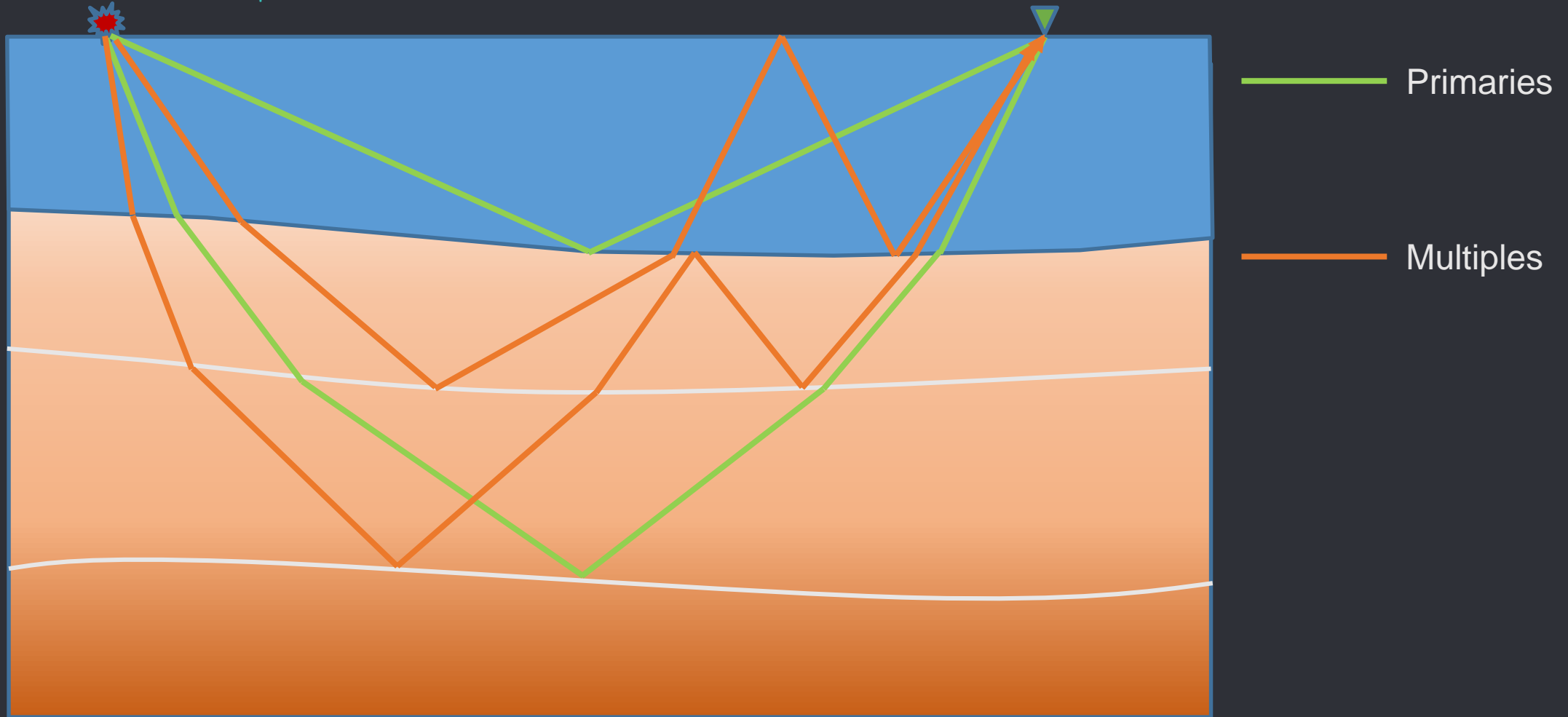# Zero-Offset Demultiple – Efficient Demultiple of Near-Offset Marine Seismic Data in RadExPro
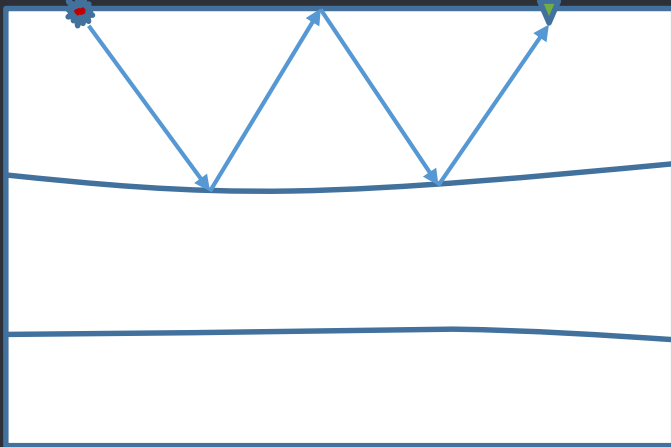
Problem of Multiple Waves
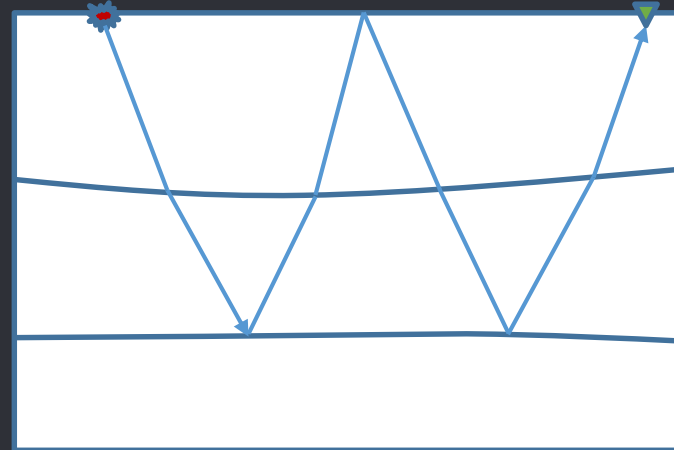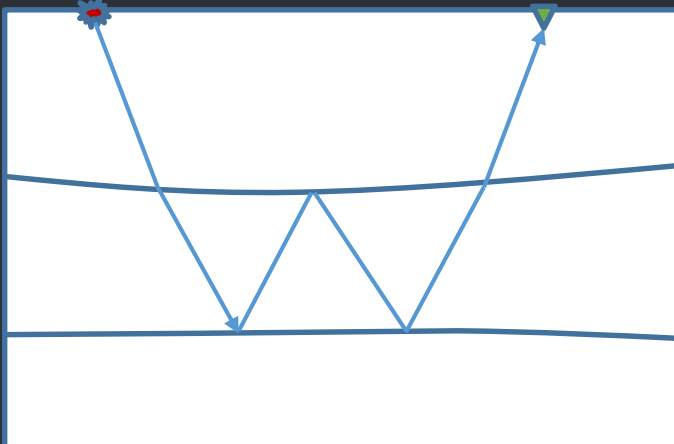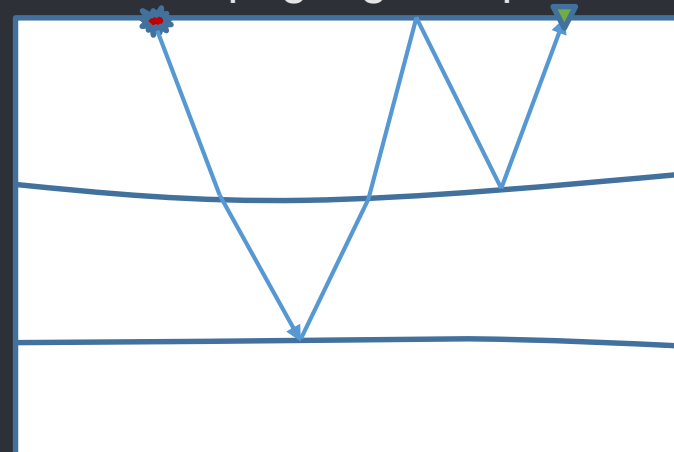
Primaries

Multiples

Types of Multiples

Water bottom multiple

Reflector multiple

Internal multiple

Reflector peg-leg multiple

o **Main Multiple Elimination Techniques**

1. Periodicity of Multiples – **Deconvolutions**

2. Different Move-Out between Multiples and Primaries -- **Radon/F-K/Tau-Pi demultiple, slant-stack, etc.**

3. Wavefied Prediction and Subtraction – **SRME**

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                              -- very limited usability: flat seafloor only, very shallow water, not very efficient

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Multiple Elimination

o **Main Multiple Elimination Techniques**

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    3. Wavefied Prediction and Subtraction – **SRME**

          -- work well for multi-channel data, time-consuming
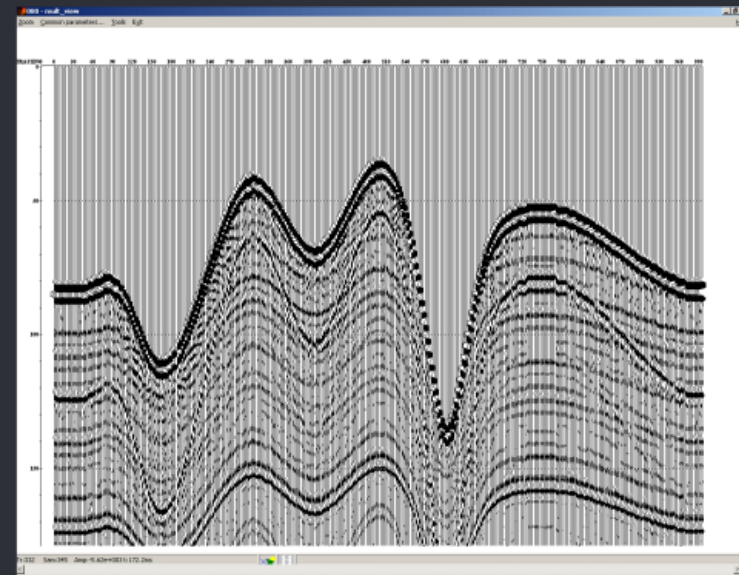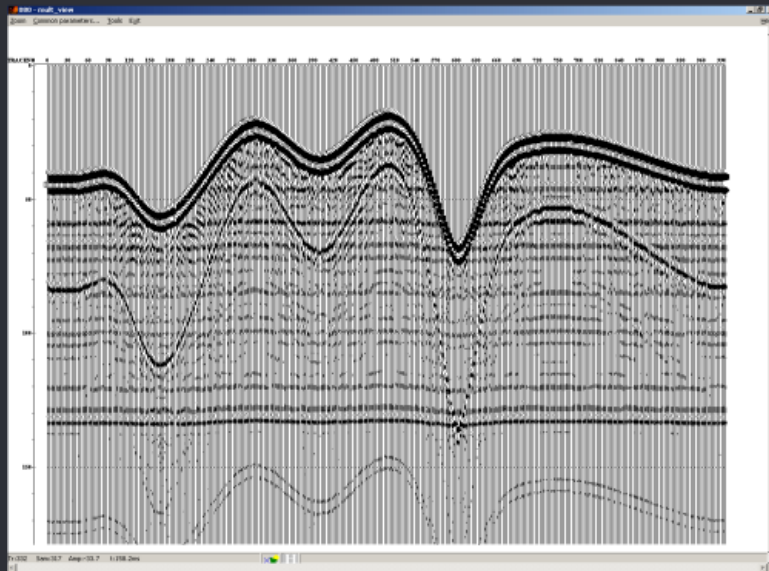
          HR/URH specific – **Zero-Offset Demultiple**

    -- for single-channel near-offset data

Multiple Elimination: Zero-Offset Demultiple

Zero-offset demultiple theory

1. An approximate model of multiples created from data itself:
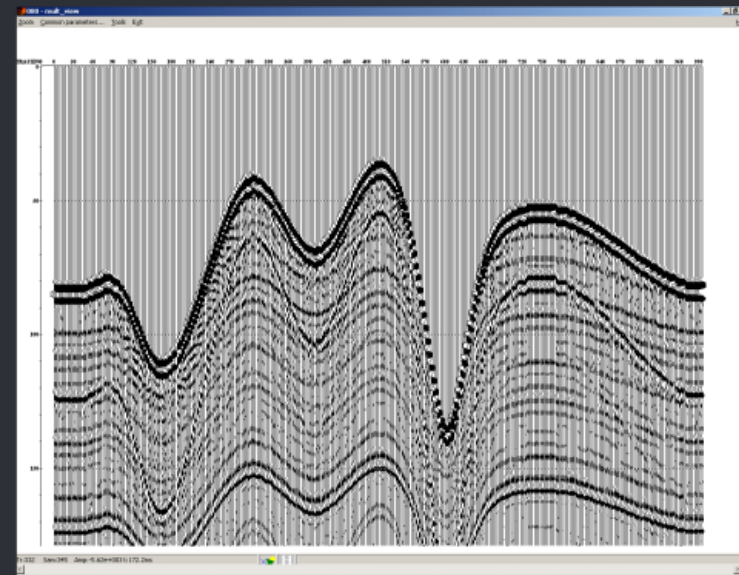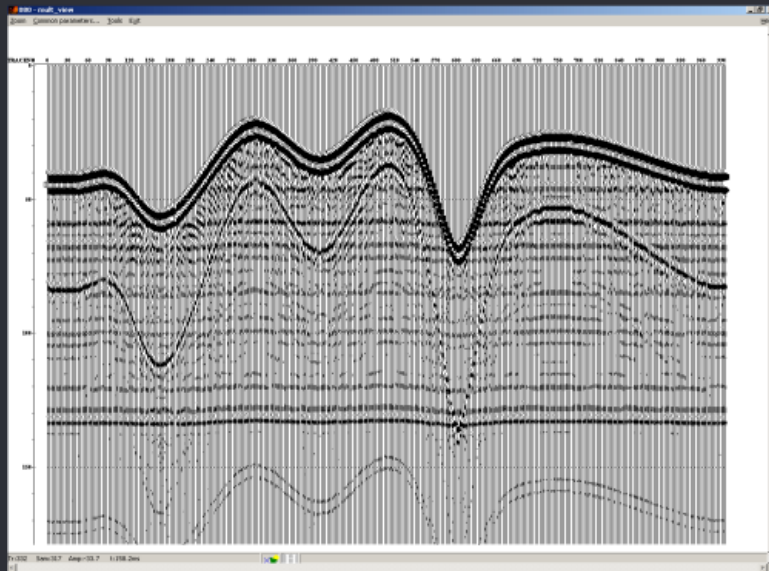
o   Statics shift to the time of seafloor reflection

