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Change Log

**MED\_AO6 AREA – OWF ZONE 3  
UHR SEISMIC SURVEY**

MED\_TEC\_50\_FACTUAL  
REPORT - SEISMIC SURVEY -  
OWF ZONE 3 AO6 AREA\_0


PROJECT No.  
113401341

**FACTUAL REPORT**

No. OF PAGES  
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## ABBREVIATIONS

<b>ADCP</b>	Acoustic Doppler Current Profiler
<b>ASV</b>	Assumed Sound Velocity
<b>Ch</b>	Channel
<b>cm</b>	Centimetre
<b>CMP</b>	Common Mid-Point
<b>C-O</b>	Computed Minus Observed
<b>CoG</b>	Centre of Gravity
<b>CRP</b>	Central Reference Point
<b>CSP</b>	Central Shot Point


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## ABBREVIATIONS

<b>DEMOB</b>	Demobilisation
<b>DGEC</b>	Direction générale de l'énergie et du climat
<b>DP</b>	Dynamic Positioning
<b>DPO</b>	Dynamic Positioning Officer
<b>DPR</b>	Daily production report
<b>EP</b>	Environmental Protection
<b>FLO</b>	Fisheries Liaison Officer
<b>GNSS</b>	Global Navigation Satellite System
<b>GPS</b>	Global Positioning System
<b>GRS</b>	Geodetic Reference System
<b>GSO</b>	Geophysical Services Offshore
<b>h</b>	Hour
<b>IMO</b>	International Maritime Organization
<b>J</b>	Joule
<b>JNCC</b>	Joint Nature Conservation Committee
<b>kHz</b>	Kilohertz
<b>LAT</b>	Low Astronomical Tide
<b>m</b>	Meters
<b>min</b>	Minutes
<b>MBES</b>	Multibeam echosounder
<b>mm</b>	Millimetre
<b>MOB</b>	Mobilisation
<b>MRU</b>	Motion Reference Unit
<b>POB</b>	Personnel On Board
<b>PAM</b>	Passive Acoustic Monitoring
<b>PPP</b>	Precise Point Positioning
<b>PPSU</b>	Pulse Power Supply Unit
<b>QA-QC</b>	Quality Assurance – Quality Control
<b>RTE</b>	Réseau de Transport d'Électricité


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## ABBREVIATIONS

RTK	Real Time Kinematics
s	Second
SHOM	Service Hydrographique et Océanographique de la Marine
SN	Serial Number
SRF	Ship's Reference Frame
SVP	Sound Velocity Profiler
SVS	Sound Velocity Sensor
TBC	To be confirmed
TTS	TTSurvey Ltd (Seismic equipment hire company)
UHR	Ultra-High Resolution
UTC	Coordinated Universal Time
UTM	Universal Transverse Mercator
VSAT	Very-Small-Aperture Terminal
WB	Water Bottom
WD	Water Depth
WGS84	World Geodetic System 1984
WT	Work time
ZH	Hydrographic Zero or Hydrographic Datum

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## EXECUTIVE SUMMARY

According to the detected bathymetric results in the acquired lines of the offshore windfarm survey area, the depth range correspond between -83.56 meters in the shallowest part at the north-western region, to -115.11 meters in the deepest part at the eastern region.

The seabed slopes are gentle, with average seabed gradients of 1.05°, maximum values of 29.26° and minimum values of 0°. The seabed gradient was computed at 22 planned borehole locations distributed over the range of water depths across the site.

Late Pleistocene sediments, comprising interbeds of soft silty clay and coarser reworked sands occur throughout the OWF area. Unconsolidated sediments extend to deeper than the depth of interest within the OWF survey area (60m+) in thickness, and the units all dip gently towards the southeast.


No shallow gas, or other geohazards are expected within the OWF area.

## 1. INTRODUCTION

### 1.1. PROJECT OVERVIEW

Tecnoambiente carried out four geophysical surveys within the proposed MED\_AO6 lot located along the southeast coast of the French Mediterranean shore in the Gulf of Lion. The areas of interest are located in the Gulf of Lion off the French Mediterranean coast. These areas are 4 offshore windfarm (Zone 1 OWF, Zone 2 OWF, Zone 3 OWF and Zone 4 OWF) and 3 offshore substations (Zone 1 OSS, Zone 2 OSS and Zone 3 OSS) which are under investigation in this project (Figure 1-1). Each site is under consideration for a windfarm and offshore substation.

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The area of relevance in this report is Zone 3, located off the coast of Perpignan. This survey area is divided in two sites (Figure 1-2):

- Offshore Substation (OSS) (4.23 km<sup>2</sup>)
  - *Dimensions: 1.06 km x 3.98 km*
  - *Bathymetric range: -94 m to -99 m (Vertical reference Bathylli v2 ZH)*
- Windfarm area (OWF) (363.12 km<sup>2</sup>)
  - *Dimensions: 27.18km x 20.60 km.*
  - *Bathymetric range: -84 m to -115 m (Vertical reference Bathylli v2 ZH)*

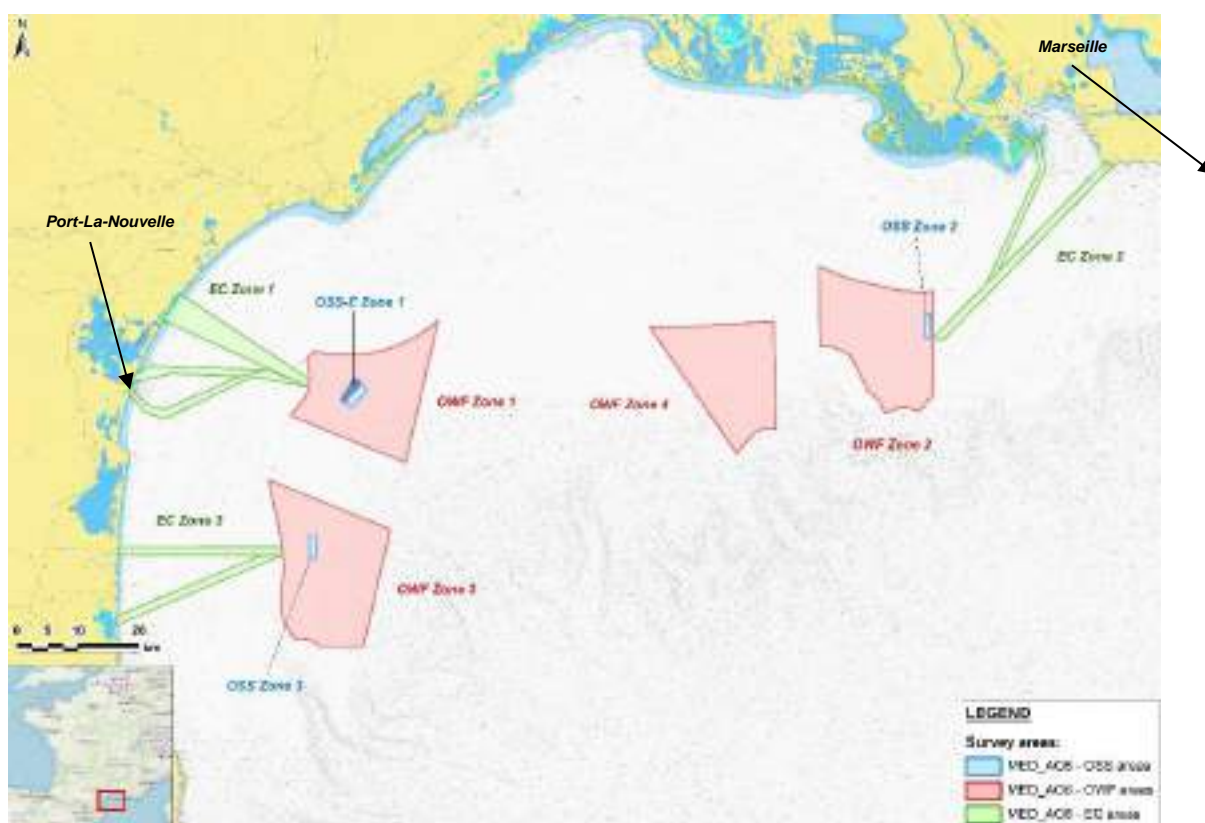

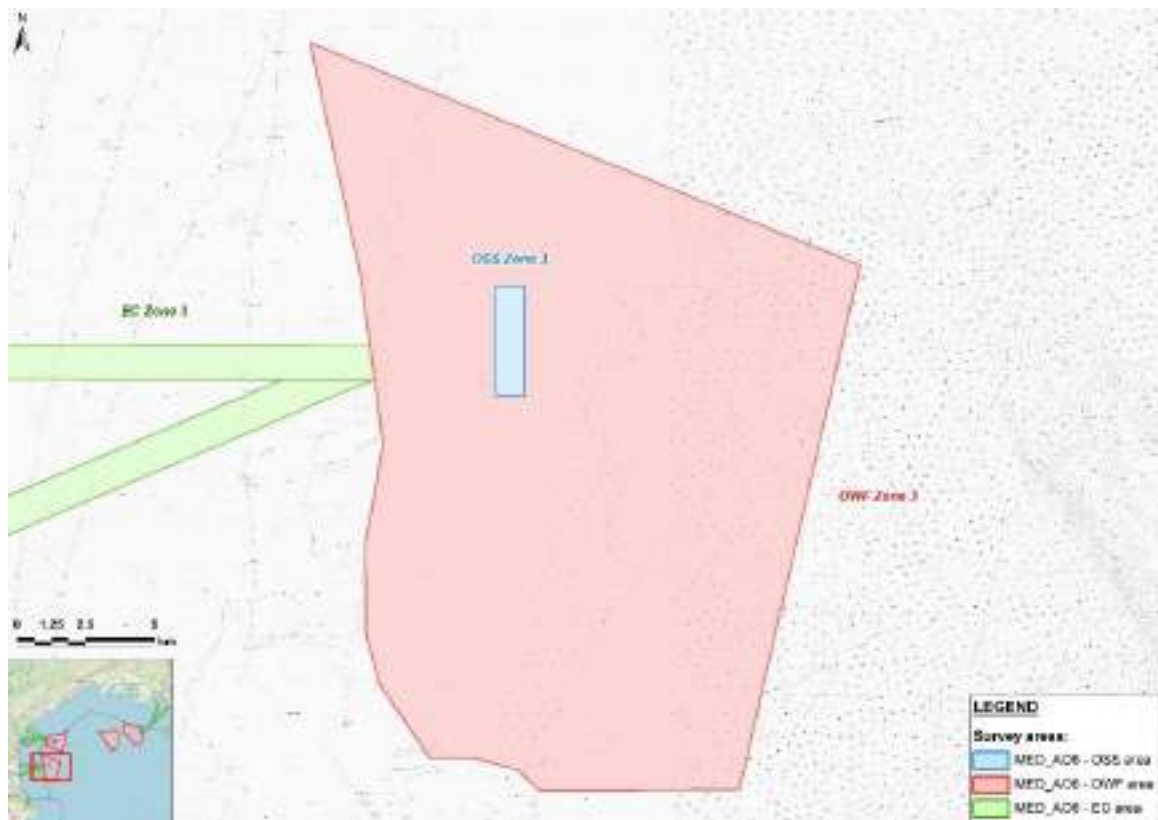


Figure 1-1: MED\_AO6 survey area.

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**Figure 1-2:** Windfarm area (OWF) and Offshore Substation (OSS) in the MED\_AO6 Zone 3 Survey area.

The following data were used in the study:


- 510.11 km of MBES and UHRS data

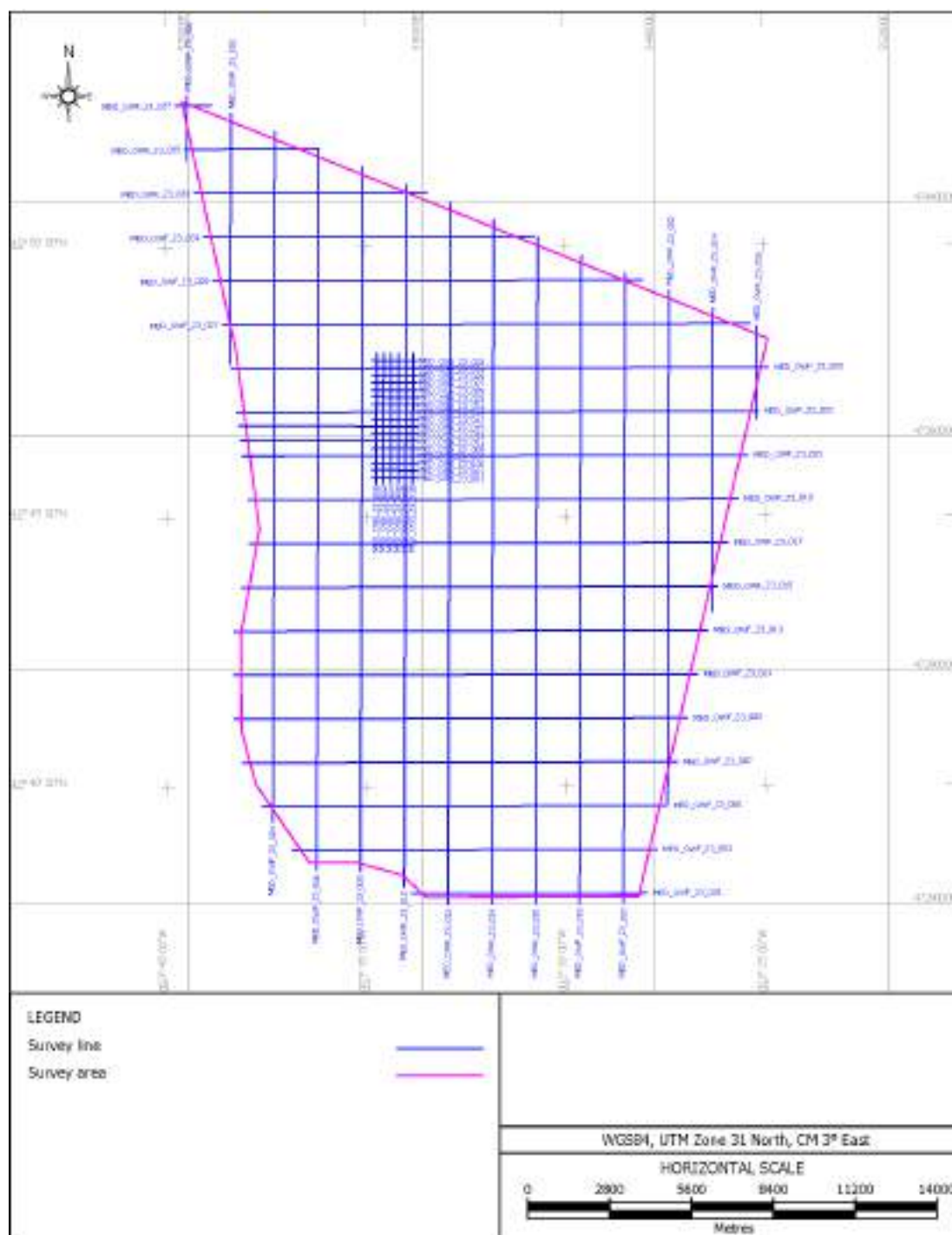
The goals of this first phase of the geophysical surveys are to perform

1. 2D UHR surveys in the wind farm areas in zones 1 to zone 4,
2. 2D UHR survey on offshore substations in zones 1 to zone 3.

Figure 1-3 shows the survey line plan.


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**Figure 1-3:** Line plan for MED\_AO6 Zone 3 Windfarm area (OWF).

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## 1.2. SCOPE OF WORK

The objective of the site survey was to perform a geophysical survey over the proposed OWF and OSS sites comprising MBES, SBP and UHRS datasets. The purpose of this was to:

- To define the water depths and seabed topography.
- To define the shallow (nominally 30 m BSB) subsurface geology.
- Review proposed borehole locations for geohazards.

The main purpose of the study is to provide an interpretation of the geophysical data to better understand the main characteristics of the seabed and geology at the project location and to undertake a derisking study over the MED\_AO6 Zone 3 OWF site.

## 1.3. GEODETIC PARAMETERS


### 1.3.1. Survey datum

These parameters are detailed below.

**Table 1:** Datum parameters table

DATUM	
Survey Datum:	WGS 84
Spheroid	GRS 1980
Semi-Major Axis (a)	6378137.000000000
Semi-Minor Axis (b)	6356752.314245179
Inverse Flattening (1/f)	1/298.257223563

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**Table 2:** Projection parameters table.

PROJECTION	
Projection	UTM
False Easting	500000
False Northing	0
Latitude of Origin	0°00'00.000000"
Central Meridian	3°00'00.000000"
UTM Zone	31 N
Scale Factor on CM	0.9996
Units:	Meters


### 1.3.2. Vertical datum

The vertical datum used in the QINSy software is Bathyelli v2.0 ZH geoid published by the SHOM in December 2013. The Bathyelli v2.0 ZH (SHOM 2013) is a surface based on the GRS 1980 spheroid, and it is a set of surfaces each of which defines the separation of one vertical datum from the WGS84 ellipsoid to the vertical maritime reference Hydrographic Datum or Hydrographic Zero. These ellipsoidal heights are given in meters.

This geoid covers the intersection between the SHOM tidal model and the different tidal zones of France.

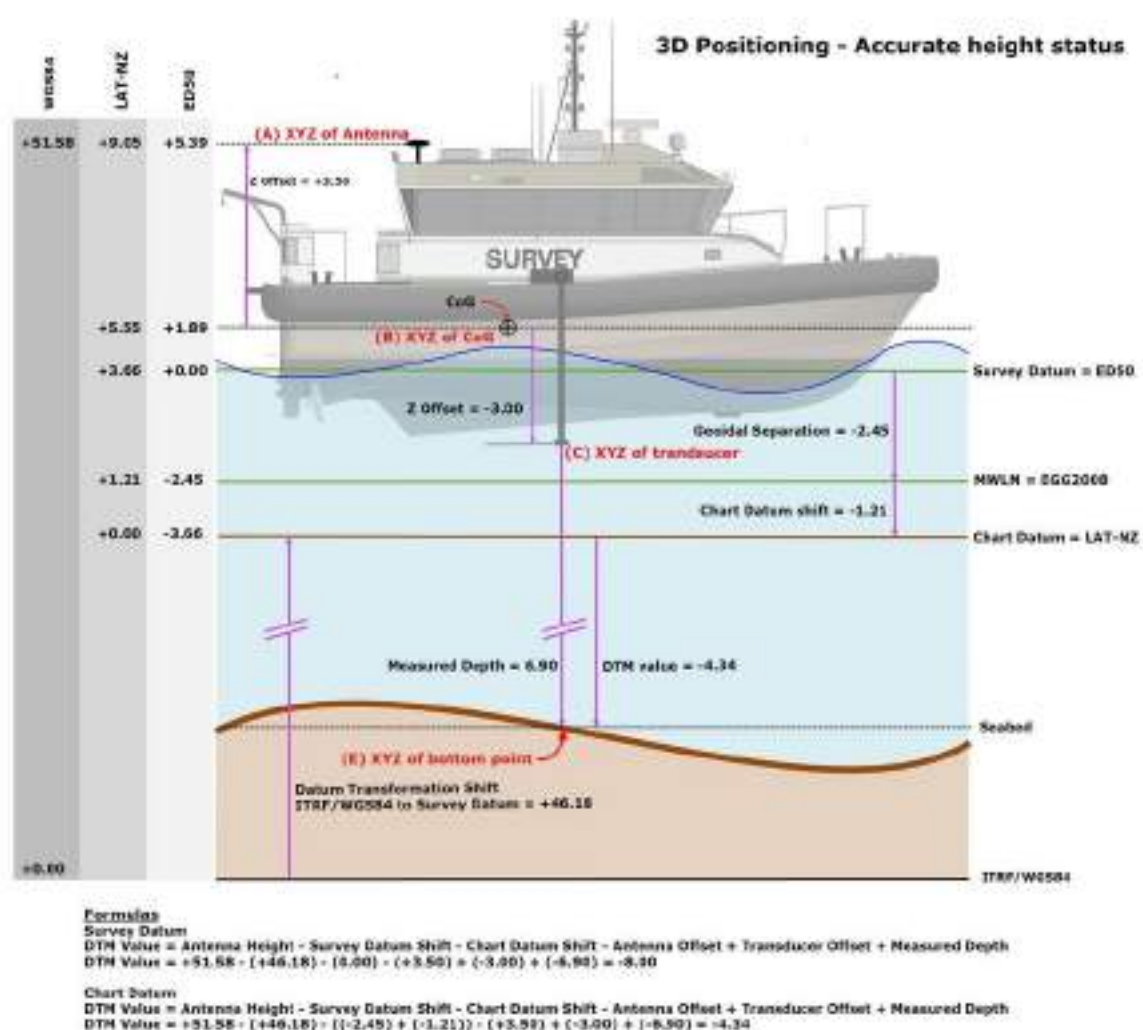
For the survey area MED\_AO6 Z3, the corrections to hydrographic zero are made by tidal observations of the port Port-La Nouvelle (43°01' N – 03° 04' E). The difference between the hydrographic zero and the LAT reference level for this port is 0.34 m, according to the study by SHOM "*Références Altimétriques Maritimes. Ports de France métropolitaine et d'outre-mer*" of 2019.

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### 1.3.3. Tidal reduction


In order to carry out the survey as accurately as possible, Tecnoambiente was receiving MarineStar PPP corrections by satellite signal. When using an accurate GNSS system the tidal corrections were carried out in real-time through QINSy computations, as it is shown in the next figure.



**Figure 1-4:** QINSy's method for accurate tide calculation.

In the event that corrections drop out they can be applied in post processing.

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## 2. METHODOLOGY

### 2.1. MBES BATHYMETRY

#### 2.1.1. Data acquisition

The objective during the data acquisition is the referencing of the acquired seismic data, therefore, the total coverage of the study area was not necessary. Due to this the project lines have been designed with a spacing of 1500 meters.


During the data acquisition, the vessel's master must follow the previously programmed routes of the project lines, governed by the indications of the computer screen (Helmsmann indicator), which is shown, by means of visual and audible alarms, when it separates from its course more than a specified amount (variable according to weather conditions in the area, but never more than 2.5 metres from the theoretical line), and also when there is a problem in a peripheral, such as the loss of GPS corrections.

While the master follows the navigation lines, the acquisition module of the hydrography program captures all the position data sent by the GPS, as well as the soundings sent by the multibeam sounder for each transmission pulse, as well as the values of the heading, wave height, roll and head angles sent by the MRU.

Parallel to the data entry, the data acquired by the equipment and peripherals is synchronized. This process is carried out by QINSy itself, complemented by the input of the time and the pulse per second (PPS) provided by the MRU, so that all the data is time synchronised.

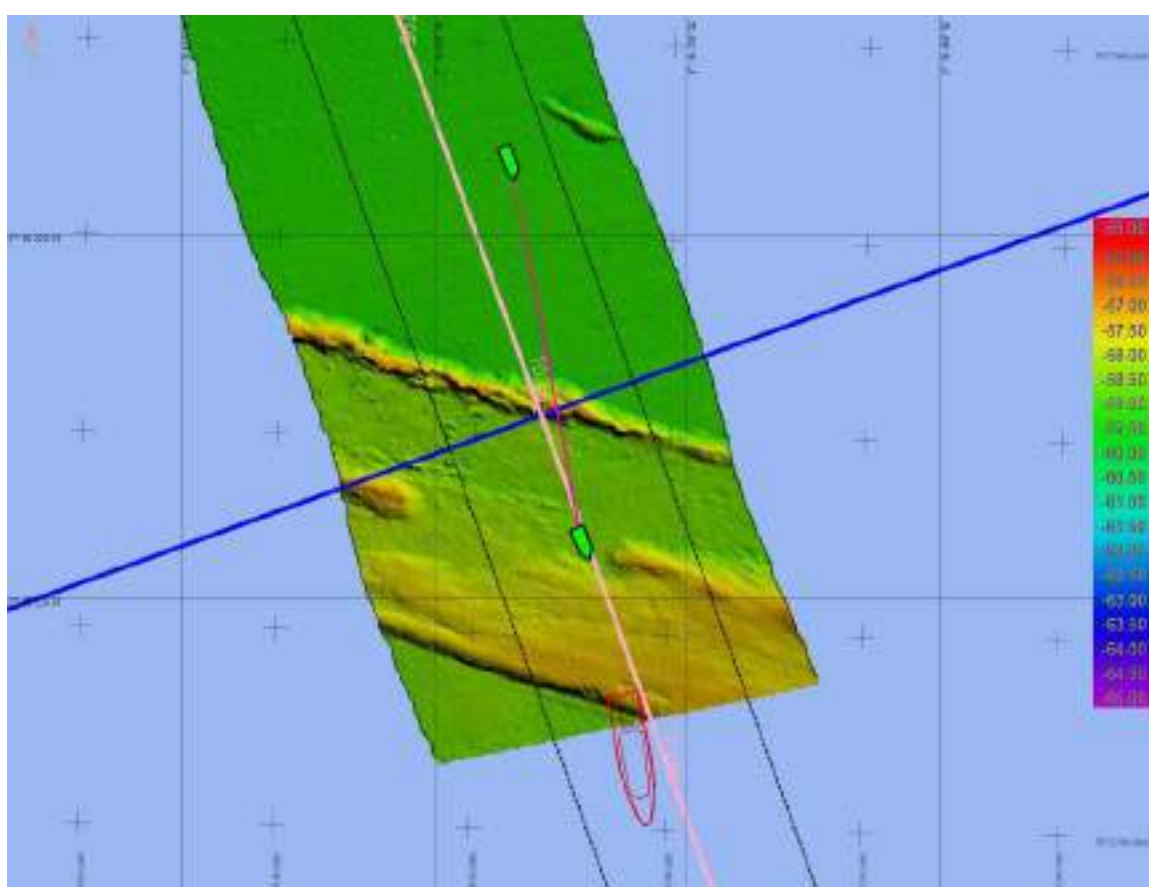
The guidelines followed by Tecnoambiente during the survey for MBES data acquisition were the following ones:

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- IT-CM-01. Guidelines for Hydrography Project management, 5
- IT-CM-04. Bathymetric survey, 1
- IT-CM-14 Survey Basics Guidance, 1
- IT-CM-15 Online Surveying procedure, 3

These guidelines can be found in the quality plan document MED\_TEC\_04\_Quality Plan.



**Figure 2-1:** MBES bathymetry data acquisition with the QINSy software.

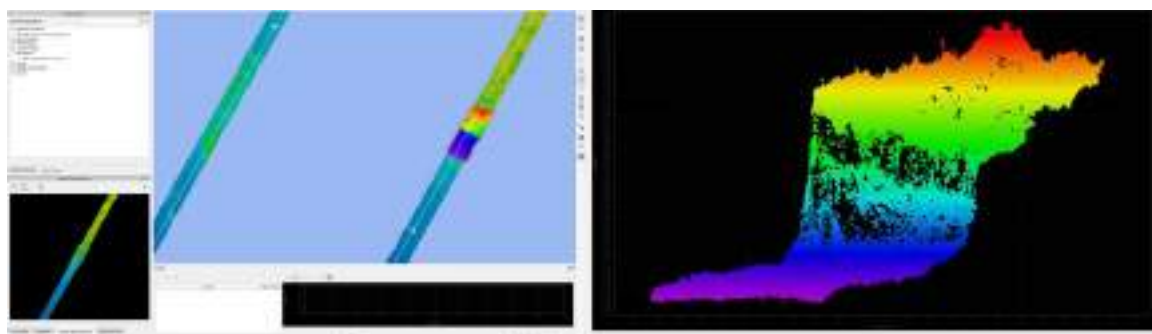
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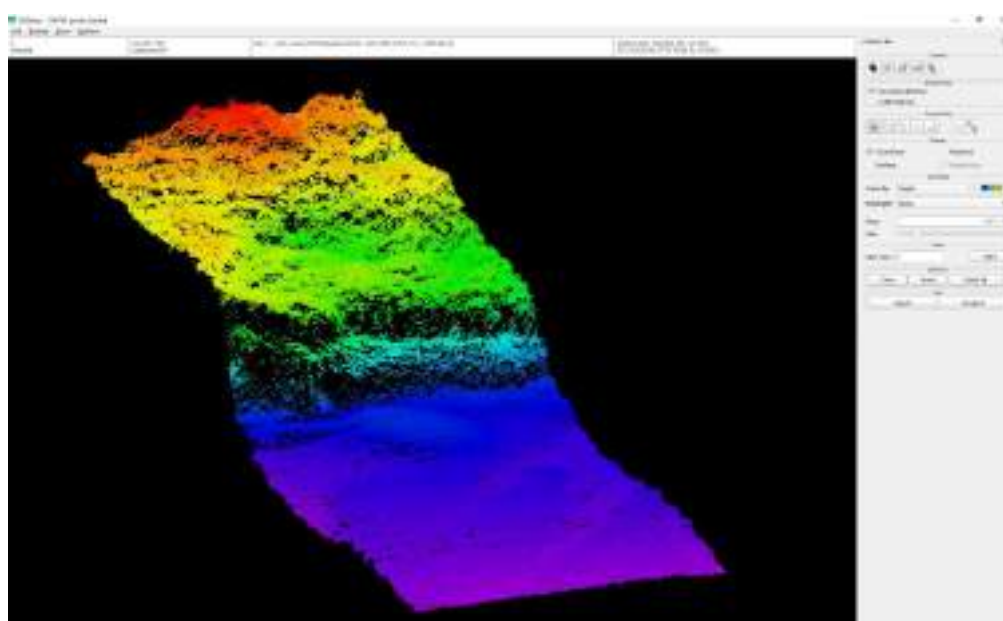
### 2.1.2. Data processing

A single head Kongsberg EM 2040 high resolution MBES system that is permanently installed on the Geo Focus vessel was used to produce digital terrain models (DTMs).

Along the processing phase of the acquired data, the lines on the screen are processed in order to manually match the height of the bathymetric lines and also correct the noise that appears in the records, noise produced by multiple factors such as, multipath in position, air bubbles, motor interference of the vessel etc. in the digital register of soundings.




**Figure 2-2:** Processing screen of MBES bathymetry data with the Qimera software.



**Figure 2-3:** 3D image of the MBES bathymetry processing.

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Once the possible existing errors in the records have been deleted, a digital model of the terrain with 1 x 1 m grid size has been made with a minimum cell size to obtain the maximum resolution of the seabed.

The general MBES processing workflow is presented in the following figure.




**Figure 2-4:** MBES bathymetry processing overview.

## 2.1. UHR SEISMIC

### 2.1.1. Data acquisition

UHR Seismic data was acquired using GSO 400-tip Sparker sled and Applied Acoustics CSP-N pulsed power supply unit were mobilised as the acquisition source, interfaced with a Geometrics GEOEEL LH16 recording system and 48 channel UHR streamer. The first 24 channels of the streamer at 1m group interval and the remaining 24 channels at 2m. The streamer was kept at a depth of 1m by a head and tail buoy as well as 2 Digicourse 5011 levellers (Birds).

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Accurate positioning was collected using Modulus 101G GPS pods mounted on each towed system, Sparker sled as well as head & tail buoys for streamer positioning.

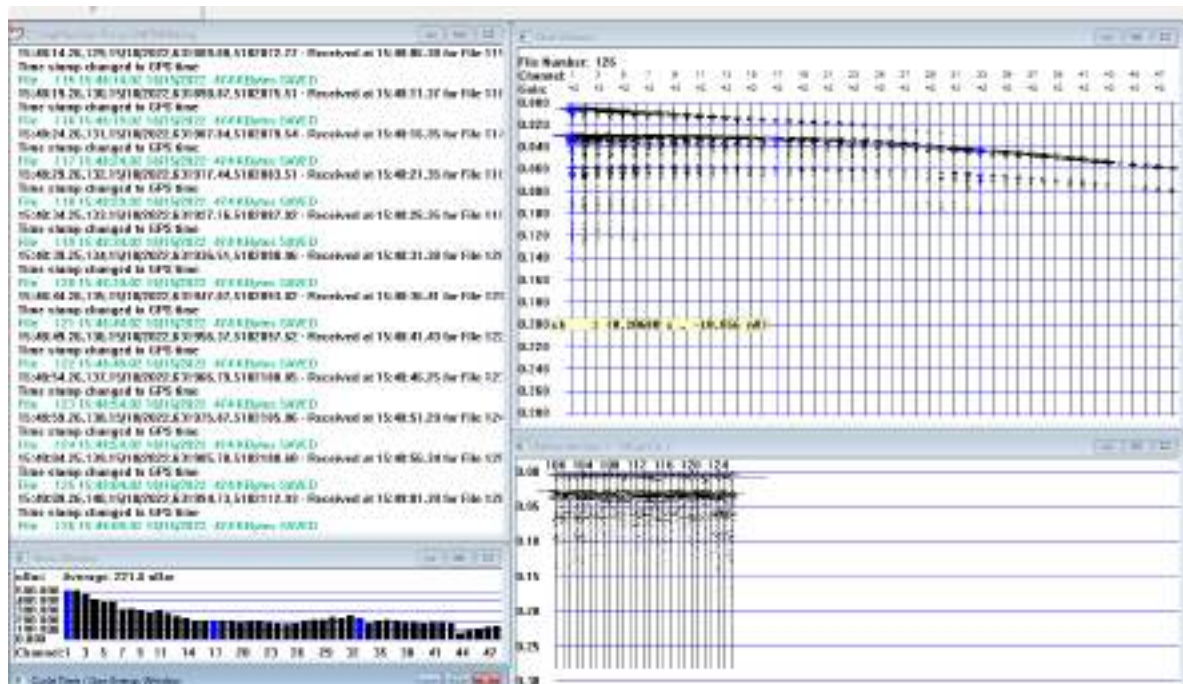
The shot point interval for the survey was 1 m, giving a nominal fold of 36 when binning with a CDP spacing of 1m to keep the bins consistent with the variable channel spacing. True fold will vary around this value when real source and receiver positions are used rather than nominal geometry, according to variations in ship speed and feather angle changes between shots.

**Table 3:** UHRS operational parameters.

Parameter	Value
Active Streamer Length	75m
Number of channels	48
Group Length	Channels 1-24: 1 m
	Channels 25-48: 2 m
Target Tow Depth	1m +/-0.5m
Near Offset	~5-6m
Sample Rate	0.0625ms
Record Length	0.250ms
Shot Point Interval	1m
Source	Sparker – GSO – 400 tips
Target Source Tow Depth	0.3 m

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**Figure 2-5:** Screenshot from Geometrics LH16 software during UHR Seismic acquisition.

The guidelines followed by Tecnoambiente during the surveying for UHR Seismic data acquisition were the ones provided from TTS, which are:

- IT-CM-17 Sparker Deployment Recovery, 1
- IT-TTS- 01\_Geoel Instrument Verification Procedure
- IT-TTS-02\_Multichannel Seismic Streamer Procedure
- IT-TTS-03\_Sparker Pulse Test Procedures
- IT-TTS-04\_Streamers Recovery

These guidelines can be found in the quality plan document MED\_TEC\_04\_Quality Plan.

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### 2.1.2. Data processing


Data processing and interpretation was performed within the MED\_AO6 area to a recorded length of 100 m sub-seabed for both OWFs and OSSs. This interpretation was done for evaluation of seabed and sub-seabed conditions.

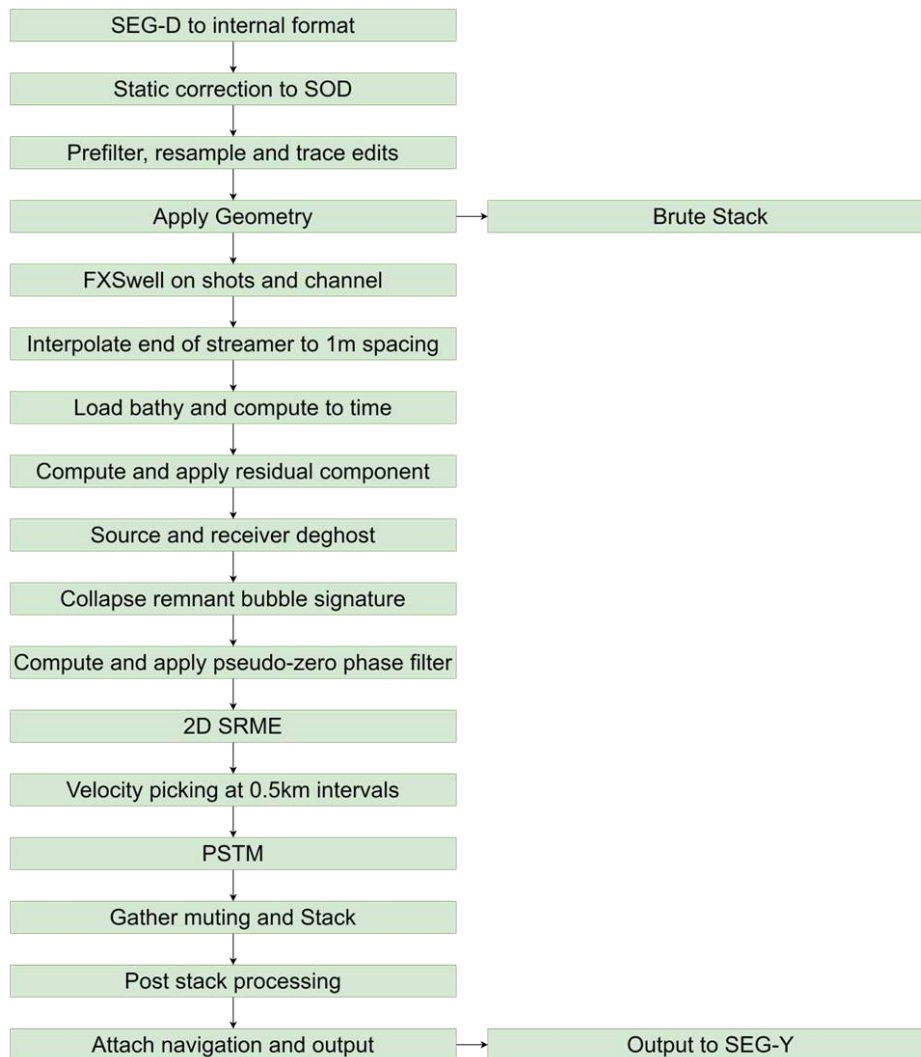
The dataset was quality controlled offshore on board the vessel Geo Focus by Peak Processing using a Linux based system with Landmark's ProMAX/SeisSpace processing software.

