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Geological, archaeological and metocean information for the support of offshore wind farm development on the west Portuguese continental shelf

- Figueira da Foz -

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SUMMARY

This report compiles and interprets geophysical, geological, archaeological and metocean information and data relevant for understanding the geological nature of the seafloor in the Figueira da Foz area for the development of wind farms.

The information includes a summary of the regional geology, existent seismic reflection data, seafloor sampling, archaeological and metocean data in the area of interest.

Interpretation of high-resolution vintage seismic profiles that are property of IPMA is included for the determination of thickness of unconsolidated sediments for which maps are provided.

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1. INTRODUCTION

1.1. Preamble

The Portuguese government expressed the intention of developing until 2030 up to 10 GW of electrical production centers based on renewable energy sources of oceanic origin. Accordingly, an interministerial working group (Despacho n.º 11404/2022) was set up to produce a report with contributions and recommendations aiming to accomplish the goal set by the government. This working group released, in December 2022, a preliminary report with an initial spatialization plan for the preferred areas for the development of the ocean based renewable energy production areas. After this initial spatial plan proposal, a public hearing (Despacho nº 1396-C/2023) followed, including meetings with the several stakeholders and the setup of a commission to put forward a proposal for the affectation plan (Proposta de Plano de Afetação para as Energias Renováveis Offshore – PAER). From a working group that included 21 public organizations and a roundabout at national level of meetings with stakeholders, resulted the revised version for the allocated areas for wind farms installation shown in Figure 1.1.

The allocated areas for offshore wind farms total an area of 3176 km^2. The Figueira da Foz area corresponds to 1325 km^2.

The present report aims at compiling, organizing, and describing the available geological and geophysical relevant information of the seafloor in the Figueira da Foz area. This information includes: i) a summary of the geological setting; ii) position maps of existent seismic reflection data, iii) surface sediment samples, iv) surface sediment maps, and v) interpretation of vintage high resolution seismic profiles including the mapping of the surficial sediments layer thickness (probably unconsolidated sediments), correspondent to the time difference between the reflections of the sea bottom and sediment/bedrock interface, being the last intended as the uppermost geometrical unconformity between undeformed and tectonized strata. Information on the OIL & Gas available data will be included in the extended version of this report.

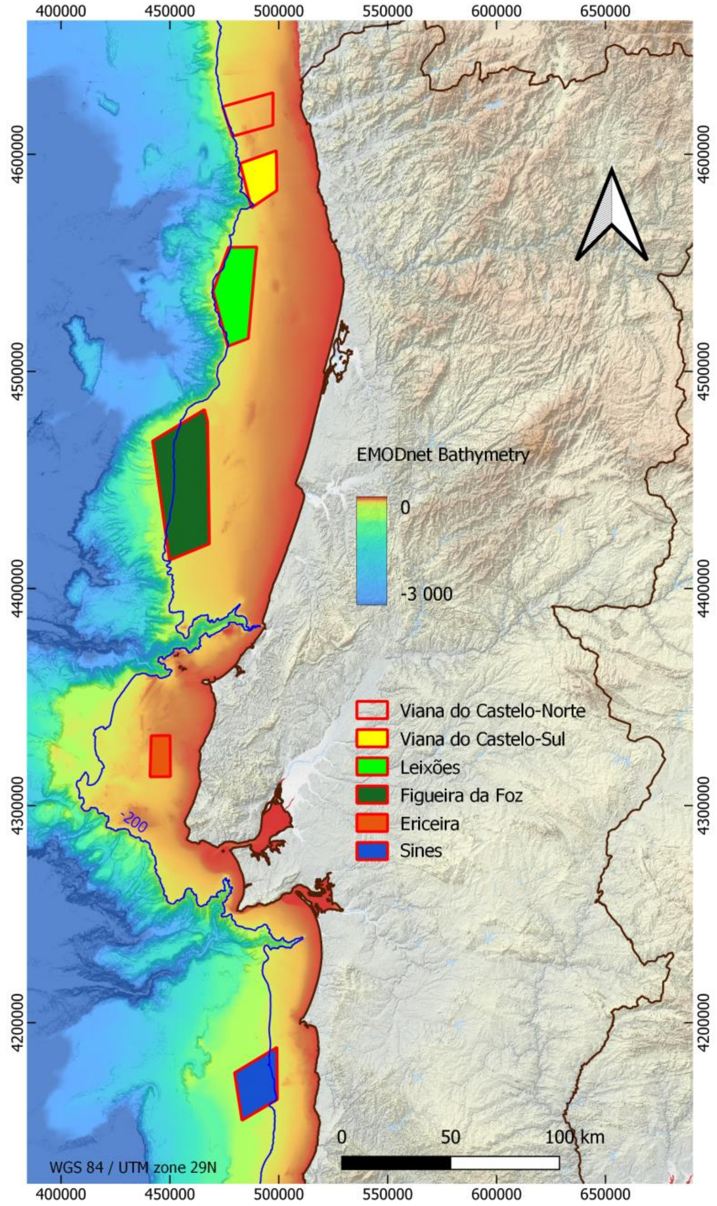


Figure 1.1 - Map showing the allocated areas for installation of offshore wind farms.
(https://participa.pt/contents/consultationdocument/Plano%20de%20Afeta%C3%A7%C3%A3o_PAER_Versao_CP_outubro.pdf)

1.2. Geological Setting

Figueira da Foz offshore wind farm areas is located on the continental shelf on the northwest of Portugal (Western Iberian Margin – WIM), west of the Mondego River (Figure 1.2). In this area the width of the continental shelf is approximately 60 km. The continental shelf break lies around the 180 m depth.

The WIM developed in strict relation with the opening of the Atlantic Ocean. The Lusitanian Basin (LB), which constitutes a significant portion of the WIM, is a Meso-Cenozoic basin developed as a multiphase rift throughout much of the Mesozoic, overlying a Paleozoic basement made of metamorphic and magmatic rocks. The LB evolution started during the Late Triassic-Early Jurassic, with the onset of the first rifting event, after which two other rifting episodes – Late Jurassic and Early Cretaceous – affect the area. The continental break-up occurred close to the Early and Late Cretaceous transition. During the Mesozoic the sedimentation translates the alternation between continental, transitional and marine environments, with siliciclastic (of varying grain size and cements) and carbonate (mainly limestone, sporadically dolomites) lithologies being the more common.

During the Cenozoic the basin was affected by two tectonic inversion episodes of Eocene and Miocene ages associated with the Alpine orogeny that reactivated the Pre-Mesozoic faults (mostly Late Hercynian faults) and folded the sedimentary units. The sedimentation is mainly detrital with carbonate formations included. The thickness of the Mesozoic is highly variable, mainly controlled by the development of syn-rifting faults and/or salt basins. The thickness of the Cenozoic is controlled by tectonic inversion structures. A main erosive unconformity (late Miocene to Pliocene age) separates the underlying sedimentary packages from the sediment package on top considerably less consolidated.

Sedimentary rocks of Cenozoic age cover the continental shelf at the Figueira da Foz area (Figure 1.2): Miocene sandstones, limestones, siltstones and claystones in most of the area, and Paleogene limestones, dolomites and sandstones; between the area of interest and the shore, Cretaceous limestone, dolomites, sandstone and claystones occur. These sediments are overlain by unconsolidated sediments of Pleistocene and Holocene age.

The unconsolidated sediments are mainly supplied to the shelf by two rivers (Mondego and Vouga River). Several authors have focused on recent sediment distribution and characterization, having reported the presence of different classes of sediments, which ranges from mud to gravel (Dias et al. 1991 1984, 1992, 2001, 2002; Jouanneau et al. 2002; Magalhães et al. 1991, 1992; Fraga 1983; Vitorino et al. 2002a,b).

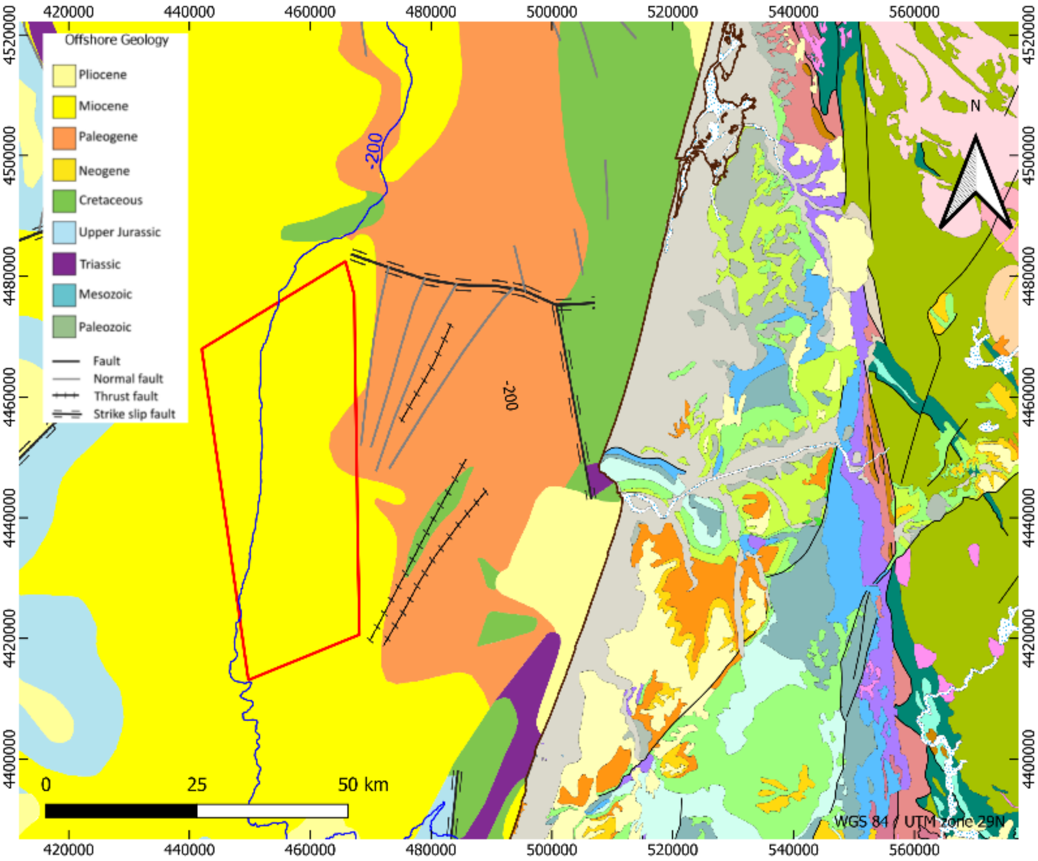


Figure 1.2 - Geological map of Figueira da Foz area, Portugal.

2. AVAILABLE DATA

For this work, previously acquired geophysical data (IPMA's high-resolution seismic reflection surveys; and Direção-Geral de Energia e Geologia (DGEG) medium to low resolution seismic reflection surveys) were analyzed, as well as published material (*e.g.* oil and gas exploration reports; PhD thesis; scientific papers). Figure 2.1 presents all the data used for this report, including seismic reflection surveys and surface sediments samples for Figueira da Foz area. The seismic reflection survey coverage of the designated area is very restricted and only 4 samples were collected in previous campaigns. To overcome the small amount of data the seismic lines covering the continental shelf between the area and the shore were also analyzed, as well as 2 superficial sediments samples collect in the vicinity of the polygon (Figure 2.1).

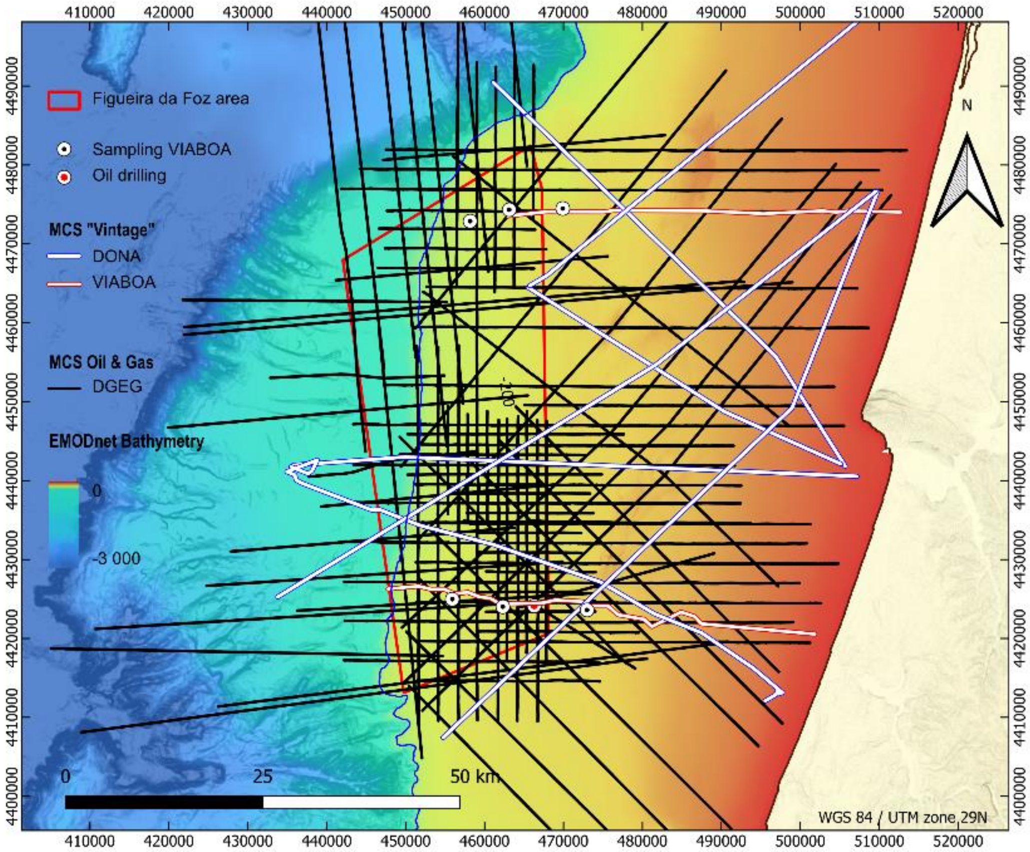


Figure 2.1 - Available data for the Figueira da Foz area used in the current report

2.1. Geophysical data

The datasets of seismic reflection profiles consist of lines acquired during 2 ‘vintage’ surveys (VIABOA – 1975; and DONA - 1986) covering the continental shelf near the Figueira da Foz area, and 112 seismic lines (Table 2.1) from the oil & gas data inventory from DGEG (Figure 2.1). The acquired seismic reflection profiles are approximately 660 km long, with 90 km of them acquired over the studied area.

The **VIABOA** survey took place between the 13th and the 29th October 1975, aiming to acquire geological data to access the continental shelf sedimentary cover. The promotor was the Serviço de Fomento Mineiro (SFM) and the contractors were the SFM and the Instituto Hidrográfico (IH). The survey was conduct on the Almeida Carvalho vessel; the positioning was made by the crew officials by marked and estimated points, radar and DECA with an interval of 10 minutes. The seismic equipment used was Sparker SIG 72J 6 KV with an energy source of 18-36-72 J; streamer of 100m with an active section of 2.1 m with 4 elements. Register Muirhead with amplifier and higg cut and low cuts hardware filters SIG. Shooting rates of 3 and 6 shots per second.

The **DONA** survey took place between the 5th and the 12th December 1986, aiming to acquire geological data to access the continental shelf sedimentary cover. The promotor was the Serviço de Fomento Mineiro (SFM) and the contractors were the SFM and the Instituto Hidrográfico (IH). The survey was done on the Almeida Carvalho vessel; the positioning was done from satellite signal with an interval of 10 minutes. The seismic equipment used was Uniboom and Sparker.

The seismic lines from DGEG were not considered for cartographic purposes. A synthesis of the data characteristics from each survey is available in the forms of Annex 9.1. All the information was extracted from survey reports and from the seismic headers of the SGY’s. The estimated vertical resolution of the seismic data from the oil & gas surveys varies from 20 to 30m.

Table 2.1 - Synthesis of the available Oil & Gas surveys and existent number of lines covering the area of Figueira da Foz

Survey	Operator	Year	Nº of lines
ESSO 1973	Esso	1973	12
GSI 1984	GSI	1984	21
PETROBRAS 2008	Petrobras	2008	18
SHELL 1973	Shell	1973	25
SHELL 1974	Shell	1974	21
SUN 1973	Sun	1973	7
TGS-NOPEC 2000	TGS-NOPEC	2000	8

2.2. Well Data

Oil and Gas exploration companies drilled several wells in the Portuguese continental margins. Data from these drilling campaigns is available at DGEG; a synthesis of that data focused on the implementation area is presented in this report.

One well was drilled in the Figueira da Foz area (Figure 2.1), 14C-1A, by Shell, in the year 1975. Table 2.2 presents relevant data on the drilling of the well.

Table 2.2 - Oil and Gas exploration wells

Name	Abbreviation	Operator	Drilling Year	Total Depth (m)	Water Depth (m)
14C – 1A	14C – 1A	SHELL P. PORTUGAL	1975	2142	133

Information collected from the exploration well refers to Mesozoic and Paleogene formations of the basin (Table 2.3). With initial drilling without sample recovery, there is no information on the shallow formations or the unconsolidated sedimentary cover.

Table 2.3 - Synthesis of data from oil and gas exploration well 14C-1A

Depth (m)	Formation	Lithology	Stratigraphy
seabed-529	Espadarte	Dolomites and dolomitic sandstones alternating with terrigenous clays	Paleogene
529-693	Dourada	Sandy dolomites and marls	Upper Cretaceous (post Cenomanian)
693-760	Cacém upper member	Dolomites	Cenomanian
750-802	Cacém Lower member	Dolomites with marls	
802 - 1145	Torres Vedras	Sandstones and claystones with sandy dolomites intercalations and lignite layers; argillaceous limestones with marls and sandstones at the base	Lower Cretaceous
1145 – 1243	Coimbra	Dolomitic limestones and marls	Lower Jurassic (?Sinemurian-Pliensbachian)
1243 – EOW	Dagorda	Red shales, halite and anhydrite	Upper Triassic - base Lower Jurassic

2.3. Surface Sediments

During the oceanographic campaign VIABOA (1975) unconsolidated surface sediments were sampled with Van Veen and Shipek grabs. In the area of Figueira da Foz a total of 4 samples were collected, and the data on those samples and on 2 more samples collected in the vicinity, as well as a summary description of the sediment types is presented in Table 2.4. Location of the sampling sites is shown in Figure 2.1. The sampled sediments are mostly sands, of variable grain size and generally with abundant bioclasts; one of the samples was described as clay.

The "Carta de Sedimentos Superficiais da Plataforma Continental", published by the Instituto Hidrográfico (2010) is the main document on the continental shelf surficial geology. At the area of Figueira da Foz most of the unconsolidated sediments are Pleistocene or Holocene in age; some consolidated detrital Pliocene sediments and Cretaceous limestone are also present in the area.

The unconsolidated sediments of the area (Figure 2.2) are mainly detrital with various grain sizes (ranging between mud and coarse sand) and variable bioclastic and lithoclastic components. The description of the sediments follows the Folk classification scheme, and the textural meaning is presented in Table 2.4.

Table 2.4 - Surficial sediments samples from VIABOA campaign

ID	Latitude	Longitude	Date	Depth (m)	Observations
VB094	40.405432	-9.492975	22/10/1975	155	Glauconite-rich fine sand
VB095	40.418765	-9.434640	22/10/1975	145	Poorly sorted sand
VB096*	40.420433	-9.354639	22/10/1975	130	Medium-grained sand, green, with bioclasts
VB106	39.973757	-9.516300	23/10/1975	145	Silty fine-grained sand with bioclasts
VB107	39.965425	-9.441298	23/10/1975	130	Silty fine-grained sand with bioclasts
VB108*	39.962092	-9.316297	23/10/1975	120	Gray silty- sandy- clay

* samples collected outside the study area

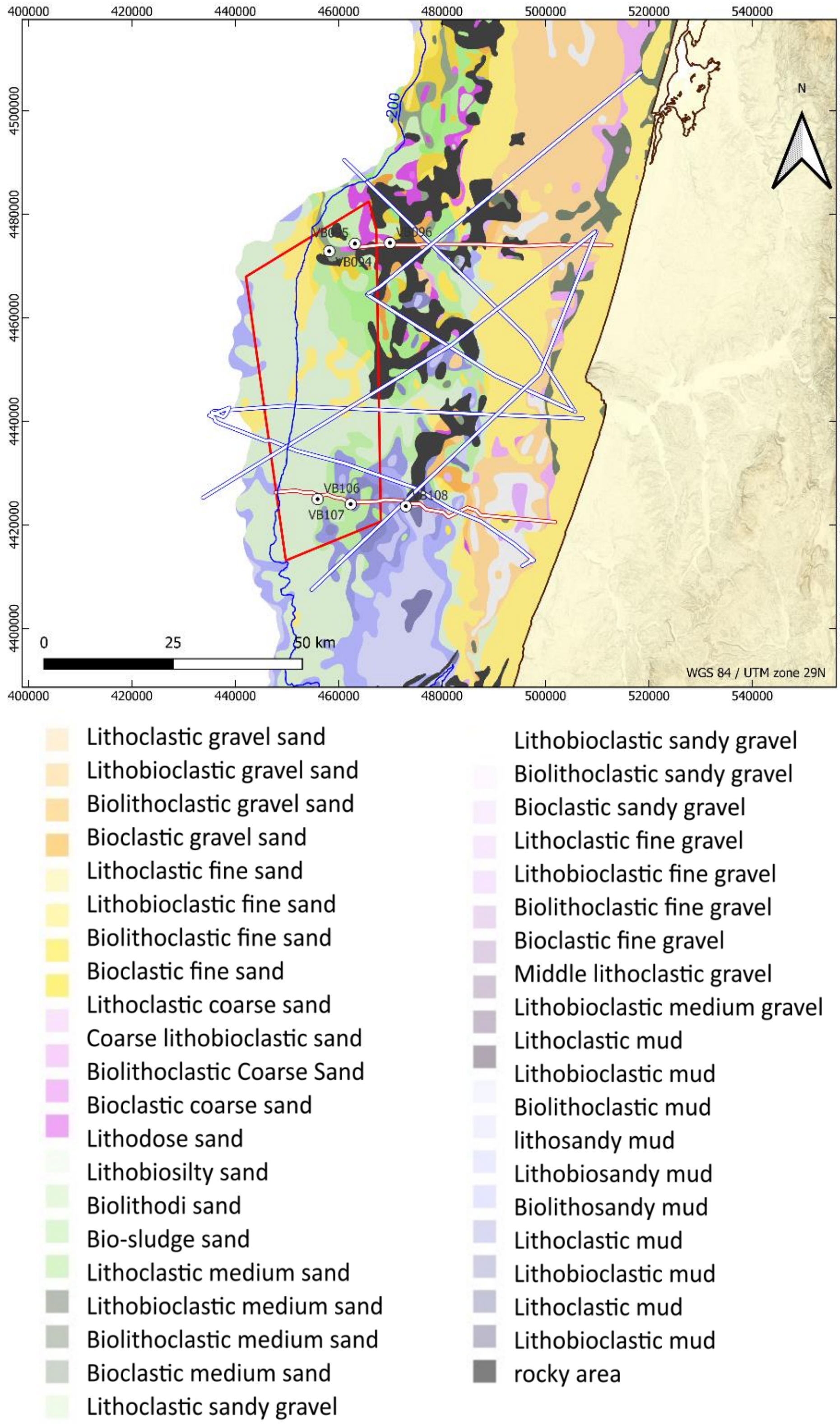


Figure 2.2 - Surficial sediments map (IH, 2010).

Table 2.5 - Reference values for the surficial sediments classification according to IH map

Gravel sediments	Sand sediments	Muddy Sediments
Mud < 10% Sand + Mud < 50% Gravel >50% Avg ≥ 2 mm	Mud < 10% Sand + Mud > 50% Avg ≤ 2 mm	Mud > 10%
Lithoclastic	carbonate < 30%	
Lithobioclastic	30% < carbonate < 50%	
Biolithoclastic	50% < carbonate < 70%	
Bioclastic	carbonate > 70%	

Rocky outcrops of the continental shelf offshore Figueira da Foz occupy a small area in the eastern side and correspond to Paleogene limestone, dolomites and sandstones. Besides the Paleogene, pre-Quaternary formations in this area are the Miocene sandstones, limestones, siltstones and claystones, occurring in the western portion of the Figueira da Foz sector (Figure 1.2). These sediments constitute the substrate of the loose sediments in the area.

2.4. Metocean Data

Information on wave and wind conditions are fundamental for the planning of the geophysical surveys. Data from a 45 years' time series was used to assess the number of days available with optimal conditions for the surveys as well as the more favorable months.

Offshore hindcast data was obtained running a 3rd generation wave prediction model on a global grid and on several regional grids (EU-shelf, Mediterranean, Black Sea, Red Sea, Persian gulf) when appropriate. The used global grid has a resolution of 50 km; the models provide 3-hourly time series of wave spectra and parameters covering a period of approximately 45 years (1979 – near present day). Hindcast data was extracted for the years 1980-2023; satellite measurements (1992-2022), collected within a radius of 20 to 40 km around the central location of the area were used to calibrate model hindcast significant wave height.

The data (Annexes 9.2, 9.3) is presented in a graphical format and includes: (i) the fraction of workable days and the number of workable days per month against the years analyzed, including all-year averages, for all 12 hours windows length (wave height and wind speed limits); and (ii) the mean delay time spent waiting for weather windows per month against the years analyzed, including all-year averages.

2.5. Archeological Heritage

The study of the underwater cultural heritage factor (PCS) aimed to characterize the maritime use of the area where the project is located and the occurrence of maritime accidents, allowing to define its archaeological potential. Compilation of the data from different data bases allowed the mapping of the occurrences of higher potential, and differentiate between the involved remains defining their historical importance and their dangerousness.

The data was collected from the files stored at the Centro Nacional de Arqueologia, the United Kingdom Admiralty (“Wrecks and Obstructions Shapefiles”) accessible at the Marine Data Portal, the wrecksite.eu the biggest database devoted to ship wrecks, and from the Base de Dados de Arqueologia Nacional Endovélico.

The collected data is described in Table 2.6.

Table 2.6 - List of information collected from the archeological databases

Typology	Type of occurrence (Ship wreck, Finding, Aircraft crash)
Chronology	Period from which the detected traces come/year of occurrence
Latitude	Geographical coordinate
Longitude	Geographical coordinate
Designation	Name given to an archaeological site or name given by sources for known shipwrecks
Origin	Ship flag for shipwrecks and aircraft crashes
Hull Material	Wood; Iron/Steel
Cargo	Material that was on board at the time of the sinking
Dimensions max. (m)	Largest known size of the wreck
Asset Value	High; Medium; Low
Explosives	Probable presence of explosives – Yes or No

3. ‘VINTAGE’ HIGH RESOLUTION SEISMIC SURVEYS

3.1. Surveys’ Description

IPMA seismic data repository has a set of 2D high resolution seismic data from old seismic campaigns from the 70s and 80s, herein named as ‘vintage’. A selected set of these seismic lines (Figure 3.1) were interpreted with the purpose of assessing the thickness of the unconsolidated sedimentary cover of the Figueira da Foz area. Data was collected during three campaigns: the VIABOA (1975) and the DONA (1986). Table 3.1 contains the seismic acquisition characteristics of the campaigns that included sediment sampling (Van Veen, Shipek and Kastenlot grabs). Although most of the seismic surveys coverage is located outside the area of interest, it was decided to use all the available lines in this study.

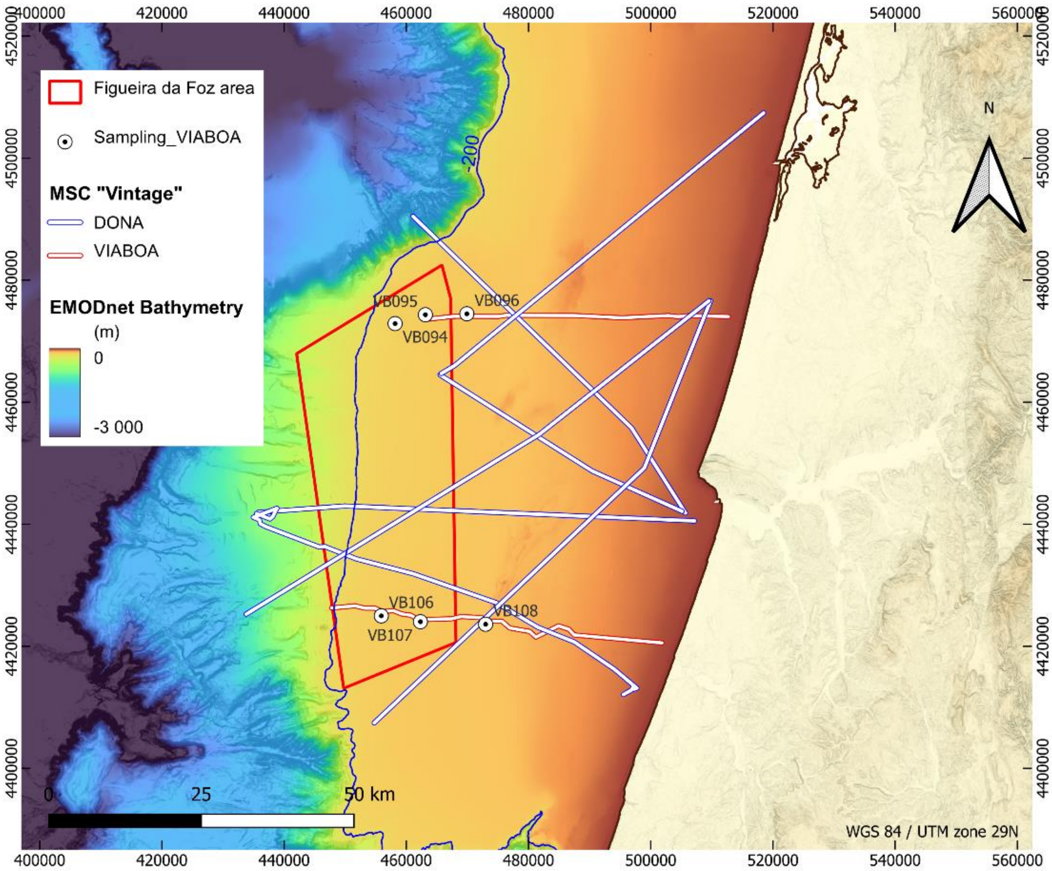


Figure 3.1 - 'Vintage' High-Resolution Seismic Surveys location.

Table 3.1 Data of the ‘vintage’ seismic surveys

	VIABOA	DONA
Dates:	13 - 29 October 1975	5 – 12 December 1986
Promotor:	Serviços de Fomento Mineiro, SFM (Portuguese state)	Serviços de Fomento Mineiro, SFM (Portuguese state)
Contractor:	SFM and Hydrographic Institute (IH)	SFM and Hydrographic Institute (IH)
Objective:	Acquisition of geologic data to access the shelf sedimentary cover	Acquisition of geological data on the continental shelf between Douro River’s mouth and the Nazaré Canyon
Vessel:	NRP Almeida Carvalho	NRP Almeida Carvalho
Positioning:	Made by the crew officials by marked and estimated points, radar and DECA with an interval of 10 minutes	From satellite with an interval of 10 minutes
Seismic Equipment	Sparker SIG 72J 6 KV with an energy source of 18-36-72 J; streamer of 100m with an active section of 2.1 m with 4 elements. Register Muirhead with amplifier and higg cut and low cuts hardware filters SIG. Shooting rates of 3 and 6 shots per second	Uniboom and Sparker
Sediment Sampling Equipment	Van Veen and Shipek grabs	Van Veen grad and gravity corer

3.2. ‘Vintage’ Seismic Data

The ‘vintage’ seismic data originally in printed format was rasterized to digital format. These digital images are in grayscale *.tiff* format with 200 to 300 dpi resolution. The vertical registered window, in *ms* varies from 330 to 1000 *ms*. Furthermore, shot points location and navigation time are marked in images (Figure 3.2). These ‘vintage’ seismic data were converted to SEGY format, enabling the seismic interpretation with interpretation software. A description of this procedure is presented as follows.

