RadExPro seismic software

RadExPro seismic software for high resolution marine seismic processing

RadExPro – complete solution for High-Resolution marine seismic processing

Various types of marine seismic surveys:

Single channel

2D Multichannel
(variable spacing groups, slanted streamers)

3D acquisitions

OBN surveys

RadExPro – complete solution for High-Resolution marine seismic processing

Various types of marine seismic surveys:

Single channel

2D Multichannel
(variable spacing groups, slanted streamers)

3D acquisitions

OBN surveys

All types of HR/UHR sources:

Sparker

Boomer

Airgun

RadExPro seismic software

RadExPro – complete solution for High-Resolution marine seismic processing

Various types of marine seismic surveys:

Single channel

2D Multichannel
(variable spacing groups, slanted streamers)

3D acquisitions

OBN surveys

All types of HR/UHR sources:

Sparker

Boomer

Airgun

Applications:

Geohazard assessment for top-hole drilling

Renewable energy developments

Pipeline routes and offshore installations

Geological studies for near-surface processses

Other applications (dredging, boulder detections, etc.)

Acquisition and frequency content problems

High frequency content - additional requirements in terms of processing algorithms, they need to be adjusted for URH data:

- Shallow towing and noisier ships result in increased noise level
- Sea swelling affect correlation of high frequencies – problem of marine statics
- Less control over the towing depth, so standard deghosting approaches cannot be used
- ...

Noise attenuation

Shallow tow of the spread results in increased level of noise

Small vessels do not provide same low noise level comparing to large-scale seismic vessels

Towing techniques during acquisition may result in increased noise level

Available solutions:

Filtering (bandpass, Butterworth, TVBF)

TFD Noise attenuation

FK, Radon filtering

2D/3D Sparse FK, Sparse Radon filtering

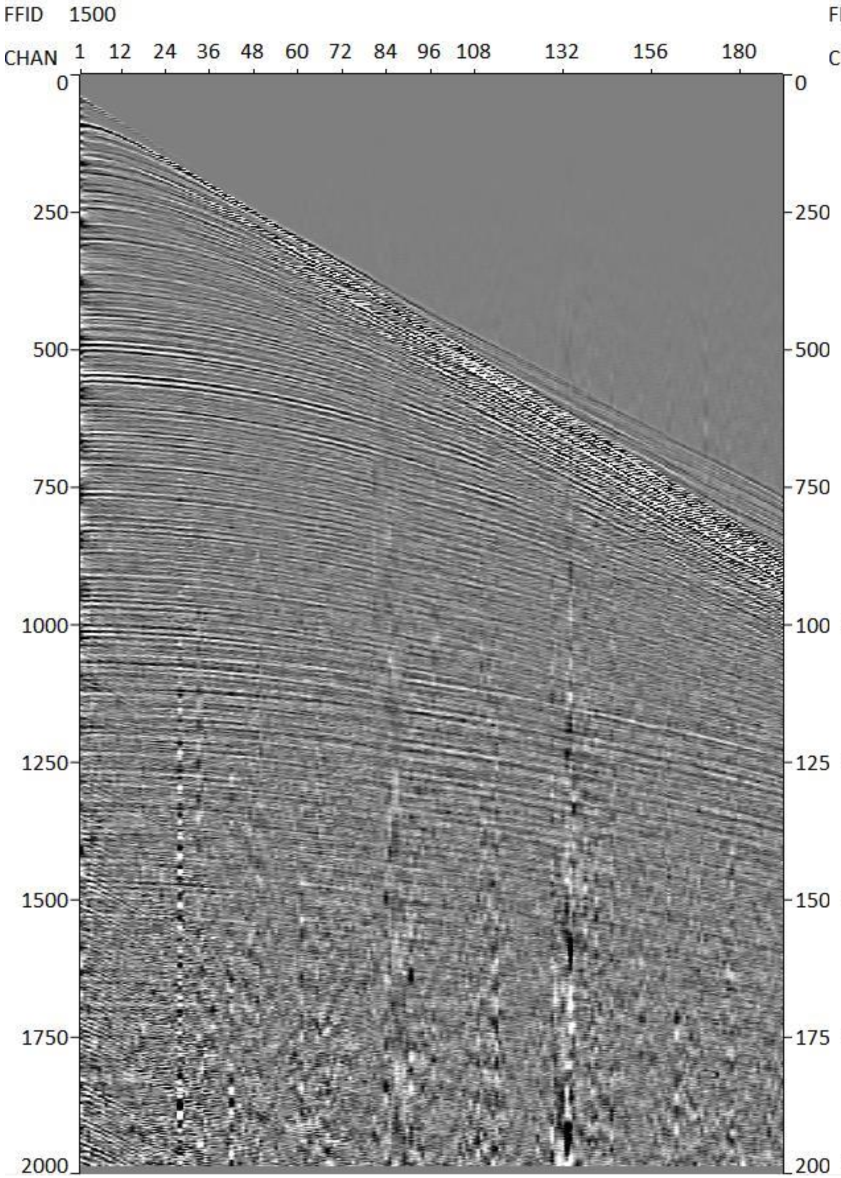
2D/3D FXY predictive filtering

Other techniques can be implemented with available algorithms

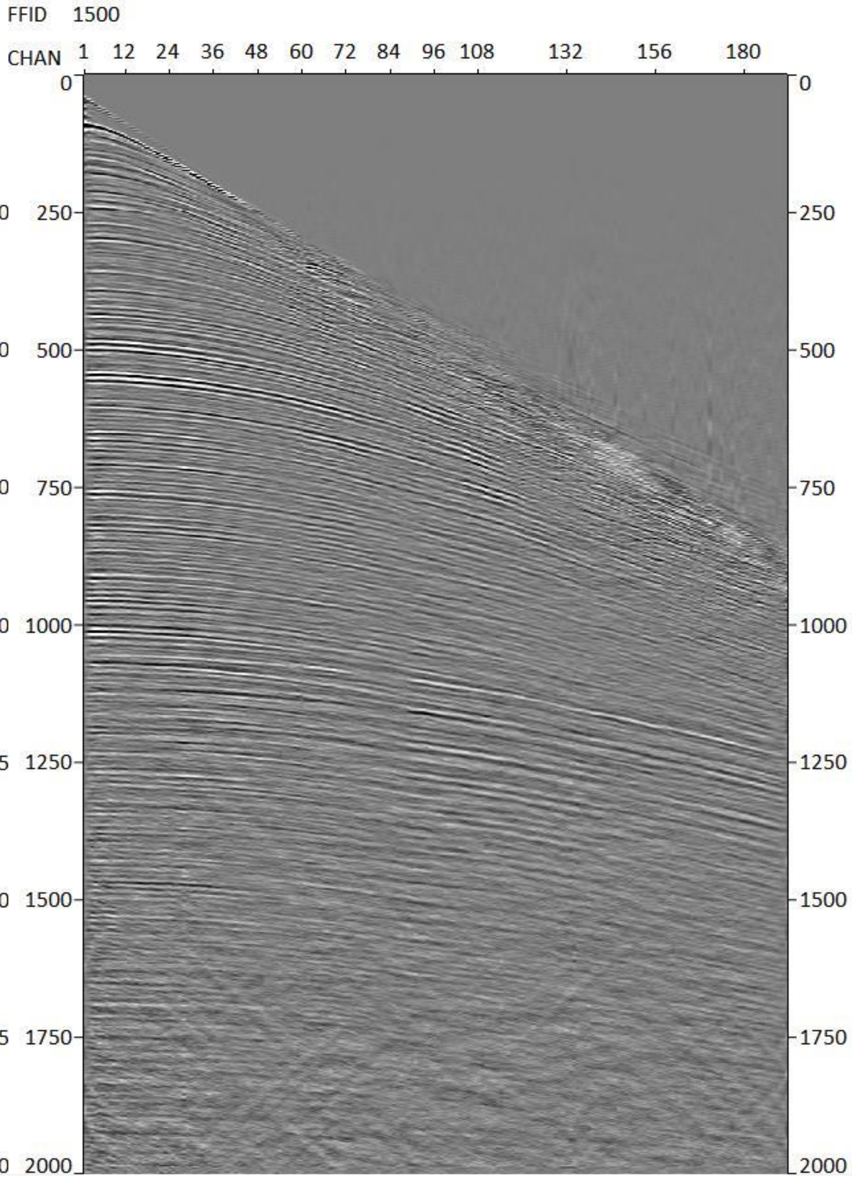
RadExPro seismic software

Noise attenuation

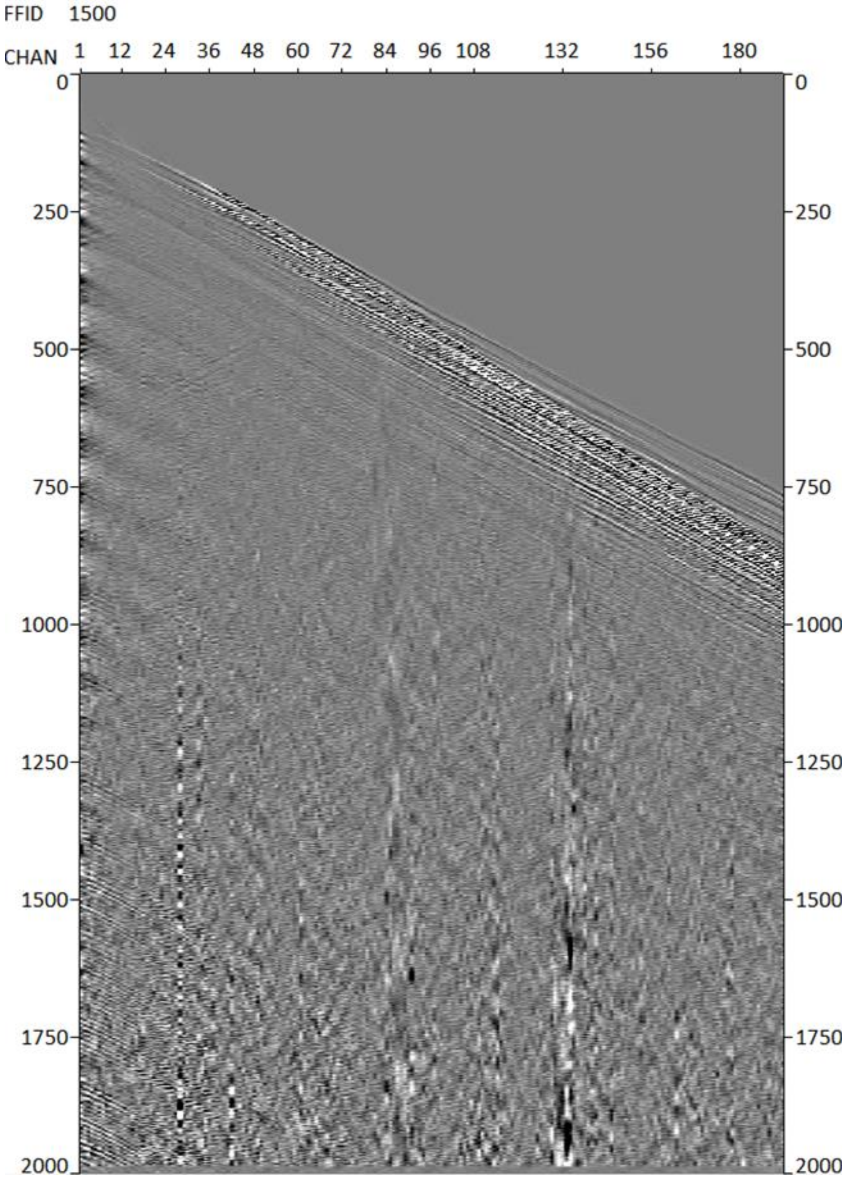
Initial shot gather



Shot gather after denoising



Difference



Static corrections

High frequencies, presented in the data result in very short wavelengths

Even small swell motion during acquisition results in high static disturbance

Statics reduces image resolution due to incoherent stacking

Available solutions:

Swell filtering

Trim statics

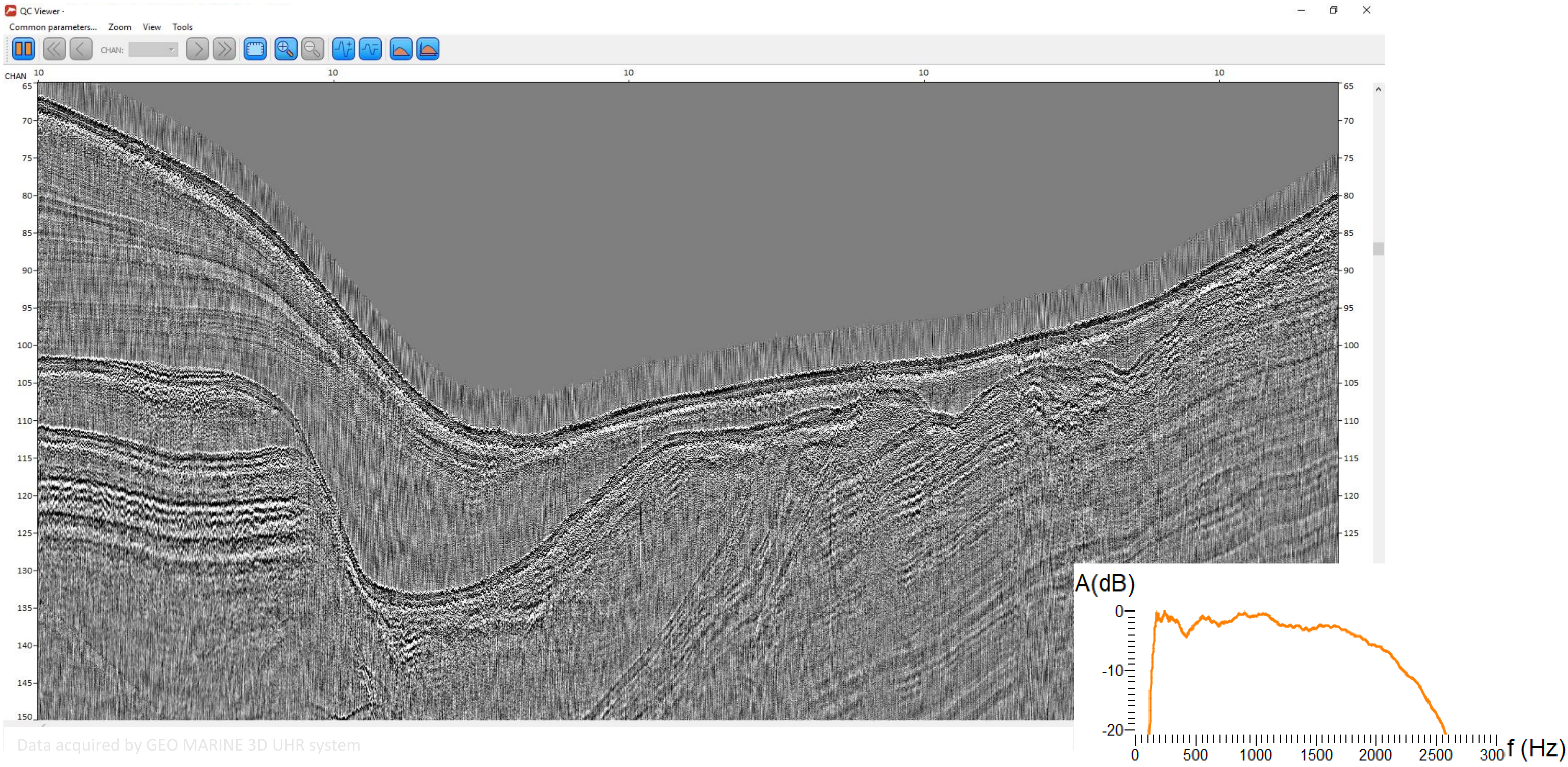
COSA*

Custom

* “3D pre-processing techniques for marine VHR seismic data”
N. Wardell, P. Diviacco, R. Sinceri - First break volume 20.7, July 2002

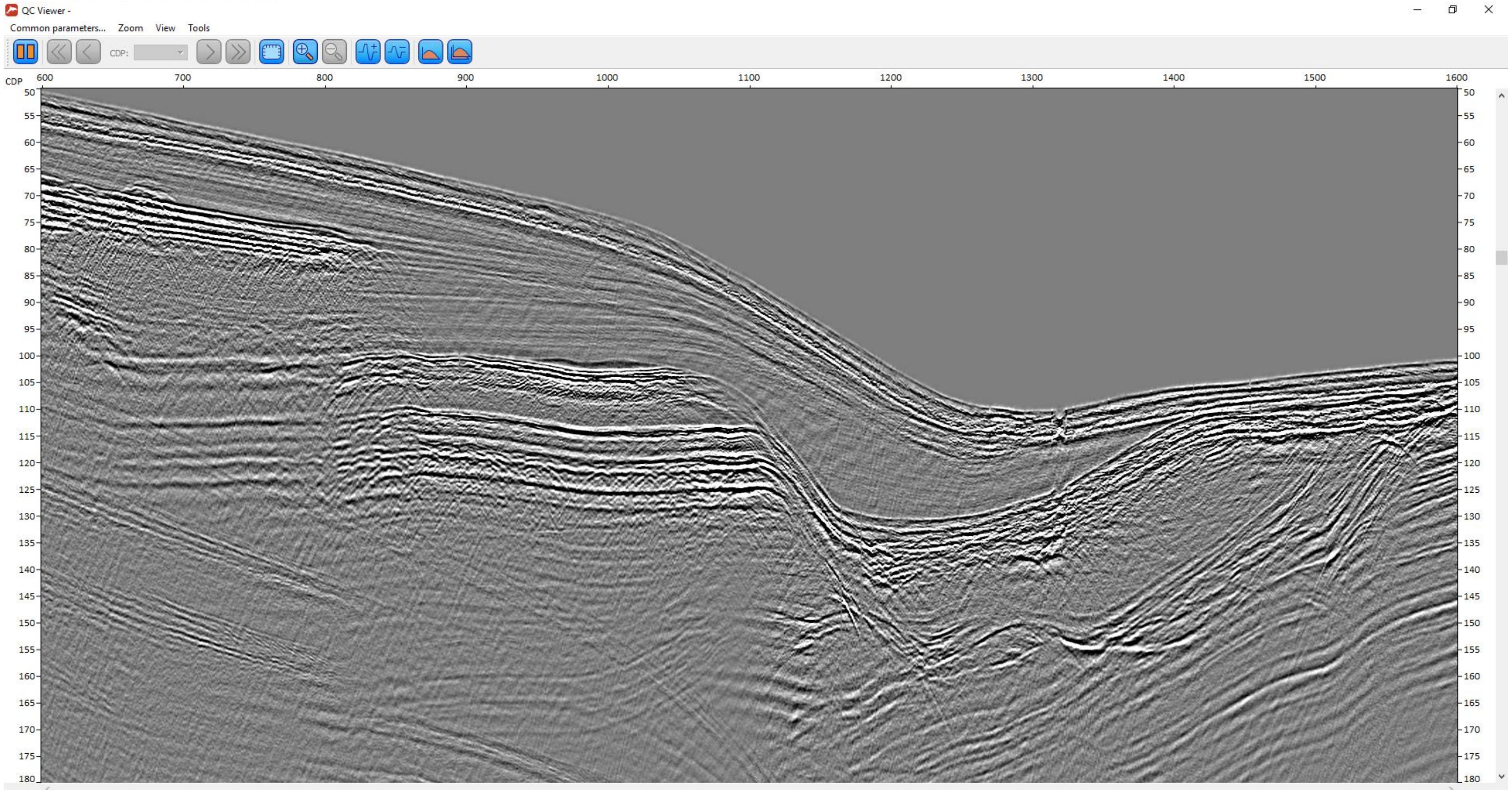
HR static corrections

Swell Effect on Multichannel Sparker Data – Channel #10



HR static corrections

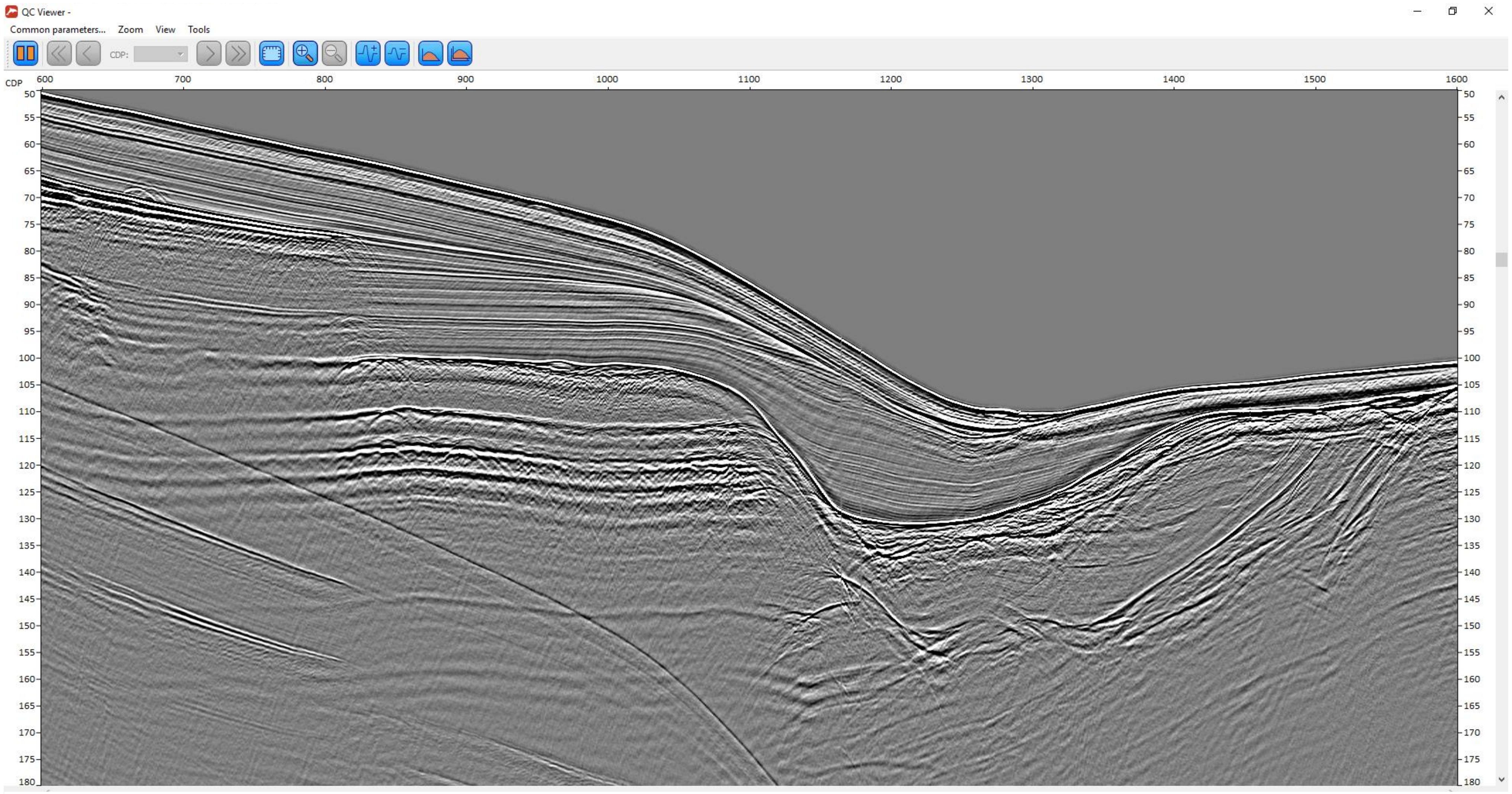
Swell Effect on Multichannel Sparker Data – Brute Stack



