



# FWI Preparation

## NZ 3D Processing

*14 October 2020*

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Passion for Geoscience

- **Objective:**

To evaluate FWI initial model and wavelet.

- **Procedure:**

Initial depth velocity model was converted and smoothed from legacy time RMS model. This is used for FWI synthetic shot modelling.

FWI synthetic shot data is compared with real shot data for both streamer and OBN survey to evaluate the initial model.

- **Display:**

Initial velocity, source wavelet, and FWI synthetic.

- **Observation and Recommendation:**

The water velocity of the initial model is quite reasonable. At some places the velocity just beneath sea floor may be too fast.

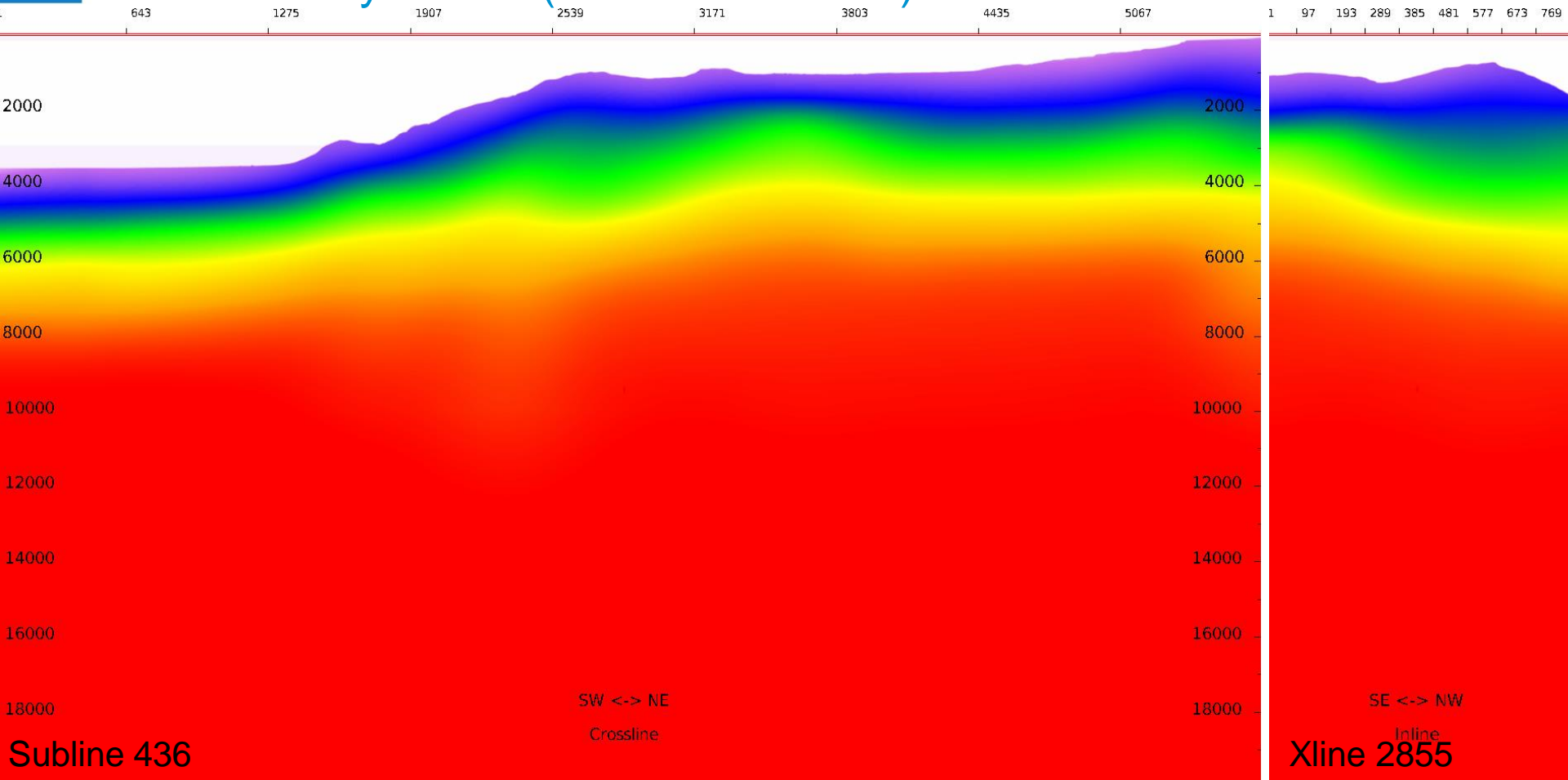
Current OBN data seems to have recording issues. The shape of the wavelet from real data does not match with synthetic data.



# Initial Velocity Model



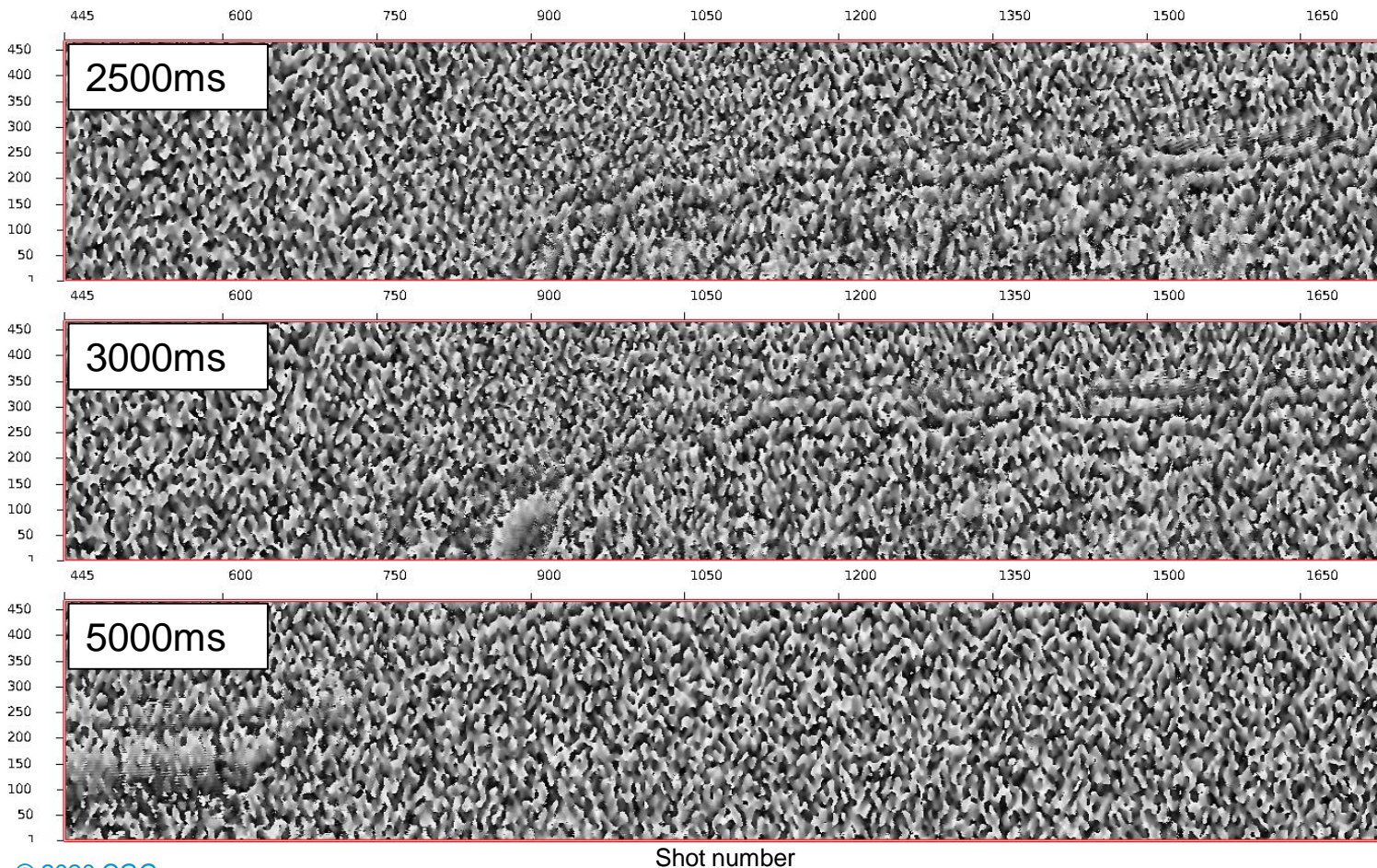
# Initial Velocity Model (12.5m x 18.75m)



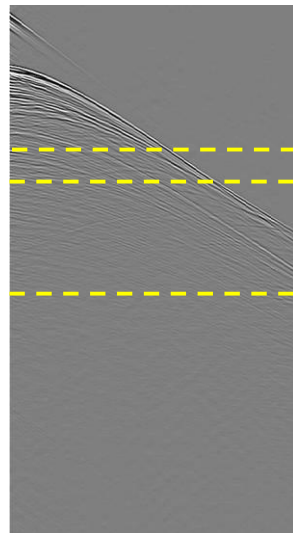


# Seq 018 Gun 1 Cable 2 Phase Time Slice: 2.0Hz

5



- Noise is dominate below 2 Hz.
- It is not recommended to start FWI at this frequency.

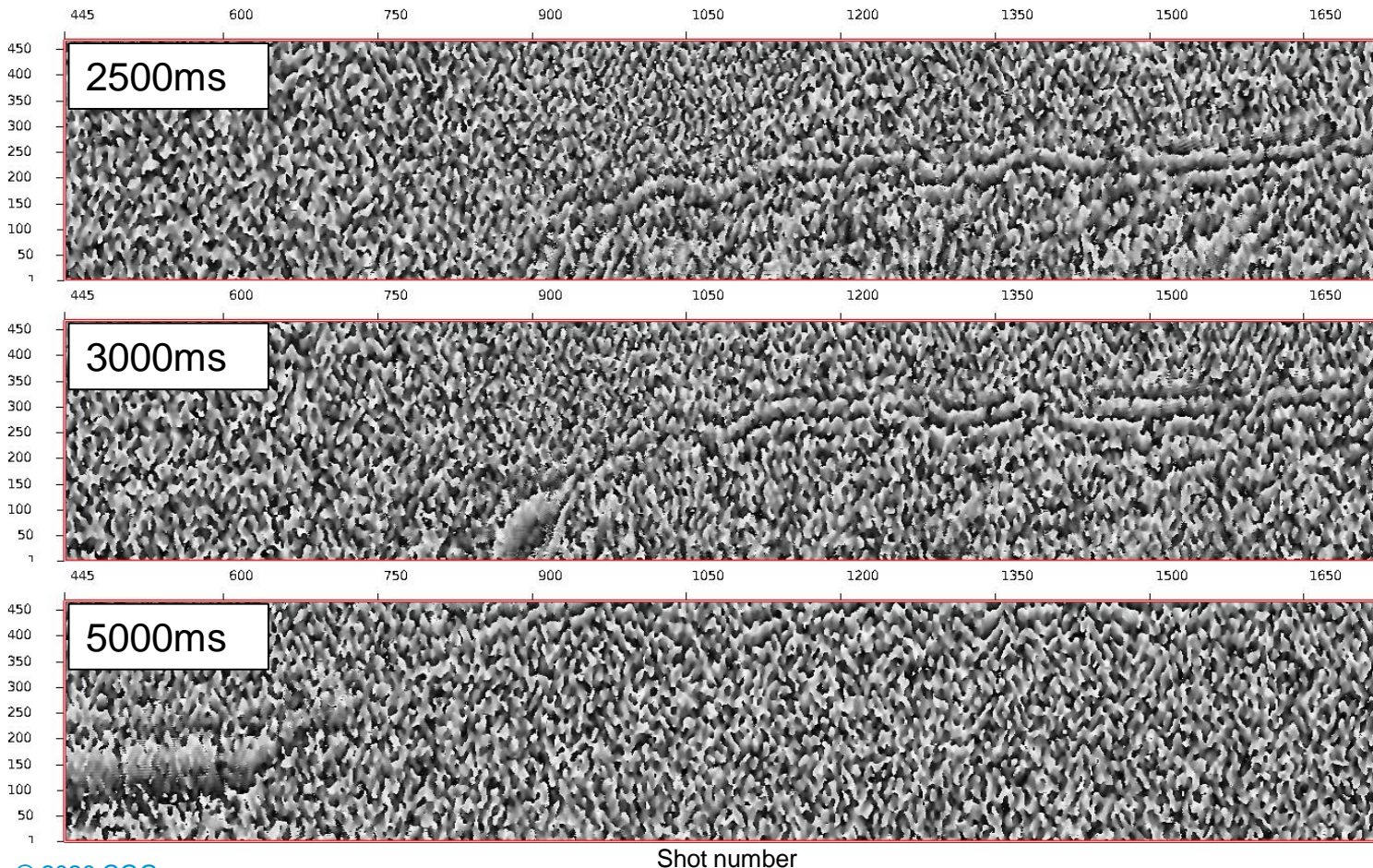






# Seq 018 Gun 1 Cable 2 Phase Time Slice: 2.5Hz

6



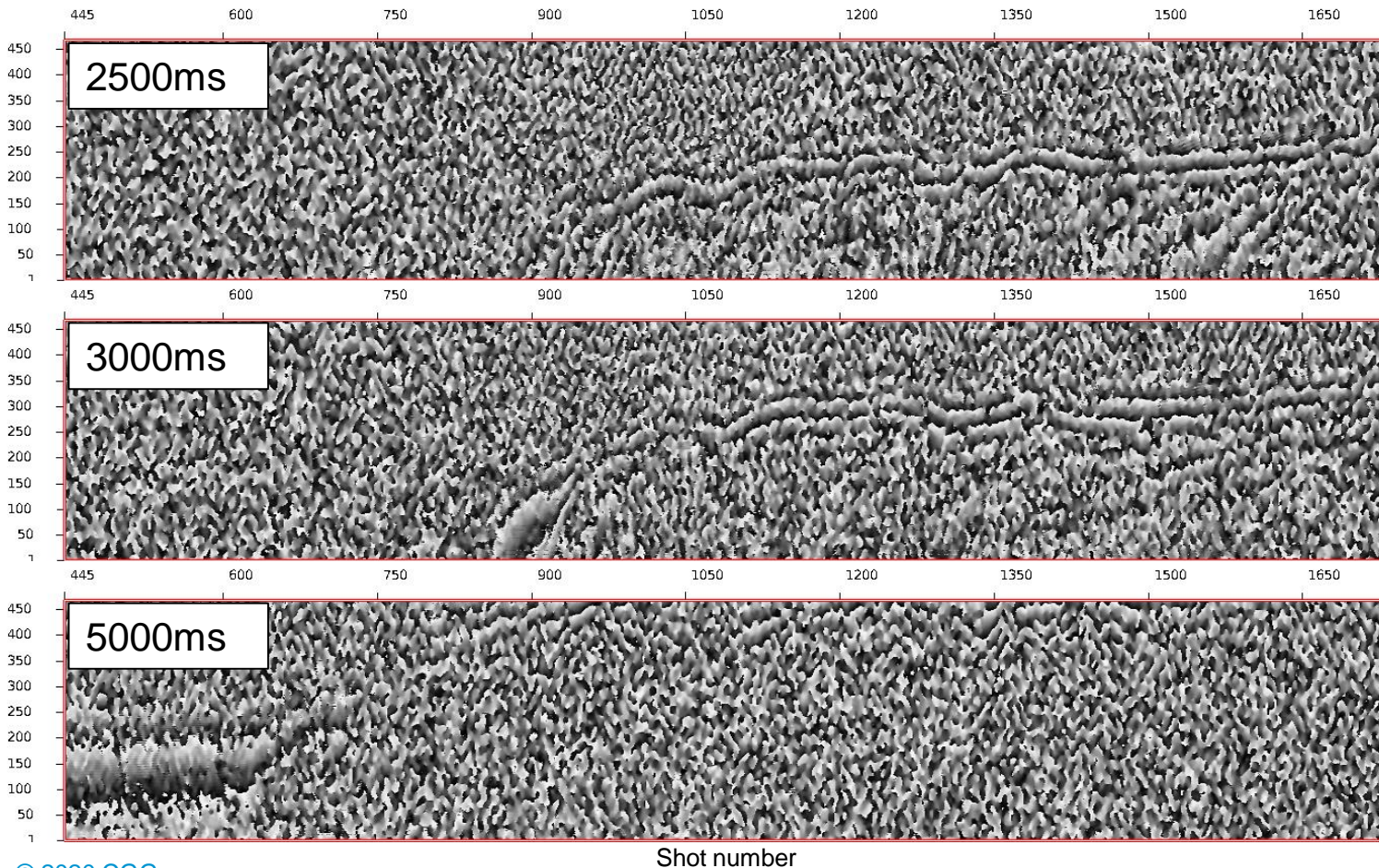
- Continuous signal appears at 2.5 Hz
- It is recommended to start FWI at this frequency.





# Seq 018 Gun 1 Cable 2 Phase Time Slice: 3.0Hz

7



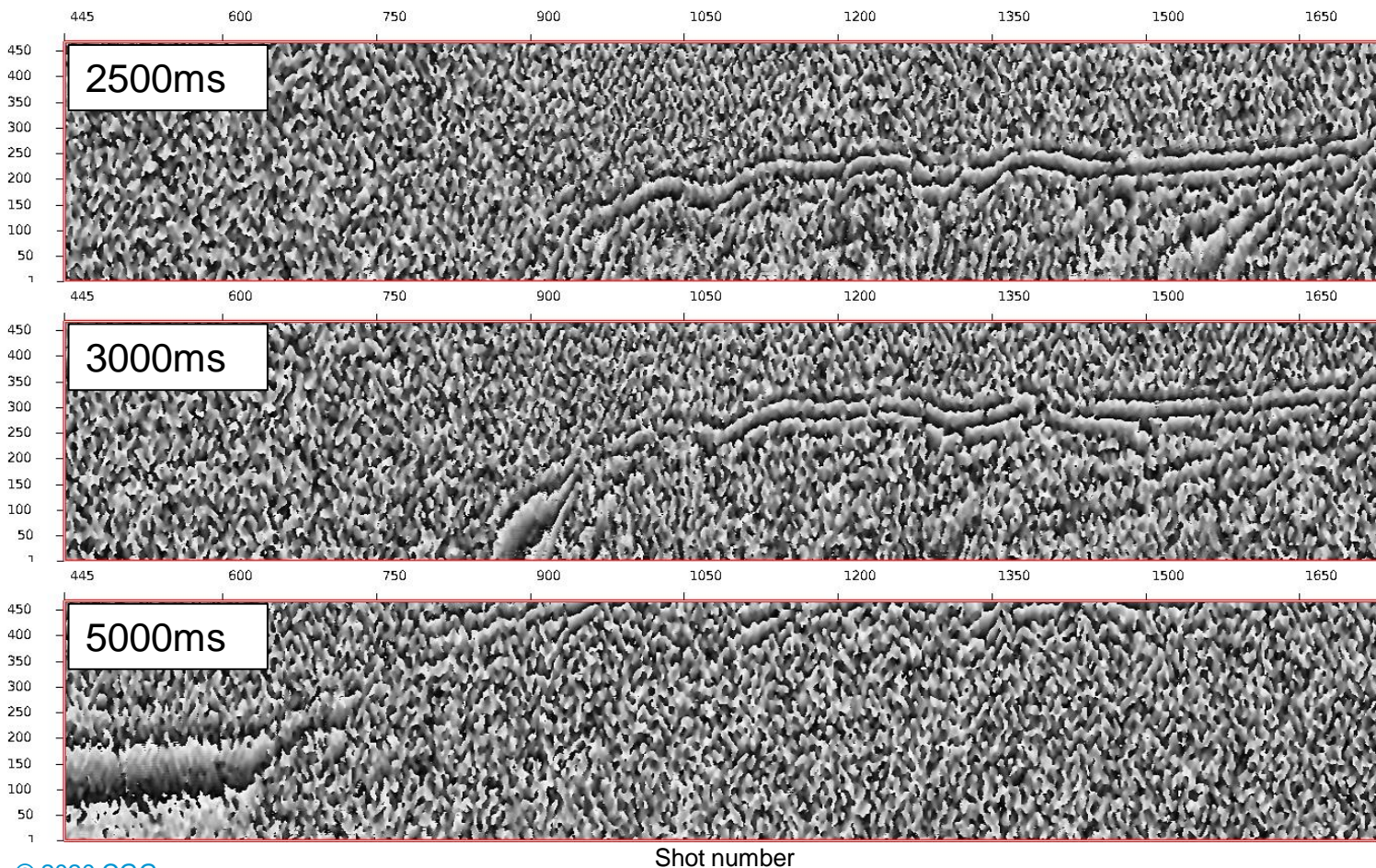
- More continuous signal appears at 3 Hz.





# Seq 018 Gun 1 Cable 2 Phase Time Slice: 3.5Hz

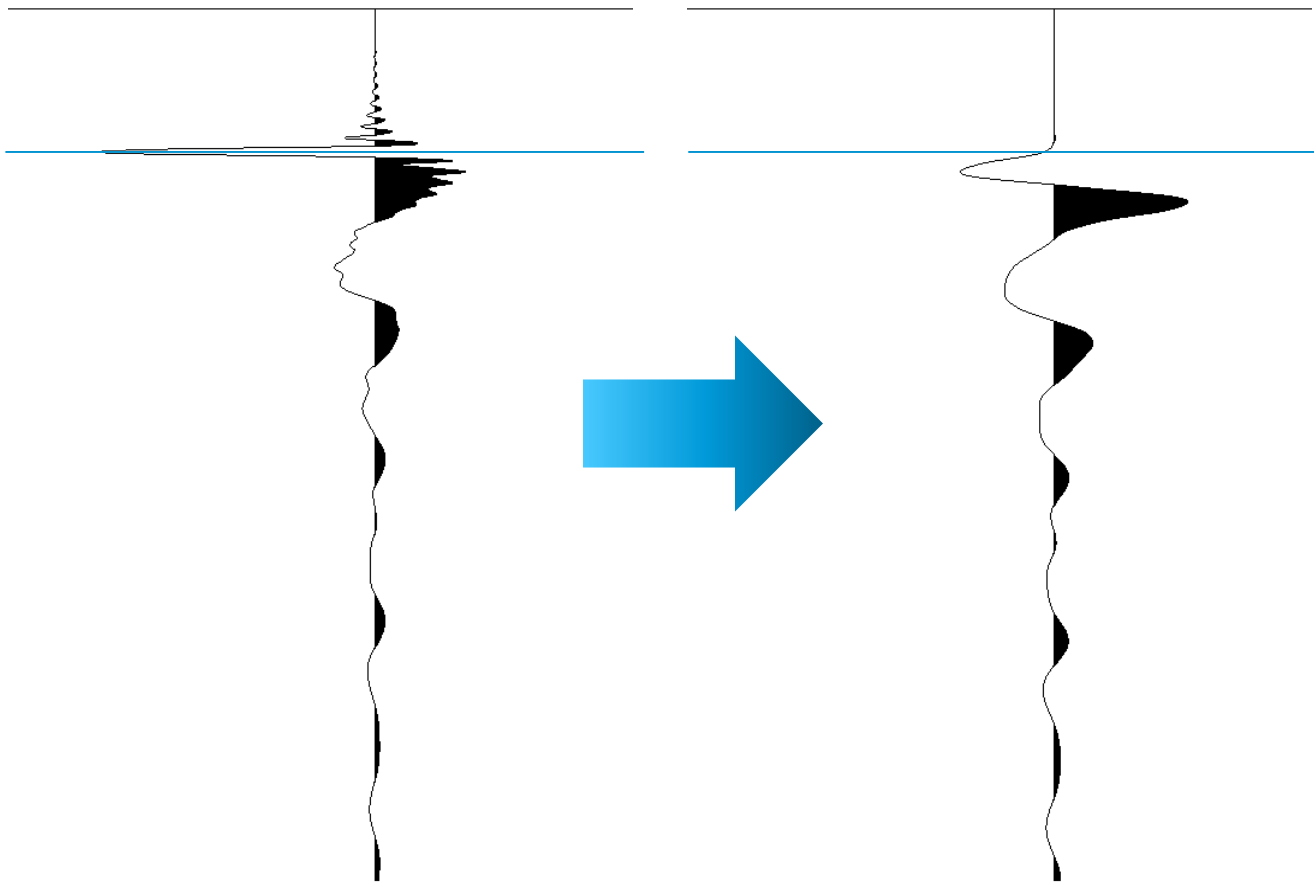
8



- More continuous signal appears at 3 Hz.

# FWI Synthetic VS Real Data Streamer



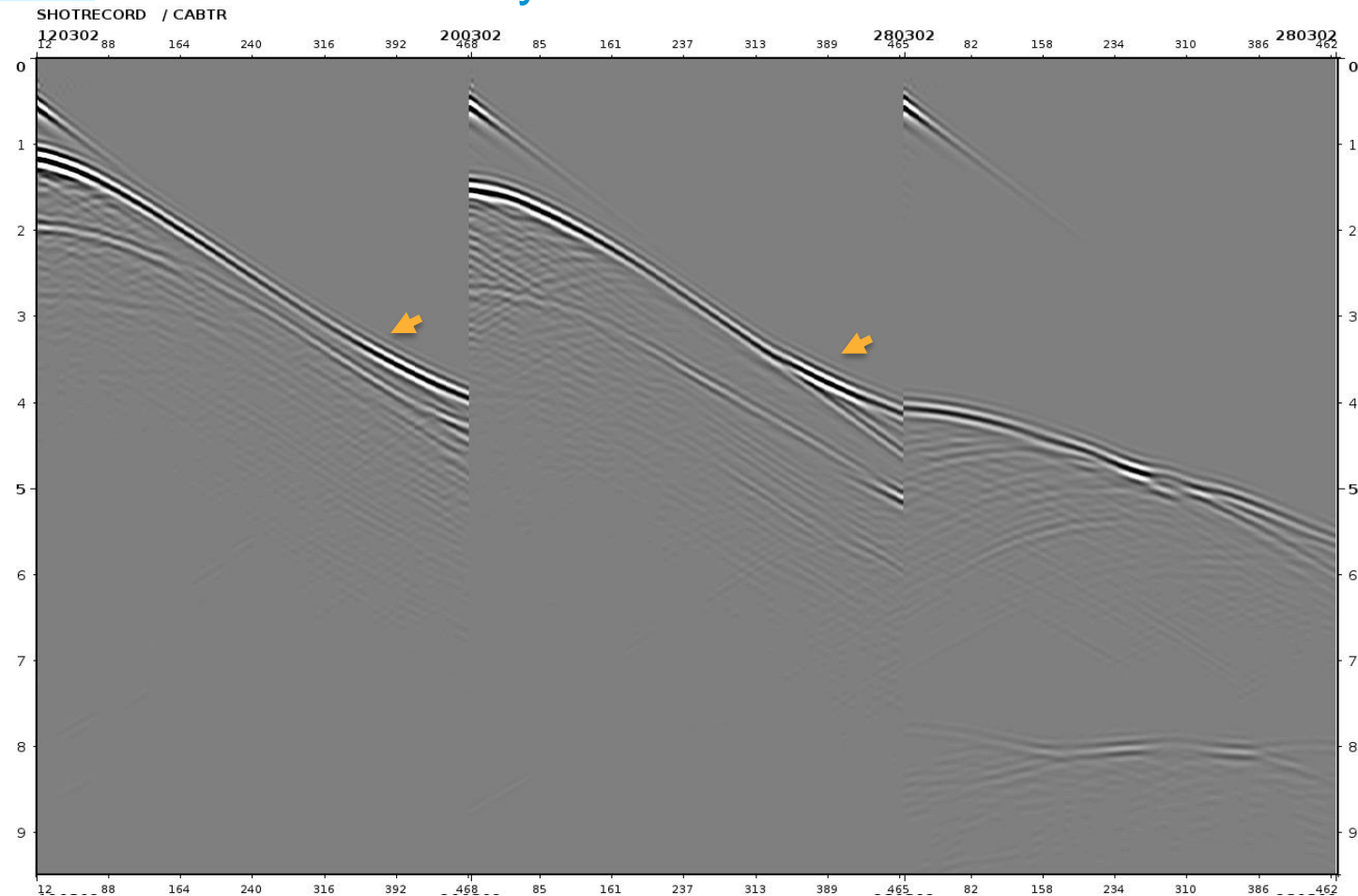


- A 20 Hz (40 dB/Oct) minimum phase filter is applied to both source wavelet and seismic data for FWI synthetic and inversion.



# Streamer: FWI Synthetic Data

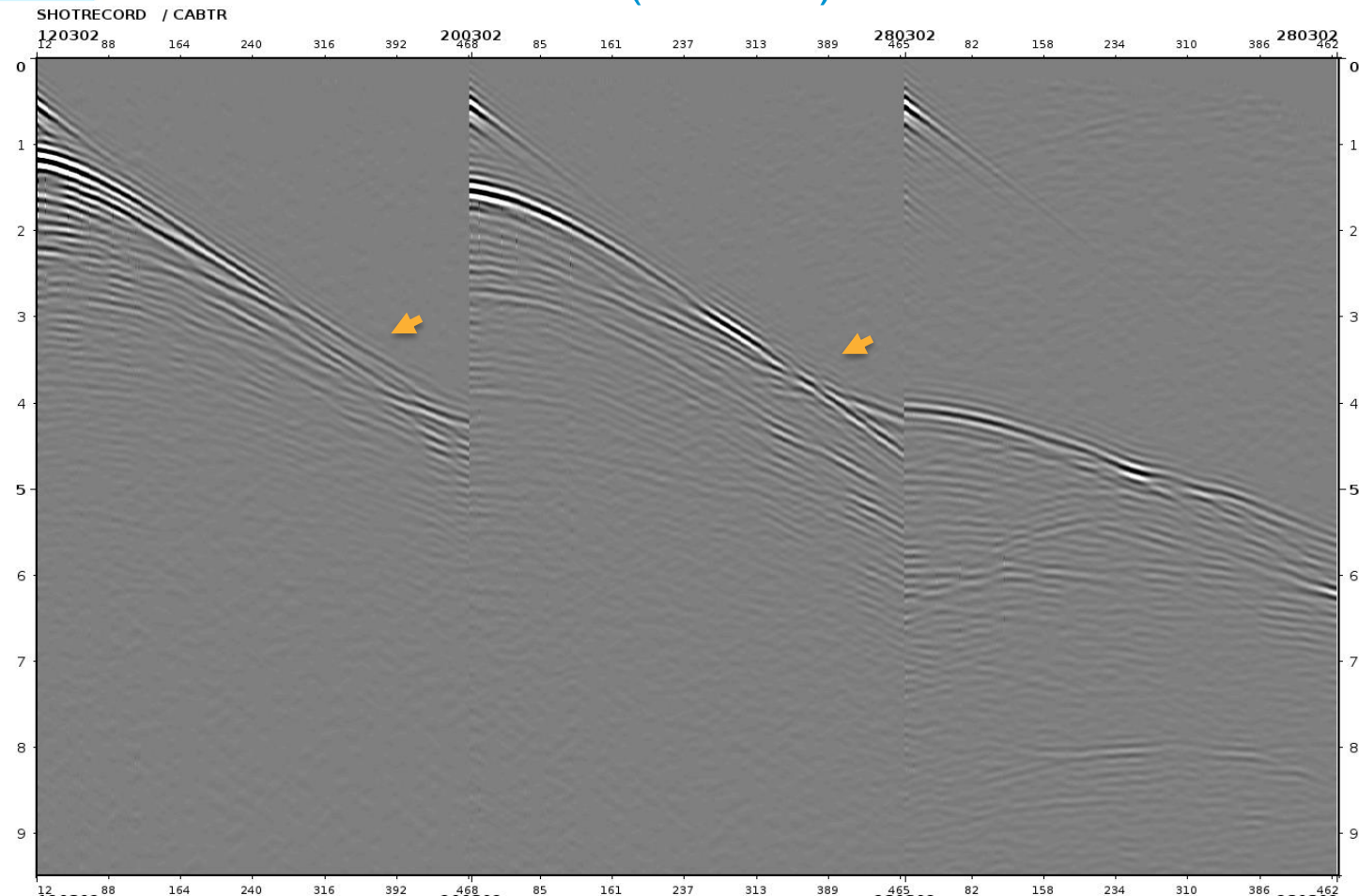
11



- FWI Synthetic shots generated up to 10 Hz.

# Streamer: Real Data (<10 Hz)

12



- Synthetic and read data have a good match around water bottom reflection.
- Differences are observed in the diving wave zone indicating velocity errors in the initial model.



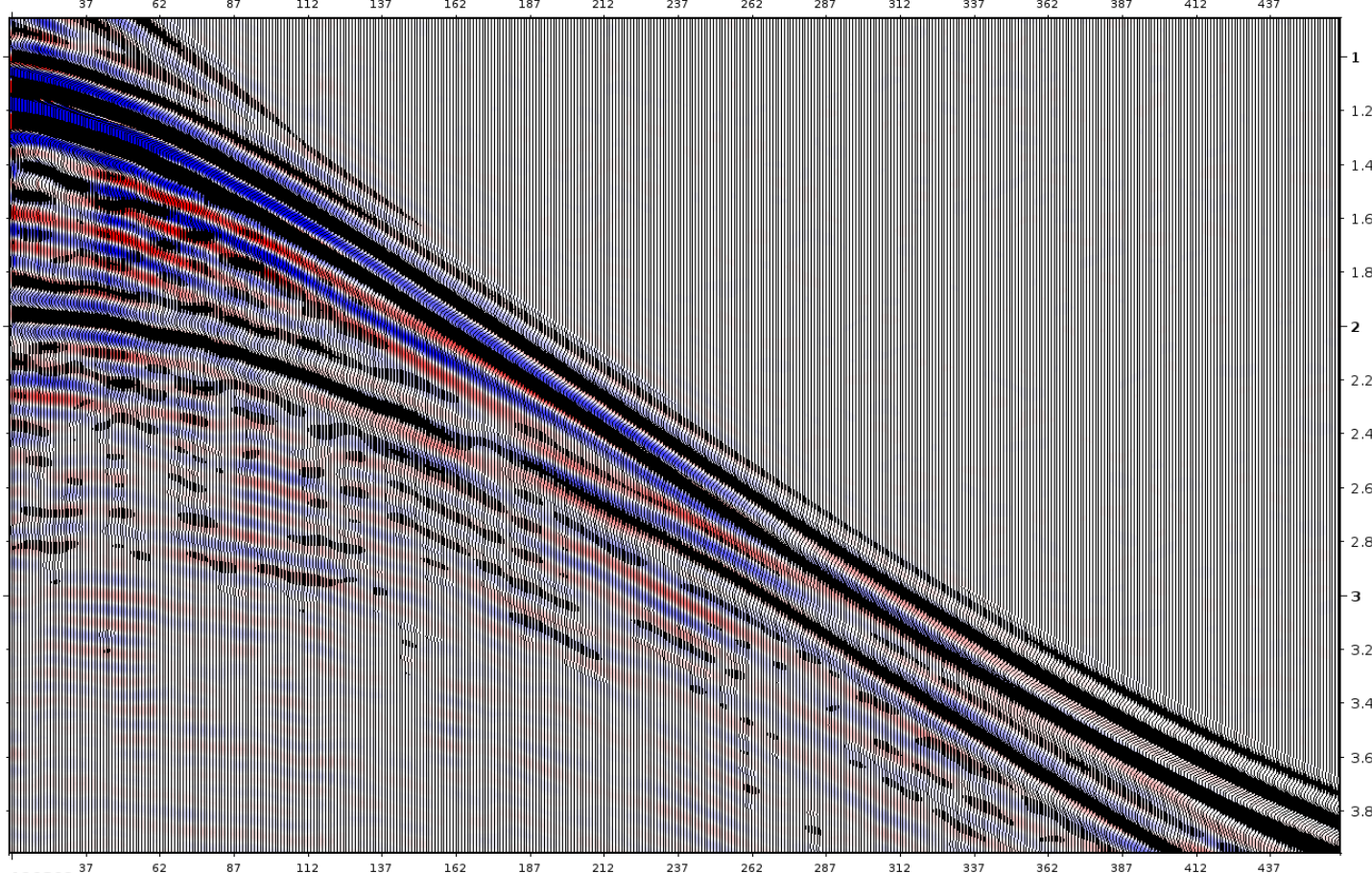


# Streamer Shallow: FWI Synthetic Overlay on Real

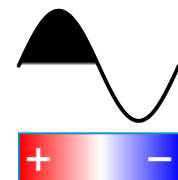
13

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120302



- Synthetic and read data have a good match around water bottom reflection.
- Differences are observed in the diving wave zone indicating velocity errors in the initial model.

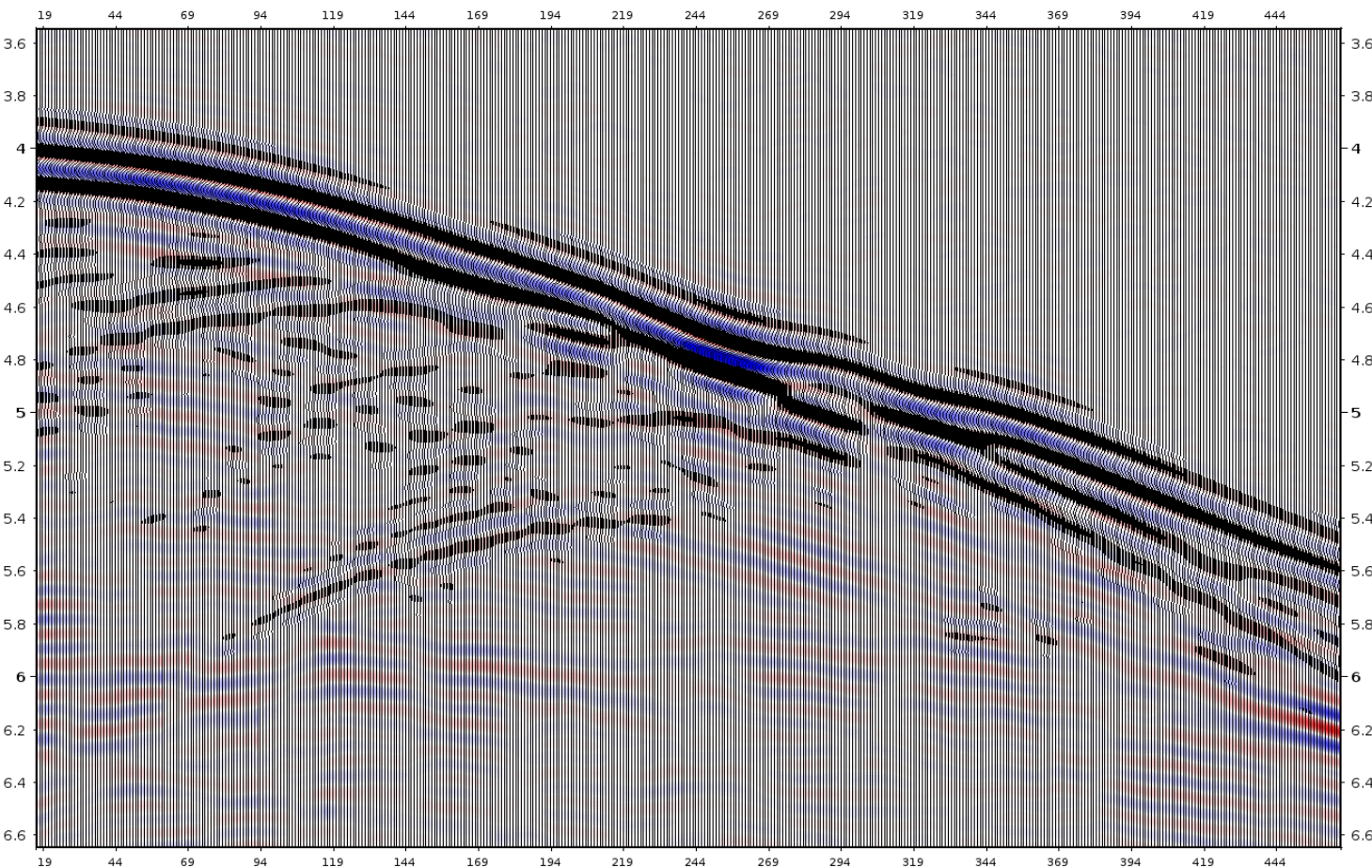




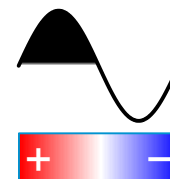
# Streamer Deep Water: FWI Synthetic Overlay on Real

14

SHOTRECORD / CABTR



- In the deep water area, no clear diving wave energy is recorded due to limited cable length.
- Water bottom reflection energy of synthetic data matches with that of real data, indicating a good water velocity in the initial model.

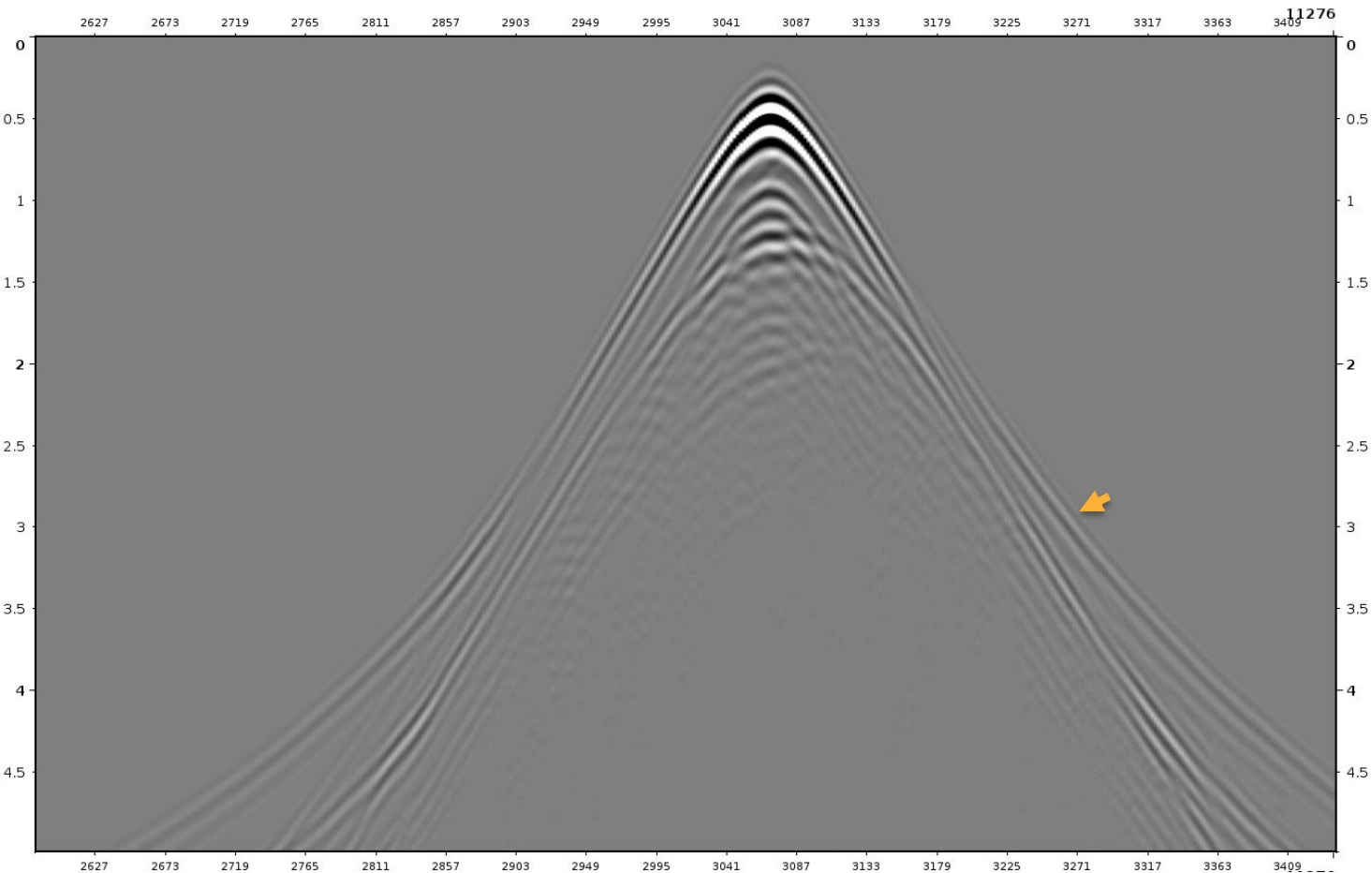


# FWI Synthetic VS Real Data Streamer





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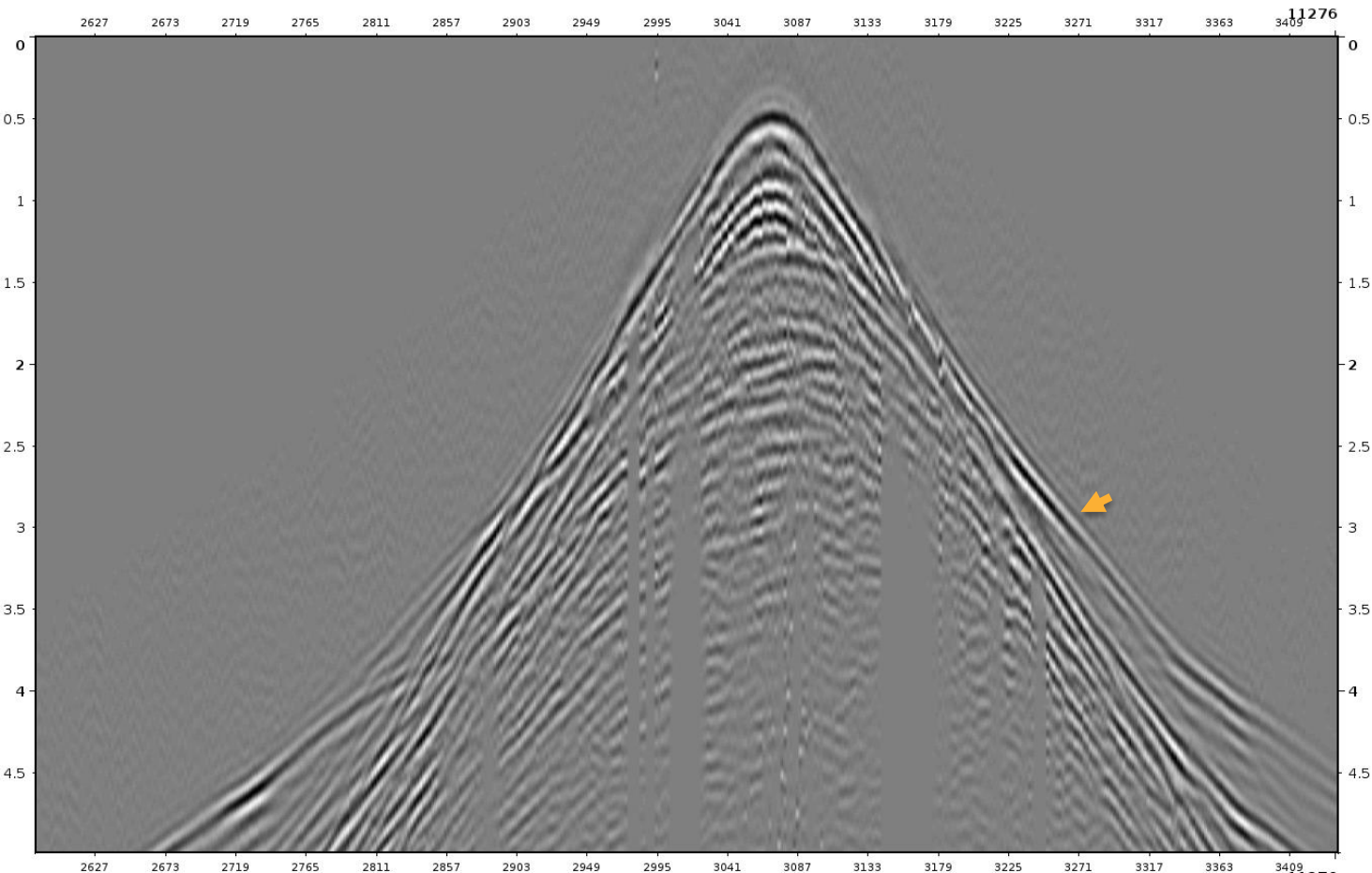
- FWI Synthetic data generated up to 10 Hz.



# OBS: Real Data (< 10 Hz)

17

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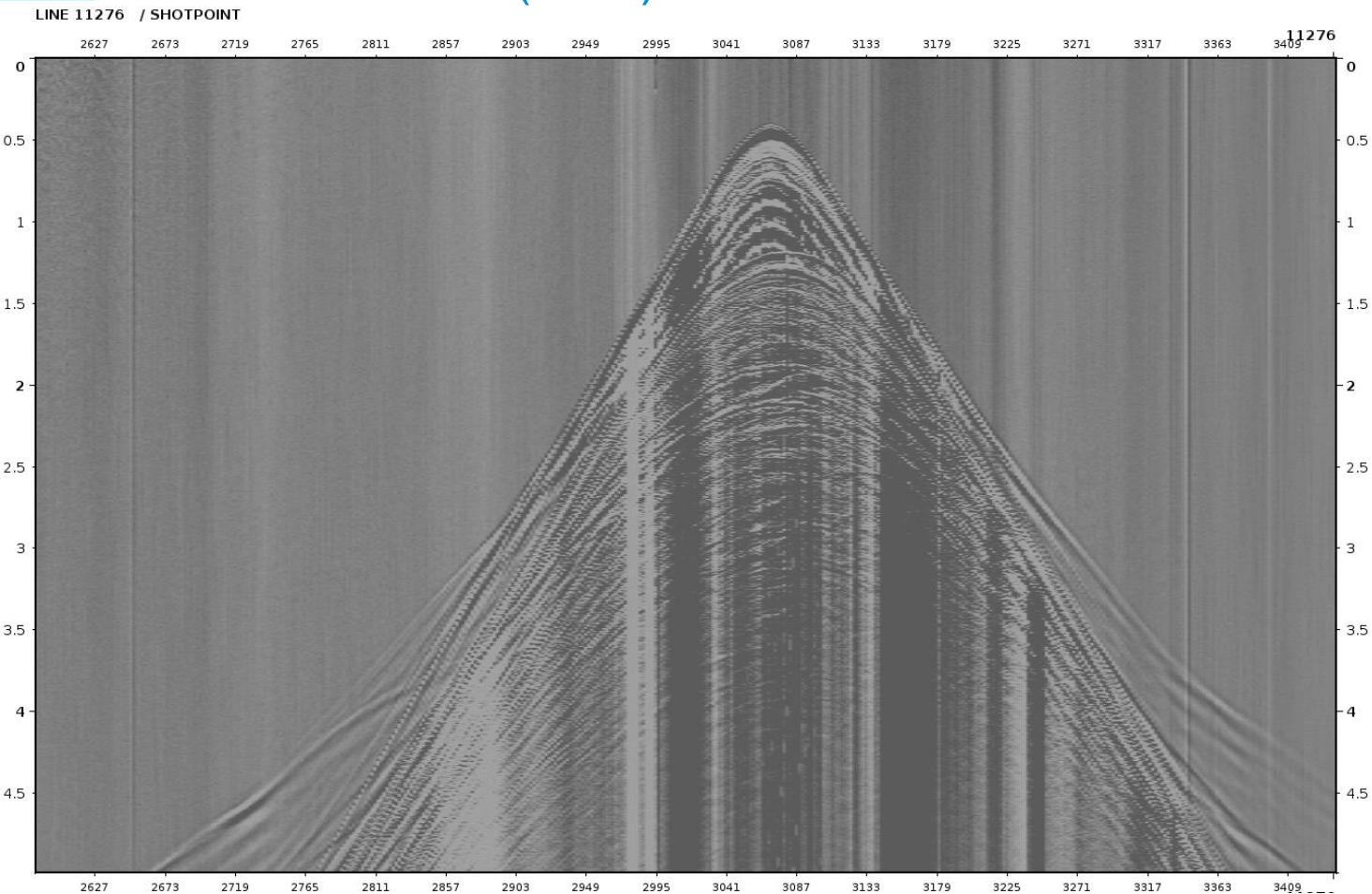
- Compared with FWI synthetic data, the real data matches at a few places (Orange Arrow).
- The shape of wavelets do not match between synthetic and real data.





# OBS: Real Data (Raw)

18



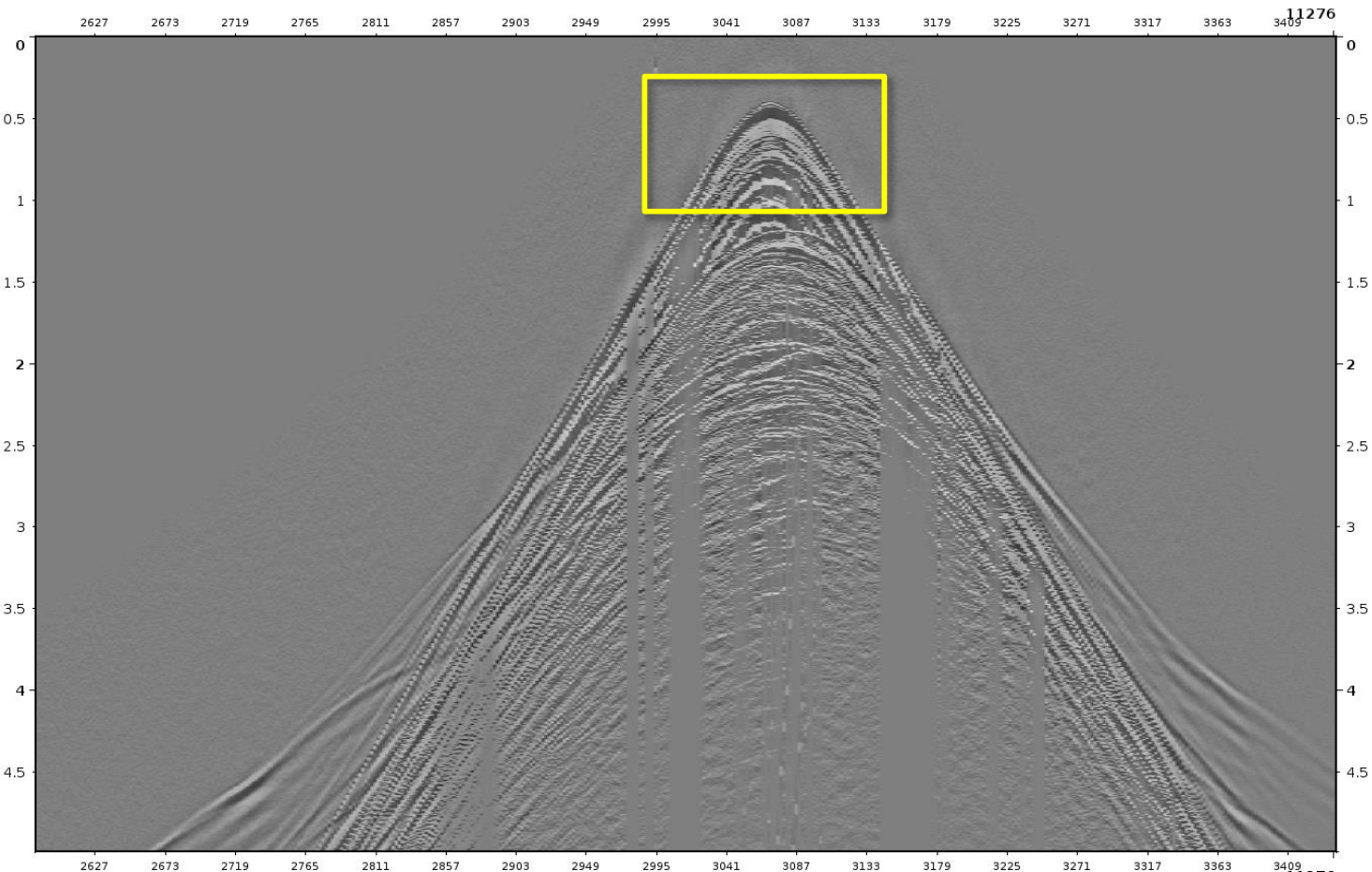
- The color of the raw data seems gray and is not similar with normal seismic data.



# OBS: Real Data (>2 Hz)

19

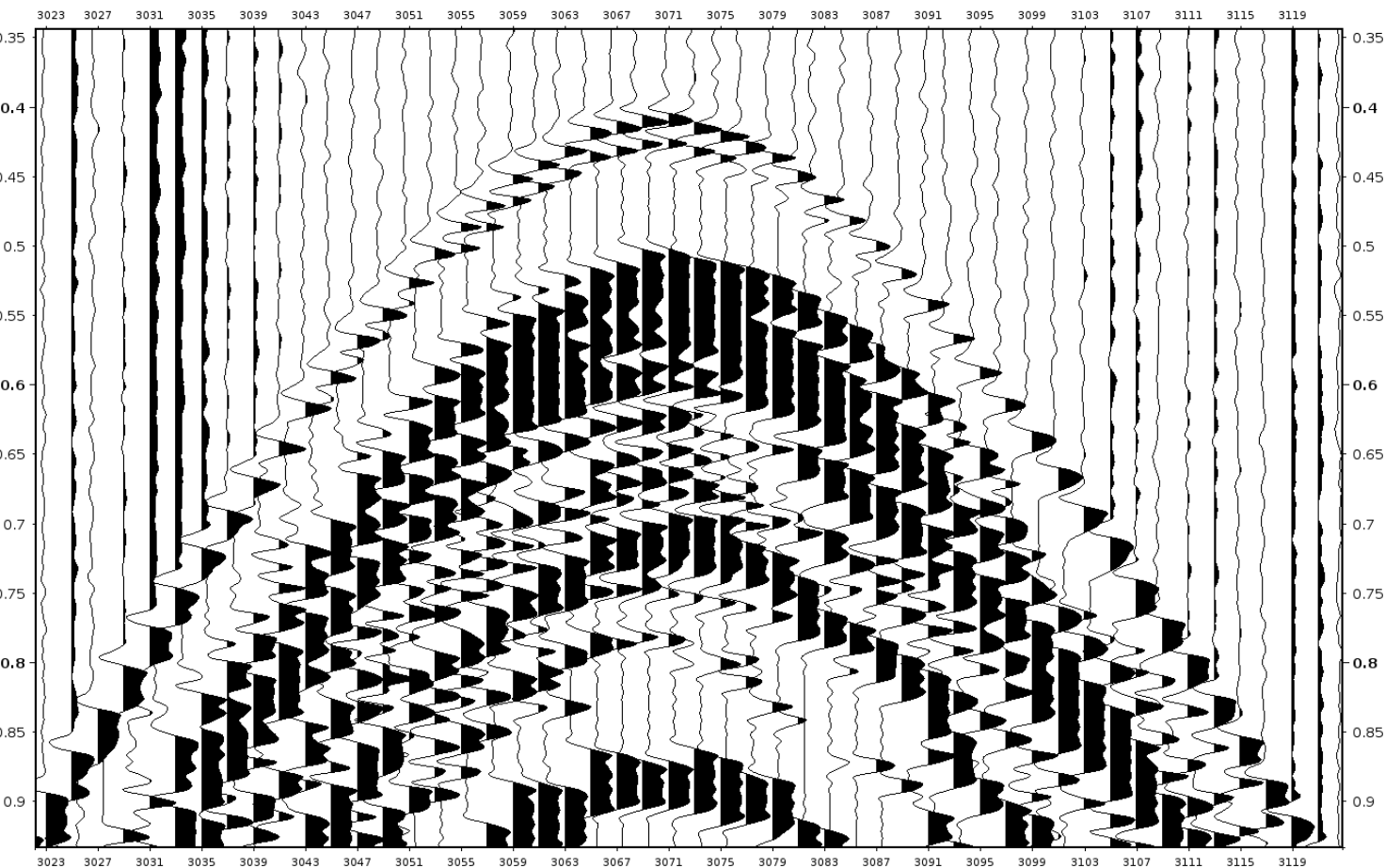
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- After 2 Hz low cut filter, removing DC noise, the color remains abnormal.



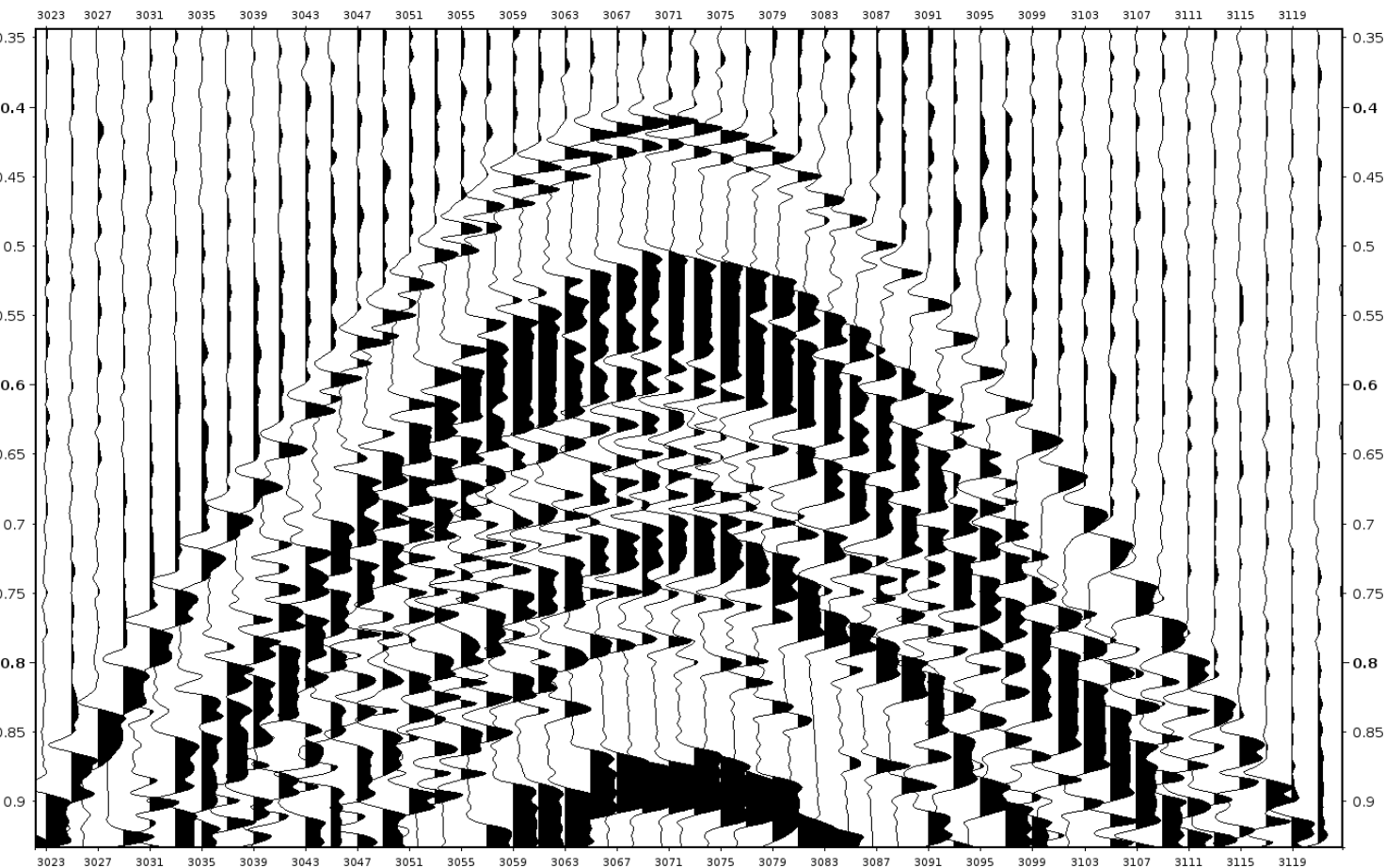
LINE 11276 / SHOTPOINT



- The first break energy is recorded as a trough, and followed by the ghost peak. This observation is consistent with streamer data.
- Below the first break, there's around 50ms of negative values that remains almost the same, followed by 50ms of positive with almost same value. This is not normal.



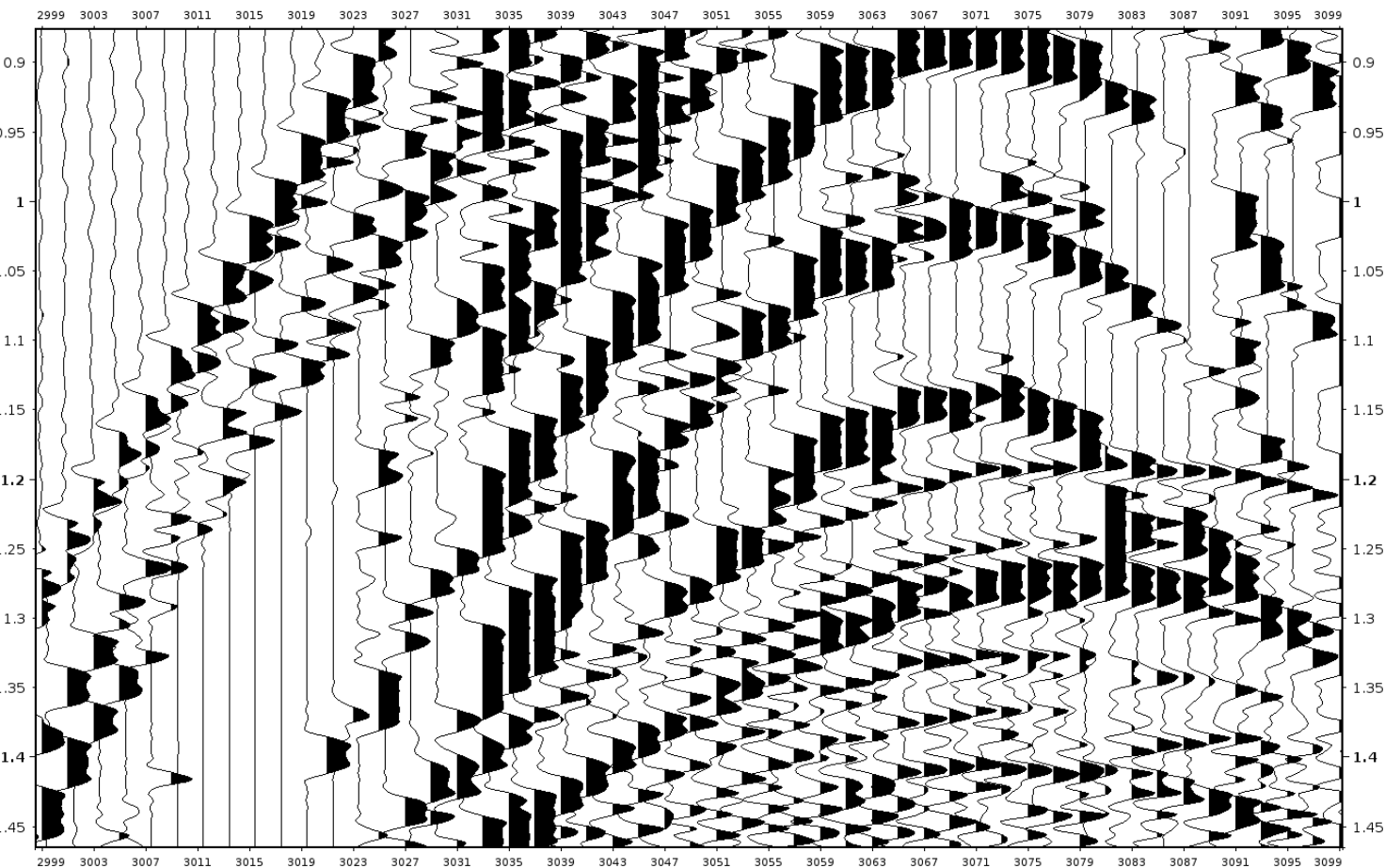
LINE 11276 / SHOTPOINT



- The first break energy is recorded as a trough, and followed by the ghost peak. This observation is consistent with streamer data.
- Below the first break, there's around 50ms of negative values that remains almost the same, followed by 50ms of positive with almost same value. This is not normal.



LINE 11276 / SHOTPOINT

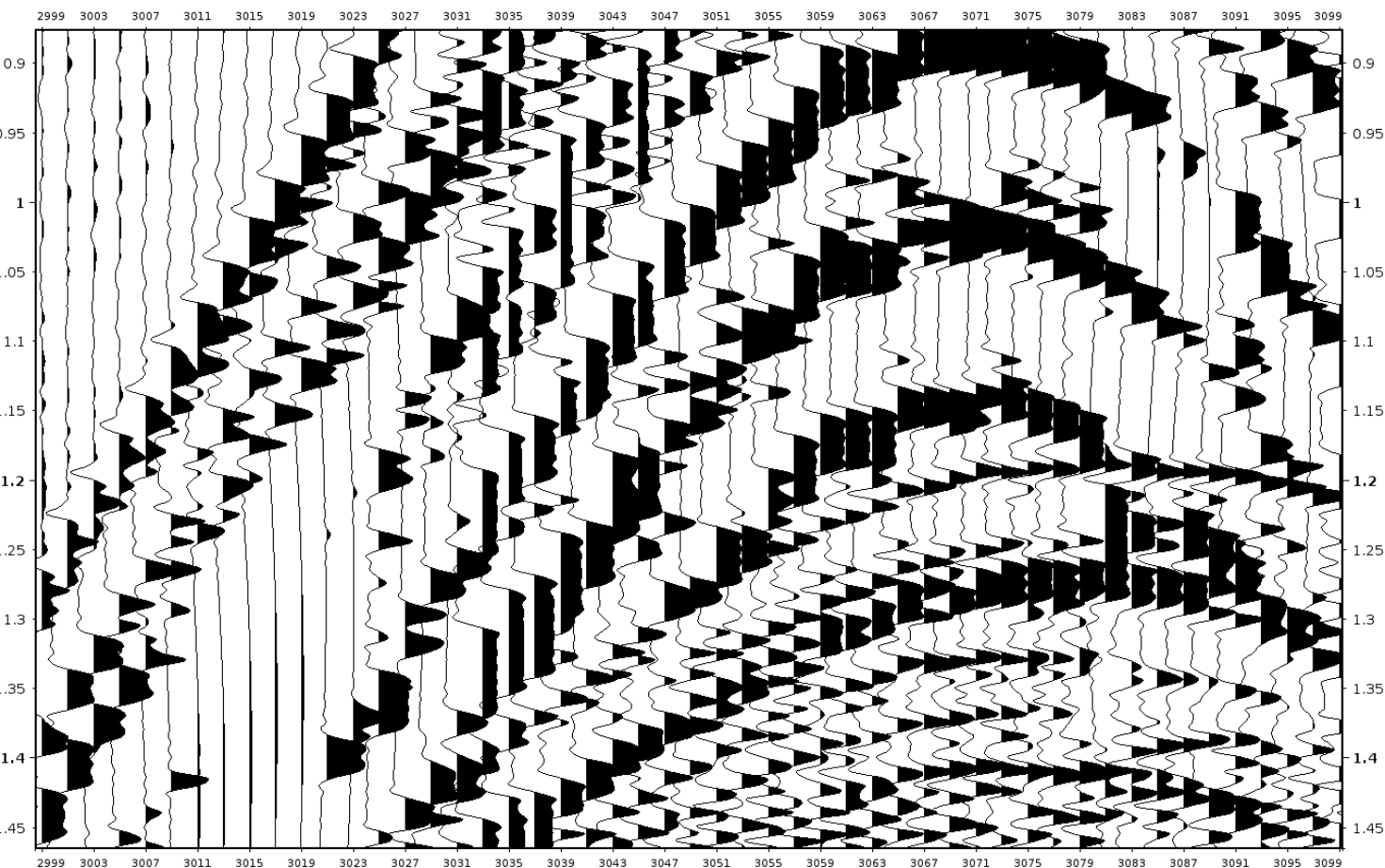


- Similar observation can be found elsewhere, where the “constant” values extend a much longer period.





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- Similar observation can be found elsewhere, where the “constant” values extend a much longer period.

- The shape of the wavelet is one of the key components for FWI inversion.
- FWI synthetic data matches well with streamer data around water bottom, indication a reasonable water velocity in the initial model.
- FWI synthetic data does not match well with OBS data around water bottom.
- The OBS data shows abnormal recordings that will affect the FWI.



# Isotropic FWI

## NZ 3D Processing

*28 October 2020*

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- **Objective:**

To QC isotropic (ISO) FWI result.

- **Procedure:**

Isotropic FWI was run with both streamer and OBS data from 2.5 Hz to 7Hz. Only refraction energy is used in the velocity inversion. For OBS data, a mute is applied to exclude the data that is affected by the recording issue.

To evaluate the result, a depth migration volume was generated using data after low cut filter.

- **Display:**

Velocity and FWI synthetic.

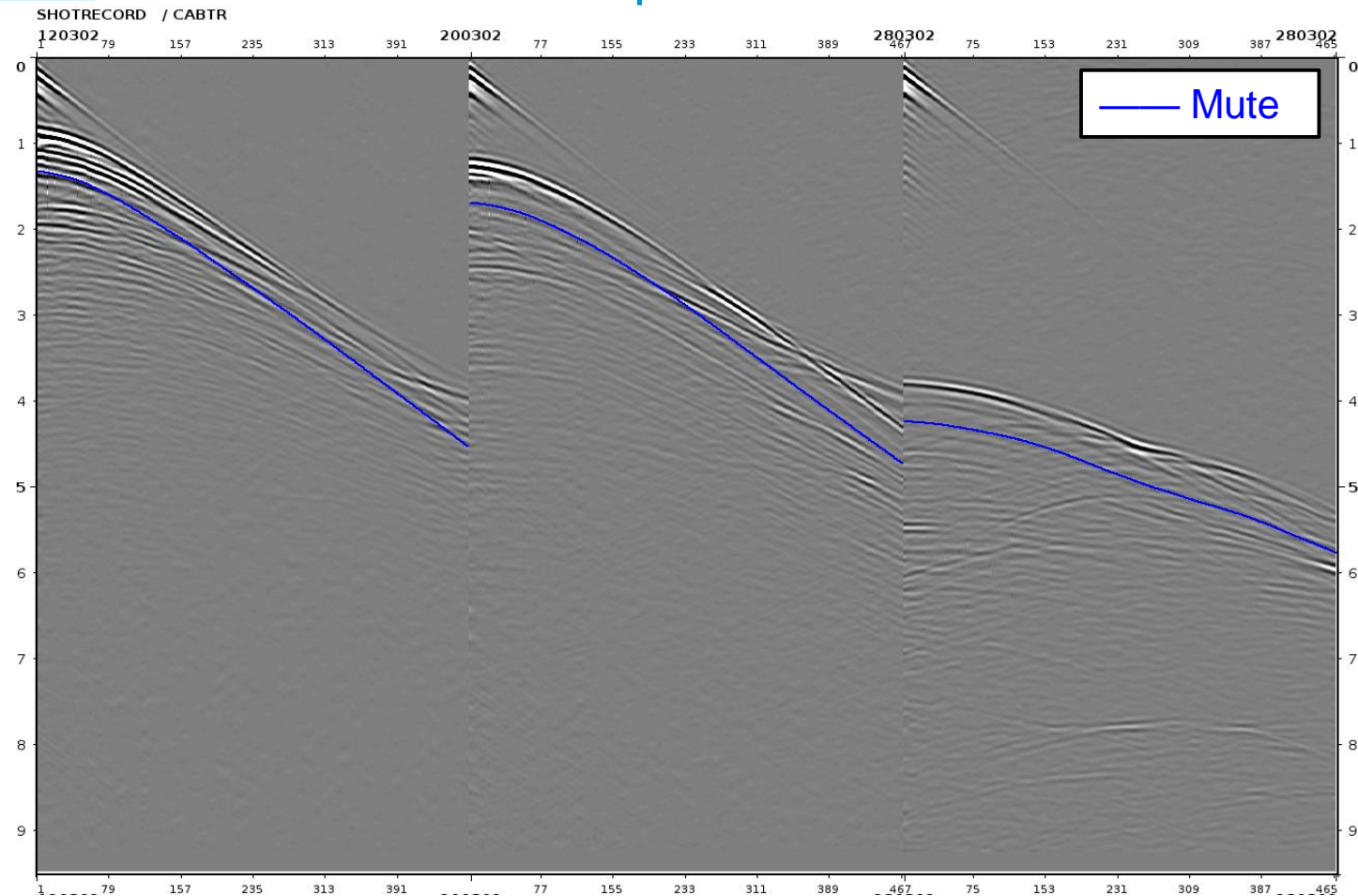
- **Observation and Recommendation:**

Current ISO FWI gives reasonable update down to ~2km beneath Water Bottom (WB). Velocity updated deeper than this depth is hard to be evaluated at the moment, due to interference of multiples. We're working on a VMB depth migration volume with major preprocessing steps applied (de-ghost and de-multiple), so we can evaluate the ISO fwi model and proceed to ISO tomography before building TTI model and TTI FWI.



# Streamer 001: FWI Input

3

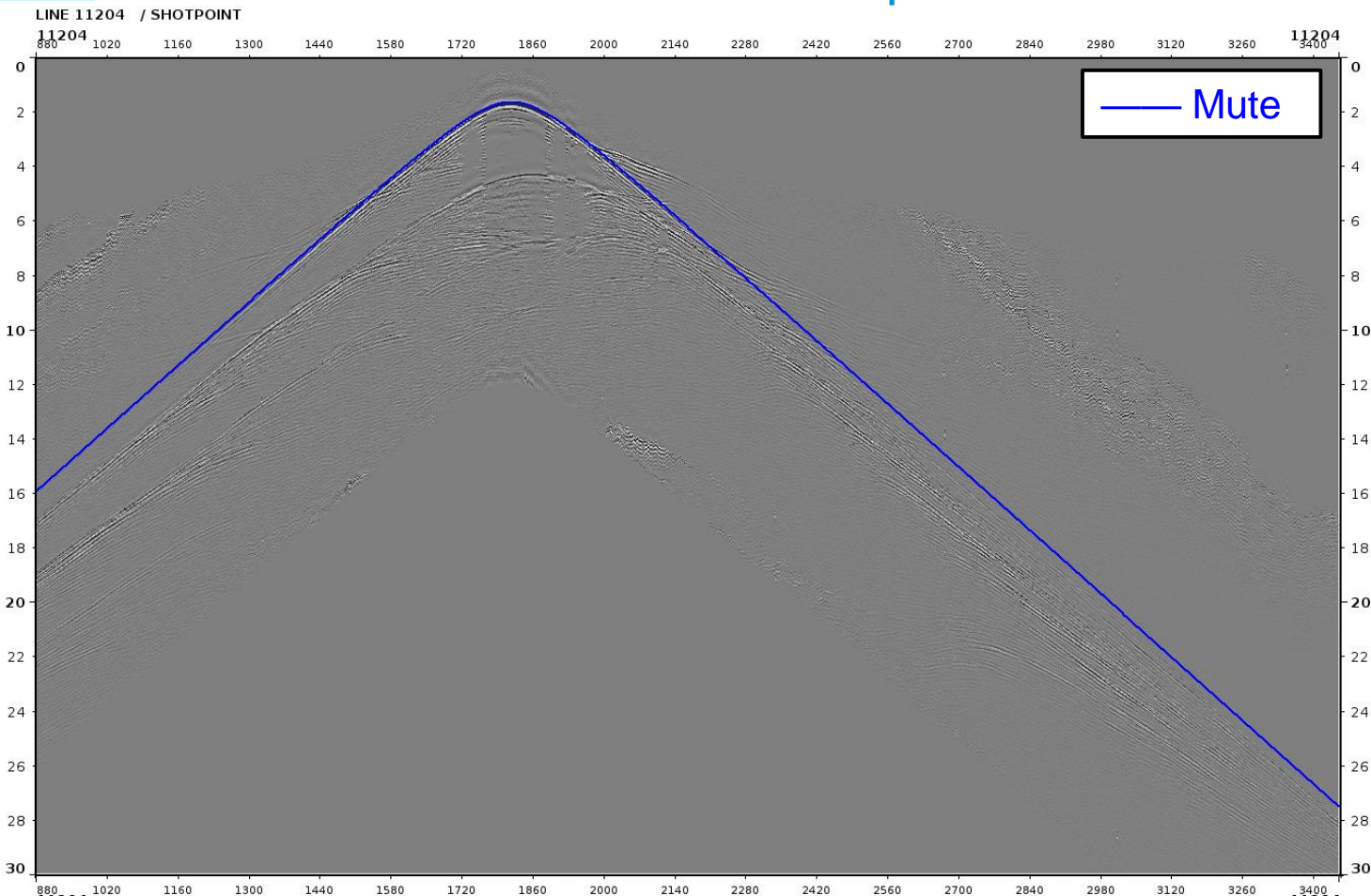


- The reflection energy (below the blue line) is muted.



# OBS Node 058: Mute on FWI Input

4



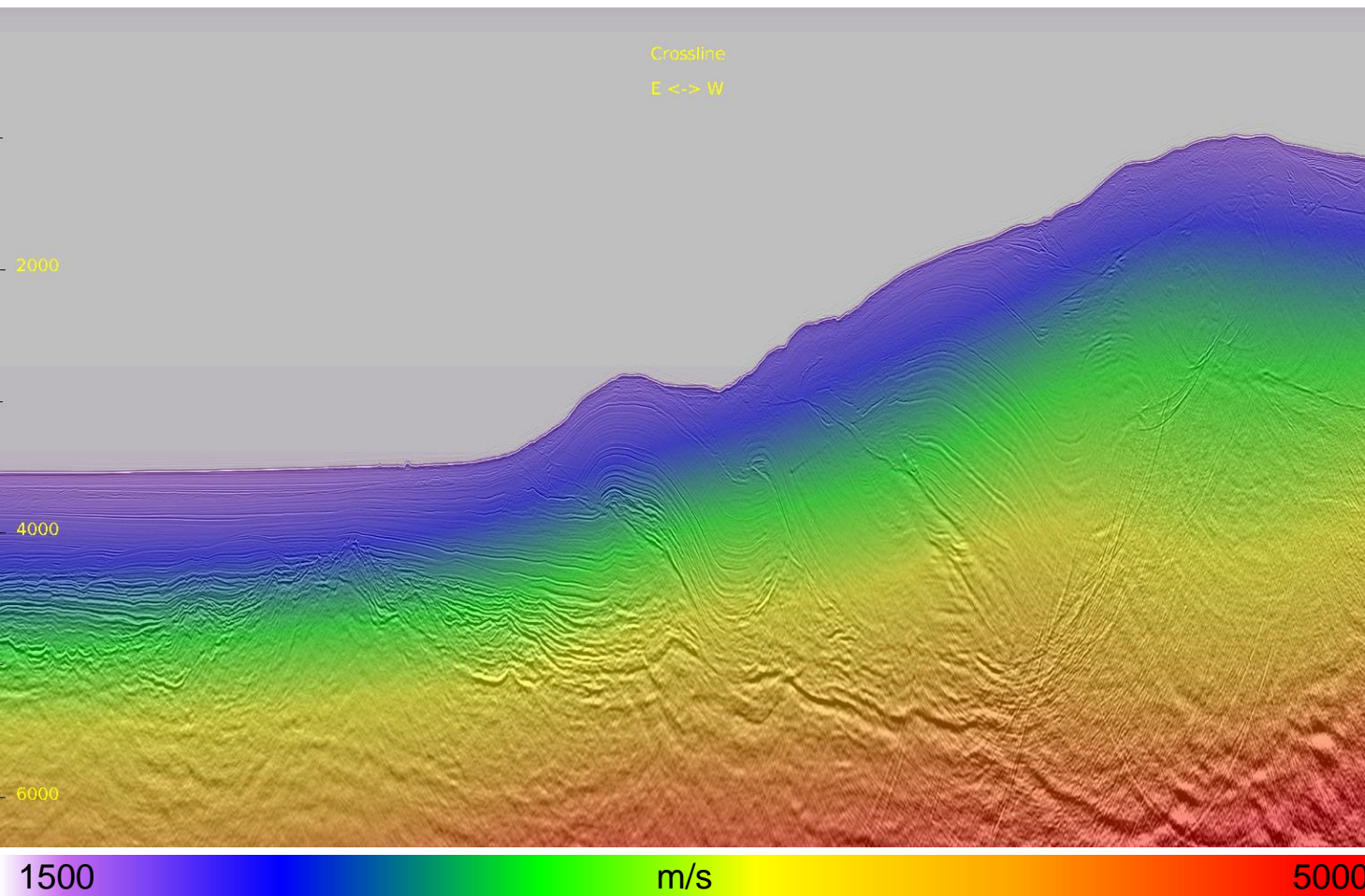
- The reflection energy (below the blue line) is muted, where recording issue happens when amplitudes are high.

# Velocity Model

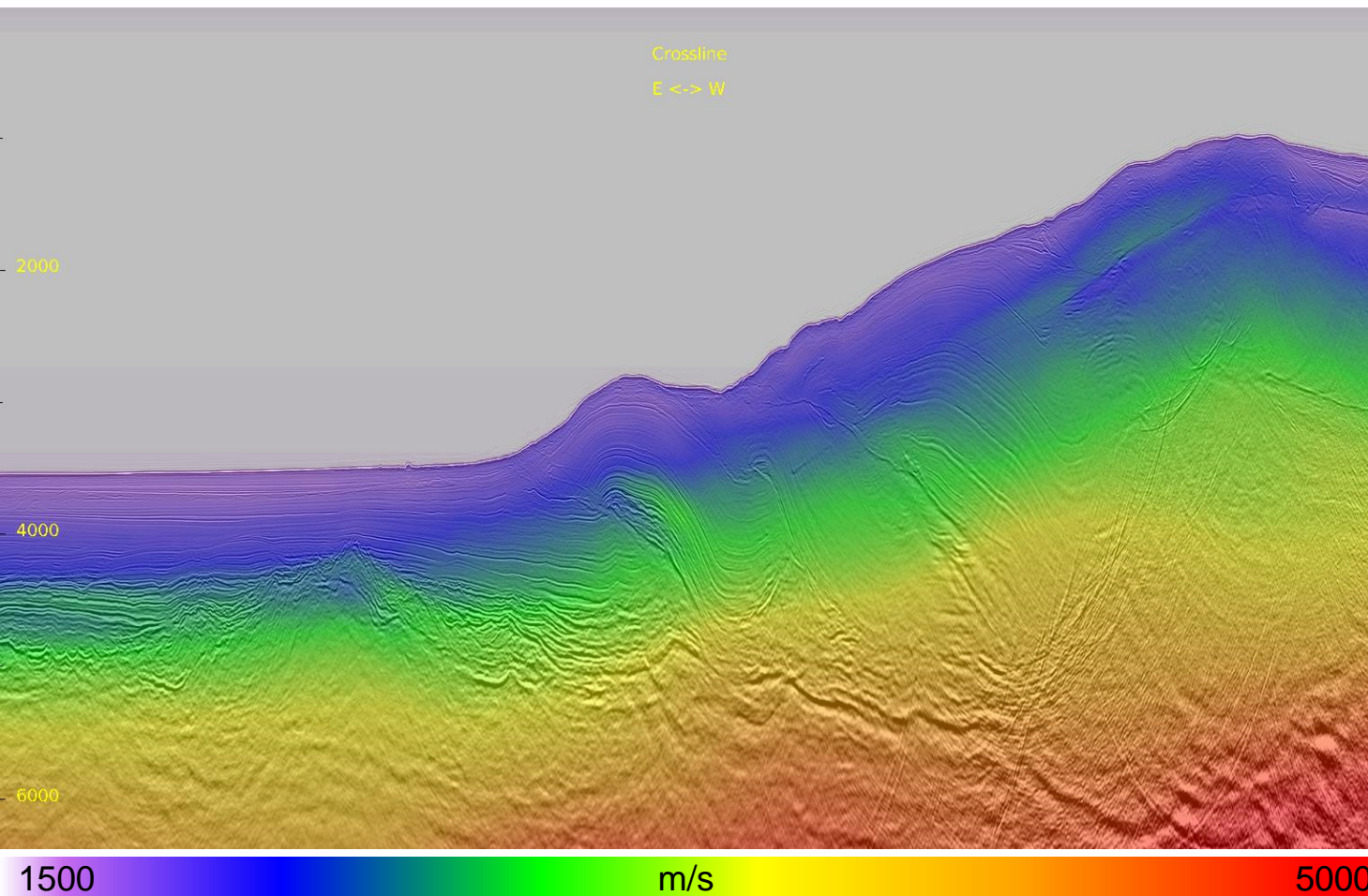


# Inline 436 East: Initial Velocity

6

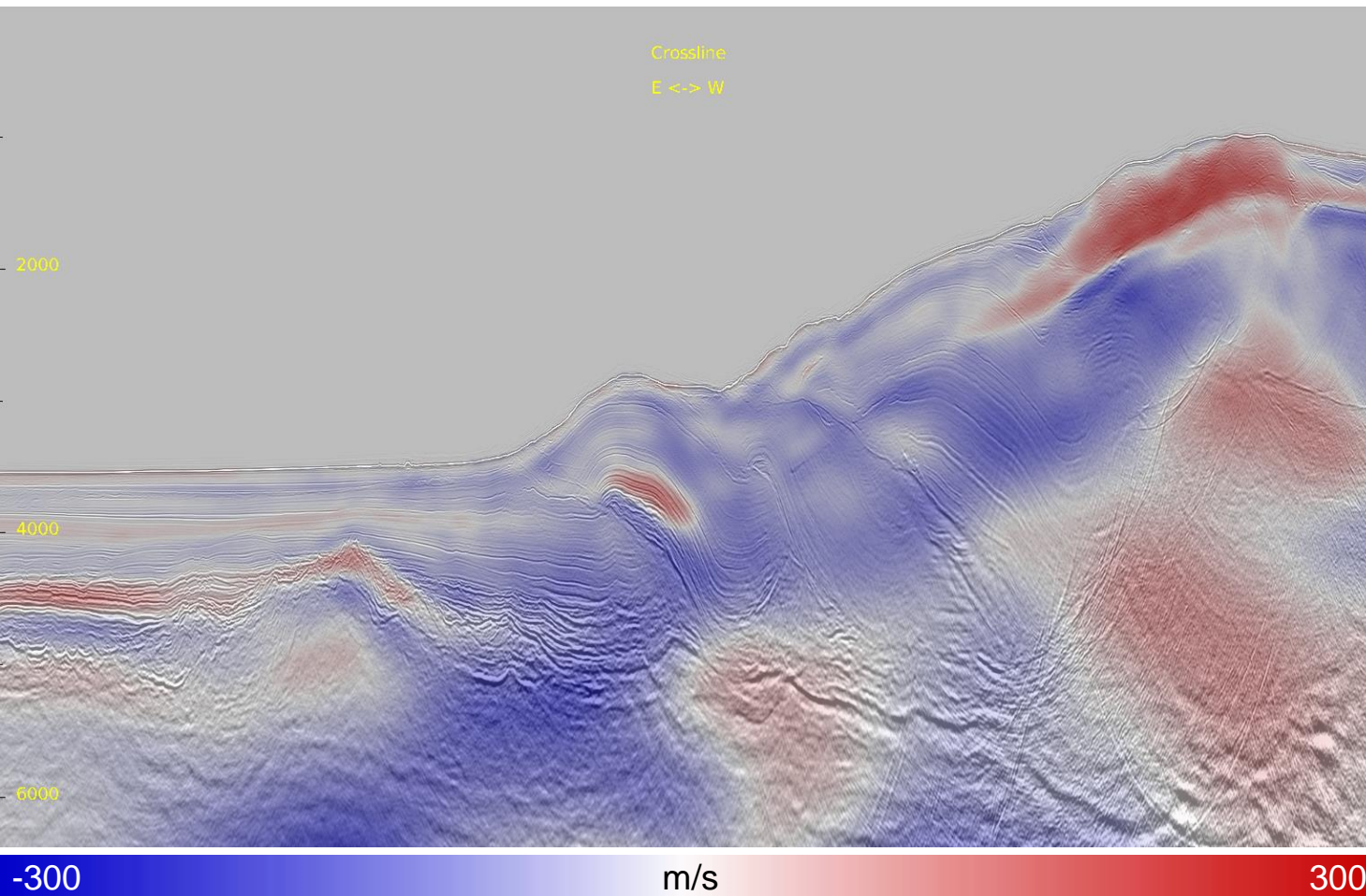


- Initial velocity is smooth.



- ISO FWI gives reasonable update that follows geology, down to 2km beneath water bottom.





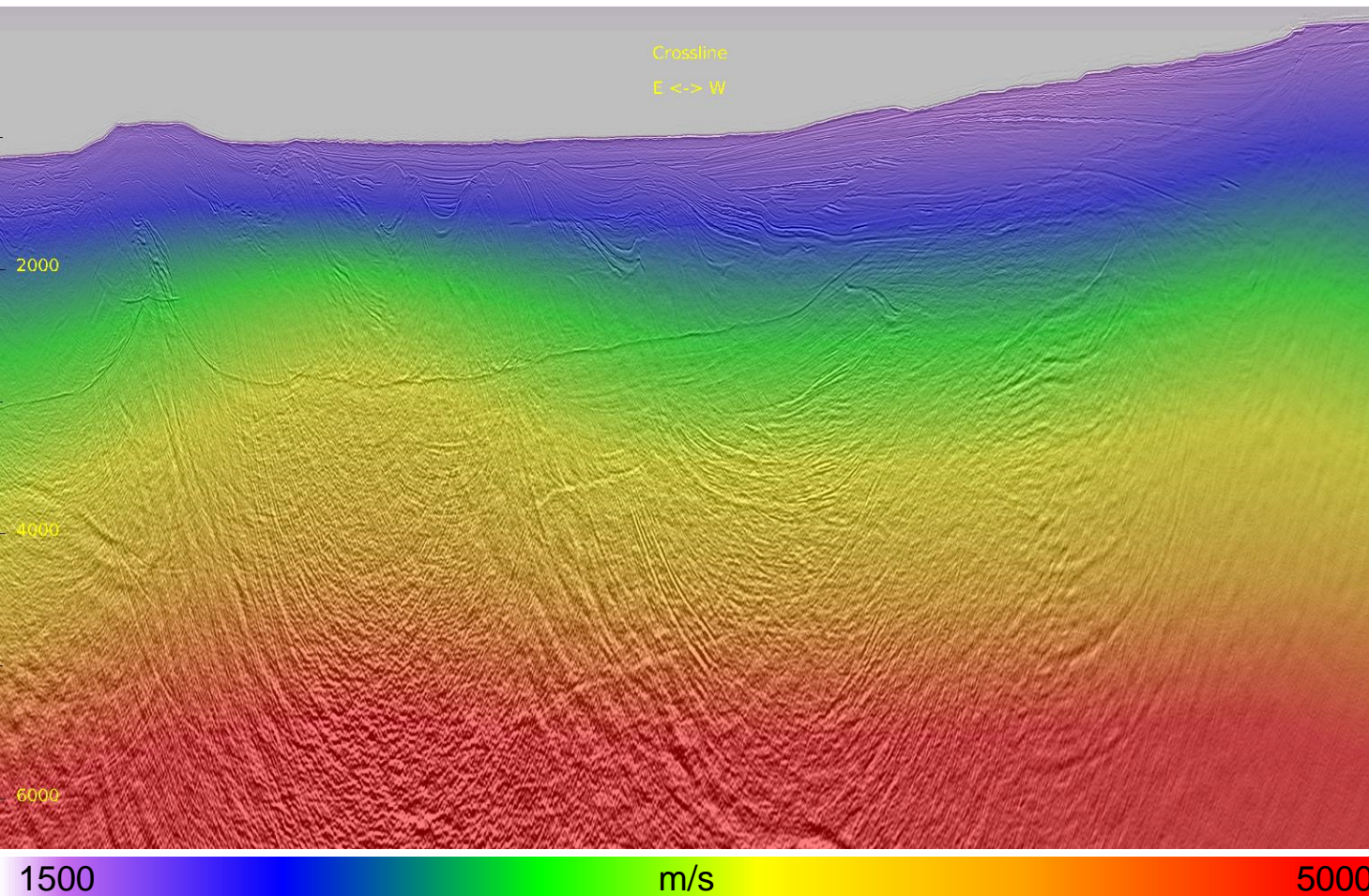
- ISO FWI gives reasonable update that follows geology, down to 2km beneath water bottom.
- The perturbation deeper than 2km beneath water bottom is hard to be assessed, due to interference of multiples on seismic data.





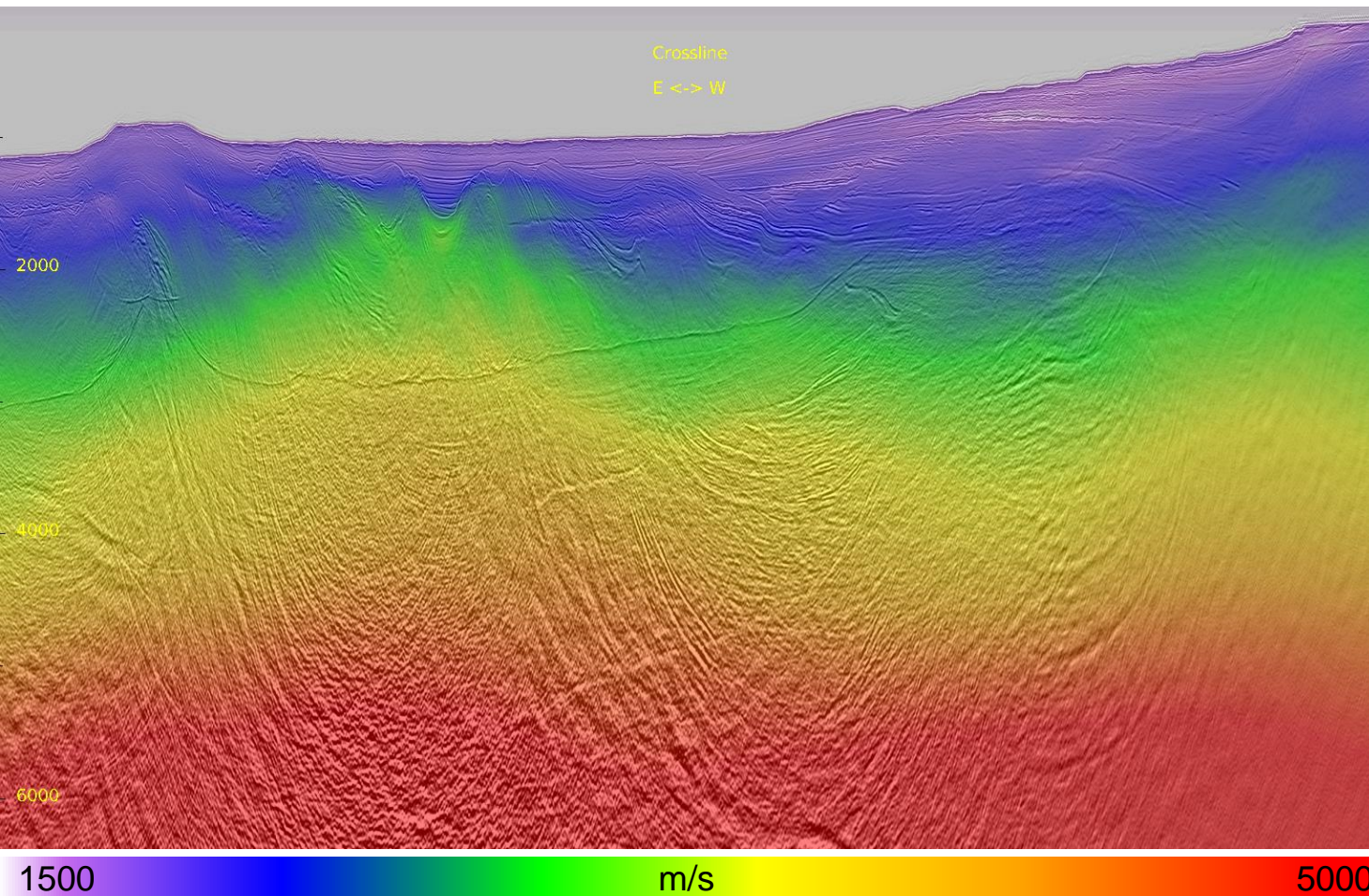
## Inline 436 West: Initial Velocity

9



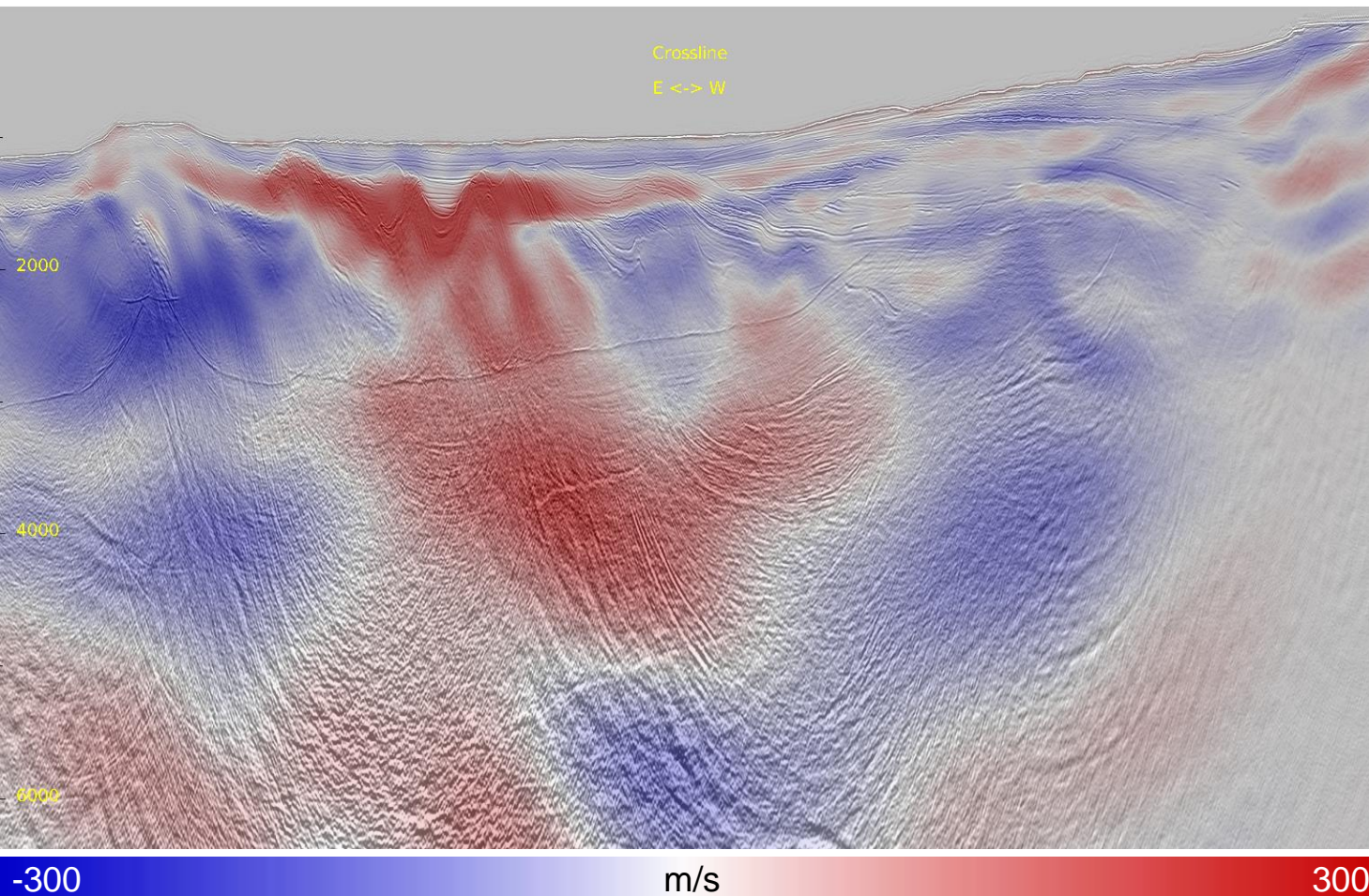
- Initial velocity is smooth.





- ISO FWI gives reasonable update that follows geology, down to 2km beneath water bottom.



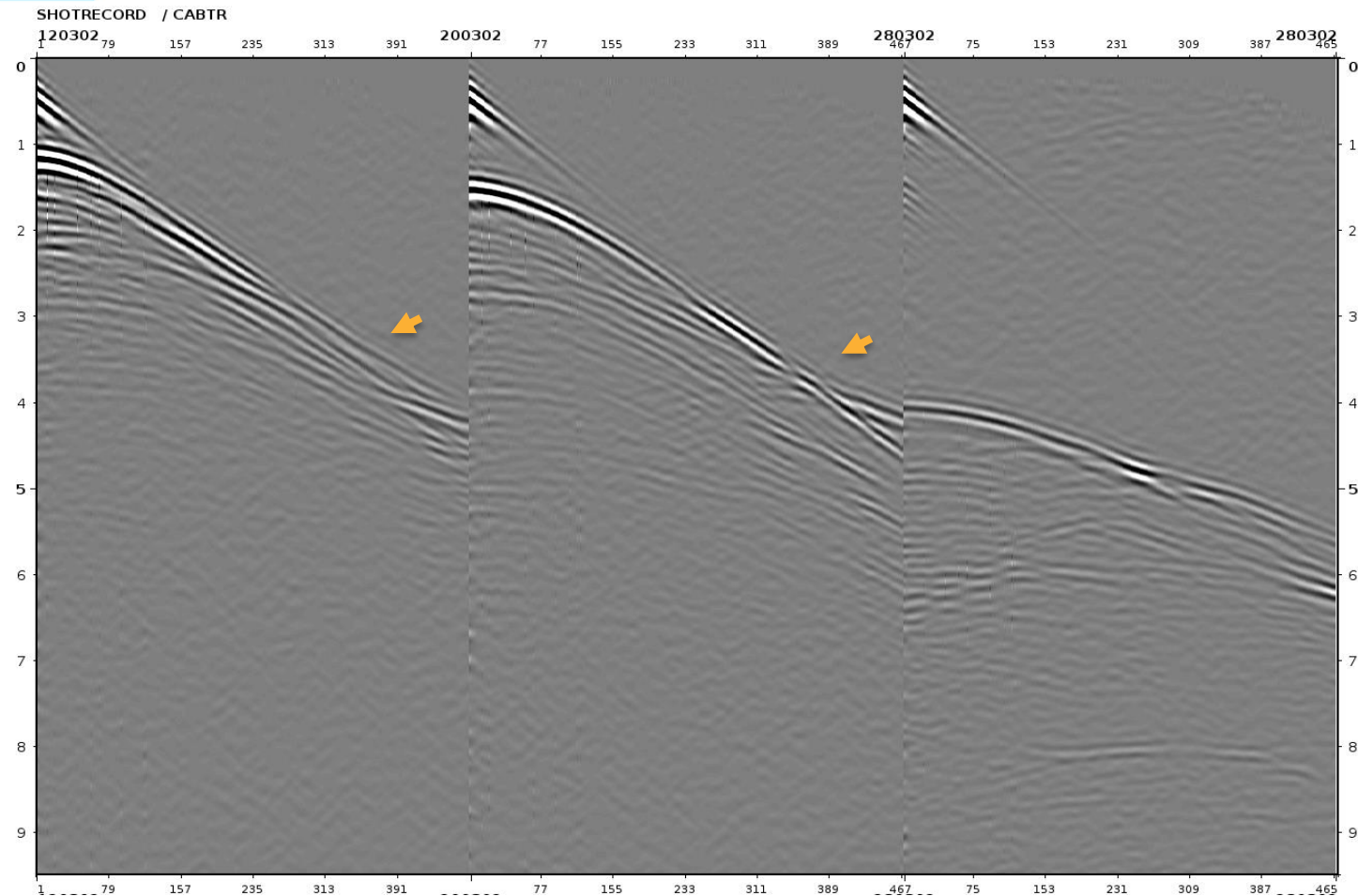


- ISO FWI gives reasonable update that follows geology, down to 2km beneath water bottom.
- The perturbation deeper than 2km beneath water bottom is hard to be assessed, due to interference of multiples on seismic data.

# FWI Synthetic VS Real Data Streamer ( $< 7$ Hz)





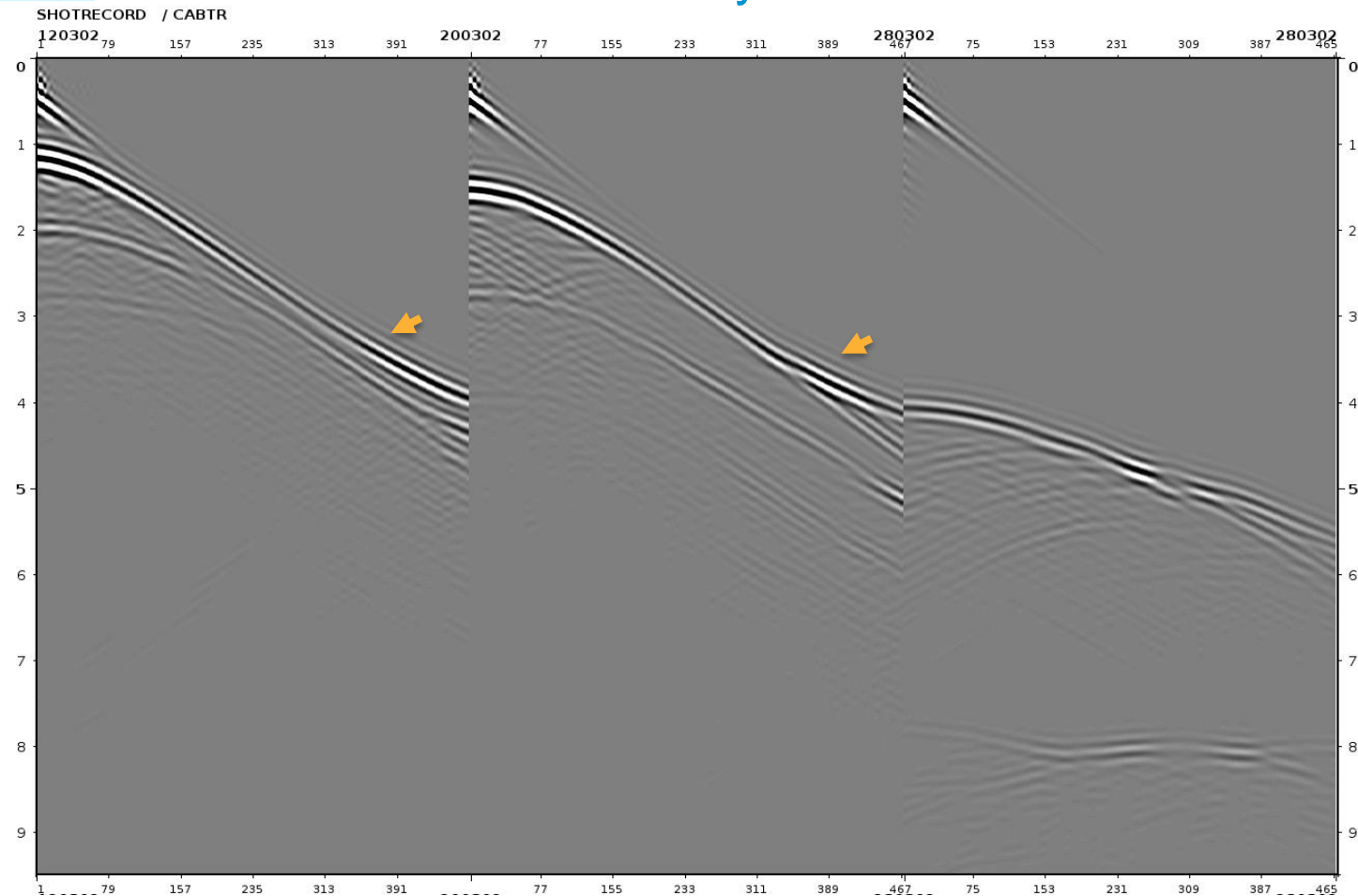


- With initial velocity, synthetic shot and real data matches not very well from mid to far channels.

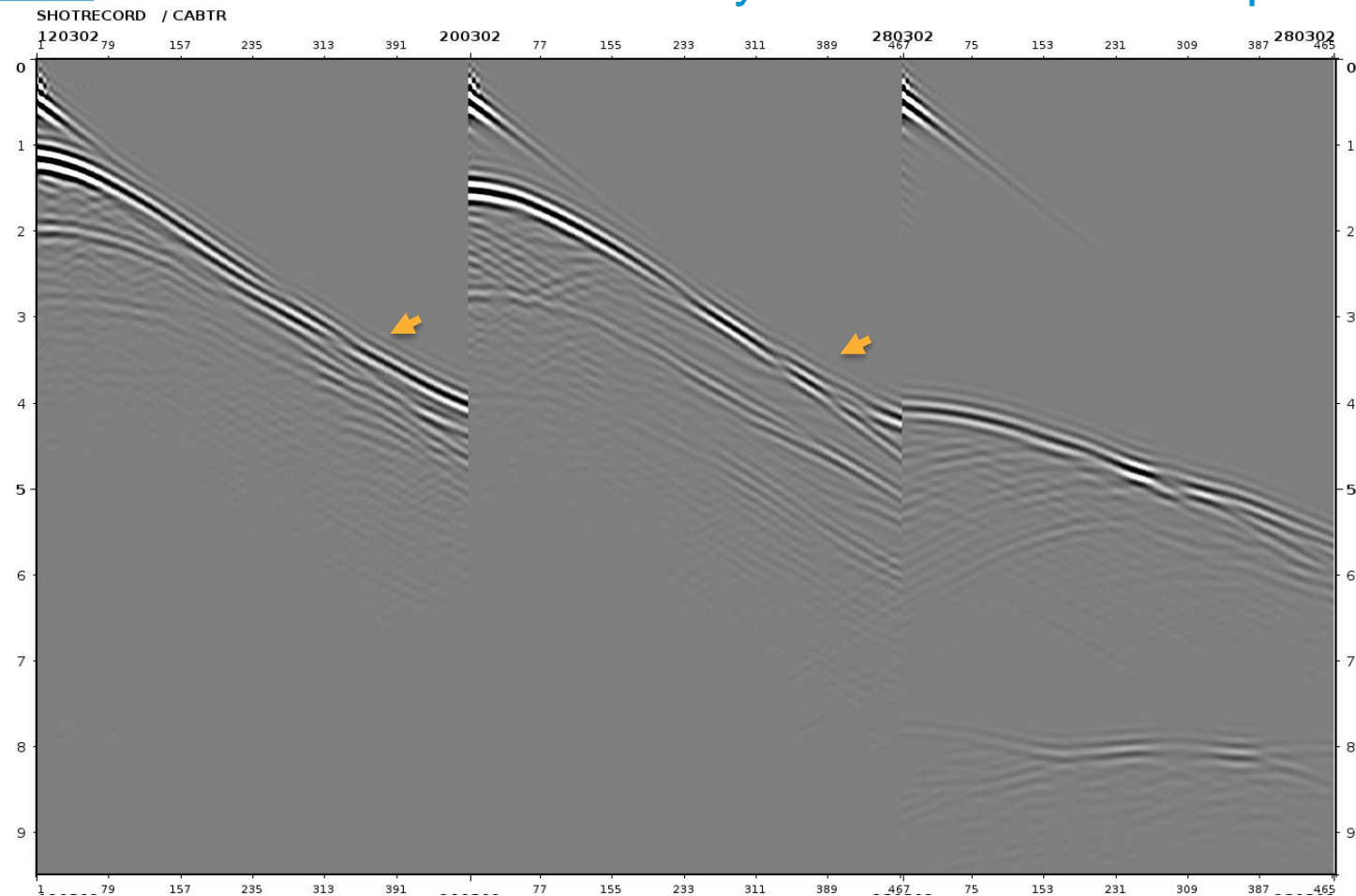


# Streamer 001: ISO FWI Synthetic Shots with Initial Velocity

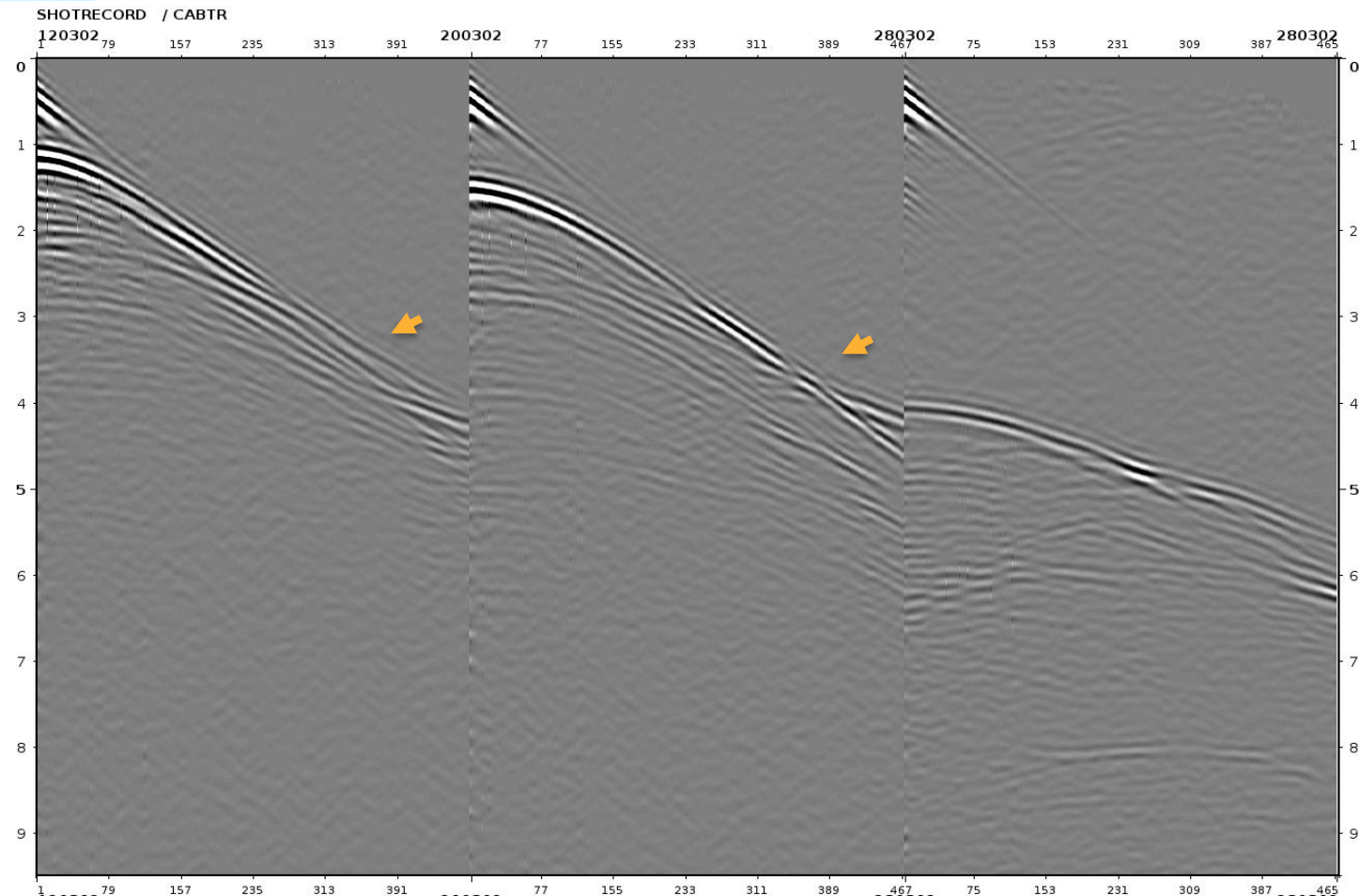
14



- With initial velocity, synthetic shot and real data matches not very well from mid to far channels.



- After ISO FWI date, synthetic shots and real data matches better through out all channels.



- After ISO FWI date, synthetic shots and real data matches better through out all channels.

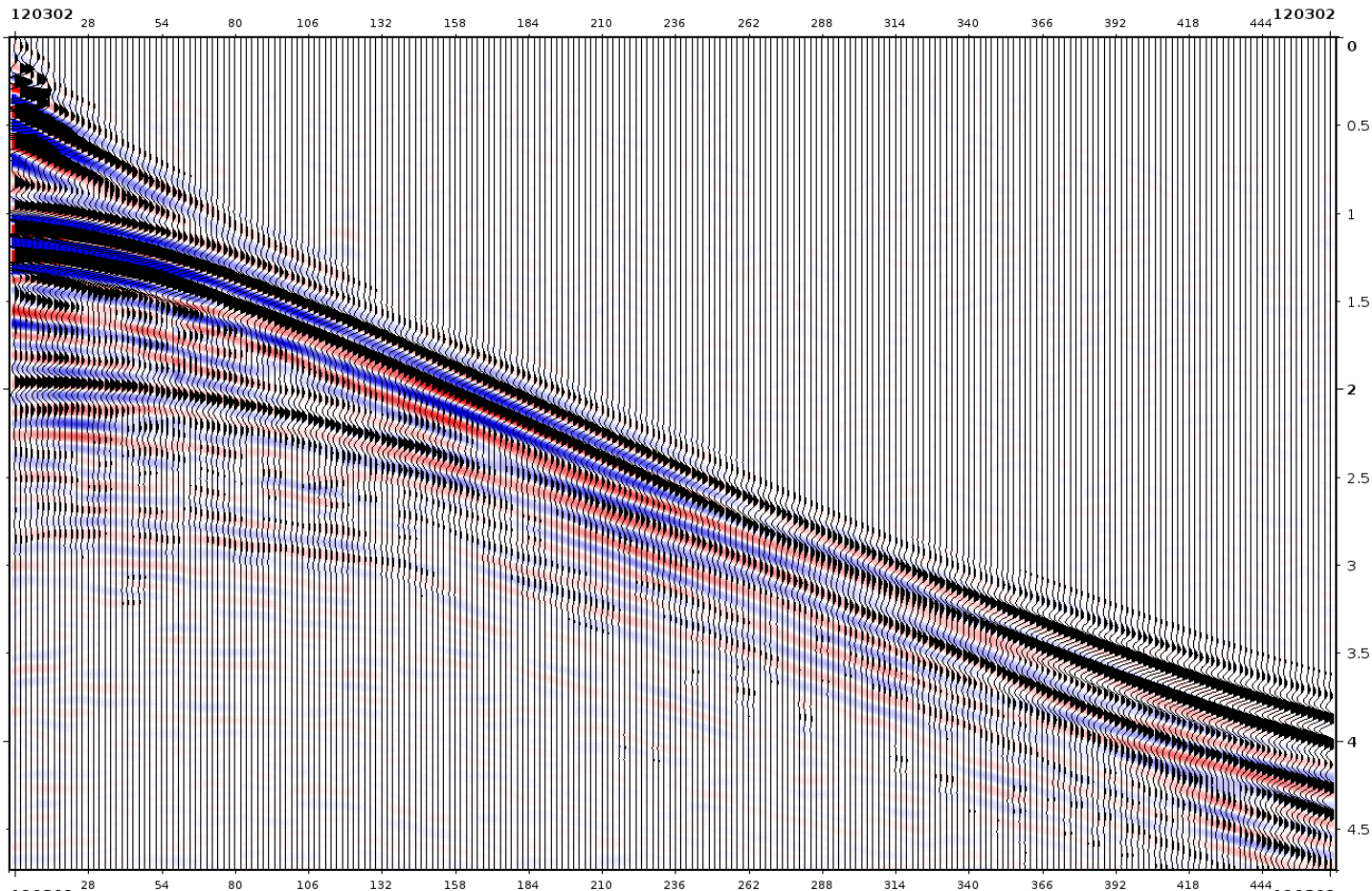




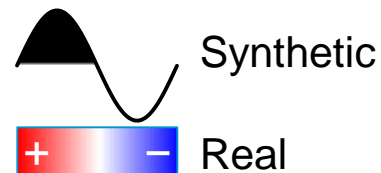
# Streamer 001 Synthetic Overlaid on Real: Initial Velocity

17

SHOTRECORD 120302 / CABTR



- With initial velocity, synthetic shot and real data matches not very well from mid to far channels.

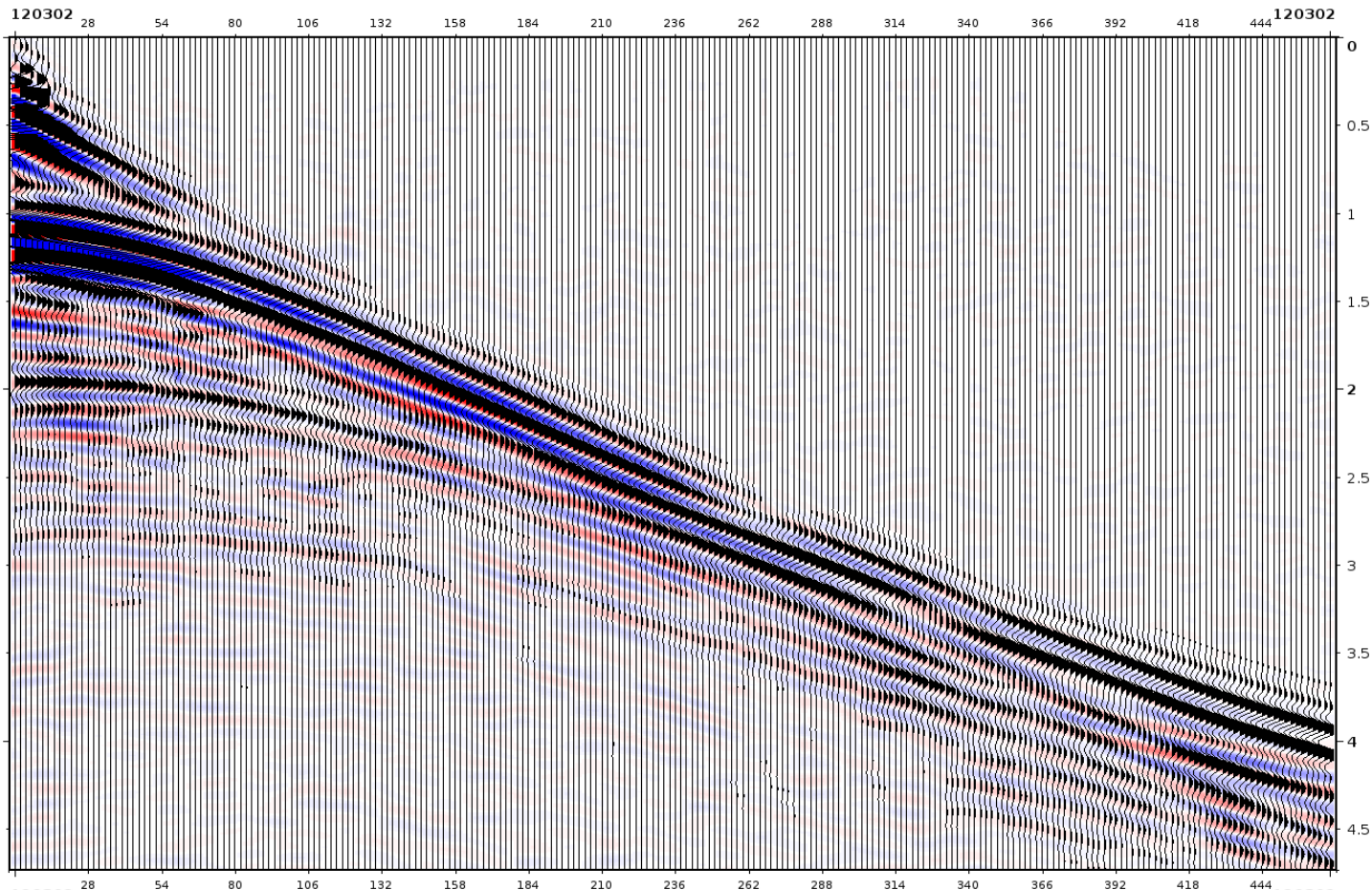




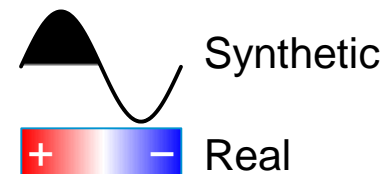
# Streamer 001 Synthetic Overlaid on Real: ISO FWI Velocity

18

SHOTRECORD 120302 / CABTR



- After ISO FWI date, synthetic shots and real data matches better through out all channels.



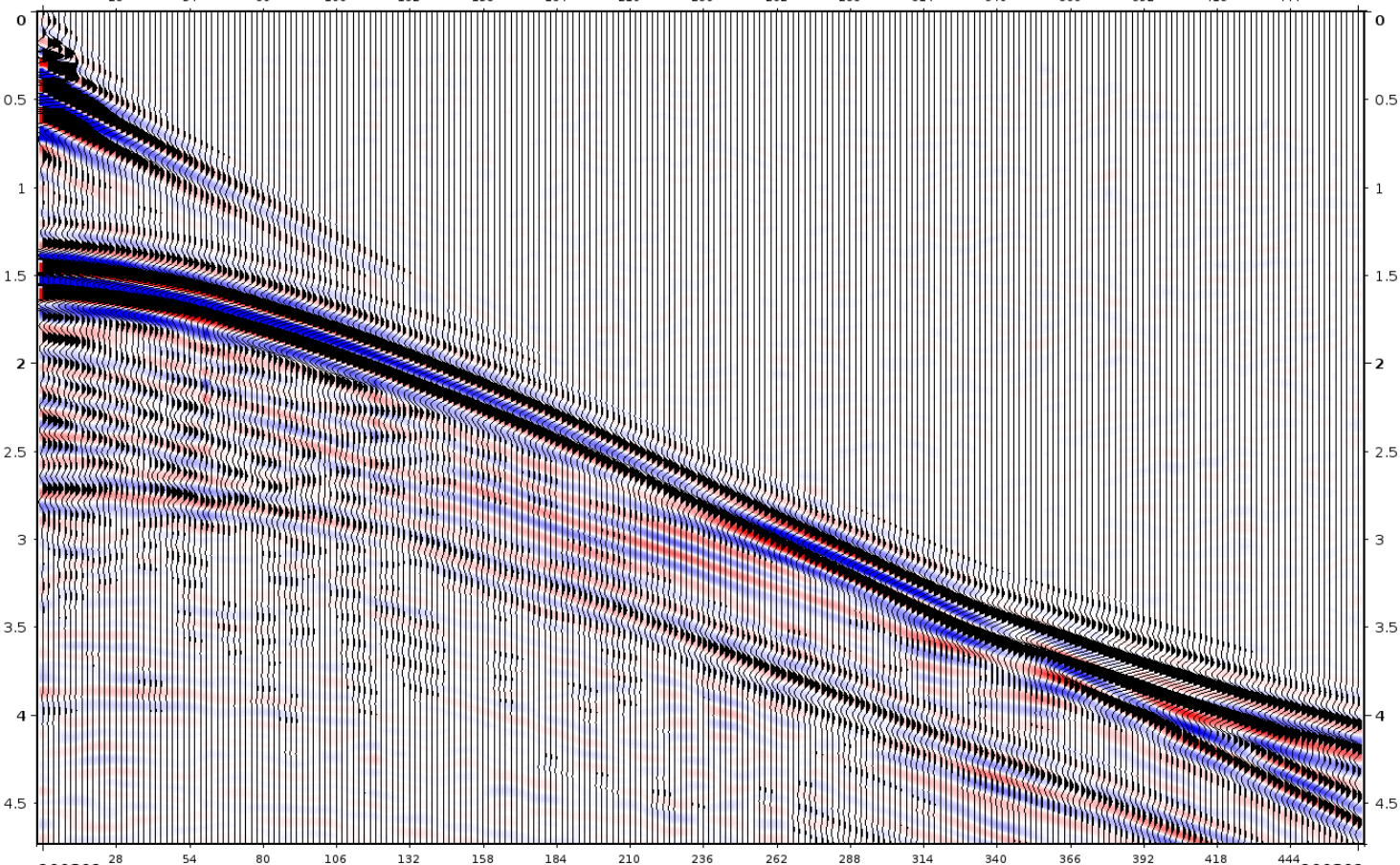


# Streamer 001 Synthetic Overlaid on Real: Initial Velocity

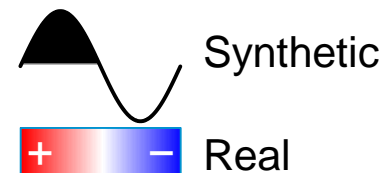
19

SHOTRECORD 200302 / CABTR

200302 28 54 80 106 132 158 184 210 236 262 288 314 340 366 392 418 444 200302



- With initial velocity, synthetic shot and real data matches not very well from mid to far channels.





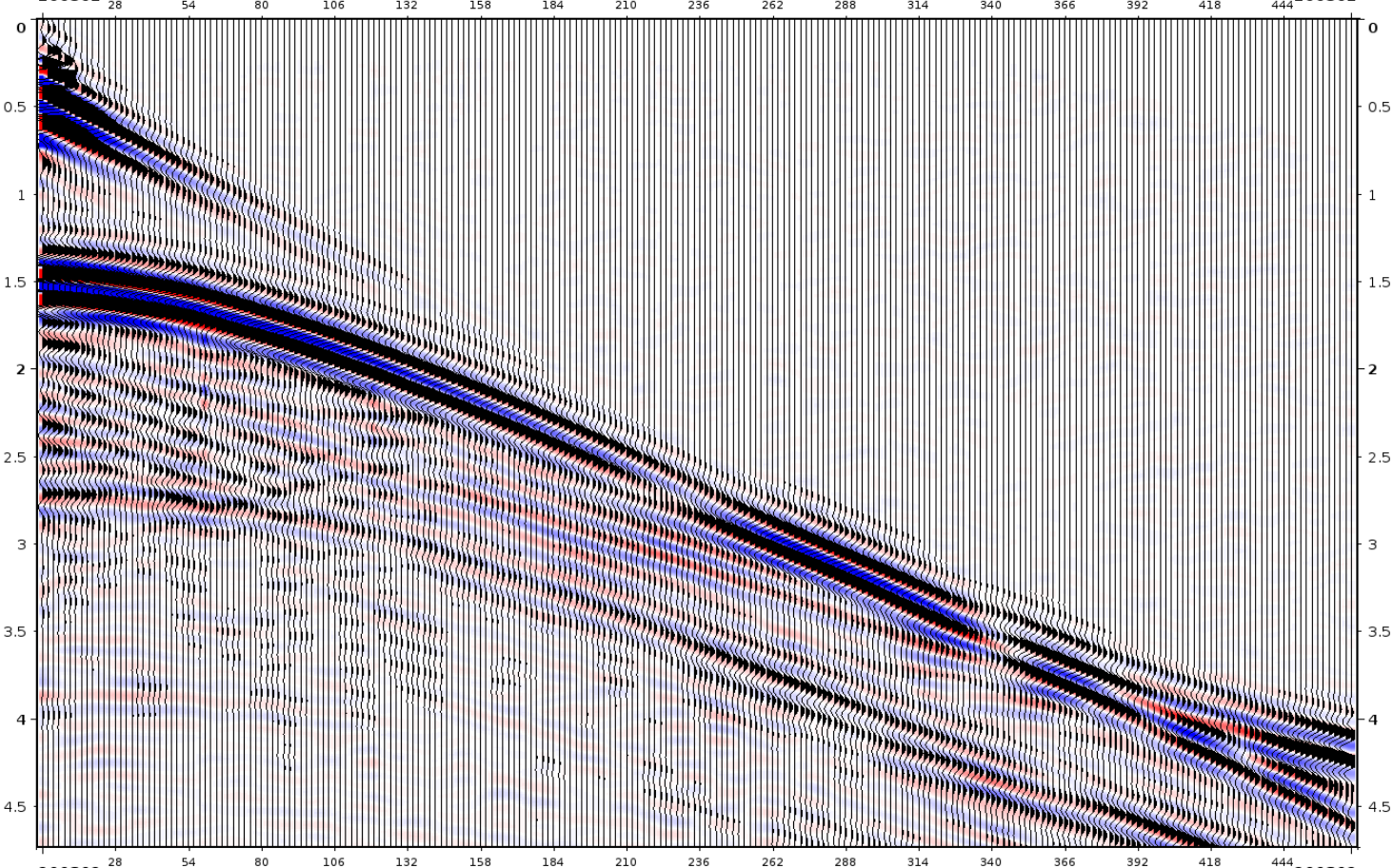
# Streamer 001 Synthetic Overlaid on Real: ISO FWI Velocity

20

SHOTRECORD 200302 / CABTR

200302

200302



- After ISO FWI date, synthetic shots and real data matches better through out all channels.



Synthetic

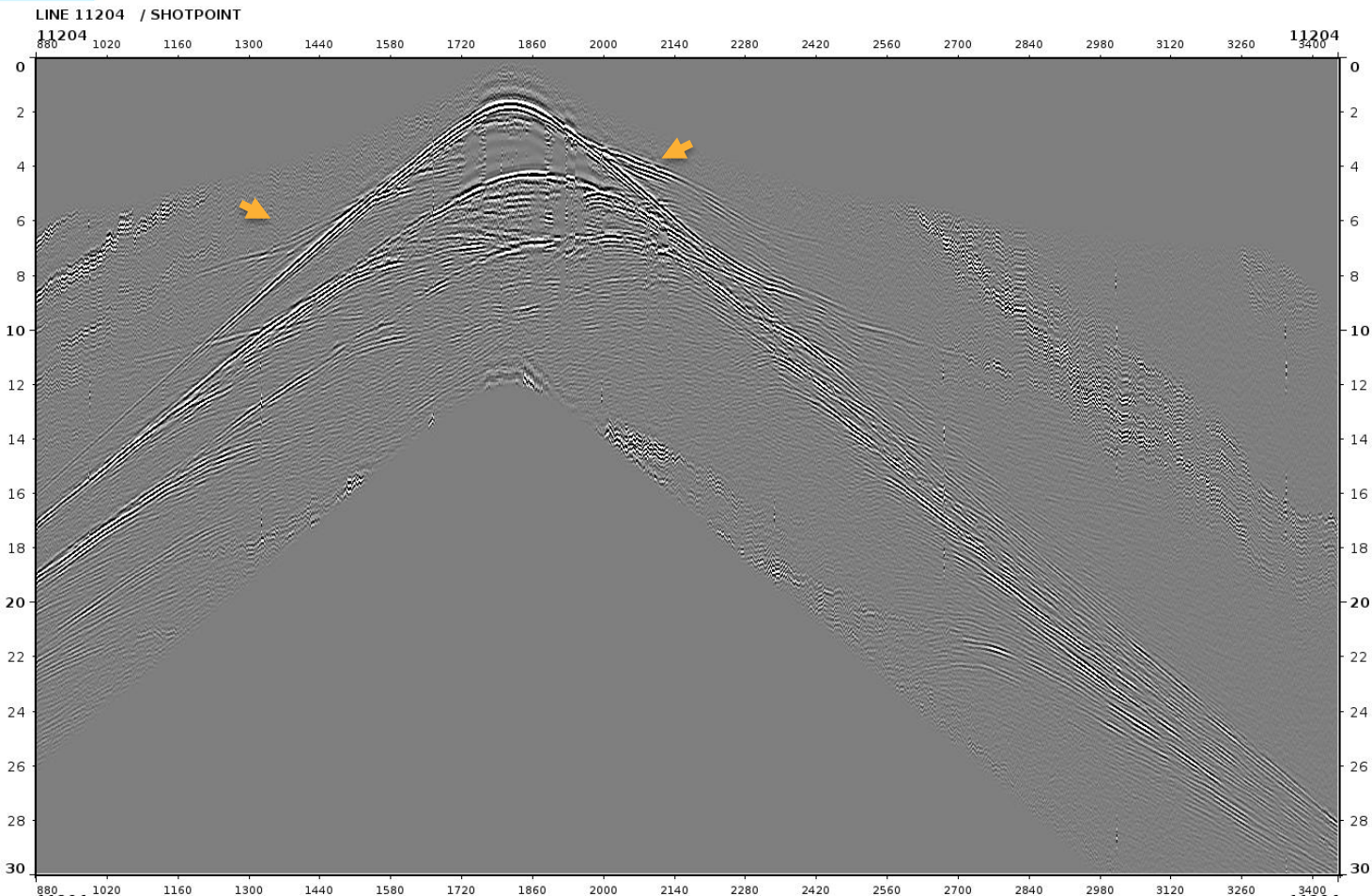


Real

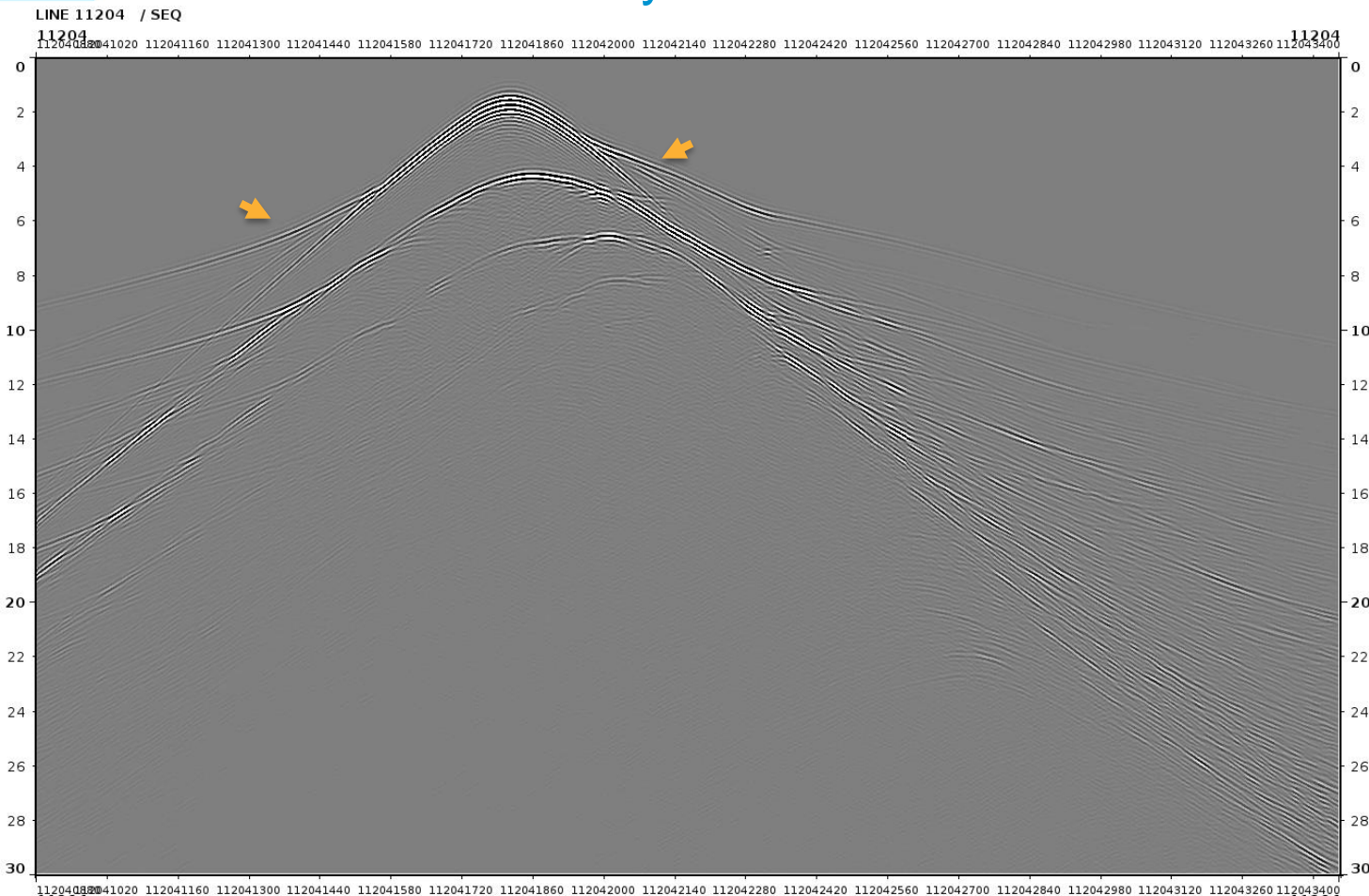


# FWI Synthetic VS Real Data OBS

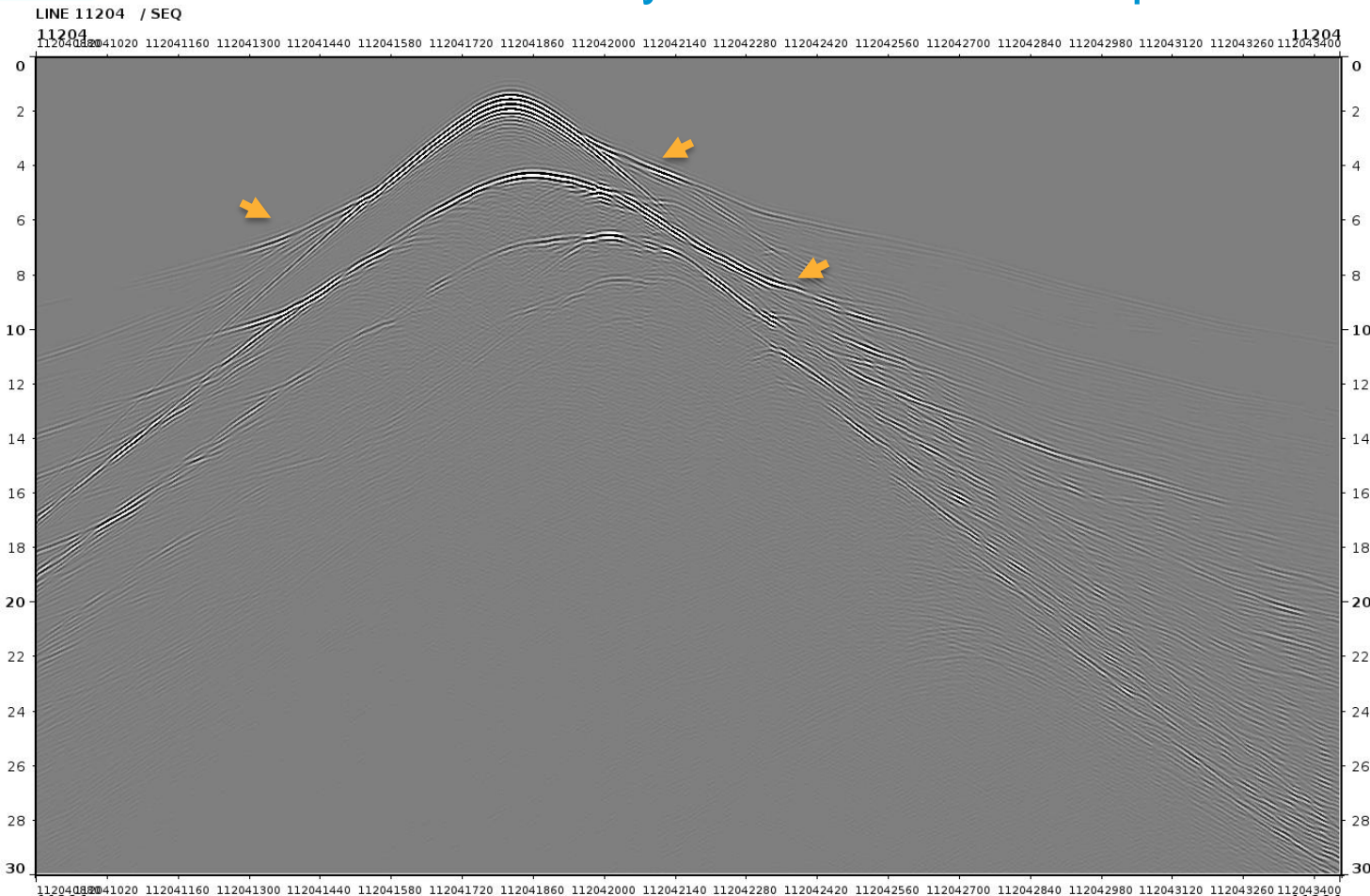




- With initial velocity, synthetic shot and real data matches not very well.

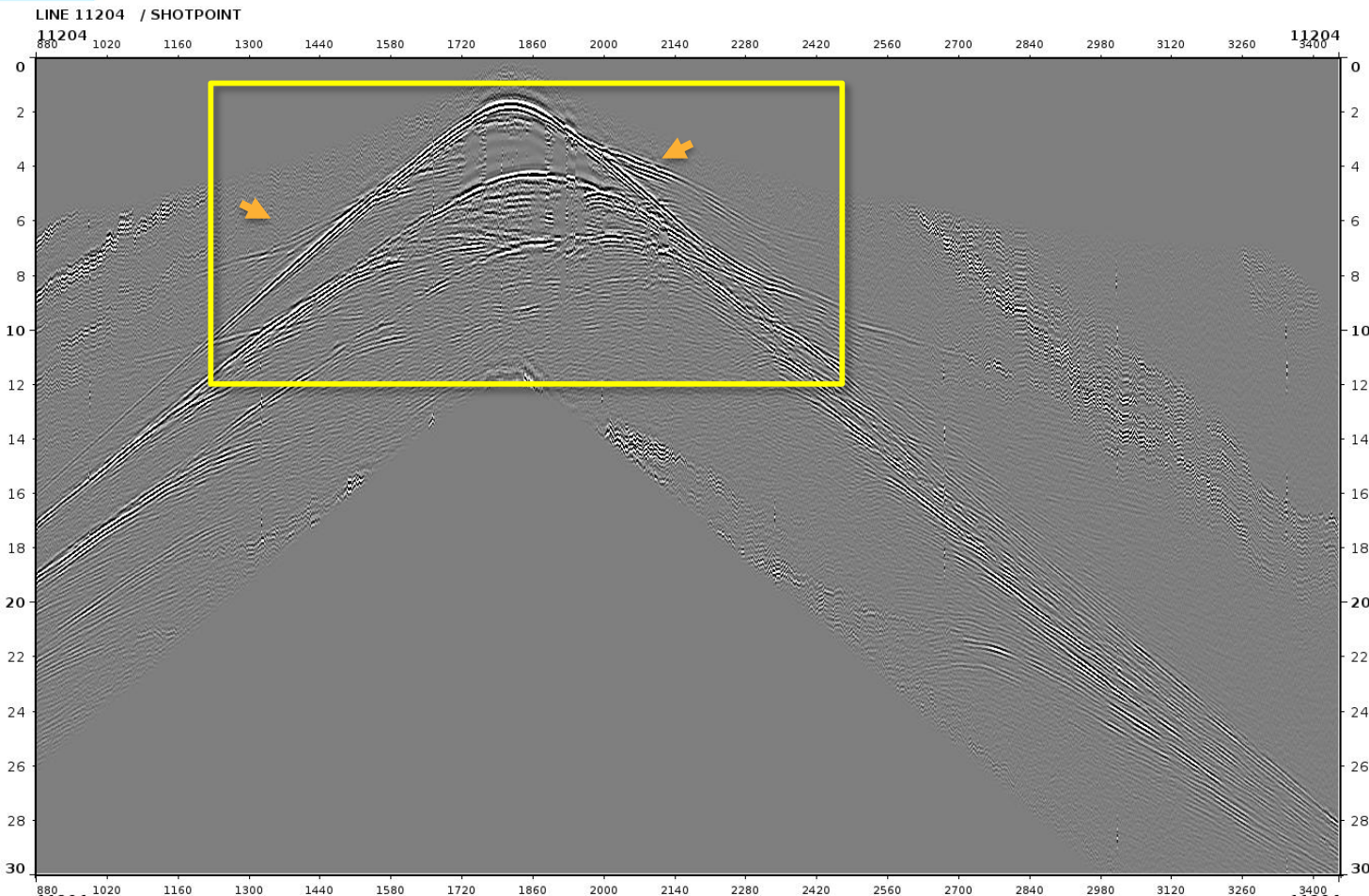


- With initial velocity, synthetic shot and real data matches not very well.



- After ISO FWI date, synthetic shots and real data matches better.
- Mismatches at far offset remains, where ISO FWI may suffer from cycle skipping due to large velocity error in deep section.





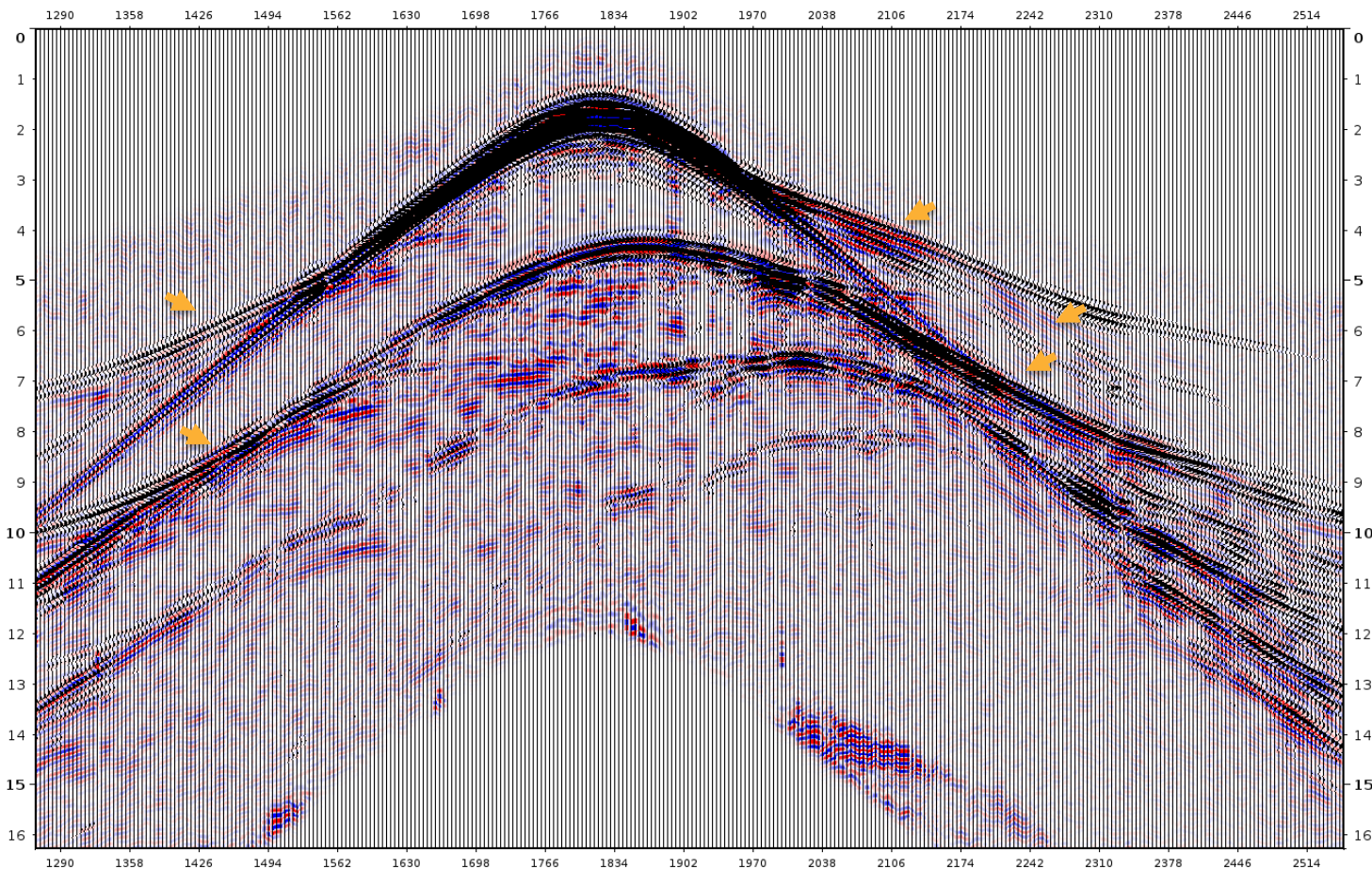
- After ISO FWI date, synthetic shots and real data matches better.
- Mismatches at far offset remains, where ISO FWI may suffer from cycle skipping due to large velocity error in deep section and/or anisotropic effect.



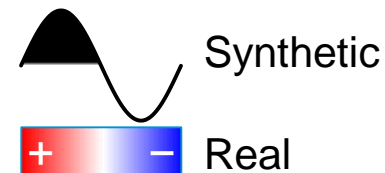
# OBS 058 Synthetic Overlaid on Real: Initial Velocity

26

LINE 11204 / SHOTPOINT



- With initial velocity, synthetic shot and real data matches not very well.



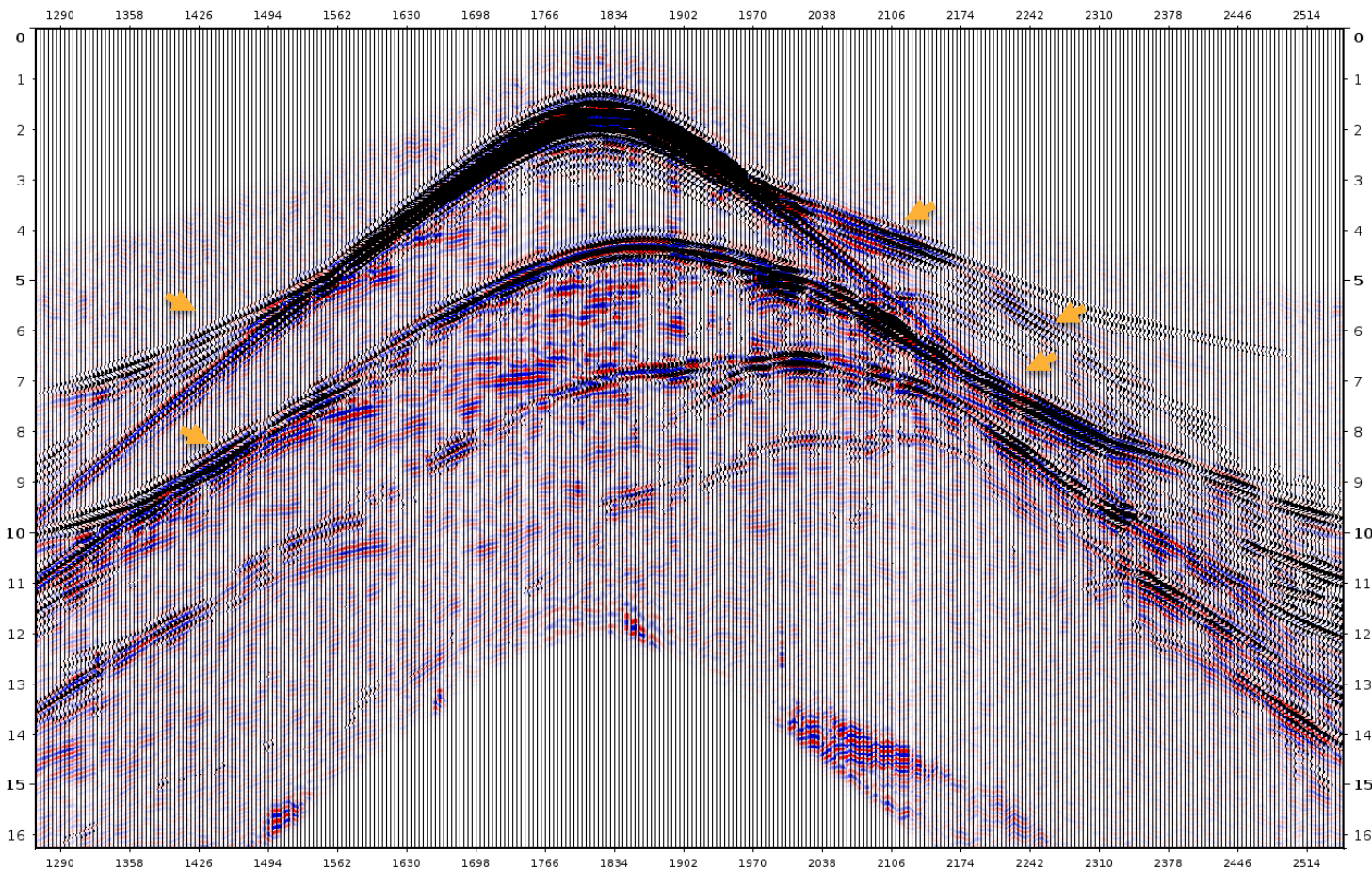




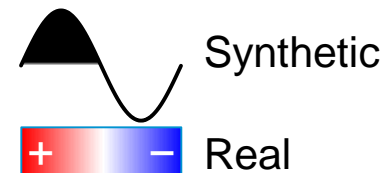
# Streamer 001 Synthetic Overlaid on Real: ISO FWI Velocity

27

LINE 11204 / SHOTPOINT



- After ISO FWI date, synthetic shots and real data matches better.
- Mismatches at far offset remains, where ISO FWI may suffer from cycle skipping due to large velocity error in deep section and/or anisotropic effect.



- ISO FWI gives reasonable update that follows geology down to ~2km beneath water bottom.
- Deeper than 2km beneath water bottom, we have less confidence due to increasing chances of cycle skipping and/or anisotropic effects.
- We plan to use reasonable update to continue with ISO tomography, which may provide better starting model for TTI FWI, especially in the deep section.





# Isotropic FWI – Migration QC

## NZ 3D Processing

*11 November 2020*

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- **Objective:**

To QC isotropic (ISO) FWI result via depth migration.

- **Procedure:**

The VMB migration input is prepared from the production data after linear noise attenuation.

Several key steps were applied to reasonably clean the data. These processes include WCS, RMC, 2D deghost, 3D demultiple, and some simple denoise.

Kirchhoff depth migrations were done with 5 km aperture and down to 15 km. A time variant scale was applied to balance the amplitude for QC purpose.

- **Display:**

Velocity and migrated depth full stack & gathers.

- **Observation and Recommendation:**

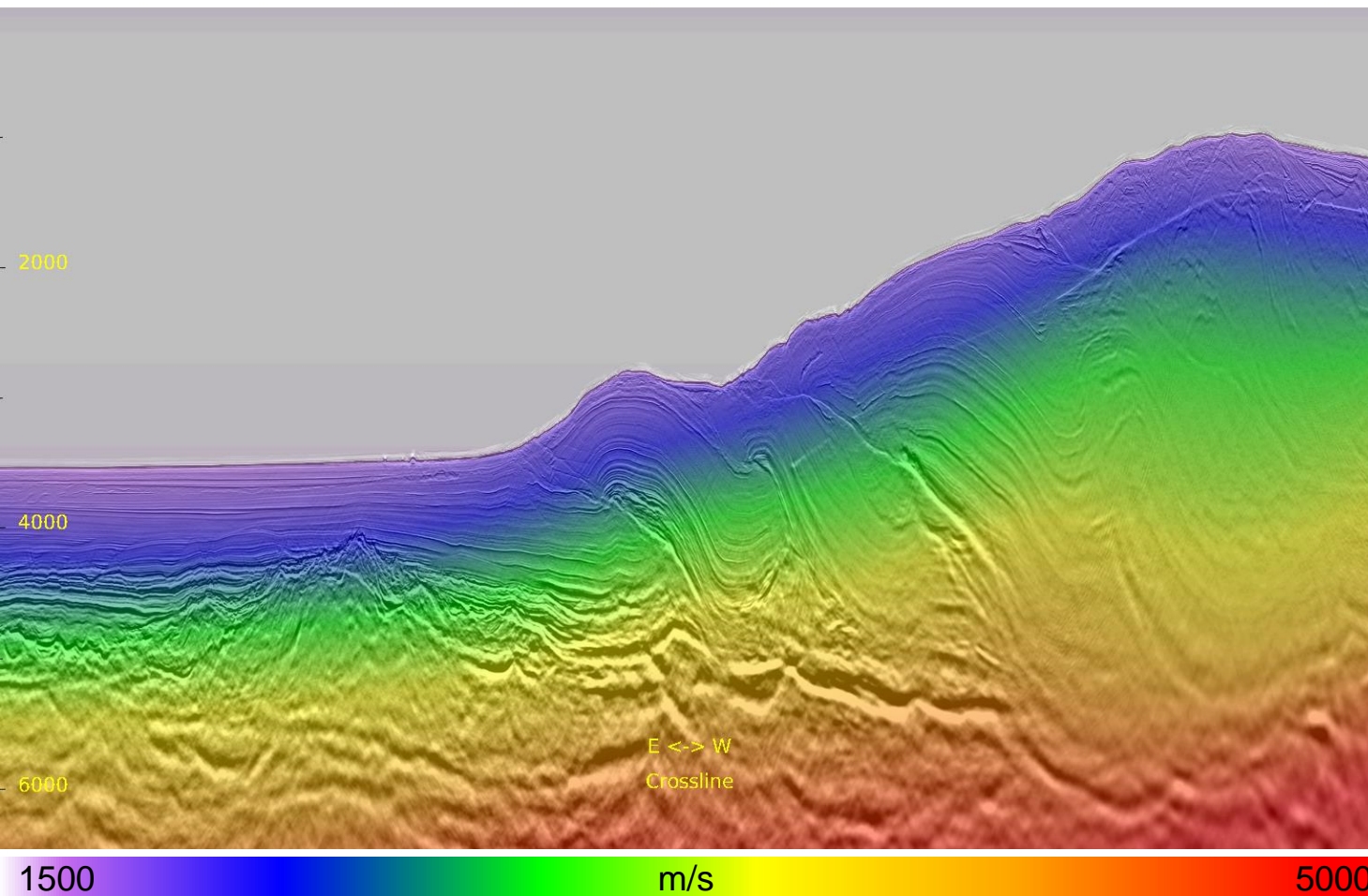
ISO FWI velocity gives overall flatter gathers and improvements on migrated stack, compared to initial velocity. We recommend to move on to ISO tomography.

# Velocity Model



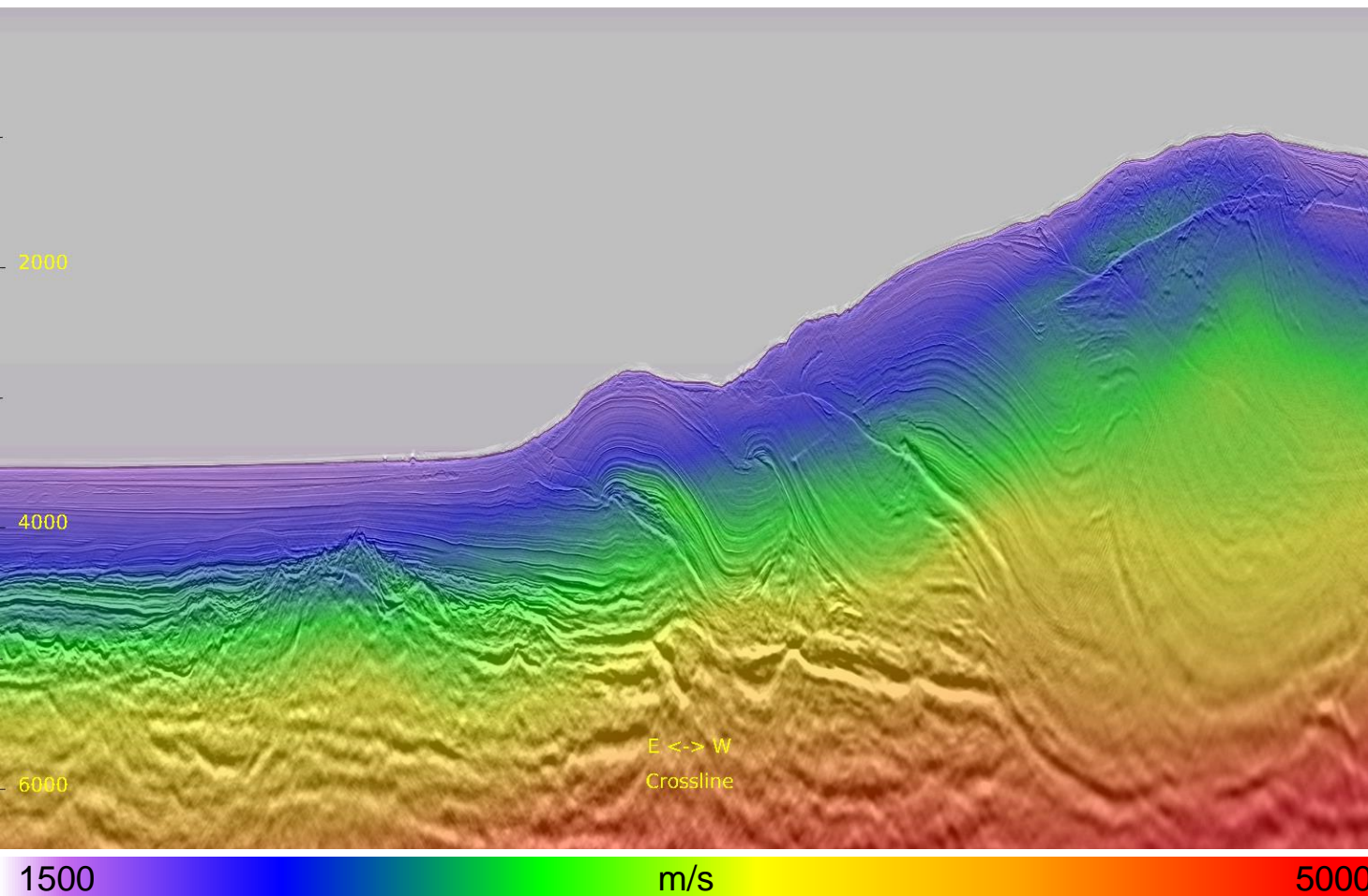
# Inline 436 East: Initial Velocity

4

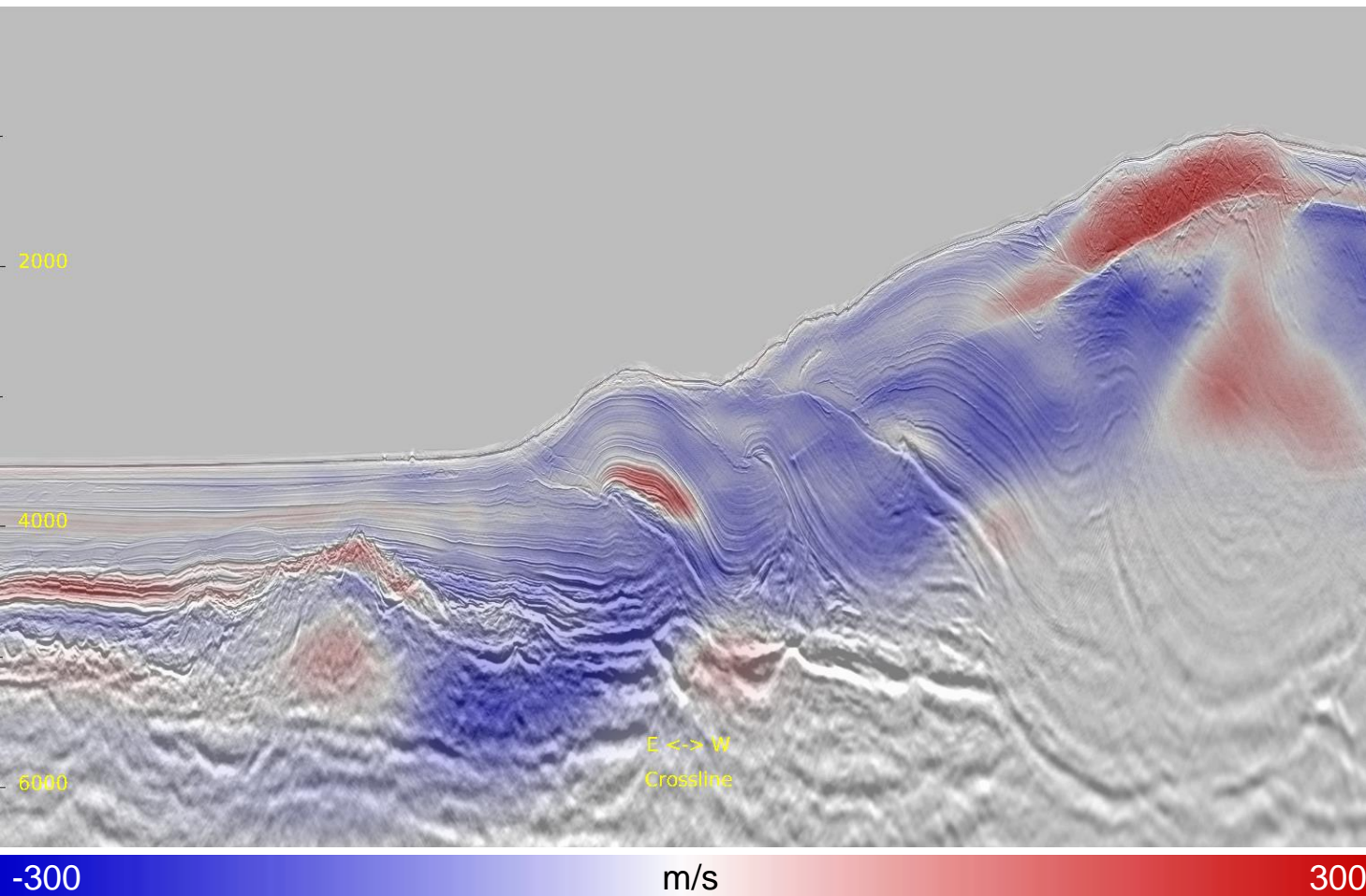


- Initial velocity is smooth.





- ISO FWI gives reasonable update that follows geology, down to 2km beneath water bottom.

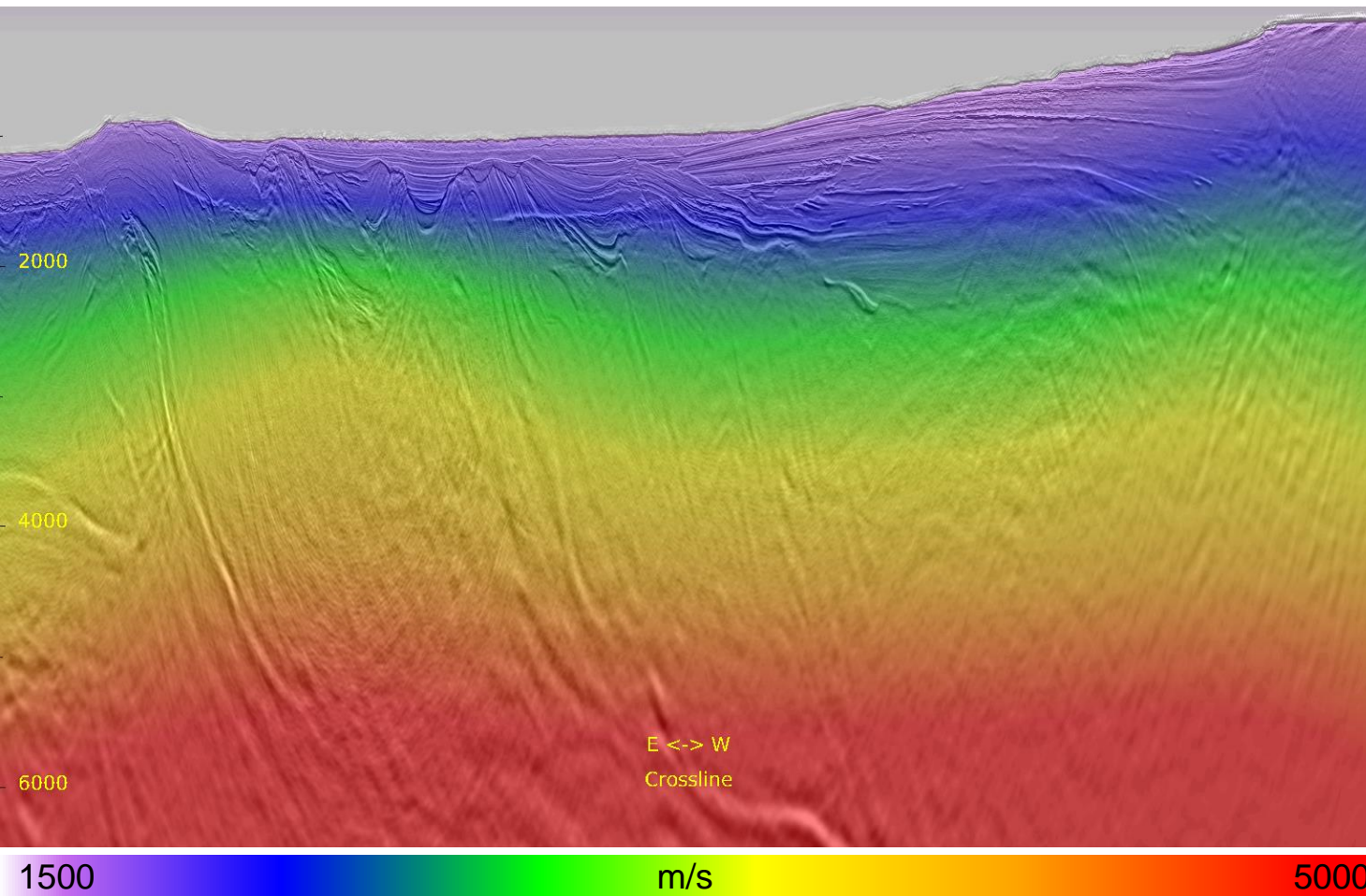


- ISO FWI gives reasonable update that follows geology, down to 2km beneath water bottom.
- The perturbation deeper than 2km beneath water bottom is removed with taper.



# Inline 436 West: Initial Velocity

7

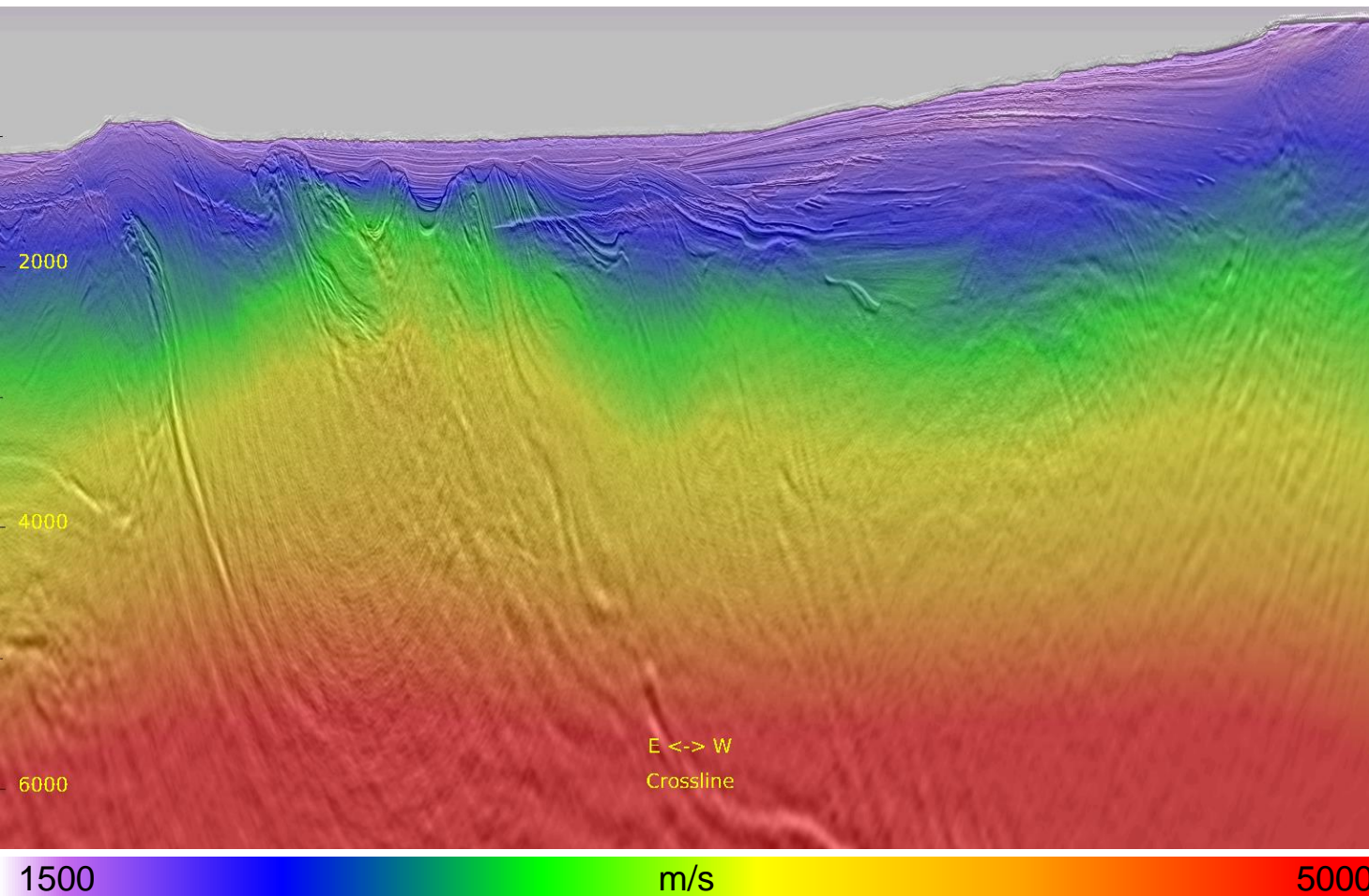


- Initial velocity is smooth.



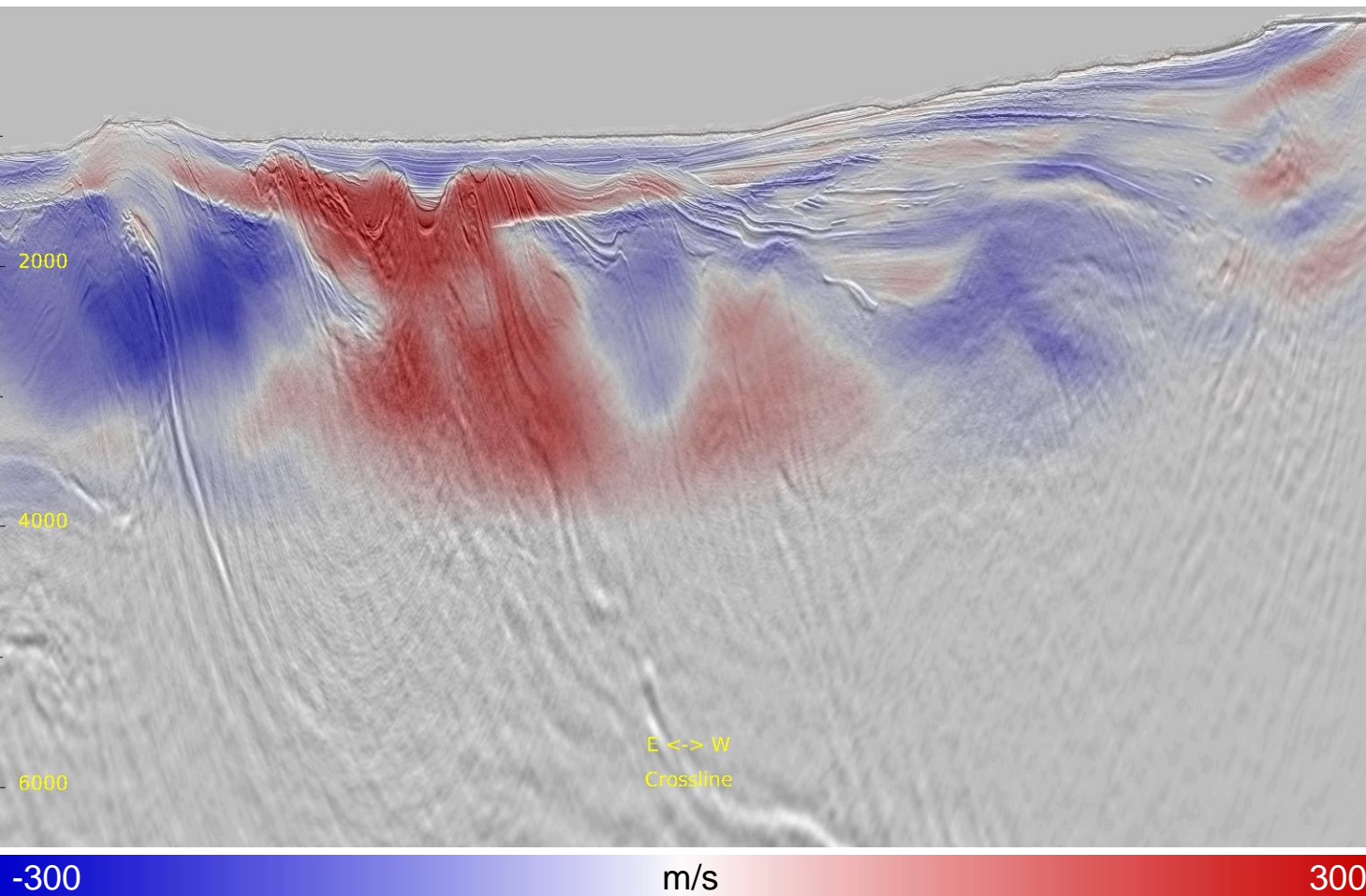
## Inline 436 West: Modified ISO FWI Velocity

8



- ISO FWI gives reasonable update that follows geology, down to 2km beneath water bottom.





- ISO FWI gives reasonable update that follows geology, down to 2km beneath water bottom.
- The perturbation deeper than 2km beneath water bottom is removed with taper.

