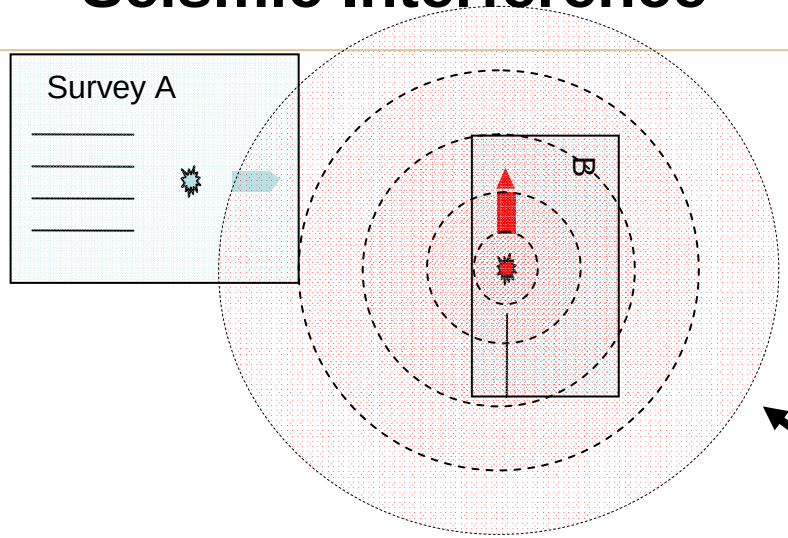
Seismic Interference

The perspective of the site surveys

Thomas Elboth

Sept, 2012

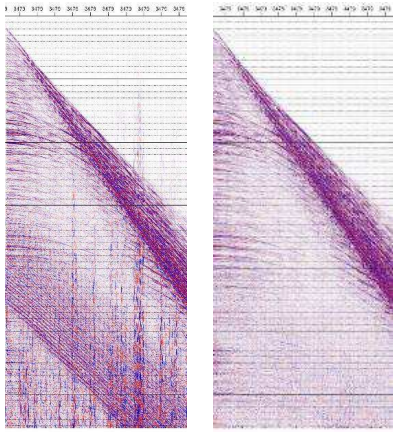
Seismic Interference



←Up to 100km→

Site-survey perspective

How to remove



Fugro Survey AS

- Responsible for Site Surveys in Norwegian waters
- Operates together with our sister company in Aberdeen 6 survey vessels
- Does approx 30 site and route survey reports yearly

Why Do Site Surveys?

"Site surveys are performed to **minimise the risk** of harm to personnel and equipment, and to protect the natural environment. The objective of any site survey is to **identify all possible constraints and hazards** from man-made, natural and geological features which may affect the operational or environmental integrity of a proposed drilling operation…"

OGP Guidelines for the conduct of offshore drilling hazard site surveys, 2011

OGP International Association of Oil & Gas Producers

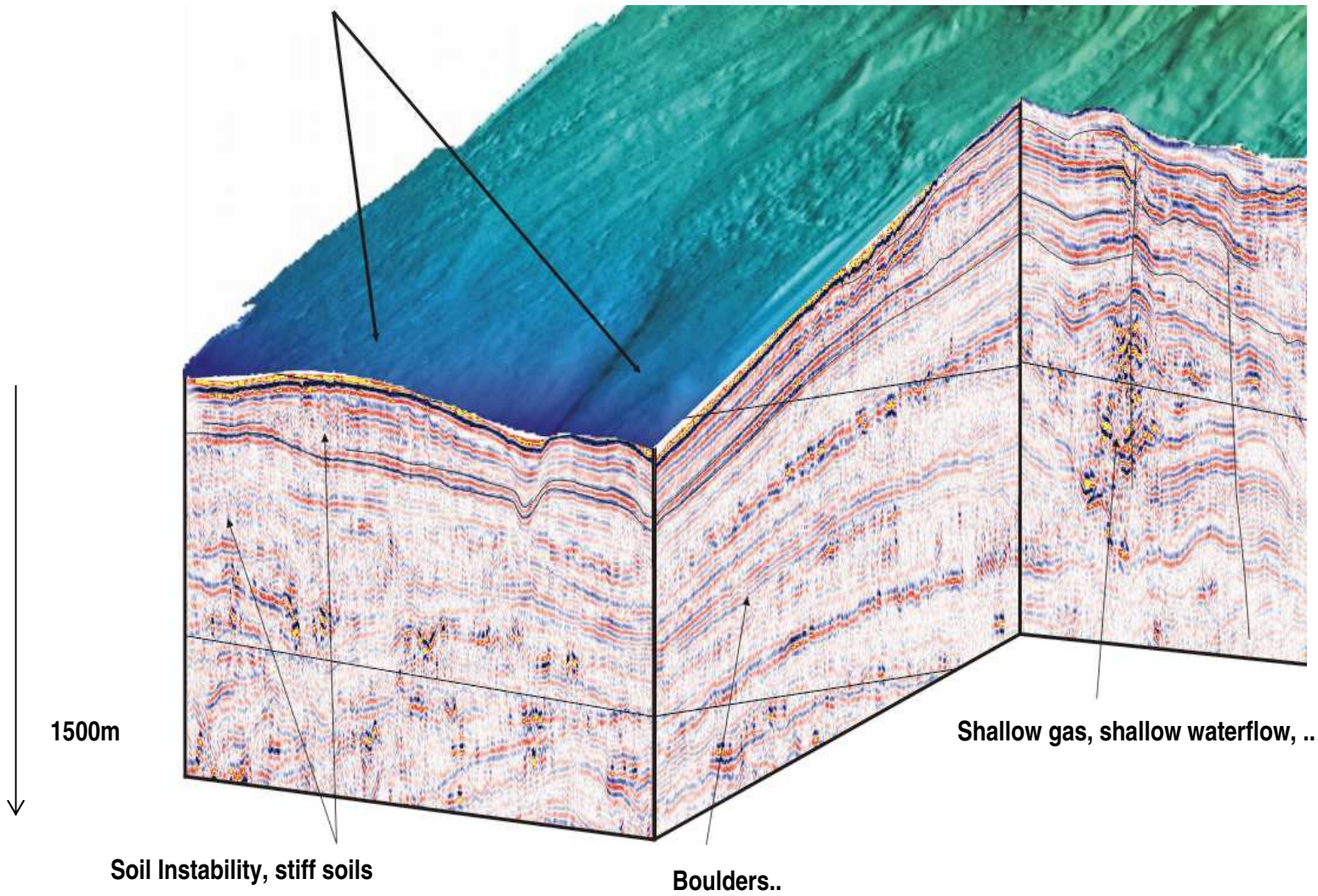
Why do a site survey

- Meet requirements
  - Authority regulations
    - Ptil: Aktivitetsforskriften
    - KLIF guidelines
    - Sjøfartsdir: Ankringsforskriften
  - Operator policy
  - Rig Insurance requirements
- Minimize your costs
  - Avoid over engineering
  - Avoid costly unwanted incidents

You should do a site survey before

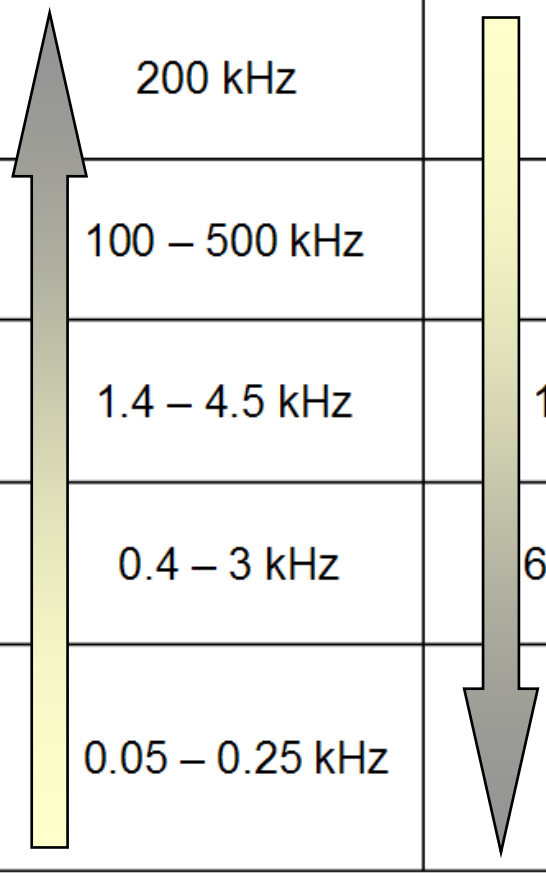
- Drilling a well
- Laying pipelines and cables (route survey)
- Engineering activity on the seabed

