DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2006/61

Horns Rev II Offshore Windfarm

Geophysical Survey, Windfarm

Client: ENERGI E2 A/S, A. C. Meyers Vænge 9,
DK-2450 Copenhagen SV, DENMARK

Jørn Bo Jensen, Peter Gravesen, Steen Lomholt,
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& Hanne Ebbesen

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF THE ENVIRONMENT

G E U S

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MINISTRY OF THE ENVIRONMENT

GEUS

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21. Appendix H: Proposal for vibrocore sampling

1. Introduction

1.1 Aims and objectives of the geophysical survey

ENERGI E2 was awarded the concession for the offshore Windfarm Horns Rev 2 in 2005 by the Danish Energy Authority. The installed capacity of the Windfarm of approximately 215 MW will be exported to a connection point on land via a submarine cable. For the development of project a geophysical survey of the Windfarm area has been conducted by The Geological Survey of Denmark and Greenland (GEUS) in May 2006. The brief objectives of the survey include for the Windfarm area and the Transformer Platform but are not limited to:

- To provide data for the ongoing environmental statement and the subsequent technical development on a various number of different subjects.
- To provide an accurate hydrographical chart of the potential development areas
- To map seabed features within the potential development areas including natural features and artefacts, obstructions and Ship Wrecks.
- To provide broad-based seabed classification of surface sediments for final design of a baseline benthic survey.
- To provide information on the shallow geology. Map variations in thickness of loose or mobile sediment cover, assessment of sand waves, dunes.
- To identify and locate any existing cable, pipelines, boulders, unexploded ordnance or other features that may impact on foundation or cable installation.
- To provide information and locate any existing ripples, boulders, visible fishing activities, inclinations or other features that may impact on foundation installation.
- To provide information on the geology of soil interfaces. Map variations in thickness of soil interfaces and provide information for the archaeological assessments of the area.

1.2 The survey area

The survey area is located north-west of the outermost part of Horns Rev. The area covers approximately 58 km^2 with an overall length of 12 km from south to north and a width of 6 km from east to west. The listed points defining a set of UTM zone 32 coordinates (Euref89) limit the Windfarm area.

Point #	UTM Easting	UTM Northing
N1	411,756	6,168,863
N2	414,671	6,166,253
N3	412,331	6,160,063
N6	407,187	6,161,942
N7	409,214	6,167,058
N1m	410,938	6,169,553
N4m	412,254	6,158,379
N5m	407,088	6,158,470
N5n	407,051	6,157,551
N4n	412,218	6,157,760

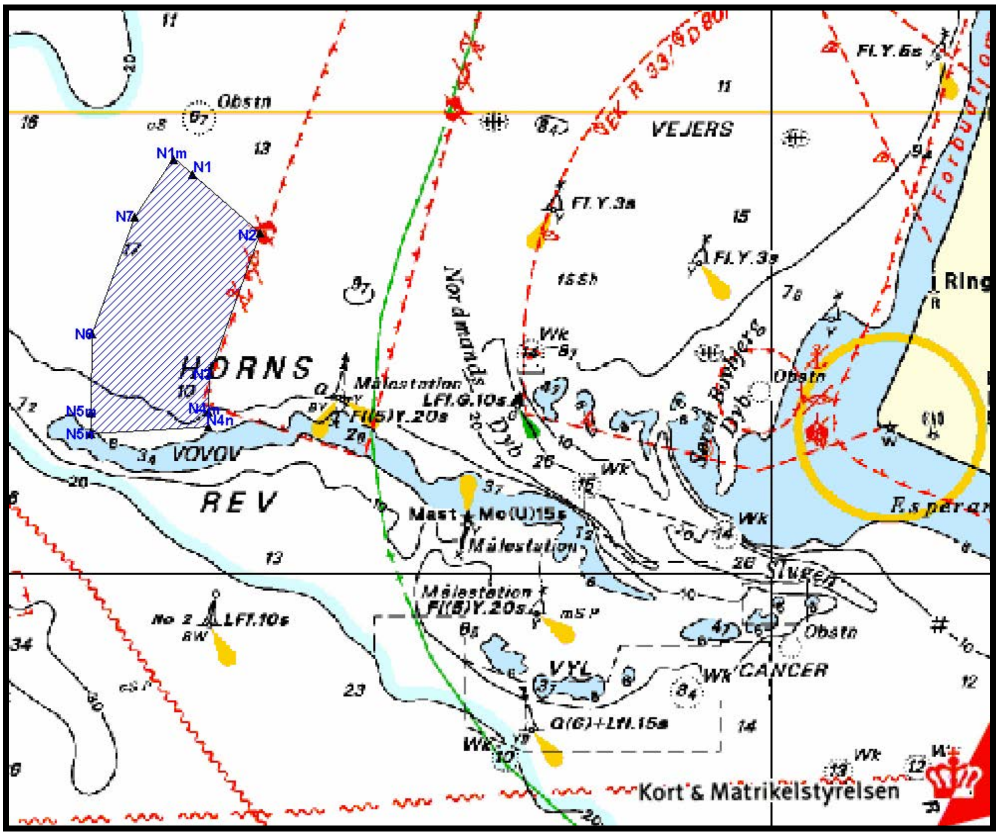


Figure 1. Horns Rev 2 Windfarm, hatched area.

1.3 Scope of work

This report presents the final results of the programme of shallow seismic reflection acquisition, Side Scan Sonar and Magnetometer acquisition in the HR 2 area at the West coast of Jylland (Figure 1and Appendix A1). The objective of the investigations was to map the seabed and the subsoil in the Windfarm area.

The Geophysical survey and the seabed sampling were carried out during the period from 2006-04-21 to 2006-05-14.

In order to be able to evaluate the seabed in the Windfarm area, a geophysical survey was carried out, including a variety of instruments, Sparker, a Benthos Side Scan Sonar, Marine Caesium Magnetometer and a Kongsberg EM 3002 Multibeam.

The knowledge of the seabed surface sediments and the subsoil has been achieved with this combination of data acquisition systems, supplemented by 15 seabed samples, collected in the Windfarm area.

To be sure to get a proper seismic penetration (>25m) it was decided to use a Sparker system with high power. That gives a seismic resolution in the order of less than 50 cm.

During all the survey activities, a RTK navigation system with a vertical resolution at less than ±5 cm and with an accuracy of < 1m X Y direction was used.

The NaviPac software system has been used for acquisition of navigation data and offsets of instruments and the QINSy acquisition have been used for the bathymetric survey.

The geophysical survey and the seabed sampling are done by GEUS, while Dansurvey has assisted GEUS with the Multibeam survey. During the project Dansurvey has changed the organisation, and a new company, Scansurvey, has been established but the overall responsibility is still at Dansurvey.

2. Acquisition equipment and procedures

2.1 Geo-Sparker 200

The Geo-Spark series is a new generation of very high-resolution multi-tip sparkers and HV pulsed power supplies developed and manufactured by Geo-Resources Instruments.
It has been designed for operation with the Geo-Spark 1000 Pulsed Power Supply using the Preserving Electrode Mode. In this patented mode the electrodes are negative with respect to the frame (ground referenced), reducing the electrode wear to practically zero.

The Geo-Spark 200 source system is capable to acquire very high-resolution seismic profiles of the "shallow" sub-bottom strata. Depending on the energy level, the geology and water depth, the effective penetration can exceed 300 - 400 ms below seabed.
The standard Geo-Spark 200 very high-resolution seismic spread typically consists of

- Geo-Spark 200 Sparker source c/w cable and patch panel
- Geo-Sense dedicated high resolution single channel streamer
- Geo-Spark 1 kJ solid state pulsed power supply

Array Depth: Adjustable from 10 cm to 40 cm below surface
Array Geometry; Planar configuration of 0.75 x 1.00 m for enhanced downward projection of acoustic energy
Number of active Electrode Modules (1 - 4) corresponding to 50, 100, 150, or 200 tips can be selected onboard
Electrode Modules can be used with:
Small diameter tip, surface = 0.45 mm2, for low power per tip
Large diameter tips, surface = 2.50 mm2, for high power per tip
Energy Level: Recommended max energy per tip in PE mode:
3 Joule / tip for small diameter tips
12.5 Joule / tip for large diameter tips
Standard Configuration
For use with the Geo-Spark 1000 PPS, a combination of 2 modules with 50 small diameter tips plus 2 modules with 50 large diameter tips
Primary Pulse Length: Around 0.5 ms
Dominant Frequencies: Between 500 - 2000 Hz, depending on the selected energy level

PE Mode

The Geo-Spark 200 Multi-tip Sparker is specifically designed for operation with the Geo-Spark 1000 High Voltage Pulsed Power Supply in Preserving Electrode Mode. In this patented mode, the electrodes have negative potential with respect to the frame (ground referenced).

Figure 2. Sparker System

2.2 Side Scan Sonar

The Benthos SIS-1600 Series Side Scan Sonar is a fully integrated system that uses both advanced Chirp and conventional continuous wave (CW) technologies—single frequency or dual frequency—and an advanced high-speed communications link to acquire high resolution side scan sonar images.

The Benthos SIS-1600 is a complete side scan sonar survey system that includes a topside acquisition system and software, a 100-meter tow cable, the CL-160 Communications Link, and one of two available tow vehicles: the TTV-196 Tow Vehicle, which acquires long range, high resolution Chirp side scan sonar images in a single frequency band; and the

TTV-196D Tow Vehicle, which acquires long range, high resolution Chirp side scan sonar images in two frequency bands simultaneously.

Figure 3. Benthos Side Scan Sonar.

System Highlights

▲ CL-160 Communications Link
▲ 100 kHz, 100 meter range
▲ 400 kHz, 100 meter range
▲ Topside sonar processor

System Features

The TTV-196D Tow Vehicle includes the transceiver electronics, the processing and communications electronics, the port and starboard side scan transducer arrays, the pitch, roll and heading sensors, and the optional sensors. The optional sensors include a water temperature sensor, a pressure sensor, a magnetometer, and a responder. Hydro dynamically stable tow vehicle with operating depth up to 1,750 meters.

Features

■ Dynamic range - high frequency data up to 150 meters
■ Enhanced resolution
■ Repeatable transmitted waveforms

- Constant temporal resolution
- The pulse characteristics are programmable
- Stainless steel construction
- Seaconnet shipwreck, 400 kHz, 75 meter range

SYSTEM SPECIFICATIONS

Software
Application: Third party data acquisition and display (i.e.TEI “Isis Lite”, Chesapeake, “Sonarmap”)
Operating System: Microsoft® Windows® XP Professional

Hardware
Processor CPU: Intel® Pentium® 4 processor
Memory: 512 DDR SDRAM
I/O Ports: Wireless keyboard/mouse
RS-232 serial
Parallel
Ethernet 10/100 BaseT
Graphics Processor: Integrated high resolution graphics
Data Sorage: High capacity hard drive, CD/DVD-RW drive
CL-160 Communications Link

Physical Characteristics
Construction: 316 stainless steel
Dimensions: 11.4 cm (4.5 in.) outside diameter by 177.8 cm (70 in.) long
Weight in Air: 34 Kg (75 pounds)
Weight in Water: 25 Kg (55 pounds), approx.
Operating Depth: 1,750 meters
Towing Speed: 1 to 8 knots operational
Input Power: 144 VDC, 32 watts nominal

Side Scan Sonar
Acoustic Source Level: +225 dB re 1uPa @ 1 meter
Range: 25 to 500 meters each channel

Frequency Range
Chirp Frequency Range:

(TTV-196D): Simultaneously sweeps in the 110 kHz to 130 kHz and 370 kHz to 390 kHz bands

CW Frequency

(TTV-196D): Simultaneous 123 kHz and 383 kHz

Transducer Radiation

(TTV-196D): 0.5 degrees horizontal, 55 degrees vertical (110 kHz to 130 kHz band), 0.5 degrees horizontal, 35 degrees vertical (370 kHz to 390 kHz band)

2.3 G-880 Marine Caesium Magnetometer

The Geometrics high resolution marine Caesium magnetometer system has been used for this survey. It has simultaneous readings may be obtained from up to 6 individual sensors through cable lengths to 2500 ft. System features include very high sensitivity measurements of total field and gradient combined with rapid sampling.

A Larmor counter provides direct connection to a host CPU for integrated Side Scan Sonar. The G-880 is completely digital, unaffected by shipboard noise, easily deployed and simple to operate.

A key element in the high performance of the system is the conditioning and the counting of the Larmor signal. Using a proprietary design mounted into the electronics pressure vessel, sensitivity, measurement rates, number of sensors and data format are selected by commands from the vessel. Counters from multiple sensors may be concatenated together to provide a sequential stream of RS232 data for transmittal through the tow cable.

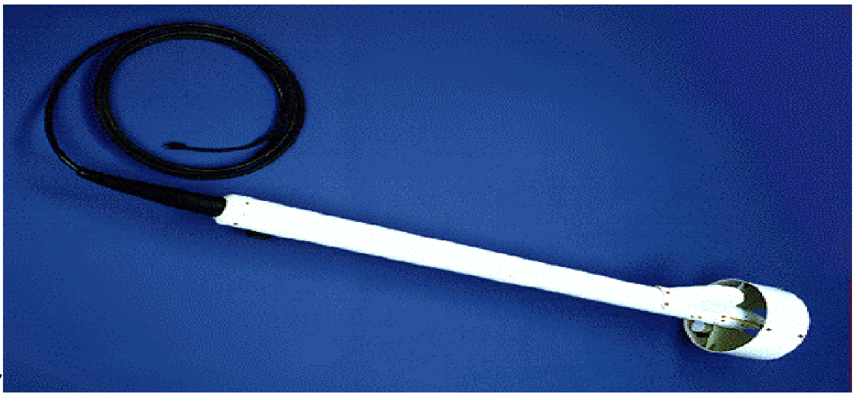
7 

Figure 4. G-880 Magnetometer.

Features

- Sensitivity 0.02nT at 10 samples per second - selectable.
- Multi-sensor gradiometer arrays for precise search or diurnal corrected total field.
- Quick-connect integration to Side Scan Sonar systems with simultaneous data display.
- Tow cable lengths to 2500 ft. - digital data immune to shipboard noise.
- Petroleum - oceanographic - or search surveys.

Technical

Operating Principle: Self-oscillating split-beam Caesium Vapour (non-radioactive Cs133) with automatic hemisphere switching.
Operating Range: 17,000 to 100,000 nanno Tesla (nT)
Heading Error: +/- 0.5 nT

Sensitivity: 90% of all readings will fall within the following Peak-to-Peak envelopes:

1. 0.05nT at 0.1 sec cycle rate
2. 0.03nT at 0.2 sec cycle rate
3. 0.01nT at 1.0 sec cycle rate

Operating Zones: For highest signal-to-noise ratio, the sensor long axis should be oriented at 45^o, +/- 30^o to the earth's field angle, but operation will continue through 45^o, +/- 35^o.
Gradient Tolerance: > 500nT / inch; >20,000nT / meter.
Three wire RS232, magnetic, up to 6 A/D channels for other sensors if present.

Larmor Counter:

1. Integrated into sensor electronics in 'fish'
2. Ref Osc: Nominal 22 MHz
3. Output data concatenated with other counters or data sources if present
4. A/D converters: 3 single and 3 differential, 12 bit resolution.

Control functions: Keyboard commands from surface

<u>Tow Cable:</u>

1. Shielded twisted pair of #12 conductors with 8 separate #20 conductors

2. Strain member: Kevlar, 10,000 lbs breaking strength
3. Maximum working load: 1250 lbs
4. Outside diameter: 0.65 inch
5. Bending diameter: 24 inch
6. Weight: Air: 215 lbs per 1000 ft. Water: 70 lbs per 1000 ft

lengths selectable to 2,500 ft (762 meters)

Power Supply:

1. Converts 115/220 50/60Hz AC to 28 to 32 VDC, 150 W
2. Provides cable junction for power & data

   8 x 9 x 4.5 inches, 6 lb

Environmental:

1. Operating / Storage Temperature: -45^{o}C to +60^o C (-40^o F to +140^o F)

   Depth: Pressure vessels in 'fish' rated to 4,000 ft (increased depth possible upon request)

Sensor 'Fish':

1. Heavy duty filament wound fiberglass, free flooded with stabilizer ring-fin assembly
2. Length:83 inches (cable stiffener and bulkhead termination adds 16 inches to length
3. Body outside diameter: 4.5 inches
4. Ring-fin outside diameter: 14.25 inches
5. weight in air: 38 lbs; in water: 12 lbs

2.4 Multibeam EM 3002.

The used system is a high resolution Kongsberg EM3002D dual head seabed mapping system. Each head delivers a 1.5° beam for transmission and reception, where the swath coverage of the dual head system can reach up to 10 times the water depth. In the high density mode of operation each head acquires up to 254 soundings per ping. The operating frequencies are 293 and 307 kHz to avoid interference between the two heads. The operation range of the system is from 1m to 150m, which is also a function of salinity and temperature. The depth resolution is very high (~1cm), the across track measurement accuracy is a function of depth and the distance from nadir position, a nominal range resolution of 5cm is reported.

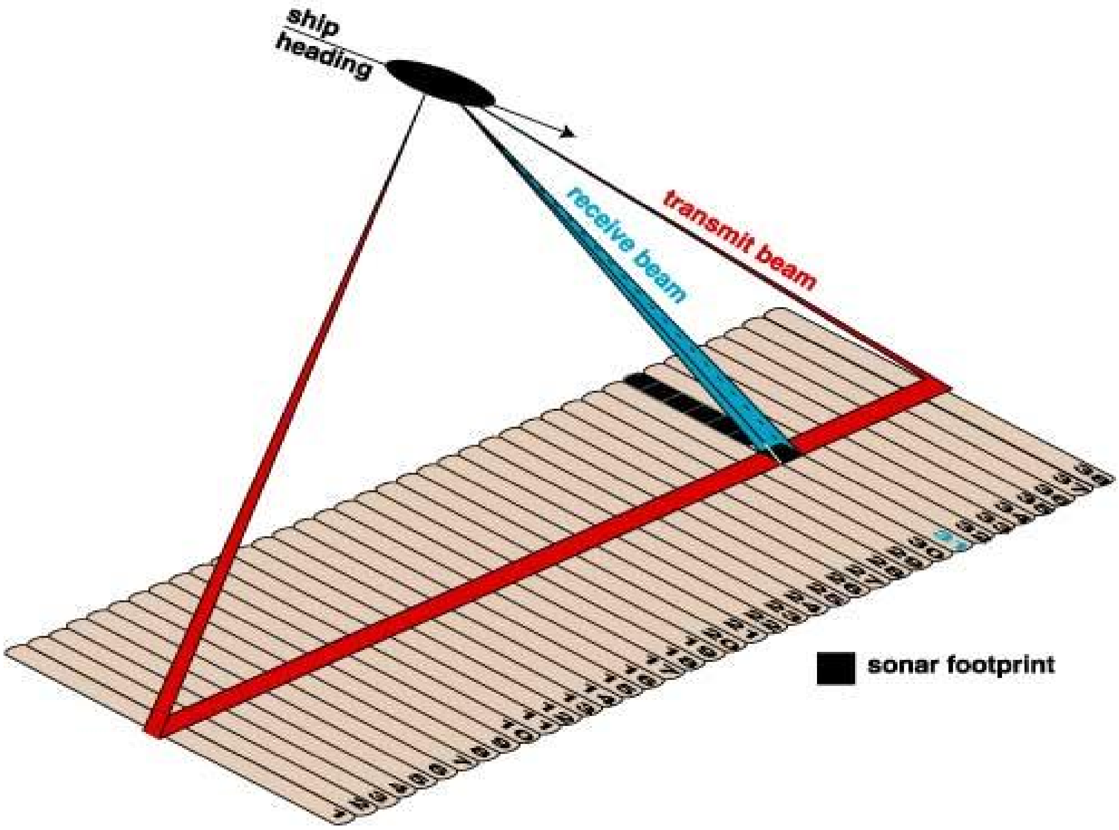


Figure 5. Schematic diagram of Multibeam system operation.

Figure 6. The Kongsberg EM3002D side mounted at the survey vessel M/S Hans M.

Technical Specifications

Overall specifications per Sonar Head

Frequency: 293, 300 or 307 kHz

Maximum ping rate: 40 Hz

Number of beams per ping and sonar head: 160

Number of soundings per ping and sonar head: Up to 254

Beam width: 1.5 x 1.5 degrees

Beam spacing: Equidistant or equiangular

Coverage sector: 130 degrees per sonar head

Transmit beam steering: ±15 degrees in 0.5 degrees steps along track

Depth resolution: 1 cm

Pulse length: 150 μs

Range sampling rate: 14, 14.3 or 14.6 kHz (5 cm)

Beam forming method: Time delay with dynamic focusing in near-field.

Data storage rate: 50 to 400 MB/h (max at about 5-10 m depth)

Frequencies of 293 and 307 kHz are used in dual Sonar Head systems.

Receive beam width is inversely proportional with the cosine of the beam pointing angle with respect to the Sonar Head (i.e. beam width is 2.1° at ±45° beam pointing angle and 3.0° at ±60°).

Interfaces

• Serial lines with operator selectable baud rate, parity, data and stop bit length for:

- Motion sensor (roll, pitch, heave and optionally heading) in format supported by sensors from Applied Analytics, Seatex, TSS and IXSEA
- Gyrocompass in either NMEA 0183 HDT or SKR82/LR60 format
- Positions in either Simrad 90, NMEA 0183 GGA or GGK format
- Sonar head depth in Digiquartz compatible format
- External clock in NMEA 0183 ZDA format
- Sound speed sensor in AML Smartprobe format

EM 3002 / Base version

28 855-164929 / B

• Interface for a 1 PPS (pulse per second) clock sync signal

• Ethernet and serial line interface for input of tide and sound speed data and output of all data normally logged to disk.

Physical specifications

Sonar Head

Diameter: 332 mm
Height: 119 mm (+27 mm for connector)
Weight: 25 kg (15 kg in water)
Pressure rating: 500 m water depth
Diameter of cable to Sonar Head: 17 mm
Connector: Subconn LPBH9F
Material: Titanium
Power: 24 Vdc, 1 A (available from the Processing Unit)
A Sonar Head with pressure rating of 1500 m water depth is available with the same specifications except for height (121 mm) and a restriction in maximum swath width to 3.5 times depth (120° angular coverage sector).

Processing Unit

Height: 177 mm
Width: 427 mm (excluding rack fixing brackets)
Depth: 392 mm (excluding handles and connectors)
Weight: 14.5 kg
Power: 115 Vac (60 Hz) and 230 Vac (50 Hz), < 250 W

Operator Station
Height: 127 mm
Width: 427 mm (excluding rack fixing brackets)
Depth: 480 mm (excluding handles and connectors)
Weight: 20 kg
Power: 115 Vac (60 Hz) and 230 Vac (50 Hz), < 300 W

LCD monitor
Height: 400 mm (excluding mounting bracket)
Width: 460 mm (excluding mounting bracket)
Depth: 71 mm (excluding mounting bracket)
Weight: 9.2 kg
Power: 115 Va

2.5 NaviPac System

APPLICATIONS – The NaviPac software is integrated navigation and data acquisition software specifically suited for applications like:

- General navigation
- Hydrographical & oceanographic surveying
- Geophysical & seismic surveying

Modularity
NaviPac is modularity through use of multi tasking, multithreading and networking capabilities of the Windows NT, Windows 2000 and Windows XP operating system. The software is highly flexible and user configurable, and the user interface adheres to The Microsoft Interface Guidelines making it very intuitive and easy to operate.

Navigatio set-up
The NaviPac set-up module provides geodetic parameters, navigation systems, devices, offsets and port settings.

Device I/O drivers
A vast number of field-tested device I/O drivers are provided for most available positioning systems, GPS/DGPS receivers, gyros, motion/attitude sensors, tide-gauges, singlebeam

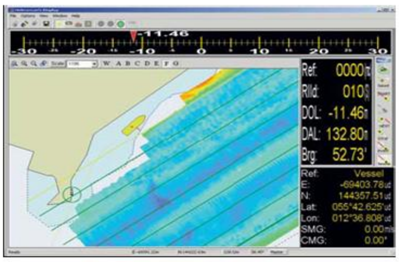
echosounders, magnetometers, dynamic positioning systems, autopilots, etc. Generic I/O drivers allow definition or customization of own device I/O drivers. Data is interfaced via RS232, a LAN or via a digital I/O interface.

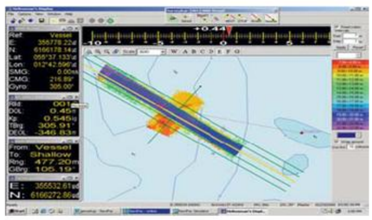
Time Synchronization

Time stamping of sensor data, incoming as well as utgoing, can be done in two ways, either by the internal computer clock or by he PPS output available from most GPS receivers. Using the PPS output data are synchronized relative to the GPS/UTC time frame, resulting in an accuracy of a few milliseconds.

Survey Planning

NaviPac allows for survey planning through quickly creation of planned survey area and survey lines. A variety of methods for creation of survey lines is provided, e.g. by click-and-drag (of mouse/trackball), input of survey line coordinates, offset (parallel) survey lines, cross lines, circles, arcs etc. Survey lines can easily be adapted to fit a defined survey area. Creation of templates allows input of other data formats.





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2.6 QINSy System

Total Hydrographic Solution!

QINSy is a turnkey solution for all types of marine navigation, positioning and surveying activities. From survey planning to data collection, data cleaning, volume calculations and chart production, QINSy has a seamless data flow from a large variety of hardware sensors, all the way to a complete chart product. QINSy runs on a standard PC platform under the Windows XP operating system. The software is not only independent of sensor manufacturer, but also hardware independent.

QINSy supports the following sensor types:

- Navigation Sensors
- NMEA
- GPS, DGPS and RTK
- Gyro's and Compasses
- Range/Range, Range/Bearing, Total Stations
- Motion Sensors
- ARPA and AIS
- LBL and USBL
- Inertial and Doppler
- User Defined :
    - Bathymetry Sensors
    - Singlebeam and Multibeam
    - Mechanical Profilers
    - SVP and Moving SV Profilers
- User Defined
    - Side Scan Sonar Sensors
    - Digital and Analog
    - Auto Pilot Sensors
    - NMEA
- User Defined
    - Magnetometer Sensors
    - NMEA
- User Defined

- Input and Output of Generic Sensors (analog, weather, rpm, environmental, etc.)
- NMEA

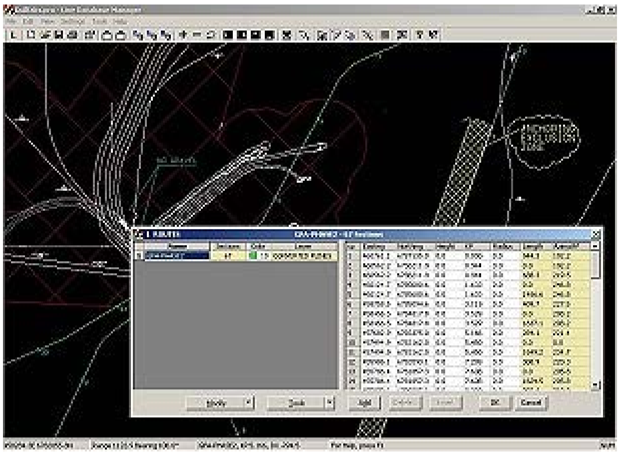
QINSy Console

Gathering and organizing the various QINSy 7 programs in a single desktop application, called the Console, makes navigation through the program suite at each phase of the project. guided through the various program modules designed specifically for survey planning, data collection, data processing and chart production. Program Managers provide a complete overview of project status at each phase. The main program modules are:

- Planning
- On-line
- Replay and SSS Processing
- Processing and Data Cleaning

Survey Lines

The Line Database Manager is a toolbox for survey planning, allowing the surveyor to manually define, automatically generate and/or import from ASCII and DXF files, the following line types:



- Targets and Symbols
- Single Lines
- Survey Grids
- Routes
- Wing Lines
- Cross Lines

Data can also be exported to ASCII or DXF.

The Line Database Manager works interactively in real-time with the Online Navigation Display where points, lines and routes can be generated right in the Navigation Display during data ac Survey Configuration

Created at the planning stage with the Setup program, a Template Database contains all survey configuration parameters pertinent to the project. QINSy supports most of the datums, projections, US State Planes, units and geoidal models used world-wide. The template contains vessel shapes, administrative information, as well as vessel offsets and I/O parameters. It is a complete reflection of your current survey set up, and fully editable to kick-start your next project.

Real-Time Final Results - Data Collection and Output

Raw Sensor Data

All raw sensor data is logged and permanently stored in a fast relational database (*.db) to which the entire survey configuration is copied from the template. Raw data can be analysed and edited using the Analyse program, making it ready for the Replay program and generation of new results if that is necessary. Results data (X,Y,Z and attributes) is stored to one of several formats, primarily the QPS internal format (*.qpd), but also to ASCII, FAU or Helical SDS format.

Data Storage

How raw and results data files are split up during acquisition is your choice. Data may be stored on a line-by-line basis, by file size, or by manual intervention. Whatever the method, data is normally stored in several separate databases for convenience in processing.

Accurate Timing and Ring Buffers

Supremely accurate timing is imperative in many survey situations. QINSy uses a very sophisticated timing routine based on the PPS option (Pulse Per Second) available on almost all GPS receivers. All incoming and outgoing data is accurately time stamped with a UTC time label. Internally, QINSy uses so-called "observation ring buffers", so that data values may be interpolated for the exact moment of the event or ping. Real-Time DTM Production

All computations of position are performed in 3D. In combination with RTK or real-time tide sensors, this means that all depth observations are immediately available in absolute survey datum coordinates. This unique technique is called "on-the-fly DTM production". QPS was the first company introducing the "delta heave" method, which means that the quality of the final DTM is not longer affected by heave drift caused by vessel turns.

Advanced Gridding Methods

For multibeam surveys, "gridding" is the predominant data reduction method. However, achieved reduction usually comes at the cost of loss of resolution. In QINSy there are two gridding methods, namely;

- An irregular gridding method in which the size of cells created in real-time is directly related to variation of the seafloor. In general, large cells, more appropriately called tiles, are created in flat seabed conditions and small tiles created in feature rich areas with slopes, wrecks, rocks, and sand ripples. This on-the-fly method effectively reduces the volume of data without loss of resolution.

- A regular multi-level gridding method. Based on the minimum cell size, 5 additional grids are generated on-the-fly. Grid file size is no longer an issue, since there is no limit to the number of grid cells. If the minimum cell size is selected to be 1 x 1 meter, then automatically the following grid levels are being generated:
  - 2 x 2
  - 4 x 4
  - 8 x 8
  - 16 x 16
  - 64 x 64 being the overview level

This grid can be used not only for bathymetry, but also for SSS Mosaicing, magnetometer data, seabed classifications, etc.

Both methods provide maximum flexibility in data acquisition since there is no longer any need to pre-define grid boundaries.

XYZ Data

Reduced point data output to tiles is accompanied in parallel with output of all soundings to a second file (*.qpd, *.sds, *.fau, *.pts or other).

Either reduced or full datasets are available for further DTM processing.

Processing - Validation, Editing, Calibration, Tide Reduction

Data Cleaning and Filtering

Applying various filters and corrections for motion, tide and refraction, QINSy is designed to output almost final results at the time of data acquisition. Moreover, the many quality assurance functions equip the surveyor with tools to qualify results data in real-time. Starting with cleaner and thinned data, effectively reduces time spent in post processing.

XYZ Attributes

All X, Y, Z and attributes are stored during data acquisition in a fast database, with the following attributes attached to each point:

- Identification (vessel name, system type, ping number, beam number, etc.)
- Status (accepted, rejected, filtered, manually edit, etc.)
- Backscatter
- Full 3D Geo-Referenced Side Scan Sonar (Snippet)

- User Defined On-line Flags
- Quality Parameters

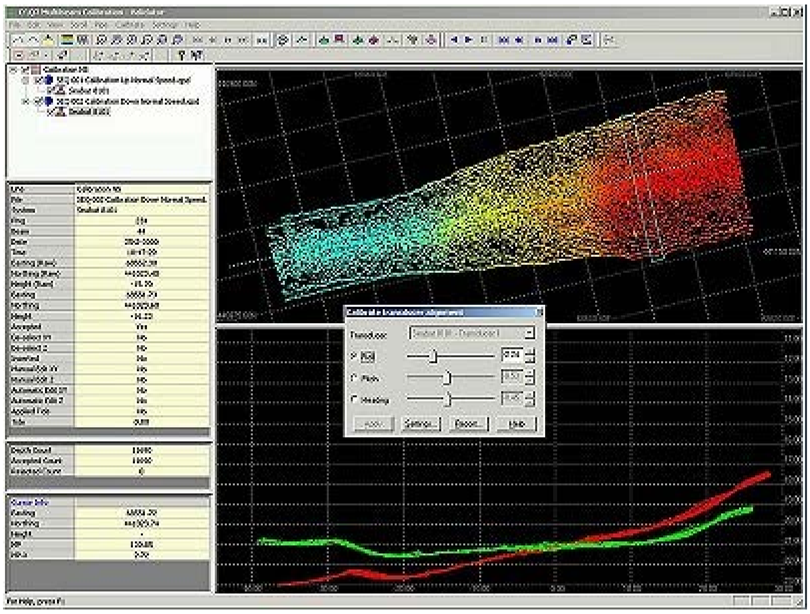
QINSy Processing Manager

All XYZ files are listed in the QINSy Processing Manager, tabulated against a history of processes performed on each file. This provides a complete overview of the project processing status. Processing programs are launched from the Processing Manager:

- The Tide Definition and Processing utility supports various methods for tidal reduction.
- The Validator supports both manual and automated data cleaning including advanced 3D splined surface cleaning

The QINSy Validator

Multibeam exploded the volume of point data and created data handling challenges both at the acquisition and processing phases. The Validator has 4 different views, 3 of which can be opened simultaneously:



- Plan View
- Cross View
- Profile View
- 3D View

Multibeam Calibration

Multibeam calibration with QINSy is inter-active and very easy. The Validator offers tools to calibrate for errors in:

- Roll
- Pith
- Yaw
- Timing

Single beam and Multibeam Data Editing

Editing of single beam or Multibeam data. A variety of automated cleaning algorithms are available:

- Apply On-line Flags
- Clip Below / Clip Above
- Adaptive Clipping
- Median and Mean
- Butterworth
- 3D Spline Surface Despiker
- Multiply/Shift

The Validator adds fully automated pipeline detection features, such as:

- Top of Pipe Detection
- Bottom of Trench
- Mean Seabed Detection

2.7 RTK Navigation system

An AD Navigation DC202 GPS/GLONASS L1/L2 RTK long range receiver was used for the survey.

The RTK receivers from provide real time positioning data at the 1 cm level while attaining the highest reliability and stability possible. Seamless Combination GPS and GLONASS is the heart of the AD Navigation DC-202 RTK receiver. By seamlessly combining the GPS and GLONASS system, the RTK receivers access the total of 40 positioning satellites. During normal operation, the receiver track 30-50% more satellites than does a GPS-only system. Using diversity receiver techniques (dual antenna system), reception of the UHF signal is significantly improved compared to normal systems, even under difficult radio conditions.

The base station sends CMR corrections at up to 5Hz. The diversity receiver technique, in combination with high update rate of CMR correction broadcasts, results in operational RTK up to 80 kilometres from the RTK base station. With two GPS/GLONASS antennas installed, accuracies of 0.01 deg are achieved at 10 times per second. The unit contains no moving parts, and neither calibration nor maintenance is needed.

Technical specifications

Tracking: 20 Channel Dual Constellation (DC) GPS/GLONASS L1/L2

Cold start: < 60 secondsWarm

start: < 10 seconds

Reacquistion: < 1 second

Processing: Co-op Tracking and Advanced Multipath ReductionDC200 Series RTK Positioning1 and Heading

Accuracies2:Horizontal: 1 cm + 0.15 ppm RMS

Vertical: 1.5 cm + 0.15 ppm RMS (DC201/202)

Heading: 0.01 degrees RMS (DC202 only)Update Rate:

Positioning: 5Hz (DC201/202) 20Hz

Optional Heading: 10Hz (DC202 Only) 20Hz

Optional RTK Initialisation1: Typically 10-30 seconds

Operating Range3: Up to 80 km

Built-in UHF Radio

Modem: Frequency Range: 380-470 MHz25 Khz

Channel Separation19,200 bps on Air Transmission

Diversity Reception (Dual Antenna System)

Timing: External PPS Output PPS to TTL converted to RS232 Interrupt

Signal Output formats: GPS based NMEA-0183

Messages Proprietary ASCII and Binary

Output Formats CMR/RTCM, Differential Corrections

Input Formats: CMR/RTCM, Differential Corrections

Accessories:GPS/GLONASS L1/L2

Marine Antenna AC and DC Power Cables DB 9 Serial Cables Physical specifications

Power input: 12-28 VDC or 110-230 AC

Size: 2U 19” rack unit, 254 mm (d), 89 mm (h)Weight: 4.8 kg

Environmental: Vibration, EMI: EN 60945

Temperature:Operation: -20 to 55oC

Storage: -40 to 70oC

Communications: 4 x RS232 com ports, DB9, 115,200 bps1 x RS232 TTL, DB91 x PPS output, BNC-F1 x GPS antenna input, TNC-F (N optional) 2 x UHF antenna input, TNC-F (N optional)

1 Performance is dependent on GPS/GLONASS satellite geometry, environment, ionosphere conditions and distance to the base station

2 Antenna separation > 10 meter

3 Operating range is depending on availability of differential correction dataNote: Specifications subject to change without notice.

3. Health, Safety and Environment.

GEUS undertake full responsibility to provide for the safety, security and health of GEUS' personnel and to observe the respective laws and regulations of the area of operations.
GEUS tries continuously to improve the safety management skills of its personnel both ashore and aboard ships, including preparing for emergencies related both to safety and environmental protection. The target is zero level for injury, accidents, and lost time. The target is further to eliminate or control hazards by risk management at all workplaces.
GEUS covenants, warrants, and represents that its personnel and the personnel of its subcontractors are suitably trained to safely perform the service. The objectives of GEUS' Safety Management Manual are achieved by:

- Senior Management ownership of a Health & Safety Culture achieved by visible investment in GEUS' personnel.

- Maintaining high standards of safety consciousness, personal discipline and individual accountability by adherence to a comprehensive and documented system of training.

- Actively promoting employee participation in measures aimed at improving safety and protecting the environment including the right to stop work should the operational risk be found unacceptable. .

- Communications to personnel of known or potential hazards that may affect themselves, their colleagues, the ships equipment or the environment.

- Continuously reviewing all Health, Safety & Environmental mandatory rules, regulations, industry codes and guidelines that are relevant to our work sites, and business.

- Providing operational and health risk assessment.

- Maintaining a schedule of workplace auditing

All employees are required to comply with Safety and Pollution Prevention Regulations and Procedures at all times and to take the necessary precautions to protect themselves, their colleagues, the ship, its equipment, and the environment.

GEUS provides external assessed comprehensive safety training for its marine personnel as follows:

- Personnel Survival Techniques
- Fire prevention and fire fighting
- Elementary first aid
- Personal Safety and social responsibilities

3.1 Safety overview

There was one Safety Instruction meeting on board the ship before it left Esbjerg for the testing of equipment. The survey crew was instructed on the safety rules on board the ship. With crew change, new instructions were performed.

3.2 Accidents, near miss and unsafe Acts

Accidents

There were no accidents during the survey.

Near miss

There were no equipment miss reports during the survey.

Unsafe Acts

There were no unsafe acts reported.

Minor incidents.

There were neither equipment minor incidents reported nor personal minor incident.

3.3 Environmental incidents

There has been no environmental incident during the survey.

4. Survey Vessel

4.1 Ship configuration

The seismic survey and seabed sampling campaign included one ship - M/S Hans M. It was used for the combined shallow seismic, side scan and Multibeam Survey. M/S Hans M was hired by Esvagt, Esbjerg and it can be seen on figure 7.

Figure 7. M/S Hans M.

The survey configuration of M/S Hans M is shown in Figure 8. Navigation was carried out by RTK DGPS connected to the NaviPac Navigation Acquisition computer distributing navigation data corrected for offset to the ISIS Side Scan data acquisition computer, Delph Seismic data acquisition computer and through QINSy, the Multibeam acquisition system. The mentioned data acquisition computers are connected to the sound sources in the water, via the individual power transmitters.

No tidal correction data are used during the survey. A RTK GPS system with high accuracy in x, y and z is used instead.

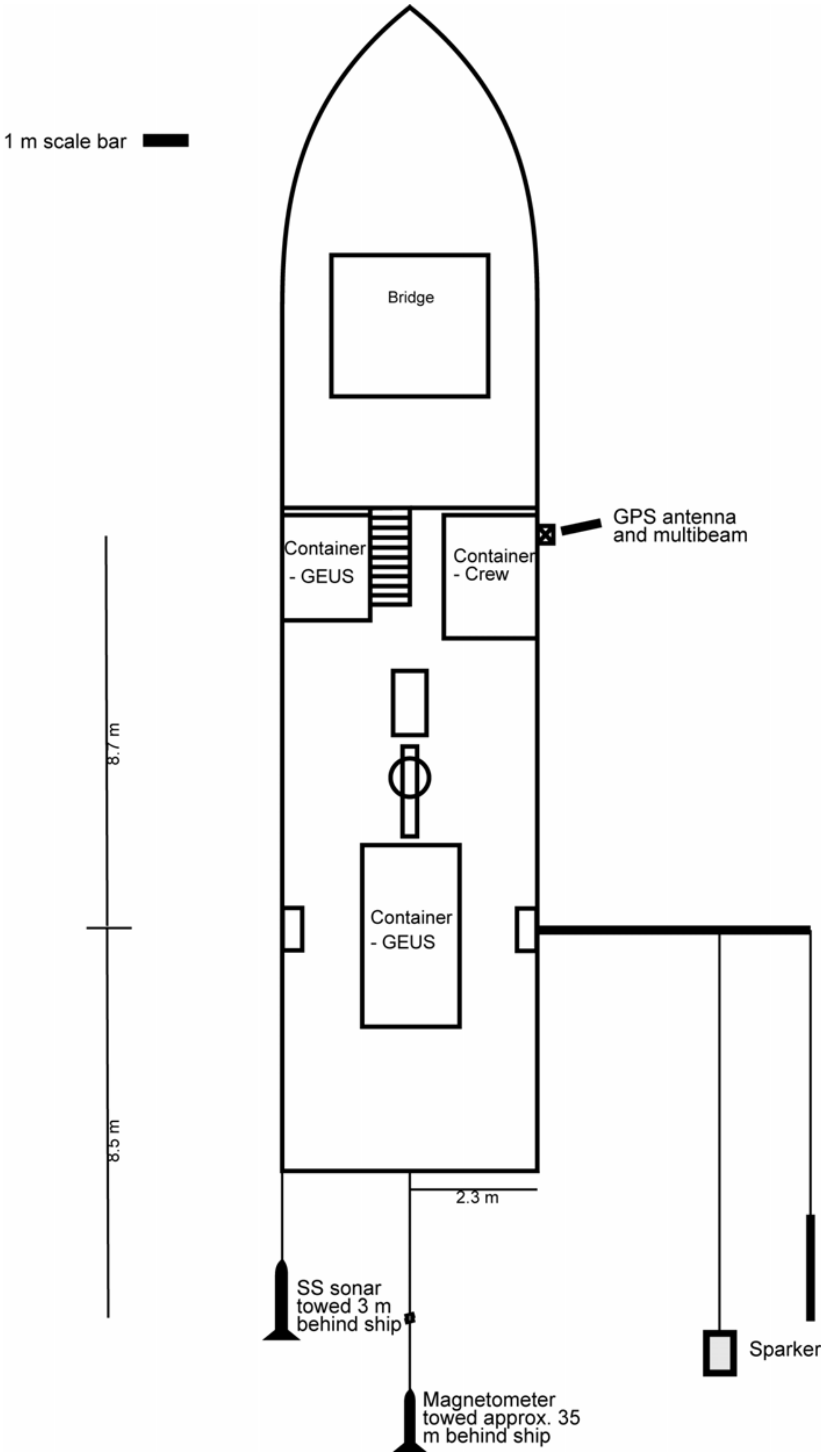


Figure 8. Acoustical equipment onboard M/S Hans M (not in scale).

The location and offsets of the acoustical equipment onboard M/S Hans M is shown in figure 8.

The Multibeam system was side mounted on M/S Hans M and the Side Scan sonar, the Sparker catamaran and streamer and the Magnetometer was towed behind.
The Multibeam dual head Sonar system was side mounted with the GPS reference antenna on top, as shown in figure 9.

Figure 9. Multibeam acoustical equipment onboard M/S Hans M.

The side Scan System is towed behind the ship central with offsets of X=-4,6m Y=-16.7m. The Sparker system was towed in the port site, with the catamaran offsets of X=6m Y=-17.2m and the streamer offset of X=4m Y= -15.2m as shown on figure 8.
The Magnetometer is towed behind the ship central with offsets X=-2.3m Y=-48.7m.

Figure 10. Sparker seismic equipment towed after M/S Hans M.

5. Survey preparation

5.1 Mobilisation Trials

Checks was performed on each instrument before survey commencement to ensure that all the sensors and processing equipment specified are functioning correctly and performing within the manufacturer's specifications.

All checks were performed with supervision of the Employer's Representative, in order to establish any requirements for additional calibrations and any corrections that shall be applied to the gathered data. The Sparker seismic equipment was selected for the cable route survey.

Calibration of the Multibeam system was conducted in presence of the Employer's Representative on the 2nd of May 2006. (See the attached “Patch test 02052006, appendix C1)

5.2 Positioning Systems

The surface positioning system was available during all phases of the survey and it provided an absolute accuracy of better than 3m. The system is an AD Navigation DC202 GPS/GLONASS L1/L2 RTK long range system, and it is based upon the differential Global Positioning System (DGPS). The positioning system was displayed onboard and real time quality control was maintained.
Before the mobilisation, the DGPS positioning system was checked against a calibrated reference point, the top of Blåvands Huk Lighthouse, where the antenna was located (See appendix C2) and the controlpoints 1000 and 1001 established by "Landinspektørerne Syd I/S" the 25th of April 2006 on Pier in fishery harbour in Esbjerg (See report, Position check Esbjerg, Appendix C3).

5.3 Compass

The vessel heading was be measured by compass and logged on the navigation computer to enable the offsets to the various fixed and towed sensors to be computed.
The compass calibration carried out alongside pier by means of coordinated points.

5.4 Bathymetry

The transducer was side mounted as described in section 5. The multibeam echo sounder was compensated for heave in order to obtain heave corrected echo sounder records. Data was digitally recorded and displayed in analogue form for QC purposes.
A comprehensive report on test procedures is attached in appendix C1.

5.4.1 Velocity test (SVP)

During the survey, SVP tests have been carried out at least twice every day and the results have been used for calibration of the echo sounder, if data shows change in sound velocity in the sea, supplementary SVP was carried out.

Figure 11. The SVP probe is made ready for a sound velocity profile.

5.5 Side Scan sonar

A test of the side scan sonar equipment was carried out with supervision of the Employer's Representative, in order to establish any requirements for additional calibrations and any corrections that shall be applied to the gathered data.

The side-scan sonar was a dual frequency hydrographical sonar and was able to identify objects as small as 1 m in horizontal dimension. Data was recorded digitally with all data automatically referenced for position and event data.

The system shall be operated at a range of 50 metres. During mobilisation the system was rub tested and wet tested for a 15 minute period to ensure that the system is operating to the manufacturer’s specifications.

The side scan sonar was tested in sea to localise seabed features at the seabed.

5.6 Sparker survey

The Sparker instrument turned out to be the best suited equipment for the cable route survey, because the low frequency band allowed acceptable deep penetration. The system is described in detail above. It is surface towed and seabed conditions were determining the choice of system.

The system is capable of delineating hard and soft layers in the first 25 metres sub seabed with a definition of 0.5-1 metres near the seabed and 1.5 metres at depth. It is understood that penetration may be less in the event that the sub seabed is dense. The sparker system has a reliable performance record, with sharp signature at input energy at 300 Joules, and be capable of operating at the maximum firing rates specified by the manufacturer.

All data was recorded digitally for subsequent processing and interpretation in SEGY format and was automatically referenced for position and event data (record length shall be 150ms). Signal processing on board the survey vessel was provided, including (but not limited to) time varying gain, band-pass filtering, stacking and heave or swell compensation.

The sparker and hydrophone was towed in such a configuration as to minimise the effects of propeller wash, ship's noise and vessel motion, the hydrophone shall be balanced to maximise data quality. The Employer's Representative agreed that the selected configuration gives the best results.

As part of the quality control, a pulse test from the Sparker was performed in the harbour. Prior to the commencement of reporting the seismic horizons were selected as the key strata for reporting shall be determined in consultation between Contractor and Employer's Representative.

A test was prepared during the start up of the survey and supervised by the Employer's Representative

5.7 Magnetometer

The marine magnetometer was a Caesium Vapour type and capable of recording variations in magnetic field strength during survey to an accuracy of better than 0.1nT. All measurements are recorded in Gamma which is equal to nanoTesla.

The system has repetition rate selectable between 0.5 and 10 seconds and all data was recorded digitally via NaviPac (including sensor offset and tow depth).

Prior to commencing fieldwork, sea trials was conducted in an area of demonstrably low magnetic gradient to establish the optimum deployment location for the magnetometer, such that vessel heading errors are less than 10 nT. The marine magnetometer data is presented as a data listing of targets determined.

6. Summery of events

Date	Time	Activity	Comments
21-04-2006	08.00-20.00	Installing and mobilising Hans M	Work on ship
22-04-2006	08.00-20.00	Installing and mobilising Hans M	Work on ship
23-04-2006	08.00-20.00	Installing and mobilising Hans M	Work on ship
24-04-2006	08.00-20.00	Installing and mobilising Hans M	Work on ship
25-04-2006	08.00-20.00	Installing and mobilising Hans M	Work on ship
26-04-2006	08.00-20.00	Installing and mobilising Hans M	Work on ship
27-04-2006	08.00-20.00	Installing and Test of equipment	Work on ship
28-04-2006	08.00-18.00	Test of equipment in sea	
29-04-2006	08.00-18.00	Test of equipment in sea	
30-04-2006	08.00-18.00	Test of equipment in sea	
01-05-2006	08.00-18.00	Test of equipment in harbour	
02-05-2006	00.00-21.30	Test and calibration of equipment	Sea stat quite
02-05-2006	21.30-24.00	Surveying Windfarm area	Sea stat quite
03-05-2006	00.00-24.00	Surveying Windfarm area	6-9 m/s SSE, Waves: 0.5m
04-05-2006	00.00-24.00	Surveying Windfarm area	8-12 m/s (Max 15 m/s) SSE, Waves:0,6-1m
05-05-2006	00.00-24.00	Surveying Windfarm area	9-11 m/s ESE, Waves:1m
06-05-2006	00.00-24.00	Surveying Windfarm area	5-8 m/s ESE, Waves:0,6-1m
07-05-2006	00.00-06.00	Surveying Windfarm area	10 m/s E, Waves:1m
	00.60-24.00	Transit Esbjerg and crew change	
08-05-2006	00.00-08.00	Crew change + supply	
	08.00-13.00	Transit to survey area	
	13.00-24.00	Surveying Windfarm area	1-8 m/s E-SE, Waves:0,1-0,7m
09-05-2006	00.00-24.00	Surveying Windfarm area	4-7 m/s ESE, Waves:0,5m
10-05-2006	00.00-24.00	Surveying Windfarm area	2-8 m/s ESE, Waves:0,3-0,5m
11-05-2006	00.00-24.00	Surveying Windfarm area	2-6 m/s N-NE, Waves:0,3-0,5m
12-05-2006	00.00-24.00	Surveying Windfarm area + Cable Corridor	0-4 m/s NW, Waves:0,2-0,8m
13-05-2006	00.00-24.00	Surveying Cable Corridor + Grab sampling	6-10 m/s NW, Waves:0,5-1m
14-05-2006	00.00-01.00	Grab sampling	10 m/s ESE, Waves:1,5m
	00.10-06.00	Transit Esbjerg	
	06.00-10.00	Crew change and processing of Multibeam data.	

7. Seabed Sampling

7.1 Grab samples

15 Seabed samples have been collected by BioConsult in 2005 inside the HR2 Windfarm area. The seabed sampling have been used to determine the seabed sediment composition and to help interpretation of the side scan sonar data, acquired during the seismic survey.

Results from the standard grain size analysis are listed in appendix B. (Ref. 8).

The median diameters of the samples are listed in table 1.

Size Classes	Sample no.	16	17	18	19	20	21	22
Silt and clay	(< 0,063 mm):	0.63	0.77	0.84	0.76	0.85	0.71	0.78
Sand, fine	(0,063 - 0,200 mm):	6.33	2.24	1.63	6.60	1.97	3.11	12.61
Sand, medium	(0,2 mm - 0,6 mm):	91.22	95.32	88.82	77.08	82.45	61.64	83.96
Sand, coarse	(0,6 mm - 2 mm):	1.82	1.65	8.63	15.53	14.53	32.75	2.61
Gravel	(> 2 mm):	0.00	0.02	0.07	0.04	0.20	1.79	0.04
	Median	0.31	0.34	0.42	0.35	0.41	0.47	0.29

Size Classes	Sample no.	23	24	25	26	27	28	29	30
Silt and clay	(< 0,063 mm):	0.66	0.74	0.86	0.69	0.49	0.42	0.72	0.41
Sand, fine	(0,063 - 0,200 mm):	1.96	3.45	3.92	4.24	3.52	2.59	4.95	2.31
Sand, medium	(0,2 mm - 0,6 mm):	55.53	60.74	59.79	60.61	66.23	67.83	55.46	63.40
Sand, coarse	(0,6 mm - 2 mm):	36.69	28.95	32.22	34.08	29.67	28.93	37.83	33.33
Gravel	(> 2 mm):	5.16	6.13	3.21	0.38	0.08	0.23	1.03	0.55
	Median	0.50	0.45	0.48	0.46	0.47	0.48	0.52	0.50

Table 1. Grain size classes and Median diameter of the seabed samples from the Windfarm area.

As it can be seen from table 1, all samples are medium grained (0.2 mm – 0.6 mm), with a large component of coarse grained sand (0.6 – 2mm).

7.2 Boreholes, CPT's and vibrocores

On basis of the seismic data 7 borehole locations (BH 1 – BH 7) have been selected, in order to clarify the lithology and the stratigraphy, CPT's have been carried out in all the wind turbine locations and 10 6m vibrocores have been carried out in areas with near sea-bed soft layers the coring activities has been carried out and reported by GEO (Danish Geotechnical Institute) (ref. 10).

8. General geological setting in the Horns Rev area

8.1 Topography

The Horns Rev is a series of seabed structures located offshore west of Blåvands Huk. They can be followed into the North Sea to at least 7^{o} 20` E. The Horns Rev consists broadly of the Inner Horns Rev and the Outer Horns Rev separated by the 20 m deep channel Slugen (Figure . 1, Appendix A1) (ref. 1).

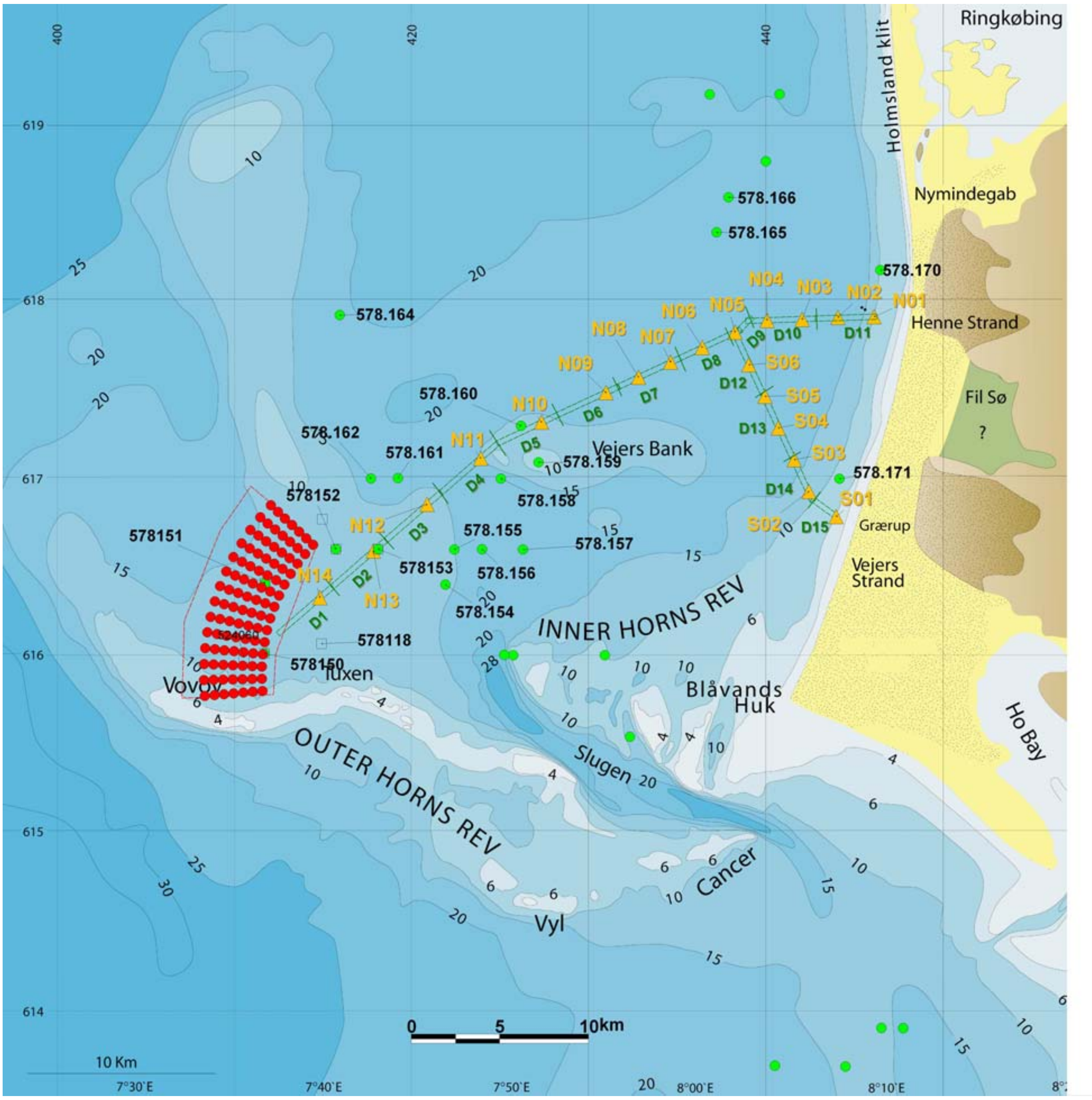


Figure 12. Overview map showing the Windfarm Horns Rev 2 and the cable corridor.

The Inner Horns Rev just west of Jylland is a 6 km wide sand bank that extent 16 km out into the North Sea. In some areas the top of the bank is situated only 1 m below sea level, but generally the water depths are between 2 and 7 m. West of the Slugen Deep the Outer Horns Rev extends approx. 40 km westwards into the North Sea. The water depth is often between 4 and 10 m but can be lesser.

Along the coastline between Blåvands Huk and Henne Strand the seabed is a 5-10 km broad flat area which slopes regular from 0 m to 15 m below sea level towards the west. Most of the seabed area north of the Horns Rev is a rather flat area with water depths mainly between 10 and 15 m. The Vejers Bank is a small more shallow area with water depths below 10 m.

The Windfarm area is situated north of the Outer Horns Rev´s Vovov high (water depths 7-18 m below sea level).

8.2 Pre-Quaternary deposits

Tertiary strata - most likely of Miocene age - form the basis of the Quaternary deposits at a depth of generally more than 50 m below the seabed. The level of this surface, however, is beyond the relevance level for the Windfarm project. Therefore, the focus in the present mapping is the Quaternary deposits overlying the Tertiary deposits.

8.3 Quaternary deposits

The following deposits from the Quaternary have been recognised below the seabed: Older interglacial (Holsteinian) (more than 240.000 years from present time). The Saalian glacial (Between 240.000 and 130.000 years from present), the Eemian interglacial (Between 130.000 and 117.000 years from present), the Weichselian glacial (Between 117.000 and 11.500 years from present) and the Holocene (postglacial) (From 11.500 years from present to present). The Quaternary succession can be divided into several units based on marked seismic reflectors and the seismic internal structures of the units. The general stratigraphy, which will be described in the following sections, is illustrated in Figure 13.

And the suggested correlation of the Pleistocene formations in the North Sea in general is illustrated in Figure 14.

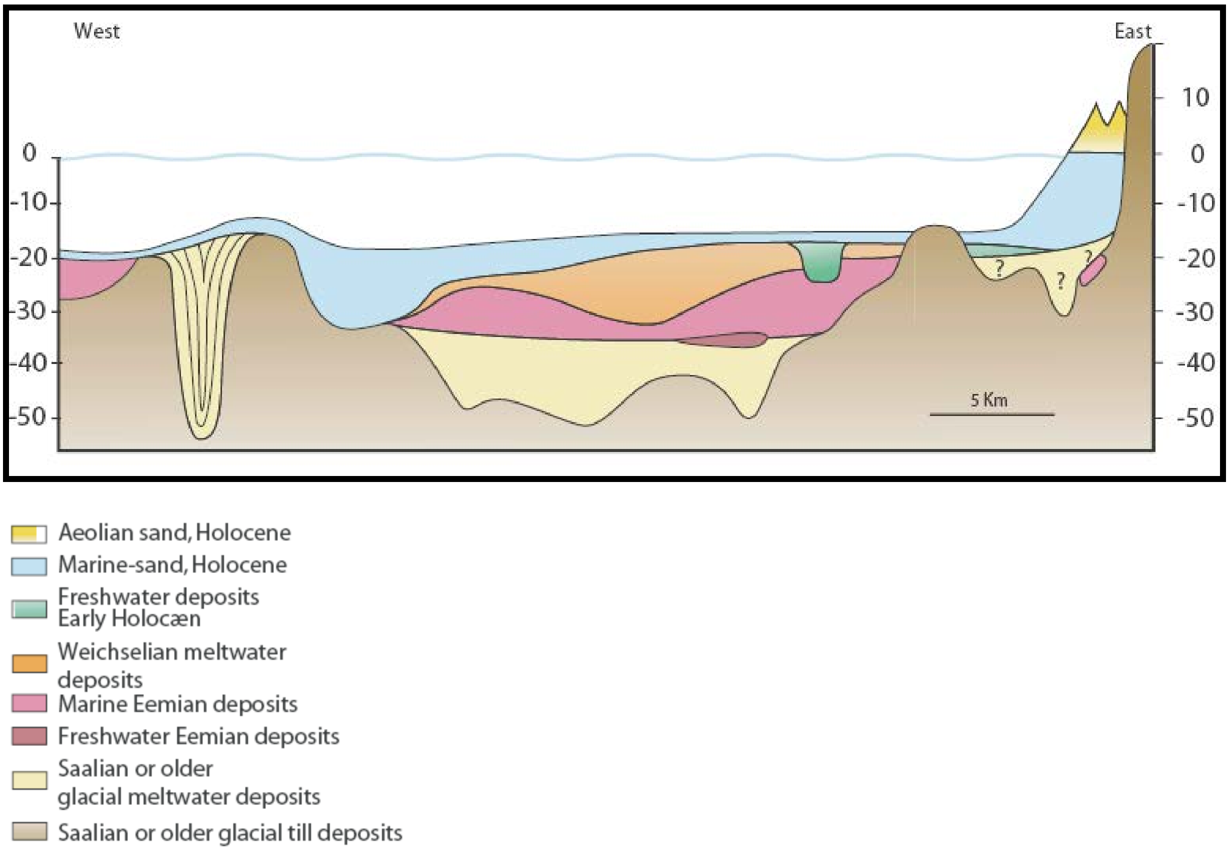


Figure 13. General geological West – East profile, from the northern part of Horns Rev to the Jutland coast. From ref. 5.

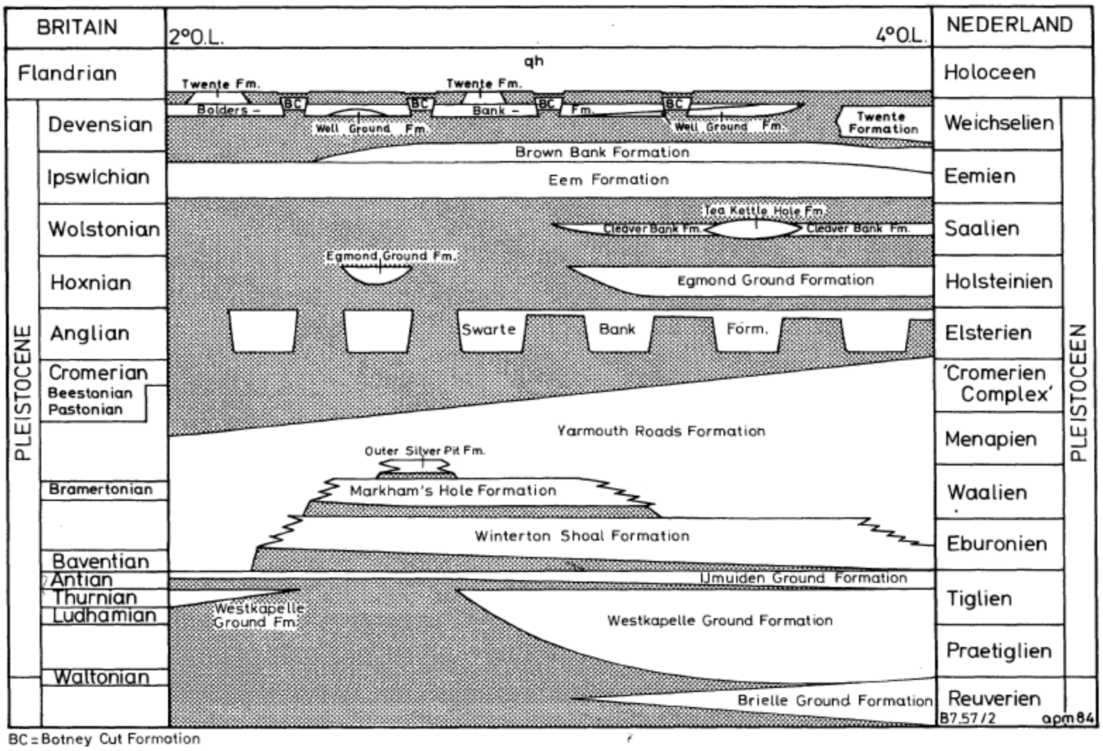


Figure 14. Pleistocene formations in the North Sea in general. From ref. 9.

8.3.1 Older interglacial (Holsteinian).

Marine interglacial deposits older than the Saalian are recognised in the central North Sea (ref. 3) and onshore Jylland between Varde and Skærbæk up to 130m thick marine clay deposits from the late Elsterian – Holsteinian are known from many drill holes (ref. 4). The climate and environment conditions during this period have been similar to the present day North Sea. The occurrence of these types of deposits cannot be excluded in the Horns Rev area and perhaps older glacial deposits (Elsterian) can occur as well.
The lithological data from the Cores BH1 – BH7 (ref. 10) Confirms the stratigraphy established on basis of the seismic data and in core BH 5, interglacial marine clay (12.7m – 24.3m below seabed) was verified in the Horns Rev glacial hill deposits. The Holsteinian age of the interglacial deposits was verified by the results of foraminifer investigations (paragraph 9.1.1).

8.3.2 Saalian glacial

The most important Quaternary deposits in the area are probably of Saalian age.
The top of the glacial deposits is represented by a regional erosion surface shown as a marked seismic unconformity on top of the glacial deposits (Figure 13).
This reflector is correlated to the surface of the Saalian, Varde hill island (bakke-ø) landscape onshore and the Vovov hill island located below and north of Outer Horns Rev. The old Saalian landscape onshore protrudes above the flat post-glacial (Weichselian) melt water deposits.
Due to re-advances of the ice sheets the older deposits within the Horns Rev bakke-ø landscape has been truncated. Below the unconformity and truncation surface chaotic seismic reflectors displays small-scale hummocky clinoforms, vertical and sub horisontal reflectors and channel like features. In the offshore region similar structures have been recognised in the southern North Sea.

In the area north of the Horns Rev a succession of seismic units have been defined in the sequence above the erosion reflector. These units are deposited where the Saalian landscape forms a wide depression / basin down to at least 35 m below sea level. The oldest unit in the basin is the Upper Saalian Melt water Unit with a maximum thickness of up to 20 m, which consists of fine-medium gravely sand known from a few boreholes.
In some areas the erosion reaches down to about 50 m below sea level between the Vovov Bakkeø and the onshore Saalian landscape. The units yield evidences of the different stages of development such as sea level fluctuations since the end of the Saalian glacial period.

On Vovov hill island the glacial top surface lies from to 18 to 20 m below sea level. At the north-eastern rim of the survey area the surface drops to 39 m below sea level where the western margin of the Horns Rev valley is situated.

A few boreholes from the area have information about the Saalian hill island deposits from which it is demonstrated that melt water sand and gravel are found inside the Glacial hill. The Saalian consists mainly of medium and coarse-grained sand and gravel with subordinate fine-grained sand with silt layers but also mainly fine-grained and silty sand with mica and plant fragments occur. This is similar to the onshore Danish hill islands in western Jylland where the deposits also are very sandy (ref. 2, ref. 5). Sandy and clayey tills and diamictons with gravels, stones and boulders may also be expected even though only one boreholes have encountered a thin layer of sandy clay till. The existence of many large boulders on the seabed in the western and middle part of the survey area may indicate that tills are located below the seabed in the area as the boulders perhaps have been washed out of the tills.

The chaotic seismic picture points to strongly disturbed deposits and that whole Saalian consist of glaciotectonic deformed sand and gravel (and tills) which have been eroded at the end of the Saalian (ref.3). The seismic sections also show several channels and valleys cut down into the Glacial hill. The reflectors inside these structures have parallel features and points to water deposited sediments. Therefore, the valleys have probably been filled of melt water sand and gravel during the last phase of the Saalian when the large glacier melted (ref.7). Valleys in the Horn Rev area and the surroundings have been mapped (ref. 9) and an Elsterian or Saalian age has been suggested. It may, however, not be excluded that the top deposits in these valleys also can be younger.

Onshore Jylland the Saalian Varde hill island is situated close to the coast and it reach highs of 25 m above sea level. In the areas close to the shoreline, the hill island deposits is found below younger deposits but the Varde Bakkeø slopes from + 25 m above sea level to – 20 m below sea level just outside the coastline. The whole area is regarded as one connected hill island which along the rim towards the west has been severe eroded (ref. 2).

8.3.3 Eemian interglacial

The Eemian unit has in earlier studies been mapped in the Horns Rev area based on weakly, light structure reflectors on the seismograms and the top is often a marked reflector (ref. 2, ref. 6). The lower boundary of the deposits is often marked by reflectors which show small channel structures eroded into the layers below. The Eemian deposits overlie the Saalian hill island and/or melt water Unit.

The Eemian is up to 13 m thick and the top of the unit has been found between 11 and 14 m below sea level. The top slopes gently towards the west. The deposition of the unit is related to the highest sea level of the Eemian period. This shallow Eemian sea covered almost the whole area but only partly flooded the Saalian glacial deposits such as the Vovov Bakkeø. Between Vovov hill island and Jylland occasionally Eemian freshwater sediments with plant material are deposited in depressions and occur below younger Eemian marine clays and sands.

In borehole no. 578150 in the Windfarm area marine Eemian deposits have been proved by biostratigraphical data. The Eemian is located at a depth of approximately -14 m bsl, covered by Holocene sediments. The deposits are olive grey silty clay and sandy silt with sand lenses. The sediments are often bioturbated and contain shells and shell fragments. Also fine-medium grained, weakly silty and laminated sand occurs. Furthermore Eemian layers are reached in F4 (VIB 36) (Ref. 10) in a depth of approximately –14 m bsl (See paragraph 9.1.1. The marine Eemian layers form a wedge which is onlapping the Vovov hill island but patchy channel infill occurs in the central part of the Windfarm area.
Eemian fresh water lake deposits are found below marine layers and fresh water layers with plant content.

8.3.4 Weichselian glacial

The Weichselian deposits show a seismic signature characterised by short wavy reflections and hummocky clinoforms pointing to channels and small lakes. The thickness is from 3 to 11 m. Deposits from the Weichselian have only been found in restricted areas east of the Vovov Bakkeø. From regional studies it is known, that the area was ice-free during the Weichselian. The deposits represent remnants of a distal river system outlet probably from the Skjern River to the northeast as a continuation of the onshore sandur deposits. Due to the intense erosion and re-deposition in the Late Weichselian and the Holocene melt water and floodplain deposits from the Weichselian period have not been recognised except locally in the coastal area.

However, a Weichselian valley, the 5 km wide and 10 m deep so-called Horns Rev Valley, has been found cutting the Eemian as well as the Saalian deposits to at least 38 m below the seabed (See Figure 13). Borehole data shows that the valley is filled with Weichselian fine and medium grained well sorted melt water sand (ref. 2). The sand is covered by Holocene sand.

8.3.5 Holocene deposits

The base of the Holocene marine deposits is defined and characterised as a regional erosional surface and the seismic pattern shows a horizontal layering. In some parts of the area inclined reflectors can be interpreted as spit deposit or basin fill deposits. The surface cut into the Saalian deposits and when present also into the Eemian marine deposits and the Weichselian melt water deposits.

The Holocene marine deposits form a relatively thin sand cover over all the glacial and interglacial sediments in the whole survey area. In small depressions Early Holocene freshwater sediments with plant material can occur.

The thickness of the Holocene sand layers is between 1 and 2 m in many areas as on parts of the Vovov Hill island but where the thickness of the Holocene deposits can increase to 6-8 m. In the Horns Rev Valley the Holocene deposits can reach a thickness of 25 m. Along the west coast of Jylland the thickness of the deposits increases to 20 m.
The mobile sediments on the seabed are the top Holocene sediments and these thin deposits shows a variation in grain size over the area. From the west coast of Jylland and approx. 25 km to the west the sand is fine-to very fine grained and silty. Further to the west the sand is fine-to medium grained but with larger areas of medium to coarse grained gravely sand and gravel at Vejers Bank and north of the Vovov hill island.
Several boreholes also show a variation in grain size in the area. In most of these boreholes the sand is medium and coarse grained, often with gravel, burrows and shells and shell fragments at all levels which demonstrate the marine origin of the deposits. Fine grained silty sand and thin silt and clay layers which are strongly bioturbated are found, often intercalated with the more coarse grained deposits.

9. Geological results of the survey

The results of the Windfarm investigation are presented in the following paragraphs including biostratigraphical studies of sediments from the boreholes (BH 1 – BH 7) and the vibrocores (ref. 10) plus mapping on basis of the acoustical data.
The acoustical results are presented in the Charts D101-108 (Appendix D) and Seismic profiles E1-E2 (Appendix E) with respect to the geology and bathymetry.

9.1 Biostratigraphical analysis

In order to document the seismically established stratigraphy samples has been taken from strategic sediment layers, believed to be marine interglacial deposits, melt water clays and Holocene organic layers.
The samples have been screened for contents of foraminifers, shell material, pollen and macro plant remains. The findings make it possible to describe the depositional environment and the climate as basis for an interpretation of the stratigraphy of the layers.

9.1.1 Results of foraminifer analysis

BH 1

Samples no: 68650 15m below seabed and 68602 28m below seabed contain few shells no marine fauna. The deposits must be freshwater sediments.

BH 2

Samples no. 68603 5m below seabed, 68605 8.5m below seabed, 68607 13.5m below seabed, 68608 21m below seabed and 68609 24m below seabed contain few shells no marine fauna. The deposits must be freshwater sediments.

BH 5

Samples no.68611 13.5 m below seabed and 68612 17.5m below seabed.
Full fauna counting off benthic foraminifers. The fauna is dominated by the Cosmo politic species *Elphidium excavatum.* Few boreal species (*A. beccerii*) present but the fauna is not warm enough to be from the Eemian period. The fauna looks very much like the present from the Danish coastal area or from the Holsteinian interglacial period. Holsteinian and the recent time are very similar in the benthic foraminifers' fauna.
Sample no. 68614 23.5m below seabed

The benthic foraminifers' fauna reminds very much of the fauna in sample 68611 and 68612, but in addition *Quinqueloculina seminulum* is found in en relatively large frequency. This species is a boreal low water type. A lot of snails are found in the sample.
The clay layer in the depth interval 12.7m – 24.3m below seabed is interpreted as Holsteinian interglacial deposits.

BH 6

Samples no. 68620 7m below seabed, 68621 11m below seabed, 68622 18m below seabed, 68623 27m below seabed, 68626 32m below seabed, 68625 35m below seabed and 68624 38m below seabed contain no shells. The deposits must be freshwater sediments.

VIB-36 (vibrocore in position 36)

Samples 68634 1.1m below seabed, 68630 1.7m below seabed, 68631 2.7m below seabed, 68632 3.7m below seabed and 68633 4.7m below seabed. The uppermost sample is believed to be Holocene marine while the lowermost 4 samples are believed to be Eemian marine samples because of the characteristic olive grey clay very fine sand with contents of Turitella snails. Due to lack of time only the results from sample 68633 is included in this report. It is clearly not the Holocene period, because Lusitanian species have been found. The fauna is comparable to Eemian faunas found in earlier studies in the area.

9.1.2 Results of pollen analysis

Two samples from Horns Rev 2, Coring BH7 were analysed for pollen in order to date a sandy gyttja sediment sequence (at the depth interval of -3 to -5 m) which was sandwiched between layers of pure sand. Five samples from the sandy gyttja layer were also analysed for their macrofossil content in order to characterize the depositional environment.

Pollen analysis

Pollen and spores in the two samples were relatively well-preserved. The pollen concentrations were low and hence only a relatively low number of pollen and spores were counted (see Table 2) accordingly percentage calculations have not been made. In both samples the tree pollen was dominated by *Pinus* (Pine), *Betula* (Birch), *Alnus* (Alder), *Corylus* (Hazel) and *Quercus* (Oak) while *Ulmus* (Elm) and *Tilia* (Lime) only occurred sporadically. The herb pollen was dominated by Poaceae (Grass family) and in one of the samples (68615) by *Artemisia* (Mugwort) and Chenopodiaceae (Goosefoot family) as well.

	68615	68618
	n	n
Pinus	10	11
Populus	1	
Betula	17	43
Corylus	24	24
Alnus	39	36
Quercus	11	6
Ulmus	2	1
Tilia	1	
Salix	1	9
Sorbus		1
Juniperus		2
Calluna	6	5
Sum trees and shrubs	112	138
Poaceae	14	14
Pteridium aquilinum	1	1
Artemisia	3	
Chenopodiaceae	5	
Rumex		1
Filipendula		1
Potentilla type		2
Umbelliferae		1
Sum dry ground herbs	23	20
Sphagnum	1	2
Dryopteris type	5	3
Carex type	5	24
Sum wet ground	11	29
Pediastrum	3	1
Dinoflagellate	5	

Table 2 Pollen counting.

Macrofossil analysis

Samples from five depth levels (no. 68615-68619) were washed through two sieves with mesh sizes of 0.5 and 0.2 mm. The following macrofossils were identified (but not quantified) in the five samples:

68615 3.3m below seabed: Shell fragment of *Cerastoderma* sp., sand and gravel (much less than in the samples below).

68616 3.7m below seabed: Unidentified shell fragments, fish bone, *Betula* fruit plus sand and gravel.

68617 4.3m below seabed: Shell fragments of *Cerastoderma* sp., unidentified shell fragments, twig fragments, wood fragments, *Carex* sp. nutlet, sclerotia of the fungus *Cenococcum geophilum* plus sand and gravel.

68618 4.7m below seabed: Shell fragment of *Cerastoderma* sp., unidentified shell fragments, many moss stems, bark fragments, wood fragments, twig fragments, *Carex* sp. nutlets plus sand and gravel.

68619 5.2m below seabed: a single moss stem, unidentified shell fragments plus sand and gravel.

Dating and depositional environment

Palynological dating on the basis of only a few pollen spectra, and, as in the present case, a low pollen count, is encumbered with uncertainty. The composition of the pollen flora and the abundance of the different taxa do not allow a totally unambiguous "fit" into the post-glacial vegetational development.

The composition of the tree pollen with relatively high frequencies of *Betula*, *Corylus*, *Pinus*, *Alnus*, and *Quercus* combined with an almost total absence of *Tilia* suggest a likely dating to the close of the Boreal Period (Boreal Period: 10,000-9,000 years before present) before the immigration of *Tilia*, which takes place around 9,000 years before present. The abundance of *Alnus* is higher, while the abundance of *Ulmus* is lower than normal for this time, which might be due to local conditions.

The pollen and macrofossil data shows a mixture of marine and fresh water components. The presence of *Cerastoderma* sp. reflects a marine/brackish depositional environment, while the macrofossil finds of *Carex* sp. and mosses plus the pollen finds of *Carex* type, *Dryopteris* type, *Sphagnum* and the alga *Pediastrum* suggest the presence of fresh water reed-swamp vegetation. The high abundances of *Alnus* pollen might point in the same direction: alder carr.

Based on the present evidence it cannot be determined if the depositional environment was either marine/brackish with introduced lacustrine/terrestrial material or lacustrine with marine erosion and redeposit ion. The most likely scenario might be a near-shore marine/brackish depositional environment with introduced lacustrine/terrestrial material.

9.2 Chart D101 Survey Track Lines

The location of the 236 seismic track lines (HR_001 to HR_236) surveyed in the Windfarm area is presented on chart D101.

9.3 Chart D102 Bathymetry chart

The map of the sea bed bathymetry is based on multibeam measurements. The topography is shown as water depth contour lines (m below sea level).

The bathymetric survey has given the following results:

Water depths: In most of the middle and eastern part of the area the water depths are between 12 and 14 m. Towards the North West the water depths increase to 18 m. Towards the southwest the water depths are decreasing to 7 m.

Seabed topography: These conditions demonstrate a seabed which is relatively flat with some variations in topography between the 12 and 14 m contours, but from the 14 m contour to the 18 m contour the sea bottom is inclined downwards towards the north west. In the south-western corner of the area the sea bottom slopes from the 7 m contour to the 12 m contour towards north east.

9.4 Chart D103 Seabed sediments chart, Chart D104 Mosaic Side Scan Sonar and Chart D105 Seabed Features Chart.

The Seabed sediments map (chart 103) is based on side scan sonar data with Ground truthing by grain size analyses of 15 seabed samples (ref. 8) and data from vibrocore boreholes (ref. 1 and 10).

The constructed Side Scan Sonar mosaic (Chart 4) is based on the grid of side scan sonar lines illustrated in Chart D101.

The Seabed features map (Chart D 105) shows areas dominated by a thin sand cover with ripples, large boulders (height more than 1 m), areas where boom trawling marks are observed, and sonar/magnetometer targets and grab locations.

A combined interpretation of the D103, D104 and D105 maps shows that the seabed in the area consists of mainly Saalian glacial deposits, covered to a varying degree by Holocene sediments. A recent fragmented thin skinned top layer (< 1m in thickness) of dynamical sand (The mobile sediments) is partly involved in the sediment transport on the seabed (Appendix F1 – F4)..

Based on the side scan sonar and sediment data (ref.1, 8 and 10), the seabed of the mapped area can be divided into 4 main categories:

A. The north-eastern part of the area. The sediment is medium to coarse-grained sand and the seabed appears without large-scale bed forms except occasionally few isolated ripple areas. The water depth is about 12.5 to 14 m (Chart D103).

B. The southern part of the area. The major part of the sediment is medium sand. Locally, smaller areas (< ½ km^2) of coarse sand are found. Like category A, the seabed in this area appears without large-scale bed forms. The water depth is about 7 - 12 m (Chart D105).

C. The north-western part of the area. The sediment is medium-grained with patches of medium to coarse-grained sand. The water depth is about 15 to 18 m. The seabed is without large bed forms.

D. The remaining area, located intermediate between A, B and C, is characterised by the presence of a fragmented recent thin skinned top layer (< 1m in thickness) on glacial deposits(Appendix F1 – F4). This is documented by the existence of stones and large boulders which characterises the glacial seabed type and also is observed penetrating the thin skinned sandy areas. A major concentration of large boulders is located in the south-western part of Area D. The sand is partly involved in the sediment transport on the seabed which is documented by a general appearance of ripples. The water depth is about 12 to 15 m. The characteristically flat seabed contains larger elongated sandy areas that most of all could be described as sand sheets, that are virtually linear and oriented ca. NW – SE, often superimposed with ripples. The ripple net transport direction is toward the NE. Area D may be characterised as a starved sand transport bottom and the development and transport of the large elongated sheet like areas are thought to be caused by a combination of the progressive movement of the North Sea tidal wave and wave induced currents from waves coming from west, southwest and southerly directions. The waves are refracted around Horns Rev. Horns Rev is reacting as a huge natural breakwater to waves and currents. The transport is under normal conditions probably rather slow. In storm situations the material can be moved fast and erosions of the seabed will occur.