Data acquired by GEO MARINE 3D UHR system

HR static corrections

Swell Effect on Multichannel Sparker Data – after Hi-Res Statics application



Data acquired by GEO MARINE 3D UHR system

Designature

Wavelet shape

Problem

Signal + Ghosts + Bubble pulsations + Oscillations

Solution

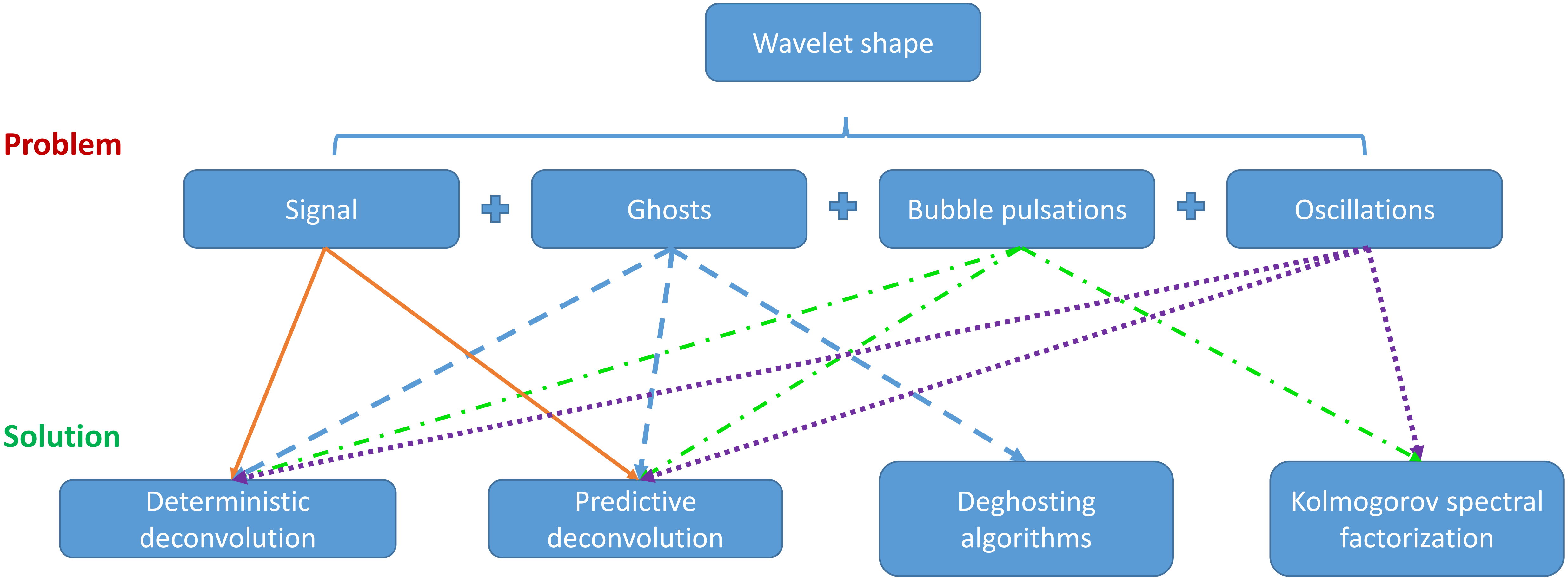
Deterministic deconvolution

Predictive deconvolution

Deghosting algorithms

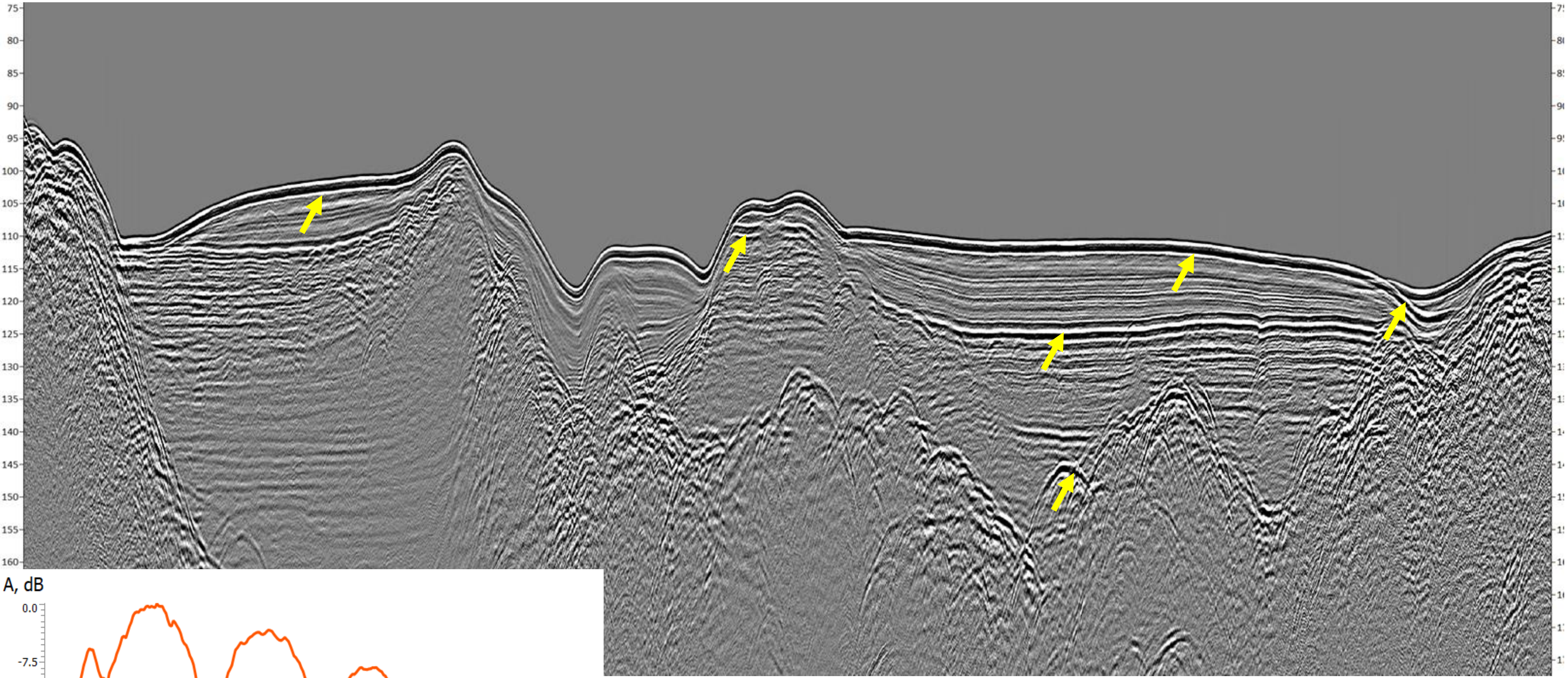
Kolmogorov spectral factorization

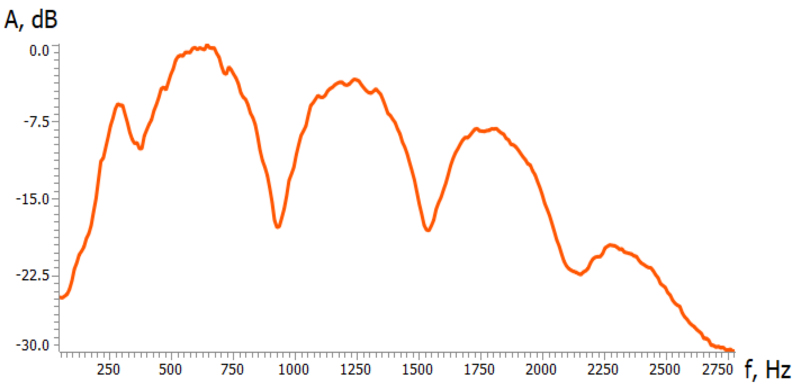
Designature



Designature by predictive deconvolution

Multichannel HR data – stack before designature





Spectrum before designature

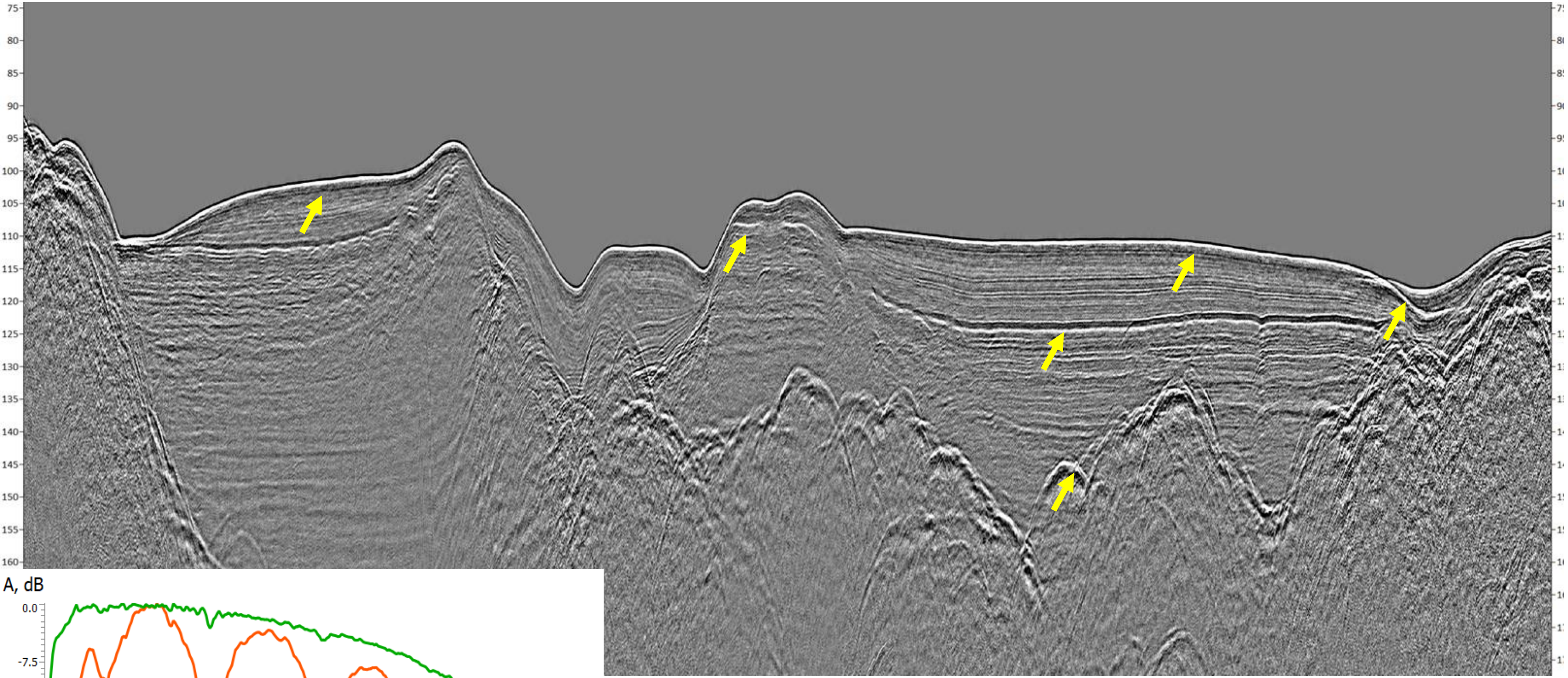
Survey parameters

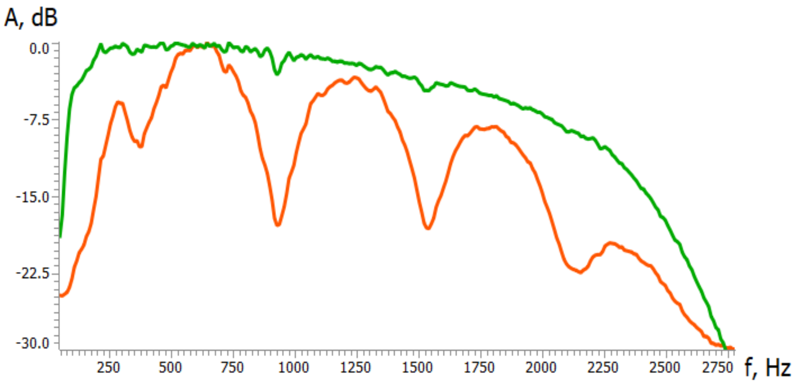
Source – sparker
Streamer – 16 chans
Water Depth – 60-90 m

*Kluesner, J., Brothers, D., Hart, P., Miller, N, Hatcher, G., 2018 Practical approaches to maximizing the resolution of sparker seismic reflection data, Marine Geophysical Research 40: 279-301

Designature by predictive deconvolution

Multichannel HR data – stack after designature





Spectrum before designature

Spectrum after designature

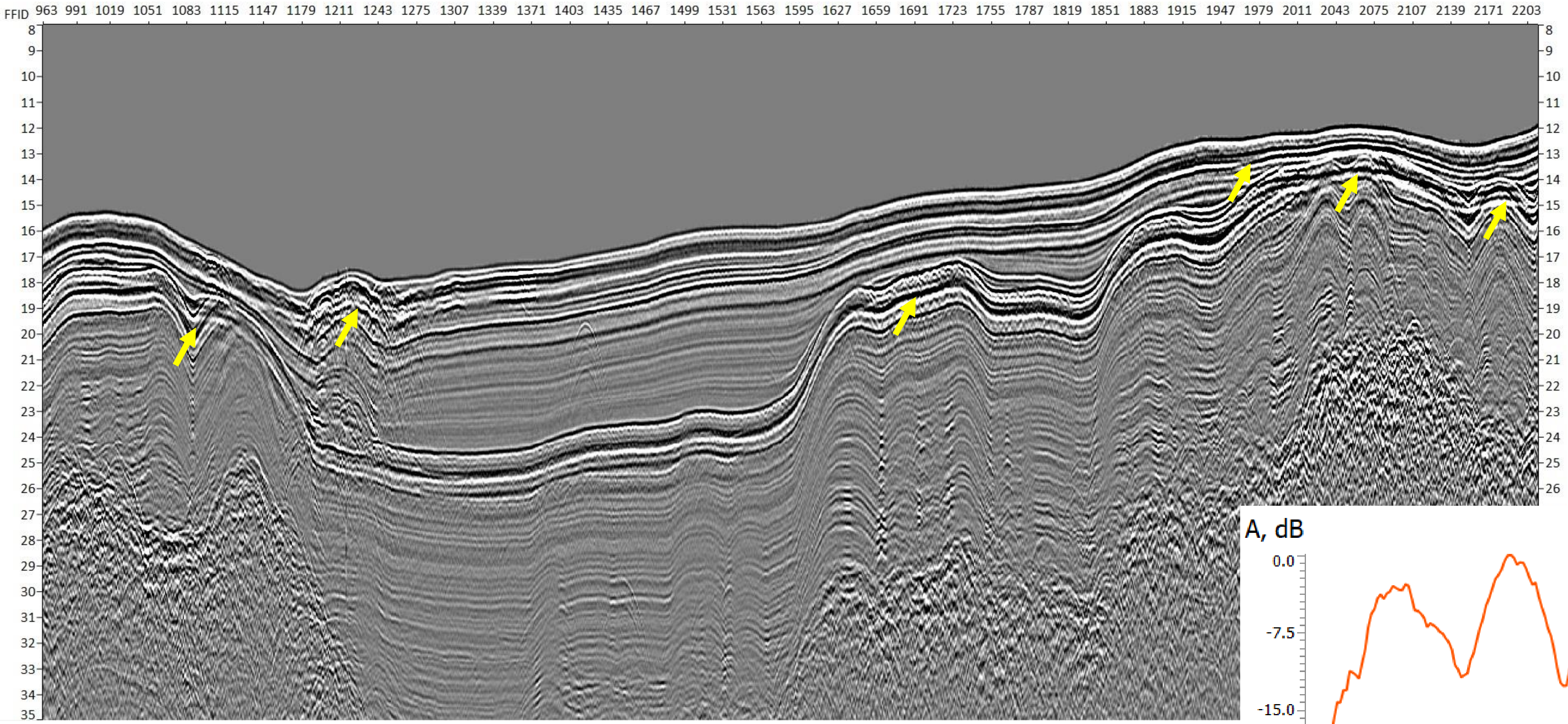
Survey parameters

Source – sparker
Streamer – 16 chans
Water Depth – 60-90 m

*Kluesner, J., Brothers, D., Hart, P., Miller, N, Hatcher, G., 2018 Practical approaches to maximizing the resolution of sparker seismic reflection data, Marine Geophysical Research 40: 279-301

Designature by statistical deconvolution

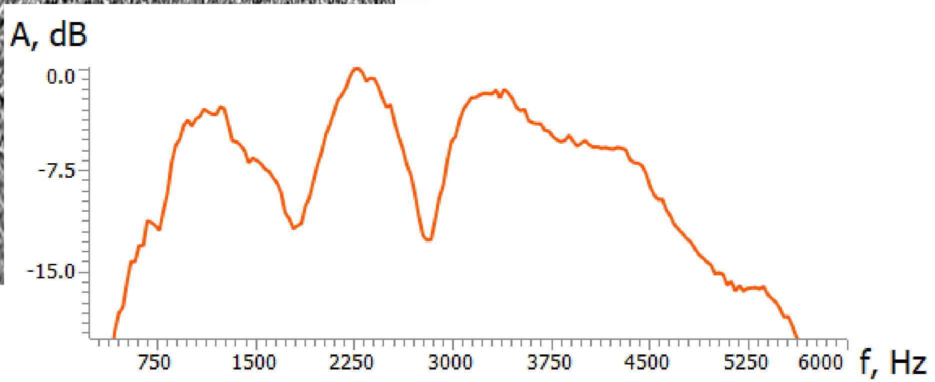
Single channel seismic section before designature



Survey parameters

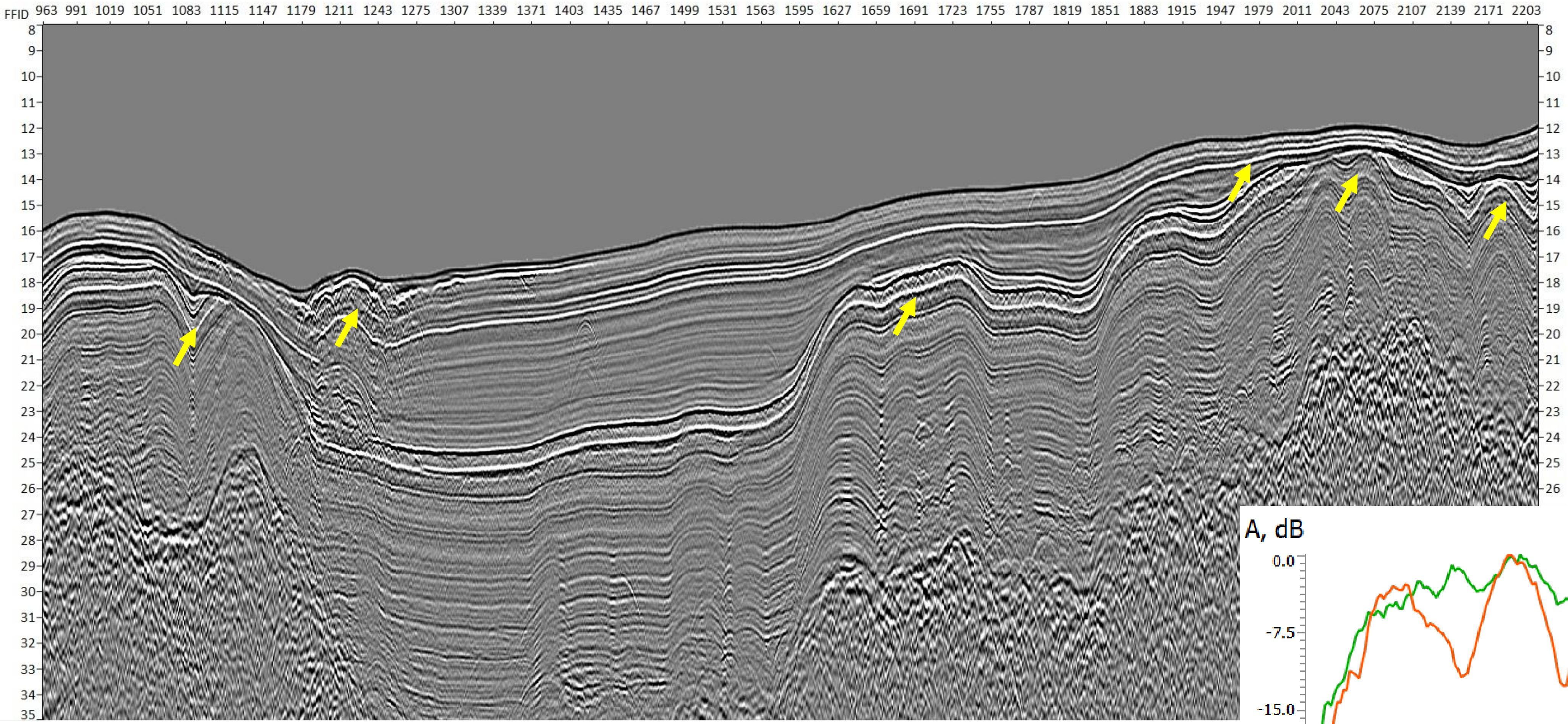
Source – sparker
Streamer – 4 channels
Water Depth – 5-10 m

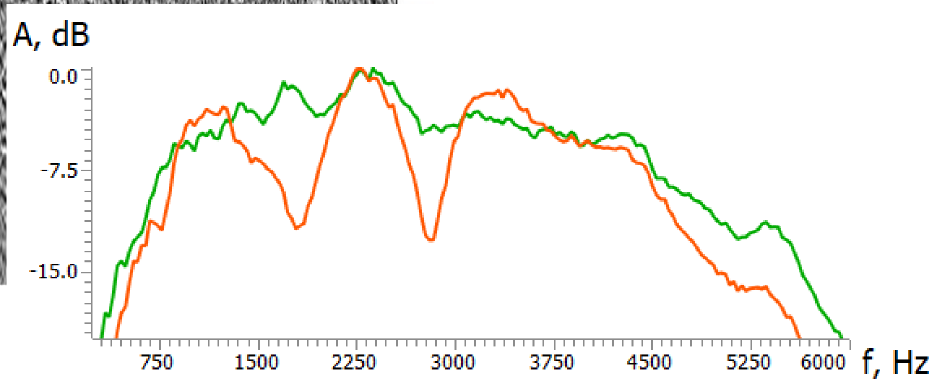
Data acquired by Geodevice



Designature by statistical deconvolution

Single channel seismic section after designature





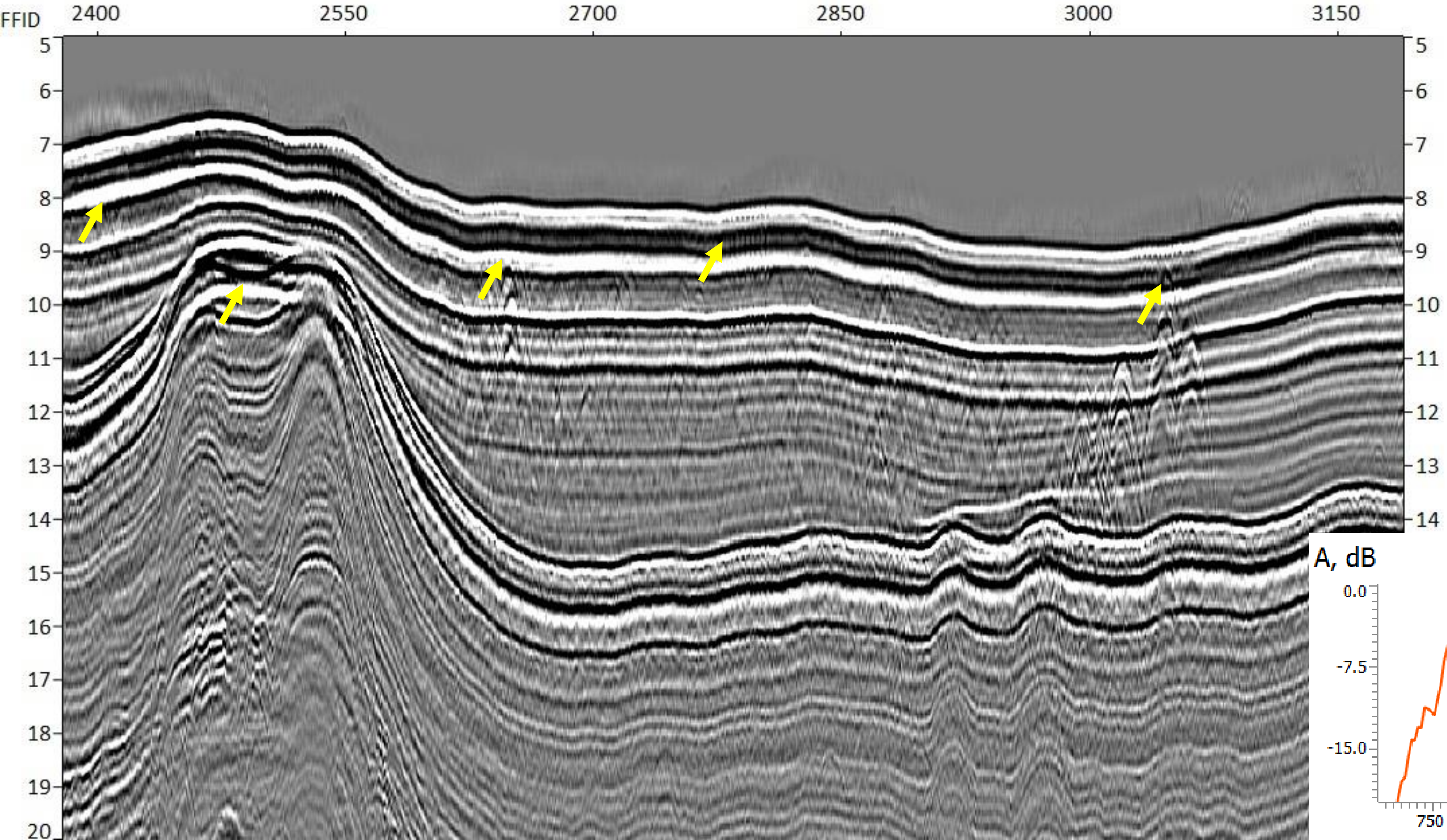
Survey parameters

Source – sparker
Streamer – 4 channels
Water Depth – 5-10 m

Data acquired by Geodevice

Designature by statistical deconvolution

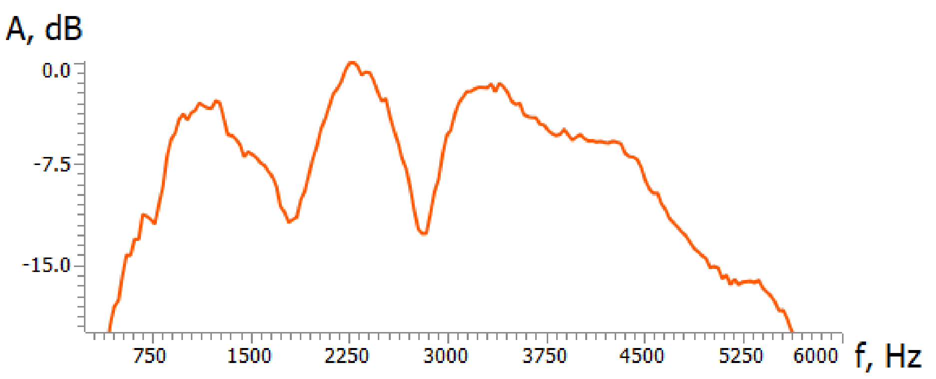
Single channel seismic section after designature



