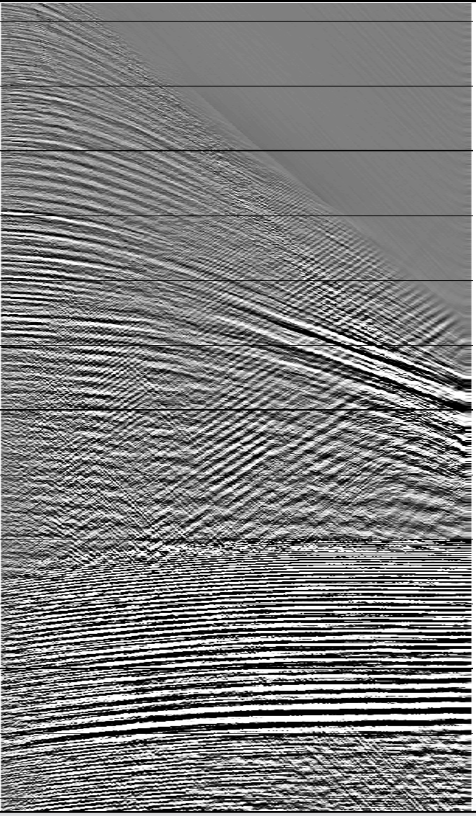
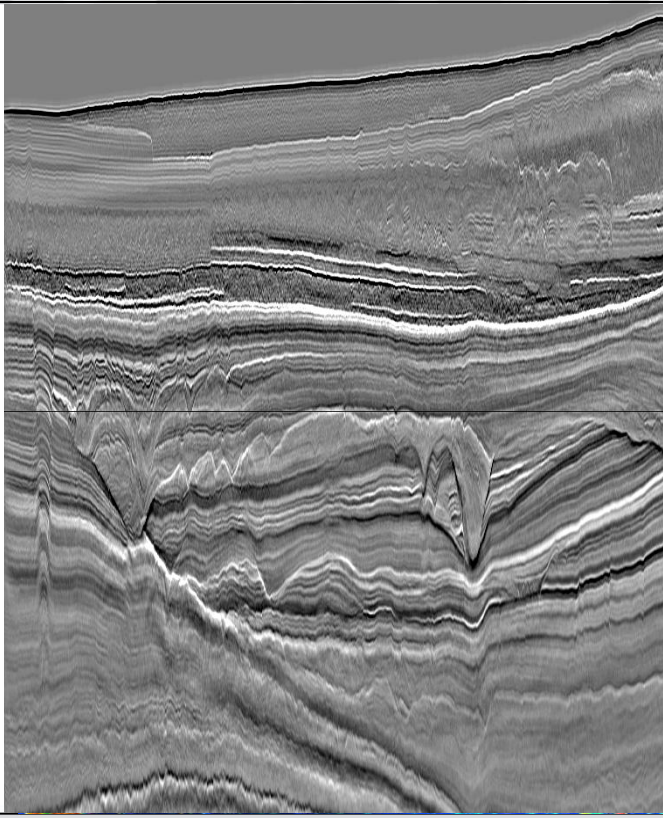
How to reduce time sharing
Stavanger 20 September 2012



Seismic interference removal on broadband data

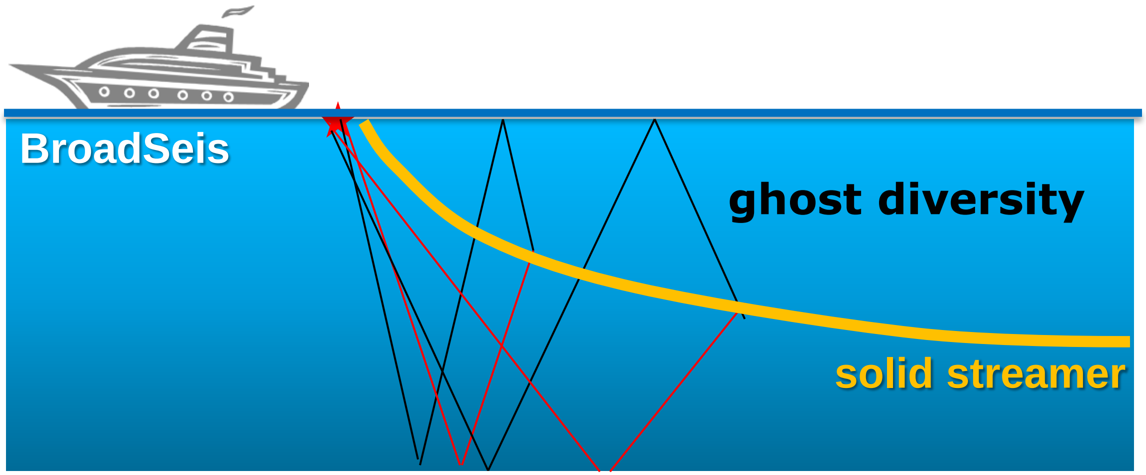


Risto Siliqi and Gordon Poole

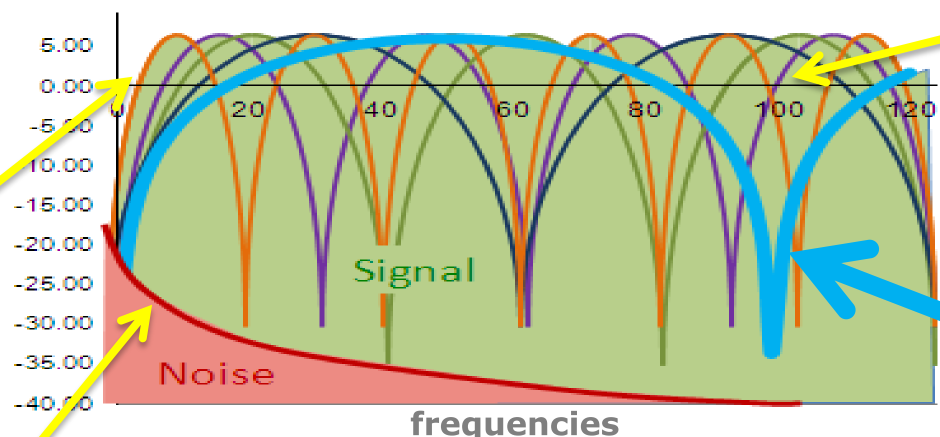
Outline

- Short description of Variable Depth Streamer (BroadSeis) technology for acquiring and processing broadband data
- Seismic Interference Noise on 3D broadband data (North Sea)
- State of the Art of Seismic Interference Attenuation
- SINAT technique on 3D broadband data
- Conclusions

Variable Depth Streamer Acquisition



Acquired Signal for any frequency bandwidth



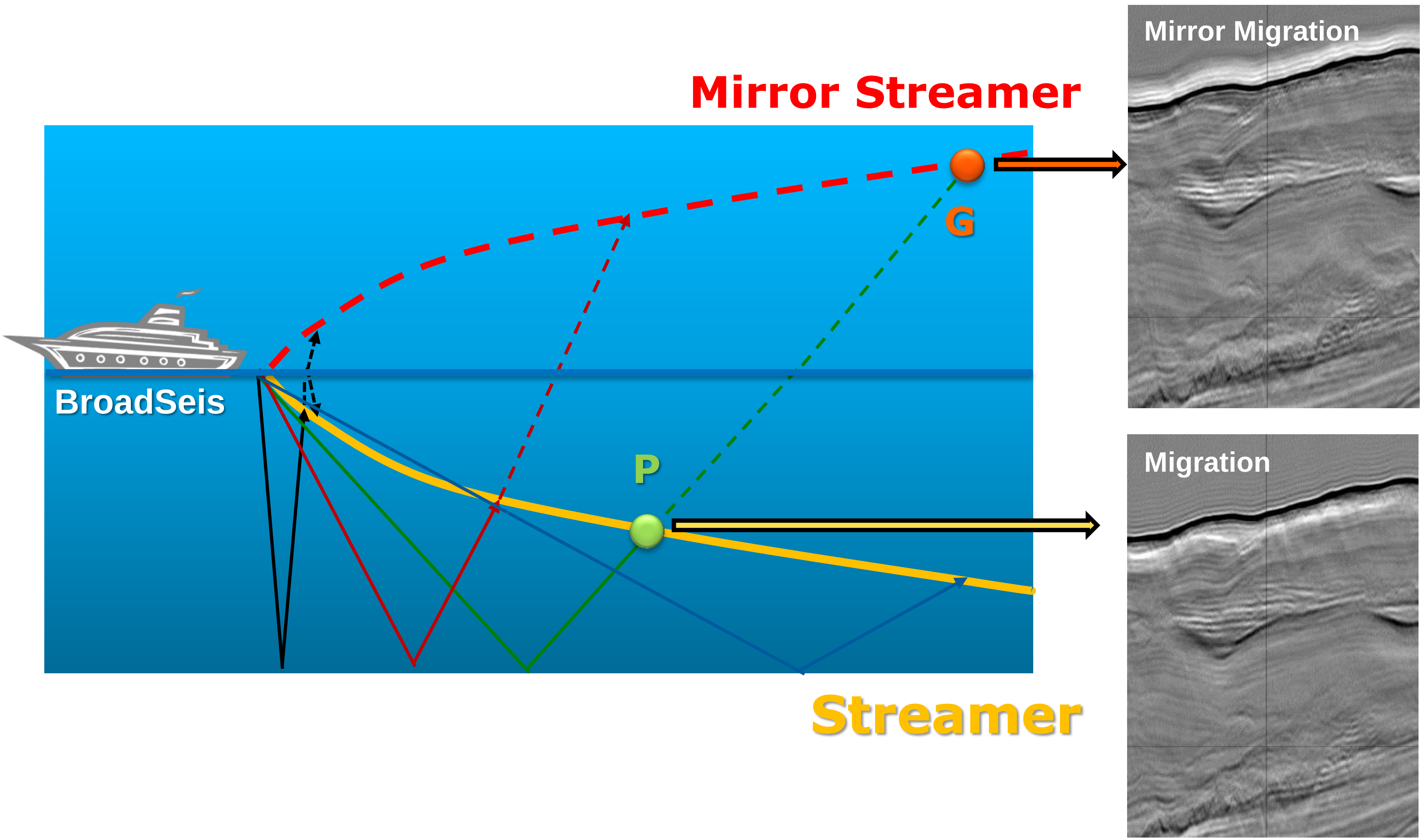
Extra High Frequencies

Extra Noise Free Low Frequencies

Conventional

Lower noise level thanks to deep tow solid streamer

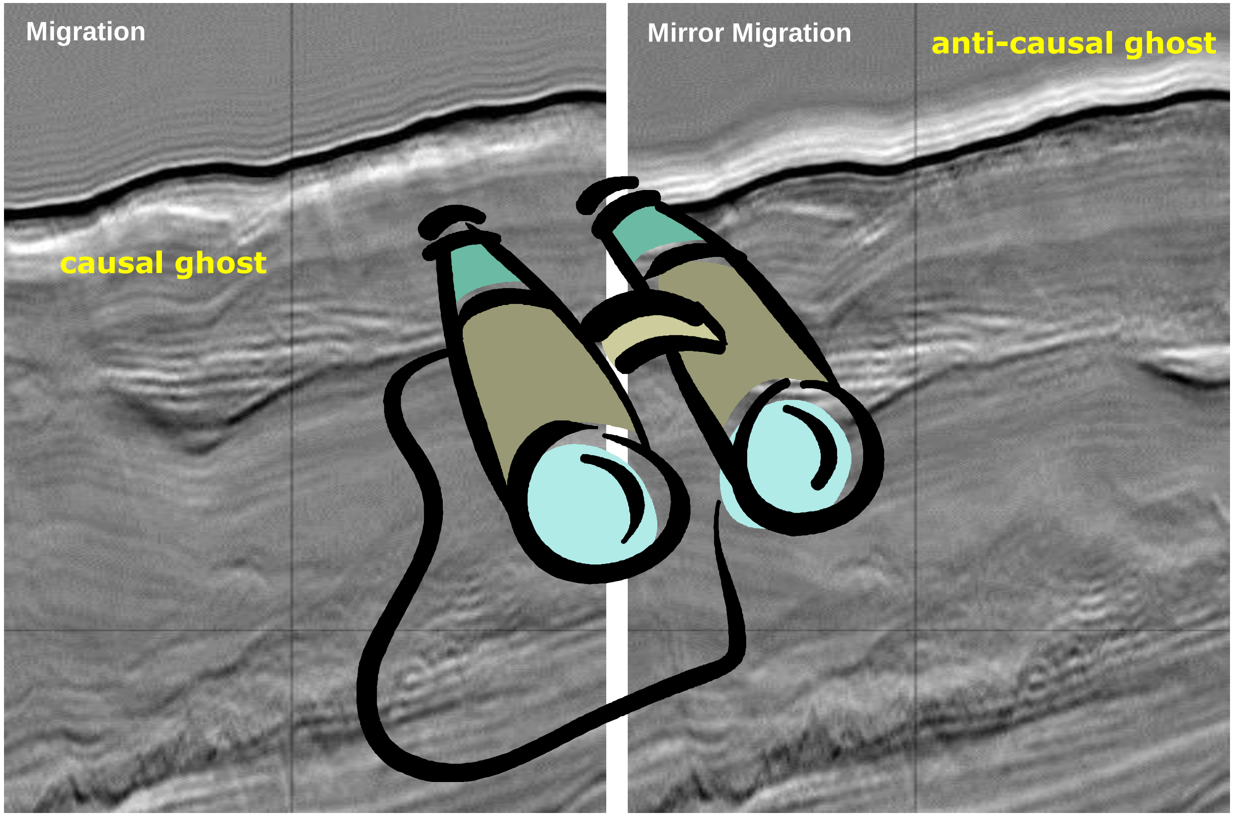
Variable Depth Streamer Processing



Variable Depth Streamer Processing

Joint Deconvolution

is like having binocular vision



Variable Depth Streamer Processing

Joint Deconvolution

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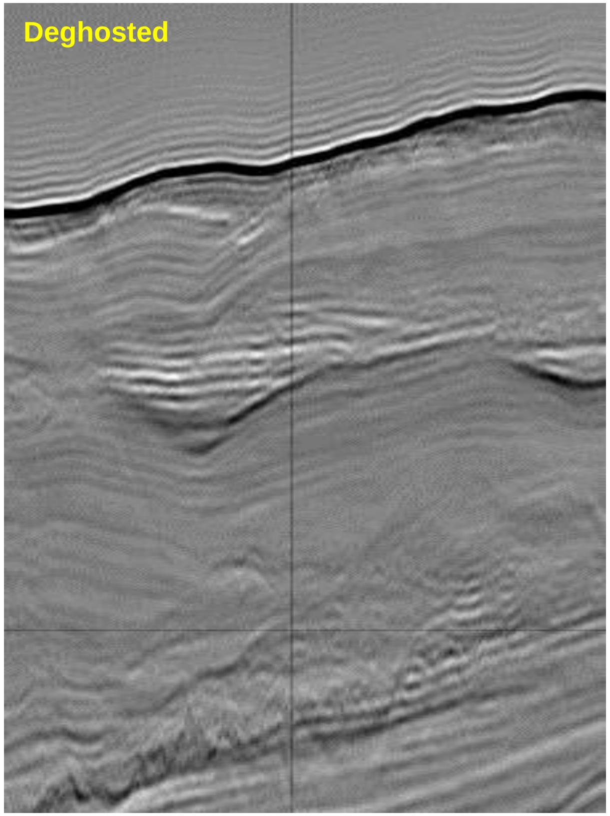

3D Deghosting:

- ✓ True amplitude
- ✓ Recovers true reflectivity
- ✓ Robust and less noisy
- ✓ Suitable for: 2D, 3D, WAZ, OBS

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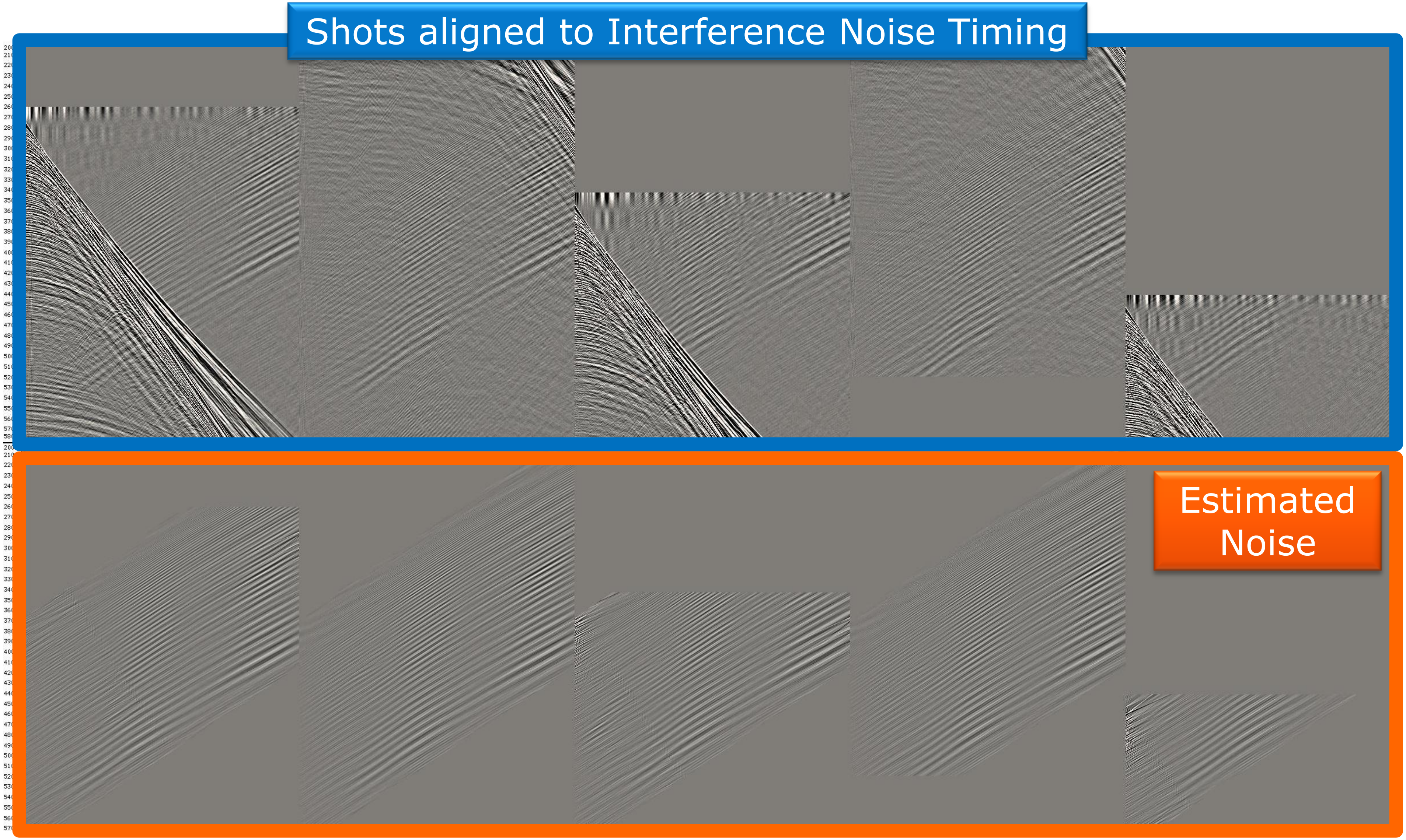
Interference Noise on Variable Depth Streamer