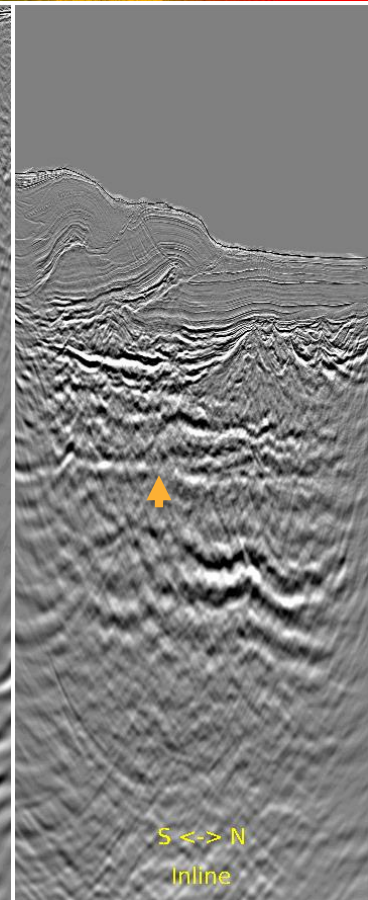
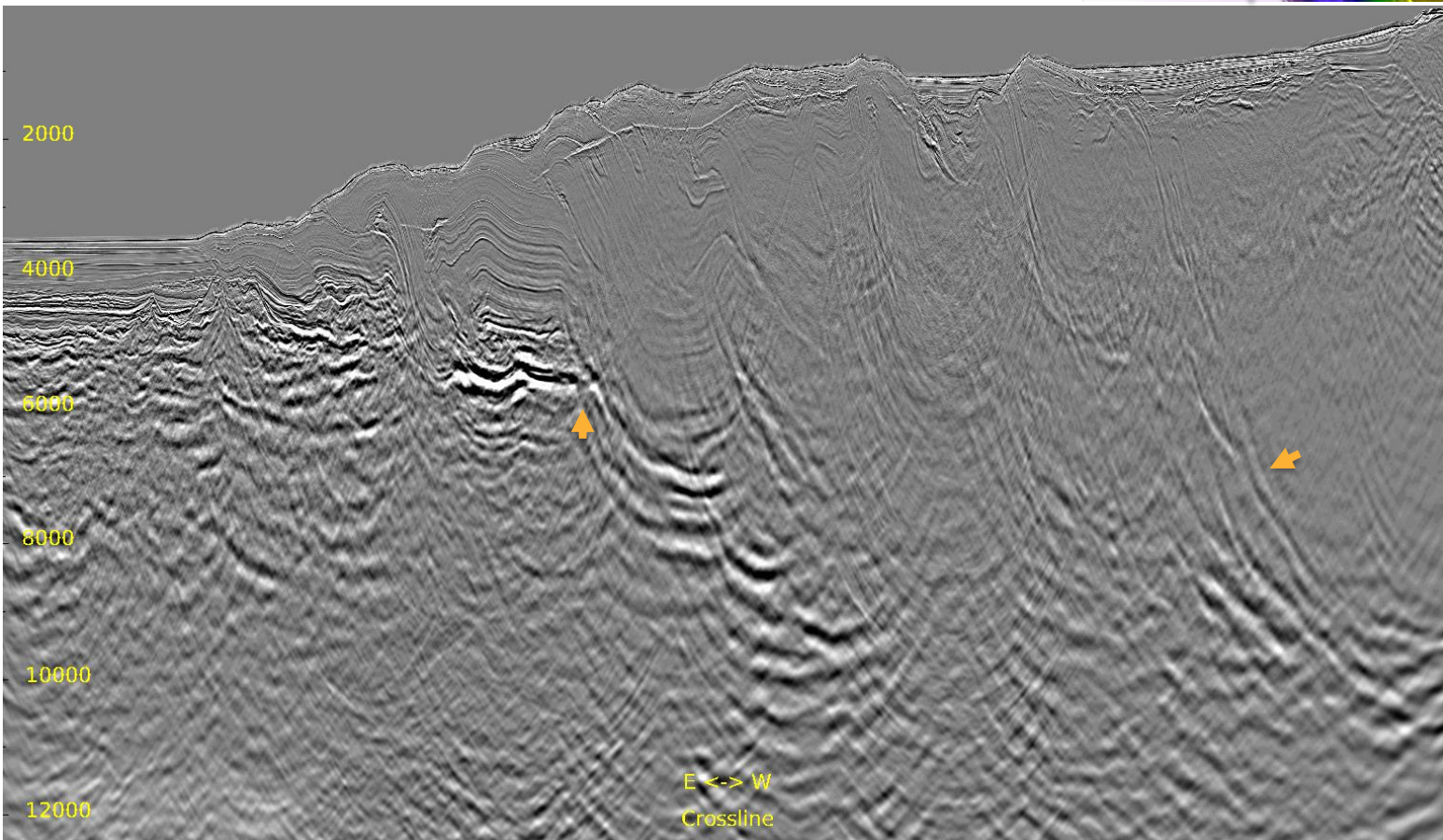
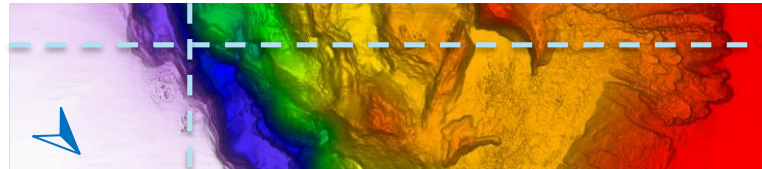
# Kirchhoff Depth Migration





# Full Stack: Initial

Inline 236 & Crossline 1540

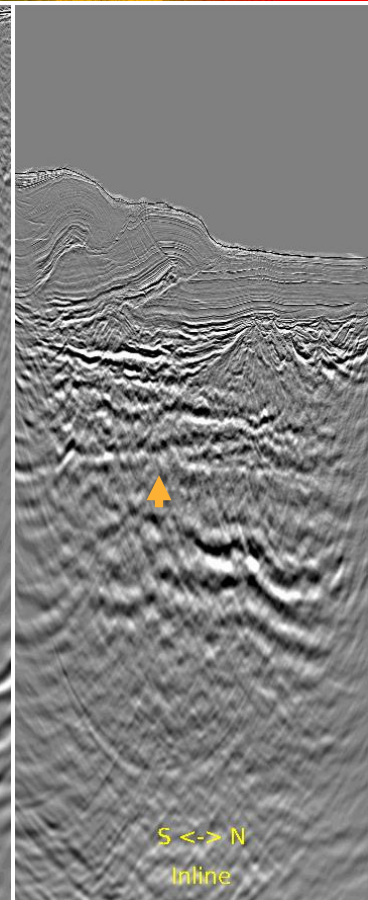
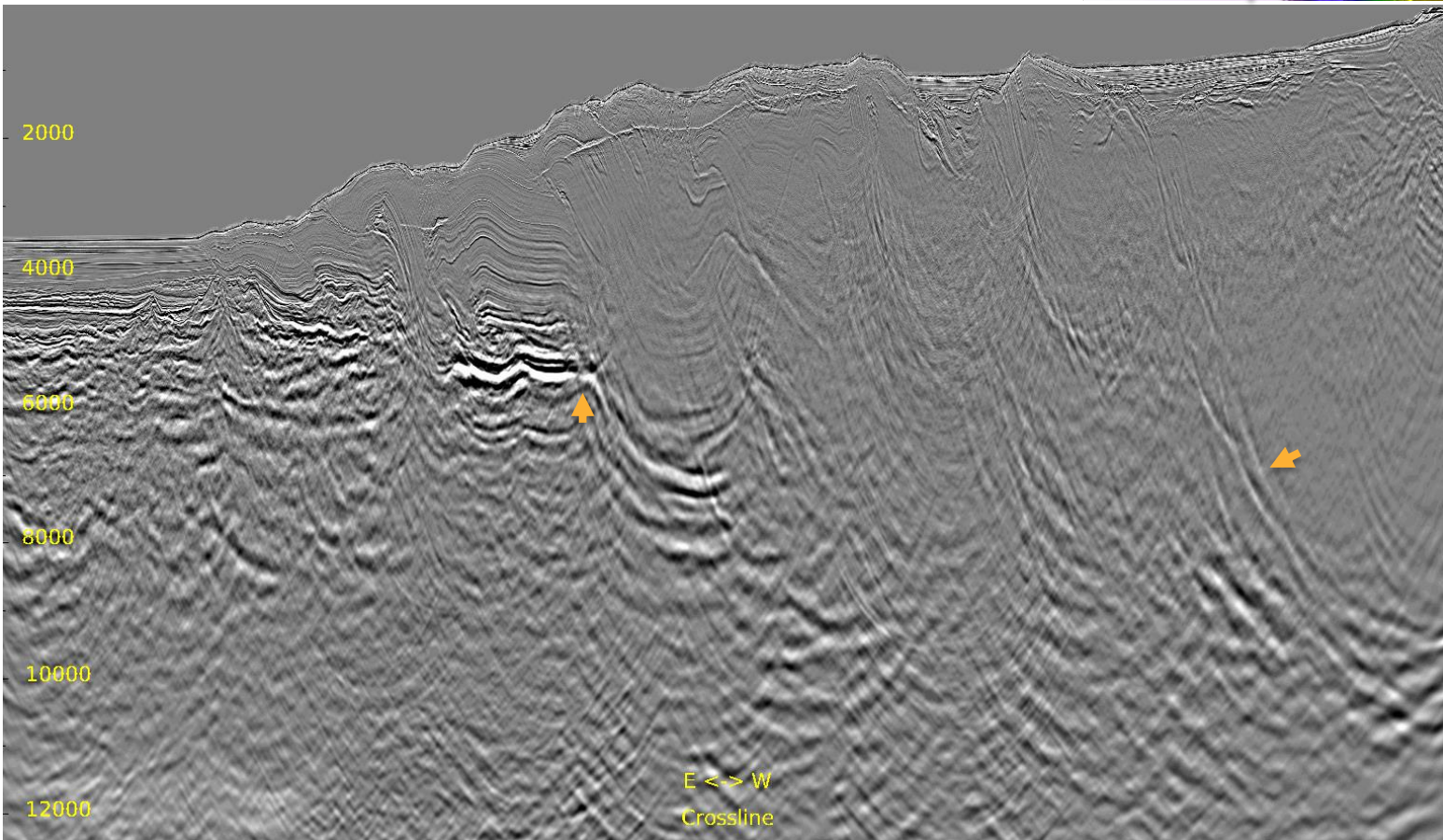
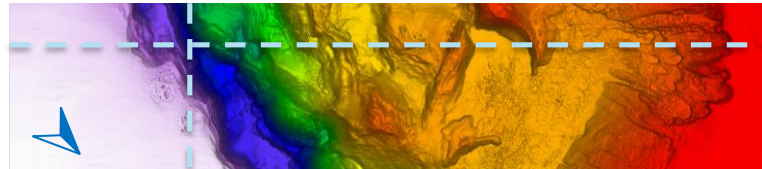






# Full Stack: ISO FWI

Inline 236 & Crossline 1540

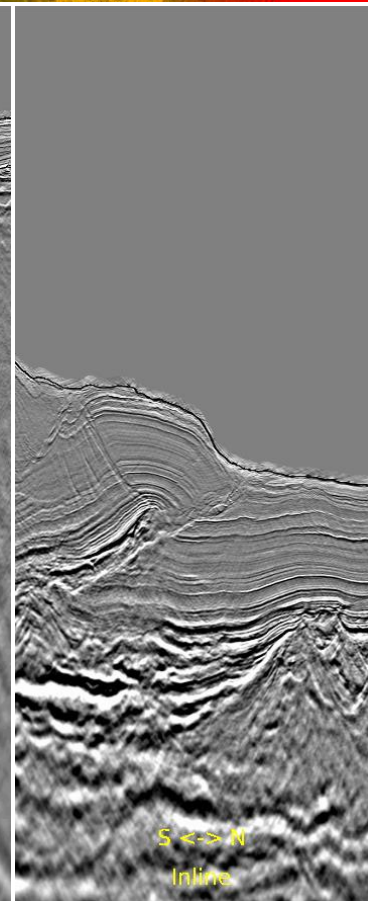
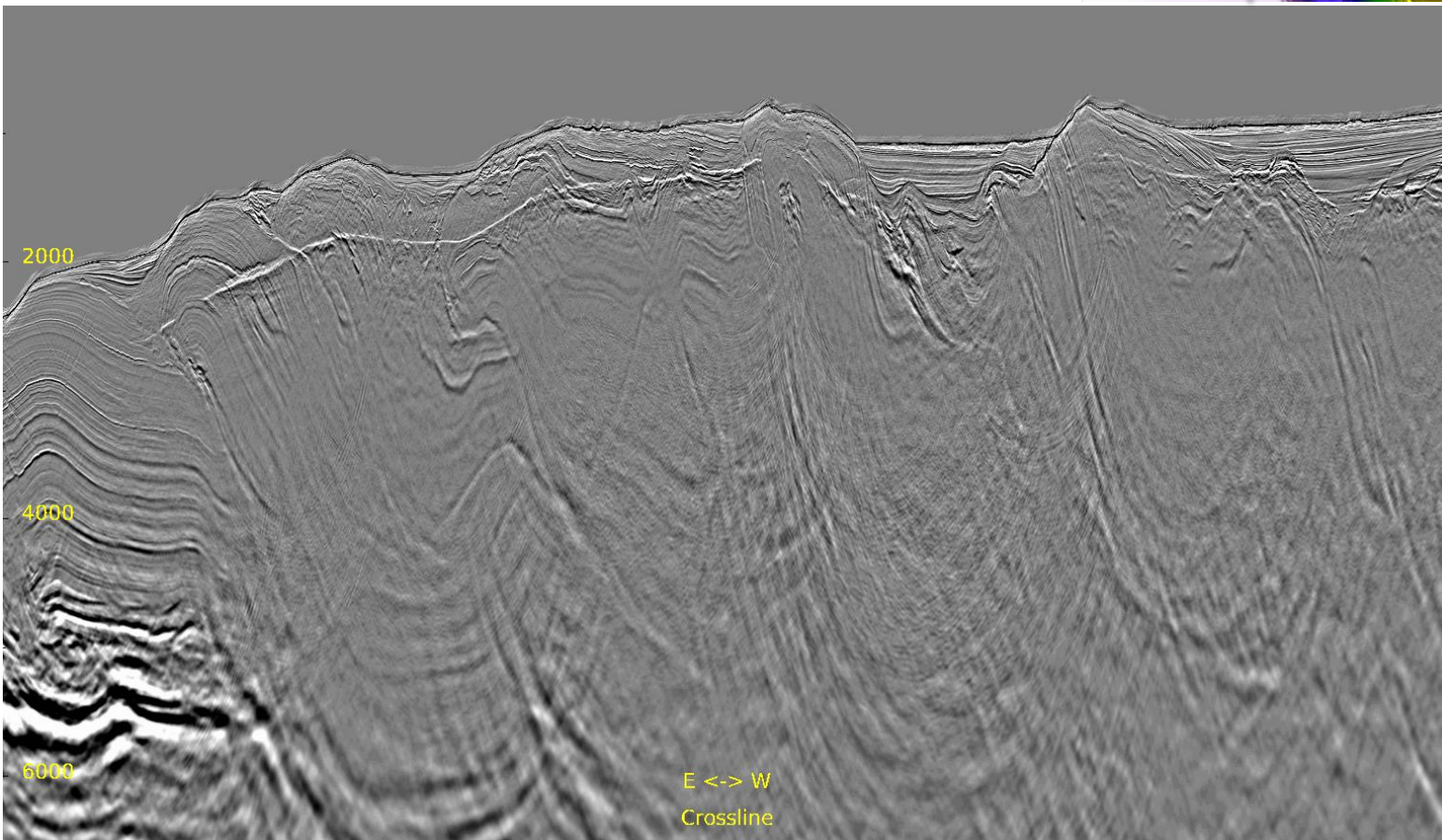
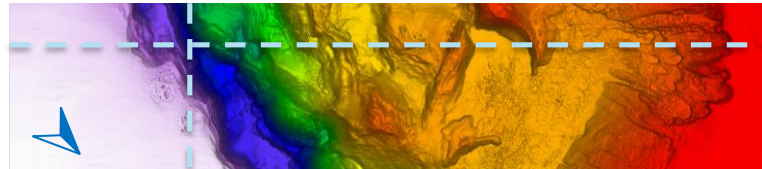






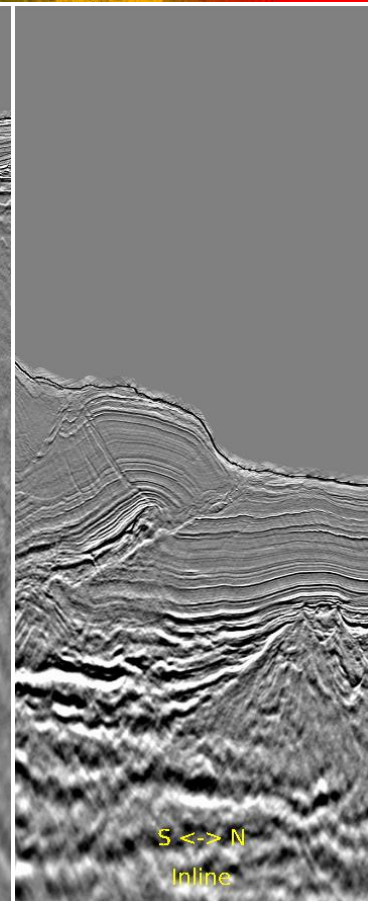
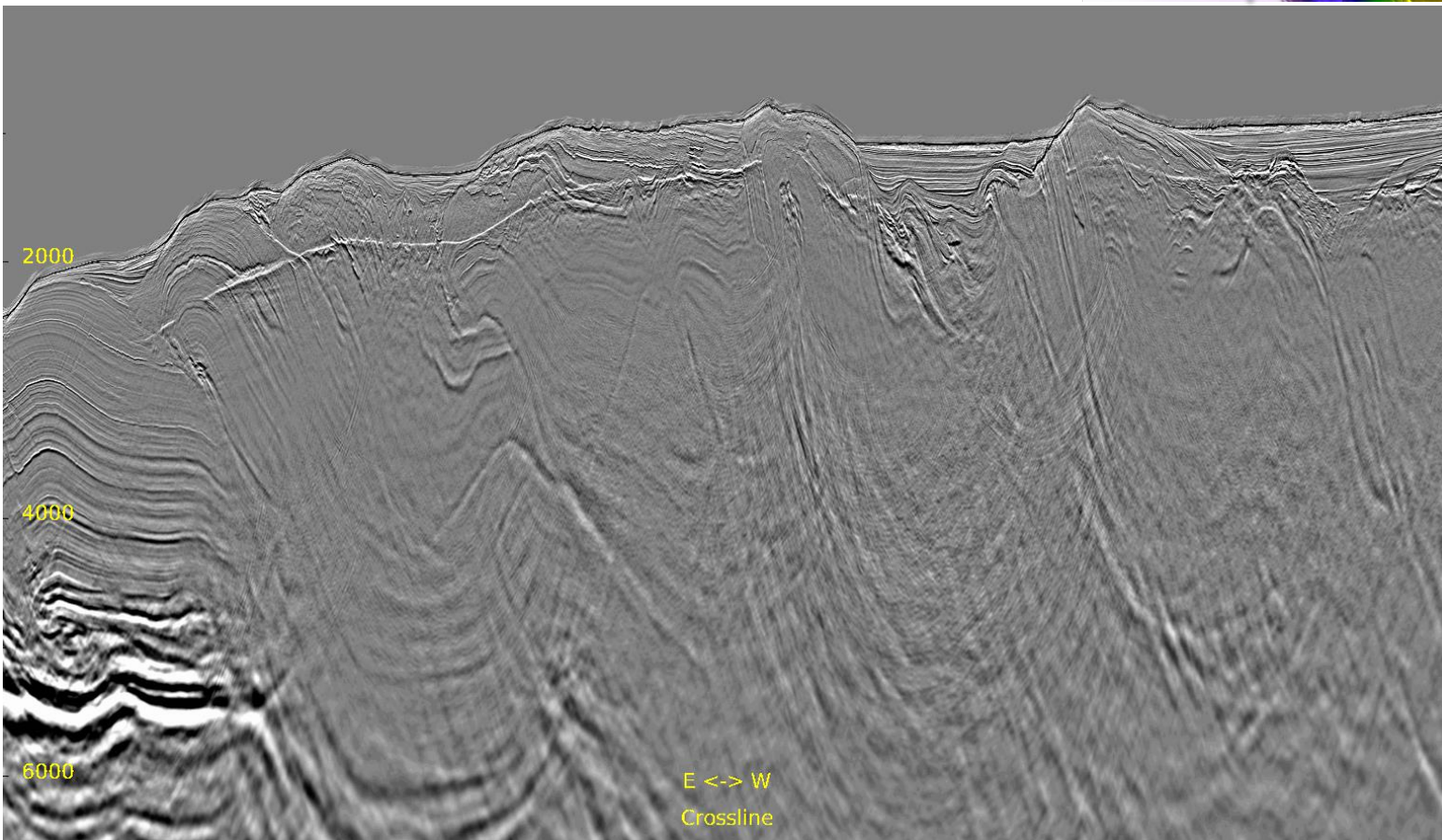
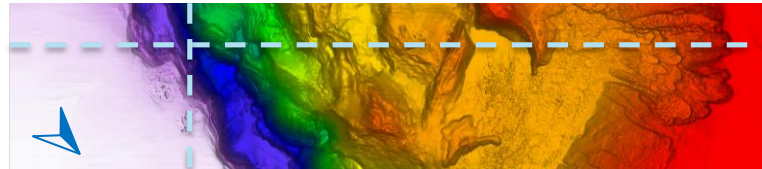
# Zoomed Full Stack: Initial

Inline 236 & Crossline 1540

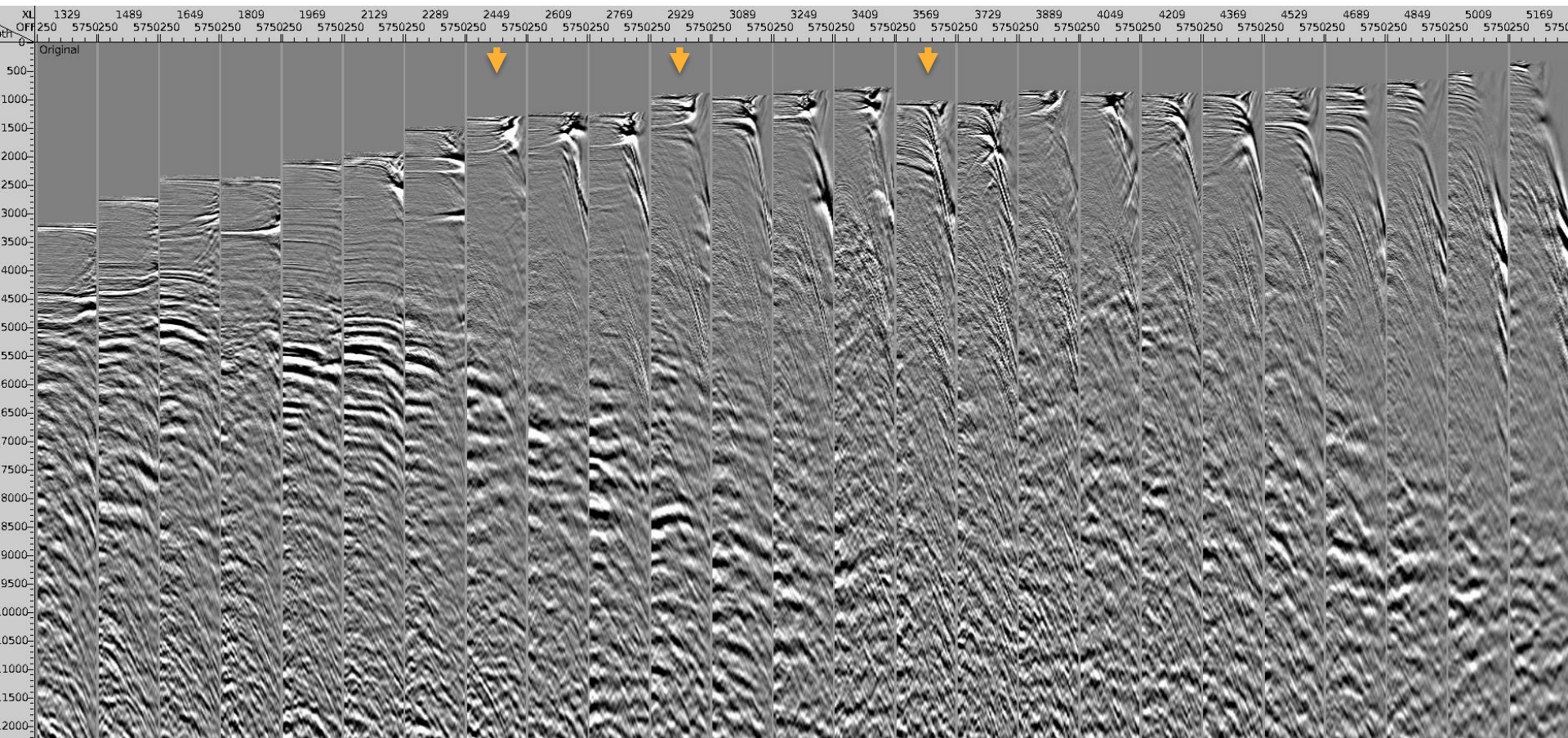


# Zoomed Full Stack: ISO FWI

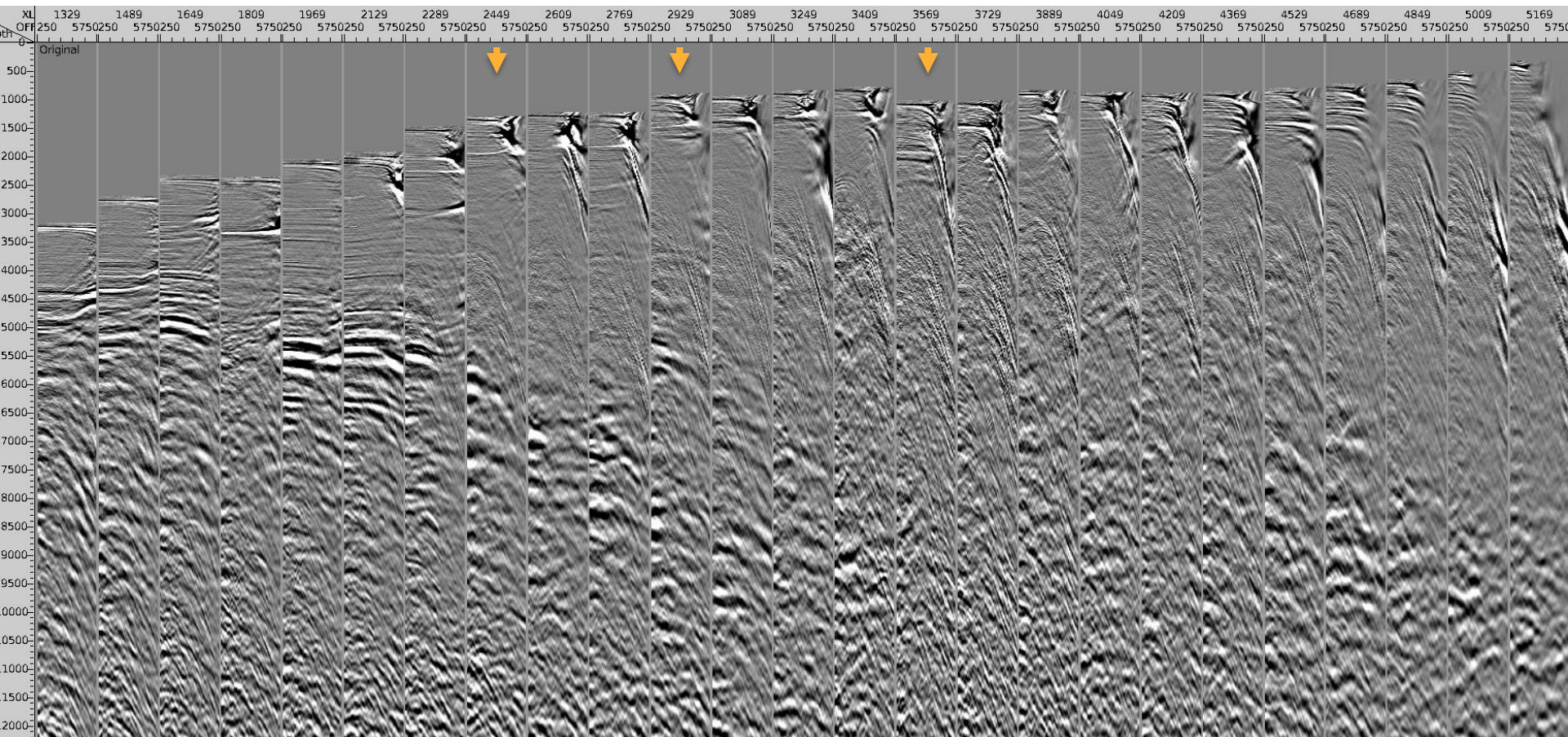
Inline 236 & Crossline 1540







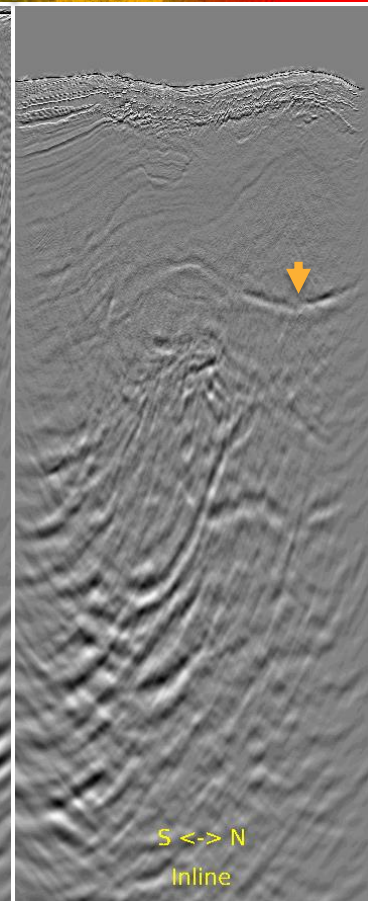
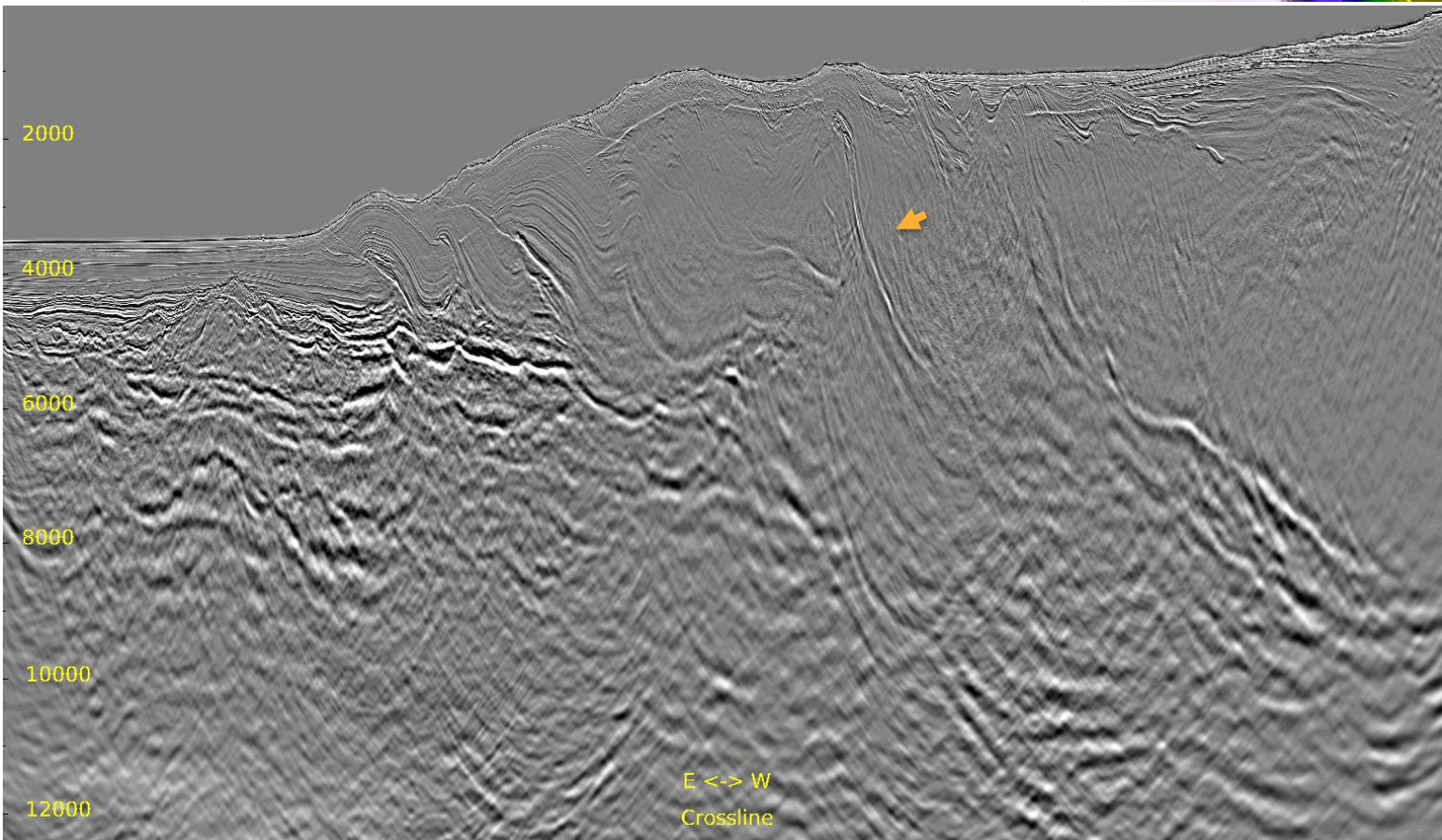
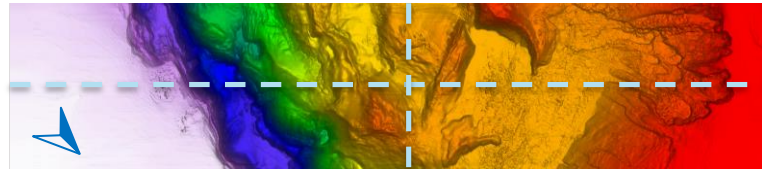






# Full Stack: Initial

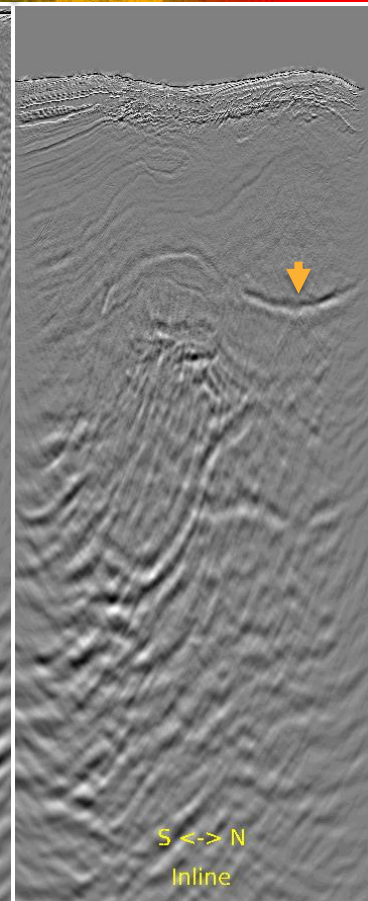
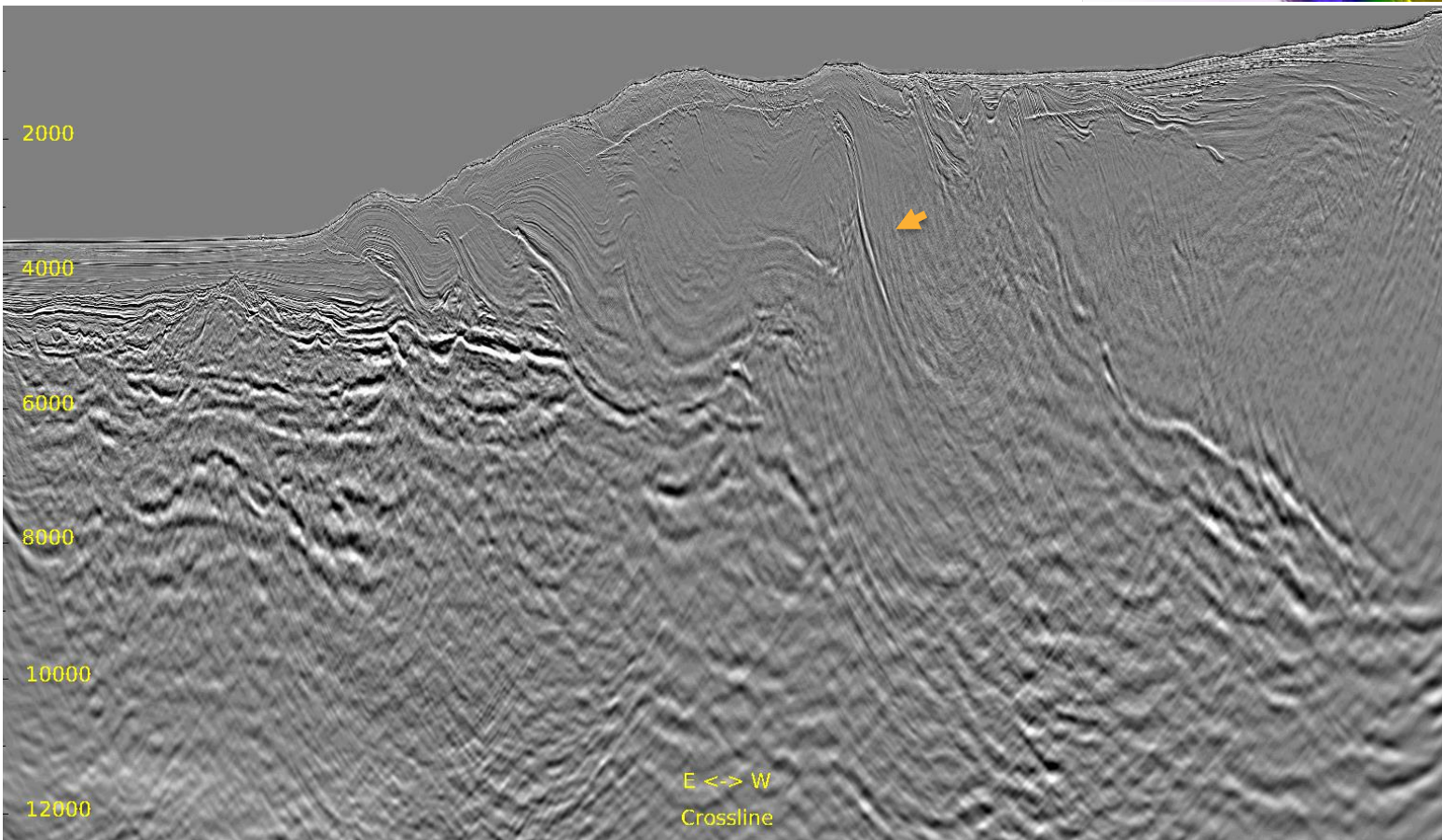
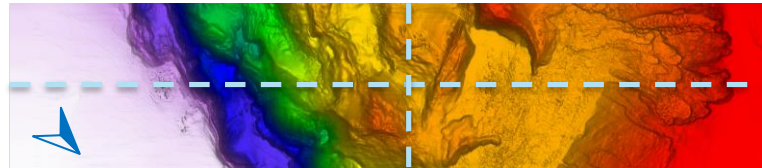
Inline 436 & Crossline 3040





# Full Stack: ISO FWI

Inline 436 & Crossline 3040

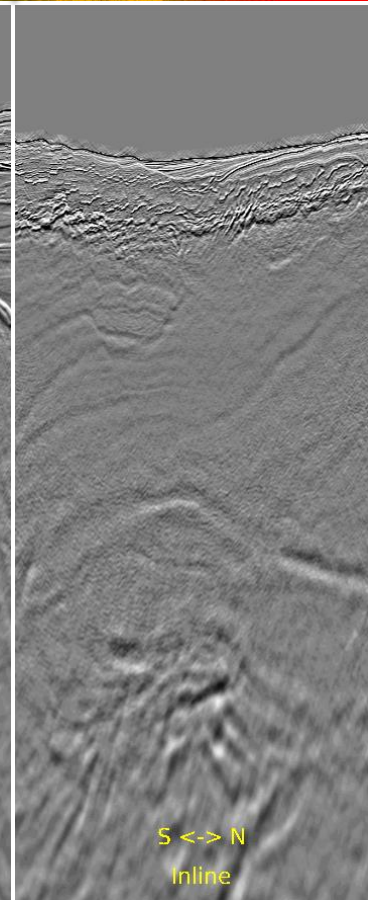
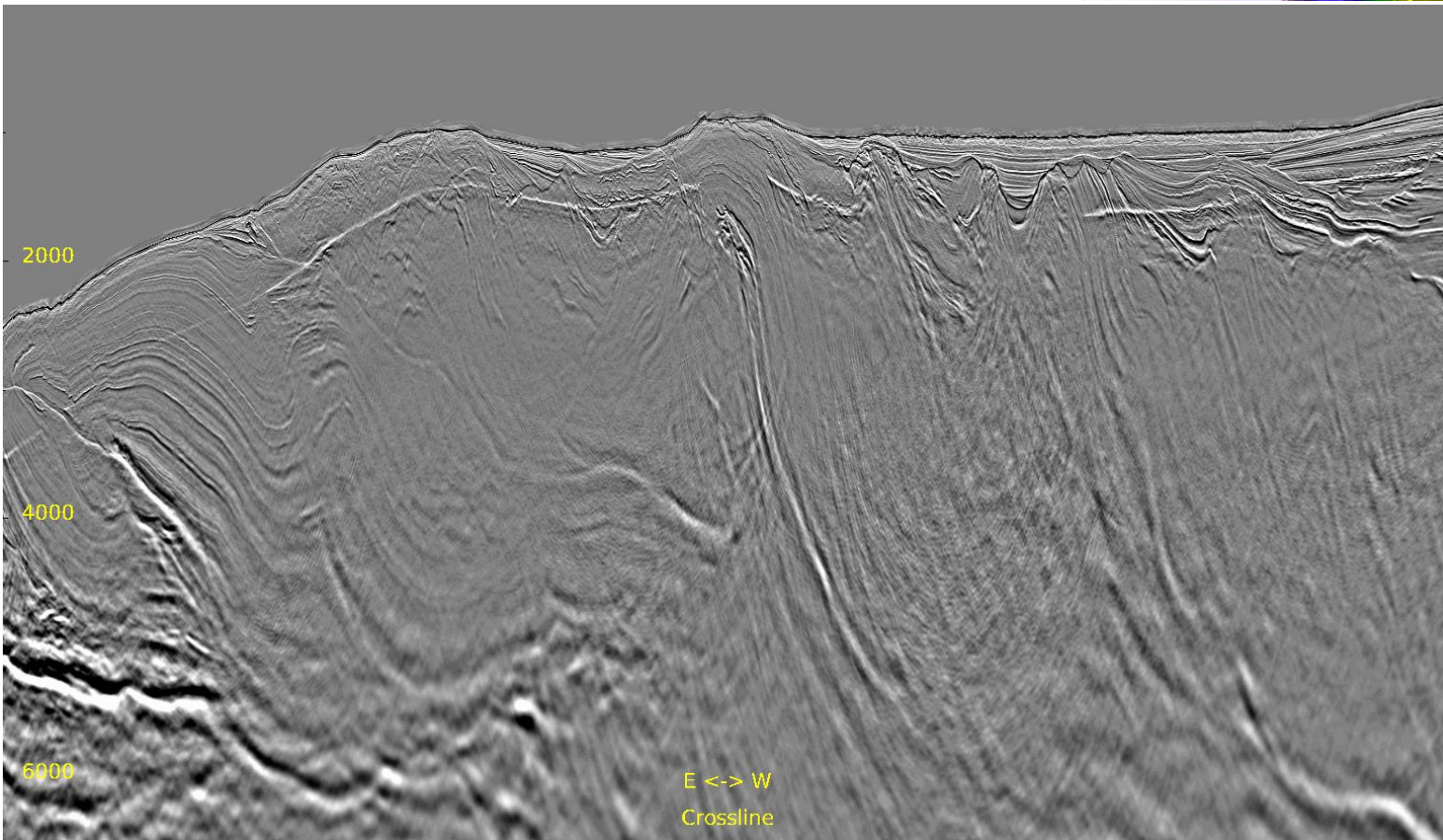
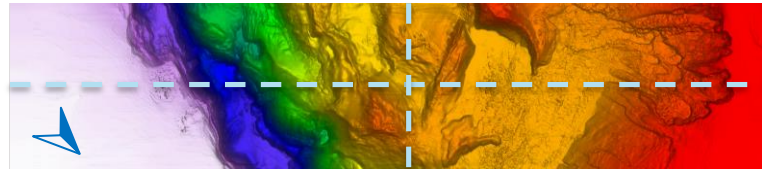






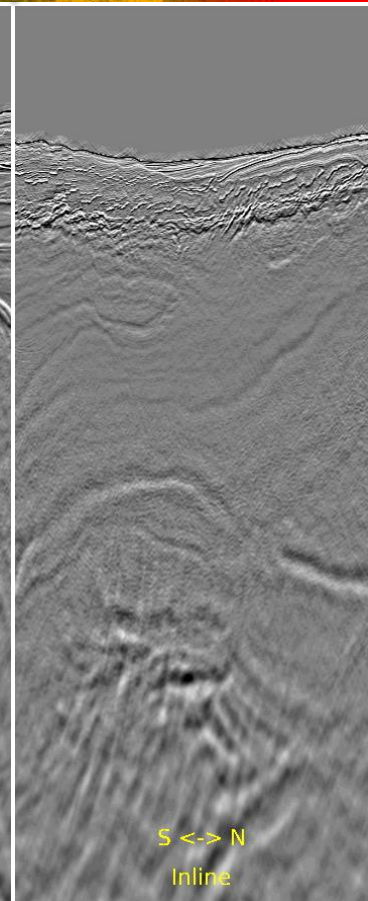
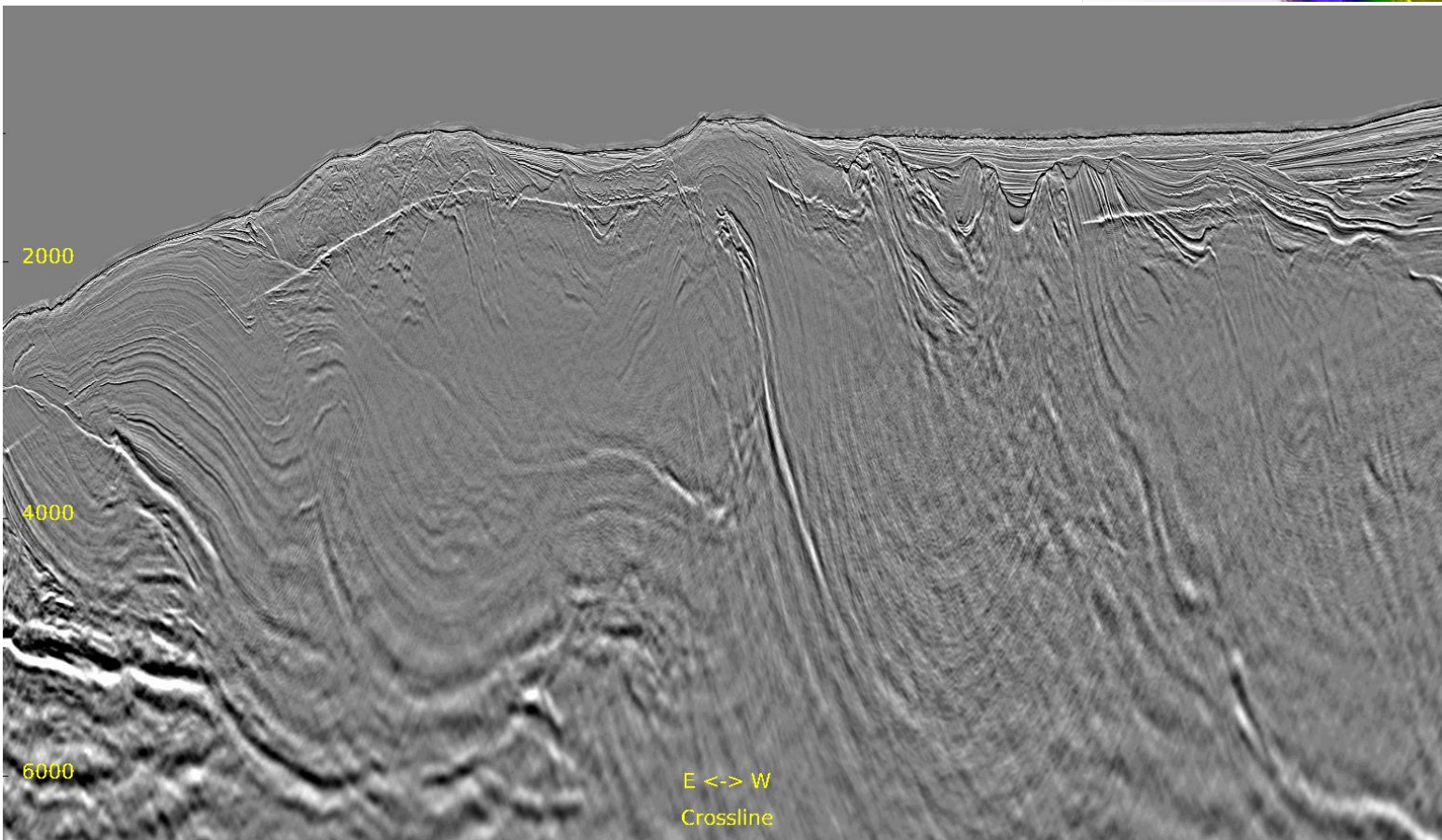
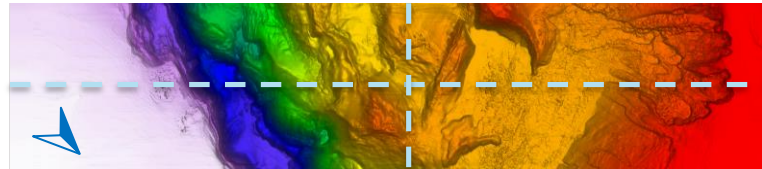
# Zoomed Full Stack: Initial

Inline 436 & Crossline 3040

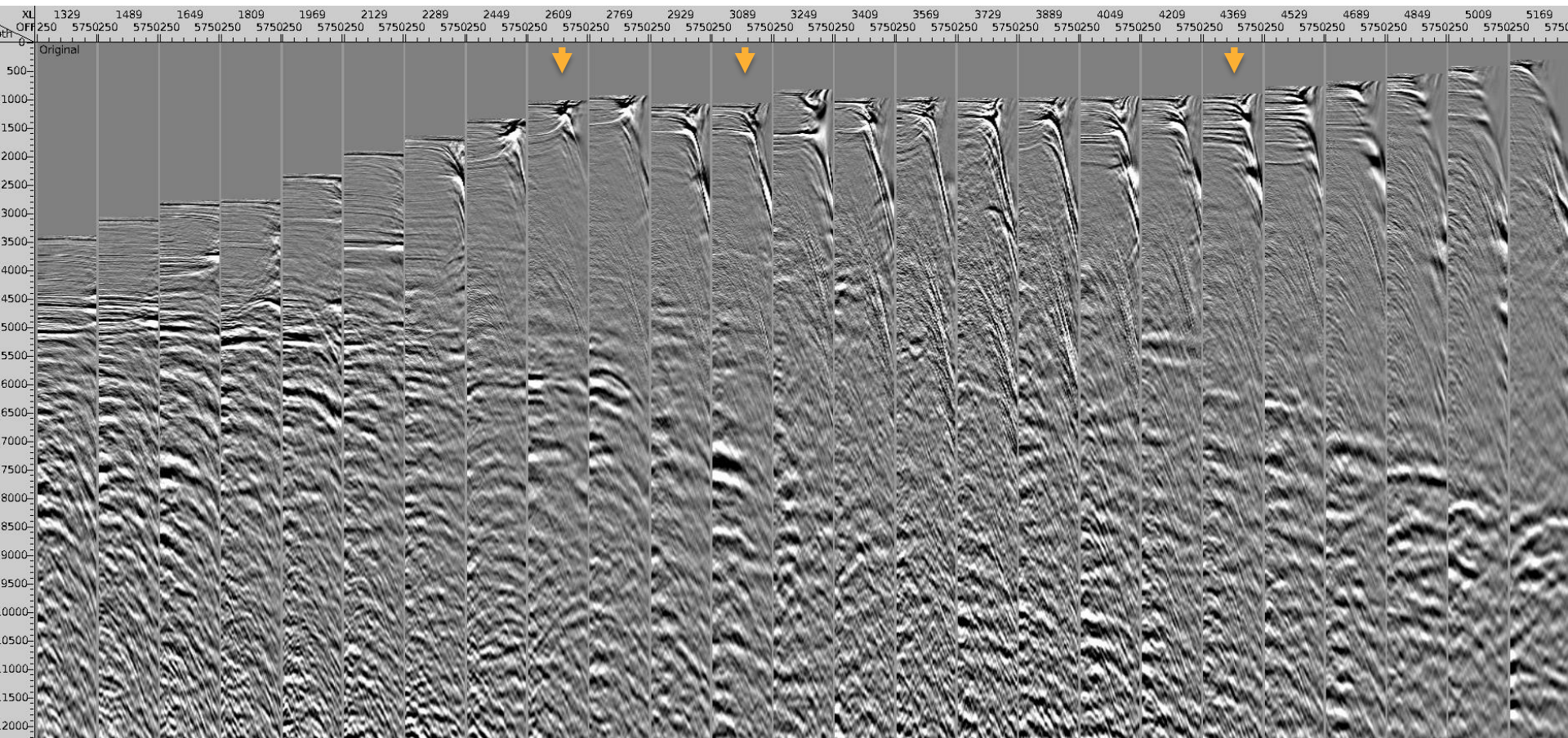


# Zoomed Full Stack: ISO FWI

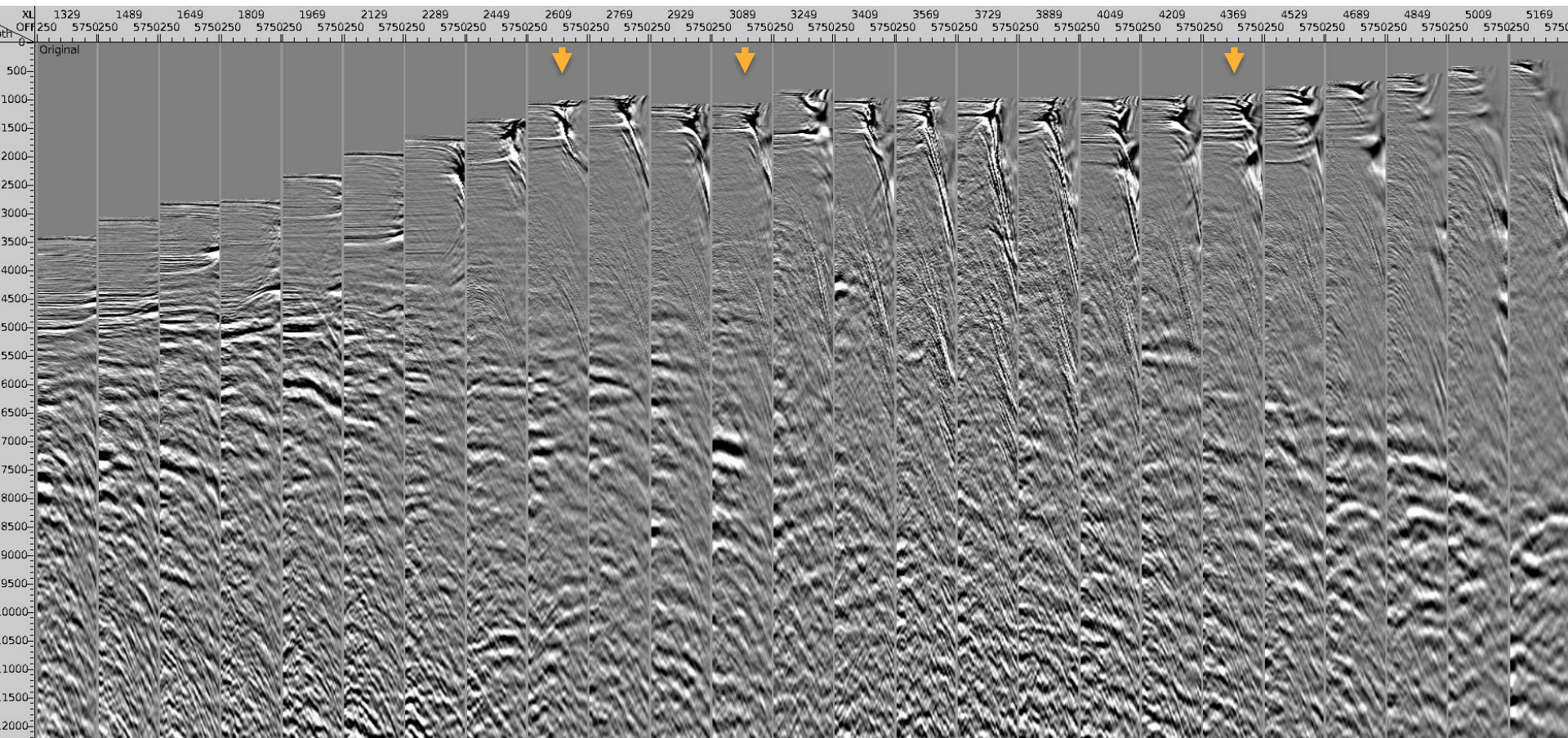
Inline 436 & Crossline 3040









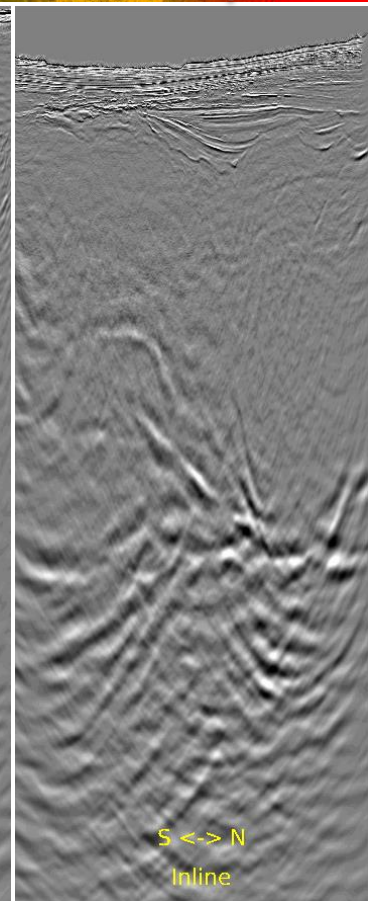
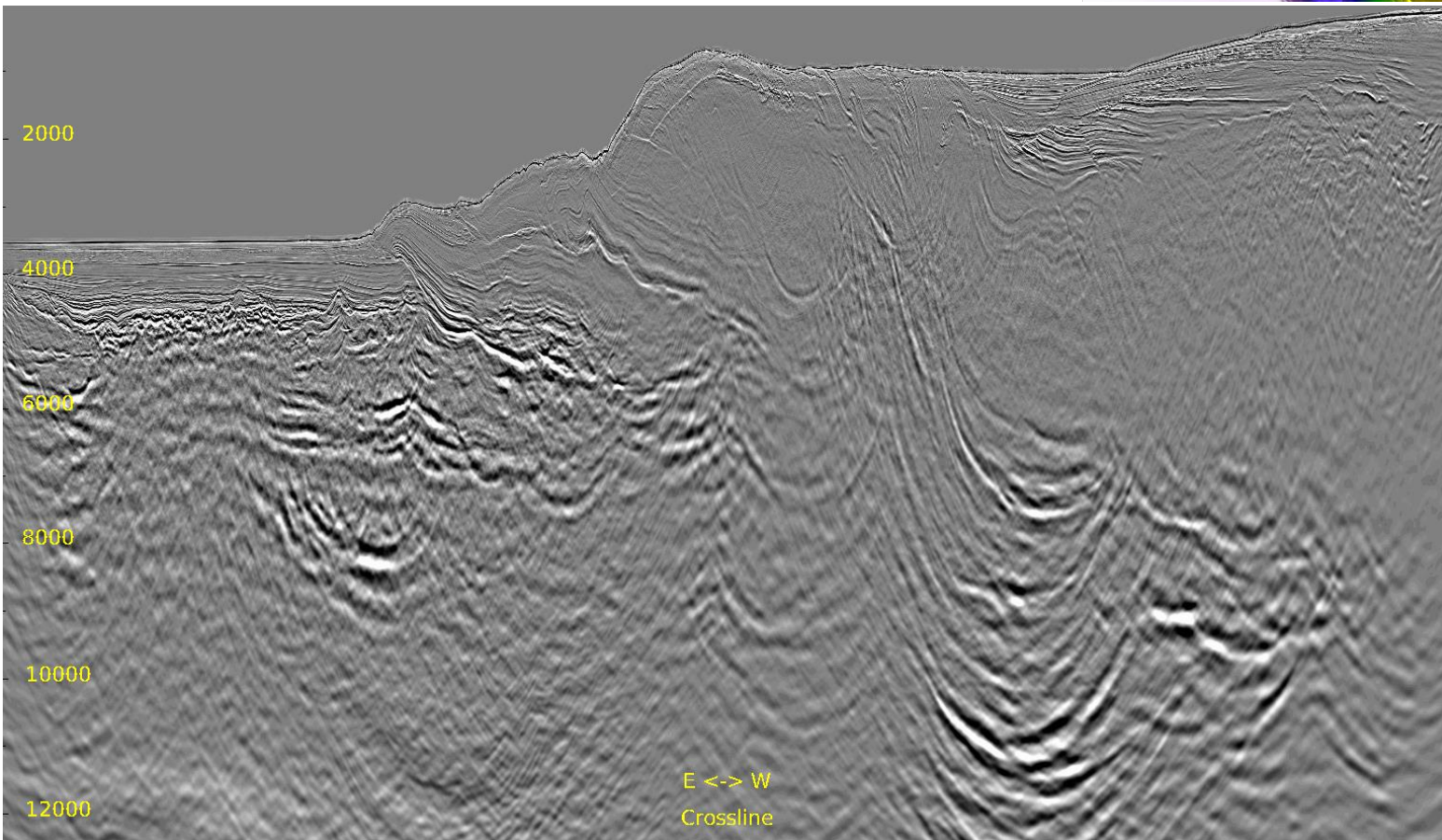
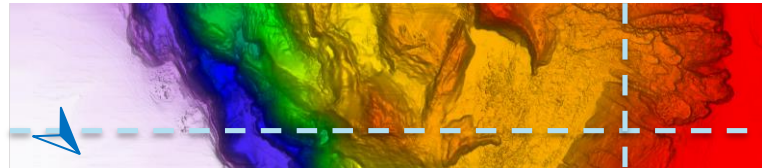






# Full Stack: Initial

Inline 636 & Crossline 4540

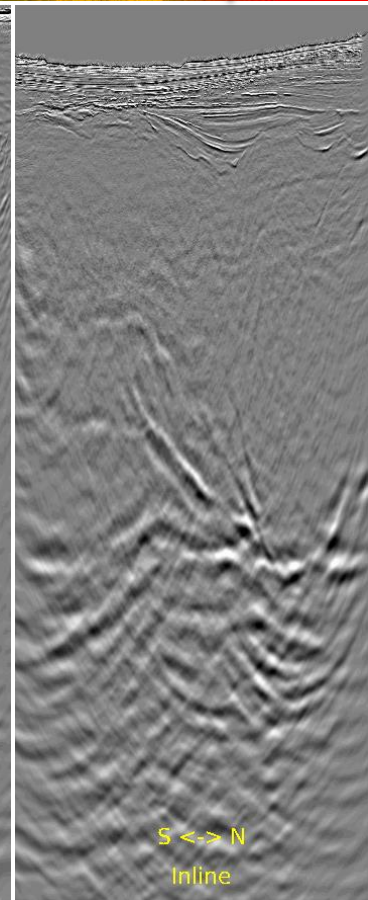
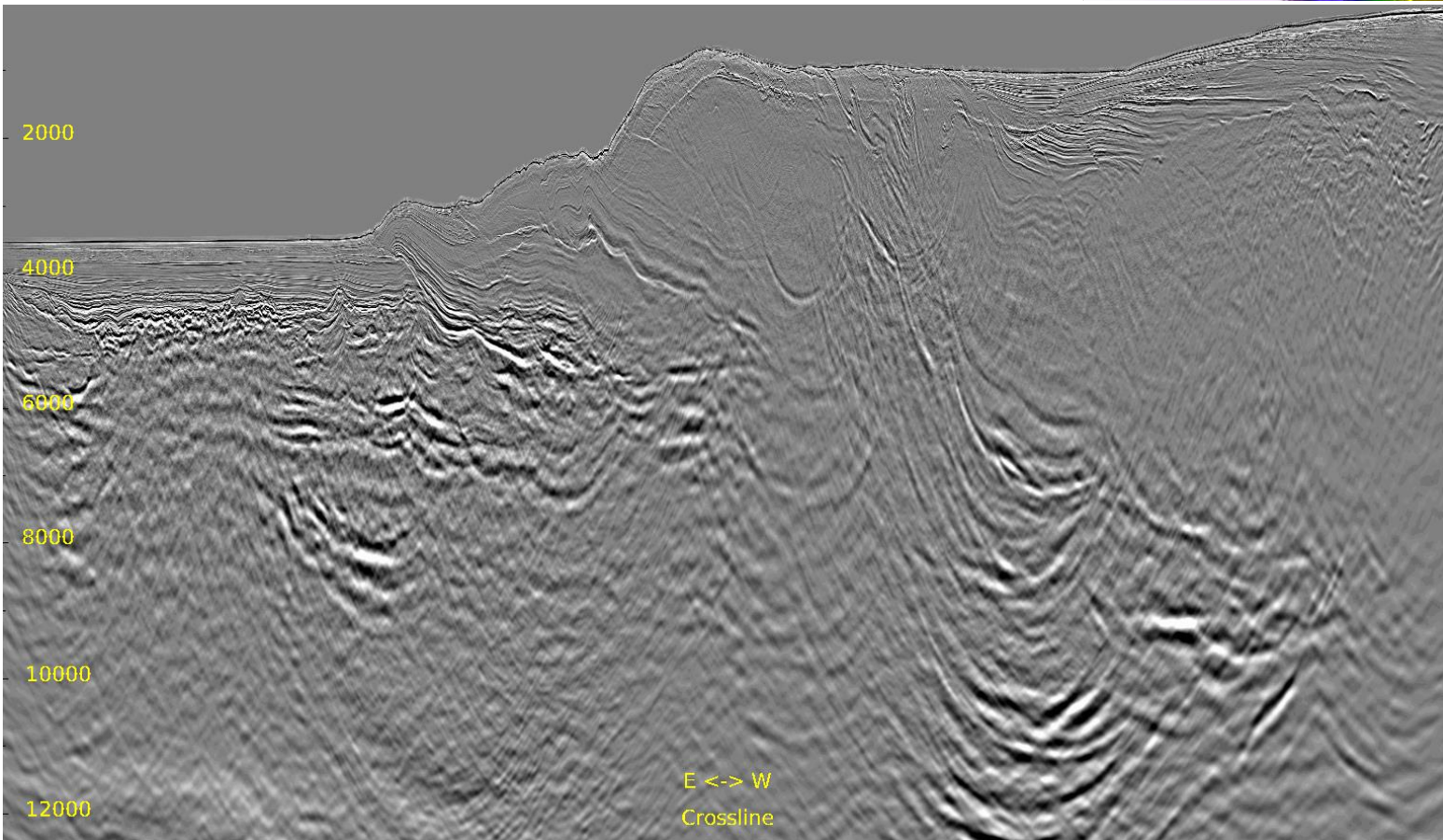
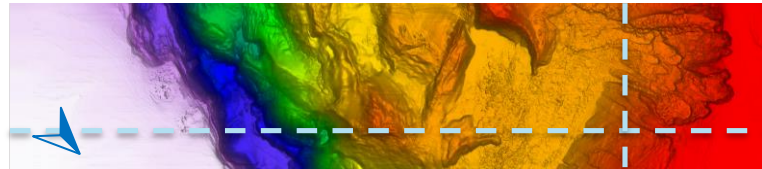






# Full Stack: ISO FWI

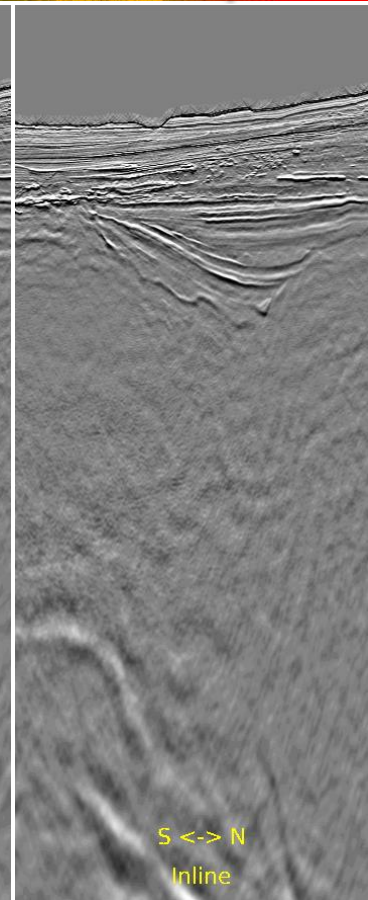
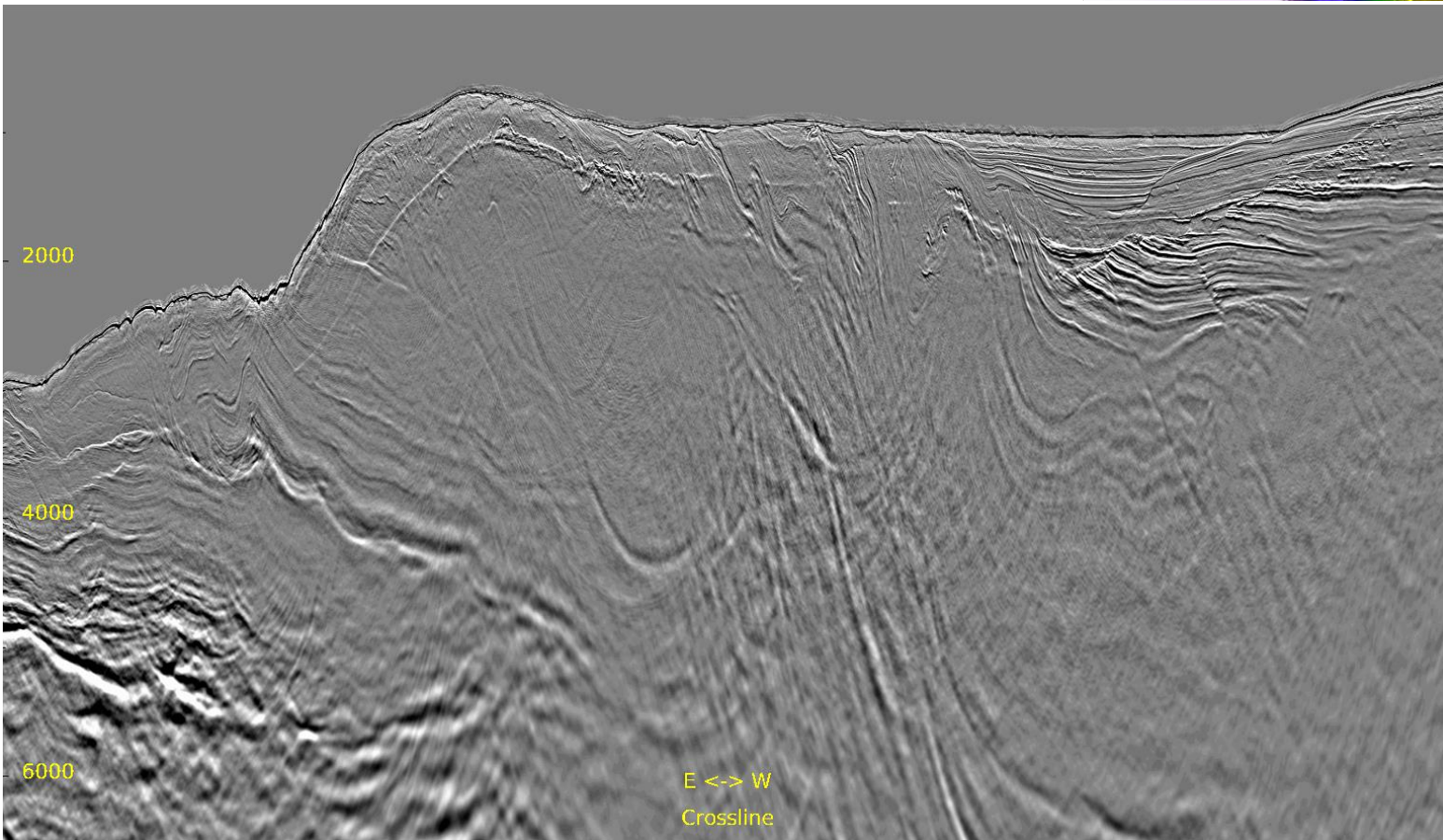
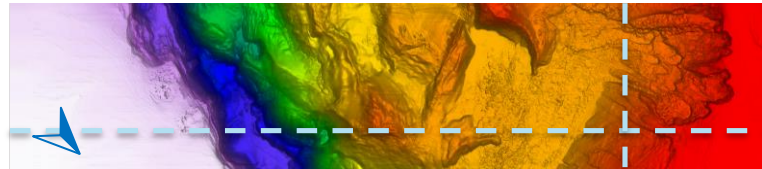
Inline 636 & Crossline 4540





# Zoomed Full Stack: Initial

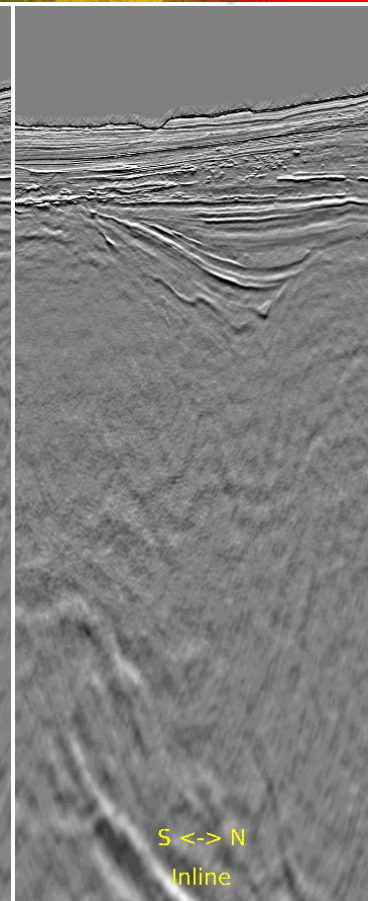
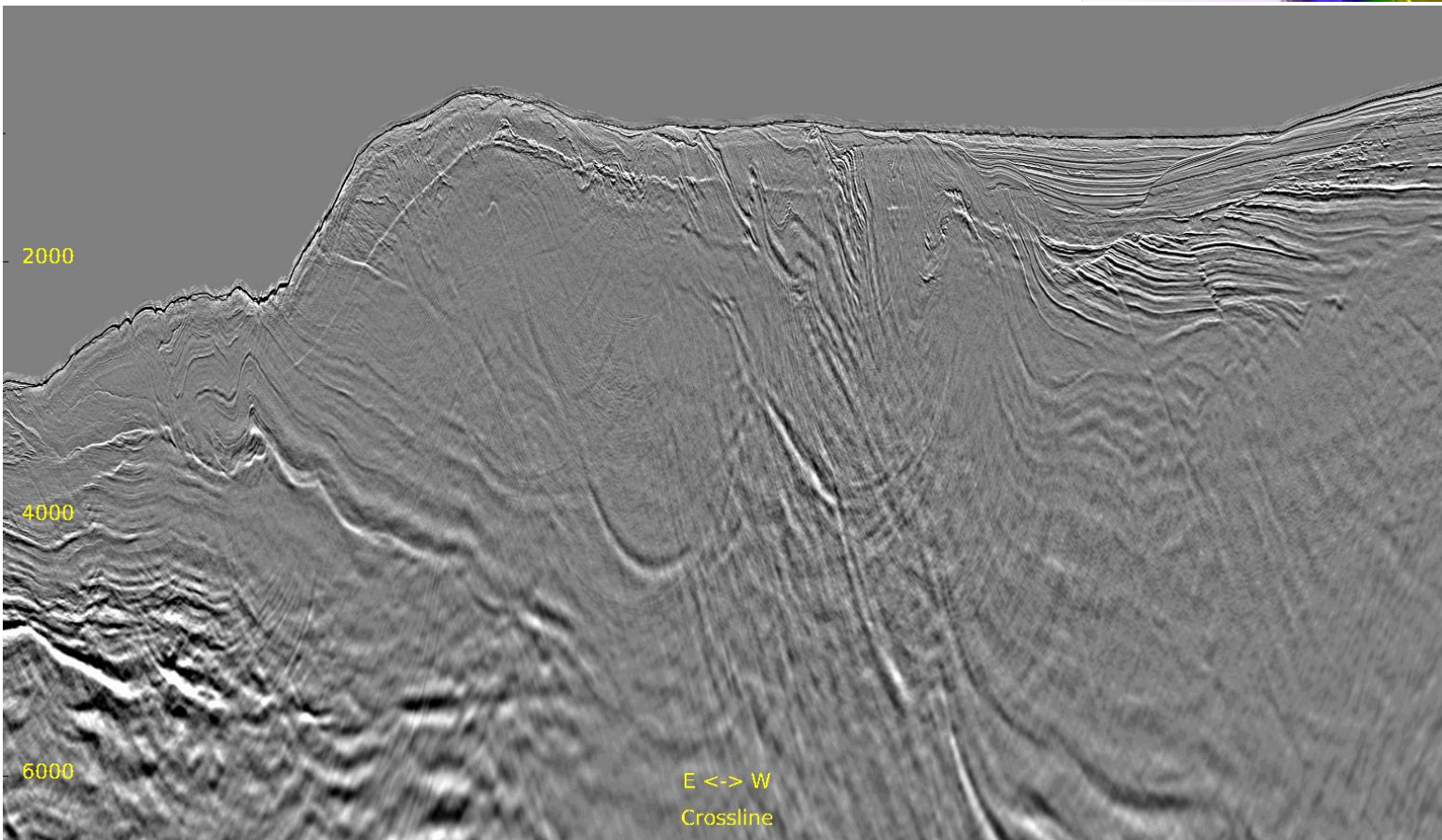
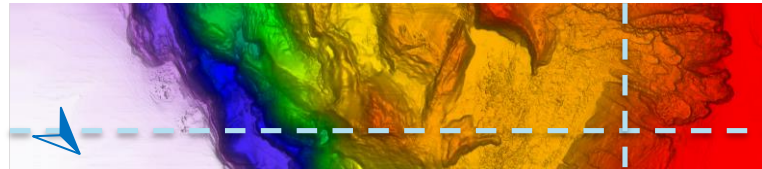
Inline 636 & Crossline 4540



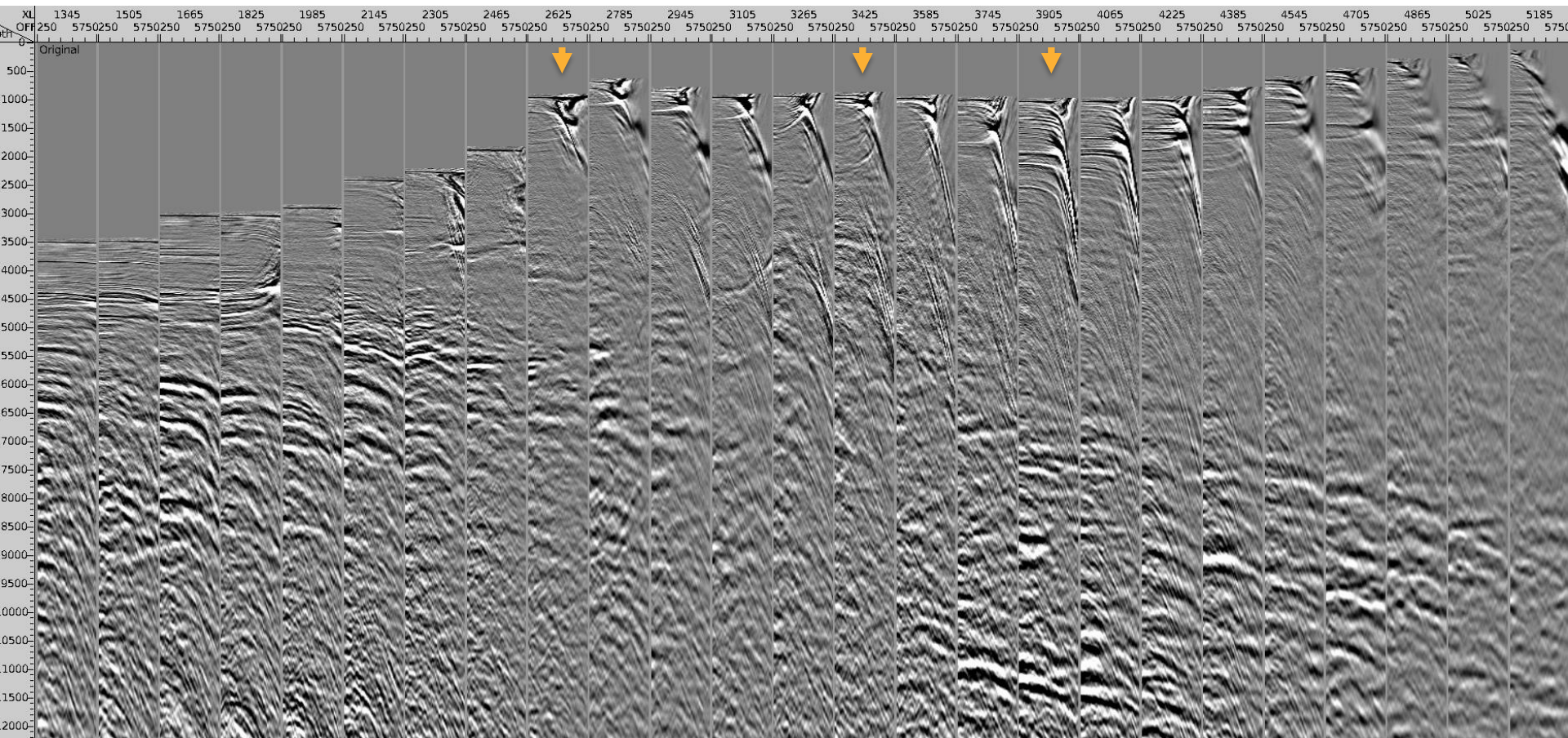


# Zoomed Full Stack: ISO FWI

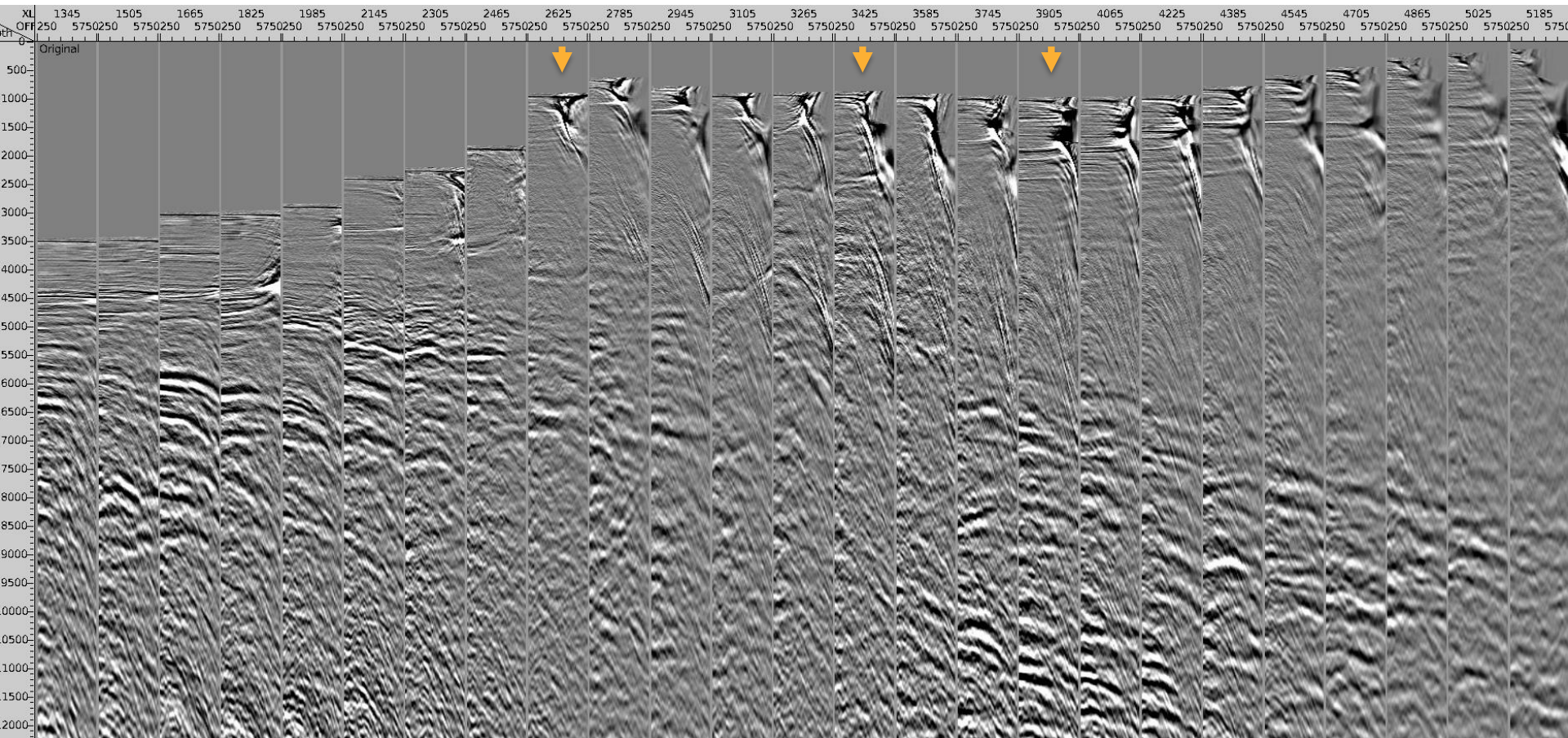
Inline 636 & Crossline 4540













# IT1 - Isotropic Tomography

## NZ 3D Processing

*25 November 2020*

[cgg.com](http://cgg.com)



INSTITUTE FOR GEOPHYSICS



Passion for Geoscience



- **Objective:**

To update overall velocity trend and get accurate shallow velocity for anisotropy analysis.

- **Procedure:**

The input is migration result after isotropic (ISO) FWI update.

Residual move-out information was picked on CDP gathers on a grid size 50m X 56.25m.

Isotropic non-linear tomography was applied globally from water bottom to 15 km.

- **Display:**

Velocity and migrated depth full stack & gathers.

- **Observation and Recommendation:**

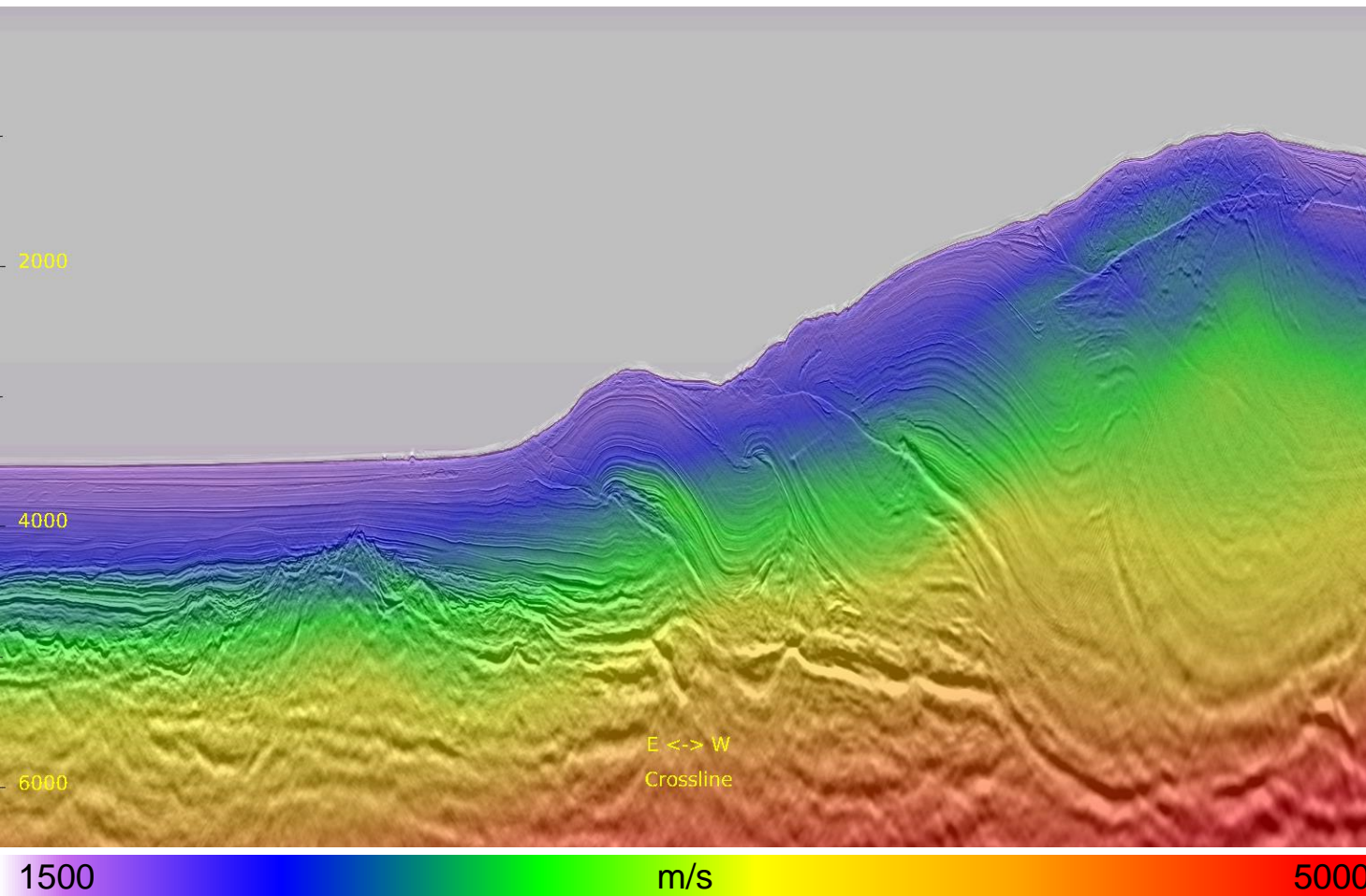
Iteration 1 (IT1) tomography globally flattens CDP gathers. Events in the deep area are simpler and more geological, compared to previous result. Events close to water bottom are flat from near to far angle, indicating a reasonable velocity for anisotropy analysis.

# Velocity Model



# Inline 436 East: ISO FWI Velocity

4

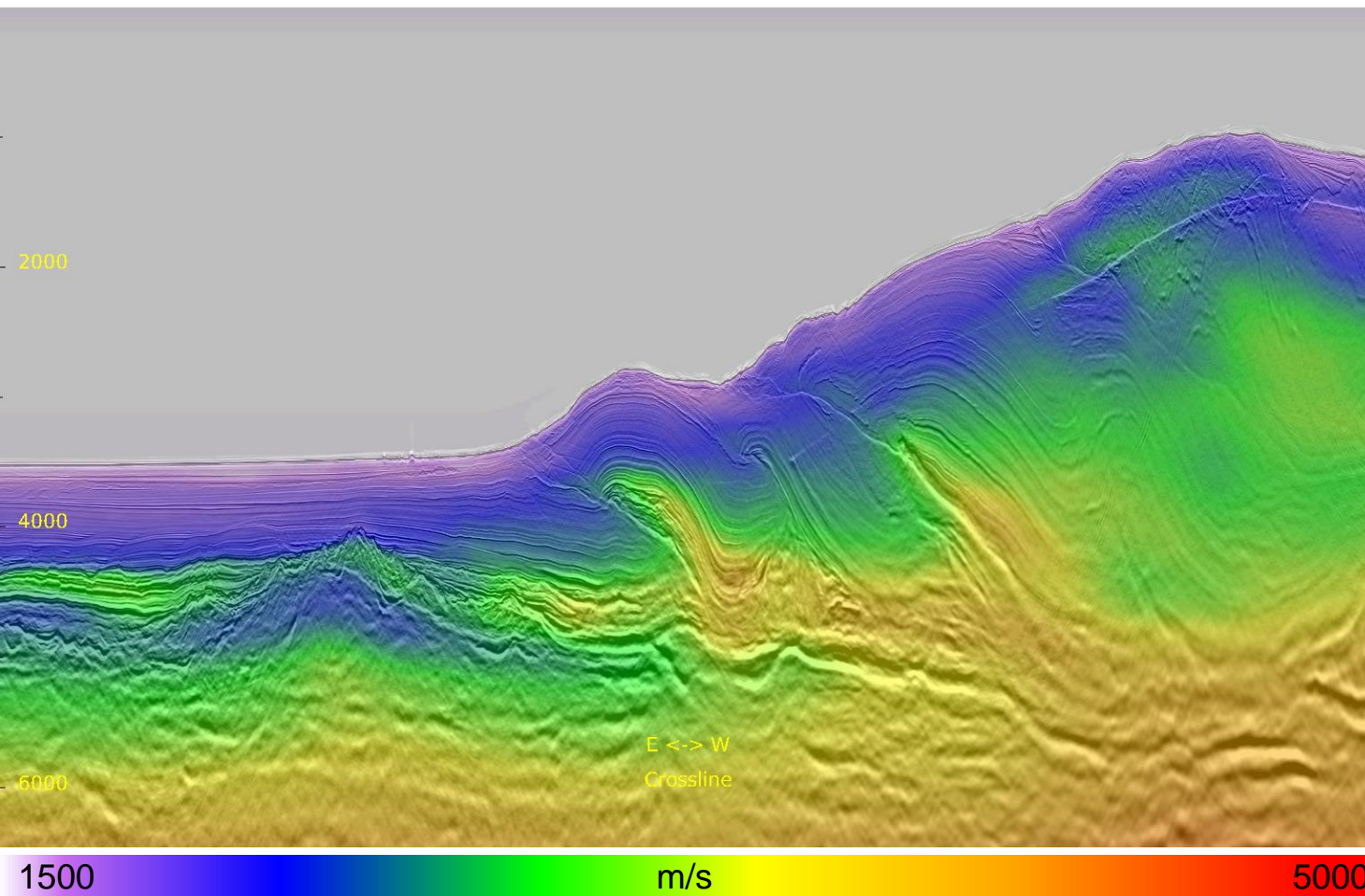


- Starting model is from Modified ISO FWI velocity.
- Deep area velocity trend still follows water bottom.



# Inline 436 East: IT1 ISO Tomography Velocity

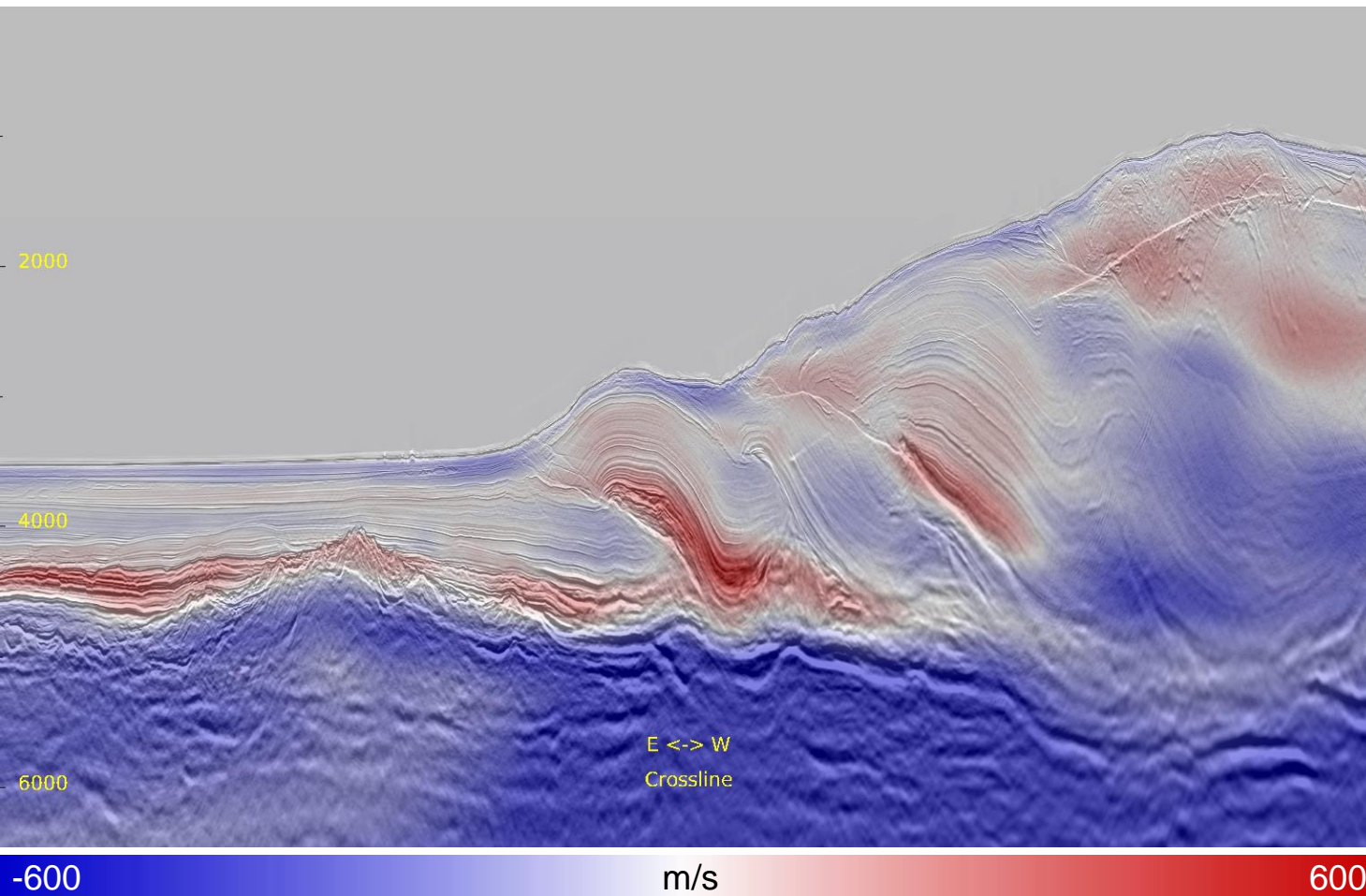
5



- IT1 ISO tomography overall slows down the velocity and provides some details that follow geology.

# Inline 436 East: Velocity Perturbation

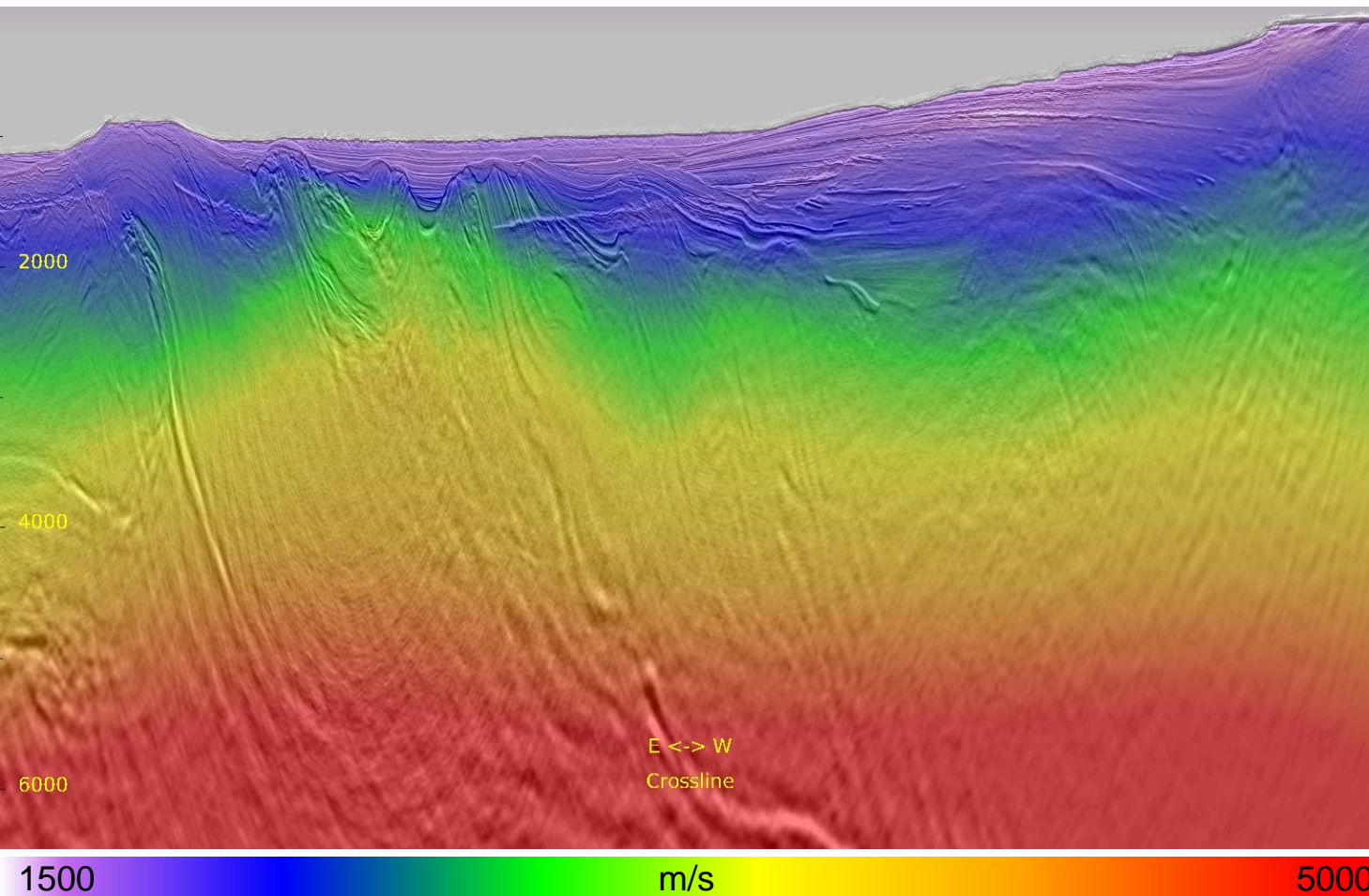
6



- IT1 ISO tomography overall slows down the velocity and provides some details that follow geology.

# Inline 436 West: ISO FWI Velocity

7

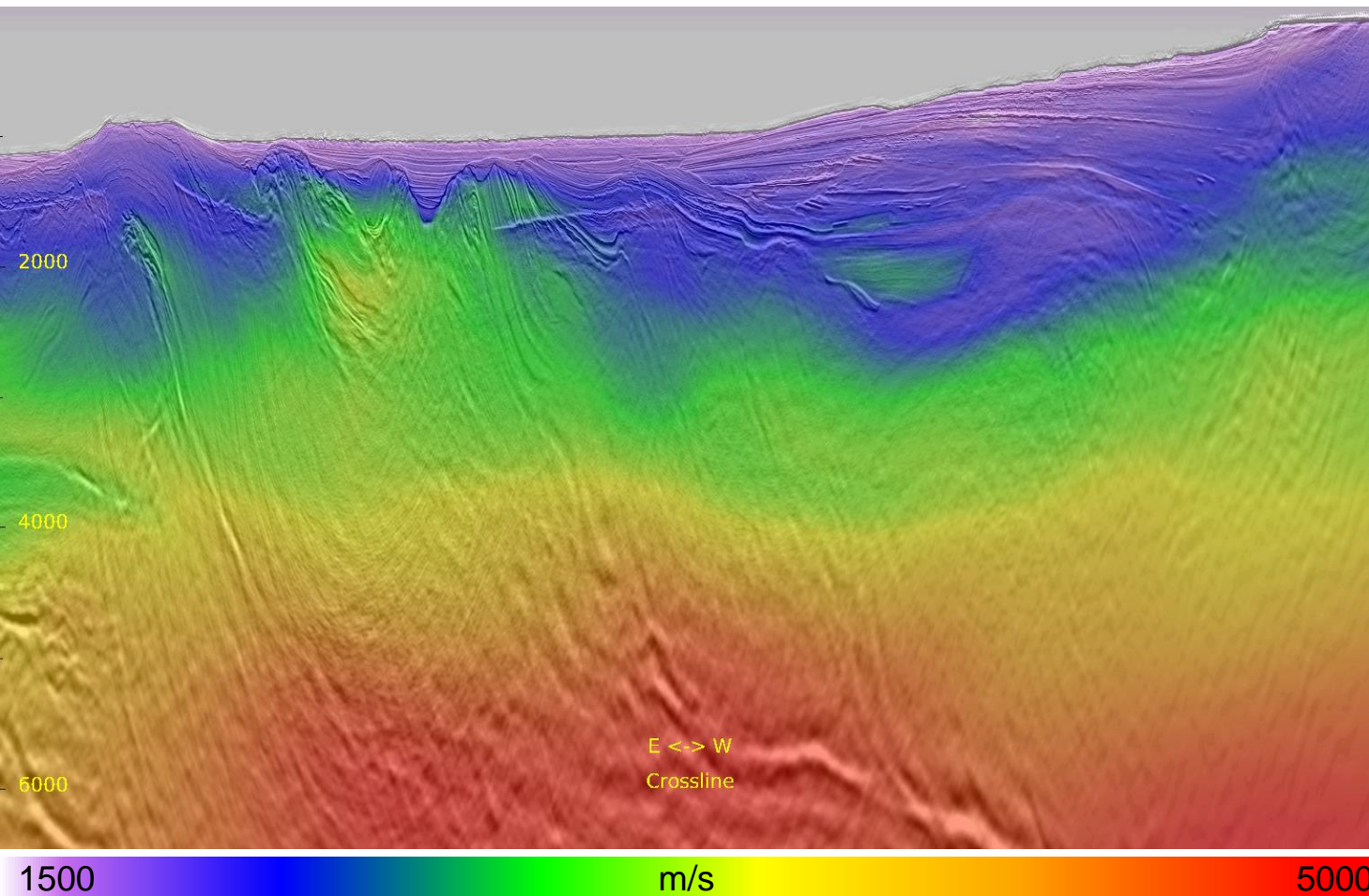


- Starting model is from Modified ISO FWI velocity.
- Deep area velocity trend still follows water bottom.

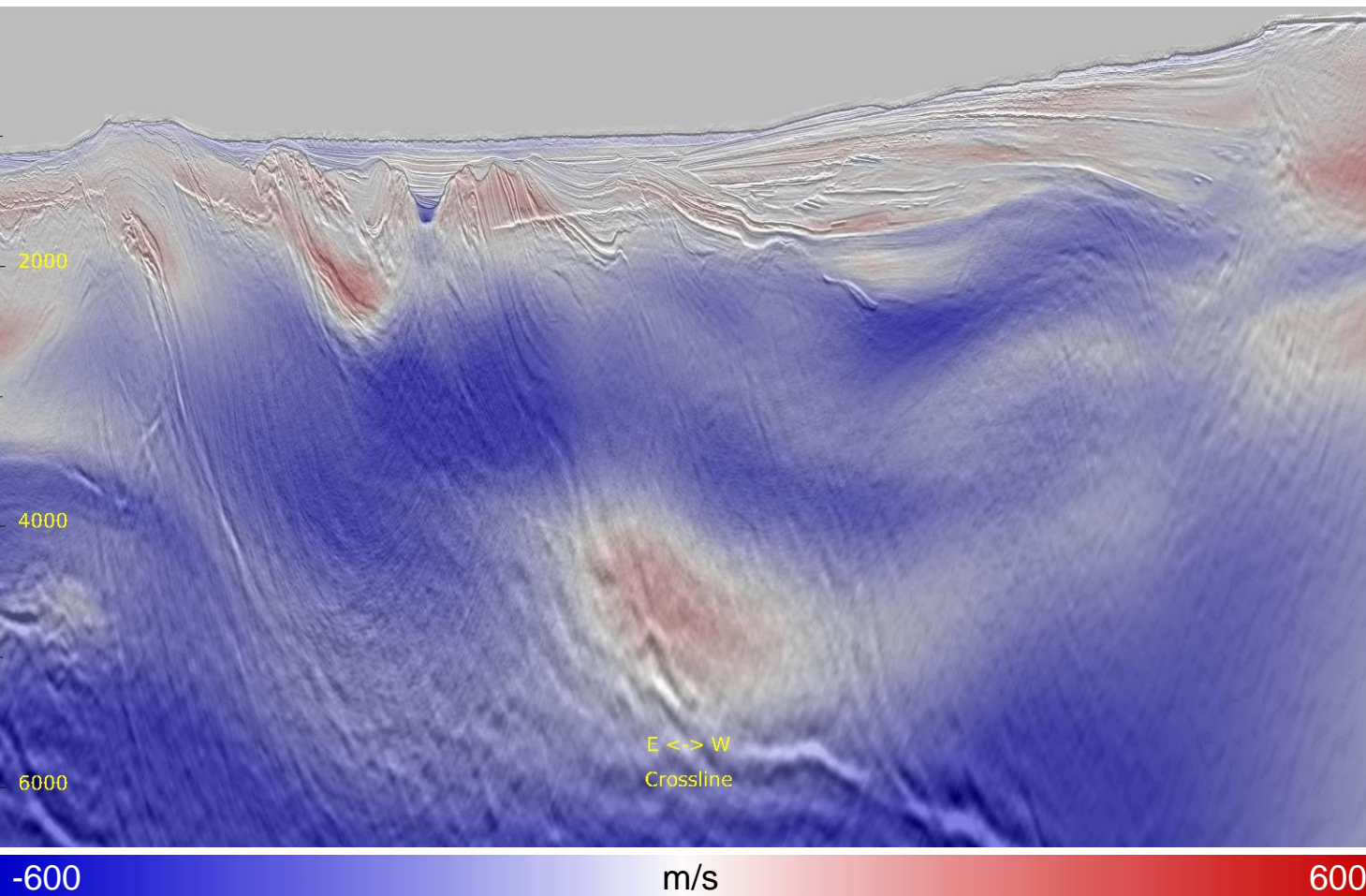


# Inline 436 West: IT1 ISO Tomography Velocity

8



- IT1 ISO tomography overall slows down the velocity and provides some details that follow geology.
- More smoothed update in low S/N area.



- IT1 ISO tomography overall slows down the velocity and provides some details that follow geology.
- More smoothed update in low S/N area.

# Kirchhoff Depth Migration

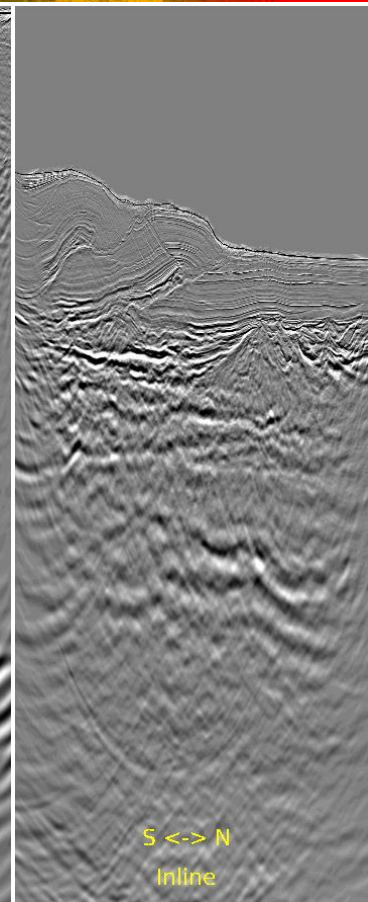
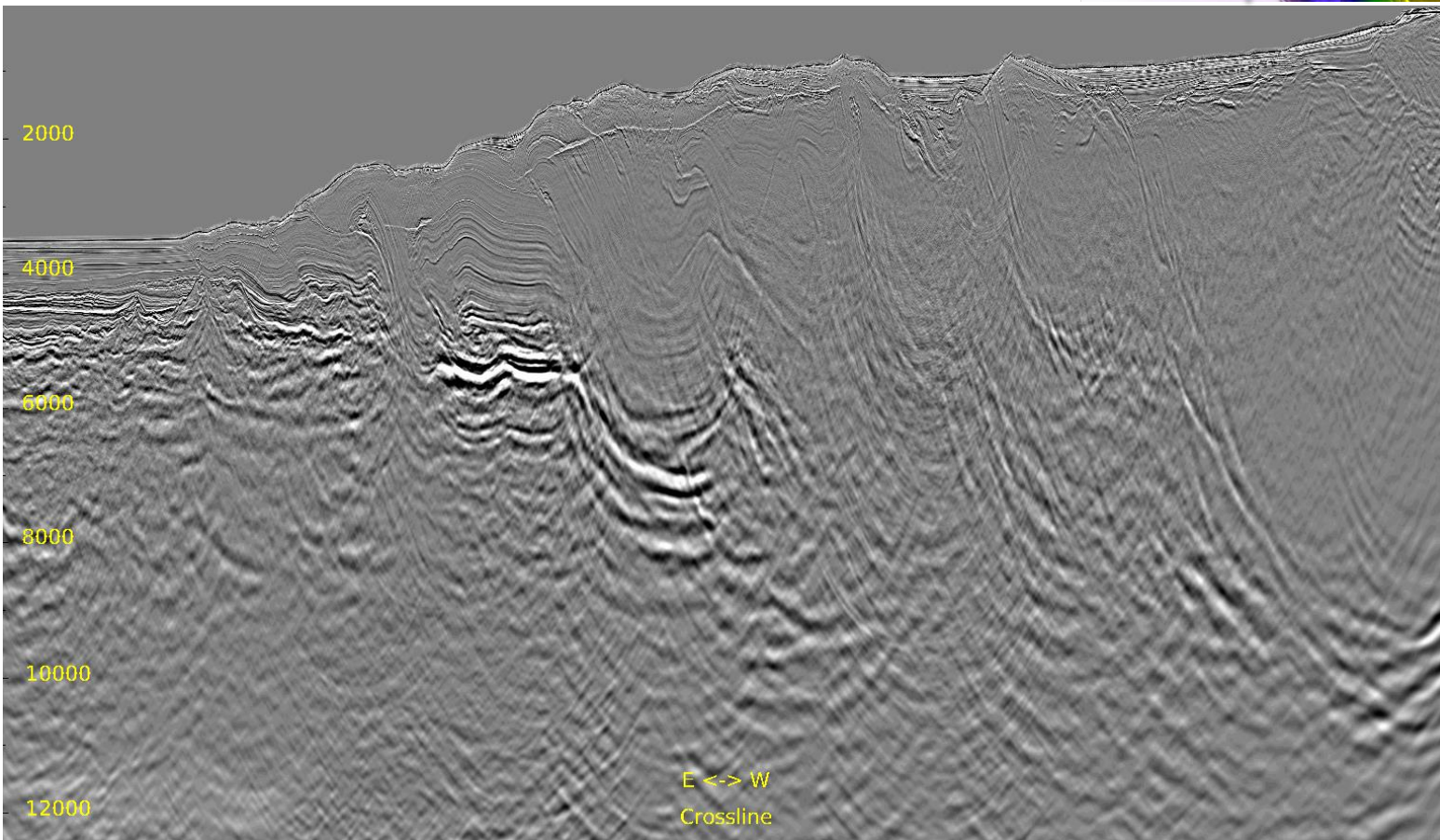
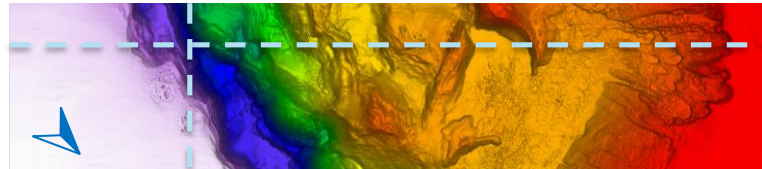






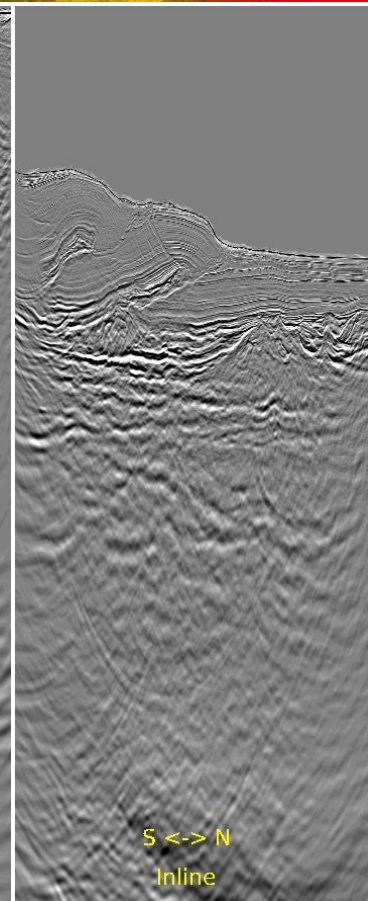
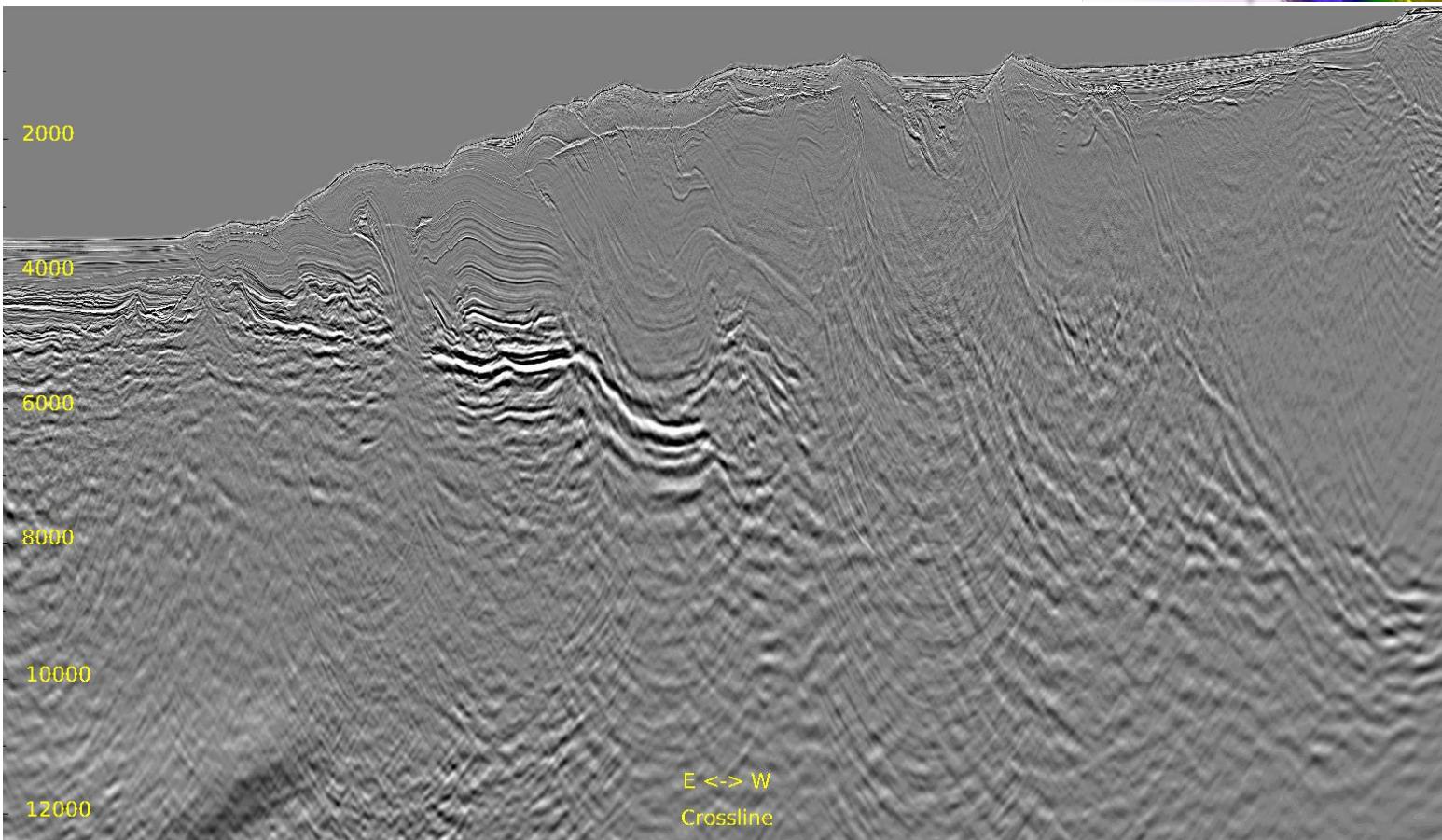
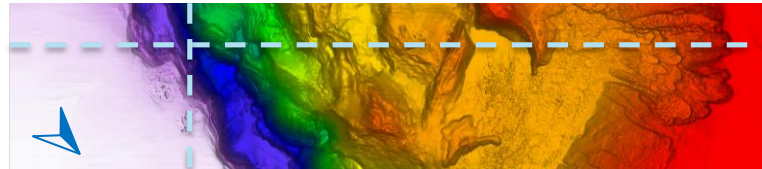
# Full Stack: ISO FWI

Inline 236 & Crossline 1540



# Full Stack: IT1 ISO Tomogray

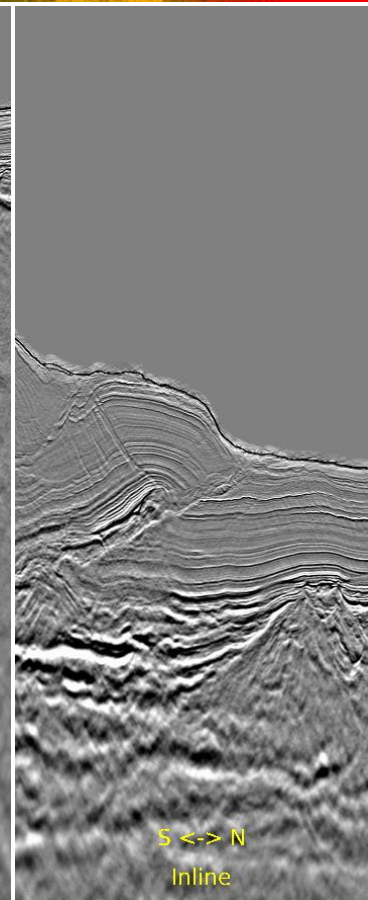
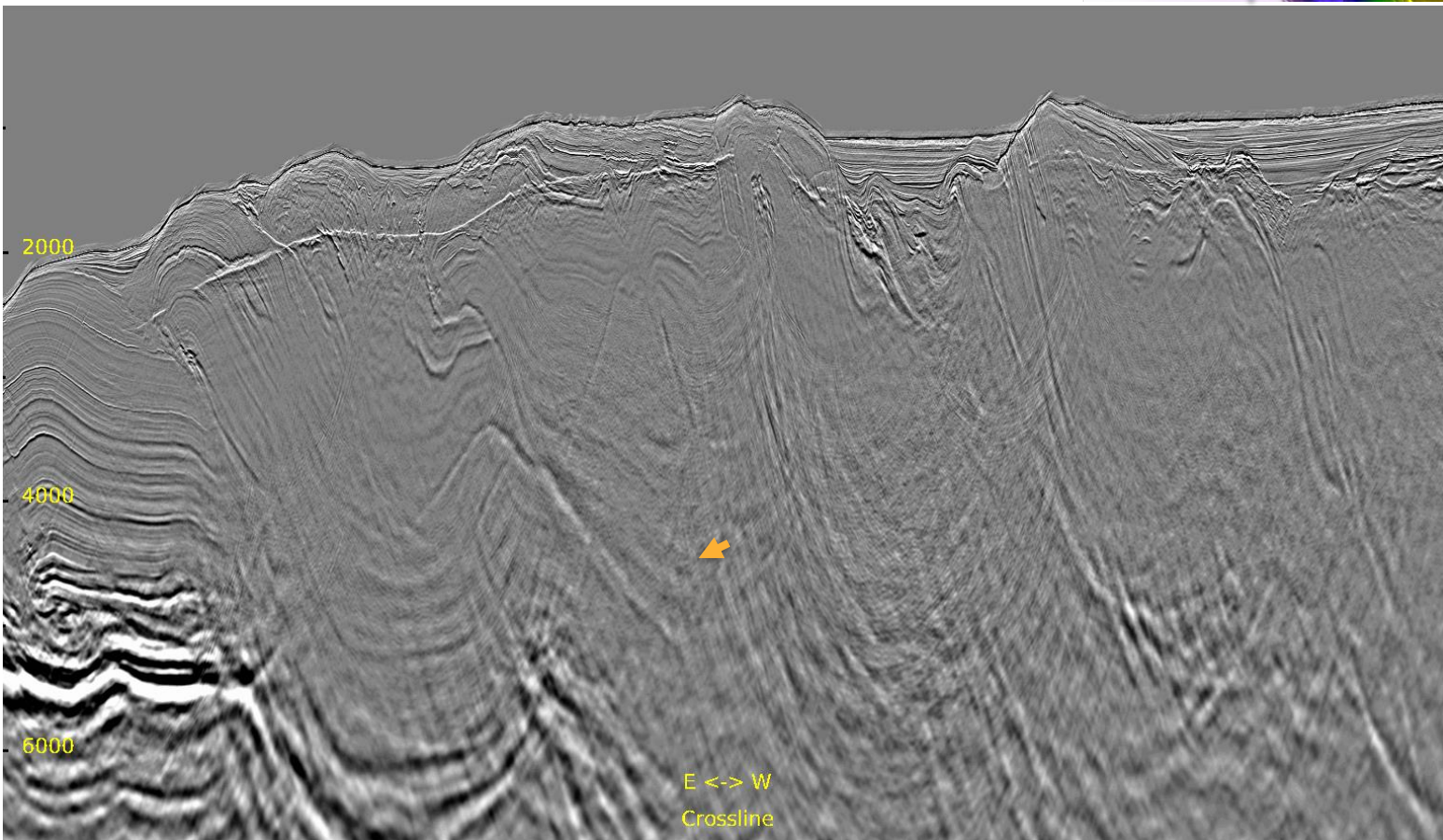
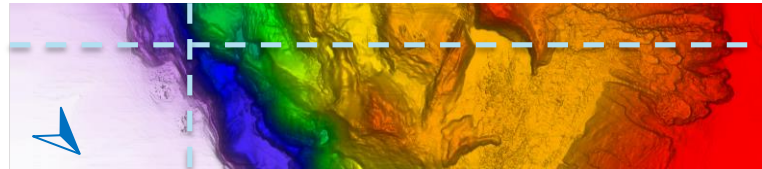
Inline 236 & Crossline 1540





# Zoomed Full Stack: ISO FWI

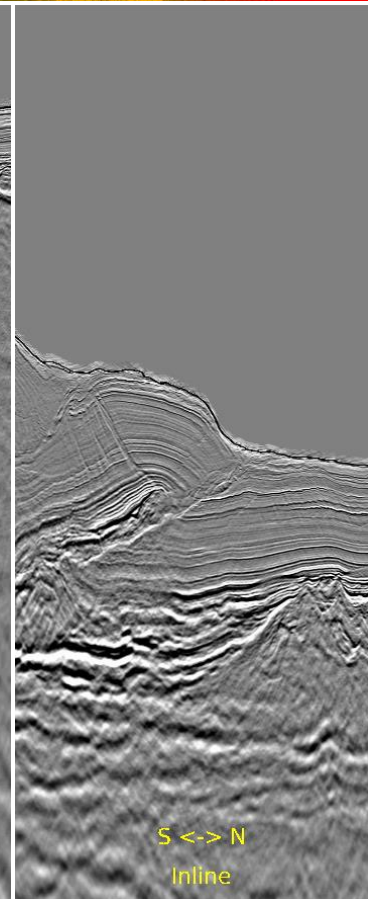
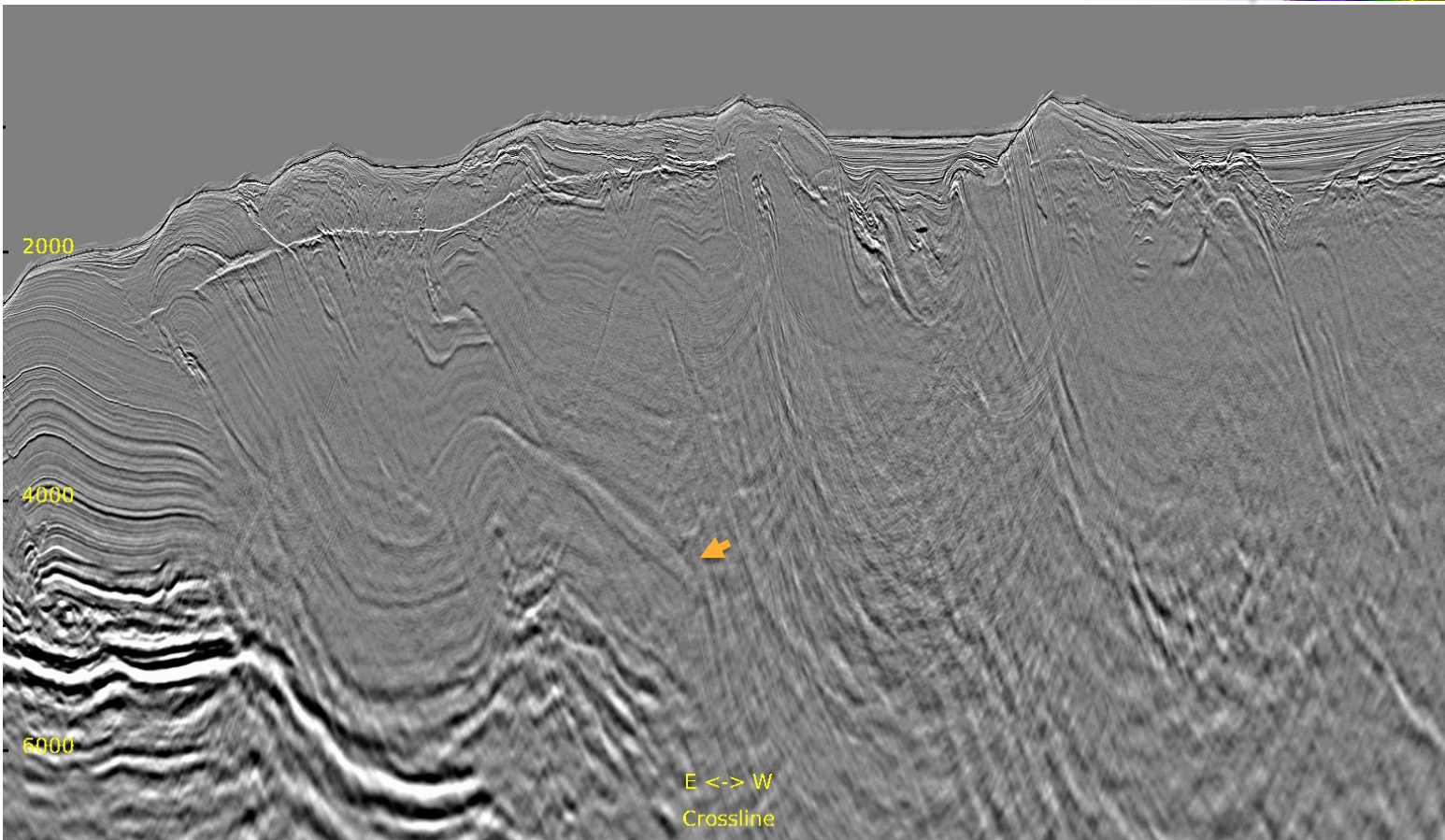
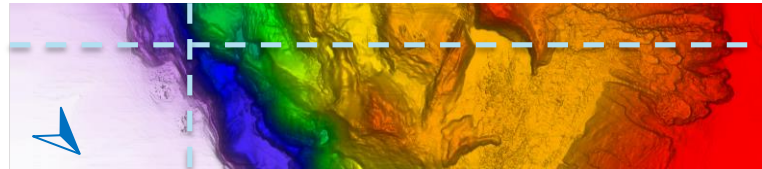
Inline 236 & Crossline 1540



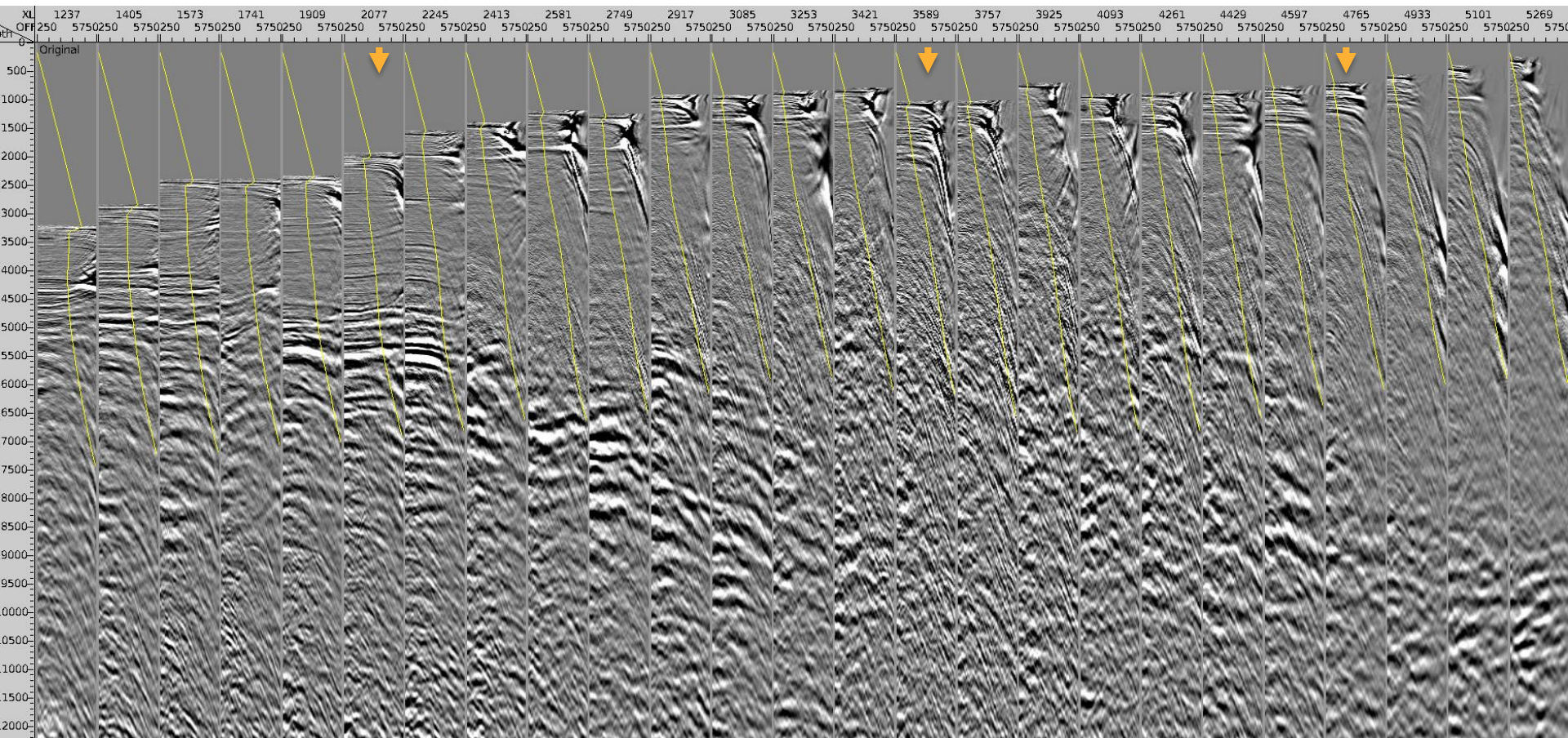


# Zoomed Full Stack: IT1 ISO Tomogray

Inline 236 & Crossline 1540







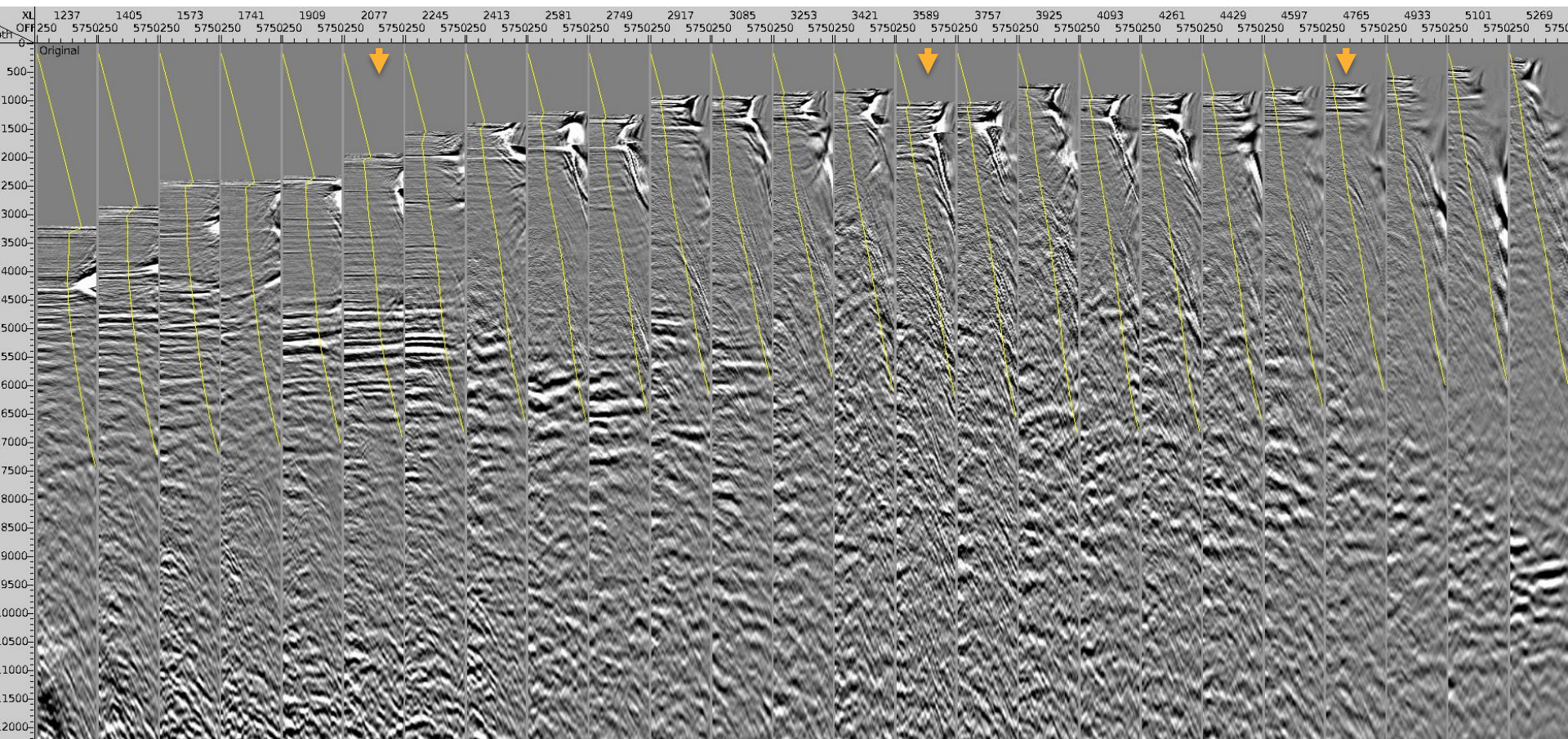




# Inline 236 CDP Gathers: IT1 ISO Tomogray

— 35° Mute

16

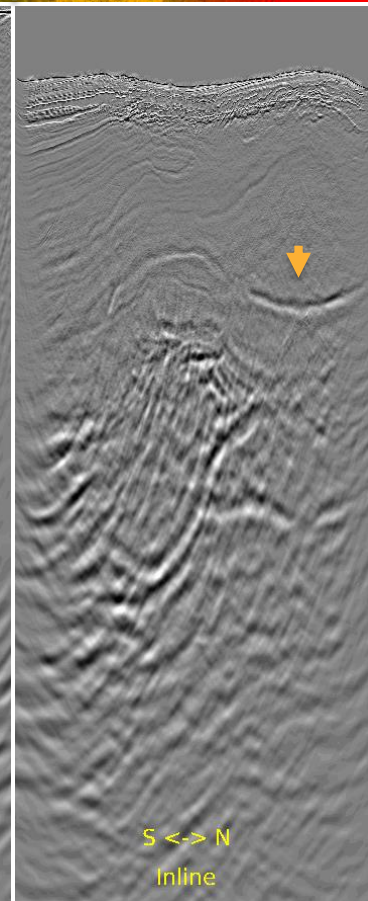
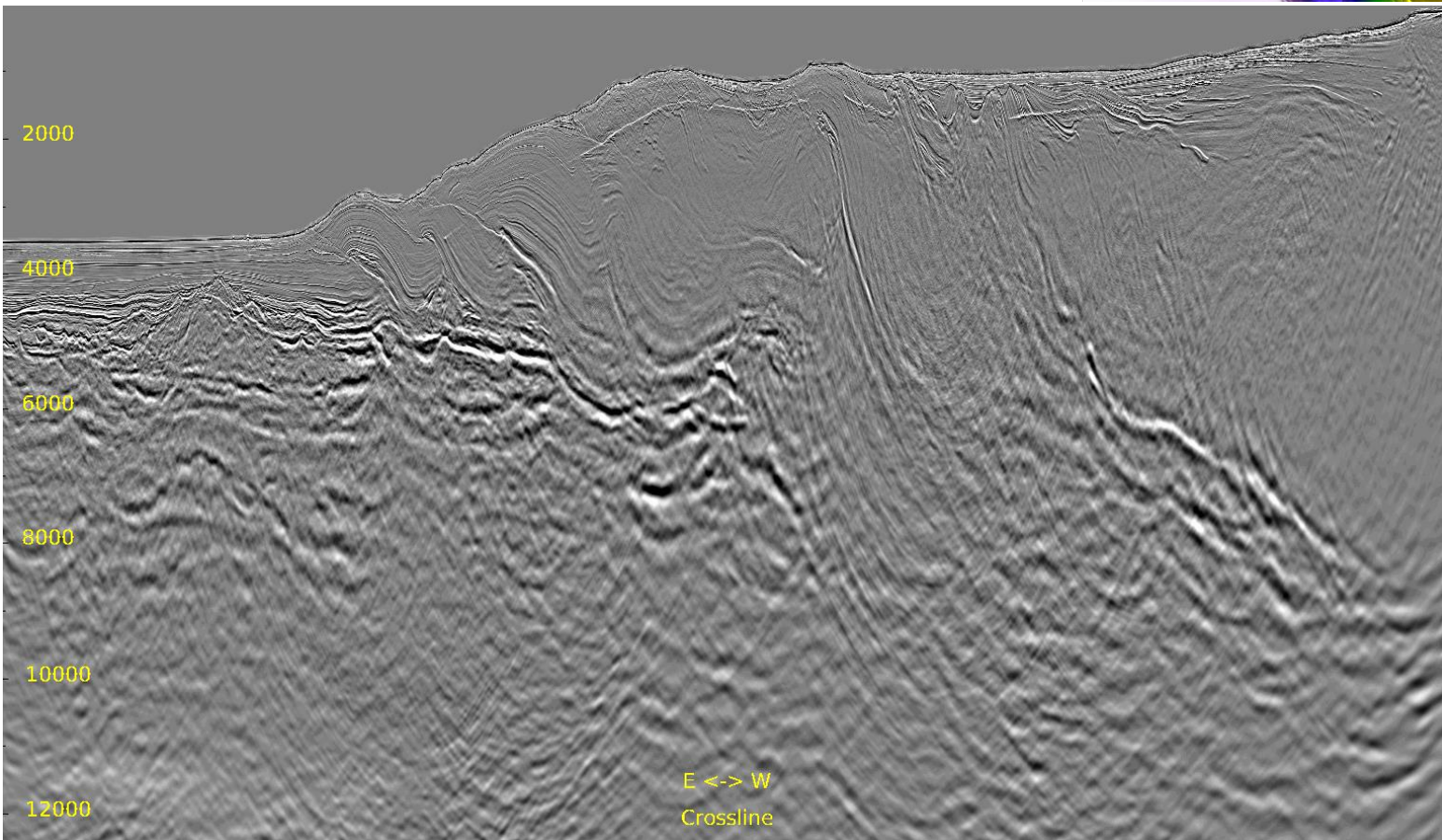
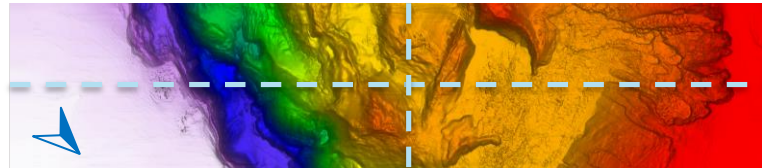






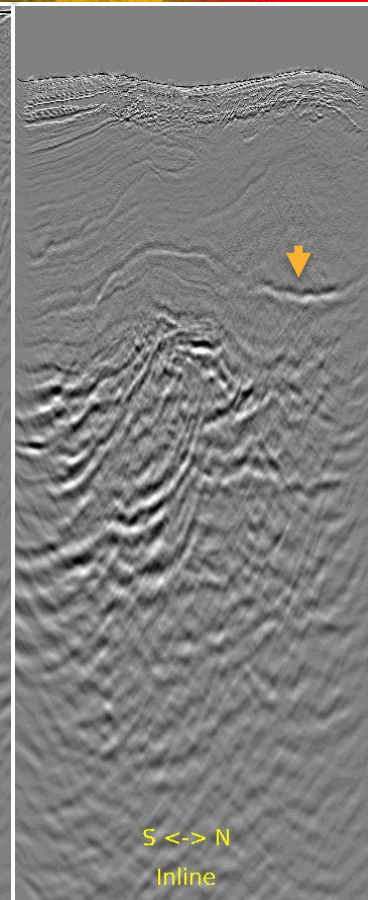
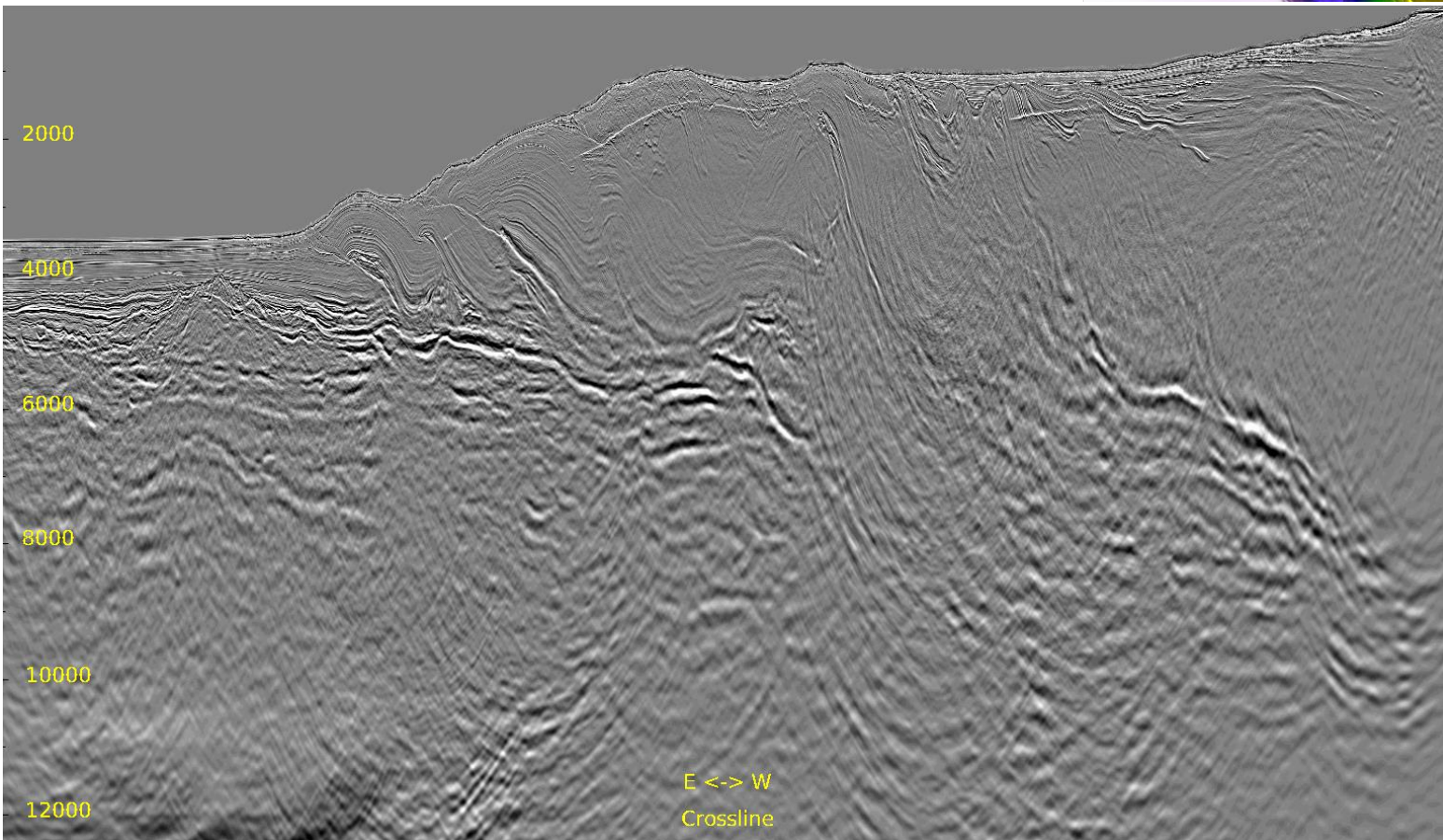
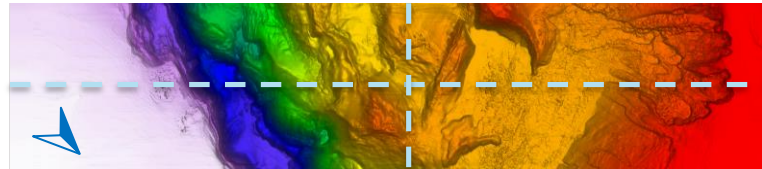
# Full Stack: ISO FWI

Inline 436 & Crossline 3040



# Full Stack: IT1 ISO Tomogray

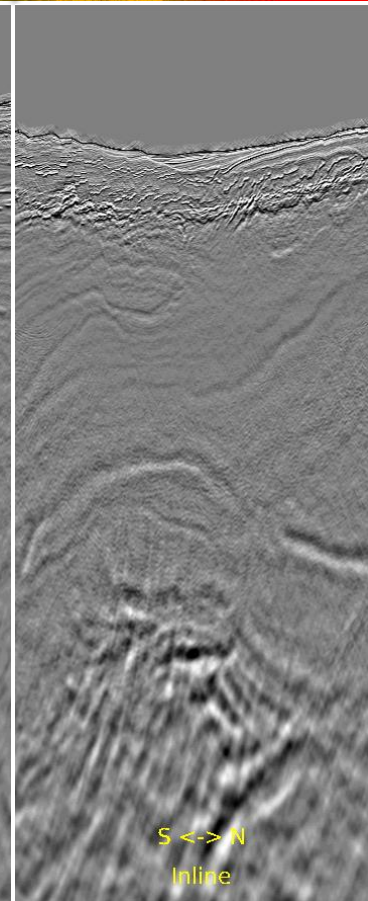
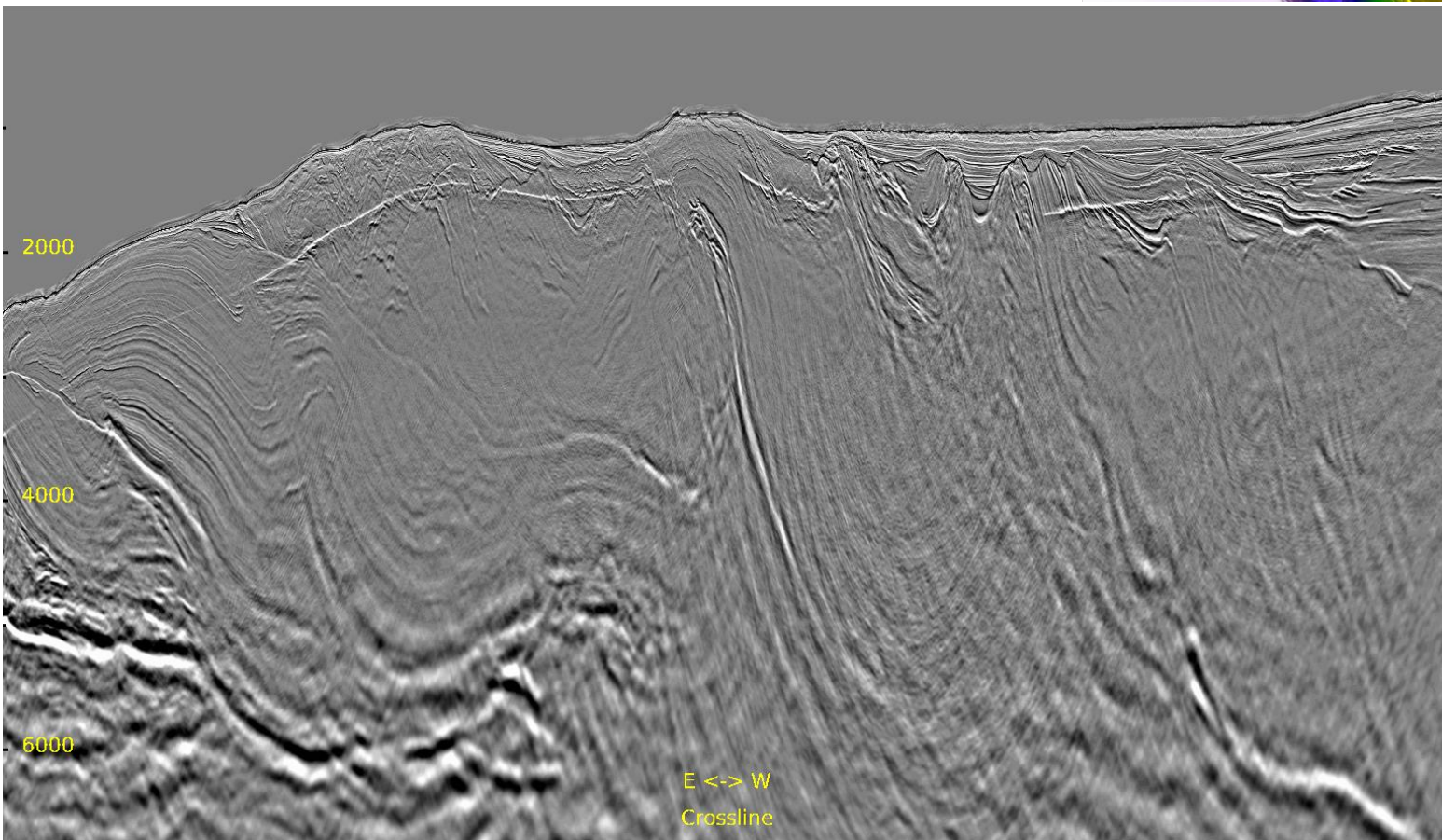
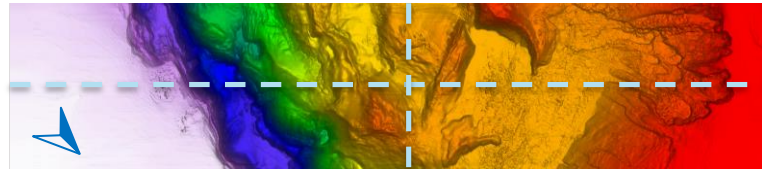
Inline 436 & Crossline 3040





# Zoomed Full Stack: ISO FWI

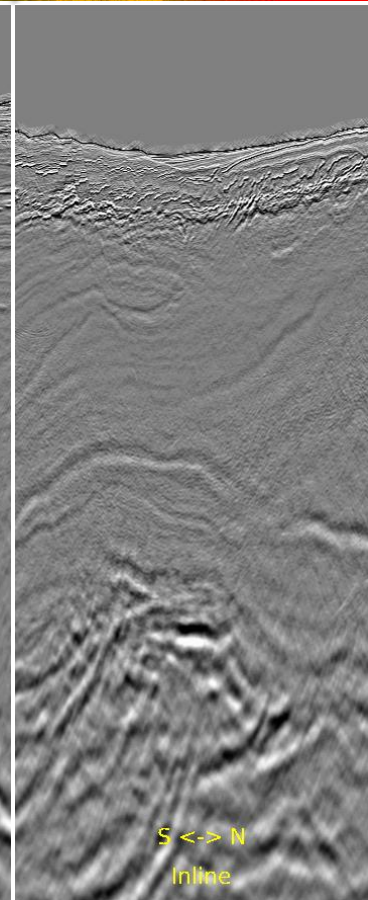
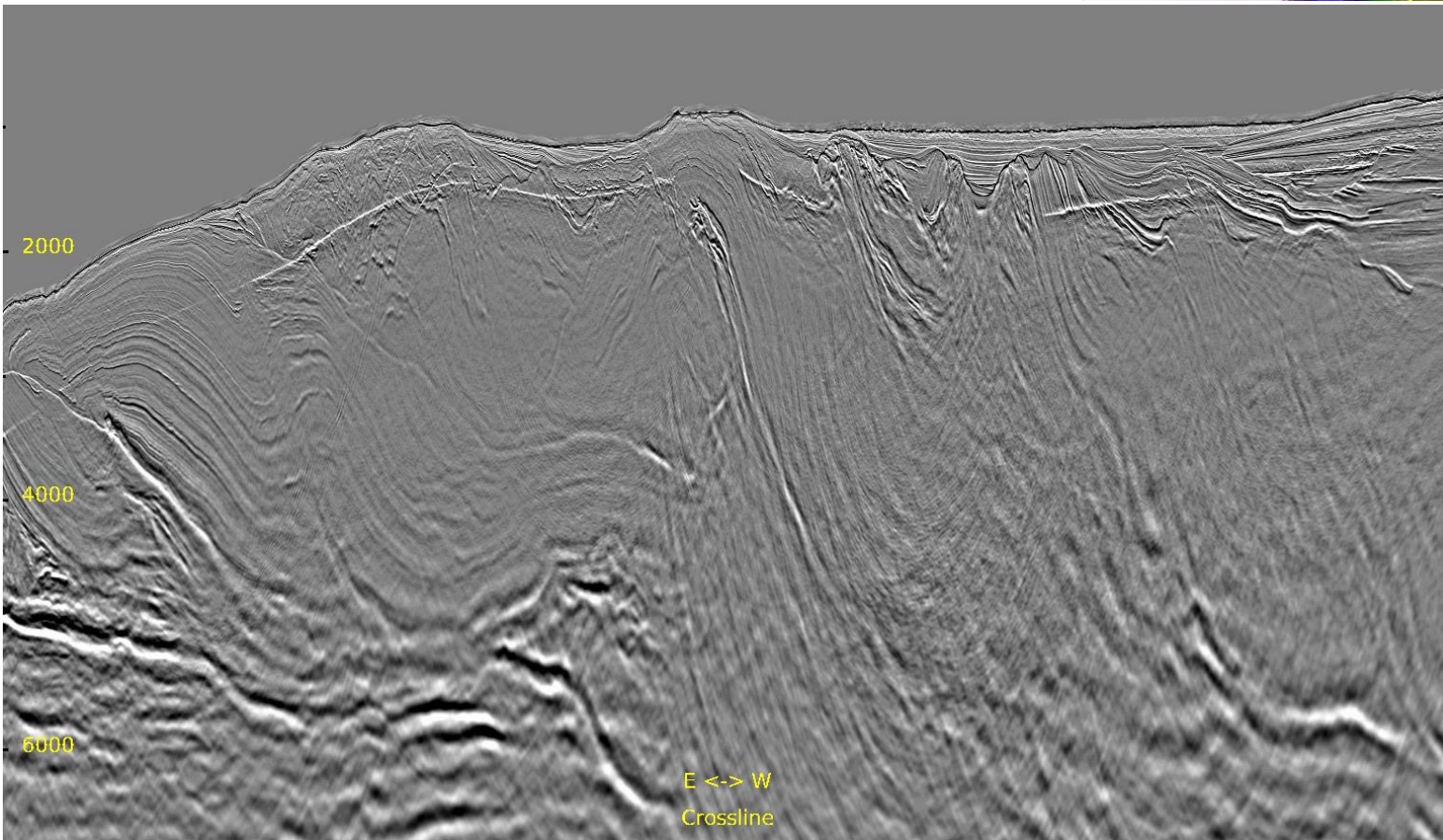
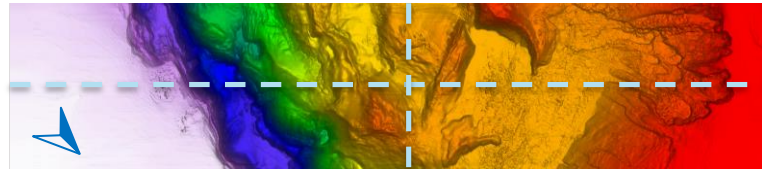
Inline 436 & Crossline 3040



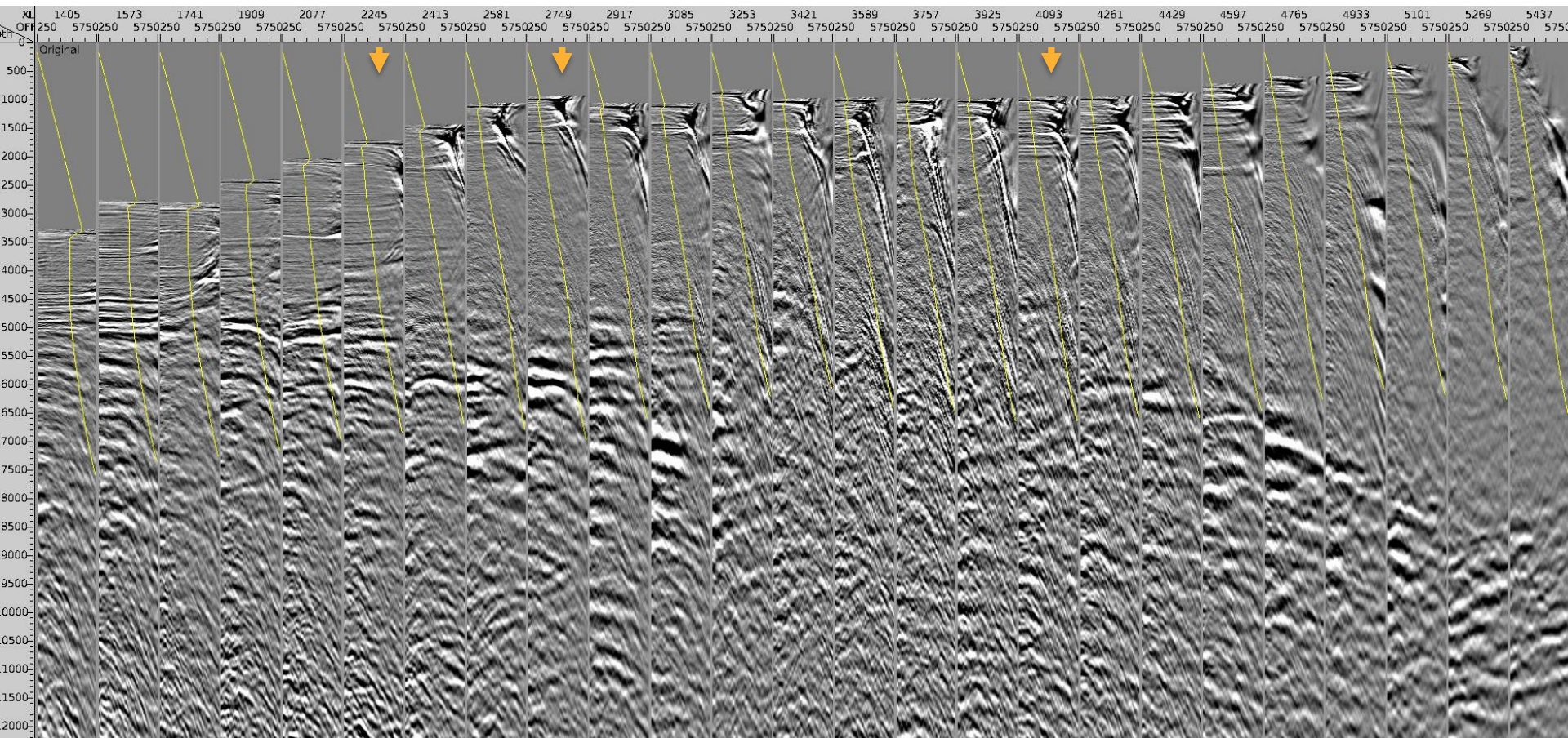


# Zoomed Full Stack: IT1 ISO Tomogray

Inline 436 & Crossline 3040







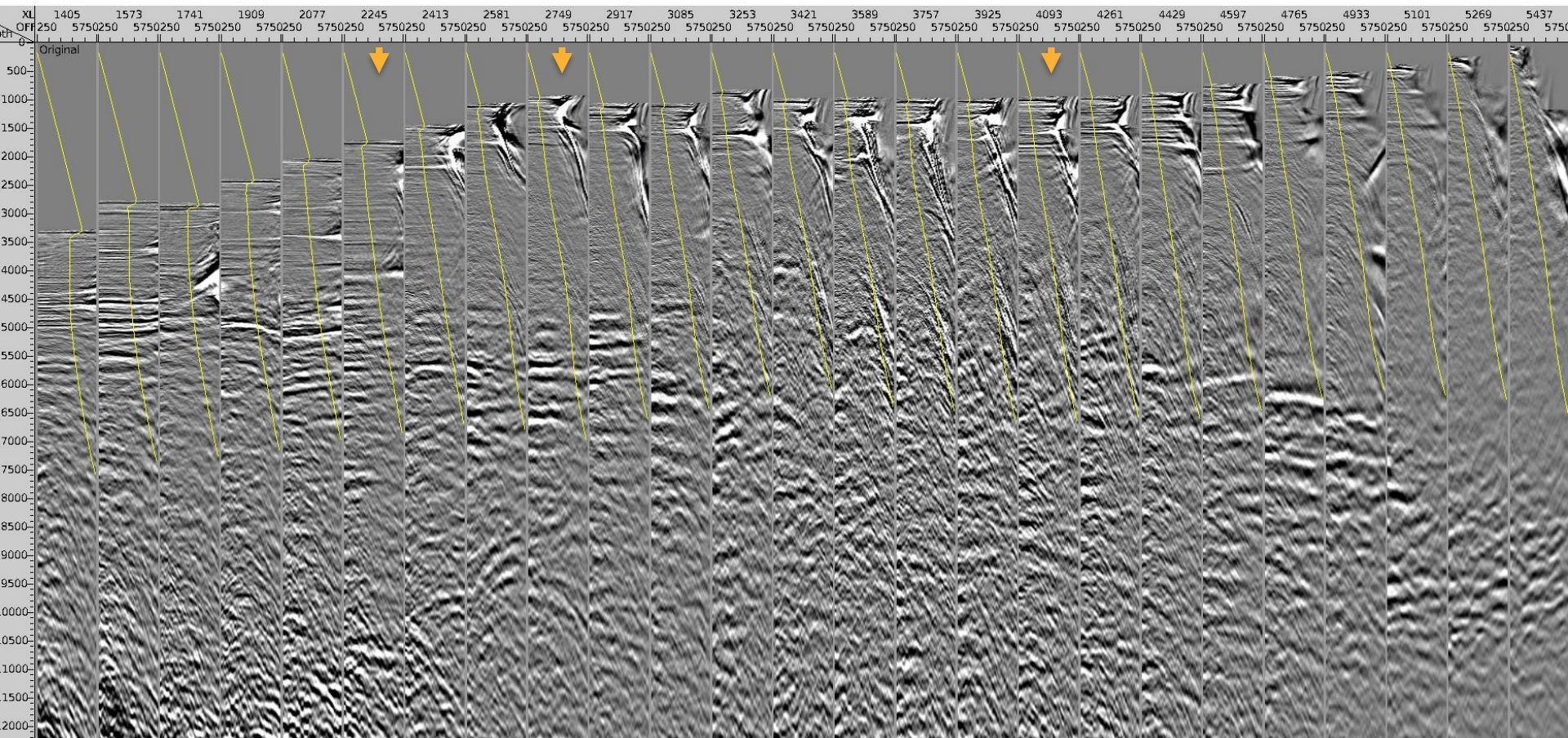




# Inline 436 CDP Gathers: IT1 ISO Tomogray

— 35° Mute

22

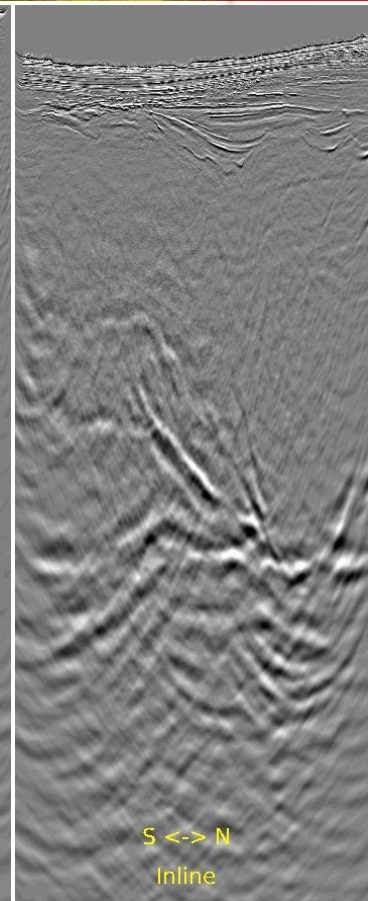
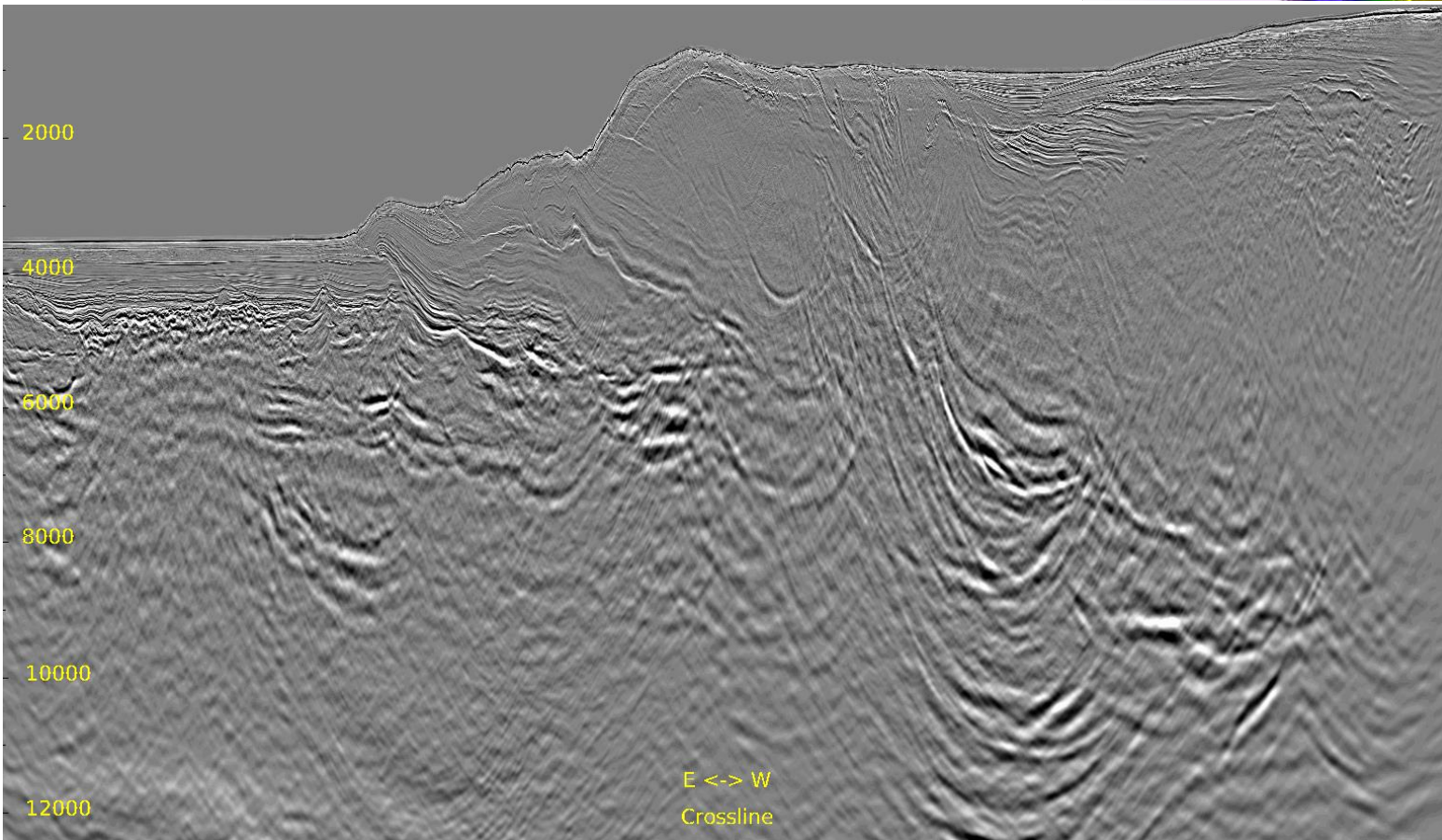
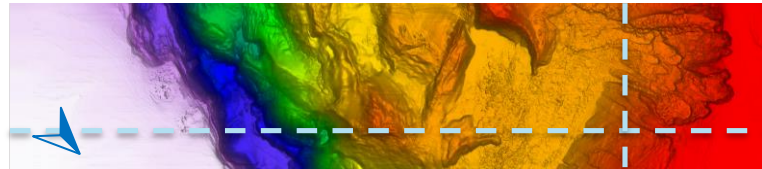






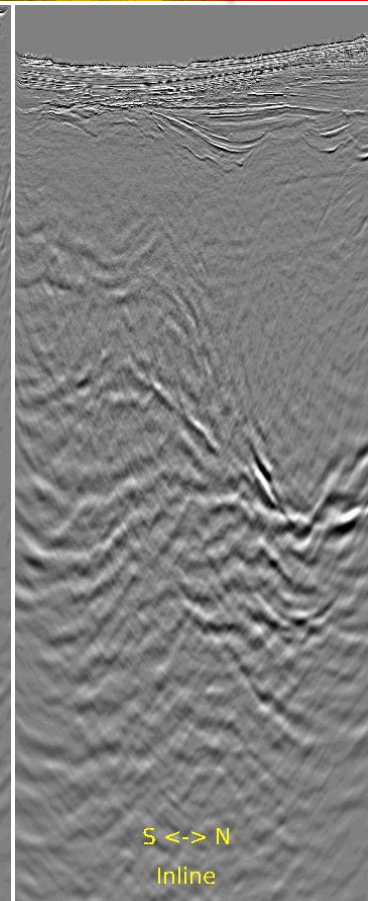
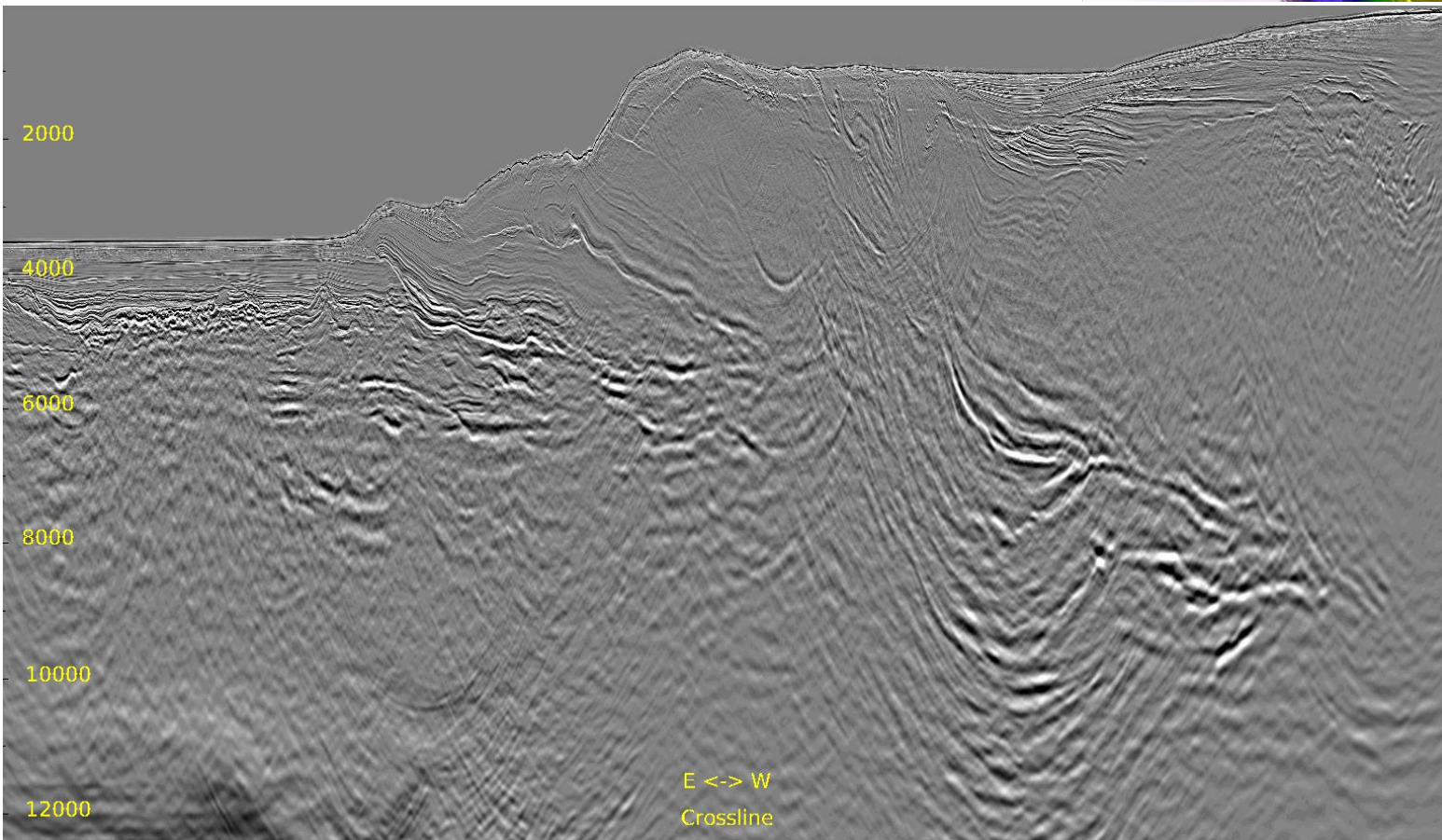
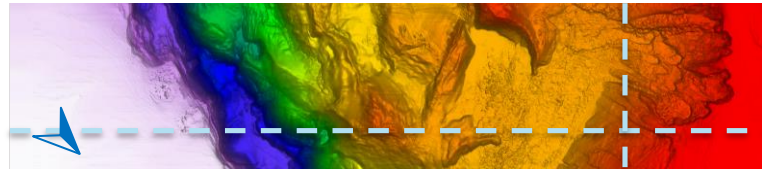
# Full Stack: ISO FWI

Inline 636 & Crossline 4540



# Full Stack: IT1 ISO Tomogray

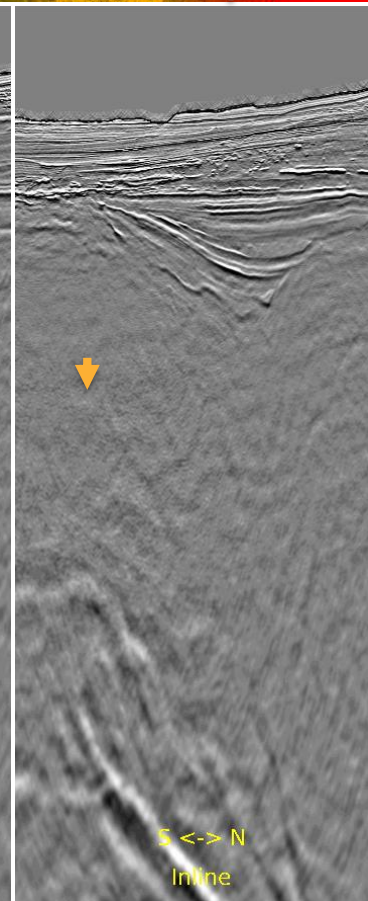
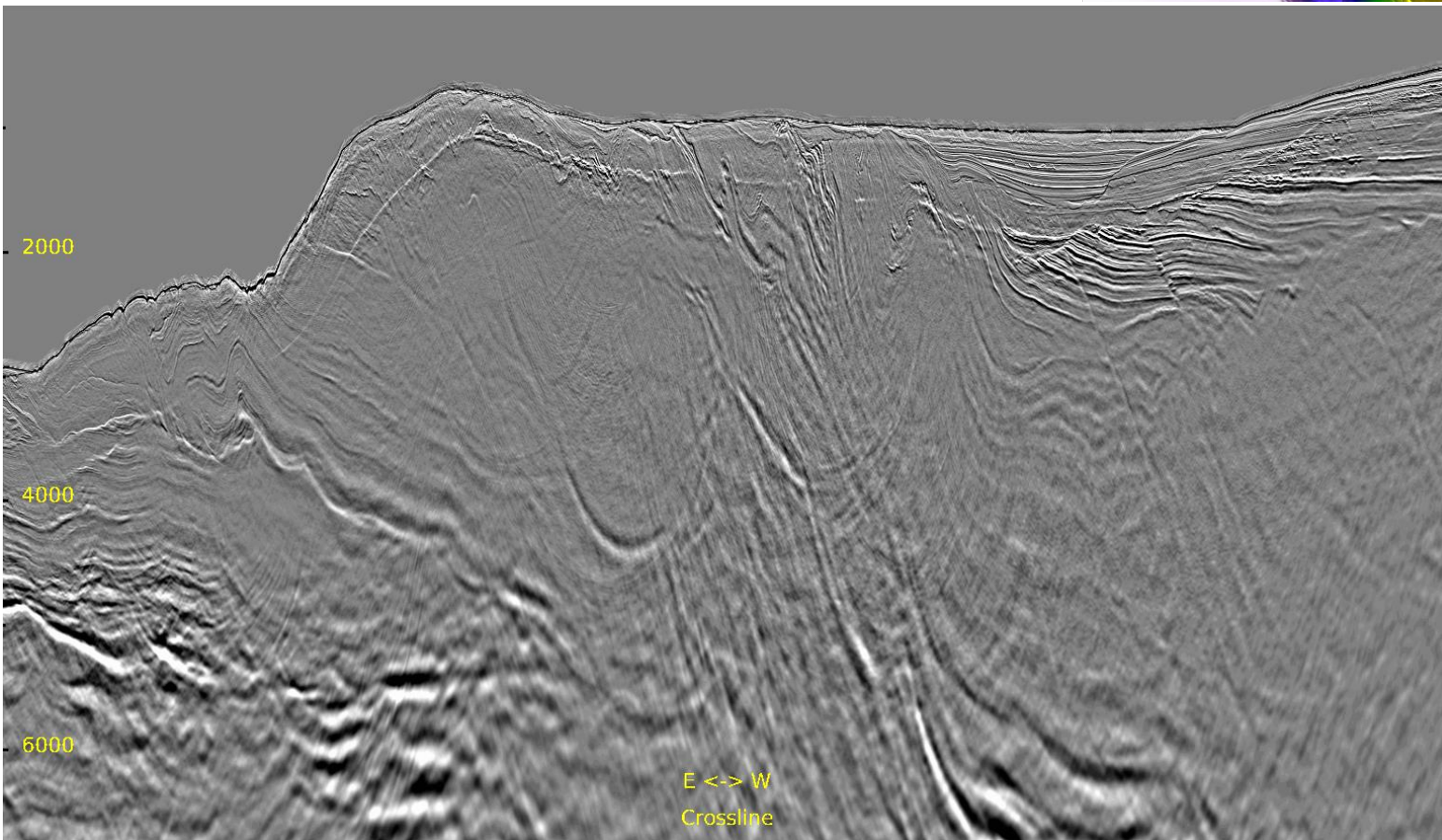
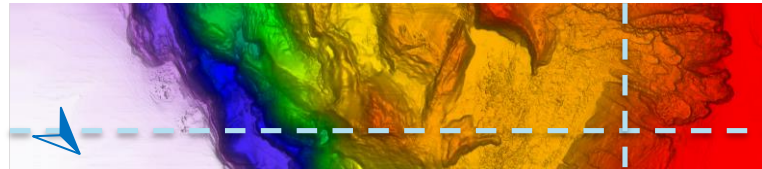
Inline 636 & Crossline 4540





# Zoomed Full Stack: ISO FWI

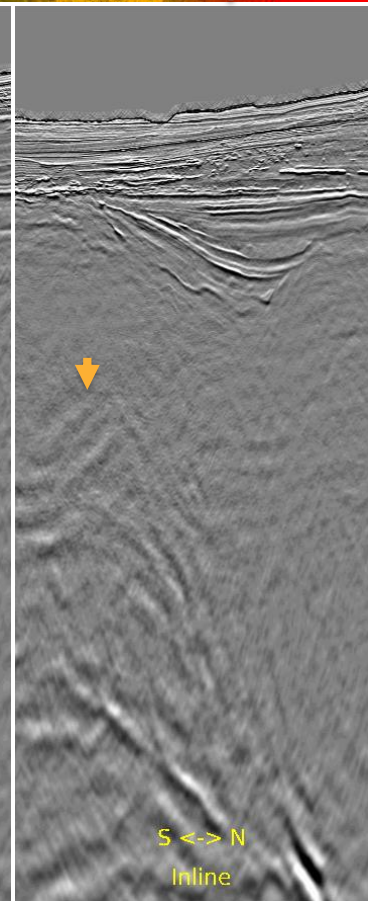
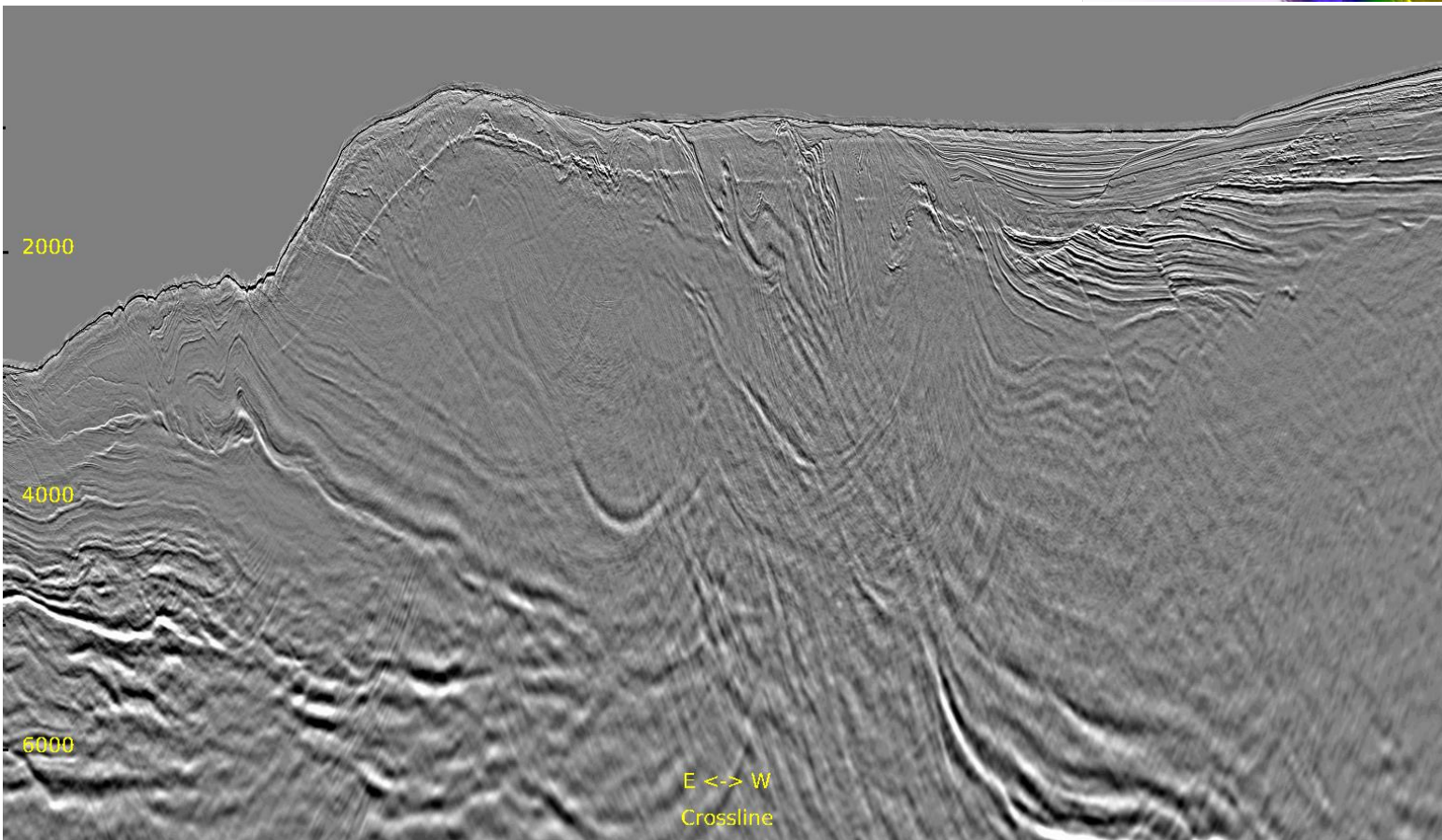
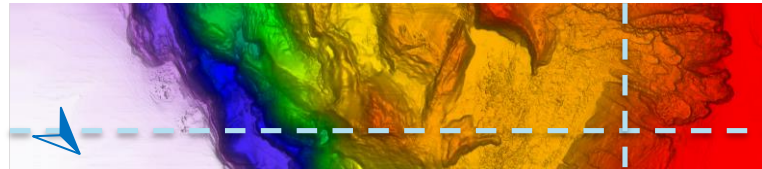
Inline 636 & Crossline 4540



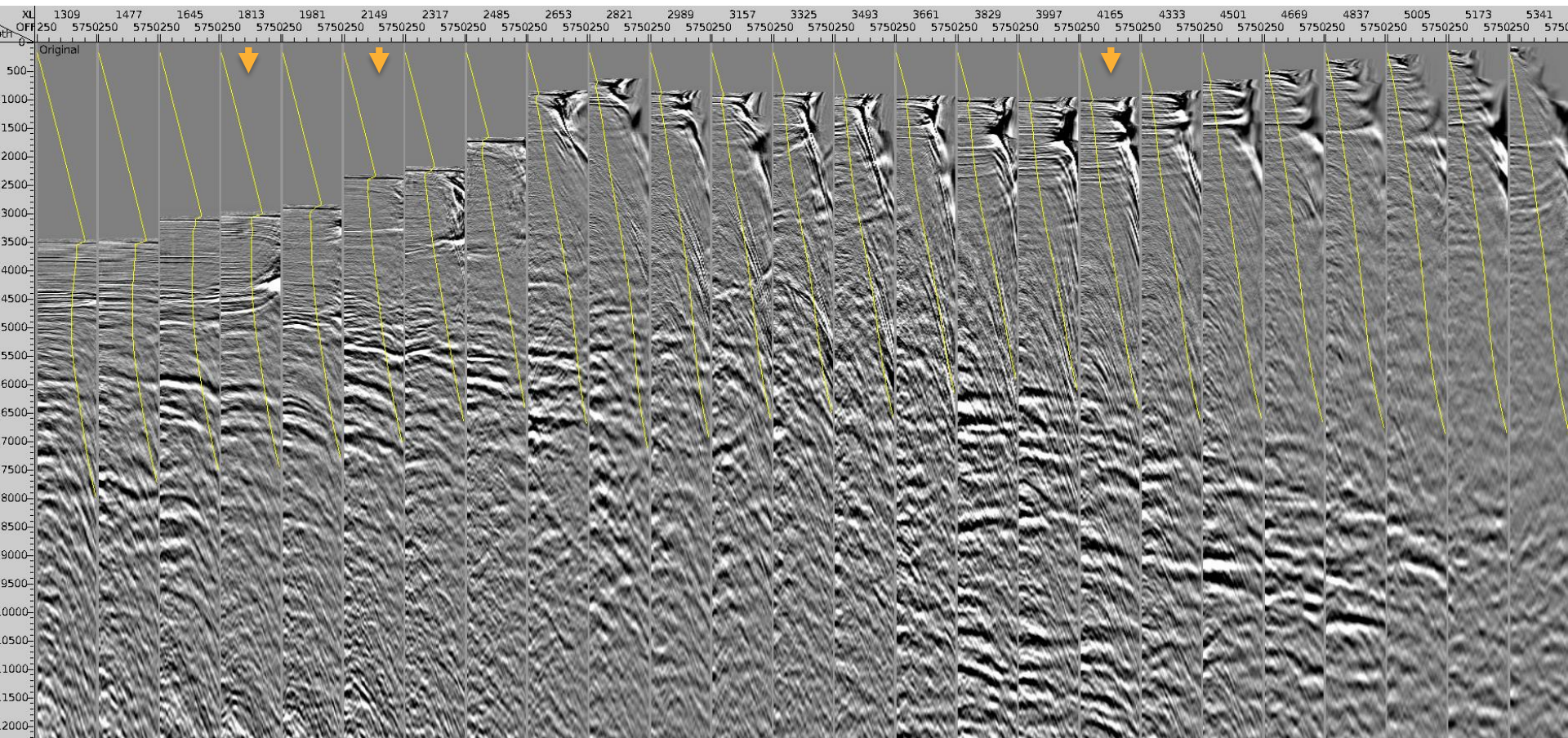


# Zoomed Full Stack: IT1 ISO Tomogray

Inline 636 & Crossline 4540







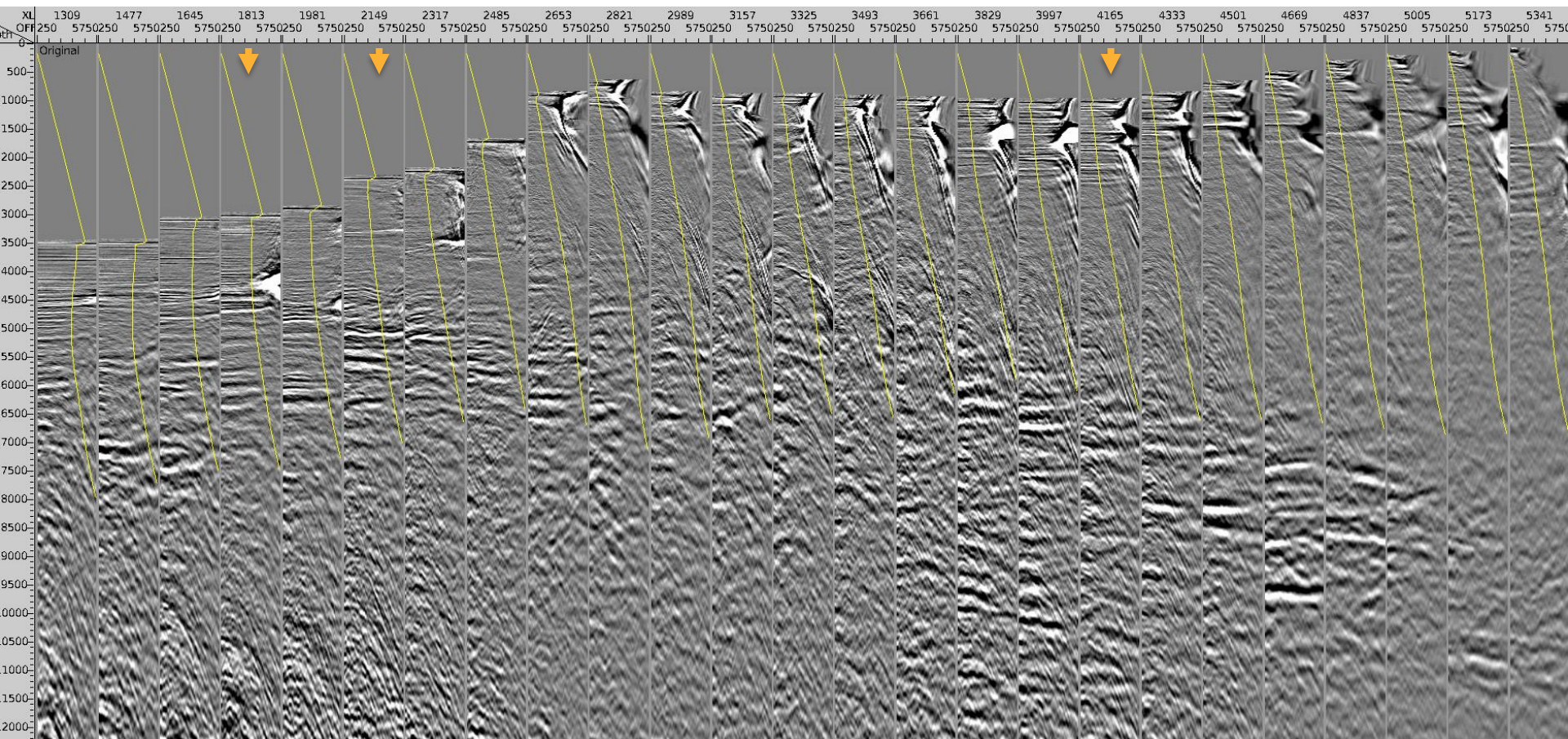




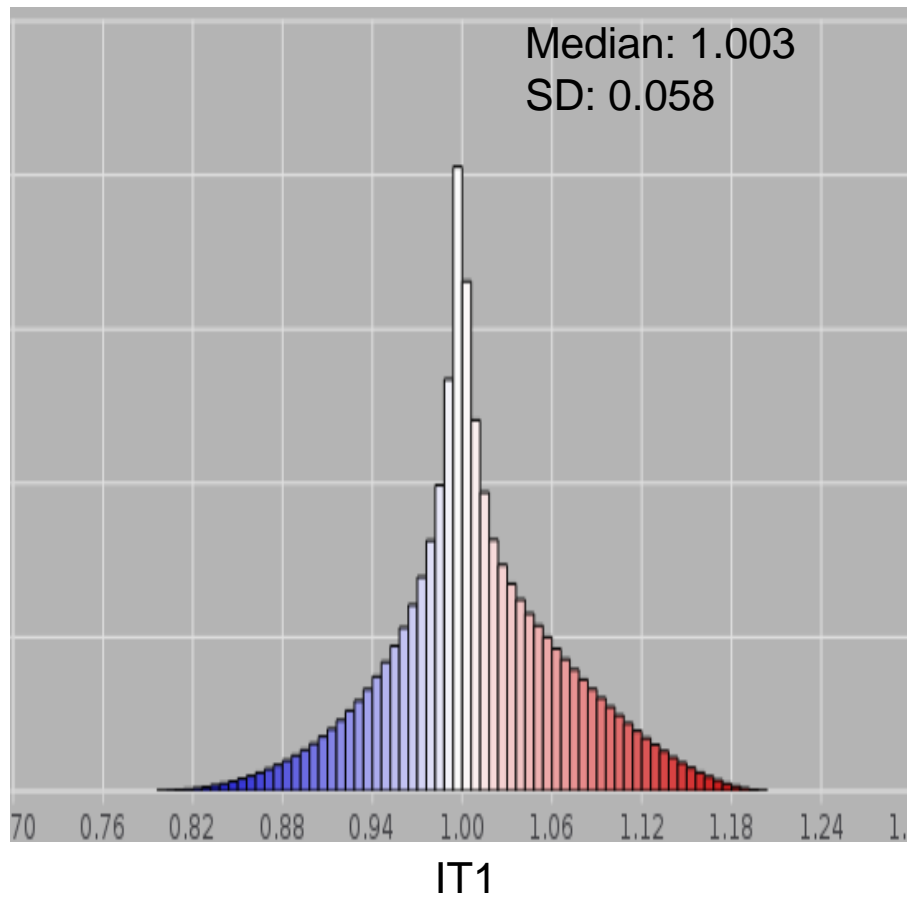
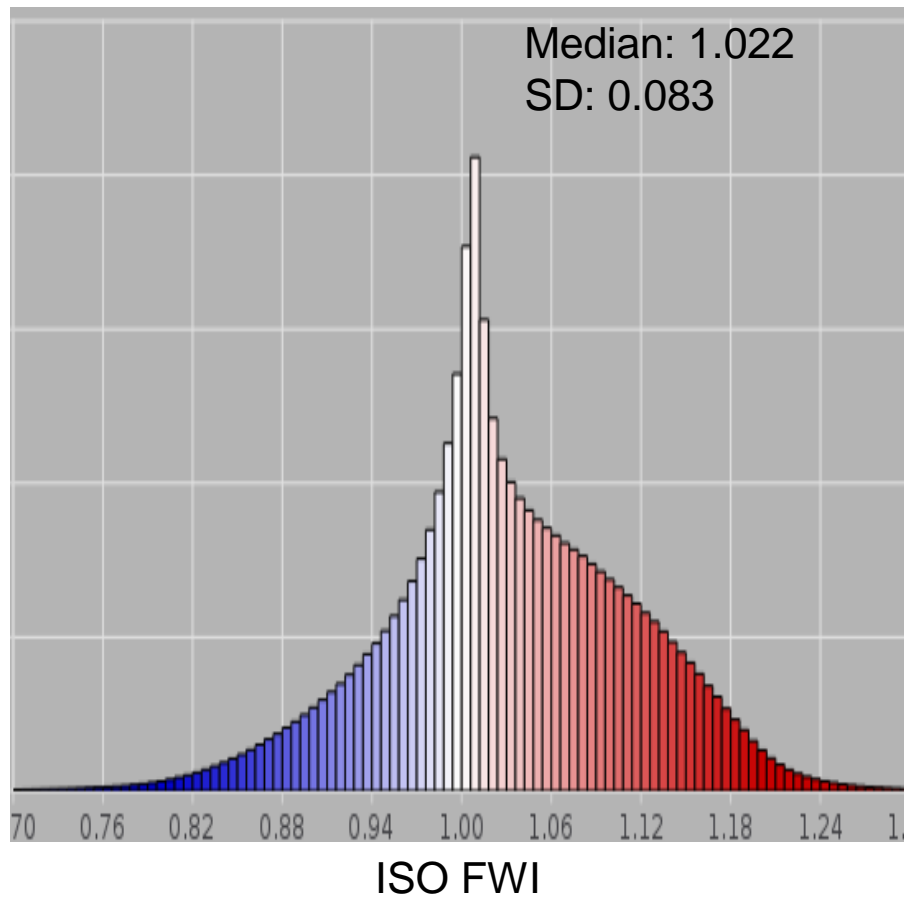
# Inline 636 CDP Gathers: IT1 ISO Tomogray

— 35° Mute

28







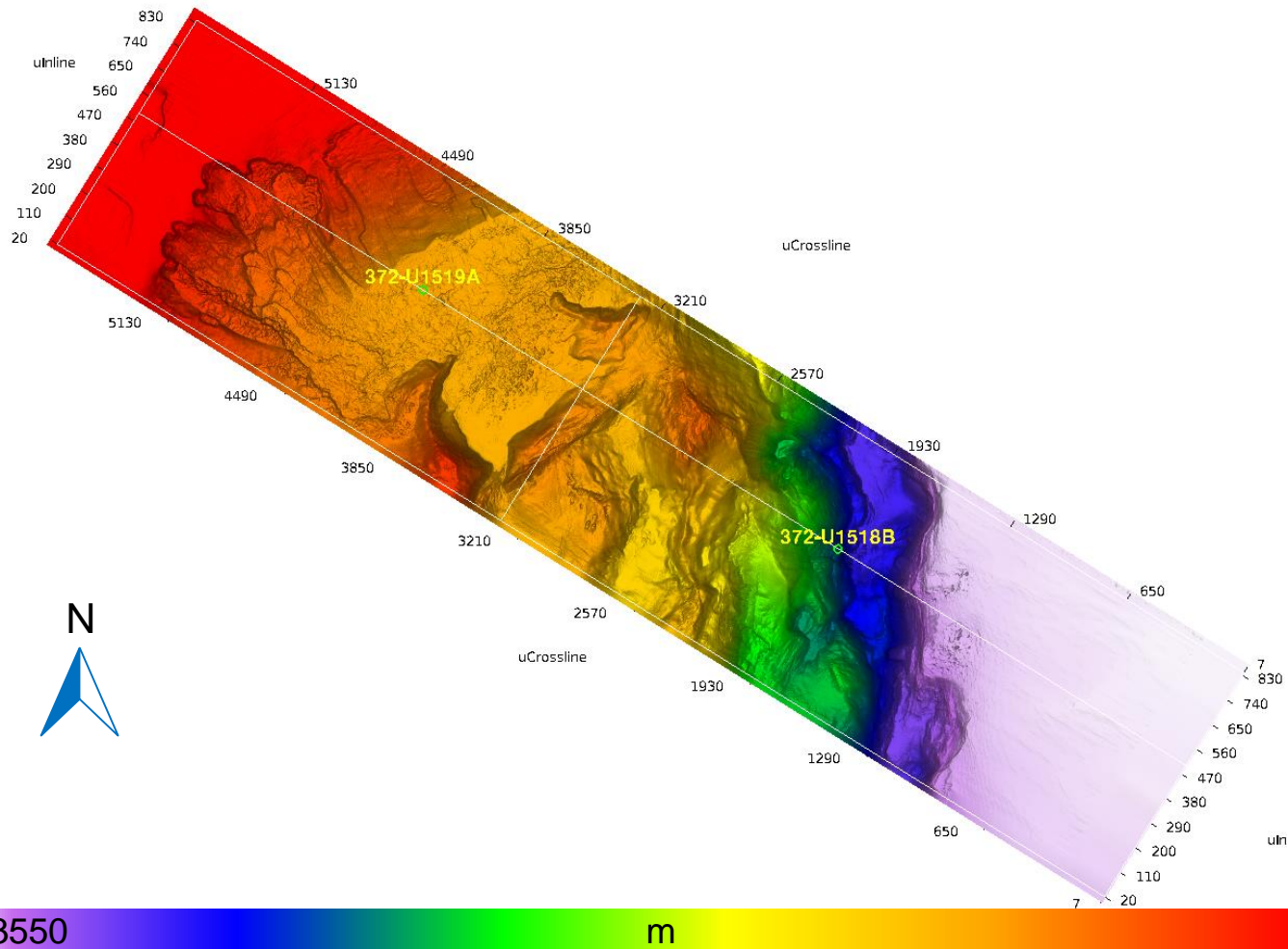


- IT1 ISO tomography gives accurate velocity close to water bottom that can be used to derive anisotropic parameters.
- IT1 gives reasonable deep velocity update which can be a good starting point for TTI FWI.