Survey parameters

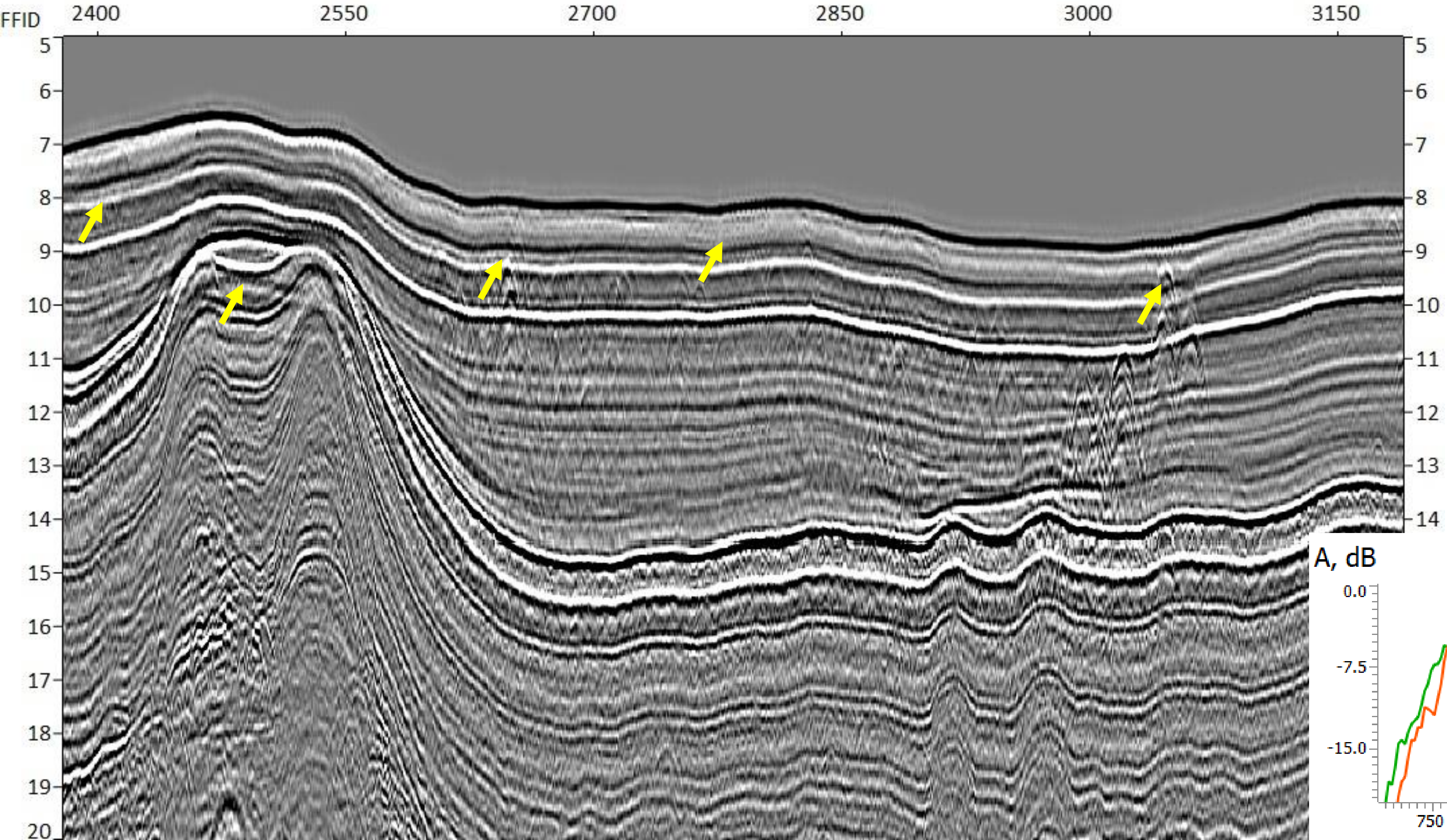
Source – FWS-125 Sparker
Streamer – 4 channels
Water Depth – 5-10 m

Data acquired by Geodevice



Designature by statistical deconvolution

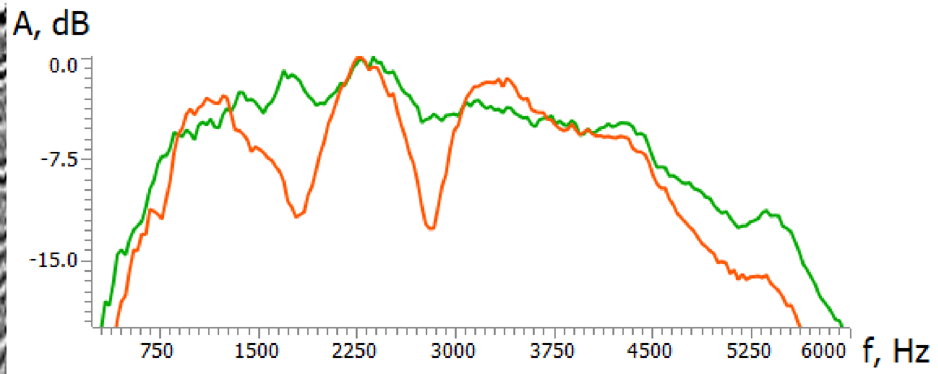
Single channel seismic section after designature



Survey parameters

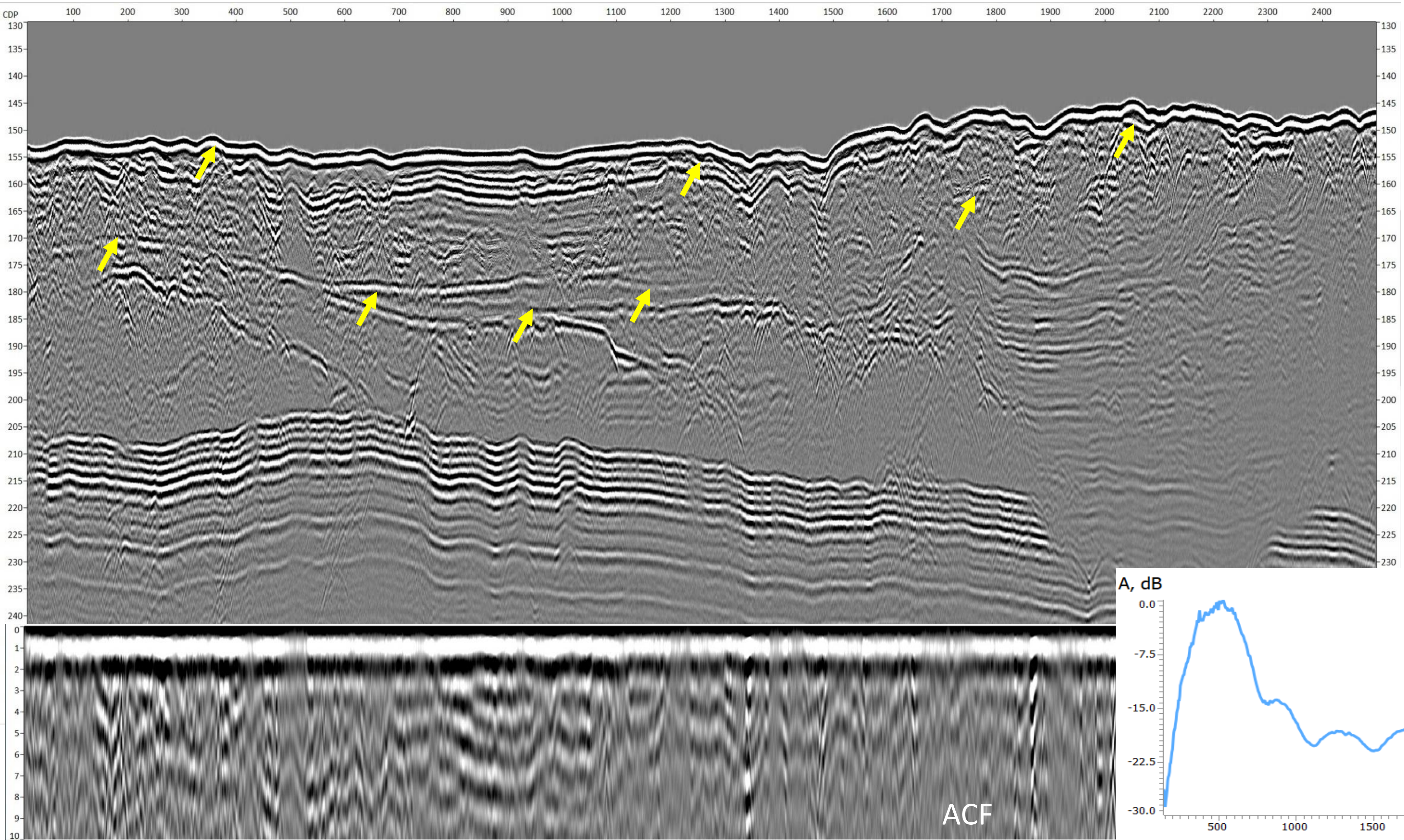
Source – FWS-125 Sparker
Streamer – 4 channels
Water Depth – 5-10 m

Data acquired by Geodevice



Designature using statistical deconvolution

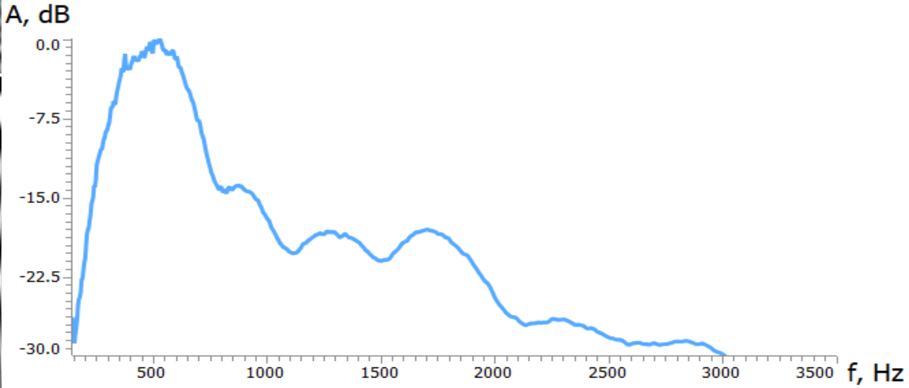
Statistical Deconvolution of sparker wavelet. Stacked section: before



Survey parameters

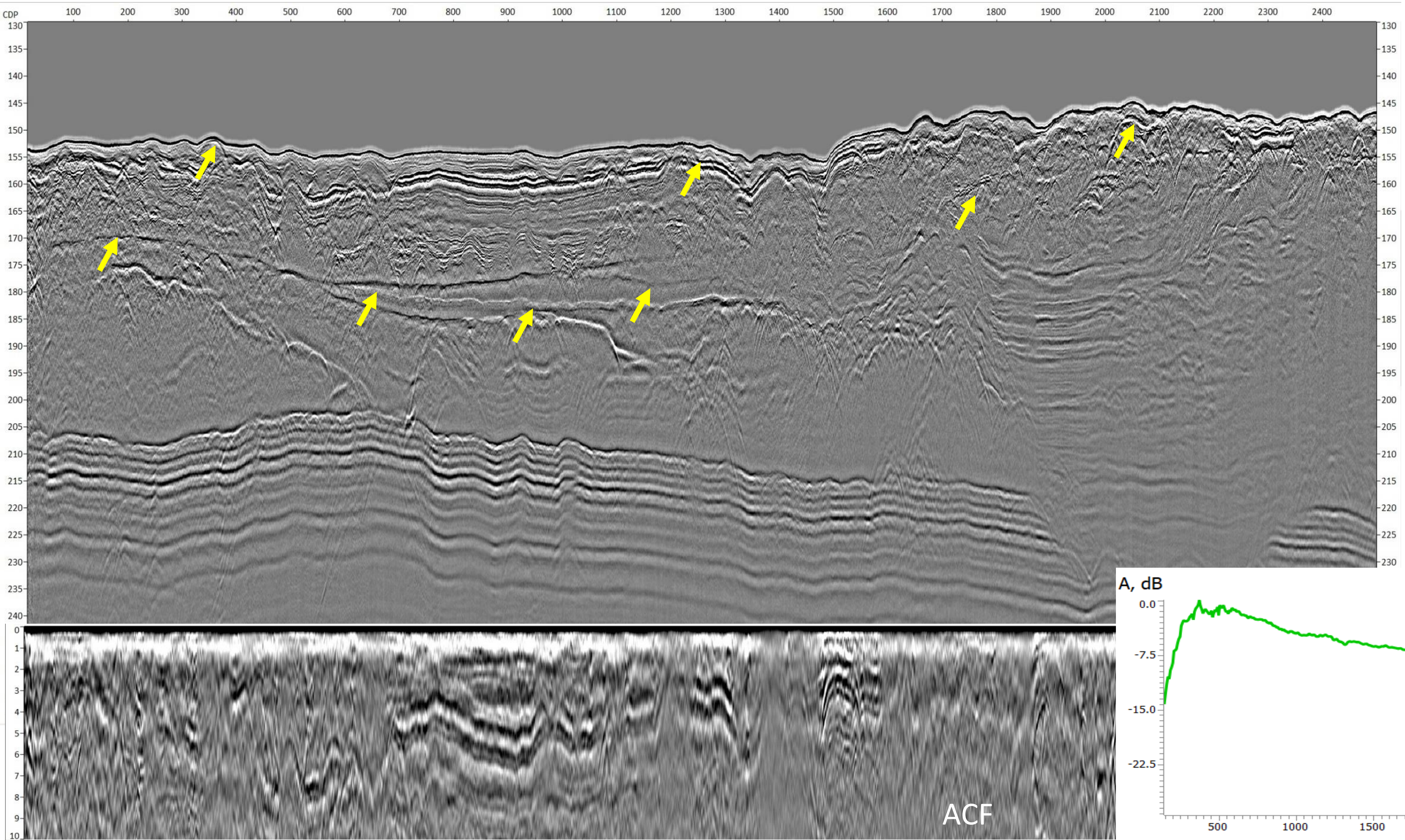
Source – sparker
Streamer – 48 channels
Water Depth – 100-110 m

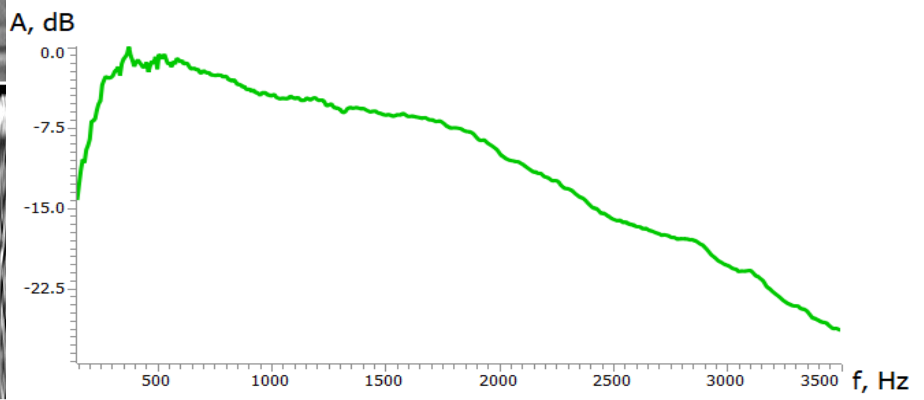
Data acquired by MAGE



Designature using statistical deconvolution

Statistical Deconvolution of sparker wavelet. Stacked section: after





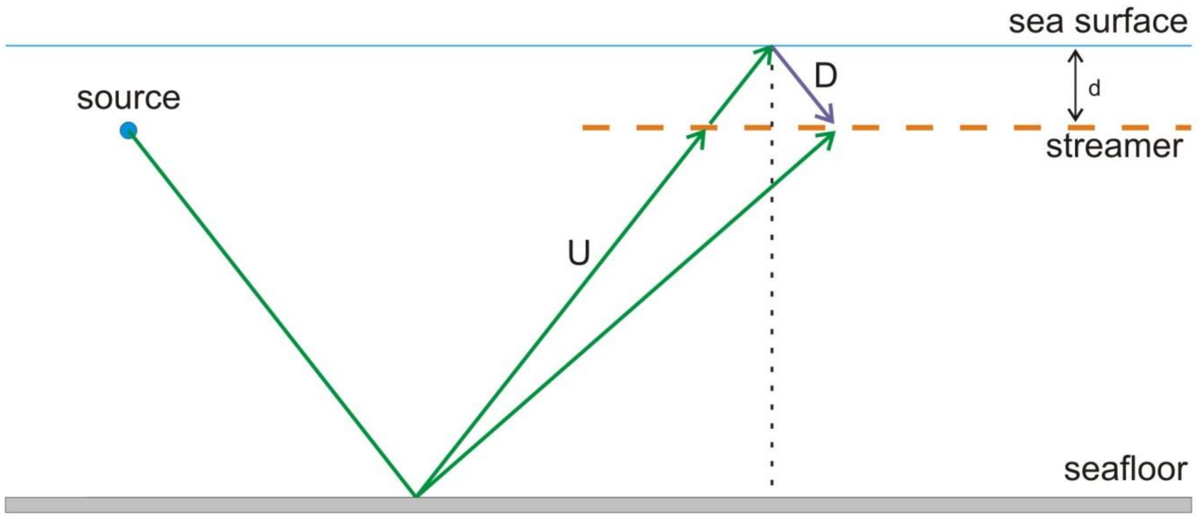
Survey parameters

Source – sparker
Streamer – 48 channels
Water Depth – 100-110 m

Data acquired by MAGE

SharpSeis - dedicated algorithm for ghosts removal

Principle scheme of marine towed acquisition



Ghost time delay: $\tau=2dcos\theta/V$

V – water velocity

d – streamer depth

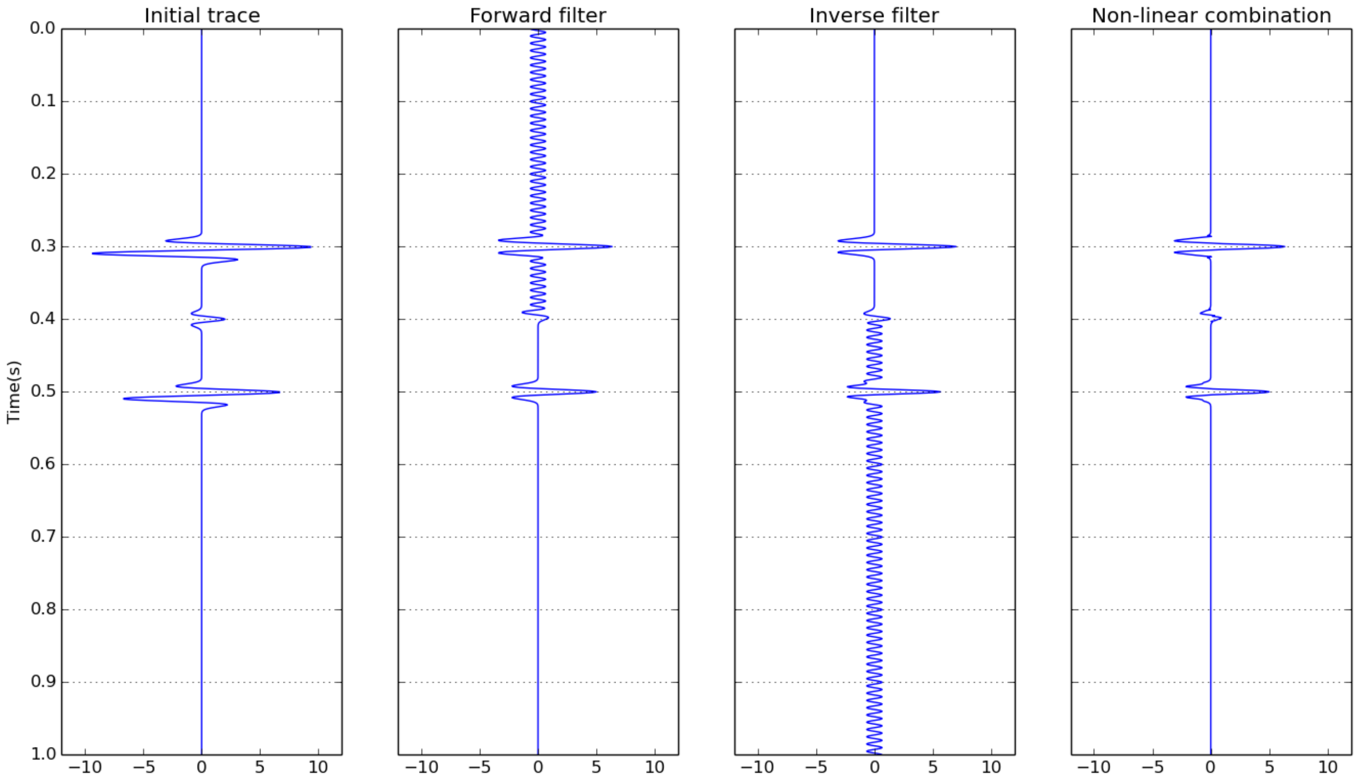
θ – angle of incidence

SharpSeis Deghosting

Solution: Adaptive Recursive Filtering *

1. Recursive filtering
2. Filtering in the reverse time
3. Nonlinear combination of forward and reverse filters
4. Regularization of the solution
5. Adaptive selection of filter parameters

(time delay and q)

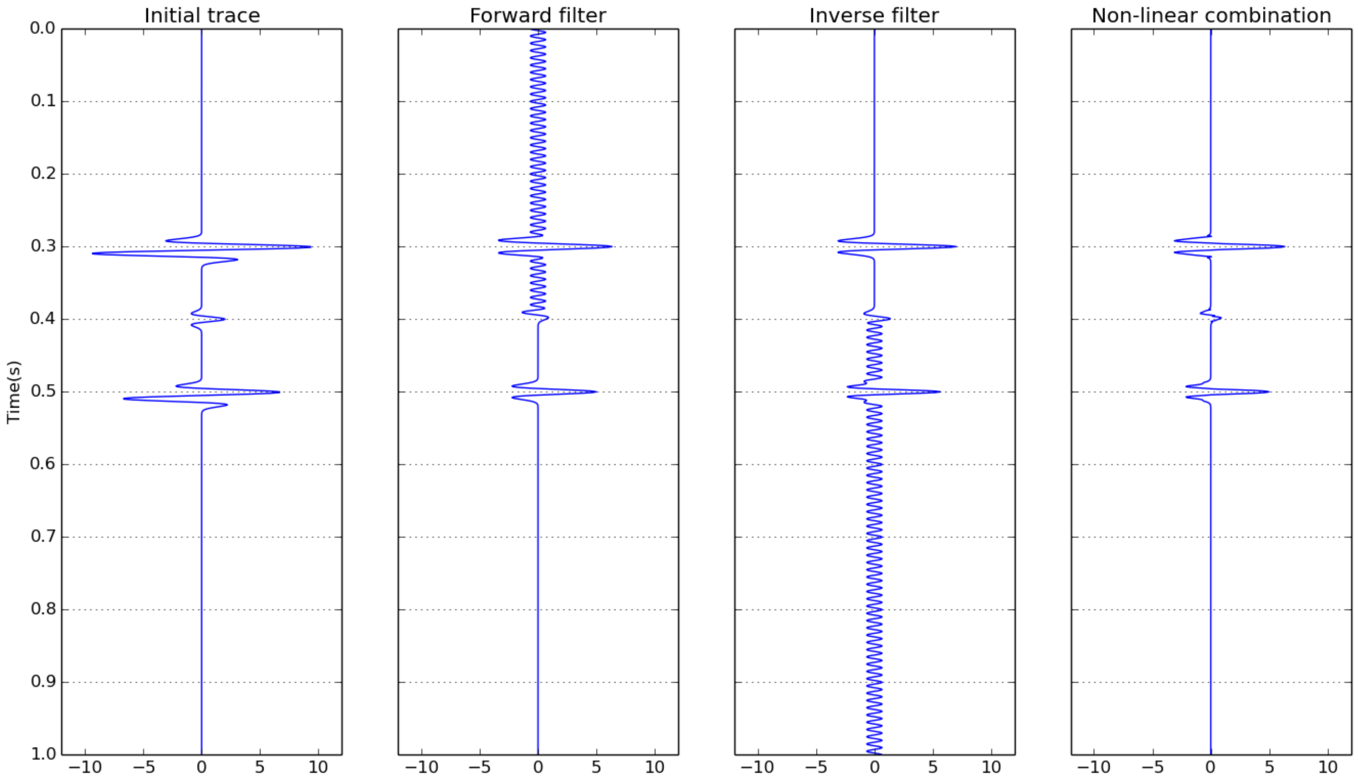


* Vakulenko S.A., Buryak S.V., Gofman P.A. and Finikov D.B., 2014, Deghosting of High Resolution Marine Seismic Data by Adaptive Filtering Algorithm, Near Surface Geoscience 2014 - 20th European Meeting of Environmental and Engineering Geophysics pp 1