CGGVeritas

consecutive shots for a central cable

6 km Variable Streamer Depth from 5m to 50 m

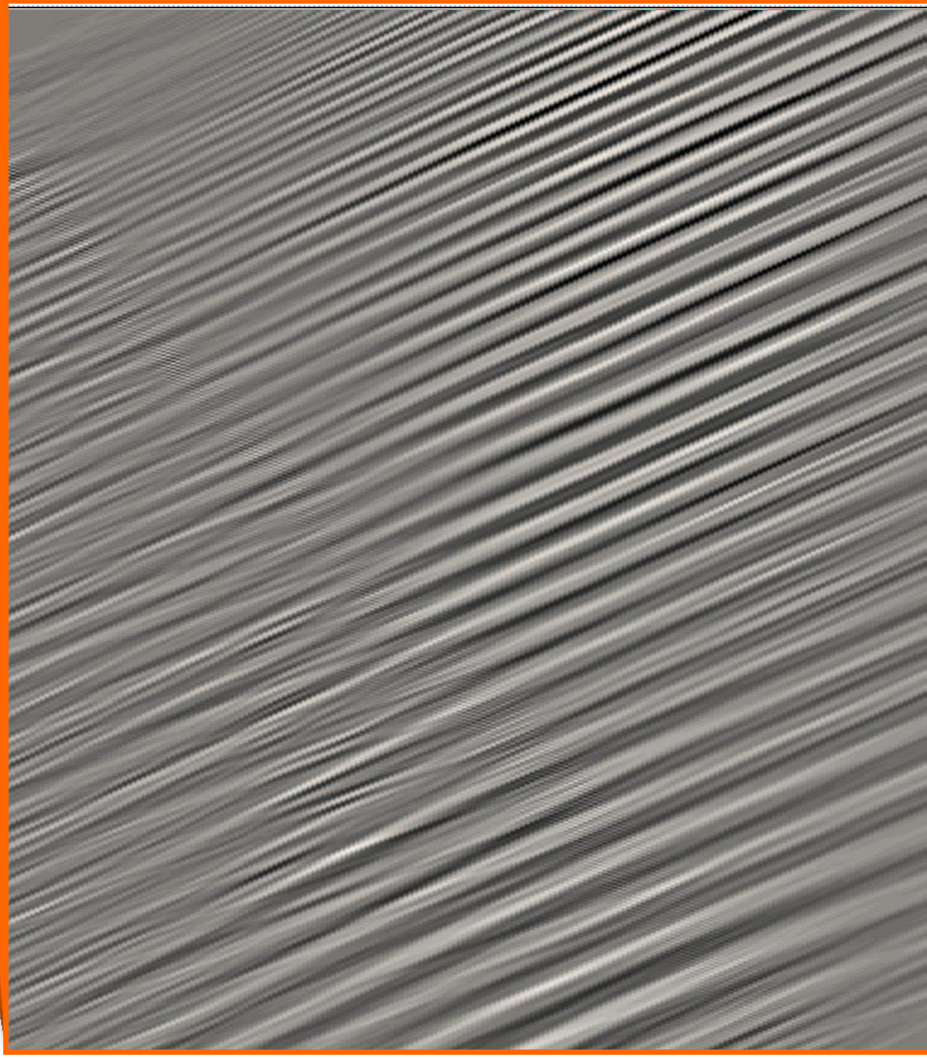
Analysis of Interference Noise



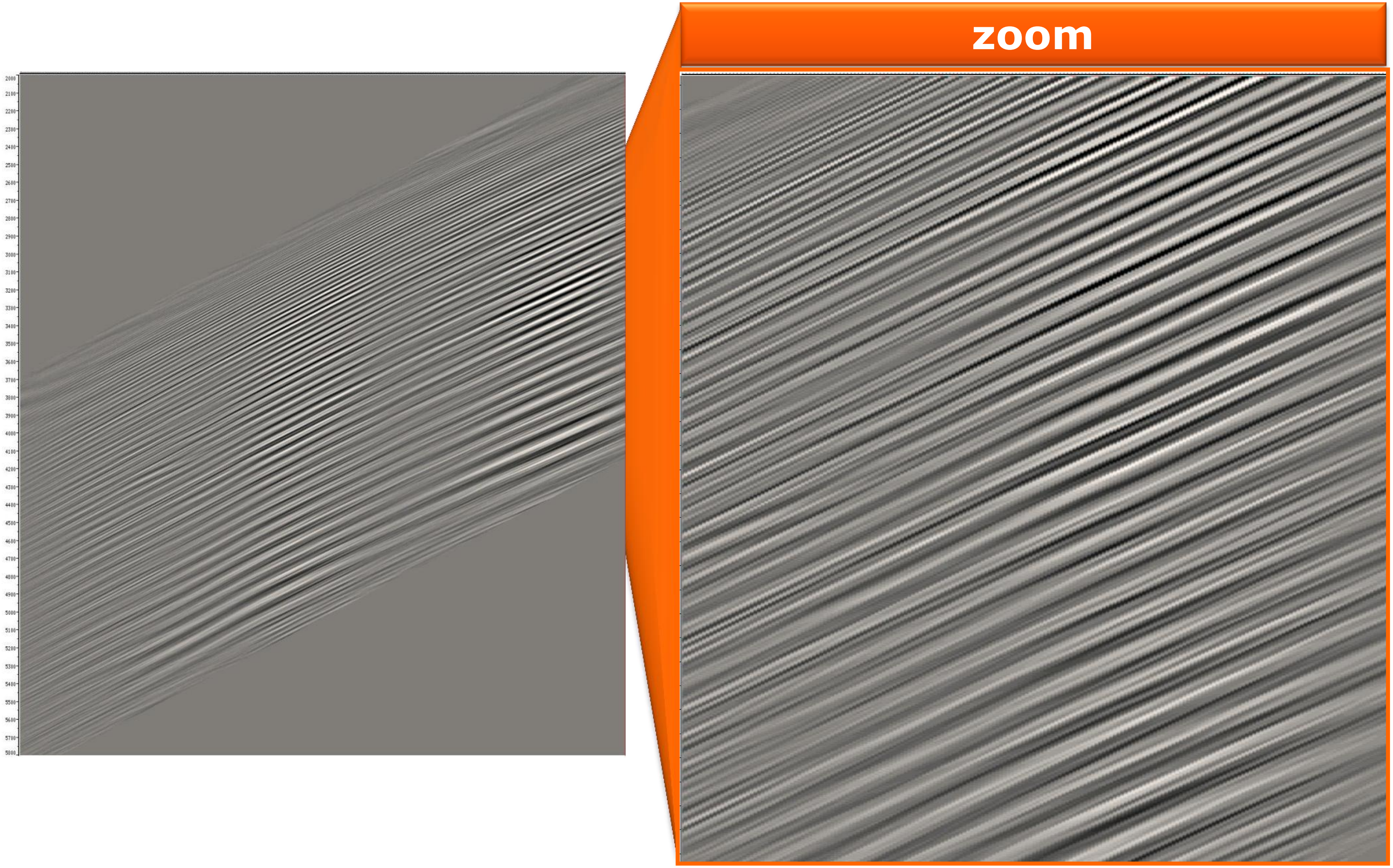
Interference Noise is not identical from shot to shot

Complexity of Interference Noise

zoom



Complexity of Interference Noise – next shot

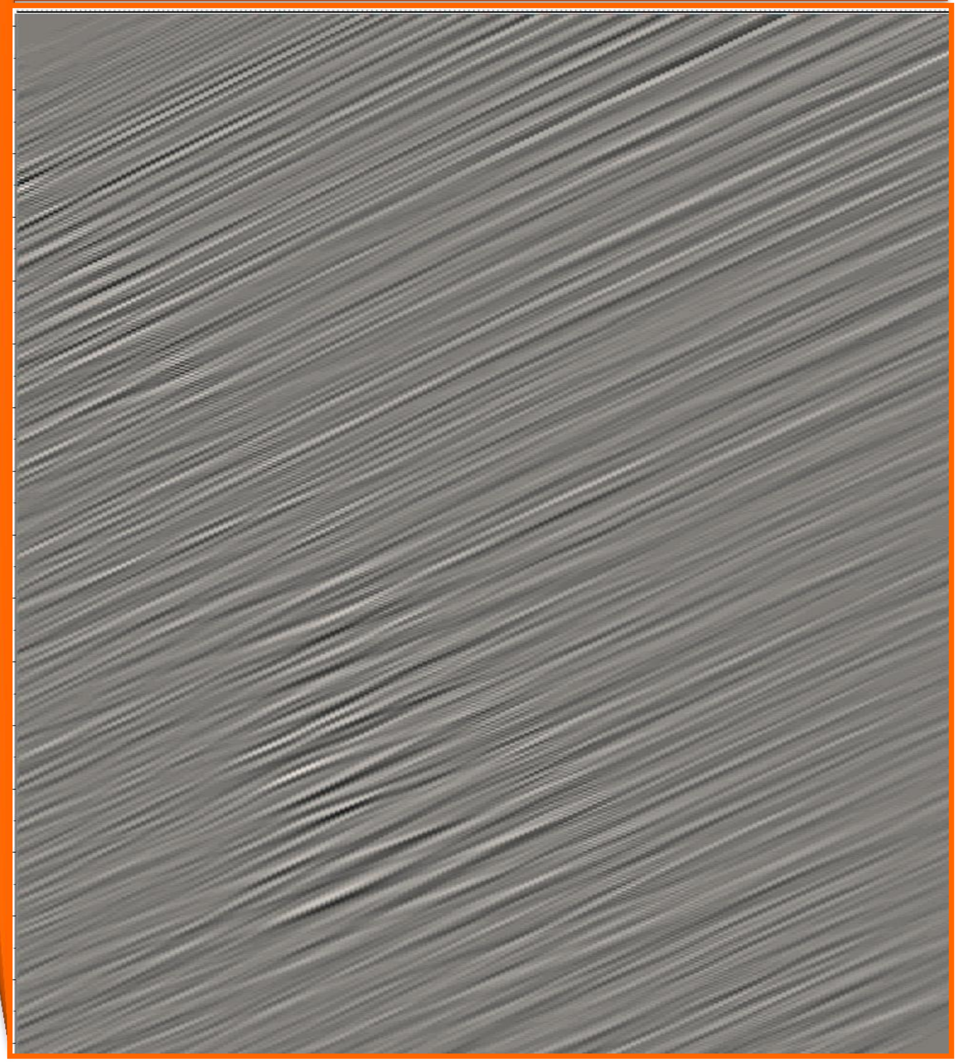


The character of the interference noise is changing quite quickly

Complexity of Interference Noise

Interference Noise differences between consecutive shots

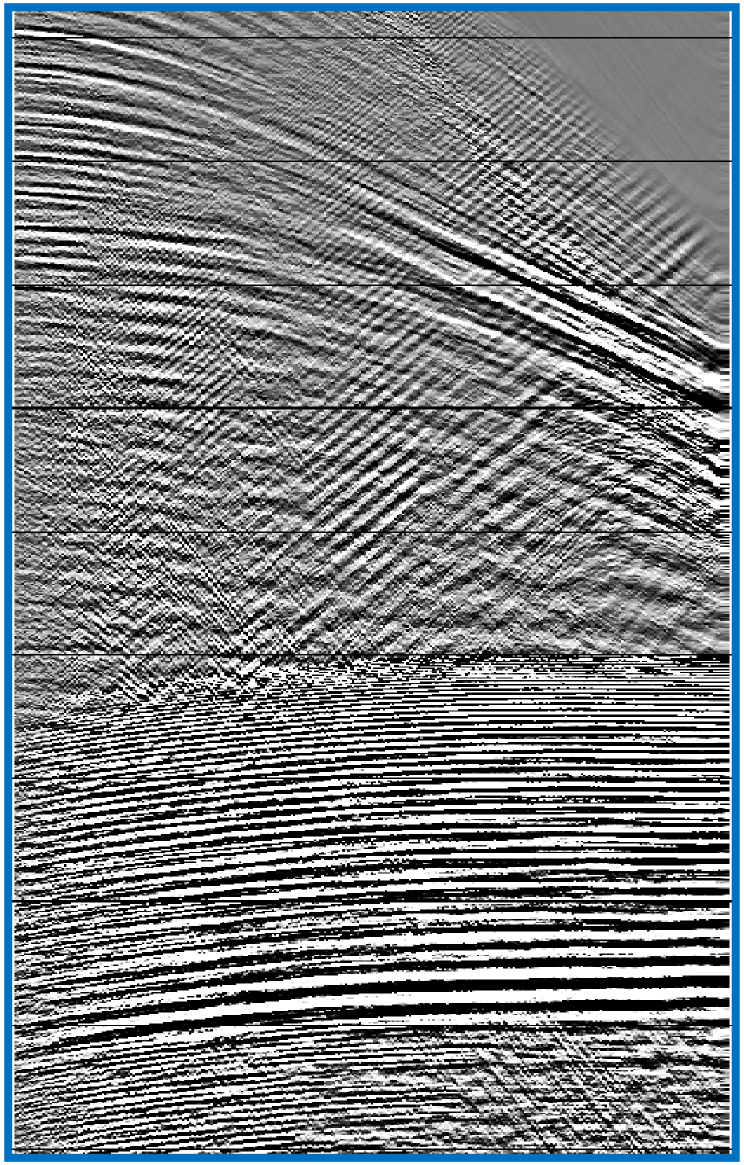
zoom



The character of the interference noise is changing quite quickly

Seismic Interference

- Other vessels, periodic shots
- With different shot intervals
- From large distances
- Can be very strong
- Hyperbolic or linear patterns
- Mainly propagated through water layer
- May travel at water bottom
- Propagation mechanism unclear
- Can be guided/dispersive



Needs to be removed!