Zero-offset demultiple theory

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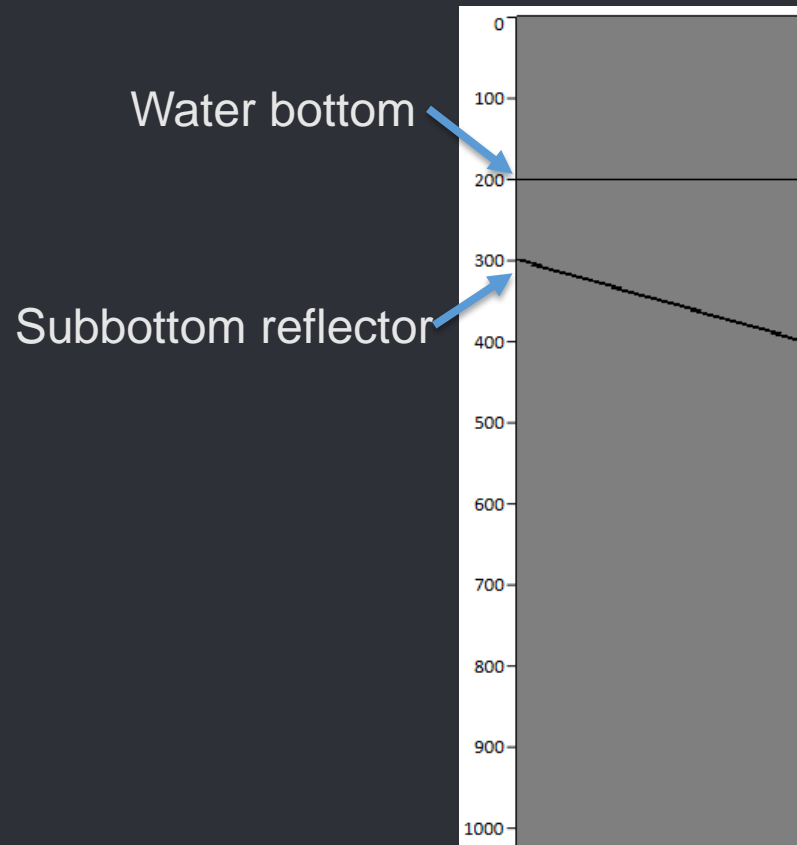o Statics shift to the time of seafloor reflection **– model of peg-leg multiples**

Zero-offset demultiple theory

1. An approximate model of multiples created from data itself:

- Autoconvolution of each trace

Zero-offset demultiple theory

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○ Autoconvolution of each trace

Water bottom

Subbottom reflector

Zero-offset demultiple theory

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Zero-offset demultiple theory

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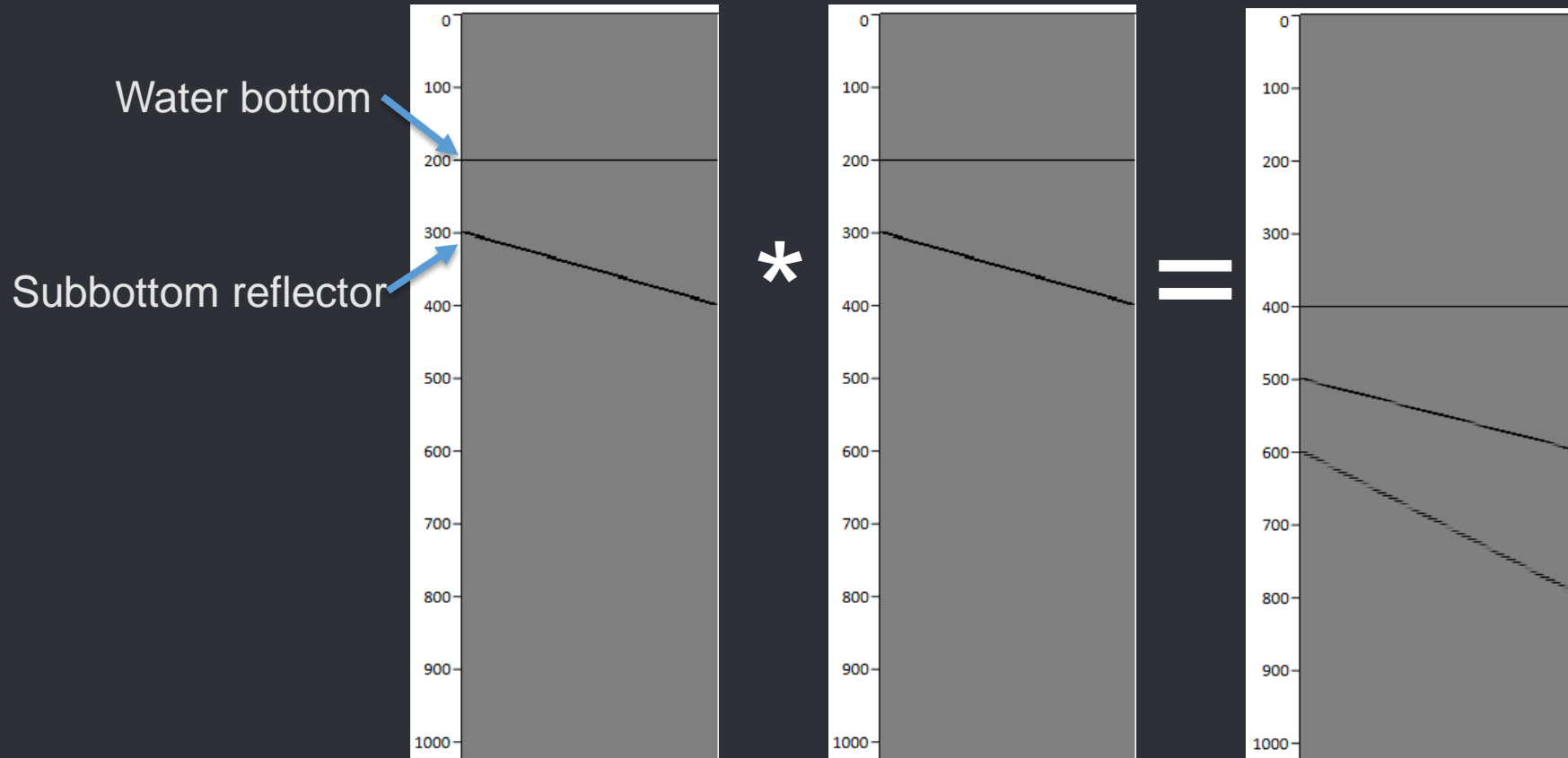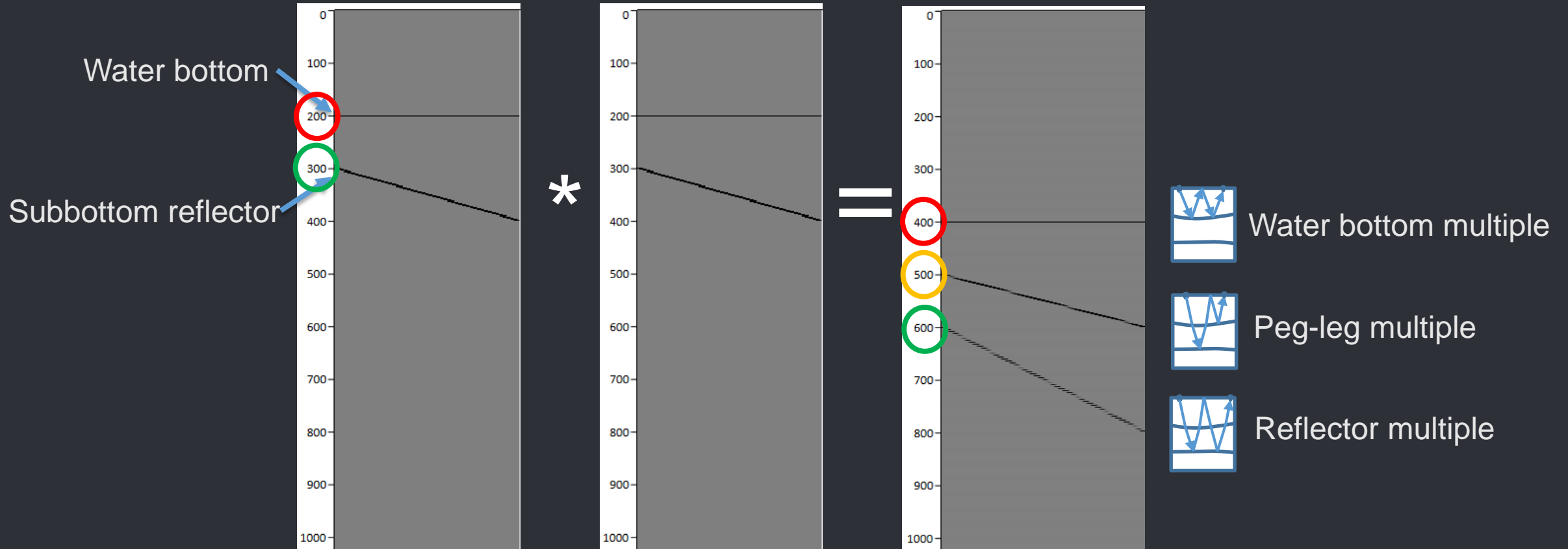
o Autoconvolution of each trace

Zero-offset demultiple theory

1. An approximate model of multiples created from data itself:

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Water bottom

Subbottom reflector

*

=

Water bottom multiple

Peg-leg multiple

Reflector multiple

Zero-offset demultiple theory

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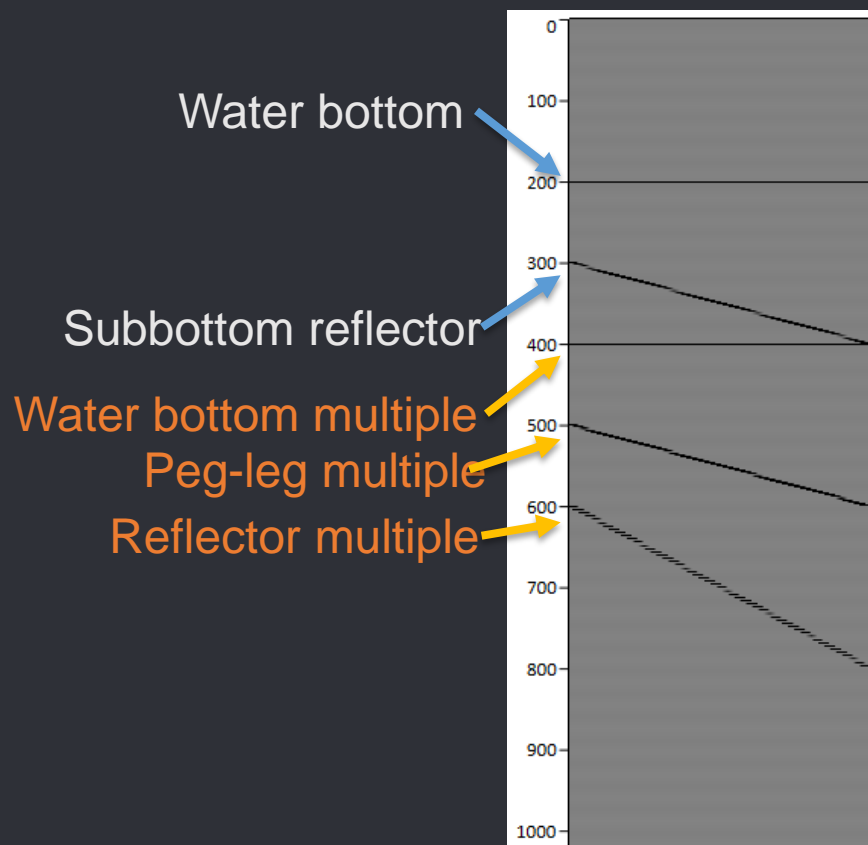
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Water bottom