SharpSeis Deghosting

Solution: Adaptive Recursive Filtering *

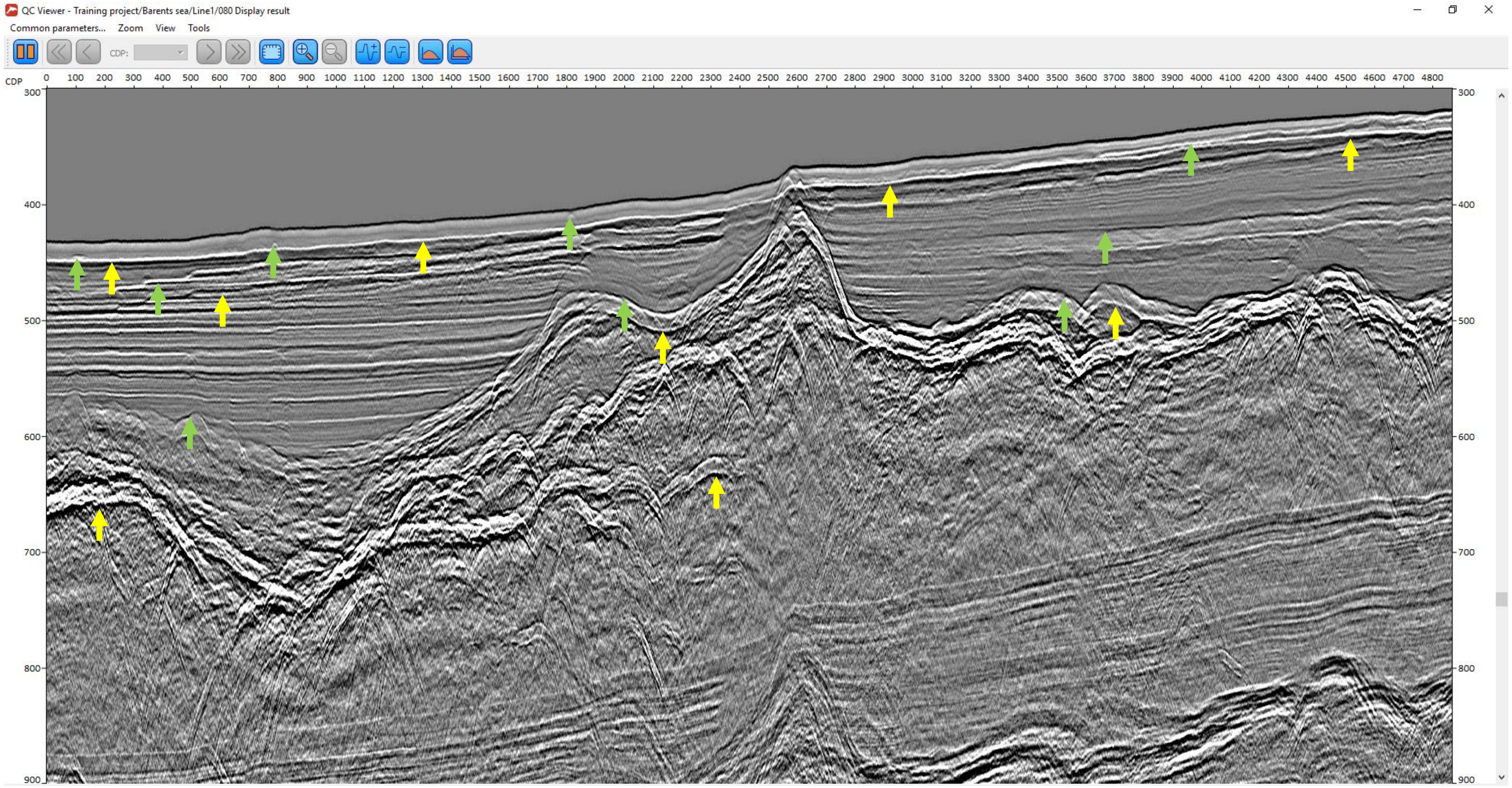
1. Recursive filtering
2. Filtering in the reverse time
3. Nonlinear combination of forward and reverse filters
4. Regularization of the solution
5. **Adaptive selection of filter parameters (time delay and q)**



* Vakulenko S.A., Buryak S.V., Gofman P.A. and Finikov D.B., 2014, Deghosting of High Resolution Marine Seismic Data by Adaptive Filtering Algorithm, Near Surface Geoscience 2014 - 20th European Meeting of Environmental and Engineering Geophysics pp 1

SharpSeis Deghosting

Deep towed streamer, small volume airgun, before deghosting



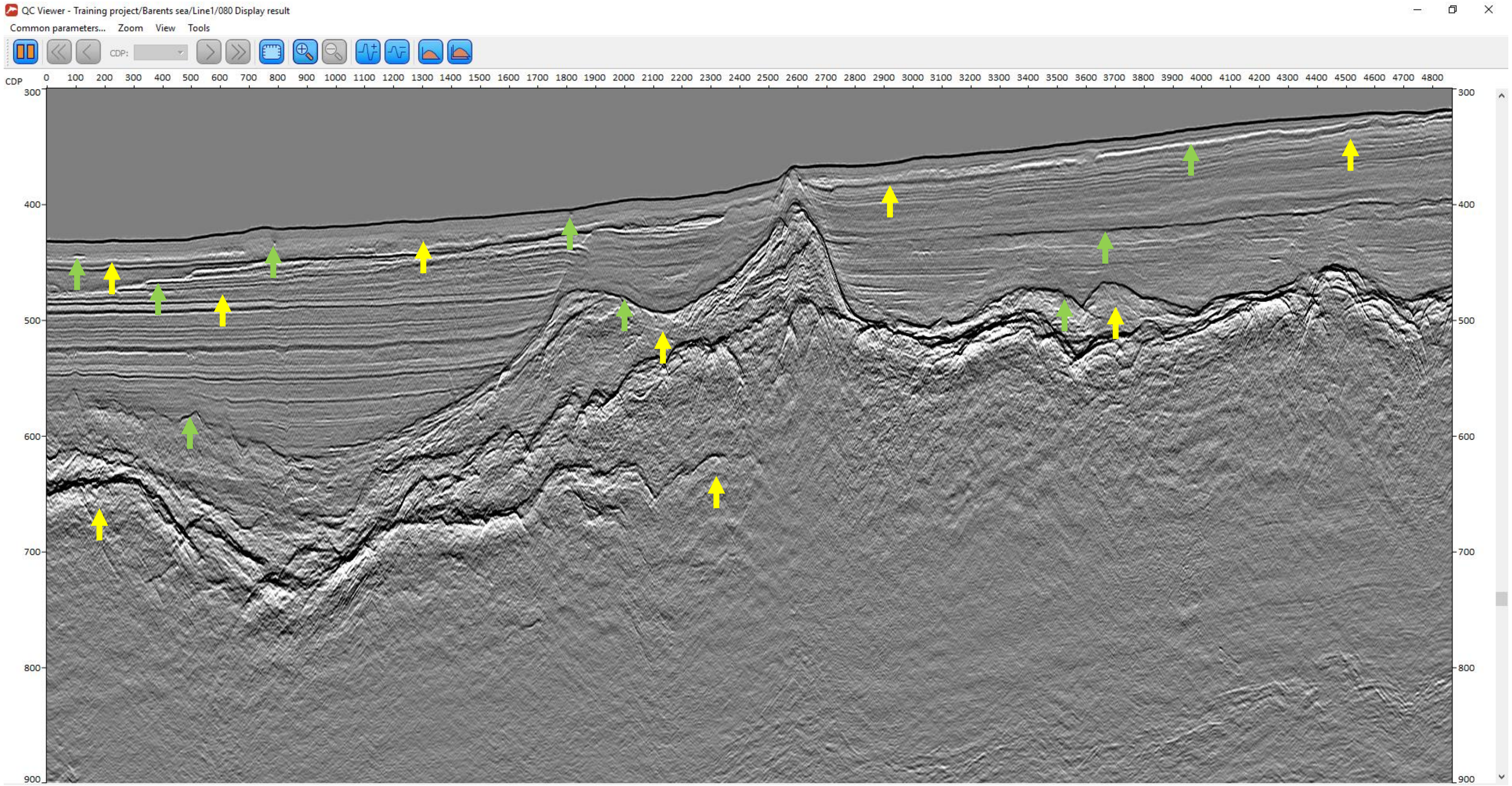
Primaries

Ghosts

Data courtesy of The University of Tromsø and UiT Centre of Excellence, Acquired with P-Cable 3D System

SharpSeis Deghosting

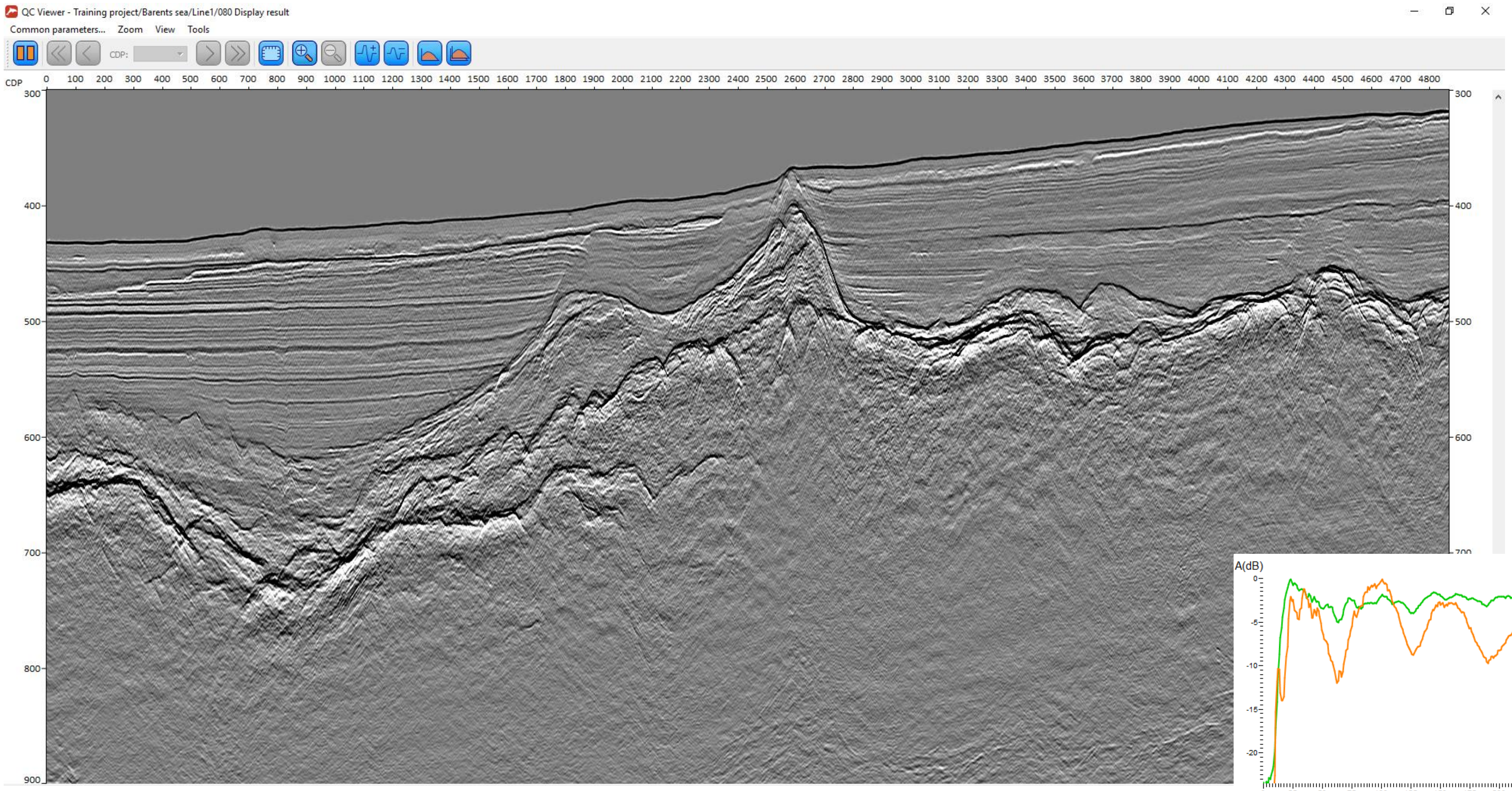
Deep towed streamer, small volume airgun, after deghosting



Data courtesy of The University of Tromsø and UiT Centre of Excellence, Acquired with P-Cable 3D System

SharpSeis Deghosting

Deep towed streamer, small volume airgun, after deghosting, spectra comparison

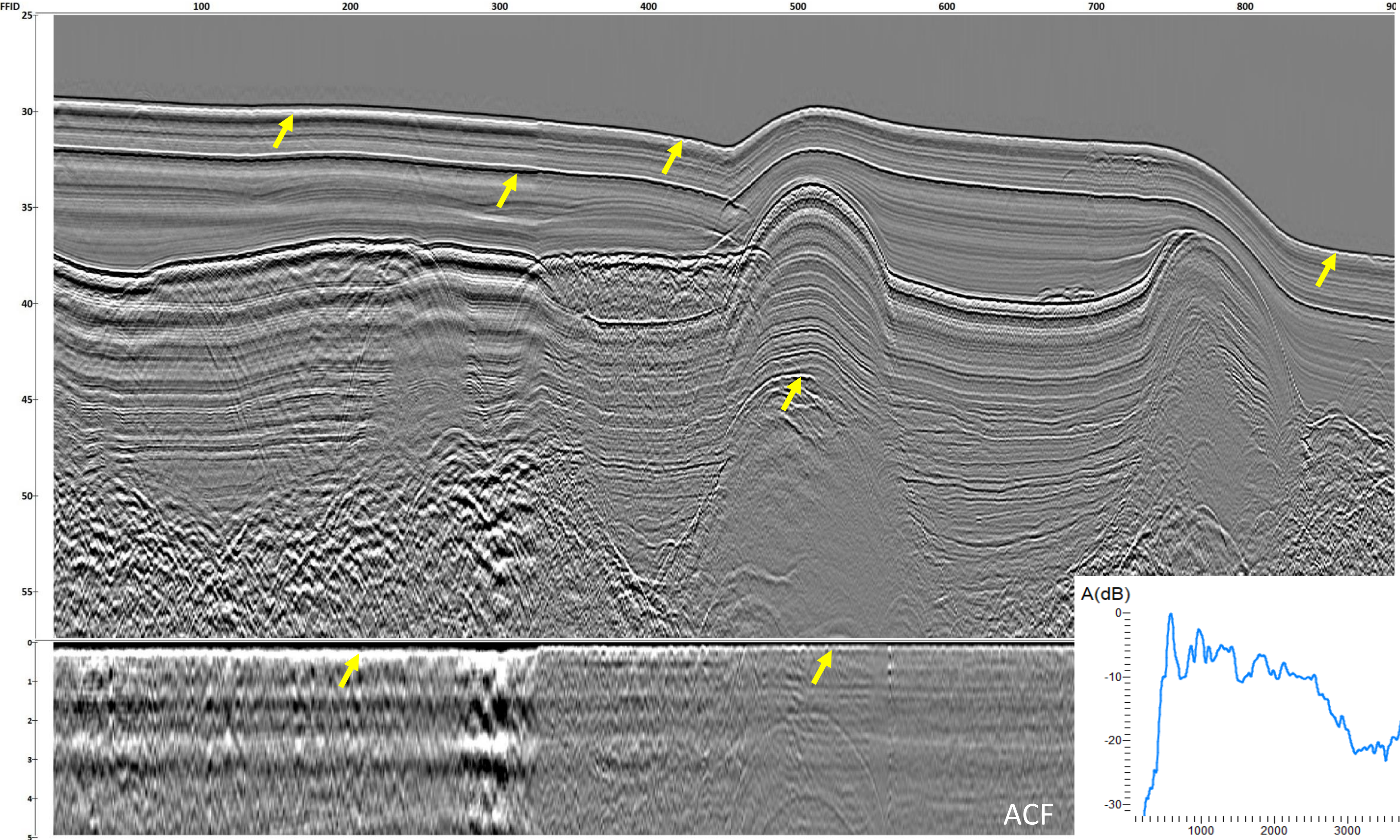


Data courtesy of The University of Tromsø and UiT Centre of Excellence, Acquired with P-Cable 3D System

RadExPro seismic software

SharpSeis Deghosting

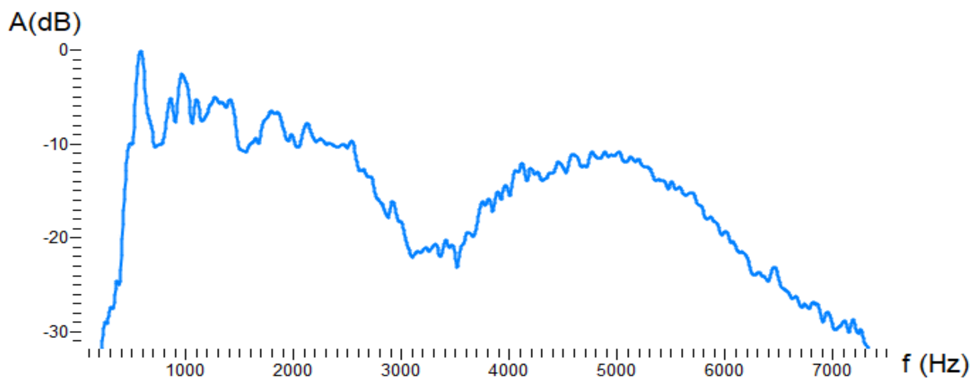
Seismic section before deghosting



Survey parameters

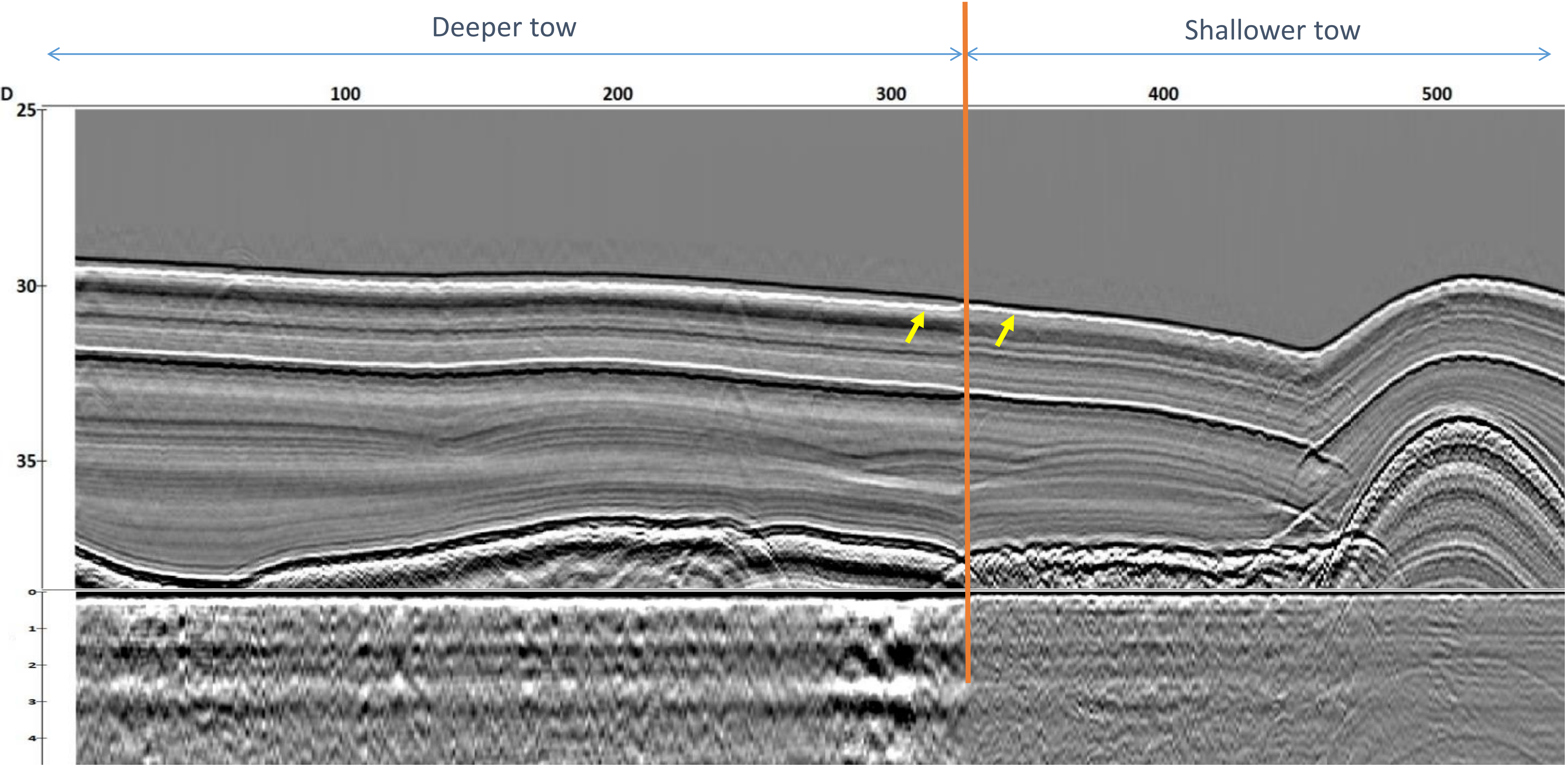
Source – G-Boomer
Streamer – 1 channel
Water Depth – 20-30 m