The dataset was then made available to Peak Processing upon completion of the fieldwork with the processing of the raw UHR seismic data performed and finalised using Shearwater Reveal version 5.1 on a small cluster.

Stacking velocities generated during the processing of the UHR data were used to help choose velocities in the time-depth calculation. Standardised velocities were chosen based on the sediment characteristics expected. For the interbedded sands and clays, as interpreted in AO6, an assumed seismic velocity of 1700m/s has been used.

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**Figure 2-6:** UHR Seismic processing overview.

For quality assurance, displays of the following were produced for each line with a copy provided to the client representative offshore, in addition to the Brute Stack SGY exported:

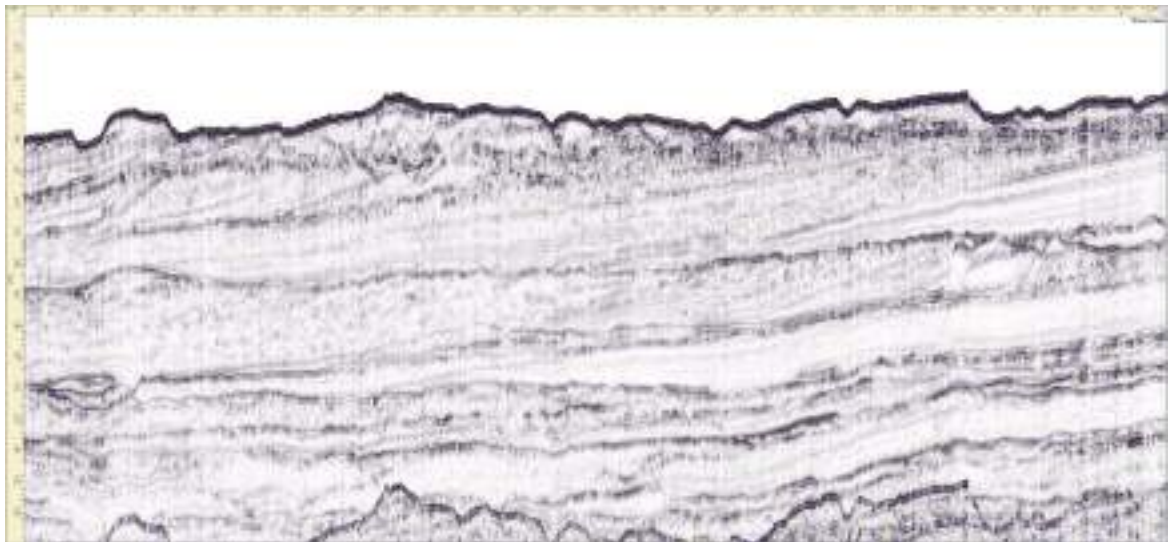
- Near trace
- Shot record examples (displayed every 100 shots)
- RMS Noise Display (calculated every 100 shots)
- Spectral Analysis

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- Offset QC checks, showing computed arrival time from offsets derived from GPS navigation data overlaid on top of the direct arrival in the data itself
- Velocity Semblance/Gather Example
- Brute Stack, annotated with trace fold header plot

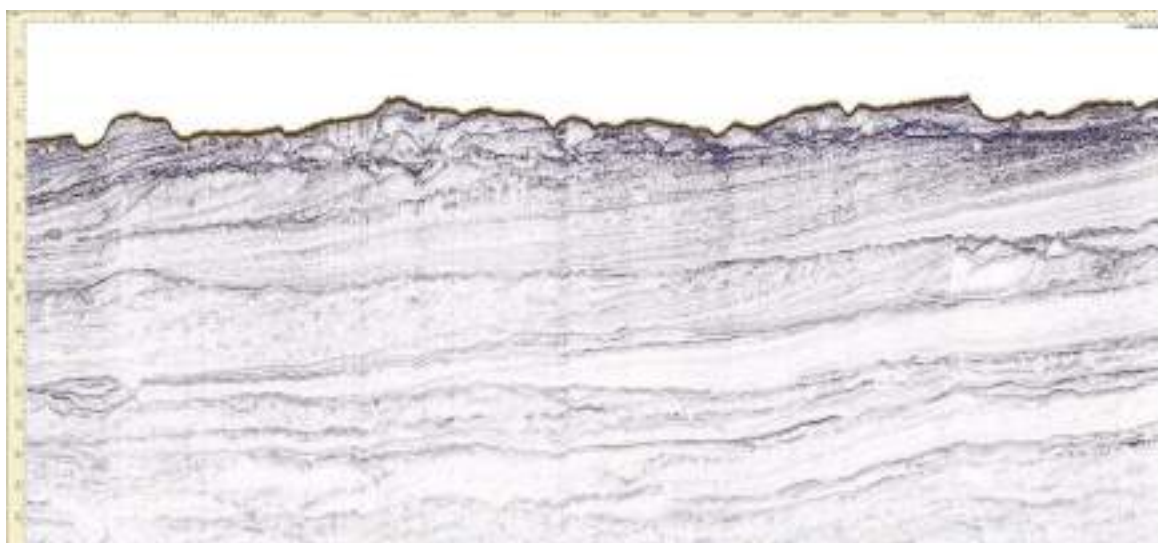
Processing of the dataset took place ashore, and full details of the processing can be found in a dedicated seismic processing report. As a summary, the evolution of the dataset can be seen in the following examples shown at three different stages of the processing:



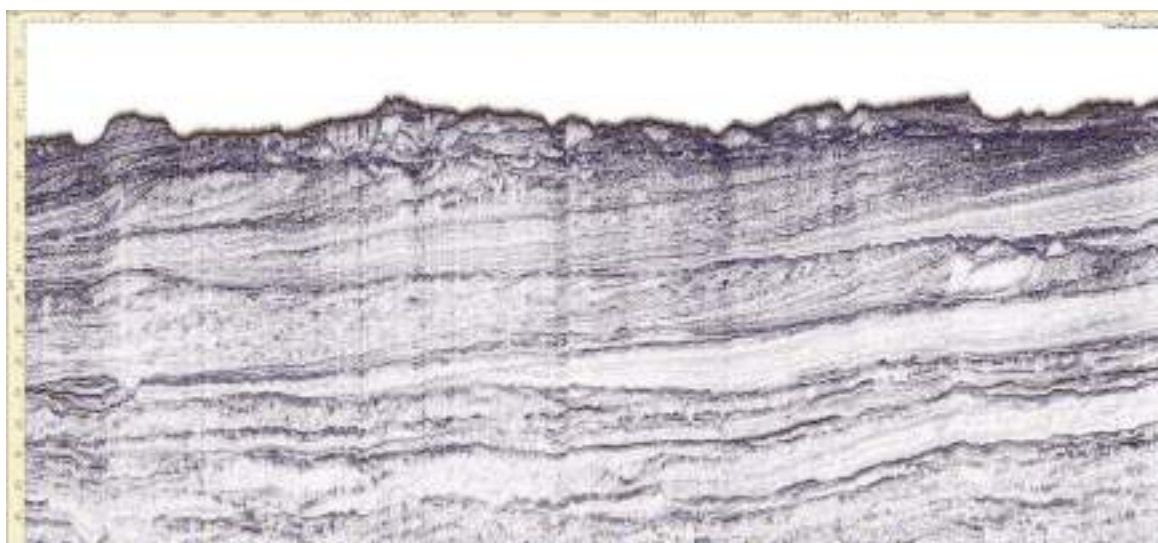
**Figure 2-7:** Minimum phase brute stack.

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**Figure 2-8:** Zero-phase corrected control stack (Demultiple, Noise filtering, Deghost, Static Correction, Far Trace Mute & Pre-Stack Migration).



**Figure 2-9:** Zero-phase corrected final processed stack (Time-Variant Bandpass filter, FK filter, Gain balancing).

Interpretation was cross-checked for consistency at all crossline locations. Additionally, geo-hazards assessment was carried out focusing on the areas for planned shallow geotechnical operations. Heave corrections are applied after datum alignment with the MBES data.

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### 3. RESULTS

#### 3.1. BATHYMETRY

The detailed resolution of the bathymetry grid (Digital Elevation Model for seabed data following QUA-01-B GIS specifications) allows for enhanced visualization of depth and interesting seafloor features. The main use of the multibeam data is to reference the seismic profiles to the real seafloor (ZH Bathyelli v2 geoid).

In the acquired lines of the MED\_AO6 Zone 3 offshore windfarm survey area, the depth range correspond between -83.56 meters in the shallowest part at the north-western region, to -115.11 meters in the deepest part at the eastern region.


A colour table for the representation of the three-dimensional terrain model was created, from red -83.56 meters depth and magenta for the maximum depth -115.11 meters.

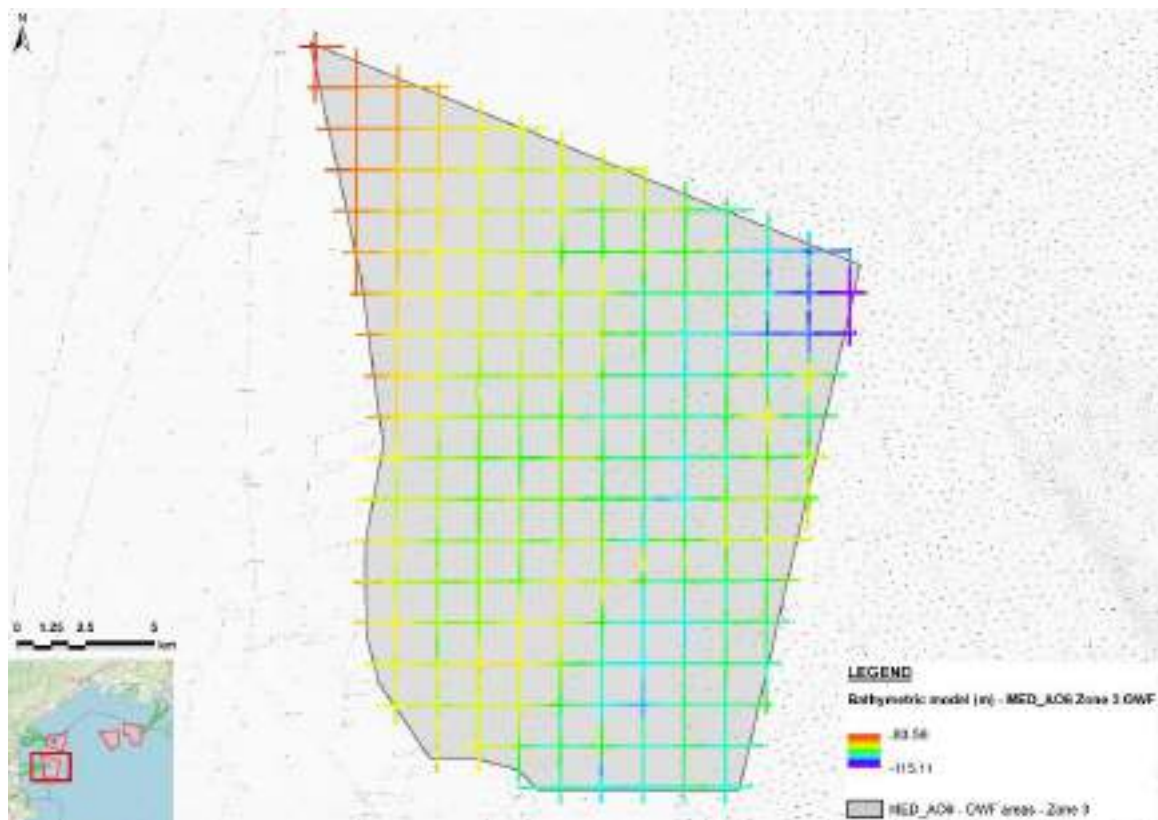


**Figure 3-1:** Colour table for the representation of the MBES terrain model.

Bathymetric data from the vessel multibeam sensor has been processed into a 1 meters grid size bathymetry for all the acquired lines.

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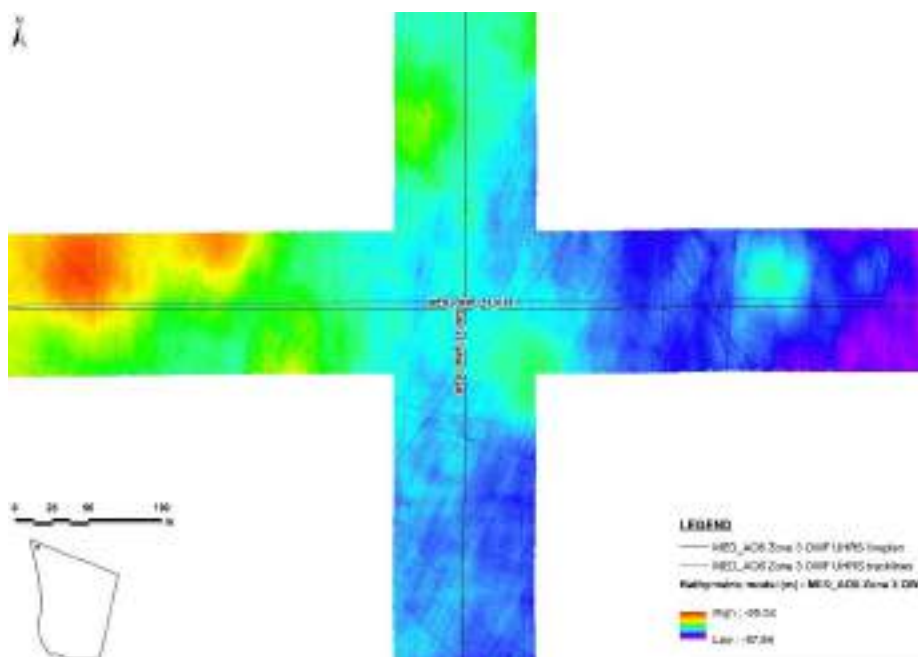


**Figure 3-2:** Whole bathymetric data grid model (1 x 1 m) for the MED\_AO6 Zone 3 OWF.

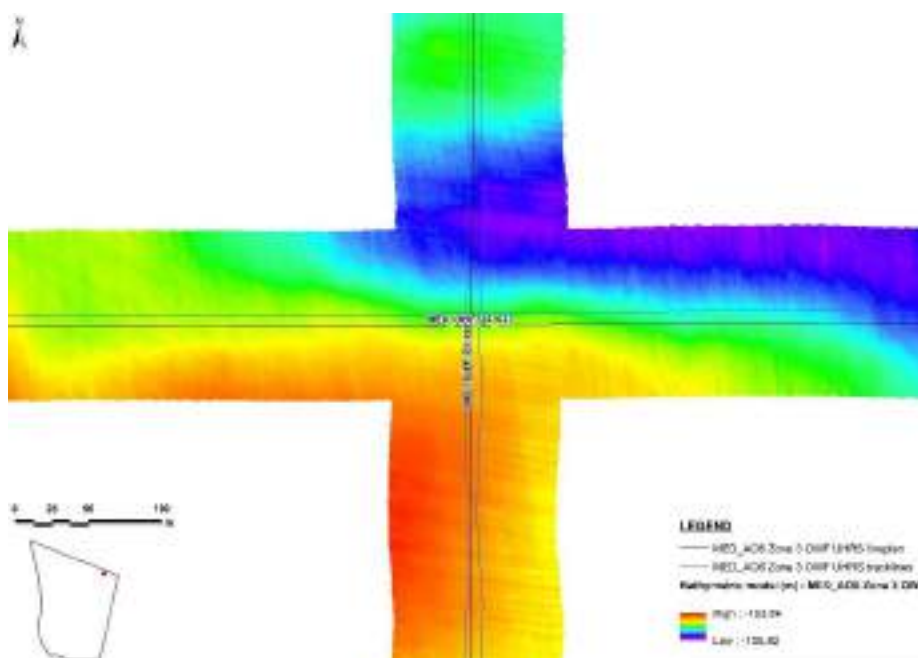
Several examples of the results of the MBES processed data are shown below:

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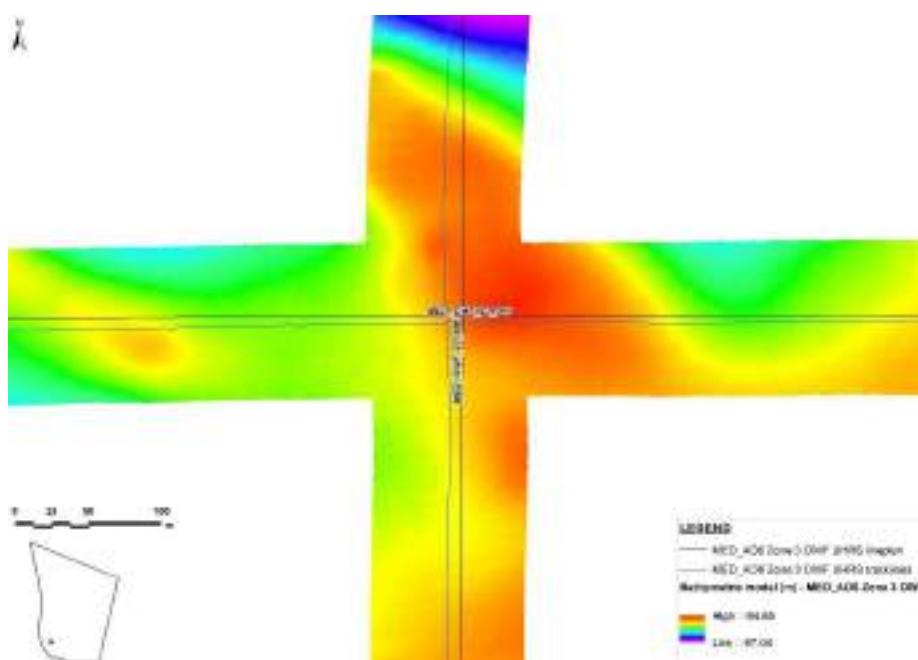
**Figure 3-3:** Detail of the bathymetric data grid model (1 x 1 m) for the offshore windfarm of the MED\_AO6 Z3 area – Survey lines and tracklines MED\_OWF\_Z3\_002-035.



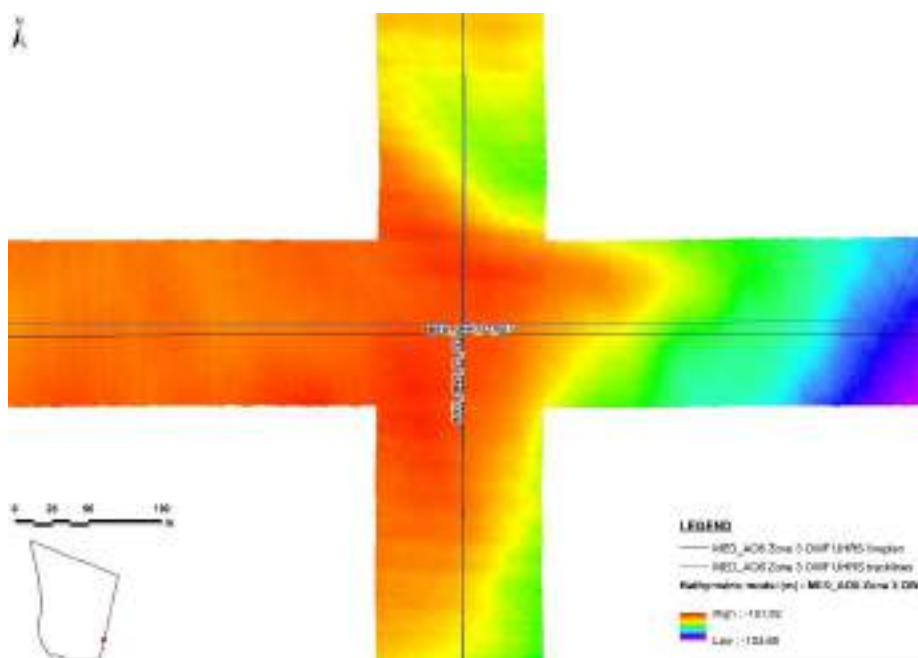
**Figure 3-4:** Detail of the bathymetric data grid model (1 x 1 m) for the offshore windfarm of the MED\_AO6 Z3 area – Survey lines and tracklines MED\_OWF\_Z3\_022-027.

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**Figure 3-5:** Detail of the bathymetric data grid model (1 x 1 m) for the offshore windfarm of the MED\_AO6 Z3 area – Survey lines and tracklines MED\_OWF\_Z3\_006-007.



**Figure 3-6:** Detail of the bathymetric data grid model (1 x 1 m) for the offshore windfarm of the MED\_AO6 Z3 area – Survey lines and tracklines MED\_OWF\_Z3\_022-007.

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## 3.2. GEOLOGY

### 3.2.1. Geological setting from background data


The Gulf of Lions is located in the northwestern sector of the Mediterranean Sea bounded by the Pyrenees and the alps. It comprises a wide shelf and continental slope, before descending to the abyssal area of the Algero-Balearic Basin. The basin formed as a result of tectonic rifting during the Oligocene – Miocene period (Gorni, et al. 1994), leading to the accumulation of a large amount of clastic sediments forming a thick wedge on the inner shelf, and more than 2km on the outer shelf (Lofi, 2002). The continental shelf edge leads to the prograding margin observed in the Gulf of Lions during the end of the last glacial cycle. The geology within the Gulf of Lion is described as a relatively low energy passive prograding margin, dominated by a rapid period of sedimentation during the Late Pleistocene, with layers of reworked sediments at a time when sea-levels were about 100m lower. At the end of the Last Glacial Maximum, sea levels were cyclically higher and lower as ice masses in the two hemispheres contracted and advanced. The deglacial succession overlies the major erosional discontinuity related sea level rises since the Last Glacial Maximum. It consists of basal transgressive deposits, subsequently reworked into dunes and sand ridges, interbedded with regressive prograding, marine derived sediments. The shelf 'relict' sands, pass rapidly into marine muds. The transition between sand and muds is outlined by a distinct regional step in sea-floor morphology. Large buried channels are also present within the Gulf of Lions, from warmer times when meltwater run off from the higher altitudes was on way to the sea, further offshore due to the lower sea levels.

There were no prior surveys used as reference when determining the geological succession in the area.

### 3.2.2. Geological sequence

Within the depth of interest (up to 30m), the MED\_AO6 OWF zone 3 area the comprises a sedimentary succession of Late Pleistocene sediments, predominantly marine derived during periods of deposition and terrestrially derived reworked sediments. Several episodes

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of sea-level rise and fall can be determined from the geology in this area. Seven coherent stratigraphic packages, over the first 30 m subsea are distinguished, with stratigraphy shown in Figure 3-7.

The shallow geology (30 m below seabed) within the MED\_AO6 Zone 3 OWF site has been divided into units based on the environmental conditions the data exhibits. These units are interpreted as either marine derived silty clay or reworked terrestrially derived silty sands. Unit 1 is acoustically quiet and parallel bedded. Evidence of unconformable surfaces and channelling events are observed in the older units. Within zone 3 these units are not as well defined as in other areas of the AO6 survey area, suggesting this area was more estuarine in nature during the transition in sea levels due to its location and change in sea levels in the area.

Six coherent stratigraphic packages, over the first 30 m subsea are distinguished, with the base of the units marked by sequence boundaries where there are clear unconformable, erosional events and a strong change in the dip angle of the sediments. The angle of dip may have been defined by the onlapping of sediments at the shelf edge, the change in a river pathway or other similar process. These events mark clear sequence boundaries where there has been a change in conditions and hence separated into varying sedimentary units.

Five horizons have been mapped within the AO6 OWF Zone 3 area which have been interpreted to highlight variations in the sediments and sequence variations, as discussed above. These are mapped based on seismic acoustic character based on the environment in which they have been interpreted to have been deposited and reworked as well as strong unconformable basal reflectors marked by a change in dip. These are, the base of the uppermost marine drape (Base of Unit 1 – H05); the base of a higher amplitude unit (Unit 2 – H10); the base of a more chaotic unit, with many channels within (Unit 3 – H20), a quieter well layered unit (Unit 4 – H30) and a further chaotic layer underneath (Unit 5 – H35). The base of Units 6, 7 and 8 are not within the depth of interest for the OWF survey and as such are only mapped within the OSS survey area. For further information on the depth to the base of these units within the OSS area, refer to the zone 3 OSS report. Due to the slope of

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the continental shelf, and the dipping nature of the beds these units are not all present over the whole site. Interpretation has generally been restricted to 30m below seabed, assuming a velocity of 1600m/s.

Within the OWF, Unit 1, interpreted as a blanket drape of acoustically quiet sediments, interpreted as a silty clay of Holocene age, and deposited since sea levels were at current levels ranges in thickness from about 0.2m in the centre of the survey area to 33m in the southeast. The base of Unit 1 (H05) has been mapped within the area and converted to depth using an asv of 1600m/s. The depth to the base of Unit 1 is illustrated as a thickness map in Figure 3-8, and a data example showing the interpretation on the UHR data is included as Figure 3-7

Below unit 1, a thin sand layer is interpreted across much of the site, the base of which has been mapped where possible from the Innomar sbp data. Due to the thickness of this unit in the eastern half of the survey area, the unit has also in some places been mapped off the UHR data, which is of equally good quality and helps to confirm that the base of the unit is being mapped on Innomar data as opposed to base of penetration. Unit 2 is illustrated in Figure 3-9.

Unit 3 occurs below Unit 1/Unit 2 with a more chaotic seismic character in the upper section. The lower section of the unit is more parallel bedded and quieter in nature but is defined as one unit due to the continuation of the dip. This unit is interpreted as being estuarine in origin and deposited and reworked during the variations in sea levels at the end of the Last Glacial Maximum. Shallow channels are also present within the unit, particularly the upper, more chaotic section. Due to the dip of this unit, the depth to the base of the unit (H20) is highly variable across the zone 3 OWF area, being absent in the northwest, present just north of the OSS area at 3m below seabed, and dips to 60m below seabed in the southeast of the survey area. Unit 3 is illustrated on Figure 3-7 and the depth to the base of Unit 3 is displayed in Figure 3-10.

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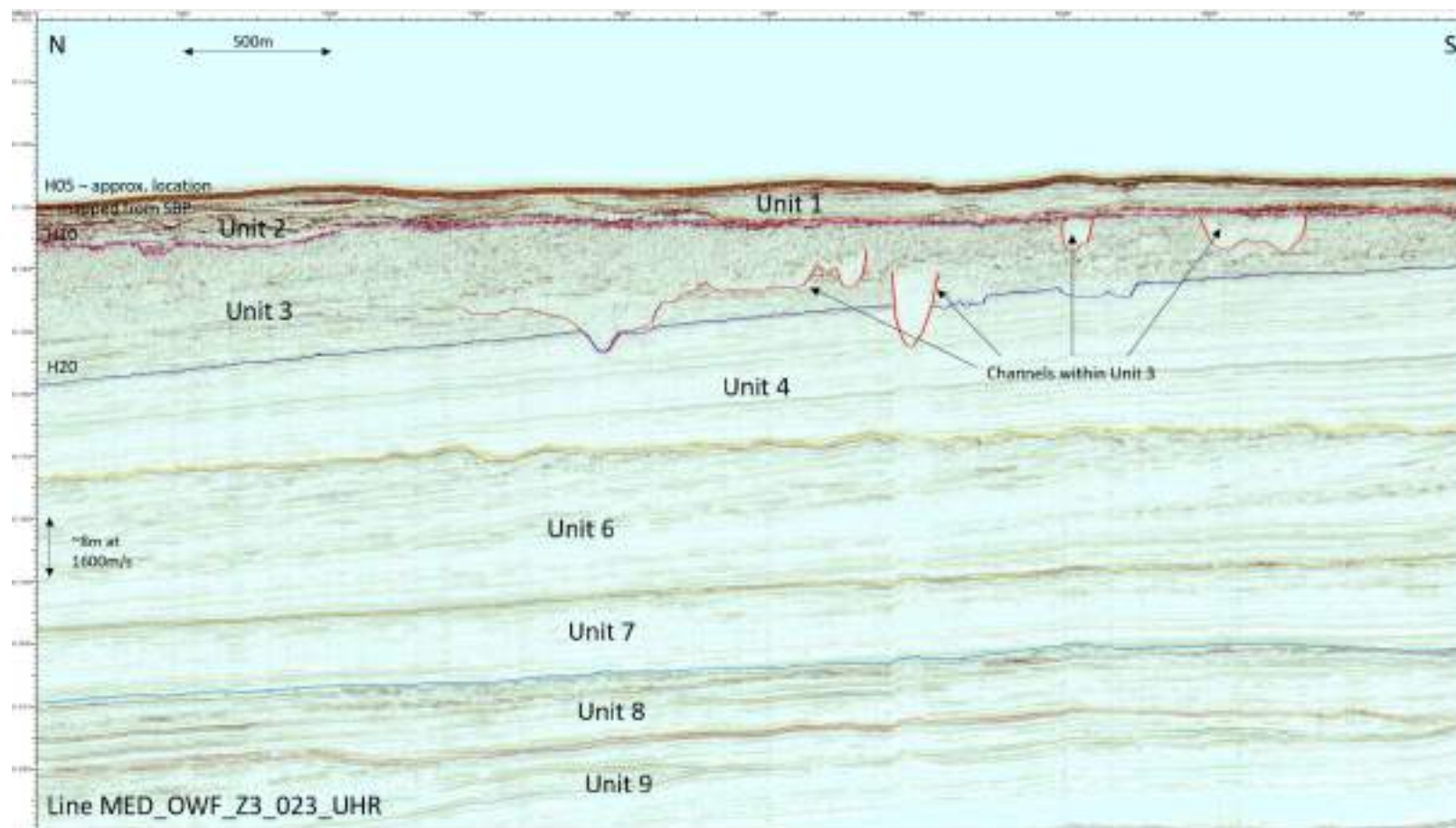
Unit 4 is a well layered, acoustically quieter unit interpreted as marine silty clay. Small acoustically brighter areas are observed on the seismic data within this section interpreted as tuning related to small channel features not distinguishable on the UHR data. The depth to the base of Unit 4 (H30) varies between 14 m below seabed in the northwest corner, to 54m below seabed in the southwest, before becoming absent in the southeast. The depth to the base of Unit 4 is illustrated in Figure 3-11.

Unit 5 is a thin unit of seismically chaotic reflectors interpreted as reworked above sea level at a time when sea levels were lower. The unit is only present in the northwest of the OWF survey area. The area affected by these processes is interpreted as having been above the sea level low stand, whilst the rest of the OWF zone was submerged, indicated by the continuation of the acoustically quiet sediments. An isopach to the base of the unit illustrated on Figure 3-12.

Unit 6 is an acoustically quiet unit with a change of dip slope compared to Units 4 and 5 above. Large slump-like features are observed within the UHR data within this unit, interpreted as contourites or turbidites, suggesting a similar sedimentary type as the marine derived silty clays above. Within the OWF the base Unit 6 has not been mapped as it is beyond the depth of interest for the OWF survey area.


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**Figure 3-7:** Line AO6\_OWF\_Z3\_023.


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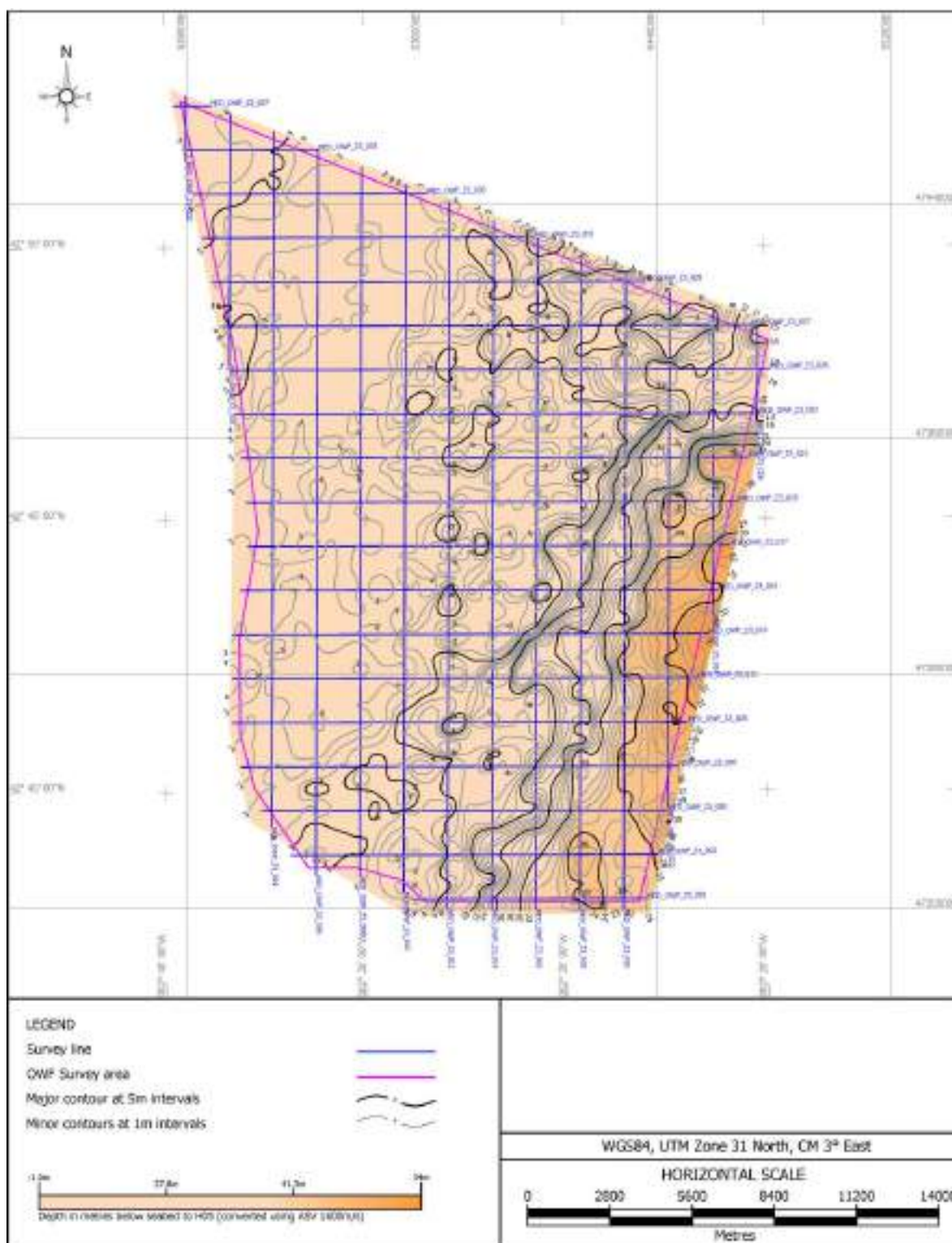
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**Table 4:** Shallow geological units.