Subbottom reflector

Water bottom multiple

Peg-leg multiple

Reflector multiple

Zero-offset demultiple theory

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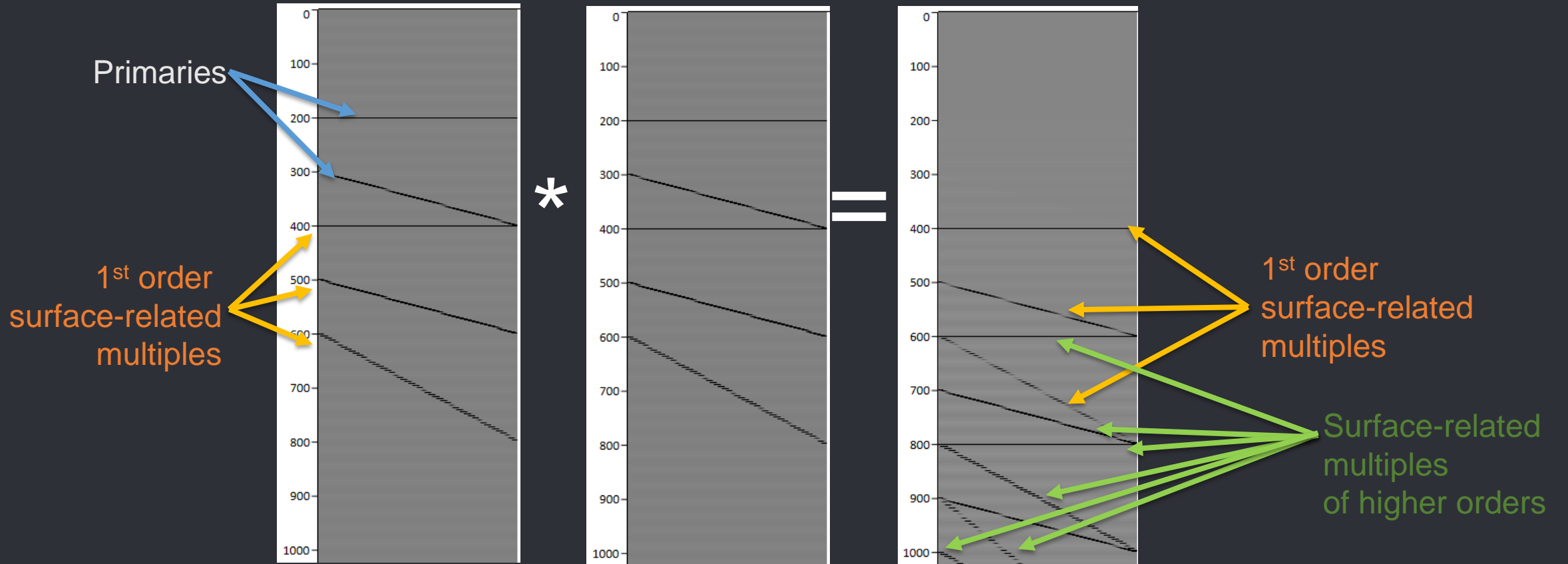
○ Autoconvolution of each trace

Primaries

1st order surface-related multiples

* =

1st order surface-related multiples

Surface-related multiples of higher orders

Zero-offset demultiple theory

1. An approximate model of multiples created from data itself:
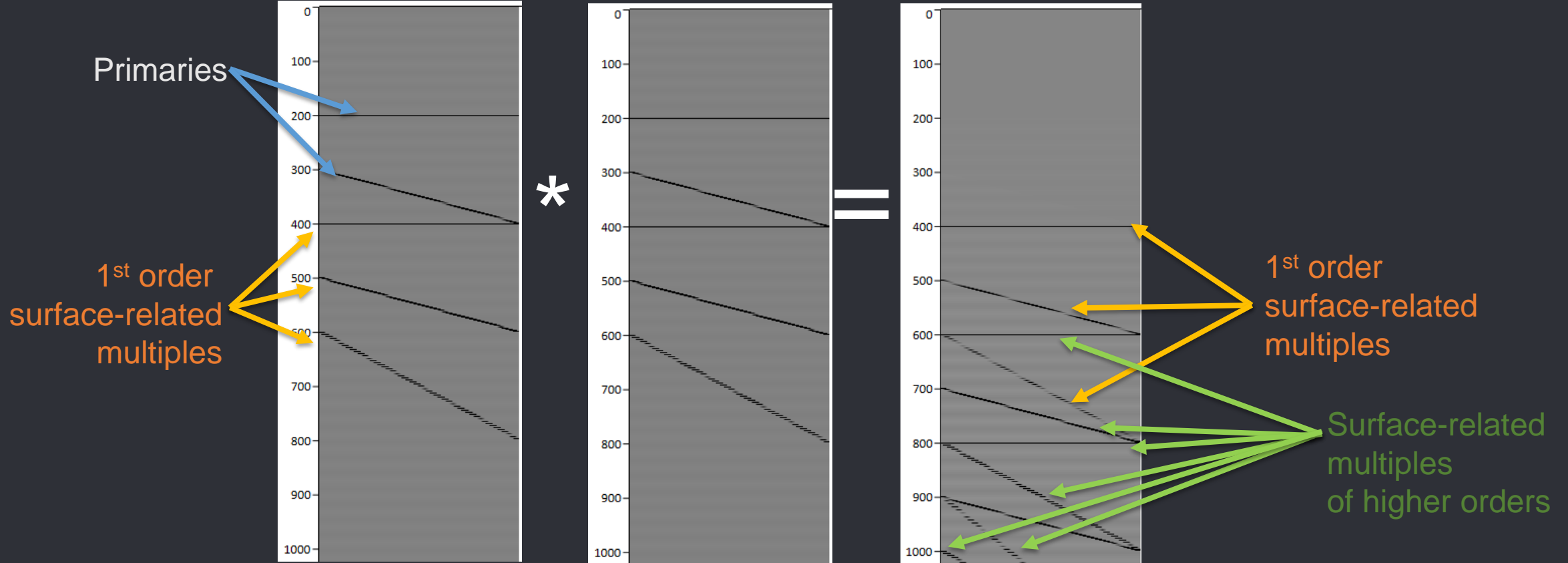
○ Autoconvolution of each trace **– model of all surface-related multiples**
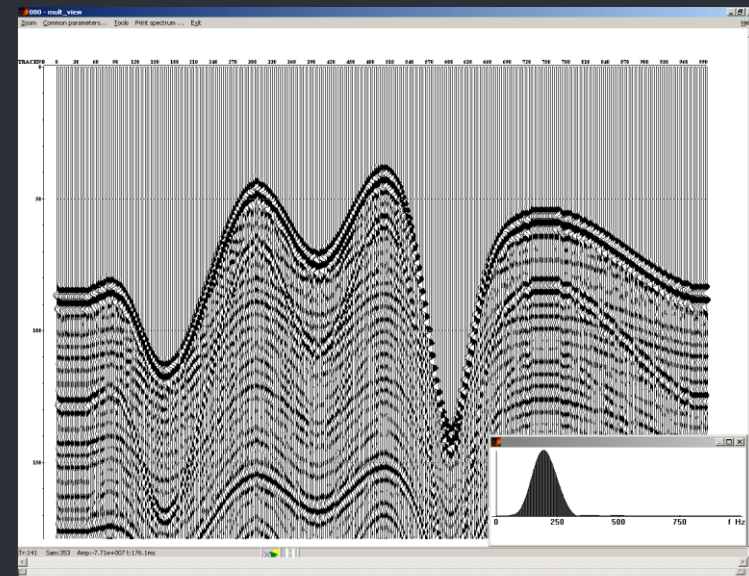

Primaries

1st order surface-related multiples

1st order surface-related multiples

Surface-related multiples of higher orders

Zero-offset demultiple theory

1. An approximate model of multiples created from data itself:

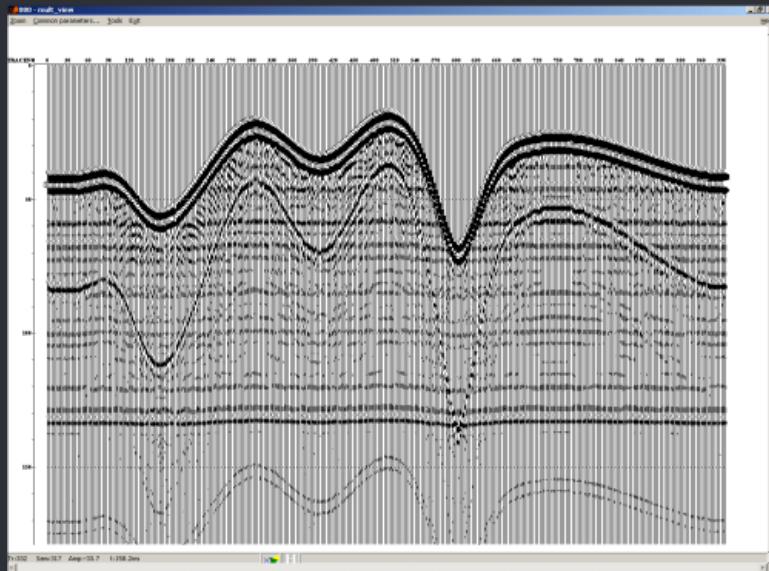o Autoconvolution of each trace **– model of ALL surface-related multiples**

Zero-offset demultiple theory

2. Model is subtracted from the data

Zero-offset demultiple theory

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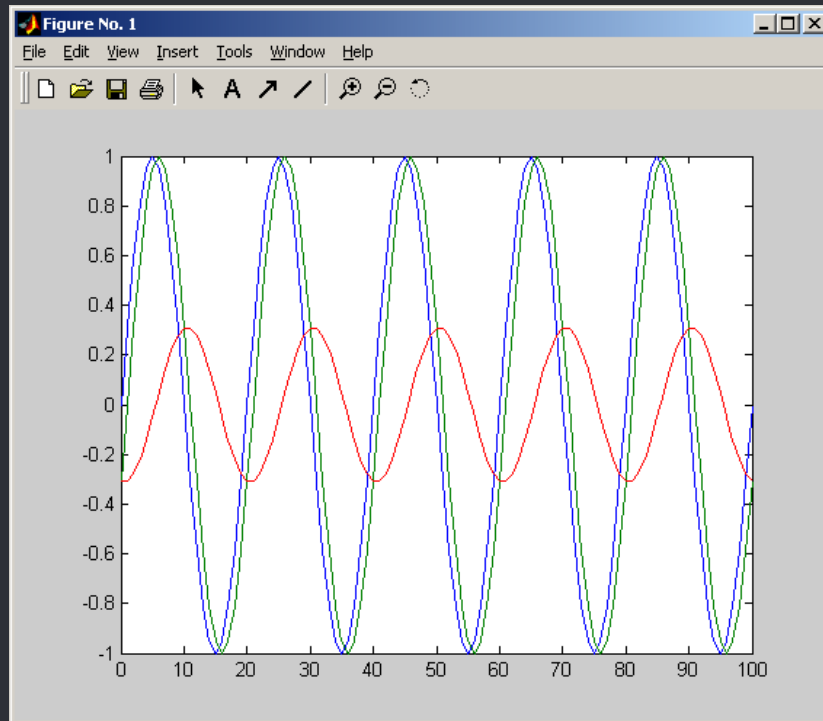o Our model is **inaccurate**, both in kinematics and in dynamics.