Data acquired by Geodevice



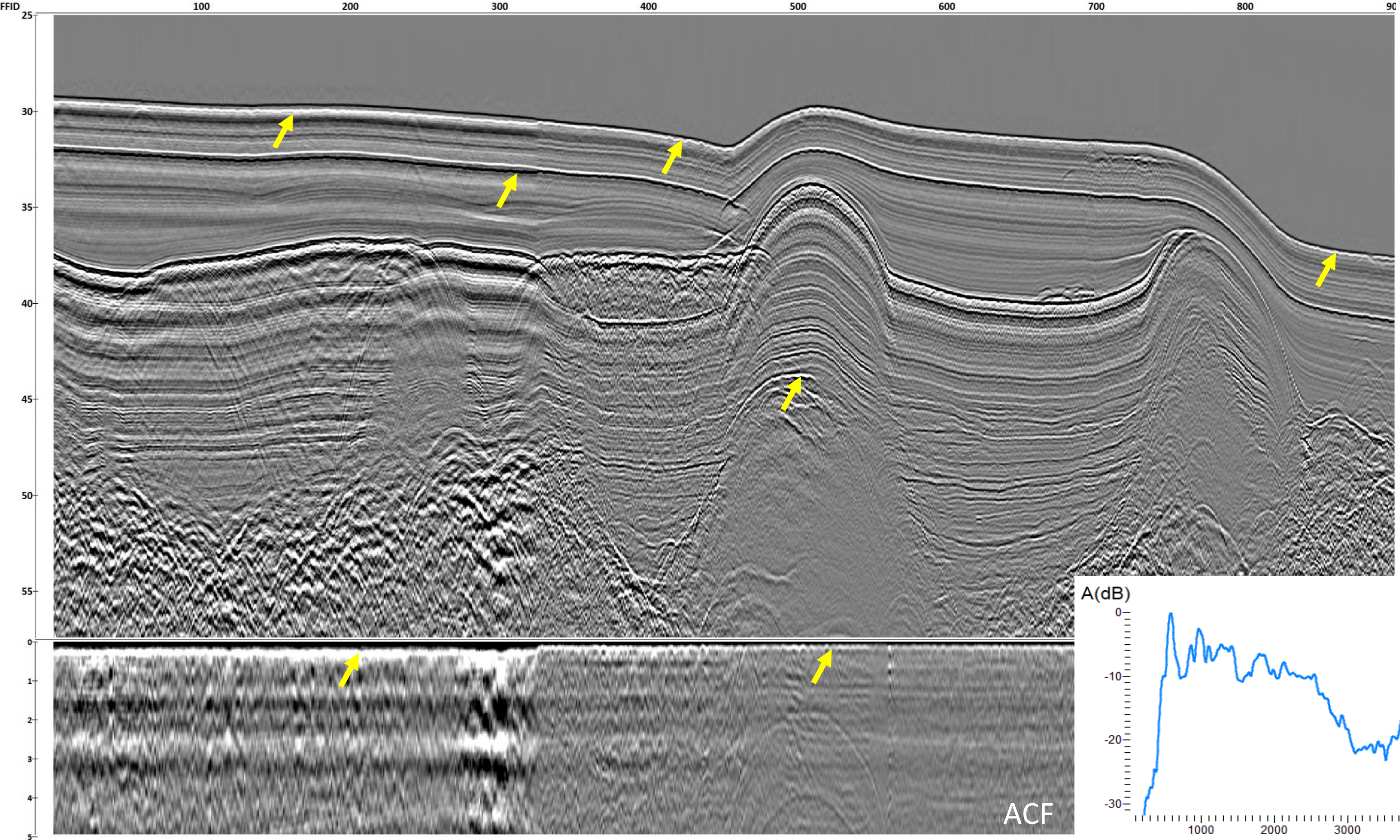
SharpSeis Deghosting

Seismic section before deghosting, zoomed



SharpSeis Deghosting

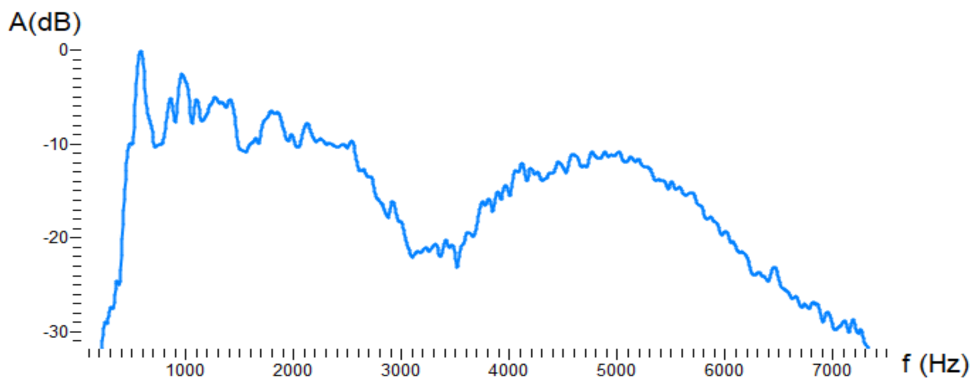
Seismic section before deghosting



Survey parameters

Source – G-Boomer
Streamer – 1 channel
Water Depth – 20-30 m

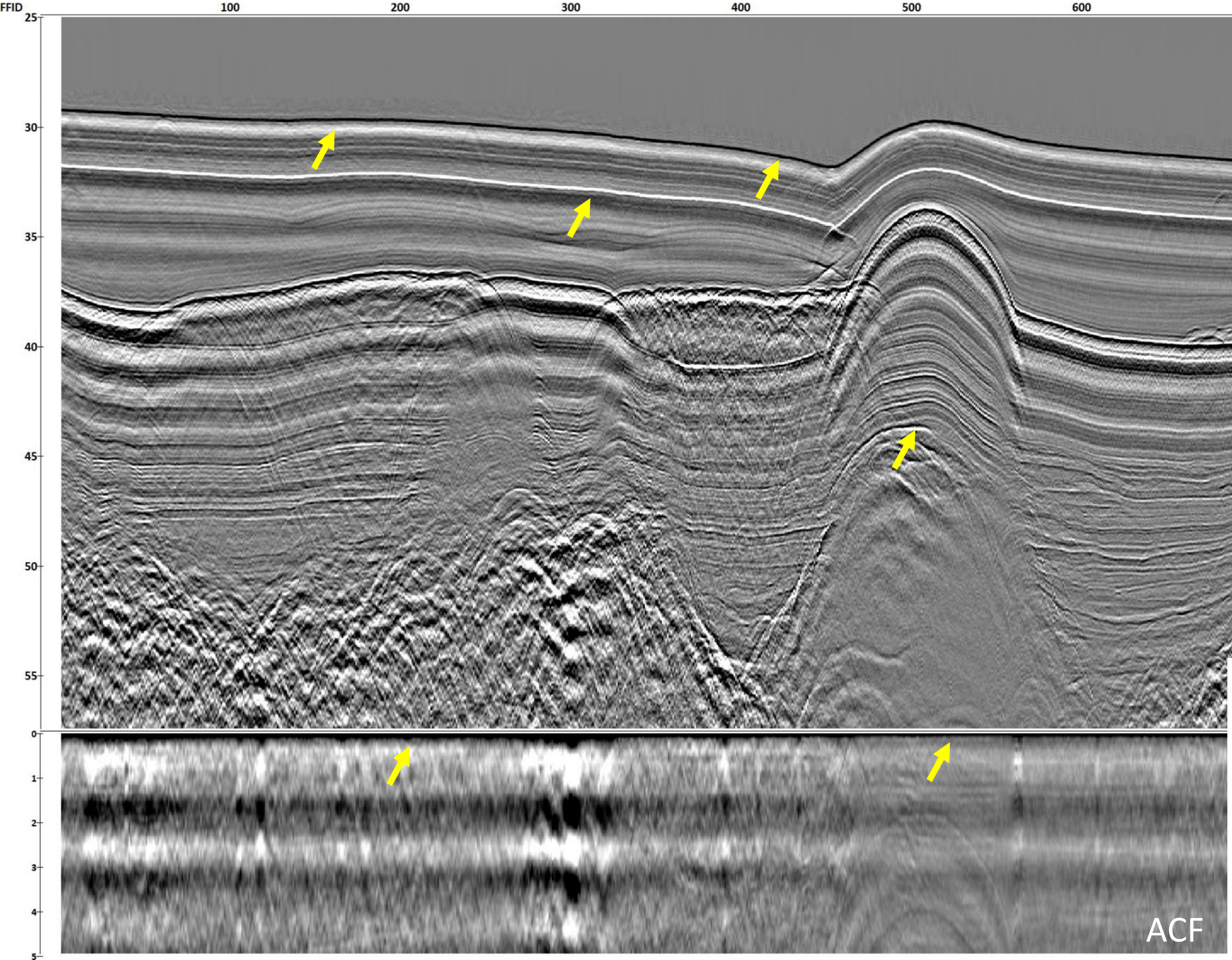
Data acquired by Geodevice



RadExPro seismic software

SharpSeis Deghosting

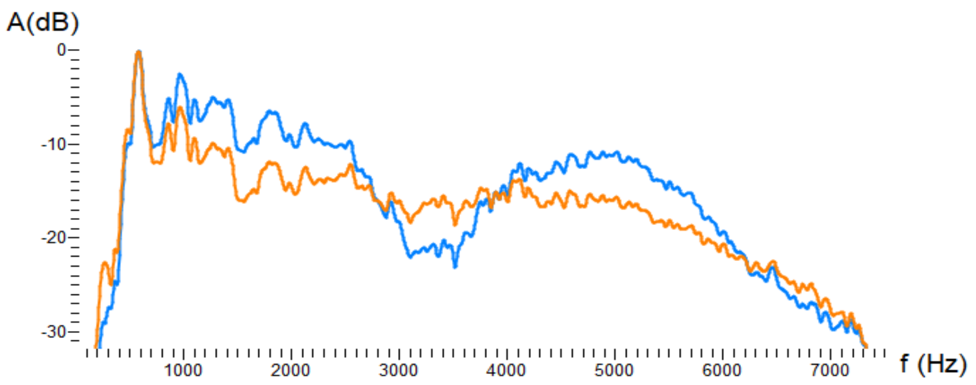
Seismic section after deghosting



Survey parameters

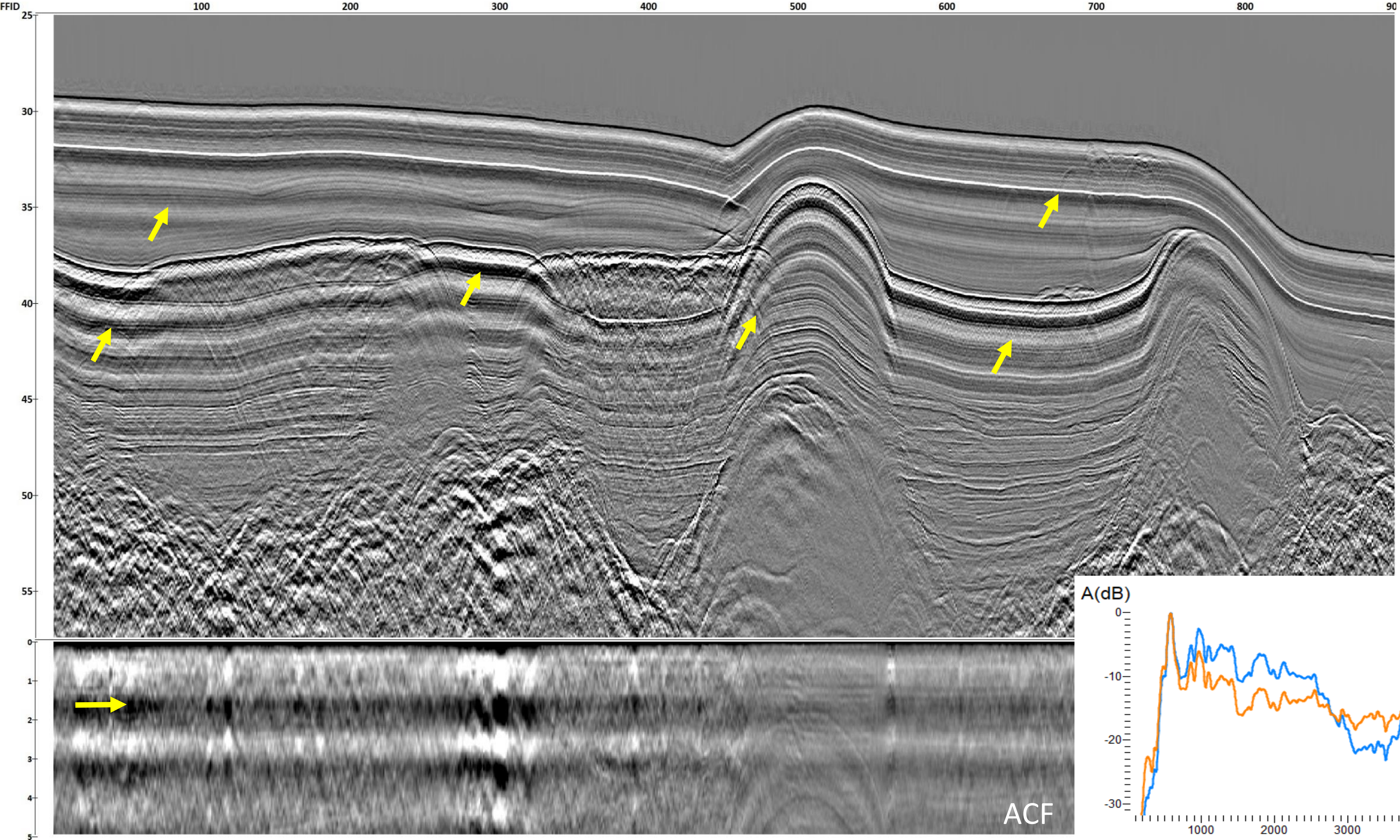
Source – G-Boomer
Streamer – 1 channel
Water Depth – 20-30 m

Data acquired by Geodevice



Bubble oscillations removal

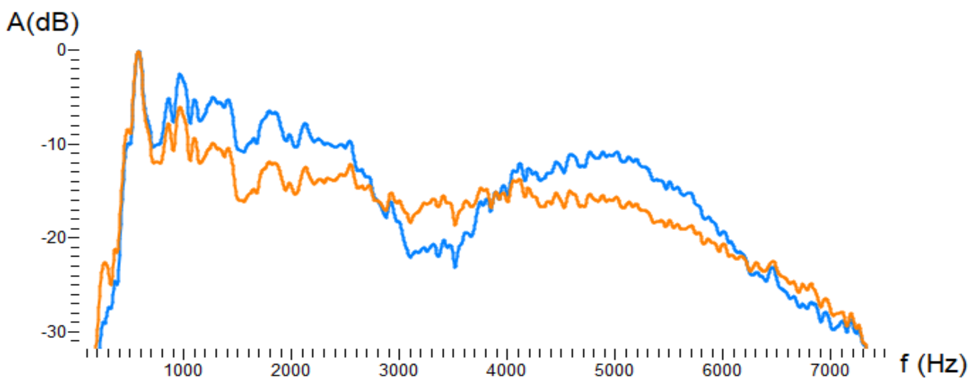
Seismic section before debubbling



Survey parameters

Source – G-Boomer
Streamer – 1 channel
Water Depth – 20-30 m

Data acquired by Geodevice



Bubble oscillation removal

Oil and gas industry typical solutions:

1. Gundalf source modelling
2. Estimation from NFH (Ziolkowski, A., 1982)

Available solutions for HR data:

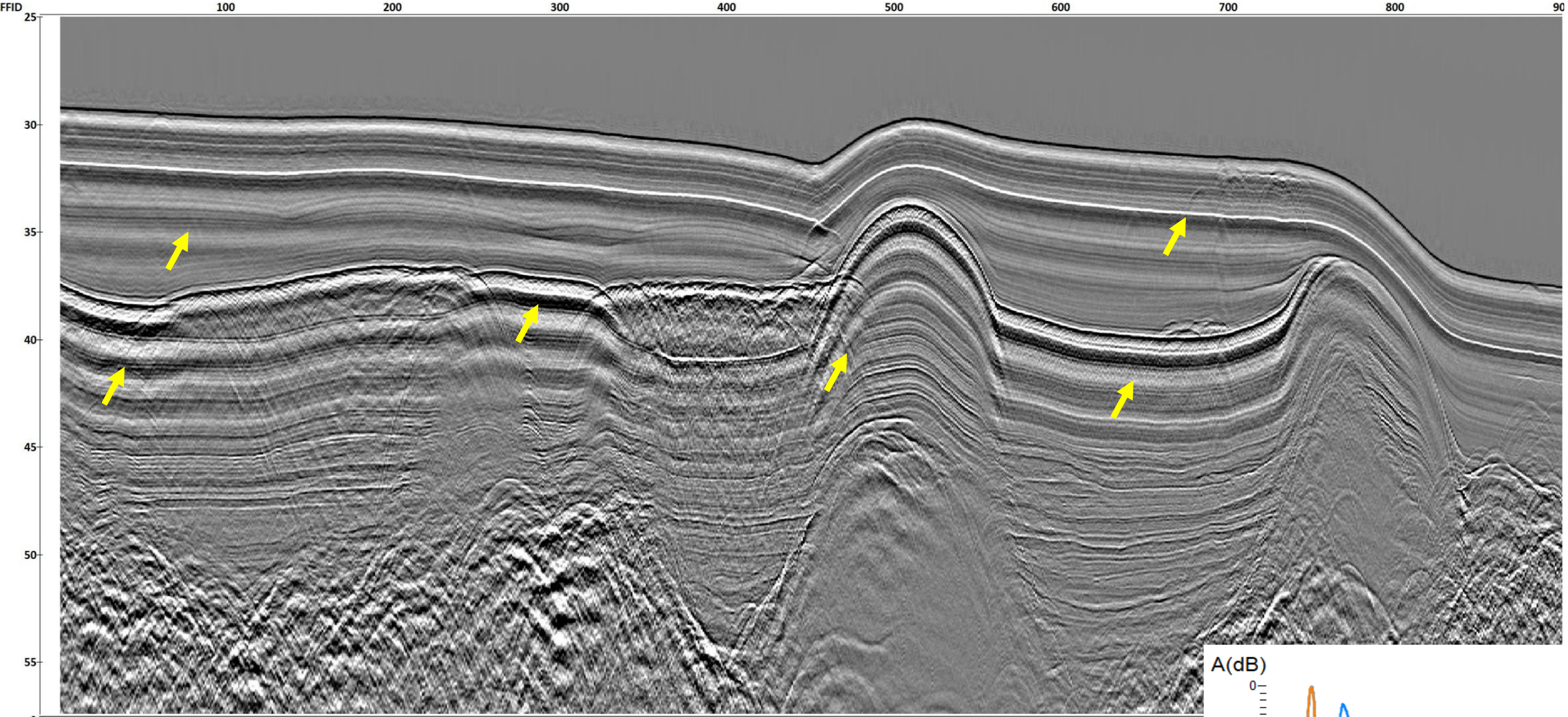
1. Wavelet extraction and inverse filter application
2. Bubble prediction filter
3. Modification of KSF (J. Claerbout and A. Guitton (2015)) *

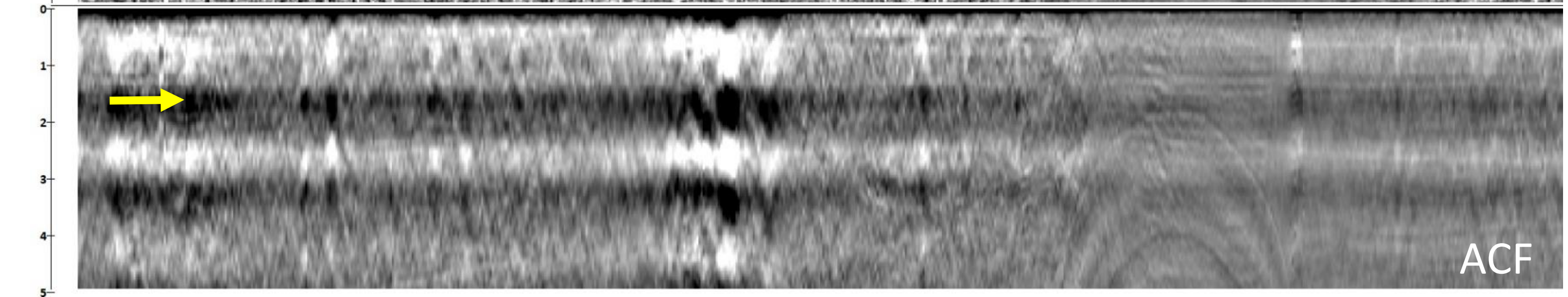
* Claerbout, J., Guitton, A., 2015, Ricker-Compliant Deconvolution: Geophysical Prospecting, Volume 63, Issue 3, pages 615-625

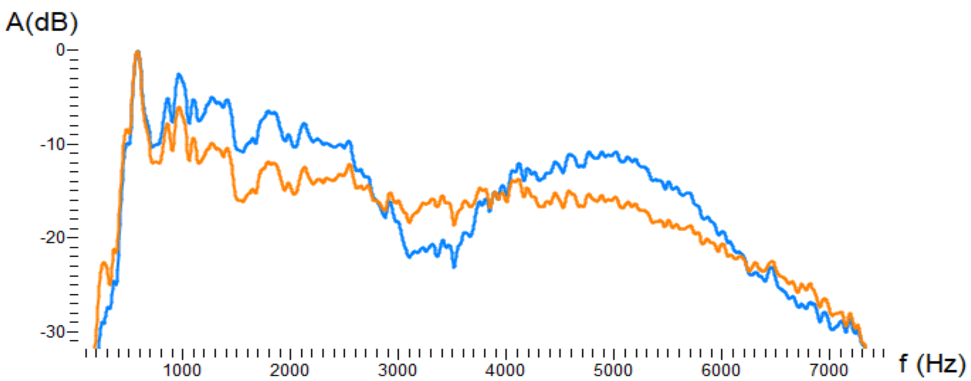
Vakulenko S.A., Poluboyarinov M.A. and Buryak S.V., 2016, Implementation and Application of Debbubling Algorithm, Based on Kolmogorov Spectral Factorization, Near Surface Geoscience 2016 - Second Applied Shallow Marine Geophysics Conference pp 1

Bubble oscillations removal

Seismic section before debubbling







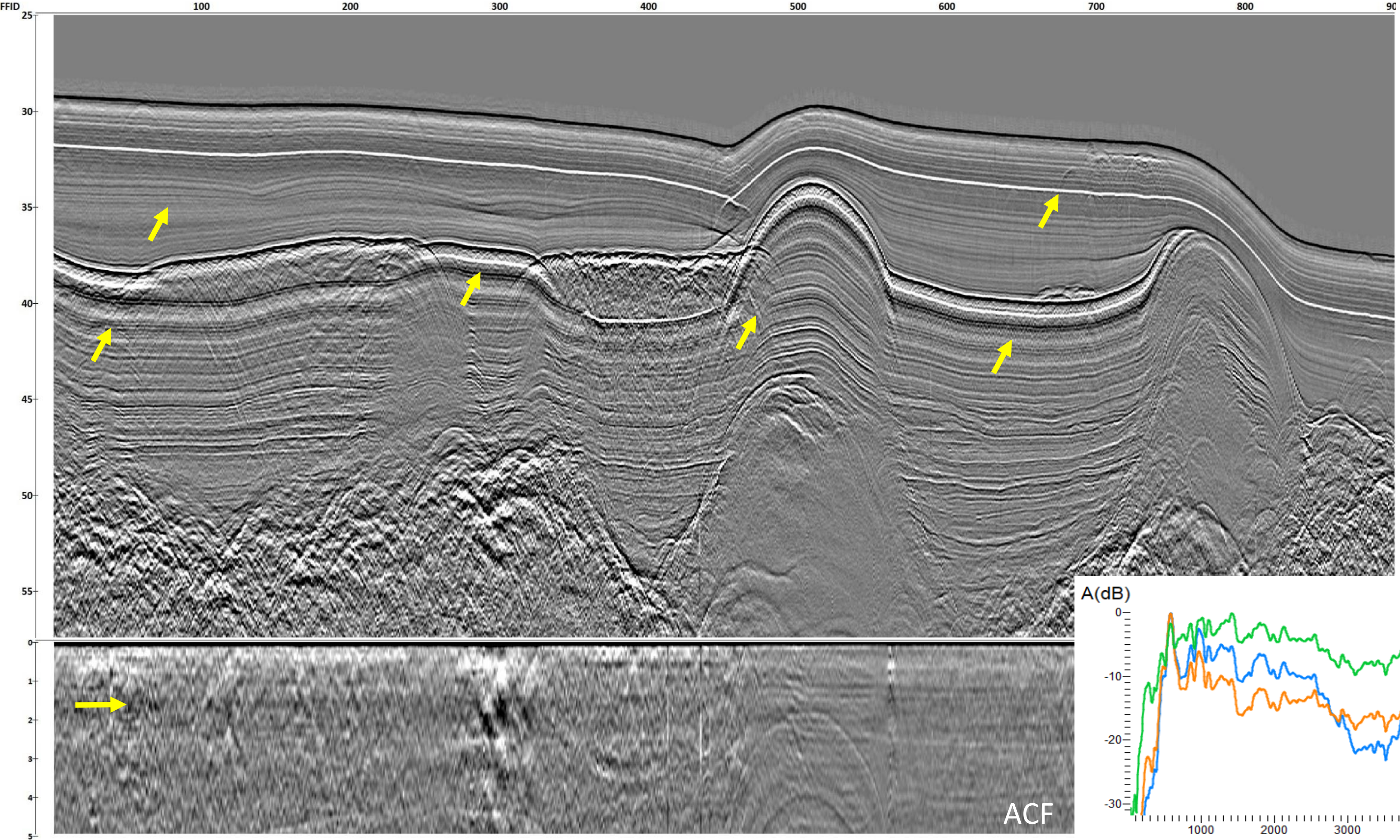
Survey parameters

Source – G-Boomer
Streamer – HRStreamer, single channel
Water Depth – 20-30 m

Data acquired by Geodevice

Bubble oscillations removal

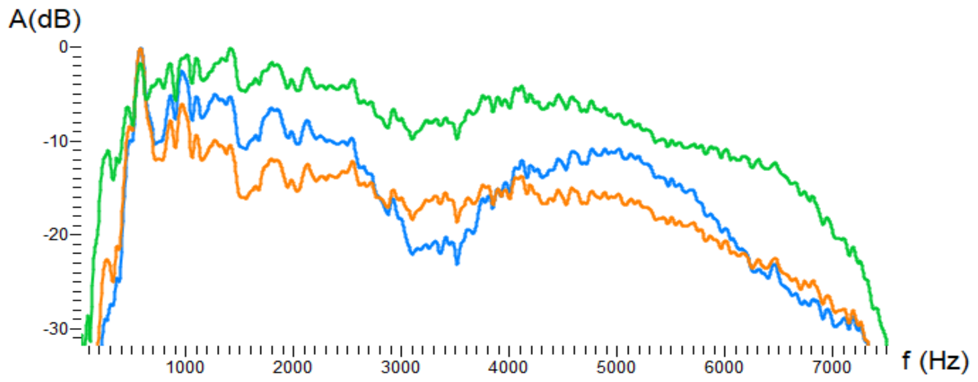
Seismic section after debubbling



Survey parameters

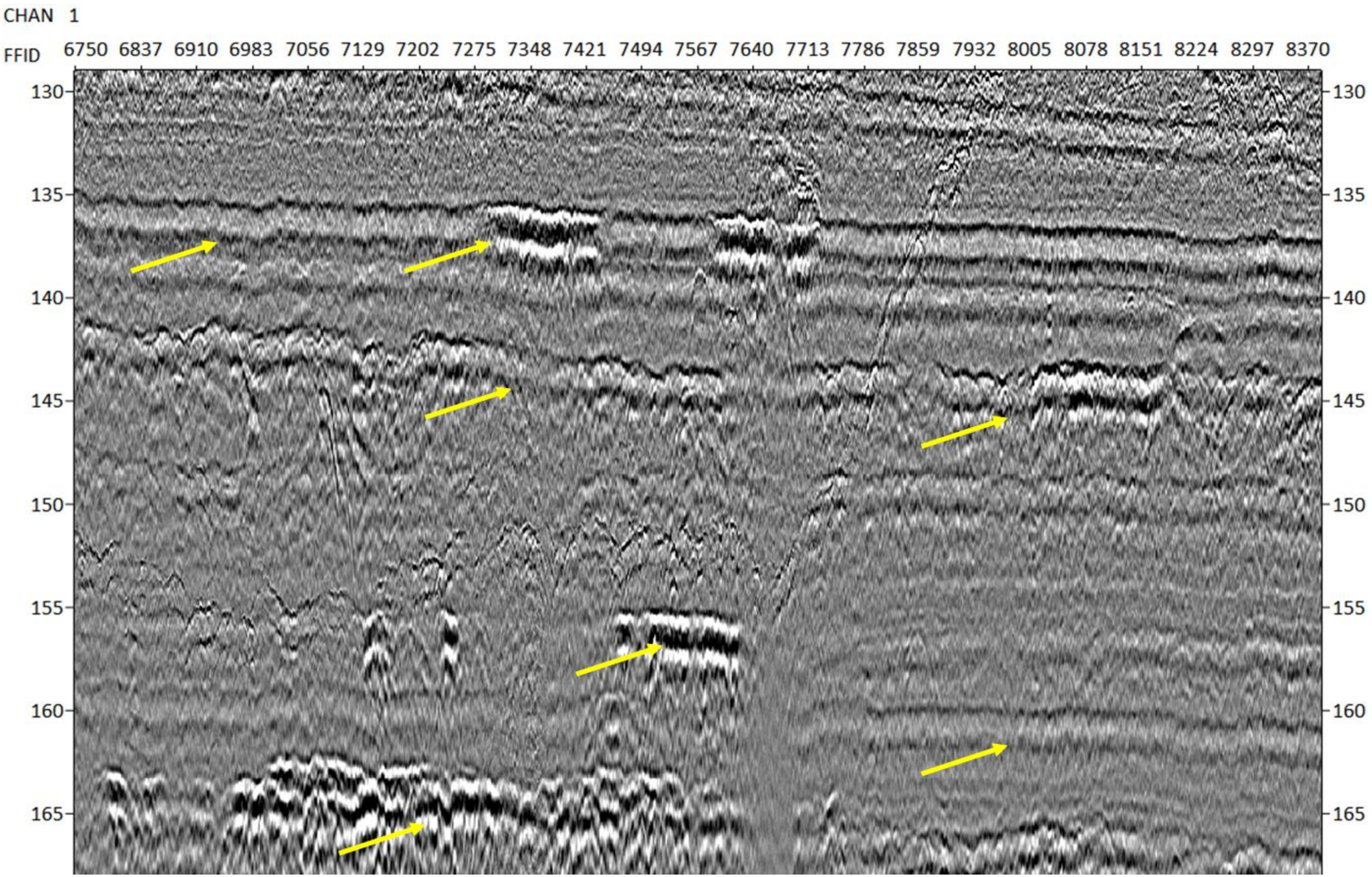
Source – G-Boomer
Streamer – HRStreamer, single channel
Water Depth – 20-30 m