The elongated sheet like bands has a band with of 1.3 – 1.5 km. The sand sheets are made of medium sand, while the glacial seabed type with ripples consists of medium to coarse sand. The intermediate area has a patchy appearance - obviously the mobile sand layer is very thin.

9.5 Chart D106 Top Glacial

The map (Chart D106) shows the contour plan of the top-glacial interface. The map is based on data from interpreted seismic sections, existing vibrocores from GEUS's archive and the boreholes BH 1 – BH 7 collected in the Windfarm project (ref. 10). Contours in 1 m intervals and depth in meter below sea level.

The most important glacial deposits in the survey area are expected to be of Saalian age but older deposits may be present in the area (e.g. Elsterian).

In the seismic sections the oldest Saalian deposits are separated from younger deposits by an unconformity which truncates the Vovov hill island (bakkeø) layers. Below the unconformity and truncation surface chaotic seismic signals displaying small-scale hummocky clinoforms, vertical and sub horisontal reflectors and channel like features (Appendix E1 and E2).

This Saalian unconformity forms most of the glacial surface in the survey area and therefore these deposits forms most of the surface on the contour map for the depth to the top glacial (Chart D106). The southernmost 1/2 of the area has water depths between 11 m and 15 m with several small depressions and elevations, representing almost a platform area without large topographical features.
An exception is the south-eastern corner where the depths between 15 and 20 m. In the northern 1/3 of the area the top surface is deeper, from 18 to 20 m below sea level. At the north-eastern rim of the survey area the surface drops to 39 m below sea level, where the western margin of the Horns Rev valley is situated. Above the unconformity outside the bank area, thin late Saalian sand deposits occur and these sediments may also be present in the survey area.
Three older vibrocores from the area give preliminary information about the Saalian deposits (No. 524060, No. 578150, No. 578151) (Appendix G) (ref. 1, ref. 8).

From two boreholes (524060 and 578151) it is demonstrated that melt water sand and gravel is found inside the Glacial hill.
The boreholes BH 1 – BH 7 collected in the Windfarm project (ref. 10) likewise shows that the Glacial hill consist of melt water sand, sandy and clayey tills and diamictons with gravel. In core BH 5 even Holsteinian interglacial clay is observed.
This is very similar to the onshore Danish hill islands in western Jylland where the deposits also are very sandy (ref. 2 and 7). The existence of many large boulders on the seabed in the western and middle part of the survey area also indicate that tills are located below the seabed in the area as the boulders have been washed out of the tills (Chart D105).

In borehole 524060 the Saalian consists mainly of medium and coarse-grained sand and gravel with subordinate fine-grained sand with silt layers while in borehole 578151 the sand is mainly fine-grained and silty with mica and plant fragments.
At the margin of the hill island borehole 578150 shows that the Saalian deposits are found below the Eemian sediments consist of medium and coarse grained sand with subordinate gravel.

The chaotic seismic reflectors points to strongly disturbed deposits and the whole Bakkeø consist of glaciotectonic deformed Saalian sand and gravel (and probably older deposits) which have been eroded by the end of the Saalian (ref.5). The seismic sections also show several channels and valleys cut into the Glacial hill (Appendix E1 and E2). A detailed description of the glacial deformations is described I chapter 9.8 and is shown on chart D109.

Weichselian deposits are probably only found along the northern and eastern rim of the survey area, where the western margin of the Horns Rev Valley is reached. Information from outside the survey area shows that the valley is filled with Weichselian fine and medium grained melt water sand (ref. 2).

9.6 Chart D107 Isopach Holocene Sand

Thickness map of Holocene deposits. Isopach contours are shown with 1 m intervals.
The Holocene deposits form a relatively thin cover over all the glacial and interglacial sediments in the whole survey area. The thickness (Chart D107) of the Holocene sand layers is between 1 and 3 m in most of the area, but can also be thinner. Along the southern margin of the area the thickness of the Holocene deposits increases to 8 m. The same pattern occurs in the northern end of the area but along the margin of the Horns Rev Valley towards north east, the Holocene deposits can reach a thickness of 25 m. In the seismic sec-

tions the lower boundary of the Holocene sediments is defined by a sharp reflector and the seismic pattern shows a horizontal layering. In some parts of the area inclined reflectors can be interpreted as spit deposit or basin fill deposits.

The mobile sediments on the seabed are the top Holocene recent sediments and these thin deposits are described above.

In the three boreholes (524060, 578150, 578151) most of the sand is medium and coarse grained, often with gravel and shells and shell fragments at all levels which demonstrate the marine origin of the deposits. The small lake deposits on the top of the Saalian hill island landscape suggested above being possible Eemian fresh water deposits could also be of Holocene origin. The sediments would in that case contain a lot of organic materials as plant remains.

The cores collected in the Windfarm project (BH 1 – BH 7 and the vibrocores) (ref. 10) confirm that the Holocene top layer consist of 2 – 7m marine sand, but the lowermost 1-2m of the unit above the glacial deposits often consist of silt – clay with a contents of marine shells. In the northernmost part of the Windfarm the thickness of the Holocene increases to more than 25m divided in an upper about 5m thick sand unit and a lower about 20m thick unit of sand to silt with a contents of organic material. On the seismic profiles the effects of contents of organic material is observed as gas reflectors.

9.7 Chart D108 Magnetometer Map

All magnetometer measurements are related to a position and recorded in Gamma which is equal to nanoTesla (nT). The magnetometer map presents the gritted variations in magnetic field strength along the survey lines.

The map shows a characteristic aerial distribution with a mixture of areas with very homogeneous field strength and areas dominated by inhomogeneous field strength. At a first glance it looks chaotic but detailed studies combined with the seismic results shows that a close connection exists between the magnetic data and the degree of glacial deformation, presented in chart D109.

In addition to the geological variation, magnetometer anomalies indicating archaeological and/or safety objects have been indicated.

9.8 Archaeological objects

The map (D108) shows the variation of the magnetic values in gamma values. Magnetometer anomalies indicating archaeological and/or safety objects

The magnetometer investigation and reporting has been carried out by Jens Schou Hansen, Vikingeskibsmuseet, Roskilde, who has written the following text (Translated by GEUS):

In connection with the establishment of the Windfarm Horns Rev 2 existing material and information have been treated. Also Side Scan Sonar measurement data and the magnetic data from the area have been investigated with the respect to point out possible marine archaeological objects.
Presentation of the magnetic anomalies is performed with the Golden Software “Surfer”. Cleaning of “spikes” is done with Excel.
The magnetic data have not been calculated by comparing with reference data from onshore.

From the Windfarm area (chart D101) all the measured survey lines were considered:

Lines: HR_001 to HR_236

And: Cross lines 1 and 2

Anomalies were found in two lines:

HR_001	E: 409 199.905m	N: 6 157 684.403m
HR_005	E: 407 888.209m	N: 6 157 835.095m

The anomalies in these positions will not give reason for more marine archaeological investigations.

9.9 Other objects

The magnetic data from the Windfarm area has furthermore been detailed examined by GEUS to locate possible minor events and sparks that could be connected to possibly fragments of ammunitions, mines etc and wrecks or part of wrecks.
Reference data from onshore have been used to compare the actual magnetic data with background reference data, to be able to evaluate possible influence from local geological layers.

Small objects at the seabed can only be detected on the single line with the present line spacing, and will only be detected if they are situated in the actual magnetometer track line. Magnetic data from the HR2 Windfarm area is shown in figure D108. An example on magnetic data from line HR80 is shown in figure 15.
As it can be seen there are numerous of minor magnetic peaks along the seismic line. These data have been examined to evaluate if they are real magnetic anomalies coursed by minor objects at the seabed.

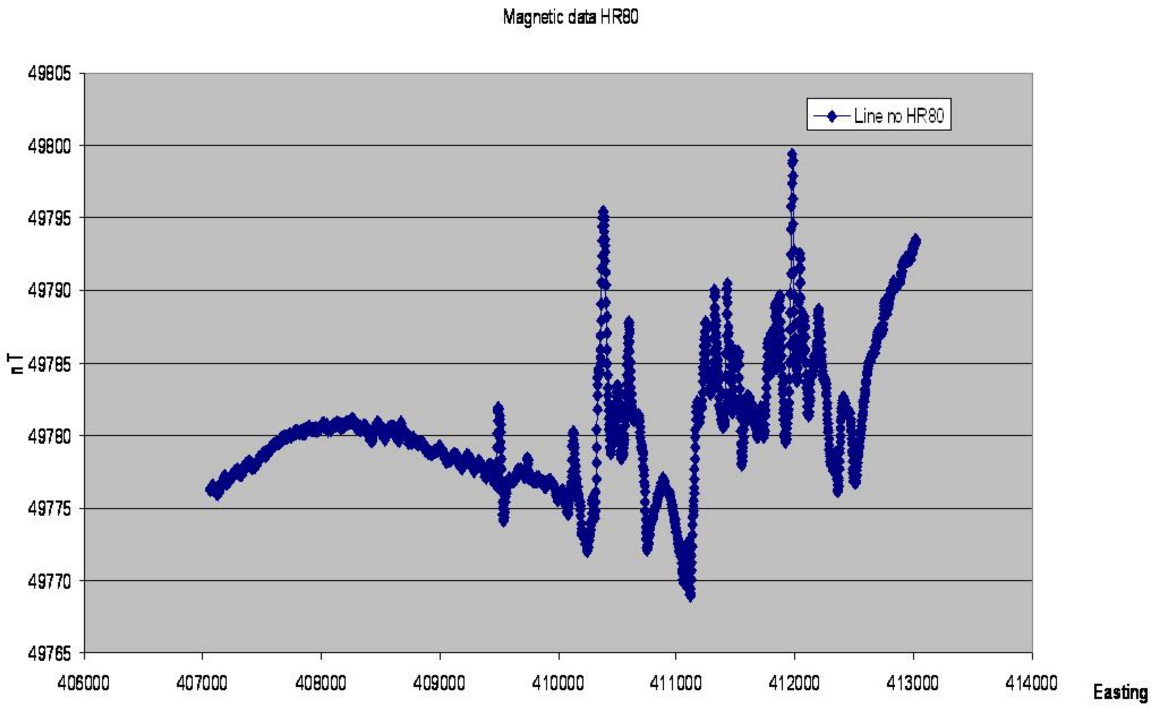


Figure 15 Magnetic data from line HR80.

Areas with magnetic spikes and anomalies are concentrated in the eastern[1] part of the area. To evaluate magnetic peaks and strong and sharp changes in magnetic strength, an analysis of changes in magnetic strength (Δ nT) is performed (figure 16).

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[1] The changes in magnetic strength is defined as: $\Delta nT = nT_2 - nT_1$, Where nT_2 is the actual magnetic strength and nT_1 is the previous value.

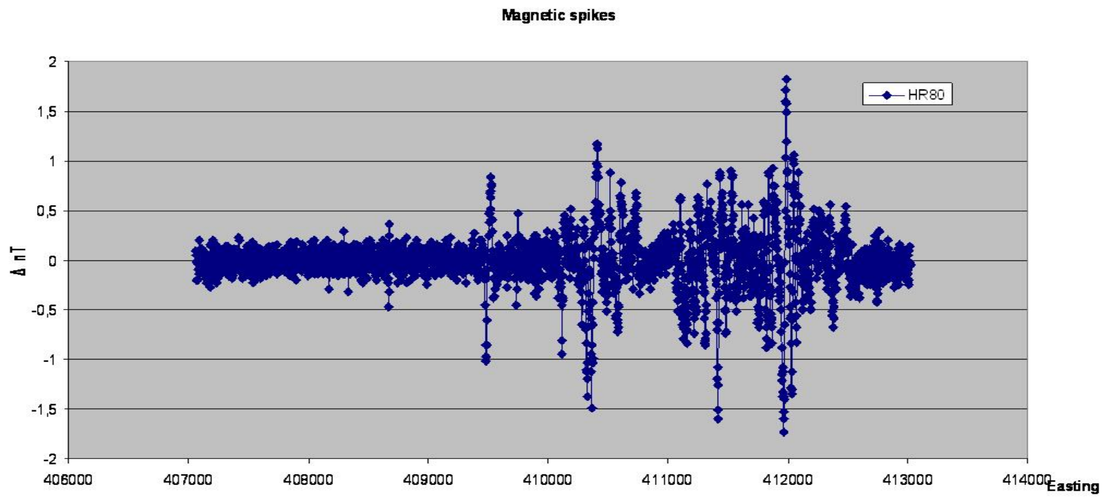


Figure 16 Changes in magnetic strength (Δ nT) along the seismic line HR 80.

To evaluate the significance of the magnetic spikes compared with the geological data a combined profile of Δ nT data and seismic data is shown in figure 17.

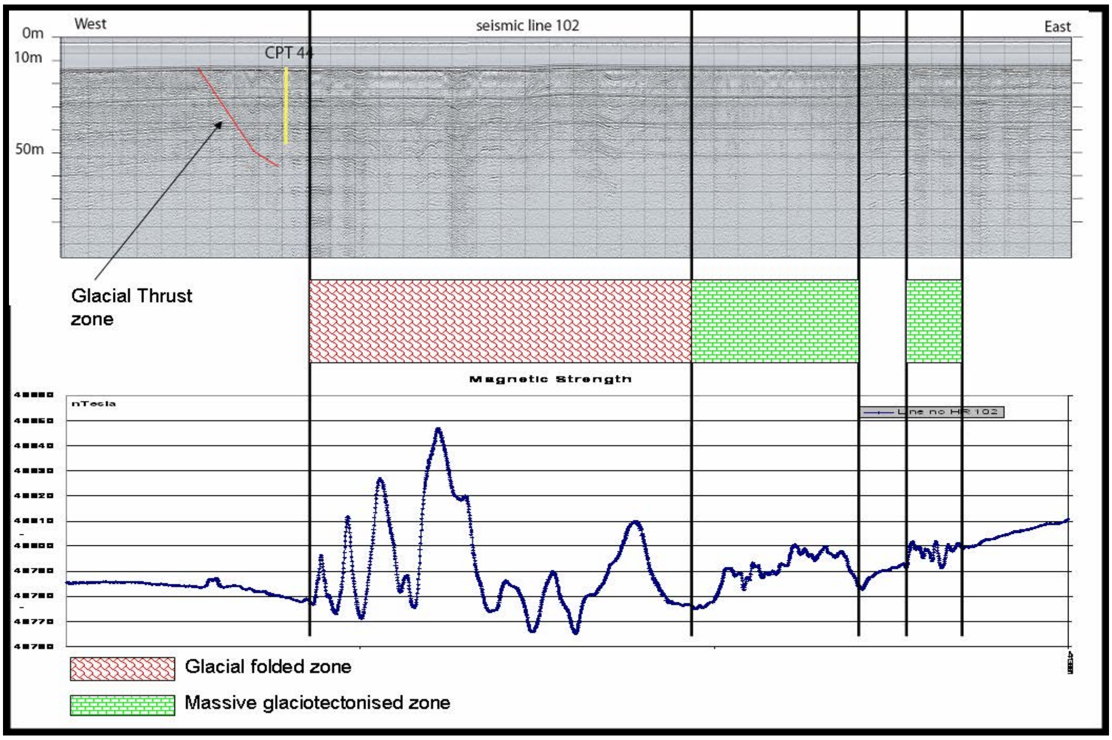


Figure 17 Magnetic data from the Windfarm area

As it can be seen in the lower part of figure 17, the magnetic anomalies are not strong, sharp peaks, but slightly changes in magnetic strength, The maximum change in magnetic strength (Δ nT) is less than 2 nT.

The seismic section in the upper part of figure 17 shows, that the magnetic anomalies are located in an area with change in the sedimentary sequences in the subsurface, due to disturbance in underlying geological layer. These layers are folded up by to glaciotectonic activities during the last Ice age. The magnetic anomalies in these zones can be explained by change in geological conditions, and mineral composition in the different layers involved in the folding of the seabed. See also figure 19 for further details.

The magnetic anomalies can be seen on all the magnetic track lines in the same area. This will not be the case, if it was a response of a single element at the seabed. These observations confirm the above mentioned observations, that the anomalies are connected to areas with changes in sediment composition.

To evaluate magnetic peaks and strong and sharp changes in magnetic strength, an analysis of changes in magnetic strength (Δ nT), as illustrated in figure 16 is performed to select possibly peaks in the areas along all the track lines in the area.
Only a few spikes have been found in the area and these are listed in Table 3.

Horns Rev Magnetic Anomaly Listing						
Ref.	**Line**	**Mag (nT)**	**Width (m)**	**Position Easting**	**Position Northing**	**Comment**
1	HR_S(-50).XTF	12	54	441212	6171969	(In cable route)
2	HR_001	17	3	409200	6157684	
3	HR_005	25	50	407888	6157835	
4	HR_006	17	124	411668	6158018	
5	HR_034	28	90	411190	6159403	
6	HR_035	25	120	411204	6159455	
7	HR_049	-27	38	409341	6160081	
8	HR_086	+4 / -4	48	409644	6161941	
9	HR_096	15	29	412964	6162572	
10	HR_109	17	23	409918	6163103	
11	HR_111	-19	23	411184	6163236	
12	HR_142	8	50	409474	6164744	
13	HR_232	40	55	411210	6169303	

Table 3 Magnetic anomalies in the Horns Rev 2 area.
The strongest magnetic anomaly in Table 3 # 13 at line HR_232 is illustrated in figure 18.

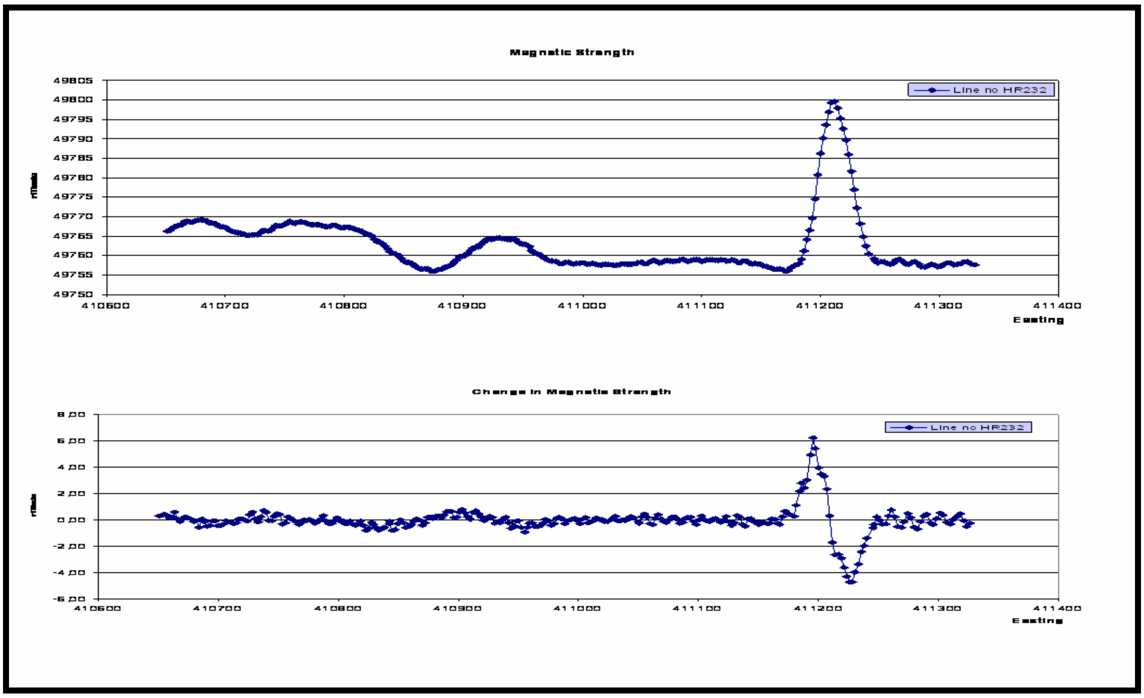


Figure 18 Magnetic anomaly no. 13.

A systematic analysis of side scan data has also been performed and the results likewise listed in table 4.

Side Scan Sonar, Target List

Targets defined as objects with any dimension > 1m

Target no.	Line	Time	Pos. Lat.	Pos. Long.	Description
3	HR_022.XTF	13:37:35	55,566767 °	7,590537 °	Lost fishing tool? 0,2m asb
4	HR_030.XTF	10:33:21	55,5702477 °	7,5726638 °	Boulder, 0.6m x 0.7m x 0.4m
5	HR_040.XTF	05:54:10	55,574079 °	7,5483882 °	Boulders 3-4 pcs, 1m x 2m x 0.5m
6	HR_072.XTF	15:47:02	55,589519 °	7,5895233 °	Unidentified obj. (wreck?), 9m x 5m
7	HR_074.XTF	14:53:09	55,588996 °	7,5496112 °	Unidentified obj. (boulder), 0.9m x 1m x 0.4m
8	HR_074.XTF	14:53:52	55,5888289 °	7,548105 °	Boulder, 1.4m x 1.0m x 0.3m
9	HR_076.XTF	13:35:18	55,5900127 °	7,5525687 °	Boulder, 1.4m x 0.9m x 0.3m
10	HR_084.XTF	09:44:22	55,5934292 °	7,5364421 °	Boulder, 1.6m x 2.0m x 0.5m
11	HR_084.XTF	09:46:18	55,5931579 °	7,5408286 °	Boulder, 0.7m x 1.0m x 0.4m
12	HR_084.XTF	09:48:43	55,5933921 °	7,5449141 °	Boulder, 1.3m x 0.8m x 0.5m
13	HR_084.XTF	09:51:10	55,5938703 °	7,5502058 °	Boulder, 2.3m x 2.0m x 0.5m
14	HR_086.XTF	09:23:14	55,5941932 °	7,5444524 °	Boulder, 0.7m x 1.6m x 0.6m
15	HR_092.XTF	05:45:42	55,5971544 °	7,5467364 °	Boulder, 1.4m x 1.1m x 0.6m
16	HR_094.XTF	05:15:13	55,5977806 °	7,5453431 °	Boulder, 0.6m x 2.2m x 0.5m
17	HR_096.XTF	03:42:33	55,5989741 °	7,540154 °	Boulder, 0.8m x 1.6m x 0.5m

Side Scan Sonar, Target List Continued

18	HR_098.XTF	03:20:20	55,5994121 º	7,5388697 º	Boulder, 0.6m x 1.4m x 0.4m
19	HR_098.XTF	03:21:00	55,5992581 º	7,5373371 º	Boulder, 1.3m x 1.3m x 0.5m
20	HR_100.XTF	01:36:36	55,6005526 º	7,5303658 º	Boulder, 1.4m x 1.9m x 0.4m
21	HR_102.XTF	00:46:50	55,6036002 º	7,6162635 º	Straight bar, 5.0m x 0.2m x 0.1m
22	HR_106.XTF	21:53:21	55,6042168 º	7,5345629 º	Boulder, 1.1m x 1.6m x 0.6m
23	HR_108.XTF	22:21:47	55,6057756 º	7,594009 º	Unidentified obj. (anchor?), 0.6m x 1.3m x 0.5m
24	HR_112.XTF	20:29:28	55,6073283 º	7,5912327 º	Unidentified obj., 0.9m x 0.8m x 0.9m
25	HR_114.XTF	19:24:42	55,6073812 º	7,5902643 º	Boulder, 1.5m x 1.2m x 1.0m
26	HR_116.XTF	18:29:45	55,6090429 º	7,5843848 º	Boulder, 1.2m x 0.9m x 0.5m
27	HR_118.XTF	17:41:06	55,6090082 º	7,5565411 º	Boulder, 0.9m x 1.2m x 0.5m
28	HR_124.XTF	13:56:23	55,6119073 º	7,548719 º	Boulder, 0.9m x 1.2m x 0.6m
29	HR_126.XTF	13:23:57	55,6135074 º	7,5708447 º	Boulder, 1.2m x 1.1m x 0.7m
30	HR_128.XTF	12:09:08	55,6137872 º	7,5605158 º	Boulder, 1.0m x 2.6m x 0.6m
31	HR_132.XTF	10:10:25	55,615759 º	7,5536352 º	Boulder, 0.7m x 1.7m x 0.6m
32	HR_134.XTF	09:49:16	55,615822 º	7,5534107 º	Boulder, 1.0m x 1.1m x 0.5m
33	HR_146.XTF	02:10:16	55,6215292 º	7,5479995 º	Boulder, 0.5m x 3.0m x 0.4m
34	HR_146.XTF	02:11:57	55,6215284 º	7,5520322 º	Boulder, 0.9m x 1.9m x 0.4m
35	HR_150.XTF	00:19:26	55,6231887 º	7,5488612 º	Boulder, 0.6m x 2.5m x 0.3m
36	HR_154.XTF	21:33:13	55,6249062 º	7,5502646 º	Straight bar, >3.8m x 0.2m x 0.1m
37	HR_162.XTF	18:12:55	55,6306323 º	7,6122632 º	Boulder, 1.0m x 1.8m x 0.2m
38	HR_170.XTF	14:01:00	55,6332713 º	7,572225 º	Boulder, 1.0m x 1.1m x 0.4m

Table 4 Side Scan Sonar Targets.

The distribution of magnetic anomalies and side scan sonar targets are shown in Chart D 110... No anomalies and targets are located at the exact same position, but target 24 and 25 and anomaly no 11 are in the vicinity of each other with a distance of 50 to 75 m..

9.10 Chart D109 Glacial deformation map

Detailed seismic interpretation revealed that the Windfarm area is located in a Saalian complicated ice marginal ridge area, influenced by ice push from an eastern direction followed by ice push from north-east. With this in mind, it is possible to classify the layers below the Holocene deposits in degrees of glacial disturbance as illustrated in seismic profile 102 (Figure 19).

The study further more showed, that there is a close correlation between the map which shows the variation of the magnetic values in gamma values (magnetometer map, Figure 20 and Chart 108) and a Chart (D109) showing seismically mapped deformation classes (Figure 21 and chart D109).

9.10.1 Weak glacial disturbed areas

The western part of the Windfarm is dominated by an area characterised as only weak disturbed by glacial ice push (Figs. 18 and 20). It is believed that the deformations from the initial ice push from east, only reached to the central part of the Windfarm, but a re-advance from a north-eastern direction resulted in deformation of the northern and central part. This means that the weak disturbed areas are divided in a north western and a south western area.

Characteristic for the 2 areas is, that below the Holocene deposits exists a rather simple layering in general with an approximately 20m thick glaciofluvial sandy top layer above glacial clays. On the magnetometer map (Figure 20) this type of seabed shows no magnetic anomalies due to the homogeneous layering.

9.10.2 Glacial folded areas

The eastern 2/3 of the Windfarm is influenced by glacial deformation, either as folding or heavy glacial deformation. In the folded areas, is it possible to identify seismic reflectors that show a characteristic wavy appearance (seismic profile Figure 19)? It is in the folded areas that Holsteinian, interglacial clay deposits have been found in BH 5 (Figure 21 (Chart 109)). It shows that the soft interglacial clay can be folded up to a position close to the seabed, but on the seismic profiles it is possible to identify and interpret the layering. On the magnetometer map, lack of strong magnetic anomalies makes it possible to distinguish the areas from the heavy glacial deformed areas.

9.10.3 Heavy Glacial disturbed areas

The heavy glacial disturbed areas are interfingering with the folded areas, with a general south-west north-east direction. On the seismic profiles, the reflections in general are chaotic and the deeper reflectors disappear. It is not possible from the seismic data to establish any stratigraphy and the sediment layering must also be expected to be chaotic, with many shifts in lithology.

The magnetometer map shows a lot of anomalies, that gives a rather uneven map surface. This is clearly related to the chaotic lithological distribution, which also gives differences in contents of magnetic minerals.

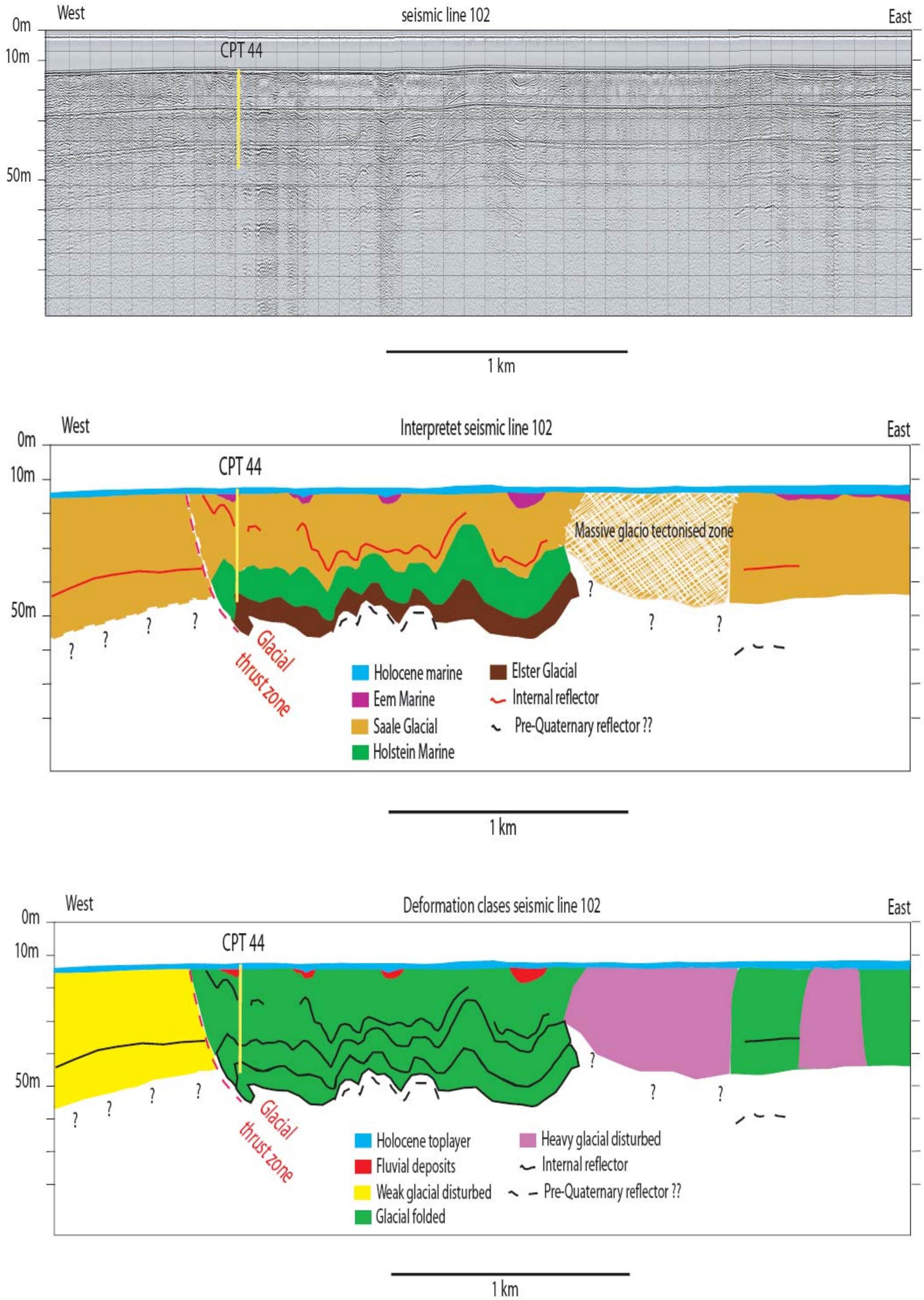


Figure 19. Seismic line 102, interpreted seismic (revised stratigraphy) and deformation classes.

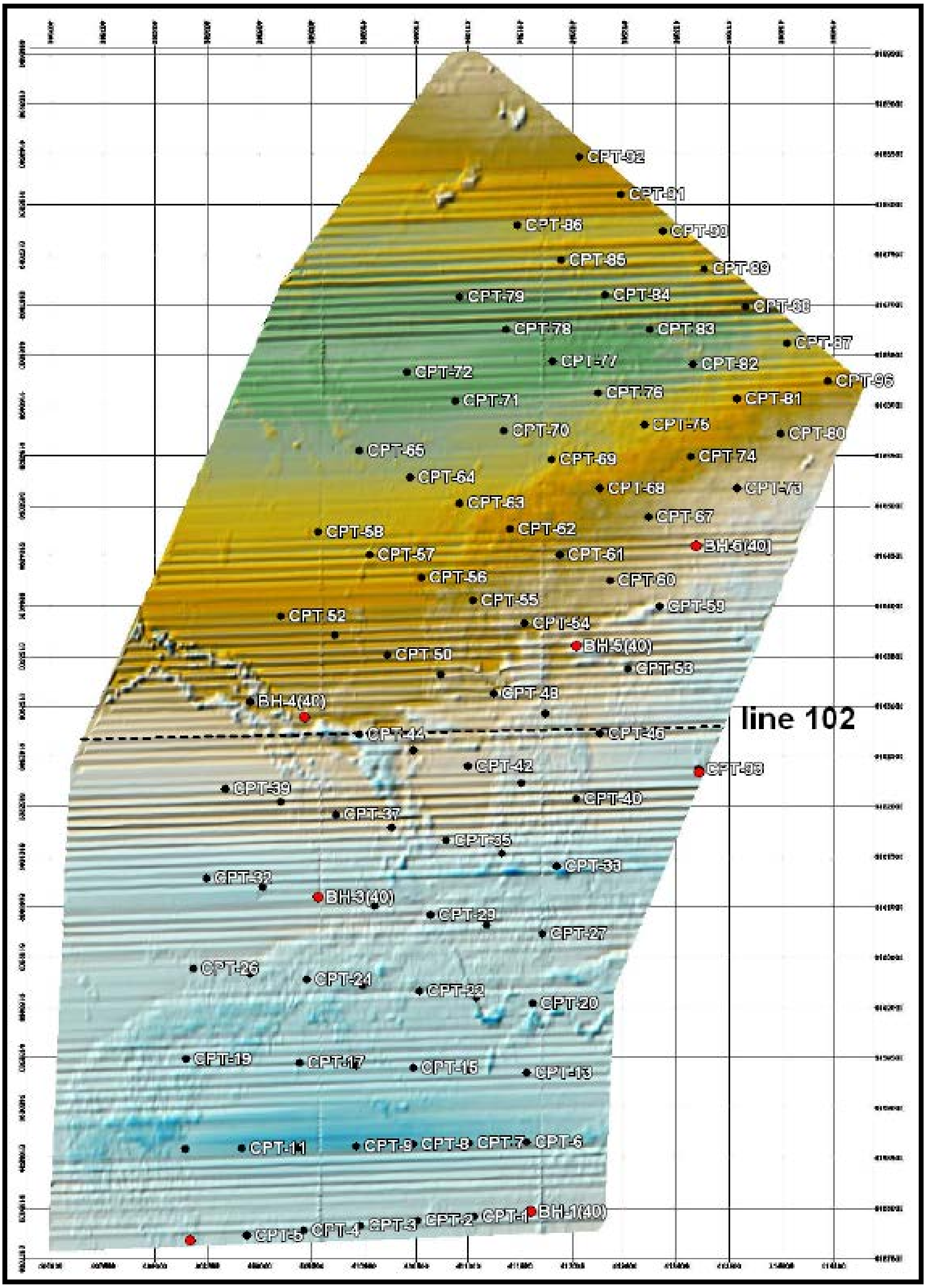


Figure 20. Magnetic anomalies in the Windfarm area and location of CPT's and Boreholes. (large map chart D108).

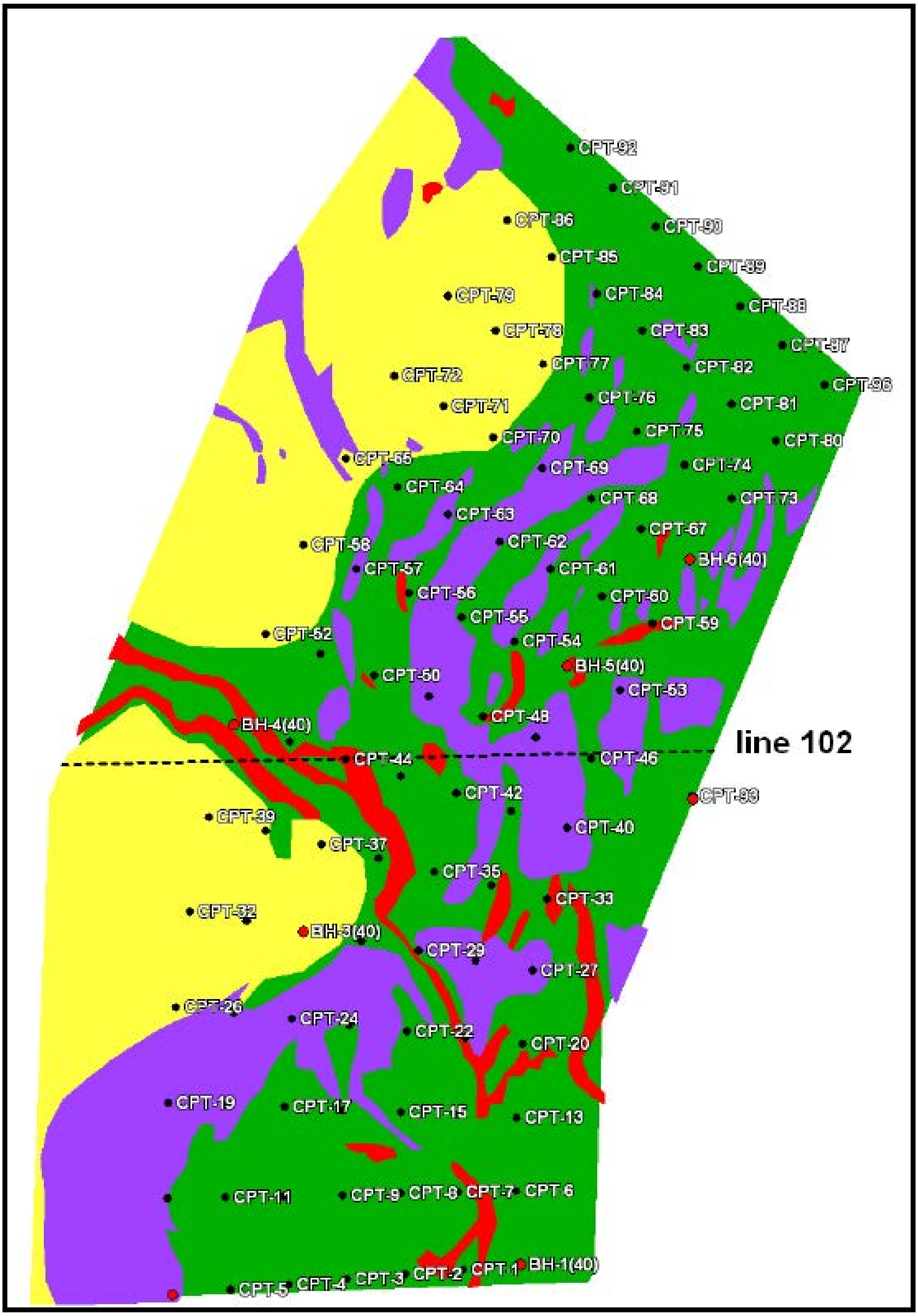


Figure 21. (Chart 109) Deformation classes in the Windfarm area. Seismic line 102 is located. (Large map Chart D109).

9.10.4 Fluvial deposits

The fluvial deposits, on the glacial surface, overprint the above mentioned classes. A dominant north-west south-east trending fluvial system is observed, as well as apparently elongated in filled depressions. A close inspection of the system shows, as demonstrated in seismic line 102 (Figure 19), that the fluvial system, as well as the elongated depressions, in general follows the depressions in the synclinals from the folded areas.

On the magnetometer map, the fluvial system is possible to identify because of relatively large anomalies trending north-west south-east.

9.10.5 The pattern of deformation classes

The combination of the deformation classes reveals the previously mentioned complicated ice marginal deformation history.

From the south-west north-east trending border, between deformation and non deformation, it is obvious that an ice push must have taken place from east, but ice push in the north western part of the Windfarm, plus the overprinting north-west south-east trending folding fluvial pattern shows, that a final re-advance from north-east modified the previous ice marginal deformations.

9.11 Evidence of large-scale glaciotectonic in the region (Fanø Bay)

Large glaciotectonic deformation complexes has been described in the Fanø Bay about 35km south-east of the Horns Rev Windfarm area (Figure 22) (ref.3). In the Fanø Bay, investigations of deep seismic investigations have made it possible to investigate the complete architecture of trust faults and the related folds (Figure 23). The east- west seismic profiles show the western margin of the trust faults, plus the combination of folding and areas with heavy deformations. The structural trends are indicated on figure 24.

The striking resemblances of the 2 areas are significant, with ice push from an eastern direction and even the divisions in an initial ice push followed by a more north-eastern ice push are similar.

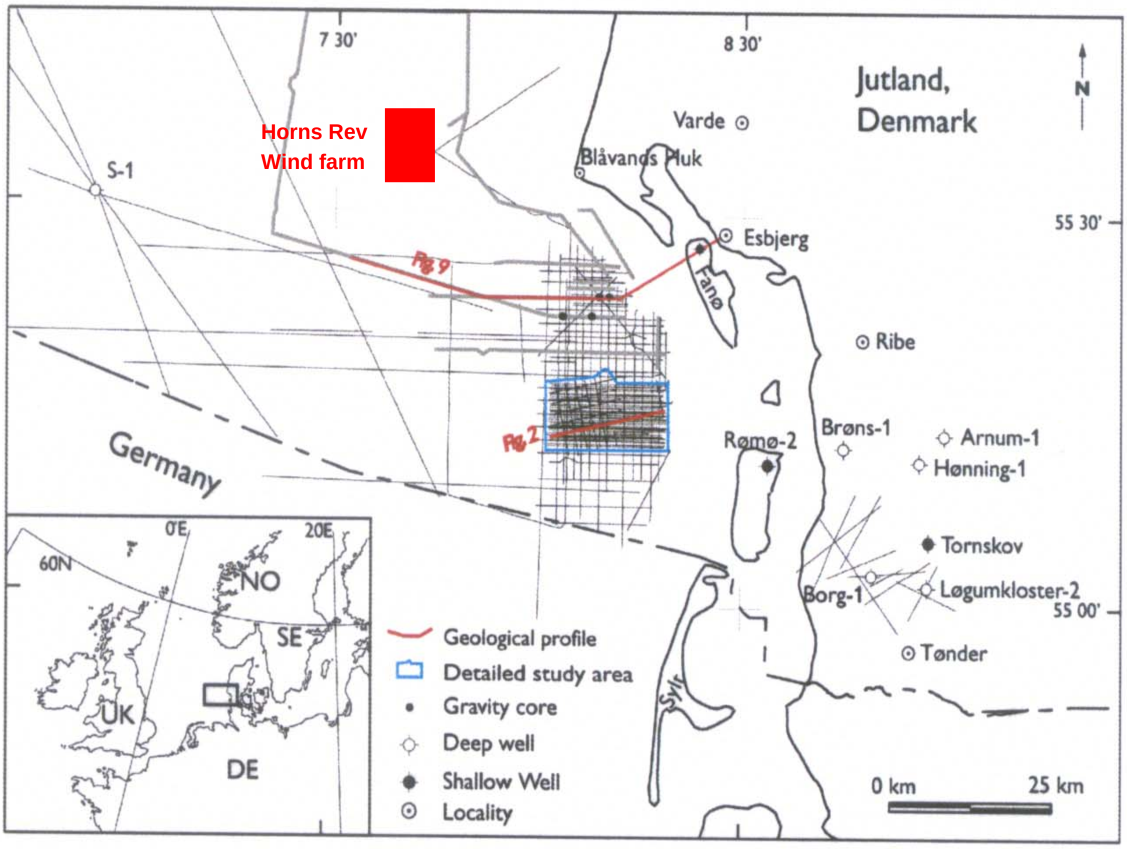


Figure 22. Map showing the location of Fanø Bay glaciotectonic thrust complex (ref. 3).

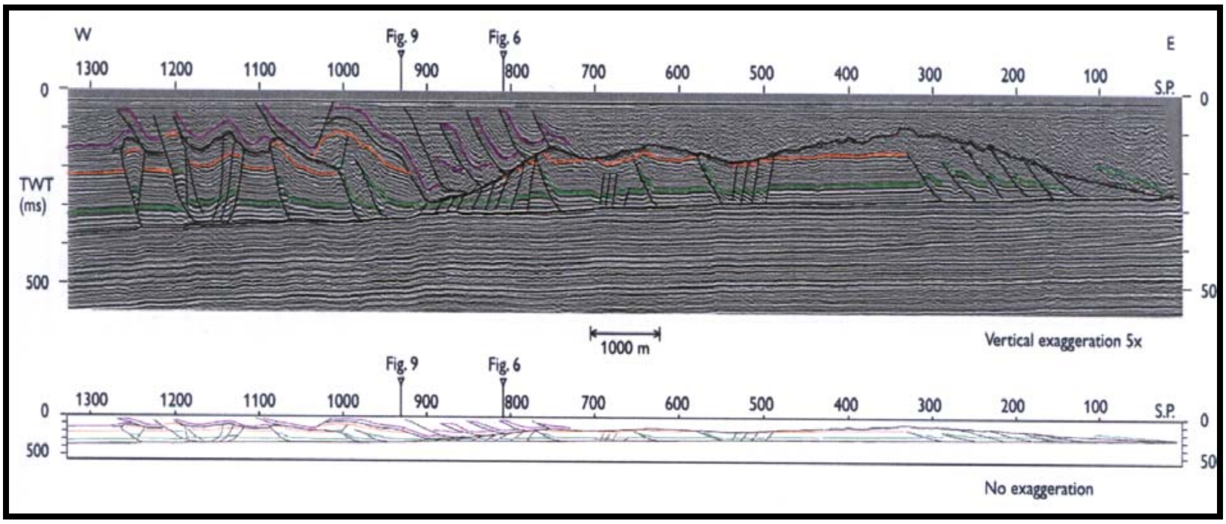


Figure 23 Seismic section showing thrust faults and related folding. Profile location indicated as Fig.2 on Figure 22. (ref.3).

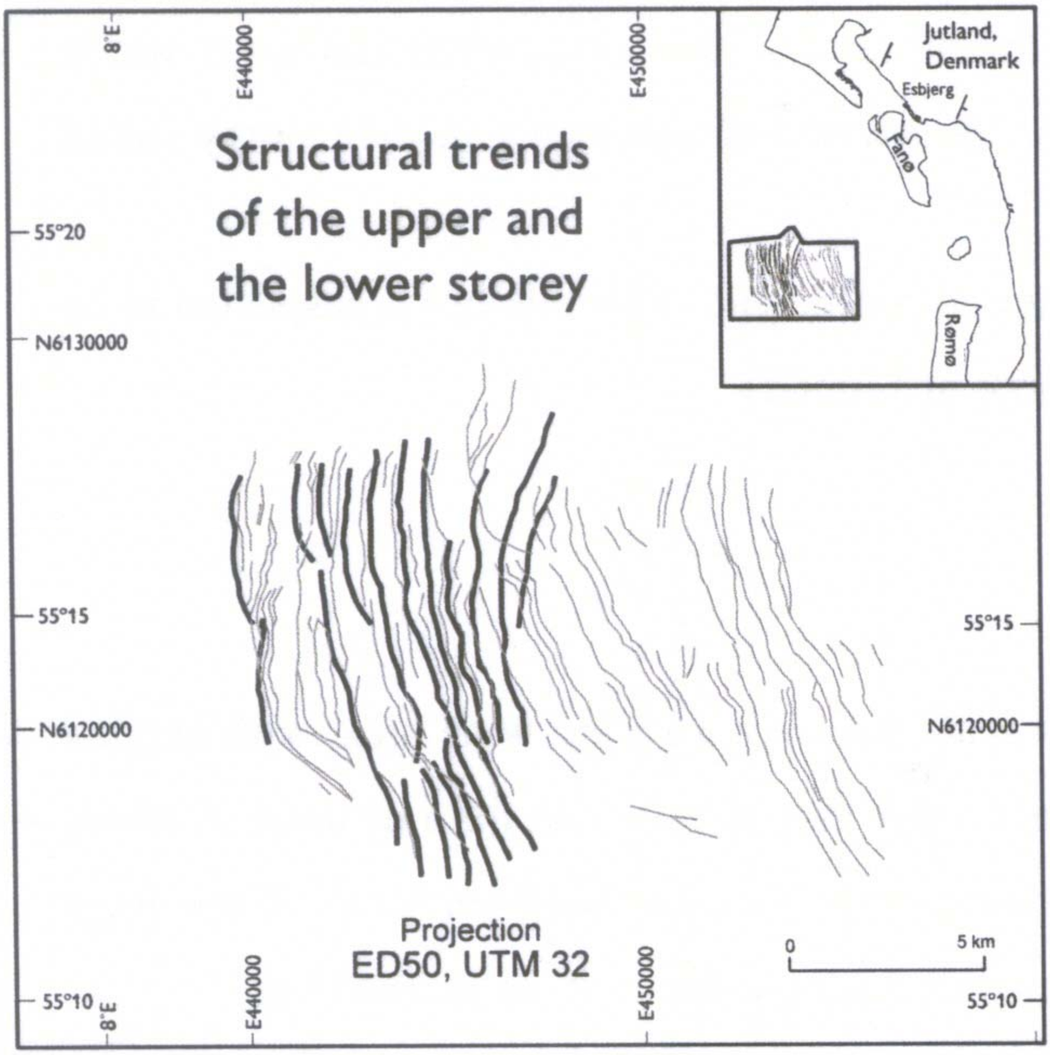


Figure 24. Map comparing the deformation trends from the initial ice push from east (grey lines) and the final north-east ice push (black lines) (ref.3).

10. Detailed seismic investigations in CPT and Core locations

10.1 Introduction

Detailed inspections of the seismic data have been made as background for geotechnical evaluation of the individual CPT, core and vibrocore locations. In the following paragraphs the CPT data are presented together with close-ups of the seismic data and evaluations of lithology and deformation classes are made. It must be taken into account that in the points were we only have CPT data; the presented evaluation is an interpretation of two indirect methods. This means that the lithological interpretation is guiding and not actual evidence on a specific lithology.

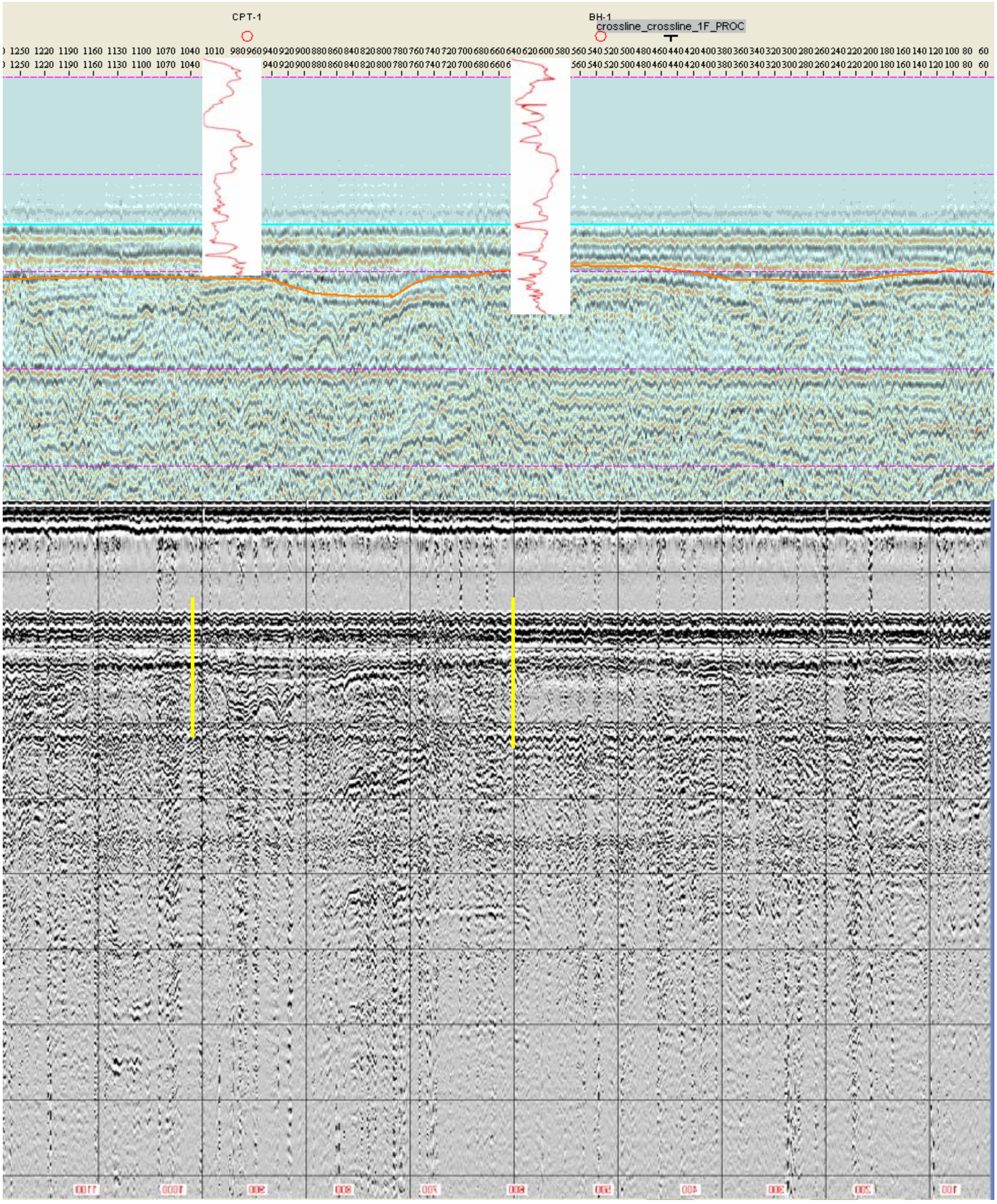
The seismic examples are shown in two versions, a colour and a greyscale.

The vertical scale of the seismic lines is 10ms between each horizontal scale lines, which corresponds to 7.5m, when using a sound velocity of 1500m/s. The horizontal scale is about 80m between the vertical scale lines.

10.1.1 A1 (BH 1(40)) and A2 (CPT 1)

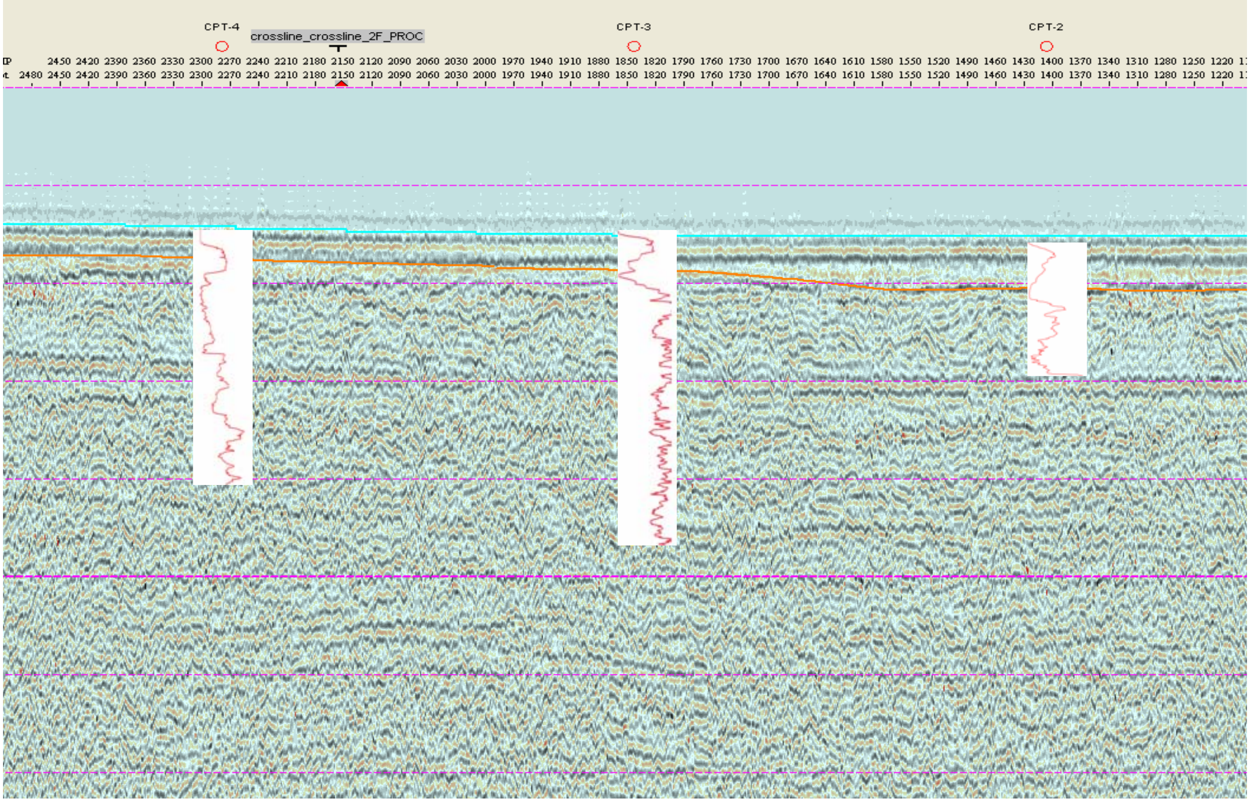
The Seismic line HR 05 in combination with CPT 1 and BH 1 plus Figure 21 (Chart 109) shows, that both points are located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. About 7m meter thick Holocene top sand layer exists above glacial deposits consisting of about 5m sand on top of 10 – 15m layered sand and clay.

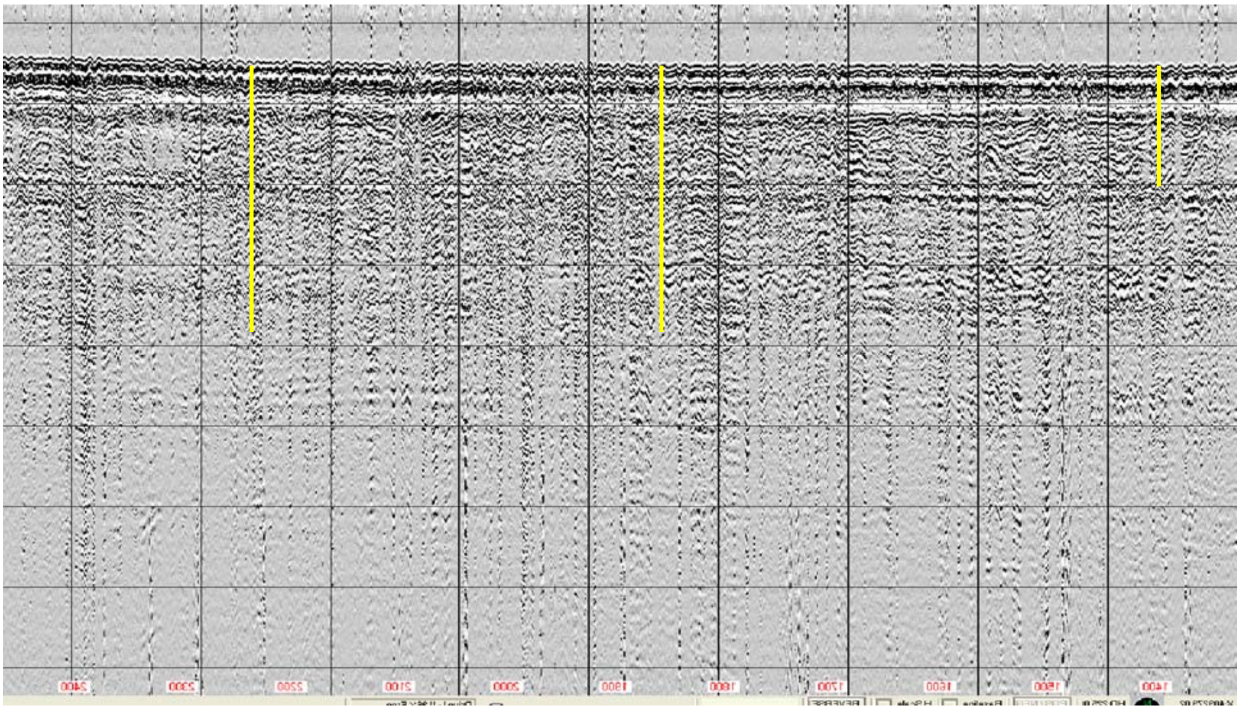
Biostratigraphical investigations show that the glacial deposits are freshwater deposits (paragraph 9.1.1).



10.1.2 A3 (CPT 2) A4 (CPT 3) and A5 (CPT 4)

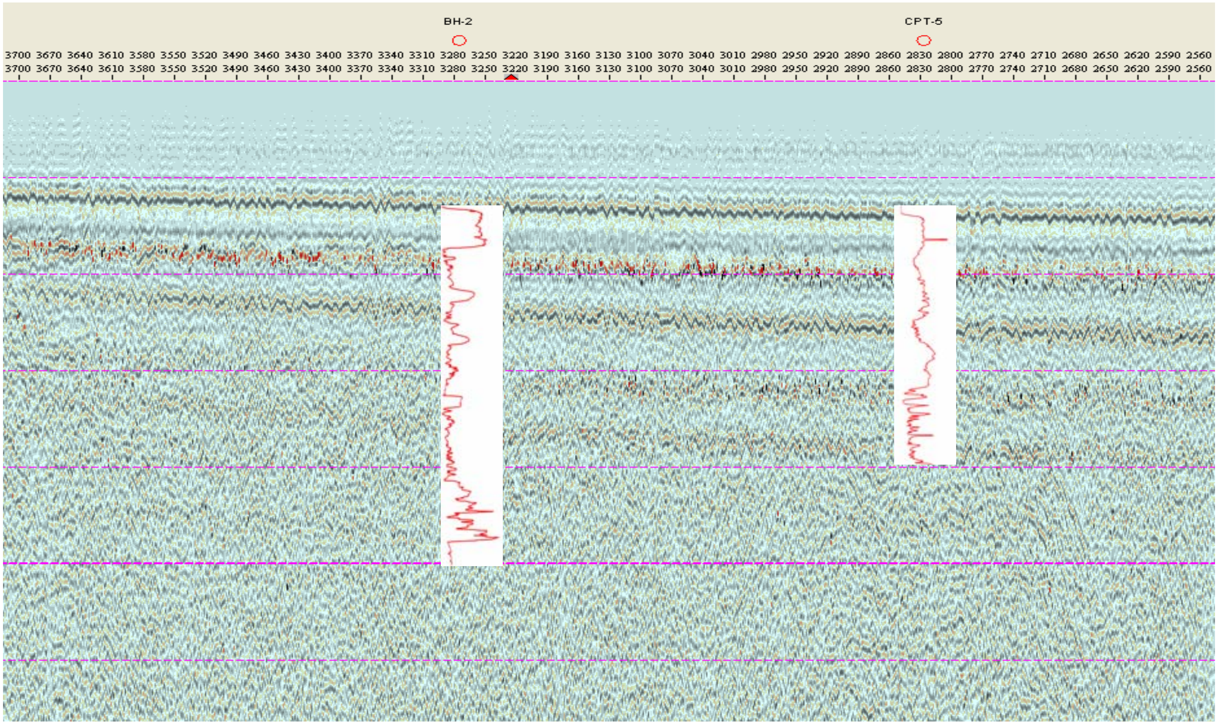
The Seismic line HR 05 in combination with CPT 2, 3 and 4 plus Figure 21 (Chart 109) shows, that all 3 points are located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. An about 3 - 5m meter thick Holocene top sand layer exists above glacial deposits consisting of about 20m layered sand and clay.

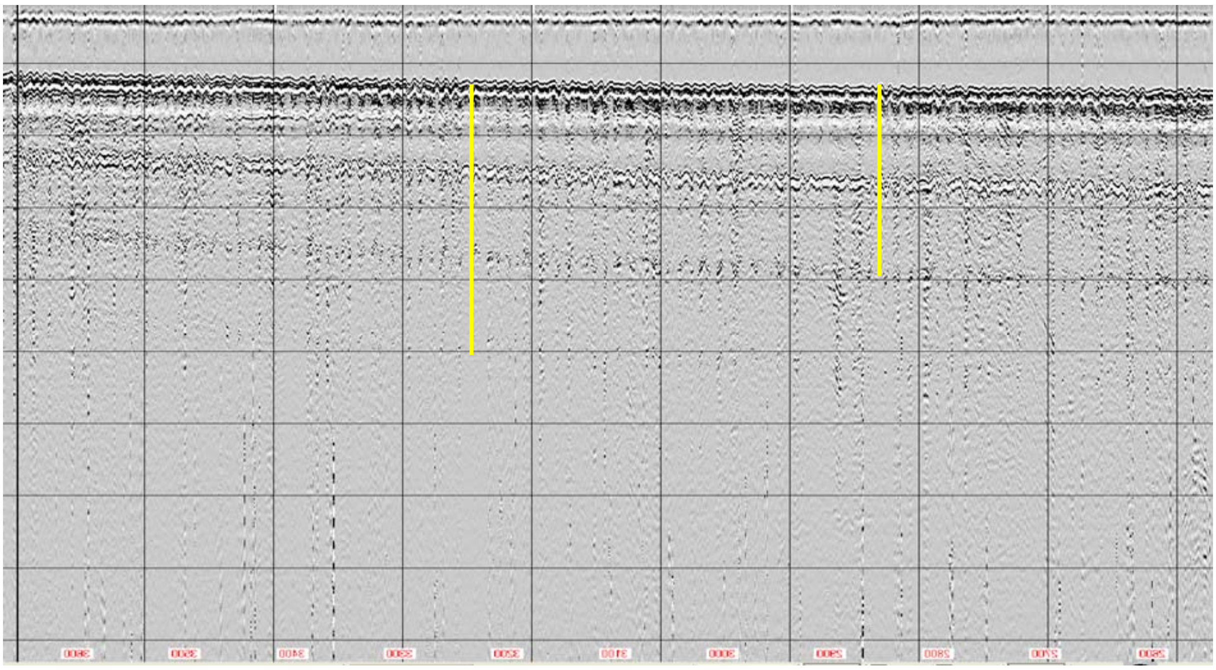




10.1.3 A6 (CPT 5) and A7 (BH 2(40))

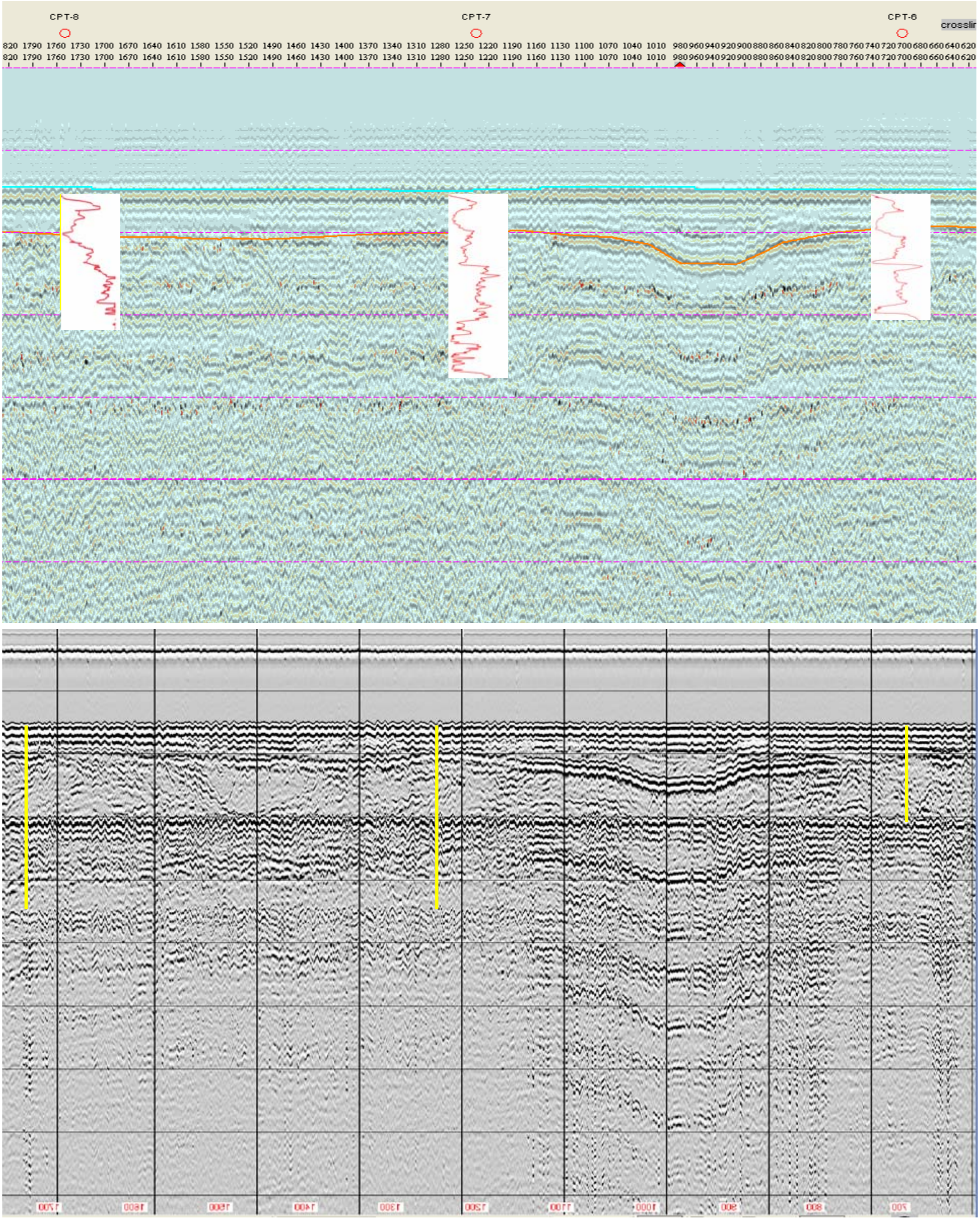
The Seismic line HR 05 in combination with CPT 5 and BH 2 plus Figure 21 (Chart 109) shows, that CPT 5 is located in the folded deformation class while BH 2 is located in the heavy disturbed zone. This means that in CPT 5 it is possible to identify and interpret the seismic reflectors often with a wavy appearance while. In BH 2 It is not possible from the seismic data to establish any stratigraphy and the sediment layering must also be expected to be chaotic, with many shifts in lithology. In CPT 5 a 3m meter thick Holocene top sand layer exists above glacial deposits consisting of about 20m layered sand and clay. In BH 2 a 4.5m Holocene sand layer covers more than 25m glacial clay and sand. Biostratigraphical studies of the glacial deposits shows that it is freshwater deposits (Paragraph 9.1.1)





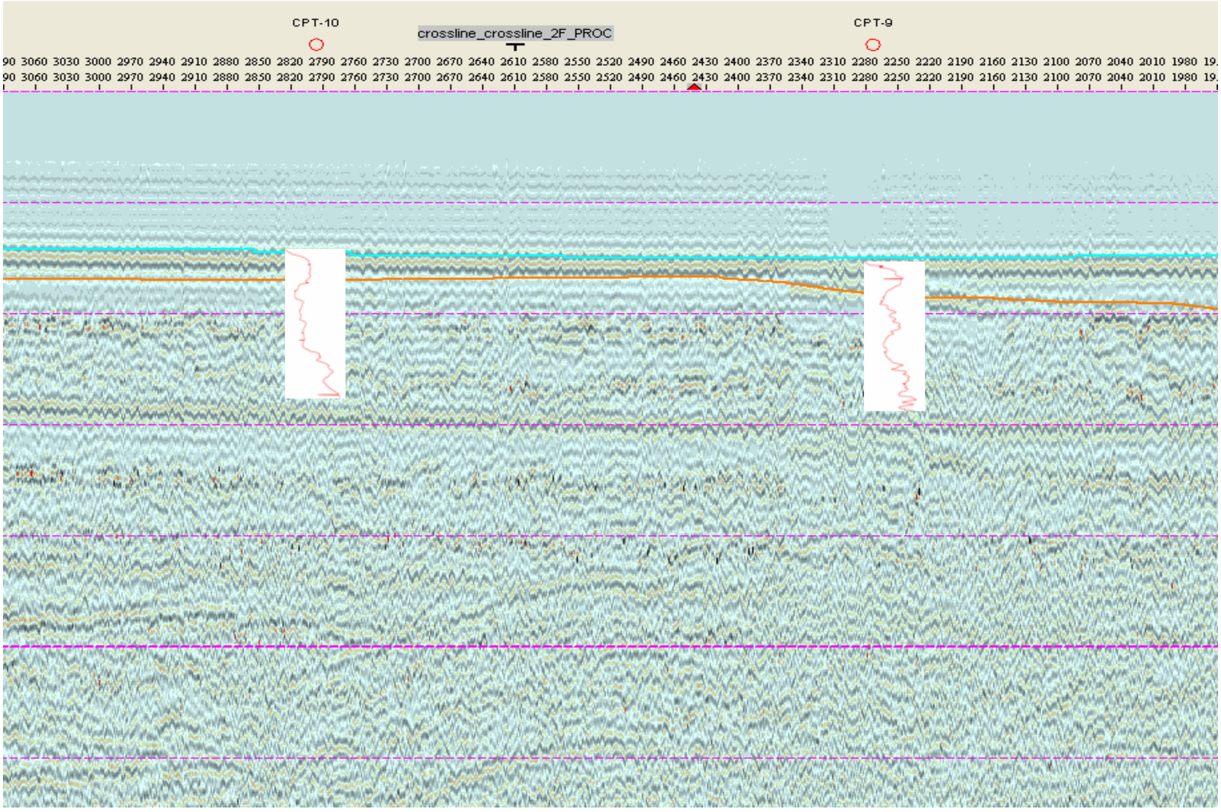
10.1.4 B1 (CPT 6), B2 (CPT 7) and B3 (CPT 8)

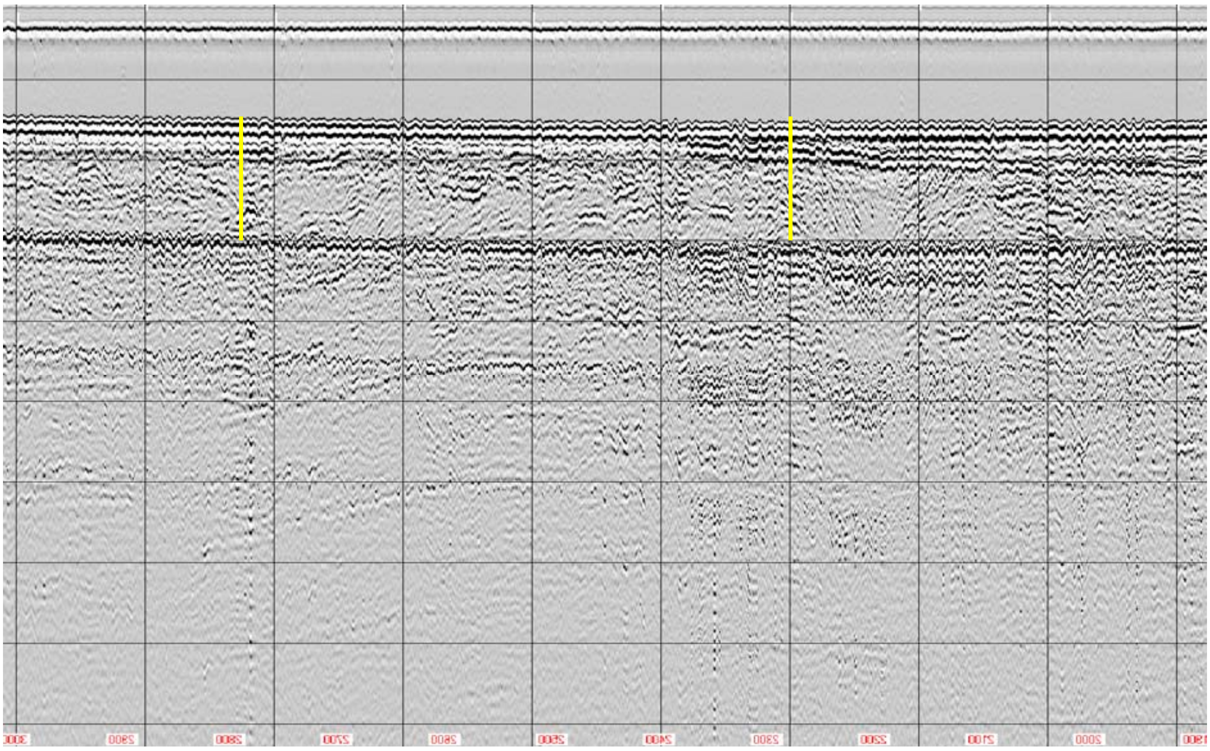
The Seismic line HR 18 in combination with CPT 6, 7 and 8 plus Figure 21 (Chart 109) shows, that all 3 points are located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. About 5m meter thick Holocene top sand layer exists above glacial deposits consisting of about 20m layered sand and clay.



10.1.5 B4 (CPT 9) and B5 (CPT 10)

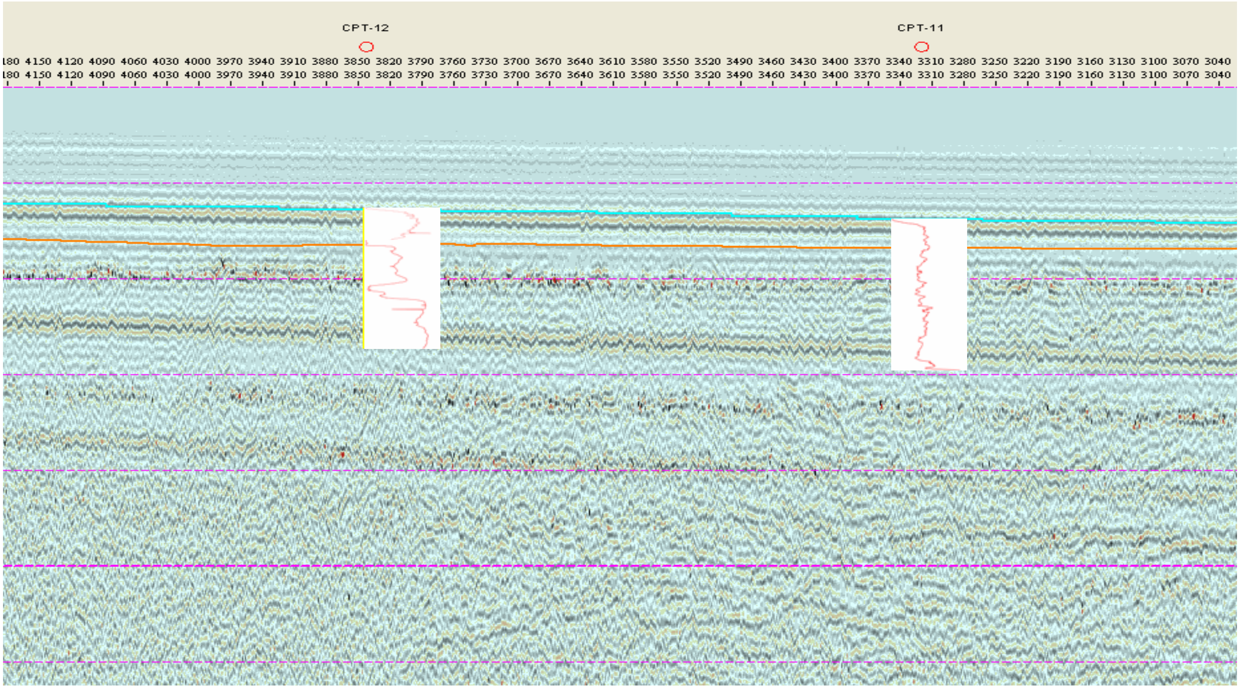
The Seismic line HR 18 in combination with CPT 9 and 10 plus Figure 21 (Chart 109) shows, that both points are located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. About 3-5m meter thick Holocene top sand layer exists above glacial deposits consisting of about 10m layered sand and clay (seismic indication of about 20m).

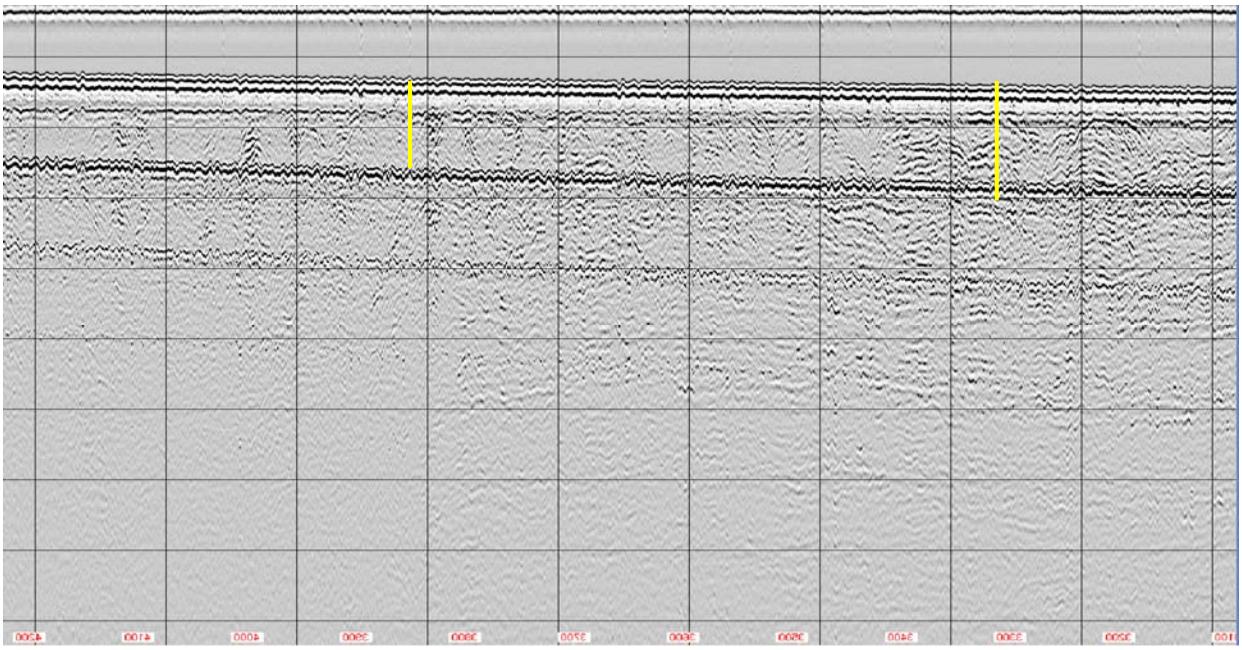




10.1.6 B6 (CPT 11) and B7 (CPT 12)

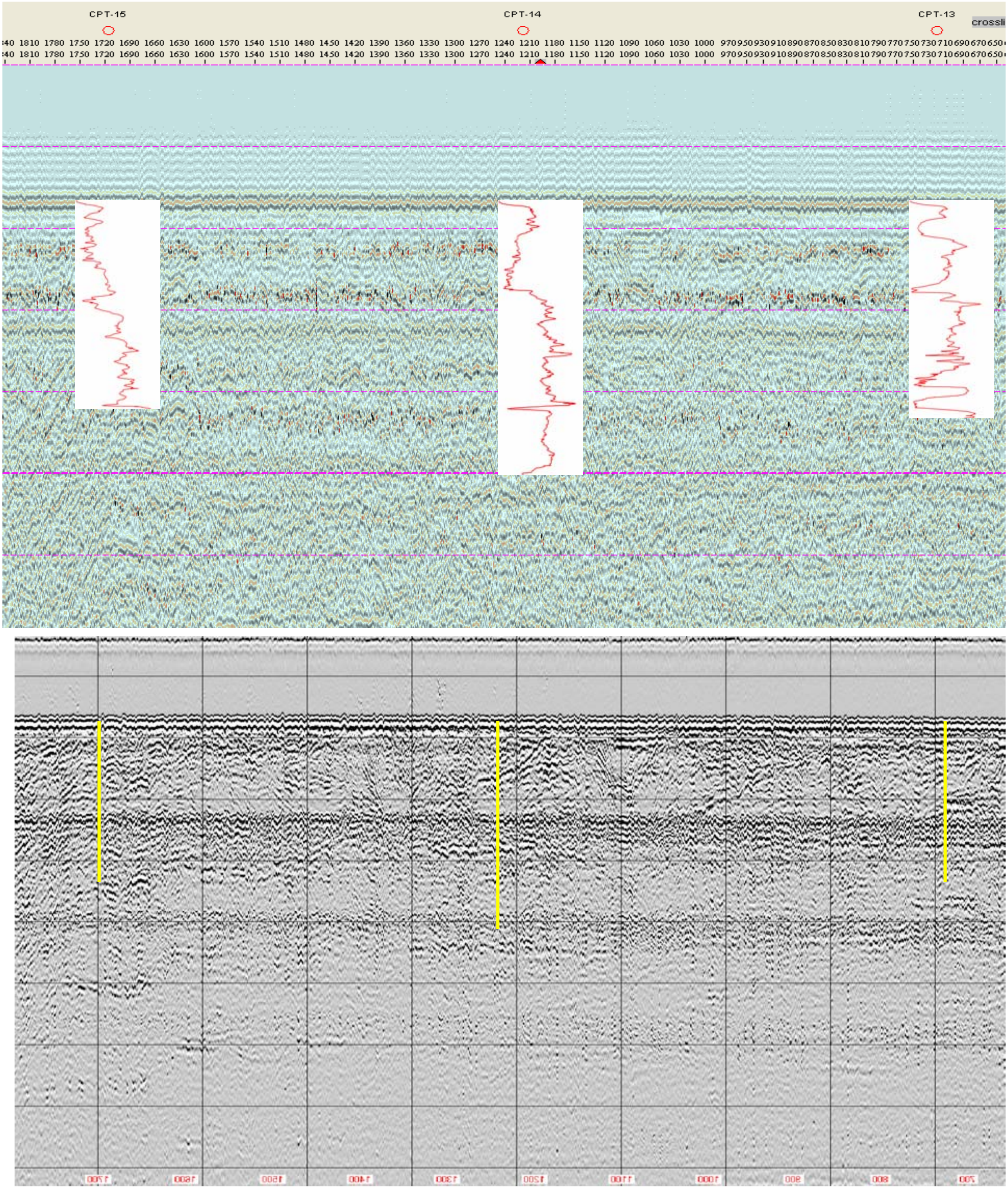
The Seismic line HR 18 in combination with CPT 11 and 12 plus Figure 21 (Chart 109) shows, that CPT 11 is located in the folded deformation class while CPT 12 is located on the margin to the heavy disturbed zone. This means that in CPT 11 it is possible to identify and interpret the seismic reflectors often with a wavy appearance while. In CPT 12 It is partly not possible from the seismic data to establish any stratigraphy and the sediment layering must also be expected to be chaotic with many shifts in lithology. In CPT 11 3 m meter thick Holocene top sand layer exists above glacial deposits consisting of about 10m (seismic indication of about 20m) layered sand and clay. In CPT 12 3m Holocene sand covers 10m glacial clay and sand (seismic indication of about 20m).





