3D Velocity Model Building and Seismic Imaging Combining Tomography and Model Based Approaches in the Peniche Basin*

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Abstract

The deep-water Peniche basin is located in the eastern North Atlantic offshore Portugal. This undrilled, unexplored area was recently surveyed with a high-resolution, narrow azimuth, Broadseis, 3200 km^2 3D seismic survey. Because stratigraphic features with salt-related structural component, salt-related structural traps and pinchouts against salt diapirs are present in this area; accurate imaging of the geological structures is a key factor to reduce the uncertainty of the potential prospects. Pre-stack depth migration helps to improve the seismic image around complex targets with sharp lateral velocity variations. However, high velocity salt body contrasts associated with steeply dipping complex-shaped structures, basement highs, carbonates layers, turbidites, numerous unconformities and faults pose significant challenges for the imaging of this basin. Sediment sections show large velocity variation from relatively consistent, slow, sediment basins on the south, to quite fast layers and faulted blocks on the north. The sea floor has also significant variations, associated with basement highs. Despite advances in migration algorithms, the derivation of a realistic earth model remains an important challenge, requiring tight integration of geologic interpretation and geophysical skills. While generic salt environment workflow to tackle such challenges involves several iterations of depth migration, model updating and picking of the top and base of the salt bodies; tomography methods alone fail at properly modelling deep, steeply dipping and poorly constrained complex geological structures in the salt overhangs or to accurately position high velocity carbonates contrast. Here an approach combining both tomography updates, interleaved with model-based approaches, is an effort at stabilizing the deep overhangs velocity trend, to constrain the carbonate velocity contrast and to better image the deep salt and basement boundaries. The result of this approach largely improves the salt and carbonates

geometries and the resolution and stability of the velocity model, thus leading to an improved final migrated image.

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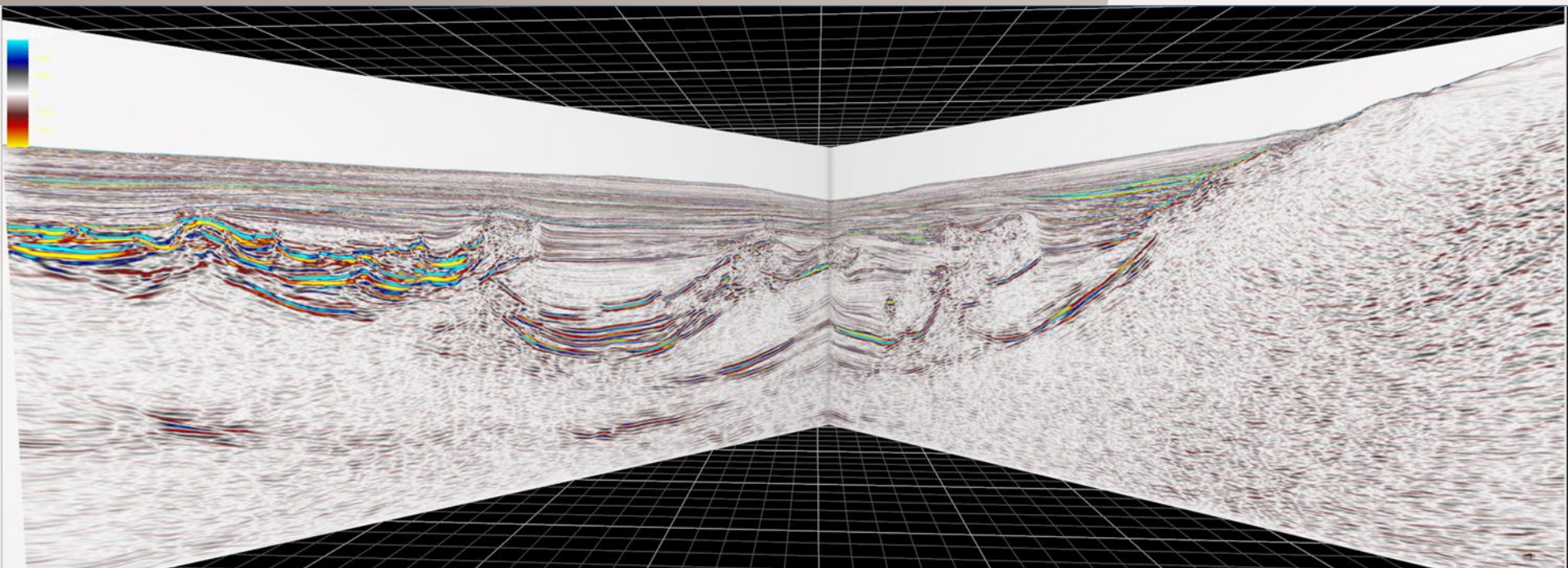
3D velocity model building and seismic imaging combining tomography and model based approaches in the Peniche Basin

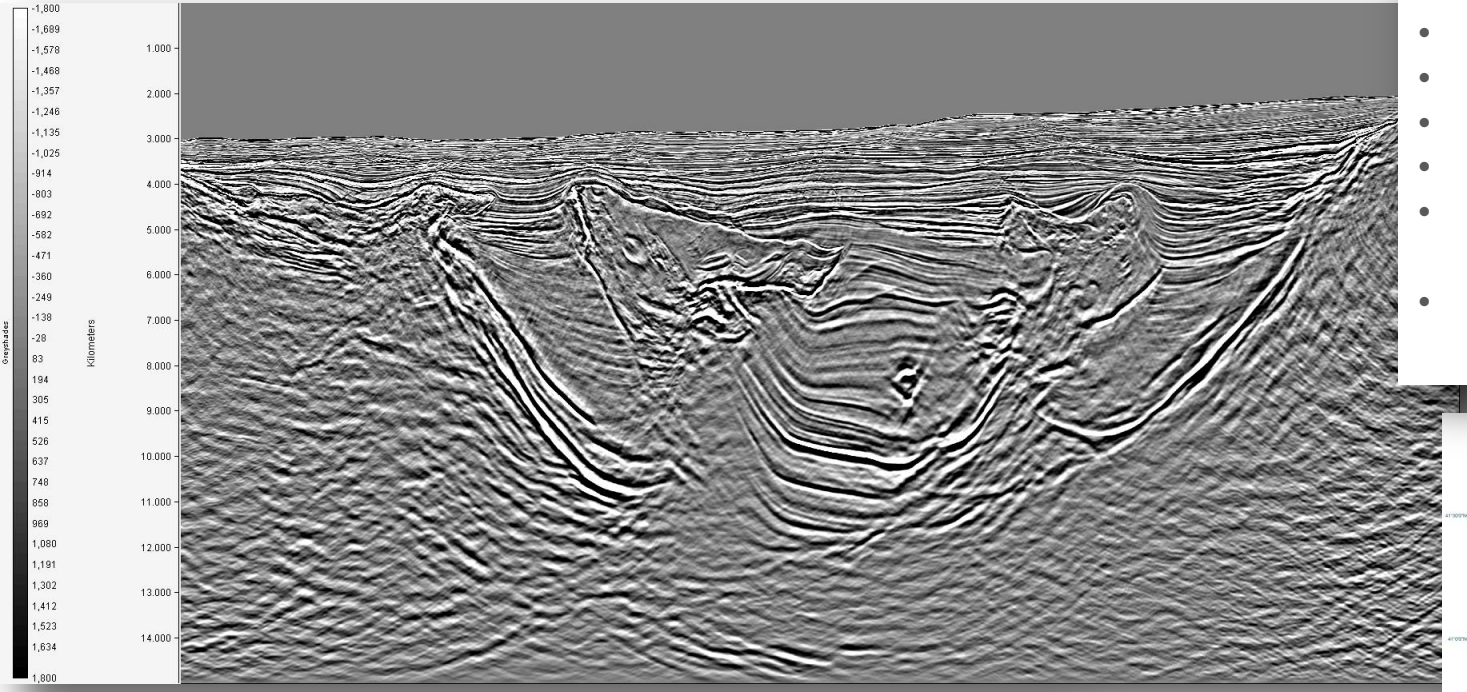


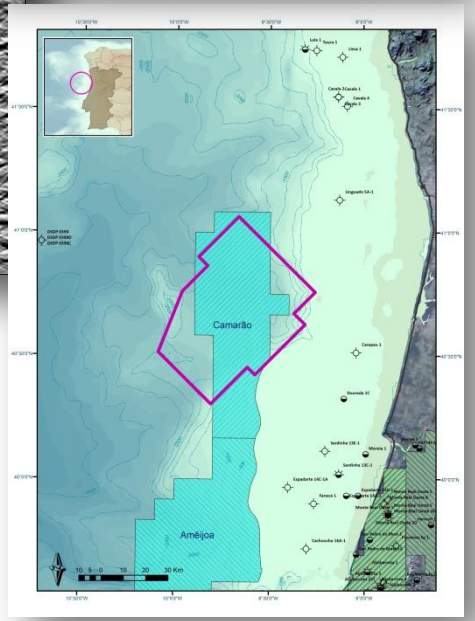
Outline

- Introduction
- Challenges
- TSDIP measurements
- Overhang sediment velocity trend
- Salt interactive modeling
- Fast velocity layer and basement modeling
- Results
- Conclusion

Project Area and 3D Outline

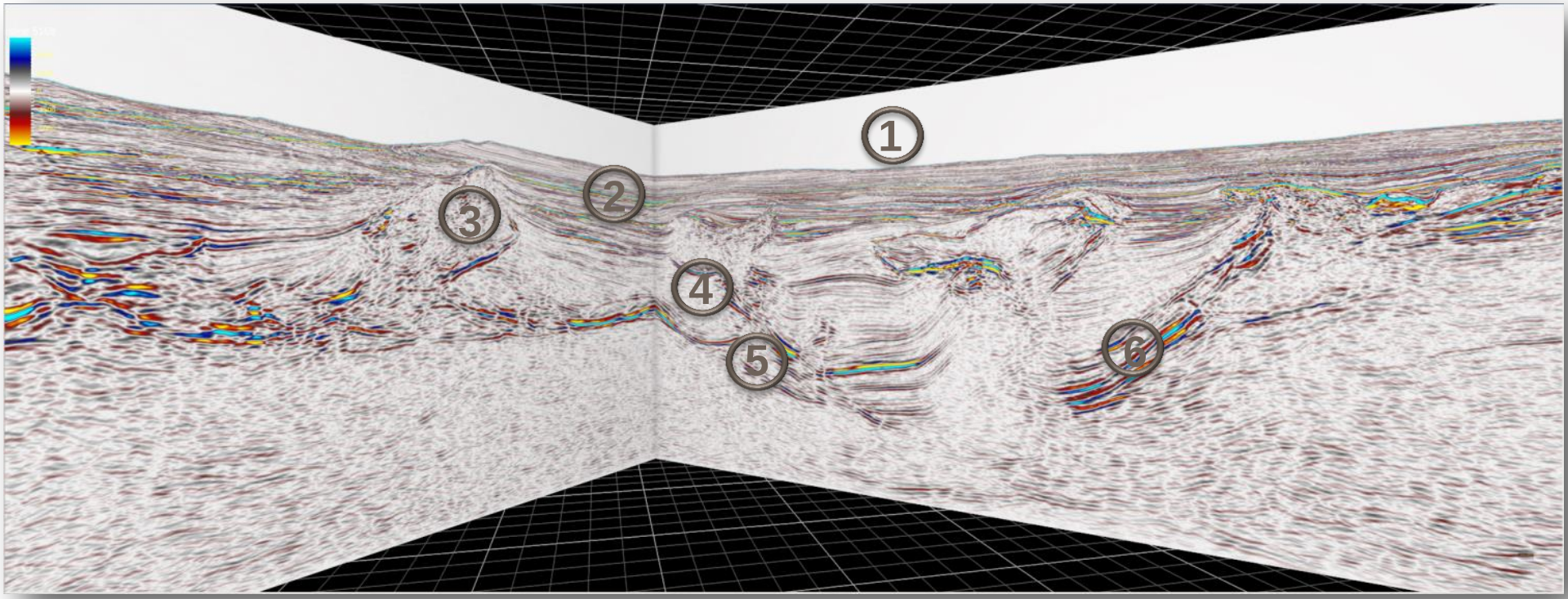
- Peniche
- Camarao block 3D
- PSDM
- Offshore Portugal
- 3D Broadseis NAZ
- 3200 km2
- Seabed: 200-3500m
- Deep canyon crossing the area
- Hard water bottom in the platform area



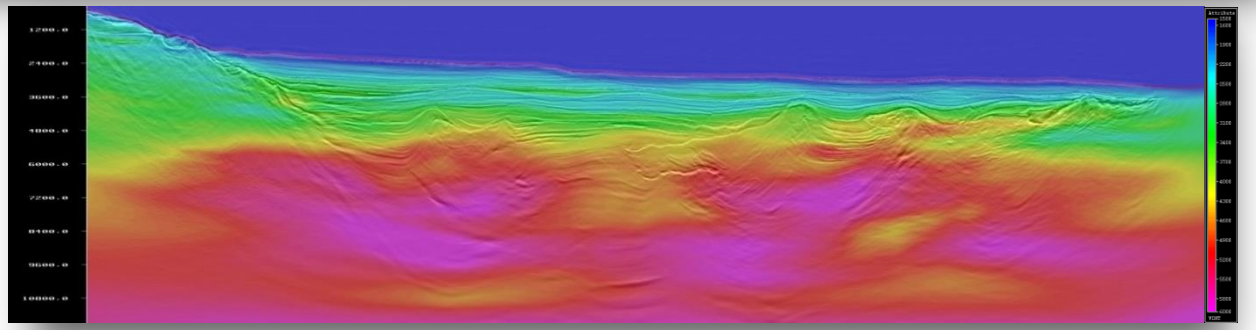


- High velocity contrasts associated with complex salt
- Basement highs
- Carbonate layers, unconformities, faults.
- Large velocity variation from relatively well behaved, slow, deep sediment basins on the south, to fast layers and faulted blocks on the north.
- No wells in the area
- PSDM performed in parallel with the full PSTM processing