Can we simply subtract it?
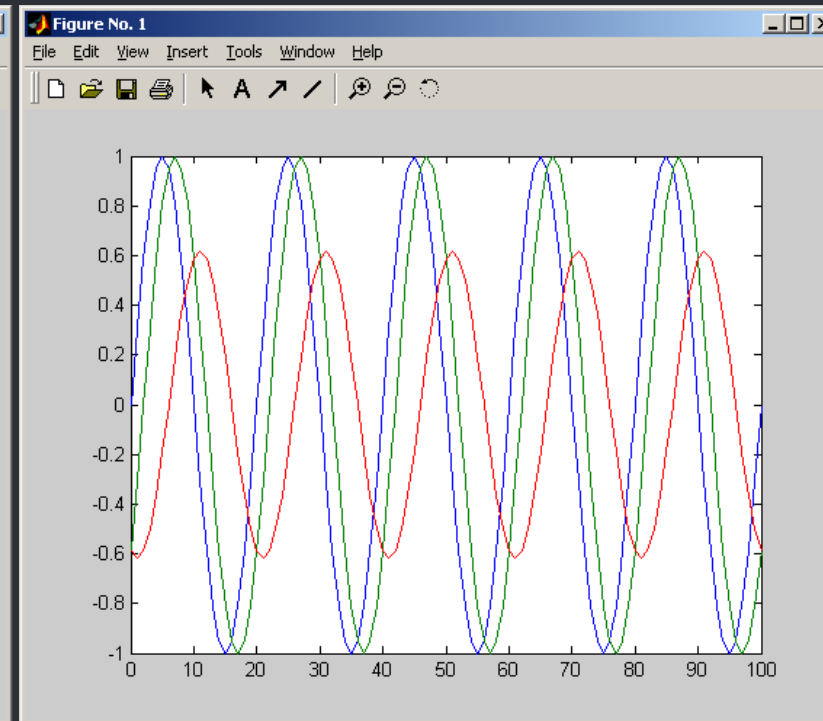
Zero-offset demultiple theory

2. Model is subtracted from the data

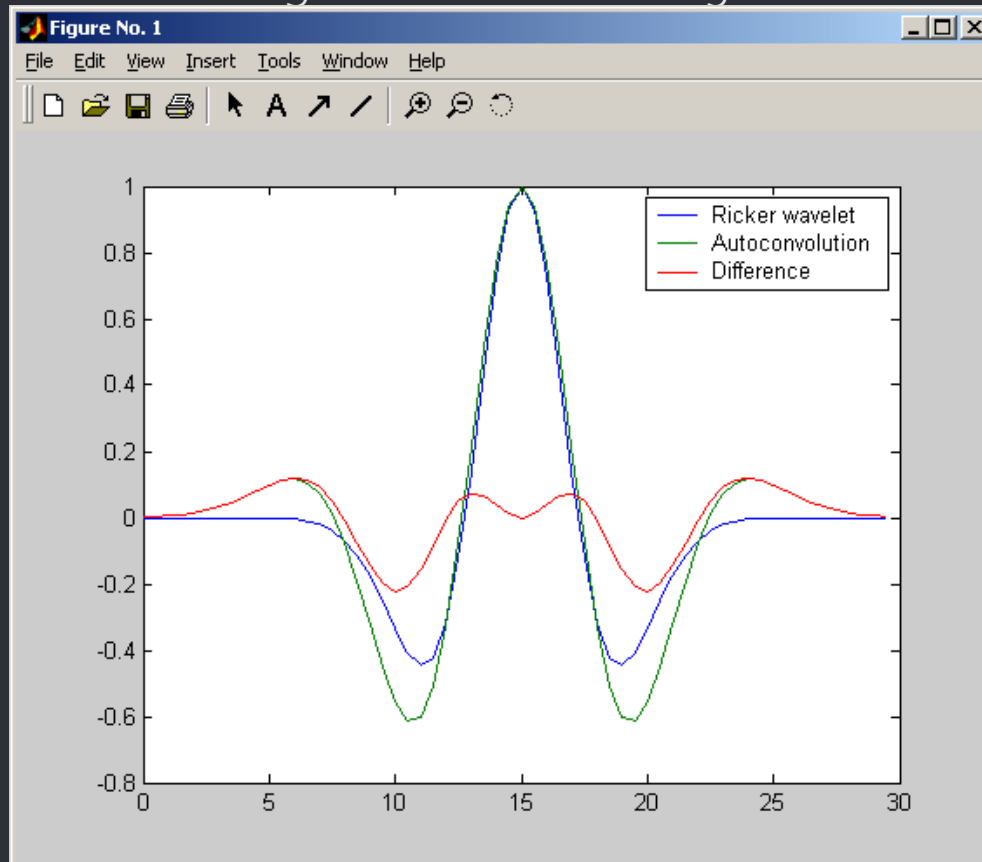o Subtracting with inaccurate kinematics:

Shift of 1 sample   Shift of 2 samples

Zero-offset demultiple theory

2. Model is subtracted from the data

o Subtracting with inaccurate dynamics:

o Autoconvolution results in change of wavelet

o Adequate amplitude decay compensation is difficult to achieve

Zero-offset demultiple theory

2. Model is to be subtracted from the data **ADAPTIVELY**

The task of adaptive subtraction of the model of multiples from the initial wavefield is posed in the following way: for each trace it is required to define *f(x,t)* minimizing in RMS sense the following functional:

$$J = \sum_{t} \left(Z(x,t) - \sum_{k=-M}^{M} f\ (x-k,t) * K\ (x-k,t) \right)$$

f(x,t) are filters instead of coefficients, this description of distortions is essentially more general and includes waveform fluctuations caused by, particularly, frequency-dependent attenuation as well as amplitude variations

$Z(x,t)$ Current trace of the original wavefield

$K(x,t)$ Initial model of multiples for this trace

x Current trace number

k Index of a neighboring trace from the current trace (from –*M* to *M*)

t TWT time

This task can be solved with the help of standard techniques, particularly with the help of Wiggins-Robinson-Levinson algorithm for multi-channel filters.

As a result of this step:

For each trace X we calculate a filter *f(x,t)*

This filter minimizes everything that is in common between the original trace and the model of multiples at traces within the neighborhood *(x-M, x+M)*

STRONG SUPPRESSION OF MUILTIPLES

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For each trace X we calculate a filter *f(x,t)*

This filter minimizes everything that is in common between the original trace and the model of multiples at traces within the neighborhood *(x-M, x+M)*

STRONG SUPPRESSION OF MUILTIPLES

Final step:

We assume that the filters *f(x,t)* shall not be changing too abruptly from trace to trace.

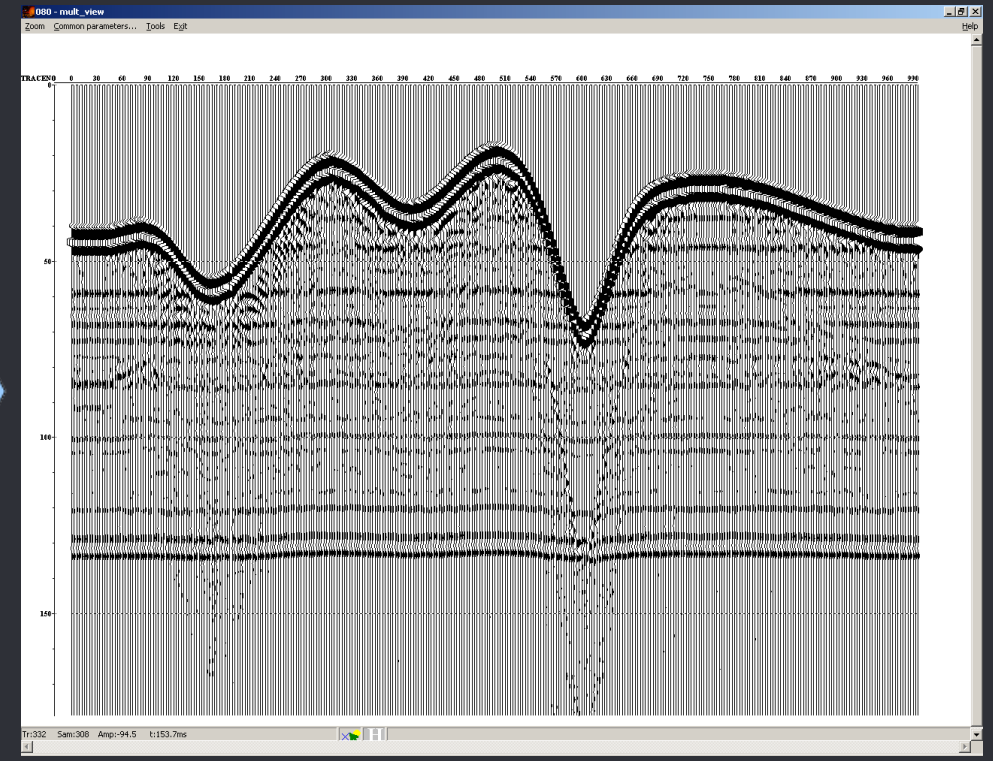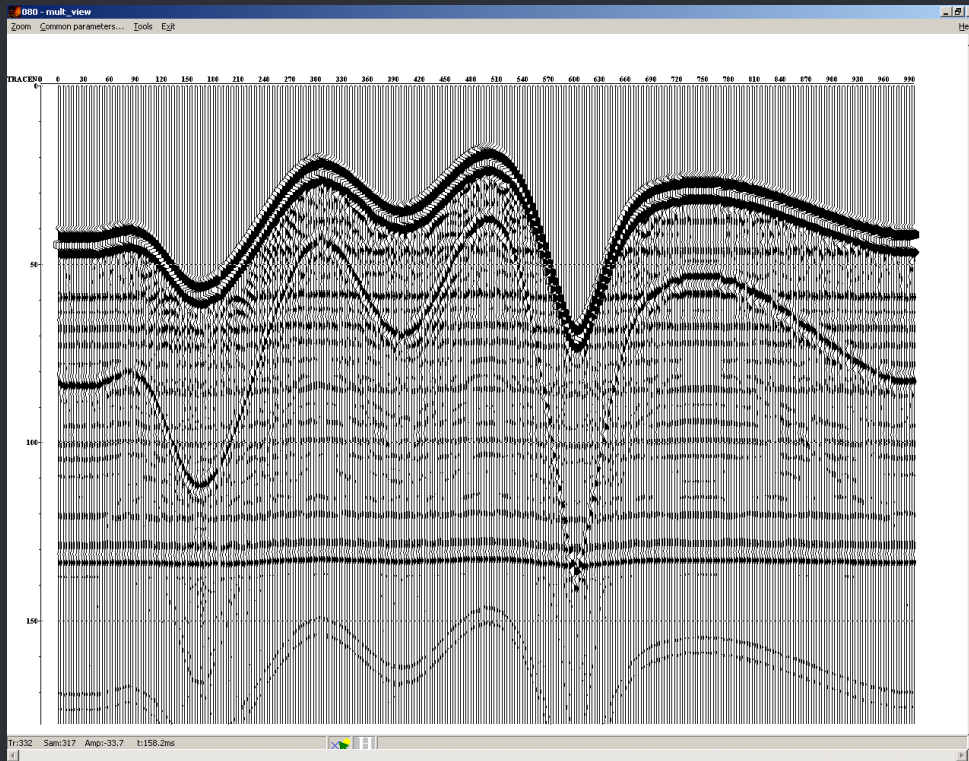So we average the filters over *N* neighboring traces:

