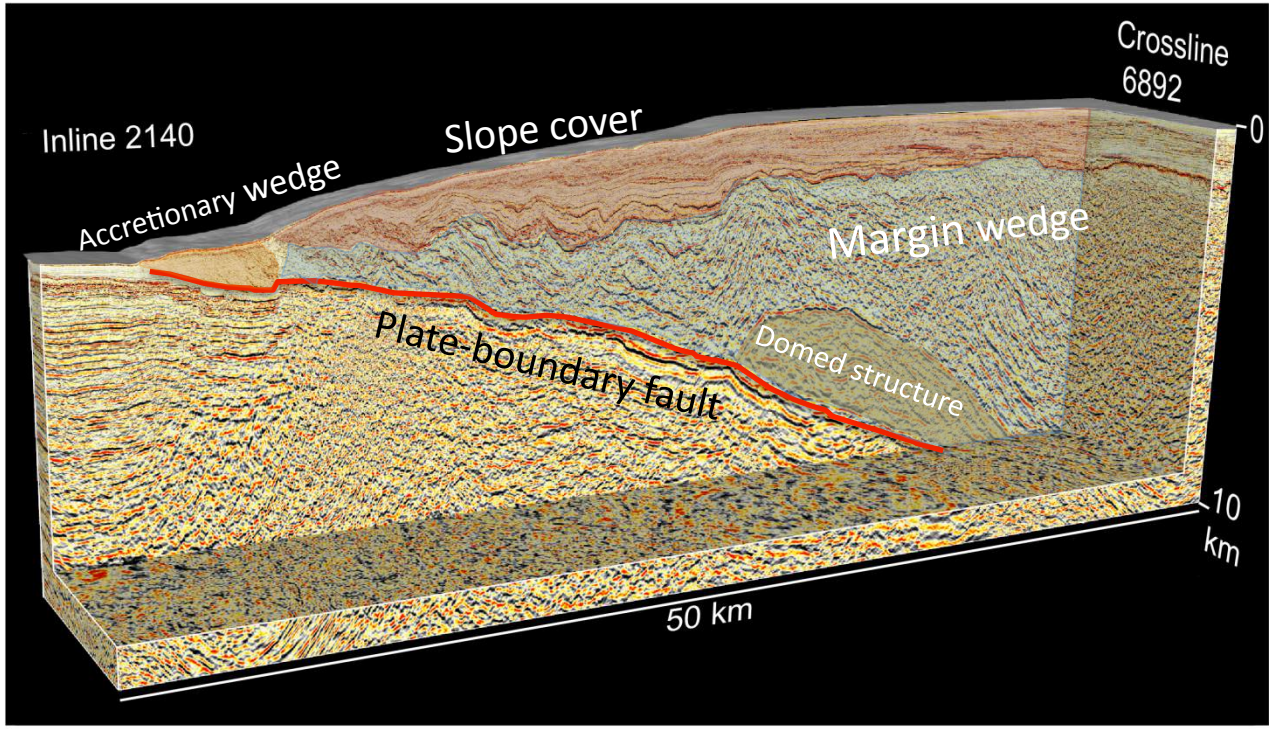
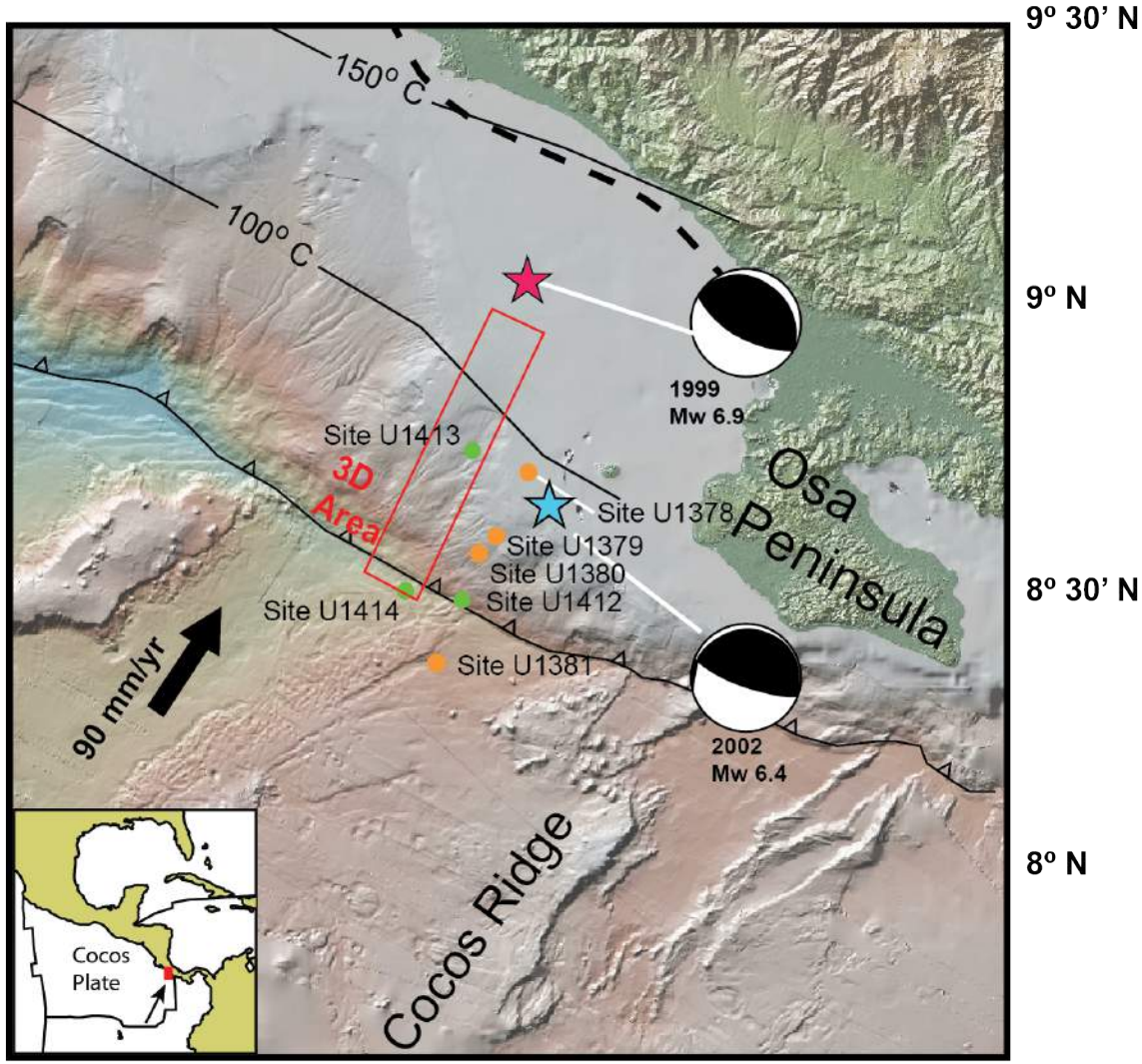
Highlights from the Costa Rica 3D Seismic Project

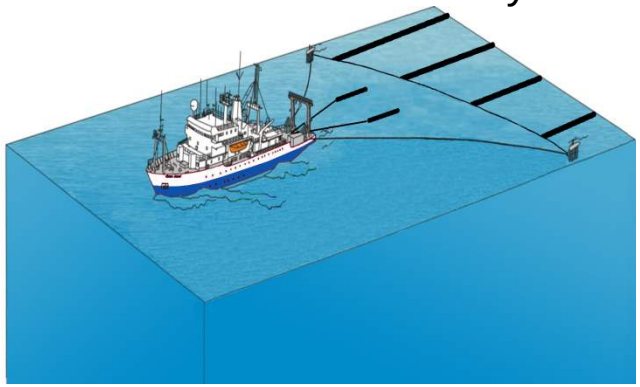


Nathan Bangs, Kirk McIntosh, Eli Silver, Jared Kluesner, César Ranero

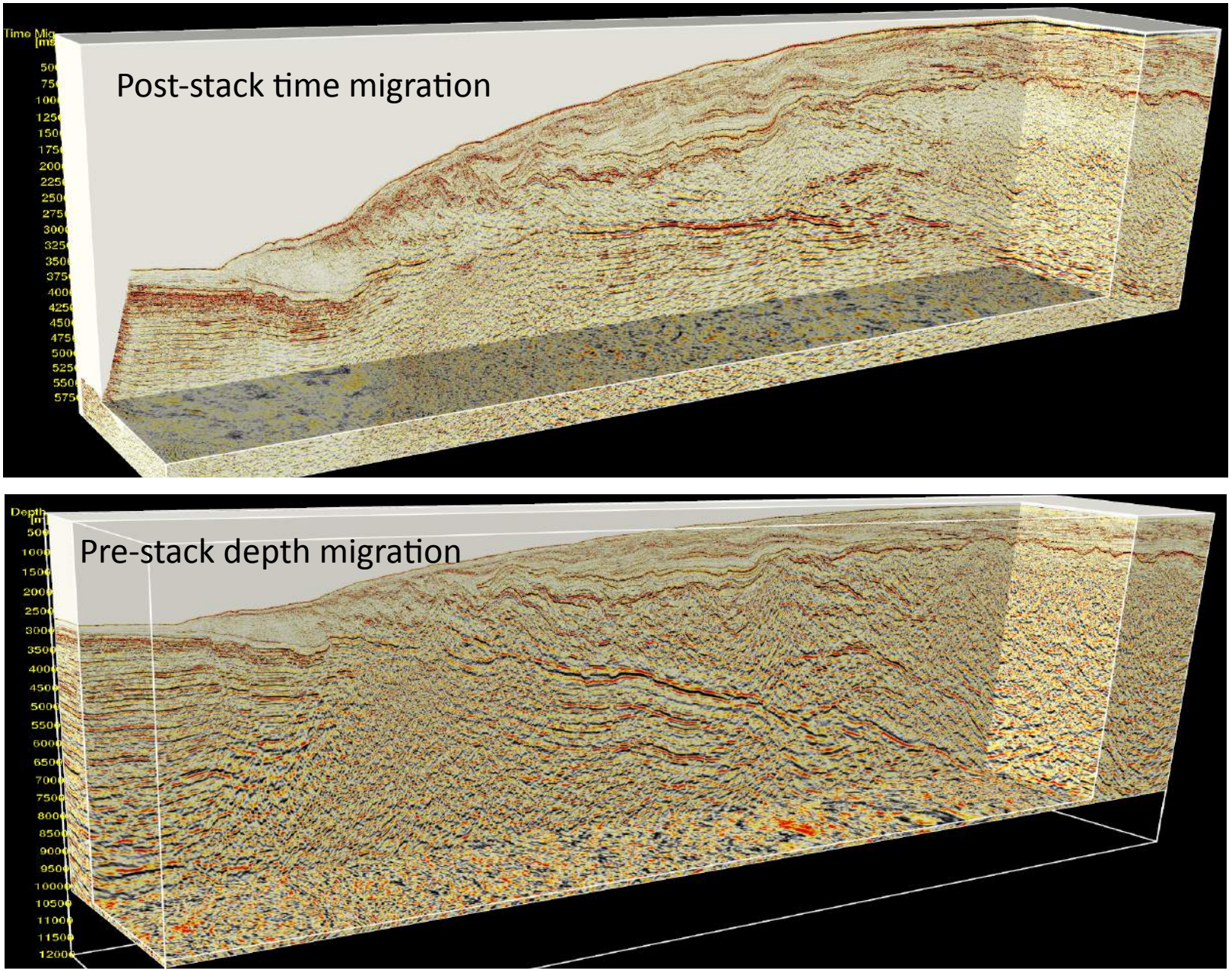
Costa Rica 3D Survey



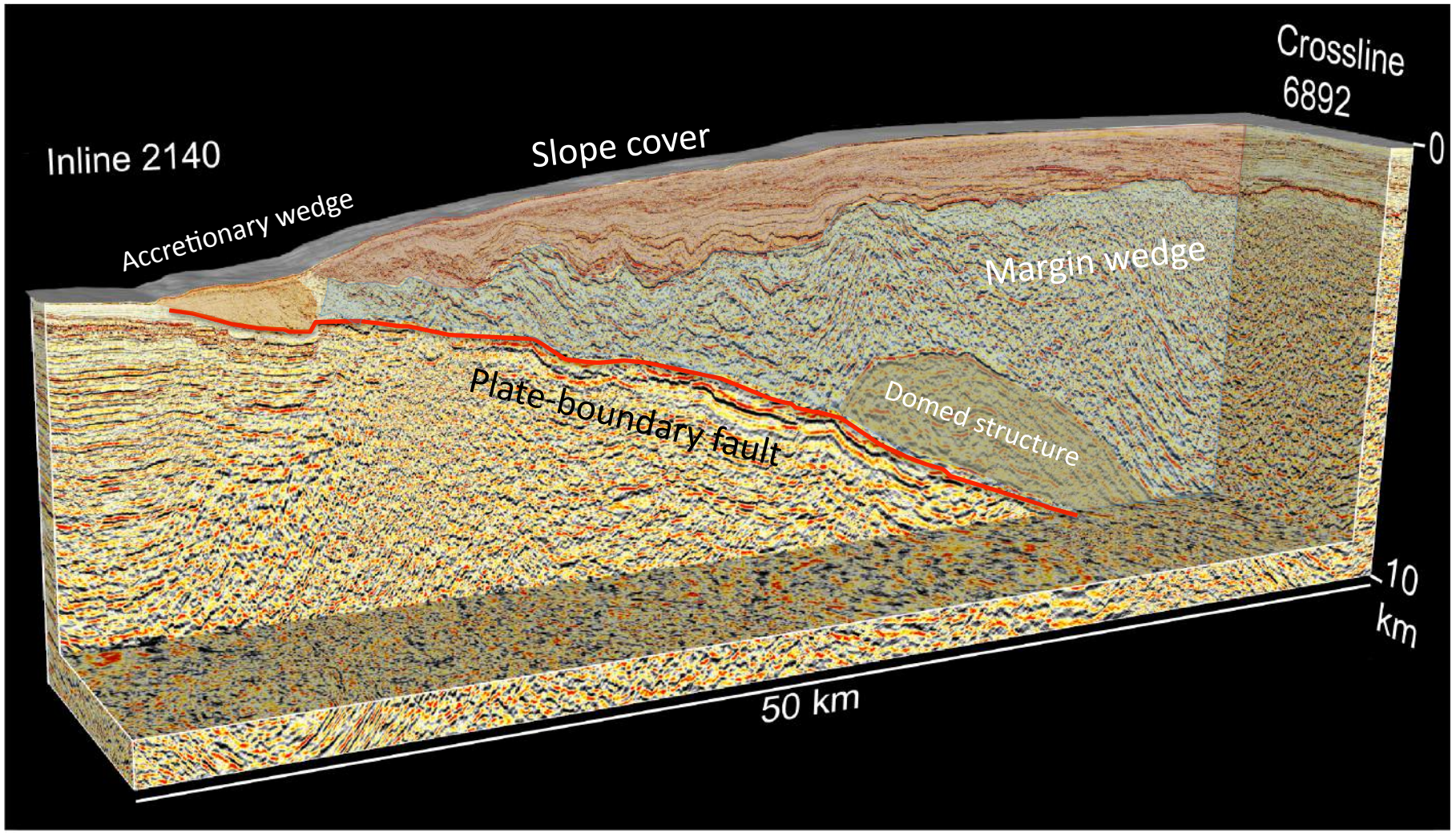
4 6-km streamers
150 m streamer spacing
3200 in^3 dual source array



Time vs Depth Migration



Overview of the Costa Rica 3D seismic volume



What controls slip on the plate interface?

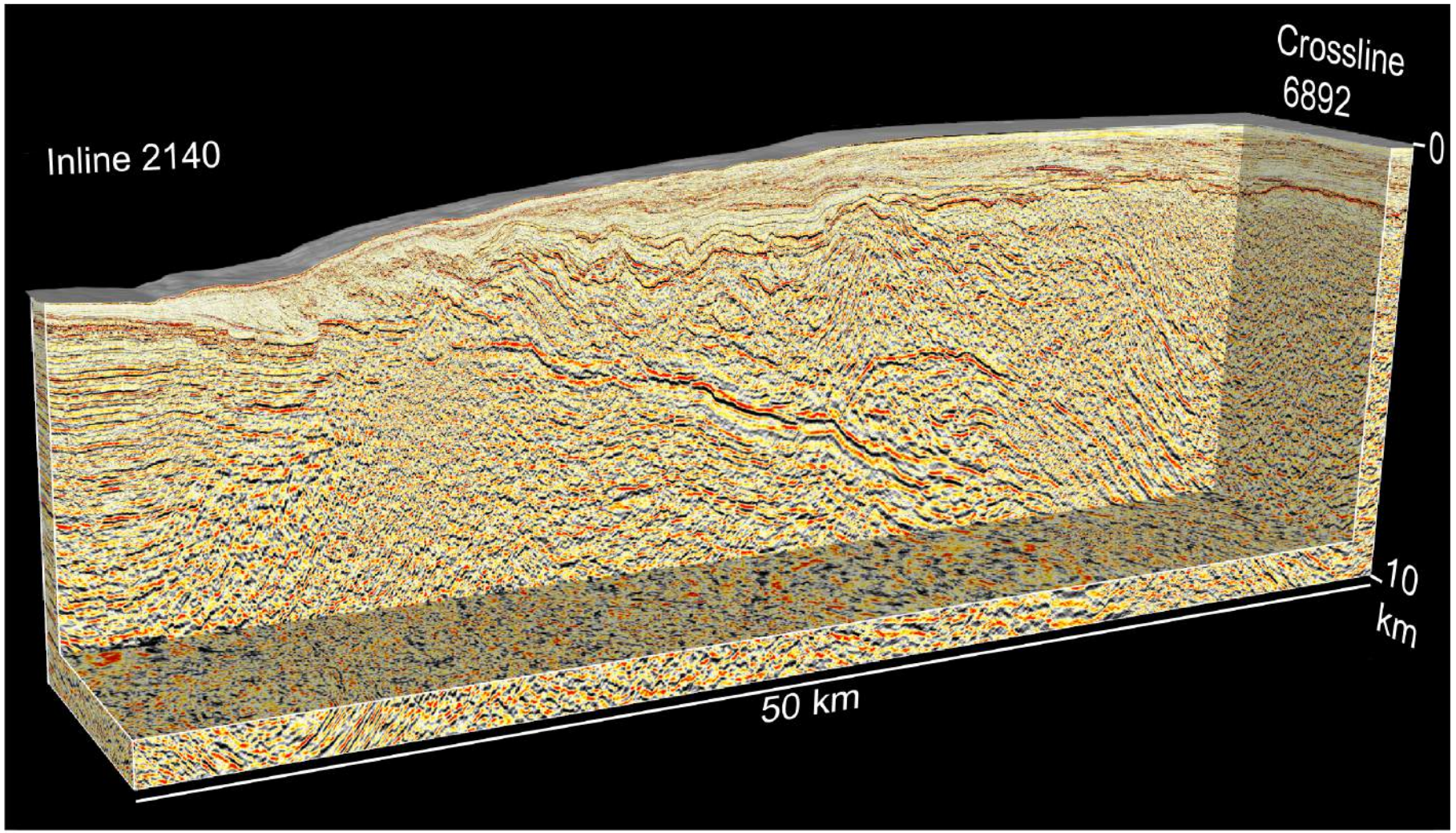


Plate-boundary thrust reflection amplitude

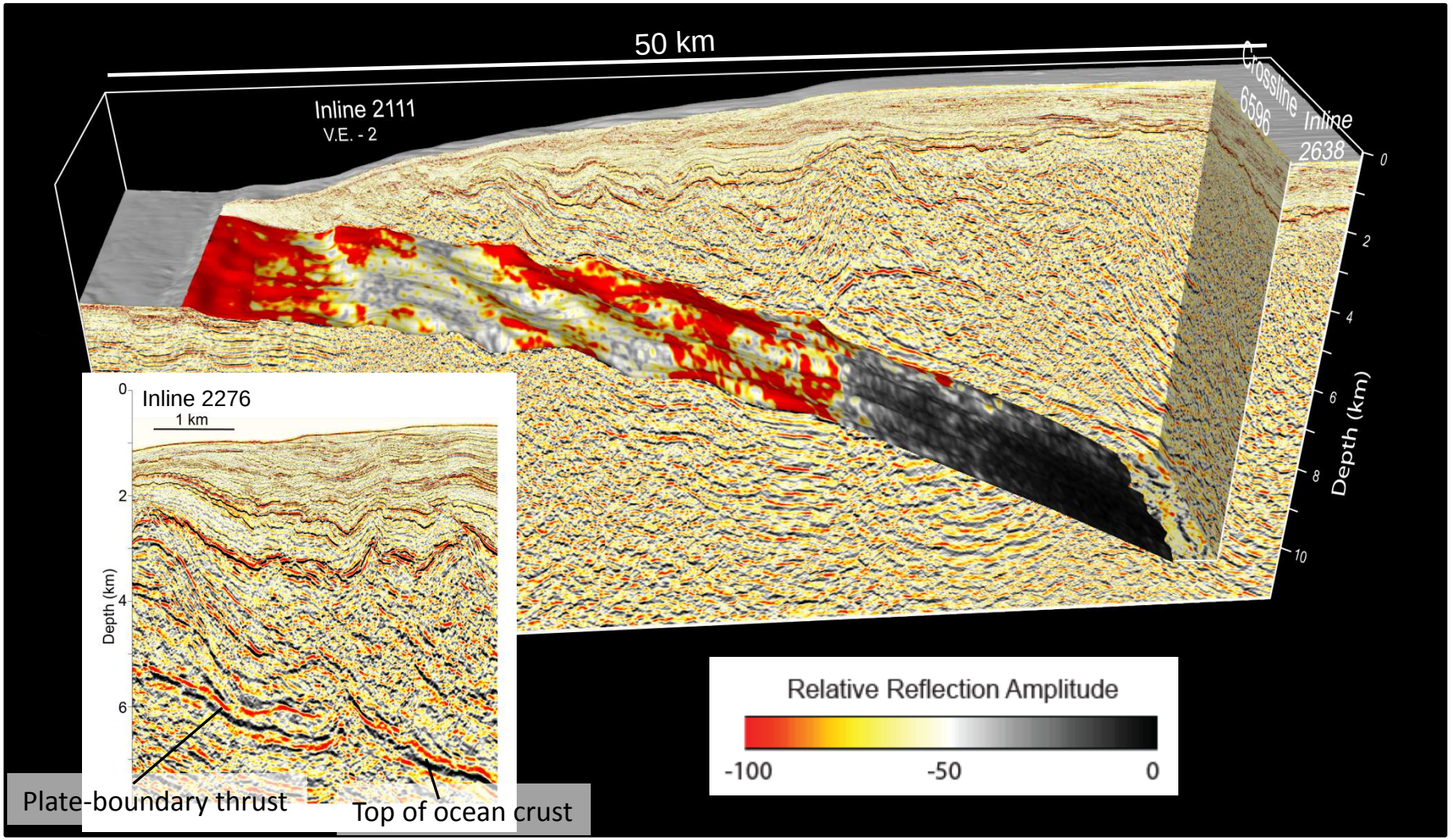
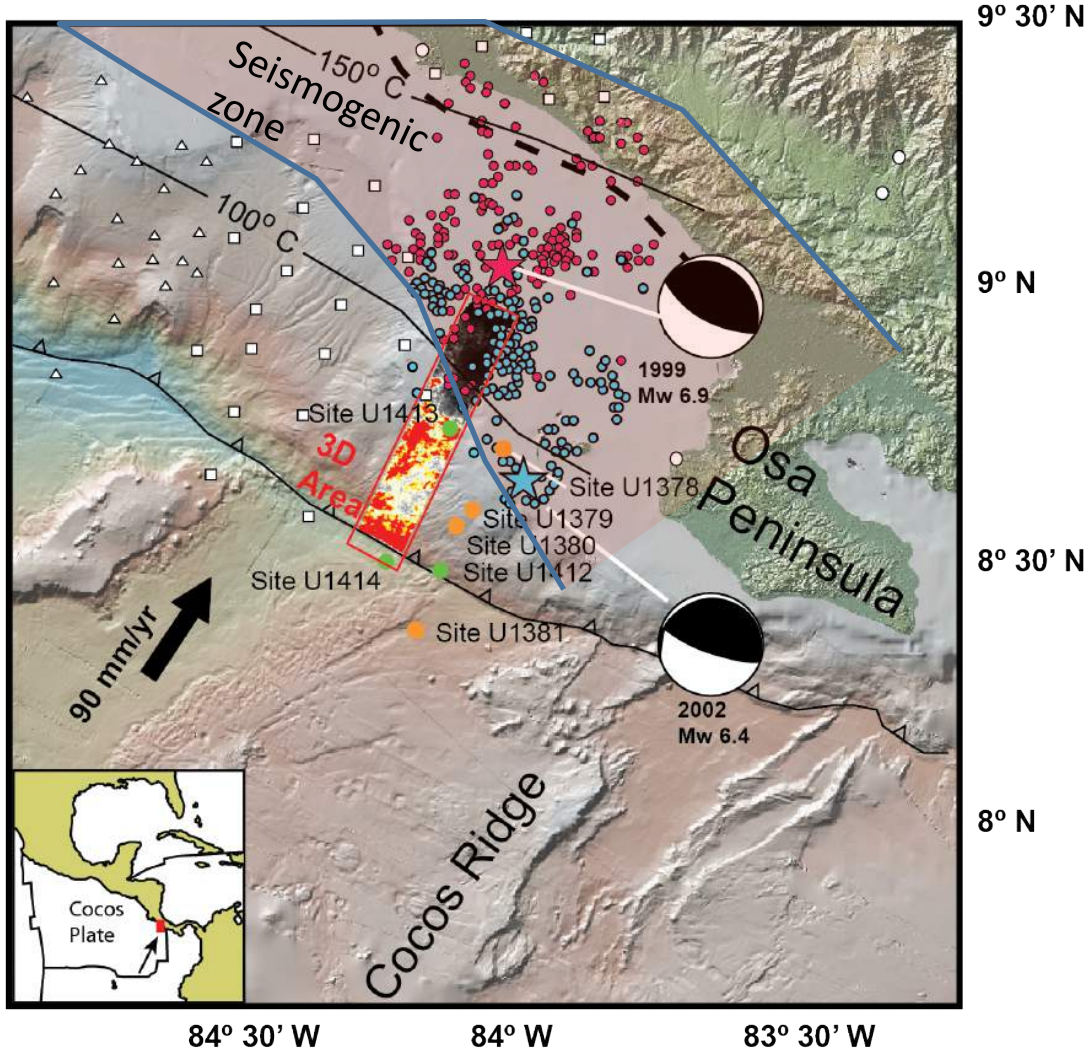


Plate-boundary reflection amplitude and seismicity



What controls the fluid content along the plate-boundary thrust?

Isotherms from Harris et al. 2010

Microseismicity from Arroyo et al. 2013

Plate-boundary thrust reflection amplitude

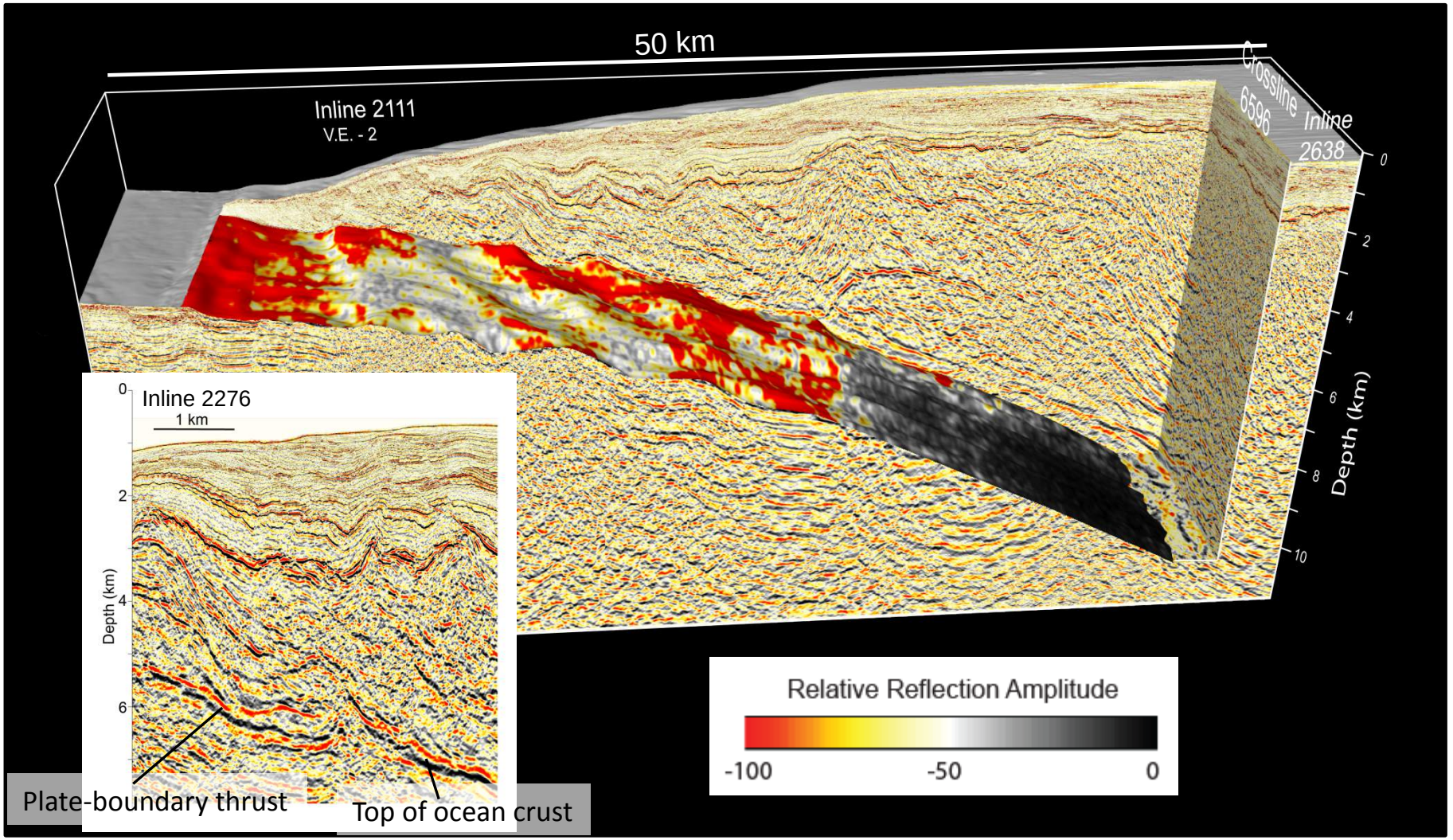
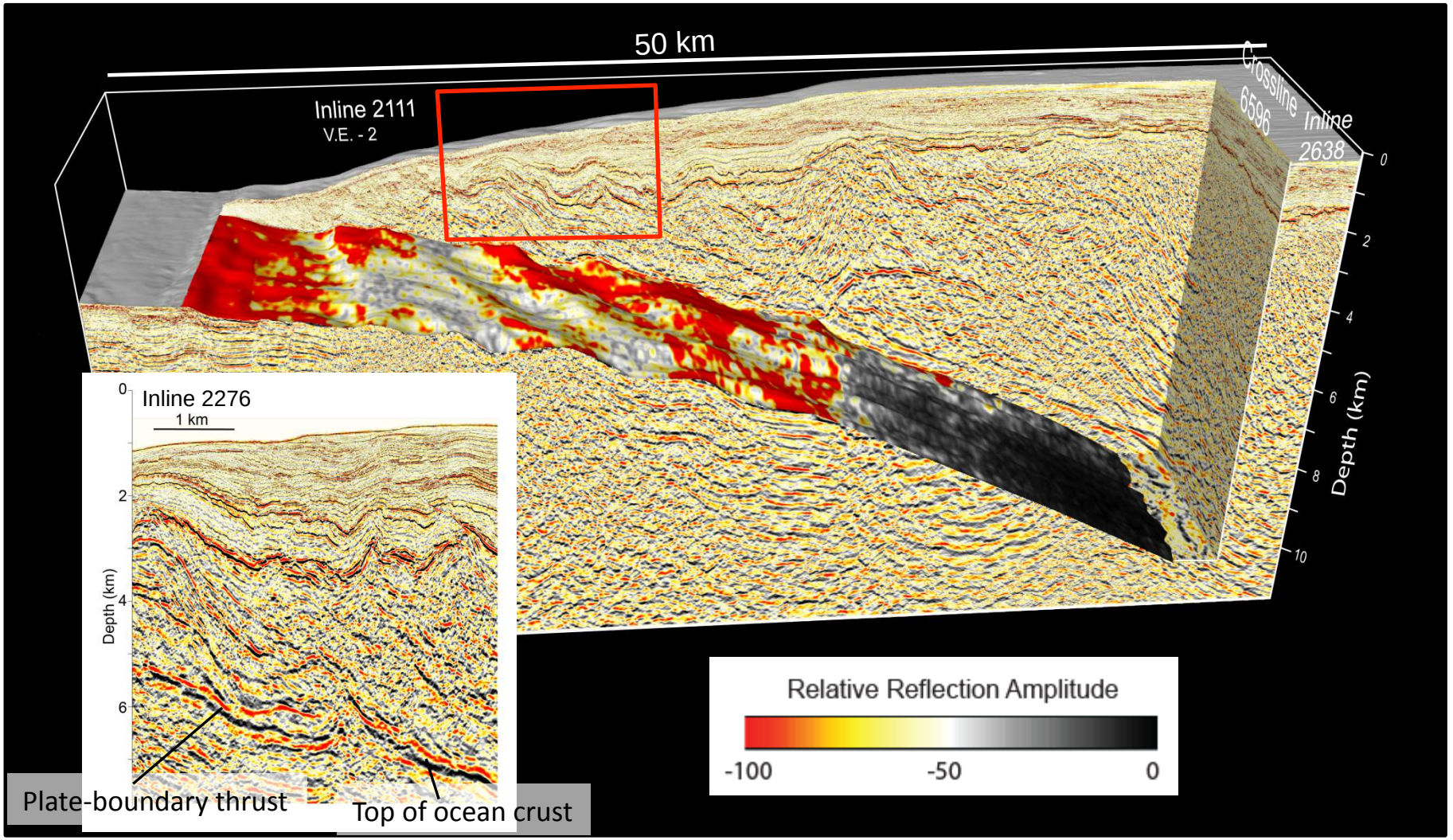
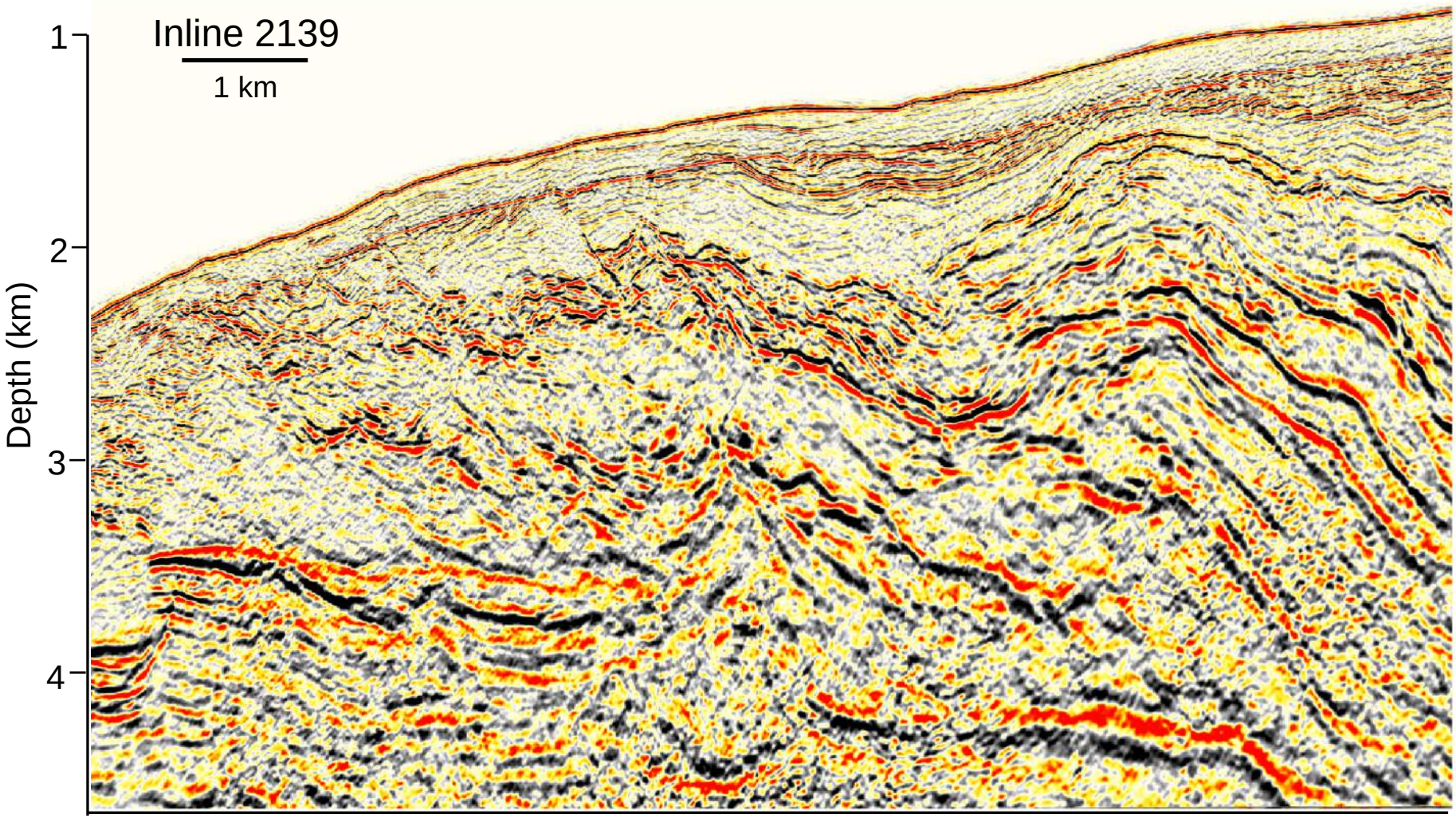