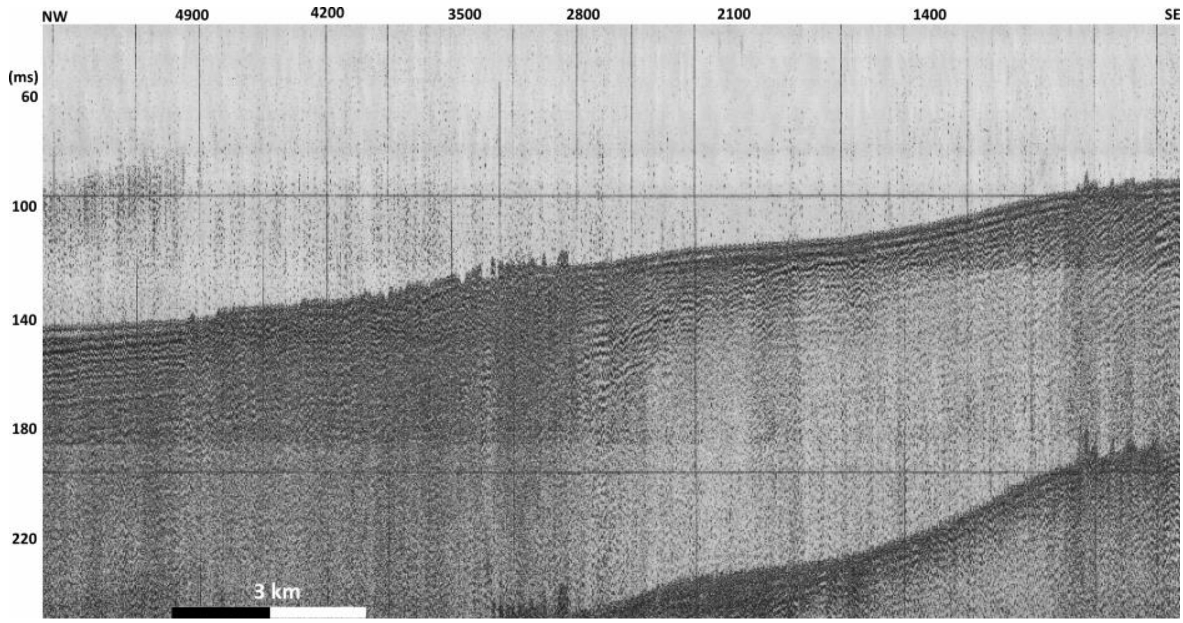


Figure 3.2 - Example of 'vintage' seismic profile of MD02185 line from MIDOU campaign 1985 IPMA. Vertical marks refer to shotpoint locations and horizontal marks to time scale.

3.3. Methodology

The methodology used to transform the digital images of vintage seismic data into SEG-Y format and its interpretation is summarized in the following workflow (Figure 3.3).

Figure 3.3 - Representation of the Workflow adopted for vintage seismic data interpretation.

3.3.1. Transformation of Vintage Seismic Images into SEGY Format

The transformation of digital images into SEGY format was performed with software scripts in open-source repositories, which were adapted and modified by the *Seislab* (Laboratório de Geologia e Geofísica Marinha - IPMA) team. The images were cropped to the usable area of seismic data. For each "Fora" (fix point) location was assigned the spatial information regarding UTM coordinates (WGS84_ UTM_Zone_29N), obtained from navigation and available in the campaign reports and the coordinates for the remaining shotpoints were interpolated or extrapolated. The SEGY Revison 1 was the format adopted for the SEGY files. Additionally, a Quality Control (QC) of the SEGY was carried out, to check the seismic image quality and checked the accuracy of the shot point's location (Figure 3.4; Figure 3.5).

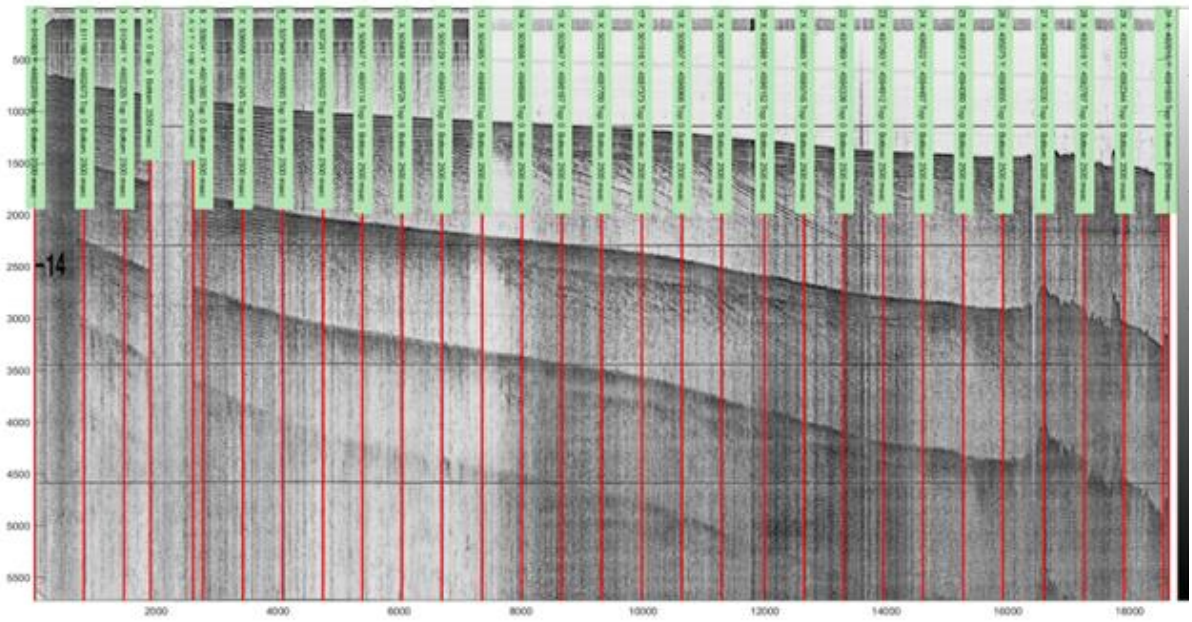


Figure 3.4 - Example of SEGY QC. Seismic profile with shot points location with UTM coordinates.

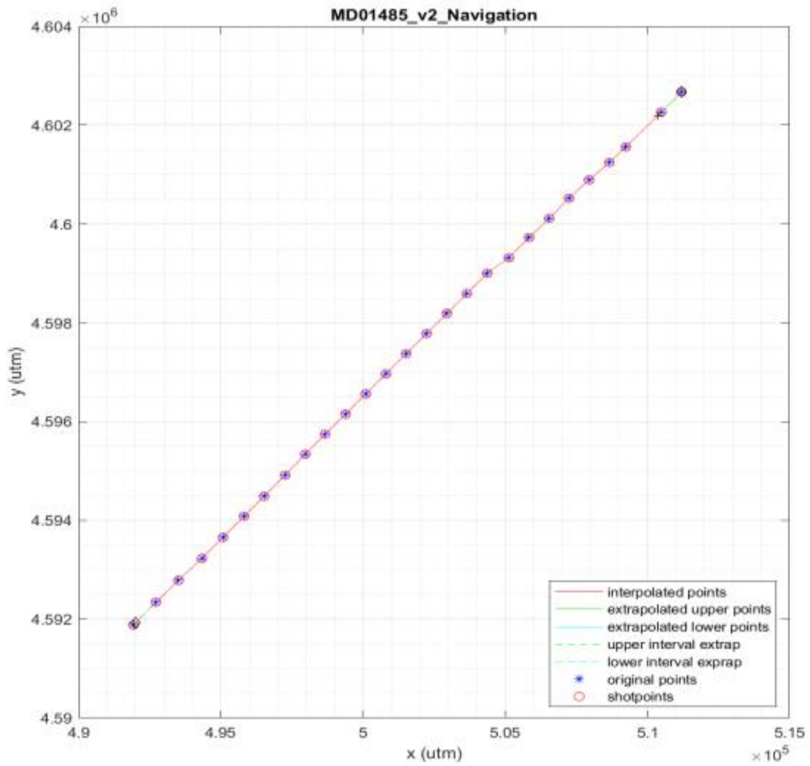


Figure 3.5 - Example of SEGY navigation QC.

3.3.2. Seismic Processing

Two seismic processing flows, using simple techniques, were applied, to the converted SEGYs. The objectives of the applied processing flows were, for the first one to apply geometrical corrections and homogenize sampling rates, and for the second one to remove noisy data and enhance seismic-to-noise ratio. The geometrical corrections were focused on the following main steps:

- Correction of navigation (elimination of duplicate coordinates due to the rounding and reinterpolation);
- Sample rate homogenization to a sample of 0.1 ms for all lines;
- Delays correction;
- Test of horizontalization correction;
- Sum of seismic traces and line length adjustments;
- Correction of vertical positioning by bulk line shift, to fit EMODnet bathymetry converted to time using a sound velocity of 1500 m/s;
- QC of navigation positioning;

After applying all the geometrical corrections (Figure 3.6) a new SEG-Y file was exported (res.seg). On the second processing flow, a Bandpass Filter and Spatial Filter were used to enhance reflection continuity, and a new SEG-Y was exported (proc.seg) (Figure 3.7).

Quality Control was also applied to seismic processing results (Figure 3.8).

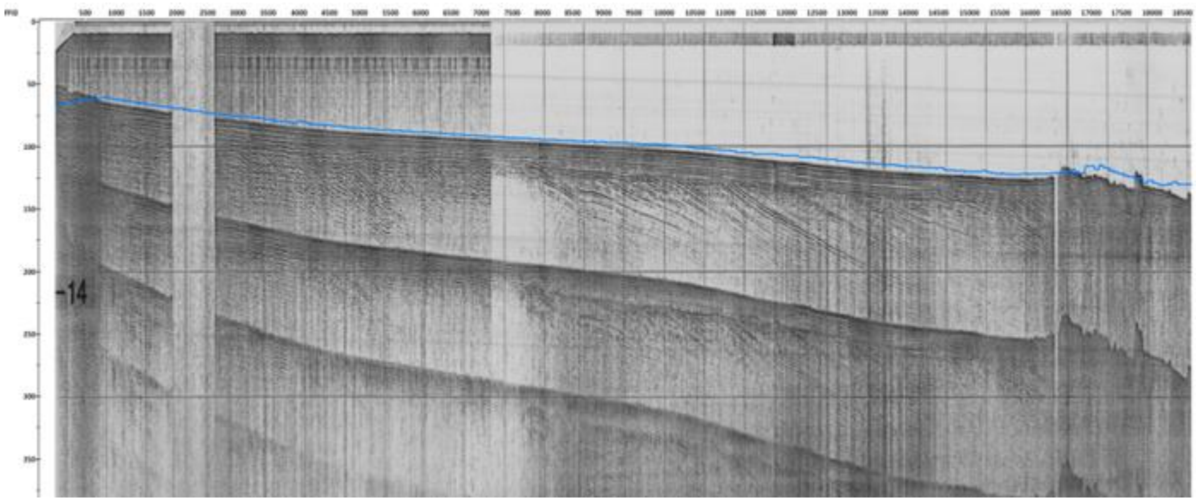


Figure 3.6 - SEG-Y (res.sgy) seismic profile after geometrical corrections. Blue line represents the seabed (data from IPMA database - EMODnet).

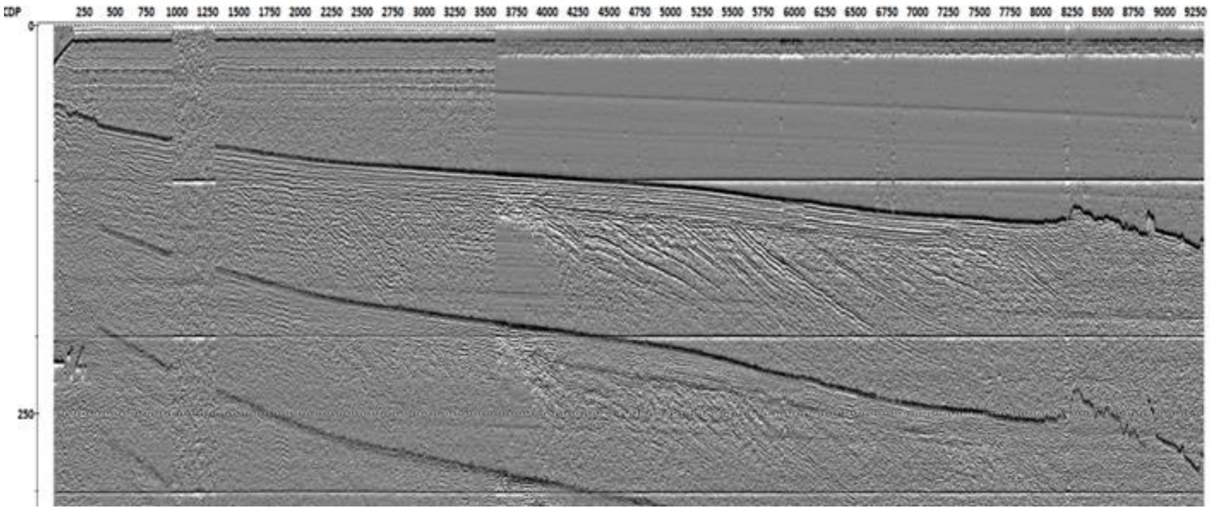


Figure 3.7 - SEG-Y (proc.sgy) processed seismic profile of the line presented in Figure 3.6.

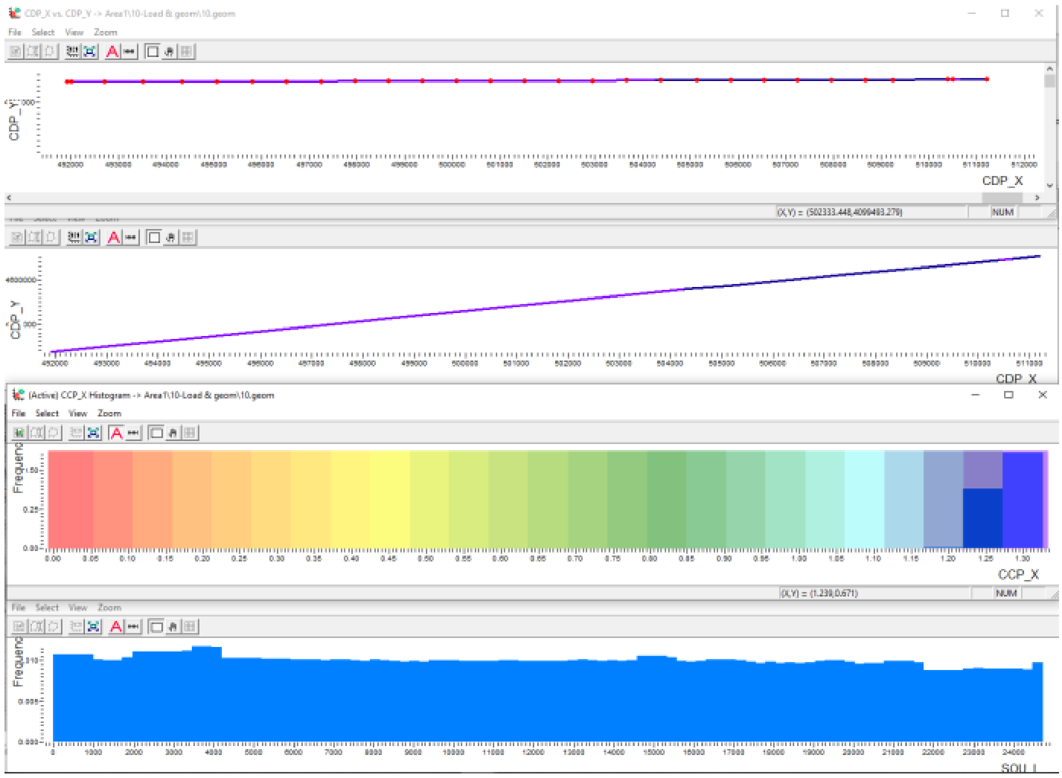


Figure 3.8 - Example of QC plot of navigation positioning for a 'vintage' IPMA seismic line. A- navigation plot of the seismic traces coordinates, "foras" (red dots) with original navigation coordinates and the interpolated coordinates colored according to trace spacing classes (panel C); B- Navigation plot with equal scale axis and dots colored according to trace spacing classes (panel C); C- Frequency of traces distribution by trace spacing classes; D- Frequency of traces distribution by cumulative trace spacing classes.

3.4. Interpretation of High-Resolution Seismic Data

The interpretation of the vintage seismic datasets was based on the two (res.sgy and proc.sgy) outputted versions of SEG-Y files resultant from the processing stage. The original seismic data has different image quality (Figure 3.9, Figure 3.10), levels of noise (i.e. ringing, ghosts), and positioning accuracy. These differences have an impact on the seismic processing results and on the seismic interpretation potential of the datasets.

The positioning accuracy of the interpreted seismic lines was evaluated by comparison of the picked sea bottom reflection with the EMODnet bathymetry (grid with a 150 m cell size) converted to two-way time (TWT), using a sound velocity of 1500 m/s.

Vertical corrections were applied to the seismic data in order to minimize the observed discrepancies between the picked sea bottom from the seismic data and the EMODnet bathymetry used as reference. A bulk vertical shift was applied to each seismic line in order to minimize the misfit with the bathymetry and the mistiest with crossing seismic lines (Table 3.2). Finally, the resultant misfit between the picked seismic sea bottom and the EMODnet bathymetry was evaluated by generating a surface (grid) resultant from the computed difference between the interpolated picked sea bottom from the seismic lines and the EMODnet bathymetry.

In Annex 9.4 the cross sections of the 'vintage' seismic lines for the Figueira da Foz area are displayed. For each seismic line the resulting processed seismic (proc.sgy) and the seismic interpretation of the seabed (blue line) and the base of the unconsolidated sediments (red line) are presented.

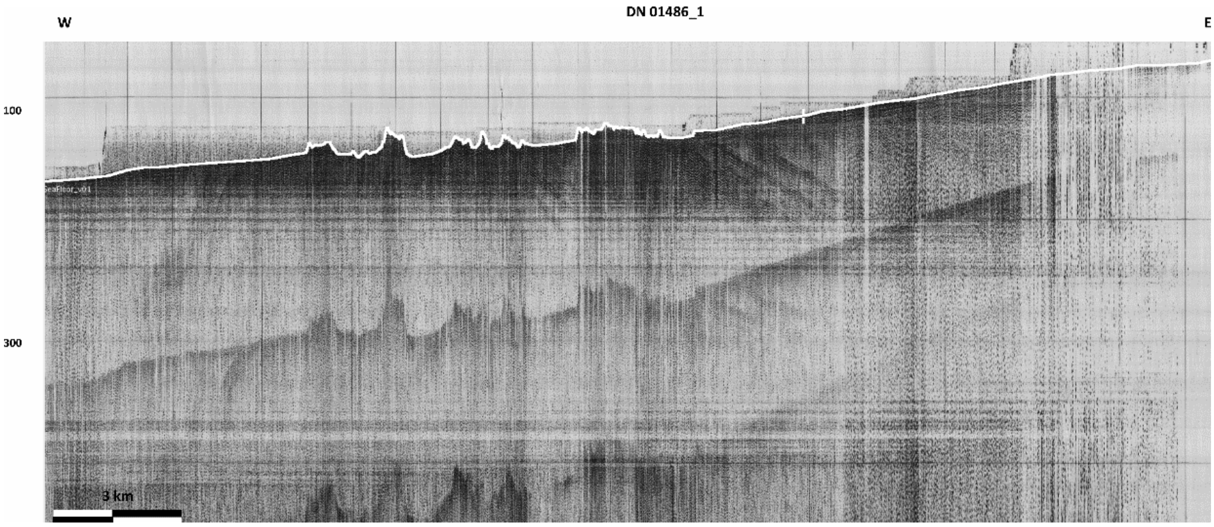


Figure 3.9 - Details of seismic line DN01486_1 highlighting the image quality. The white line refers to the interpreted seabed.

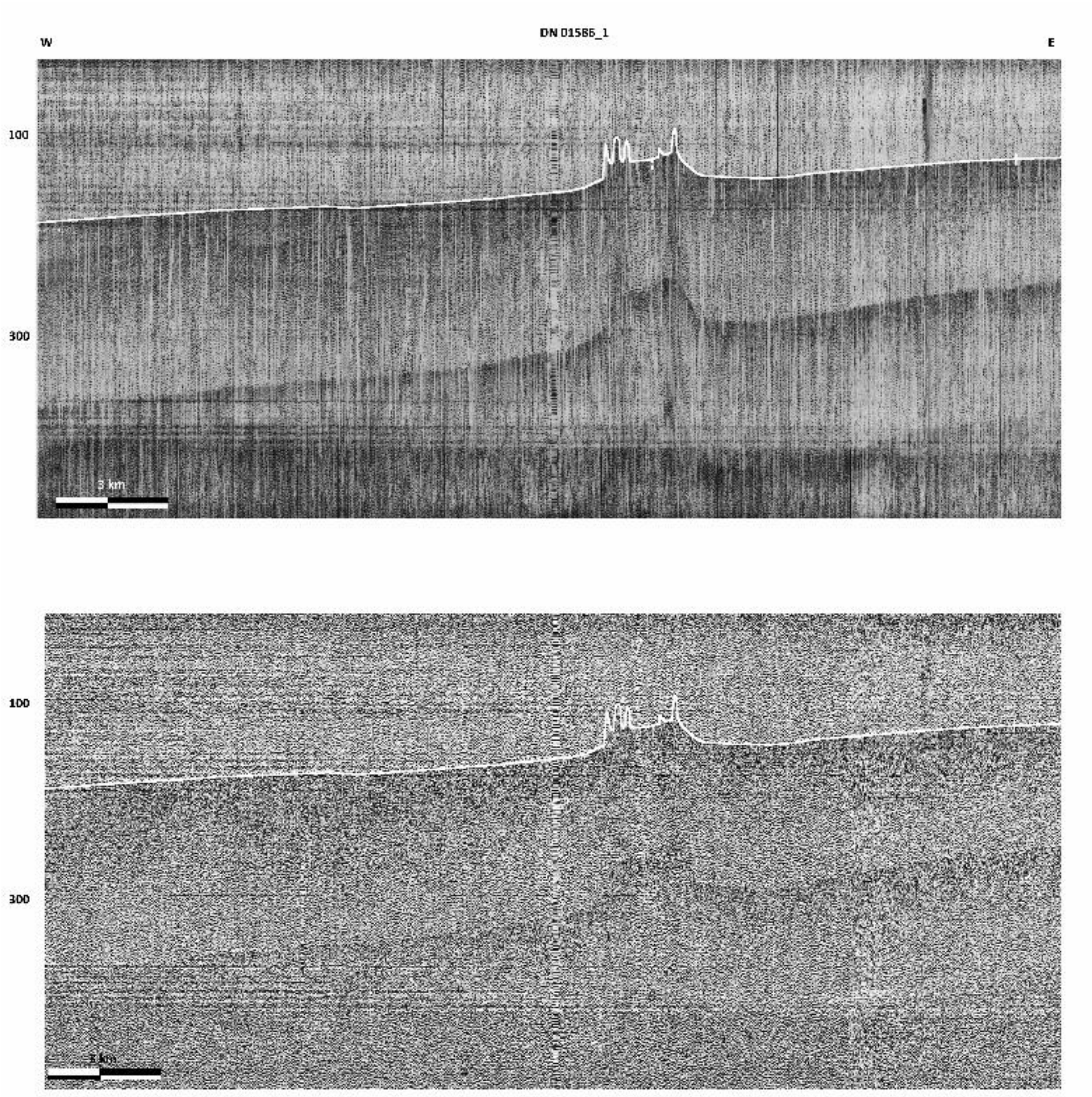


Figure 3.10 - Detail of DN01586_1 seismic line interpretation (A – res.sgy, B – proc.sgy seismic files), with the seabed in white.

Table 3.2 - Vertical shifts applied to the interpreted seismic lines to improve its adjustment to the reference EMODnet bathymetry and minimized the misties between crossing seismic lines.

Line Name	Survey	Original Shift	New Shift
VB01475	VIABOA	0	-13
VB01675	VIABOA	0	1
DN01486_1	DONA	0	-2
DN01486_2	DONA	0	7
DN01586_1	DONA	0	1
DN01586_2	DONA	0	0
DN01886_1	DONA	0	1
DN01886_2	DONA	0	-1
DN01986	DONA	0	1
DN02186_1	DONA	0	5
DN02186_2	DONA	0	3
DN02186_3	DONA	0	0
DN02286_1	DONA	0	-6
DN02286_2	DONA	0	-1
DN02386	DONA	0	-3

The seismic interpretation of the vintage seismic data aimed to infer the thickness of the recent sediments package. The seabed and the base of the recent sedimentary unit horizons were interpreted considering a best-case scenario, where the seabed corresponds to the first high amplitude reflector and the base of the recent sediments corresponds to the first unconformity identified in the seismic data. Considering the seismic data quality, it is not straightforward to distinguish significant reflections from spurious ones (e.g. noise and ghosts). This uncertainty in the seismic interpretation can lead to an overestimation of the thickness of the recent unconsolidated sedimentary package.

3.5. Estimation of Unconsolidated Sediments Thickness

The base of the unconsolidated sediments seismic unit was picked in the vintage seismic lines, identified as the post Alpine orogeny unconformity. Onshore these sediments correspond to poorly consolidated sands with an argillaceous matrix of Pliocene to Quaternary age. The bedrock in the whole area of interest consists of Cretaceous through Eocene sedimentary rocks. According to EMODnet-Geology (https://emodnet.ec.europa.eu/en/geology) map these units are made up of limestones, dolomites and sandstones.

A map with the interpretation of the base of the unconsolidated sediments in all ‘vintage’ lines is presented in *Figure 3.11* and in *Figure 3.12* overlying the map of sediments from IH (2010). The quality of the vintage seismic lines did not allow for an accurate determination of the base of sediments horizon in all the lines. In some instances, it was not possible to depict with a high degree of certainty the base of the unconsolidated sediments, even with the use of seismic attributes. Given these constraints the presented data should be considered a best-case scenario, possibly with some overestimated values, regarding the unconsolidated sediments thickness in the Figueira da Foz area.

The shallower seismic unit in the Figueira da Foz area, believed to correspond to the unconsolidated sediments, observable outside the Mesozoic and Cenozoic formations outcrops, overlies a deformed (probably Miocene) unit resting on top of an erosional surface. The seismic facies characterizing the unit are: 1) transparent; 2) parallel (sub-horizontal) reflectors of low to medium amplitude.

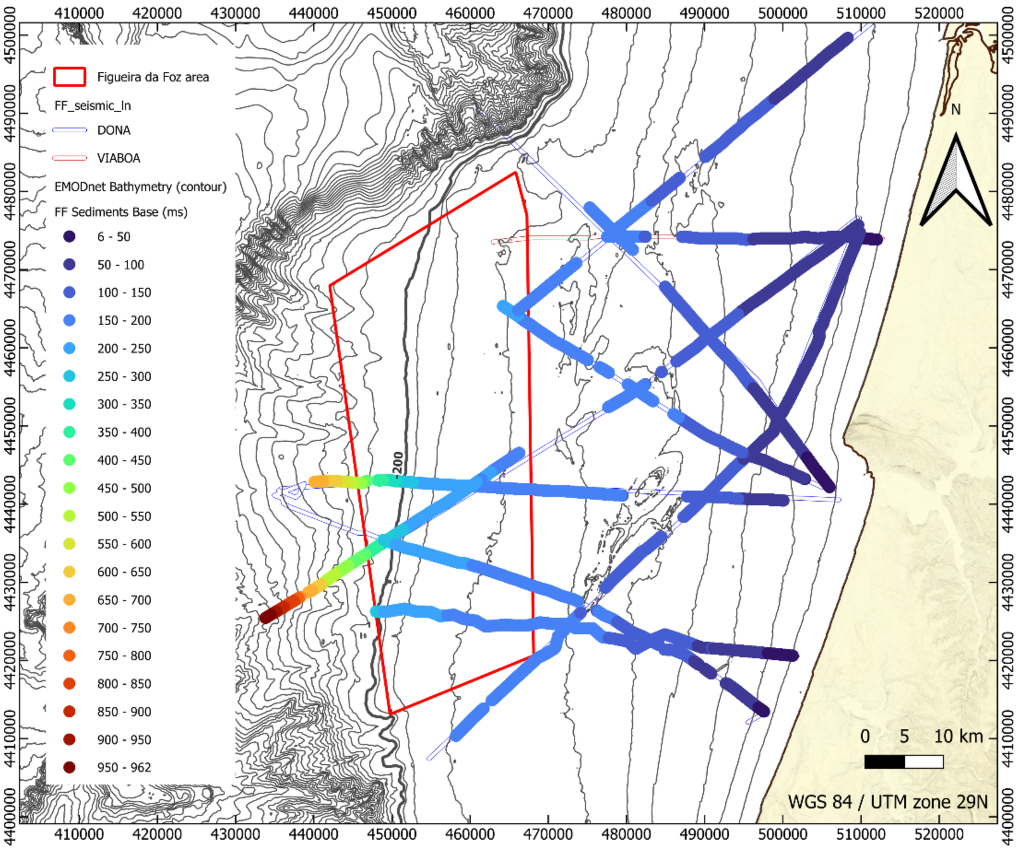


Figure 3.11 - Map of the base of unconsolidated sediments seismic unit (in ms - TWT).

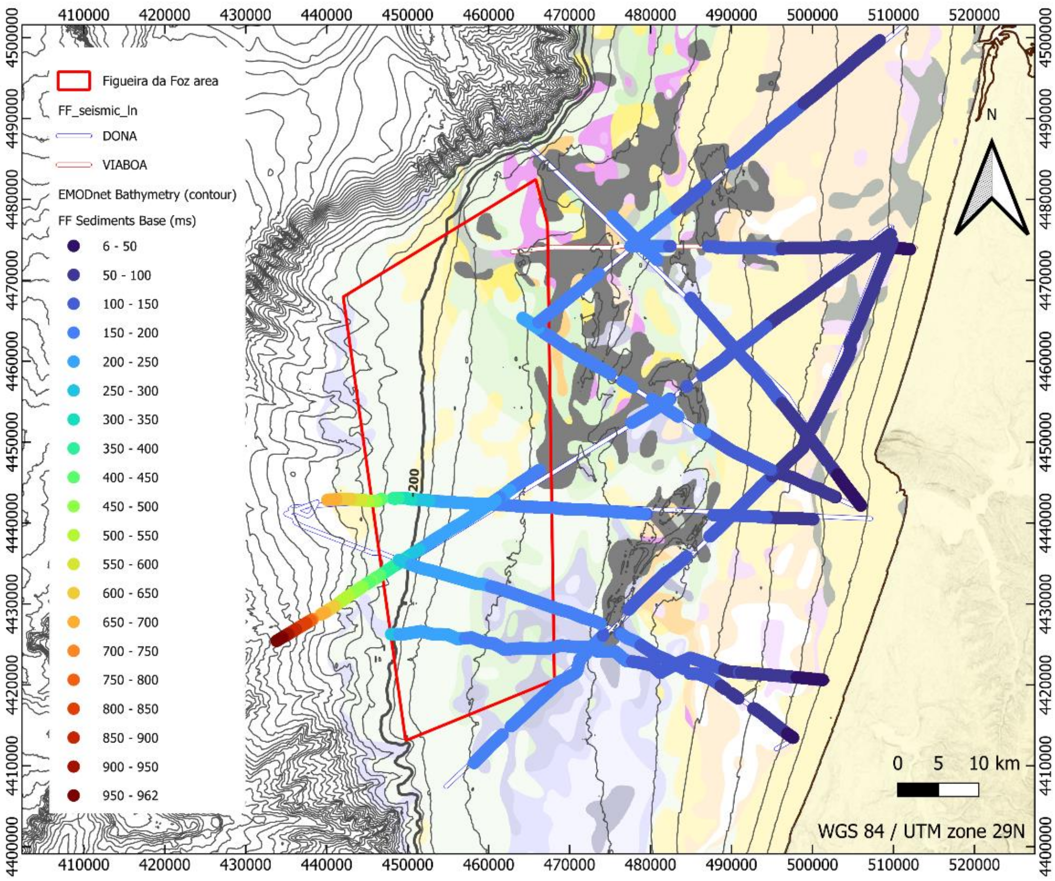


Figure 3.12 - Map of the base of the unconsolidated sediments seismic unit overlying IH (2010) continental shelf sediments map (values in ms - TWT; legend for the IH map presented in Figure 2.2)

The thickness of the recent sediments package was computed from the difference between the interpreted seafloor horizon and the base of the unconsolidated sediments horizon: Figure 3.13 presents the computed thickness of the unconsolidated sediments along the lines in TWT; and Figure 3.14 shows the same data plotted on top of the surficial sediments map from the IH (2010).

The conversion to depth was done using a sound velocity value considered to be an acceptable approximation of the velocity for loose sediments in the area and used in previous projects: 1700 m/s. The maps of the calculated values are presented in *Figure 3.15*, and in *Figure 3.16* overlaying the surficial sediments map of the IH (2010).

The unconsolidated sediment thickness ranges between nil and a maximum value of 28 ms (TWT), with a median value of 9 ms. Considering a value of 1700 m/s for the velocity of the sound the thickness of the unit varies between 0 and approximately 24 meters, with a median value of 14 meters.

Taking into consideration the crude estimation of the sound velocity for the unit, the range limits of 1500 m/s and 2000 m/s were used to establish a worst-case scenario and a best-case scenario for the thickness of the formation. Considering those values the thickness of the unconsolidated sediments maximum values range between 21 m and 28 m.