Model Building Units definition



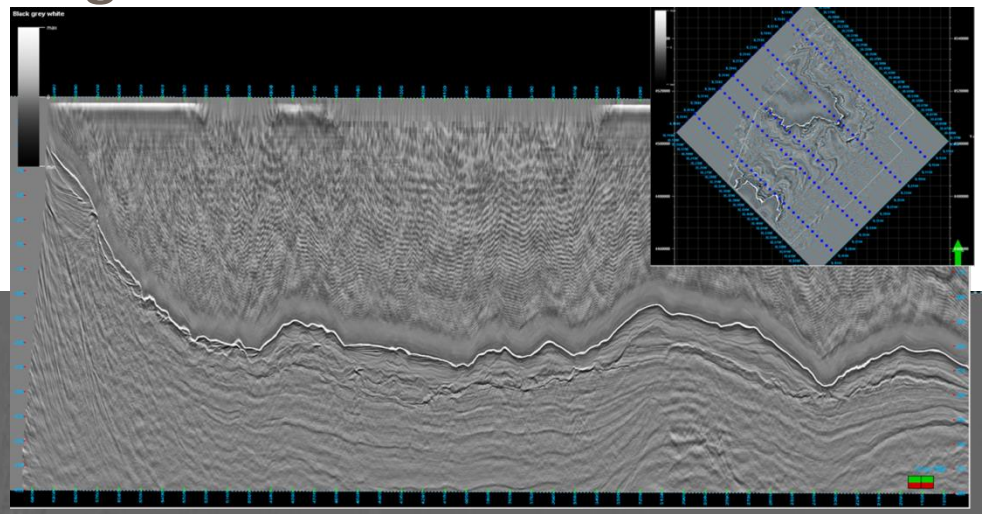
1. Water layer,
2. shallow sediments,
3. shallow salt canopies,
4. overhangs,
5. deep salt
6. carbonates/basement

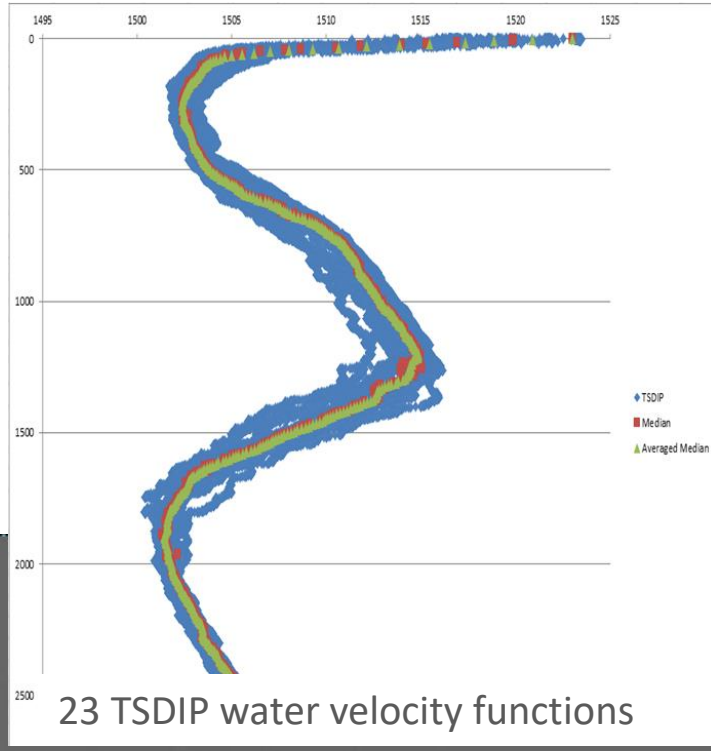


Unstable unconstrained tomography test result (V: 1500-6000ms-1)