Review of prior solutions

- Time sharing
- Automatic scaling or surgical blanking
- Crossline f-x prediction filtering
  (on common offset and common receiver gathers)
- Arrival time picking, coordinate estimation, flattening,
  f-k or Radon filtering
- Dynamically re-adjusting own shot interval
- Deriving interference noise timing and modeling

Most related prior work

Huaien et al (1989 SEG)

" Attenuation of marine coherent noise"

Crossline f-x prediction filter
(on common offset and common receiver gathers)

Gulunay and Pattberg (2001 SEG)

"Seismic interference noise removal"

Inline f-x prediction error filter followed by f-x-y prediction filter

Gulunay, Magesan, and, Baldoc (2004 SEG)

"Seismic Interference Noise Attenuation (SINAT)"

Gulunay (2007 TLE, Dec Issue)

"Two different Algorithms for seismic interference noise attenuation"

SINAT's Assumptions

SINAT: Seismic Interference Noise ATtenuation

uses the fact that:

SIGNAL

- Predictable in common shot domain
- Predictable in common channel domain

INTERFERENCE NOISE

- Predictable in common shot domain
- **Unpredictable** in common channel domain

SINAT: Seismic Interference Noise Attenuation

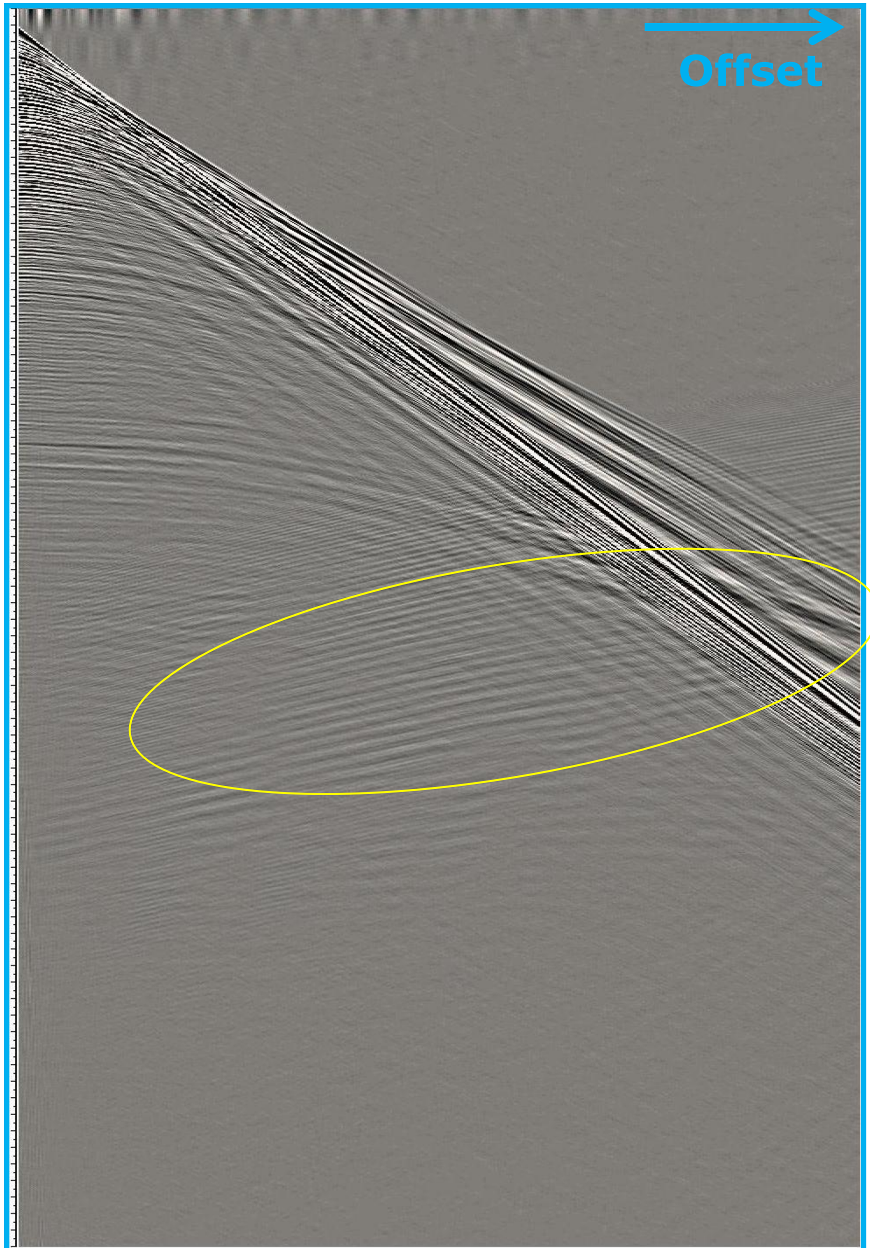
SINAT consists of two stages:

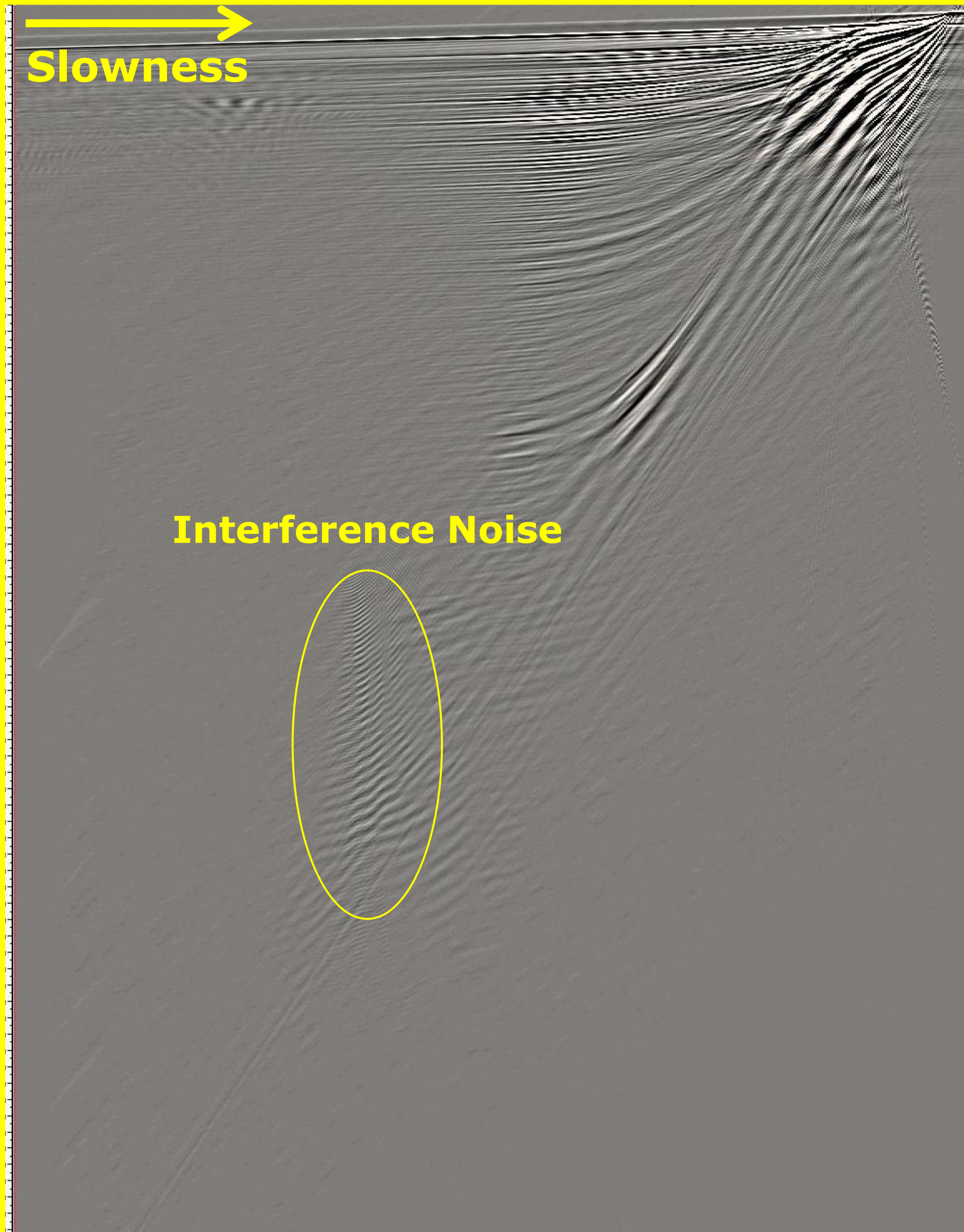
1) Flagging traces and time windows affected by noise
2) Reconstructing the affected energy using f-x reconstruction

The method is more effective when applied in the tau-p domain because:

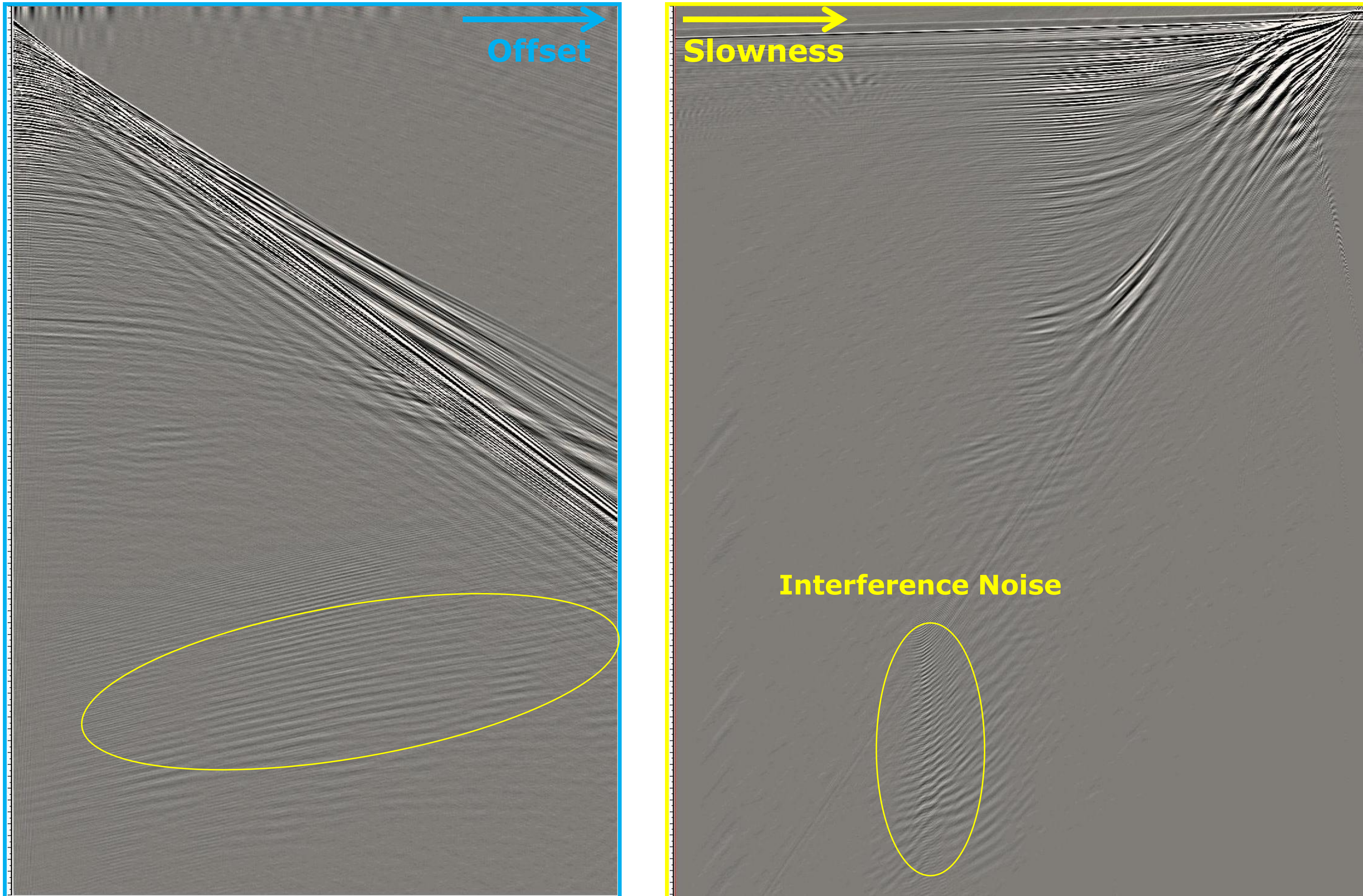
- ✓ The shot-p domain naturally **separates signal and noise** when they have a different apparent velocity (they fall on different p-traces)
- ✓ This helps with more aggressive noise attenuation and **signal preservation**
- ✓ The f-x prediction will only have to **reconstruct signal** when it shares the same p-trace as the noise