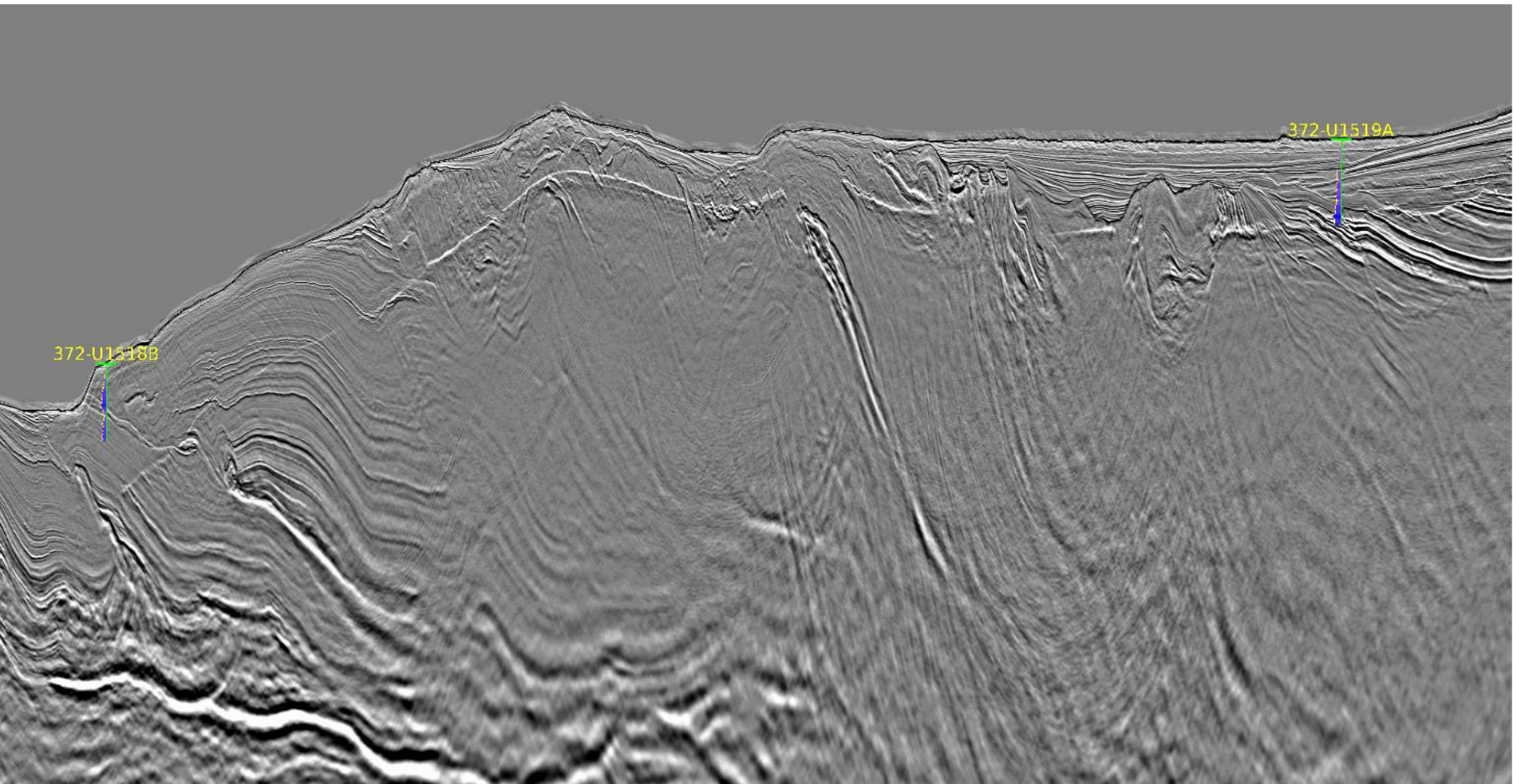
# Initial Well Analysis

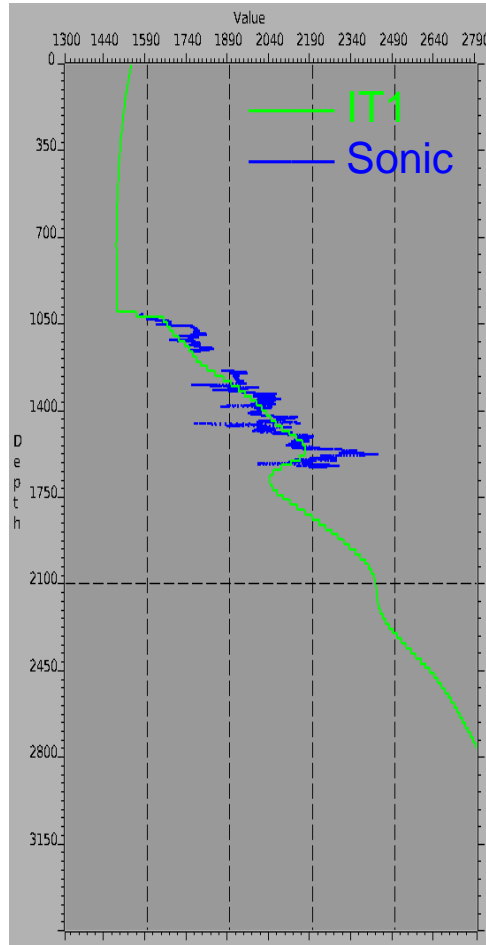
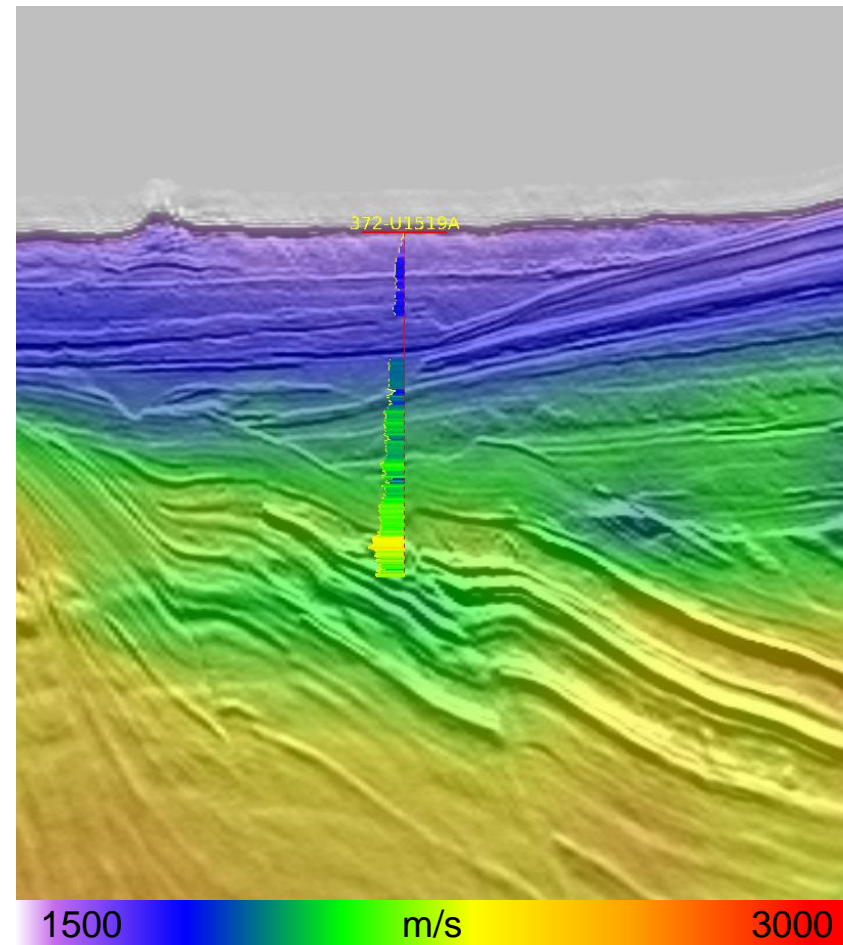






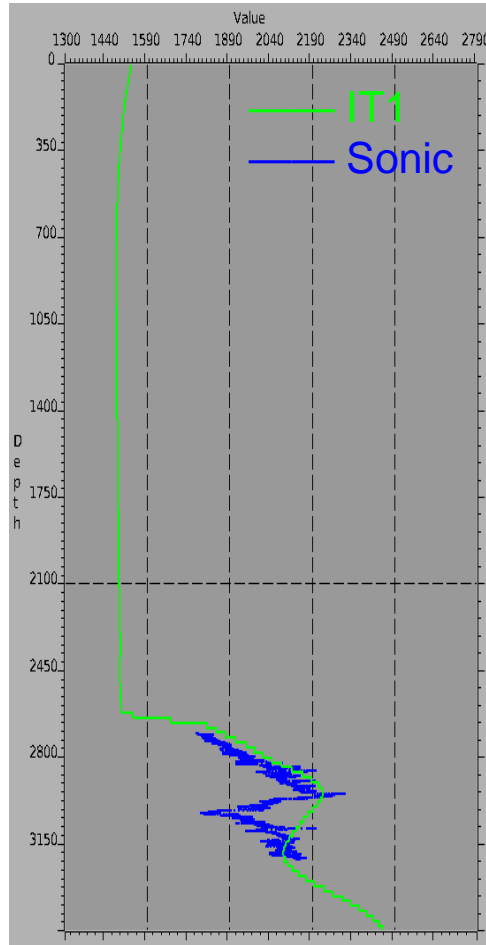
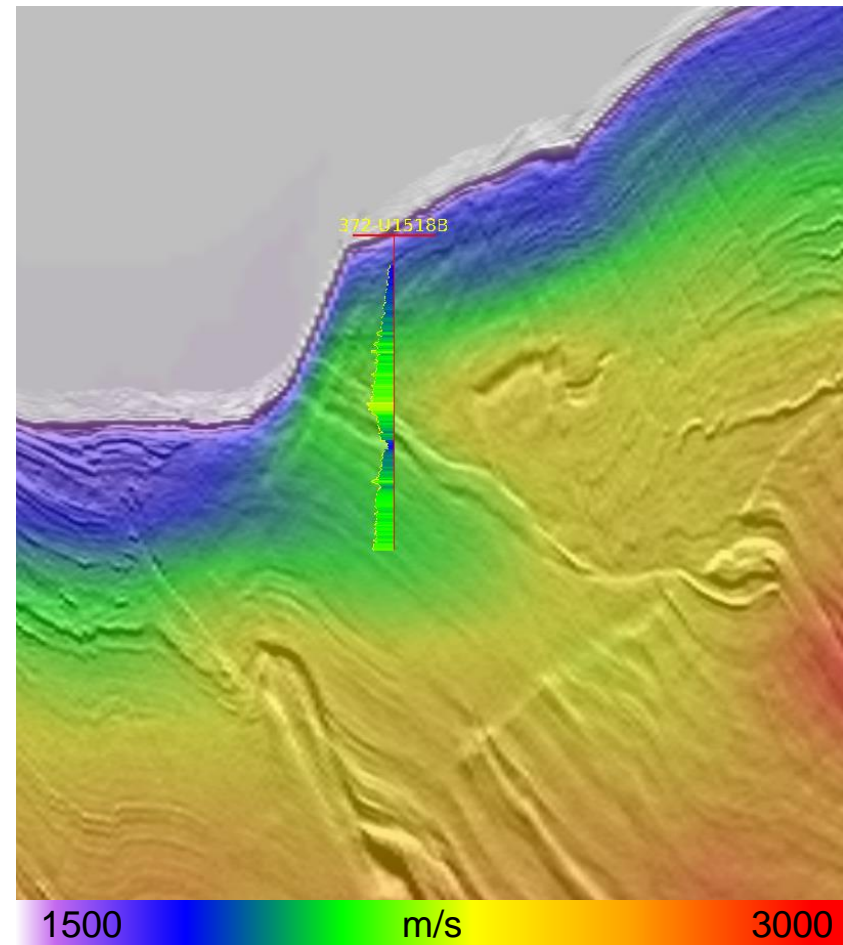
- Among the 3 available wells, only 2 of them are in our survey coverage, U1519A and U1518B.
- Both wells are close to Inline 500.



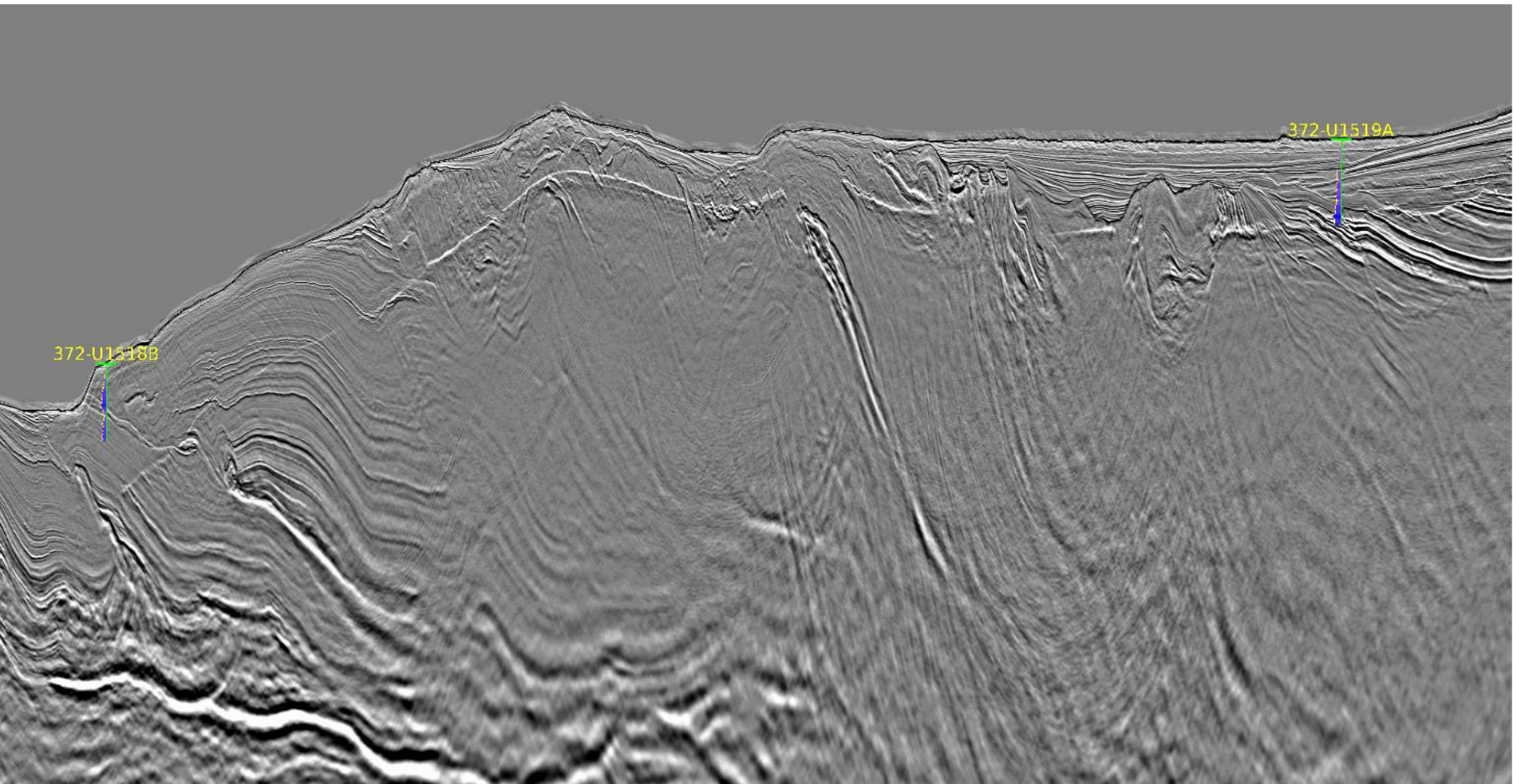


- At U1519A, ISO velocity matches with well sonic quite well, indicating 0 delta.





- At U1518B, ISO velocity follows the well sonic trend and faster than the sonic.
- An estimated 4% delta is needed to make velocity match the well sonic.





# IT1 – Unconformity Surfaces

## NZ 3D Processing

*04 December 2020*

[cgg.com](http://cgg.com)



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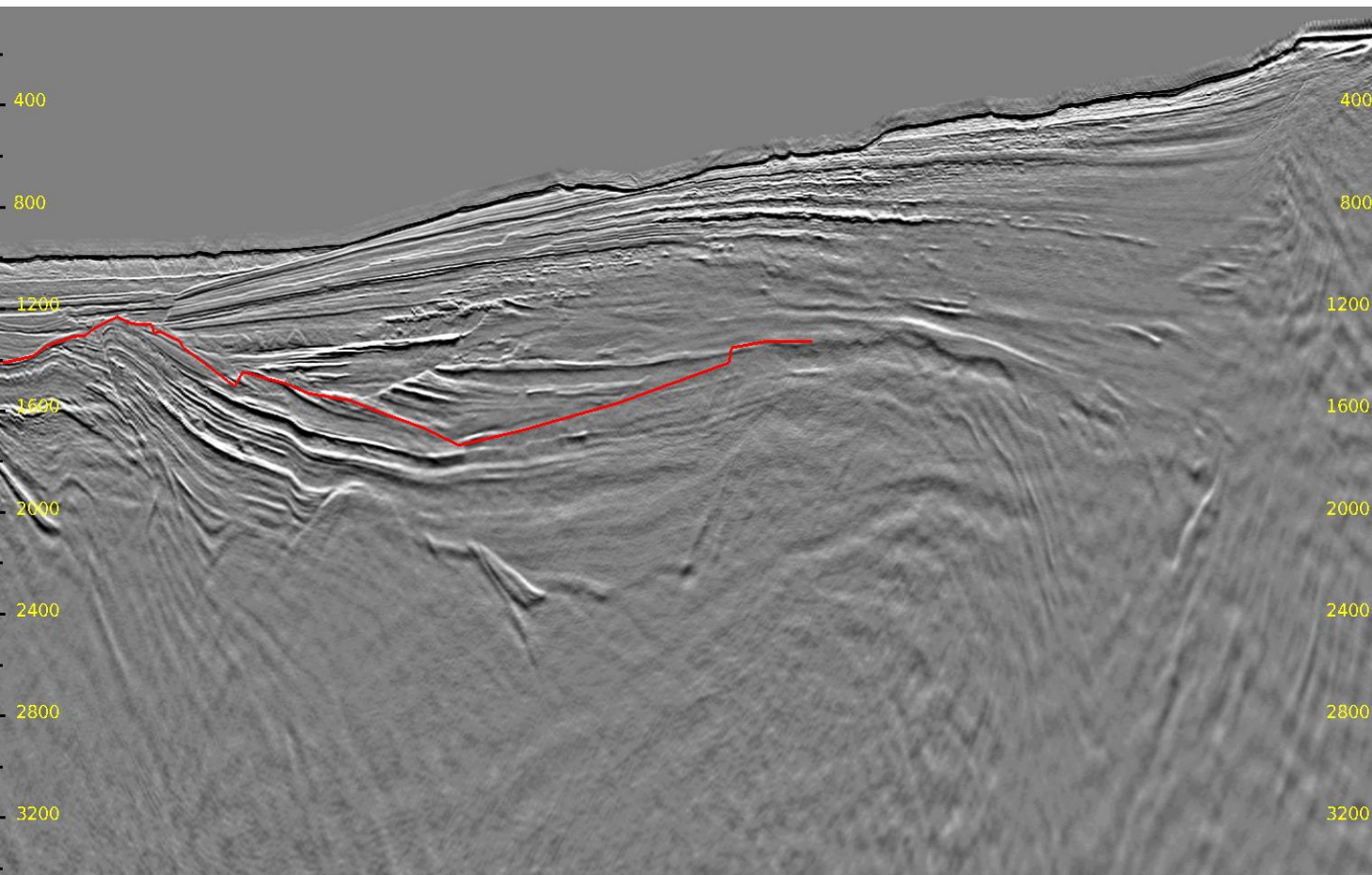
Passion for Geoscience



- The unconformity surfaces were load to the system and overlaid on corresponding stack volume.
- In inline direction, the surface matches the volume well, while edge of the survey is not fully covered.
- In crossline direction, sudden jumps between picked inlines are observed.
- Interpolation of the surface was also tested, which does not resolve the jumps in the crossline direction.

# Inline 450: Raw Unconformity Surface

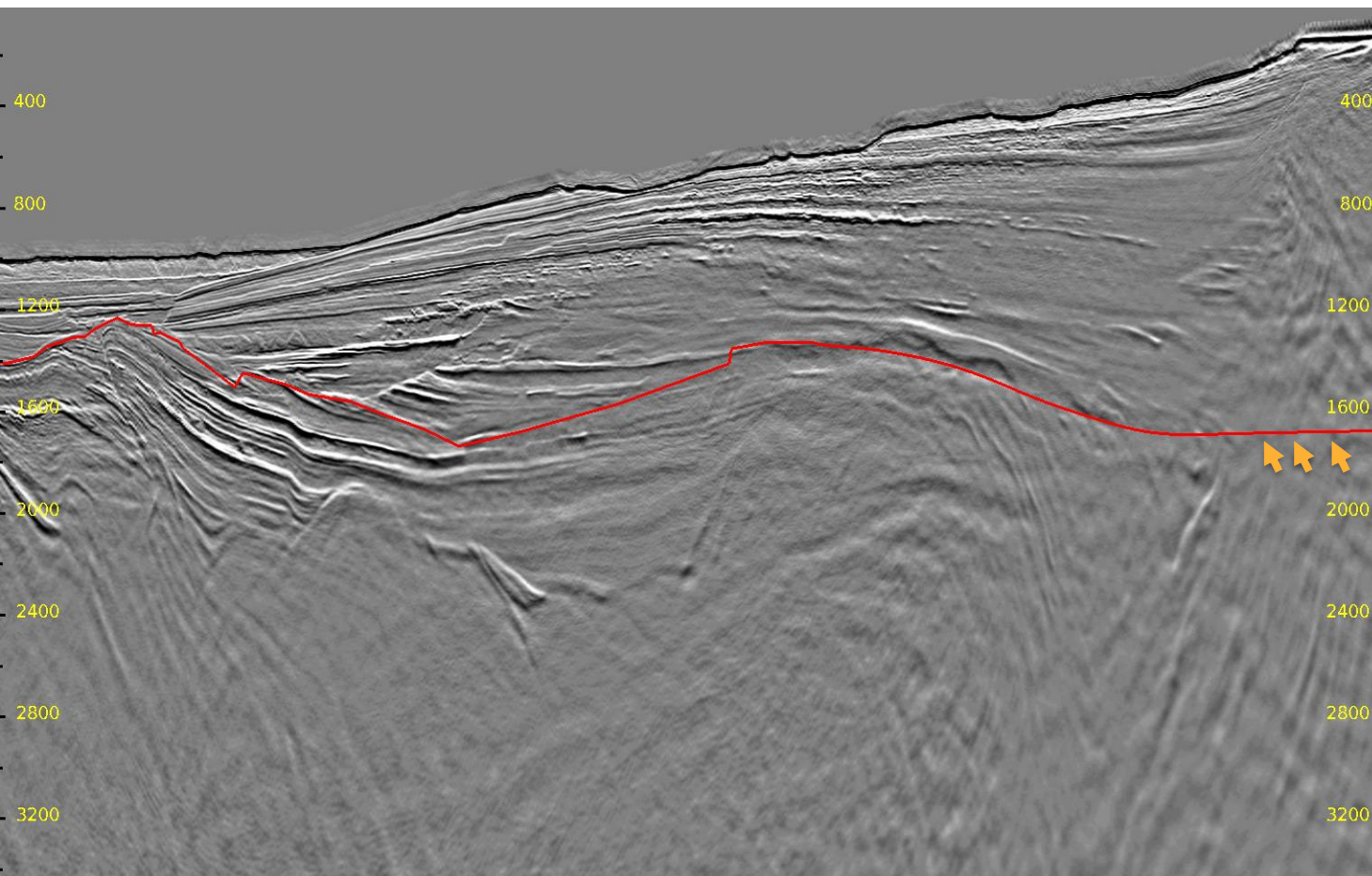
3



- Raw surface without interpolation.

# Inline 450: Interpolated Unconformity Surface

4

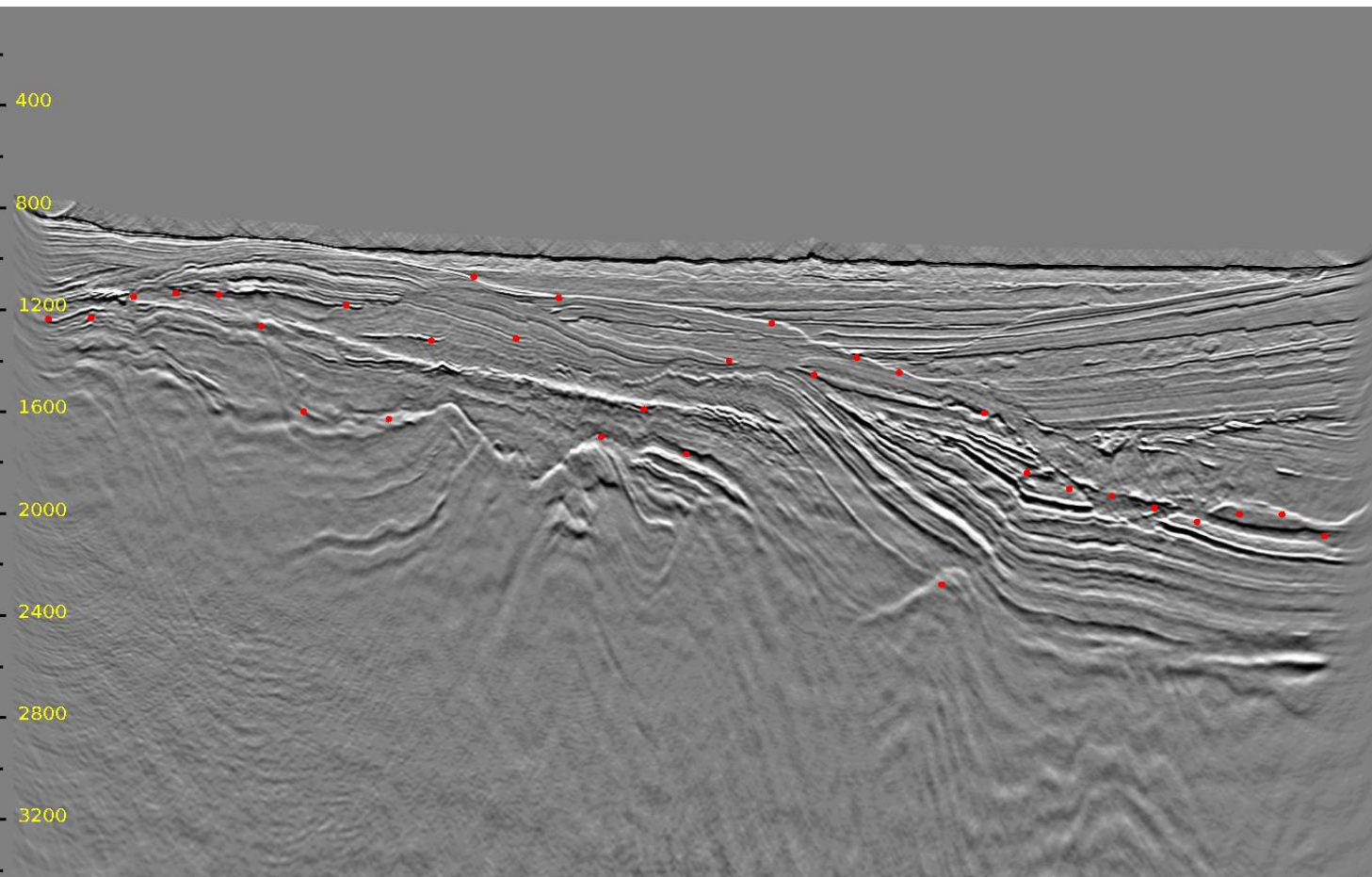


- Interpolated surface shows cutting through of events in the shallow water area.



# Crossline 4095: Raw Unconformity Surface

5

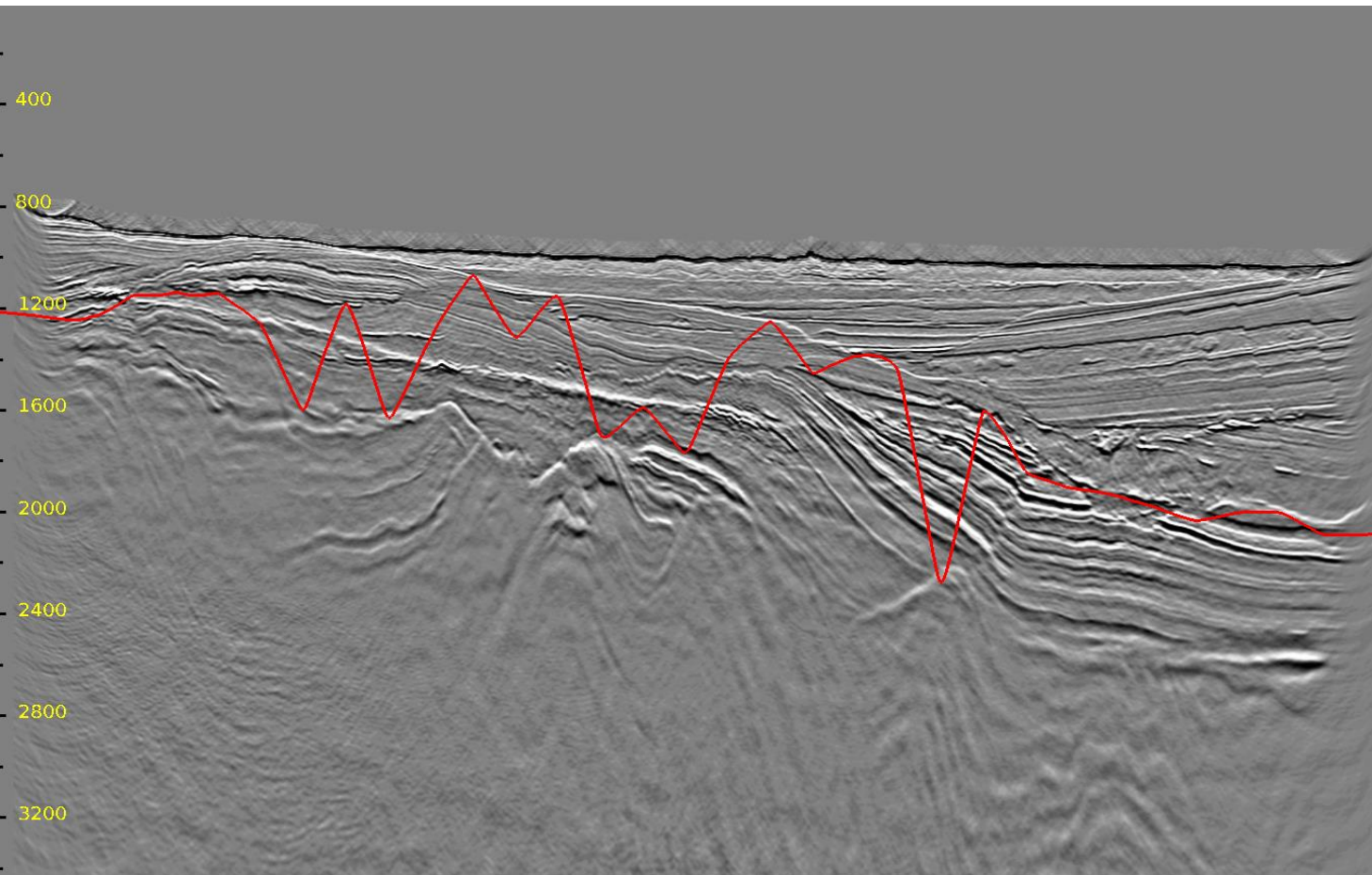


- In the crossline direction, pick inlines seem to jump among different events.



# Crossline 4095: Interpolated Unconformity Surface

6



- After interpolation, the surface crosses over multiple events.



# IT2 – TTI Model

## NZ 3D Processing

*08 December 2020*

[cgg.com](http://cgg.com)



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Passion for Geoscience



- **Objective:**

To convert IT1 ISO model to TTI models.

- **Procedure:**

Based on the well analysis, we constructed delta model with 4% below unconformity surface and 0% above the surface, where unconformity surface was picked on IT1 volume.

Epsilon is  $1.25 \times \text{Delta}$ , which is 5% based on epsilon scanning result.

Theta and phi was also picked on IT1 volume with depth variant smoothing.

- **Display:**

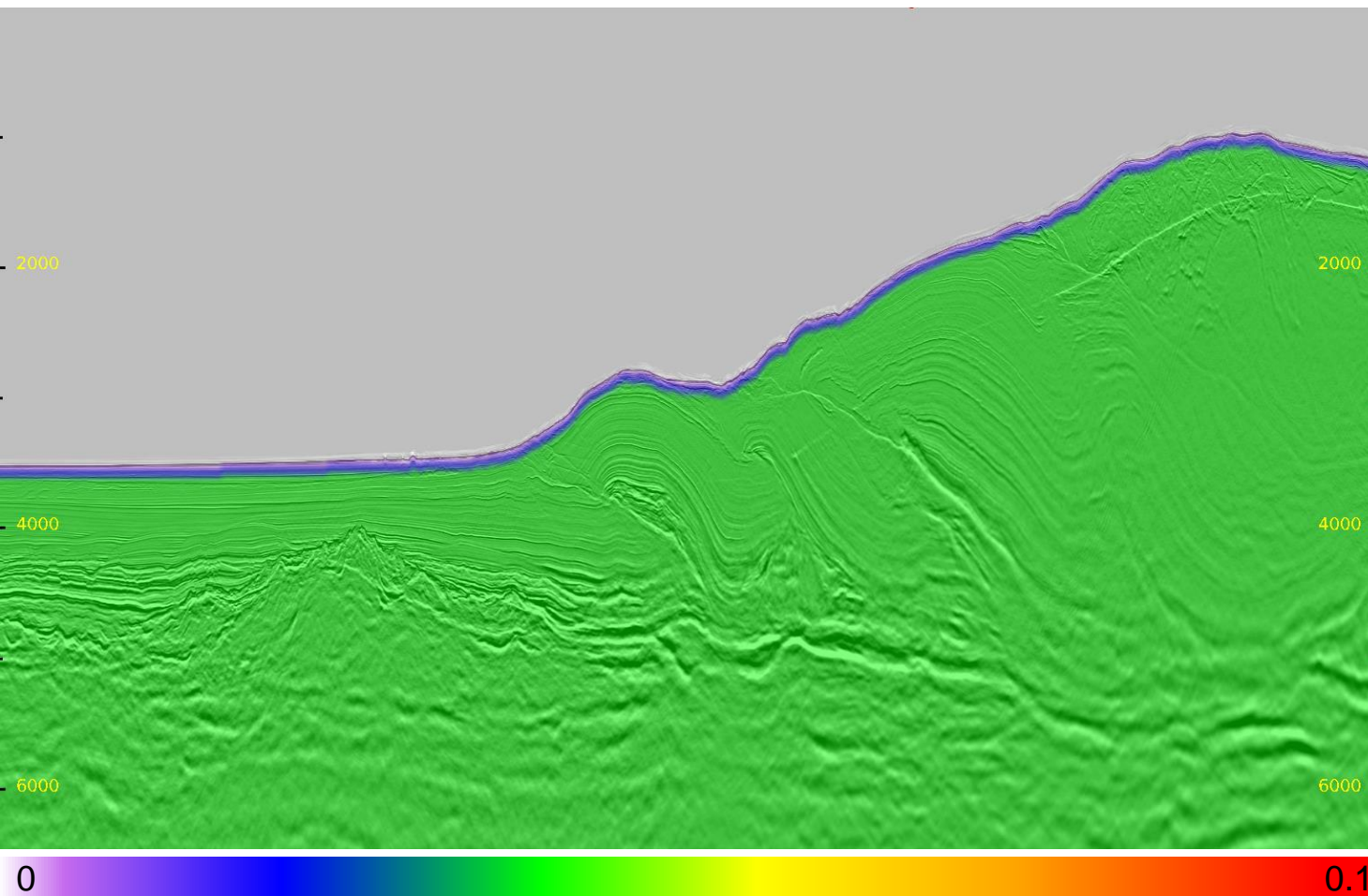
Velocity models, profiles at well locations, and migrated depth full stack & gathers.

- **Observation and Recommendation:**

Introducing TTI parameters results in a upward shift of migration result where delta is not 0%. The TTI velocity is now matches well sonic recordings.

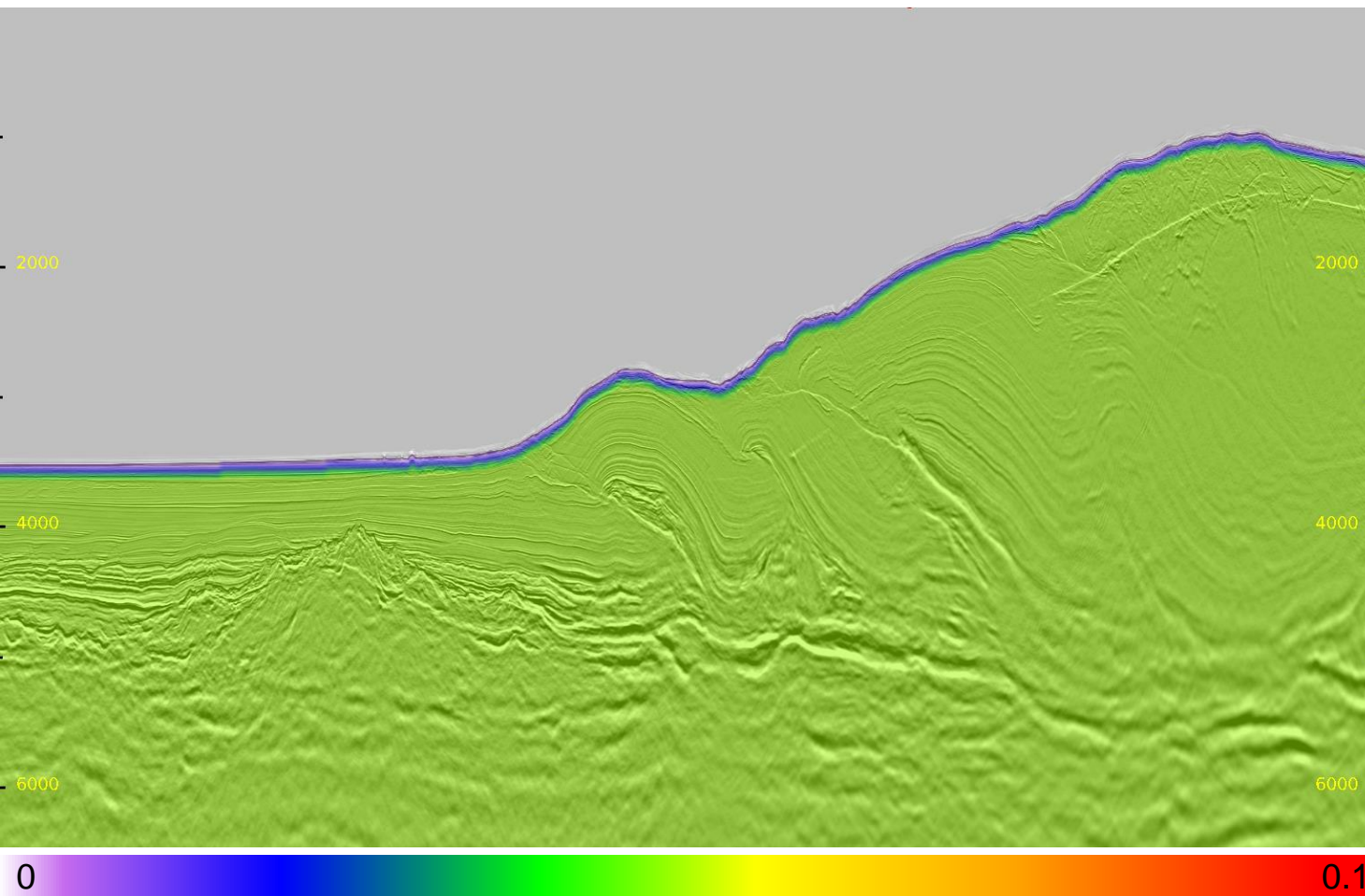
# Velocity Models



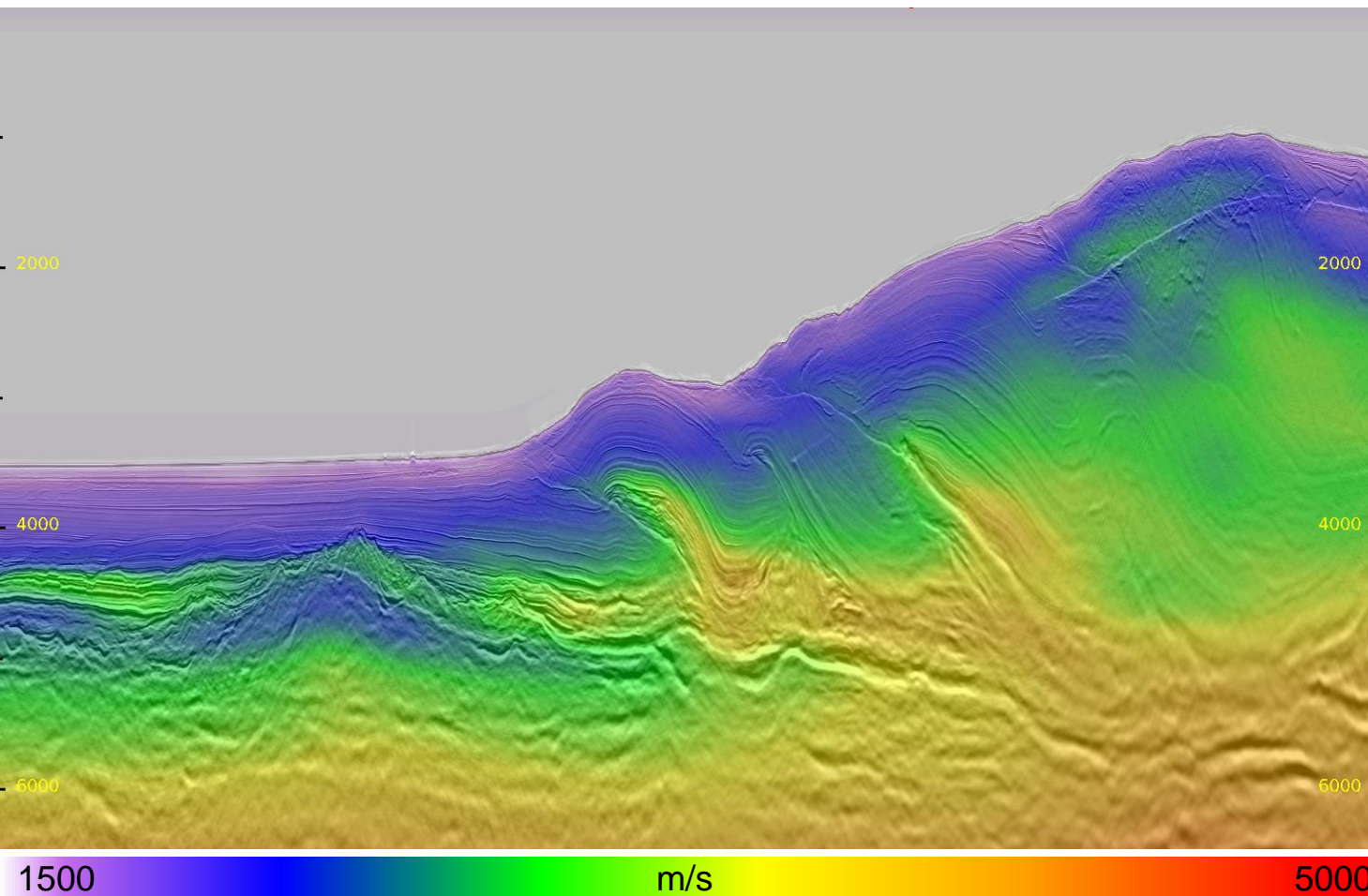


- Below unconformity surface, the delta is 4%, 0% else where, with a 100m taper below the surface.
- TTI migration seismic in the back ground.





- Epsilon is 1.25 times delta, that is 5%, based on epsilon scanning result.
- TTI migration seismic in the back ground.

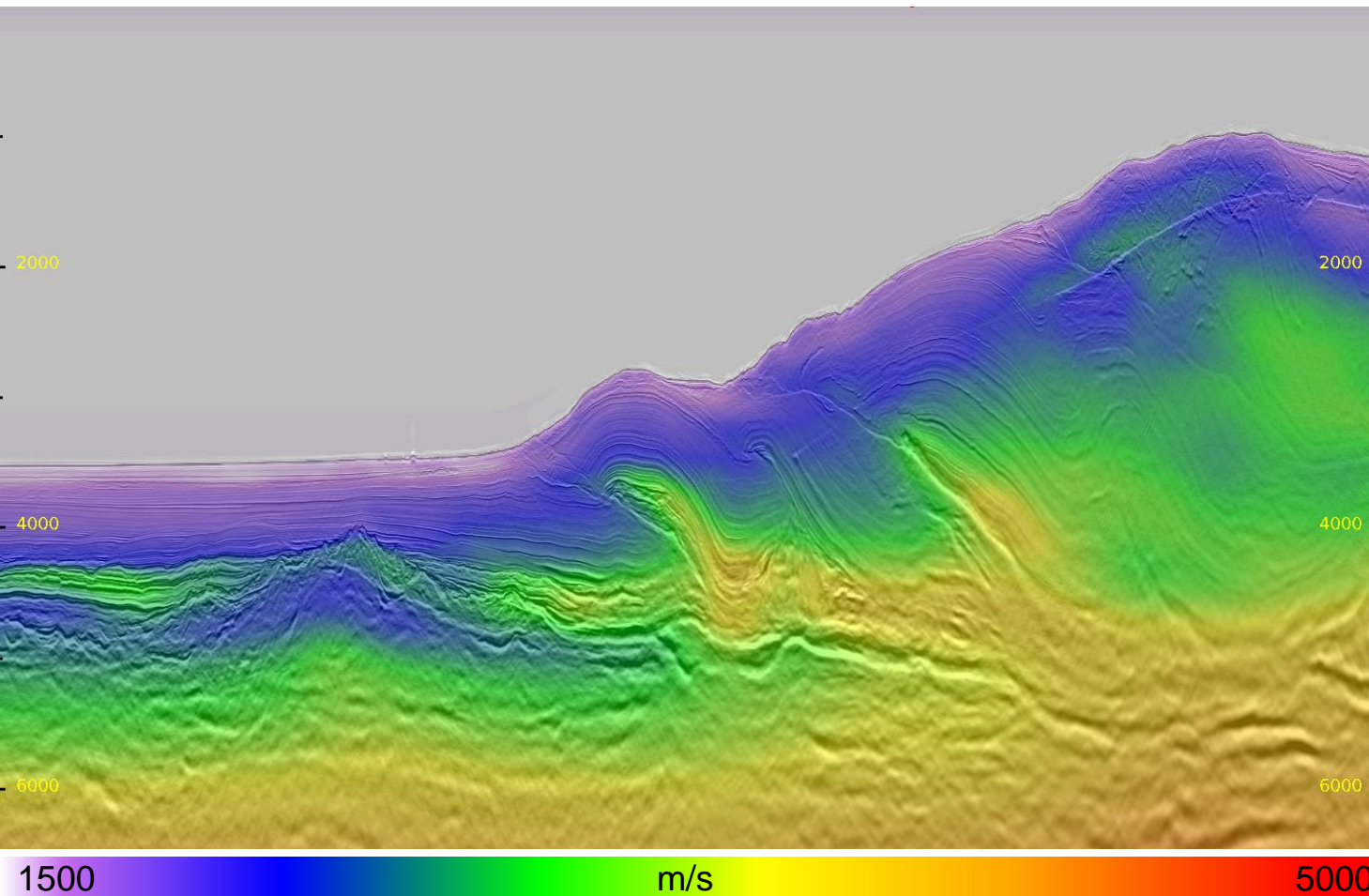


- IT1 ISO migration seismic in the back ground.



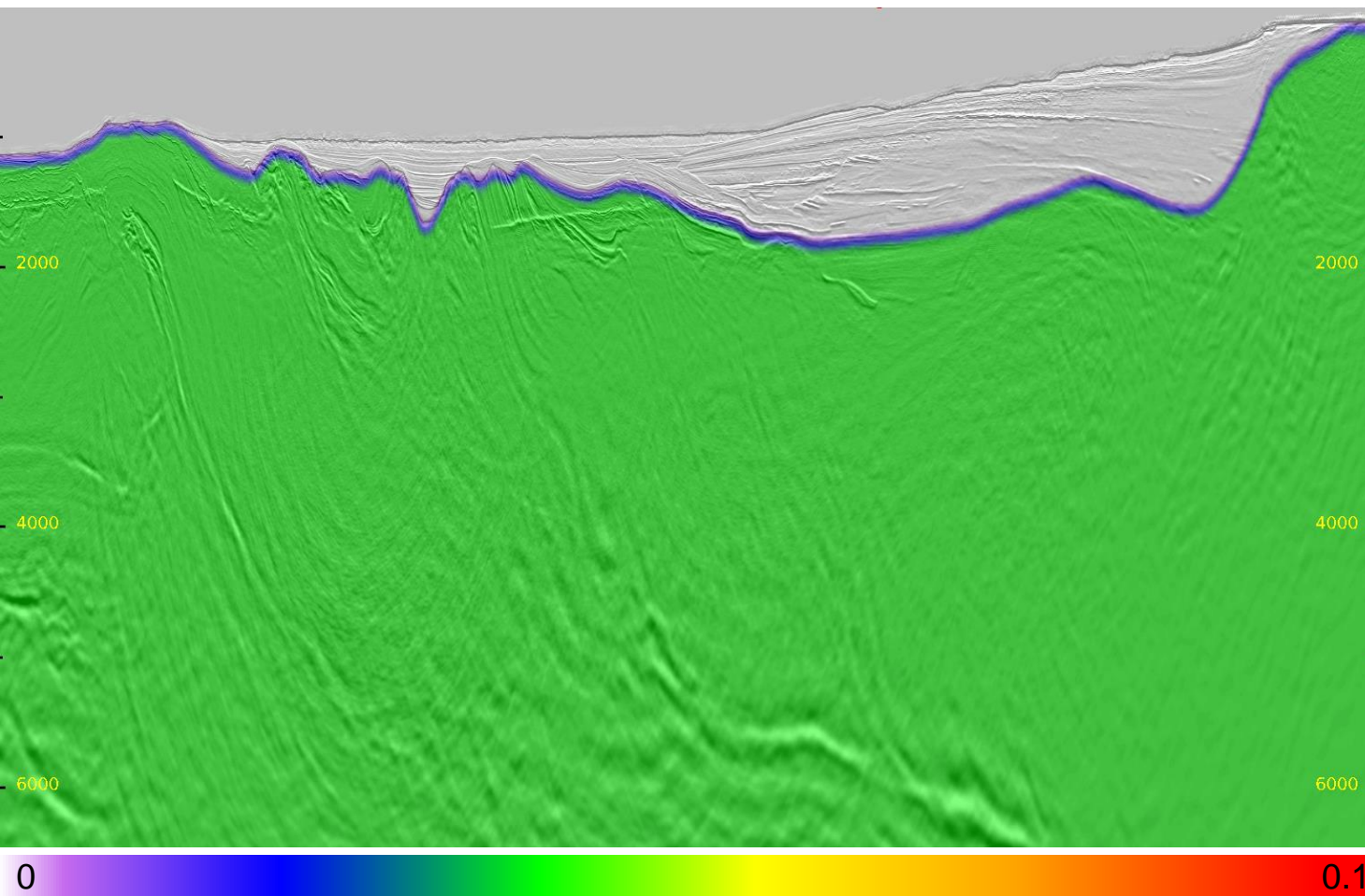
## Inline 436 East: TTI Velocity

7

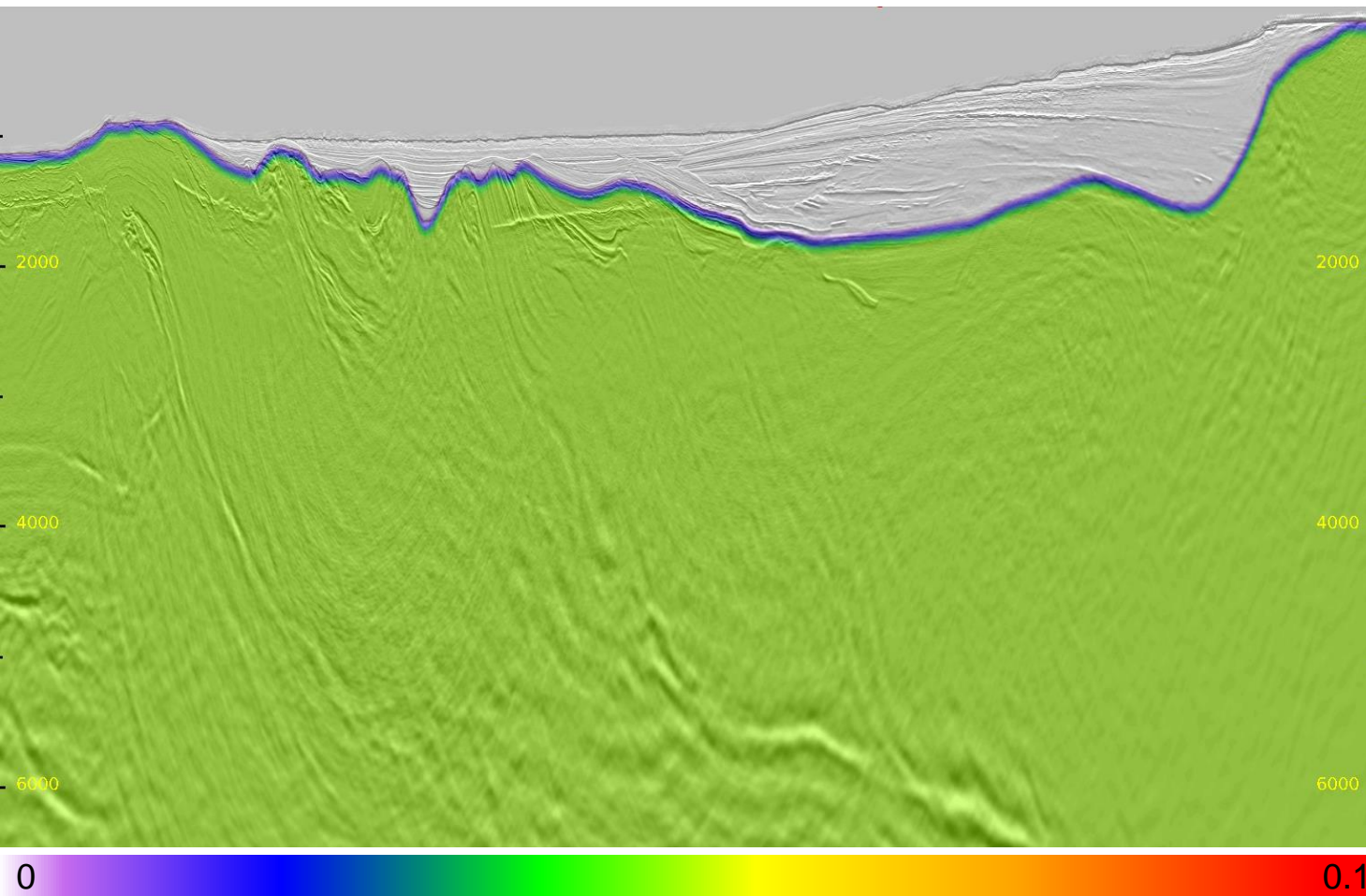


- IT2 converted TTI velocity shows slow down below unconformity surface due to 4% delta.
- TTI migration seismic in the back ground.





- Below unconformity surface, the delta is 4%, 0% else where, with a 100m taper below the surface.
- TTI migration seismic in the back ground.

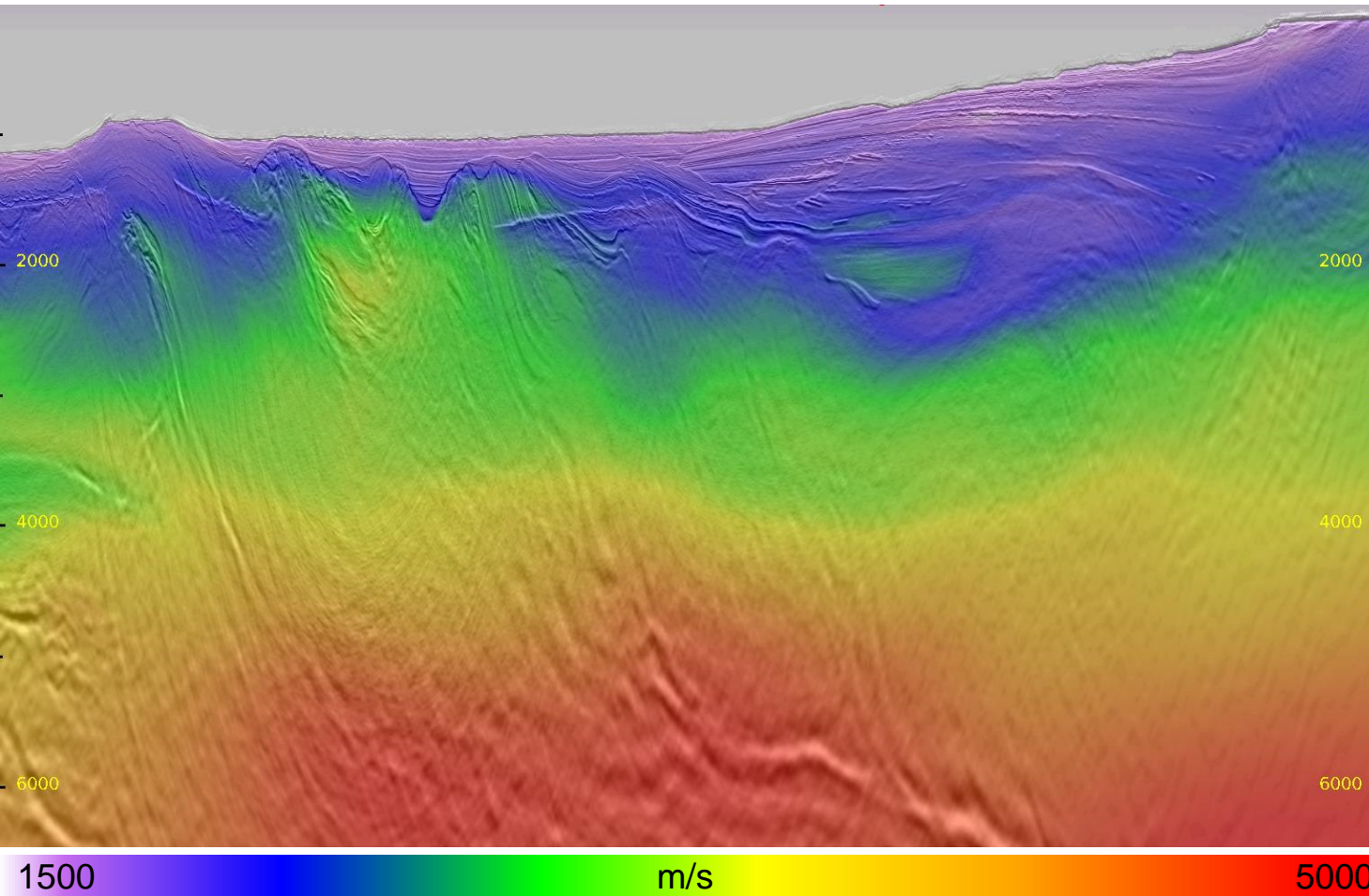


- Epsilon is 1.25 times delta, that is 5%, based on epsilon scanning result.
- TTI migration seismic in the back ground.



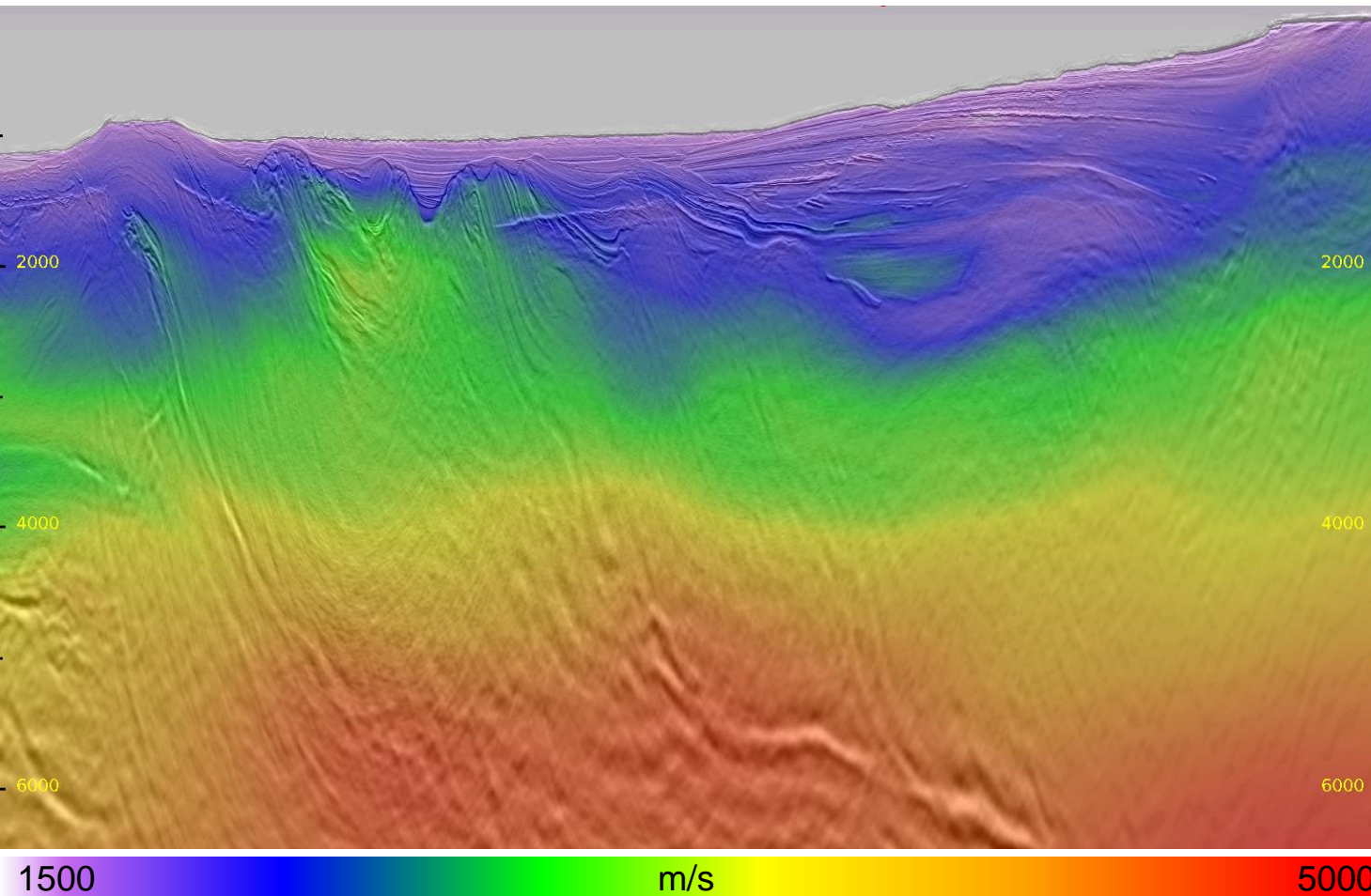
## Inline 436 West: ISO Velocity

10

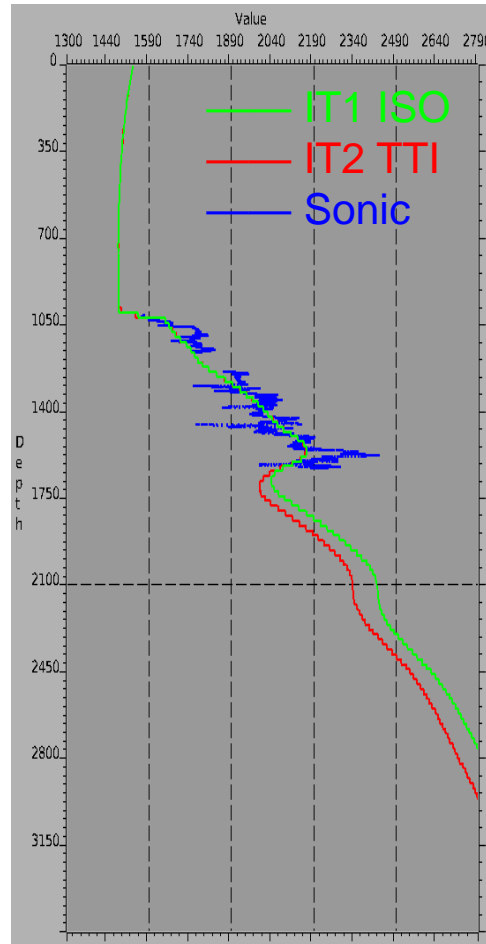
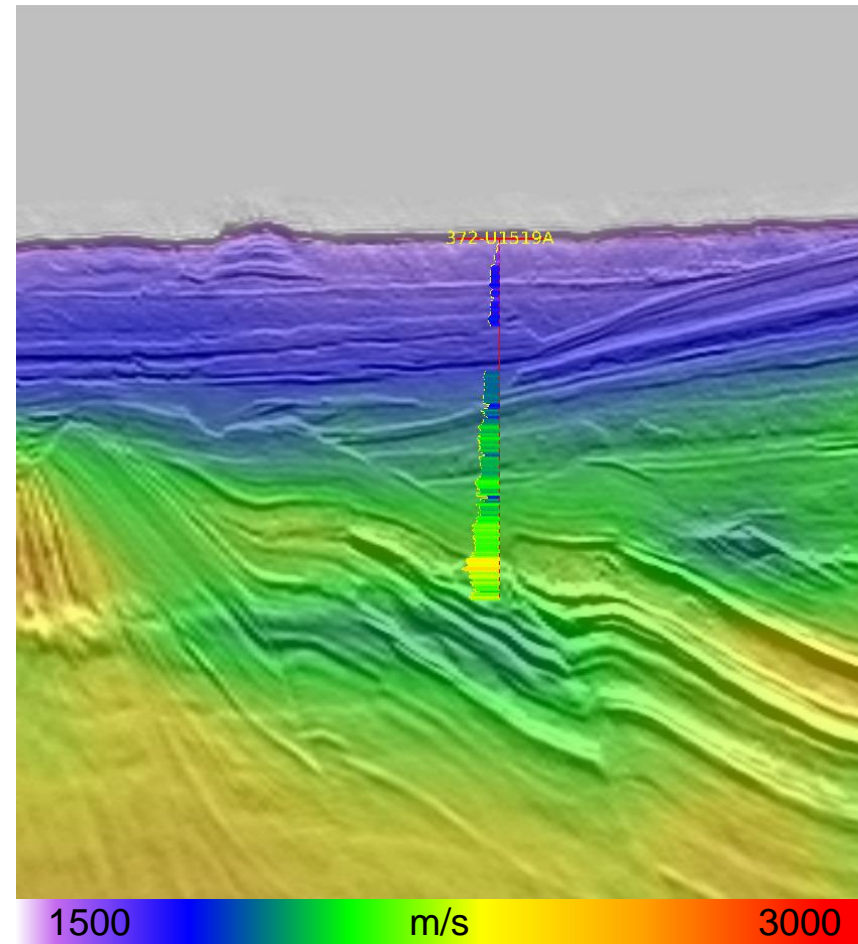


- IT1 ISO migration seismic in the back ground.

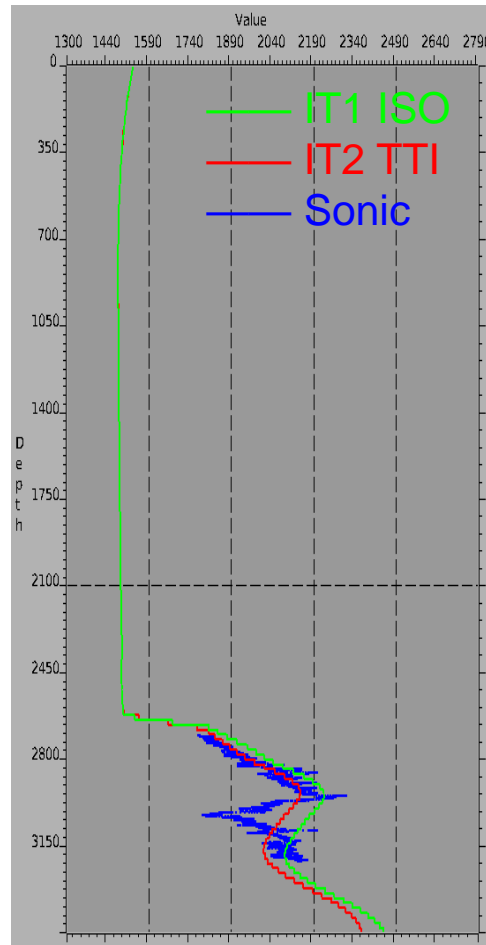
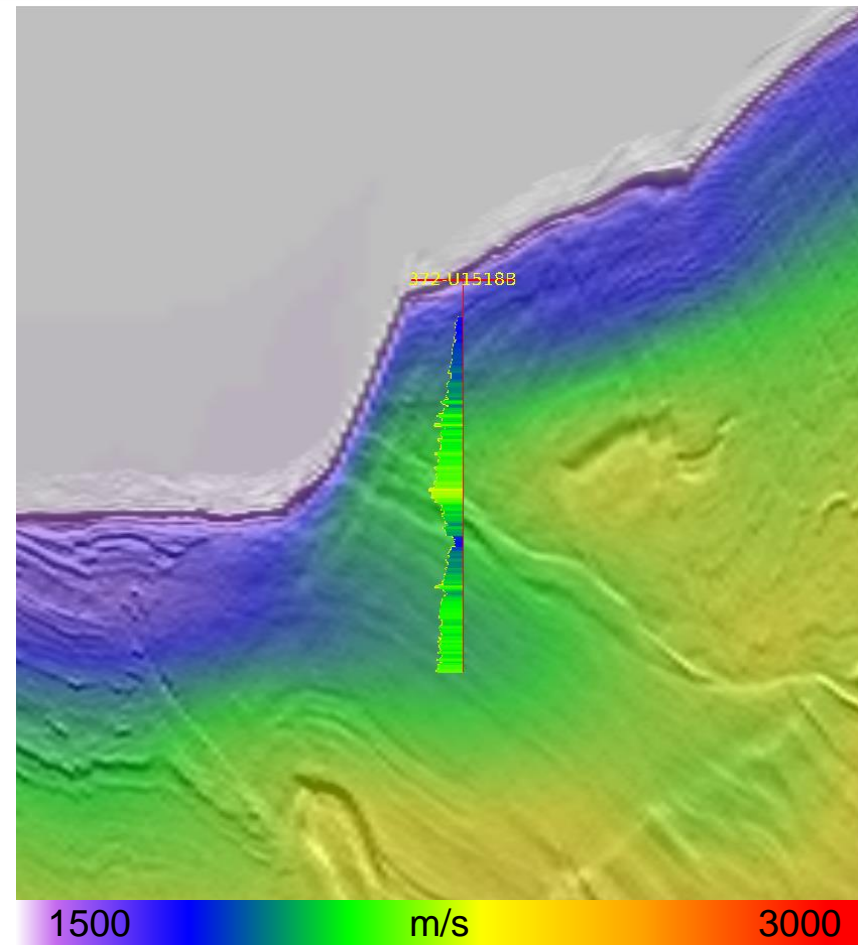




- IT2 converted TTI velocity shows slow down below unconformity surface due to 4% delta.
- TTI migration seismic in the back ground.



- At U1519A, both ISO and TTI velocity matches well, since delta is 0% above unconformity.



- At U1518B, TTI velocity matches with well after we introduce 4% delta.

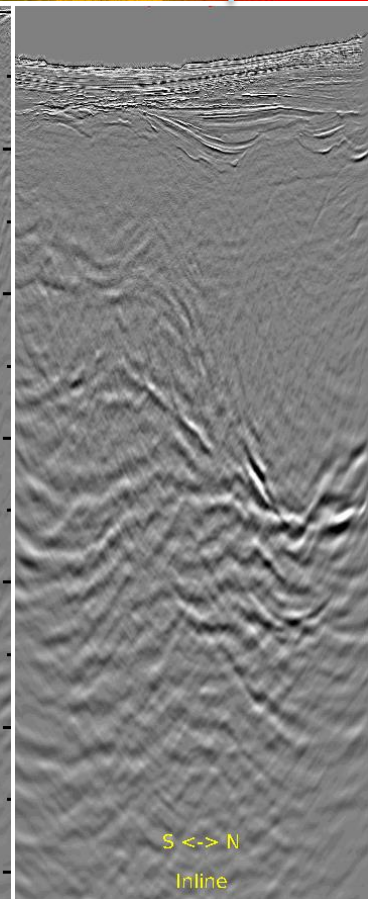
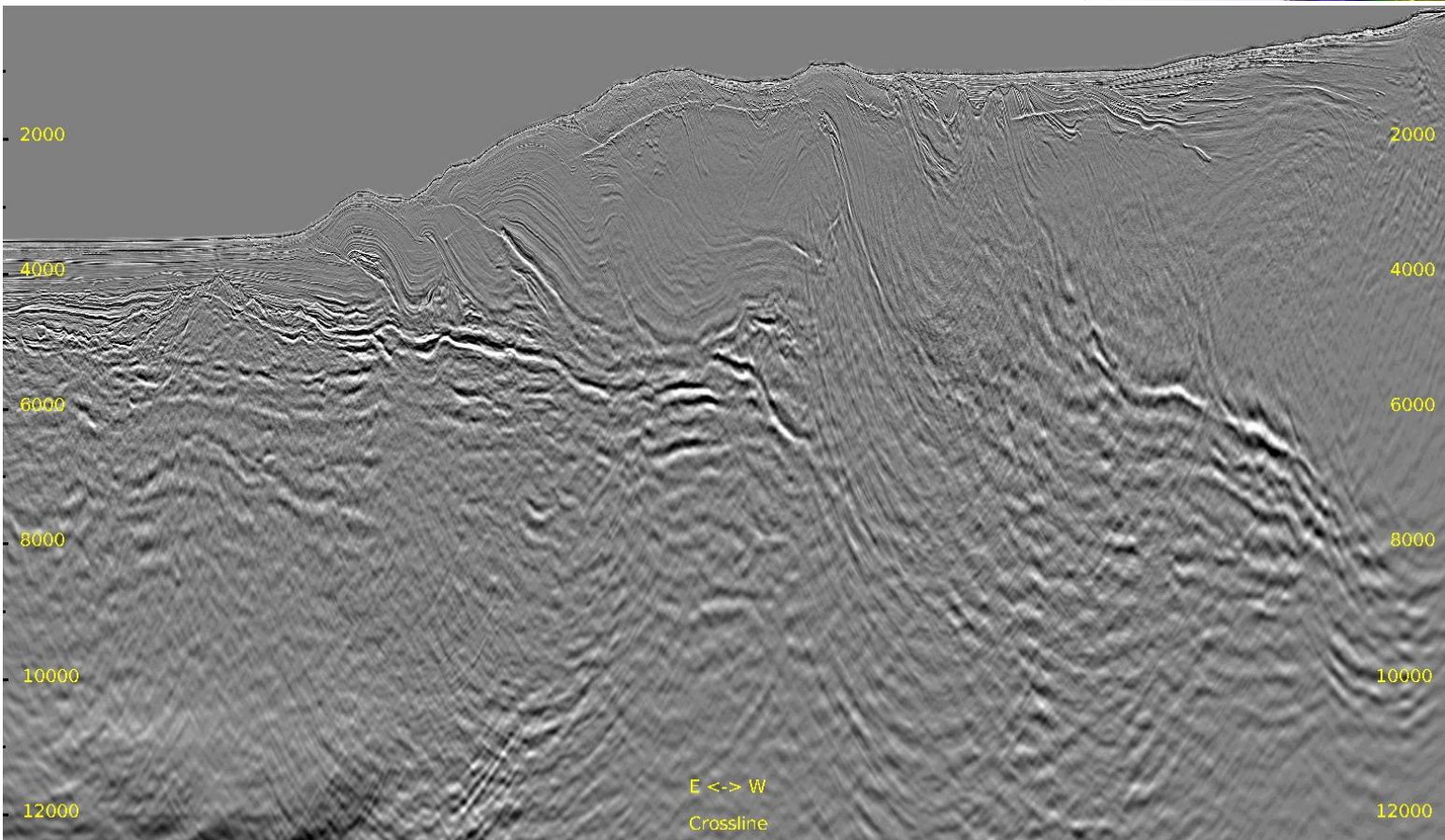
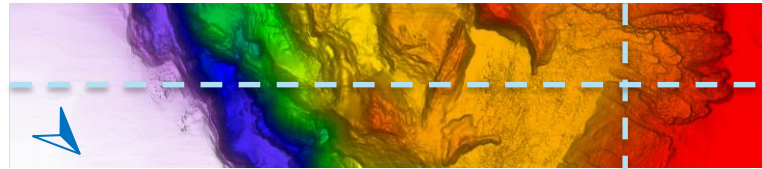


# Kirchhoff Depth Migration



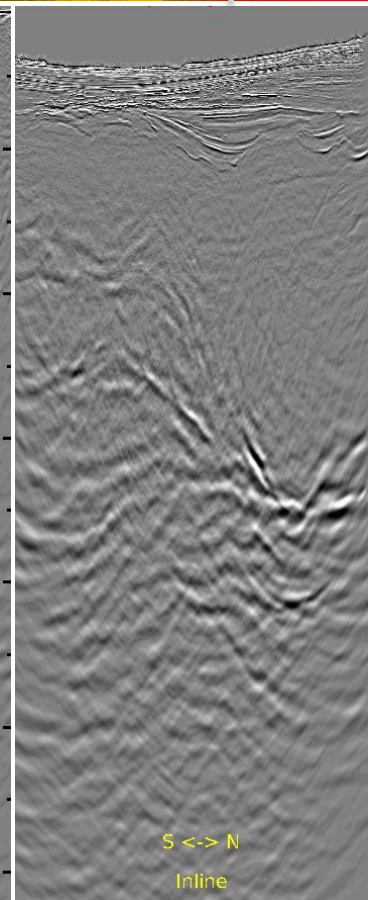
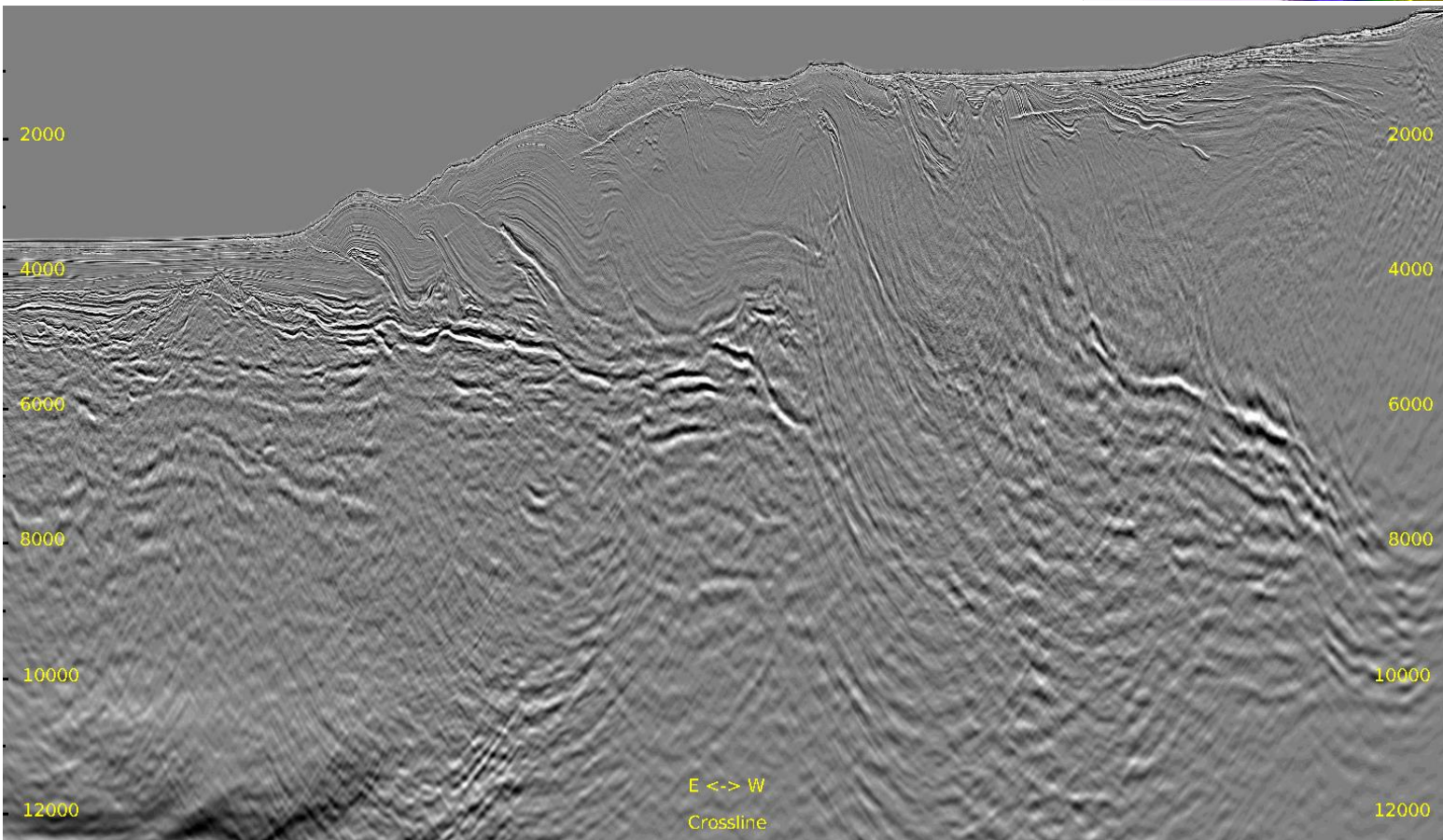
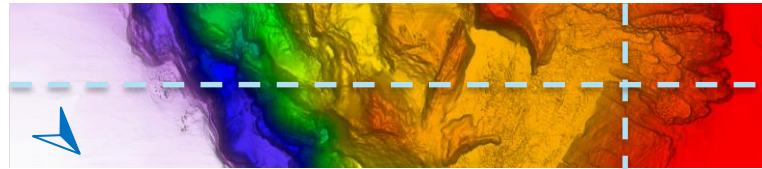
# Full Stack: IT1 ISO

Inline 436 & Crossline 4540



# Full Stack: IT2 TTI

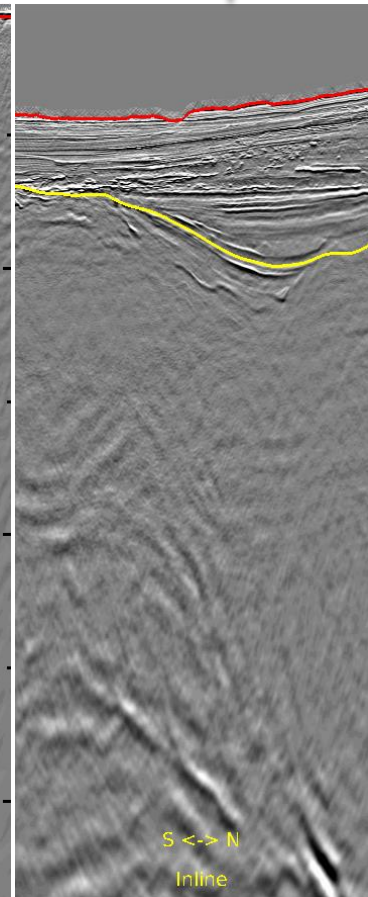
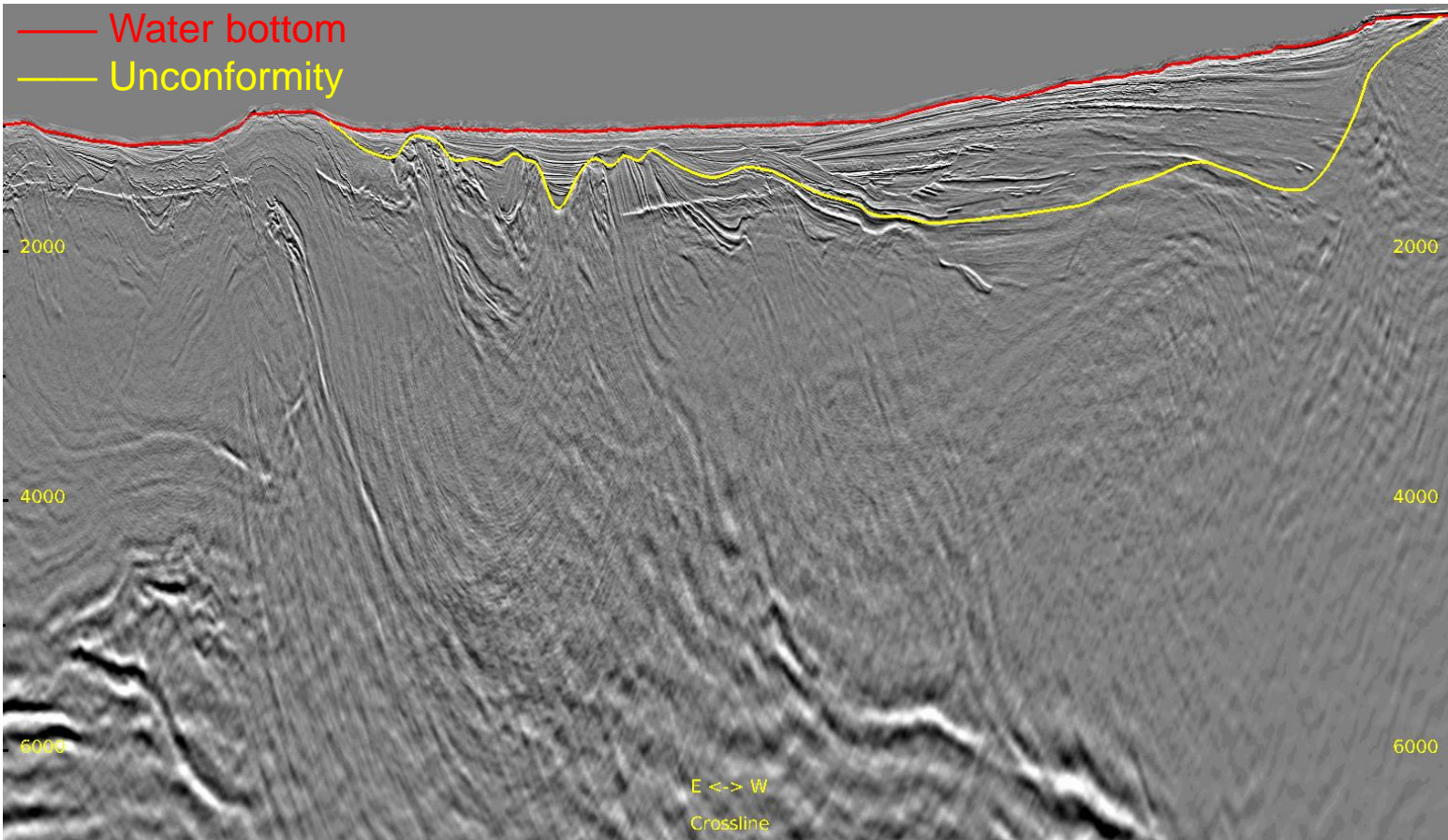
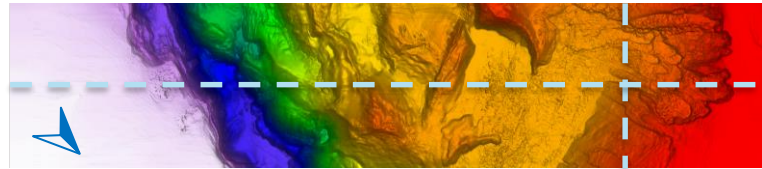
Inline 436 & Crossline 4540





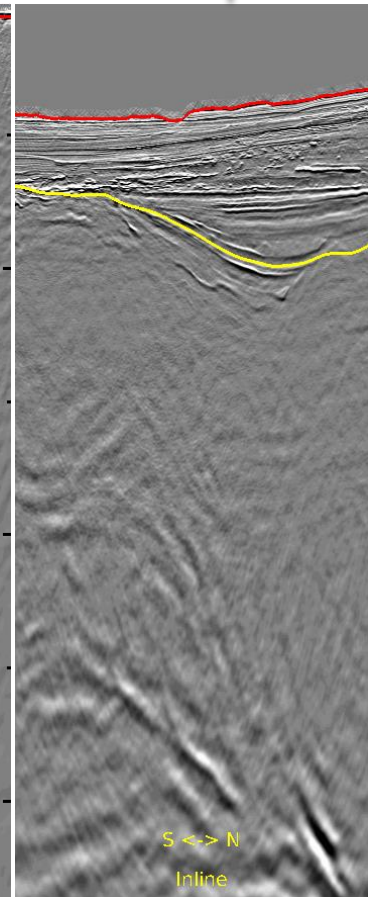
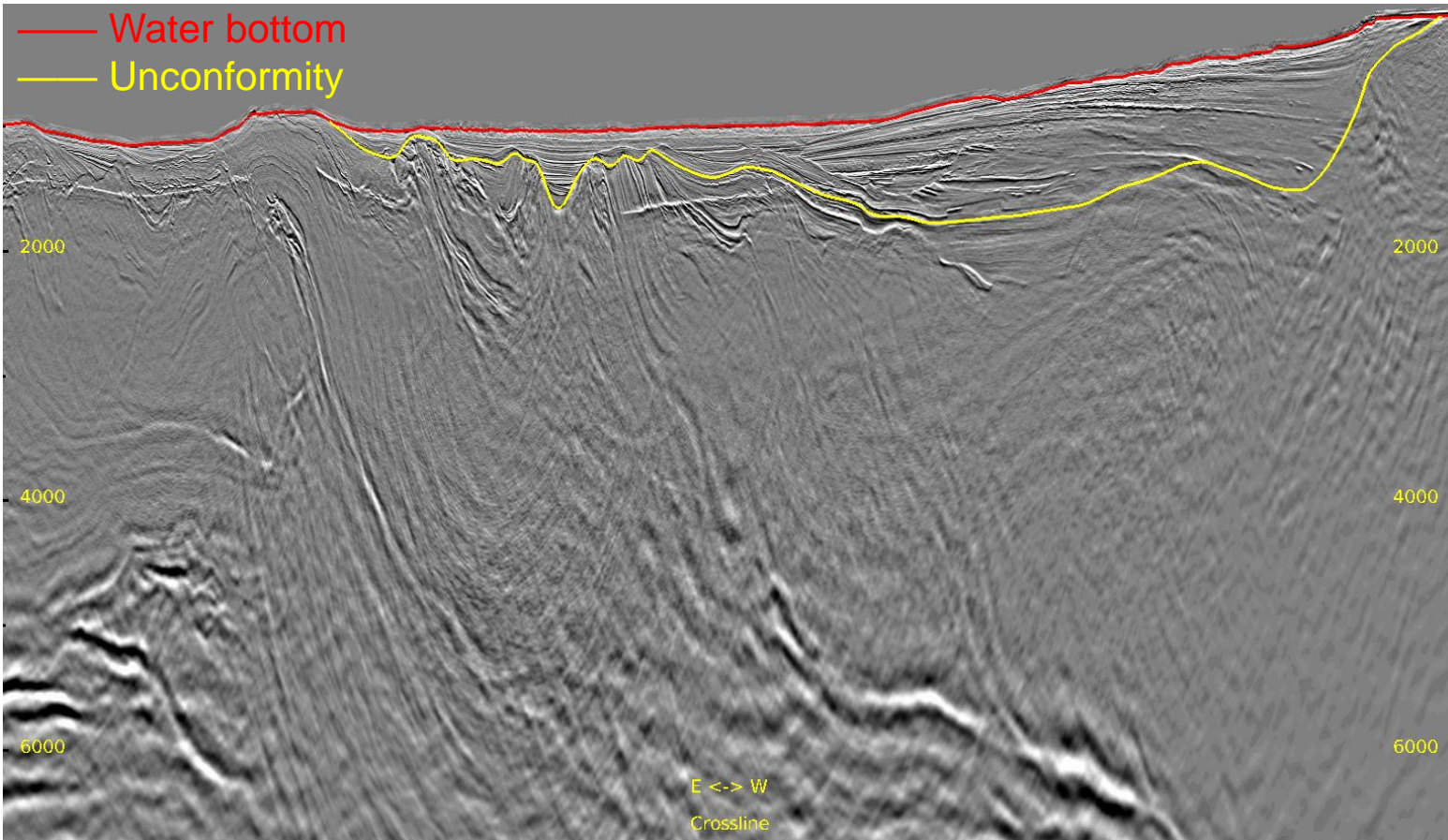
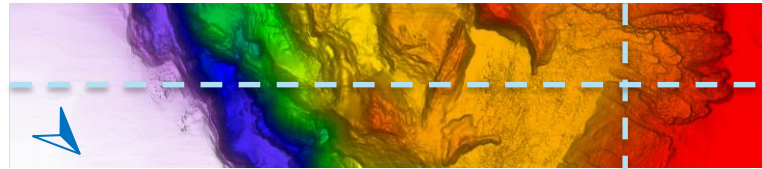
# Zoomed Full Stack: IT1 ISO

Inline 436 & Crossline 4540

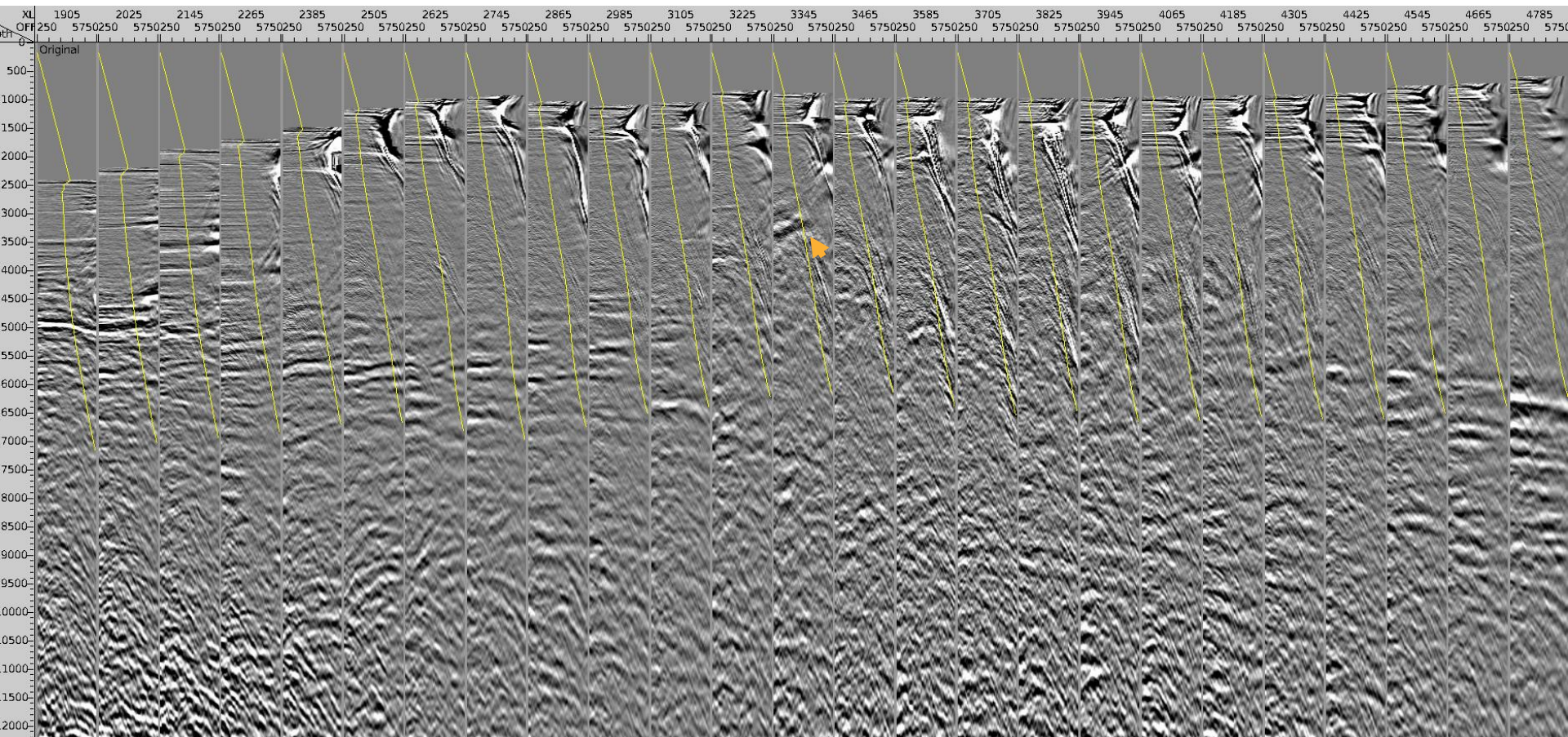


# Zoomed Full Stack: IT2 TTI

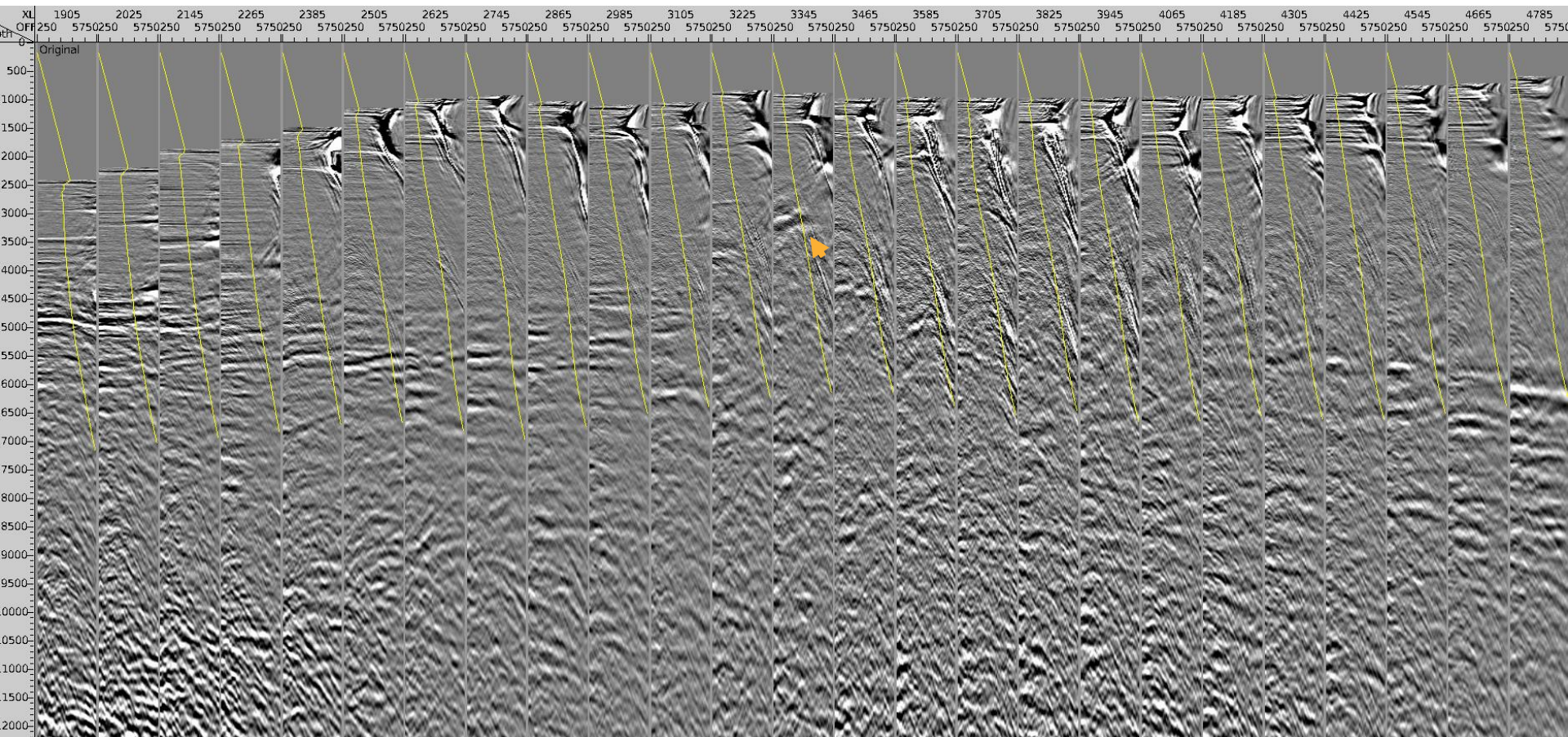
Inline 436 & Crossline 4540







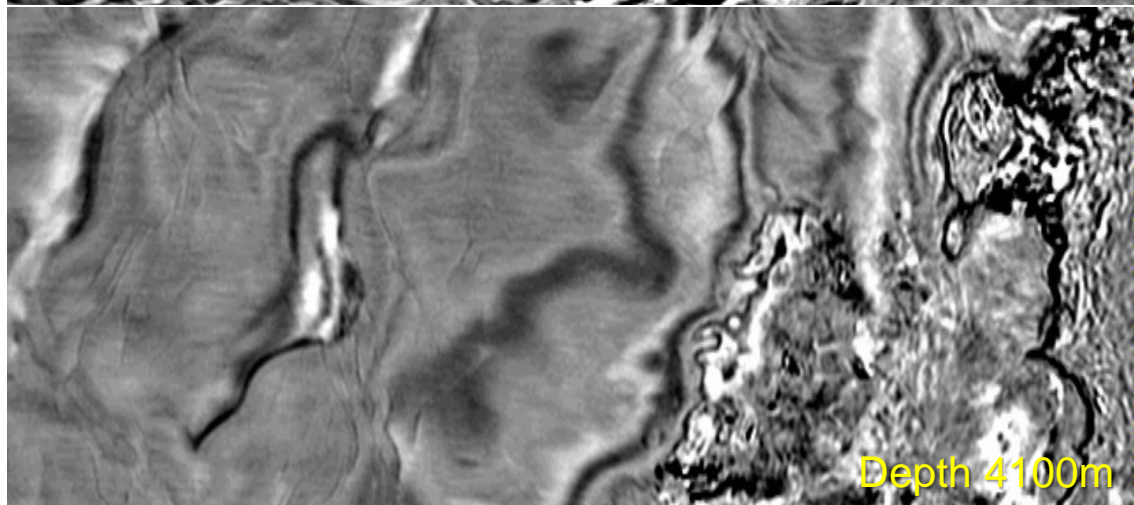
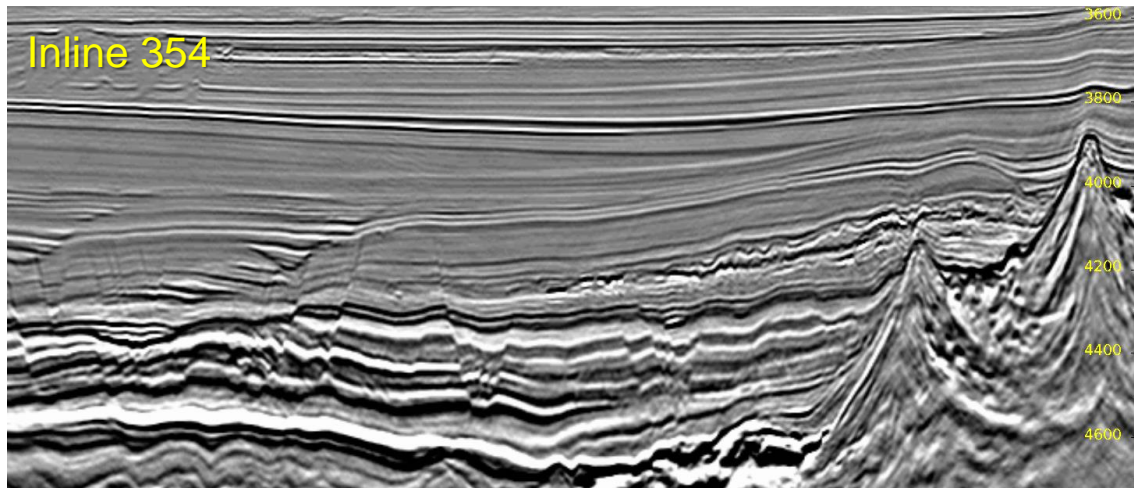
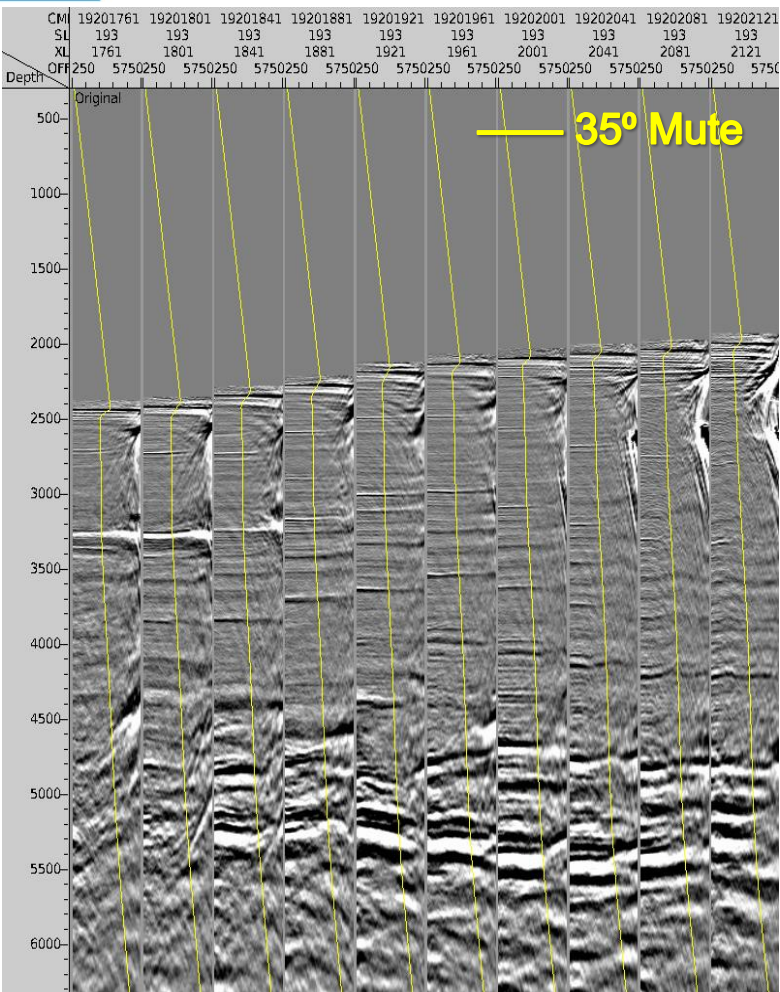




# Epsilon Scans





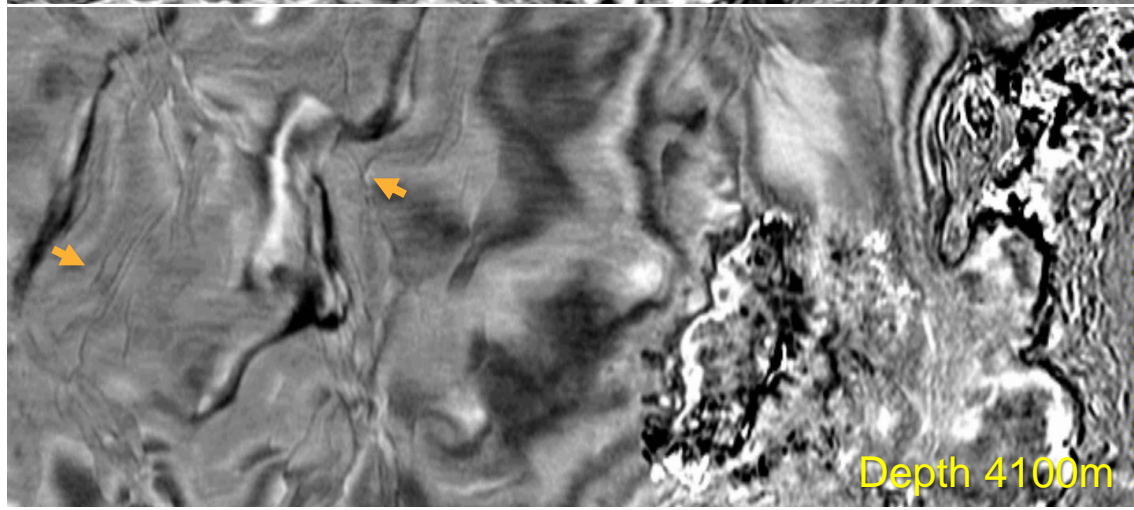
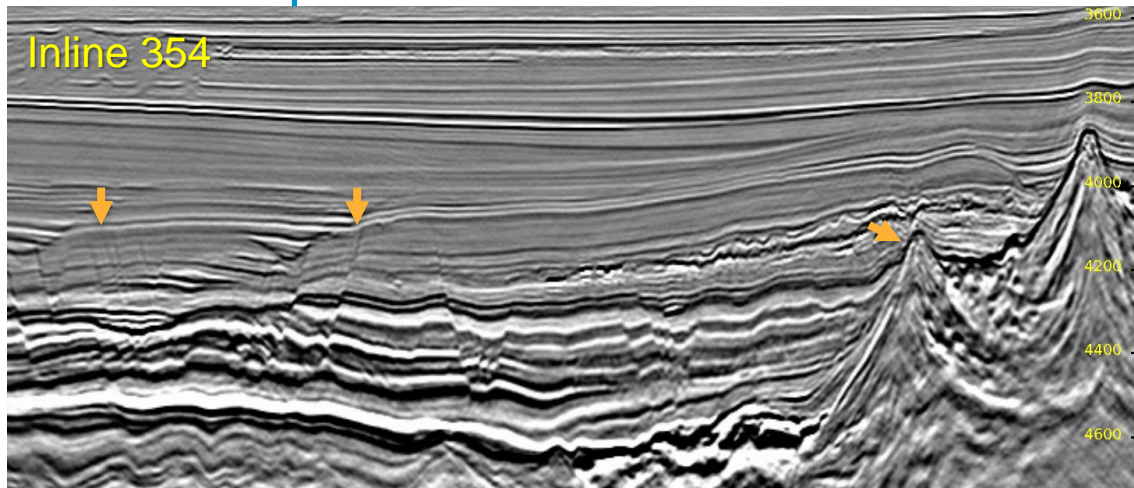
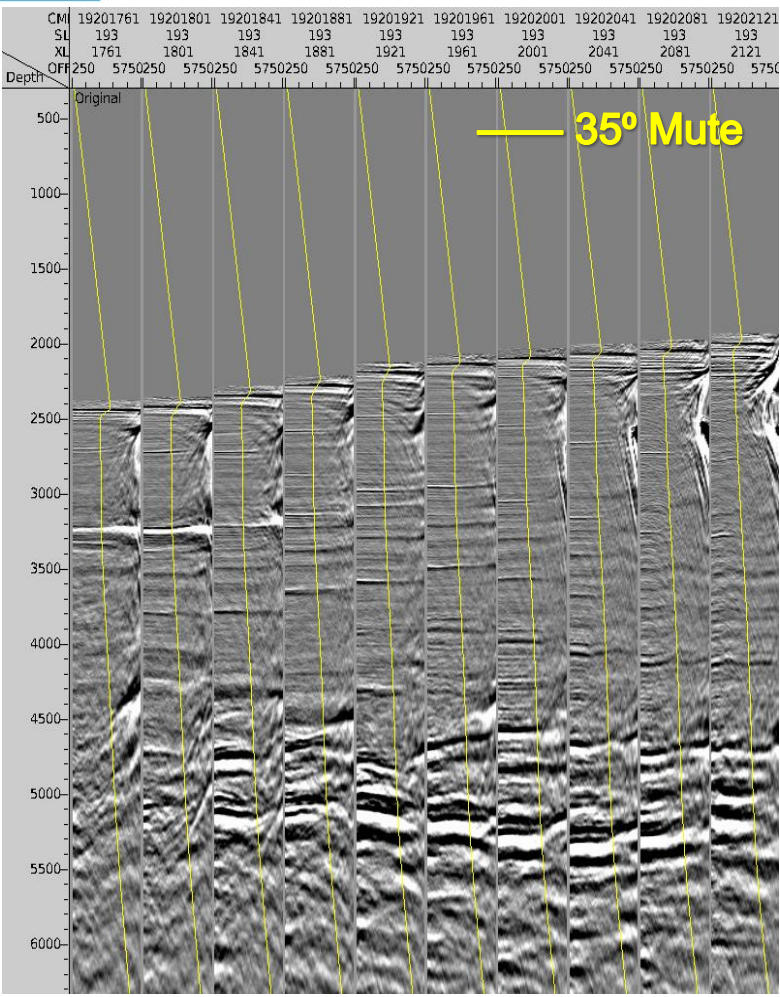






# TTI CDP Gathers & Full Stack: 4% Epsilon

23

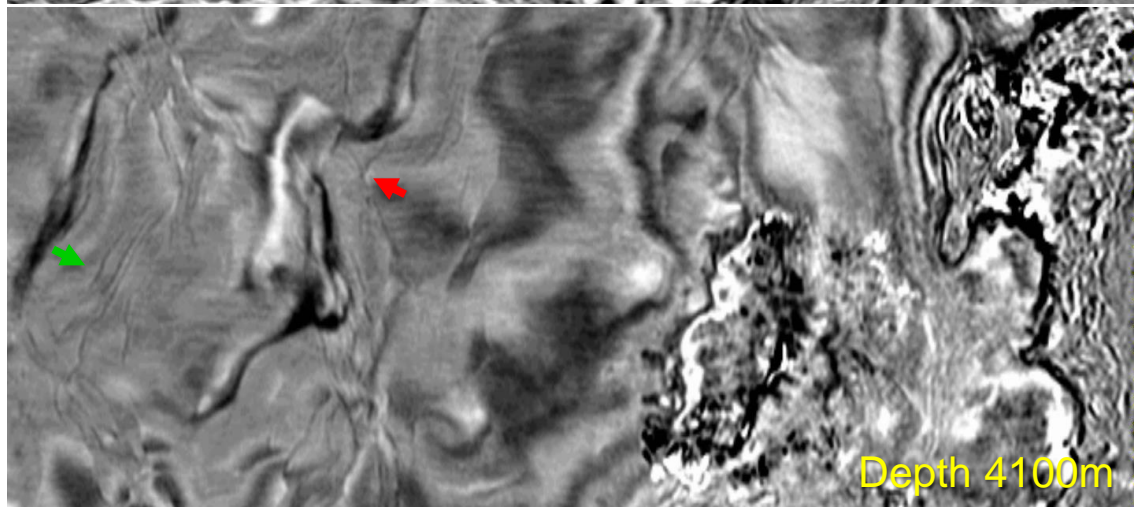
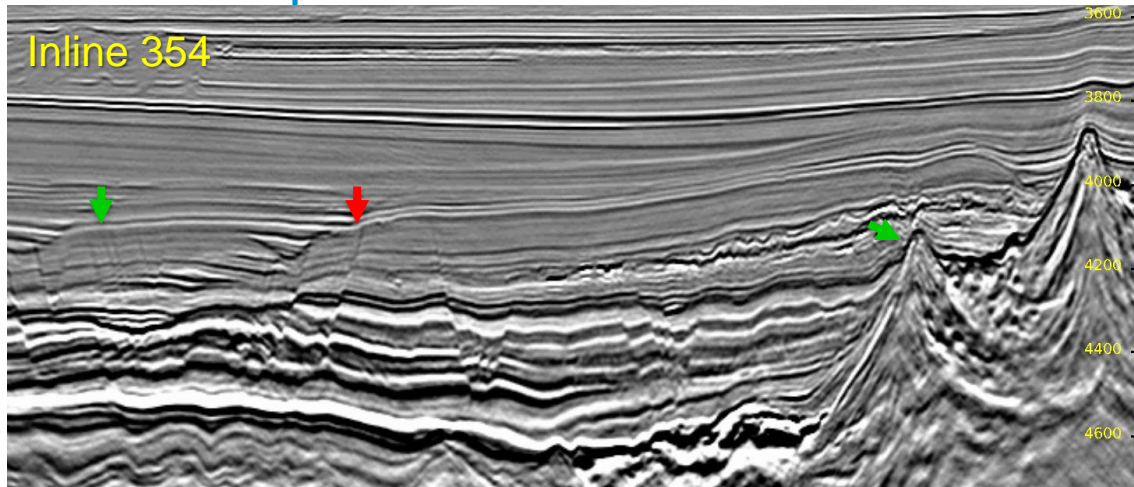
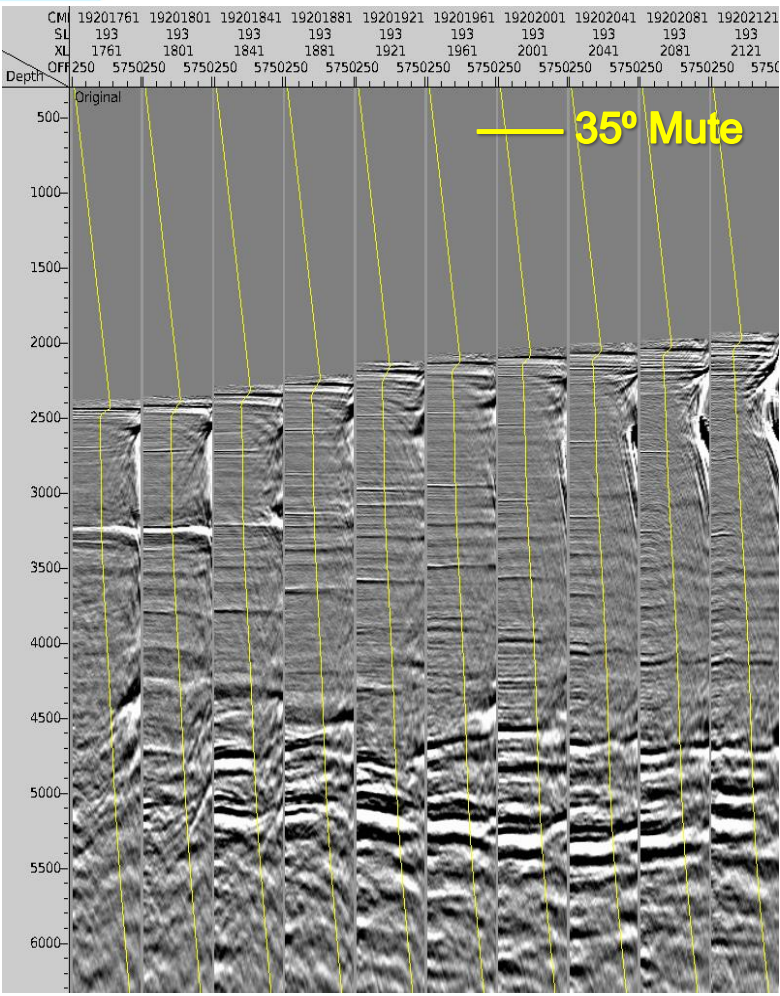






# TTI CDP Gathers & Full Stack: 5% Epsilon

24

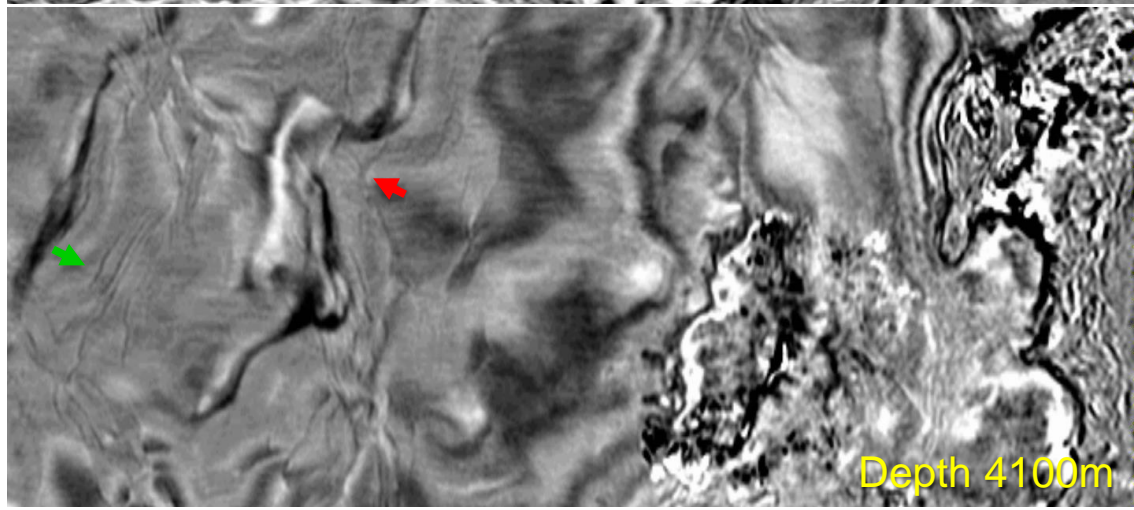
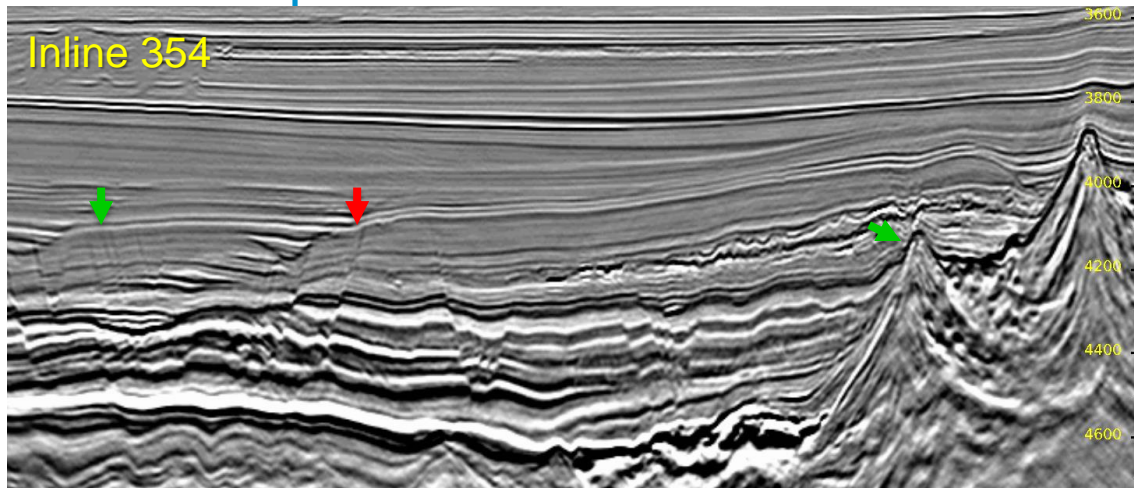
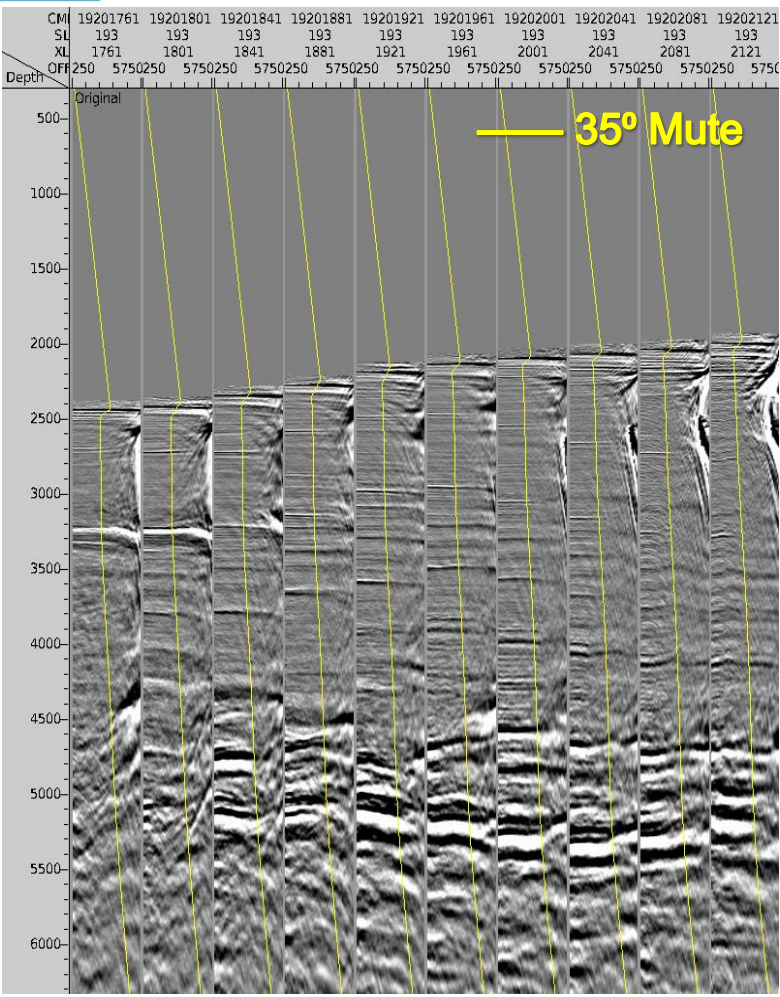






# TTI CDP Gathers & Full Stack: 6% Epsilon

25



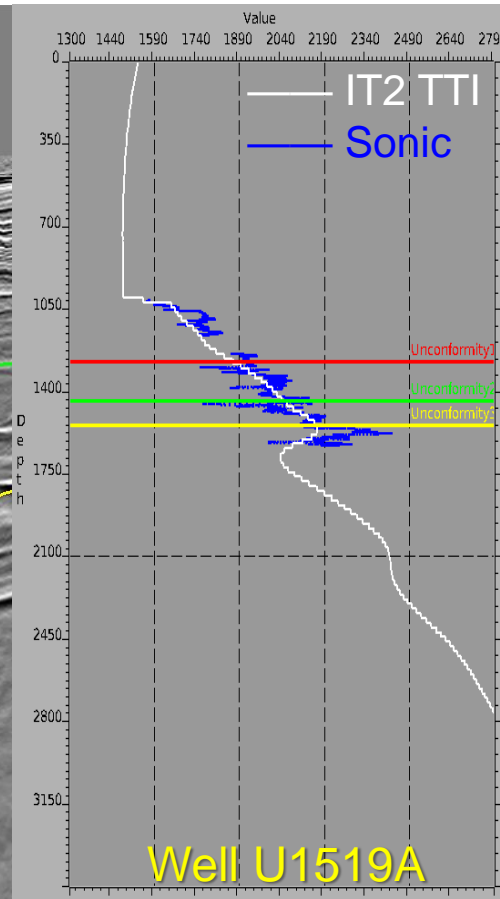
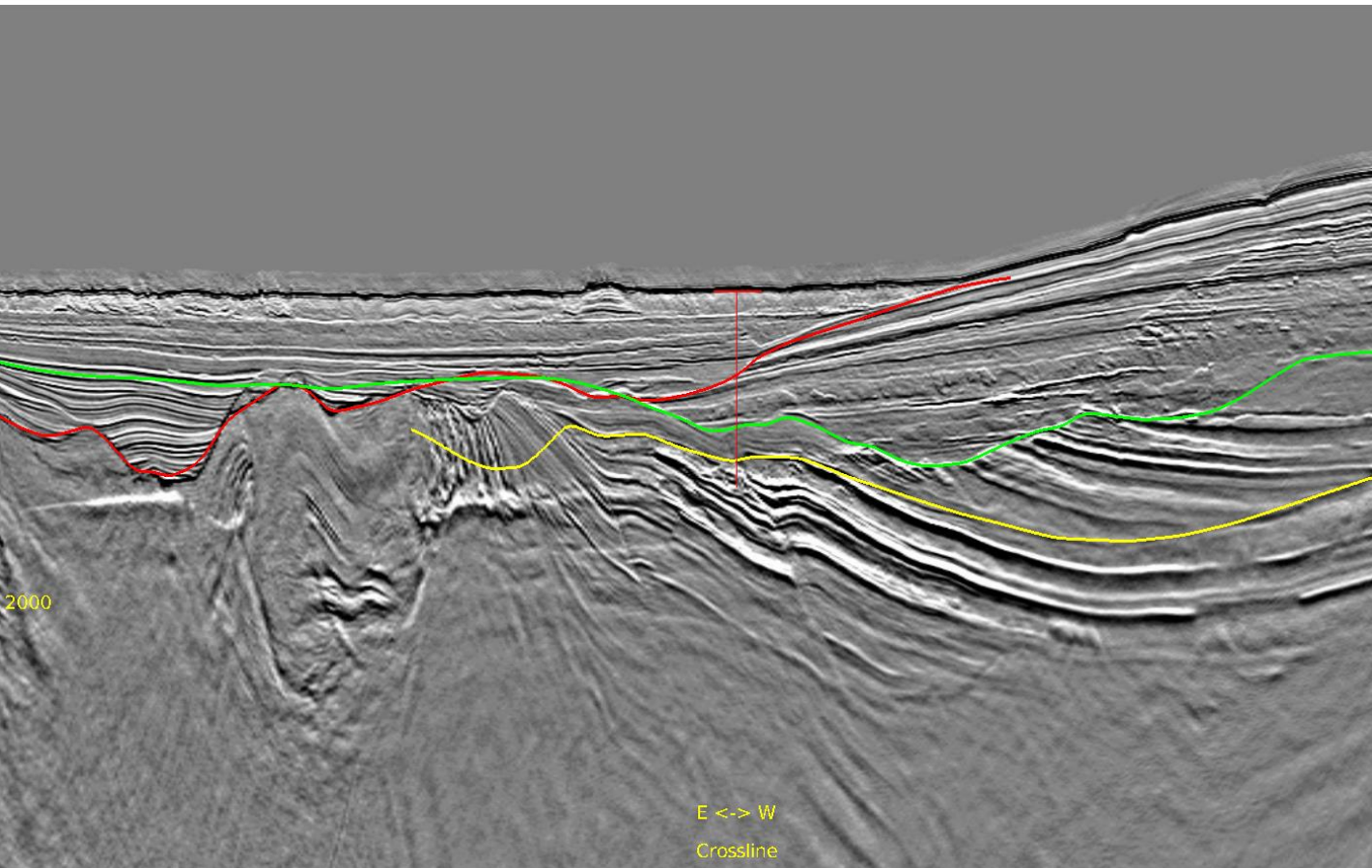


# Unconformity Surfaces



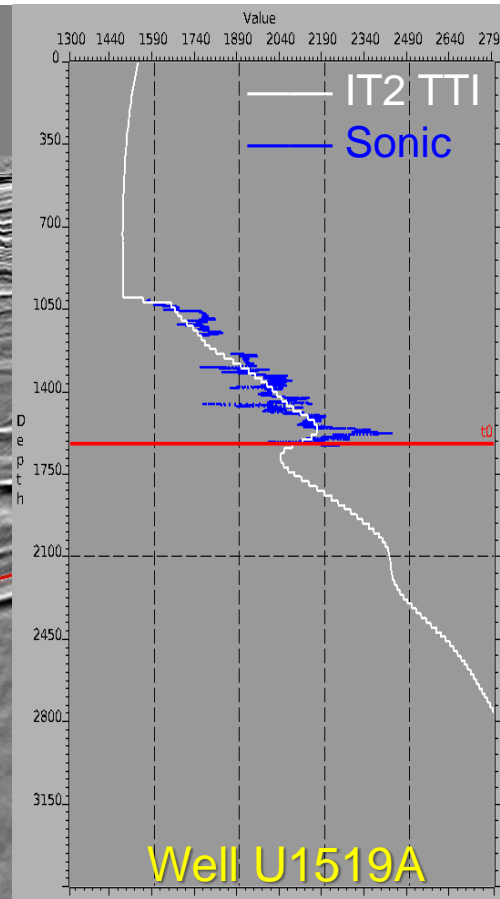
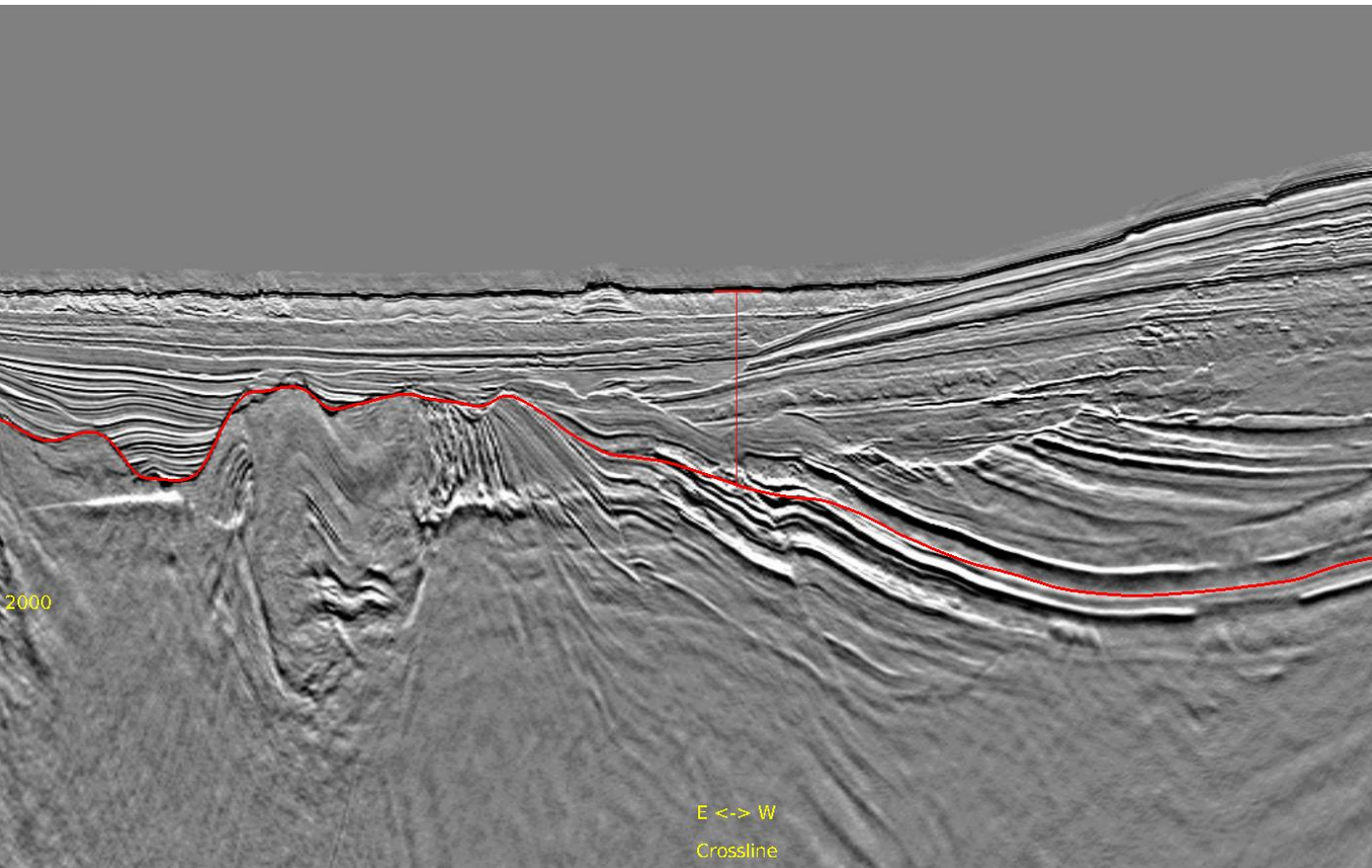
# Well U1519A Inline 501: UTIG Surfaces

27



# Well U1519A Inline 501: CGG Surface

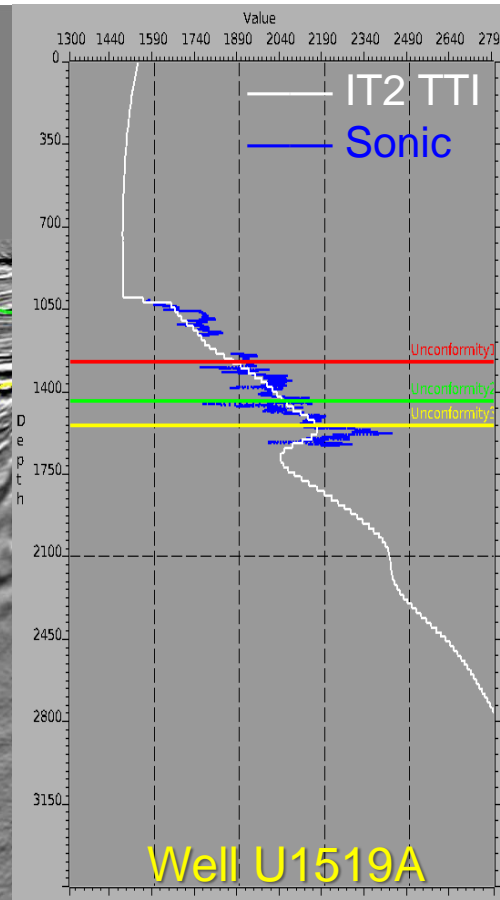
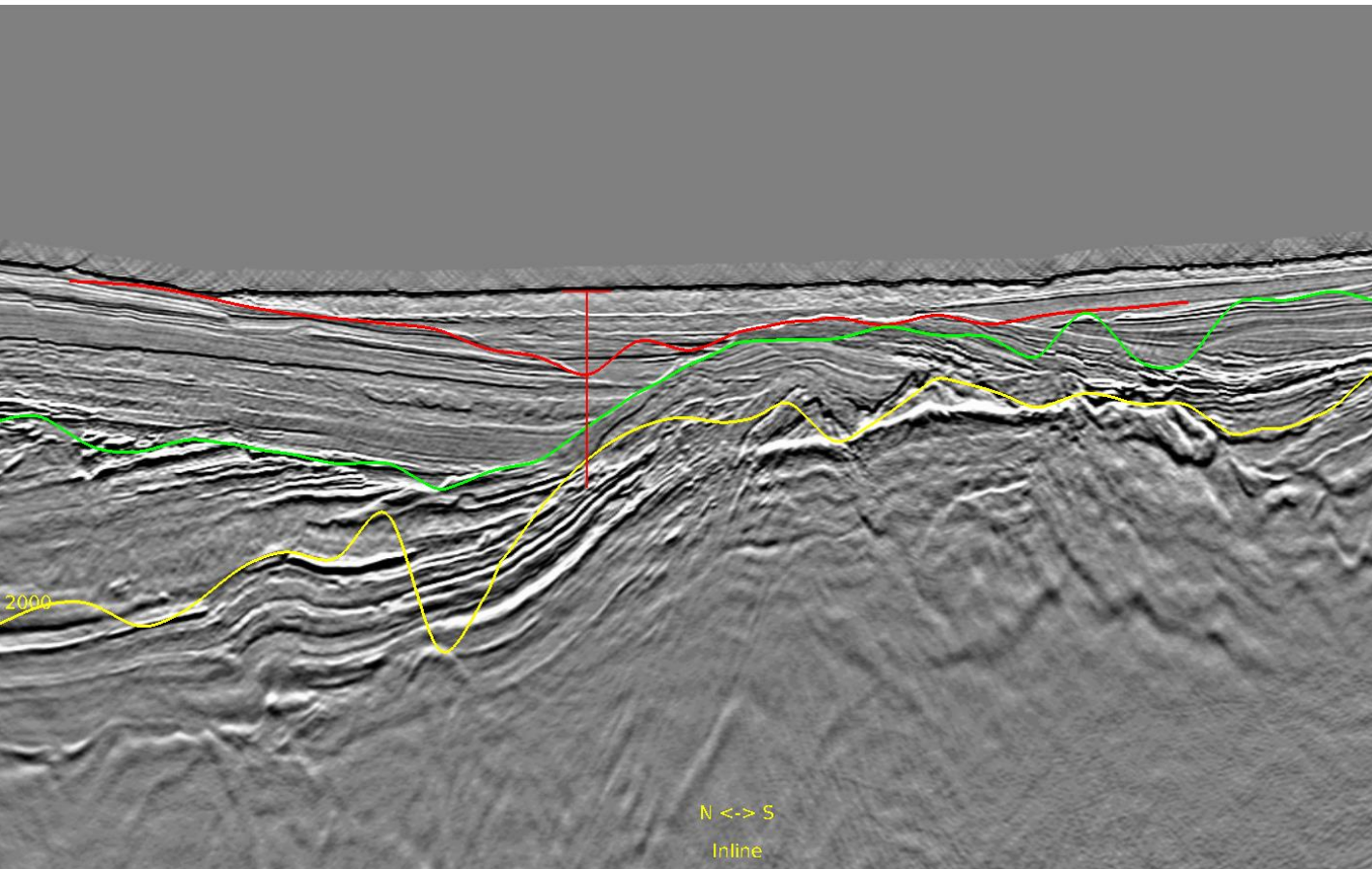
28





# Well U1519A Xline 4199: UTIG Surfaces

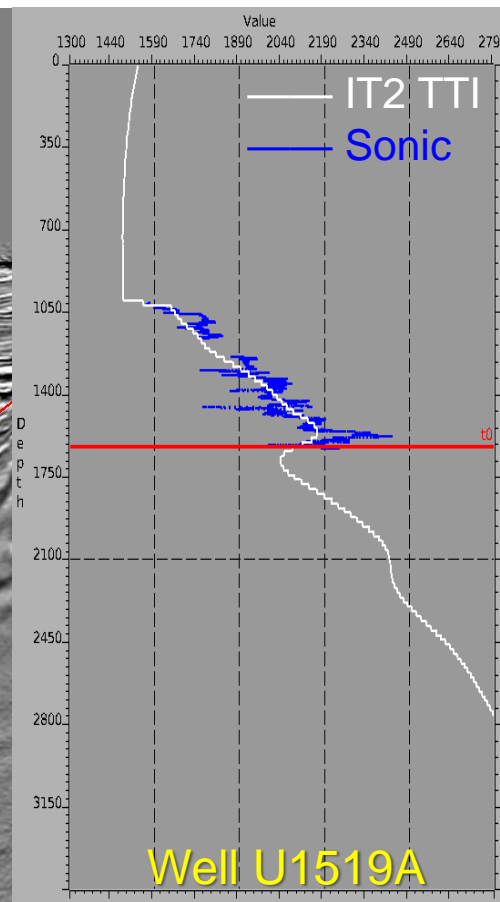
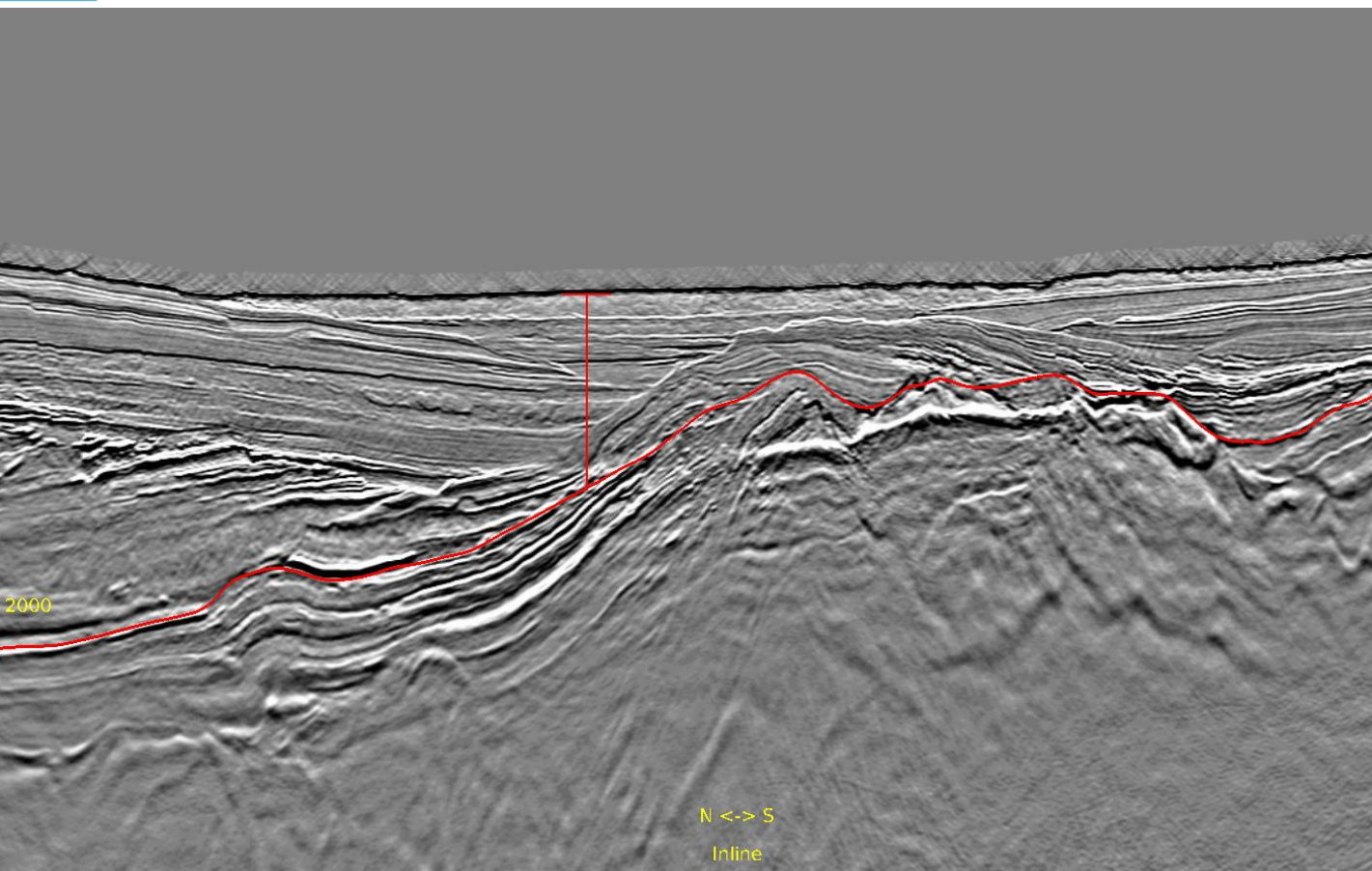
29

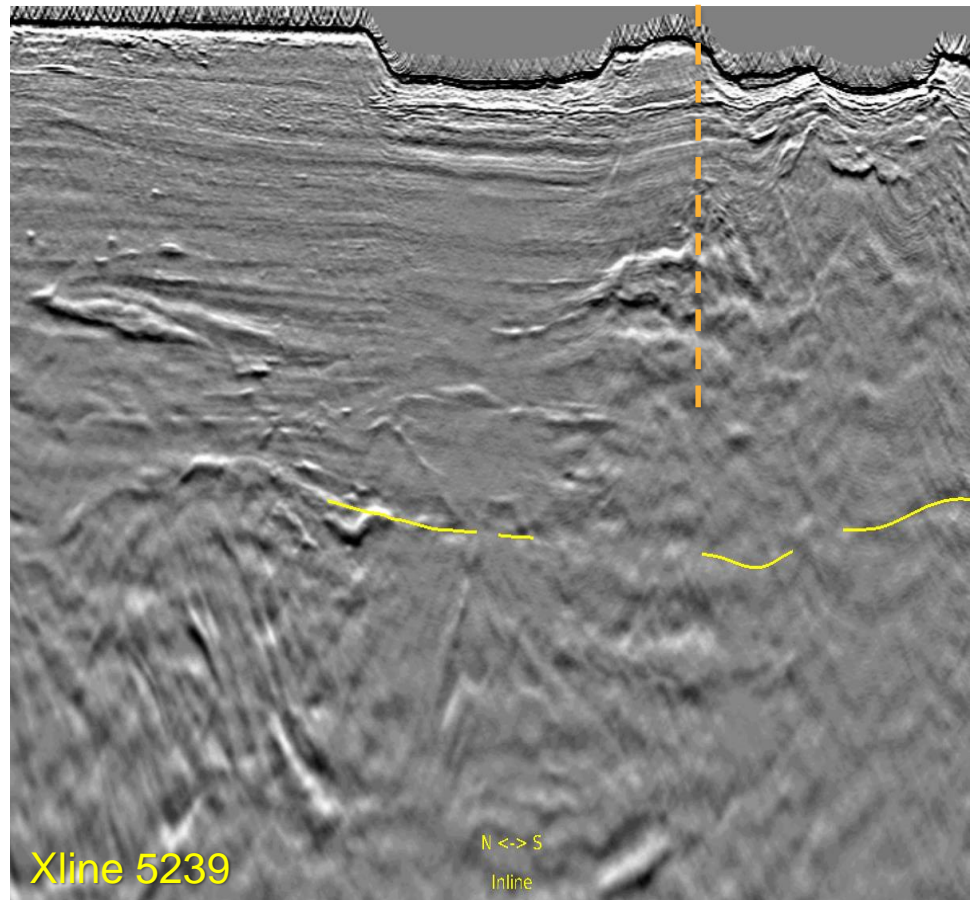
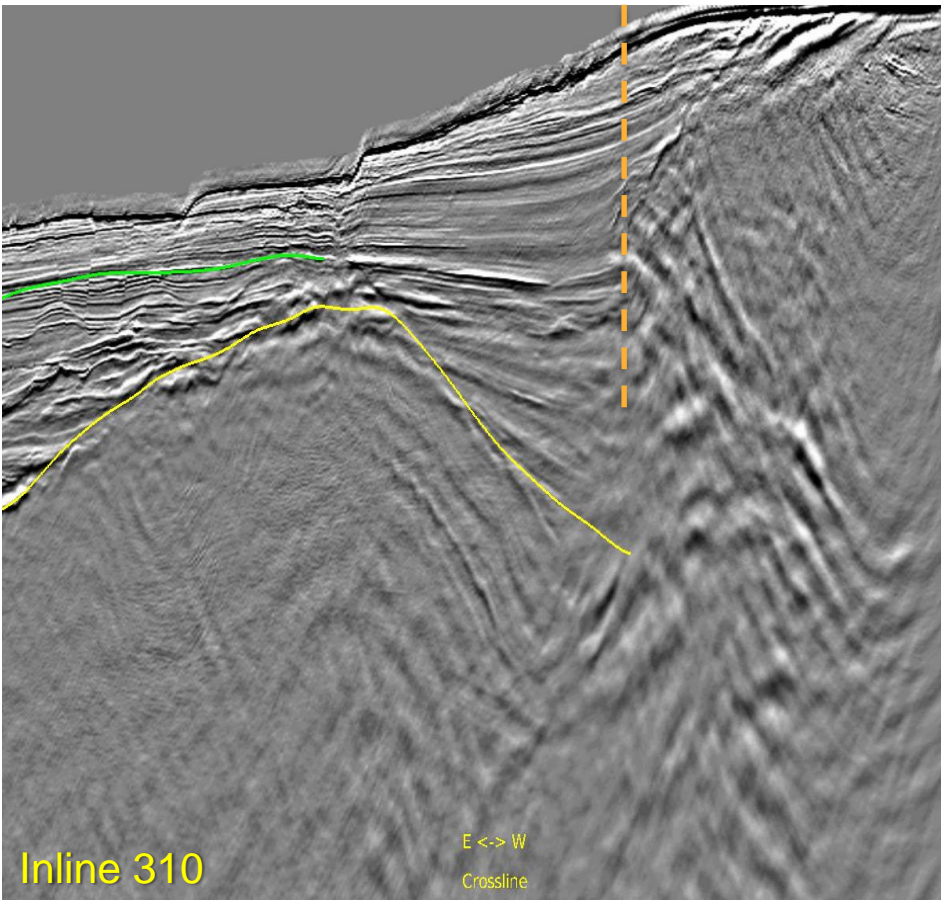




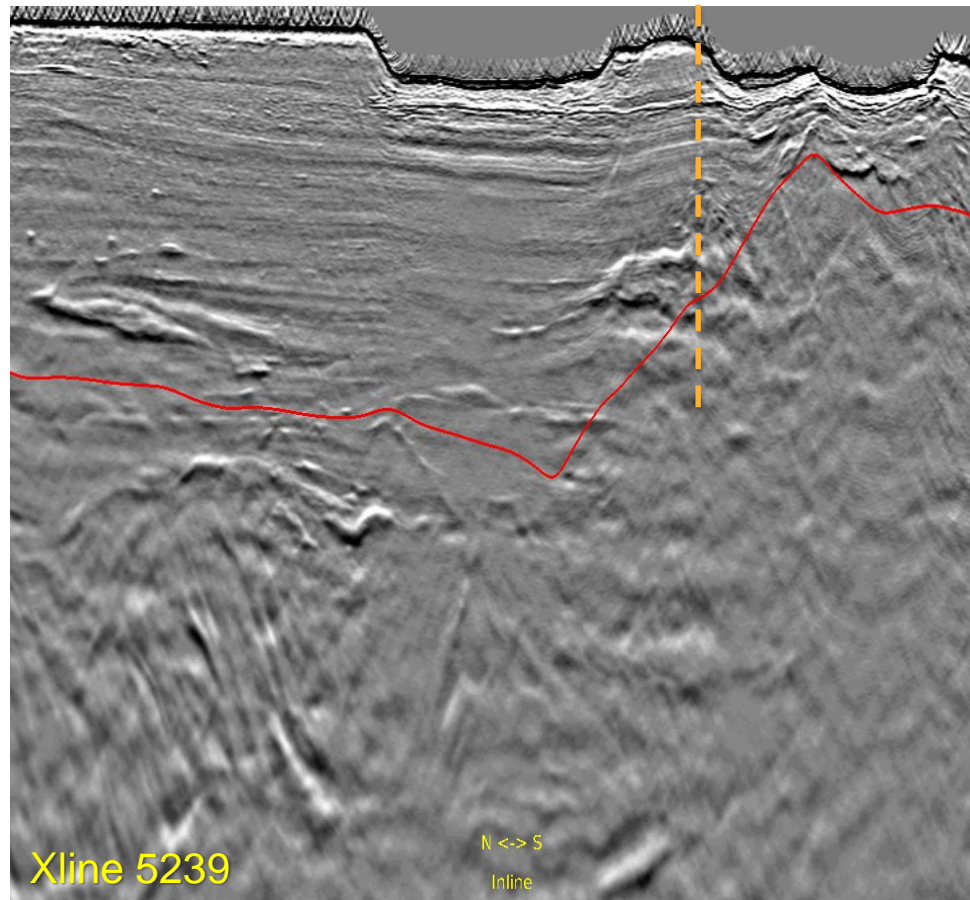
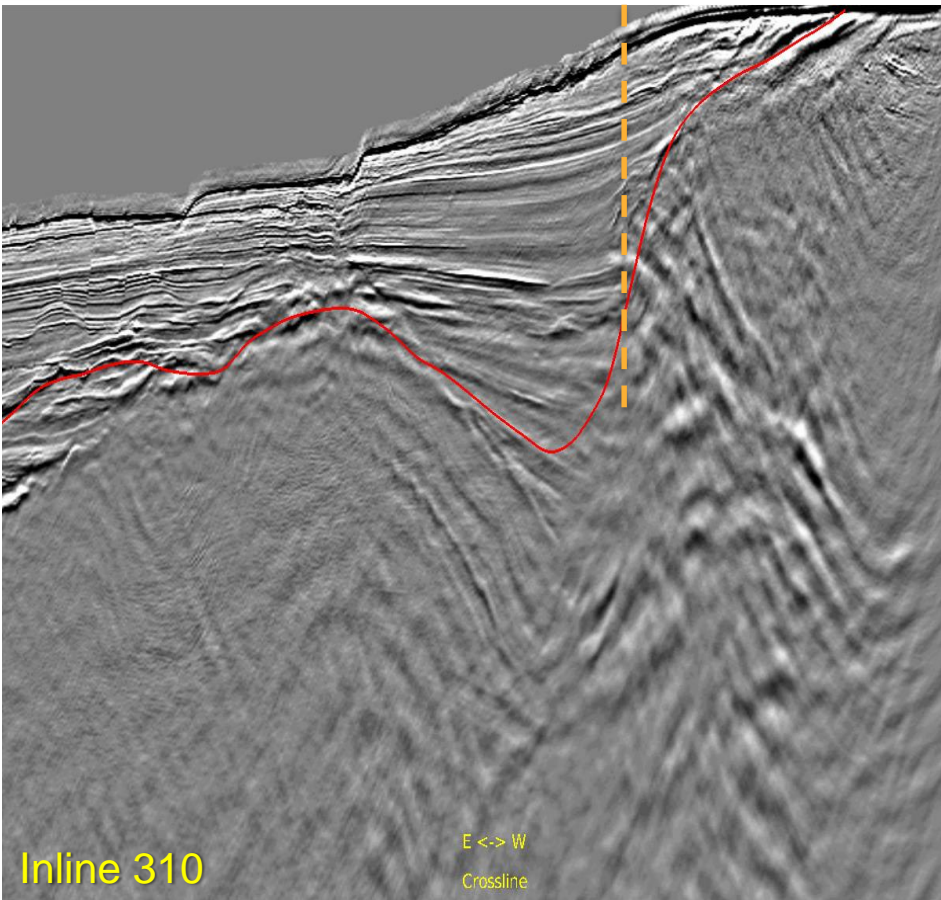
# Well U1519A Xline 4199: CGG Surface

30









- TTI conversion seems reasonable. And it's recommended to use one round of TTI tomography to fine tune the velocity, before TTI FWI.
- There's still a need to adjust unconformity surfaces to get more geological transition from 0% delta to 4% delta. This adjustment will not bring significant changes to the current result.



# IT2 – TTI Tomography

## NZ 3D Processing

*23 December 2020*

[cgg.com](http://cgg.com)



INSTITUTE FOR GEOPHYSICS



Passion for Geoscience



- **Objective:**

To adjust TTI velocity model for TTI FWI.

- **Procedure:**

We updated delta and epsilon base on the new unconformity surfaces. We further updated the velocity using TTI tomography (TOMO) to get better starting model for TTI FWI.

- **Display:**

Velocity models and migrated depth full stack & gathers.

- **Observation and Recommendation:**

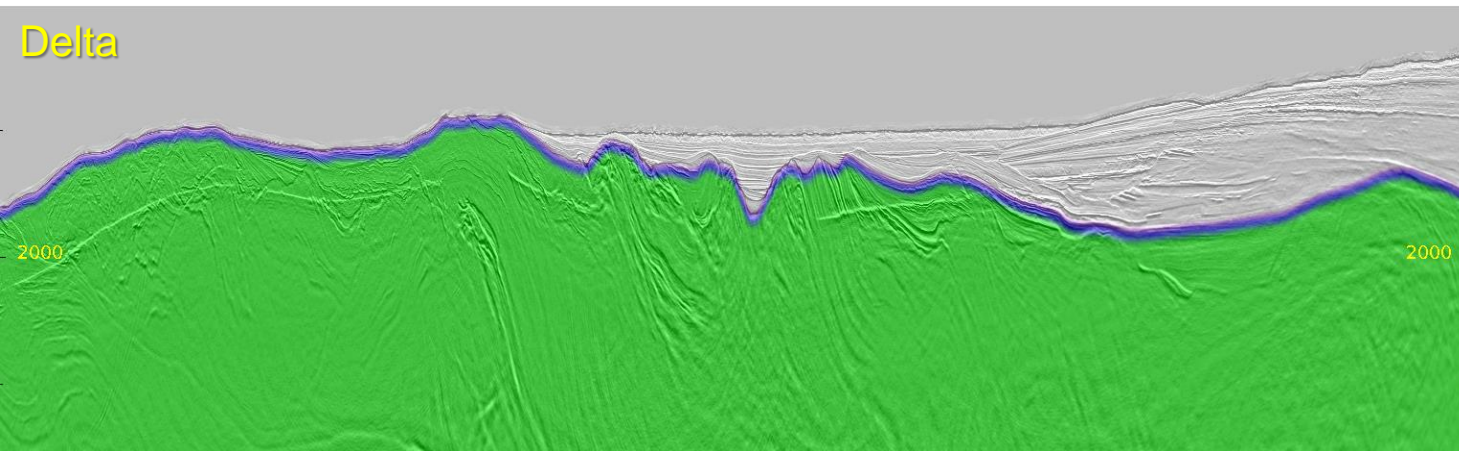
The TTI tomography reasonably improves the gather flatness and event focus on stack. We recommend to move on to TTI FWI.