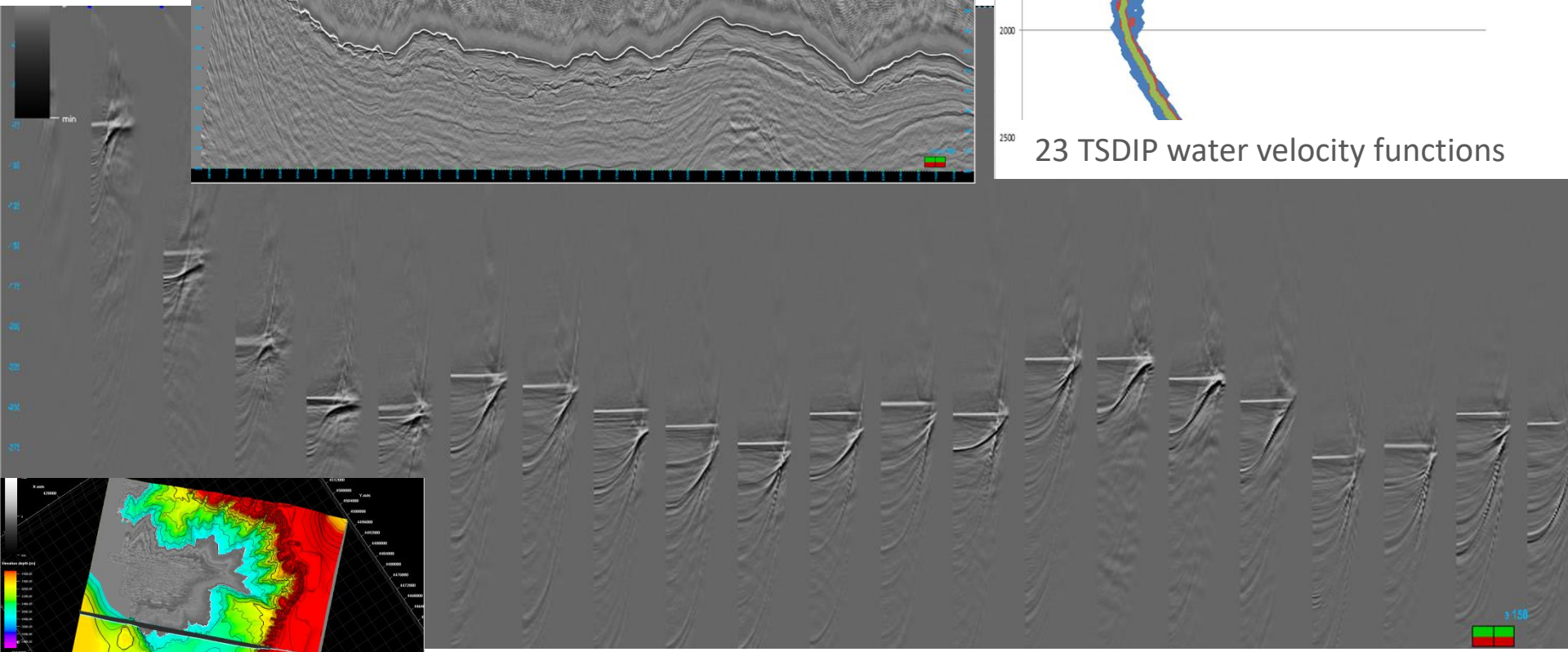
Waterflood QC

In-line gathers and stack QC





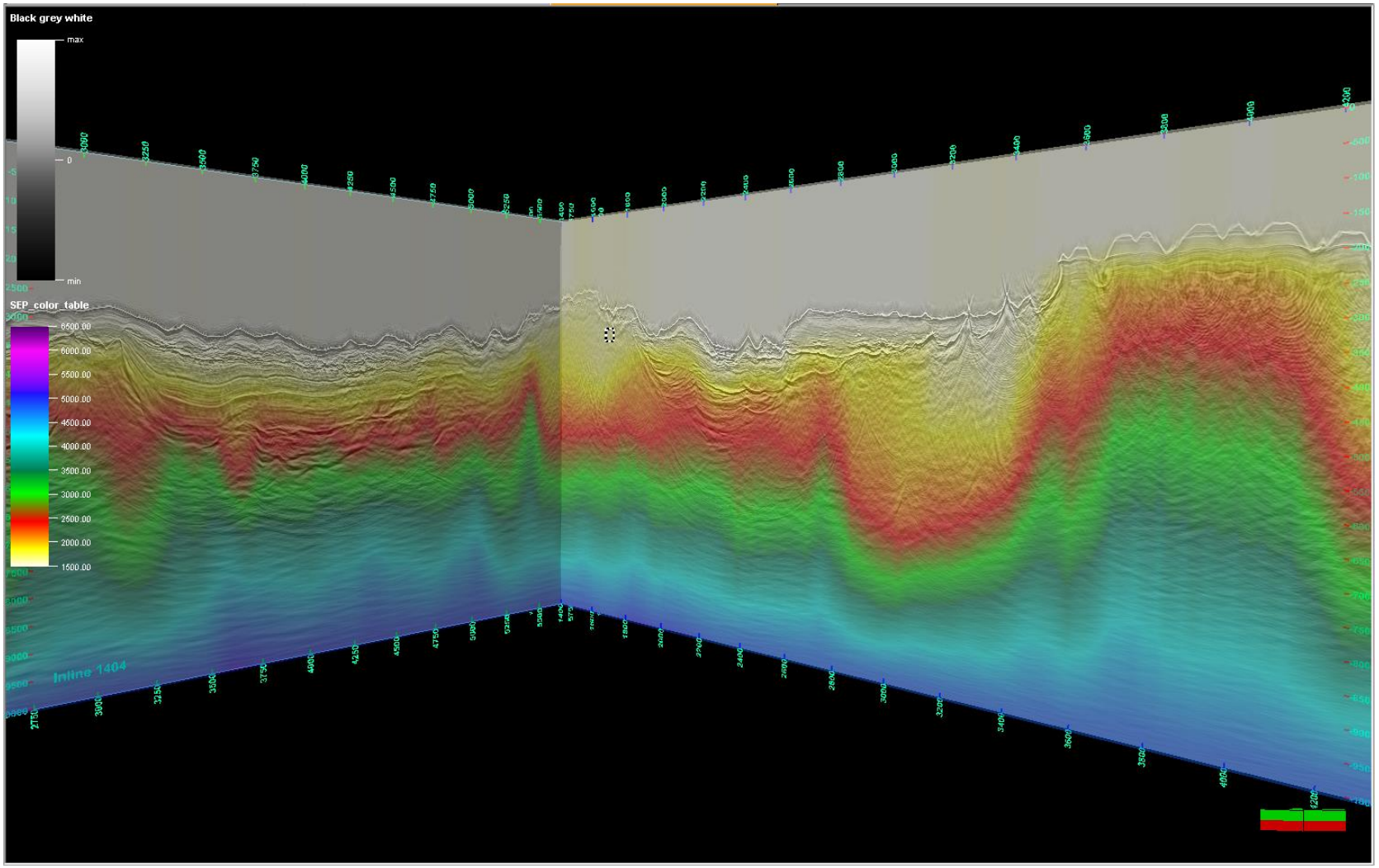
23 TSDIP water velocity functions



4000m

Water Bottom map on Z 2765m

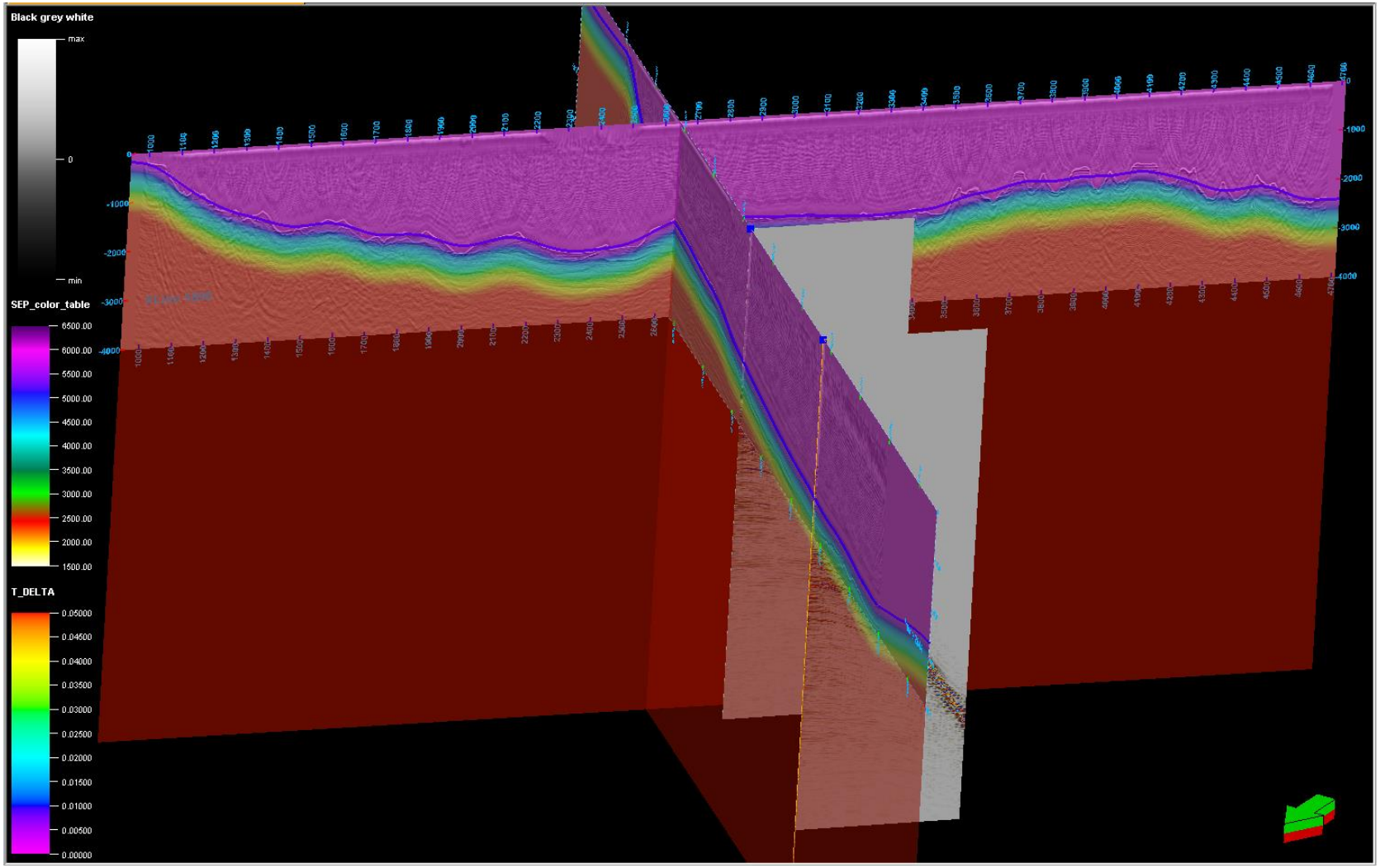
Onboard 1KM x 1KM Time RMS velocities



10000m

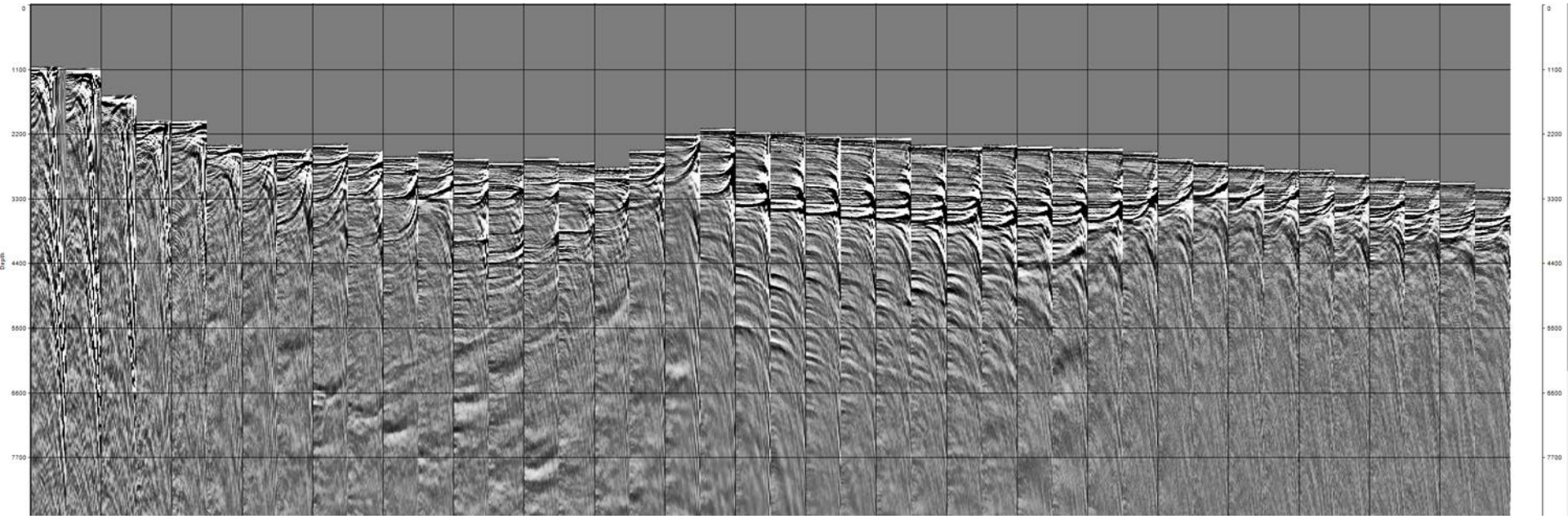
Delta

Single function from smooth WB



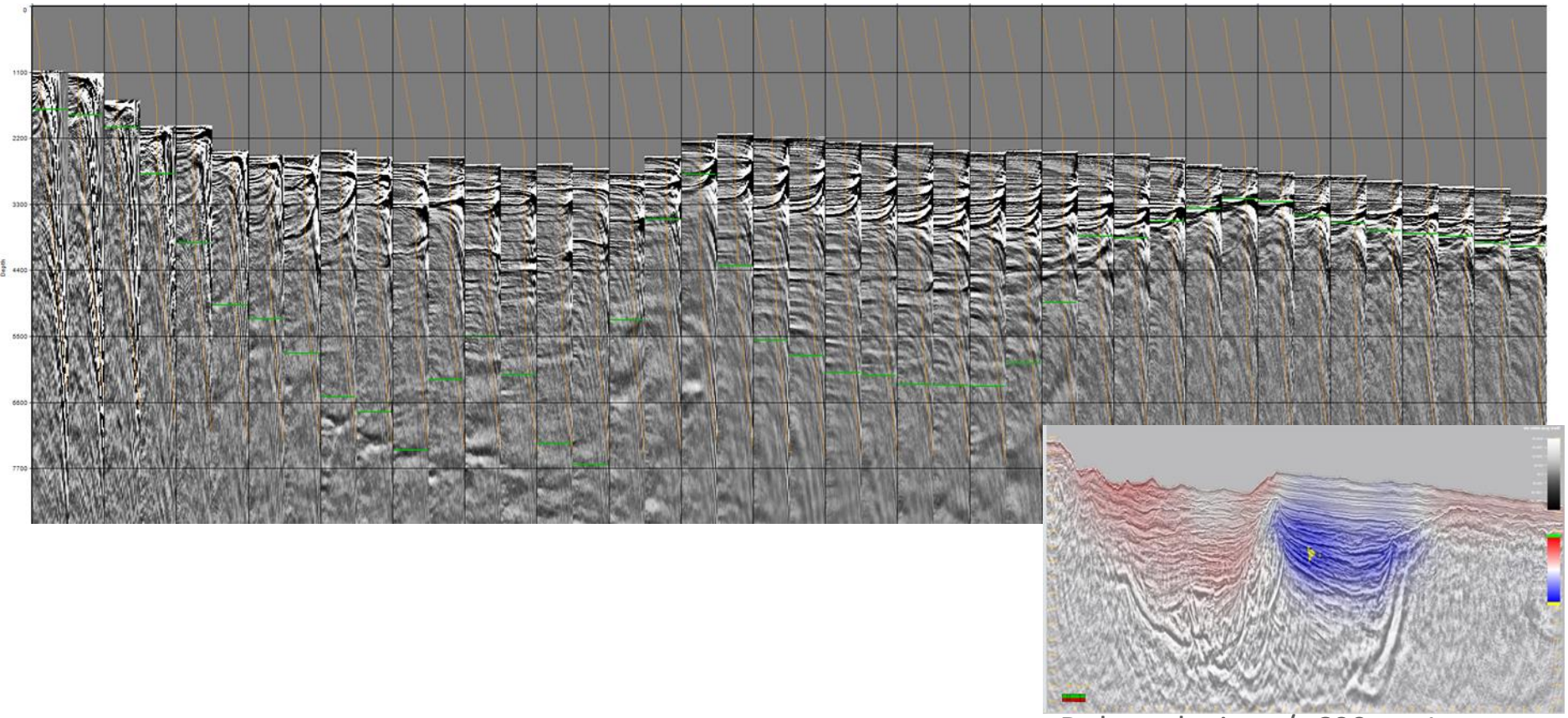
Vint1 TTI model

XL CIG – Before regional update



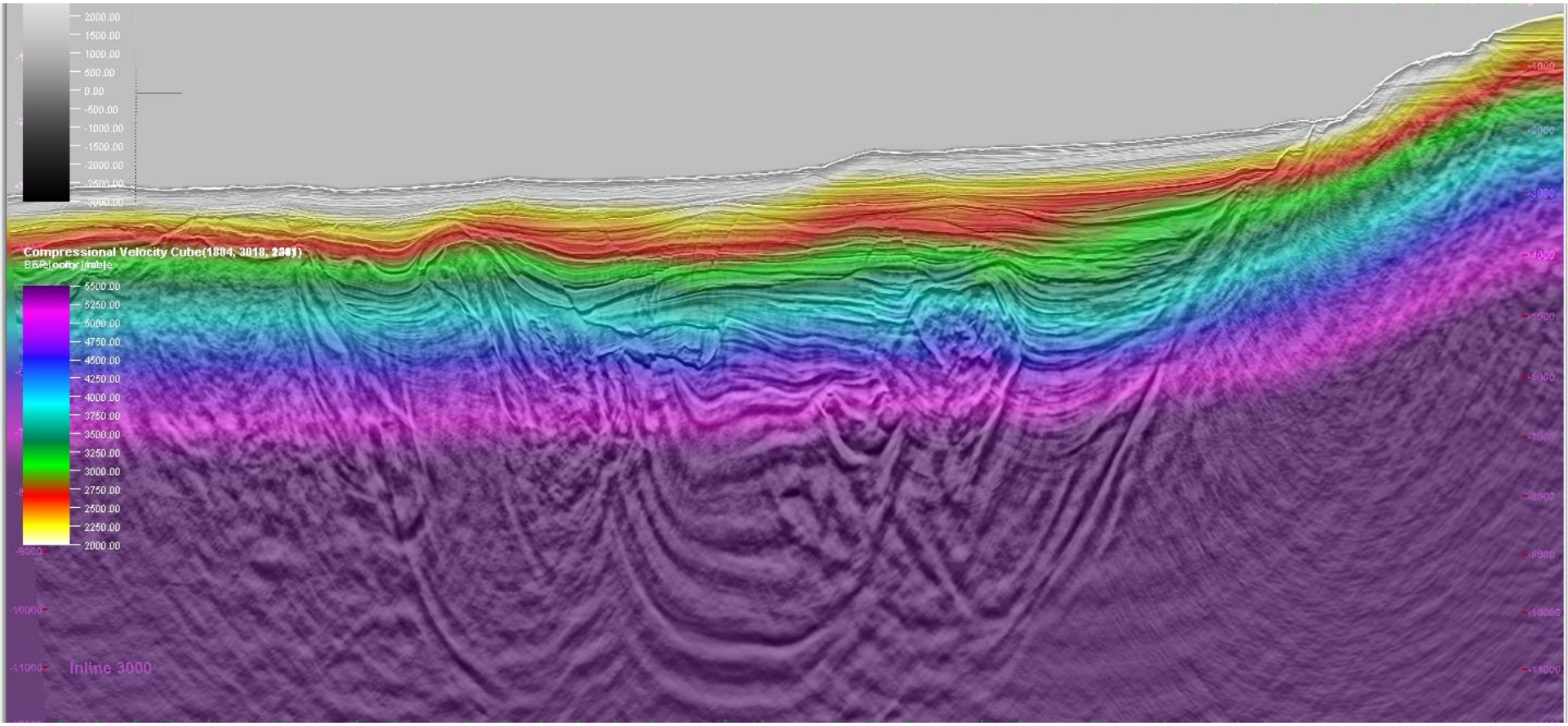
Vint2 TTI model

XL CIG – After regional update (Mask overlaid)