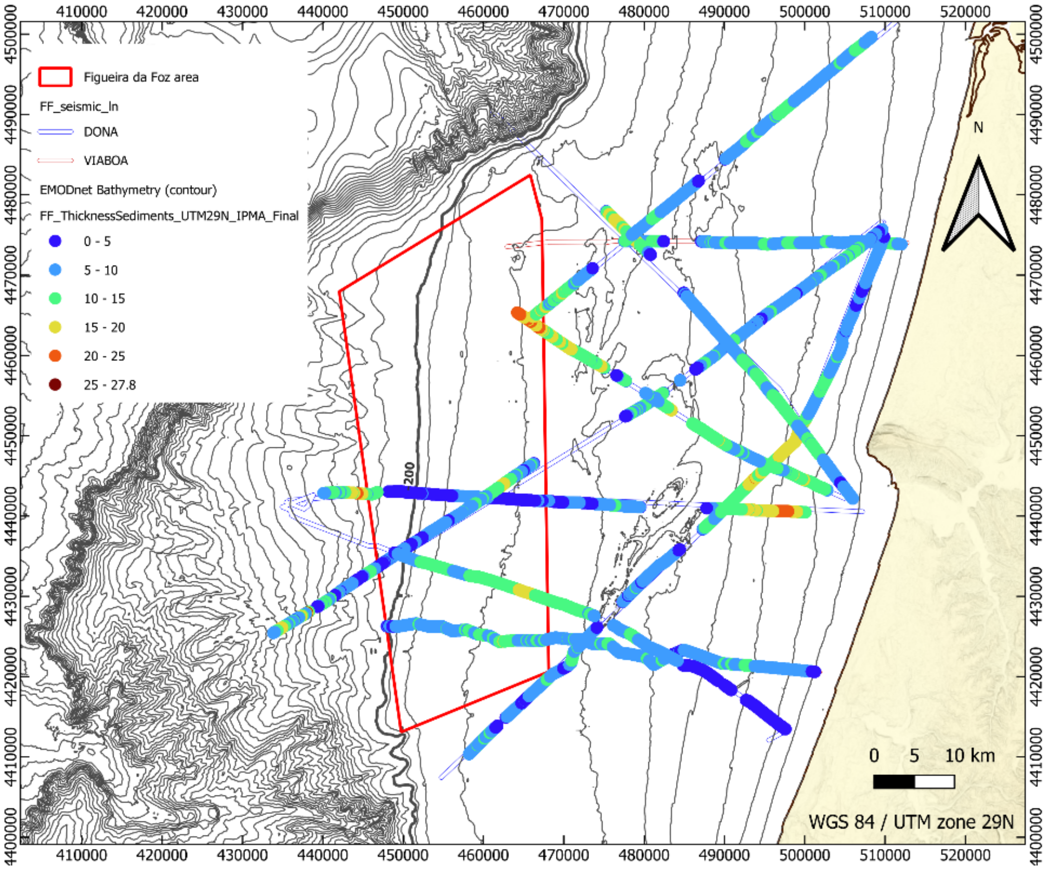


Figure 3.13 - Thickness of the shallower unit, probably of unconsolidated sediments, from the interpretation of the 'vintage' seismic sections (values in ms).

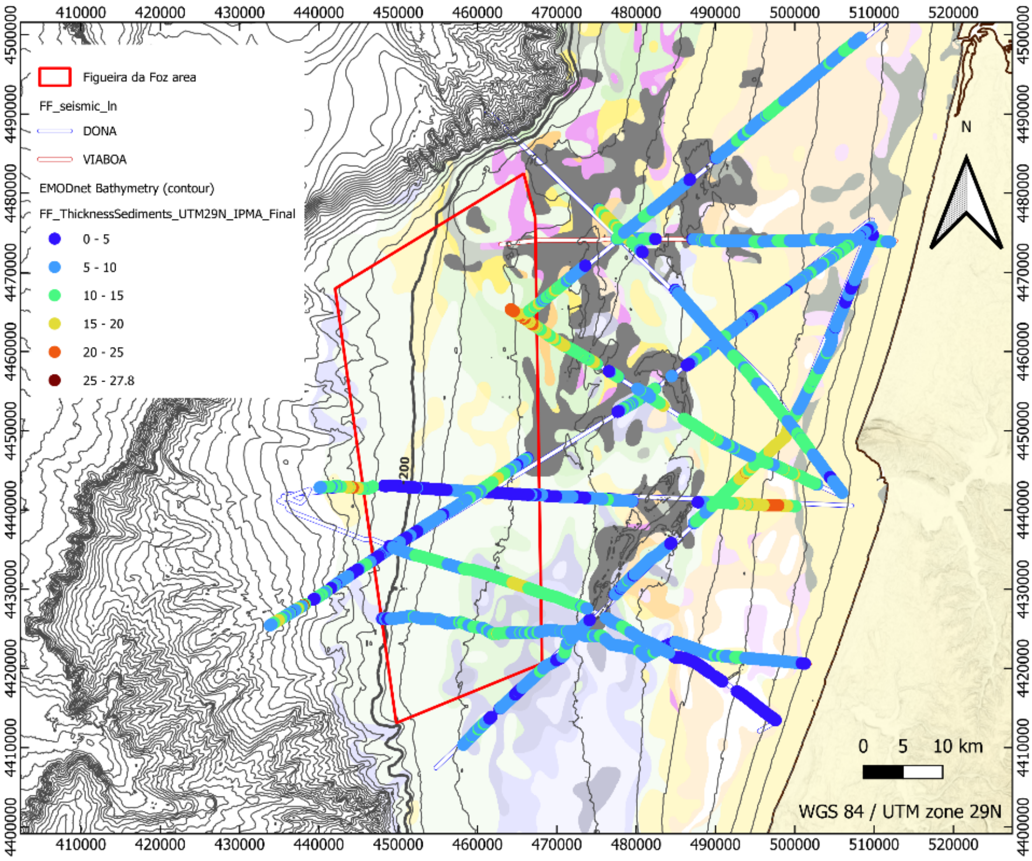


Figure 3.14 - Thickness of the shallower unit (in ms), probably of unconsolidated sediments, from the interpretation of the 'vintage' seismic sections plotted over the Surficial Sediments Map (legend for the IH map presented in Figure 2.2).

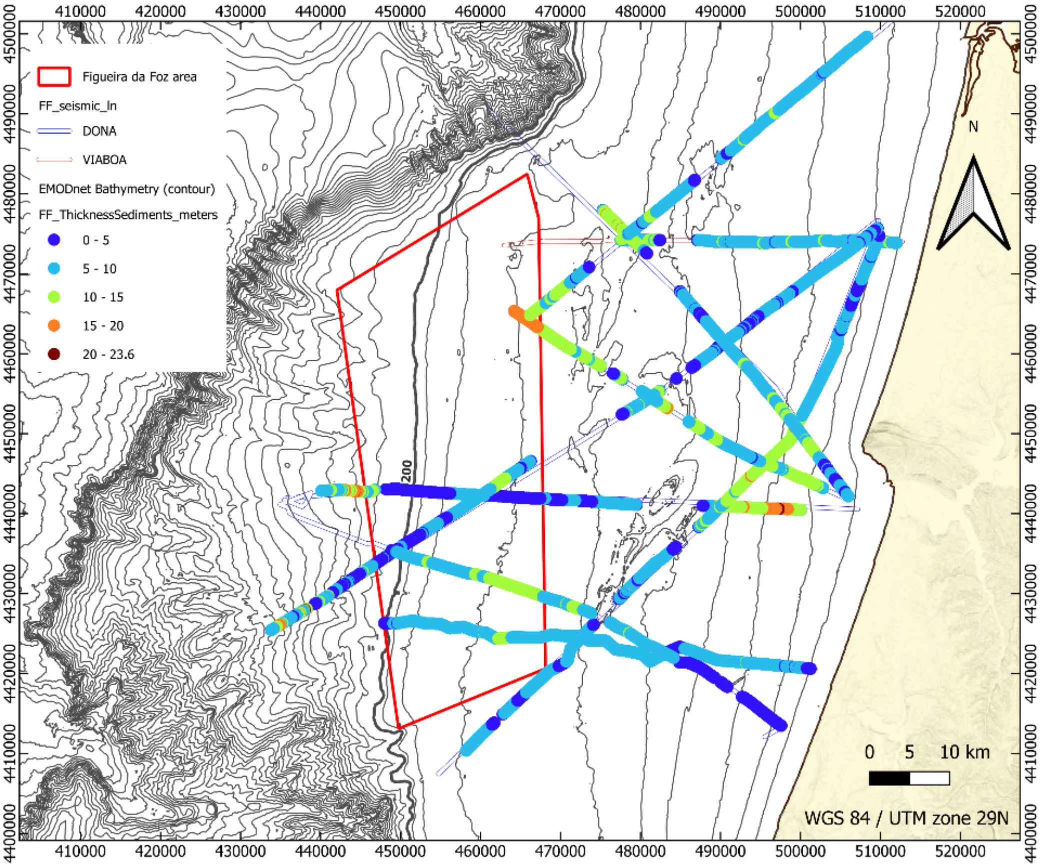


Figure 3.15 - Thickness of the shallower unit (in m), probably of unconsolidated sediments, from the interpretation of the 'vintage' seismic sections, converted to depth using an average sound propagation velocity of 1700 m/s

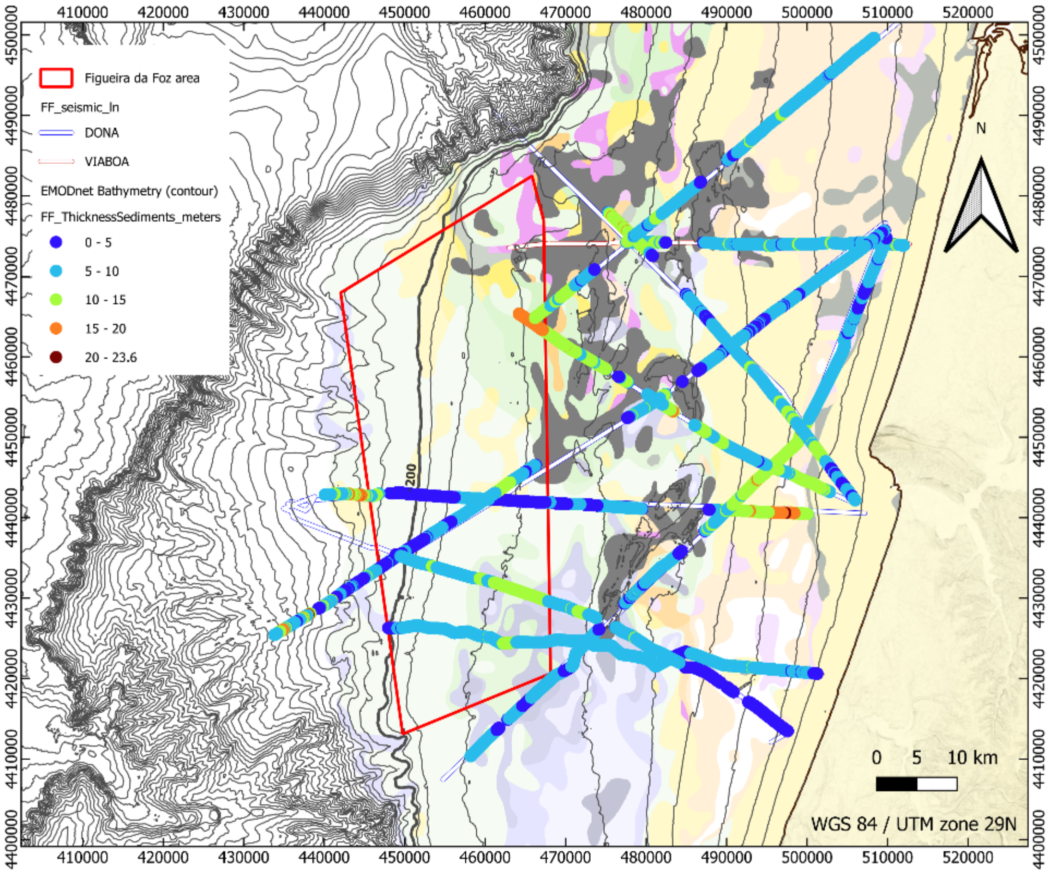


Figure 3.16 - Thickness of the shallower unit (in m), probably of unconsolidated sediments, from the interpretation of the 'vintage' seismic sections, converted to depth using an average sound propagation velocity of 1700 m/s (legend for the IH map presented in Figure 2.2).

4. MEDIUM TO LOW RESOLUTION SEISMIC SURVEYS EVALUATION (OIL & GAS)

4.1. Surveys' Description

Oil and Gas exploration activities provide a vast set of information, namely of medium- to low-resolution seismic surveys, represented in Figure 4.1. Surveys covering the area of Figueira da Foz were initially conducted during the 1970's and the latest in 2002. They were acquired and processed by different companies (Table 4.1 and Annex 9.1). The surveys provide a varying quality image of the Mesozoic geology of the area.

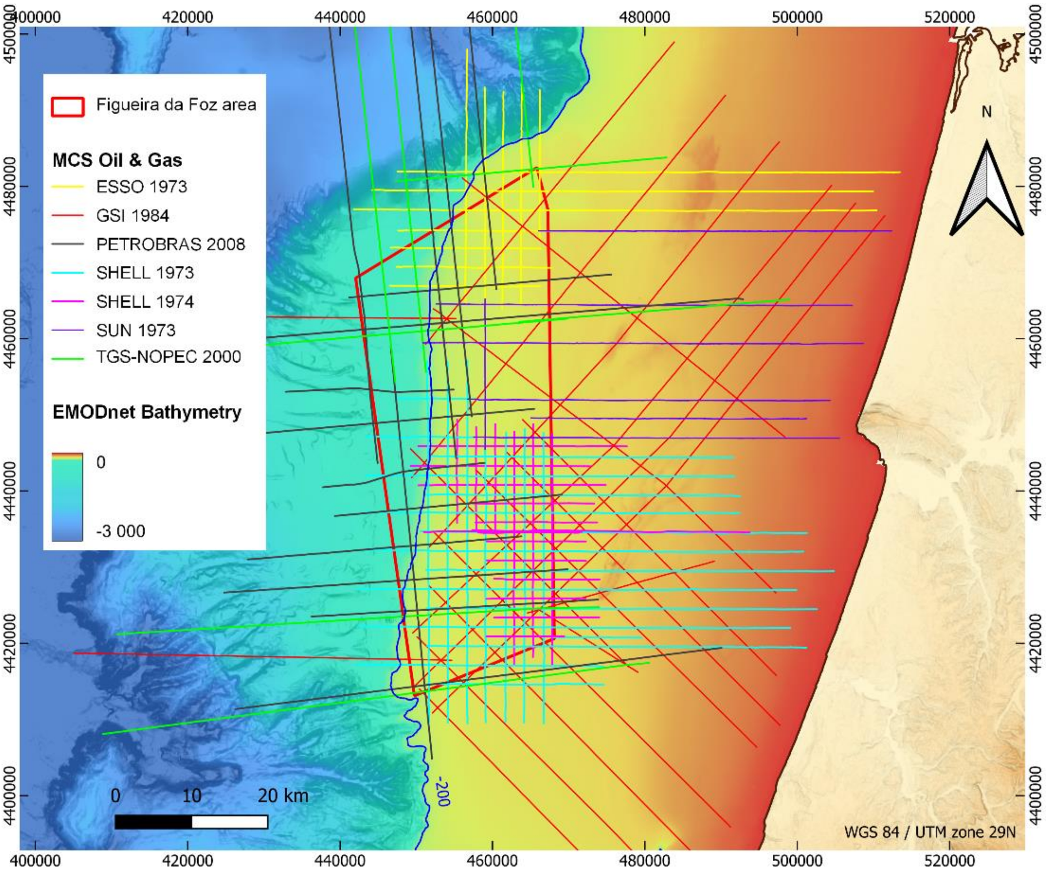


Figure 4.1 - Oil and Gas exploration seismic surveys location.

Table 4.1 - Oil and Gas exploration surveys

Survey	Operator	Year	Nº of lines
ESSO 1973	Esso	1973	12
GSI 1984	GSI	1984	21
PETROBRAS 2008	Petrobras	2008	18
SHELL 1973	Shell	1973	25
SHELL 1974	Shell	1974	21
SUN 1973	Sun	1973	7
TGS-NOPEC 2000	TGS-NOPEC	2000	8

4.2. Evaluation of Quality and Potential Interest

Seismic surveys covering the area of interest were acquired in different years, using various acquisition systems, and processed by different companies with different workflows. Detailed data on the surveys is presented in Annex 9.1.

Evaluation of the quality and applicability of the surveys to the development of wind farms was done semi-quantitatively by applying two classification scales: i) the quality assessment was done using a five-element scale, focusing on the quality of the imaging; and ii) the applicability was also assessed using a five-element scale, focusing on the capacity of imaging the thin veneer of loose sediments in the area. The scales are presented in the Table 4.2.

Table 4.2 Evaluation criteria applied to the Oil and Gas seismic surveys

Quality	Applicability
1 – Poor	1 – Inadequate Coverage
2 – Weak	2 – Low Resolution
3 – Medium	3 – Medium Resolution
4 – Good	4 – High Resolution
5 – Very Good	5 – Very High Resolution

Quality scale is self-explained, while Applicability needs some clarification: 1 - Inadequate Coverage refers to lines only covering small portions of the interest area; 2 – Low Resolution, refers to lines where the shallower package of sediments is invisible due to the resolution of the survey; 3 – Medium Resolution refers to lines where the thickest portions of the unconsolidated sediments package are resolvable; 4 – High Resolution refers to lines where the loose sediments package is clearly visible in most part of the line; 5 – Very High Resolution lines (absent in the set evaluated) refers to lines where the shallower package of sediments is visible and the seismic characteristics of the units are resolvable and characterizable.

The evaluated surveys of oil and gas exploration are of variable quality and in general with resolutions not suitable for the purpose of planning wind farm structures, with a classification of applicability less than 2. Figure 4.2 presents a spider diagram synthesizing the results of the evaluation.

The evaluation of the interest in re-processing the lines for improving the imaging of the first 10 m to 30 m, would imply a more detailed evaluation of the raw data, unavailable for IPMA.

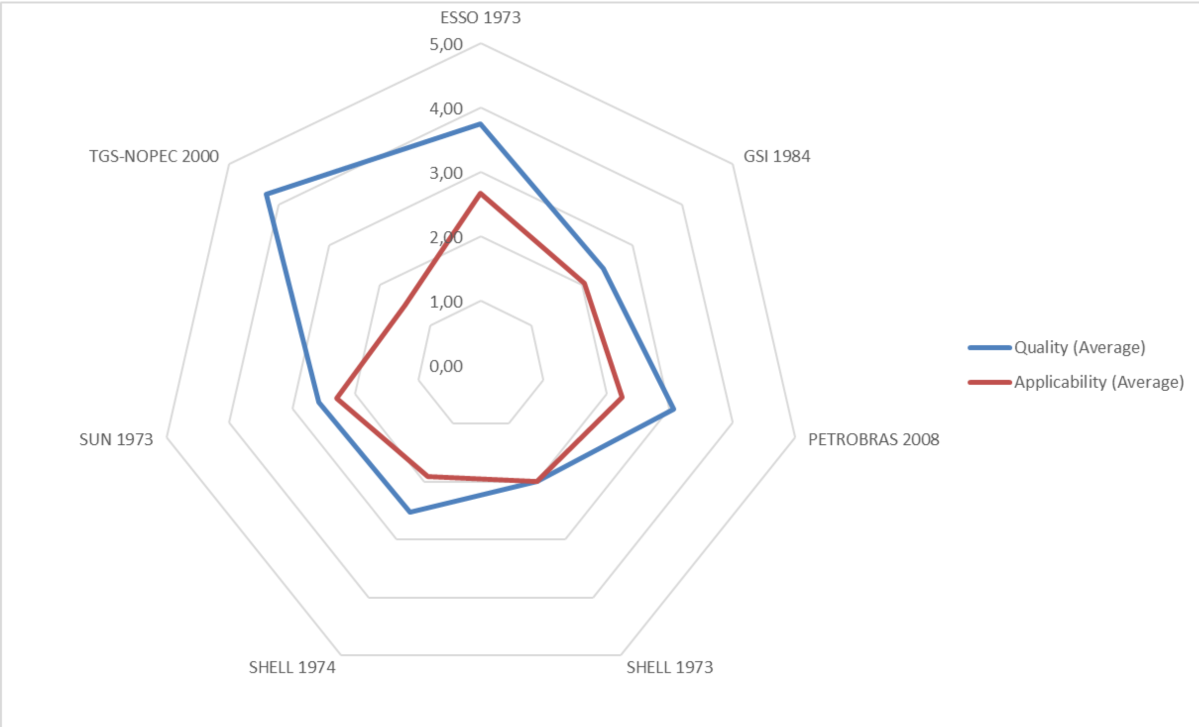


Figure 4.2 Results of the Oil and Gas seismic surveys evaluation.

5. METOCEAN DATA

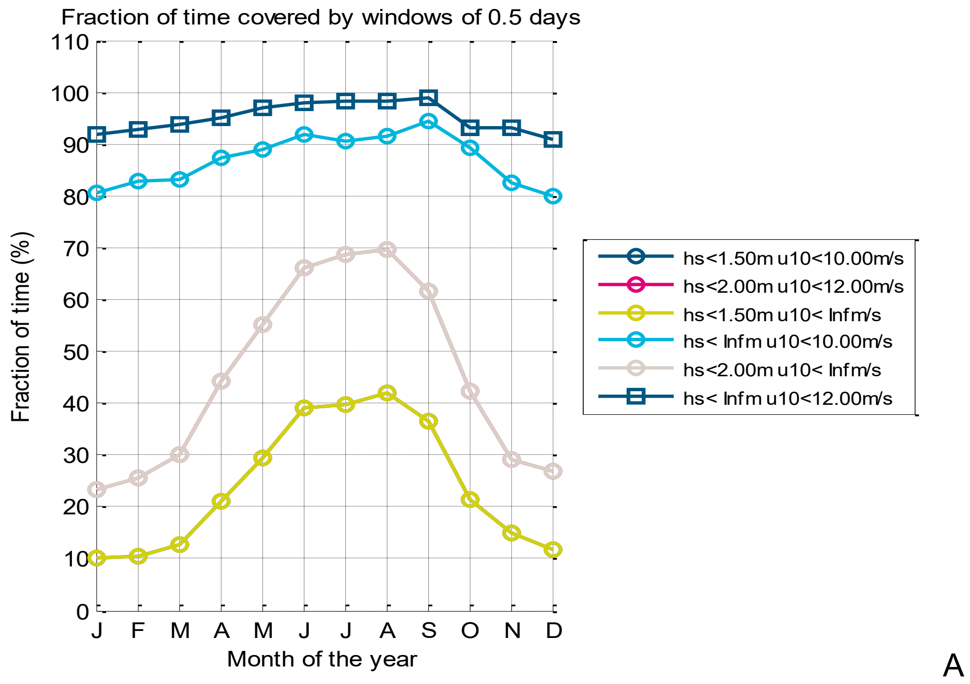
Analysis of the significant wave height and wind speed at 10 m above the sea surface time-series was done considering 12-hour periods for the conditions described in Table 5.1.

Table 5.1 Scenarios for metocean persistency analysis

Scenario	Wave Significant Height (m)	Wind Speed (m/s)
C1	< 1.50	< 10.00
C2	< 2.00	< 12.00
C3	< 1.50	no limit
C4	no limit	<10.00
C5	< 2.00	no limit
C6	no limit	< 12.00

Figure 5.1A and Figure 5.1B present the results of the analysis for the central point of the Figueira da Foz deployment area regarding the fraction of time covered by 12 hours windows per month (minimum, maximum and mean values for the 12 months are presented in Annex 9.2, 9.3). Results show that regardless of scenario, months with better joint conditions of significant wave height and 10 m high wind speed are the months of the June-September period (Figure 5.1A). For the number of 12 hour windows, the results are similar (Figure 5.1B). The estimated delay time (Figure 5.2) is significantly different between the scenarios: for scenarios C3 and C5, the period of May to September, is the more favorable for the work at the sea.

Detailed plots are presented in Annex 9.3.



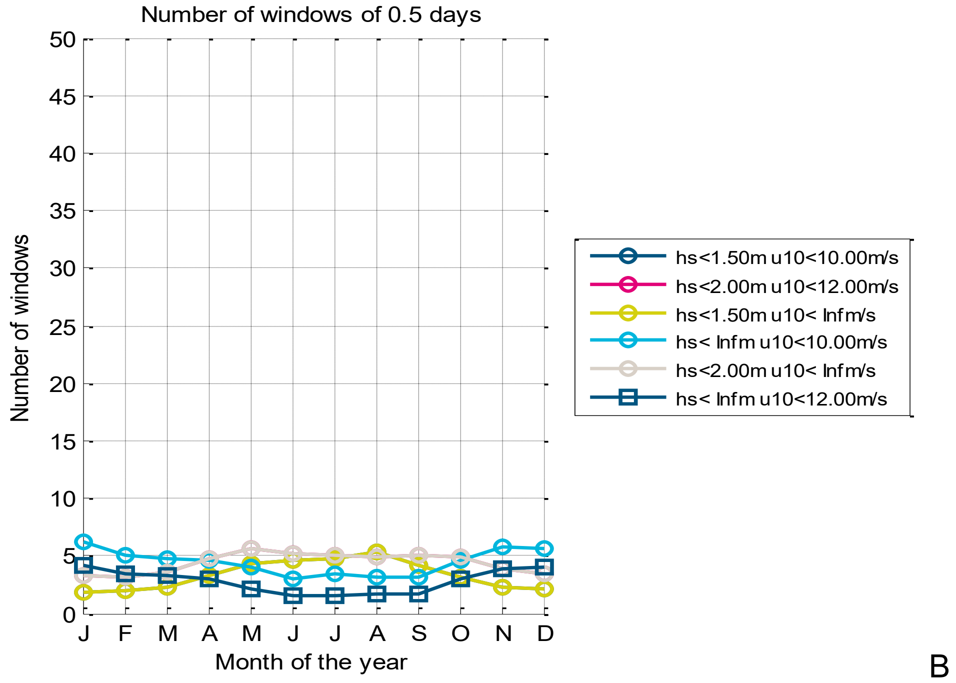


Figure 5.1 Variation over the years of the extent (A) and the number of weather windows (B) per month

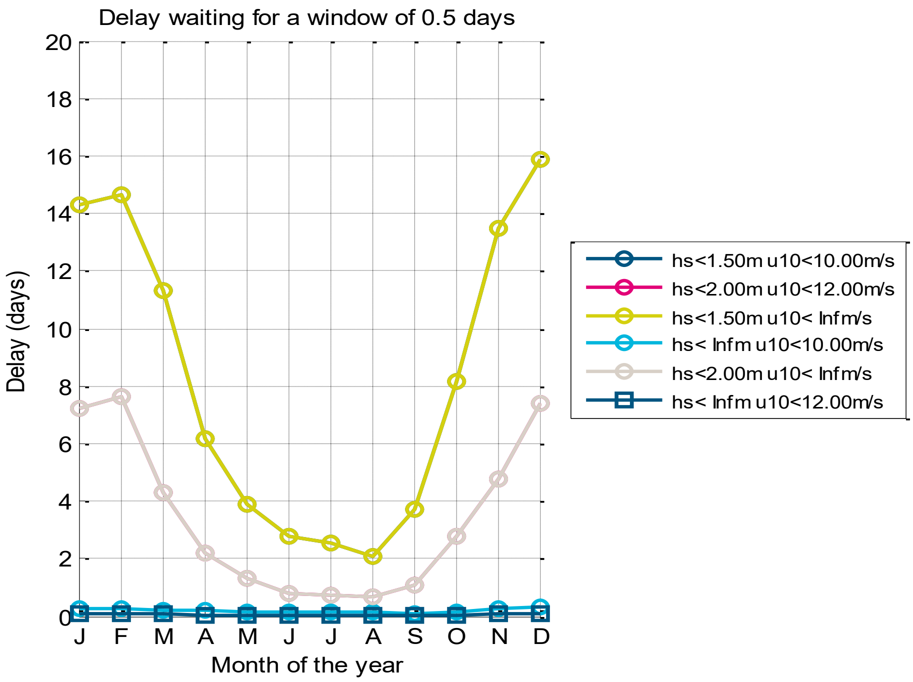


Figure 5.2 Variation of mean delay waiting for weather windows over the years

6. ARCHAEOLOGICAL HERITAGE

The nearby onshore area includes the import port complex of Figueira da Foz. The earliest known settlements on the Mondego occupy positions overlooking the river and show vast contact networks as far as the Mediterranean, although here evidence of settlements dates back only to the Iron Age. During the Antiquity a Roman port was probably located close to the current Mondego River mouth that probably constituted the main port complex until the Lower Middle Age. No archeological sites were identified in the area, although some submerged pre-historical settlements are probable to occur.

In the wind farm deployment area 78 occurrences were registered: 34 confirmed shipwrecks (from 1917 to 2009), 4 plane crashes and 40 of undetermined character. In the adjacent areas 35 occurrences were registered: 9 correspond to chance finds of artifacts, like amphorae and lead anchor stumps (ID 210) that testify to the passage of vessels from the Roman Period. Two occurrences have their origin in the First World War, the trawlers Germano and Serra do Gerês, sunk by German submarines.

Occurrences caused by the Second World War were also found: (i) the crash of a British Bristol Beaufighter fighter off Cape Mondego; (ii) and the crash of an American B26 Marauder bomber. The B26 Marauder is a bomber capable of carrying up to c. 1300 kg of; it is impossible for us to estimate what the exact configuration and armament on board both aircraft would have been at the time of their losses.

The two remaining aircraft that fell into the region's waters are the result of accidents, both involving the same aircraft, F86F Saber jets that crashed in 1963 and 1977. These aircraft were typically armed with 4, 50 caliber machine guns with 265 bullets per gun complemented by 900 kg of bombs or up to 16 .517 missiles. The exact configuration of the armament on board these aircraft at the time of their loss is also unknown.

Figure 6.1 is a map of the occurrences found in the area of Figueira da Foz.

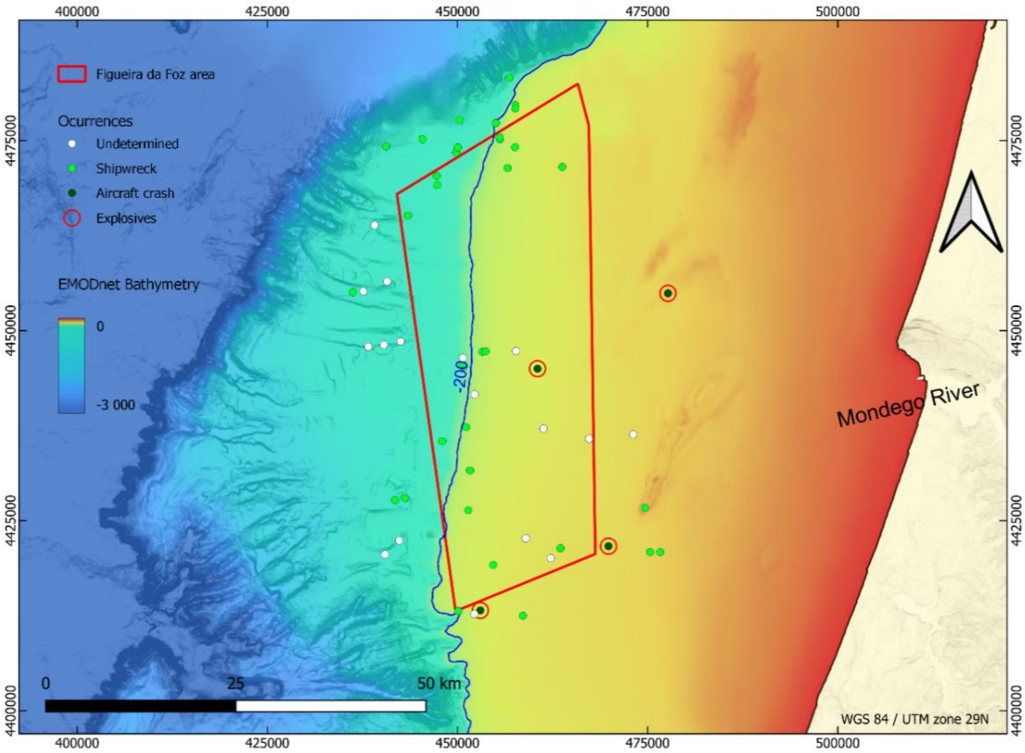


Figure 6.1 Location of potential archeological occurrences

7. CONCLUDING REMARKS

The continental shelf of the area of interest is a smooth surface dipping offshore, covered by a package of unconsolidated sediments that can vary from 0 m to 24 m maximum thickness.

Sediment samples collected using grab collectors indicate grain sizes varying mainly from fine grained sand to gravel. Hard rock outcrops are indicated on the map of surficial sediments (Figure 2.2), which are consistent with seismic profiles.