Advantages of Tau-p domain – Shot 2

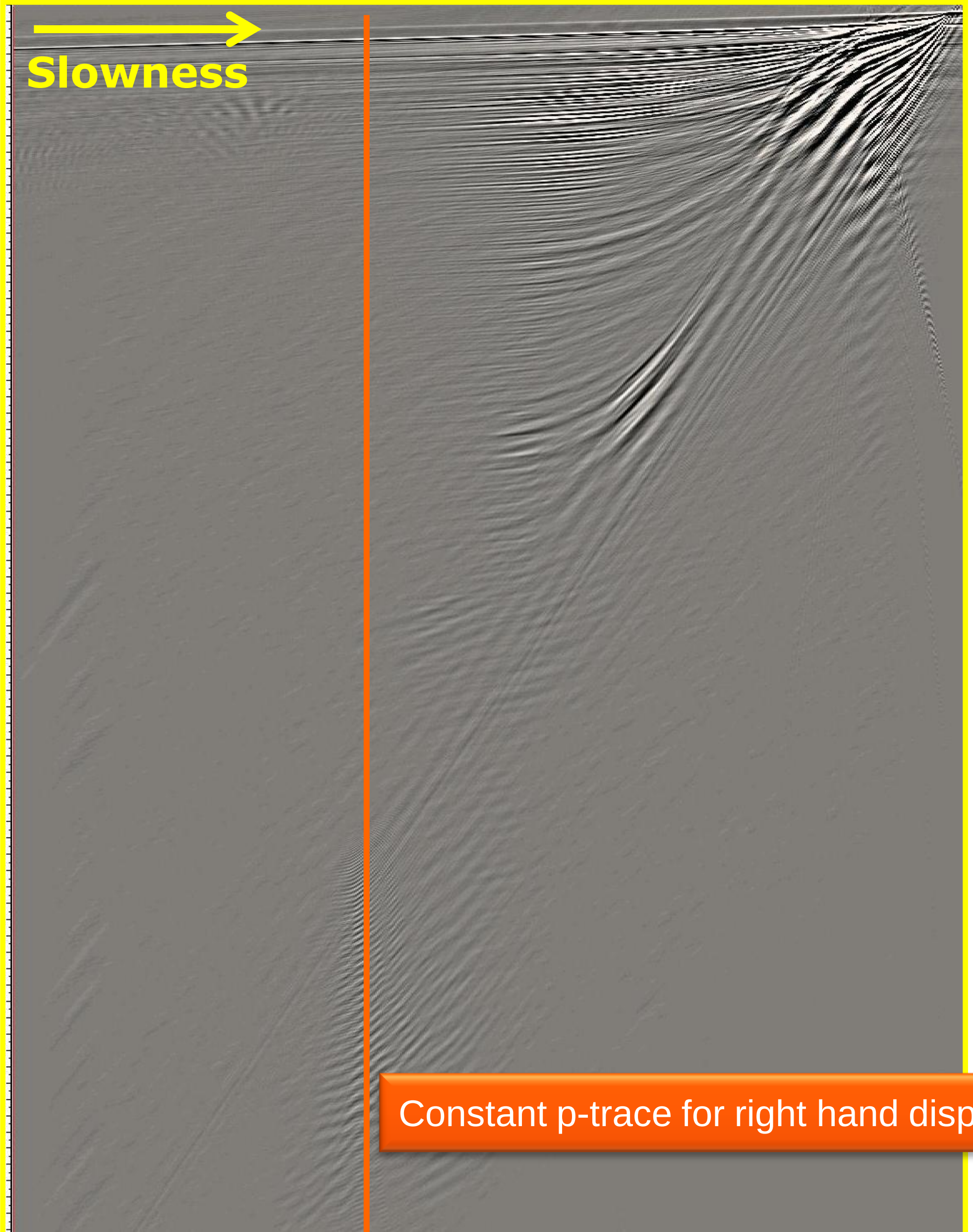


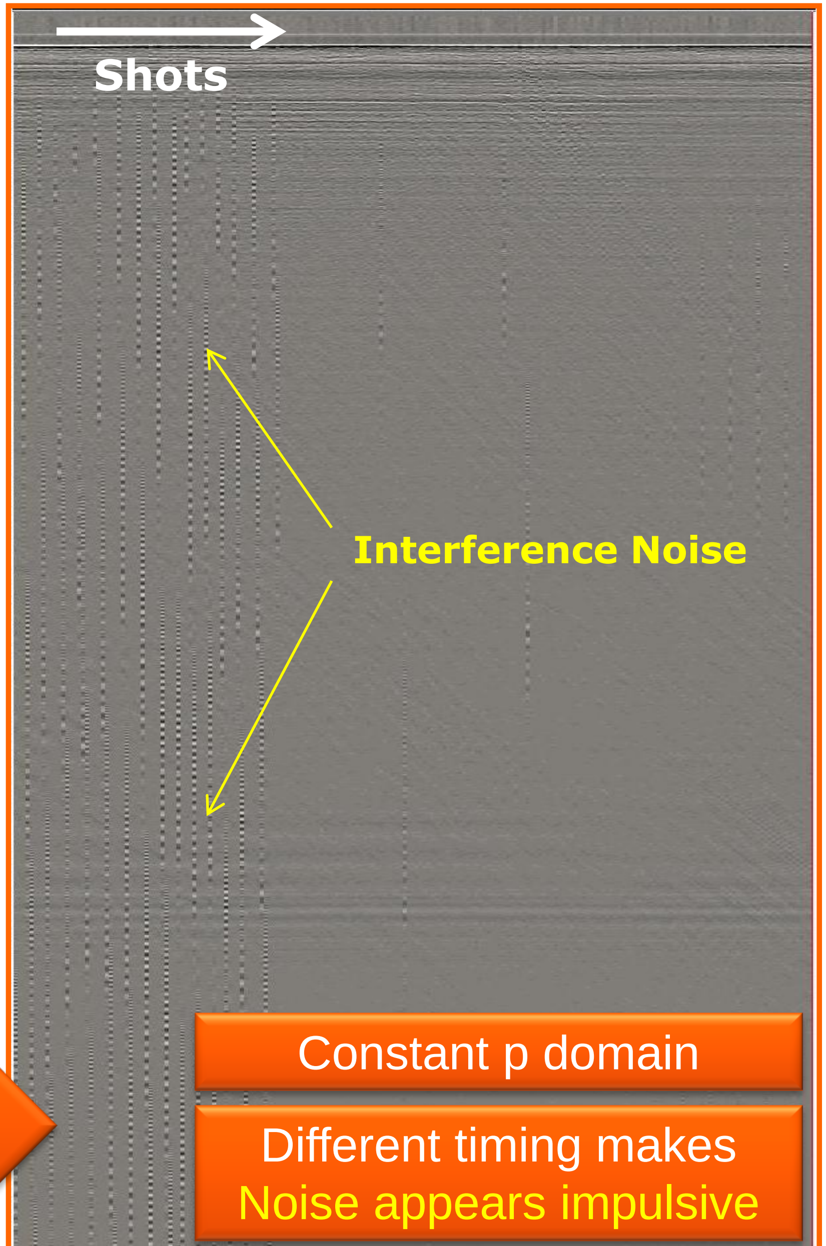


Advantages of Tau-p domain – Shot 3



Advantages of Tau-p domain





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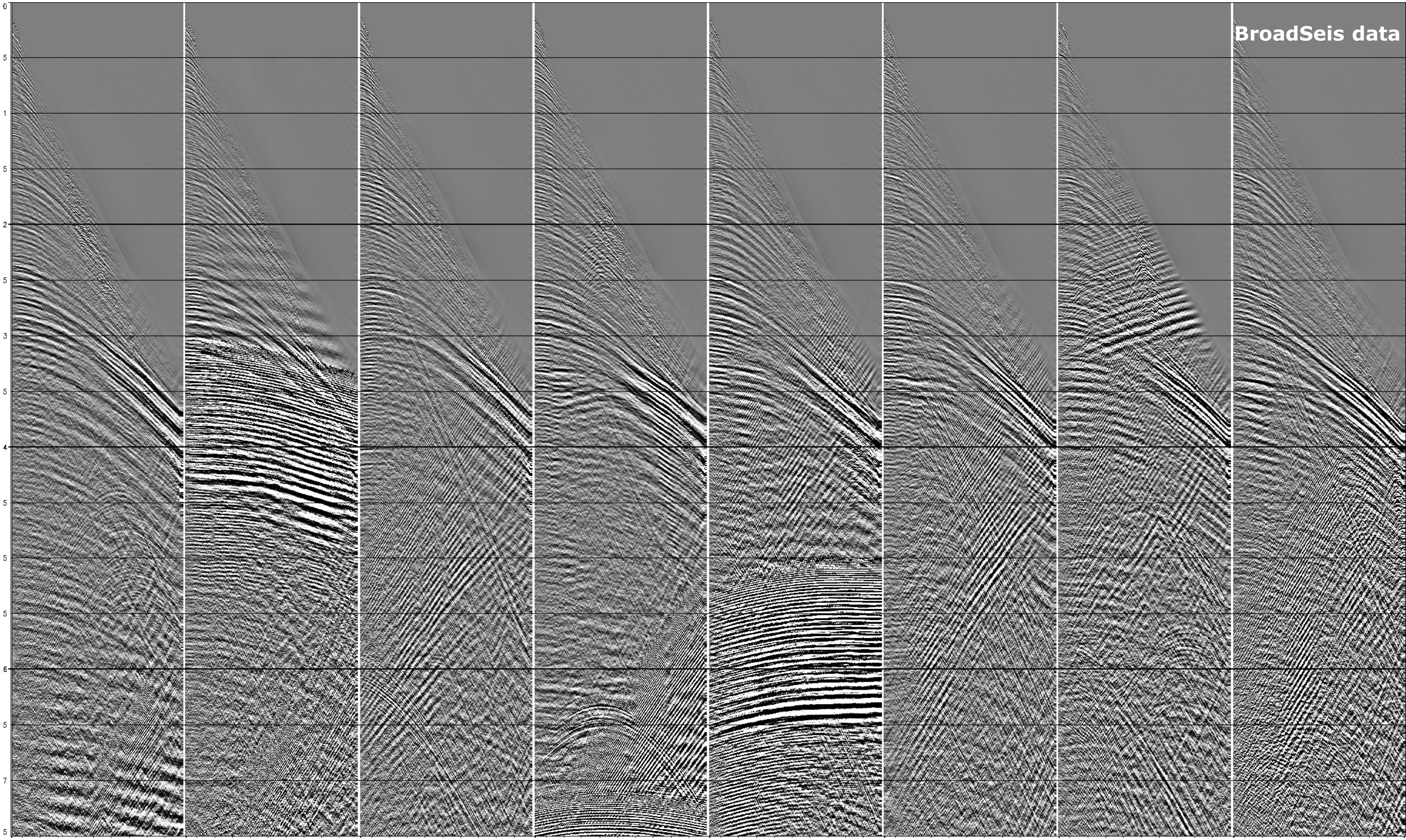
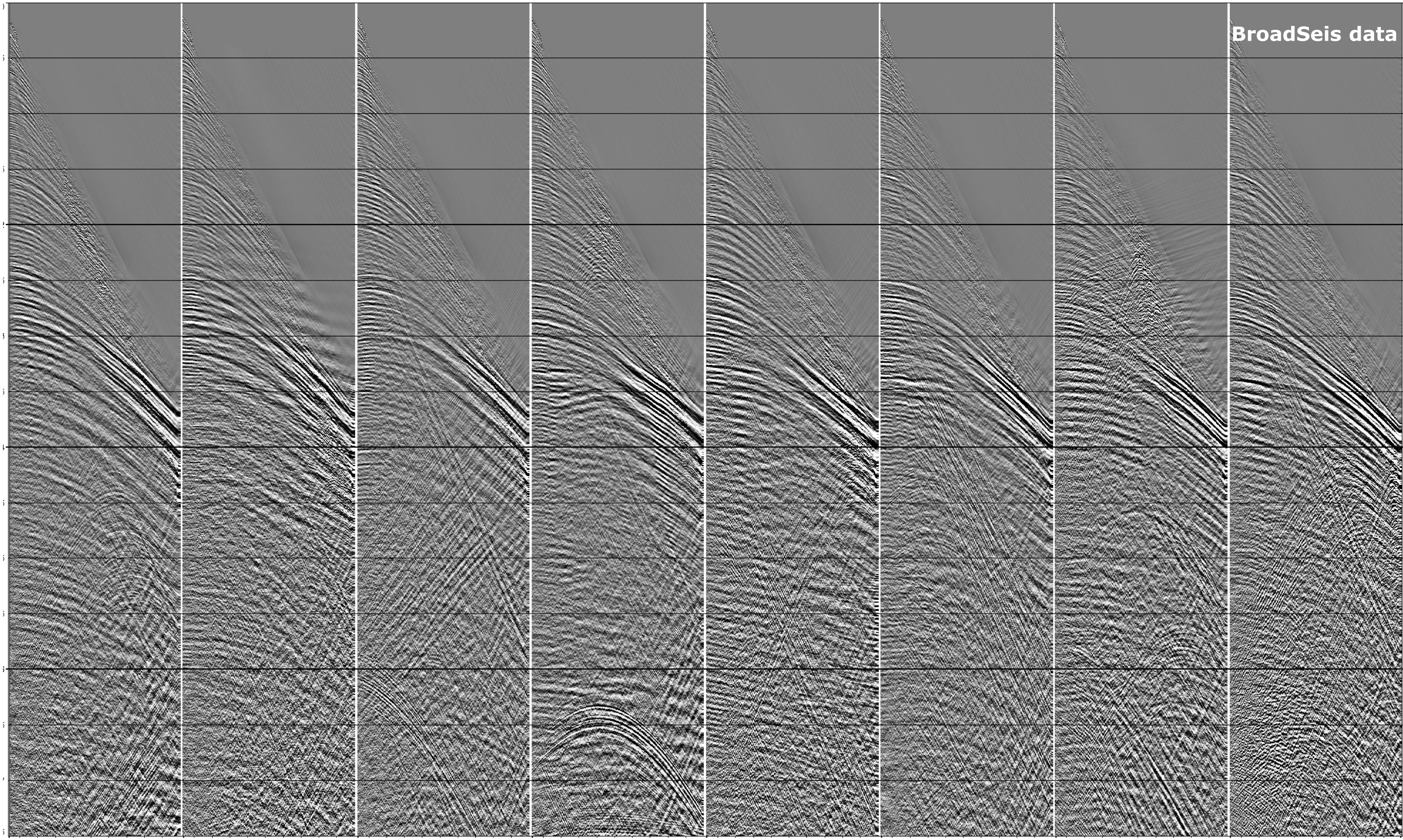
Input shots (with Interference Noise)

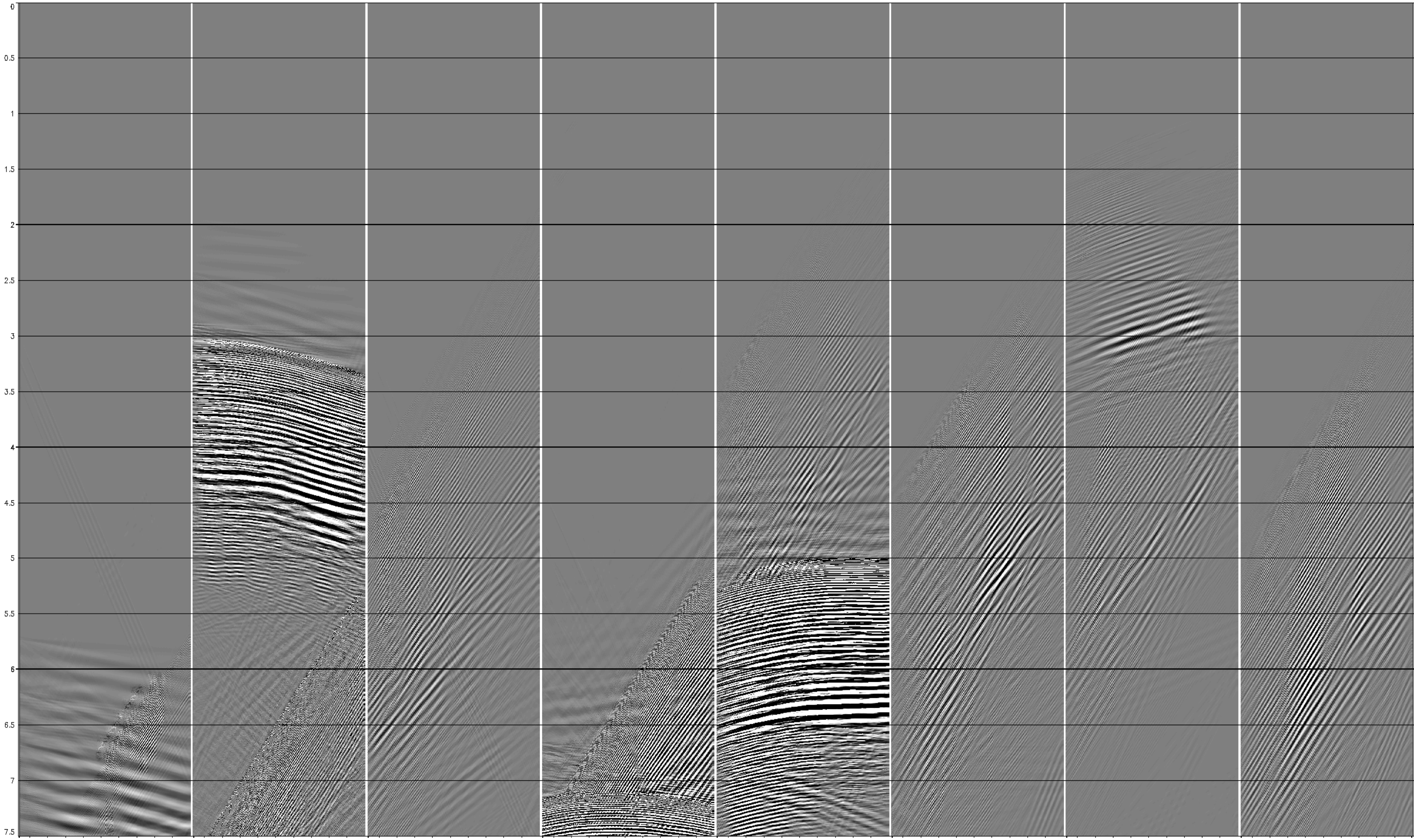


Input shots with at least **three sources of interference noise**

Output shots (without Interference Noise)