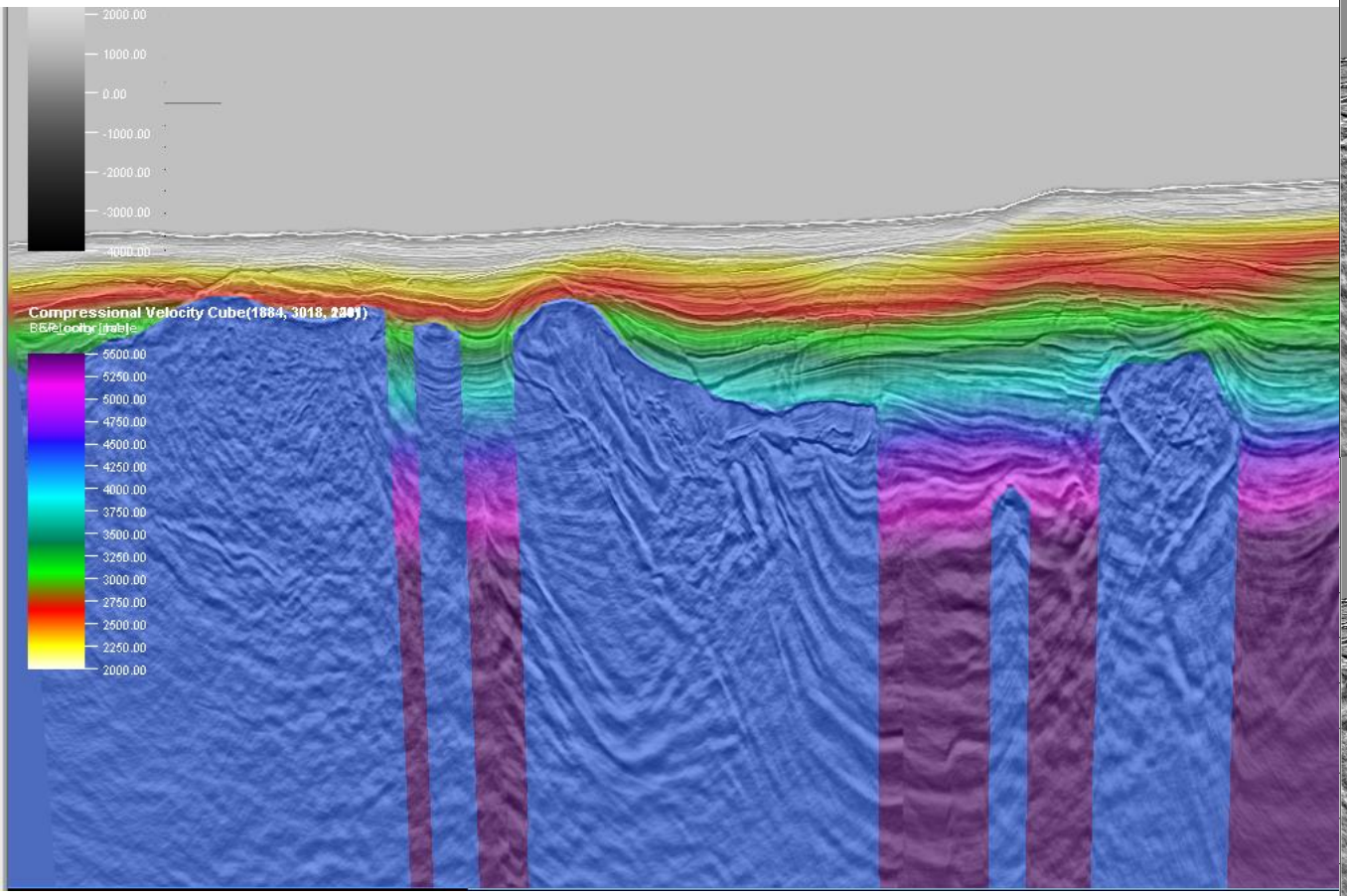
Delta velocity +/- 600ms-1

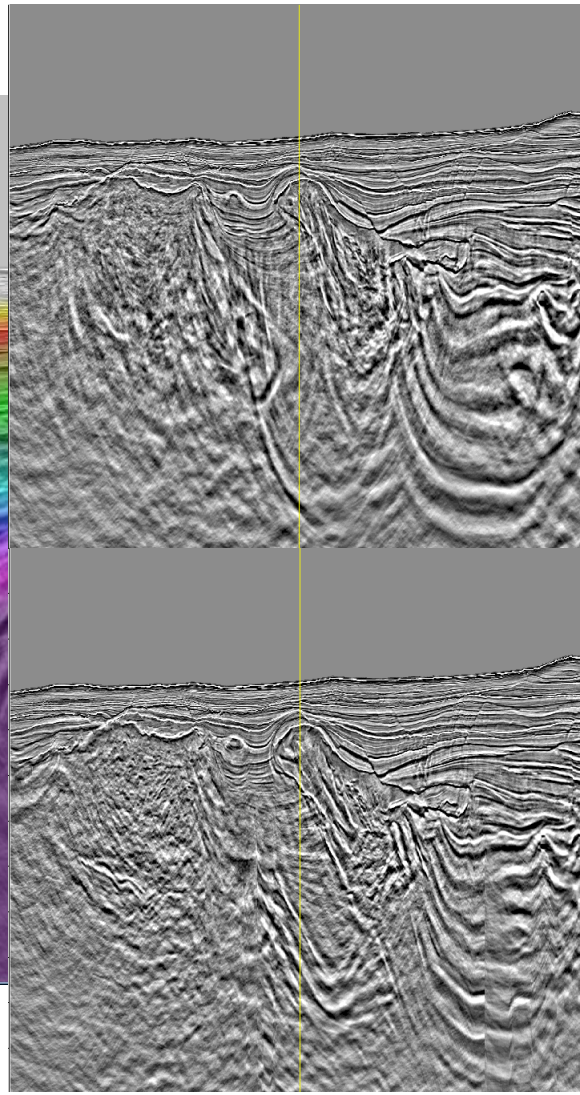
TTI update 4 - IL



12000m

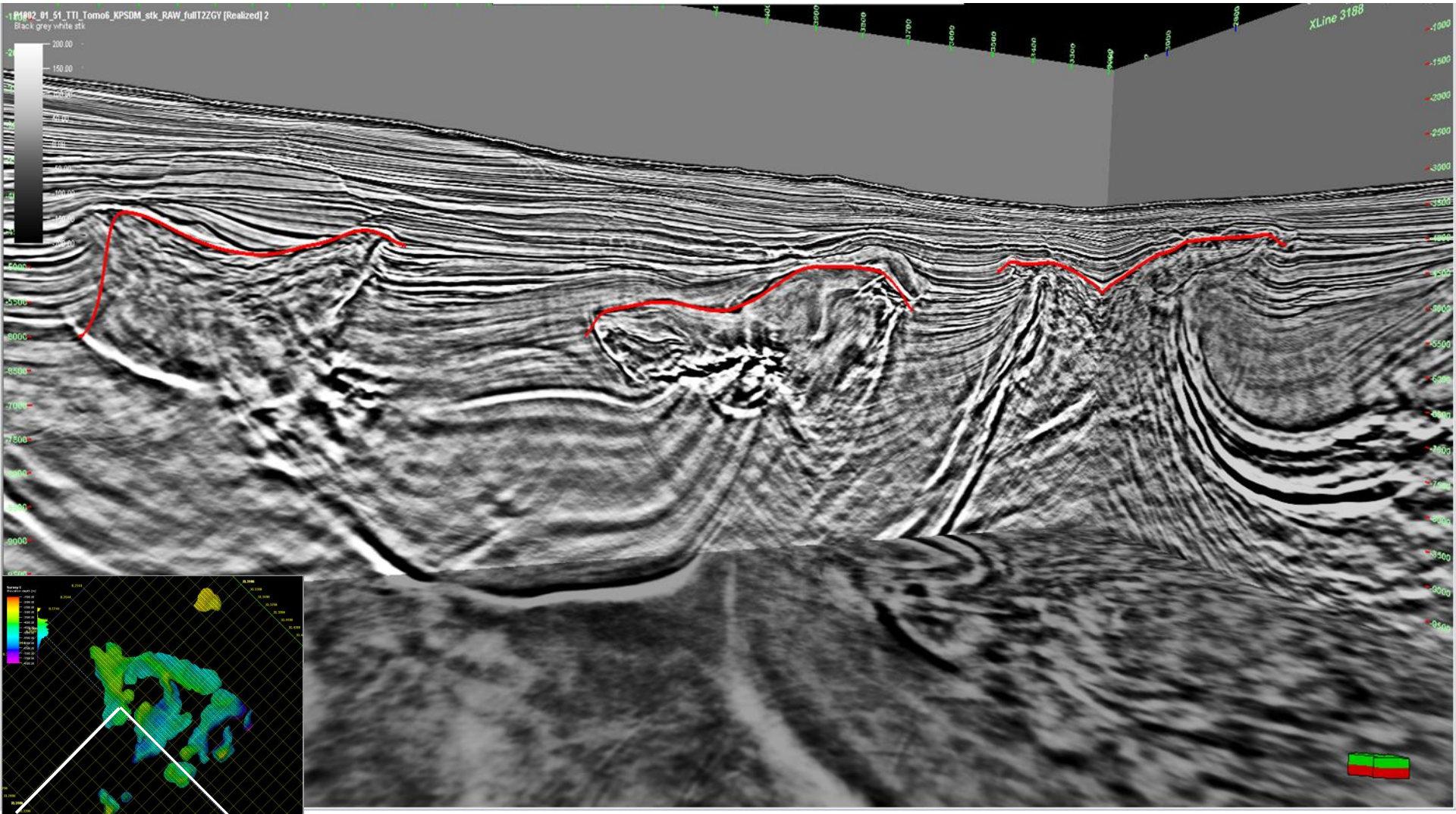
Salt Flood 4350m/s - IL





TTI update 6 - Fast Track Sed flood KDM

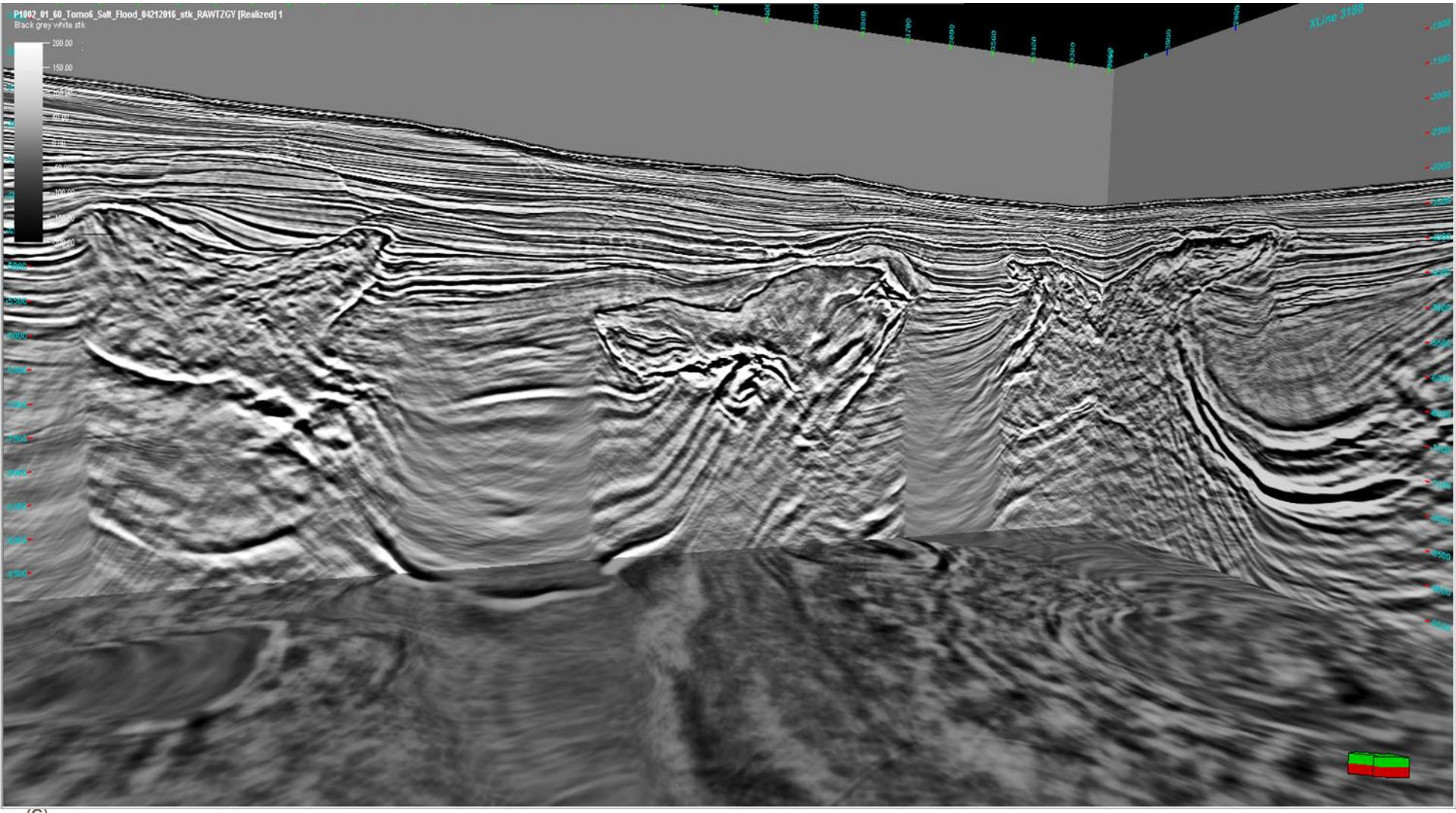
IL, XL, Z9900m – TOS1



Z scale 1

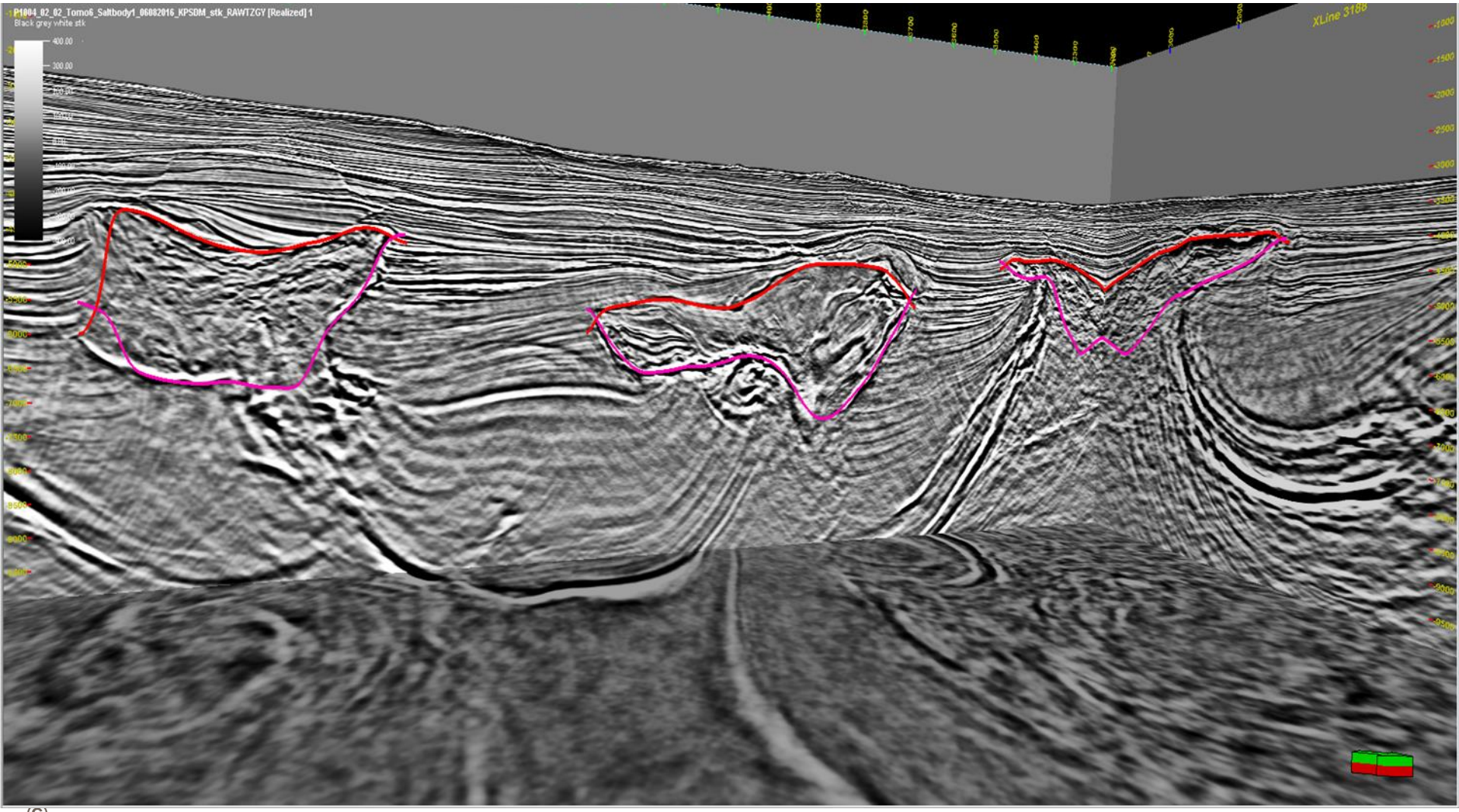
TTI update 6 - Fast Track Salt flood KDM