$$f_{final}(x,t) = \frac{\sum_{j=-N/2}^{N/2} f(x-j,t)}{N+1}$$

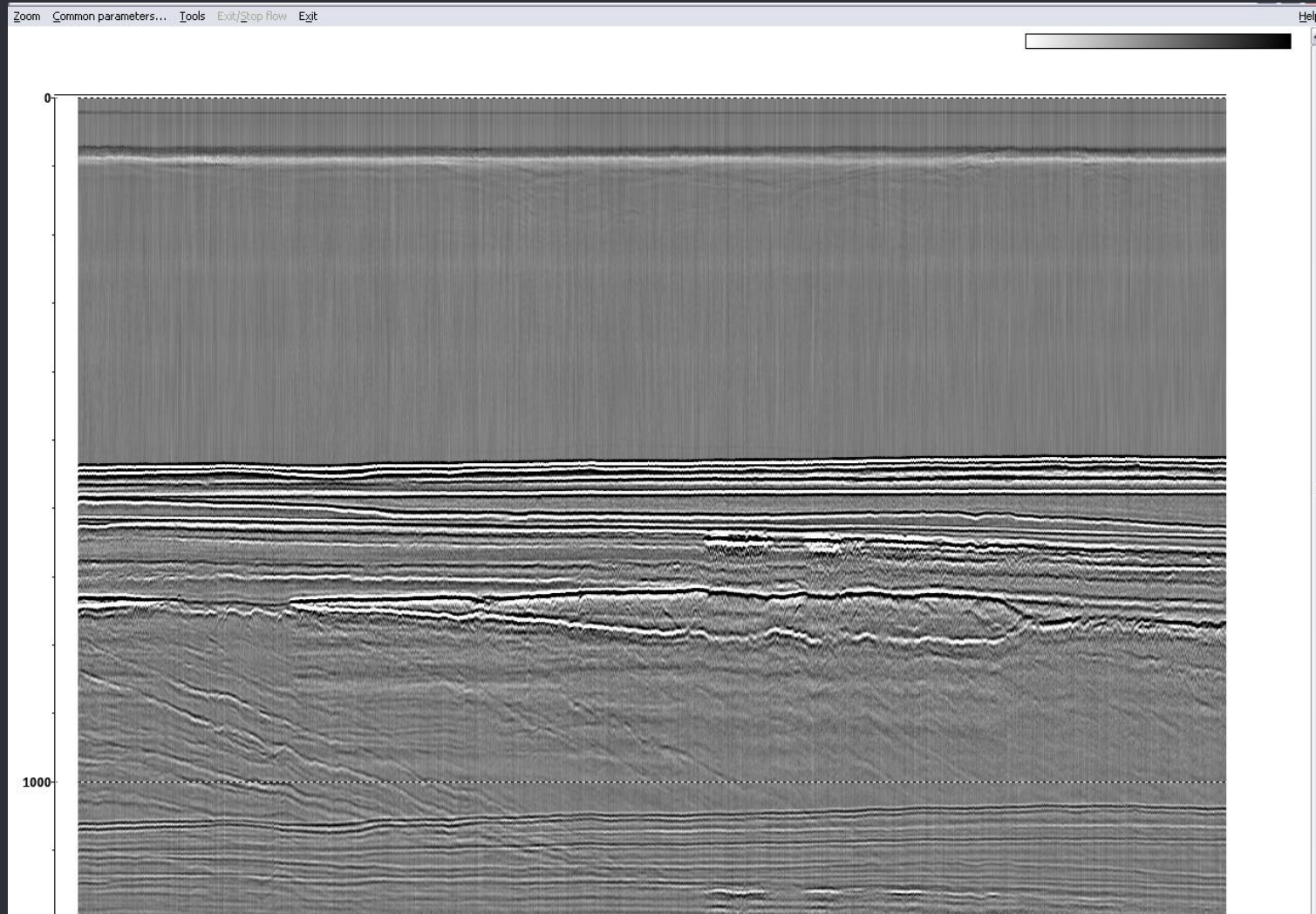**THIS STEP HELPS PRESERVING PRIMARIES**

Zero-offset demultiple theory

2. Model is subtracted from the data **ADAPTIVELY**

Zero-offset demultiple examples: before

Data acquired by P-Cable 3D HR system

Multiple Elimination: Zero-Offset Demultiple

Zero-offset demultiple examples: multiple model

Data acquired by P-Cable 3D HR system
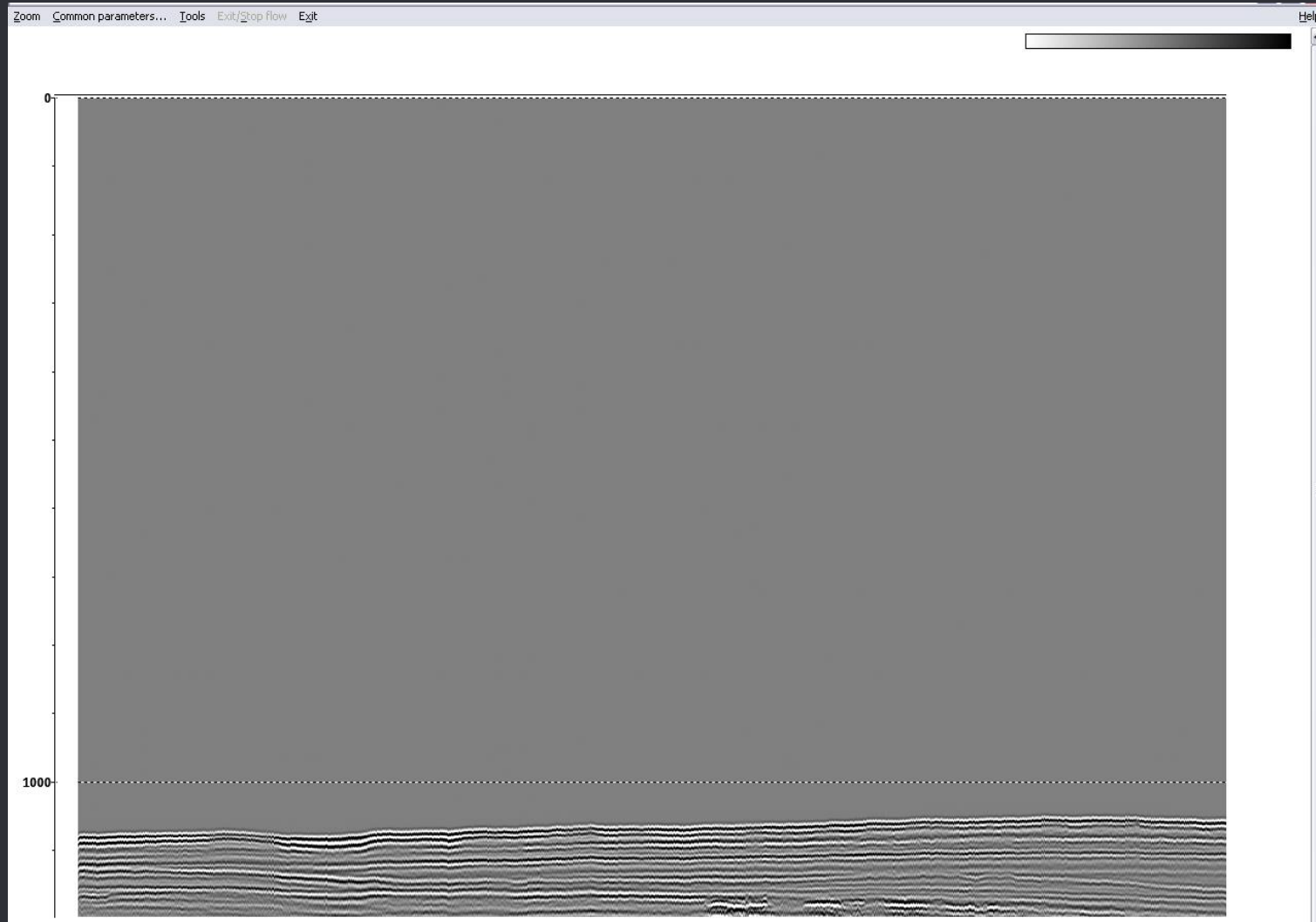
Zero-offset demultiple examples: subtraction result
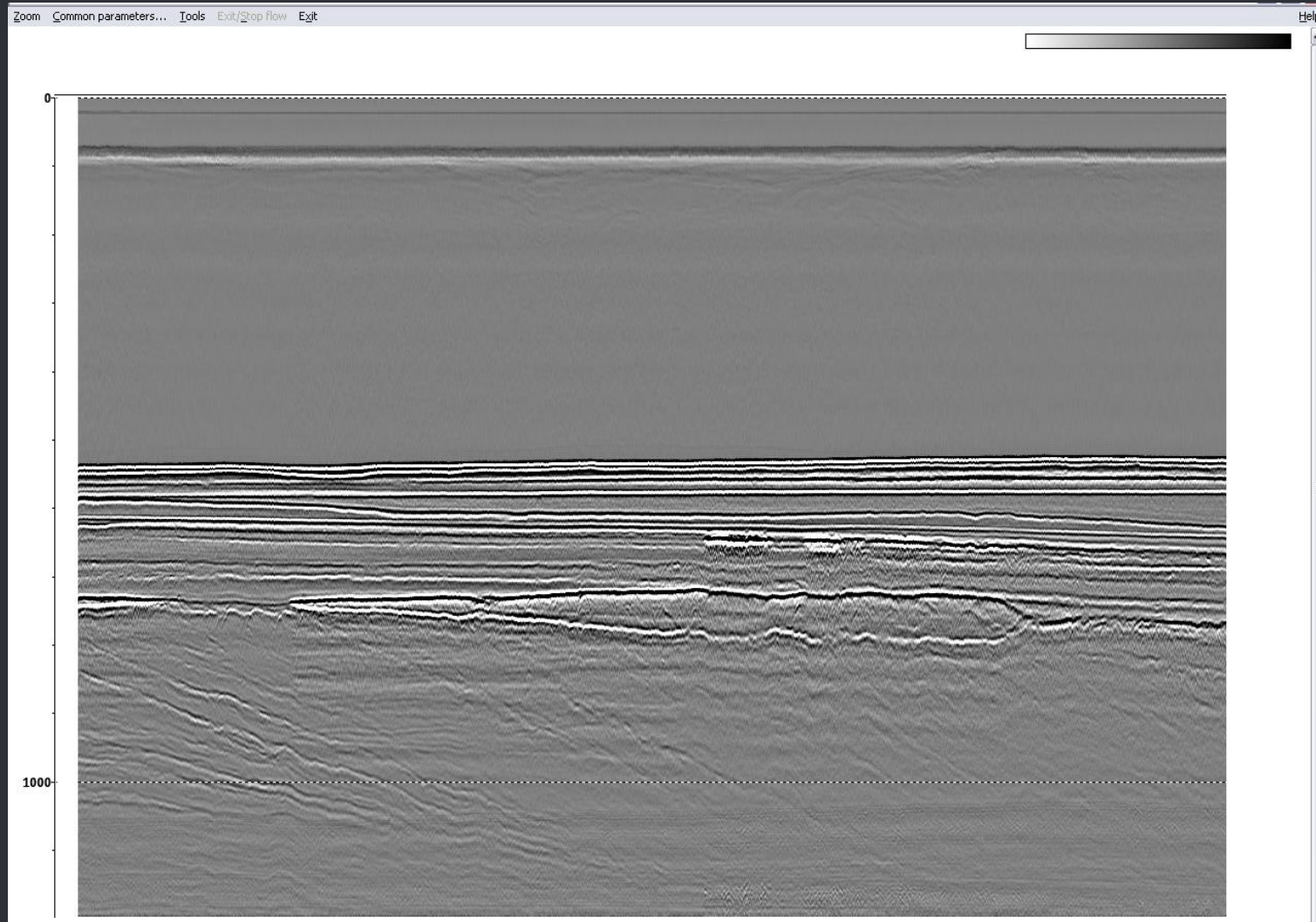
Data acquired by P-Cable 3D HR system