# Velocity Models

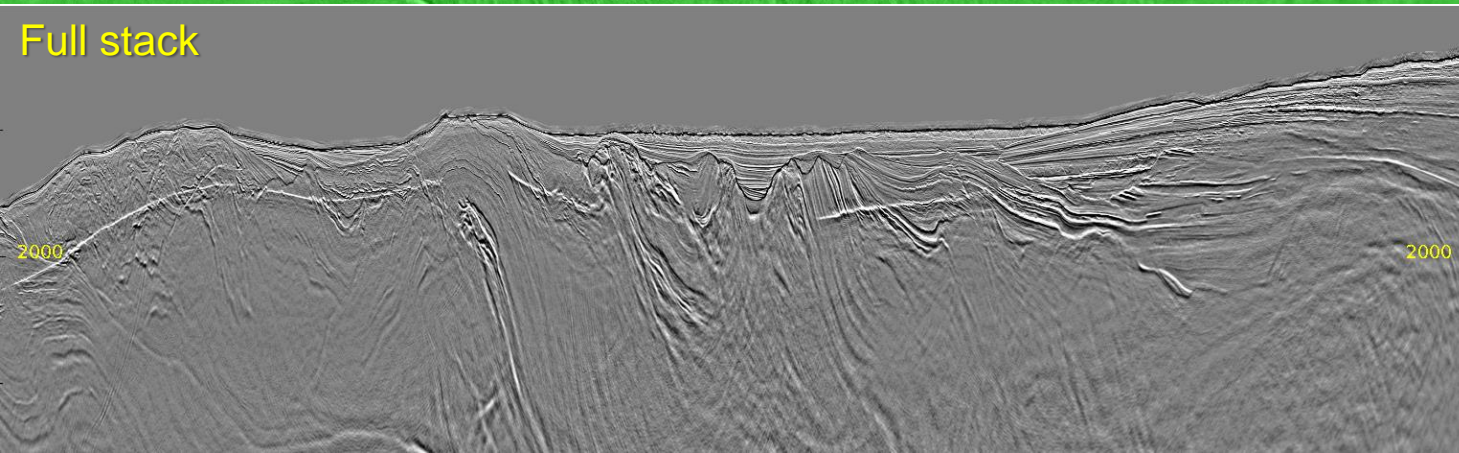


# Inline 436: IT2 TTI Stack with Old Delta & Epsilon

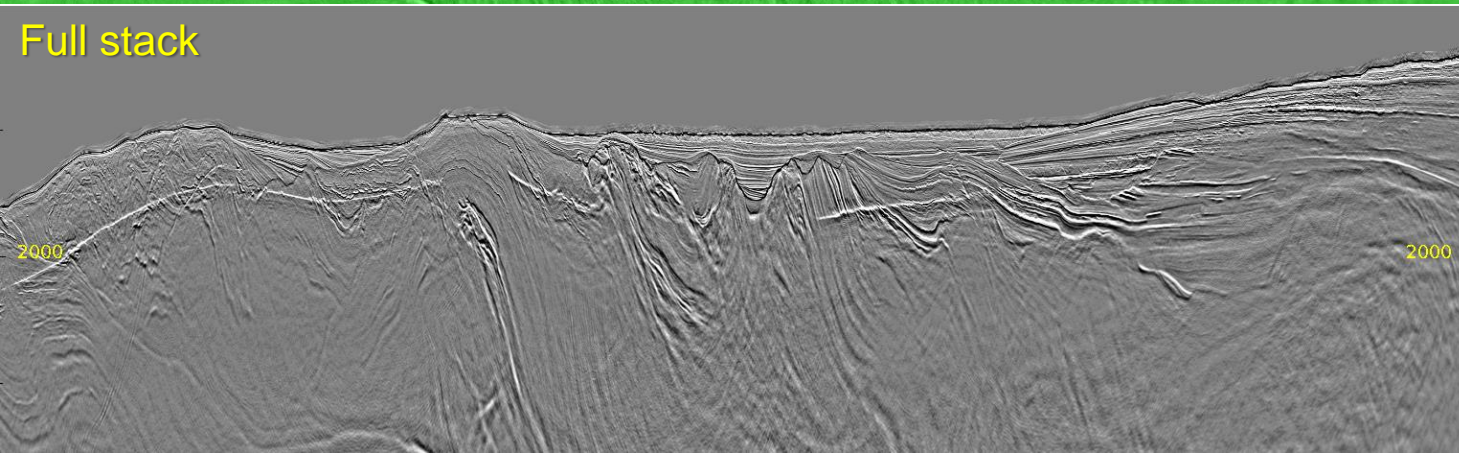
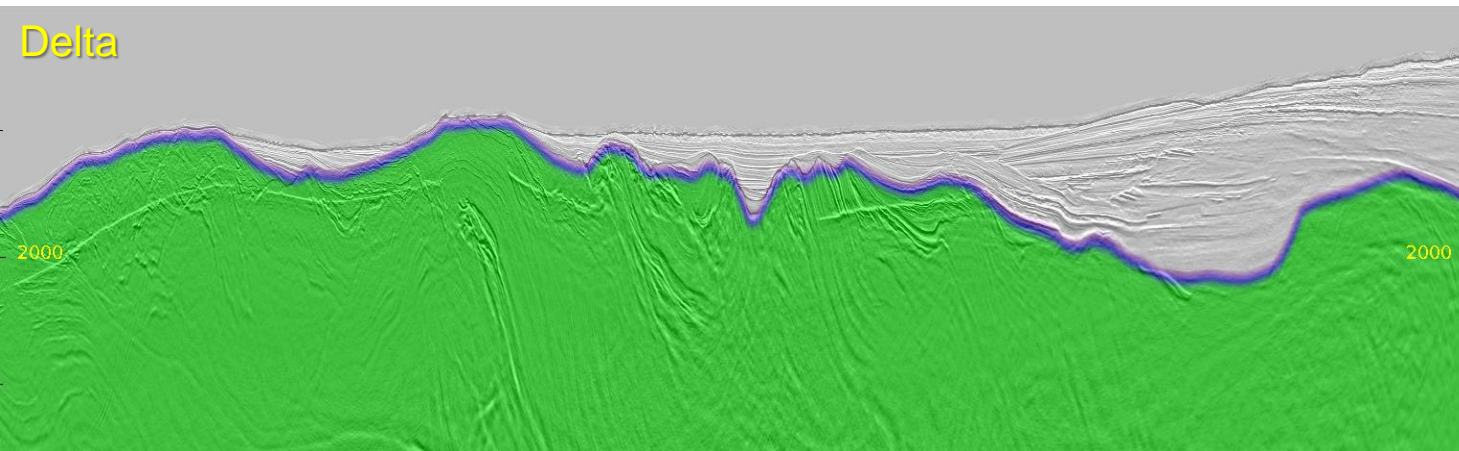
4



- Old delta and corresponding seismic.





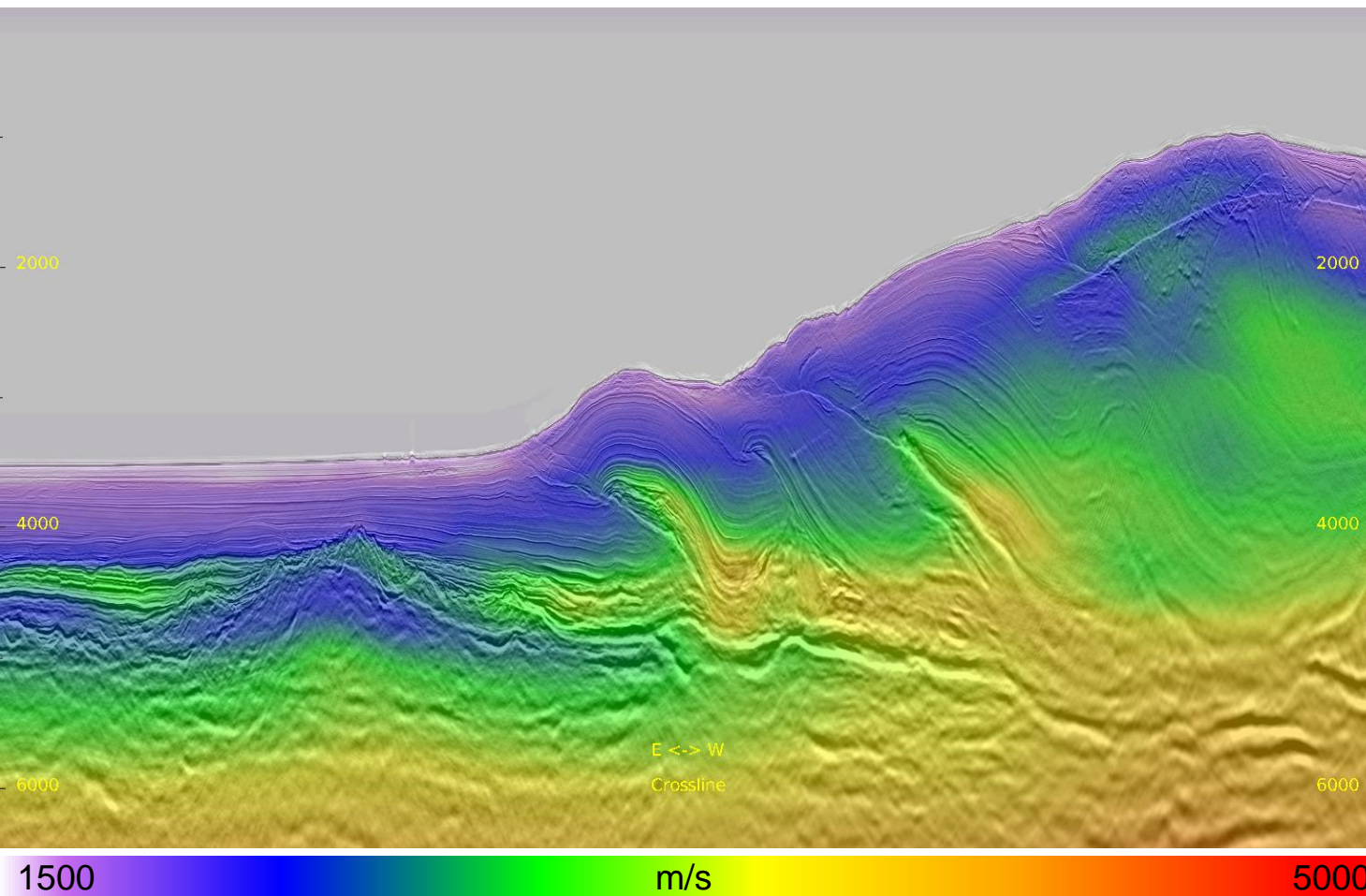


- New data and corresponding seismic.
- The change of delta causes minor shift on the seismic, due to corresponding velocity change.



# Inline 436 East: IT2 TTI Velocity before Tomography

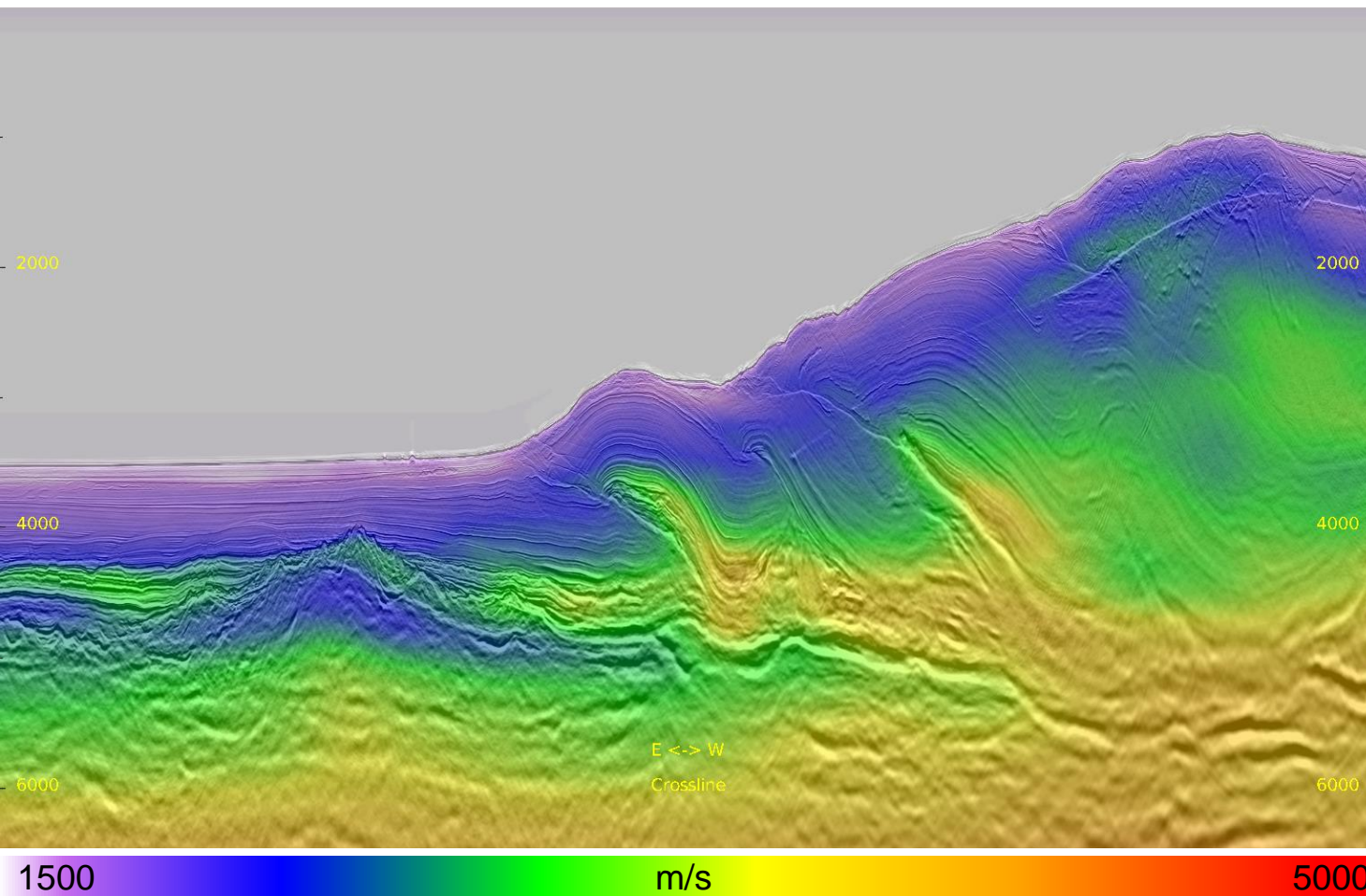
6



- IT2 converted TTI velocity with new delta and epsilon.

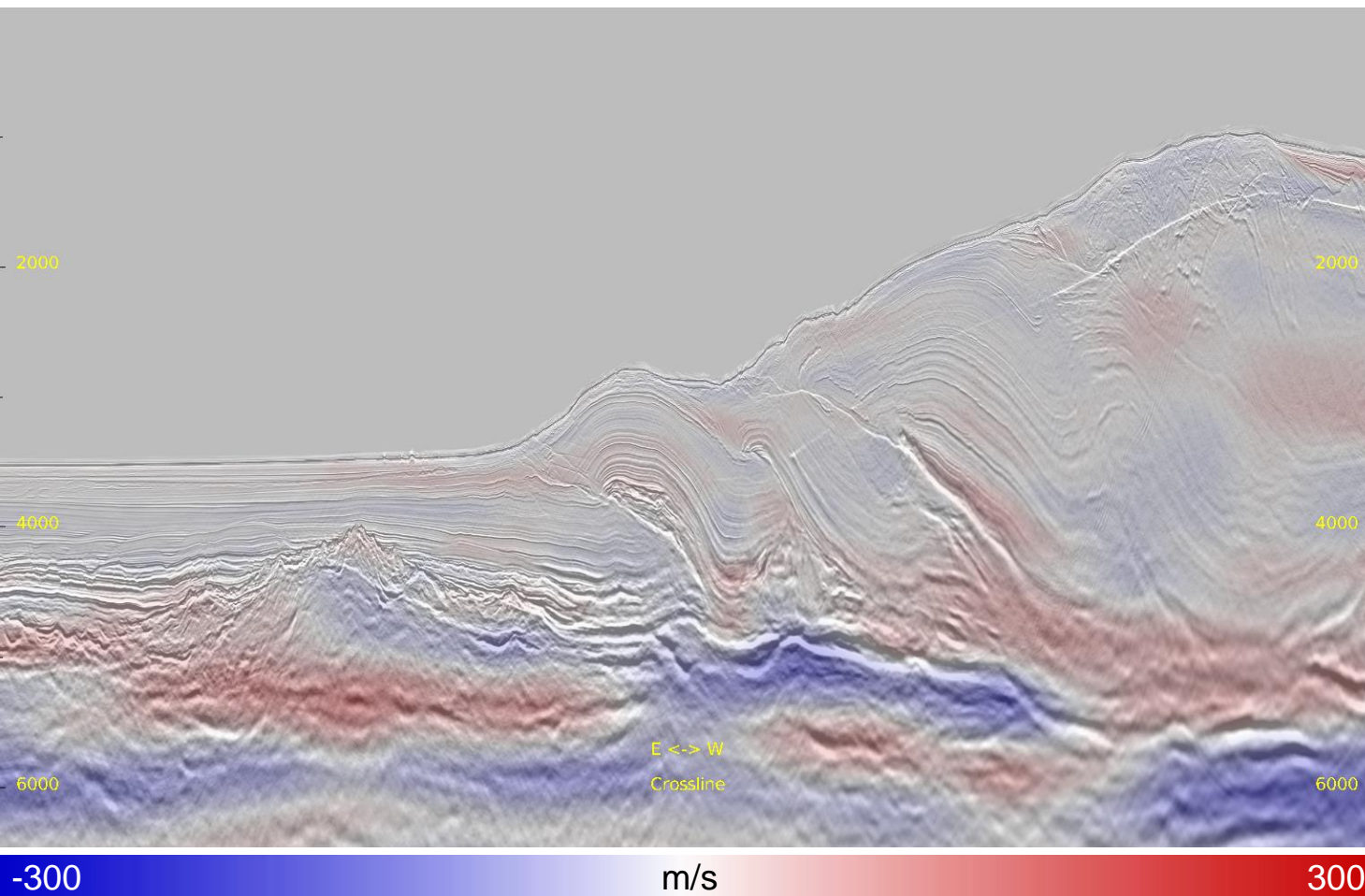
# Inline 436 East: IT2 TTI Velocity **after** Tomography

7



- IT2 tomographic TTI velocity with new delta and epsilon.



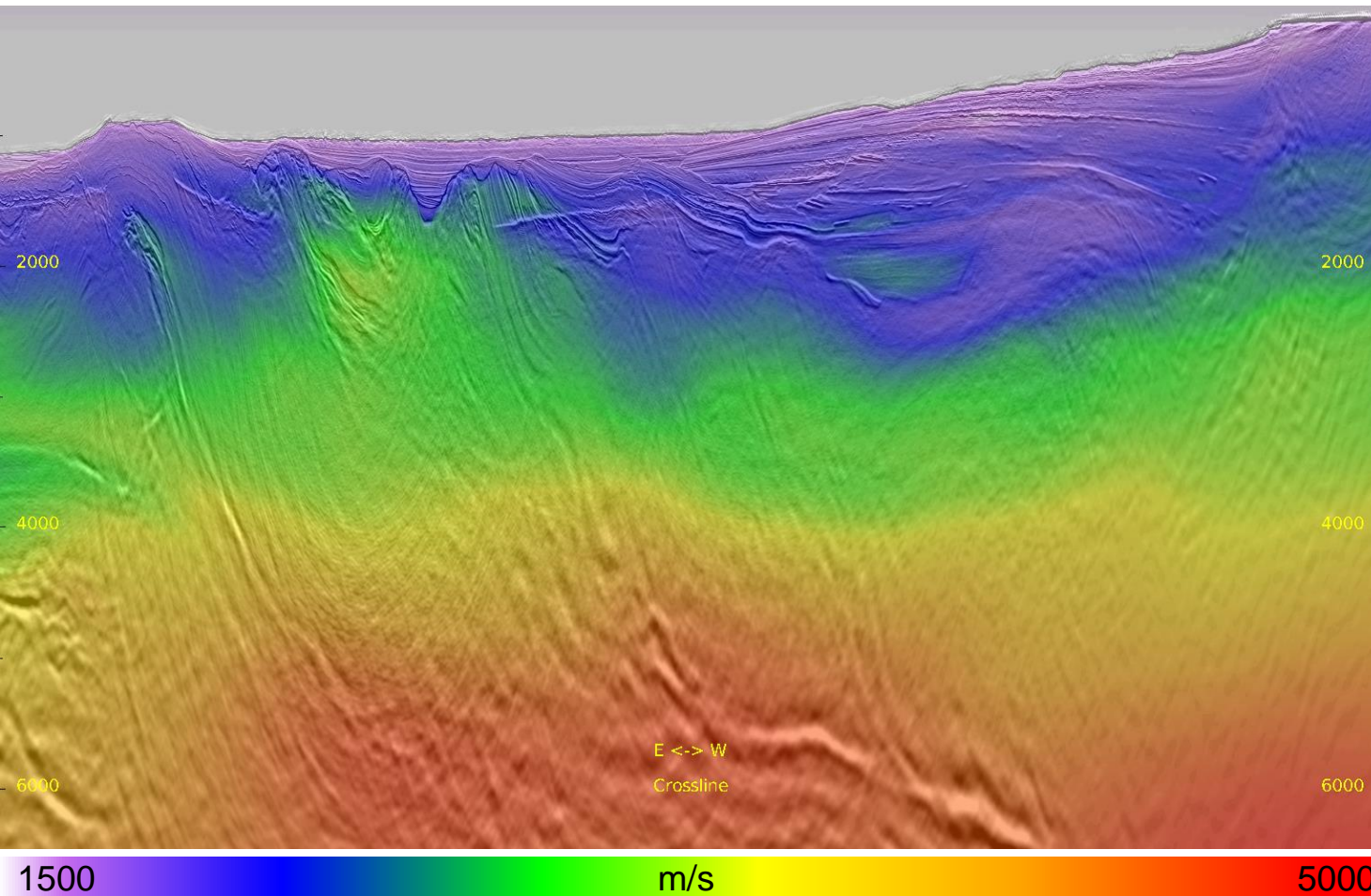


- Starting from a better velocity, IT2 TTI tomography gives smaller perturbation compared to IT1 ISO tomography.

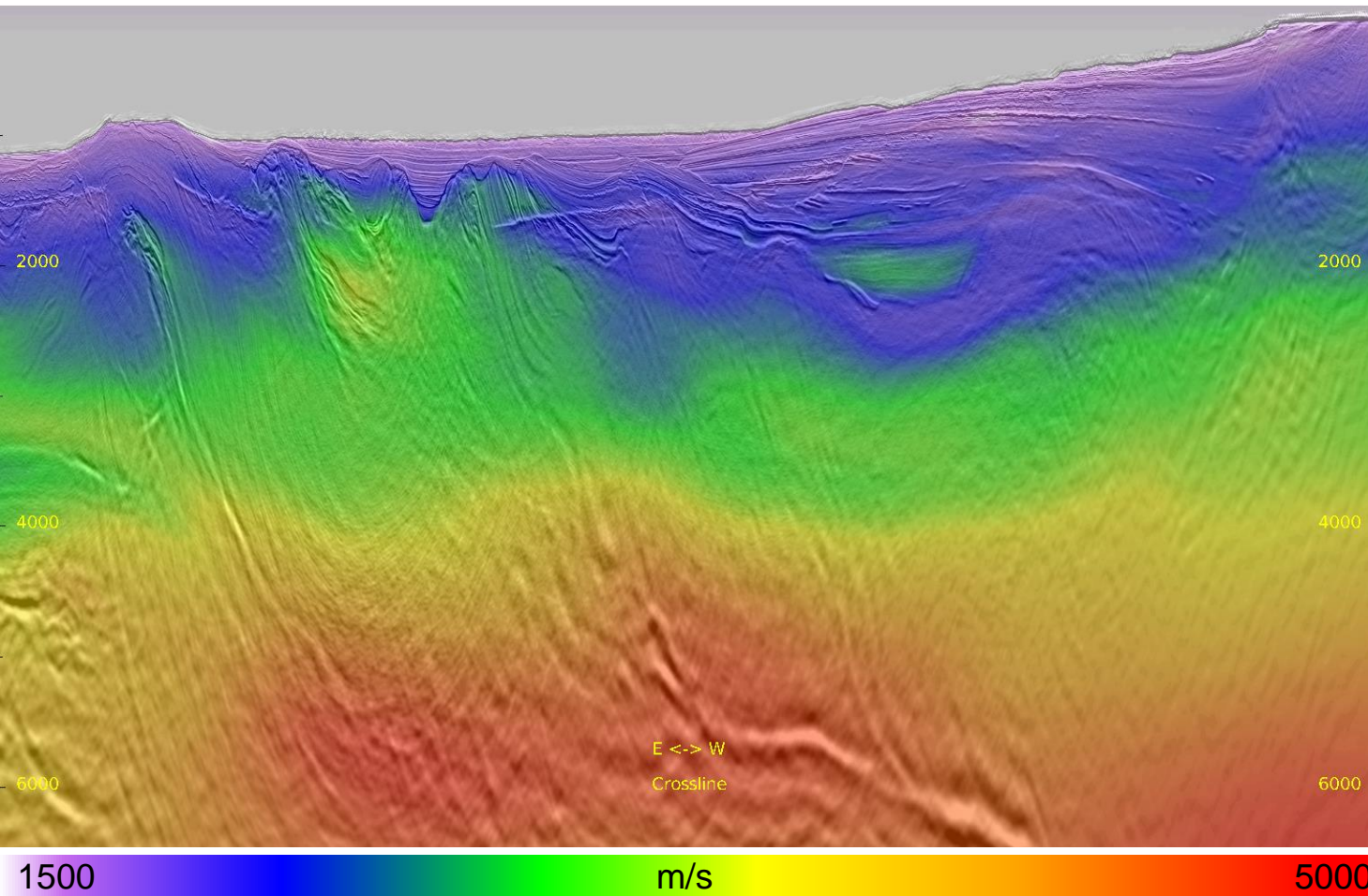


# Inline 436 West: IT2 TTI Velocity before Tomography

9

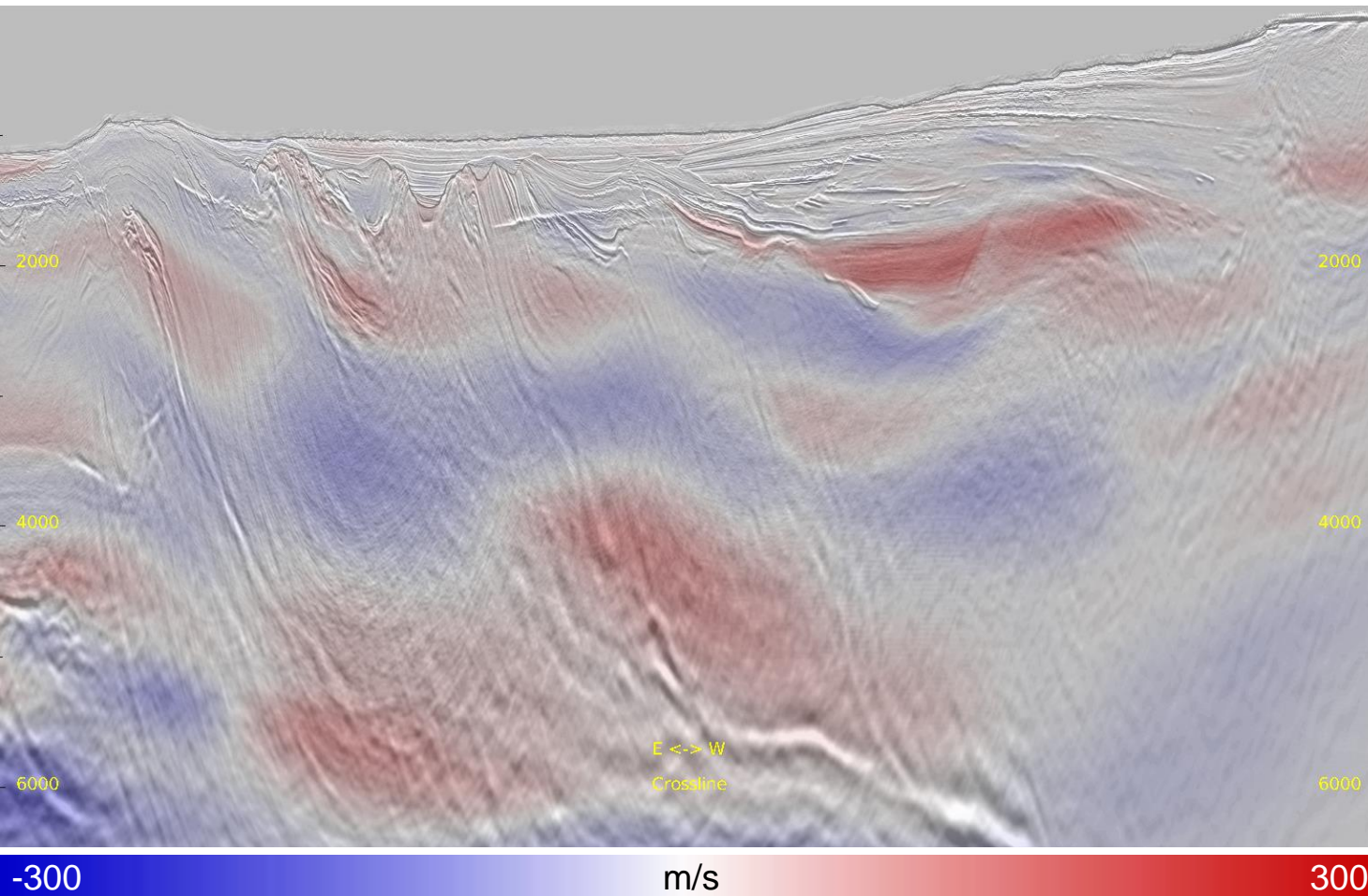


- IT2 converted TTI velocity with new delta and epsilon.



- IT2 tomographic TTI velocity with new delta and epsilon.





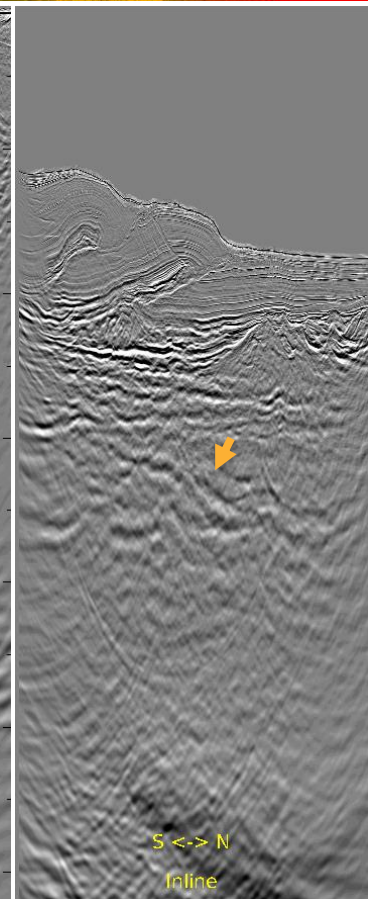
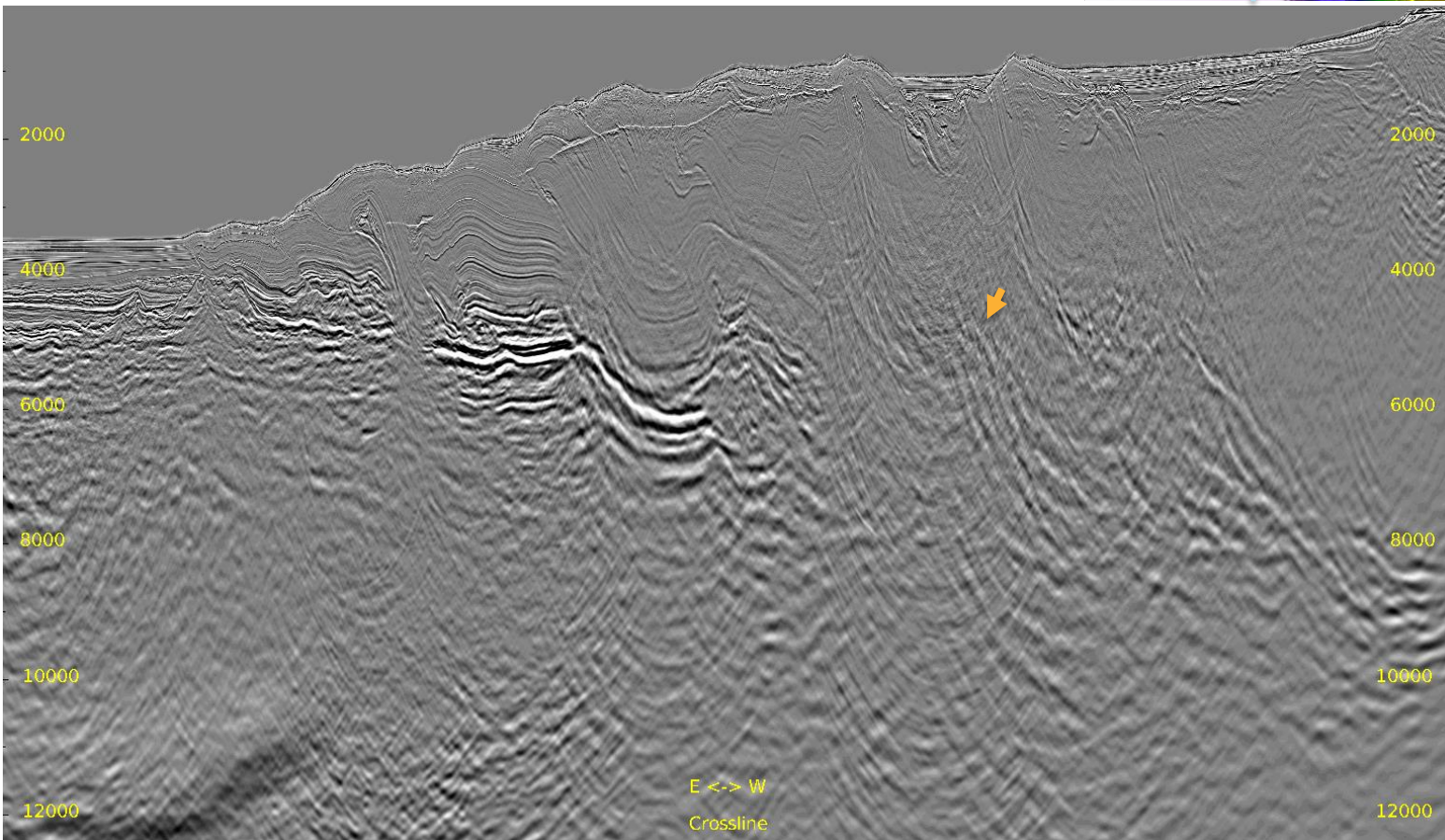
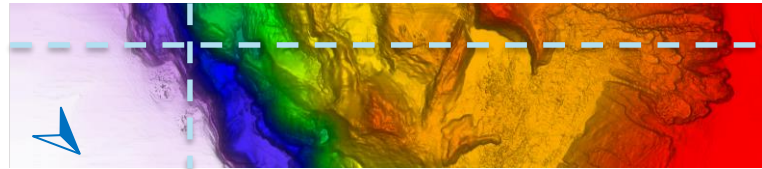
- Starting from a better velocity, IT2 TTI tomography gives smaller perturbation compared to IT1 ISO tomography.

# Kirchhoff Depth Migration



# Full Stack: before TTI TOMO

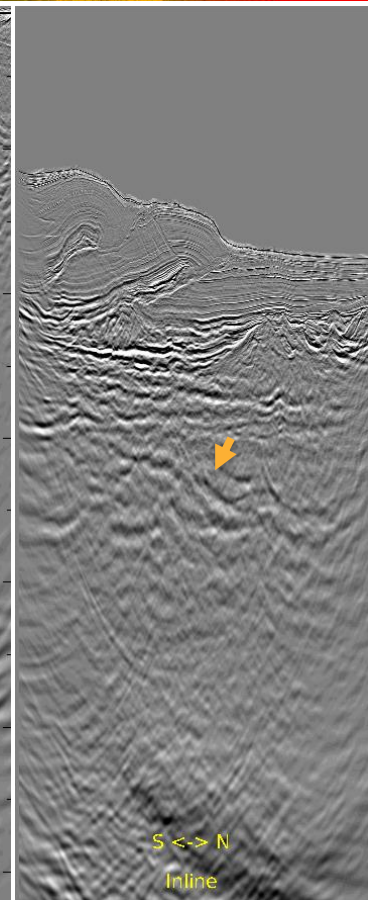
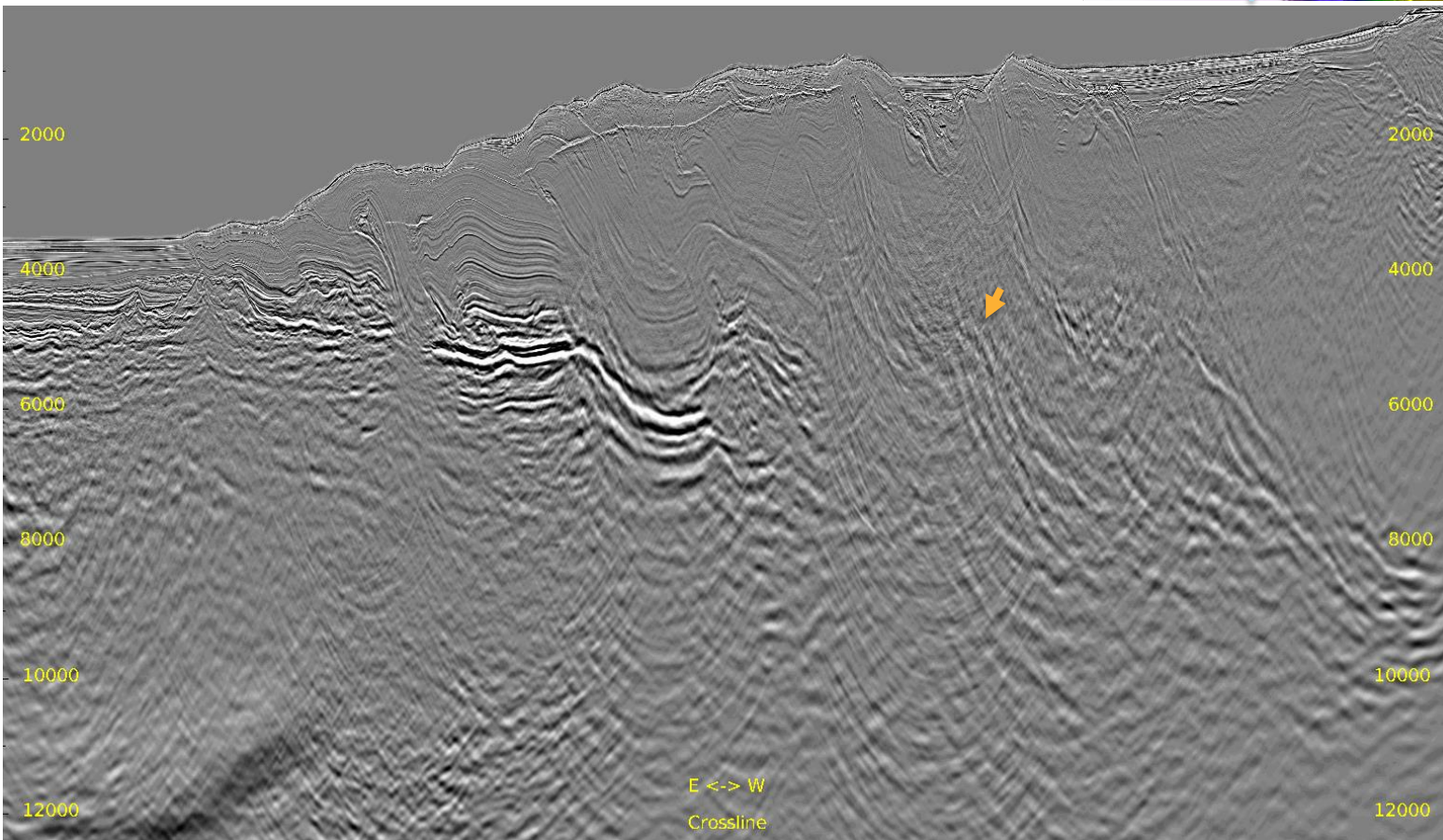
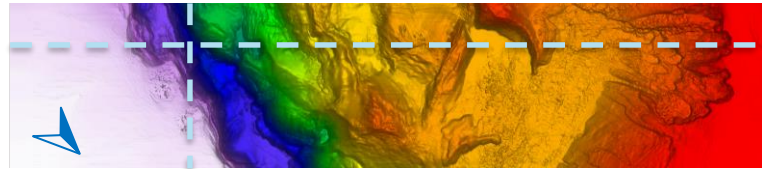
Inline 236 & Crossline 1540





# Full Stack: after TTI TOMO

Inline 236 & Crossline 1540



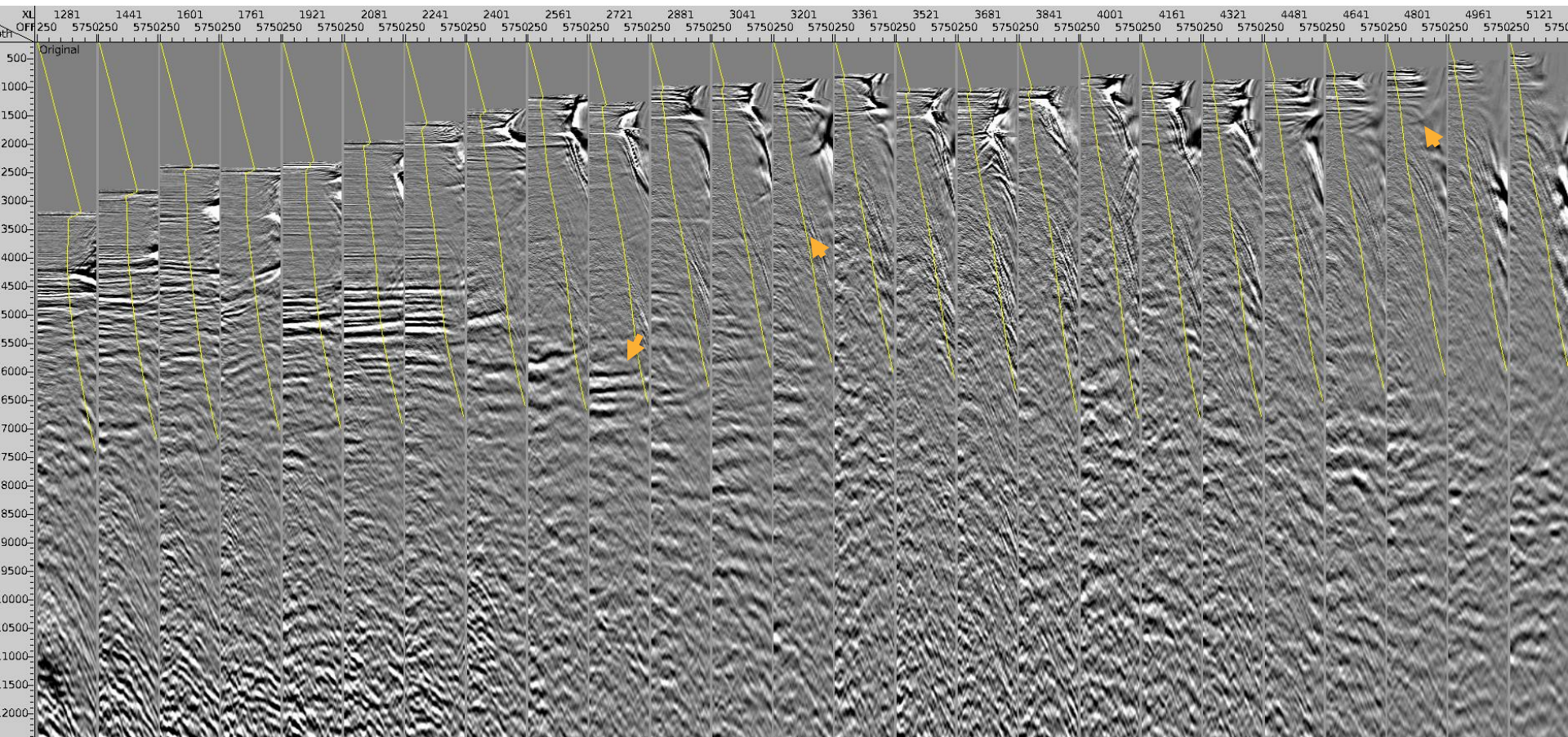




# Inline 236 CDP Gathers: before TTI TOMO

— 35° Mute

15



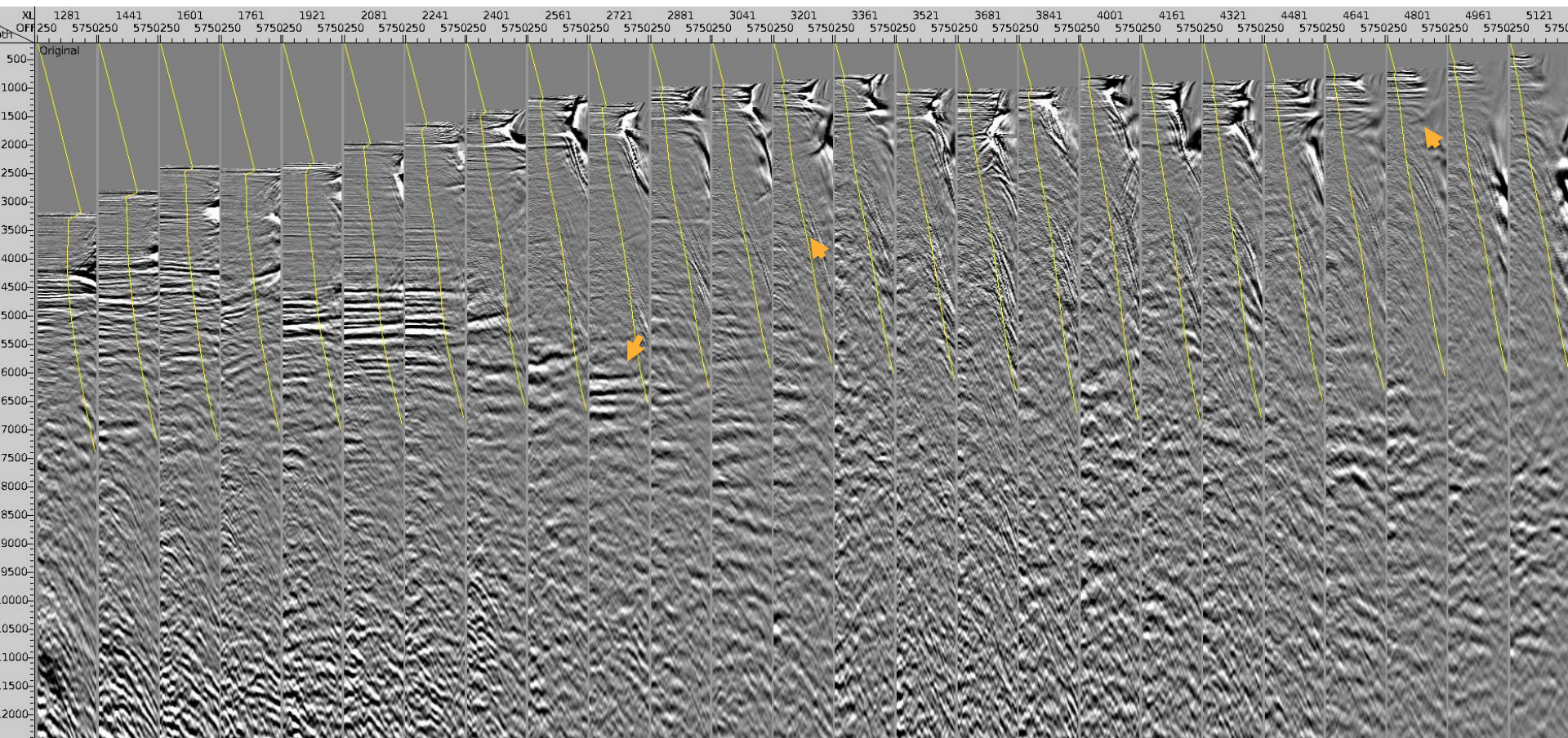




# Inline 236 CDP Gathers: **after** TTI TOMO

— 35° Mute

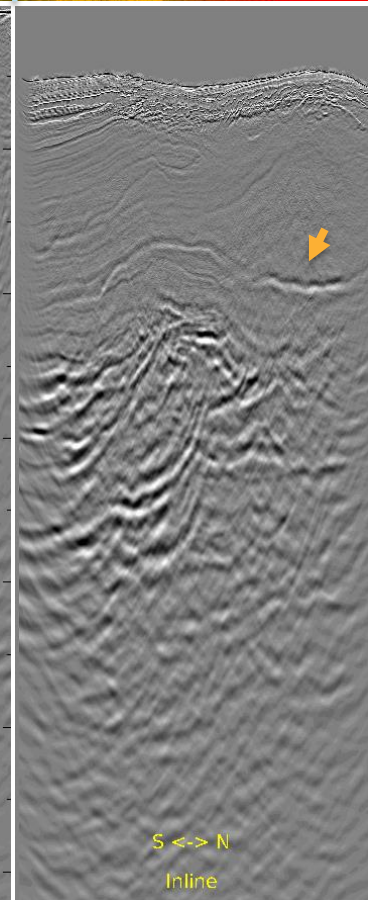
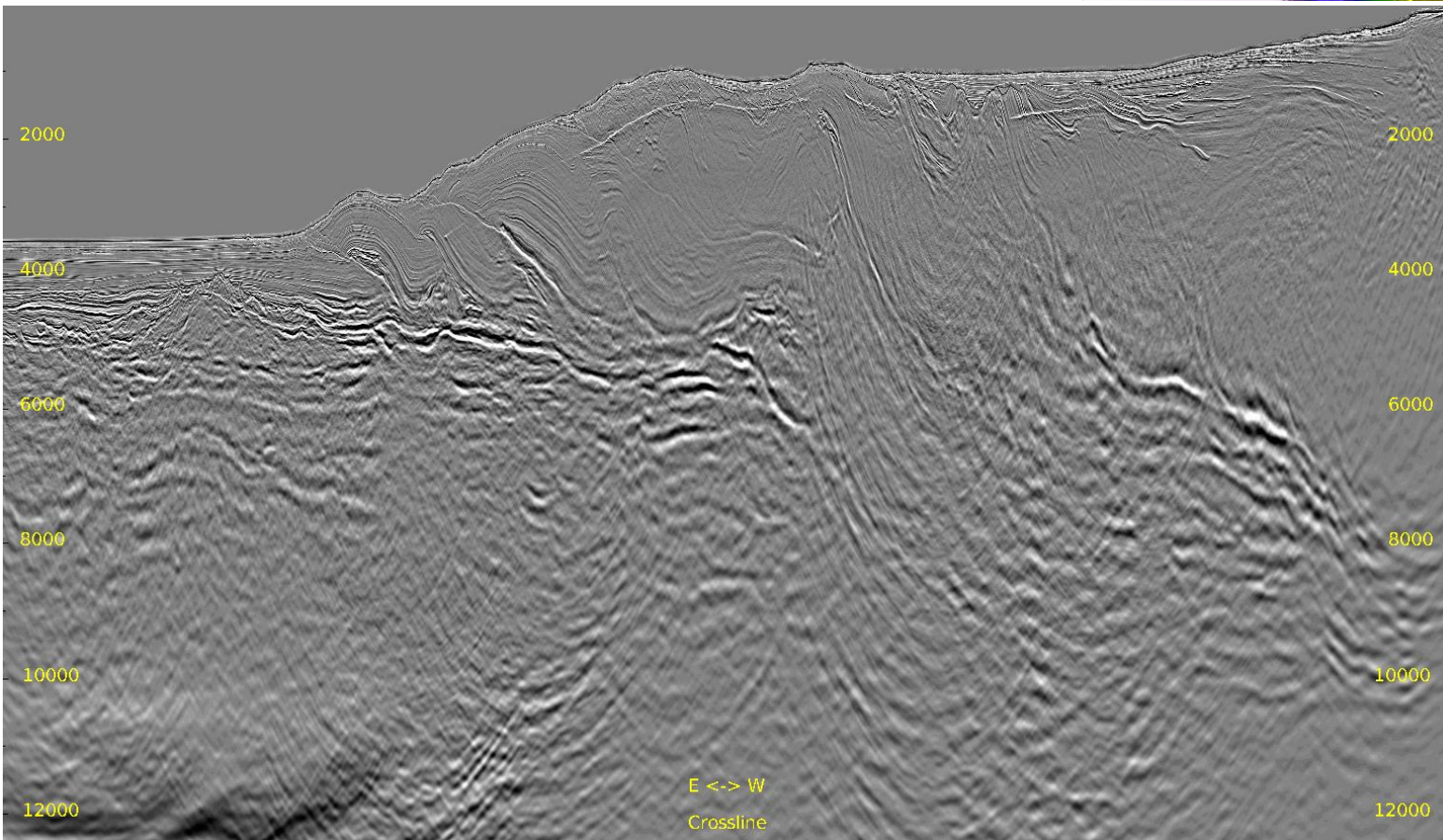
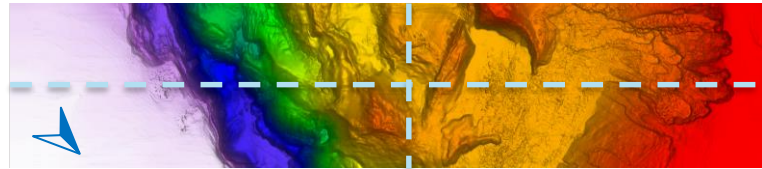
16





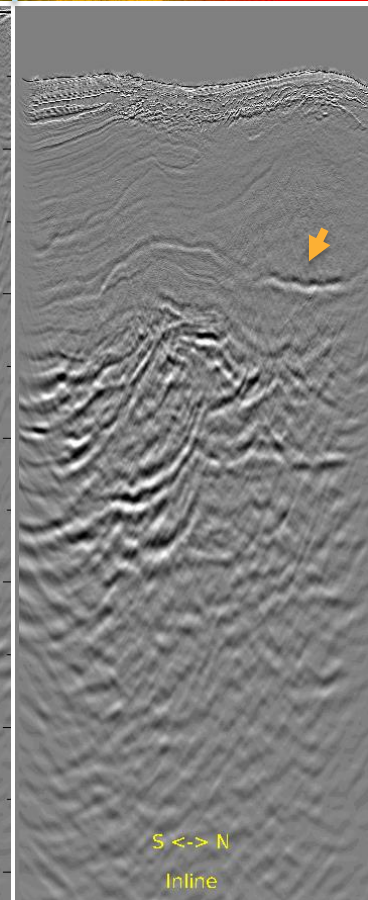
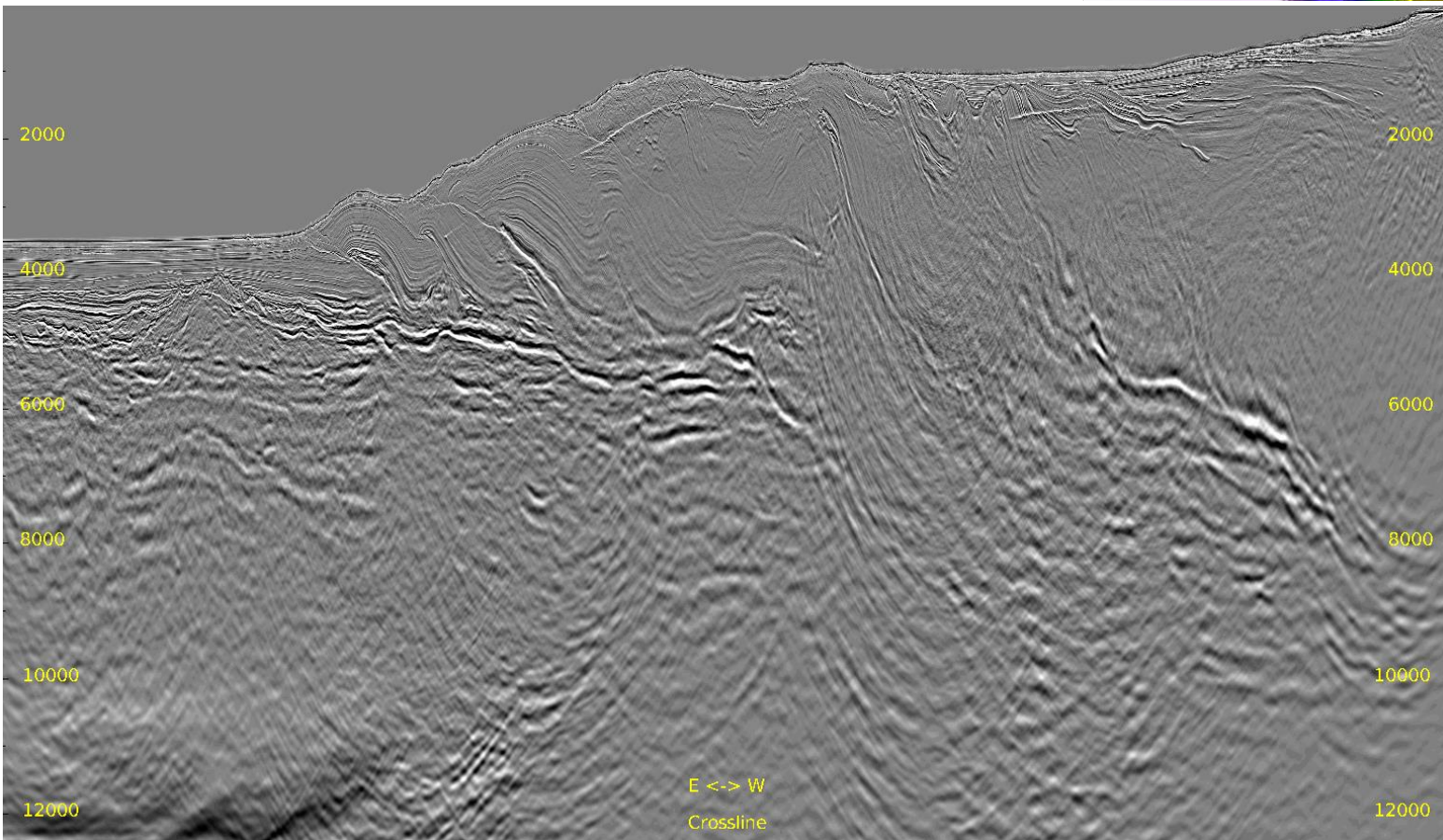
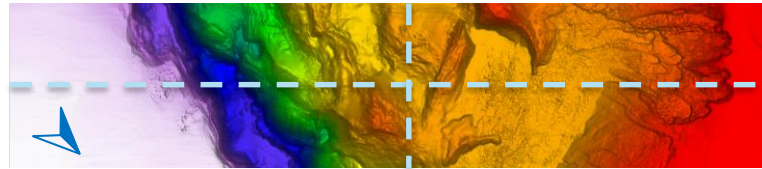
# Full Stack: before TTI TOMO

Inline 436 & Crossline 3040



# Full Stack: after TTI TOMO

Inline 436 & Crossline 3040







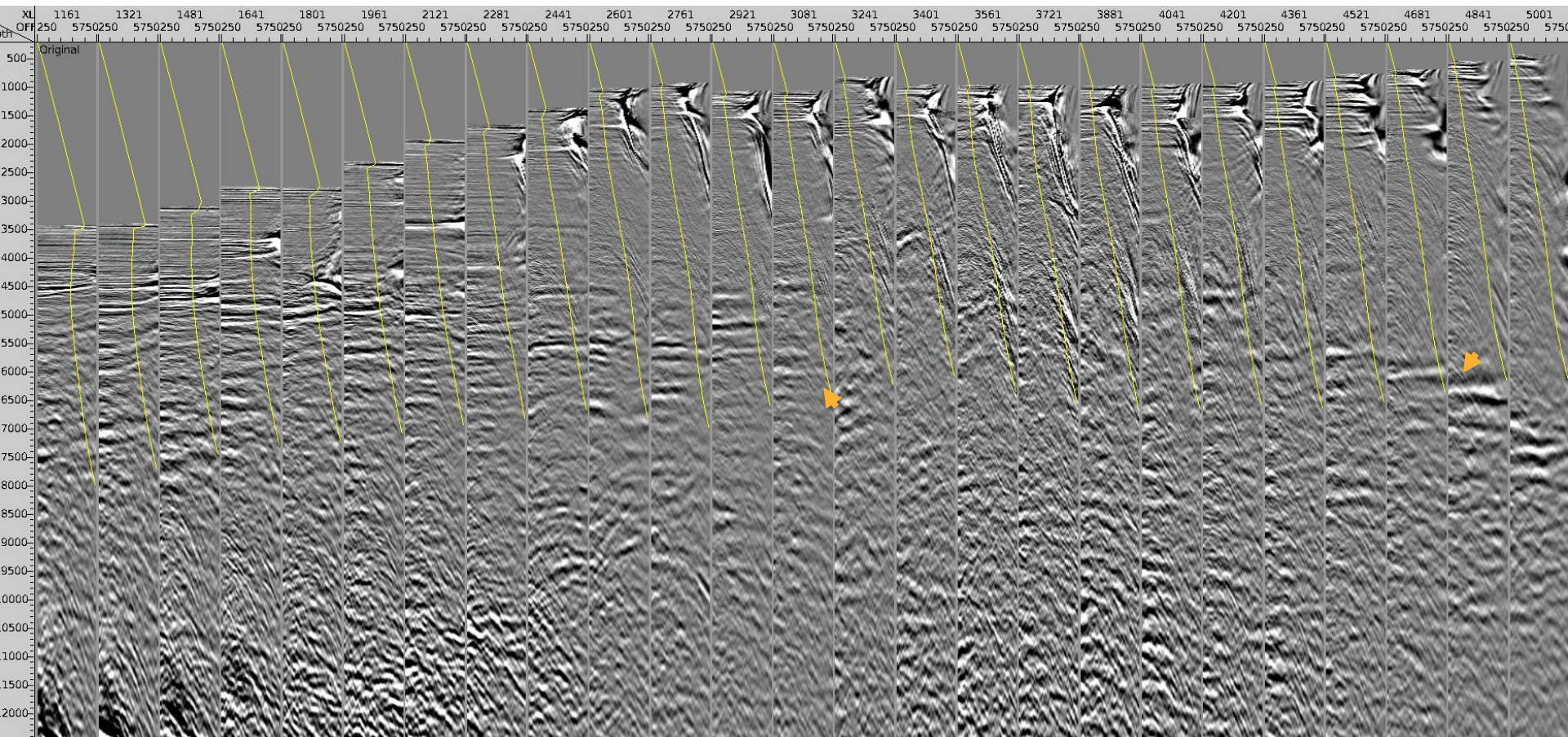




# Inline 436 CDP Gathers: **after** TTI TOMO

— 35° Mute

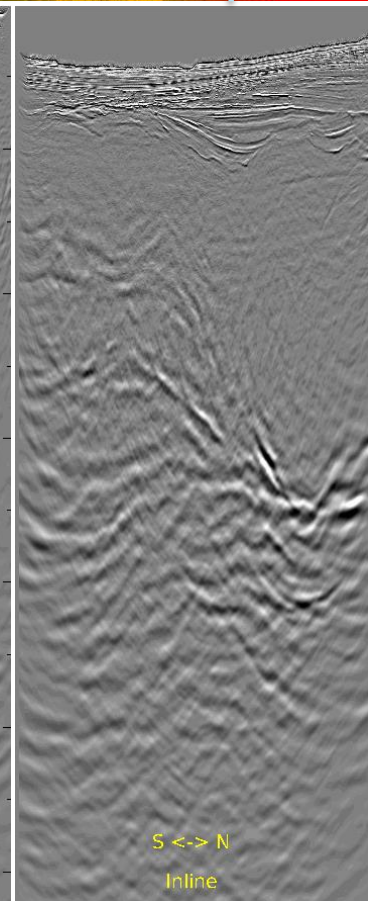
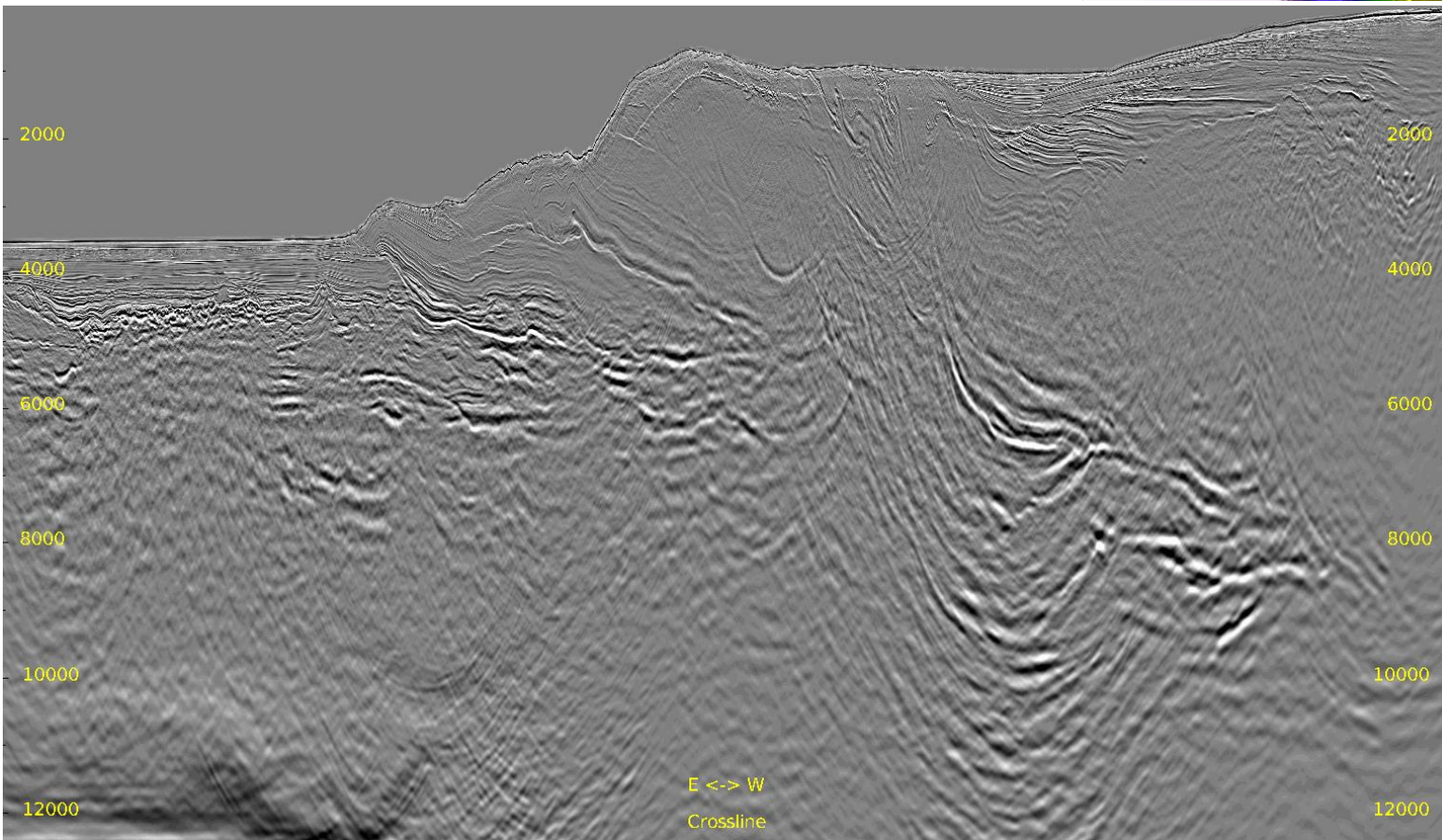
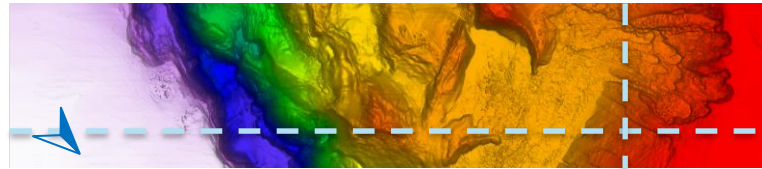
20





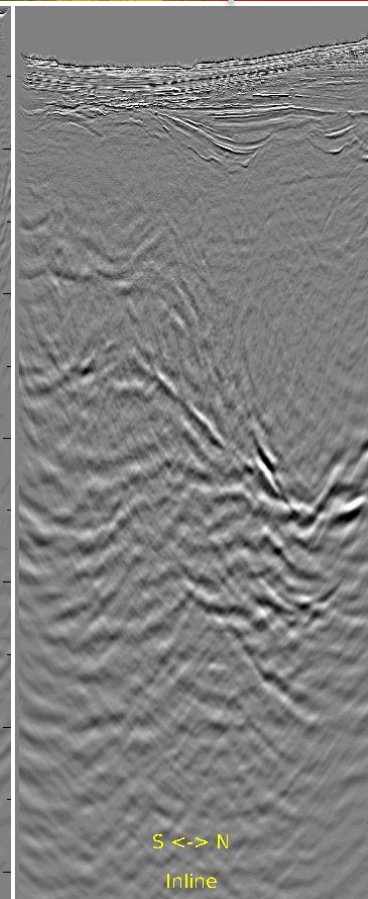
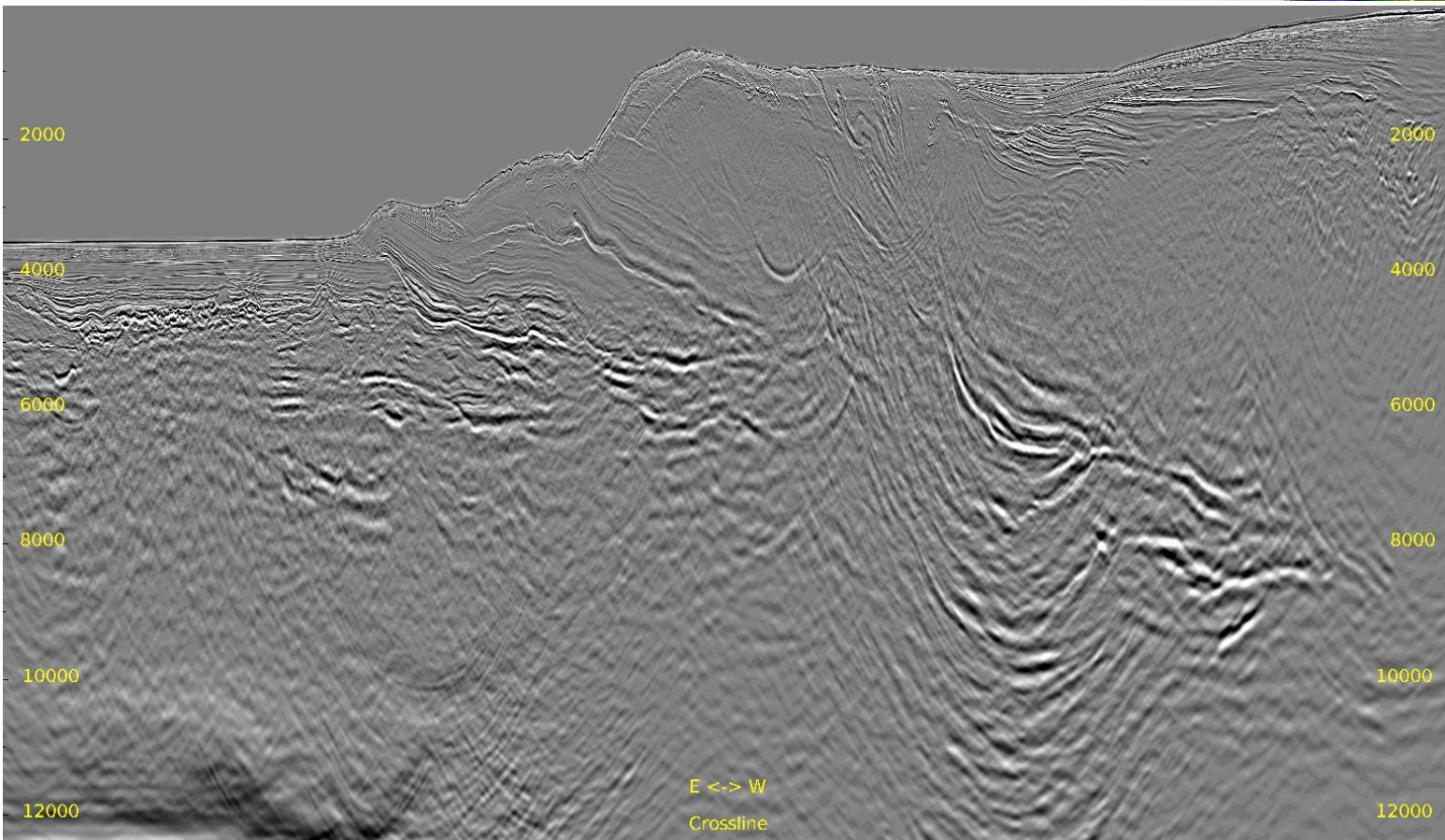
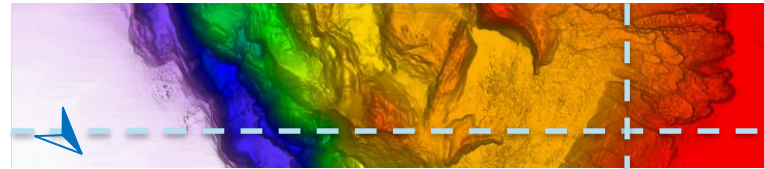
# Full Stack: before TTI TOMO

Inline 636 & Crossline 4540



# Full Stack: after TTI TOMO

Inline 636 & Crossline 4540



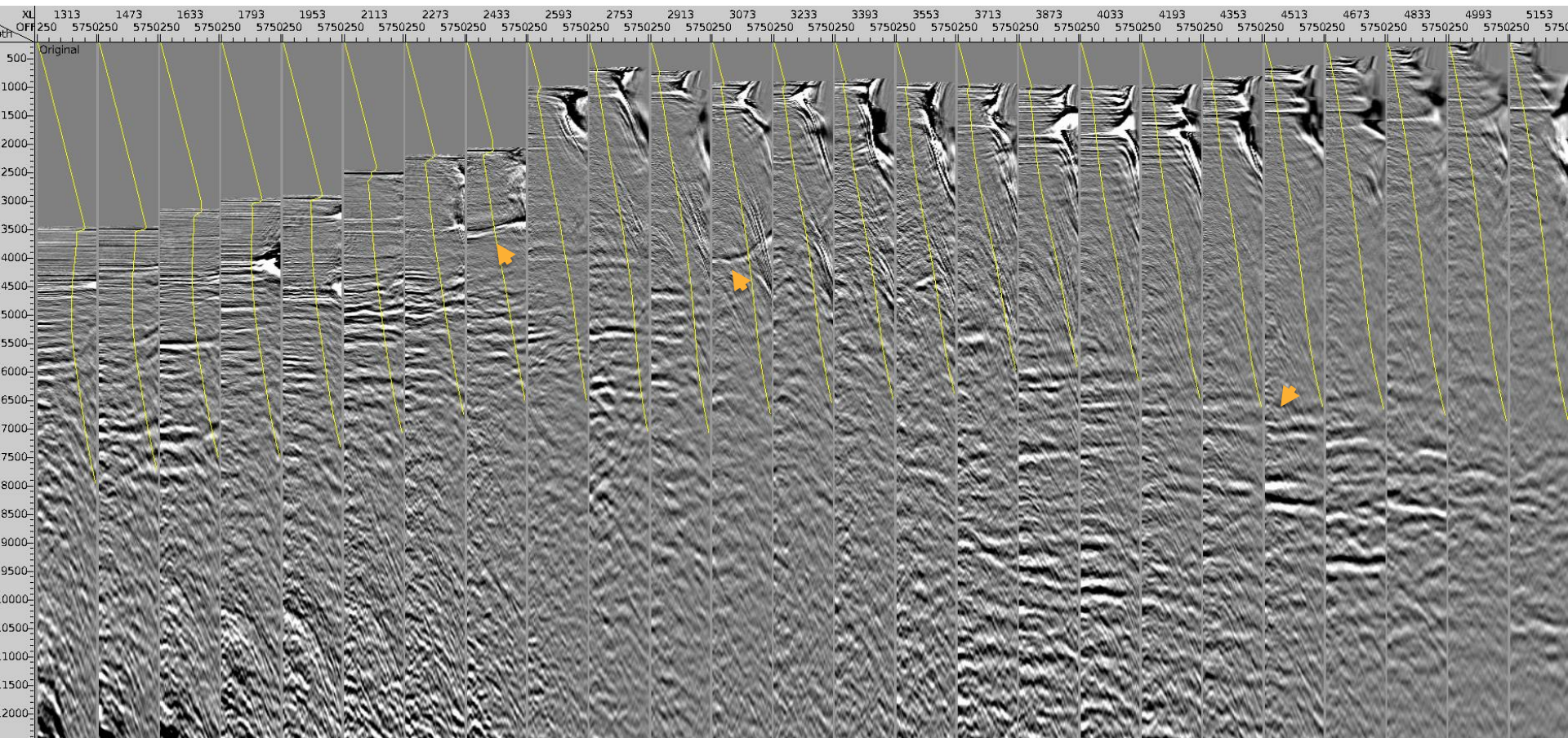




# Inline 636 CDP Gathers: before TTI TOMO

— 35° Mute

23



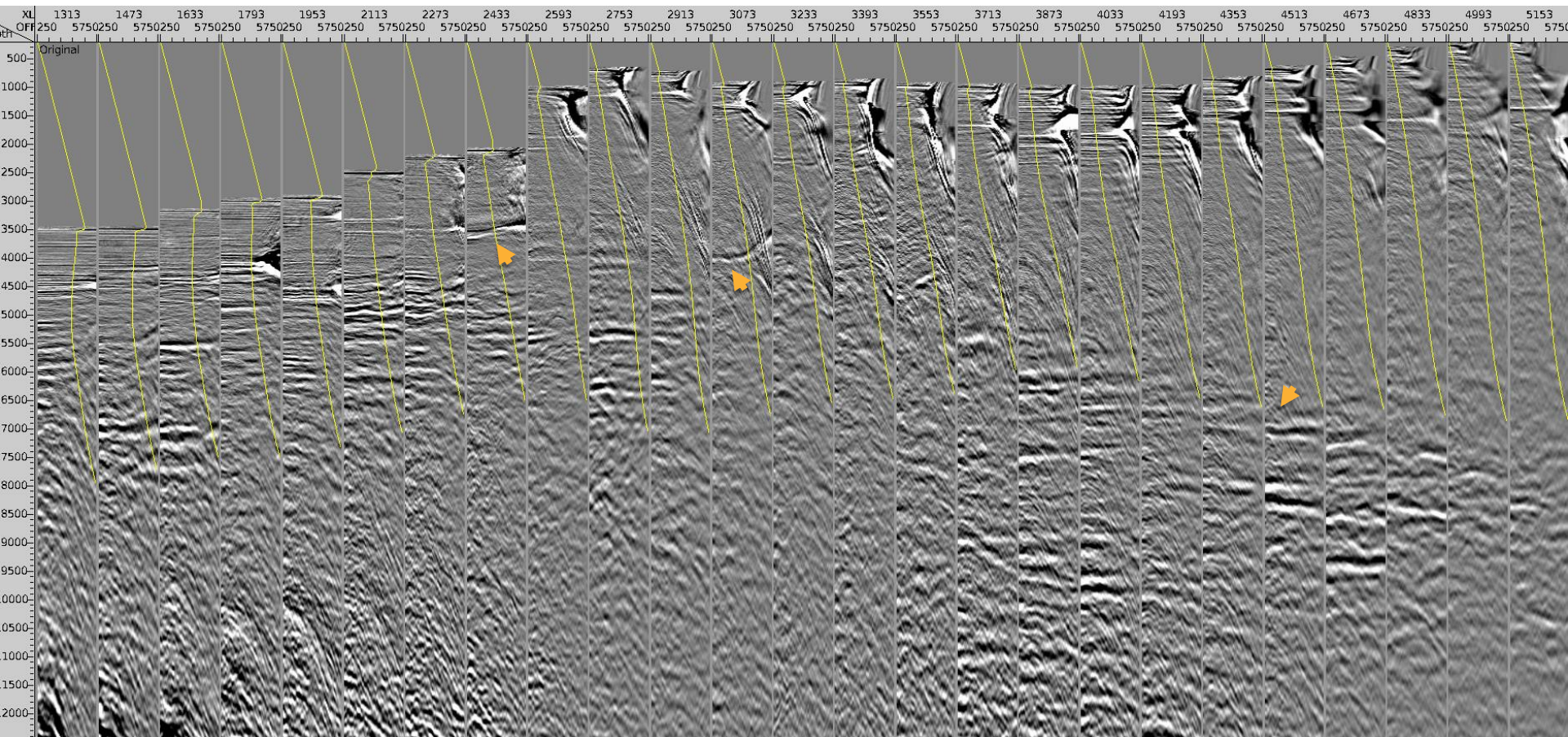




# Inline 636 CDP Gathers: **after** TTI TOMO

— 35° Mute

24



- TTI tomography overall gives reasonable improvement.
- High resolution velocity is needed in the shallow (2~3 km beneath the water bottom) to heal the weird shape of events on gathers.
- Following TTI FWI will target at a high resolution update to further improve the result.





# IT3 - TTI FWI 7Hz

## NZ 3D Processing

06 January 2021

[cgg.com](http://cgg.com)



INSTITUTE FOR GEOPHYSICS



Passion for Geoscience

- **Objective:**

To QC intermediate 7Hz TTI FWI result.

- **Procedure:**

TTI FWI was run with both streamer and OBS data from 2.5 Hz to 7Hz. Refraction energy is used in both data sets and reflection energy of streamer data is also included in the inversion.

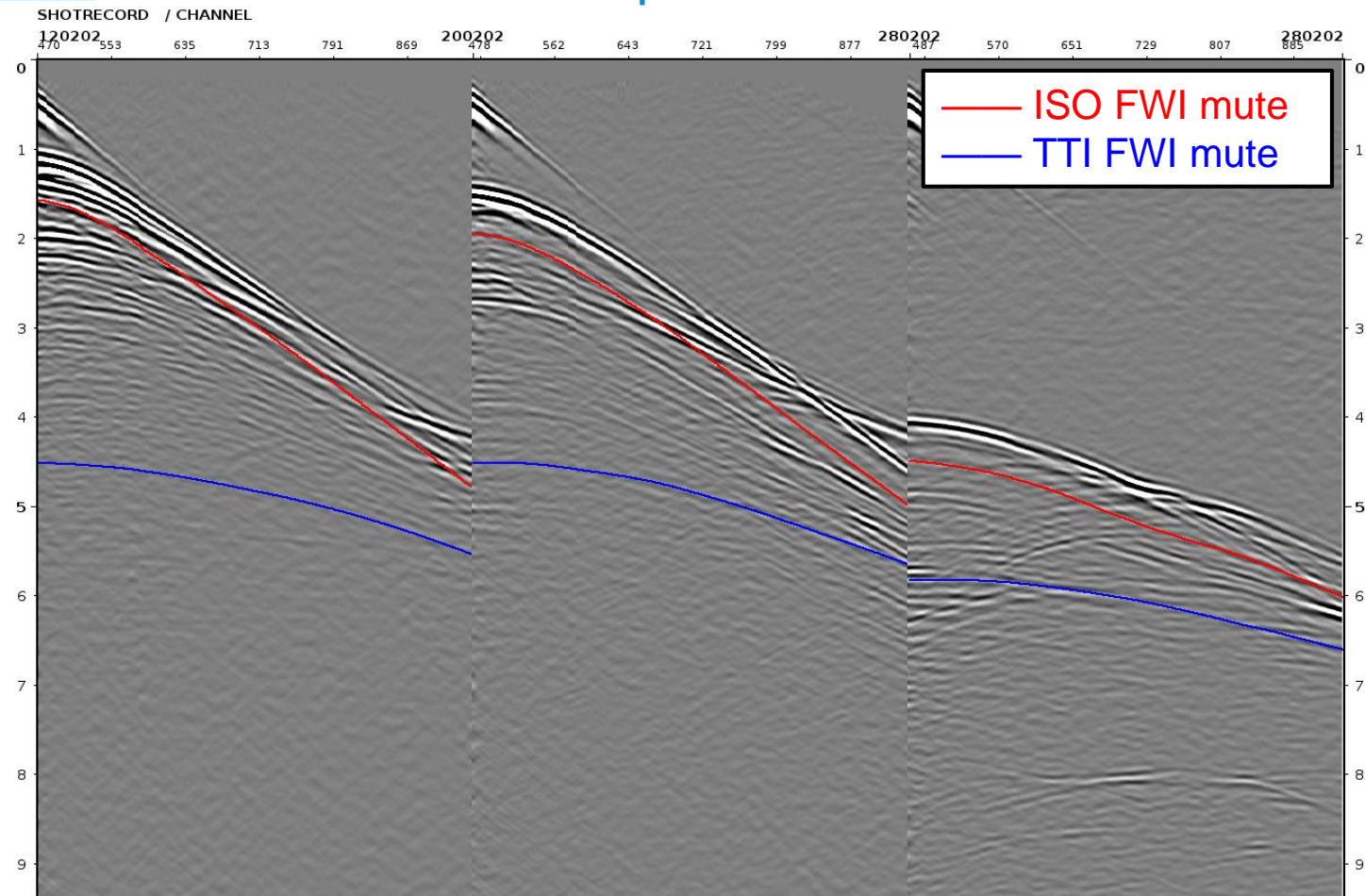
7Hz TTI FWI velocity was used to generate the synthetic shots.

- **Display:**

Velocity and FWI synthetic.

- **Observation and Recommendation:**

Current TTI FWI gives more detailed velocity that aligns more with geology, compared with IT2 TTI tomographic velocity. Synthetic shots have better match with the real data indicating a reasonable update. We'll continue the TTI FWI update to 12 Hz according to our contract.



- The reflection energy below the blue line is mute.
- Compared to ISO FWI, part of the reflection energy is included in the inversion to get more resolution in the velocity.
- OBN input data is not changed (refraction only), due to the low quality of it's reflection zone.



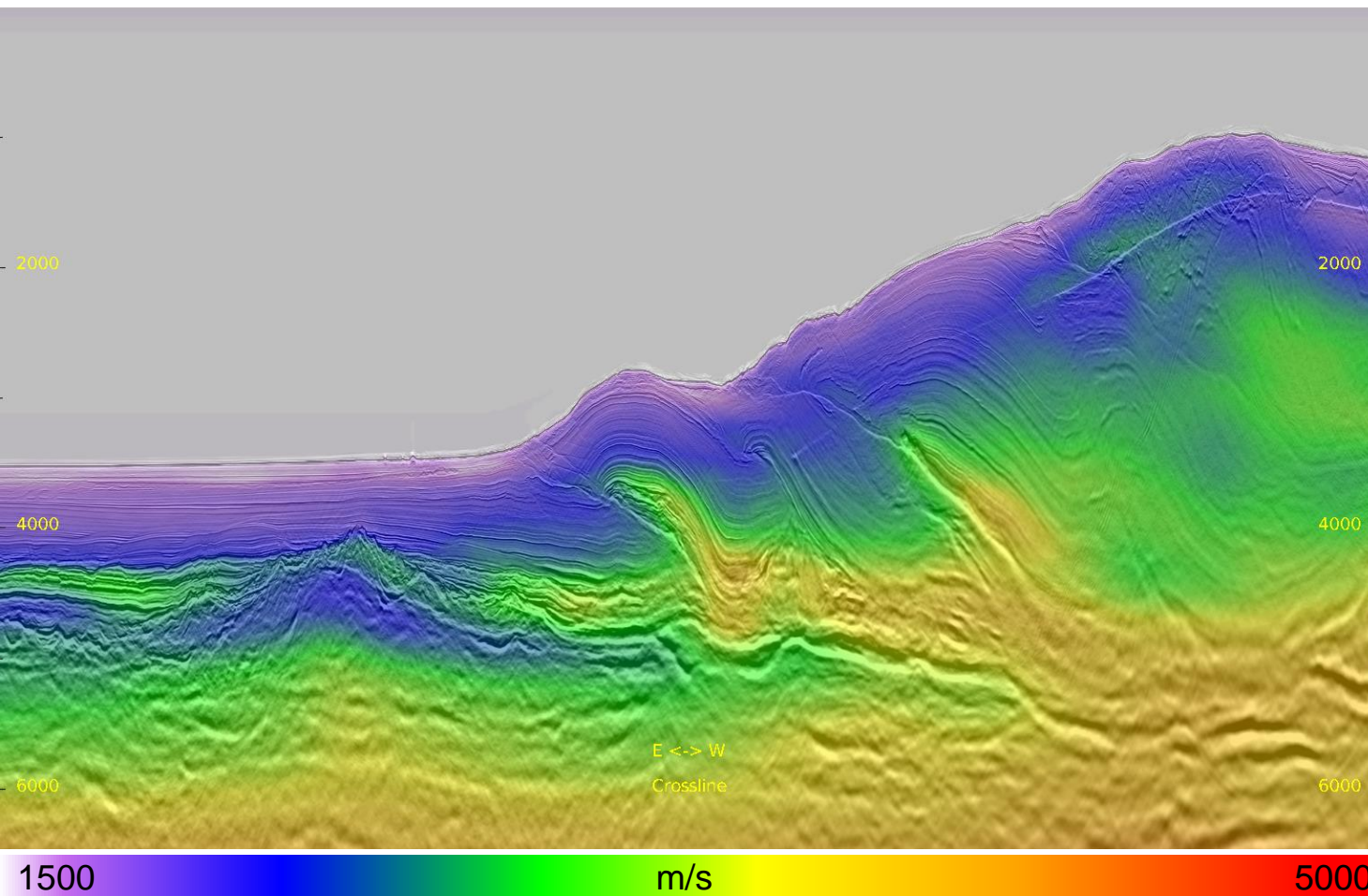
# Velocity Model





# Inline 436 East: IT2 Velocity

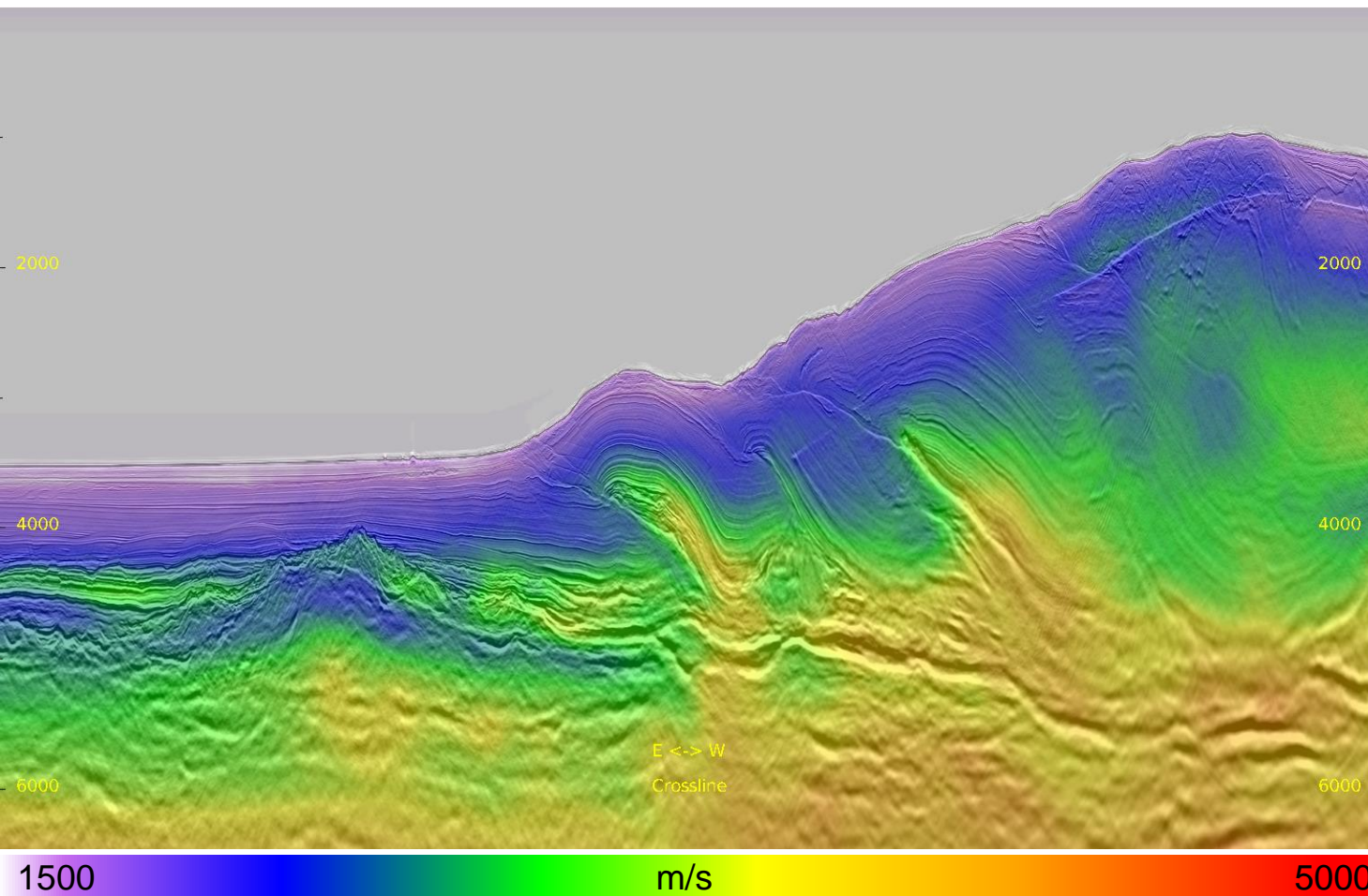
5



- Starting velocity is from IT2 TTI tomography.

## Inline 436 East: 7Hz TTI FWI Velocity

6

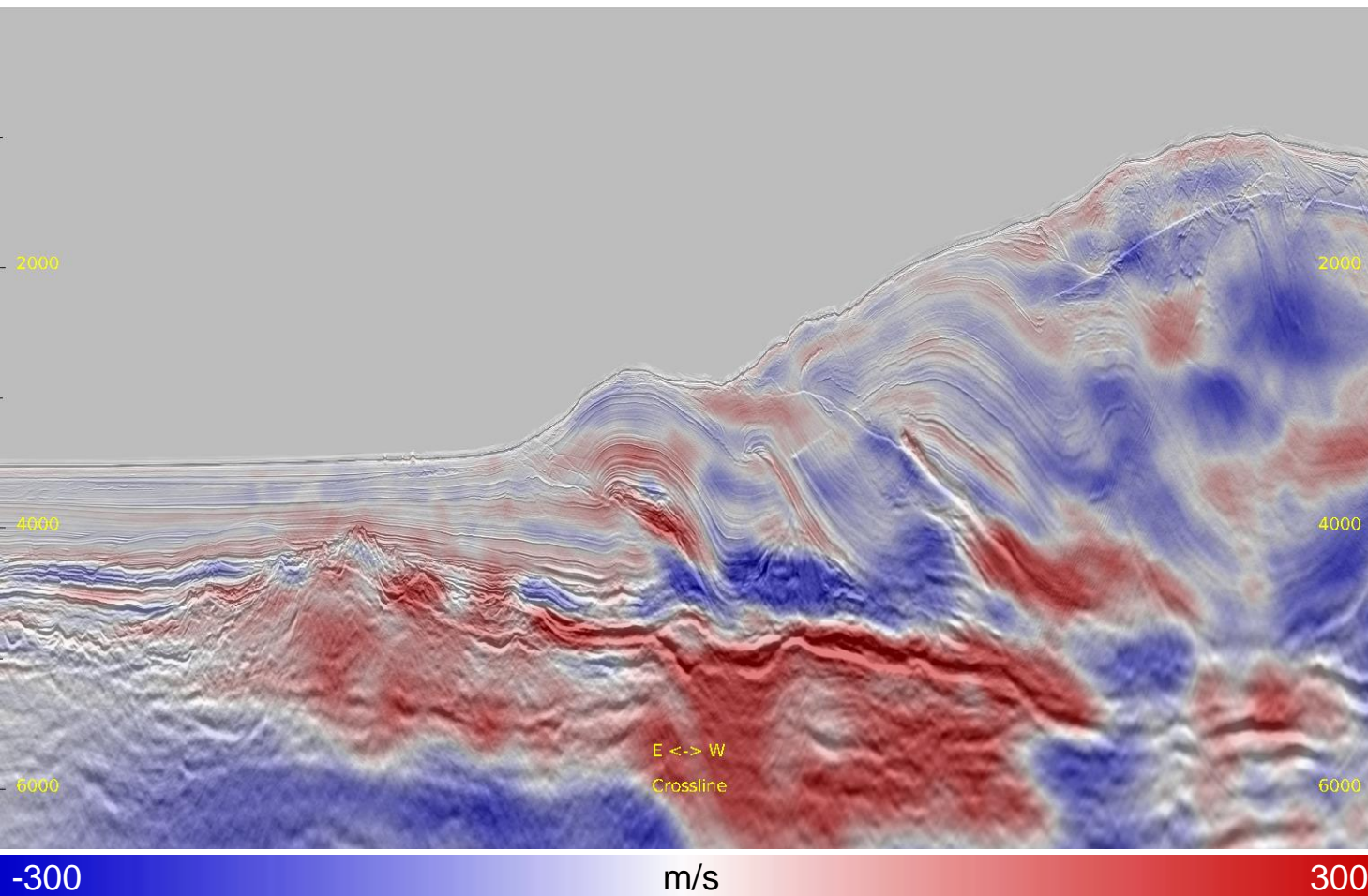


- TT FWI velocity aligns more with geology.



# Inline 436 East: Velocity Perturbation

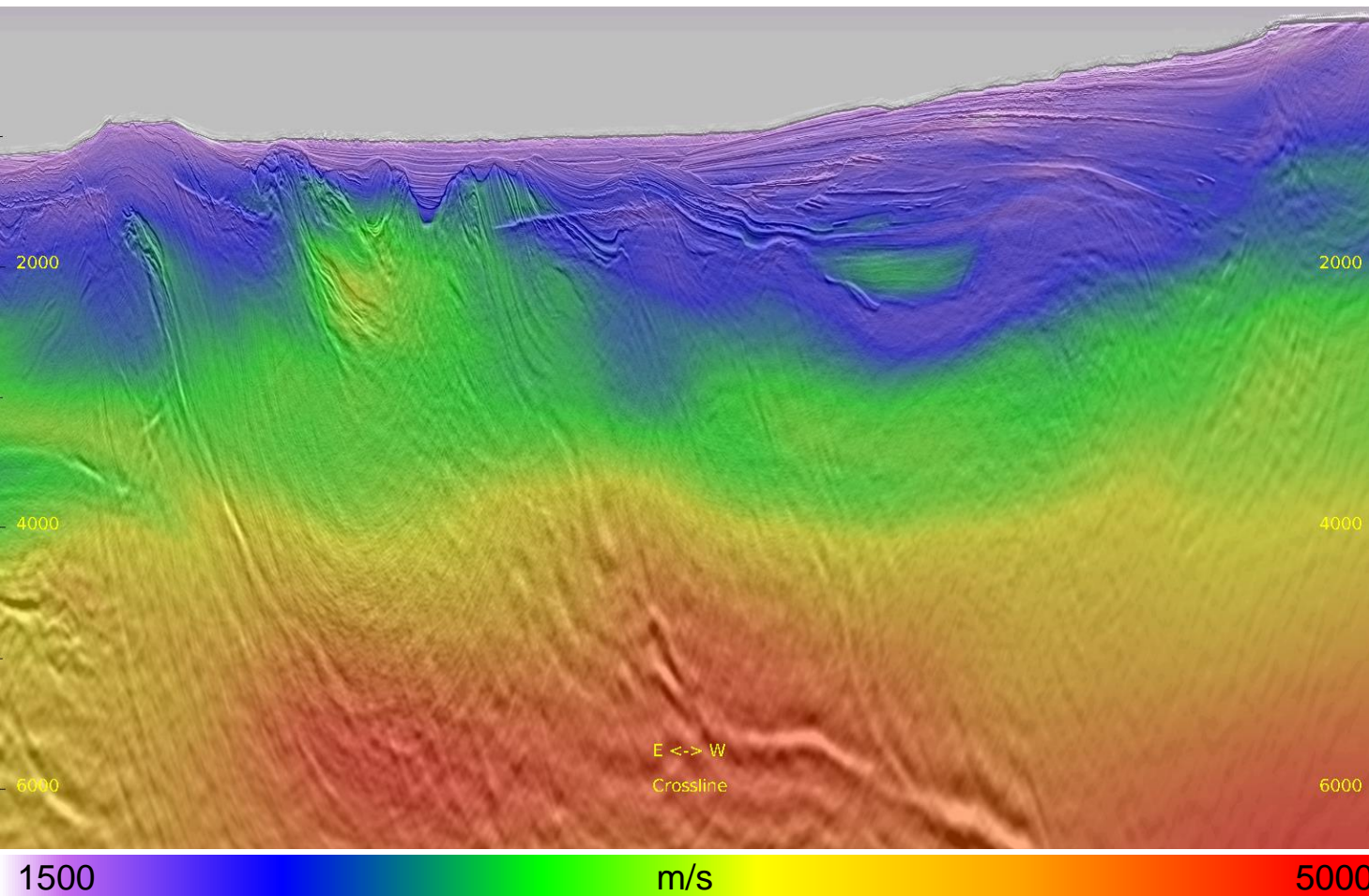
7



- TTI FWI give detailed velocity perturbation.

## Inline 436 West: IT2 Velocity

8

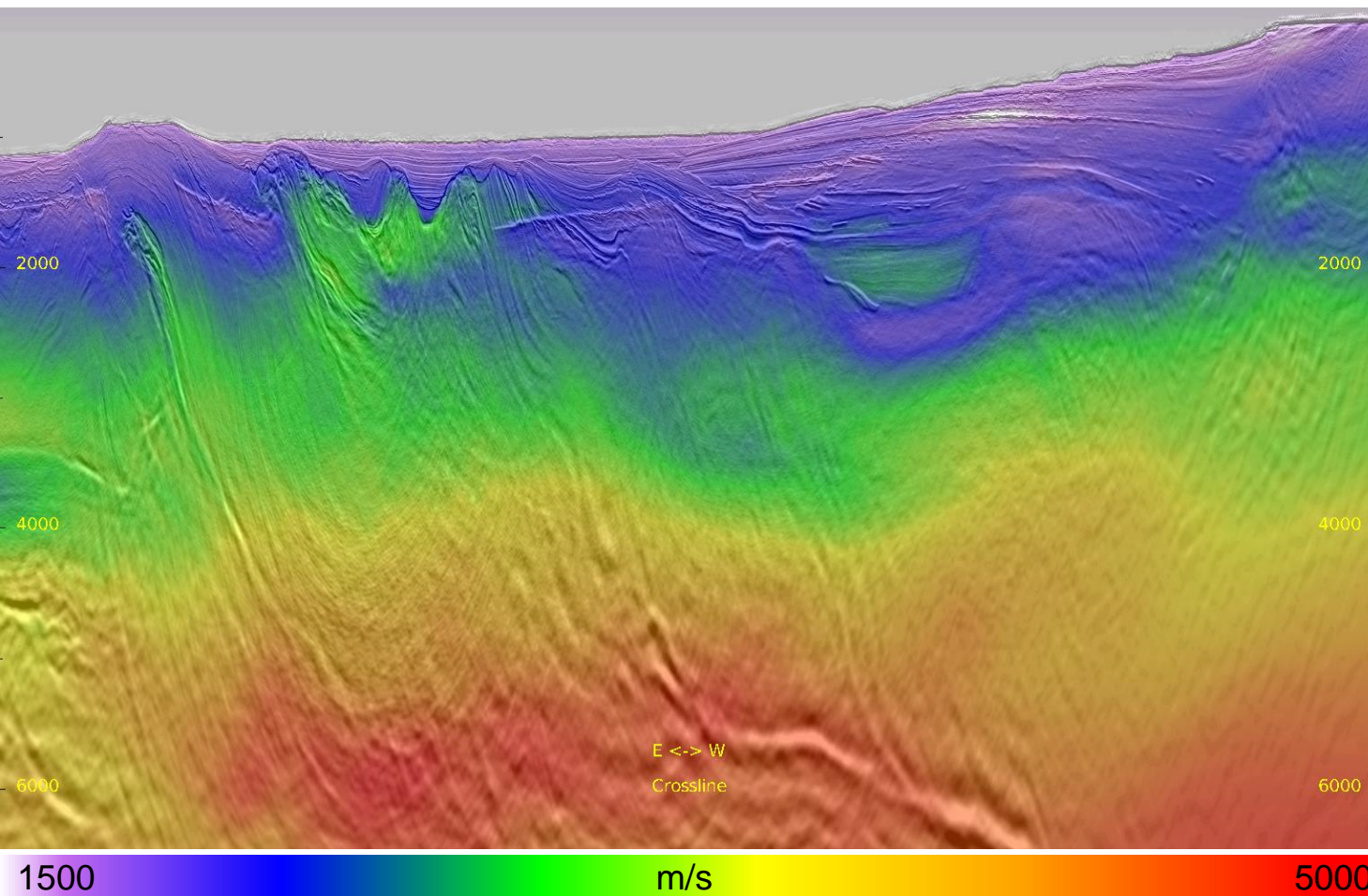


- Starting velocity is from IT2 TTI tomography.



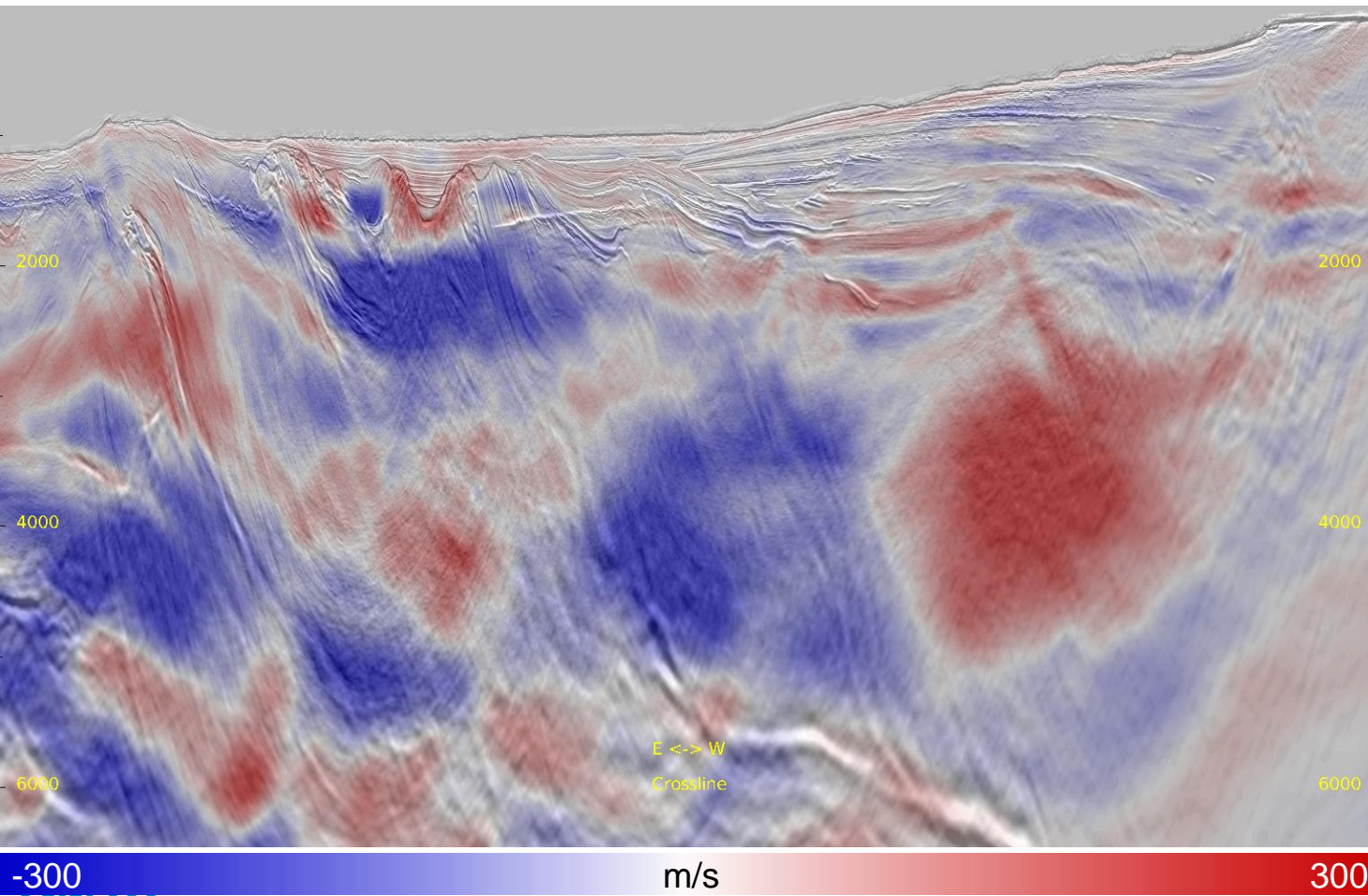
# Inline 436 West: 7Hz TTI FWI Velocity

9



- TT FWI velocity aligns more with geology.





- TTI FWI give detailed velocity perturbation.

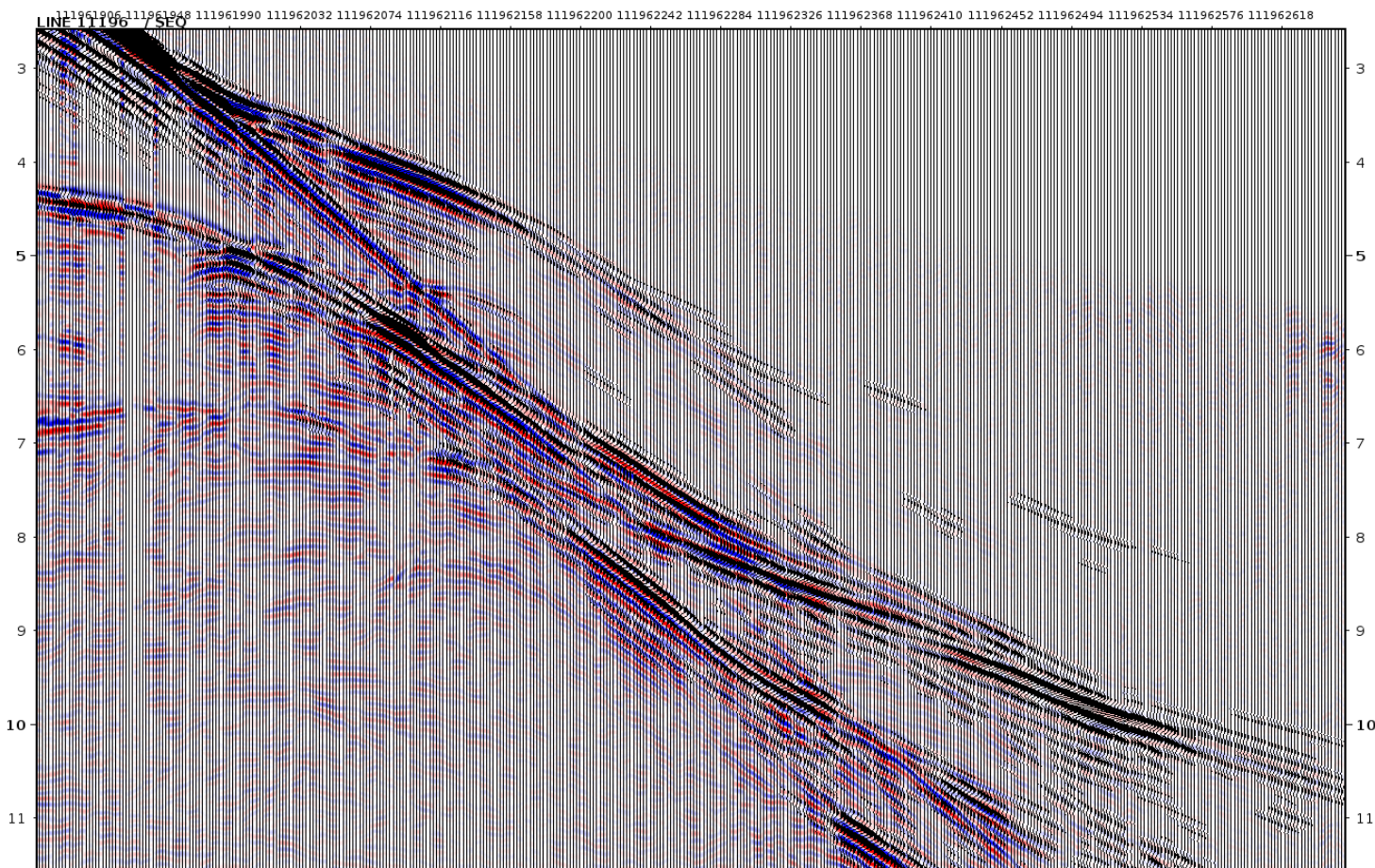
# FWI Synthetic VS Real Data ( $< 9$ Hz)



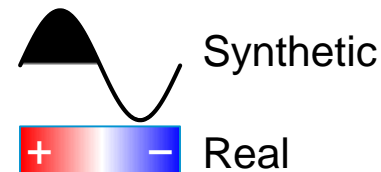


# OBS 058 Synthetic Overlaid on Real: IT2 Velocity

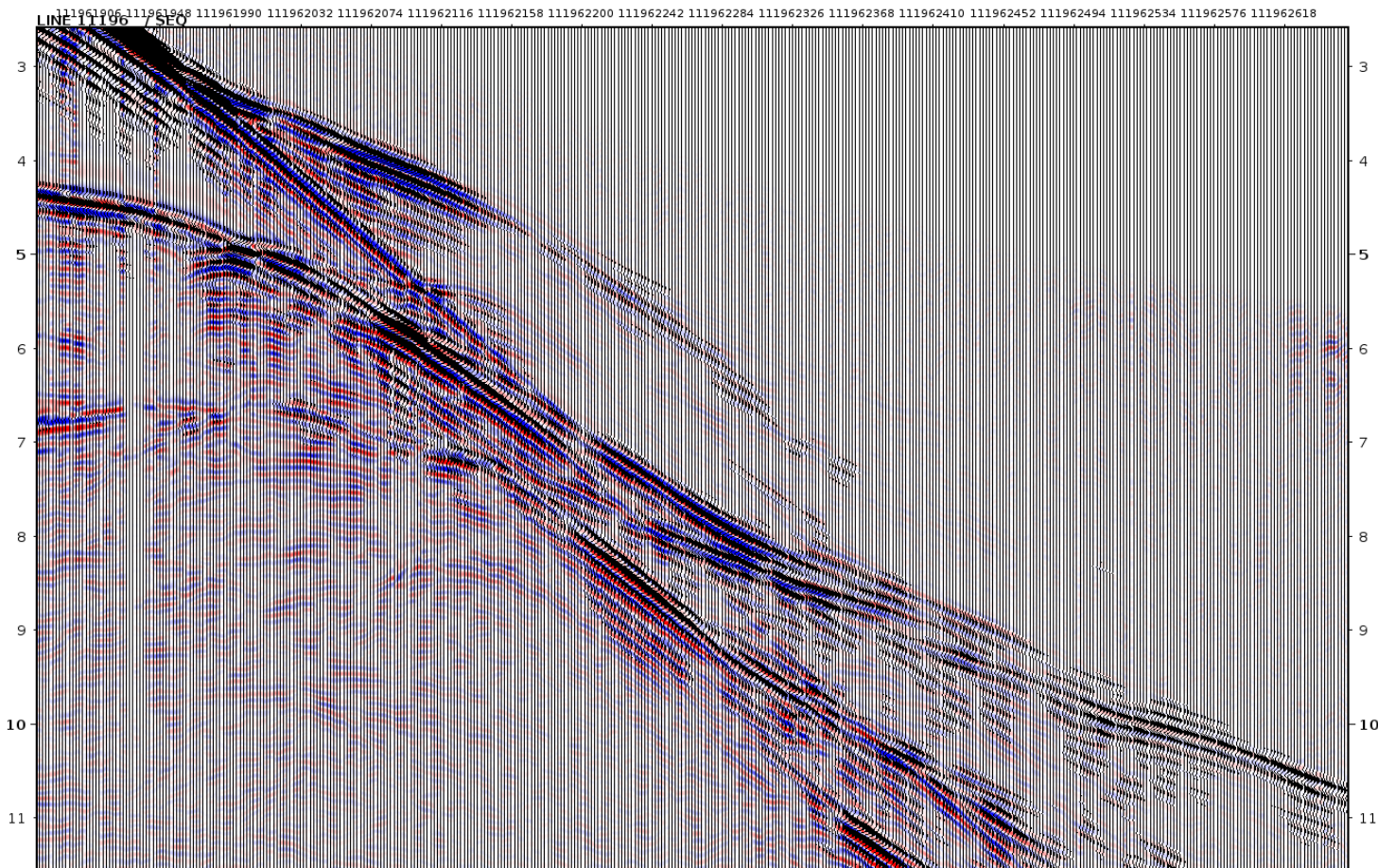
12



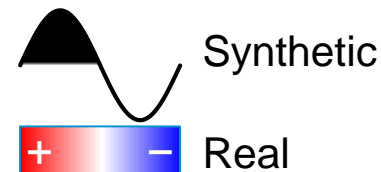
- Before TTI FWI, synthetic shot and real data matches not very well from mid to far channels.







- After TTI FWI date, synthetic shots and real data matches better through out all channels.

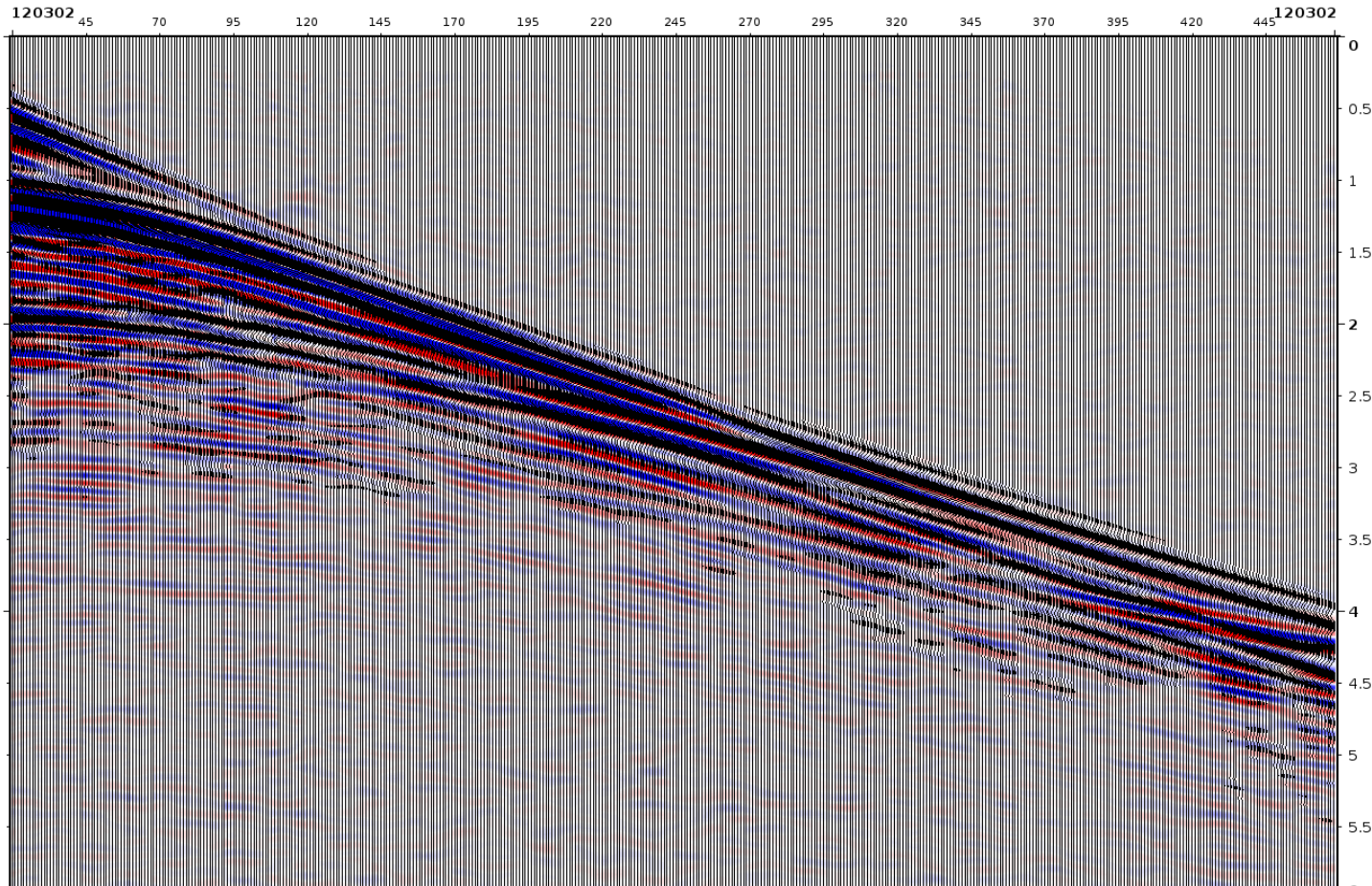




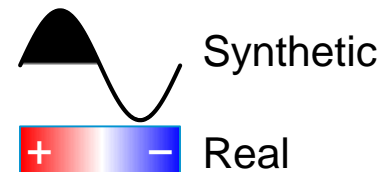
# Streamer 001 Synthetic Overlaid on Real: IT2 Velocity

14

SHOTRECORD 120302 / CABTR



- Before TTI FWI, synthetic shot and real data matches not very well from mid to far channels.





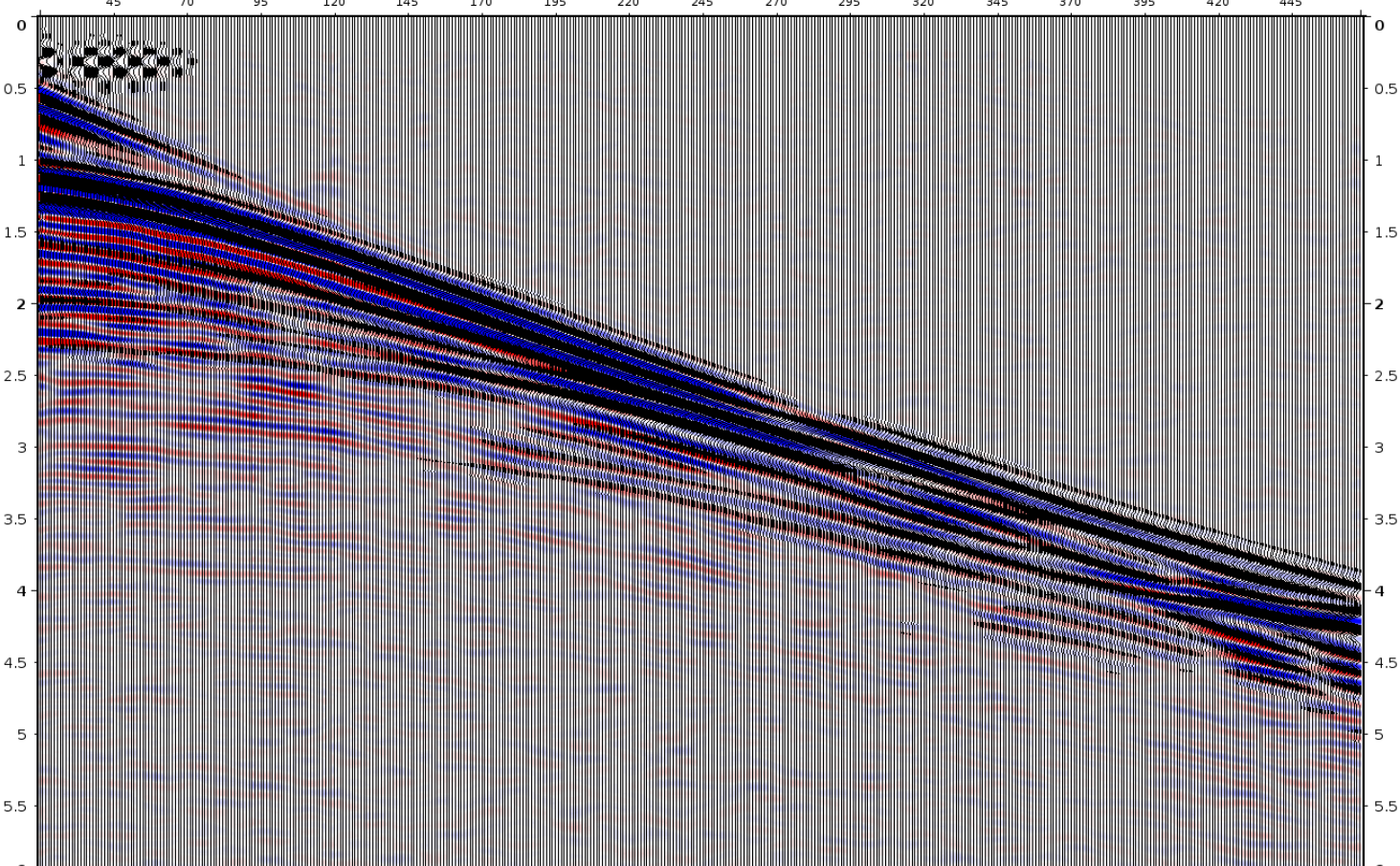
# Streamer 001 Synthetic Overlaid on Real: IT3 7Hz FWI Velocity

15

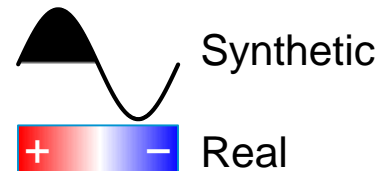
SHOTRECORD 120302 / CABTR

120302

120302



- After TTI FWI date, synthetic shots and real data matches better through out all channels.







# IT3 – 12Hz TTI FWI

## NZ 3D Processing

*20 January 2021*

[cgg.com](http://cgg.com)



INSTITUTE FOR GEOPHYSICS



Passion for Geoscience

- **Objective:**

To QC 12 Hz TTI FWI result.

- **Procedure:**

TTI FWI was run with both streamer and OBS data from 2.5 Hz to 12Hz. Refraction energy is used in both data sets and reflection energy of streamer data is also included in the inversion. An updated migration input was used with less residual multiples and artifacts, mainly due to the change from 2D deghost to 3D deghost and common offset denoise.

- **Display:**

Velocity, migrated depth full stack & gathers.

- **Observation and Recommendation:**

12Hz TTI FWI gives more detailed velocity that aligns more with geology, compared with IT2 TTI tomographic velocity. Migration with FWI velocity shows overall improvement, especially dipping events in the target area.

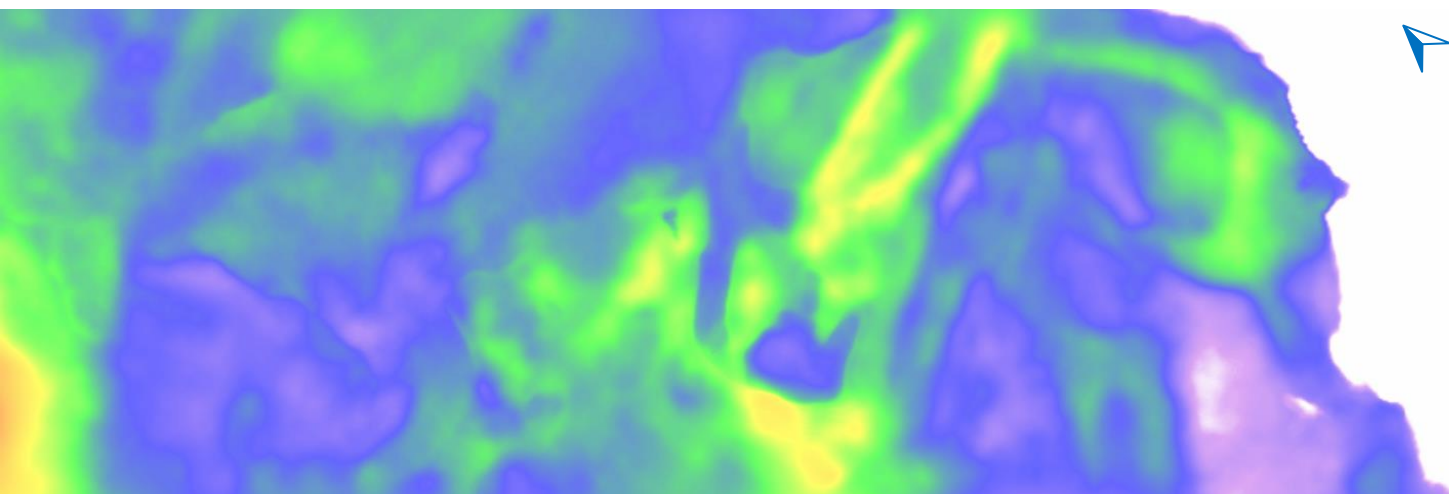
# Velocity Model





# Depth 1400m: IT2 Velocity

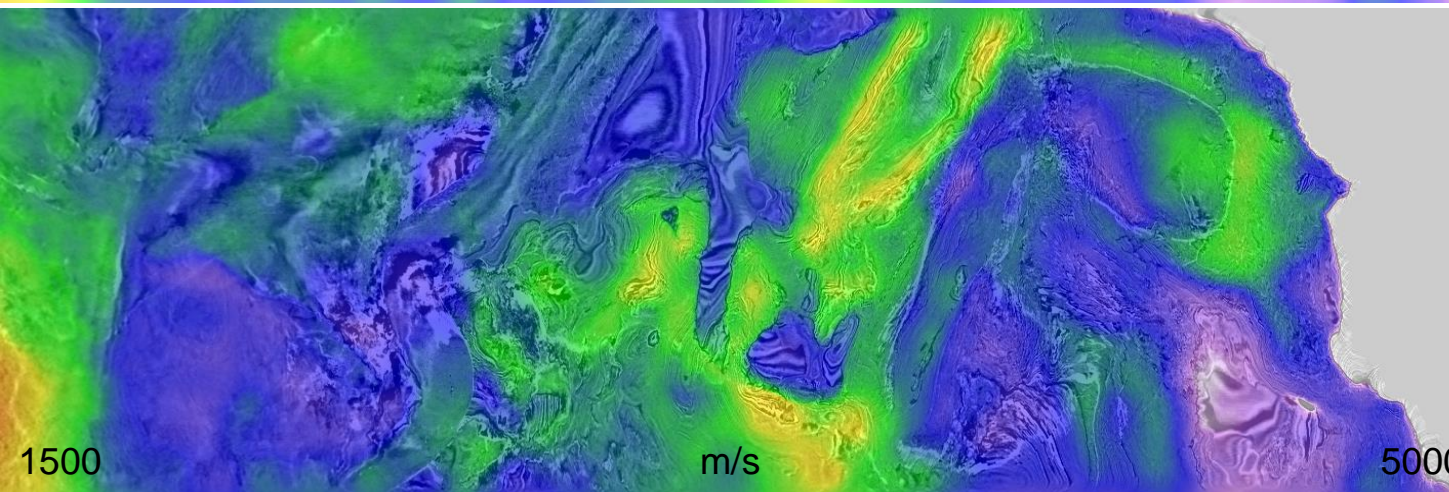
4



1500

Starting velocity is from IT2 TTI tomography.

m/s



3500

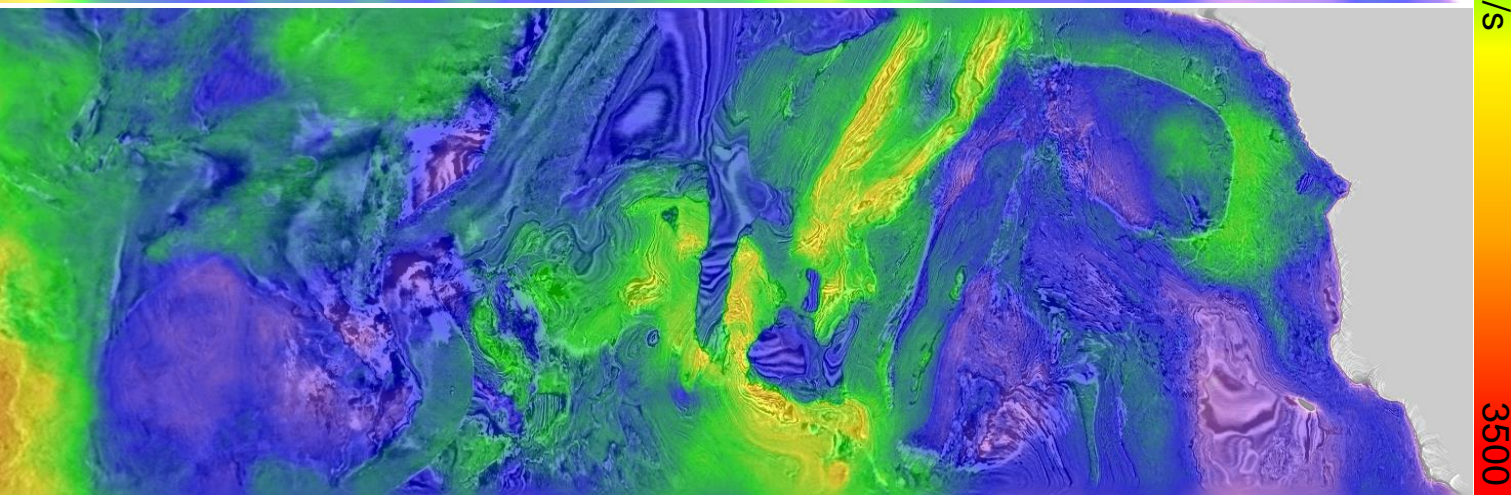
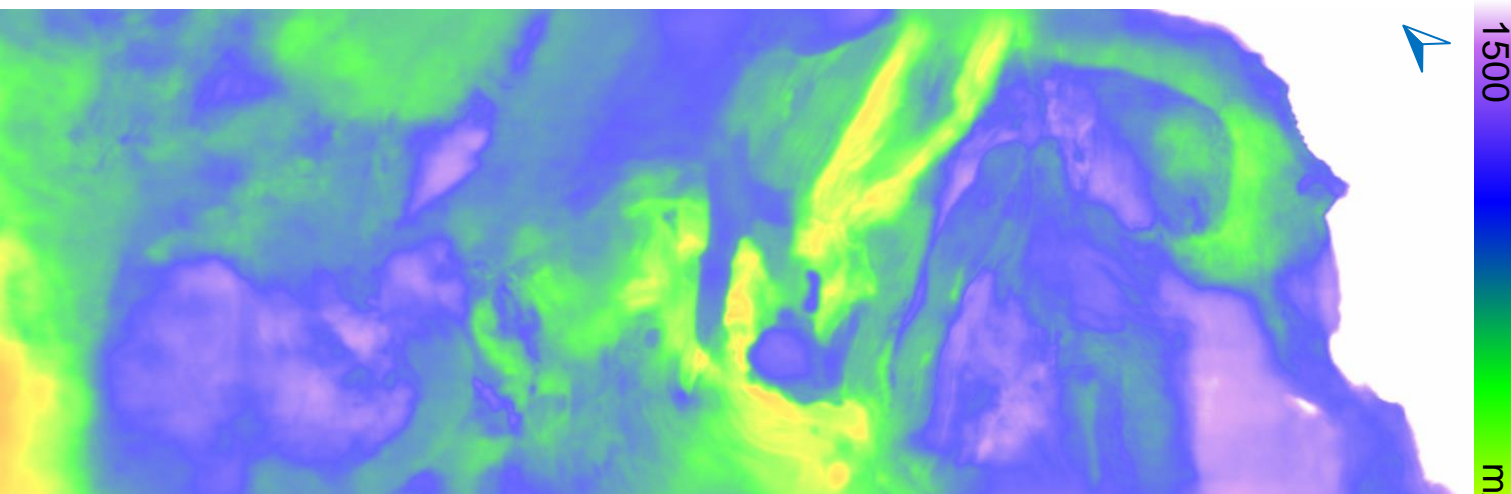
5000

m/s

1500

# Depth 1400m: IT3 12Hz TTI FWI Velocity

5



1500

m/s

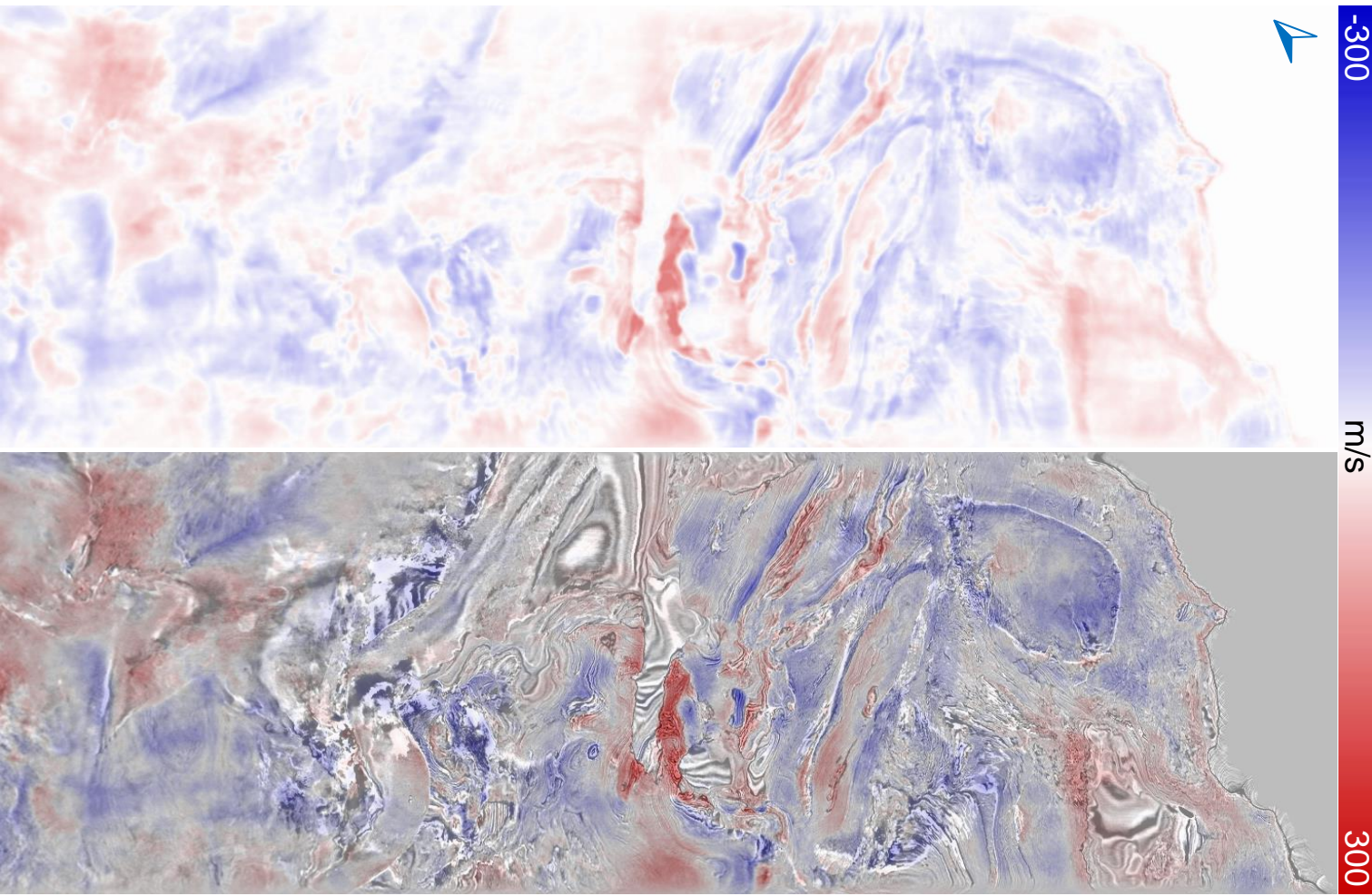
3500

TT FWI velocity aligns more with geology and provides more details.



# Depth 1400: Velocity Perturbation

6



-300

m/s

300

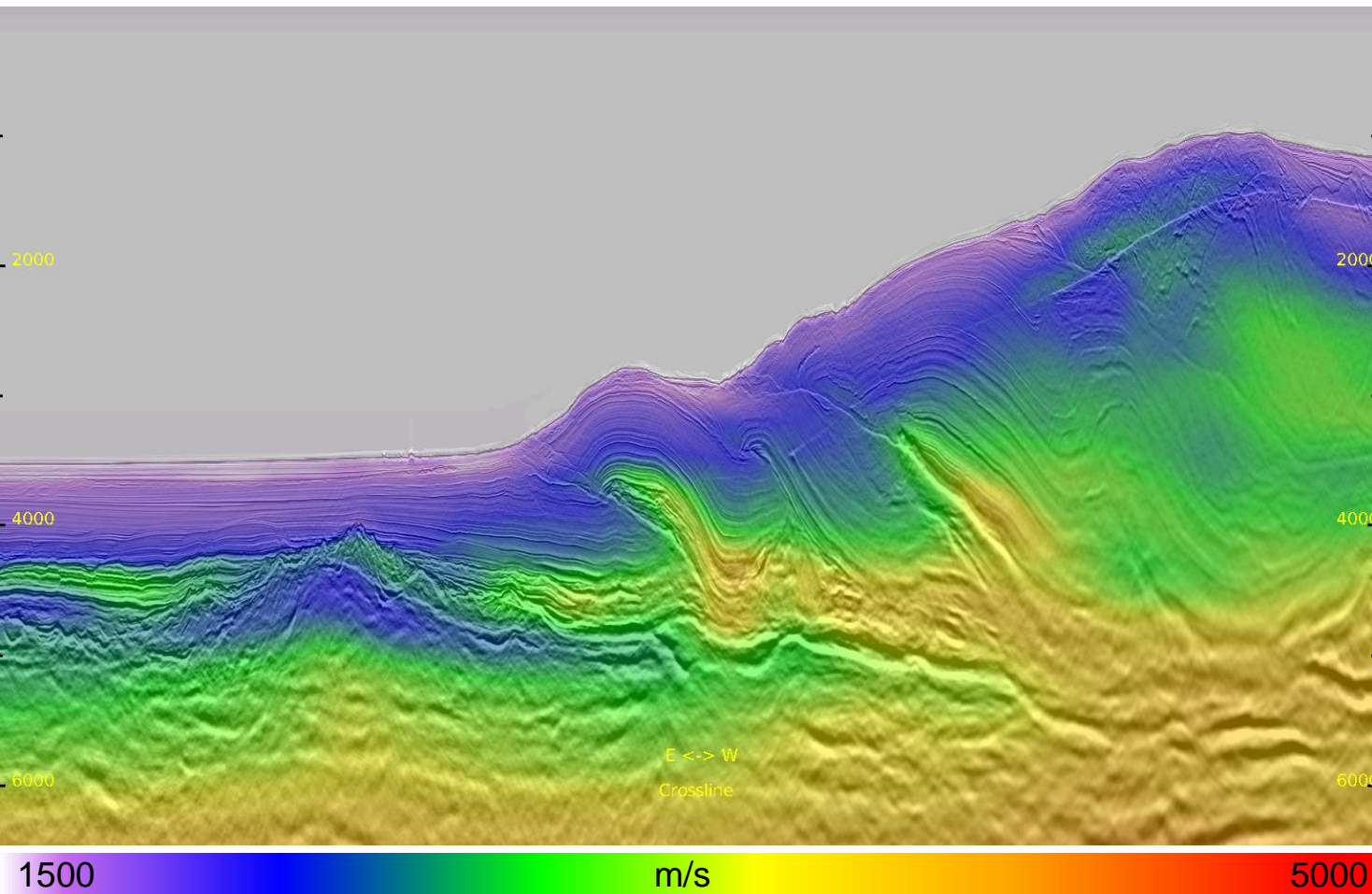
TTI FWI give detailed velocity perturbation.





# Inline 436 East: IT2 Velocity

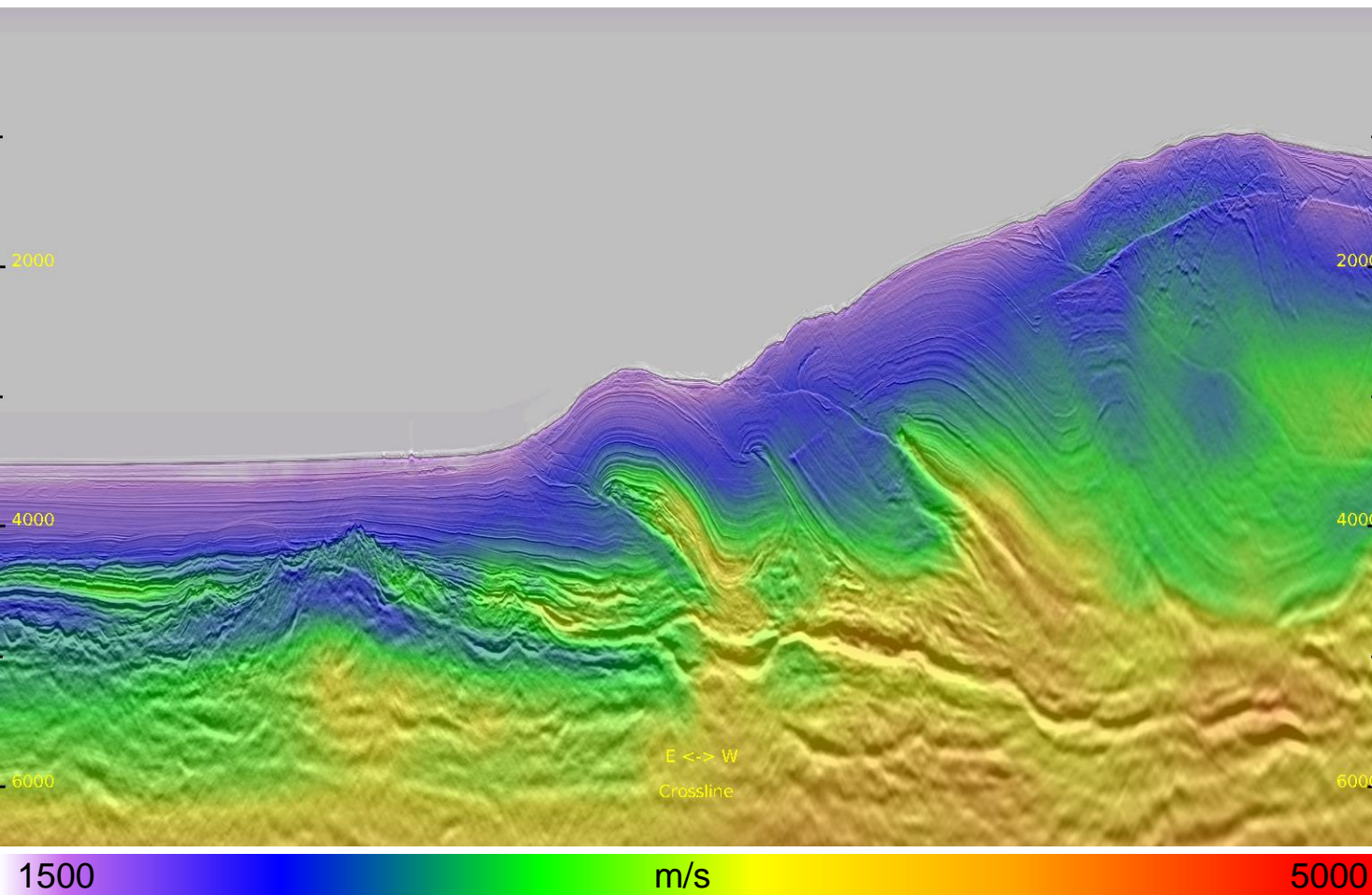
7



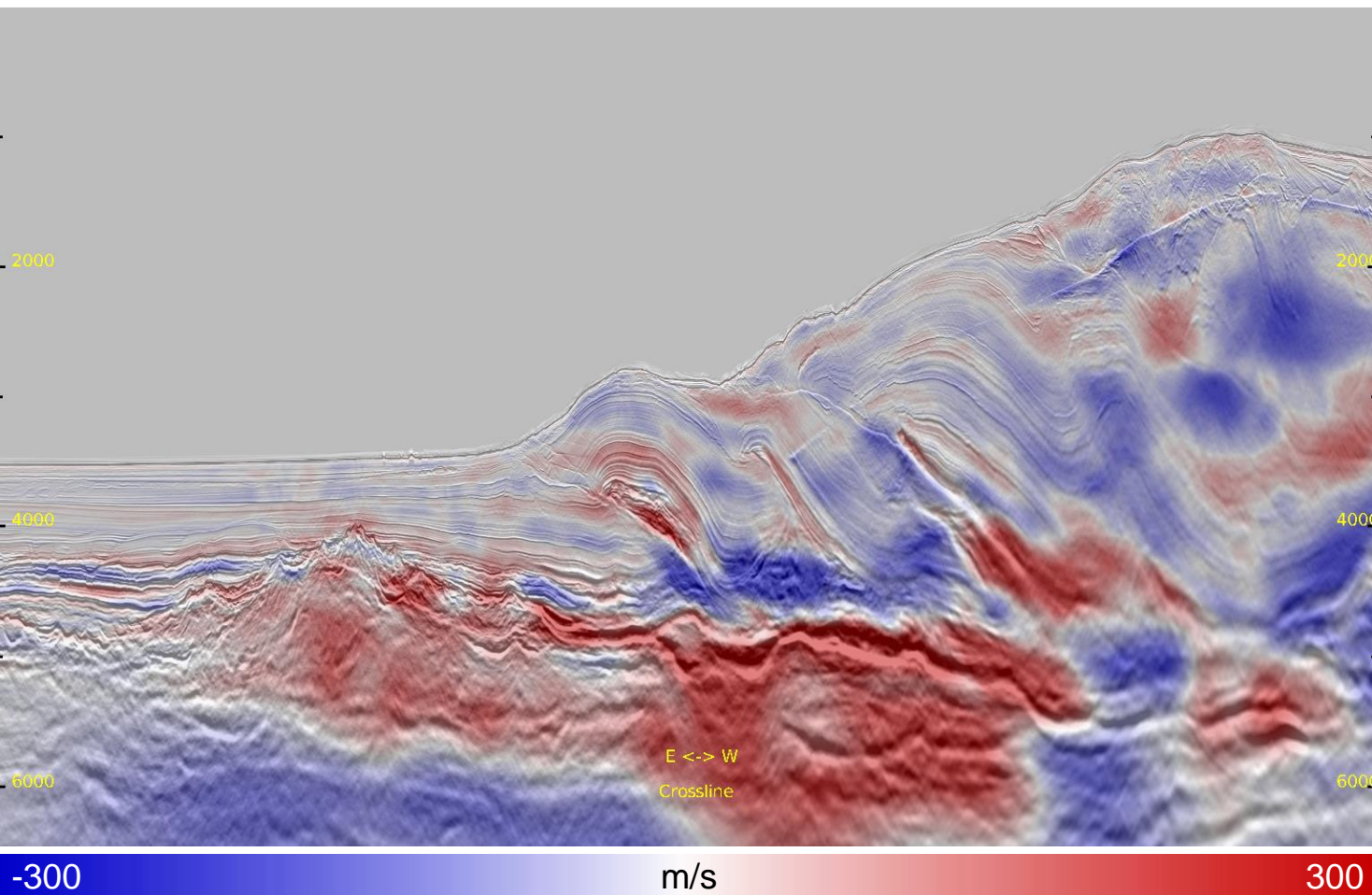
- Starting velocity is from IT2 TTI tomography.

# Inline 436 East: IT3 12Hz TTI FWI Velocity

8



- TT FWI velocity aligns more with geology and provides more details.



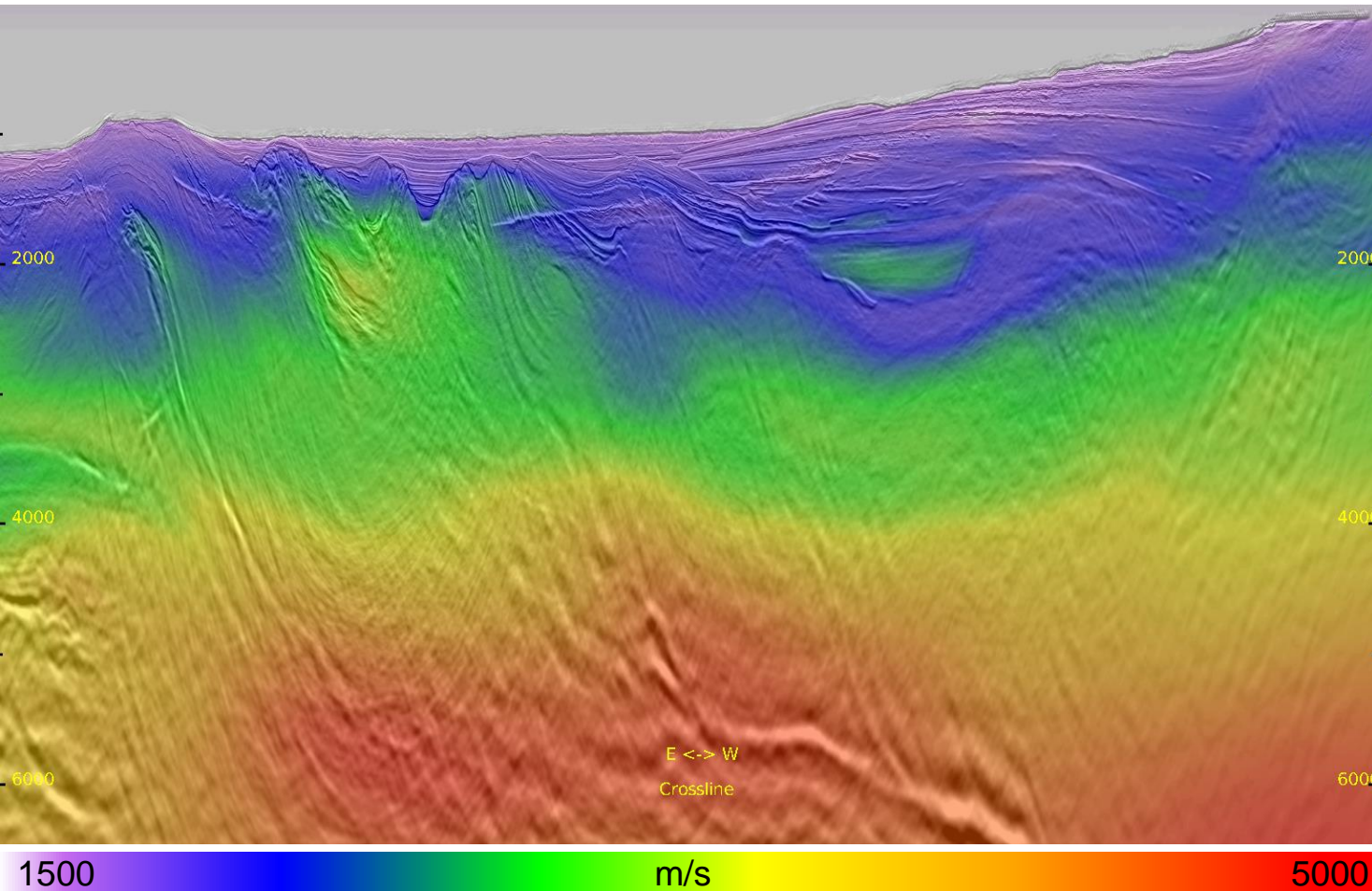
- TTI FWI give detailed velocity perturbation.



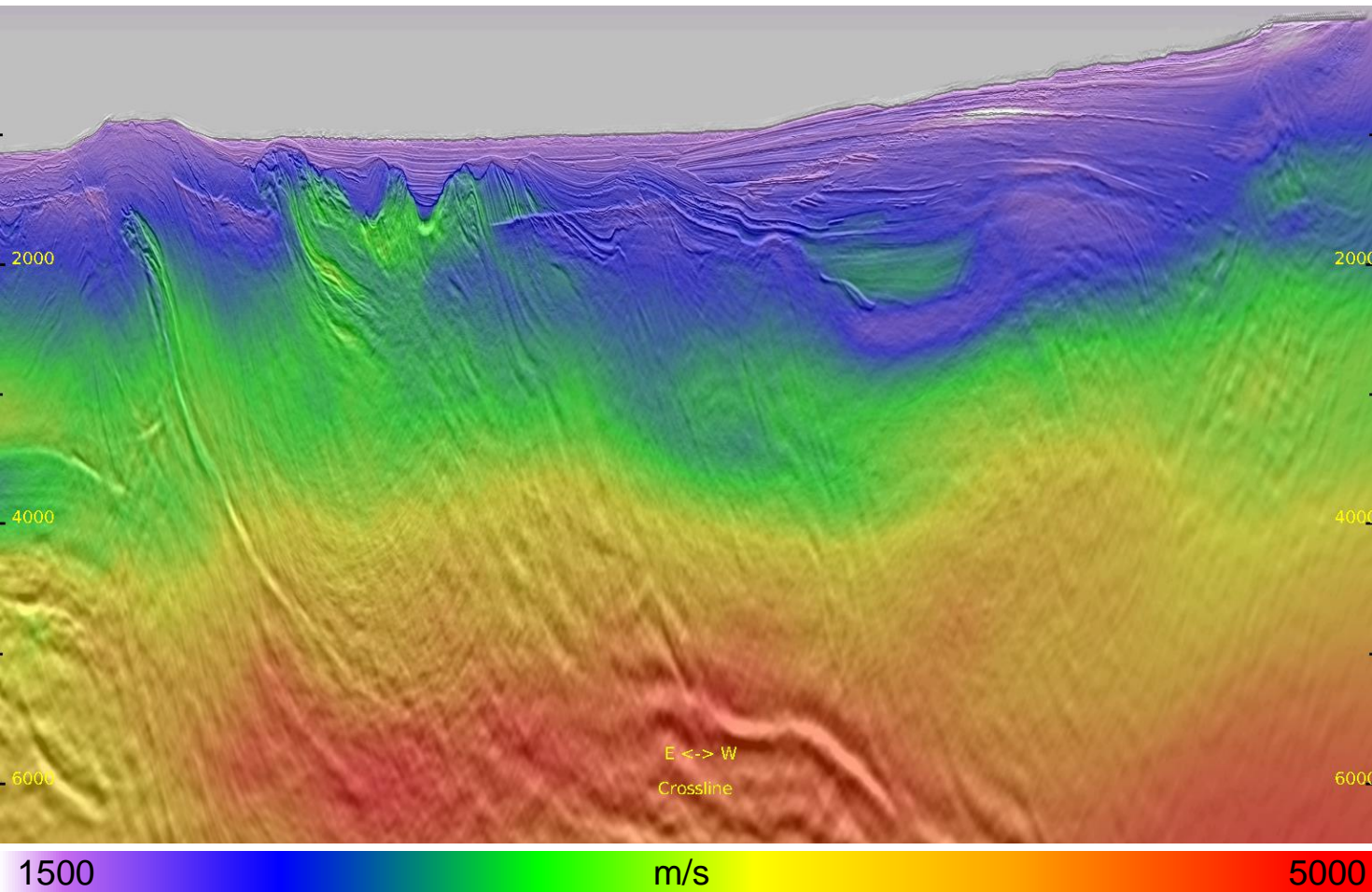


# Inline 436 West: IT2 Velocity

10

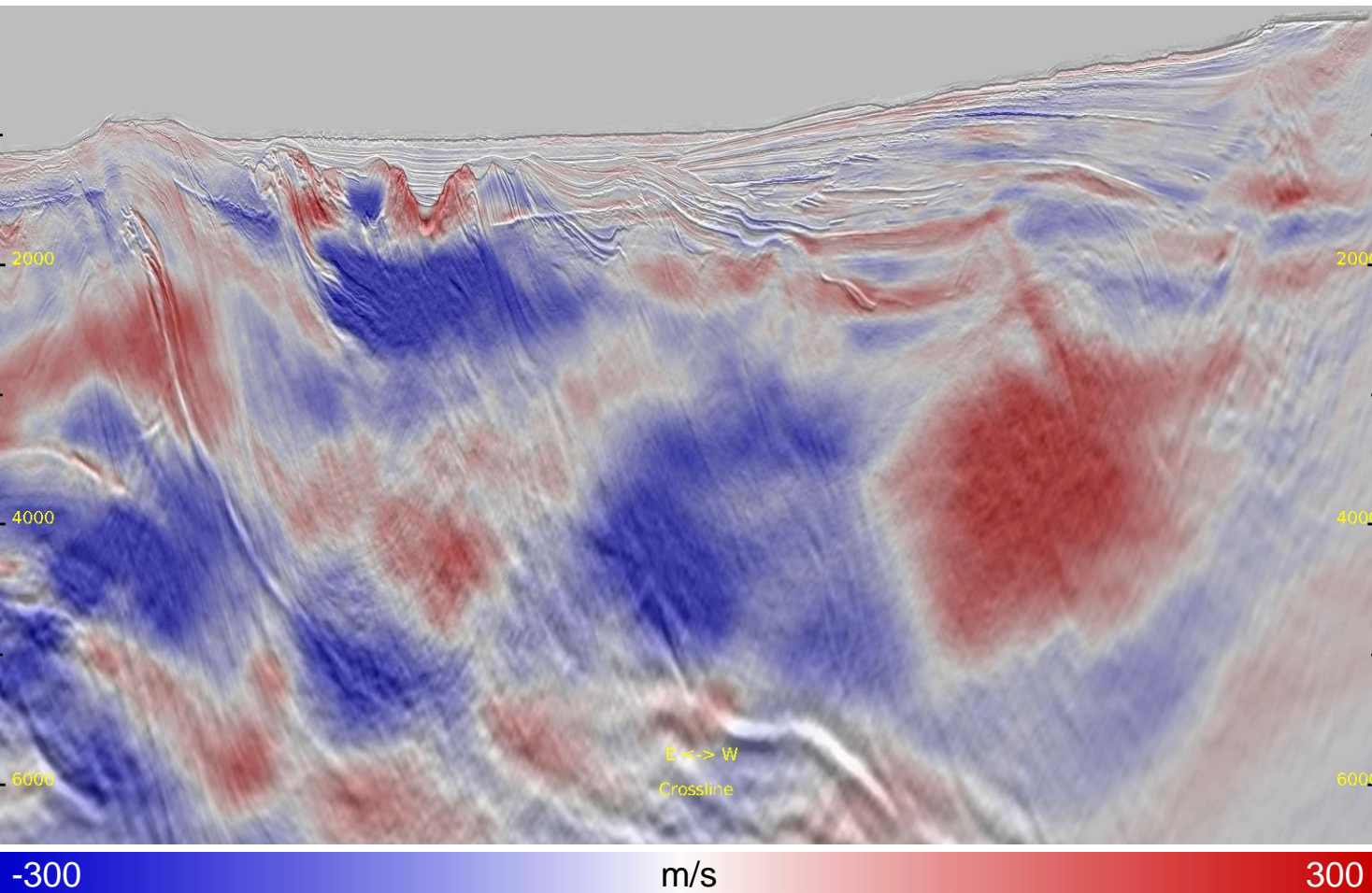


- Starting velocity is from IT2 TTI tomography.



- TT FWI velocity aligns more with geology and provides more details.





- TTI FWI give detailed velocity perturbation.