Typical potential hazards

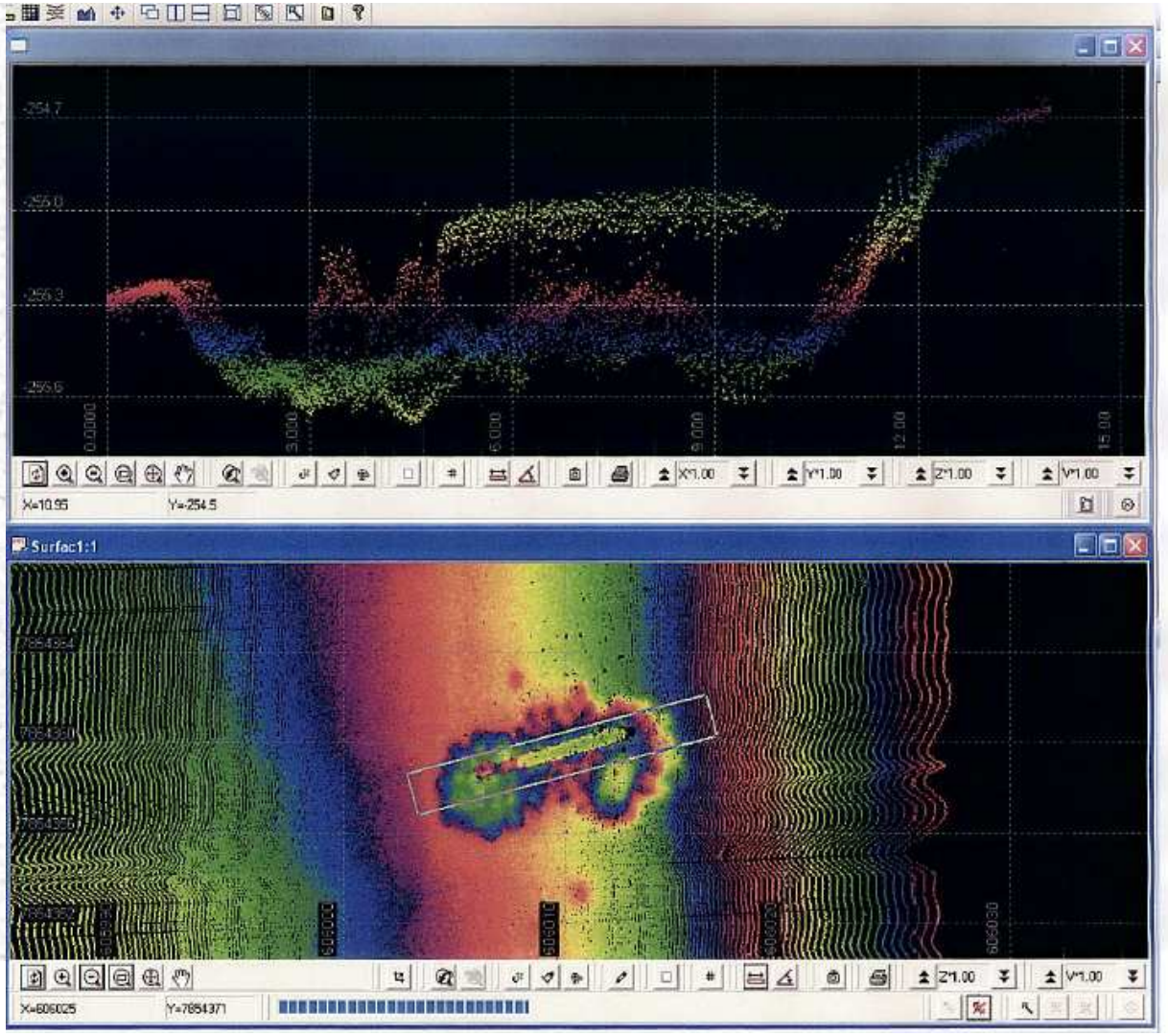


What tools are used

Source	Function	Frequency	Penetration through Seabed
Echo Sounder – Multibeam	Ascertain water depth	200 kHz	-
Side Scan Sonar	Identify seabed features	100 – 500 kHz	-
Sub-bottom Profiler – Pinger	Identify very shallow soils	1.4 – 4.5 kHz	10 – 30 m
Sub-bottom Profiler – MAG	Identify intermediate soils	0.4 – 3 kHz	60 – 100 m
Multi-channel Seismic	Identify deep soils and drilling hazards	0.05 – 0.25 kHz	1500 m



Tools for seabed survey

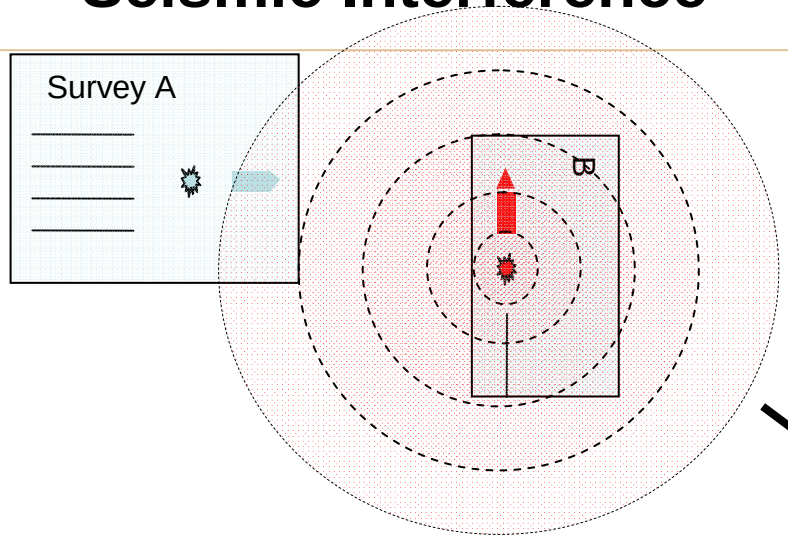


Tools for sub seabed survey

- To investigate sub-seabed hazards and soil instability
  - sub-bottom profilers (e.g. pinger, sparker and mini air gun)
  - digital high resolution multi-channel 2D seismic

Typical acquisition parameters site survey:
- Active streamer length : 1200 m
- Dist. between groups : 12.5 m
- No. of groups : 96
- Sampling rate : 1 ms
- Recording length : 2.5 sec
- Shot point distance : 12.5 m
- Streamer depth : 2.5 m (± 0.5 m)
- Source towing depth : 2.5 m (±1 m)
- Depth sensors on each section

Seismic Interference



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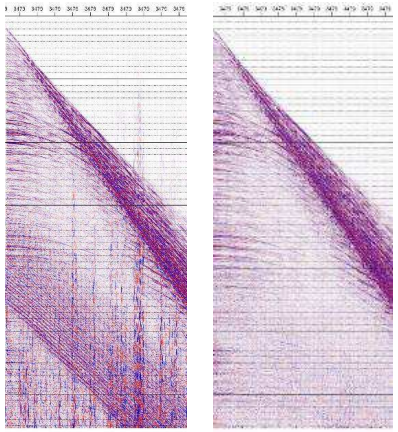
Site-survey perspective

How to remove



Time-sharing

- Statistics from Fugro Survey:

1. North Sea March 2012 , 5% of operational time
2. North Sea autumn 2011 , 10% of operational time
3. North Sea North summer 2011 , >20% of operational time

SI-Solutions

Traditional:

- Timesharing
  - Problem:
    Cost
  - Advantage:
    Perfect results

New solution:

- Ignore SI. Attenuate in processing
  - Problem:
    Does not always work
  - Advantage:
    Low cost

The third option:
Plan ahead and coordinate, to avoid timesharing

Site-Survey vessels

Versatile:

- If on standby, they can do:
  - Sea-bottom profiling
  - Geotechnical surveys
  - Environmental surveys

  } Need to plan ahead

- Typical short lines
  - Can take advantage of line-changes

Small:

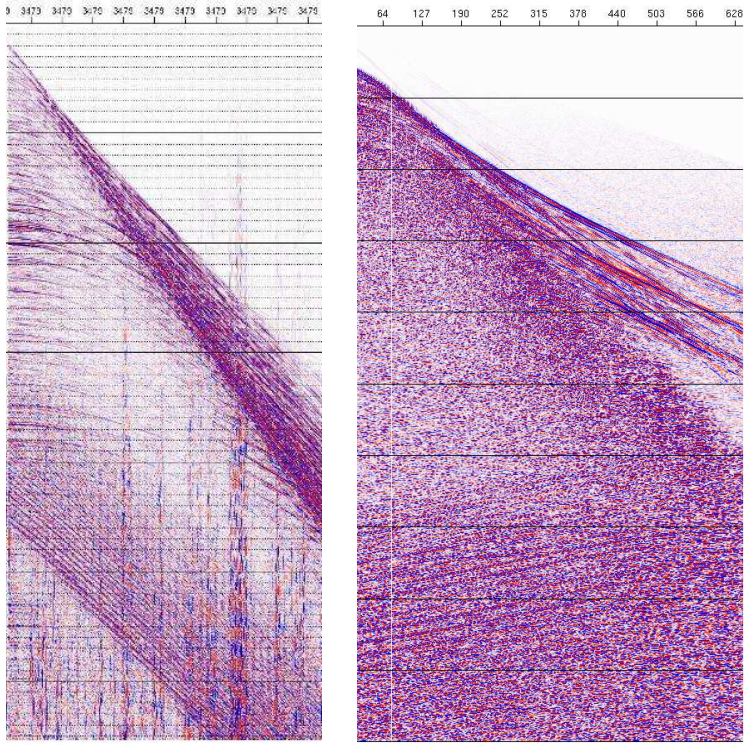
- Often difficult to agree on time-sharing
  - Unclear rules

    Time-share pr vessel or pr operating company in an area???

- Sometimes difficult to obtain accurate info on seismic activity in an area

Onboard QC/processing

- Only basic QC is standard on site survey vessels
- Advanced QC or full onboard processing can help evaluate if SI is acceptable or not
  - Direction
  - Amplitude
  - Time
  - And one other nice thing (next slide)

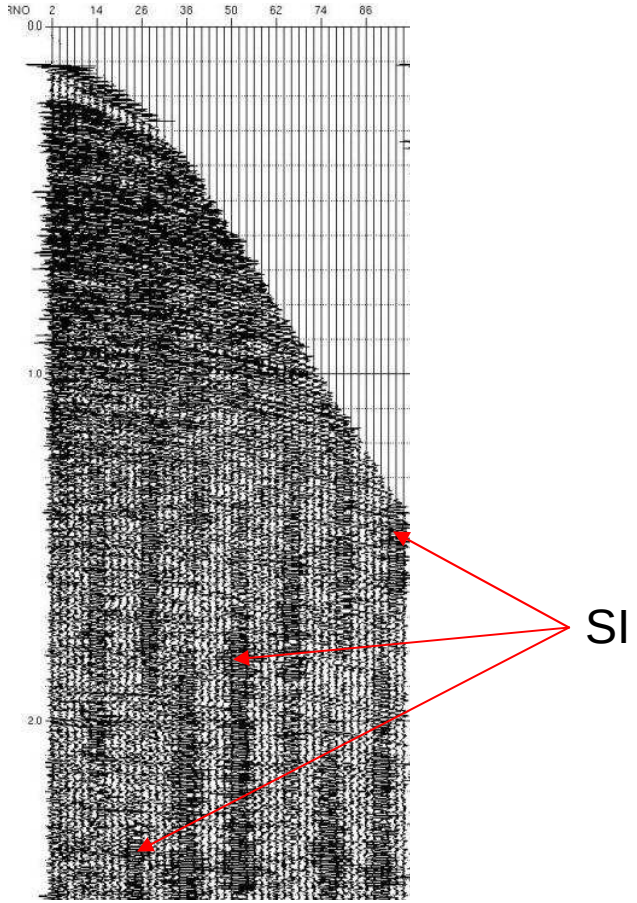


Left : Difficult to attenuate
Right: Easy to attenuate

Onboard QC/processing

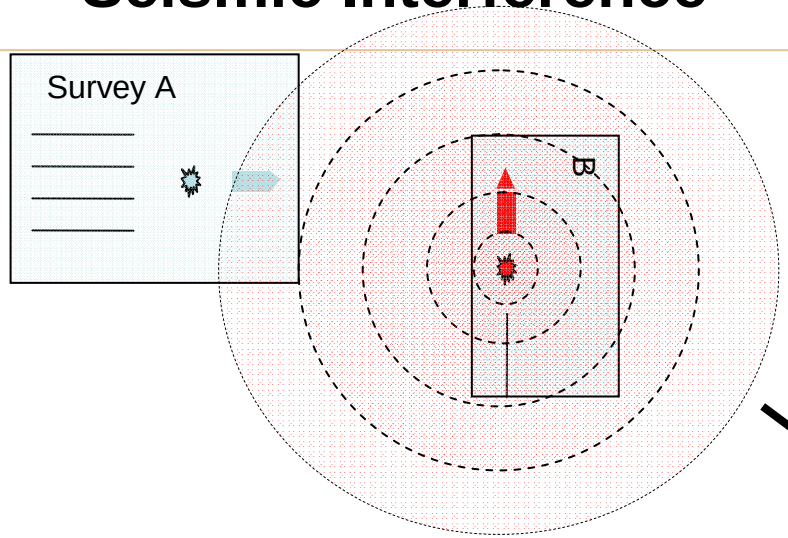
- Site-survey shot-point interval: ~3s
- Conventional seismic shot-point interval: 8-15s
- Sort data to CMP

  →Apply de-noising algorithms to remove the SI



Site-survey data
sorted to CMP-domain

Seismic Interference



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Site-survey perspective

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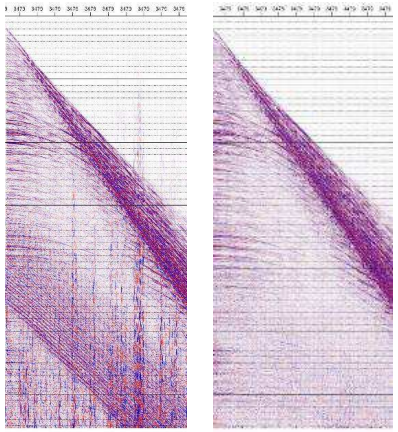


General approach to remove SI

1. Transform and/or sort the data into a domain where we can separate SI from the seismic data.

2. In this new domain: Remove the SI.

3. Transform and/or sort the data back to the normal (shot/cmp) domain.

The challenge is to identify the most suitable domain where the denoising should take place!