Plate-boundary thrust reflection amplitude



Thrusts are a result of shortening within margin wedge?



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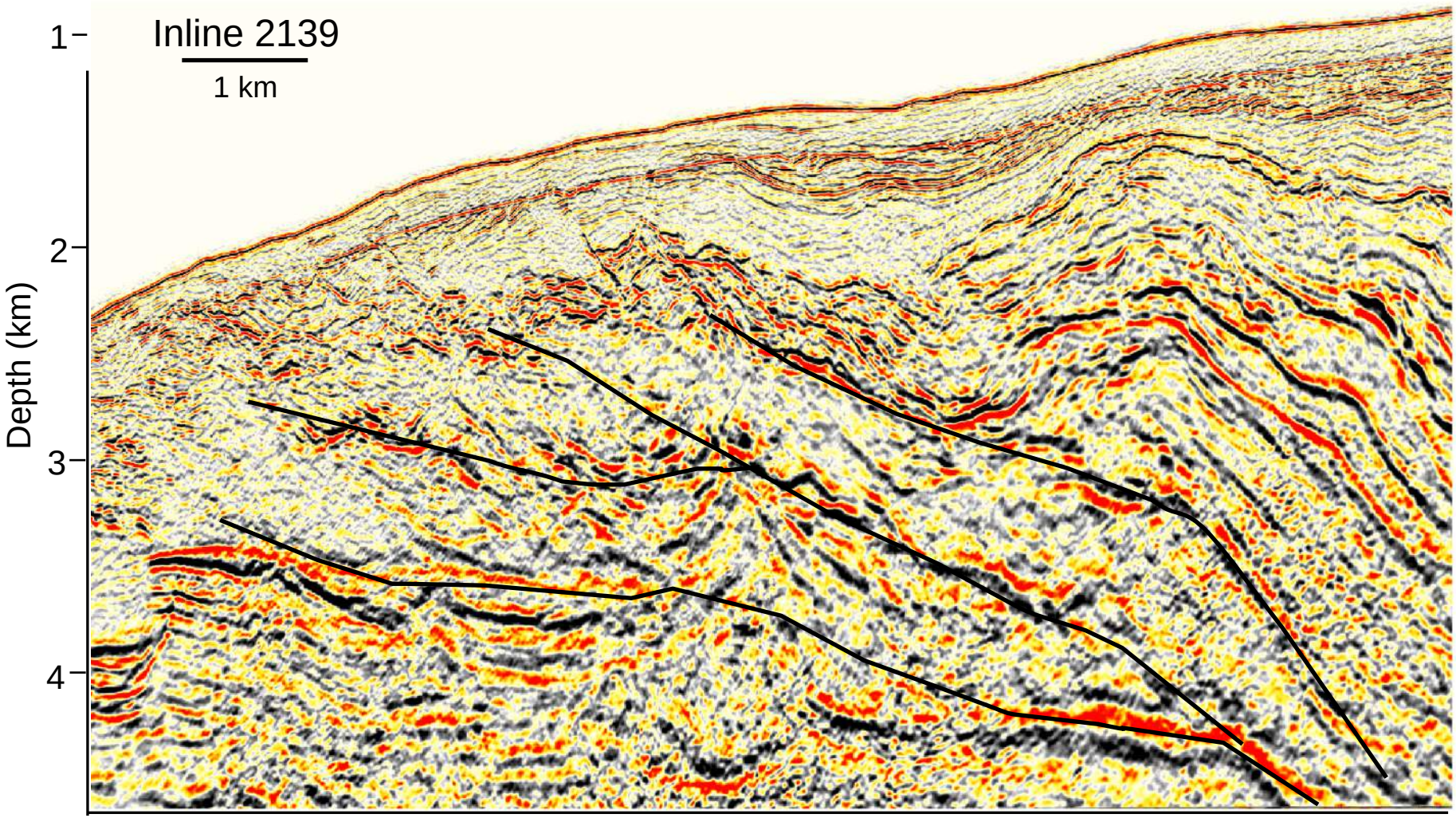
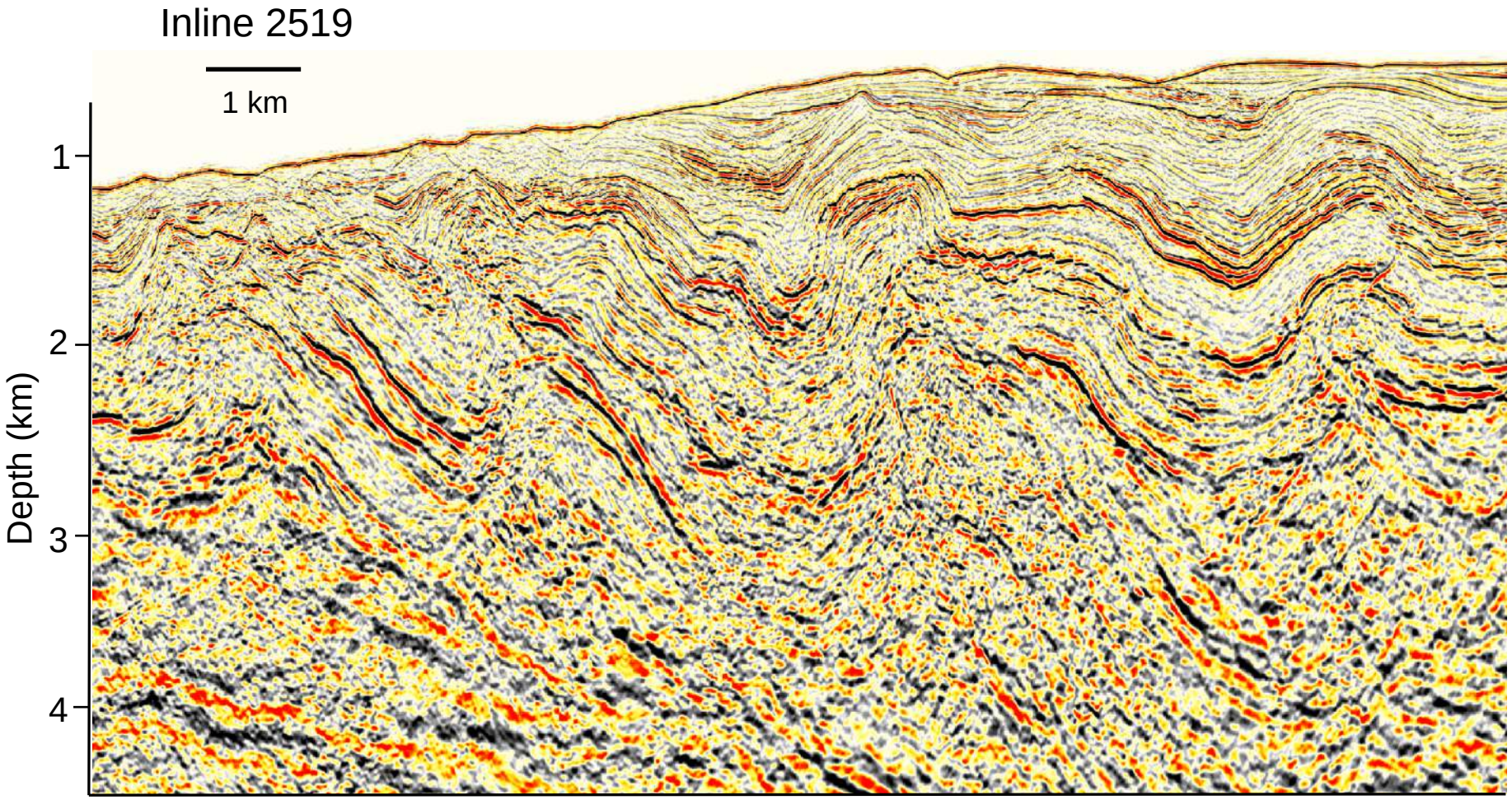


Significant shortening (km) within the slope cover due to thrusts within the margin wedge.



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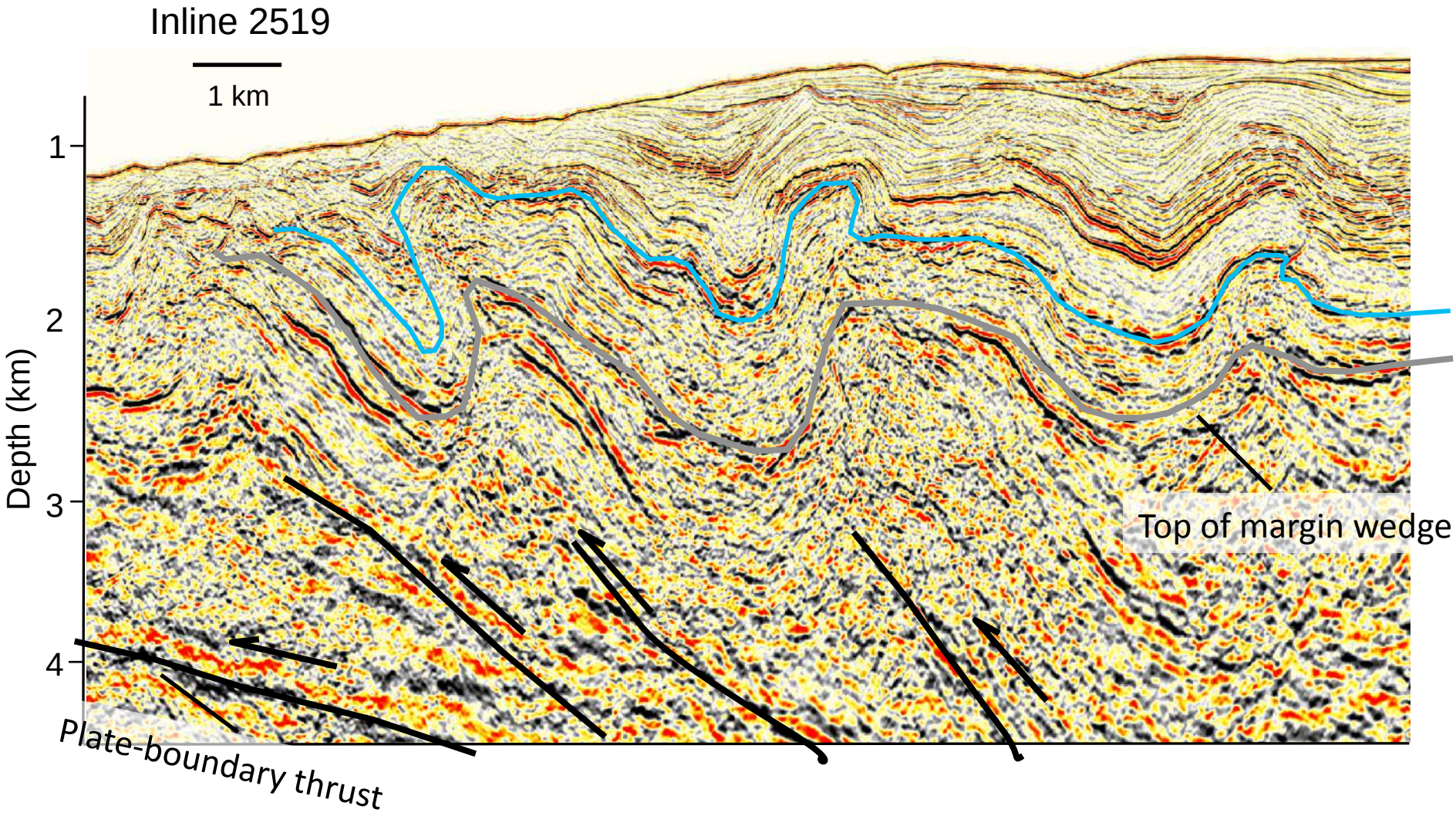
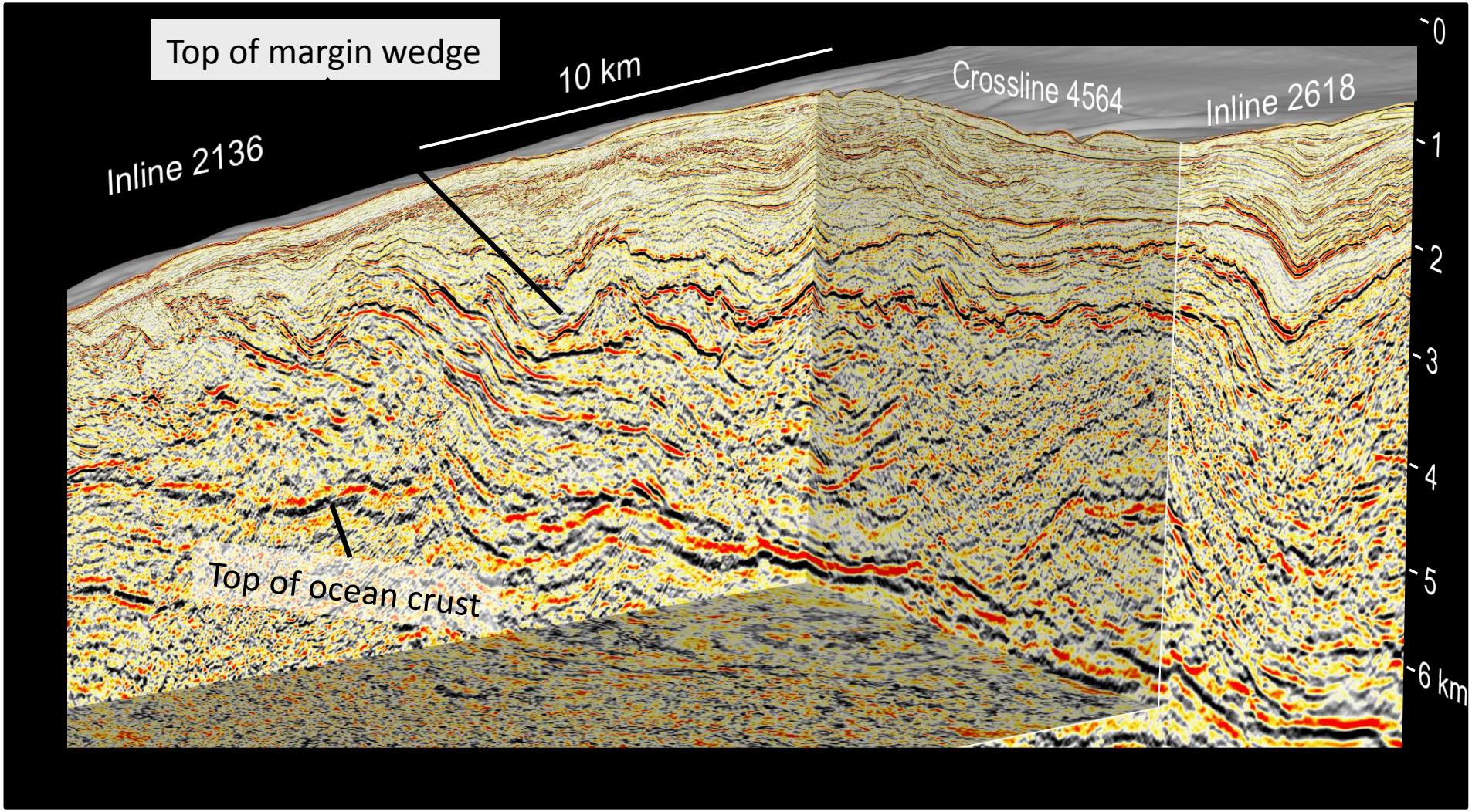
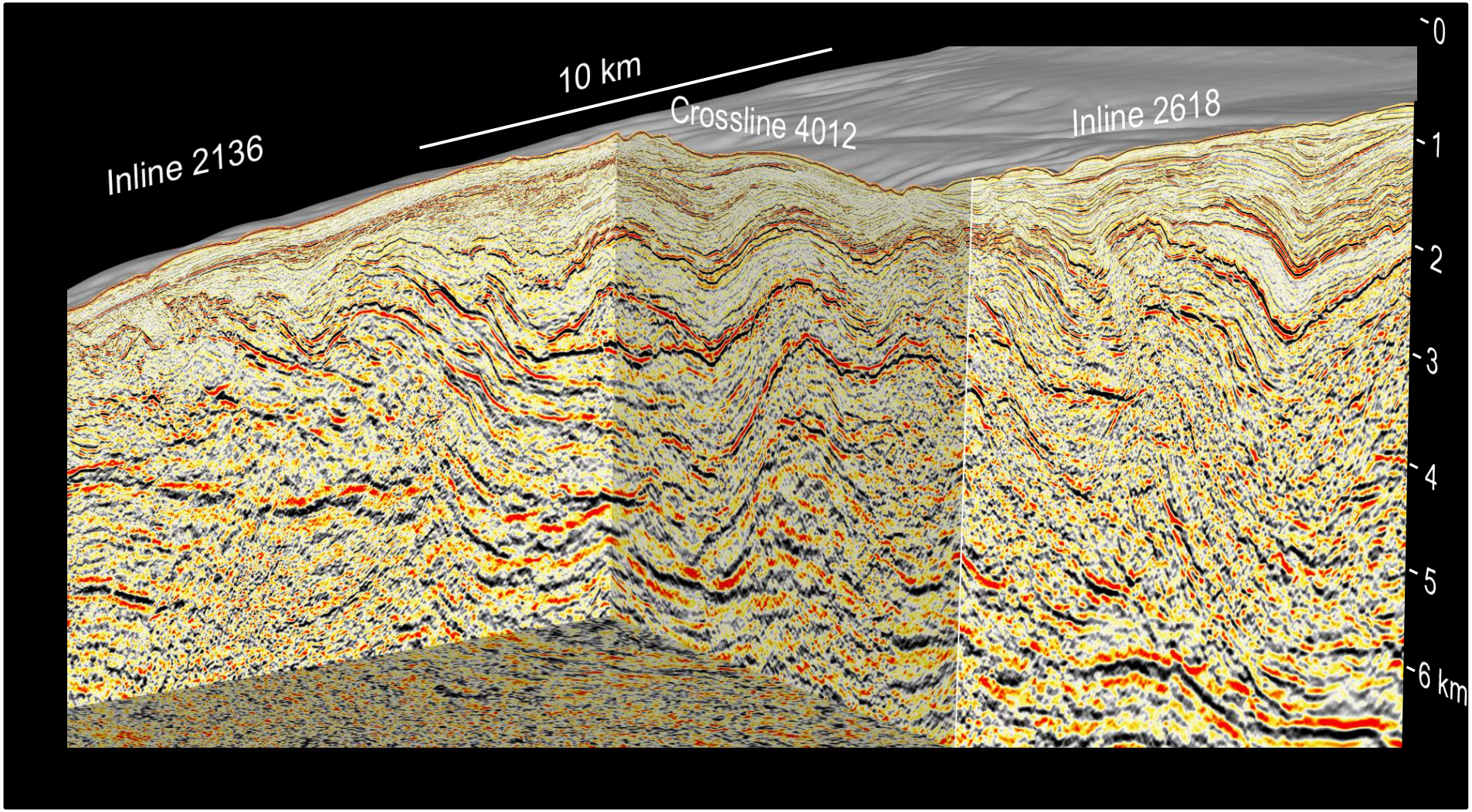


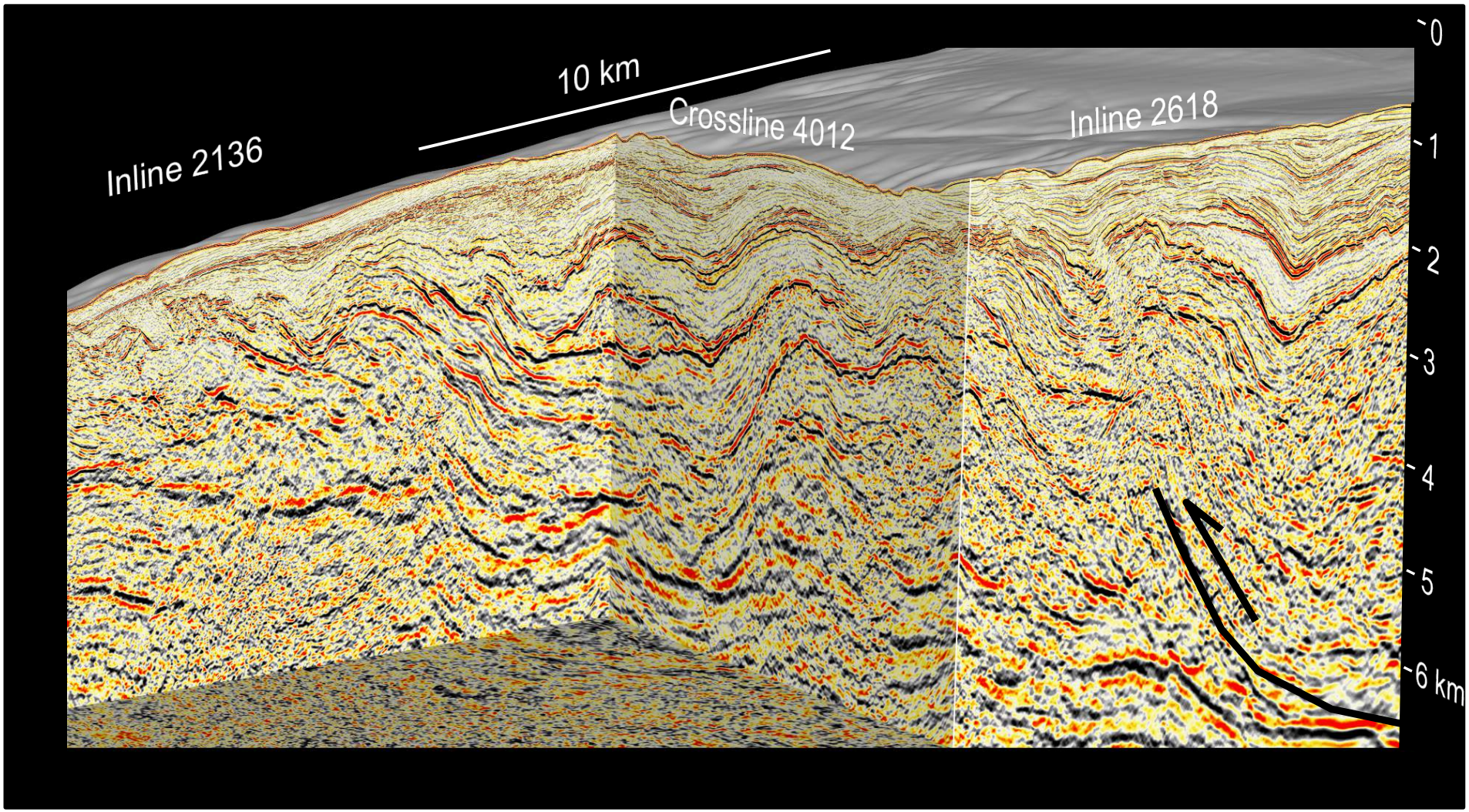
Margin wedge structure in 3D



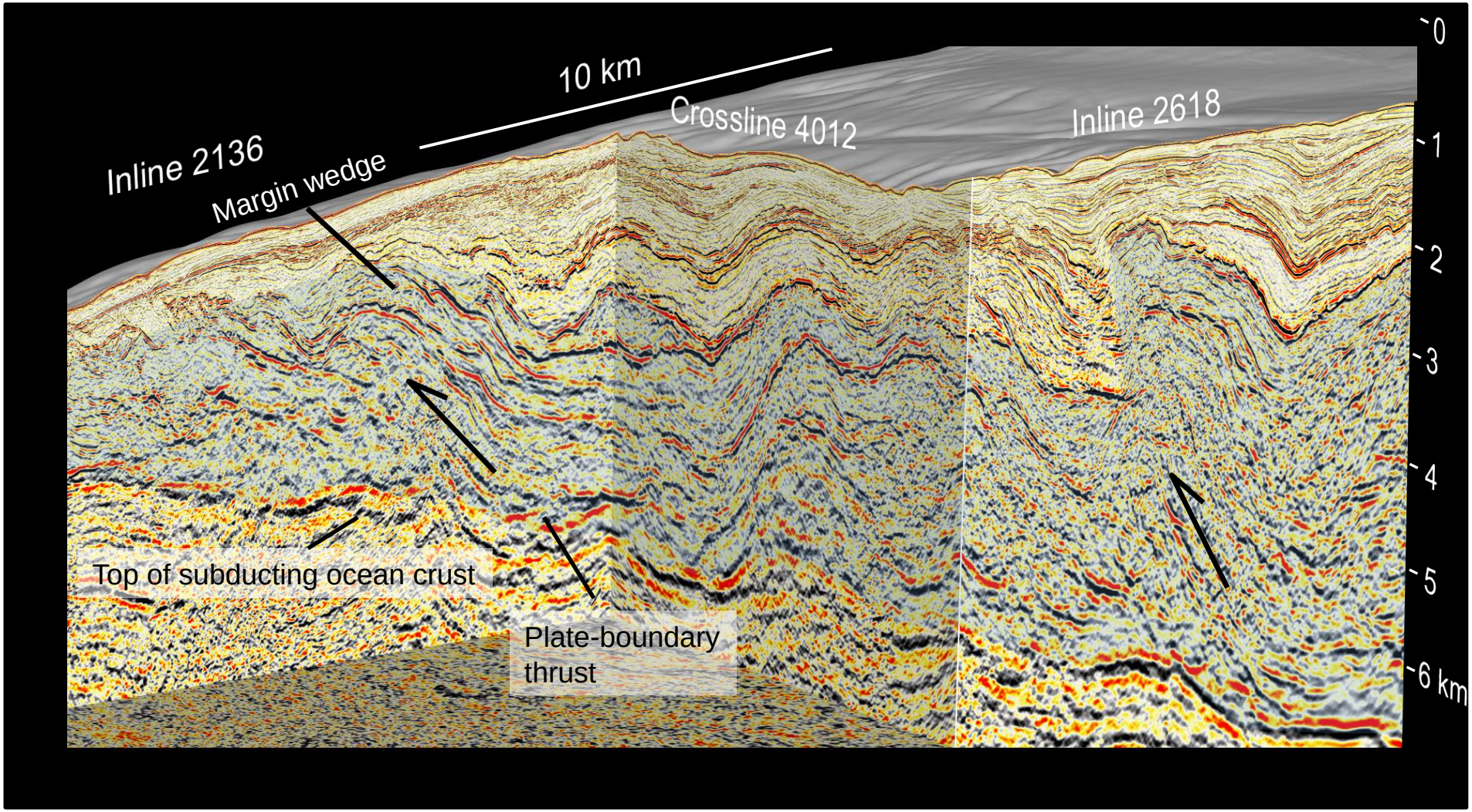
Margin wedge thrusts cutting through entire overriding plate