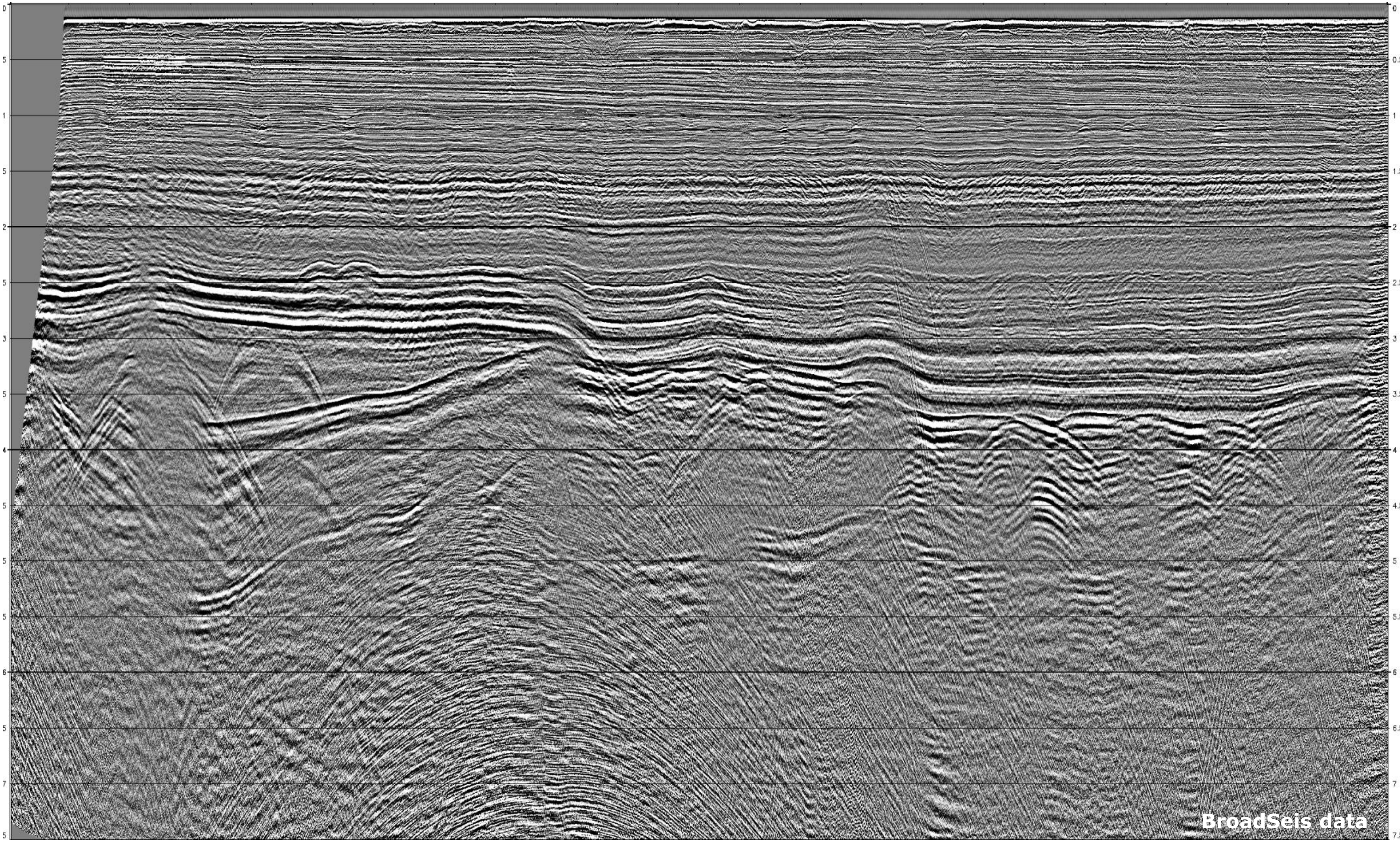


Difference – Removed Interference Noise

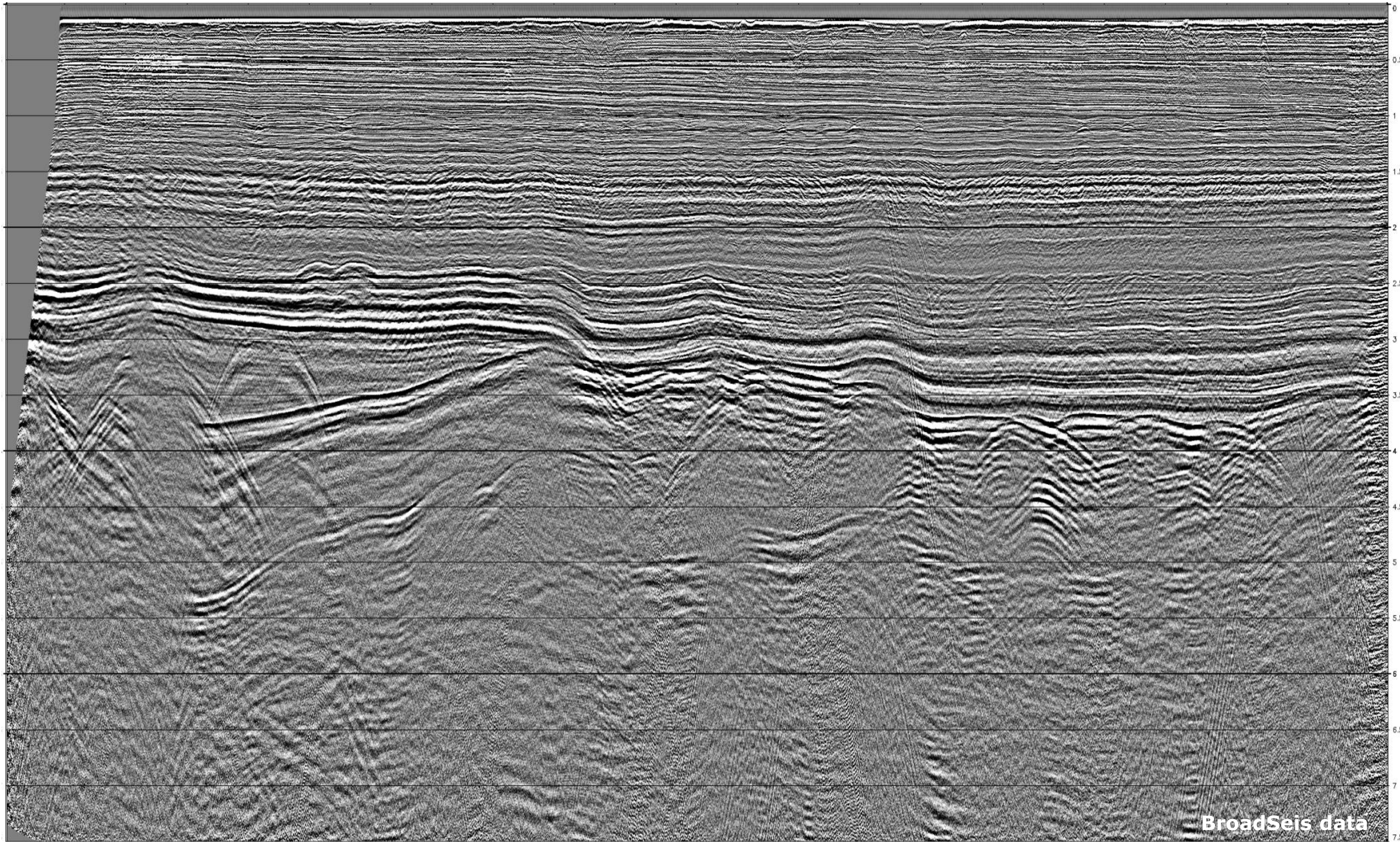


Broadband Seismic Interferences

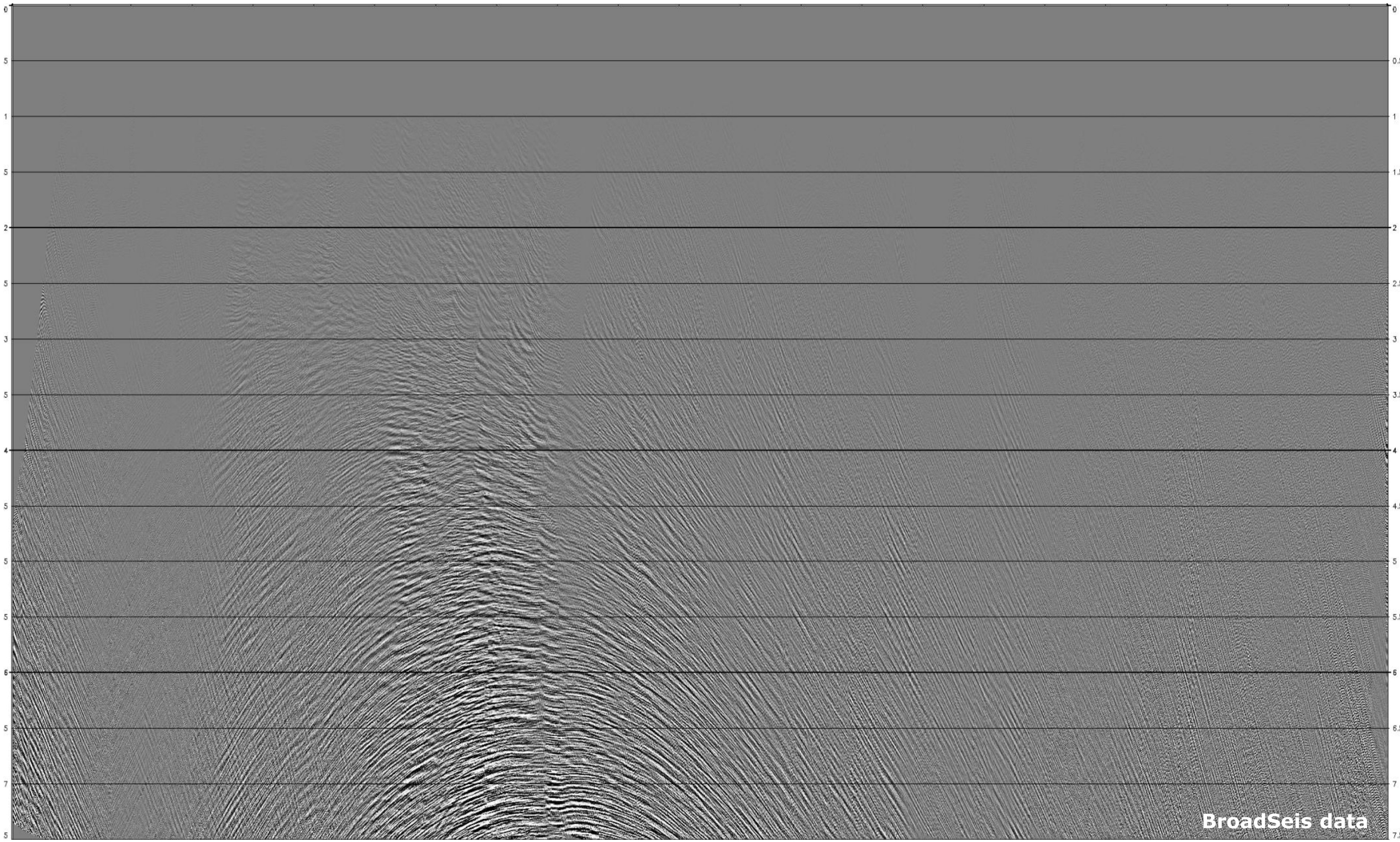
Input stack (with Interference Noise)



Output stack (without Interference Noise)

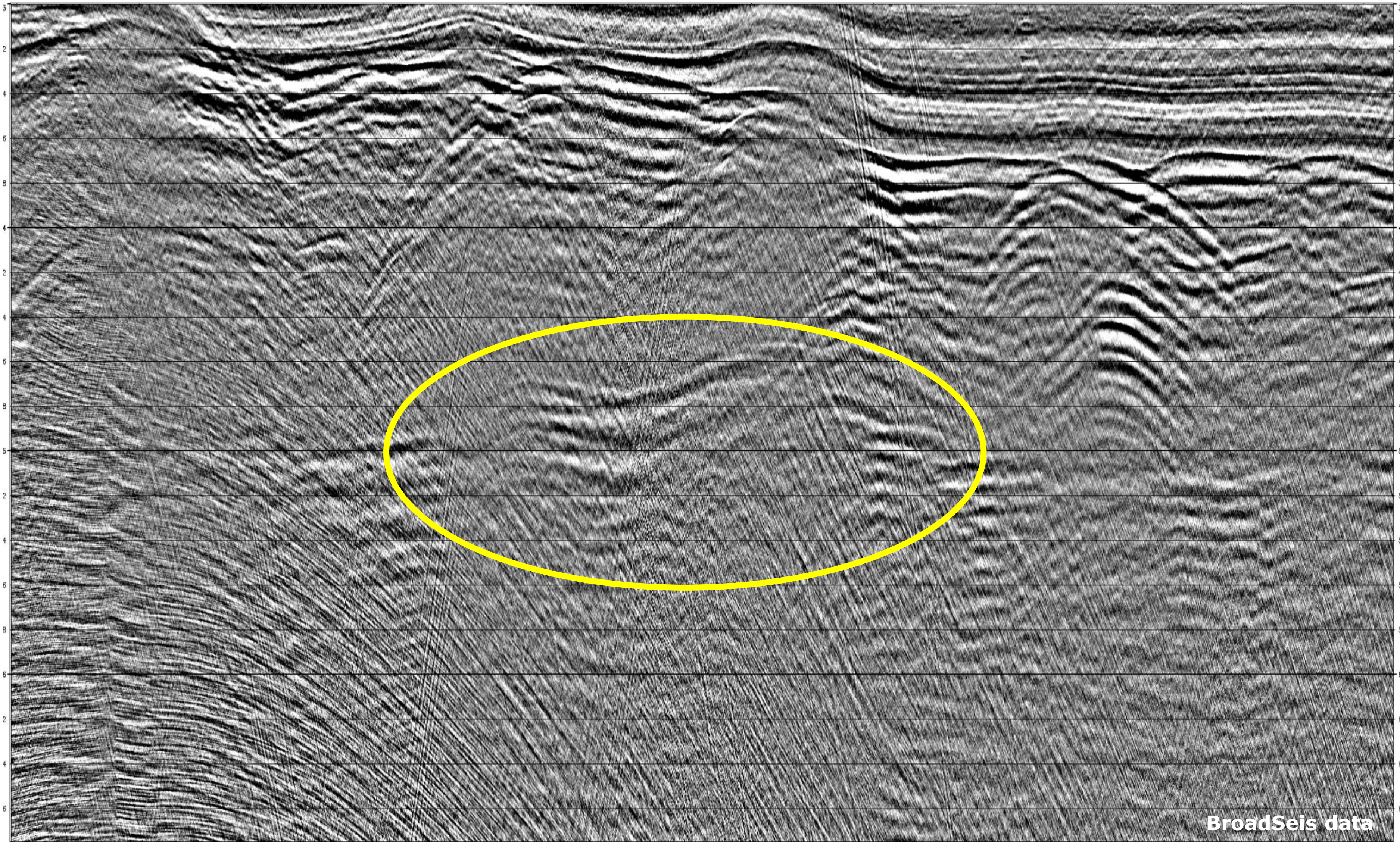


Difference – Removed Interference Noise



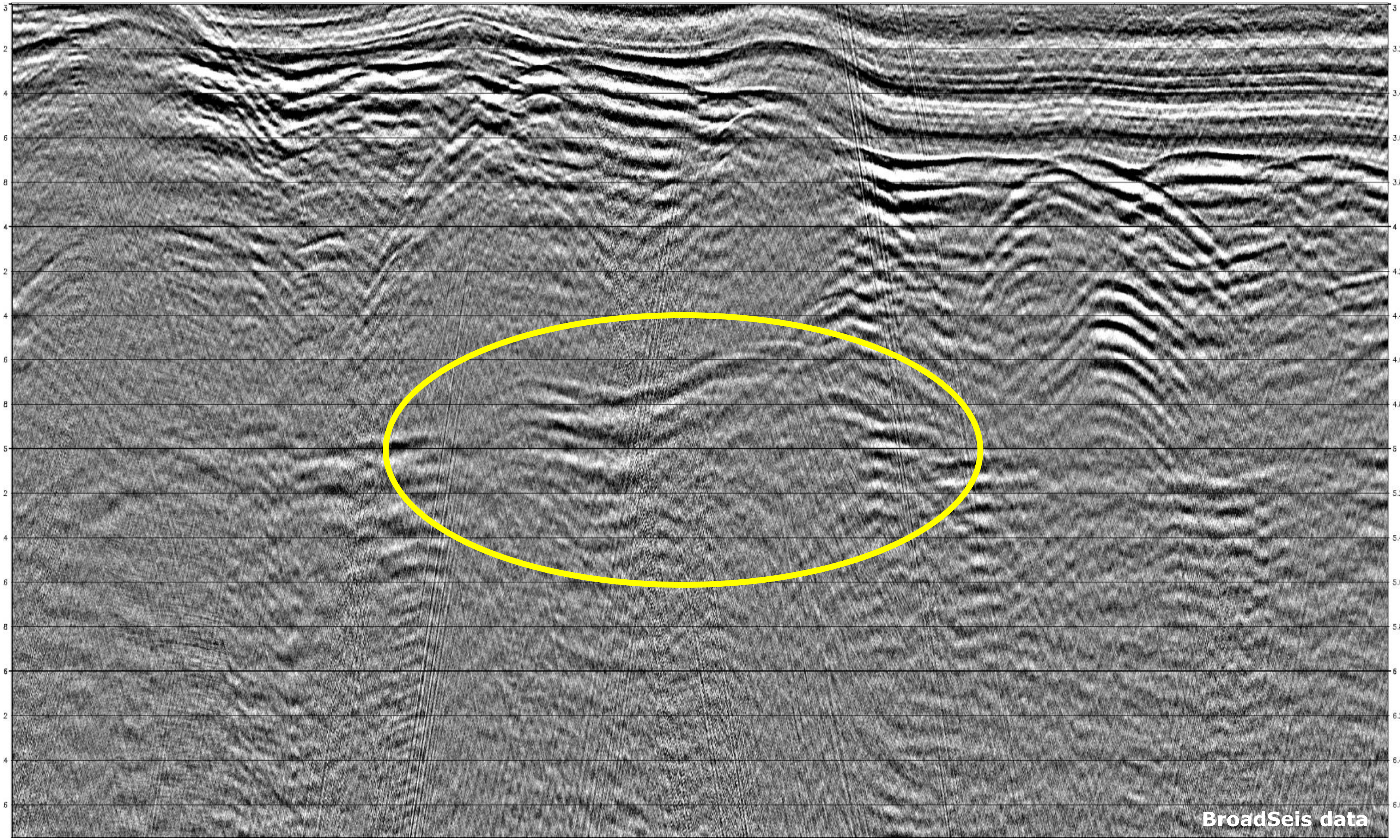
Broadband Seismic Interferences

Zoom: Input stack (with Interference Noise)



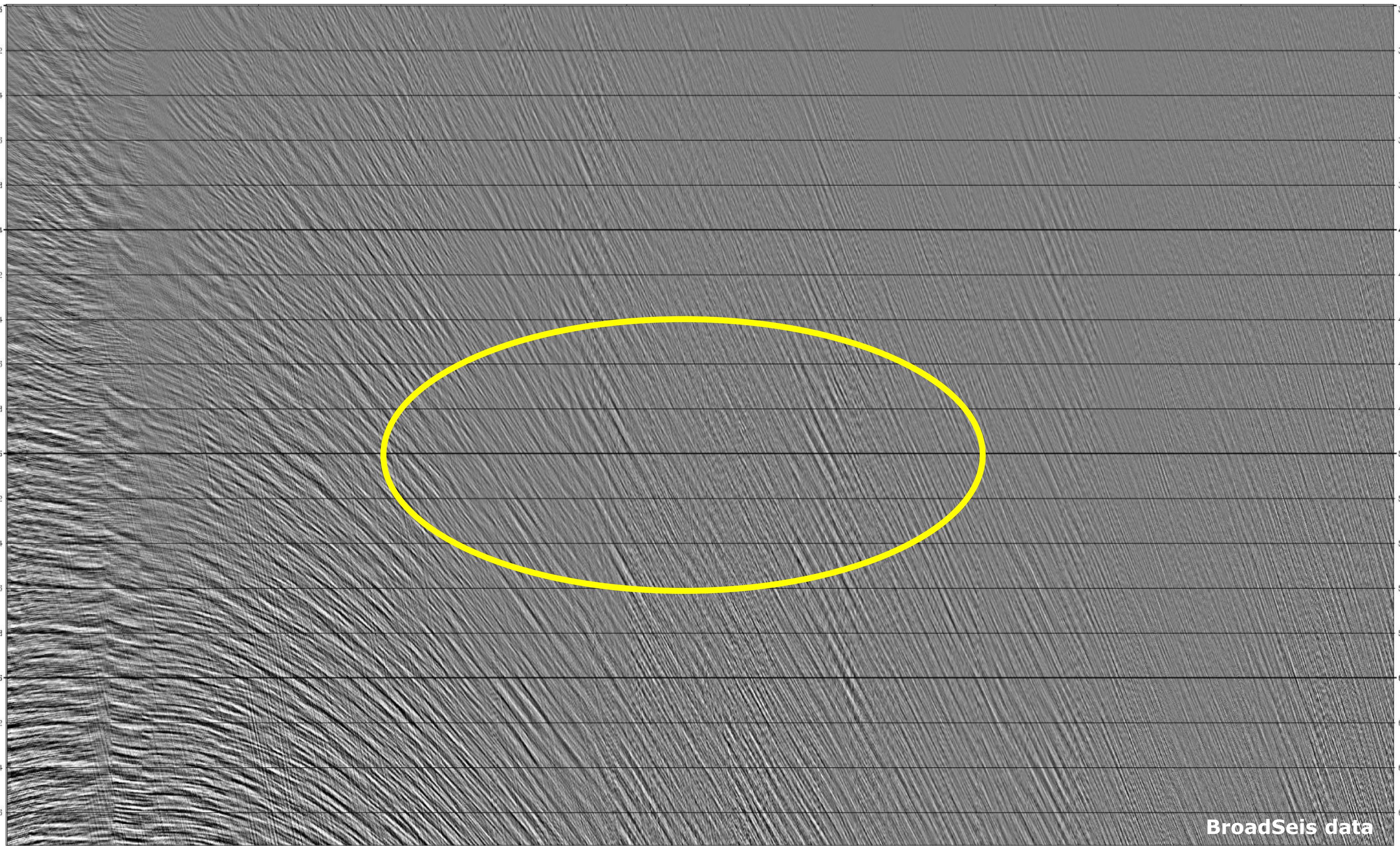
Very well preserved Low Frequency Signal

Zoom: Output stack



Very well preserved Low Frequency Signal

Zoom: Difference - Removed Interference Noise



Very well preserved Low Frequency Signal

Impact of SI attenuation on the processing sequence

Comparison of full broadband processing

with and without Seismic Interference Attenuation

SI removal specificities

- SI removal (SINAT)
- Direct arrival attenuation
- Designature
- Denoise
- Demultiple
- Migration Mirror Migration
- Joint deconvolution

- Direct arrival attenuation
- Designature
- Denoise
- Demultiple
- Migration Mirror Migration
- Joint deconvolution