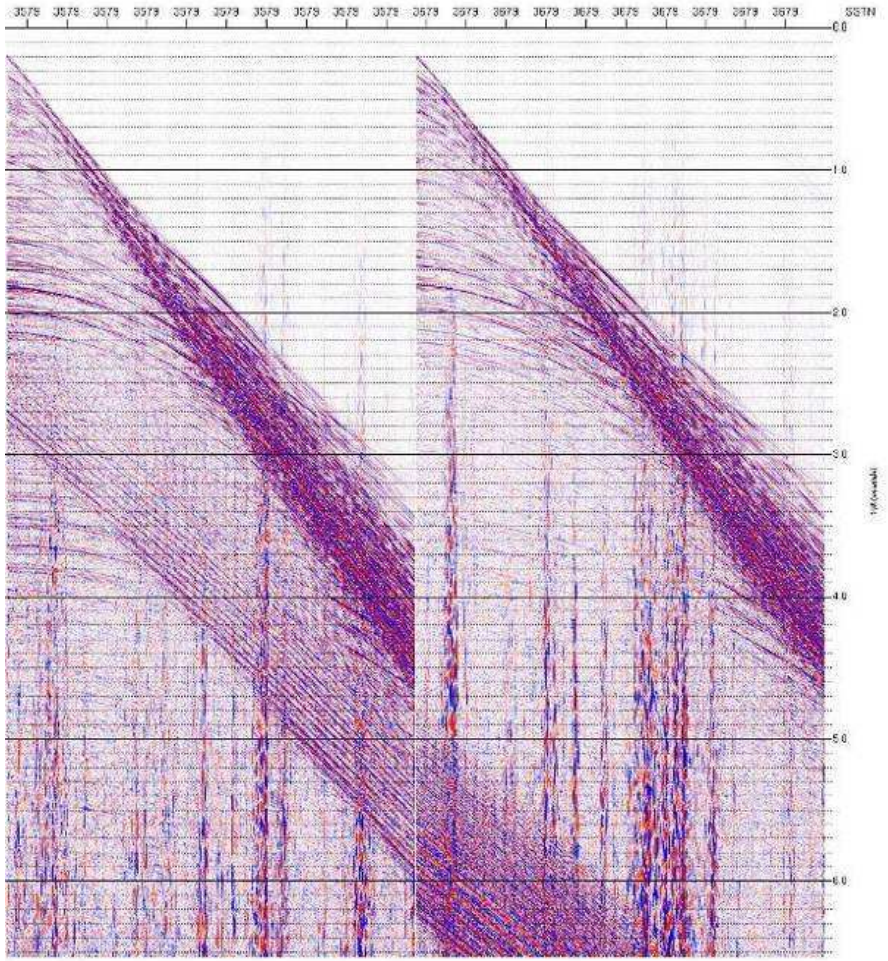
The story

- We present a few examples on how Fugro Seismic Imaging through careful processing have removed SI

- Specialized software modules and processing flows

Case 1: Conventional seismic data

- Strong SI + some swell-noise.
- SI comes from the front, and has similar move-out as the data.
- SI is visible on all shots.

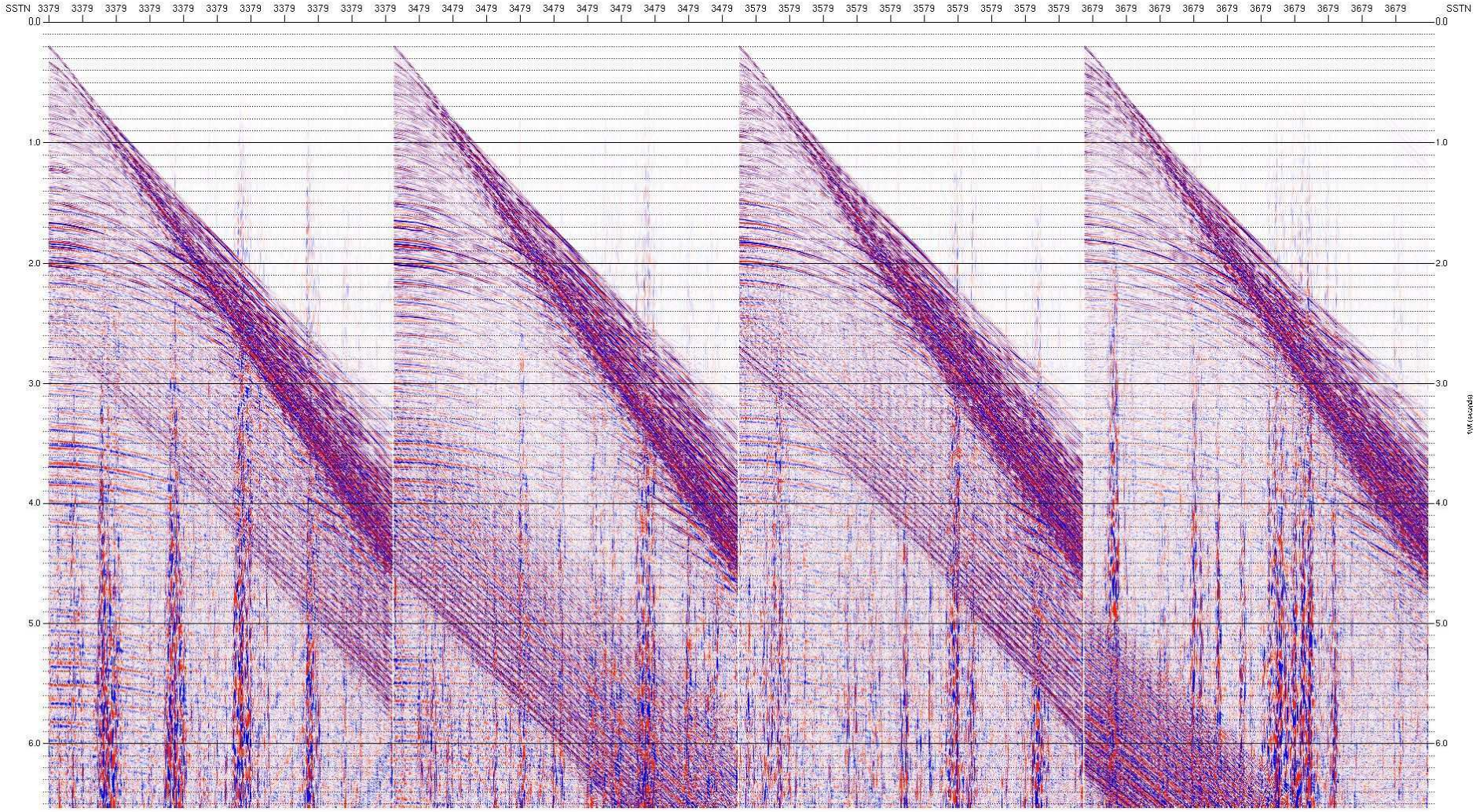


Shot-gathers

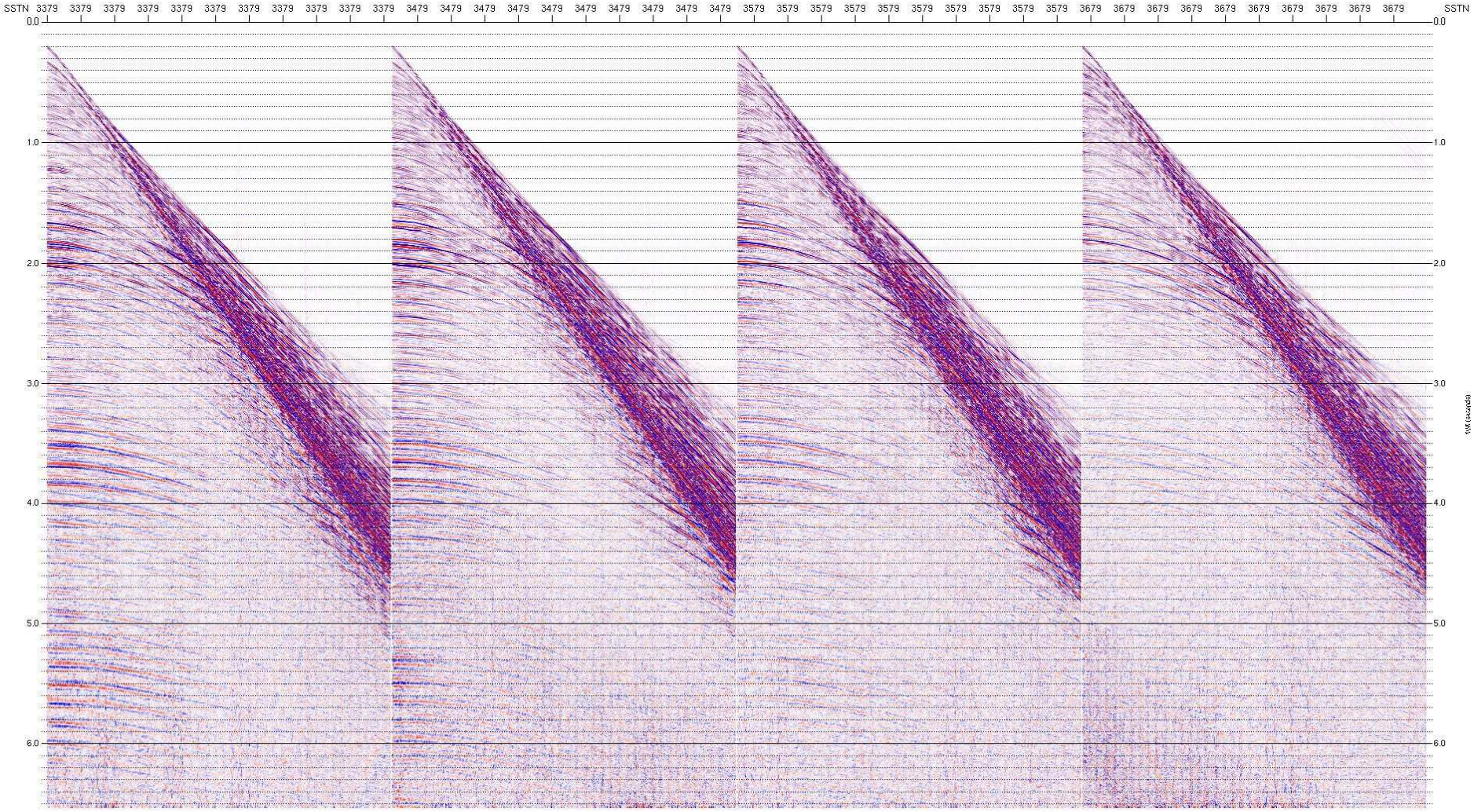
Parameters : Seismic Interference removal