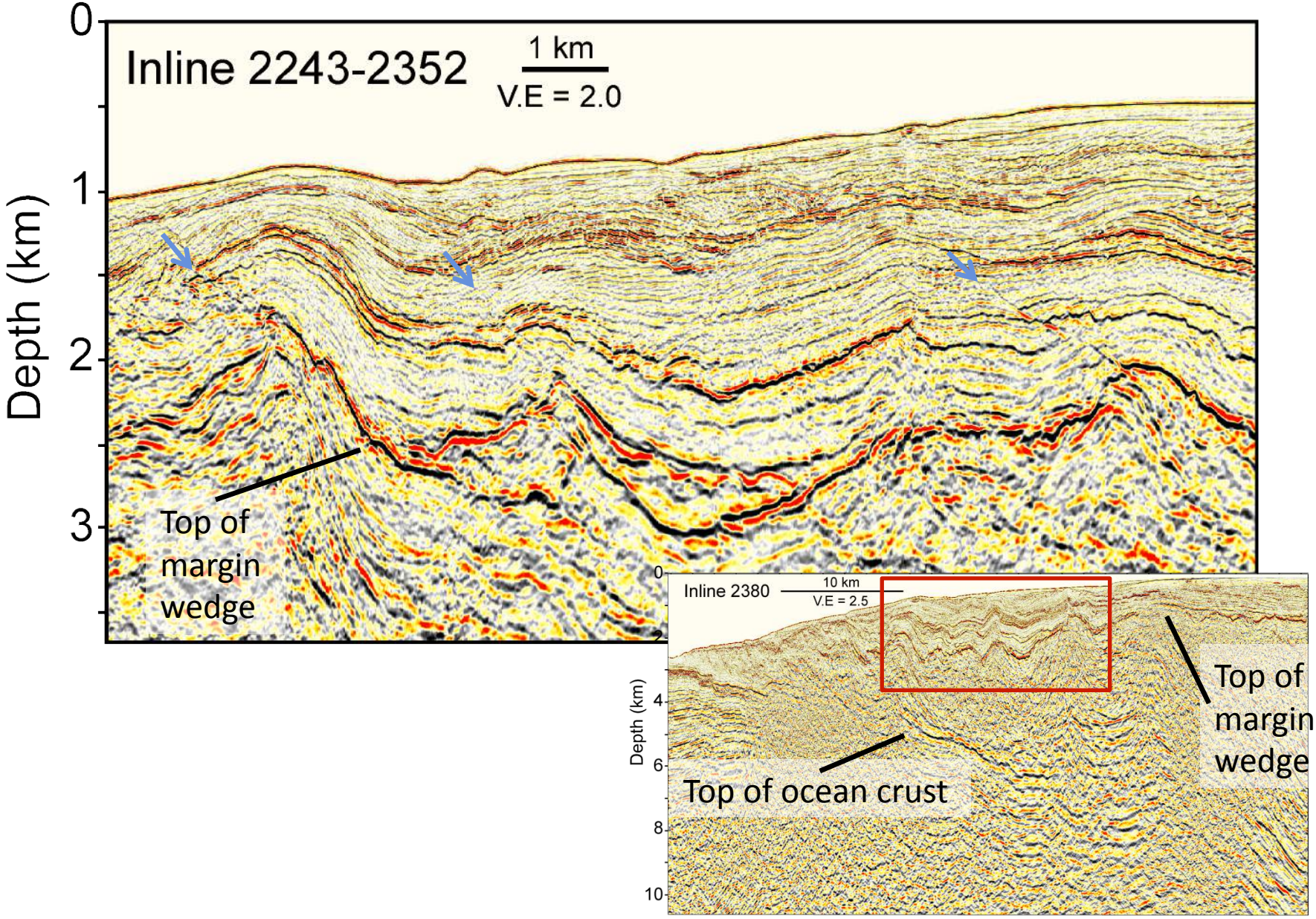
Margin wedge thrusts cutting through entire overriding plate



Margin wedge layering and thrusts (largely compressional)

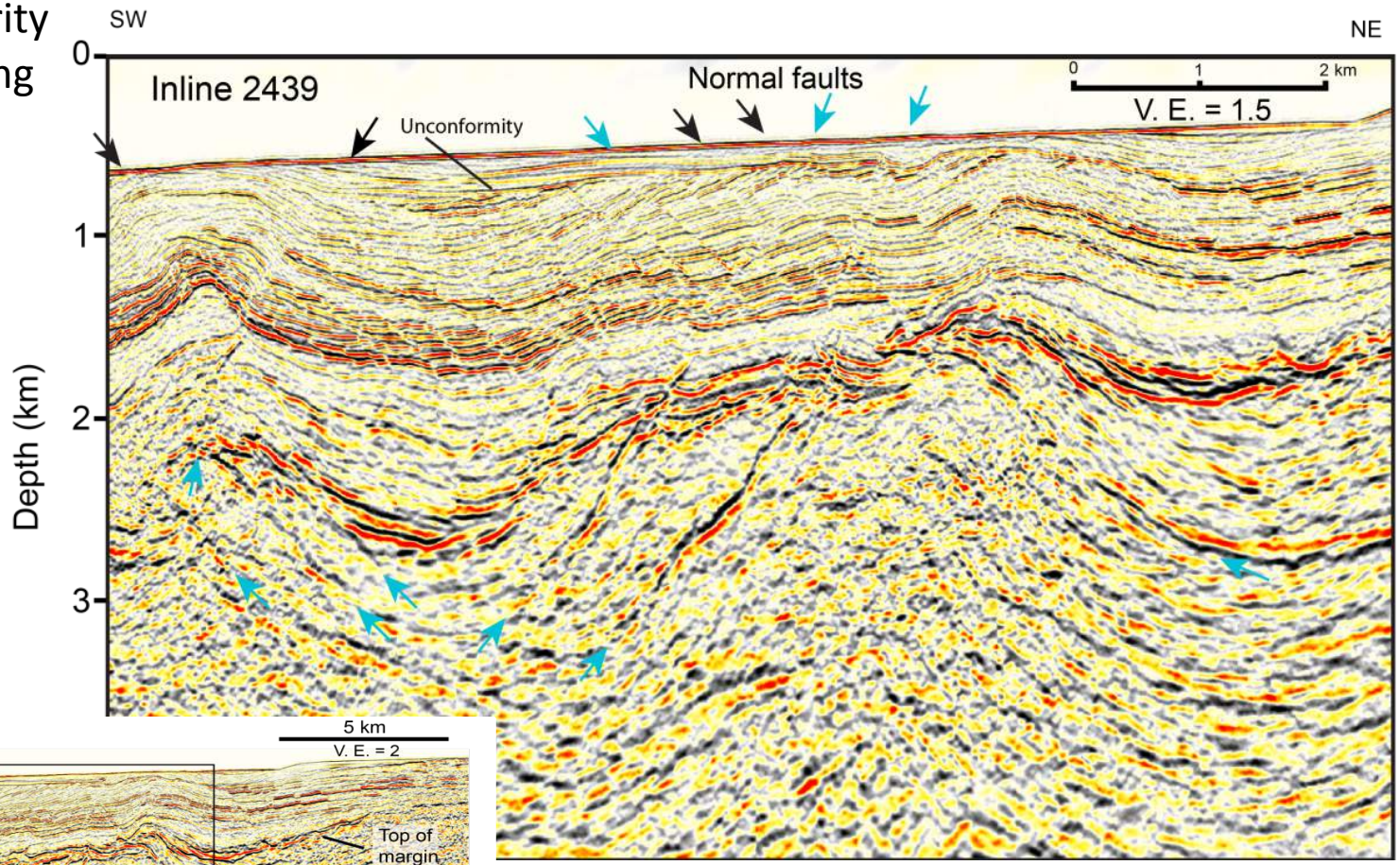


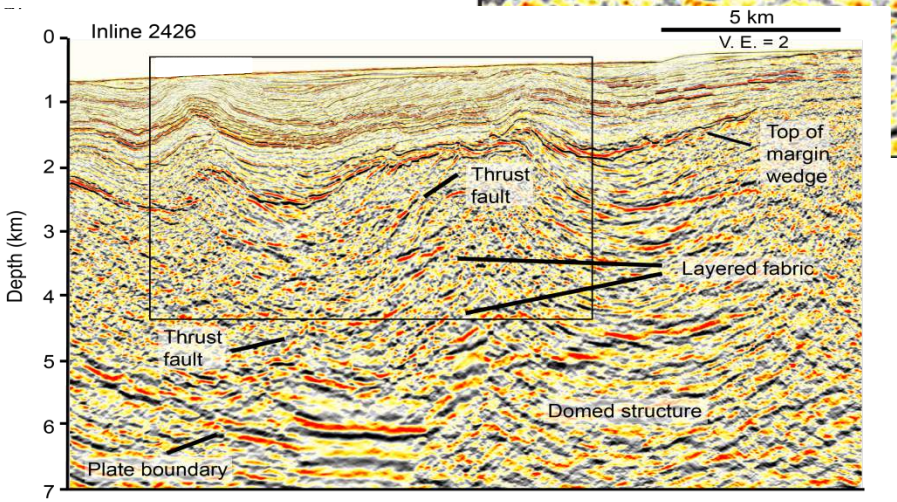
Fault-plane reflections margin wedge



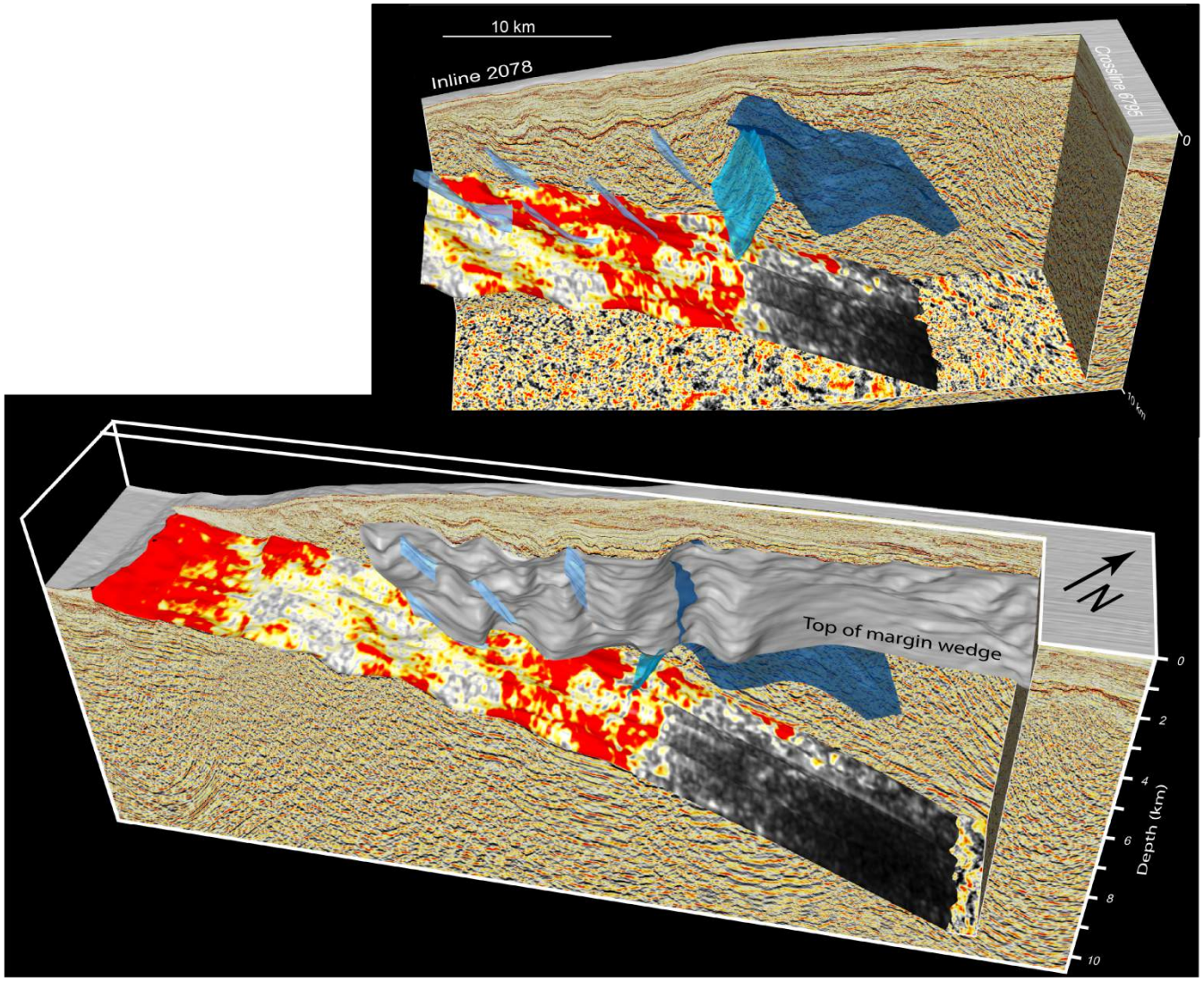
Upper slope margin wedge faults

- Thrust faults offsetting normal faults
- Reversed polarity
- Seaward dipping

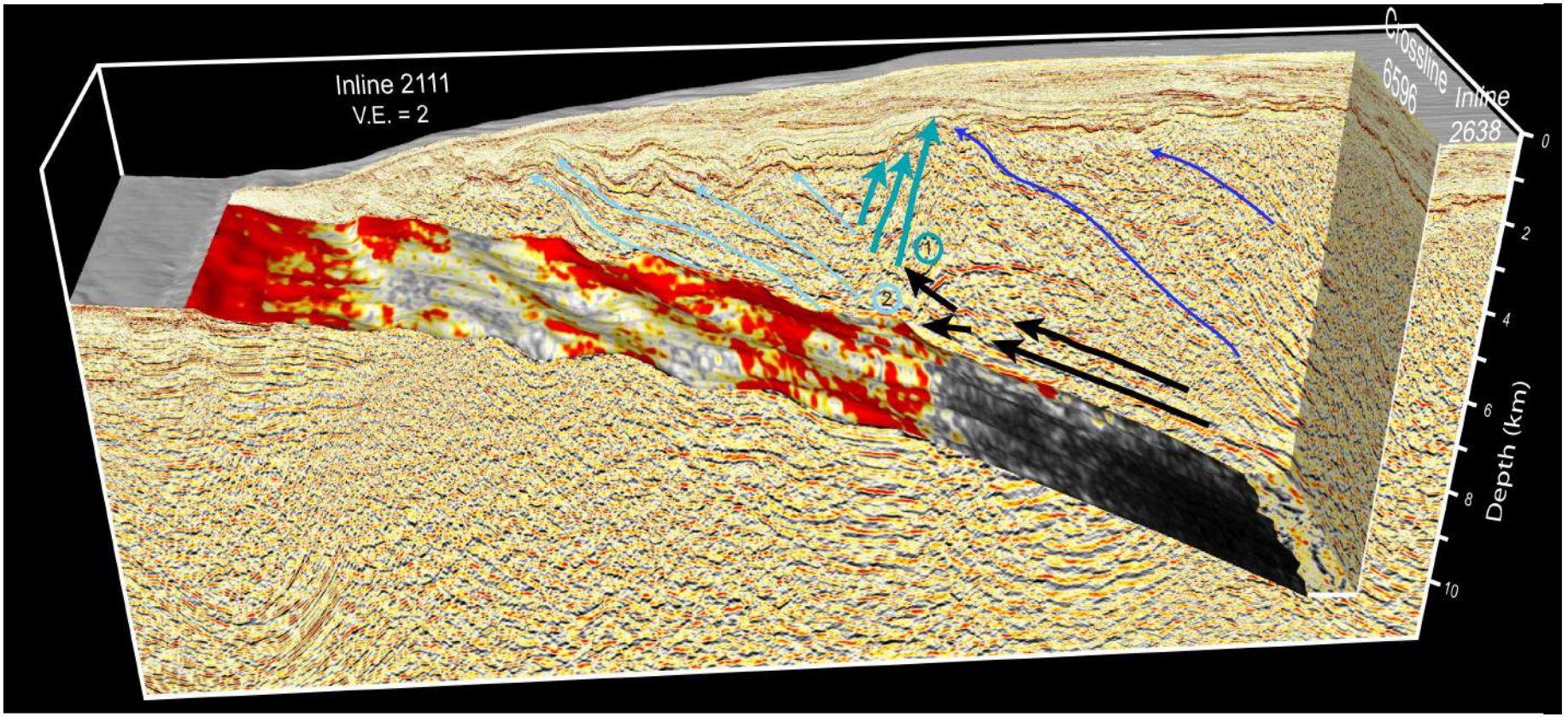




Fault systems within the margin wedge

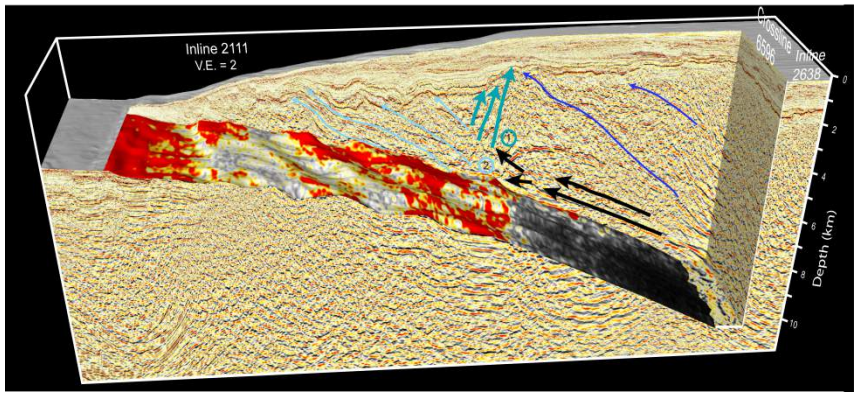


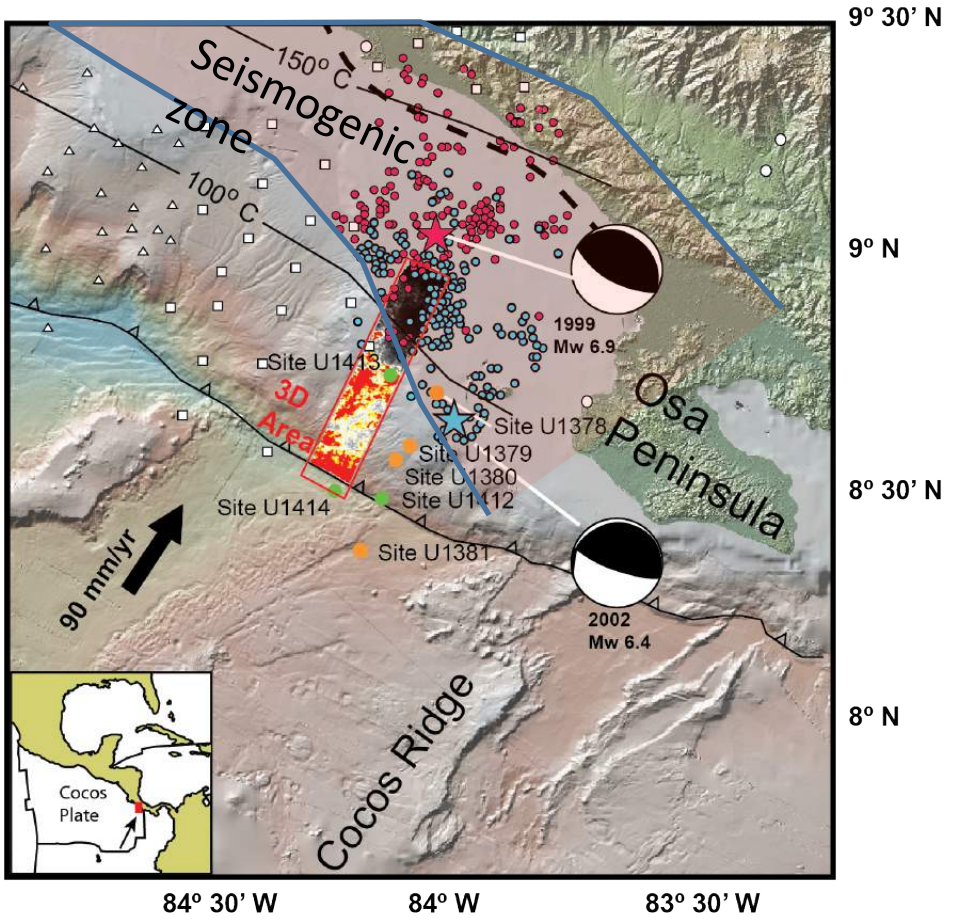
Fluid migration through the margin wedge



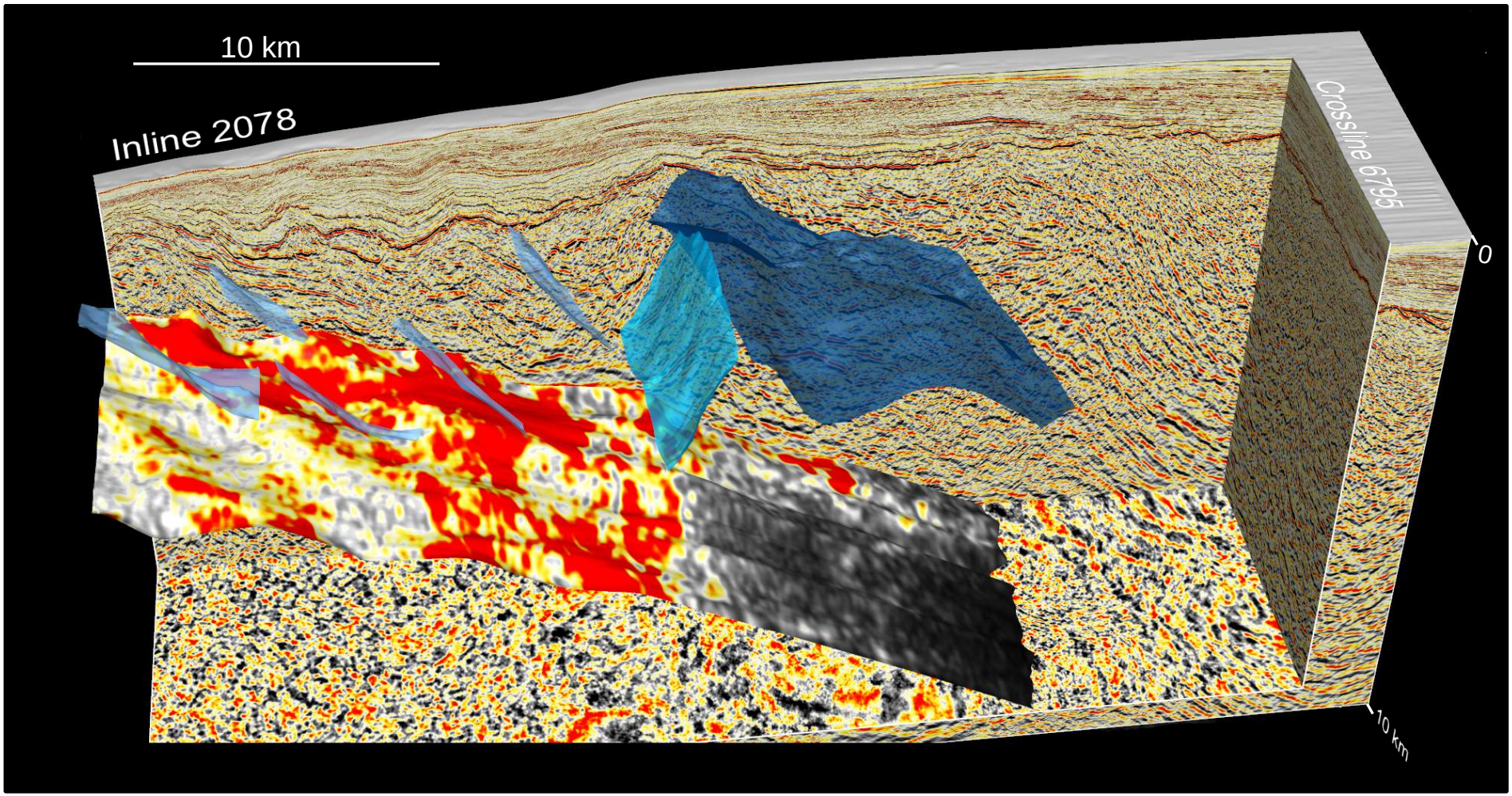
Significant results so far…….

- Margin wedge is made up of sequences of layered clastic material that is currently undergoing shortening by folding and thrusting.
- Fluid migration through the margin wedge plays a critical role in fluid loss from the plate interface by controlling drainage or as a source of fluids.
- Fluids along the plate interface are significant for controlling fault slip behavior.

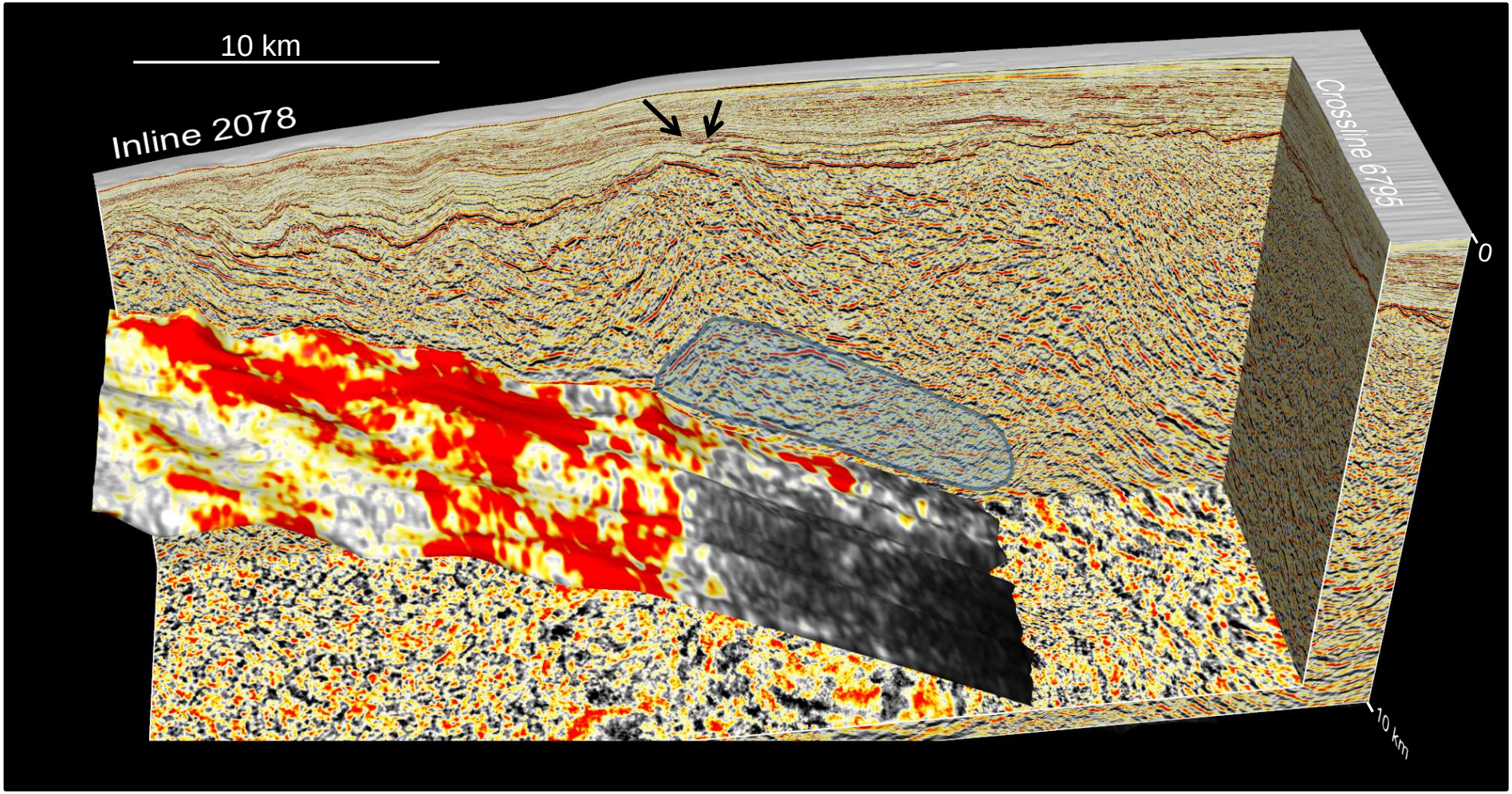


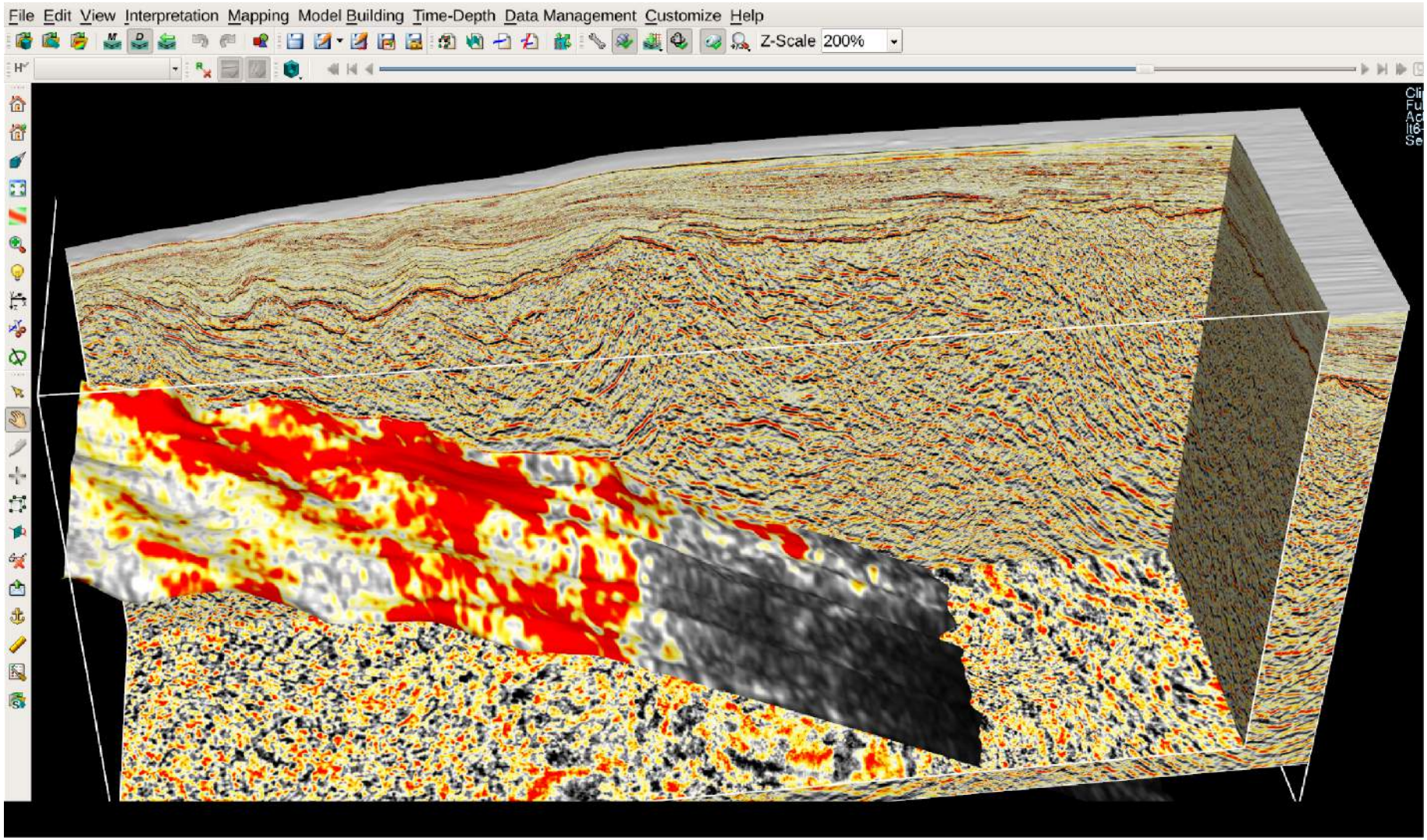


Three primary margin wedge fault systems



Fluid focusing above “mystery structure”