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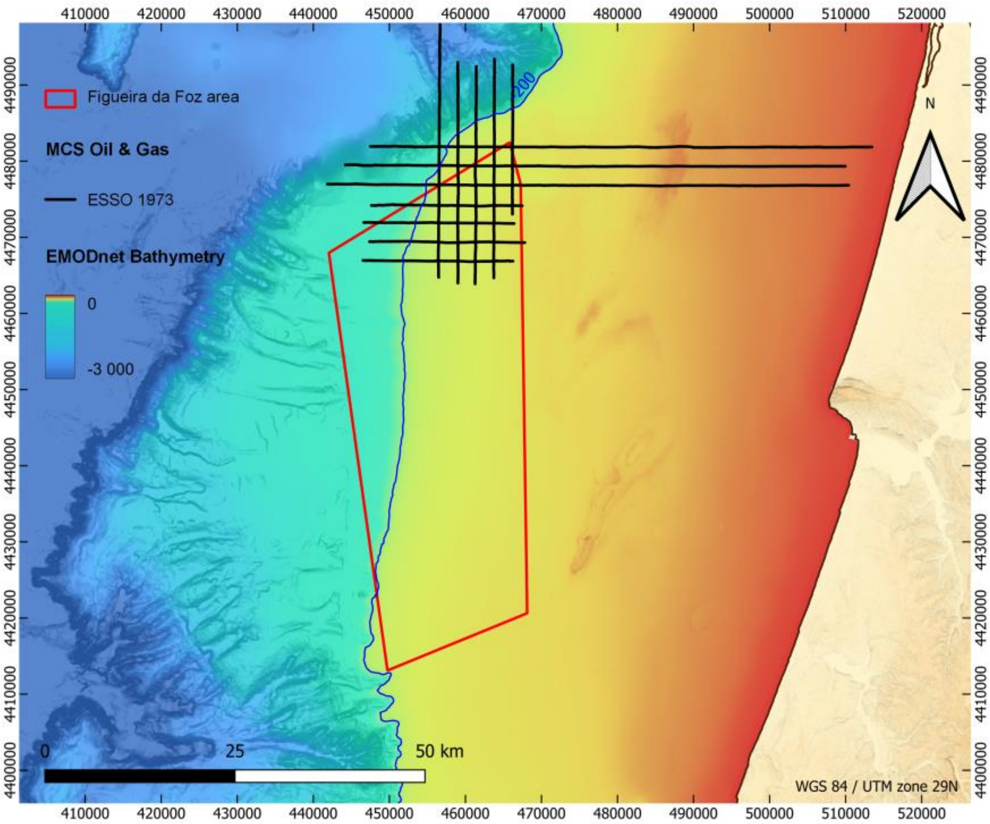
9. ANNEXES

9.1. Oil and Gas Surveys Characterization Files

<table>
<tr><td>Survey Name</td><td colspan="2">ESSO</td><td colspan="2">Survey Dates</td><td>October 1973</td></tr>
<tr><td>Promotor</td><td colspan="2">Esso Exploration</td><td colspan="2">Contractor</td><td>Seismograph Service LTD</td></tr>
<tr><td>Vessel</td><td colspan="2">M.V. Seis Mariner</td><td colspan="2">Data Holder</td><td>DGEG (Portugal)</td></tr>
<tr><td>Main Objectives</td><td colspan="5">Oil & Gas exploration</td></tr>
<tr><td>Positioning</td><td colspan="5">Primary: Extended Range Shoran; Secondary: Doppler Sonar Nav. Syst.</td></tr>
<tr><td>Type of Data</td><td colspan="5">Processed seismic data in SEG-Y format</td></tr>
<tr><td colspan="6">Seismic data</td></tr>
<tr><td>Seismic Source</td><td colspan="5">Bolt Associates Incorporated; Airgun array, Total Volume/Pressure/Energy: 1200 cu.in./150atm</td></tr>
<tr><td>Seismic Receiver</td><td colspan="5">Seismic Engineering, length: 2400m, group spacing: 50m, number of channels: 48.</td></tr>
<tr><td>Sample Size (ms)</td><td>4</td><td>Trace Length (ms)</td><td>6000</td><td>Shotpoint Interval (m)</td><td>25</td></tr>
<tr><td>Seismic Processing</td><td colspan="5">Velocity analysis; Predictive Deconvolution; Horizontal Stacking</td></tr>
<tr><td>Observations</td><td colspan="5">Estimated line length in area of interest: 155km</td></tr>
<tr><td colspan="6">Data Coverage in Area of Interest</td></tr>
<tr><td colspan="6">
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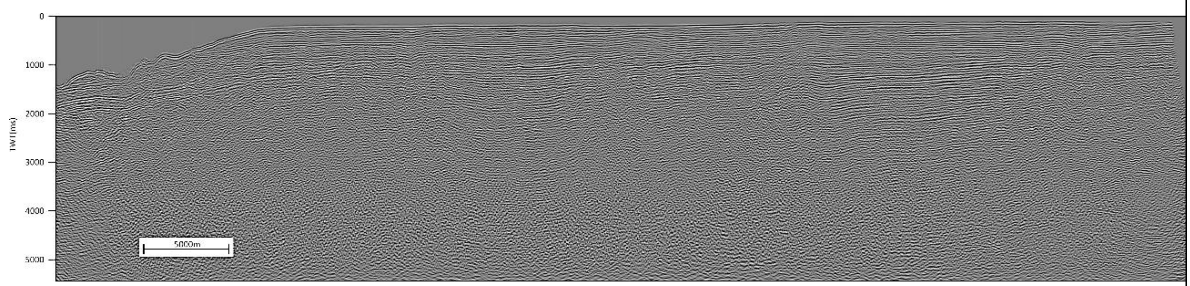
<tr><td colspan="6">Seismic Data Example</td></tr>
<tr><td colspan="6">
</td></tr>
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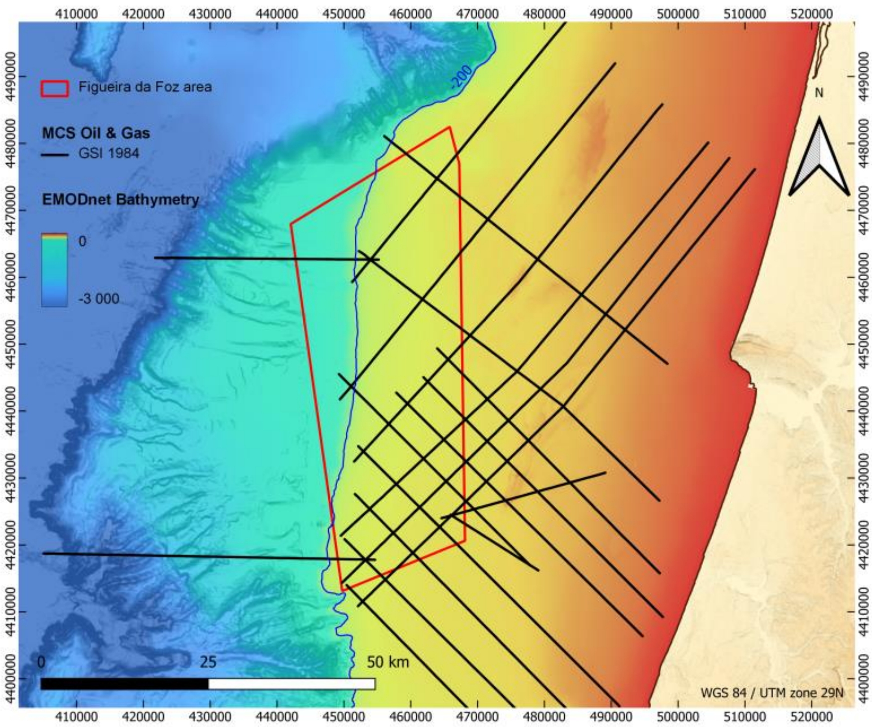
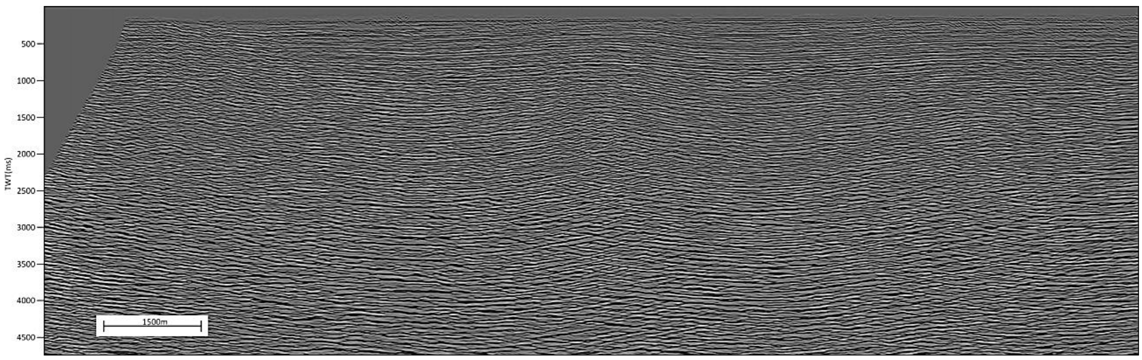
Survey Name	GSI Party No 293B		Survey Dates	11/11/1984 to 6/12/1984	
Promotor	Tullow/DPEP-DGGE		Contractor	Geophysical Services International	
Vessel	M/v P.E.Haggerty		Data Holder	DGEG (Portugal)	
Main Objectives	Oil & Gas exploration				
Positioning	SYLEDIS & GEONAV				
Type of Data	Processed seismic data in SEG-Y format				
Seismic data					
Seismic Source	Type; Airgun array, Total Volume/Pressure/Energy: 2775cu.in./1800-2000 psi.				
Seismic Receiver	Texas Instrument Neutral Buoyancy, length: 3039m, groups spacing: 25m, number of channels: 120.				
Sample Size (ms)	2	Trace Length (ms)	6000	Shotpoint Interval (m)	25
Seismic Processing	Velocity analysis; NMO correction; CDP stack; Deconvolution; FK Migration				
Observations	Estimated line length in area of interest: 280km				

Data Coverage in Area of Interest



Seismic Data Example



<table>
<tr><td>Survey Name</td><td colspan="3">PETROBRAS
BR2008 2D Survey</td><td colspan="2">Survey Dates</td><td colspan="2">20/06/2008 to 10/11/2008</td></tr>
<tr><td>Promotor</td><td colspan="3">Petrobras International
Braspetro B.V.</td><td colspan="2">Contractor</td><td colspan="2">SCAN Geophysical A.S.A.</td></tr>
<tr><td>Vessel</td><td colspan="3">M/V Geo Searcher</td><td colspan="2">Data Holder</td><td colspan="2">DGEG (Portugal)</td></tr>
<tr><td>Main Objectives</td><td colspan="7">Oil & Gas exploration</td></tr>
<tr><td>Positioning</td><td colspan="7">Starfix HP/ Skyfix XP systems from Fugro AS</td></tr>
<tr><td>Type of Data</td><td colspan="7">Processed seismic data in SEG-Y format</td></tr>
<tr><td colspan="8">Seismic data</td></tr>
<tr><td>Seismic Source</td><td colspan="7">Type: Bolt 1500 & 1900 Long Life; Airgun array, Total Volume/Pressure/Energy: 4200cu.in./2000 psi.</td></tr>
<tr><td>Seismic Receiver</td><td colspan="7">Manufactured by Input-Output Inc., length: 10000m, groups spacing: 12.5m, number of channels: 800.</td></tr>
<tr><td>Sample Size (ms)</td><td>2</td><td>Trace Length (ms)</td><td colspan="2">10000</td><td colspan="2">Shotpoint Interval (m)</td><td>25</td></tr>
<tr><td>Seismic Processing</td><td colspan="7">Velocity analysis; Pre-Stack Time Migration; Debubble; Pre-Stack Time Migration; F-K Filter; Post Stack Matching.</td></tr>
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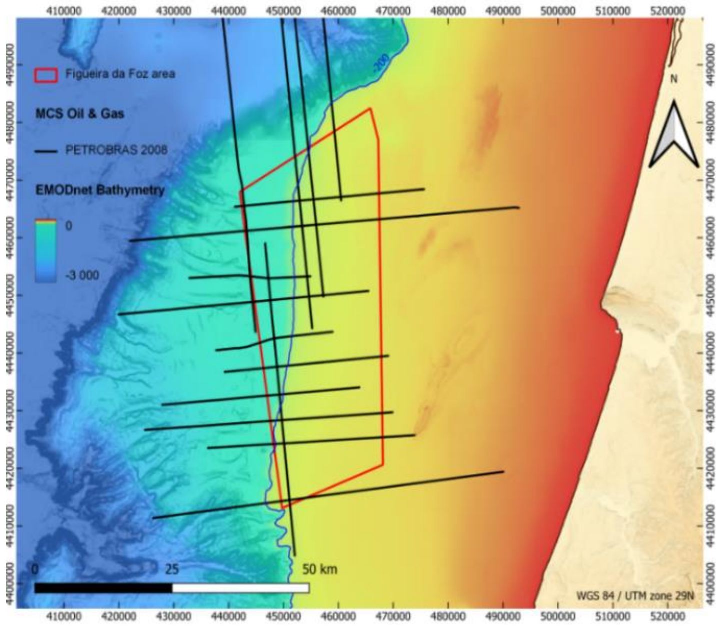
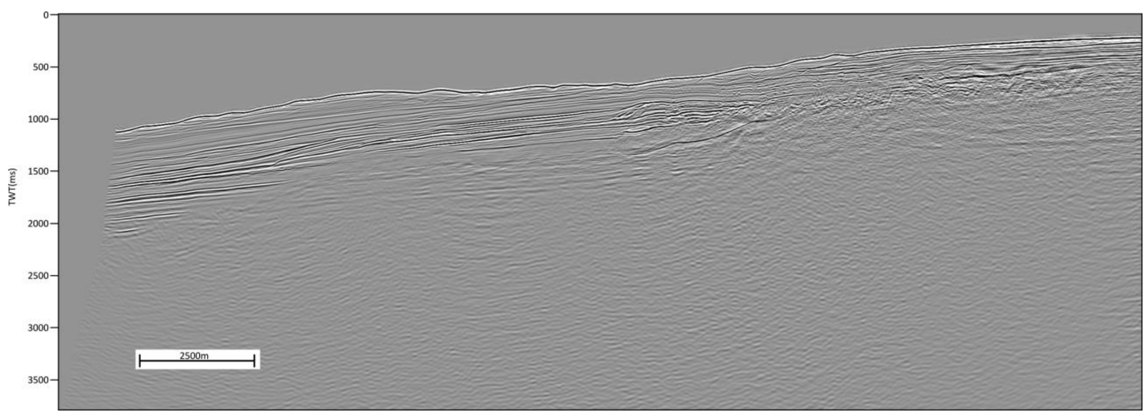
<tr><td colspan="8">Data Coverage in Area of Interest</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="8">Seismic Data Example</td></tr>
<tr><td colspan="8"></td></tr>
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<table>
<tr><td>Survey Name</td><td colspan="2">SHELL73</td><td colspan="2">Survey Dates</td><td>01/10/1973 to 02/12/1973</td></tr>
<tr><td>Promotor</td><td colspan="2">Shell Prospex Poruguesa S.A.R.L.</td><td colspan="2">Contractor</td><td>Seismograph Service LTD</td></tr>
<tr><td>Vessel</td><td colspan="2">M.V. Seis Mariner</td><td colspan="2">Data Holder</td><td>DGEG (Portugal)</td></tr>
<tr><td>Main Objectives</td><td colspan="5">Oil & Gas exploration</td></tr>
<tr><td>Positioning</td><td colspan="5">Primary: Extended Range Shoran; Secondary: Doppler Sonar Nav. Syst.</td></tr>
<tr><td>Type of Data</td><td colspan="5">Processed seismic data in SEG-Y format</td></tr>
<tr><td colspan="6">Seismic data</td></tr>
<tr><td>Seismic Source</td><td colspan="5">Bolt Associates Incorporated; Airgun array, Total Volume/Pressure/Energy: 1200cu.in./150atm</td></tr>
<tr><td>Seismic Receiver</td><td colspan="5">Seismic Engineering, length: 2400m, groups spacing: 50m, number of channels: 48.</td></tr>
<tr><td>Sample Size (ms)</td><td>4</td><td>Trace Length (ms)</td><td>6000</td><td>Shotpoint Interval (m)</td><td>25</td></tr>
<tr><td>Seismic Processing</td><td colspan="5">Velocity analysis; Predictive Deconvolution; Horizontal Stacking</td></tr>
<tr><td>Observations</td><td colspan="5">Estimated line length in area of interest: 481km</td></tr>
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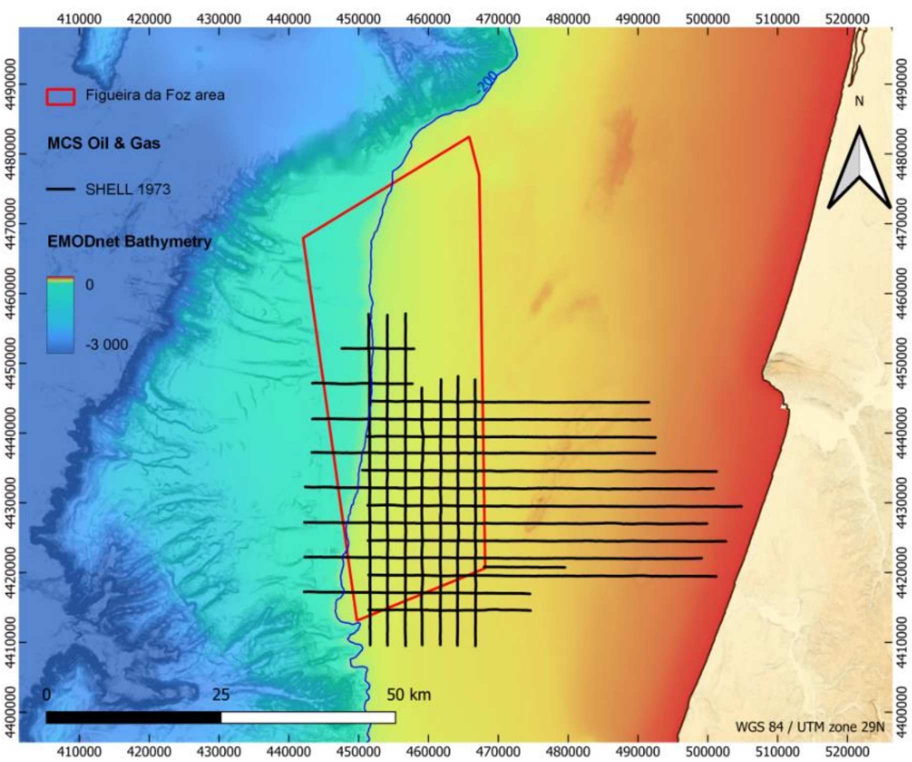
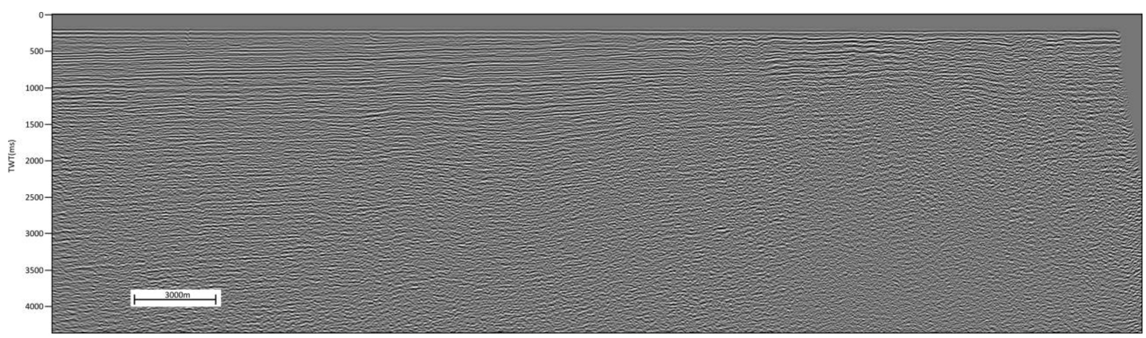
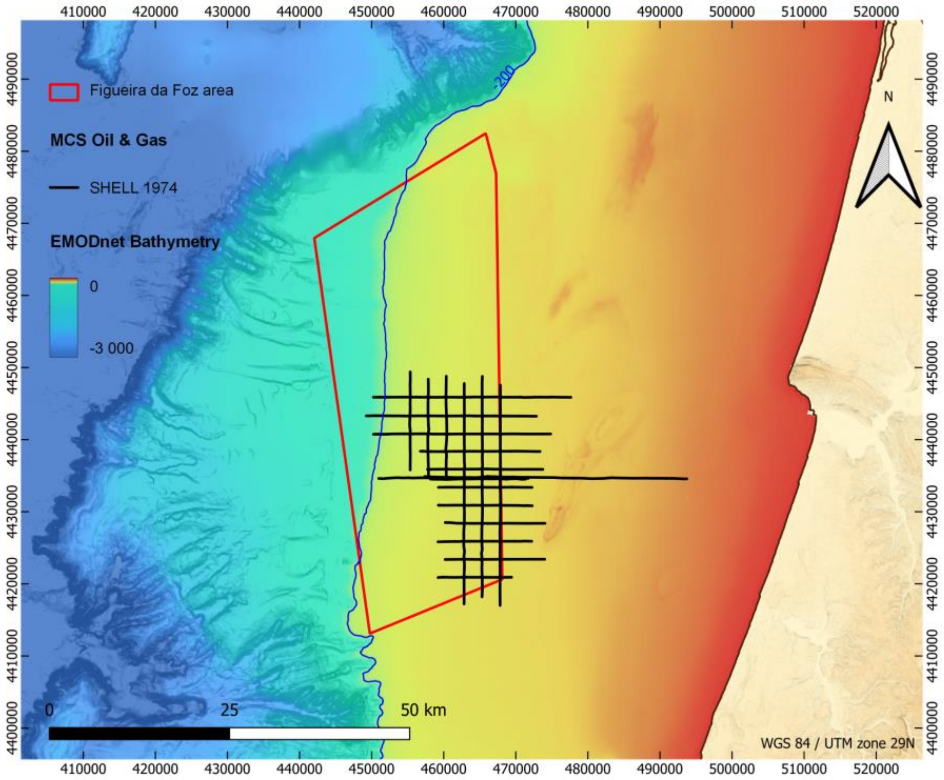


Seismic Data Example

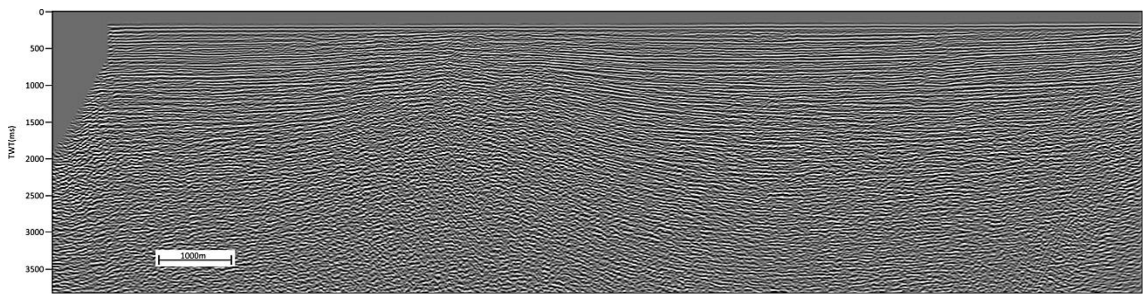


Survey Name	SHELL74		Survey Dates	11/04/1974 to 11/07/1974	
Promotor	Shell Prospex Poruguesa S.A.R.L.		Contractor	Seismic Explorations International	
Vessel	M/V Seismic Surveyor		Data Holder	DGEG (Portugal)	
Main Objectives	Oil & Gas exploration				
Positioning	Complete X-R Shoran system.				
Type of Data	Processed seismic data in SEG-Y format				
Seismic data					
Seismic Source	Airgun array, Total Volume/Pressure/Energy: 1602cu.in./2000psi				
Seismic Receiver	Seismic Engineering Company, length: 2400m, groups spacing: 25m, number of channels: 96.				
Sample Size (ms)	4	Trace Length (ms)	6000	Shotpoint Interval (m)	25
Seismic Processing	Velocity analysis; Predictive Deconvolution; Horizontal Stacking				
Observations	Estimated line length in area of interest: 283km				

Data Coverage in Area of Interest

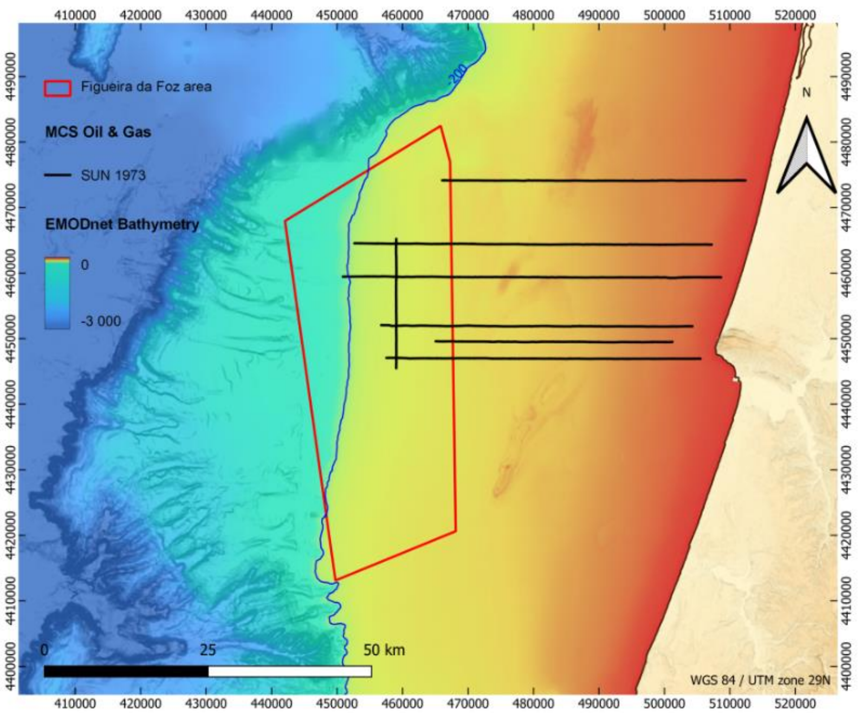


Seismic Data Example

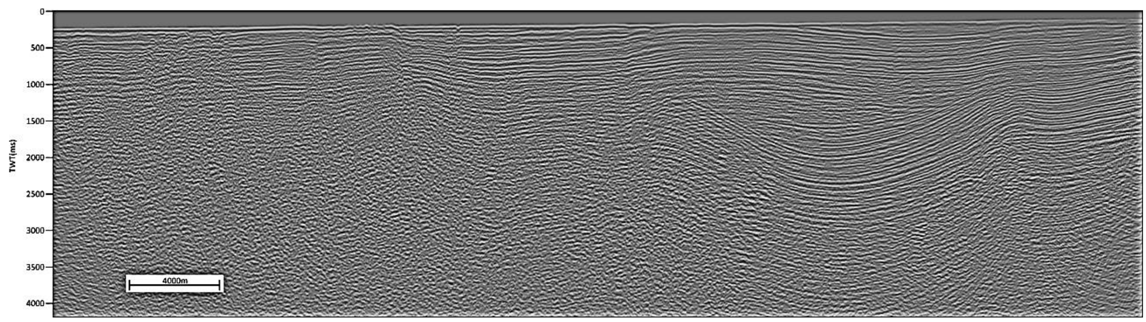


Survey Name	SUN	Survey Dates	1st to 22nd October - 1973		
Promotor	Portugal SUN oil Company	Contractor	Seismograph Service LTD		
Vessel	M.V. Seis Mariner	Data Holder	DGEG (Portugal)		
Main Objectives	Oil & Gas exploration				
Positioning	Primary: Extended Range Shoran; Secondary: Doppler Sonar Nav. Syst.				
Type of Data	Processed seismic data in SEG-Y format				
Seismic data					
Seismic Source	Bolt Associates Incorporated; Airgun array, Total Volume/Pressure/Energy: 1200cu.in./150atm				
Seismic Receiver	Seismic Engineering Company, length: 2400m, groups spacing: 50m, number of channels: 48.				
Sample Size (ms)	4	Trace Length (ms)	6000	Shotpoint Interval (m)	25
Seismic Processing	Velocity analysis; Predictive Deconvolution; Horizontal Stacking				
Observations	Estimated line length in area of interest: 62.5km				

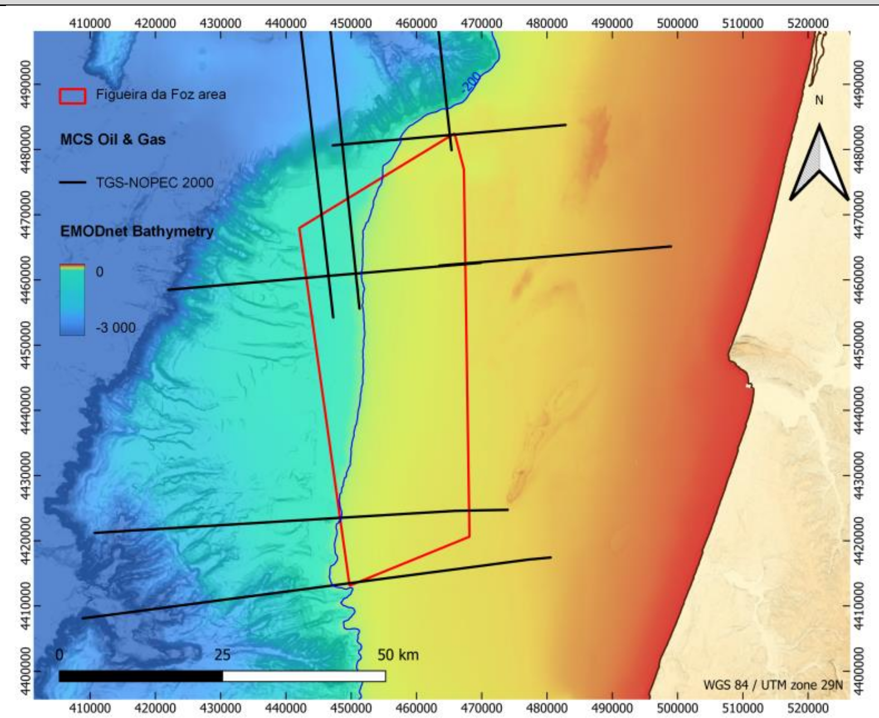
Data Coverage in Area of Interest



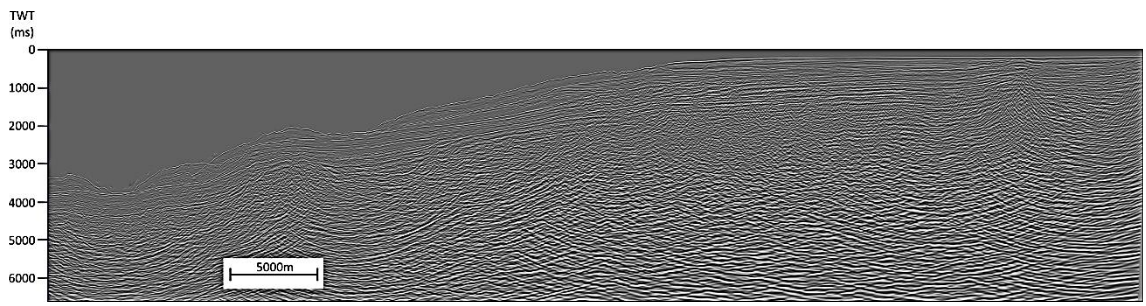
Seismic Data Example



<table>
<tr><td>Survey Name</td><td colspan="3">Portugal Deep 2000</td><td colspan="2">Survey Dates</td><td>Dec.1999 to Mar. 2002</td></tr>
<tr><td>Promotor</td><td colspan="3">TGS-NOPEC Geophysical Company</td><td colspan="2">Contractor</td><td>Dalmorneftegophysica (DMNG)</td></tr>
<tr><td>Vessel</td><td colspan="3">M/V Zephyr</td><td colspan="2">Data Holder</td><td>DGEG (Portugal)</td></tr>
<tr><td>Main Objectives</td><td colspan="6">Oil & Gas exploration</td></tr>
<tr><td>Positioning</td><td colspan="6">Starfix multi differential GPS operated by Fugro Survey</td></tr>
<tr><td>Type of Data</td><td colspan="6">Processed seismic data in SEG-Y format</td></tr>
<tr><td colspan="7">Seismic data</td></tr>
<tr><td>Seismic Source</td><td colspan="6">Type: Airgun, Model: Tuned Bolt array, Total Volume/Pressure/Energy: 2800cu.in./2000 psi.</td></tr>
<tr><td>Seismic Receiver</td><td colspan="6">Streamer type: SYNTRAK RDA, length: 6000m, groups spacing: 12.5m, number of channels: 480.</td></tr>
<tr><td>Sample Size (ms)</td><td>2</td><td>Trace Length (ms)</td><td>6000</td><td>Shotpoint Interval (m)</td><td colspan="2">37.5</td></tr>
<tr><td>Seismic Processing</td><td colspan="6">Minimum phase conversion; NMO correction; Velocity analysis; CMP stack; Deconvolution; Kirchhoff time migration.</td></tr>
<tr><td>Observations</td><td colspan="6">Estimated line length in area of interest: 78km</td></tr>
<tr><td colspan="7">Data Coverage in Area of Interest</td></tr>
</table>



Seismic Data Example



9.2. Metocean Synthetic Data

Parameters for persistency analysis:

Location: 40°09'N, 009°31'W

Data Period: 1980-2023

Window: 0.5 days

Scenario	Wave Significant Height (m)	Wind Speed (m/s)
C1	< 1.50	< 10.00
C2	< 2.00	< 12.00
C3	< 1.50	no limit
C4	no limit	<10.00
C5	< 2.00	no limit
C6	no limit	< 12.00