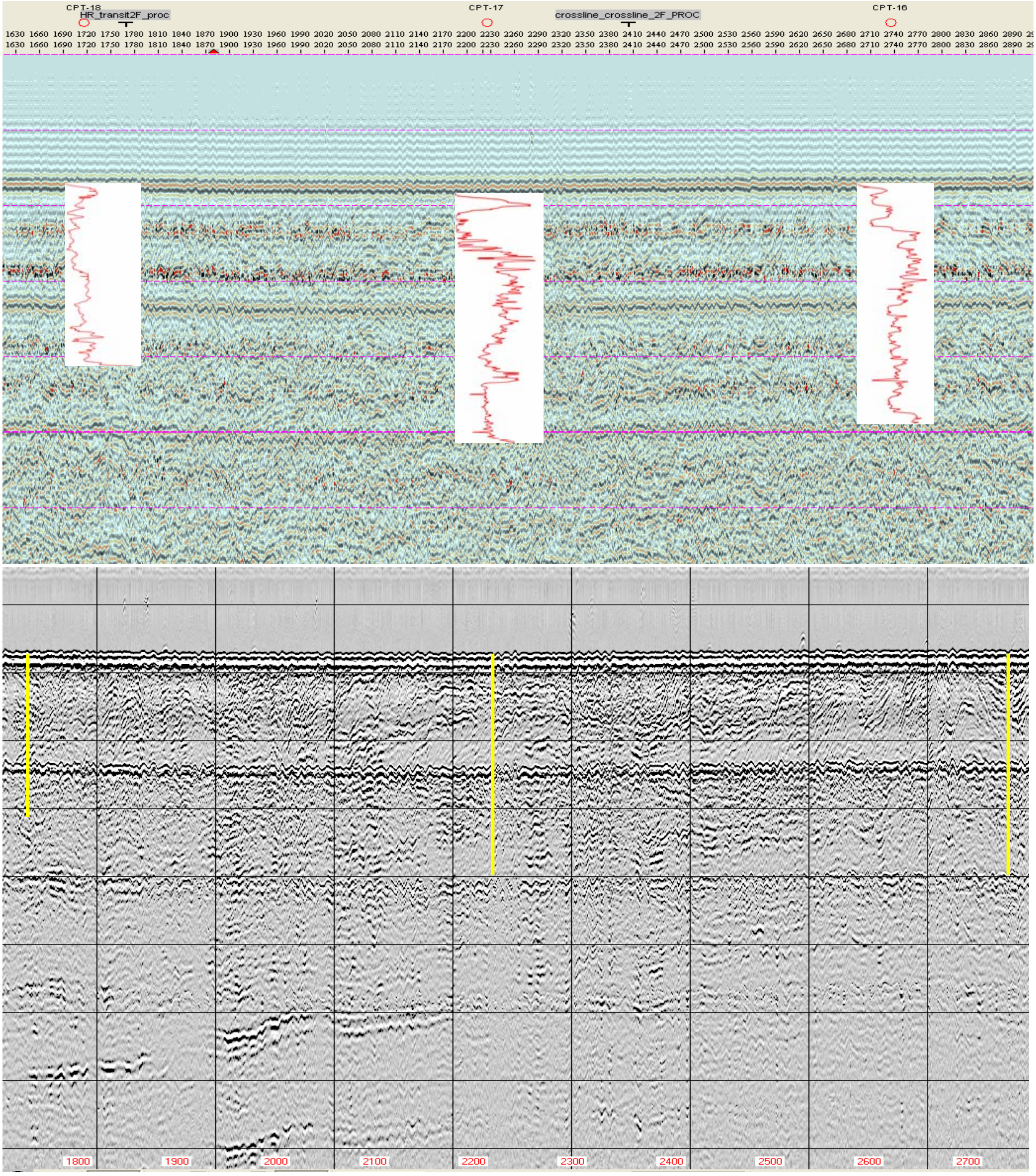
10.1.7 C1 (CPT 13), C2 (CPT 14) and C3 (CPT 15)

The Seismic line HR 34 in combination with CPT 13, 14 and 15 plus Figure 21 (Chart 109) shows, that all 3 points are located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. About 2m meter thick Holocene top sand layer exists above glacial deposits consisting of about 25m layered sand and clay.



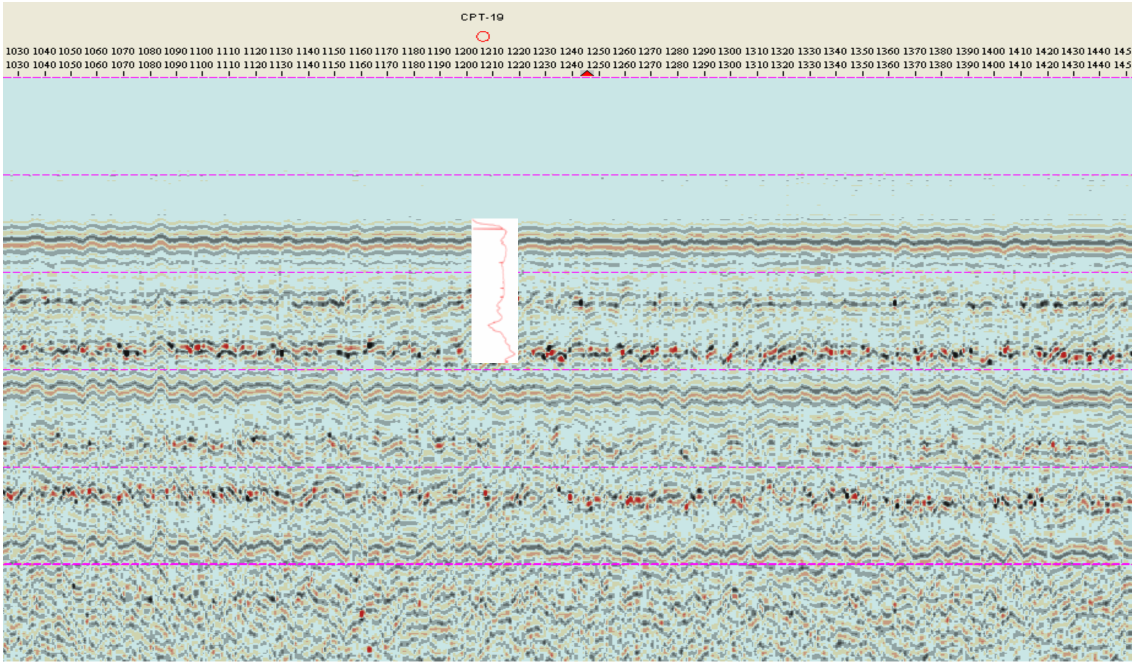
10.1.8 C4 (CPT 16), C5 (CPT 17) and C6 (CPT 18)

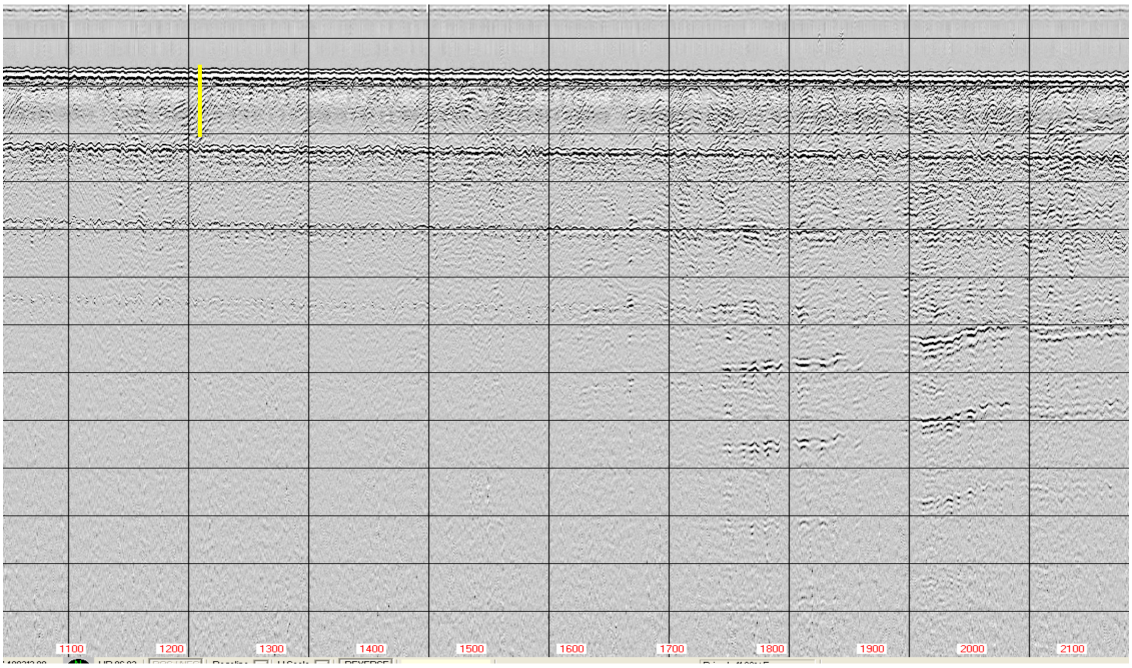
The Seismic line HR 34 in combination with CPT 16, 17 and 18 plus Figure 21 (Chart 109) shows, that all 3 points are located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. 1 -2m meter thick Holocene top sand layer exists above glacial deposits consisting of about 25m layered sand and clay.



10.1.9 C7 (CPT 19)

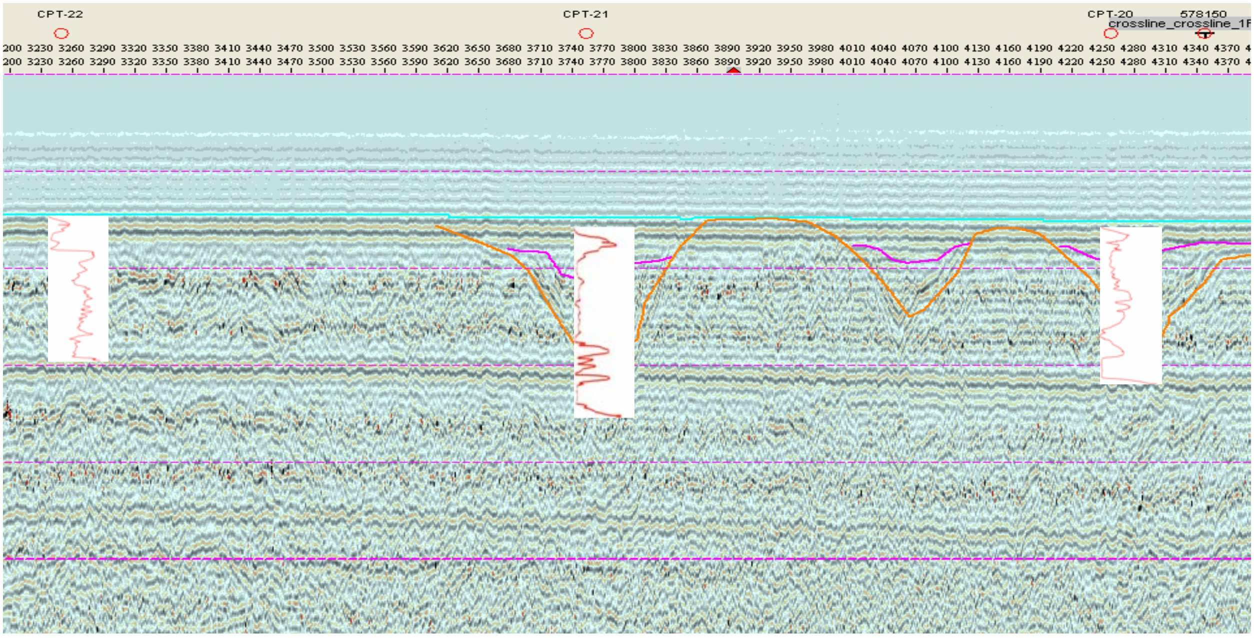
The Seismic line HR 36 in combination with CPT 19 plus Figure 21 (Chart 109) shows, that CPT 19 is located in the heavy disturbed zone. This means that It is not possible from the seismic data to establish any stratigraphy and the sediment layering must also be expected to be chaotic with many shifts in lithology. In CPT 19 1 – 2m Holocene sand covers more than 20m glacial clay and sand.

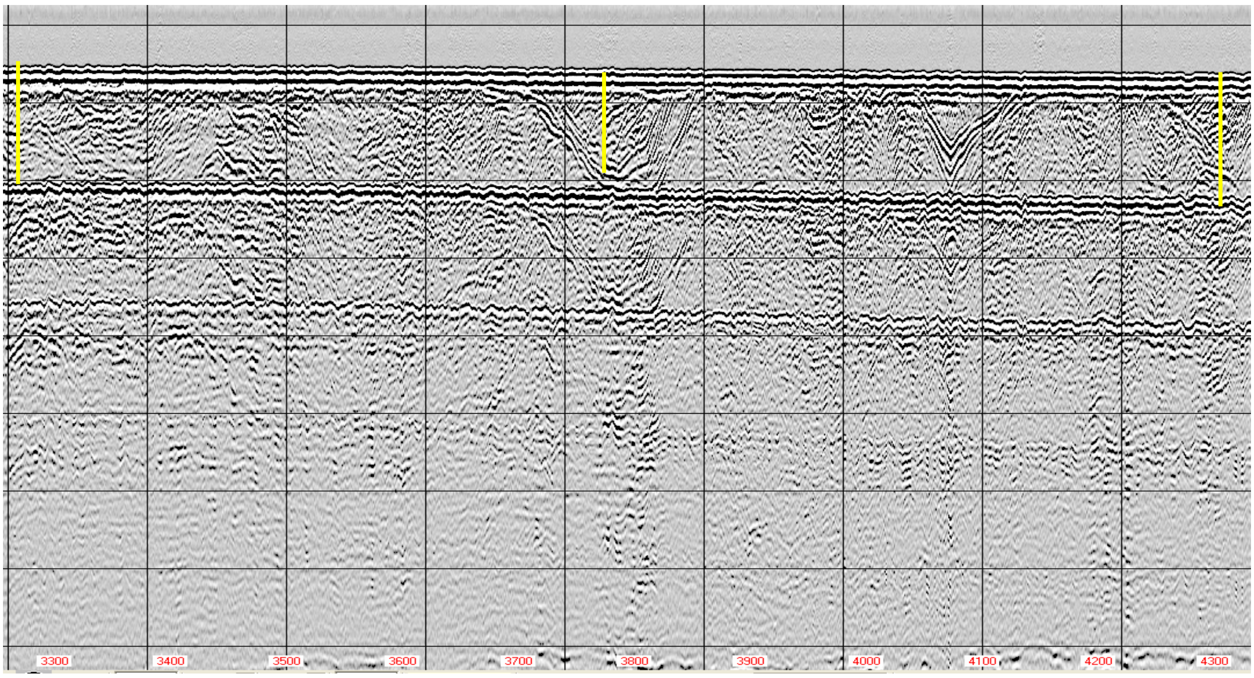




10.1.10 D1 (CPT 20), D2 (CPT 21) and D3 (CPT 22)

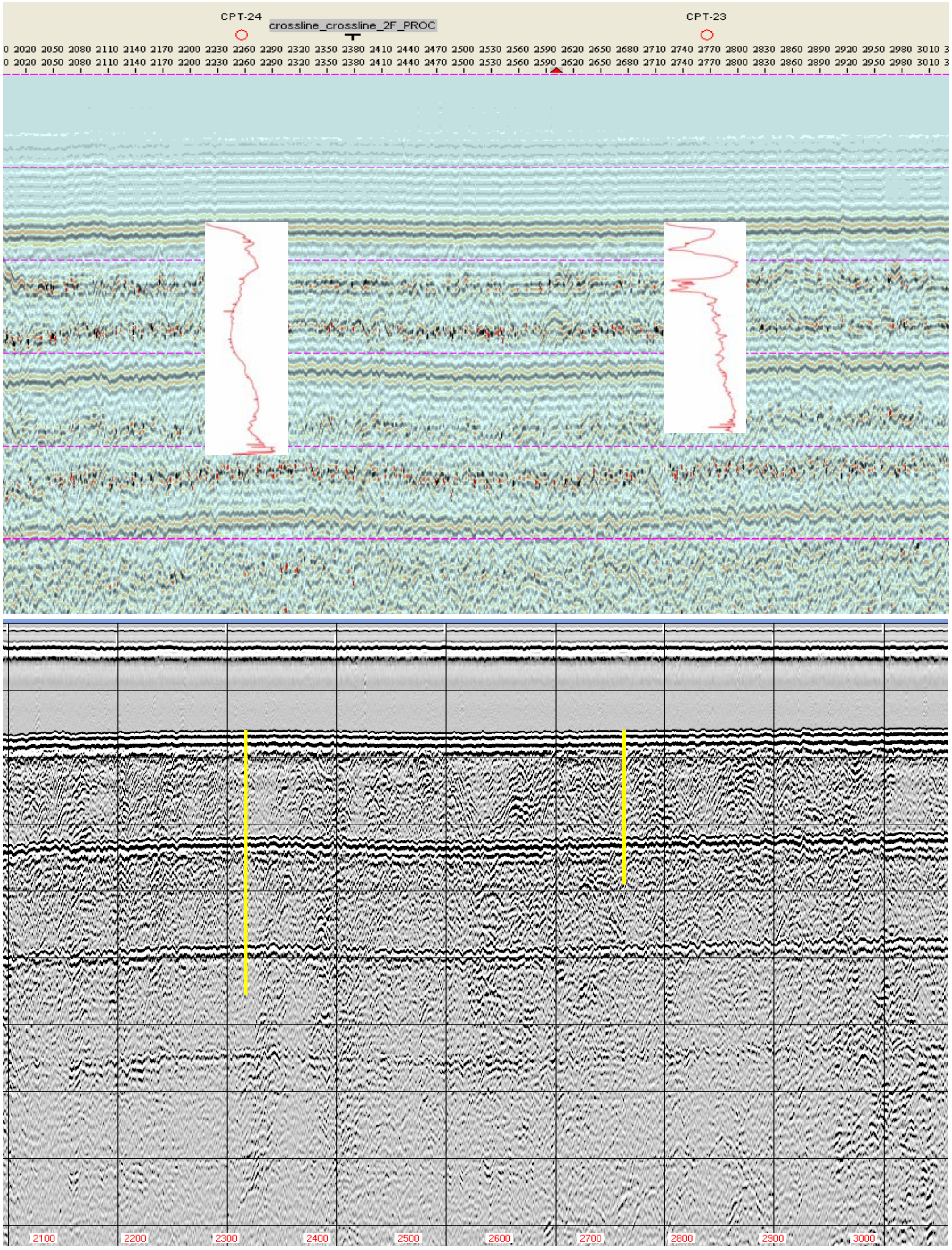
The Seismic line HR 48 in combination with CPT 20, 21 and 22 plus Figure 21 (Chart 109) shows, that CPT 21 and 22 are located in the fluvial deposits zone in elongated depressions, in general following the depressions in the synclinals from the folded areas. CPT 22 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. In CPT 20 and 21 3-5m meter thick Holocene top sand layer exists above about 10m glaciofluvial infill deposits consisting of sand onto of glacial deposits. CPT 22 has 2 - 3m Holocene top sand above glacial deposits consisting of about 10m (seismic indication of about 20m) layered sand and clay.





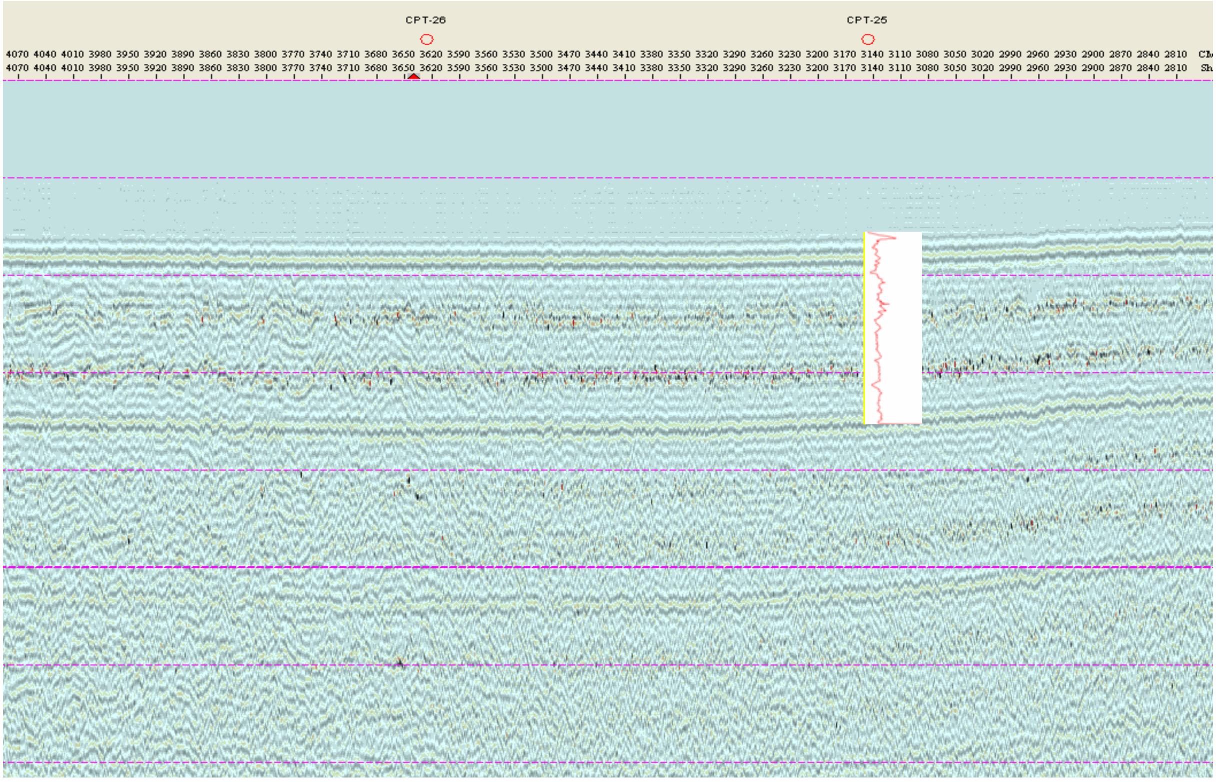
10.1.11 D4 (CPT 23) and D5 (CPT 24)

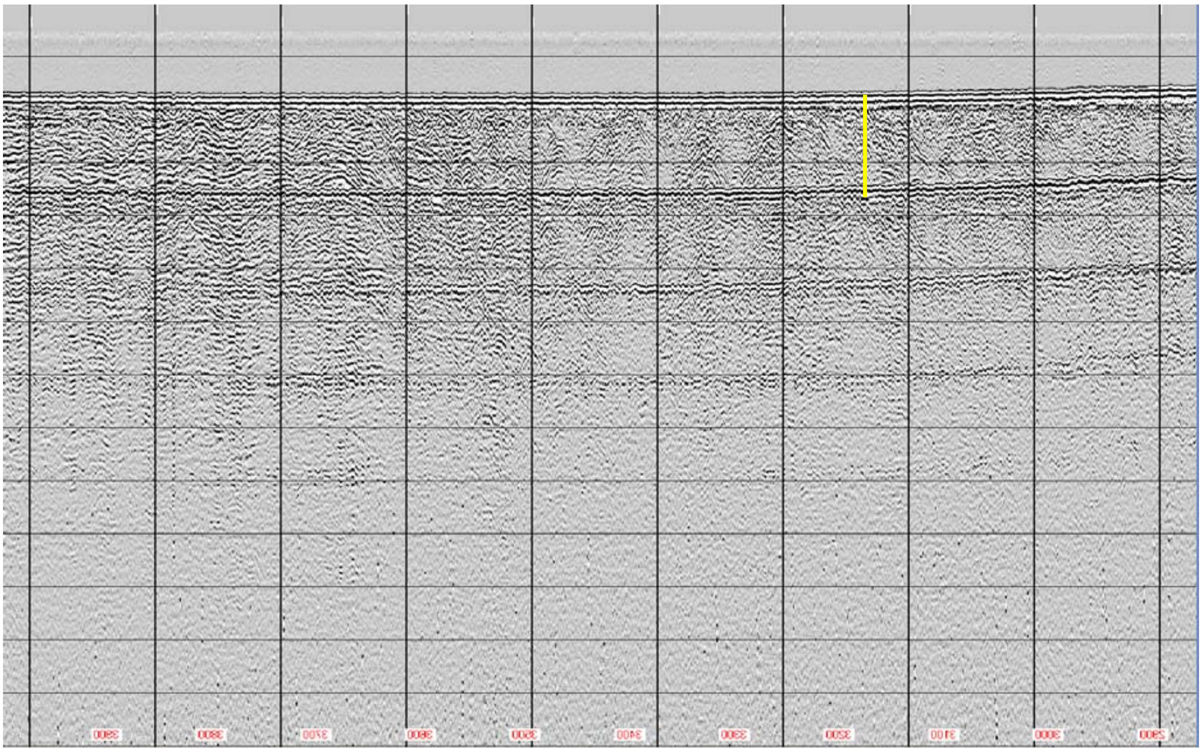
The Seismic line HR 52 in combination with CPT 23 and 24 plus Figure 21 (Chart 109) shows, that CPT 23 is located in the folded deformation class while CPT 24 is located in the heavy disturbed zone. This means that in CPT 23 it is possible to identify and interpret the seismic reflectors often with a wavy appearance while. In CPT 24 It is not possible from the seismic data to establish any stratigraphy and the sediment layering must also be expected to be chaotic with many shifts in lithology. In CPT 23 1-2 m meter thick Holocene top sand layer exists above glacial deposits consisting of about 10m (seismic indication of at least 20m) layered sand and clay. In CPT 24 1-2m Holocene sand covers 30m glacial clay and sand with chaotic bedding.



10.1.12 D6 (CPT 25) and D6 (VIB-25)

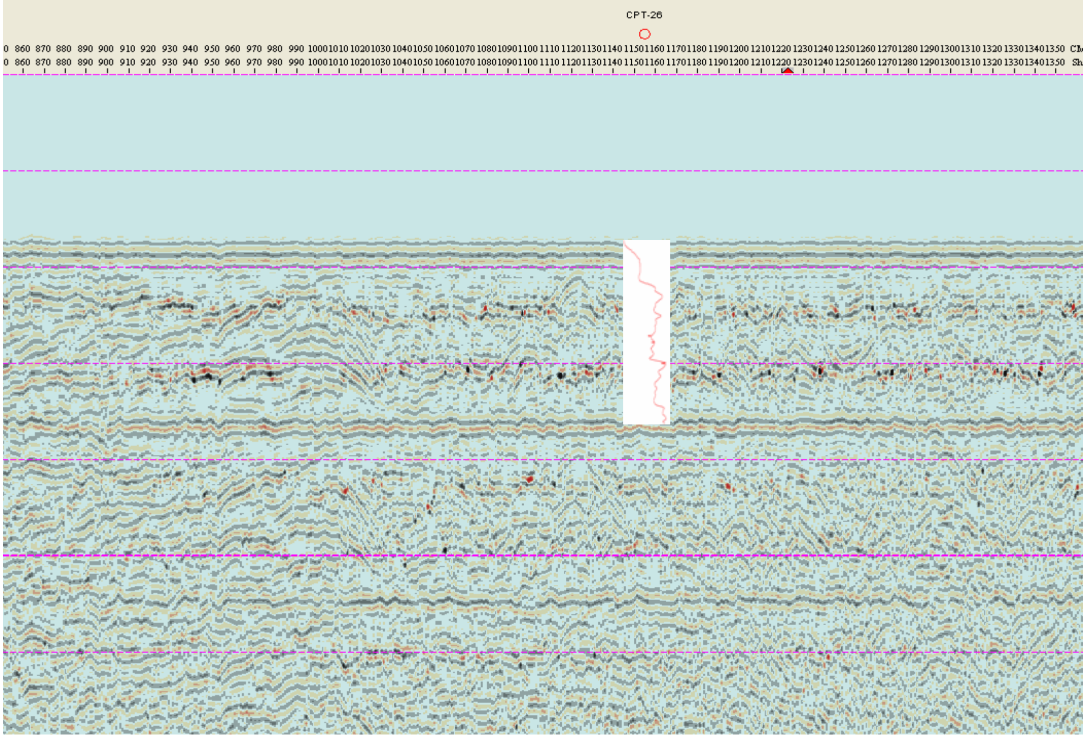
The Seismic line HR 54 in combination with CPT 25 and VIB-25 plus Figure 21 (Chart 109) shows, that CPT 25 is located in the heavy disturbed zone. This means that It is not possible from the seismic data to establish any stratigraphy and the sediment layering must also be expected to be chaotic with many shifts in lithology. In CPT 25 and VIB-25 2.5m Holocene sand covers more than 10m glacial clay and sand.

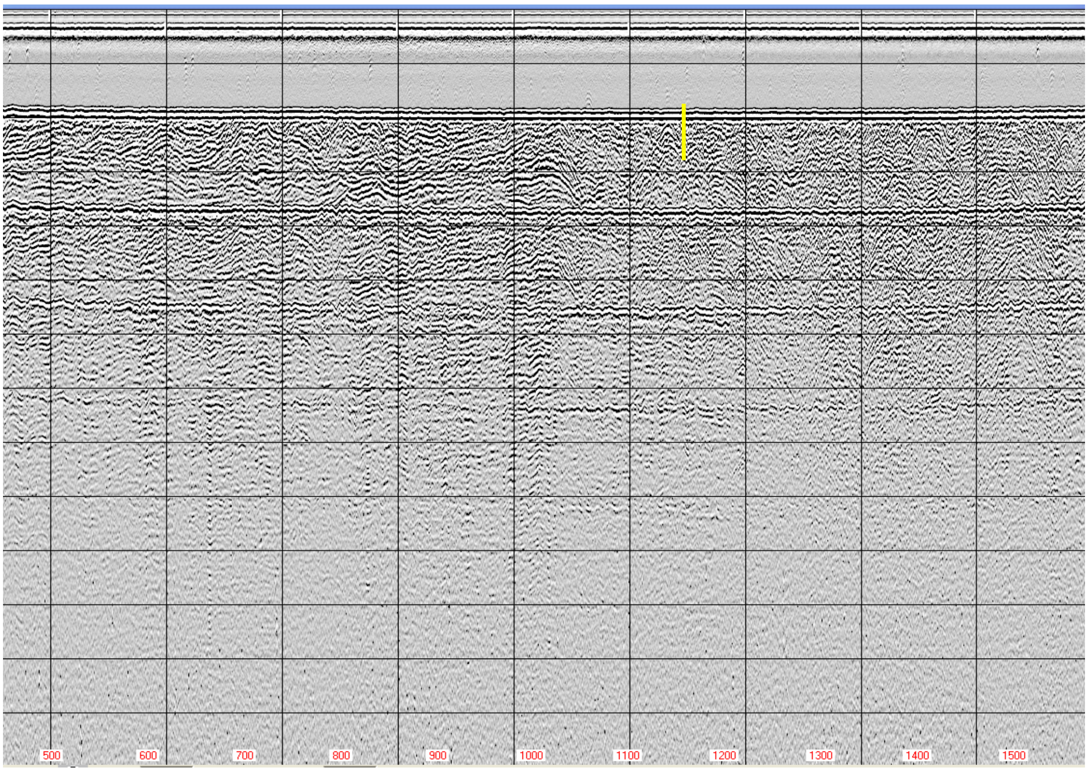




10.1.13 D7 (CPT 26)

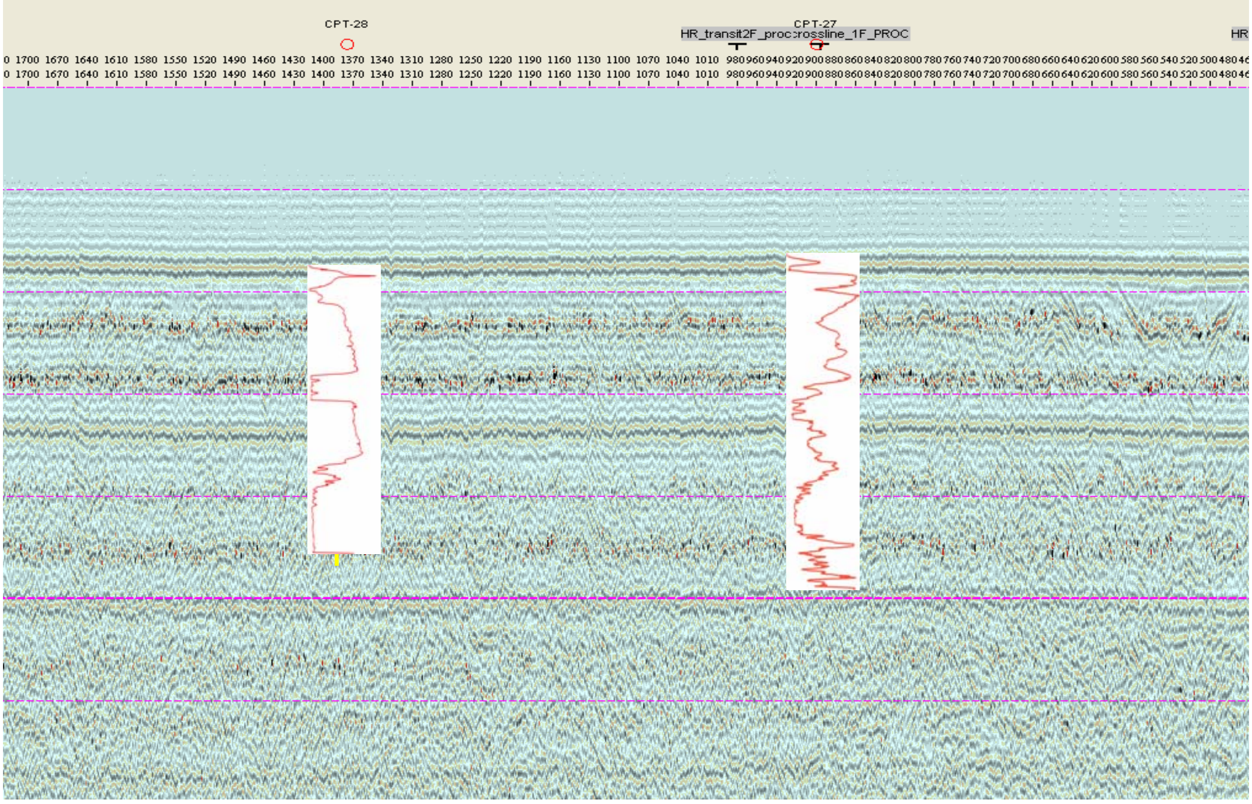
The Seismic line HR 56 in combination with CPT 26 plus Figure 21 (Chart 109) shows, that CPT 26 is located in the weak disturbed zone. This means that below the Holocene deposits exists a rather simple layering in general with an approximately 20m thick glaciofluvial sandy layer above glacial clays.
In CPT 26 1-2m Holocene sand covers more than 20m glaciofluvial sand.

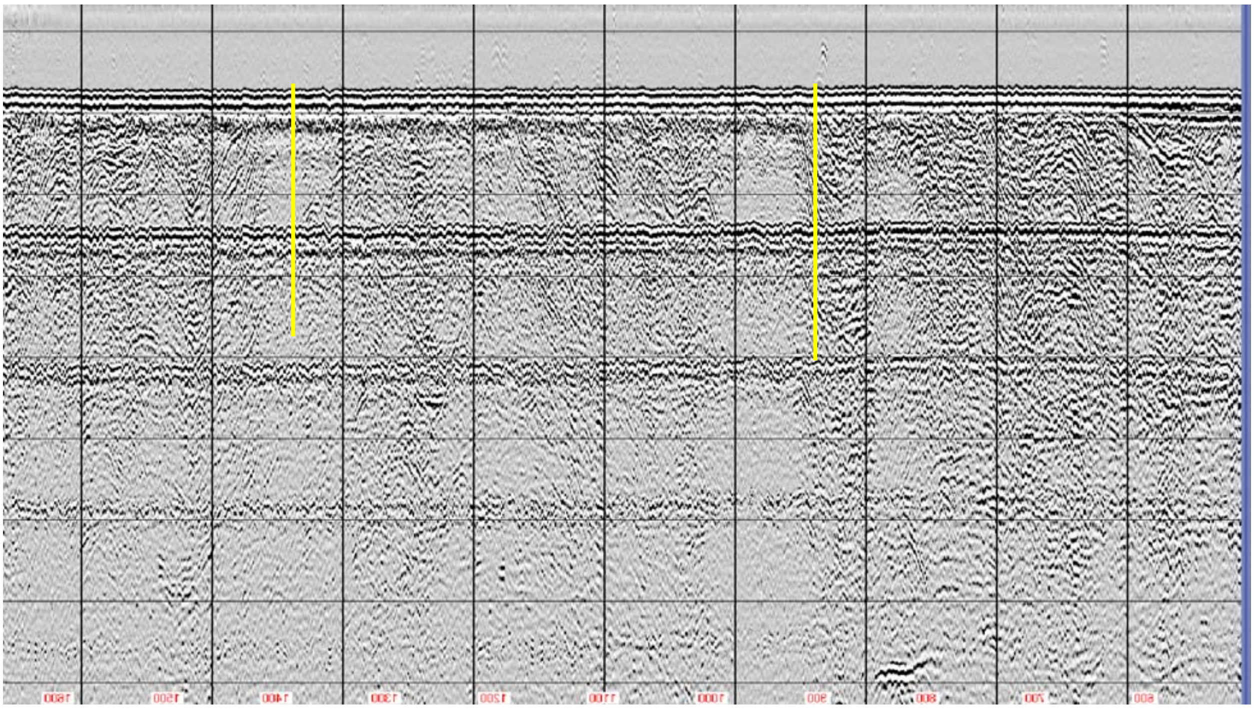




10.1.14 E1 (CPT 27) and E2 (CPT 28)

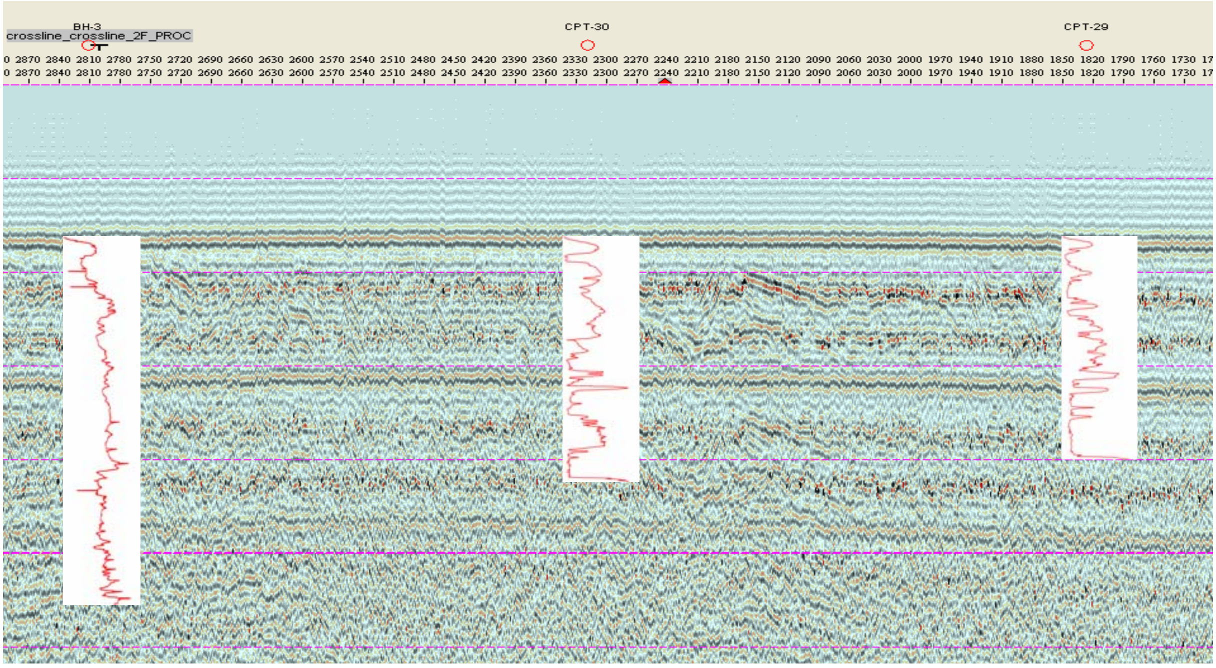
The Seismic line HR 62 in combination with CPT 27 and 28 plus Figure 21 (Chart 109) shows, that CPT 27 and 28 is located in the heavy disturbed zone. This means that It is not possible from the seismic data to establish any stratigraphy and the sediment layering must also be expected to be chaotic with many shifts in lithology. In CPT 27 and 28 1-2 m meter thick Holocene top sand layer covers 30m glacial clay and sand with chaotic bedding.

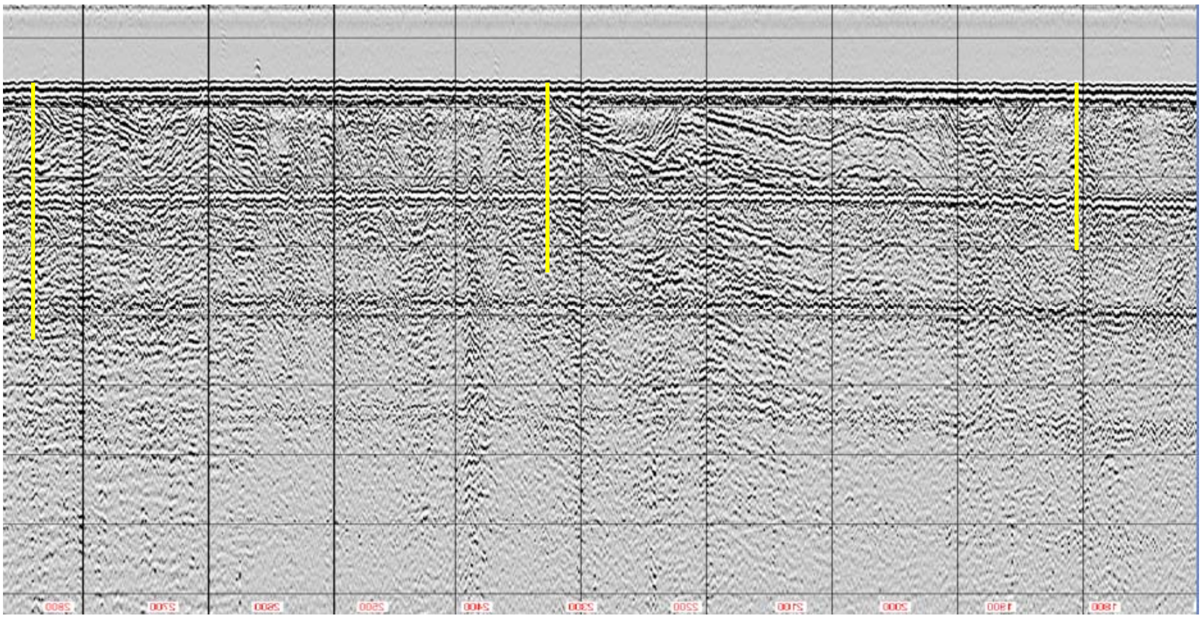




10.1.15 E3 (CPT 29, E4 (CPT 30 and E5 (BH 3(40))

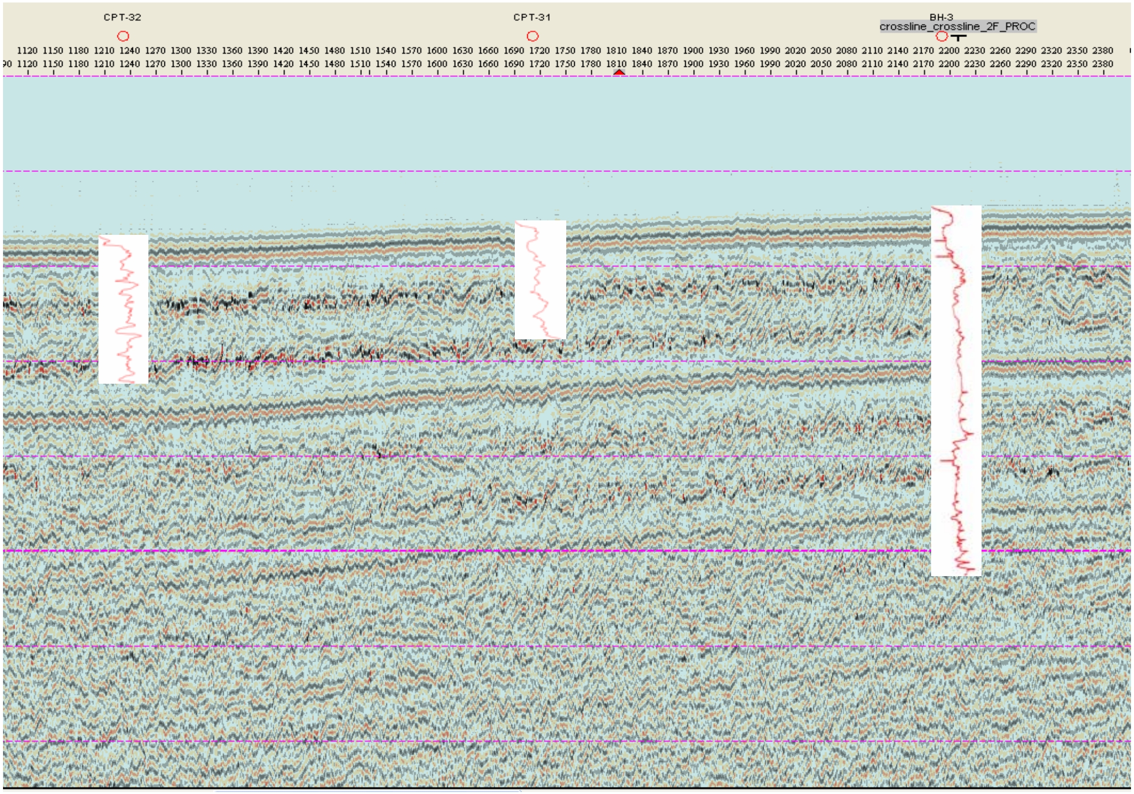
The Seismic line HR 66 in combination with CPT 29, 30 and BH 3 plus Figure 21 (Chart 109) shows, that CPT's29 and 30 are located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. BH 3 is located in the weak disturbed zone. This means that below the Holocene deposits exists a rather simple layering in general with an approximately 20m thick glaciofluvial sandy layer above glacial clays. In CPT 29 and 30 2-3m meter thick Holocene top sand layer covers 25m glacial clay and sand. In BH 3 6m Holocene sand covers more than 30m glaciofluvial sand.

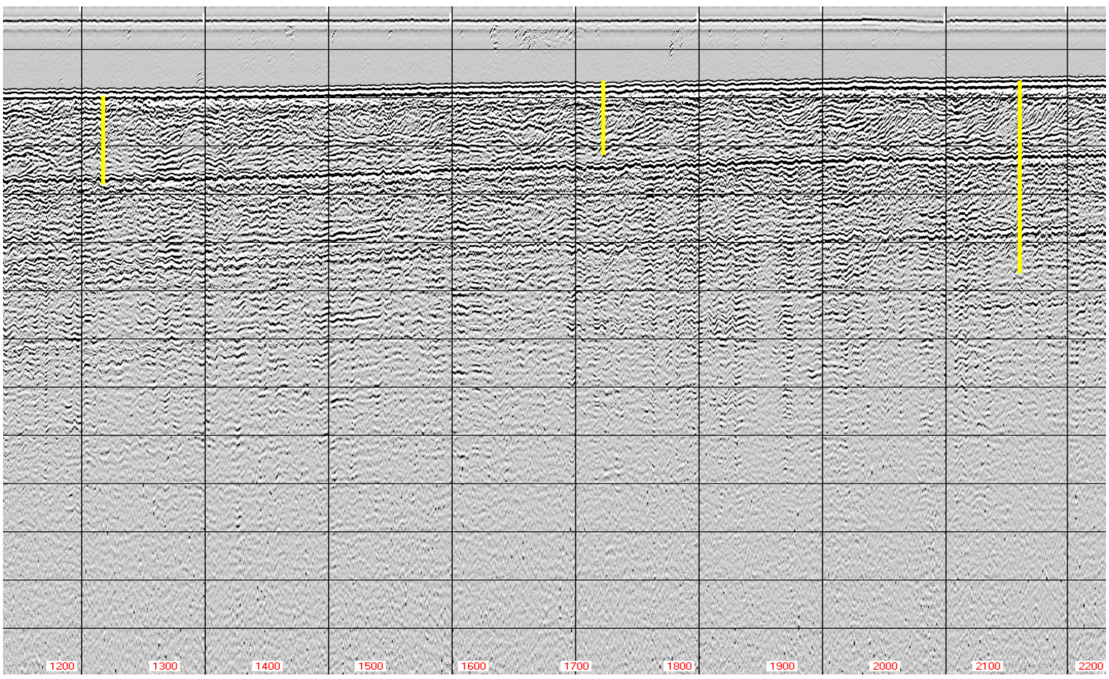




10.1.16 E6 (CPT 31), E7 (CPT 32) and E5 (BH 3(40)

The Seismic line HR 72 in combination with CPT 21, 32 and BH 3 plus Figure 21 (Chart 109) shows, that they all are located in the weak disturbed zone. This means that below the Holocene deposits exists a rather simple layering in general with an approximately 20m thick glaciofluvial sandy layer above glacial clays. In CPT 31and 32 about 3m Holocene sand covers more than 30m glaciofluvial sand.

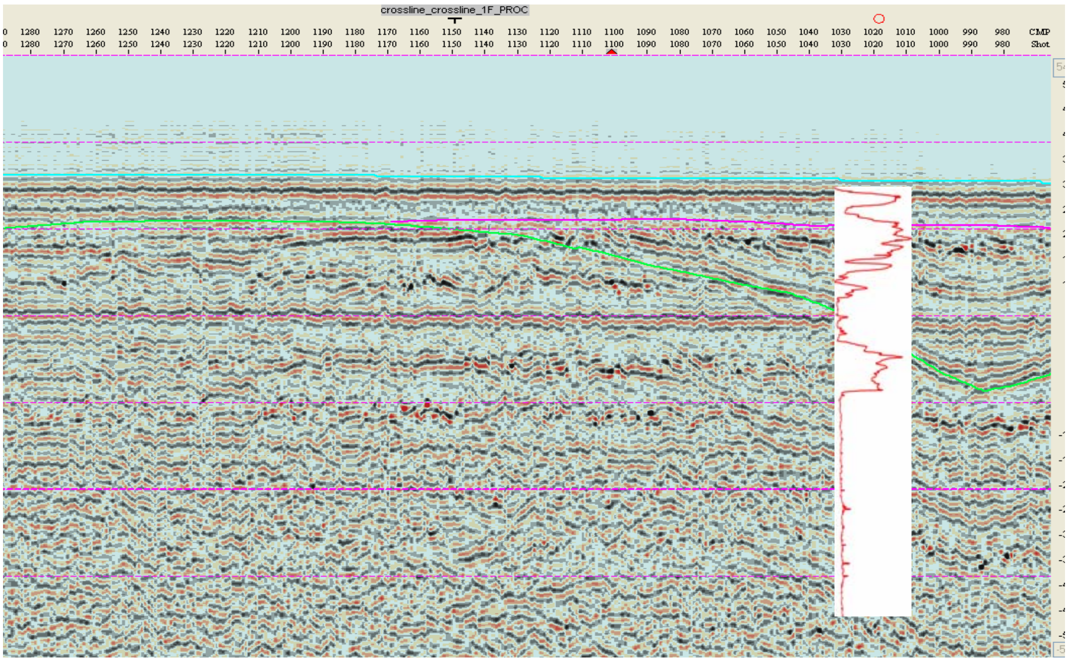


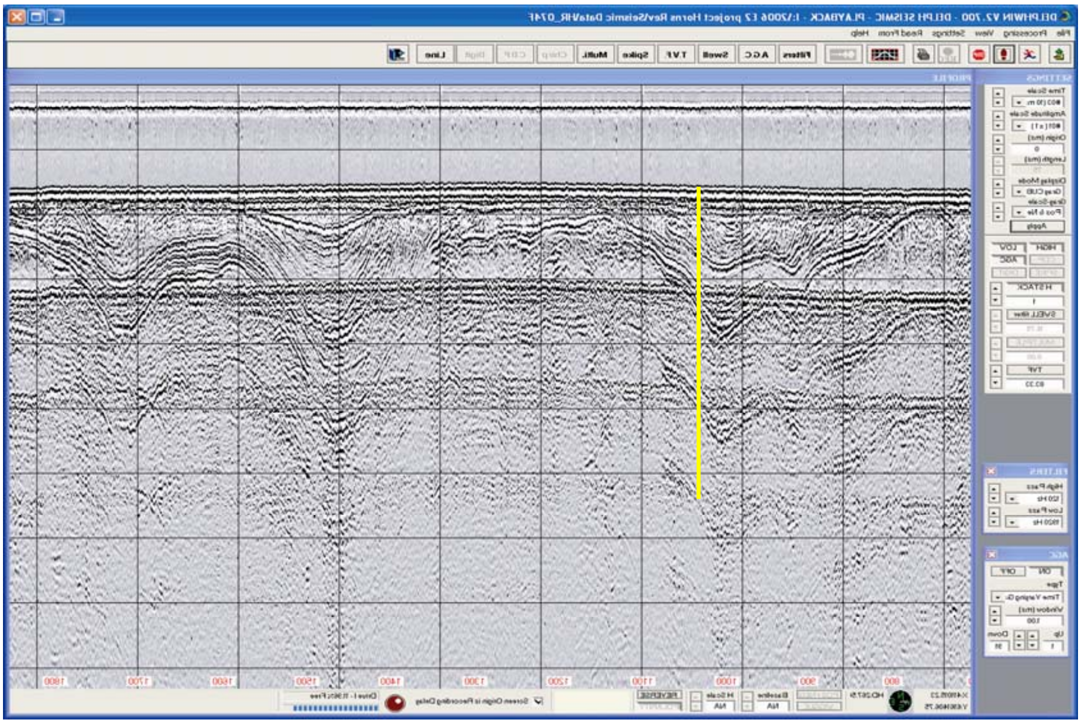


10.1.17 F1 (CPT 33) and F1 (VIB 33)

The Seismic line HR 74 in combination with CPT 33, vibrocore 33 plus Figure 21 (Chart 109) shows, that CPT33 and VIB 33 is located in the fluvial deposits zone in elongated depressions, in general following the depressions in the synclinals from the folded areas. 2 meter thick Holocene top sand layer exists, above an infilled valley consisting of about 5m sand on top of 4m clay.

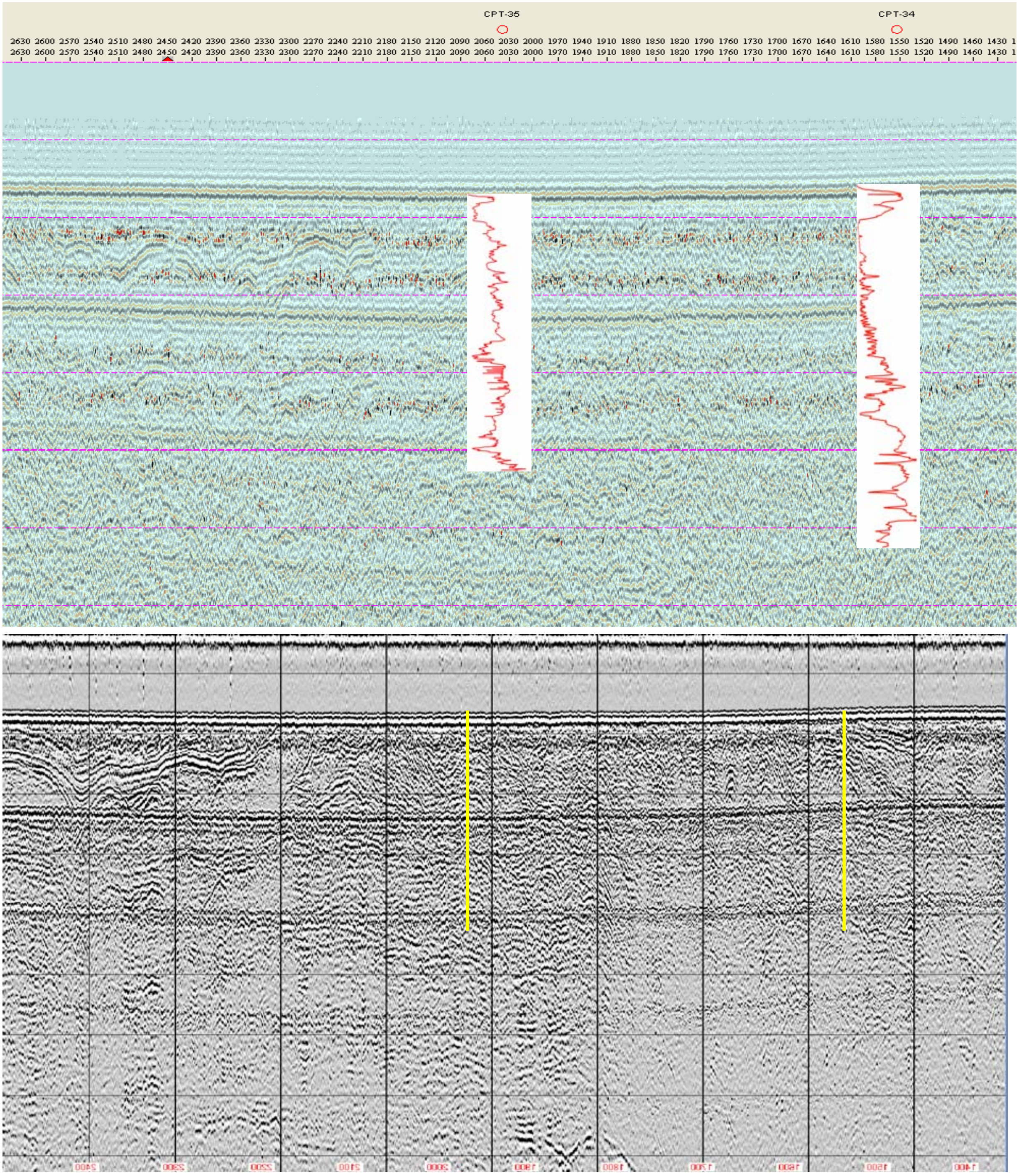
Below the channel we have glacial deposits consisting of about 5m sand on top of more than 15m clay that could be melt water clay or interglacial clay.





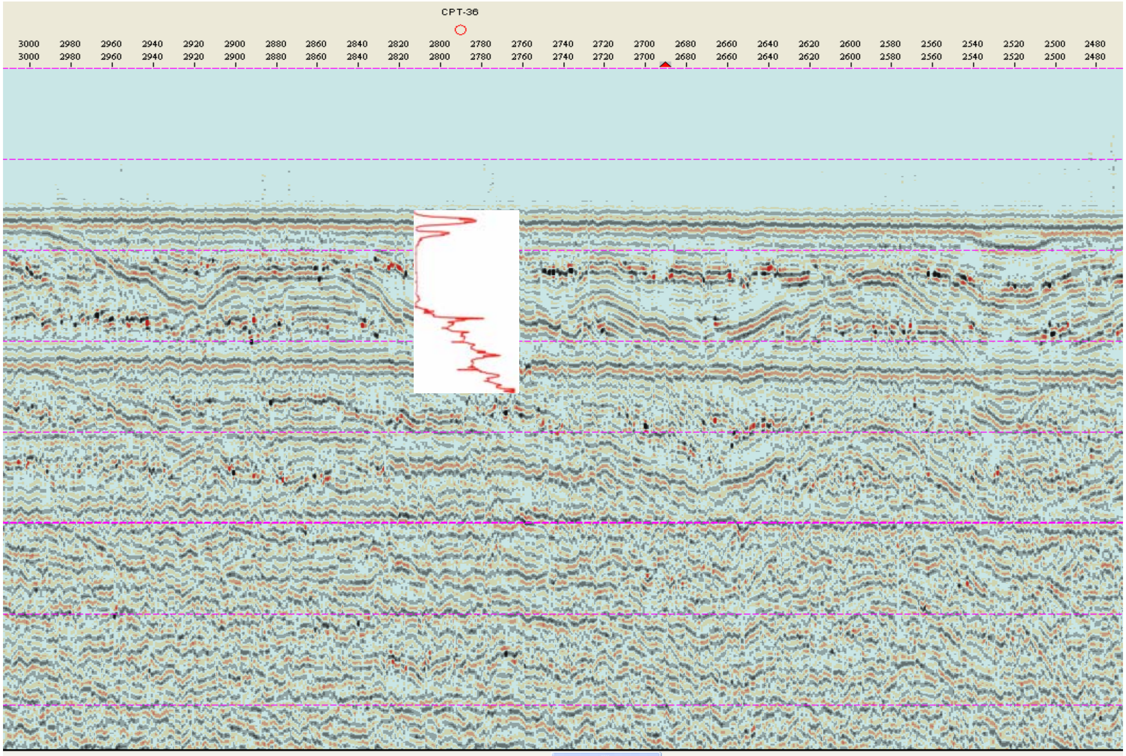
10.1.18 F2 (CPT 34), F2 (VIB 34) and F3 (CPT 35)

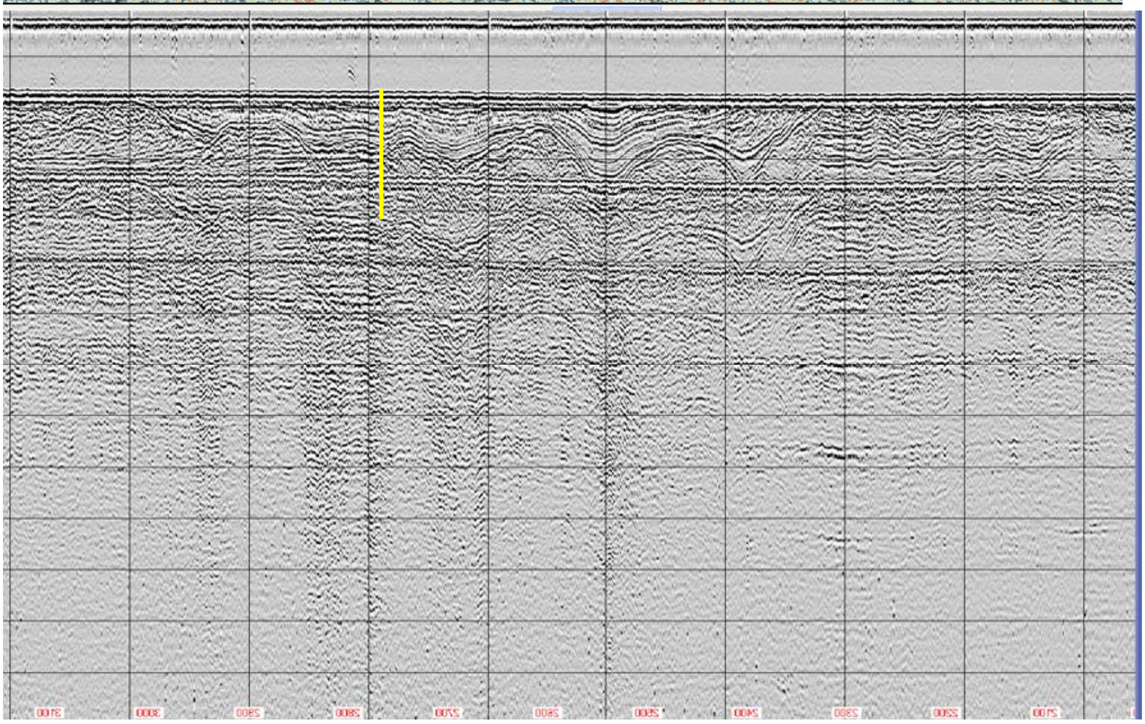
The Seismic line HR78 in combination with CPT 34, vibrocore 34 and CPT 35 plus Figure 21 (Chart 109) shows, that they both are located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. Between the CPT's a heavy disturbed zone exists. In CPT 34 and 35 3m meter thick Holocene top sand layer covers 25m glacial clay and sand. VIB-34 indicates that the uppermost 2m of the clay is marine.



10.1.19 F4 (CPT 36) and F4 (VIB 36)

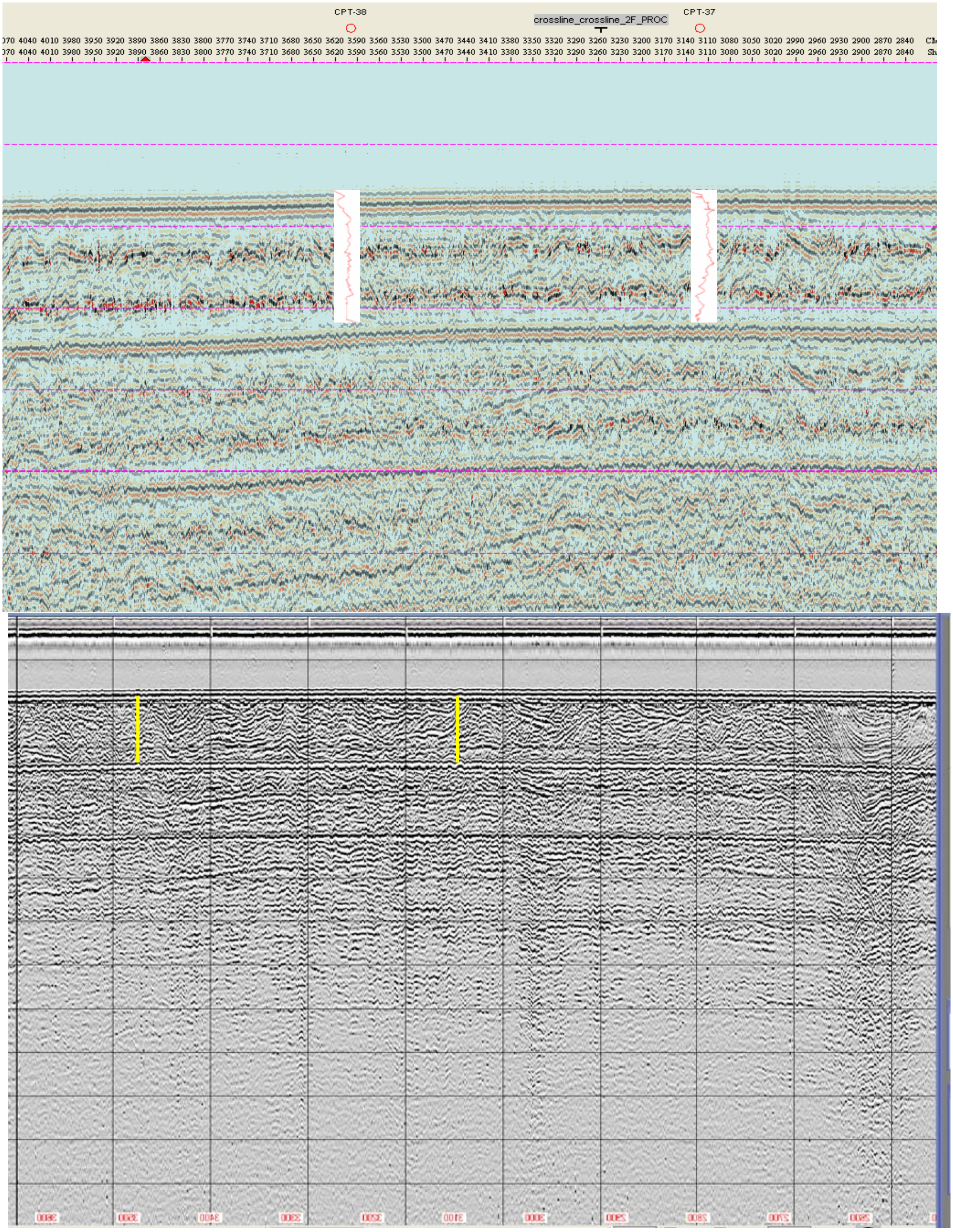
The Seismic line HR 82 in combination with CPT 36, vibrocore 36 plus Figure 21 (Chart 109) shows, that CPT 36 is located in the fluvial deposits zone in elongated depressions, in general following the depressions in the synclinals. 1.8m Holocene top sand layer exists above 2m silt and 2.5m clay with few shells. The clay is deposited in a channel like structure above the glacially folded deposits and is believed to be either Holocene or Eemian interglacial clay. Below the clay follows about 7m of glacially disturbed sand.





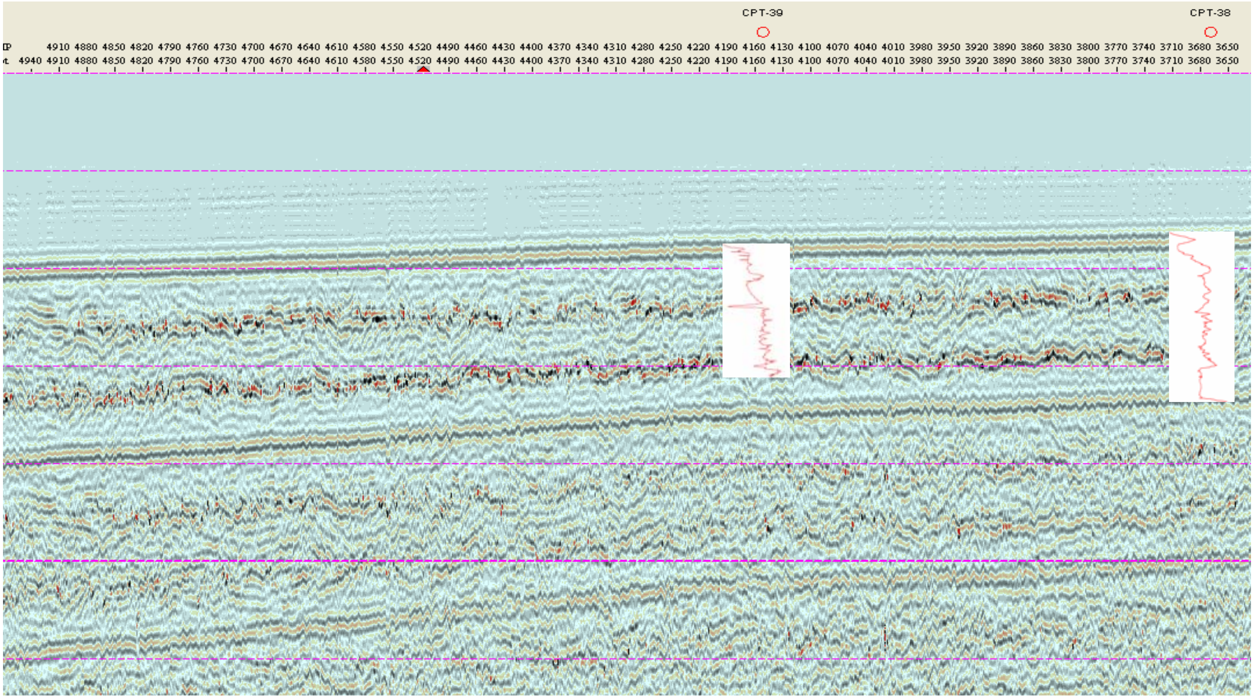
10.1.20 F5 (CPT 37) and F6 (CPT 38)

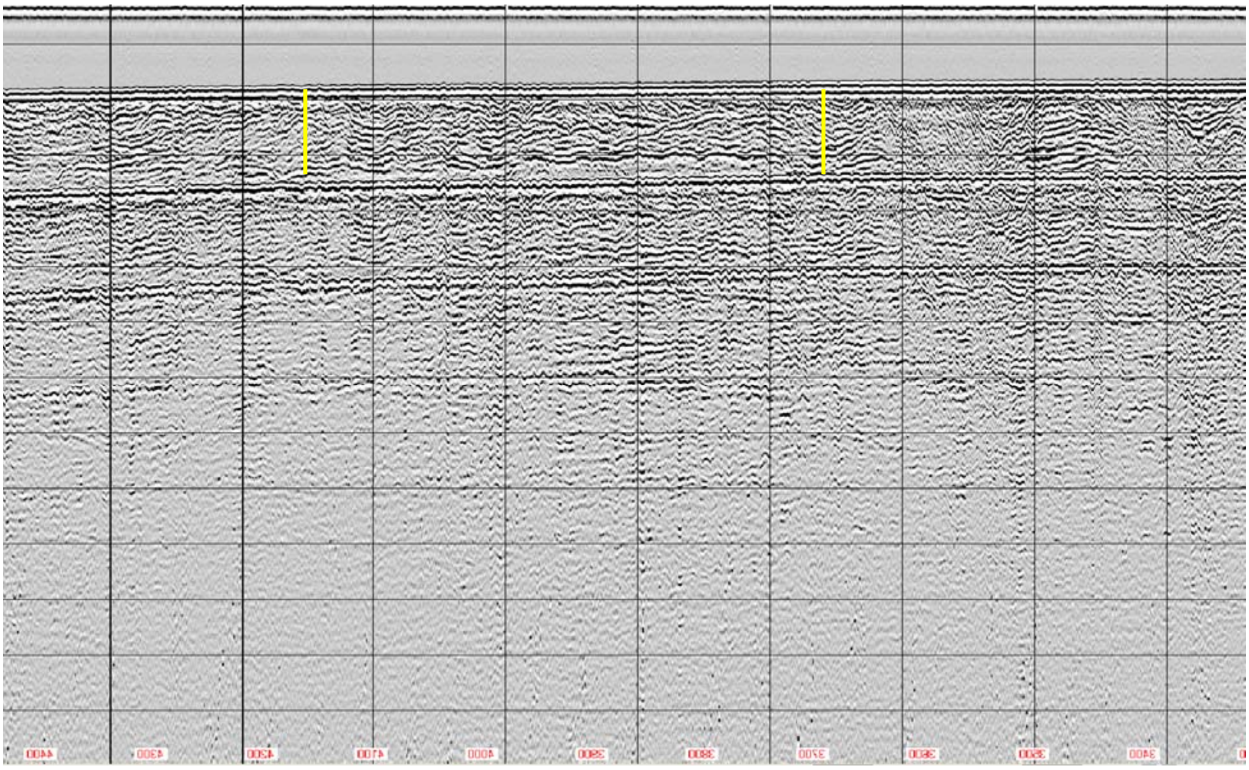
The Seismic line HR 86 in combination with CPT 37 and 38 plus Figure 21 (Chart 109) shows, that they are located in the weak disturbed zone. This means that below the Holocene deposits exists a rather simple layering in general with an approximately 20m thick glaciofluvial sandy layer above glacial clays. In CPT 37 and 38 little m Holocene sand covers more than 10m glaciofluvial sand (more than 20m according to the seismic data).



10.1.21 F6 (CPT 38) and F7 (CPT 39)

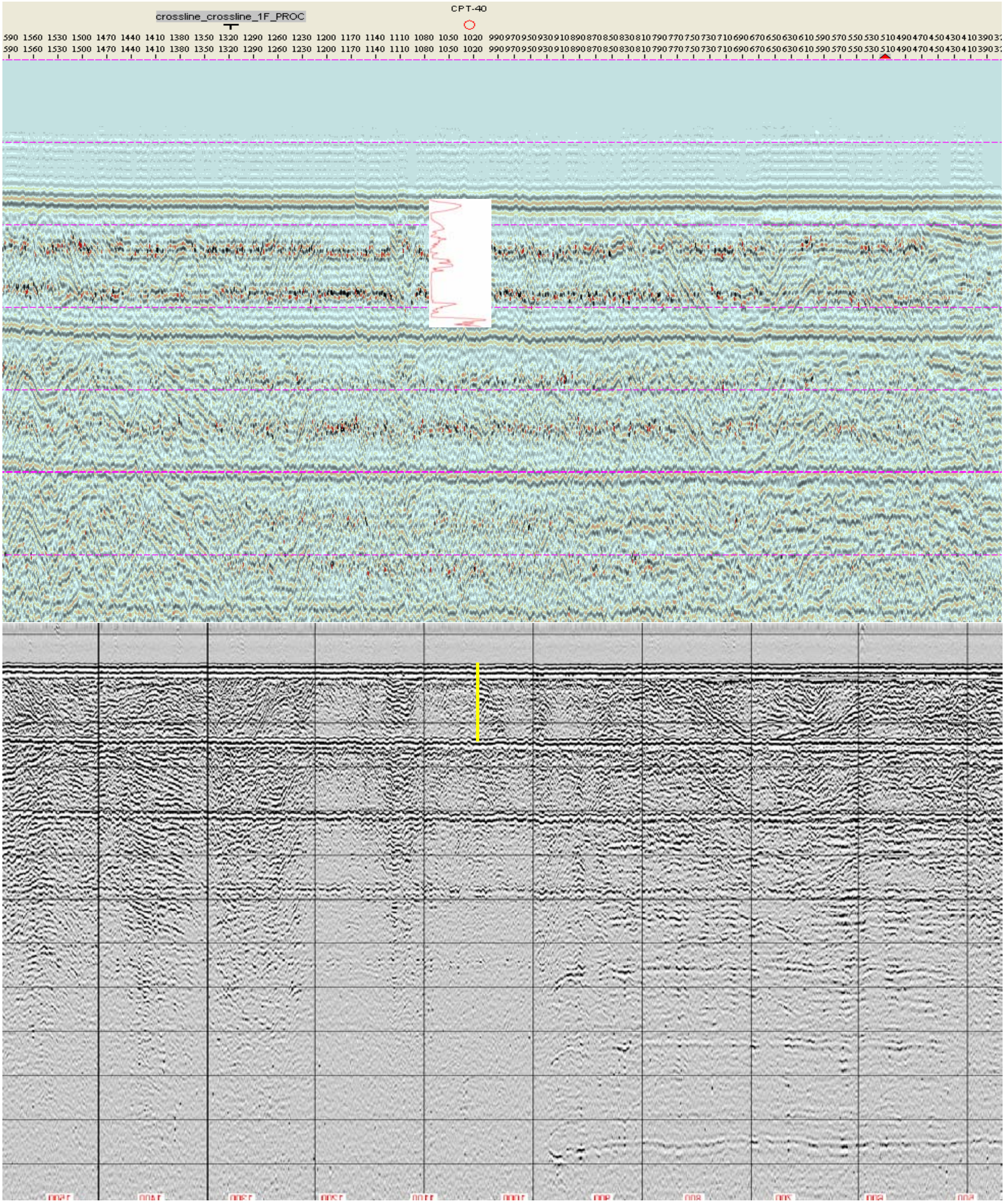
The Seismic line HR 90 in combination with CPT 38 and 39 plus Figure 21 (Chart 109) shows, that they are located in the weak disturbed zone. This means that below the Holocene deposits exists a rather simple layering in general with an approximately 20m thick glaciofluvial sandy layer above glacial clays. In CPT 38 and 39 few m Holocene sand covers more than 10m glaciofluvial sand (more than 20m according to the seismic data).





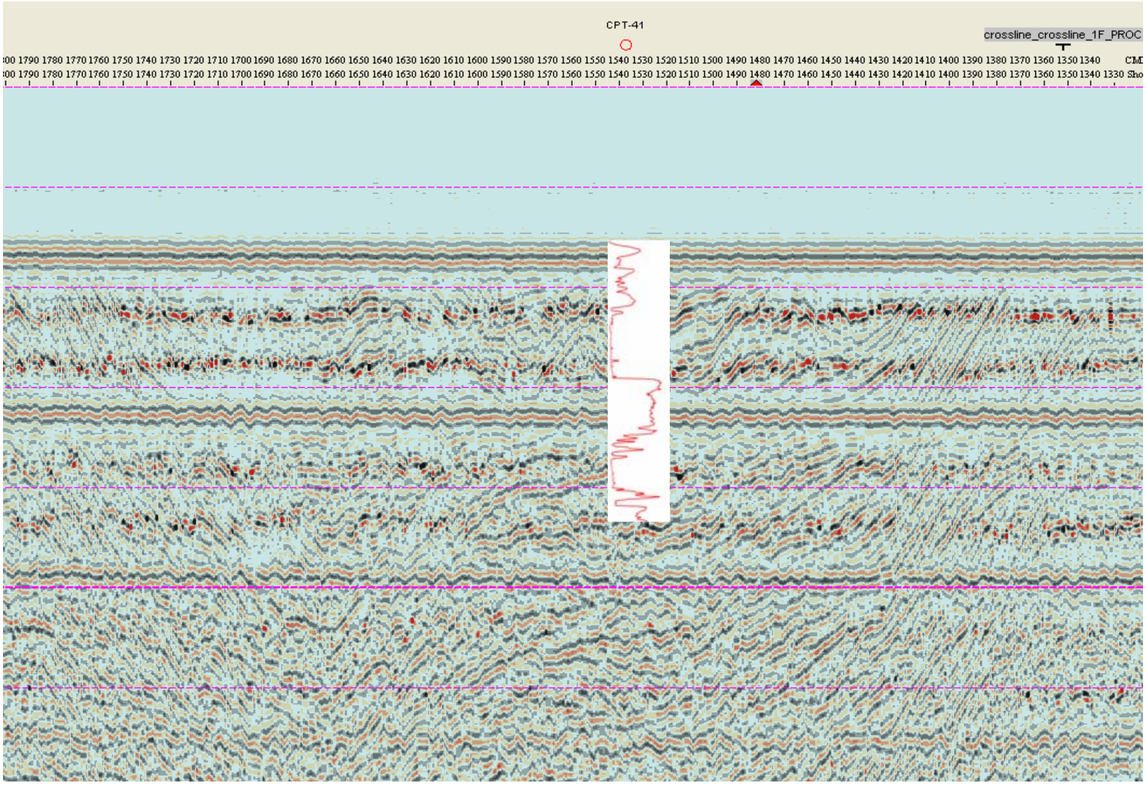
10.1.22 G1 (CPT 40)

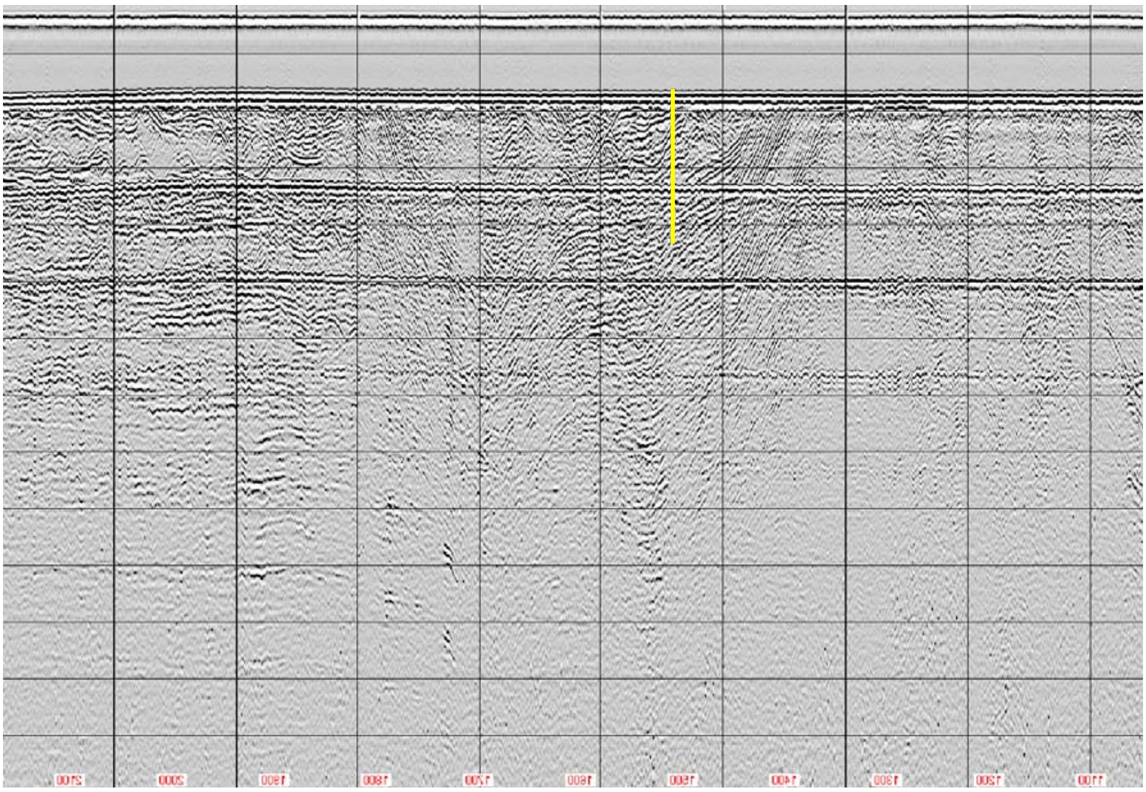
The Seismic line HR 86 in combination with CPT 40 plus Figure 21 (Chart 109) shows, that CPT 40 is located in the heavy disturbed zone. This means that it is not possible from the seismic data to establish any stratigraphy and the sediment layering must also be expected to be chaotic with many shifts in lithology. In CPT 40 1-2 m meter thick Holocene top sand layer covers 15m glacial clay and sand with chaotic bedding.