Data acquired by Geodevice



Bubble oscillations removal

Seismic section before debubbling

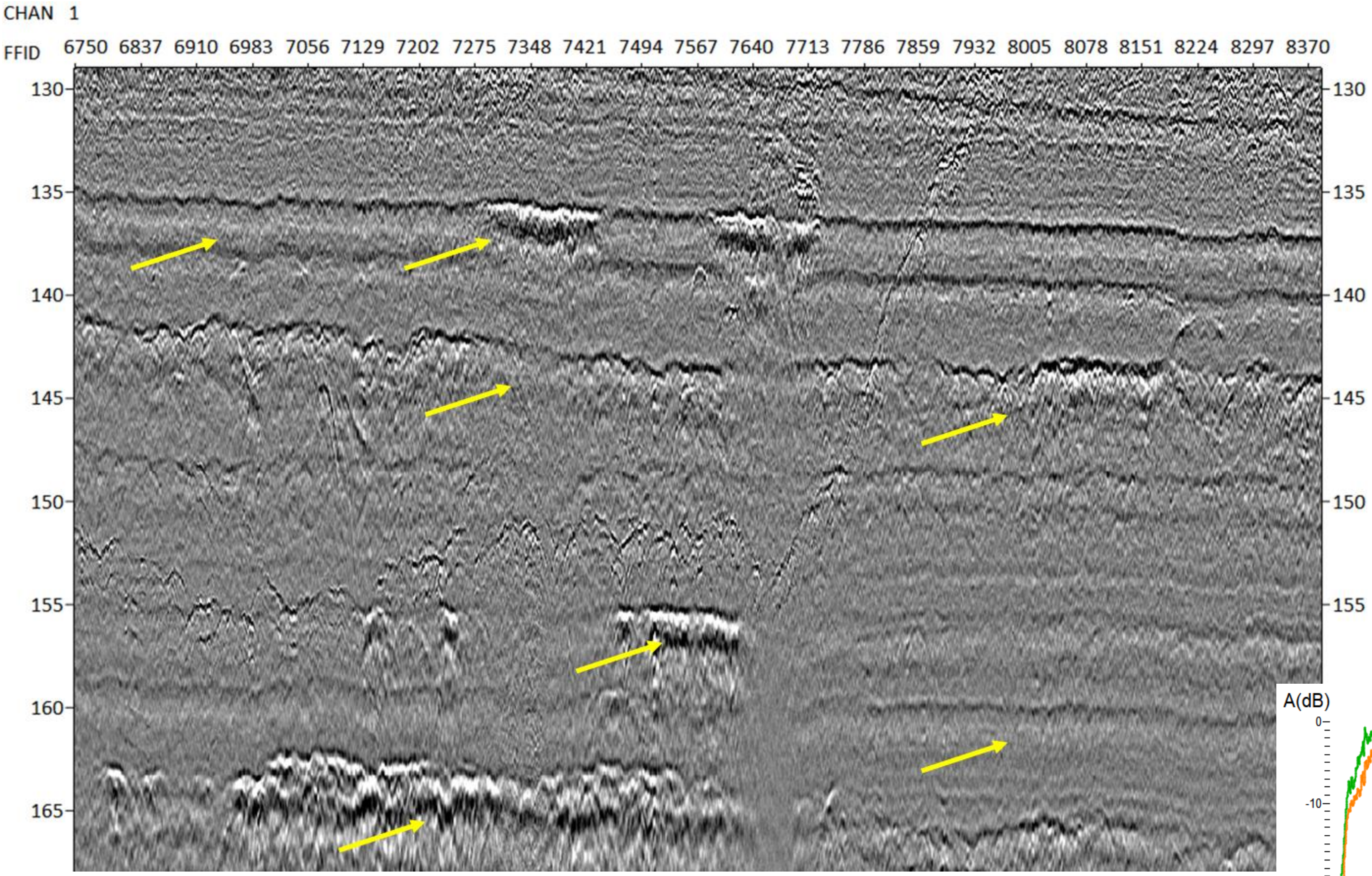


Survey parameters

Source – Fresh Water Sparker (FWS-250)
Streamer – HRStreamer, 4 channels
Water Depth – 40-60 m

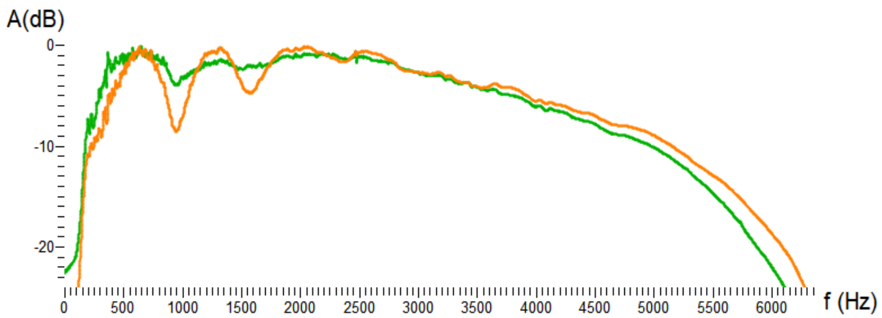
Bubble oscillations removal

Seismic section after debubbling



Survey parameters

Source – Fresh Water Sparker (FWS-250)
Streamer – HRStreamer, 4 channels
Water Depth – 40-60 m



Designature outline

- Modern HR marine seismic acquisitions use various sources for signal generation. Depending on the source type and its parameters, source signature may significantly vary.
- Resulting complicated wavelet, when convolved with the reflectivity series, significantly reduces resolution of the final image and needs to be eliminated.
- RadExPro provides various algorithms for designature of HR seismic data to achieve high resolution of the resulting image.

Multiple elimination

Multiple reflections is well-known problem for marine seismic data

High frequencies, presented in the data result in large static differences between modelled multiple and multiple itself

Adaptive subtraction and adjusted static parameter provides good demultiple results

Available solutions:

Zero-offset demultiple (single channel, post-stack)

SRME (multichannel pre-stack, subtraction adapted for HR)

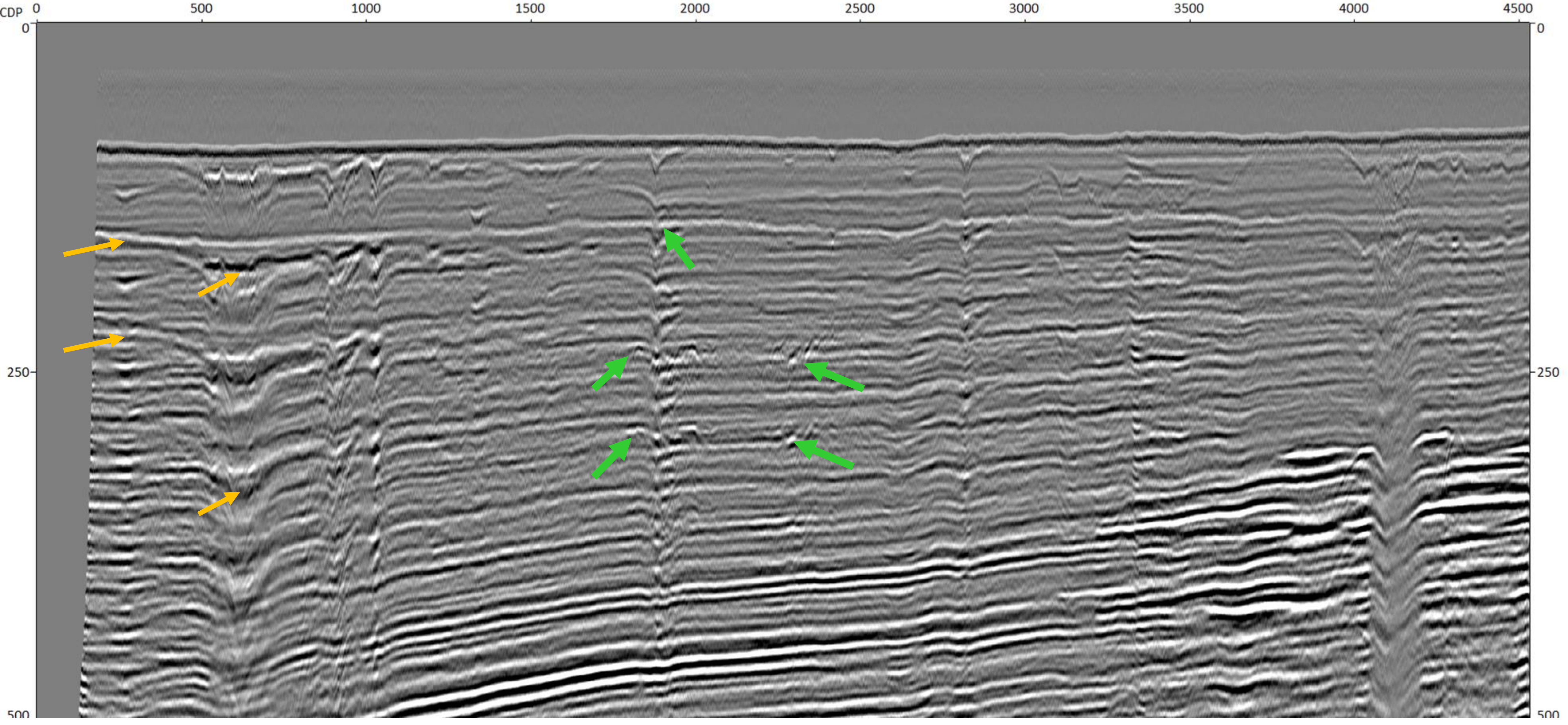
Tau-pi deconvolution

Radon demultiple

Custom algorithms (modelling and adaptive subtraction)

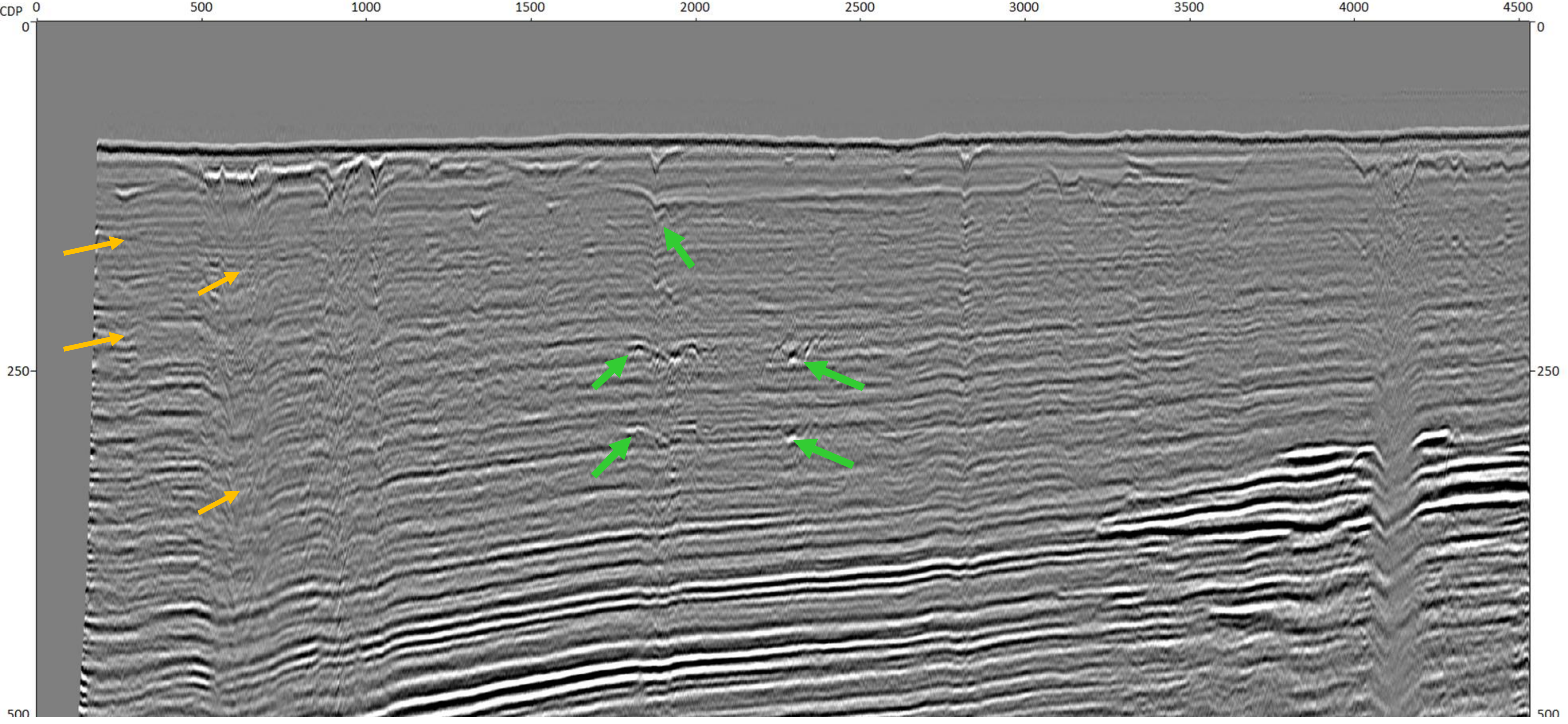
Pre-stack demultiple: SRME

Stacked seismic section – before multiple elimination



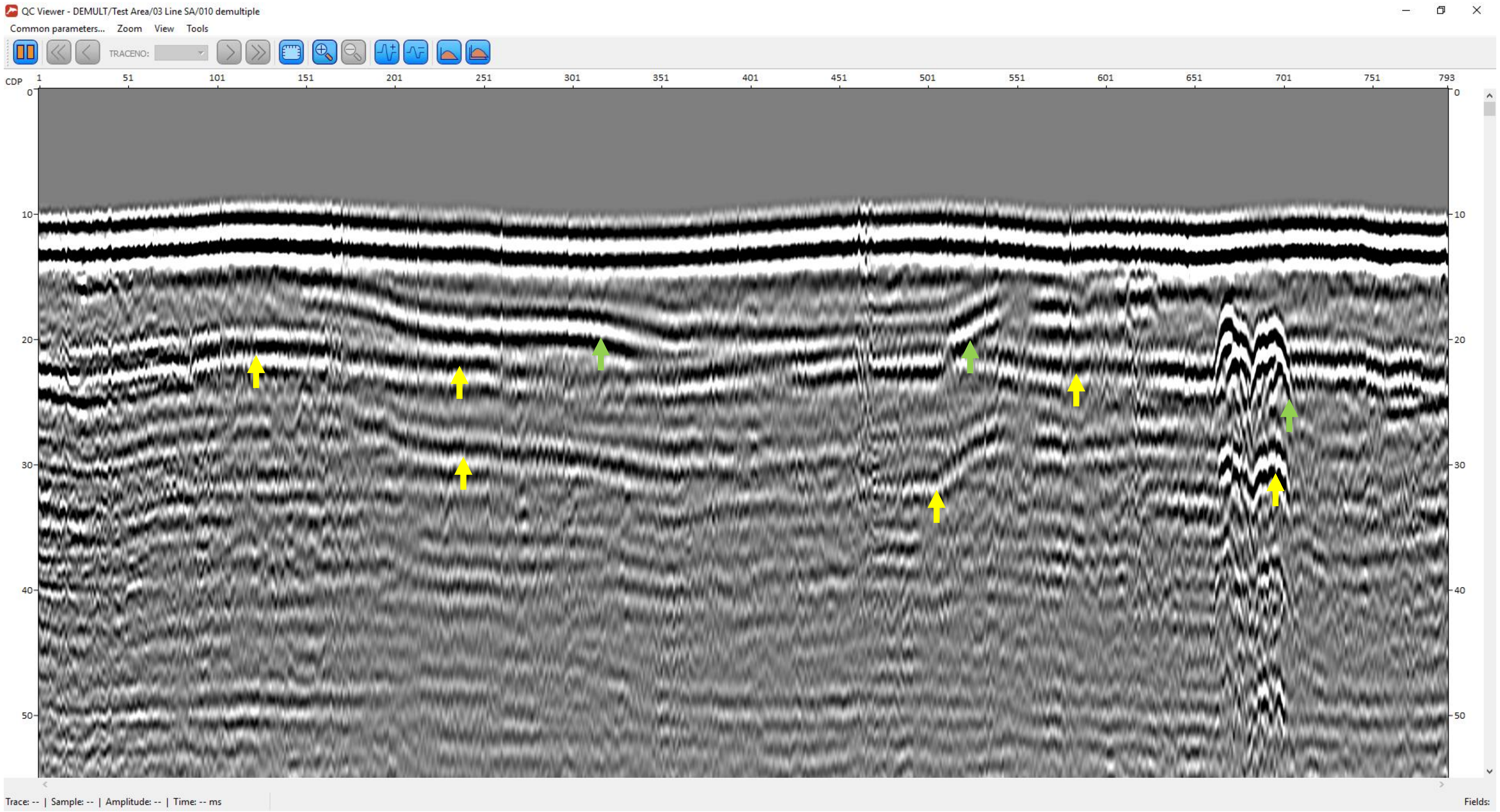
Pre-stack demultiple: SRME

Stacked seismic section – after multiple elimination



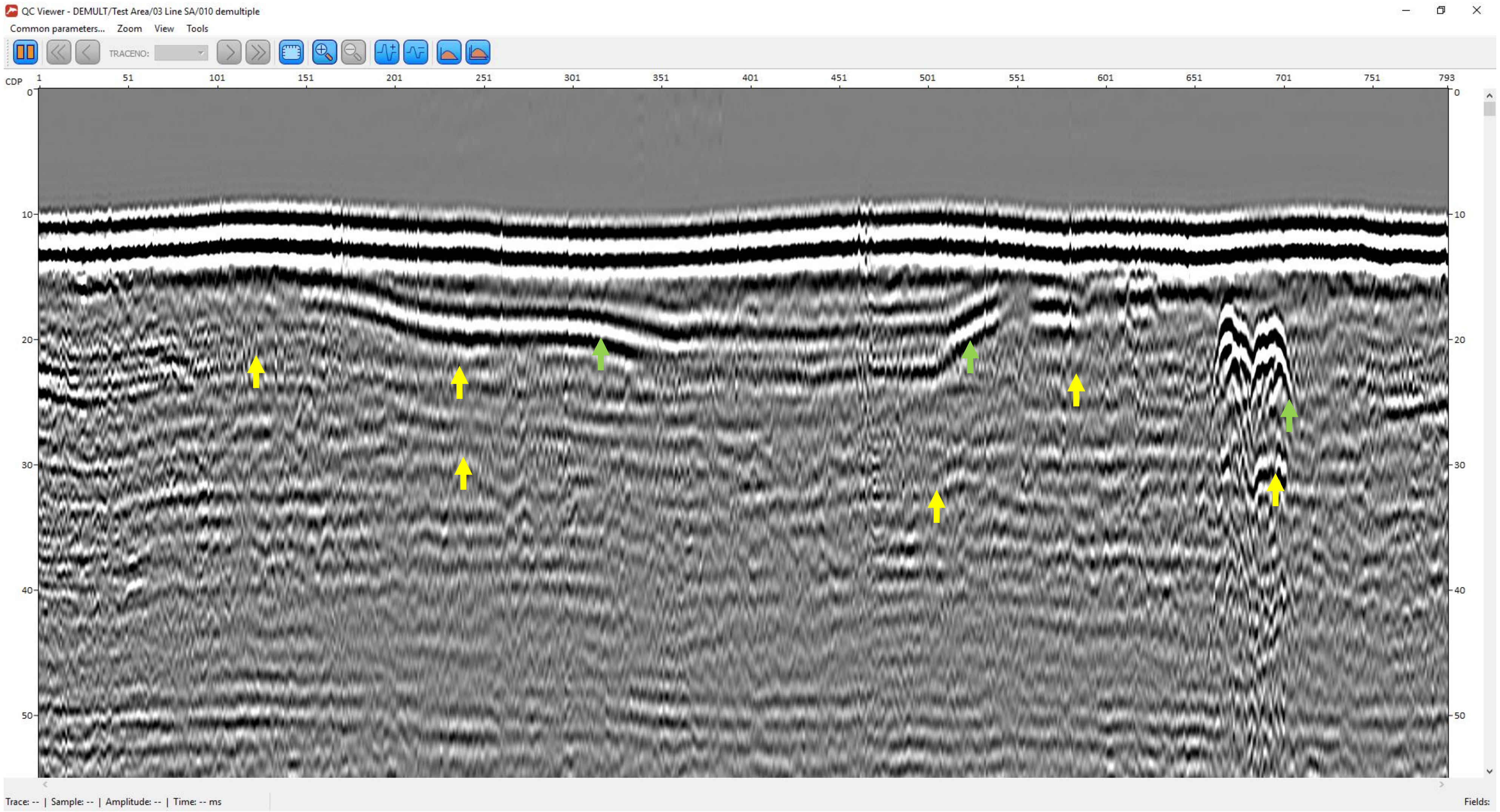
Zero-offset demultiple

Single channel boomer data – before multiple elimination



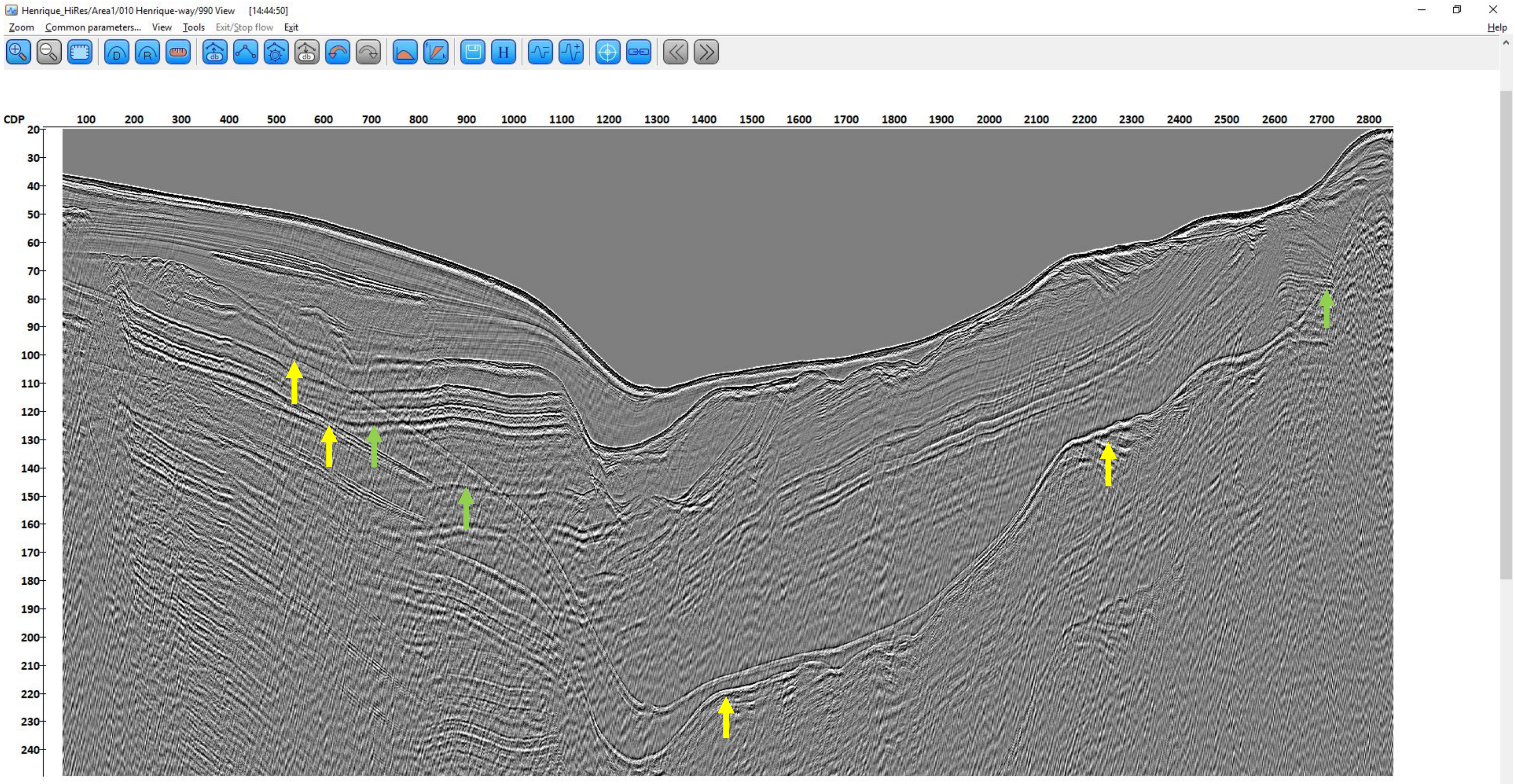
Zero-offset demultiple

Single channel boomer data – after multiple elimination



Post-stack demultiple

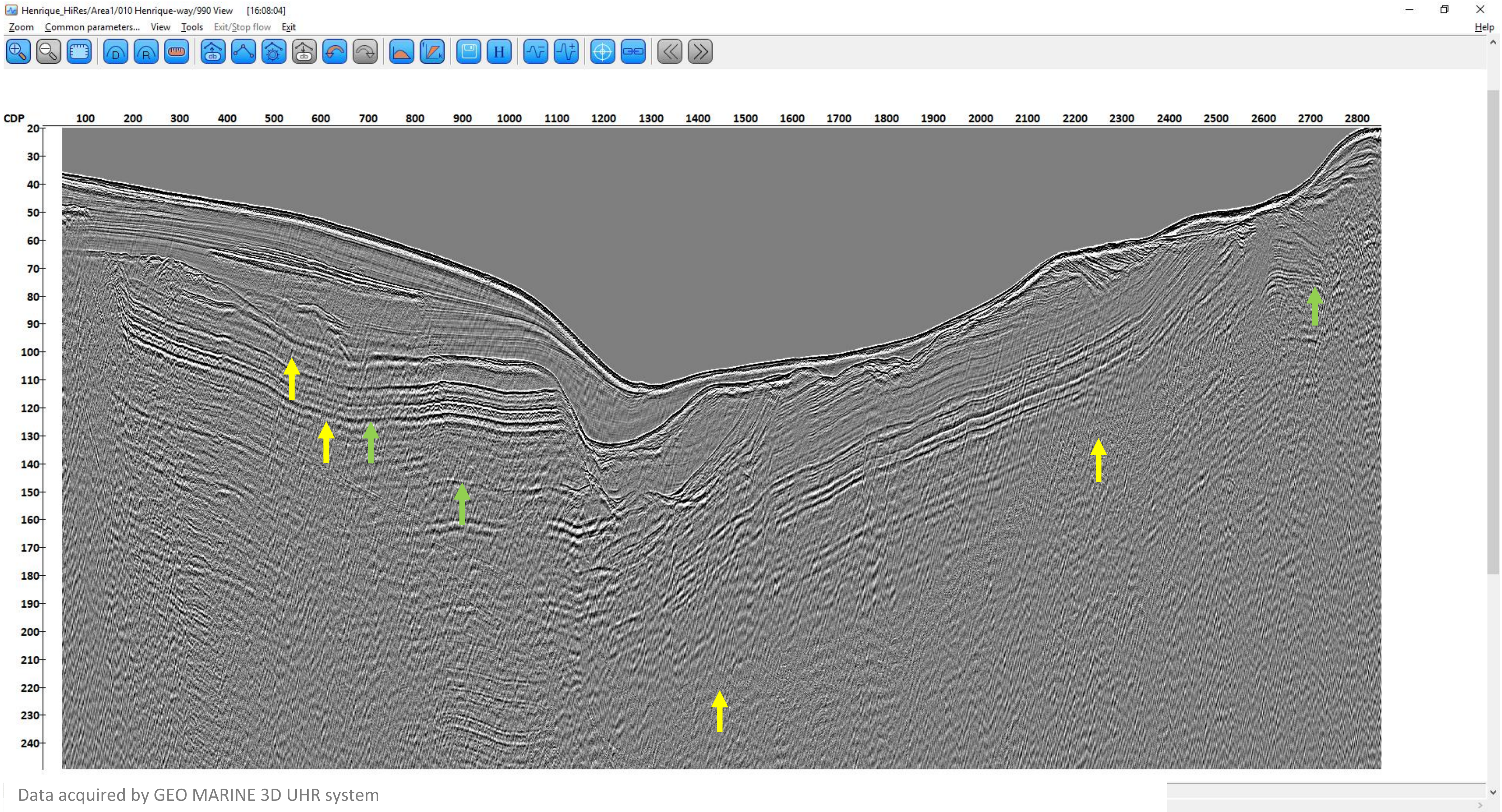
Stacked data (16 channels) – before multiple elimination