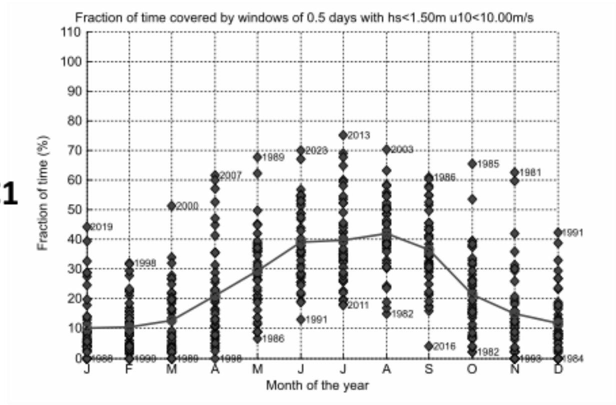
Fraction of time covered by 12 hours windows per month																		
(% time)																		
Limit	**C1**	**C1**	**C1**	**C2**	**C2**	**C2**	**C3**	**C3**	**C3**	**C4**	**C4**	**C4**	**C5**	**C5**	**C5**	**C6**	**C6**	**C6**
Month	**min**	**mean**	**max**	**min**	**mean**	**max**	**min**	**mean**	**max**	**min**	**mean**	**max**	**min**	**mean**	**max**	**min**	**mean**	**max**
Jan	0	10	44	0	23	63	0	10	44	59	81	98	0	23	63	77	92	100
Feb	0	11	32	0	26	72	0	11	32	59	83	100	0	26	72	81	93	100
Mar	0	13	51	2	30	77	0	13	51	21	83	99	2	30	77	73	94	100
Apr	0	21	62	9	44	83	0	21	62	68	87	100	9	44	83	81	95	100
May	6	29	68	27	55	91	6	29	68	70	89	100	27	55	91	87	97	100
Jun	13	39	70	39	66	86	13	39	70	70	92	100	39	66	86	84	98	100
Jul	18	40	75	38	69	89	18	40	75	66	91	100	38	69	89	92	98	100
Aug	15	42	70	46	70	92	15	42	70	73	92	100	46	70	92	88	98	100
Sep	4	37	61	41	62	88	4	37	61	82	94	100	41	62	88	94	99	100
Oct	2	21	65	21	42	79	2	21	65	78	89	100	21	42	79	32	93	100
Nov	0	15	63	3	29	91	0	15	63	64	83	98	3	29	91	84	93	100
Dec	0	12	42	0	27	64	0	12	42	51	80	96	0	27	64	74	91	100

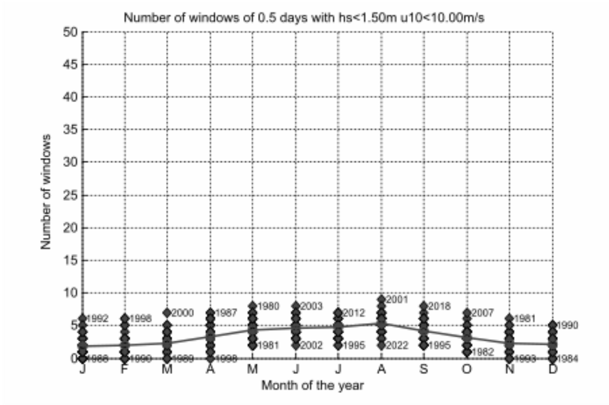
Fraction of time covered by 12 hours windows per month																		
(number of windows)																		
Limit	**C1**	**C1**	**C1**	**C2**	**C2**	**C2**	**C3**	**C3**	**C3**	**C4**	**C4**	**C4**	**C5**	**C5**	**C5**	**C6**	**C6**	**C6**
Month	**min**	**mean**	**max**	**min**	**mean**	**max**	**min**	**mean**	**max**	**min**	**mean**	**max**	**min**	**mean**	**max**	**min**	**mean**	**max**
Jan	0,00	1,80	6,00	0,00	3,34	8,00	0,00	1,80	6,00	3,00	6,18	11,00	0,00	3,34	8,00	1,00	4,11	11,00
Feb	0,00	1,91	6,00	0,00	3,18	7,00	0,00	1,91	6,00	1,00	4,98	8,00	0,00	3,18	7,00	1,00	3,45	9,00
Mar	0,00	2,27	7,00	1,00	3,59	8,00	0,00	2,27	7,00	1,00	4,80	9,00	1,00	3,59	8,00	1,00	3,32	9,00
Apr	0,00	3,32	7,00	1,00	4,77	8,00	0,00	3,32	7,00	1,00	4,64	10,00	1,00	4,77	8,00	1,00	3,07	7,00
May	2,00	4,30	8,00	3,00	5,59	8,00	2,00	4,30	8,00	1,00	4,02	6,00	3,00	5,59	8,00	1,00	2,11	5,00
Jun	2,00	4,66	8,00	1,00	5,23	11,00	2,00	4,66	8,00	1,00	2,95	5,00	1,00	5,23	11,00	1,00	1,55	4,00
Jul	2,00	4,68	7,00	2,00	5,11	8,00	2,00	4,68	7,00	1,00	3,50	5,00	2,00	5,11	8,00	1,00	1,59	4,00
Aug	2,00	5,27	9,00	2,00	4,95	9,00	2,00	5,27	9,00	1,00	3,18	6,00	2,00	4,95	9,00	1,00	1,66	4,00
Sep	2,00	4,18	8,00	1,00	5,02	9,00	2,00	4,18	8,00	1,00	3,14	7,00	1,00	5,02	9,00	1,00	1,66	3,00
Oct	1,00	3,11	7,00	1,00	4,84	8,00	1,00	3,11	7,00	1,00	4,61	9,00	1,00	4,84	8,00	1,00	2,98	7,00
Nov	0,00	2,25	6,00	1,00	3,86	8,00	0,00	2,25	6,00	2,00	5,82	13,00	1,00	3,86	8,00	1,00	3,84	8,00
Dec	0,00	2,14	5,00	0,00	3,43	6,00	0,00	2,14	5,00	2,00	5,68	10,00	0,00	3,43	6,00	1,00	3,95	9,00

Variation of mean delay waiting for weather windows over the years																		
(days)																		
Limit	**C1**	**C1**	**C1**	**C2**	**C2**	**C2**	**C3**	**C3**	**C3**	**C4**	**C4**	**C4**	**C5**	**C5**	**C5**	**C6**	**C6**	**C6**
Month	**min**	**mean**	**max**	**min**	**mean**	**max**	**min**	**mean**	**max**	**min**	**mean**	**max**	**min**	**mean**	**max**	**min**	**mean**	**max**
Jan	2,95	14,29	43,56	0,95	7,24	27,94	2,95	14,28	43,56	0,02	0,28	0,70	0,95	7,24	27,94	0,00	0,10	0,34
Feb	1,97	14,64	43,06	0,54	7,63	29,44	1,97	14,64	43,06	0,00	0,26	0,77	0,54	7,63	29,44	0,00	0,09	0,35
Mar	1,16	11,33	36,44	0,55	4,31	12,03	1,16	11,33	36,44	0,01	0,23	0,87	0,55	4,31	12,03	0,00	0,08	0,43
Apr	0,87	6,20	22,94	0,23	2,21	8,31	0,87	6,20	22,94	0,00	0,18	0,77	0,23	2,21	8,31	0,00	0,05	0,27
May	0,56	3,88	13,79	0,12	1,29	3,50	0,56	3,88	13,79	0,00	0,17	1,13	0,12	1,29	3,50	0,00	0,04	0,20
Jun	0,97	2,76	7,89	0,21	0,77	3,17	0,97	2,75	7,89	0,00	0,13	0,96	0,21	0,77	3,17	0,00	0,03	0,22
Jul	0,58	2,55	8,00	0,13	0,71	2,66	0,58	2,55	8,00	0,00	0,14	0,76	0,13	0,71	2,66	0,00	0,02	0,09
Aug	0,49	2,09	5,50	0,12	0,65	2,10	0,49	2,09	5,50	0,00	0,12	0,55	0,12	0,65	2,10	0,00	0,02	0,14
Sep	1,02	3,72	11,18	0,15	1,09	2,90	1,02	3,72	11,18	0,00	0,06	0,26	0,15	1,09	2,90	0,00	0,01	0,07
Oct	1,44	8,17	22,13	0,31	2,77	12,02	1,44	8,17	22,13	0,00	0,15	0,64	0,31	2,77	12,02	0,00	0,06	0,17
Nov	0,81	13,48	46,06	0,22	4,79	15,45	0,81	13,48	46,06	0,02	0,25	0,72	0,22	4,79	15,45	0,00	0,08	0,29
Dec	1,91	15,86	46,56	0,70	7,39	34,69	1,91	15,86	46,56	0,04	0,33	1,57	0,70	7,39	34,69	0,00	0,12	0,54

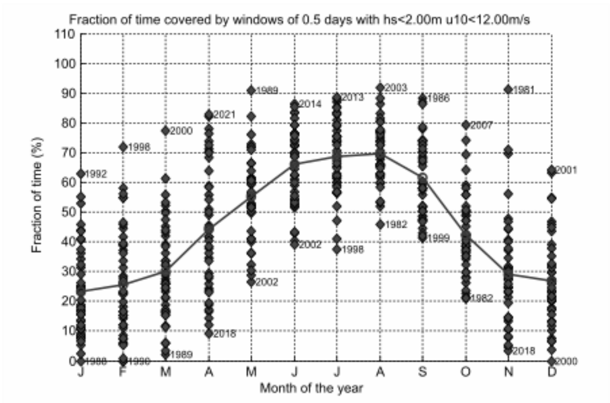
9.3. MetOcean Graphic Data

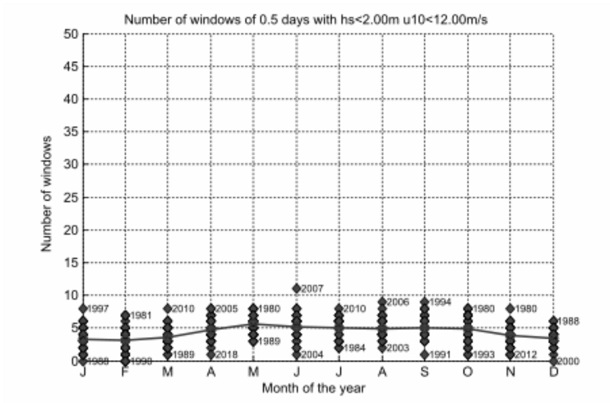
C1





C2





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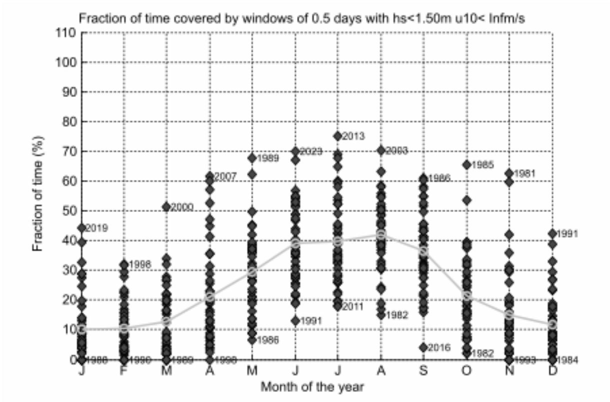

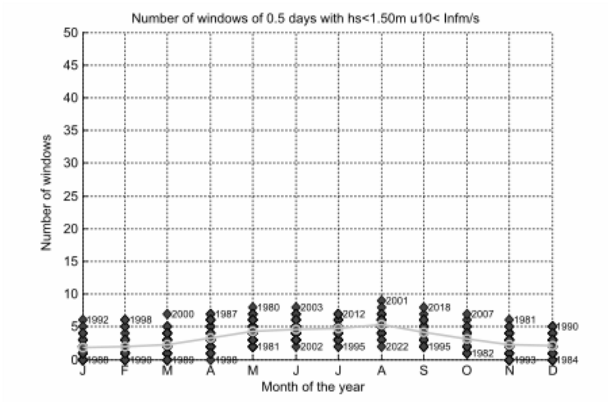

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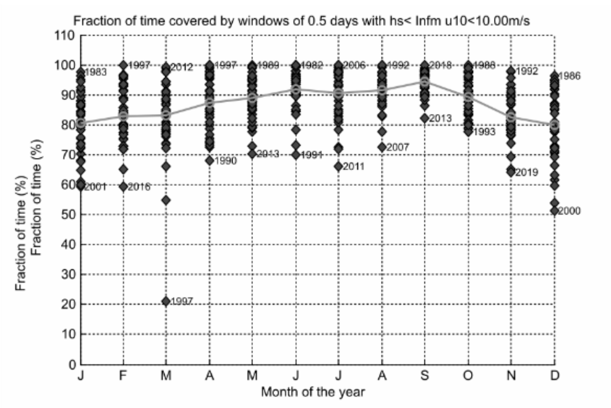
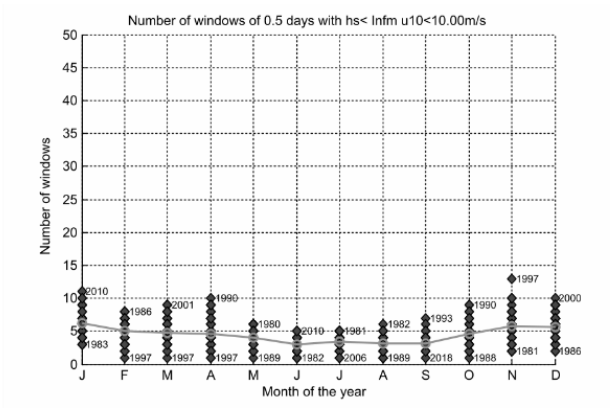
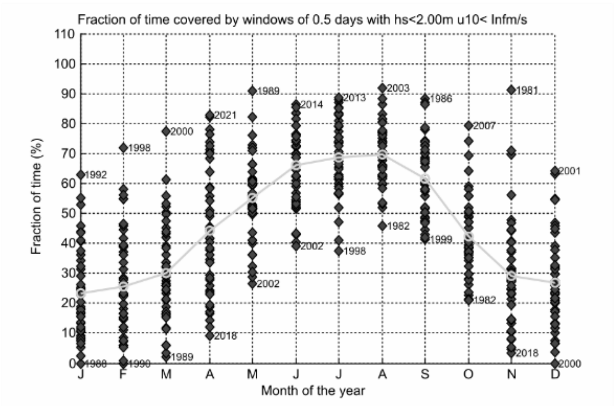

Fraction of time covered by windows of 0.5 days with hs< Infm u10<10.00m/s
Fraction of time (%)
Month of the year


Number of windows of 0.5 days with hs< Infm u10<10.00m/s
Number of windows
Month of the year

C5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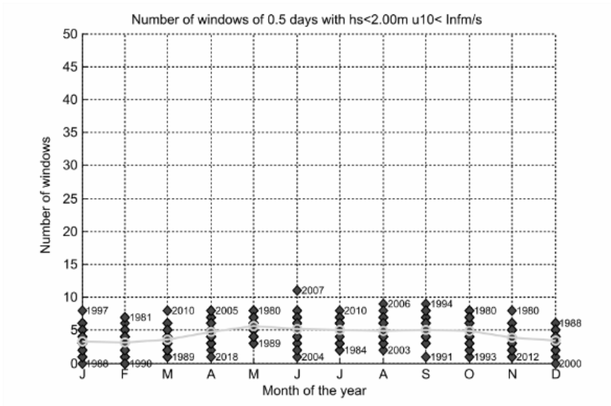
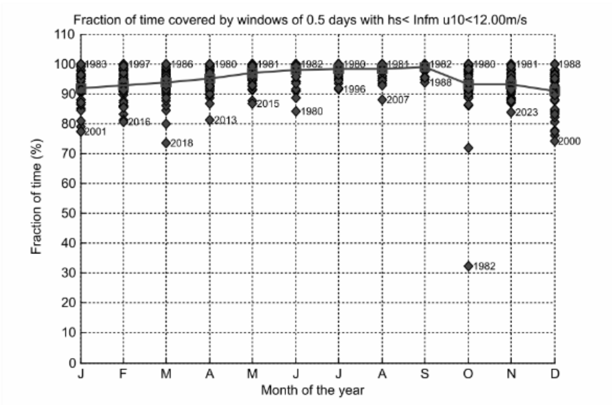
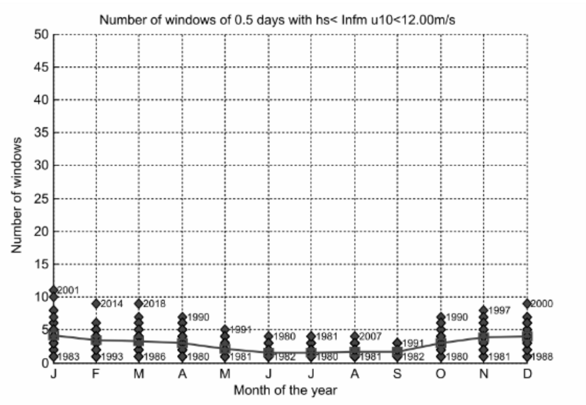
Fraction of time (%)
Month of the year

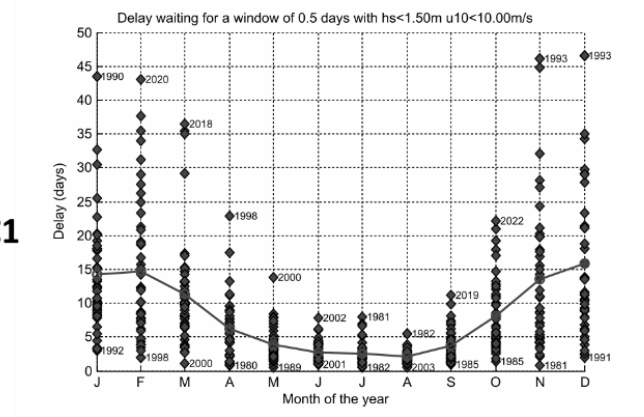

Number of windows of 0.5 days with hs<2.00m u10< Infm/s
Number of windows
Month of the year

C6

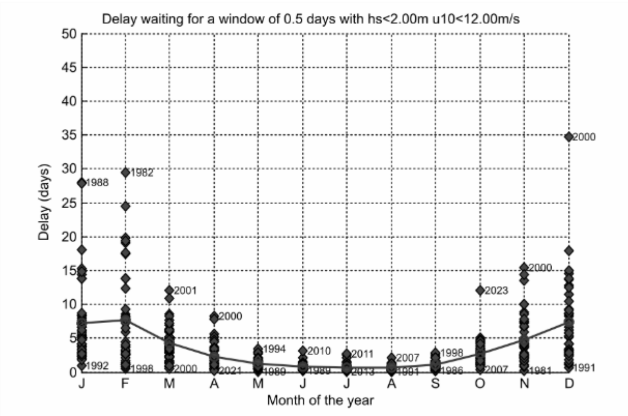

Fraction of time covered by windows of 0.5 days with hs< Infm u10<12.00m/s
Fraction of time (%)
Month of the year


Number of windows of 0.5 days with hs< Infm u10<12.00m/s
Number of windows
Month of the year

C1



C2



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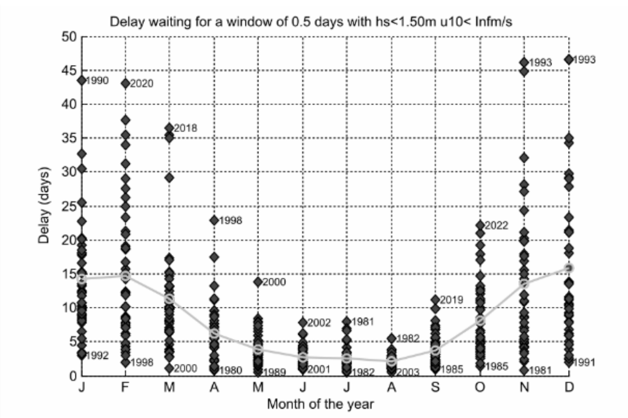
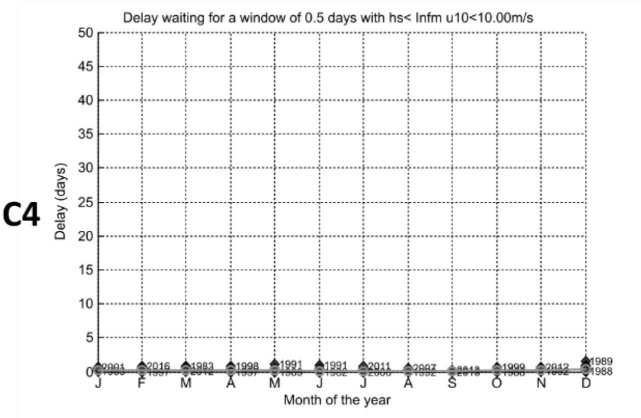
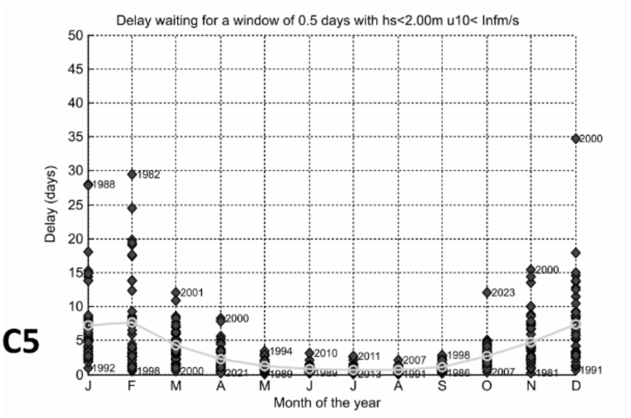


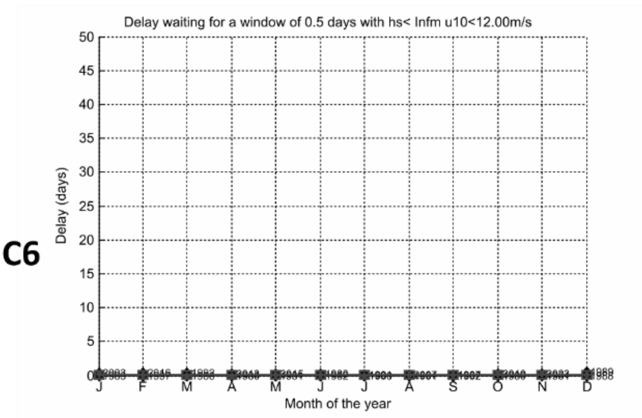
C4



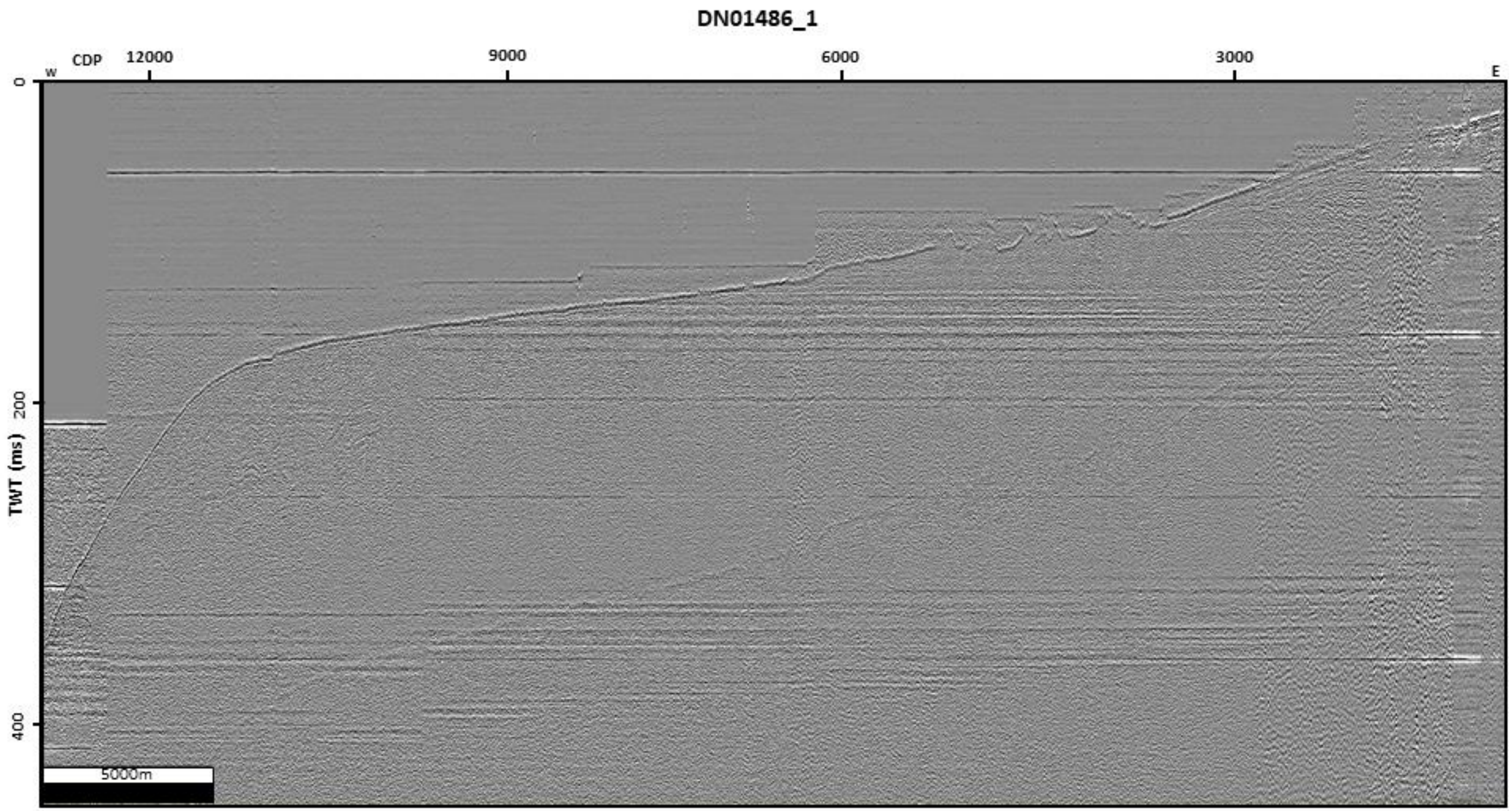
C5



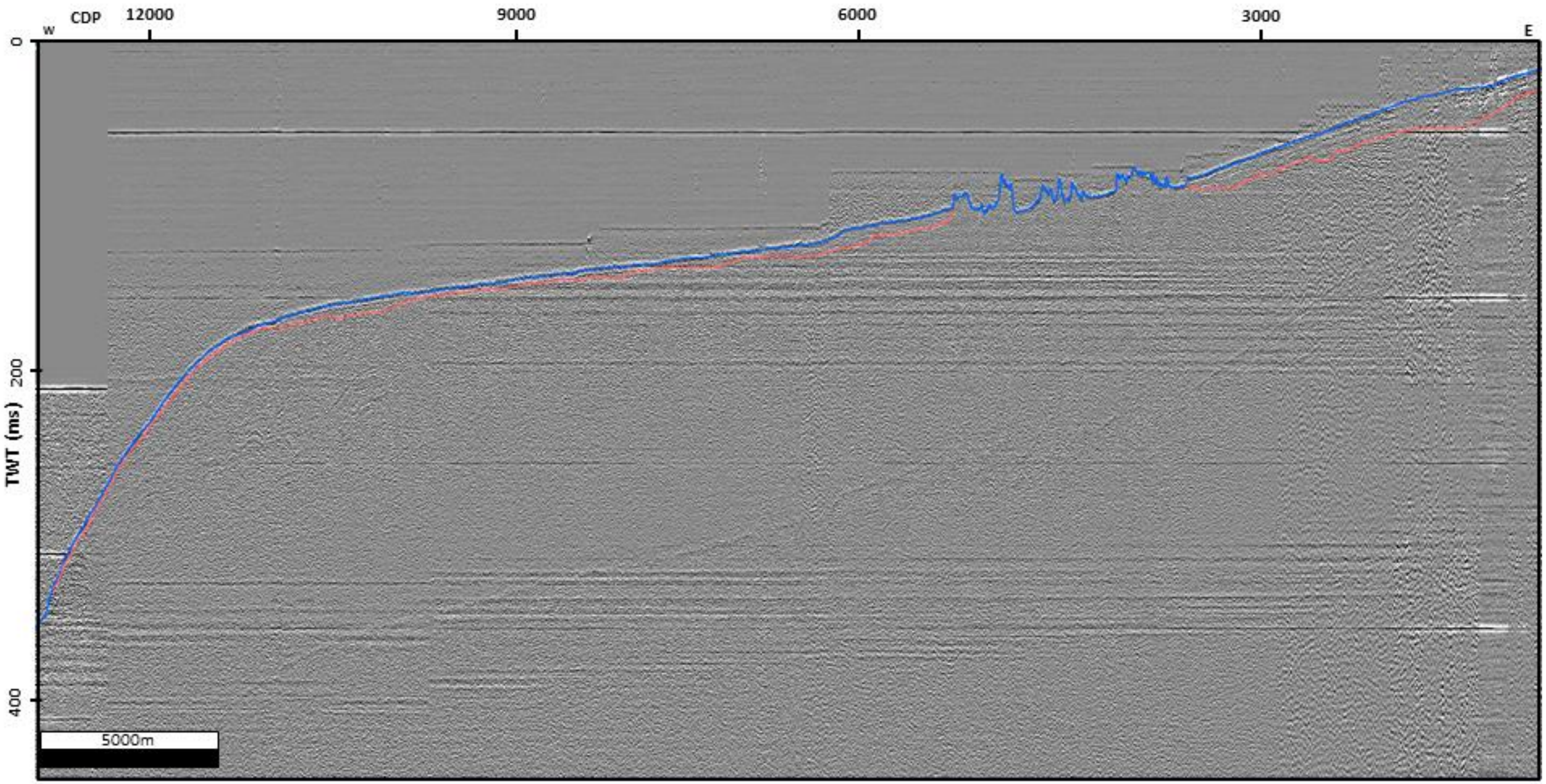
C6

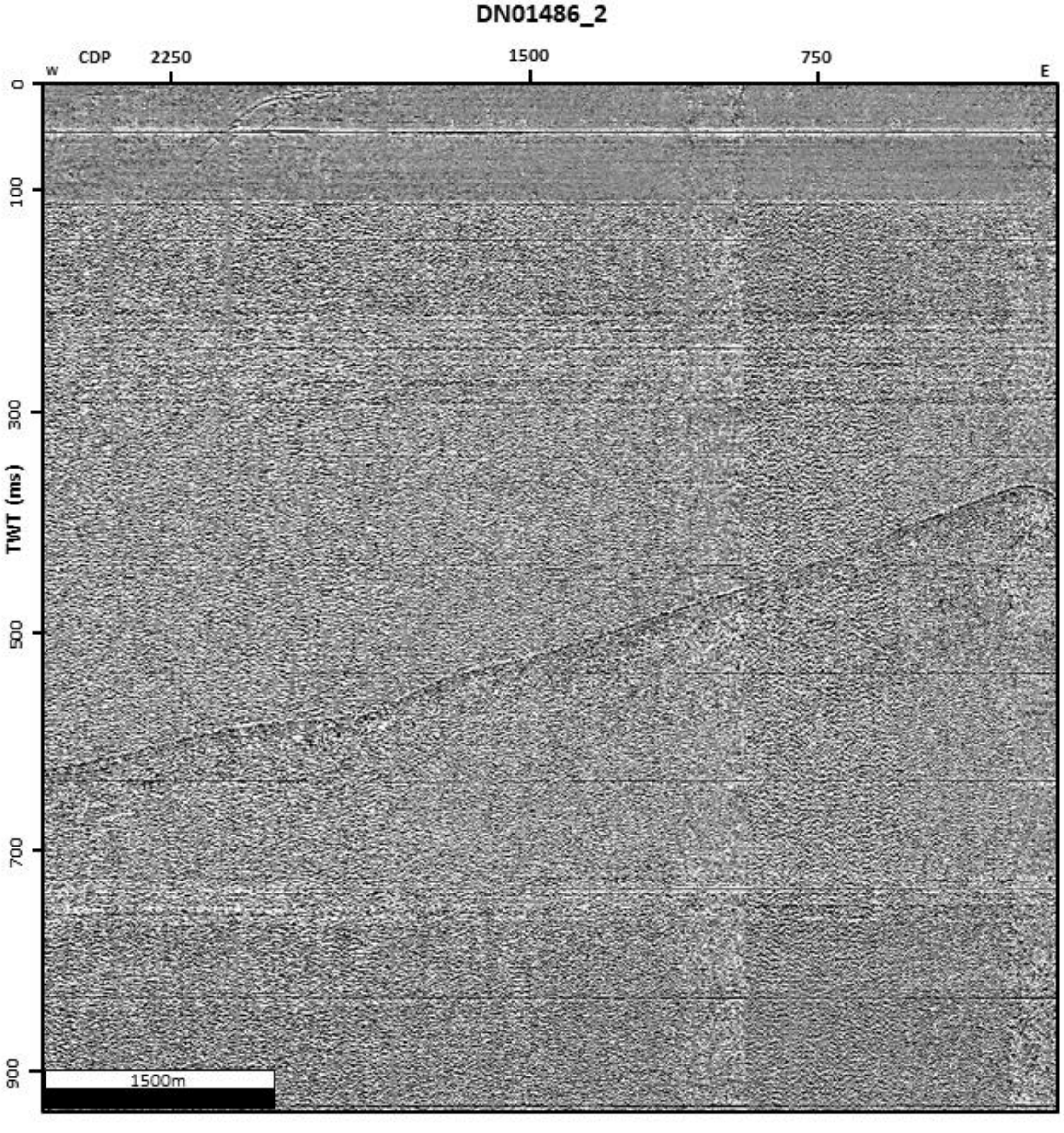


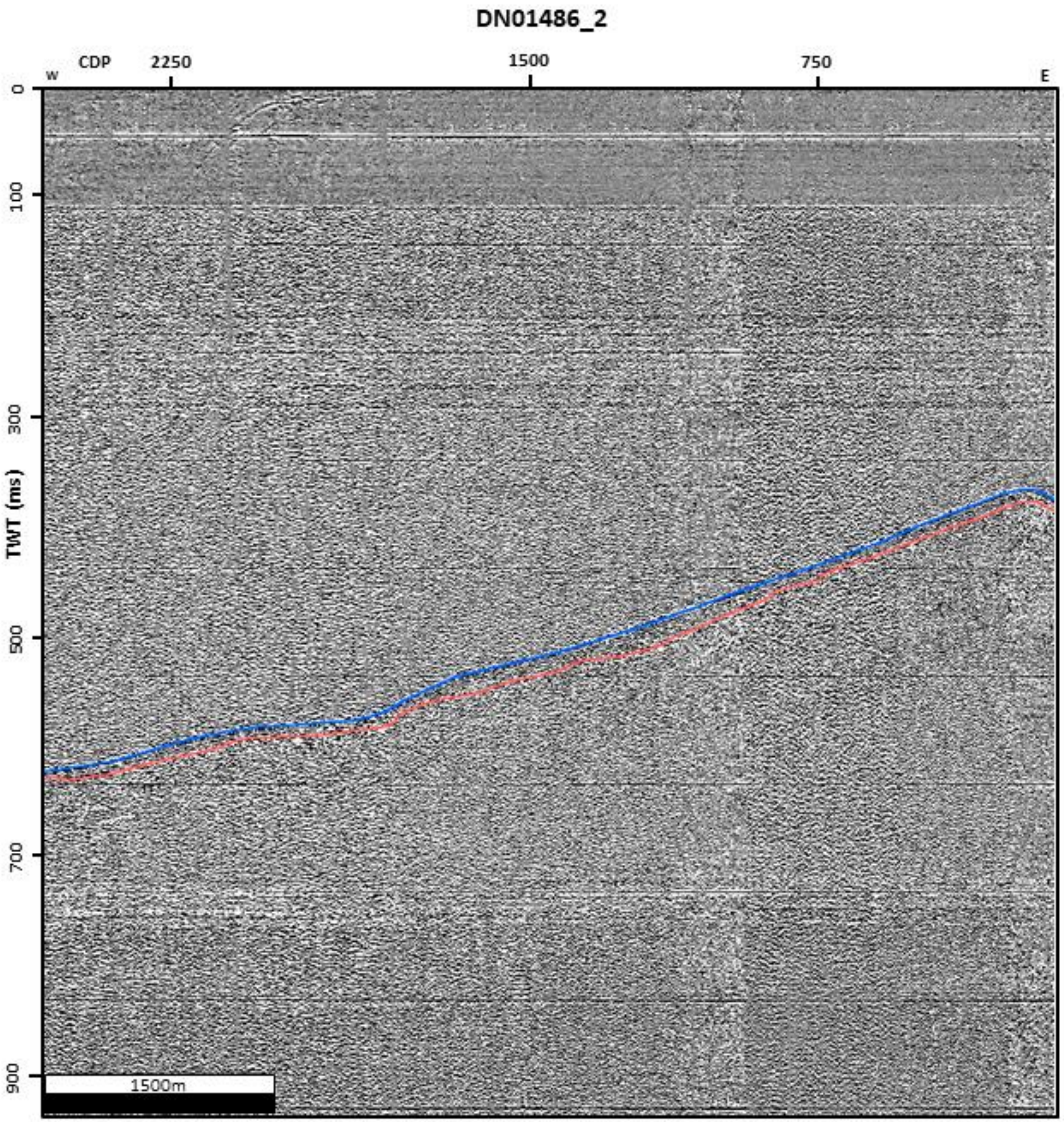
9.4. Examples of 'Vintage' Seismic Sections