Unit	Upper surface	Lower surface	Description	Depositional Environment
1	Seabed	H05	Acoustically quiet unit with little to no structure within it, occasional areas of higher amplitude interpreted as small channelling. Mapped off the Innomar data and between 0.1 and 34m below seabed. The basal reflector is difficult in places, in part due to the complex nature of the depositional environment.	Shallow marine, a drape of sediment deposited since sea level rise and the area was exposed.
2	H05	H10	Discontinuous reflectors, a package of sediment marking multiple events of depositional reworking and erosion. Exposed above sea level. Acoustically of higher amplitude. Evidence of unconformities, channelling, contourites within. Strong normal phase reflector at the top of the unit, often a reverse phase reflector marks its base. Interpreted as predominantly sandy in nature, some coarser material, and occasional small clay beds may be present within.	Estuarine/lacustrine depositional and then terrestrially reworked.
3	H10	H20	Discontinuous reflectors, a package of sediment marking multiple events of depositional reworking and erosion. Acoustically quieter at the base. Exposed above sea level. Acoustically of higher amplitude. Evidence of unconformities, channelling, contourites within. Strong normal phase reflector at the top of the unit, often a reverse phase reflector marks its base. Interpreted as predominantly sandy in nature, some coarser material, and occasional small clay beds may be present within.	-
4	H20	H30	Acoustically quiet unit with little to no structure within it. Interpreted as marine clays rapidly deposited during a period of rapid sea level rise and higher sea levels during warmer periods at the end of the last glacial maximum.	Marine deposited during rapid sea level rise.
5	H30	H35	Discontinuous reflectors, a package of sediment marking multiple events of depositional reworking and erosion. Exposed above sea level. Acoustically of higher amplitude. Evidence of unconformities, channelling within. Strong normal phase reflector at the top of the unit, often a reverse phase reflector marks its base. Where present, thin across much of the site. Interpreted as predominantly sandy in nature, some coarser material, and occasional small clay beds may be present within.	Estuarine/lacustrine depositional and then terrestrially reworked.
6	H35	H40	Acoustically quiet unit with little to no structure within it. Interpreted as marine clays rapidly deposited during a period of rapid sea level rise and higher sea levels during warmer periods at the end of the last glacial maximum.	Marine deposited during rapid sea level rise.


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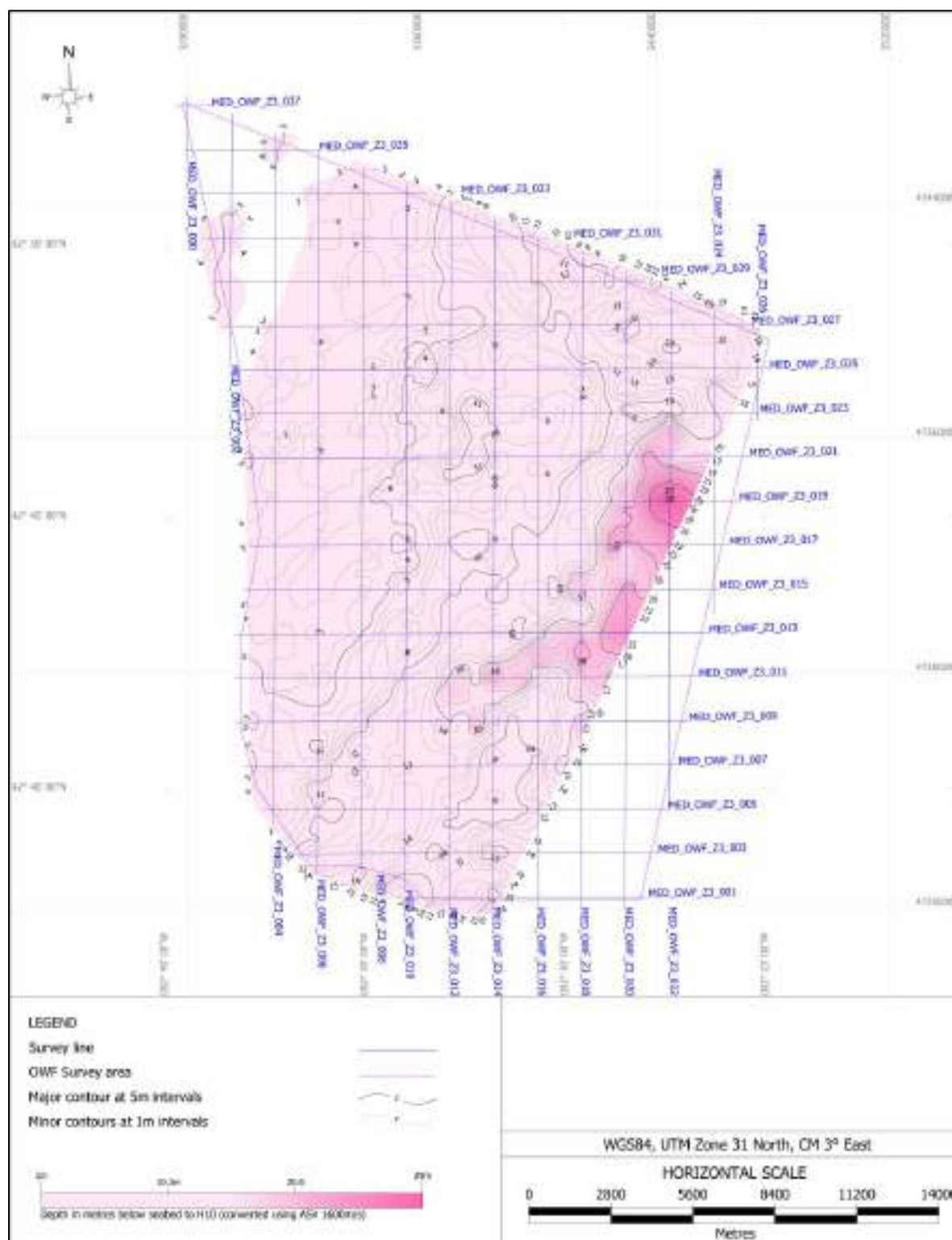
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**Figure 3-8:** Isopach of Unit 1 (H05)


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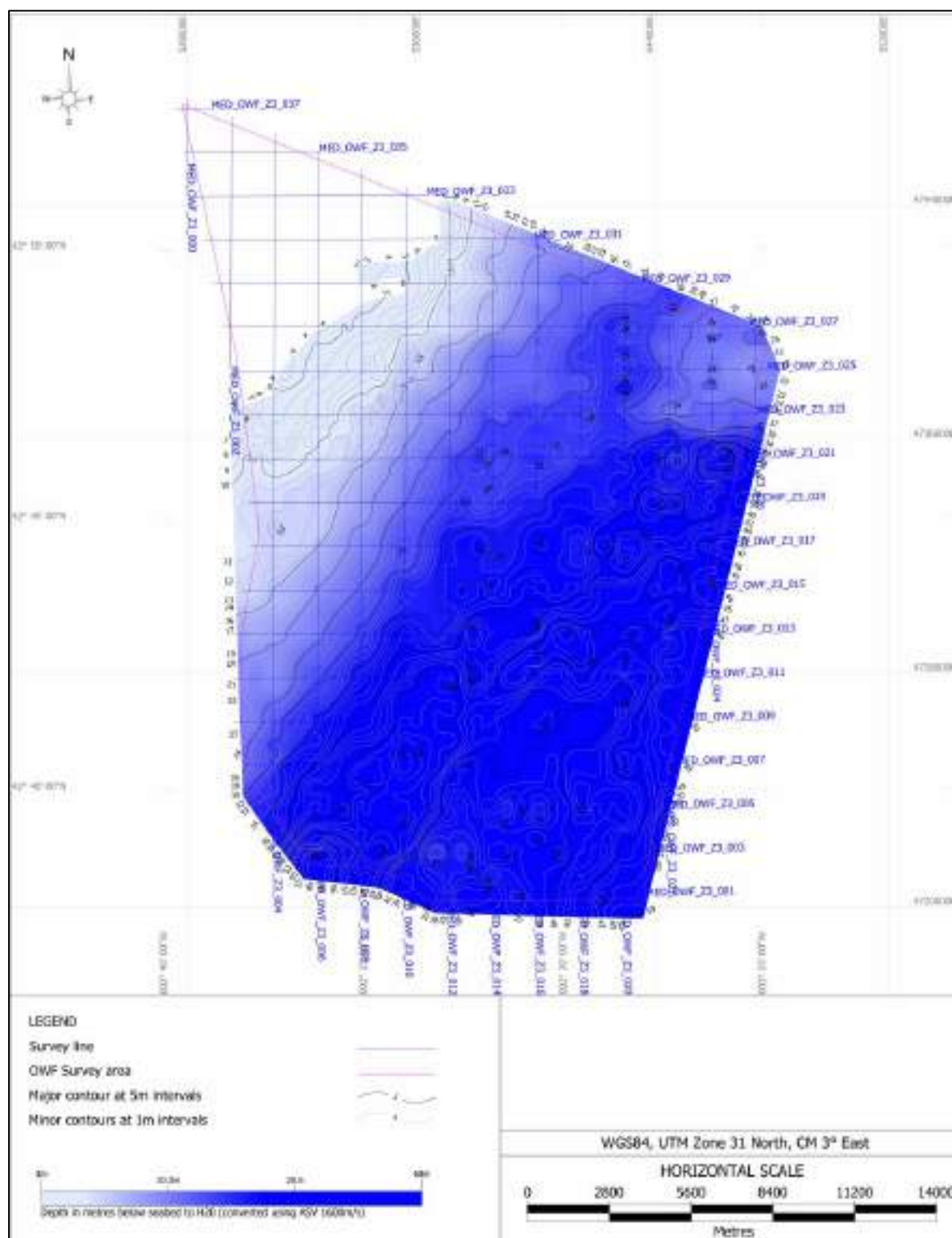
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**Figure 3-9: Isopach Unit 2 (H10).**


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**Figure 3-10:** Isopach of Unit 3 (H2O).

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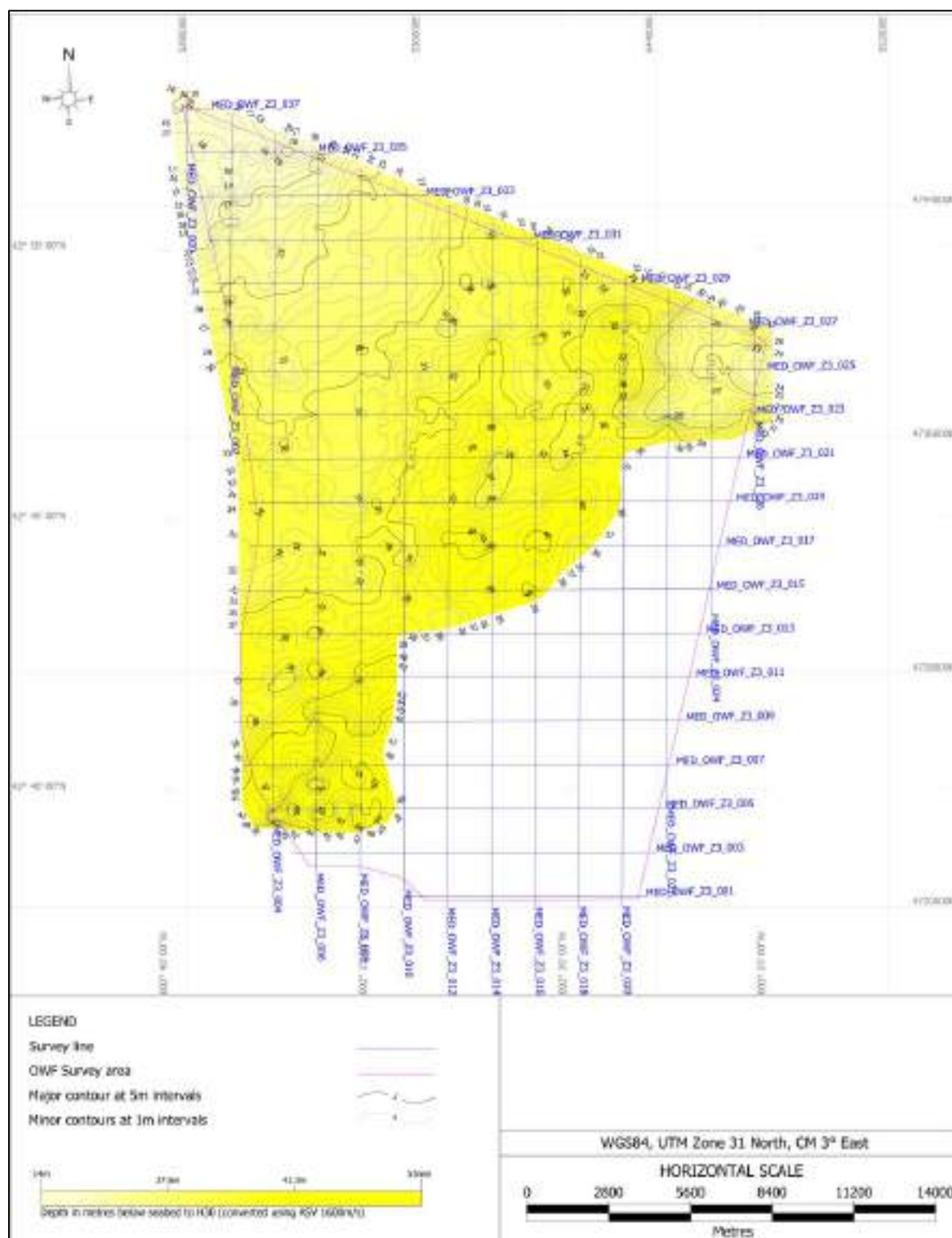

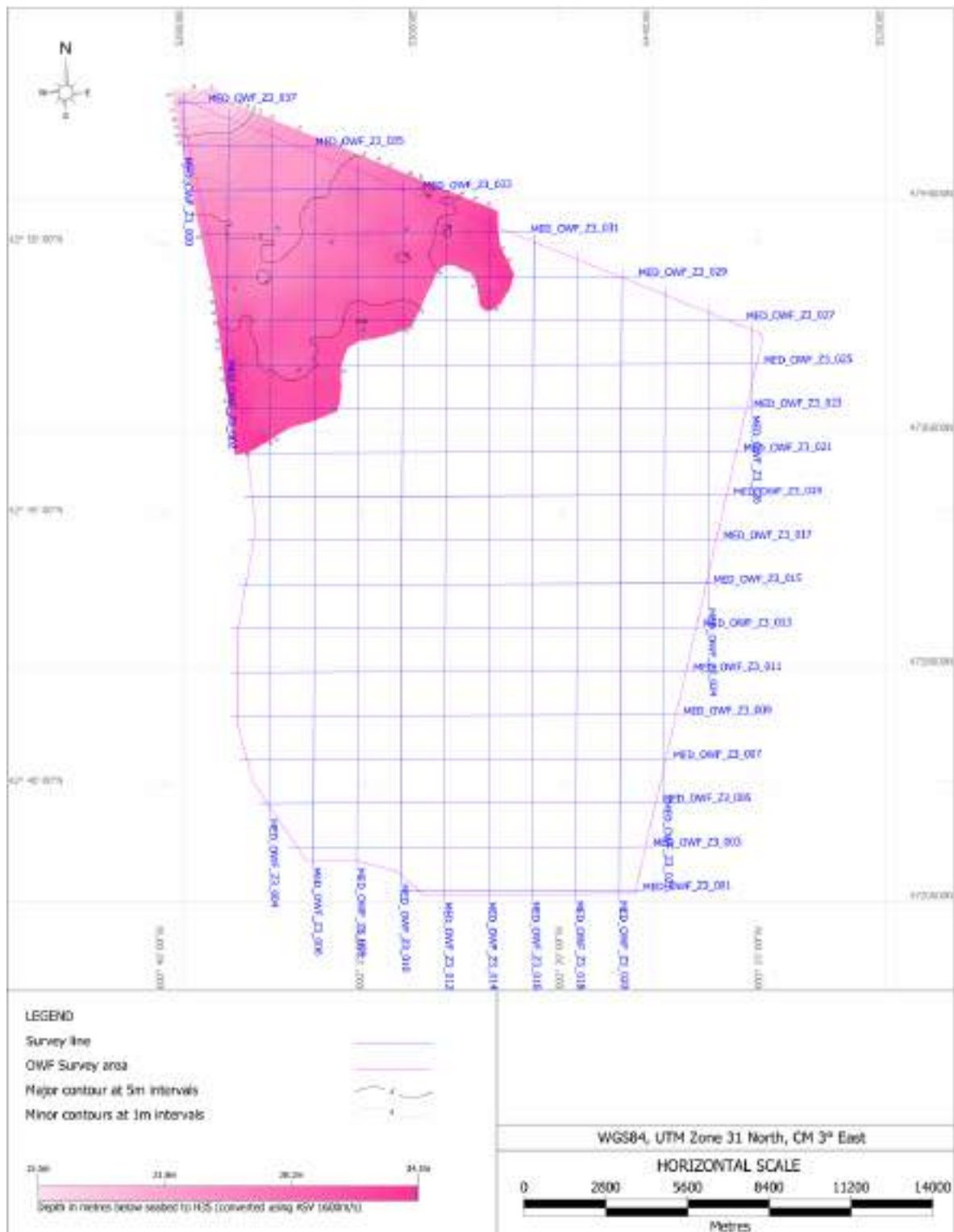


Figure 3-11: Isopach of Unit 4 (H30).


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**Figure 3-12:** Isopach of Unit 5 (H35).

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### 3.2.3. Geohazards

The shallow geology has been checked for any evidence of any shallow geohazards that may affect the installation or operation of a floating wind farm. Constraints may relate to composition and distribution variability of sediments (at the seabed and in the subsurface) within the first 30 m below the seafloor. Other constraints may relate to past or presently active geological processes, such as faulting.

A summary of geological conditions and potential constraints on infrastructure and engineering activities, applied to the MED\_AO6 site, is provided in (Table 5) modified after (Mellet, Long, Carter, Chiverell, & Van Landeghem, 2015).

There is no evidence of any geohazards within the survey area within the depth of interest within OWF Zone 3.


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**Table 5:** Geological characteristics / processes and potential constraints.

Geological characteristic / process	Potential constraint	MED_AO6 OWF site
<b>Seabed sediments</b>		
Soft muds	Low strength means they will not bear large loads	Probable
Coarse lag (gravel to boulders) deposits	May be present below mobile sediment	Probable
<b>Mobile sediment</b>		
Migrating bedforms change topography (can create seabed features several metres height)	Can bury or expose structures or create a barrier to activities	Not evident
Mobile sediment can change sediment characteristics at seabed	Mobile sediment is constantly changing. Therefore, expect variation between samples taken from the same site at different times.	Not evident
Bedforms can migrate in the opposite direction to that predicted from morphology and tidal residual	Do not assume sediment migration pathways from morphology. Repeat bathymetric surveys should be carried out.	Not evident
<b>Gas/fluid escape and MDAC</b>		
Gas or fluid present in shallow subsurface	Can lead to blowouts when drilling	Not evident
MDAC	Creates a hard substrate that is recognized as a special habitat that must be preserved	Not evident
<b>Quaternary</b>		
Variable sediment thickness	Locally, sediment thickness can change from thin (<5 m) to thick (> 50 m) over a short distance	Expected
Variable lithology (vertically and spatially)	Glacial processes rework and deposit sediments that are highly variable over large areas. Smaller and isolated features such as channels are not always mapped across the site. With the large line spacing some of the variations may not be incorporated into the interpretation.	Expected
Heterogeneous sediment composition	Sediments are typically glacially diamict which are poorly sorted mixtures of silt, sand, gravel, and clay. Diamicts can be interbedded with sands.	Probable
<b>Bedrock</b>		
Bedrock outcrop at seabed	Provides a hard substrate for emplacement of seabed infrastructure.	Not evident
Faulting	Active faults are susceptible to ground surface ruptures that can compromise infrastructure; seabed forms that indicate pre-existing seabed instability, surface displacements, or fluid escapes are conditions that pose risk to infrastructure; Sub-surface fault zones may provide preferential conduits for gas migration, or may be hydraulically active during (or shortly after) earthquakes	Not evident

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The depth values were converted from time (TWT) using sound velocity of 1,600 m/s in sediments and 1,510 m/s in the water column.

### 3.2.4. Background data summary and regional geology


To provide background context for regional stratigraphy and structural geology relevant portions of text from (Bassetti, 2006) are reproduced here:

*In the Gulf of Lions, which is considered as a relatively low energy continental shelf, most of the authors still consider that the offshore sands are relict features, only the transgressive processes, at a time when sea-level was lower by about 100 m, being able to rework sediments (Aloisi, 1986; Berné et al., 1998; Monaco, 1971). However, ultra-high resolution seismic data, coring and 14C dating, as well as numerical modelling of wind stress on oceanic circulation, allow us to demonstrate that a mobile carpet of sand is periodically active at the shelf edge, feeding slope and rise deposits and contributing to the episodic reworking of shelf morphology.*

#### *Morphology and seismic facies of post-glacial deposits*

*(a) Sand ridges- In the studied area, the major morphological feature is represented by the sand ridges, localized between 95 and 110 m water depth. They have limited areal (Bassetti et al. (Marine Geology)) distribution, variable heights (up to 9 m) a mainly WNW-ESE orientation, as recognized on the bathymetric maps. They have an irregular topography and mainly show a linear, elongated shape. On the chirp profiles their surface is smooth, they form bodies of maximum length of 5 km and they rest on a major erosional surface (ravinement surface) that is possibly exposed beyond the ridge field. The ridges have an asymmetric transverse profile (with the steepest slope facing the SW). At times, they show a nearly symmetric profile, but it concerns only the smaller bodies. They show distinct clinoforms, dipping in the SW direction and some chaotic internal reflections probably in relation with coarse-grained material diffracting seismic waves. However, some major erosional surfaces (discontinuities) can be recognized within the ridge, that may be related*


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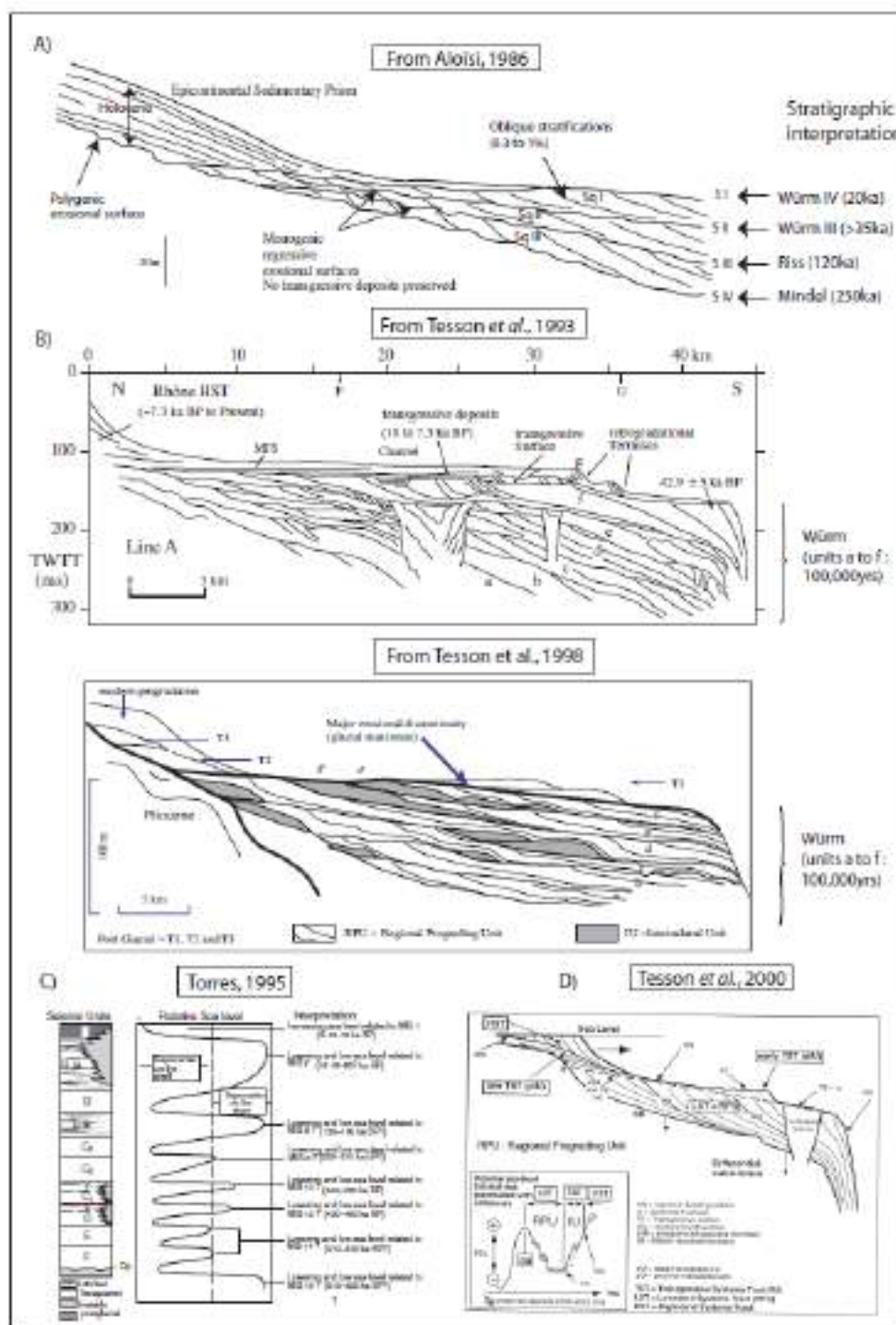
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	Title	MED_TEC_50_Factual report - Seismic survey - OWF Zone 3 A06 area_0				

*to storm events affecting the ridge growth, although they cannot be correlated from one ridge to another.*

*(b) the dunes were only detected when we used high-resolution swath bathymetric systems, such as the EM 1000 and EM1002S. They have an average spacing of 130 m and maximum height of 2 m. Their great axis has a NNW-SSE orientation in the NE part of the surveyed area, turning progressively to NW-SE in the SW corner. Their internal structure was not detectable considering their small size. They are classified as transverse dunes in the sense of Ashley (1990) and they clearly rework the shape of the sand ridges. On top of the sand ridges, chirp and sub-bottom seismic profiles display a thick pattern of parallel reflections, that was first considered as the result of some ringing effect representing the pulse length of the seismic sources, instead of a real sedimentary layer. However, extensive coring and bathymetric data demonstrated that a distinct layer actually exists at the sea-floor interface.*


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**Figure 3-13:** Figure showing the geology (Figure 3 from Rabineau et al., 2003; Benabdellouahed, 2011; Paquet et al. - b, in preparation).

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### 3.2.5. Conclusions and recommendations/comments


Horizons were mapped to define units of similar sedimentary facies based on acoustic nature and known geology and environmental conditions during the time of deposition from background material. These have been illustrated as isopachs to show rough sedimentary thicknesses and assist with a ground model. The sediment types and any hazards present were mapped.

No evidence of shallow gas or faulting is observed.

To improve knowledge of potential geological constraints the following data acquisition could prove beneficial.

1. Acquire additional high-resolution seismic data at a closer line spacing to improve spatial mapping of stratigraphic units.
2. Acquire sidescan sonar imagery data to coincide with the multibeam bathymetry and backscatter data.
  - a. A detailed seafloor mapping with sidescan sonar data will identify potential natural and anthropogenic seafloor geohazards.
3. Acquire repeat multibeam bathymetry and backscatter data during sidescan sonar data acquisition
  - a. Use this comparative multibeam bathymetry data to assess potential for sediment mobility.
  - b. Although a recent study concluded that sediment mobility is not apparent at the NOR\_AO4 OSS site, monitoring for its potential could be beneficial for long-term development planning.
4. Acquire seabed ground-truthing “light” geotechnical data (e.g., grab samples) to confirm the variable seafloor composition illuminated with the sidescan sonar data.

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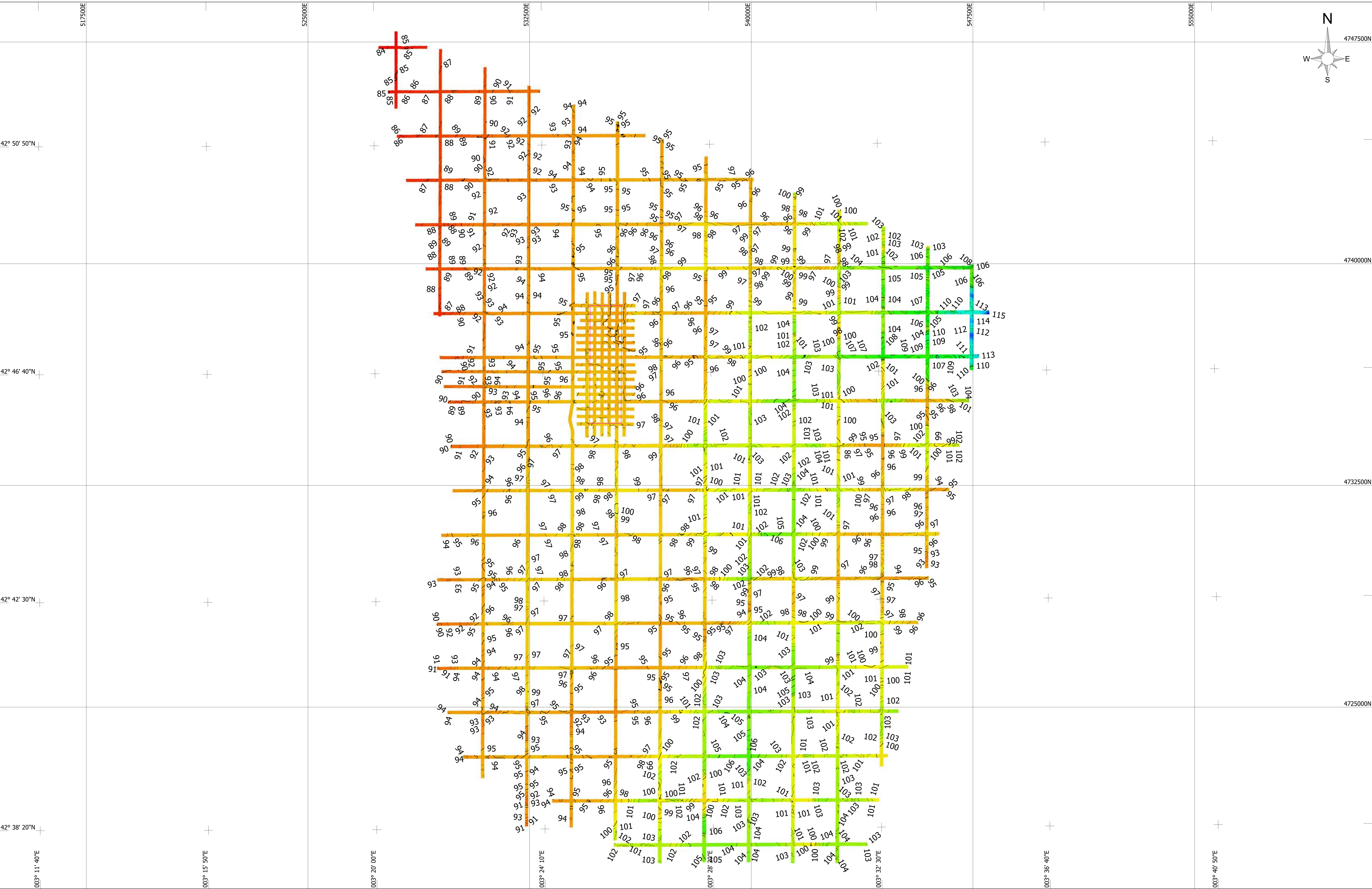
#### 4. REFERENCES