10.1.23 G2 (CPT 41)

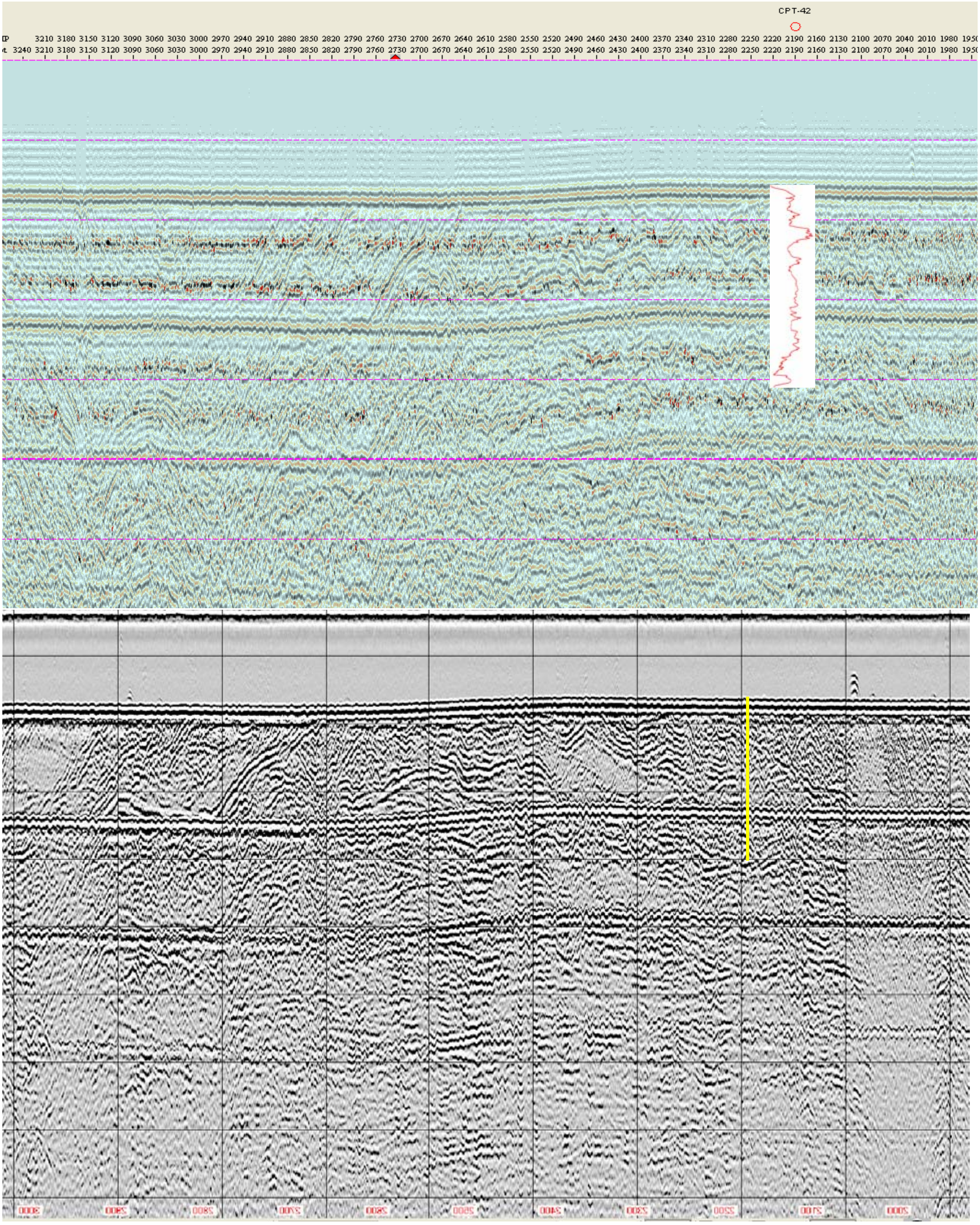
The Seismic line HR90 in combination with CPT 41 plus Figure 21 (Chart 109) shows, that CPT 41 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. In CPT 41 a few meter thick Holocene top sand layer covers 25m glacial clay and sand.





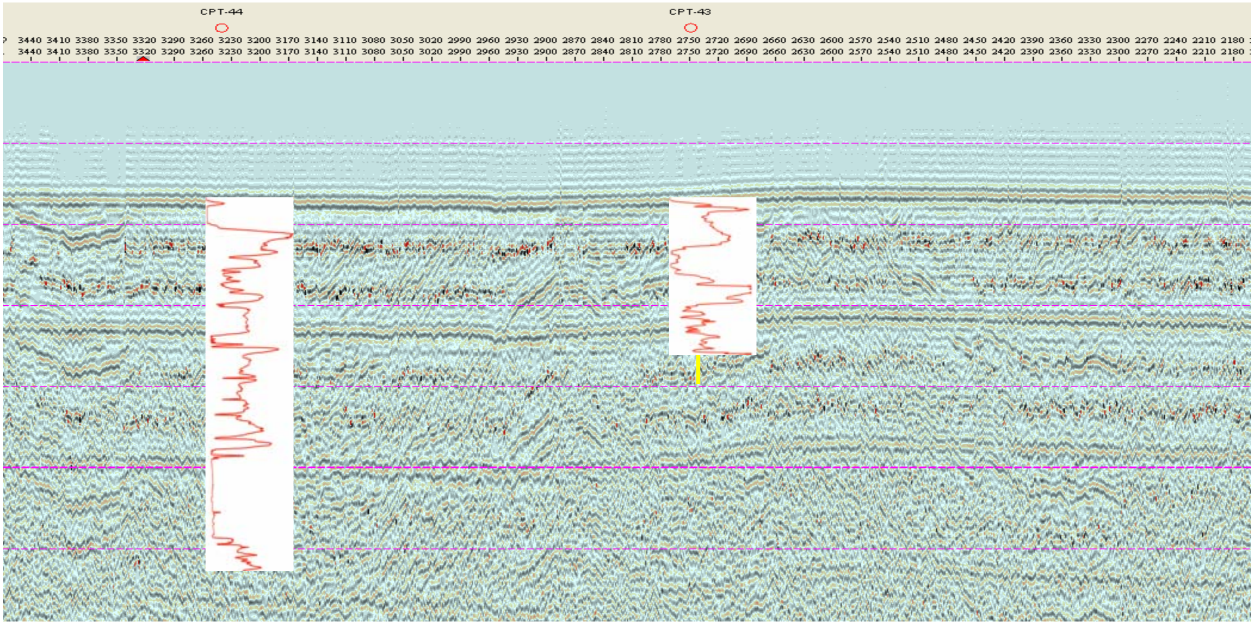
10.1.24 G3 (CPT 42)

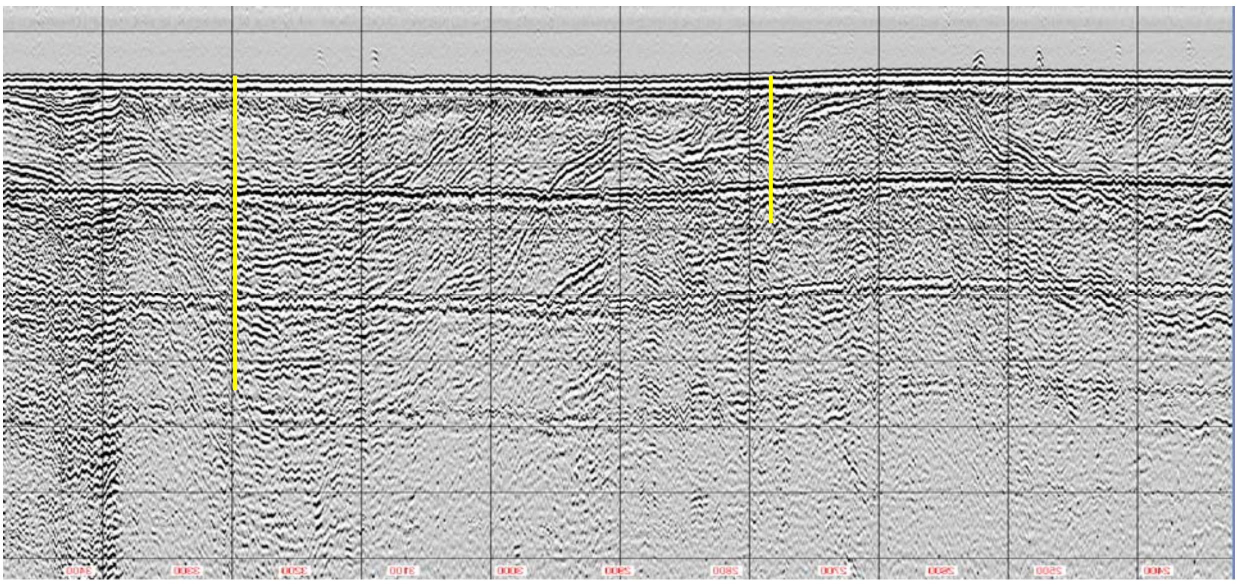
The Seismic line HR94 in combination with CPT 42 plus Figure 21 (Chart 109) shows, that CPT 42 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. In CPT42 a thin Holocene top sand layer covers 20m glacial clay and sand.



10.1.25 G4 (CPT 43), G5 (CPT 44) and G5 (VIB 44)

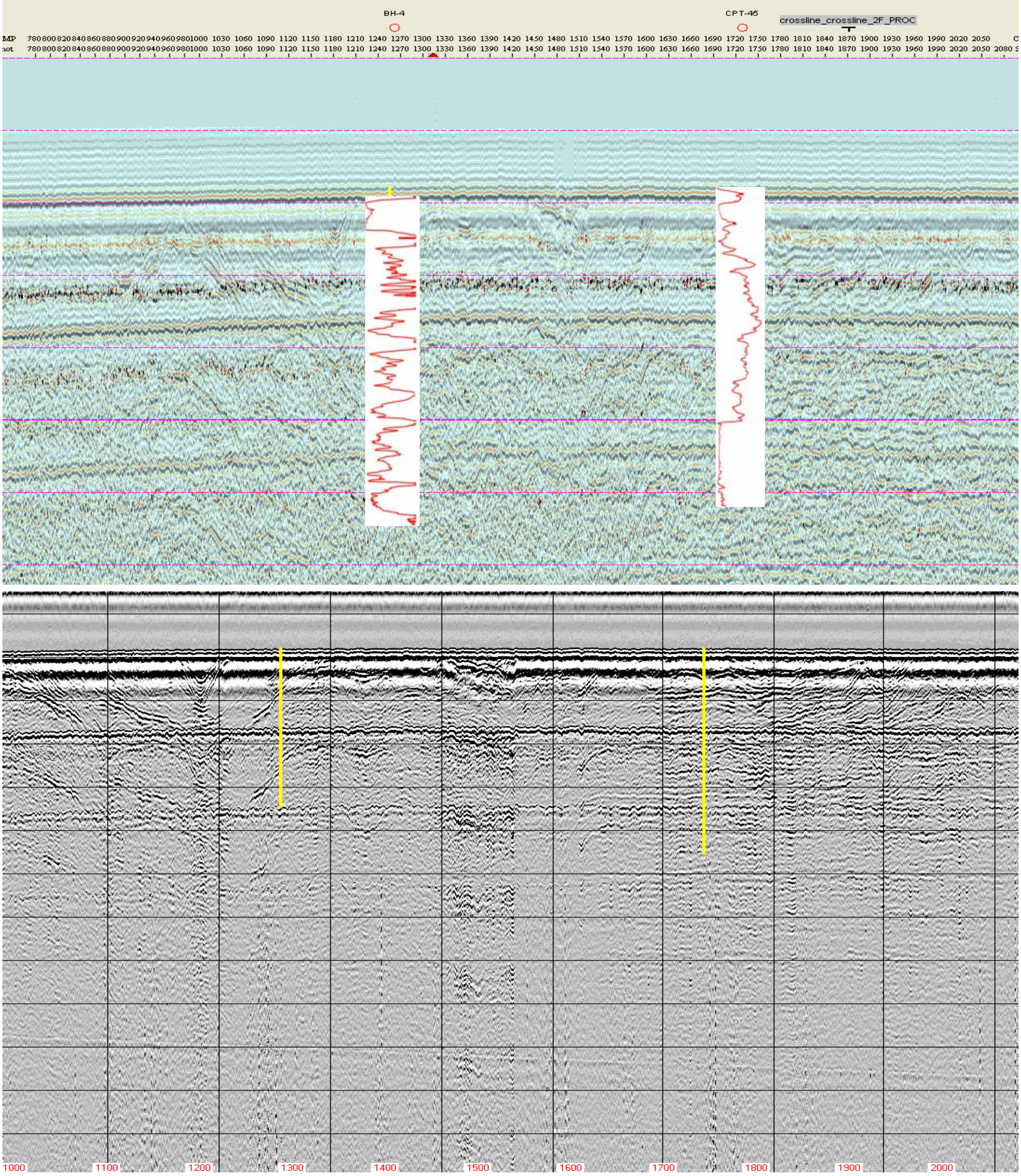
The Seismic line HR 98 in combination with CPT 43, 44 and vibrocore 44 plus Figure 21 (Chart 109) show, that CPT43 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. CPT44 is located in the fluvial deposits zone in elongated depressions, in general following the depressions in the synclinals from the folded areas. In CPT 43 a thin Holocene top sand layer exists above about 10m (seismic indication of about 20m) layered sand and clay. In CPT 44 a 0.7m Holocene top sand layer is found above a valley with Holocene/Eemian infill consisting of about 3m gyttja with shells on top of 3-4m sand and 4m clay. Below the channel we have glacial deposits consisting of about 4m sand on top of more than 15m glacial disturbed sand that could be melt water sand. Then follows above 10m clay, melt water or interglacial, which also is glacial disturbed. At the bottom we find 5m sand.
The clay layer is dipping westward and is coming closer to the surface east of CPT 44. It is probably the same stratigraphic layer we find in CPT 43 about 13m below seabed.





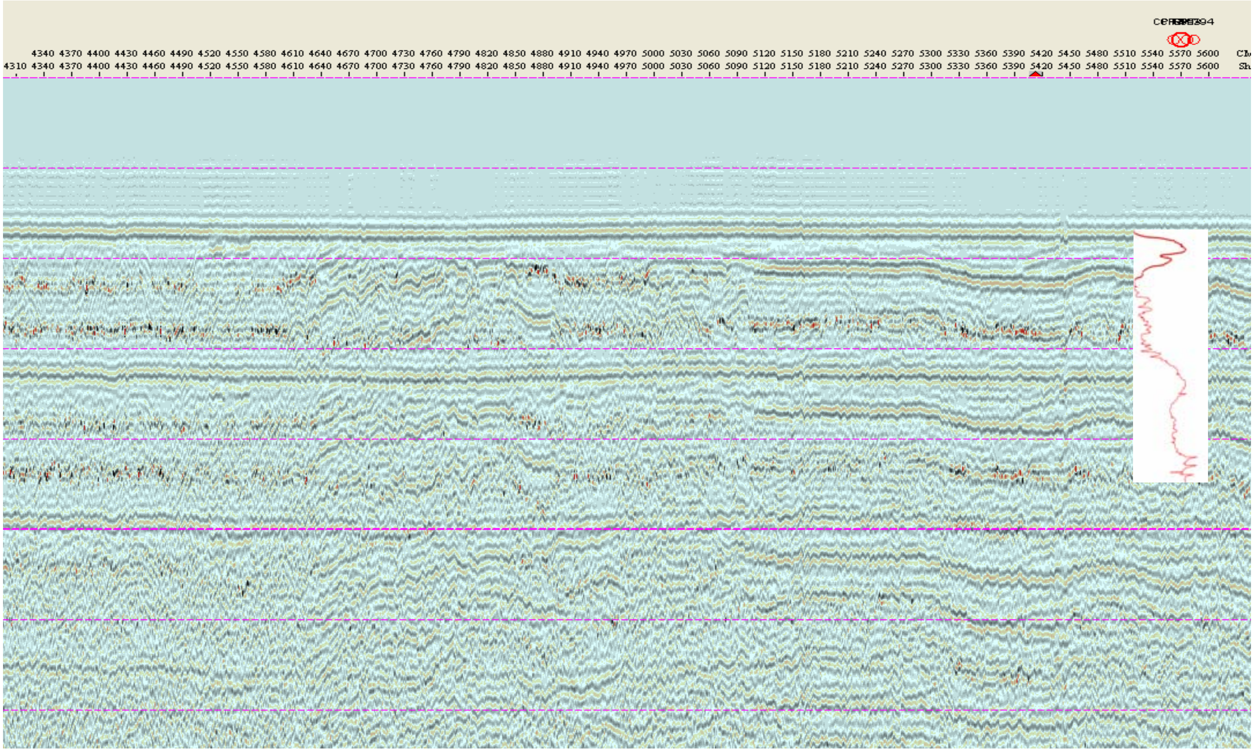
10.1.26 G6 (CPT 45) and G7 (BH 4(40))

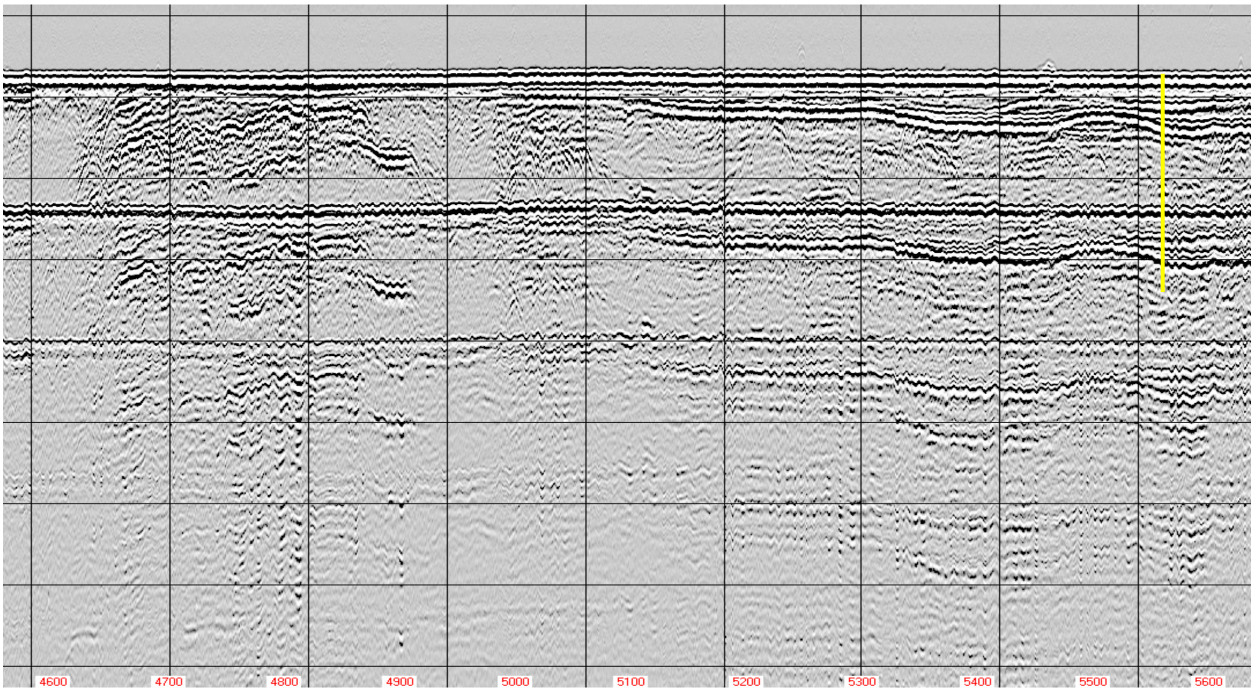
The Seismic line HR 108 in combination with CPT 45 and BH 4 plus Figure 21 (Chart 109) show, that CPT45 and BH 4 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. CPT 45 shows an about 2m Holocene top sand layer above about 33m glacial folded deposits that consist of about 23m sand above 10 m clay. CPT 45 is located just east of a channel. BH 4 shows 2.5m Holocene top sand above glacial deposits consisting of 7m gravely sand and about 40m mainly sand.



10.1.27 SUB1 (CPT 93), SUB4 (BH 7(40))

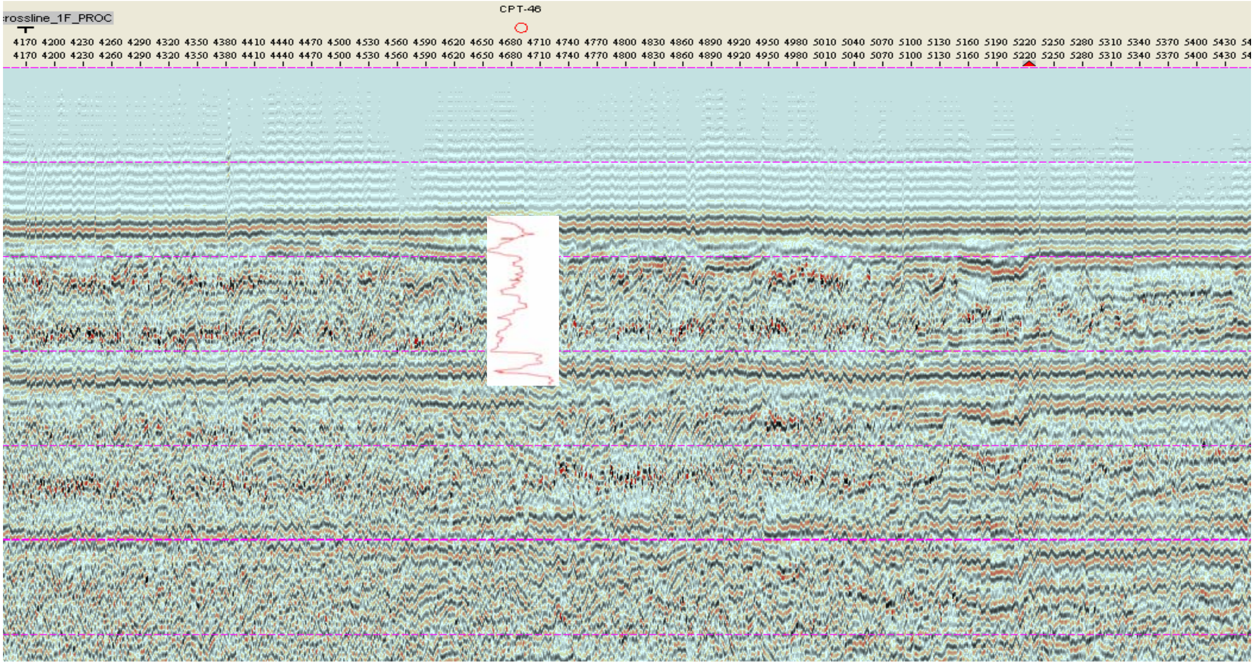
The Seismic line HR 92 in combination with CPT 93, BH 7 plus Figure 21 (Chart 109) show, that CPT 93, BH 7 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. CPT 93, BH 7 shows a 7m Holocene top layer consisting of 3m sand above 2m gyttja with shells (Pollen analysis paragraph 9.1.2) and 2m sand with shells. Below the Holocene top layer about 40m glacial deposits (mainly sand) is recorded.

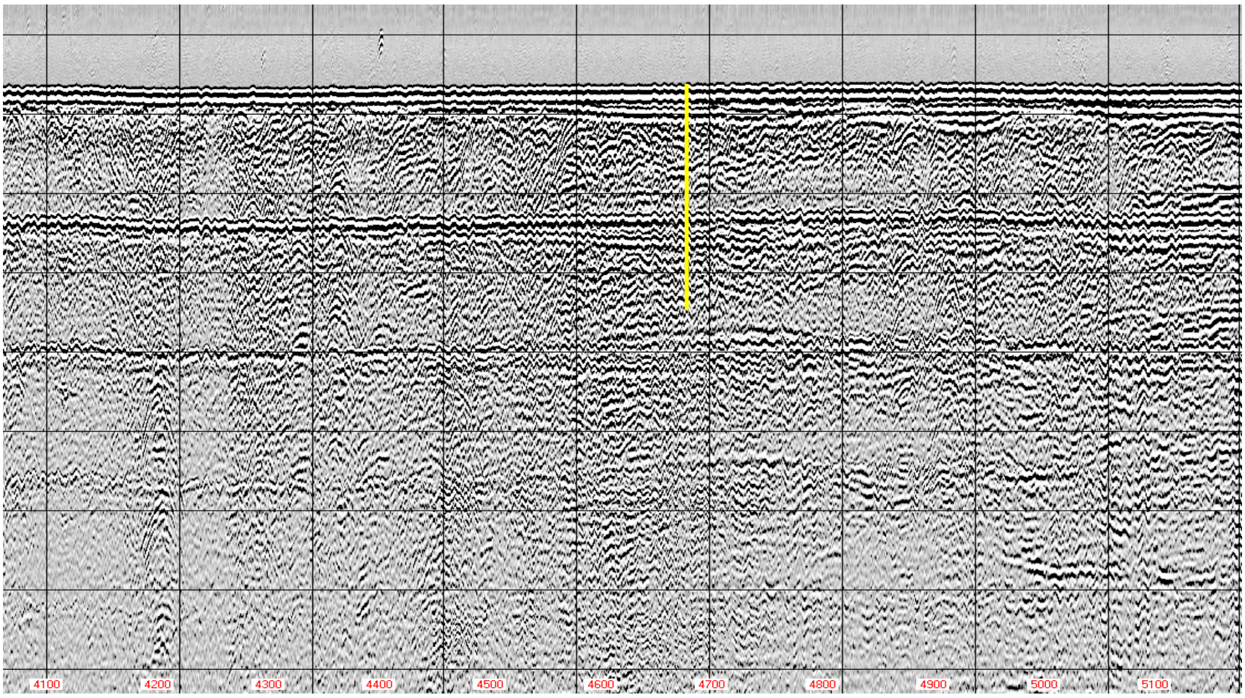




10.1.28 H1 (CPT 46)

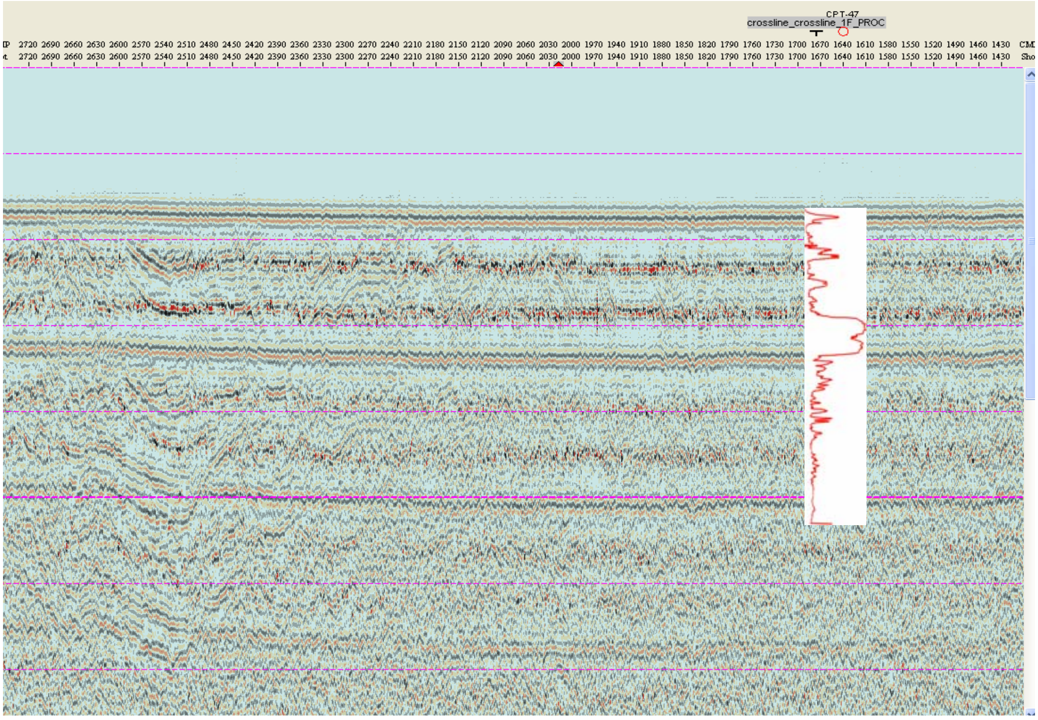
The Seismic line HR 100 in combination with CPT 46 plus Figure 21 (Chart 109) show, that CPT 46 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. CPT 46 shows 3m Holocene top sand layer above about 15m glacial sand and clay deposits (seismic evidence of 25m glacial deposits).

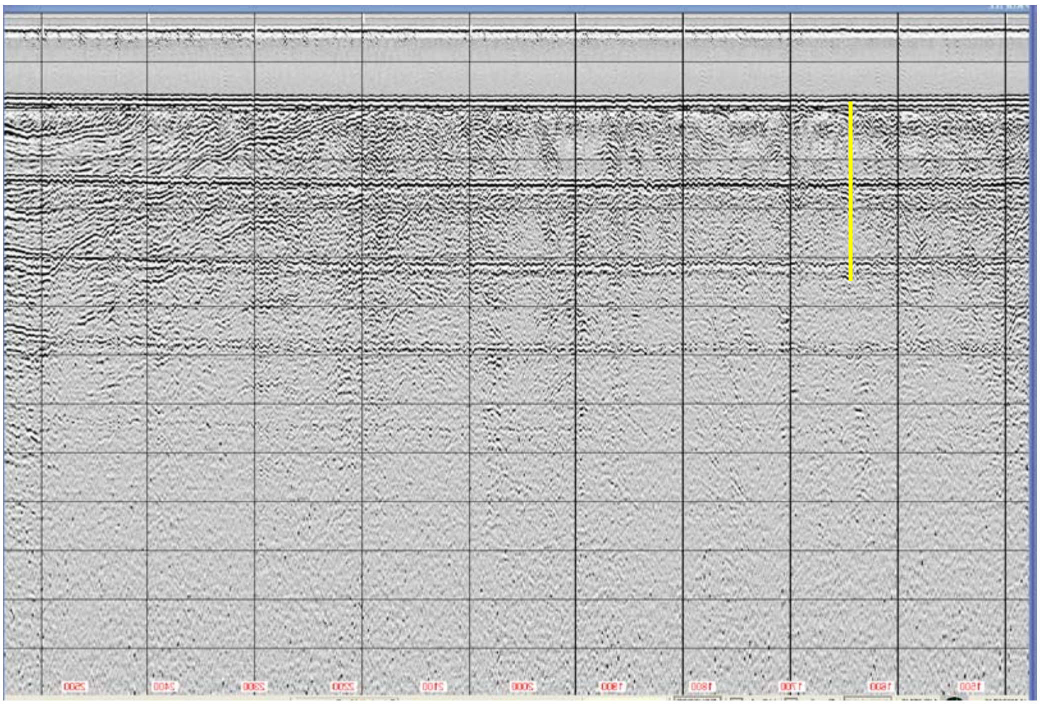




10.1.29 H2 (CPT 47)

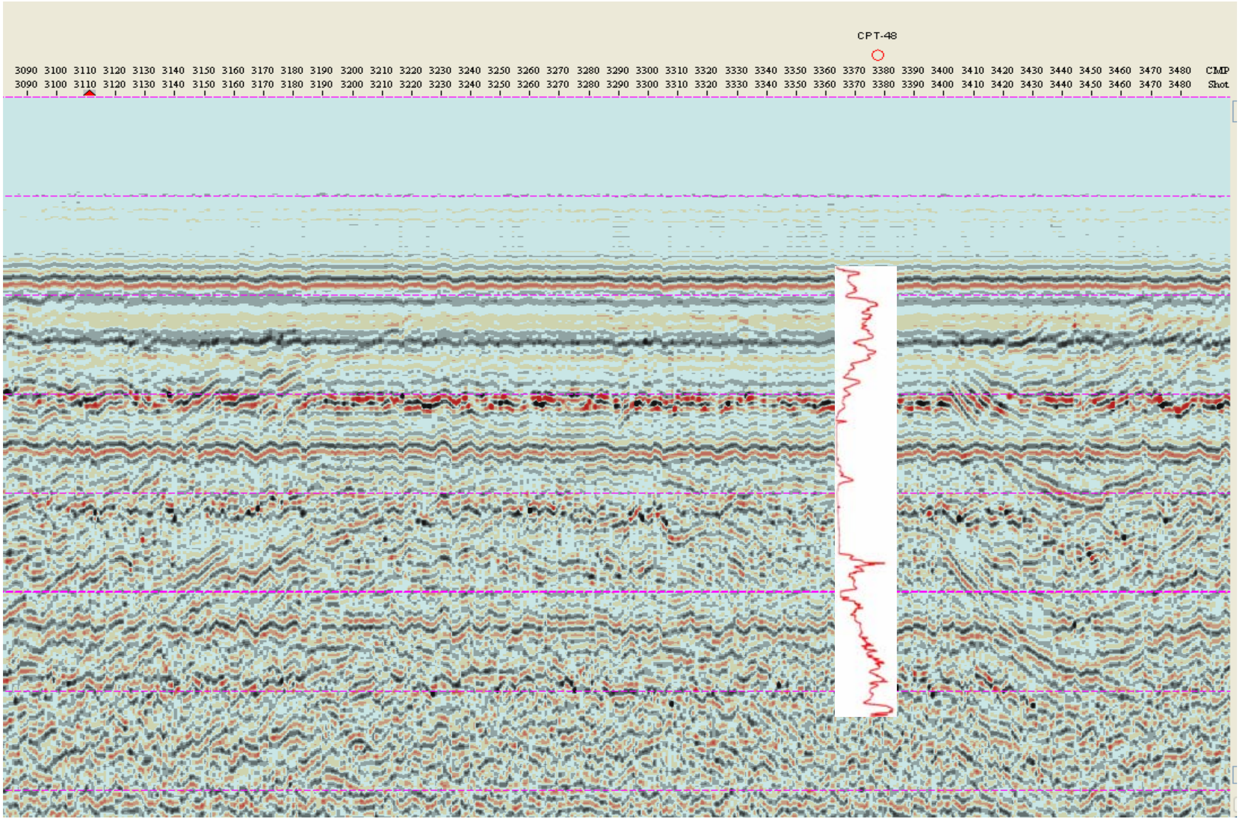
The Seismic line HR 102 in combination with CPT 47 plus Figure 21 (Chart 109) shows, that CPT 47 is located in the heavy disturbed zone. This means that it is not possible from the seismic data to establish any stratigraphy and the sediment layering must also be expected to be chaotic with many shifts in lithology. In CPT 47 1-2 m meter thick Holocene top sand layer covers 30m glacial clay and sand with chaotic bedding.

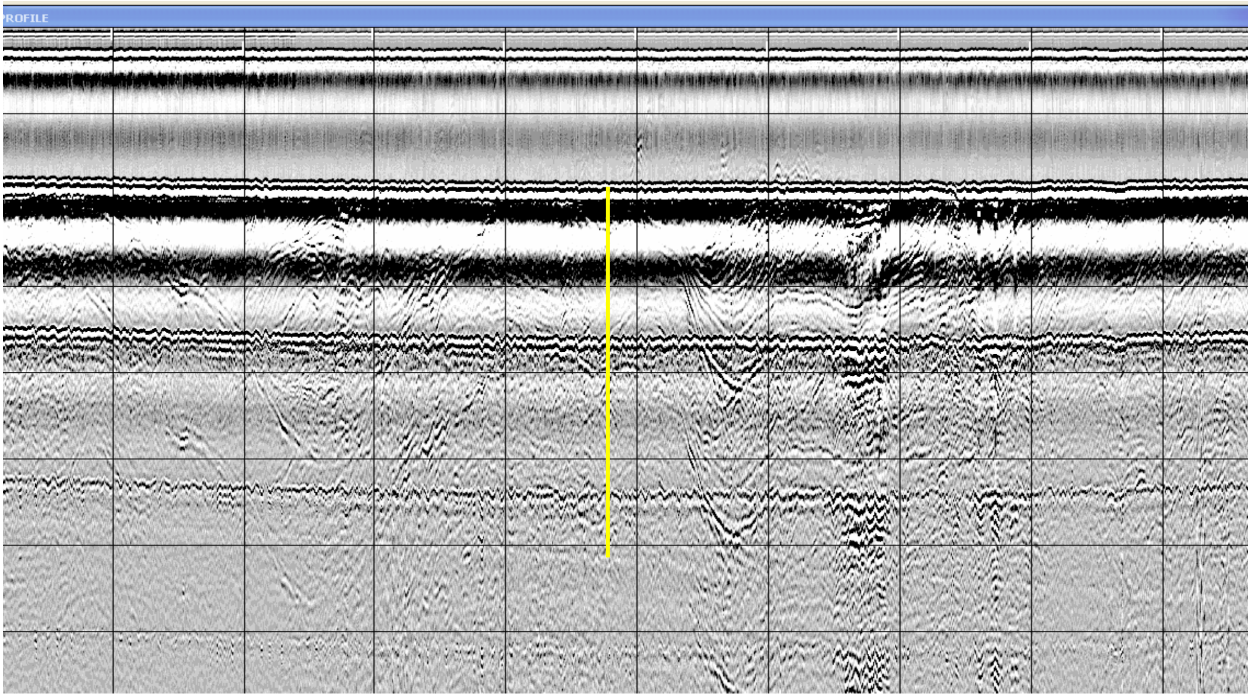




10.1.30 H3 (CPT 48)

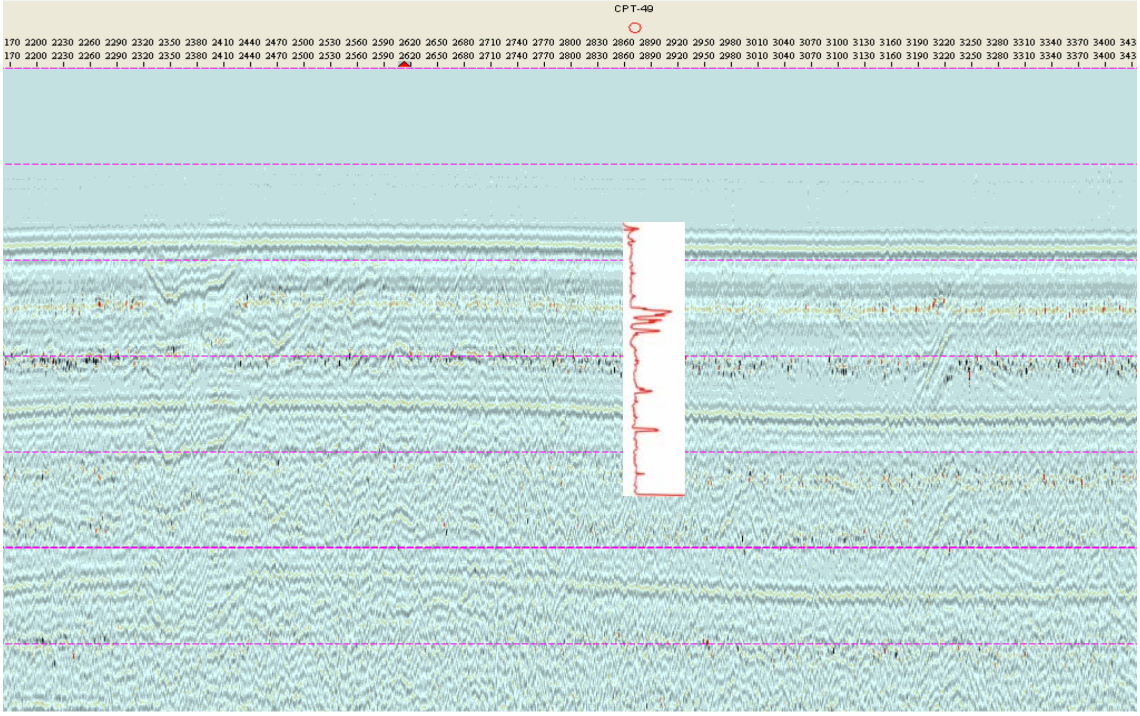
The Seismic line HR 108 in combination with CPT 48 plus Figure 21 (Chart 109) show, that CPT48 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. 2m Holocene top sand layer above more than 30m glacial disturbed deposits consisting of 10m sand, 13m melt water or interglacial clay and 8m sand.

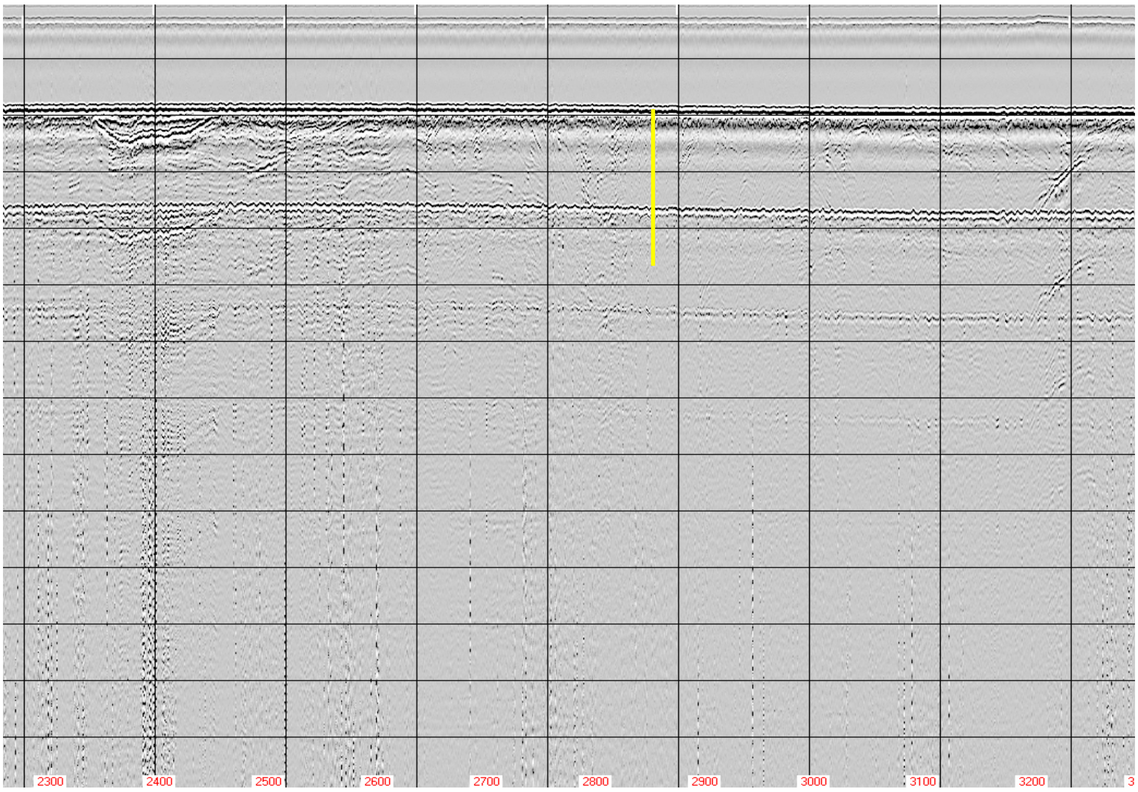




10.1.31 H4 (CPT 49), H4 (VIB 49)

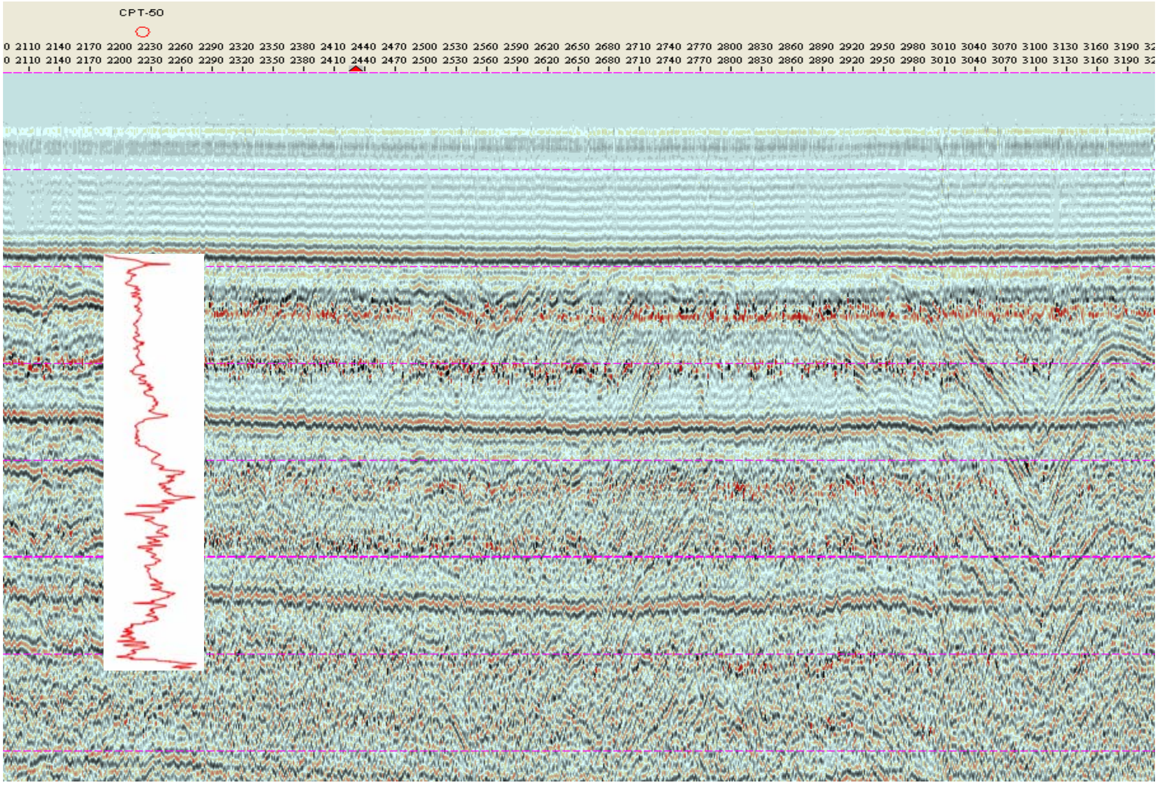
The Seismic line HR 112 in combination with CPT 49, vibrocore 49 plus Figure 21 (Chart 109) shows, that CPT 49, vibrocore 49 is located in the heavy disturbed zone. This means that it is not possible from the seismic data to establish any stratigraphy and the sediment layering must also be expected to be chaotic with many shifts in lithology. In CPT 49, vibrocore 49 2 m thick Holocene top sand layer covers 20m glacial clay and sand with chaotic bedding.

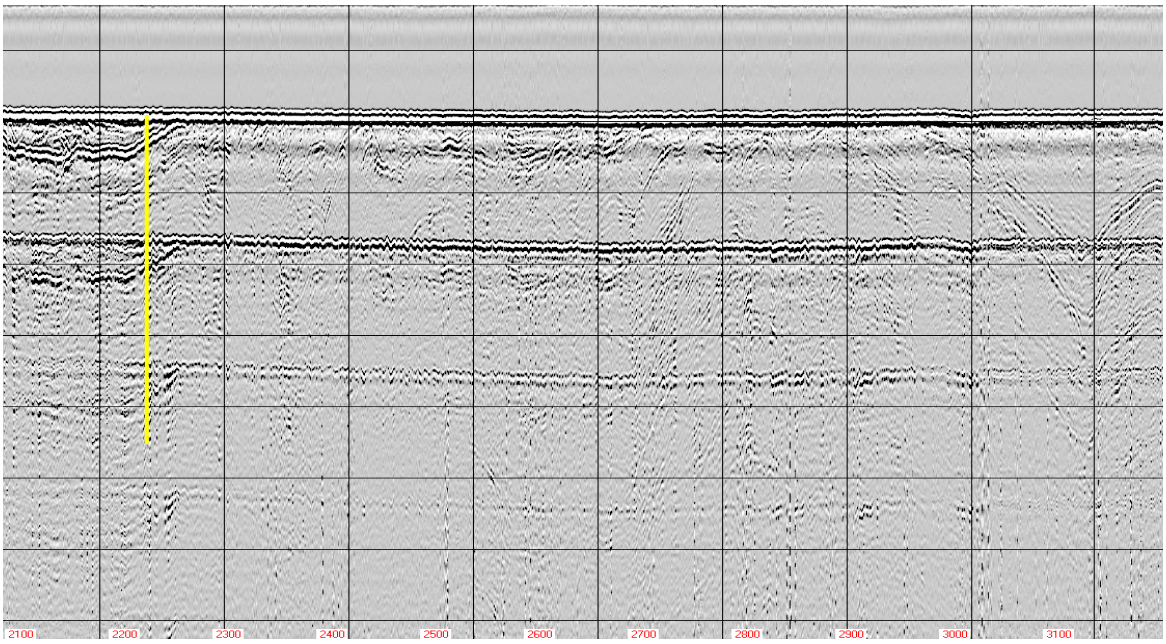




10.1.32 H5 (CPT 50)

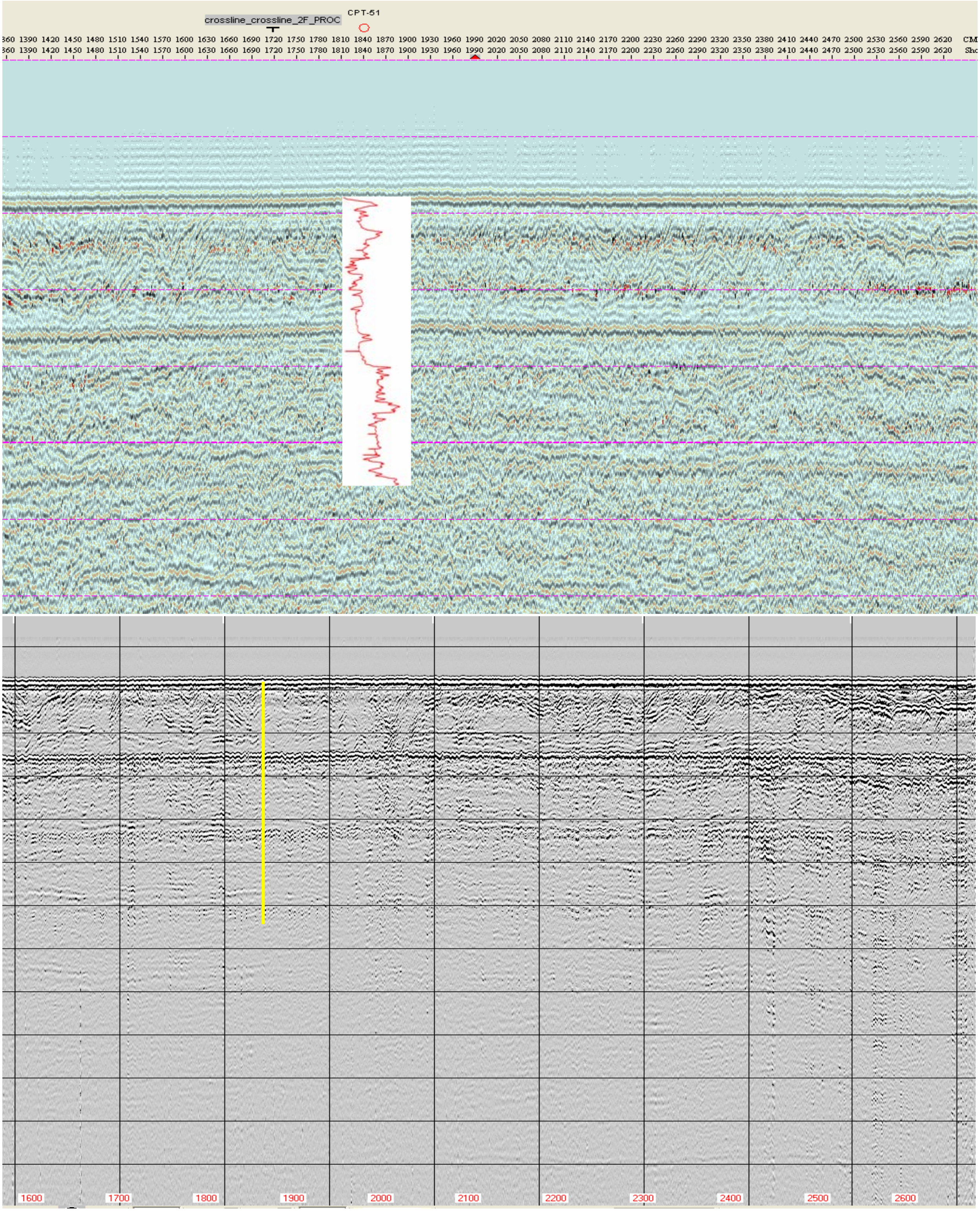
The Seismic line HR 116 in combination with CPT 50 plus Figure 21 (Chart 109) show, that CPT 50 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. A thin Holocene top sand layer above more than 30m glacial disturbed sand and clay occur.





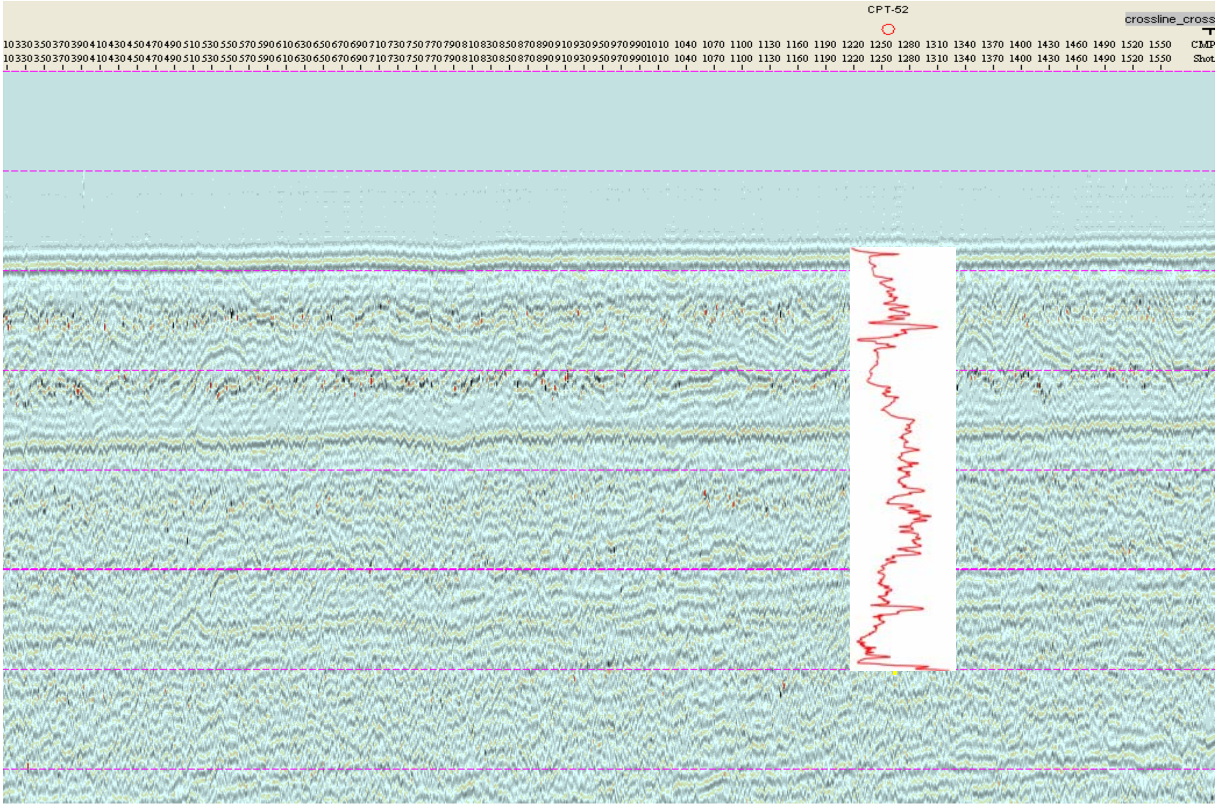
10.1.33 H6 (CPT 51)

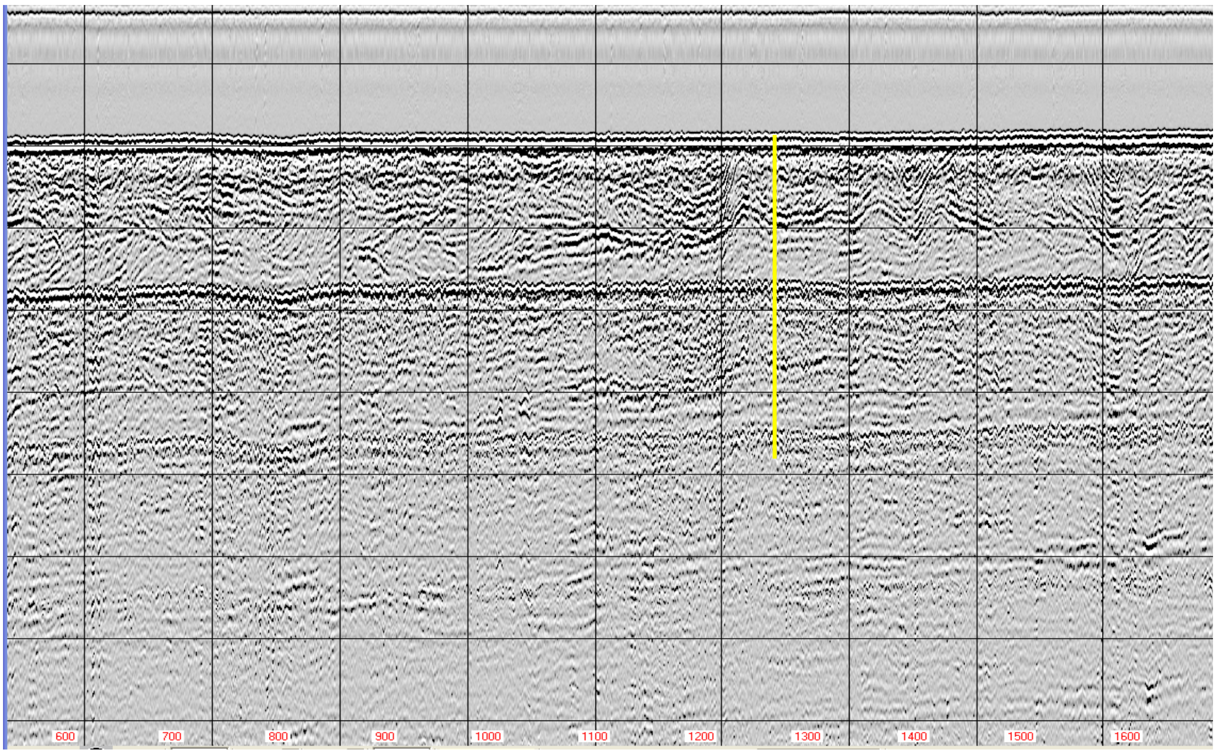
The Seismic line HR 120 in combination with CPT 51 plus Figure 21 (Chart 109) show, that CPT 51 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. A thin Holocene top sand layer above more than 30m glacial disturbed sand and clay is found.



10.1.34 H7 (CPT 52)

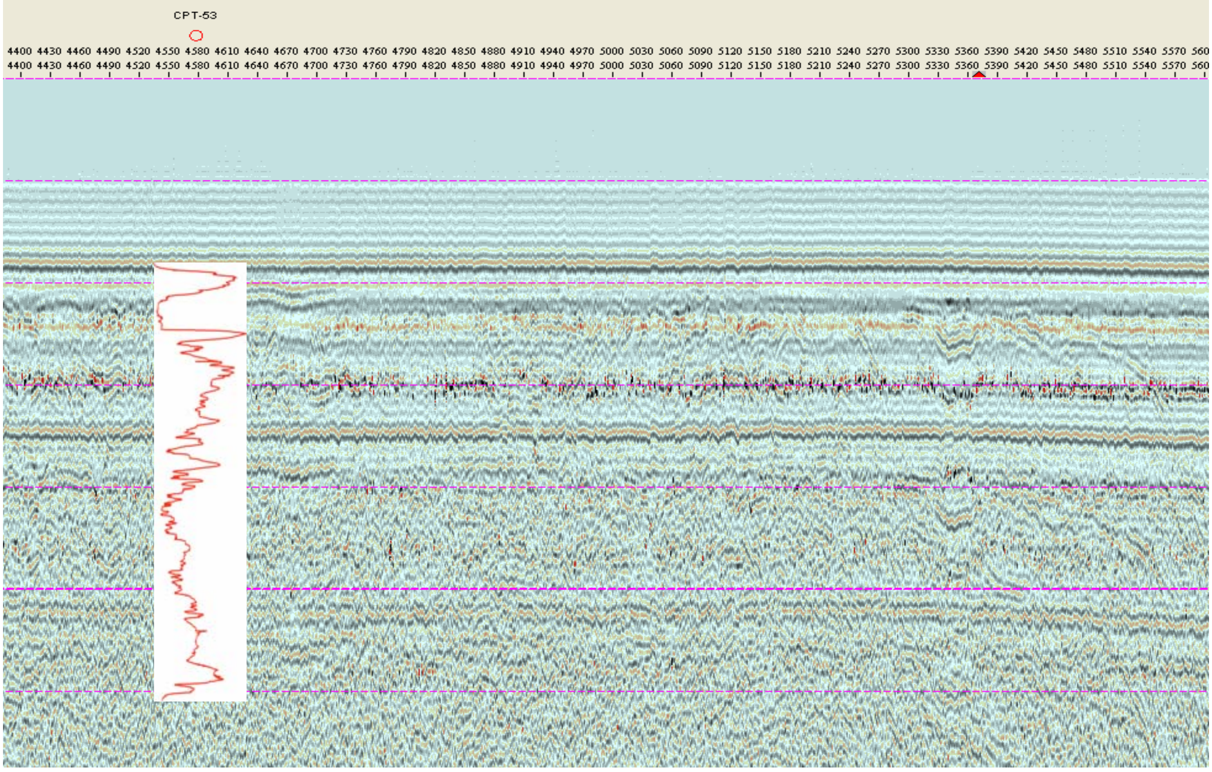
The Seismic line HR 124 in combination with CPT 52 plus Figure 21 (Chart 109) shows, that CPT 52 is located in the weak disturbed zone. This means that below the Holocene deposits exists a rather simple layering in general with an approximately 20m thick glaciofluvial sandy layer above glacial clays. In CPT 52 a thin Holocene sand layer covers more than 30m glaciofluvial sand.

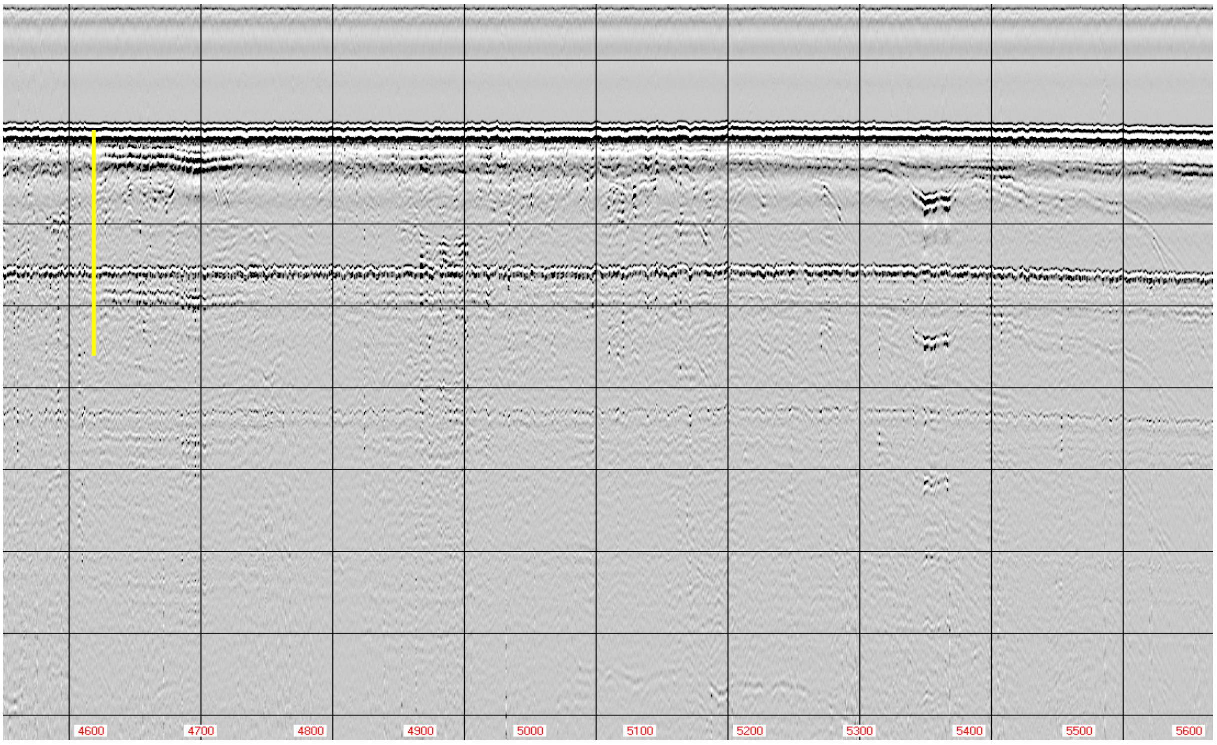




10.1.35 I1 (CPT 53)

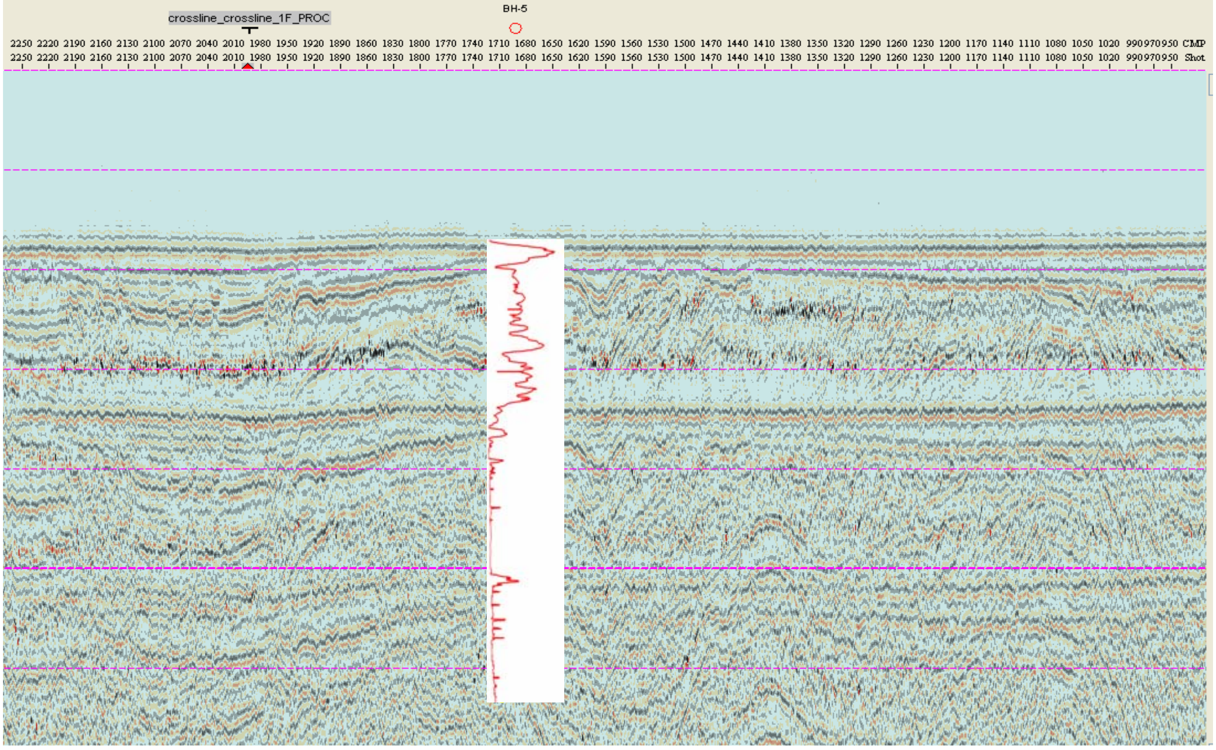
The Seismic line HR 112 in combination with CPT 53 plus Figure 21 (Chart 109) shows, that CPT 53 is located in the heavy disturbed zone. This means that it is not possible from the seismic data to establish any stratigraphy and the sediment layering must also be expected to be chaotic with many shifts in lithology. In CPT 50 3-5 m meter thick Holocene top sand layer (lower part more fine-grained), covers 30m glacial clay and sand with chaotic bedding.

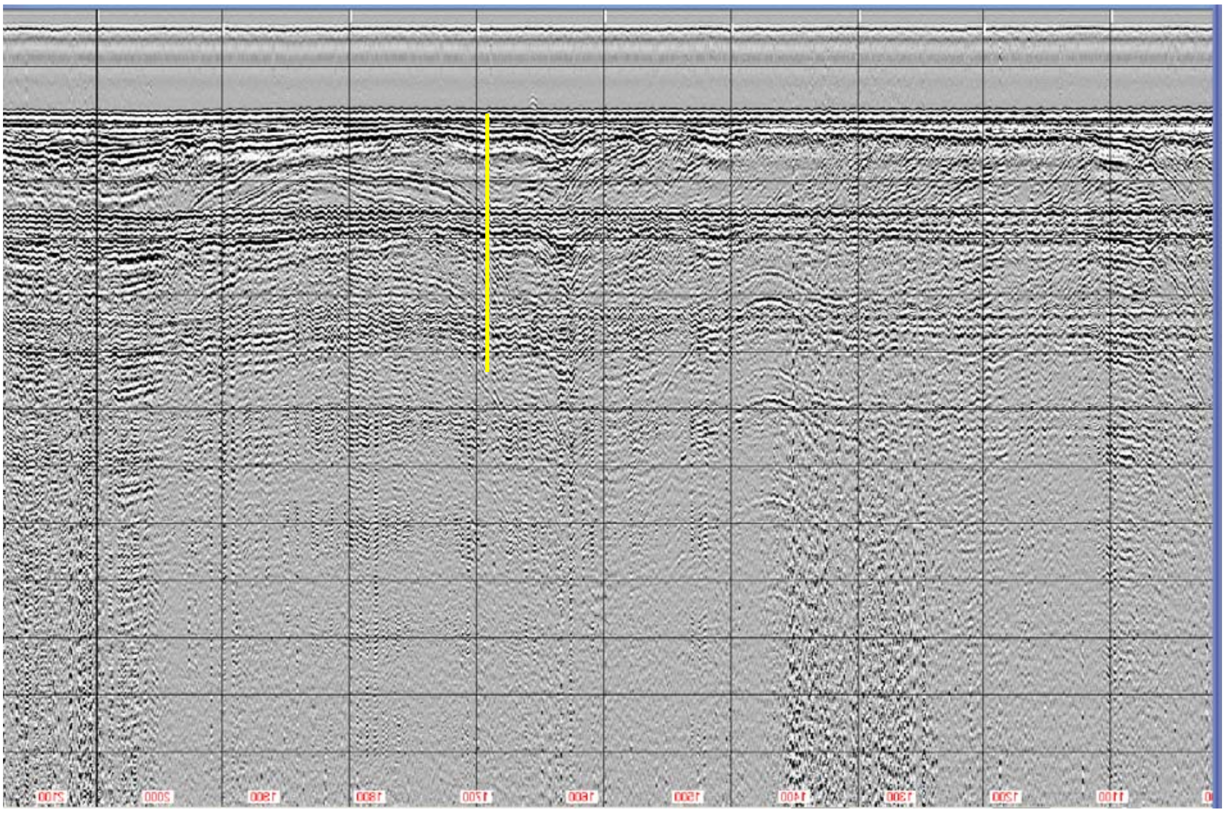




10.1.36 I2 (BH 5)

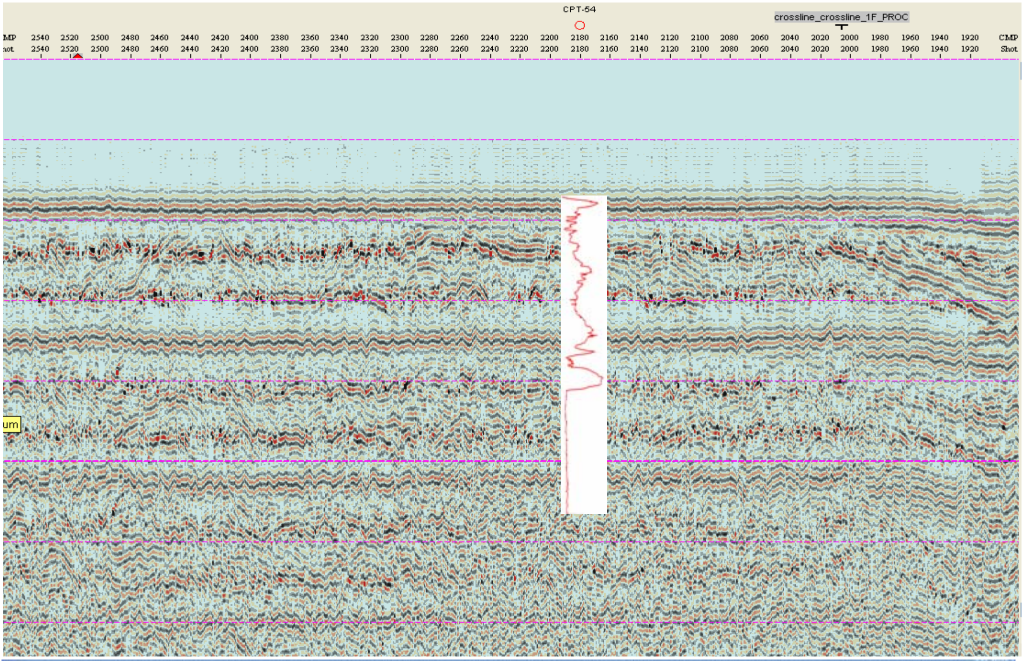
The Seismic line HR 118 in combination with BH 5 plus Figure 21 (Chart 109) show, that BH 5 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. A 4.5m Holocene top sand layer covers 5m glacial sand followed by about 12m Holsteinian interglacial clay (Biostratigraphical studies paragraph 9.1.1) and about 15m mainly glacial till.

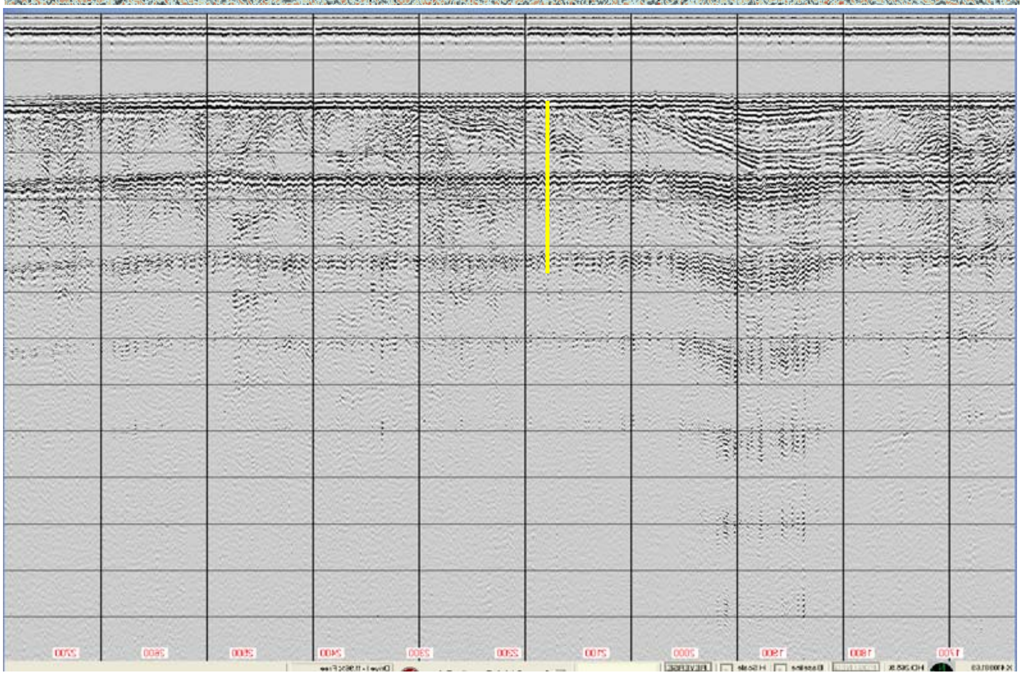




10.1.37 I3 (CPT 54)

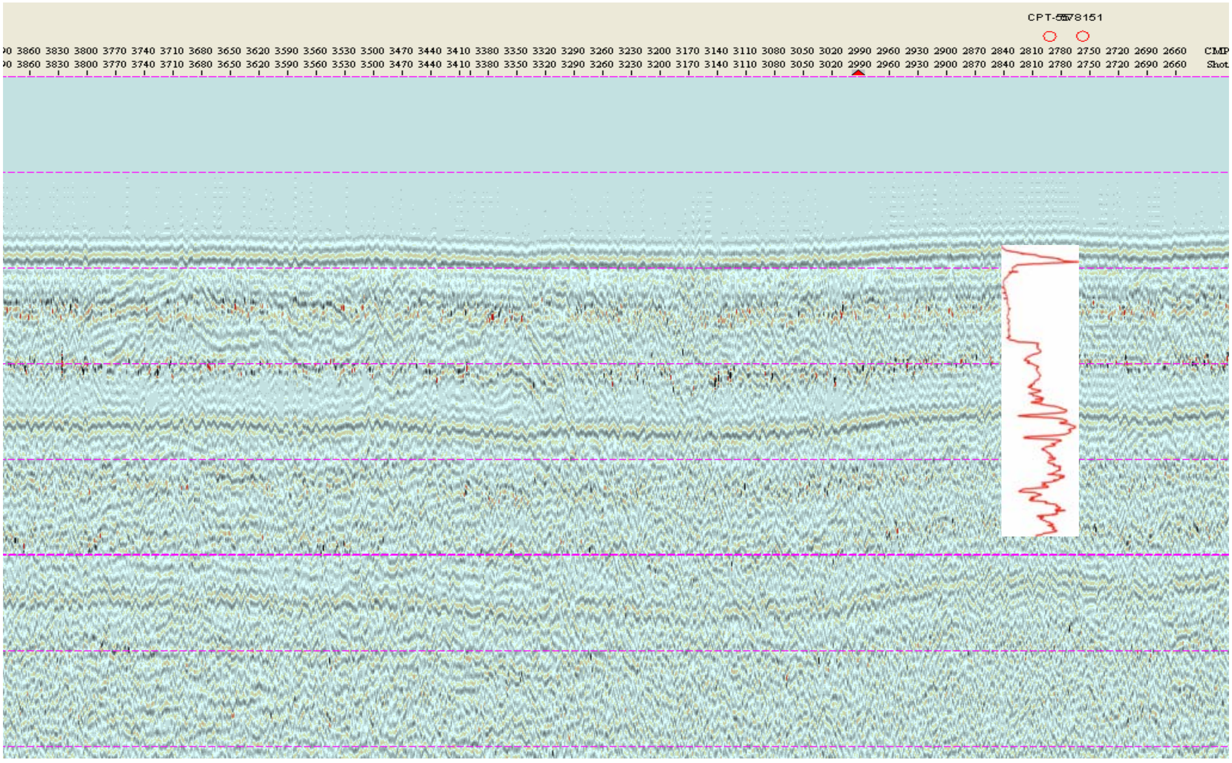
The Seismic line HR 122 in combination with CPT 54 plus Figure 21 (Chart 109) show, that CPT 54 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. About 2m Holocene top sand layer covers more than 30m glacial disturbed deposits consisting of 15m sand and 12m melt water or interglacial clay.