- 1. Mild swell-noise attenuation in CO-domain using Fugro Statistical de-noising methods.
- 2. Make a model of the SI from the data using a Stationary Wavelet transform:
  - Apply NMO to shot record
  - Transform shot records using a Stationary Wavelet transform
  - Mute the SI (examples will follow)
  - Transform data back to time-frequency, keeping the SI
  - Remove NMO
  - Apply Random noise attenuation to improve the model of SI
  - Output SI model
- 3. Subtract the output model 2. from the Input data 1.
- 4. Output shot with SI removed.
- 5. Additional swell-noise/SI attenuation

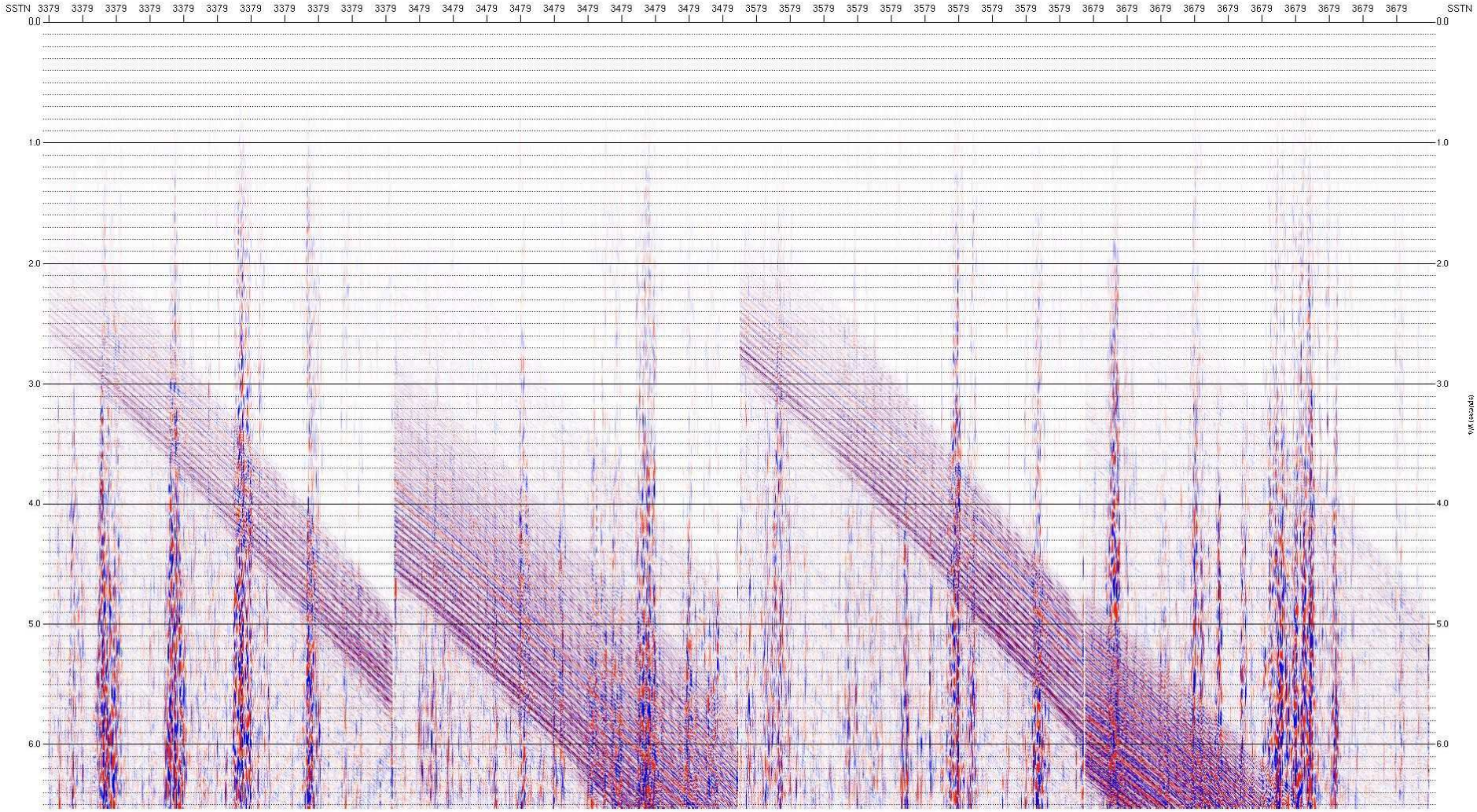
1. Shots : Input