BroadSeis specificities

Image Gathers – sequence without SINAT

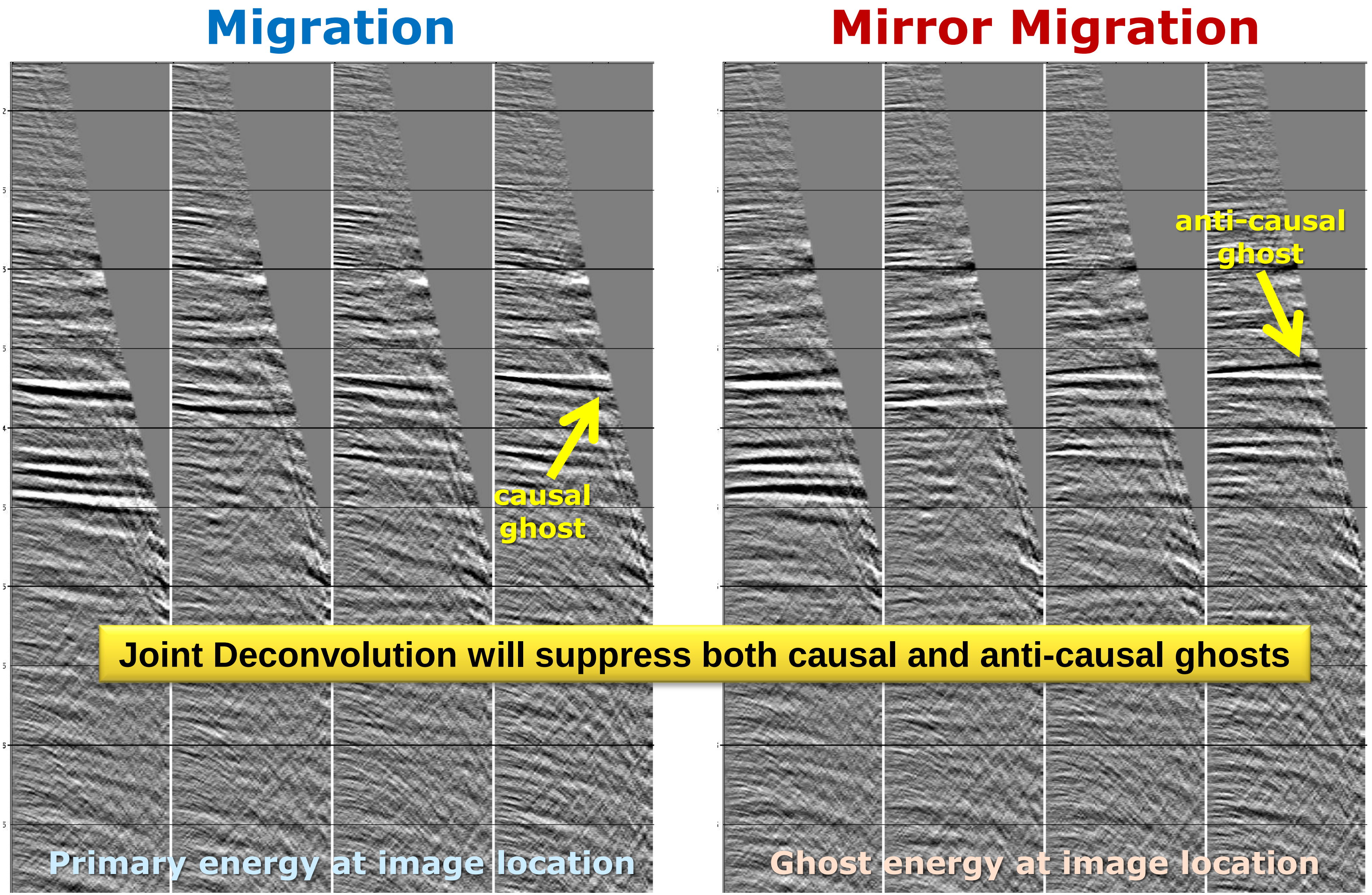
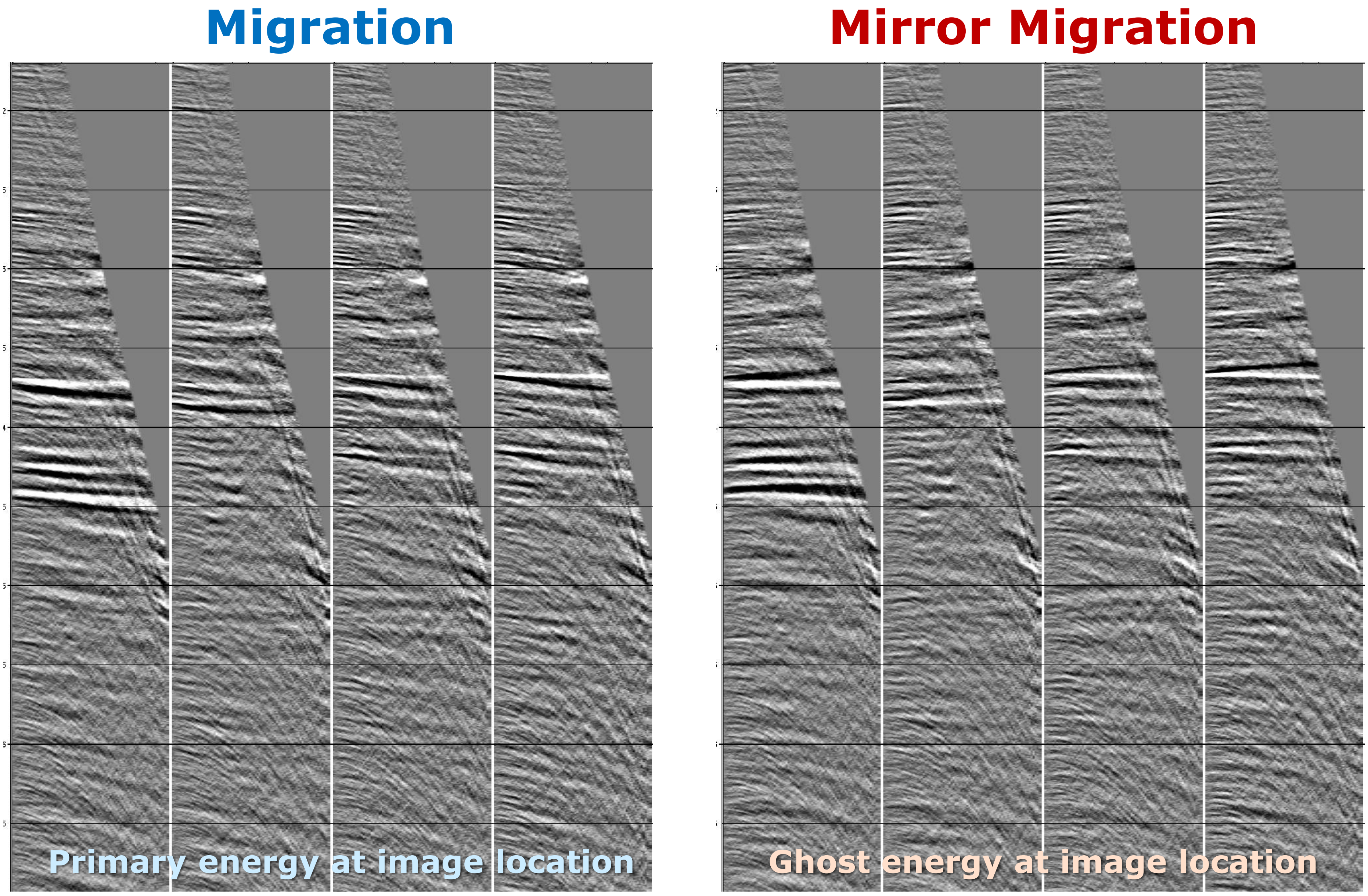
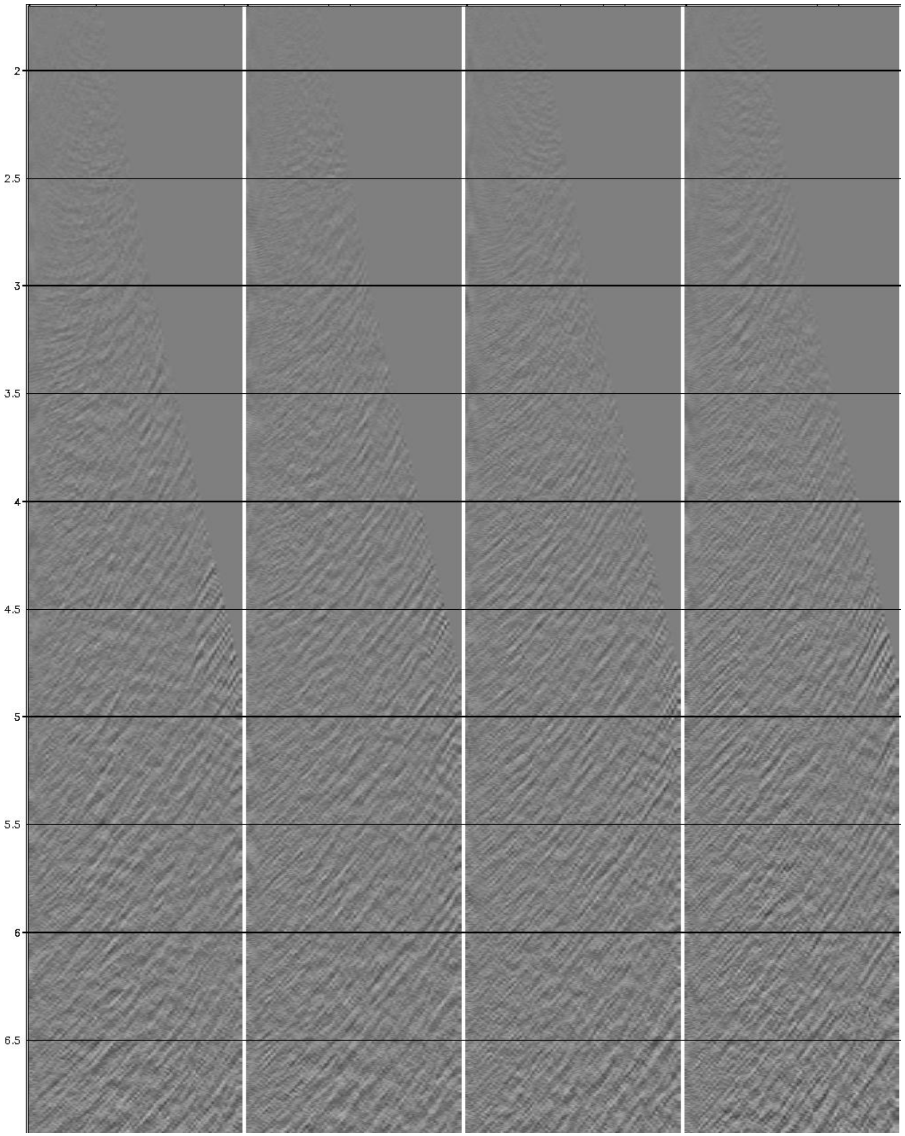


Image Gathers – sequence with SINAT



Difference between sequences with and without SINAT

Migration



Mirror Migration

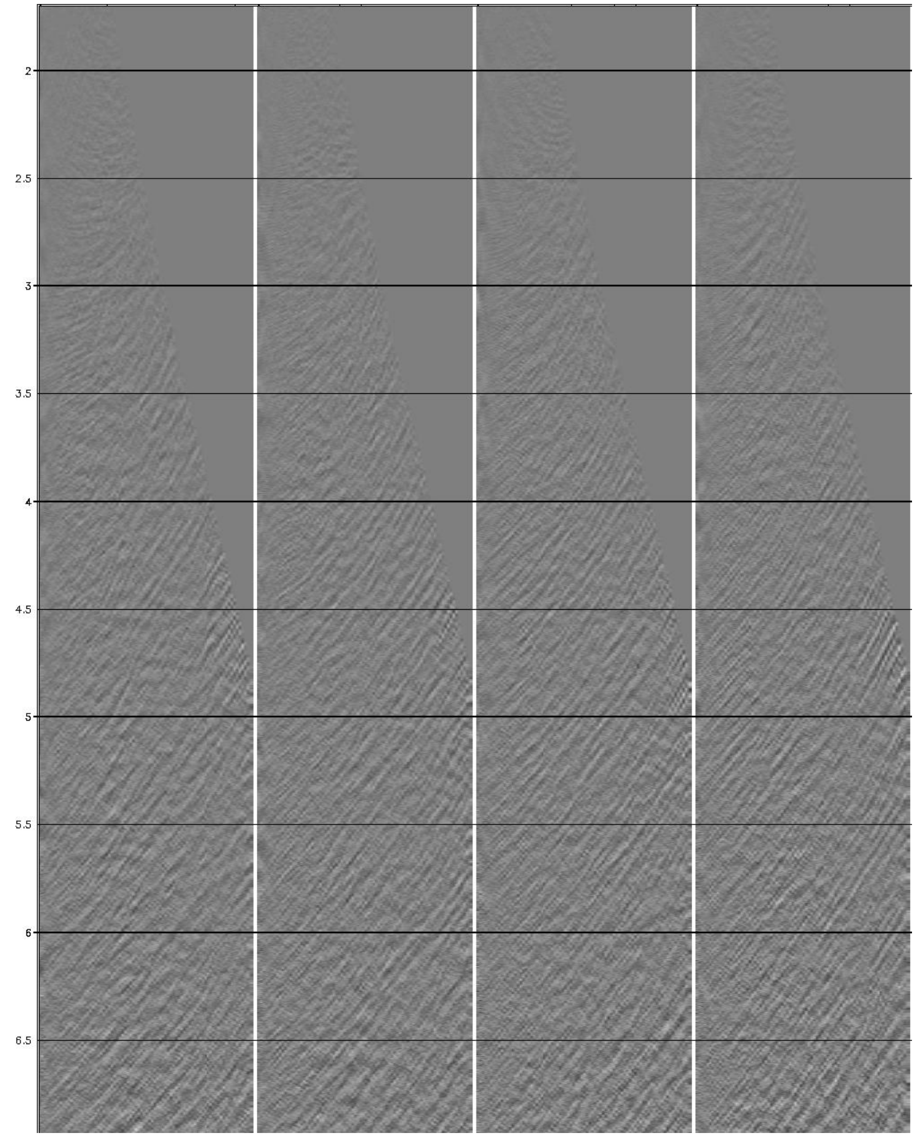
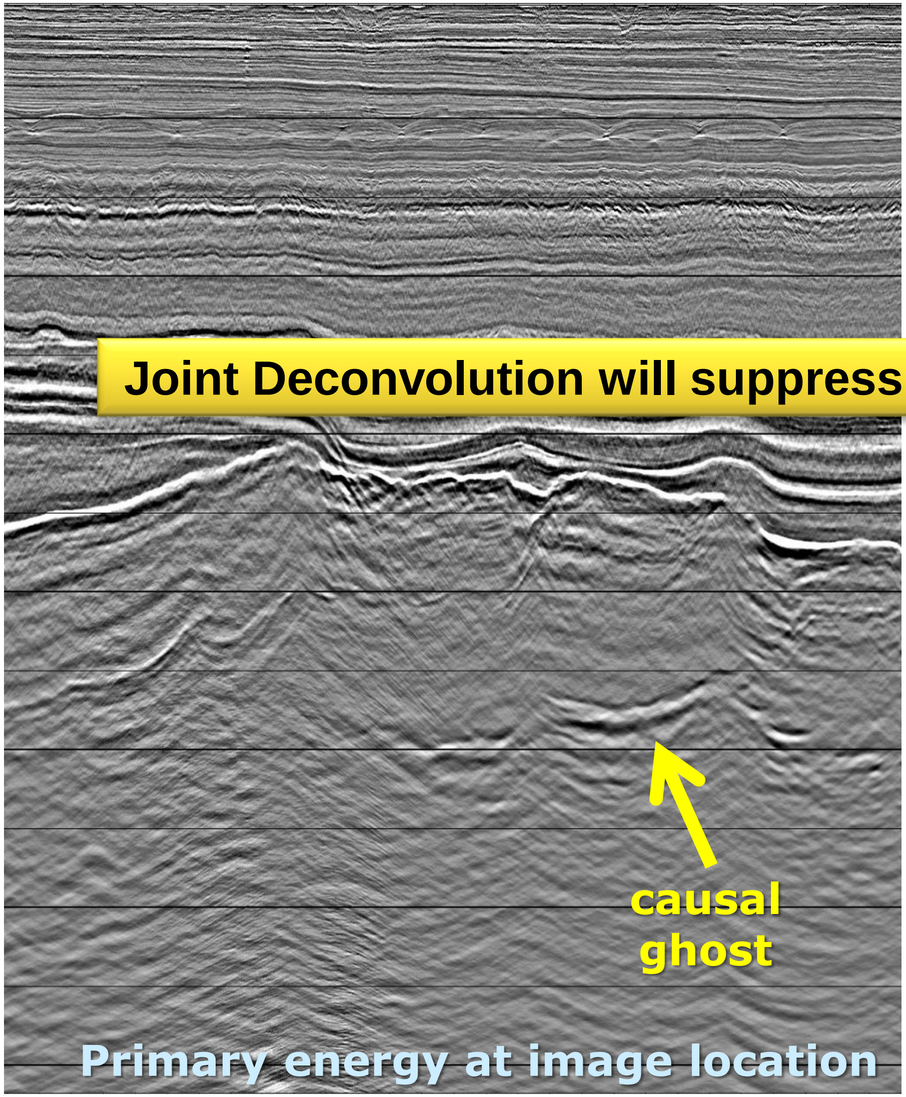
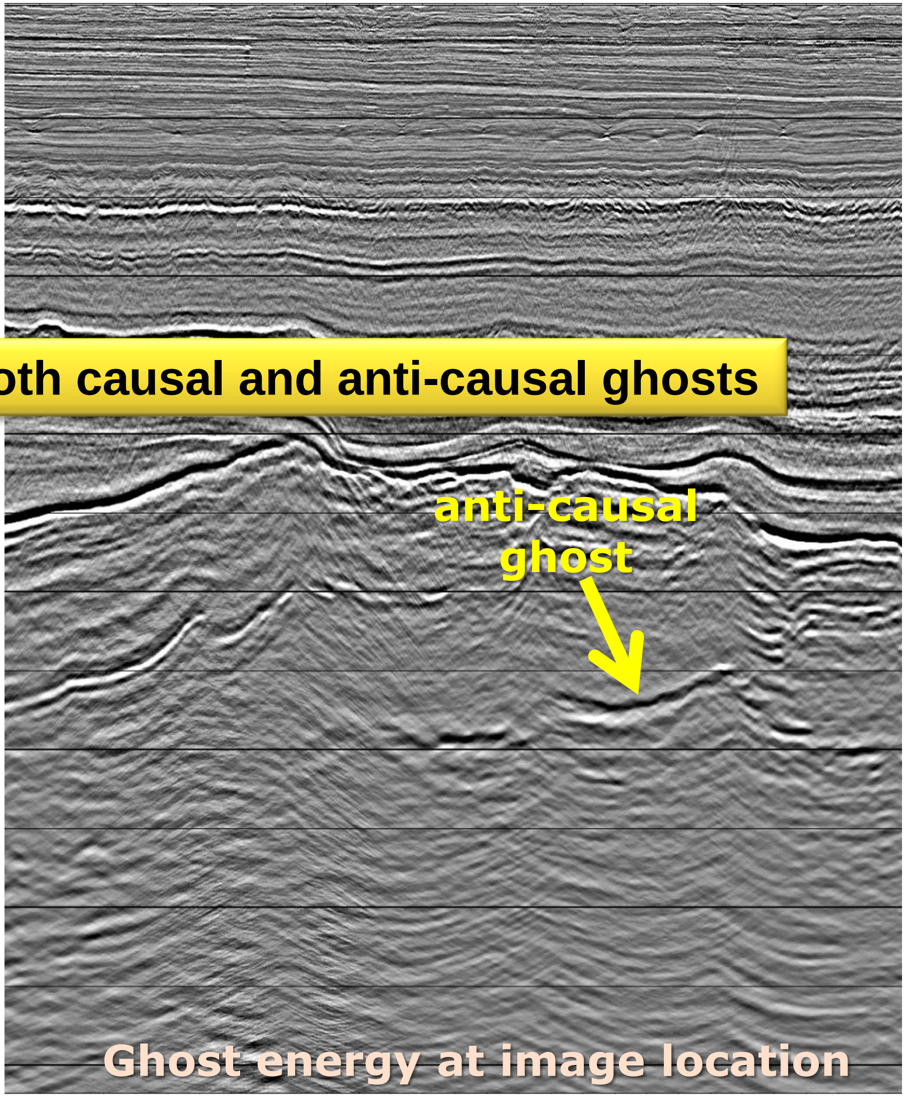