Zero-offset demultiple examples: before

Data acquired by P-Cable 3D HR system
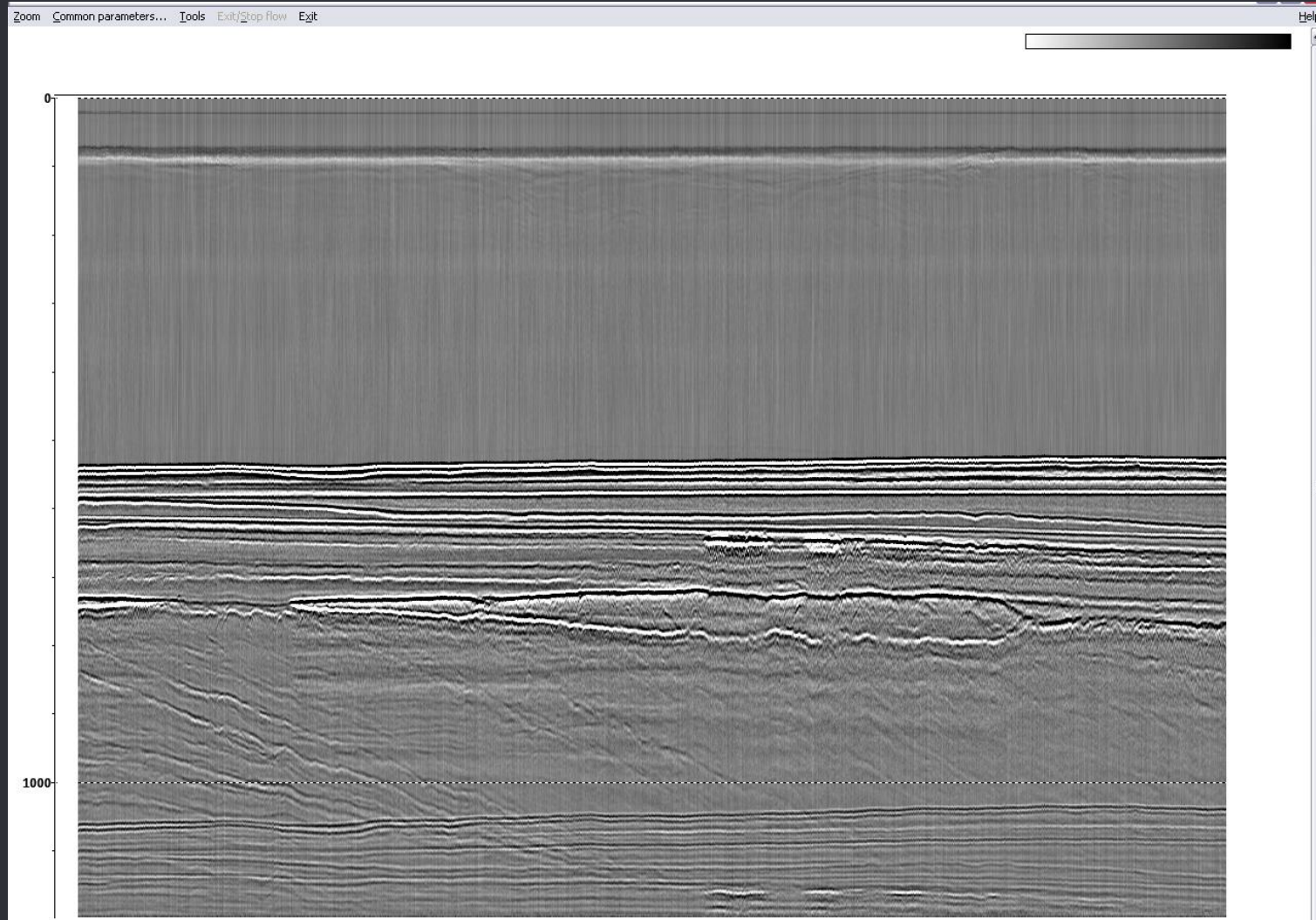
Single channel boomer data – before multiple elimination
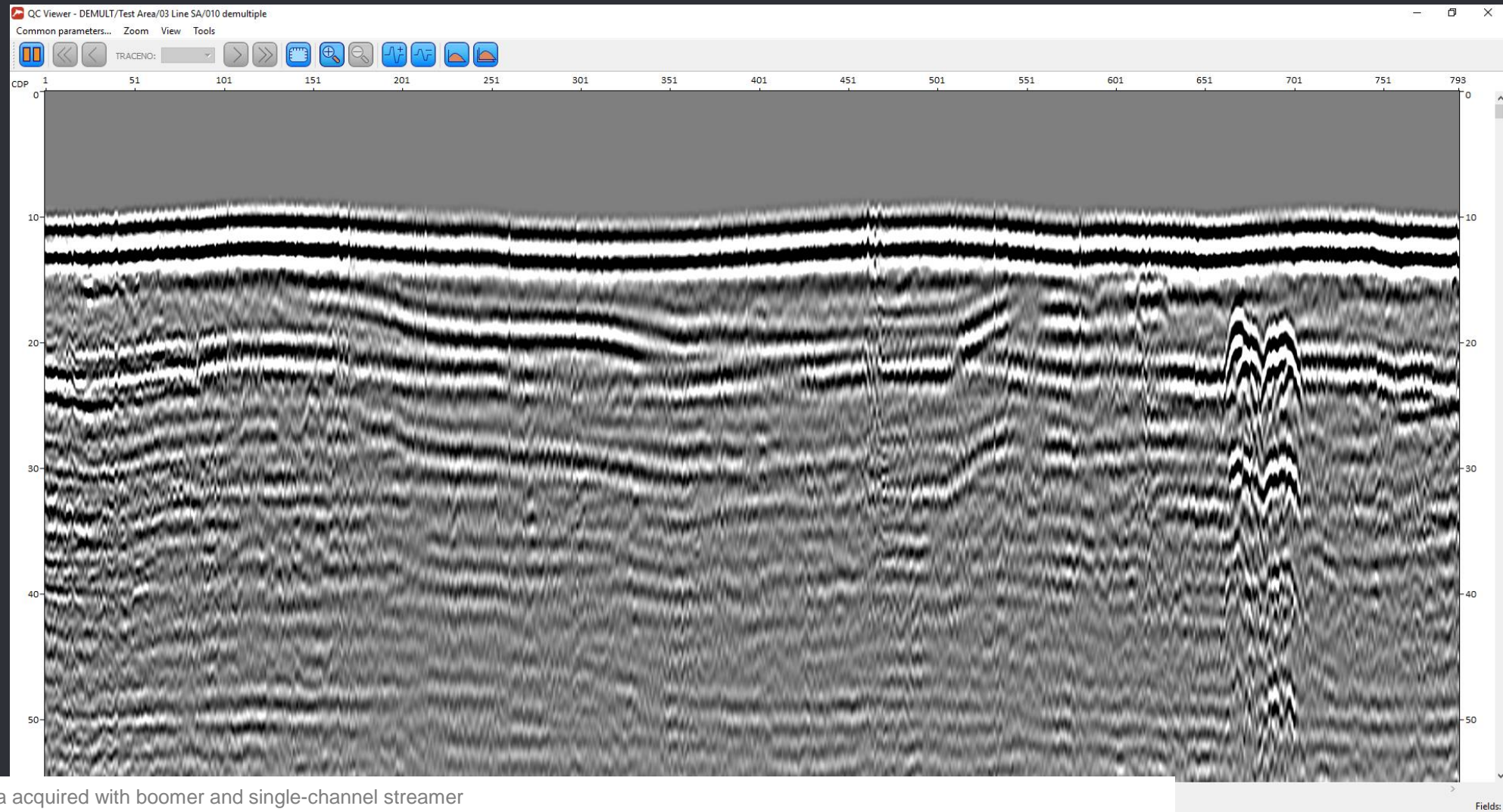
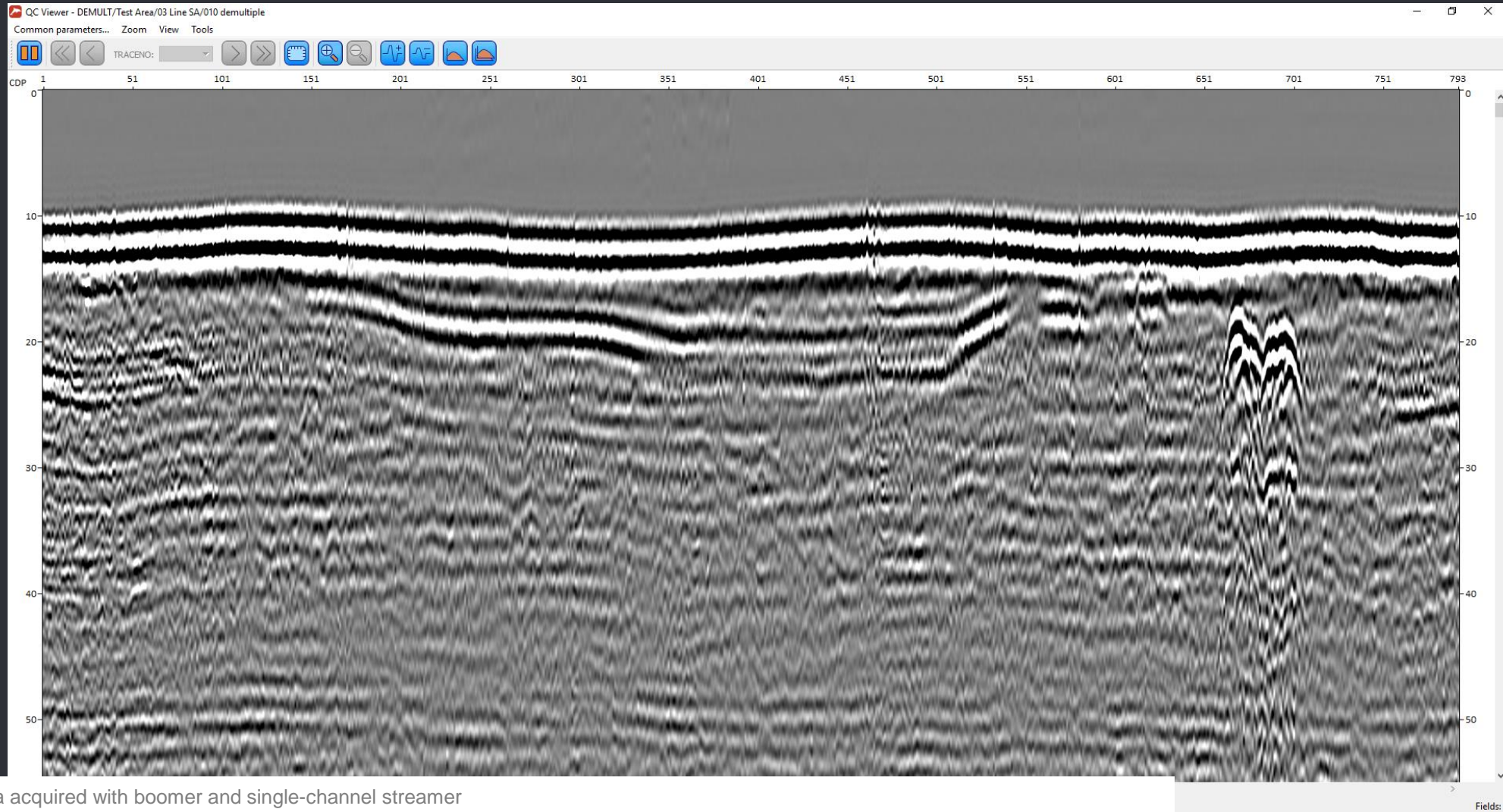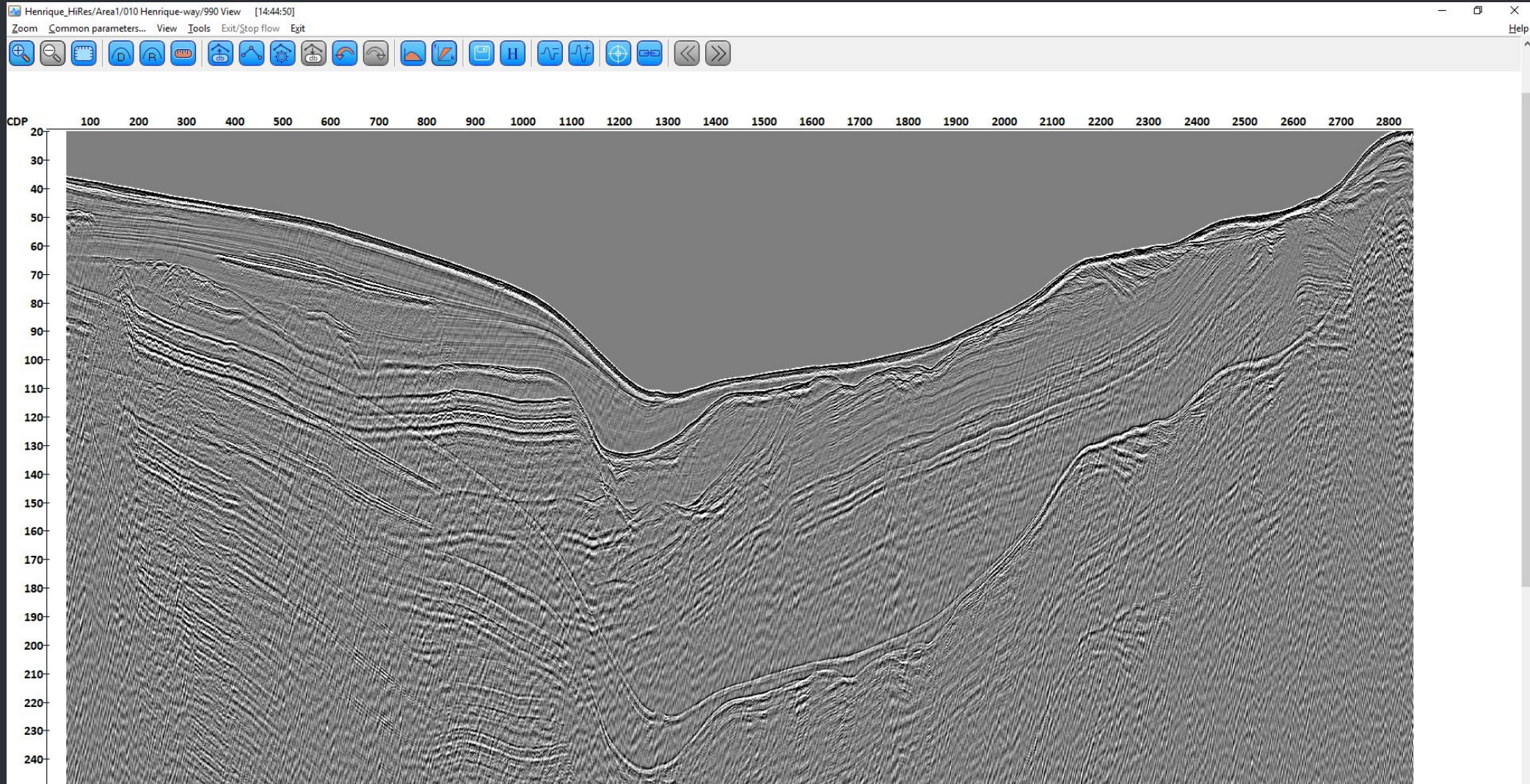Data acquired with boomer and single-channel streamer