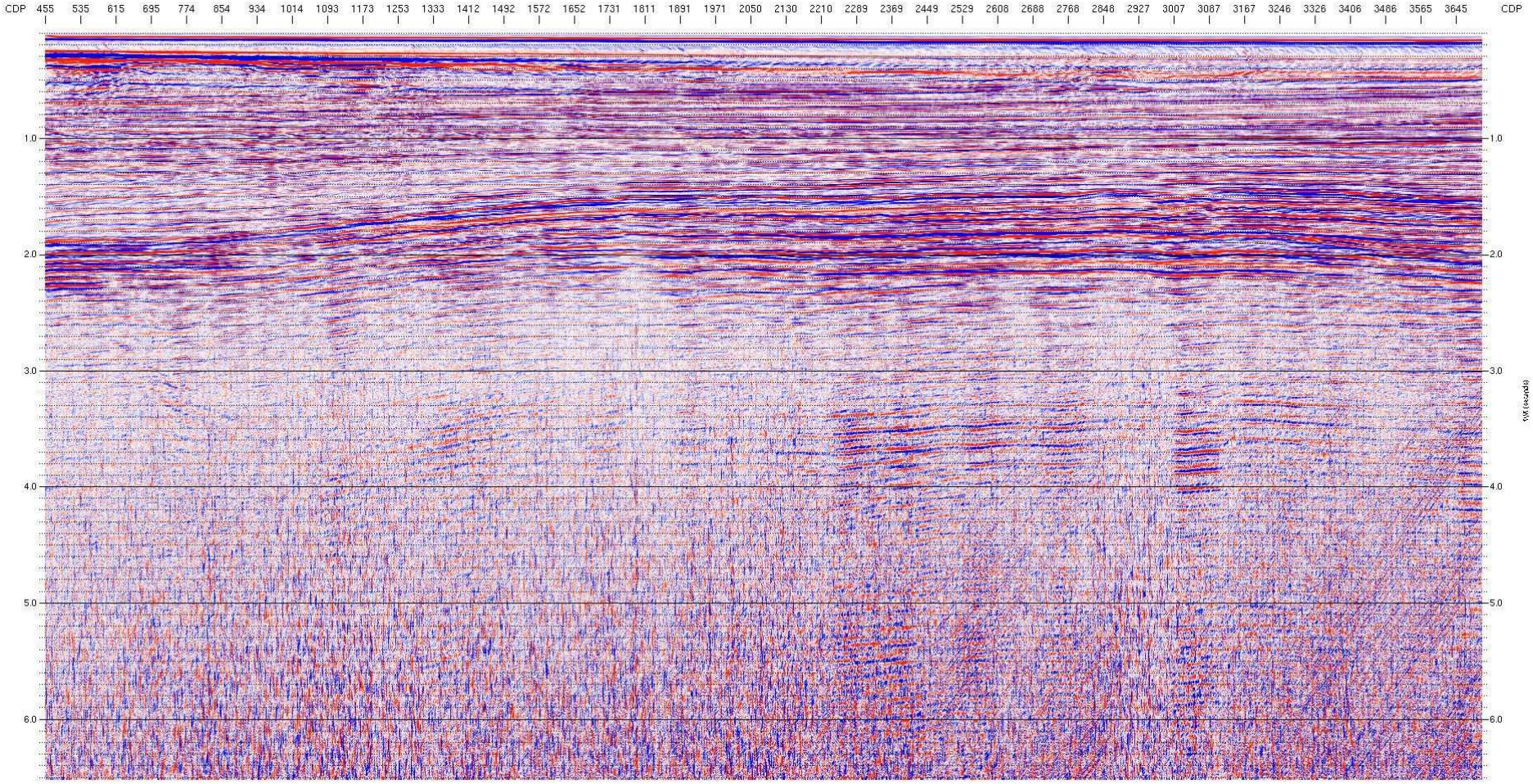
After final noise attenuation



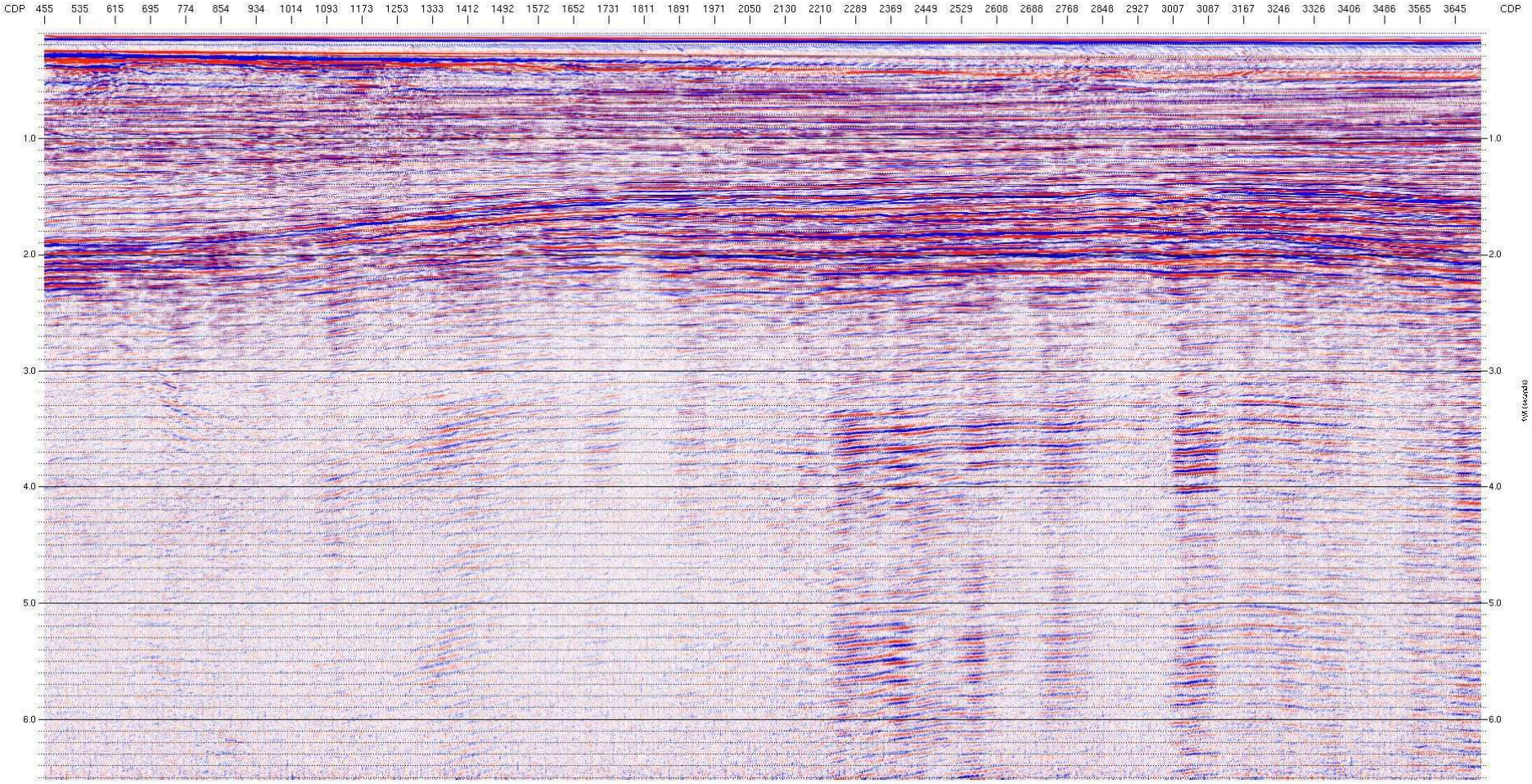
Difference



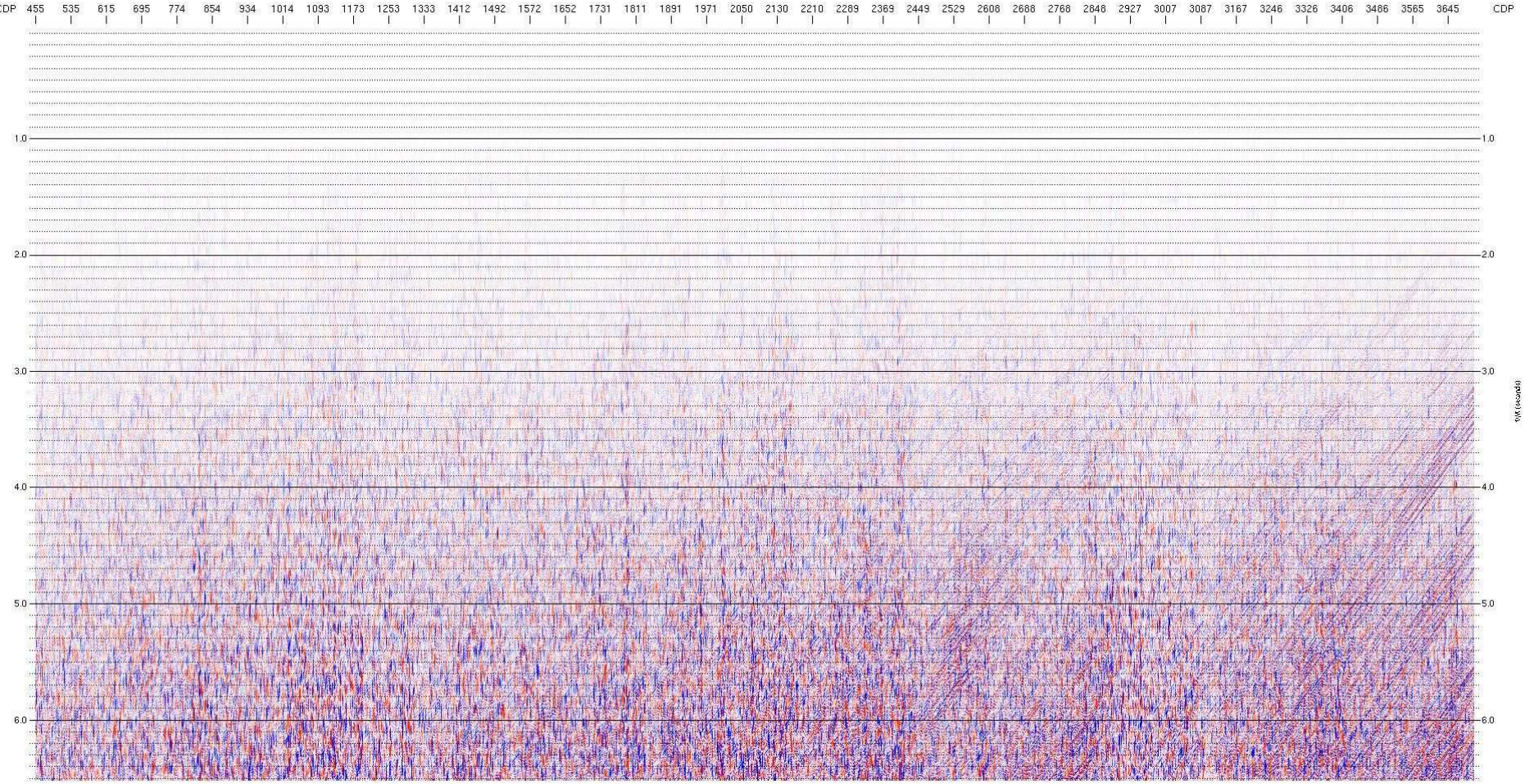
1. Stack : Input



4. Stack : After noise attenuation



Difference

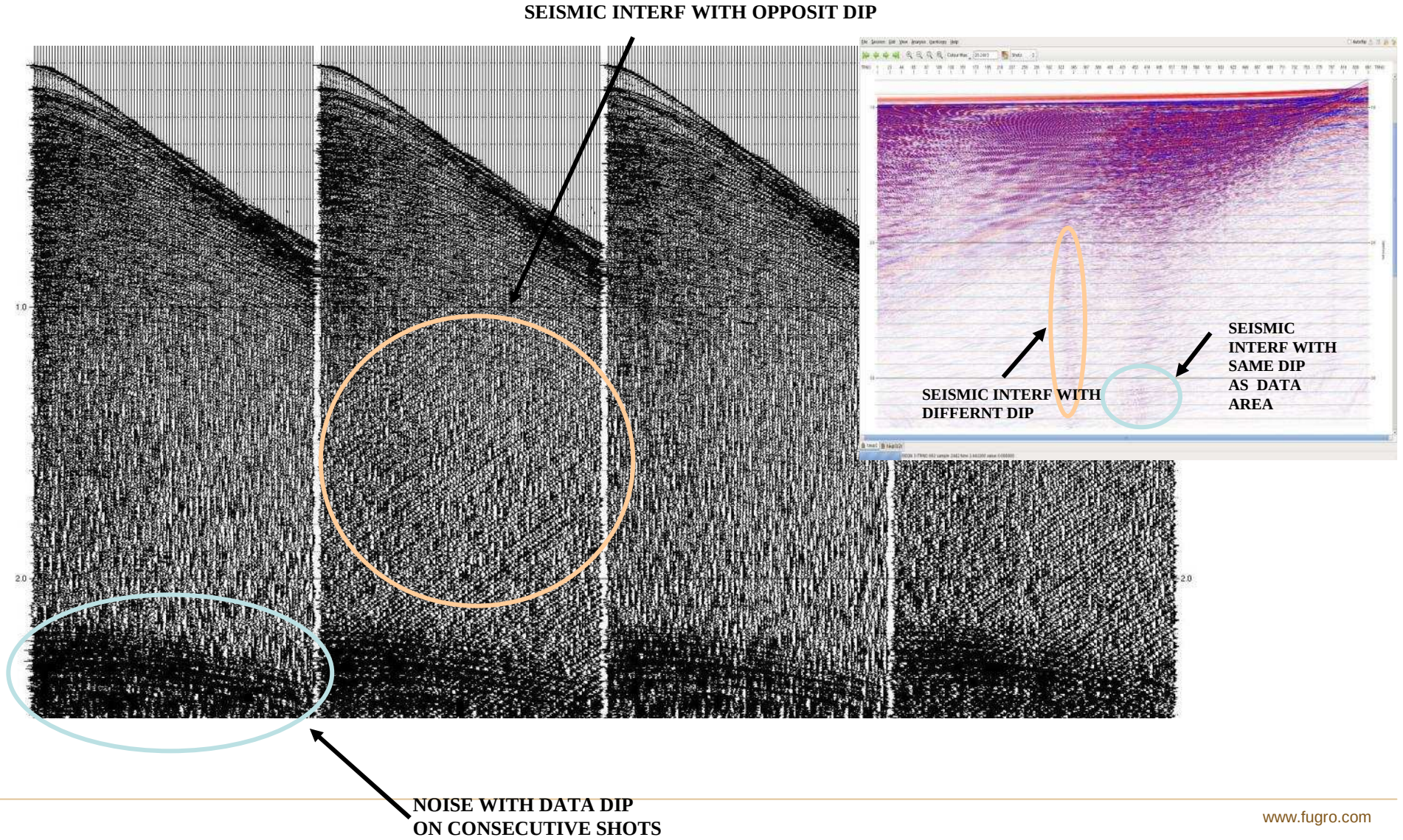

CDP 455 535 615 695 774 854 934 1014 1093 1173 1253 1333 1412 1492 1572 1652 1731 1811 1891 1971 2050 2130 2210 2289 2369 2449 2529 2608 2688 2768 2848 2927 3007 3087 3167 3246 3326 3406 3486 3565 3645 CDP
1.0
2.0
3.0
4.0
5.0
6.0
TWT (seconds)

Case 2: Site-survey data

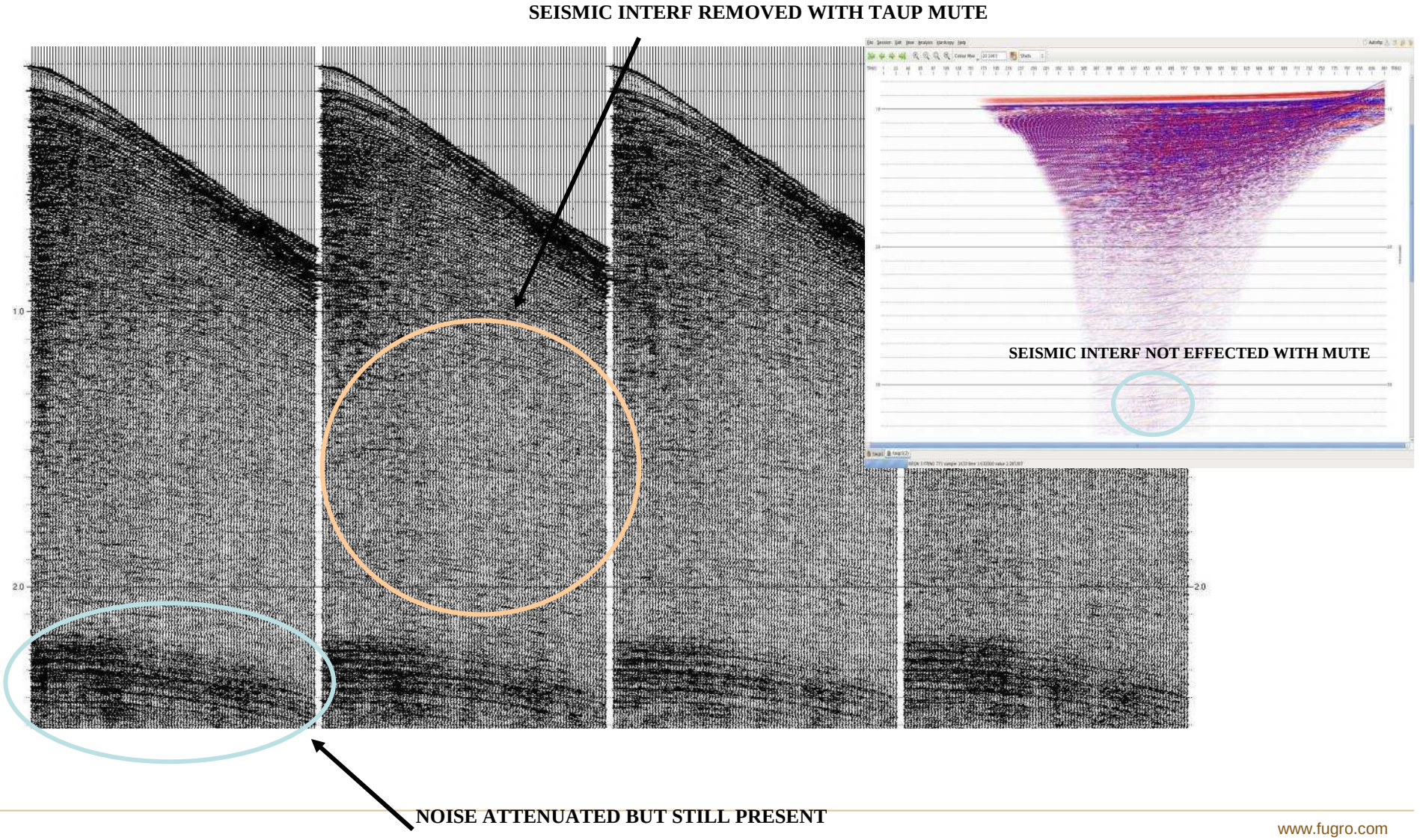
- Examples from site-survey processing in the North and Barents Sea.