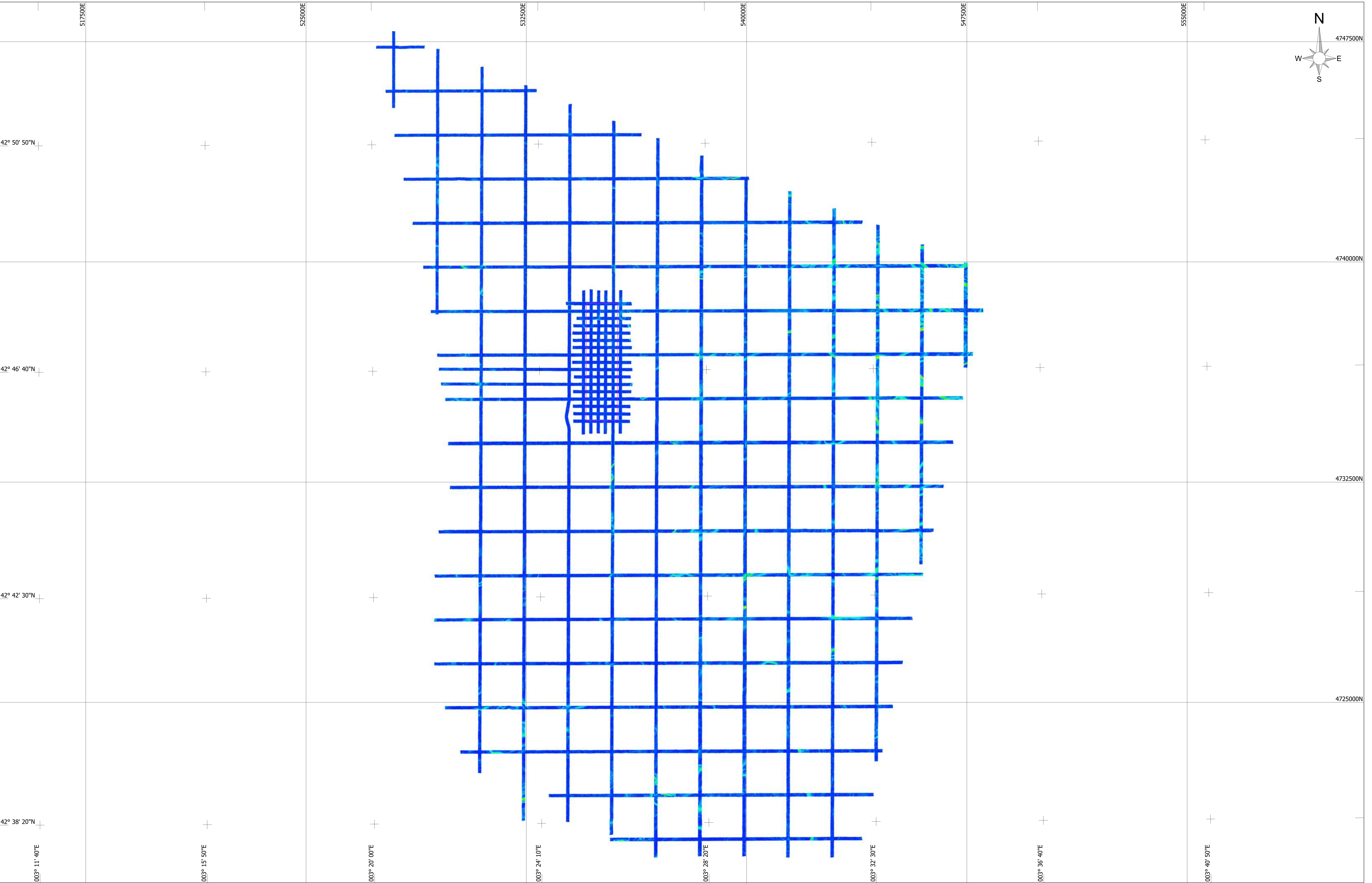
- Actimar. (2021). *Offshore wind farm and its connection to the Bay of Seine, Hydro-sedimentary and morphodynamic analysis*.
- Barrie, J. V., & Conway, K. (2014). Seabed characterization for the development of marine renewable energy on the Pacific margin of Canada. *Continental Shelf Research*, 45-52. doi:http://dx.doi.org/10.1016/j.csr.2013.10.016
- Benabdellouahed, M., Dugue, O., Tessien, B., Thinon, I., Guennoc, P., & Bourdillon, C. (2014). New mapping of the bedrock of the Bay of Seine and landsea. *Geology of France*, 26.
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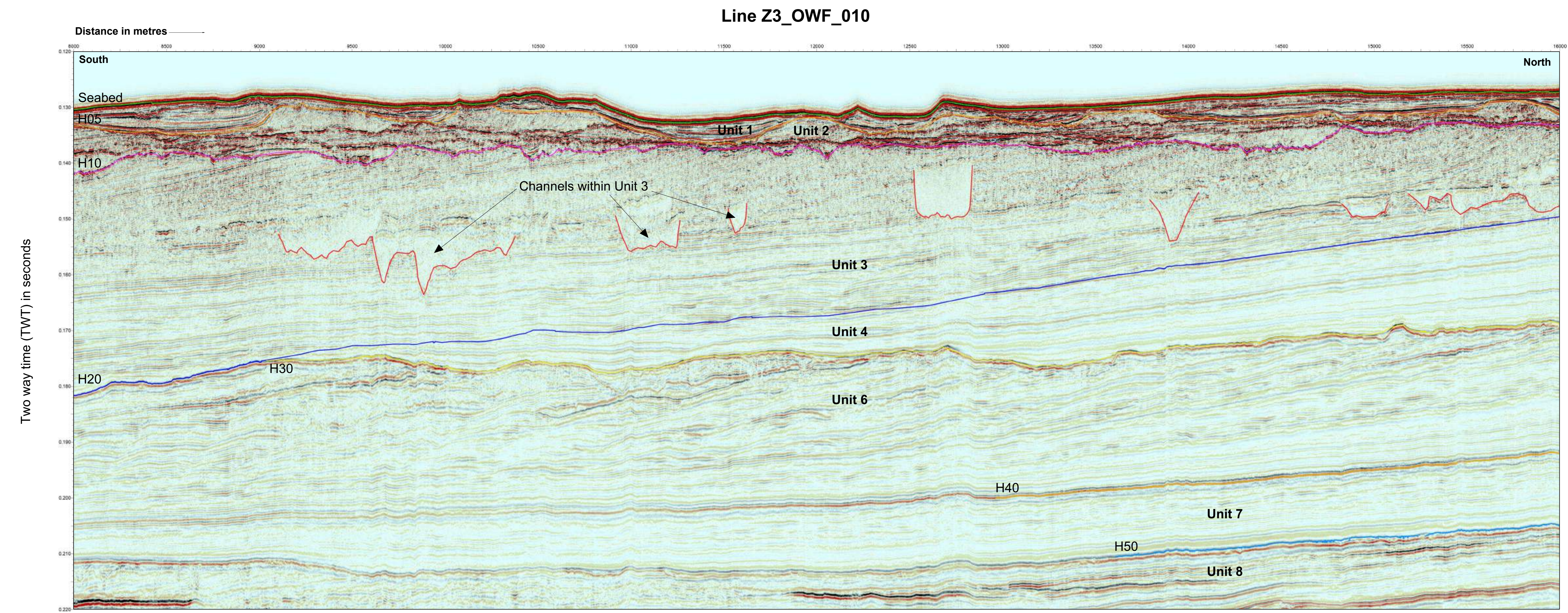
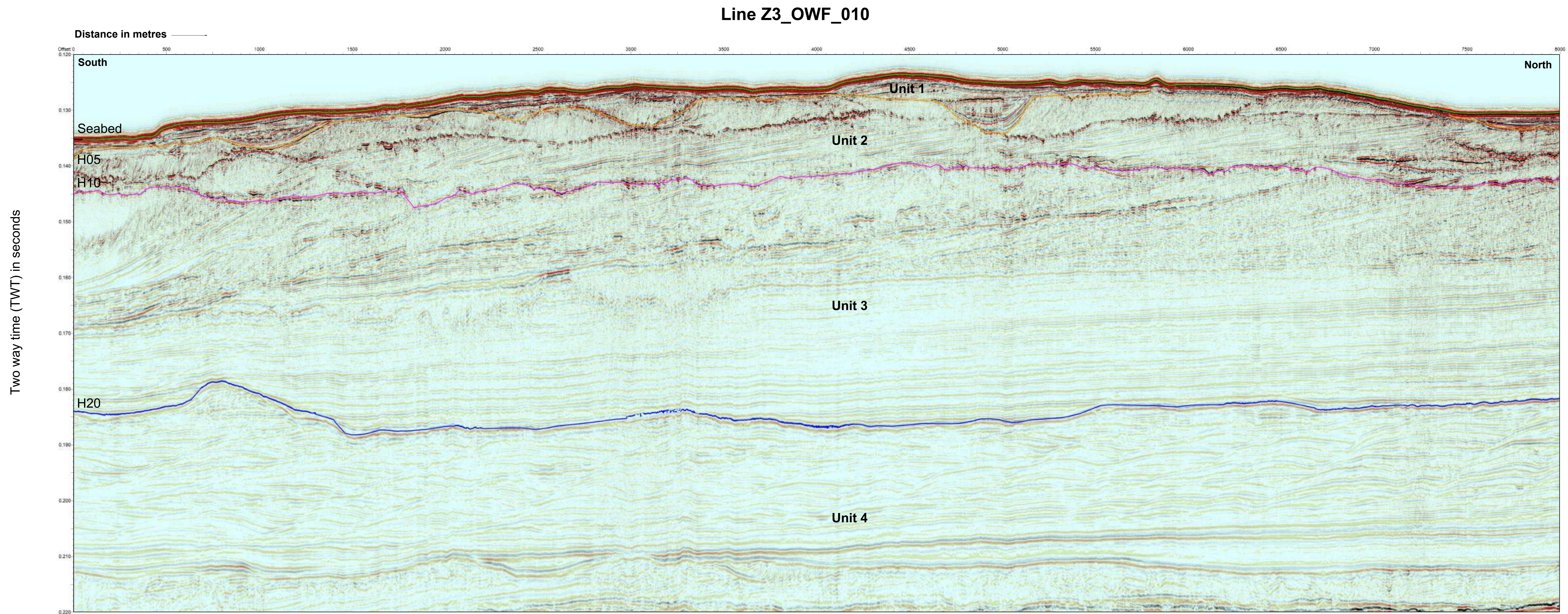
<b>Confidentiality</b>	<i>Diffusion restreinte (restricted)</i>	<b>Pages</b>	<i>Page 44 of 48</i>
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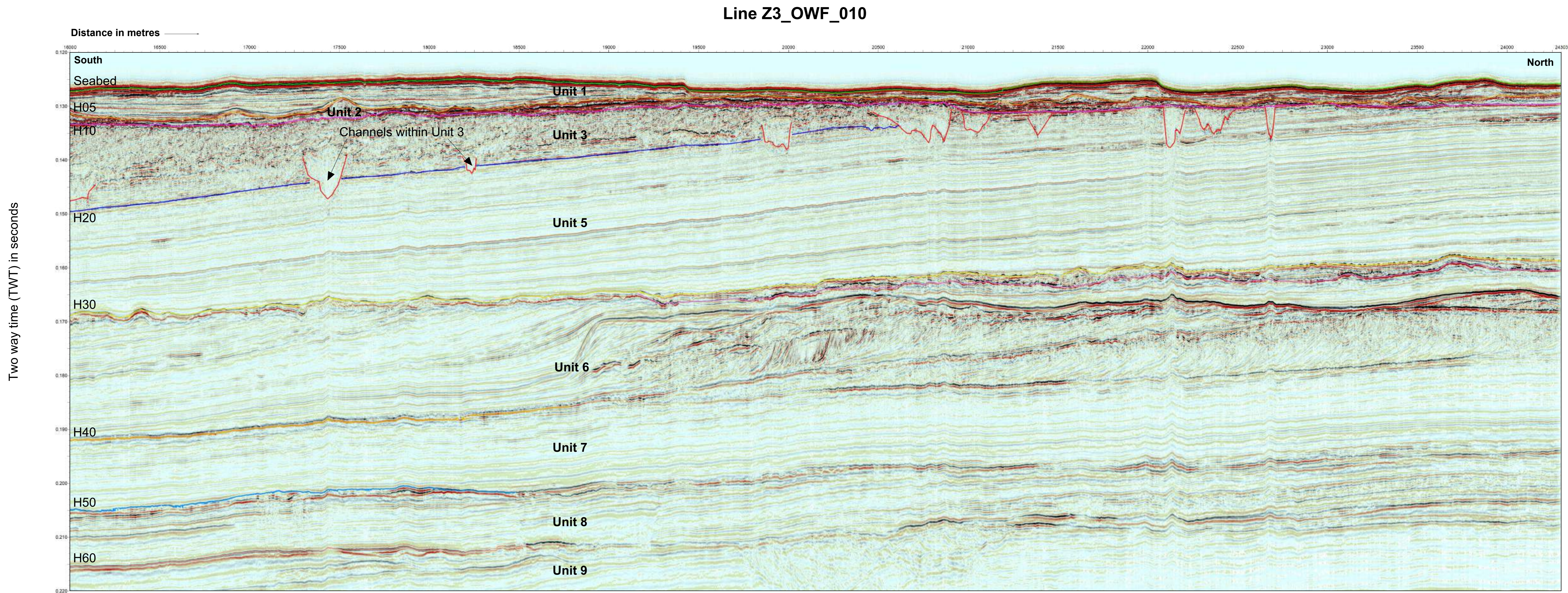
## APPENDIX I – CHARTING

CHART NUMBER	CHART TITLE
1	Z3_OWF_BATHYMETRY
2	Z3_OWF_GRADIENT
3	Z3_OWF_PROFILE_010_P1
4	Z3_OWF_PROFILE_010_P2
5	Z3_OWF_PROFILE_023
	Z3_OWF_EXTENDED_CHANNELS
7	Z3_OWF_ISOPACH_H05
8	Z3_OWF_ISOPACH_H10
9	Z3_OWF_ISOPACH_H20
10	Z3_OWF_ISOPACH_H30
11	Z3_OWF_ISOPACH_H35

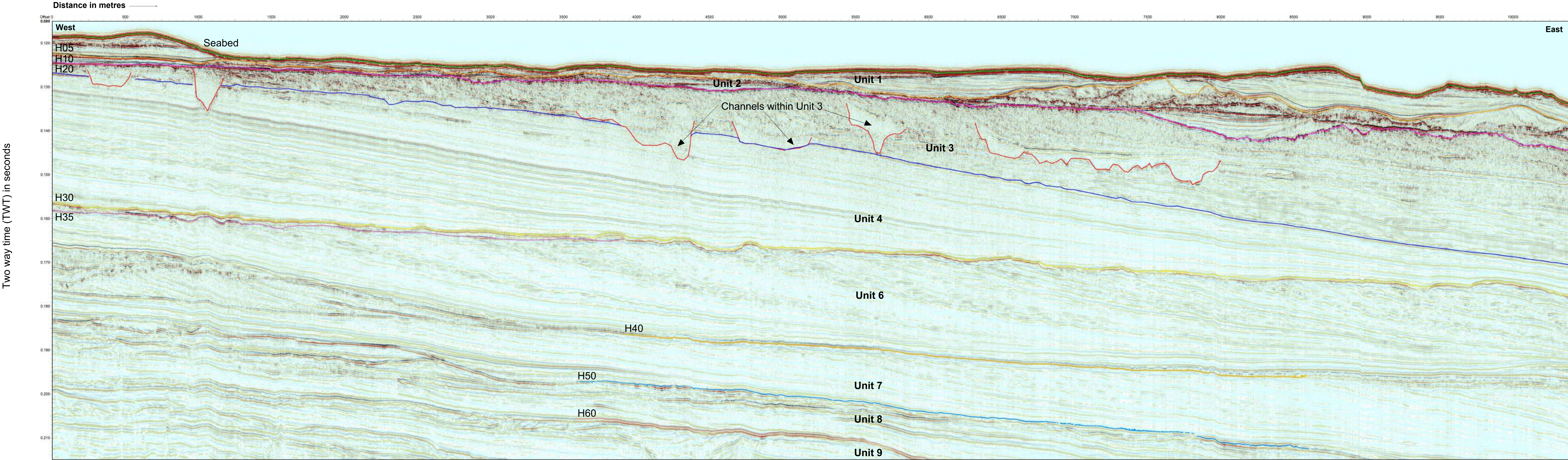




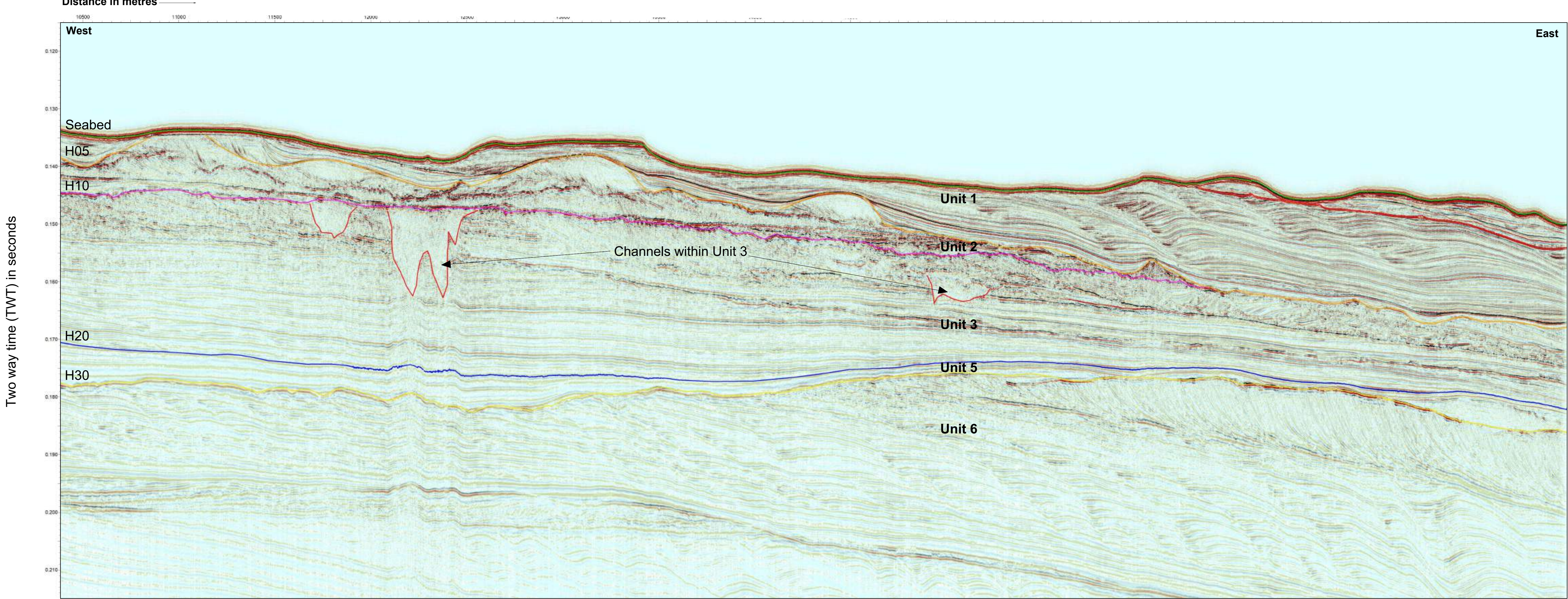


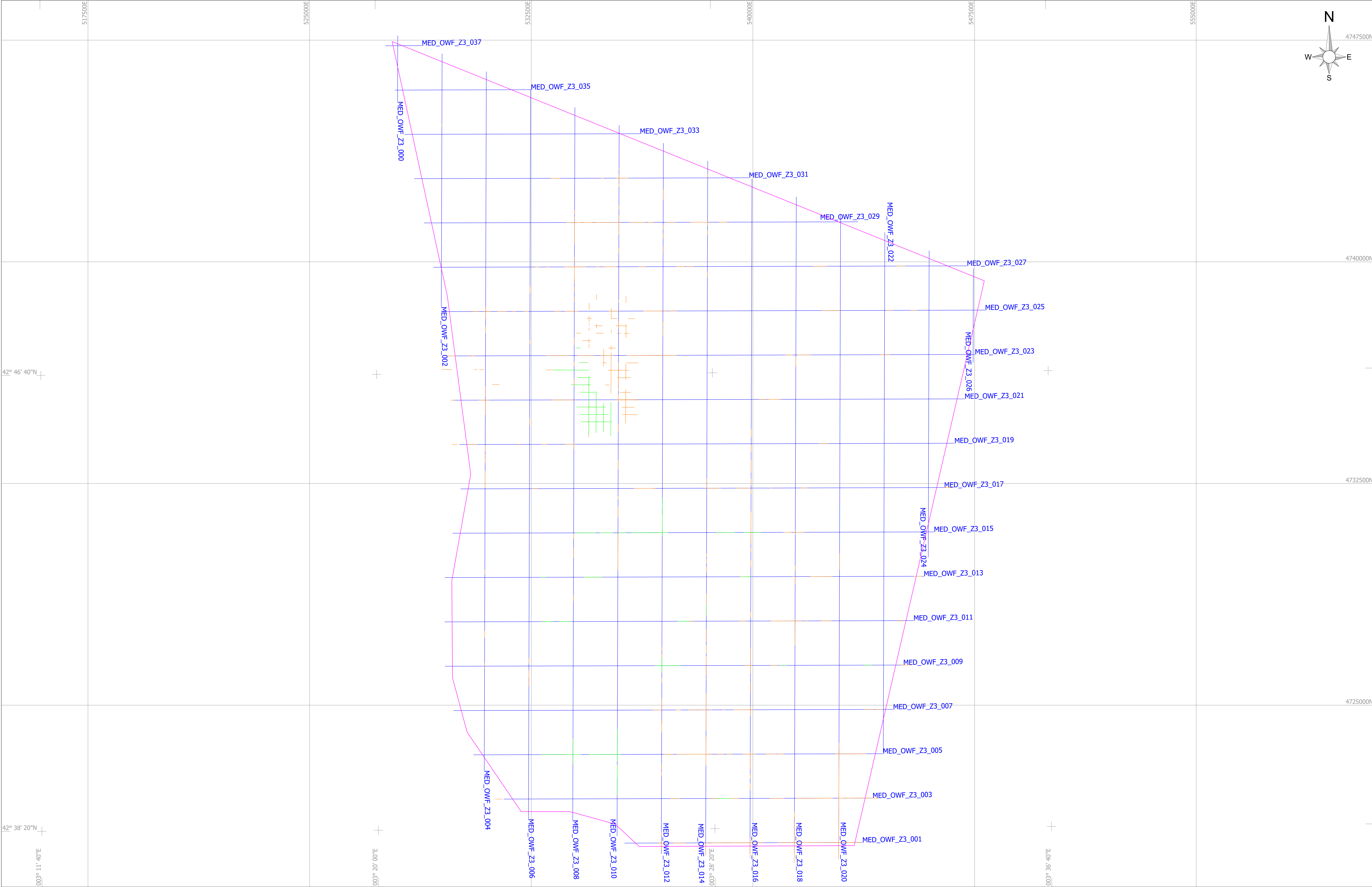


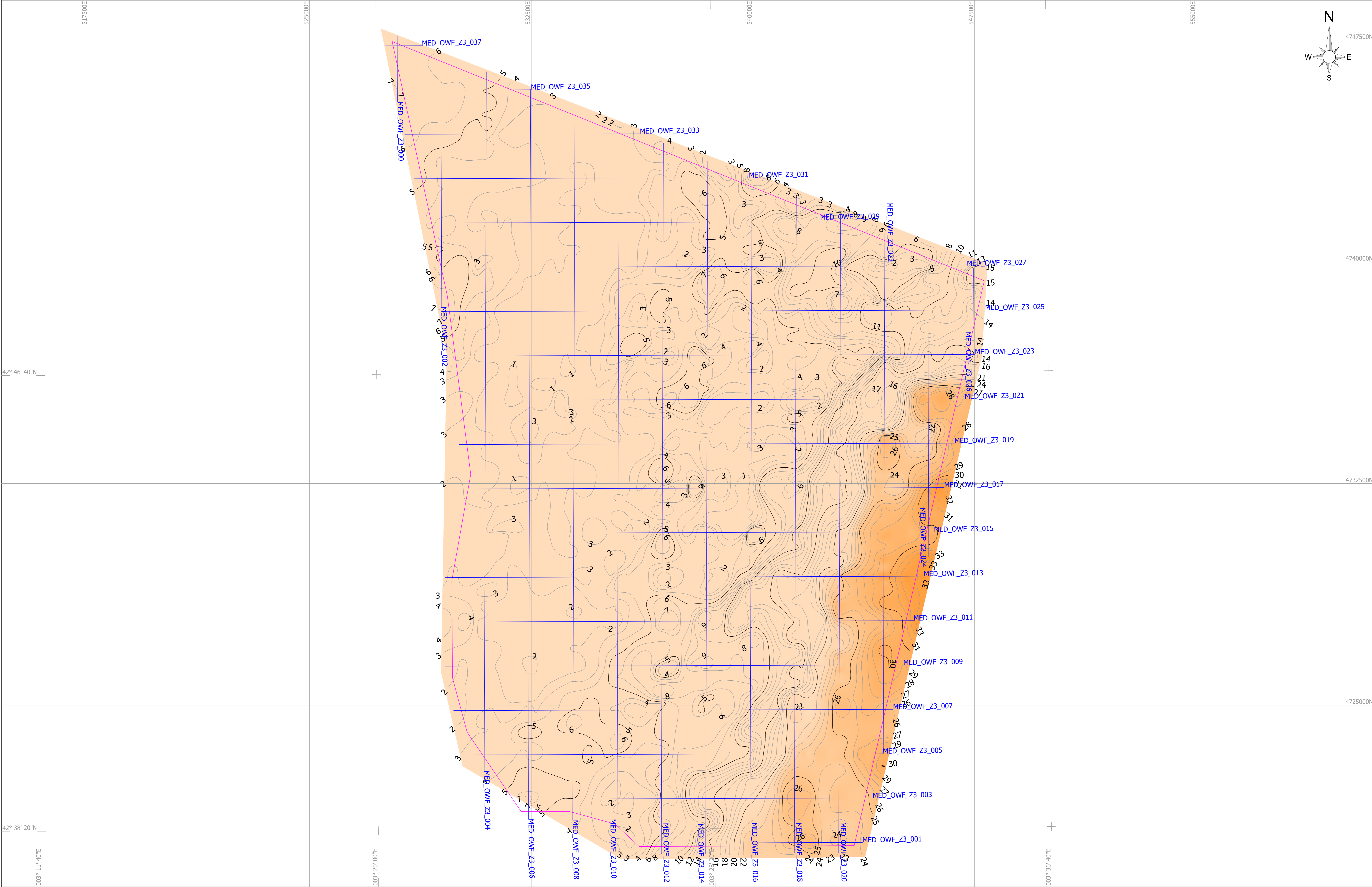
Line Z3\_OWF\_023

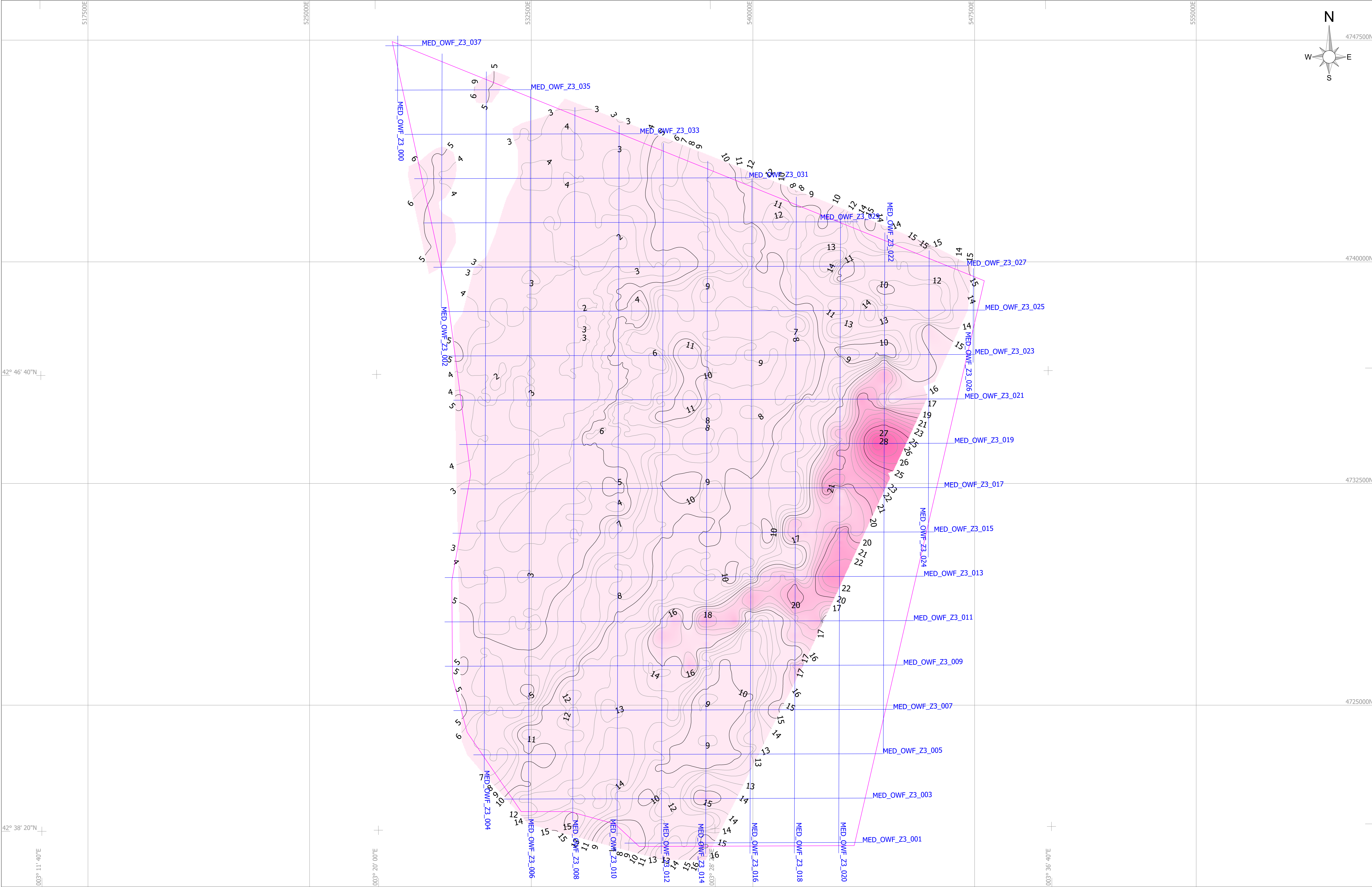




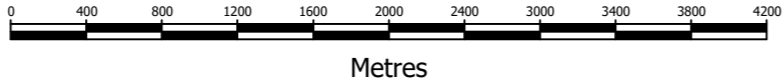
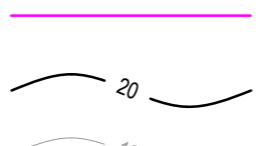


Line Z3\_OWF\_023

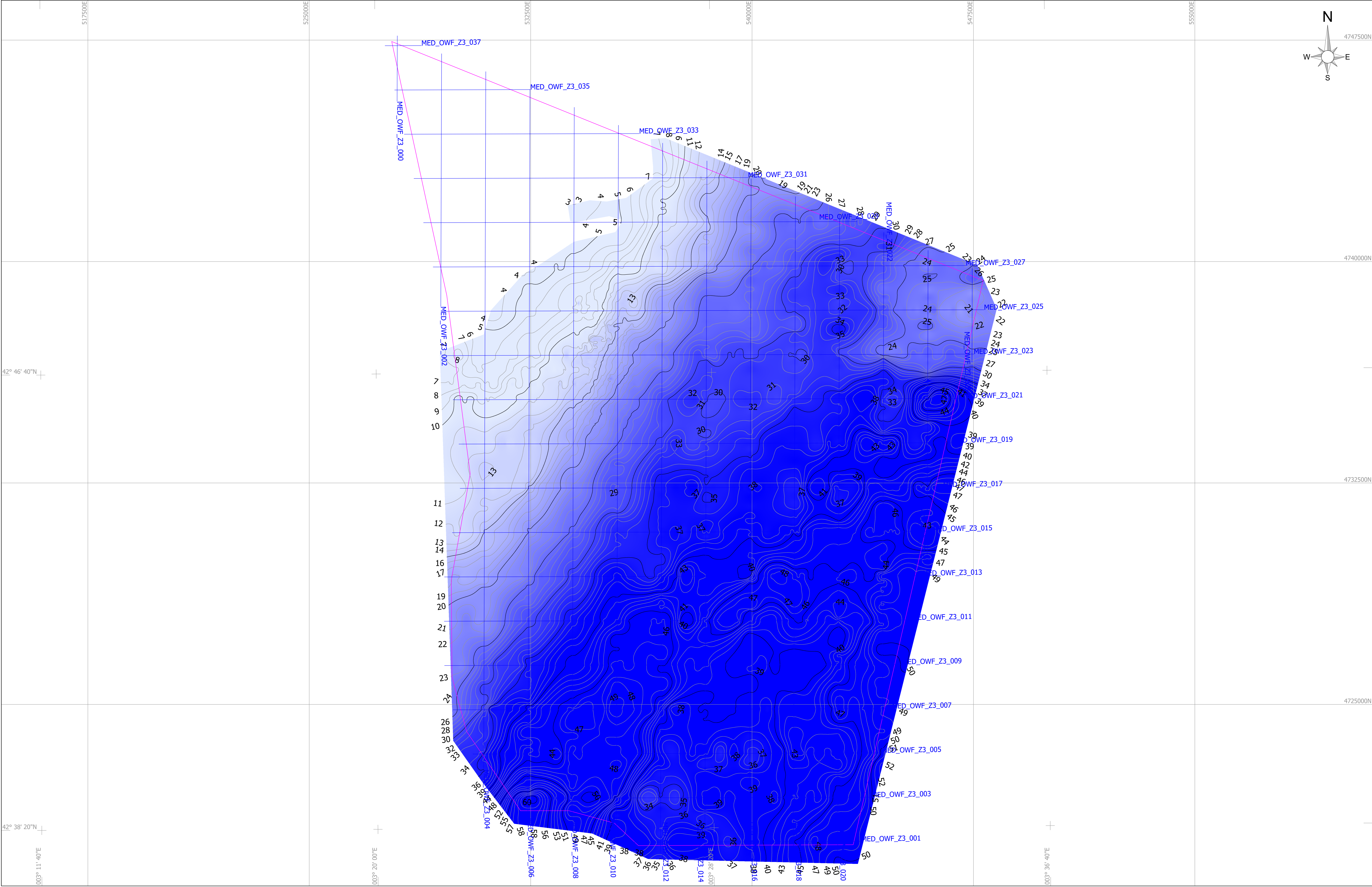


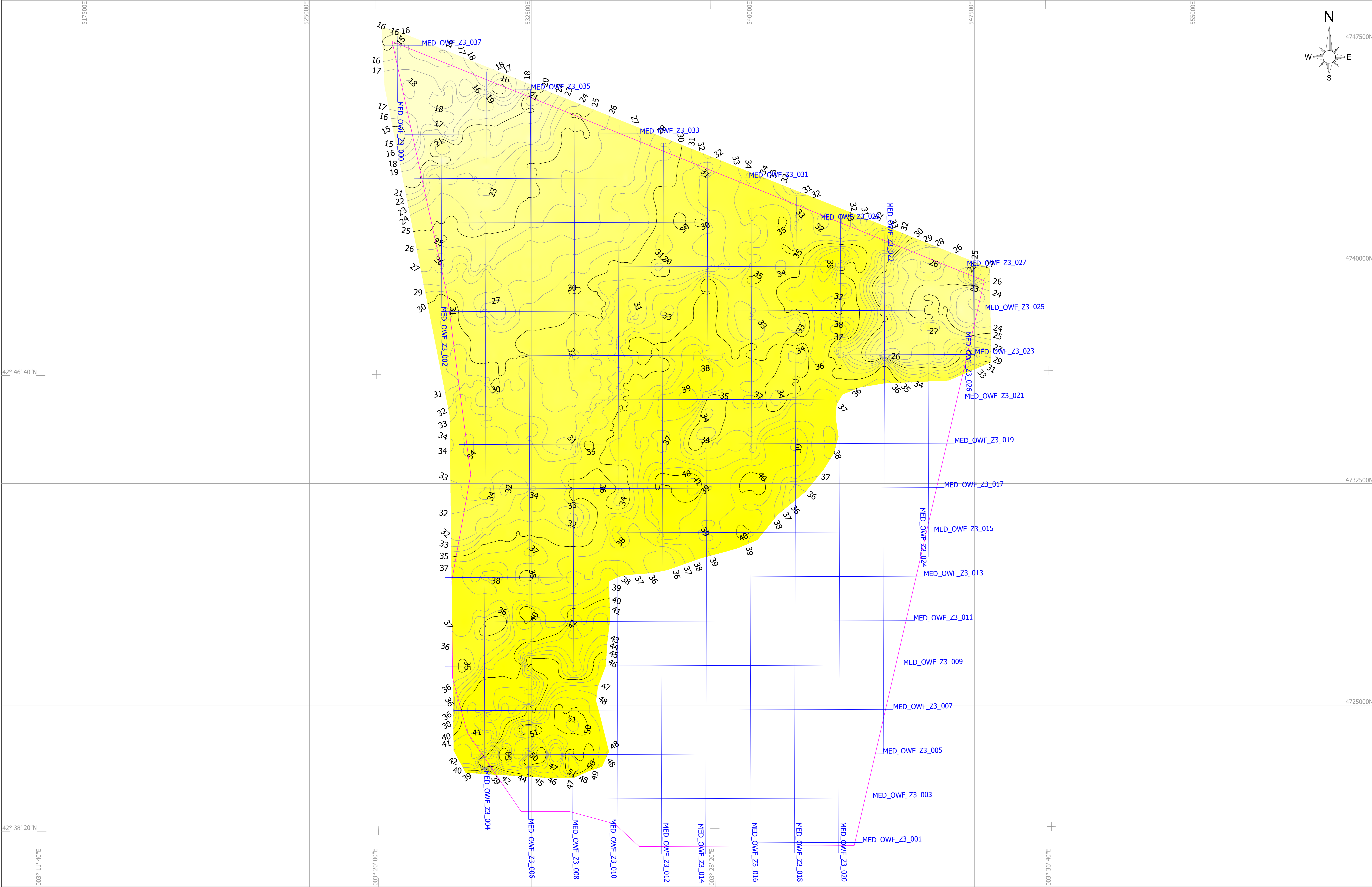


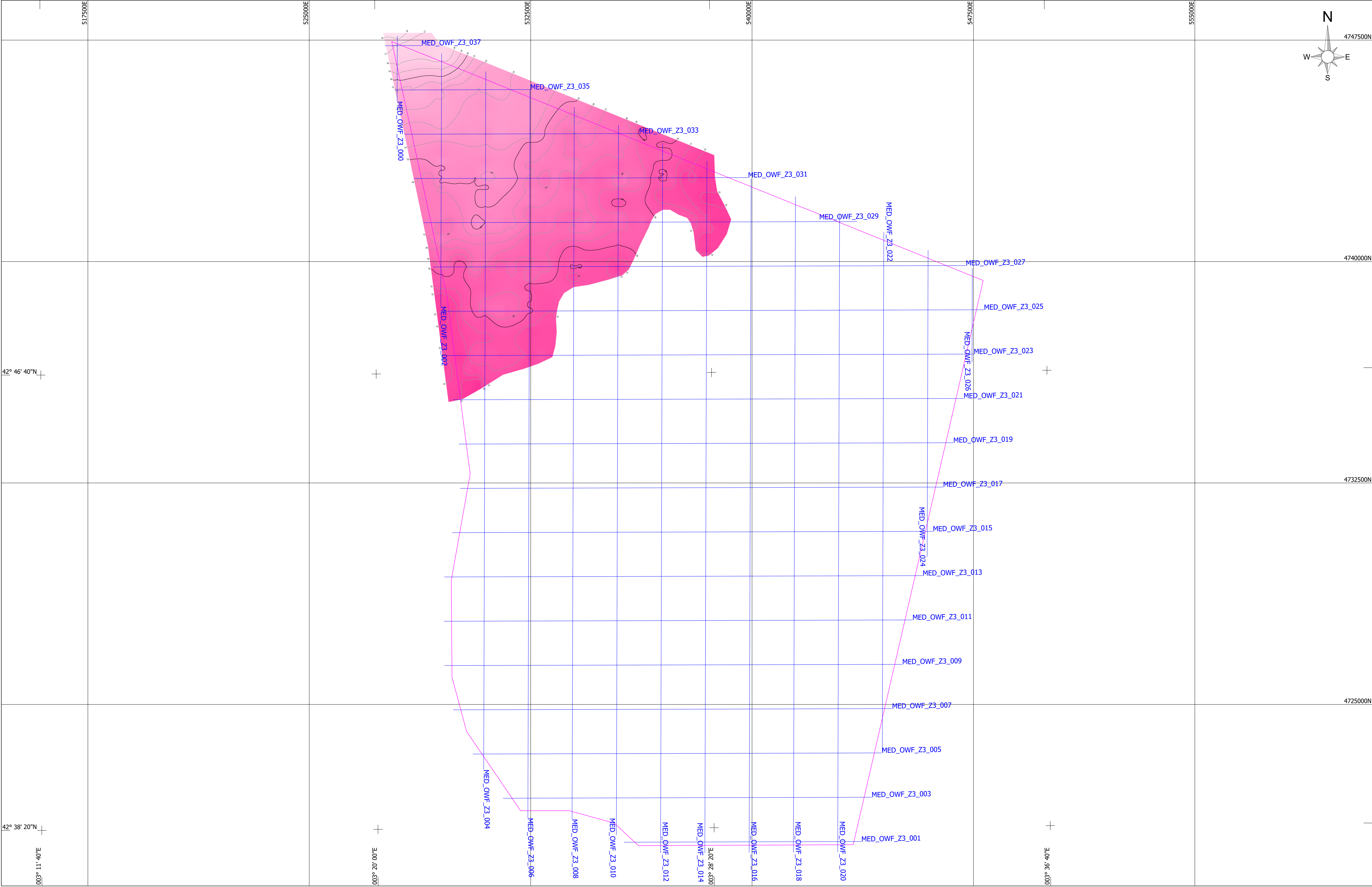




<div> MINISTÈRE DE LA TRANSITION ÉCOLOGIQUE</div>	<div> TECNOAMBIENTE L'AMBIENTE S'ADAPTE</div>	CARTOGRAPHIC INFORMATION  ELEVATION REFERRED TO BATHYELLI v2 GEOID	GRAPHIC SCALE <div></div>	DATE: June 2023	LEGEND: OWF Survey area Major contour at 5m intervals Minor contour at 1m intervals	<div> Depth in metres Data gridded at 1m cell size</div> <div></div>	<div></div>	PROJECT TITLE: Geophysical Survey - A06 OWF Area	AREA: A06 Zone 3	CHART: x of x
								CHART TITLE: A06 Zone 3 OWF Area Isopach H10 Chart	REFERENCE: A06 Zone 3	SCALE: 1:40000