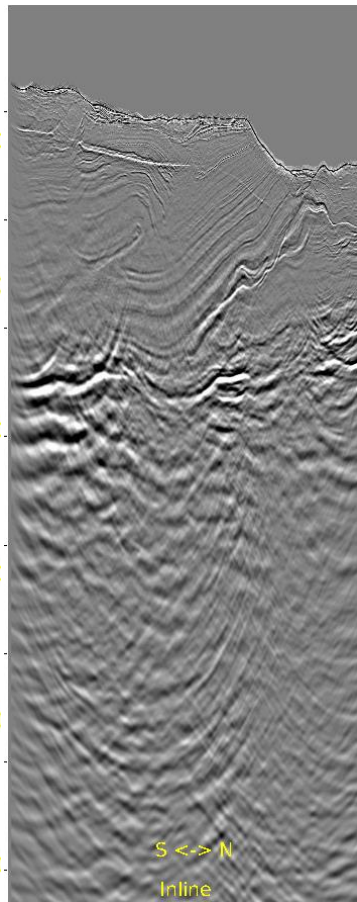
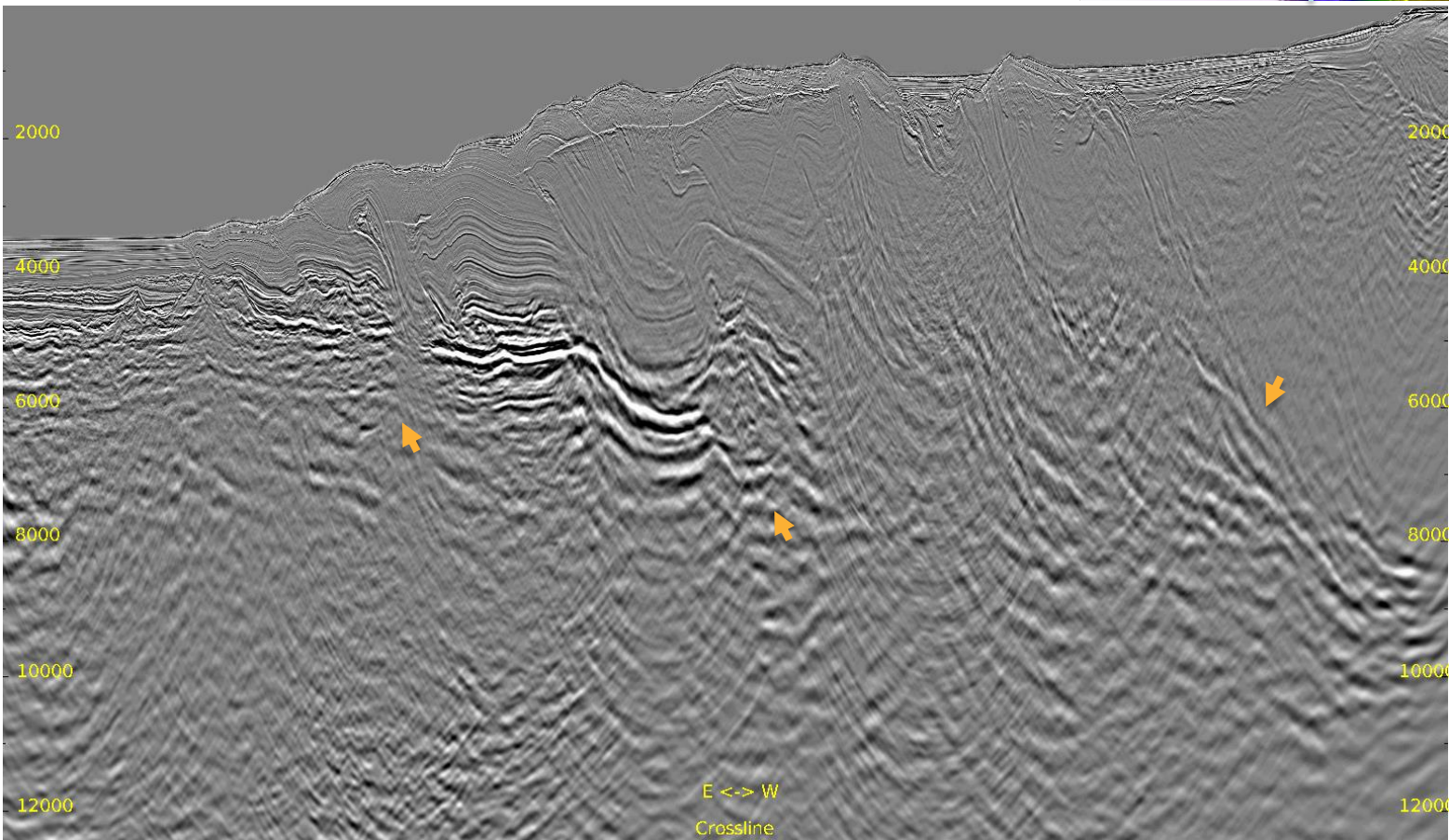
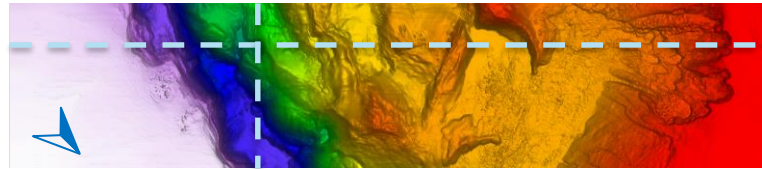


# Kirchhoff Depth Migration



# Full Stack: before TTI FWI

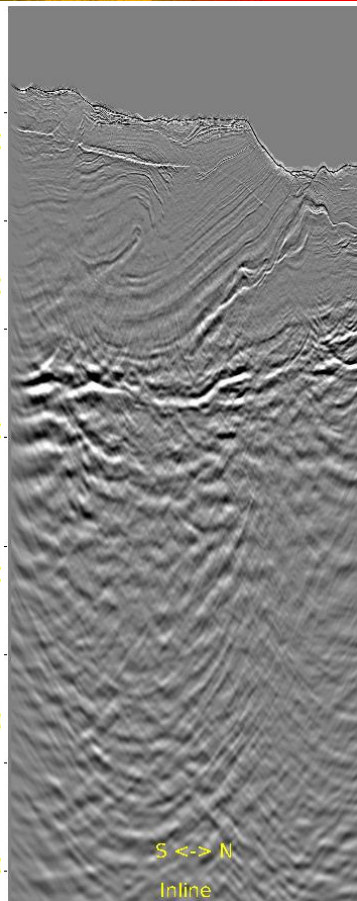
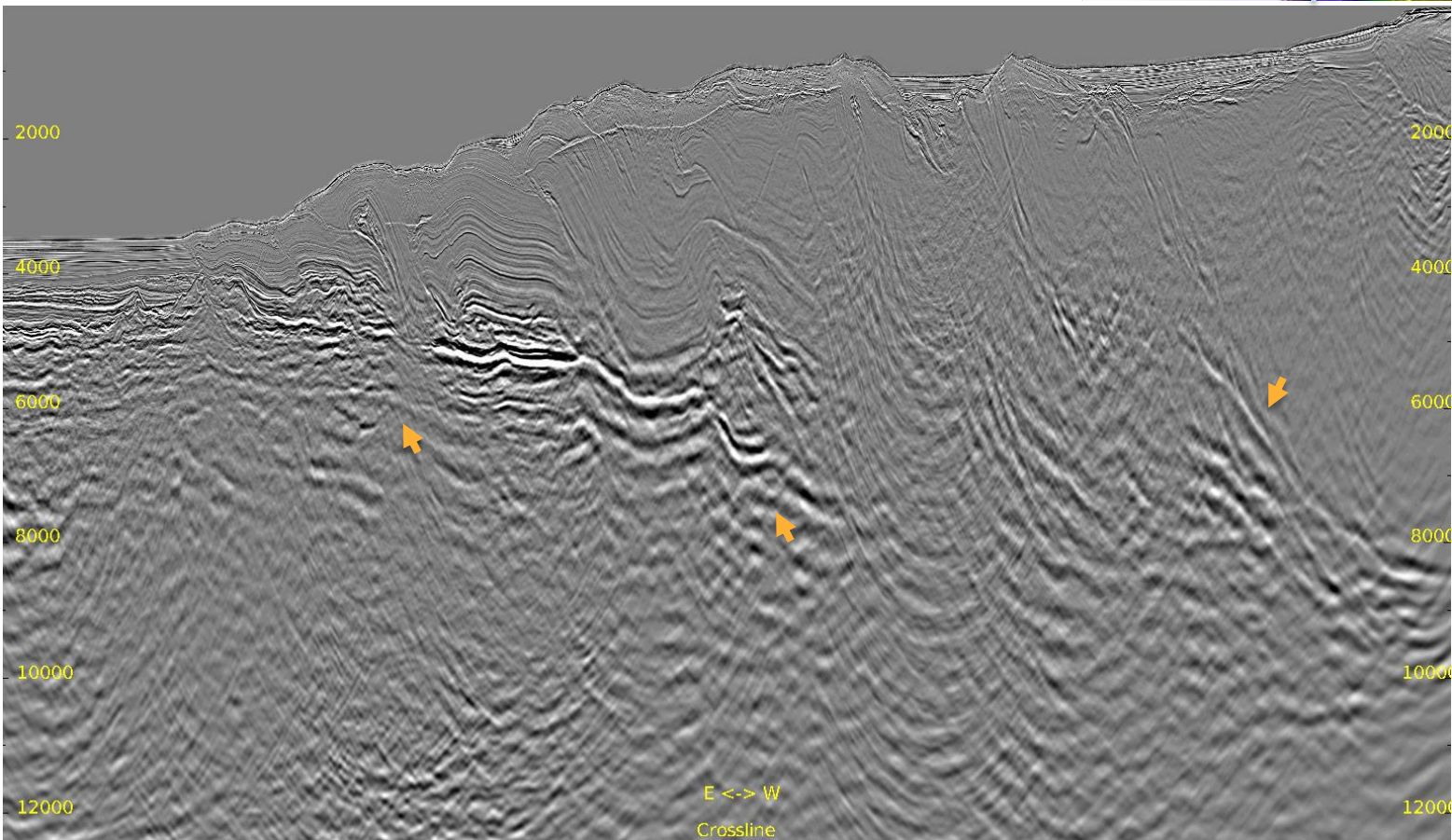
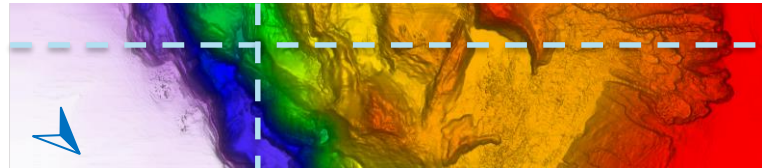
Inline 236 & Crossline 2368





# Full Stack: after TTI FWI

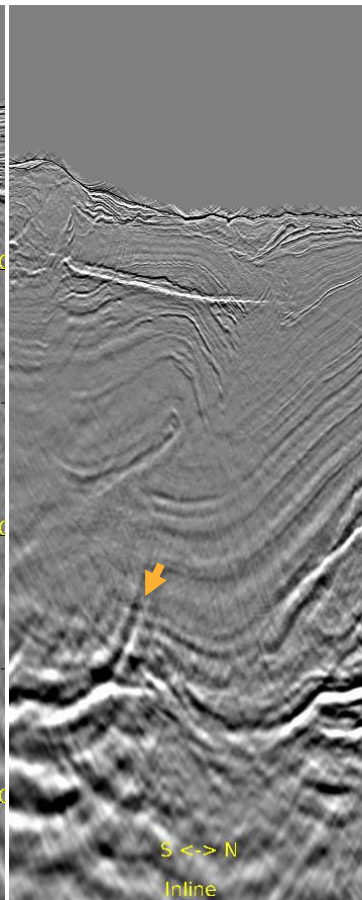
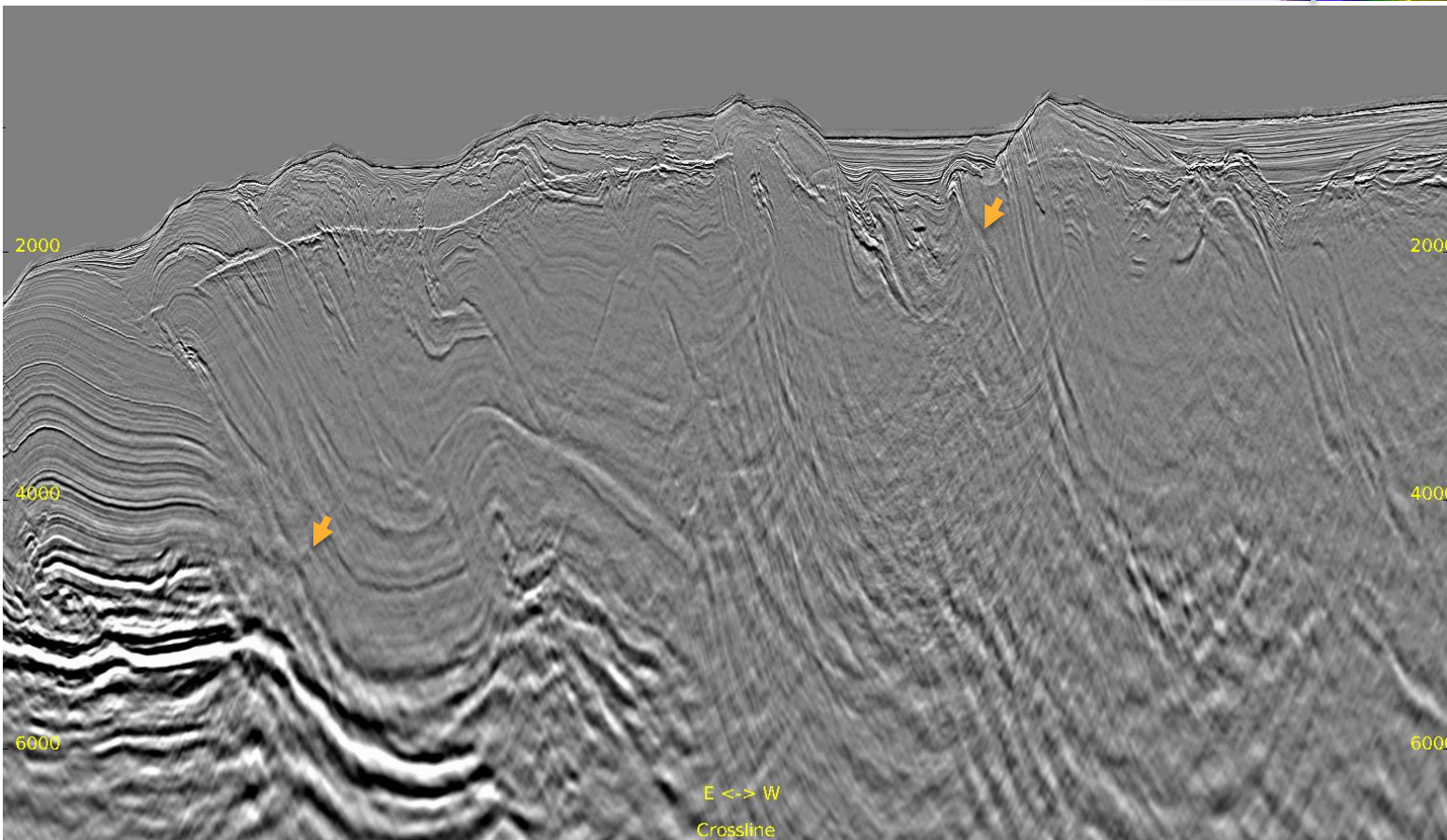
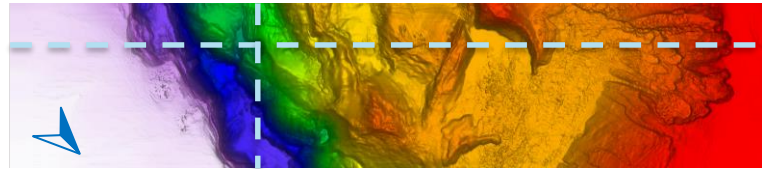
Inline 236 & Crossline 2368





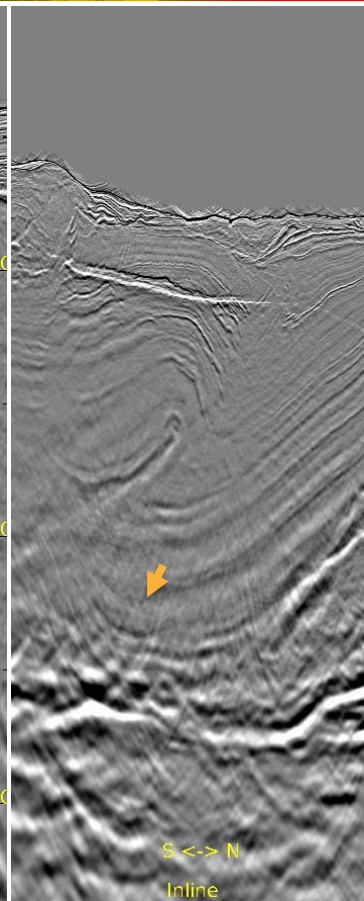
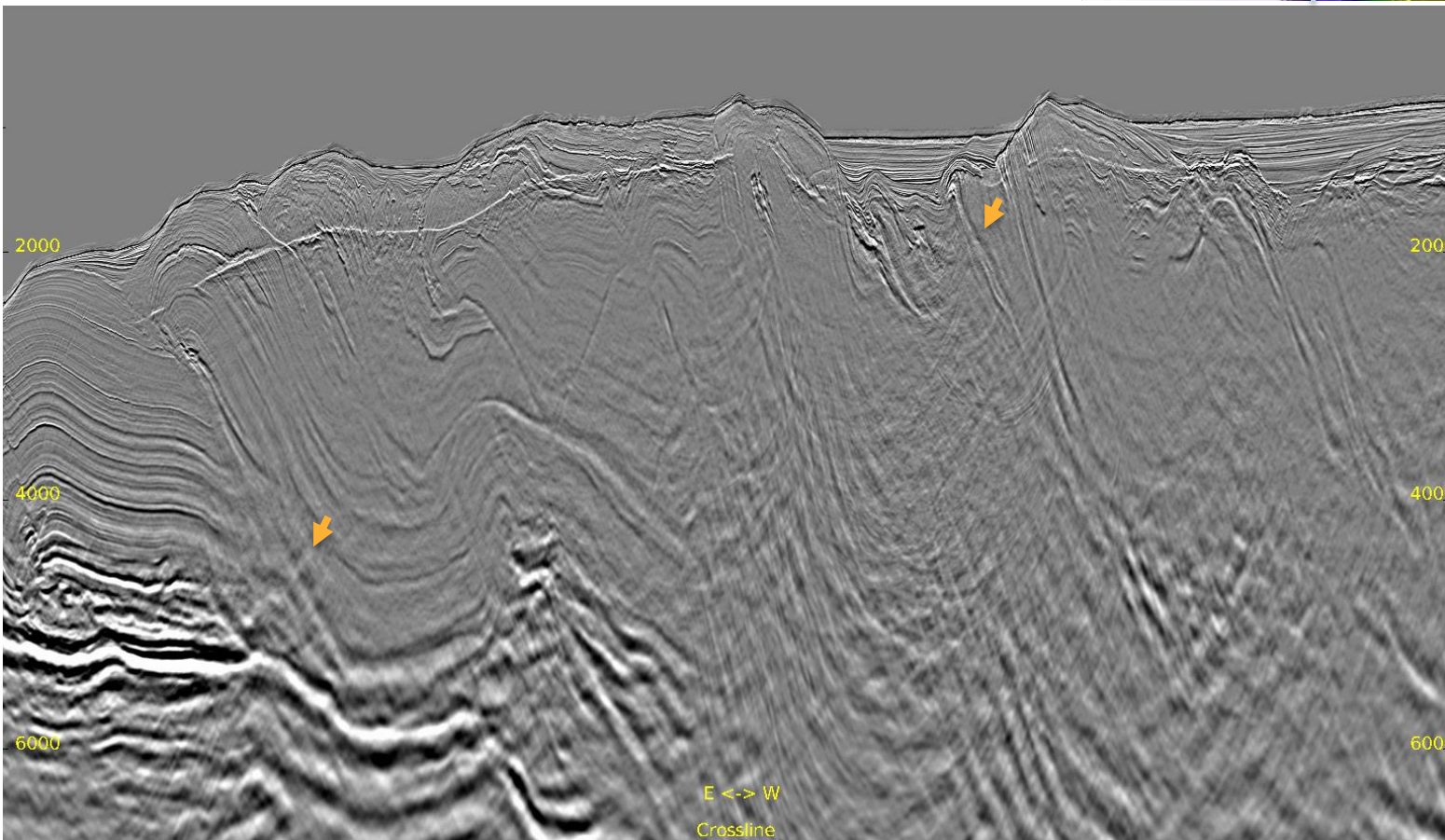
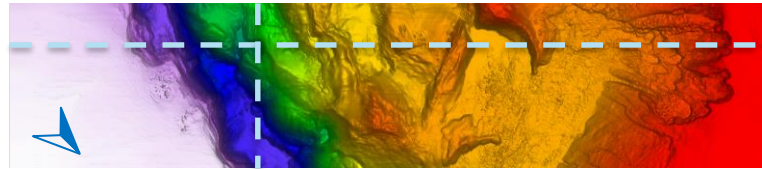
# Zoomed Full Stack: before TTI FWI

Inline 236 & Crossline 2368



# Zoomed Full Stack: after TTI FWI

Inline 236 & Crossline 2368



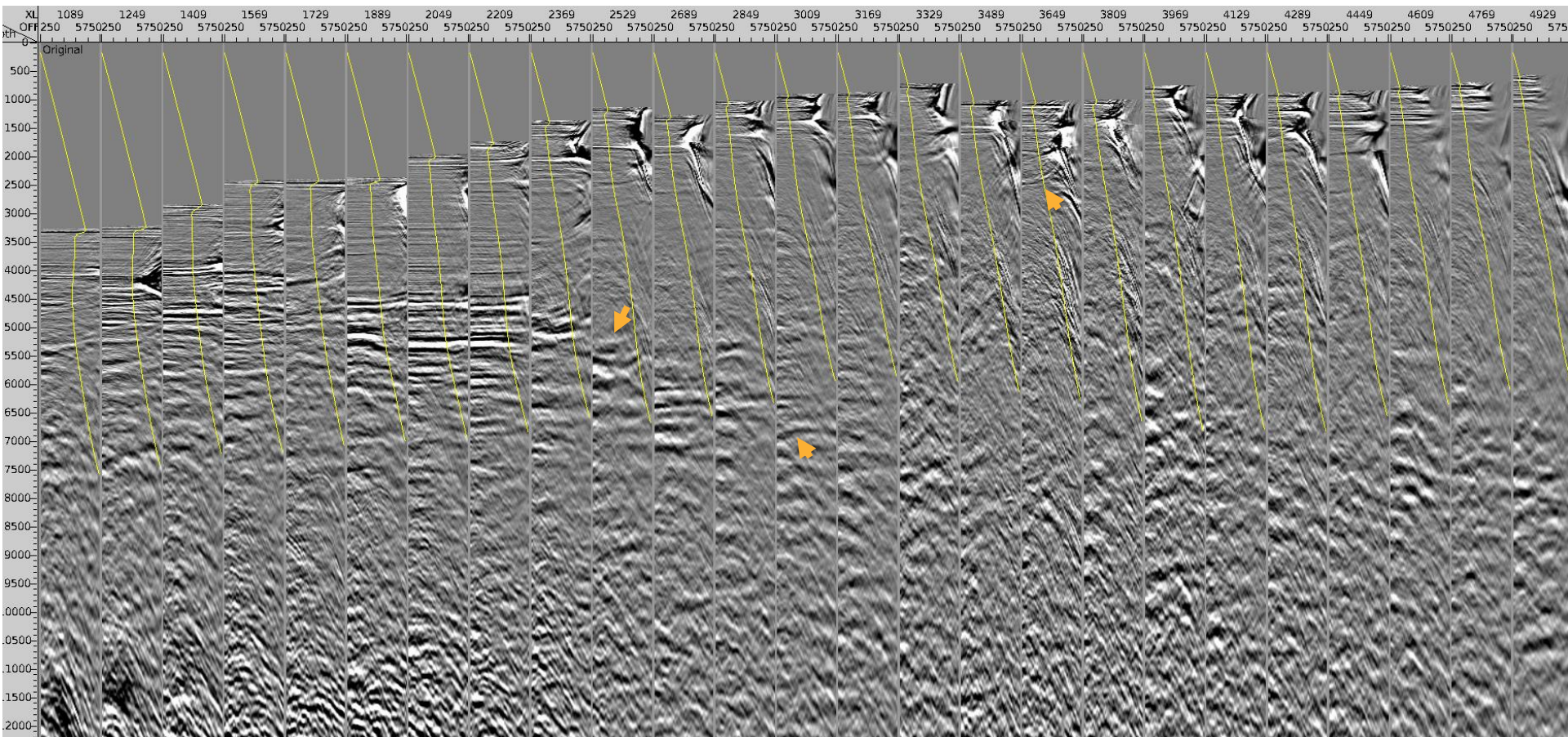




# Inline 236 CDP Gathers: before TTI FWI

— 35° Mute

18



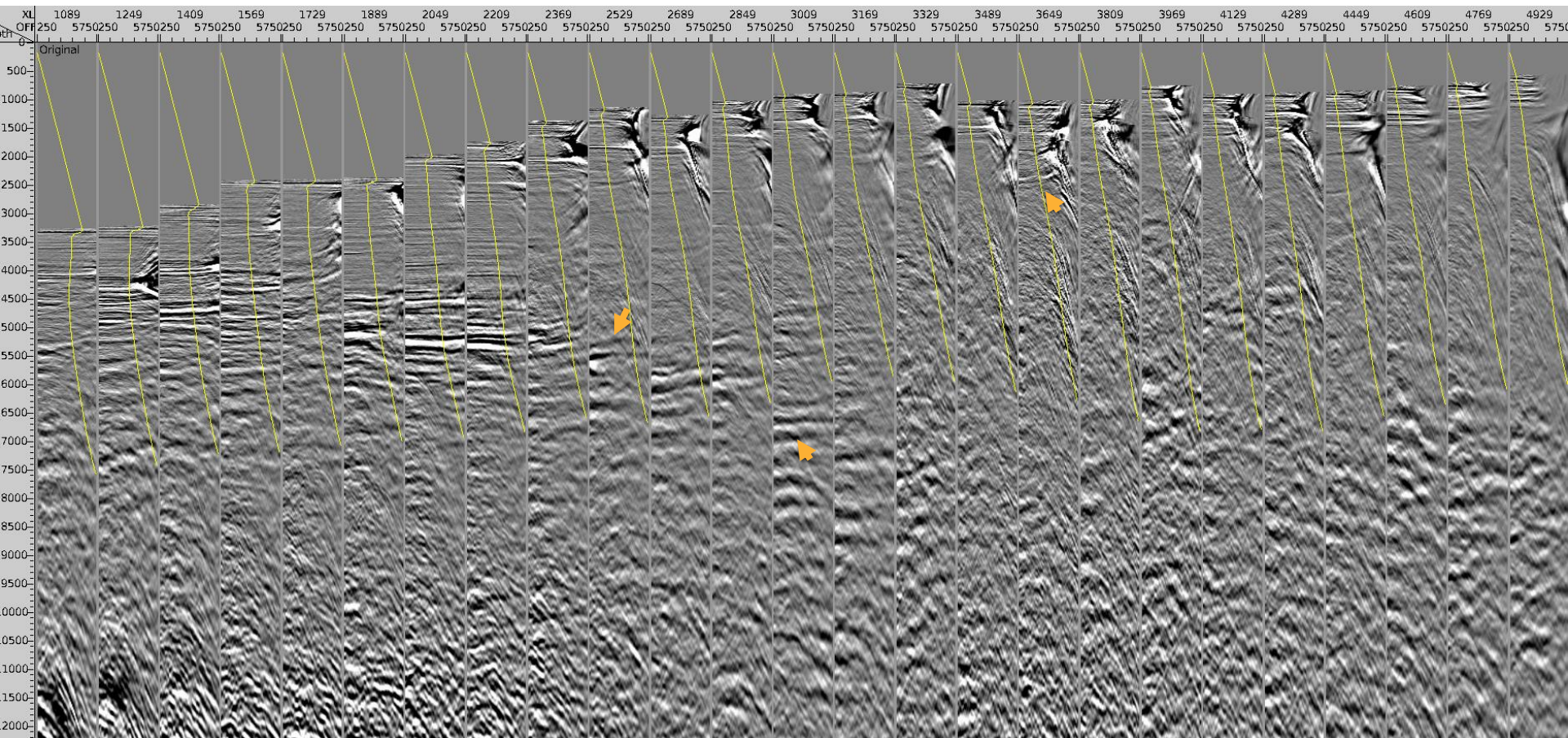




# Inline 236 CDP Gathers: **after** TTI FWI

— 35° Mute

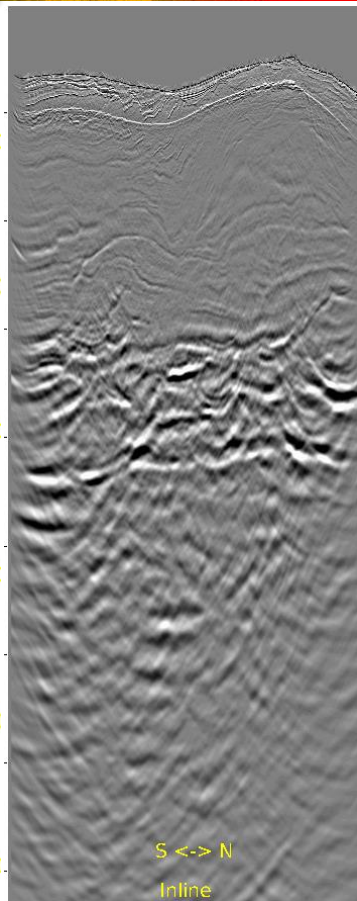
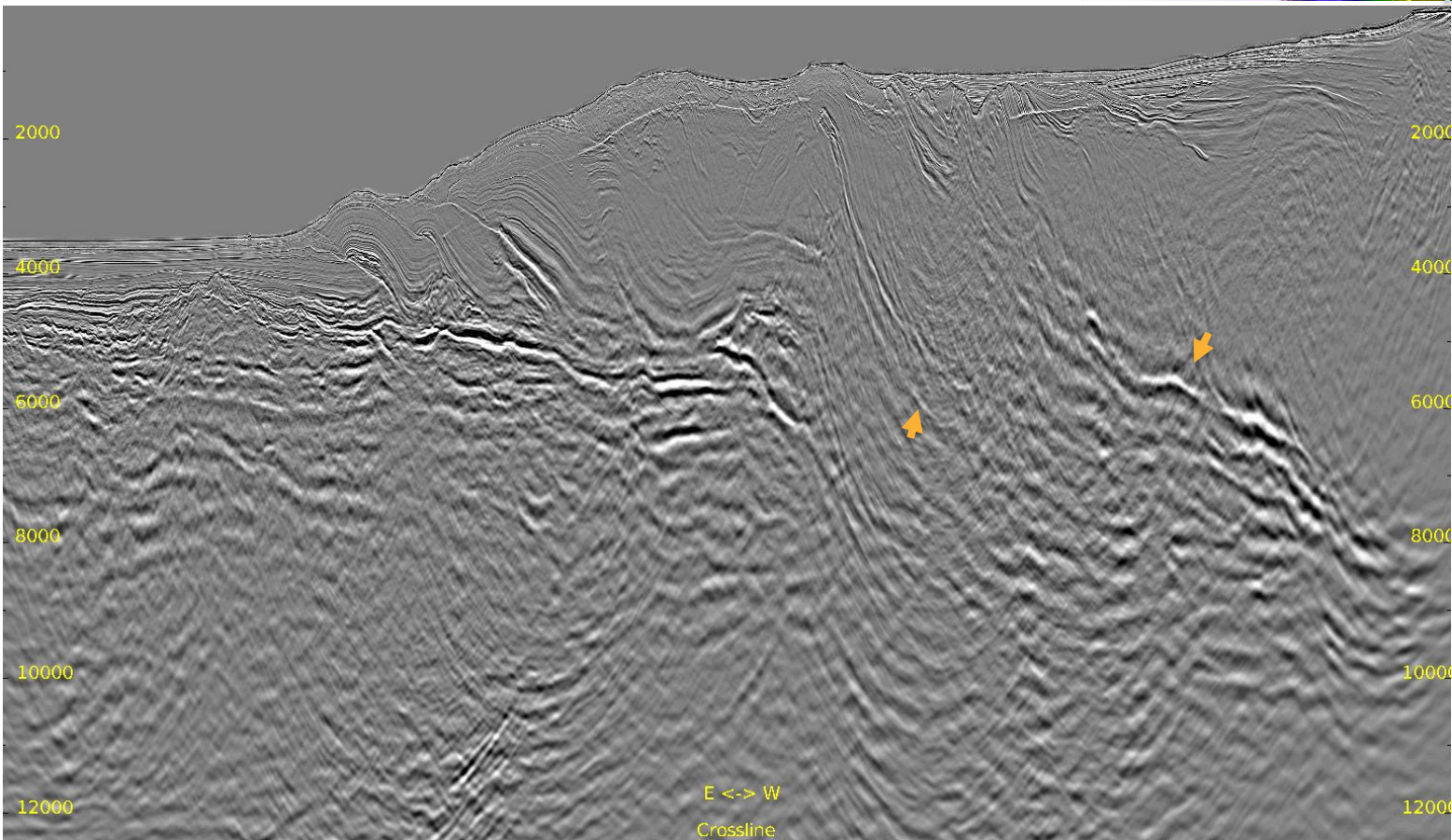
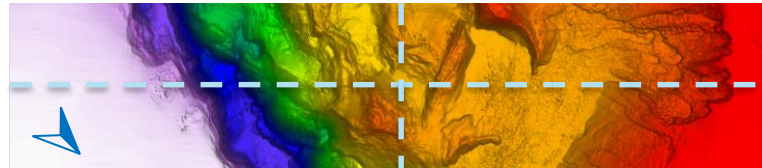
19





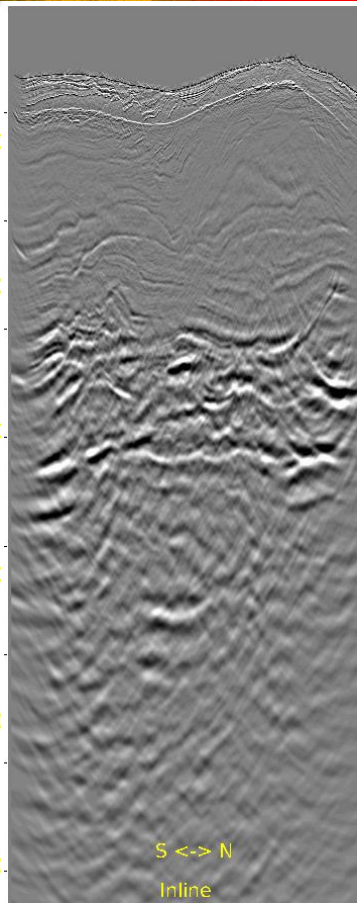
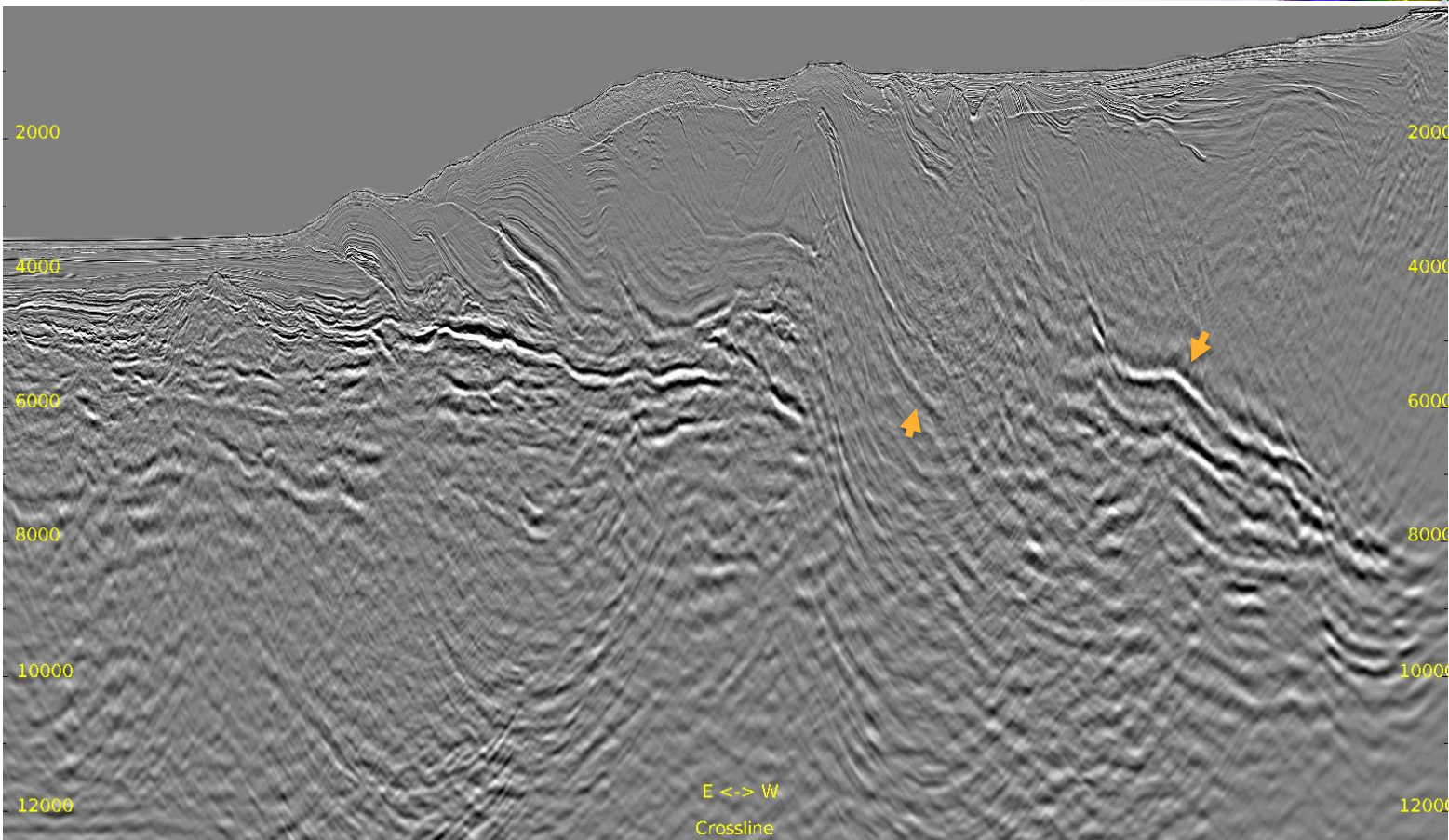
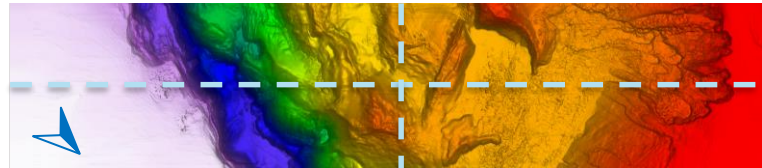
# Full Stack: before TTI FWI

Inline 430 & Crossline 2889



# Full Stack: after TTI FWI

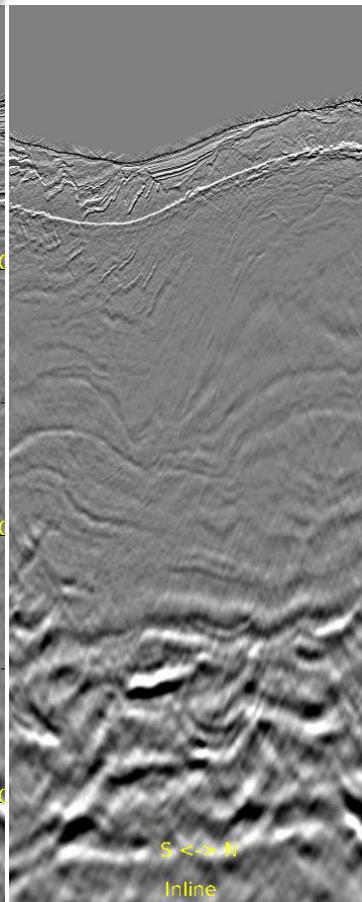
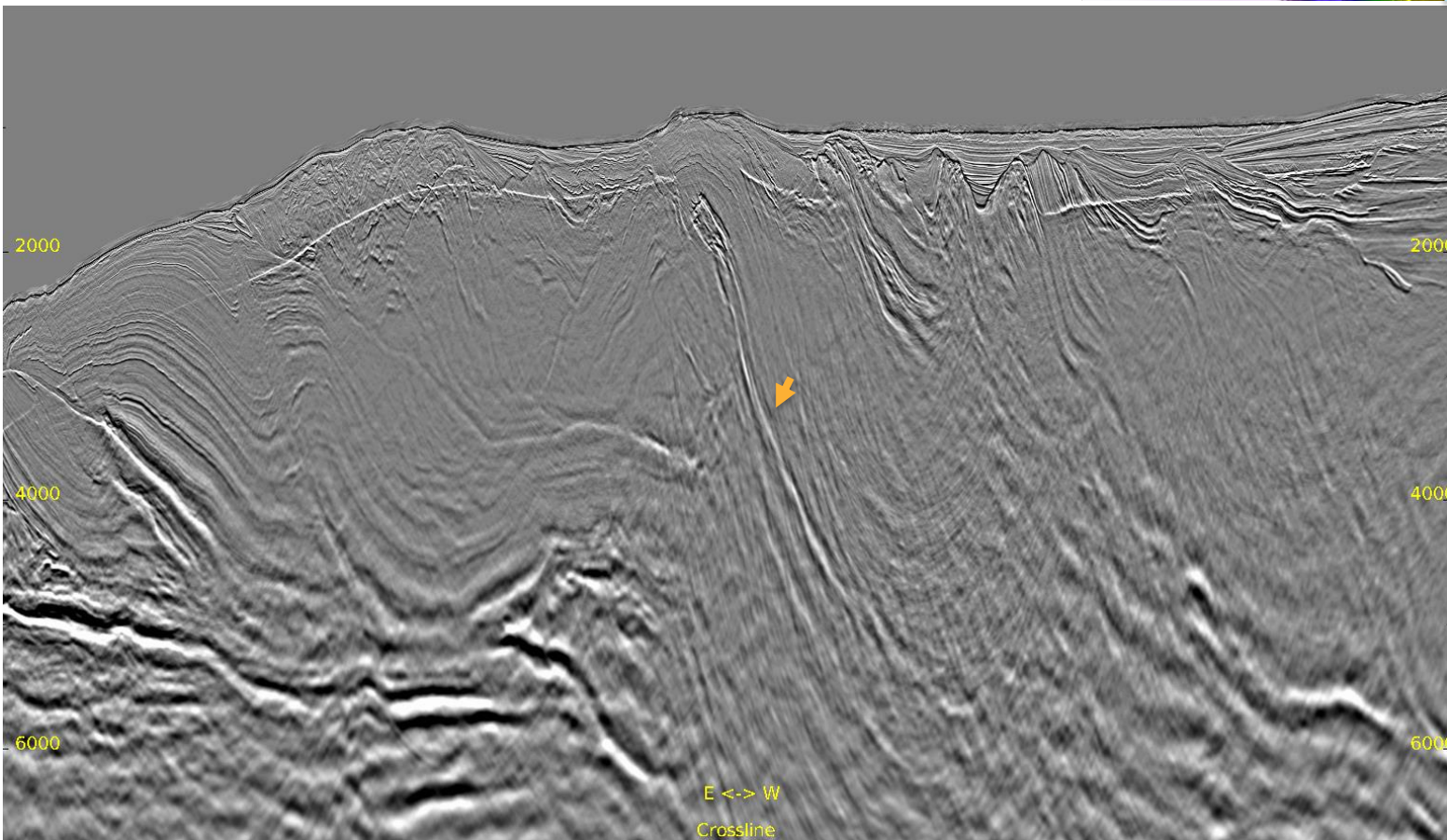
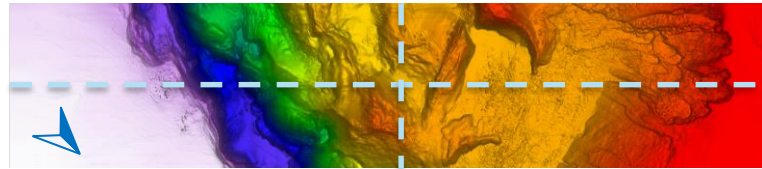
Inline 430 & Crossline 2889





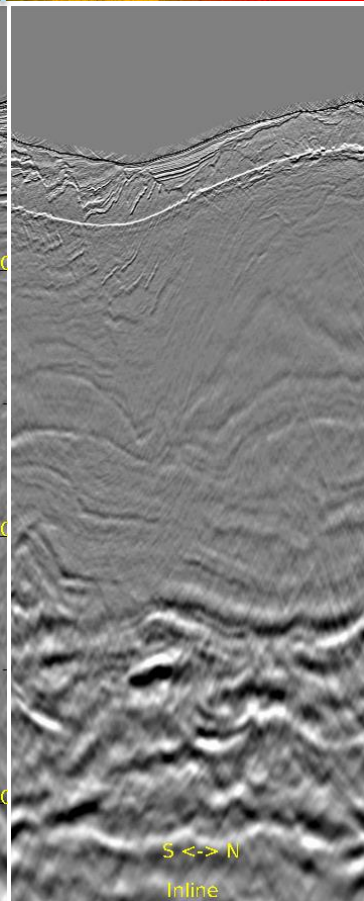
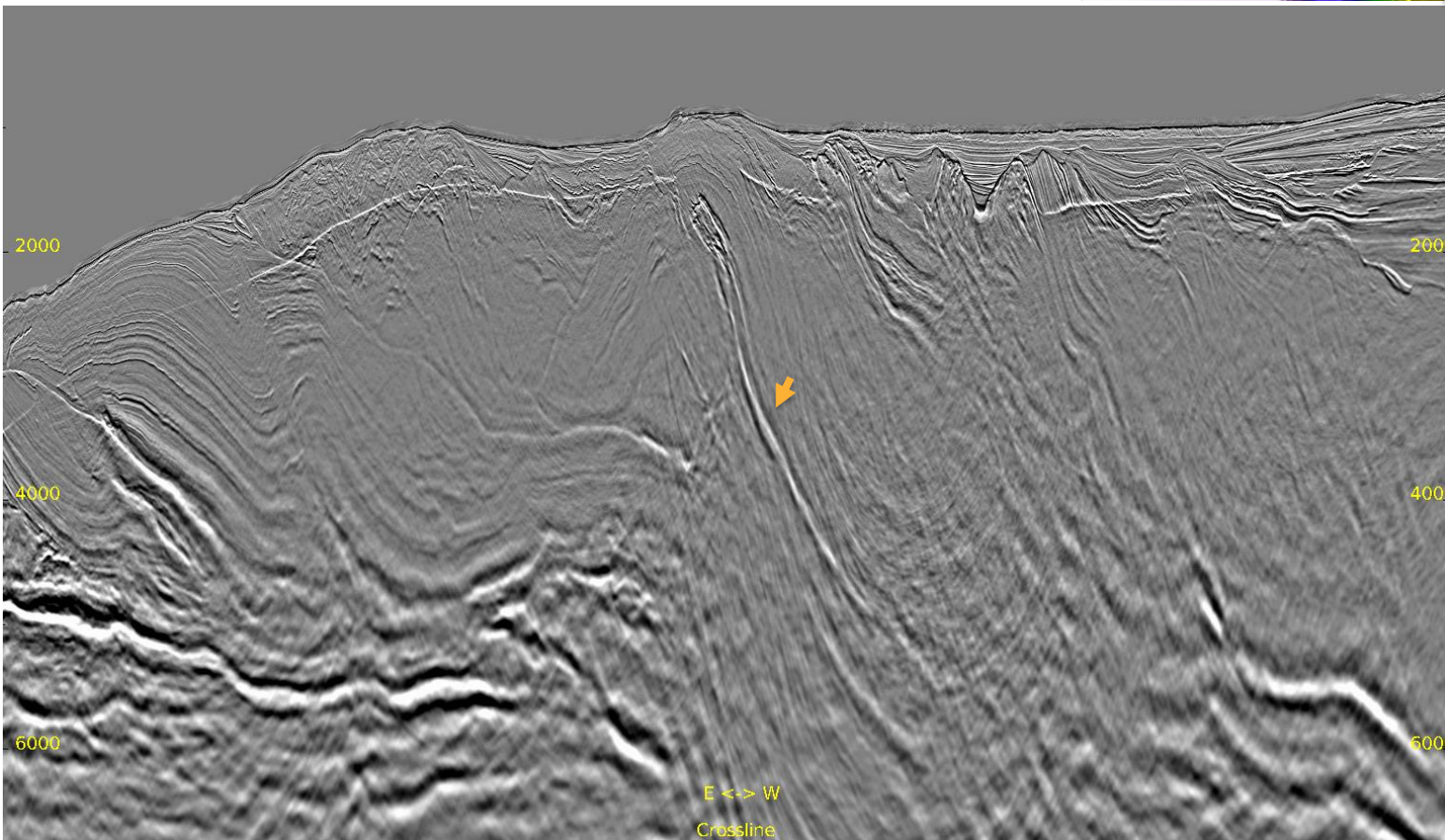
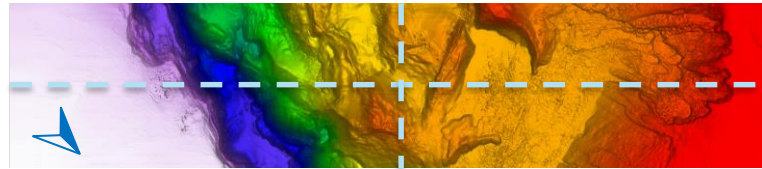
# Zoomed Full Stack: before TTI FWI

Inline 430 & Crossline 2889



# Zoomed Full Stack: after TTI FWI

Inline 430 & Crossline 2889



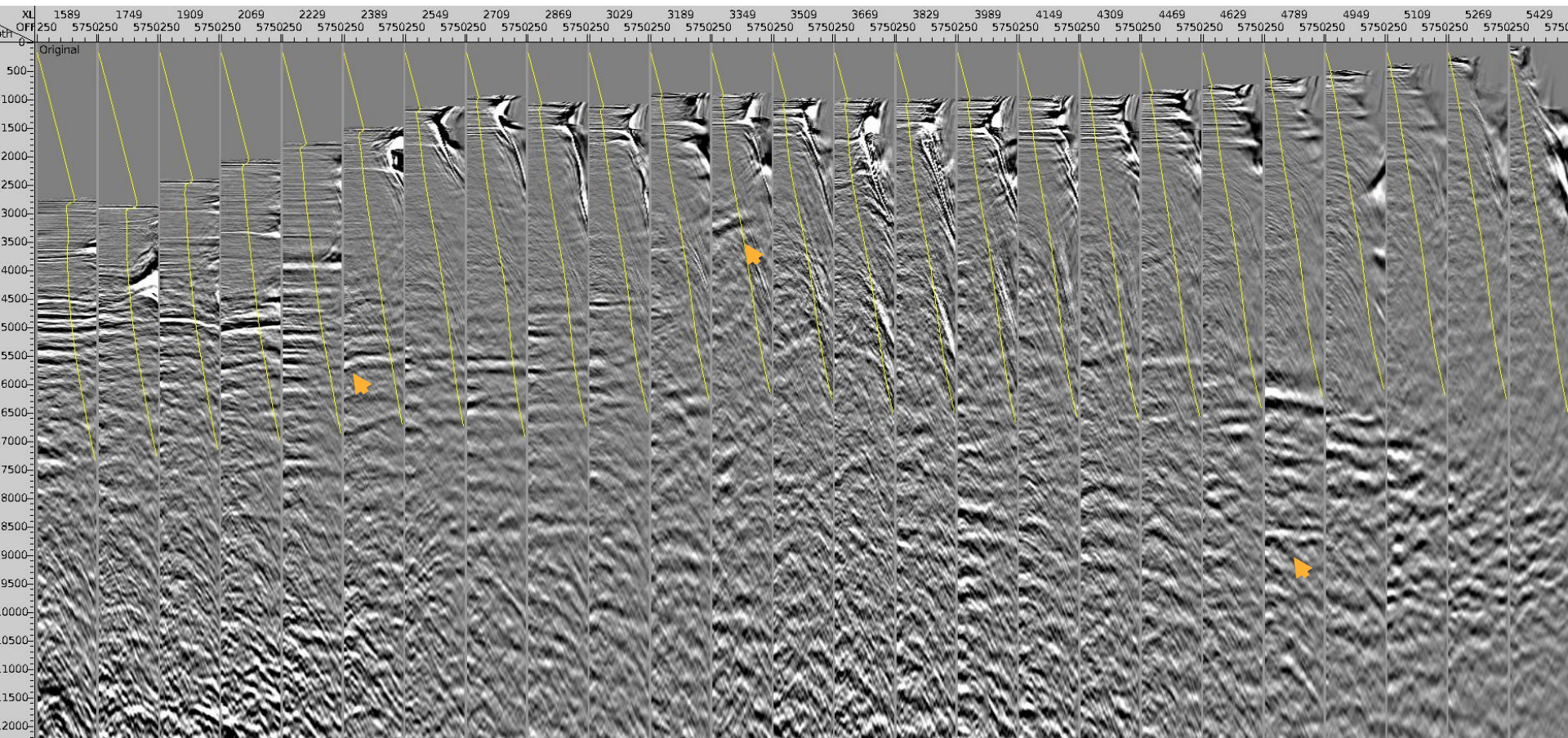




# Inline 430 CDP Gathers: before TTI FWI

— 35° Mute

24



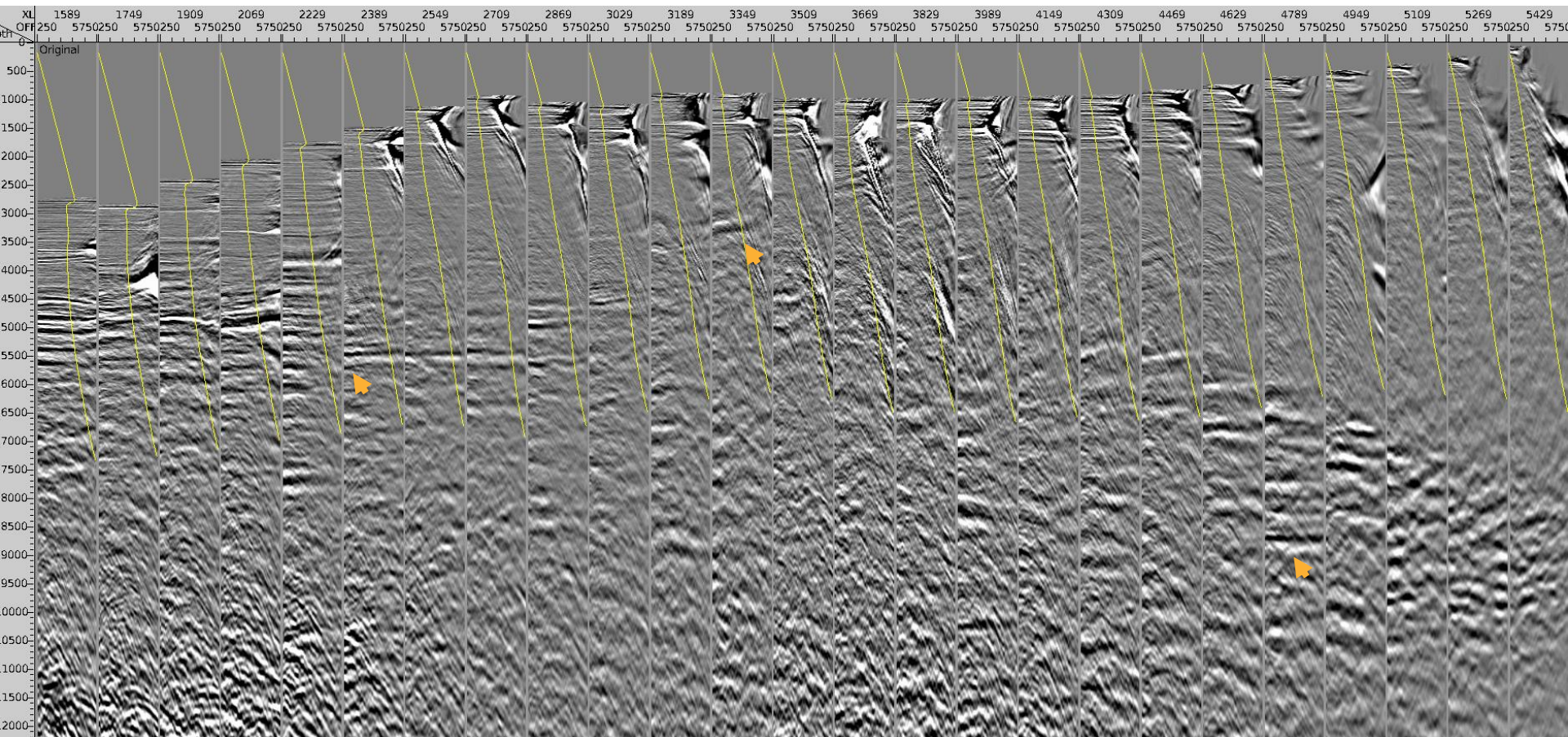




# Inline 430 CDP Gathers: **after** TTI FWI

— 35° Mute

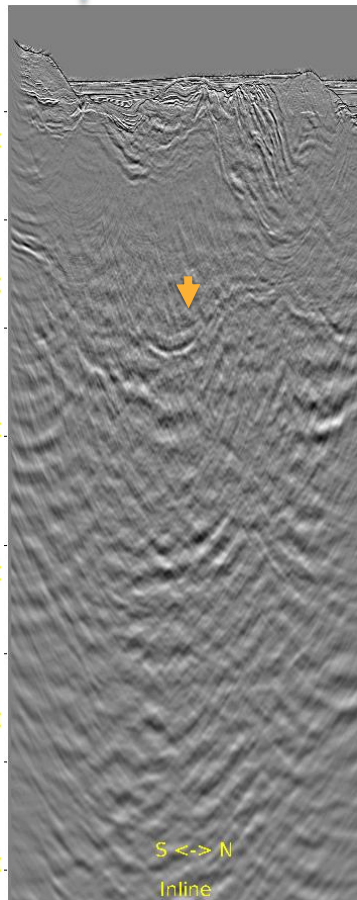
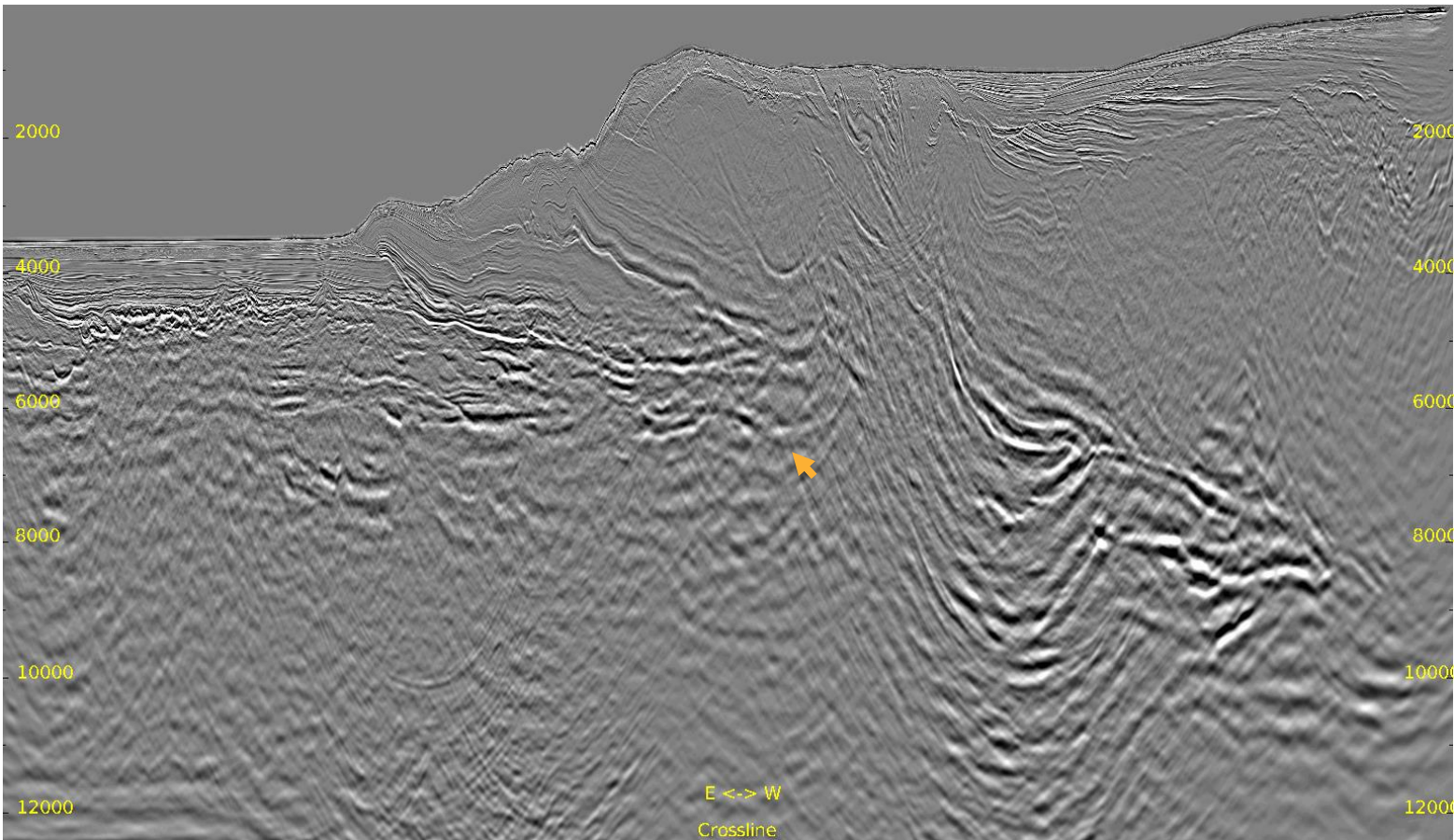
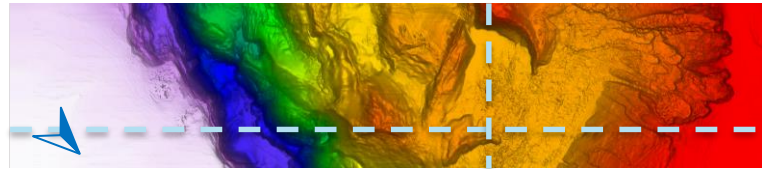
25





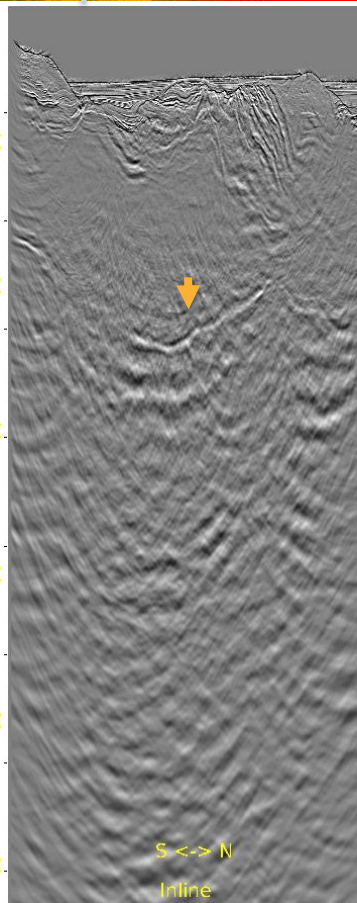
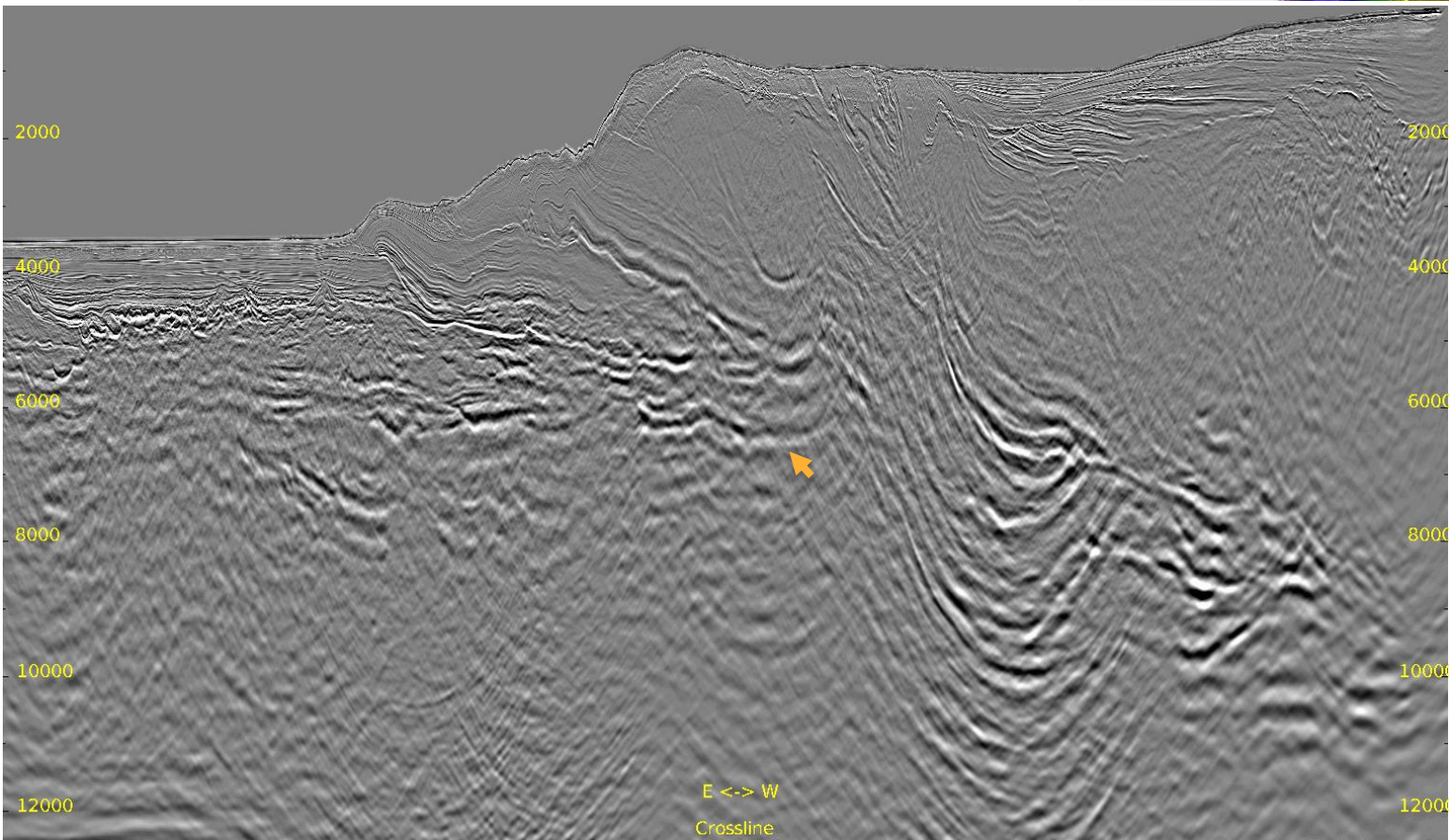
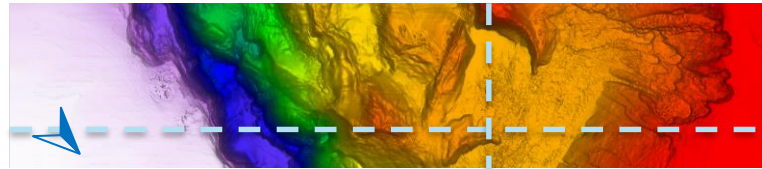
# Full Stack: before TTI FWI

Inline 628 & Crossline 3524



# Full Stack: after TTI FWI

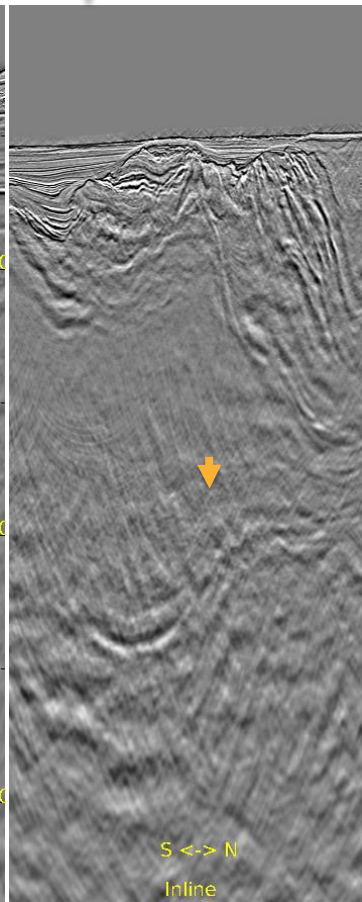
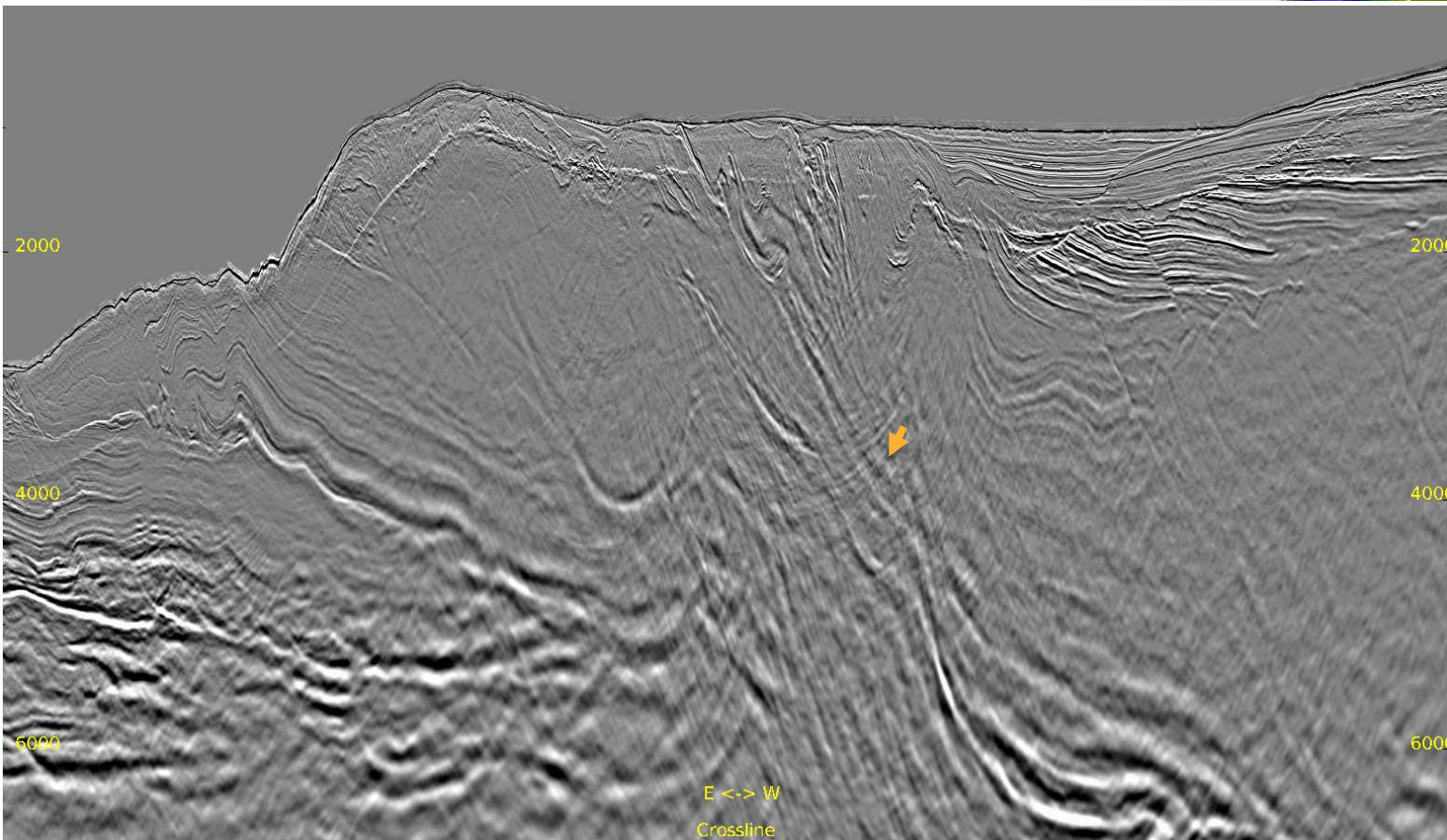
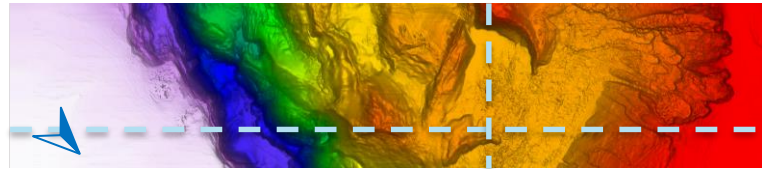
Inline 628 & Crossline 3524





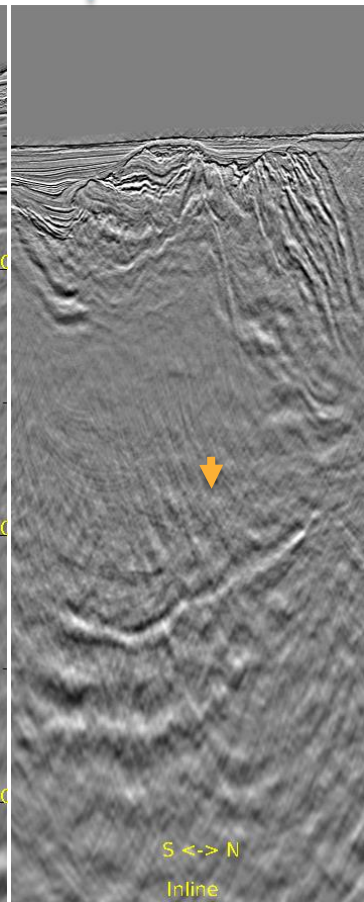
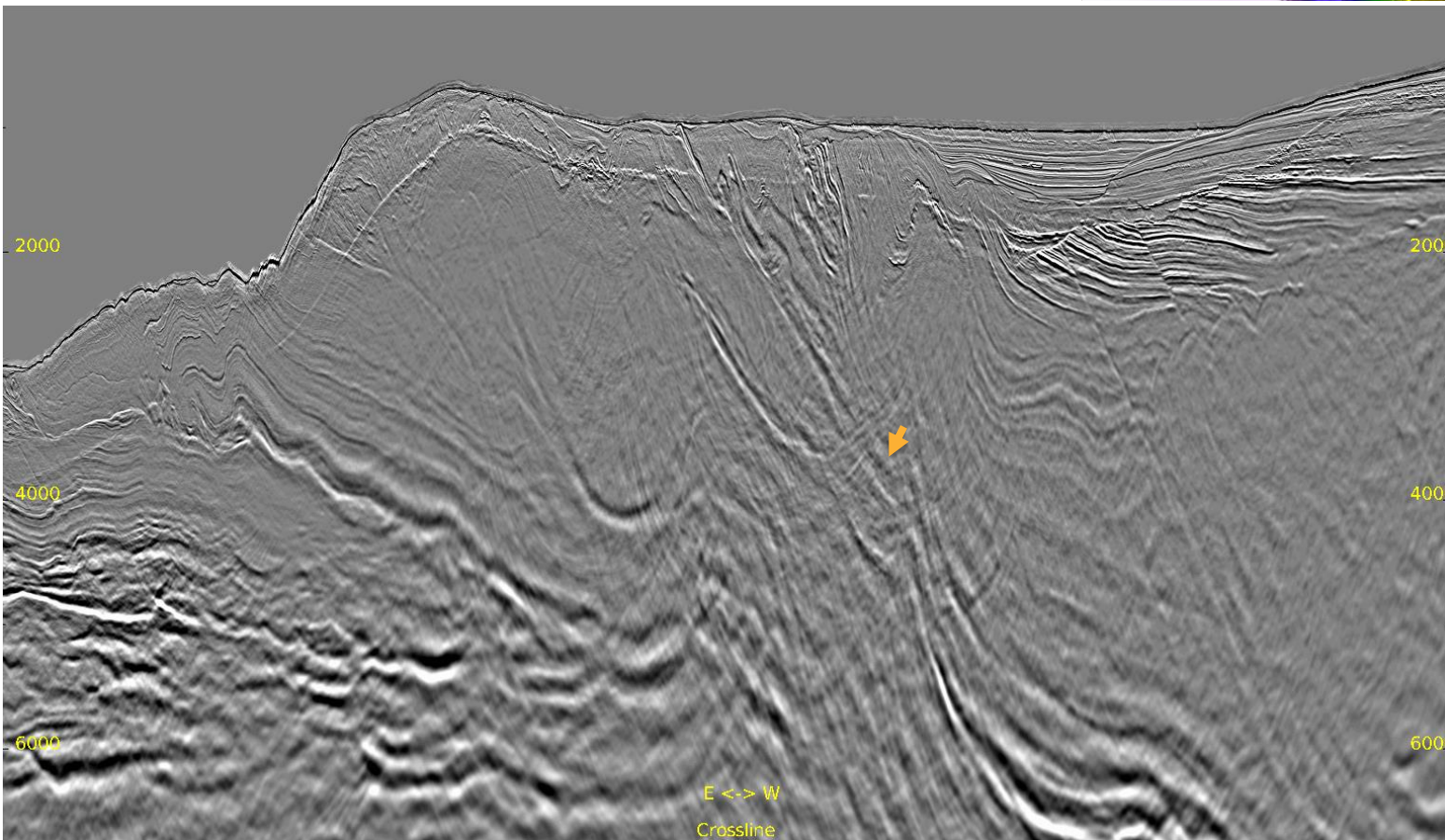
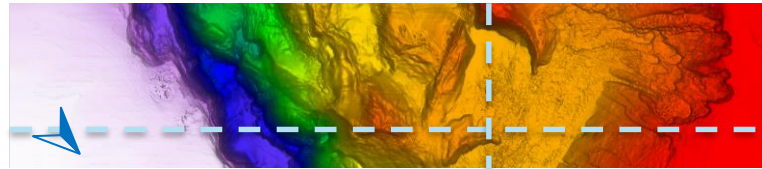
# Zoomed Full Stack: before TTI FWI

Inline 628 & Crossline 3524



# Zoomed Full Stack: after TTI FWI

Inline 628 & Crossline 3524



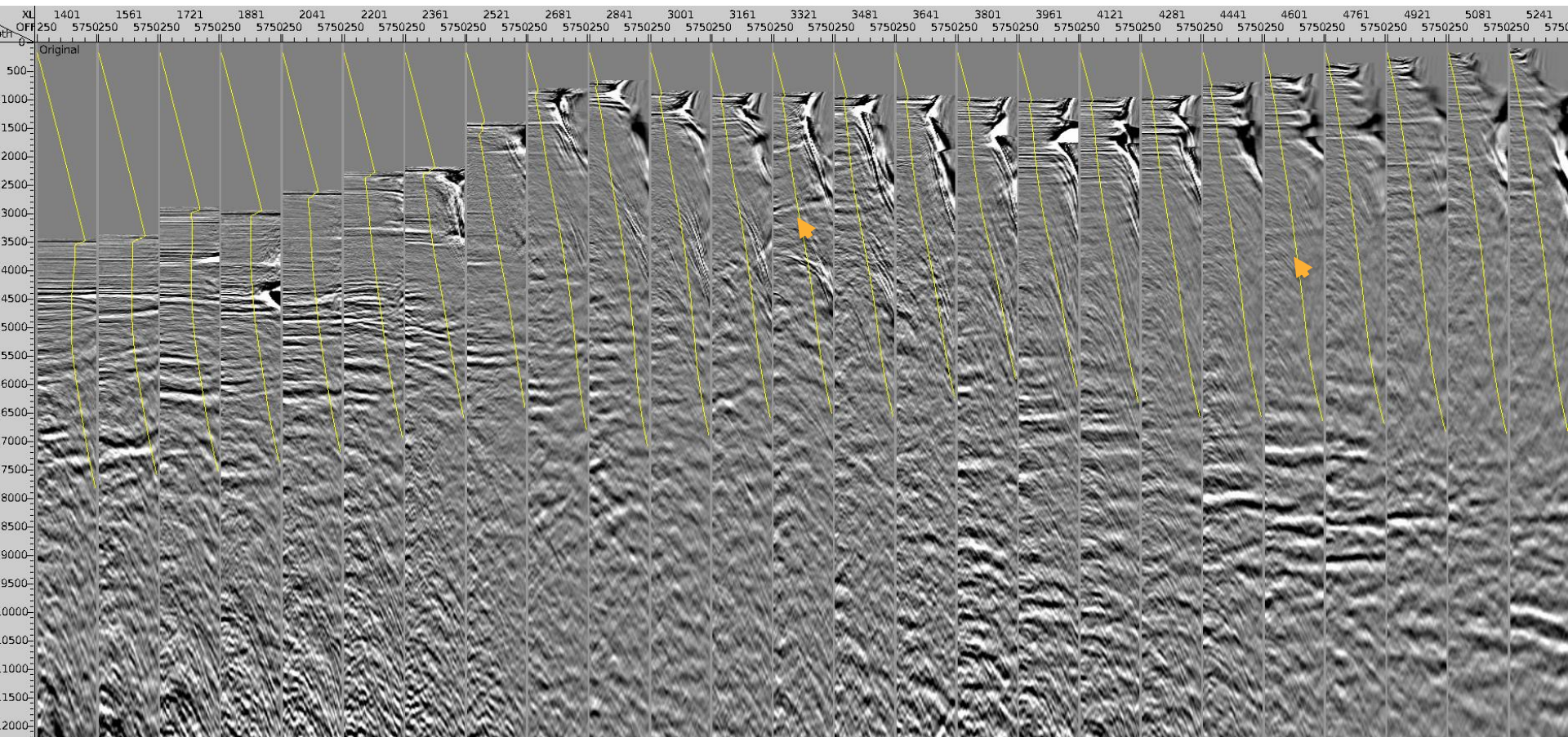




# Inline 628 CDP Gathers: before TTI FWI

— 35° Mute

30



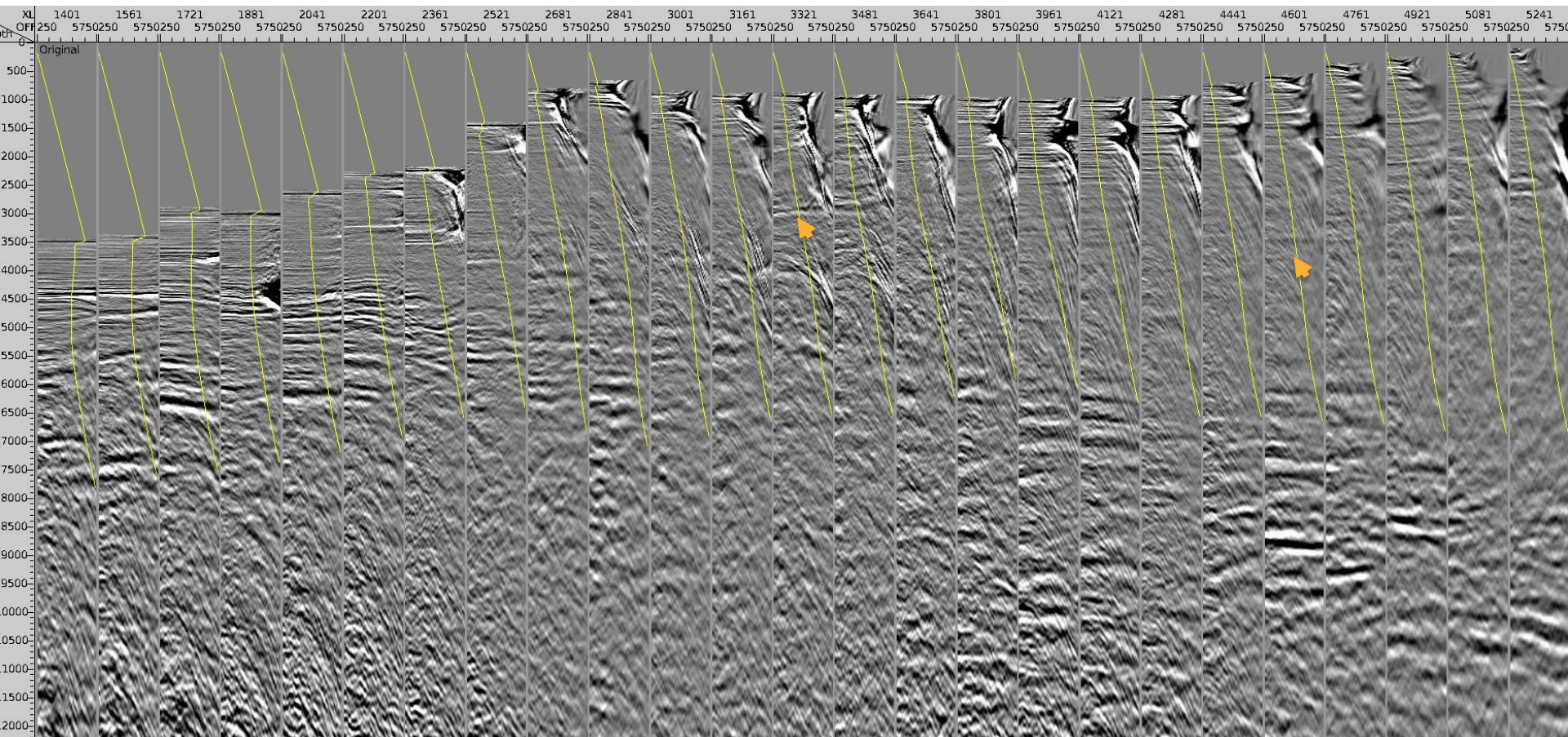




# Inline 628 CDP Gathers: after TTI FWI

— 35° Mute

31





# IT4 – RTM Test

## NZ 3D Processing

24 March 2021

[cgg.com](http://cgg.com)



INSTITUTE FOR GEOPHYSICS



Passion for Geoscience

- **Objective:**

To evaluate the benefit from RTM compared to Kirchhoff migration.

- **Procedure:**

TTI RTM was run to 20Hz using IT4 velocity.

- **Display:**

Migrated depth full stack & gathers.

- **Observation and Recommendation:**

20Hz TTI RTM result has less migration swings and high frequency noises. Events in the deep sections are more continuous and better illuminated at places where velocity is complex.



Inline 601

Kirchhoff

RTM

4km

8km

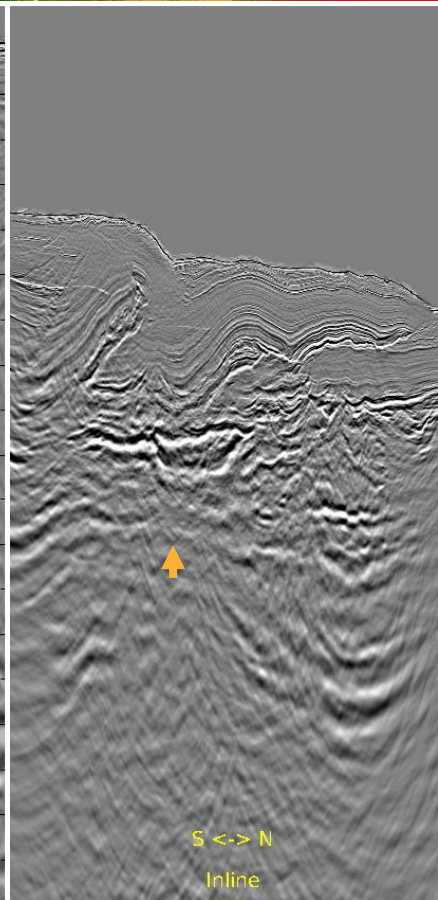
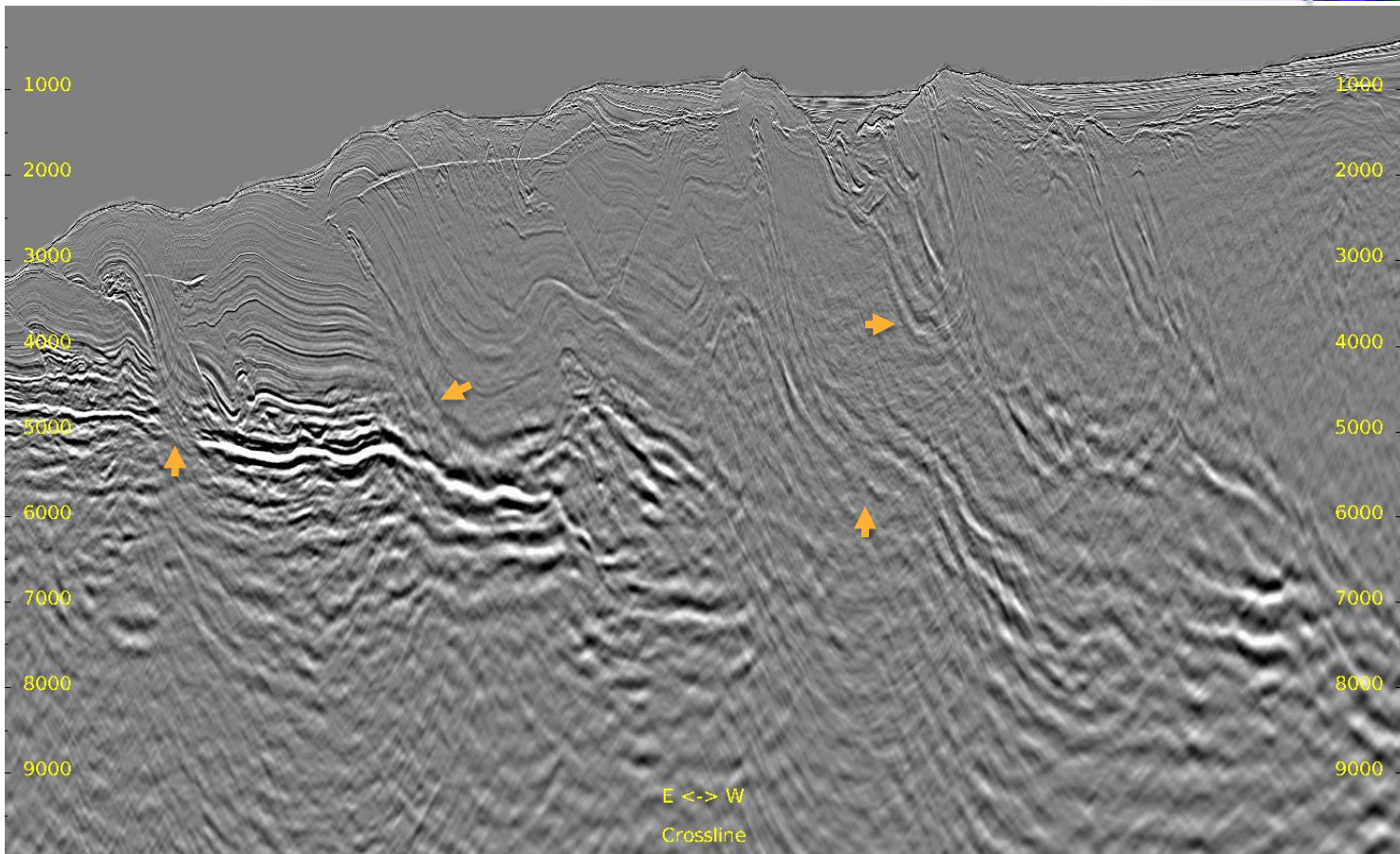
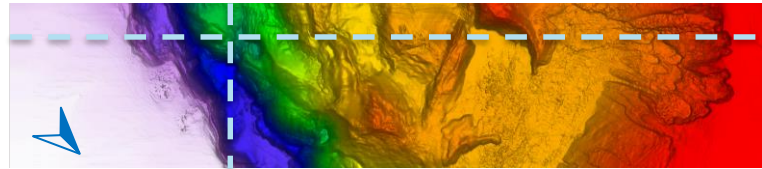
Xline 3898

Kirchhoff

RTM

# Full Stack: TTI Kirchhoff Migration

Inline 209 & Crossline 1683

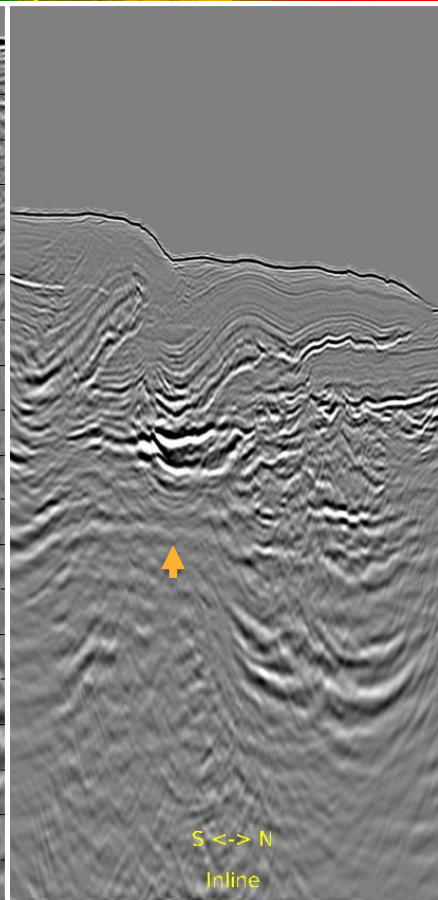
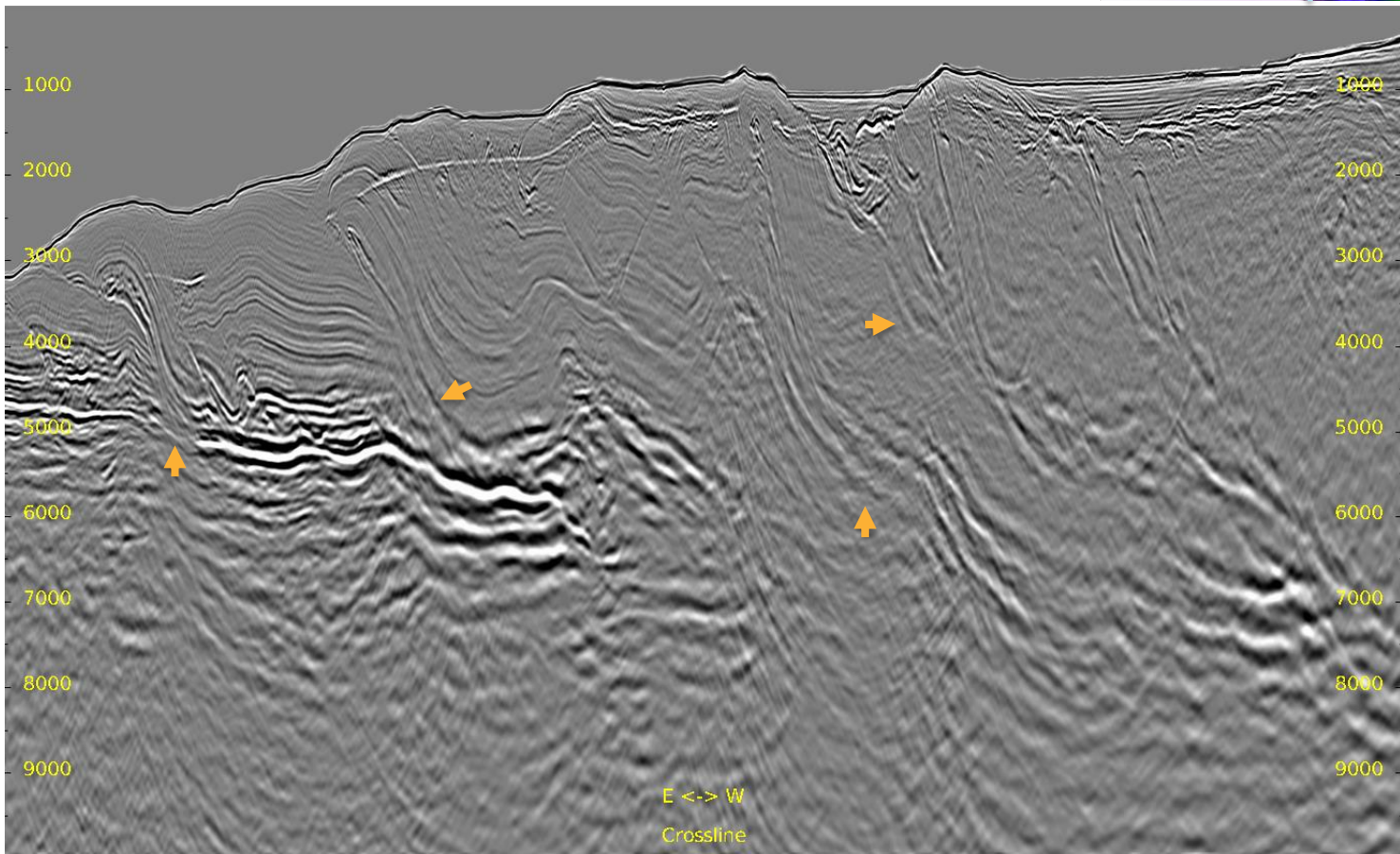
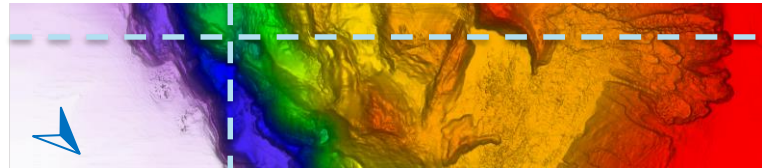






# Full Stack: TTI RTM

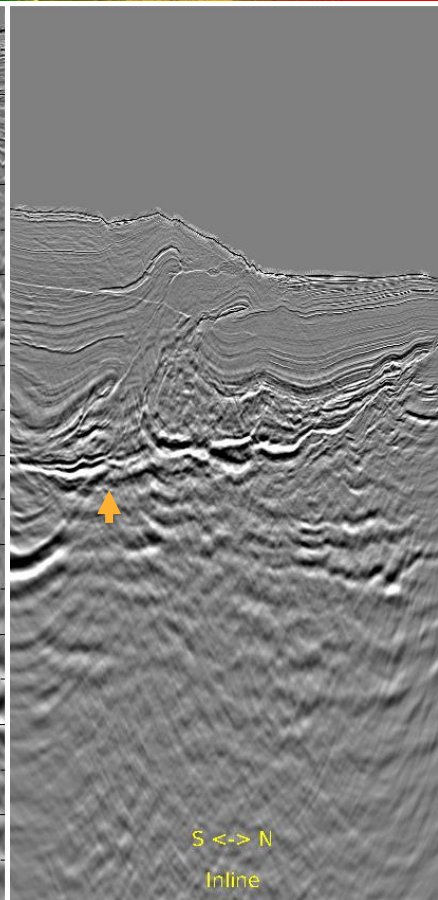
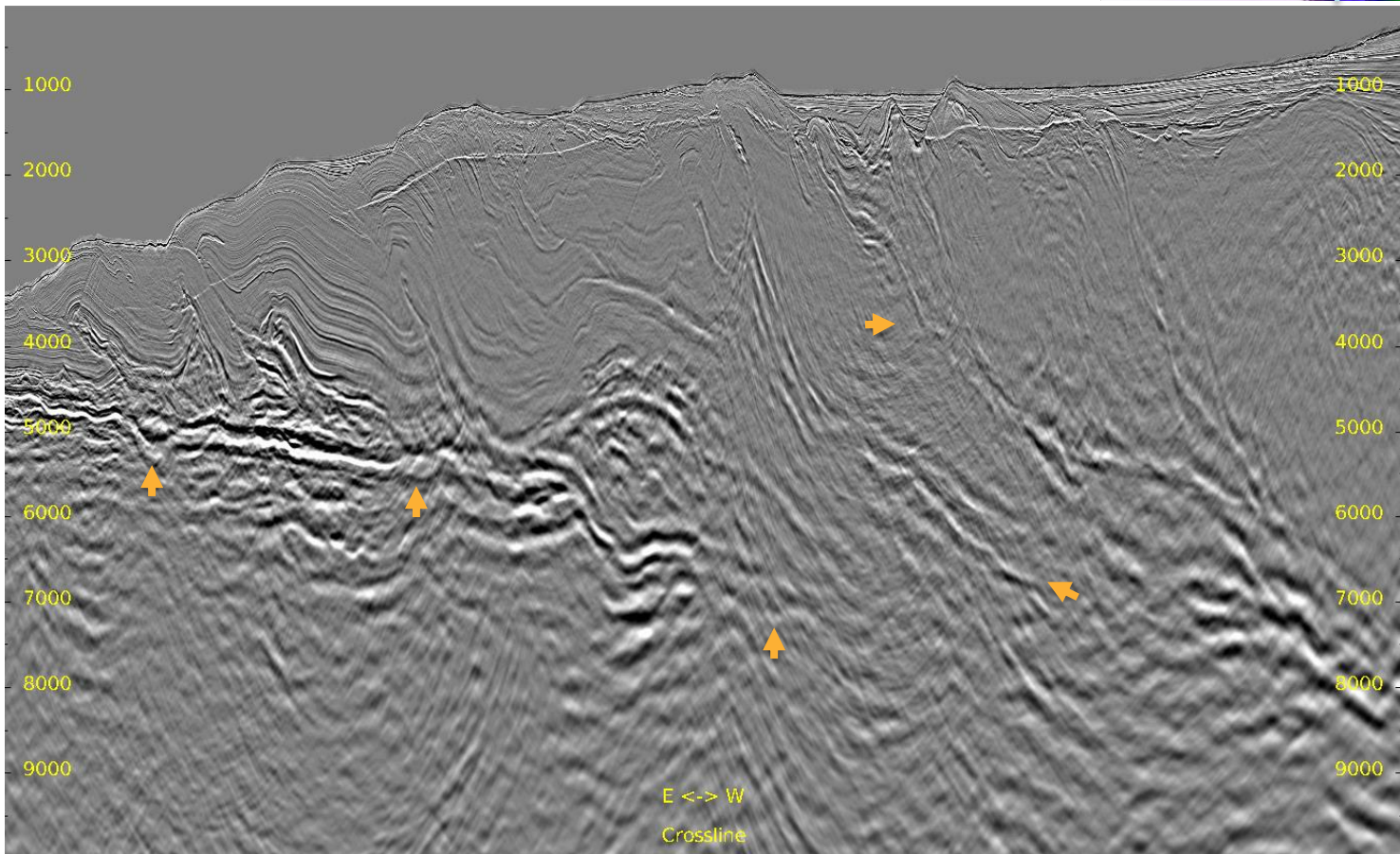
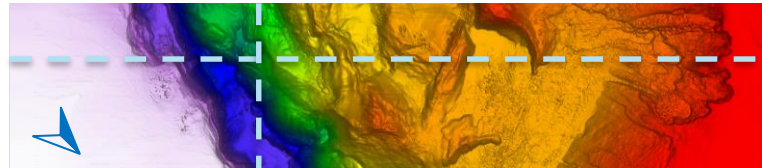
Inline 209 & Crossline 1683





# Full Stack: TTI Kirchhoff Migration

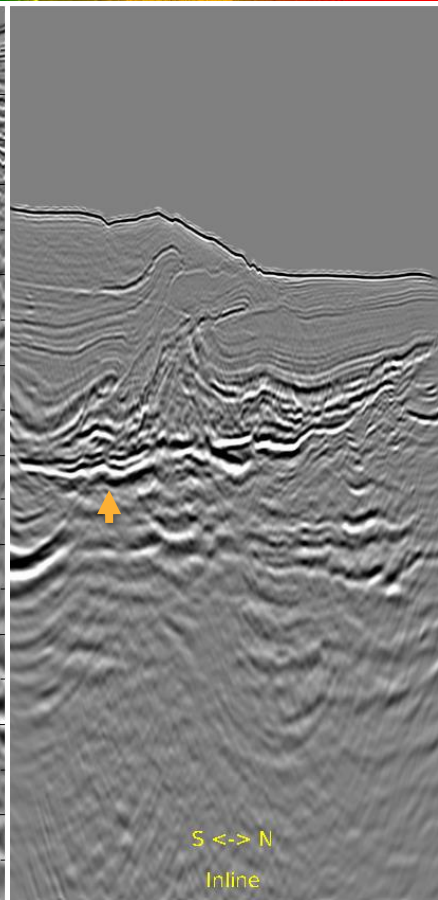
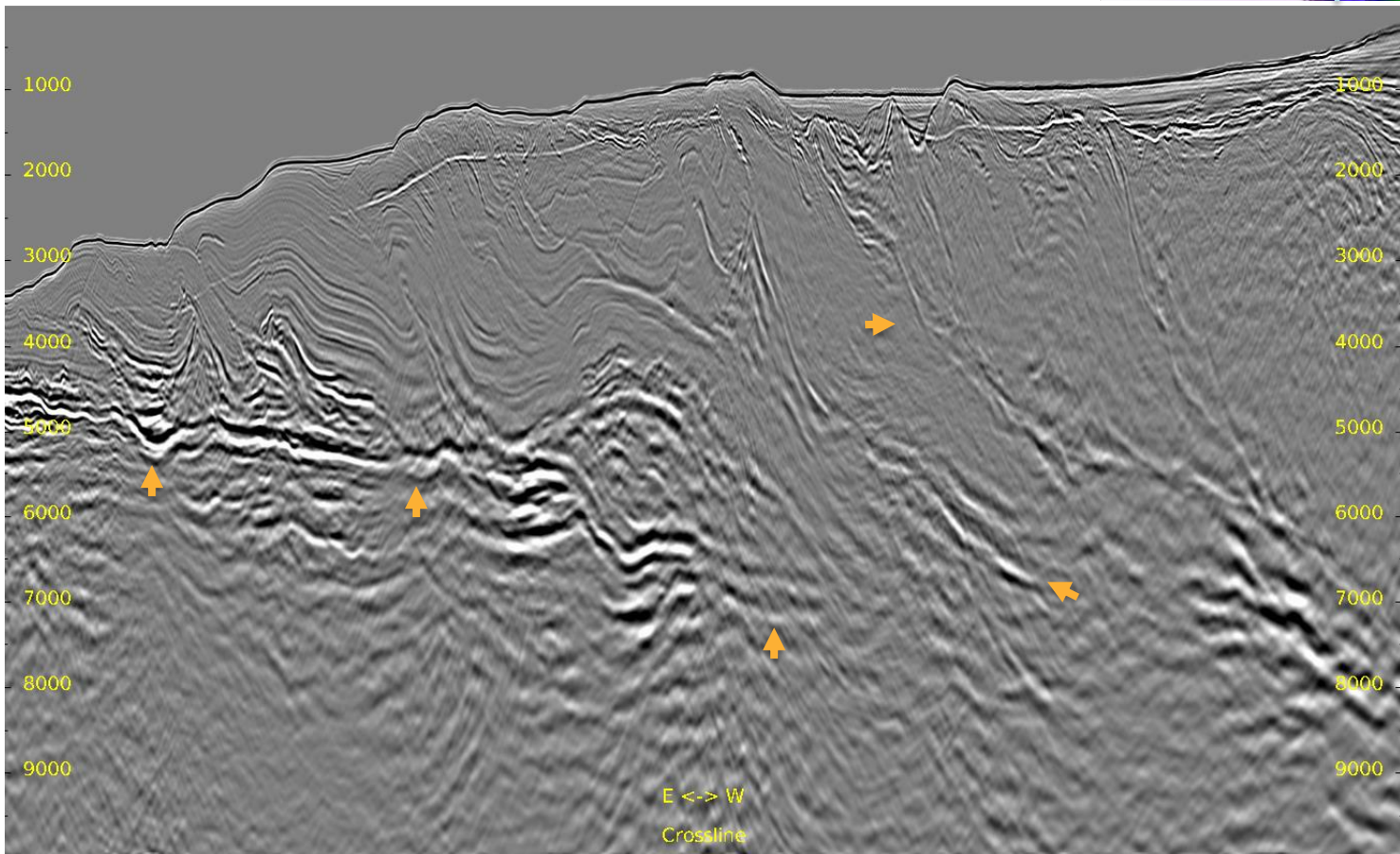
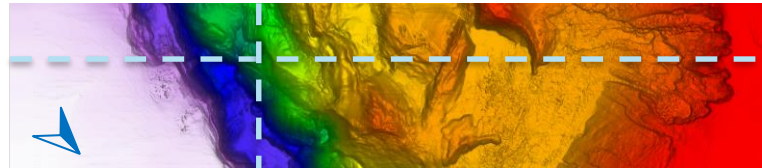
Inline 329 & Crossline 1835





# Full Stack: TTI RTM

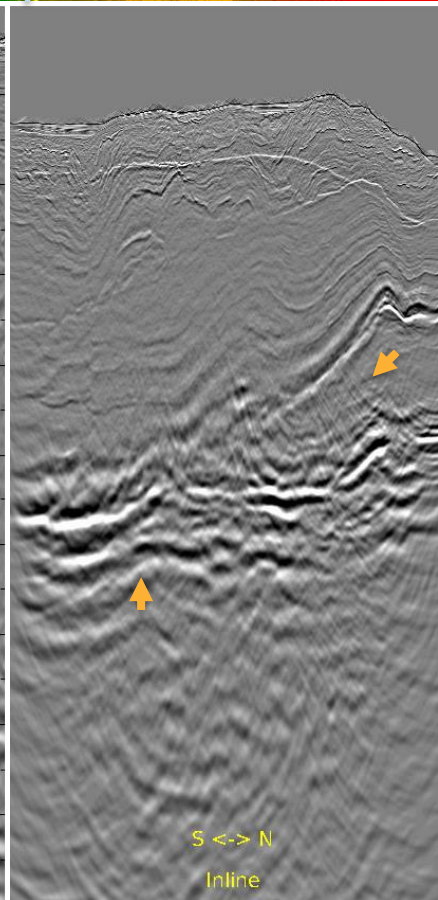
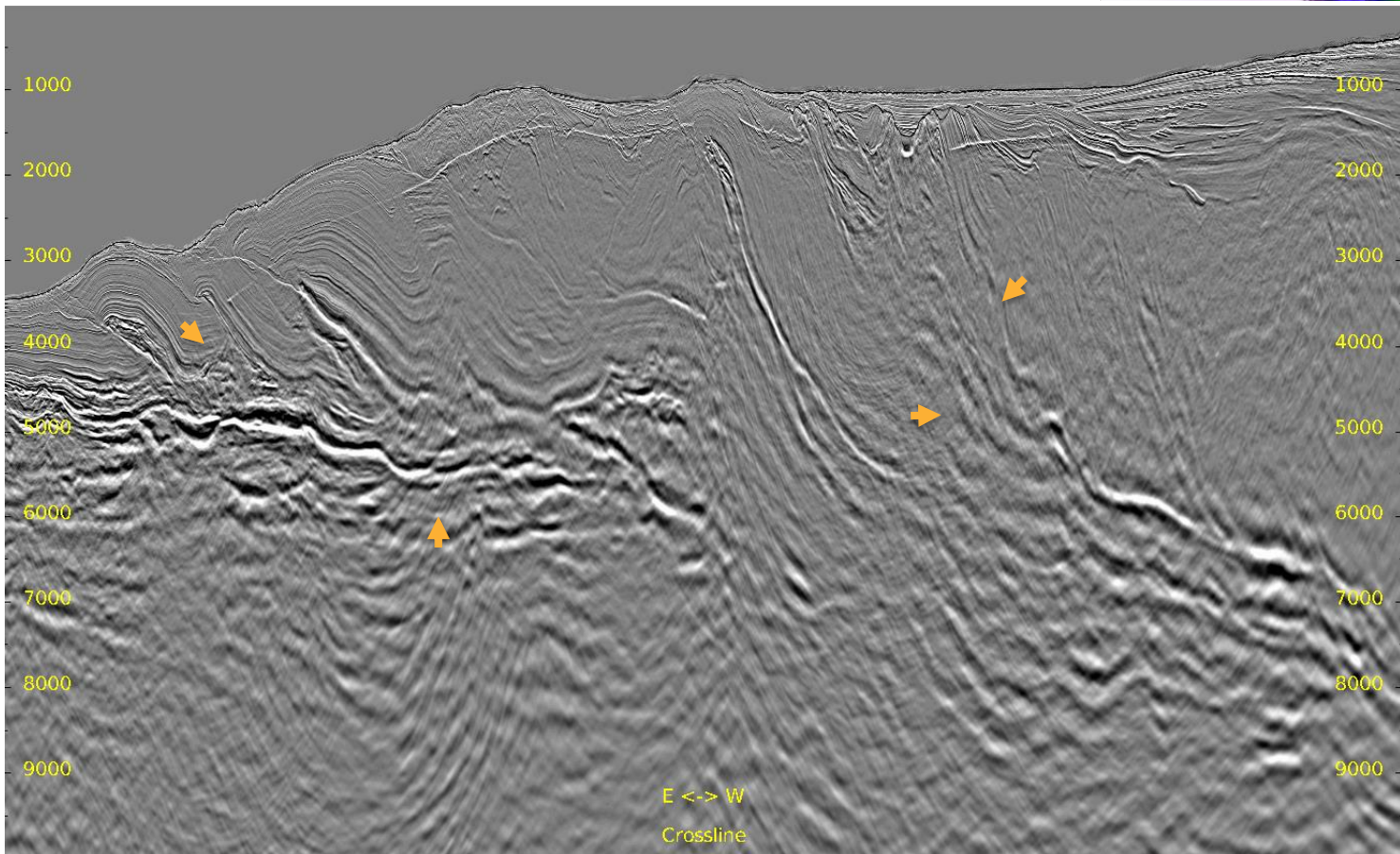
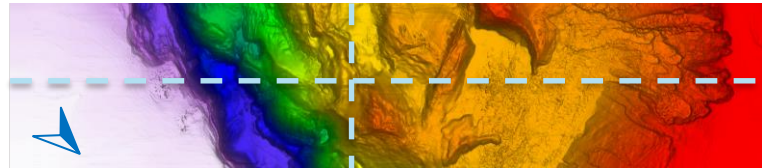
Inline 329 & Crossline 1835





# Full Stack: TTI Kirchhoff Migration

Inline 436 & Crossline 2585

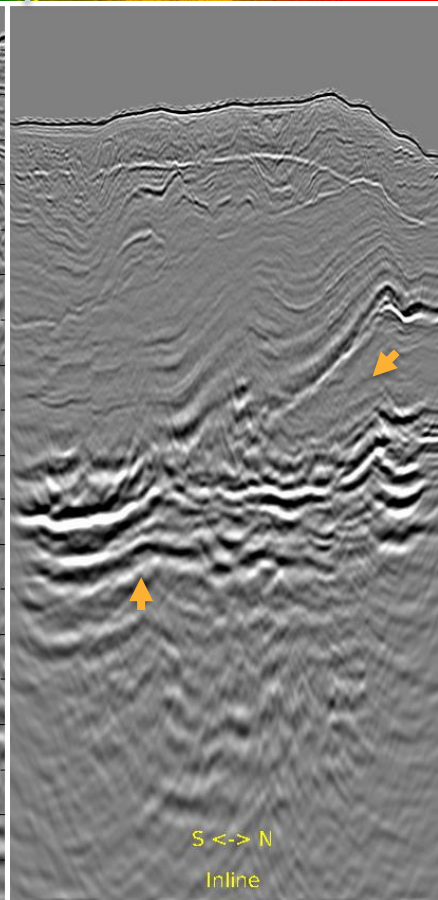
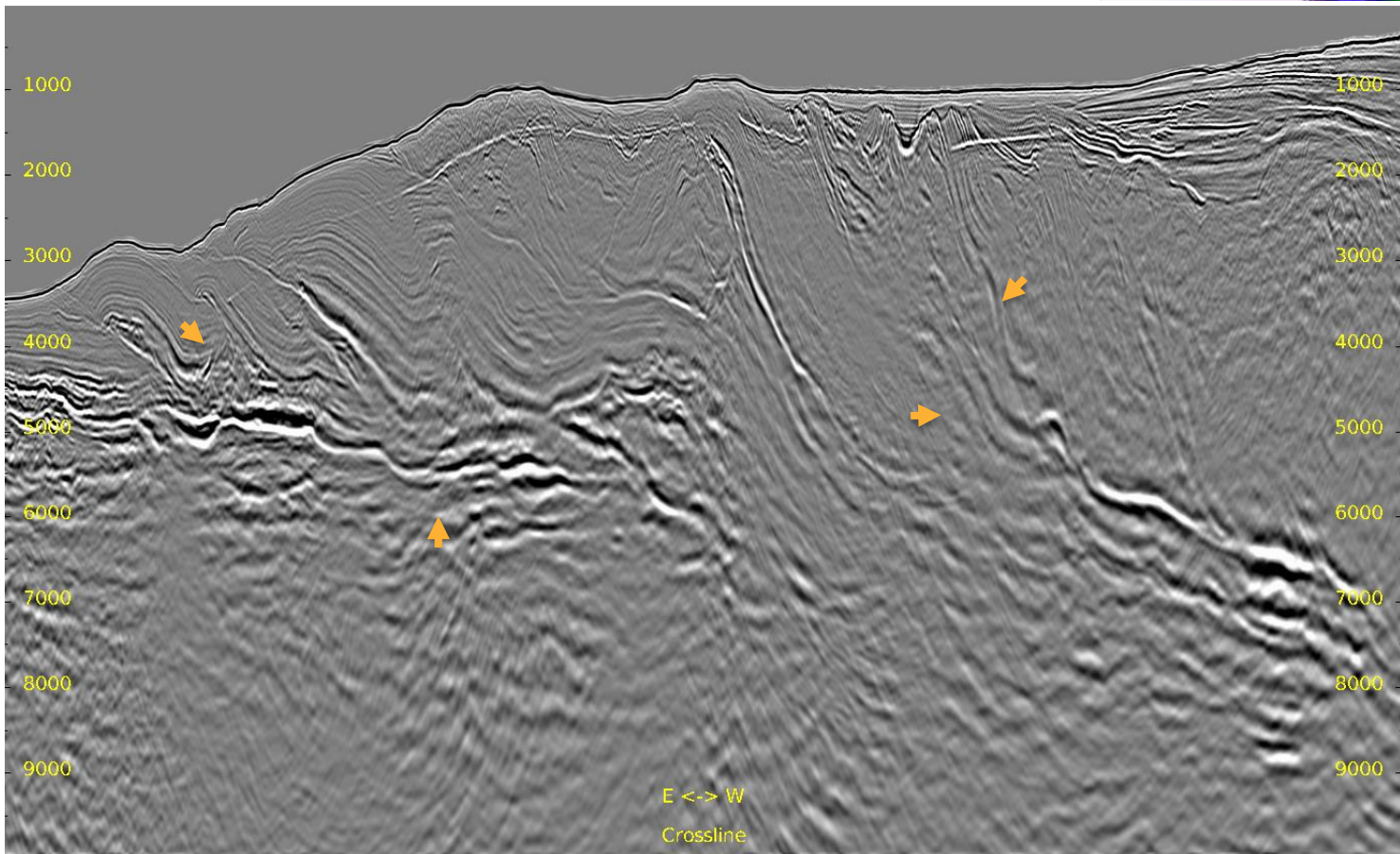
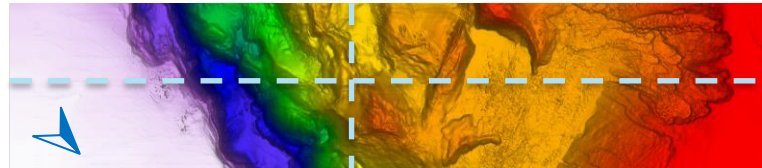






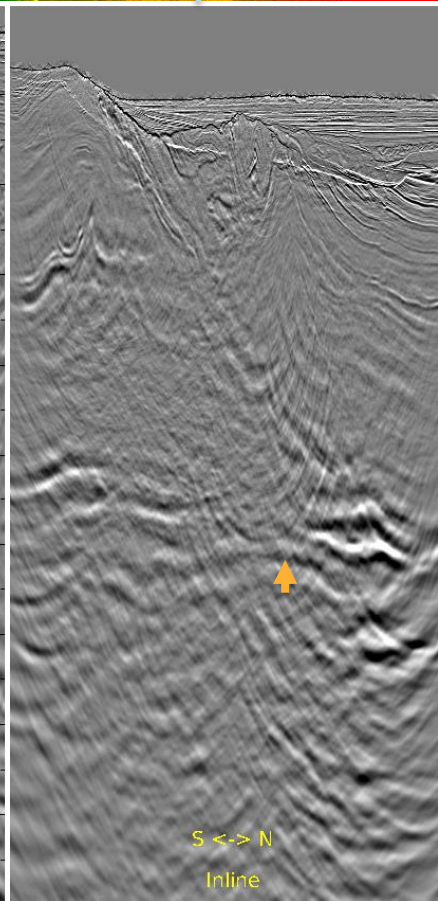
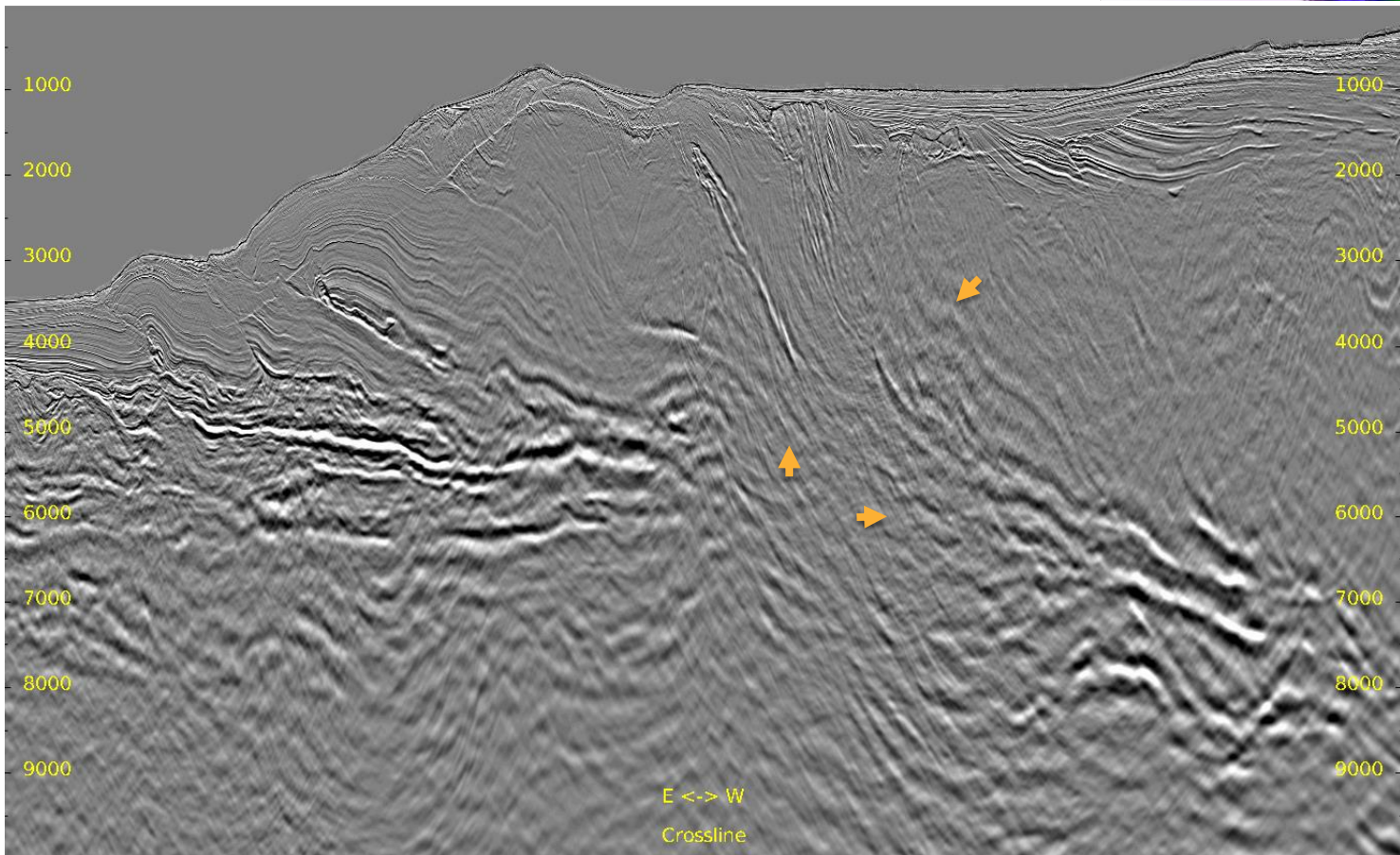
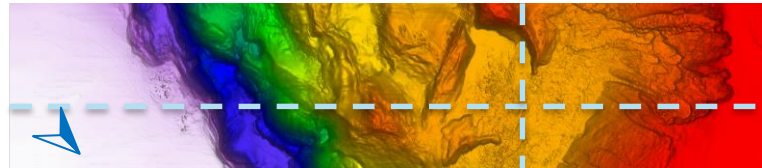
# Full Stack: TTI RTM

Inline 436 & Crossline 2585



# Full Stack: TTI Kirchhoff Migration

Inline 537 & Crossline 3843

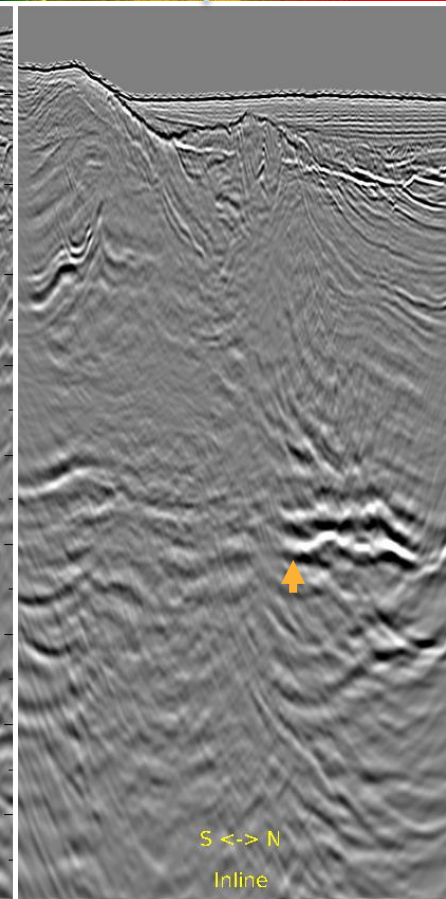
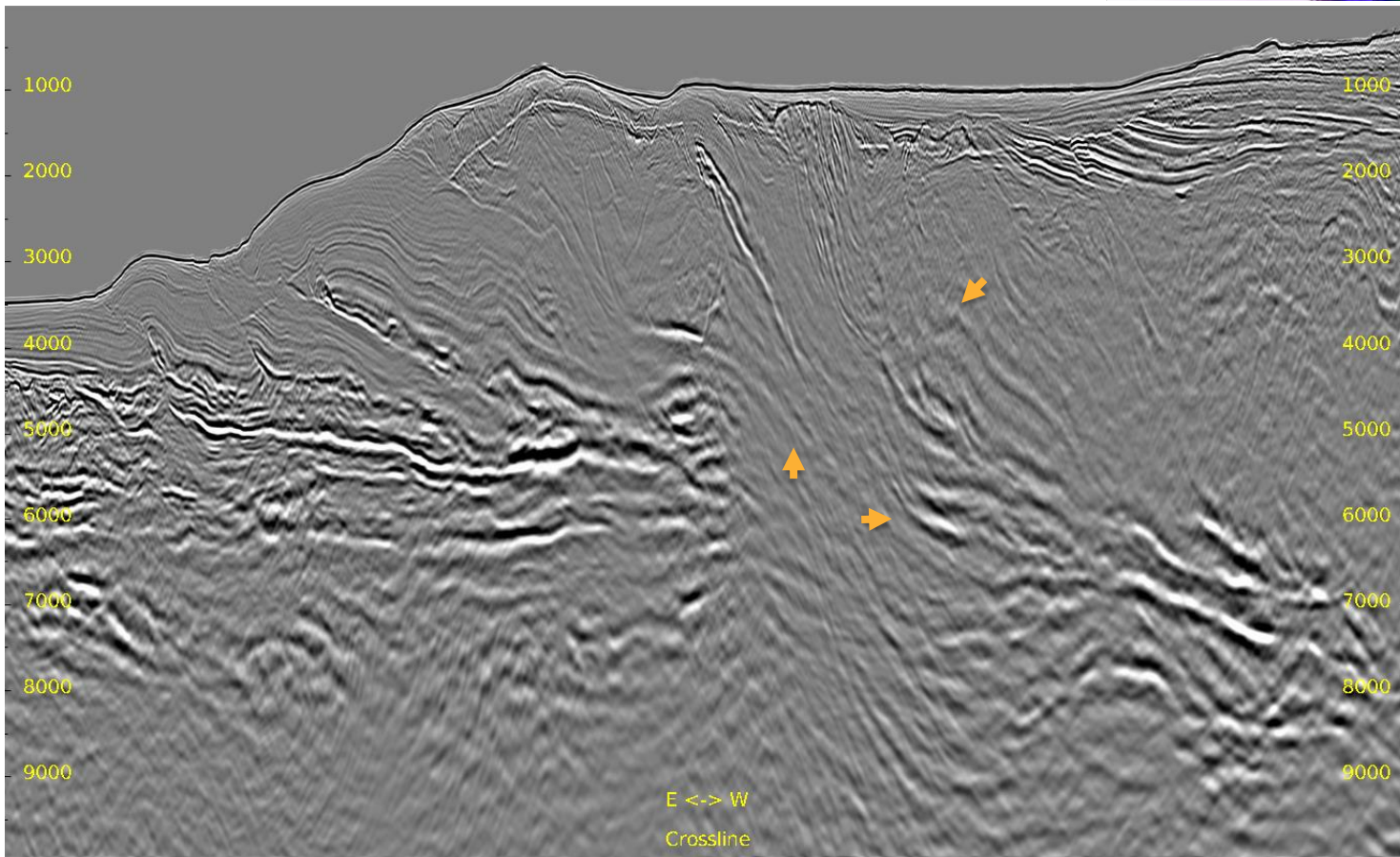
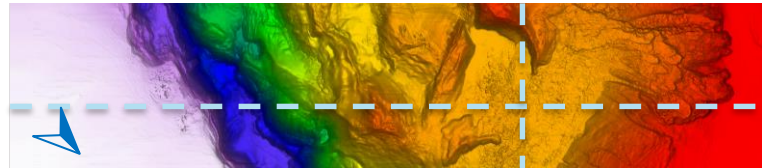






# Full Stack: TTI RTM

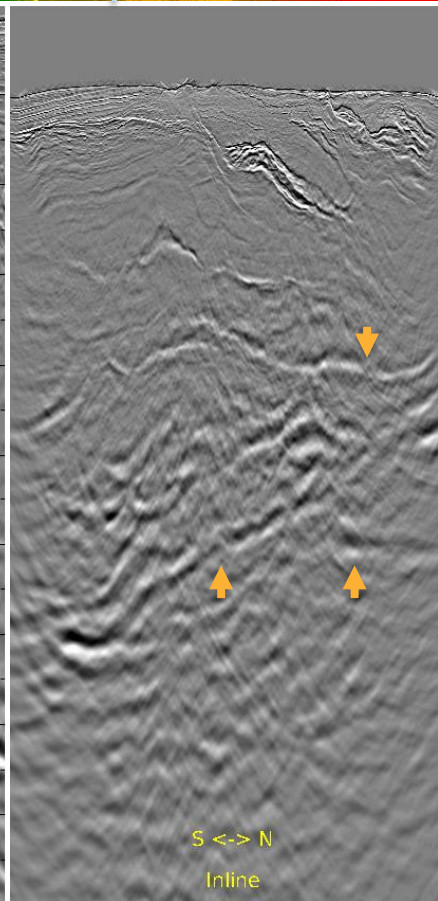
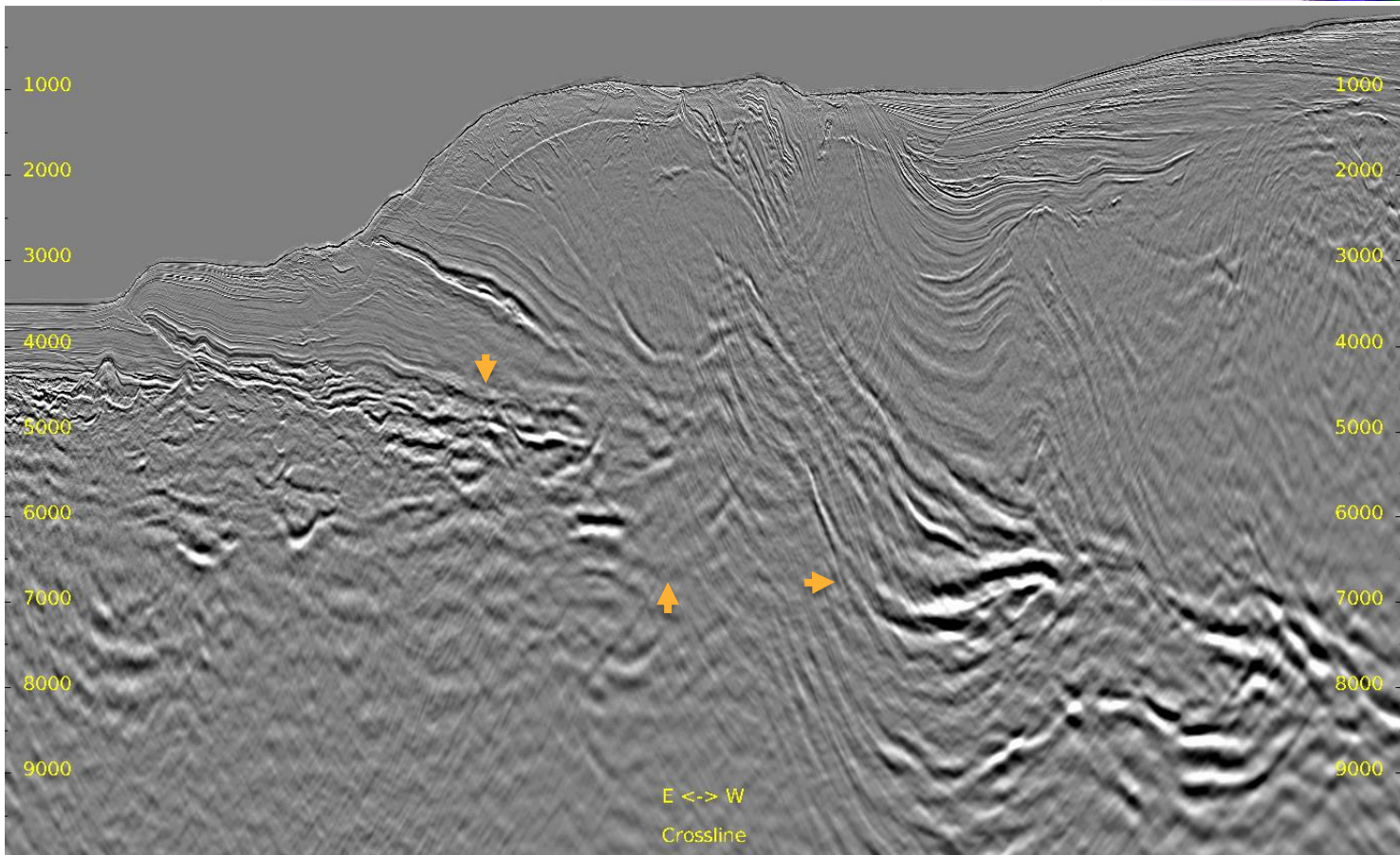
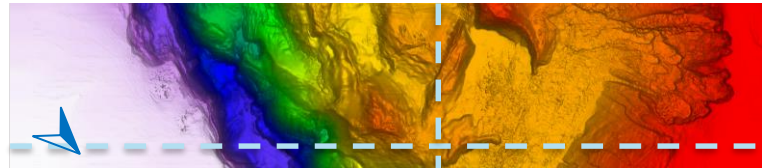
Inline 537 & Crossline 3843





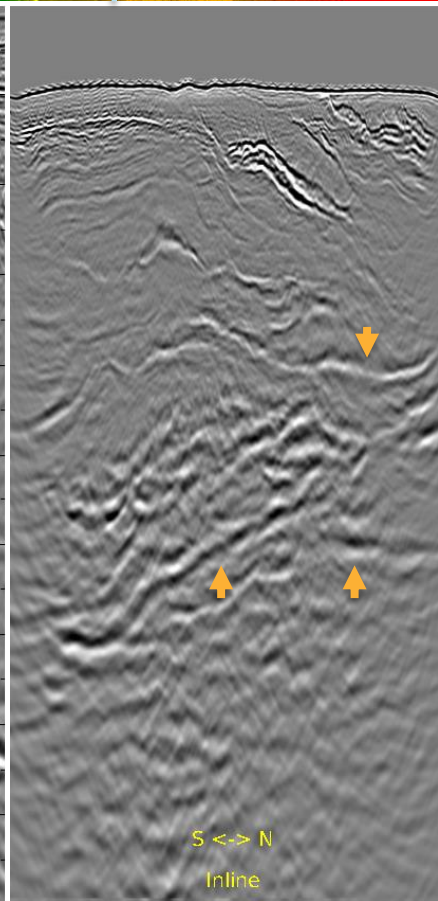
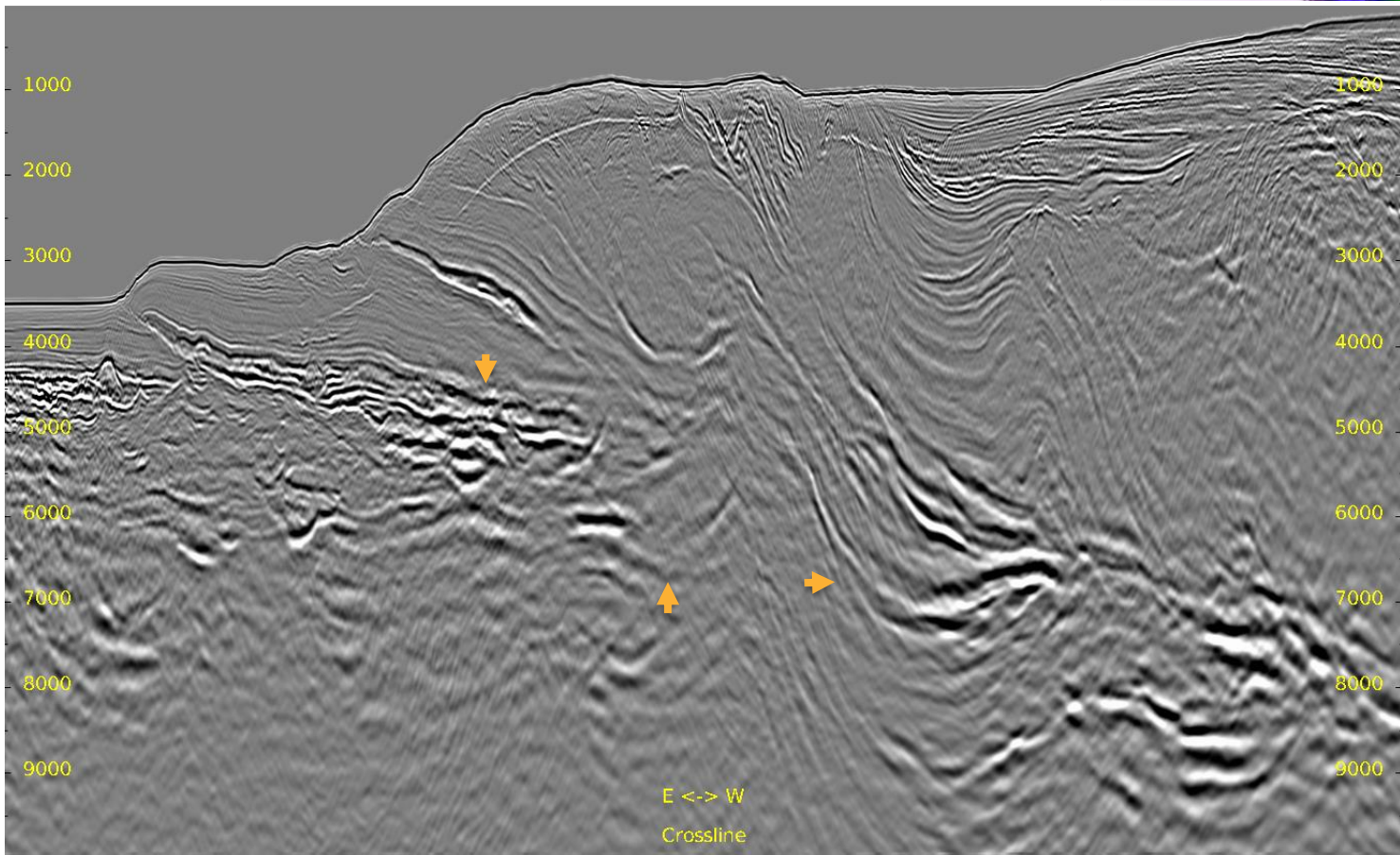
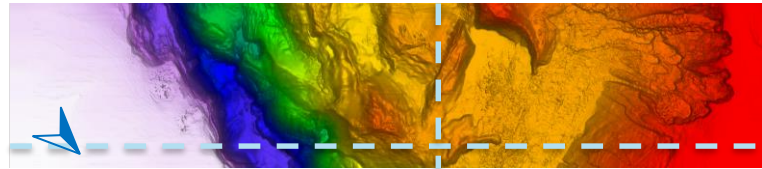
# Full Stack: TTI Kirchhoff Migration

Inline 725 & Crossline 3231



# Full Stack: TTI RTM

Inline 725 & Crossline 3231







# IT4 – TOR Test

## NZ 3D Processing

*24 March 2021*

[cgg.com](http://cgg.com)



INSTITUTE FOR GEOPHYSICS



Passion for Geoscience



- **Objective:**

To evaluate the benefit from tilted orthorhombic (TOR) VMB.

- **Procedure:**

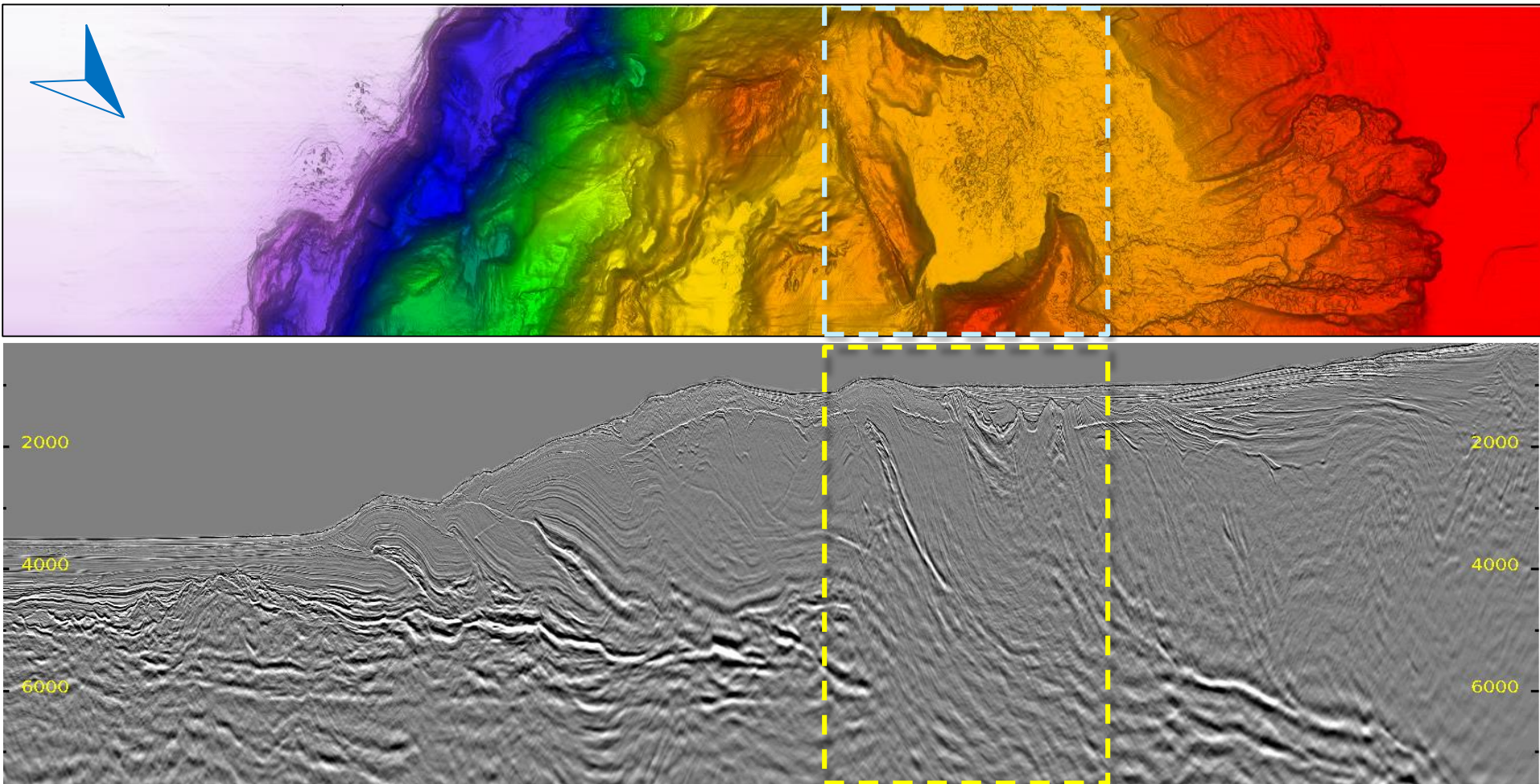
OBS data was divided into 6 azimuth sectors, which were used to run 6 TTI FWI. Tilted orthorhombic TOR models were then built base on 6 TTI models to handle azimuthal anisotropy. OBS only TOR FWI was run using converted TOR models as starting model to fully utilize the benefit from TOR setting.

- **Display:**

Velocity models, migrated depth full stack & gathers.

- **Observation and Recommendation:**

20Hz TTI QRTM result has less migration swings and high frequency noises. Events in the deep sections are more continuous and better illuminated at places where velocity is complex.

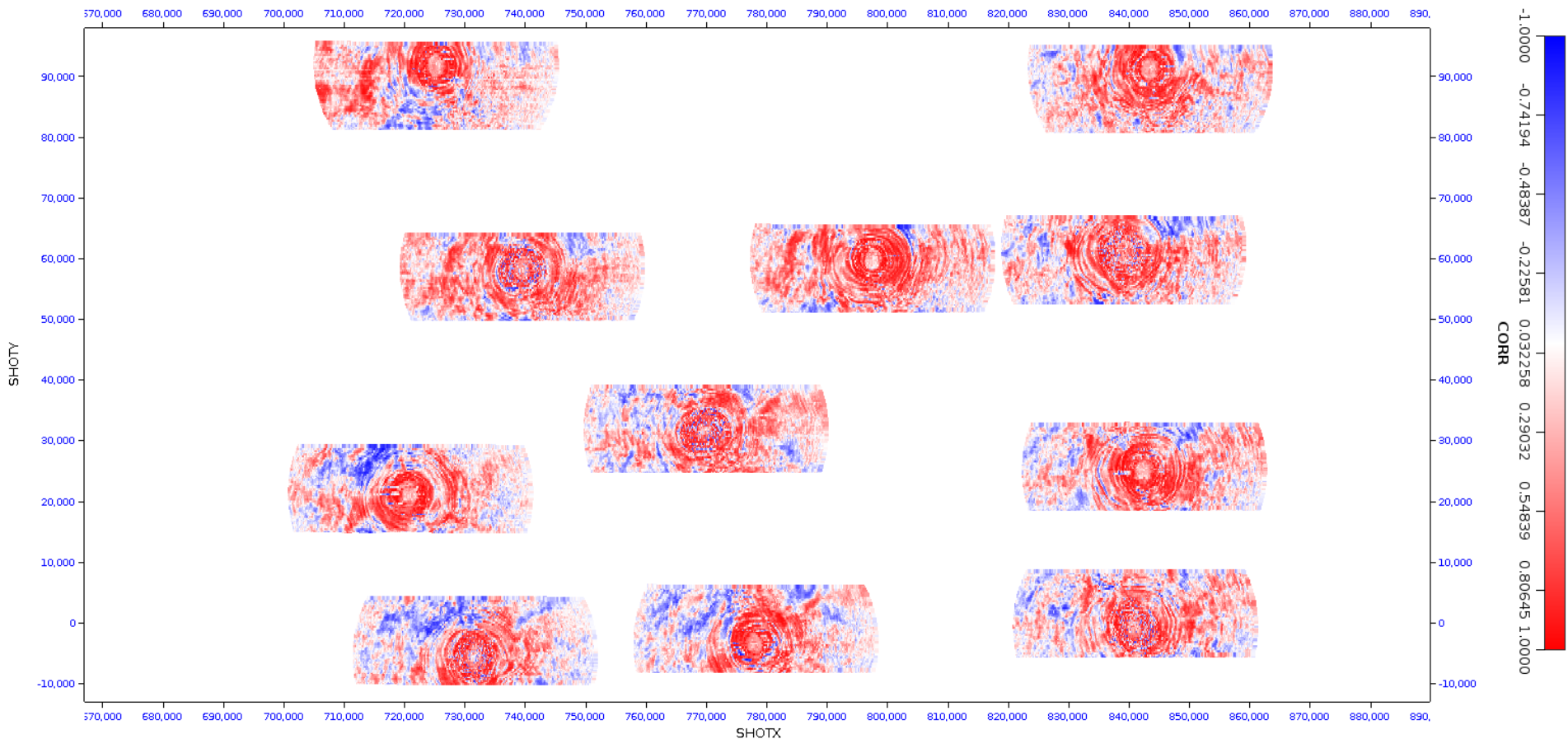






# Synthetic and Real Data X-correlation: IT4 TTI Velocity

4



# TOR Conversion





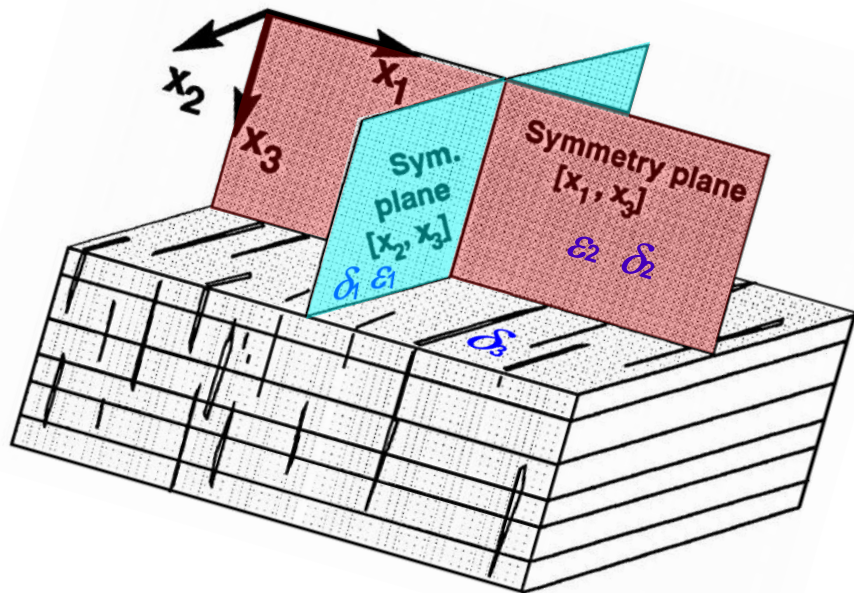


Figure courtesy of Professor Tsvankin

Tilted Transverse Isotropy (TTI)

$$V_{x1} = V_{x2} \neq V_{x3}$$

Parameters:

$$V_p, \delta, \varepsilon, \theta, \varphi$$

Tilted Orthorhombic

$$V_{x1} \neq V_{x2} \neq V_{x3}$$

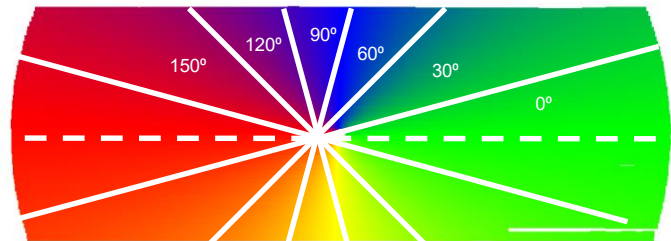
Parameters:

$$V_p, \delta_1, \delta_2, \delta_3, \varepsilon_1, \varepsilon_2, \theta, \varphi, \varphi_2$$

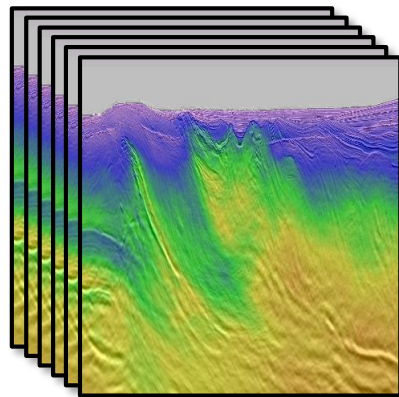


# From TTI to TOR

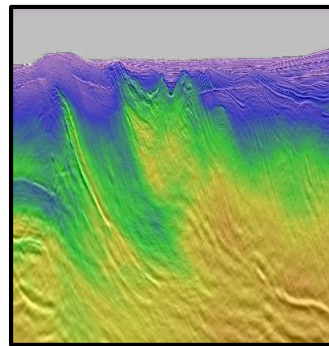
7



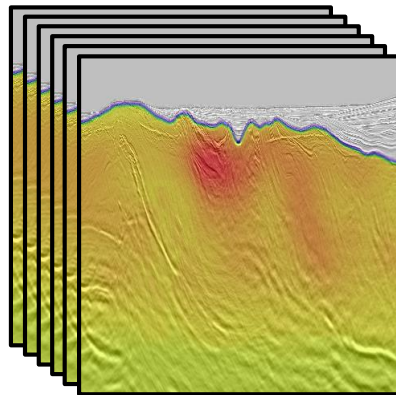
Azimuthal TTI FWI



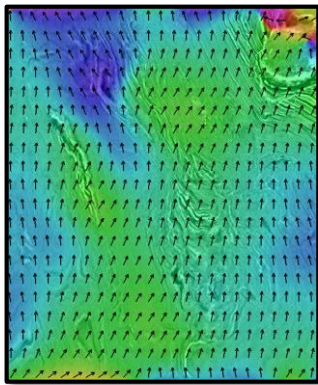
$V_{ISO}^{FWI} \text{ Azimuth}$



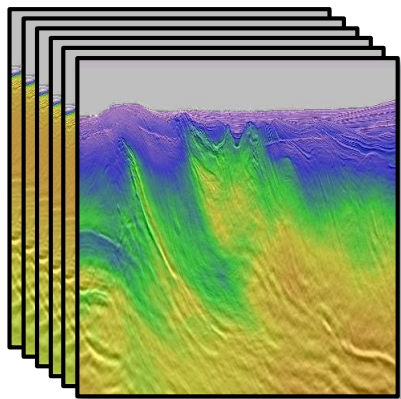
$V_{Slow}$



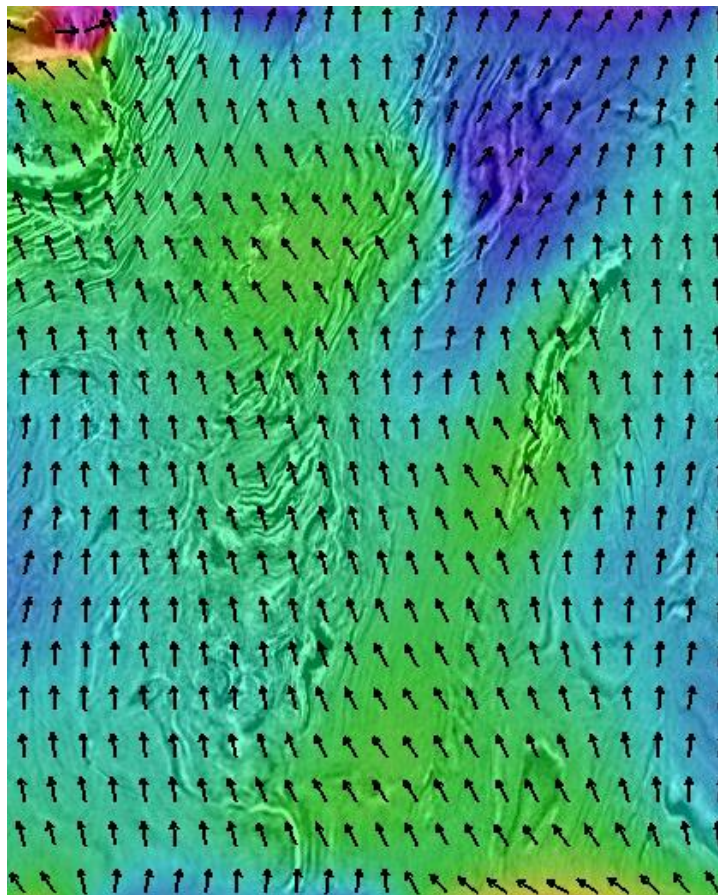
$Eps_{Azimuth}$



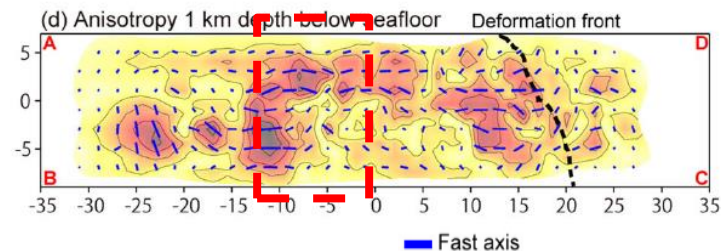
Slow velocity direction



ORT Parameters



- Slow velocity azimuth is aligned with dip direction of the structures, around 90 degree azimuth.
- This observation agrees with what's reported in the JAMSTEC paper.



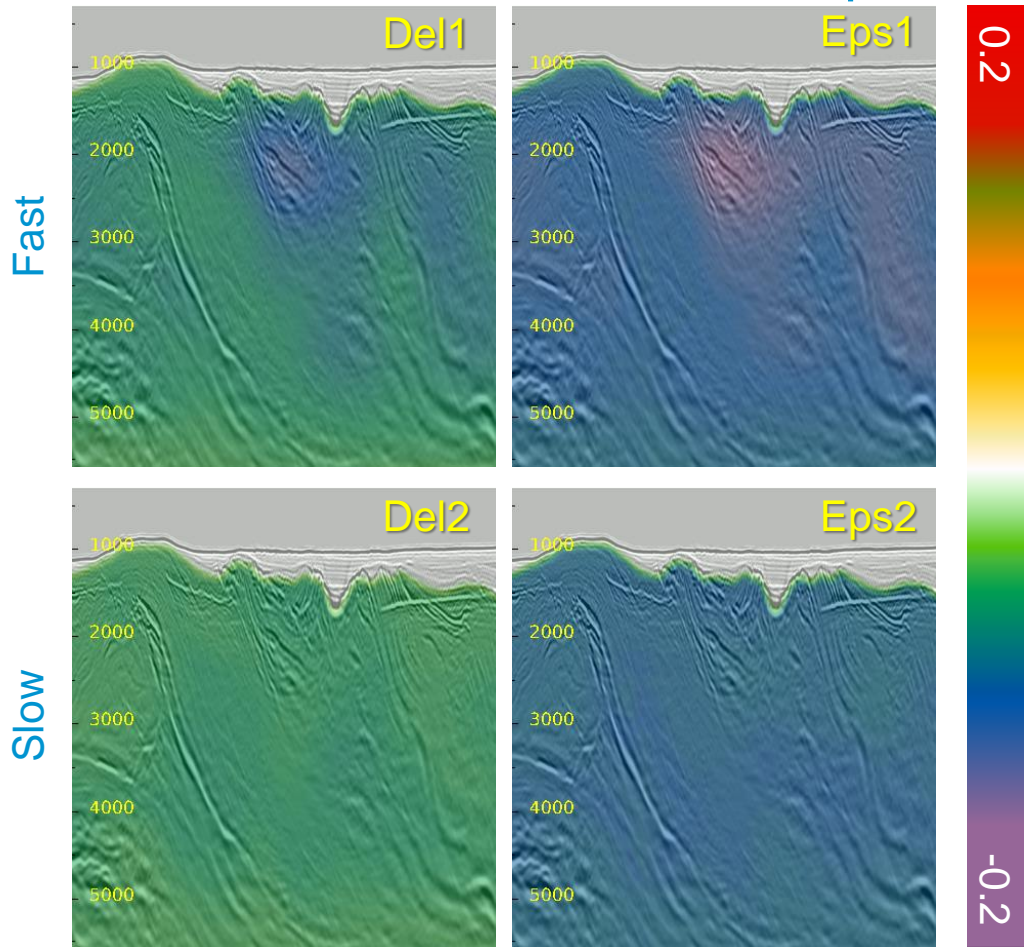
Ryuta Arai, et al., Three-Dimensional P Wave Velocity Structure of the Northern Hikurangi Margin From the NZ3D Experiment: Evidence for Fault-Bound Anisotropy, Journal of Geophysical Research: Solid Earth, 2020.

←→ Acquisition direction





# TOR Parameters: Deltas and Epsilons

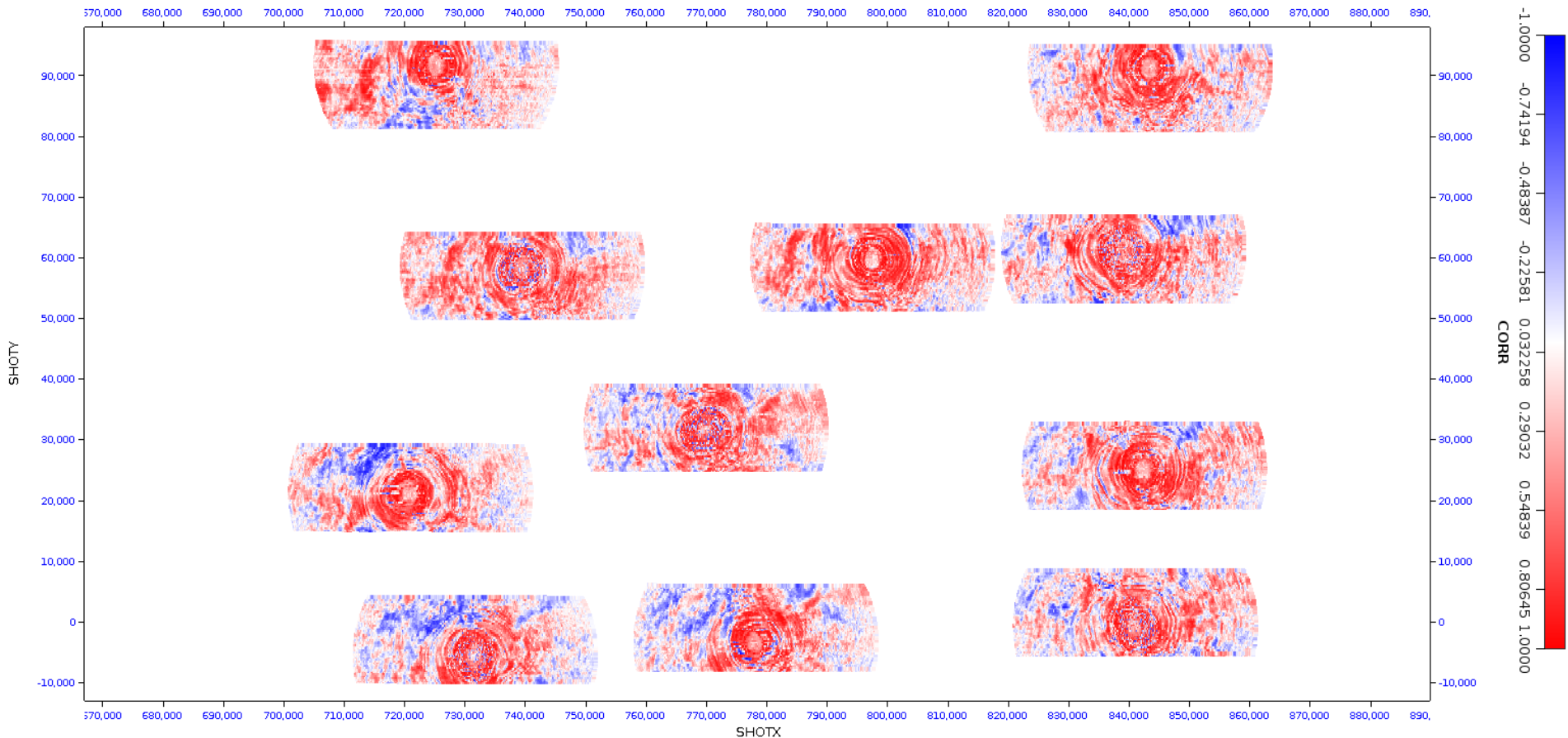


- Maximum ~6% del and eps difference between fast and slow velocity azimuth.
- This observation also aligns with what's reported in the JAMSTEC paper.



# Synthetic and Real Data X-correlation: IT4 TTI Velocity

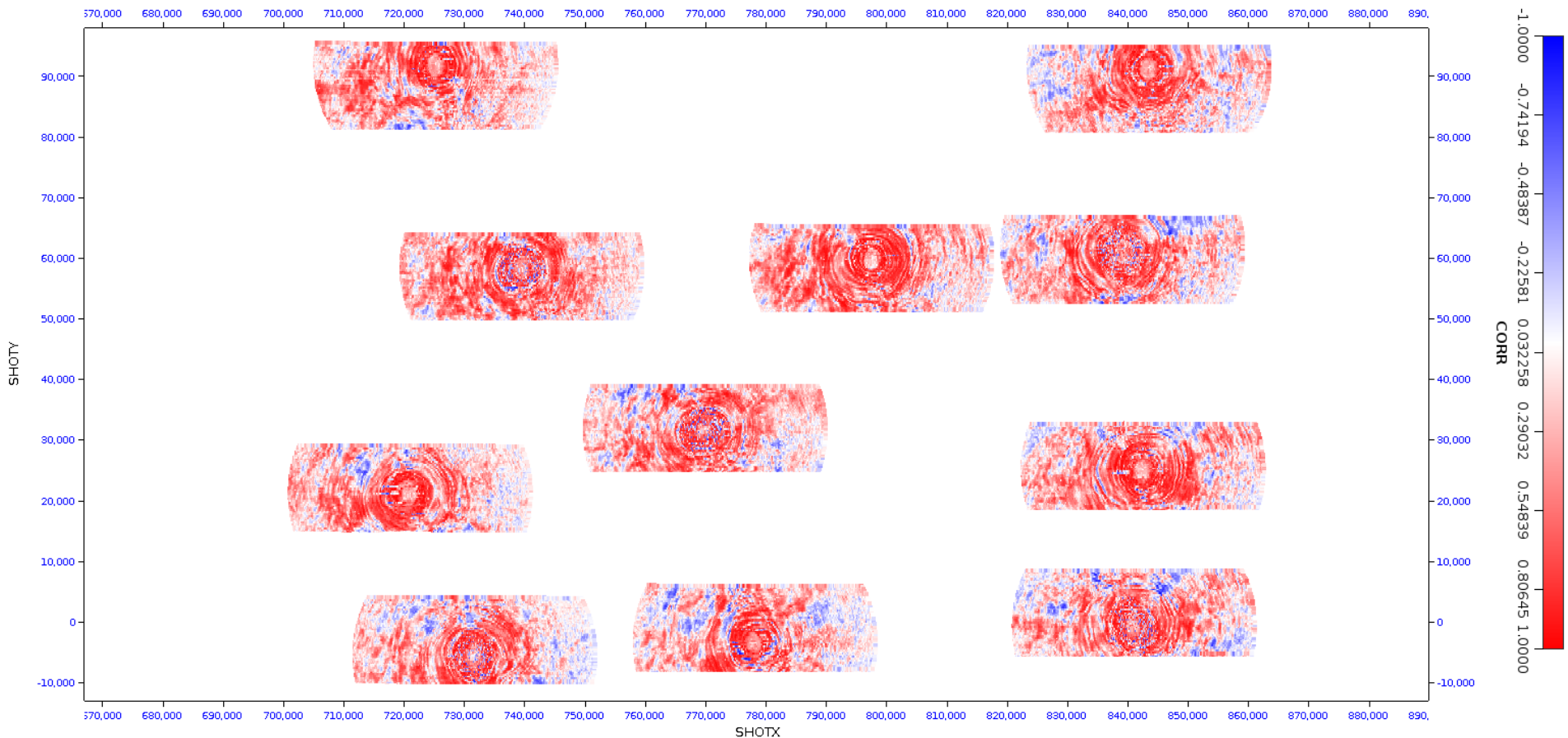
10



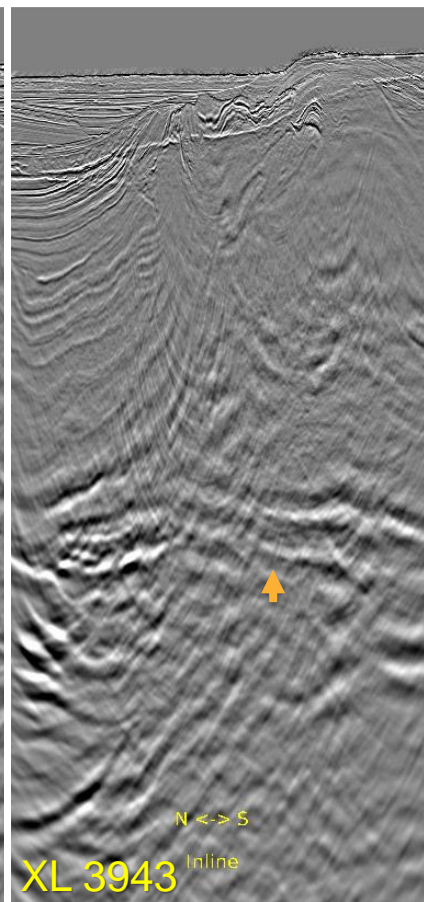
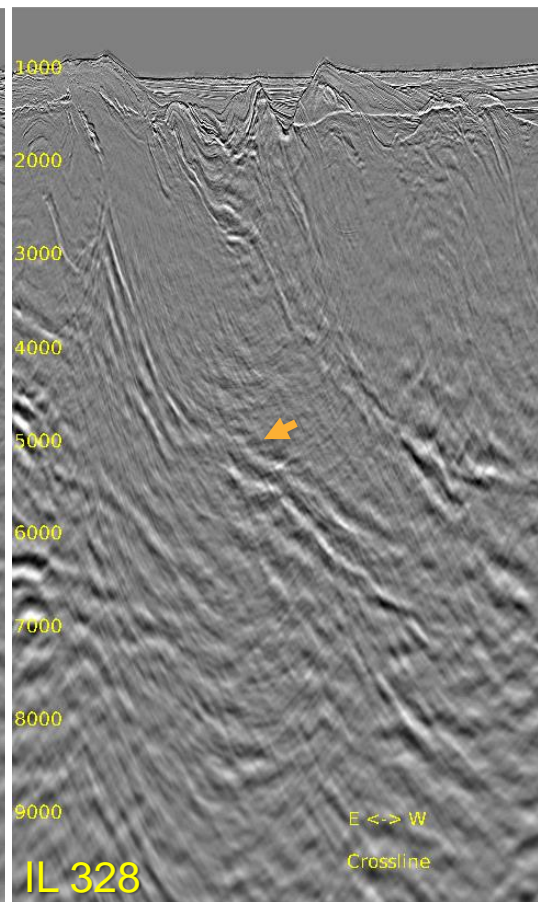
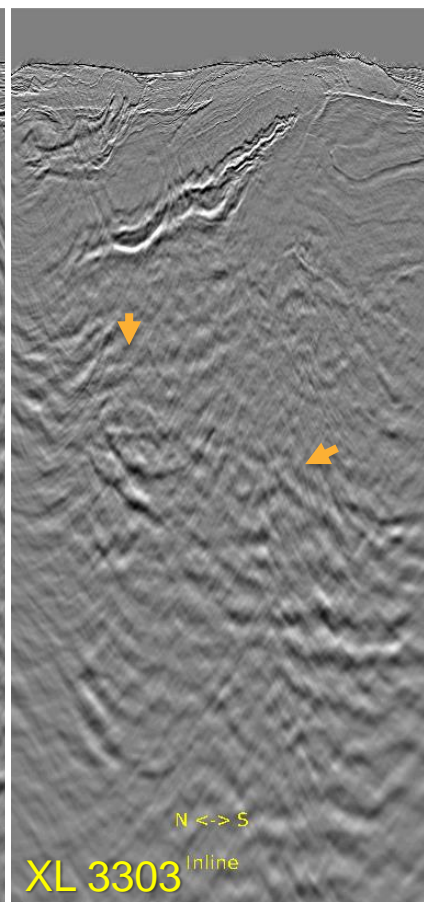
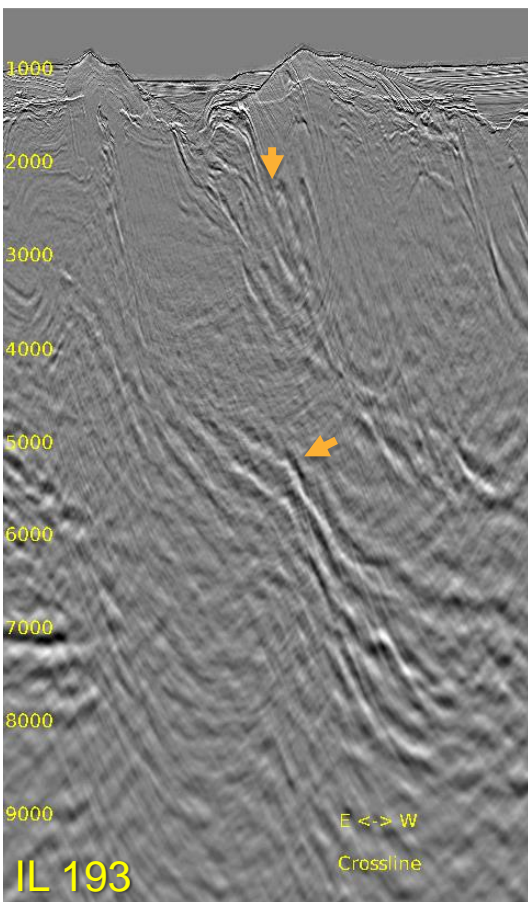


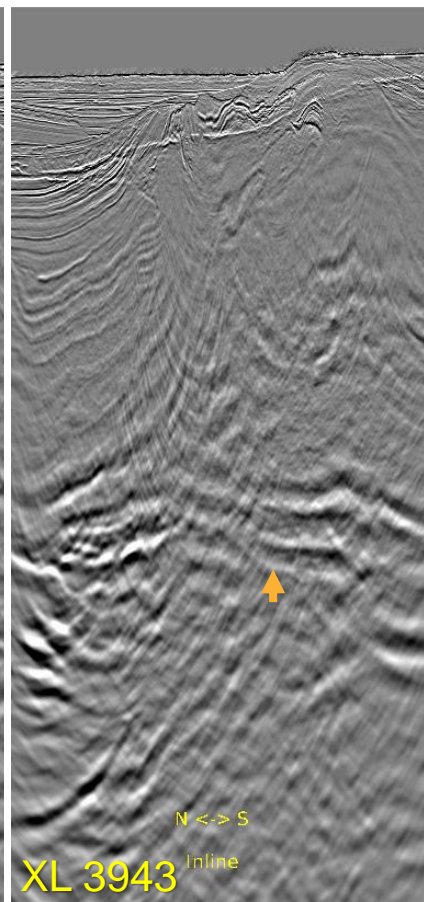
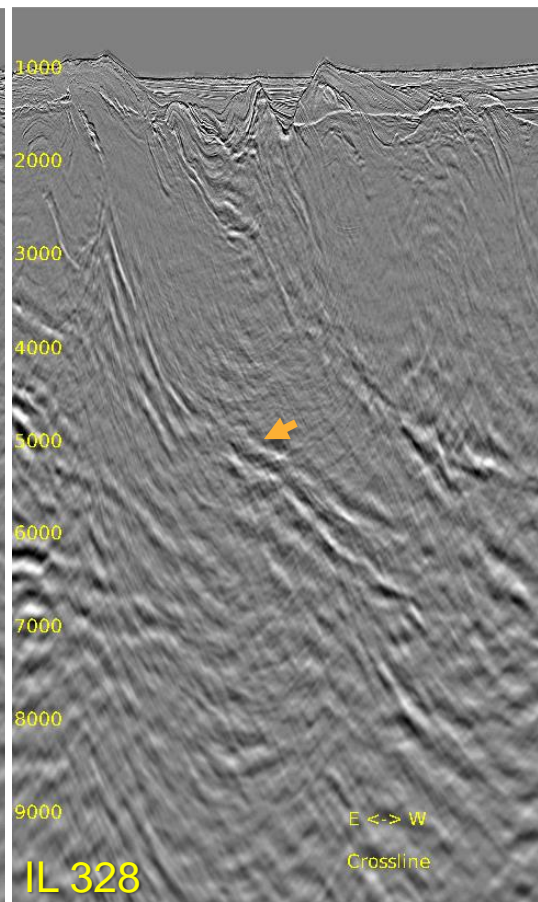
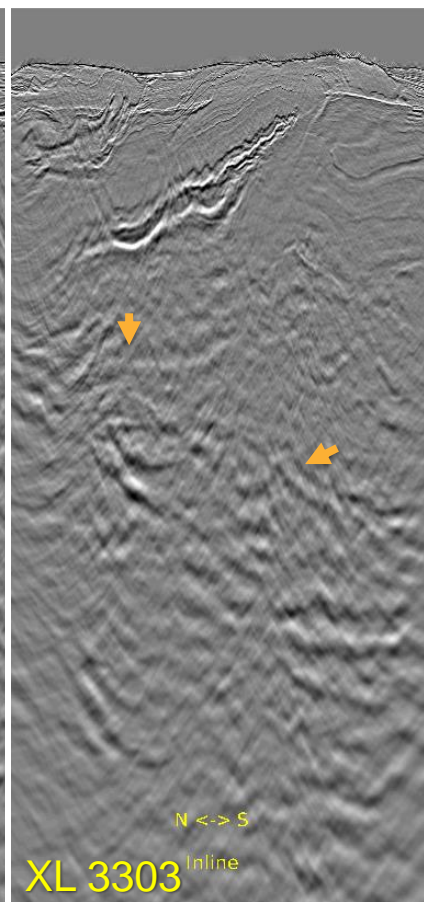
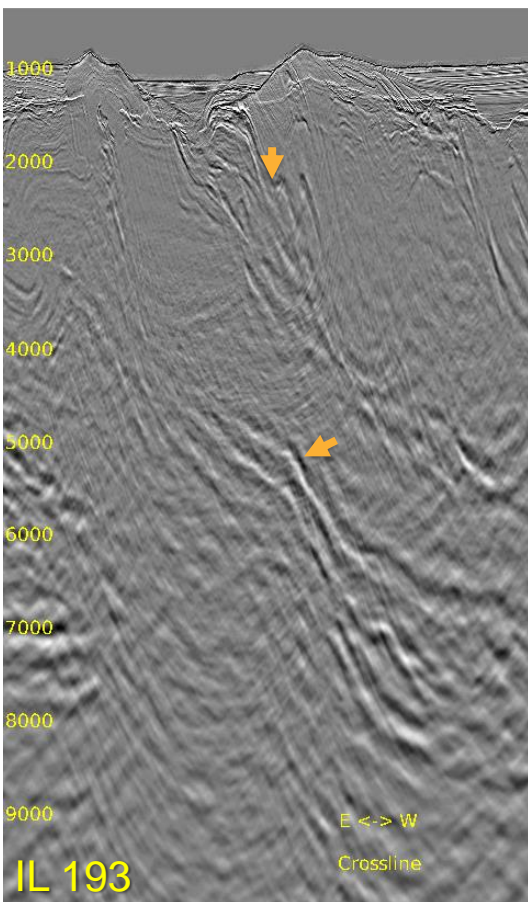
# Synthetic and Real Data X-correlation: Converted TOR Velocity

11









# TTI vs TOR FWI

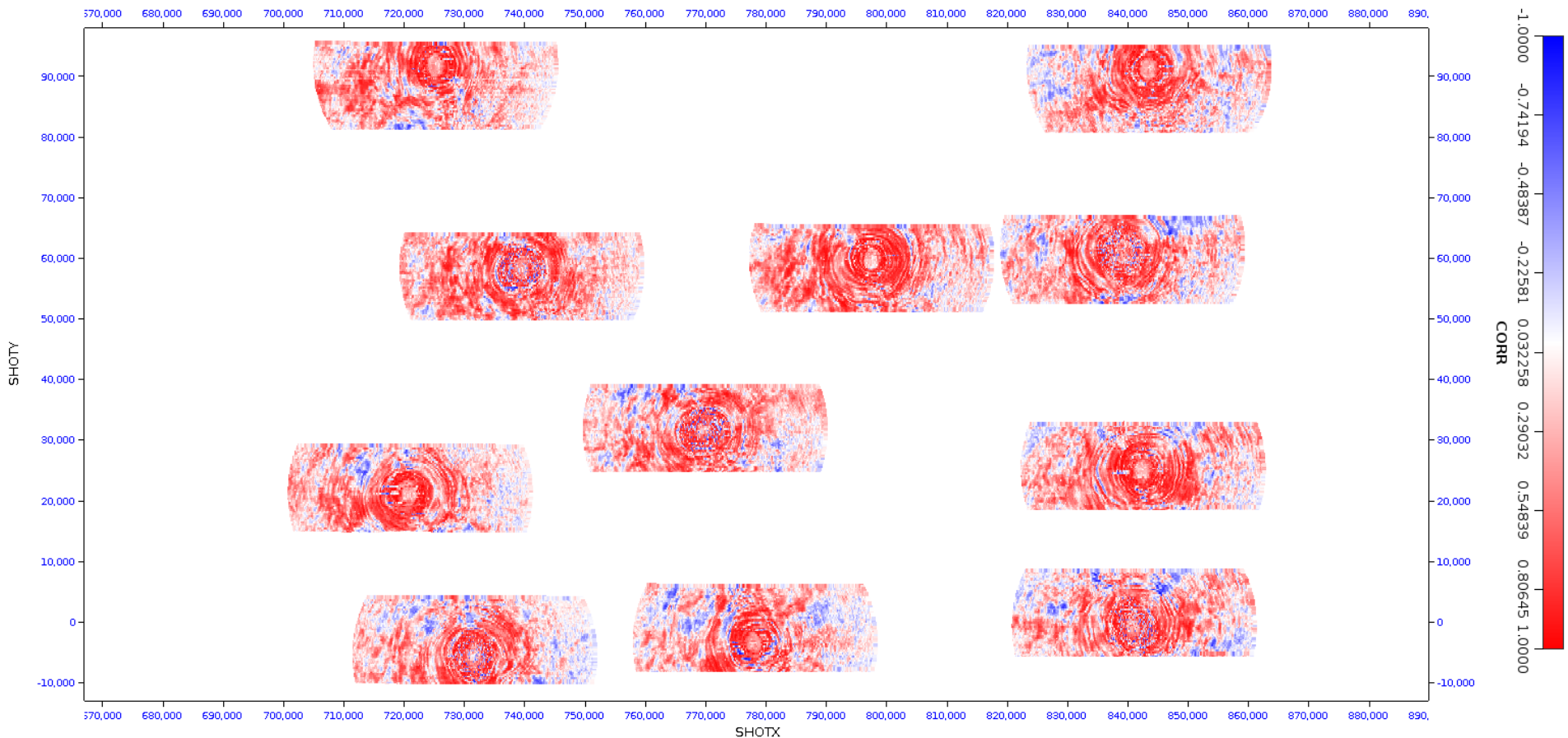






# Synthetic and Real Data X-correlation: Converted TOR Velocity

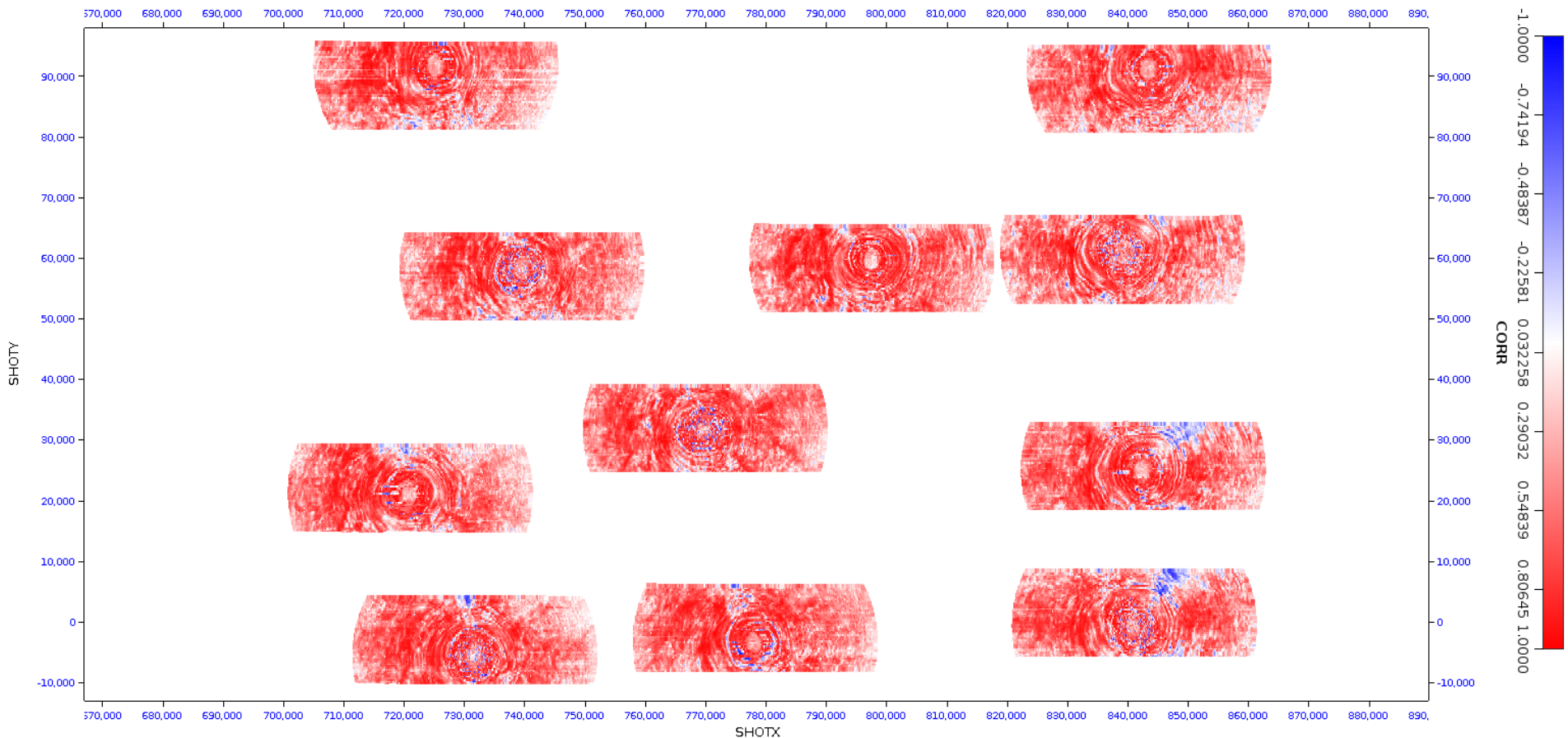
15





# Synthetic and Real Data X-correlation: TOR FWI Velocity

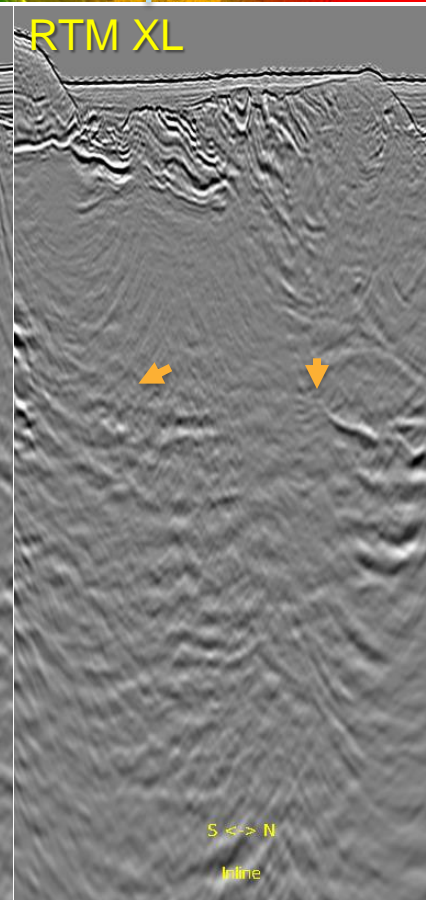
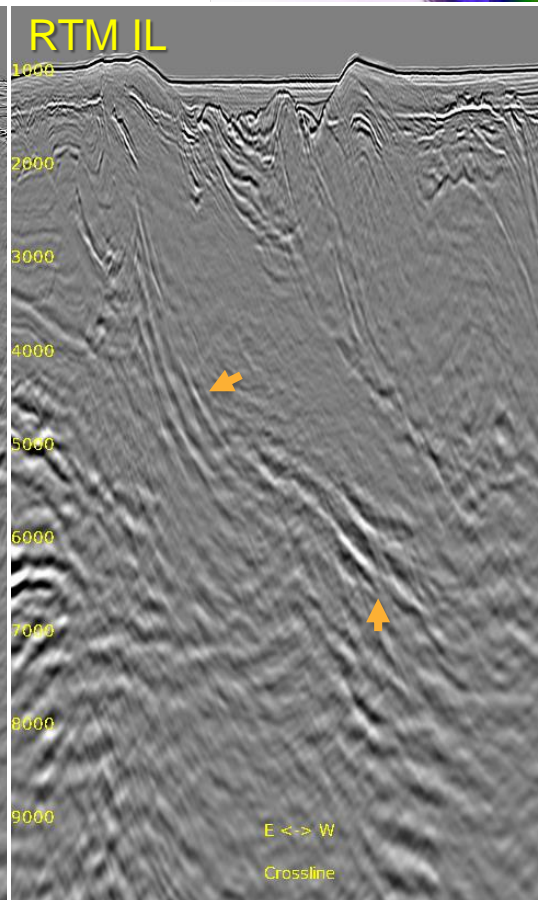
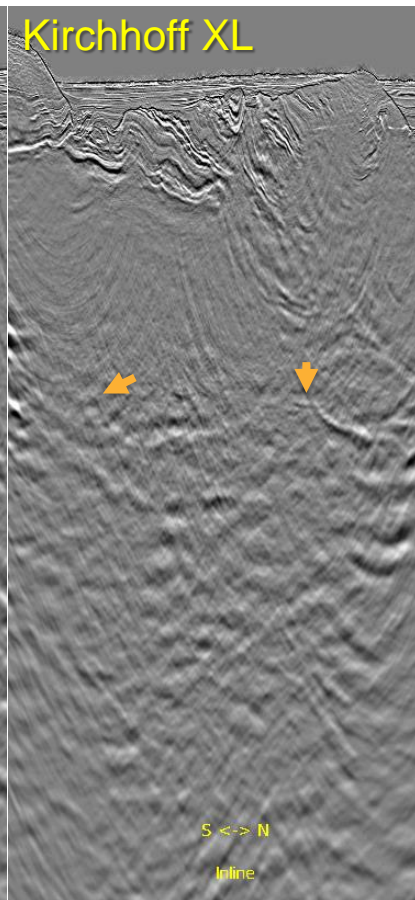
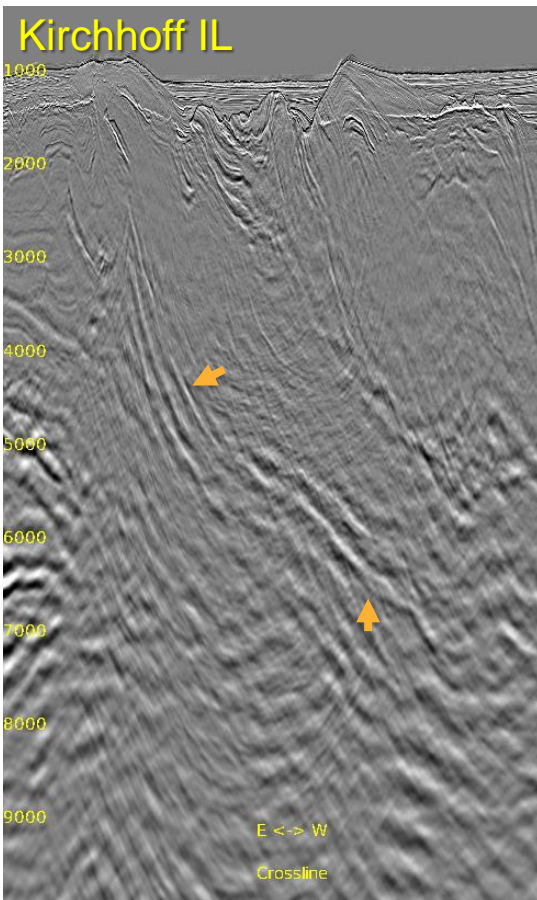
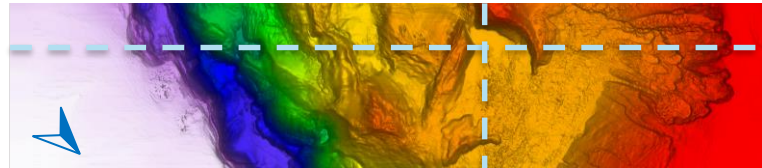
16





# Full Stack: IT4 TTI Result

Inline 307 & Crossline 3579

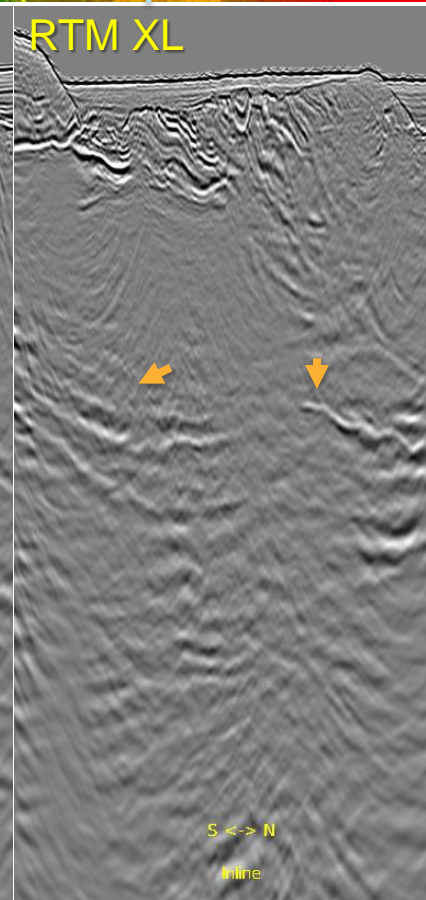
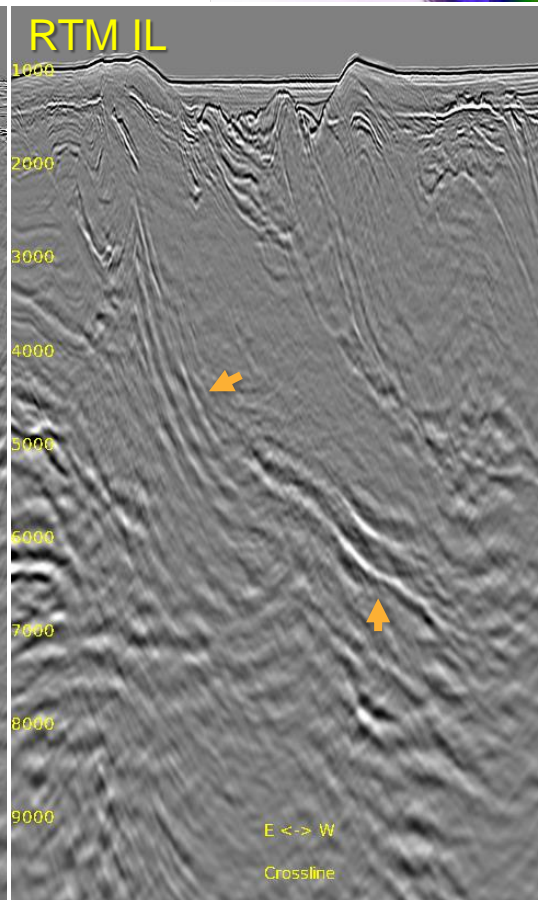
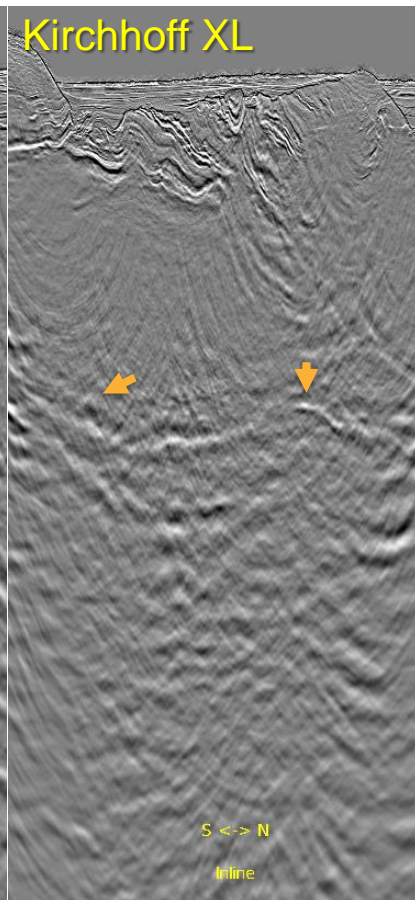
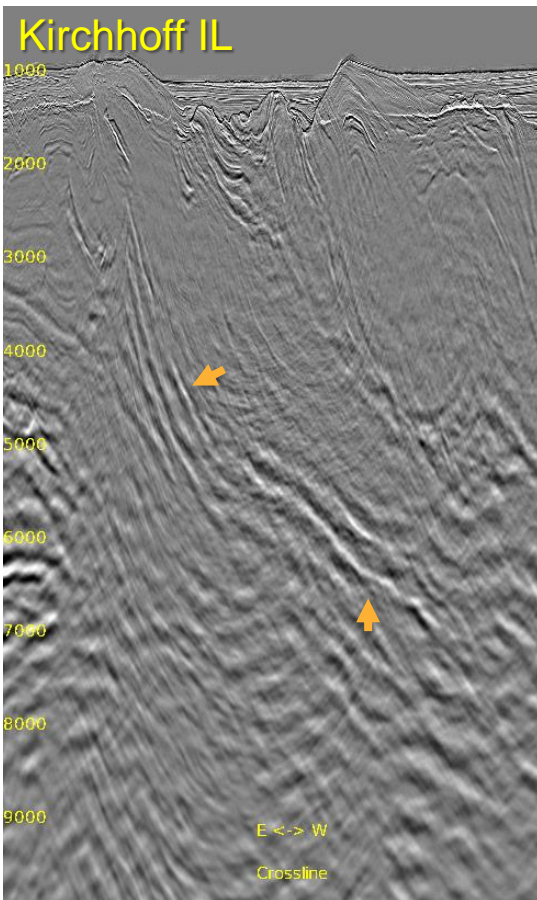
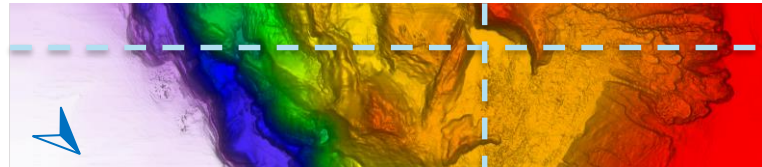






# Full Stack: TOR FWI Result

Inline 307 & Crossline 3579





# IT4 – Part 1

## NZ 3D Processing

*03 February 2021*

[cgg.com](http://cgg.com)



INSTITUTE FOR GEOPHYSICS



- **Objective:**

To further improve deep velocity, especially in the middle and west part.

- **Procedure:**

Based on IT3 result, theta and phi were updated. Epsilon is increased from 5% to 8% in the middle to west part based on previous epsilon scanning result. TTI FWI was then run with updated anisotropy from 2.5Hz to 5Hz.

- **Display:**

Velocity, migrated depth full stack & gathers.

- **Observation and Recommendation:**

In the low S/N area from middle to west of the survey, the velocity in the deeper area is more geological and results in a better imaging of the central dipping events. We'll continue to focus this area for better velocity.

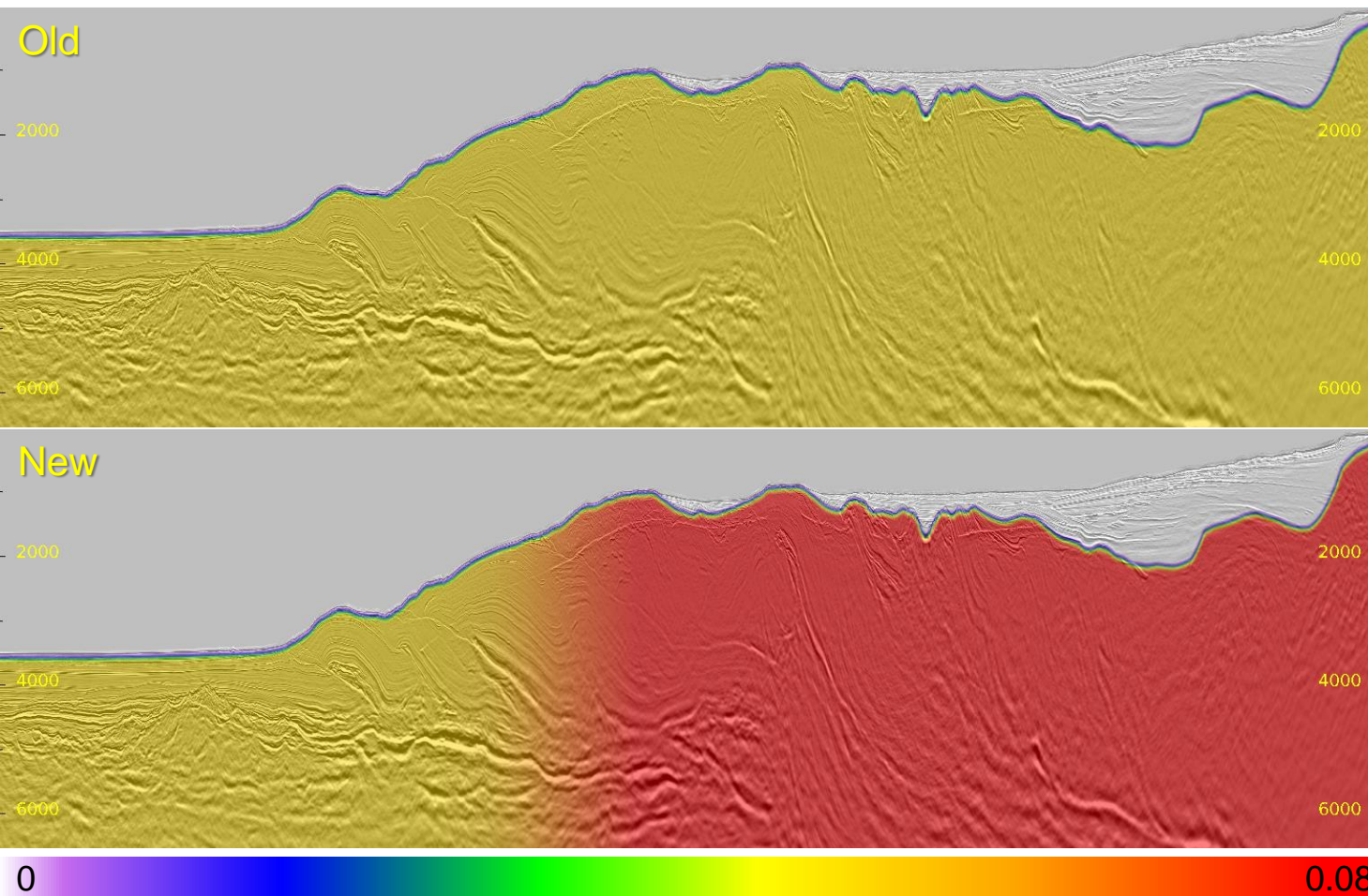


# Velocity Model



# Inline 436: Update on Epsilon

4

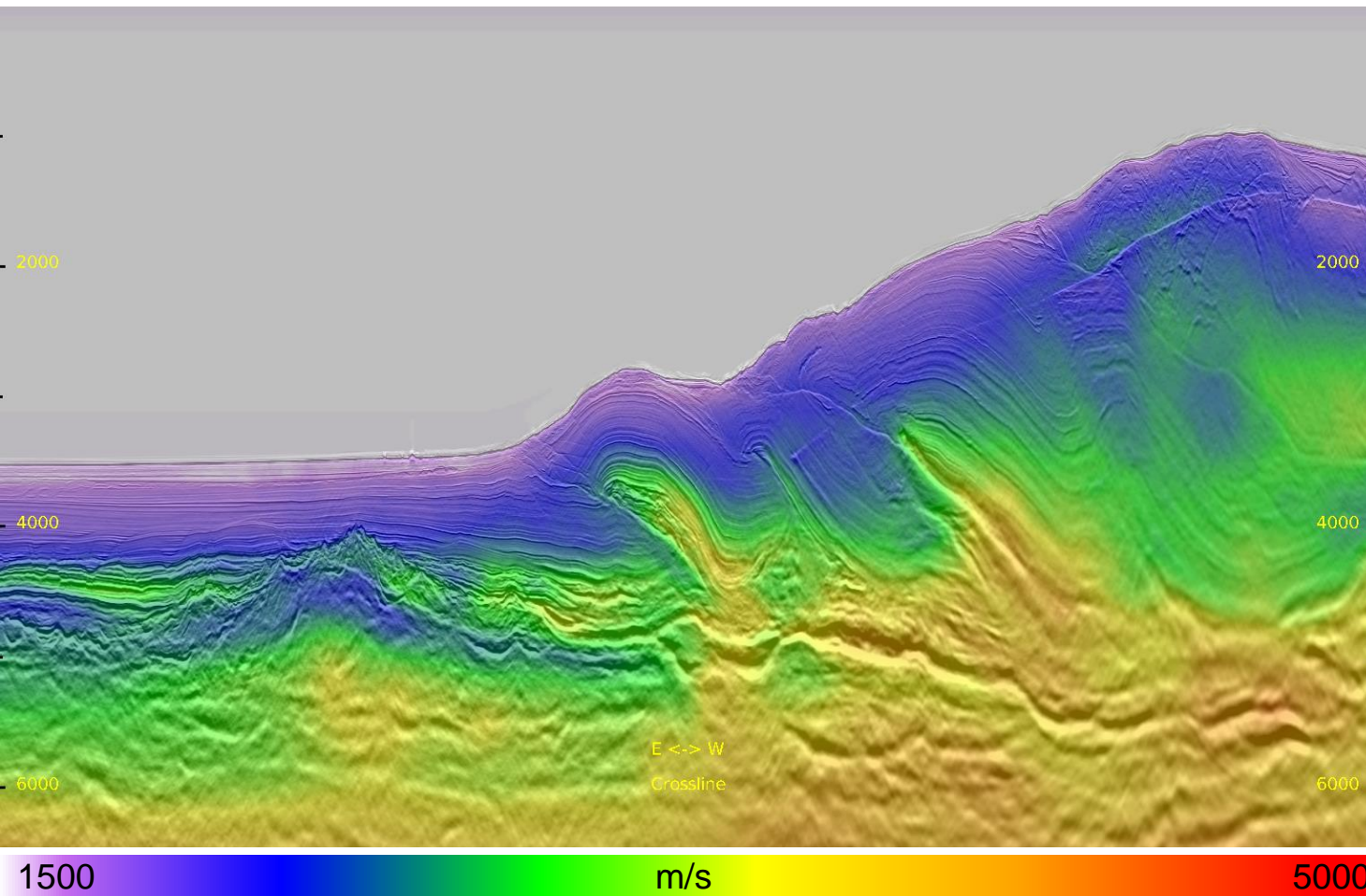


- Base on epsilon scan result, the epsilon value was increased for the middle and west part.