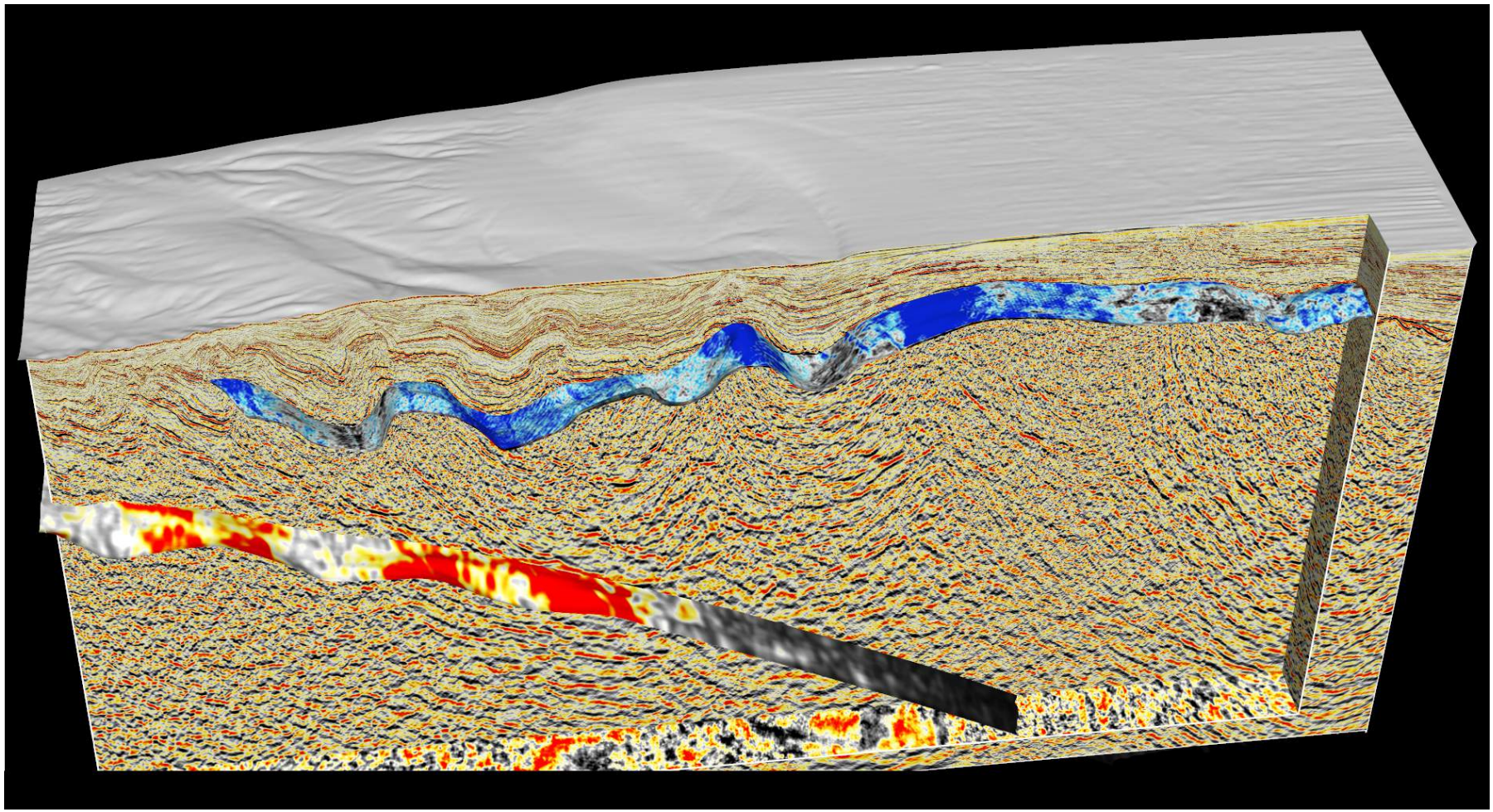



File Edit View Interpretation Mapping Model Building Time-Depth Data Management Customize Help
Z-Scale 200%

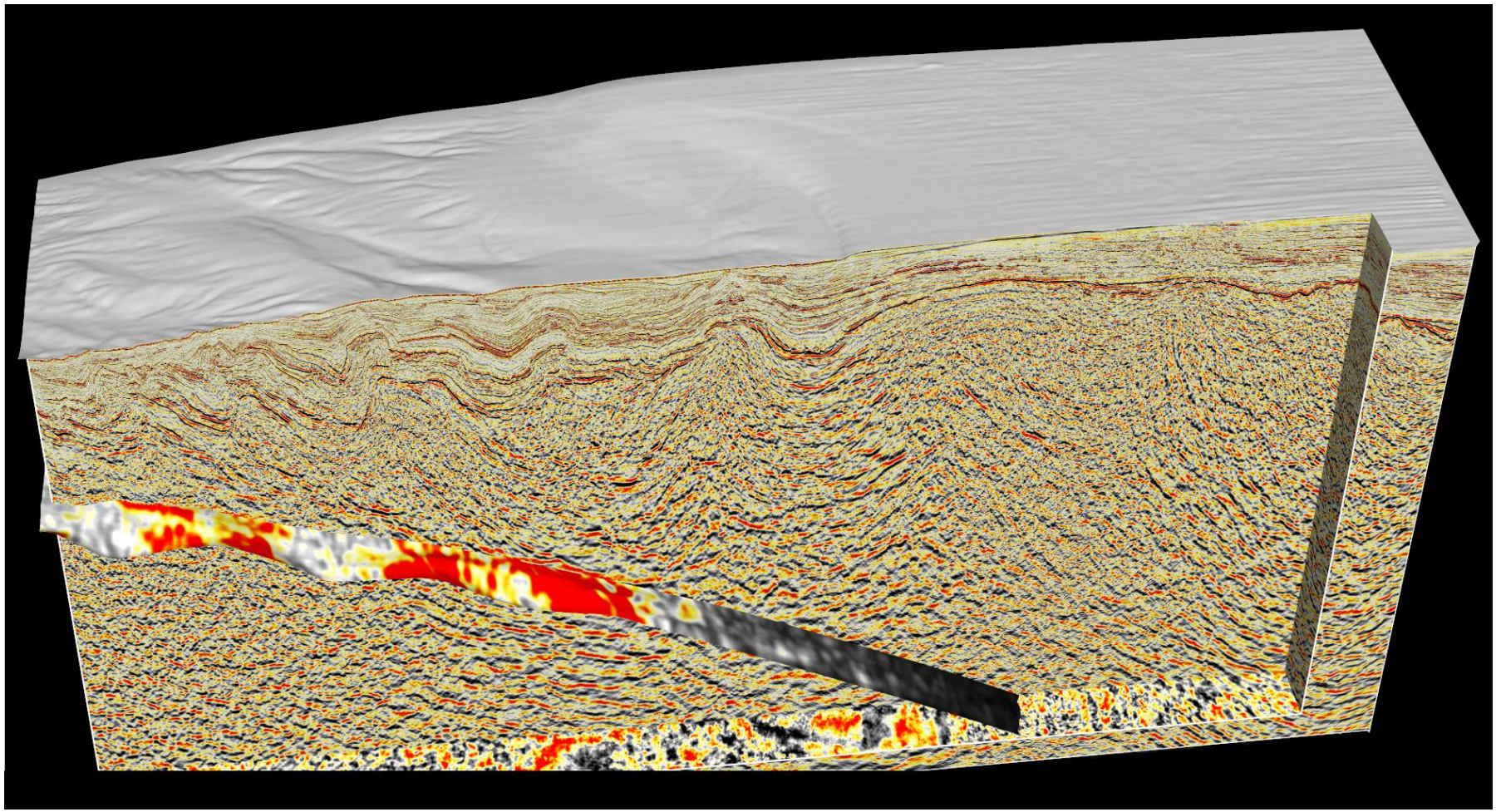
Conclusions

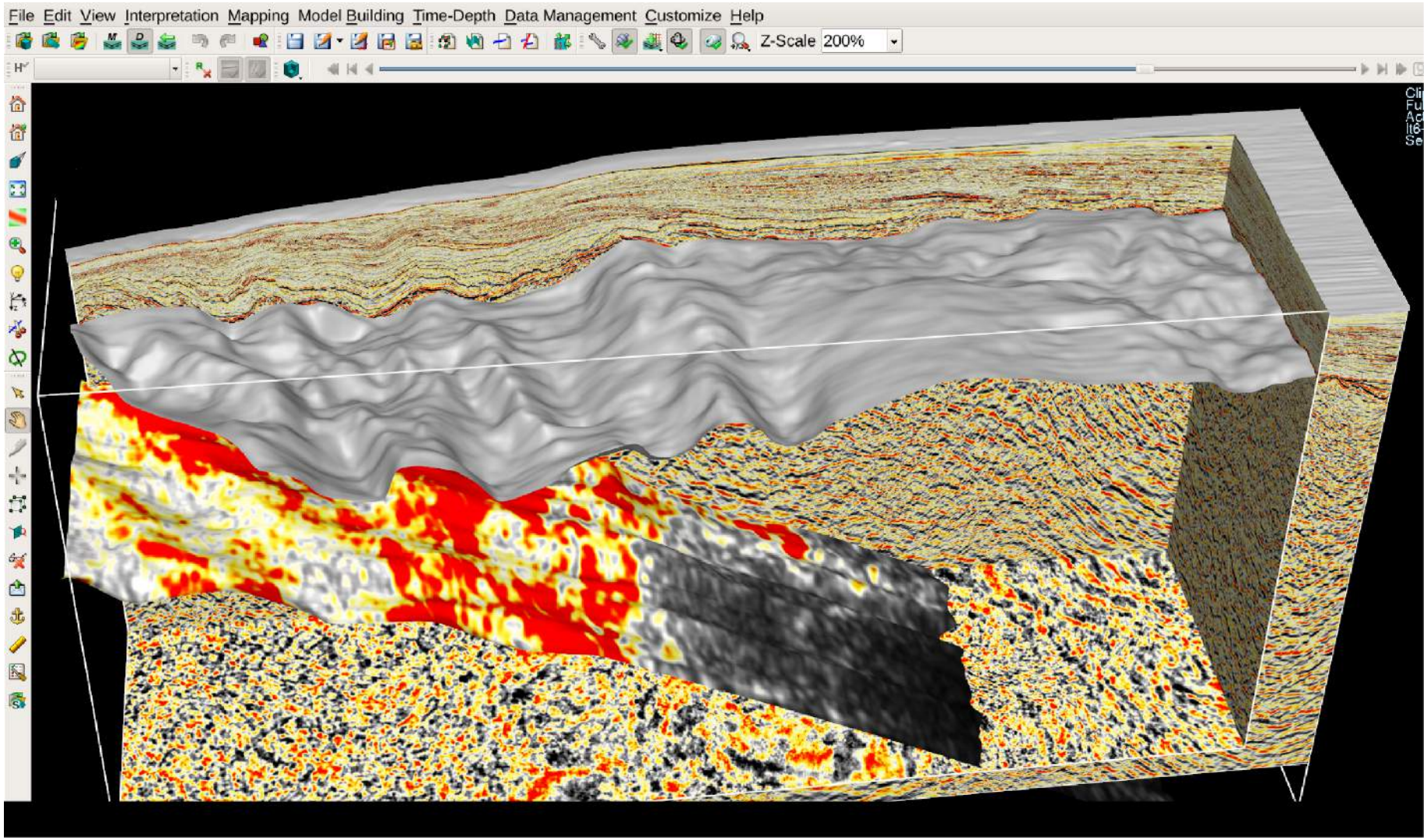
- Strong coincidental relationship between plate boundary reflectivity and seismicity implies a role of fluids in non-accretionary/erosional margins as in accretionary margins.
- Fluid sources from subducted sediment is small (especially in comparison to accretionary margins) implying either other fluid sources or very slow drainage.
- Plumbing system plays a significant role in the drainage of the plate interface as major throughgoing thrust/high-angle reverse faults stratigraphy? provide connections directly through the margin wedge and shallower extensional normal faults provide pathways through the slope cover.
- Significant amplitude changes coincide with significant deep structures that either act to change plumbing system rather than a contrast in fault material properties.
-

SE edge of 3D volume



Vent and pockmark/mound locations

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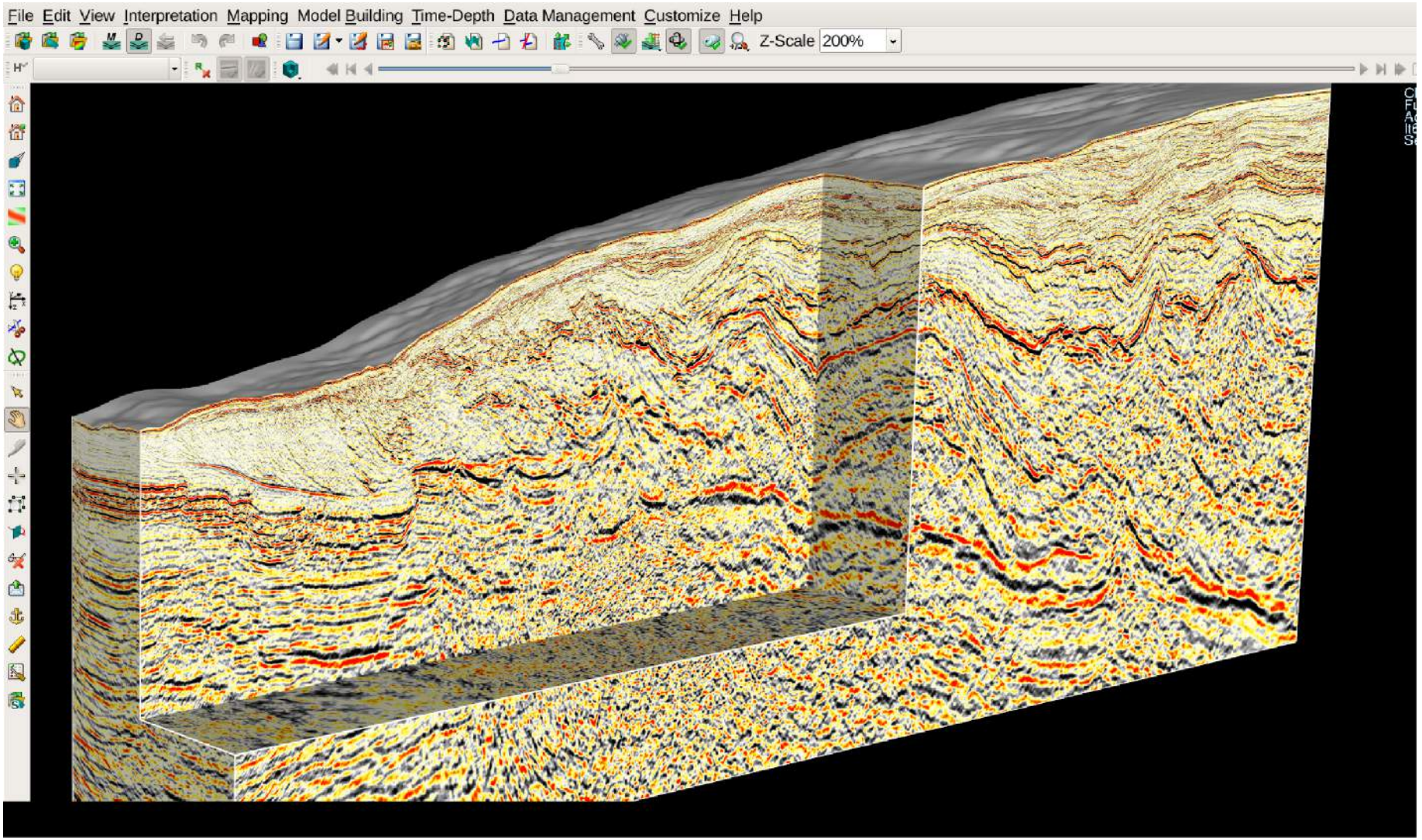
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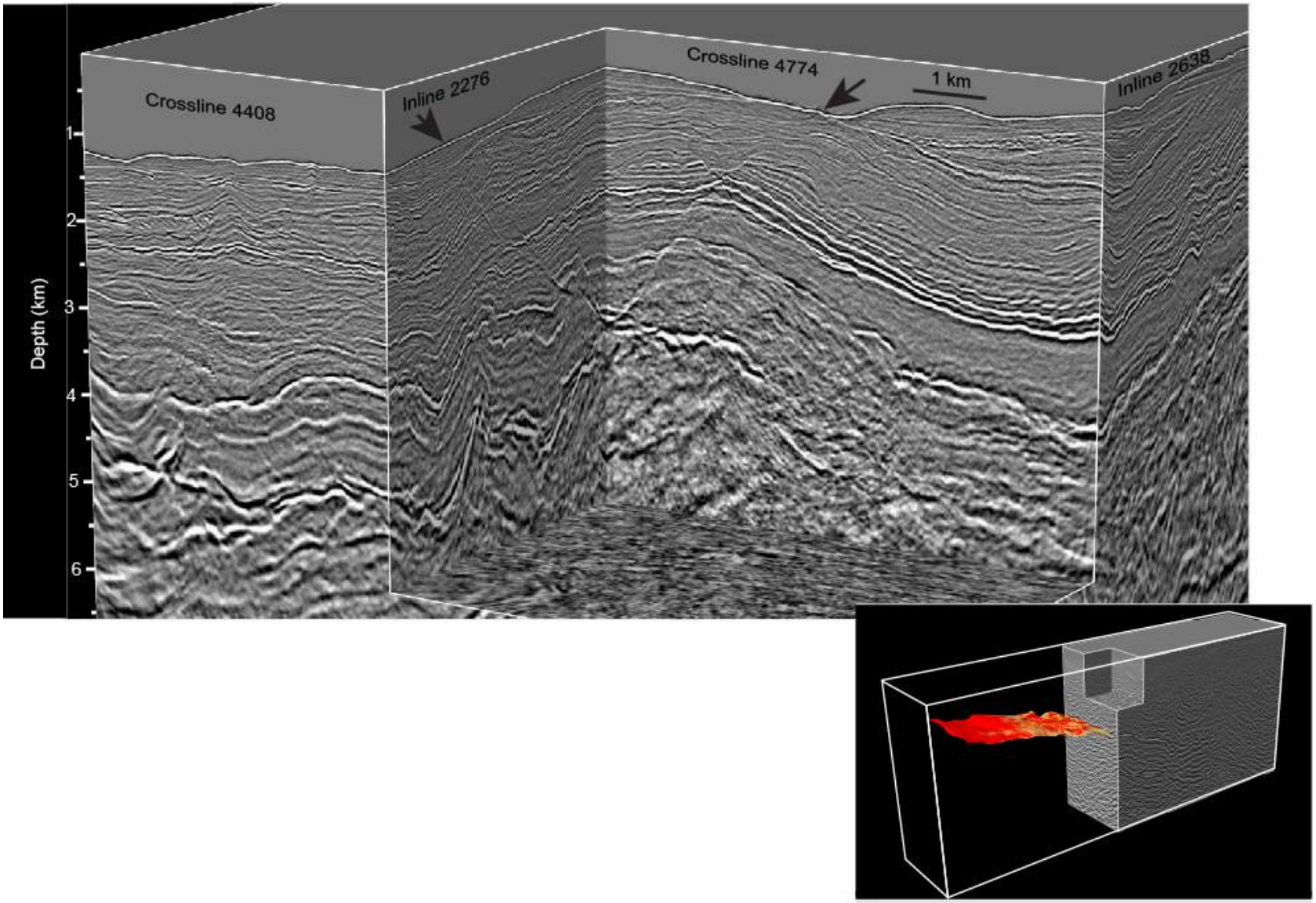
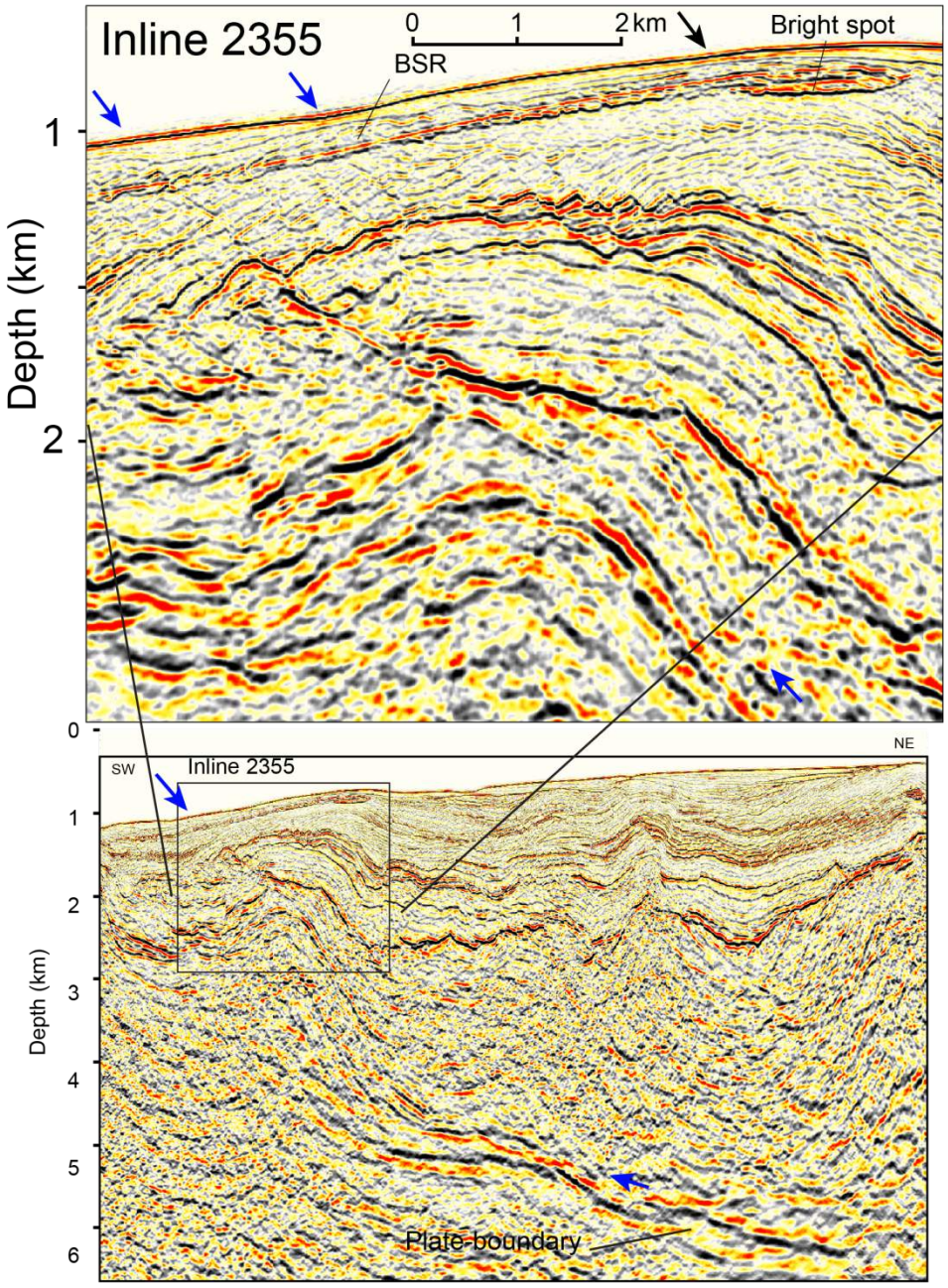
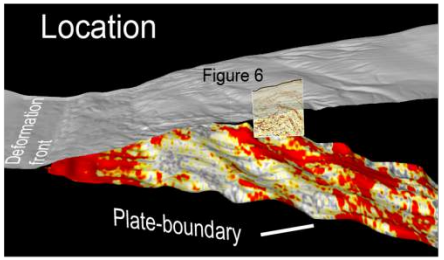
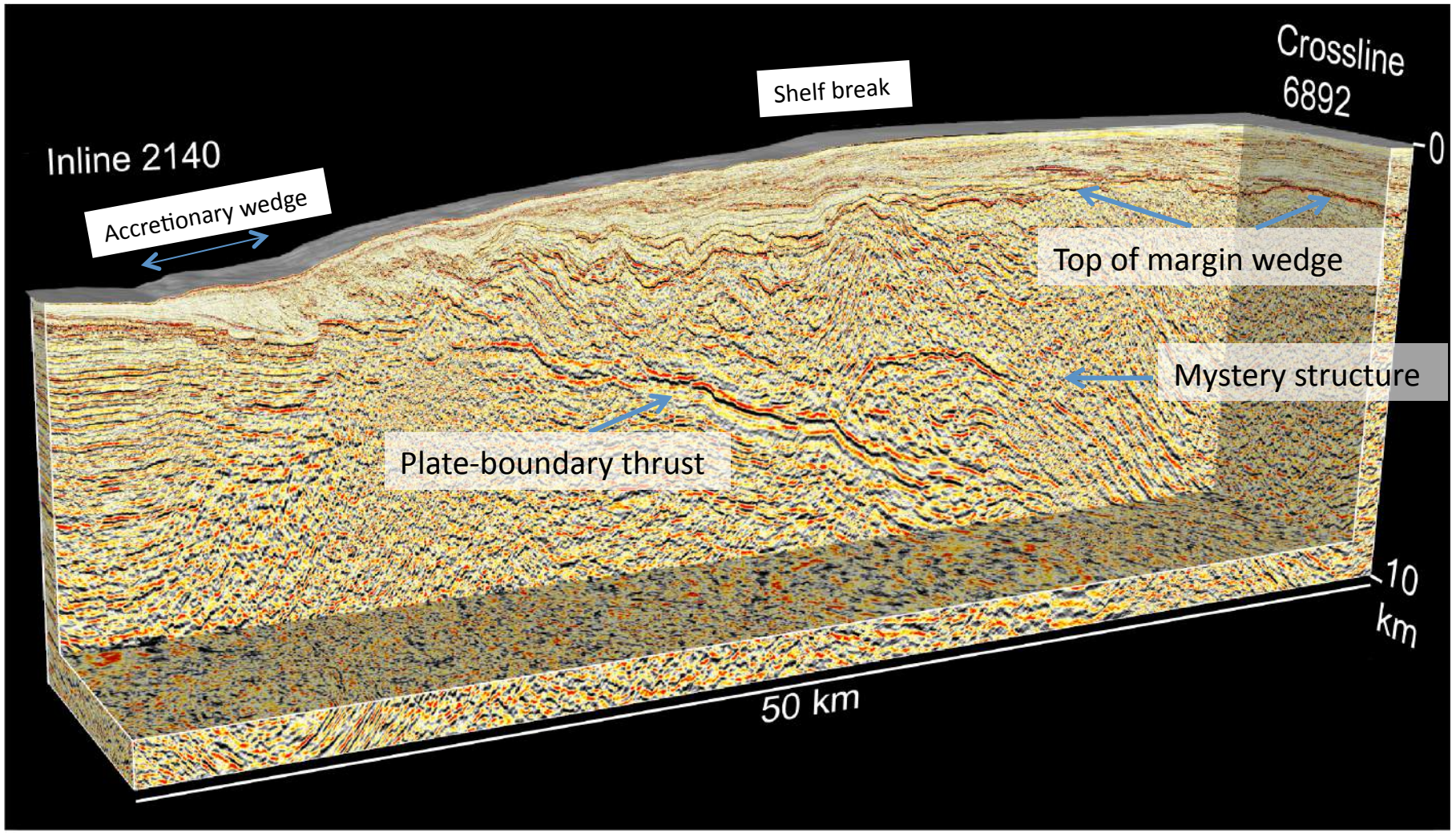

Crossline 4408
Inline 2276
Crossline 4774
1 km
Inline 2638
Depth (km)
1
2
3
4
5
6



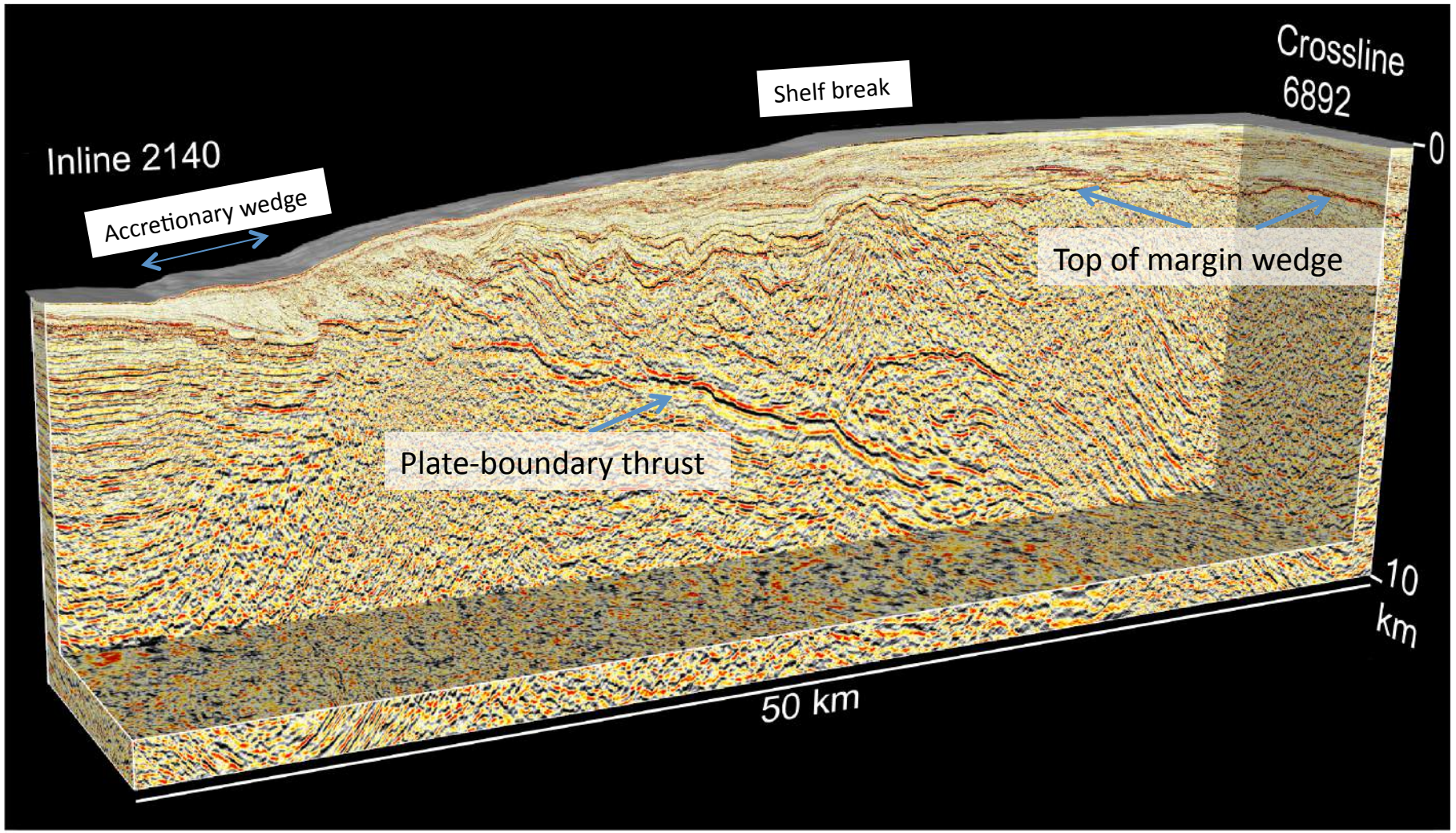
Fluids in frontal zone



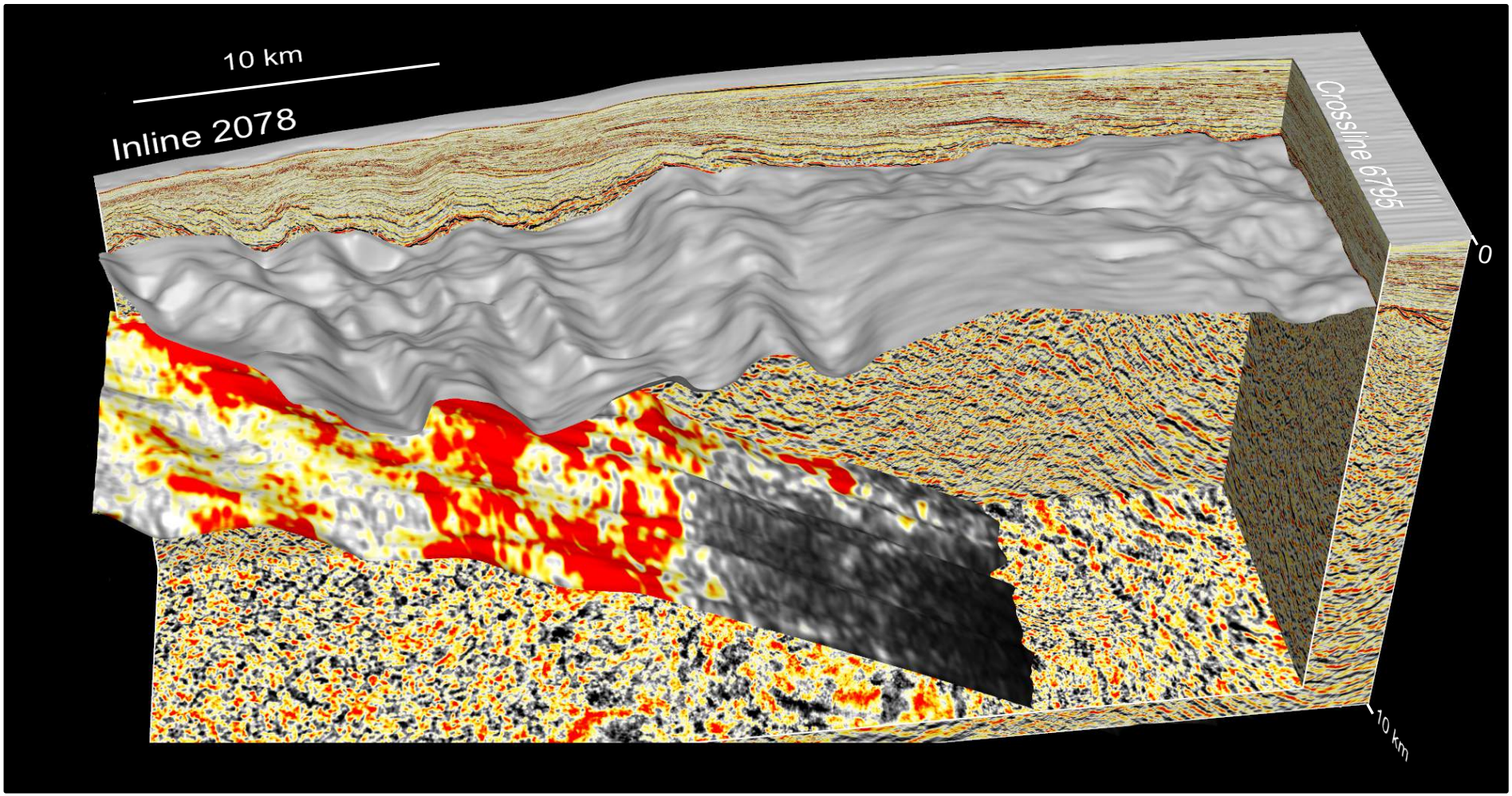
Margin Structure to show where we will be looking