## **APPENDIX II – SEISMIC PROCESSING OVERVIEW**



Le réseau  
de transport  
d'électricité



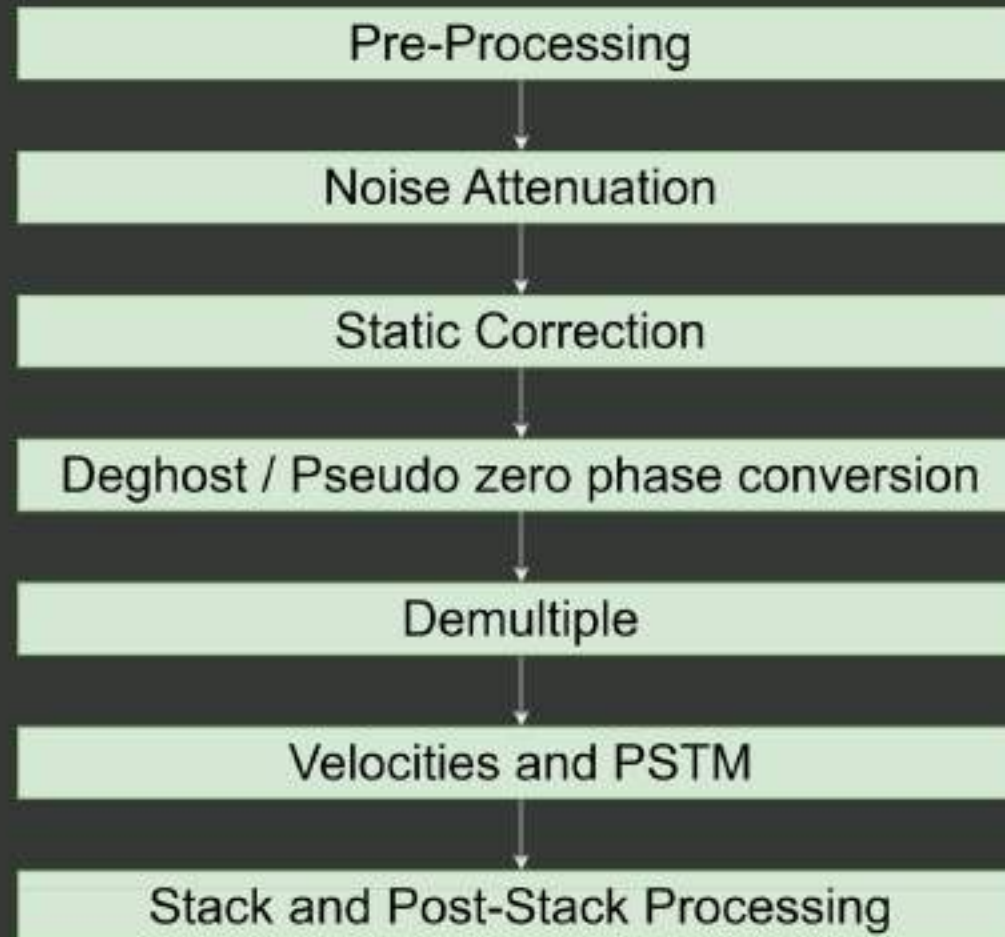
# MED\_AO6 SEISMIC PROCESSING OVERVIEW

# UHR SURVEY PARAMETERS

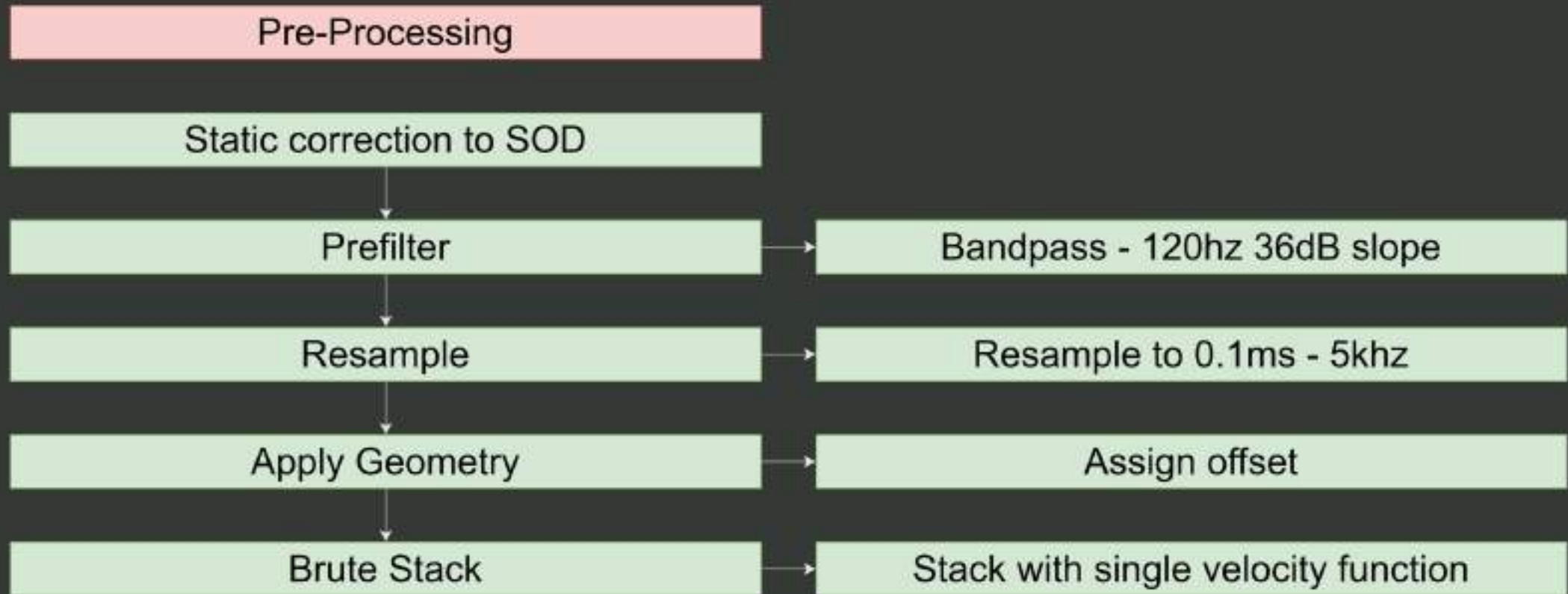
PARAMETER	VALUE
Sample Rate	0.0625ms
Record Length	0.250ms
Shot Point Interval	1m
Source	Sparker – GSO – 400 tips
Target Source Tow Depth	0.4m

PARAMETER	VALUE
Active Streamer Length	75m
Number of channels	48
Group Length	Channels 1-24 : 1m Channels 25-48 : 2m
Target Tow Depth	1m +/-0.5m
Near Offset	~5-6m

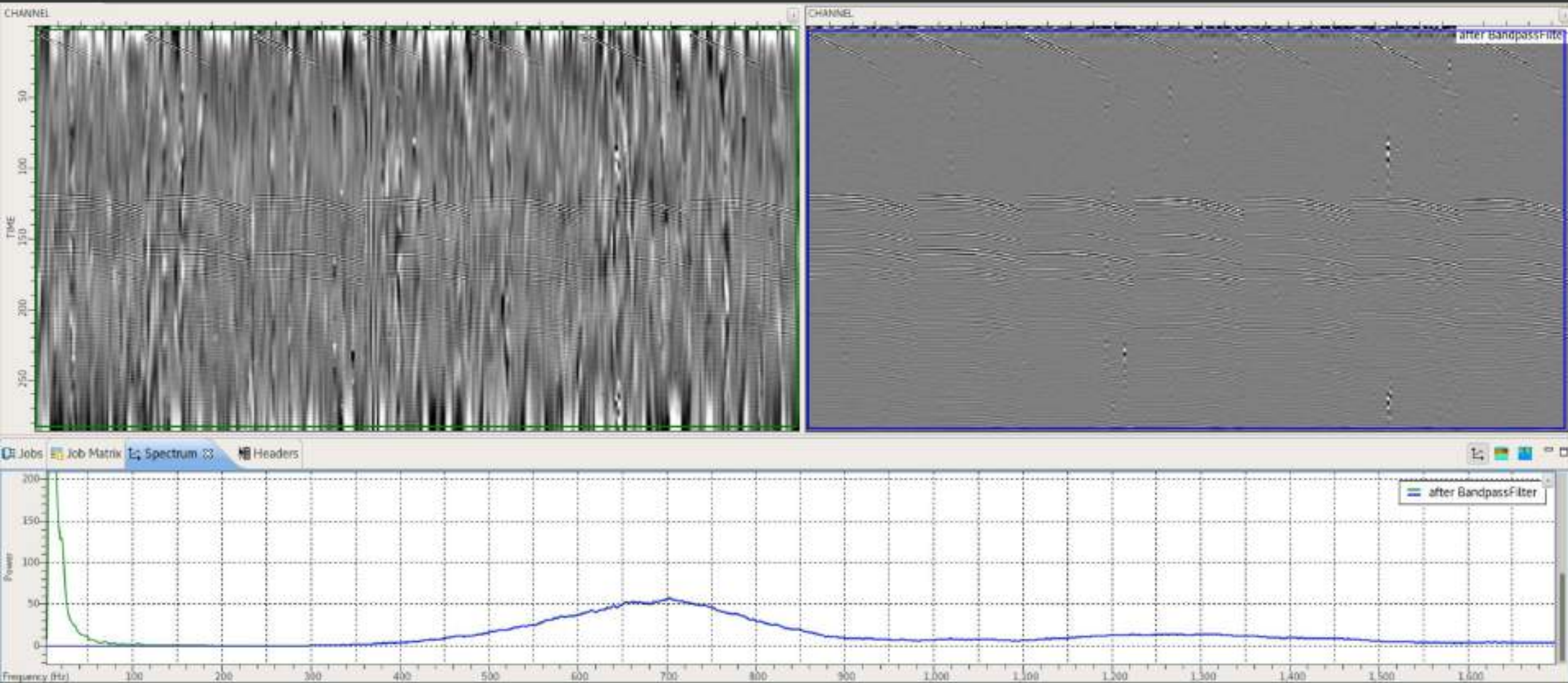
# SEISMIC PROCESSING OVERVIEW



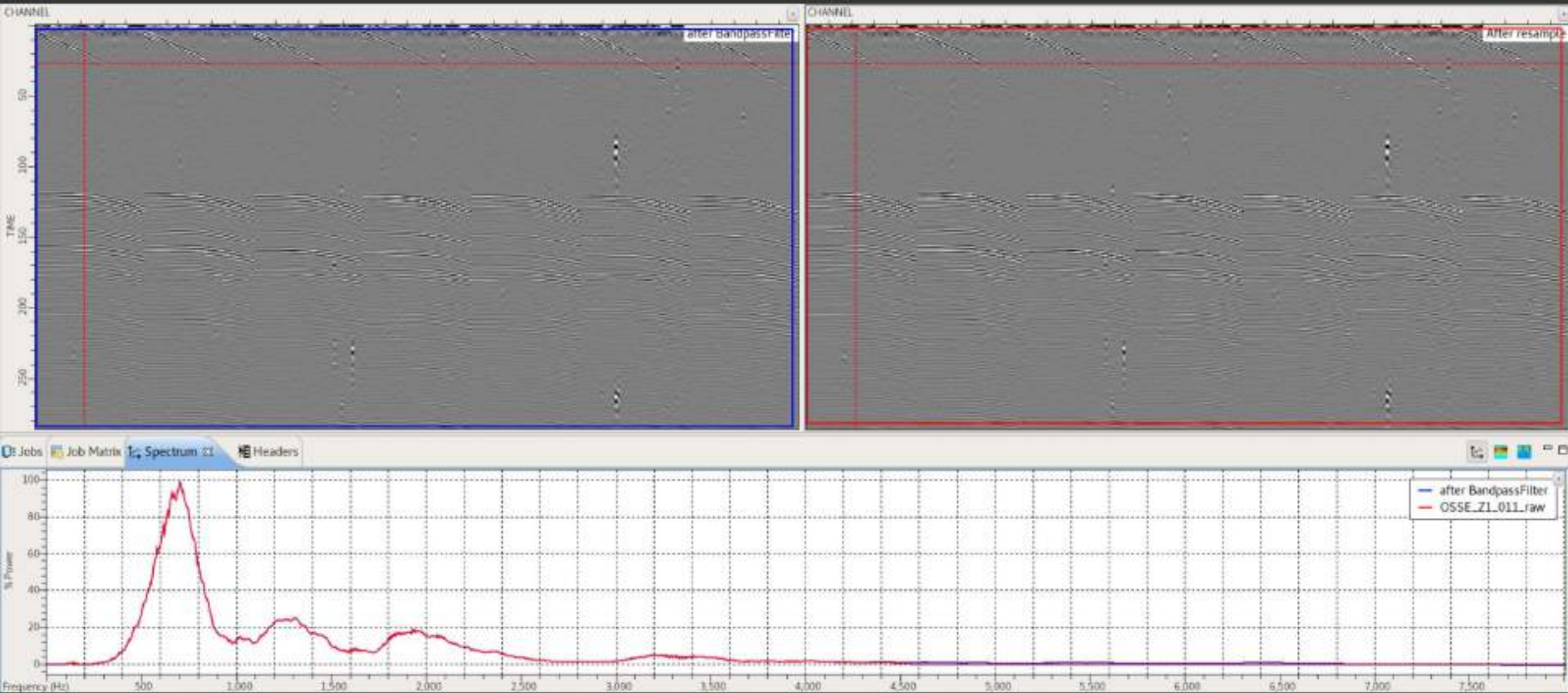
# PREPROCESSING



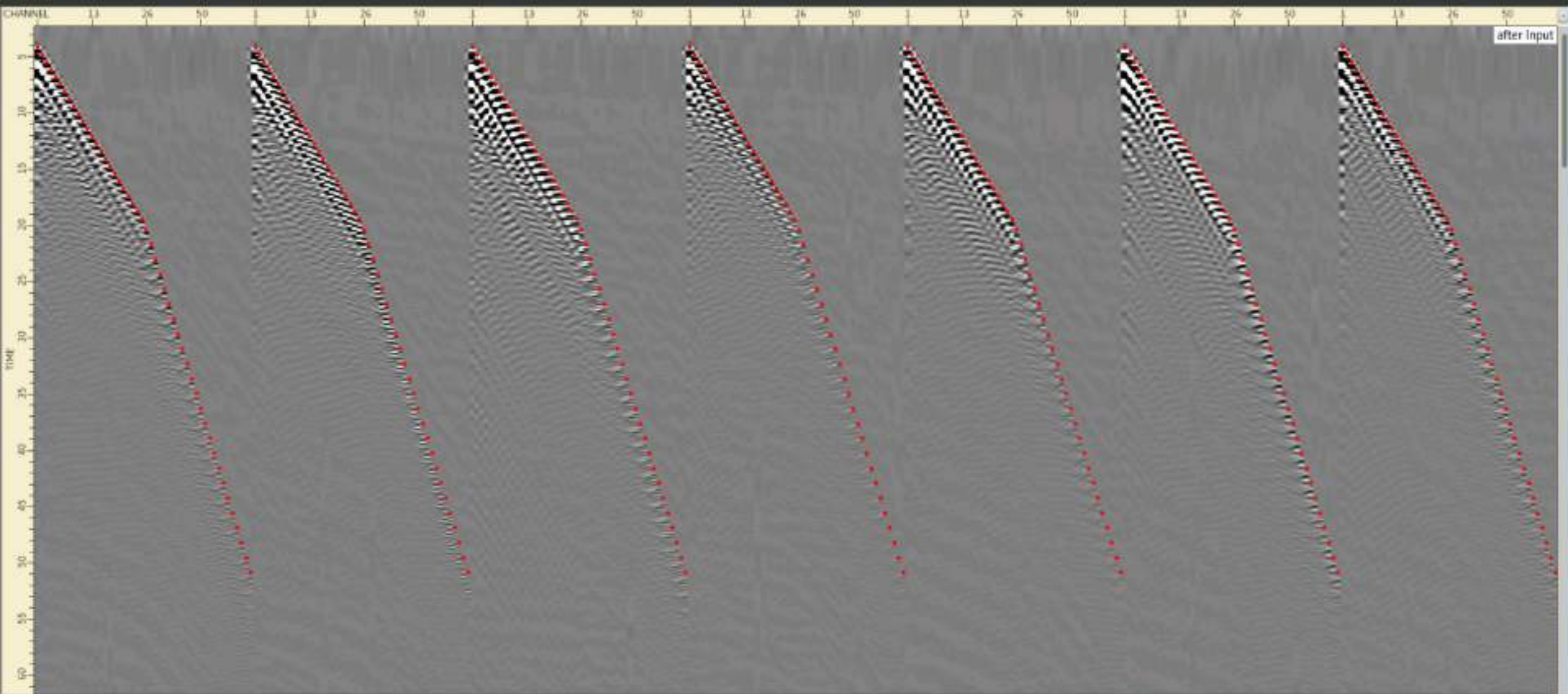
# PRE-FILTER



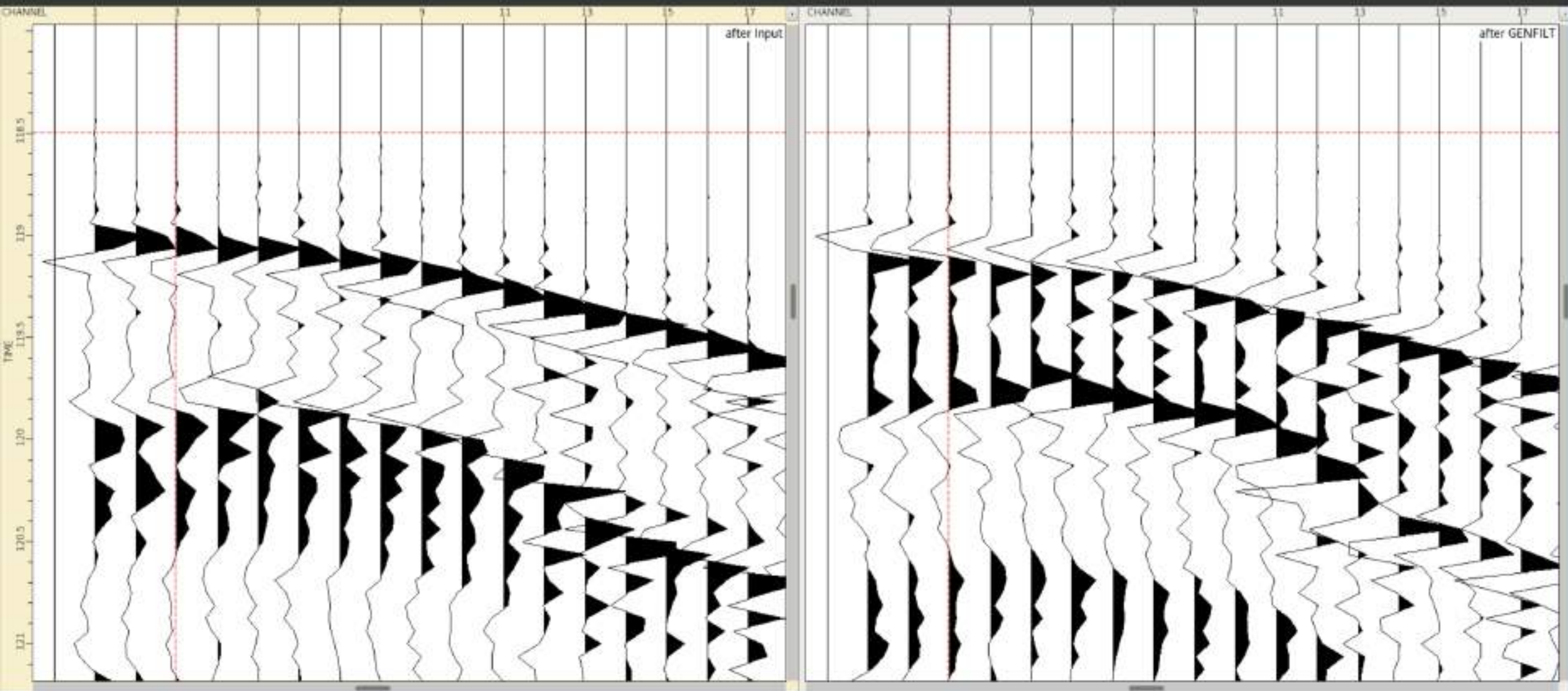
# INCREASE SAMPLE RATE TO 0.1MS



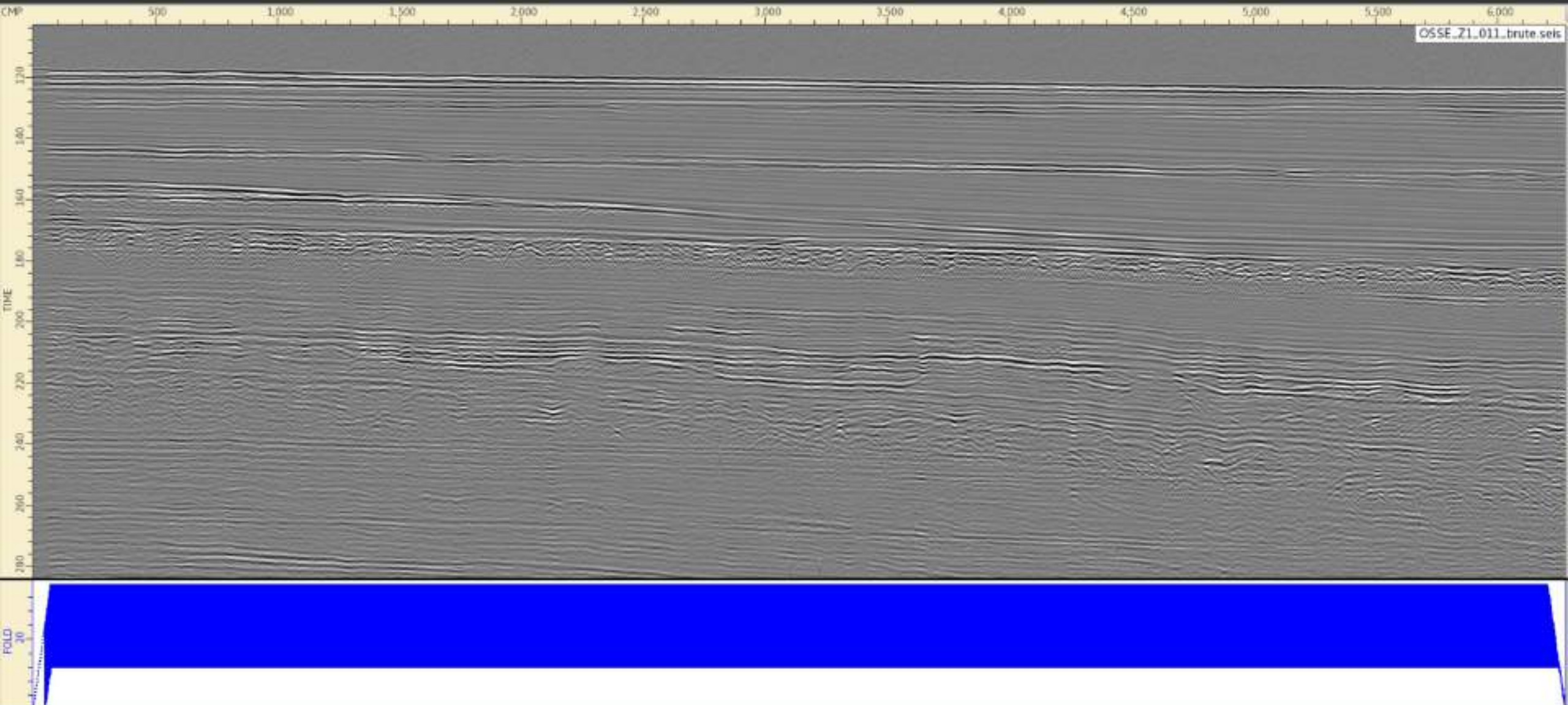
# DIRECT ARRIVAL GEOMETRY QC



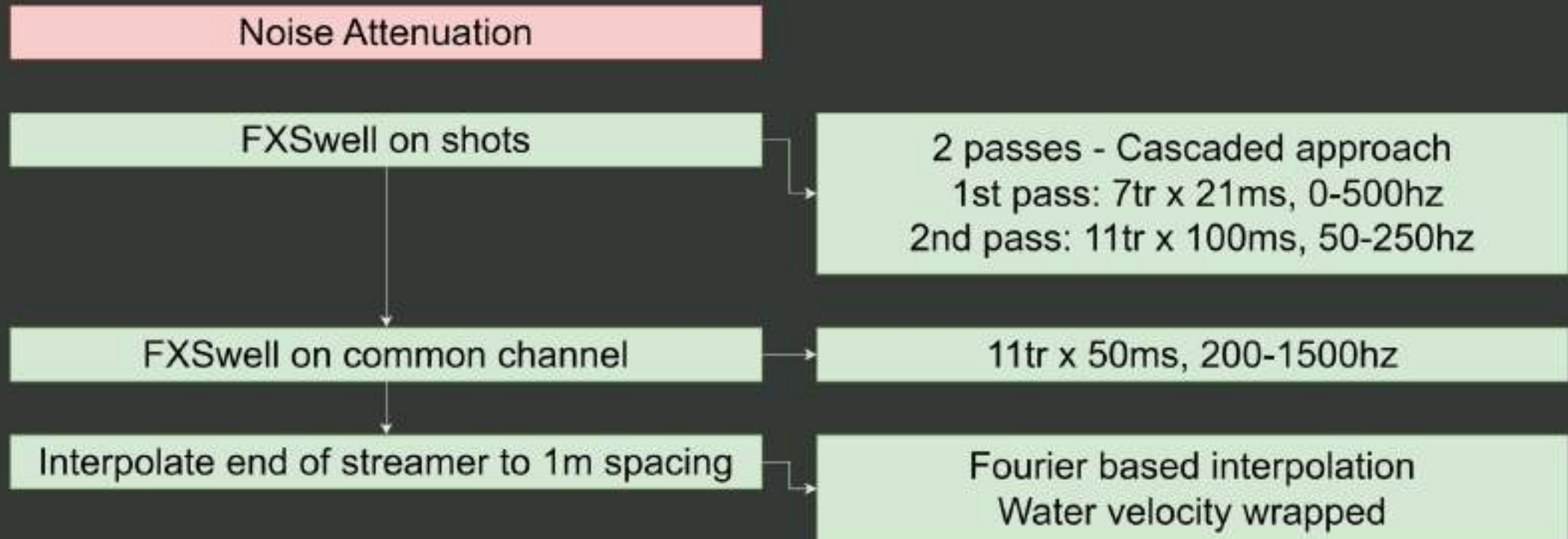
# FLIP POLARITY



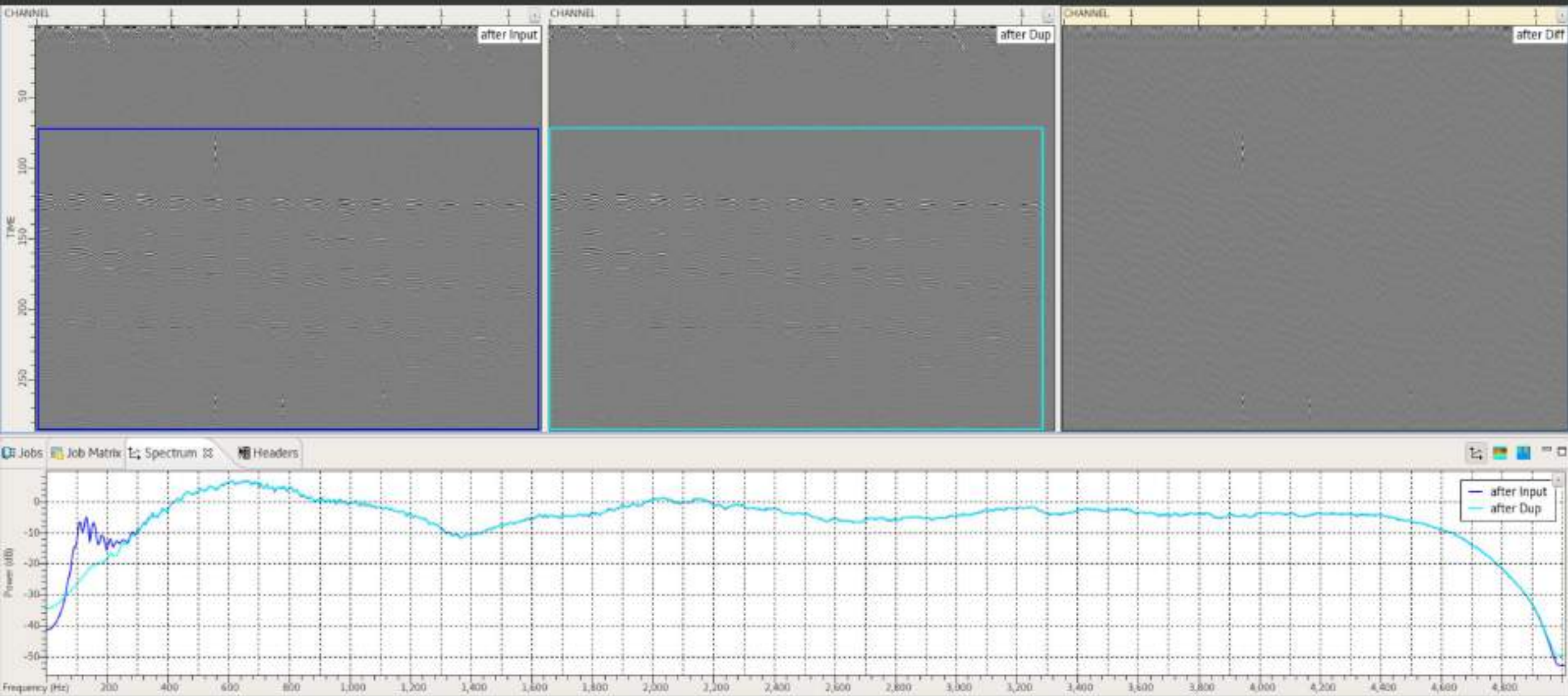
# BRUTE STACK



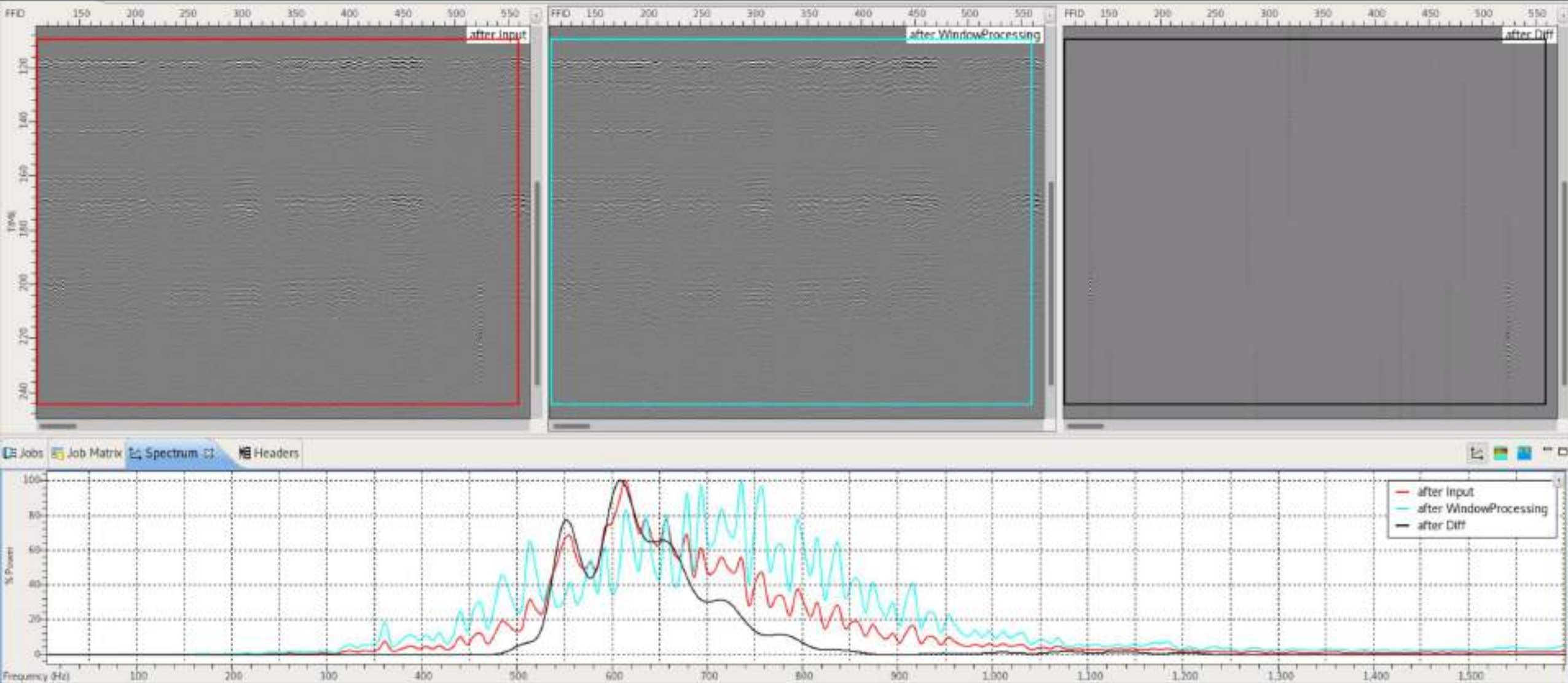
# NOISE ATTENUATION



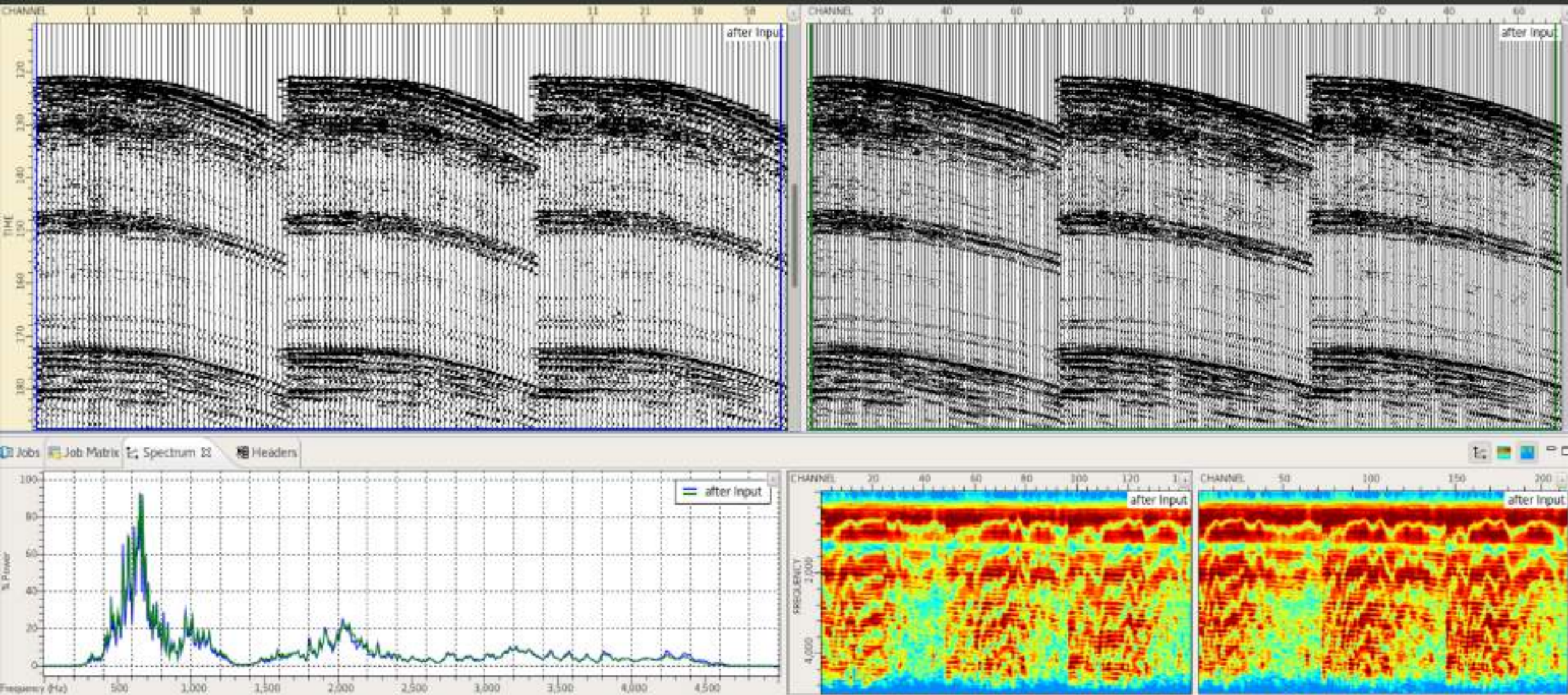
# 1<sup>ST</sup> PASS NOISE ATTENUATION – FXSWELL ON SHOTS