# Inline 436 East: IT3 Velocity

5

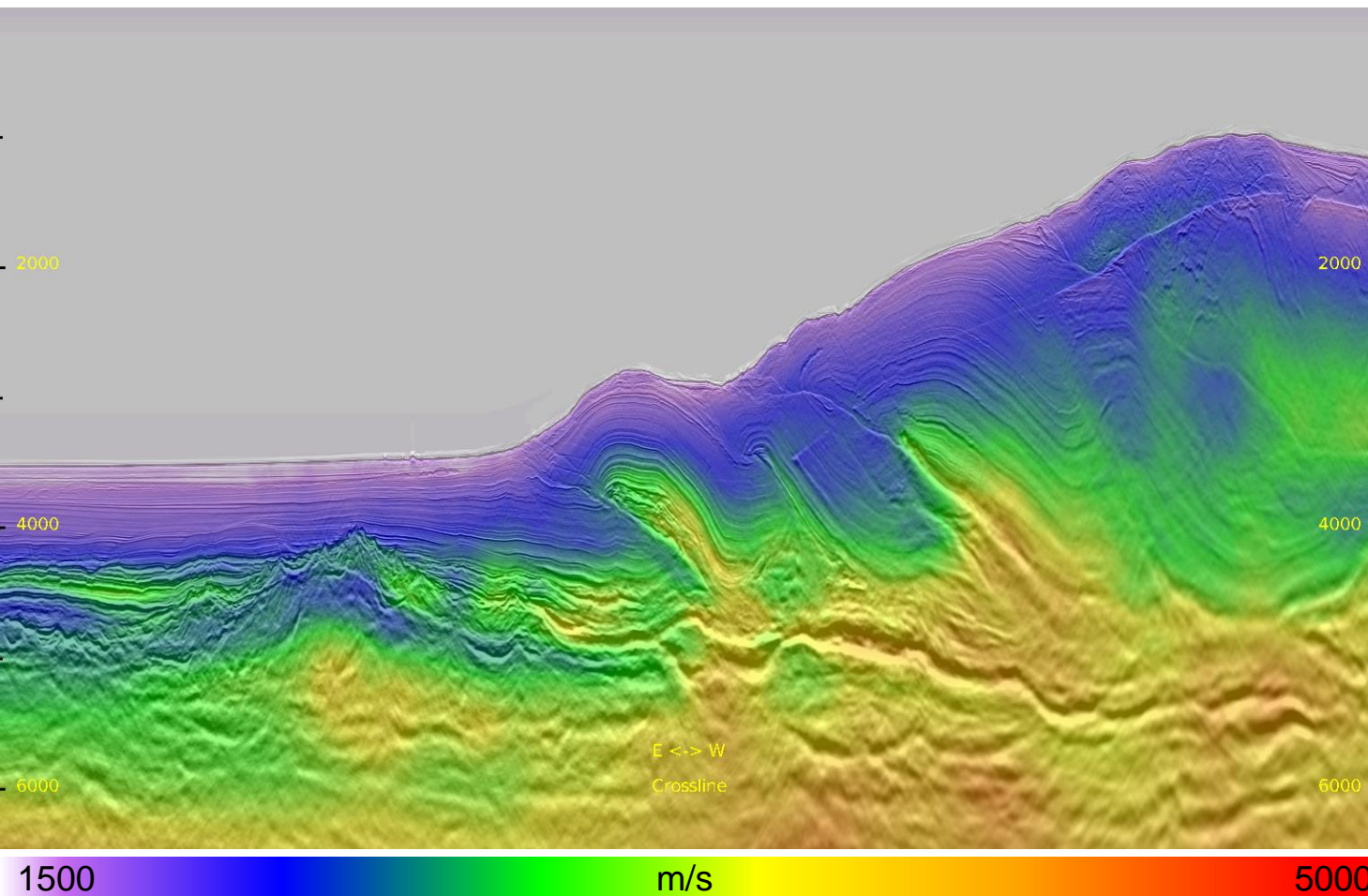


- Starting velocity is from IT3 TTI FWI.



# Inline 436 East: Current Velocity

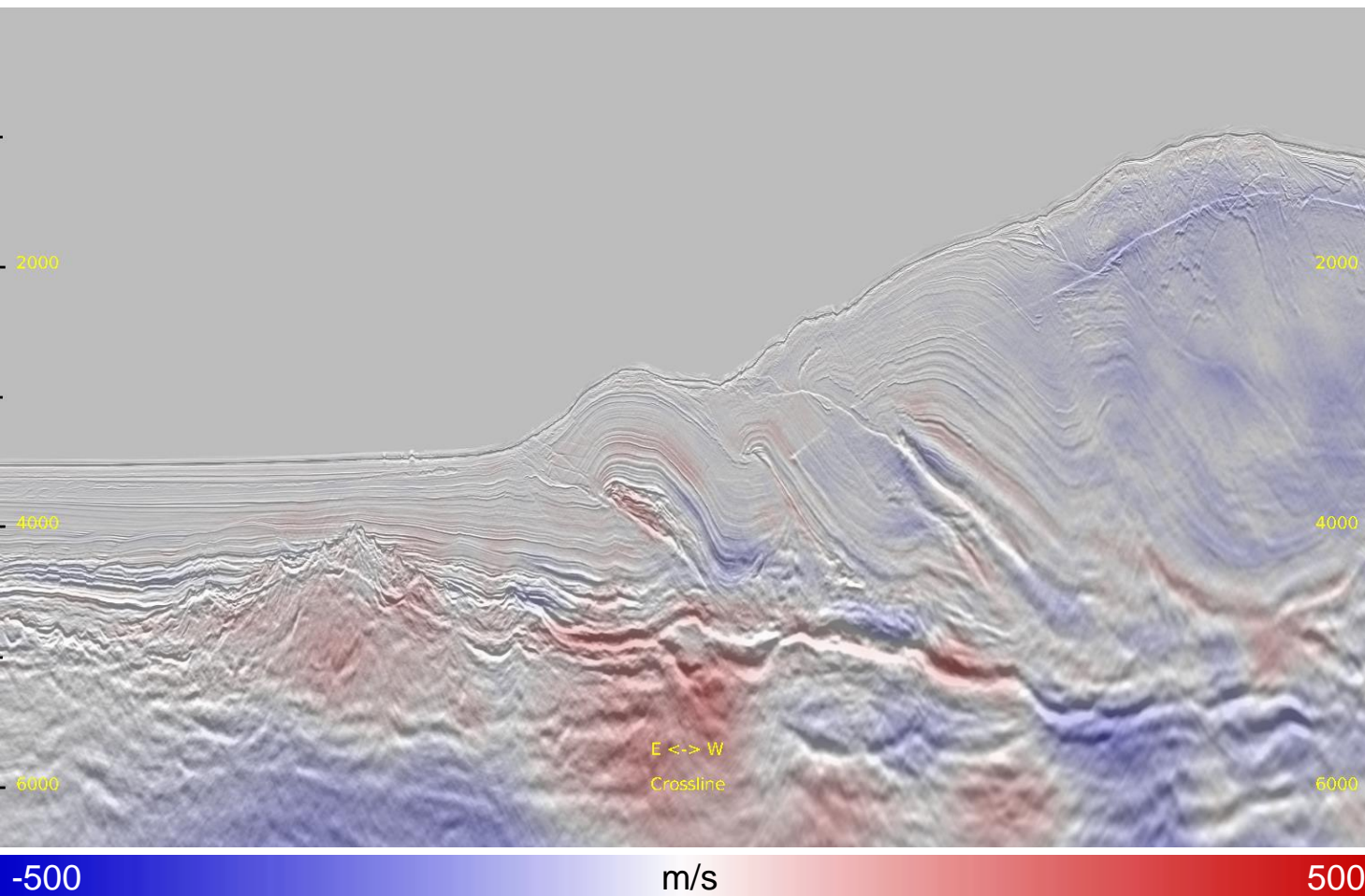
6



- Velocity perturbation is small in this area.

# Inline 436 East: Velocity Perturbation

7

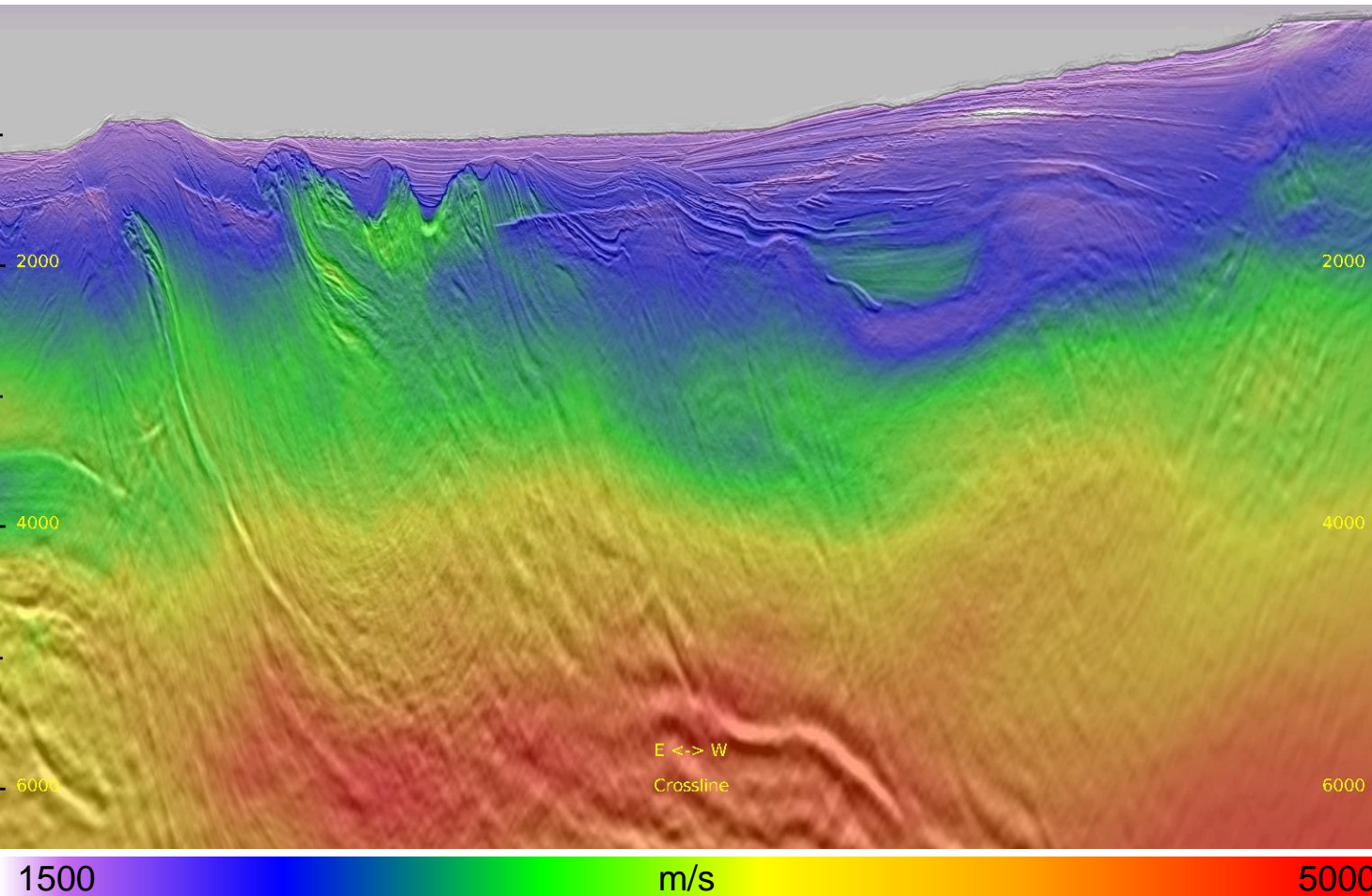


- Velocity perturbation is small in this area.



# Inline 436 West: IT3 Velocity

8

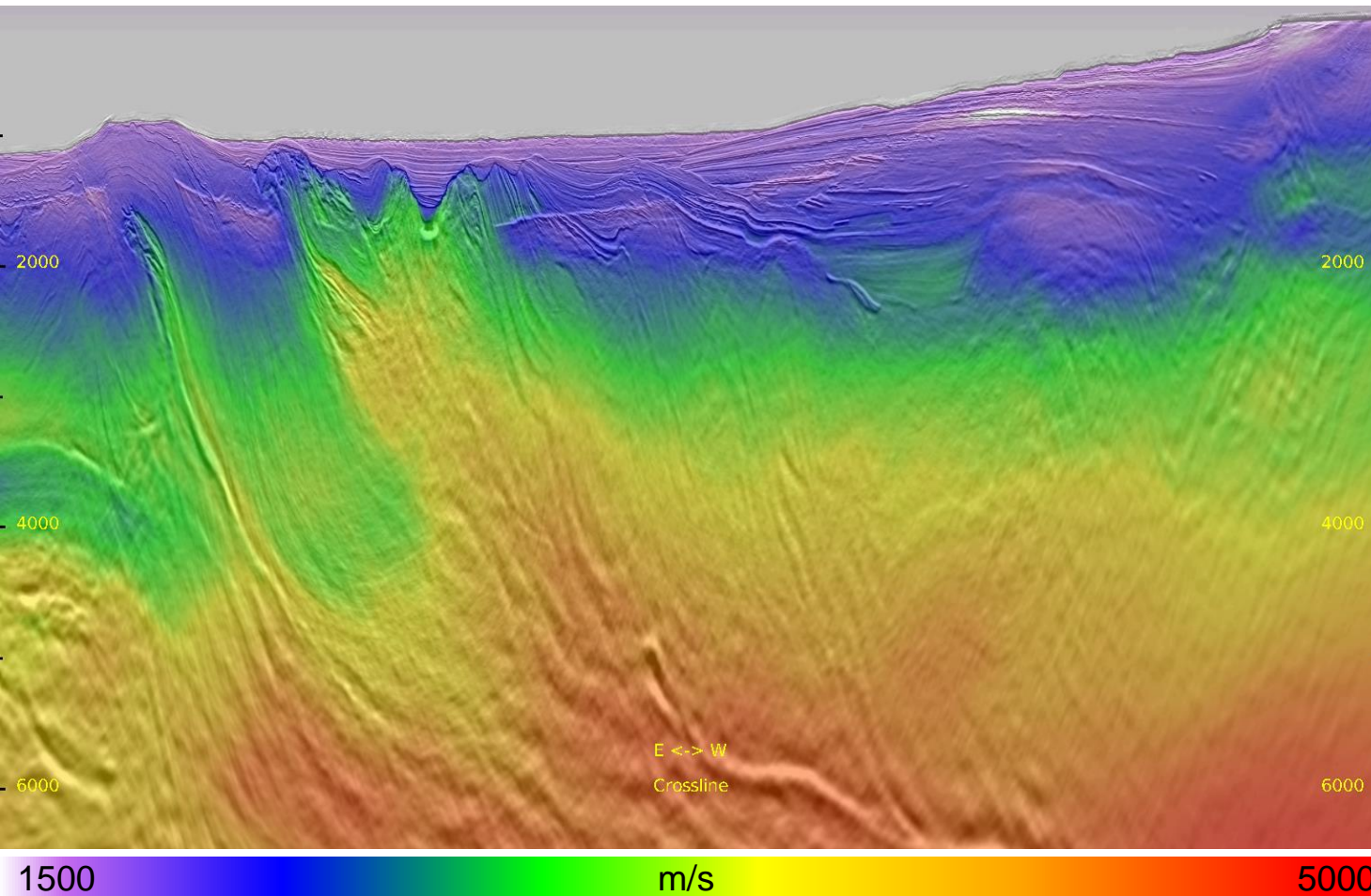


- Starting velocity is from IT3 TTI FWI.

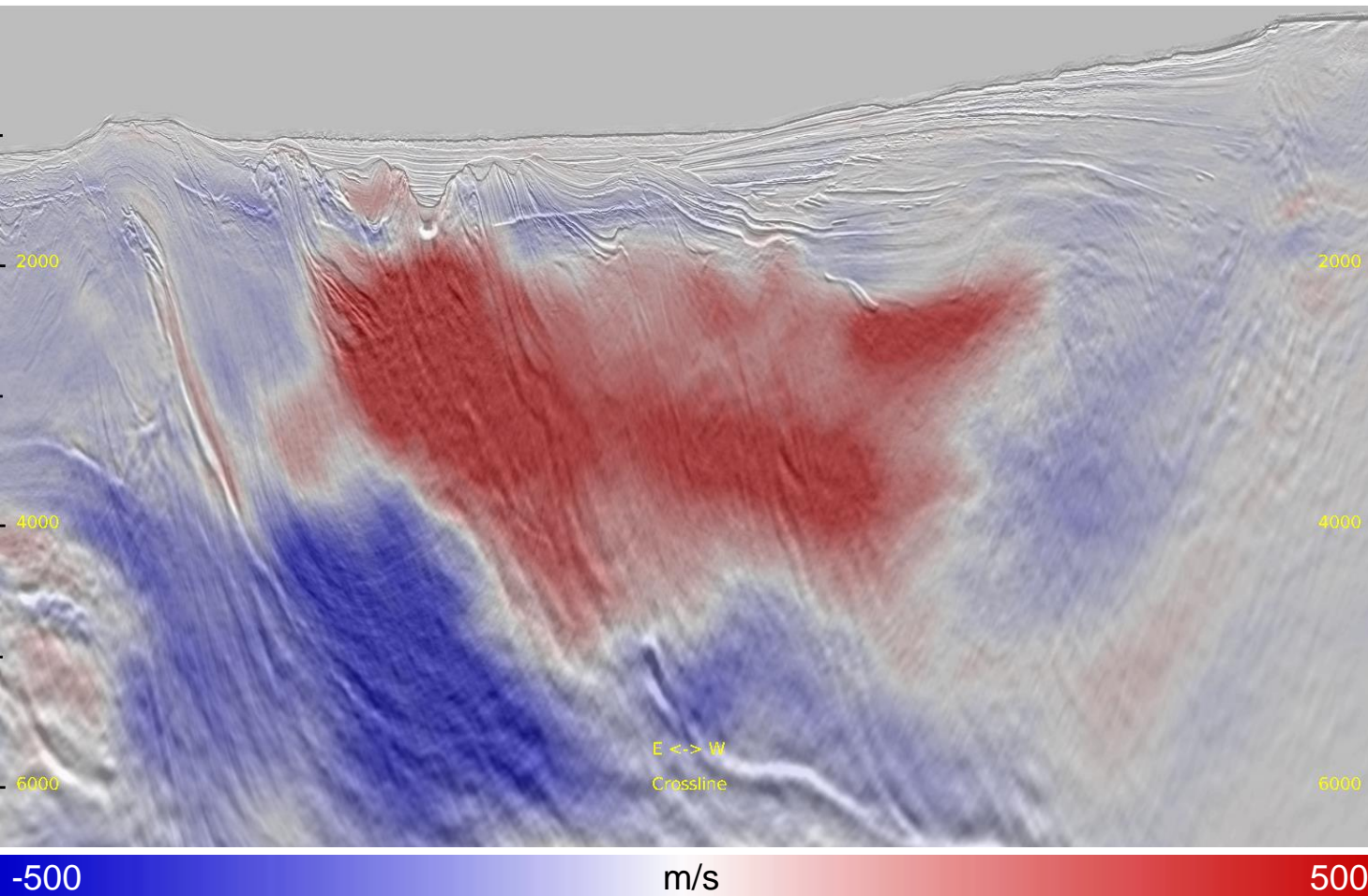


## Inline 436 West: Current Velocity

9



- After update with new anisotropy, the velocity is more geological in the deep part.



- Velocity perturbation is more in the deep part.

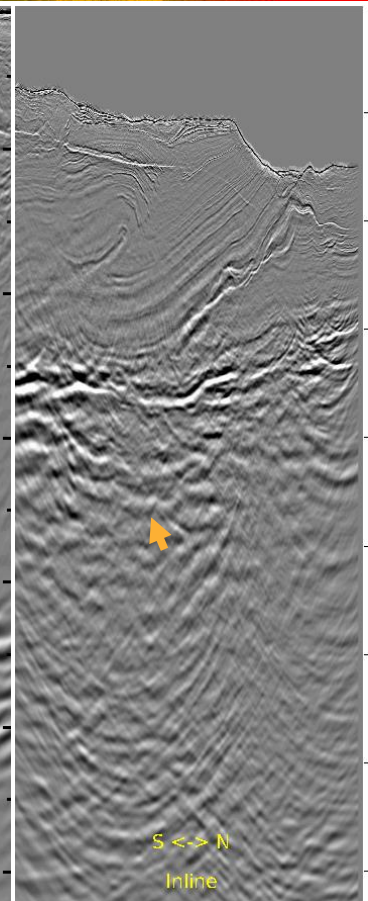
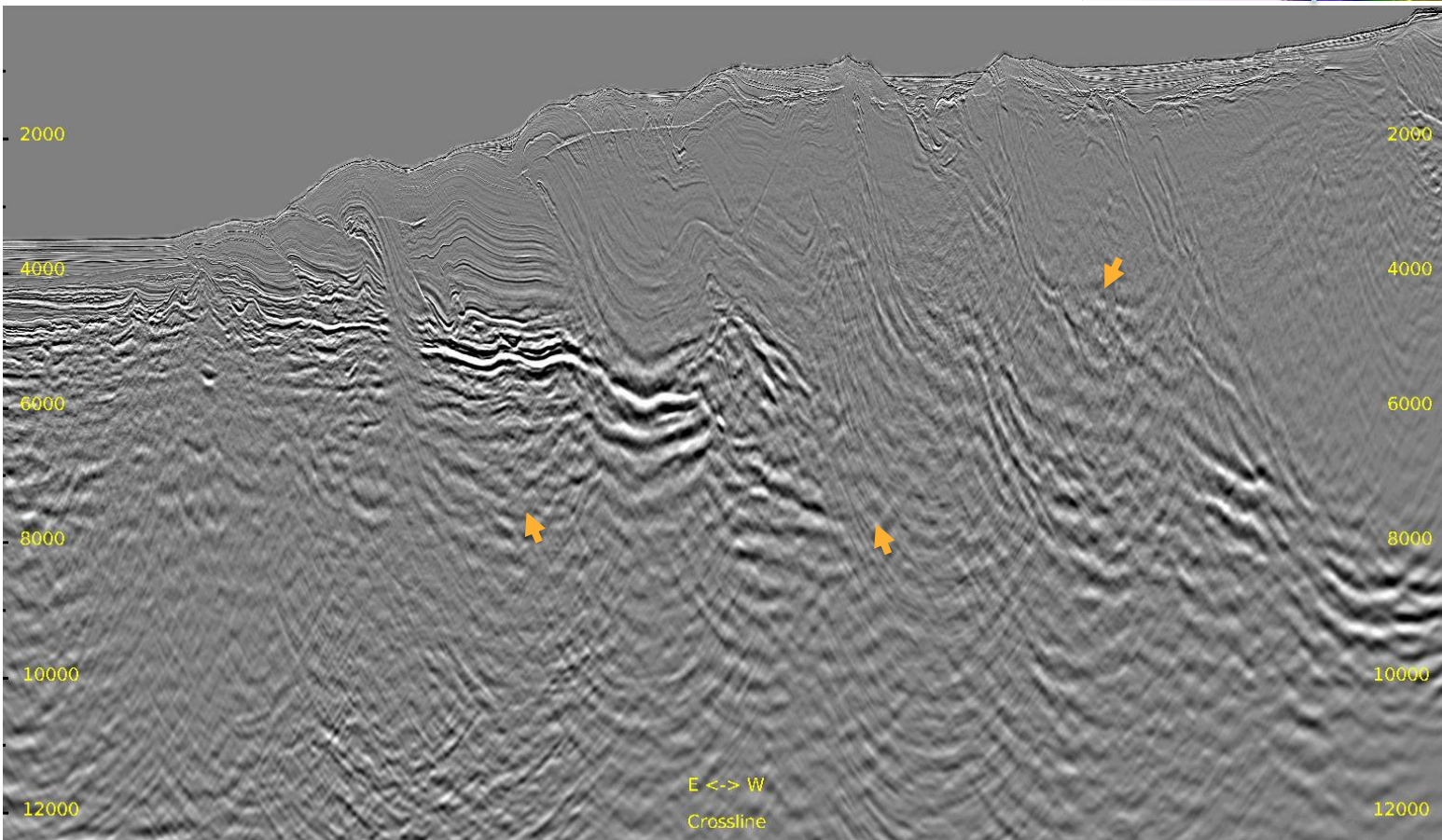
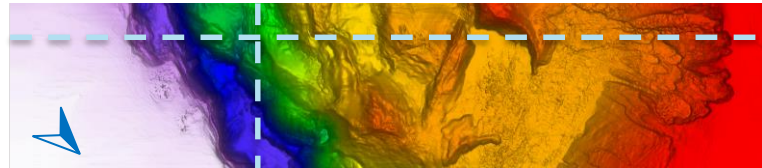
# Kirchhoff Depth Migration





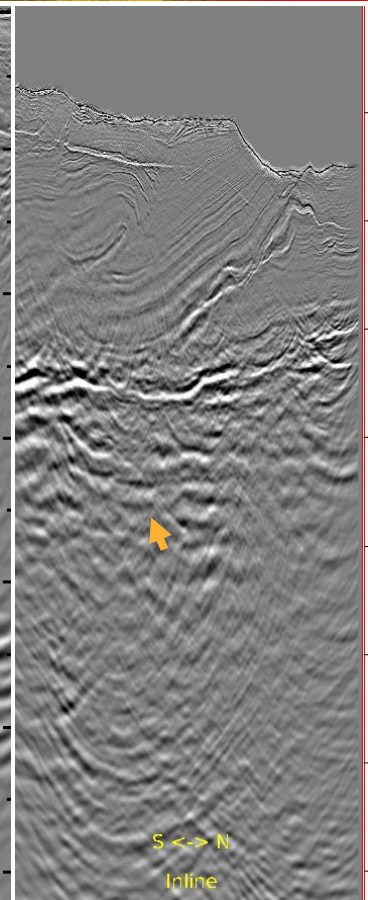
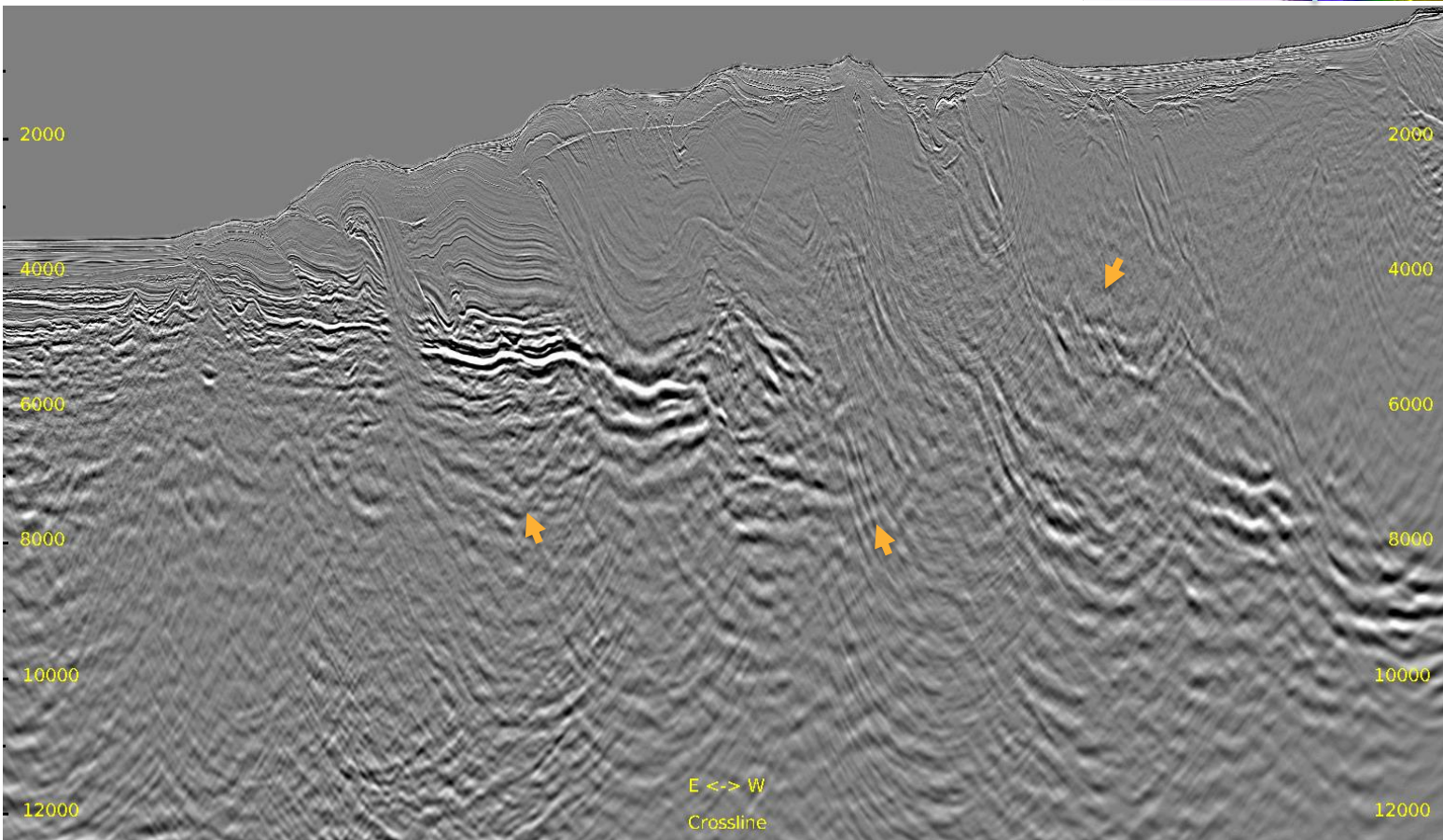
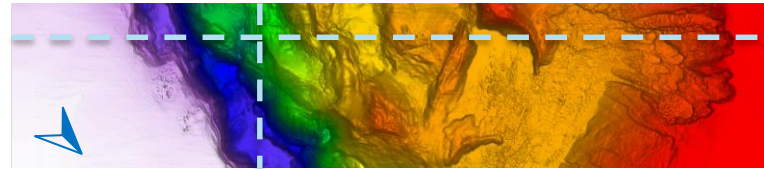
# Full Stack: IT3 Result

Inline 205 & Crossline 2368



# Full Stack: Current Result

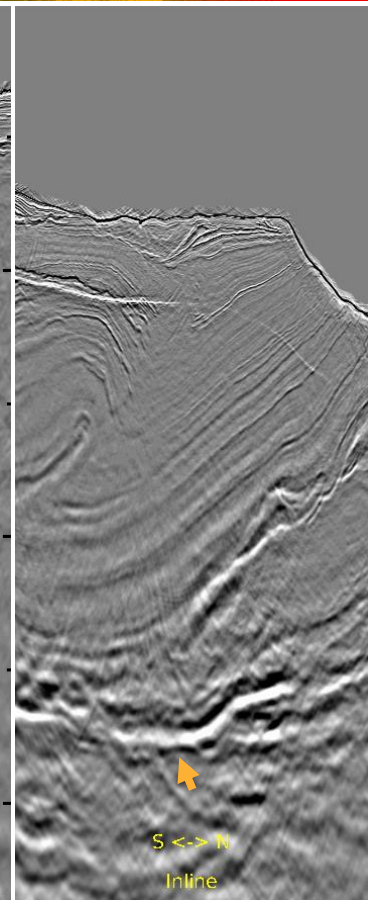
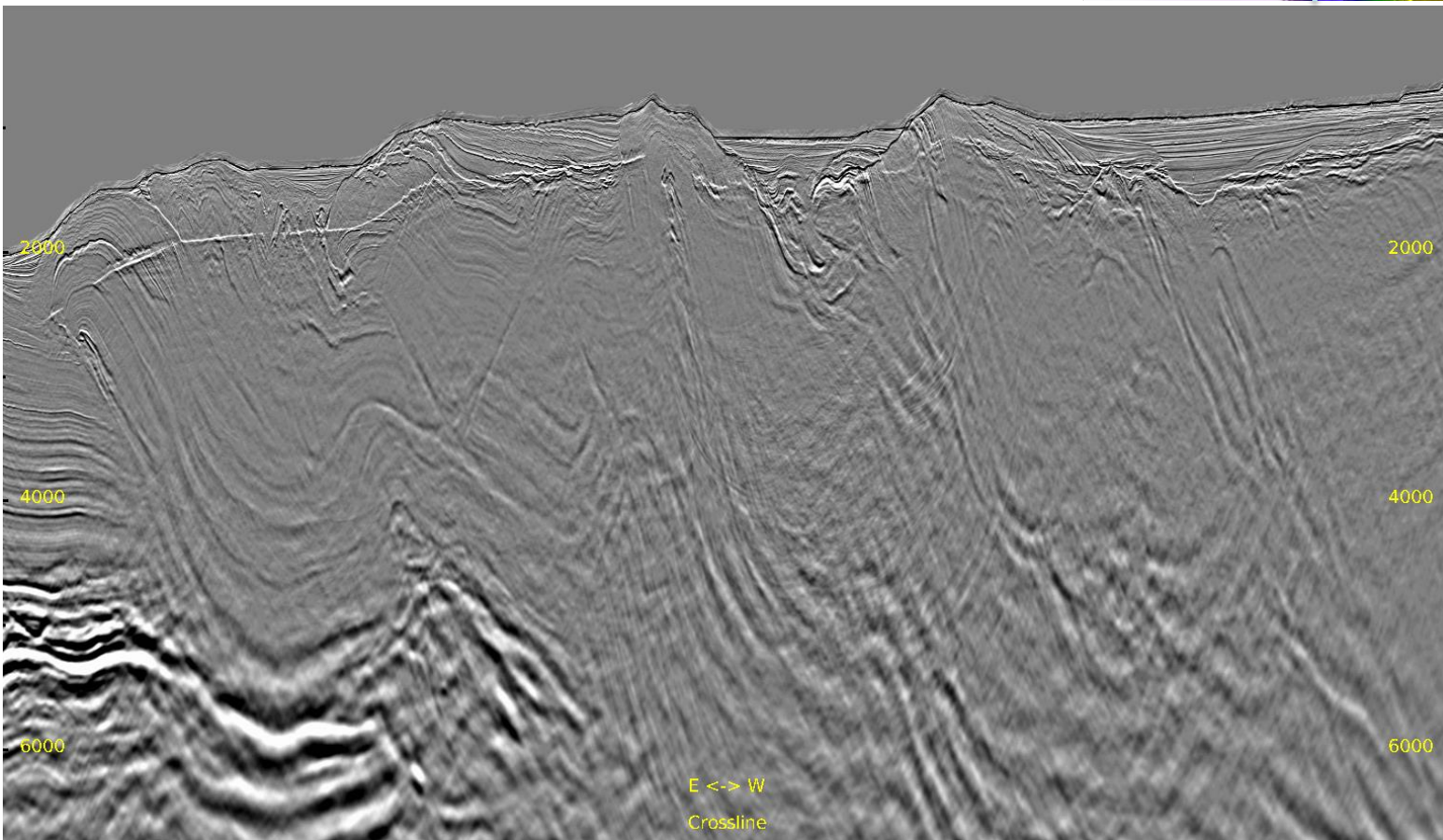
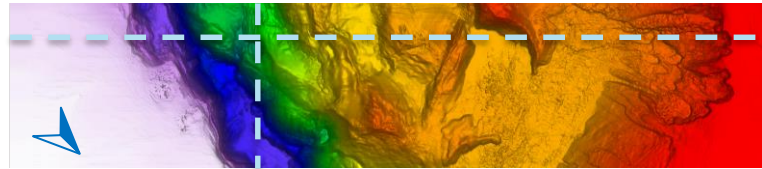
Inline 205 & Crossline 2368





# Zoomed Full Stack: IT3 Result

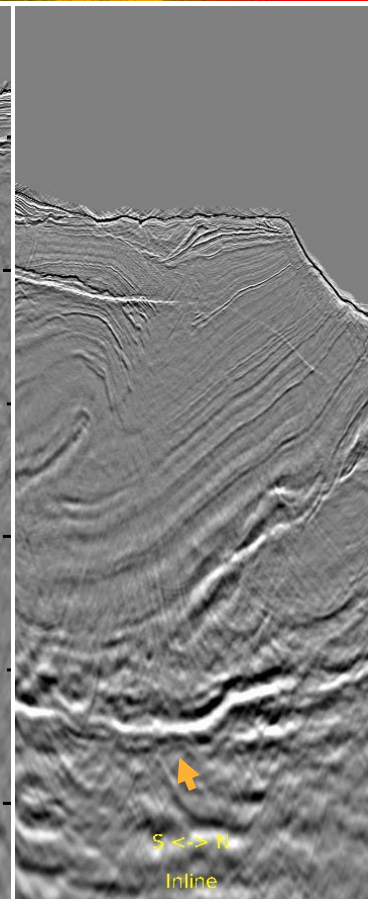
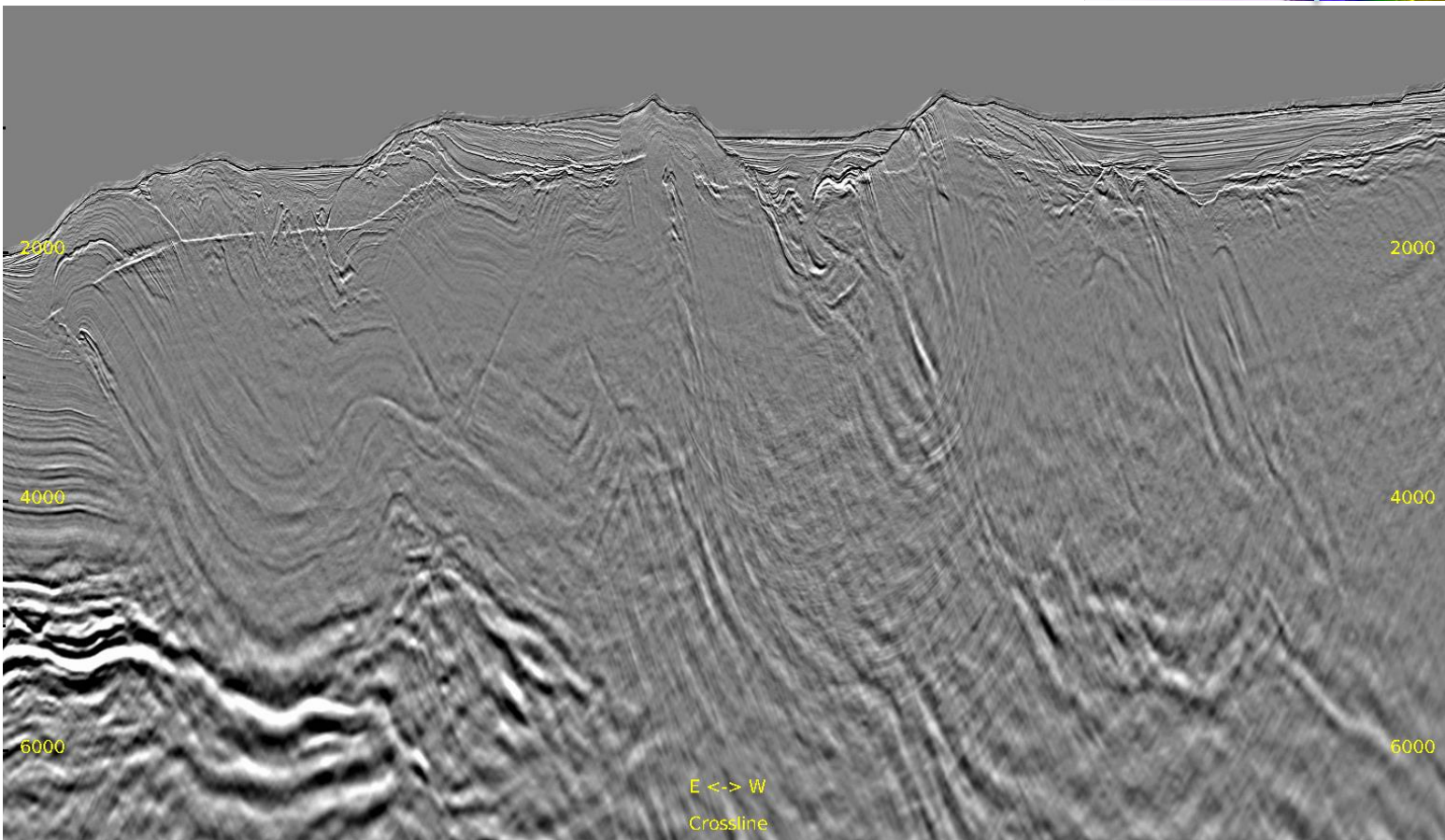
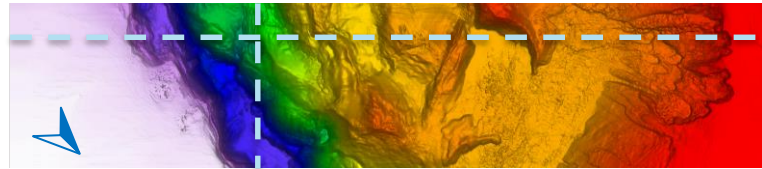
Inline 205 & Crossline 2368



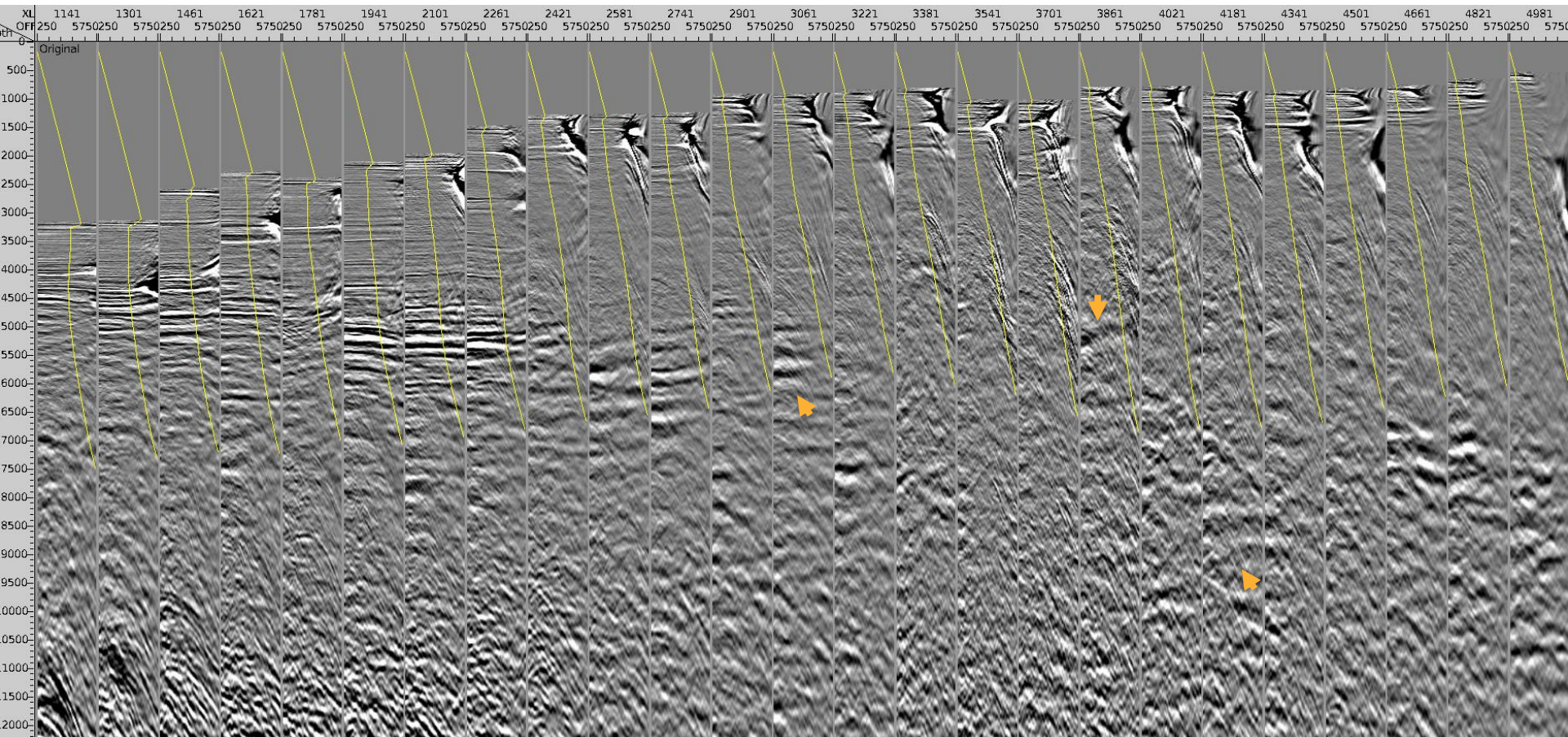


# Zoomed Full Stack: Current Result

Inline 205 & Crossline 2368







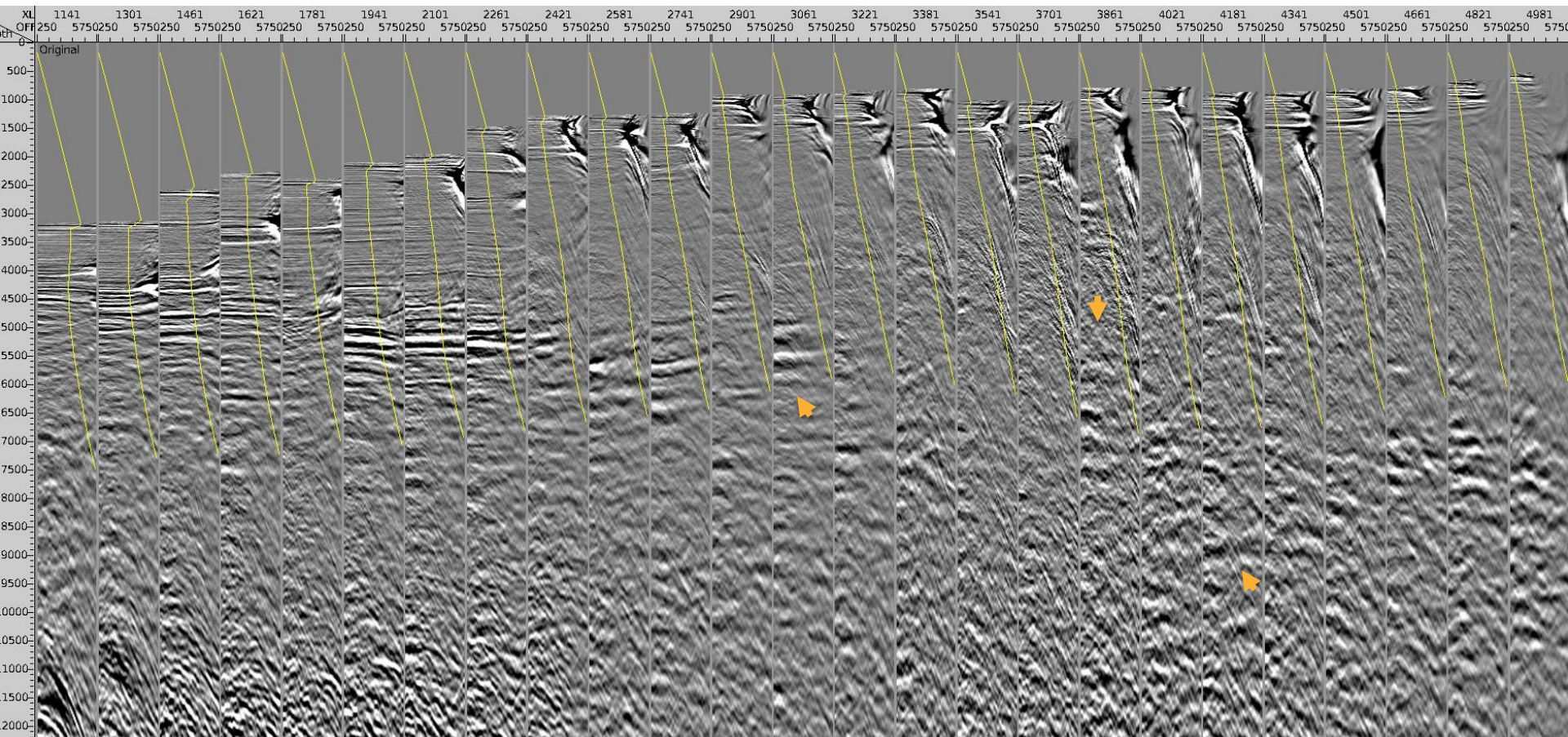




# Inline 205 CDP Gathers: Current Result

— 35° Mute

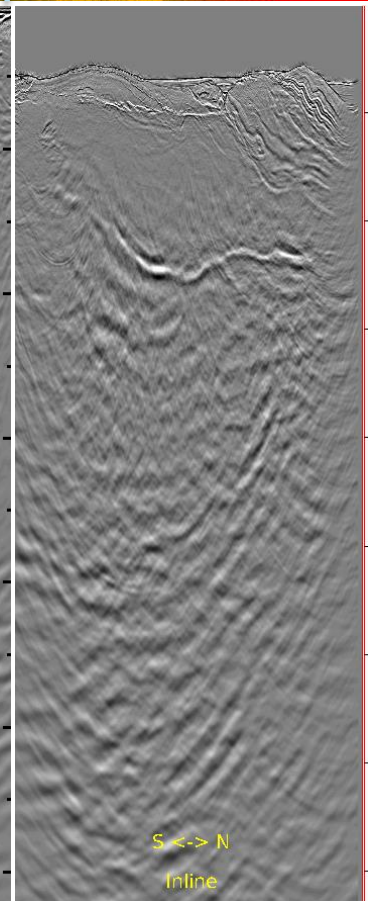
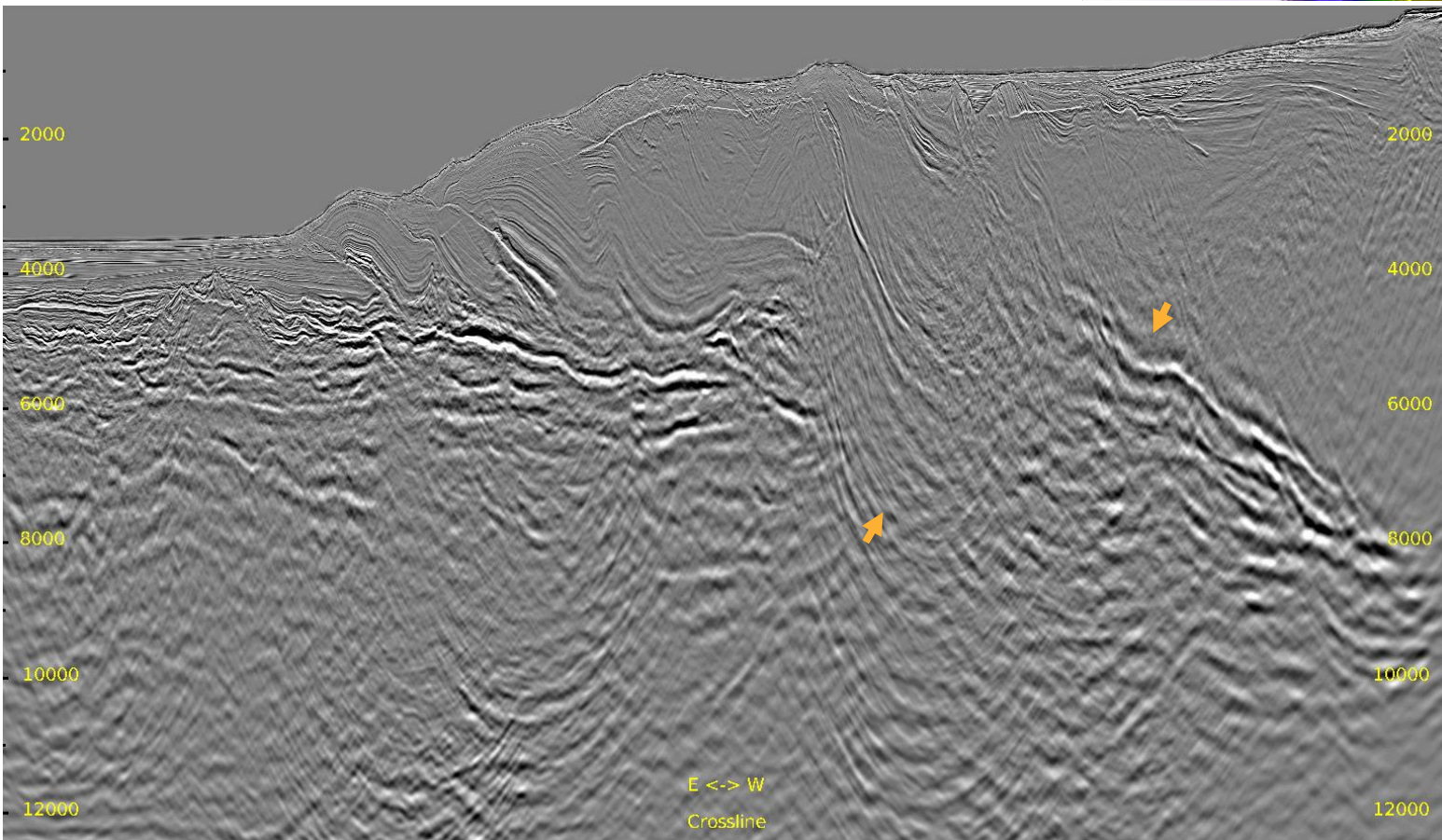
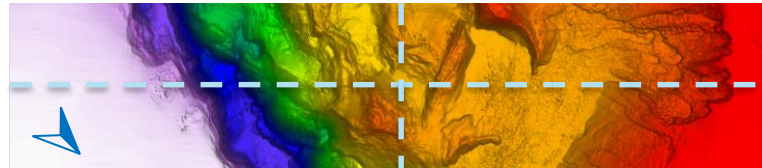
17





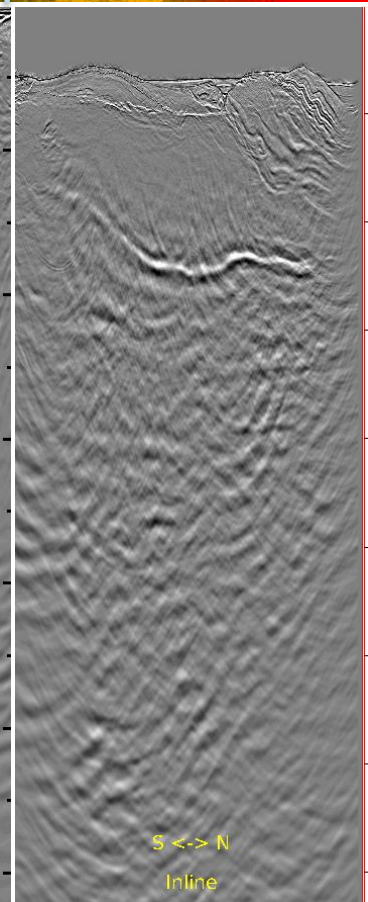
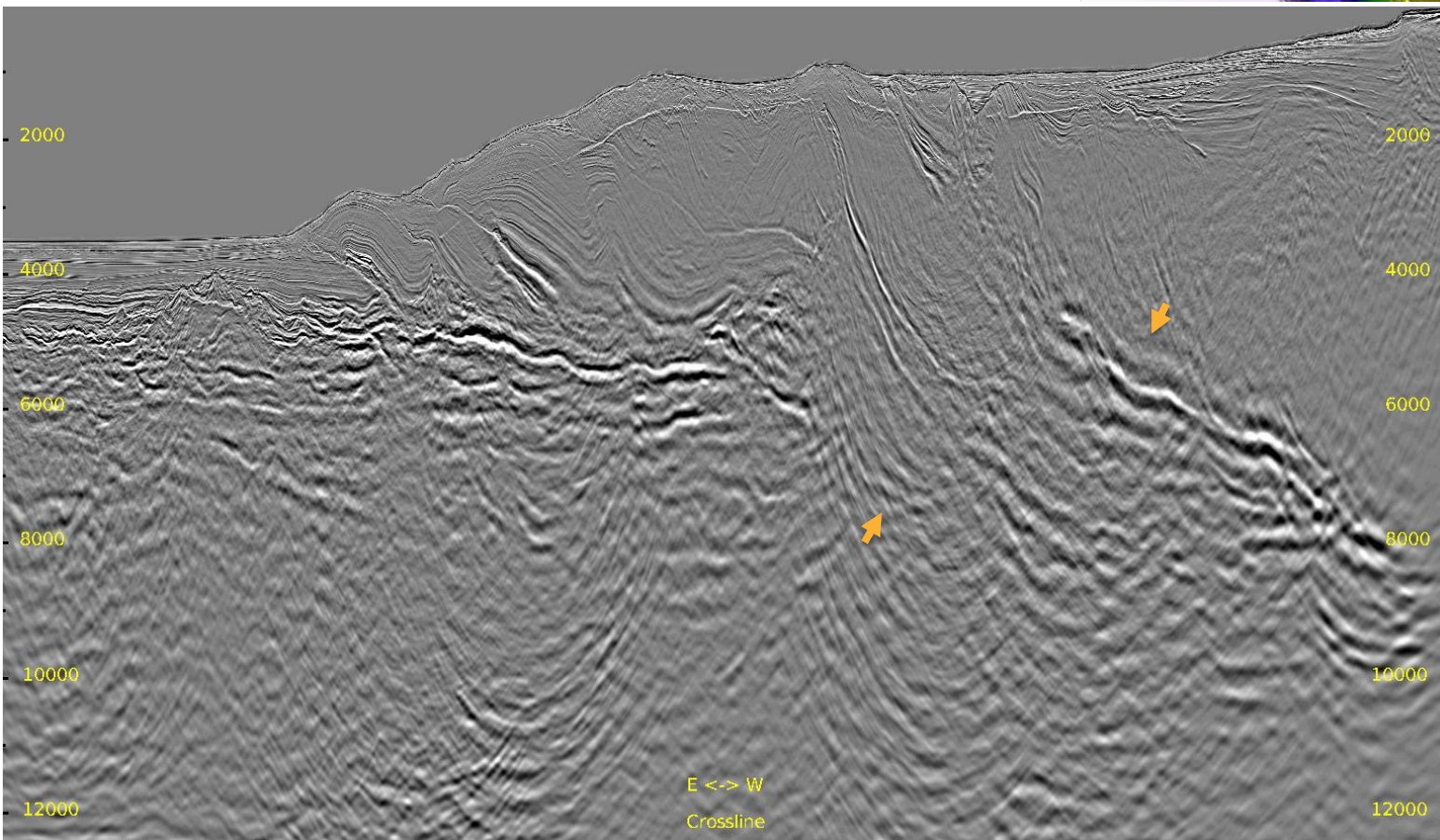
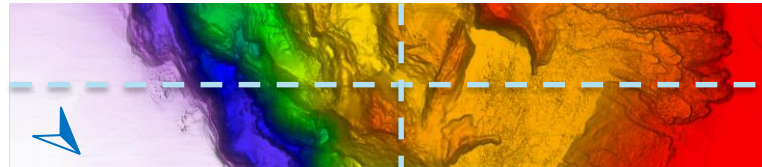
# Full Stack: IT3 Result

Inline 418 & Crossline 3411



# Full Stack: Current Result

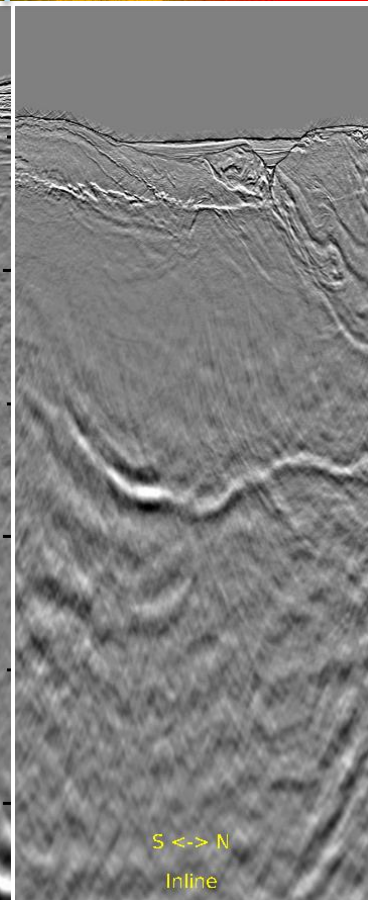
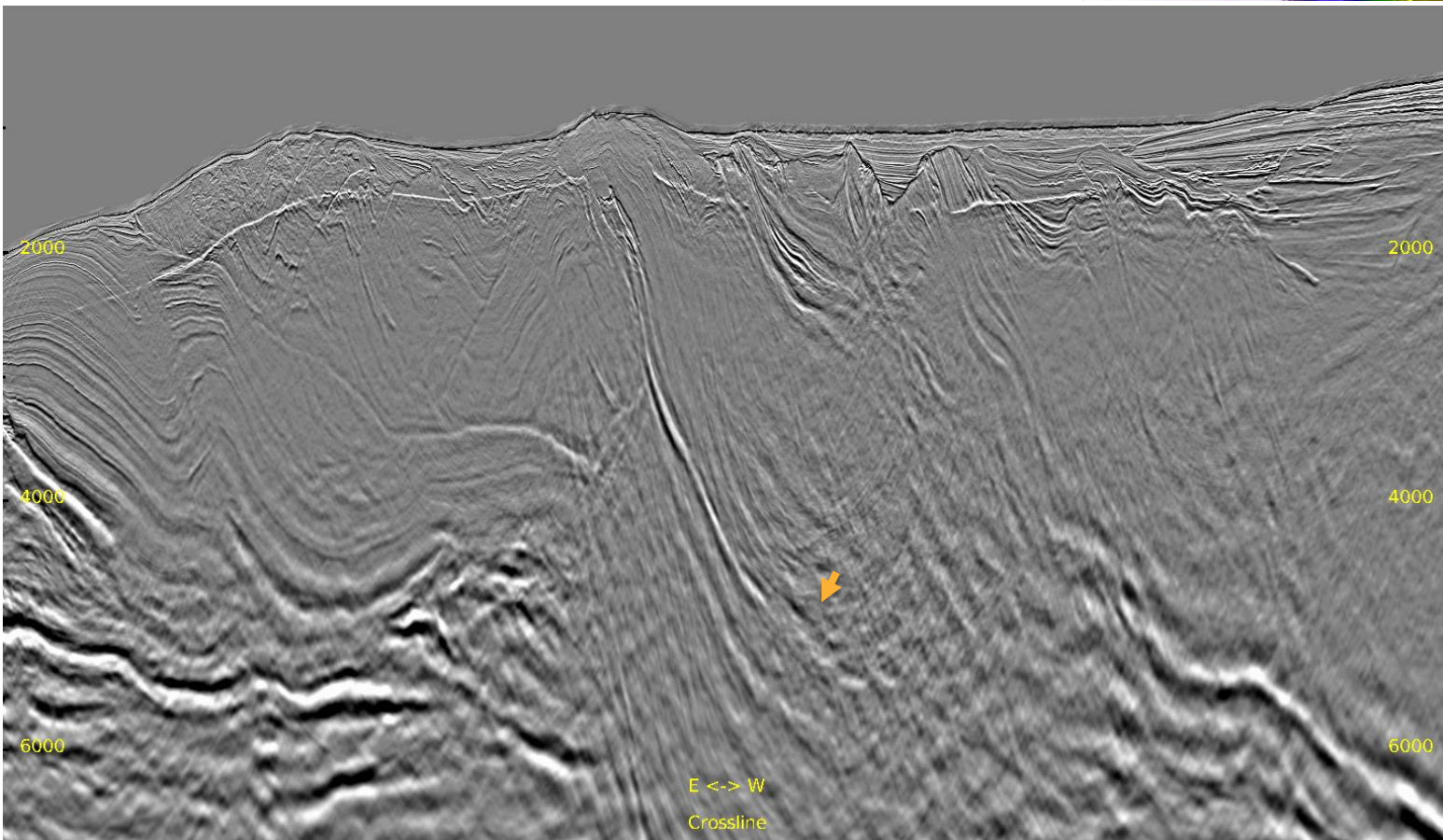
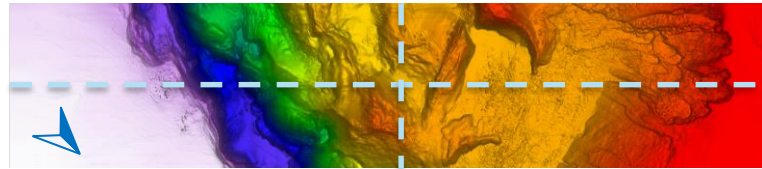
Inline 418 & Crossline 3411





# Zoomed Full Stack: IT3 Result

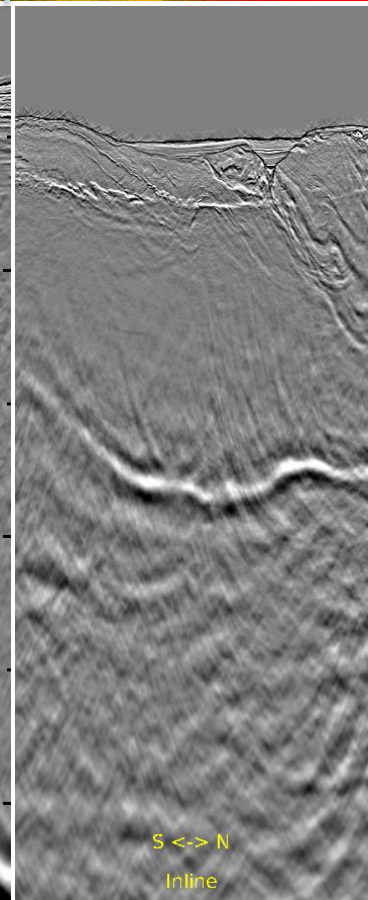
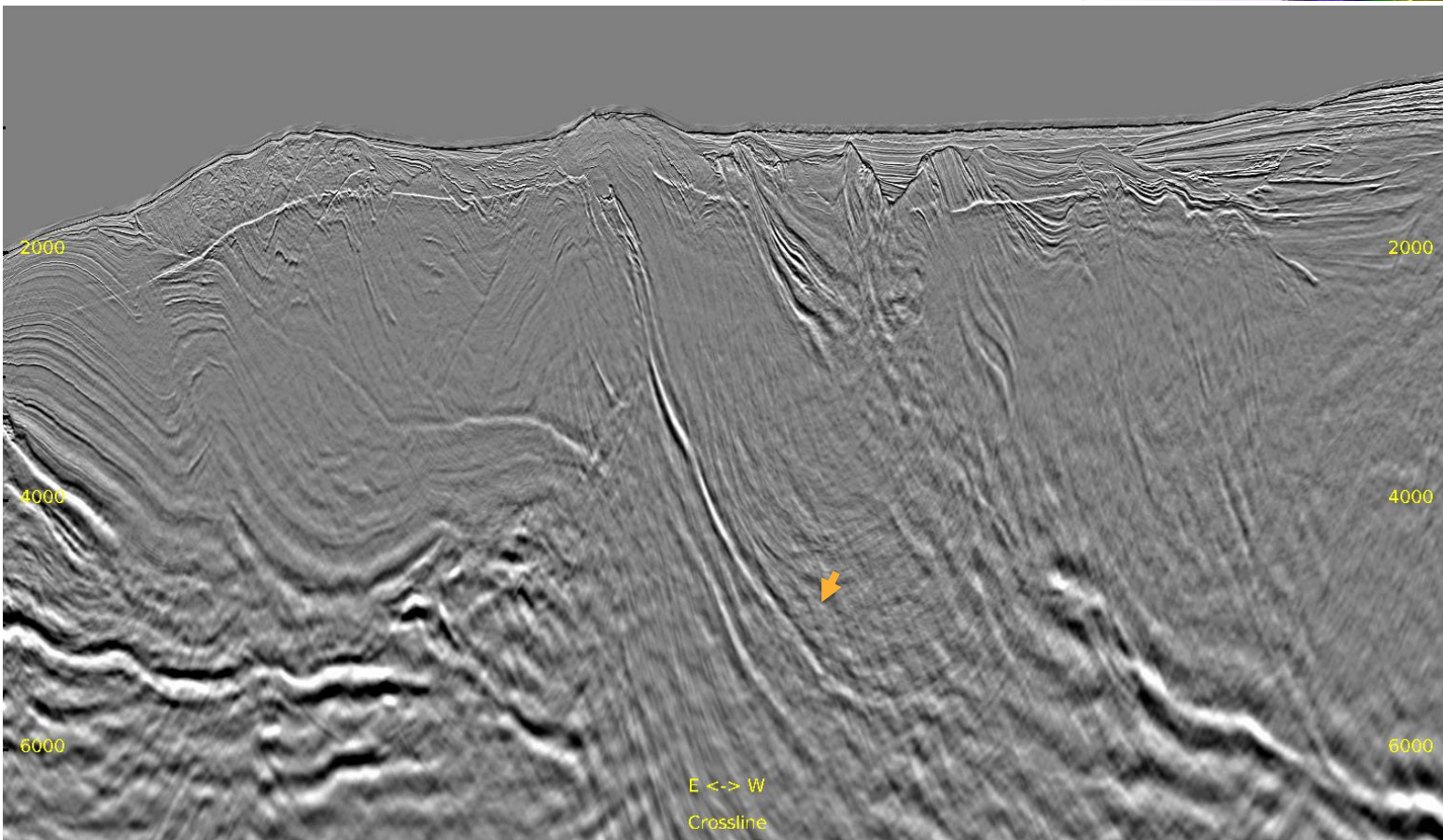
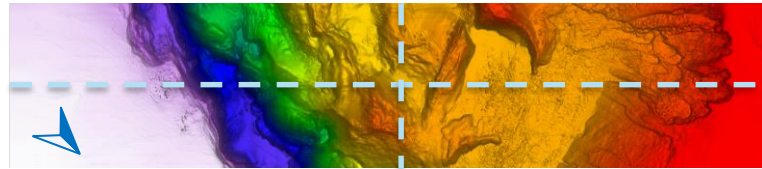
Inline 418 & Crossline 3411



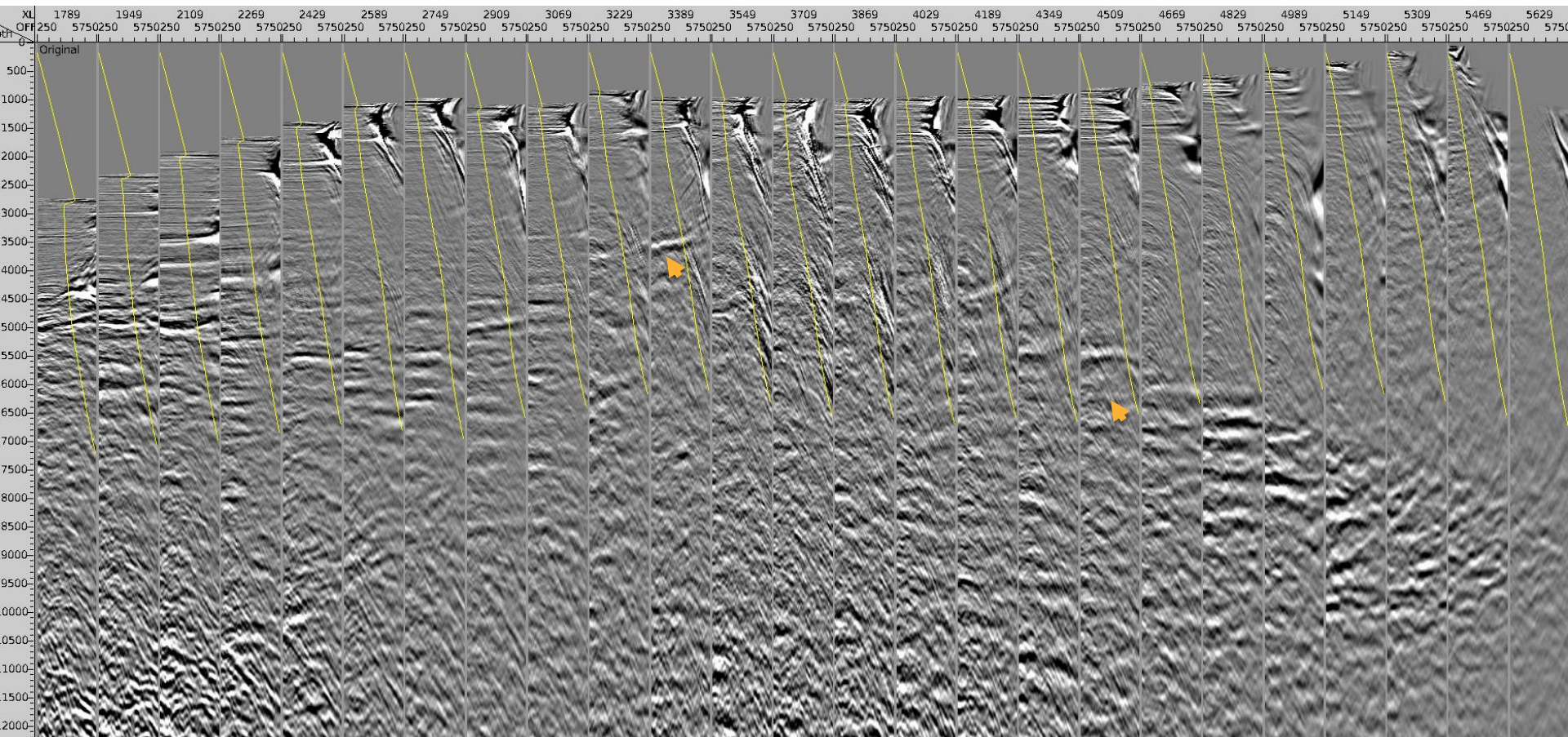


# Zoomed Full Stack: Current Result

Inline 418 & Crossline 3411







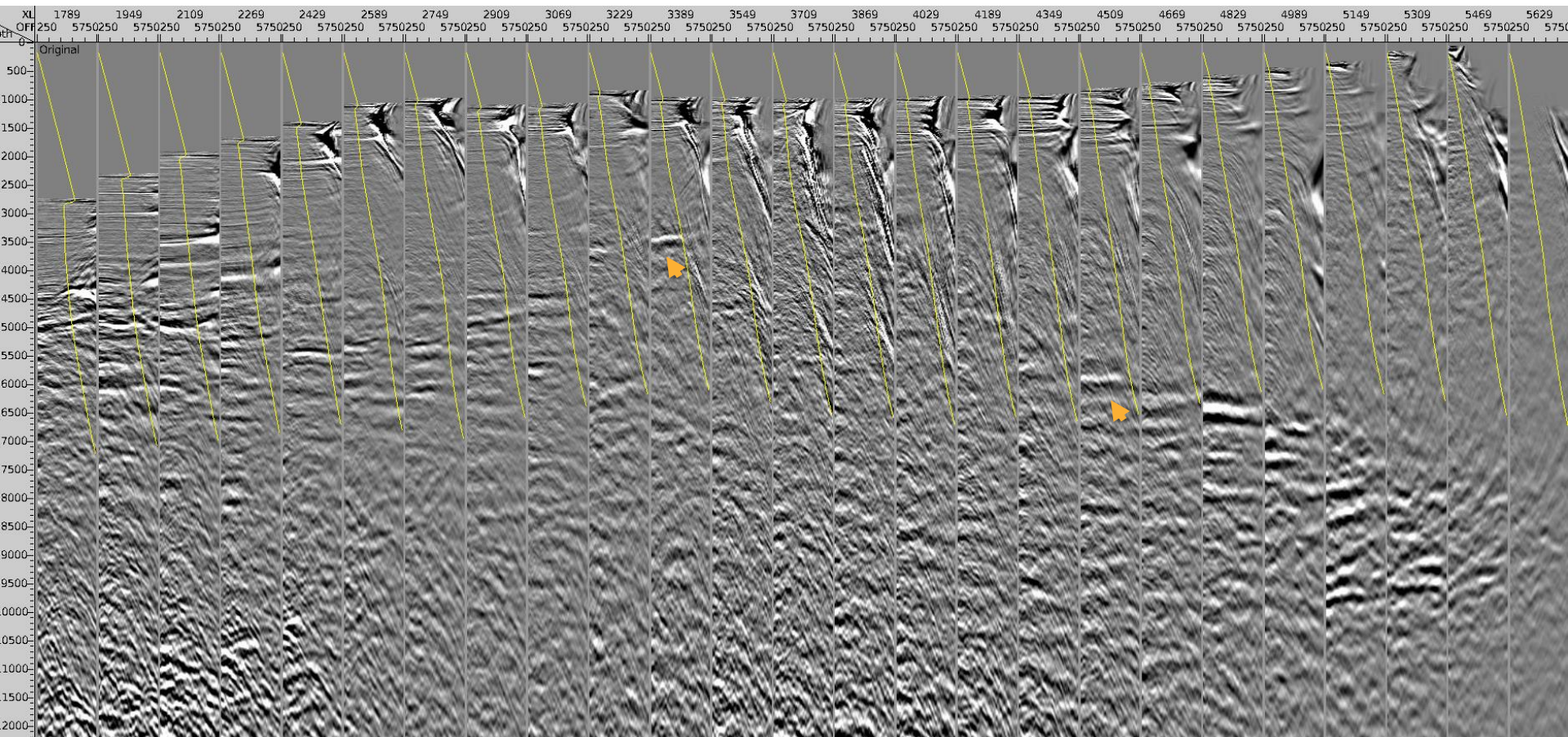




# Inline 418 CDP Gathers: Current Result

— 35° Mute

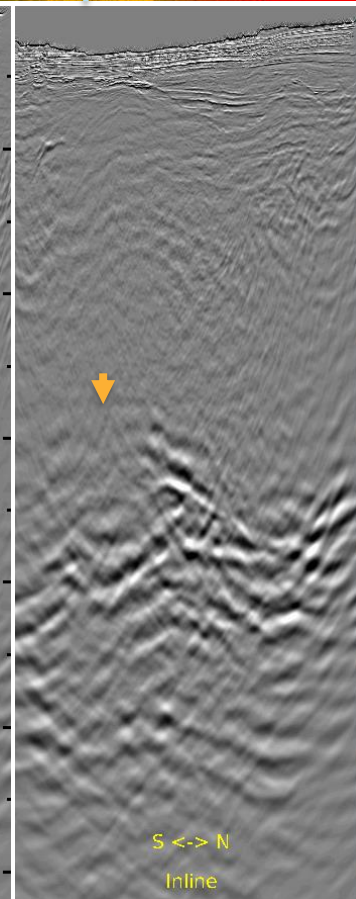
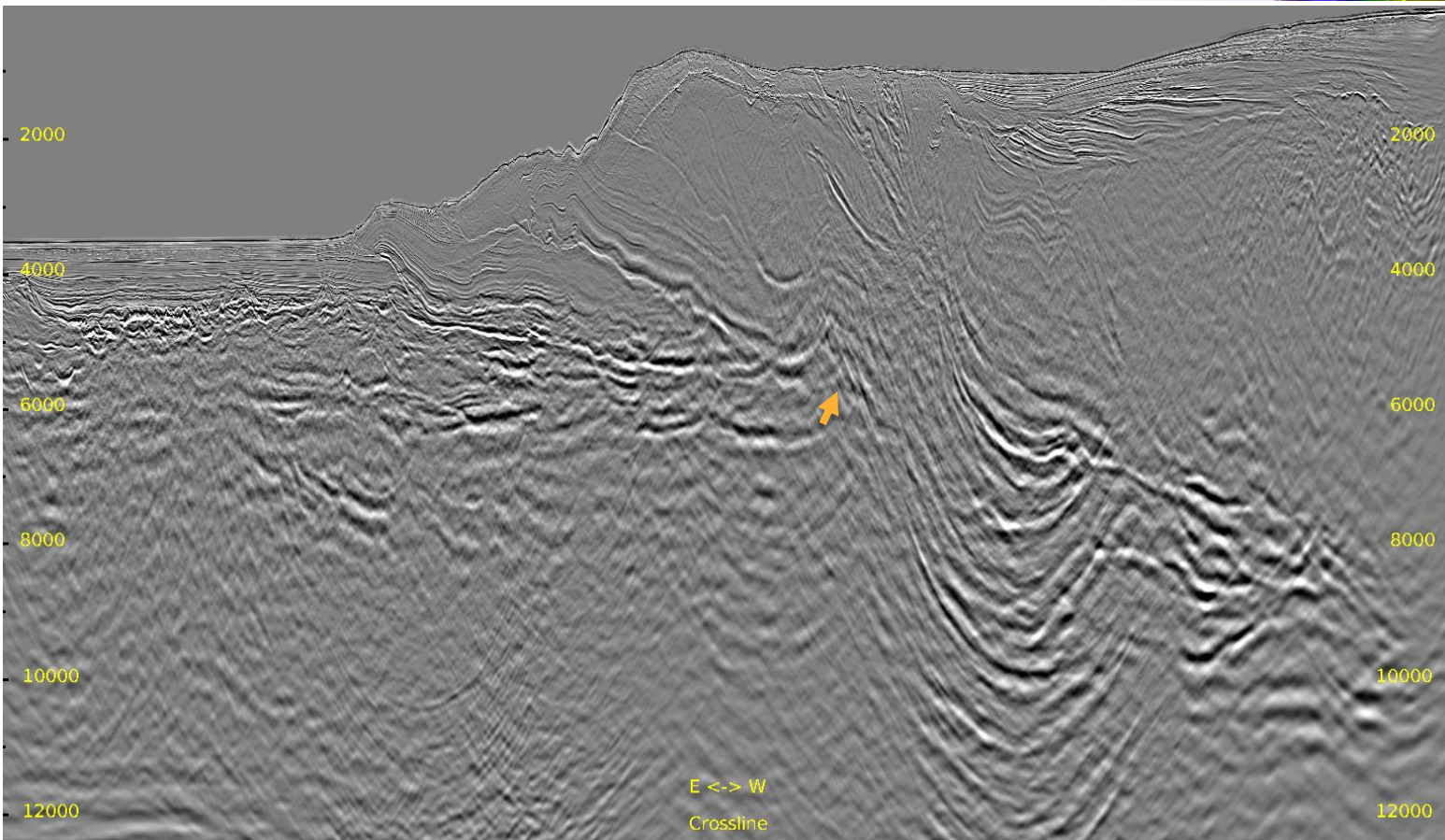
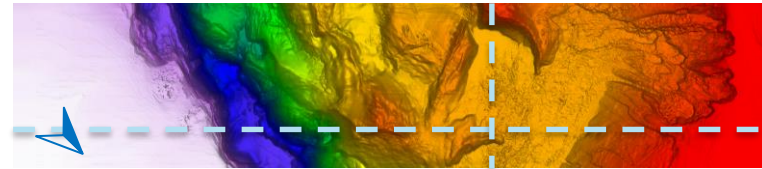
23





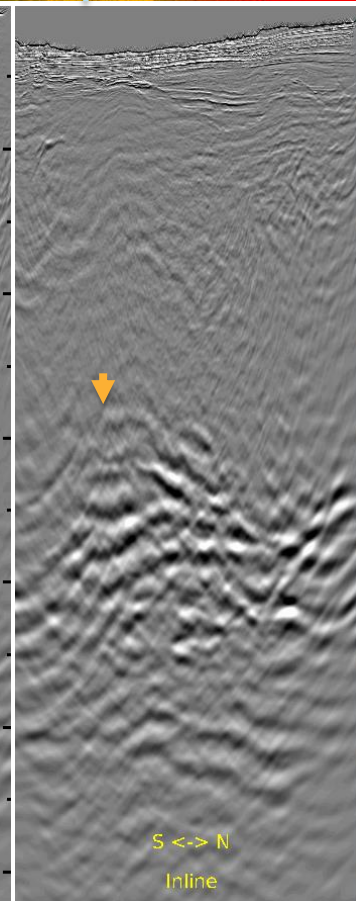
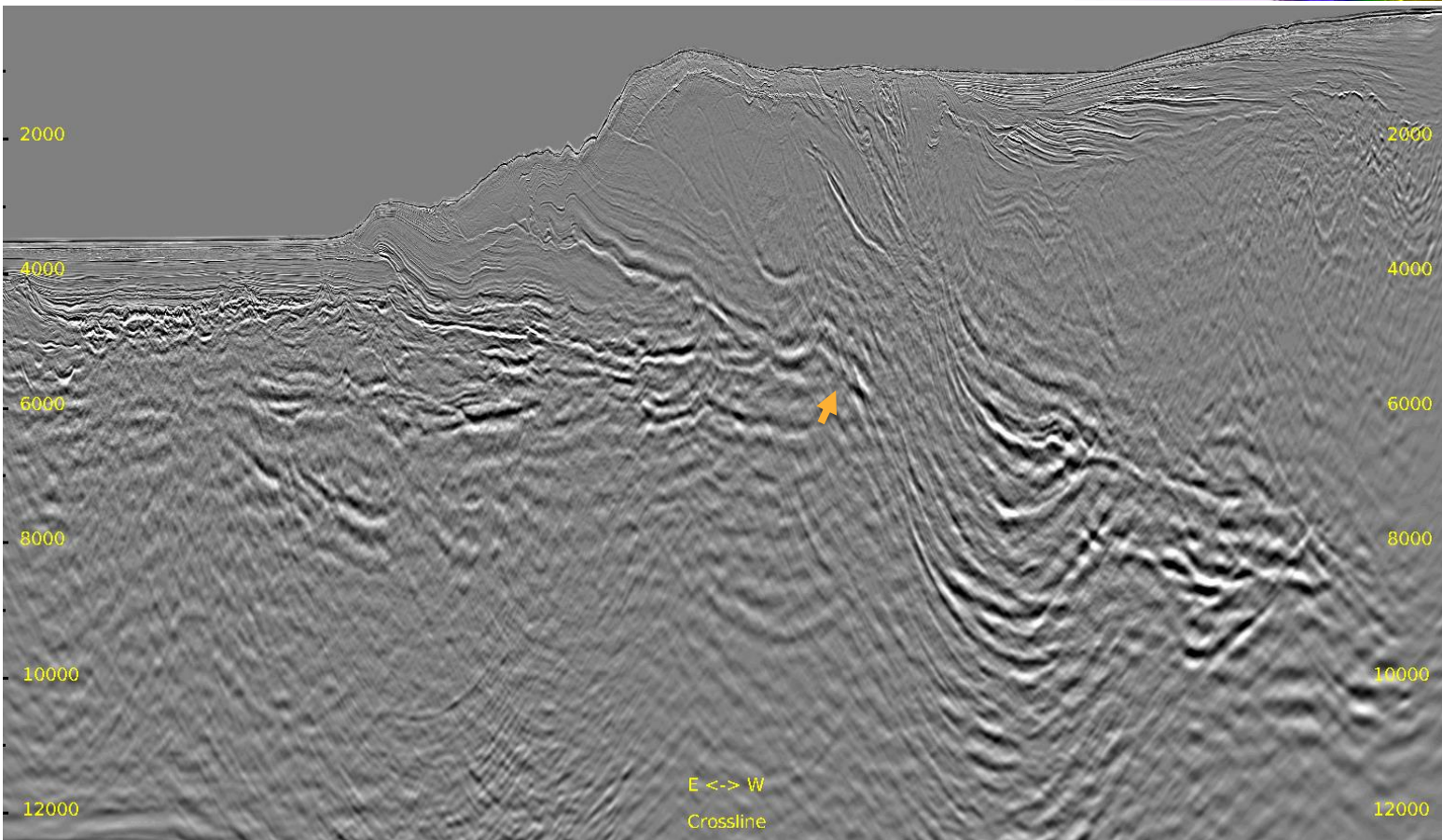
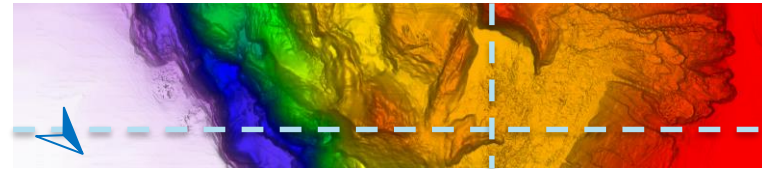
# Full Stack: IT3 Result

Inline 620 & Crossline 4880



# Full Stack: Current Result

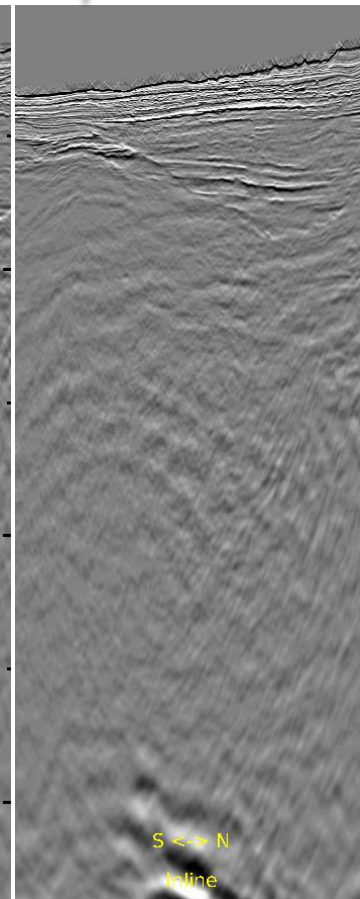
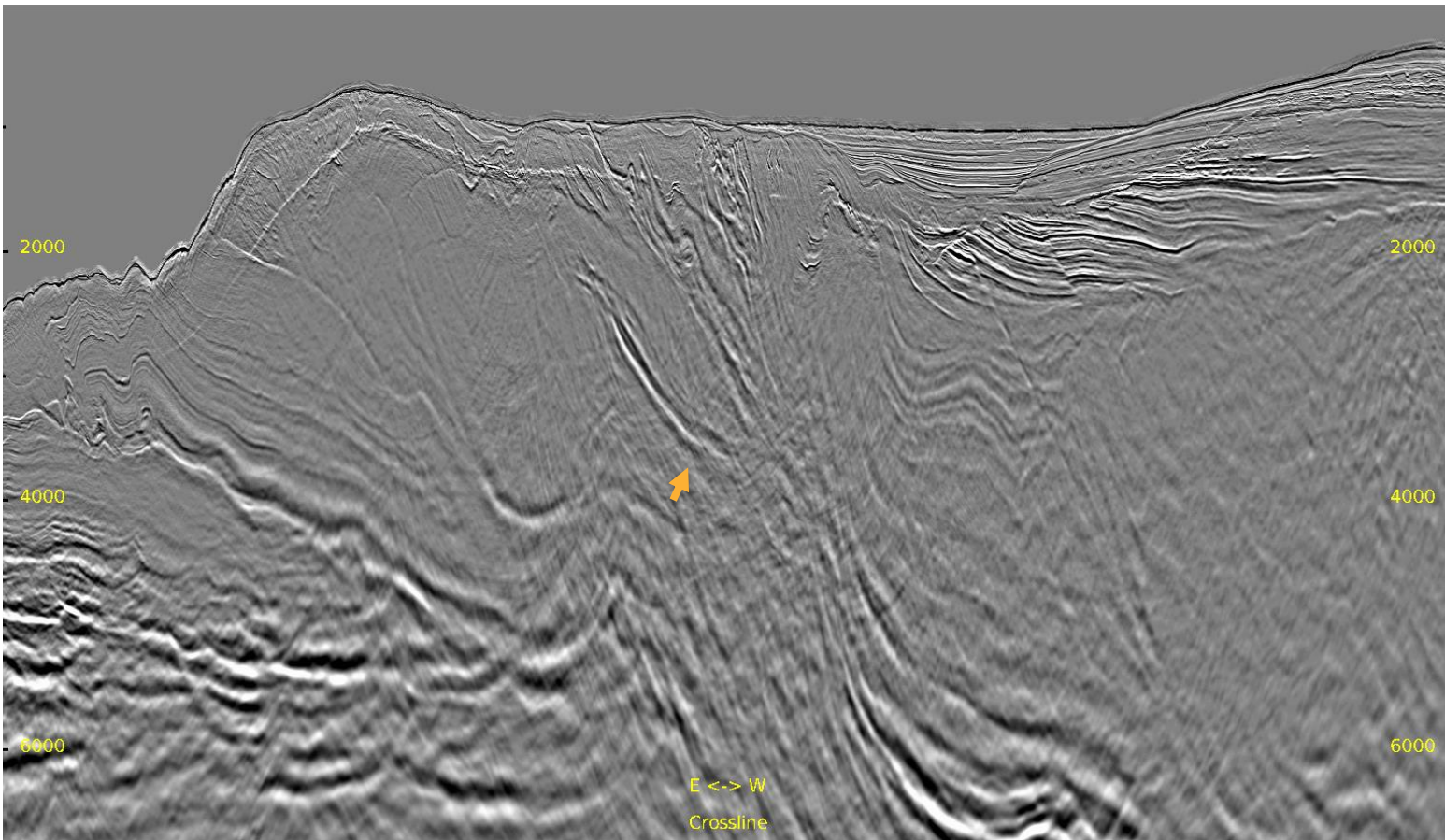
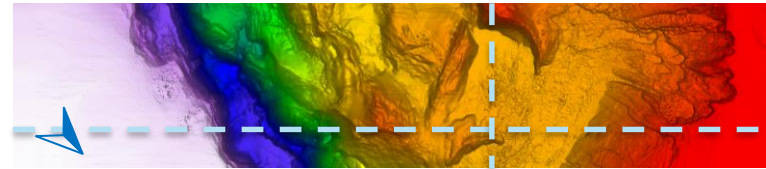
Inline 620 & Crossline 4880





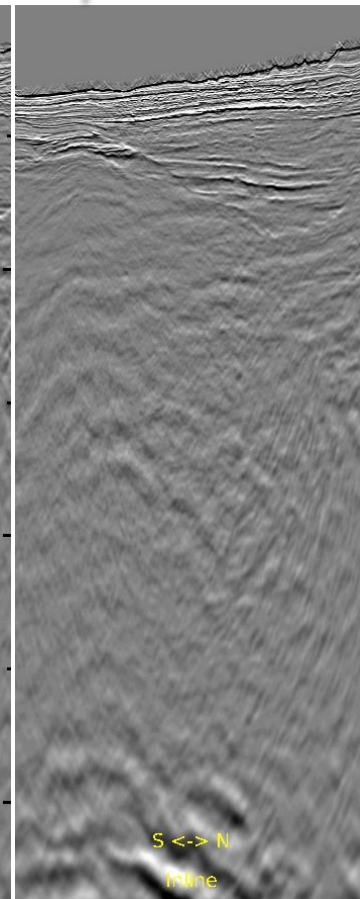
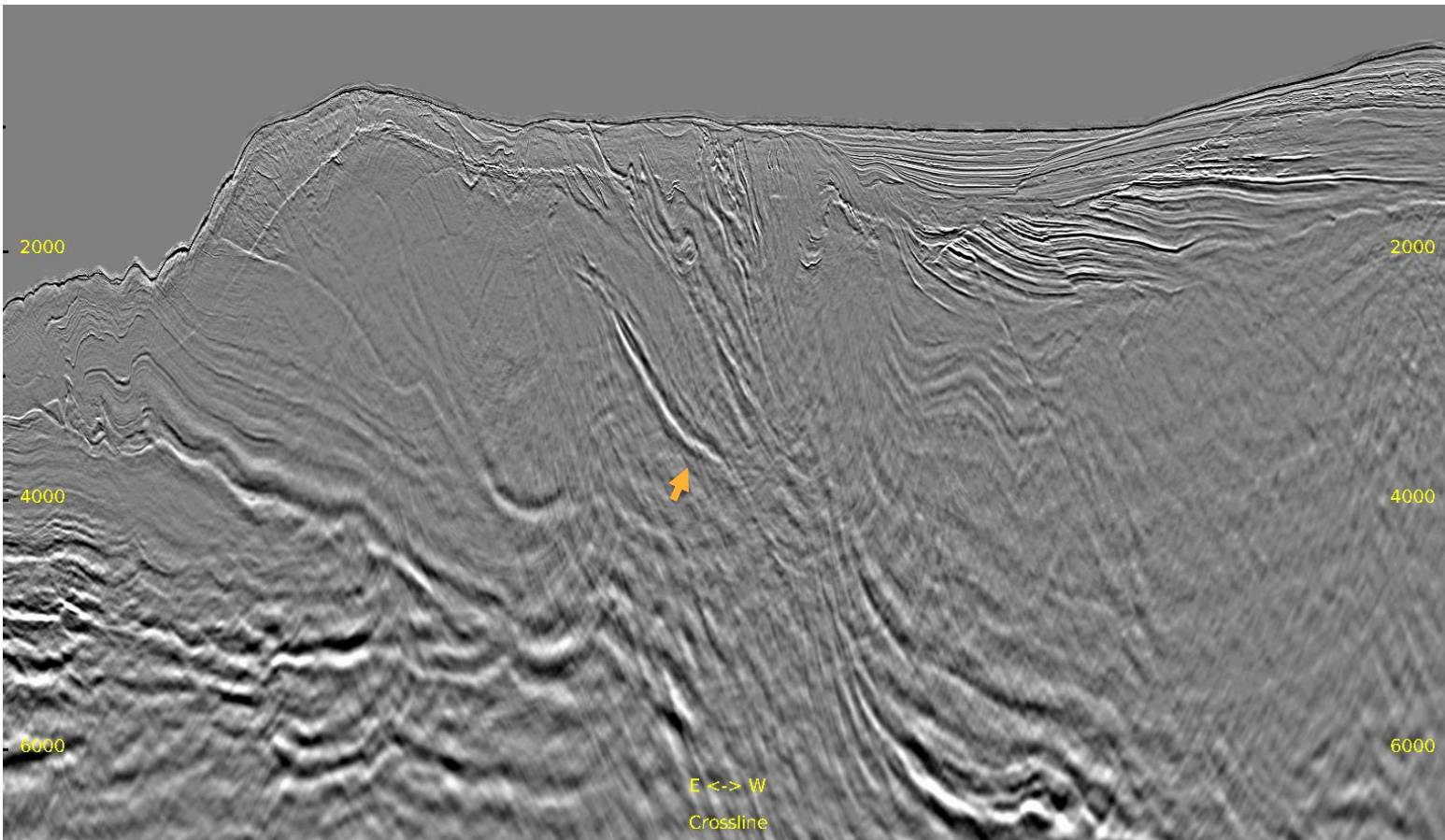
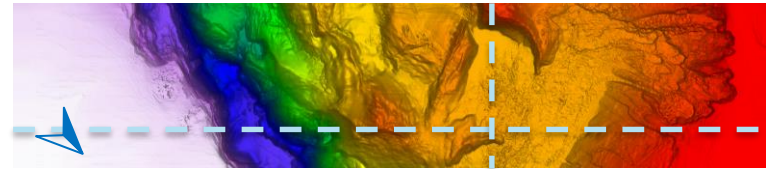
# Zoomed Full Stack: IT3 Result

Inline 620 & Crossline 4880

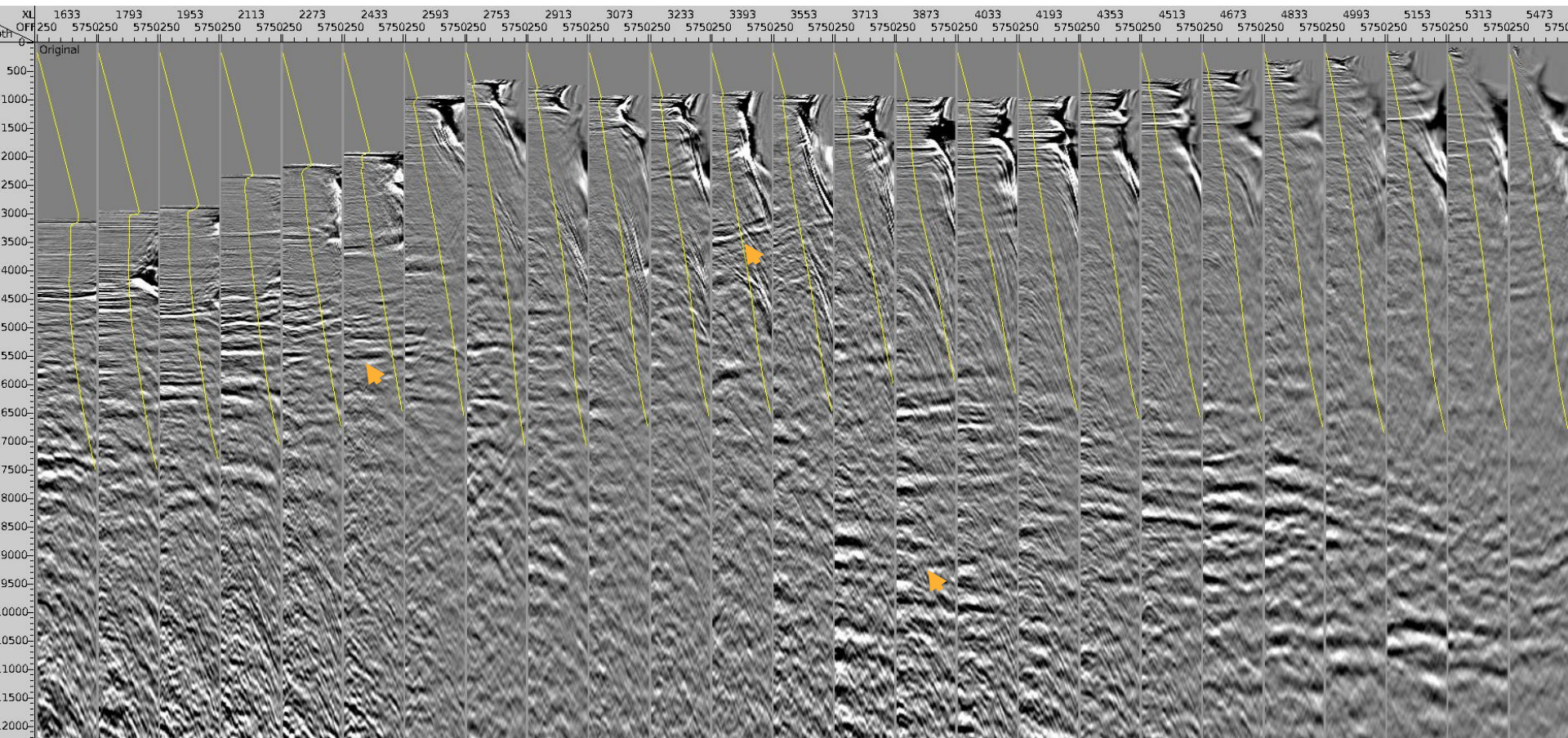


# Zoomed Full Stack: Current Result

Inline 620 & Crossline 4880







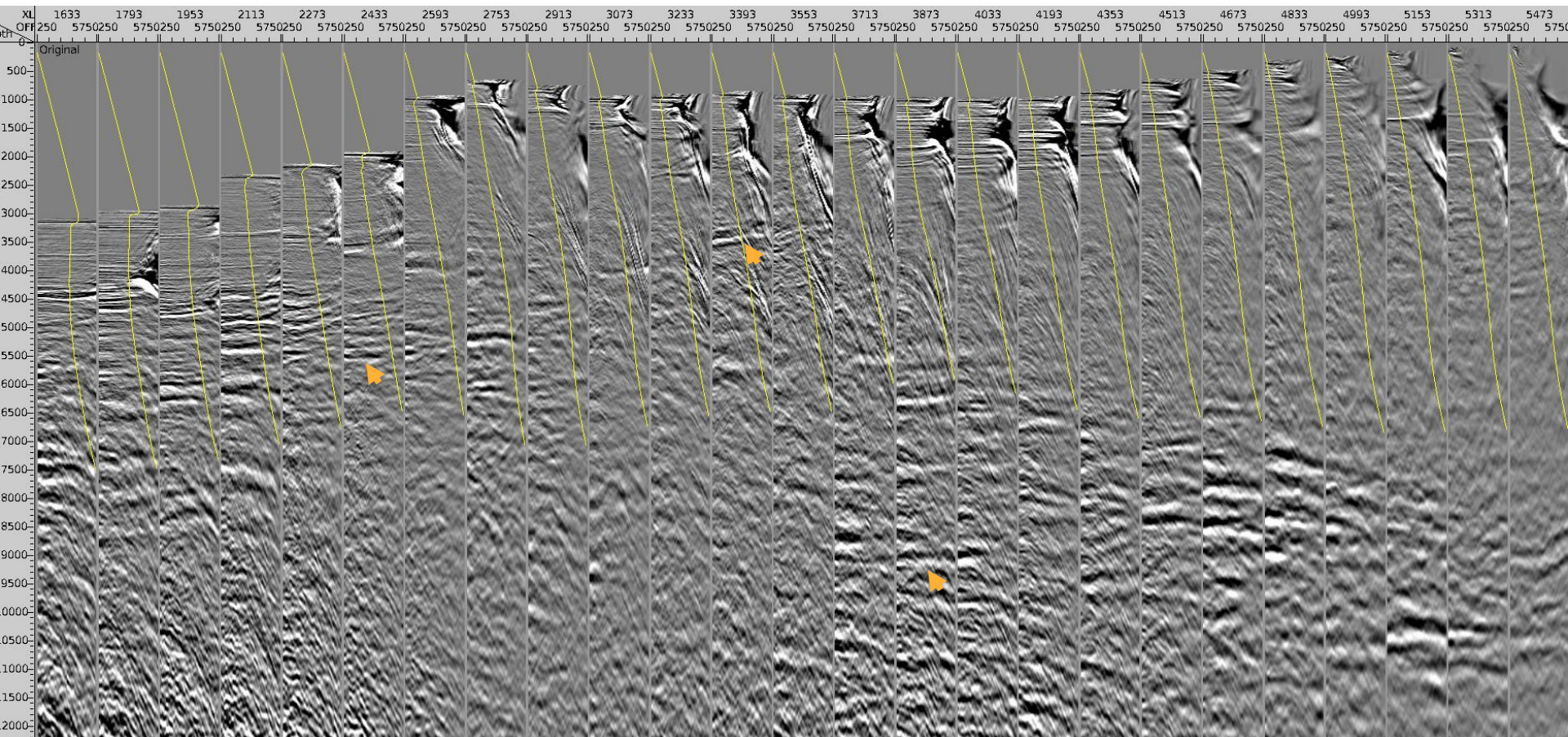




# Inline 620 CDP Gathers: Current Result

— 35° Mute

29







# IT4 – Part 2

## NZ 3D Processing

*17 February 2021*

[cgg.com](http://cgg.com)



INSTITUTE FOR GEOPHYSICS



Passion for Geoscience

- **Objective:**

To further improve deep velocity, especially in the middle and west part.

- **Procedure:**

Following the previous intermediate result, TTI FWI was run to 6Hz. An anomalous inverse Q absorption model was derived from FWI velocity (mainly below the BSR where gas accumulates) and was added to the FWI velocity only inversion. This approach gives a FWI velocity that results in flatter gathers in the gas zone.

- **Display:**

Velocity, migrated depth full stack & gathers.

- **Observation and Recommendation:**

In the low S/N area from middle to west of the survey, the velocity in the deeper area is more geological and results in a better imaging of the central dipping events. We'll continue to focus this area for better velocity.

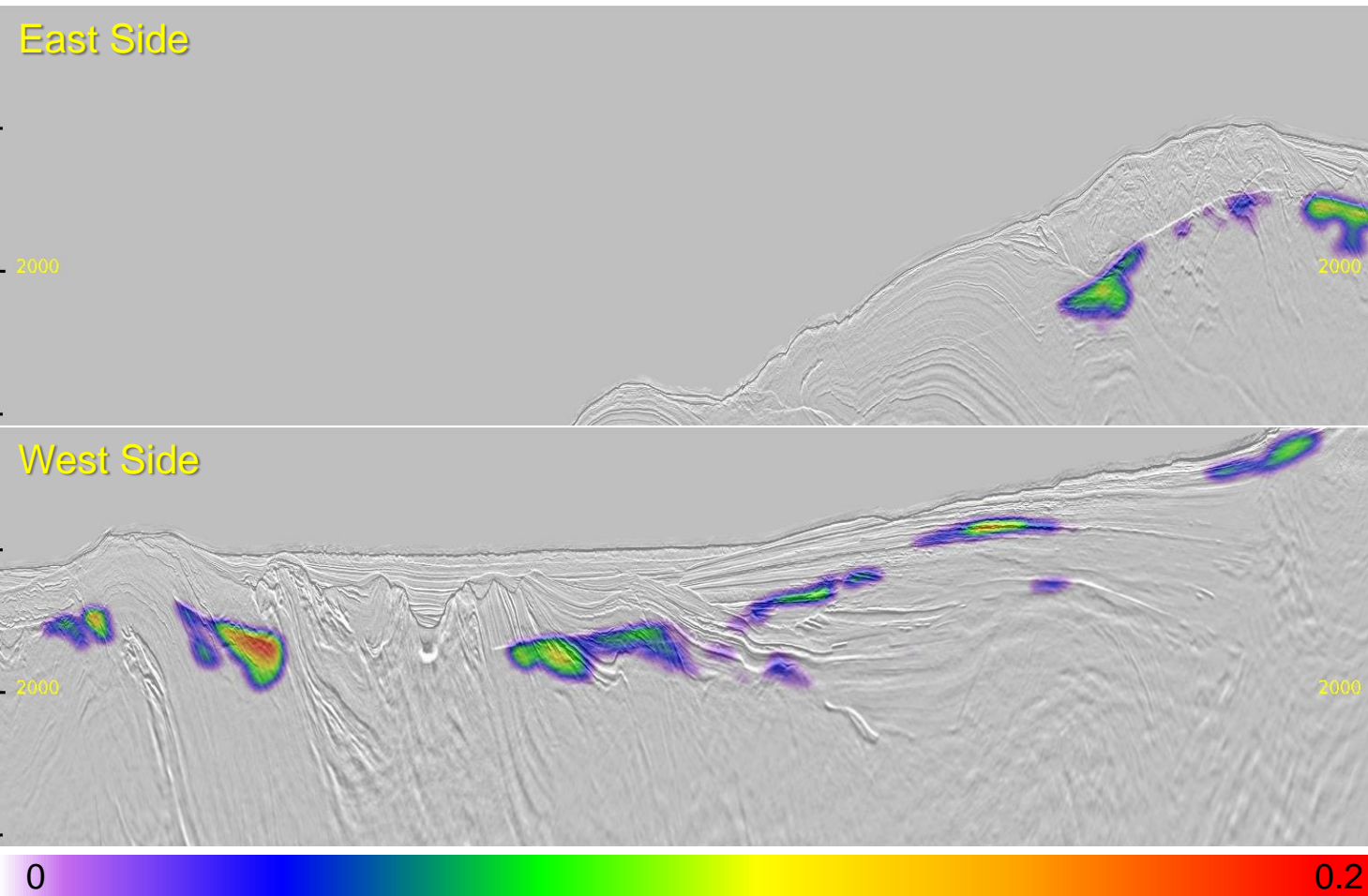


# Velocity Model



# Inline 436: Anomalous Inverse Q Model

4

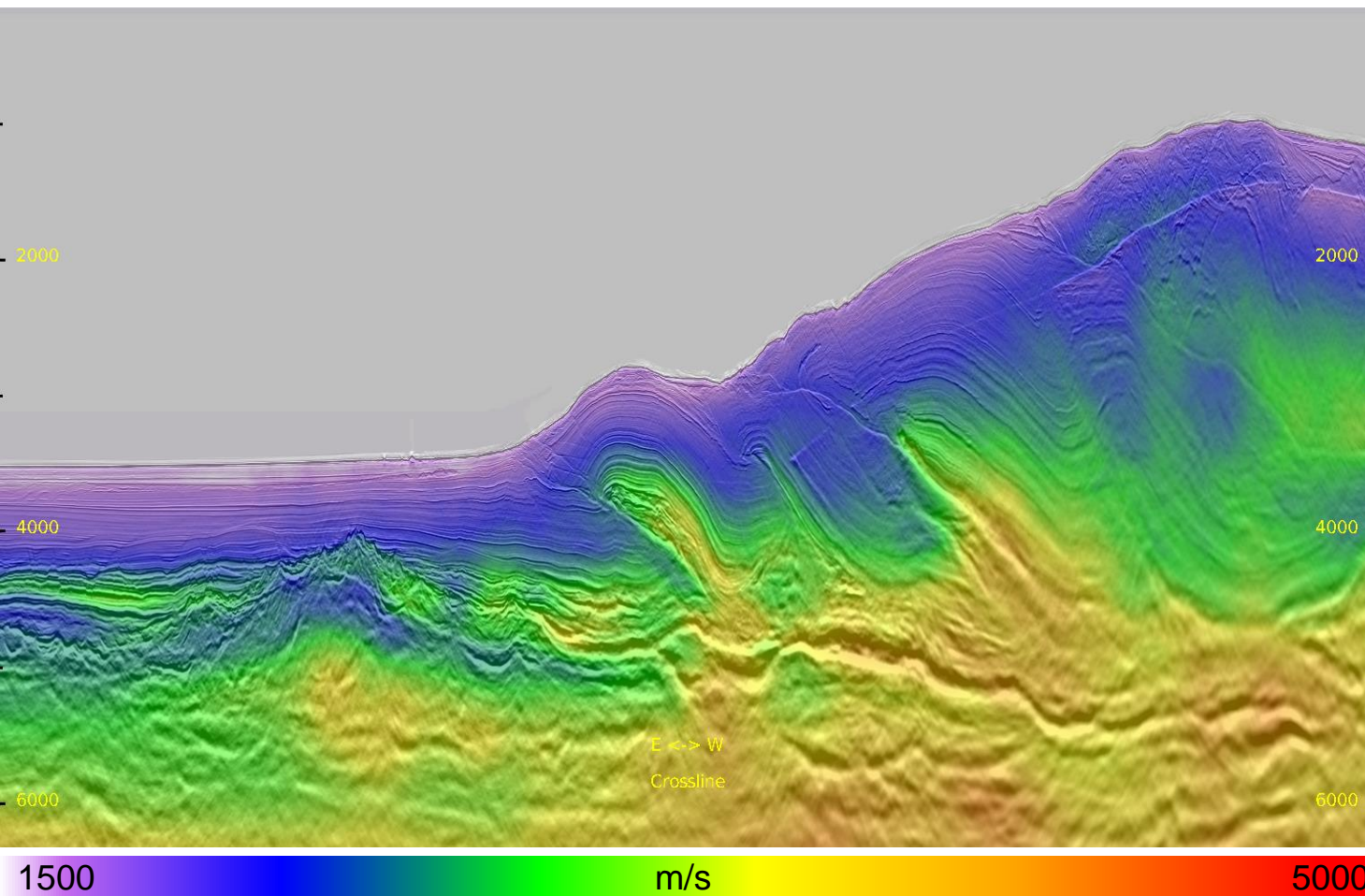


- An anomalous inverse Q Model was derive from the FWI velocity.



# Inline 436 Eest: Previous Velocity

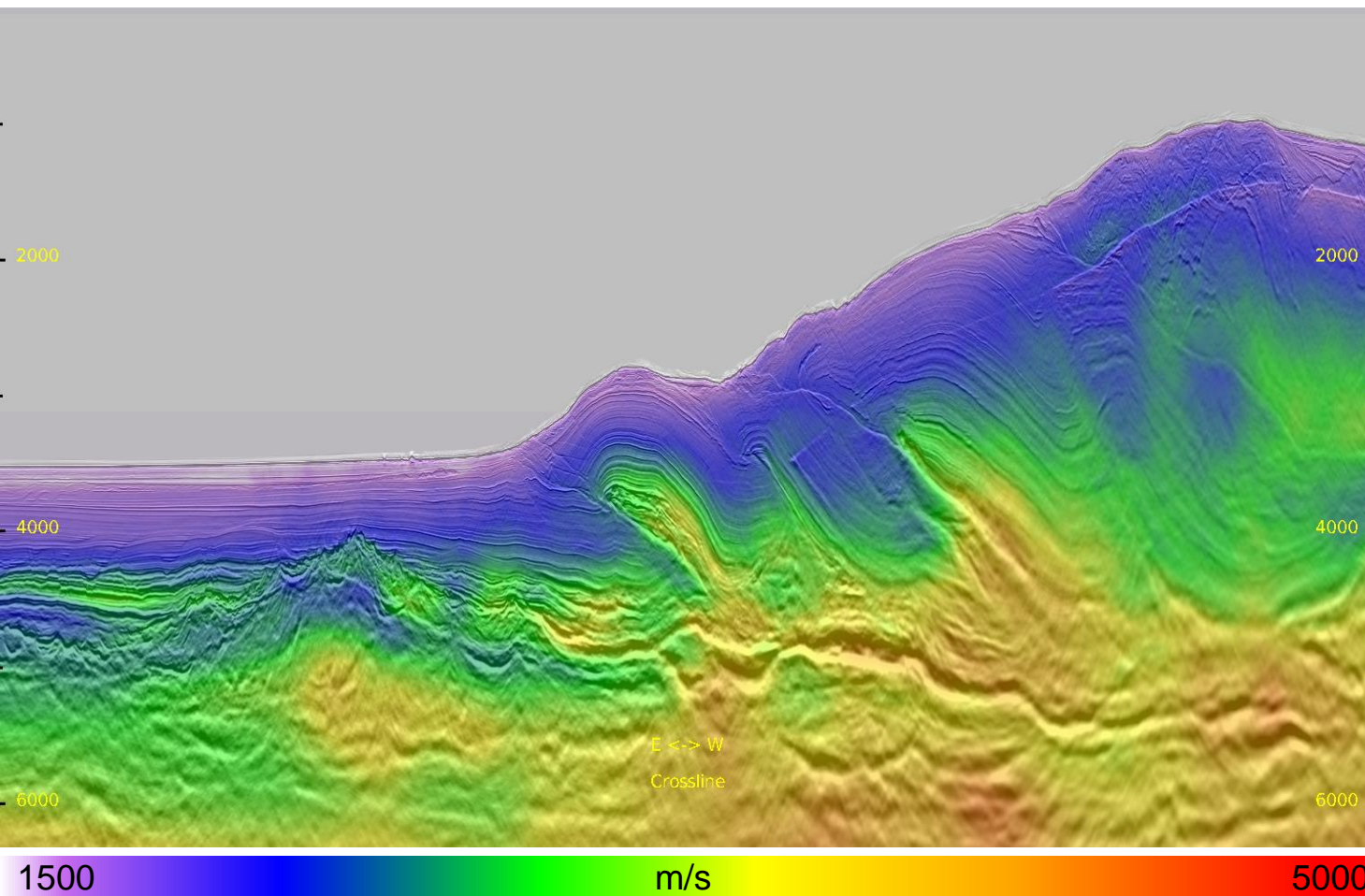
5



- Previous preliminary FWI velocity

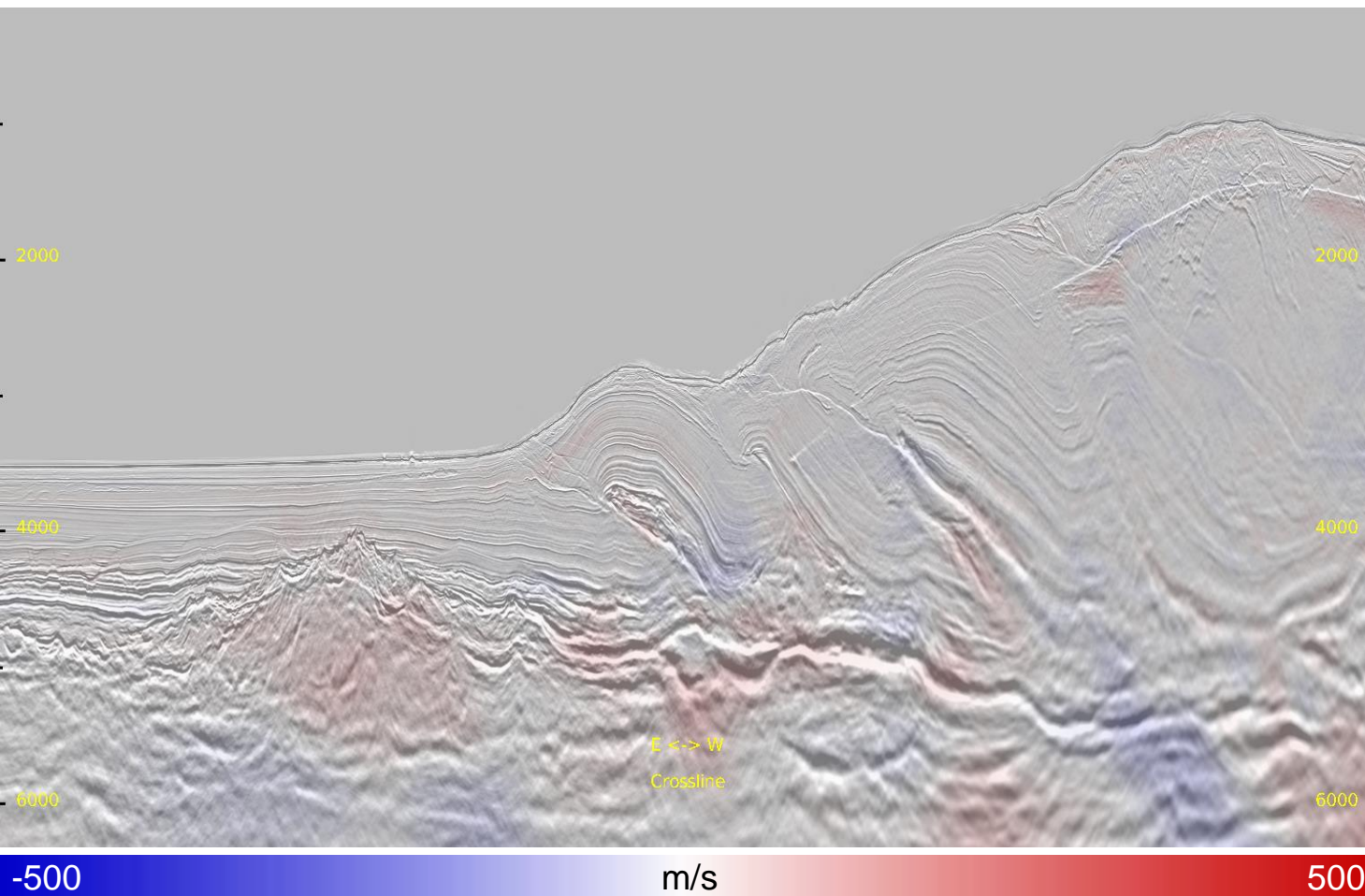
# Inline 436 Eest: Current Velocity

6



- Current TTI FWI velocity considering anomalous Q absorption.

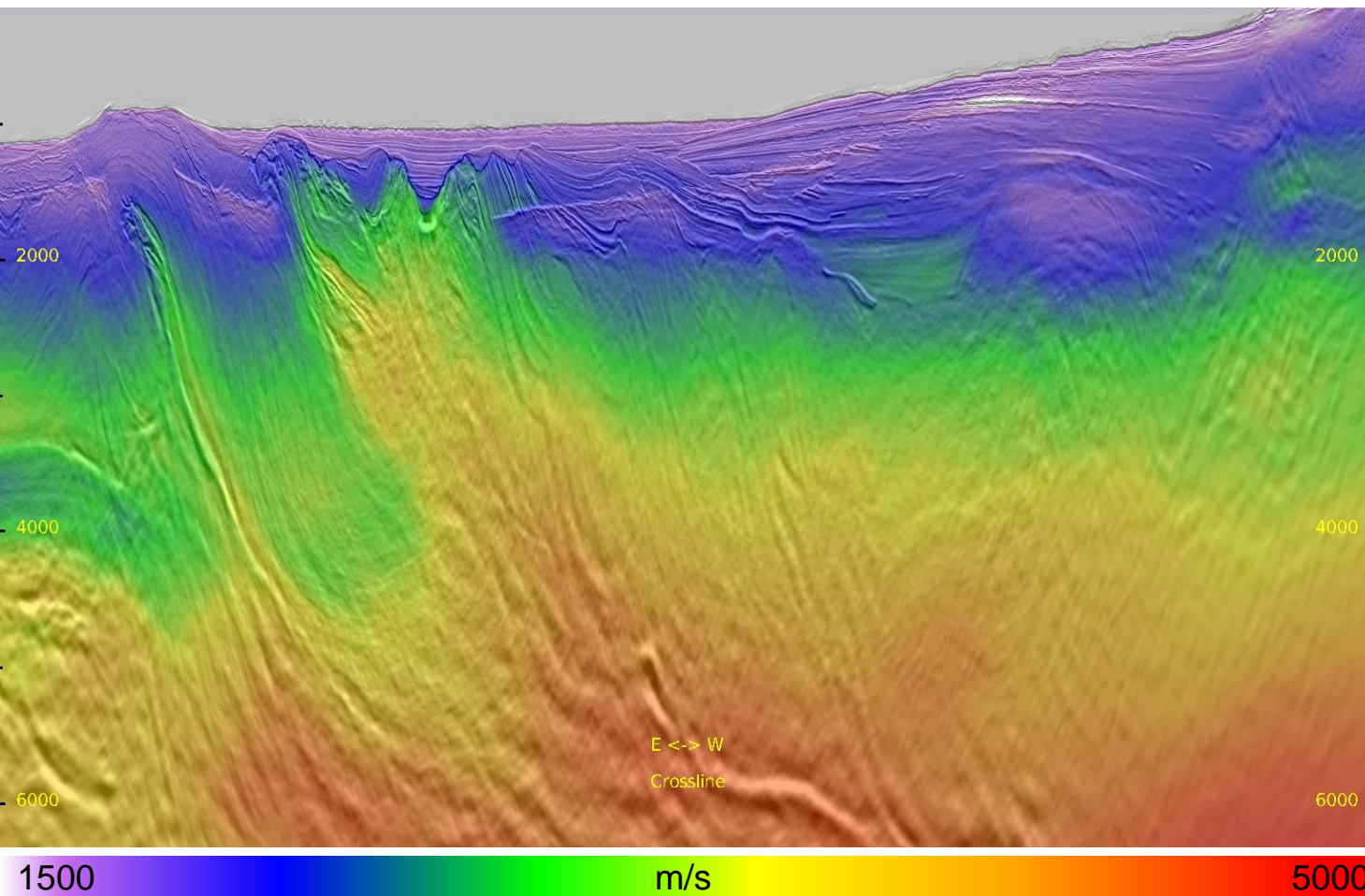




- Velocity perturbation shows a increase of velocity below the BSR.

# Inline 436 West: Previous Velocity

8

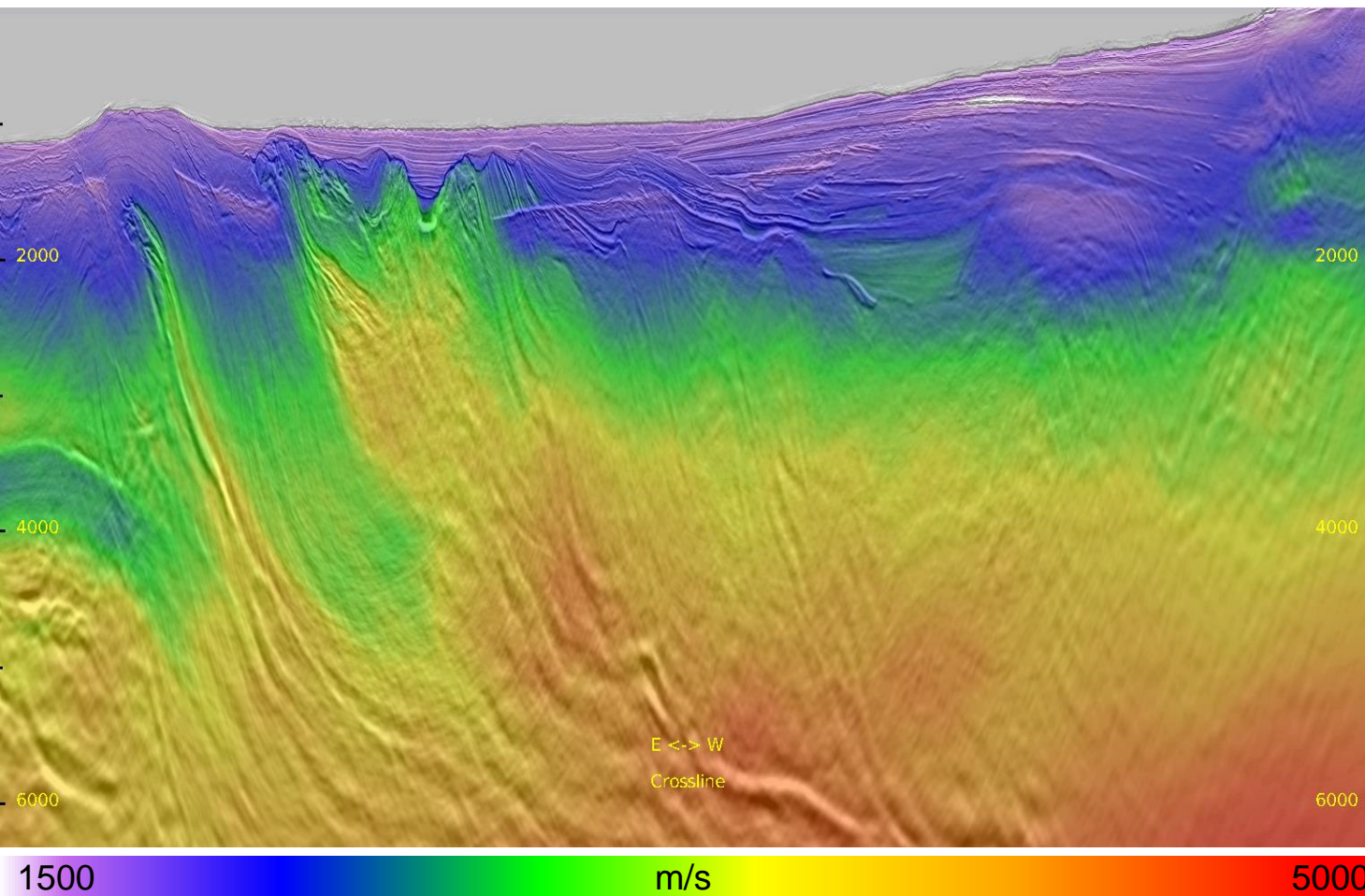


- Previous preliminary FWI velocity

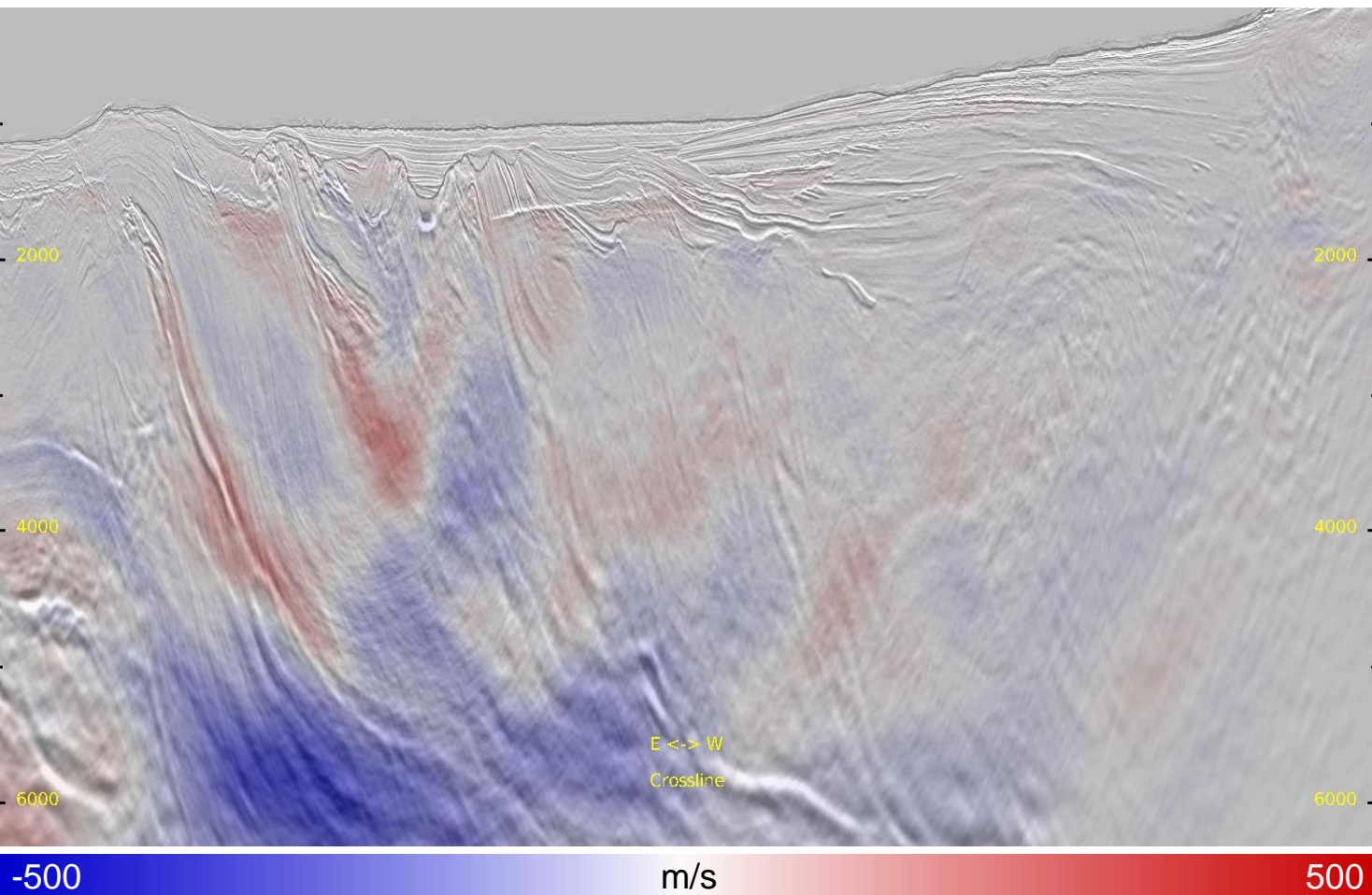


# Inline 436 West: Current Velocity

9



- Current TTI FWI velocity considering anomalous Q effect.



- Velocity perturbation shows a increase of velocity below the BSR and in the gas zone.

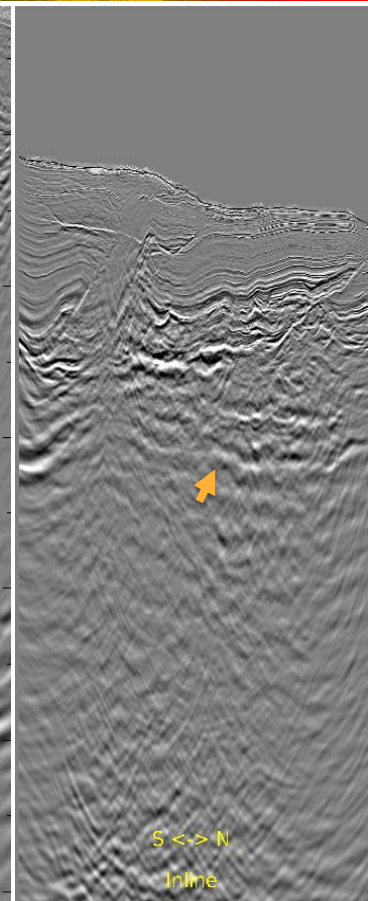
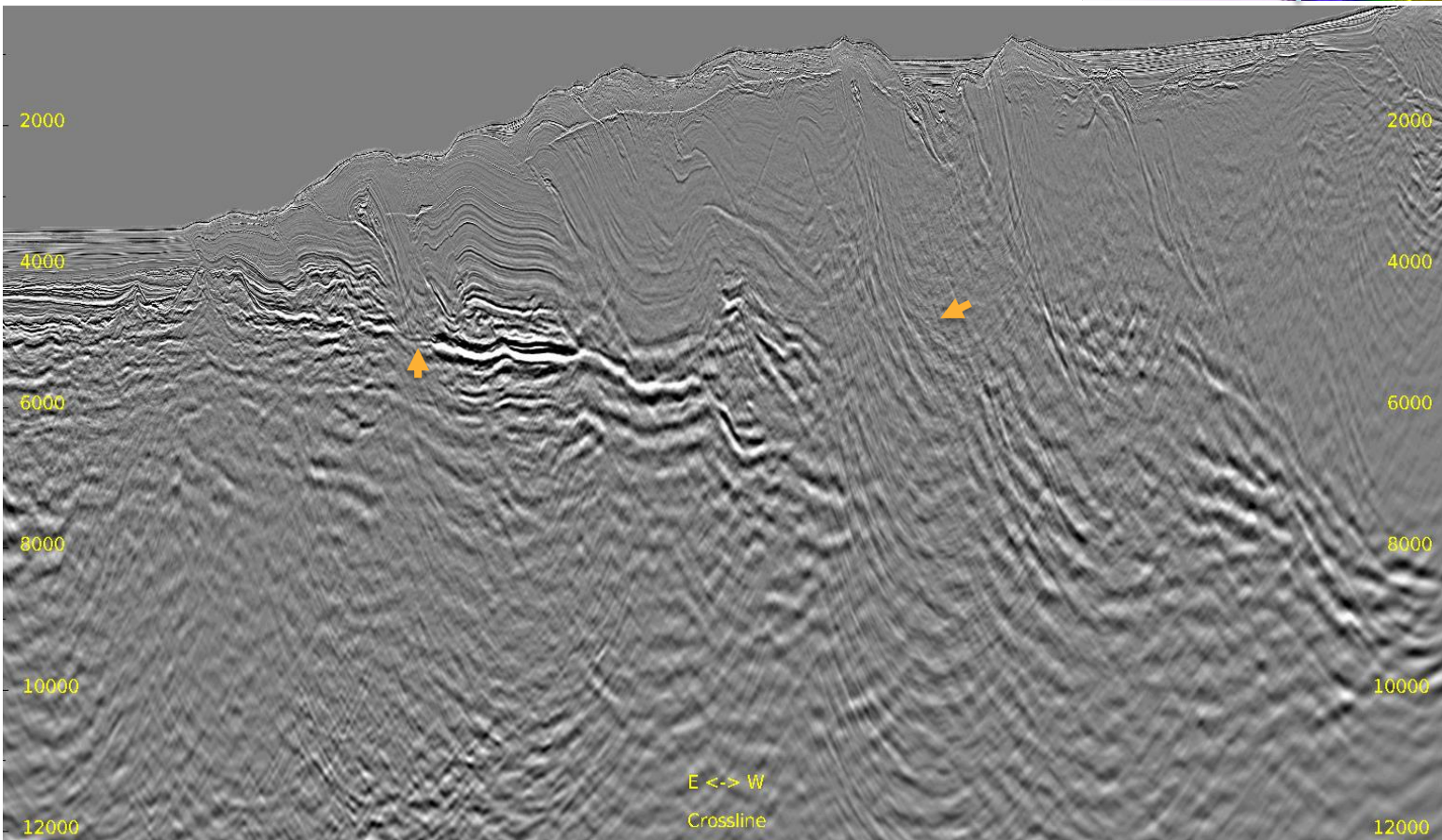
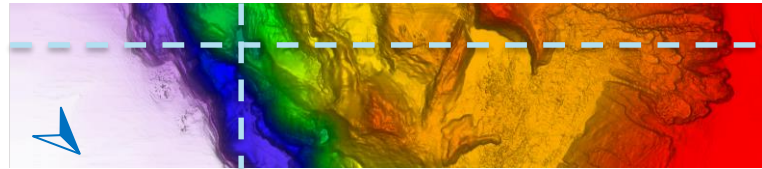


# Kirchhoff Depth Migration



# Full Stack: Previous Result

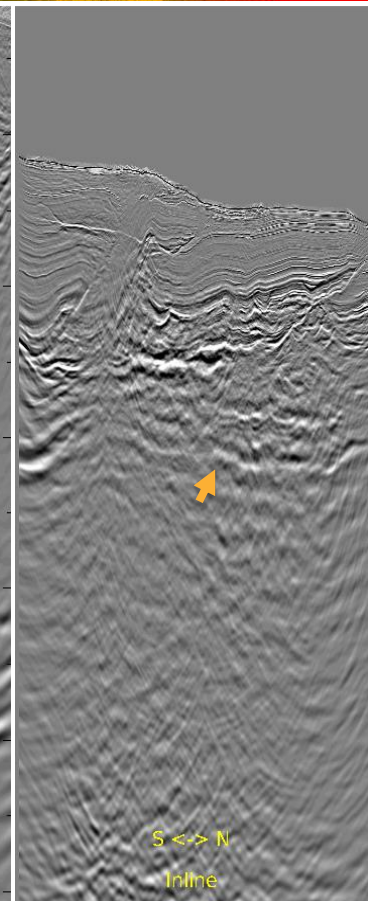
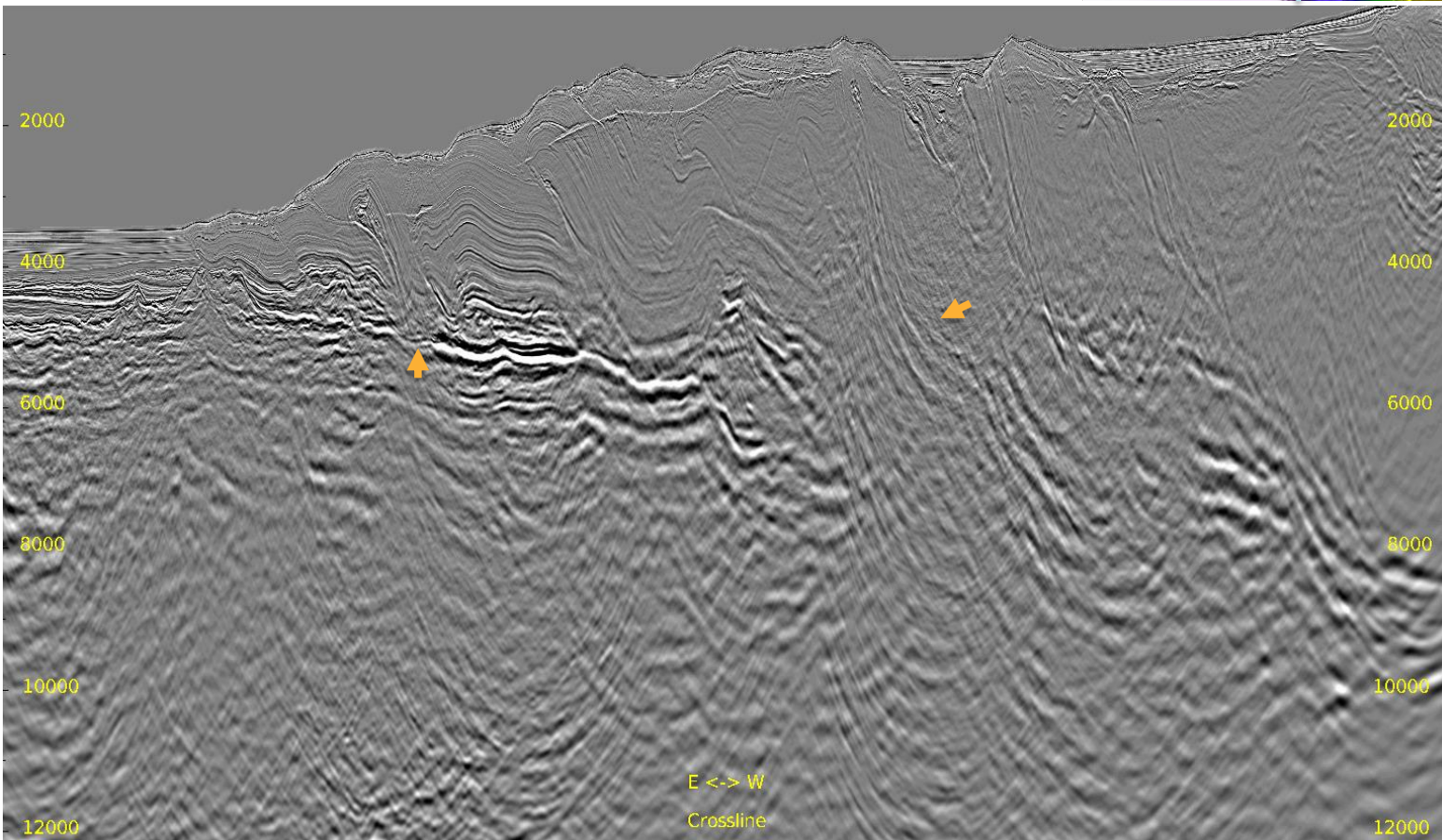
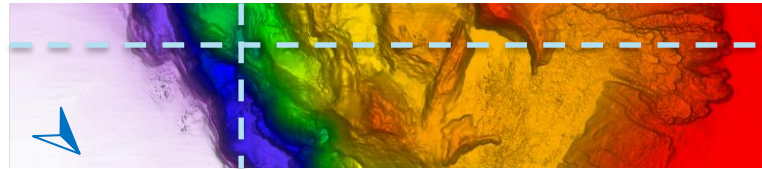
Inline 236 & Crossline 1774





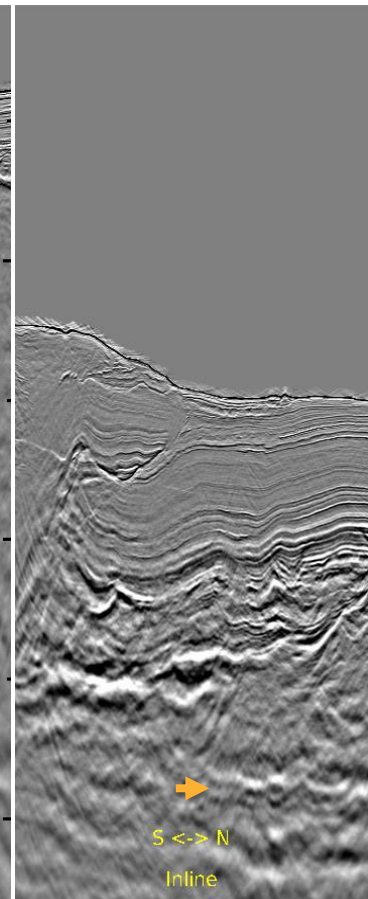
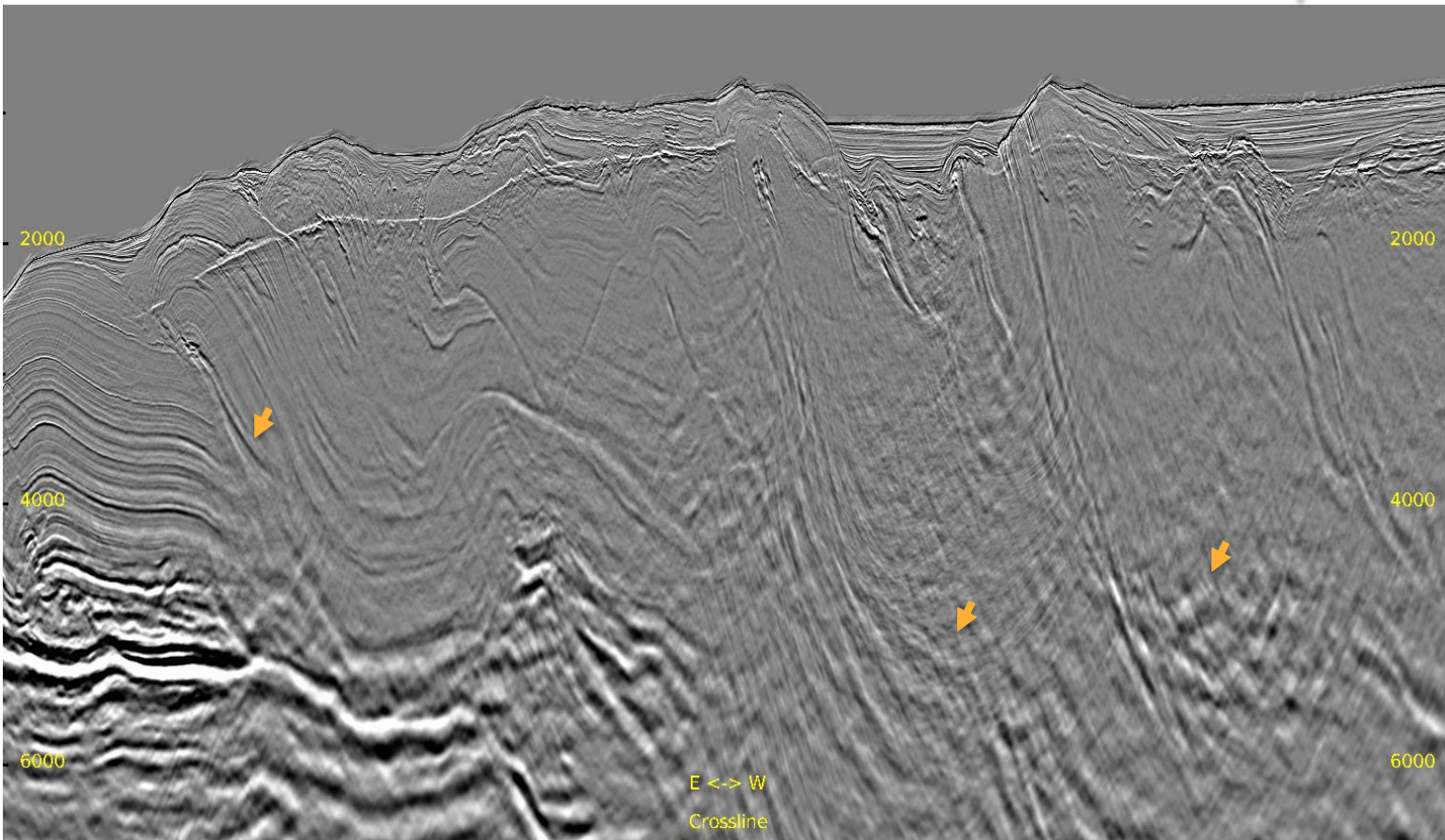
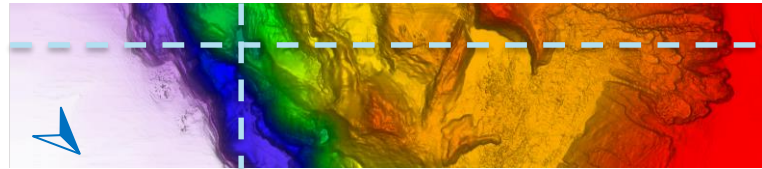
# Full Stack: Current Result

Inline 236 & Crossline 1774



# Zoomed Full Stack: Previous Result

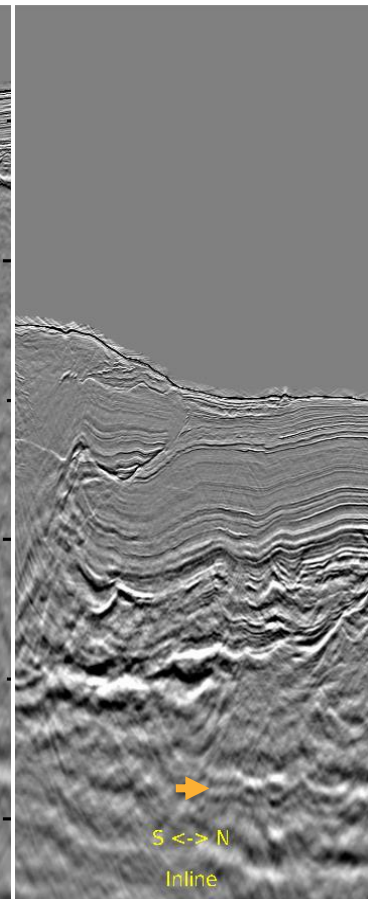
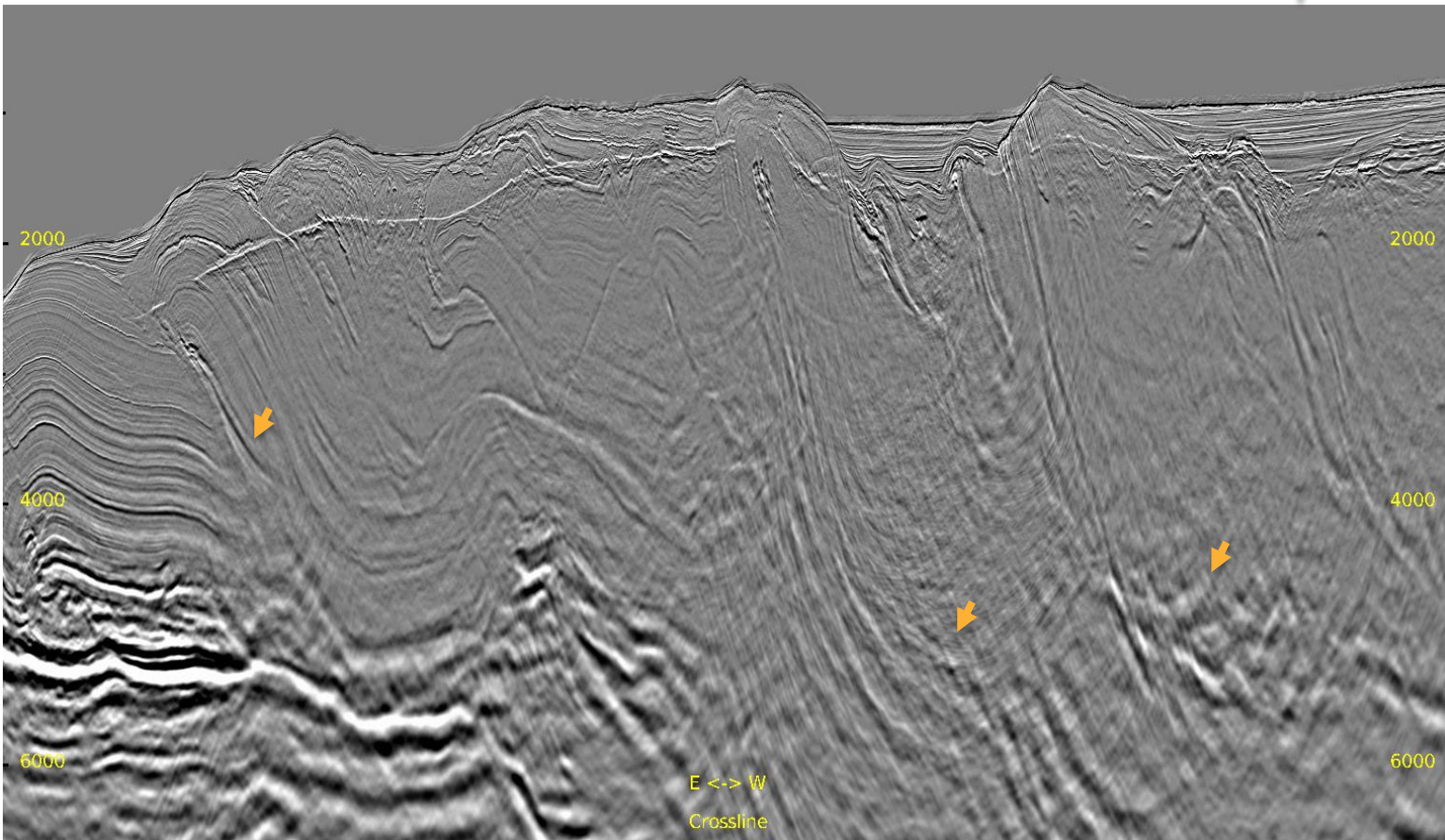
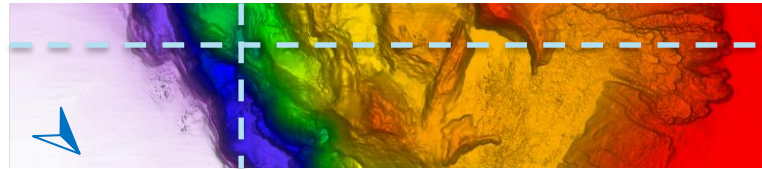
Inline 236 & Crossline 1774





# Zoomed Full Stack: Current Result

Inline 236 & Crossline 1774



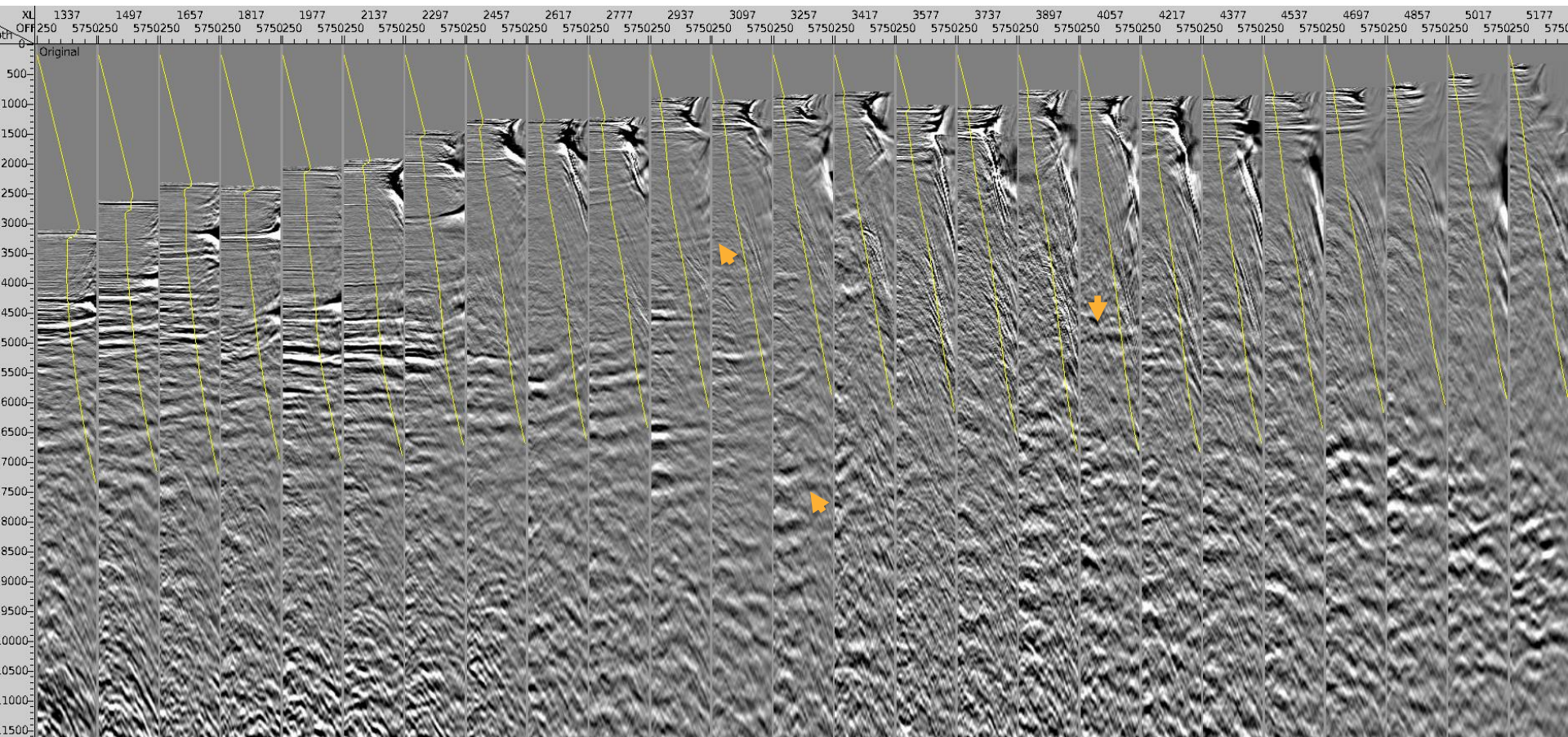




# Inline 236 CDP Gathers: Previous Result

— 35° Mute

16



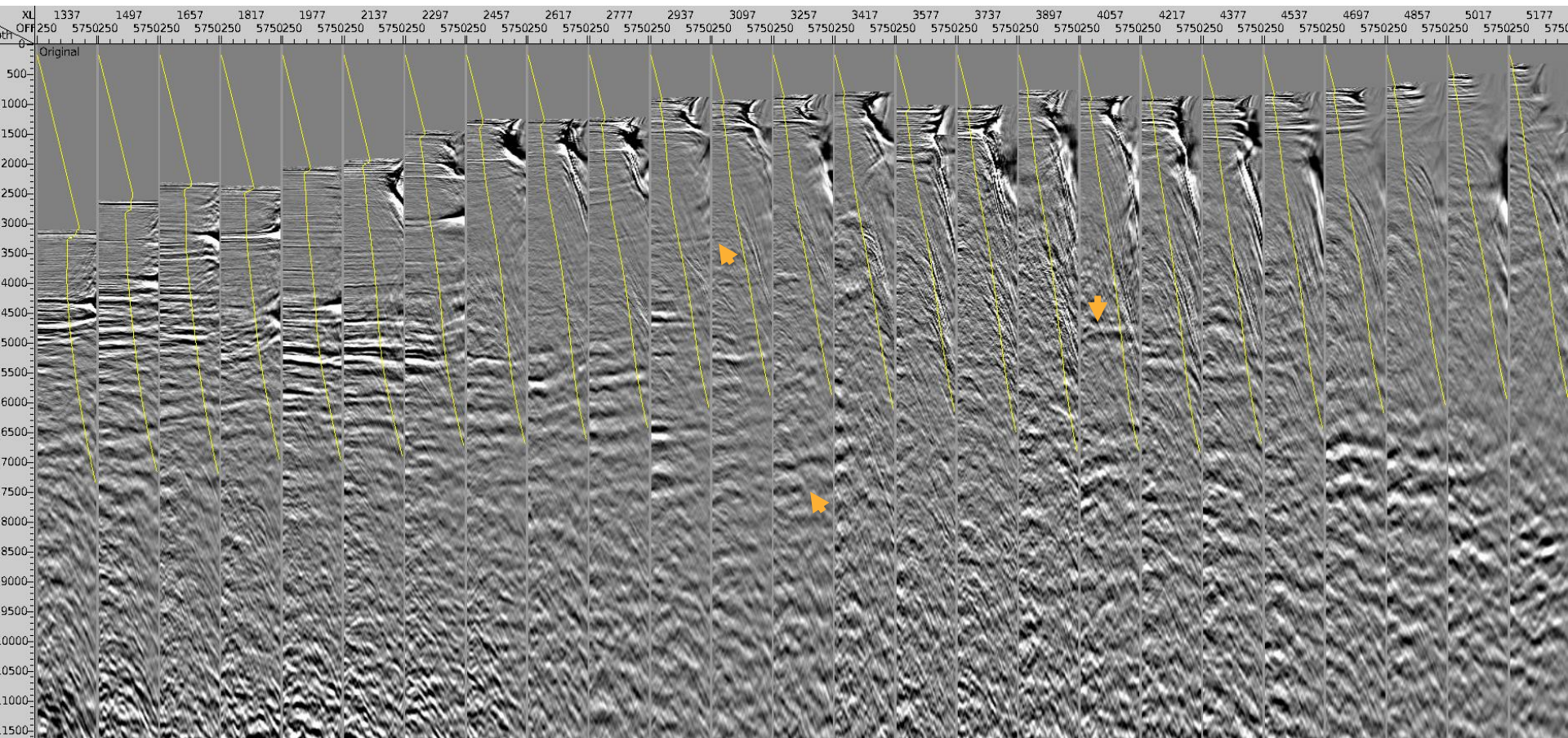




# Inline 236 CDP Gathers: Current Result

— 35° Mute

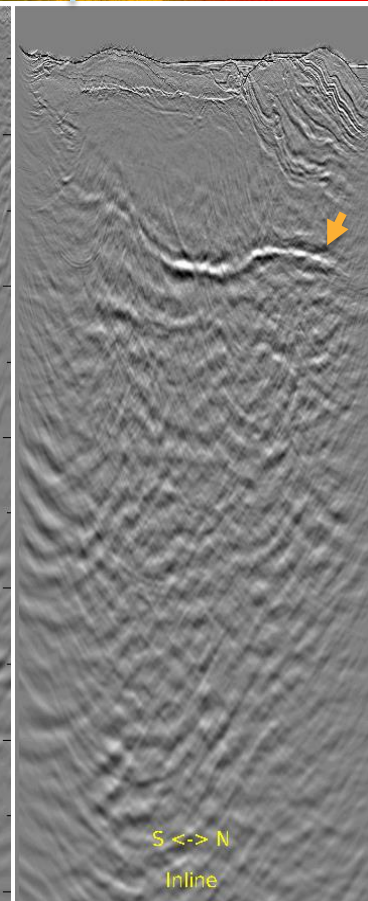
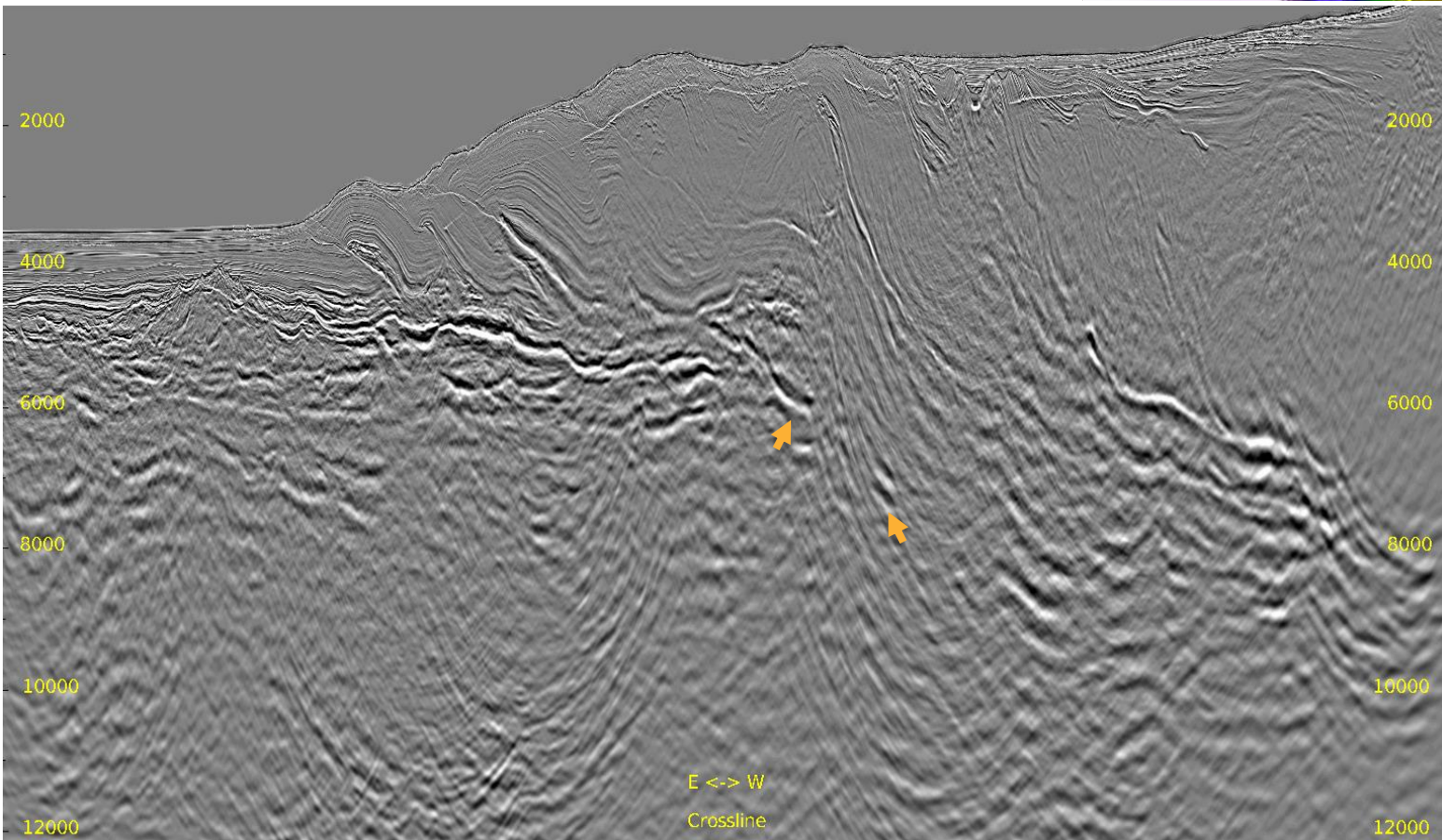
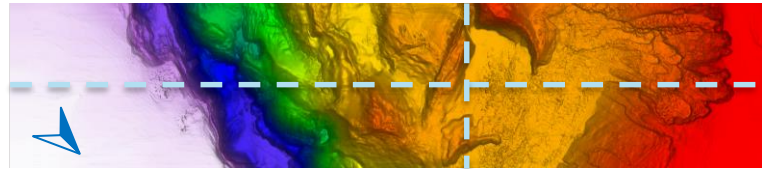
17





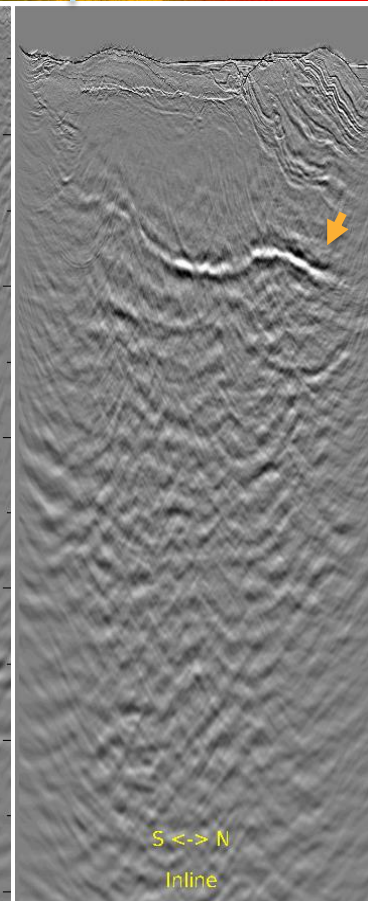
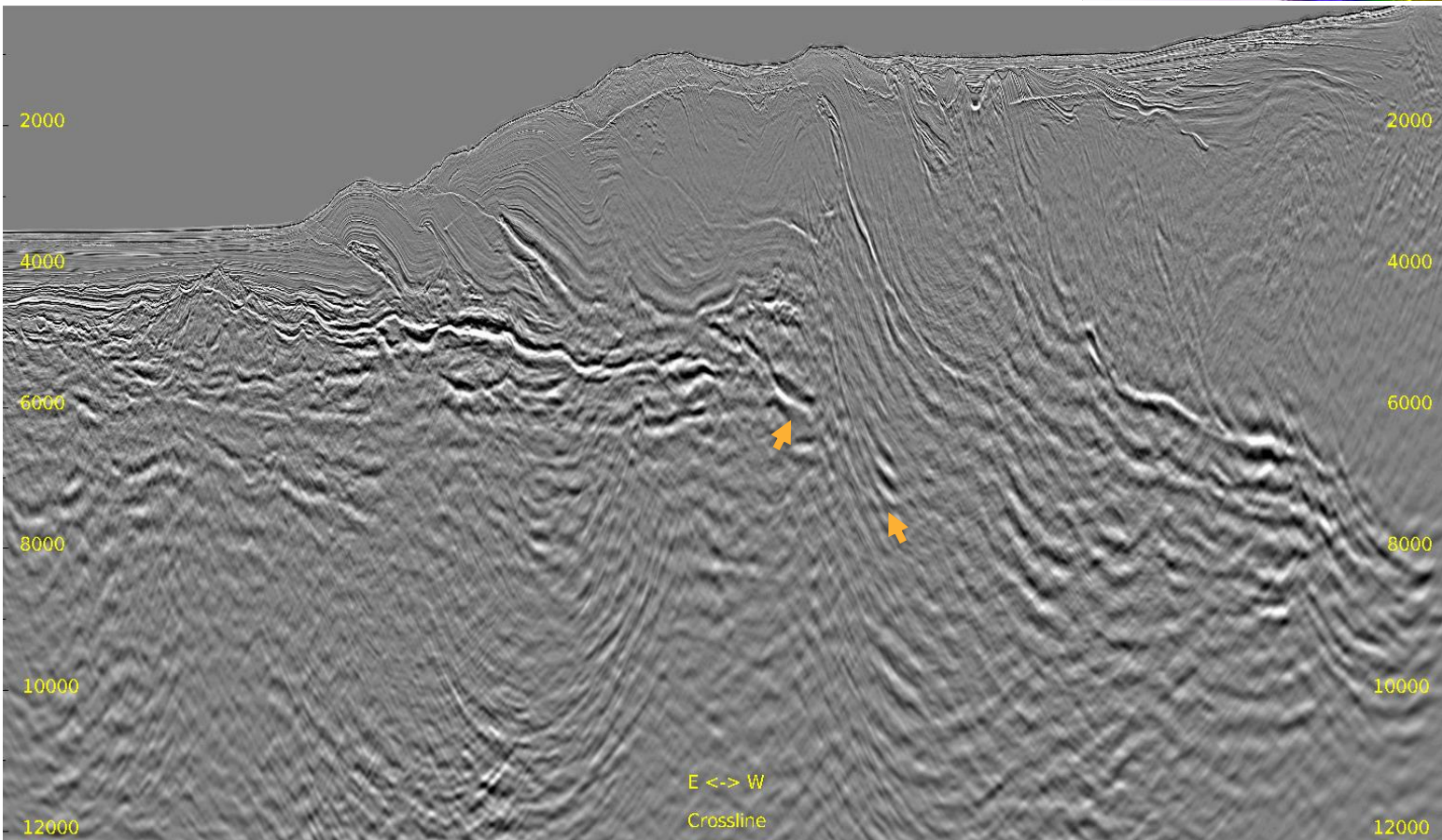
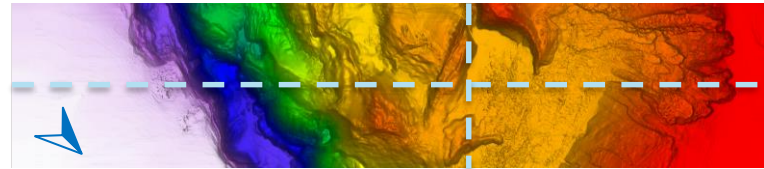
# Full Stack: Previous Result

Inline 436 & Crossline 3423



# Full Stack: Current Result

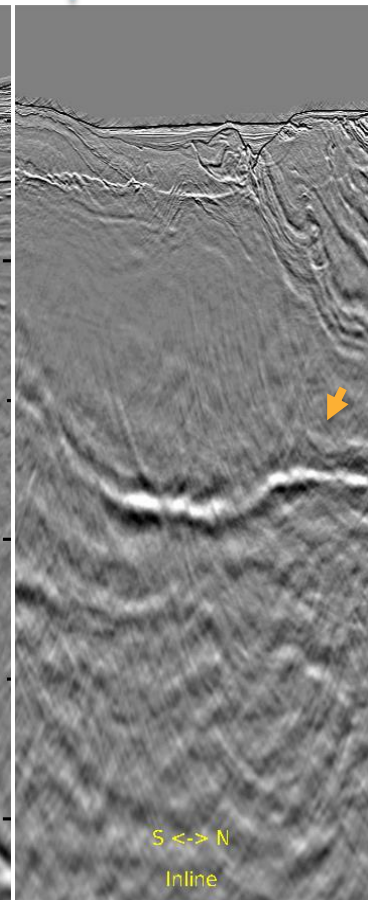
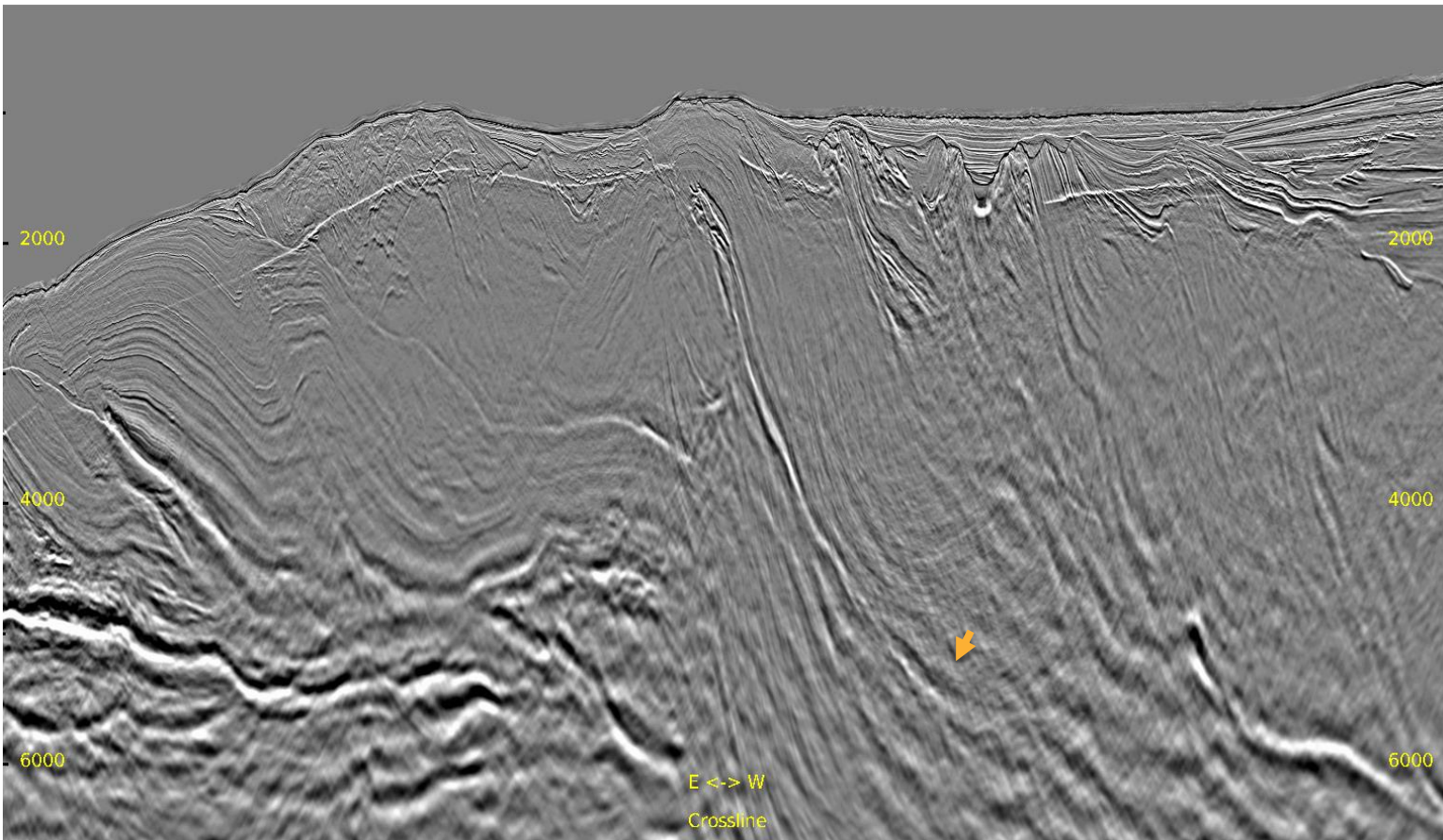
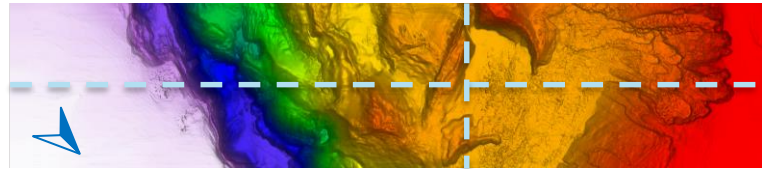
Inline 436 & Crossline 3423





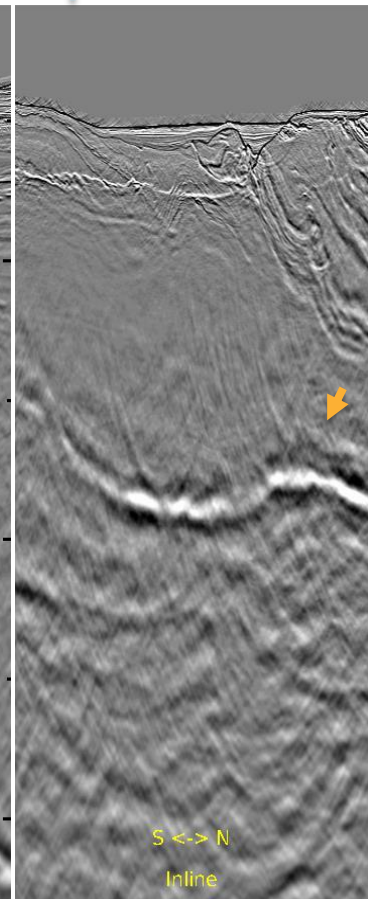
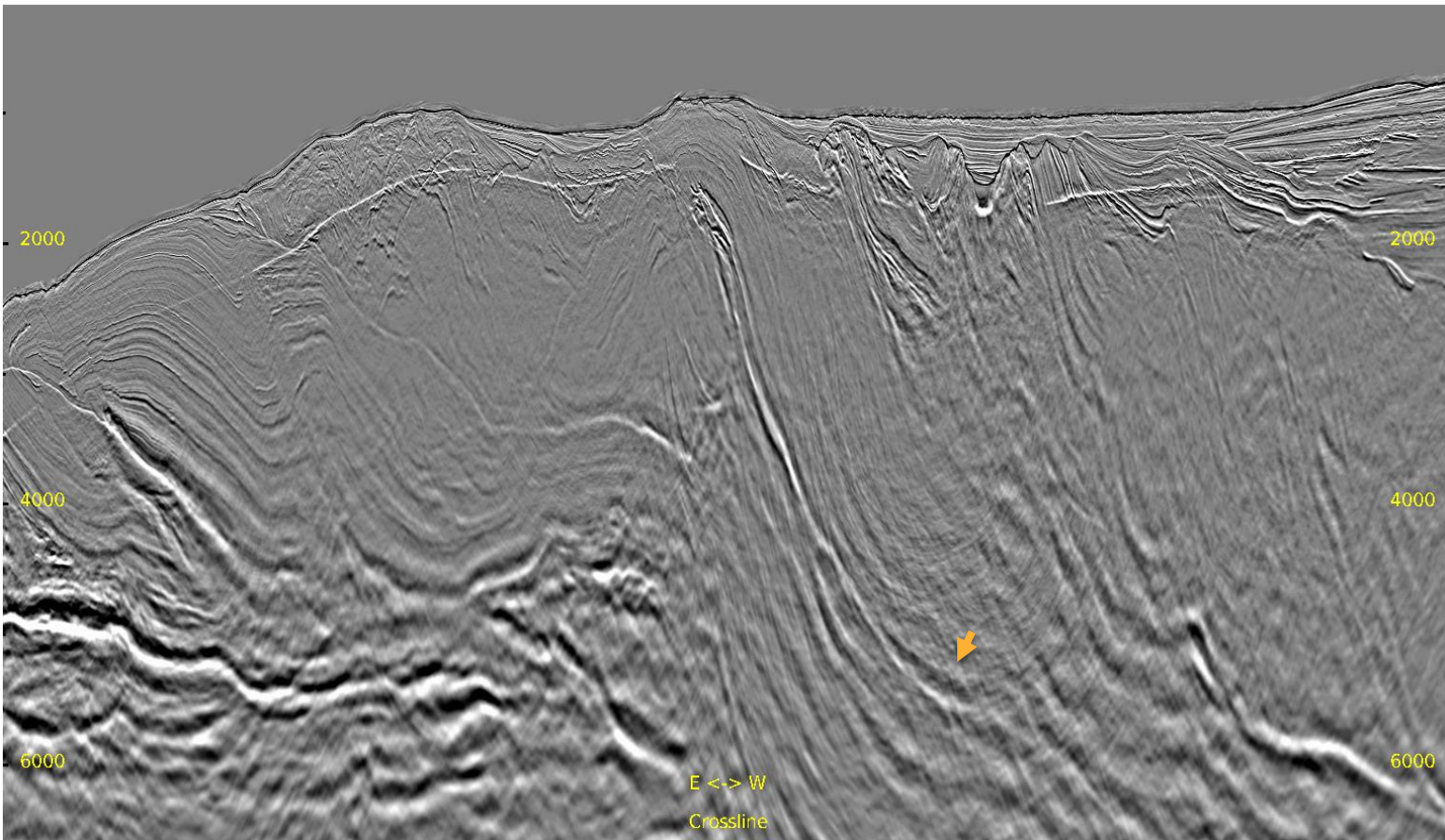
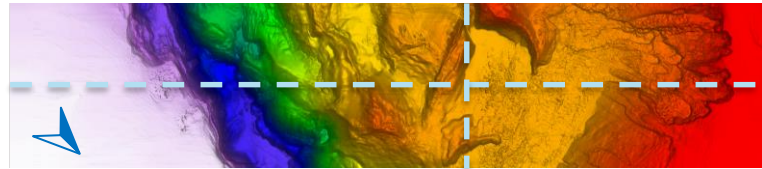
# Zoomed Full Stack: Previous Result