Data acquired by GEO MARINE 3D UHR system

Post-stack demultiple

Stacked data (16 channels) – after multiple elimination



Data acquired by GEO MARINE 3D UHR system

3D Regularization

Sea and ocean currents as well as other obstacles (GPS positioning) often result in gaps in CDP coverage

Non-equal offset distribution results in footprints on time slices

Available solutions:

3D Regularization

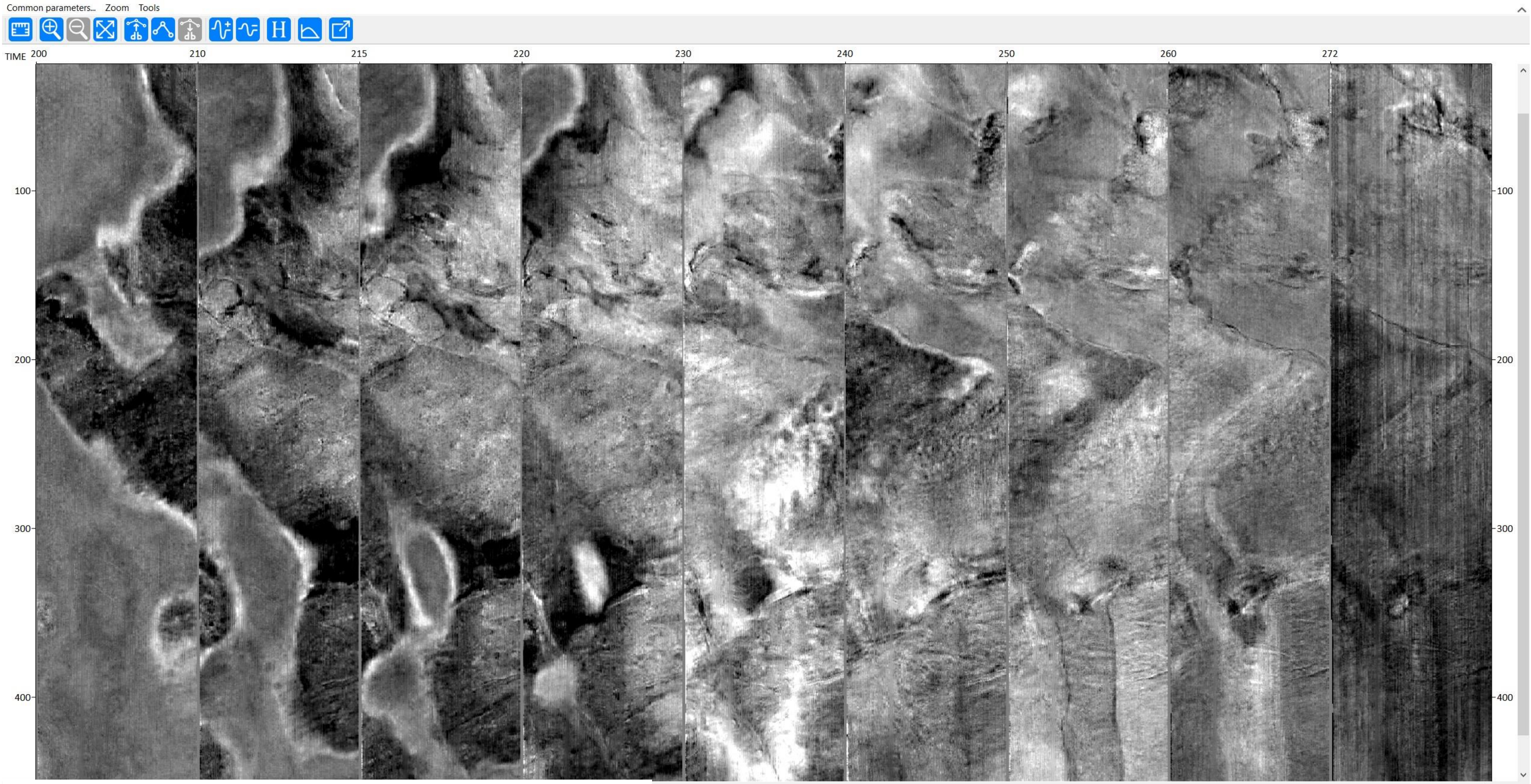
3D Regularization

Time slices before regularization

3D survey, flip-flop airguns + slanted streamers

3D Regularization

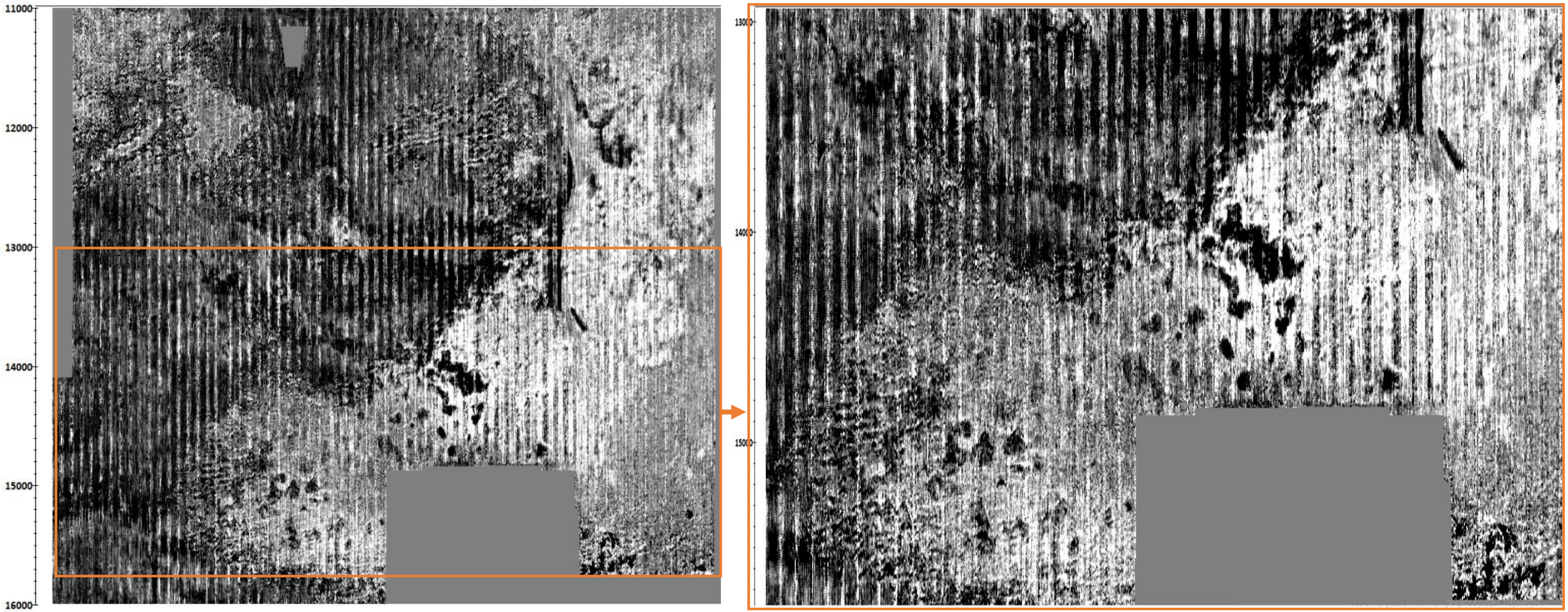
Time slices after regularization



3D survey, flip-flop airguns + slanted streamers

Footprints attenuation

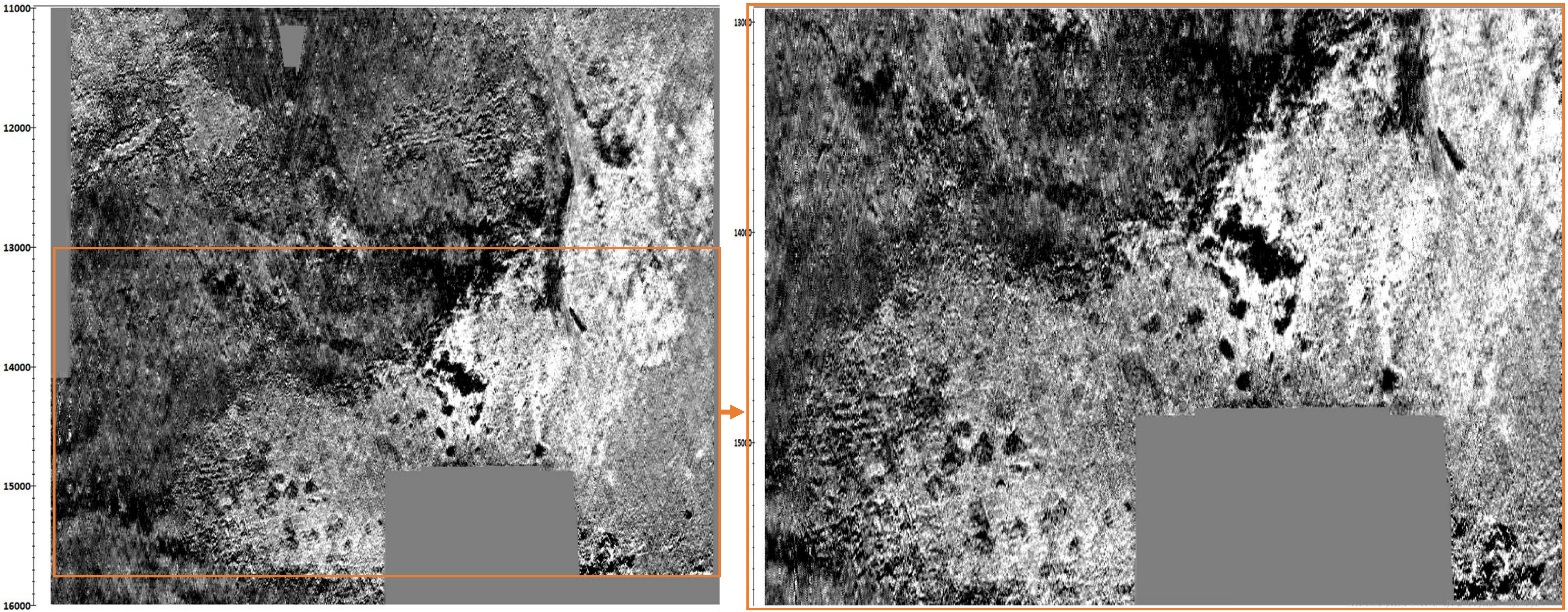
Time slices (100 ms) – before FPA



Large scale seismic for shallow imaging purposes

Footprints attenuation

Time slices (100 ms) – after FPA



Large scale seismic for shallow imaging purposes

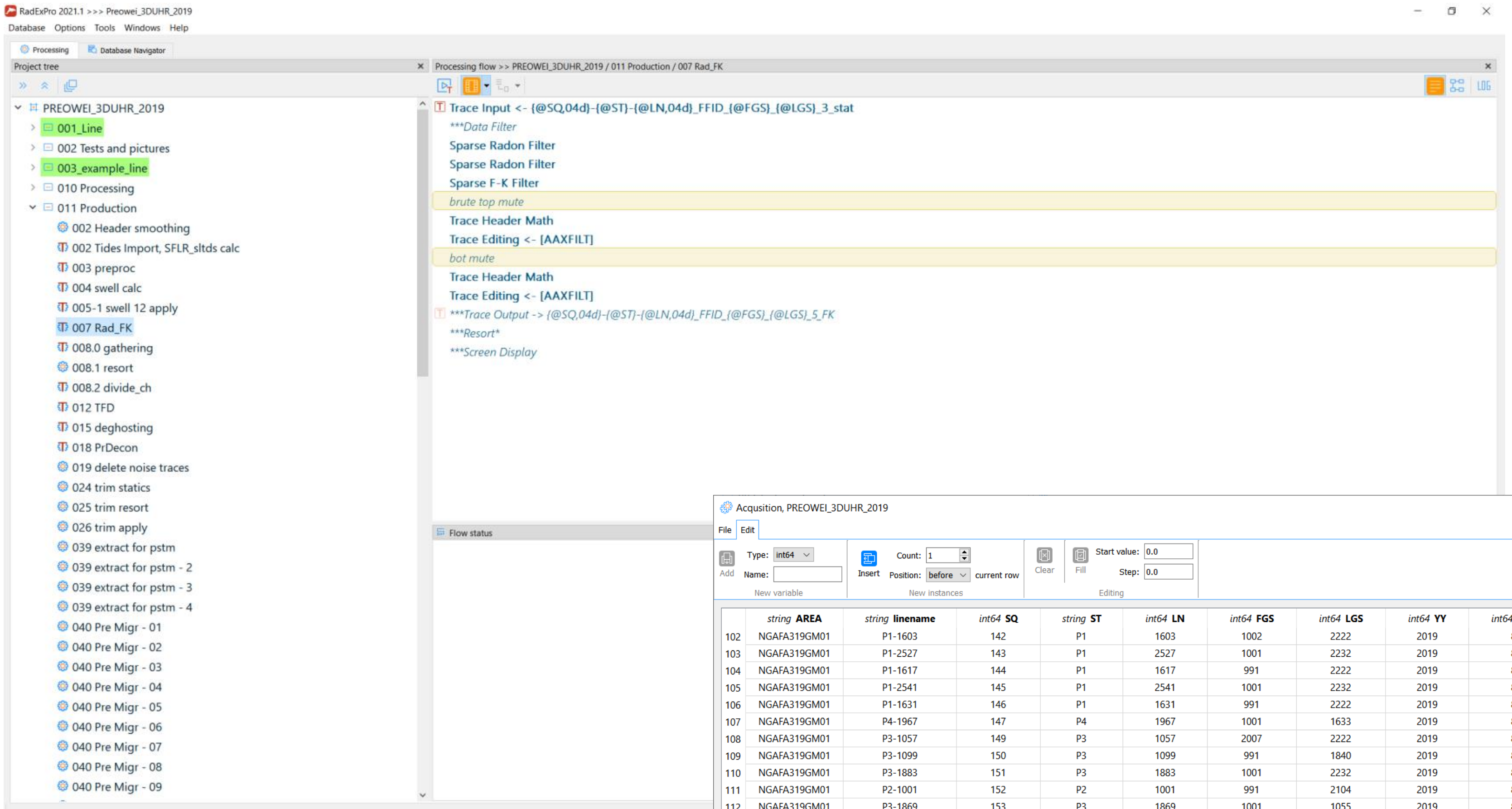
User-friendly interface, replica tables and queues