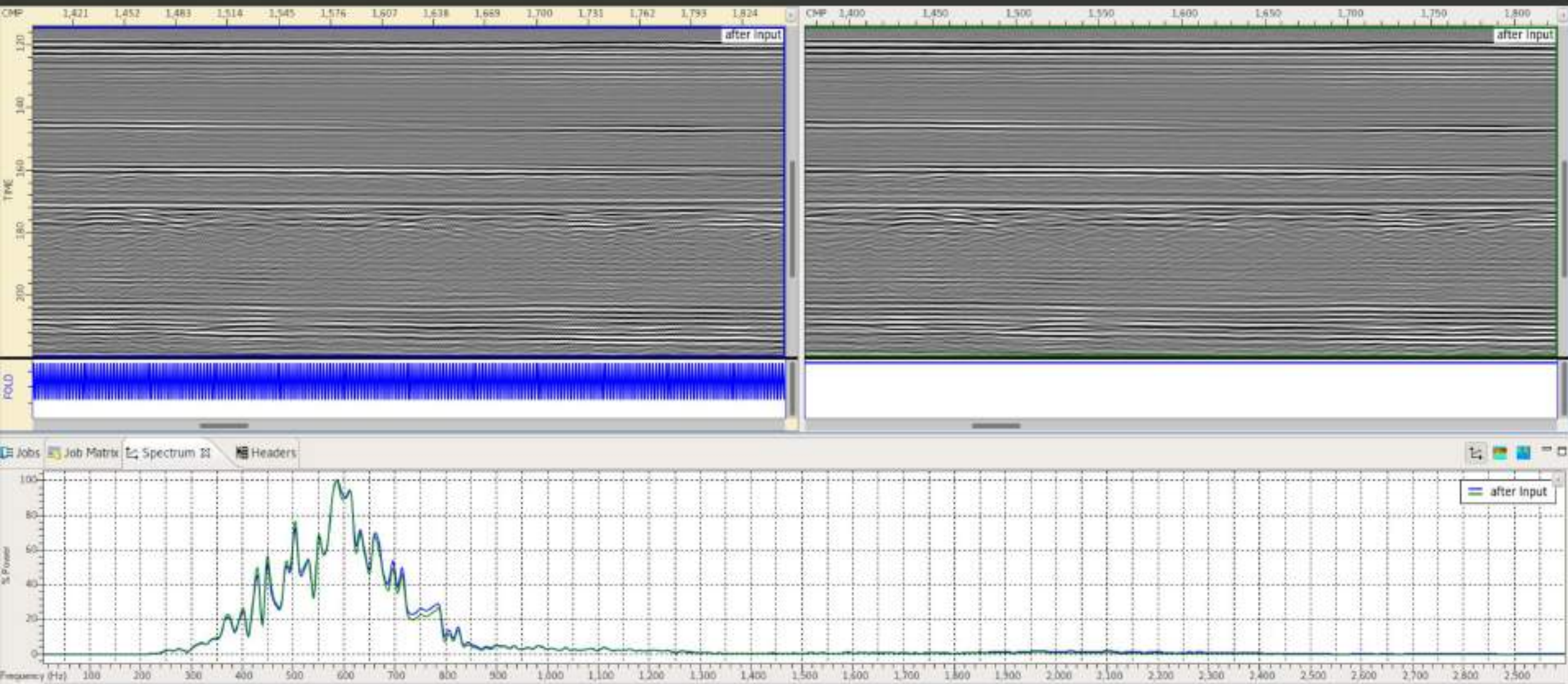
# 2<sup>ND</sup> PASS NOISE ATTENUATION – FXSWELL ON CHANNELS



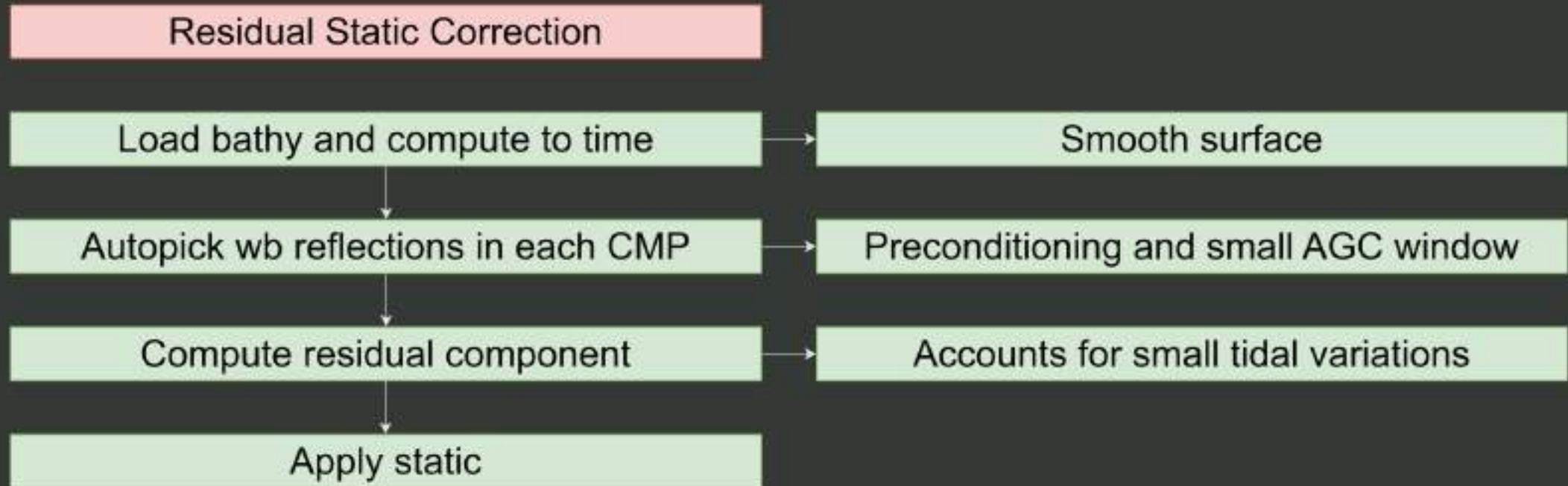
# INTERPOLATE SHOTS TO 1M RECEIVER SPACING



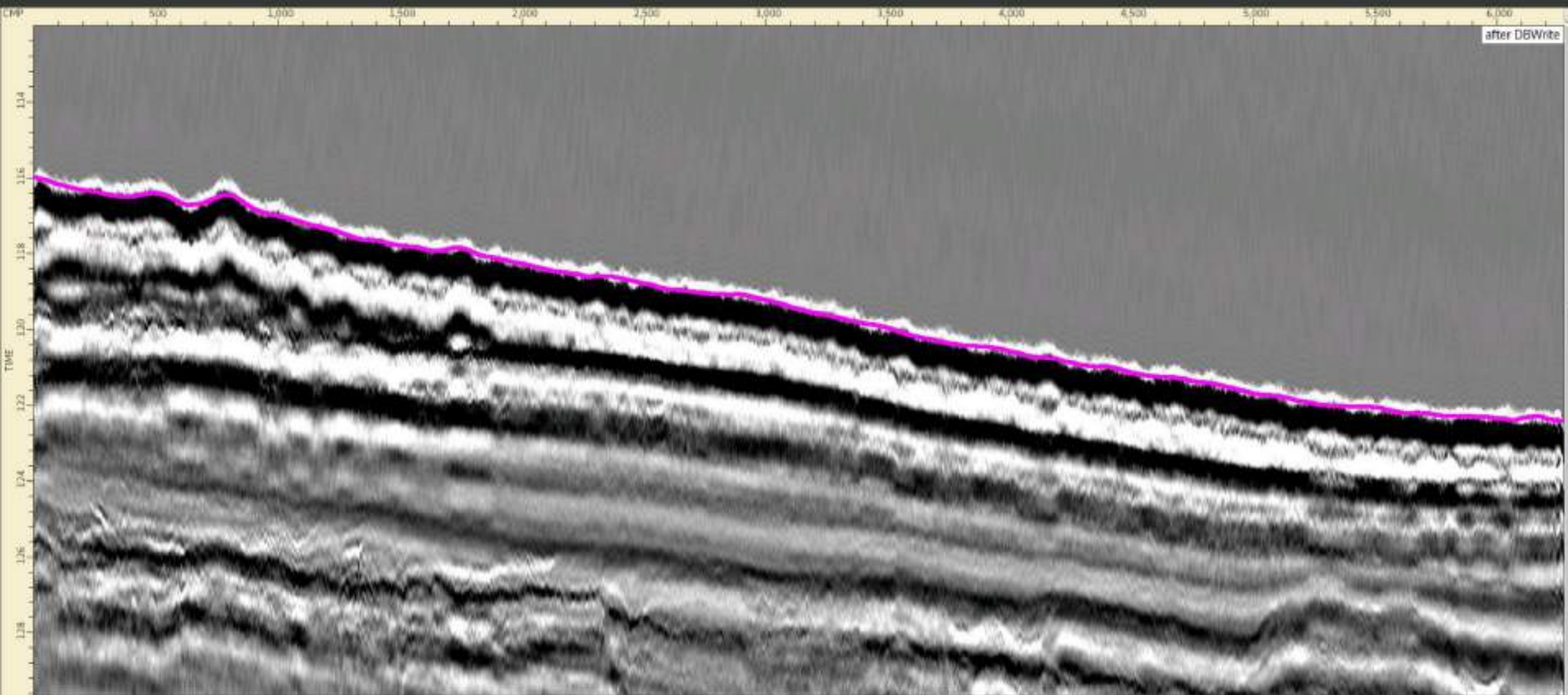
# DENOISE STACK VS. INTERPOLATED STACK



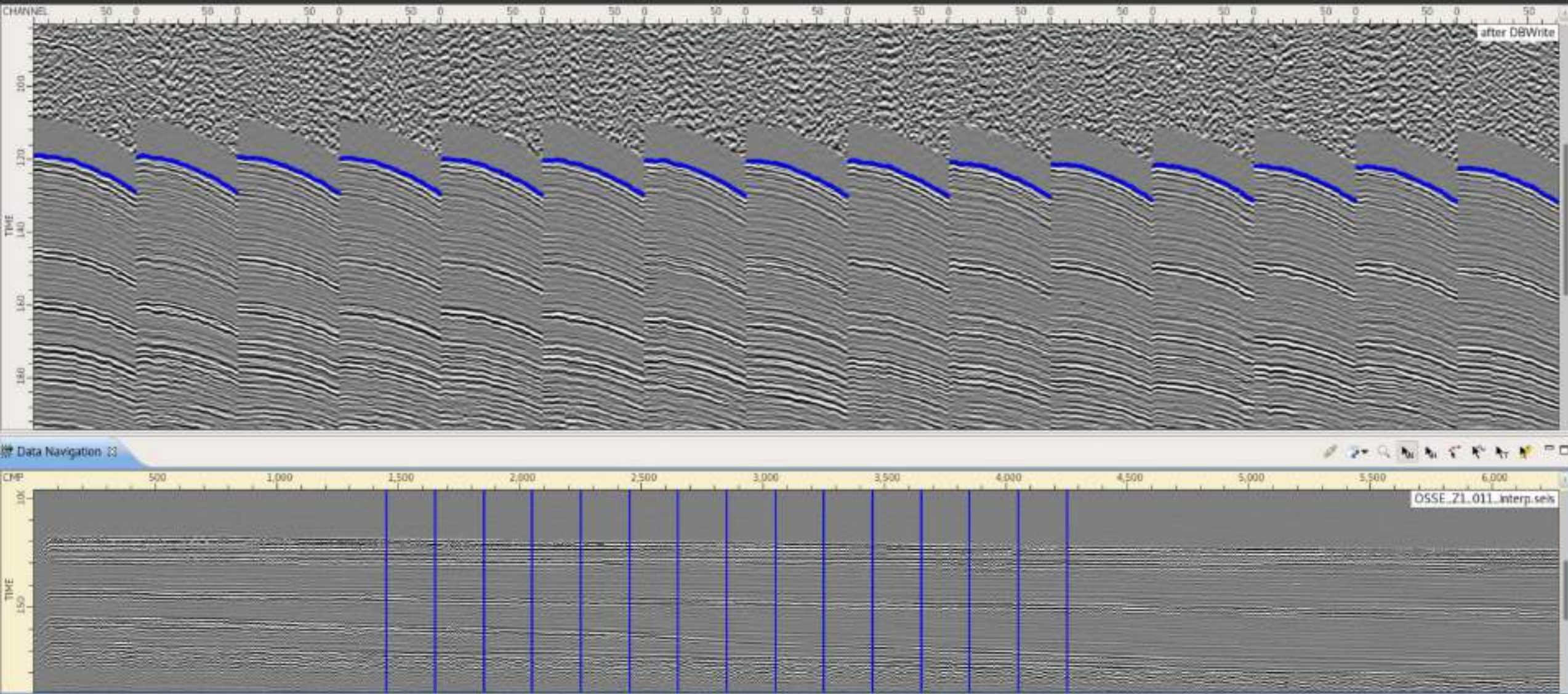
# RESIDUAL STATIC CORRECTION



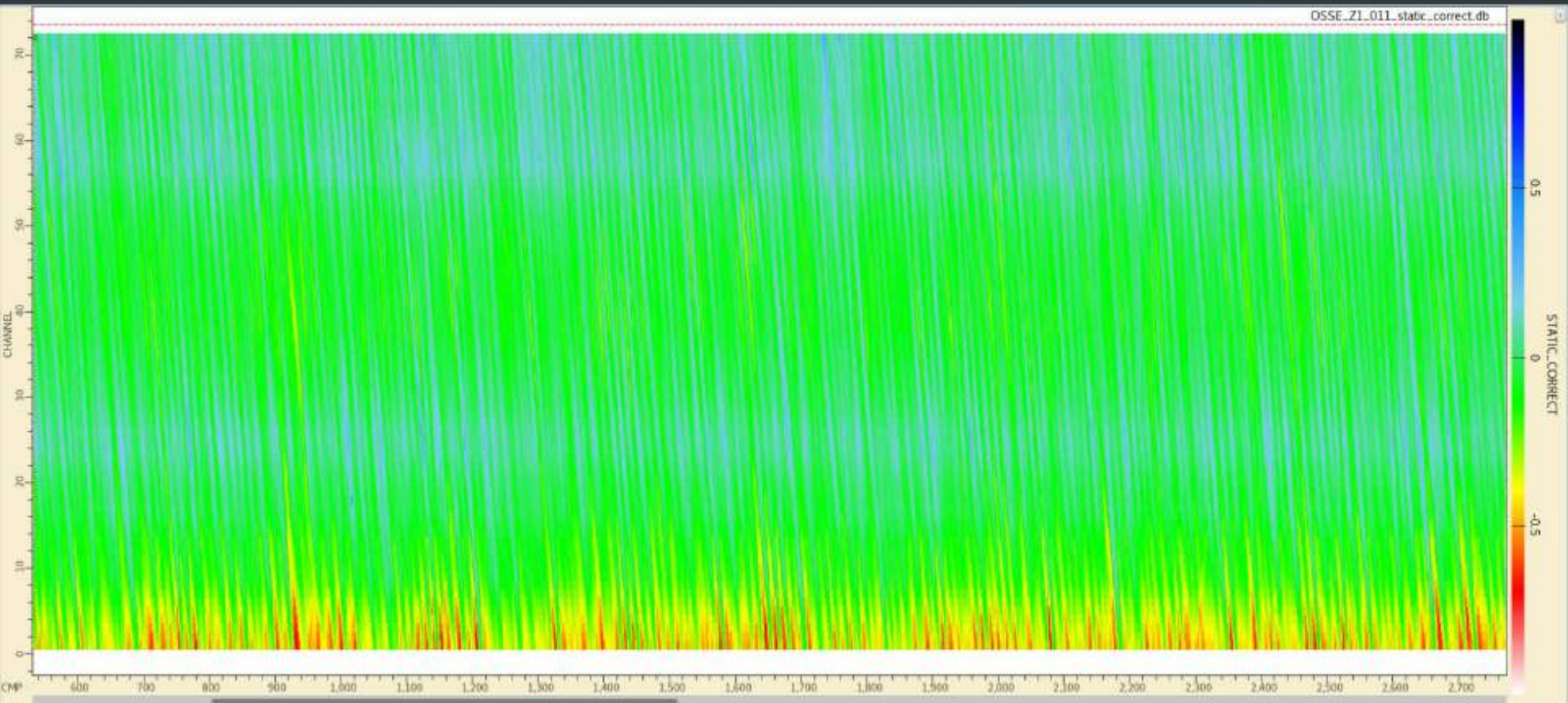
# MULTIBEAM OVERLAY ON STACK



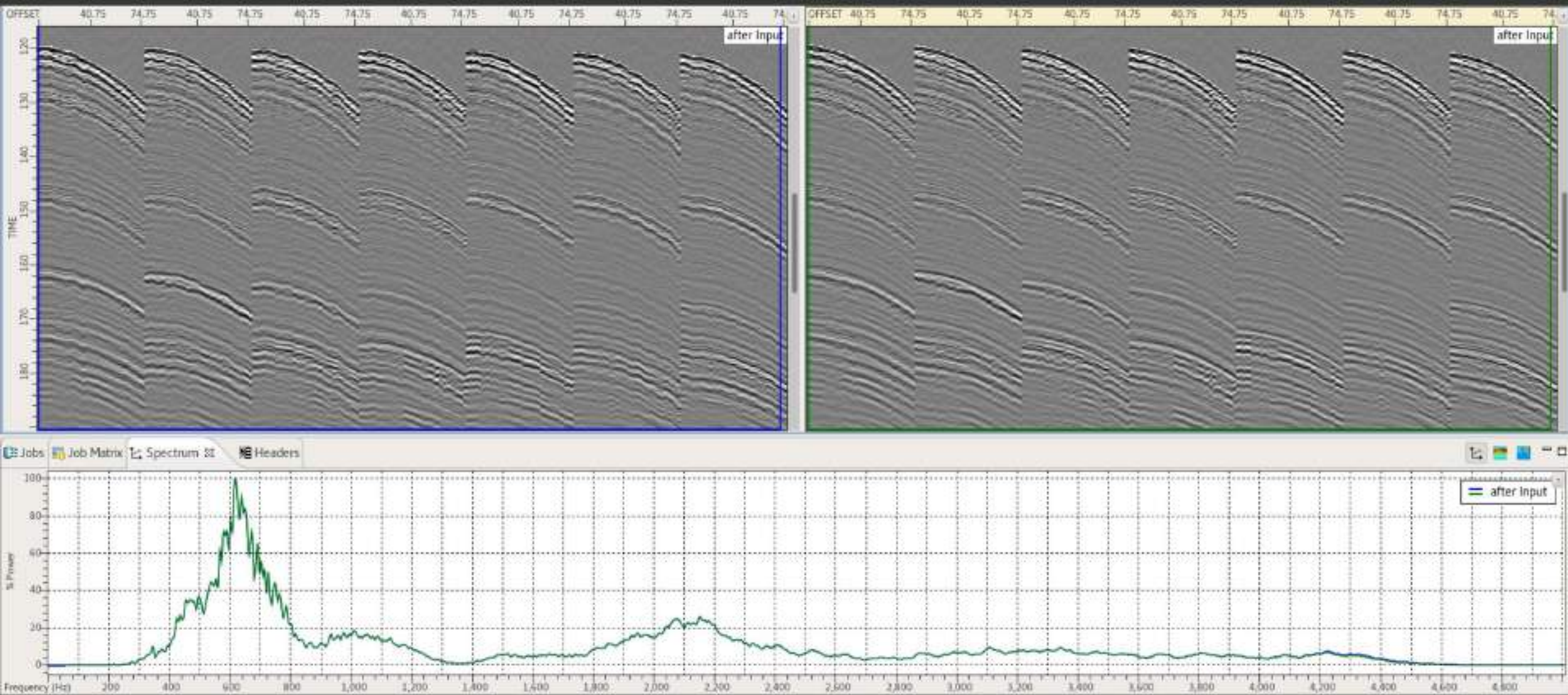
# AUTOPIKED WB REFLECTION TIMES



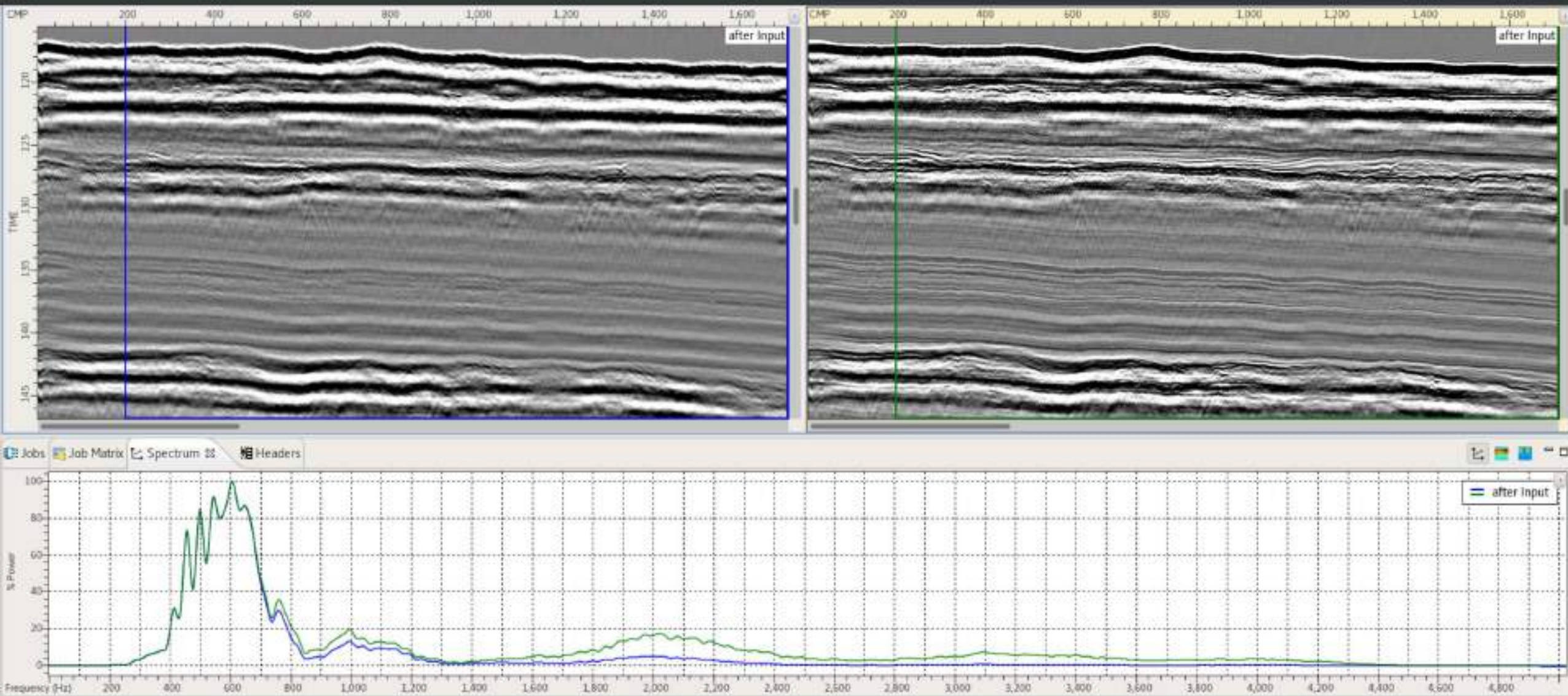
# STATIC MAP



# CMPS BEFORE AND AFTER CORRECTION

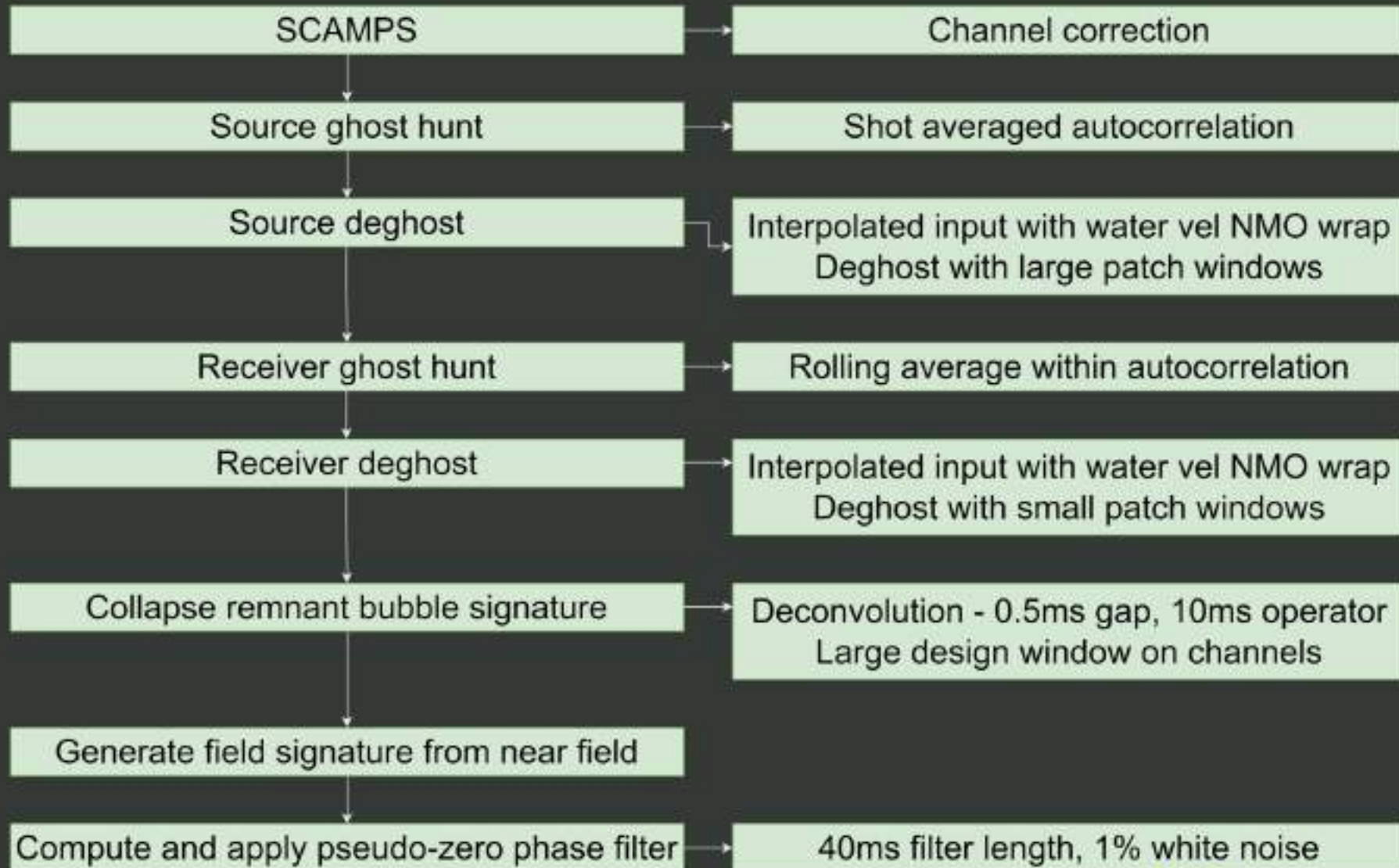


# INTERPOLATED STACK VS. CORRECTED STACK



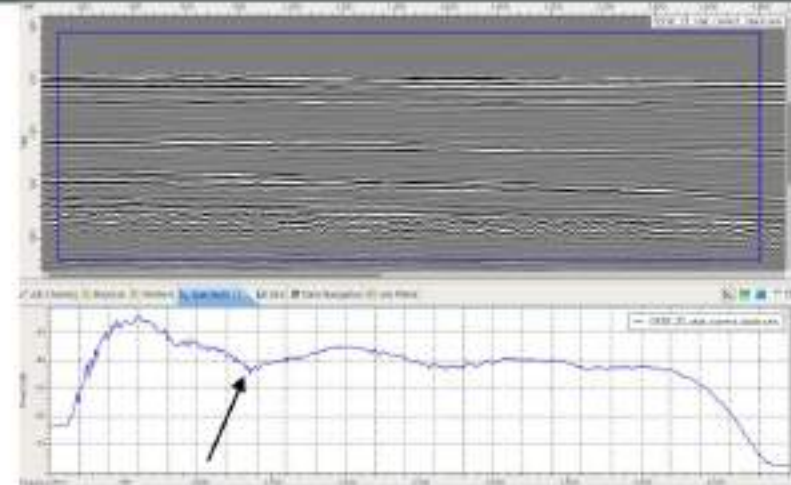
# DEGHOST AND PSEUDO-ZERO PHASE CONVERSION