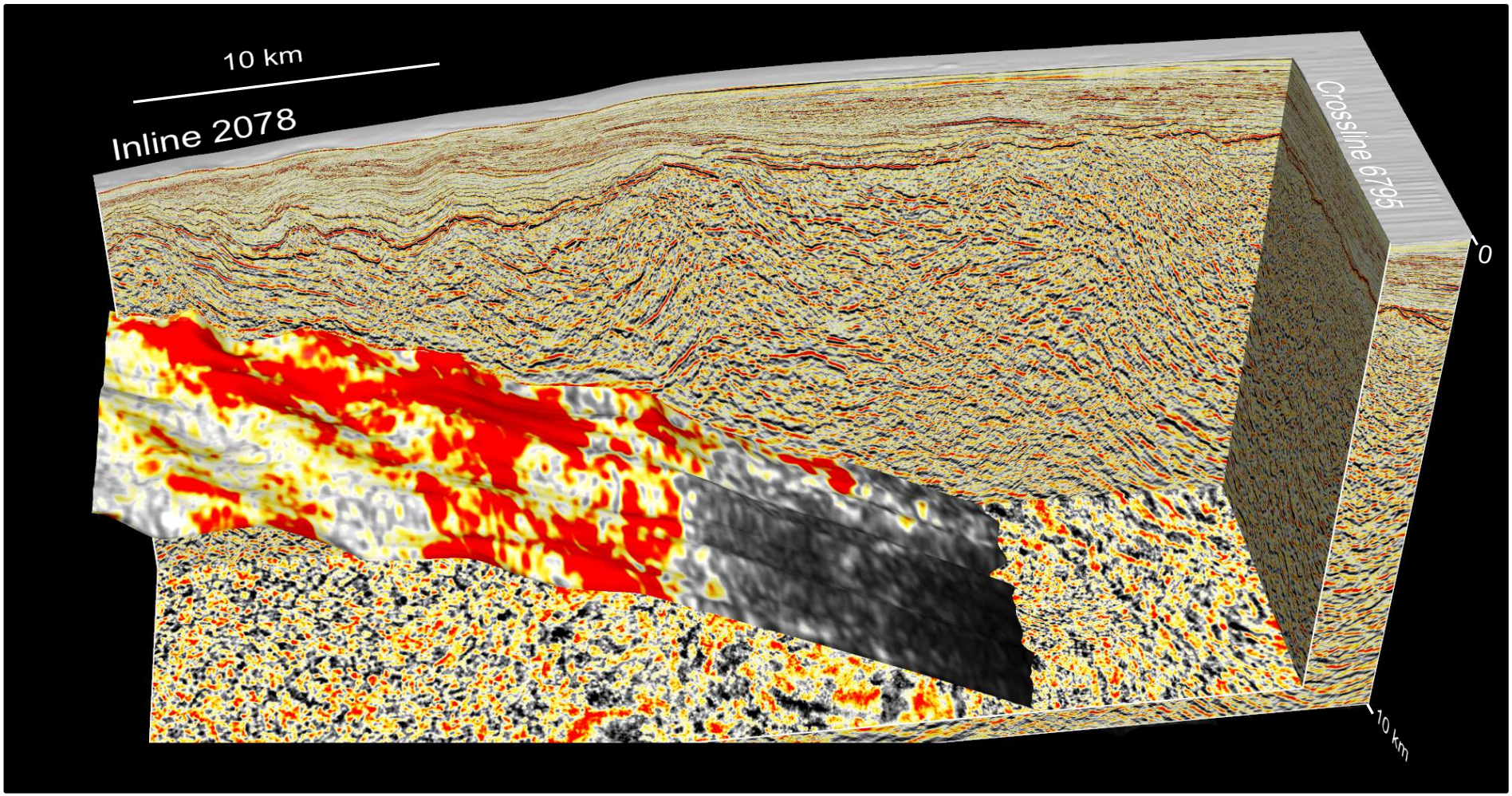
Overview of the Costa Rica 3D seismic volume



Top of margin wedge in 3D



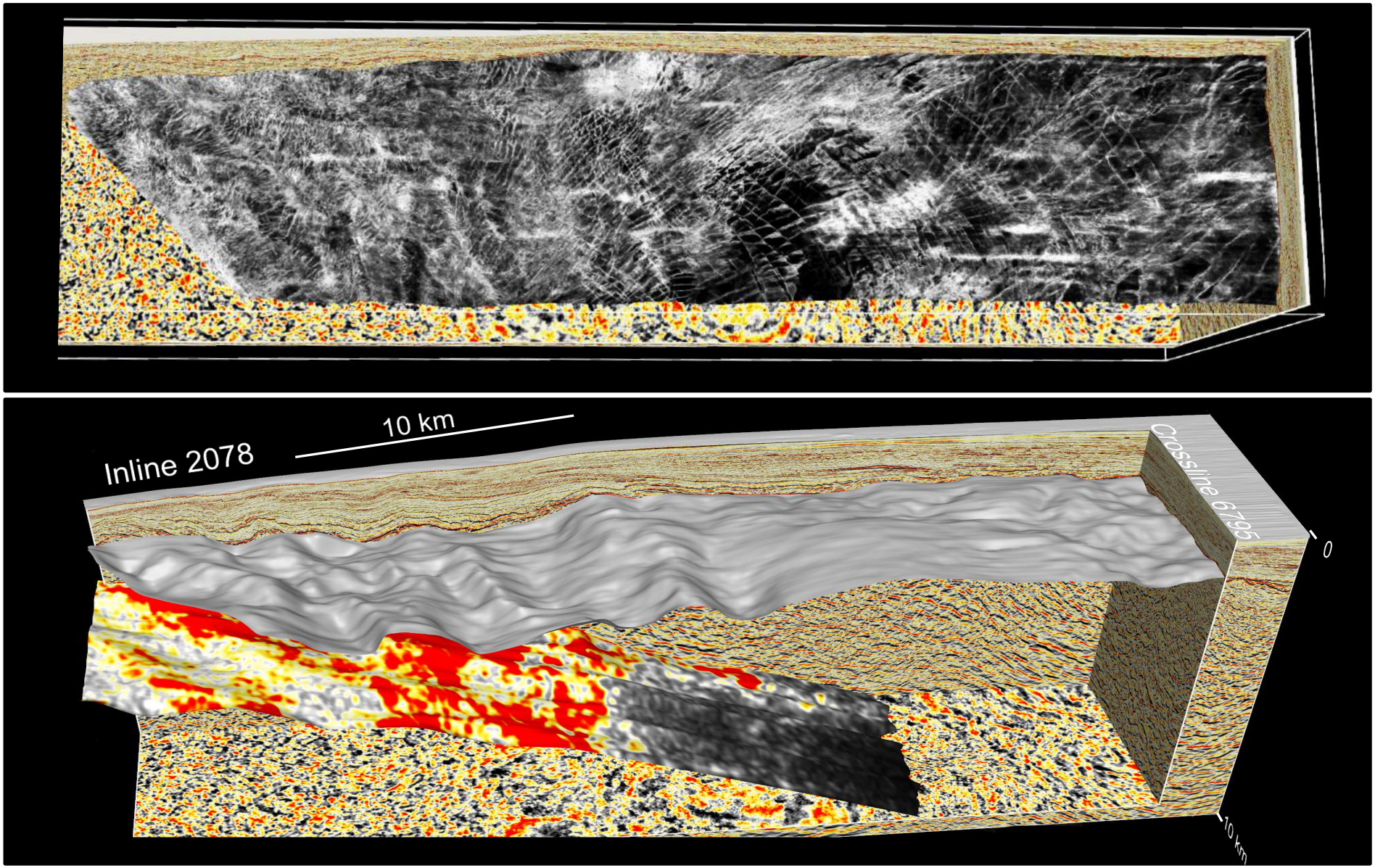
Slope cover



Note: Numerous fault syst

Faults in the slope cover

Seismic Coherence of slope cover projected on top of margin wedge



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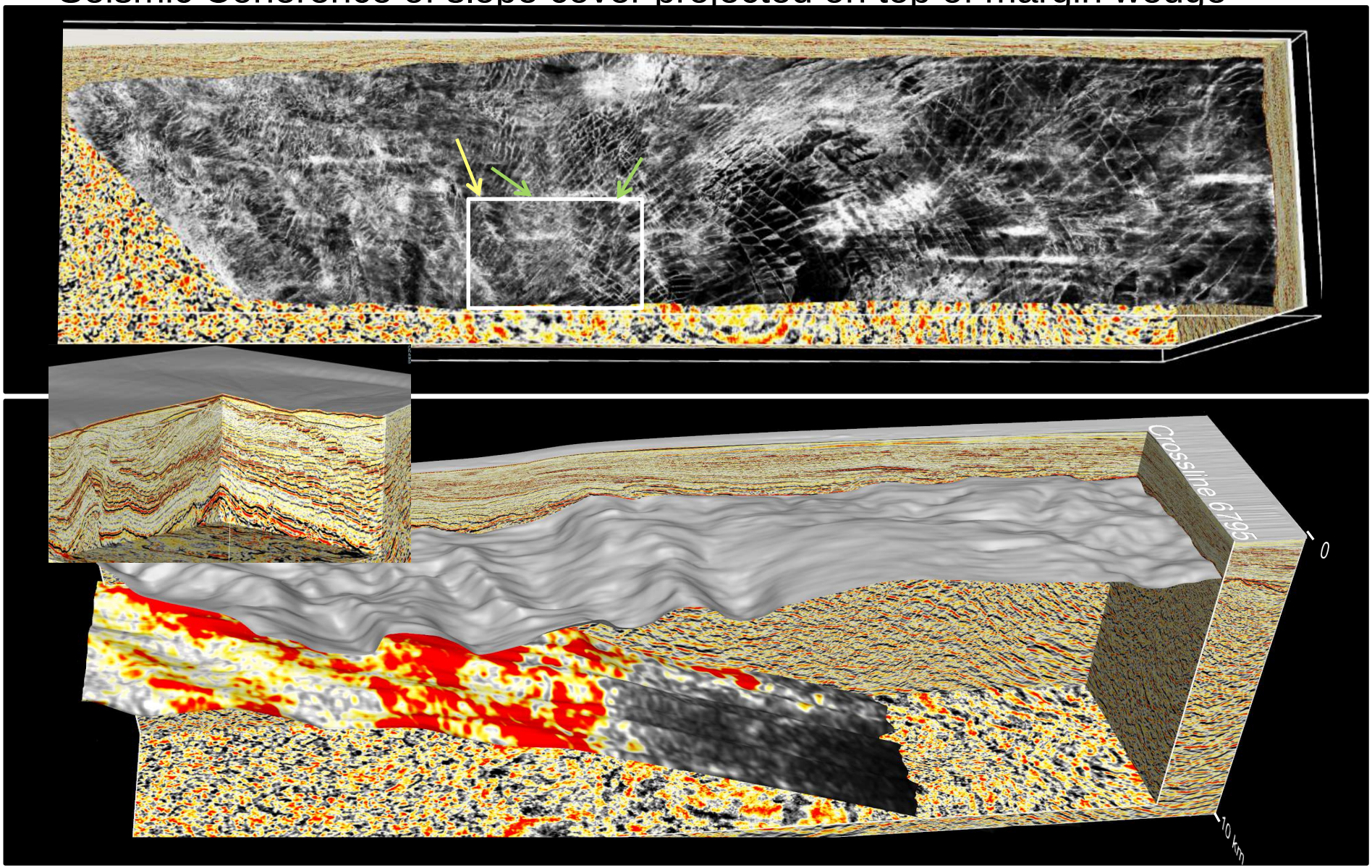

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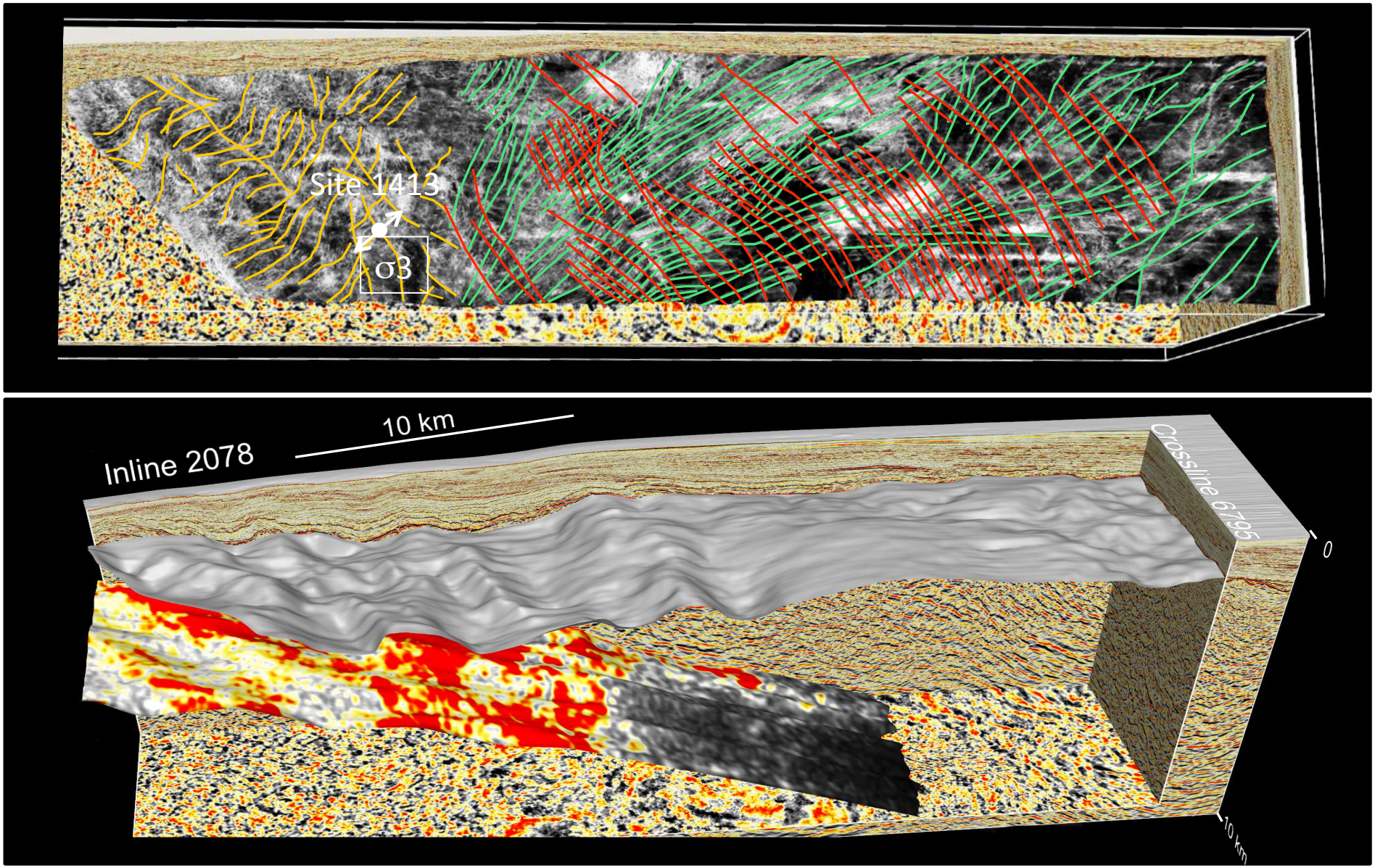
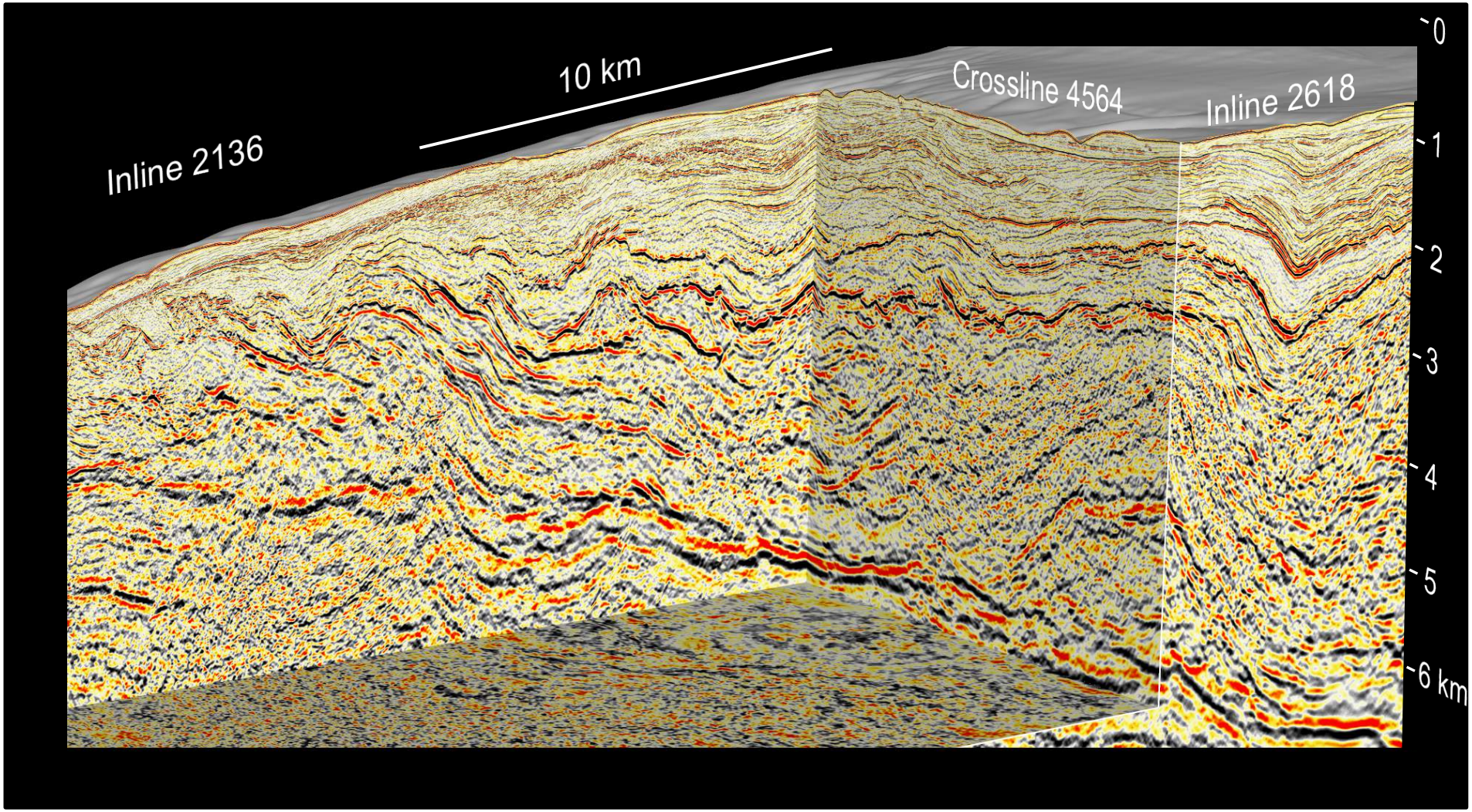
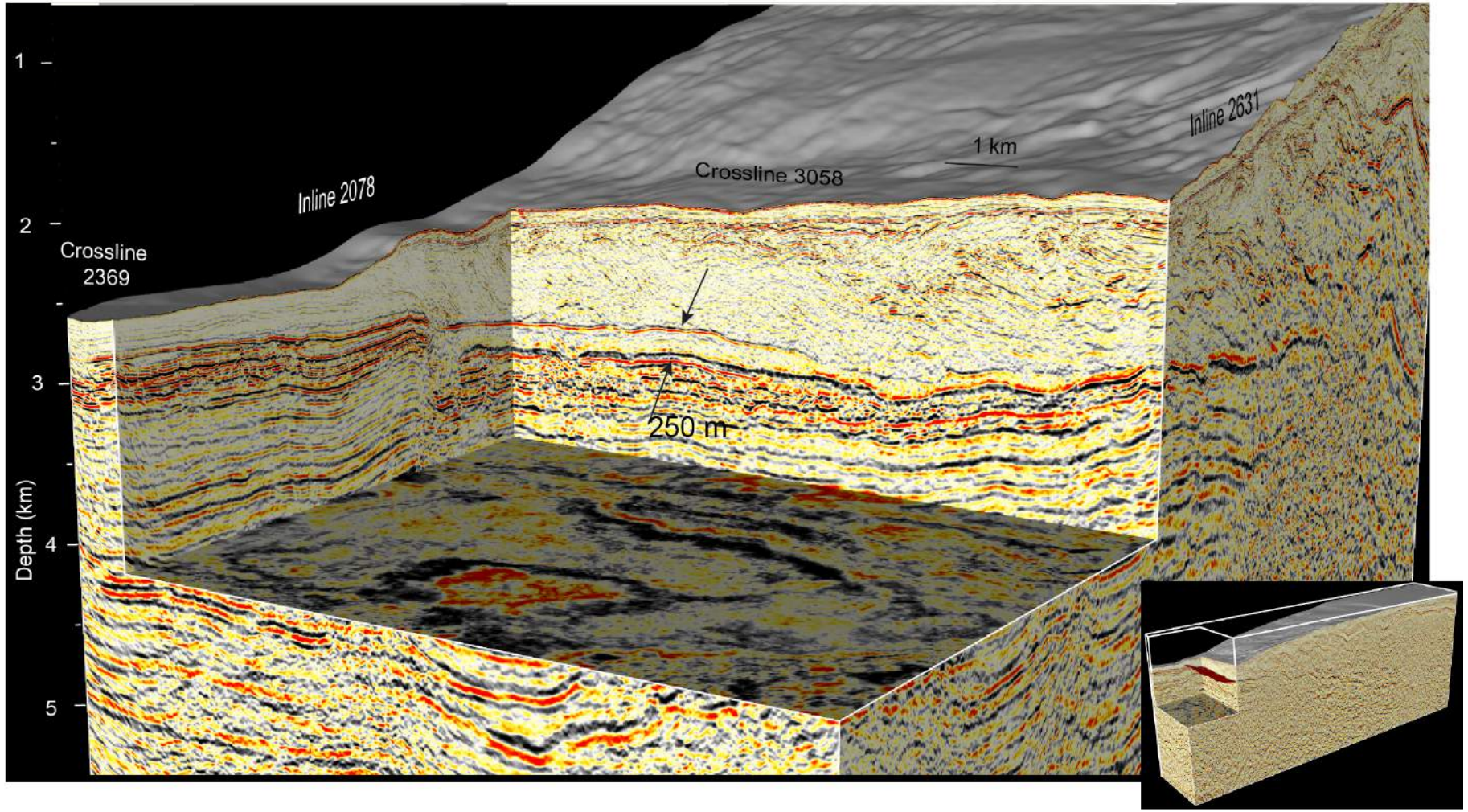


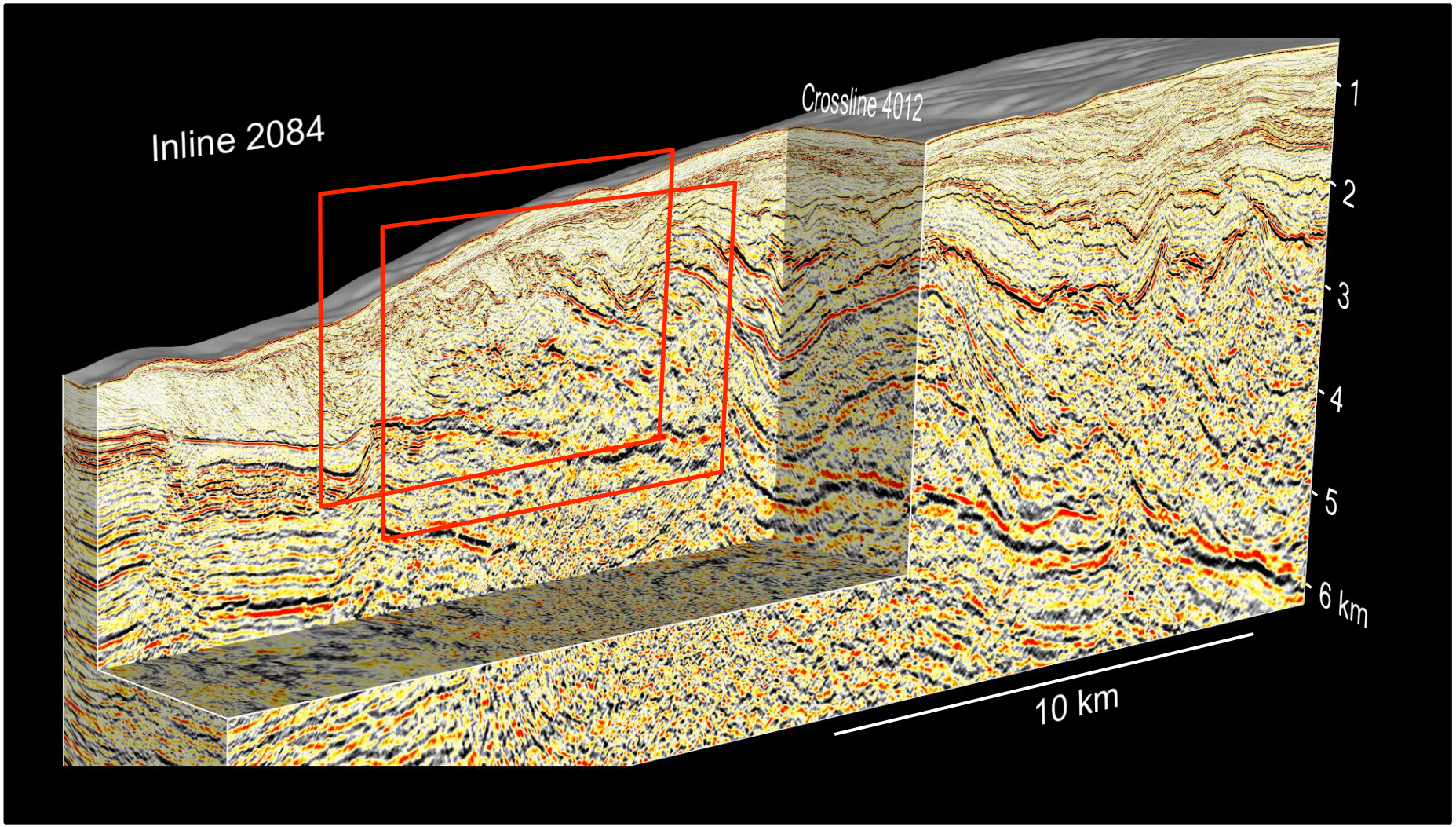
Deeper “underplating”
Layering within deeper/thicker margin wedge



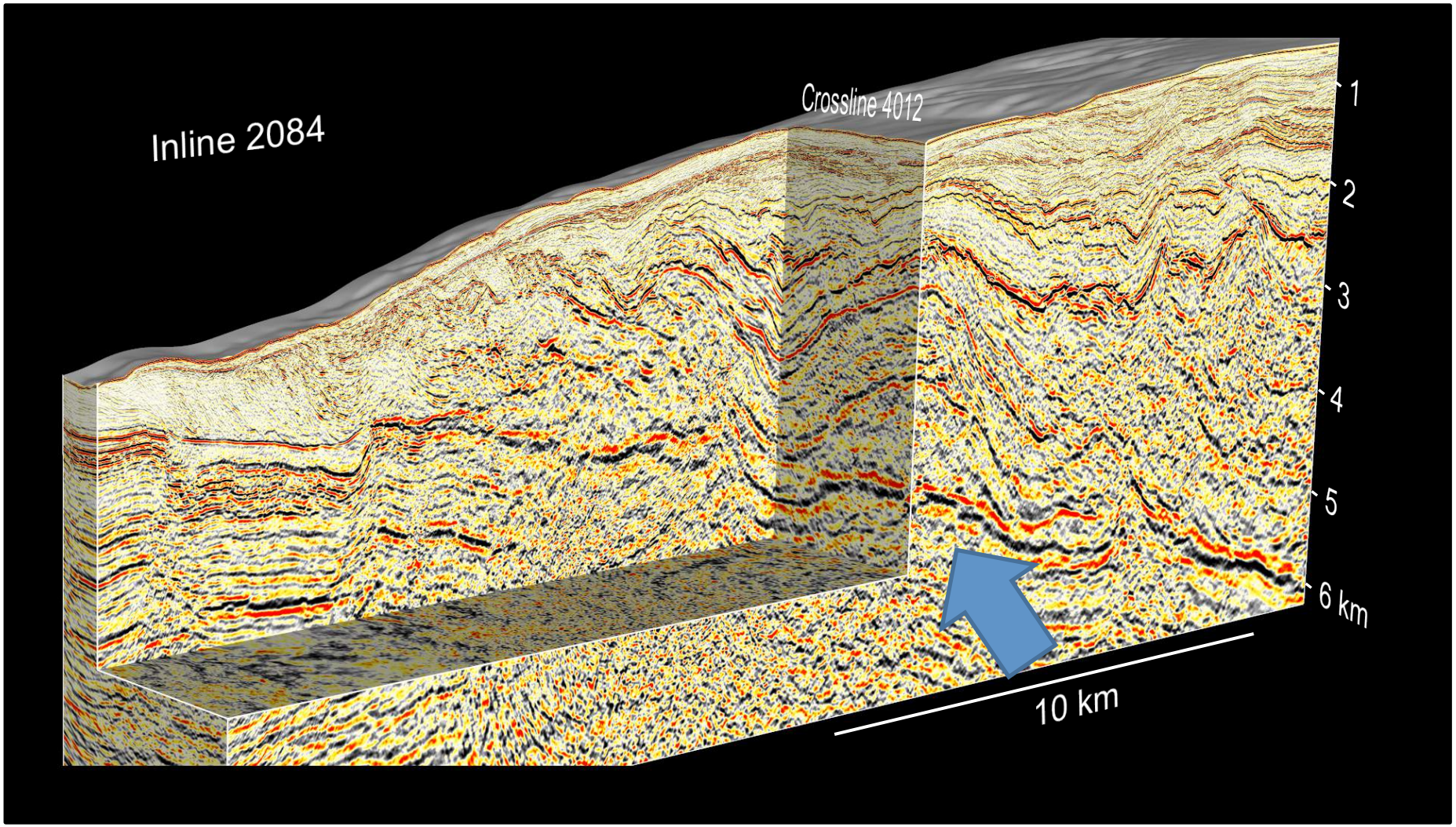
Deformation front



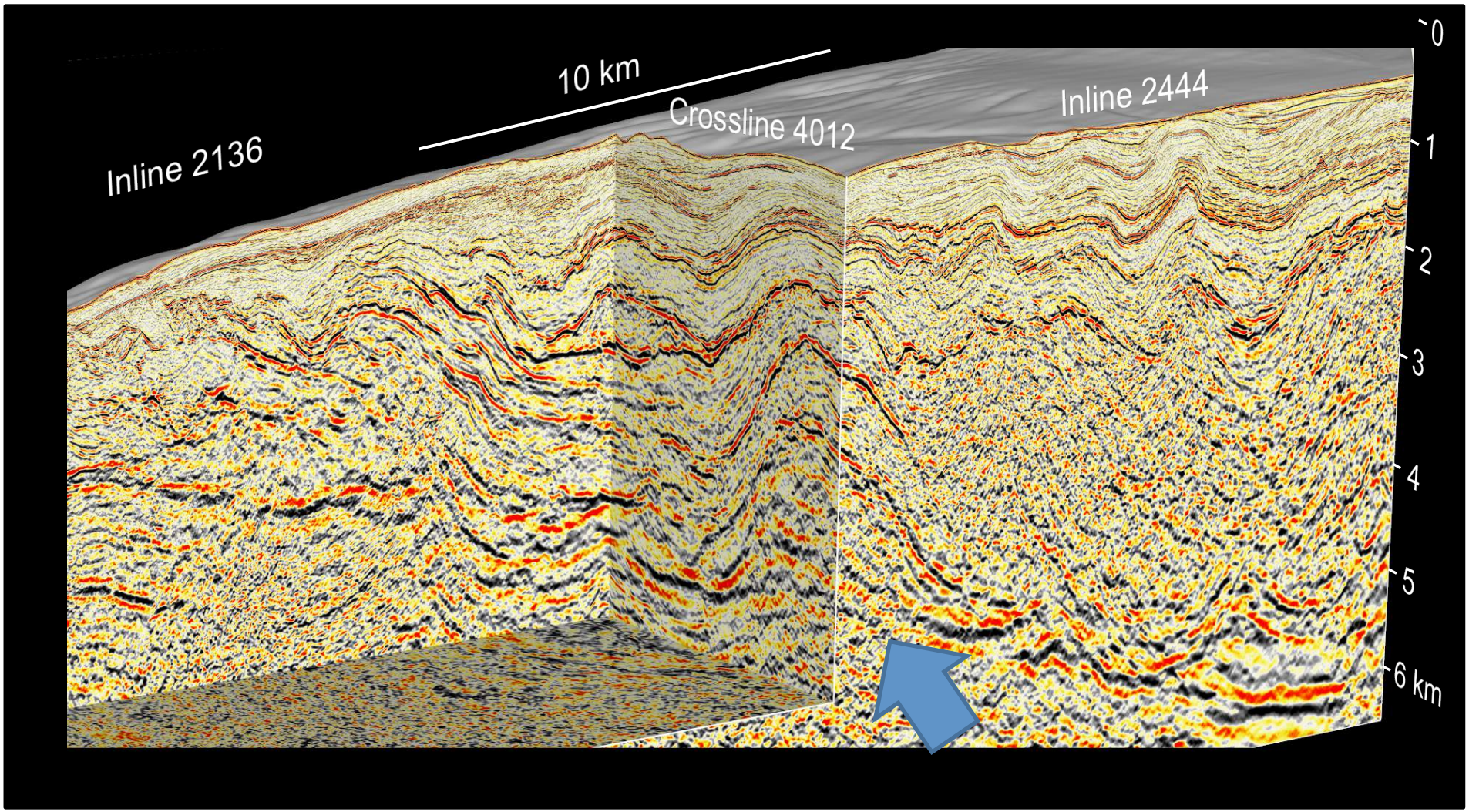
Connections to plate interface along layering