Image Stack – sequence without SINAT

Migration

Mirror Migration

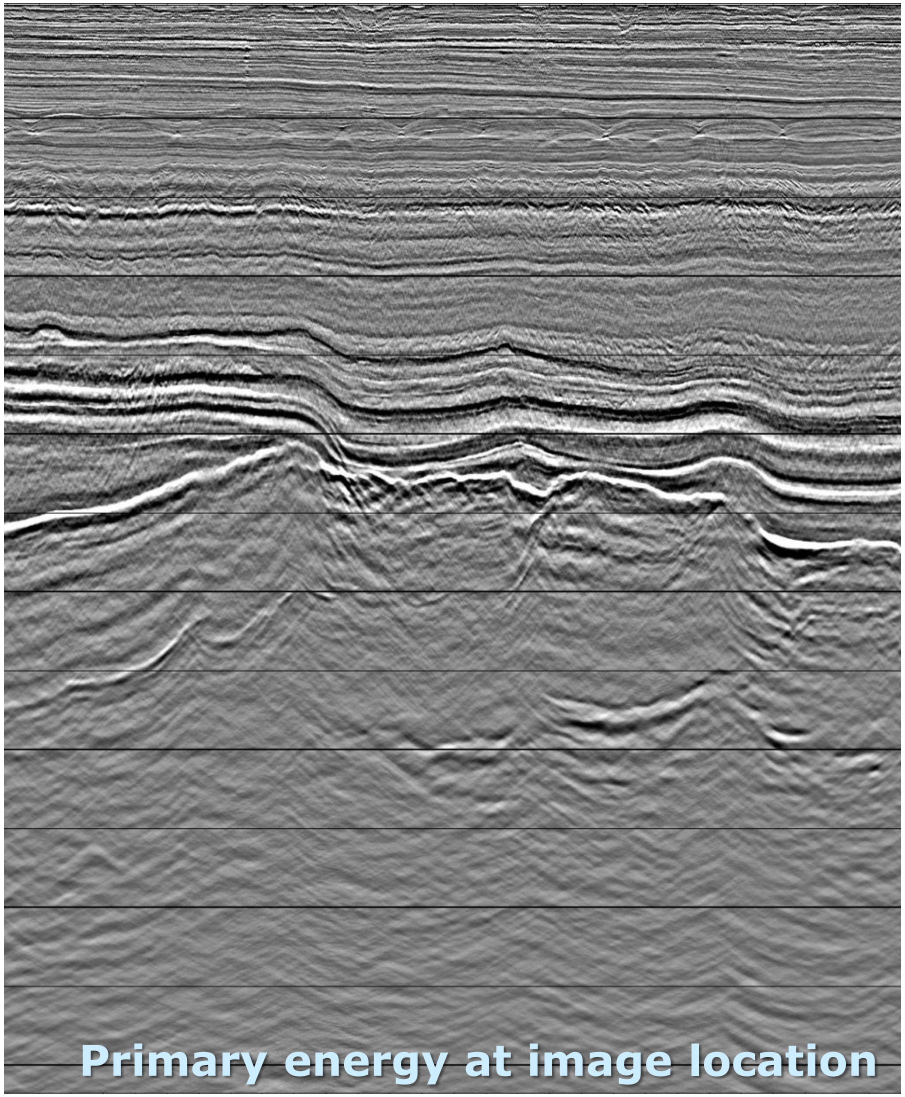




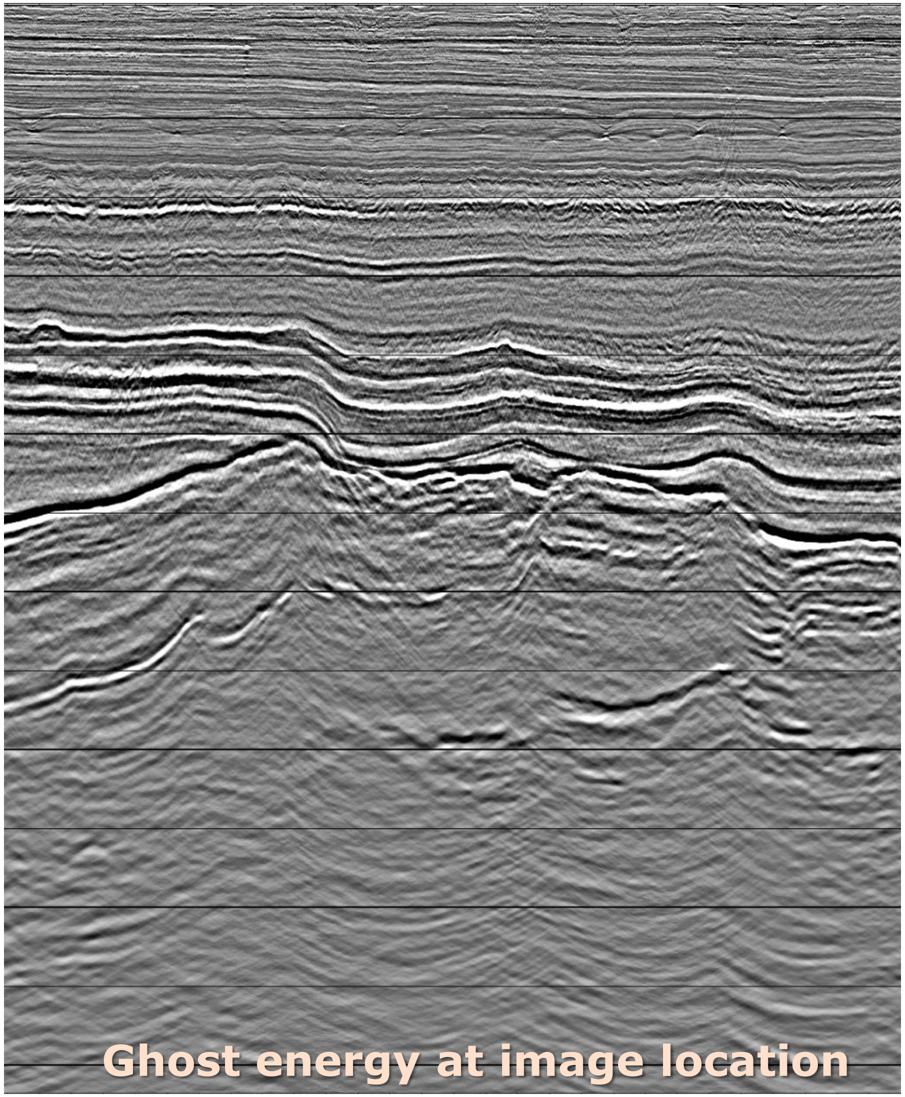
Joint Deconvolution will suppress both causal and anti-causal ghosts