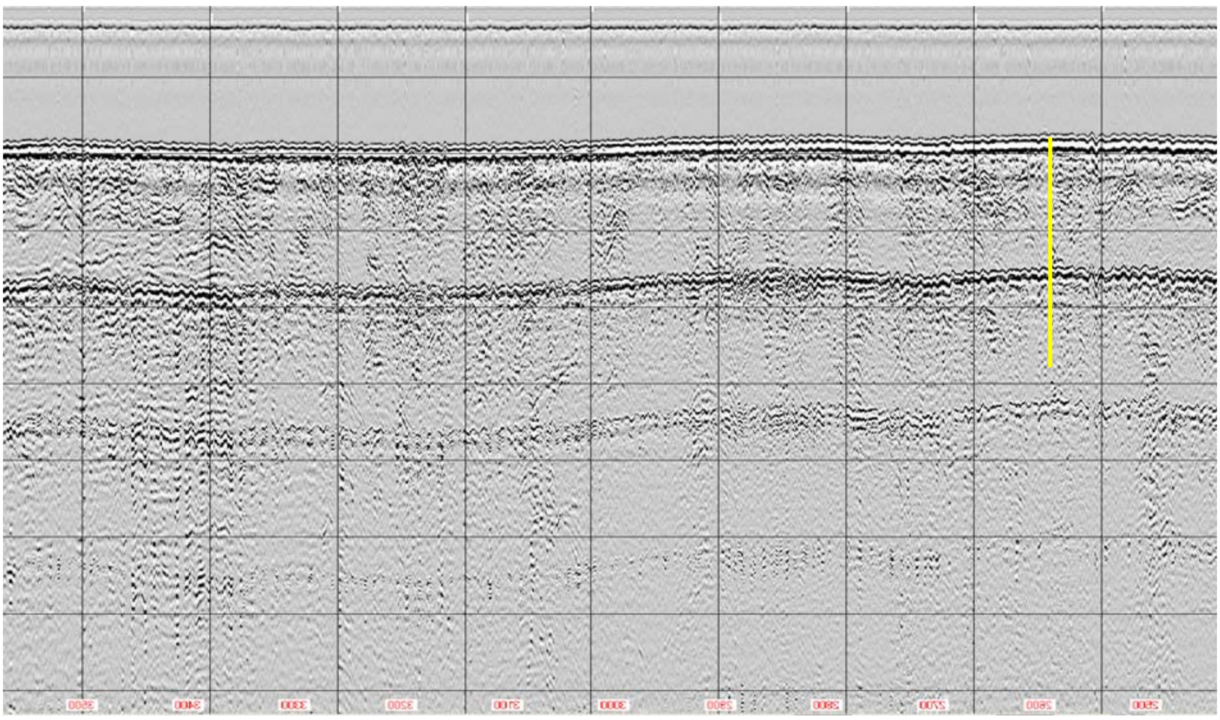




10.1.38 I4 (CPT 55), I4 (VIB 55)

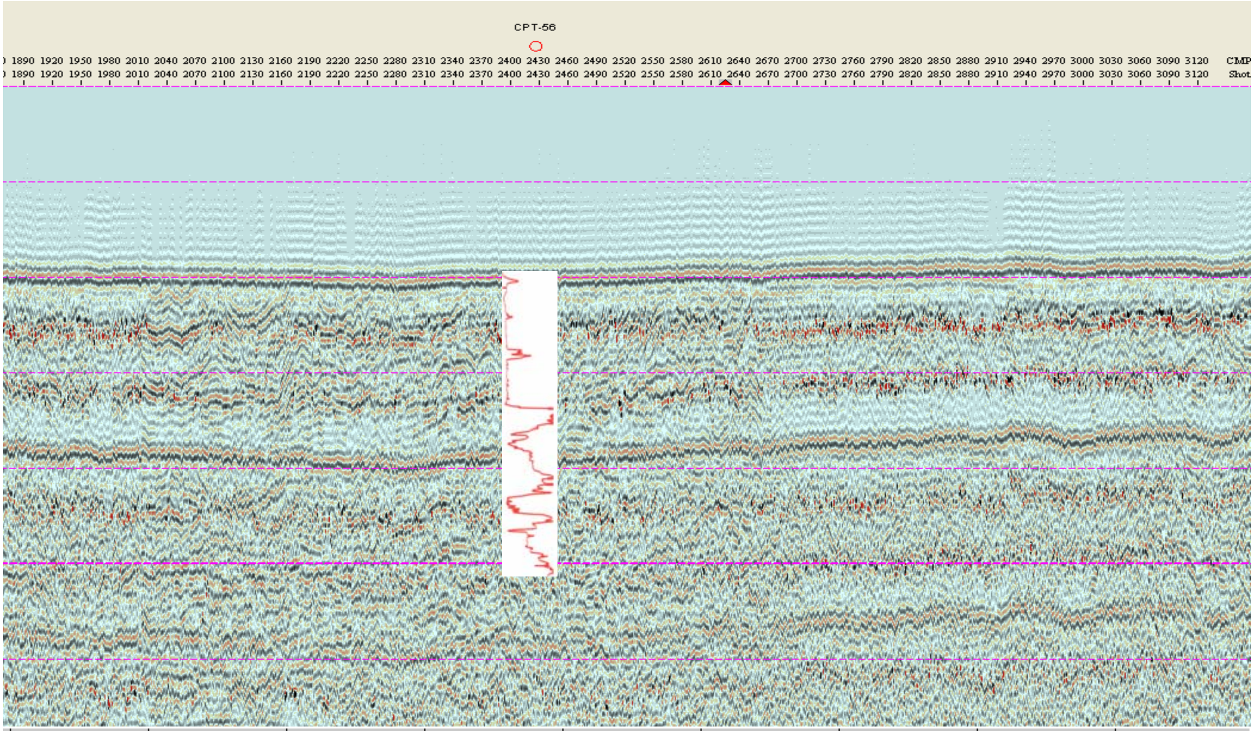
The Seismic line HR 126 in combination with CPT 55, vibrocore 55 plus Figure 21 (Chart 109) shows, that CPT 55, vibrocore 55 is located in the heavy disturbed zone on the margin to a folded deformation zone. This means that it is not possible from the seismic data to establish any stratigraphy and the sediment layering must also be expected to be chaotic with many shifts in lithology. In CPT 55, vibrocore 55 2 m meter thick Holocene top sand layer covers 25m glacial clay and sand with chaotic bedding.

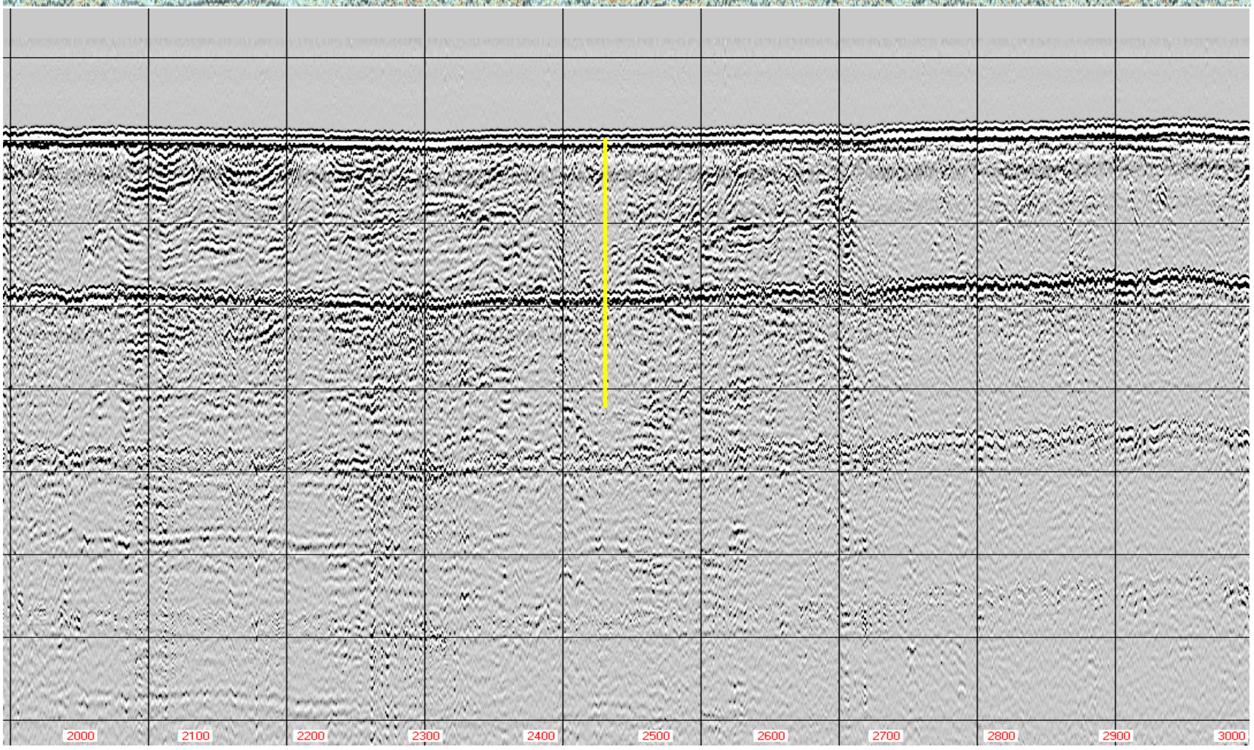




10.1.39 I5(CPT 56), I5(VIB 56)

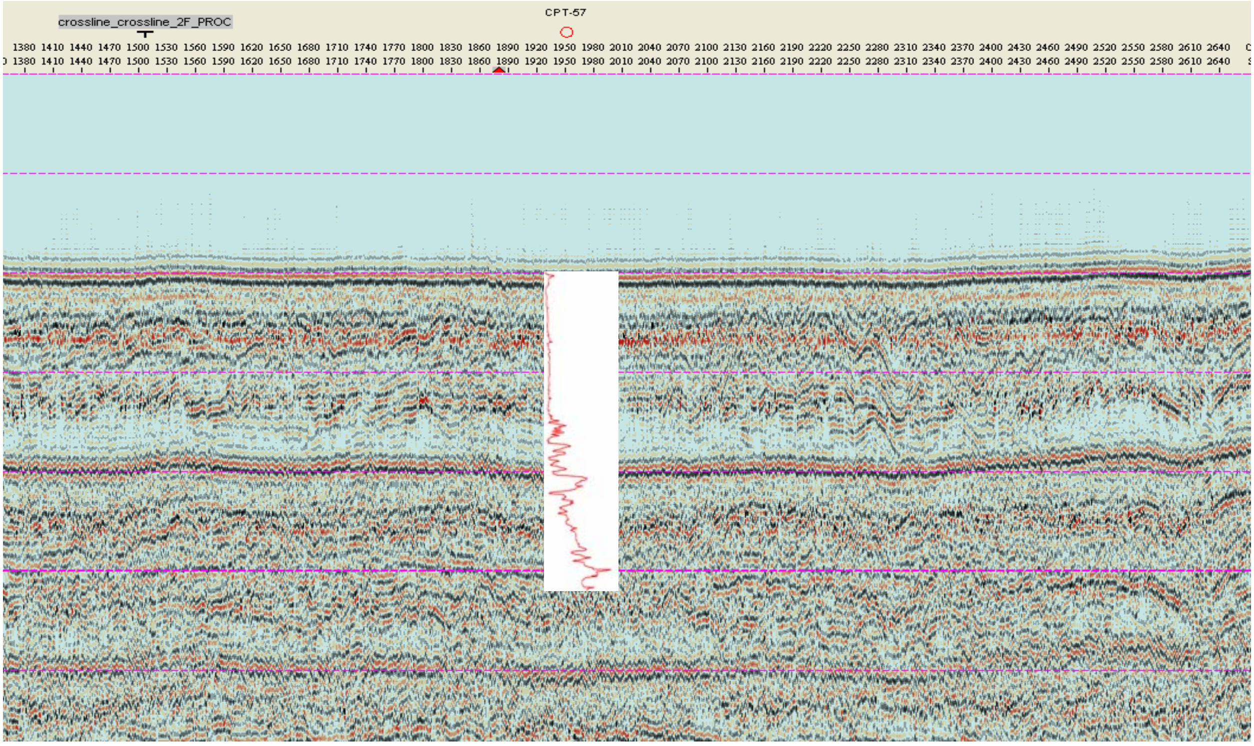
The Seismic line HR 132 in combination with CPT 56 plus Figure 21 (Chart 109) show, that CPT 56 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. A 3m Holocene top sand layer covers more than 3m clay containing shells. The CPT shows that the marine clay layer may be about 10m in thickness covering glacial sand and clay.

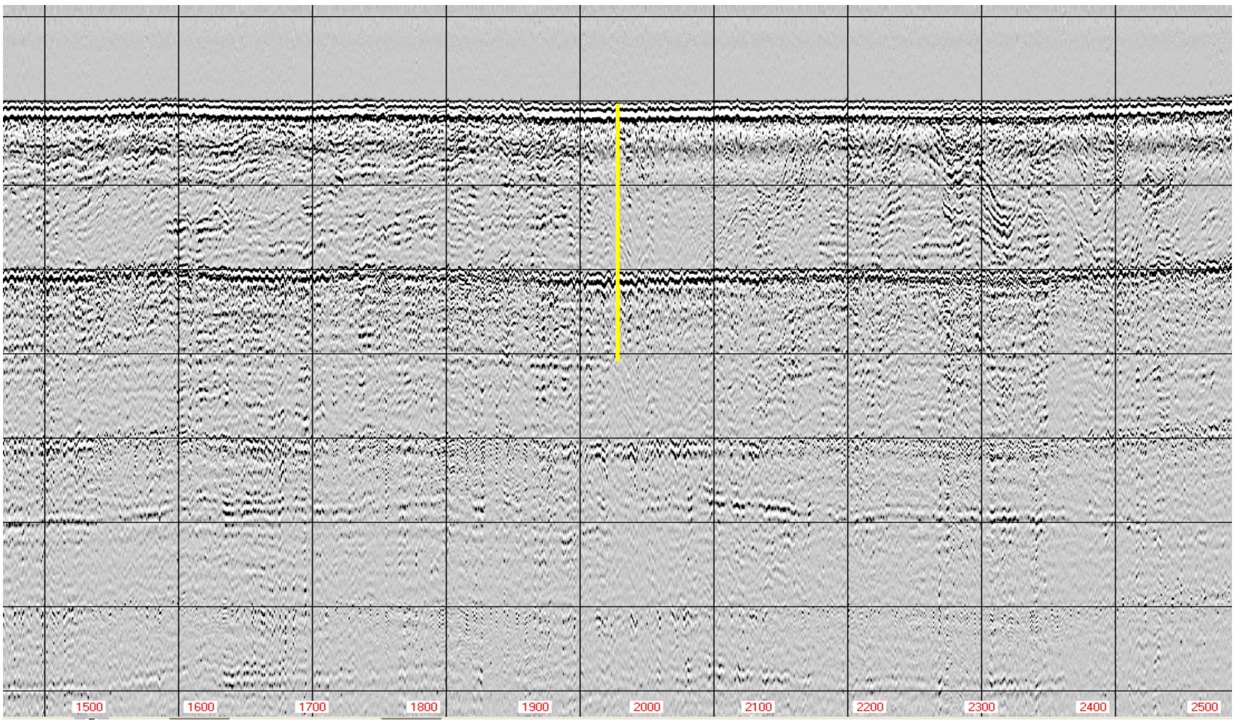




10.1.40 I6 (CPT 57)

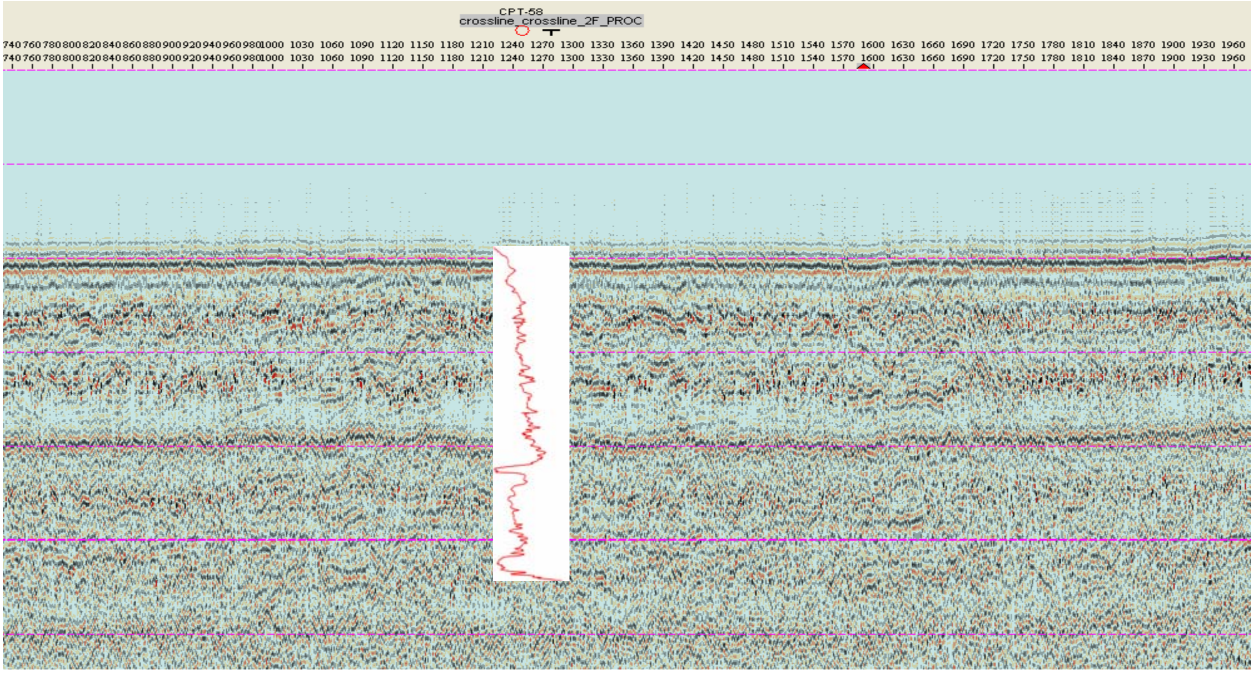
The Seismic line HR 136 in combination with CPT 57 plus Figure 21 (Chart 109) shows, that CPT 57 is located in the heavy disturbed zone. This means that it is not possible from the seismic data to establish any stratigraphy and the sediment layering must also be expected to be chaotic with many shifts in lithology. In CPT 57 a very thin Holocene top sand layer covers 25m glacial clay and sand with chaotic bedding.

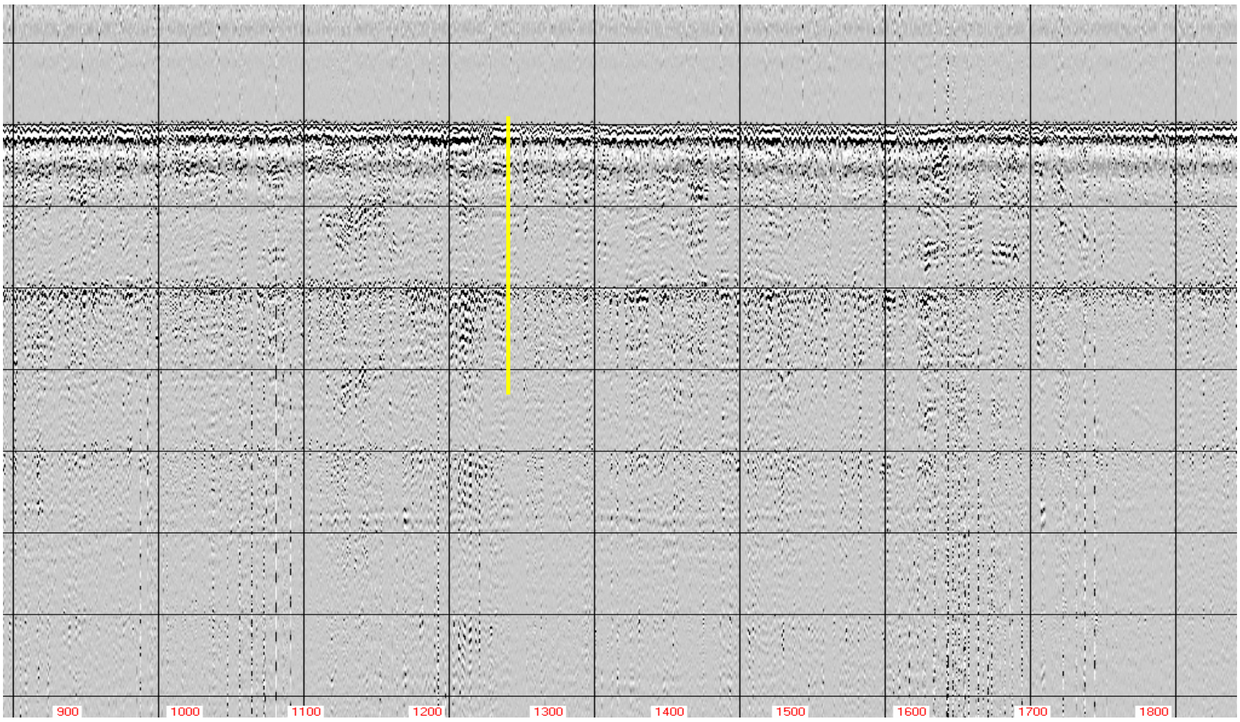




10.1.41 I7 (CPT 58)

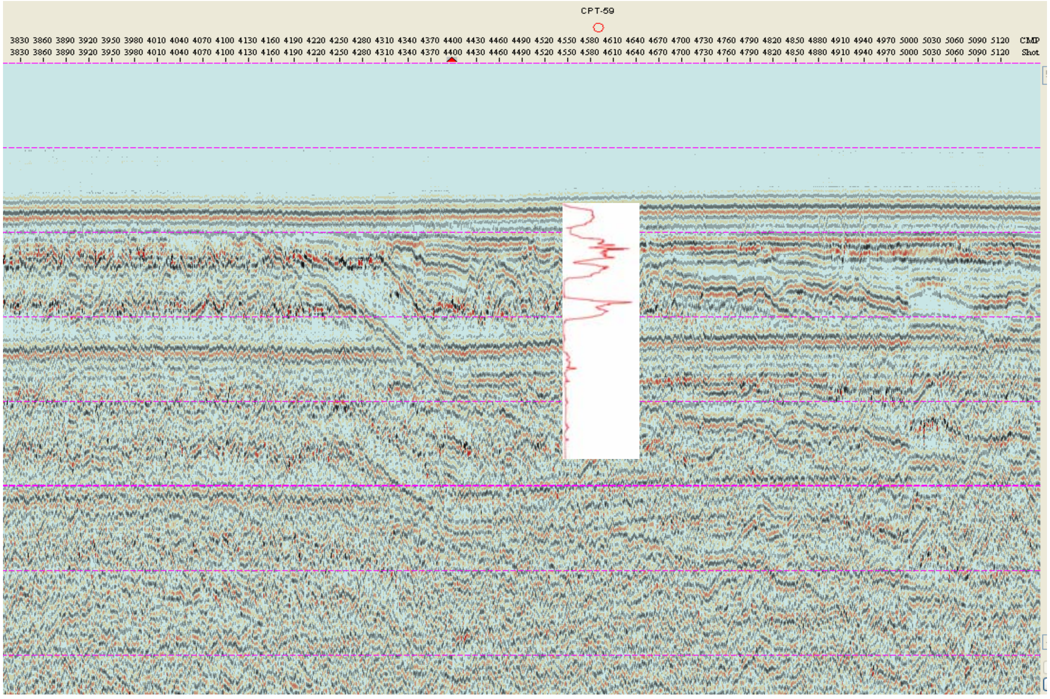
The Seismic line HR 142 in combination with CPT 58 plus Figure 21 (Chart 109) shows, that CPT 58 is located in the weak disturbed zone. This means that below the Holocene deposits exists a rather simple layering in general with an approximately 20m thick glaciofluvial sandy layer above glacial clays. In CPT 58 a thin Holocene sand layer covers more than 20m glaciofluvial sand. (Poor seismic quality).

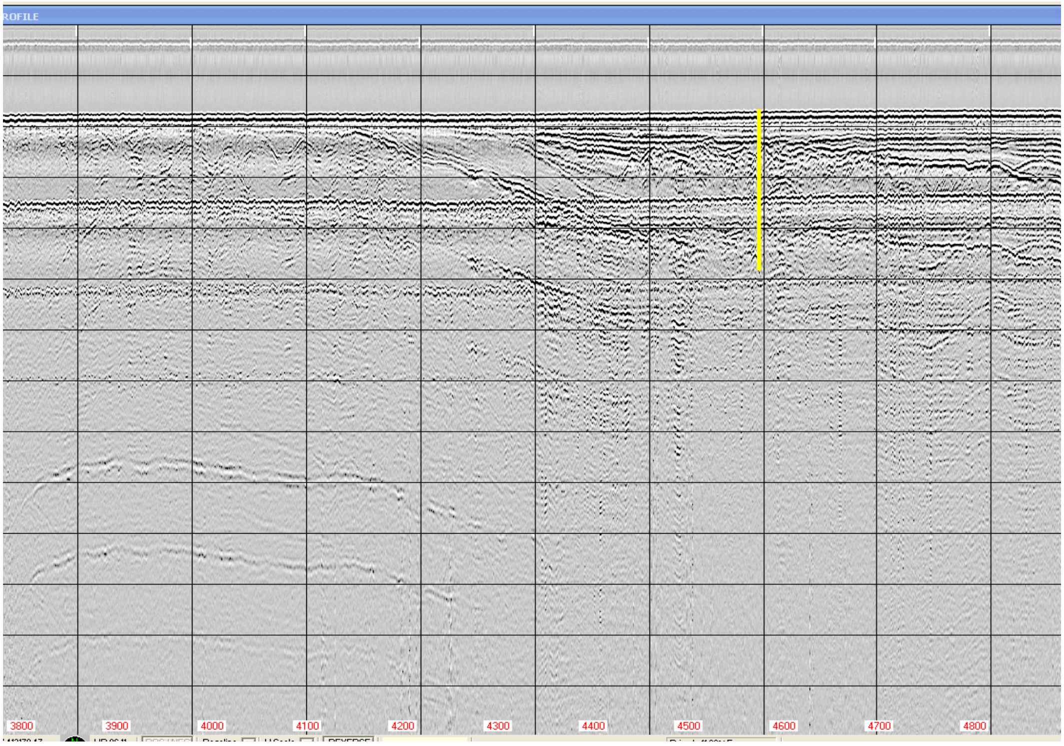




10.1.42 J1 (CPT 59)

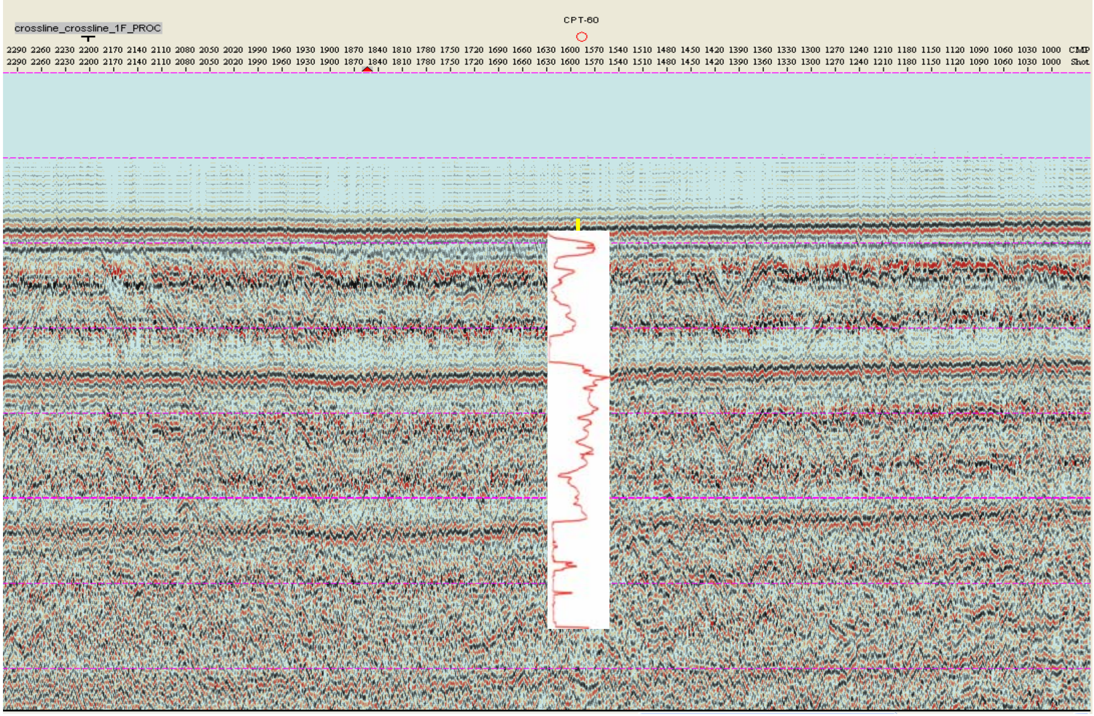
The Seismic line HR 124 in combination with CPT 59 plus Figure 21 (Chart 109) show, that CPT 59 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. About 3m Holocene top sand layer covers 25m glacial disturbed deposits consisting of 5m sand and 2m melt water or interglacial clay, 2m sand and about 15m of possible interglacial clay.

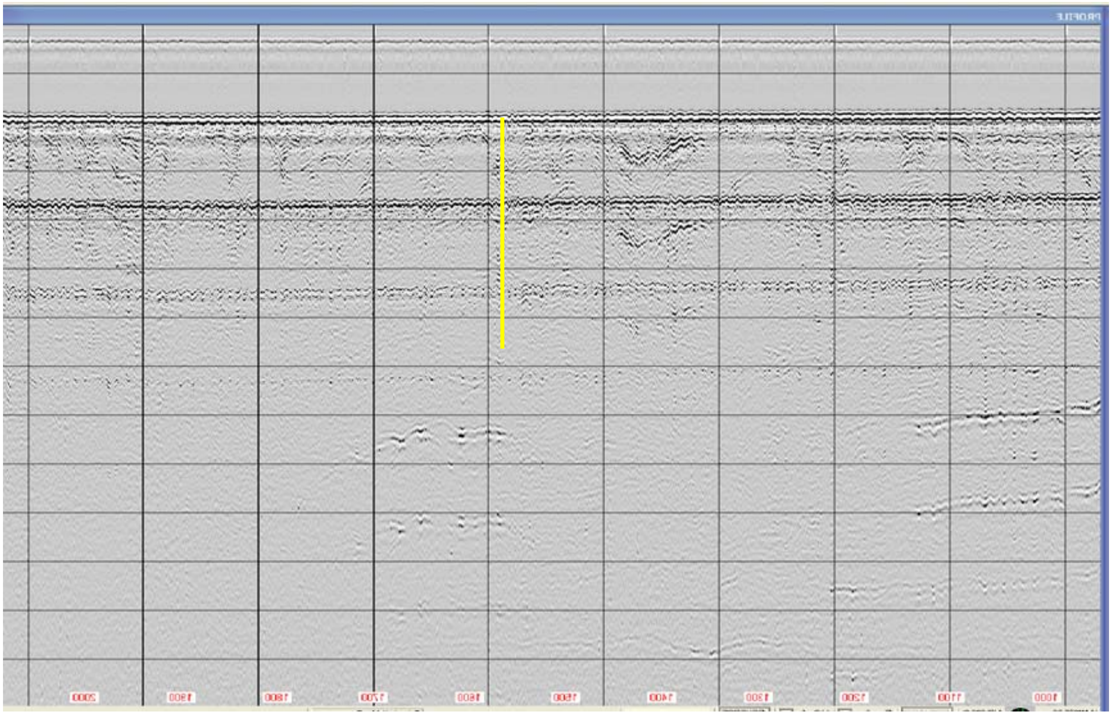




10.1.43 J2 (CPT 60)

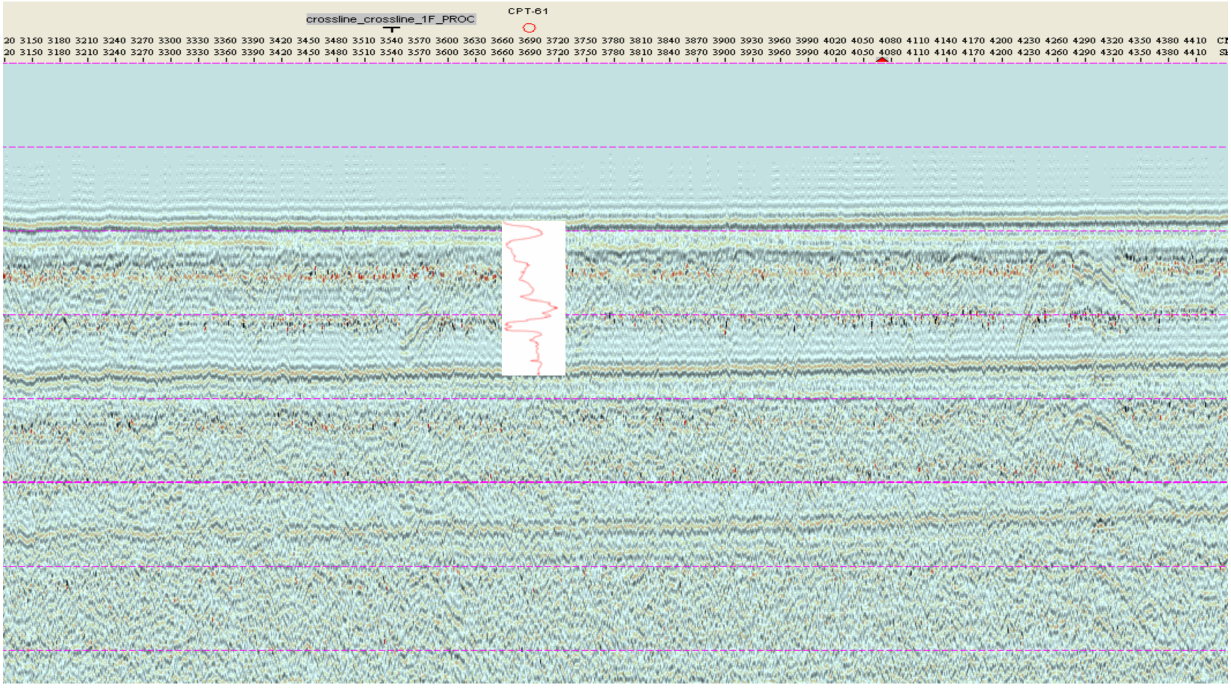
The Seismic line HR 130 in combination with CPT 60 plus Figure 21 (Chart 109) show, that CPT 60 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. A thin Holocene top sand layer above 20m glacial disturbed deposits consisting of sand and clay is followed by 15m of possible interglacial clay.

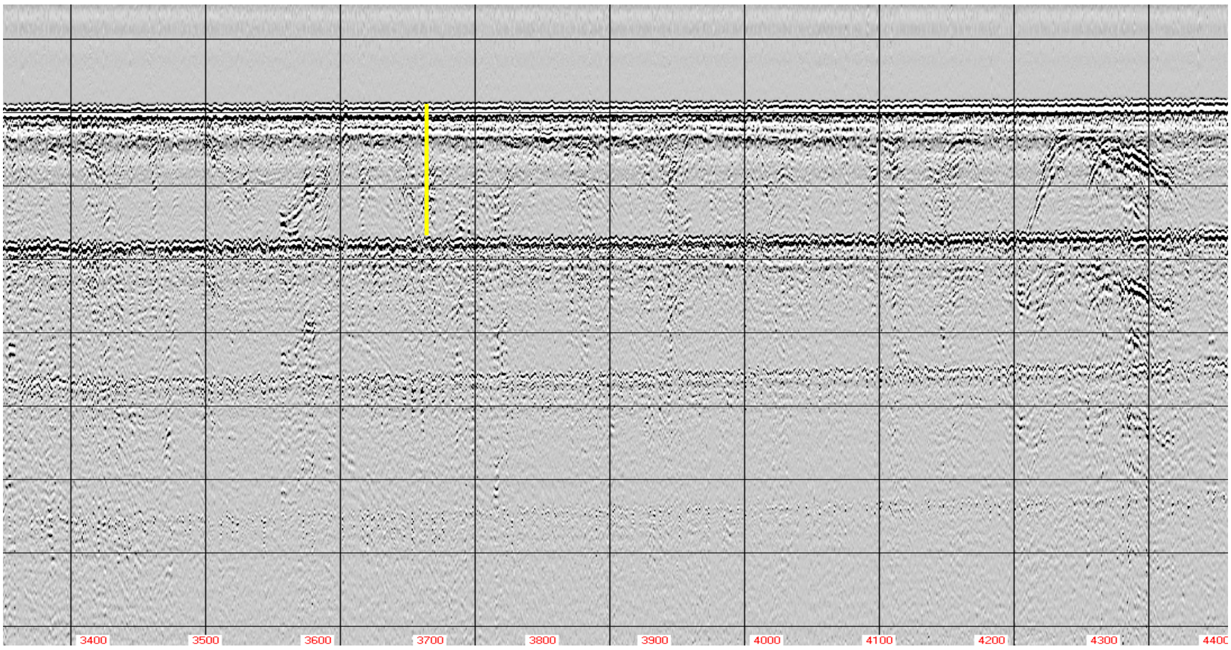




10.1.44 J3 (CPT 61)

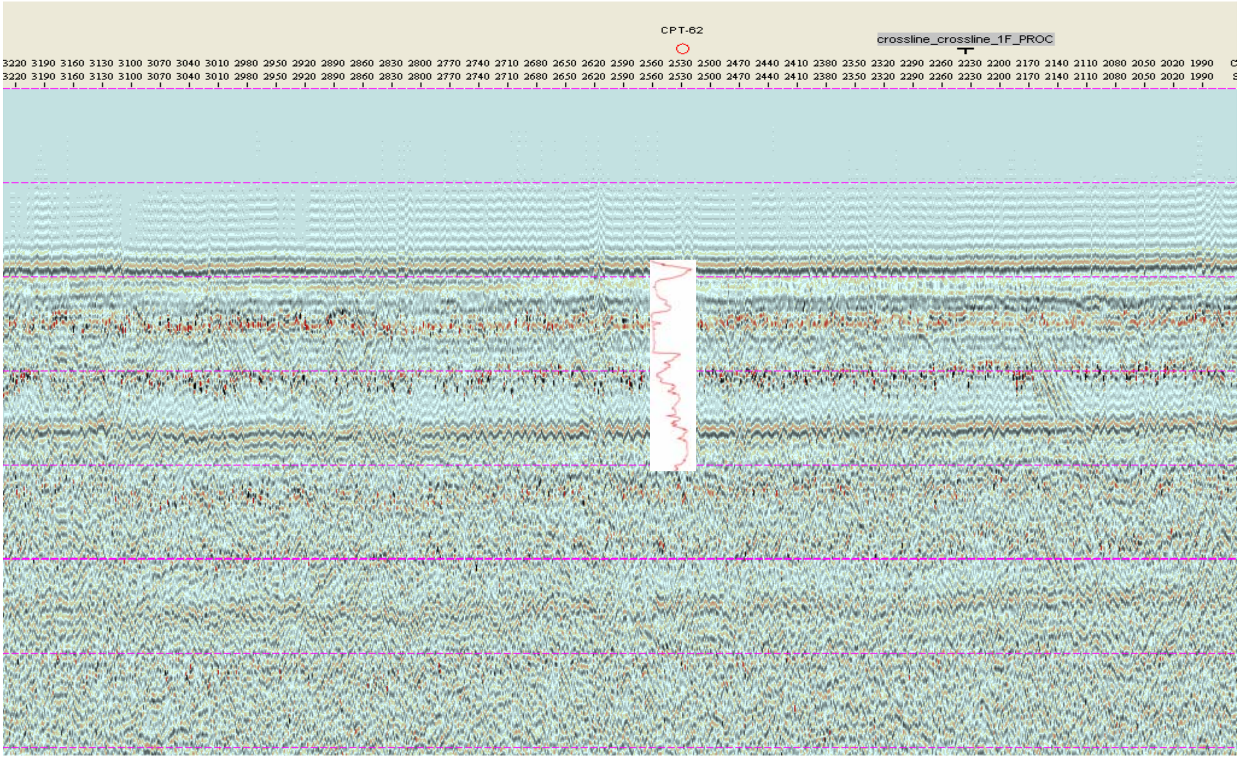
The Seismic line HR 136 in combination with CPT 61 plus Figure 21 (Chart 109) shows, that CPT 61 is located in the heavy disturbed zone on the margin to a folded deformation zone. This means that it is not possible from the seismic data to establish any stratigraphy and the sediment layering must also be expected to be chaotic with many shifts in lithology. In CPT 6 1-2 m meter thick Holocene top sand layer covers 15m glacial clay and sand with chaotic bedding.

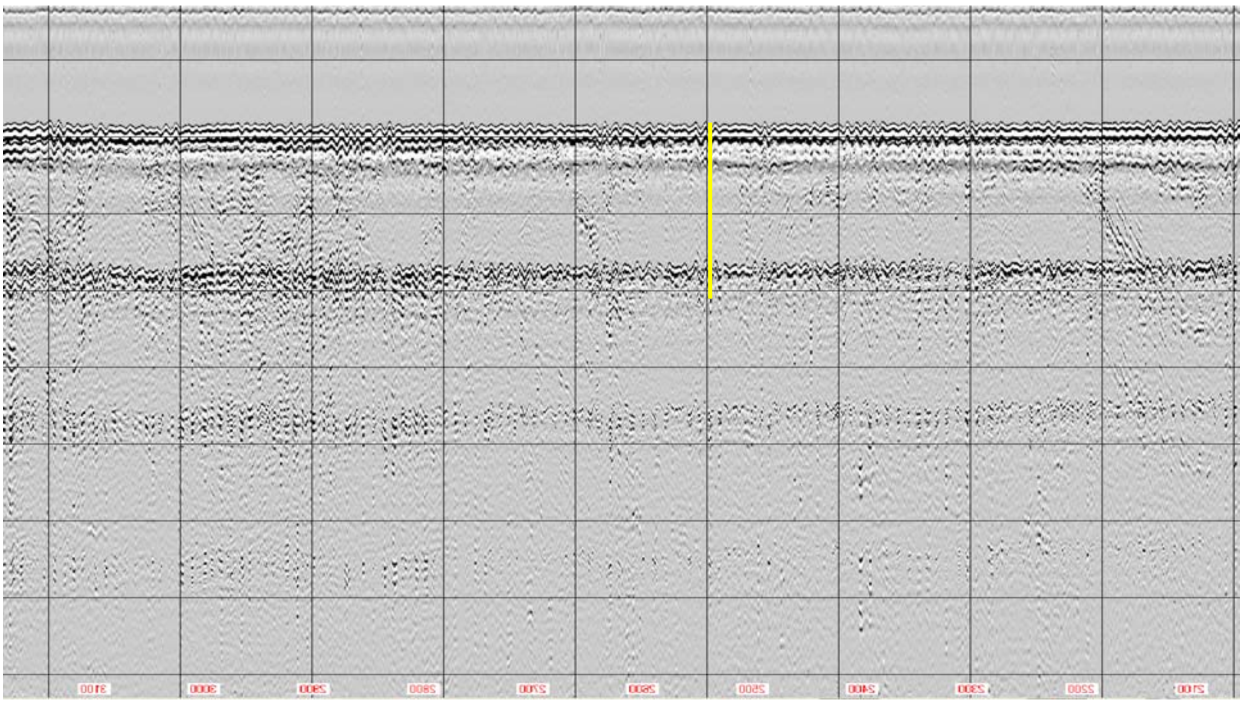




10.1.45 J4 (CPT 62)

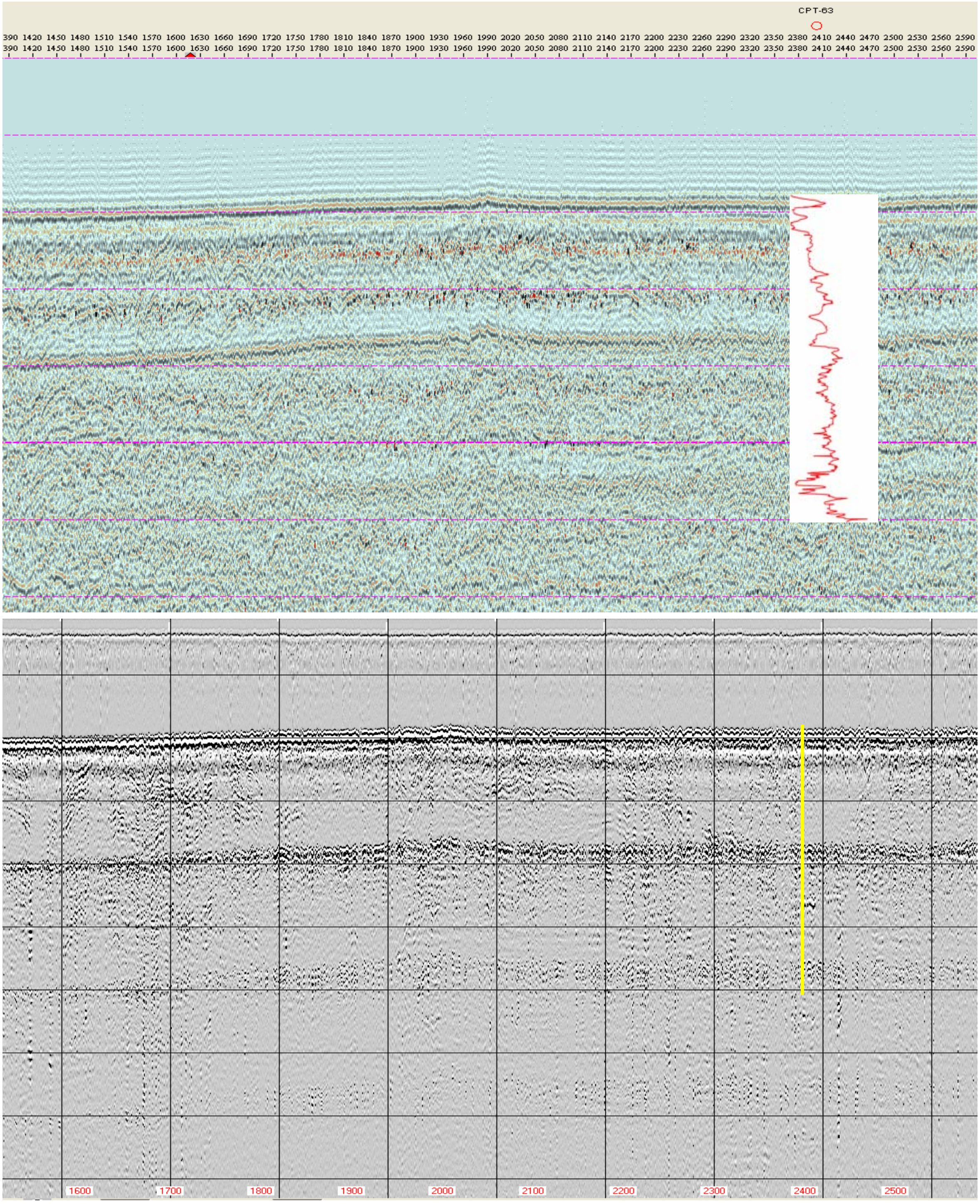
The Seismic line HR 140 in combination with CPT 62 plus Figure 21 (Chart 109) shows, that CPT 62 is located in the heavy disturbed zone on the margin to a folded deformation zone. This means that it is not possible from the seismic data to establish any stratigraphy and the sediment layering must also be expected to be chaotic with many shifts in lithology. In CPT 62 2 m meter thick Holocene top sand layer covers 20m glacial clay and sand with chaotic bedding.





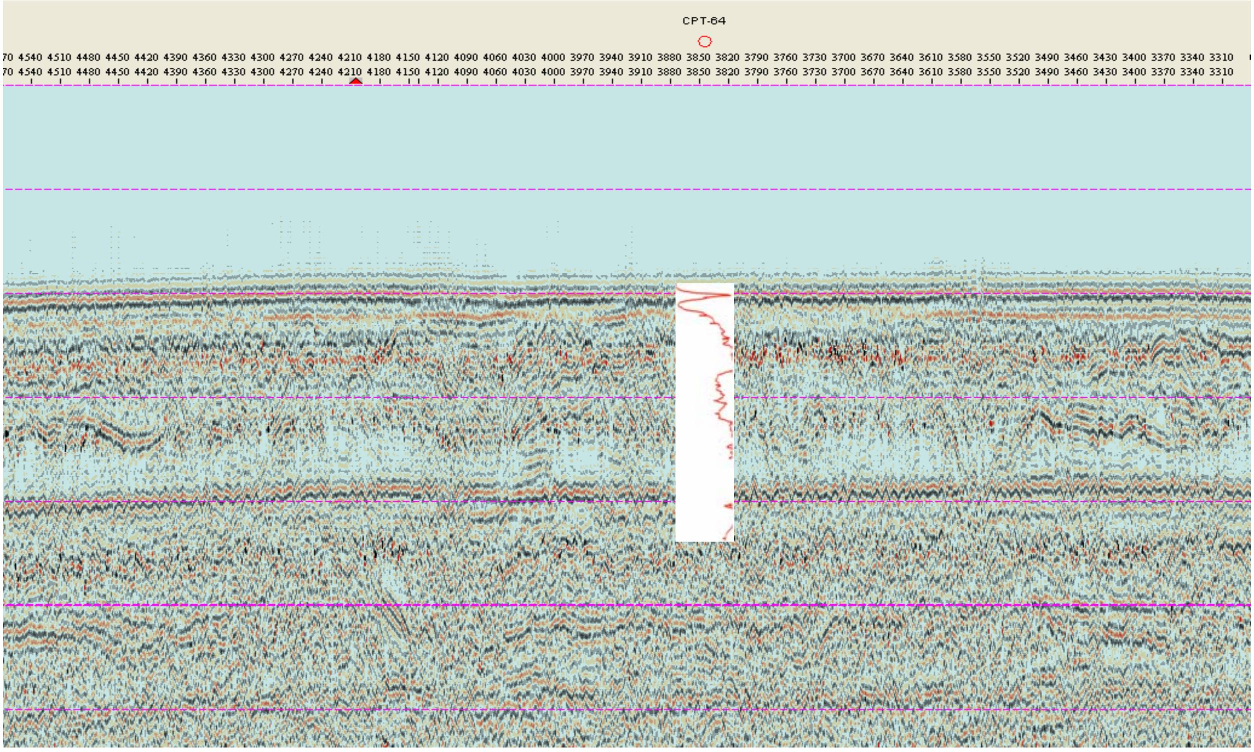
10.1.46 J5 (CPT 63)

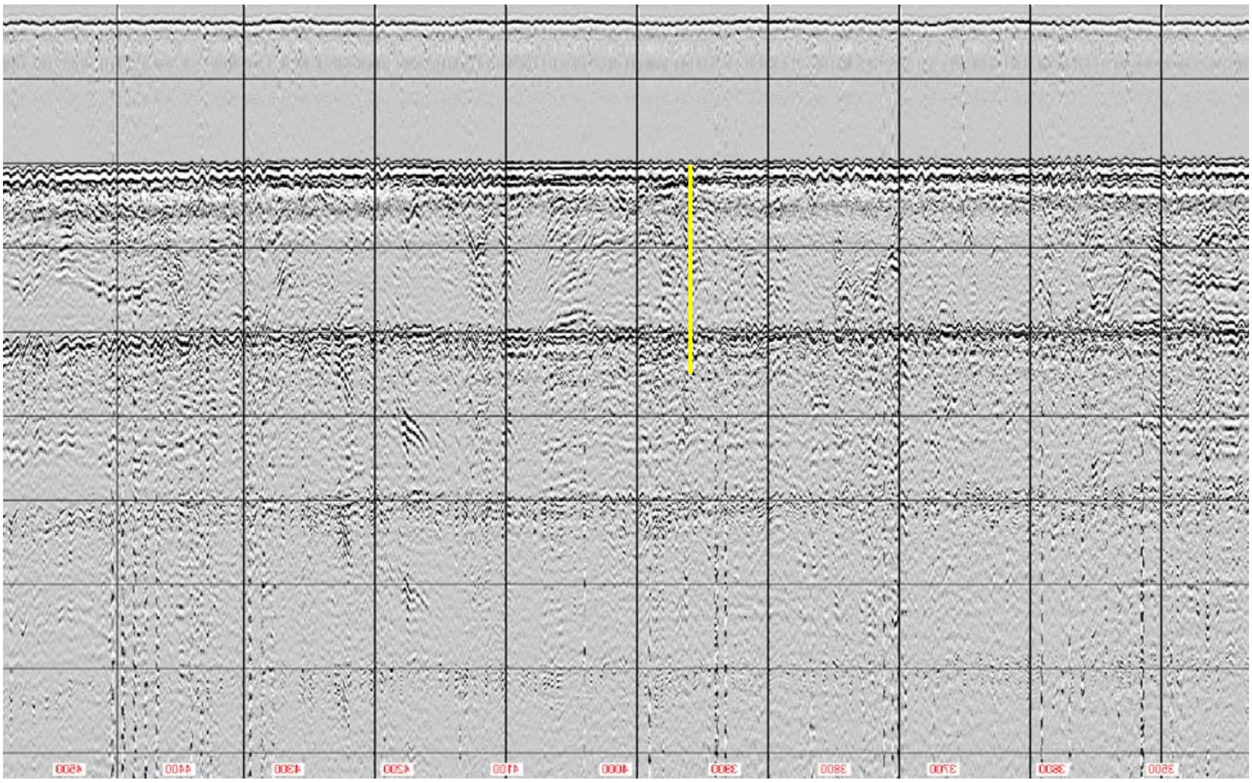
The Seismic line HR 146 in combination with CPT 63 plus Figure 21 (Chart 109) shows, that CPT 63 is located in the heavy disturbed zone on the margin to a folded deformation zone. This means that it is not possible from the seismic data to establish any stratigraphy and the sediment layering must also be expected to be chaotic with many shifts in lithology. In CPT 63 2 m meter thick Holocene top sand layer covers 35m glacial clay and sand with chaotic bedding.



10.1.47 J6 (CPT 64)

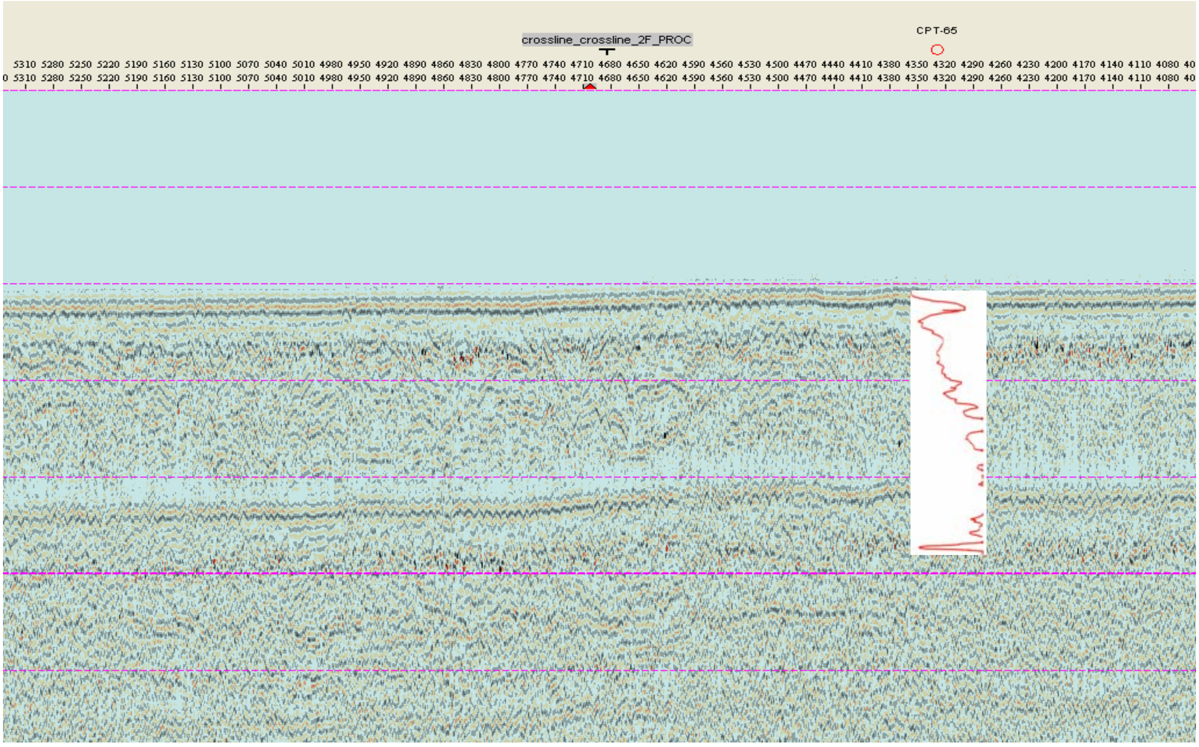
The Seismic line HR 152 in combination with CPT 64 plus Figure 21 (Chart 109) show, that CPT 64 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. A very thin Holocene top sand layer covers glacial disturbed deposits consisting of sand and clay.

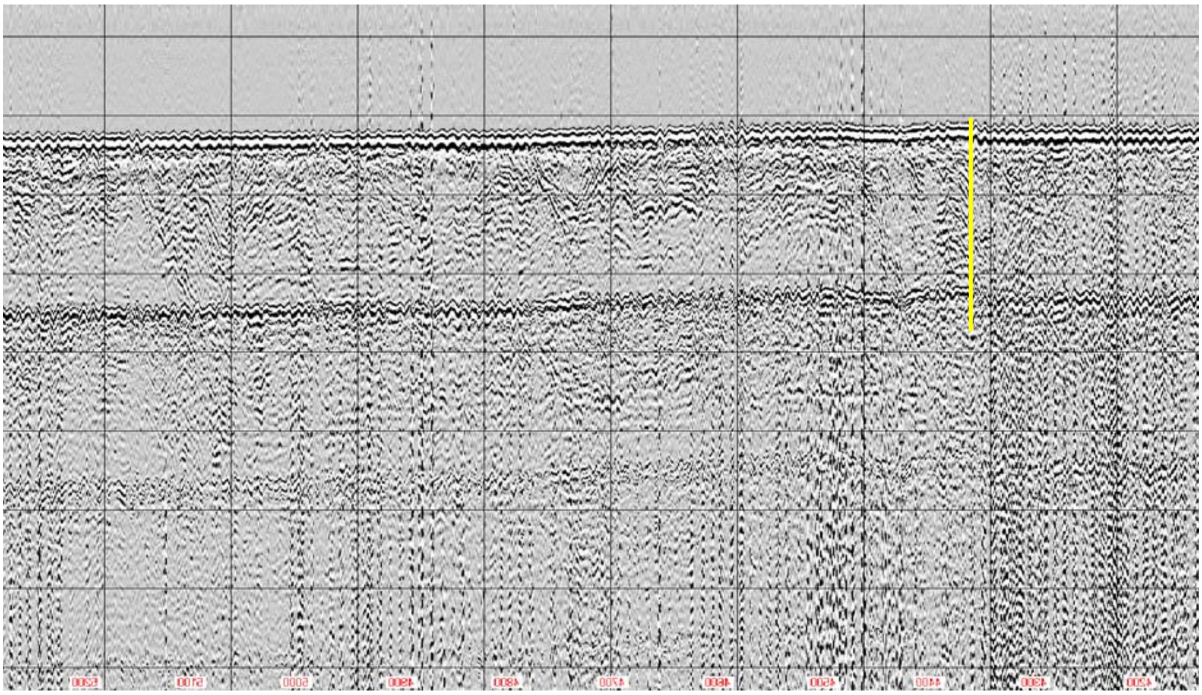




10.1.48 J7 (CPT 65)

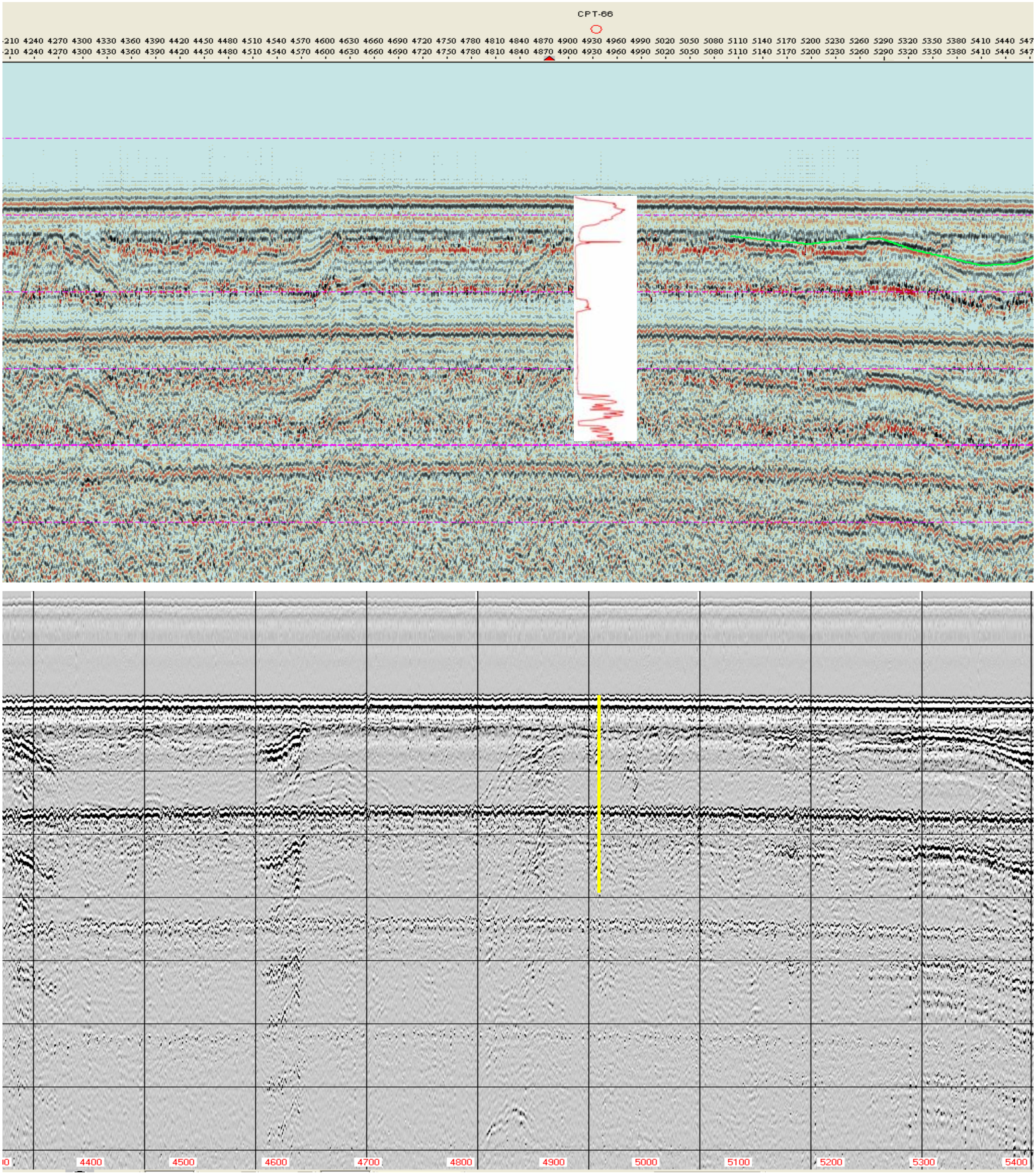
The Seismic line HR 156 in combination with CPT 65 plus Figure 21 (Chart 109) shows, that CPT 65 is located in the weak disturbed zone. This means that below the Holocene deposits exists a rather simple layering in general with an approximately 20m thick glaciofluvial sandy layer above glacial clays. In CPT 60 a thin Holocene sand layer covers more than 20m glaciofluvial sand.





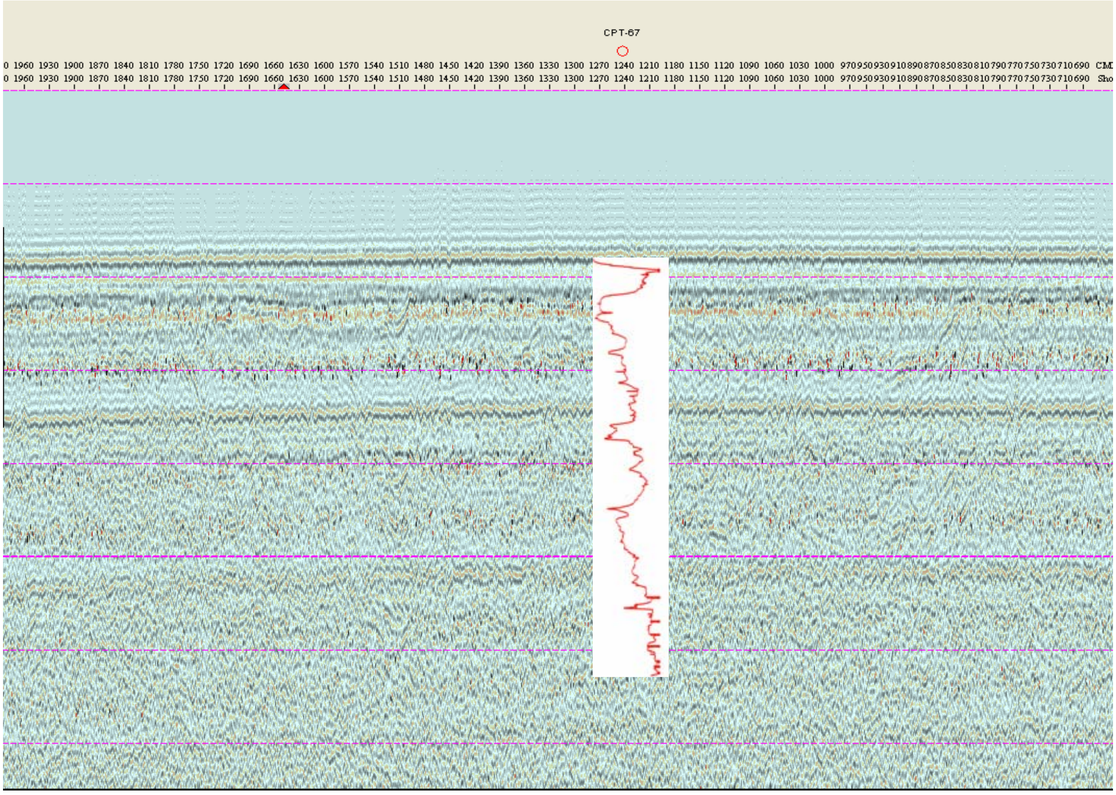
10.1.49 K1 (CPT 66), K1 (BH 6)

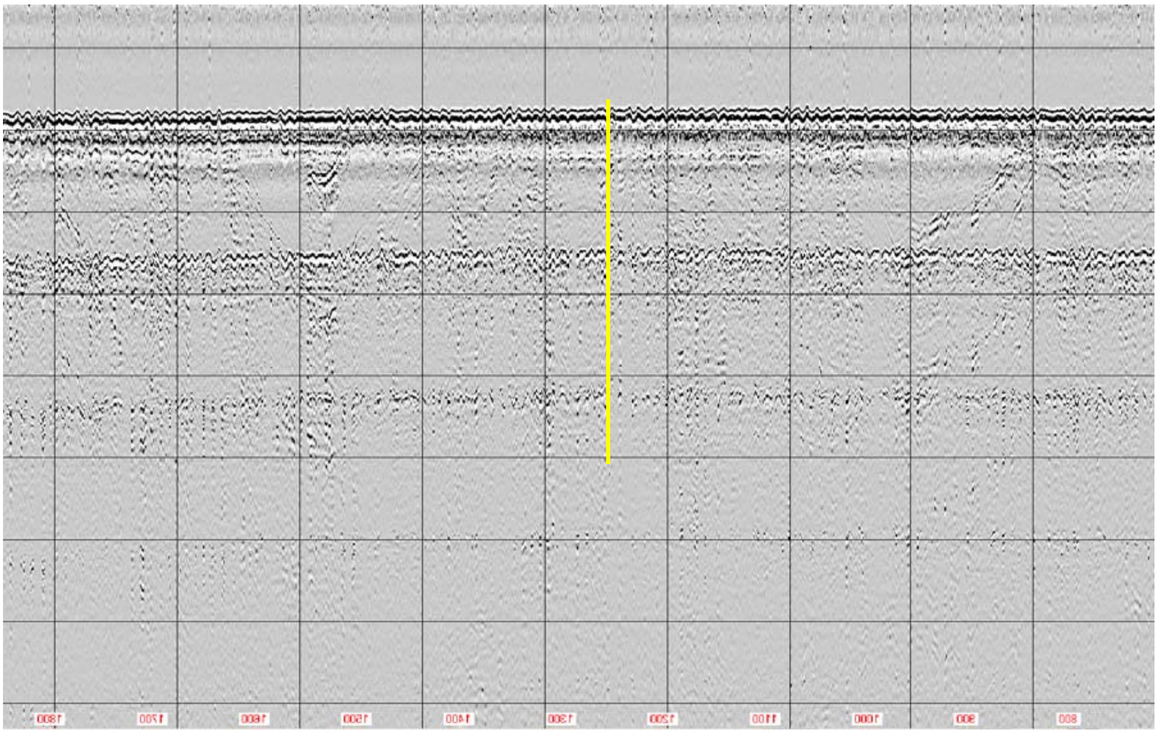
The Seismic line HR 136 in combination with CPT 66, BH 6 plus Figure 21 (Chart 109) show, that CPT 66, BH 6 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. 5.5m Holocene top sand layer with shells is found above 35m layered clay. The clay is interpreted as glaciolacustrine because biostratigraphical investigations from BH 6 show that no marine fossils are present.



10.1.50 K2 (CPT 67)

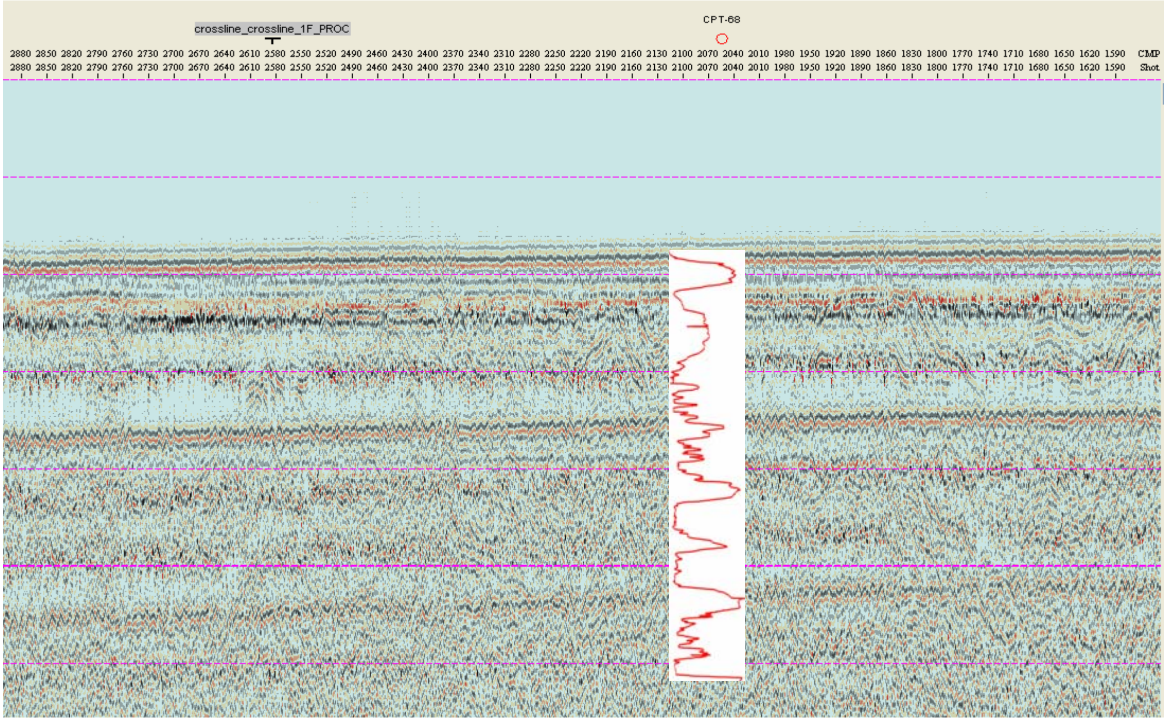
The Seismic line HR 144 in combination with CPT 67 plus Figure 21 (Chart 109) show, that CPT 67 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. 3 m Holocene top sand layers cover 20m glacial sand and clay. (Poor seismic quality).

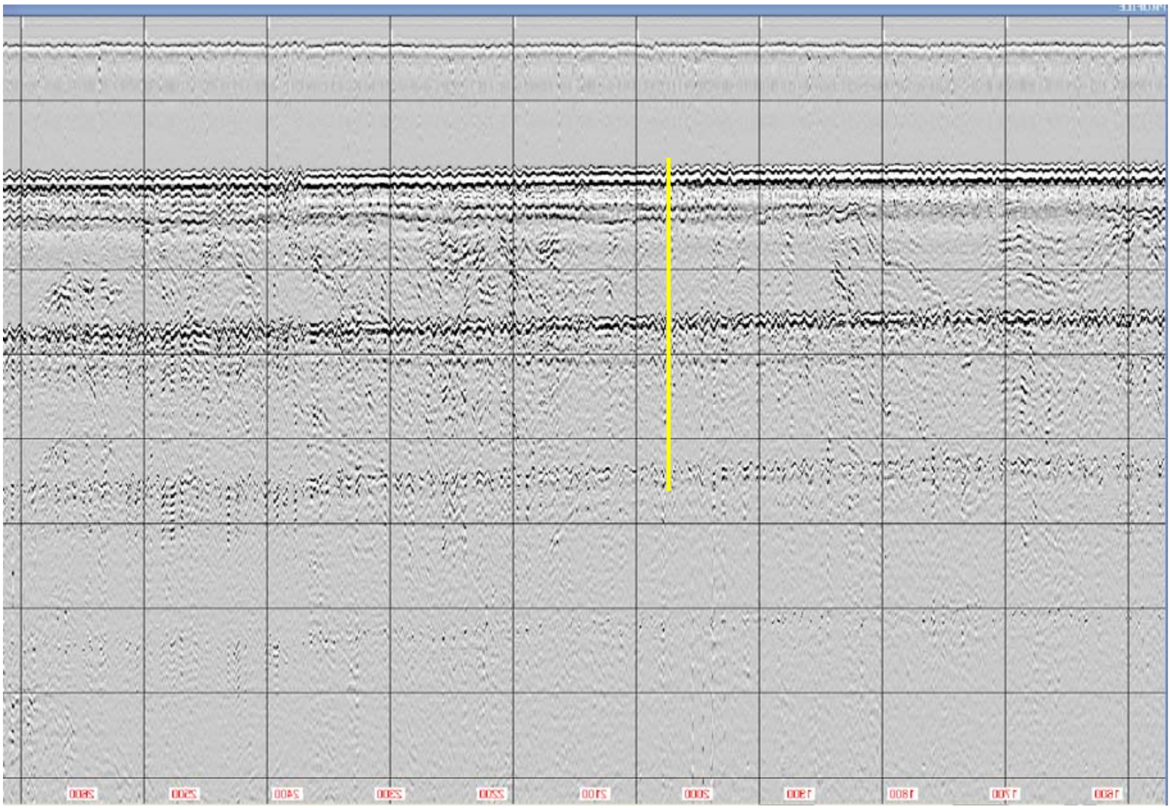




10.1.51 K3 (CPT 68)

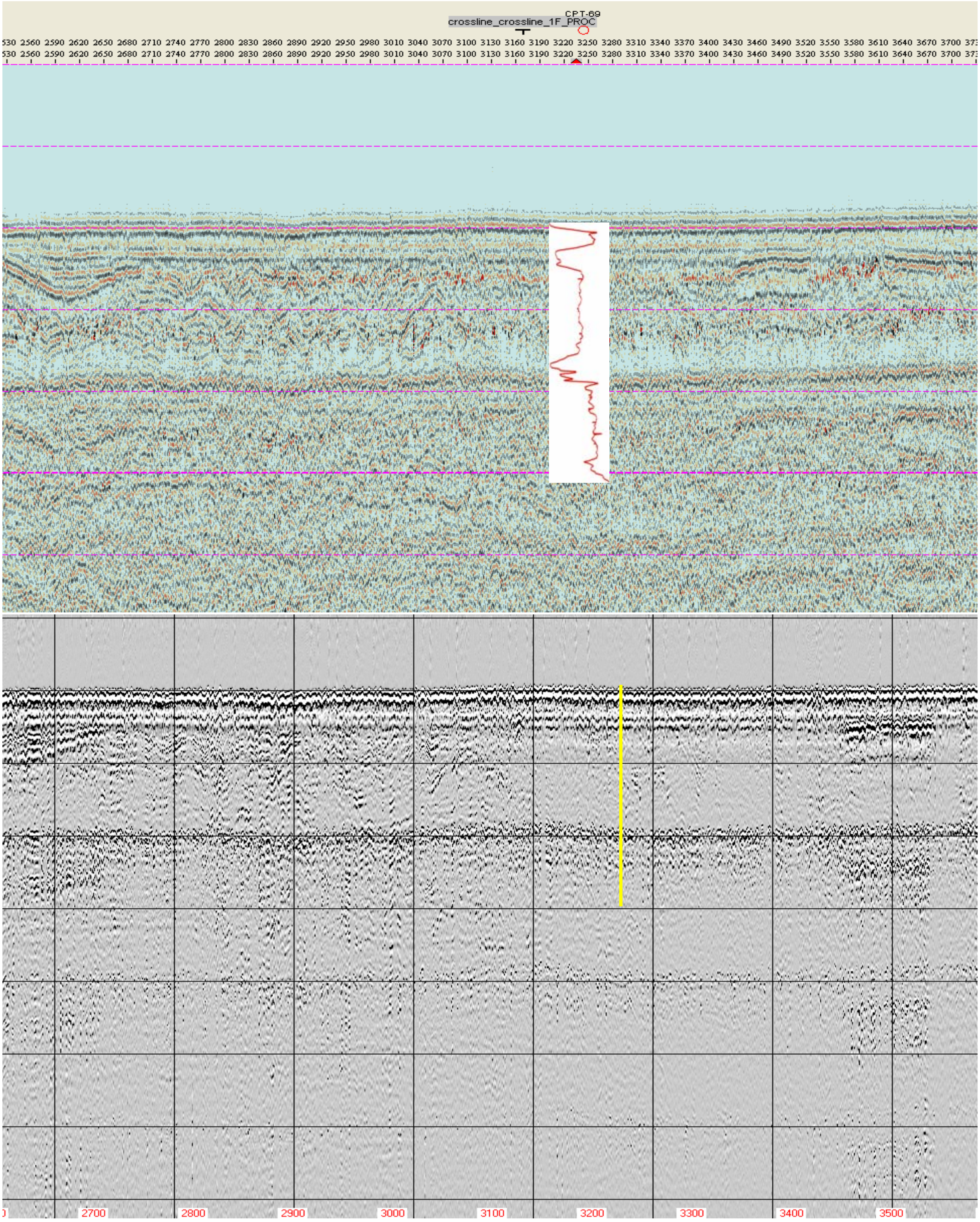
The Seismic line HR 148 in combination with CPT 68 plus Figure 21 (Chart 109) show, that CPT 68 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. 3 m Holocene top sand layer covers 25m glacial sand and clay.





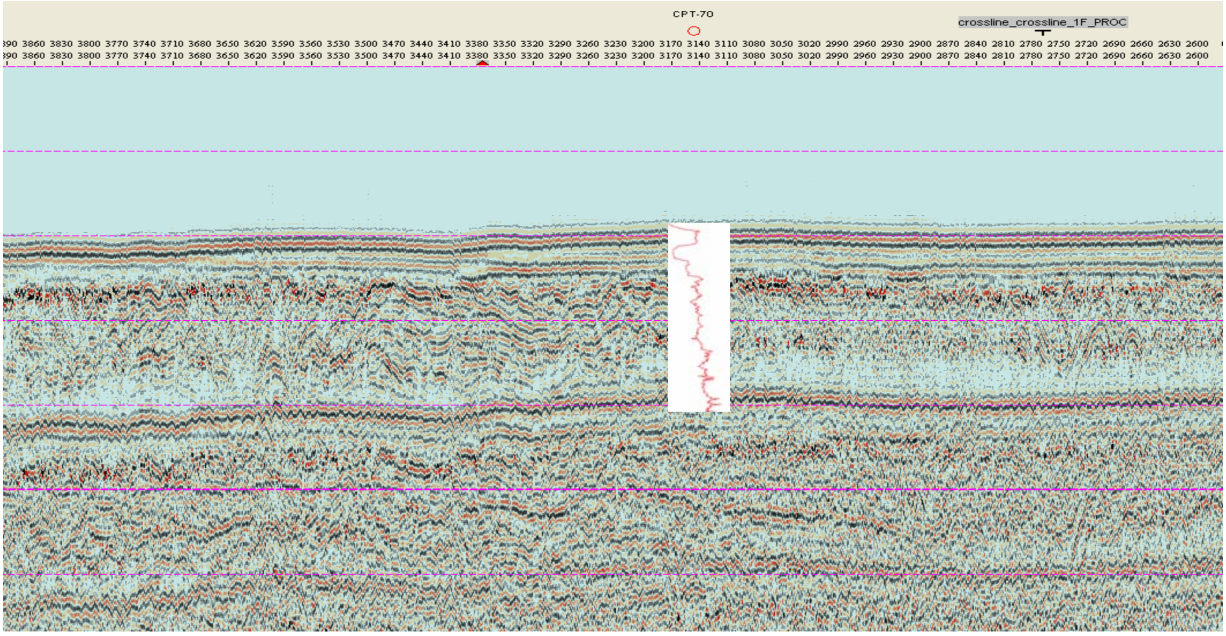
10.1.52 K4 (CPT 69)

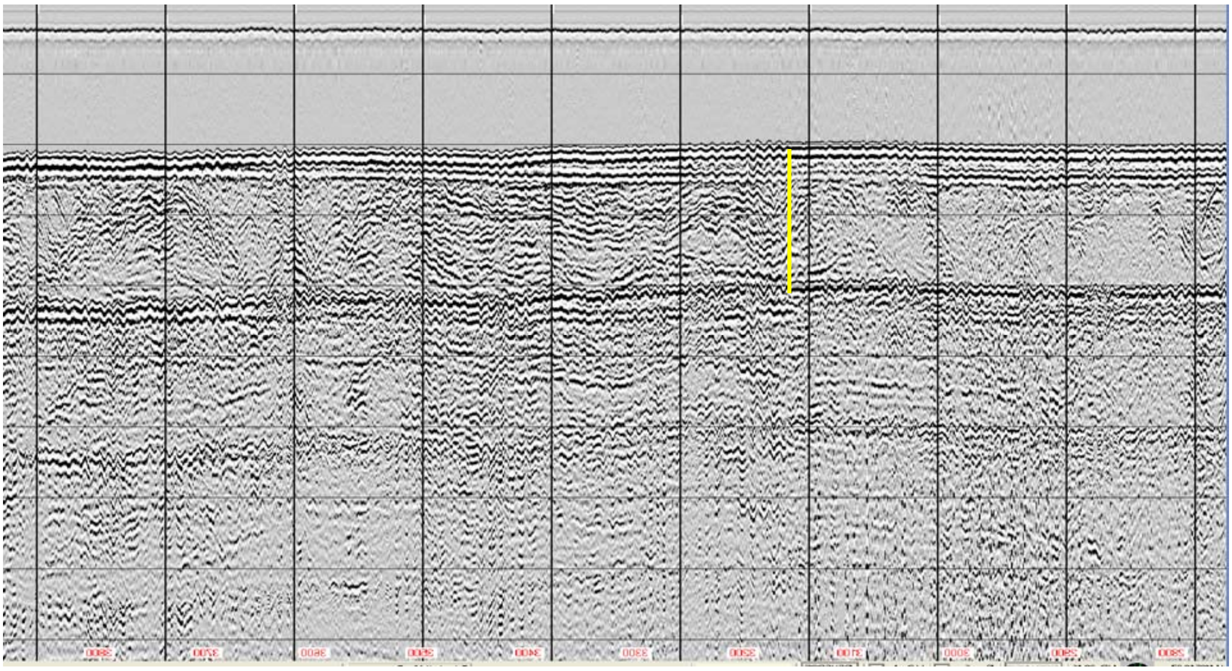
The Seismic line HR 154 in combination with CPT 69 plus Figure 21 (Chart 109) shows, that CPT 69 is located in the heavy disturbed zone on the margin to a folded deformation zone. This means that it is not possible from the seismic data to establish any stratigraphy and the sediment layering must also be expected to be chaotic with many shifts in lithology. In CPT 69 3-5 m meter thick Holocene top sand layer covers 20m glacial clay and sand with chaotic bedding.



10.1.53 K5 (CPT 70)

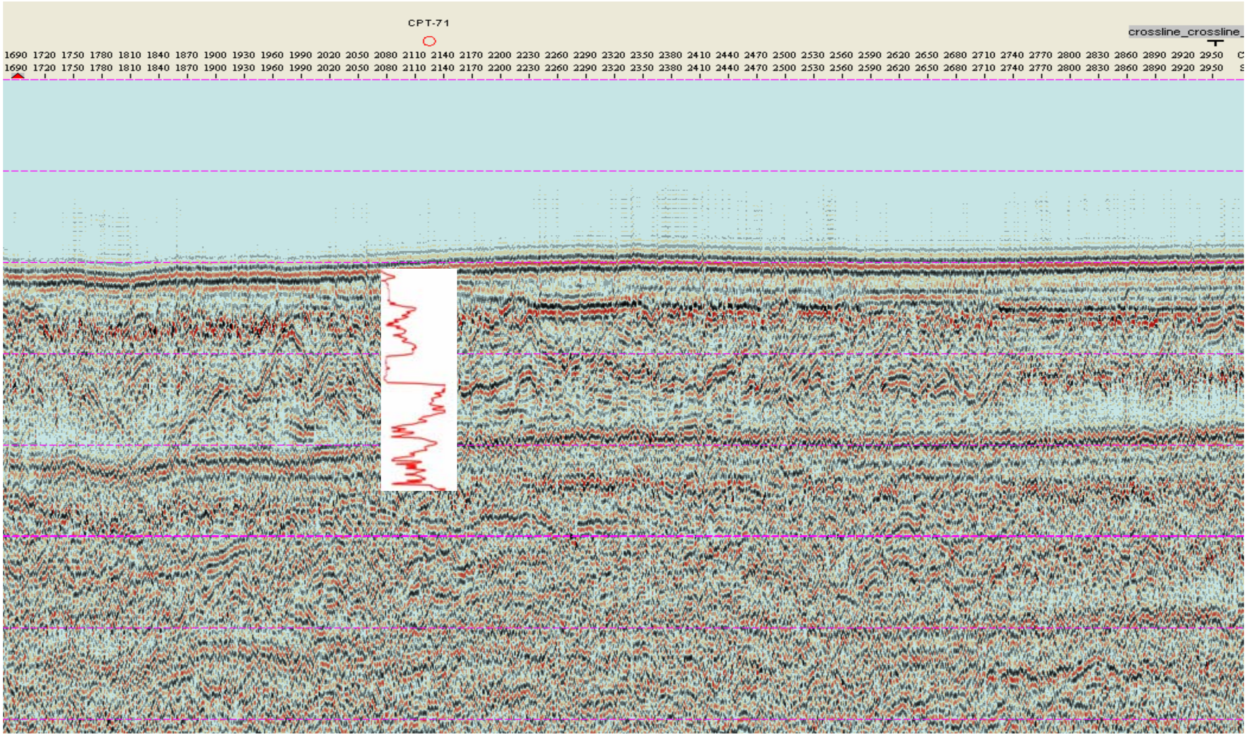
The Seismic line HR 160 in combination with CPT 70 plus Figure 21 (Chart 109) shows, that CPT 70 is located in the weak disturbed zone. This means that below the Holocene deposits exists a rather simple layering in general with an approximately 20m thick glaciofluvial sandy layer above glacial clays. In CPT 70 3-5m Holocene sand layer (fine-grained at bottom), covers more than 10m glaciofluvial sand (according to the seismic data more than 20m glaciofluvial sand) above glacial sand and clay.