- The flows are based on combining Tau-p muting and Fugros statistical denoising methods.

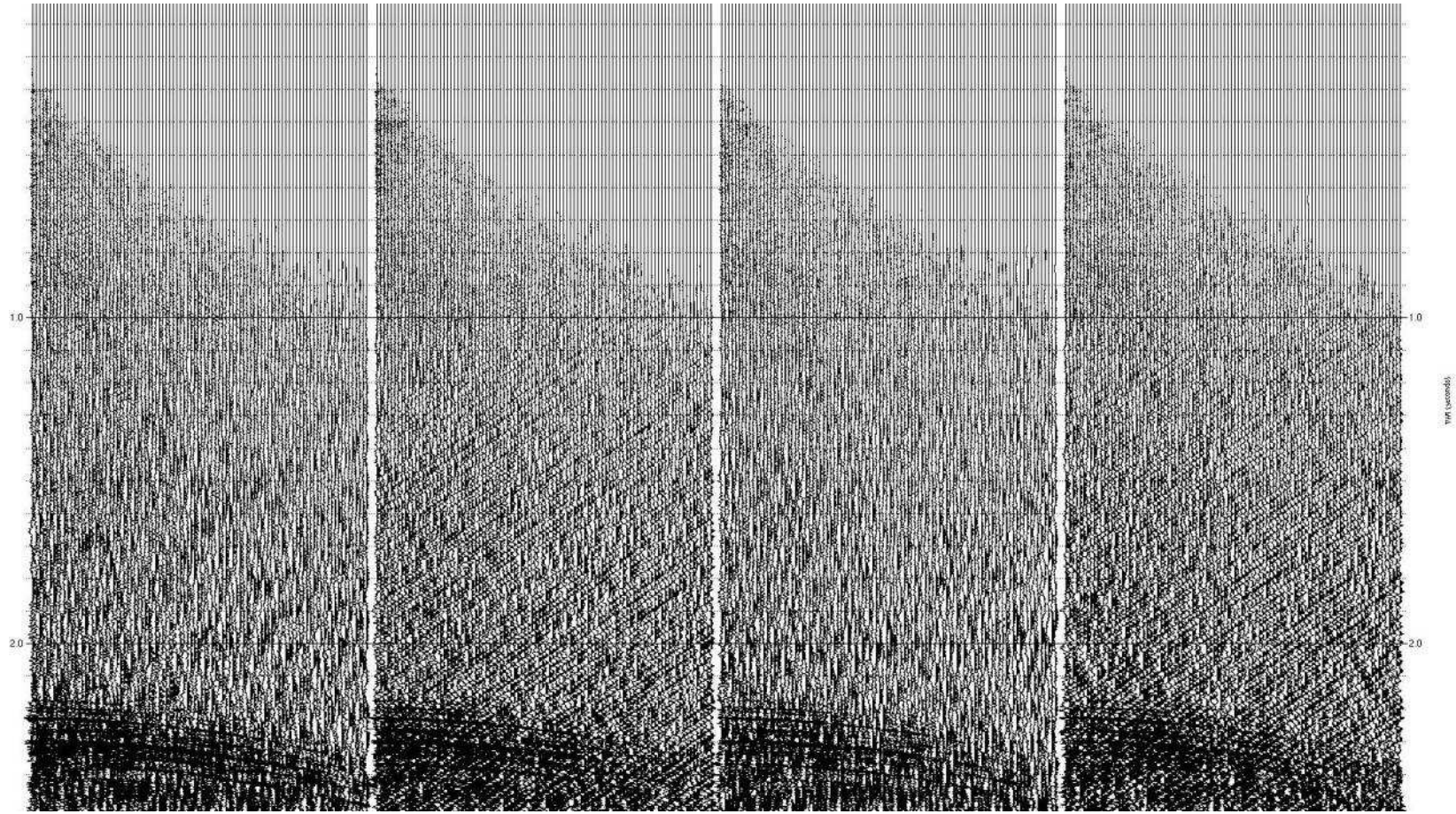
Shot gathers



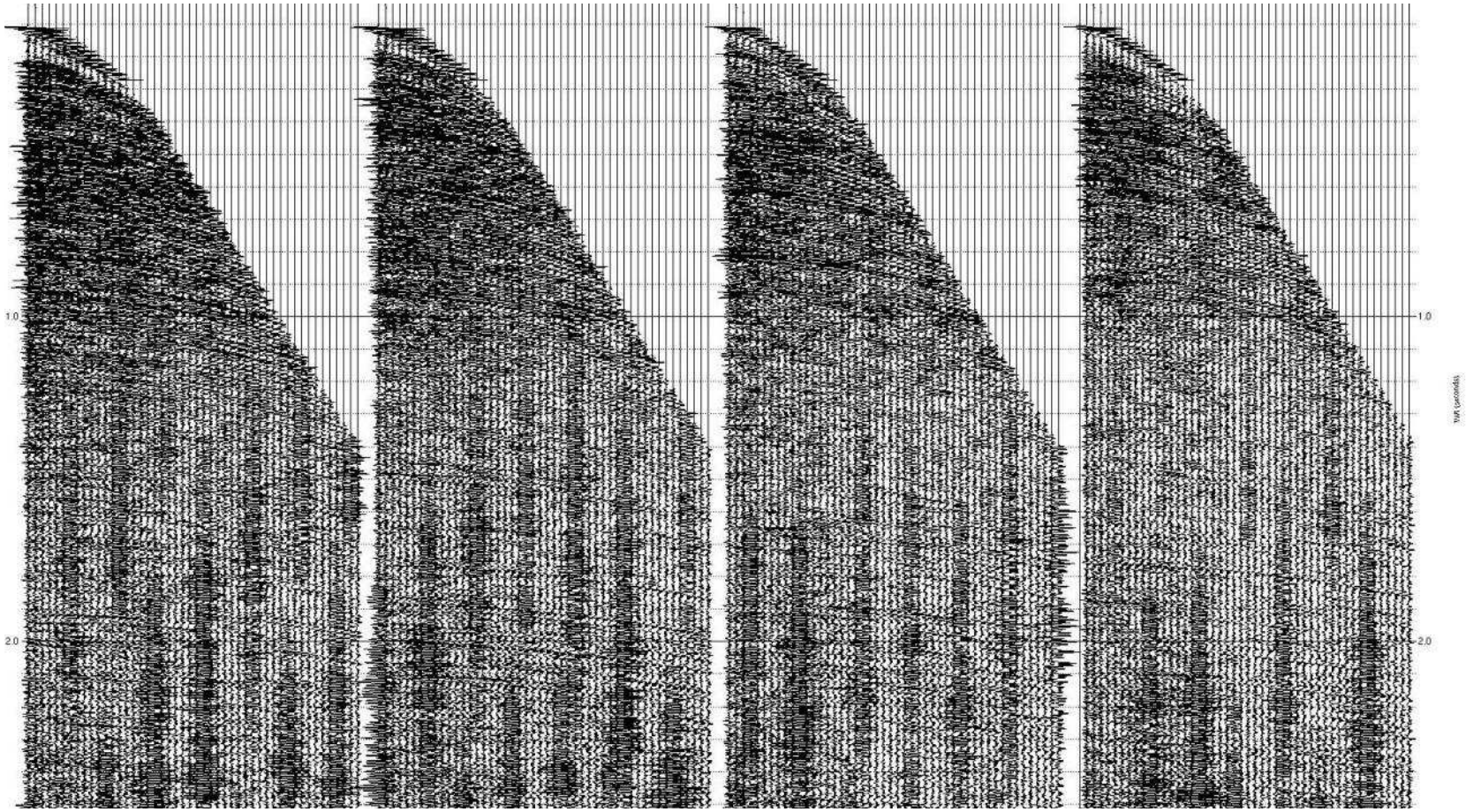
Gathers after Tau-P mute



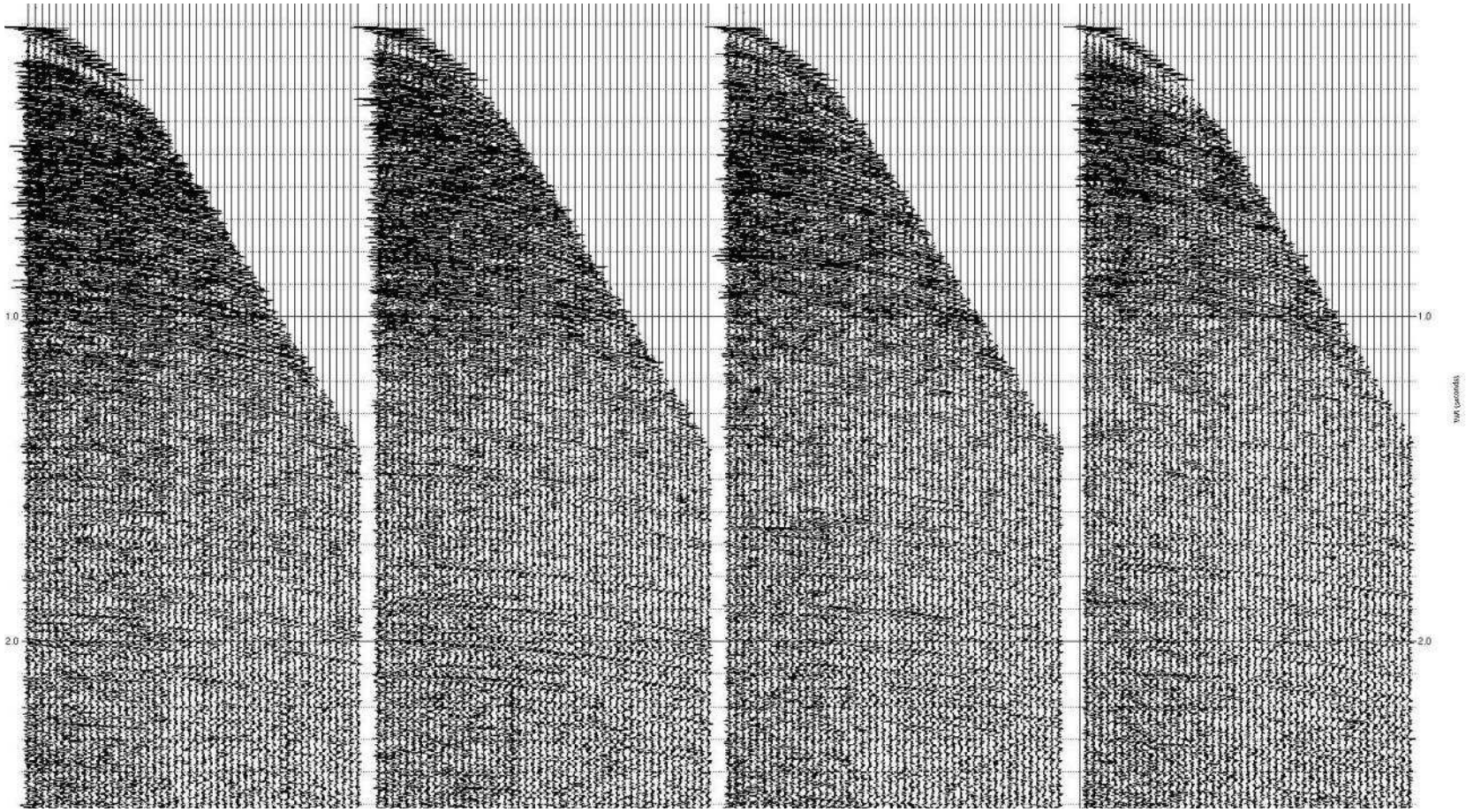
Difference



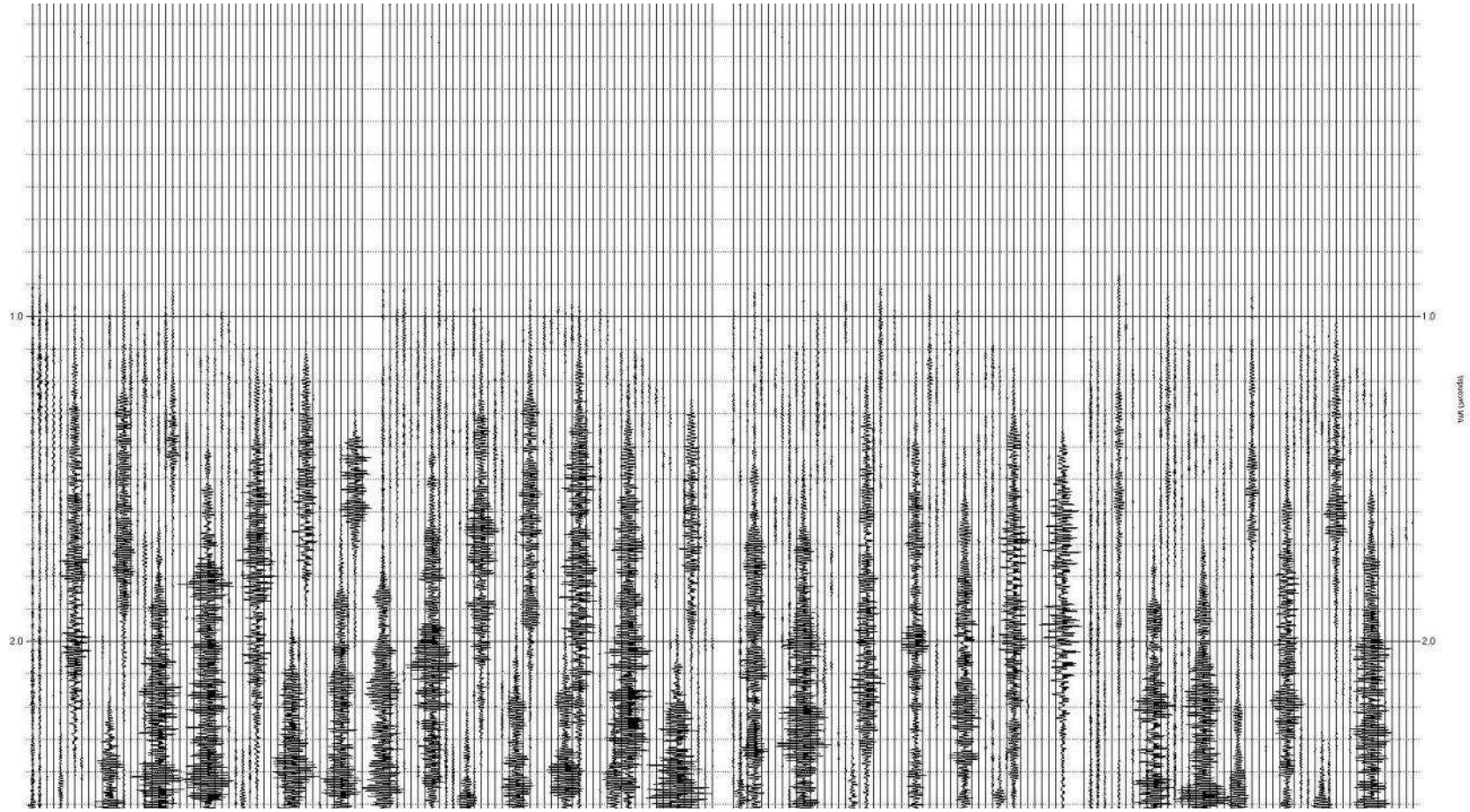
CDP’s after Tau-p mute



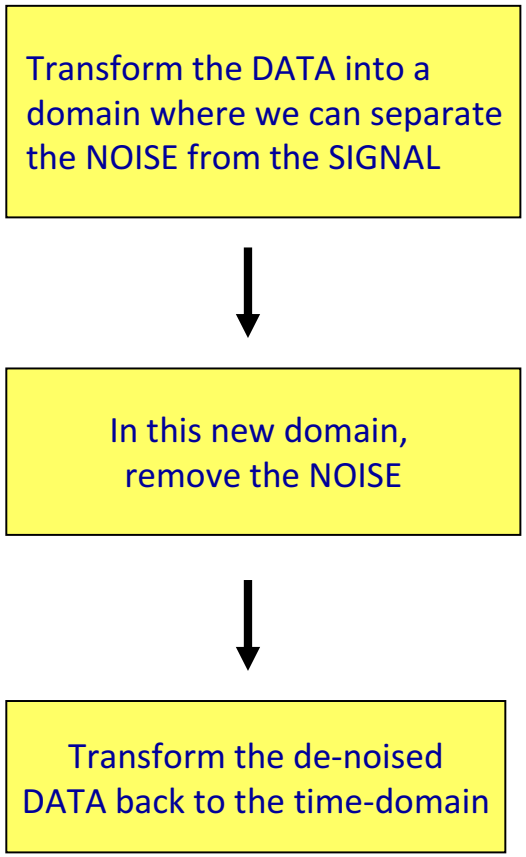
CDP’s after Fugro statistical de-noising



Difference



A new algorithm