Image Stack – sequence with SINAT

Migration

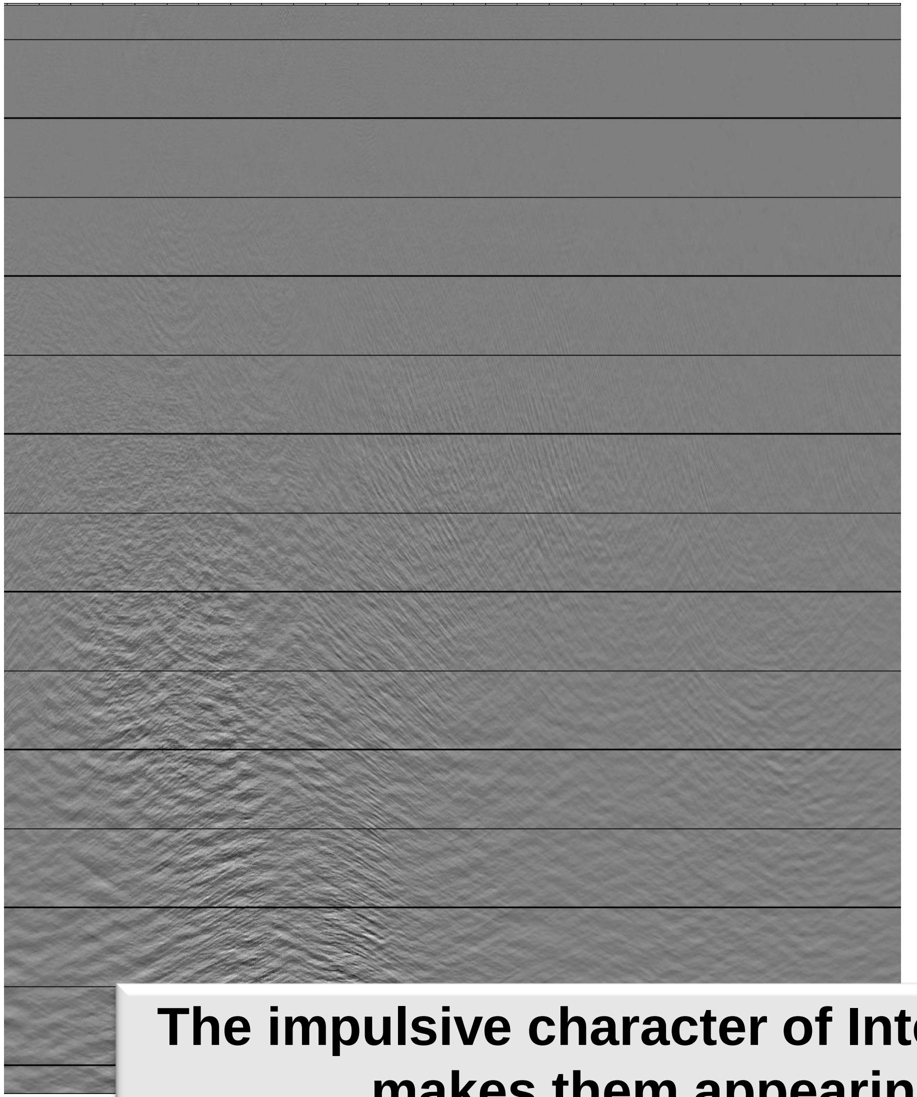


Mirror Migration

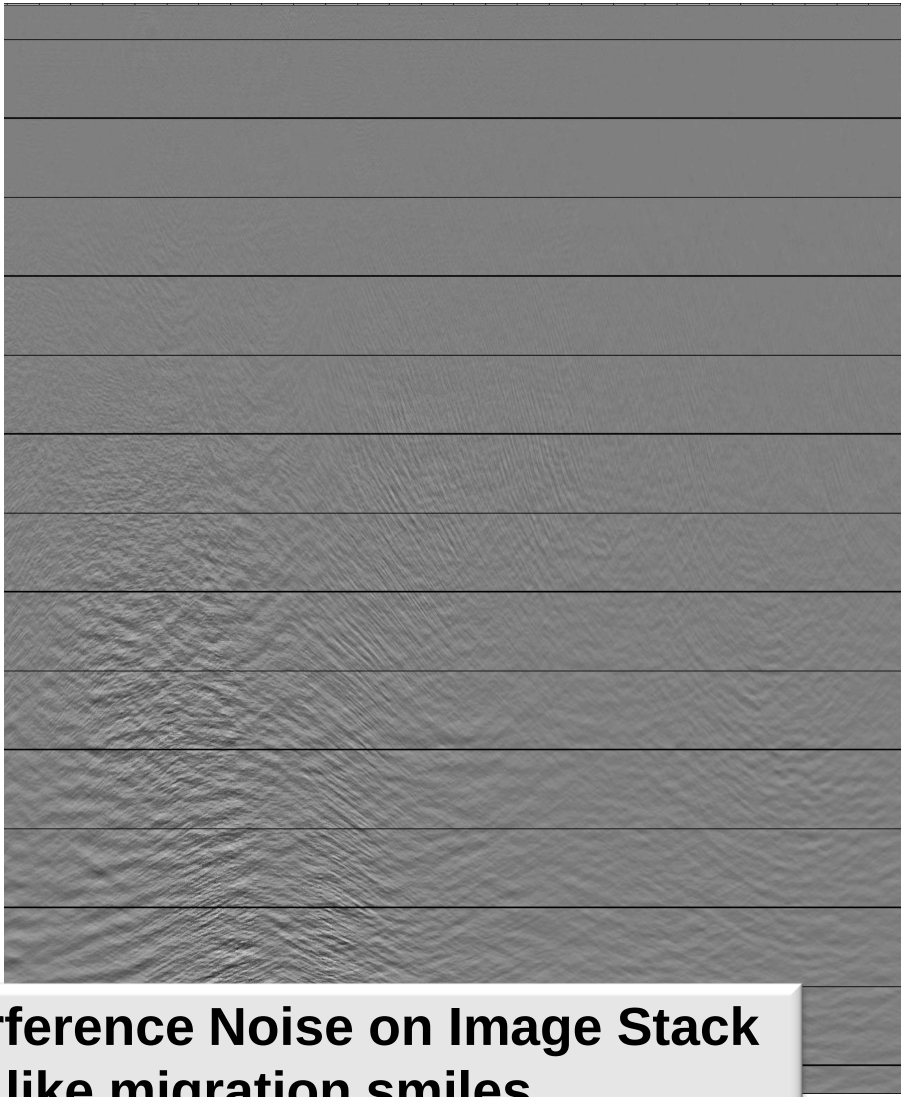


Difference between sequences with and without SINAT

Migration



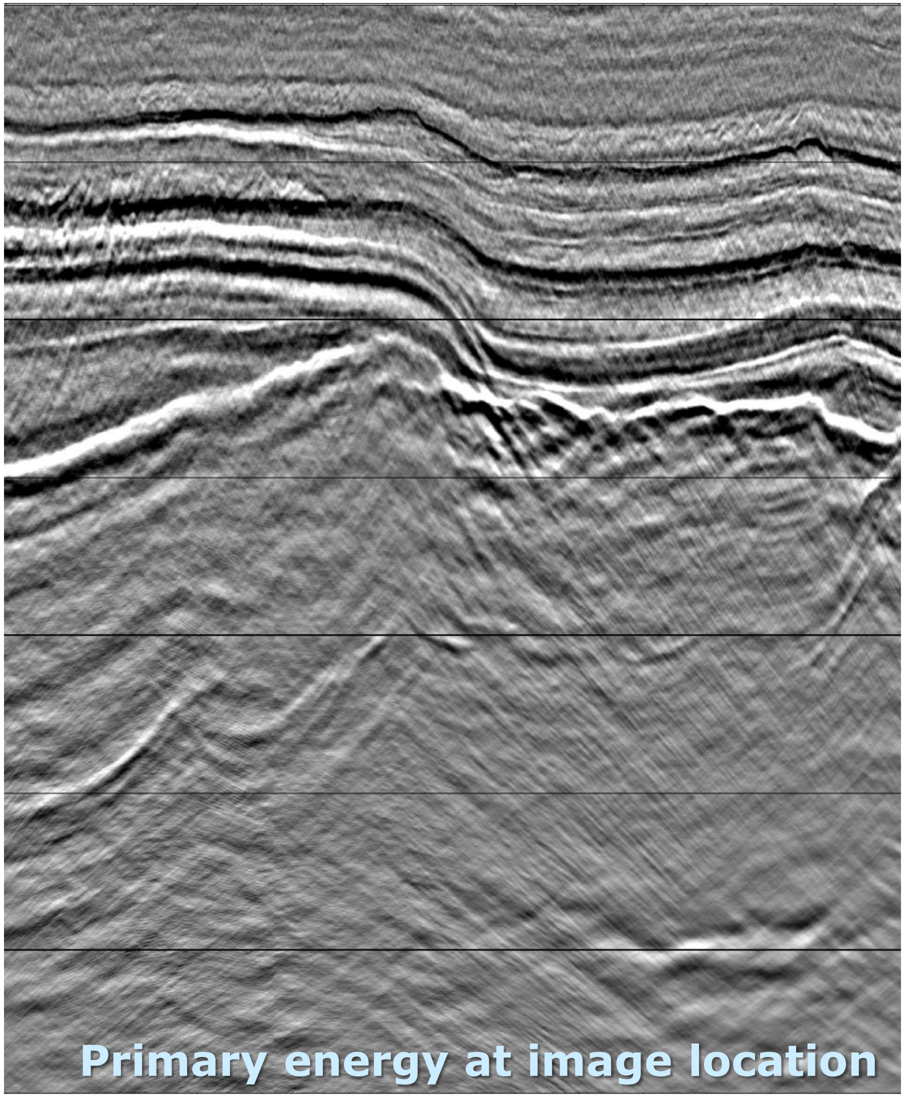
Mirror Migration



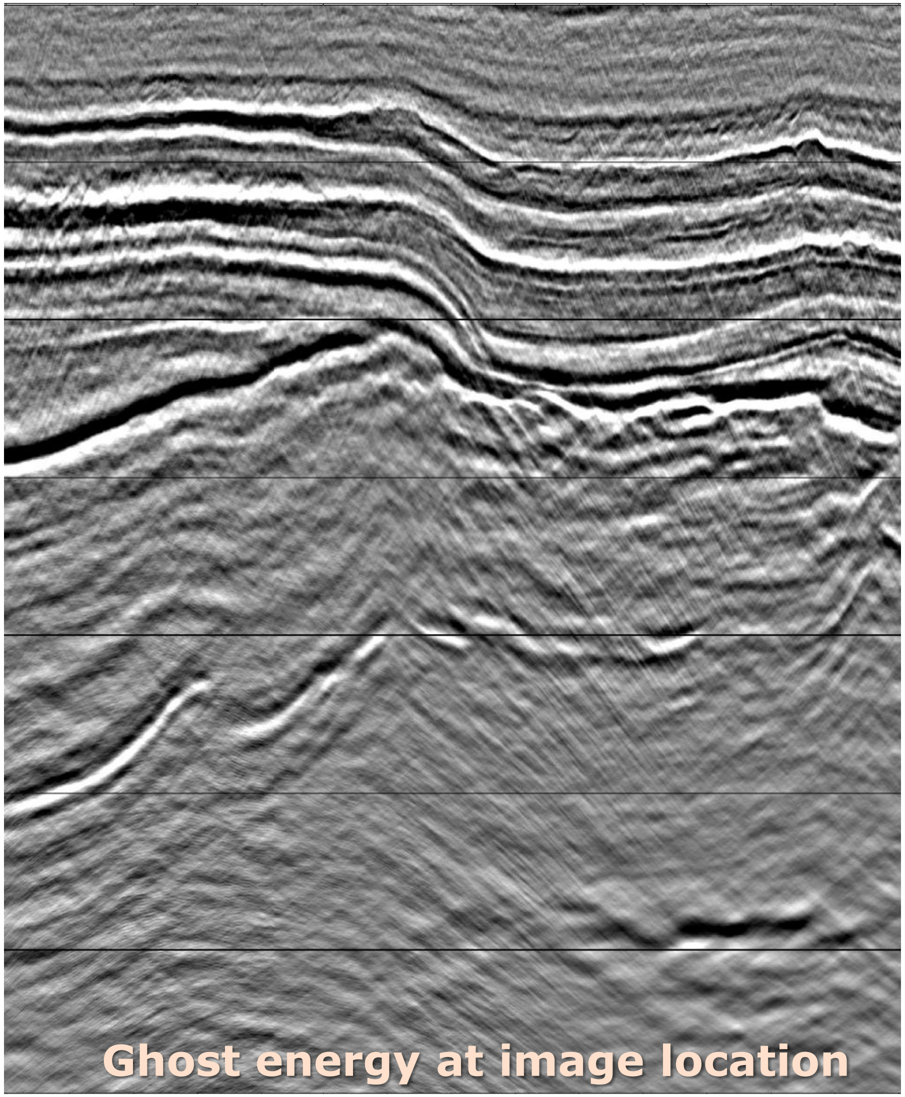
The impulsive character of Interference Noise on Image Stack makes them appearing like migration smiles

Zoom: Image Stack – sequence without SINAT

Migration

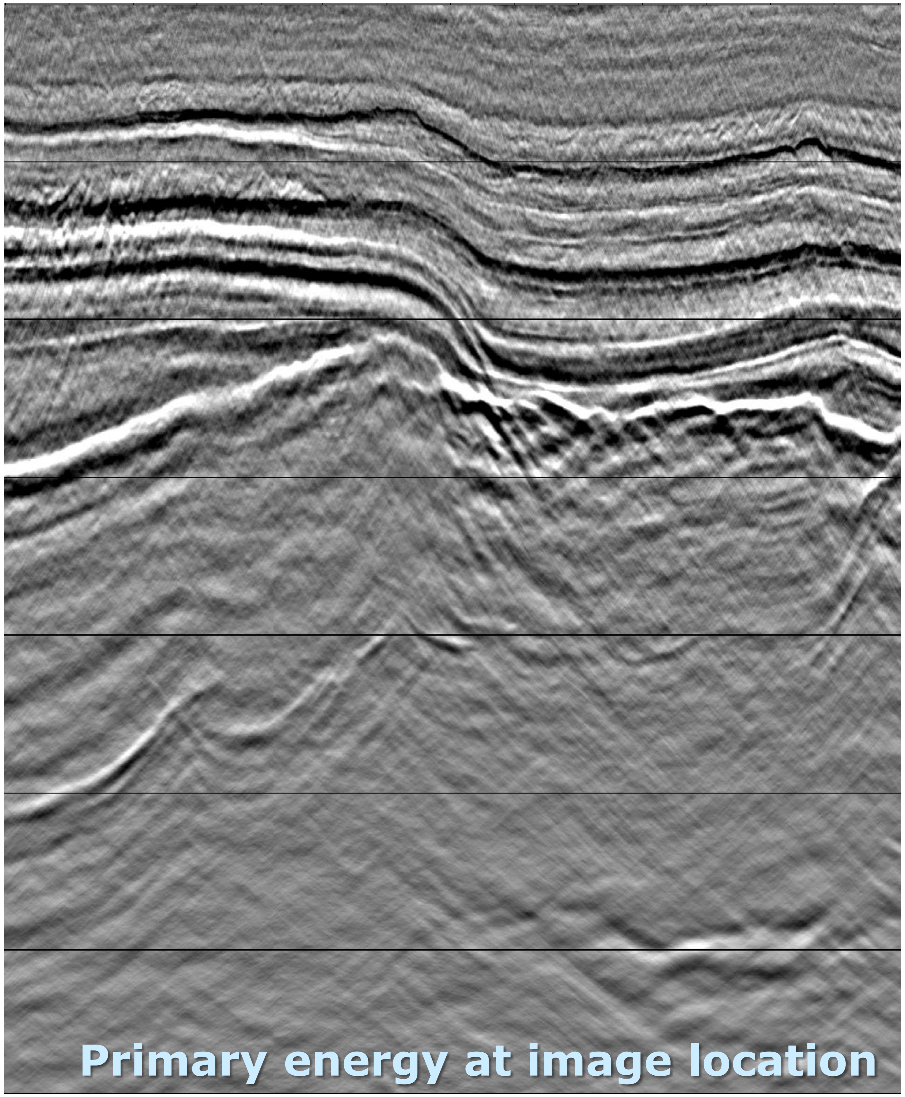


Mirror Migration

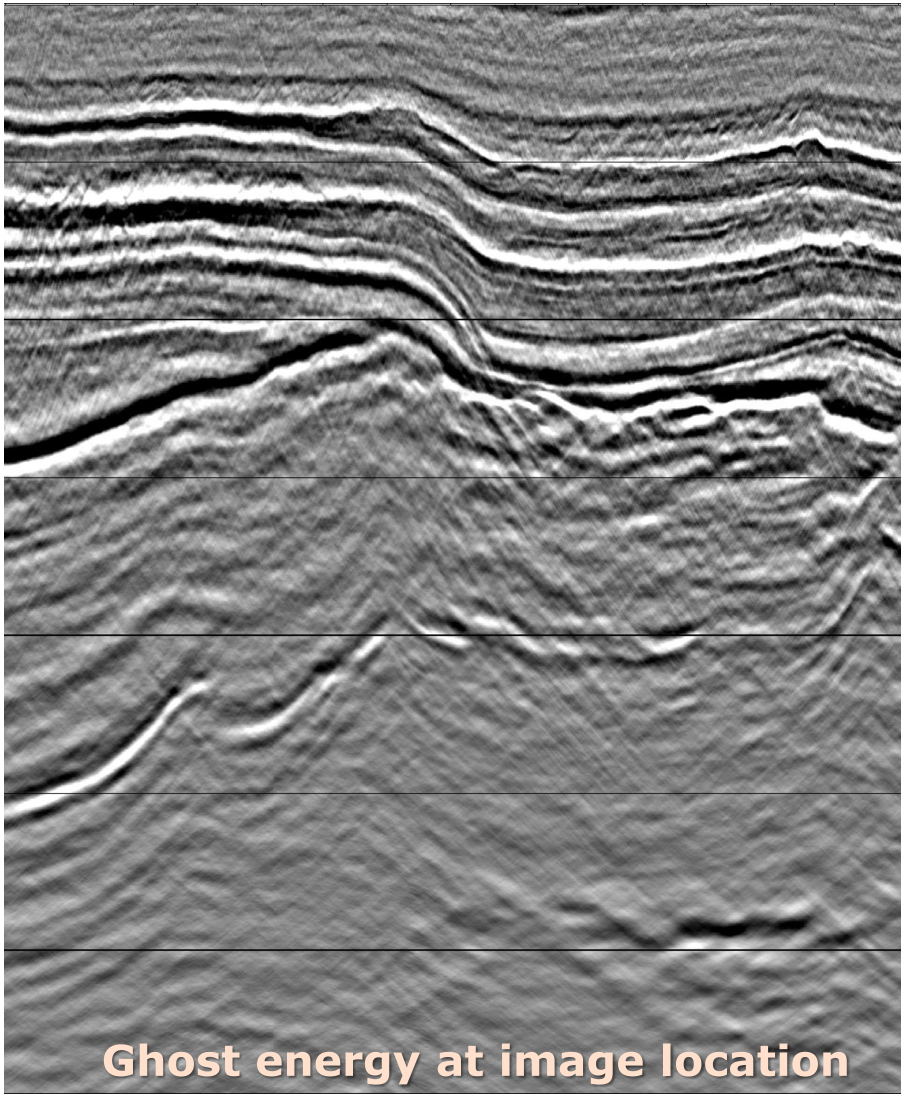


Zoom: Image Stack – sequence with SINAT

Migration

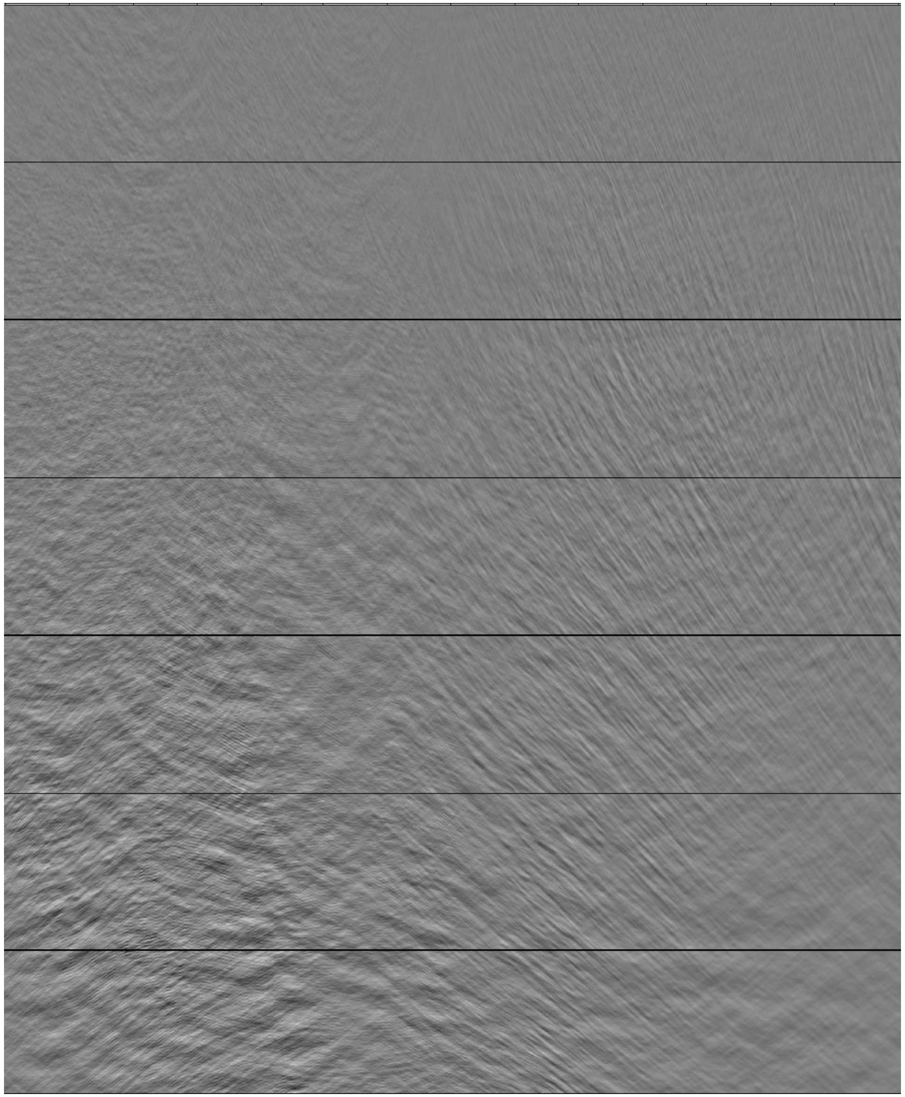


Mirror Migration

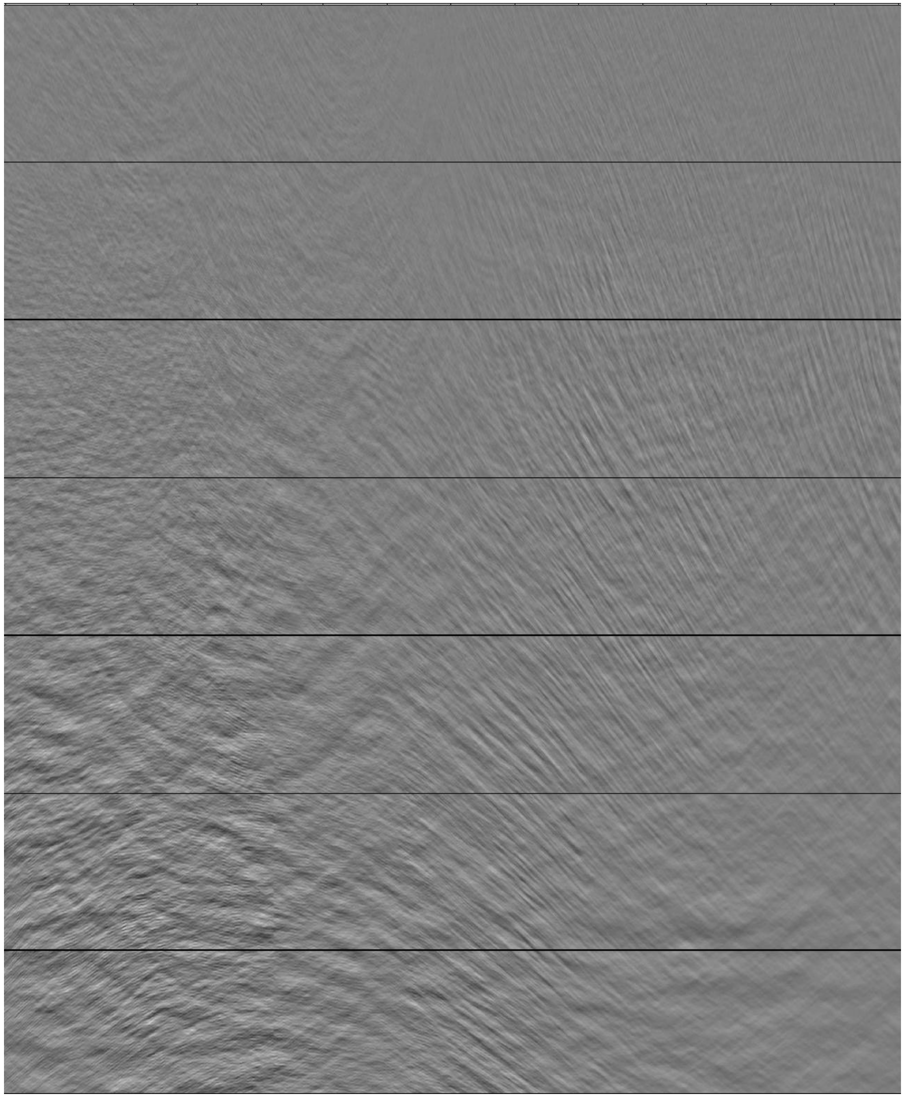


Zoom: Difference between sequences with and without SINAT

Migration



Mirror Migration



Joint Deconvolution Stack – sequence without SINAT

Cornerstone data courtesy of CGGVeritas

Joint Deconvolution Stack – sequence with SINAT

Cornerstone data courtesy of CGGVeritas

Difference between sequences with and without SINAT

Analysis

- ✓ Impulsive denoise techniques are effective at interference noise attenuation
- ✓ Application in the shot-p domain improves the effectiveness by separation of signal and noise where there is a difference in apparent velocity
- ✓ Additional information about the timing of the interference source and position, combined with continuous recording, could lead to better results by:
  - *Estimate of apparent dip range of the noise*
  - *Knowledge of the timing of the noise*
  - *Use in simultaneous modelling, i.e. make tau-p model of the noise and signal in the receiver domain (with knowledge of timeshifts required to align the noise)*

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Conclusions

- ✓ Seismic interference noise attenuation on broadband data acquired with Variable Depth Streamer (BroadSeis) is **not more problematic than on conventional data**
- ✓ As with all processing steps, it is important to ensure **low frequency** energy to be properly processed and not damaged
- ✓ Improved separation of signal and noise in the **Shot/p domain** allows application of SINAT with improved noise attenuation as well as **signal preservation**

Acknowledgements to CGGVeritas
for the permission to show
North Sea Cornerstone broadband data

Legacy data

Thank you for your attention!

BroadSeis