IL, XL, Z9900m



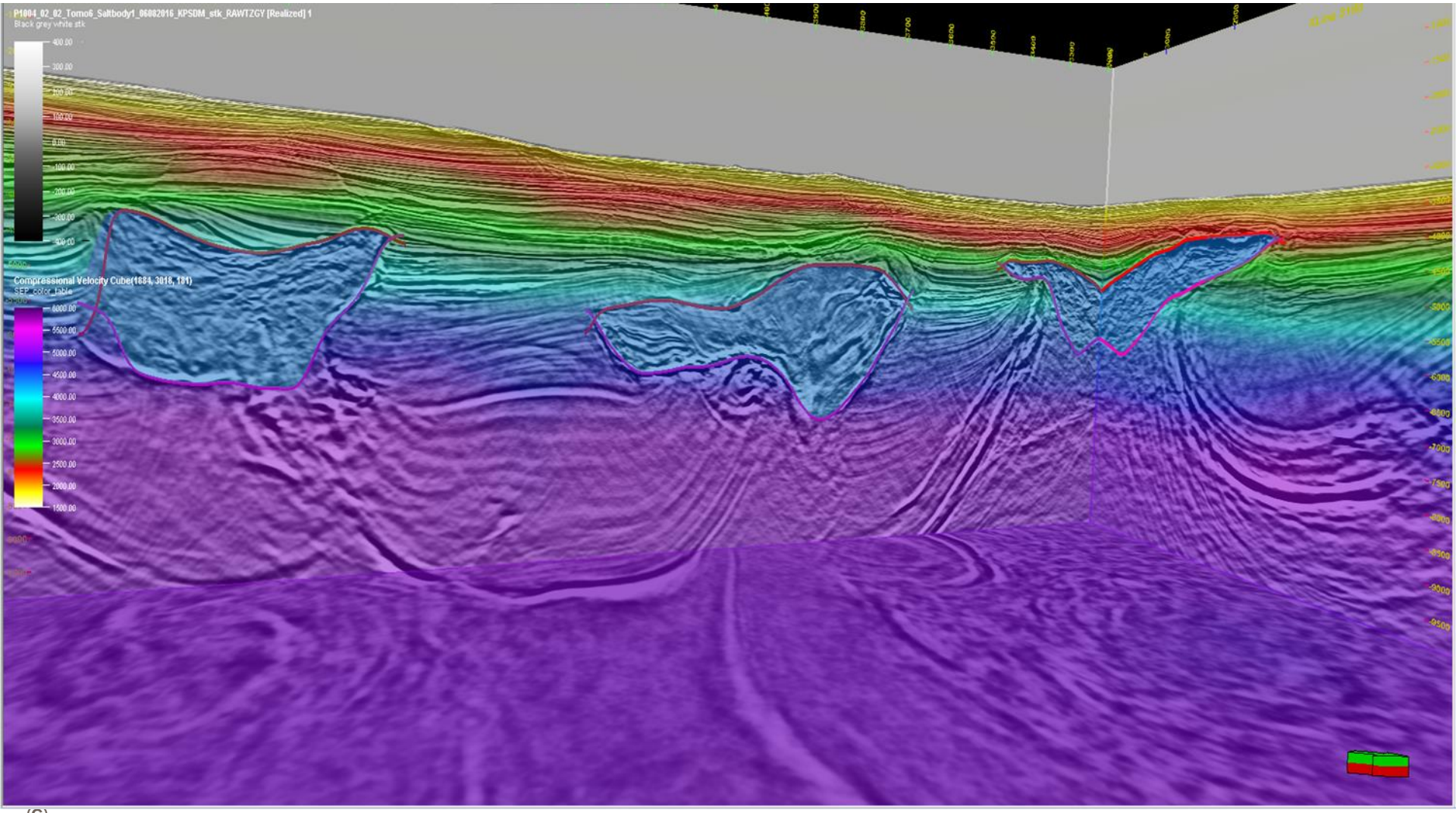
TTI update 6 - Final input Salt Body 1 KDM

IL, XL, Z9900m – TOS1 – BOS1



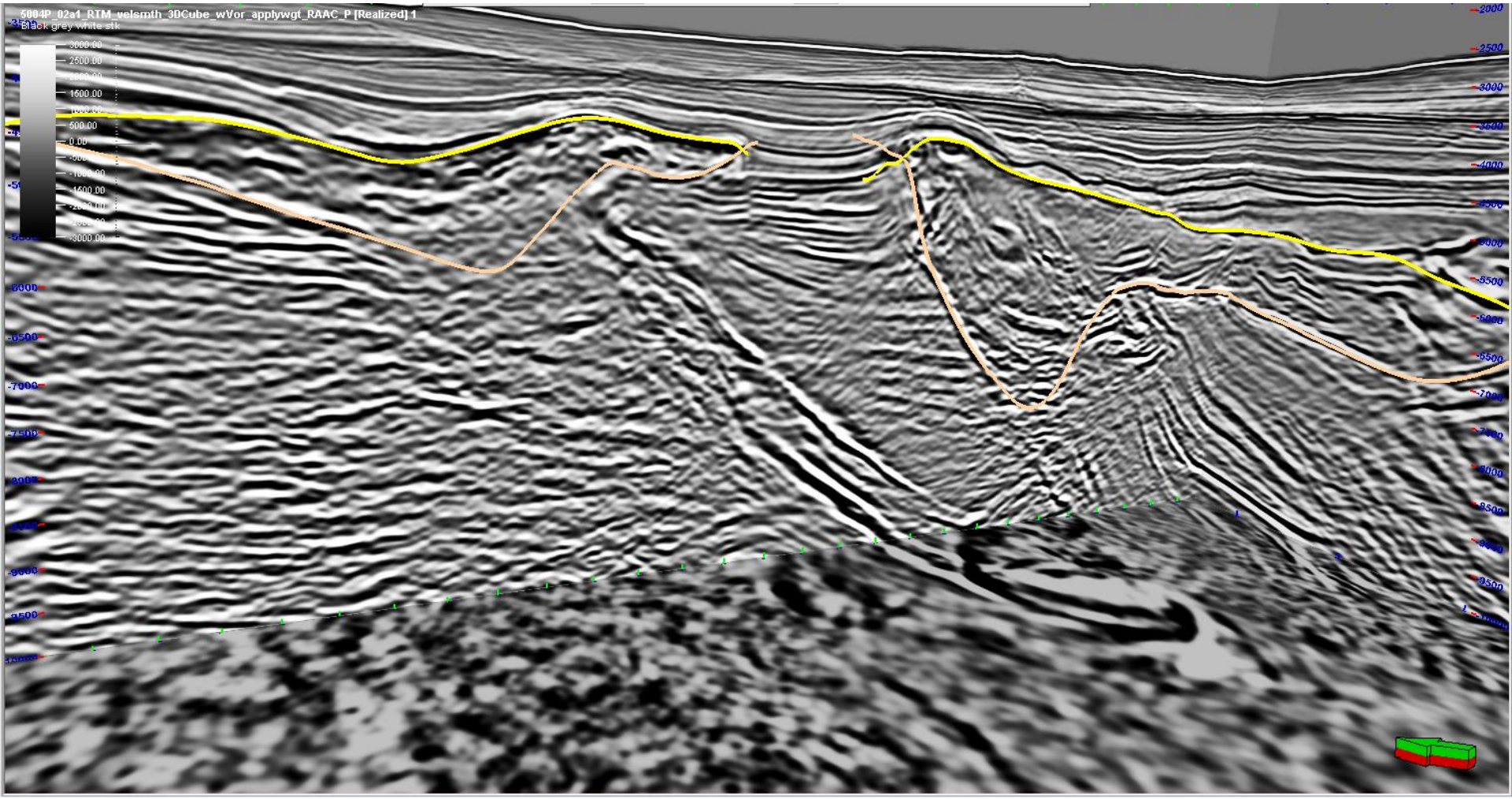
TTI update 6 - Final input Salt Body 1 KDM

IL, XL, Z9900m – TOS1 – BOS1



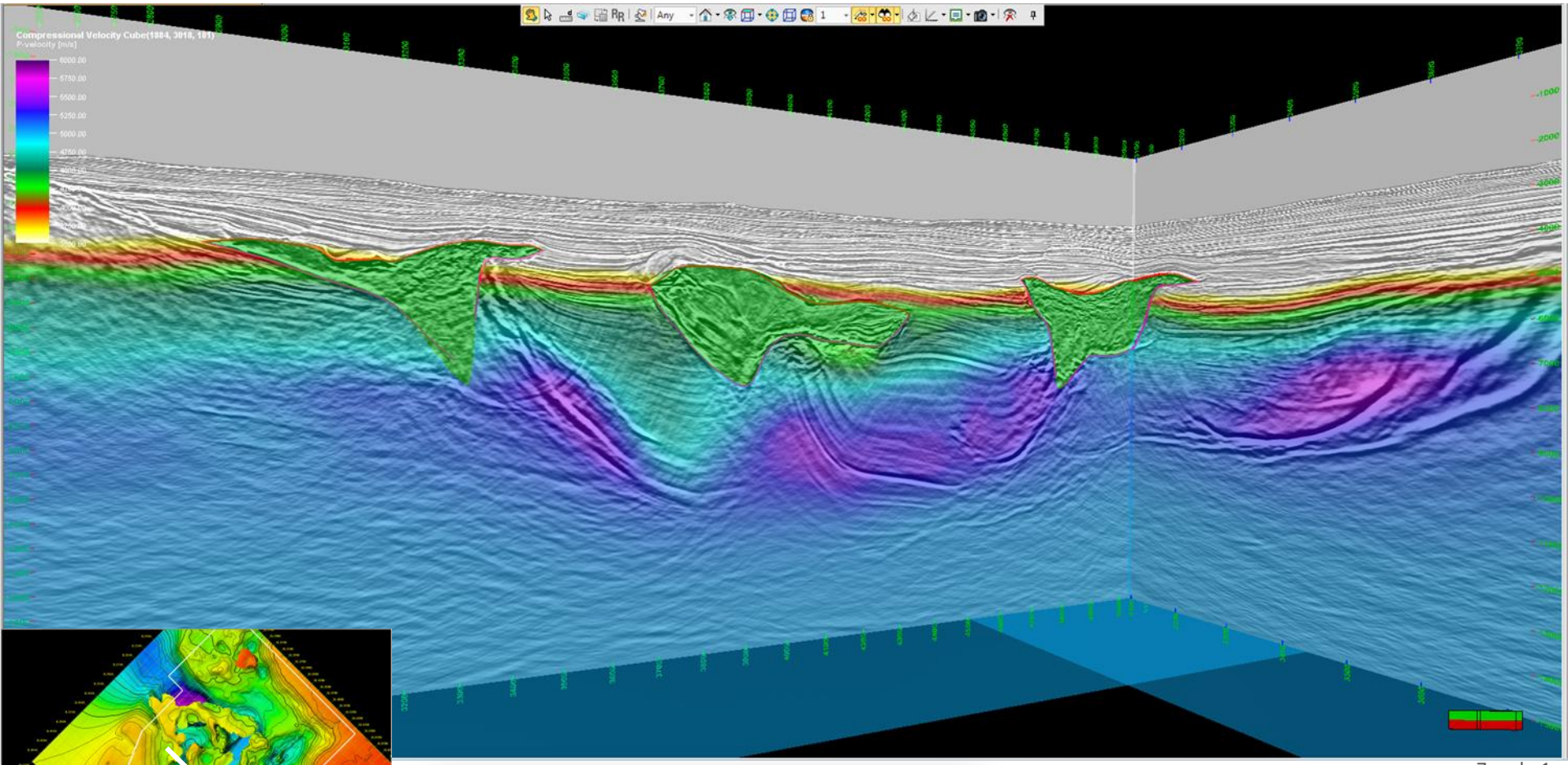
TTI update 6 - Salt flood 1 RTM

IL, XL, Z9900m – TOS1 – BOS1



TTI update 8 - Salt Body 1 KDM

IL, XL – Tomo 8 Salt Body 1 (following through salt update 1)