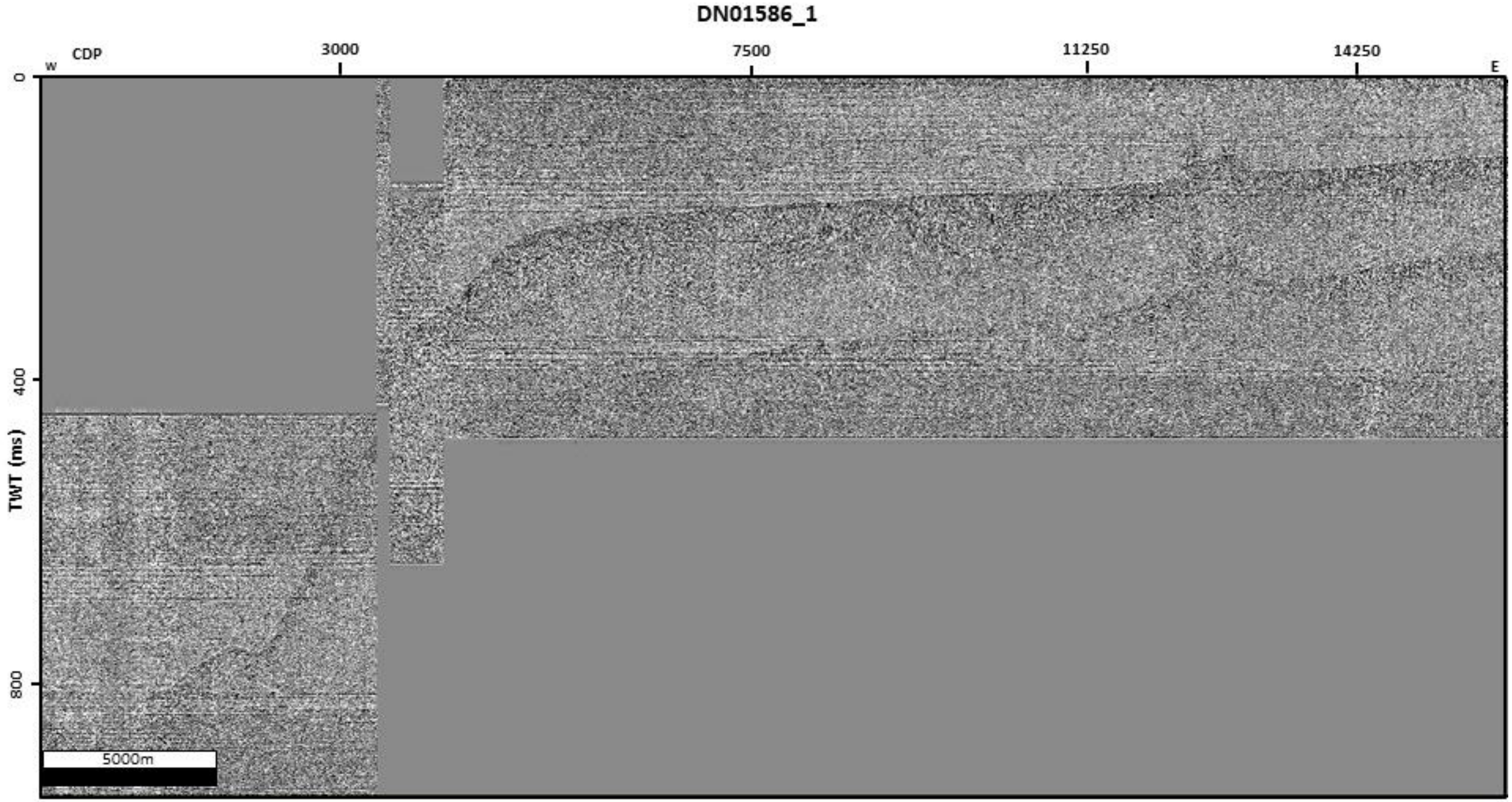

DN01486_1
W
CDP
12000
9000
6000
3000
E
0
200
400
TWT (ms)
5000m

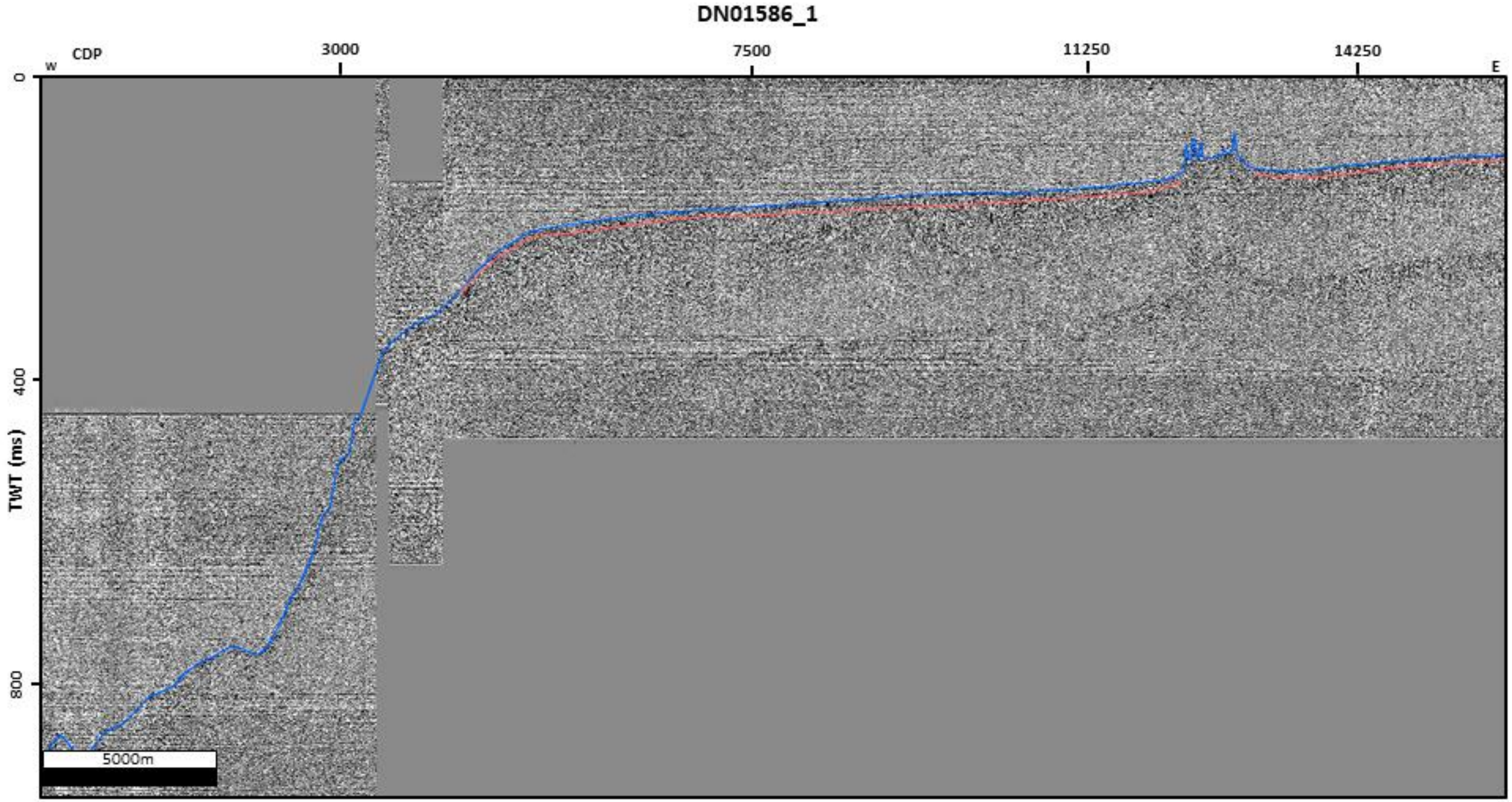
DN01486_1

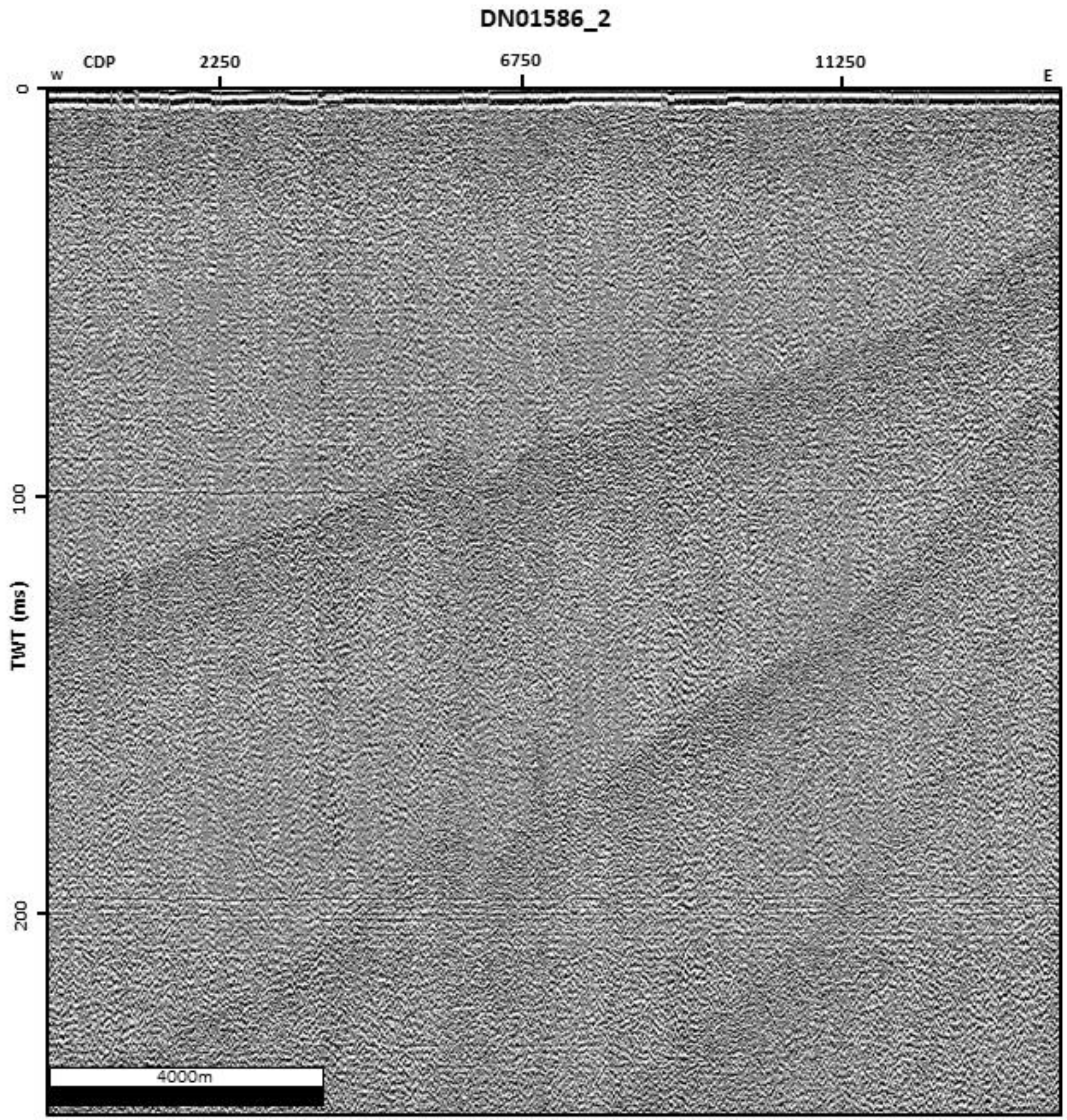


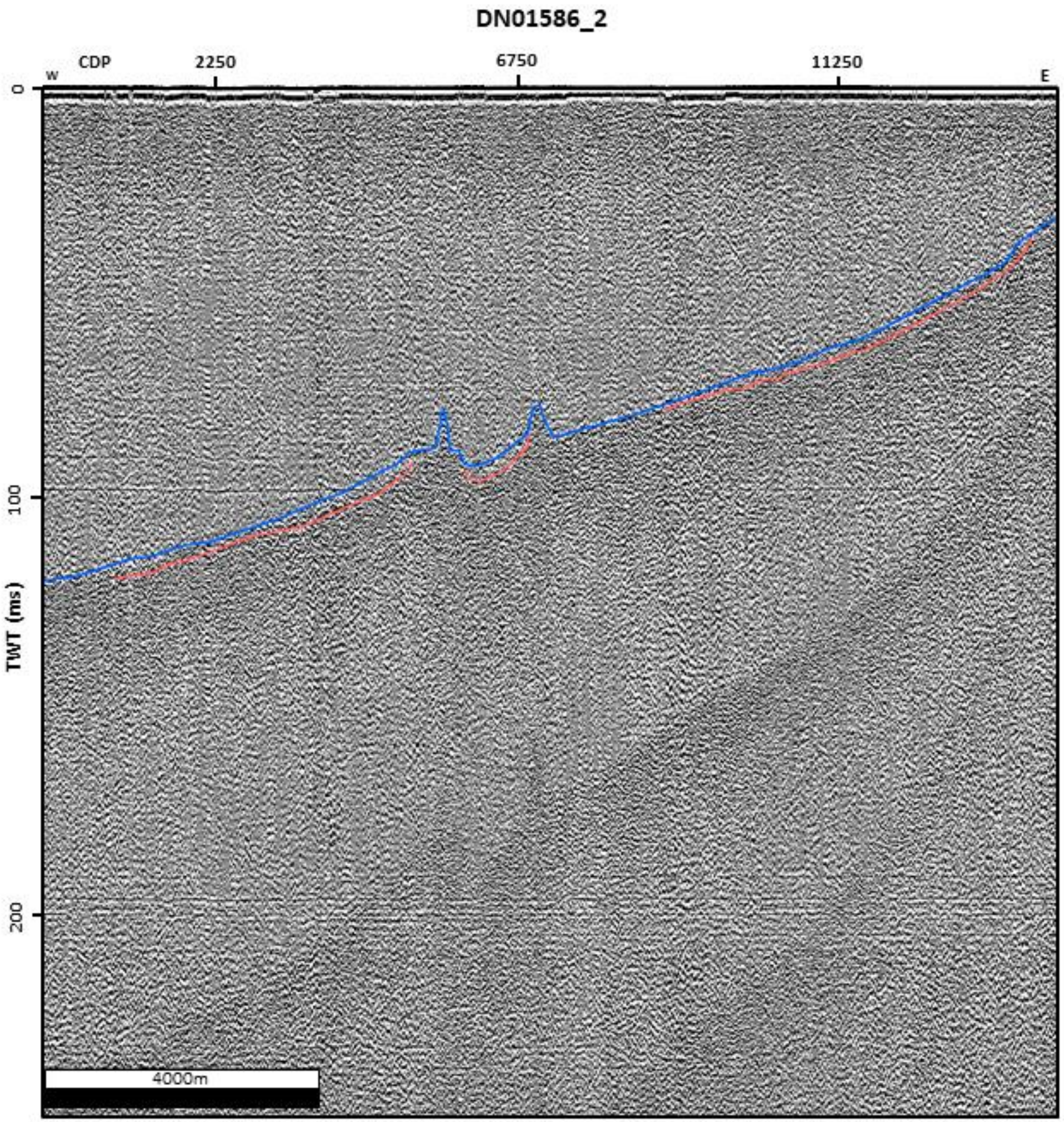

DN01486_2
W
CDP
2250
1500
750
E
0
100
300
500
700
900
TWT (ms)
1500m


DN01486_2
W
CDP
2250
1500
750
E
0
100
300
500
700
900
TWT (ms)
1500m

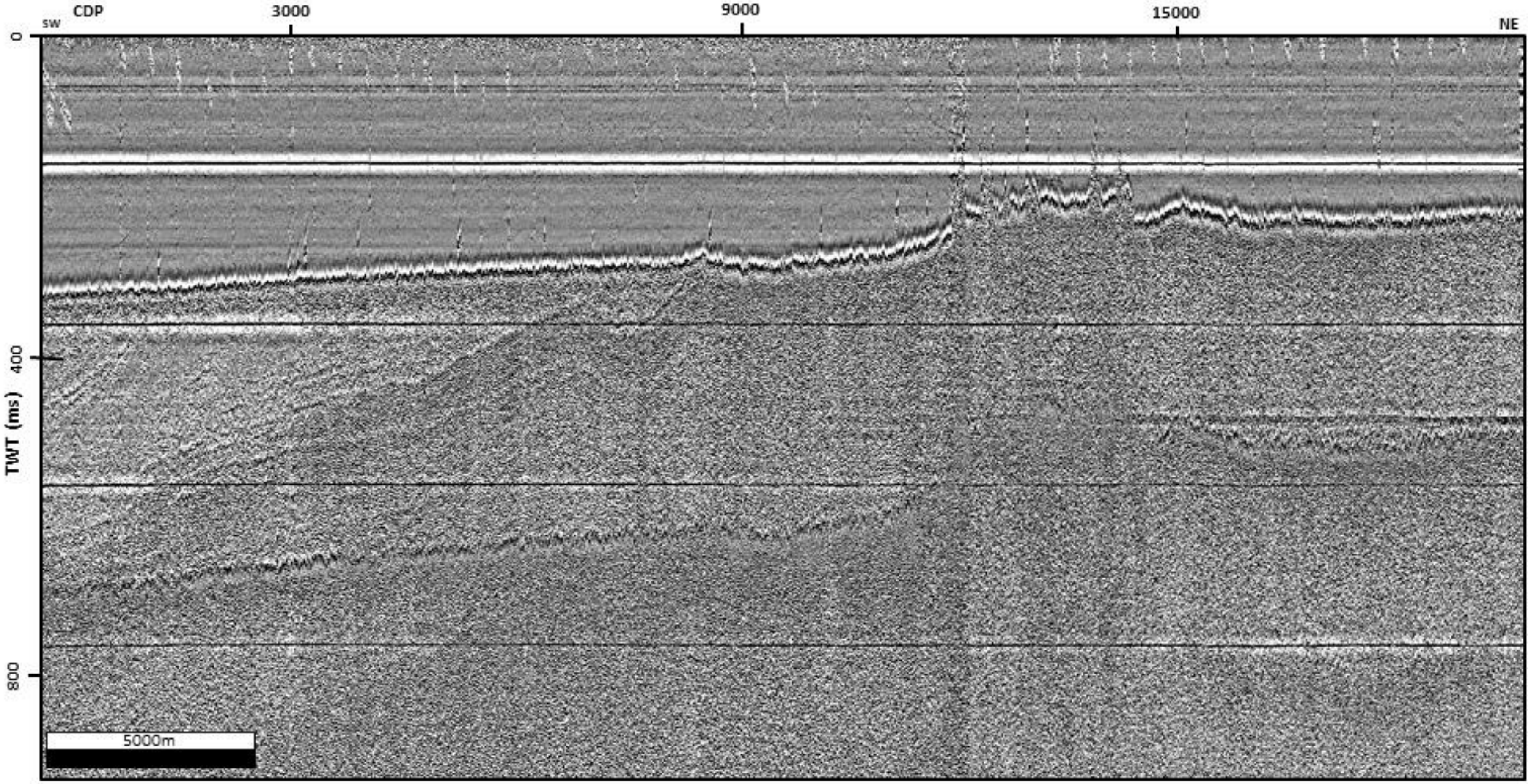

DN01586_1
W
CDP
3000
7500
11250
14250
E
0
400
800
TWT (ms)
5000m

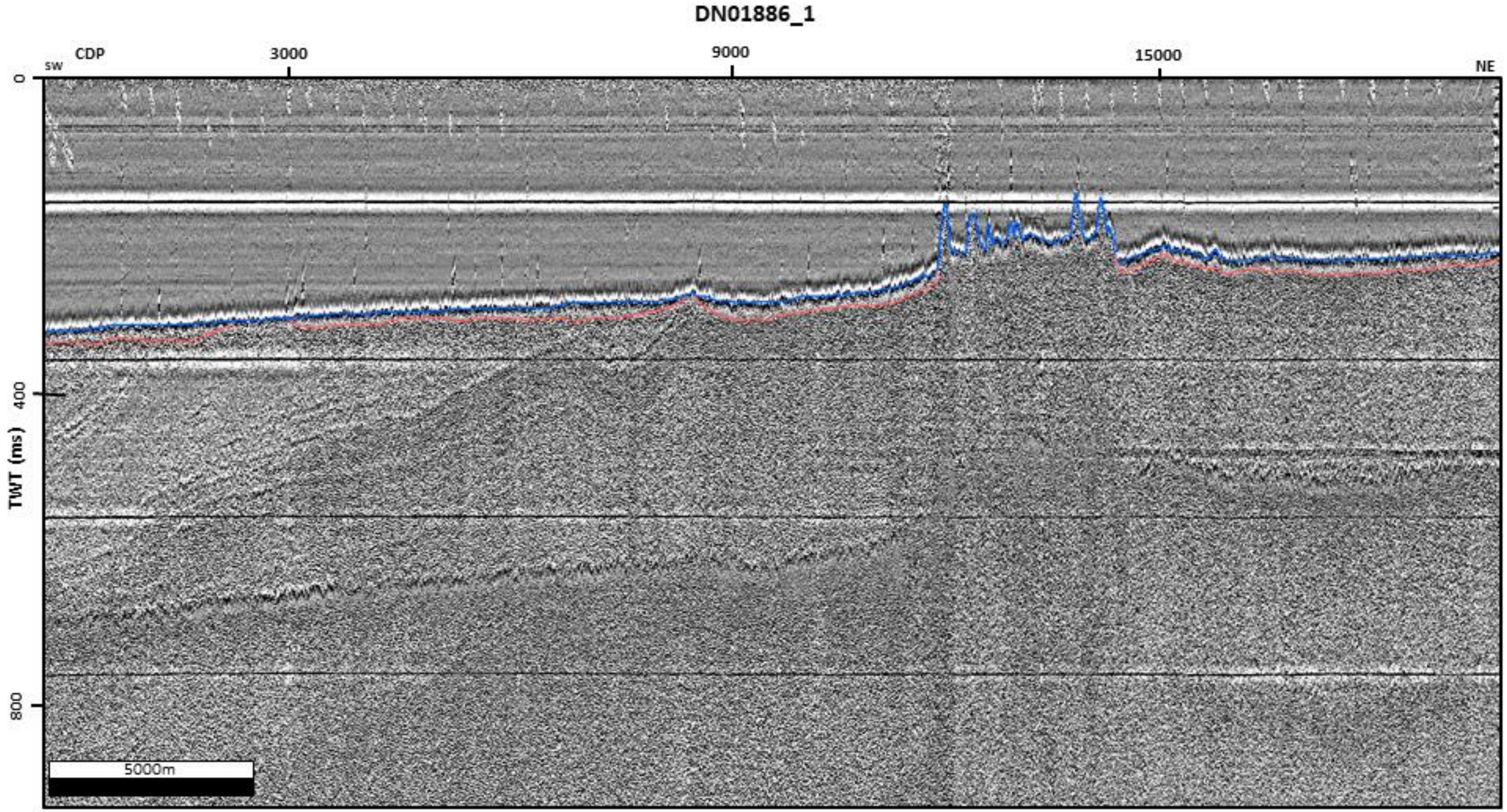

DN01586_1
CDP
3000
7500
11250
14250
W
E
0
400
800
TWT (ms)
5000m


DN01586_2
CDP
2250
6750
11250
W
E
0
100
200
TWT (ms)
4000m

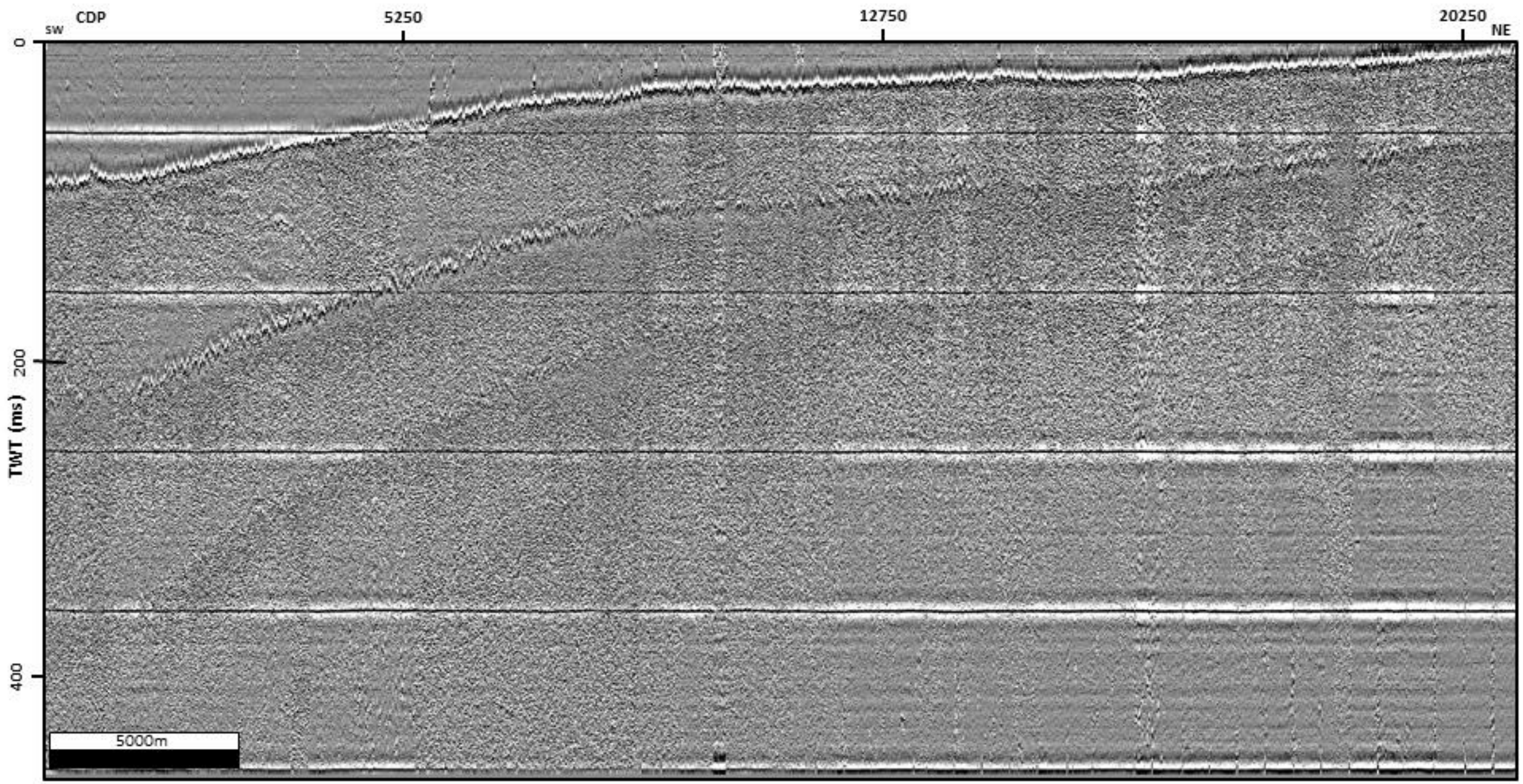

DN01586_2
CDP
2250
6750
11250
W
E
0
100
200
TWT (ms)
4000m

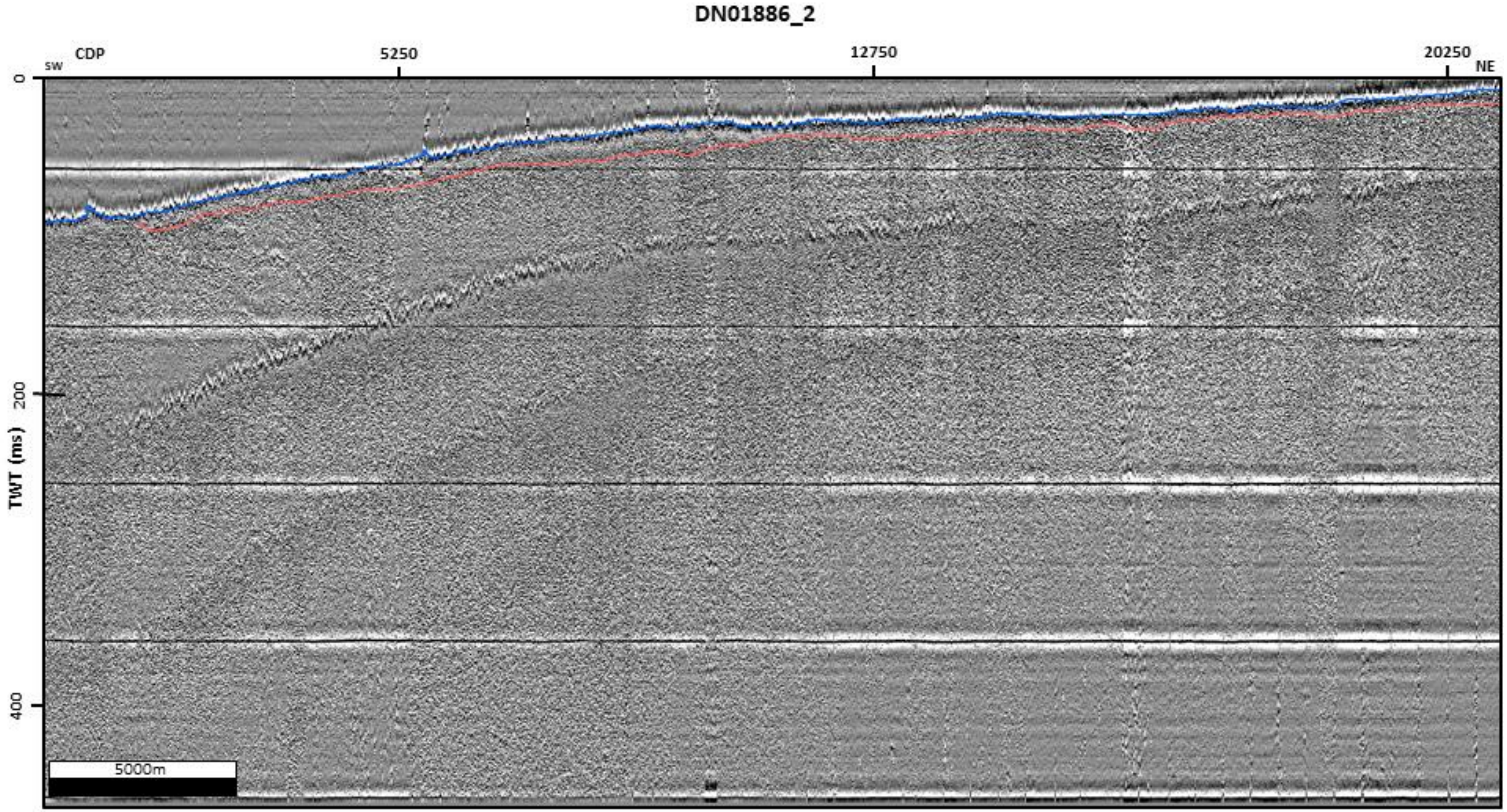
DN01886_1




DN01886_1
SW
CDP
3000
9000
15000
NE
0
400
800
TWT (ms)
5000m

DN01886_2

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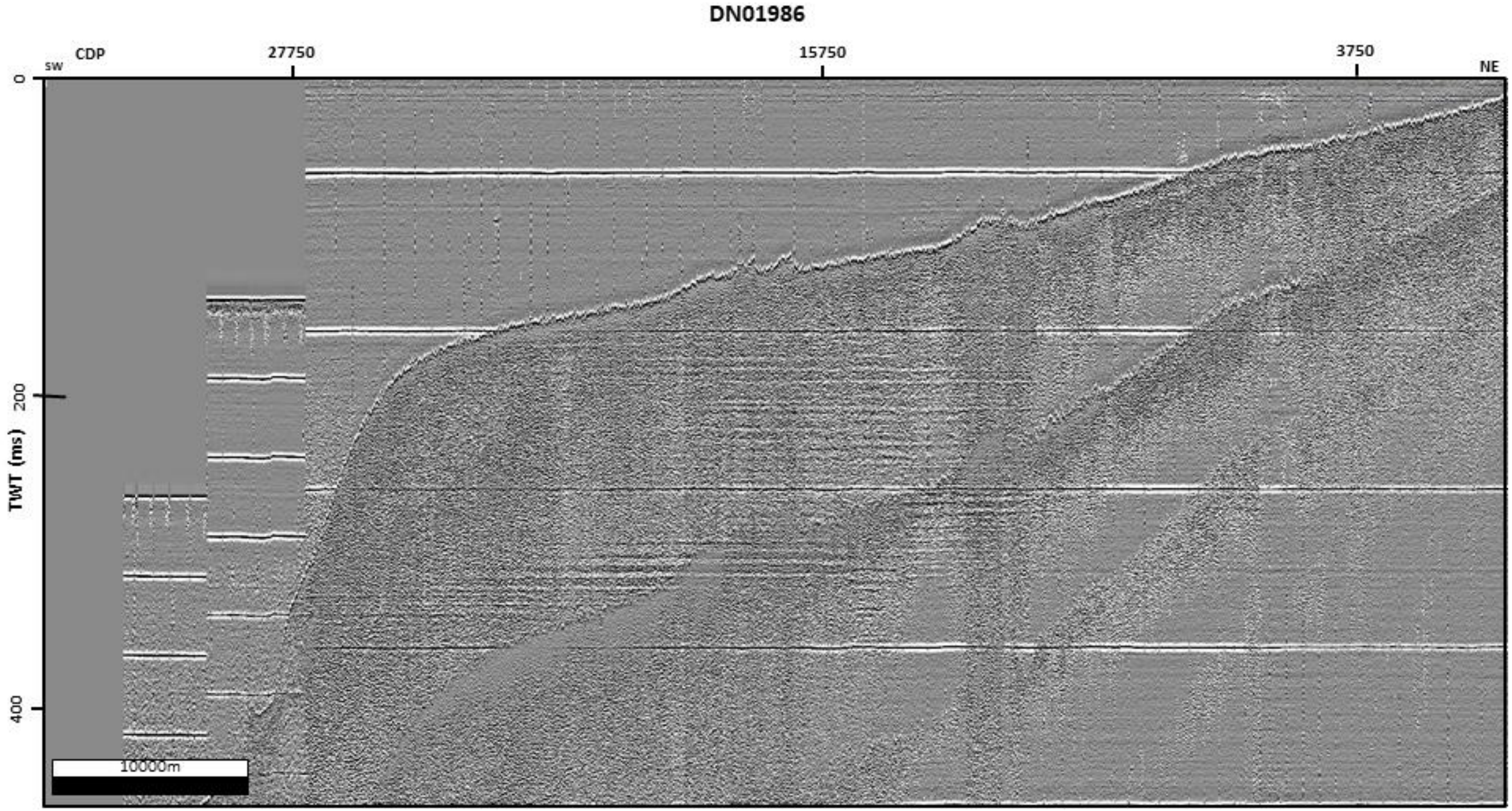