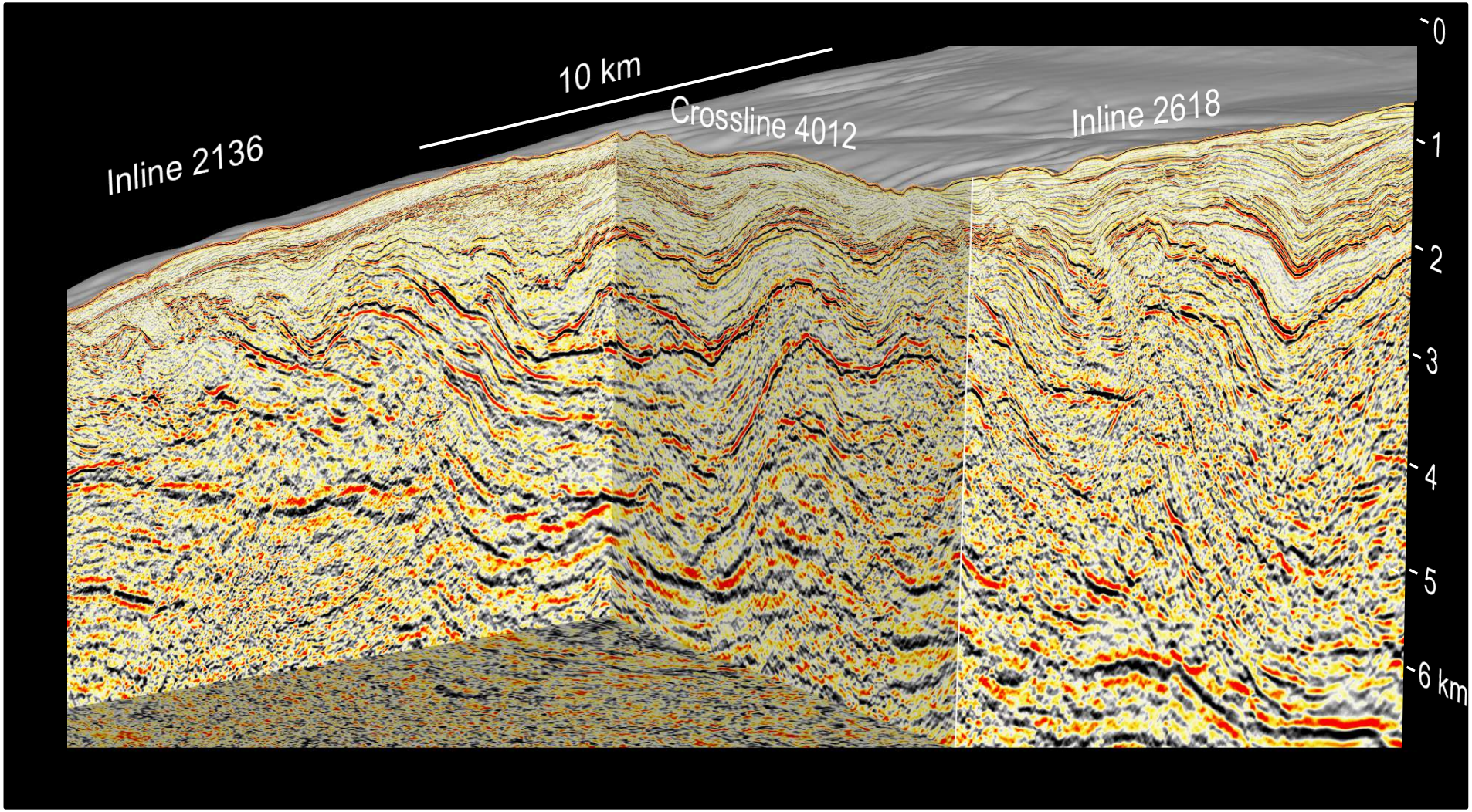
Layering within margin wedge
Faults and folds within margin wedge
Addition/removal of material forming ridges within margin wedge



Deeper example of “underplating”
Continuity of margin wedge layers and connectivity with plate interface



Continuity of layers into plate boundary Thrust fault?



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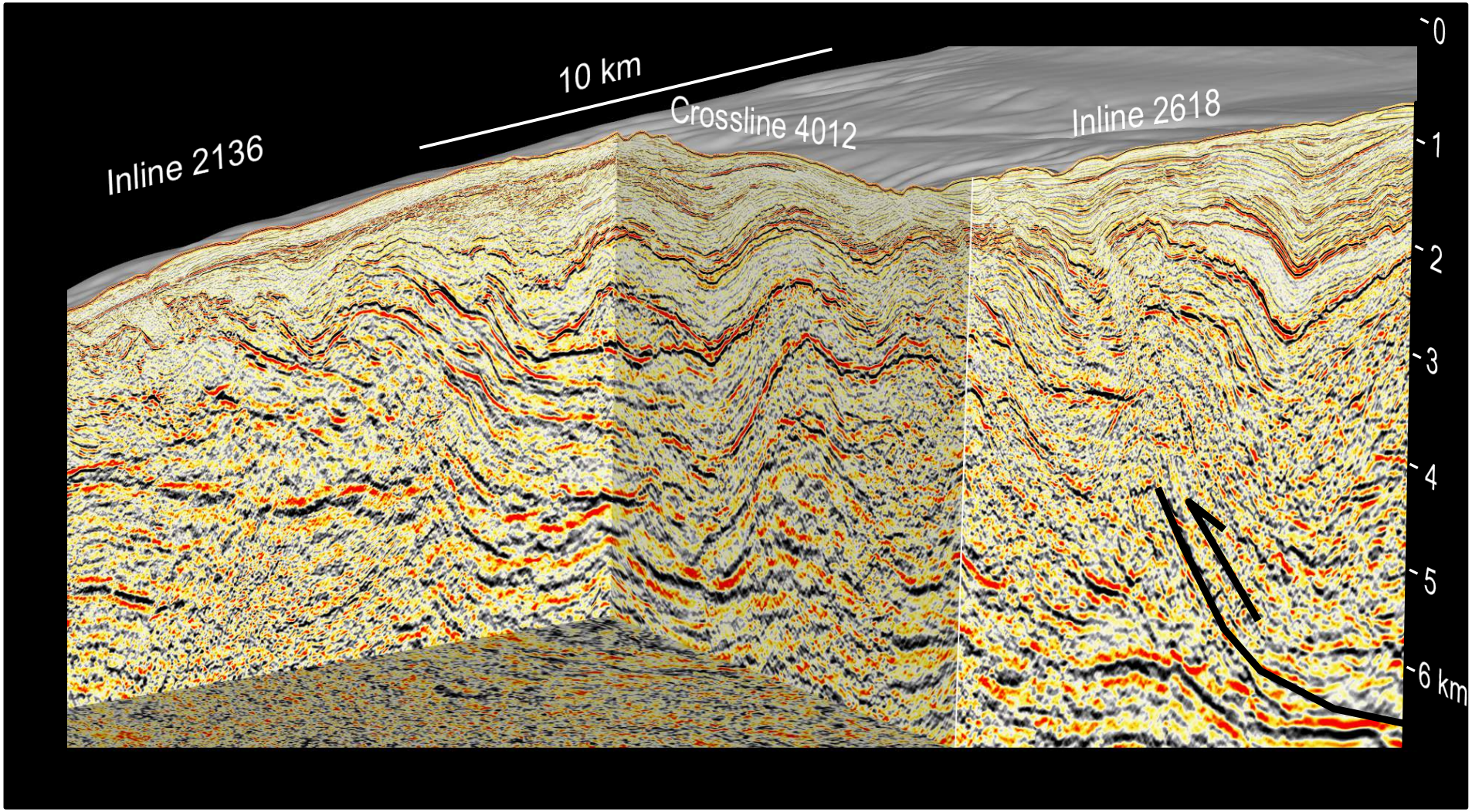
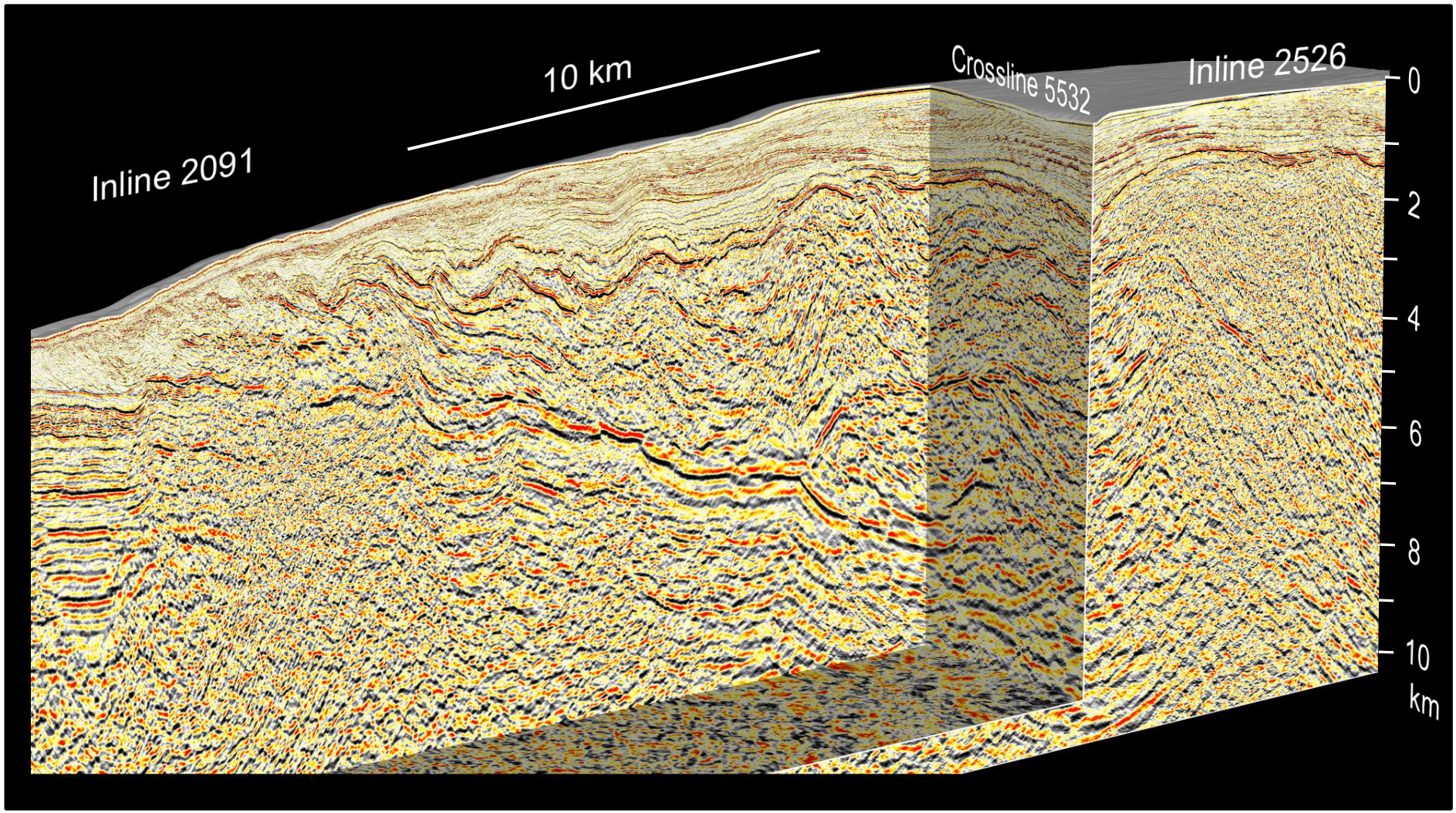
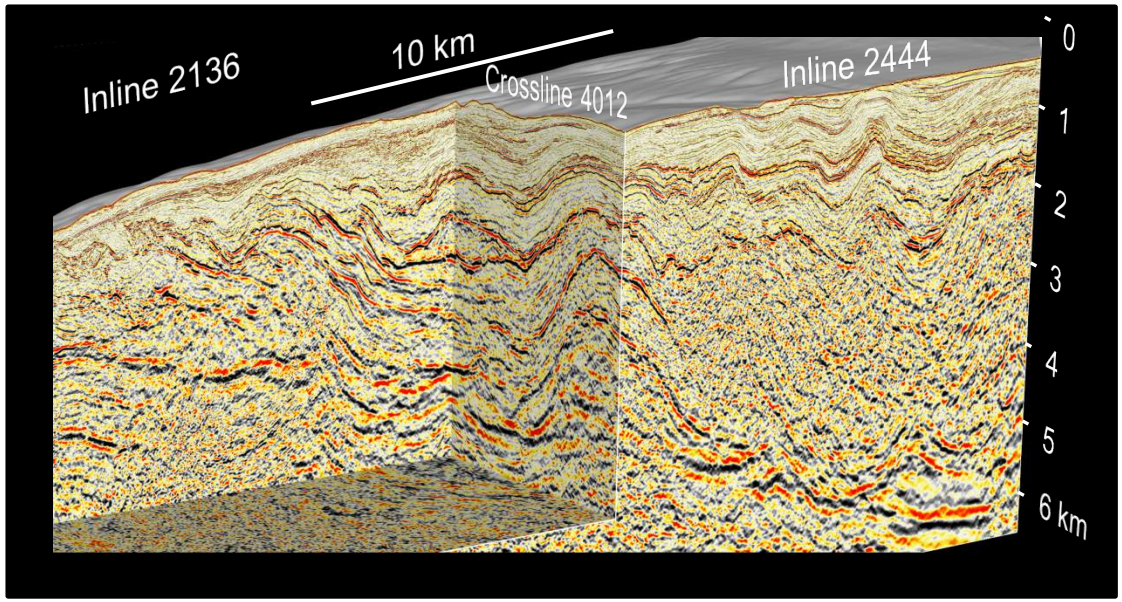


Mystery structure



Key observations of Margin Wedge Structure

- Layering (potential fluid migration pathways)
- Shortening along thrust faults (additional fluid migration pathways)
- Discordant structures forming along the base causing uplift or subsidence
- Extensive network of normal faults in slope cover (conducive to fluid migration)



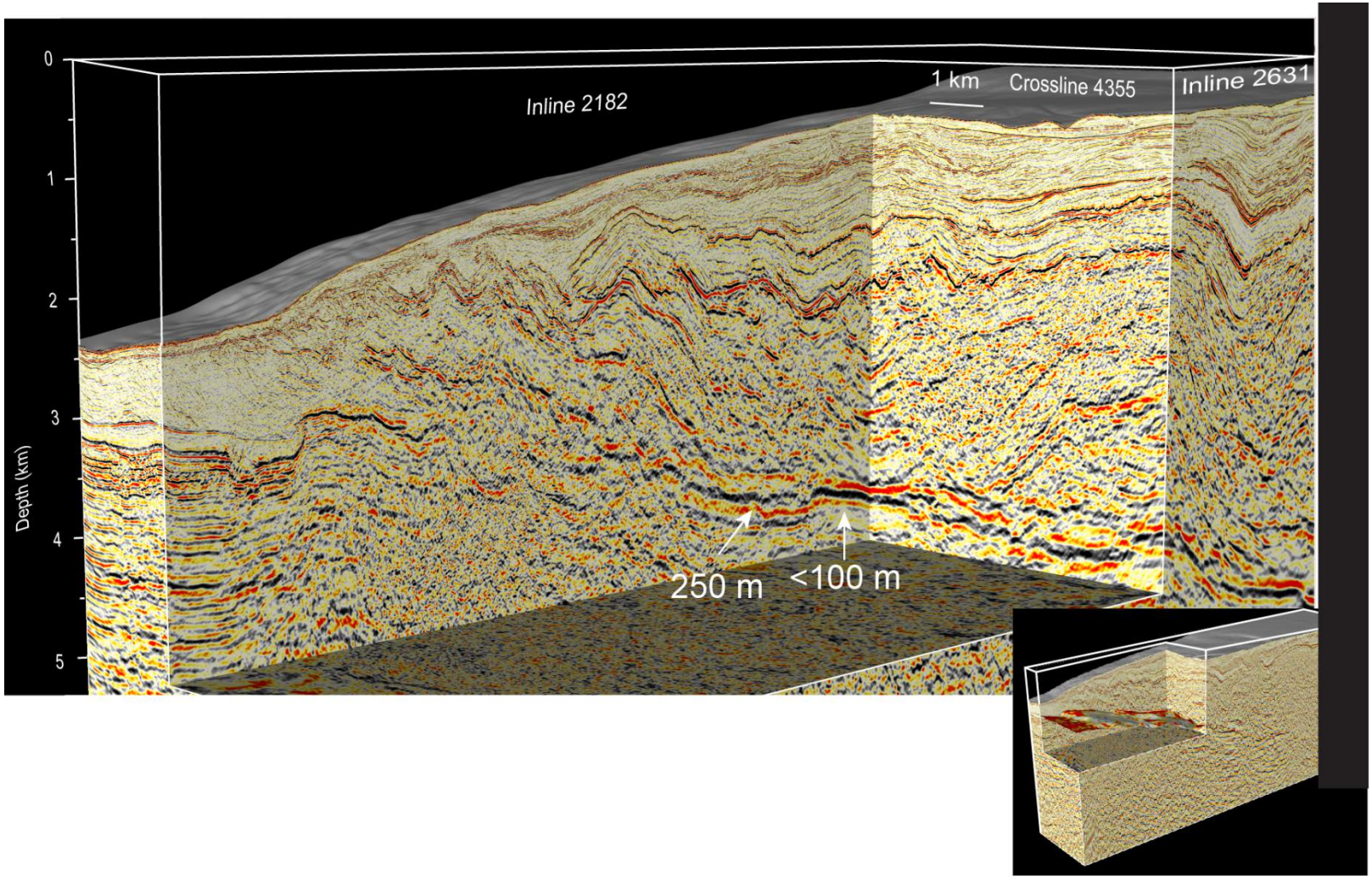
Fluids

- Sources
- Migration pathways

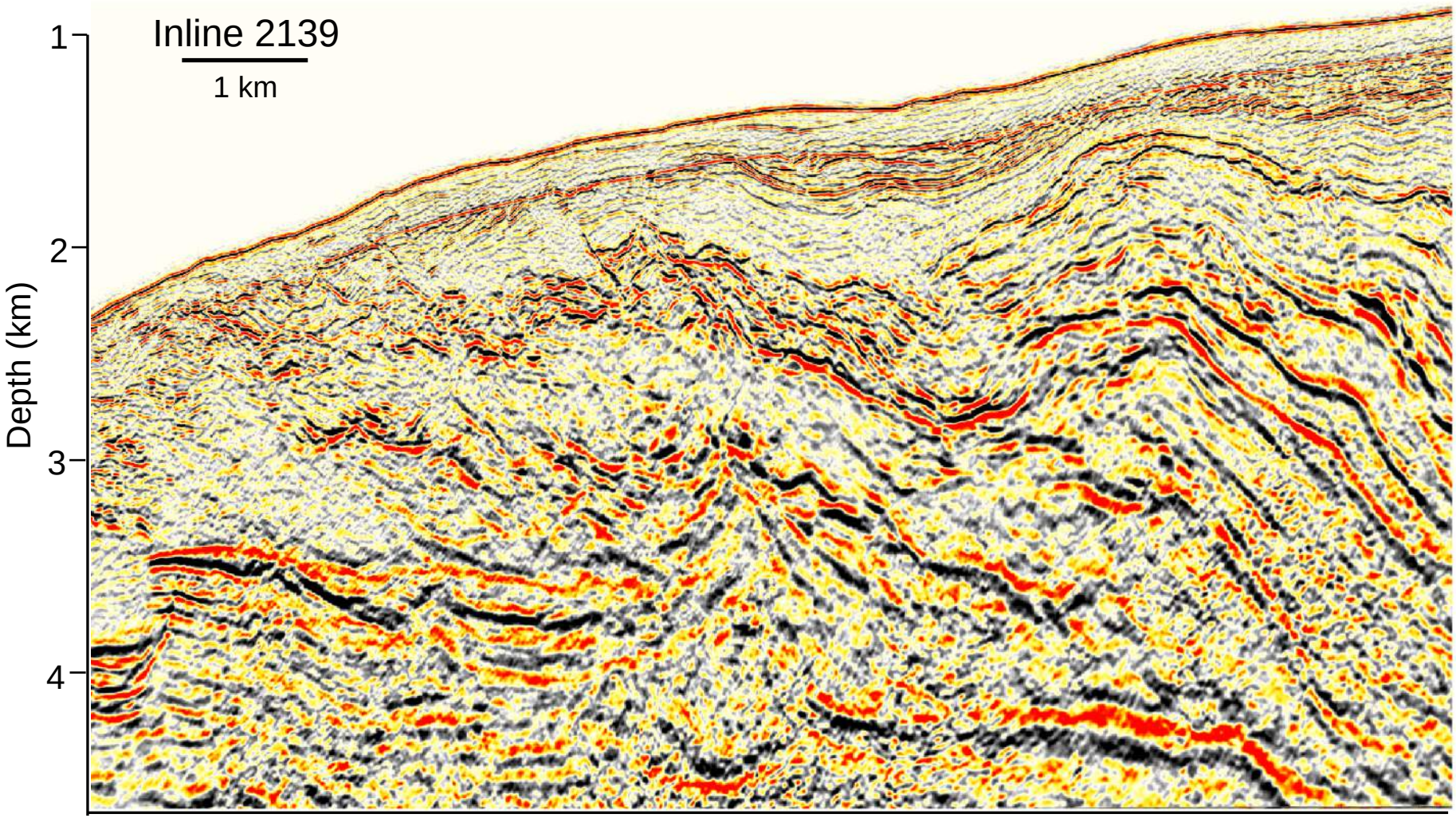
Downdip

Sediment Thicker within graben, but less than ~ 250 m

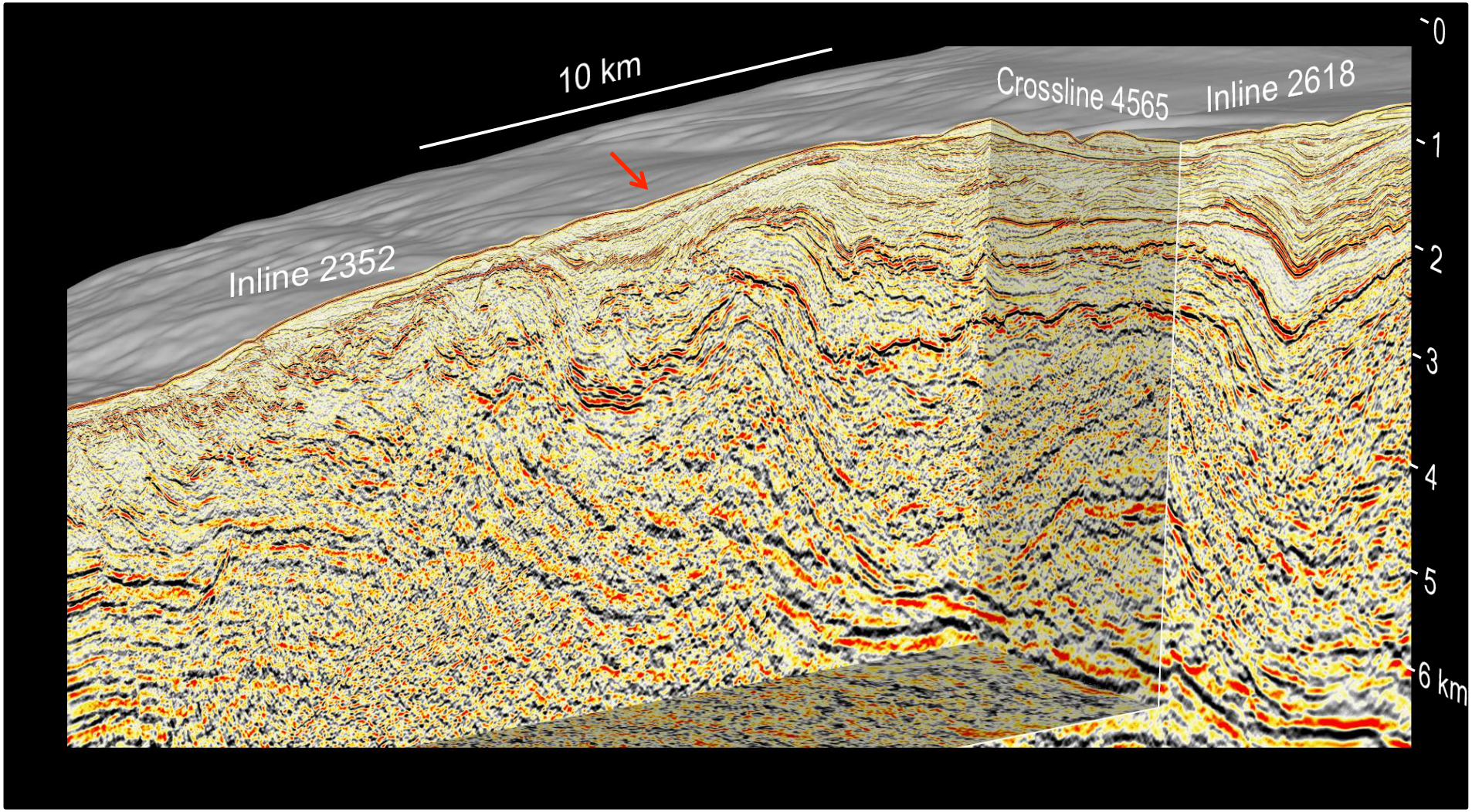
Amplitude lower in graben



Thrusts are a result of shortening within margin wedge?



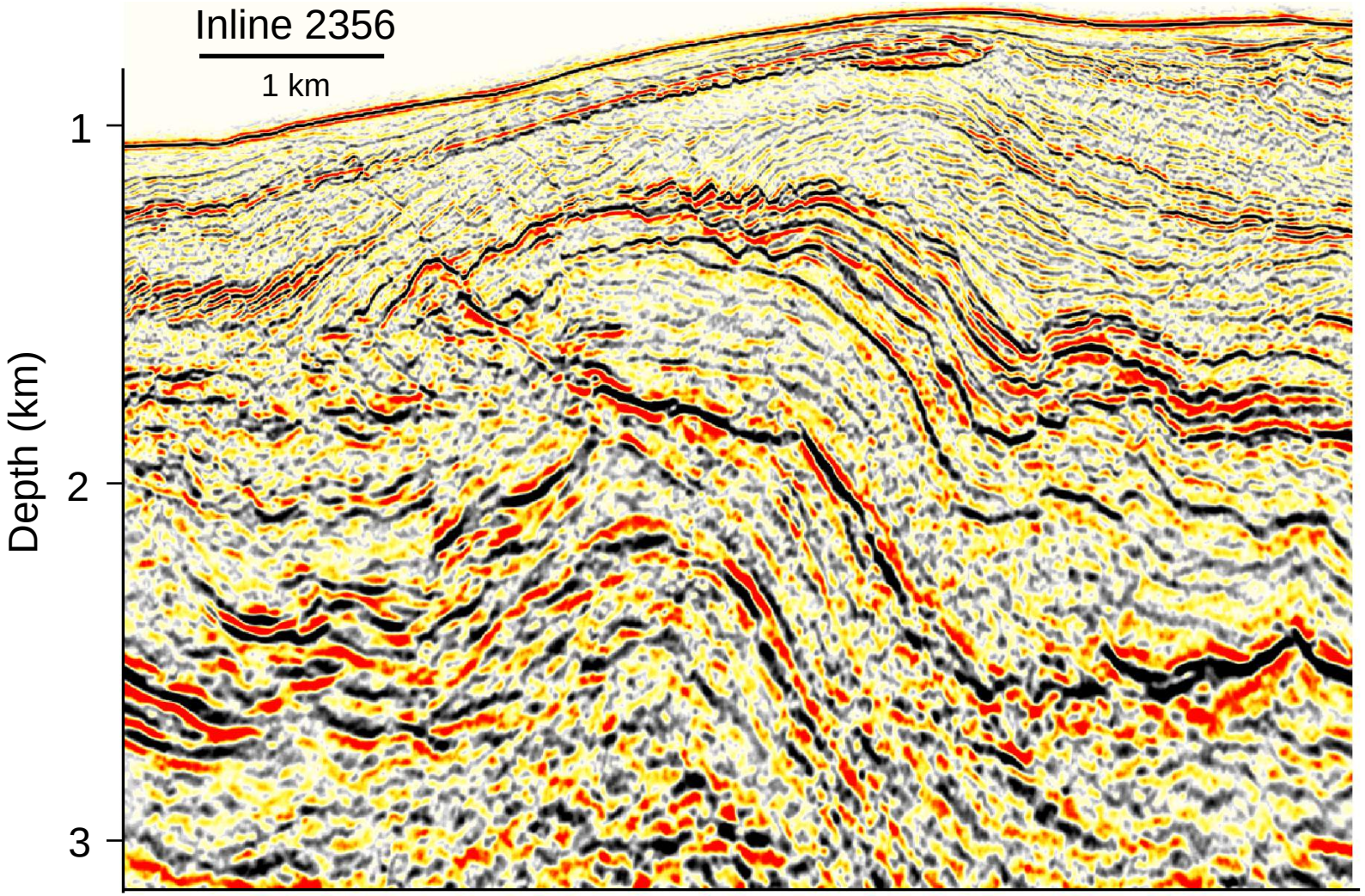
Vent system?
Deep connectivity?