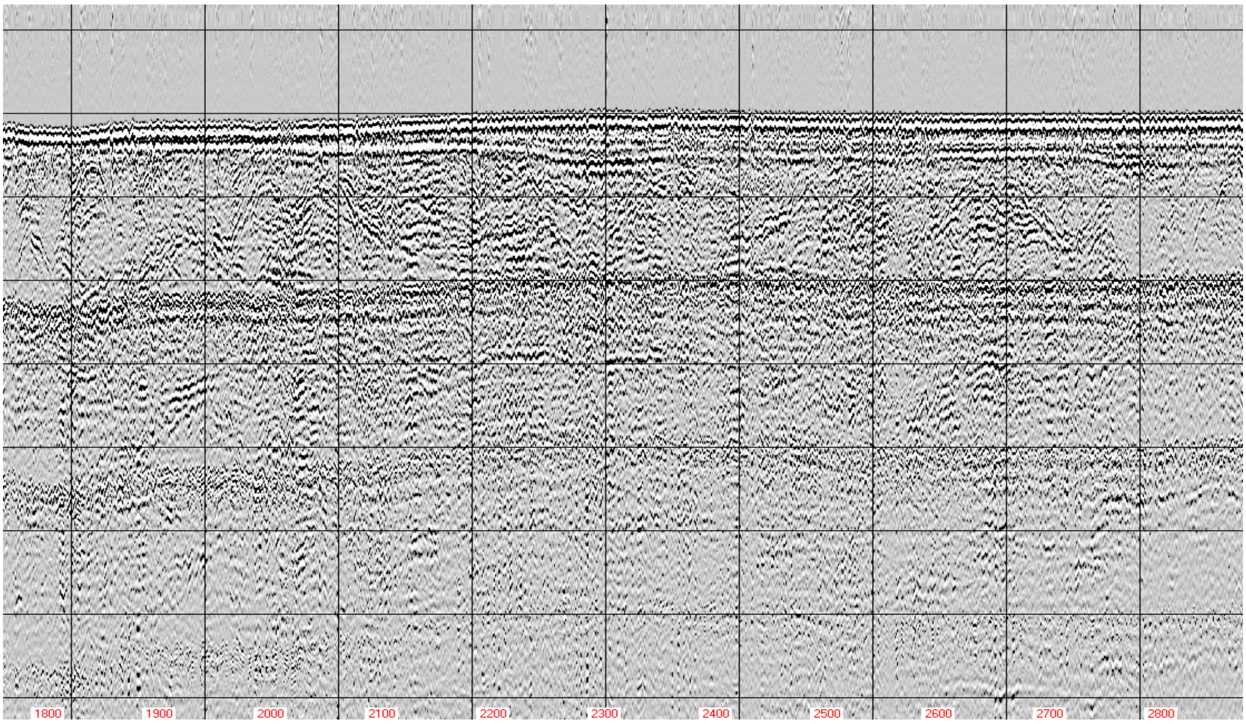




10.1.54 K6 (CPT 71)

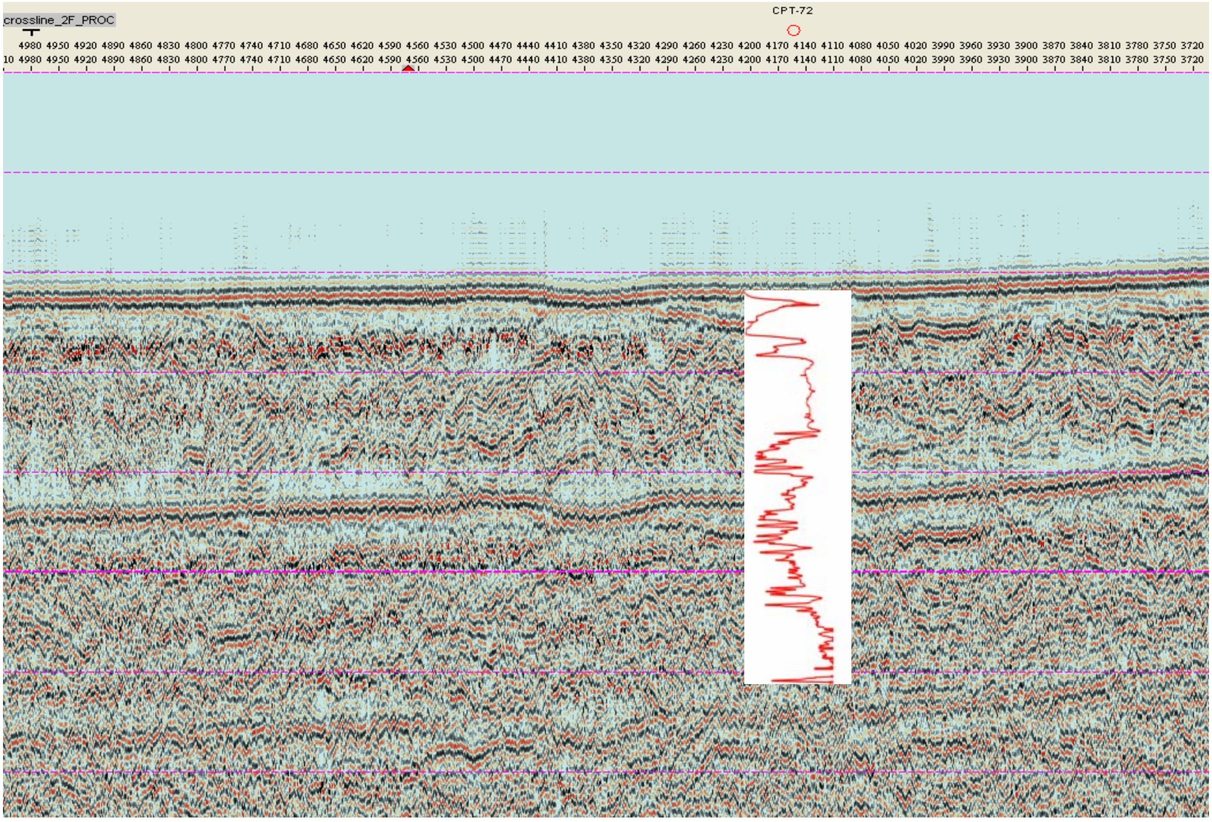
The Seismic line HR 166 in combination with CPT 71 plus Figure 21 (Chart 109) shows, that CPT 71 is located in the weak disturbed zone. This means that below the Holocene deposits exists a rather simple layering in general with an approximately 20m thick glaciofluvial sandy layer above glacial clays. In CPT 71 a 2-3m Holocene sand layer covers more than 10m glaciofluvial sand above glacial sand and clay.

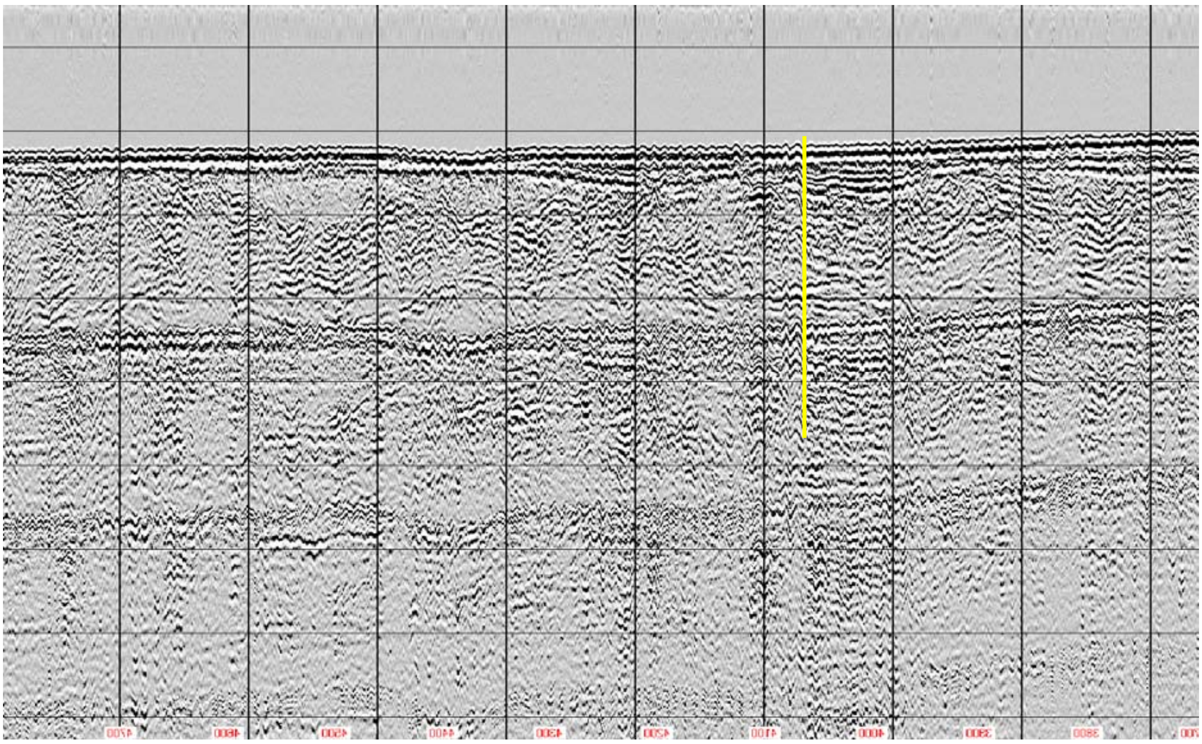




10.1.55 K7 (CPT 72)

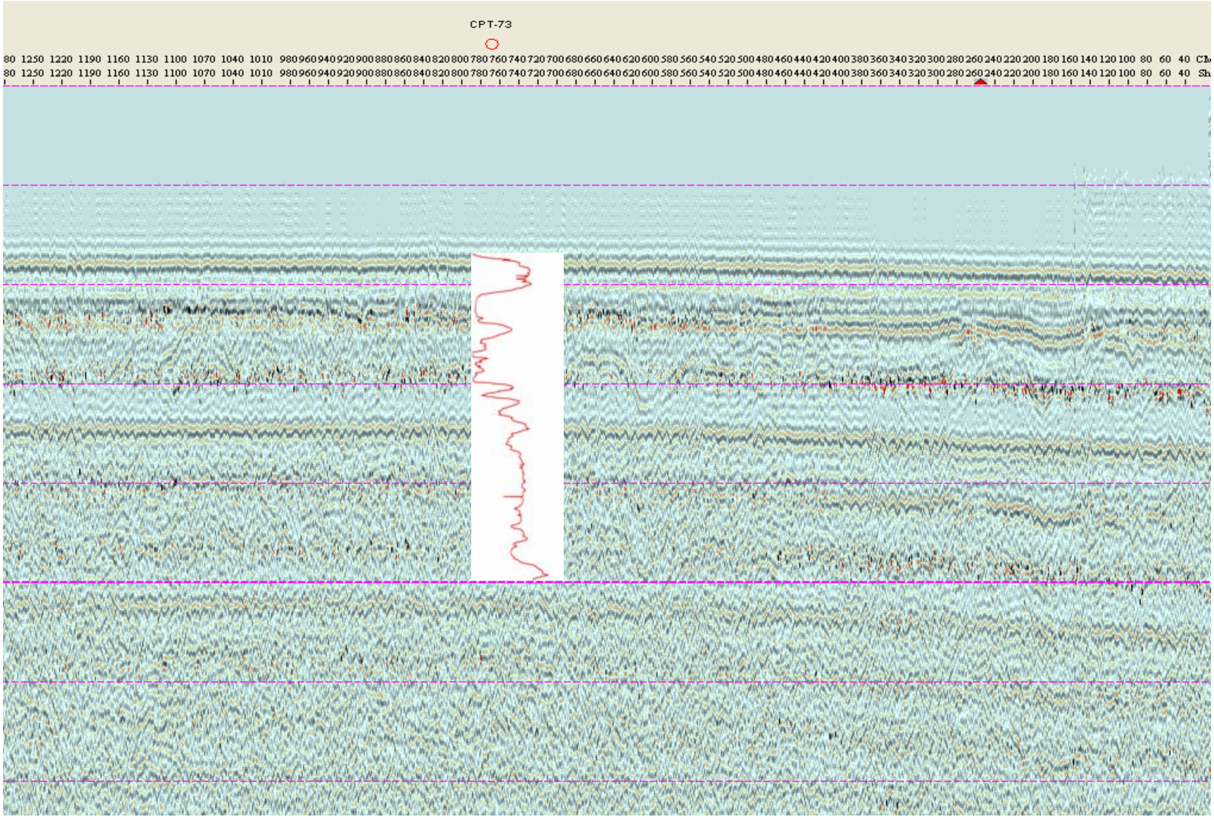
The Seismic line HR 172 in combination with CPT 72 plus Figure 21 (Chart 109) shows, that CPT 72 is located in the weak disturbed zone. This means that below the Holocene deposits exists a rather simple layering in general with an approximately 20m thick glaciofluvial sandy layer above glacial clays. In CPT 72 a 2-3m Holocene sand layer covers more than 20m glaciofluvial sand above glacial sand and clay.

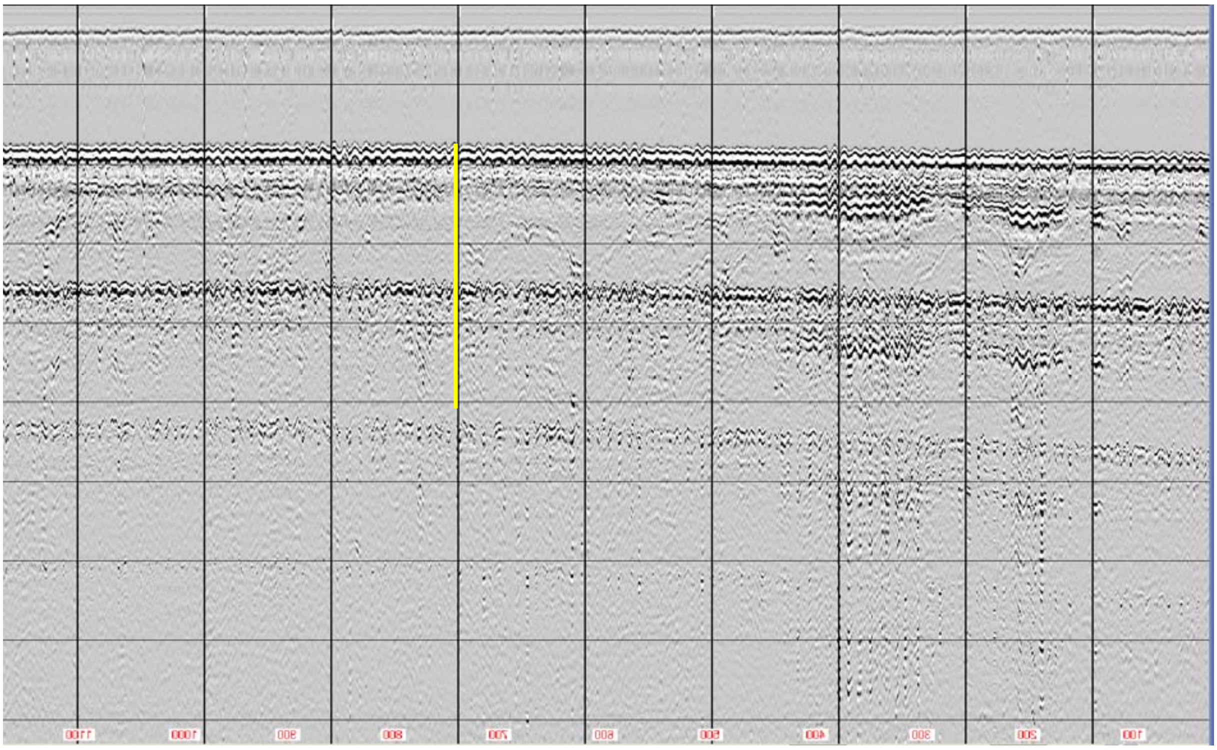




10.1.56 L1 (CPT 73)

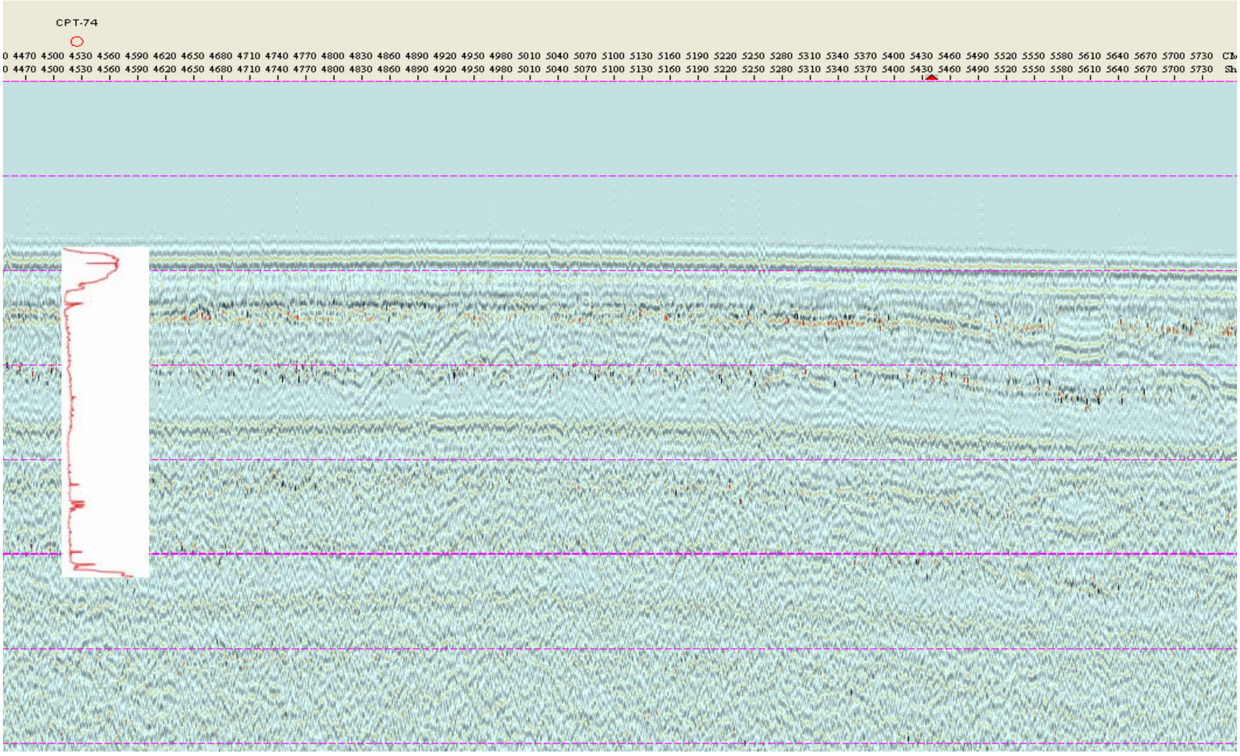
The Seismic line HR 148 in combination with CPT 73 plus Figure 21 (Chart 109) show, that CPT 73 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. 3-5m top layer of Holocene sand over Holocene fine sand to gyttja covers 20m glacial sand and clay.

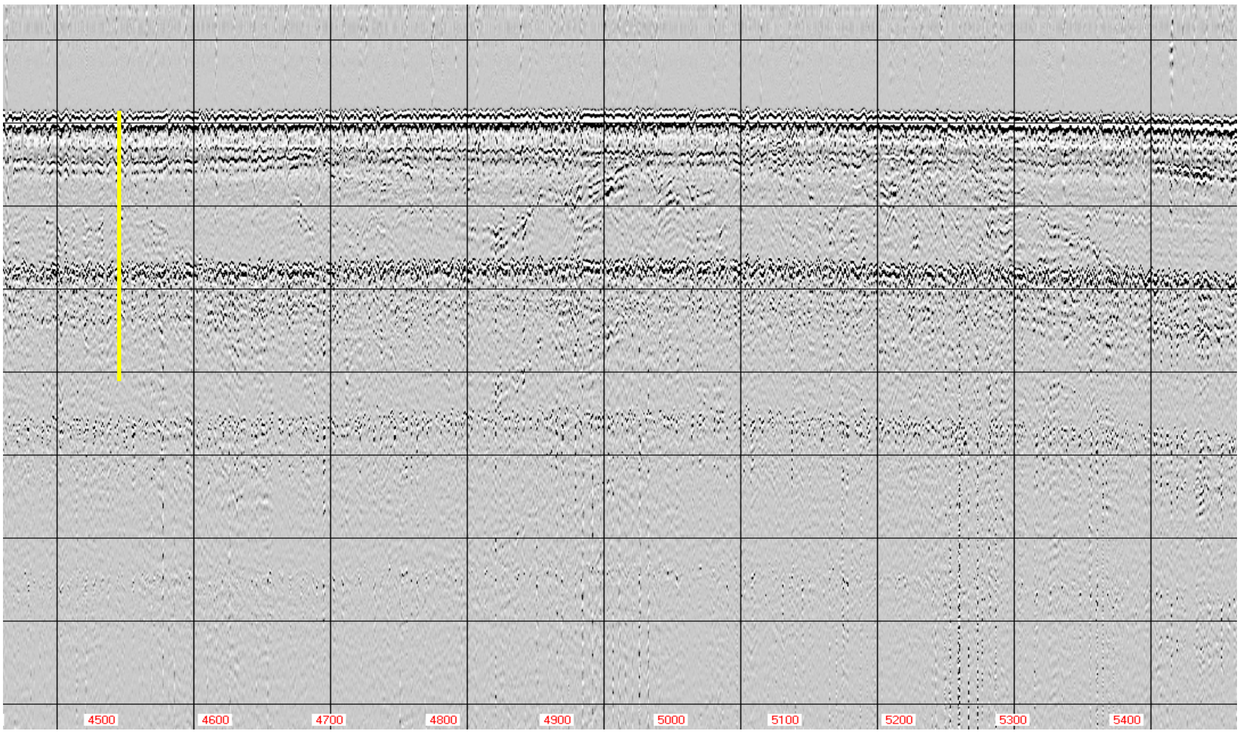




10.1.57 L2 (CPT 74)

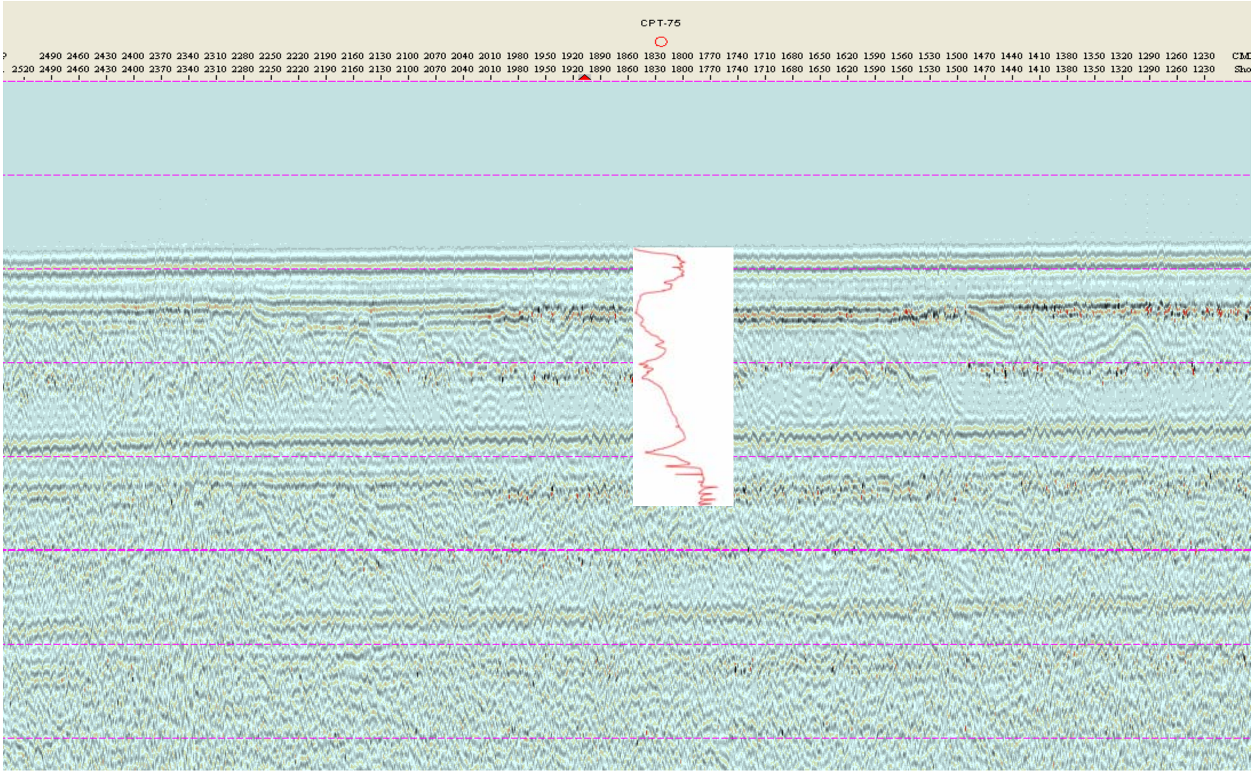
The Seismic line HR 154 in combination with CPT 74 plus Figure 21 (Chart 109) show, that CPT 74 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. A 3-5m top layer of Holocene sand over Holocene fine sand to gyttja covers 20m possibly glaciolacustrine or interglacial clay followed by glacial sand and clay. CPT 74 is very much alike CPT 66, BH 6.

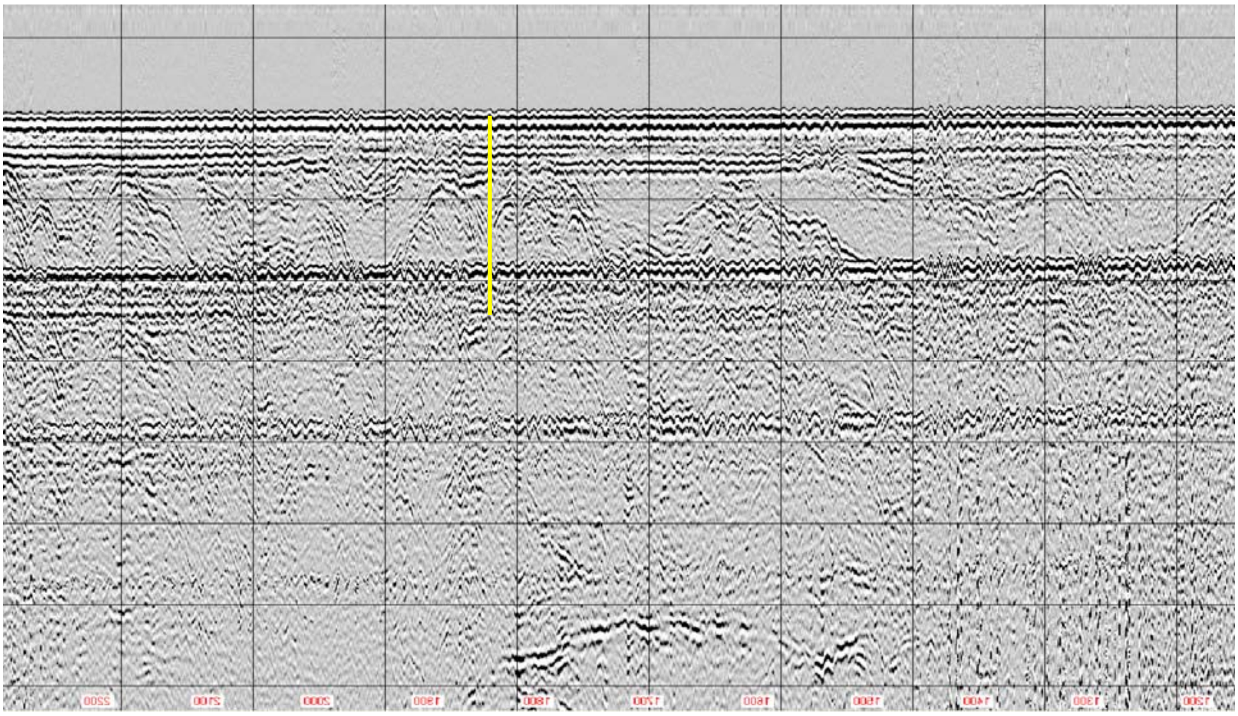




10.1.58 L3 (CPT 75)

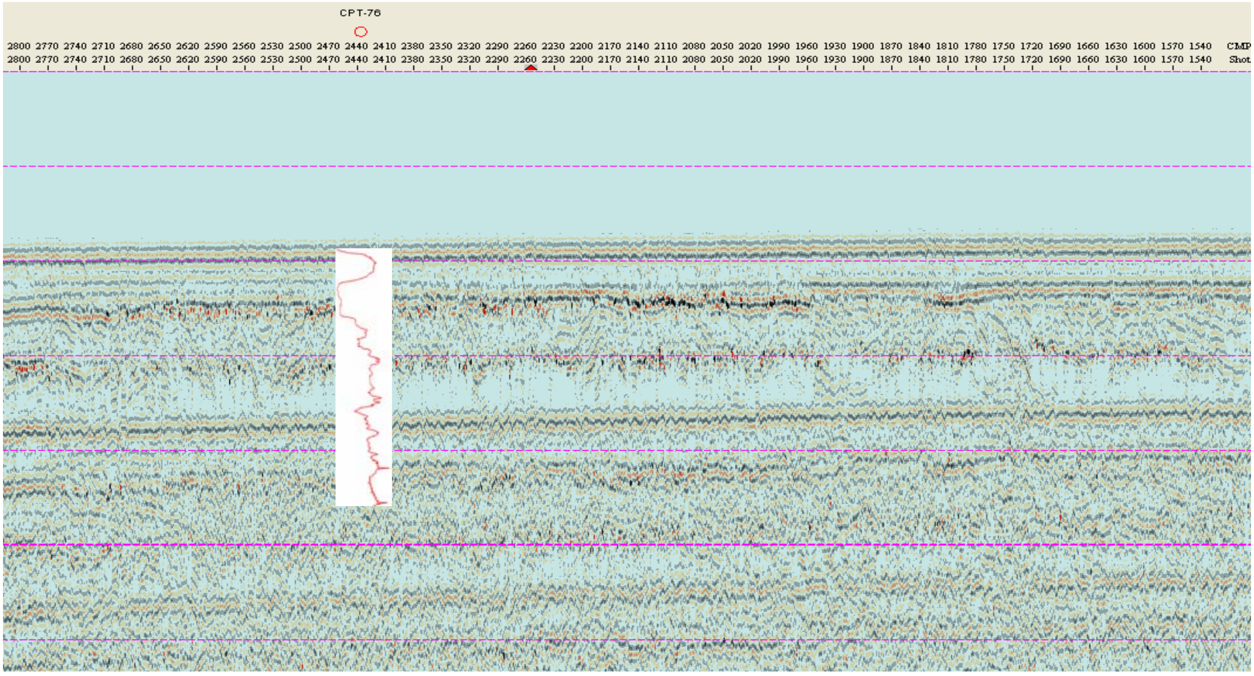
The Seismic line HR 160 in combination with CPT 75 plus Figure 21 (Chart 109) show, that CPT 75 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. A 3-5m top layer of Holocene sand over Holocene fine sand to gyttja covers 15m glacial sand and clay.

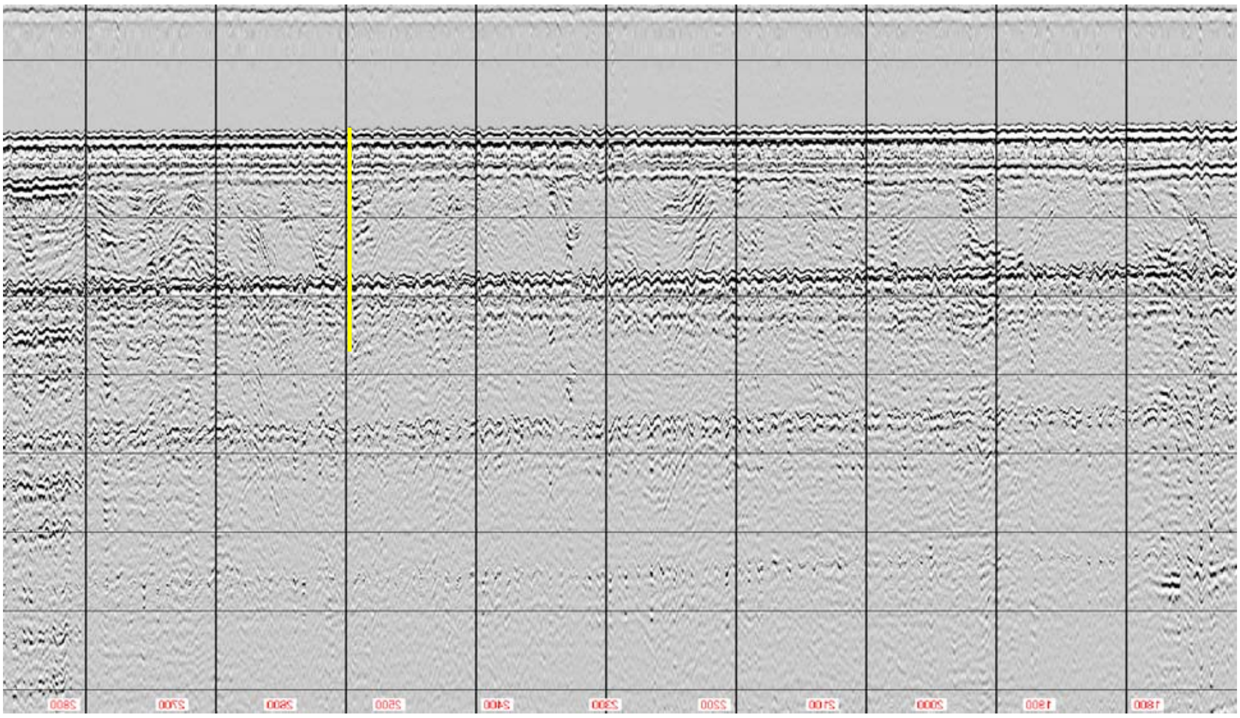




10.1.59 L4 (CPT 76)

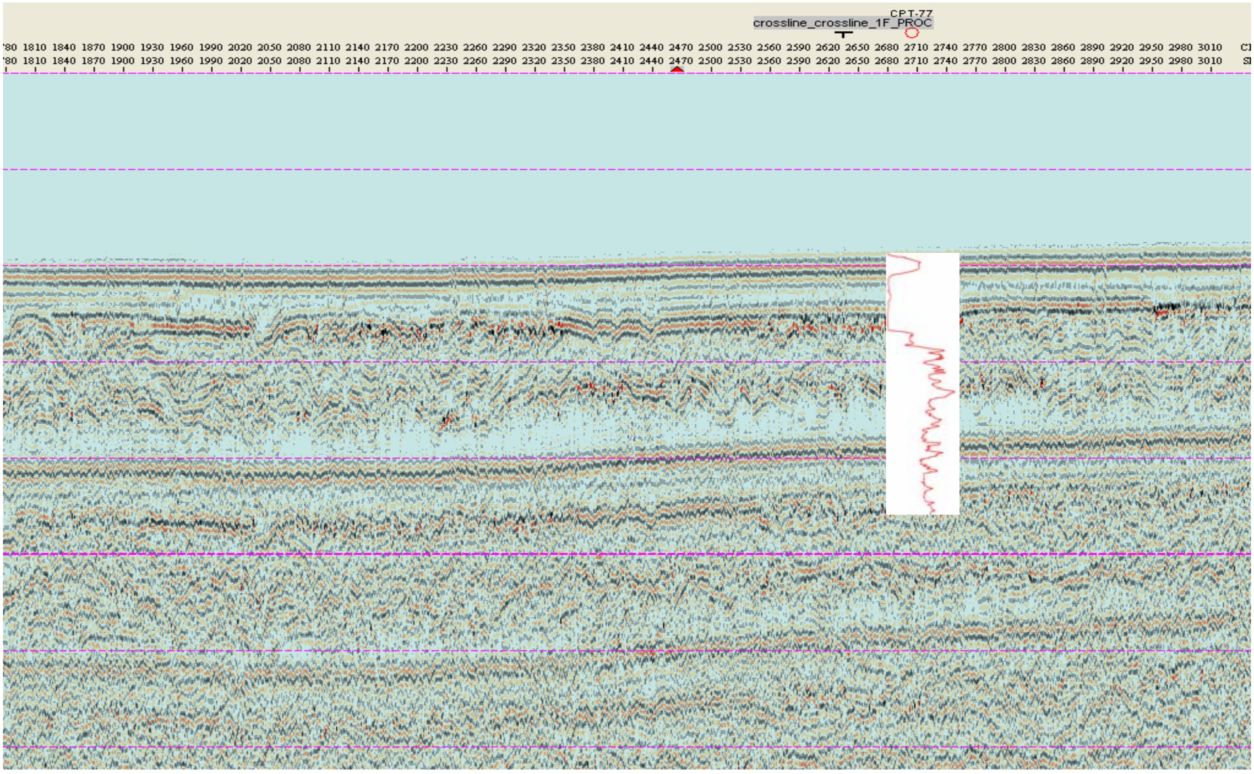
The Seismic line HR 168 in combination with CPT 76 plus Figure 21 (Chart 109) show, that CPT 76 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. A 3-5m top layer of Holocene sand over Holocene fine sand to gyttja covers 15m glacial sand and clay.

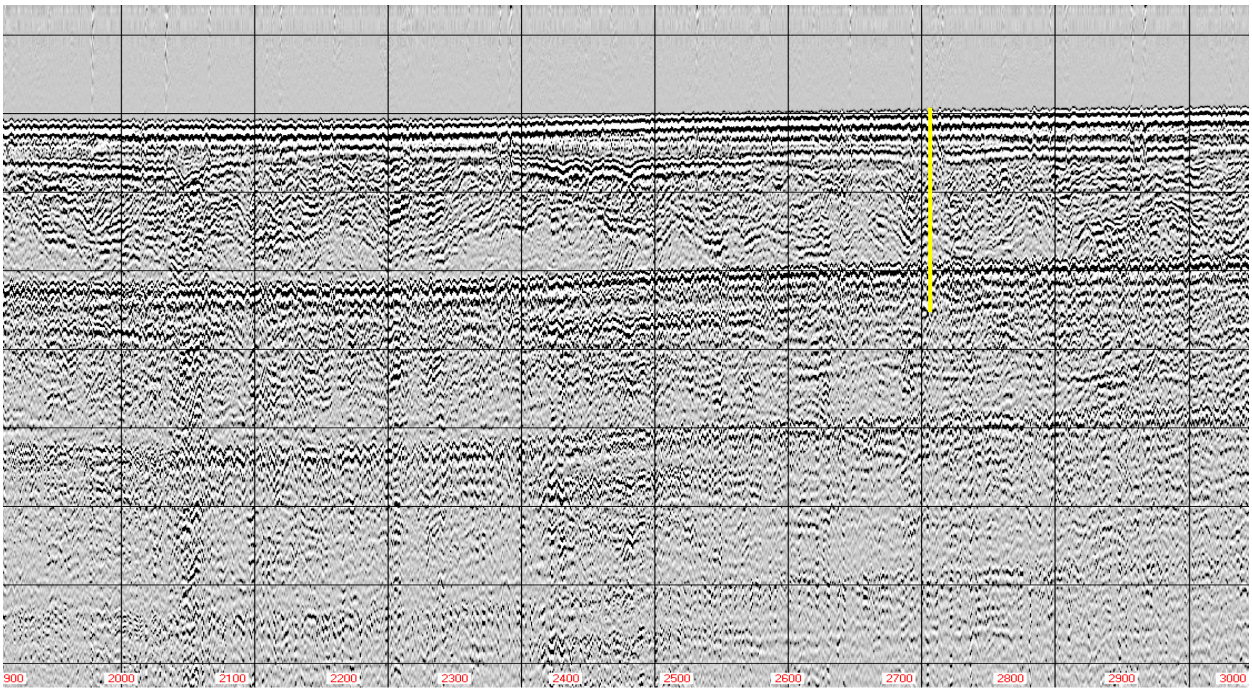




10.1.60 L5 (CPT 77)

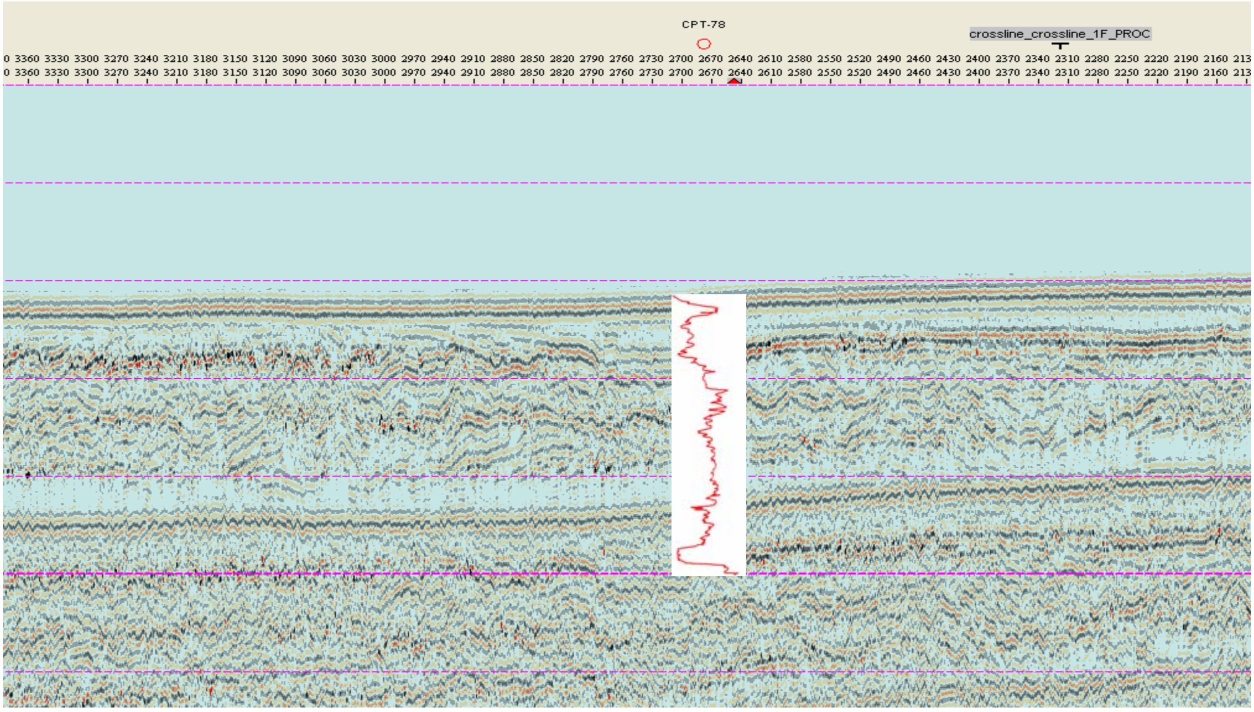
The Seismic line HR 174 in combination with CPT 77 plus Figure 21 (Chart 109) shows, that CPT 77 is located in the weak disturbed zone. This means that below the Holocene deposits exists a rather simple layering in general with an approximately 20m thick glaciofluvial sandy layer above glacial clays. In CPT 77 a 3-5m top layer of Holocene sand over Holocene fine sand to gyttja covers more than 20m glaciofluvial sand above glacial sand and clay.

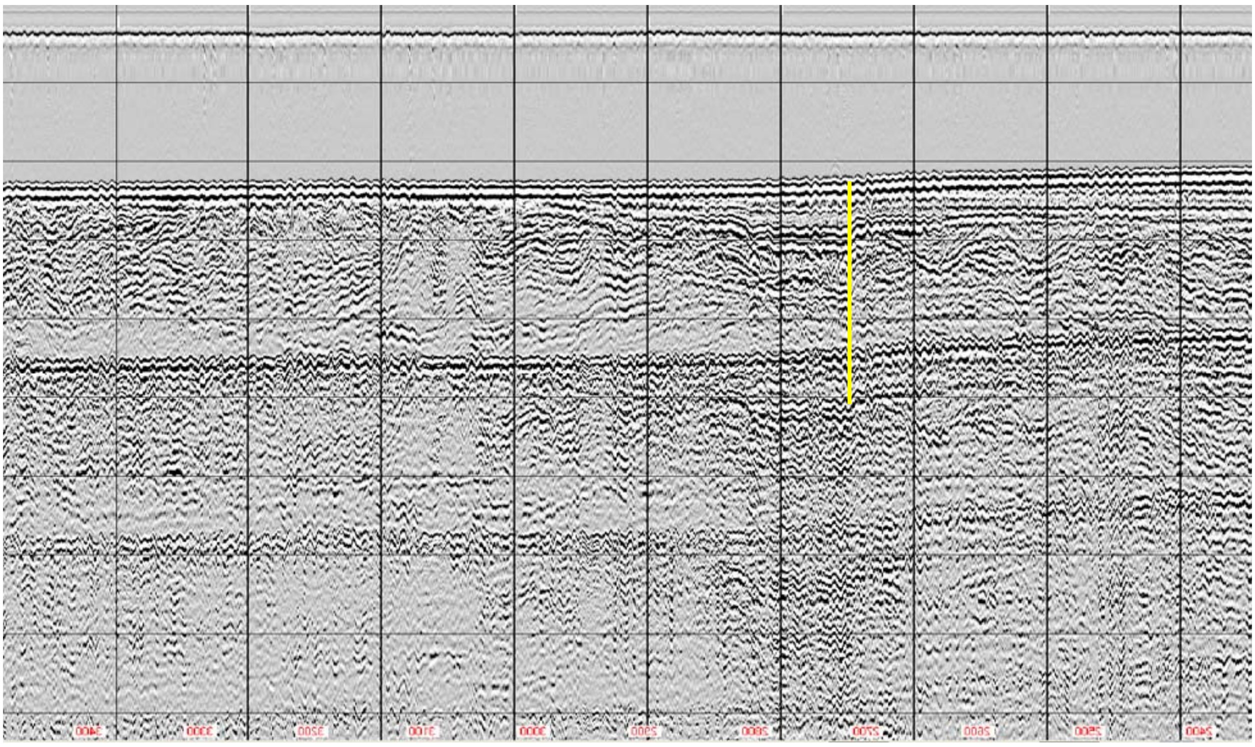




10.1.61 L6 (CPT 78)

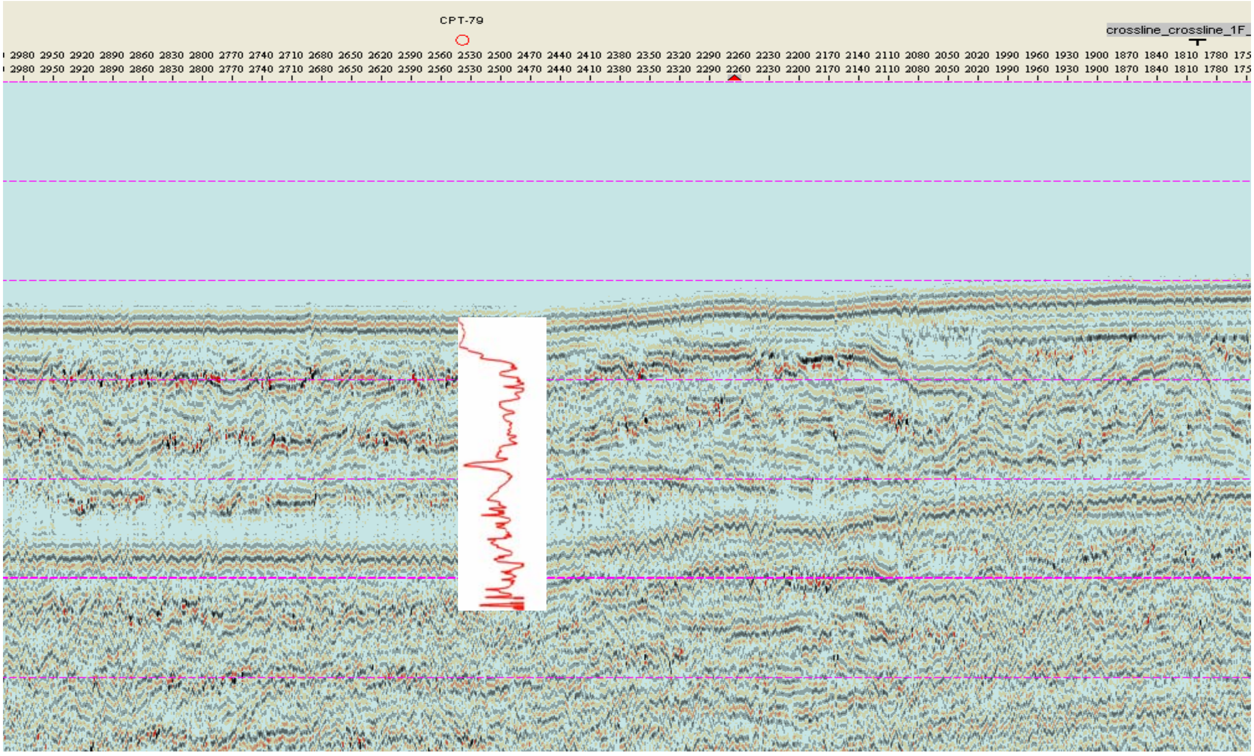
The Seismic line HR 180 in combination with CPT 78 plus Figure 21 (Chart 109) shows, that CPT 78 is located in the weak disturbed zone. This means that below the Holocene deposits exists a rather simple layering in general with an approximately 20m thick glaciofluvial sandy layer above glacial clays. In CPT 78 a 5-7m top layer of Holocene sand over Holocene fine sand to gyttja covers more than 20m glaciofluvial sand above glacial sand and clay.

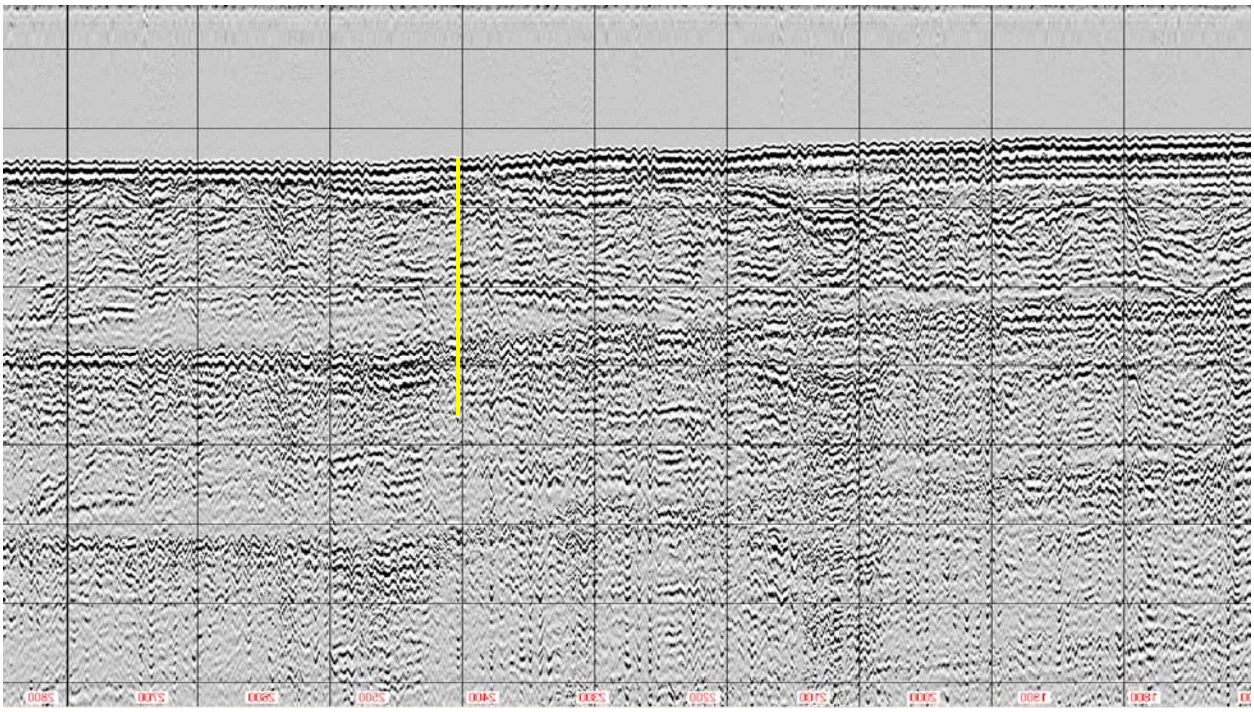




10.1.62 L7 (CPT 79)

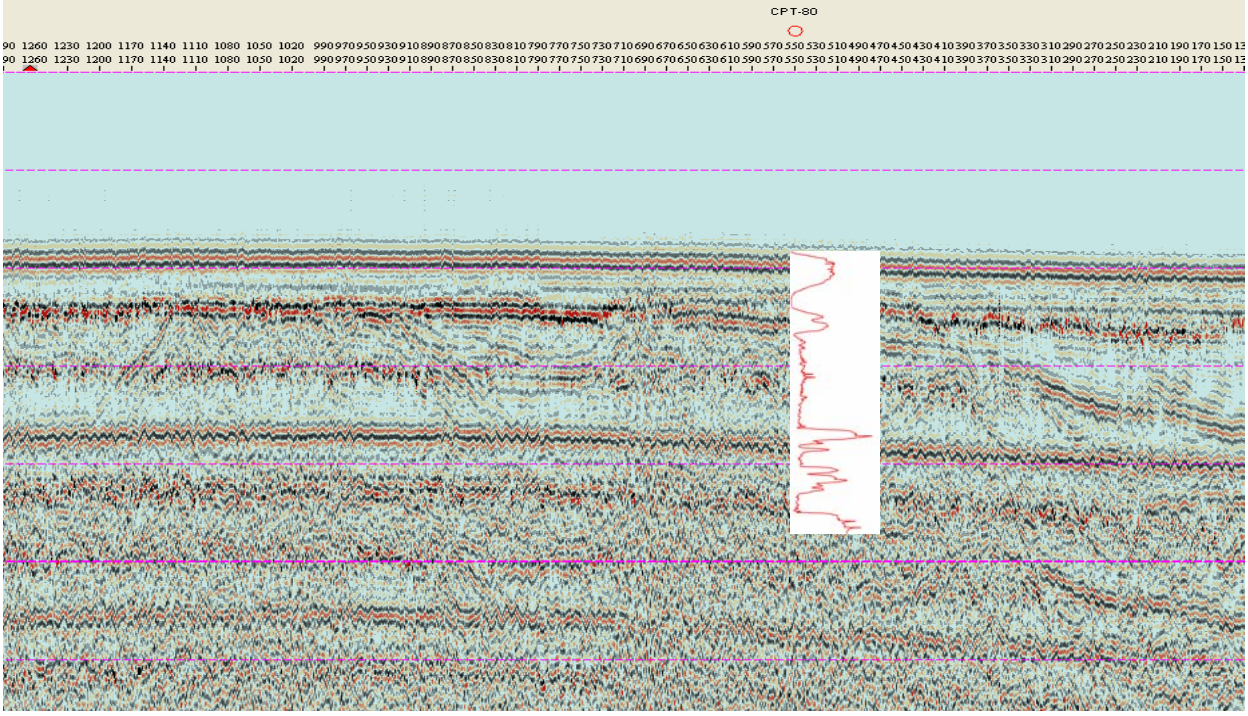
The Seismic line HR 188 in combination with CPT 79 plus Figure 21 (Chart 109) shows, that CPT 79 is located in the weak disturbed zone. This means that below the Holocene deposits exists a rather simple layering in general with an approximately 20m thick glaciofluvial sandy layer above glacial clays. In CPT 79 a 2-3m top layer of Holocene sand to gyttja covers more than 20m glaciofluvial sand above glacial sand and clay.

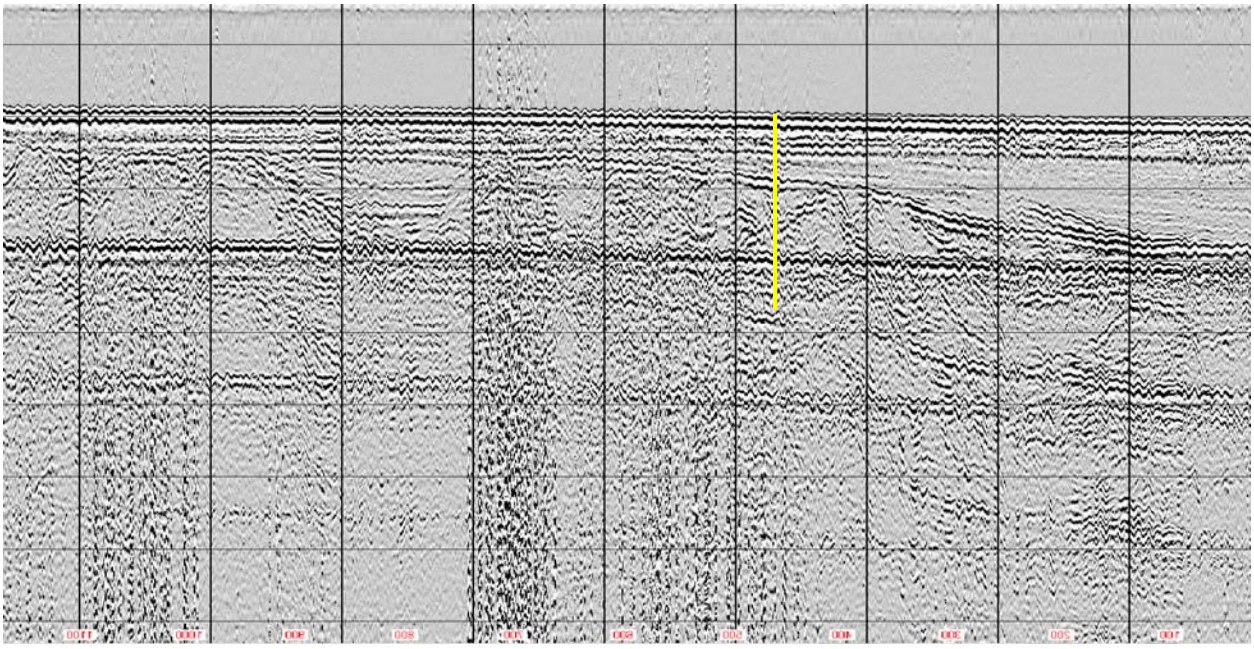




10.1.63 M1 (CPT 80)

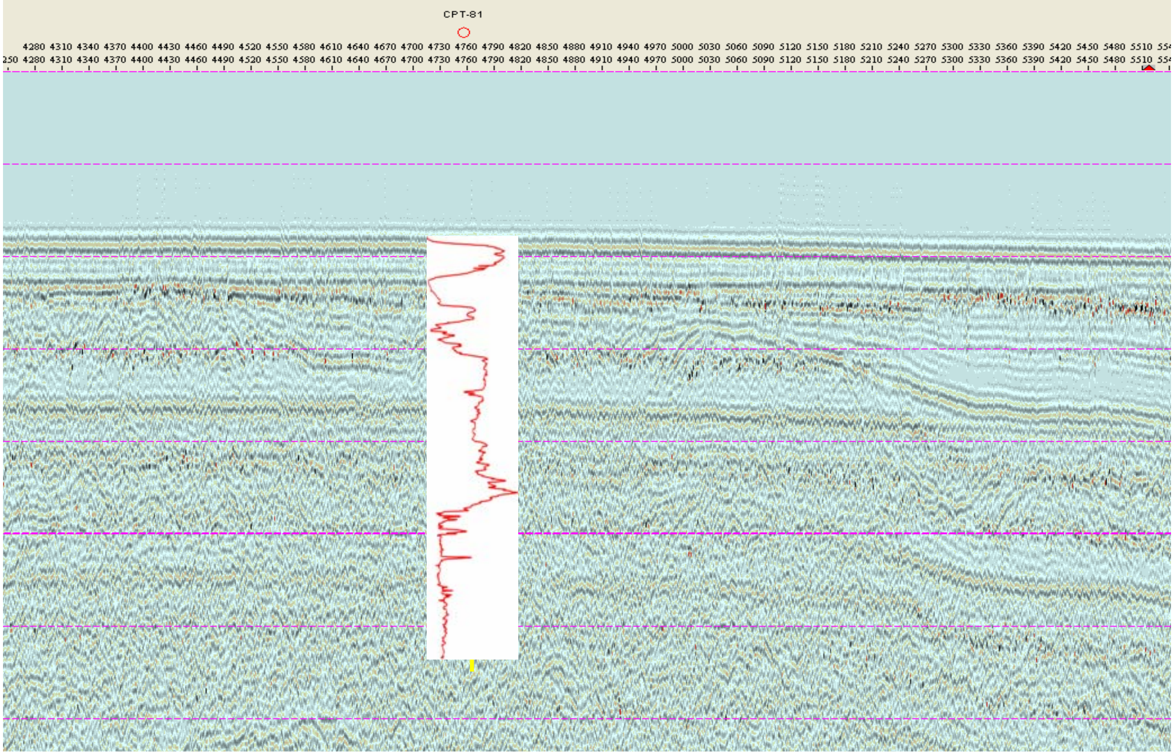
The Seismic line HR 160 in combination with CPT 80 plus Figure 21 (Chart 109) show, that CPT 80 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. A 5-7m top layer of Holocene sand over Holocene fine sand to gyttja covers few m sand followed by about 10 m clay possibly glaciolacustrine or interglacial and finally 10m glacial sand and clay.

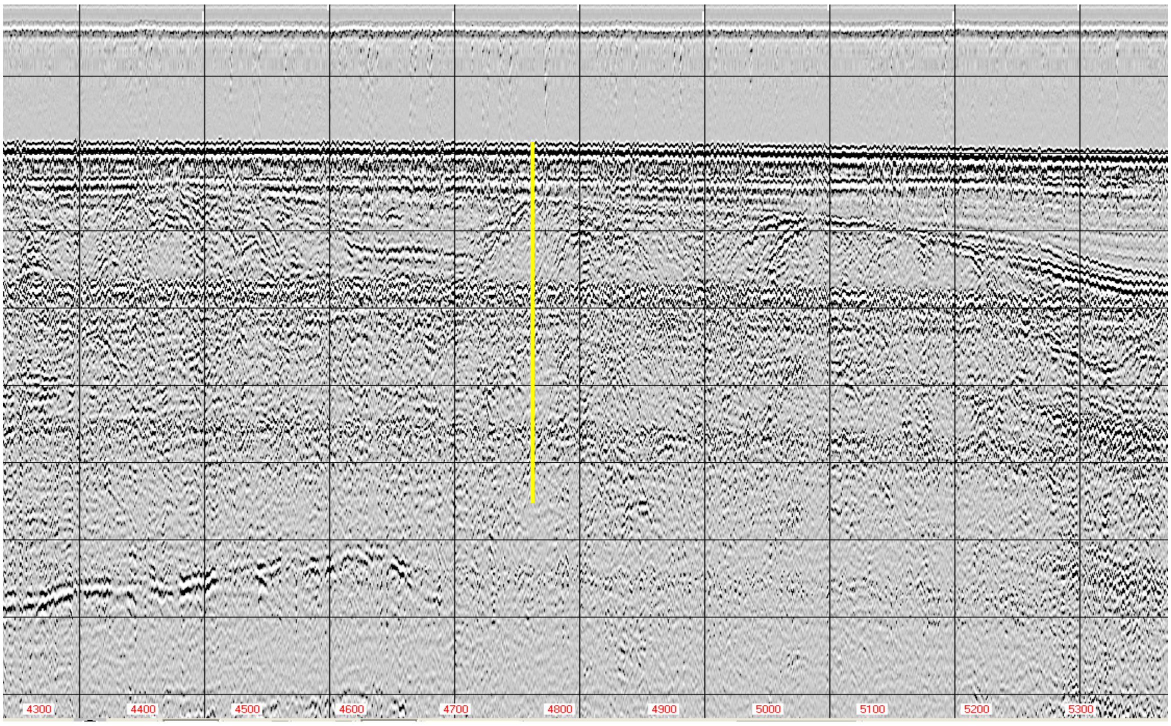




10.1.64 M2 (CPT 81, M2 (VIB 81)

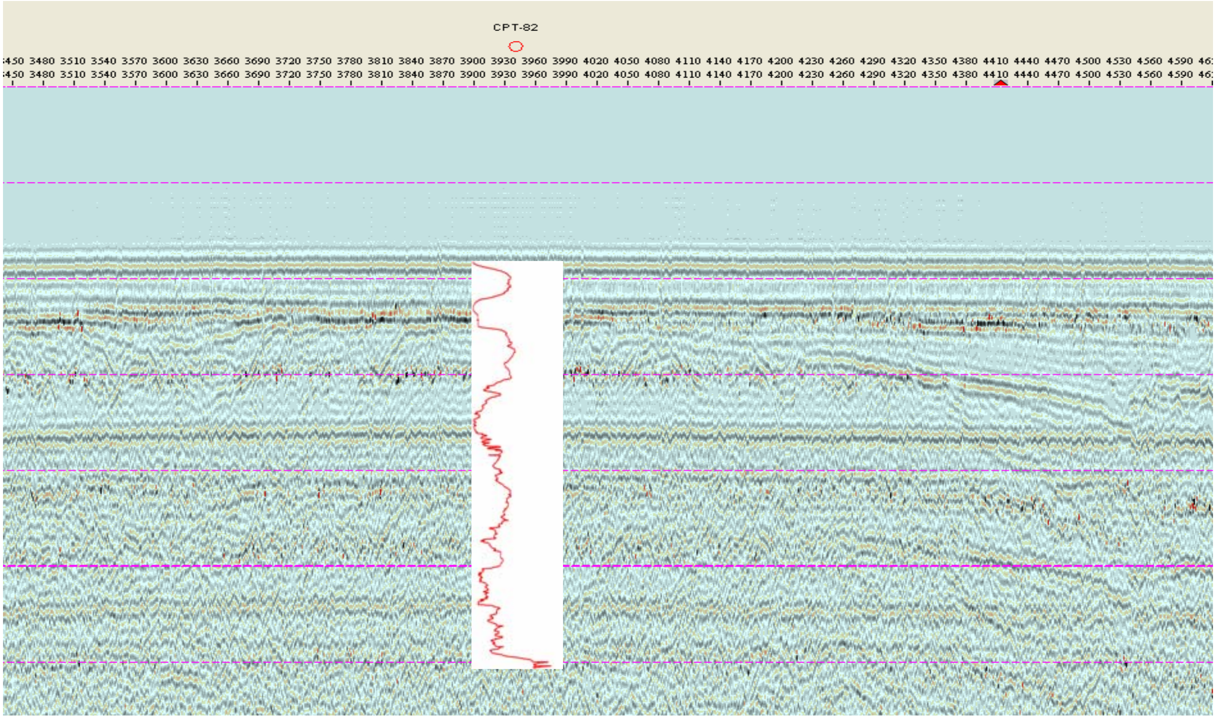
The Seismic line HR 166 in combination with CPT 81 plus Figure 21 (Chart 109) show, that CPT 81 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. 3-5m top layer of Holocene sand over Holocene fine sand to gyttja covers about 15 m glacial sand and clay followed by 10m clay possibly glaciolacustrine or interglacial.

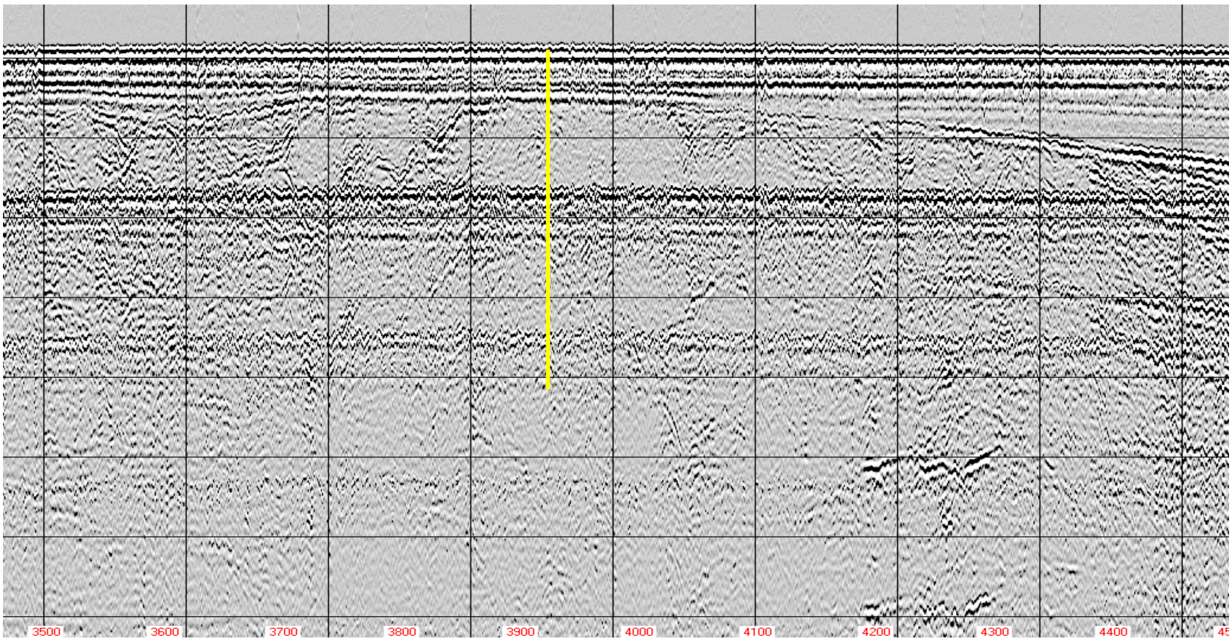




10.1.65 M3 (CPT 82)

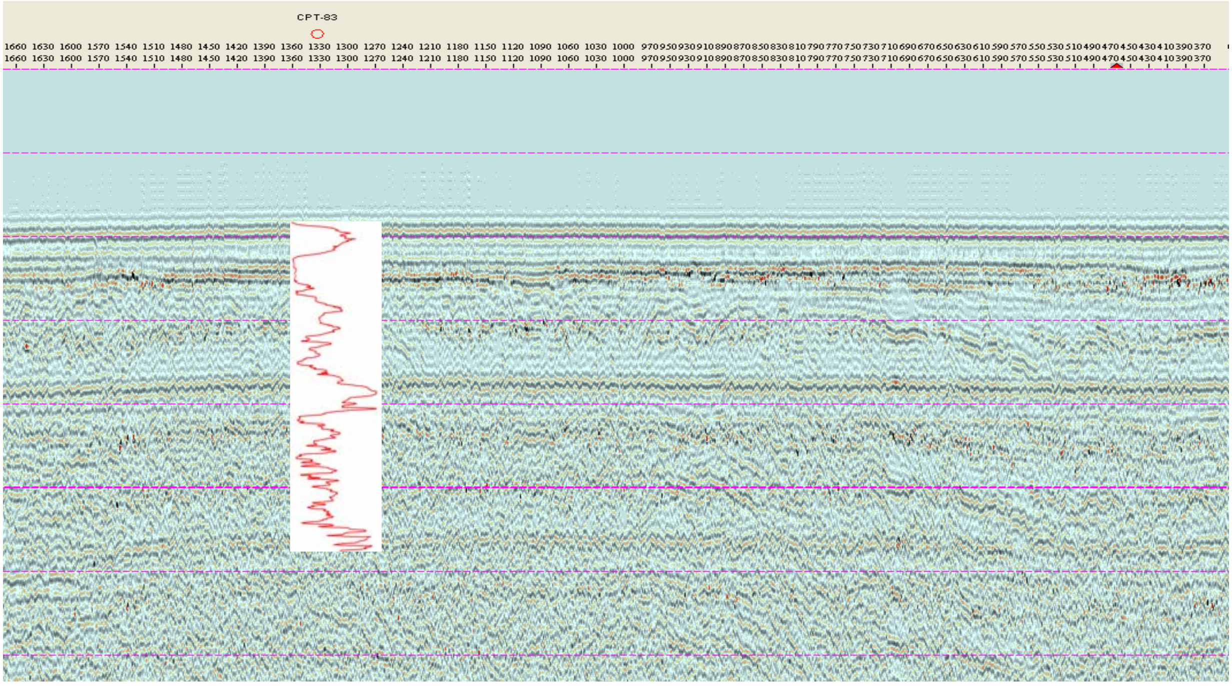
The Seismic line HR 174 in combination with CPT 82 plus Figure 21 (Chart 109) show, that CPT 82 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. 3-5m top layer of Holocene sand over Holocene fine sand to gyttja covers about 25 m glacial sand and clay.

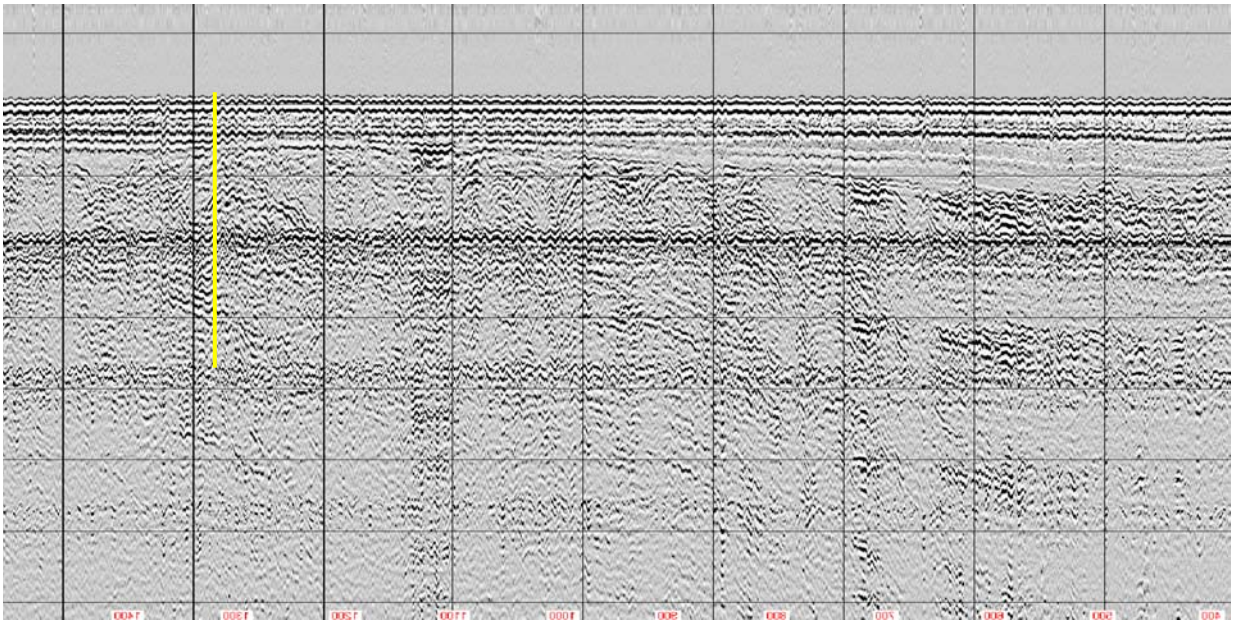




10.1.66 M4 (CPT 83)

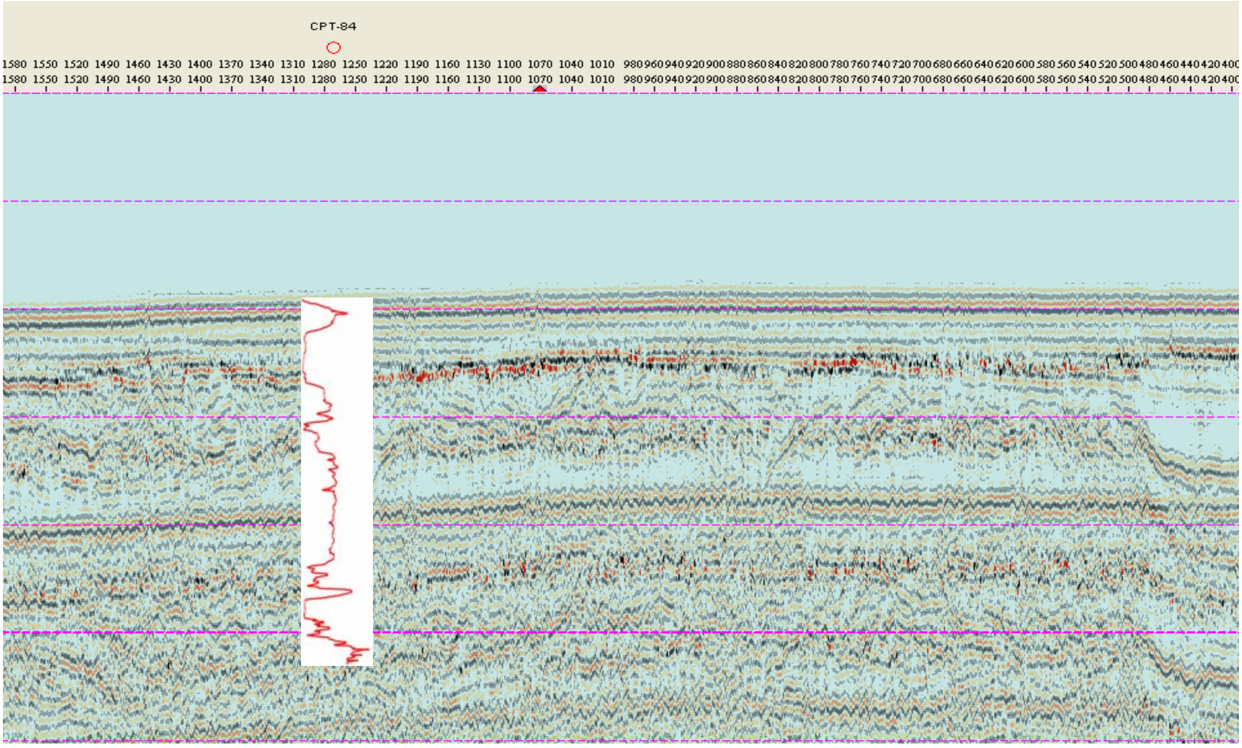
The Seismic line HR 180 in combination with CPT 83 plus Figure 21 (Chart 109) show, that CPT 83 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. 3-5m top layer of Holocene sand over Holocene fine sand to gyttja covers about 25 m glacial sand and clay.

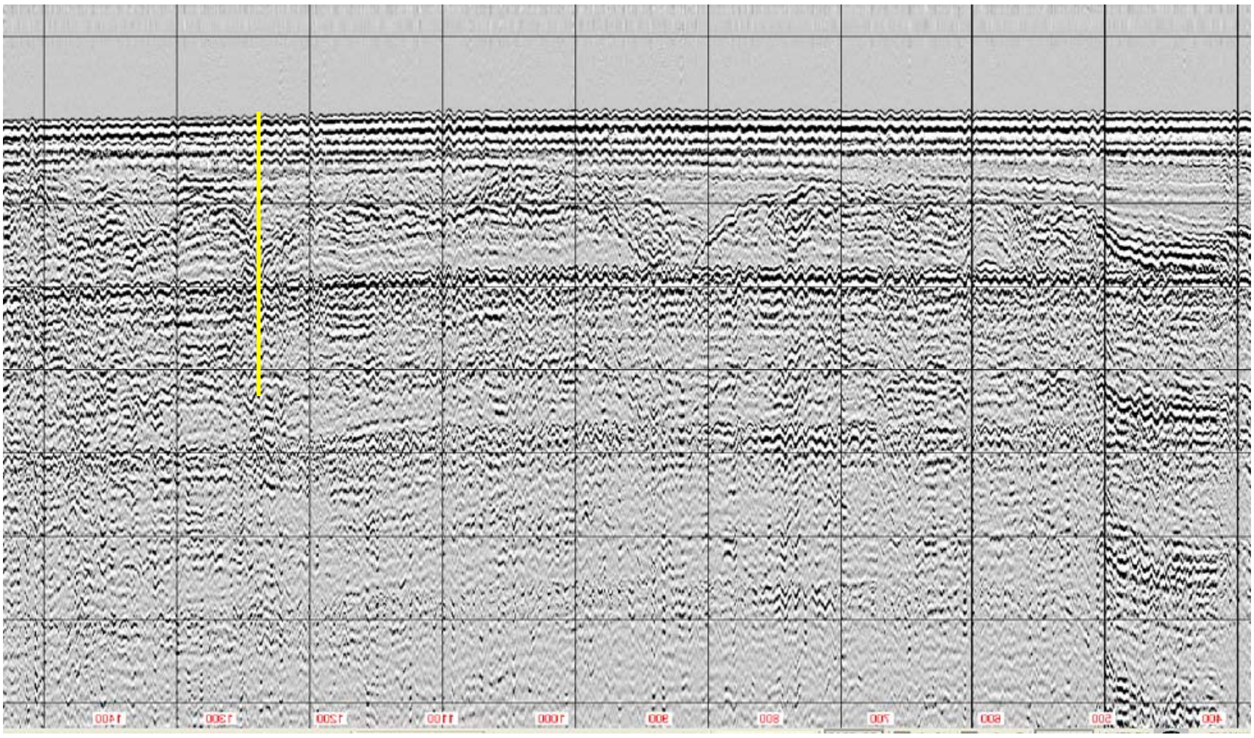




10.1.67 M5 (CPT 84)

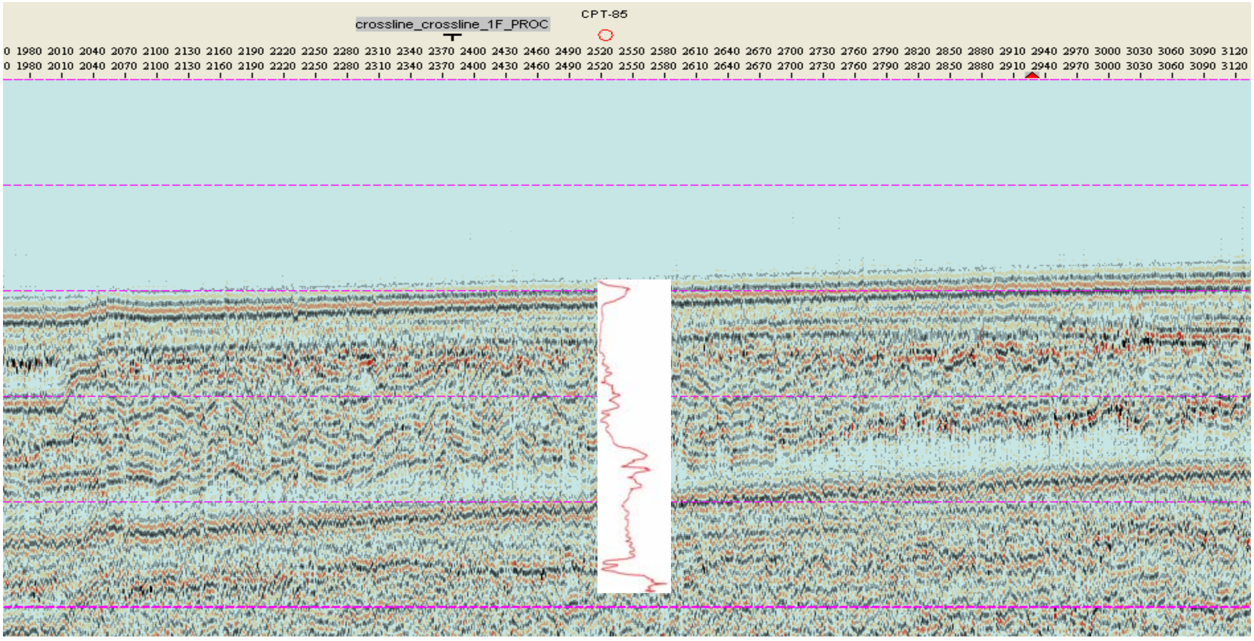
The Seismic line HR 188 in combination with CPT 84 plus Figure 21 (Chart 109) show, that CPT 84 is located in the folded deformation class. This means that it is possible to identify and interpret the seismic reflectors often with a wavy appearance. 3-5m top layer of Holocene sand over Holocene fine sand to gyttja covers about 25 m glacial sand and clay.