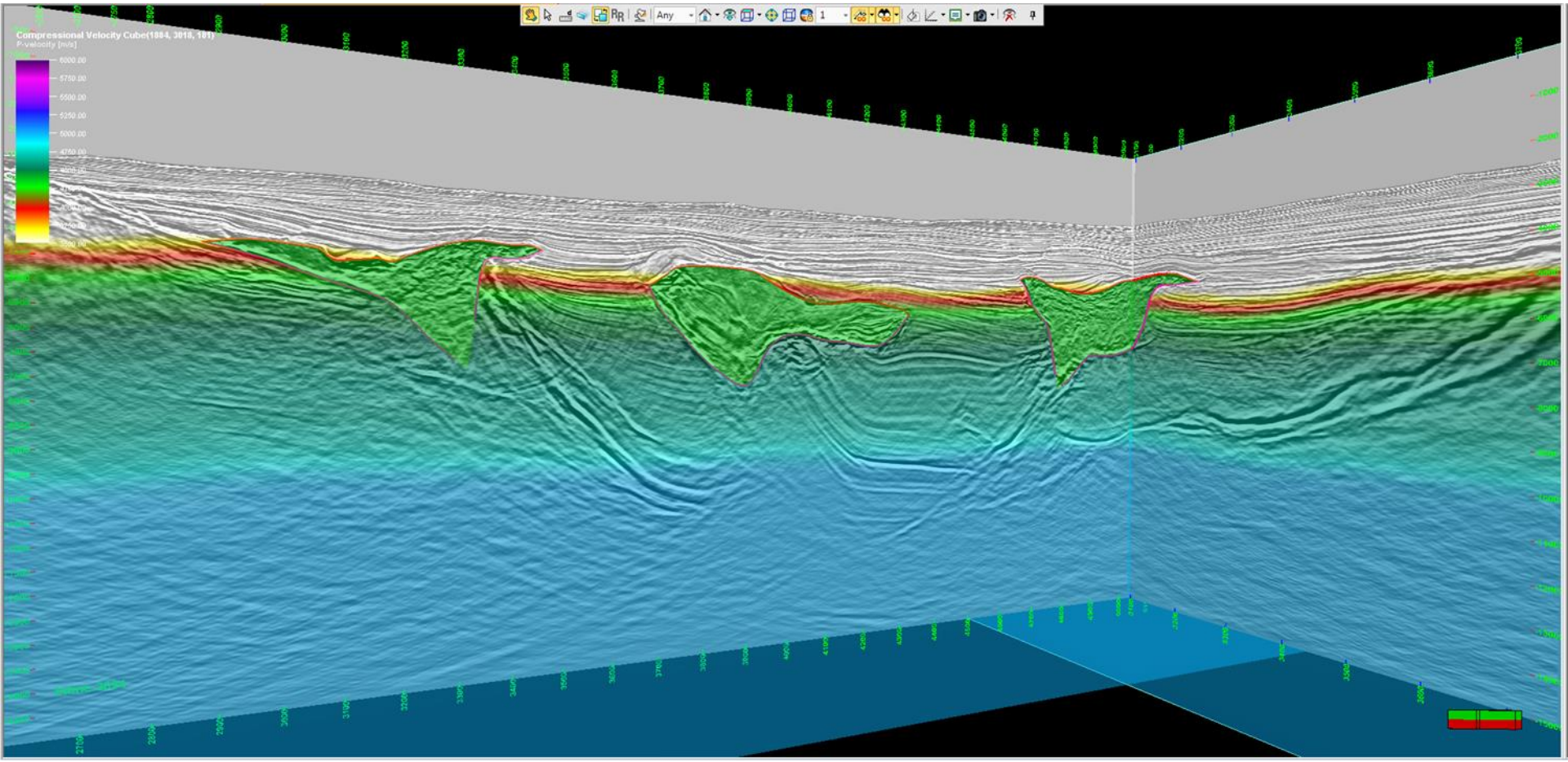


Z scale 1

- Blue – purple: 5200- 5500ms-1
- Green: 4350ms-1

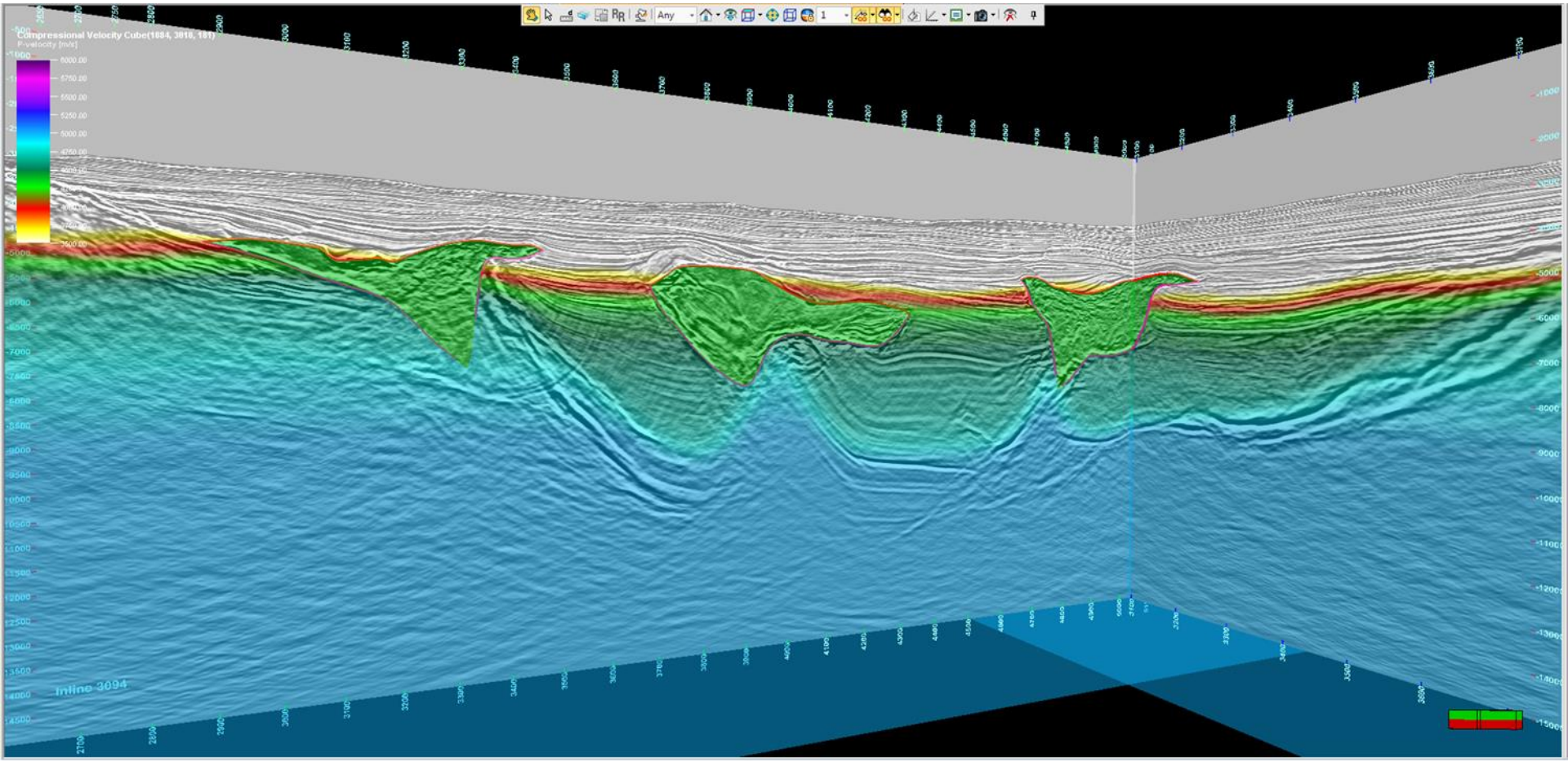
TTI update 8 - Salt Body 1 KDM

IL, XL – Tomo 8 Salt Body 1 Trend



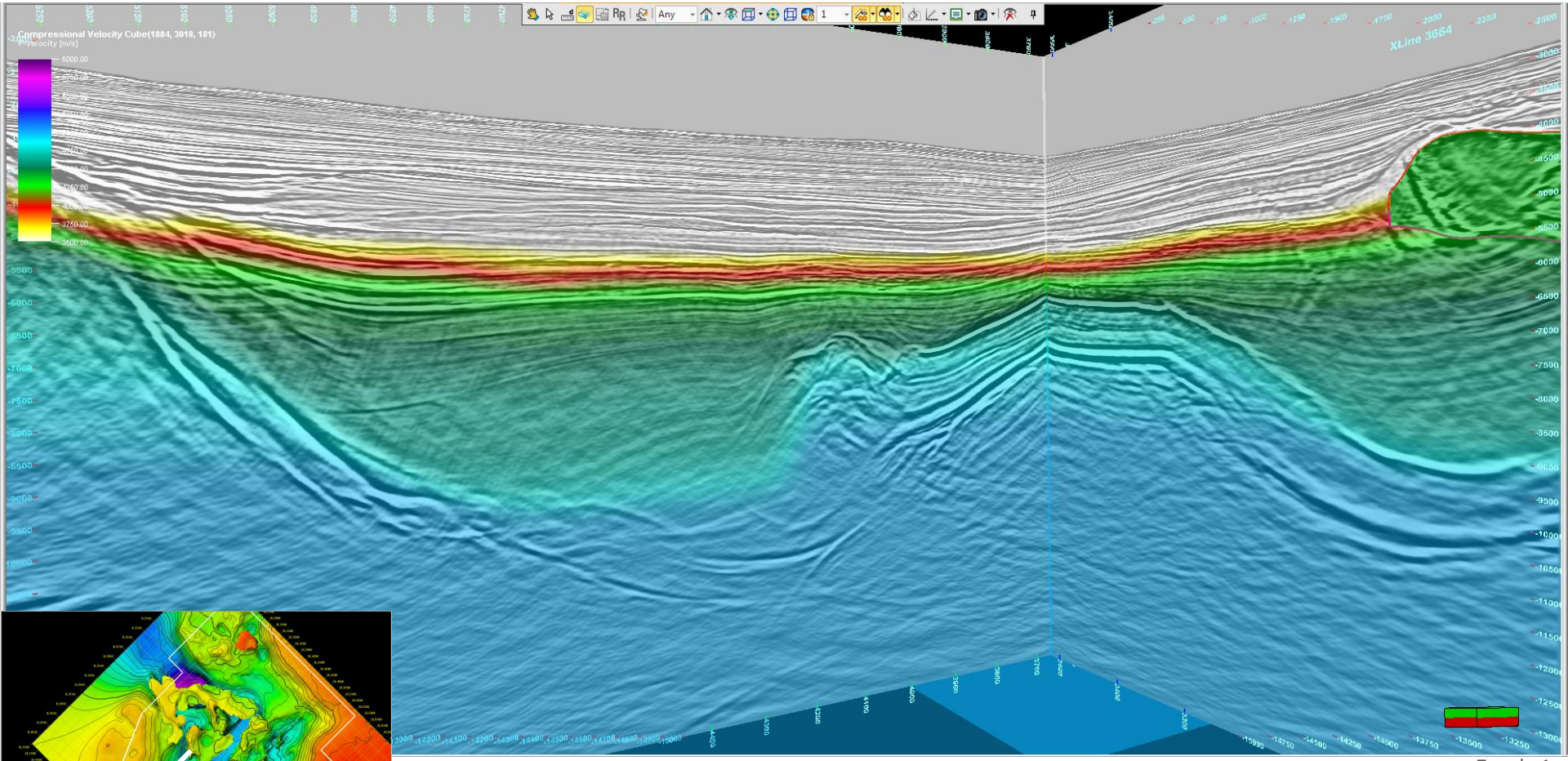
TTI update 8 - Salt Body 1 KDM

IL, XL – Tomo 8 Salt Body 1 Trend, FL flood



TTI update 8 - Salt Body 1 KDM

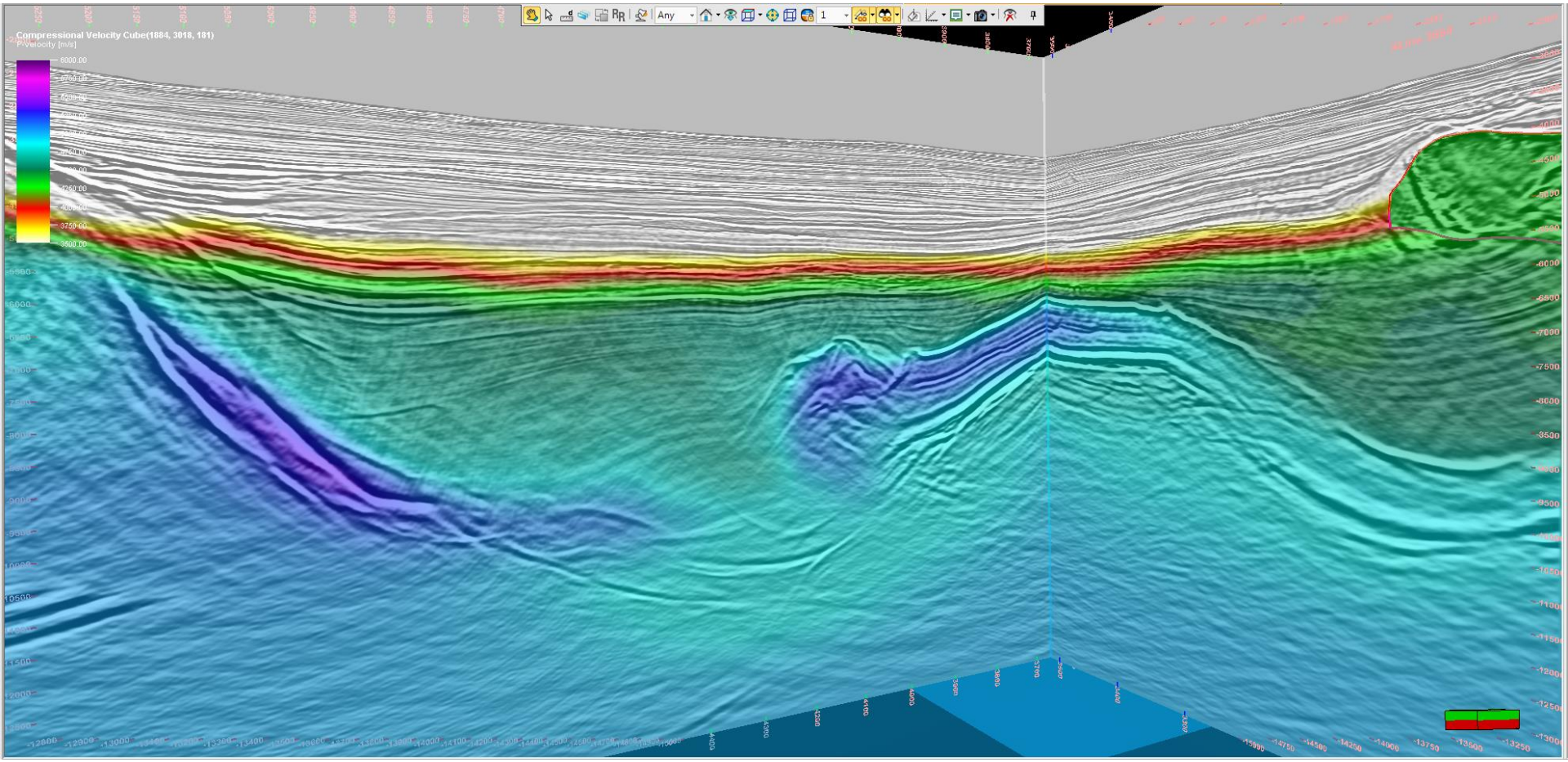
IL, XL – Tomo 8 Salt Body 1 Trend, FL flood