Inline 436 & Crossline 3423



# Zoomed Full Stack: Current Result

Inline 436 & Crossline 3423



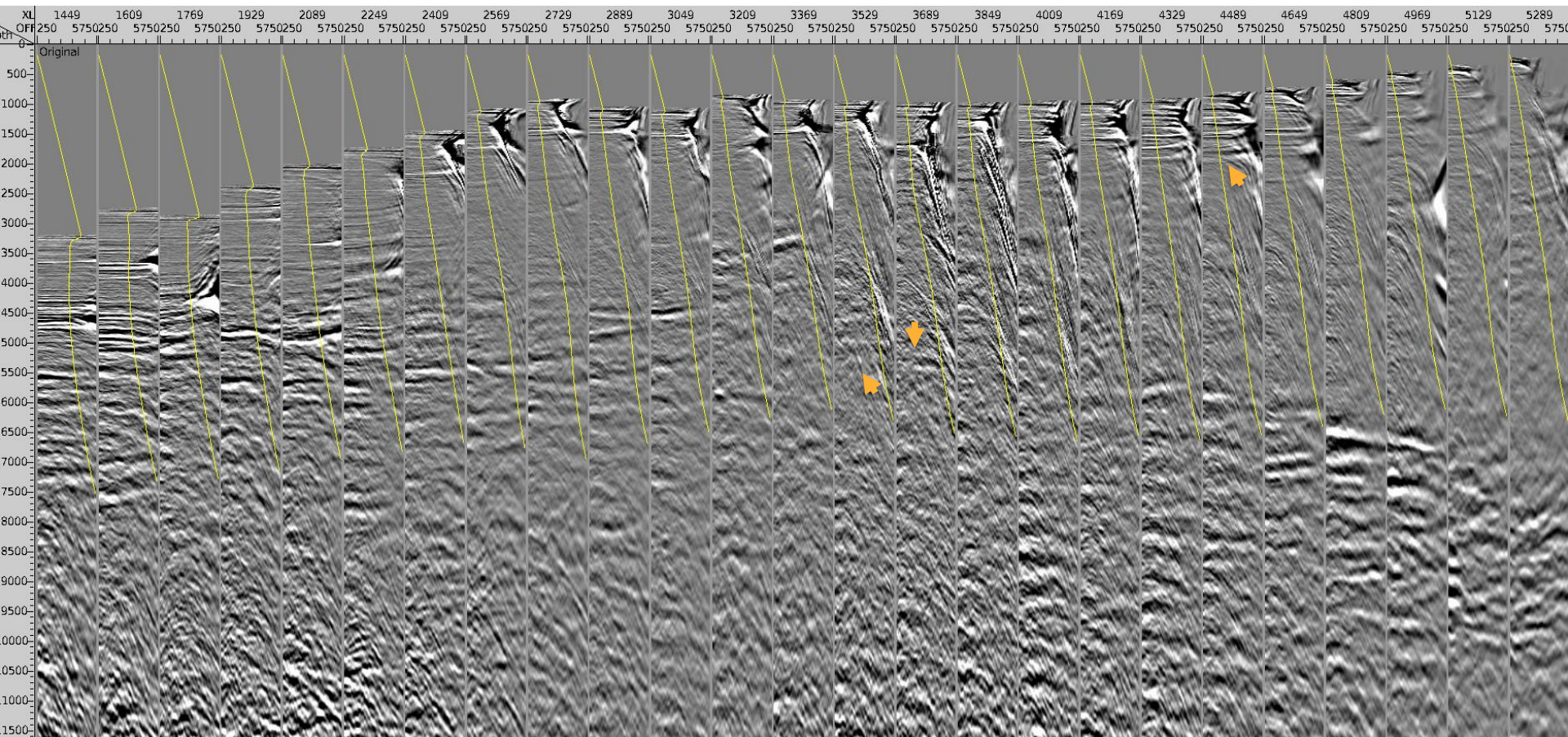




# Inline 436 CDP Gathers: Previous Result

— 35° Mute

22



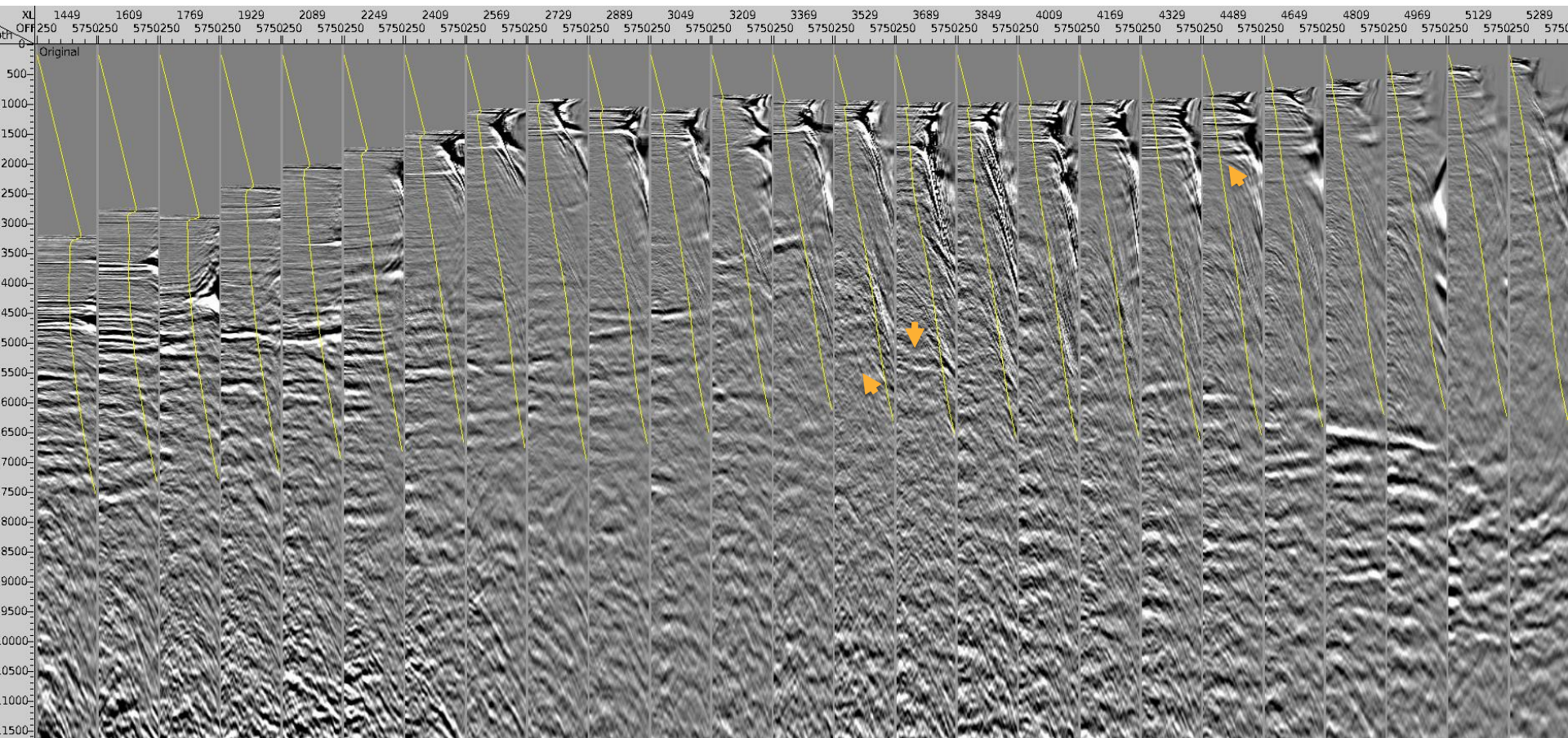




# Inline 436 CDP Gathers: Current Result

— 35° Mute

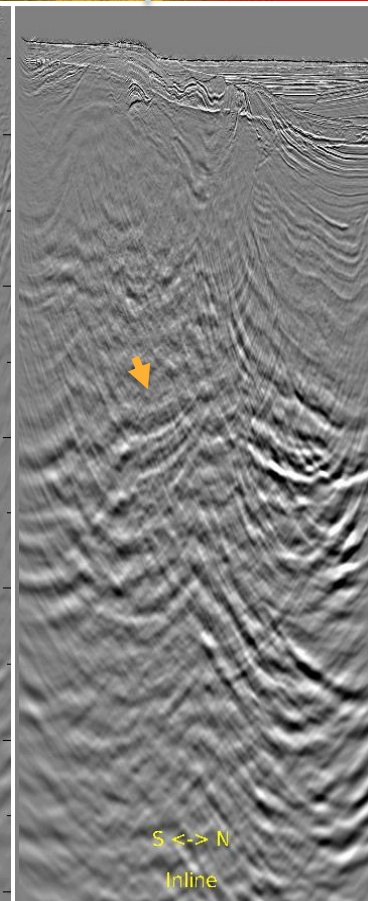
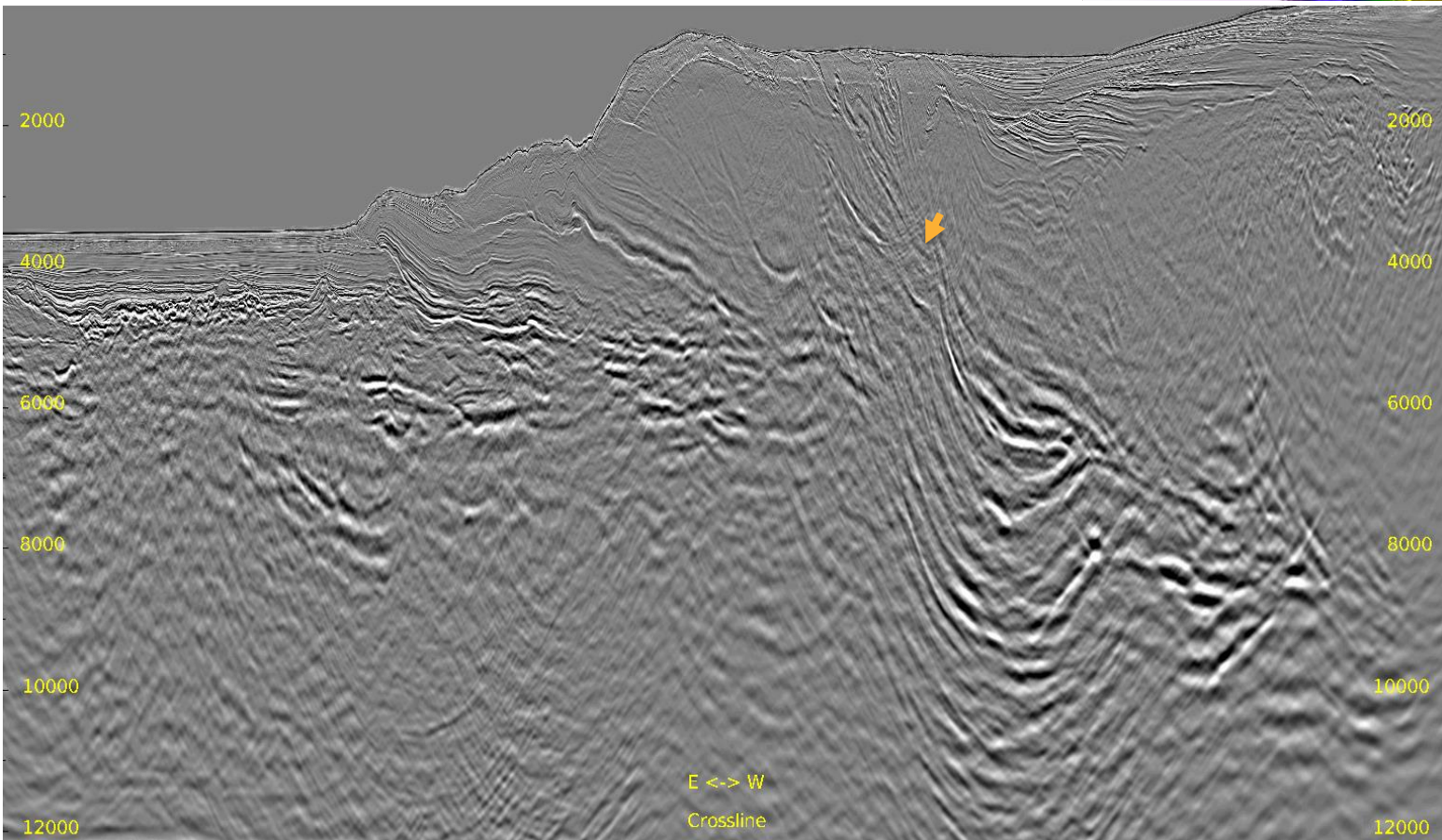
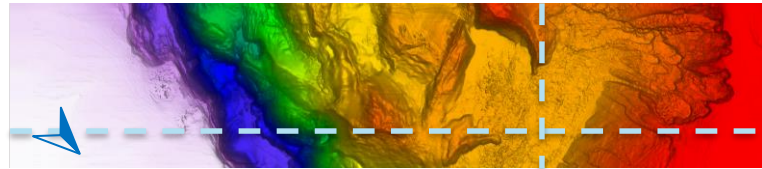
23





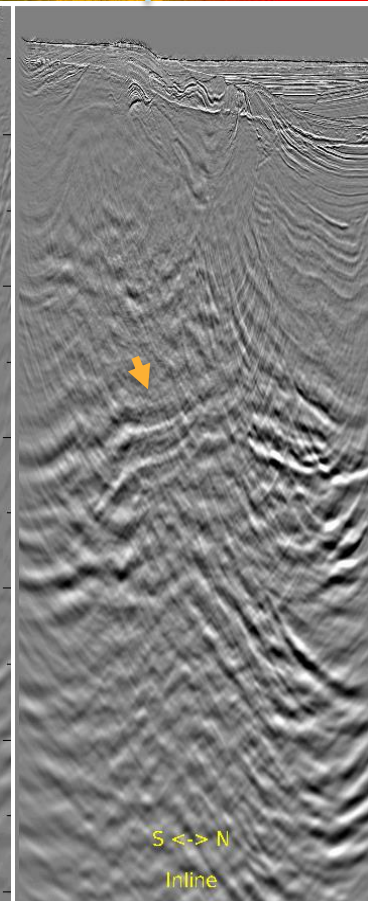
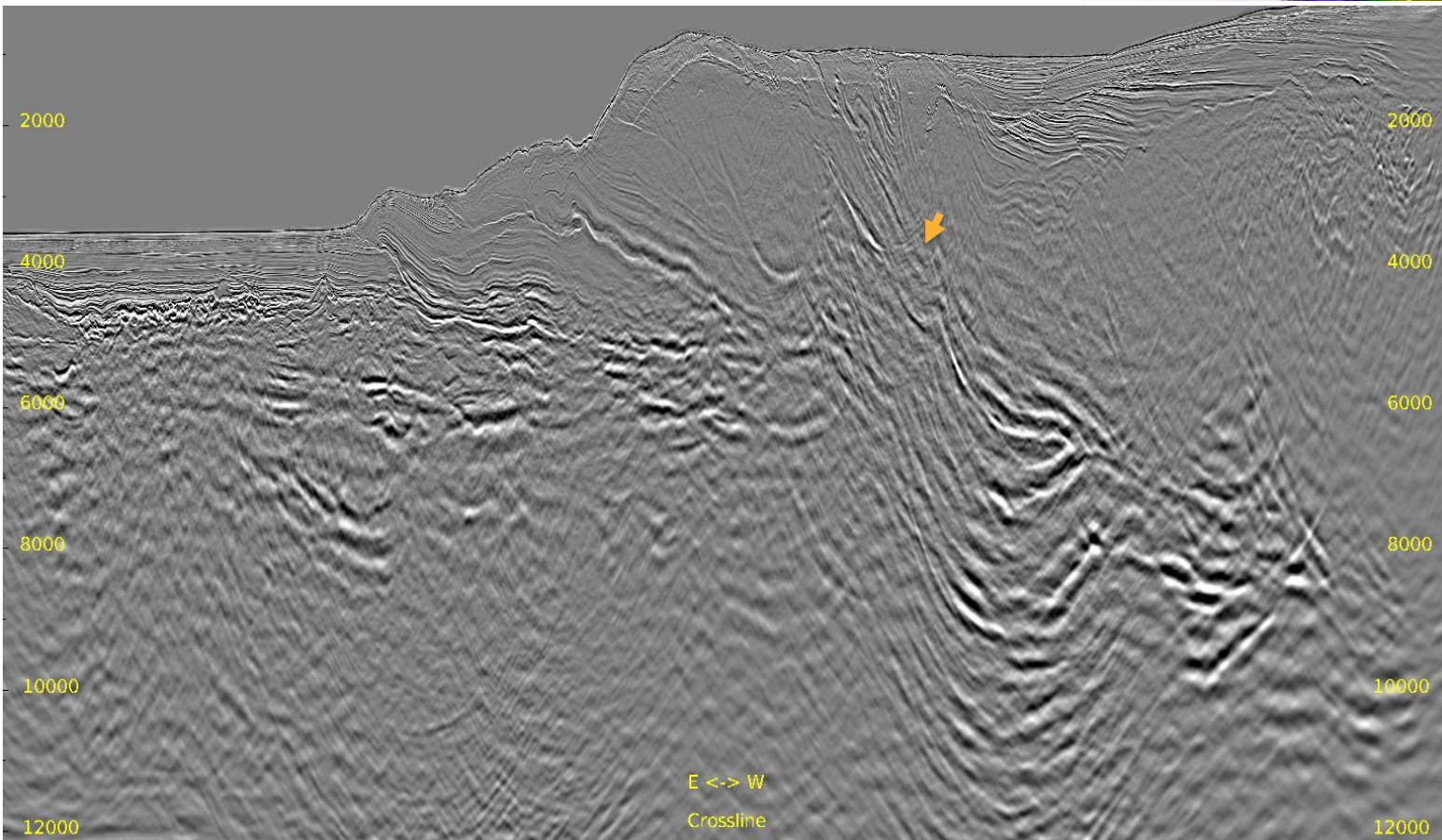
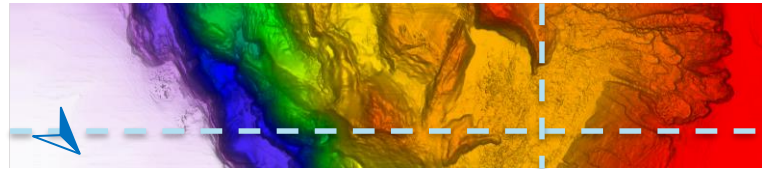
# Full Stack: Previous Result

Inline 636 & Crossline 3944



# Full Stack: Current Result

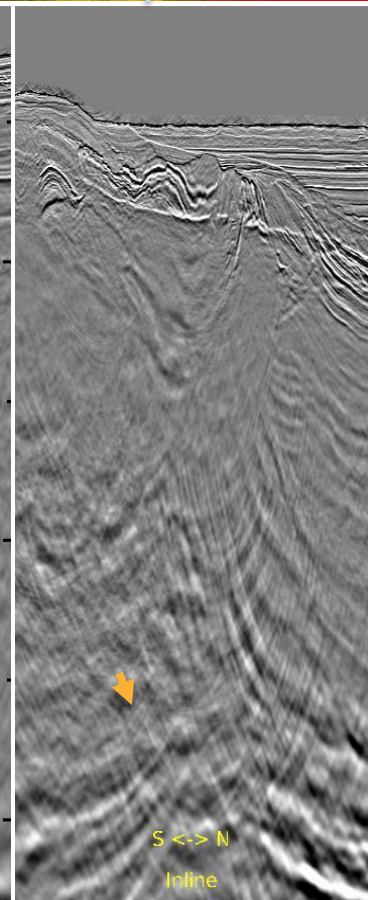
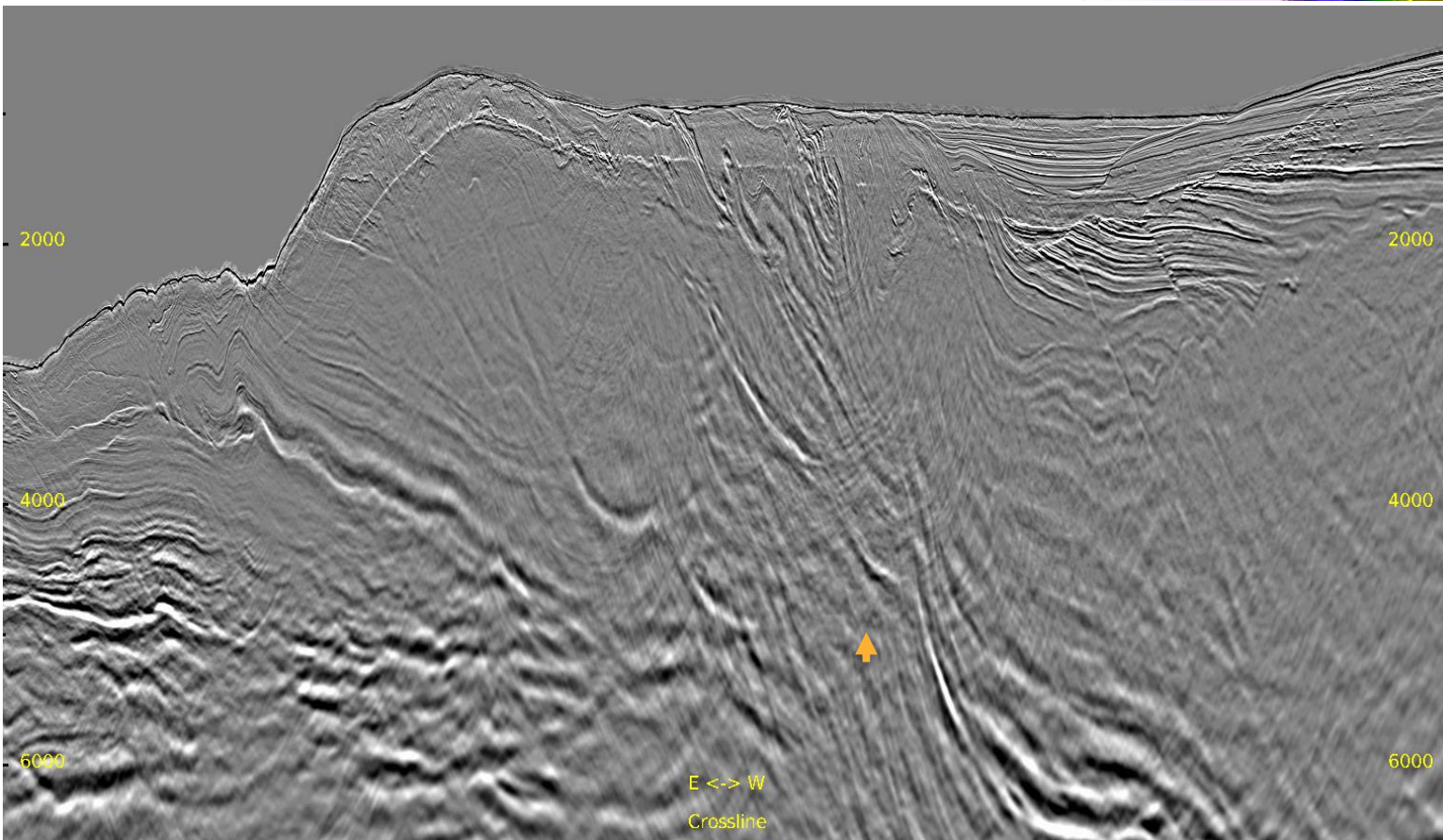
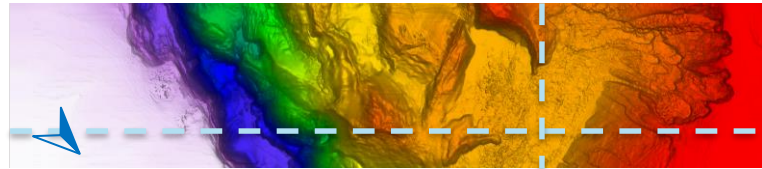
Inline 636 & Crossline 3944





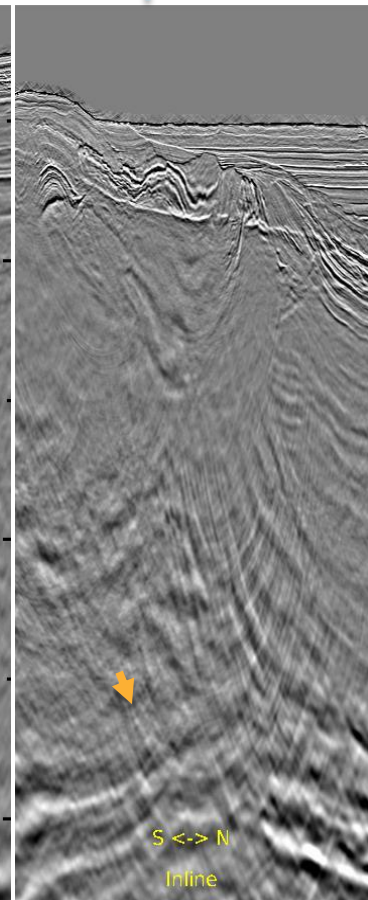
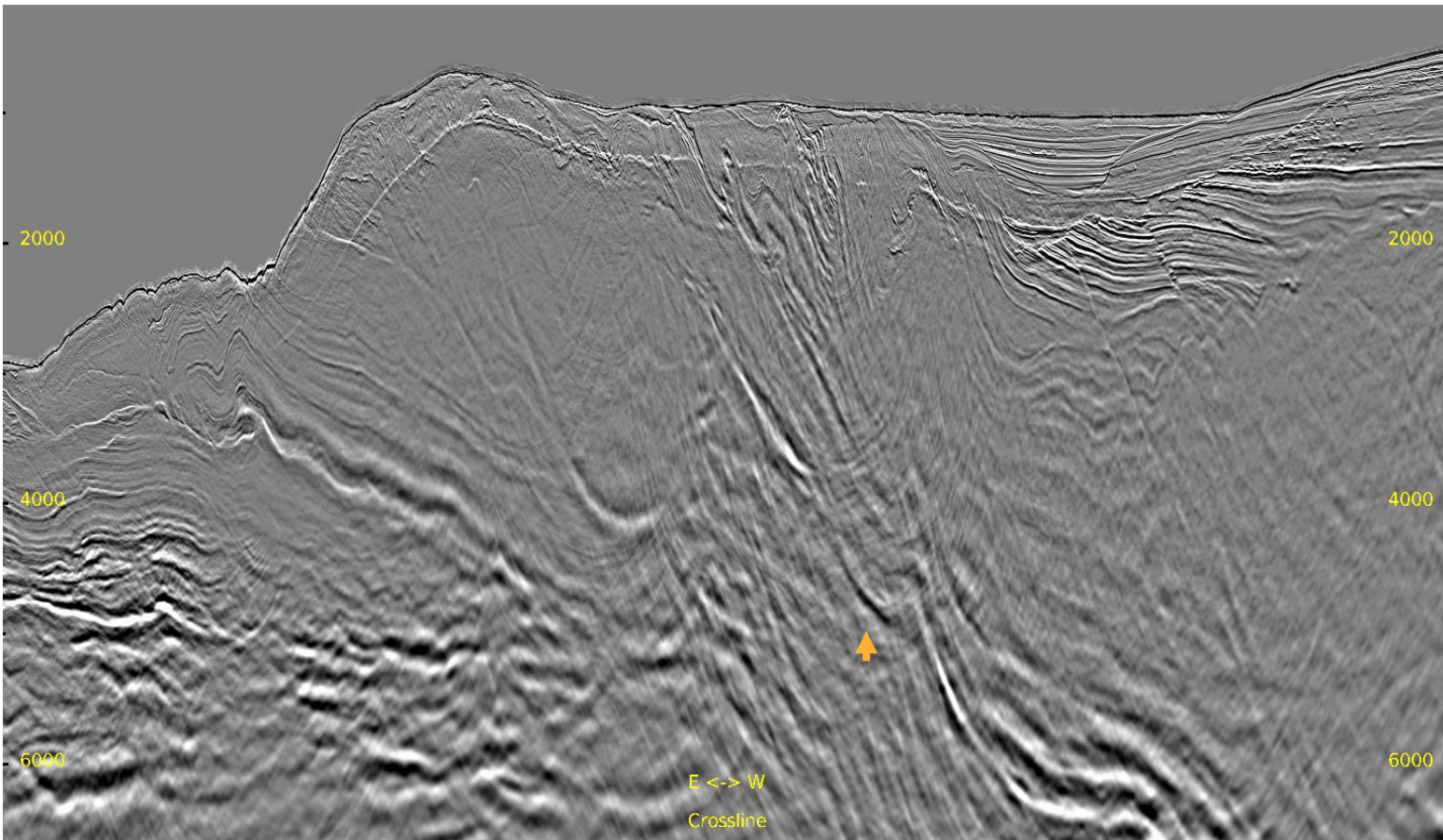
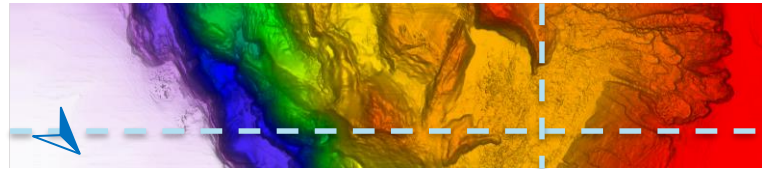
# Zoomed Full Stack: Previous Result

Inline 636 & Crossline 3944



# Zoomed Full Stack: Current Result

Inline 636 & Crossline 3944



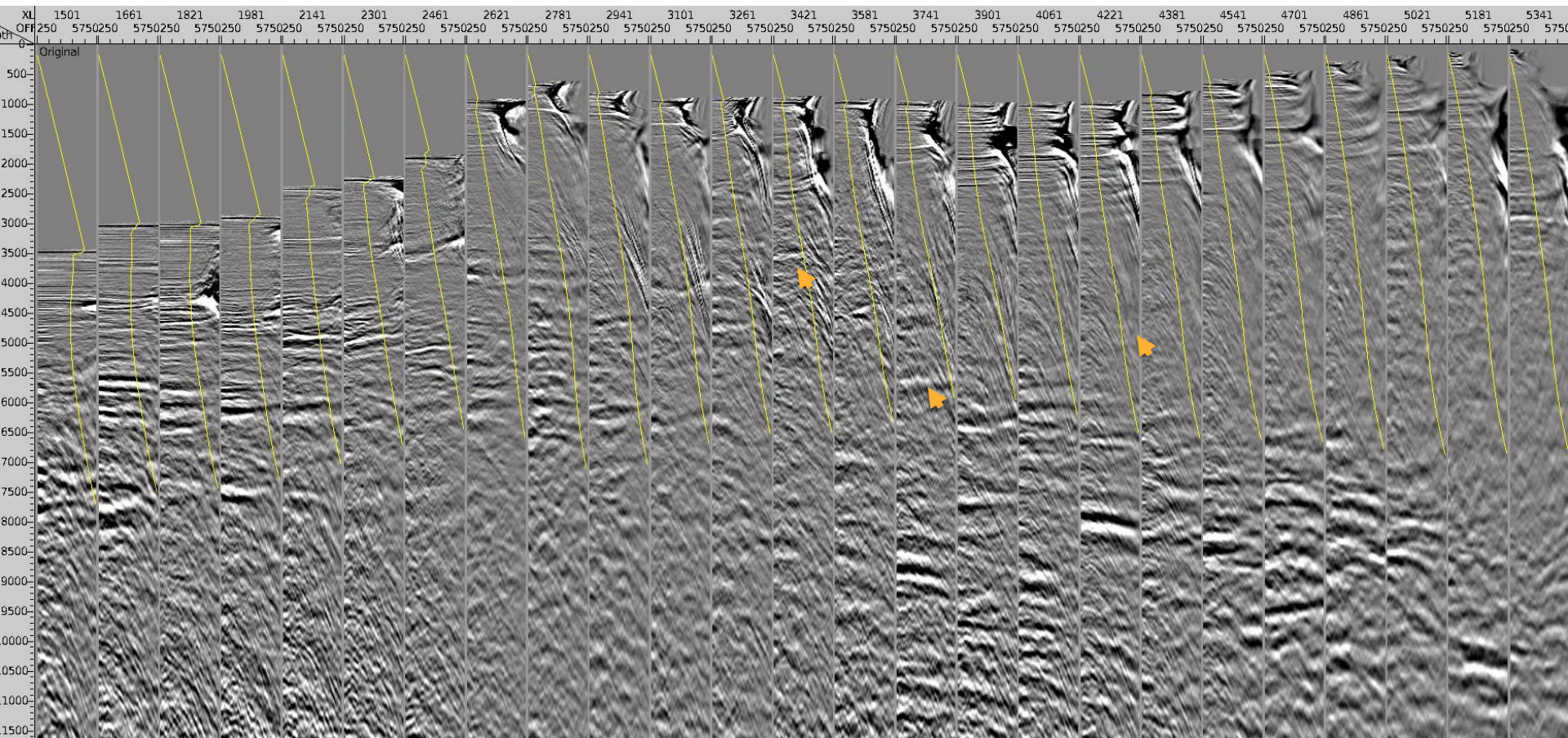




# Inline 636 CDP Gathers: Previous Result

— 35° Mute

28



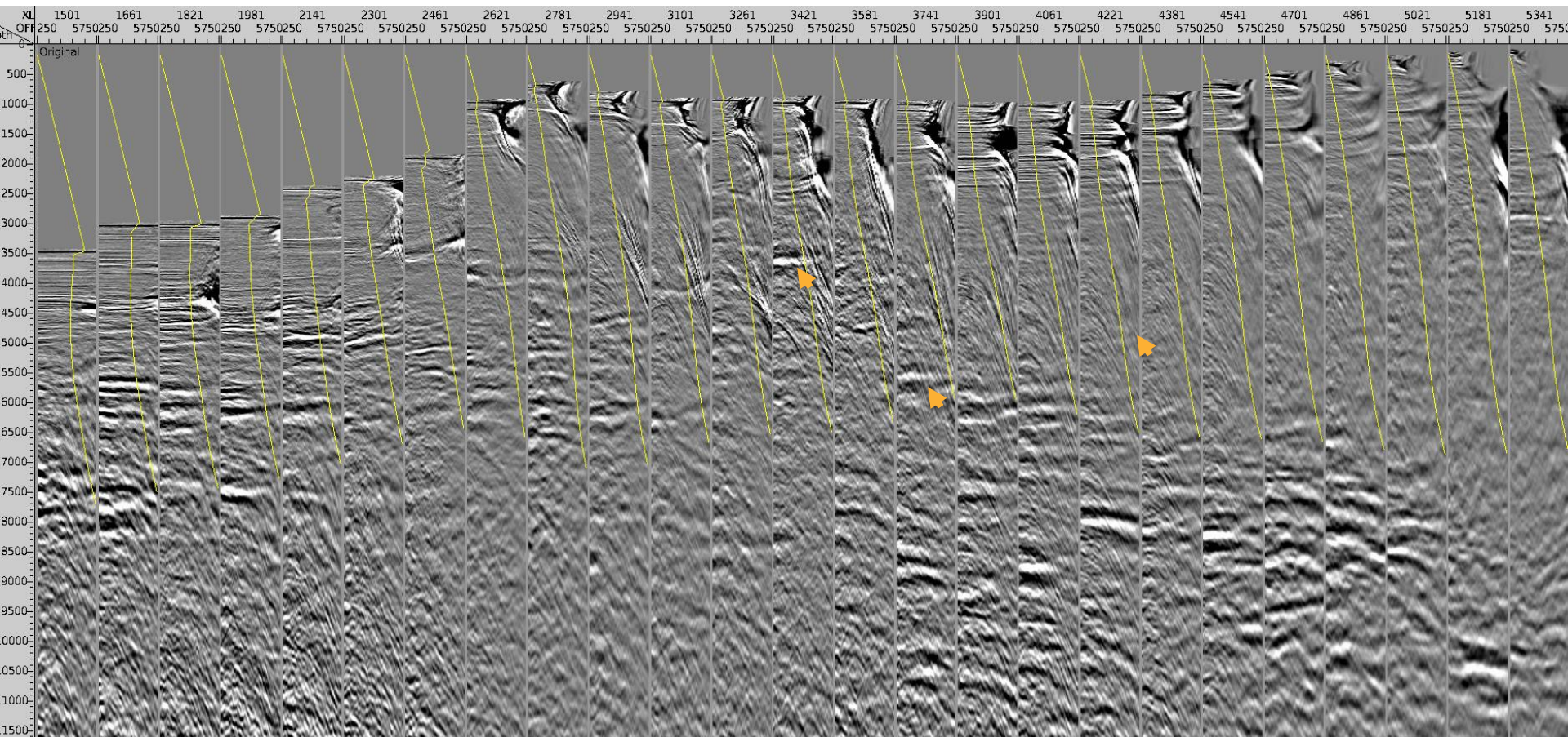




# Inline 636 CDP Gathers: Current Result

— 35° Mute

29







# IT4 – Part 3

## NZ 3D Processing

*10 March 2021*

[cgg.com](http://cgg.com)



INSTITUTE FOR GEOPHYSICS



- **Objective:**

To further improve deep velocity, especially in the middle and west part.

- **Procedure:**

Following the previous TTI FWI result, a global TTI tomography is applied to further flatten gathers, especially outside OBS data coverage.

- **Display:**

Velocity, migrated depth full stack & gathers.

- **Observation and Recommendation:**

The flatness of the gathers are improved. And events on stack have better focus and continuity. We recommend to proceed with this IT4 velocity.



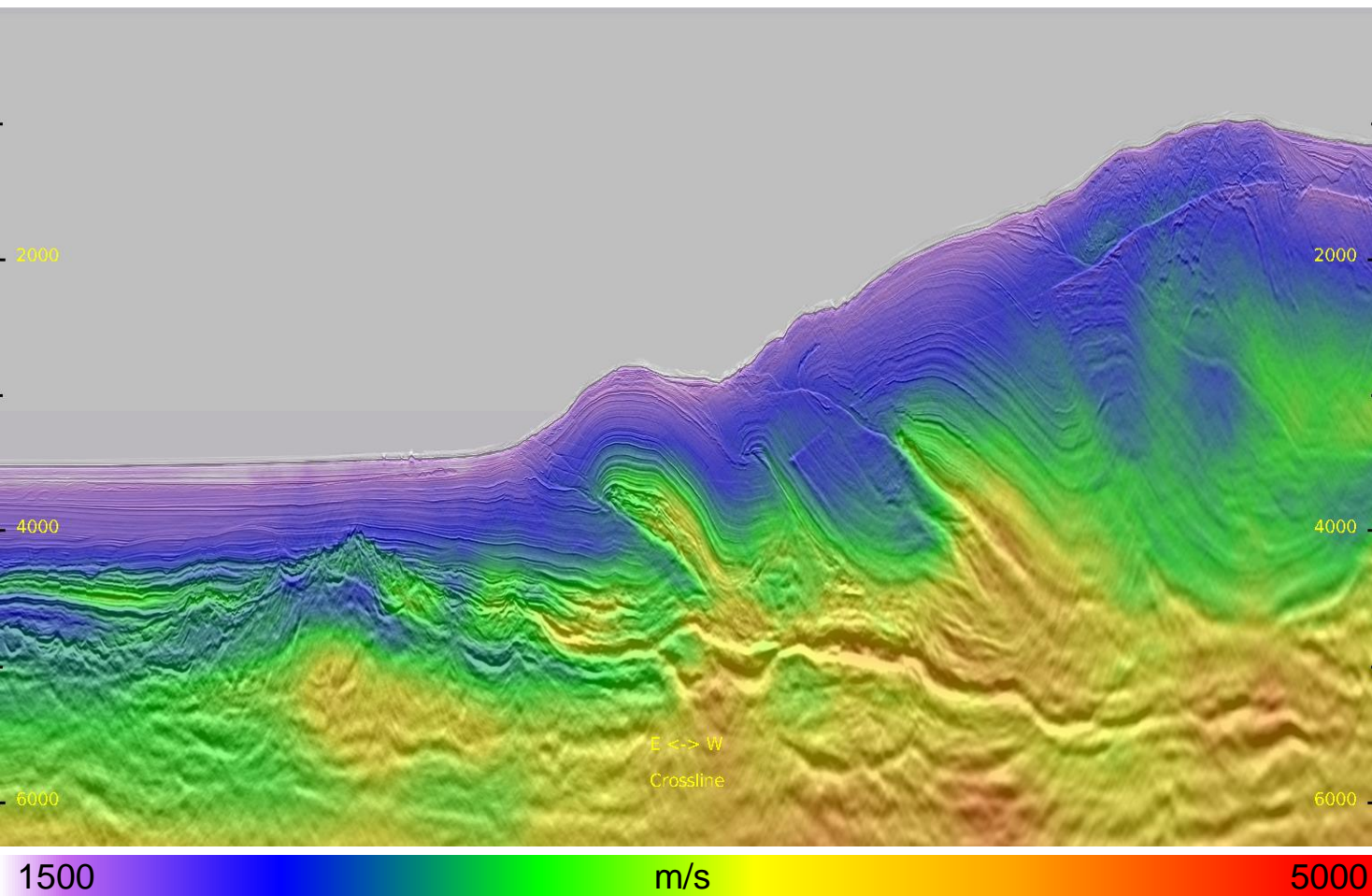
# Velocity Model



# Inline 436 East: Previous FWI Result

4

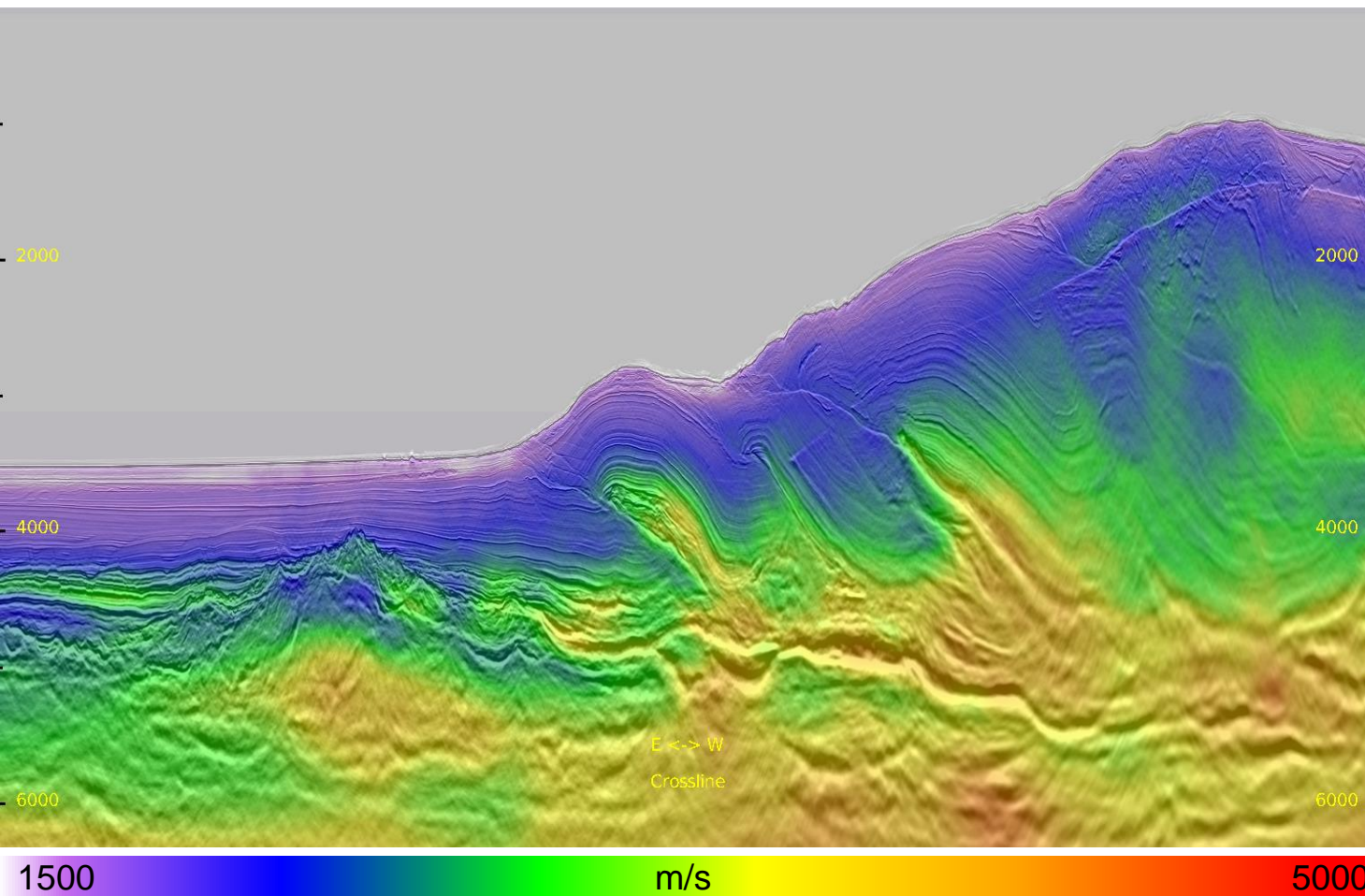
- Previous QTTI FWI velocity





# Inline 436 East: Current Tomography Result

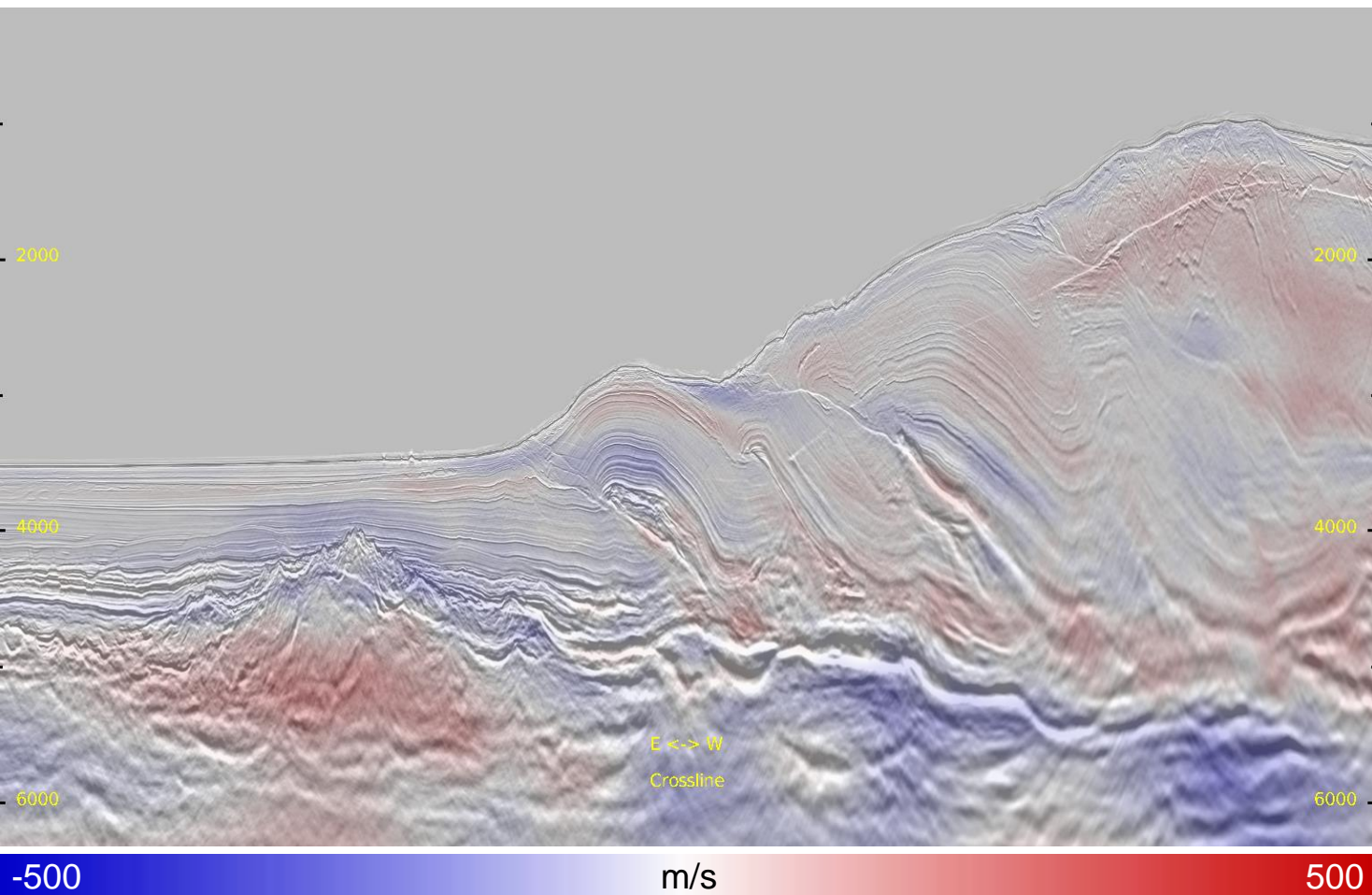
5



- Current tomography velocity.

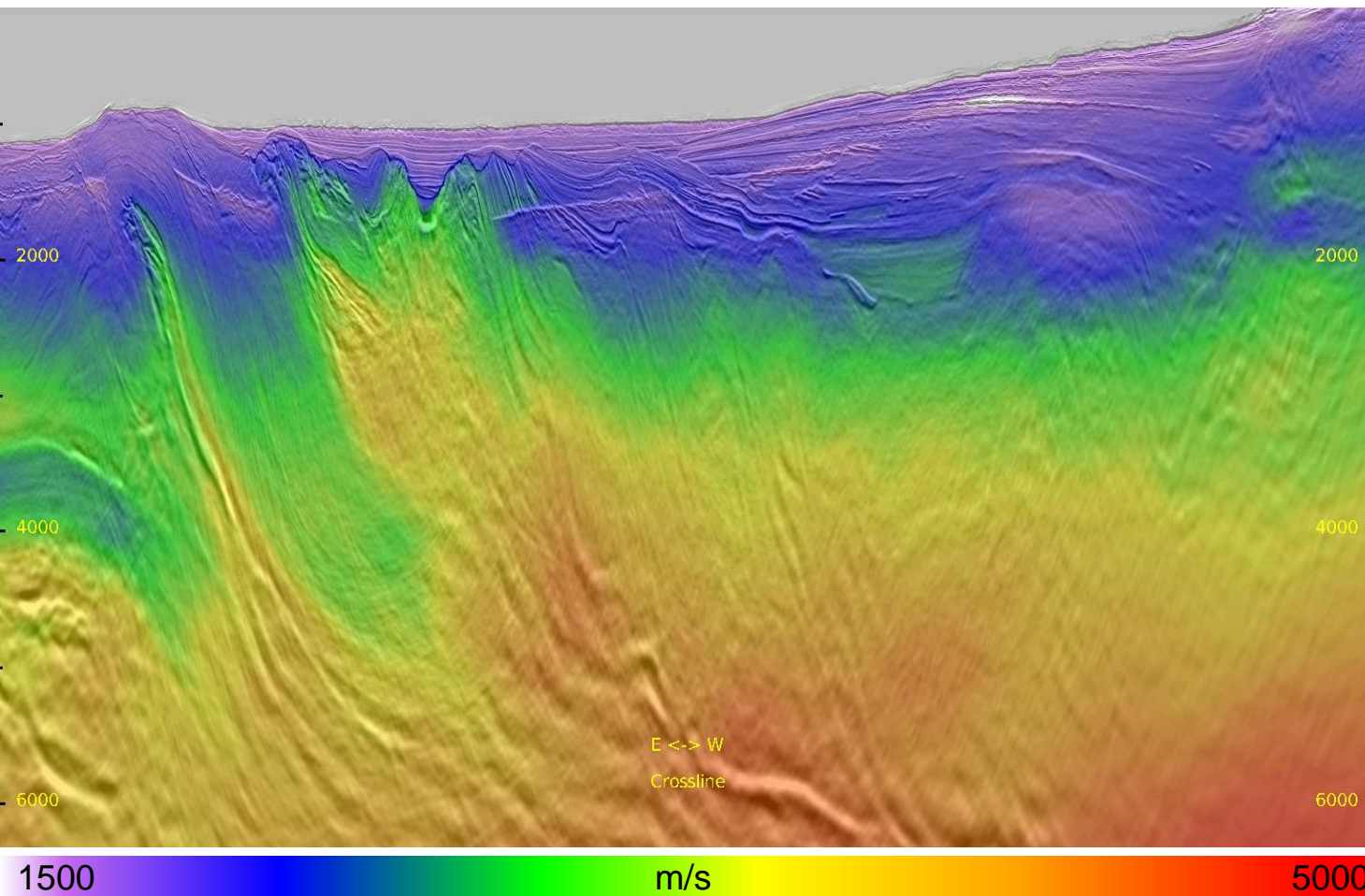
# Inline 436 East: Velocity Perturbation

6



- Relative small velocity perturbation, due to better starting model.

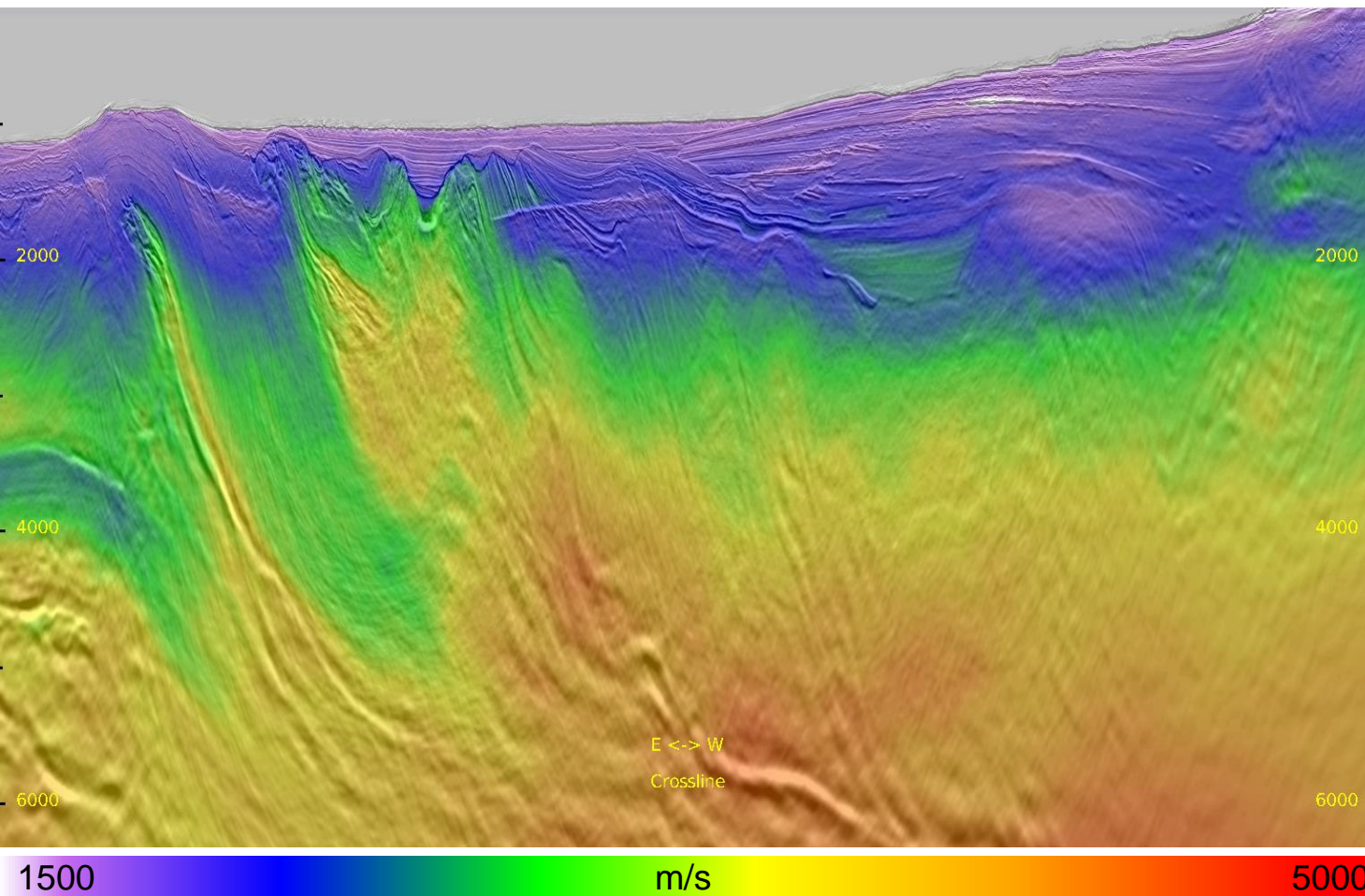




- Previous QTTI FWI velocity

# Inline 436 West: Current Tomography Result

8

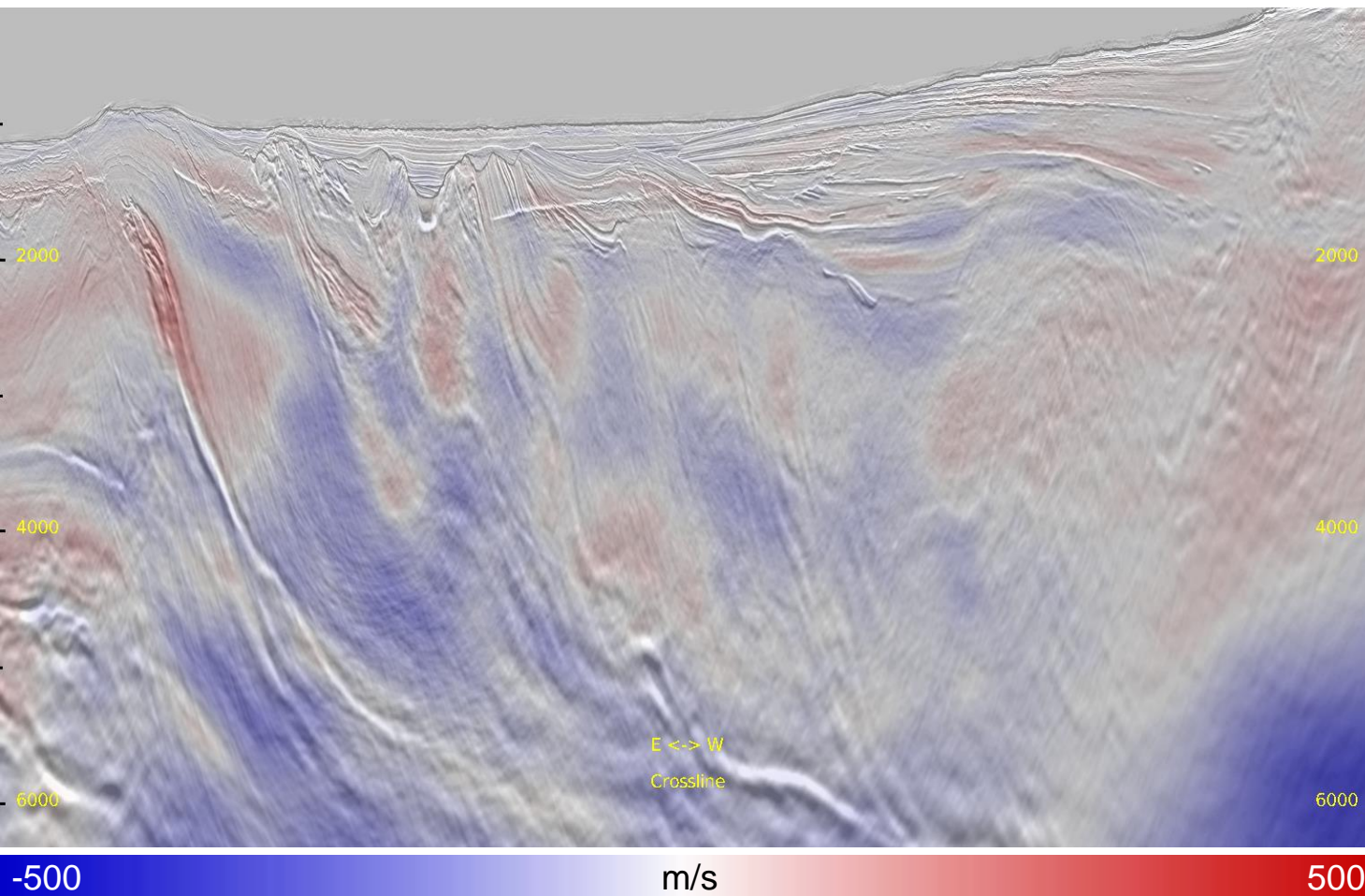


- Current tomography velocity.



# Inline 436 West: Velocity Perturbation

9



- Relative small velocity perturbation, due to better starting model.

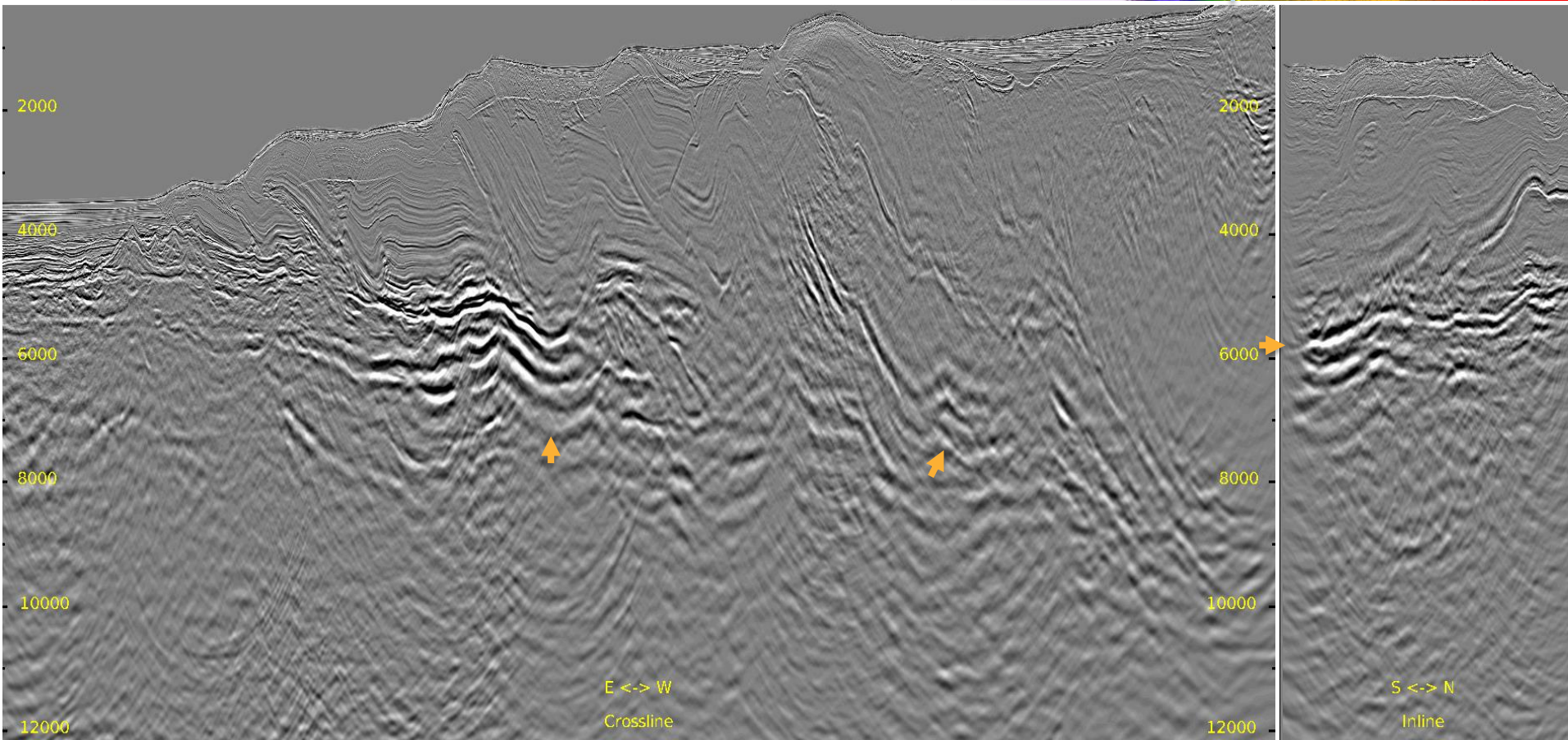
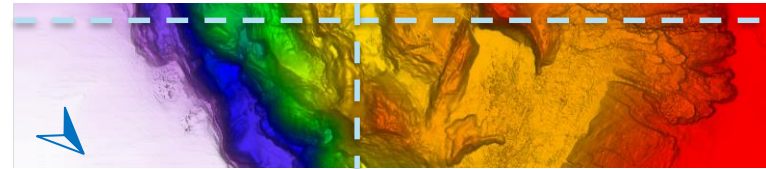
# Kirchhoff Depth Migration





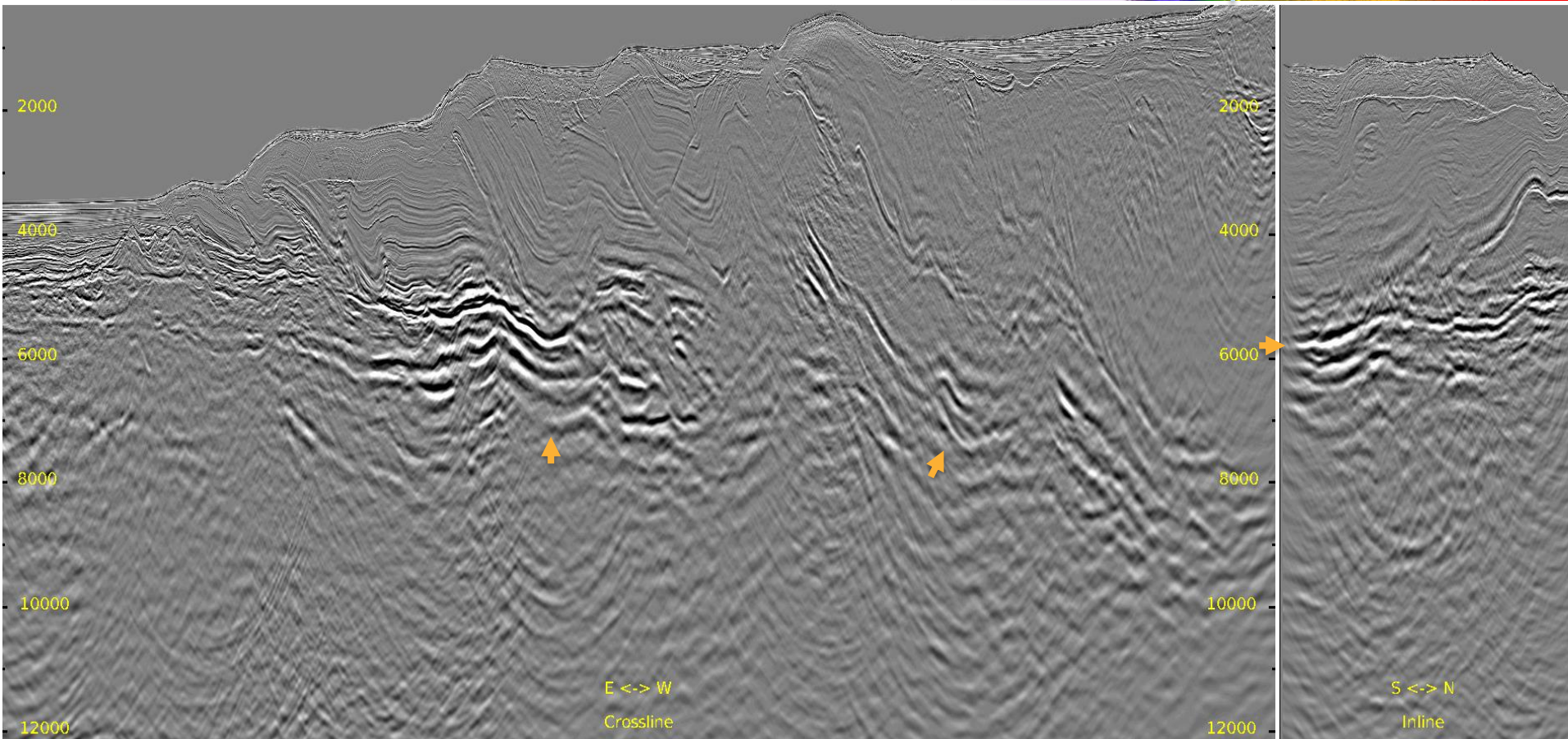
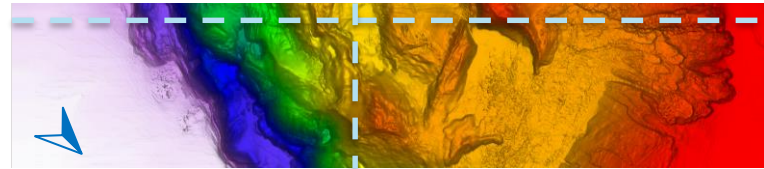
# Full Stack: Previous Result

Inline 101 & Crossline 2547



# Full Stack: Current Result

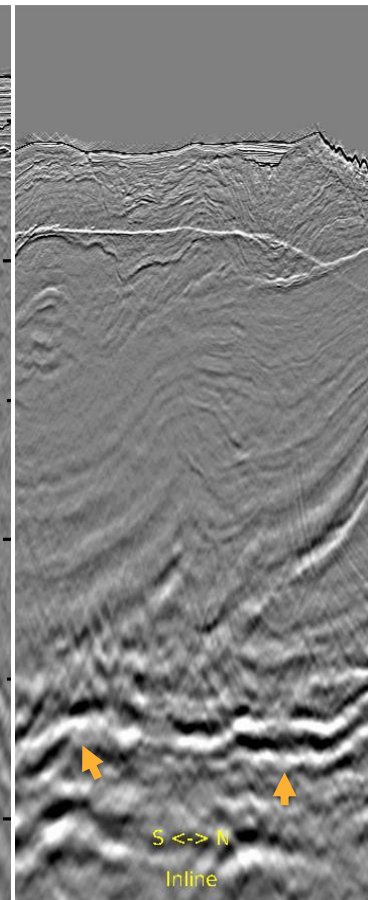
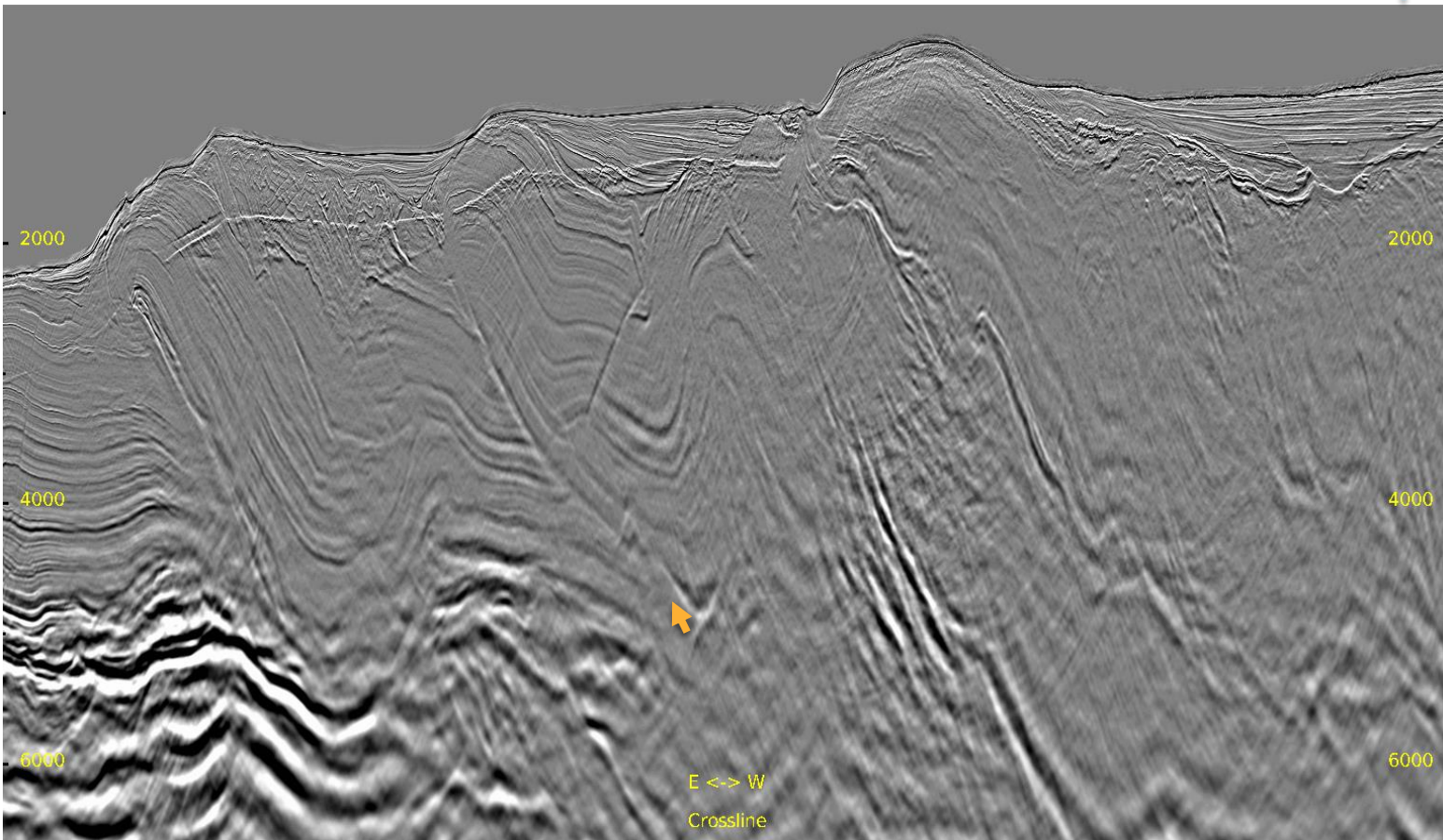
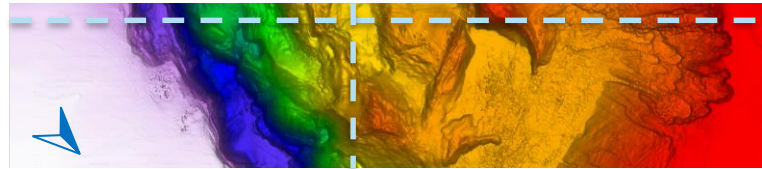
Inline 101 & Crossline 2547





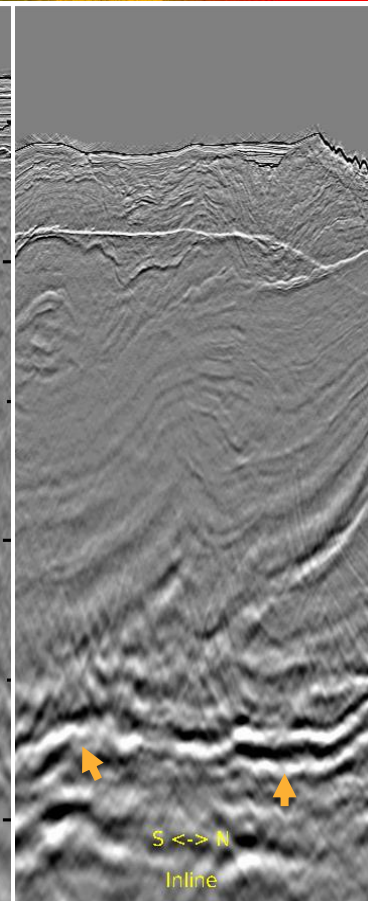
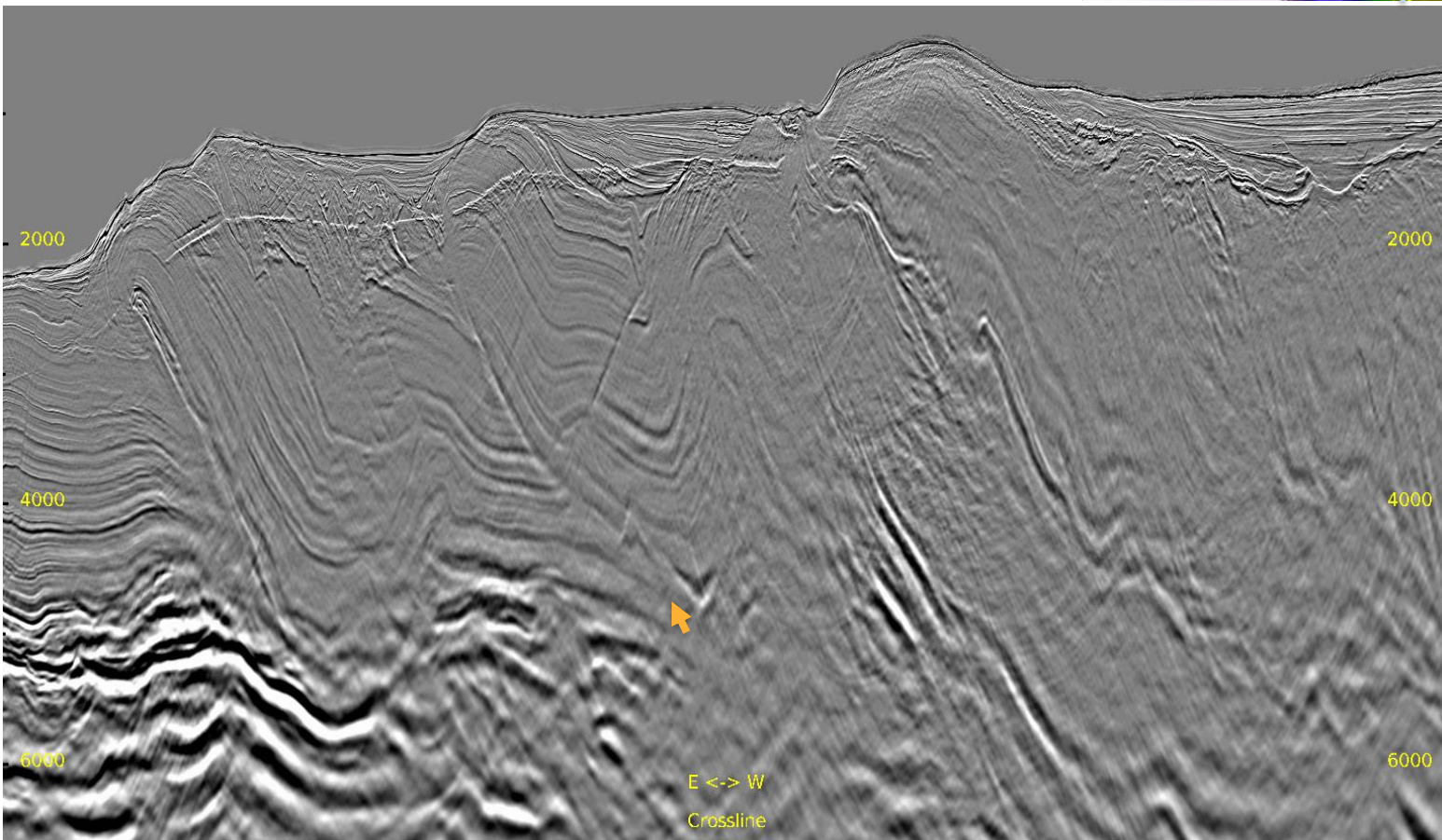
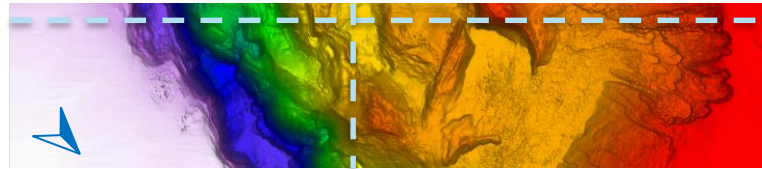
# Zoomed Full Stack: Previous Result

Inline 101 & Crossline 2547



# Zoomed Full Stack: Current Result

Inline 101 & Crossline 2547



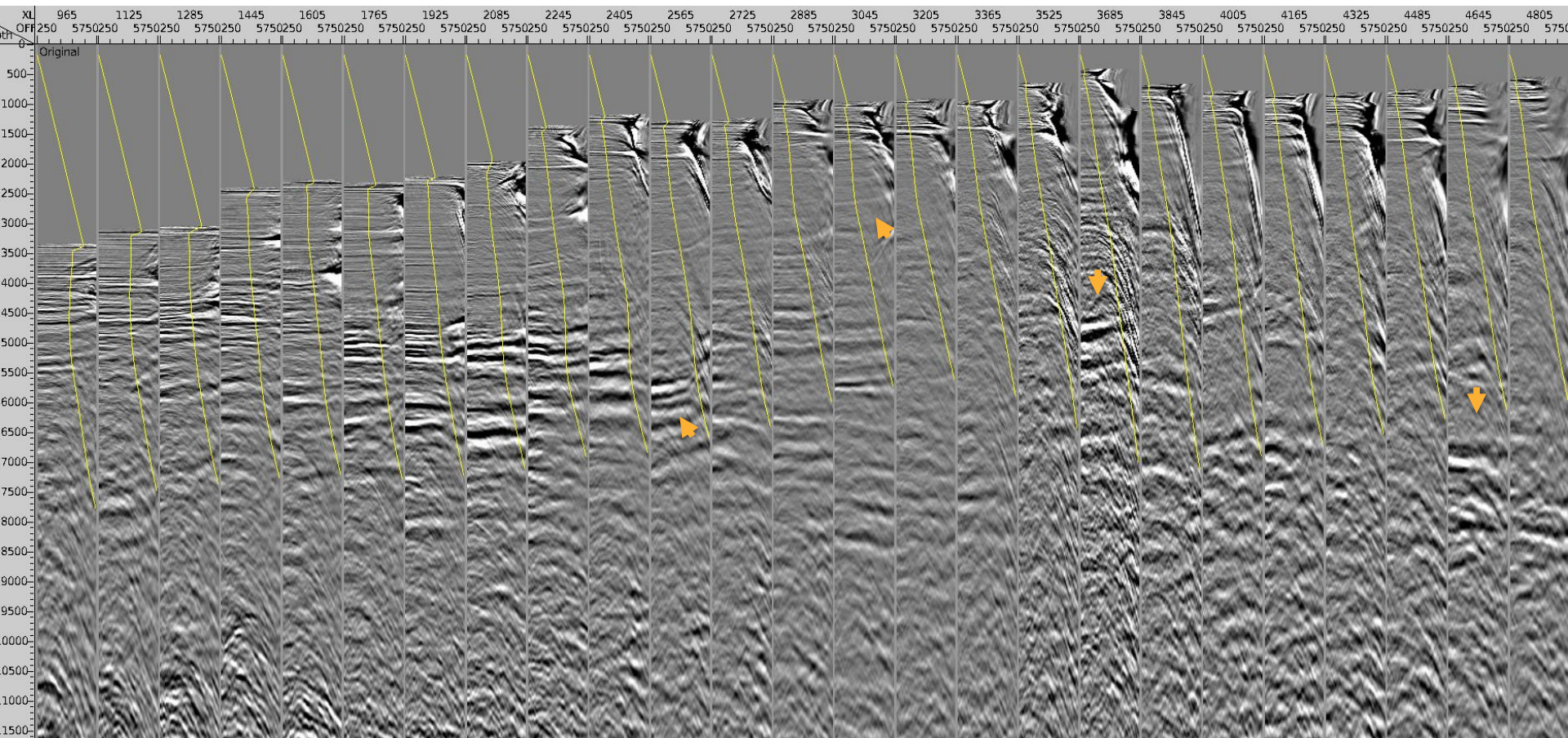




# Inline 101 CDP Gathers: Previous Result

— 35° Mute

15



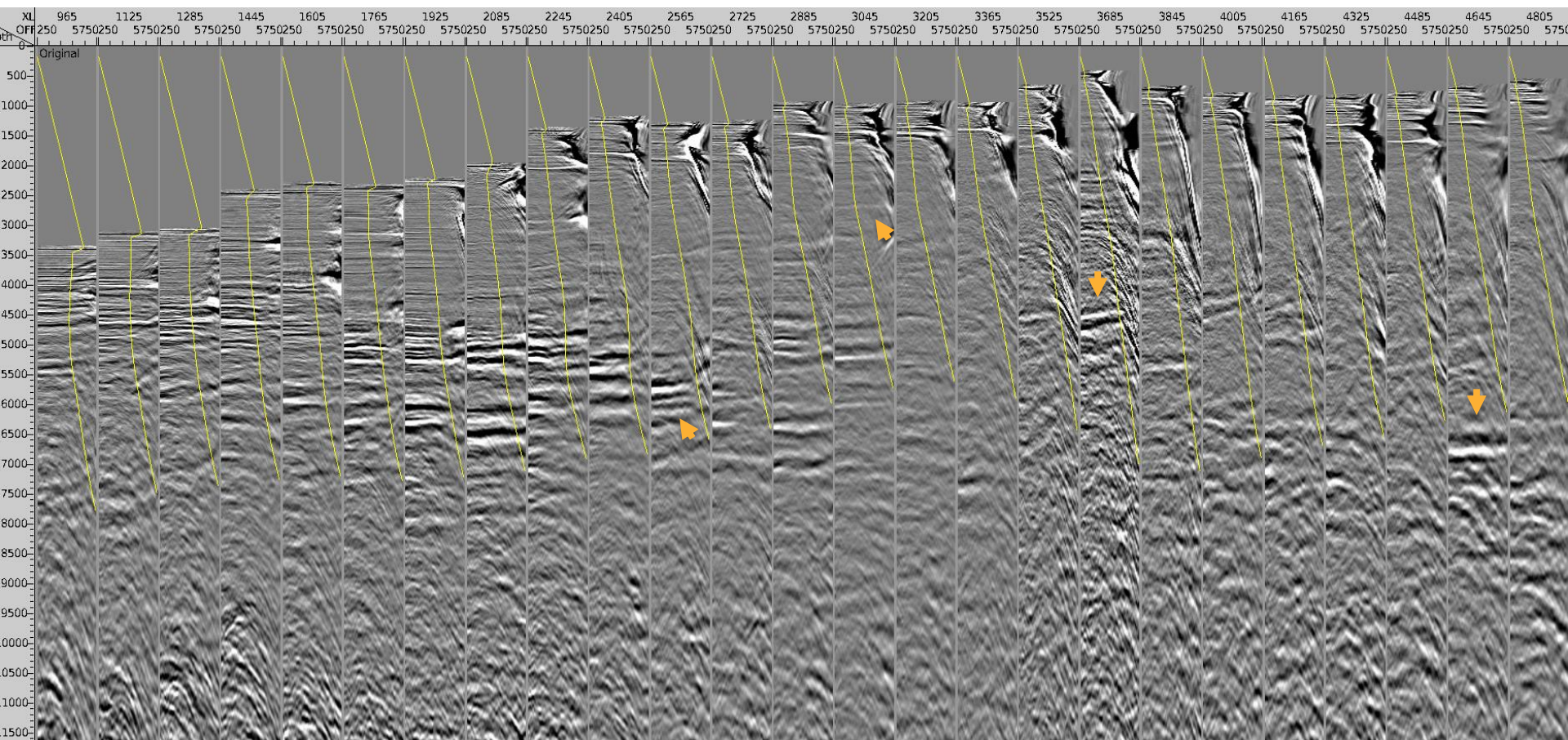




# Inline 101 CDP Gathers: Current Result

— 35° Mute

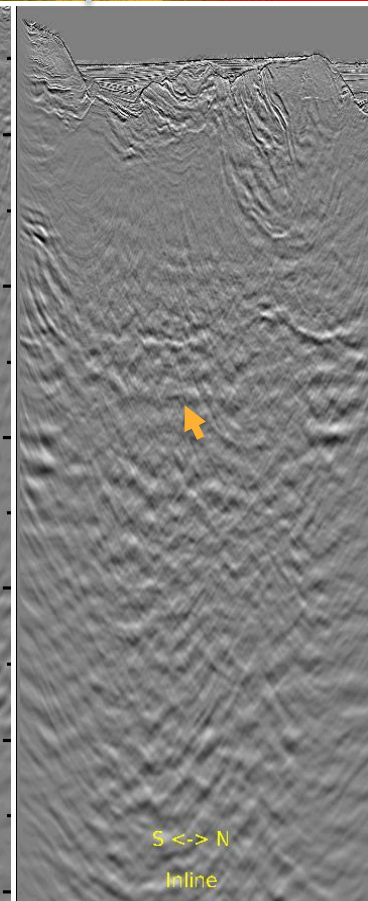
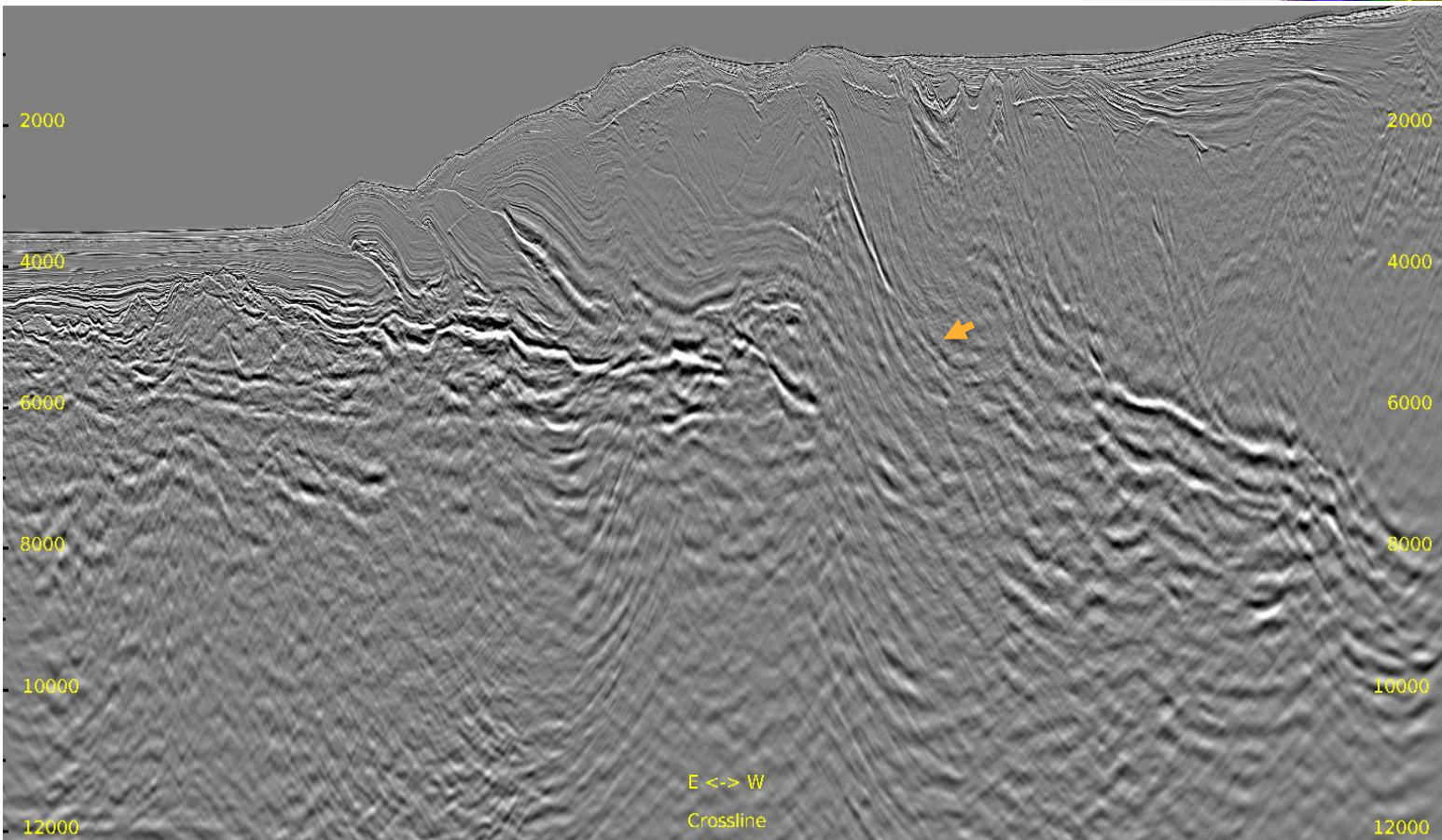
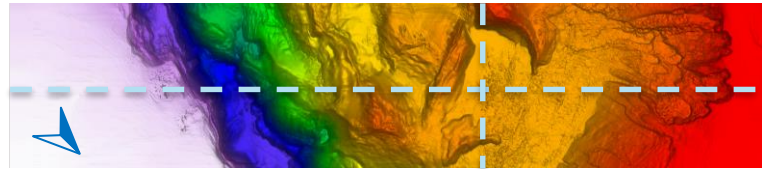
16





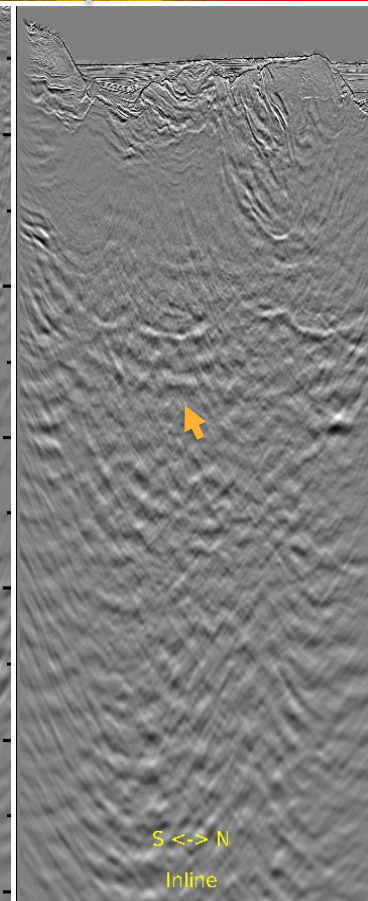
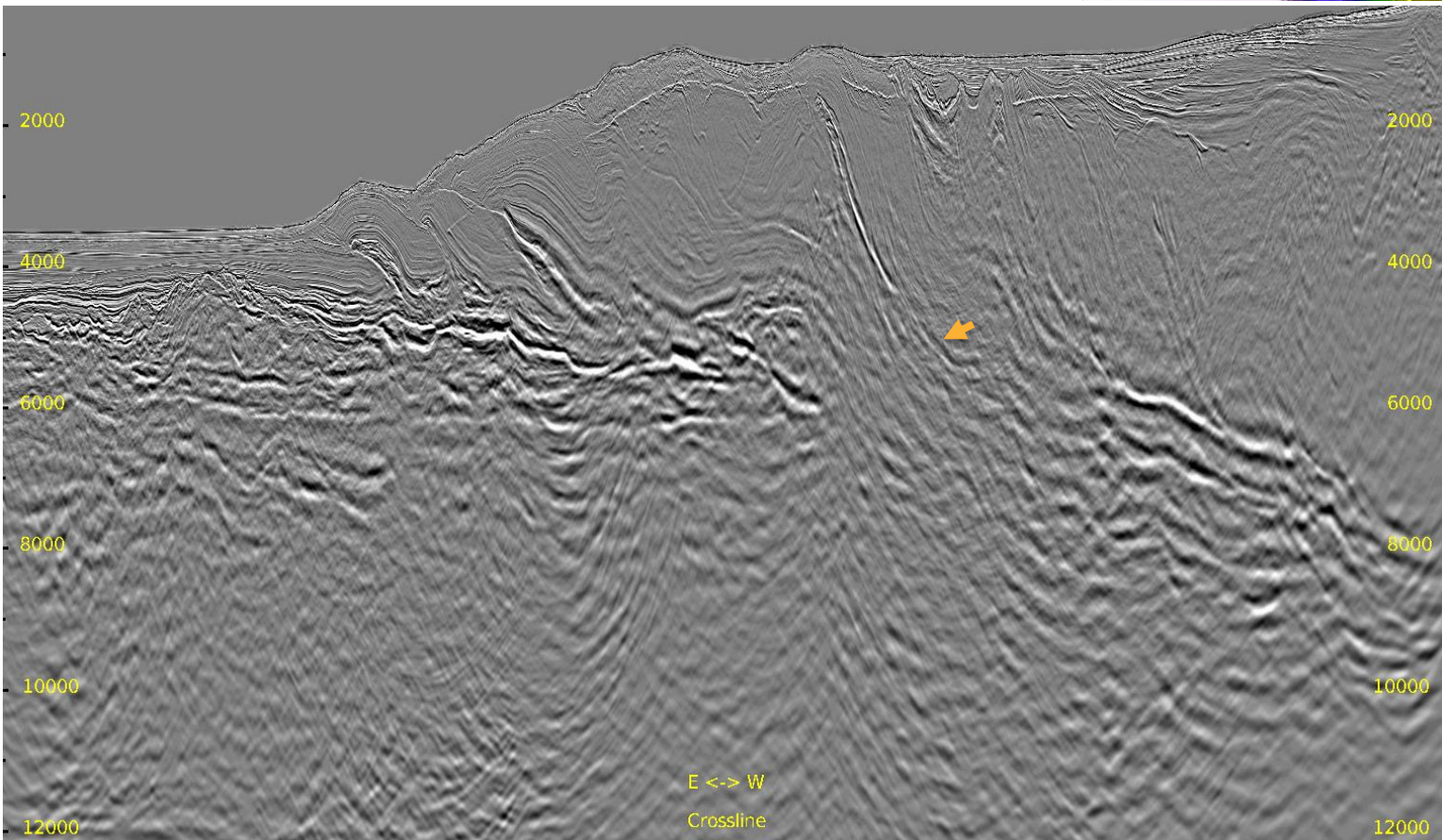
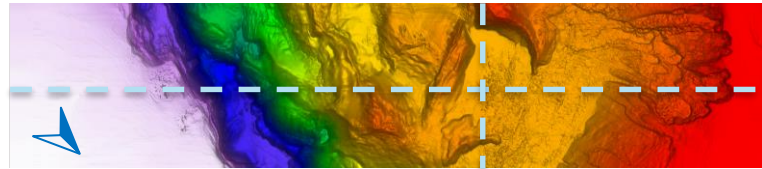
# Full Stack: Previous Result

Inline 451 & Crossline 3539



# Full Stack: Current Result

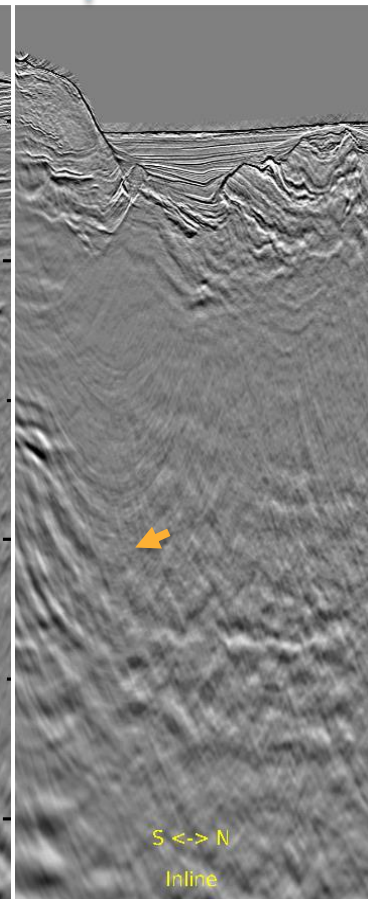
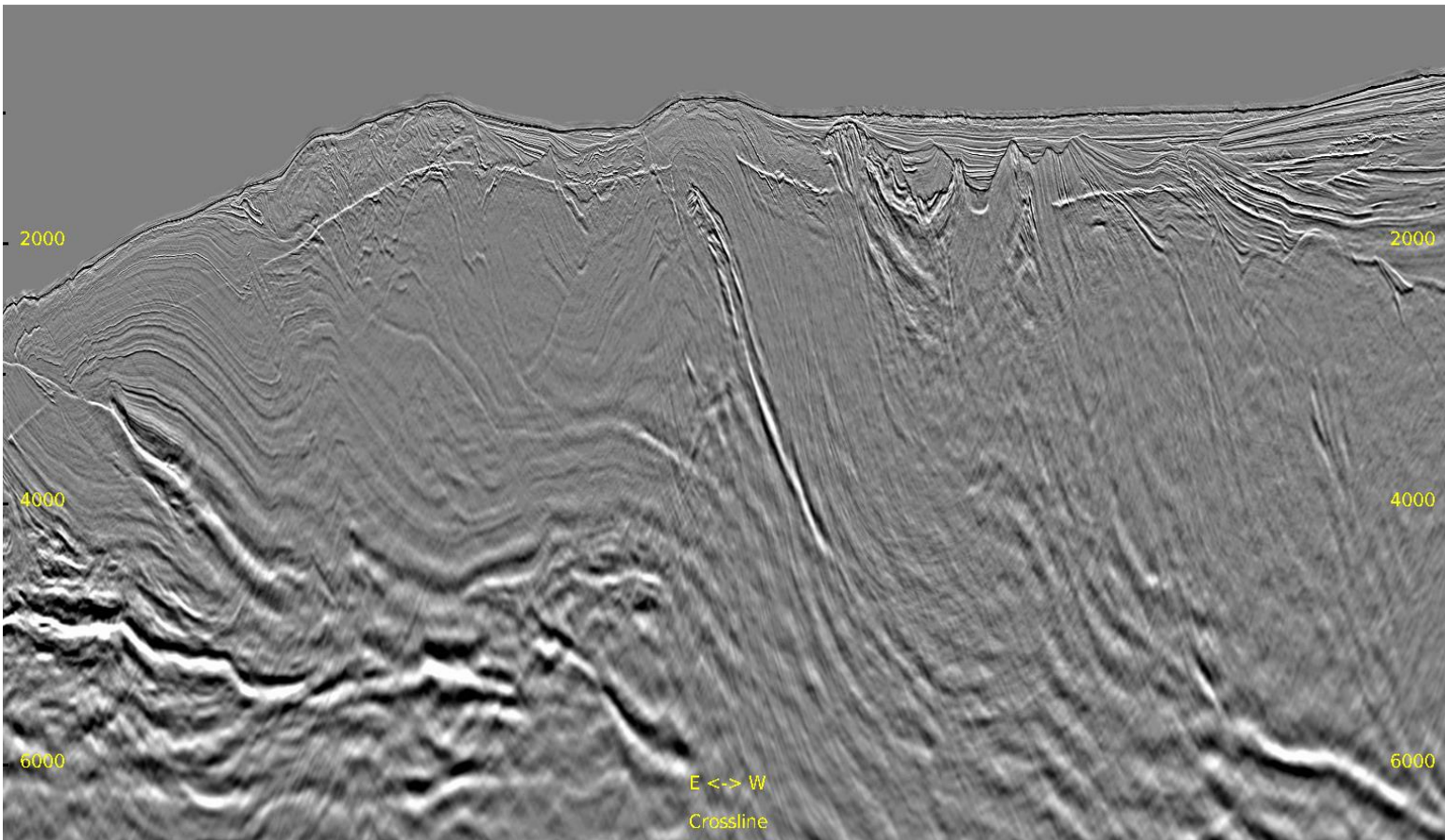
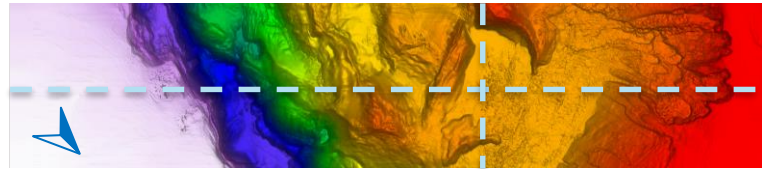
Inline 451 & Crossline 3539





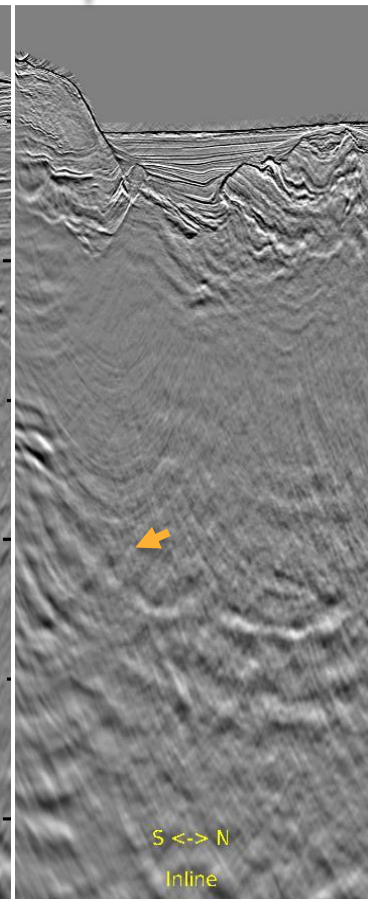
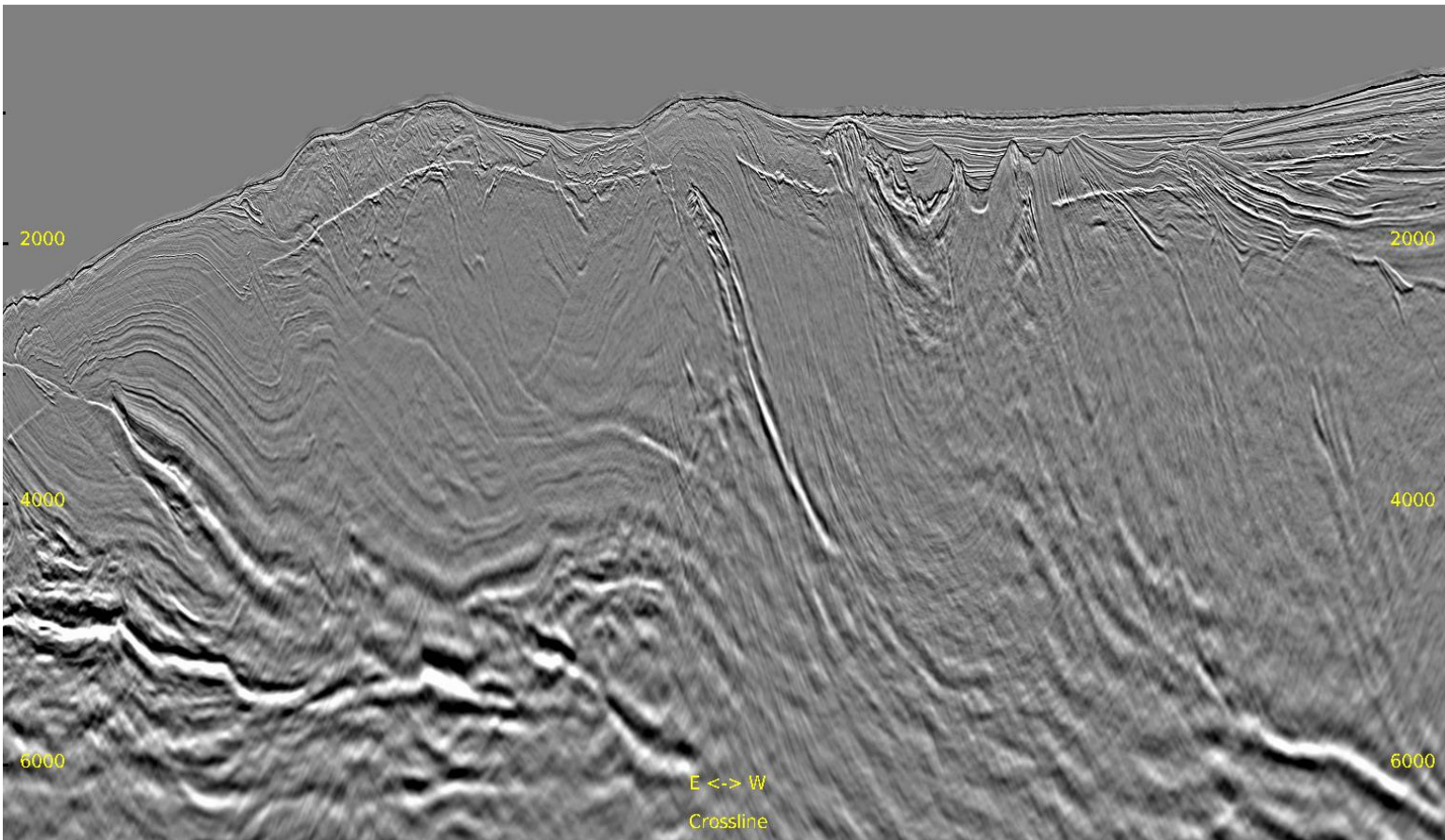
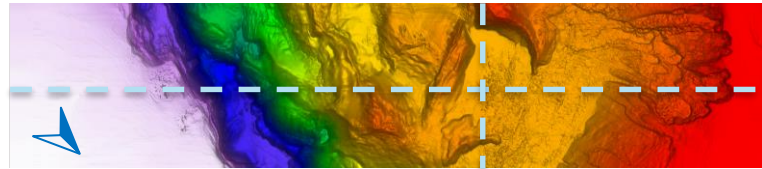
# Zoomed Full Stack: Previous Result

Inline 451 & Crossline 3539



# Zoomed Full Stack: Current Result

Inline 451 & Crossline 3539



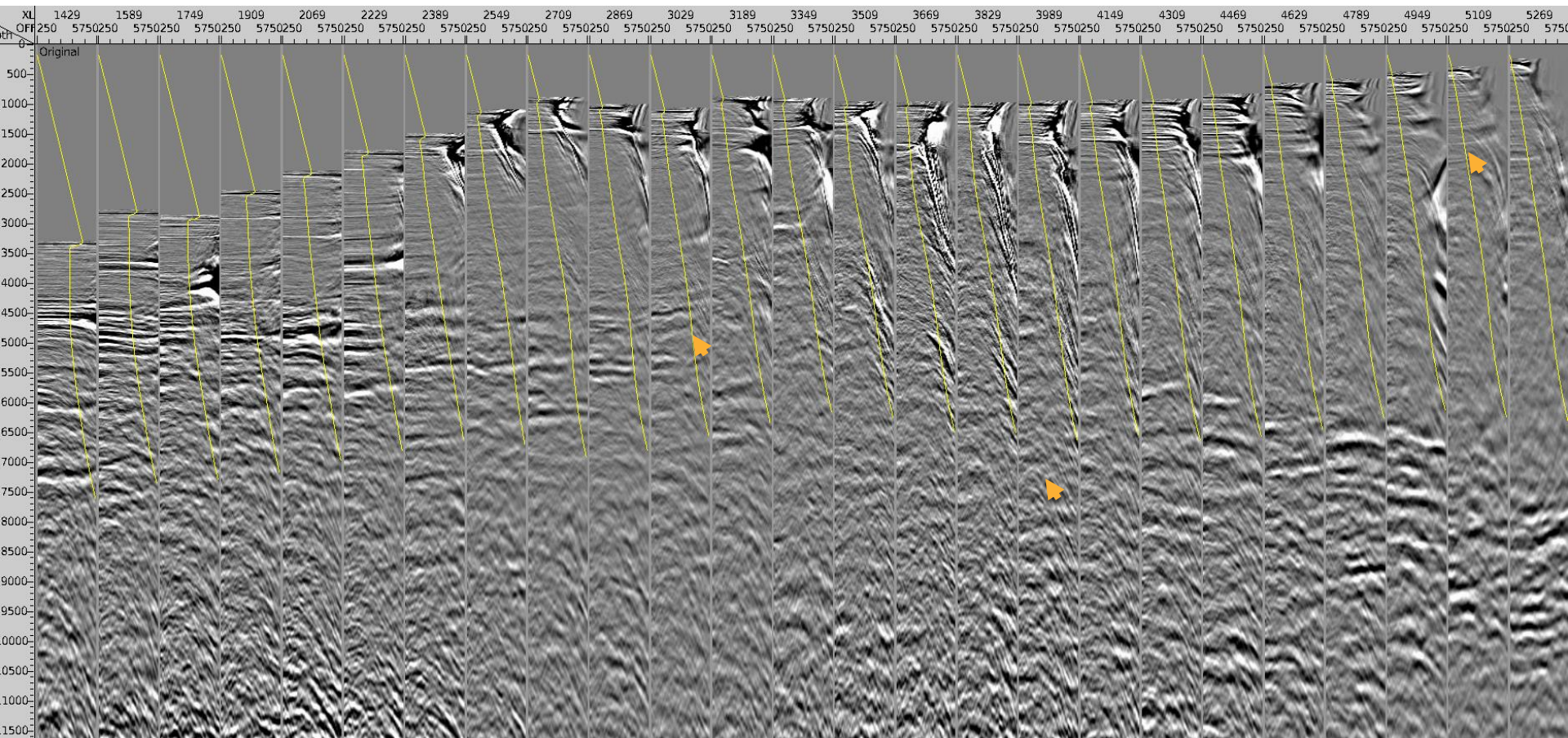




# Inline 451 CDP Gathers: Previous Result

— 35° Mute

21



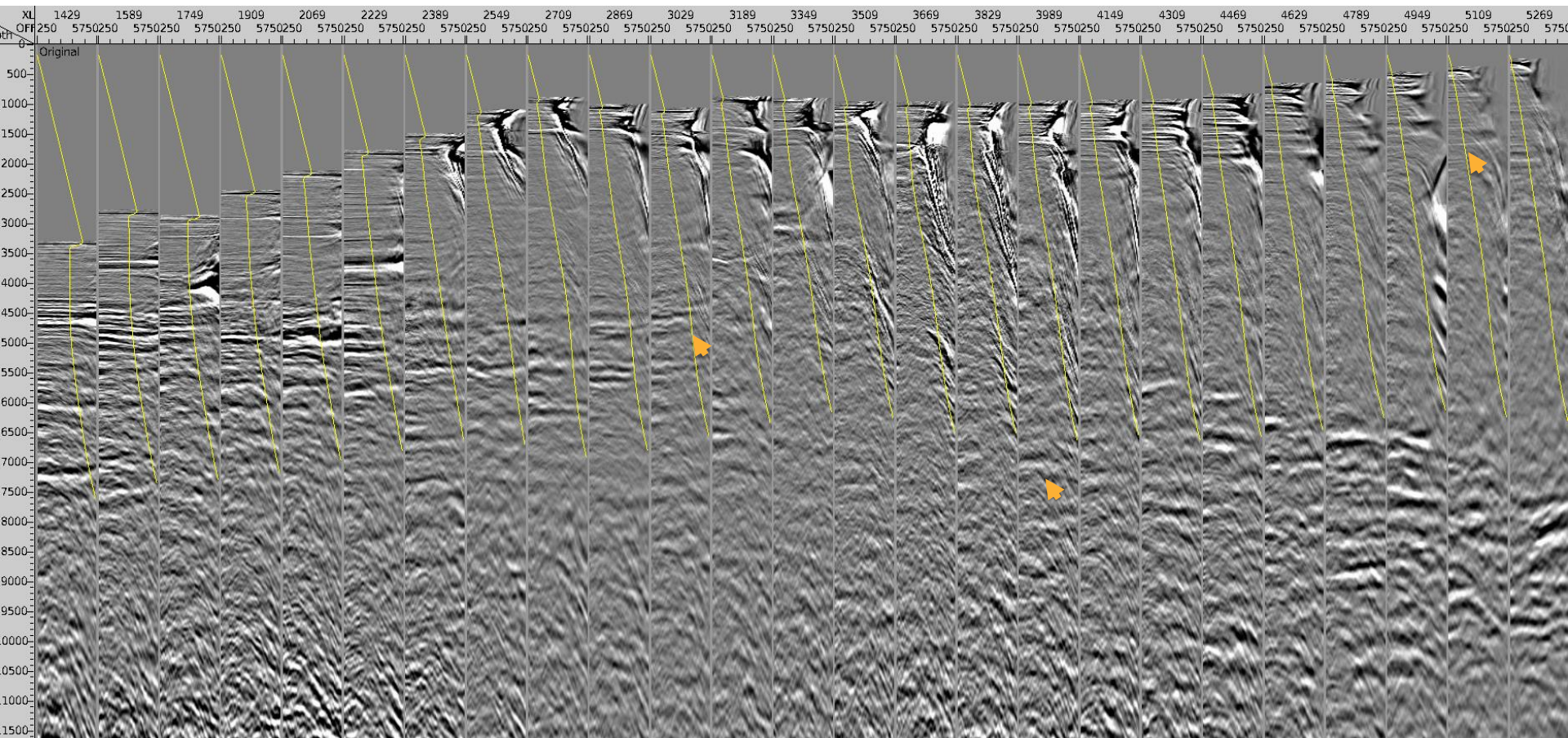




# Inline 451 CDP Gathers: Current Result

— 35° Mute

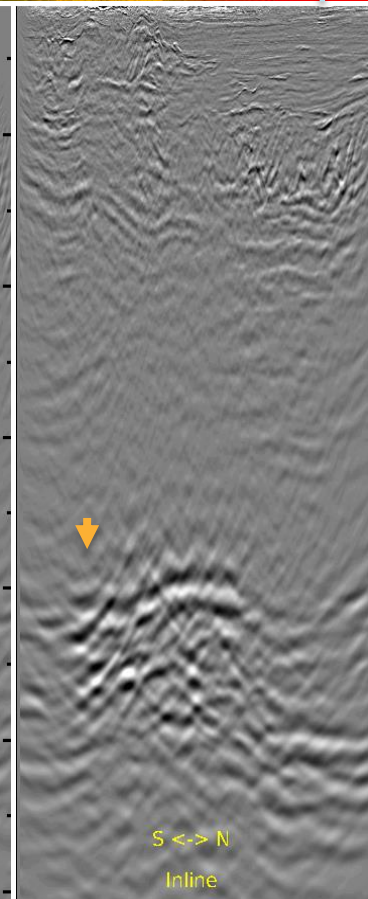
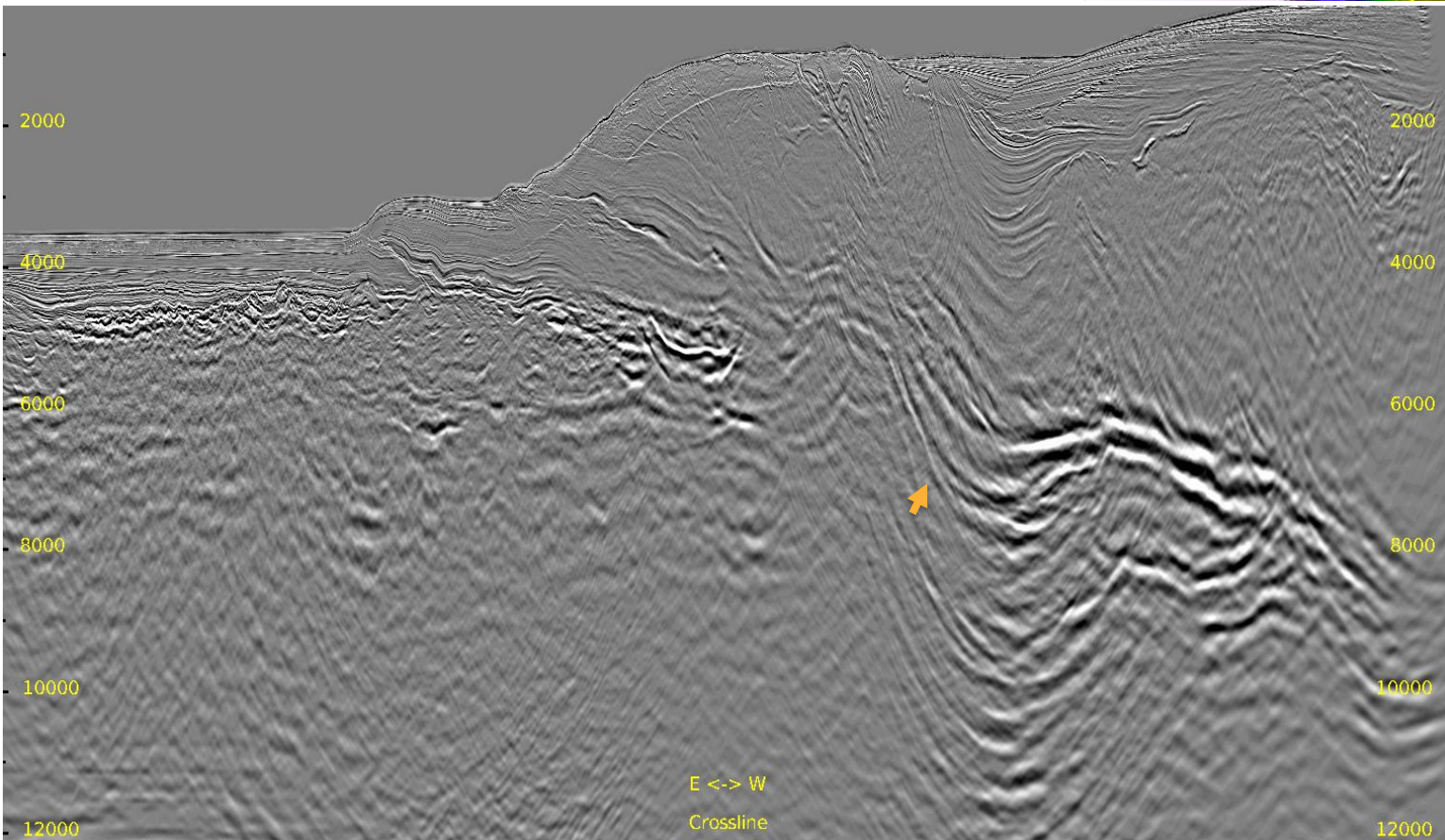
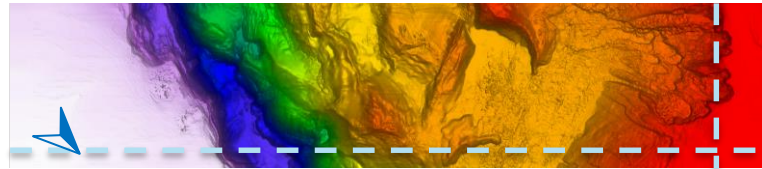
22





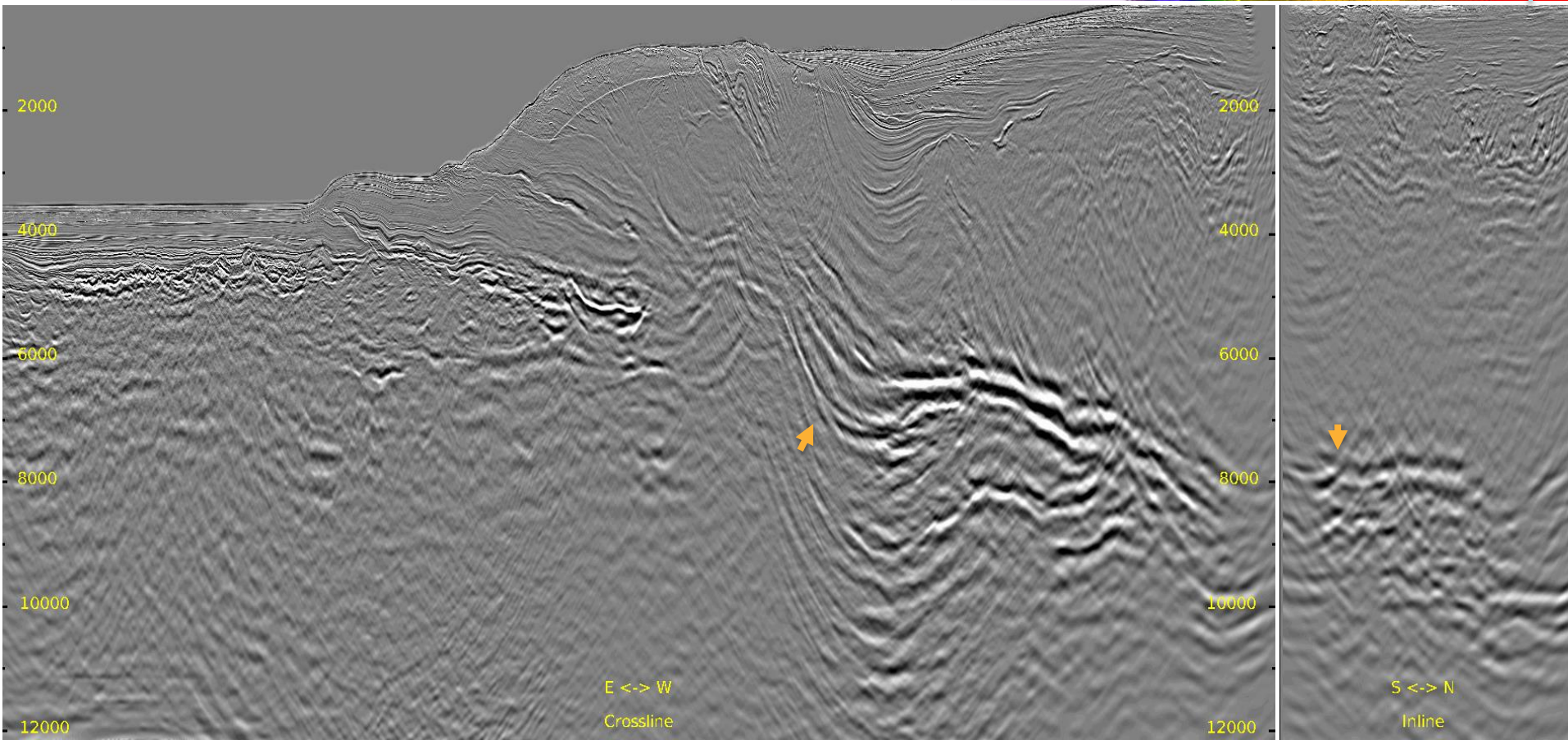
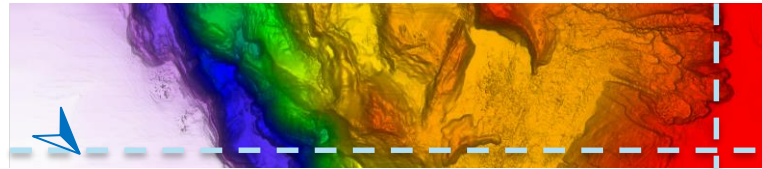
# Full Stack: Previous Result

Inline 745 & Crossline 5299



# Full Stack: Current Result

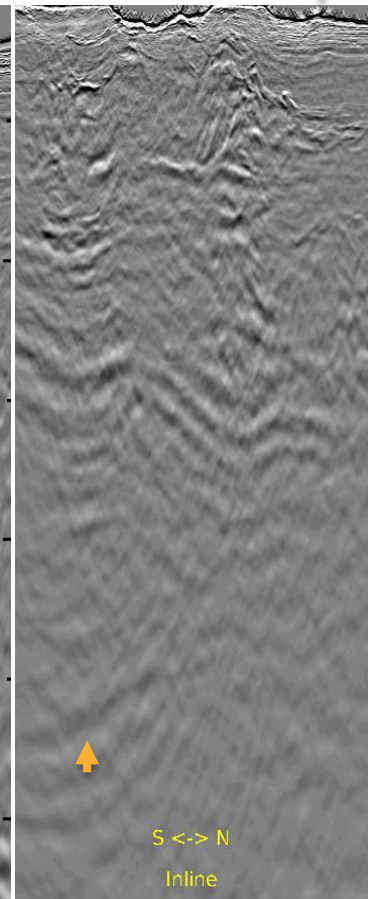
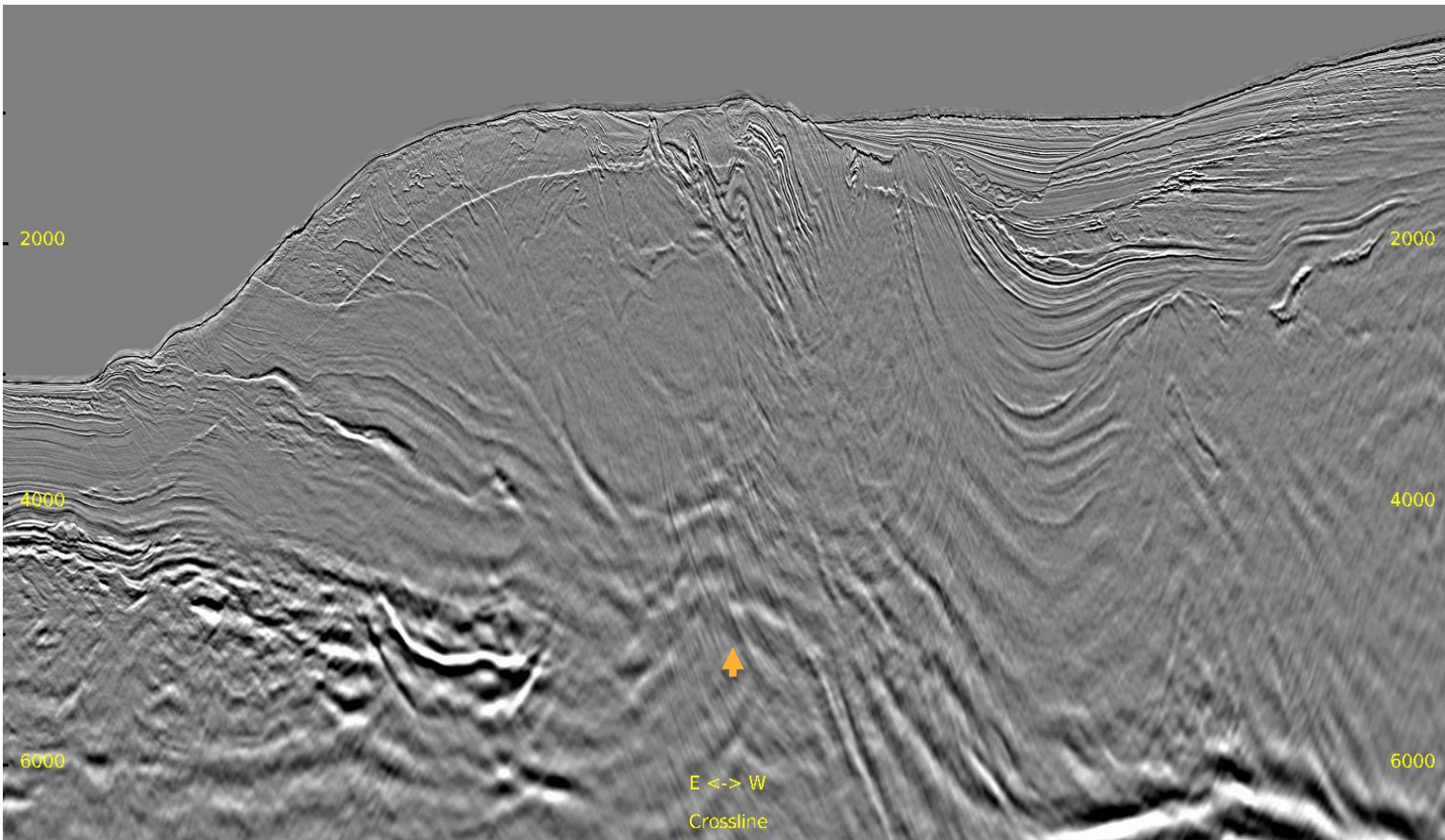
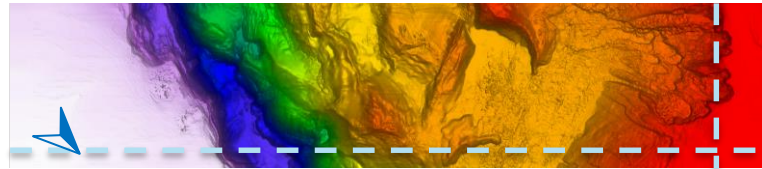
Inline 745 & Crossline 5299





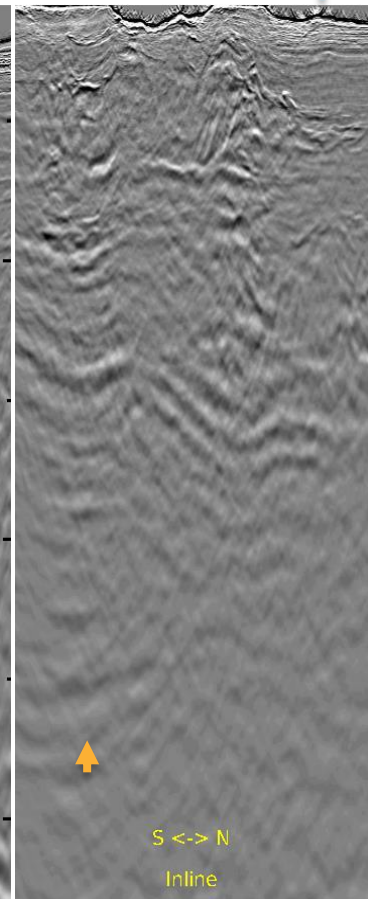
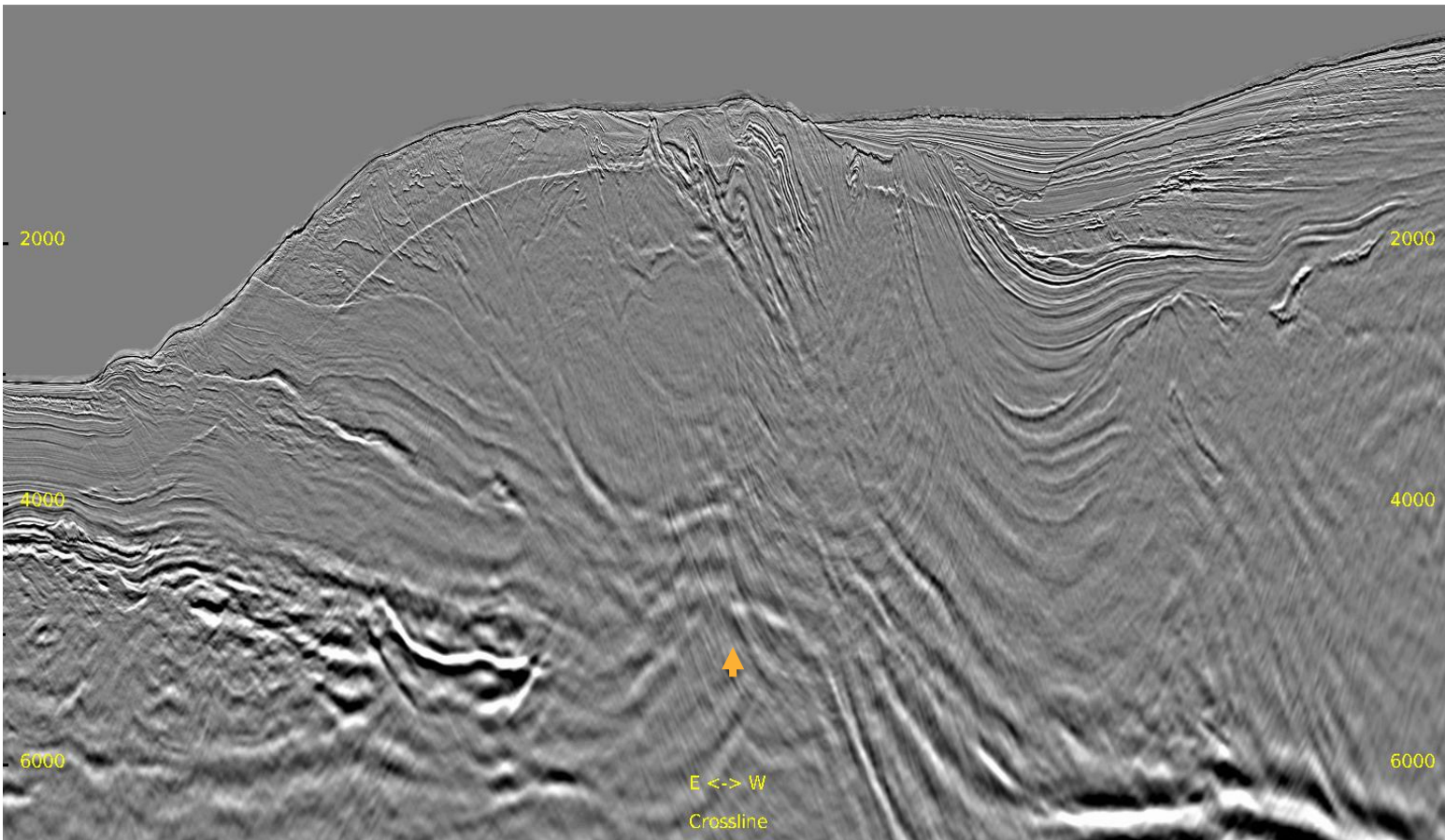
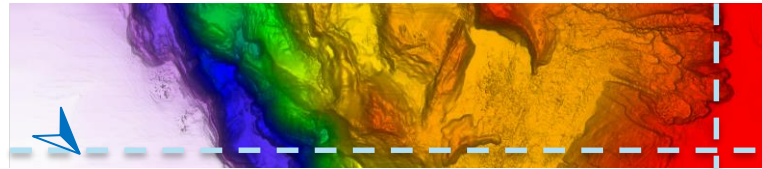
# Zoomed Full Stack: Previous Result

Inline 745 & Crossline 5299



# Zoomed Full Stack: Current Result

Inline 745 & Crossline 5299



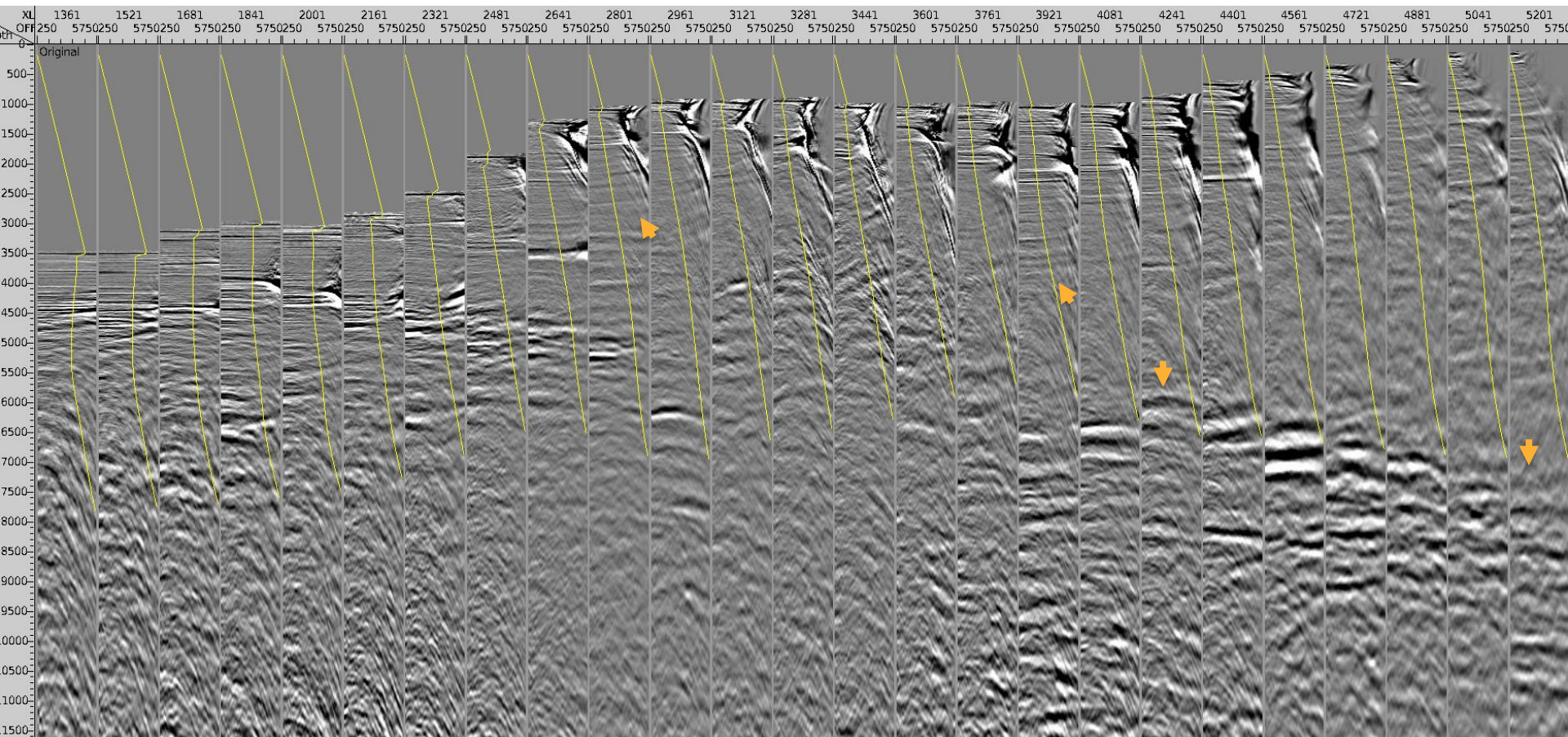




# Inline 745 CDP Gathers: Previous Result

— 35° Mute

27



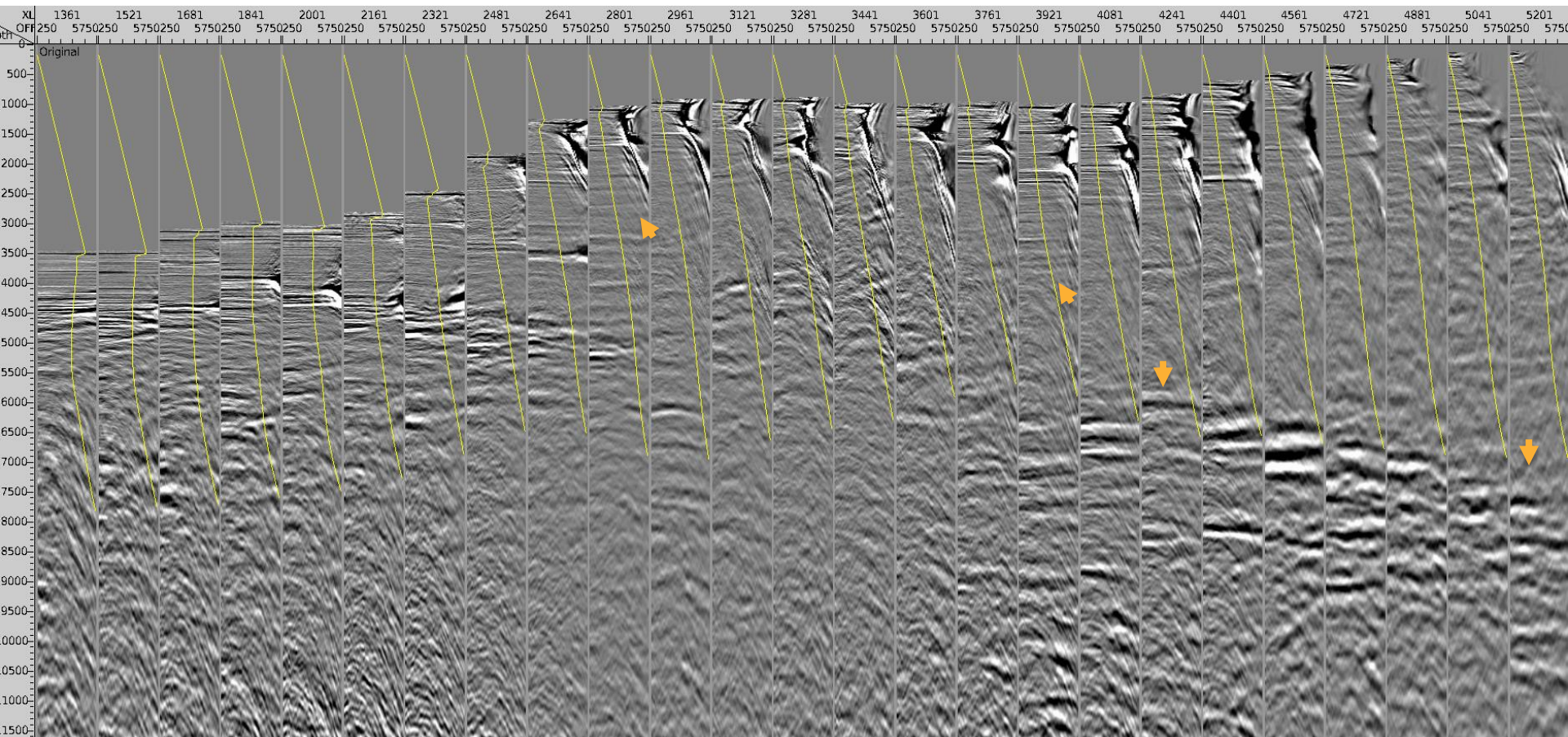




# Inline 745 CDP Gathers: Current Result

— 35° Mute

28







# IT5 – Part 1

## NZ 3D Processing

7 April 2021

[cgg.com](http://cgg.com)



INSTITUTE FOR GEOPHYSICS



Passion for Geoscience

- **Objective:**

To further improve deep velocity, especially in the middle and west part.

- **Procedure:**

Following the previous global TTI tomography, a high resolution tomography is applied on the east side and scanning tomography is applied on the east deep part, that outside the OBN FWI coverage.

- **Display:**

Velocity, migrated depth full stack & gathers.

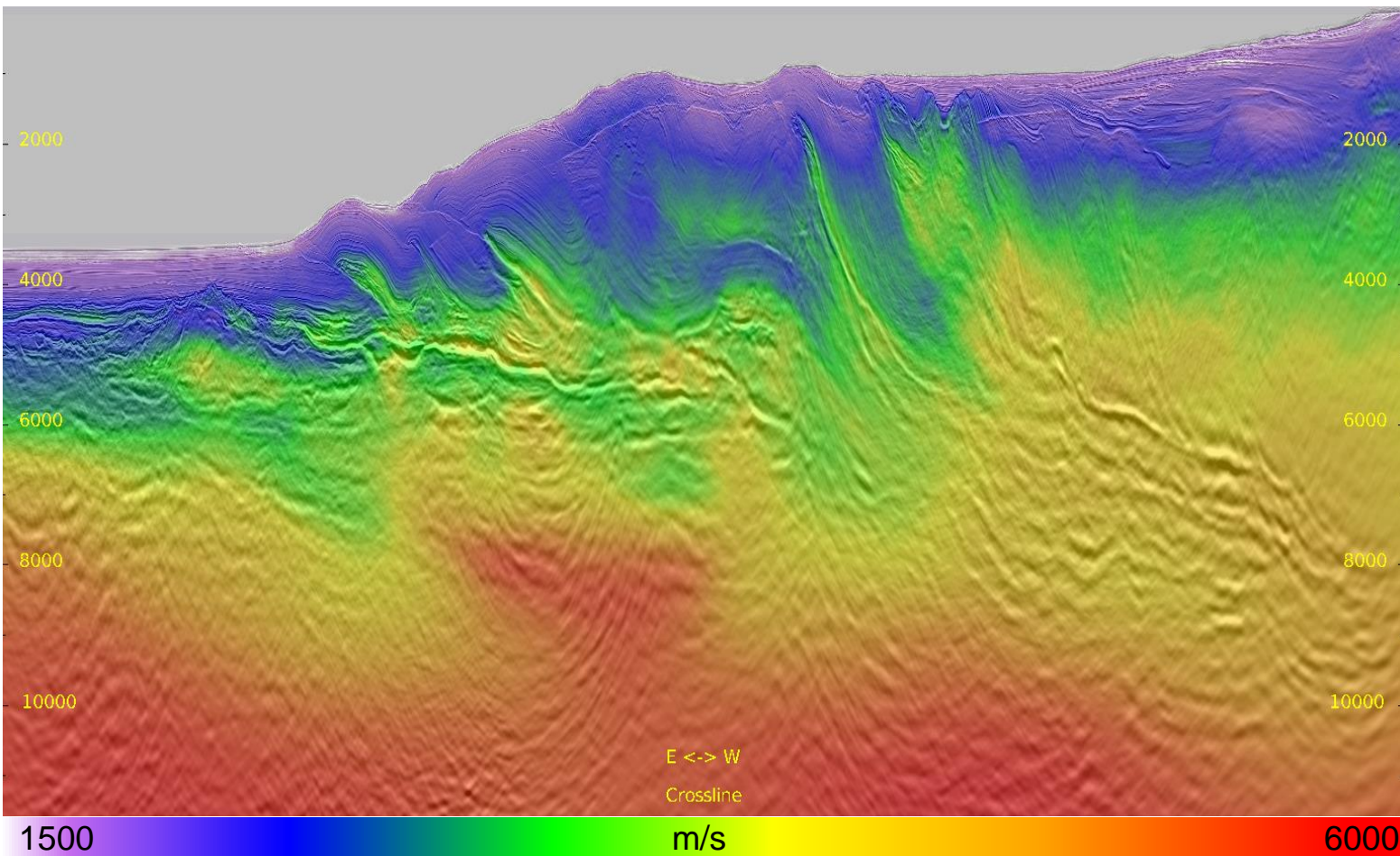
- **Observation and Recommendation:**

The flatness of the gathers are improved. And events on stack have better focus and continuity. We'll further update the deep velocity.



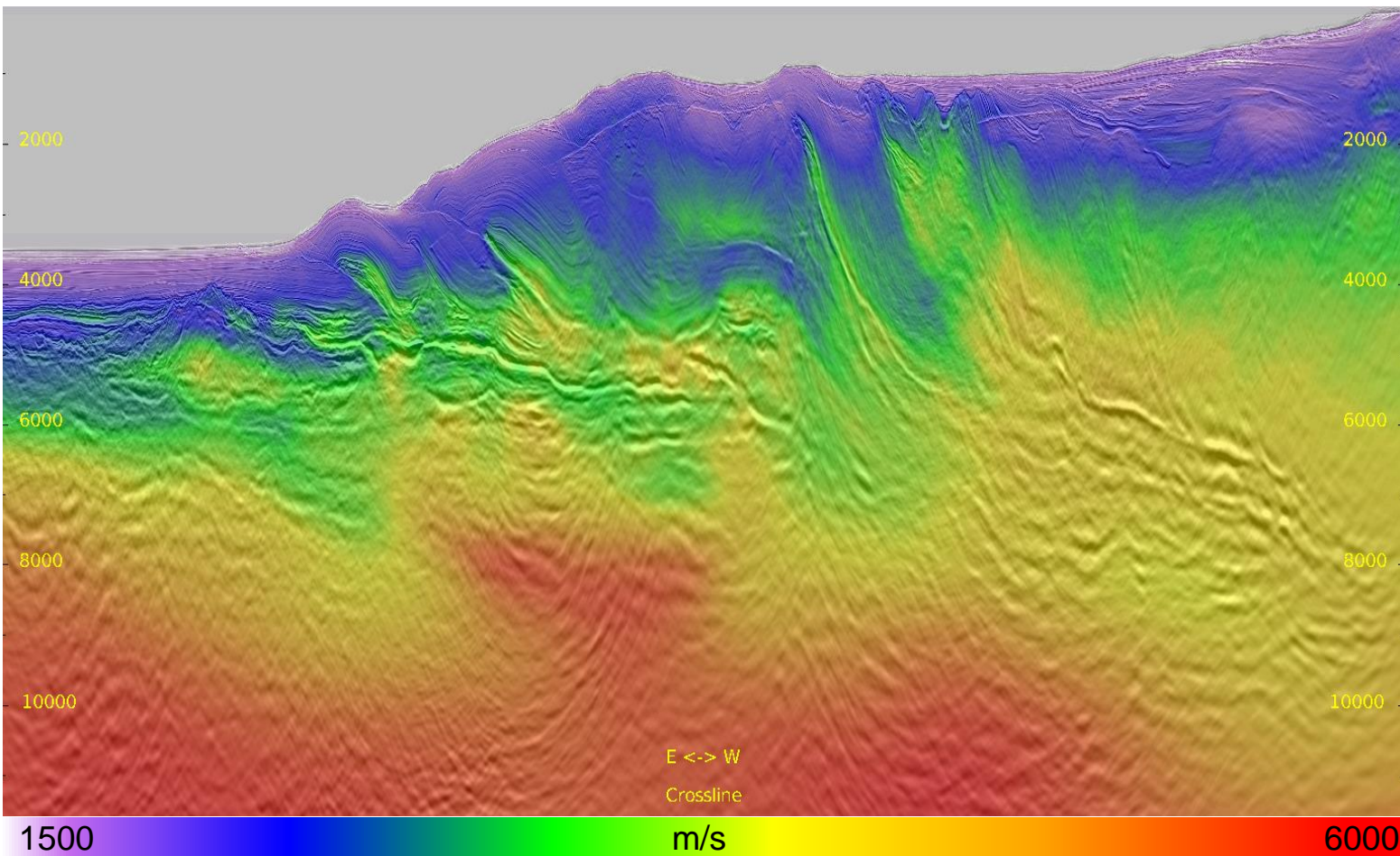
# Velocity Model





- IT4 velocity

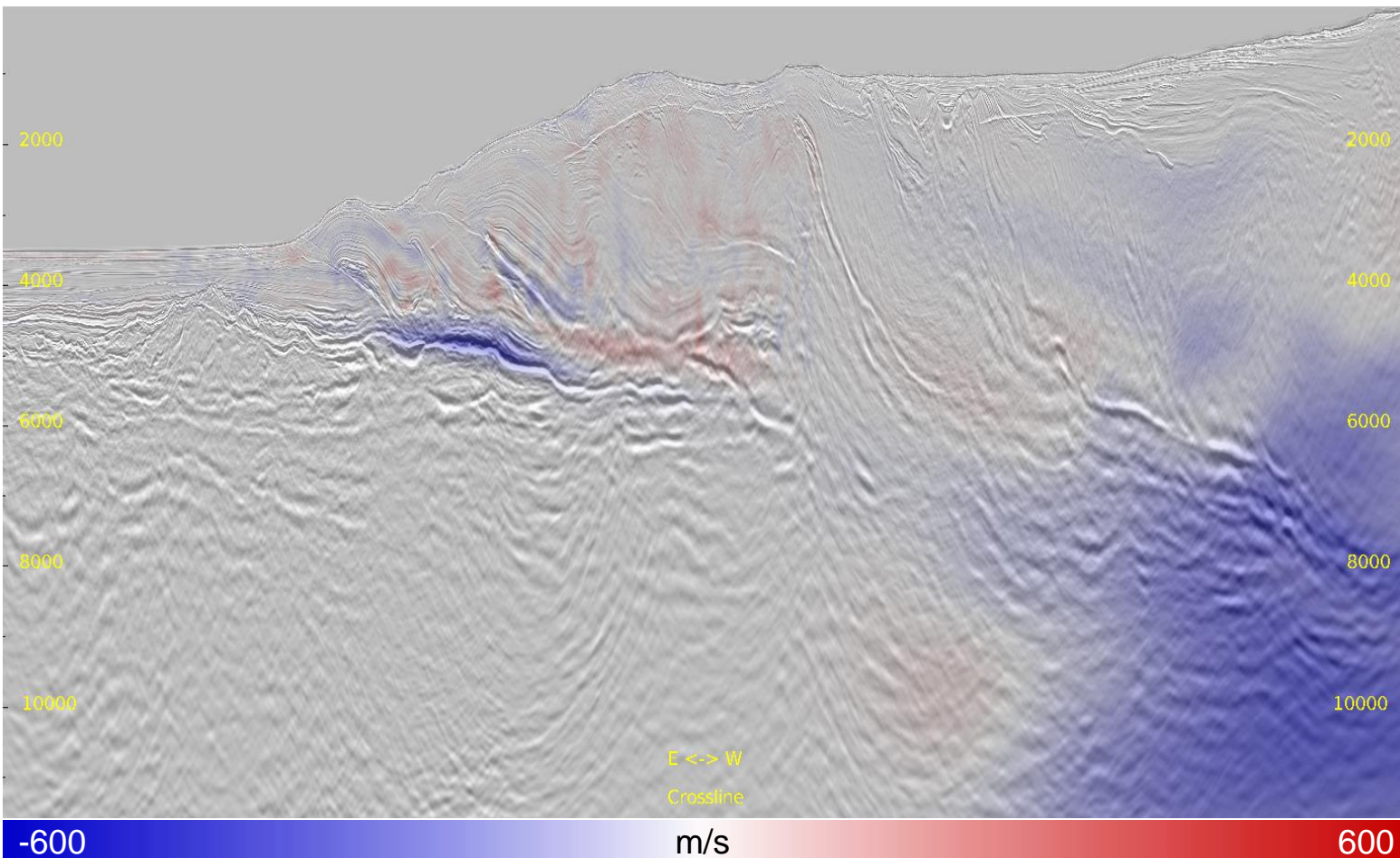




- IT5 preliminary velocity

# Inline 436: Velocity Perturbation

6



- High resolution tomography result on the east side.
- Smoothed update on the west side.

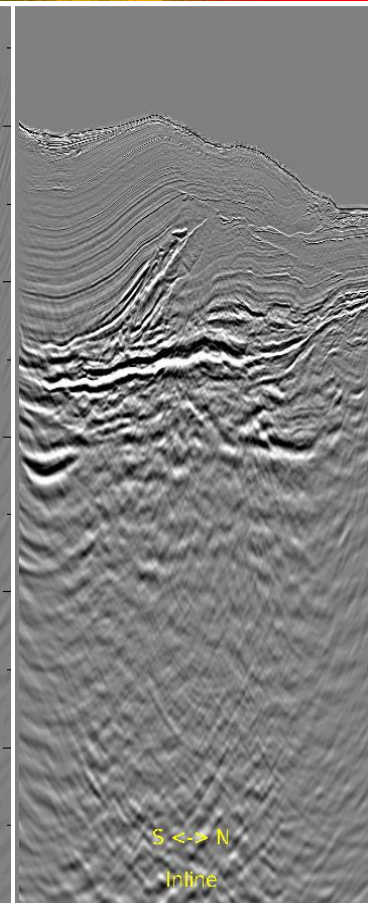
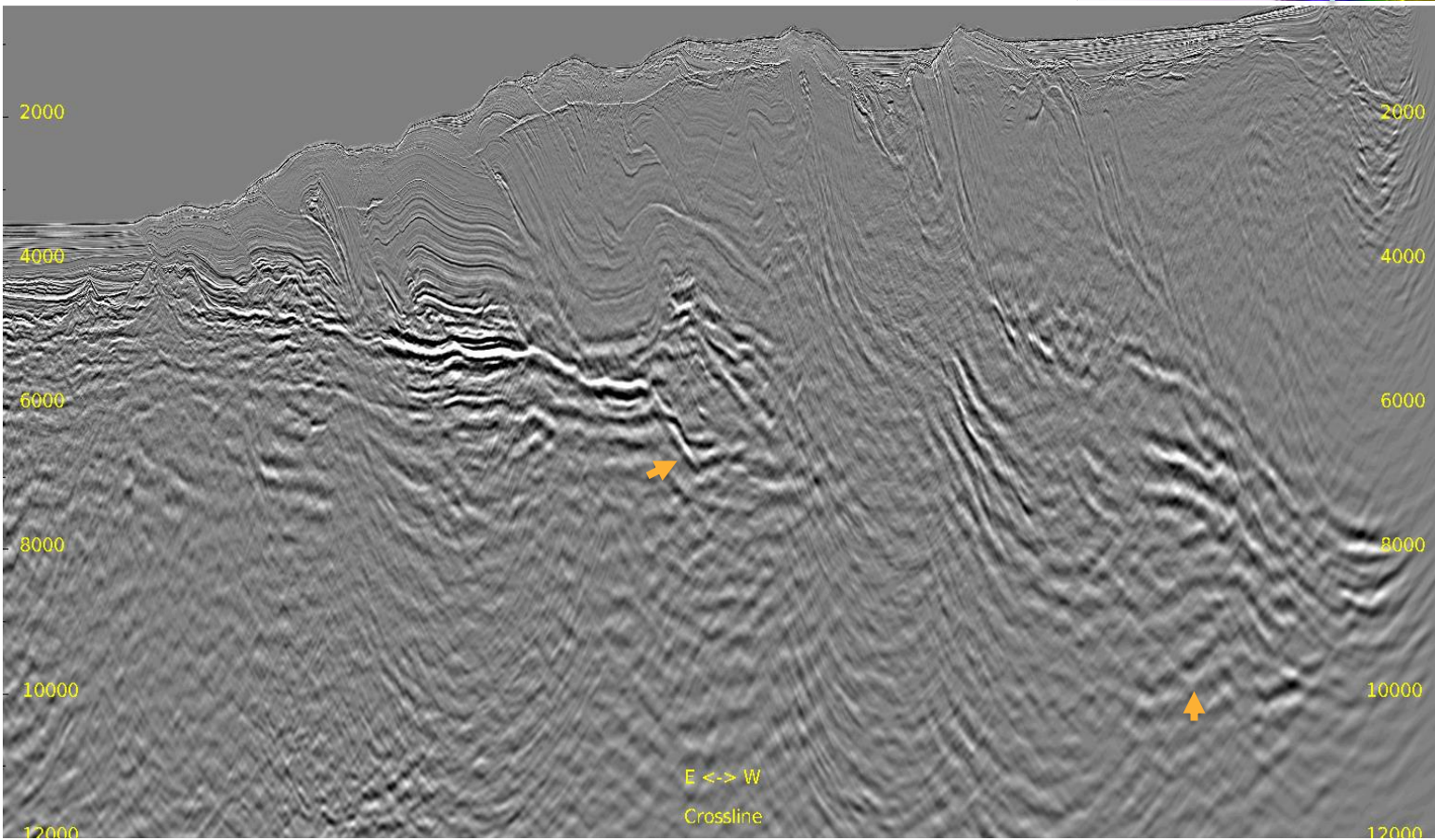
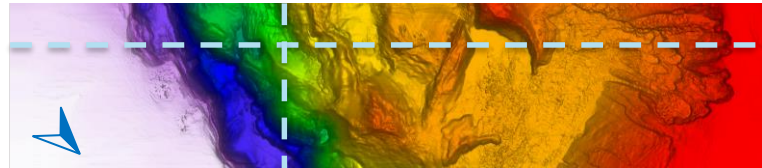


# Kirchhoff Depth Migration



# Full Stack: IT4 Result

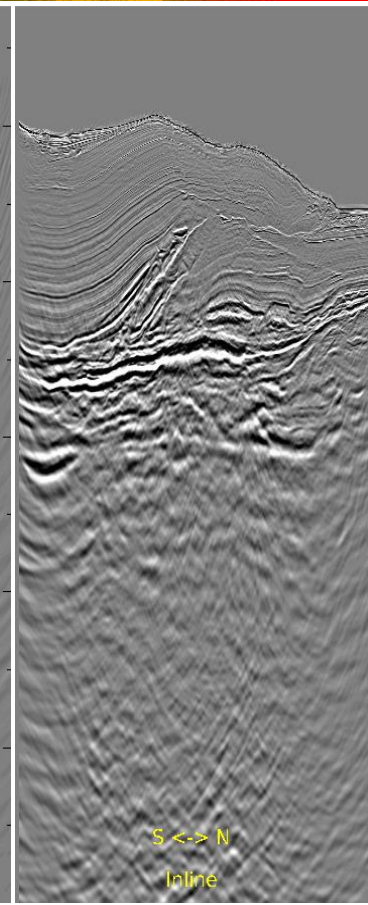
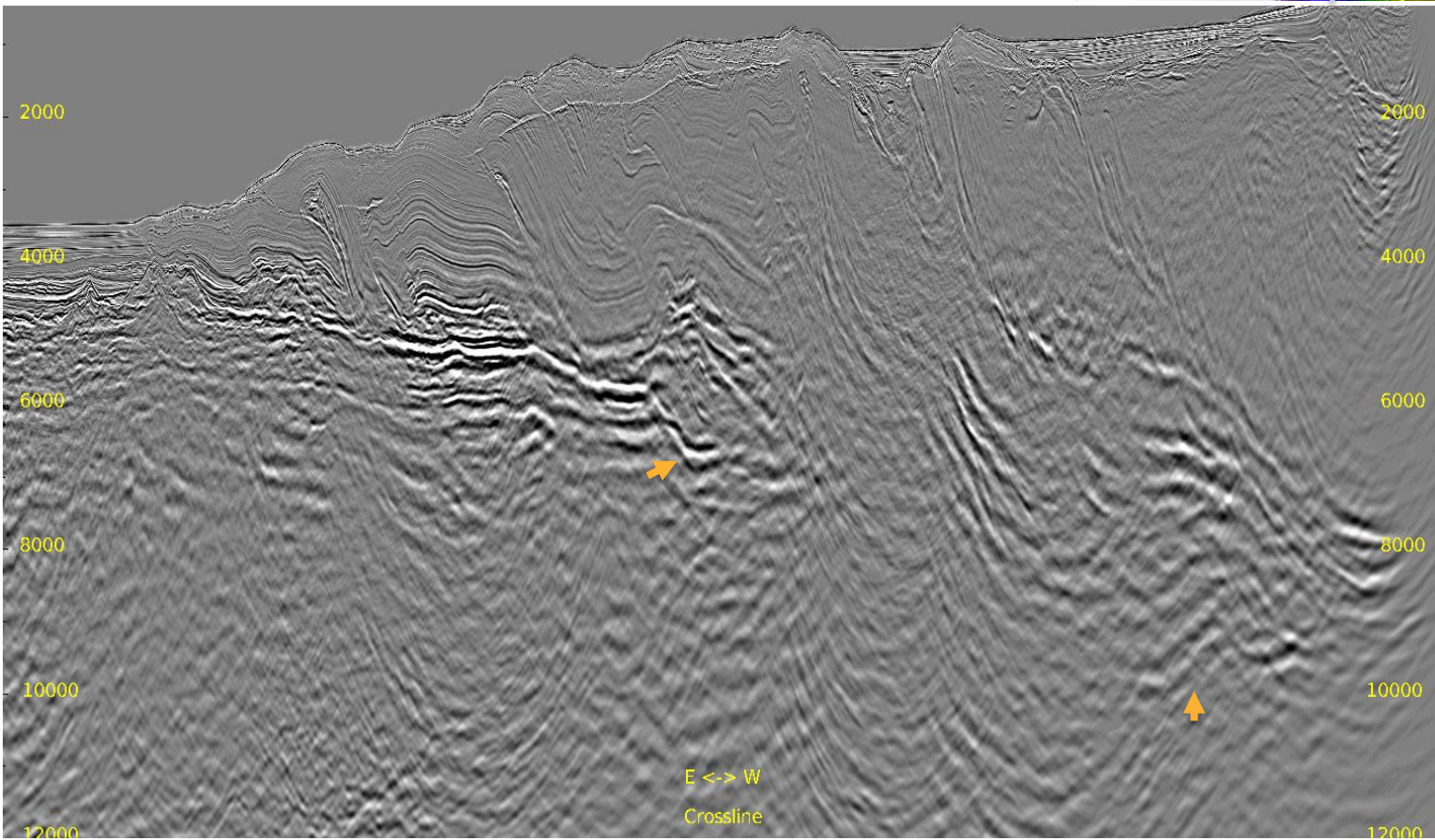
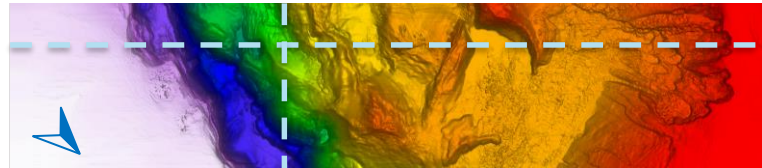
Inline 236 & Crossline 2050





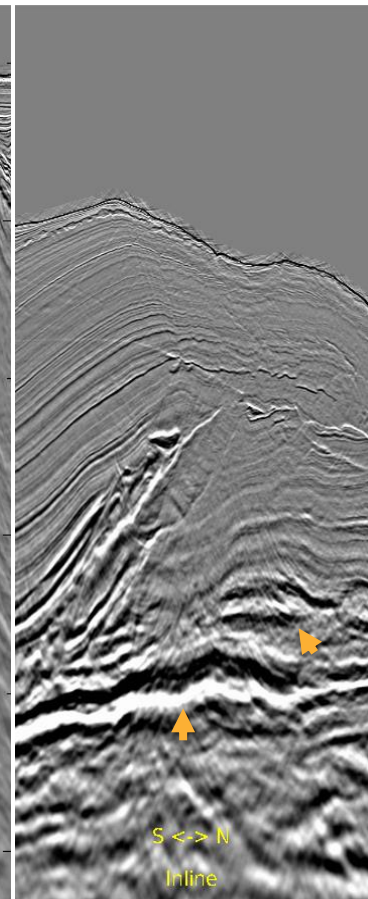
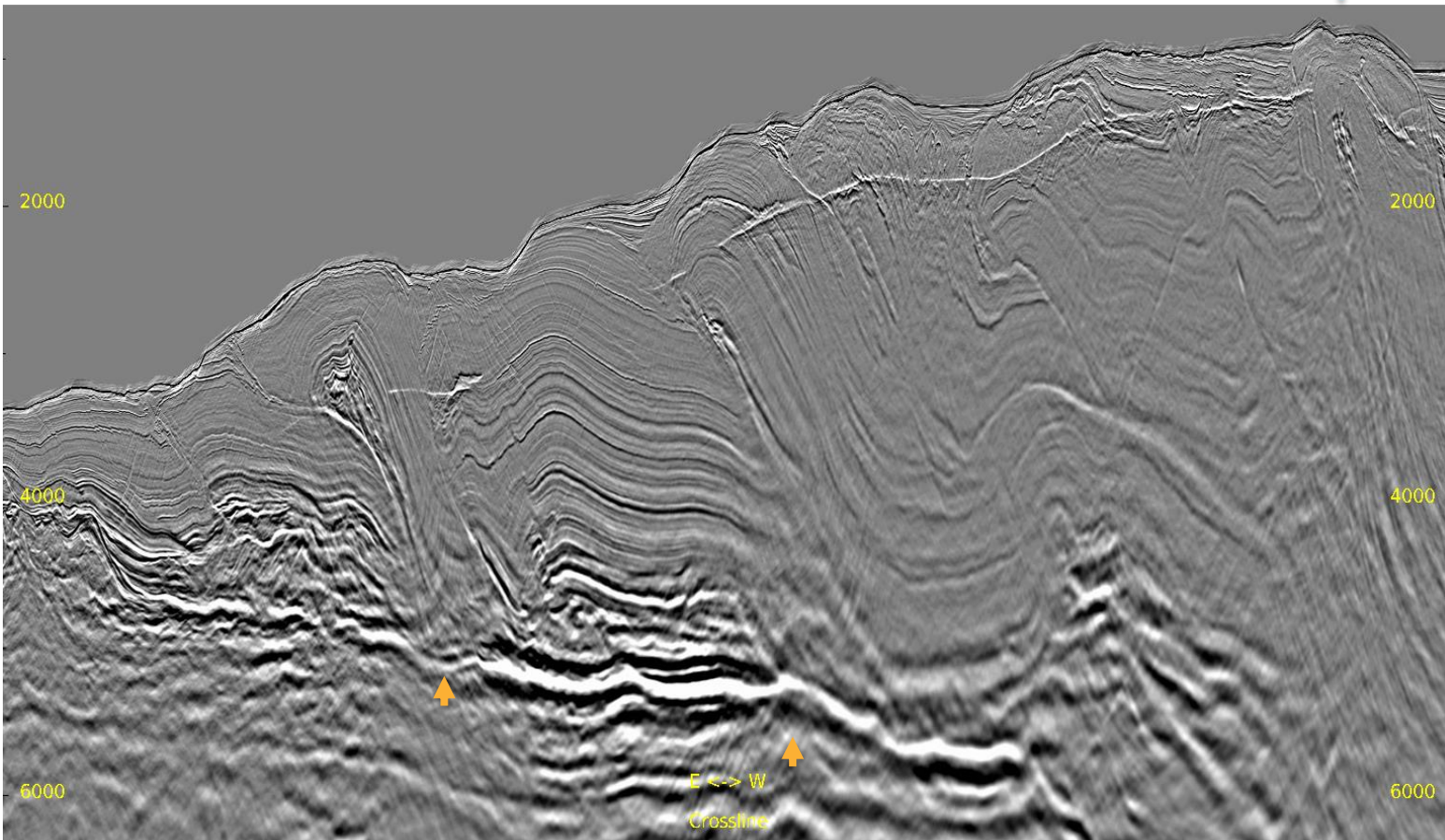
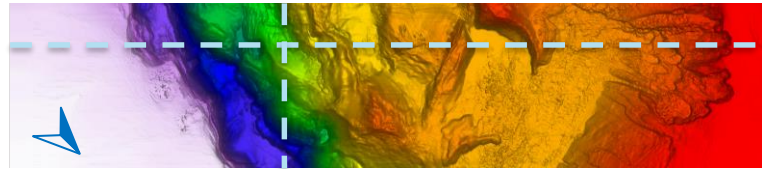
# Full Stack: Current Result

Inline 236 & Crossline 2050



# Zoomed Full Stack: IT4 Result

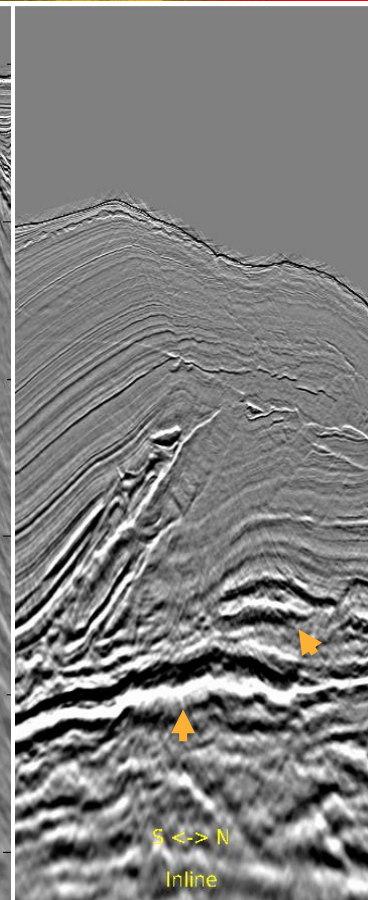
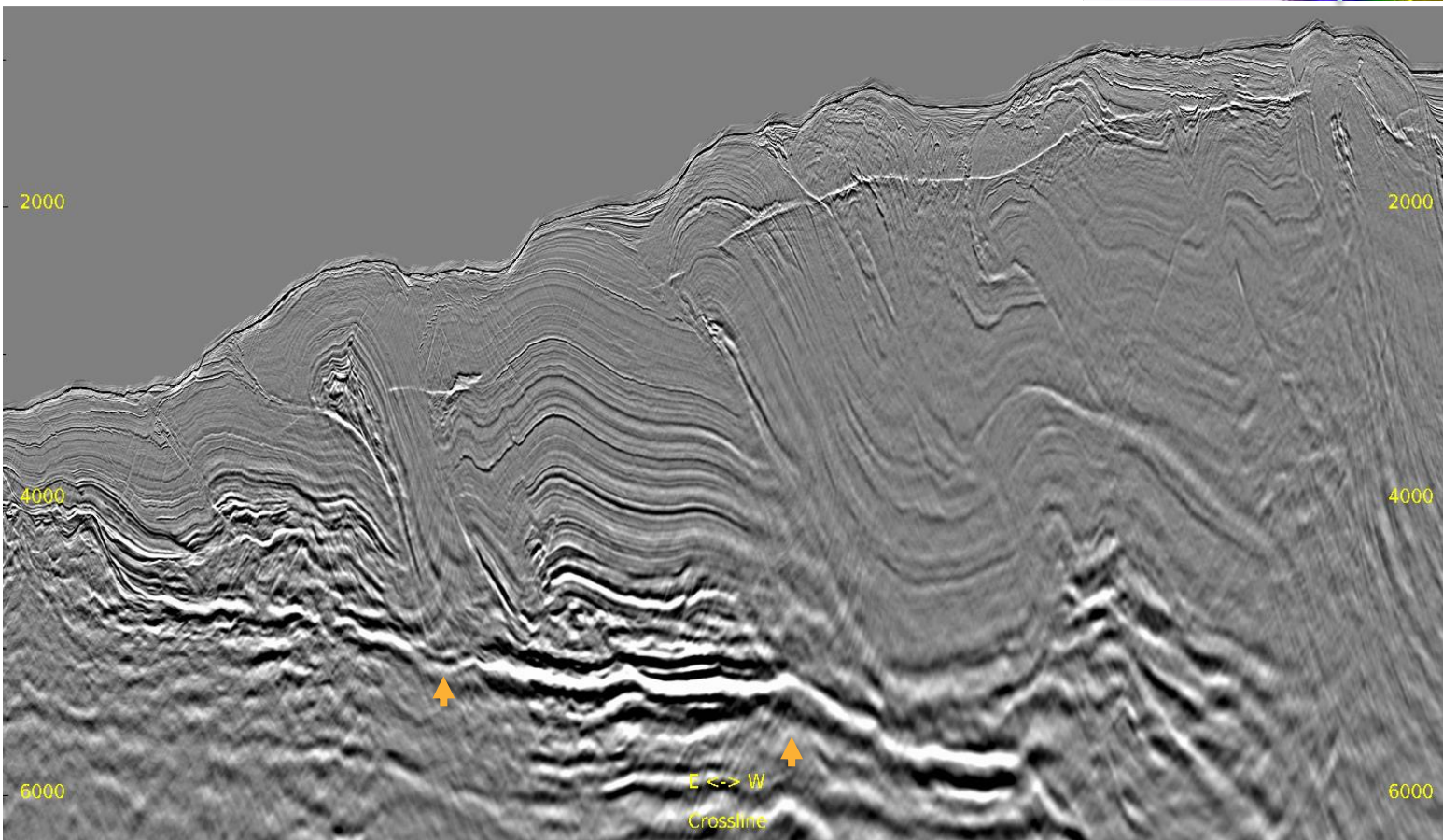
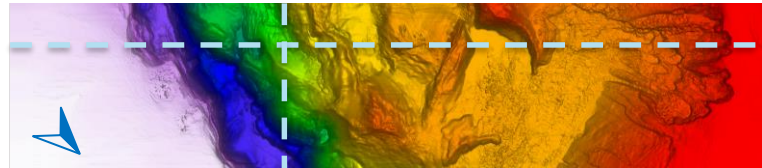
Inline 236 & Crossline 2050

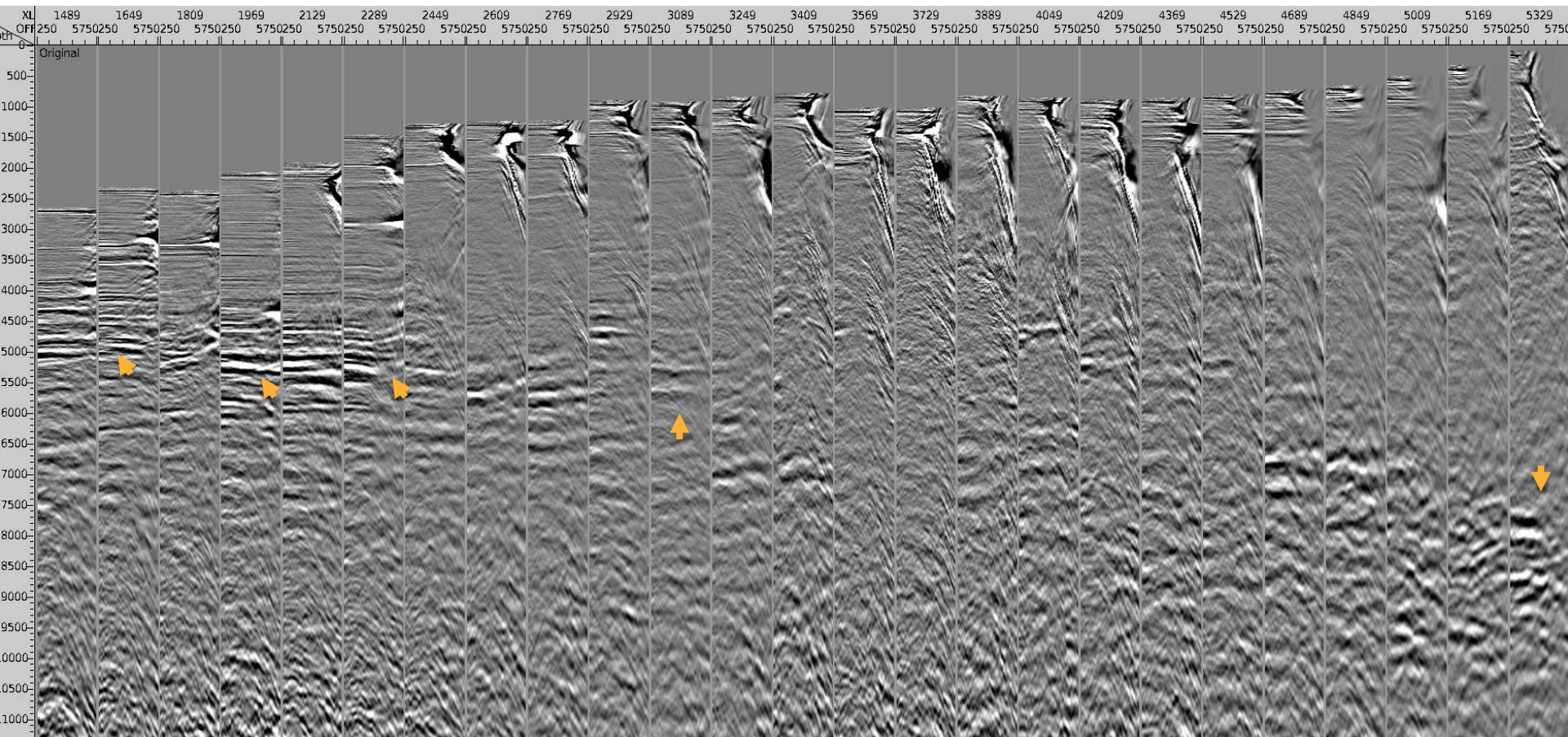




# Zoomed Full Stack: Current Result

Inline 236 & Crossline 2050





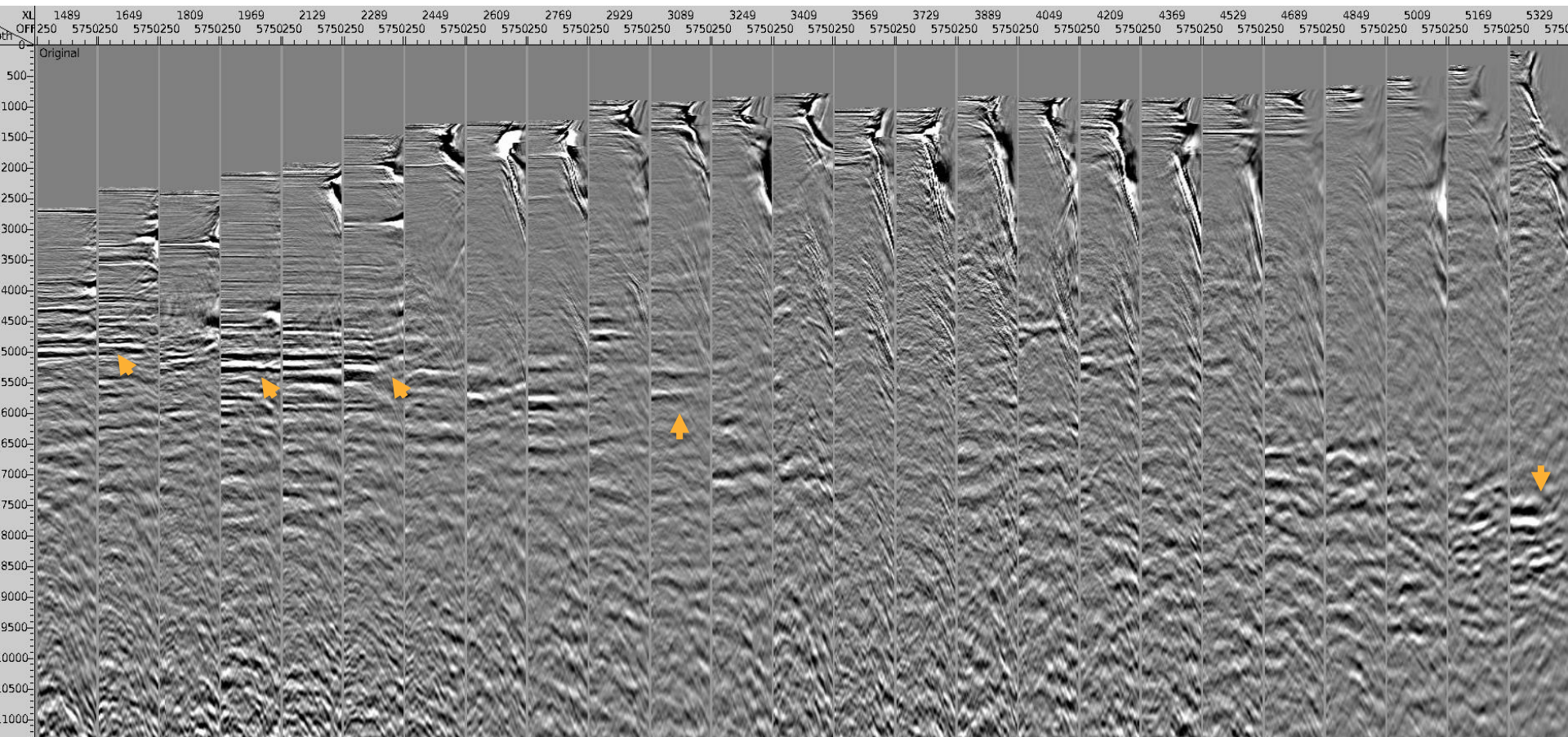




# Inline 236 CDP Gathers: Current Result

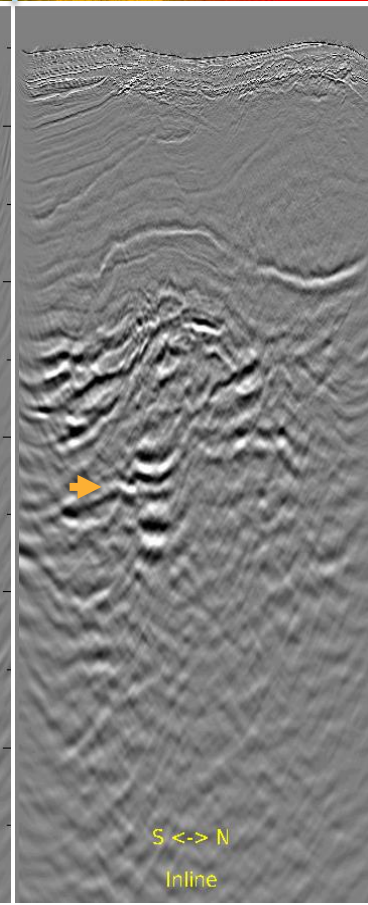
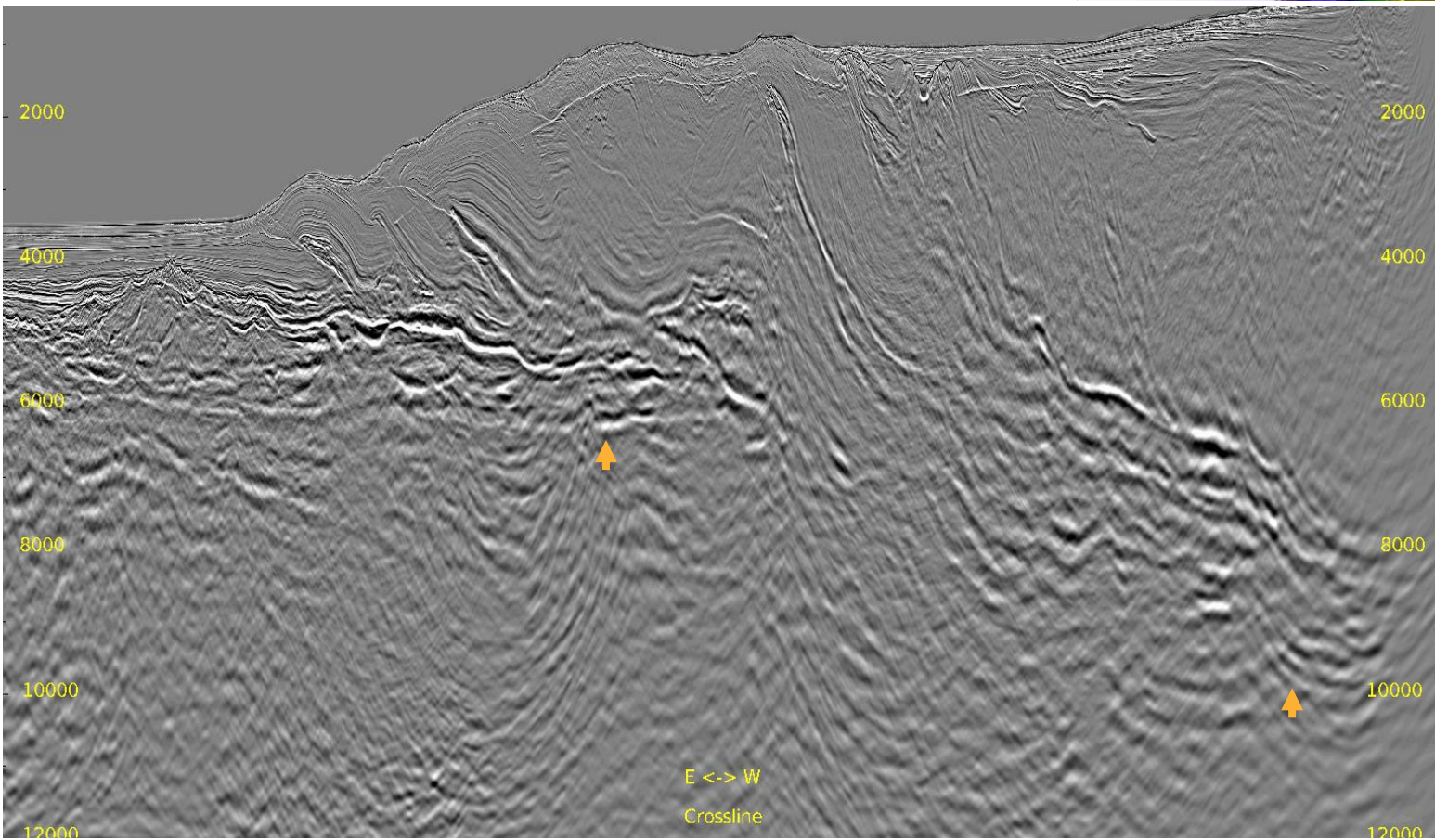
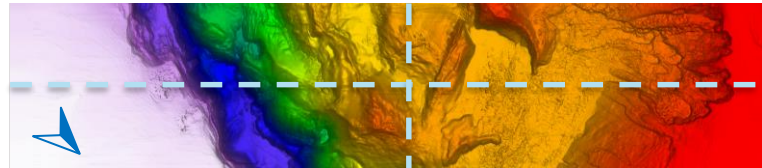
— 35° Mute