Replica tables – increased productivity

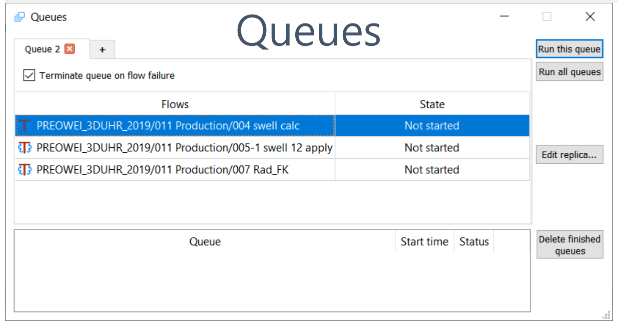
Production mode processing

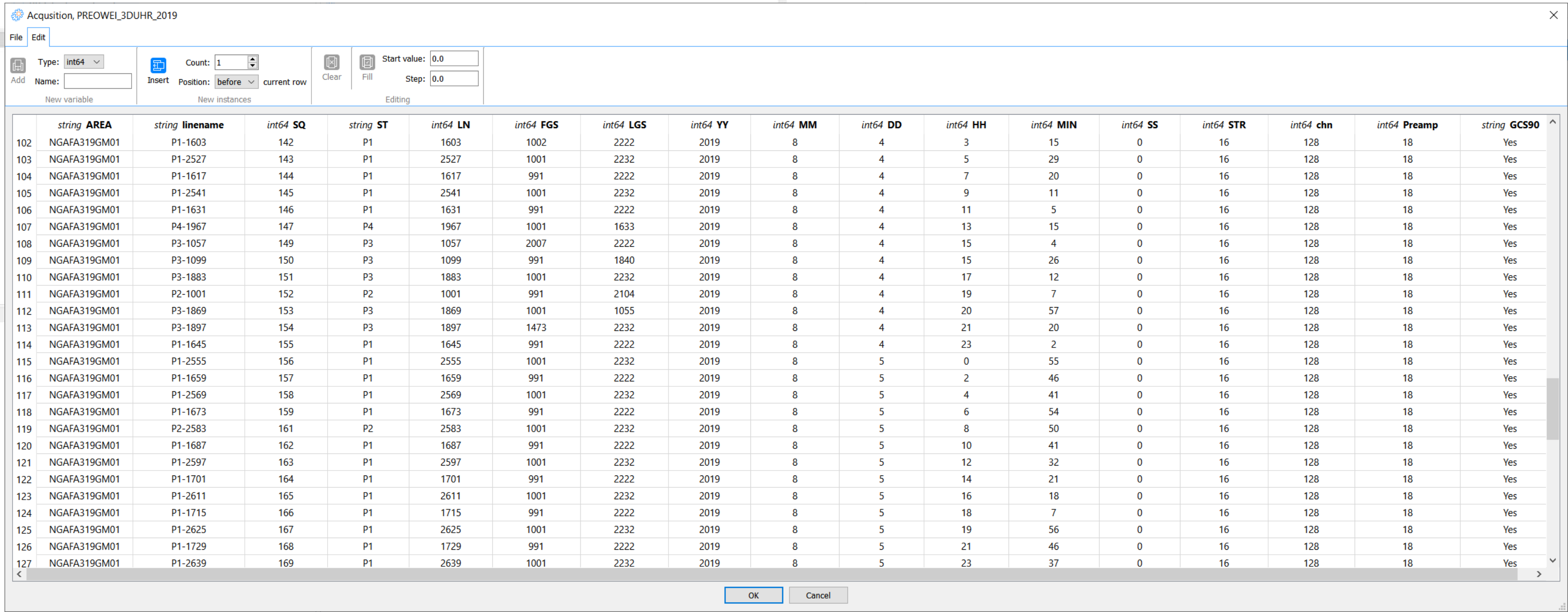
Reduce time

Reduce man-made errors

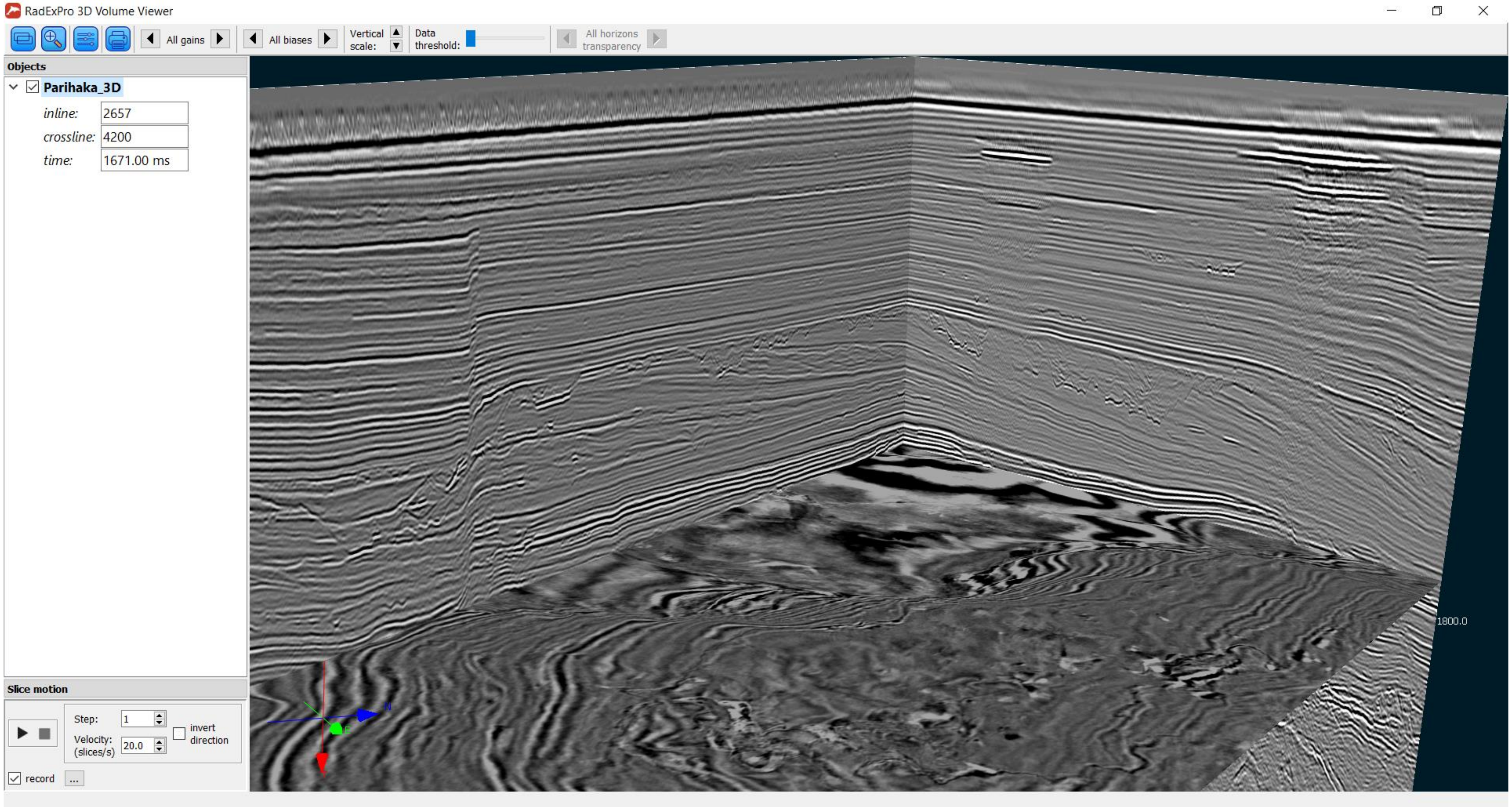


Queues





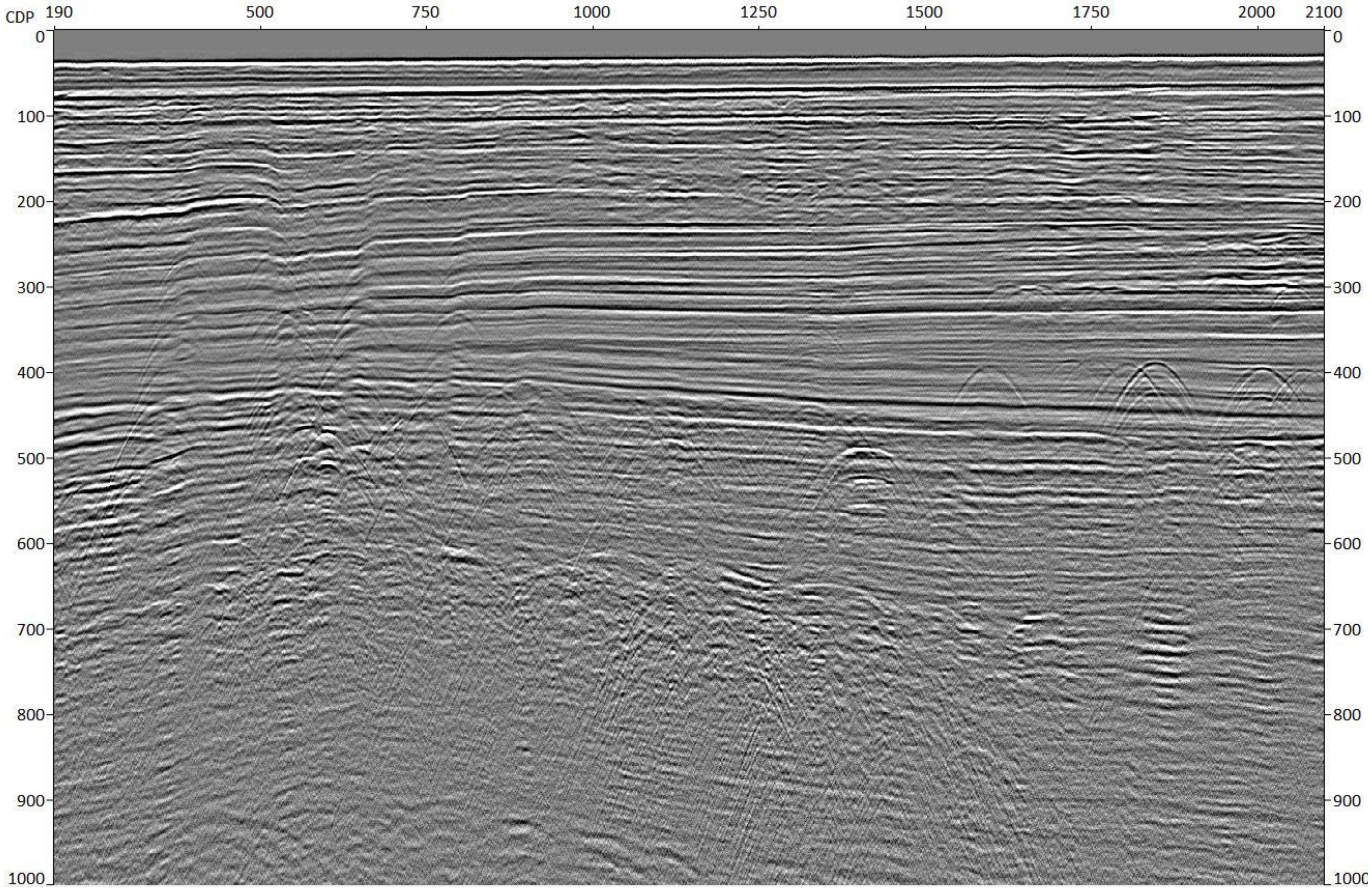
3D visualization



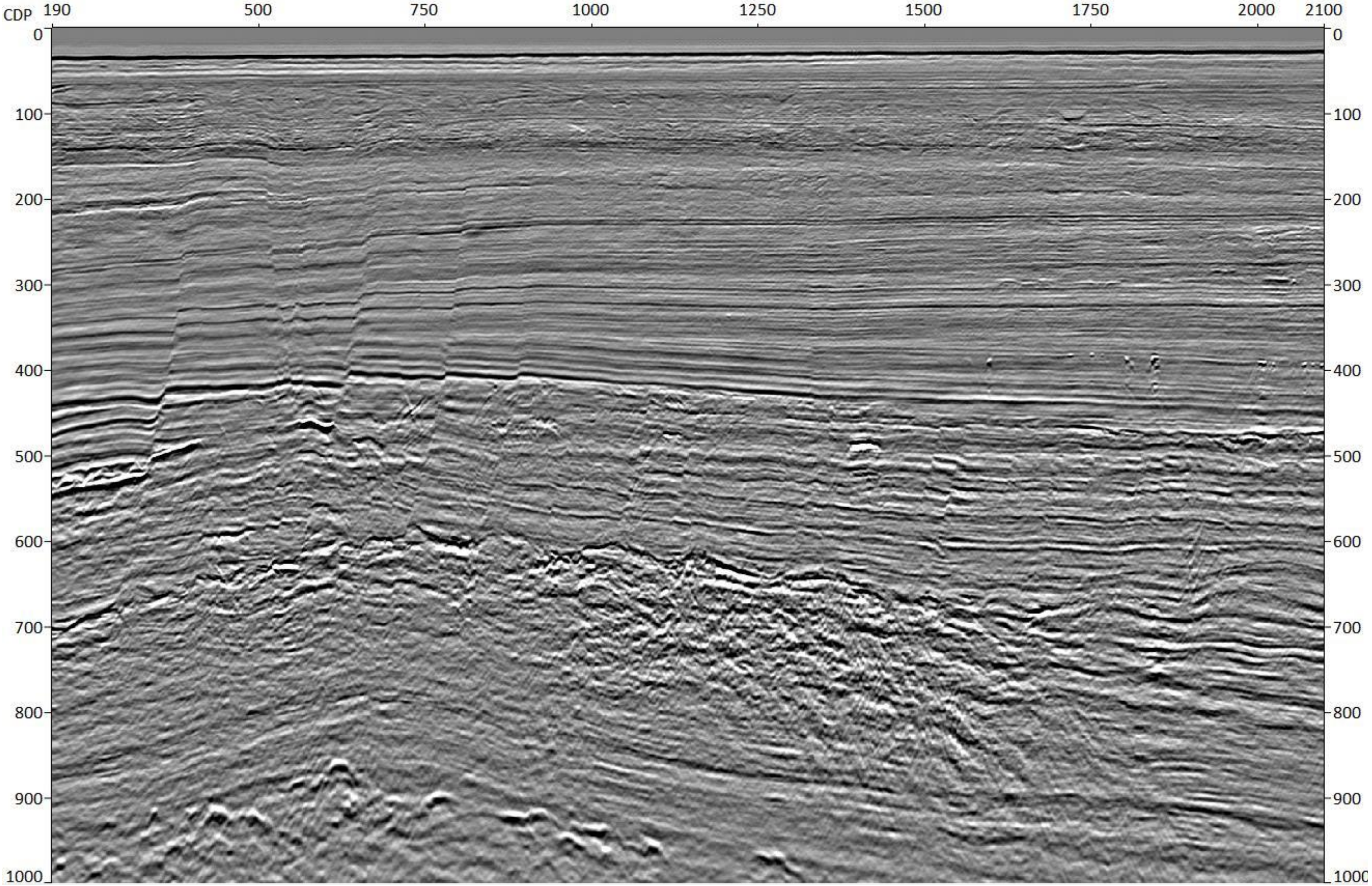
RadExPro seismic software

Some other examples

Stacked seismic section after denoising

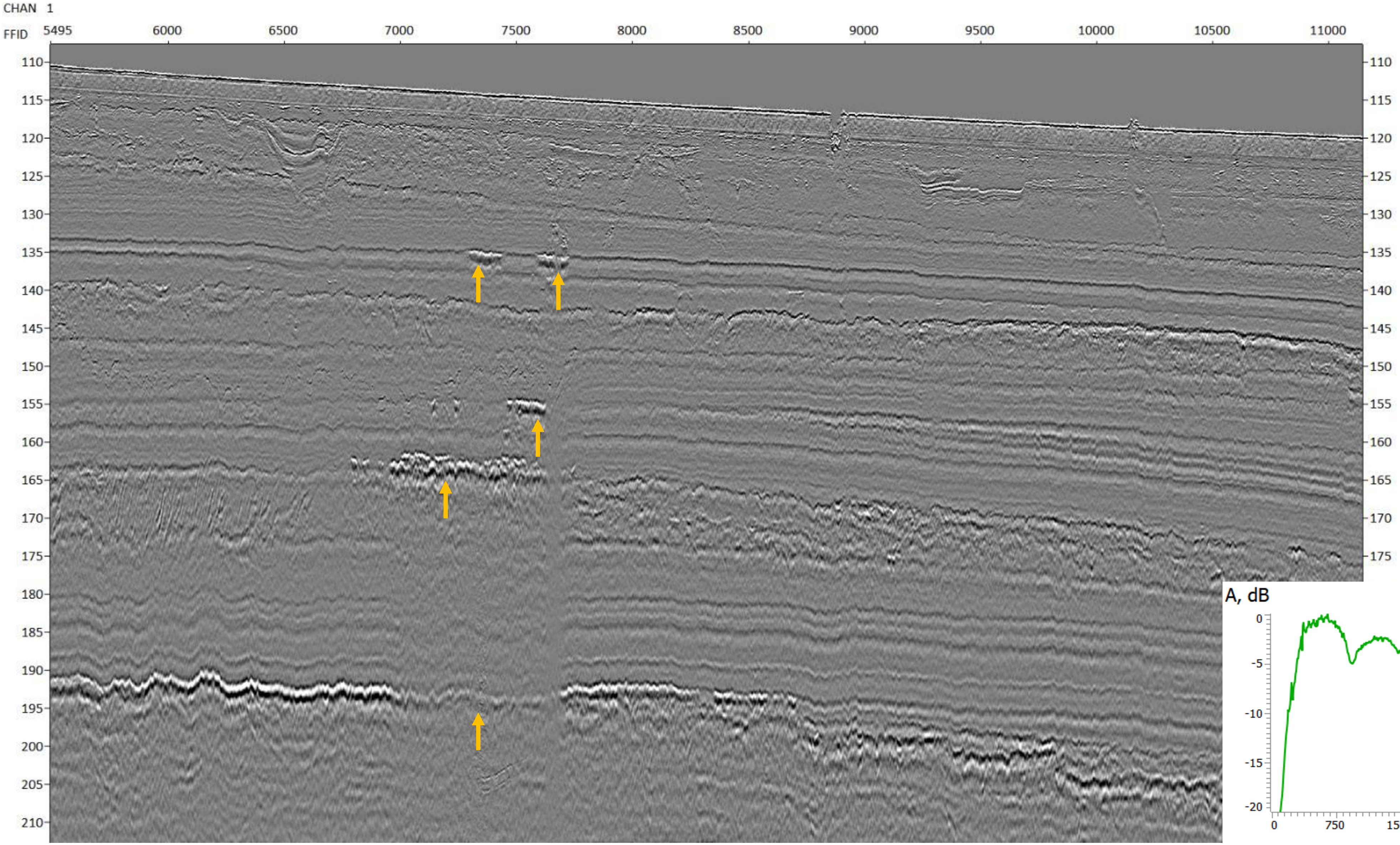


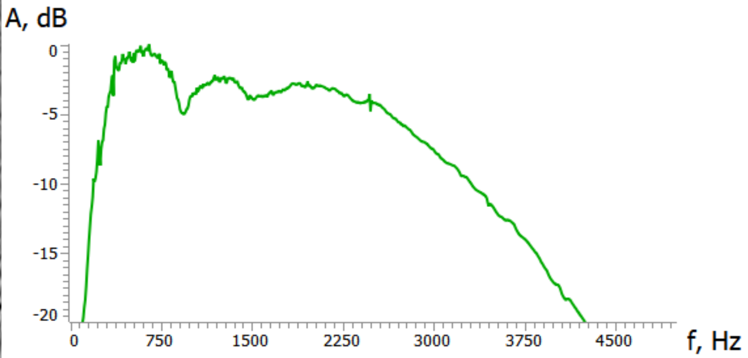
Stacked seismic section – after SRME+deghosting+PSTKM



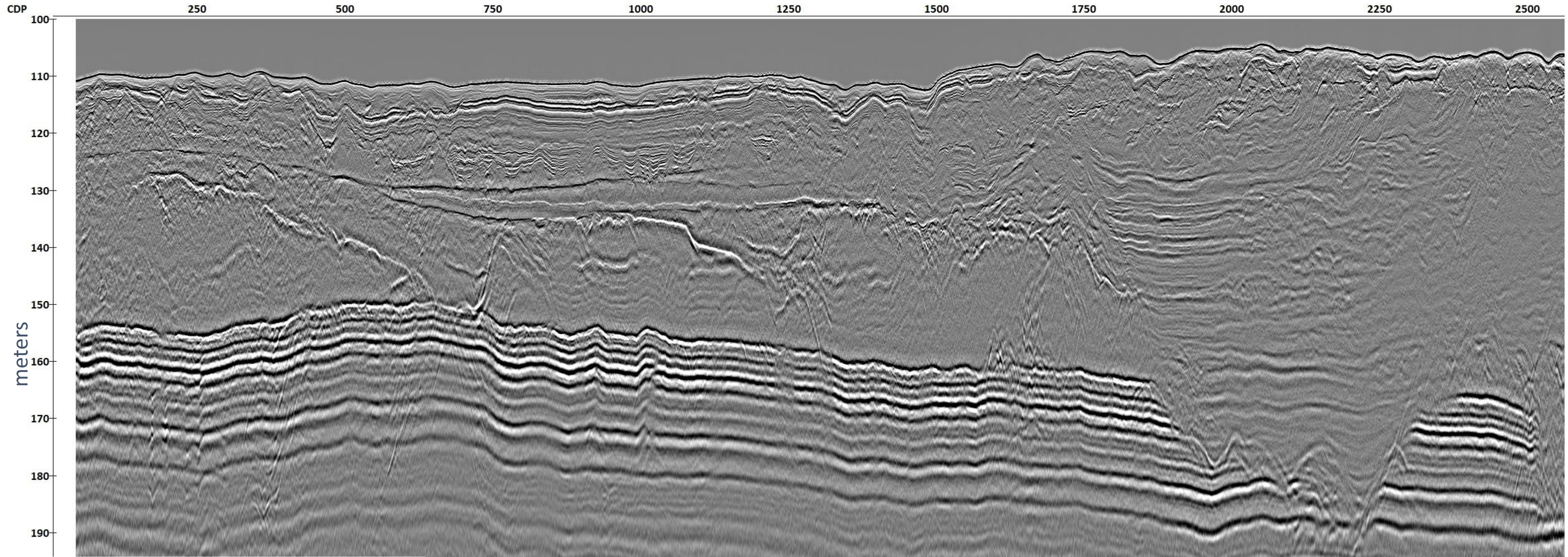
RadExPro seismic software

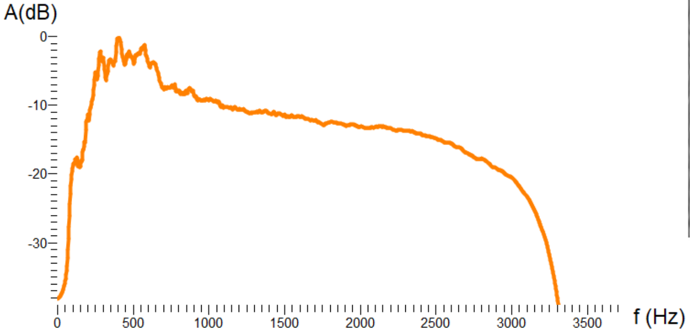
Geohazard assessment – shallow gas zones





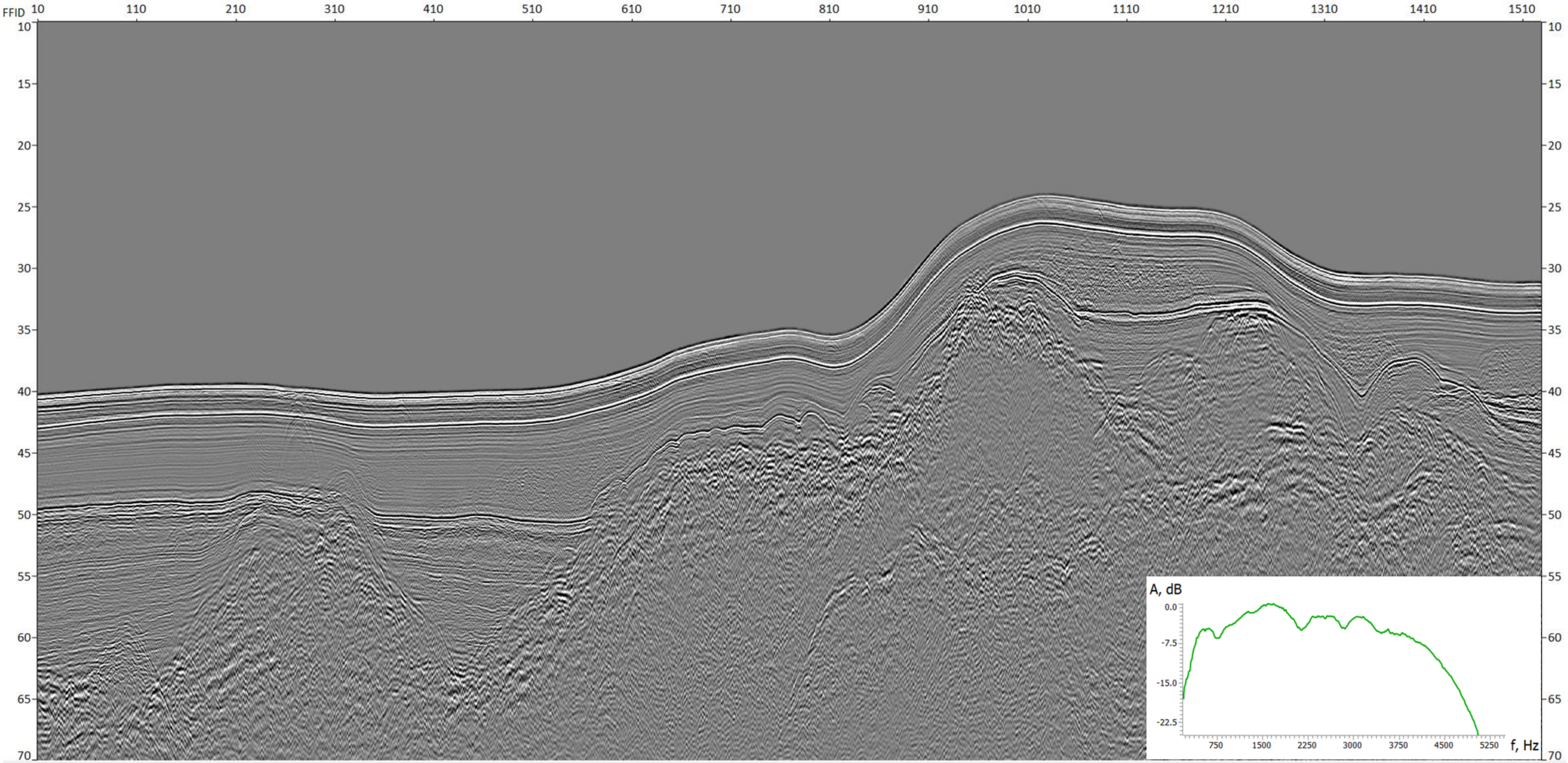
Geohazard assessment – paleo channels in the Kara Sea





Data courtesy of MAGE, source – multilevel sparker, developed by Geodevice, processed in RadExPro Seismic software

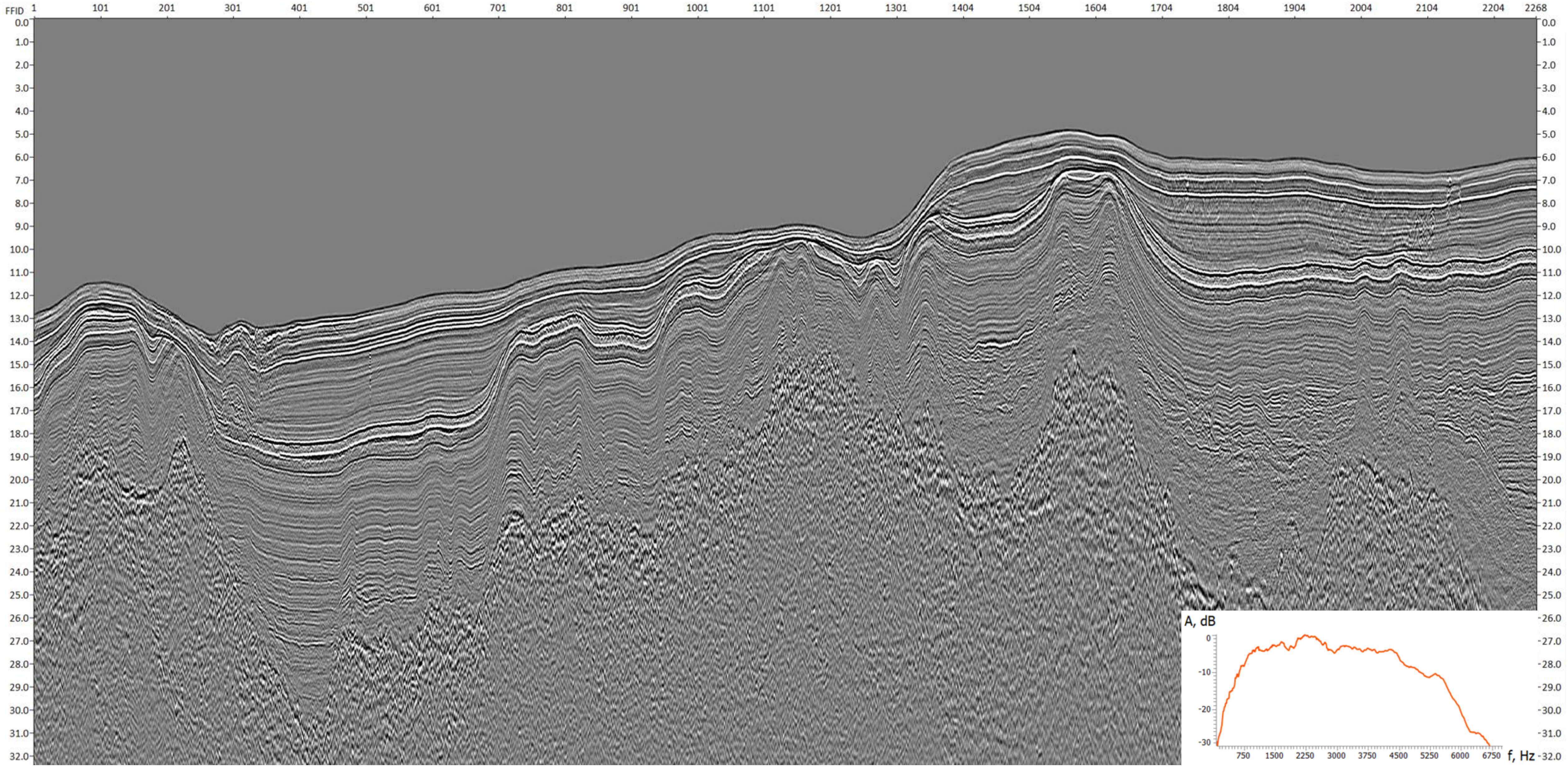
Ladoga Lake – sea trials



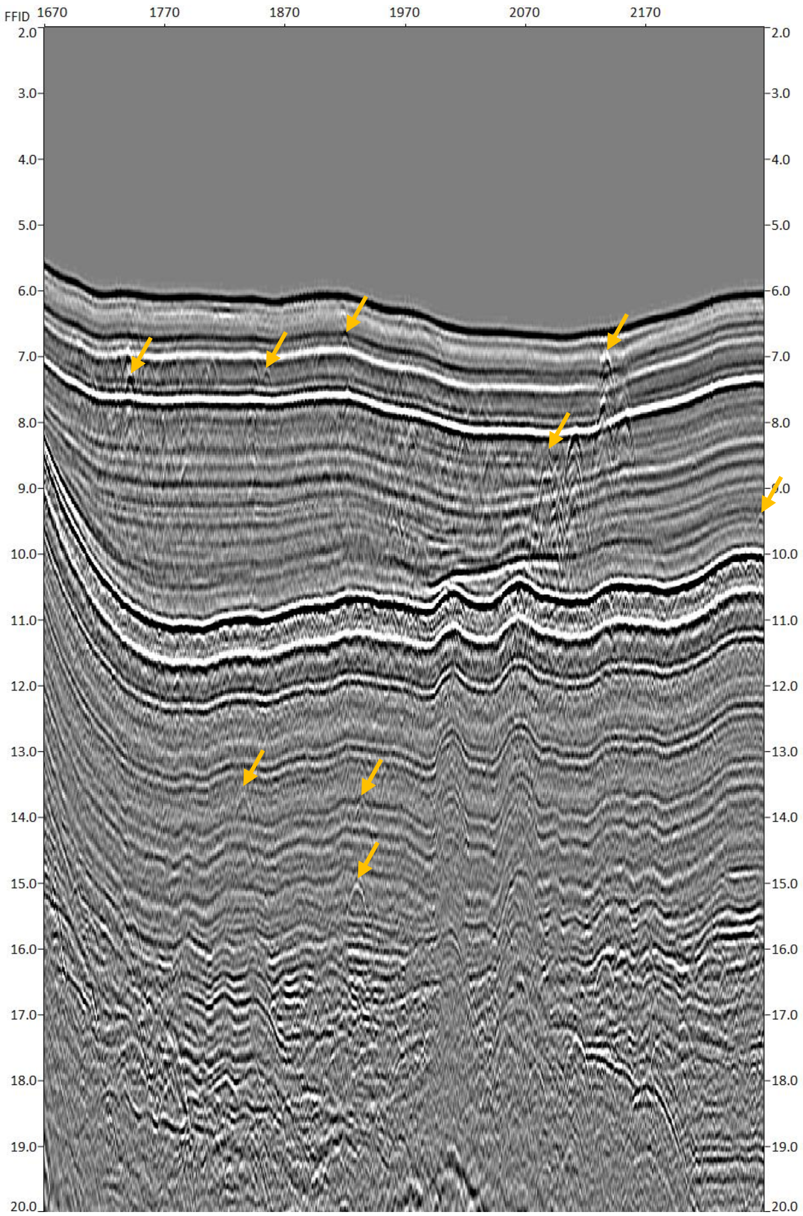
Data acquired by Geodevice with FWS-125 Sparker and 4-channel streamer, processed in RadExPro Seismic software

RadExPro
seismic software

Ladoga Lake – boulders detection



Data acquired by Geodevice with FWS-125 Sparker, processed in RadExPro Seismic software



Post-glacier boulders detection with less than 0.5 m size

Lots of diffraction hyperbolas can be seen on non-migrated image. Some of them are marked by arrows. Diffractions are caused by post-glacier boulders.

RadExPro seismic software

Some of our clients:

SANCO

magseis fairfield

FUGRO

Polarcus

GeoSurveys geophysical consultants

EGS Earth Sciences & Surveying

MMT An Ocean Infinity Company

Scripps Institution of Oceanography UC San Diego

Innomar

Cable

TERRASOND Precision Geospatial Solutions

OFG Ocean Floor Geophysics

Ørsted

INPEX

JGI, Inc.

aae technologies

Argeo

Alpine

KIGAM

EPI Group The Energy People A Carbon Neutral Company