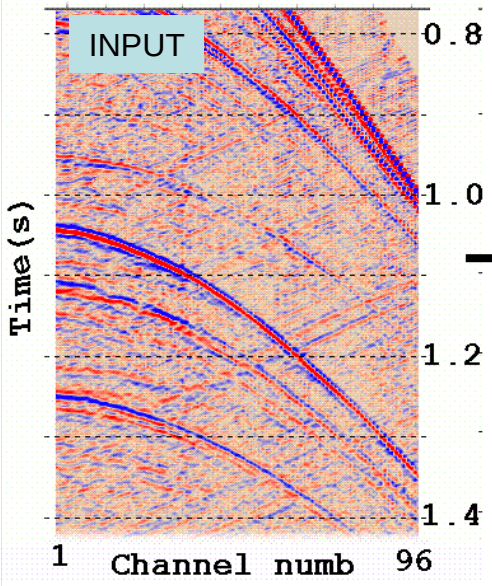


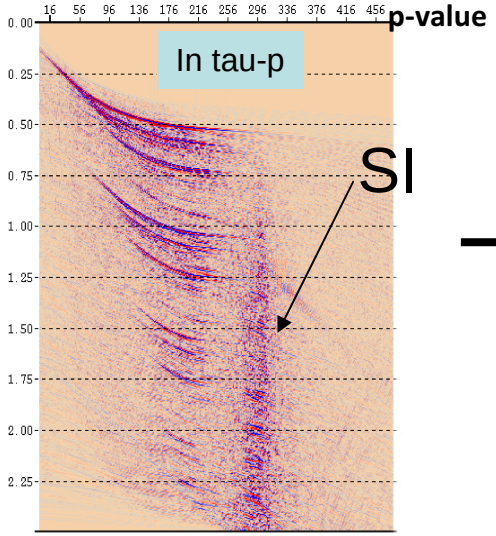
1. Tau-p transform
2. Statistical de-noising

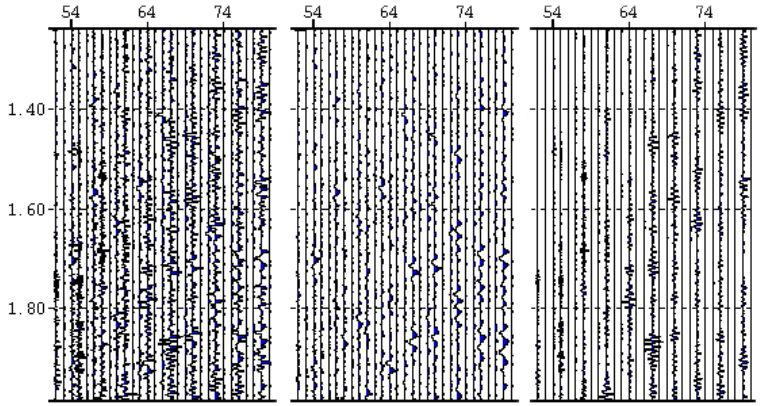
Combinations of the algorithms above + sorting to make the SI random. (Elboth et.al. EAGE 2009)

Getting the best of both worlds!

An advanced SI removal algorithm:



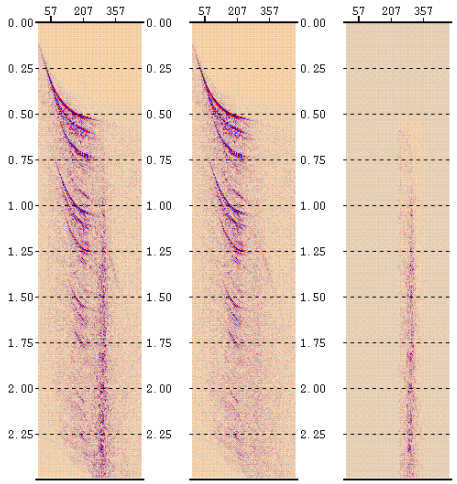




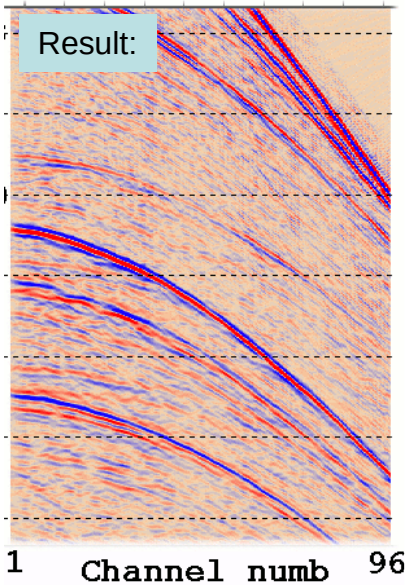
Before, after and difference from TFDN on common-p gathers.