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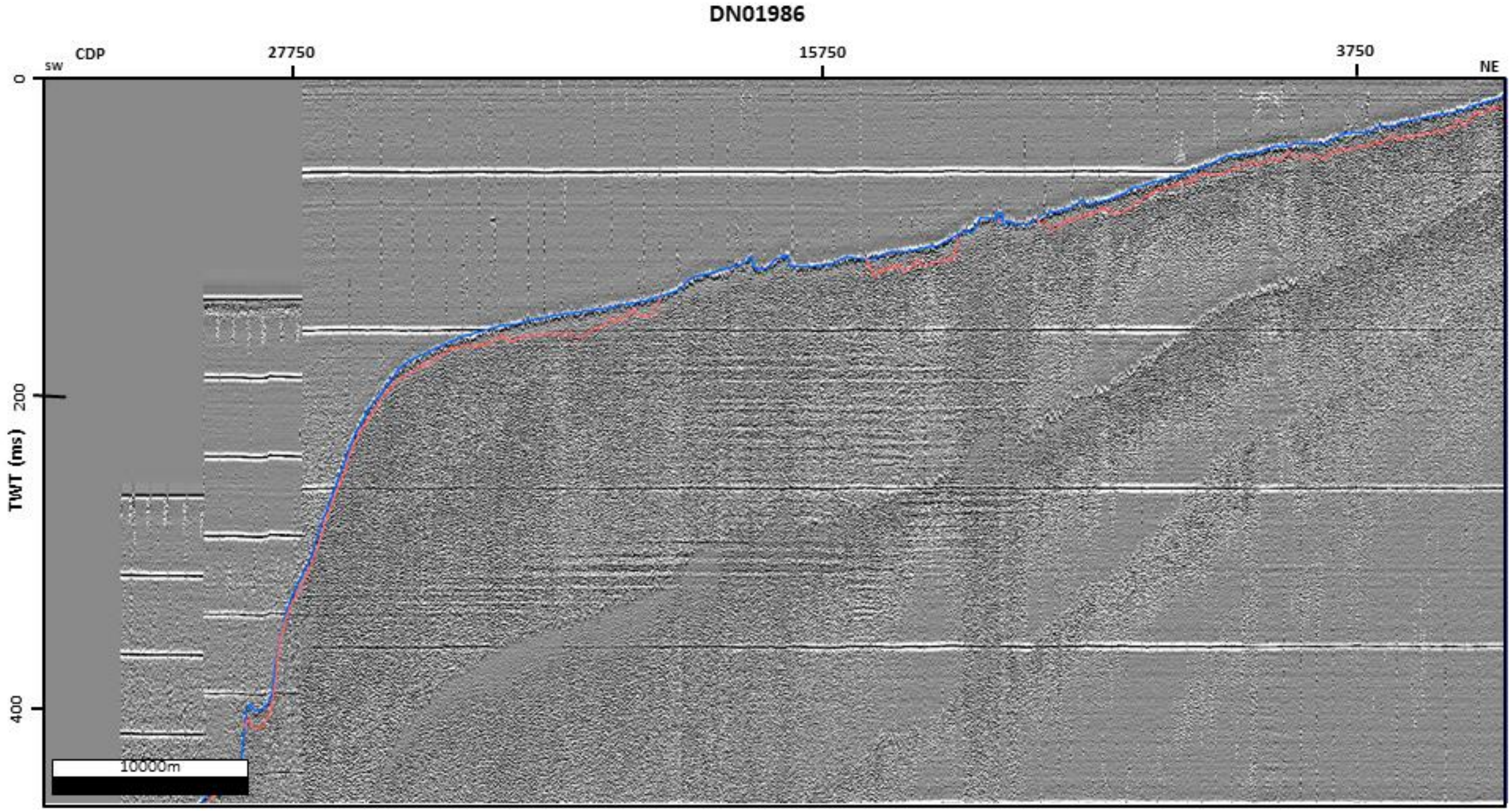
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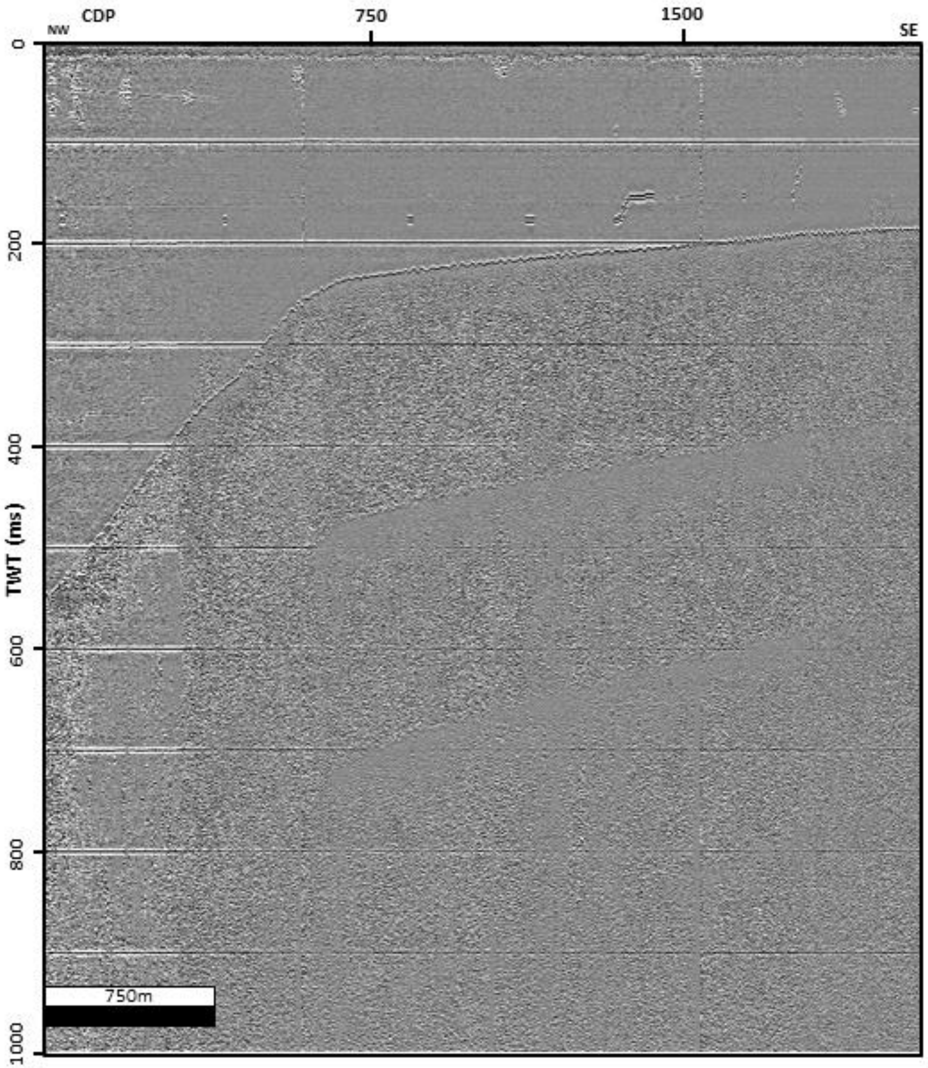

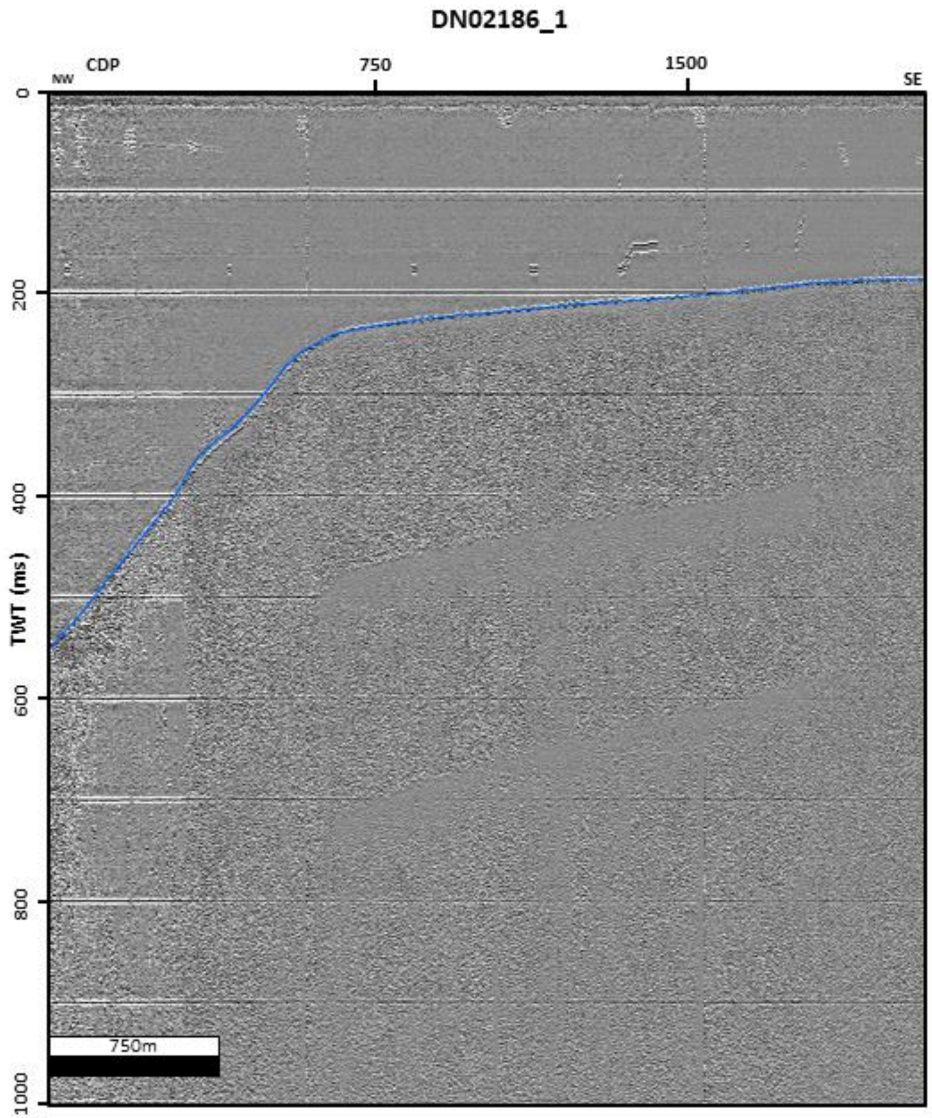
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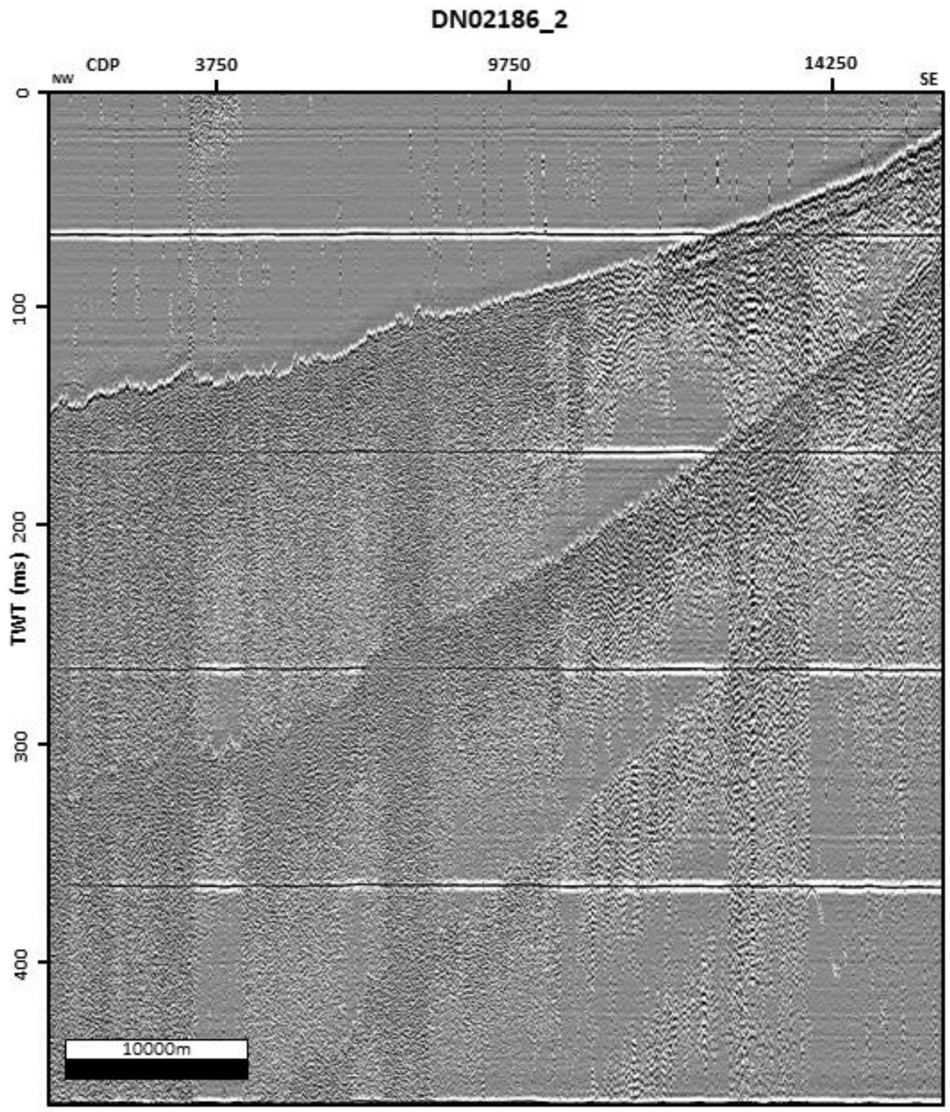
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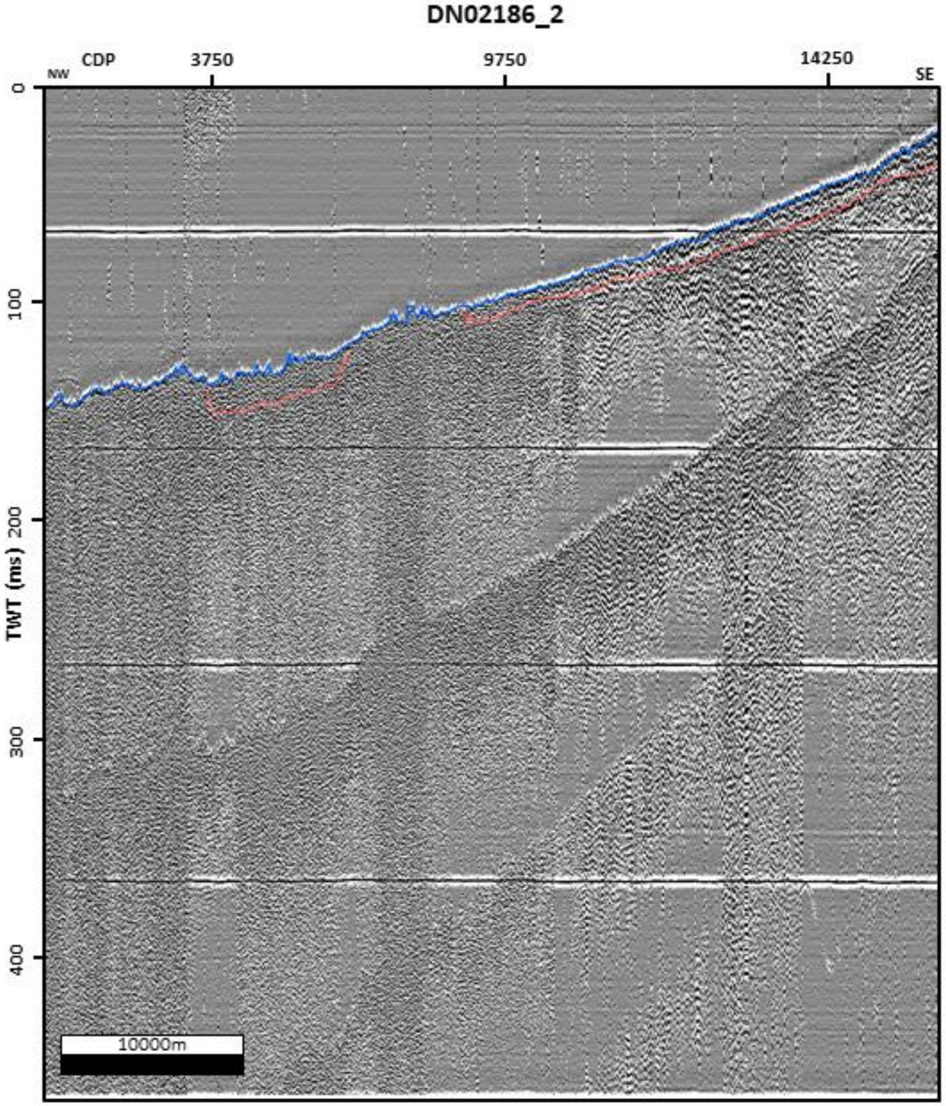
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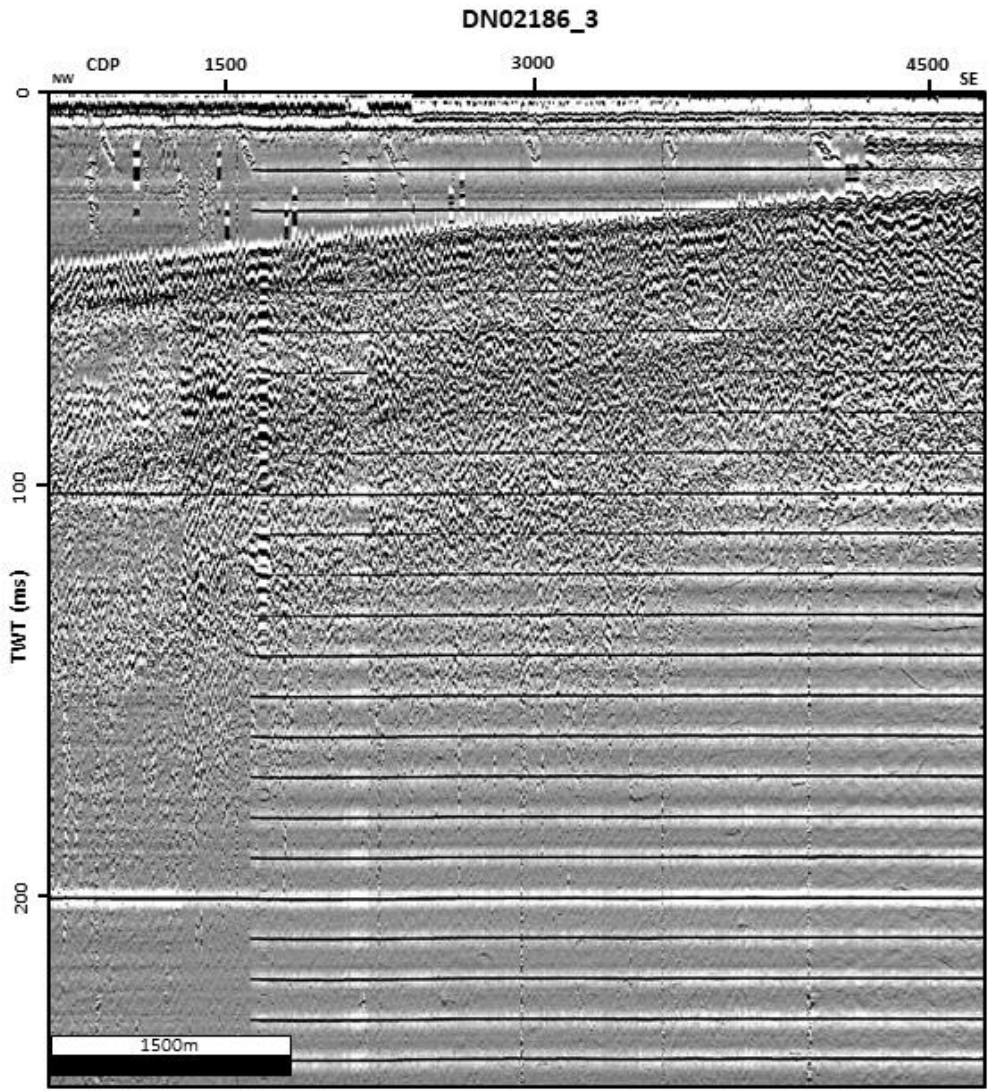
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TWT (ms)
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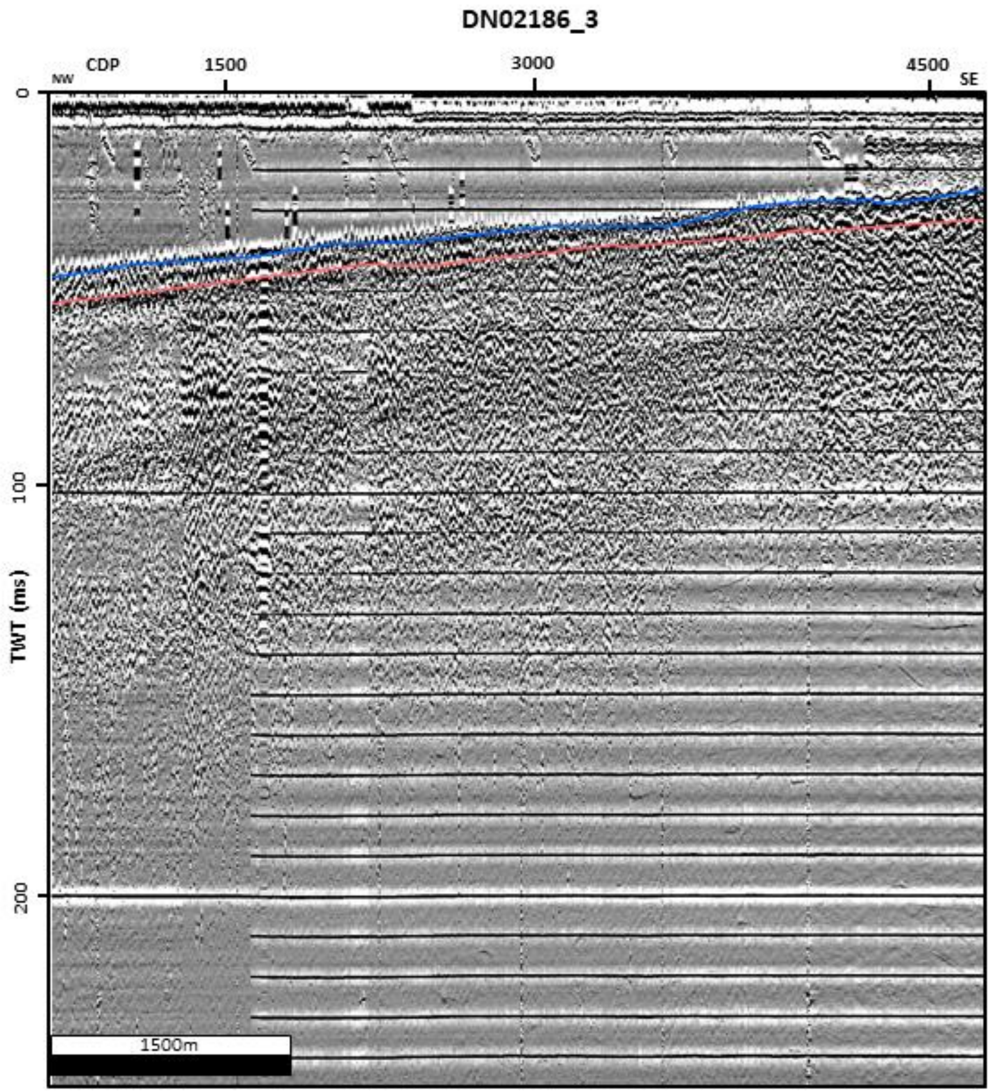
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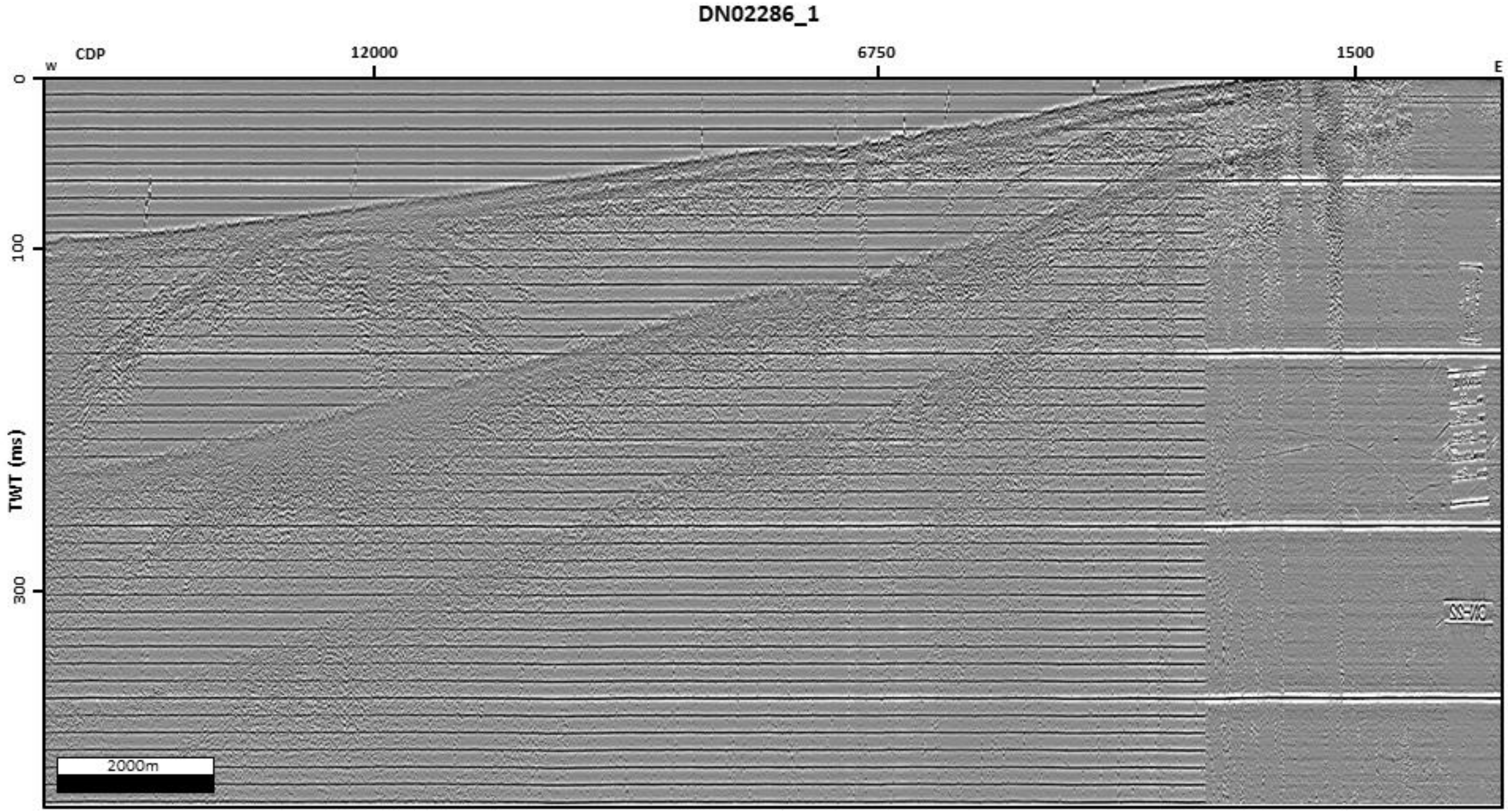
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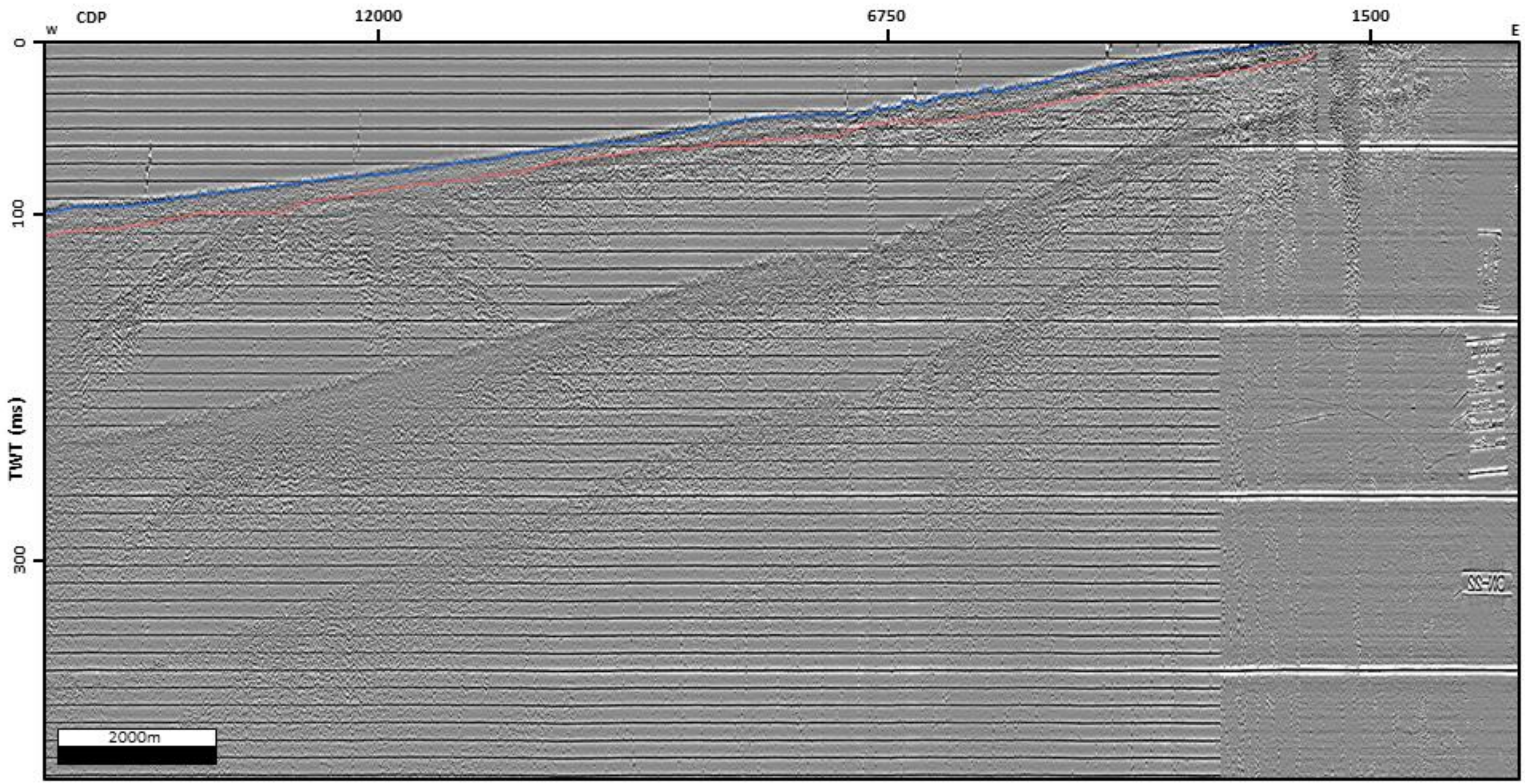
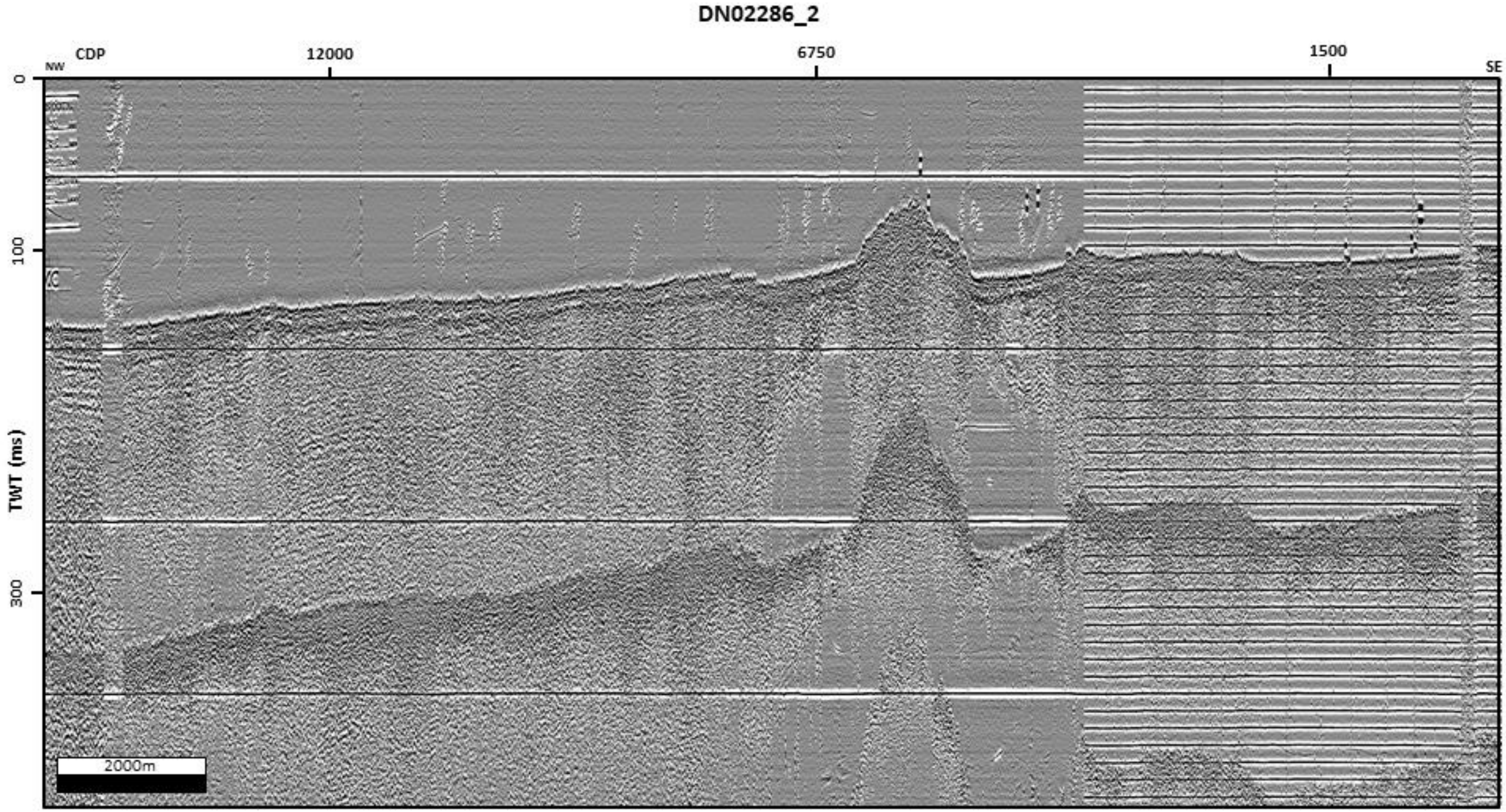
DN02286_1