Z scale 1

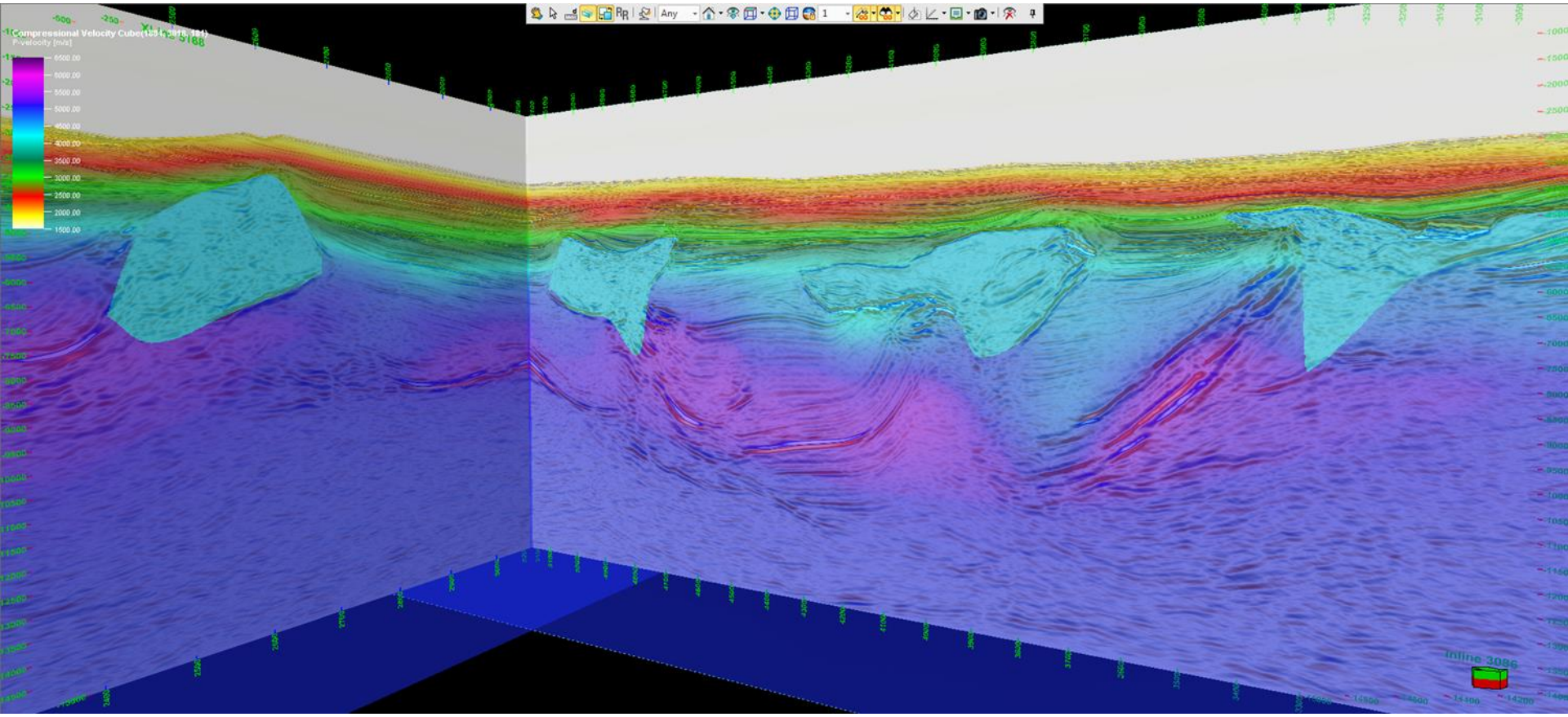
TTI update 9 - Salt Body 1 KDM

IL, XL – Tomo 9 Salt Body 1 Trend, FL flood



TTI update 8 - Salt Body 1 KDM

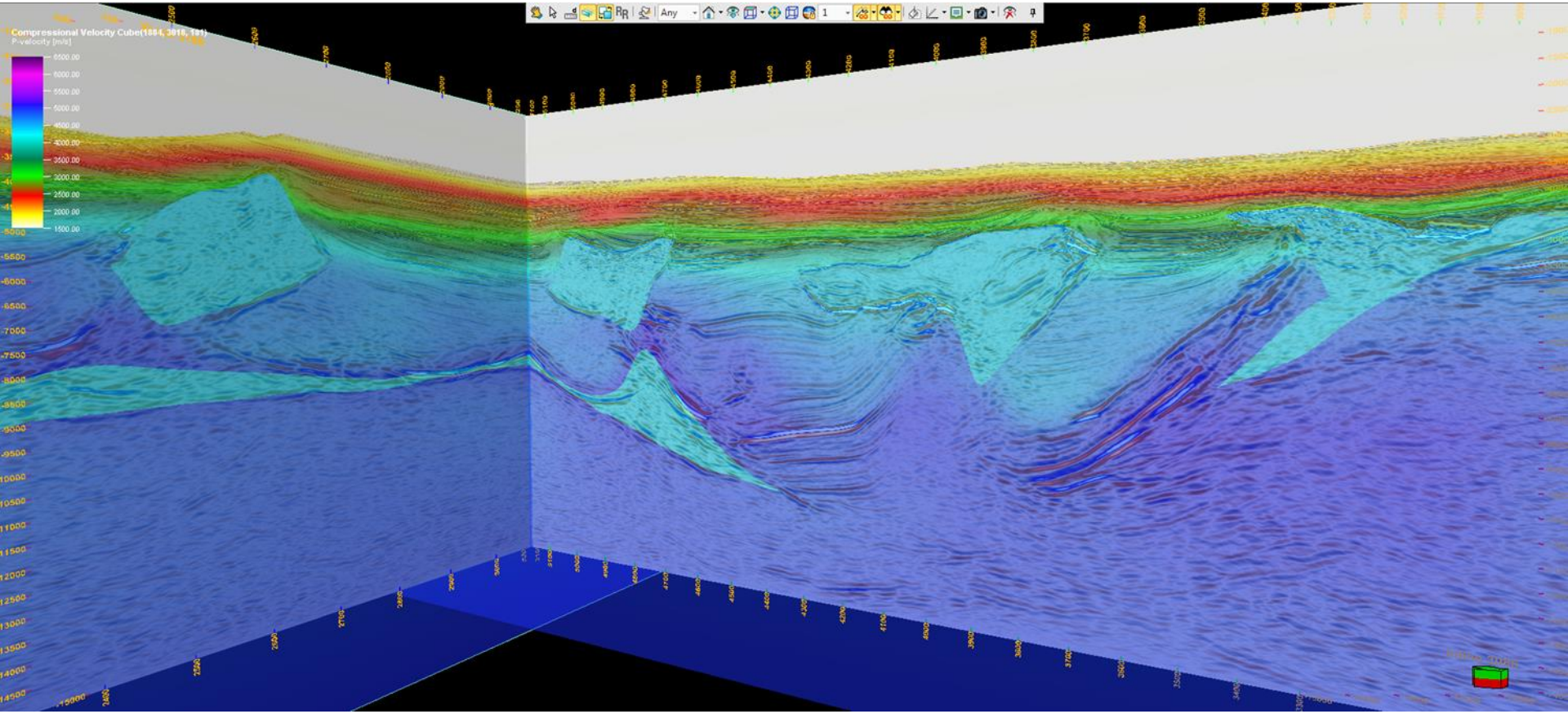
IL, XL – Tomo 8 Saltbody 1



Z scale 1

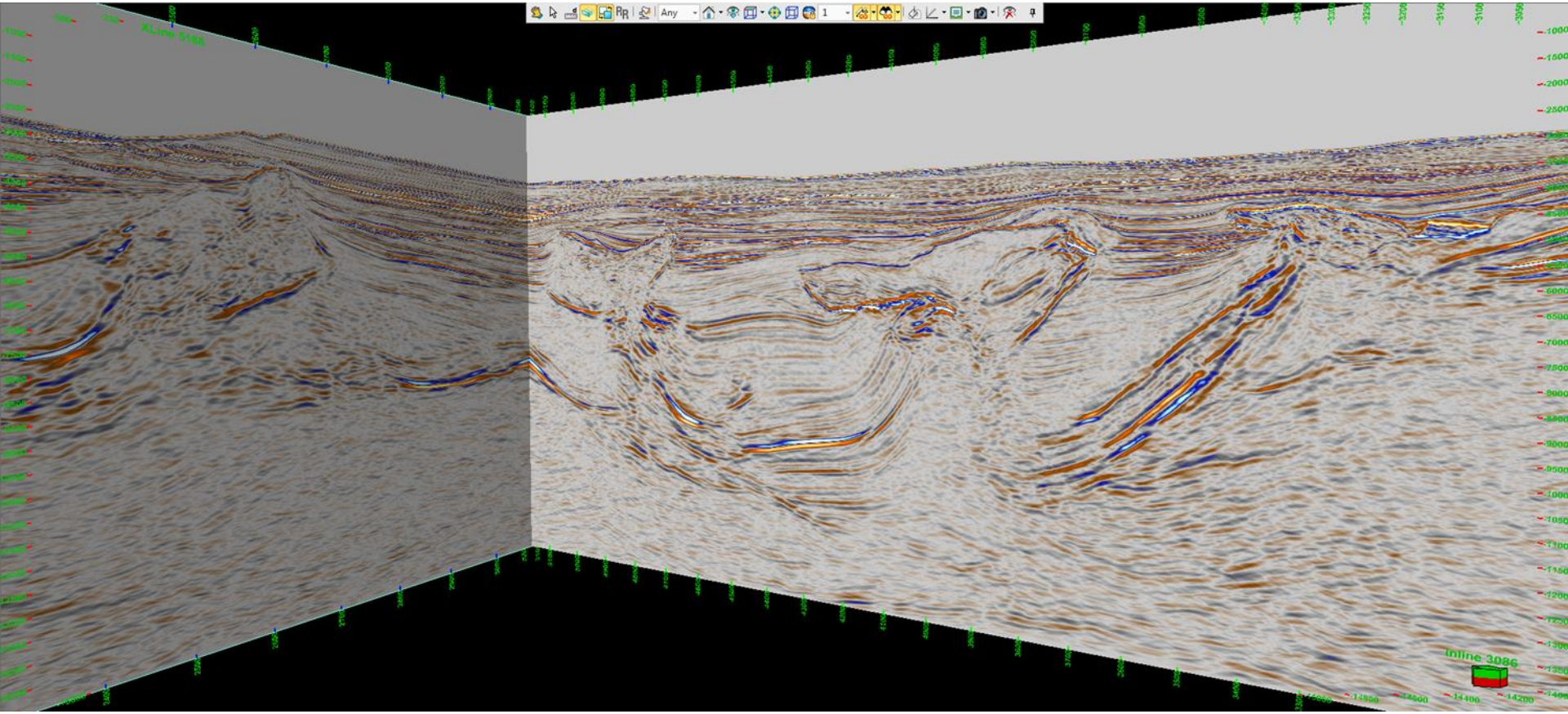
TTI update 11 - Salt Body 2 KDM

IL, XL – Final model



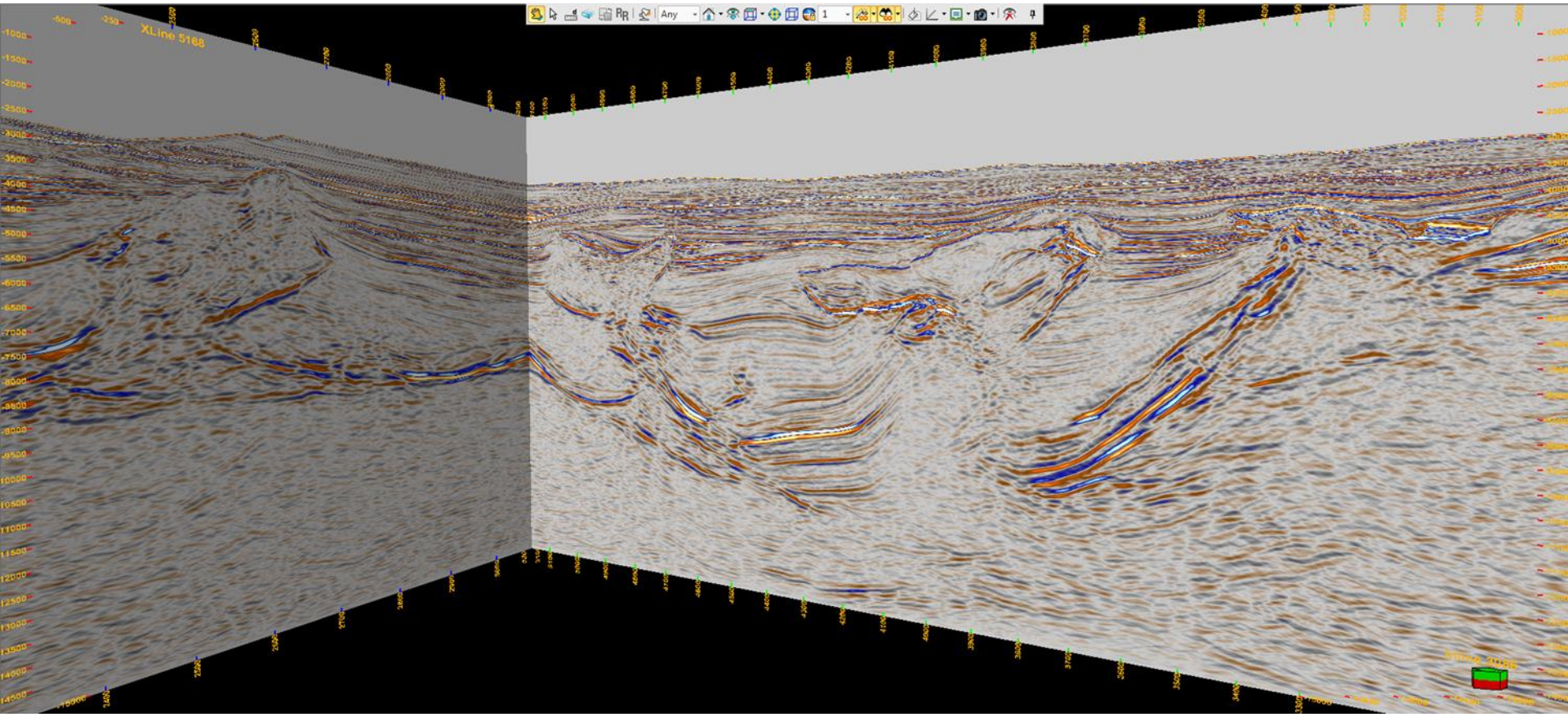
TTI update 8 - Salt Body 1 KDM

IL, XL – Tomo 8 Saltbody 1



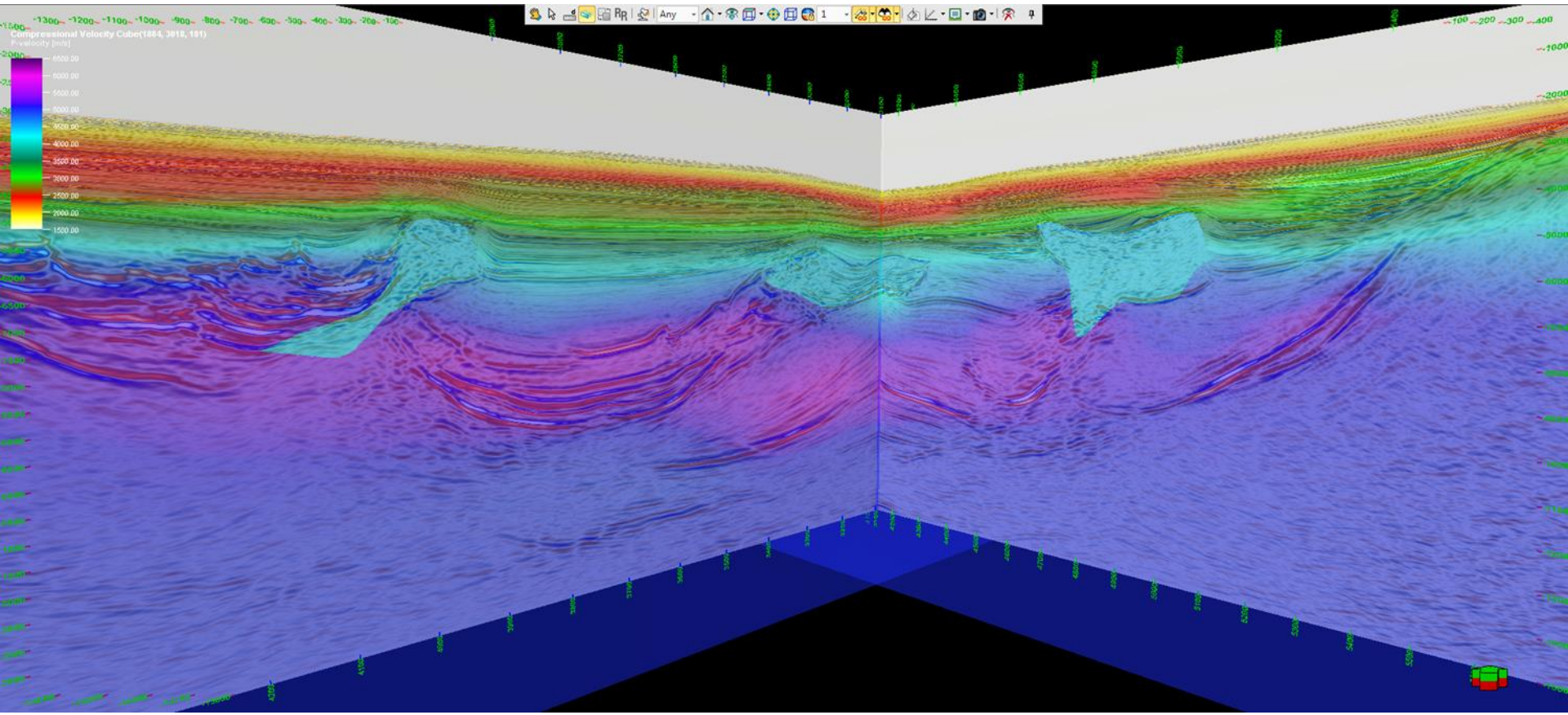
TTI update 11 - Salt Body 2 KDM

IL, XL – Final model



TTI update 8 - Salt Body 1 KDM

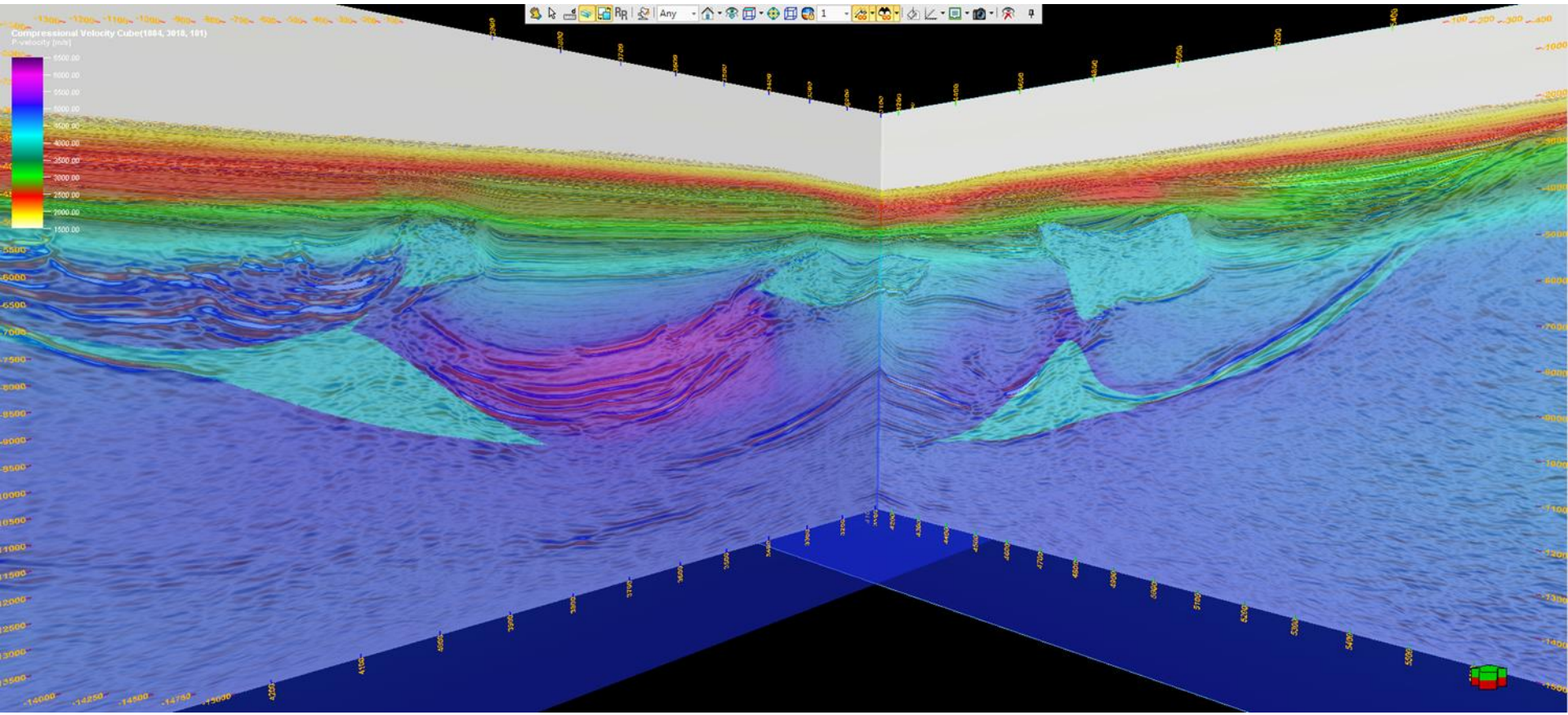
IL, XL – Tomo 8 Saltbody 1



Z scale 1

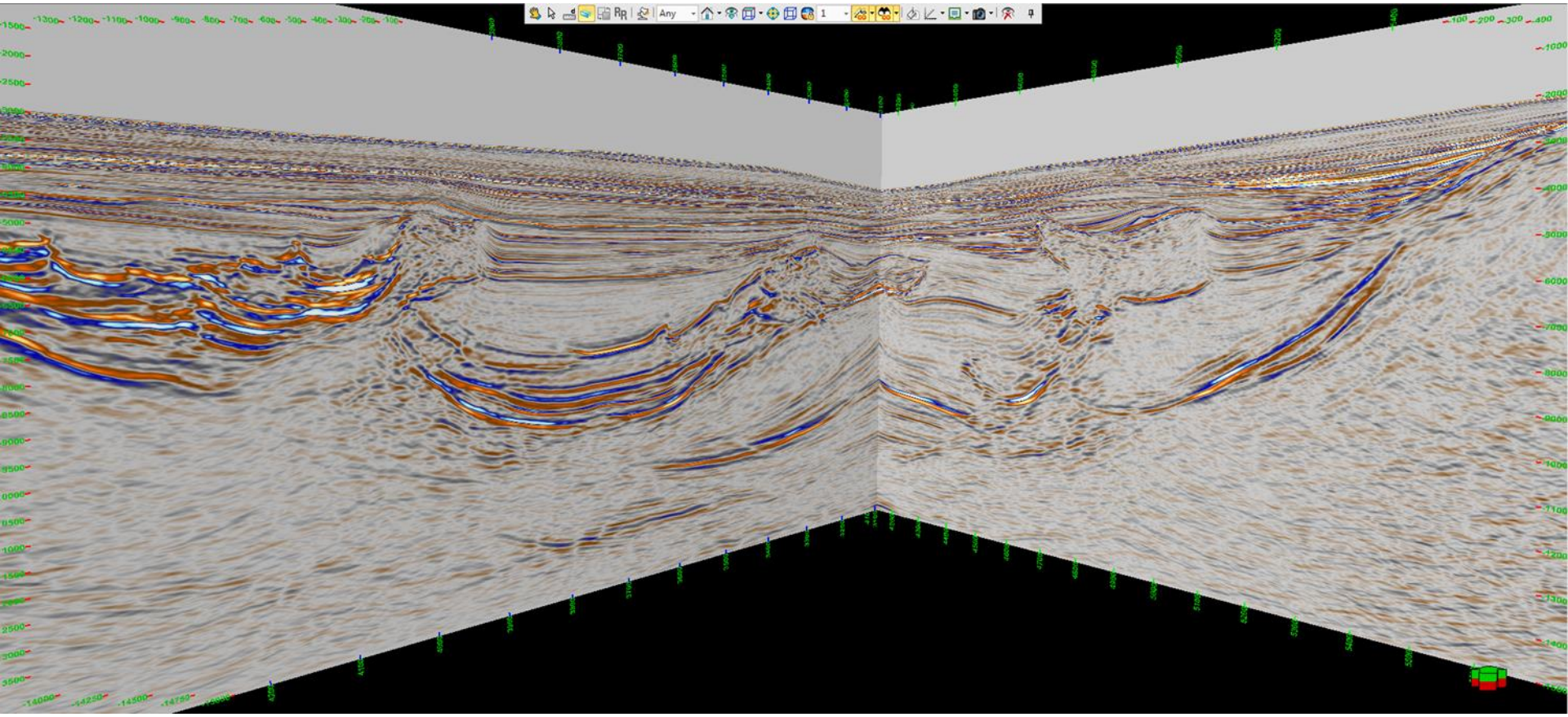
TTI update 11 - Salt Body 2 KDM

IL, XL – Final model



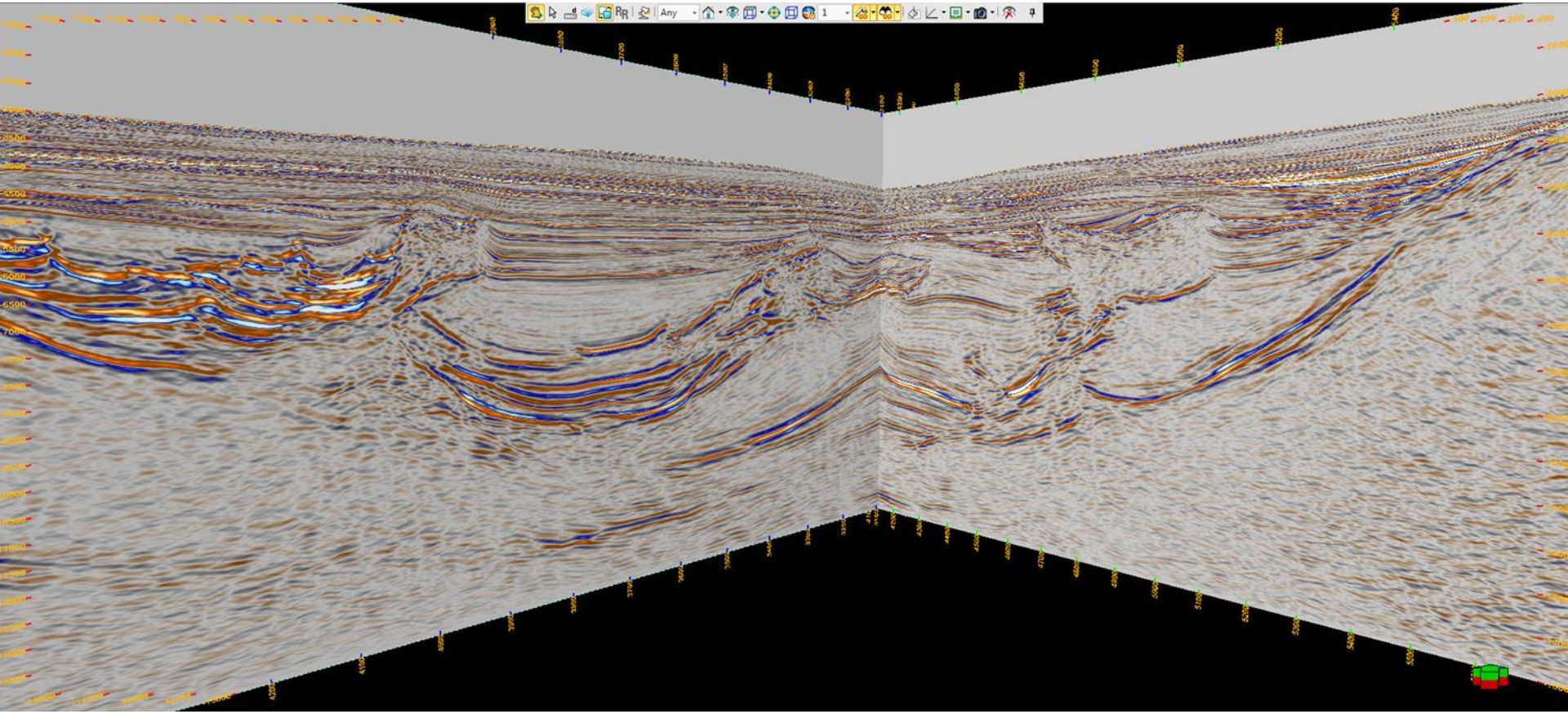
TTI update 8 - Salt Body 1 KDM

IL, XL – Tomo 8 Saltbody 1



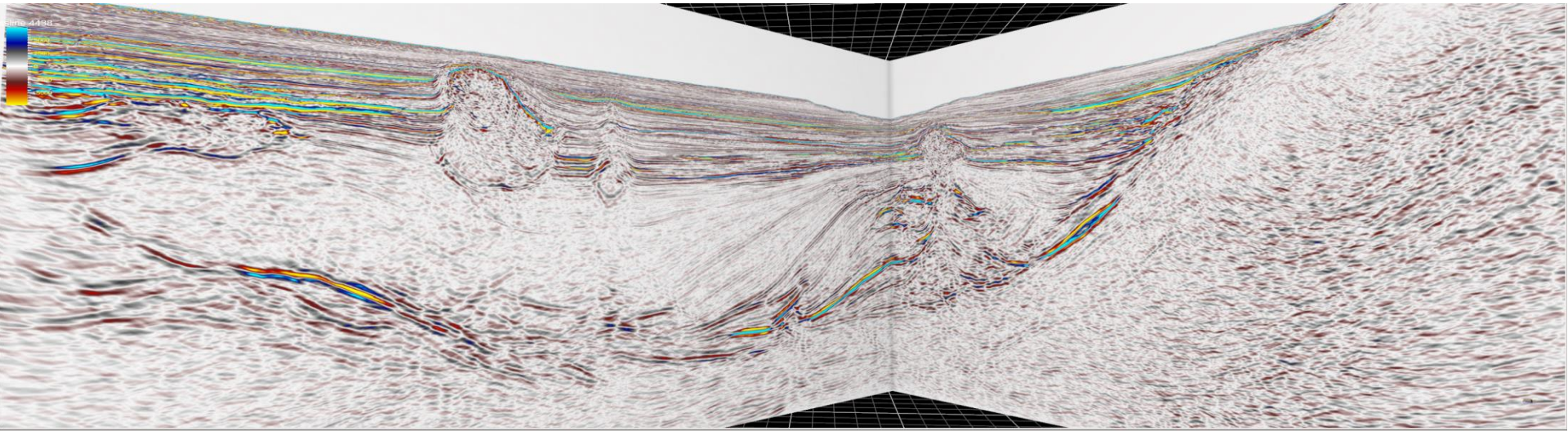
TTI update 11 - Salt Body 2 KDM

IL, XL – Final model



Conclusion

We have shown several imaging challenges characteristic of this North Atlantic, offshore Portugal seismic data . We have presented a velocity model building workflow for deep complex salt and carbonate geological settings where poorly constrained data driven approaches alone fail to provide stable results. Rather than hardly imposing strong velocity contrast like for the salt, the interpretation is used at depth, where high level of uncertainty exist, to guide the velocity trends, improve the seismic input and provide soft constrains for subsequent data driven methods. The salt and fast layer geometries, the resolution and stability of the velocity model are improved, thus leading to a better and more reliable final image helping de-risking prospects.



Acknowledgement

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