## Deghost and pseudo-zero phase conversion

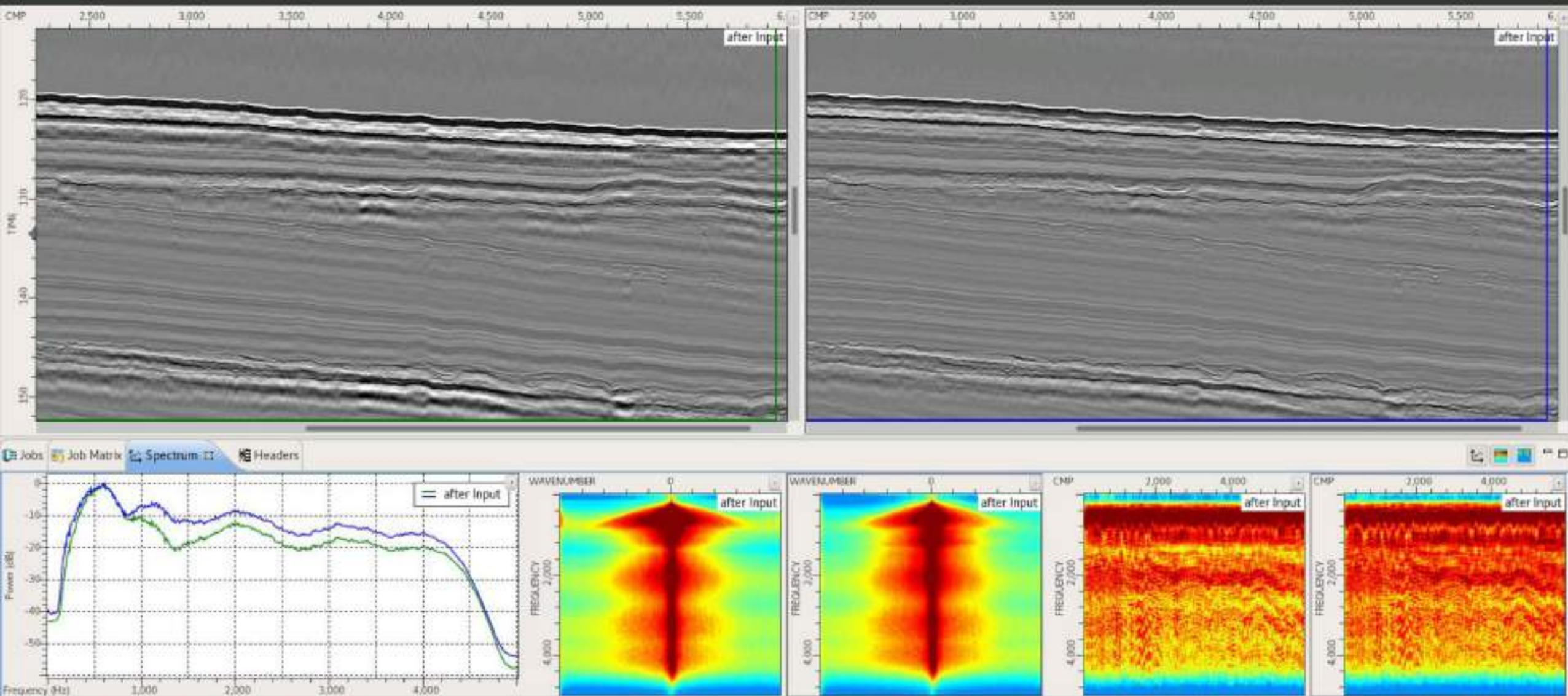


# SOURCE DEPTH CALCULATION

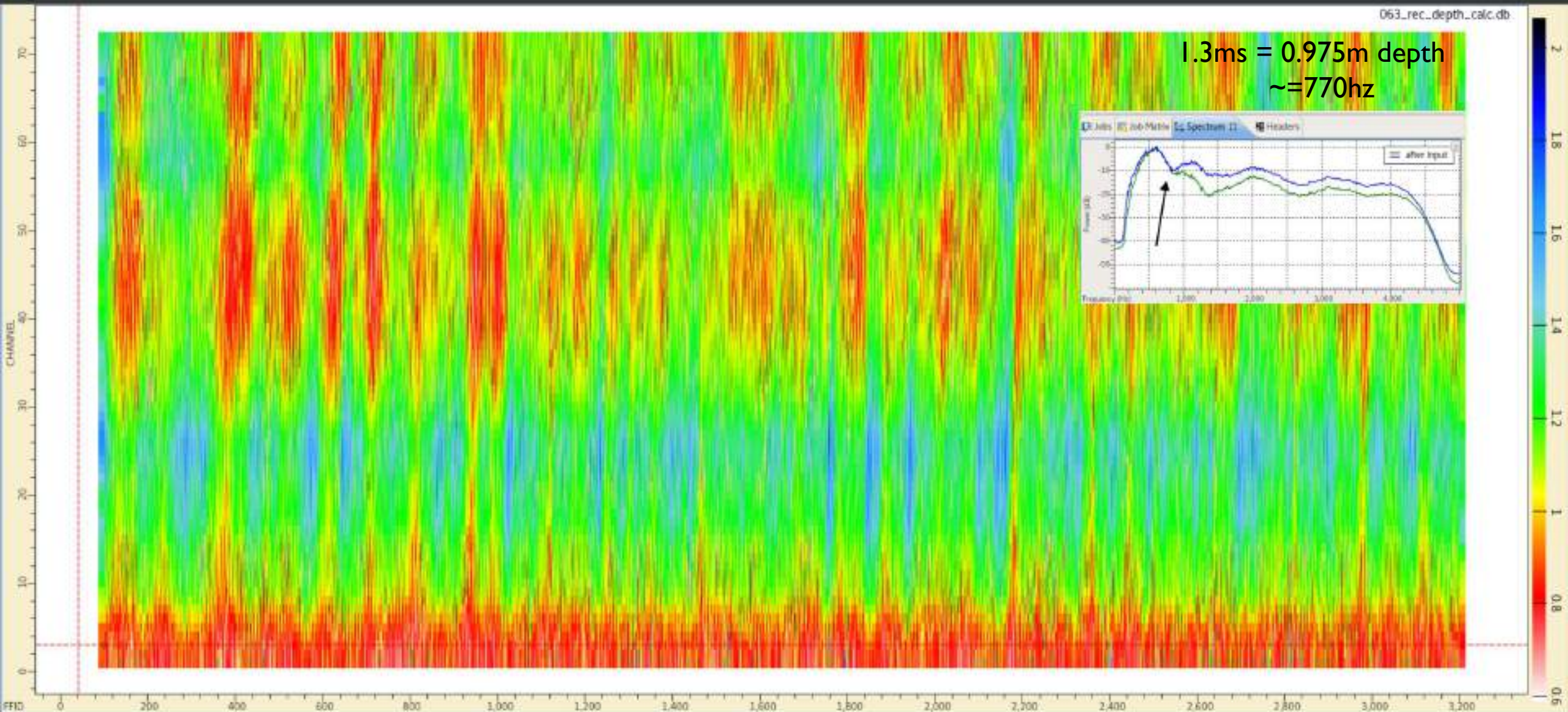
0.725ms = 0.54m depth  
≈ 1390hz



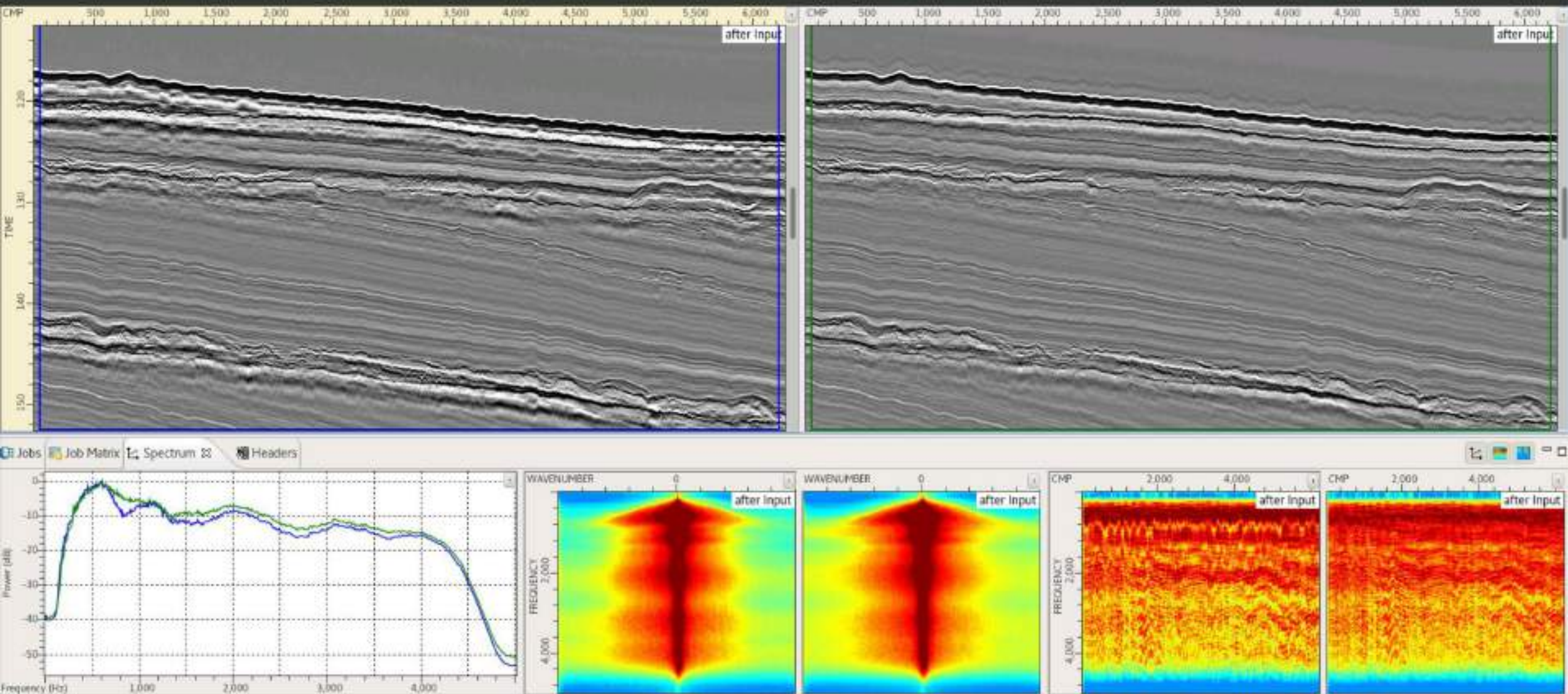
# BEFORE AND AFTER SOURCE DEGHOSTING



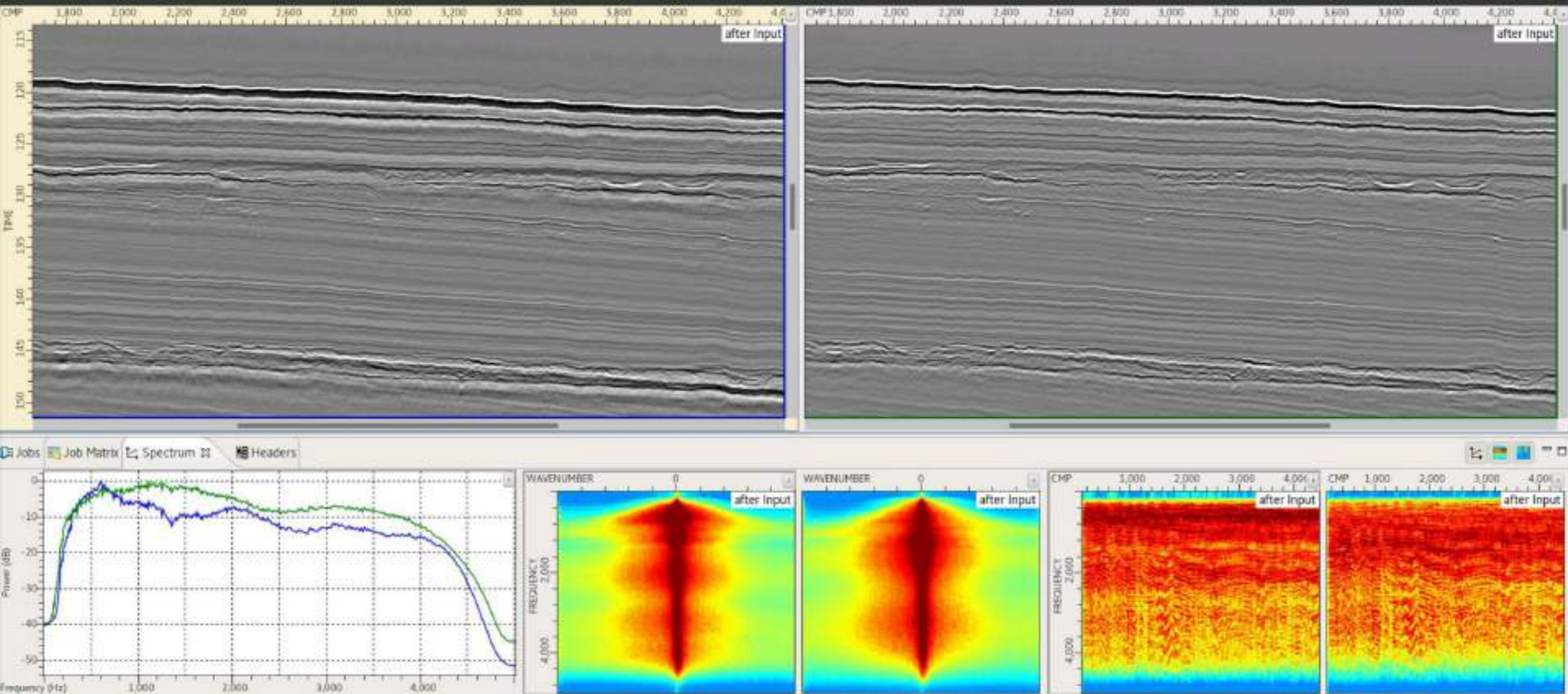
# RECEIVER DEPTHS – FFID VS. CHANNEL



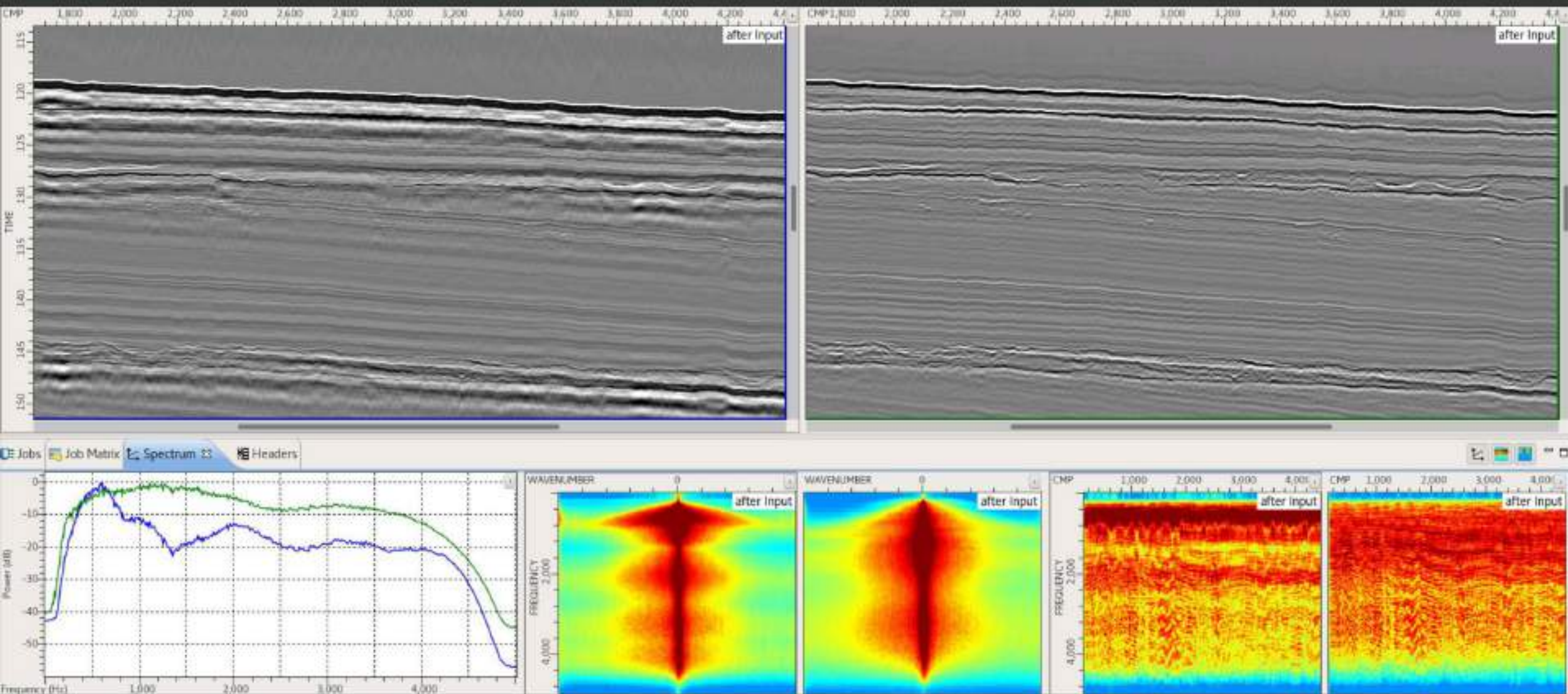
# BEFORE AND AFTER RECEIVER DEGHOSTING



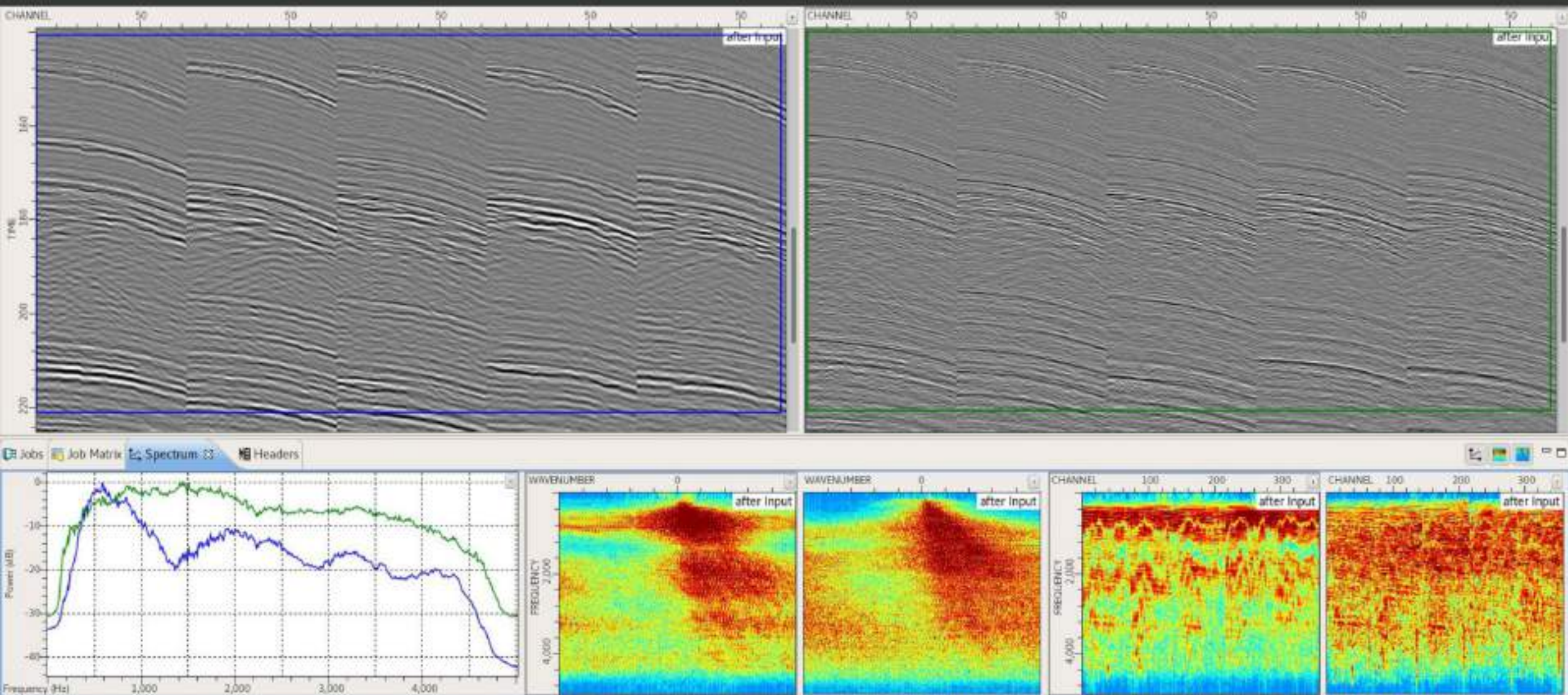
# BEFORE AND AFTER WAVELET COMPRESSION



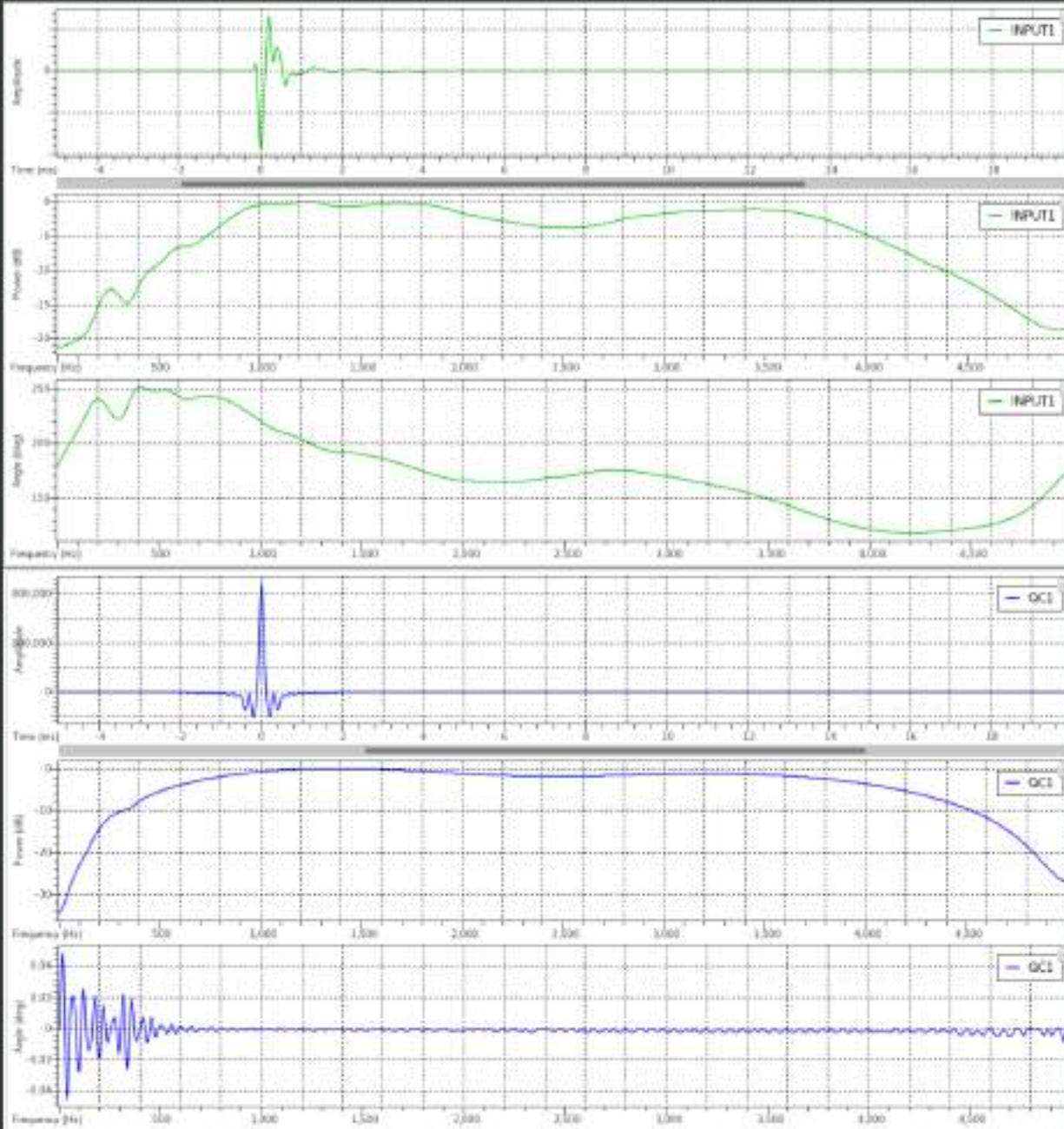
# BEFORE AND AFTER DEGHOSTING



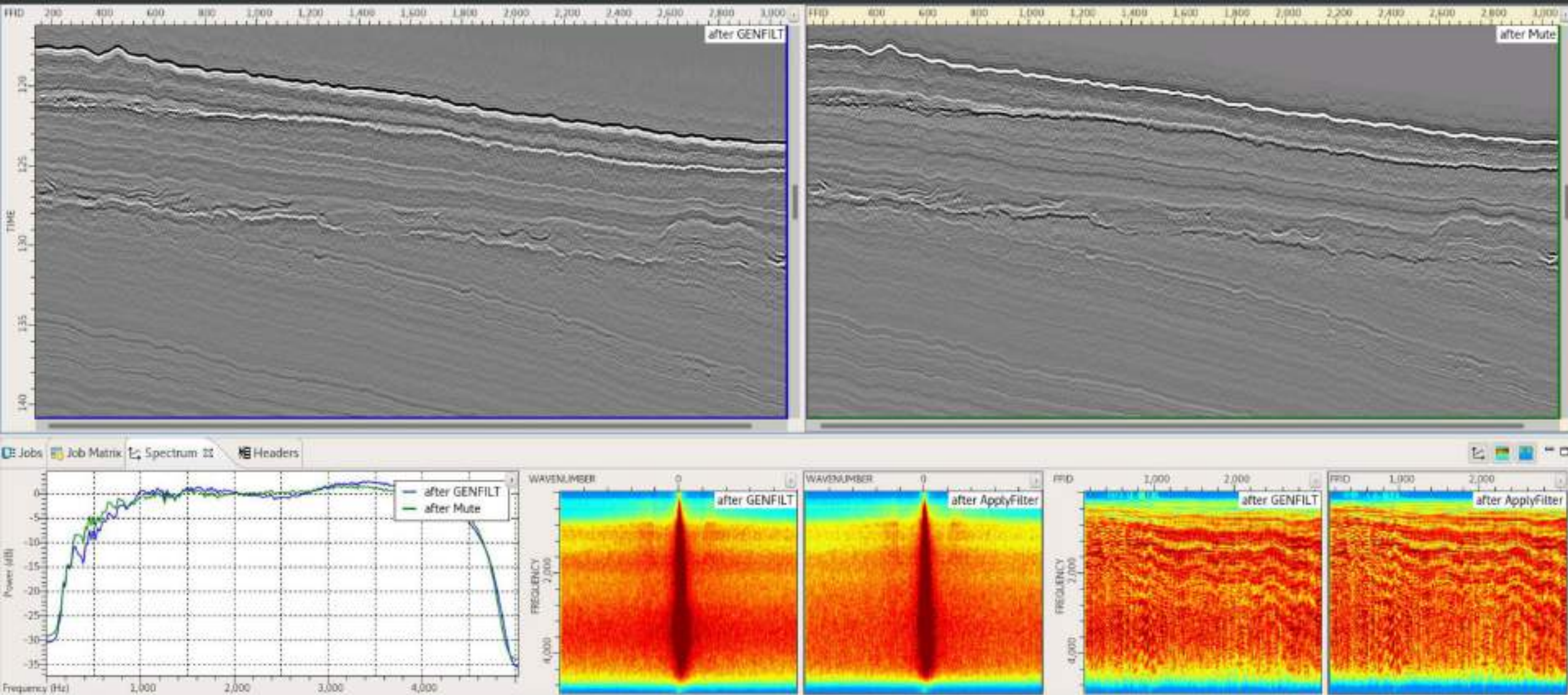
# SHOTS BEFORE AND AFTER DEGHOSTING



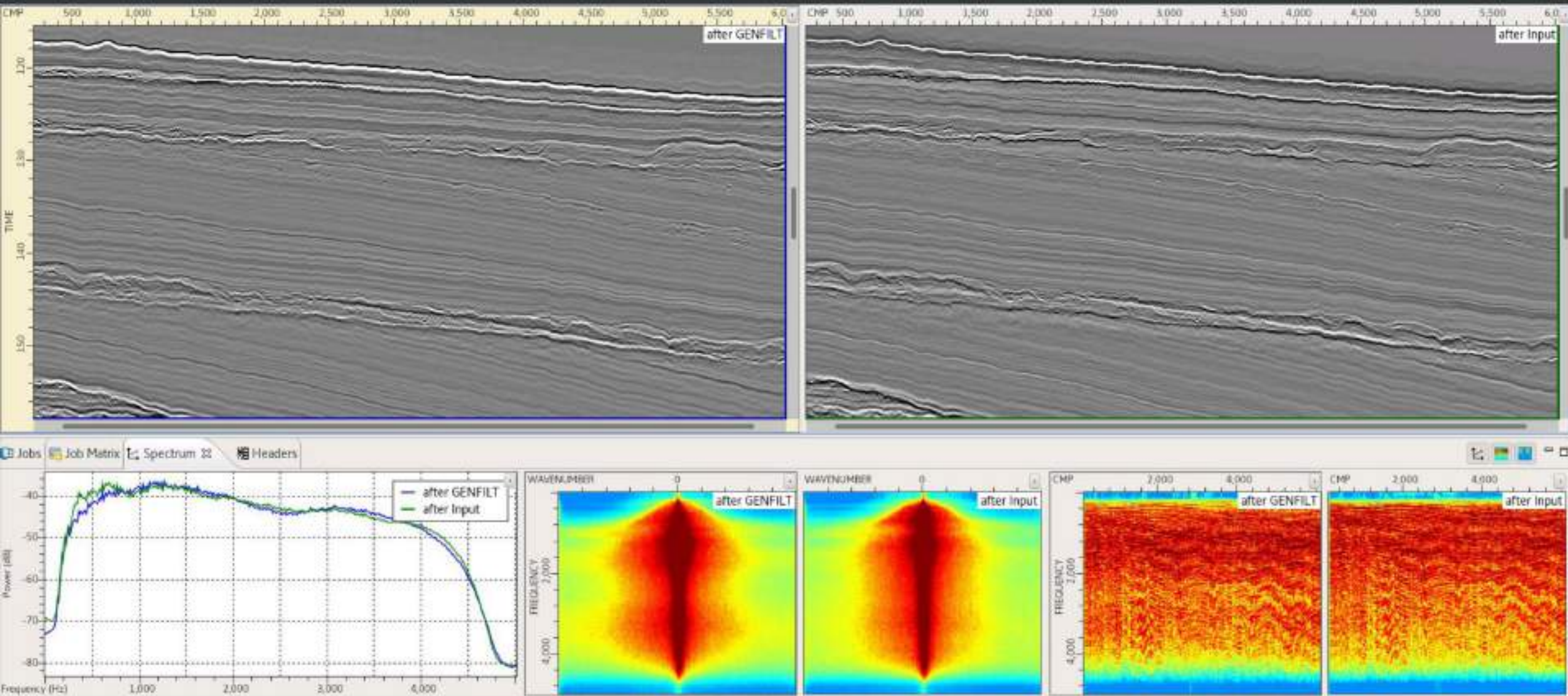
# WAVELET DESIGN



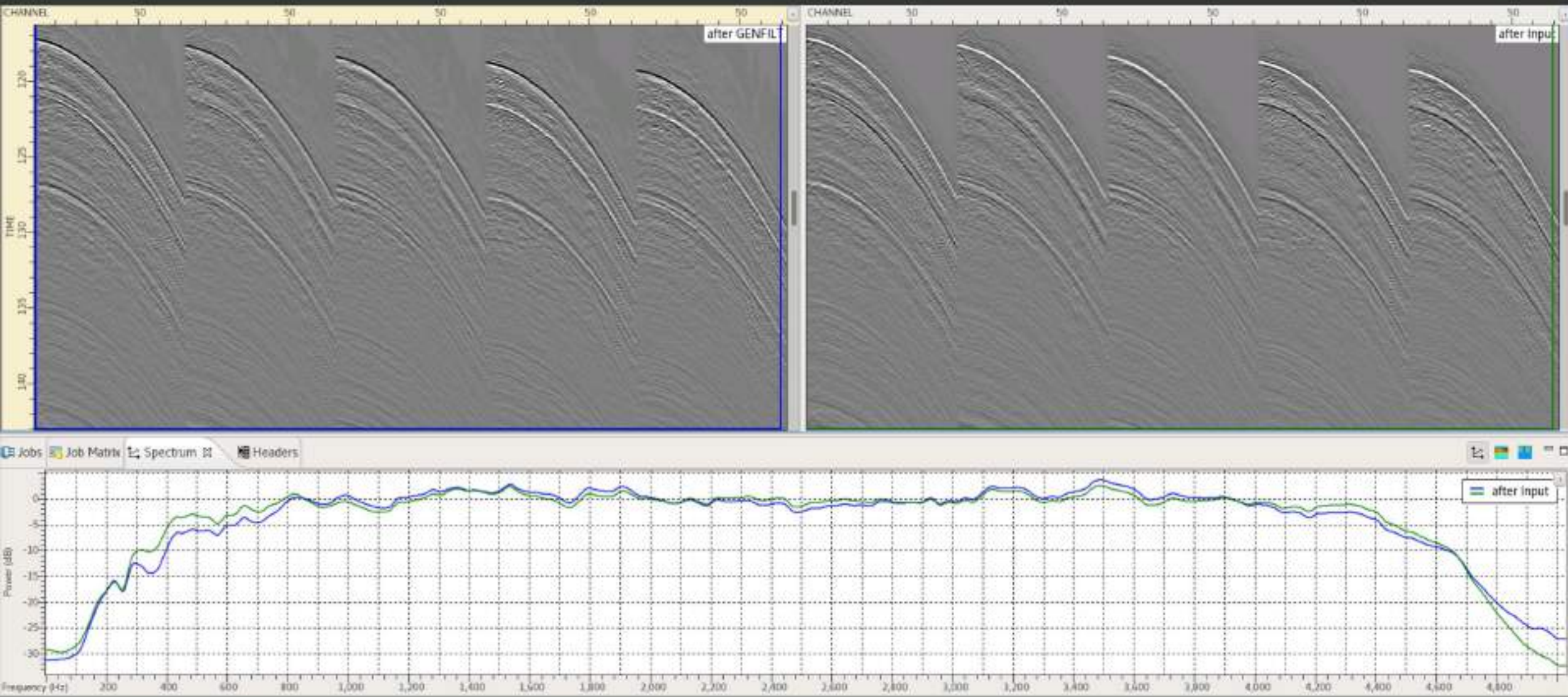
# CHANNEL 10 – BEFORE AND AFTER PSEUDO-ZERO PHASE



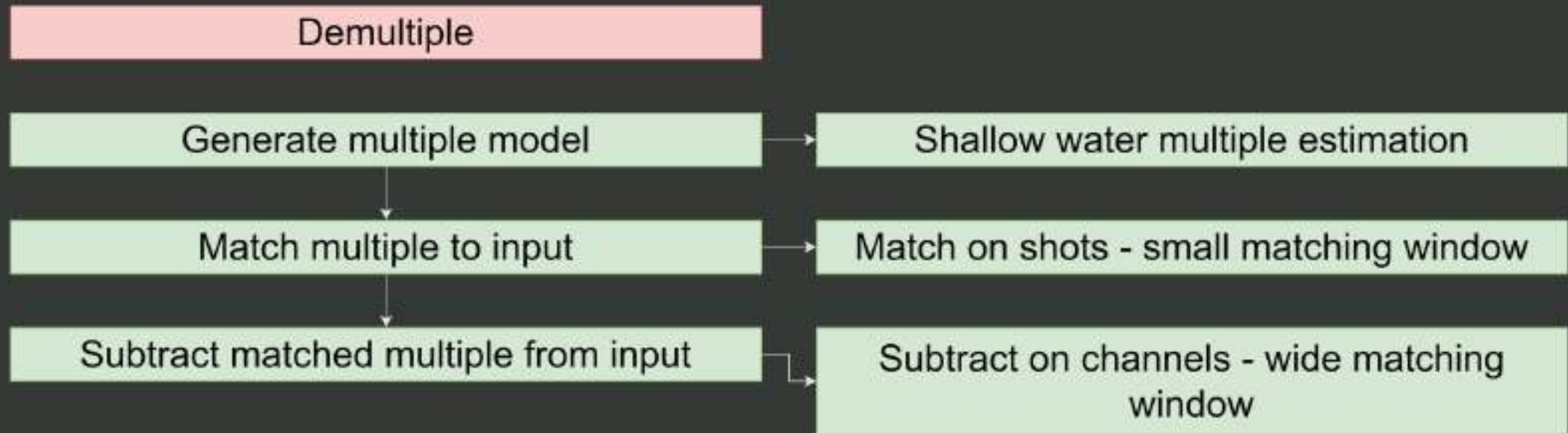
# STACKS BEFORE AND AFTER PSEUDO-ZERO PHASING



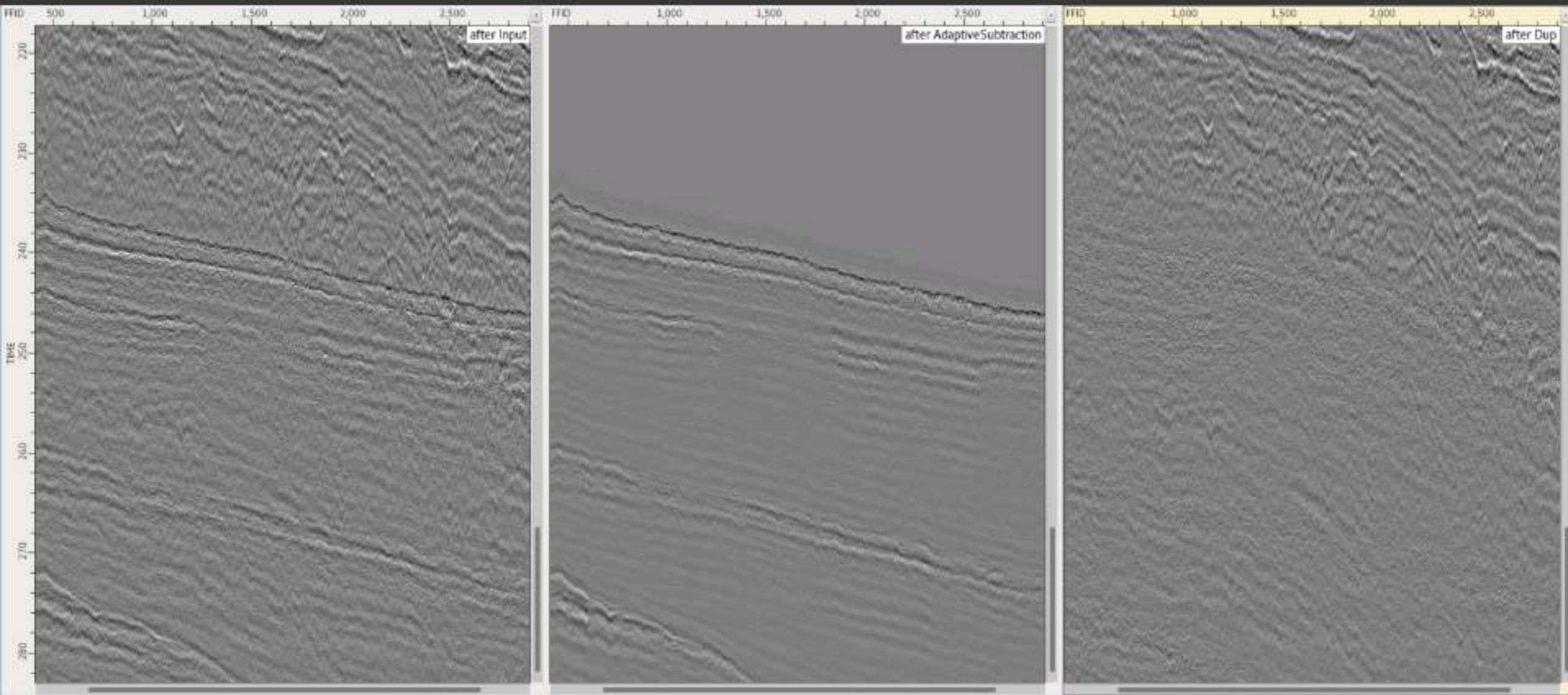
# SHOTS BEFORE AND AFTER PSEUDO-ZERO PHASING