Single channel boomer data – after zero-offset demultiple

Data acquired with boomer and single-channel streamer

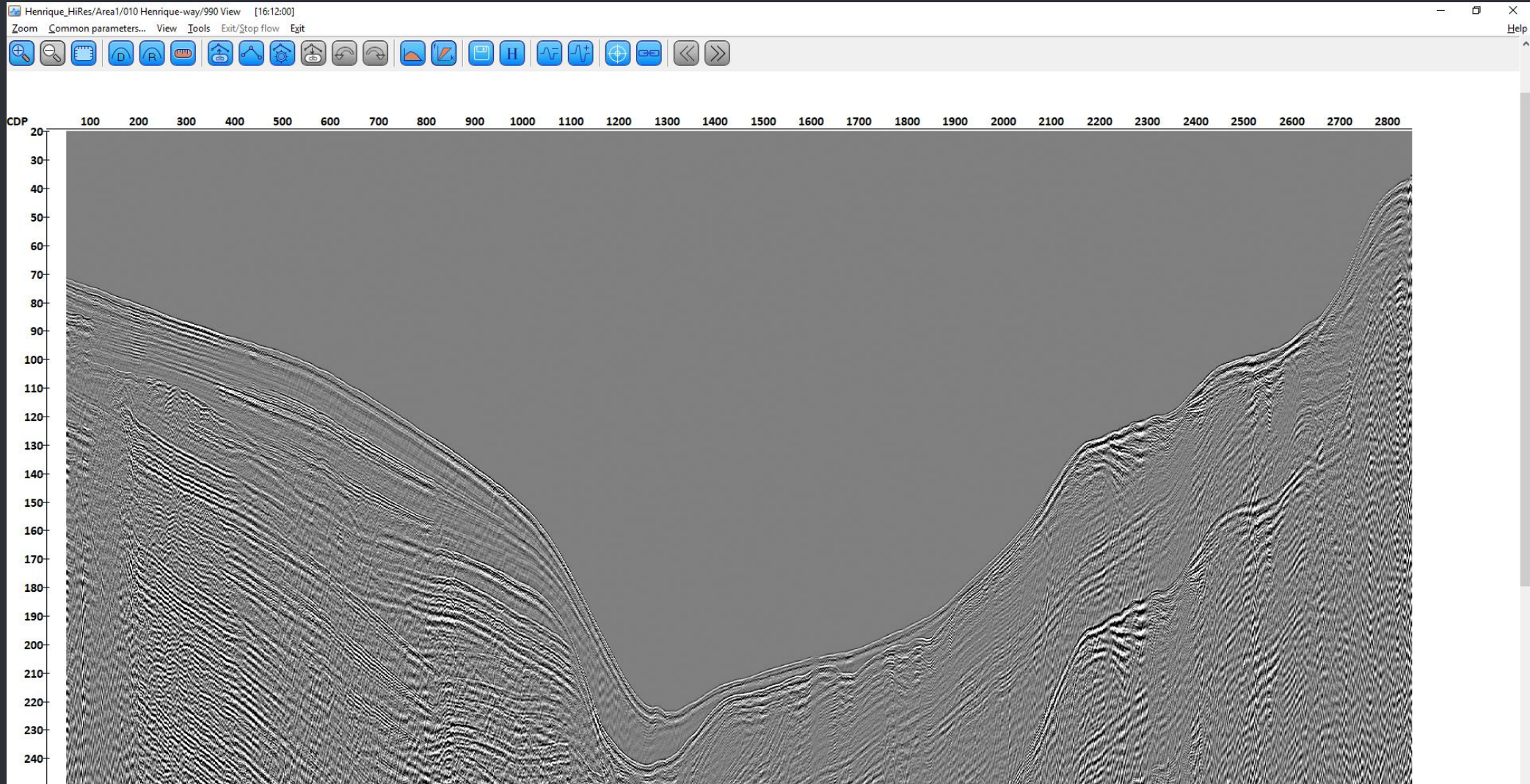# Multiple Elimination: Zero-Offset Demultiple

Before (stack of 16 channels)

Data acquired by GEO MARINE 3D UHR system, with sparker

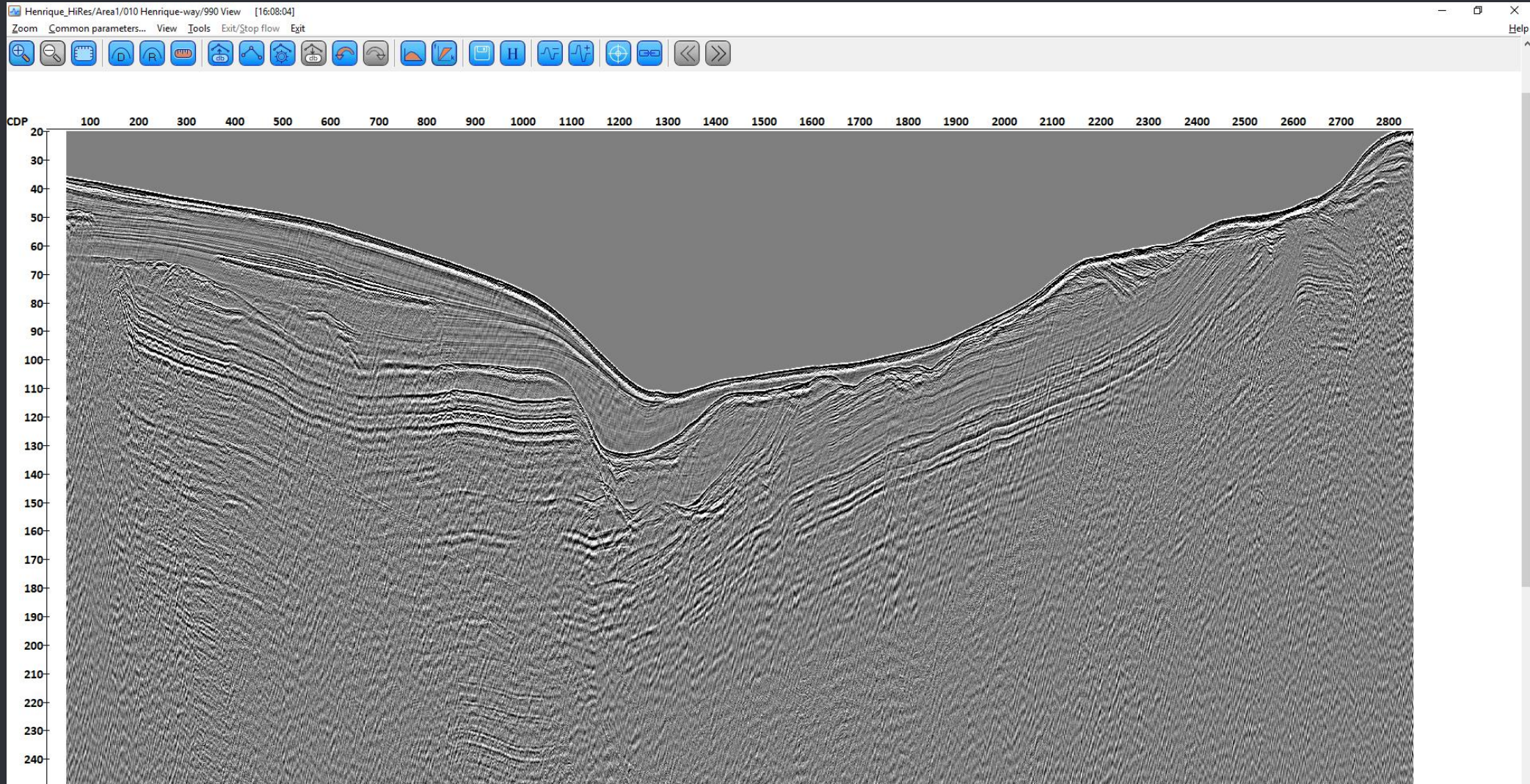# Multiple Elimination: Zero-Offset Demultiple

Model of Multiples (autoconvolution – post-stack)

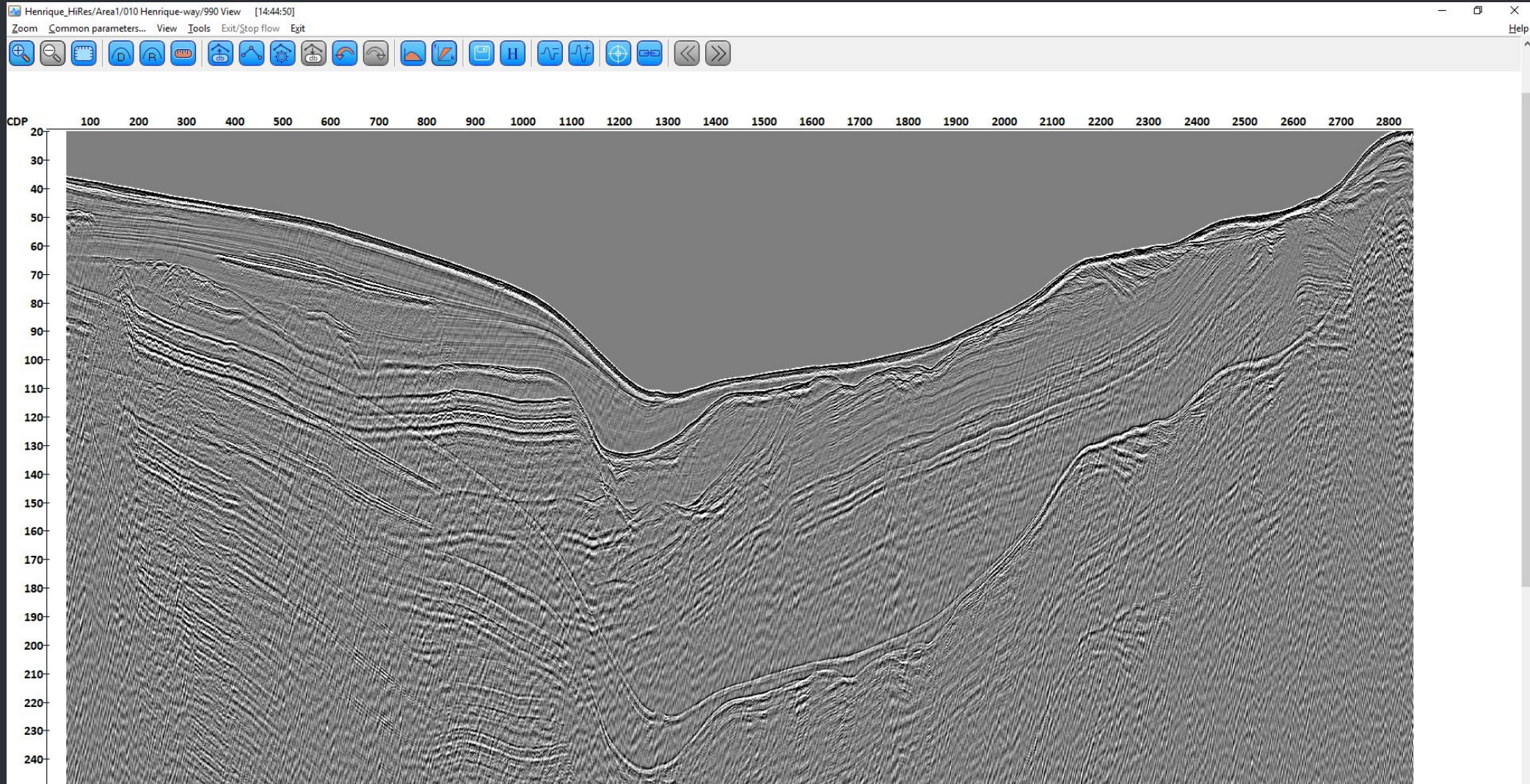Data acquired by GEO MARINE 3D UHR system, with sparker

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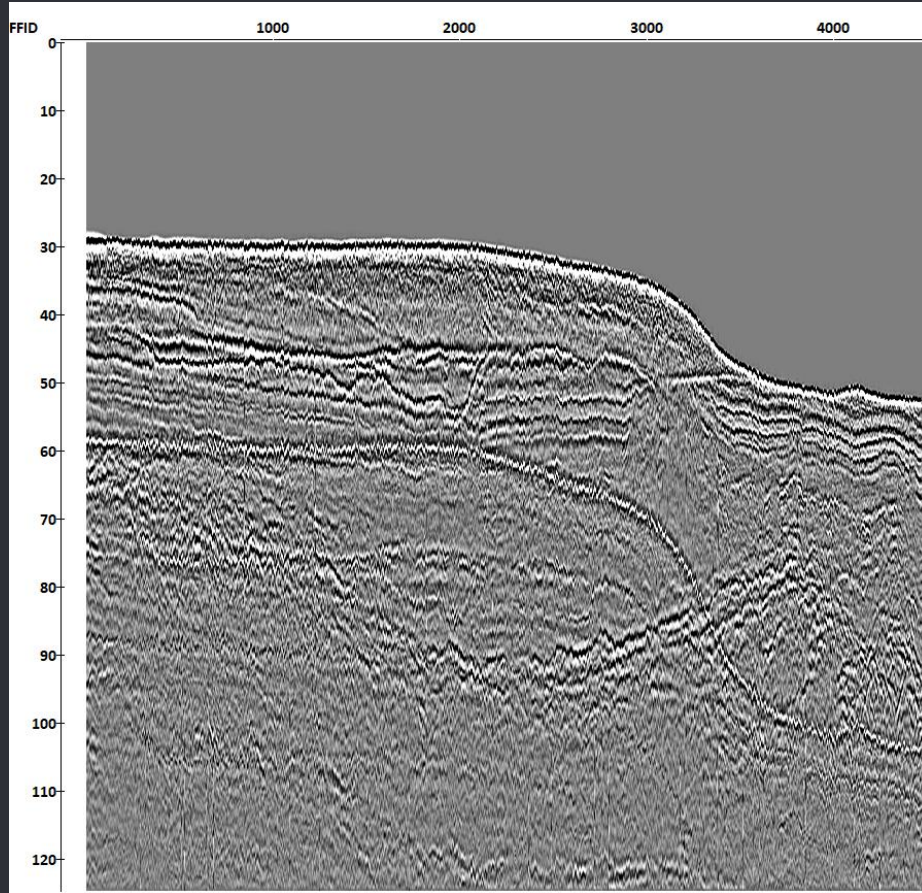
Subtraction Resullt (post-stack)