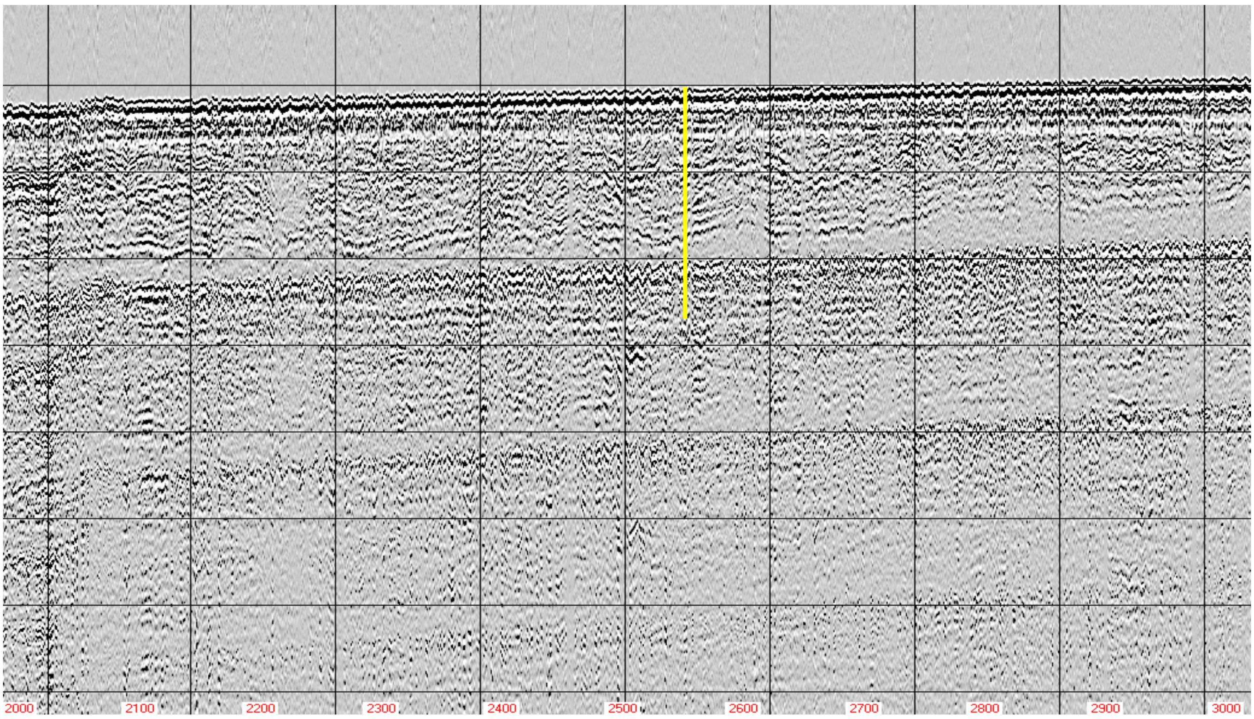




10.1.68 M6 (CPT 85)

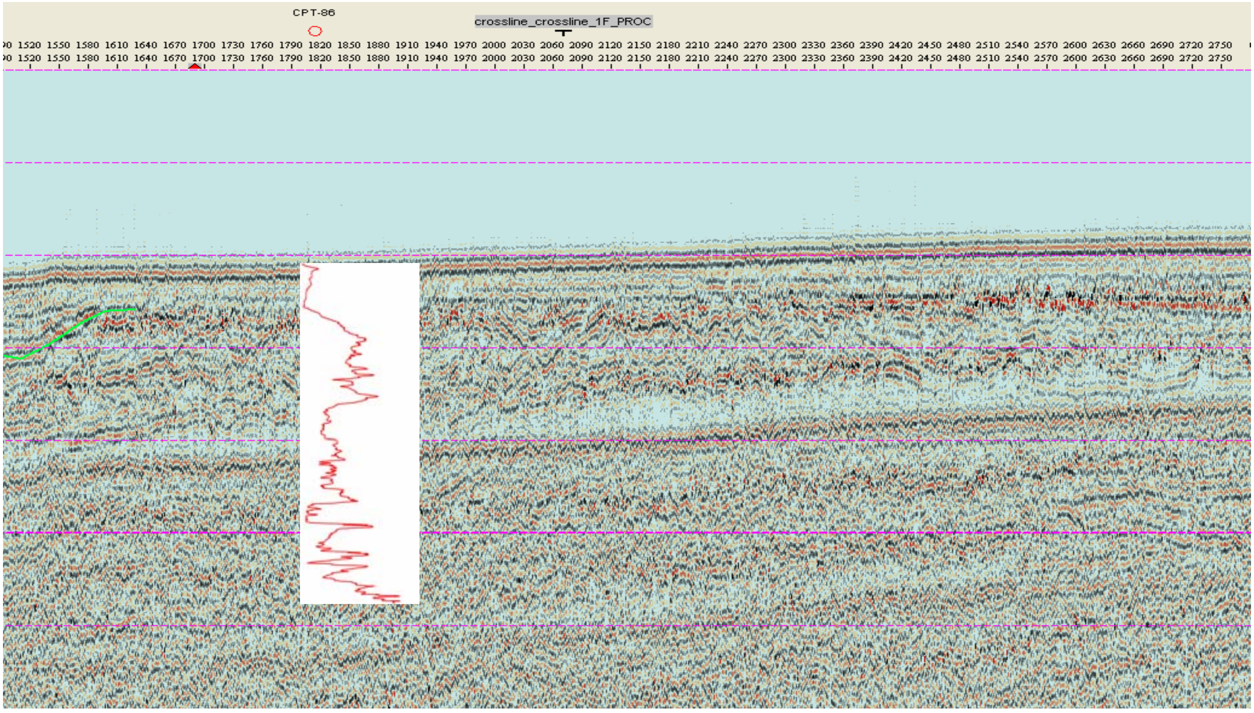
The Seismic line HR 194 in combination with CPT 85 plus Figure 21 (Chart 109) shows, that CPT 85 is located in the weak disturbed zone. This means that below the Holocene deposits exists a rather simple layering in general with an approximately 20m thick glaciofluvial sandy layer above glacial clays. In CPT 85 a 3-5m top layer of Holocene sand over Holocene fine sand to gyttja covers about 15 m glaciofluvial sand above glacial sand and clay.

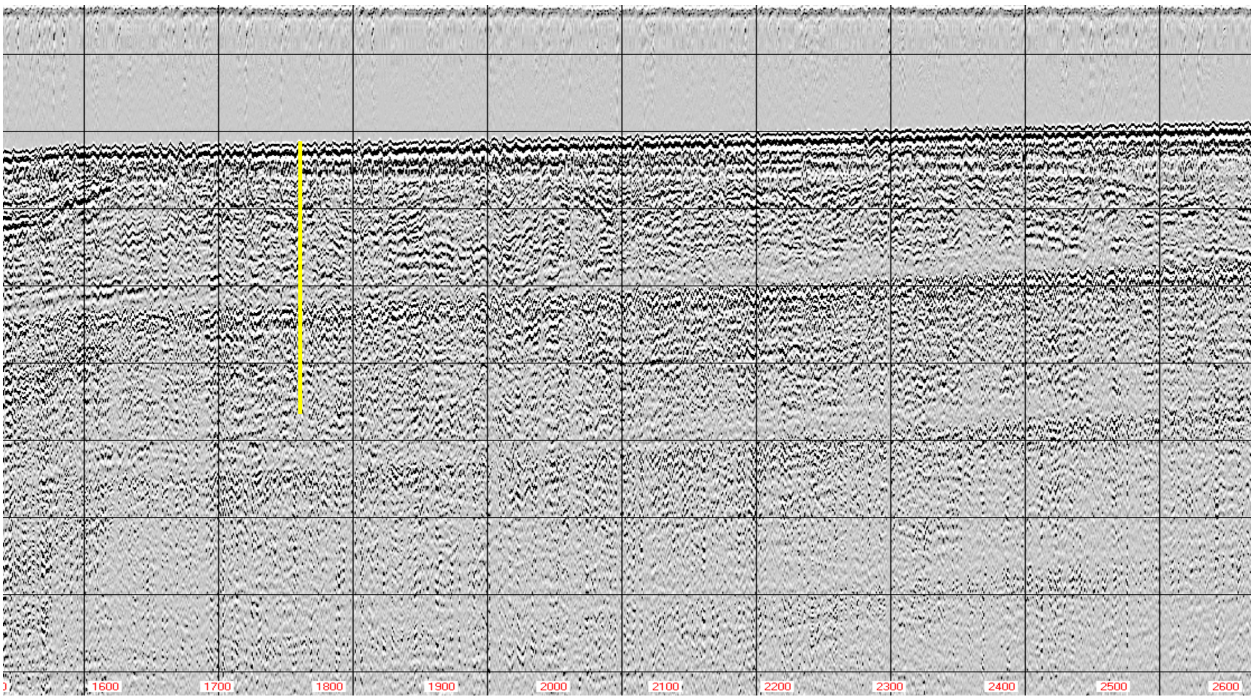




10.1.69 M7 (CPT 86)

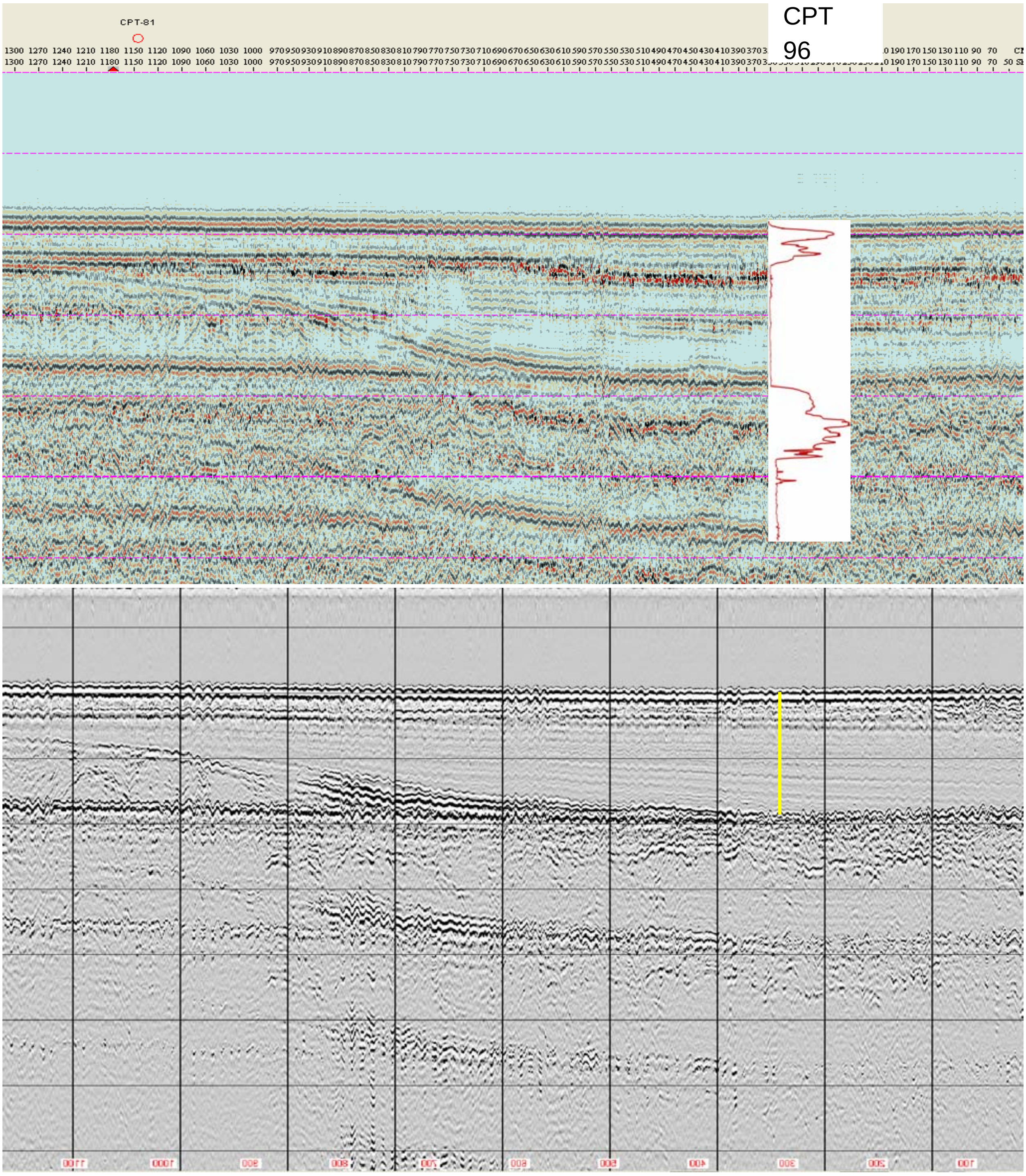
The Seismic line HR 202 in combination with CPT 86 plus Figure 21 (Chart 109) shows, that CPT 86 is located in the weak disturbed zone. This means that below the Holocene deposits exists a rather simple layering in general with an approximately 20m thick glaciofluvial sandy layer above glacial clays. In CPT 86 a 2-3m top layer of Holocene sand over Holocene fine sand to gyttja covers about 20 m glaciofluvial sand above glacial sand and clay





10.1.70 N1 (CPT 96)

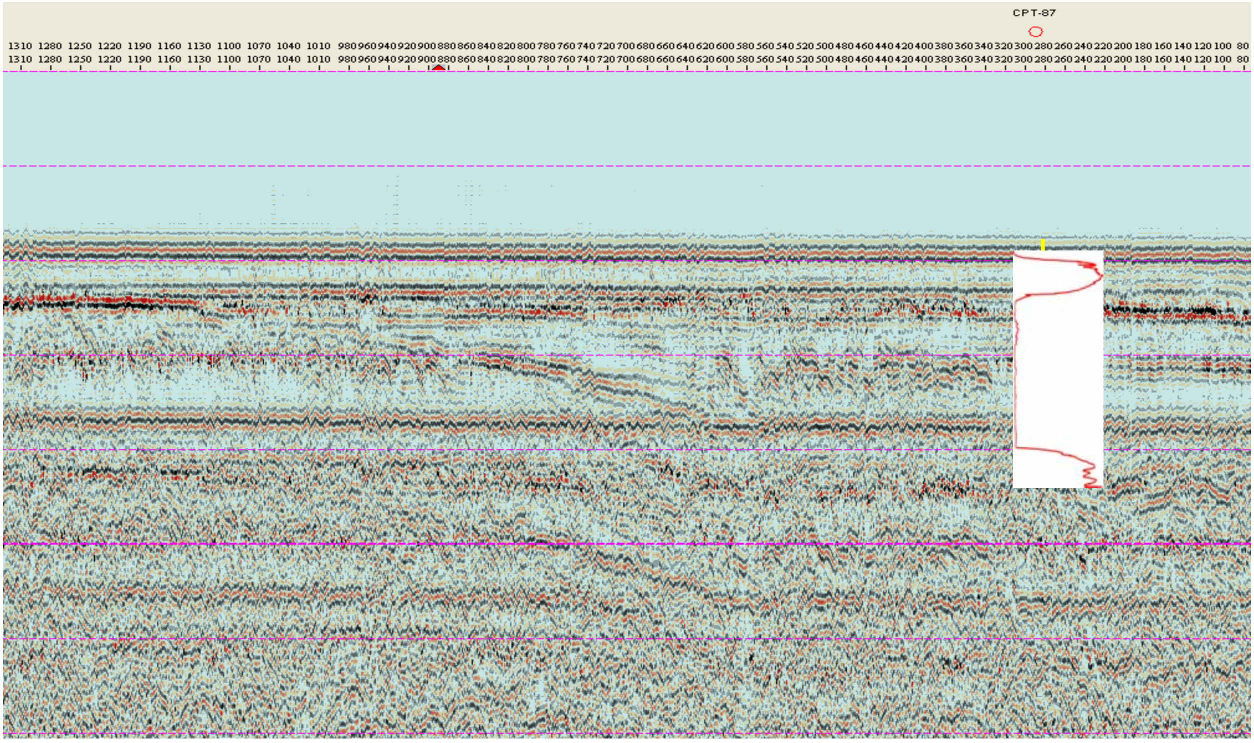
The Seismic line HR 168 in combination with CPT 96 plus Figure 21 (Chart 109) show, that CPT 96 is located on the northern margin of the Horns Rev Hill with a Holocene thickness of about 15m above the glacial folded deformation class. In the glacial part it is possible to identify and interpret the seismic reflectors often with a wavy appearance. A 3-5m top layer of Holocene fine sand to gyttja covers a layer of about 10m sand to gyttja, probably Early Holocene or Eemian deposits, above few m glacial sand and clay. The lower most 10m of CPT 96 is clay possibly glaciolacustrine or interglacial.

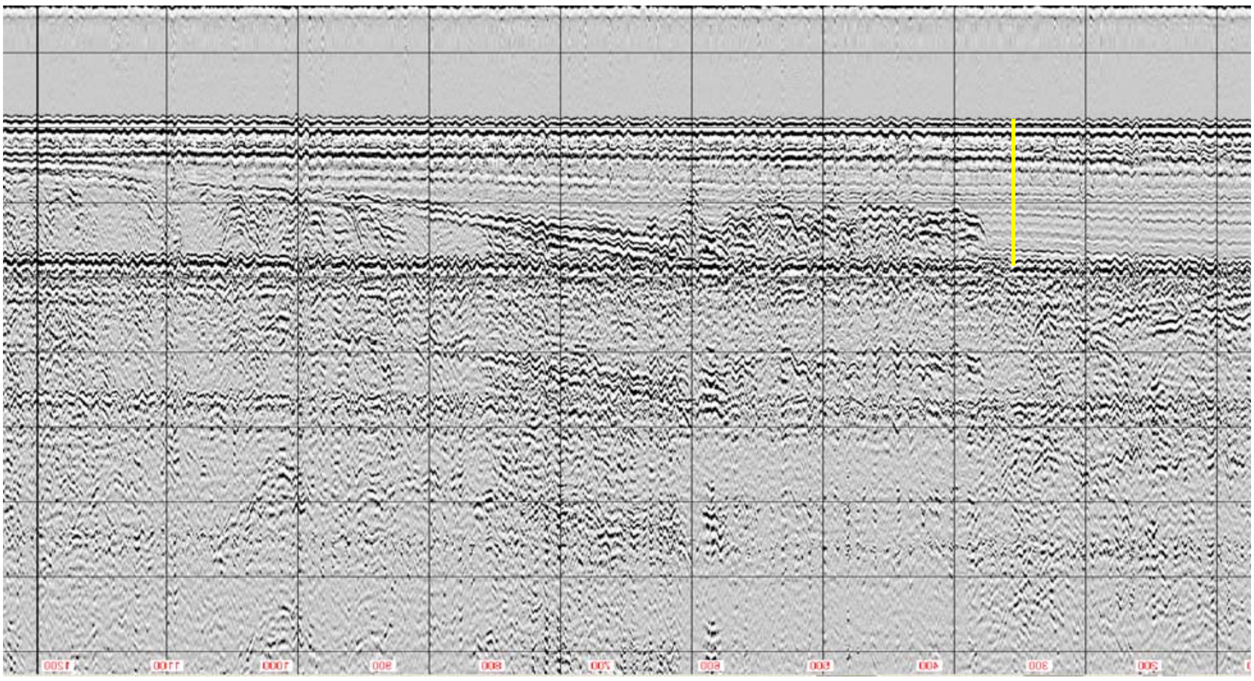


CPT 96

10.1.71 N2 (CPT 87)

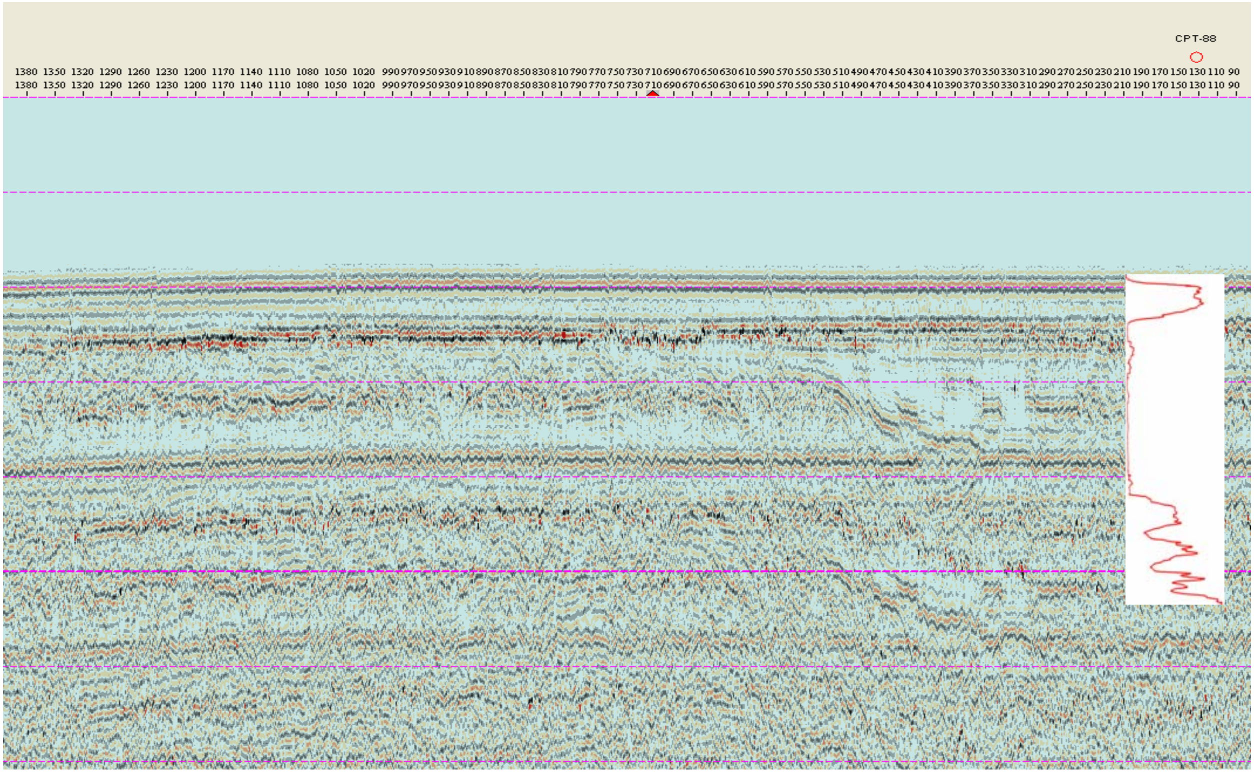
The Seismic line HR 174 in combination with CPT 87 plus Figure 21 (Chart 109) show, that CPT 87 is located on the northern margin of the Horns Rev Hill island with a Holocene thickness of about 25m above the glacial folded deformation class. In the glacial part it is possible to identify and interpret the seismic reflectors often with a wavy appearance. A 5-7m top layer of Holocene fine sand to gyttja covers a layer of about 20m sand to gyttja (organic matter indicated by gas in the sediment) probably Early Holocene or Eemian deposits above glacial sand and clay.

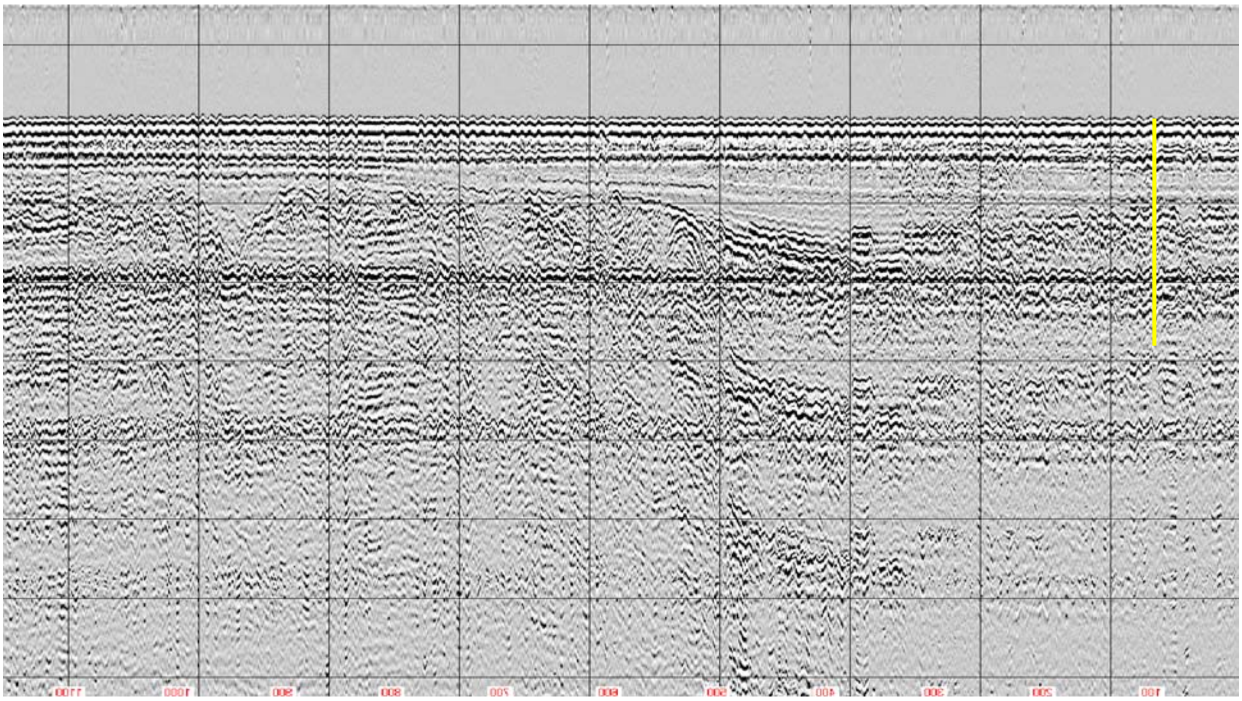




10.1.72 N3 (CPT 88)

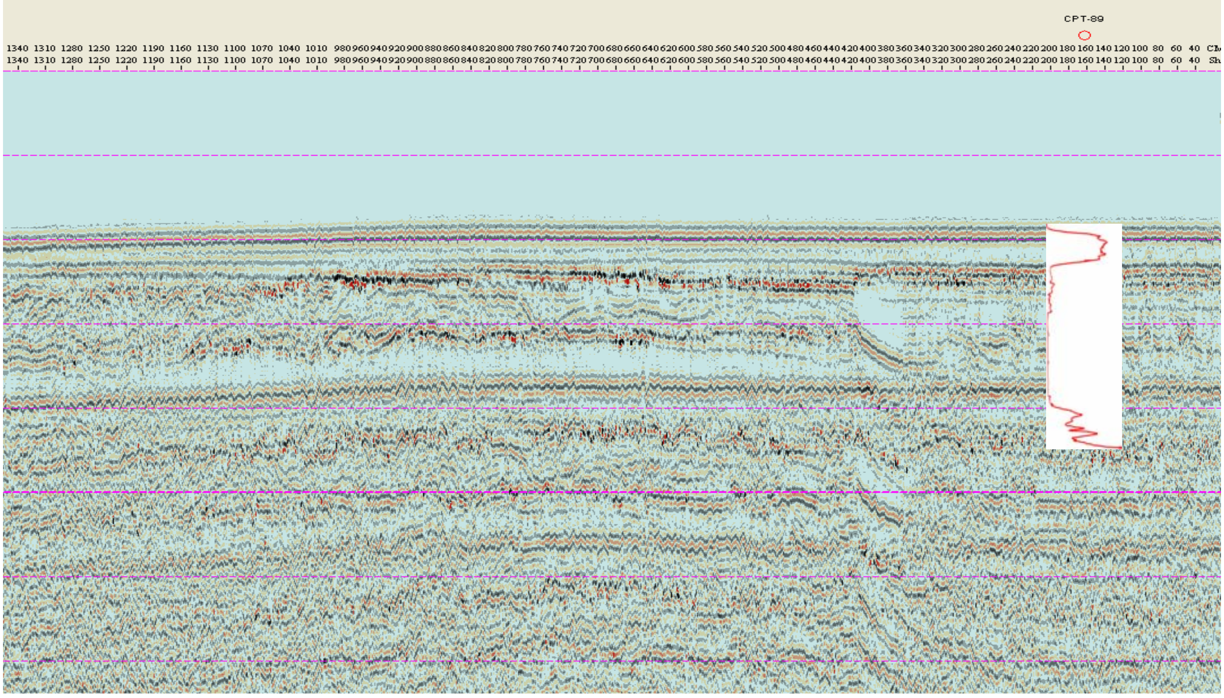
The Seismic line HR 184 in combination with CPT 88 plus Figure 21 (Chart 109) show, that CPT 88 is located on the northern margin of the Horns Rev Hill island with a Holocene thickness of about 20m above the glacial folded deformation class. In the glacial part it is possible to identify and interpret the seismic reflectors often with a wavy appearance. A 5-7m top layer of Holocene fine sand to gyttja covers a layer of about 15m sand to gyttja (organic matter indicated by gas in the sediment), probably Early Holocene or Eemian deposits above glacial sand and clay.

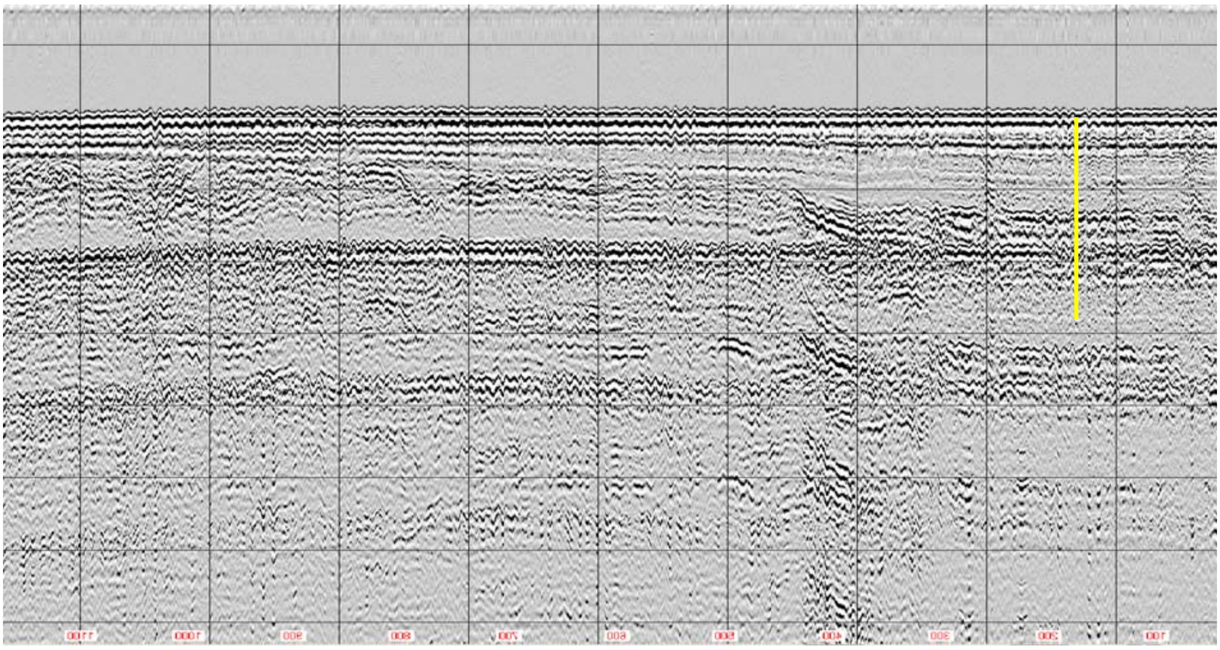




10.1.73 N4 (CPT 89)

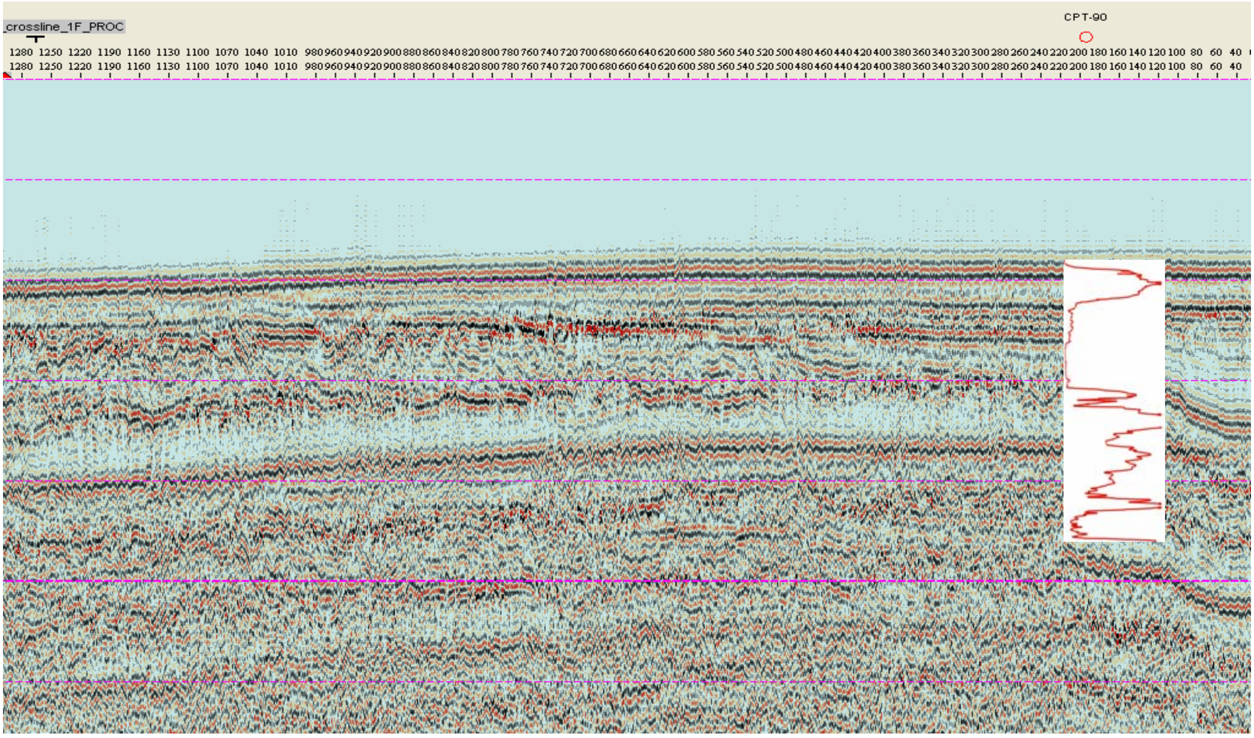
The Seismic line HR 192 in combination with CPT 89 plus Figure 21 (Chart 109) show, that CPT 89 is located on the northern margin of the Horns Rev Hill island with a Holocene thickness of about 20m above the glacial folded deformation class. In the glacial part it is possible to identify and interpret the seismic reflectors often with a wavy appearance. A 5-7m top layer of Holocene fine sand to gyttja covers a layer of about 10m sand to gyttja, probably Early Holocene or Eemian deposits, above glacial sand and clay.

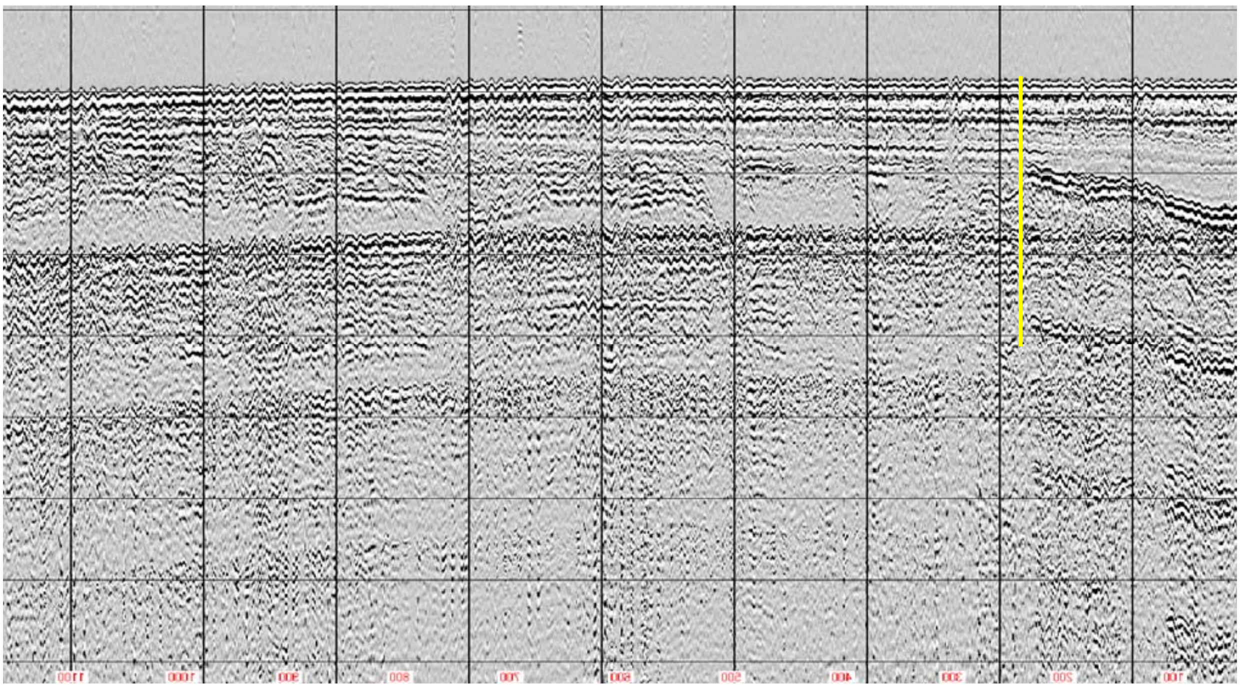




10.1.74 N5 (CPT 90)

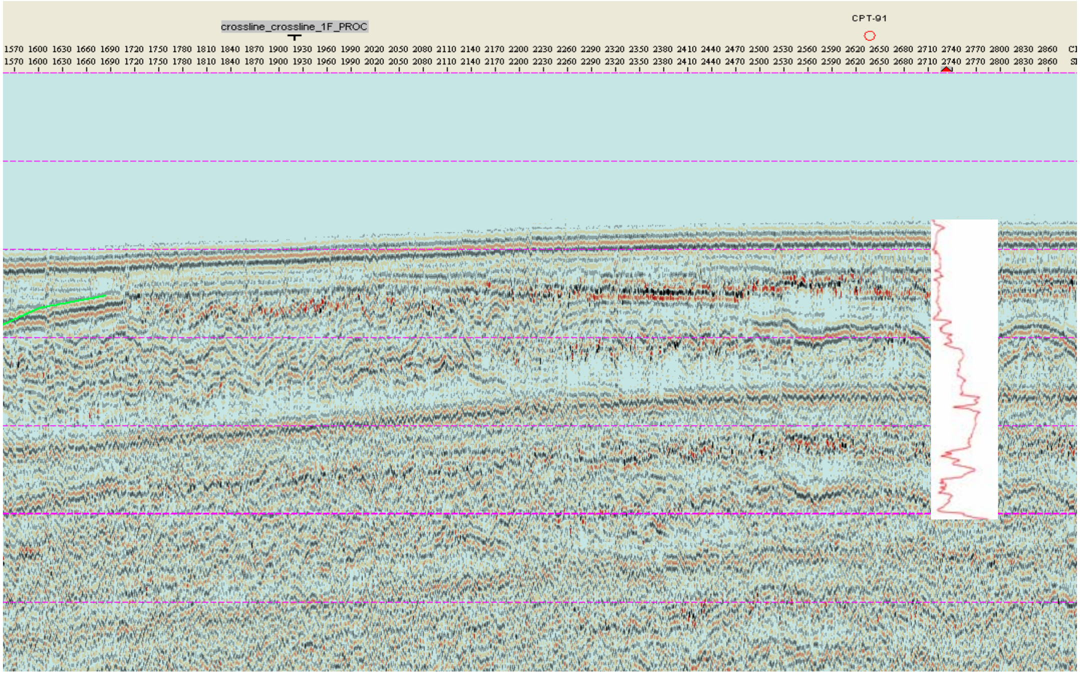
The Seismic line HR 200 in combination with CPT 90 plus Figure 21 (Chart 109) show, that CPT 90 is located on the northern margin of the Horns Rev Hill island with a Holocene thickness of about 10m above the glacial folded deformation class. In the glacial part it is possible to identify and interpret the seismic reflectors often with a wavy appearance. A 3-5m top layer of Holocene fine sand to gyttja covers a layer of about 5m sand to gyttja, probably Early Holocene or Eemian deposits, above glacial sand and clay.

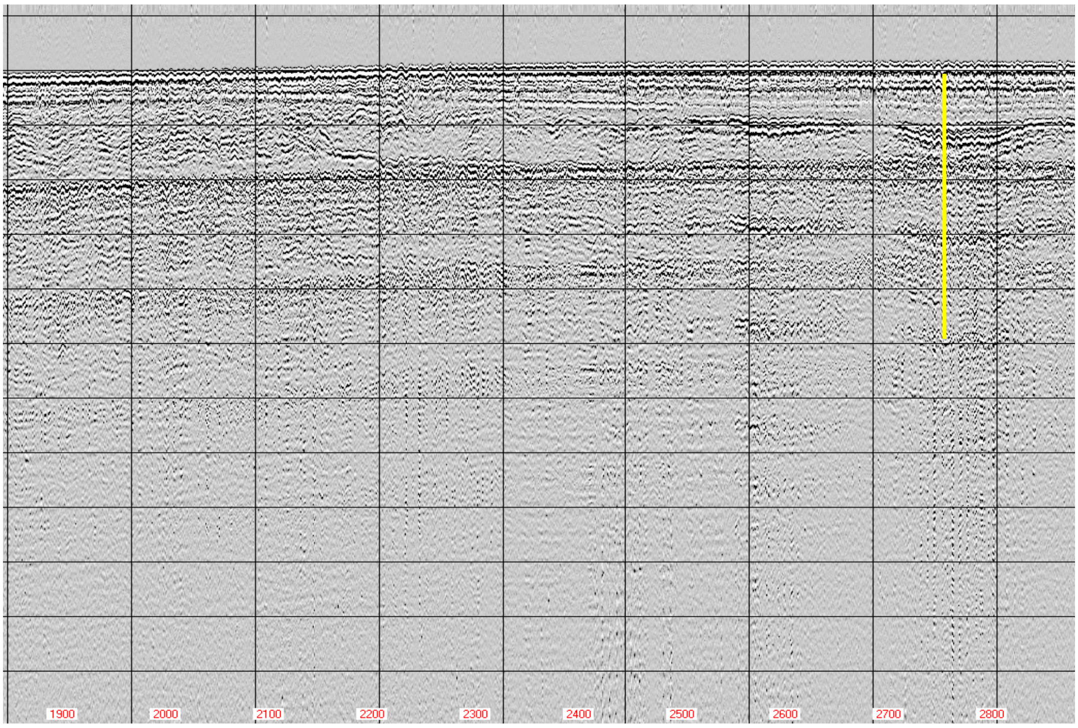




10.1.75 N6 (CPT 91)

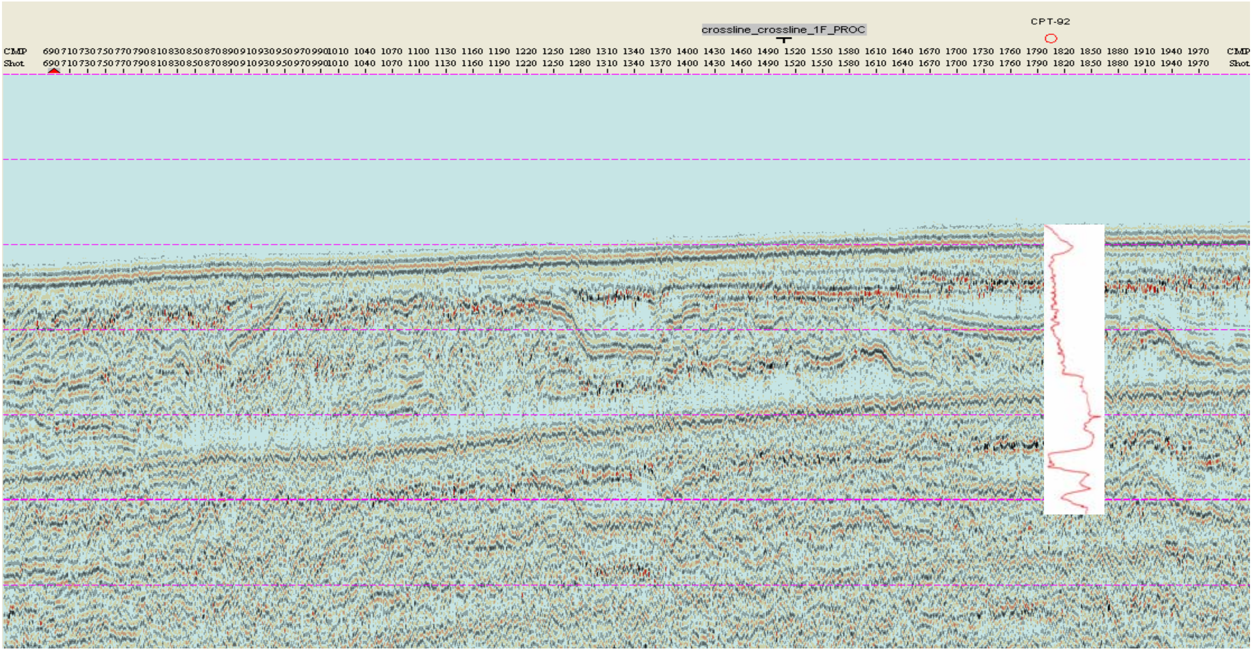
The Seismic line HR 206 in combination with CPT 91 plus Figure 21 (Chart 109) show, that CPT 91 is located on the northern margin of the Horns Rev Hill with a Holocene thickness of about 10m above the glacial folded deformation class. In the glacial part it is possible to identify and interpret the seismic reflectors often with a wavy appearance. A 3-5m top layer of Holocene fine sand to gyttja covers a layer of about 5m sand to gyttja, probably Early Holocene or Eemian deposits, above glacial sand and clay.

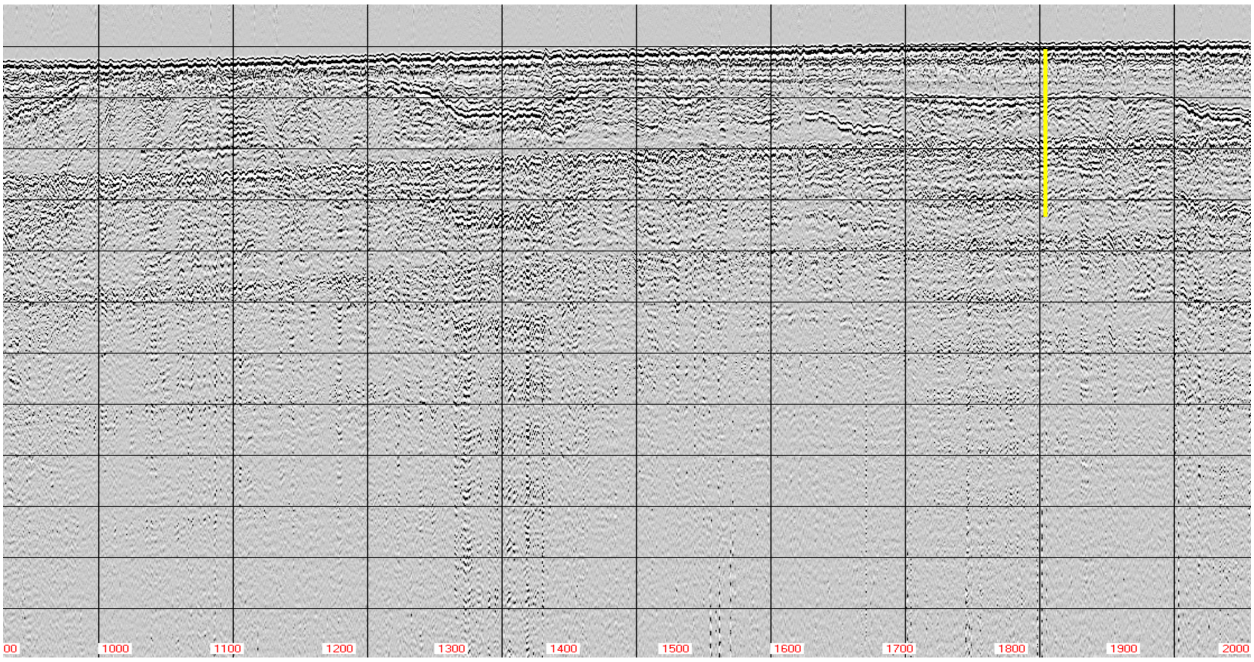




10.1.76 N7 (CPT 92)

The Seismic line HR 214 in combination with CPT 92 plus Figure 21 (Chart 109) show, that CPT 92 is located on the northern margin of the Horns Rev Hill with a Holocene thickness of about 7m above the glacial folded deformation class. In the glacial part it is possible to identify and interpret the seismic reflectors often with a wavy appearance. A 3m top layer of Holocene fine sand to gyttja covers a layer of about 5m sand to gyttja, probably Early Holocene or Eemian deposits, above glacial sand and clay.





11. E1 + E2 Seismic profiles 1

In order to show examples of the seismic data from the Windfarm area, six total sections are presented. The sections are interpreted and the legend shows the lines including the different mapped geological units. The location of the profiles is shown on the inset map which demonstrates the top glacial chart (Appendix E).

E1

Line HR 210

The northernmost example shows the Saalian glacial unconformity as also occur no the other sections. Below are glaciotectonic Saalian sediments. Shallow channels are filled with Saalian melt water deposits. Above these deposits occur more 10 m thick Holocene sediments.

Line HR 170

The Holocene sediments are more than 20 m thick, but interglacial clays may occur just above the Saalian unconformity. The Saalian deposits are disturbed and deformed.

Line HR 118

The Holocene deposits are generally thin. Channels and valleys are cut deep into the disturbed Saalian deposits and filled by Late Saalian sediments.

E2

Line HR 070

Several cannels filled with Saalian melt water sediments are cut into the disturbed Saalian glacial deposits. The Holocene deposits are relatively thin.

Line HR 050

There are many Saalian cannels in the eastern part with sediment fill. In the shallow depression towards the east it is suggested that Eemian deposits can be mapped. The Holocene sediments are thin.

Line HR 014

Again are channels and valleys cut into the deformed Saalian deposits. It is indicated that Eemian can be found in the eastern part of this his area. The Holocene deposits seem to become thicker in this line.

12. Conclusion

The geophysical survey of the Windfarm included the Windfarm area and the Transformer Platform.
The seabed surface has been classified by detailed bathymetric mapping together with Side Scan mosaic, surface sediment types and seabed features.
The subsurface sediments have been mapped on basis of seismic evidence. Most important the glacial surface of Saalian Till and Melt water deposits has been mapped as the secure foundation level for the windmills in the planed Windfarm Horns Rev 2.
The interpretation is however primarily done on seismic reflection pattern. As a consequence of this, the planed deep core positions were located in positions that improve the information level substantially in relation to geotechnical and stratigraphical interpretation.

Evaluation of the collected deep cores and CPT cores carried out in the Horns Rev 2 project revealed a more complex lithological layering than expected from the initial seismic survey, with indications of a number of weak clay layers, which are difficult to correlate due to large differences from one CPT to the next and which do not fit well to the originally established stratigraphy. The cores revealed glaciolacustrine- as well as interglacial (Holsteinian) clays.

Renewed detailed seismic interpretation revealed that the Windfarm area is located in a Saalian complicated ice marginal ridge area, influenced by ice push from an eastern direction followed by ice push from north-east. With this in mind, it was possible to classify the layers below the Holocene deposits in degrees of glacial disturbance as illustrated in seismic profile 102 (Figure 19).
The study further more showed that there is a close correlation between the magnetometer map, Figure 20, Chart 108 and Chart D109 showing seismically mapped deformation classes.

Focus has also been on the uppermost deposits above the glacial unconformity, where Eemian and Holocene deposits are known options. The deep corings supplemented by 10 vibrocores and older boreholes shows in general a few meter thick (up to 7m) Holocene top sand layers directly on the glacial surface or in channel areas on top of fine-grained Holocene and or Eemian infill. In the northern margin the more fine-grained (Holocene/Eemian) unit increases in thickness until about 20m before glacial deposits are reached.
In the area around the Substructure is documented, that more organic rich sediments can be present in the Holocene sandy sequence.

On basis of the detailed mapping, it has been possible to describe the geological setting at the individual CPT/wind turbine locations classified after degree of glacial tectonic deformation. This will be used in the individual foundation planning of the wind turbines and the substation.

13. References

Ref. 1. Larsen B. & Leth, J., 2001: Geologisk kortlægning af Vestkysten. Vol. 1 og 2. Udført for Kystdirektoratet i 2000 og 2001. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2001/96.

Ref. 2. Larsen, B. & Andersen, L.T., 2005: Late Quaternary stratigraphy and morphogenesis in the Danish eastern North Sea and its relation to onshore geology. Geologie en Mijnbouw, 84, 2.

Ref. 3. Andersen, L.T., 2004: The Fanø Bugt Glaciotectectonic Thrust Fault Complex, Southeastern Danish North Sea. Ph.D. thesis 2004. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2004/30.

Ref. 4. Jensen, J.B. & Lomholt, S., 2006: Råstoffer ved HR2 Vindmølleparken. Vurdering af mulige sand- og grusforekomster på Horns Rev. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2006/4.

Ref. 5. Larsen, B., 2003: Blåvands Huk – Horns Rev området – et nyt Skagen ?. Geologi Nyt fra GEUS.

Ref. 6. Kuijpers , A., 1995: Late Quaternary sediment distribution in the DK Sector of the North Sea: Area 582 and 524. Geological Survey of Denmark. Datadocumentation no.13.

Ref. 7. Huuse, M & Lykke-Andersen, H, 2000: Overdeepened Quaternary valleys: eastern Danish North Sea. Quaternary Science Reviews 19.

Ref. 8. Nørgaard, I, 2006: Datareport: Grain size distribution, water content and loss on ignition. Danmarks og Grønlands Geologiske Undersøgelse. Rapport 2006/26.

Ref. 9. Long, D., Laban, C., Streif, H., Cameron, T.D.J. and Schüttenhelm, R.T.E.: The sedimentary record of climatic variation in the southern North Sea. Phil. Trans. R. Soc. Lond. B 318, 523-537.

Ref. 10 GEO, 2006: Horns Rev 2 Offshore Wind Farm Geotechnical Investigations. Factual Report. Borings, CPTs and Vibrocores. GEO project no 29180. Report 1, volume 1/2.Appendix A: Overview Map Windfarm and Cable Route.

15. Appendix B: Grain size analysis of Bioconsult grab samples

Grain Size Distribution

Geotechnical

Sample Id: 16
Lab. Id: 060372
Submitter: Bio/consult
Subject: Horns_Rev2 12/12/2005
Date: Februar 2006
Executed: I. Nørgaard
Remarks: Sample < 2 mm. Too small amount of material < 0,063mm for sedigrafanalysis. Sample Flocculate

GEUS

Total Weight 106,91 g

Size Fractions

		Size	Size	Weight	Weight	Cumulated amount passing
		mm	Φ	g	%	%
Sieve Analysis	Gravel	16,00	-4,00	0,00	0,00	100,00
		8,00	-3,00	0,00	0,00	100,00
		4,00	-2,00	0,00	0,00	100,00
		2,80	-1,49	0,00	0,00	100,00
		2,00	-1,00	0,00	0,00	100,00
	Sand	1,40	-0,49	0,00	0,00	100,00
		1,00	0,00	0,10	0,10	99,90
		0,710	0,49	0,61	0,57	99,34
		0,500	1,00	2,36	2,21	97,13
		0,355	1,49	17,44	16,31	80,82
		0,250	2,00	69,43	64,94	15,88
		0,180	2,47	13,36	12,50	3,38
		0,125	3,00	2,17	2,03	1,35
		0,090	3,47	0,48	0,45	0,90
		0,063	3,99	0,29	0,27	0,63
Sedigraph Analysis	Silt	0,0442	4,50	0,67	0,63	0,00
		0,0312	5,00	0,00	0,00	0,00
		0,0221	5,50	0,00	0,00	0,00
		0,0156	6,00	0,00	0,00	0,00
		0,0110	6,51	0,00	0,00	0,00
		0,0078	7,00	0,00	0,00	0,00
		0,0055	7,51	0,00	0,00	0,00
		0,0039	8,00	0,00	0,00	0,00
		0,0028	8,48	0,00	0,00	0,00
		0,0020	8,97	0,00	0,00	0,00
	Clay	<0,0020	>8,97	0,00	0,00	0,00

The analysis is executed according to DS/EN 933-1 extended by sieves to the ½ phi scale and test portion mass 0,1 kg

Size Classes (DGF-Bulletin 1 1988)

		Weight %
Clay	(< 0,002 mm):	0,00
Silt, fine	(0,002 mm - 0,006 mm):	0,00
Silt, medium	(0,006 mm - 0,020 mm):	0,00
Silt, coarse	(0,020 mm - 0,063 mm):	0,63
Sand, fine	(0,063 mm - 0,200 mm):	6,33
Sand, medium	(0,2 mm - 0,6 mm):	91,22
Sand, coarse	(0,6 mm - 2 mm):	1,82
Gravel	(> 2 mm):	0,00
Sum:		100,00

Moments Measures

Percentile Amount in sieve	Percentile Amount passing	d(mm)	Φ
5%	95%	0,48	1,06
16%	84%	0,38	1,38
25%	75%	0,35	1,53
40%	60%	0,32	1,64
50%	50%	0,31	1,71
75%	25%	0,26	1,92
84%	16%	0,25	2,00
90%	10%	0,22	2,20
95%	5%	0,19	2,40

Moments Statistics

Mean	1,70
Sorting	0,36
Skewness	-0,02
Kurtosis	1,44
Uniformity Coefficient	1,48

Size Classes and Percentiles are found by linear interpolation

Formulas

Mean (ϕ16%+ϕ84%+ϕ50%) / 3 (Folk and Ward 1957)

Sorting (ϕ84%-ϕ16%) / 4 + (ϕ95%-ϕ5%) / 6,6 (Folk and Ward 1957)

Kurtosis (ϕ95% - ϕ5%) / (2,44 * (ϕ75% - ϕ25%)) (Folk and Ward 1957)

Skewness (ϕ16%+ϕ84% - 2*ϕ50%) / (2*(ϕ84%-ϕ16%)) + (ϕ5%+ϕ95% - 2*ϕ50%) / (2*(ϕ95%-ϕ5%)) (Folk and Ward 1957)

Uniformity Coefficient (d60% / d10%) (dgf-Bulletin 1988)

Mean, sorting, skewness and kurtosis are based on "Amount in sieve". Uniformity coefficient is based on "Amount passing".

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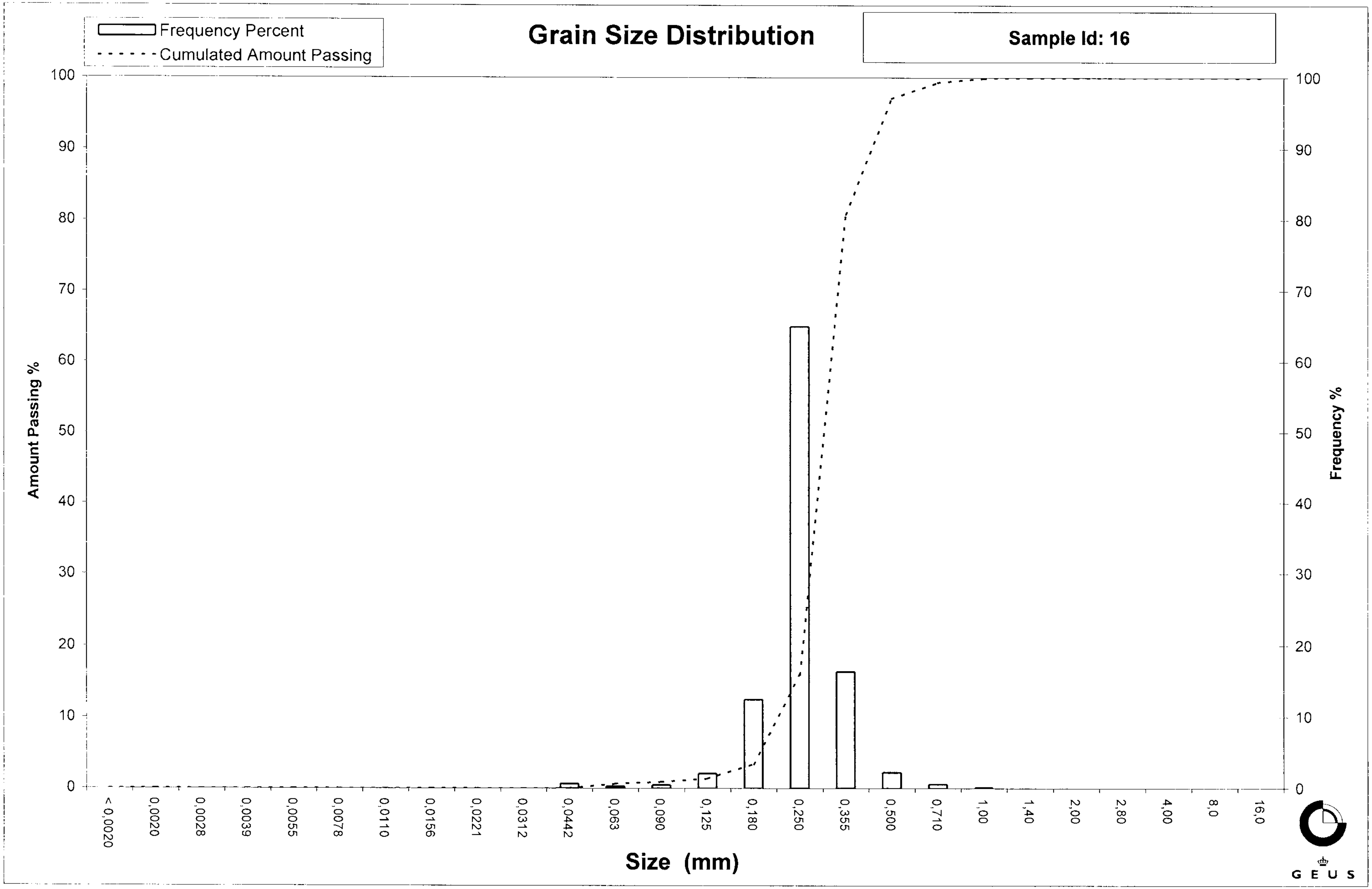

Frequency Percent
Cumulated Amount Passing
Grain Size Distribution
Sample Id: 16
Amount Passing %
Frequency %
100
90
80
70
60
50
40
30
20
10
0
< 0,0020
0,0020
0,0028
0,0039
0,0055
0,0078
0,0110
0,0156
0,0221
0,0312
0,0442
0,063
0,090
0,125
0,180
0,250
0,355
0,500
0,710
1,00
1,40
2,00
2,80
4,00
8,0
16,0
Size (mm)
GEUS

Grain Size Distribution
Geotechnical

Sample Id: 17
Lab. Id: 060373
Submitter: Bio/consult
Subject: Horns_Rev2 12/12/2005
Date: Februar 2006
Executed: I. Nørgaard
Remarks: Sample < 2 mm. Too small amount of material < 0,063mm for sedigrafanalysis. Sample Flocculate

Total Weight 106,76 g

GEUS

Size Fractions

		Size mm	Size Φ	Weight g	Weight %	Cumulated amount passing %
Sieve Analysis	Gravel	16,00	-4,00	0,00	0,00	100,00
Sieve Analysis	Gravel	8,00	-3,00	0,00	0,00	100,00
Sieve Analysis	Gravel	4,00	-2,00	0,00	0,00	100,00
Sieve Analysis	Gravel	2,80	-1,49	0,00	0,00	100,00
Sieve Analysis	Gravel	2,00	-1,00	0,02	0,02	99,98
Sieve Analysis	Sand	1,40	-0,49	0,11	0,10	99,88
Sieve Analysis	Sand	1,00	0,00	0,12	0,11	99,77
Sieve Analysis	Sand	0,710	0,49	0,18	0,17	99,60
Sieve Analysis	Sand	0,500	1,00	2,58	2,42	97,18
Sieve Analysis	Sand	0,355	1,49	44,71	41,88	55,30
Sieve Analysis	Sand	0,250	2,00	52,52	49,19	6,11
Sieve Analysis	Sand	0,180	2,47	4,63	4,34	1,77
Sieve Analysis	Sand	0,125	3,00	0,61	0,57	1,20
Sieve Analysis	Sand	0,090	3,47	0,24	0,22	0,97
Sieve Analysis	Sand	0,063	3,99	0,22	0,21	0,77
Sedigraph Analysis	Silt	0,0442	4,50	0,82	0,77	0,00
Sedigraph Analysis	Silt	0,0312	5,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0221	5,50	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0156	6,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0110	6,51	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0078	7,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0055	7,51	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0039	8,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0028	8,48	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0020	8,97	0,00	0,00	0,00
Sedigraph Analysis	Clay	<0,0020	>8,97	0,00	0,00	0,00

The analysis is executed according to DS/EN 933-1 extended by sieves to the ½ phi scale and test portion mass 0,1 kg

Size Classes (DGF-Bulletin 1 1988)

		Weight %
Clay	(< 0,002 mm):	0,00
Silt, fine	(0,002 mm - 0,006 mm):	0,00
Silt, medium	(0,006 mm - 0,020 mm):	0,00
Silt, coarse	(0,020 mm - 0,063 mm):	0,77
Sand, fine	(0,063 mm - 0,200 mm):	2,24
Sand, medium	(0,2 mm - 0,6 mm):	95,32
Sand, coarse	(0,6 mm - 2 mm):	1,65
Gravel	(> 2 mm):	0,02
Sum:		100,00

Moments Measures

Percentile Amount in sieve	Percentile Amount passing	d(mm)	Φ
5%	95%	0,49	1,02
16%	84%	0,45	1,14
25%	75%	0,42	1,24
40%	60%	0,37	1,43
50%	50%	0,34	1,54
75%	25%	0,29	1,78
84%	16%	0,27	1,88
90%	10%	0,26	1,95
95%	5%	0,23	2,11

Moments Statistics

Mean	1,52
Sorting	0,35
Skewness	-0,02
Kurtosis	0,82
Uniformity Coefficient	1,44

Size Classes and Percentiles are found by linear interpolation

Formulas

Mean (ϕ16%+ϕ84%+ϕ50%) / 3 (Folk and Ward 1957)

Sorting (ϕ84%-ϕ16%) / 4 + (ϕ95%-ϕ5%) / 6,6 (Folk and Ward 1957)

Kurtosis (ϕ95% - ϕ5%) / (2,44 * (ϕ75% - ϕ25%)) (Folk and Ward 1957)

Skewness (ϕ16%+ϕ84% - 2*ϕ50%) / (2*(ϕ84%-ϕ16%)) + (ϕ5%+ϕ95% - 2*ϕ50%) / (2*(ϕ95%-ϕ5%)) (Folk and Ward 1957)

Uniformity Coefficient (d60% / d10%) (dgf-Bulletin 1988)

Mean, sorting, skewness and kurtosis are based on "Amount in sieve". Uniformity coefficient is based on "Amount passing".

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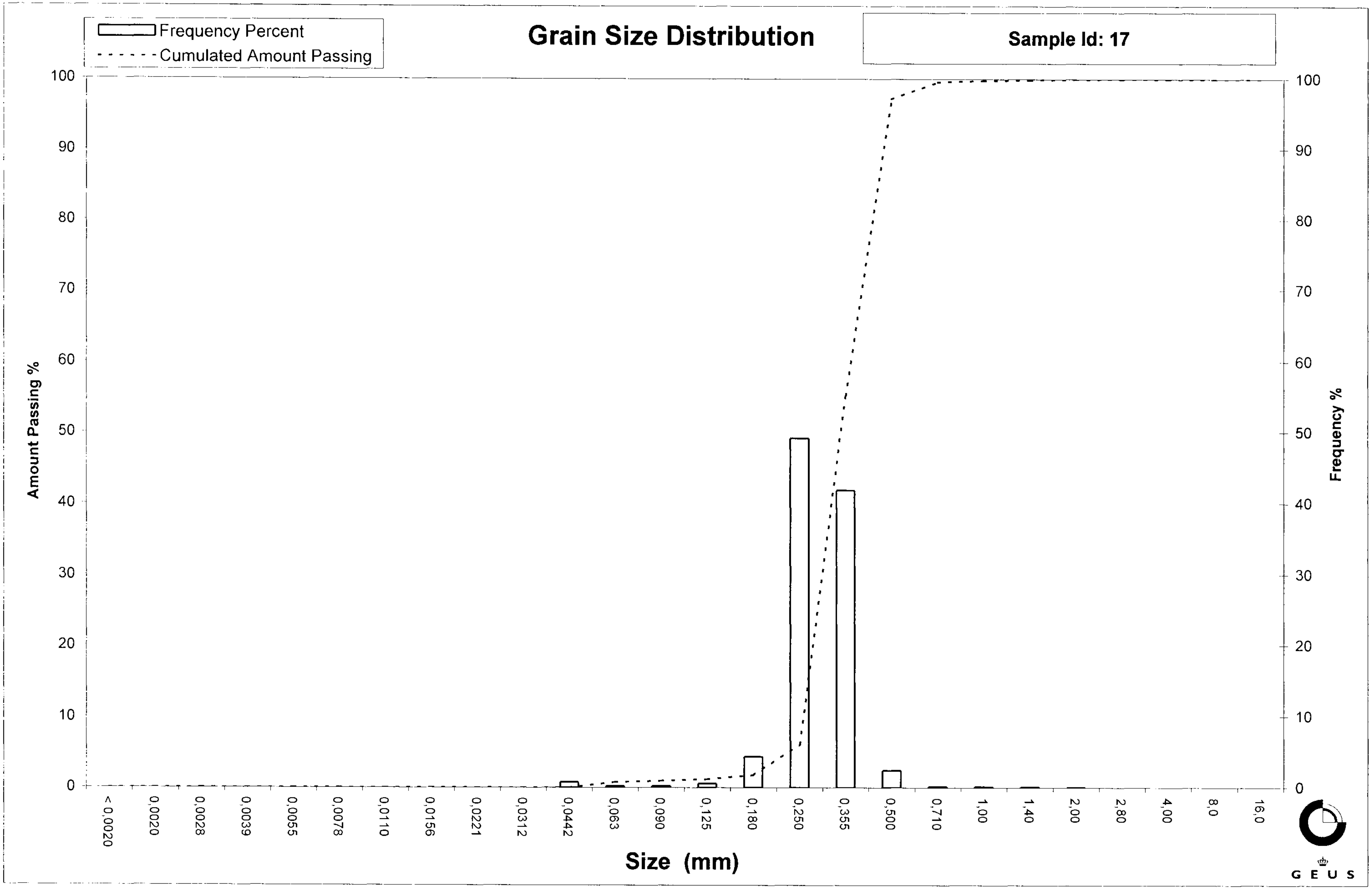
Frequency Percent
Cumulated Amount Passing
Grain Size Distribution
Sample Id: 17
Amount Passing %
Frequency %
100
90
80
70
60
50
40
30
20
10
0
< 0,0020
0,0020
0,0028
0,0039
0,0055
0,0078
0,0110
0,0156
0,0221
0,0312
0,0442
0,063
0,090
0,125
0,180
0,250
0,355
0,500
0,710
1,00
1,40
2,00
2,80
4,00
8,0
16,0
Size (mm)
GEUS

Grain Size Distribution

Geotechnical

Sample Id: 18
Lab. Id: 060374
Submitter: Bio/consult
Subject: Horns_Rev2 12/12/2005
Date: Februar 2006
Executed: I. Nørgaard
Remarks: Sample < 2 mm. Too small amount of material < 0,063mm for sedigrafanalysis. Sample Flocculate

GEUS

Total Weight 112,3 g

Size Fractions

		Size	Size	Weight	Weight	Cumulated amount passing
		mm	Φ	g	%	%
Sieve Analysis	Gravel	16,00	-4,00	0,00	0,00	100,00
		8,00	-3,00	0,00	0,00	100,00
		4,00	-2,00	0,00	0,00	100,00
		2,80	-1,49	0,00	0,00	100,00
		2,00	-1,00	0,08	0,07	99,93
	Sand	1,40	-0,49	0,14	0,13	99,80
		1,00	0,00	0,29	0,26	99,54
		0,710	0,49	1,23	1,10	98,44
		0,500	1,00	15,31	13,63	84,81
		0,355	1,49	75,42	67,16	17,65
		0,250	2,00	15,43	13,74	3,90
		0,180	2,47	2,24	2,00	1,91
		0,125	3,00	0,62	0,55	1,36
		0,090	3,47	0,41	0,37	0,99
		0,063	3,99	0,16	0,15	0,84
Sedigraph Analysis	Silt	0,0442	4,50	0,95	0,84	0,00
		0,0312	5,00	0,00	0,00	0,00
		0,0221	5,50	0,00	0,00	0,00
		0,0156	6,00	0,00	0,00	0,00
		0,0110	6,51	0,00	0,00	0,00
		0,0078	7,00	0,00	0,00	0,00
		0,0055	7,51	0,00	0,00	0,00
		0,0039	8,00	0,00	0,00	0,00
		0,0028	8,48	0,00	0,00	0,00
		0,0020	8,97	0,00	0,00	0,00
	Clay	<0,0020	>8,97	0,00	0,00	0,00

The analysis is executed according to DS/EN 933-1 extended by sieves to the ½ phi scale and test portion mass 0,1 kg

Size Classes (DGF-Bulletin 1 1988)

		Weight %
Clay	(< 0,002 mm):	0,00
Silt, fine	(0,002 mm - 0,006 mm):	0,00
Silt, medium	(0,006 mm - 0,020 mm):	0,00
Silt, coarse	(0,020 mm - 0,063 mm):	0,84
Sand, fine	(0,063 mm - 0,200 mm):	1,63
Sand, medium	(0,2 mm - 0,6 mm):	88,82
Sand, coarse	(0,6 mm - 2 mm):	8,63
Gravel	(> 2 mm):	0,07
Sum:		100,00

Moments Measures

Percentile Amount in sieve	Percentile Amount passing	d(mm)	Φ
5%	95%	0,66	0,61
16%	84%	0,50	1,01
25%	75%	0,48	1,06
40%	60%	0,45	1,16
50%	50%	0,42	1,23
75%	25%	0,37	1,43
84%	16%	0,34	1,55
90%	10%	0,30	1,75
95%	5%	0,26	1,95

Moments Statistics

Mean	1,26
Sorting	0,34
Skewness	0,11
Kurtosis	1,50
Uniformity Coefficient	1,51

Size Classes and Percentiles are found by linear interpolation

Formulas

Mean (ϕ16%+ϕ84%+ϕ50%) / 3 (Folk and Ward 1957)

Sorting (ϕ84%-ϕ16%) / 4 + (ϕ95%-ϕ5%) / 6,6 (Folk and Ward 1957)

Kurtosis (ϕ95% - ϕ5%) / (2,44 * (ϕ75% - ϕ25%)) (Folk and Ward 1957)

Skewness (ϕ16%+ϕ84% - 2*ϕ50%) / (2*(ϕ84%-ϕ16%)) + (ϕ5%+ϕ95% - 2*ϕ50%) / (2*(ϕ95%-ϕ5%)) (Folk and Ward 1957)

Uniformity Coefficient (d60% / d10%) (dgf-Bulletin 1988)

Mean, sorting, skewness and kurtosis are based on "Amount in sieve". Uniformity coefficient is based on "Amount passing".

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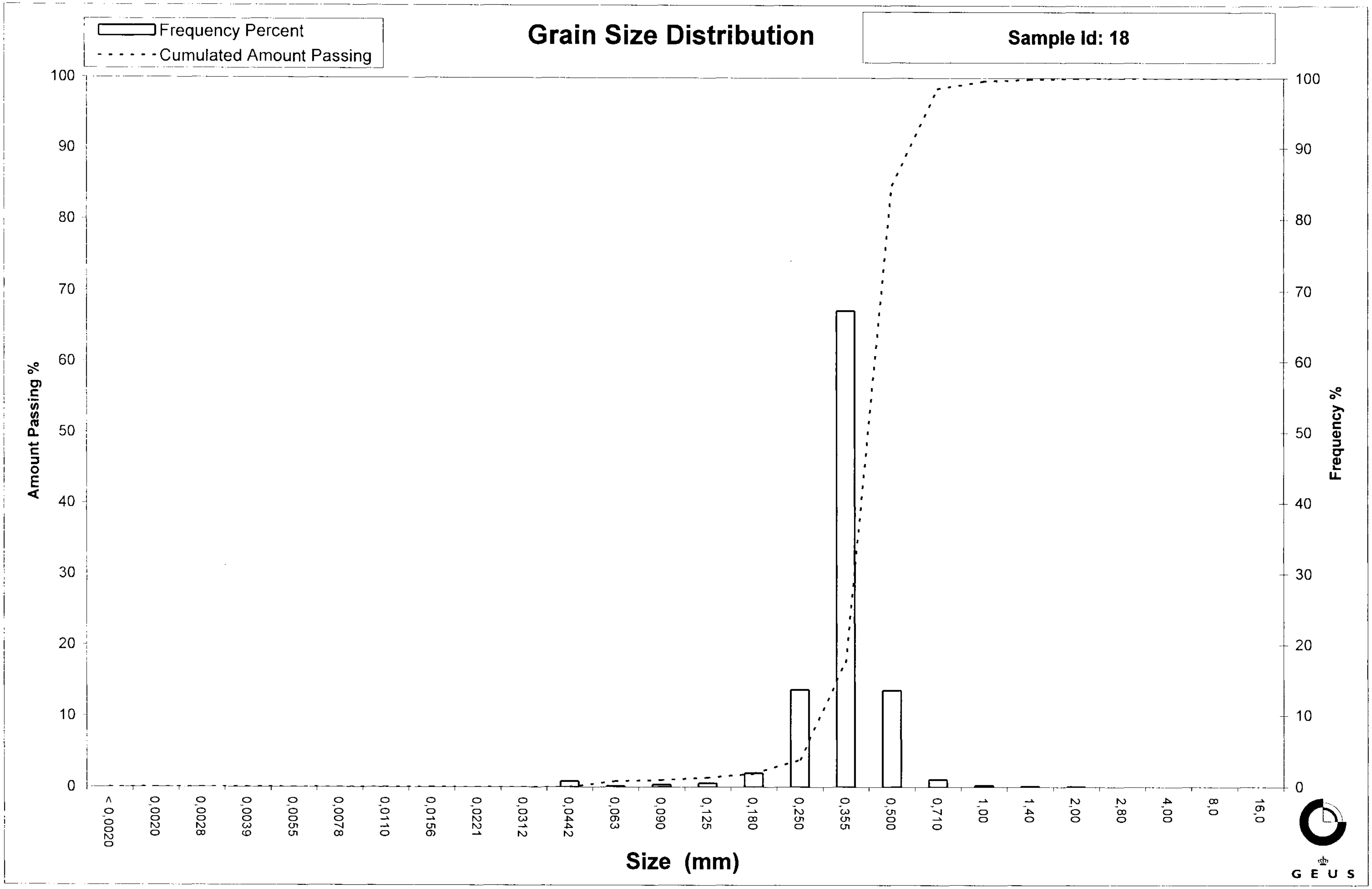

Frequency Percent
Cumulated Amount Passing
Grain Size Distribution
Sample Id: 18
Amount Passing %
Frequency %
100
90
80
70
60
50
40
30
20
10
0
< 0,0020
0,0020
0,0028
0,0039
0,0055
0,0078
0,0110
0,0156
0,0221
0,0312
0,0442
0,063
0,090
0,125
0,180
0,250
0,355
0,500
0,710
1,00
1,40
2,00
2,80
4,00
8,0
16,0
Size (mm)
GEUS

Grain Size Distribution

Geotechnical

Sample Id: 19
Lab. Id: 060375
Submitter: Bio/consult
Subject: Horns_Rev2 12/12/2005
Date: Februar 2006
Executed: I. Nørgaard
Remarks: Sample < 2 mm. Too small amount of material < 0,063mm for sedigrafanalysis. Sample Flocculate

GEUS

Total Weight 112,44 g

Size Fractions

		Size mm	Size Φ	Weight g	Weight %	Cumulated amount passing %
Sieve Analysis	Gravel	16,00	-4,00	0,00	0,00	100,00
		8,00	-3,00	0,00	0,00	100,00
		4,00	-2,00	0,00	0,00	100,00
		2,80	-1,49	0,00	0,00	100,00
		2,00	-1,00	0,04	0,04	99,96
	Sand	1,40	-0,49	0,13	0,12	99,85
		1,00	0,00	0,41	0,36	99,48
		0,710	0,49	6,85	6,09	93,39
		0,500	1,00	19,22	17,09	76,30
		0,355	1,49	27,09	24,09	52,21
		0,250	2,00	37,27	33,15	19,06
		0,180	2,47	18,42	16,38	2,68
		0,125	3,00	1,61	1,43	1,25
		0,090	3,47	0,33	0,29	0,95
		0,063	3,99	0,22	0,20	0,76
Sedigraph Analysis	Silt	0,0442	4,50	0,85	0,76	0,00
		0,0312	5,00	0,00	0,00	0,00
		0,0221	5,50	0,00	0,00	0,00
		0,0156	6,00	0,00	0,00	0,00
		0,0110	6,51	0,00	0,00	0,00
		0,0078	7,00	0,00	0,00	0,00
		0,0055	7,51	0,00	0,00	0,00
		0,0039	8,00	0,00	0,00	0,00
		0,0028	8,48	0,00	0,00	0,00
		0,0020	8,97	0,00	0,00	0,00
	Clay	<0,0020	>8,97	0,00	0,00	0,00

The analysis is executed according to DS/EN 933-1 extended by sieves to the ½ phi scale and test portion mass 0,1 kg

Size Classes (DGF-Bulletin 1 1988)

		Weight %
Clay	(< 0,002 mm):	0,00
Silt, fine	(0,002 mm - 0,006 mm):	0,00
Silt, medium	(0,006 mm - 0,020 mm):	0,00
Silt, coarse	(0,020 mm - 0,063 mm):	0,76
Sand, fine	(0,063 mm - 0,200 mm):	6,60
Sand, medium	(0,2 mm - 0,6 mm):	77,08
Sand, coarse	(0,6 mm - 2 mm):	15,53
Gravel	(> 2 mm):	0,04
Sum:		100,00

Moments Measures

Percentile Amount in sieve	Percentile Amount passing	d(mm)	Φ
5%	95%	0,79	0,35
16%	84%	0,59	0,75
25%	75%	0,49	1,02
40%	60%	0,40	1,32
50%	50%	0,35	1,52
75%	25%	0,27	1,90
84%	16%	0,24	2,08
90%	10%	0,21	2,24
95%	5%	0,19	2,40

Moments Statistics

Mean	1,45
Sorting	0,64
Skewness	-0,16
Kurtosis	0,96
Uniformity Coefficient	1,90

Size Classes and Percentiles are found by linear interpolation

Formulas

Mean (ϕ16%+ϕ84%+ϕ50%) / 3 (Folk and Ward 1957)
Sorting (ϕ84%-ϕ16%) / 4 + (ϕ95%-ϕ5%) / 6,6 (Folk and Ward 1957)
Kurtosis (ϕ95% - ϕ5%) / (2,44 * (ϕ75% - ϕ25%)) (Folk and Ward 1957)
Skewness (ϕ16%+ϕ84% - 2*ϕ50%) / (2*(ϕ84%-ϕ16%)) + (ϕ5%+ϕ95% - 2*ϕ50%) / (2*(ϕ95%-ϕ5%)) (Folk and Ward 1957)
Uniformity Coefficient (d60% / d10%) (dgf-Bulletin 1988)

Mean, sorting, skewness and kurtosis are based on "Amount in sieve". Uniformity coefficient is based on "Amount passing".