Algorithm:

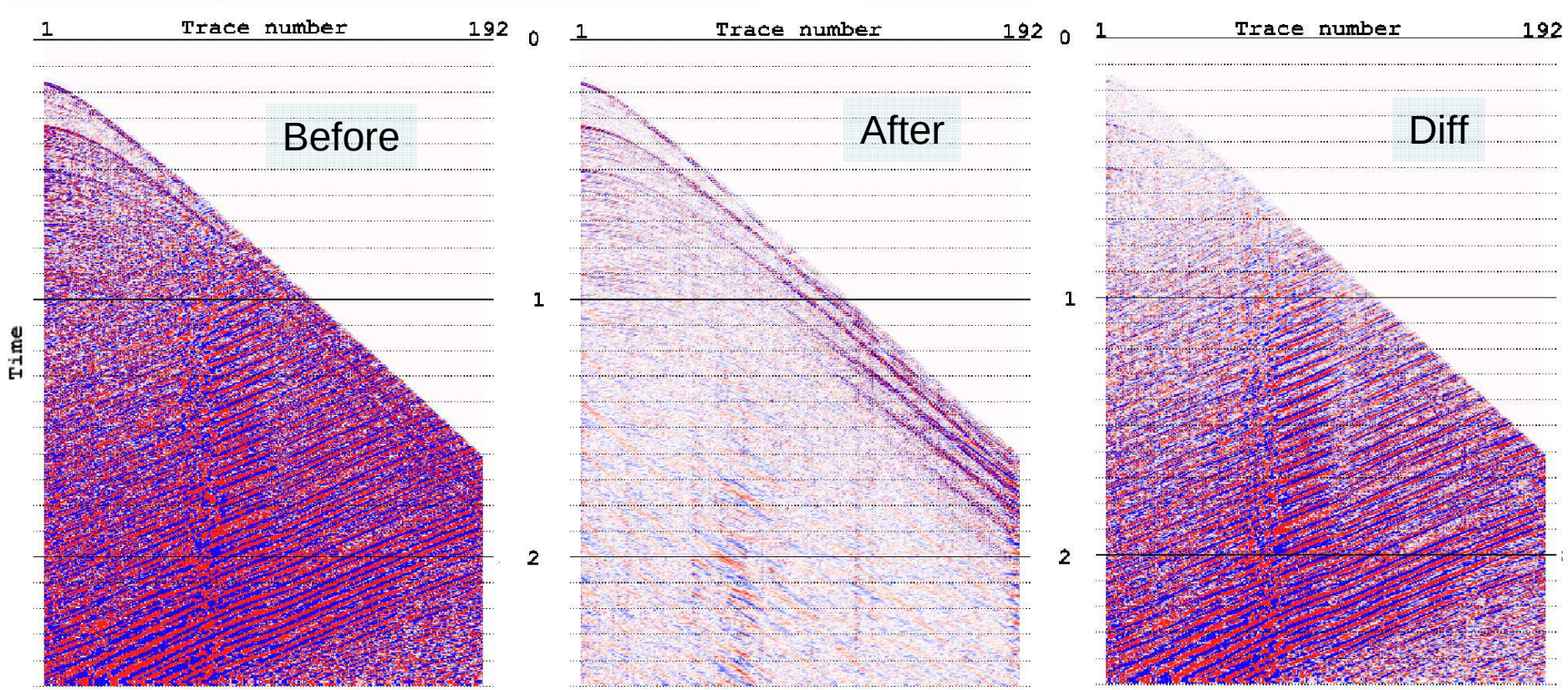
- Apply a tau-p transform on the gathers
- Sort the tau-p gathers into common-p, and identify where the SI is
- Apply TFDN on the common-p gathers
- Sort back to tau-p
- Transform data back to t-x



Before, after and difference from TFDN on tau-p gathers



TFDN + tau-p – SI removal



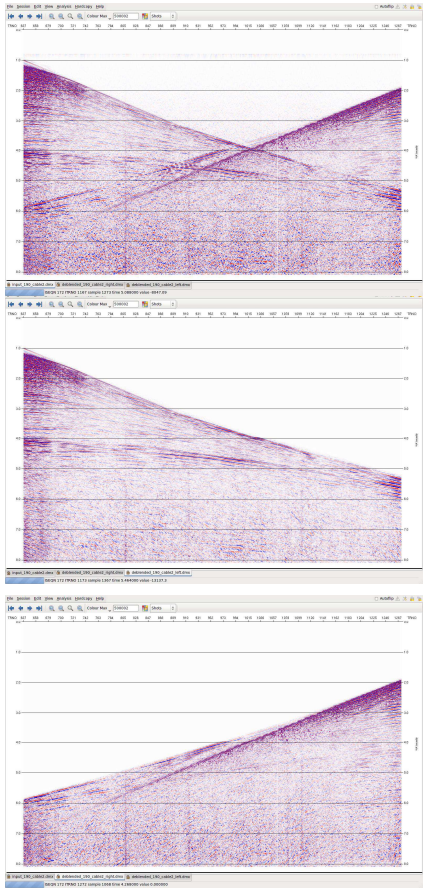
Site-survey data drowning in SI from a large 3-D vessel

SI in the near future

- In some ways, SI removal looks a bit like deblending.

- Problems:
  - We do not control when the SI arrives.
  - We do not control where it comes from.

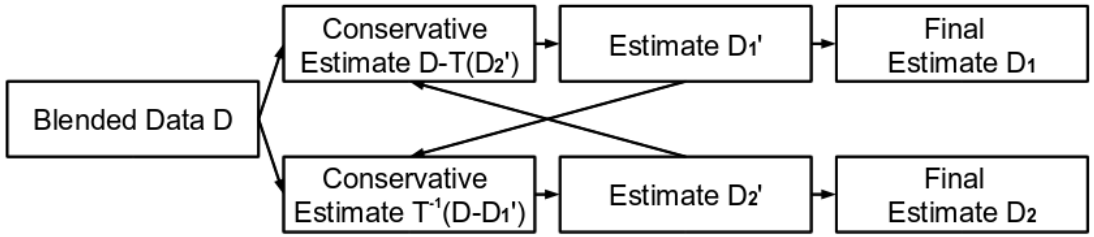
HOWEVER,



Example of deblending

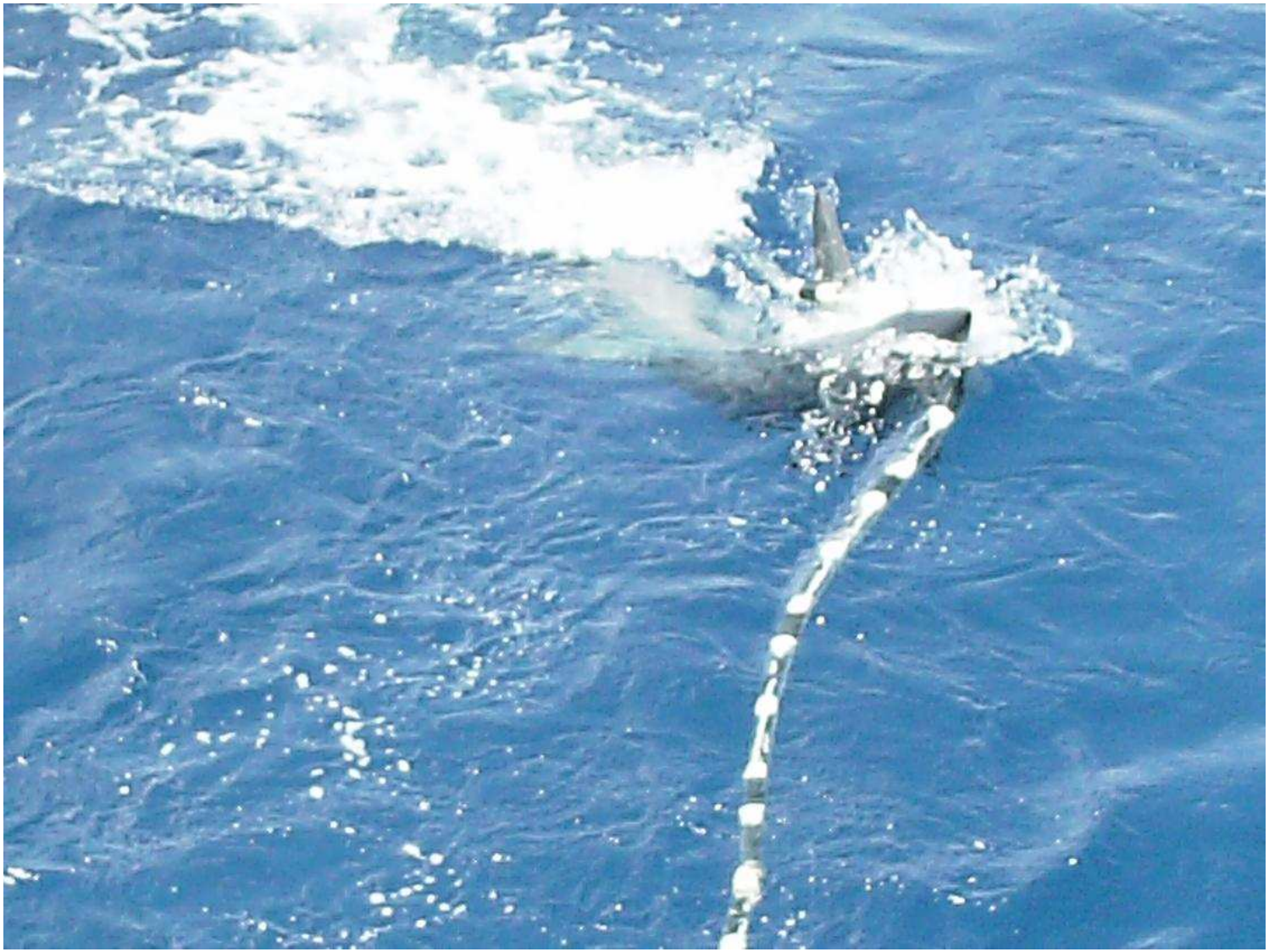
The idea for better SI-removal

- By iterating carefully, we can gradually separate SI and DATA



Algorithm after Maraschini et. al. (EAGE 2012)

This type of INTERFERENCE might be difficult to handle.



Summary

- Can we drop timesharing when we have SI?
  - In most cases YES, (but need advanced onboard QC to be sure!)
  - The short shot-point interval of site surveys compared to conventional seismic is advantageous when we want to attenuate SI
- Great need to plan/coordinate surveys to avoid unproductive standby
  - Site survey vessels can often do other types of activity when they are on seismic standby due to SI

Thank you