13



# Full Stack: IT4 Result

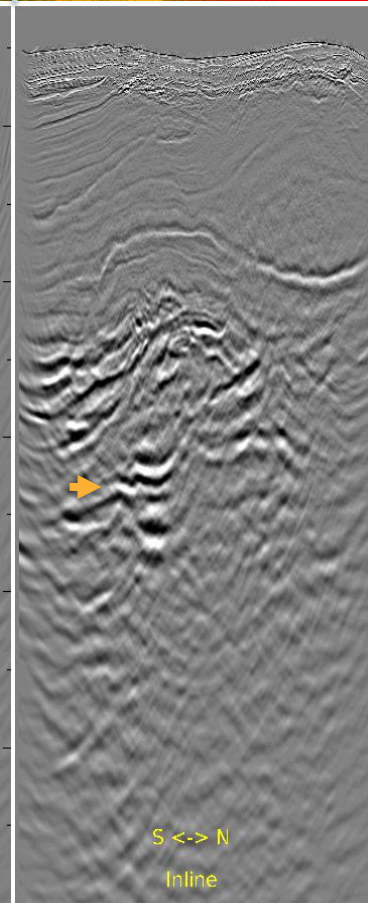
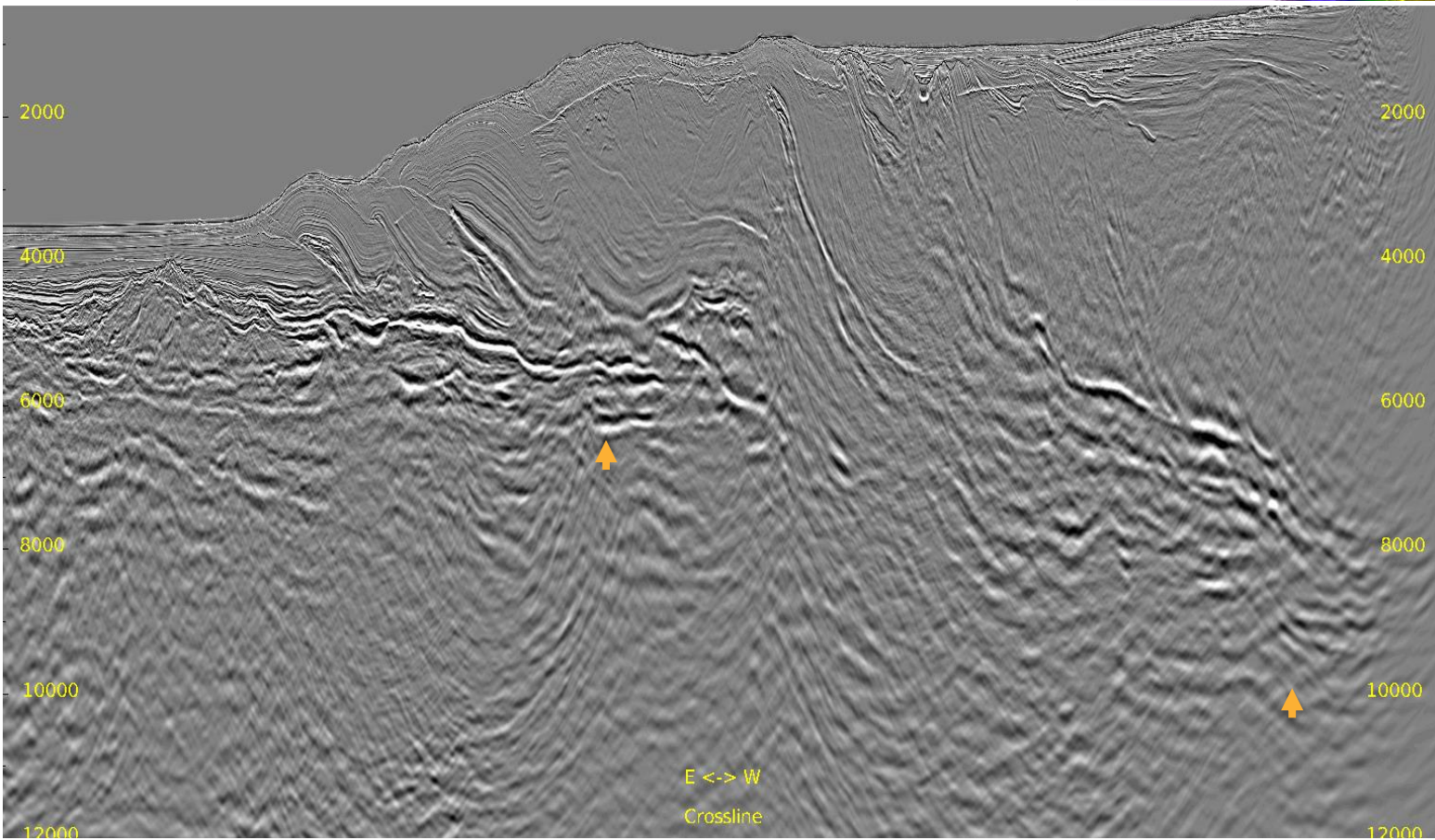
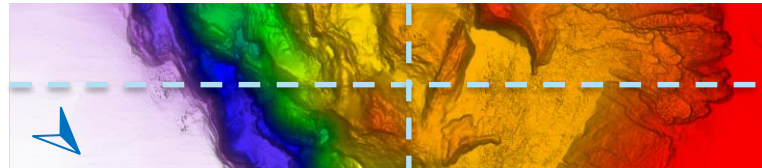
Inline 436 & Crossline 3040





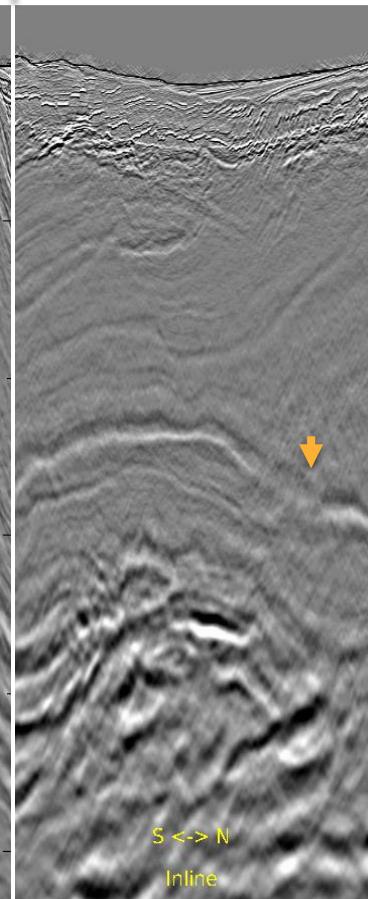
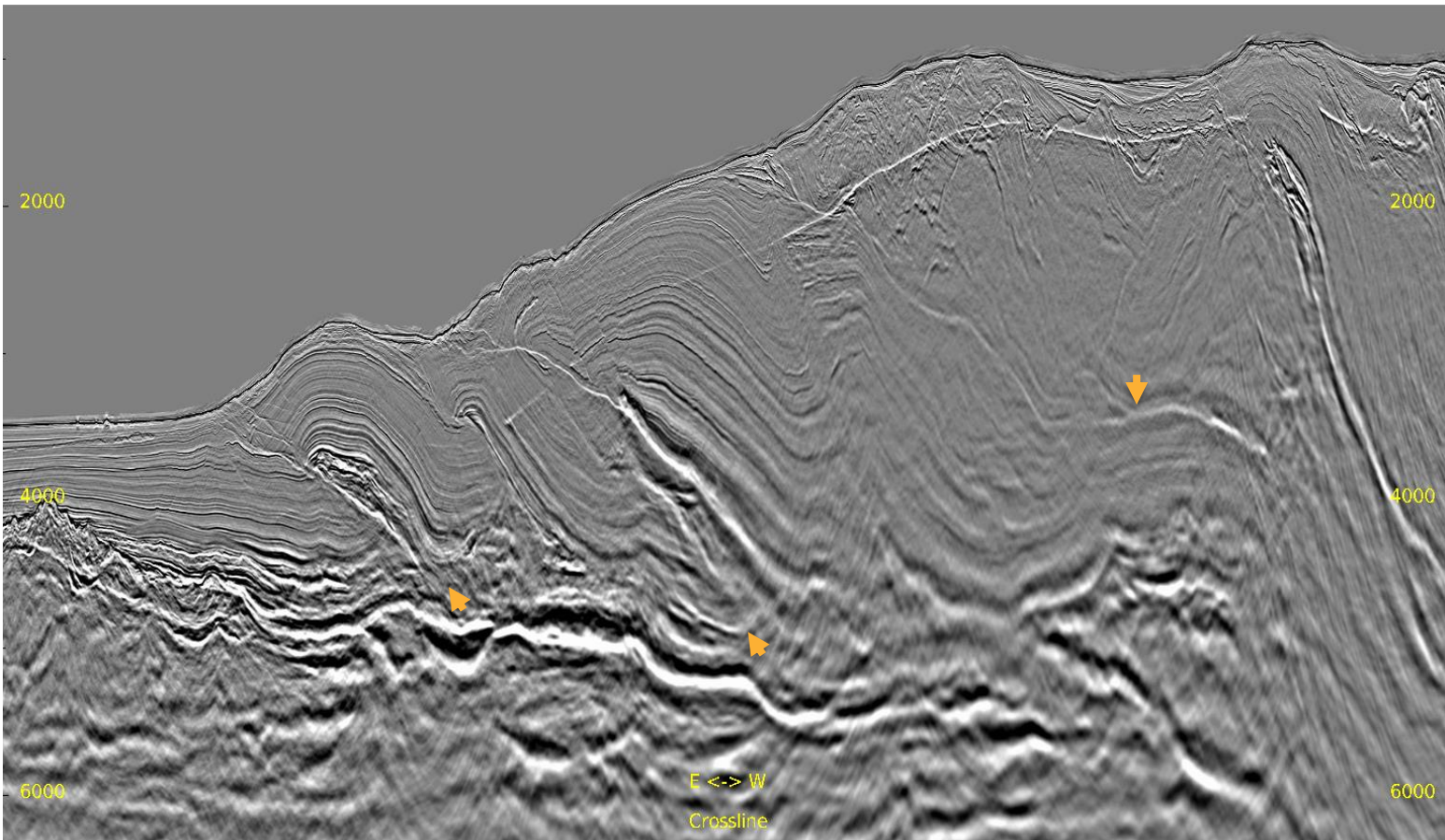
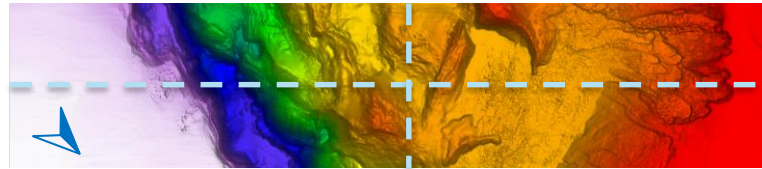
# Full Stack: Current Result

Inline 436 & Crossline 3040



# Zoomed Full Stack: IT4 Result

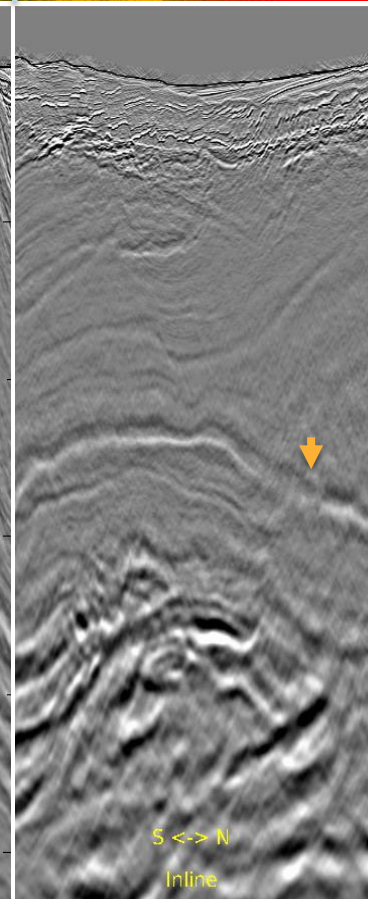
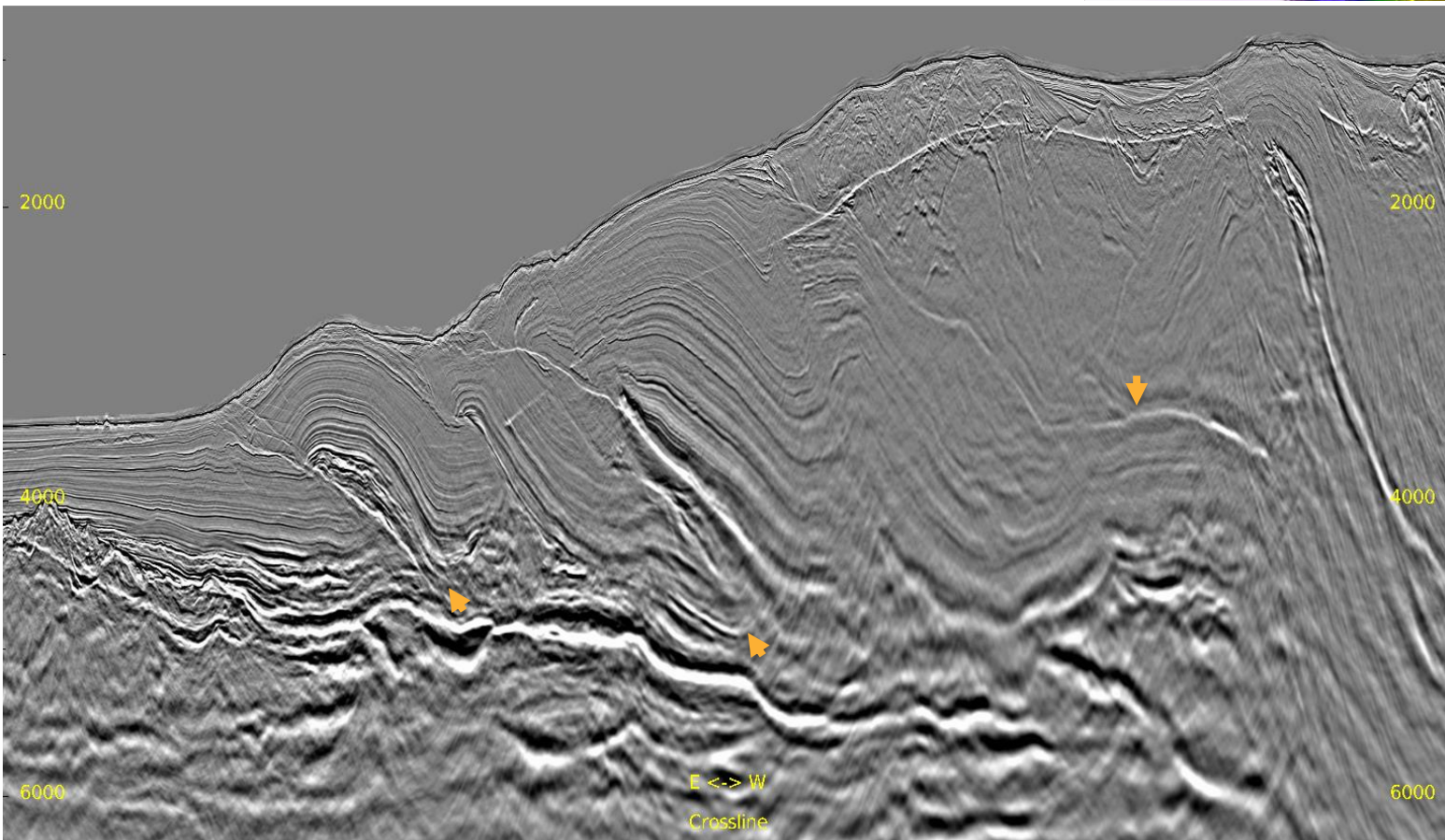
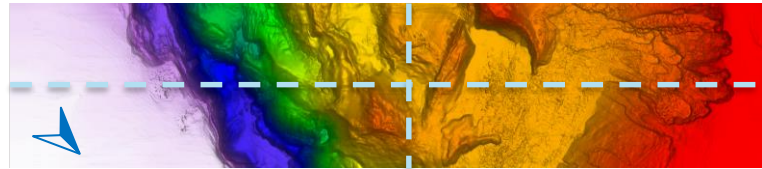
Inline 436 & Crossline 3040

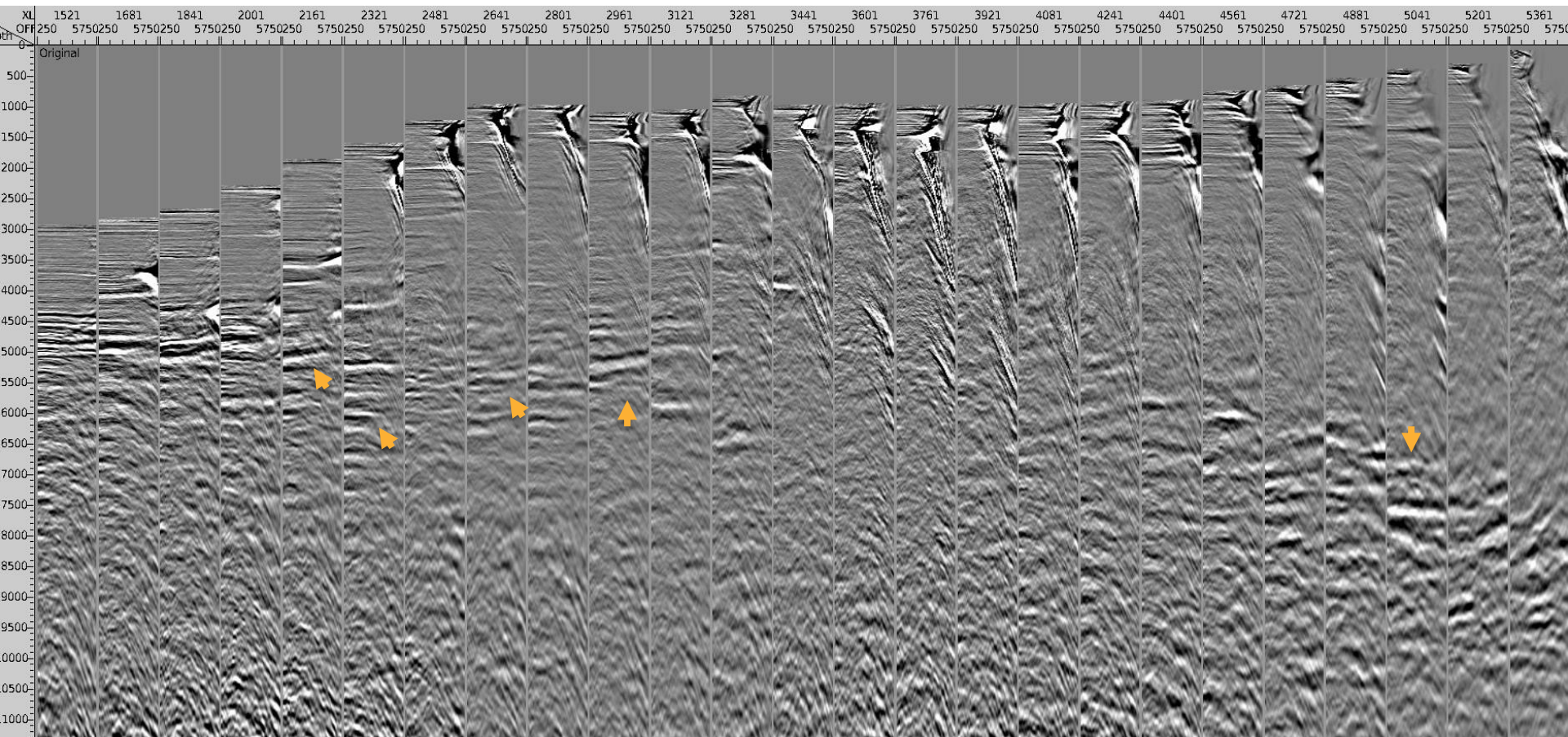




# Zoomed Full Stack: Current Result

Inline 436 & Crossline 3040





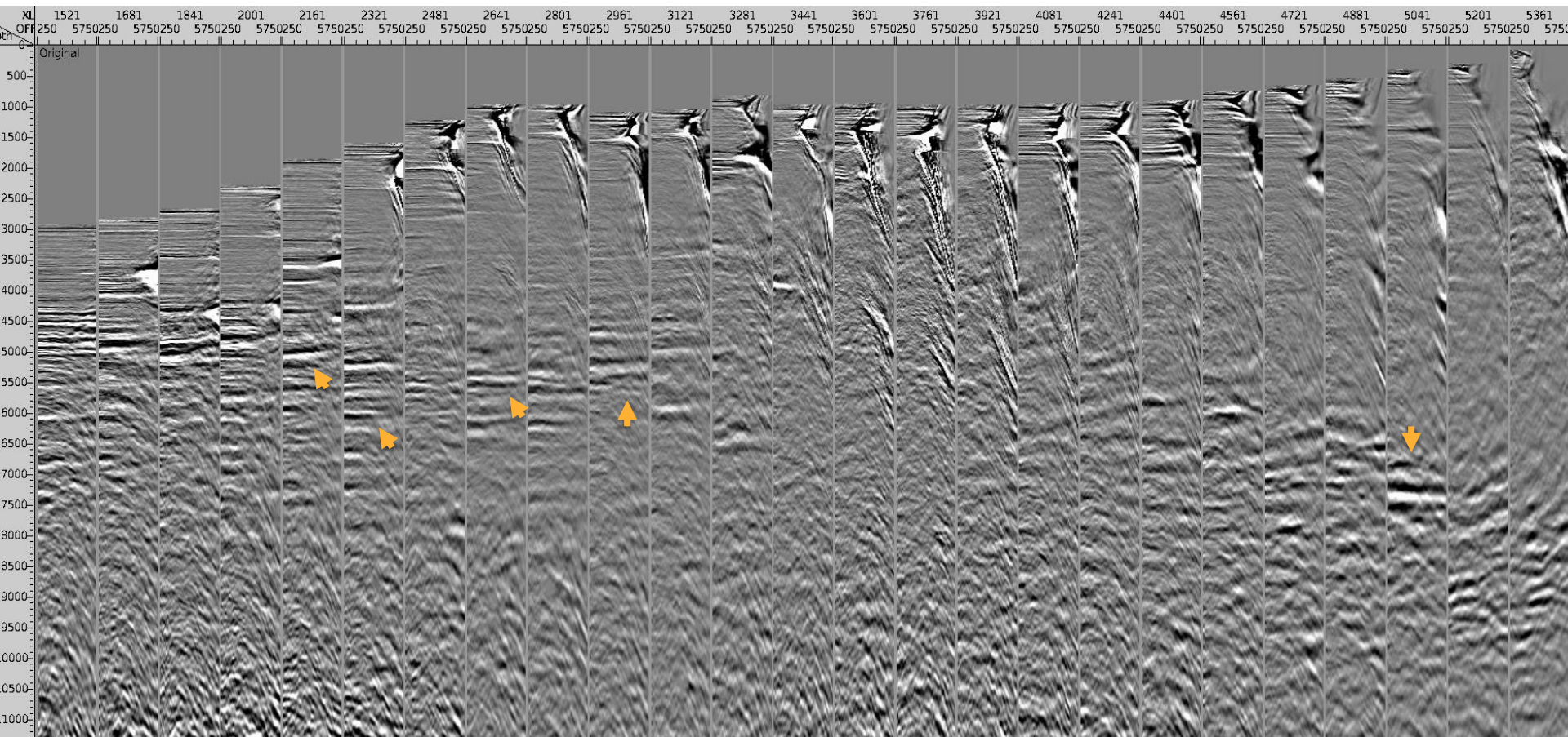




# Inline 436 CDP Gathers: Current Result

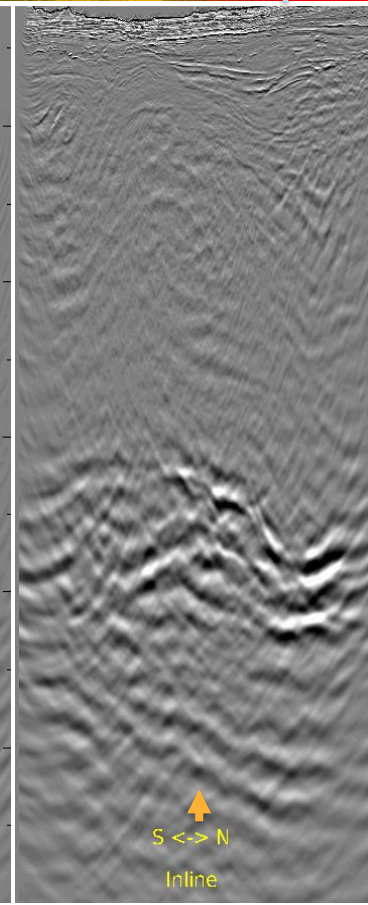
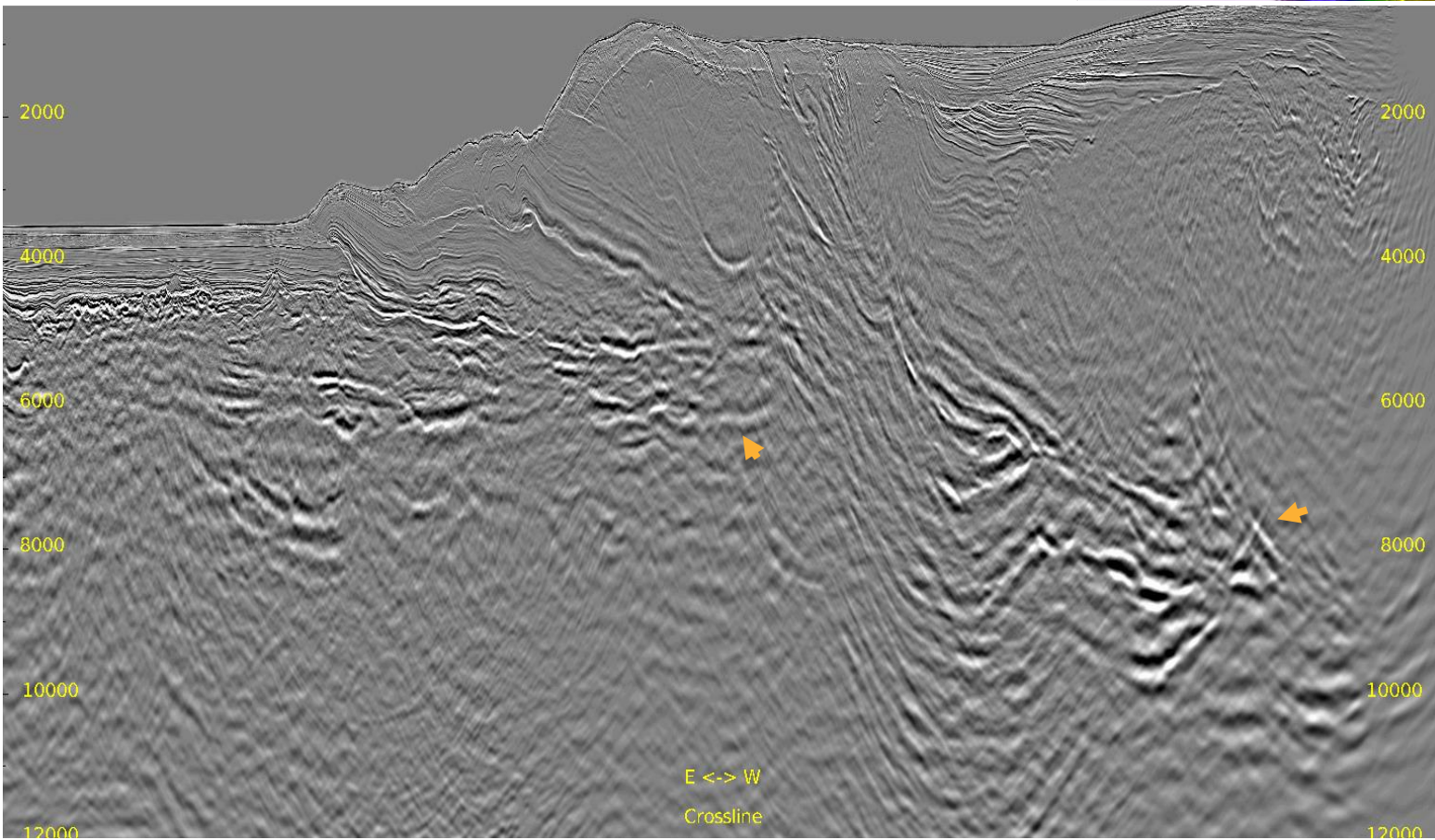
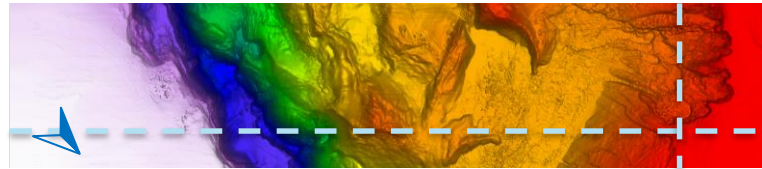
— 35° Mute

19



# Full Stack: IT4 Result

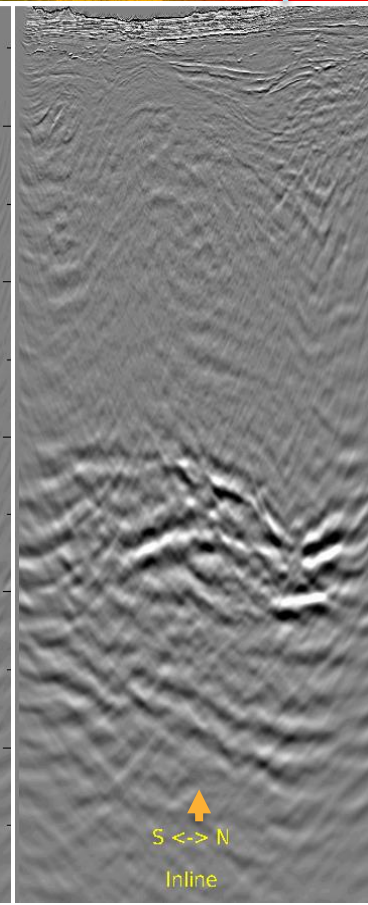
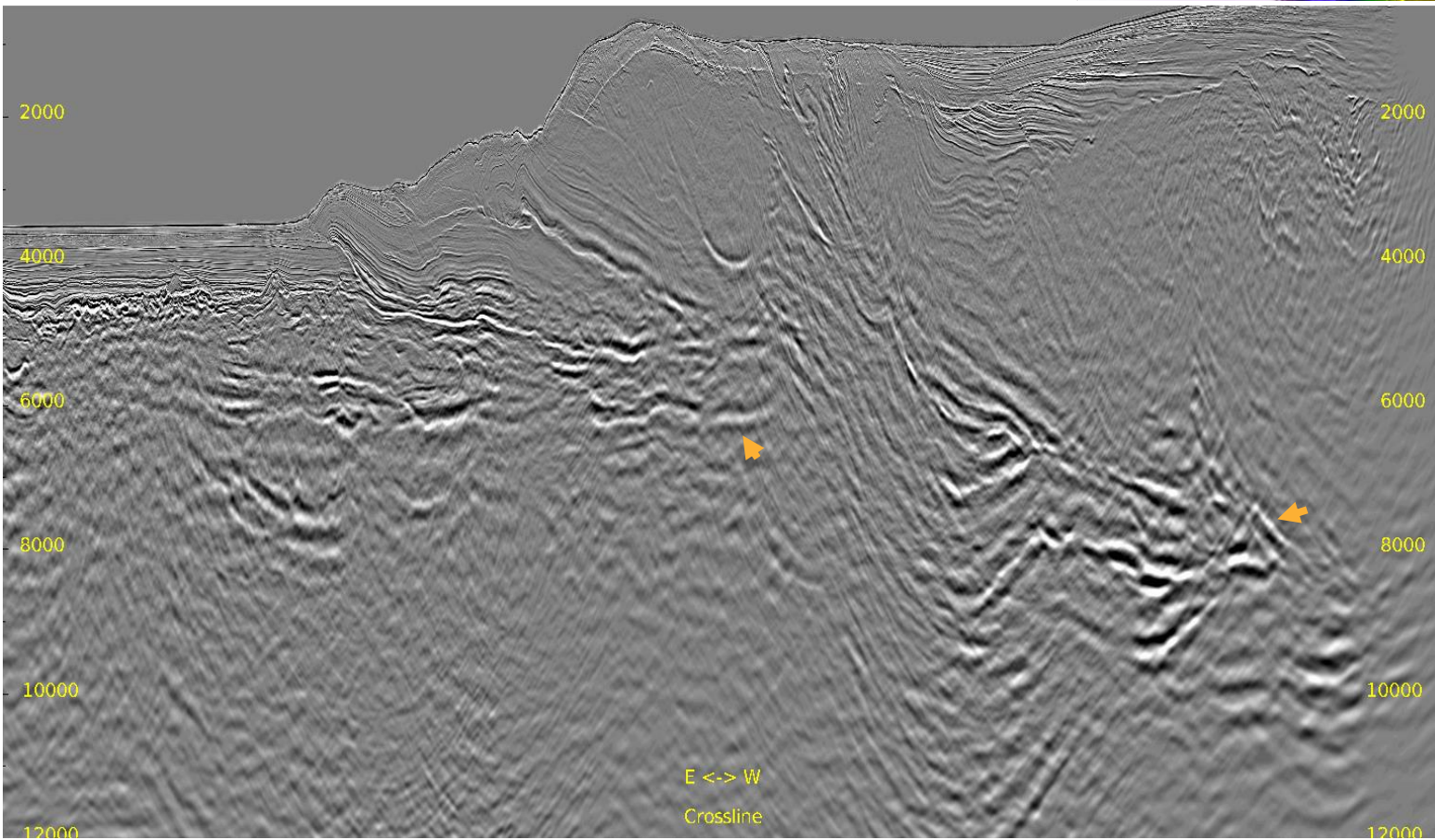
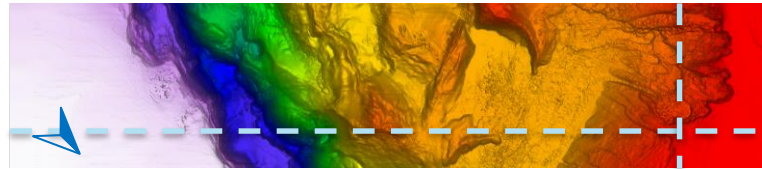
Inline 636 & Crossline 4947





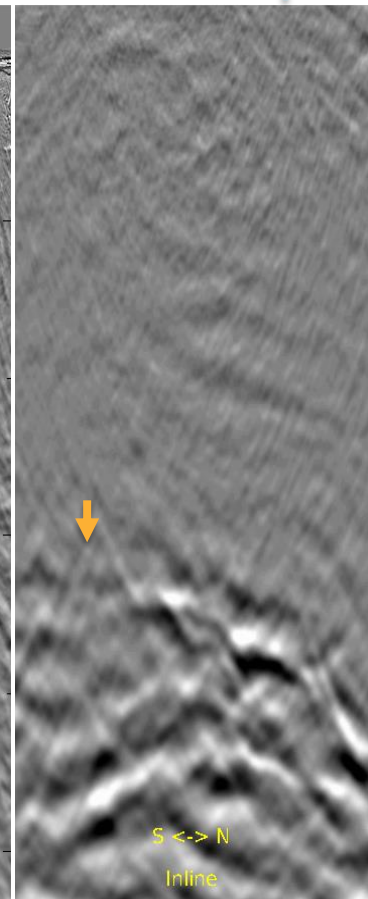
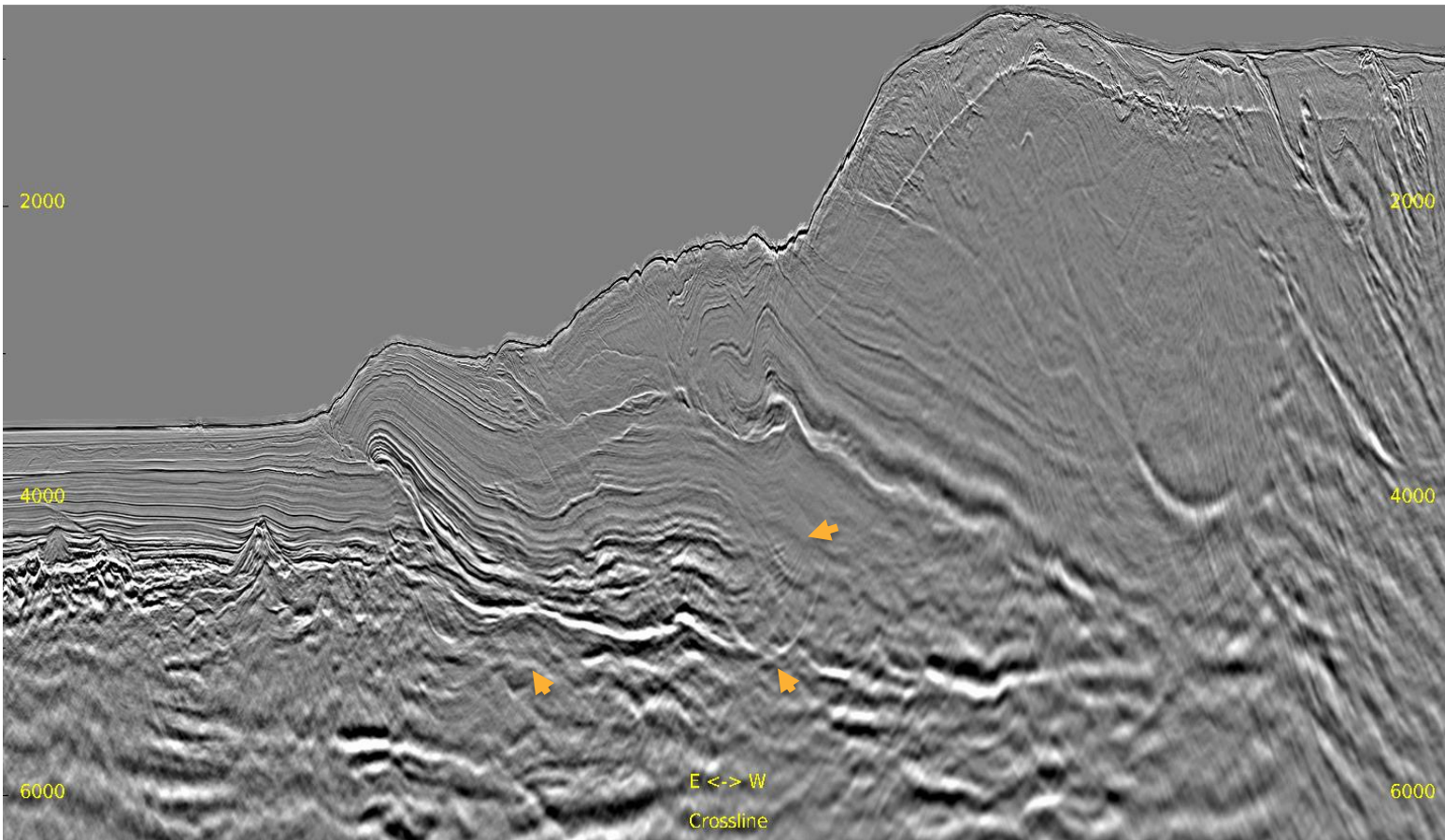
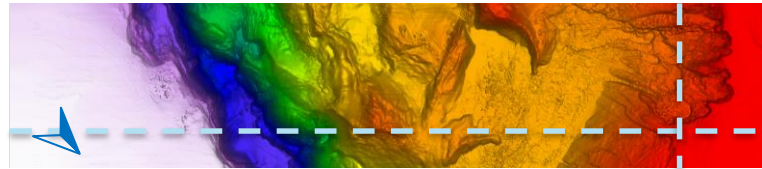
# Full Stack: Current Result

Inline 636 & Crossline 4947



# Zoomed Full Stack: IT4 Result

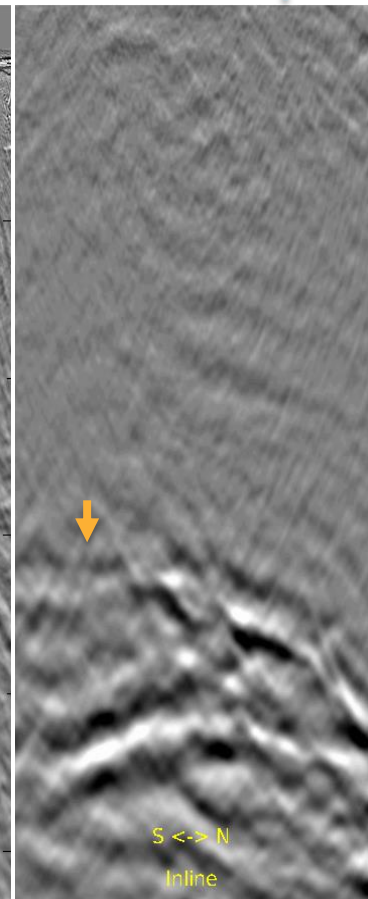
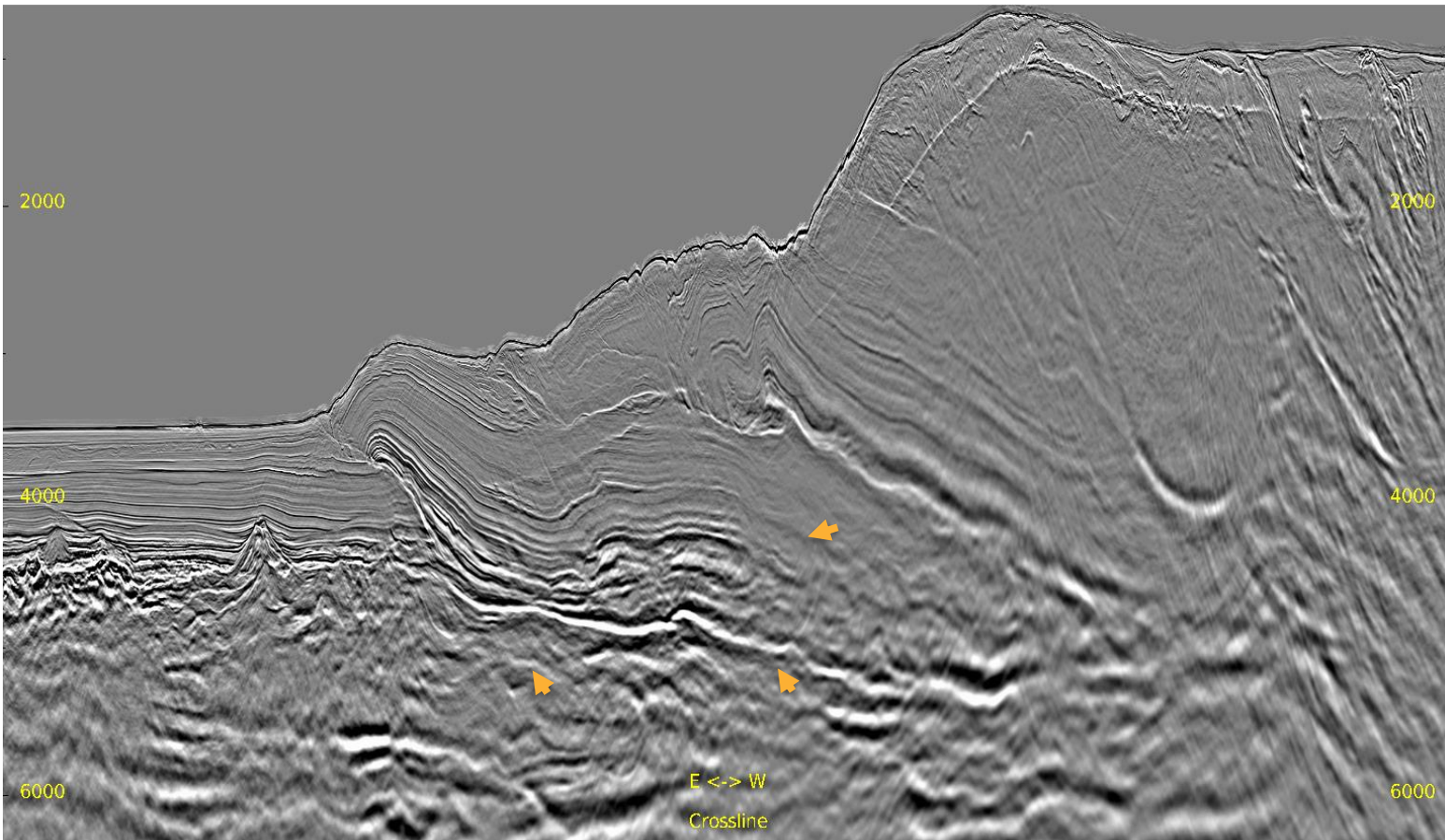
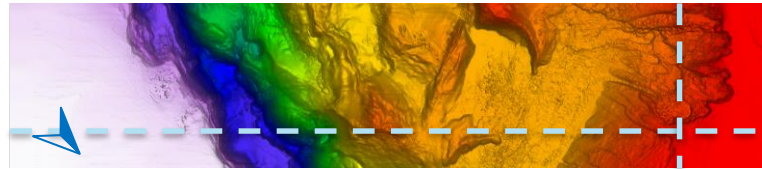
Inline 636 & Crossline 4947

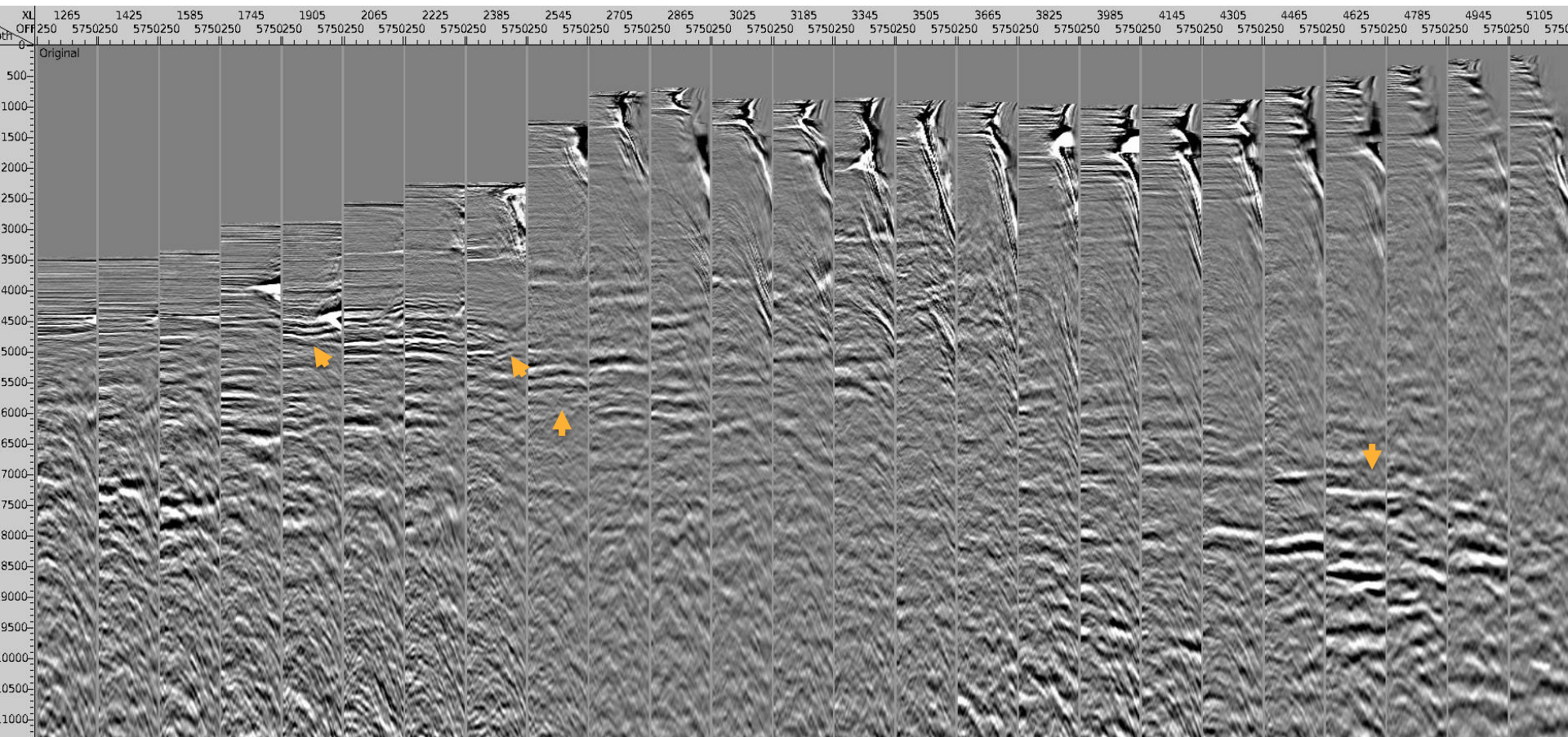




# Zoomed Full Stack: Current Result

Inline 636 & Crossline 4947











# IT5 – Part 2

## NZ 3D Processing

*21 April 2021*

[cgg.com](http://cgg.com)



INSTITUTE FOR GEOPHYSICS



Passion for Geoscience



- **Objective:**

To further improve deep velocity, especially in the middle and west part.

- **Procedure:**

Following the previous velocity update, scanning tomography is applied on the east side and deep section. Further high resolution tomography is applied to localized area to fine tune the velocity.

- **Display:**

Velocity, migrated depth full stack & gathers.

- **Observation and Recommendation:**

The flatness of the gathers are improved. And events on stack have better focus and continuity. We recommend to use this velocity for final migration.

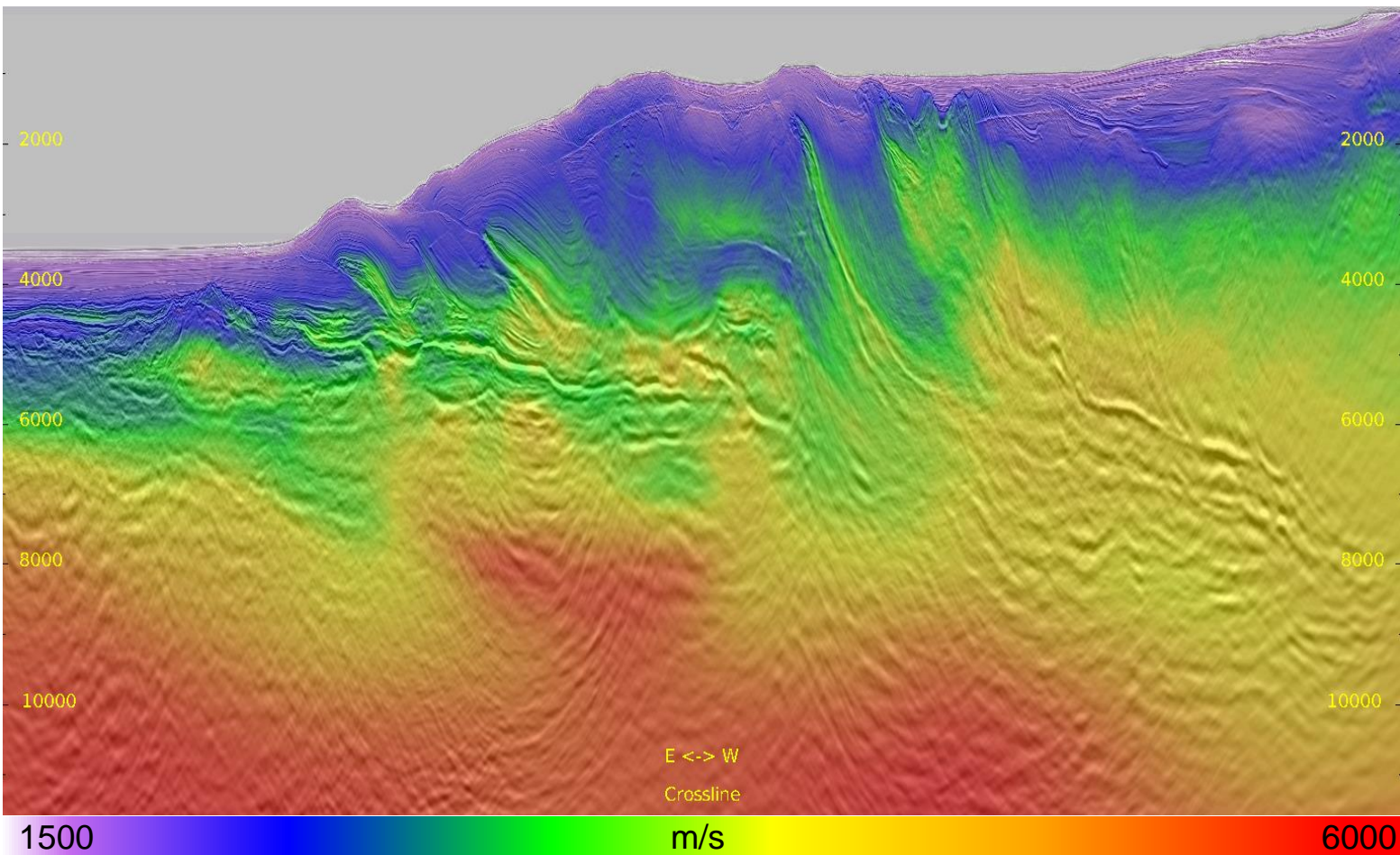
# Velocity Model



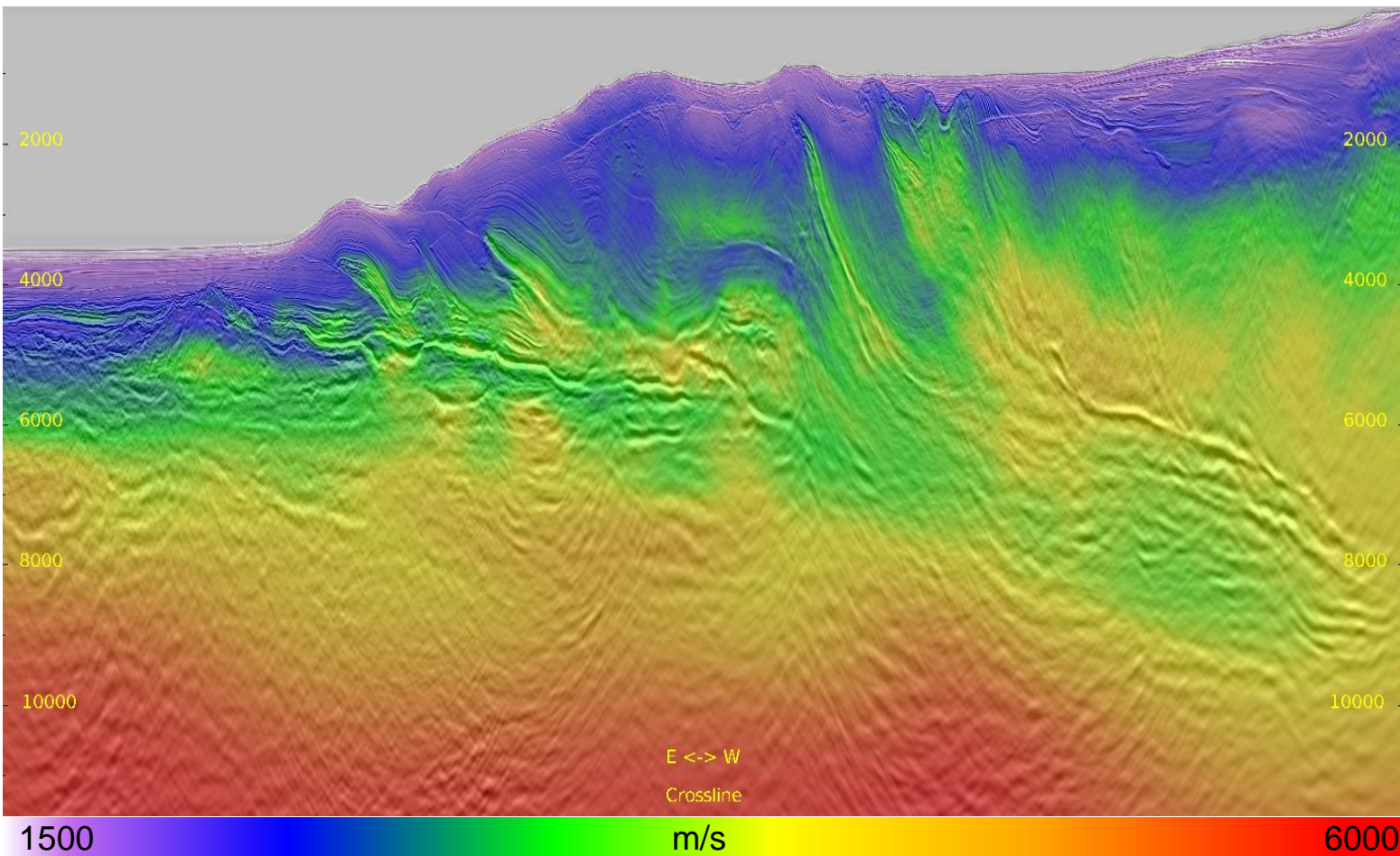


# IT5 Preliminary Velocity

4

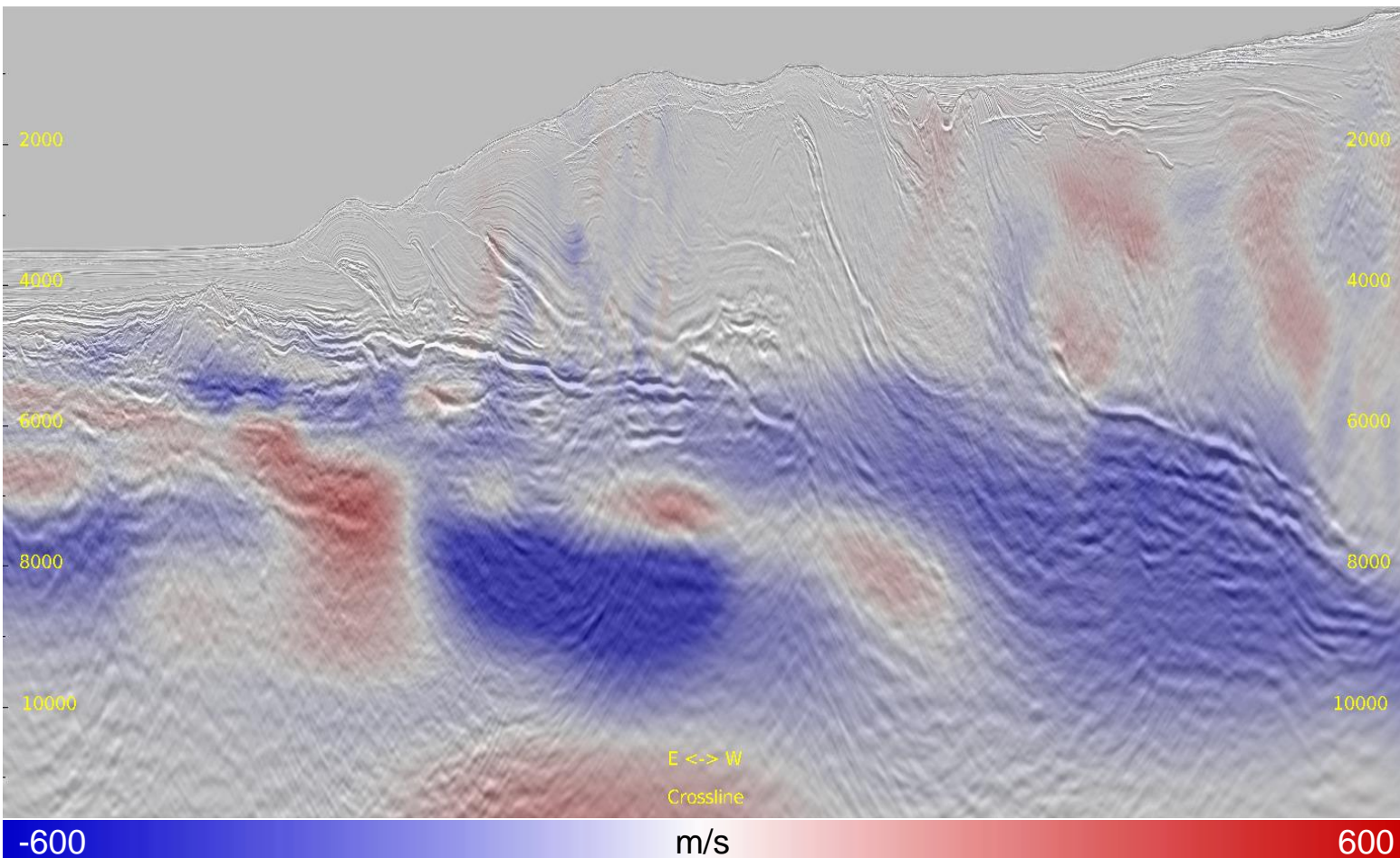


- IT5 preliminary velocity.



- IT5 final velocity.





- Localized update on the east side.
- Smoothed scanning tomography on the west side and deep section.

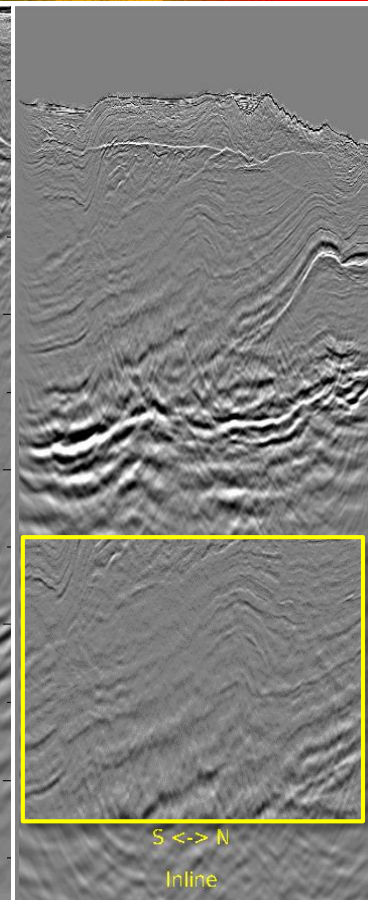
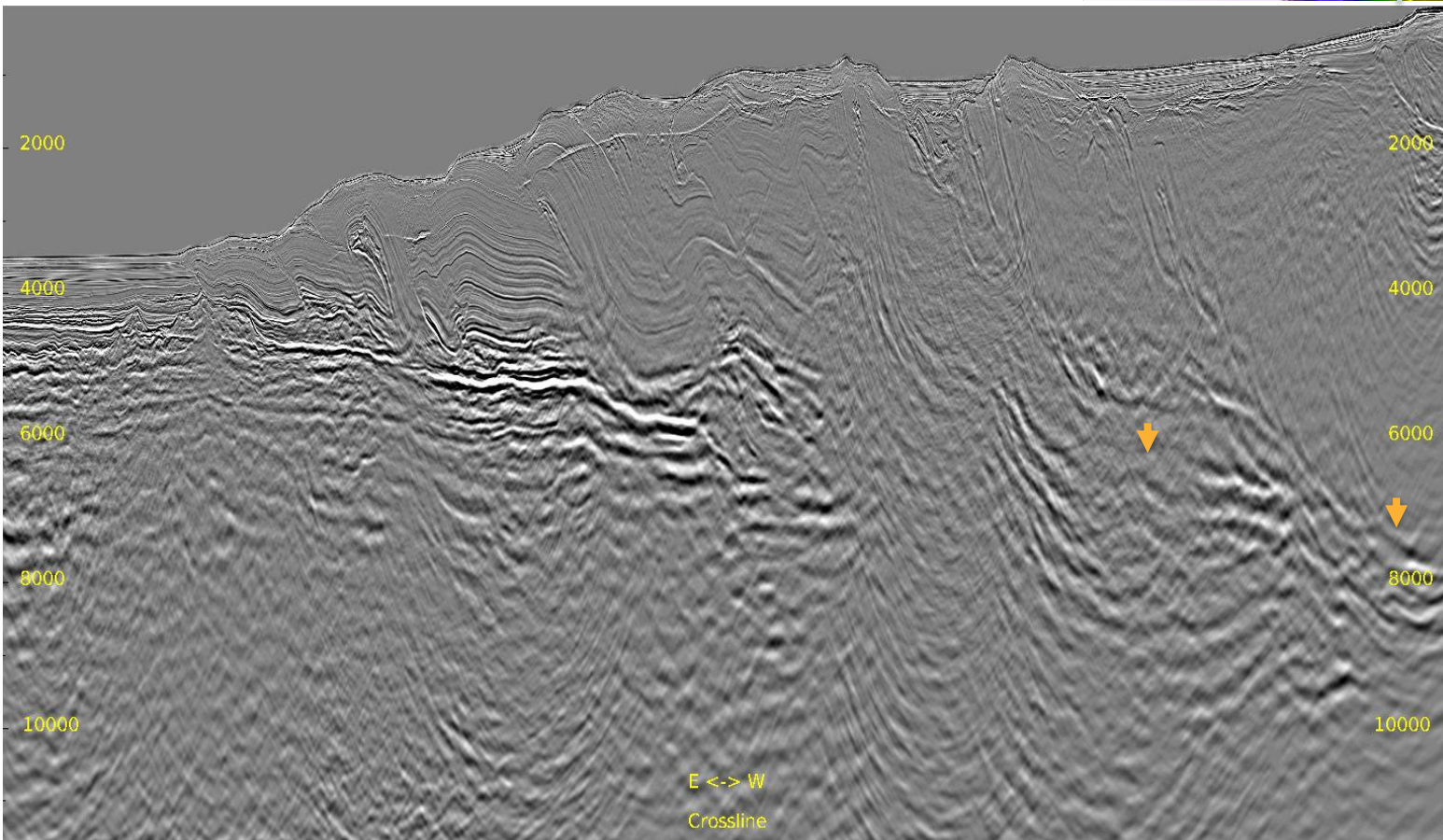
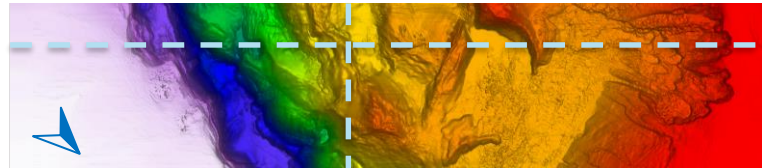
# Kirchhoff Depth Migration





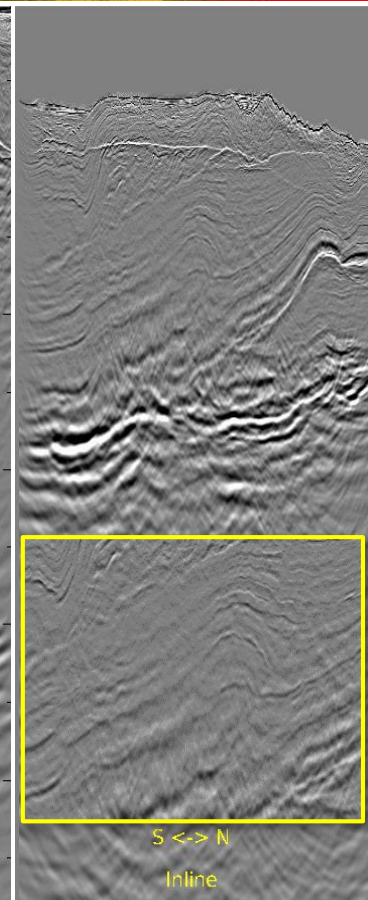
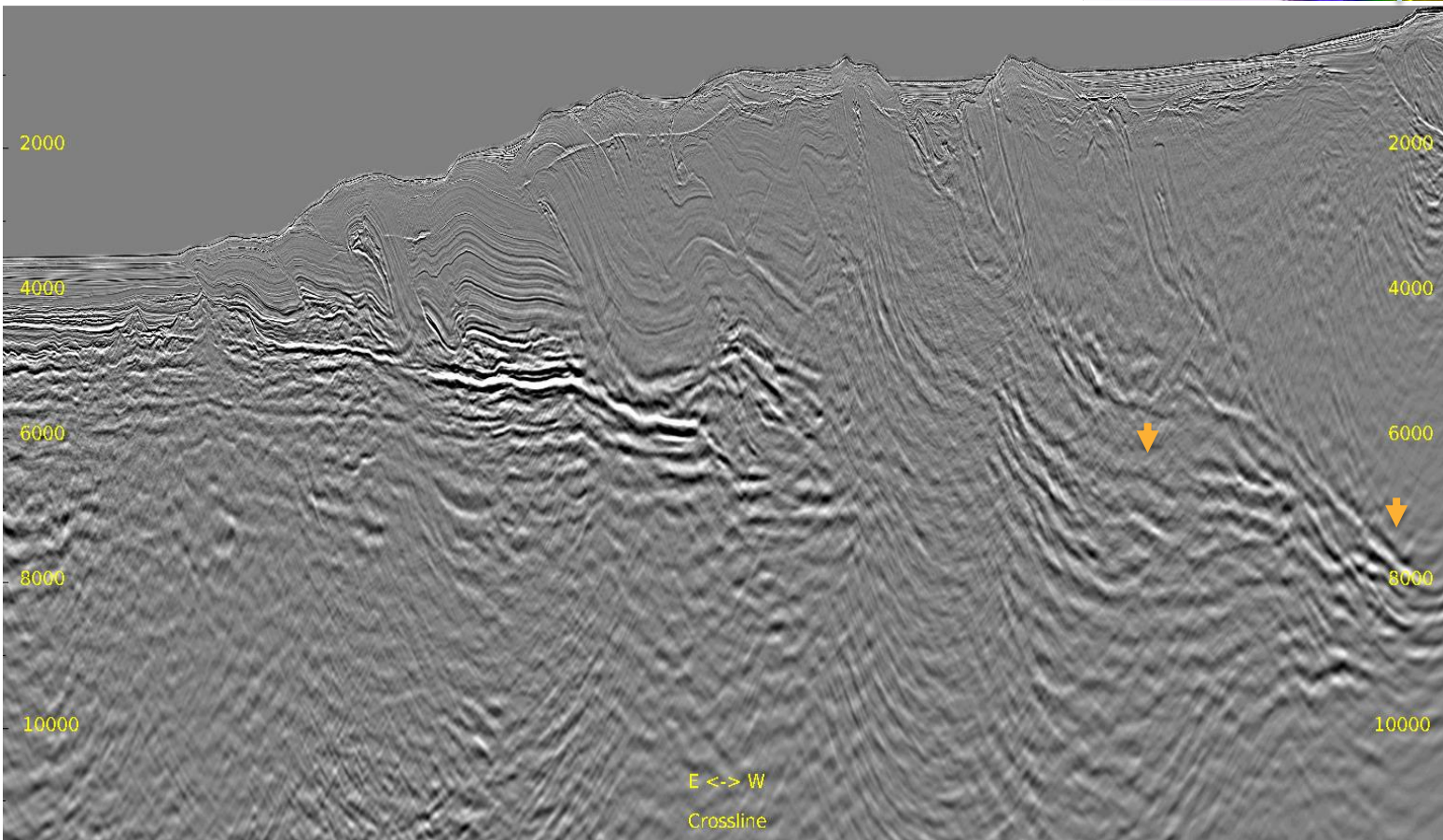
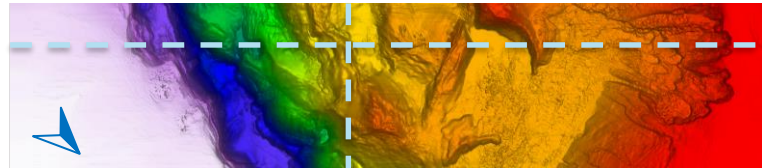
# Full Stack: IT5 Preliminary Result

Inline 225 & Crossline 2521



# Full Stack: IT5 Final Result

Inline 225 & Crossline 2521



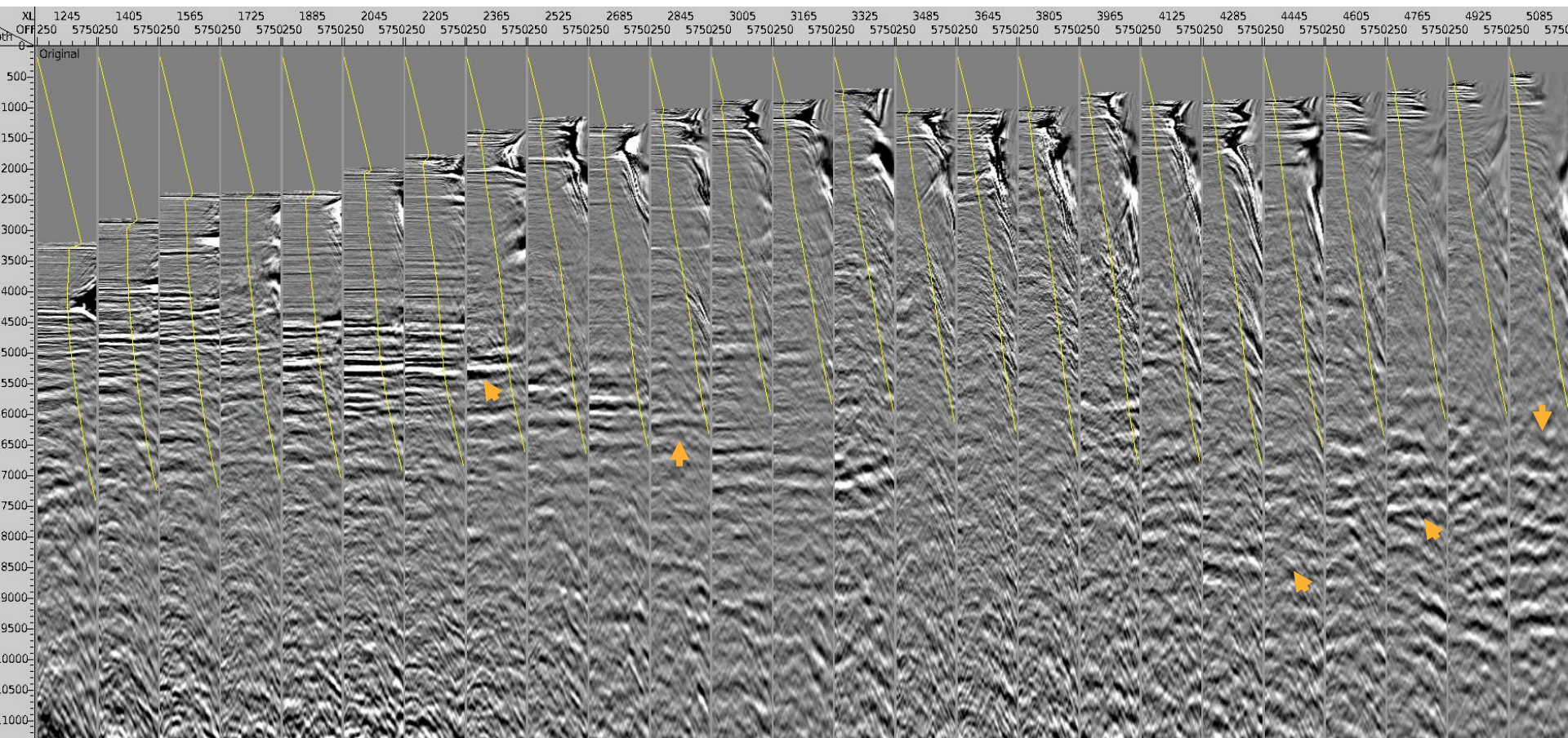




# Inline 233 CDP Gathers: IT5 Preliminary Result

— 35° Mute

10



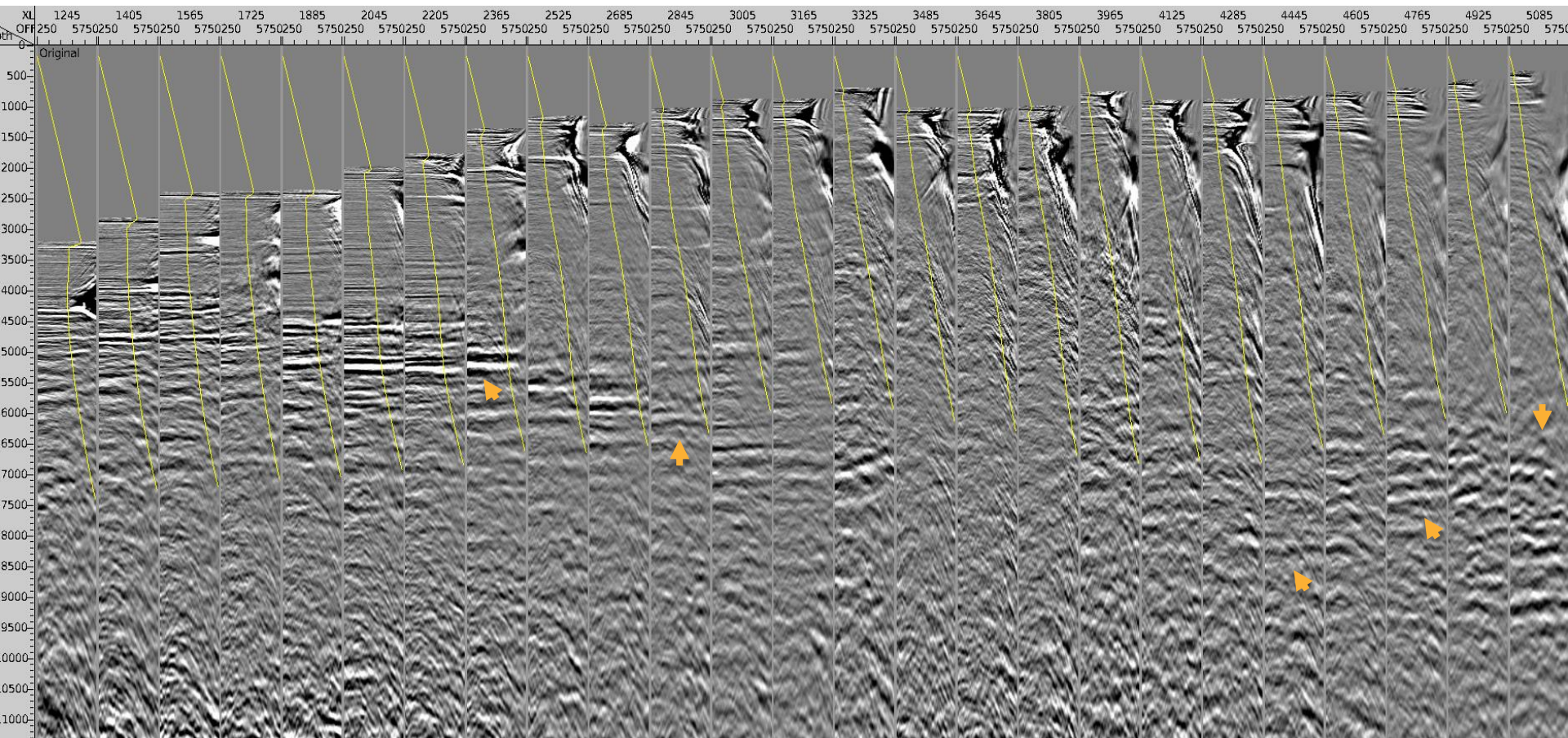




# Inline 233 CDP Gathers: IT5 Final Result

— 35° Mute

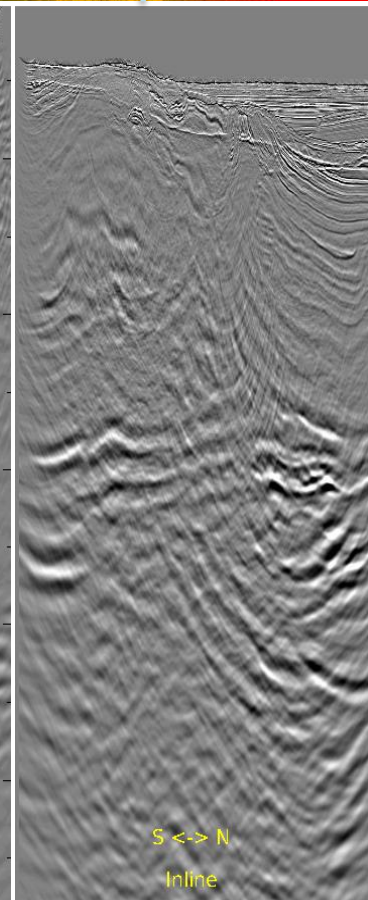
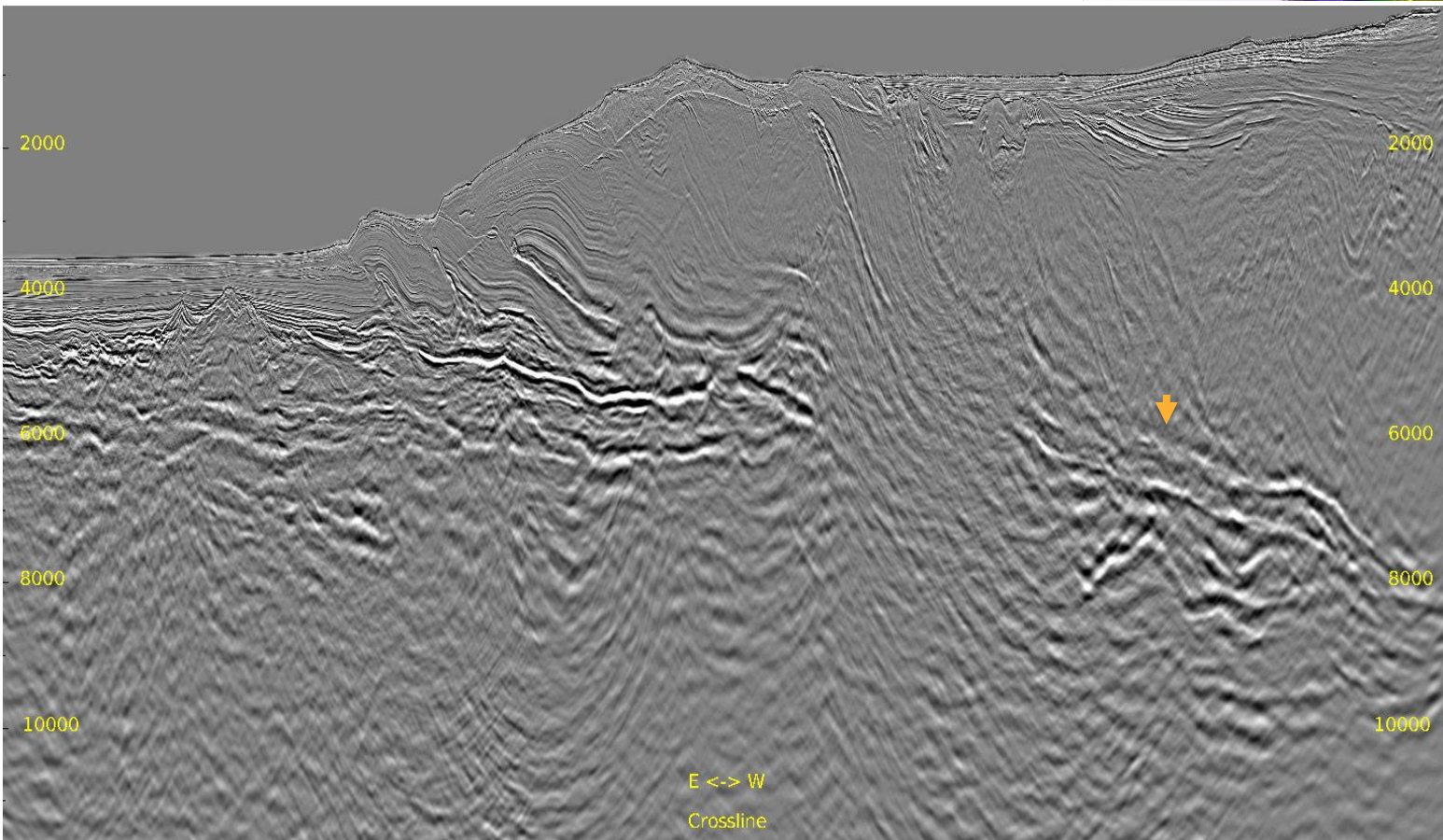
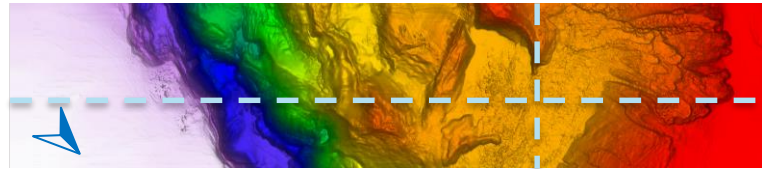
11





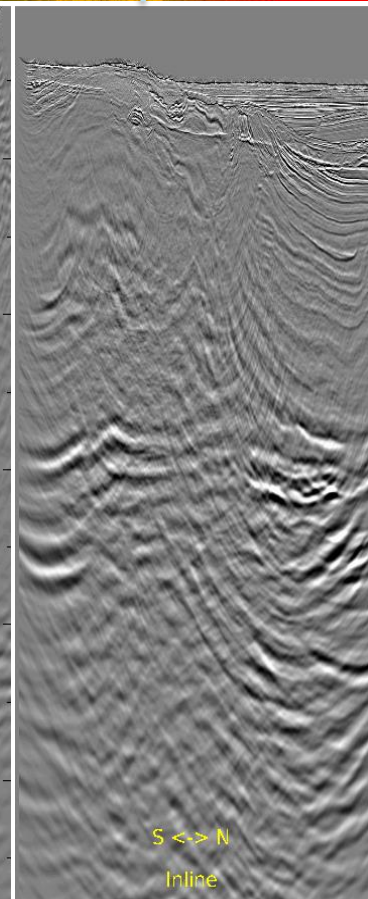
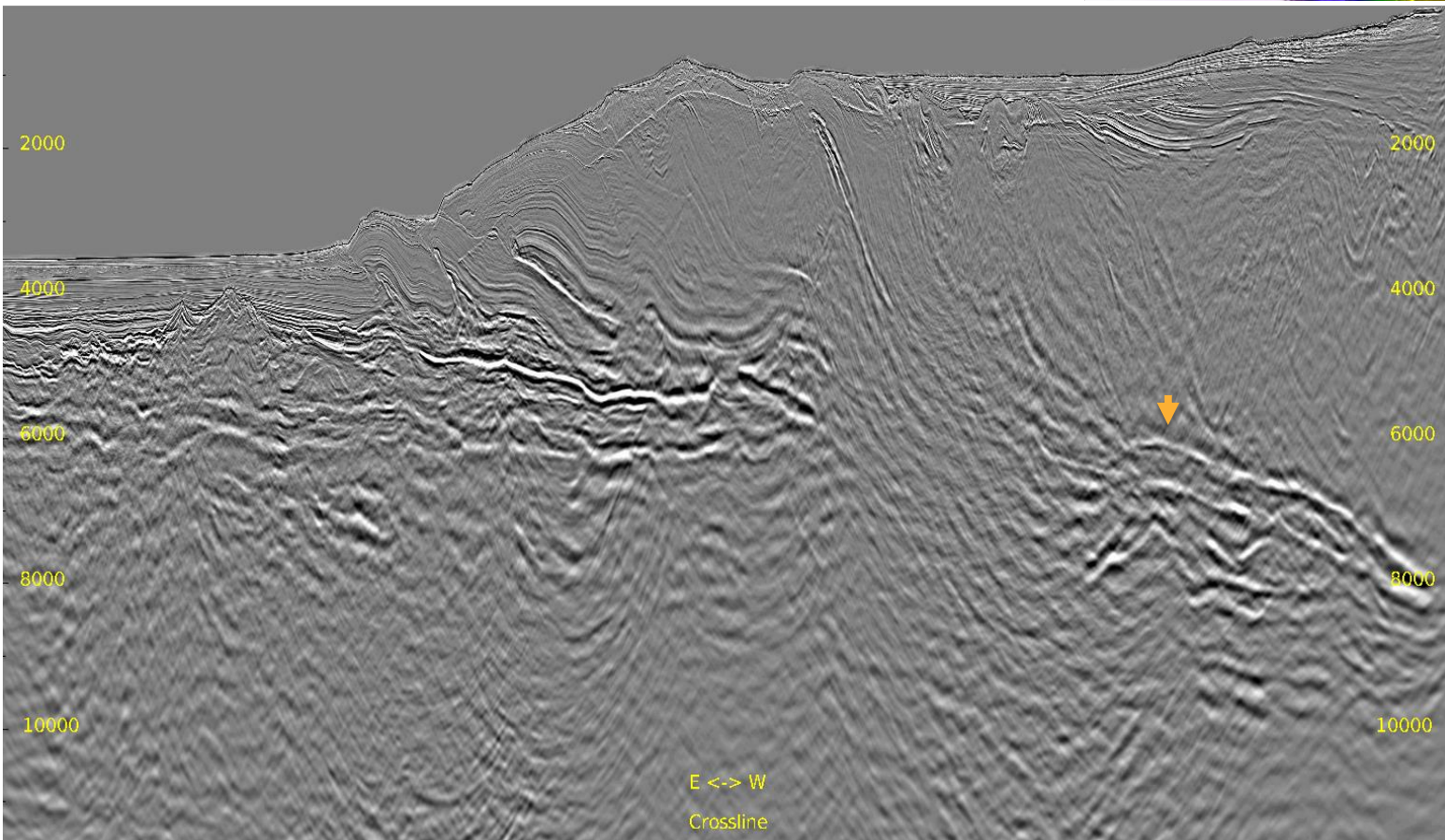
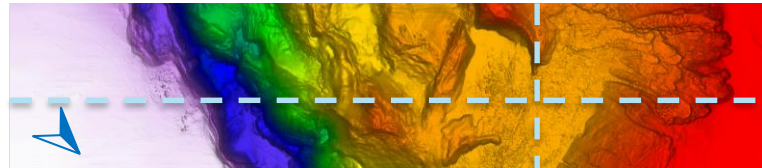
# Full Stack: IT5 Preliminary Result

Inline 500 & Crossline 3931



# Full Stack: IT5 Final Result

Inline 500 & Crossline 3931



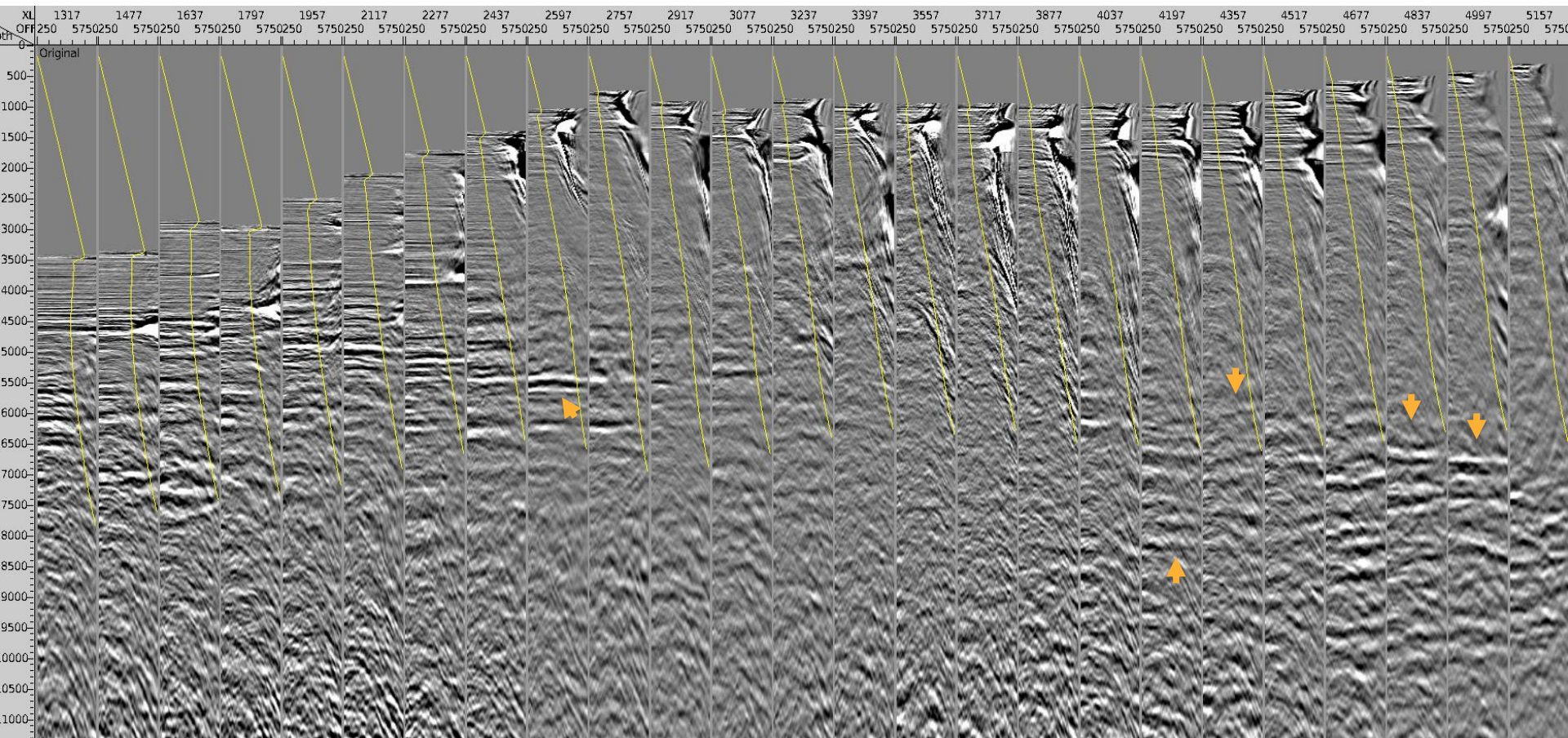




# Inline 500 CDP Gathers: IT5 Preliminary Result

— 35° Mute

14



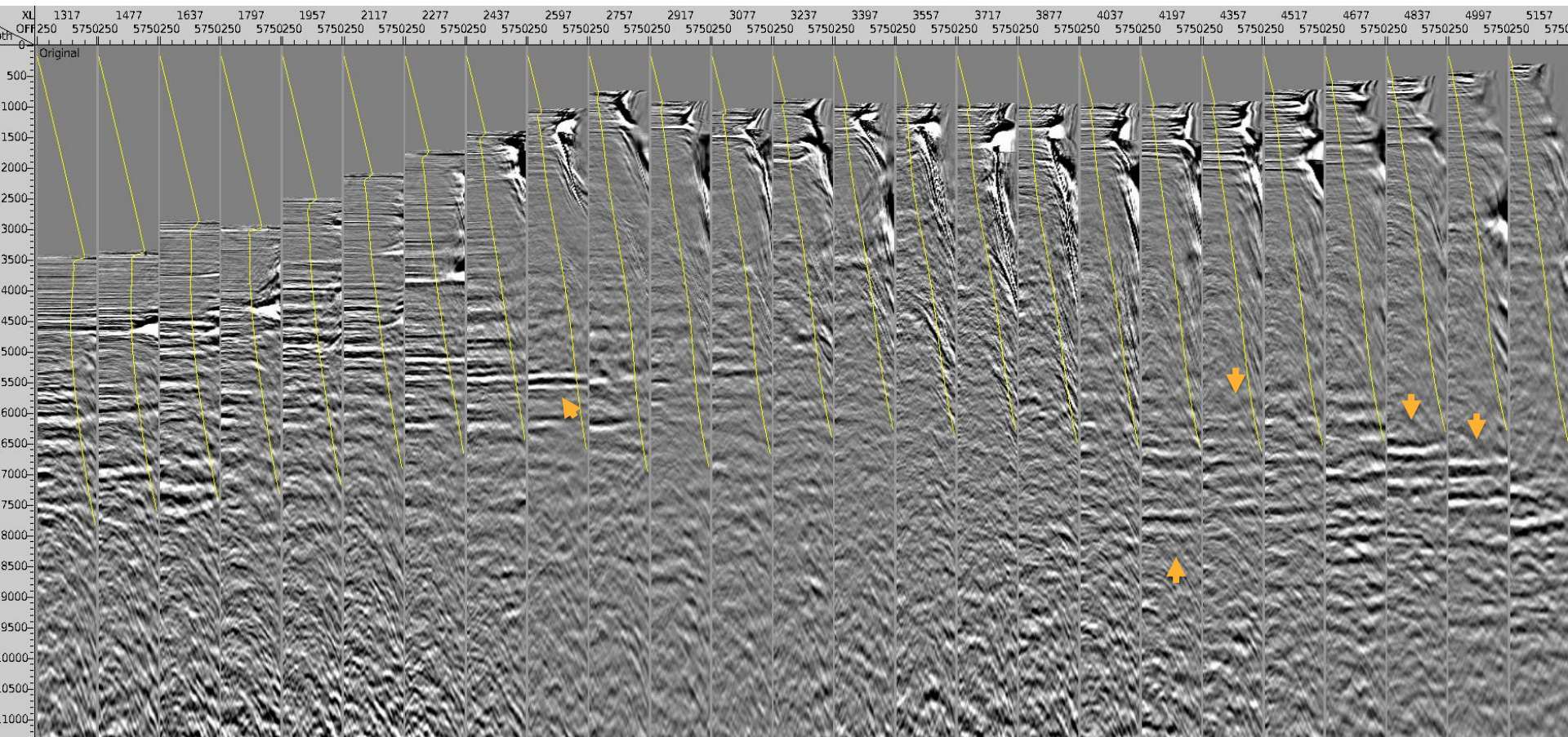




# Inline 500 CDP Gathers: IT5 Final Result

— 35° Mute

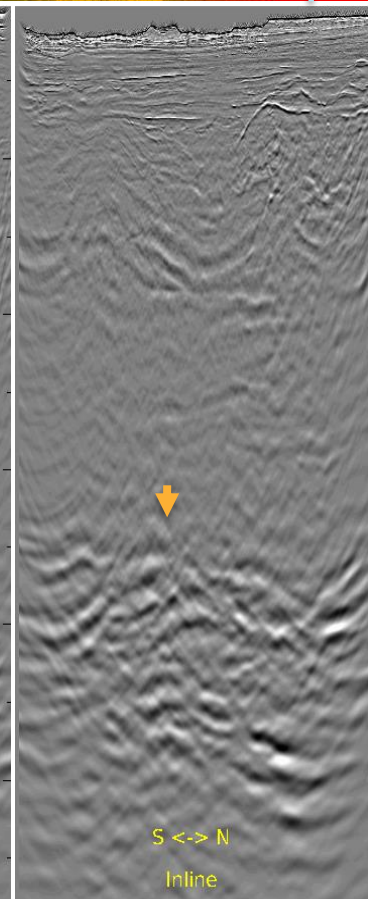
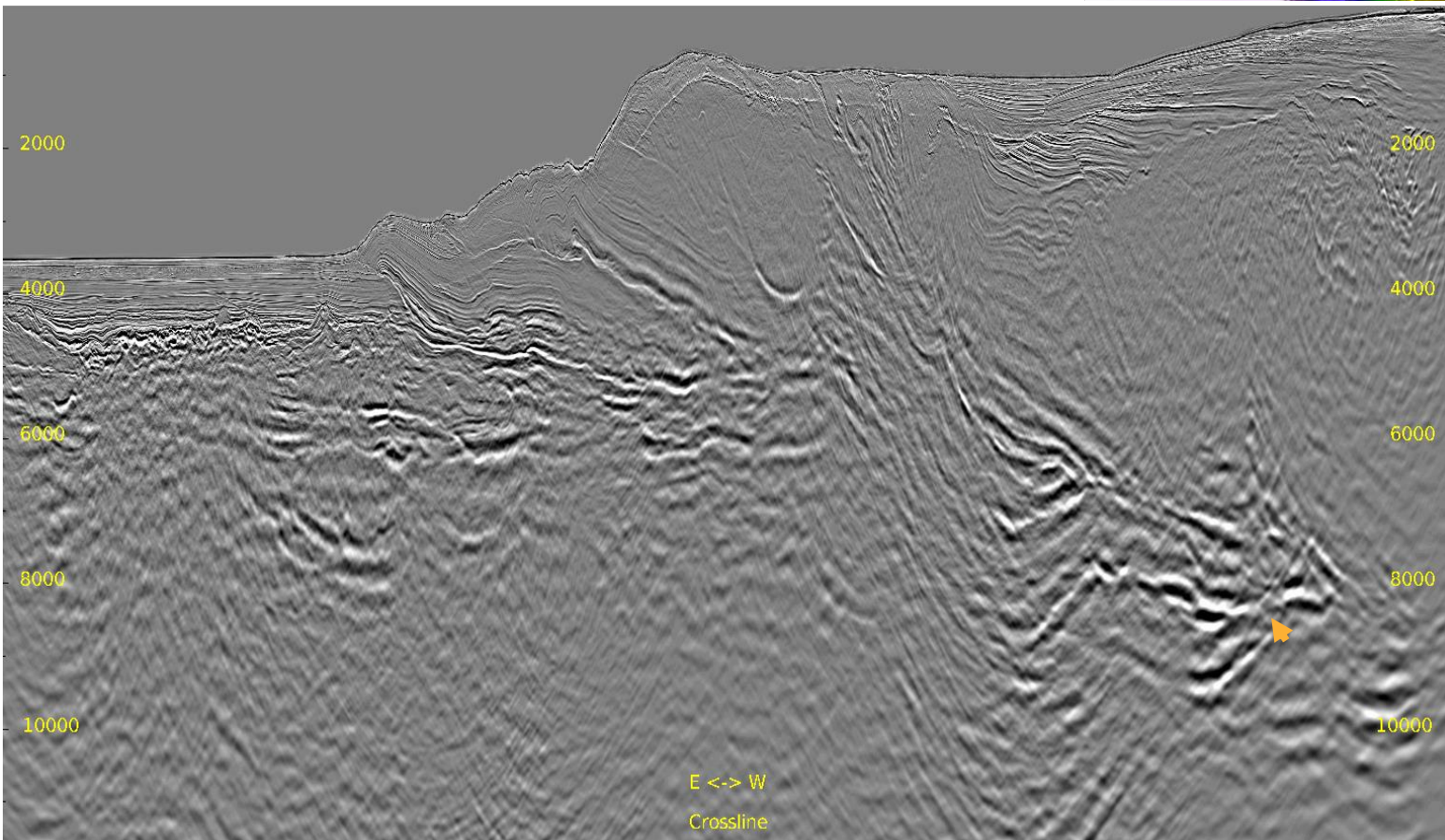
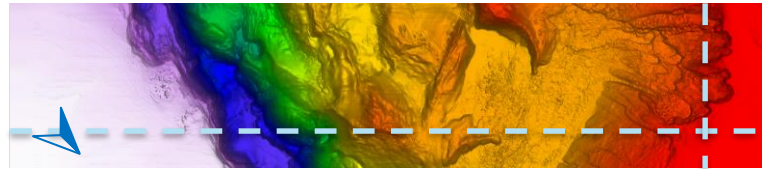
15





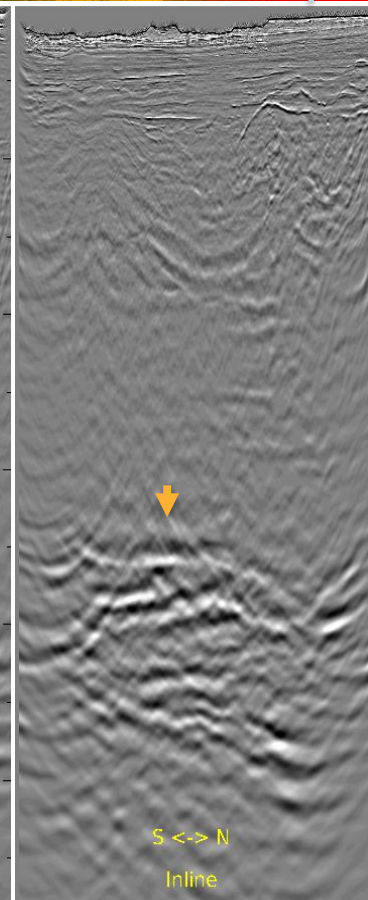
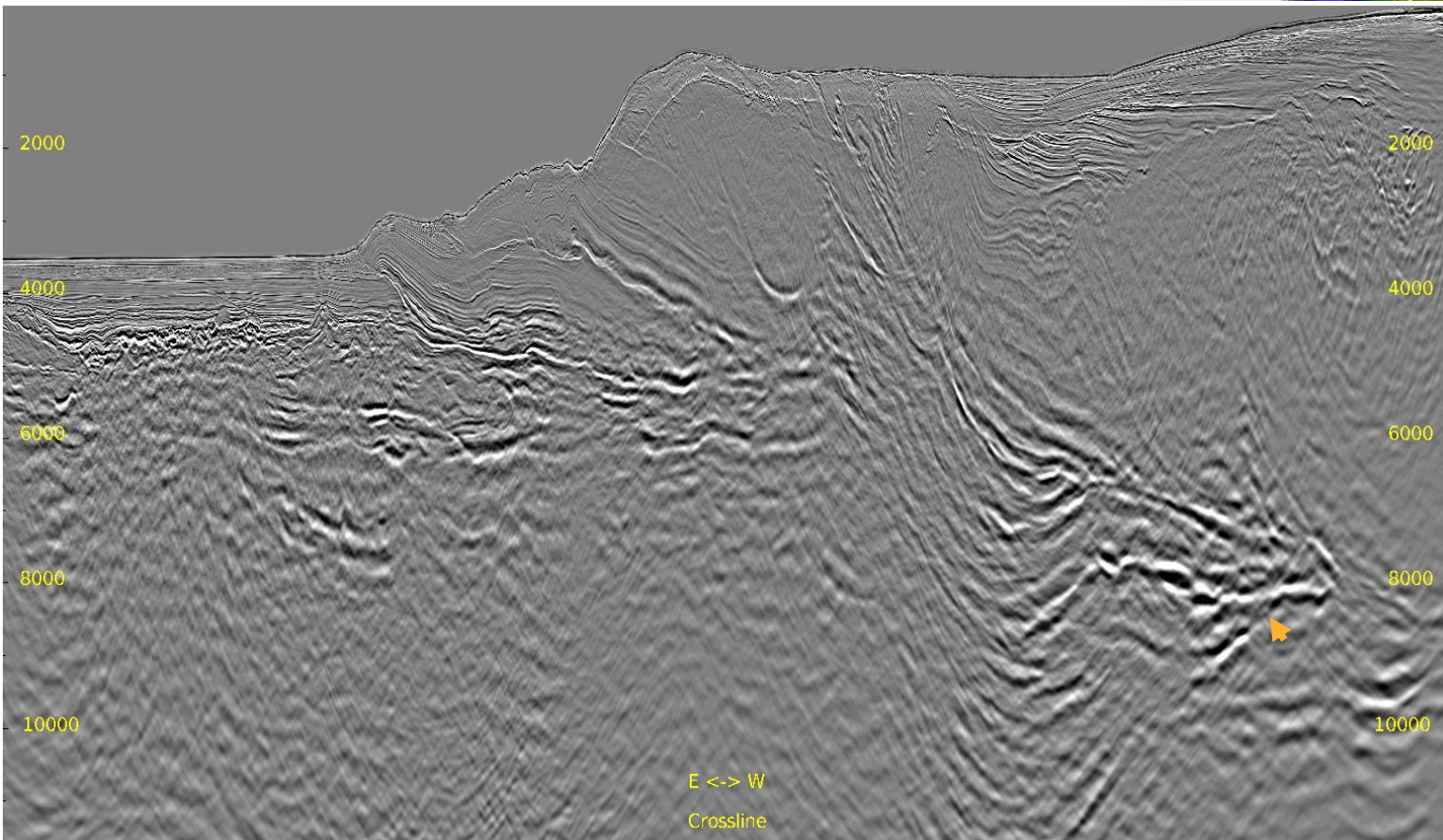
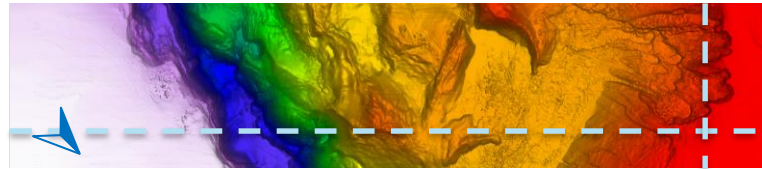
# Full Stack: IT5 Preliminary Result

Inline 636 & Crossline 5159



# Full Stack: IT5 Final Result

Inline 636 & Crossline 5159



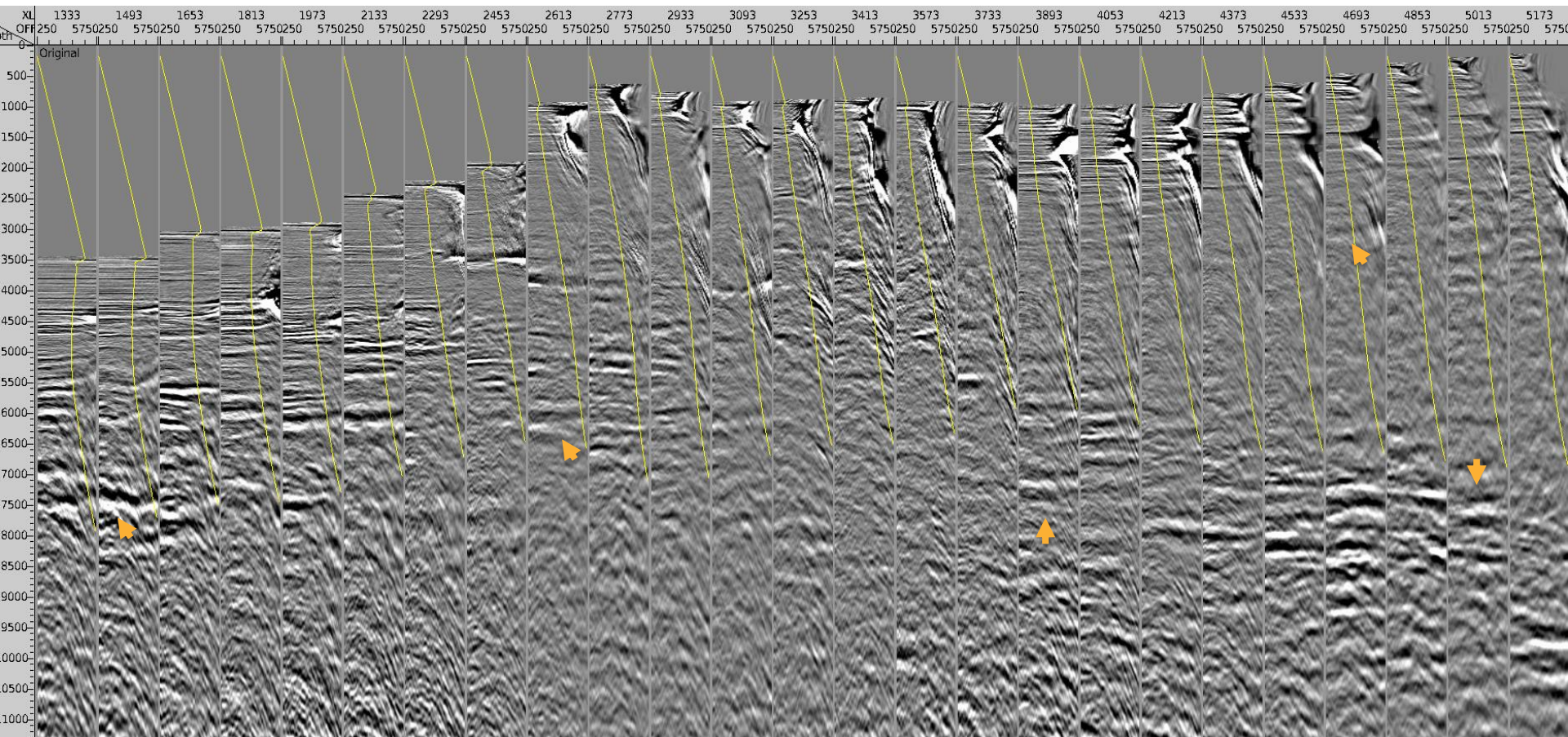




# Inline 636 CDP Gathers: IT5 Preliminary Result

— 35° Mute

18



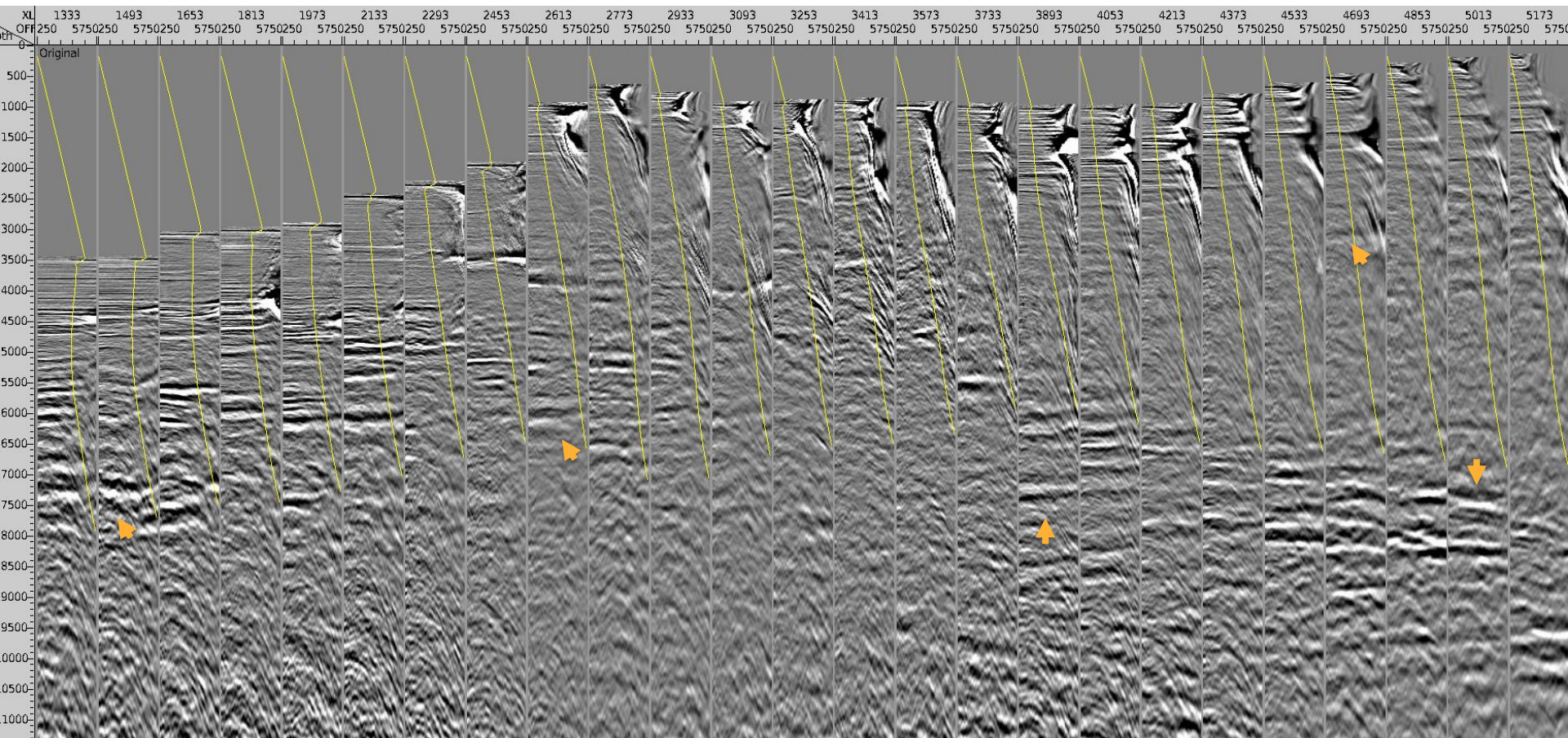




# Inline 636 CDP Gathers: IT5 Final Result

— 35° Mute

19





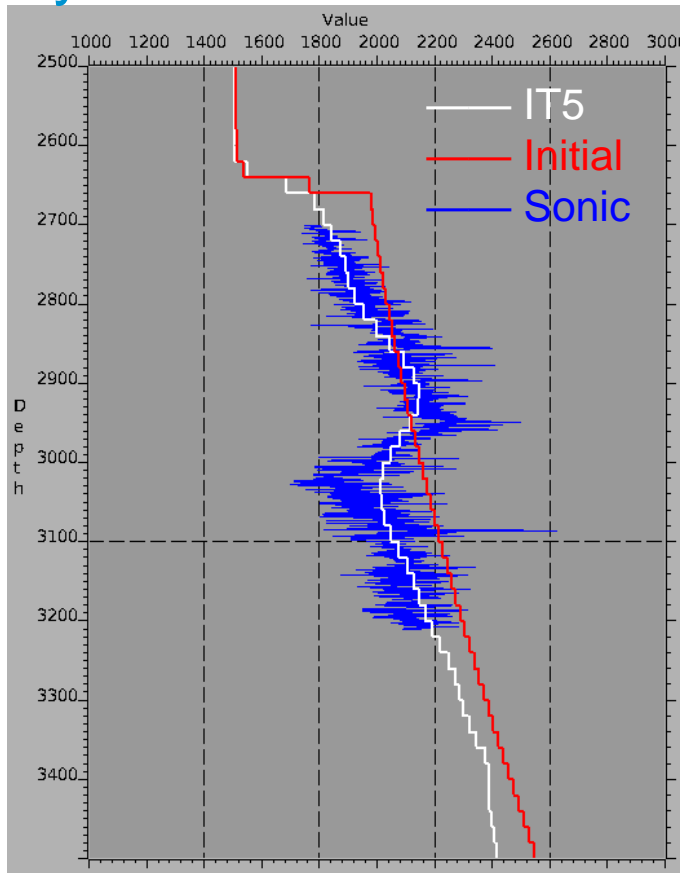
# VMB Summary

## Initial VS IT5 Final

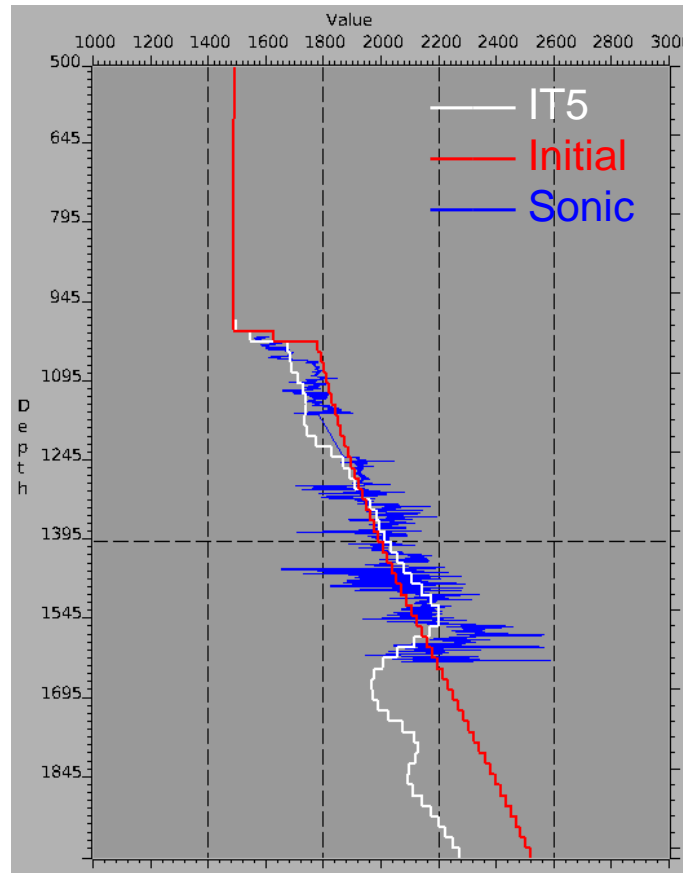


# Velocity Profile at Well Location

21



Well U1518B

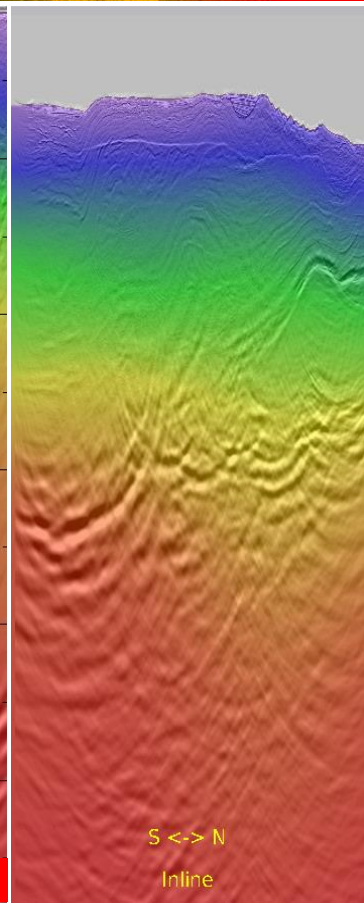
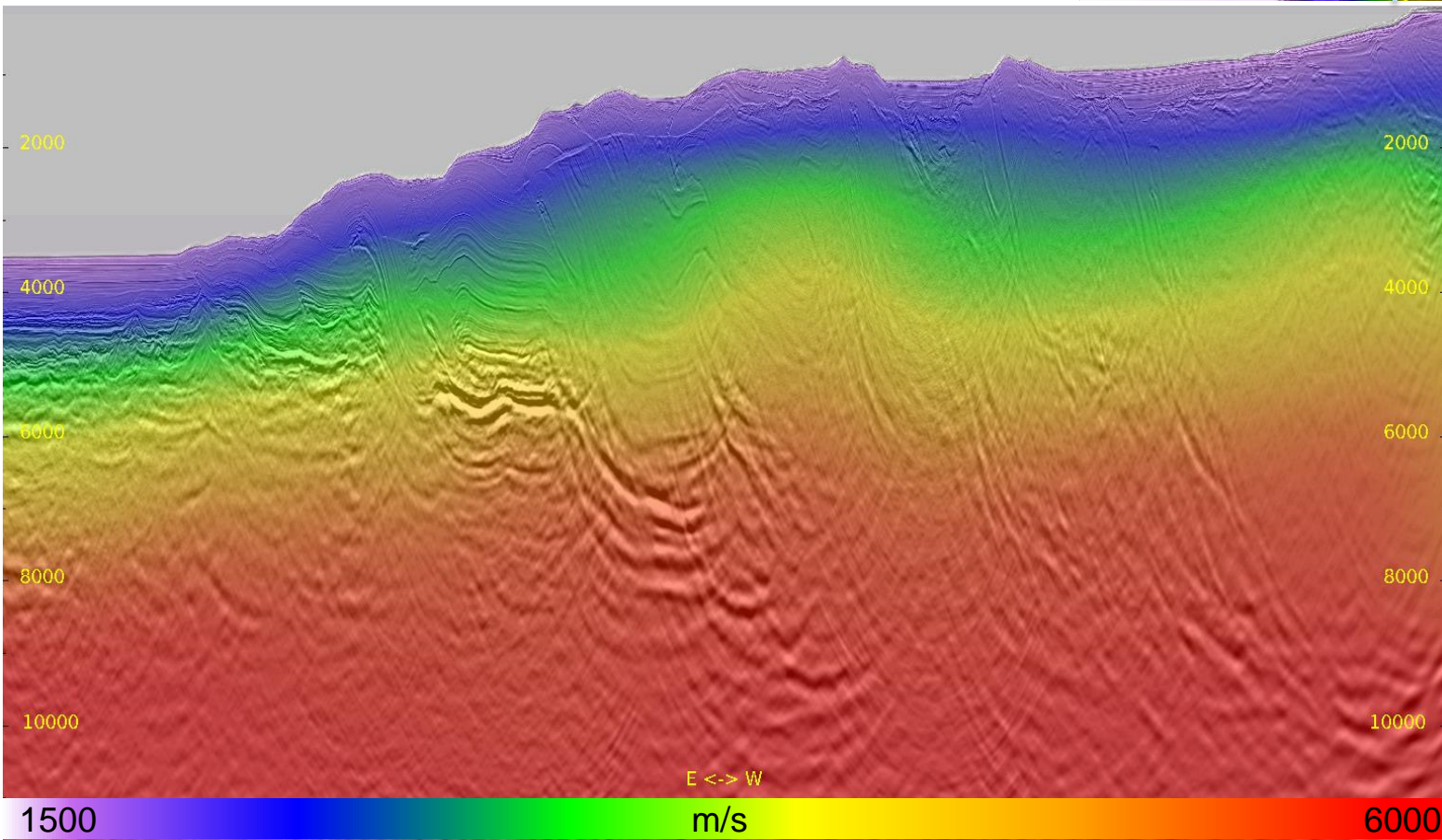
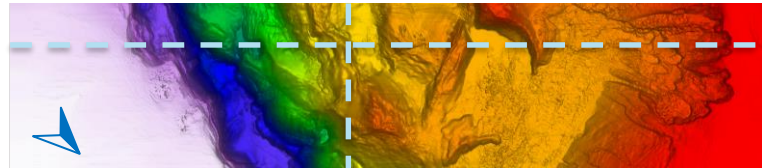


Well U1519A



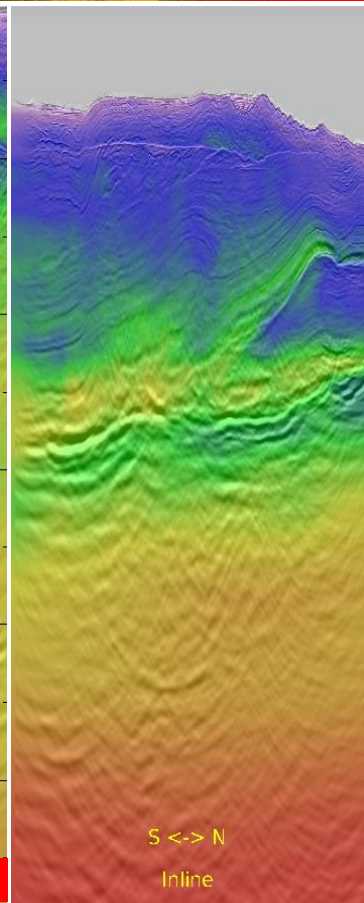
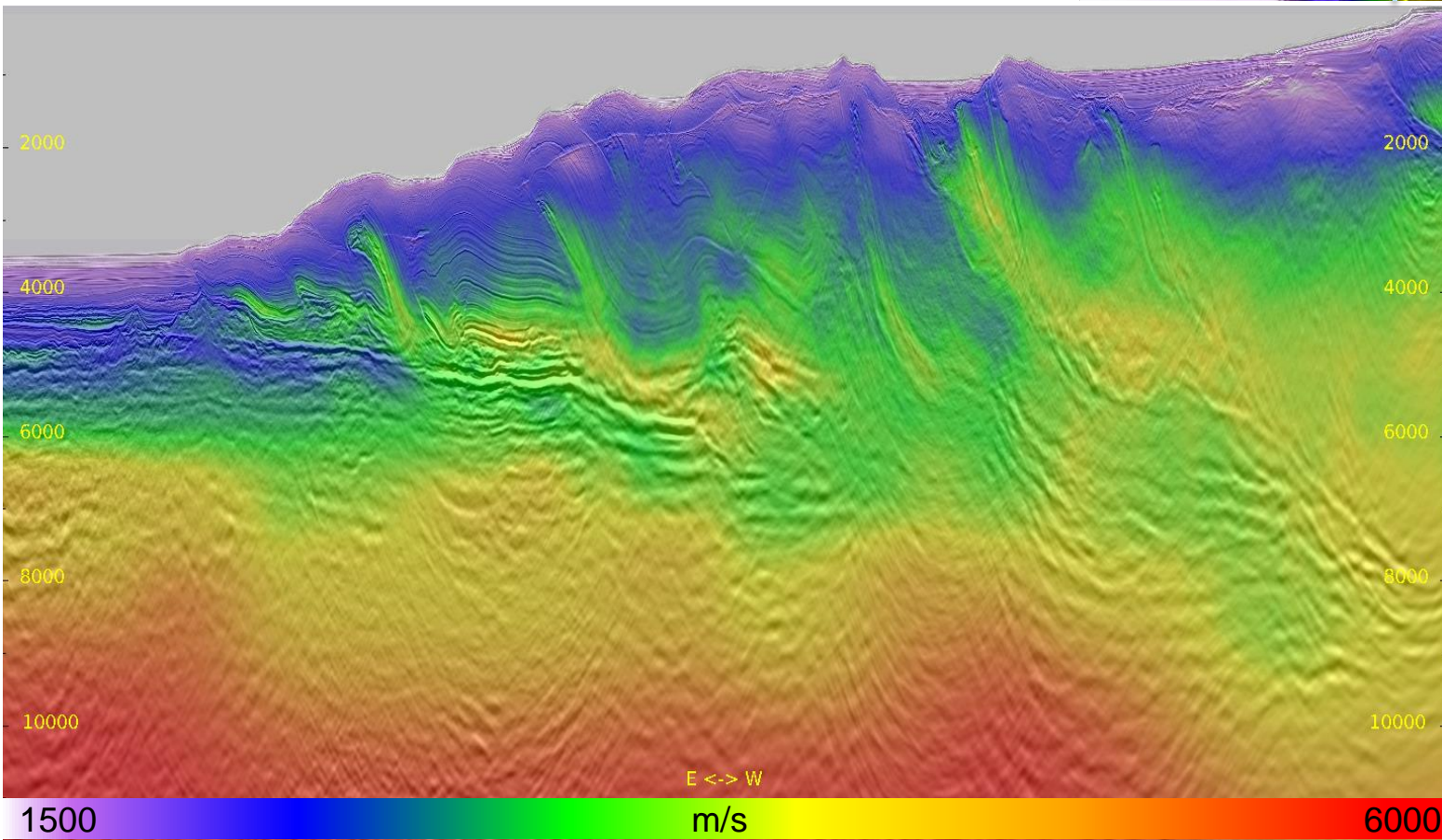
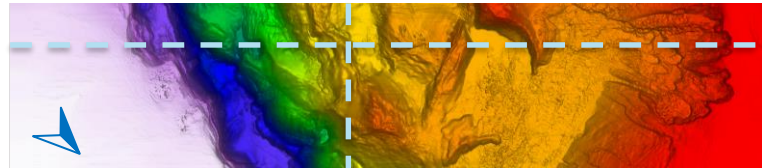
# Full Stack: Initial Velocity

Inline 225 & Crossline 2521



# Full Stack: IT5 Final Velocity

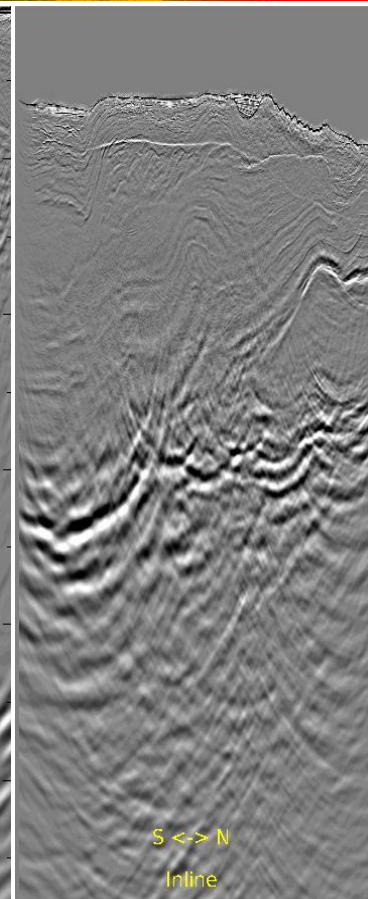
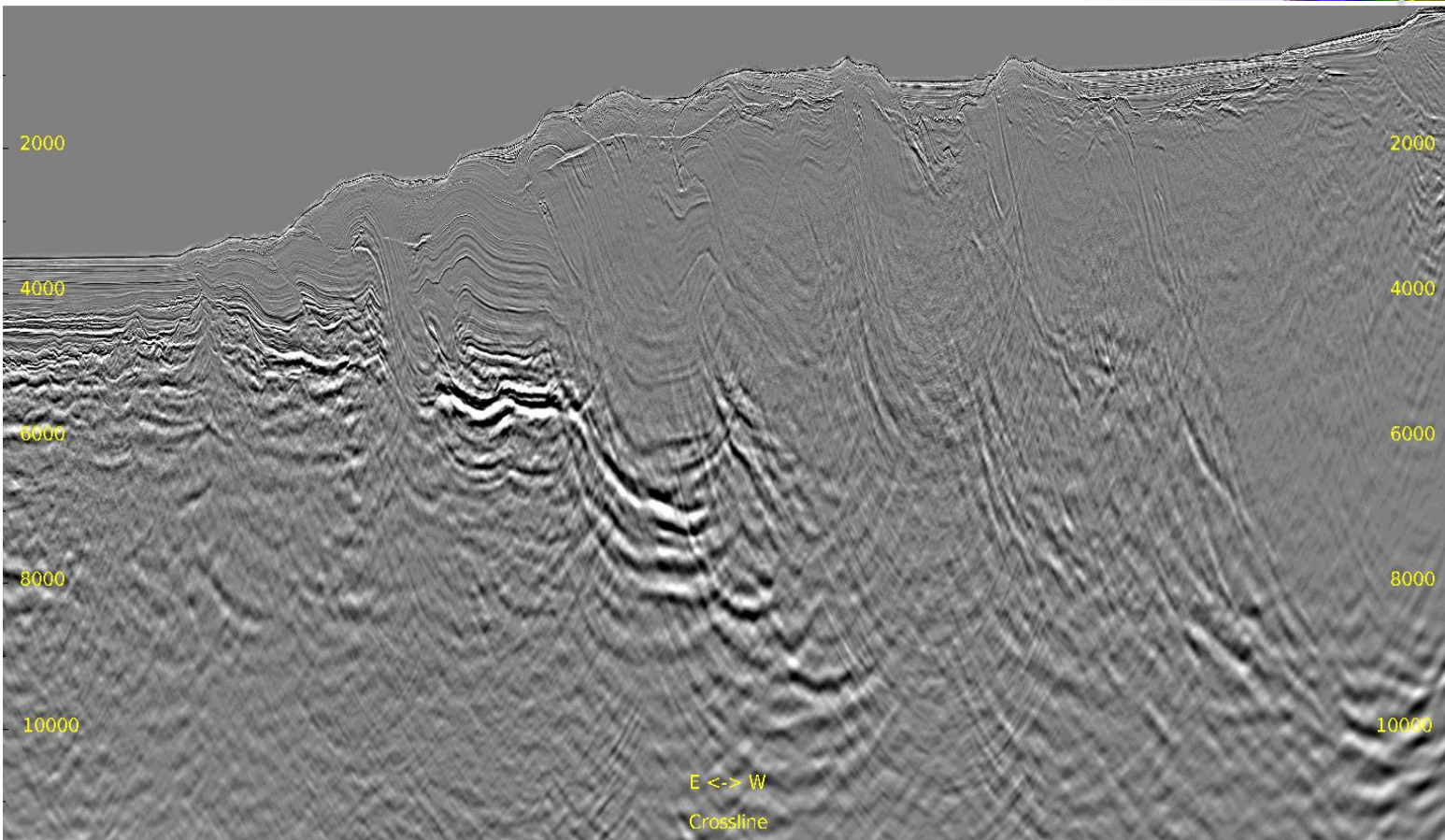
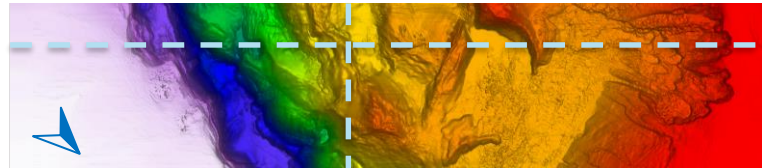
Inline 225 & Crossline 2521





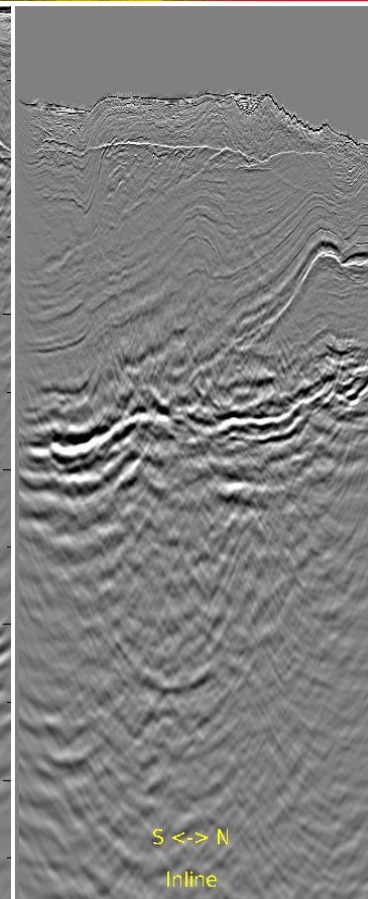
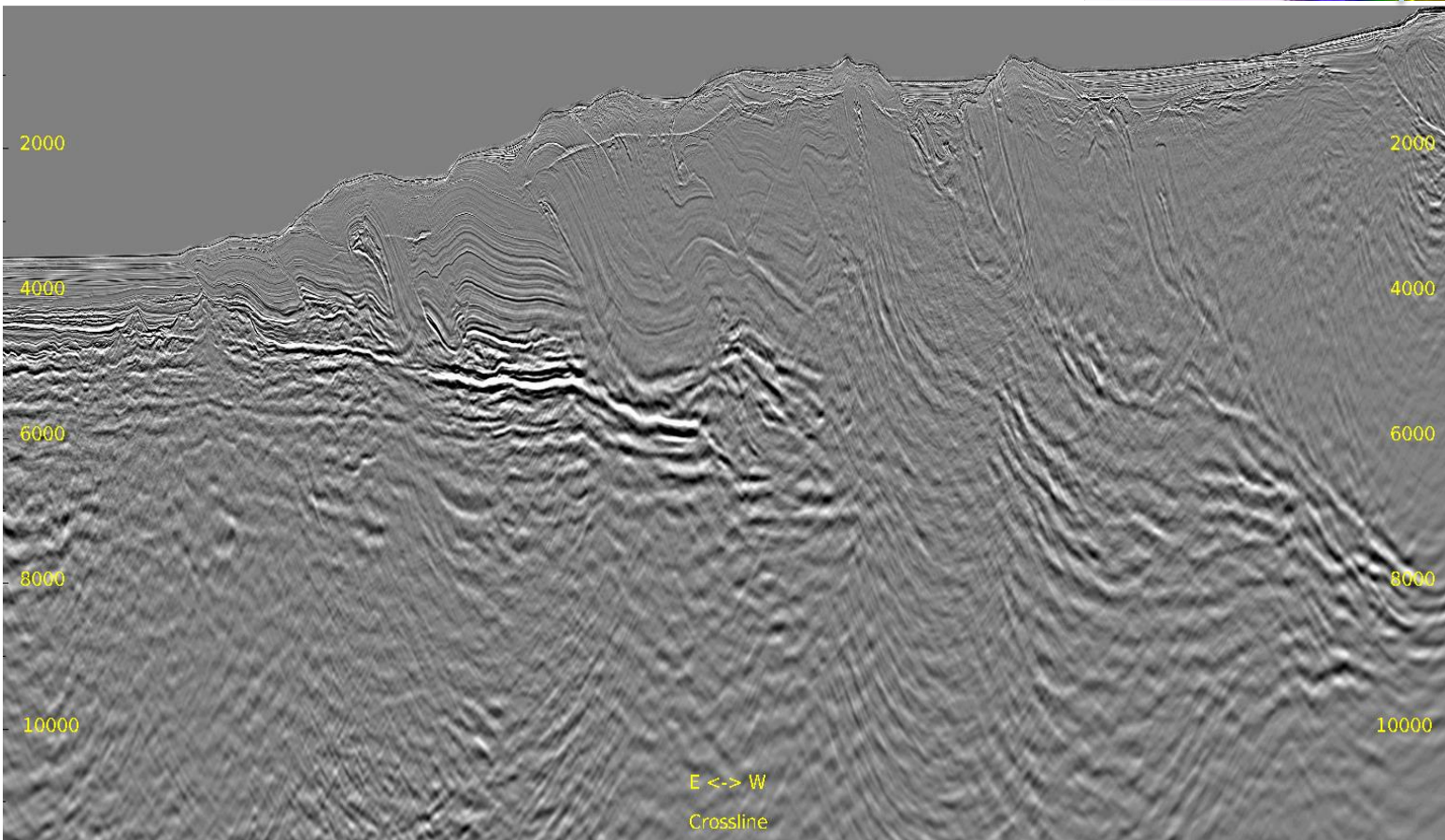
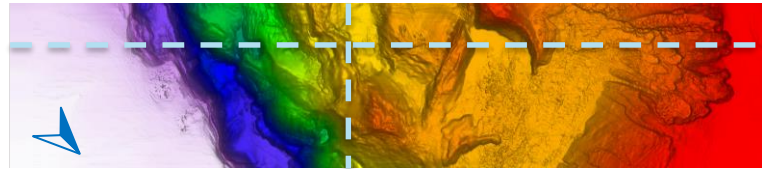
# Full Stack: Initial

Inline 225 & Crossline 2521



# Full Stack: IT5 Final

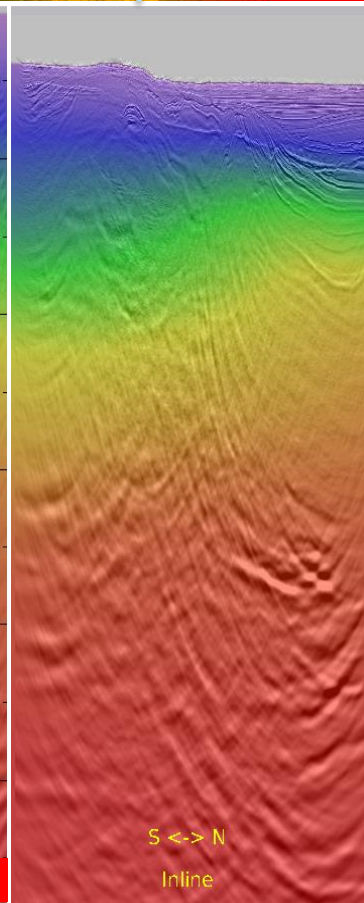
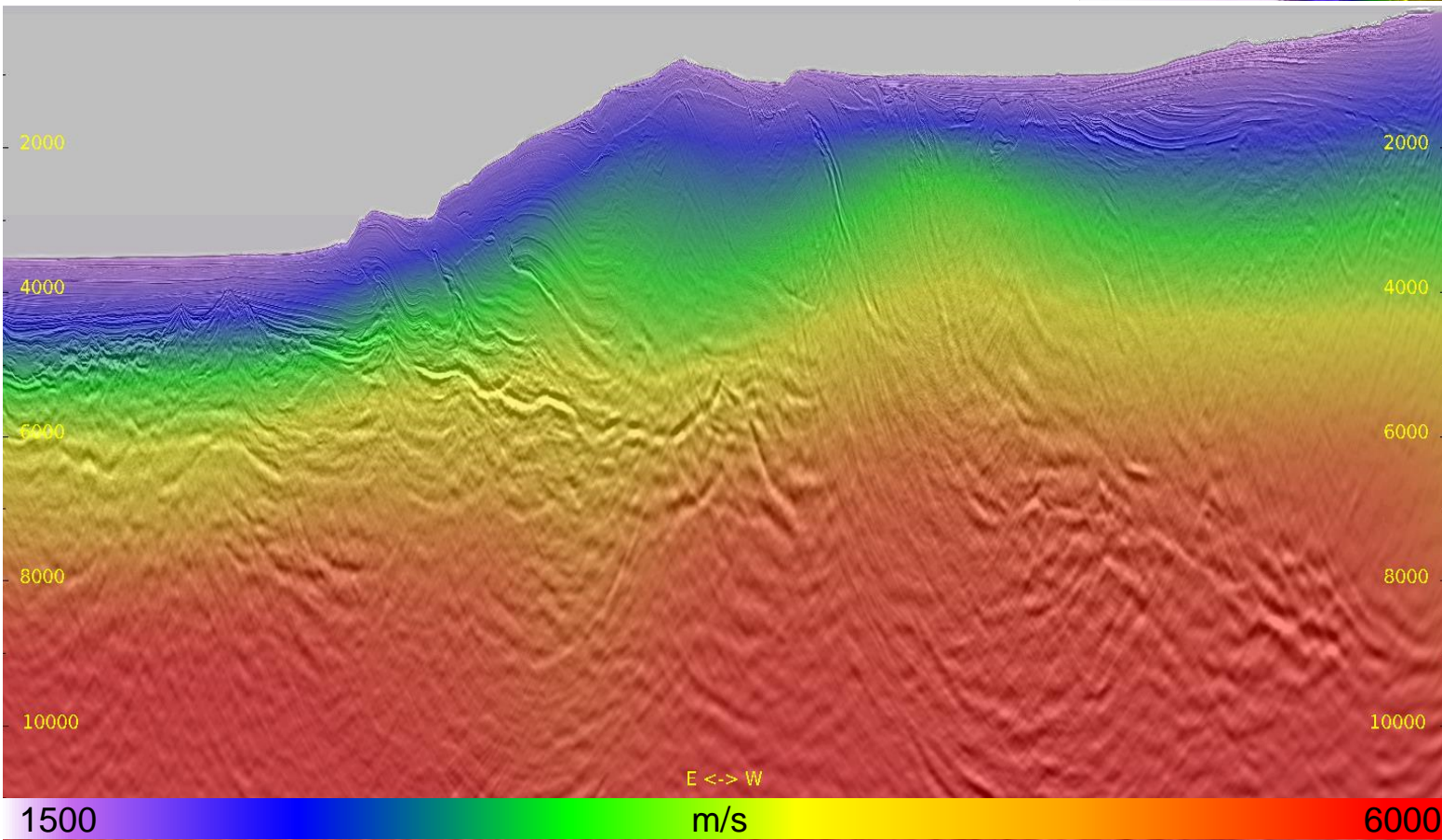
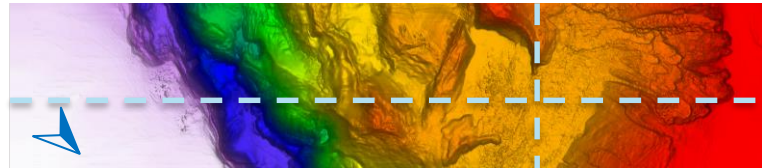
Inline 225 & Crossline 2521





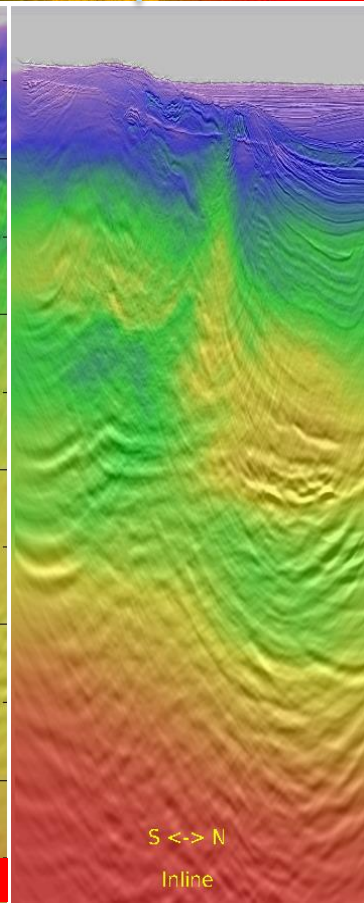
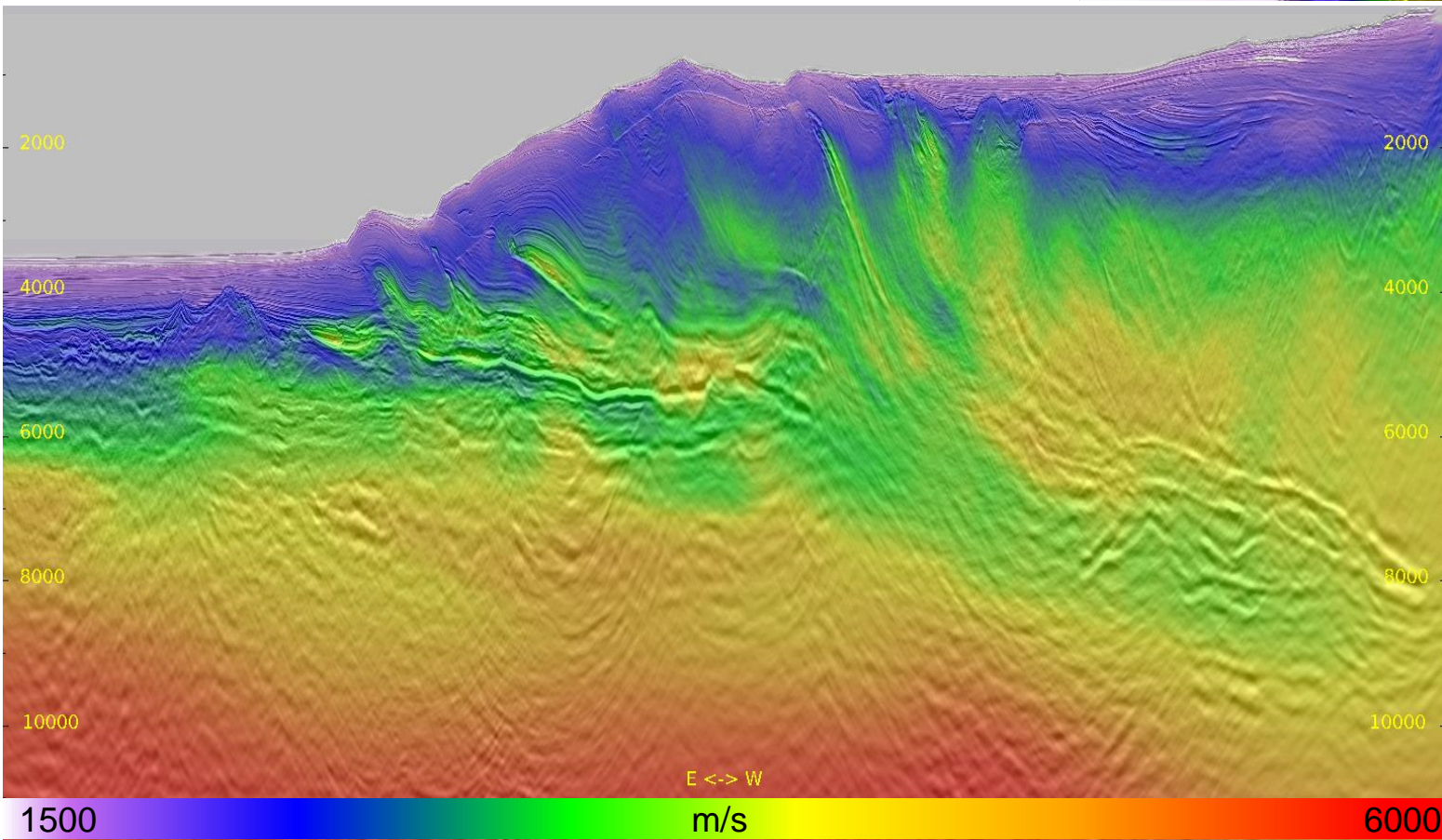
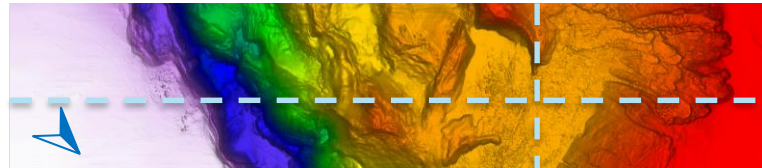
# Full Stack: Initial Velocity

Inline 500 & Crossline 3931



# Full Stack: IT5 Final Velocity

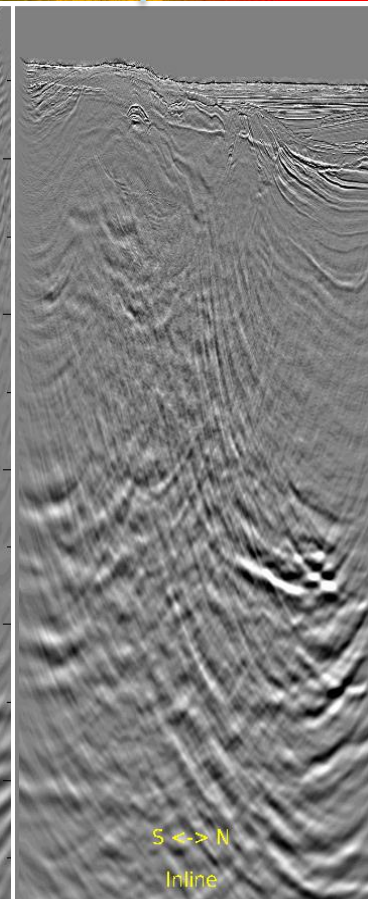
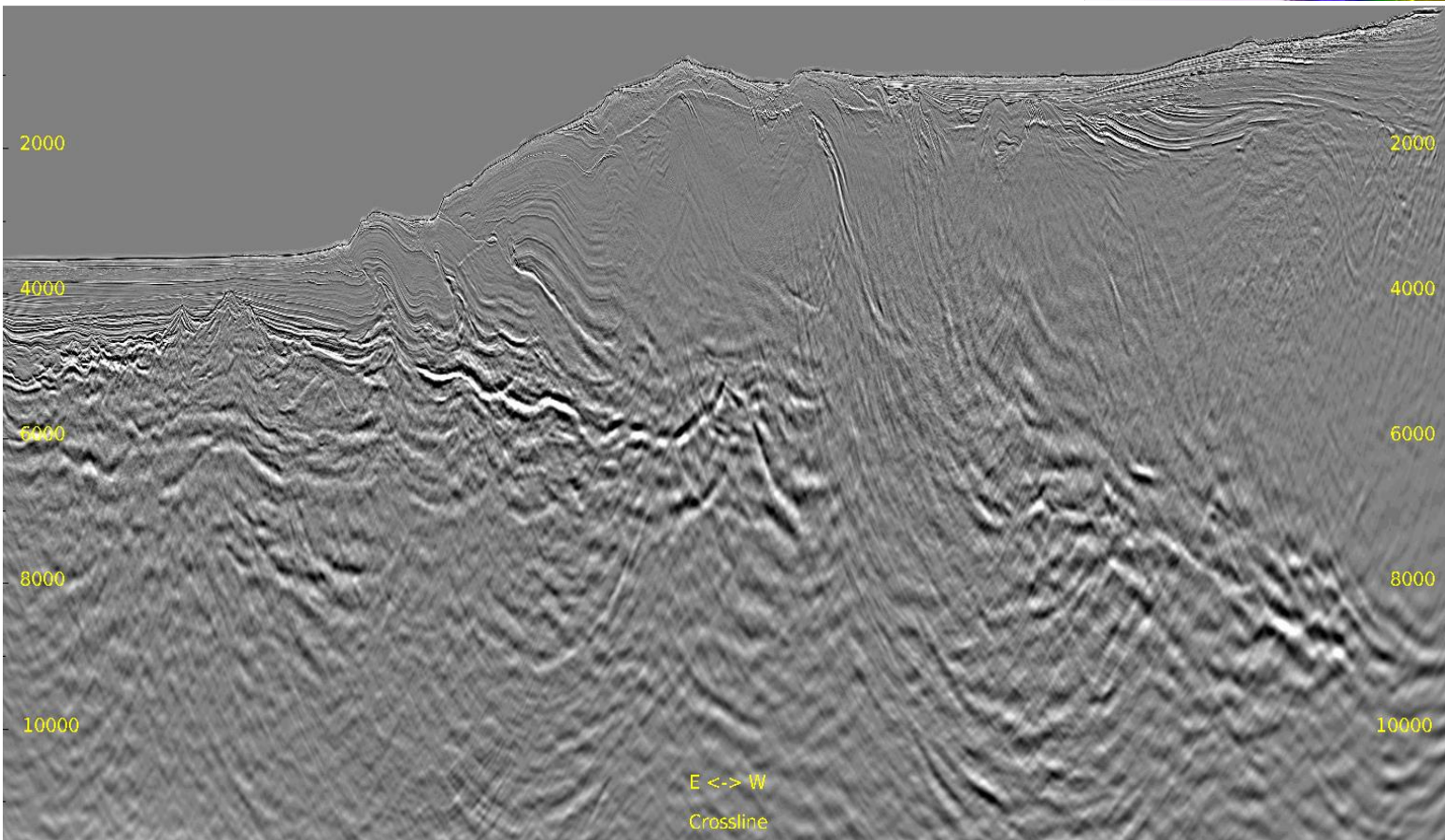
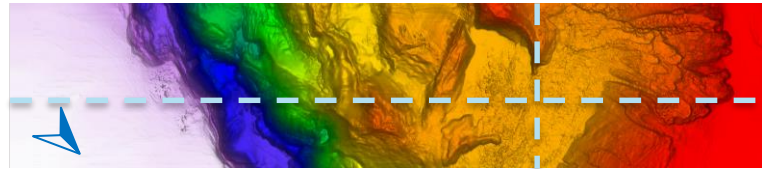
Inline 500 & Crossline 3931





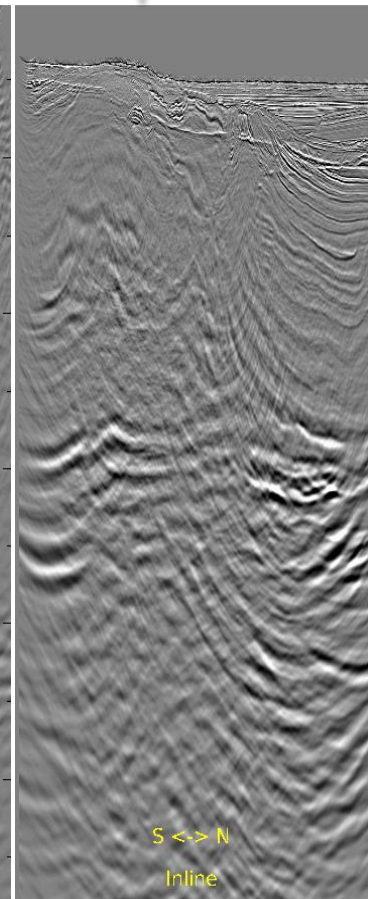
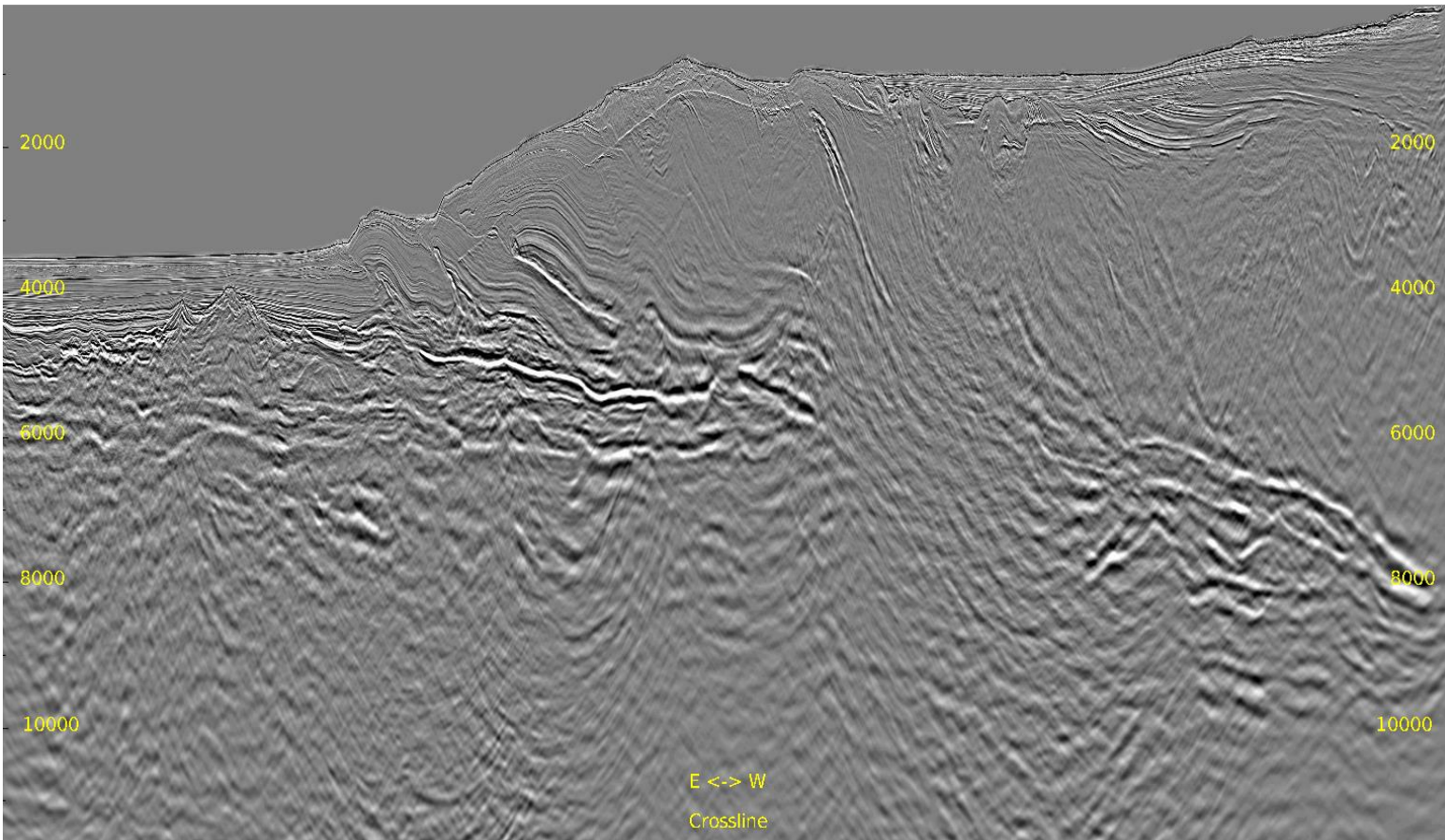
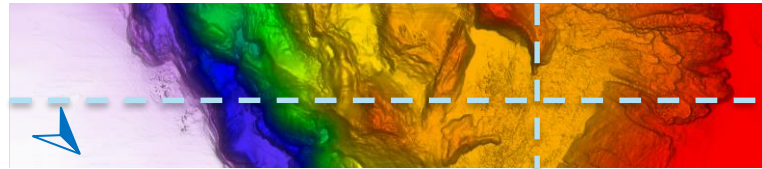
# Full Stack: Initial

Inline 500 & Crossline 3931



# Full Stack: IT5 Final

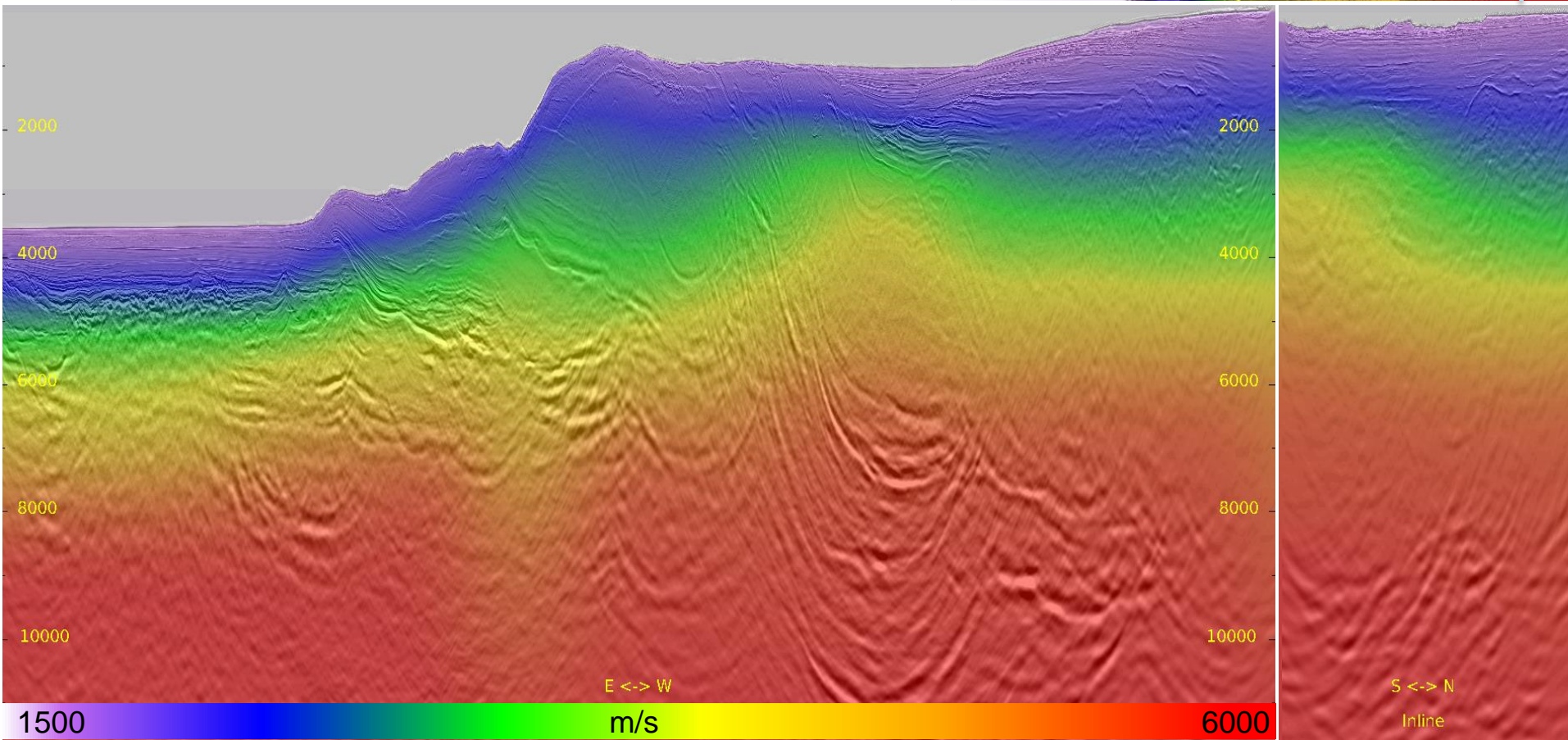
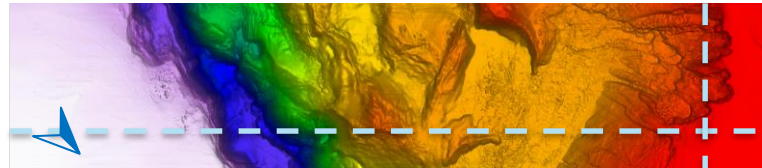
Inline 500 & Crossline 3931





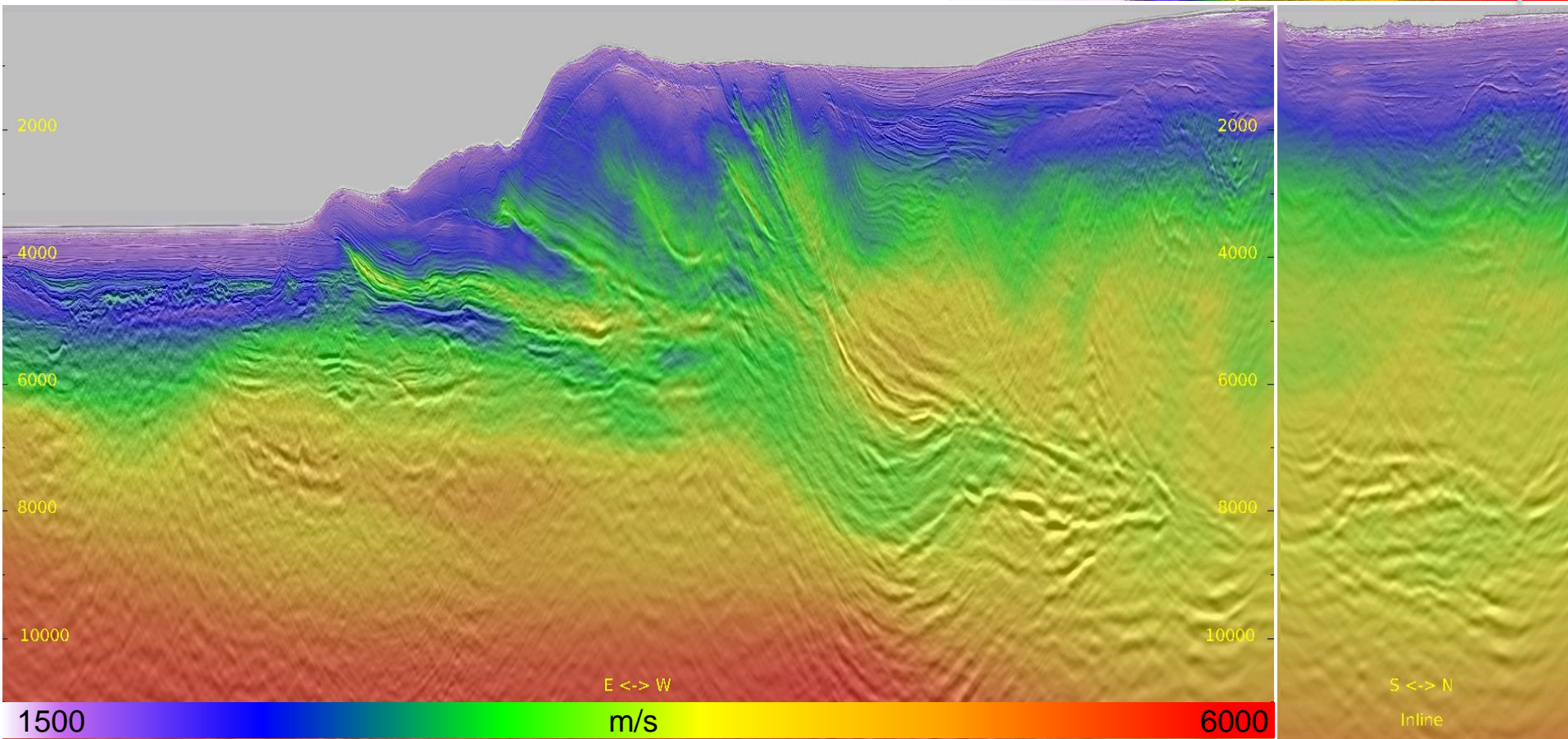
# Full Stack: Initial Velocity

Inline 636 & Crossline 5159



# Full Stack: IT5 Final Velocity

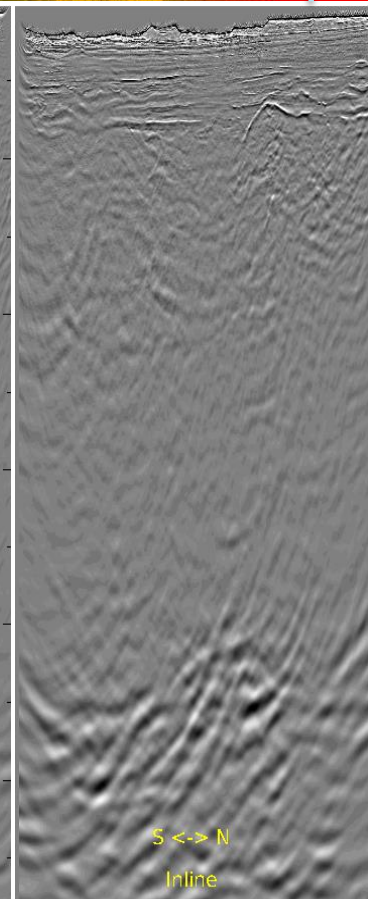
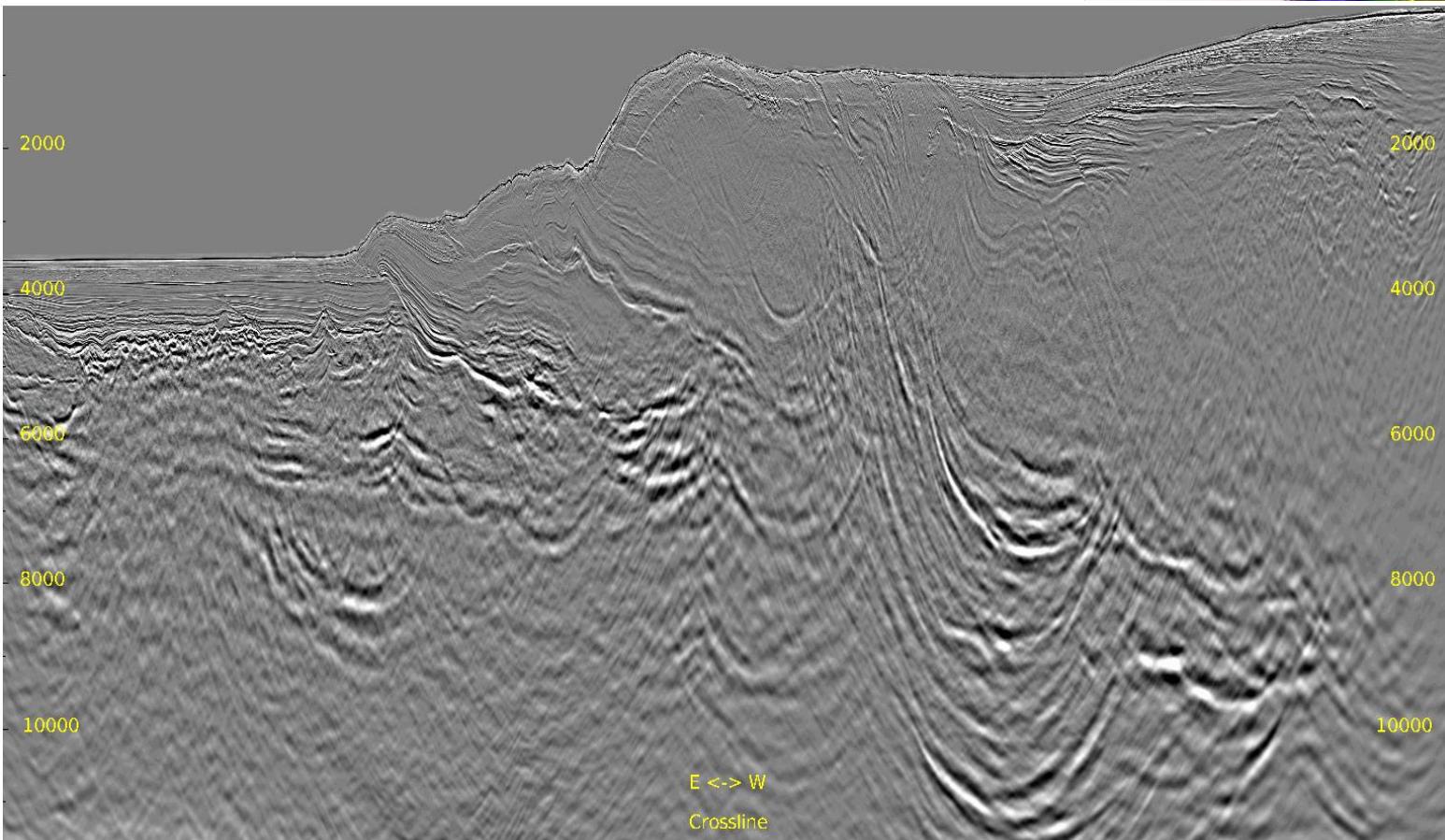
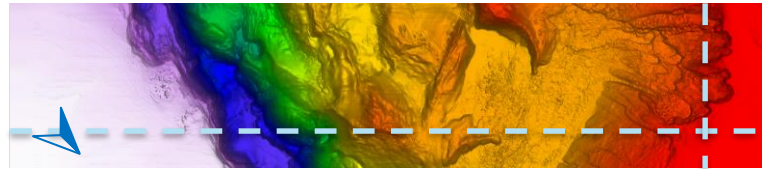
Inline 636 & Crossline 5159





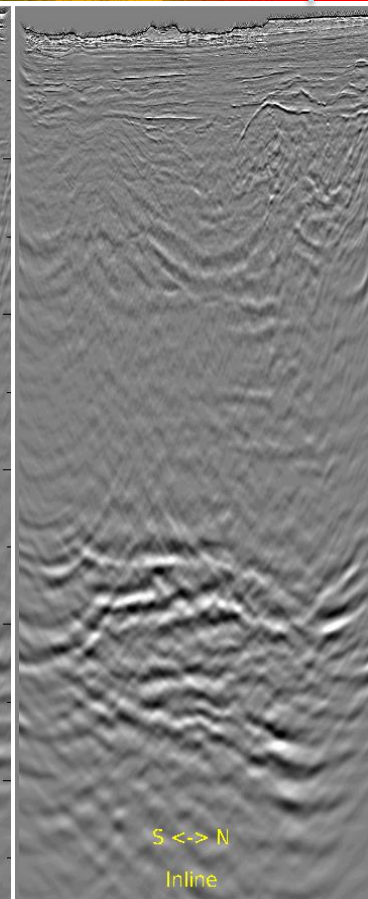
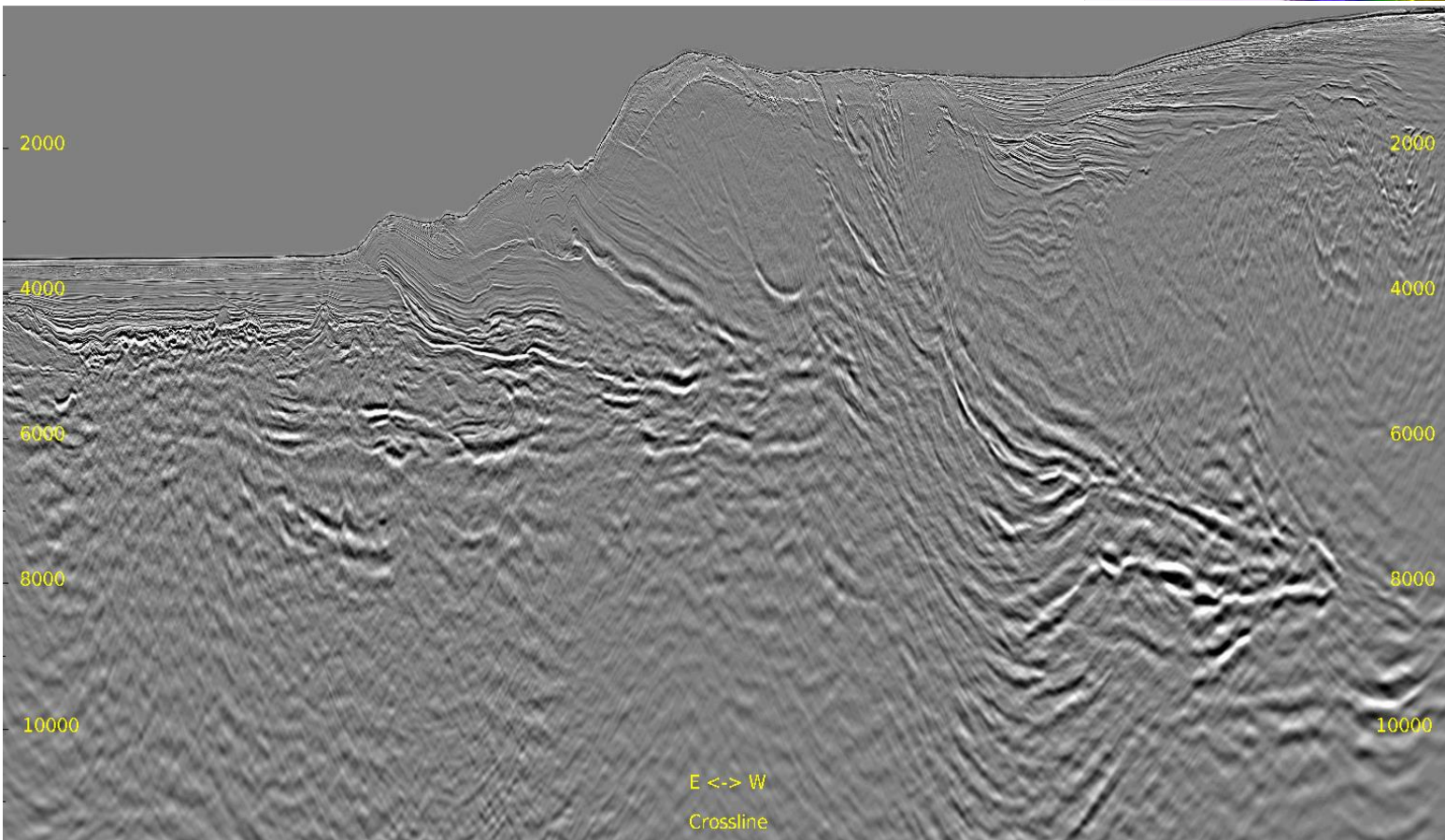
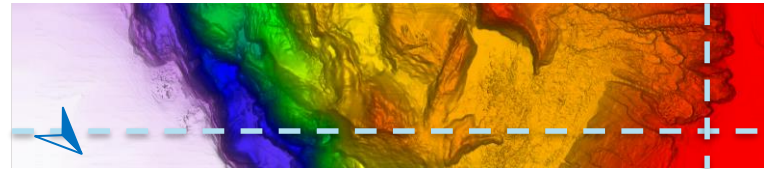
# Full Stack: Initial

Inline 636 & Crossline 5159



# Full Stack: IT5 Final

Inline 636 & Crossline 5159





- The VMB process results in a high-resolution and more geological velocity that greatly improves the stack image. We recommend to use it for final migration.
- Resulting events are shallower compared to our initial estimation at the start of the project. We recommend the final migration depth to 15km instead of 20km.