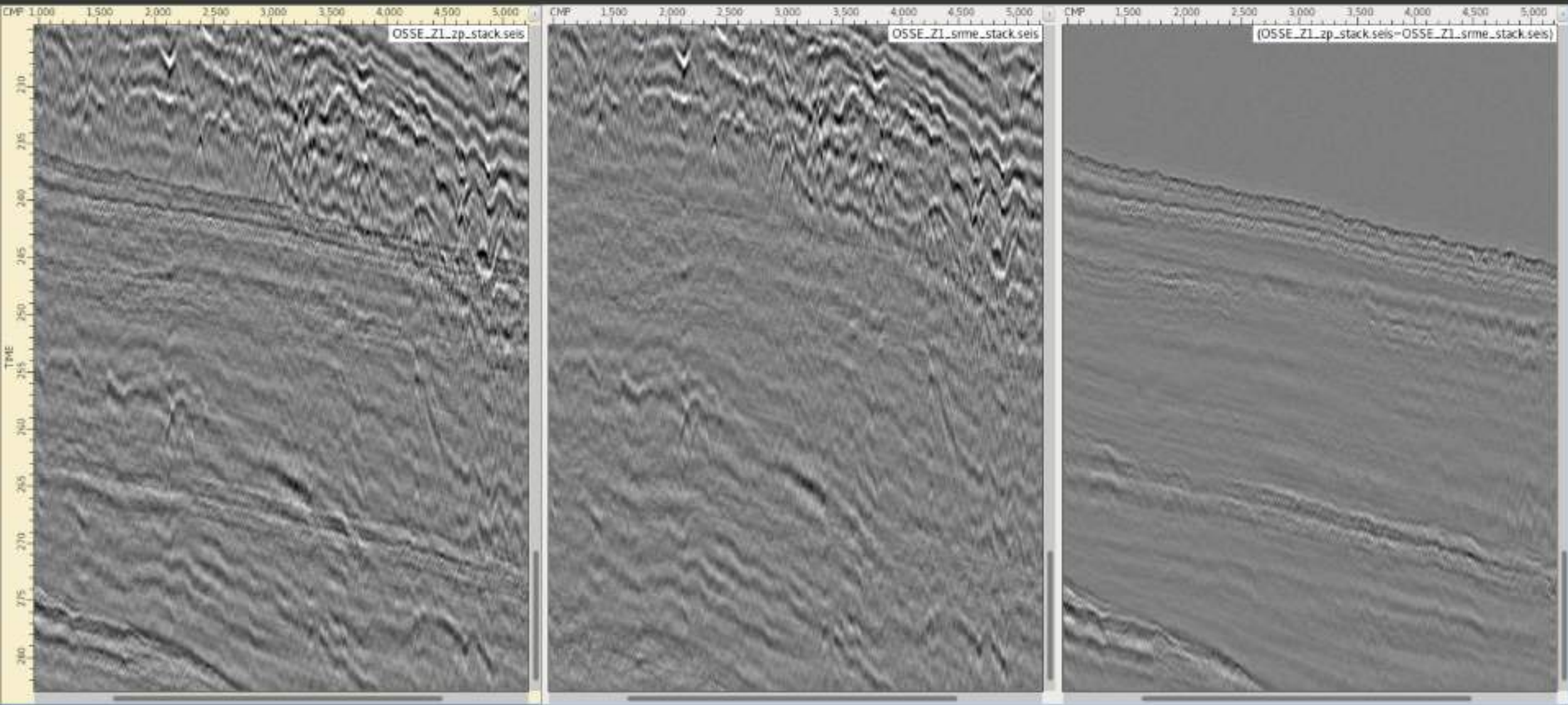
# DEMULTIPLE



# CHANNEL 1 – BEFORE, MODEL AND AFTER SUBTRACTION



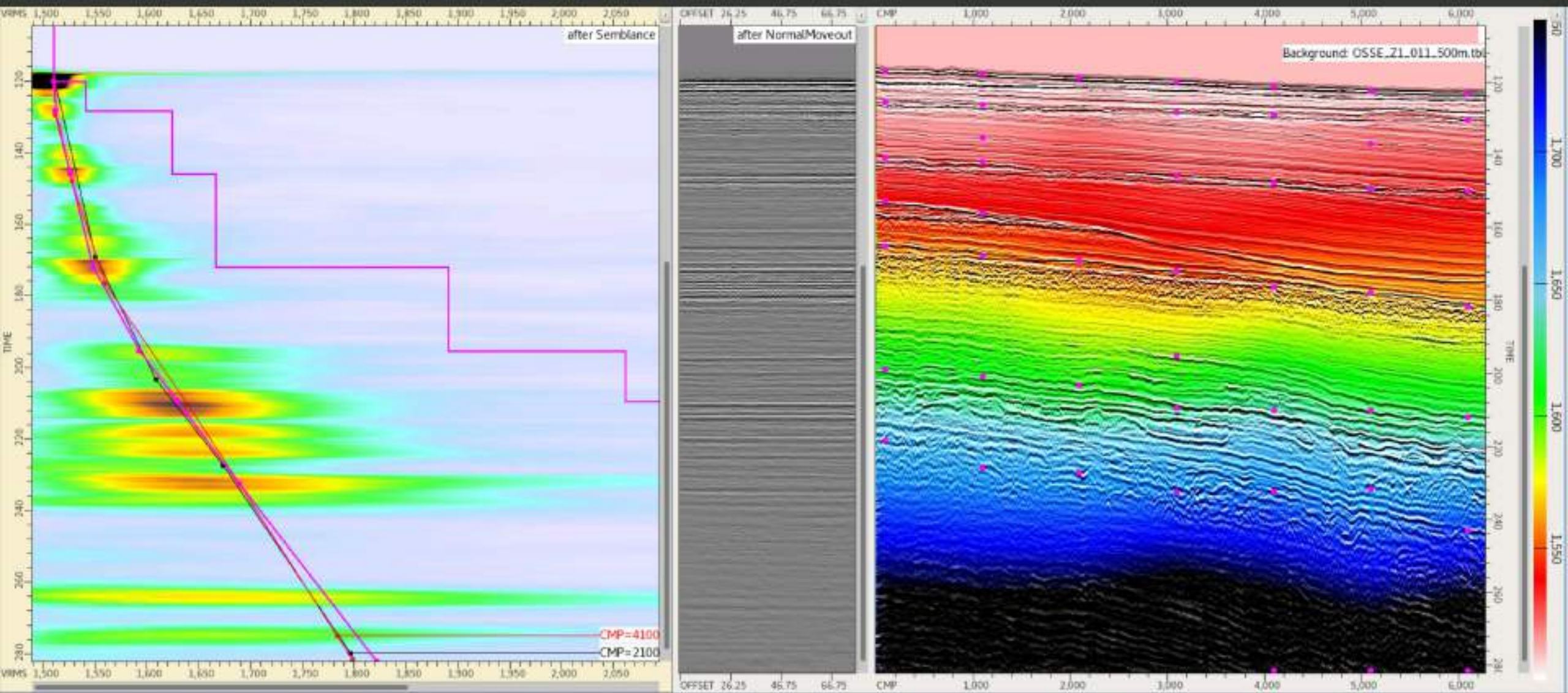
# STACKS – BEFORE, AFTER AND DIFFERENCE



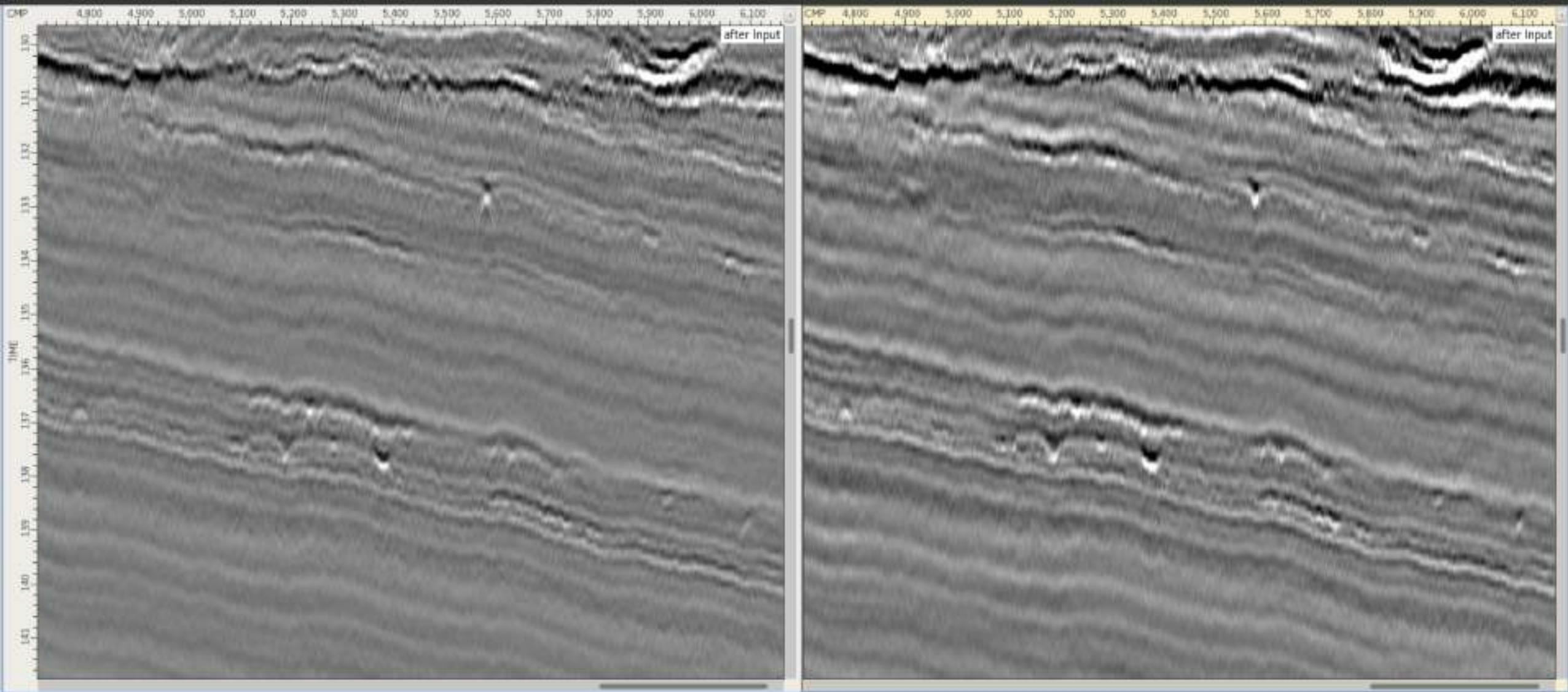
# VELOCITY PICKING, PSTM AND STACK



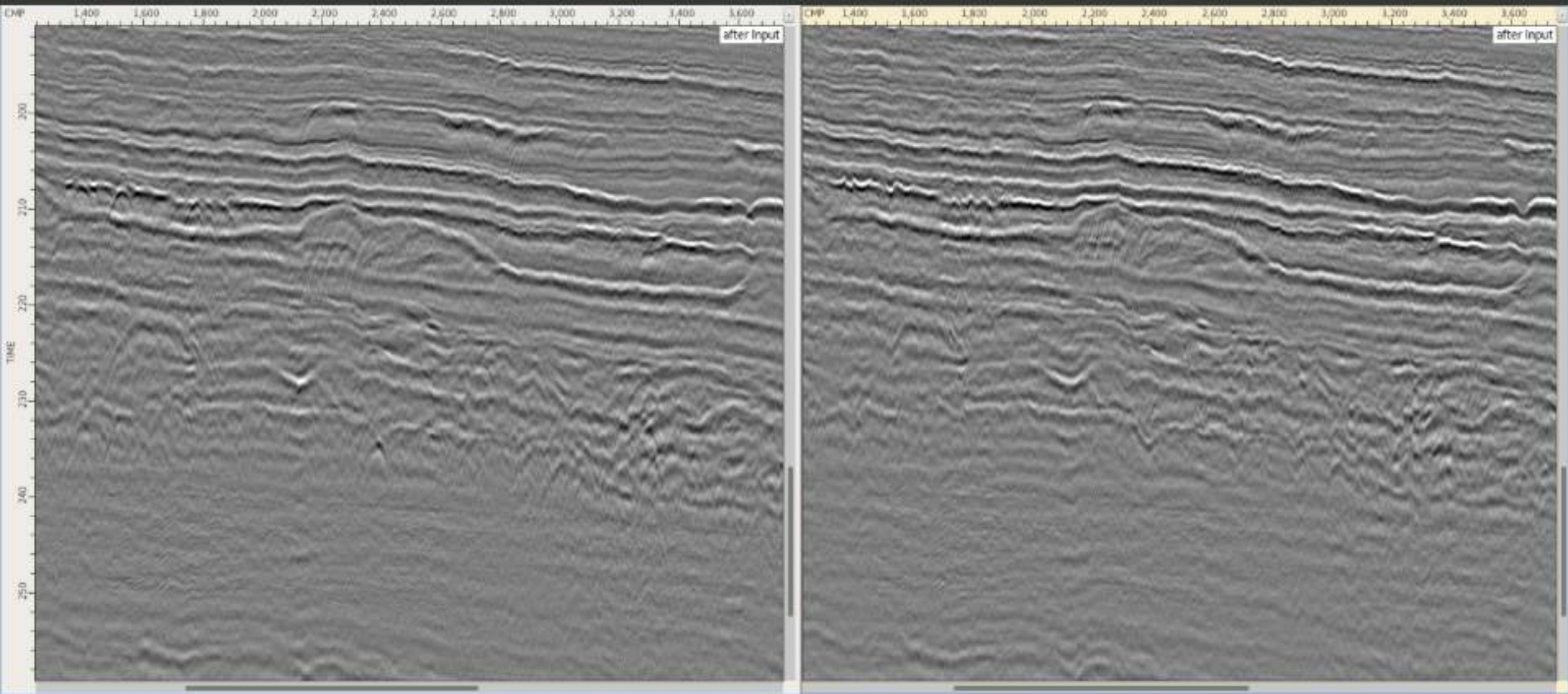
# VELOCITY PICK EXAMPLE AT 0.5KM INTERVAL



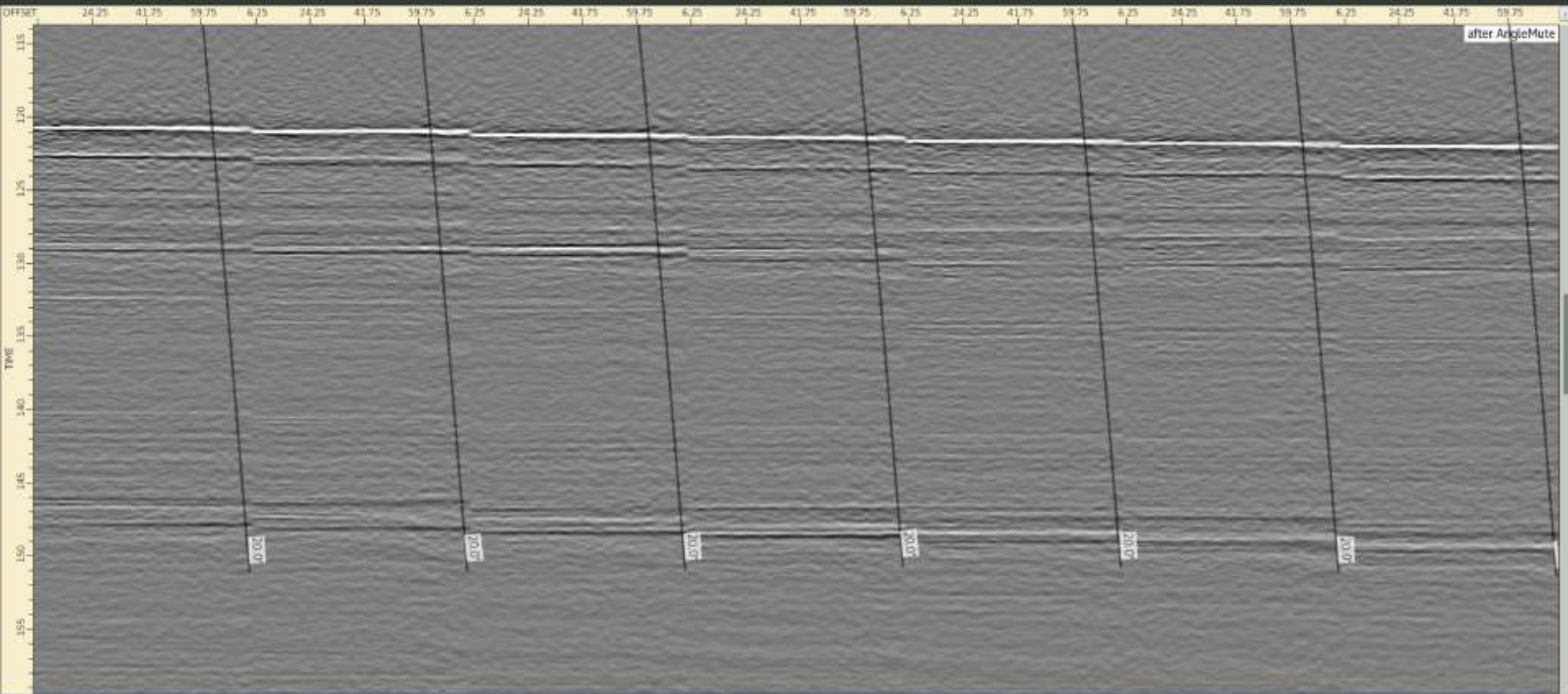
# STACKS BEFORE, AFTER MIGRATION – SHALLOW SECTION



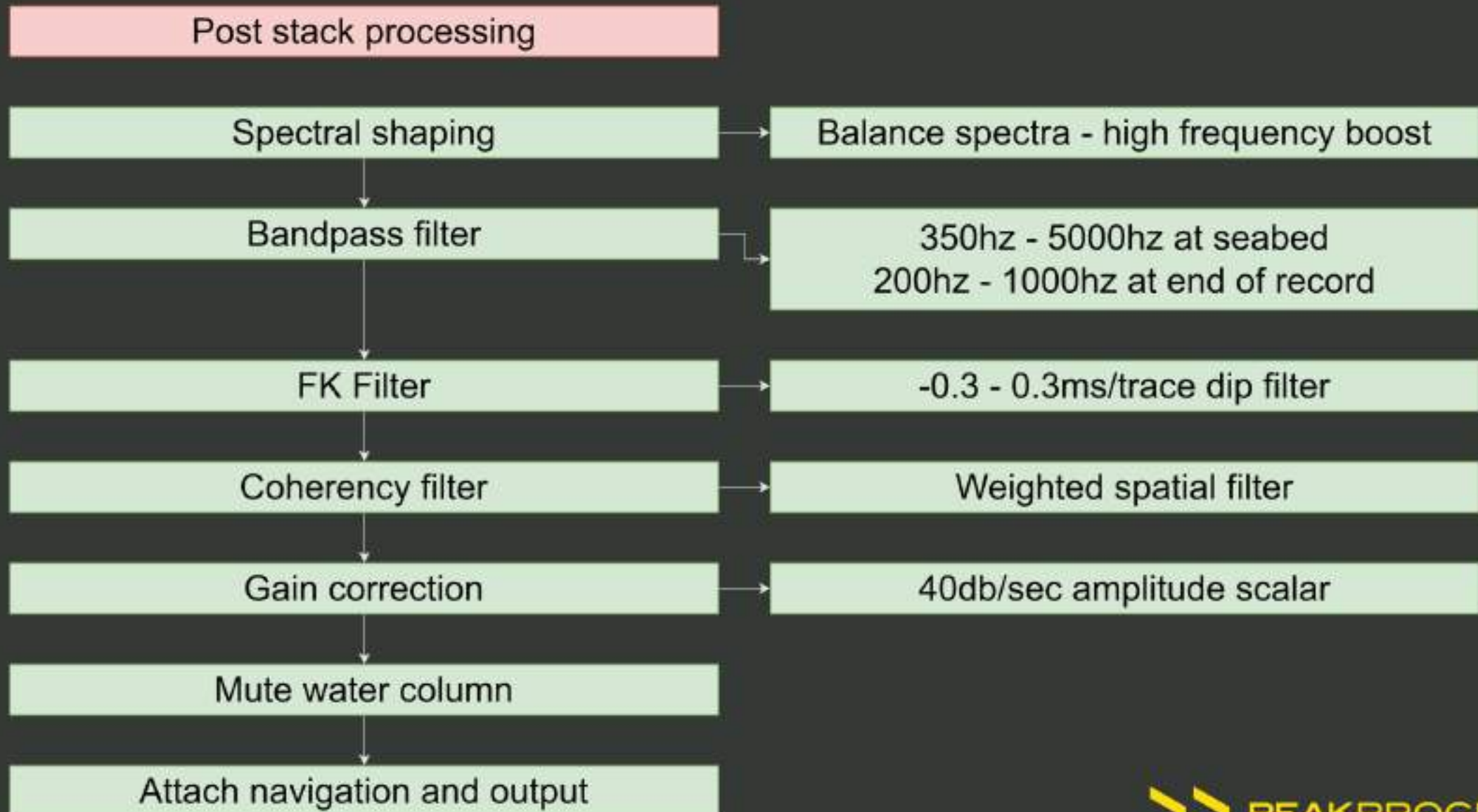
# STACKS BEFORE, AFTER MIGRATION – DEEPER SECTION



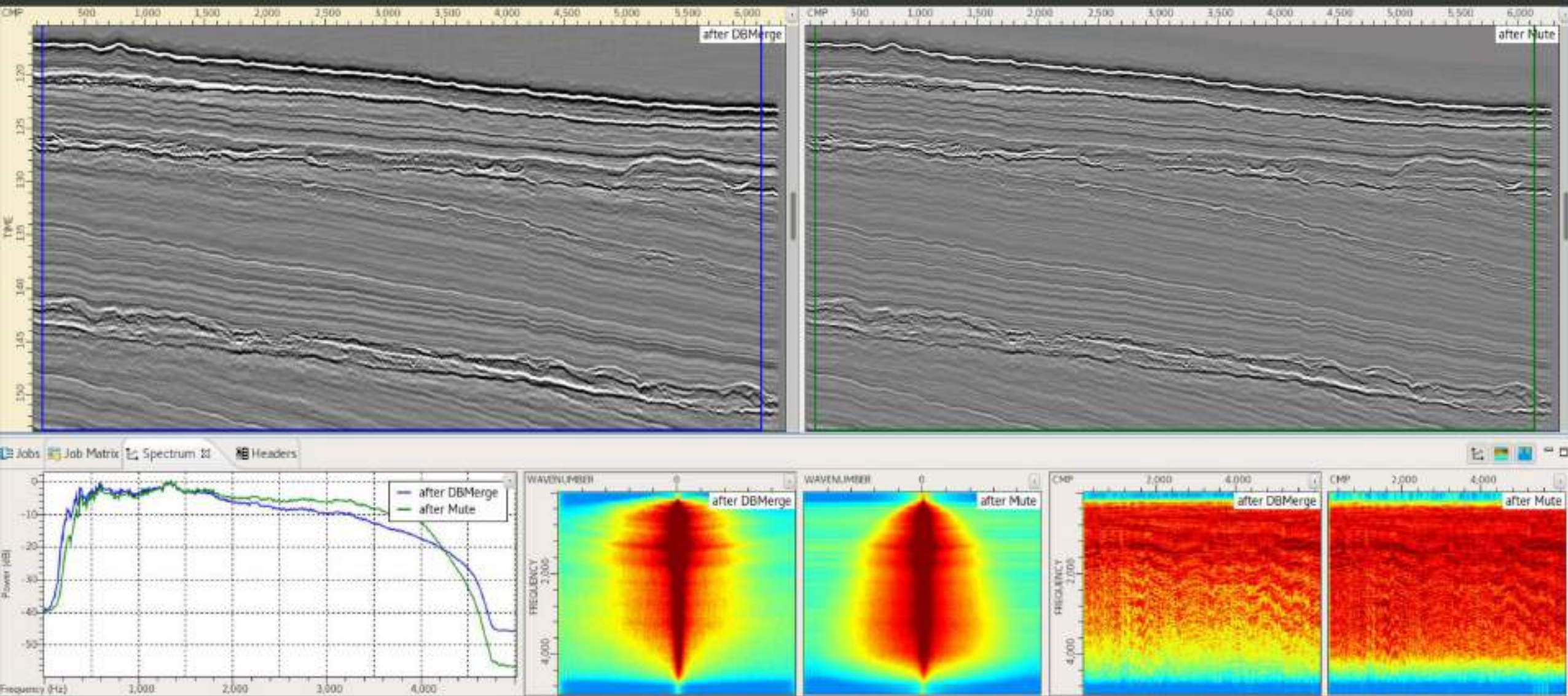
# GATHERS – PROPOSED ANGLE MUTE



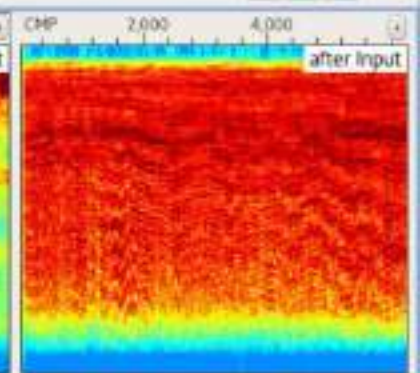
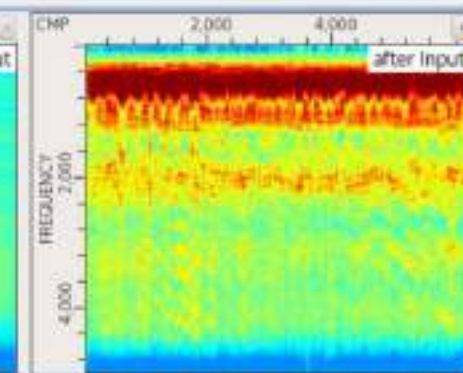
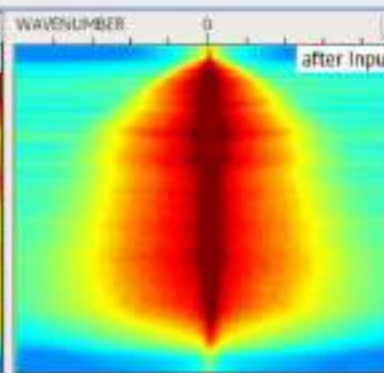
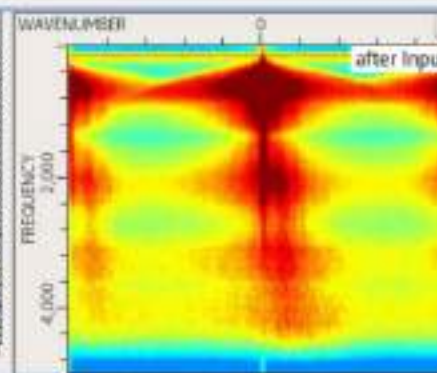
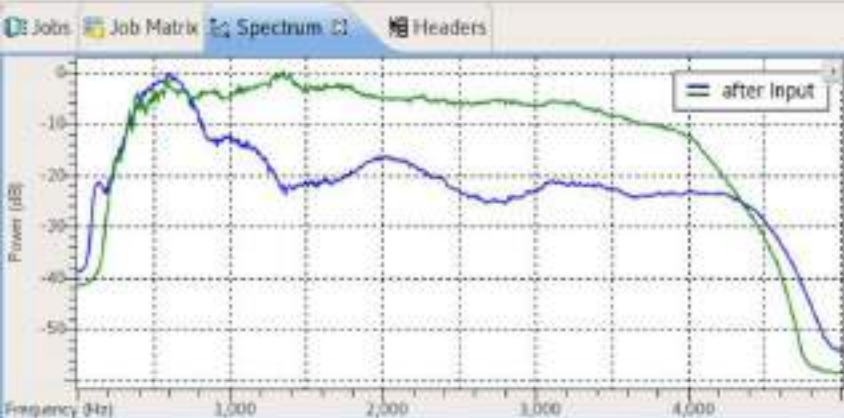
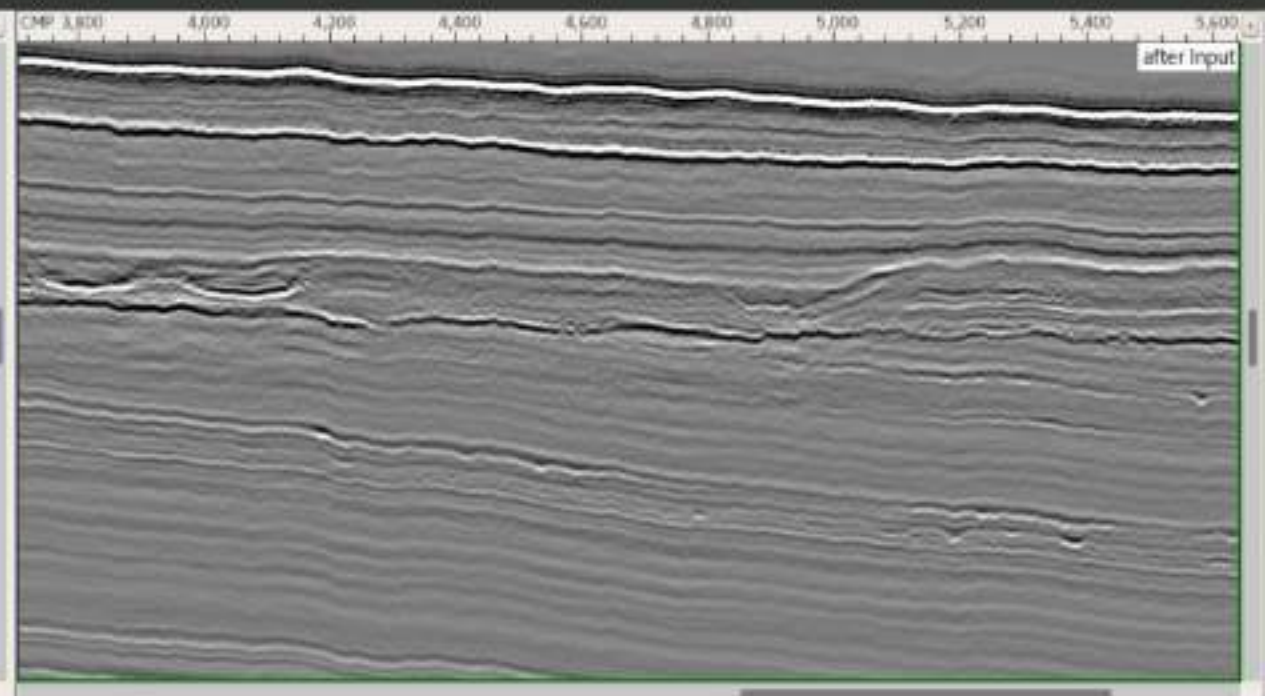
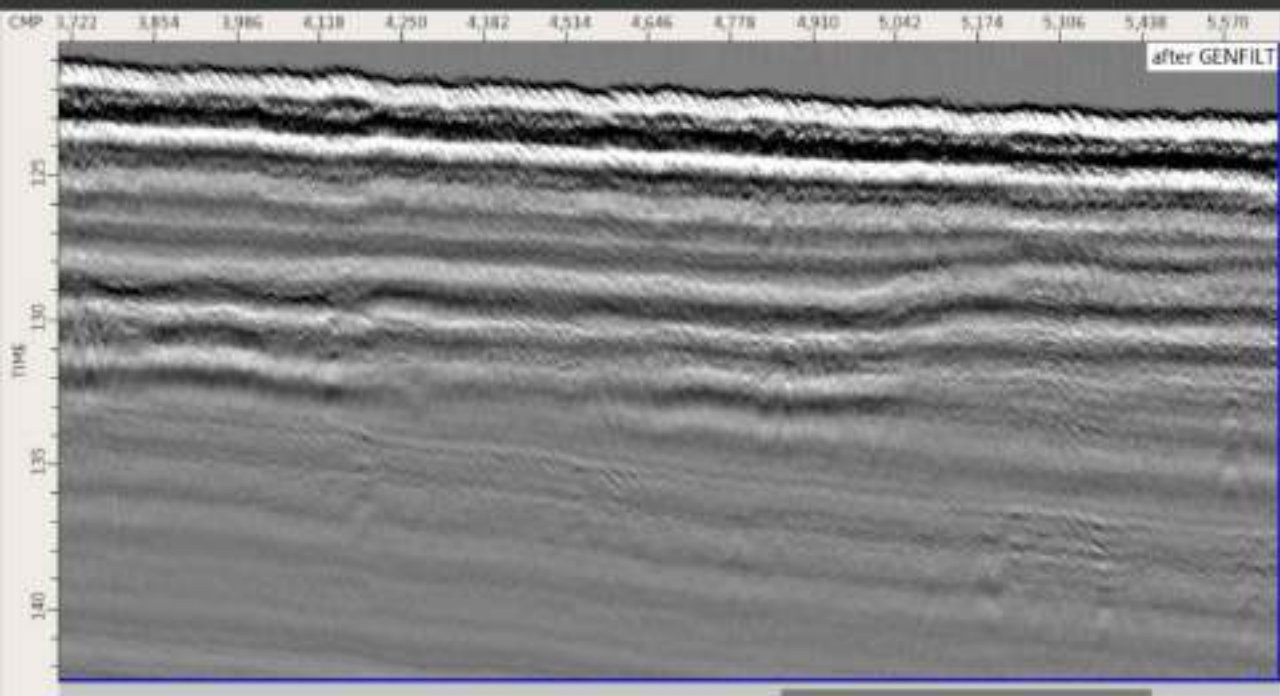
# POST STACK PROCESSING



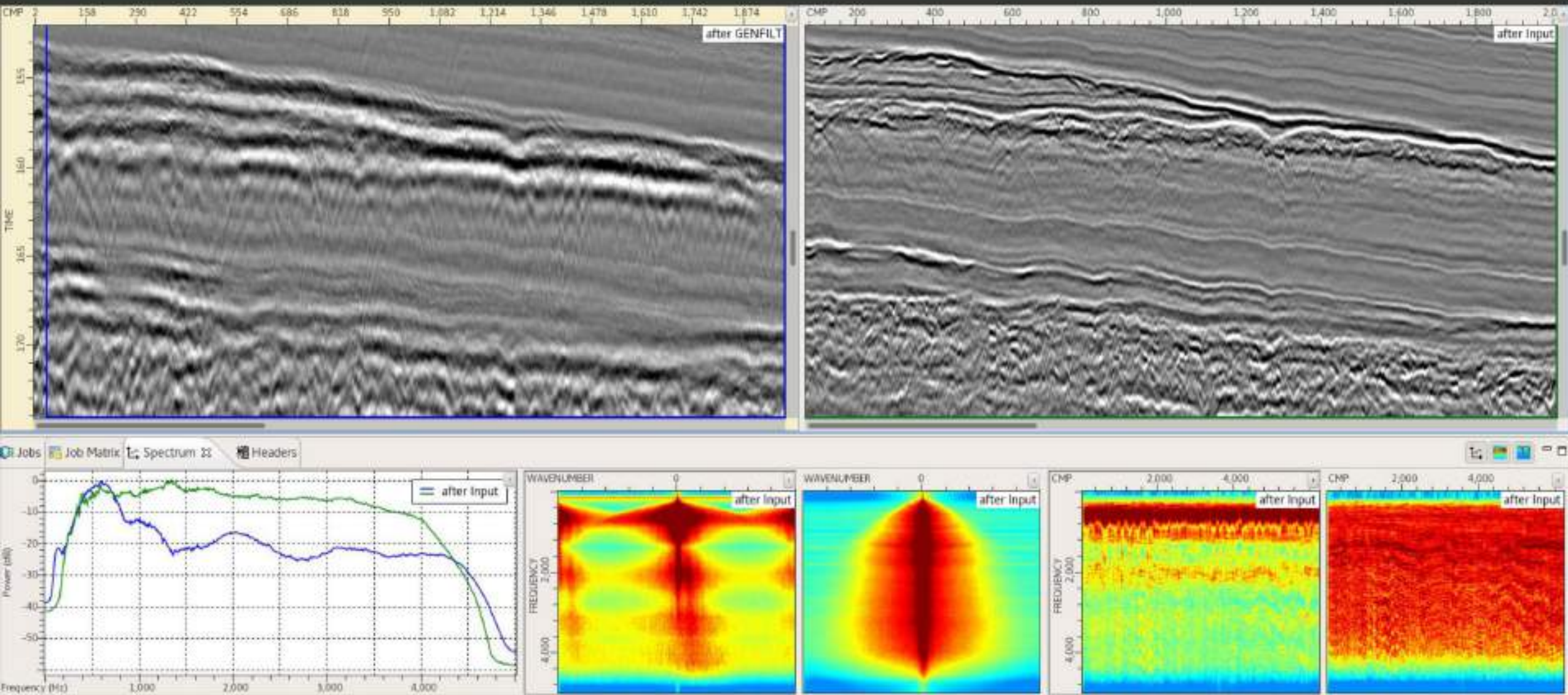
# BEFORE AND AFTER POST STACK PROCESSING



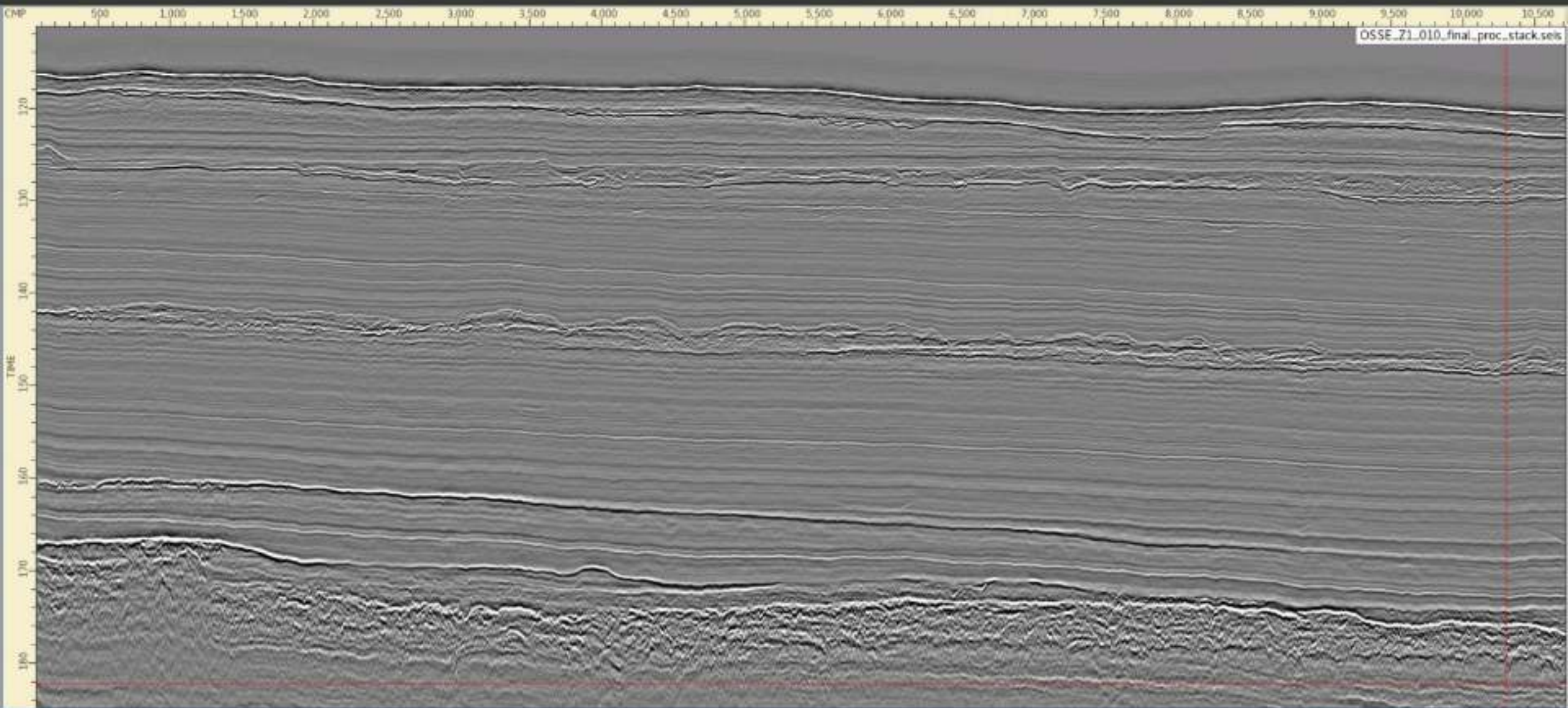
# BRUTE VS. FINAL COMPARISON



# BRUTE VS. FINAL COMPARISON



# OSSE\_Z1\_010 FINAL EXAMPLE



# OSSE\_Z1\_017 FINAL EXAMPLE