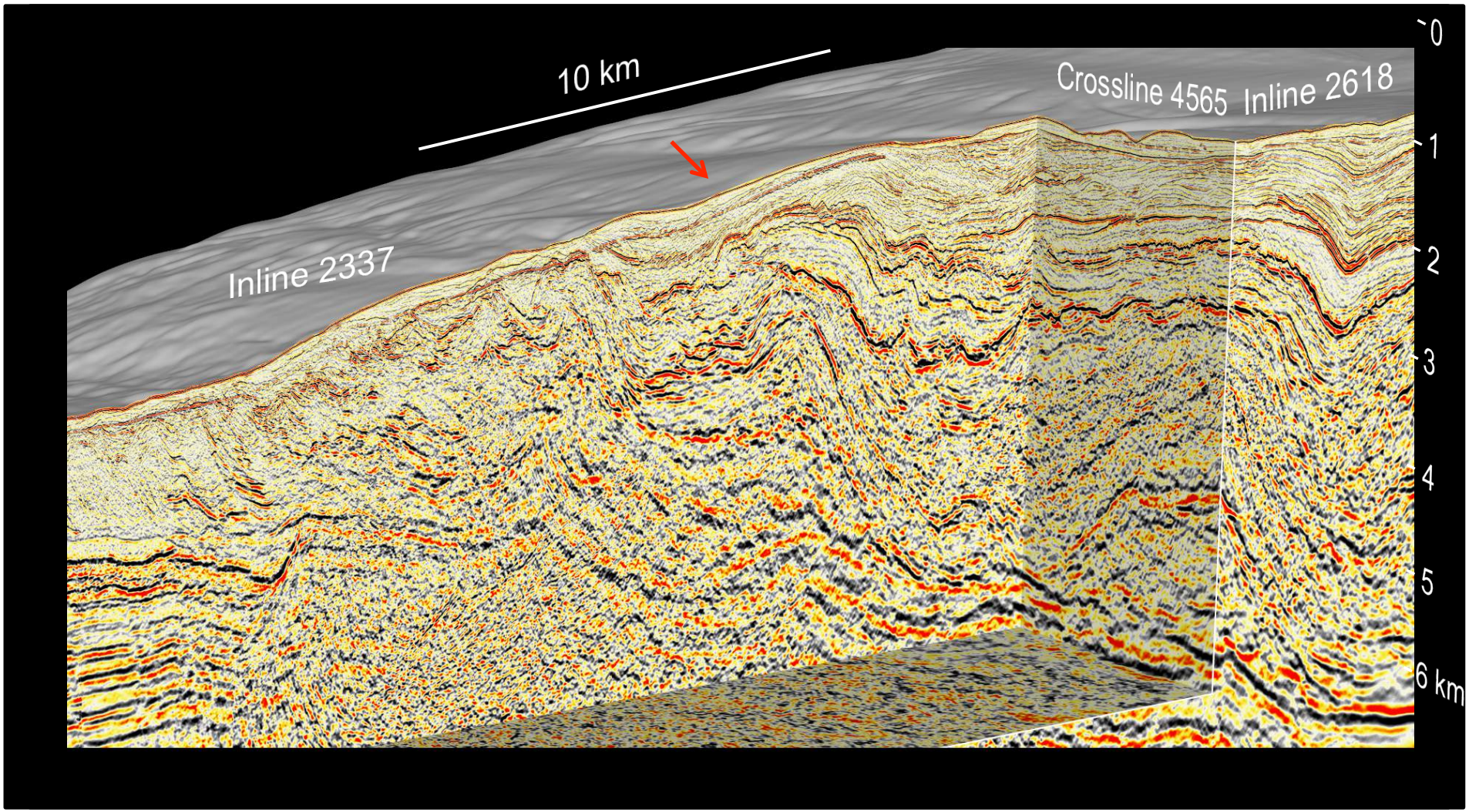
Vent systems enlarged

Note reflections from fault planes, cross-cutting strata

Flat spot, BSR

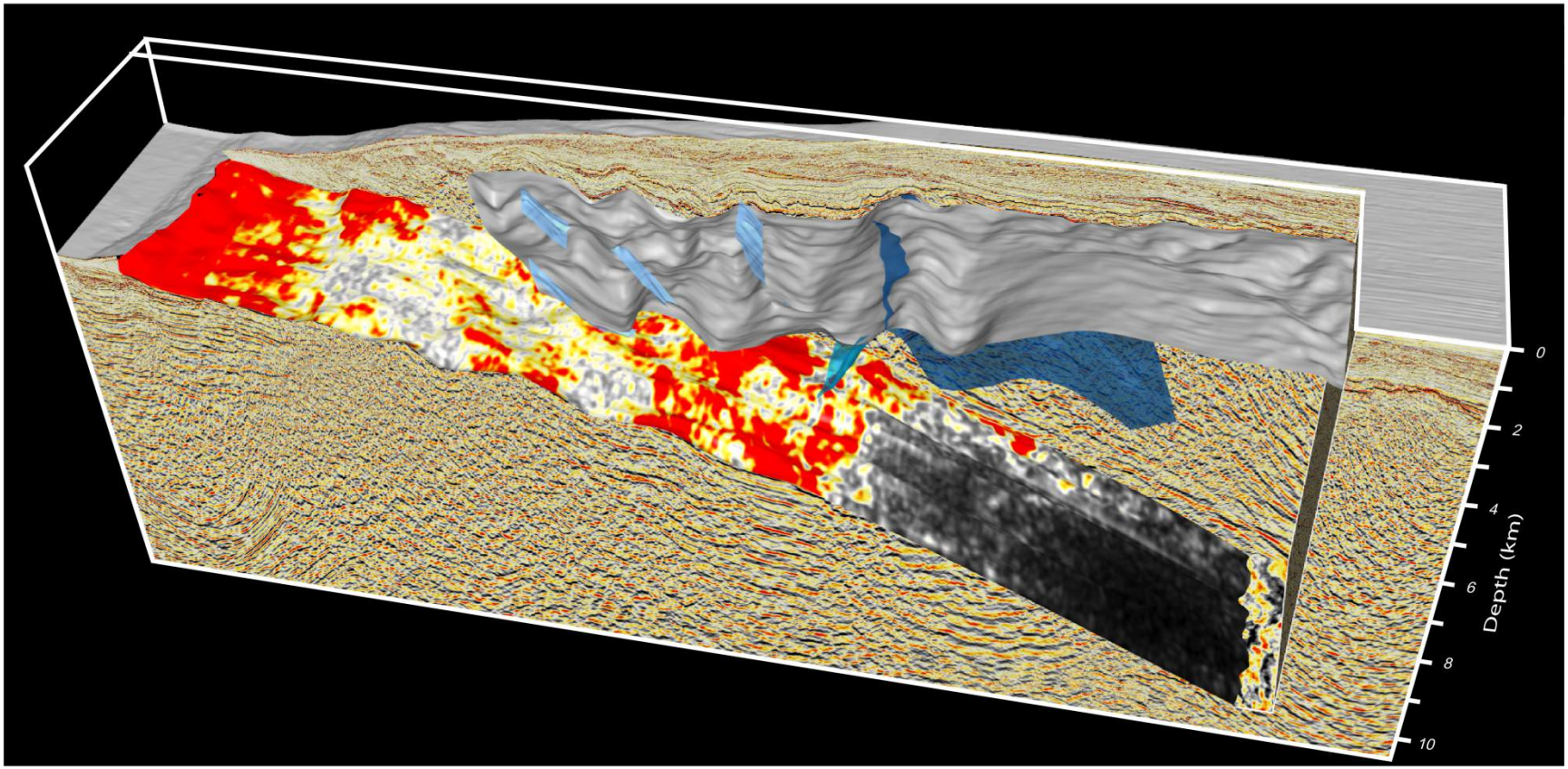


Deep connectivity

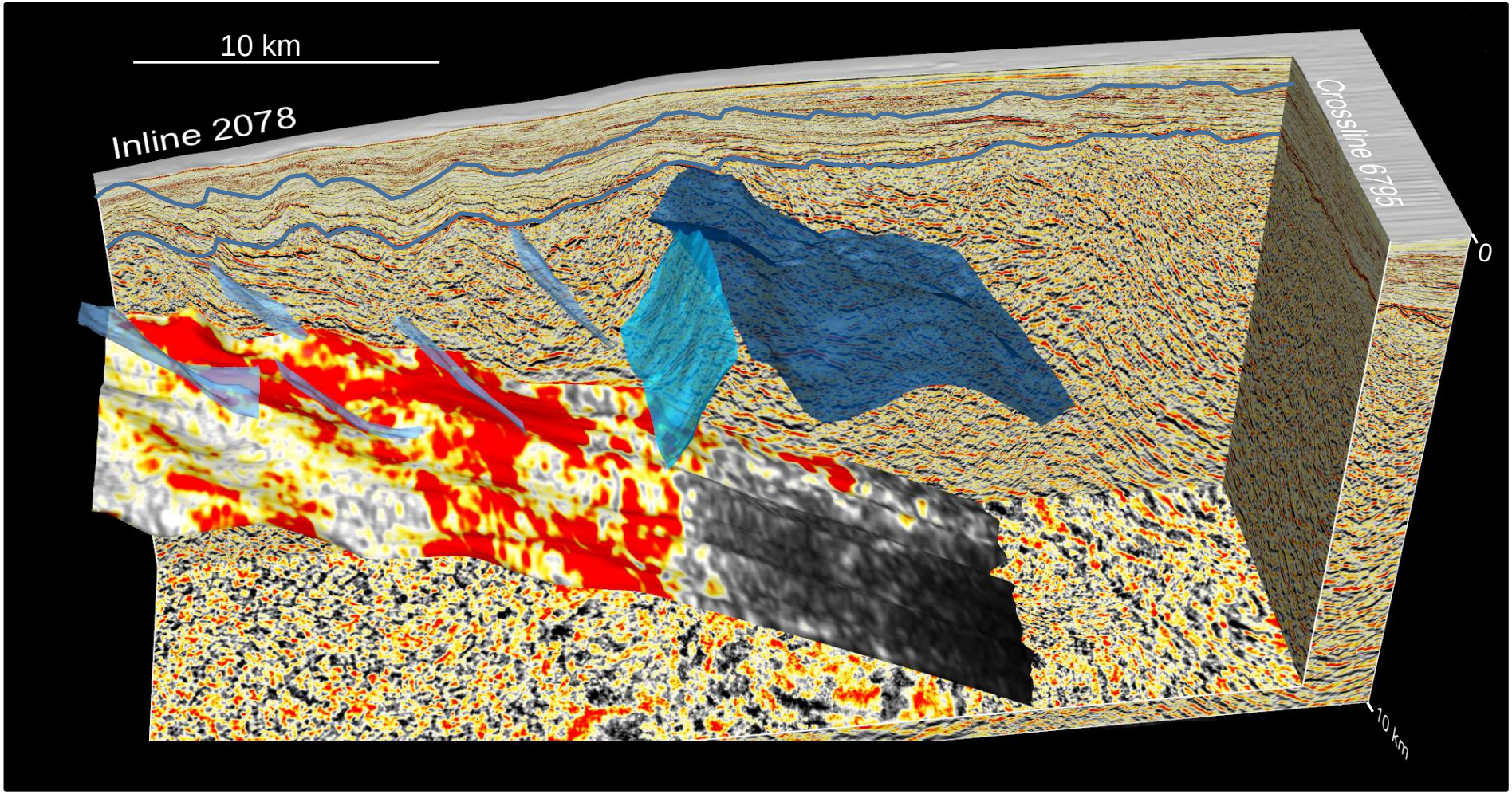


Three primary margin wedge fault systems

defined by different strikes and dips

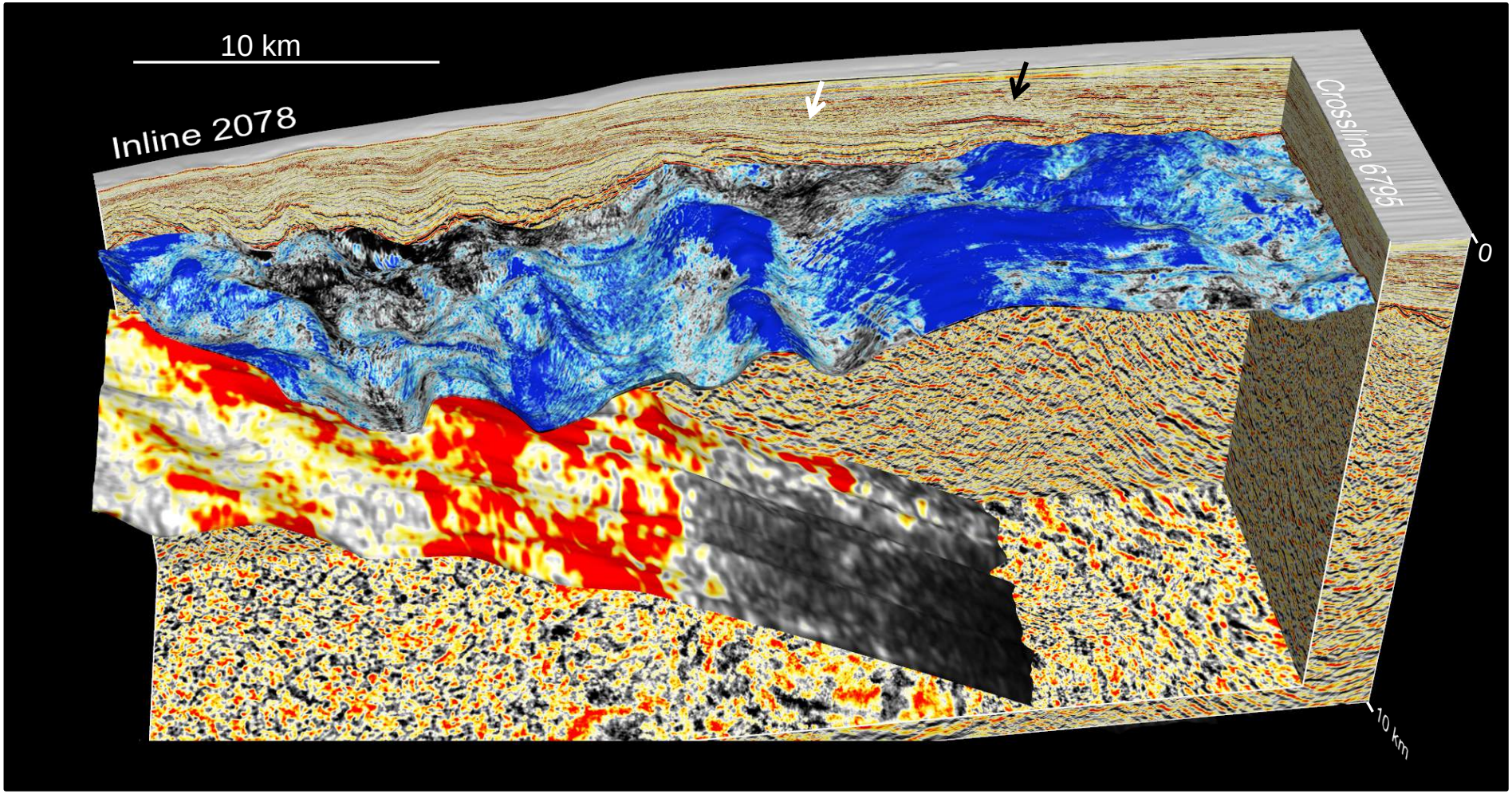


RMS amplitude with slope cover

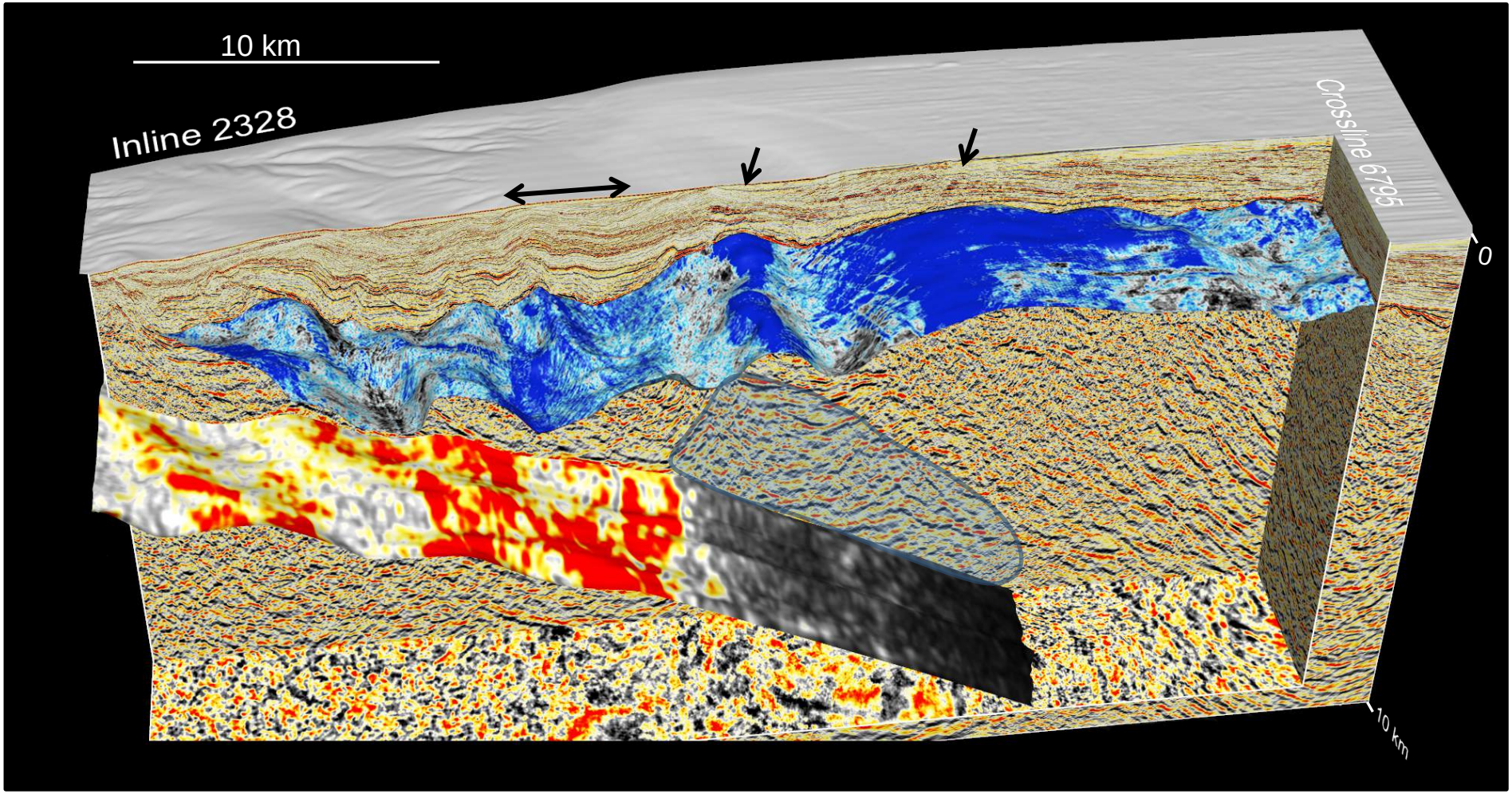


Fluid migration within slope cover

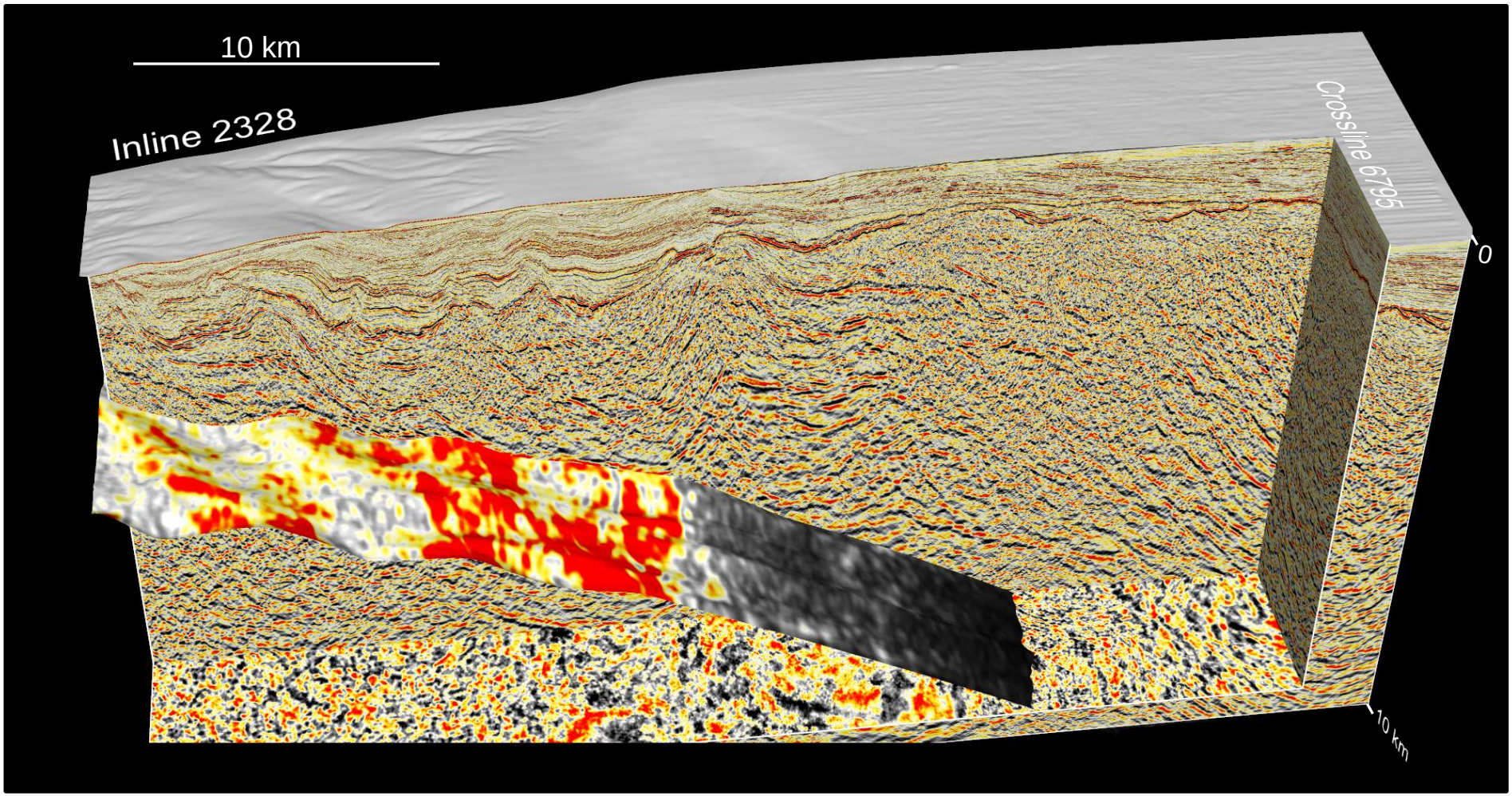
High RMS amplitude = recent fluid/gas migration from margin wedge
Low amplitudes and light colors vs. high amplitude and dark colors
Inverse correlation between fluid flow and plate-boundary amplitude