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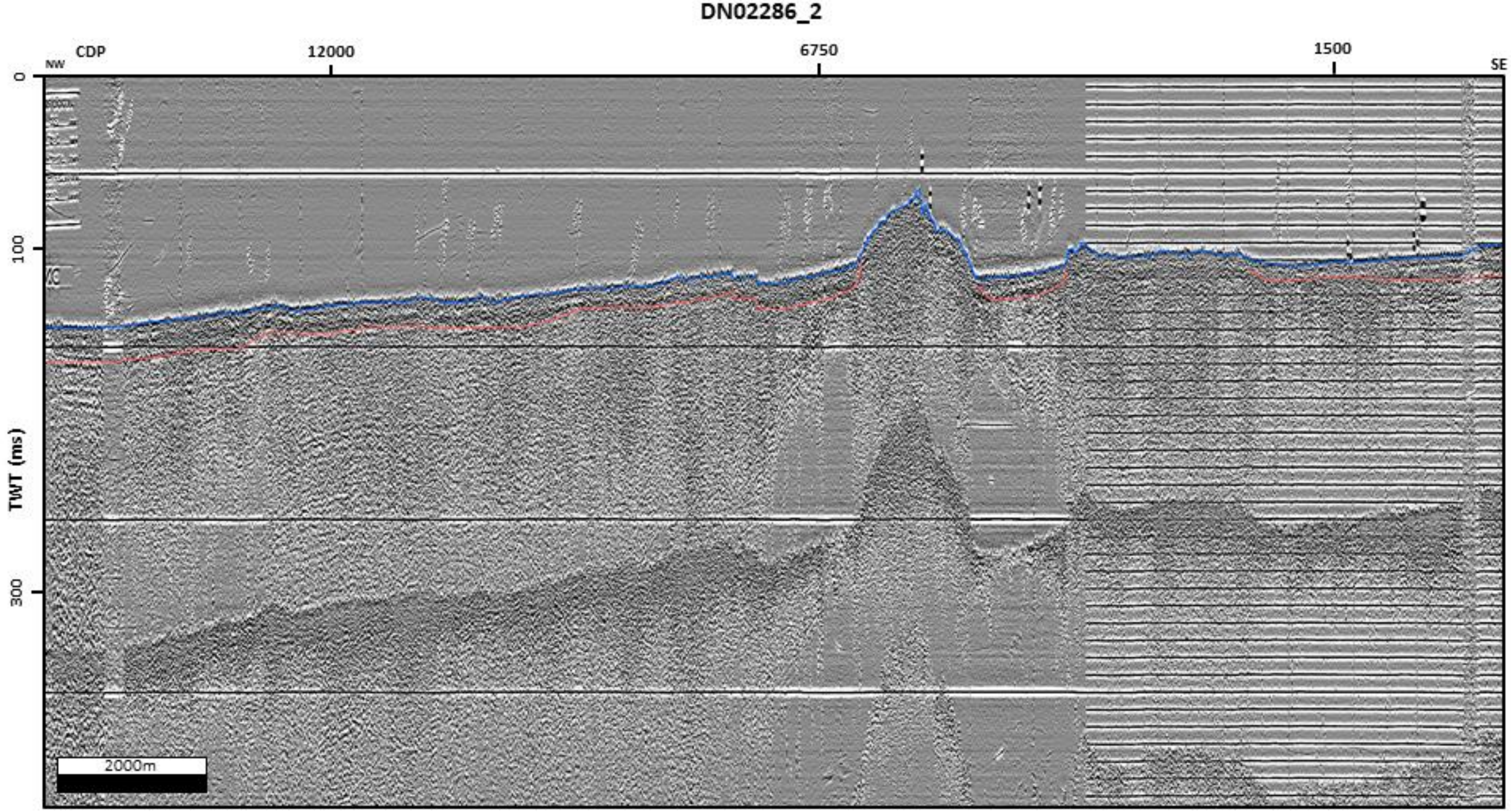
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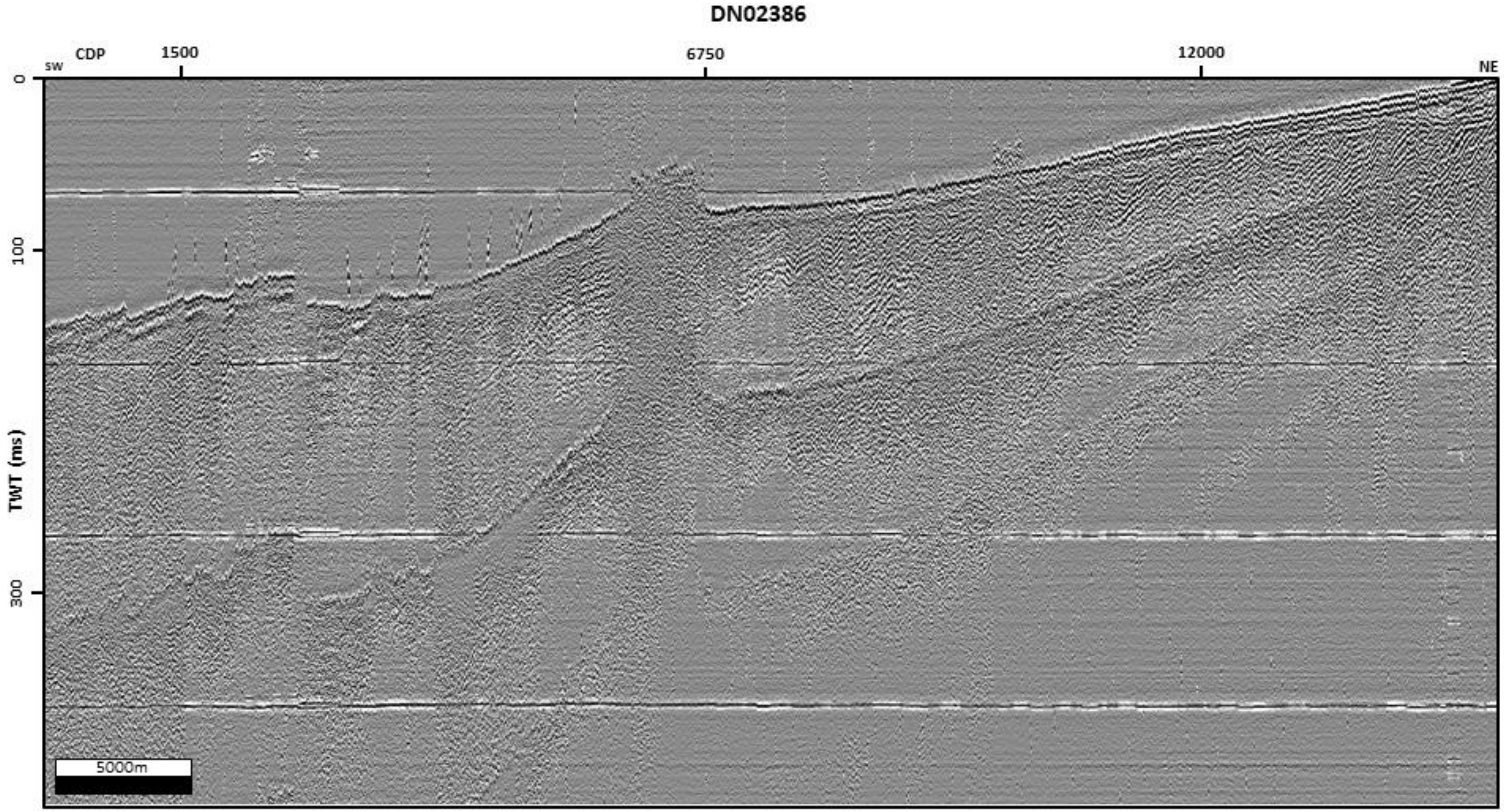
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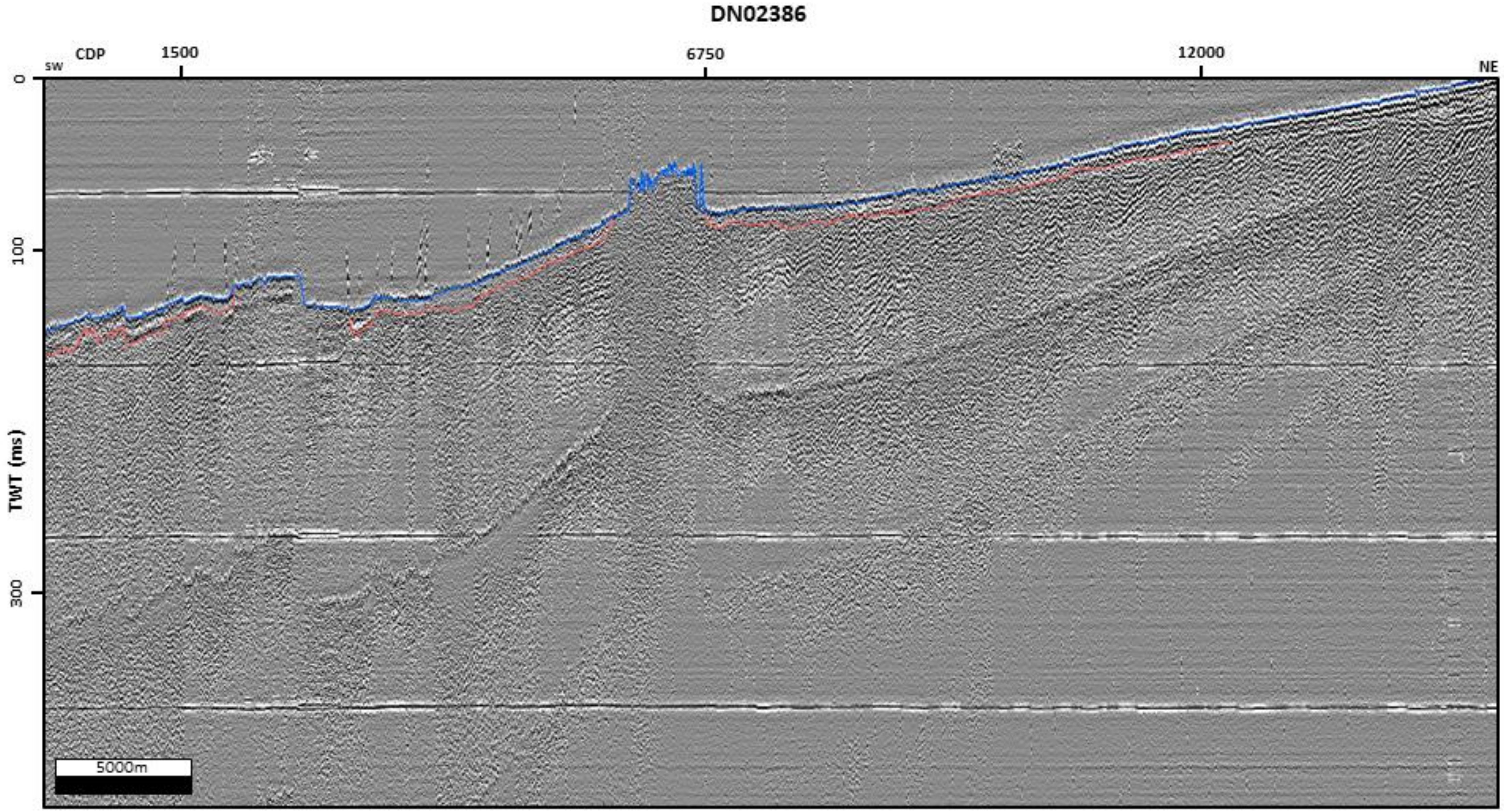
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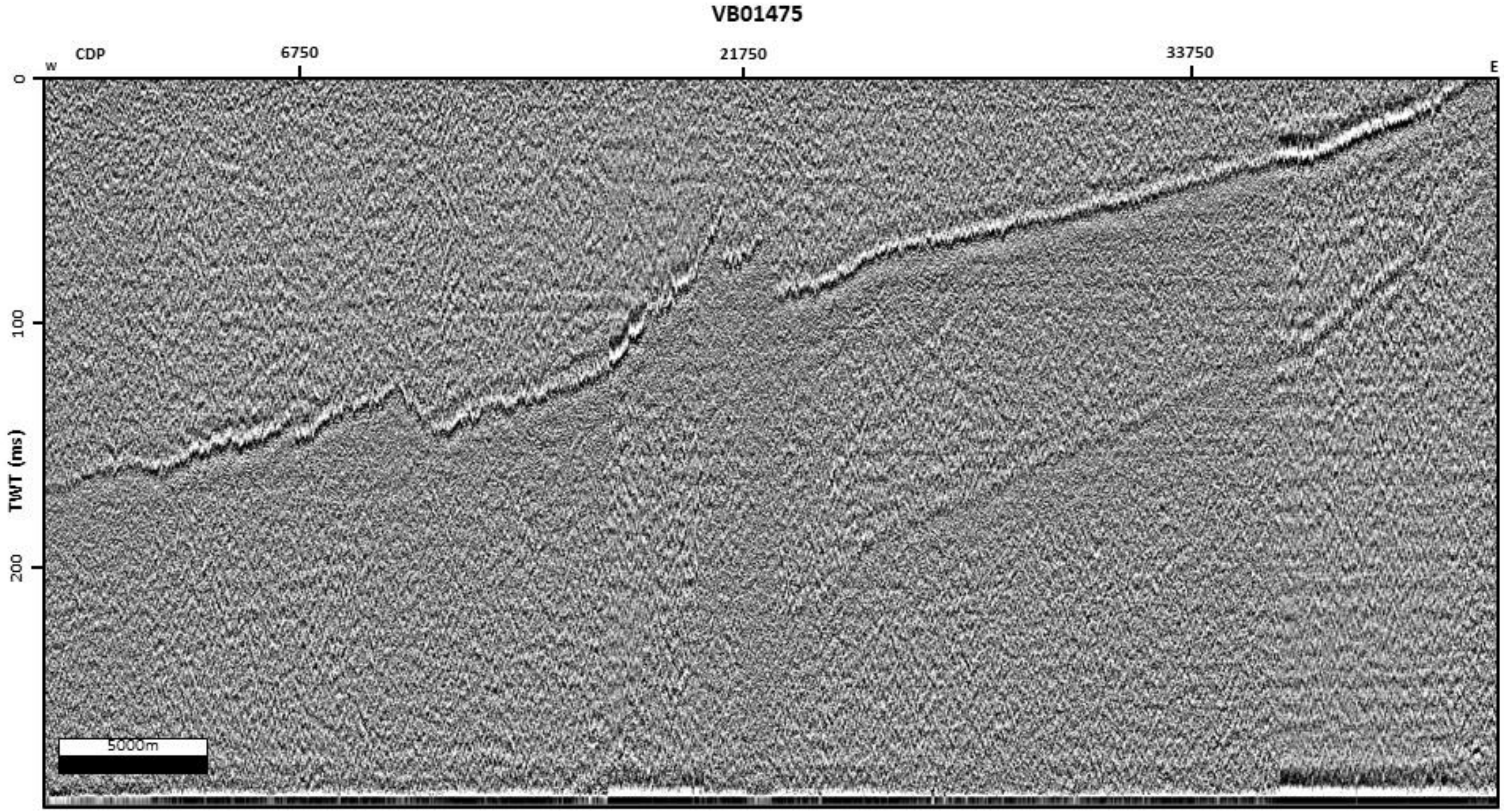
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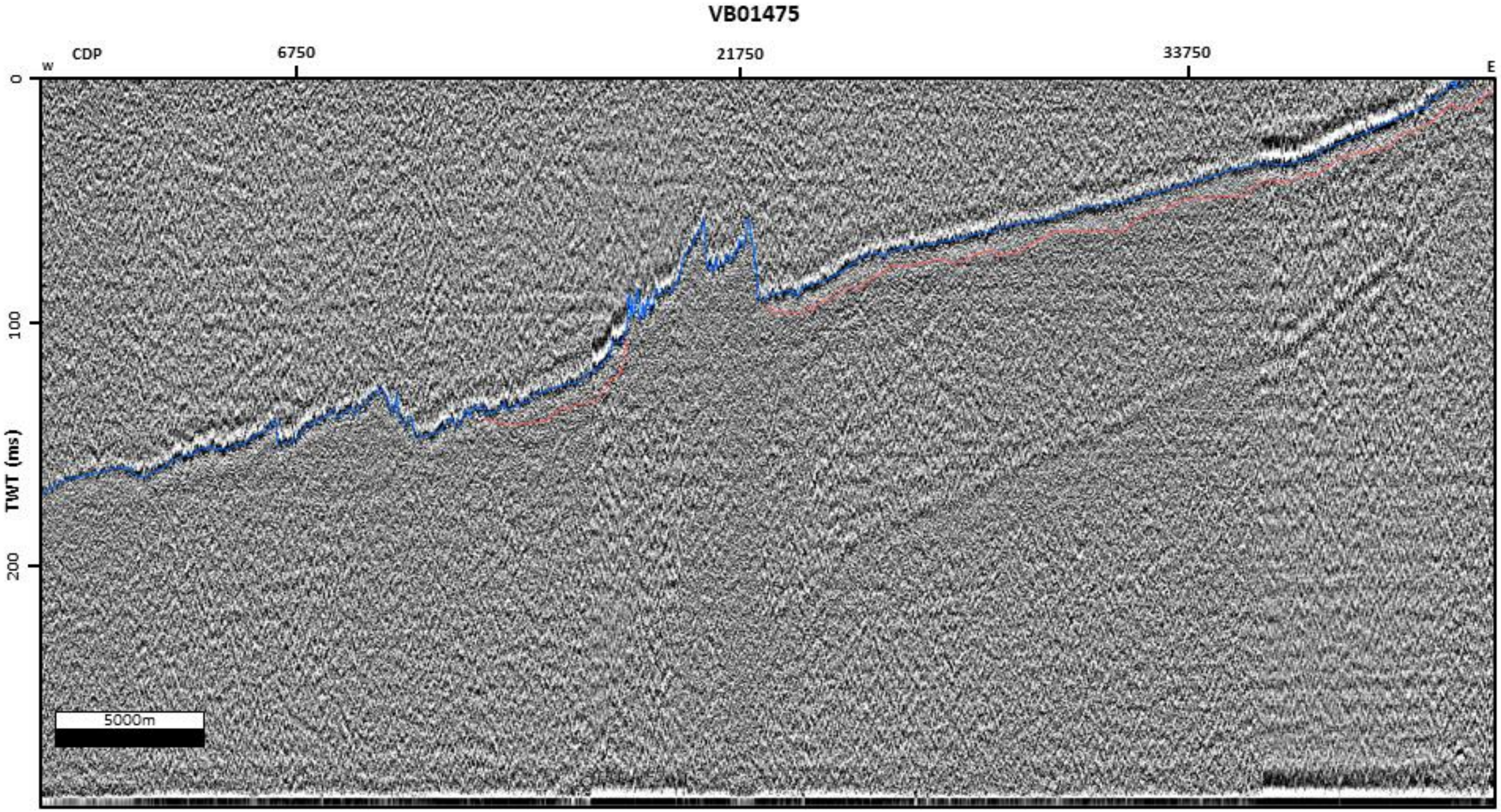
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TWT (ms)
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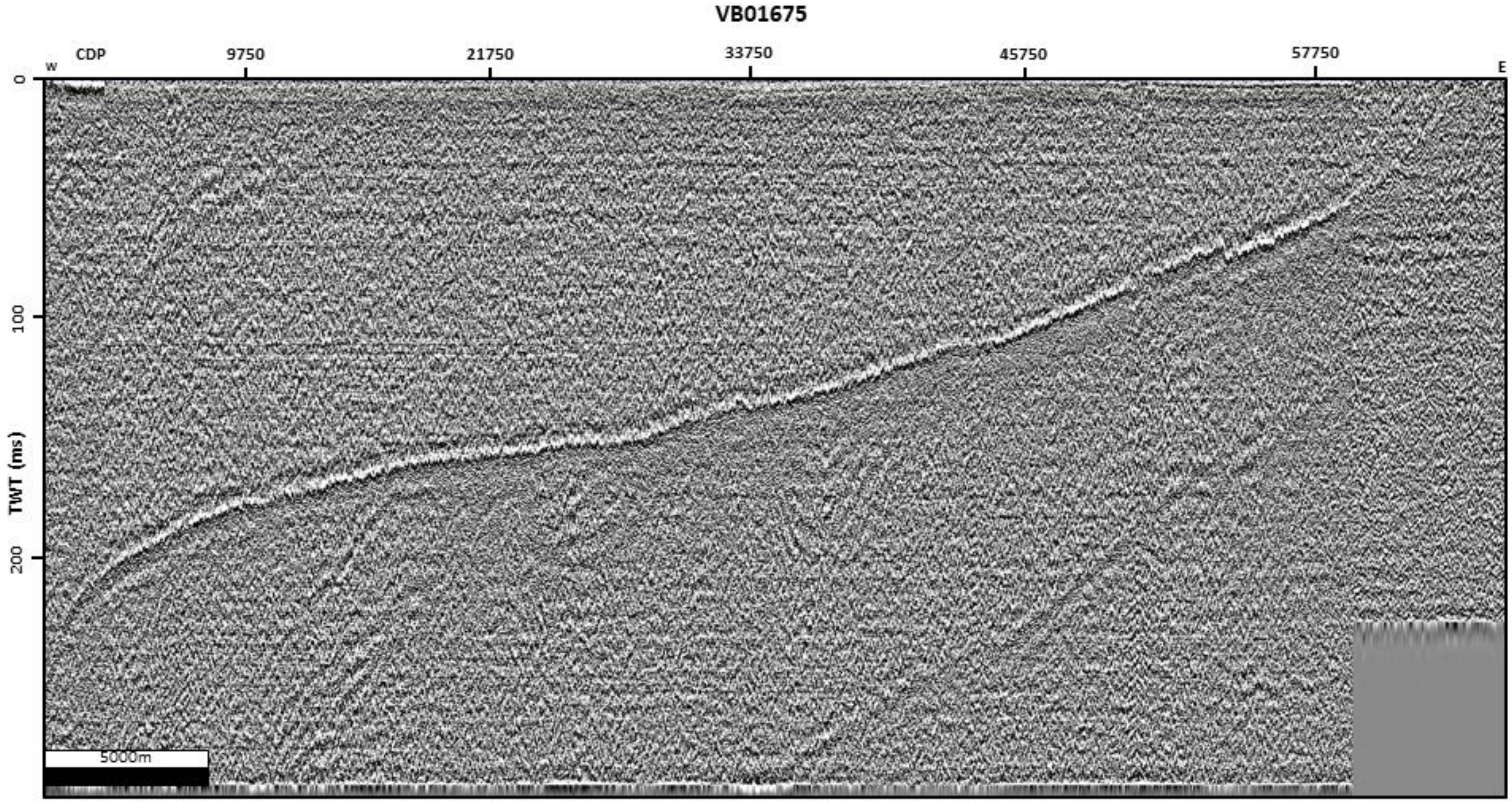
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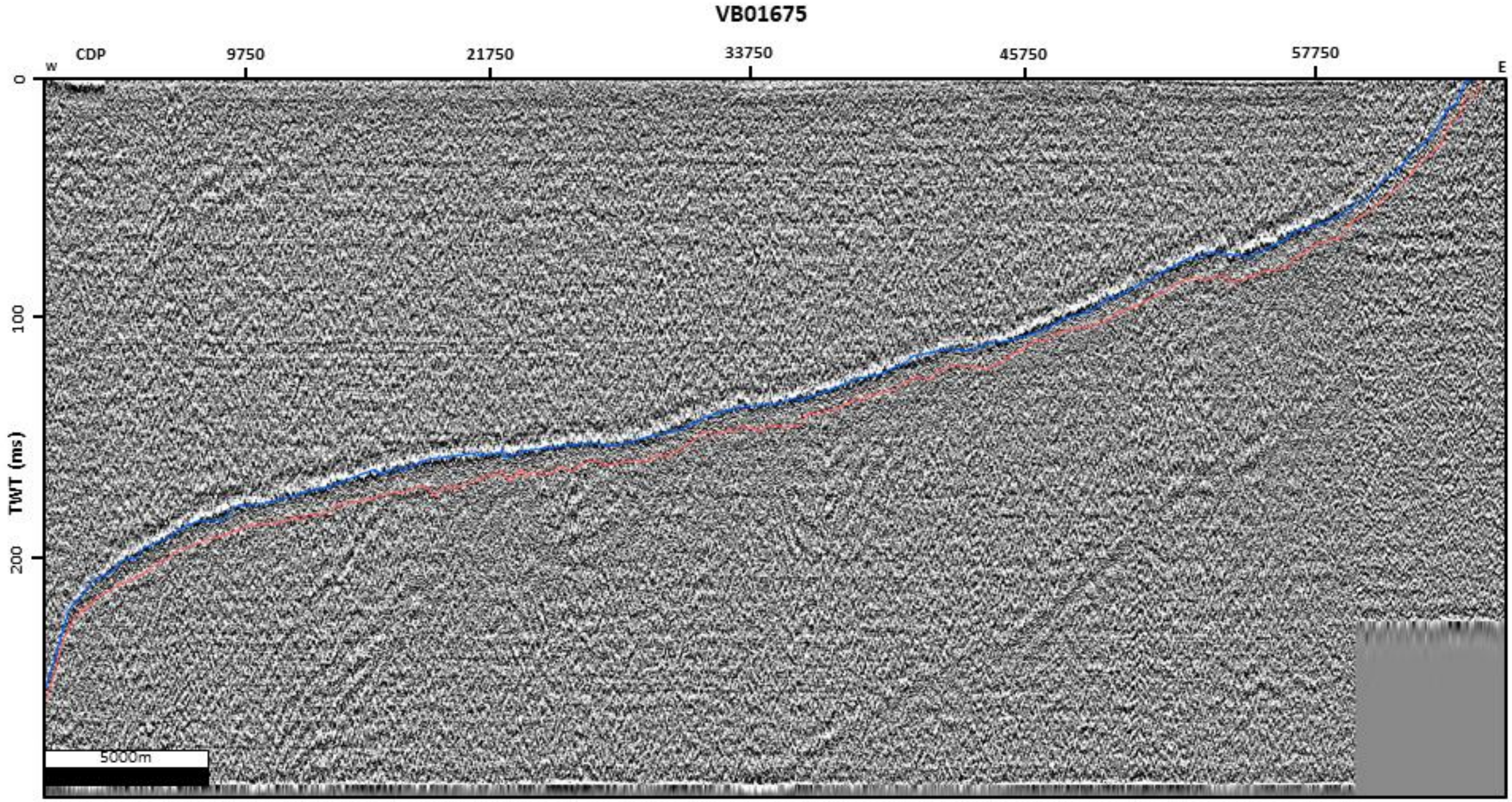
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9750
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E
0
100
200
TWT (ms)
5000m

IPMA Instituto Português do Mar e da Atmosfera

PRR Plano de Recuperação e Resiliência

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