Data acquired by GEO MARINE 3D UHR system, with sparker

Multiple Elimination: Zero-Offset Demultiple

Before (stack of 16 channels)

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Data disturbed by sea swelling

Data acquired with Bubble Pulser (by Falmouth Scientific) and single-channel streamer

Multiple Elimination: Zero-Offset Demultiple

Data disturbed by sea swelling
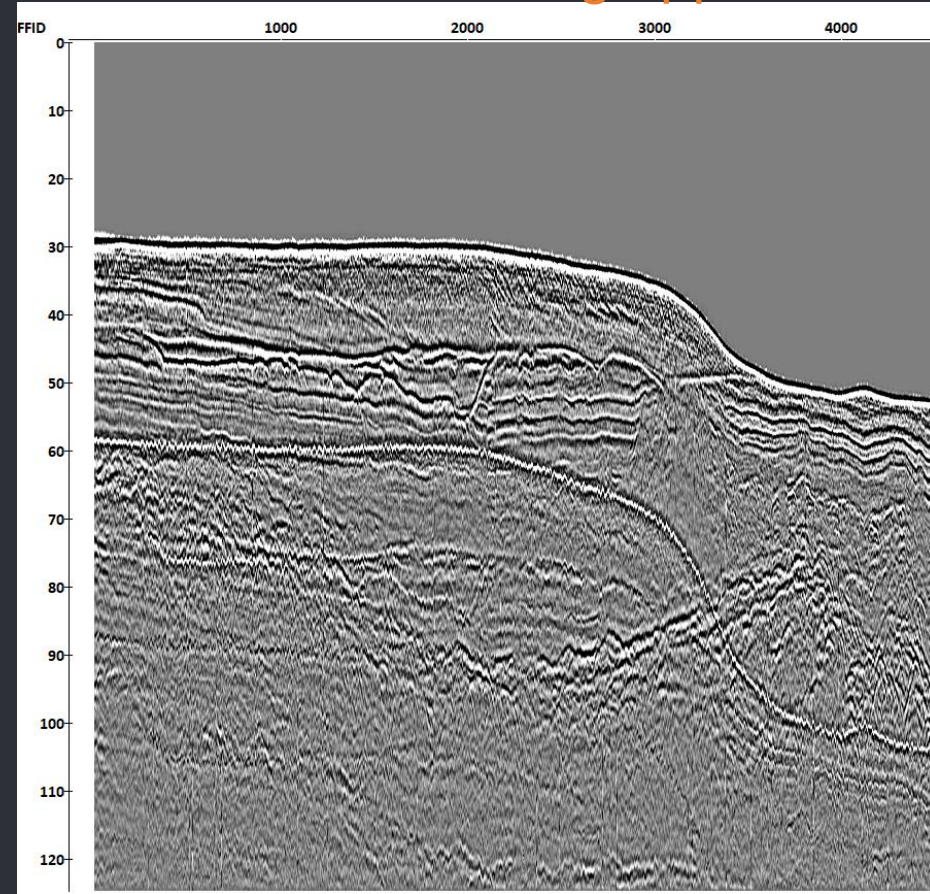
After swell filtering applied

Data acquired with Bubble Pulser (by Falmouth Scientific) and single-channel streamer

Multiple Elimination: Zero-Offset Demultiple

Data disturbed by sea swelling

After swell filtering applied

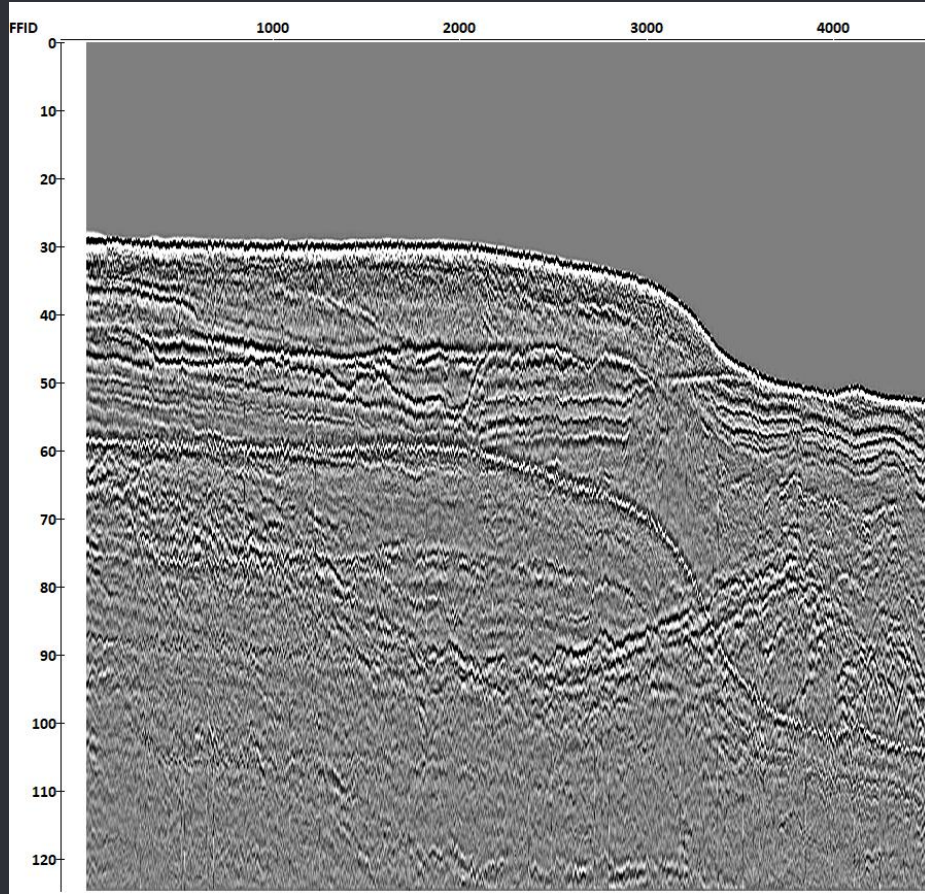## Data disturbed by sea swelling – model of multiples

Data acquired with Bubble Pulser (by Falmouth Scientific) and single-channel streamer
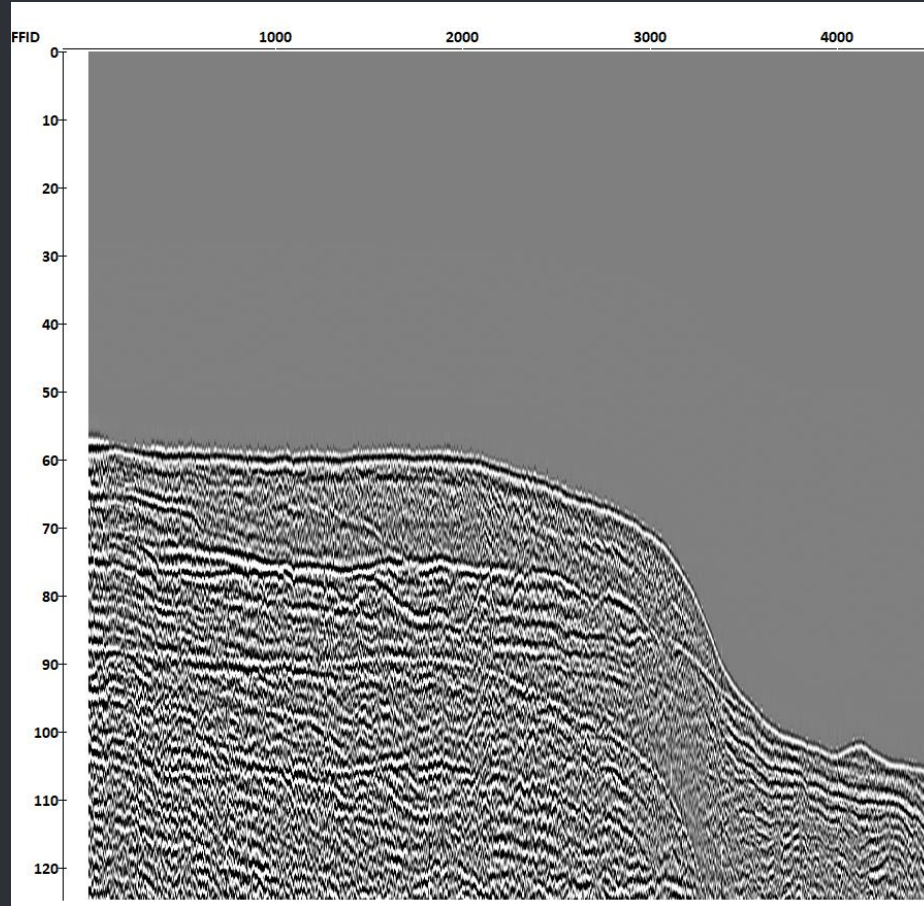
Multiple Elimination: Zero-Offset Demultiple
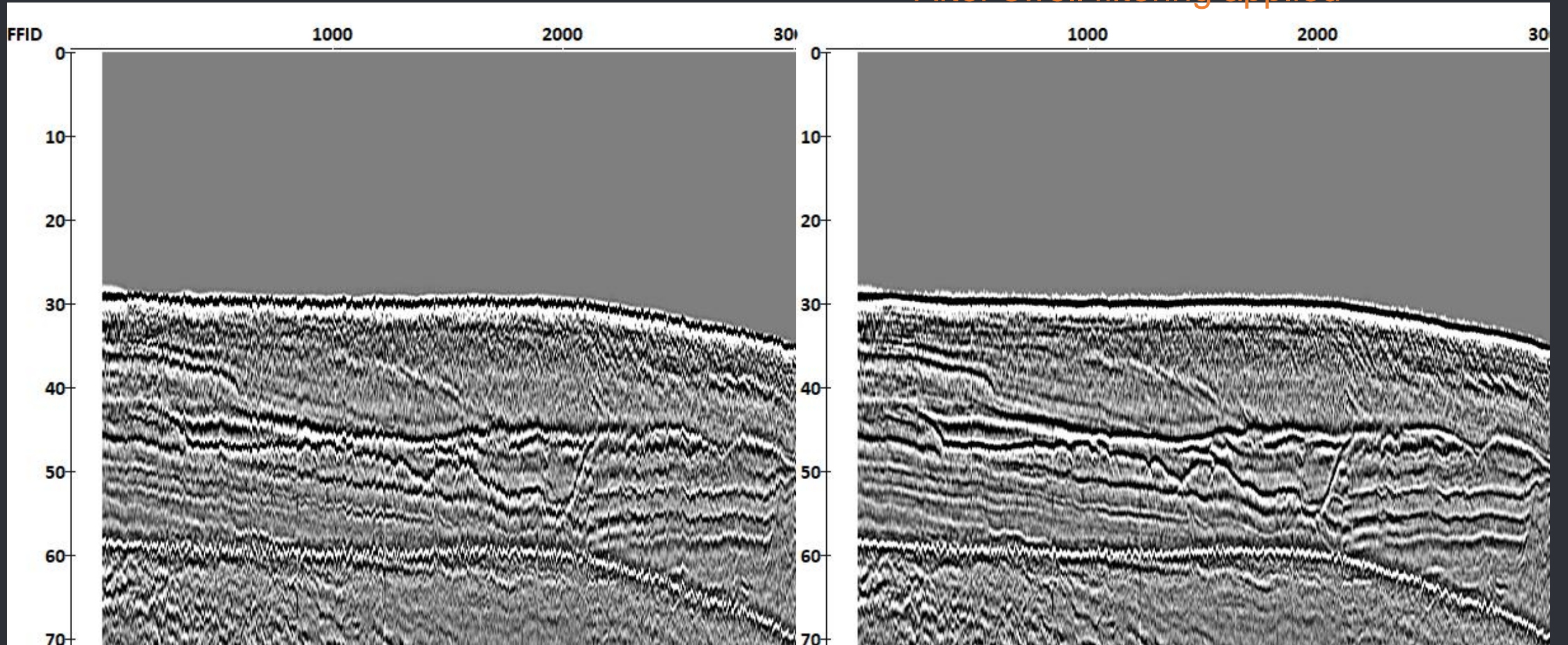
Data disturbed by sea swelling – demultiple is less efficient

Data acquired with Bubble Pulser (by Falmouth Scientific) and single-channel streamer

o Zero-Offset Demultiple technique based on approximate modeling of multiples followed by adaptive subtraction, was implemented and tested.

o It was shown that the method can be very efficient for near-offset HR/UHR marine seismic data acquired with different types of sources.

o Greater offsets and sea swelling reduce the efficiency of the algorithm

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Thank you for attention!

CONTACTS:

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