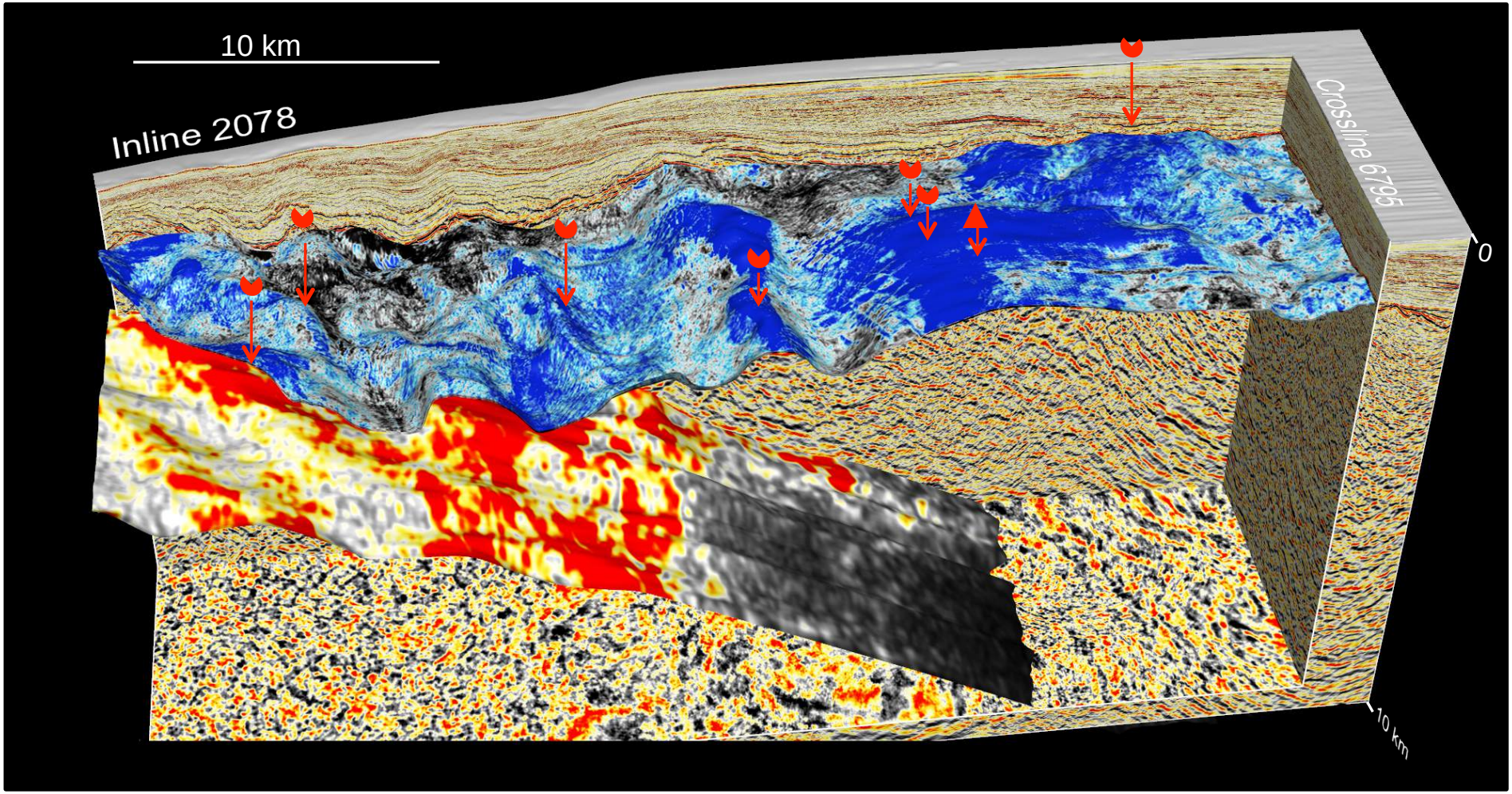
Middle swath of 3D volume

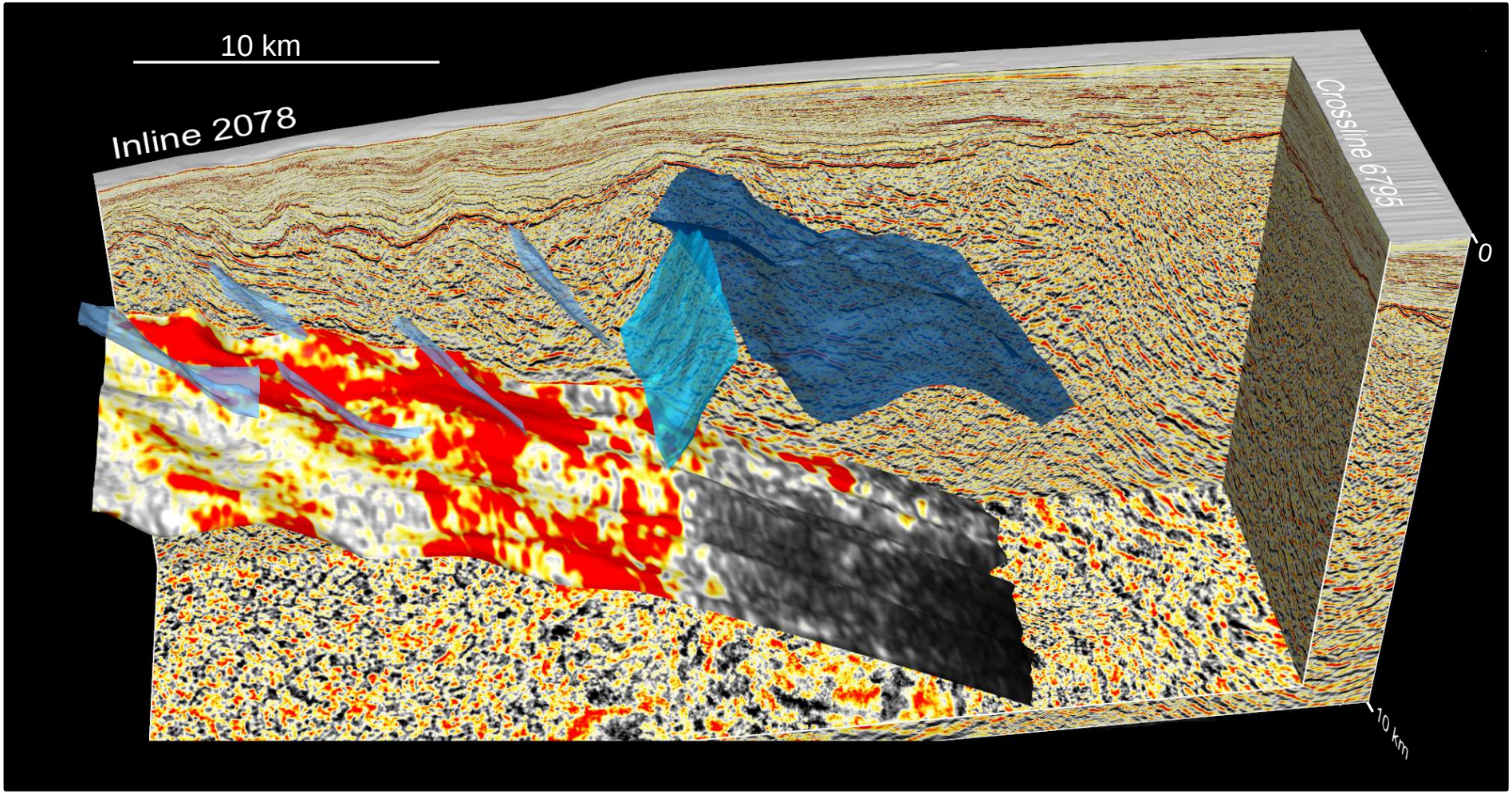


Underneath top of margin wedge
Note

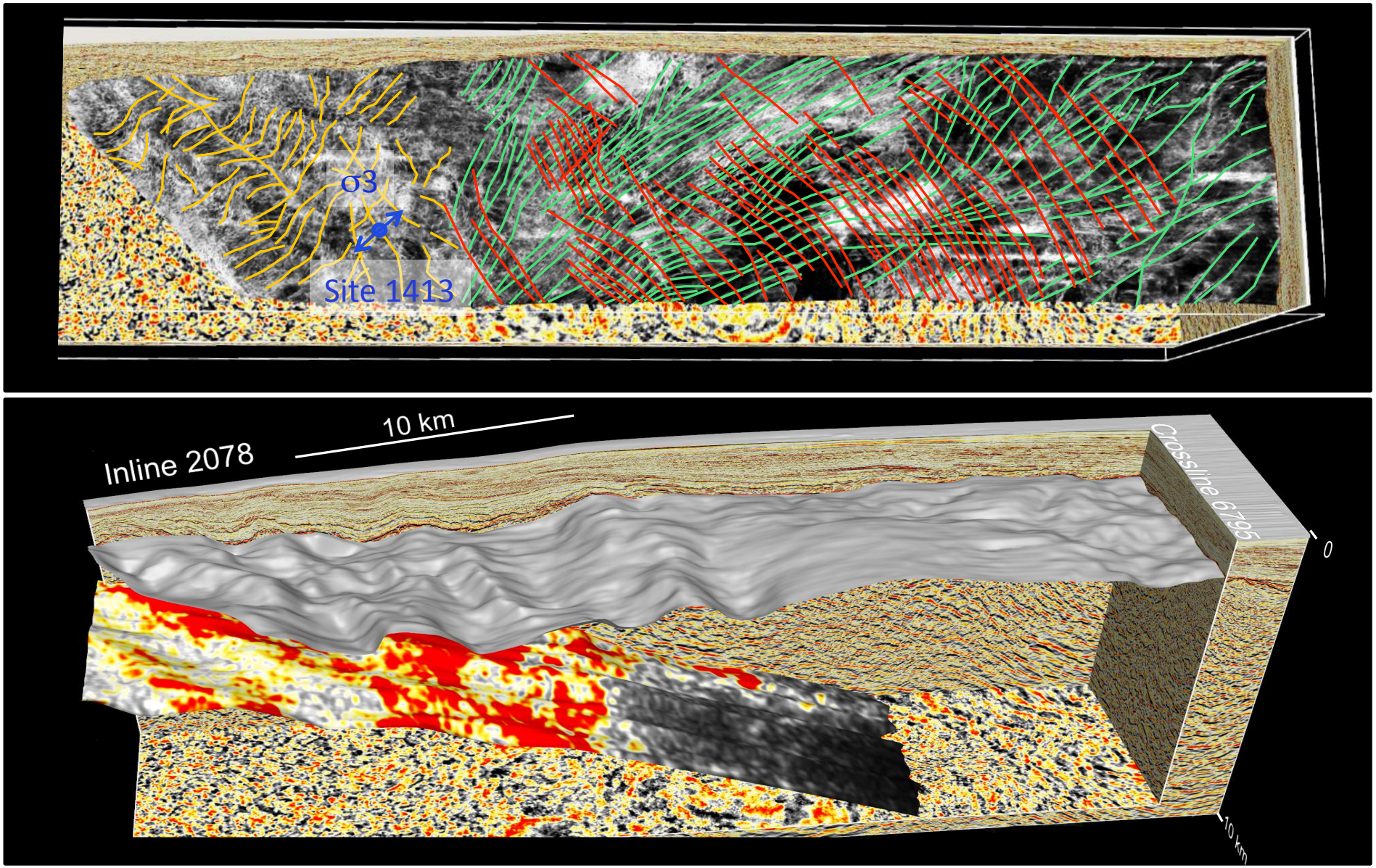


Vent/pockmark locations relative to slope cover RMS amplitude



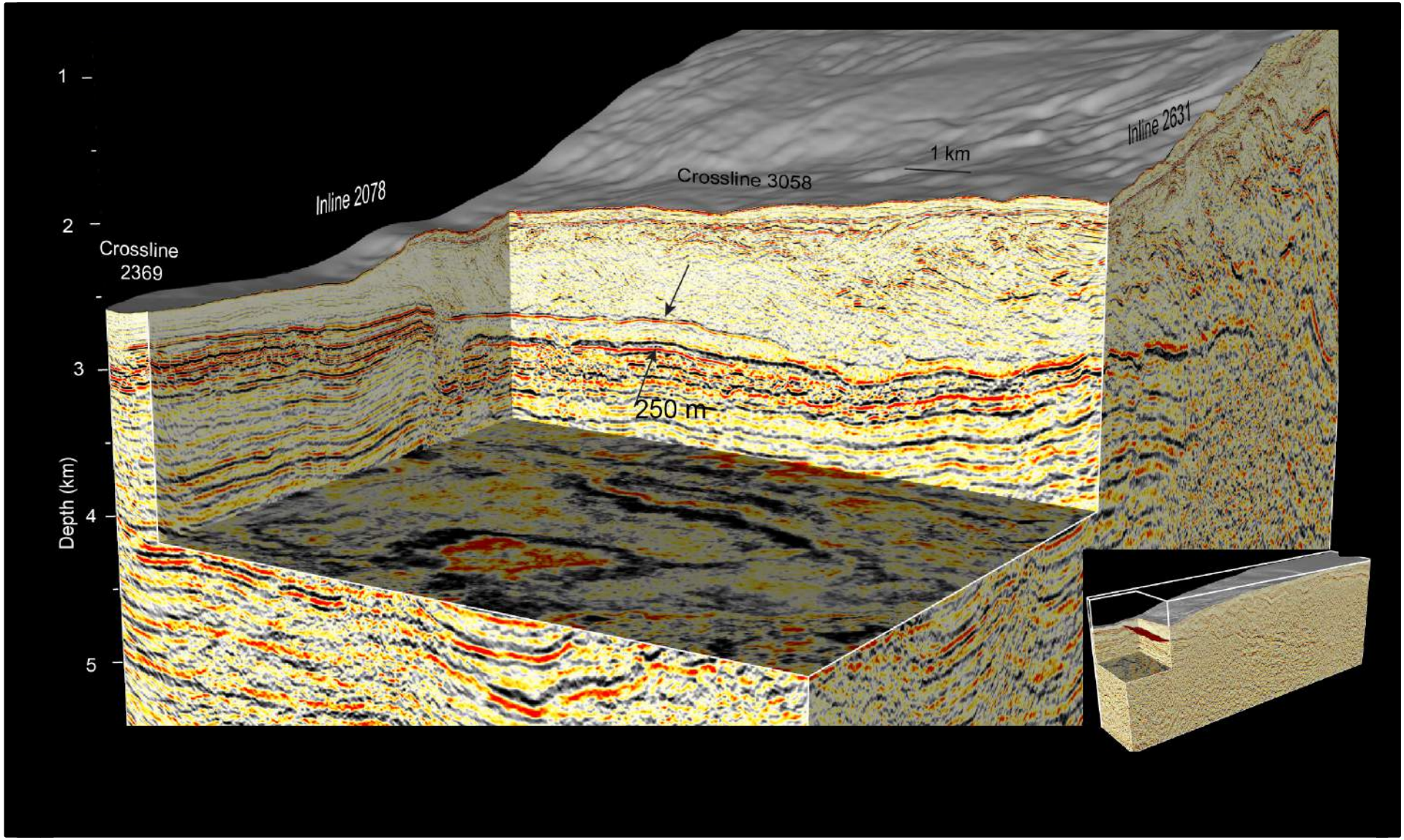

10 km
Inline 2078
Crossline 6795
0
10 km

Fault patterns in the slope cover



Deformation front (fluid sources)

0 – 250 m of underthrust sediment



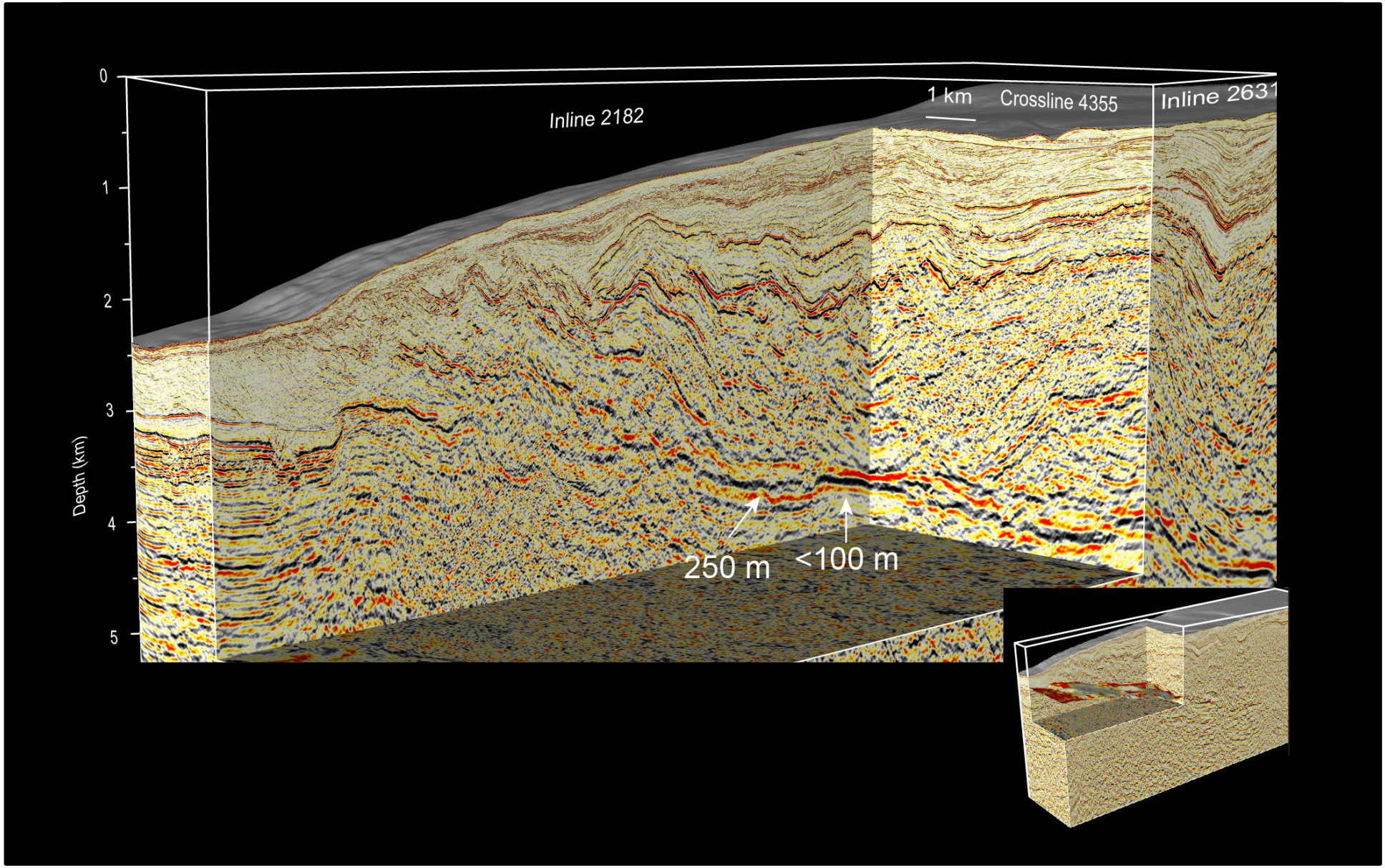
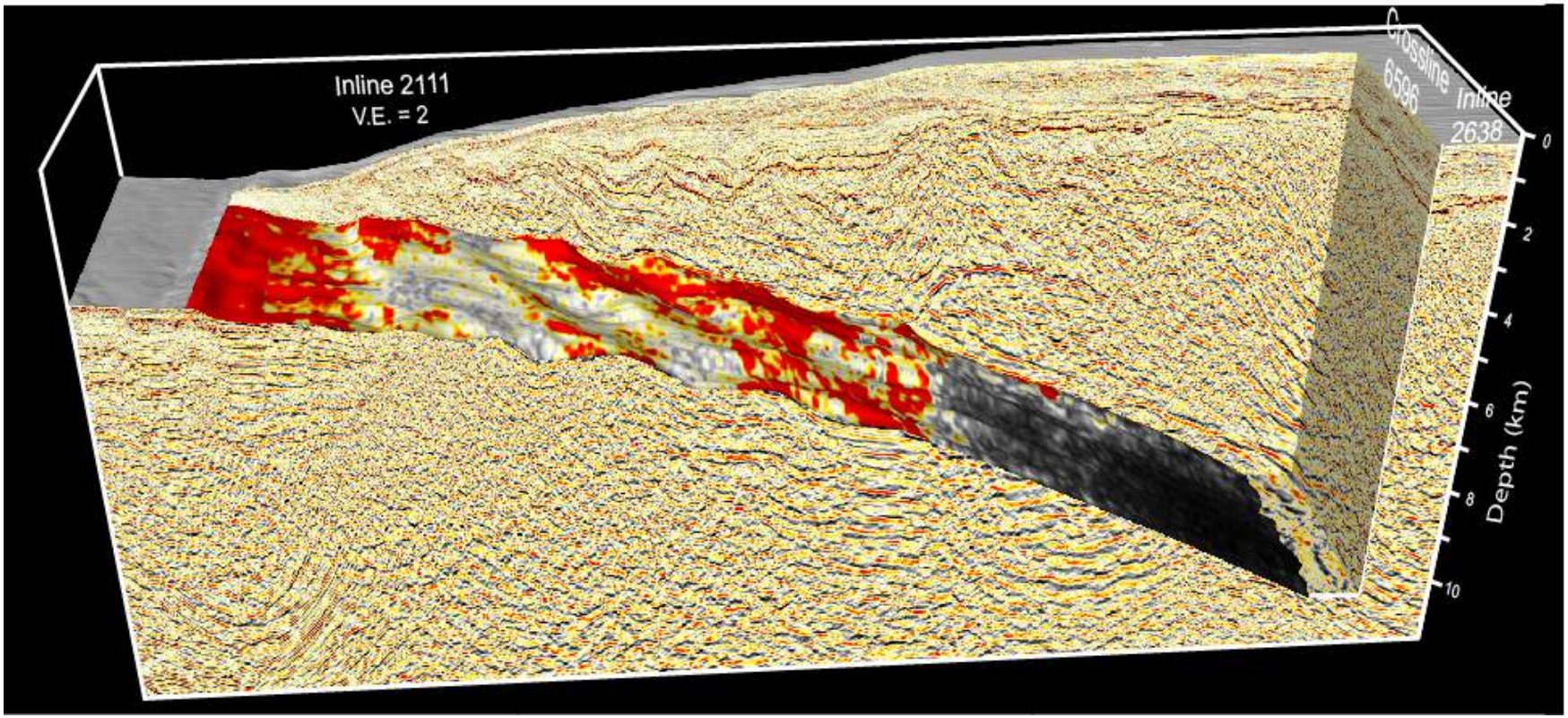
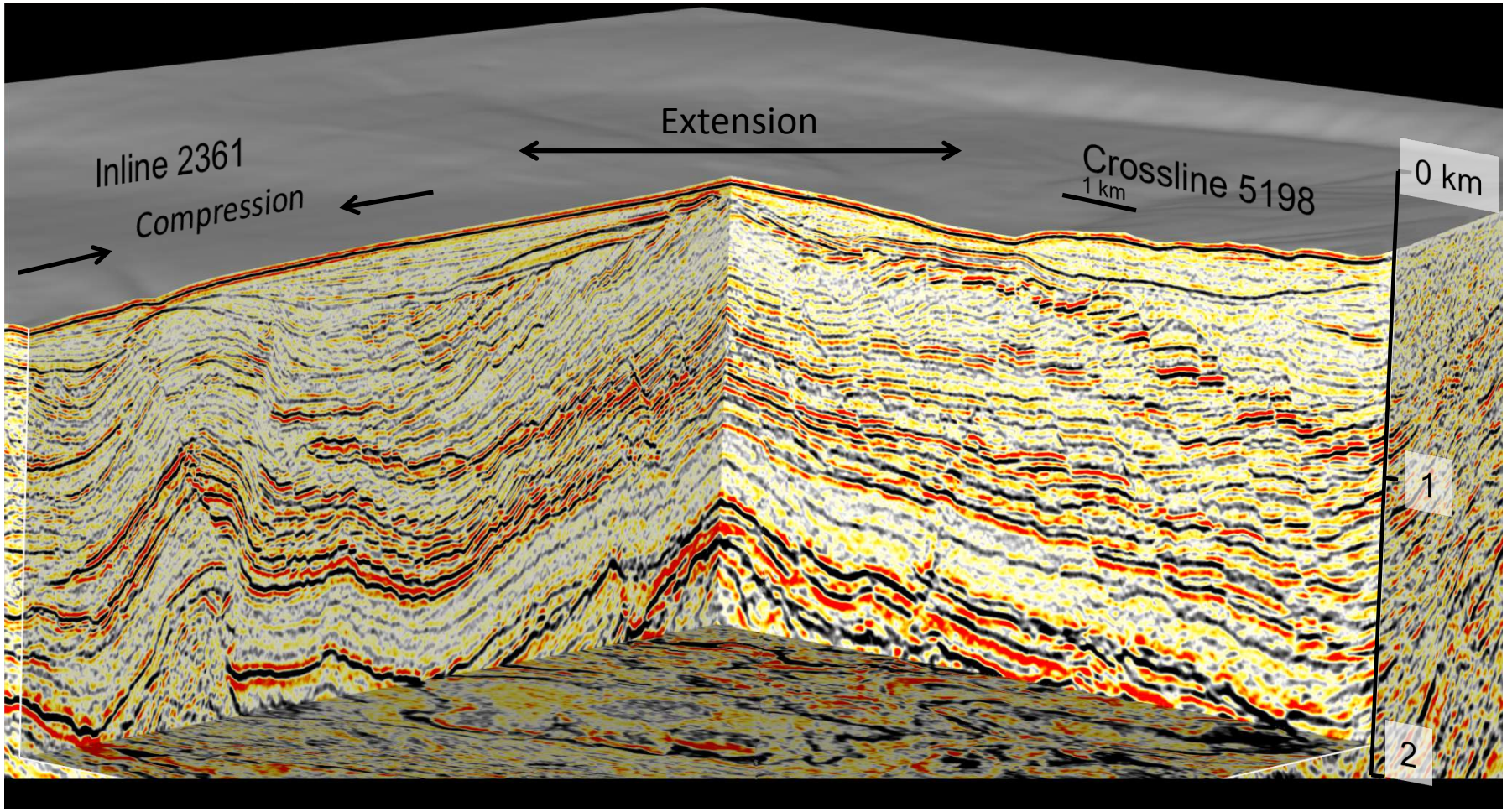

Inline 2182
1 km
Crossline 4355
Inline 2631
Depth (km)
0
1
2
3
4
5
250 m
<100 m

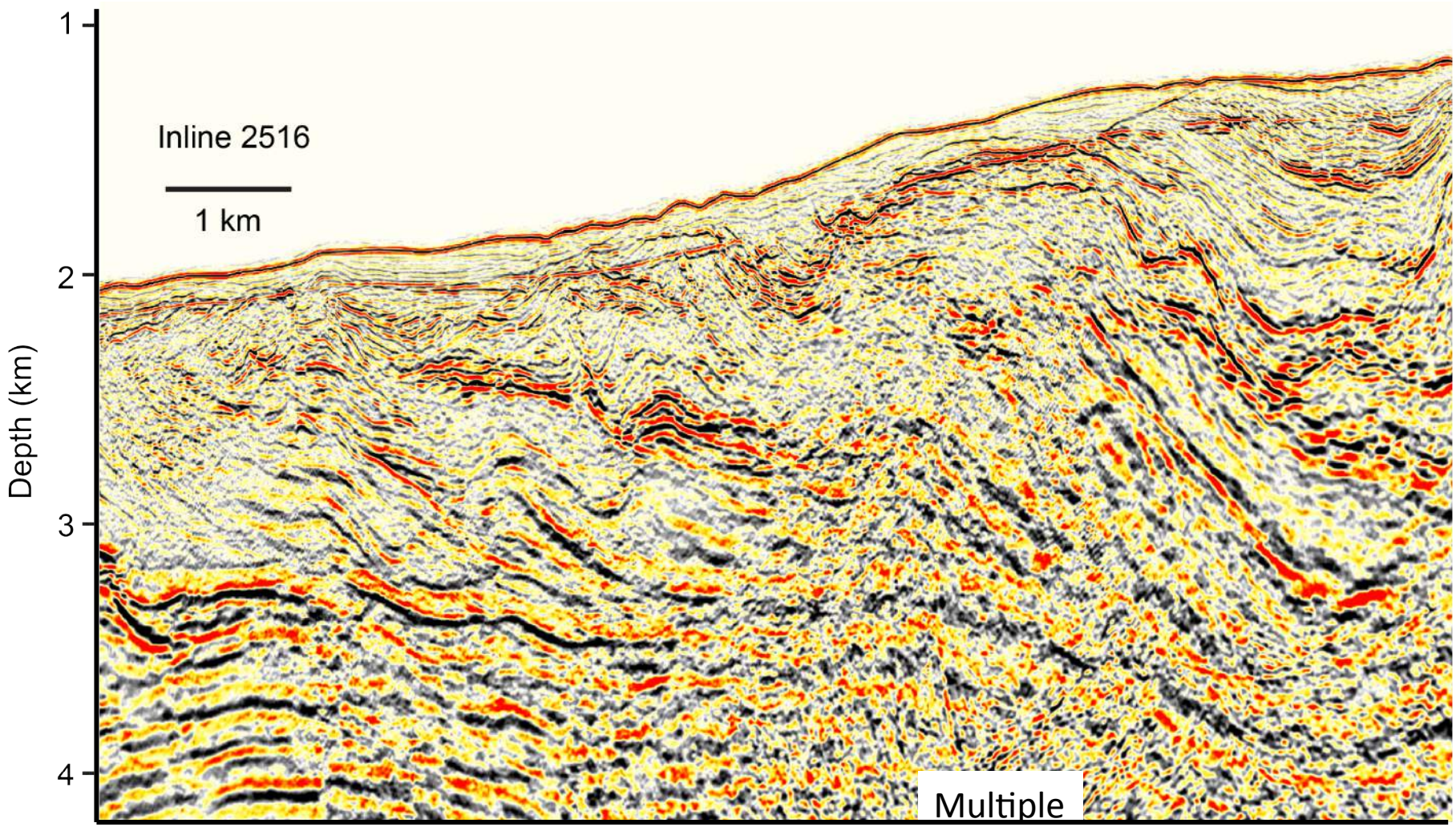
Plate-boundary thrust reflection amplitude

High amplitudes along basement ridges

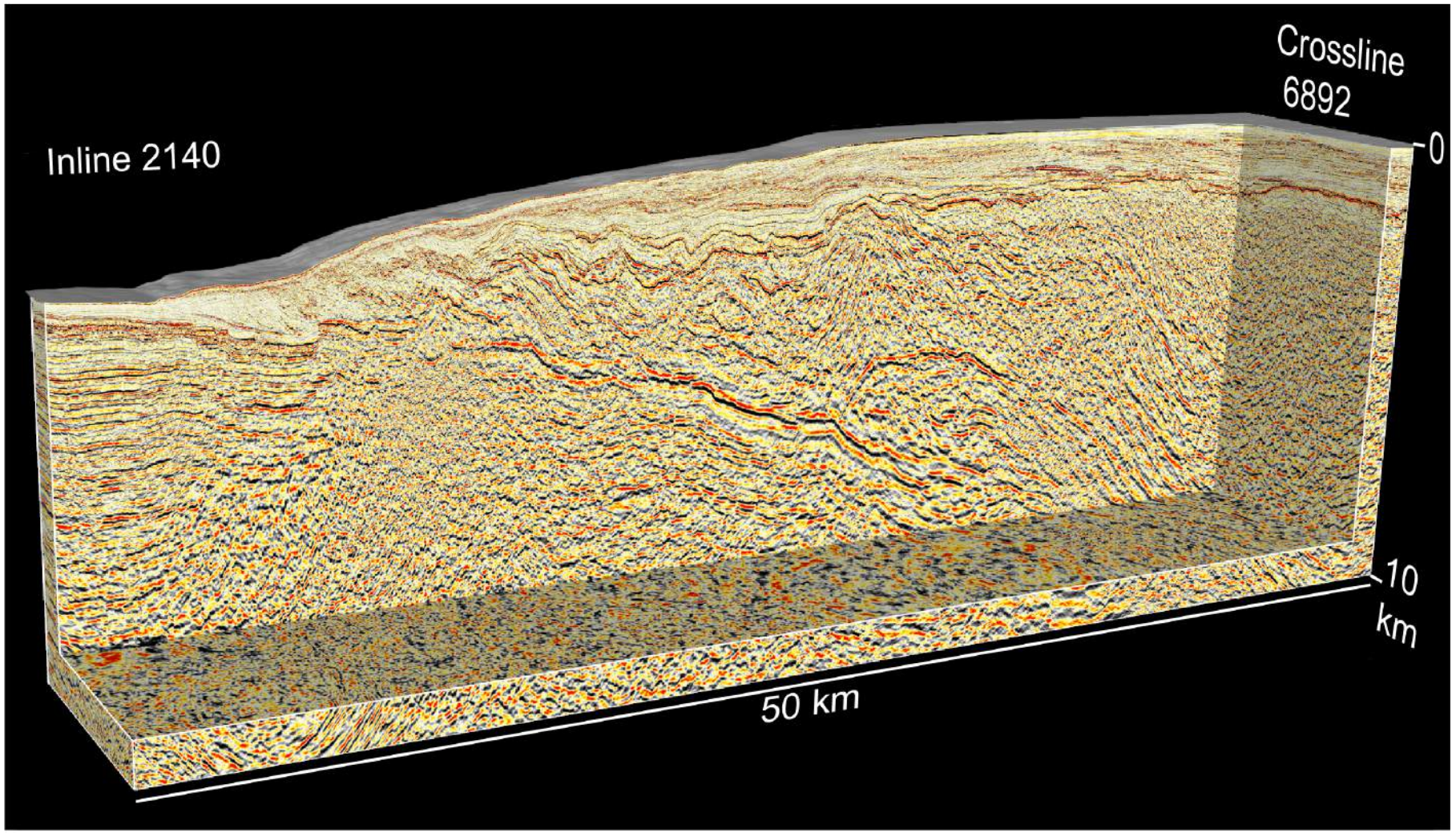


Faults in the slope cover




Inline 2516
1 km
Depth (km)
1
2
3
4
Multiple

Margin wedge is focus



Connections to plate interface along layering

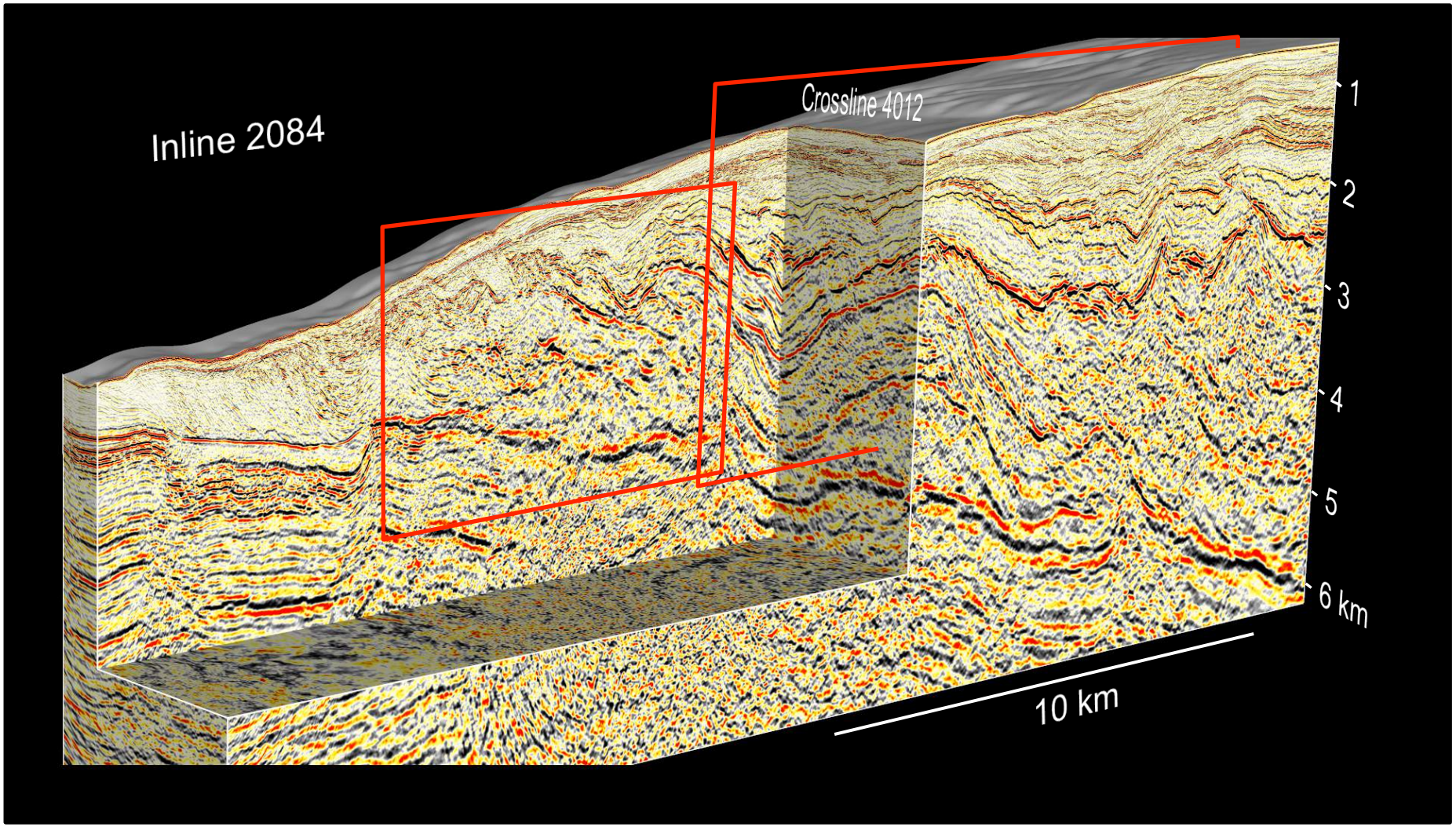
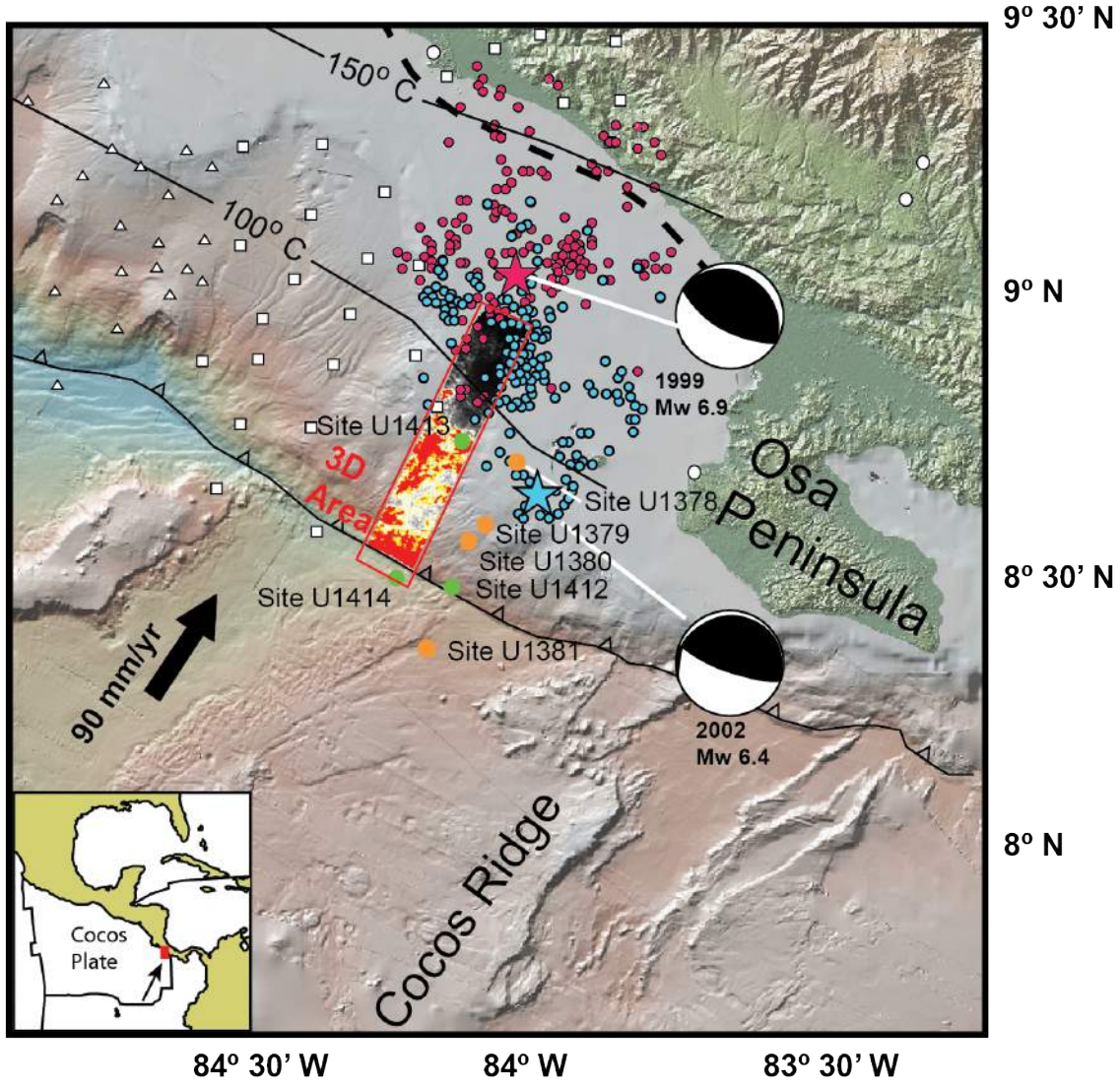


Plate-boundary reflection amplitude and seismicity



What controls the fluid content along the plate-boundary thrust?

Isotherms from Harris et al. 2010

Microseismicity from Arroyo et al. 2013