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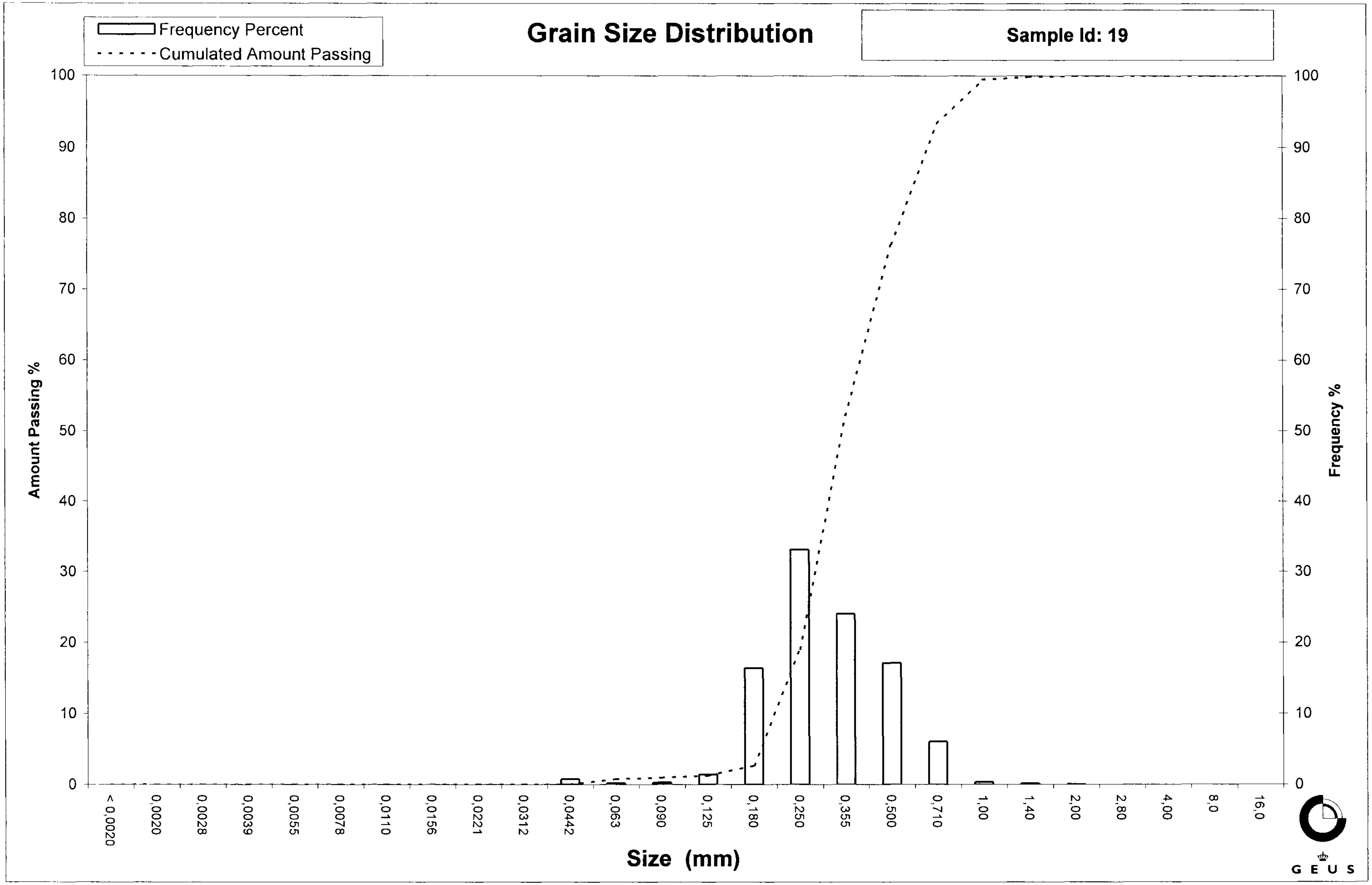

Frequency Percent
Cumulated Amount Passing
Grain Size Distribution
Sample Id: 19
Amount Passing %
Frequency %
100
90
80
70
60
50
40
30
20
10
0
< 0,0020
0,0020
0,0028
0,0039
0,0055
0,0078
0,0110
0,0156
0,0221
0,0312
0,0442
0,063
0,090
0,125
0,180
0,250
0,355
0,500
0,710
1,00
1,40
2,00
2,80
4,00
8,0
16,0
Size (mm)
GEUS

Grain Size Distribution

Geotechnical

Sample Id: 20
Lab. Id: 060376
Submitter: Bio/consult
Subject: Horns_Rev2 12/12/2005
Date: Februar 2006
Executed: I. Nørgaard
Remarks: Sample < 2 mm. Too small amount of material < 0,063mm for sedigrafanalysis. Sample Flocculate

GEUS

Total Weight 110,32 g

Size Fractions

		Size mm	Size Φ	Weight g	Weight %	Cumulated amount passing %
Sieve Analysis	Gravel	16,00	-4,00	0,00	0,00	100,00
Sieve Analysis	Gravel	8,00	-3,00	0,00	0,00	100,00
Sieve Analysis	Gravel	4,00	-2,00	0,00	0,00	100,00
Sieve Analysis	Gravel	2,80	-1,49	0,12	0,11	99,89
Sieve Analysis	Gravel	2,00	-1,00	0,10	0,09	99,80
Sieve Analysis	Sand	1,40	-0,49	0,56	0,51	99,29
Sieve Analysis	Sand	1,00	0,00	2,04	1,85	97,44
Sieve Analysis	Sand	0,710	0,49	5,33	4,83	92,61
Sieve Analysis	Sand	0,500	1,00	15,46	14,01	78,60
Sieve Analysis	Sand	0,355	1,49	53,29	48,30	30,29
Sieve Analysis	Sand	0,250	2,00	27,38	24,82	5,47
Sieve Analysis	Sand	0,180	2,47	4,10	3,72	1,76
Sieve Analysis	Sand	0,125	3,00	0,65	0,59	1,17
Sieve Analysis	Sand	0,090	3,47	0,24	0,22	0,95
Sieve Analysis	Sand	0,063	3,99	0,11	0,10	0,85
Sedigraph Analysis	Silt	0,0442	4,50	0,94	0,85	0,00
Sedigraph Analysis	Silt	0,0312	5,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0221	5,50	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0156	6,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0110	6,51	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0078	7,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0055	7,51	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0039	8,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0028	8,48	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0020	8,97	0,00	0,00	0,00
	Clay	<0,0020	>8,97	0,00	0,00	0,00

The analysis is executed according to DS/EN 933-1 extended by sieves to the ½ phi scale and test portion mass 0,1 kg

Size Classes (DGF-Bulletin 1 1988)

		Weight %
Clay	(< 0,002 mm):	0,00
Silt, fine	(0,002 mm - 0,006 mm):	0,00
Silt, medium	(0,006 mm - 0,020 mm):	0,00
Silt, coarse	(0,020 mm - 0,063 mm):	0,85
Sand, fine	(0,063 mm - 0,200 mm):	1,97
Sand, medium	(0,2 mm - 0,6 mm):	82,45
Sand, coarse	(0,6 mm - 2 mm):	14,53
Gravel	(> 2 mm):	0,20
Sum:		100,00

Moments Measures

Percentile Amount in sieve	Percentile Amount passing	d(mm)	Φ
5%	95%	0,85	0,23
16%	84%	0,58	0,78
25%	75%	0,49	1,03
40%	60%	0,44	1,17
50%	50%	0,41	1,27
75%	25%	0,33	1,59
84%	16%	0,29	1,76
90%	10%	0,27	1,89
95%	5%	0,24	2,05

Moments Statistics

Mean	1,27
Sorting	0,52
Skewness	-0,07
Kurtosis	1,34
Uniformity Coefficient	1,65

Size Classes and Percentiles are found by linear interpolation

Formulas

Mean (ϕ16%+ϕ84%+ϕ50%) / 3 (Folk and Ward 1957)

Sorting (ϕ84%-ϕ16%) / 4 + (ϕ95%-ϕ5%) / 6,6 (Folk and Ward 1957)

Kurtosis (ϕ95% - ϕ5%) / (2,44 * (ϕ75% - ϕ25%)) (Folk and Ward 1957)

Skewness (ϕ16%+ϕ84% - 2*ϕ50%) / (2*(ϕ84%-ϕ16%)) + (ϕ5%+ϕ95% - 2*ϕ50%) / (2*(ϕ95%-ϕ5%)) (Folk and Ward 1957)

Uniformity Coefficient (d60% / d10%) (dgf-Bulletin 1988)

Mean, sorting, skewness and kurtosis are based on "Amount in sieve". Uniformity coefficient is based on "Amount passing".

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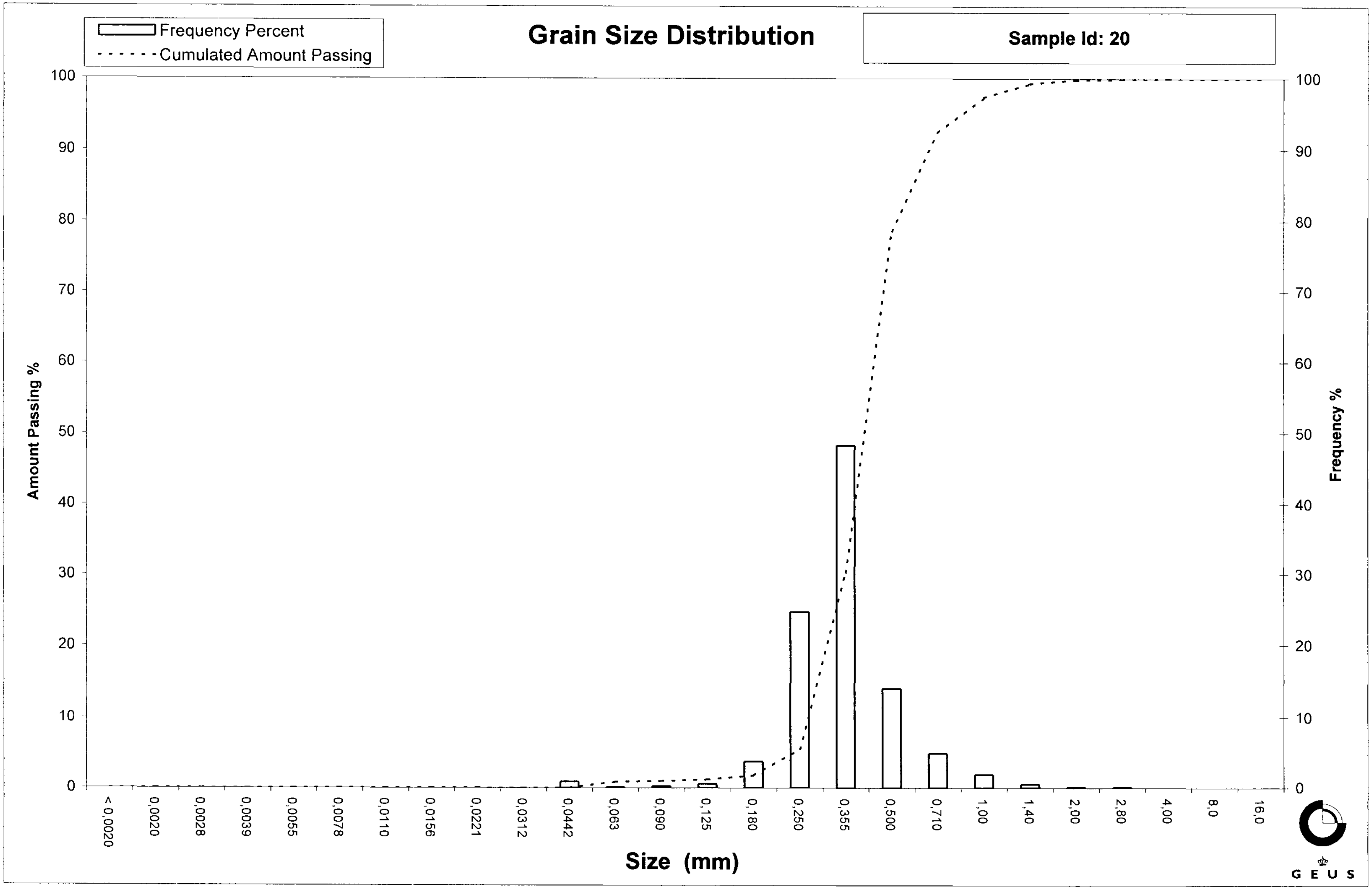
Frequency Percent
Cumulated Amount Passing
Grain Size Distribution
Sample Id: 20
Amount Passing %
Frequency %
Size (mm)
0
10
20
30
40
50
60
70
80
90
100
< 0,0020
0,0020
0,0028
0,0039
0,0055
0,0078
0,0110
0,0156
0,0221
0,0312
0,0442
0,063
0,090
0,125
0,180
0,250
0,355
0,500
0,710
1,00
1,40
2,00
2,80
4,00
8,0
16,0
GEUS

Grain Size Distribution

Geotechnical

Sample Id: 21
Lab. Id: 060377
Submitter: Bio/consult
Subject: Horns_Rev2 12/12/2005
Date: Februar 2006
Executed: I. Nørgaard
Remarks: Sample < 8 mm. Too small amount of material < 0,063mm for sedigrafanalysis. Sample Flocculate

GEUS

Total Weight 202,07 g

Size Fractions

		Size mm	Size Φ	Weight g	Weight %	Cumulated amount passing %
Sieve Analysis	Gravel	16,00	-4,00	0,00	0,00	100,00
		8,00	-3,00	0,00	0,00	100,00
		4,00	-2,00	0,65	0,32	99,68
		2,80	-1,49	1,26	0,62	99,05
		2,00	-1,00	1,71	0,85	98,21
	Sand	1,40	-0,49	3,25	1,61	96,60
		1,00	0,00	11,51	5,70	90,90
		0,710	0,49	28,84	14,27	76,63
		0,500	1,00	43,09	21,32	55,31
		0,355	1,49	45,98	22,75	32,55
		0,250	2,00	47,03	23,27	9,28
		0,180	2,47	15,45	7,65	1,63
		0,125	3,00	1,33	0,66	0,97
		0,090	3,47	0,33	0,16	0,81
		0,063	3,99	0,21	0,10	0,71
Sedigraph Analysis	Silt	0,0442	4,50	1,43	0,71	0,00
		0,0312	5,00	0,00	0,00	0,00
		0,0221	5,50	0,00	0,00	0,00
		0,0156	6,00	0,00	0,00	0,00
		0,0110	6,51	0,00	0,00	0,00
		0,0078	7,00	0,00	0,00	0,00
		0,0055	7,51	0,00	0,00	0,00
		0,0039	8,00	0,00	0,00	0,00
		0,0028	8,48	0,00	0,00	0,00
		0,0020	8,97	0,00	0,00	0,00
	Clay	<0,0020	>8,97	0,00	0,00	0,00

The analysis is executed according to DS/EN 933-1 extended by sieves to the ½ phi scale and test portion mass 0,1 kg

Size Classes (DGF-Bulletin 1 1988)

		Weight %
Clay	(< 0,002 mm):	0,00
Silt, fine	(0,002 mm - 0,006 mm):	0,00
Silt, medium	(0,006 mm - 0,020 mm):	0,00
Silt, coarse	(0,020 mm - 0,063 mm):	0,71
Sand, fine	(0,063 mm - 0,200 mm):	3,11
Sand, medium	(0,2 mm - 0,6 mm):	61,64
Sand, coarse	(0,6 mm - 2 mm):	32,75
Gravel	(> 2 mm):	1,79
Sum:		100,00

Moments Measures

Percentile Amount in sieve	Percentile Amount passing	d(mm)	Φ
5%	95%	1,29	-0,36
16%	84%	0,86	0,22
25%	75%	0,69	0,53
40%	60%	0,55	0,87
50%	50%	0,47	1,10
75%	25%	0,32	1,64
84%	16%	0,28	1,83
90%	10%	0,25	1,98
95%	5%	0,21	2,25

Moments Statistics

Mean	1,05
Sorting	0,80
Skewness	-0,11
Kurtosis	0,96
Uniformity Coefficient	2,16

Size Classes and Percentiles are found by linear interpolation

Formulas

Mean (ϕ16%+ϕ84%+ϕ50%) / 3 (Folk and Ward 1957)

Sorting (ϕ84%-ϕ16%) / 4 + (ϕ95%-ϕ5%) / 6,6 (Folk and Ward 1957)

Kurtosis (ϕ95% - ϕ5%) / (2,44 * (ϕ75% - ϕ25%)) (Folk and Ward 1957)

Skewness (ϕ16%+ϕ84% - 2*ϕ50%) / (2*(ϕ84%-ϕ16%)) + (ϕ5%+ϕ95% - 2*ϕ50%) / (2*(ϕ95%-ϕ5%)) (Folk and Ward 1957)

Uniformity Coefficient (d60% / d10%) (dgf-Bulletin 1988)

Mean, sorting, skewness and kurtosis are based on "Amount in sieve". Uniformity coefficient is based on "Amount passing".

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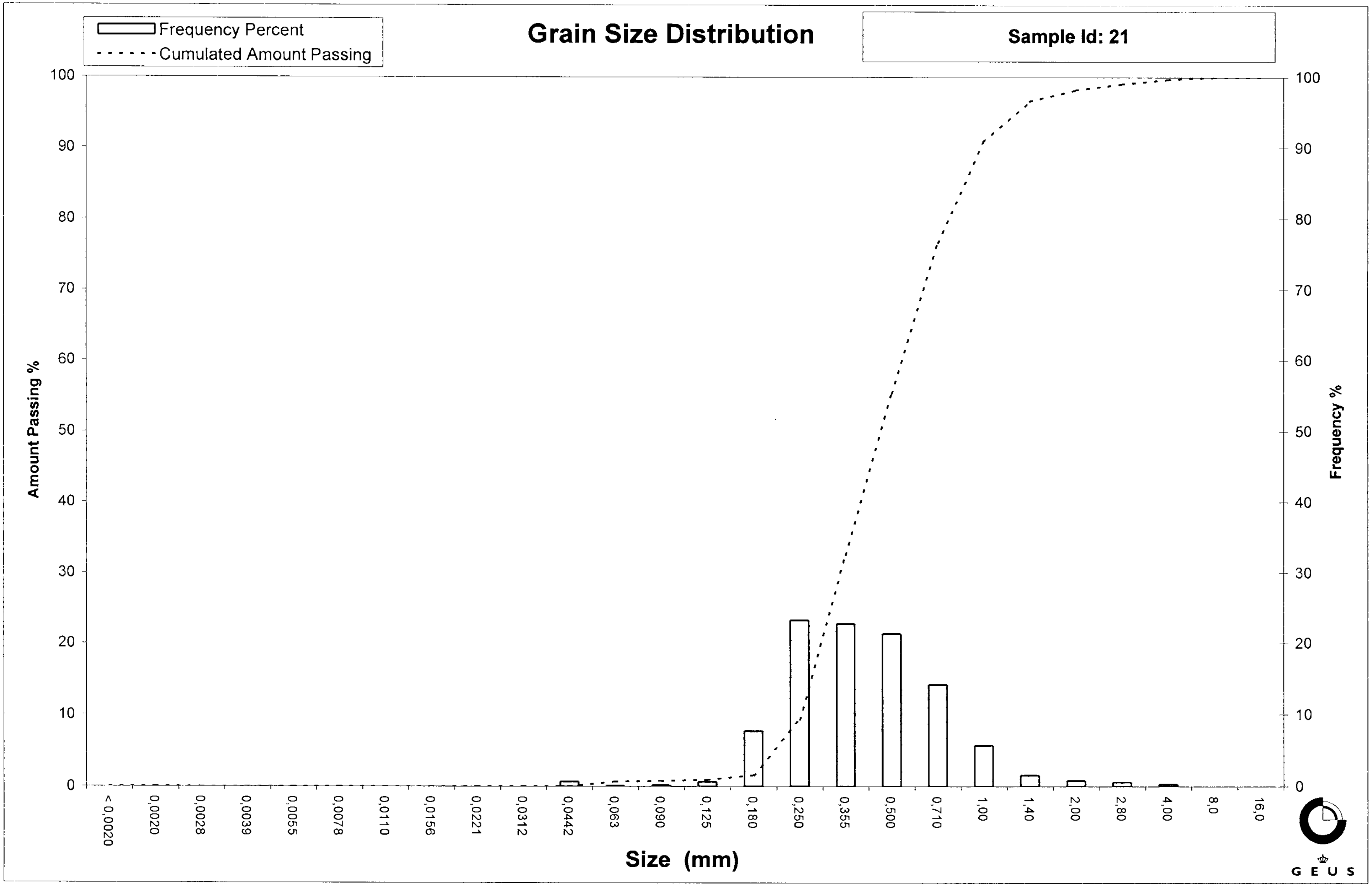

Frequency Percent
Cumulated Amount Passing
Grain Size Distribution
Sample Id: 21
Amount Passing %
Frequency %
100
90
80
70
60
50
40
30
20
10
0
< 0,0020
0,0020
0,0028
0,0039
0,0055
0,0078
0,0110
0,0156
0,0221
0,0312
0,0442
0,063
0,090
0,125
0,180
0,250
0,355
0,500
0,710
1,00
1,40
2,00
2,80
4,00
8,0
16,0
Size (mm)
GEUS

Grain Size Distribution

Geotechnical

Sample Id: 22
Lab. Id: 060378
Submitter: Bio/consult
Subject: Horns_Rev2 12/12/2005
Date: Februar 2006
Executed: I. Nørgaard
Remarks: Sample < 2 mm. Too small amount of material < 0,063mm for sedigrafanalysis. Sample Flocculate

GEUS

Total Weight 101,03 g

Size Fractions

		Size mm	Size Φ	Weight g	Weight %	Cumulated amount passing %
Sieve Analysis	Gravel	16,00	-4,00	0,00	0,00	100,00
Sieve Analysis	Gravel	8,00	-3,00	0,00	0,00	100,00
Sieve Analysis	Gravel	4,00	-2,00	0,00	0,00	100,00
Sieve Analysis	Gravel	2,80	-1,49	0,00	0,00	100,00
Sieve Analysis	Gravel	2,00	-1,00	0,04	0,04	99,96
Sieve Analysis	Sand	1,40	-0,49	0,14	0,14	99,82
Sieve Analysis	Sand	1,00	0,00	0,16	0,16	99,66
Sieve Analysis	Sand	0,710	0,49	0,61	0,60	99,06
Sieve Analysis	Sand	0,500	1,00	3,29	3,26	95,80
Sieve Analysis	Sand	0,355	1,49	14,91	14,76	81,05
Sieve Analysis	Sand	0,250	2,00	48,39	47,90	33,15
Sieve Analysis	Sand	0,180	2,47	27,94	27,66	5,49
Sieve Analysis	Sand	0,125	3,00	3,64	3,60	1,89
Sieve Analysis	Sand	0,090	3,47	0,83	0,82	1,07
Sieve Analysis	Sand	0,063	3,99	0,29	0,29	0,78
Sedigraph Analysis	Silt	0,0442	4,50	0,79	0,78	0,00
Sedigraph Analysis	Silt	0,0312	5,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0221	5,50	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0156	6,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0110	6,51	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0078	7,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0055	7,51	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0039	8,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0028	8,48	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0020	8,97	0,00	0,00	0,00
Sedigraph Analysis	Clay	<0,0020	>8,97	0,00	0,00	0,00

The analysis is executed according to DS/EN 933-1 extended by sieves to the ½ phi scale and test portion mass 0,1 kg

Size Classes (DGF-Bulletin 1 1988)

		Weight %
Clay	(< 0,002 mm):	0,00
Silt, fine	(0,002 mm - 0,006 mm):	0,00
Silt, medium	(0,006 mm - 0,020 mm):	0,00
Silt, coarse	(0,020 mm - 0,063 mm):	0,78
Sand, fine	(0,063 mm - 0,200 mm):	12,61
Sand, medium	(0,2 mm - 0,6 mm):	83,96
Sand, coarse	(0,6 mm - 2 mm):	2,61
Gravel	(> 2 mm):	0,04
Sum:		100,00

Moments Measures

Percentile Amount in sieve	Percentile Amount passing	d(mm)	Φ
5%	95%	0,49	1,02
16%	84%	0,38	1,38
25%	75%	0,34	1,55
40%	60%	0,31	1,69
50%	50%	0,29	1,80
75%	25%	0,23	2,12
84%	16%	0,21	2,28
90%	10%	0,19	2,39
95%	5%	0,17	2,54

Moments Statistics

Mean	1,82
Sorting	0,45
Skewness	0,02
Kurtosis	1,08
Uniformity Coefficient	1,61

Size Classes and Percentiles are found by linear interpolation

Formulas

Mean (ϕ16%+ϕ84%+ϕ50%) / 3 (Folk and Ward 1957)

Sorting (ϕ84%-ϕ16%) / 4 + (ϕ95%-ϕ5%) / 6,6 (Folk and Ward 1957)

Kurtosis (ϕ95% - ϕ5%) / (2,44 * (ϕ75% - ϕ25%)) (Folk and Ward 1957)

Skewness (ϕ16%+ϕ84% - 2*ϕ50%) / (2*(ϕ84%-ϕ16%)) + (ϕ5%+ϕ95% - 2*ϕ50%) / (2*(ϕ95%-ϕ5%)) (Folk and Ward 1957)

Uniformity Coefficient (d60% / d10%) (dgf-Bulletin 1988)

Mean, sorting, skewness and kurtosis are based on "Amount in sieve". Uniformity coefficient is based on "Amount passing".

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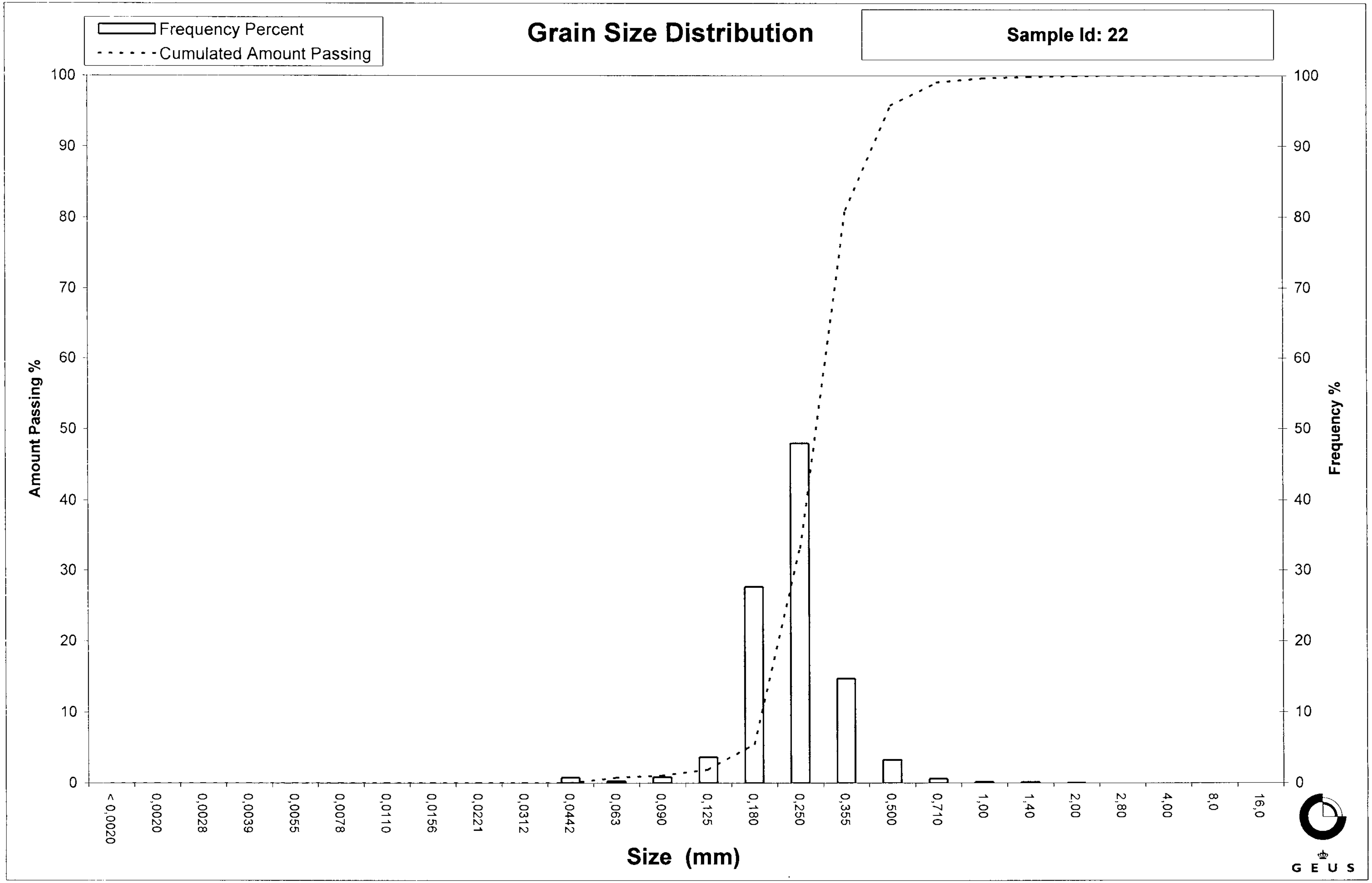

Frequency Percent
Cumulated Amount Passing
Grain Size Distribution
Sample Id: 22
Amount Passing %
Frequency %
100
90
80
70
60
50
40
30
20
10
0
< 0,0020
0,0020
0,0028
0,0039
0,0055
0,0078
0,0110
0,0156
0,0221
0,0312
0,0442
0,063
0,090
0,125
0,180
0,250
0,355
0,500
0,710
1,00
1,40
2,00
2,80
4,00
8,0
16,0
Size (mm)
GEUS

Grain Size Distribution

Geotechnical

Sample Id: 23
Lab. Id: 060379
Submitter: Bio/consult
Subject: Horns_Rev2 12/12/2005
Date: Februar 2006
Executed: I. Nørgaard
Remarks: Sample < 8 mm. Too small amount of material < 0,063mm for sedigrafanalysis. Sample Flocculate

Total Weight 200,8 g

GEUS

Size Fractions

		Size mm	Size Φ	Weight g	Weight %	Cumulated amount passing %
Sieve Analysis	Gravel	16,00	-4,00	0,00	0,00	100,00
Sieve Analysis	Gravel	8,00	-3,00	0,00	0,00	100,00
Sieve Analysis	Gravel	4,00	-2,00	0,81	0,40	99,60
Sieve Analysis	Gravel	2,80	-1,49	3,42	1,70	97,89
Sieve Analysis	Gravel	2,00	-1,00	6,13	3,05	94,84
Sieve Analysis	Sand	1,40	-0,49	11,26	5,61	89,23
Sieve Analysis	Sand	1,00	0,00	18,06	8,99	80,24
Sieve Analysis	Sand	0,710	0,49	26,02	12,96	67,28
Sieve Analysis	Sand	0,500	1,00	35,01	17,44	49,85
Sieve Analysis	Sand	0,355	1,49	49,94	24,87	24,98
Sieve Analysis	Sand	0,250	2,00	38,20	19,02	5,95
Sieve Analysis	Sand	0,180	2,47	9,37	4,67	1,28
Sieve Analysis	Sand	0,125	3,00	0,96	0,48	0,81
Sieve Analysis	Sand	0,090	3,47	0,20	0,10	0,71
Sieve Analysis	Sand	0,063	3,99	0,09	0,04	0,66
Sedigraph Analysis	Silt	0,0442	4,50	1,33	0,66	0,00
Sedigraph Analysis	Silt	0,0312	5,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0221	5,50	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0156	6,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0110	6,51	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0078	7,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0055	7,51	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0039	8,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0028	8,48	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0020	8,97	0,00	0,00	0,00
	Clay	<0,0020	>8,97	0,00	0,00	0,00

The analysis is executed according to DS/EN 933-1 extended by sieves to the ½ phi scale and test portion mass 0,1 kg

Size Classes (DGF-Bulletin 1 1988)

		Weight %
Clay	(< 0,002 mm):	0,00
Silt, fine	(0,002 mm - 0,006 mm):	0,00
Silt, medium	(0,006 mm - 0,020 mm):	0,00
Silt, coarse	(0,020 mm - 0,063 mm):	0,66
Sand, fine	(0,063 mm - 0,200 mm):	1,96
Sand, medium	(0,2 mm - 0,6 mm):	55,53
Sand, coarse	(0,6 mm - 2 mm):	36,69
Gravel	(> 2 mm):	5,16
Sum:		100,00

Moments Measures

Percentile Amount in sieve	Percentile Amount passing	d(mm)	Φ
5%	95%	2,04	-1,03
16%	84%	1,17	-0,22
25%	75%	0,88	0,18
40%	60%	0,62	0,68
50%	50%	0,50	0,99
75%	25%	0,36	1,49
84%	16%	0,31	1,71
90%	10%	0,27	1,88
95%	5%	0,24	2,08

Moments Statistics

Mean	0,83
Sorting	0,96
Skewness	-0,28
Kurtosis	0,97
Uniformity Coefficient	2,28

Size Classes and Percentiles are found by linear interpolation

Formulas

Mean (ϕ16%+ϕ84%+ϕ50%) / 3 (Folk and Ward 1957)
Sorting (ϕ84%-ϕ16%) / 4 + (ϕ95%-ϕ5%) / 6,6 (Folk and Ward 1957)
Kurtosis (ϕ95% - ϕ5%) / (2,44 * (ϕ75% - ϕ25%)) (Folk and Ward 1957)
Skewness (ϕ16%+ϕ84% - 2*ϕ50%) / (2*(ϕ84%-ϕ16%)) + (ϕ5%+ϕ95% - 2*ϕ50%) / (2*(ϕ95%-ϕ5%)) (Folk and Ward 1957)
Uniformity Coefficient (d60% / d10%) (dgf-Bulletin 1988)

Mean, sorting, skewness and kurtosis are based on "Amount in sieve". Uniformity coefficient is based on "Amount passing".

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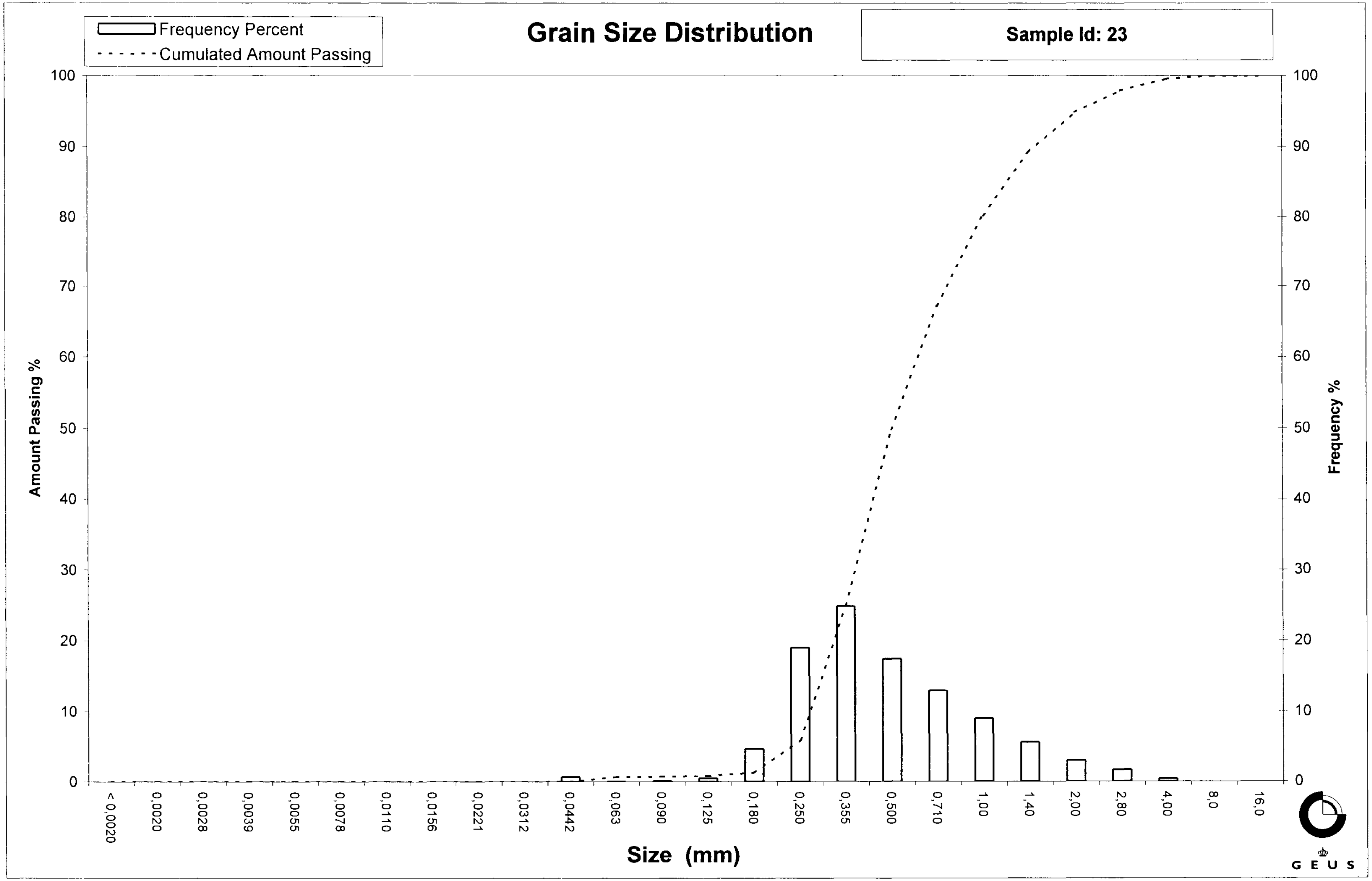

Frequency Percent
Cumulated Amount Passing
Grain Size Distribution
Sample Id: 23
Amount Passing %
Frequency %
Size (mm)
< 0,0020
0,0020
0,0028
0,0039
0,0055
0,0078
0,0110
0,0156
0,0221
0,0312
0,0442
0,063
0,090
0,125
0,180
0,250
0,355
0,500
0,710
1,00
1,40
2,00
2,80
4,00
8,0
16,0
GEUS

Grain Size Distribution

Geotechnical

Sample Id: 24
Lab. Id: 060380
Submitter: Bio/consult
Subject: Horns_Rev2 12/12/2005
Date: Februar 2006
Executed: I. Nørgaard
Remarks: Sample < 8 mm. Too small amount of material < 0,063mm for sedigrafanalysis. Sample Flocculate

Total Weight 204,73 g

GEUS

Size Fractions

		Size mm	Size Φ	Weight g	Weight %	Cumulated amount passing %
Sieve Analysis	Gravel	16,00	-4,00	0,00	0,00	100,00
Sieve Analysis	Gravel	8,00	-3,00	0,00	0,00	100,00
Sieve Analysis	Gravel	4,00	-2,00	4,58	2,24	97,76
Sieve Analysis	Gravel	2,80	-1,49	3,83	1,87	95,89
Sieve Analysis	Gravel	2,00	-1,00	4,13	2,02	93,87
Sieve Analysis	Sand	1,40	-0,49	6,89	3,37	90,51
Sieve Analysis	Sand	1,00	0,00	16,57	8,09	82,42
Sieve Analysis	Sand	0,710	0,49	20,24	9,89	72,53
Sieve Analysis	Sand	0,500	1,00	29,71	14,51	58,02
Sieve Analysis	Sand	0,355	1,49	50,82	24,82	33,19
Sieve Analysis	Sand	0,250	2,00	47,72	23,31	9,89
Sieve Analysis	Sand	0,180	2,47	16,33	7,98	1,91
Sieve Analysis	Sand	0,125	3,00	1,85	0,90	1,01
Sieve Analysis	Sand	0,090	3,47	0,36	0,18	0,83
Sieve Analysis	Sand	0,063	3,99	0,18	0,09	0,74
Sedigraph Analysis	Silt	0,0442	4,50	1,52	0,74	0,00
Sedigraph Analysis	Silt	0,0312	5,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0221	5,50	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0156	6,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0110	6,51	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0078	7,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0055	7,51	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0039	8,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0028	8,48	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0020	8,97	0,00	0,00	0,00
Sedigraph Analysis	Clay	<0,0020	>8,97	0,00	0,00	0,00

The analysis is executed according to DS/EN 933-1 extended by sieves to the ½ phi scale and test portion mass 0,1 kg

Size Classes (DGF-Bulletin 1 1988)

		Weight %
Clay	(< 0,002 mm):	0,00
Silt, fine	(0,002 mm - 0,006 mm):	0,00
Silt, medium	(0,006 mm - 0,020 mm):	0,00
Silt, coarse	(0,020 mm - 0,063 mm):	0,74
Sand, fine	(0,063 mm - 0,200 mm):	3,45
Sand, medium	(0,2 mm - 0,6 mm):	60,74
Sand, coarse	(0,6 mm - 2 mm):	28,95
Gravel	(> 2 mm):	6,13
Sum:		100,00

Moments Measures

Percentile Amount in sieve	Percentile Amount passing	d(mm)	Φ
5%	95%	2,45	-1,29
16%	84%	1,08	-0,11
25%	75%	0,78	0,35
40%	60%	0,53	0,92
50%	50%	0,45	1,14
75%	25%	0,32	1,65
84%	16%	0,28	1,85
90%	10%	0,25	2,00
95%	5%	0,21	2,27

Moments Statistics

Mean	0,96
Sorting	1,03
Skewness	-0,32
Kurtosis	1,12
Uniformity Coefficient	2,11

Size Classes and Percentiles are found by linear interpolation

Formulas

Mean (ϕ16%+ϕ84%+ϕ50%) / 3 (Folk and Ward 1957)

Sorting (ϕ84%-ϕ16%) / 4 + (ϕ95%-ϕ5%) / 6,6 (Folk and Ward 1957)

Kurtosis (ϕ95% - ϕ5%) / (2,44 * (ϕ75% - ϕ25%)) (Folk and Ward 1957)

Skewness (ϕ16%+ϕ84% - 2*ϕ50%) / (2*(ϕ84%-ϕ16%)) + (ϕ5%+ϕ95% - 2*ϕ50%) / (2*(ϕ95%-ϕ5%)) (Folk and Ward 1957)

Uniformity Coefficient (d60% / d10%) (dgf-Bulletin 1988)

Mean, sorting, skewness and kurtosis are based on "Amount in sieve". Uniformity coefficient is based on "Amount passing".

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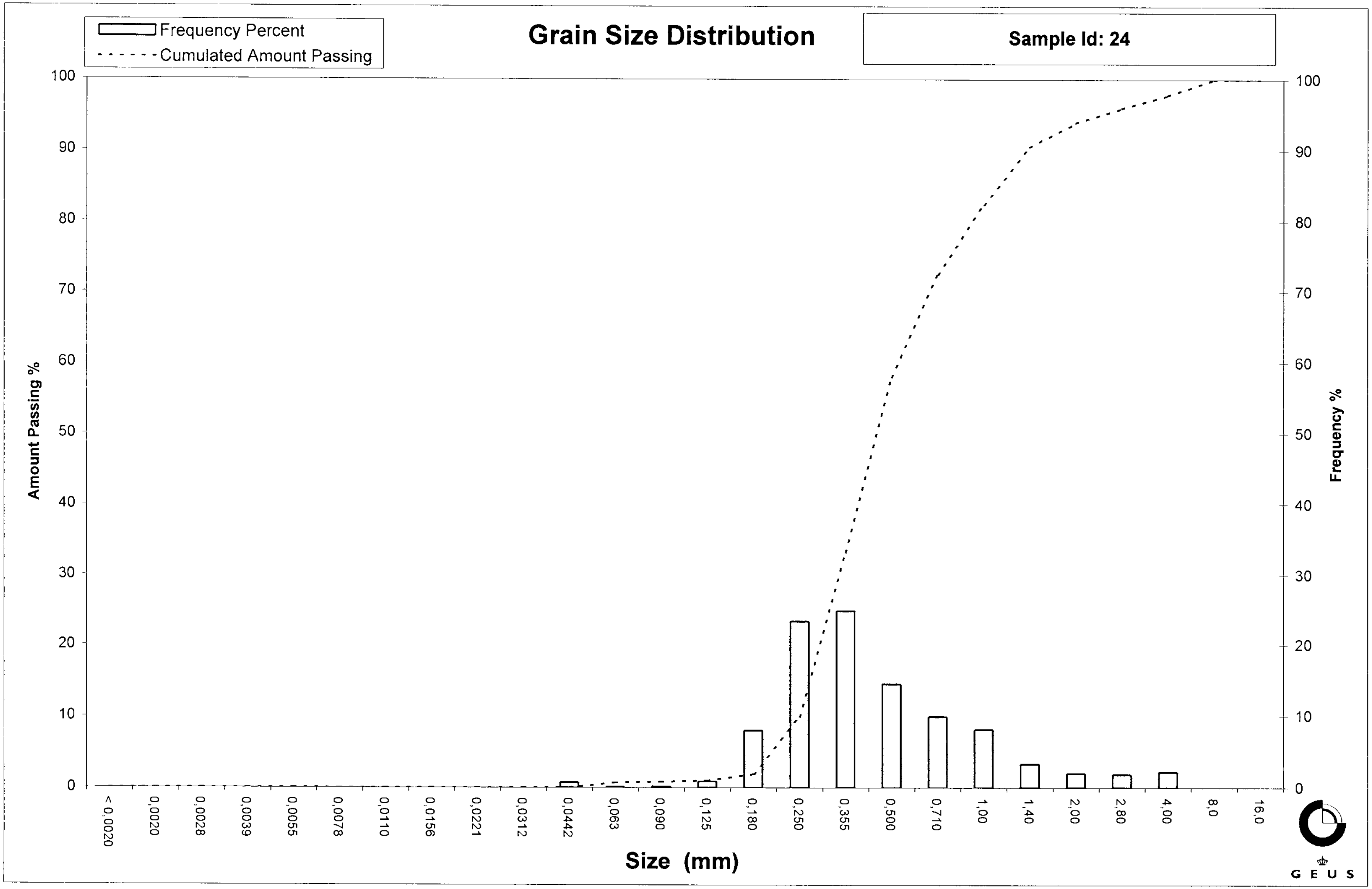

Frequency Percent
Cumulated Amount Passing
Grain Size Distribution
Sample Id: 24
Amount Passing %
Frequency %
0
10
20
30
40
50
60
70
80
90
100
< 0,0020
0,0020
0,0028
0,0039
0,0055
0,0078
0,0110
0,0156
0,0221
0,0312
0,0442
0,063
0,090
0,125
0,180
0,250
0,355
0,500
0,710
1,00
1,40
2,00
2,80
4,00
8,0
16,0
Size (mm)
GEUS

Grain Size Distribution

Geotechnical

Sample Id: 25
Lab. Id: 060381
Submitter: Bio/consult
Subject: Horns_Rev2 12/12/2005
Date: Februar 2006
Executed: I. Nørgaard
Remarks: Sample < 8 mm. Too small amount of material < 0,063mm for sedigrafanalysis. Sample Flocculate

GEUS

Total Weight 205,65 g

Size Fractions

		Size	Size	Weight	Weight	Cumulated amount passing
		mm	Φ	g	%	%
Sieve Analysis	Gravel	16,00	-4,00	0,00	0,00	100,00
		8,00	-3,00	0,00	0,00	100,00
		4,00	-2,00	0,85	0,41	99,59
		2,80	-1,49	2,31	1,12	98,46
		2,00	-1,00	3,44	1,67	96,79
	Sand	1,40	-0,49	7,43	3,61	93,18
		1,00	0,00	11,68	5,68	87,50
		0,710	0,49	22,96	11,16	76,33
		0,500	1,00	46,18	22,46	53,88
		0,355	1,49	47,79	23,24	30,64
		0,250	2,00	41,52	20,19	10,45
		0,180	2,47	16,31	7,93	2,52
		0,125	3,00	2,61	1,27	1,25
		0,090	3,47	0,53	0,26	0,99
		0,063	3,99	0,27	0,13	0,86
Sedigraph Analysis	Silt	0,0442	4,50	1,77	0,86	0,00
		0,0312	5,00	0,00	0,00	0,00
		0,0221	5,50	0,00	0,00	0,00
		0,0156	6,00	0,00	0,00	0,00
		0,0110	6,51	0,00	0,00	0,00
		0,0078	7,00	0,00	0,00	0,00
		0,0055	7,51	0,00	0,00	0,00
		0,0039	8,00	0,00	0,00	0,00
		0,0028	8,48	0,00	0,00	0,00
		0,0020	8,97	0,00	0,00	0,00
	Clay	<0,0020	>8,97	0,00	0,00	0,00

The analysis is executed according to DS/EN 933-1 extended by sieves to the ½ phi scale and test portion mass 0,1 kg

Size Classes (DGF-Bulletin 1 1988)

		Weight %
Clay	(< 0,002 mm):	0,00
Silt, fine	(0,002 mm - 0,006 mm):	0,00
Silt, medium	(0,006 mm - 0,020 mm):	0,00
Silt, coarse	(0,020 mm - 0,063 mm):	0,86
Sand, fine	(0,063 mm - 0,200 mm):	3,92
Sand, medium	(0,2 mm - 0,6 mm):	59,79
Sand, coarse	(0,6 mm - 2 mm):	32,22
Gravel	(> 2 mm):	3,21
Sum:		100,00

Moments Measures

Percentile Amount in sieve	Percentile Amount passing	d(mm)	Φ
5%	95%	1,70	-0,77
16%	84%	0,91	0,14
25%	75%	0,70	0,52
40%	60%	0,56	0,84
50%	50%	0,48	1,07
75%	25%	0,33	1,62
84%	16%	0,28	1,84
90%	10%	0,25	2,02
95%	5%	0,20	2,31

Moments Statistics

Mean	1,02
Sorting	0,89
Skewness	-0,15
Kurtosis	1,15
Uniformity Coefficient	2,26

Size Classes and Percentiles are found by linear interpolation

Formulas

Mean (ϕ16%+ϕ84%+ϕ50%) / 3 (Folk and Ward 1957)

Sorting (ϕ84%-ϕ16%) / 4 + (ϕ95%-ϕ5%) / 6,6 (Folk and Ward 1957)

Kurtosis (ϕ95% - ϕ5%) / (2,44 * (ϕ75% - ϕ25%)) (Folk and Ward 1957)

Skewness (ϕ16%+ϕ84% - 2*ϕ50%) / (2*(ϕ84%-ϕ16%)) + (ϕ5%+ϕ95% - 2*ϕ50%) / (2*(ϕ95%-ϕ5%)) (Folk and Ward 1957)

Uniformity Coefficient (d60% / d10%) (dgf-Bulletin 1988)

Mean, sorting, skewness and kurtosis are based on "Amount in sieve". Uniformity coefficient is based on "Amount passing".

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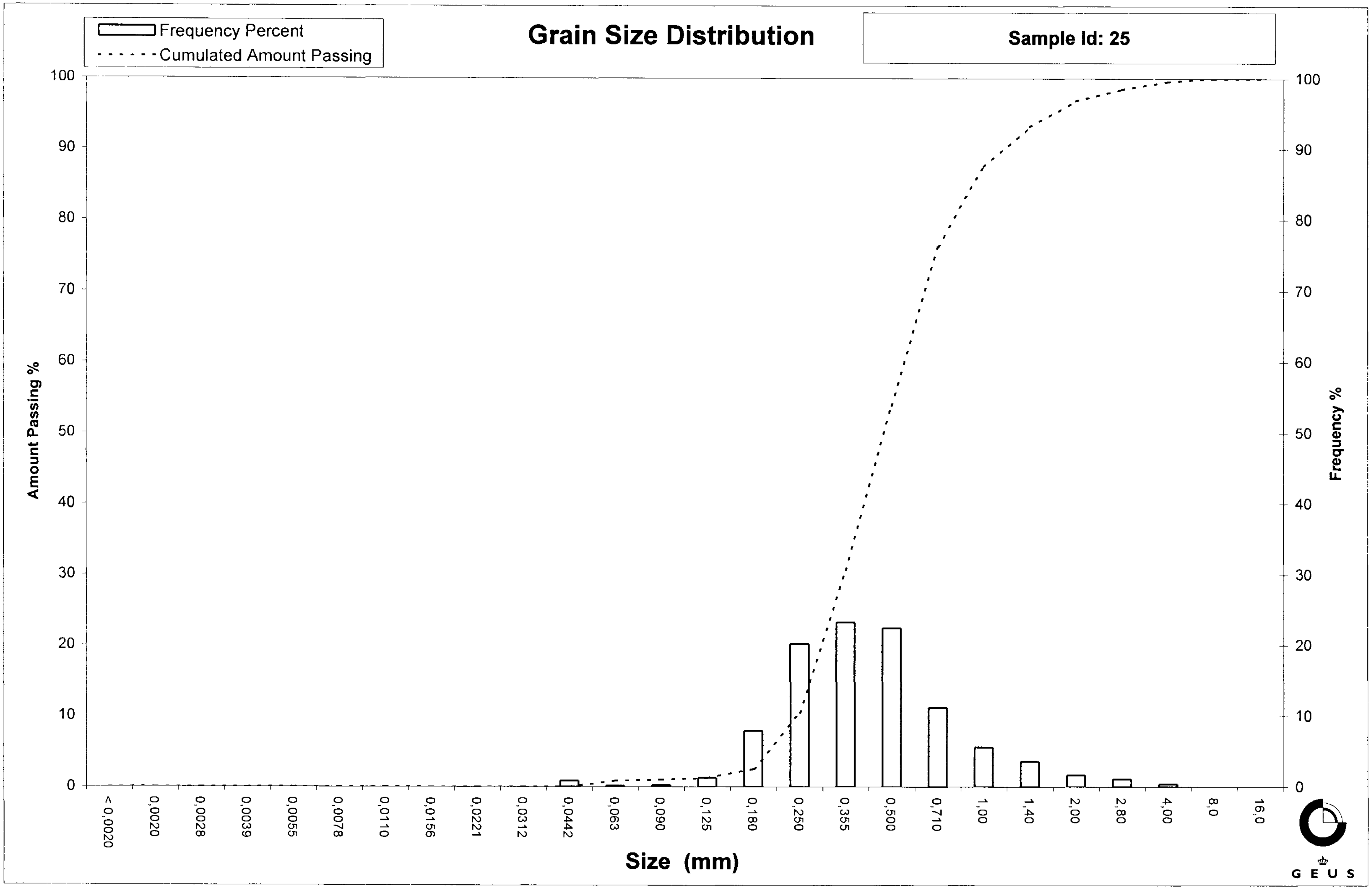

Frequency Percent
Cumulated Amount Passing
Grain Size Distribution
Sample Id: 25
Amount Passing %
Frequency %
100
90
80
70
60
50
40
30
20
10
0
< 0,0020
0,0020
0,0028
0,0039
0,0055
0,0078
0,0110
0,0156
0,0221
0,0312
0,0442
0,063
0,090
0,125
0,180
0,250
0,355
0,500
0,710
1,00
1,40
2,00
2,80
4,00
8,0
16,0
Size (mm)
GEUS

Grain Size Distribution

Geotechnical

Sample Id: 26
Lab. Id: 060382
Submitter: Bio/consult
Subject: Horns_Rev2 12/12/2005
Date: Februar 2006
Executed: I. Nørgaard
Remarks: Sample < 2 mm. Too small amount of material < 0,063mm for sedigrafanalysis. Sample Flocculate

GEUS

Total Weight 108,32 g

Size Fractions

		Size mm	Size Φ	Weight g	Weight %	Cumulated amount passing %
Sieve Analysis	Gravel	16,00	-4,00	0,00	0,00	100,00
		8,00	-3,00	0,00	0,00	100,00
		4,00	-2,00	0,18	0,17	99,83
		2,80	-1,49	0,16	0,15	99,69
		2,00	-1,00	0,07	0,06	99,62
	Sand	1,40	-0,49	0,12	0,11	99,51
		1,00	0,00	1,62	1,50	98,02
		0,710	0,49	23,42	21,62	76,39
		0,500	1,00	22,44	20,72	55,68
		0,355	1,49	22,91	21,15	34,53
		0,250	2,00	25,36	23,41	11,12
		0,180	2,47	9,38	8,66	2,46
		0,125	3,00	1,35	1,25	1,21
		0,090	3,47	0,32	0,30	0,91
		0,063	3,99	0,24	0,22	0,69
Sedigraph Analysis	Silt	0,0442	4,50	0,75	0,69	0,00
		0,0312	5,00	0,00	0,00	0,00
		0,0221	5,50	0,00	0,00	0,00
		0,0156	6,00	0,00	0,00	0,00
		0,0110	6,51	0,00	0,00	0,00
		0,0078	7,00	0,00	0,00	0,00
		0,0055	7,51	0,00	0,00	0,00
		0,0039	8,00	0,00	0,00	0,00
		0,0028	8,48	0,00	0,00	0,00
		0,0020	8,97	0,00	0,00	0,00
	Clay	<0,0020	>8,97	0,00	0,00	0,00

The analysis is executed according to DS/EN 933-1 extended by sieves to the ½ phi scale and test portion mass 0,1 kg

Size Classes (DGF-Bulletin 1 1988)

		Weight %
Clay	(< 0,002 mm):	0,00
Silt, fine	(0,002 mm - 0,006 mm):	0,00
Silt, medium	(0,006 mm - 0,020 mm):	0,00
Silt, coarse	(0,020 mm - 0,063 mm):	0,69
Sand, fine	(0,063 mm - 0,200 mm):	4,24
Sand, medium	(0,2 mm - 0,6 mm):	60,61
Sand, coarse	(0,6 mm - 2 mm):	34,08
Gravel	(> 2 mm):	0,38
Sum:		100,00

Moments Measures

Percentile Amount in sieve	Percentile Amount passing	d(mm)	Φ
5%	95%	0,96	0,06
16%	84%	0,81	0,30
25%	75%	0,70	0,52
40%	60%	0,54	0,88
50%	50%	0,46	1,12
75%	25%	0,31	1,68
84%	16%	0,27	1,88
90%	10%	0,24	2,05
95%	5%	0,20	2,32

Moments Statistics

Mean	1,10
Sorting	0,74
Skewness	0,01
Kurtosis	0,80
Uniformity Coefficient	2,26

Size Classes and Percentiles are found by linear interpolation

Formulas

Mean (ϕ16%+ϕ84%+ϕ50%) / 3 (Folk and Ward 1957)

Sorting (ϕ84%-ϕ16%) / 4 + (ϕ95%-ϕ5%) / 6,6 (Folk and Ward 1957)

Kurtosis (ϕ95% - ϕ5%) / (2,44 * (ϕ75% - ϕ25%)) (Folk and Ward 1957)

Skewness (ϕ16%+ϕ84% - 2*ϕ50%) / (2*(ϕ84%-ϕ16%)) + (ϕ5%+ϕ95% - 2*ϕ50%) / (2*(ϕ95%-ϕ5%)) (Folk and Ward 1957)

Uniformity Coefficient (d60% / d10%) (dgf-Bulletin 1988)

Mean, sorting, skewness and kurtosis are based on "Amount in sieve". Uniformity coefficient is based on "Amount passing".

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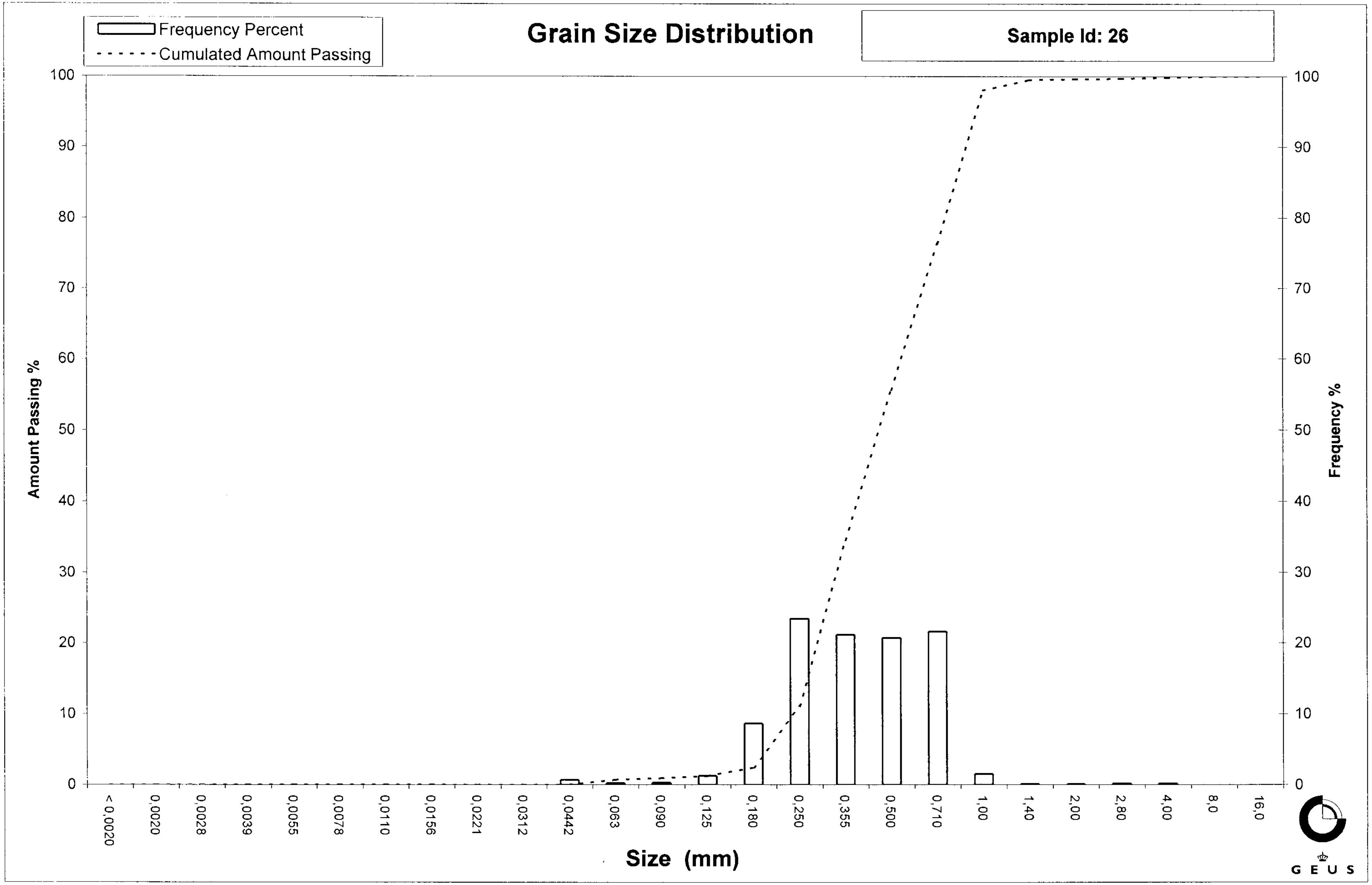

Frequency Percent
Cumulated Amount Passing
Grain Size Distribution
Sample Id: 26
Amount Passing %
Frequency %
0
10
20
30
40
50
60
70
80
90
100
< 0,0020
0,0020
0,0028
0,0039
0,0055
0,0078
0,0110
0,0156
0,0221
0,0312
0,0442
0,063
0,090
0,125
0,180
0,250
0,355
0,500
0,710
1,00
1,40
2,00
2,80
4,00
8,0
16,0
Size (mm)
GEUS

Grain Size Distribution
Geotechnical

Sample Id: 27
Lab. Id: 060383
Submitter: Bio/consult
Subject: Horns_Rev2 12/12/2005
Date: Februar 2006
Executed: I. Nørgaard
Remarks: Sample < 2 mm. Too small amount of material < 0,063mm for sedigrafanalysis. Sample Flocculate

GEUS

Total Weight 119,63 g

Size Fractions

		Size mm	Size Φ	Weight g	Weight %	Cumulated amount passing %
Sieve Analysis	Gravel	16,00	-4,00	0,00	0,00	100,00
Sieve Analysis	Gravel	8,00	-3,00	0,00	0,00	100,00
Sieve Analysis	Gravel	4,00	-2,00	0,00	0,00	100,00
Sieve Analysis	Gravel	2,80	-1,49	0,10	0,08	99,92
Sieve Analysis	Gravel	2,00	-1,00	0,00	0,00	99,92
Sieve Analysis	Sand	1,40	-0,49	0,11	0,09	99,82
Sieve Analysis	Sand	1,00	0,00	0,81	0,68	99,15
Sieve Analysis	Sand	0,710	0,49	13,80	11,54	87,61
Sieve Analysis	Sand	0,500	1,00	39,66	33,15	54,46
Sieve Analysis	Sand	0,355	1,49	28,92	24,17	30,29
Sieve Analysis	Sand	0,250	2,00	24,75	20,69	9,60
Sieve Analysis	Sand	0,180	2,47	9,35	7,82	1,78
Sieve Analysis	Sand	0,125	3,00	1,12	0,94	0,84
Sieve Analysis	Sand	0,090	3,47	0,25	0,21	0,64
Sieve Analysis	Sand	0,063	3,99	0,17	0,14	0,49
Sedigraph Analysis	Silt	0,0442	4,50	0,59	0,49	0,00
Sedigraph Analysis	Silt	0,0312	5,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0221	5,50	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0156	6,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0110	6,51	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0078	7,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0055	7,51	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0039	8,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0028	8,48	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0020	8,97	0,00	0,00	0,00
	Clay	<0,0020	>8,97	0,00	0,00	0,00

The analysis is executed according to DS/EN 933-1 extended by sieves to the ½ phi scale and test portion mass 0,1 kg

Size Classes (DGF-Bulletin 1 1988)

		Weight %
Clay	(< 0,002 mm):	0,00
Silt, fine	(0,002 mm - 0,006 mm):	0,00
Silt, medium	(0,006 mm - 0,020 mm):	0,00
Silt, coarse	(0,020 mm - 0,063 mm):	0,49
Sand, fine	(0,063 mm - 0,200 mm):	3,52
Sand, medium	(0,2 mm - 0,6 mm):	66,23
Sand, coarse	(0,6 mm - 2 mm):	29,67
Gravel	(> 2 mm):	0,08
Sum:		100,00

Moments Measures

Percentile Amount in sieve	Percentile Amount passing	d(mm)	Φ
5%	95%	0,90	0,16
16%	84%	0,69	0,54
25%	75%	0,63	0,67
40%	60%	0,54	0,90
50%	50%	0,47	1,08
75%	25%	0,33	1,61
84%	16%	0,28	1,82
90%	10%	0,25	1,99
95%	5%	0,21	2,26

Moments Statistics

Mean	1,15
Sorting	0,64
Skewness	0,14
Kurtosis	0,91
Uniformity Coefficient	2,12

Size Classes and Percentiles are found by linear interpolation

Formulas

Mean (ϕ16%+ϕ84%+ϕ50%) / 3 (Folk and Ward 1957)

Sorting (ϕ84%-ϕ16%) / 4 + (ϕ95%-ϕ5%) / 6,6 (Folk and Ward 1957)

Kurtosis (ϕ95% - ϕ5%) / (2,44 * (ϕ75% - ϕ25%)) (Folk and Ward 1957)

Skewness (ϕ16%+ϕ84% - 2*ϕ50%) / (2*(ϕ84%-ϕ16%)) + (ϕ5%+ϕ95% - 2*ϕ50%) / (2*(ϕ95%-ϕ5%)) (Folk and Ward 1957)

Uniformity Coefficient (d60% / d10%) (dgf-Bulletin 1988)

Mean, sorting, skewness and kurtosis are based on "Amount in sieve". Uniformity coefficient is based on "Amount passing".

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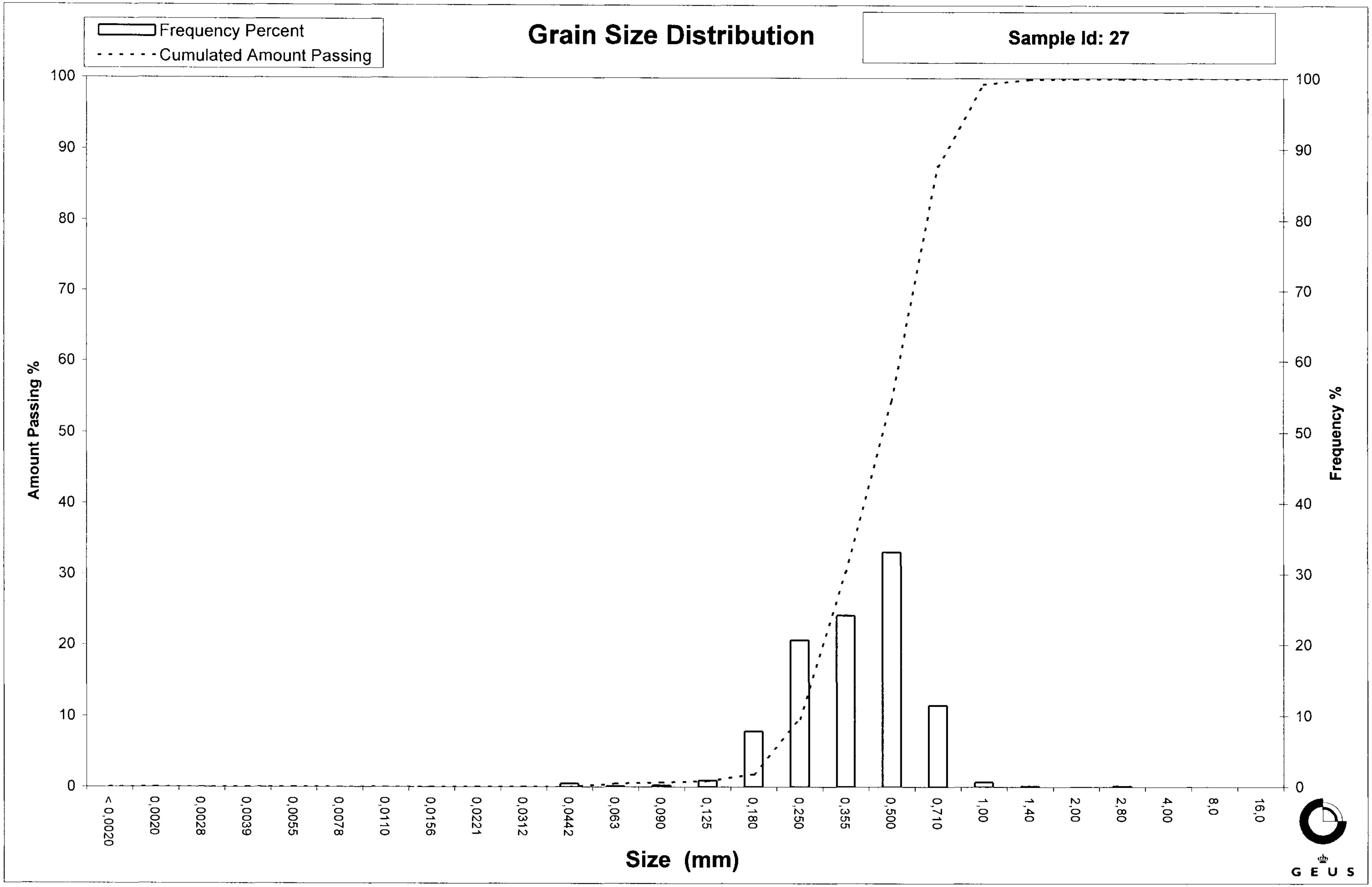
Frequency Percent
Cumulated Amount Passing
Grain Size Distribution
Sample Id: 27
Amount Passing %
Frequency %
100
90
80
70
60
50
40
30
20
10
0
< 0,0020
0,0020
0,0028
0,0039
0,0055
0,0078
0,0110
0,0156
0,0221
0,0312
0,0442
0,063
0,090
0,125
0,180
0,250
0,355
0,500
0,710
1,00
1,40
2,00
2,80
4,00
8,0
16,0
Size (mm)
GEUS

Grain Size Distribution

Geotechnical

Sample Id: 28
Lab. Id: 060384
Submitter: Bio/consult
Subject: Horns_Rev2 12/12/2005
Date: Februar 2006
Executed: I. Nørgaard
Remarks: Sample < 2 mm. Too small amount of material < 0,063mm for sedigrafanalysis. Sample Flocculate

Total Weight 108,06 g

GEUS

Size Fractions

		Size mm	Size Φ	Weight g	Weight %	Cumulated amount passing %
Sieve Analysis	Gravel	16,00	-4,00	0,00	0,00	100,00
		8,00	-3,00	0,00	0,00	100,00
		4,00	-2,00	0,00	0,00	100,00
		2,80	-1,49	0,13	0,12	99,88
		2,00	-1,00	0,12	0,11	99,77
	Sand	1,40	-0,49	0,10	0,09	99,68
		1,00	0,00	0,58	0,54	99,14
		0,710	0,49	12,11	11,21	87,93
		0,500	1,00	35,27	32,64	55,29
		0,355	1,49	38,66	35,78	19,52
		0,250	2,00	14,08	13,03	6,49
		0,180	2,47	5,26	4,87	1,62
		0,125	3,00	0,91	0,84	0,78
		0,090	3,47	0,25	0,23	0,55
		0,063	3,99	0,14	0,13	0,42
Sedigraph Analysis	Silt	0,0442	4,50	0,45	0,42	0,00
		0,0312	5,00	0,00	0,00	0,00
		0,0221	5,50	0,00	0,00	0,00
		0,0156	6,00	0,00	0,00	0,00
		0,0110	6,51	0,00	0,00	0,00
		0,0078	7,00	0,00	0,00	0,00
		0,0055	7,51	0,00	0,00	0,00
		0,0039	8,00	0,00	0,00	0,00
		0,0028	8,48	0,00	0,00	0,00
		0,0020	8,97	0,00	0,00	0,00
	Clay	<0,0020	>8,97	0,00	0,00	0,00

The analysis is executed according to DS/EN 933-1 extended by sieves to the ½ phi scale and test portion mass 0,1 kg

Size Classes (DGF-Bulletin 1 1988)

		Weight %
Clay	(< 0,002 mm):	0,00
Silt, fine	(0,002 mm - 0,006 mm):	0,00
Silt, medium	(0,006 mm - 0,020 mm):	0,00
Silt, coarse	(0,020 mm - 0,063 mm):	0,42
Sand, fine	(0,063 mm - 0,200 mm):	2,59
Sand, medium	(0,2 mm - 0,6 mm):	67,83
Sand, coarse	(0,6 mm - 2 mm):	28,93
Gravel	(> 2 mm):	0,23
Sum:		100,00

Moments Measures

Percentile Amount in sieve	Percentile Amount passing	d(mm)	Φ
5%	95%	0,89	0,16
16%	84%	0,68	0,55
25%	75%	0,63	0,67
40%	60%	0,53	0,92
50%	50%	0,48	1,06
75%	25%	0,38	1,41
84%	16%	0,33	1,61
90%	10%	0,28	1,85
95%	5%	0,23	2,13

Moments Statistics

Mean	1,07
Sorting	0,56
Skewness	0,06
Kurtosis	1,10
Uniformity Coefficient	1,91

Size Classes and Percentiles are found by linear interpolation

Formulas

Mean (ϕ16%+ϕ84%+ϕ50%) / 3 (Folk and Ward 1957)

Sorting (ϕ84%-ϕ16%) / 4 + (ϕ95%-ϕ5%) / 6,6 (Folk and Ward 1957)

Kurtosis (ϕ95% - ϕ5%) / (2,44 * (ϕ75% - ϕ25%)) (Folk and Ward 1957)

Skewness (ϕ16%+ϕ84% - 2*ϕ50%) / (2*(ϕ84%-ϕ16%)) + (ϕ5%+ϕ95% - 2*ϕ50%) / (2*(ϕ95%-ϕ5%)) (Folk and Ward 1957)

Uniformity Coefficient (d60% / d10%) (dgf-Bulletin 1988)

Mean, sorting, skewness and kurtosis are based on "Amount in sieve". Uniformity coefficient is based on "Amount passing".

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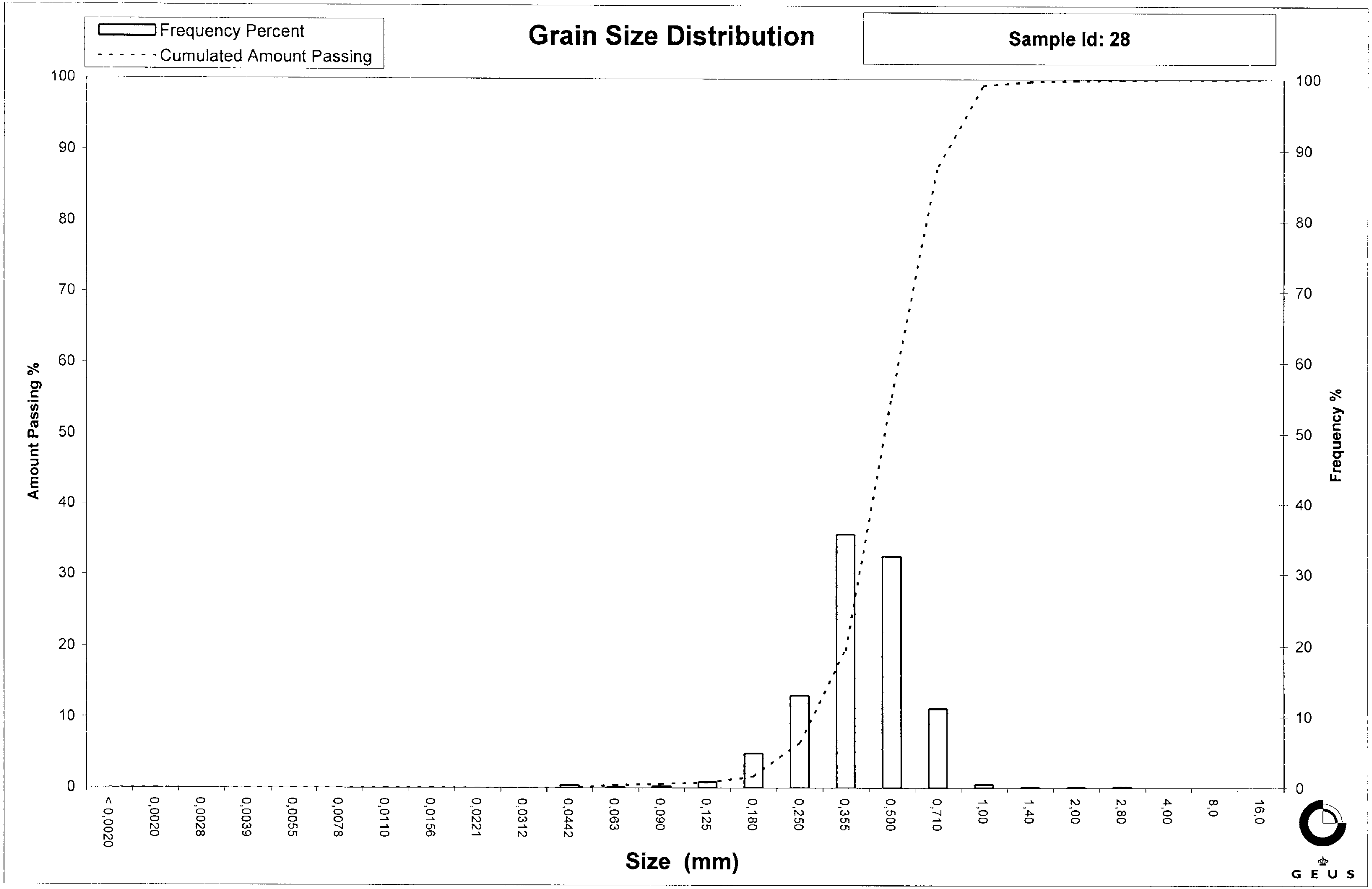

Frequency Percent
Cumulated Amount Passing
Grain Size Distribution
Sample Id: 28
Amount Passing %
Frequency %
0
10
20
30
40
50
60
70
80
90
100
< 0,0020
0,0020
0,0028
0,0039
0,0055
0,0078
0,0110
0,0156
0,0221
0,0312
0,0442
0,063
0,090
0,125
0,180
0,250
0,355
0,500
0,710
1,00
1,40
2,00
2,80
4,00
8,0
16,0
Size (mm)
GEUS

Grain Size Distribution

Geotechnical

Sample Id: 29
Lab. Id: 060385
Submitter: Bio/consult
Subject: Horns_Rev2 12/12/2005
Date: Februar 2006
Executed: I. Nørgaard
Remarks: Sample < 8 mm. Too small amount of material < 0,063mm for sedigrafanalysis. Sample Flocculate

Total Weight 204,28 g

GEUS

Size Fractions

		Size	Size	Weight	Weight	Cumulated amount passing
		mm	Φ	g	%	%
Sieve Analysis	Gravel	16,00	-4,00	0,00	0,00	100,00
		8,00	-3,00	0,18	0,09	99,91
		4,00	-2,00	0,99	0,48	99,43
		2,80	-1,49	0,61	0,30	99,13
		2,00	-1,00	0,33	0,16	98,97
	Sand	1,40	-0,49	0,69	0,34	98,63
		1,00	0,00	3,90	1,91	96,72
		0,710	0,49	39,68	19,42	77,30
		0,500	1,00	63,02	30,85	46,45
		0,355	1,49	33,49	16,39	30,05
		0,250	2,00	36,12	17,68	12,37
		0,180	2,47	19,15	9,37	3,00
		0,125	3,00	3,49	1,71	1,29
		0,090	3,47	0,72	0,35	0,93
		0,063	3,99	0,44	0,22	0,72
Sedigraph Analysis	Silt	0,0442	4,50	1,47	0,72	0,00
		0,0312	5,00	0,00	0,00	0,00
		0,0221	5,50	0,00	0,00	0,00
		0,0156	6,00	0,00	0,00	0,00
		0,0110	6,51	0,00	0,00	0,00
		0,0078	7,00	0,00	0,00	0,00
		0,0055	7,51	0,00	0,00	0,00
		0,0039	8,00	0,00	0,00	0,00
		0,0028	8,48	0,00	0,00	0,00
		0,0020	8,97	0,00	0,00	0,00
	Clay	<0,0020	>8,97	0,00	0,00	0,00

The analysis is executed according to DS/EN 933-1 extended by sieves to the ½ phi scale and test portion mass 0,1 kg

Size Classes (DGF-Bulletin 1 1988)

		Weight %
Clay	(< 0,002 mm):	0,00
Silt, fine	(0,002 mm - 0,006 mm):	0,00
Silt, medium	(0,006 mm - 0,020 mm):	0,00
Silt, coarse	(0,020 mm - 0,063 mm):	0,72
Sand, fine	(0,063 mm - 0,200 mm):	4,95
Sand, medium	(0,2 mm - 0,6 mm):	55,46
Sand, coarse	(0,6 mm - 2 mm):	37,83
Gravel	(> 2 mm):	1,03
Sum:		100,00

Moments Measures

Percentile Amount in sieve	Percentile Amount passing	d(mm)	Φ
5%	95%	0,97	0,04
16%	84%	0,81	0,30
25%	75%	0,69	0,53
40%	60%	0,59	0,76
50%	50%	0,52	0,93
75%	25%	0,33	1,62
84%	16%	0,27	1,88
90%	10%	0,23	2,11
95%	5%	0,19	2,36

Moments Statistics

Mean	1,04
Sorting	0,75
Skewness	0,22
Kurtosis	0,87
Uniformity Coefficient	2,55

Size Classes and Percentiles are found by linear interpolation

Formulas

Mean (ϕ16%+ϕ84%+ϕ50%) / 3 (Folk and Ward 1957)

Sorting (ϕ84%-ϕ16%) / 4 + (ϕ95%-ϕ5%) / 6,6 (Folk and Ward 1957)

Kurtosis (ϕ95% - ϕ5%) / (2,44 * (ϕ75% - ϕ25%)) (Folk and Ward 1957)

Skewness (ϕ16%+ϕ84% - 2*ϕ50%) / (2*(ϕ84%-ϕ16%)) + (ϕ5%+ϕ95% - 2*ϕ50%) / (2*(ϕ95%-ϕ5%)) (Folk and Ward 1957)

Uniformity Coefficient (d60% / d10%) (dgf-Bulletin 1988)

Mean, sorting, skewness and kurtosis are based on "Amount in sieve". Uniformity coefficient is based on "Amount passing".

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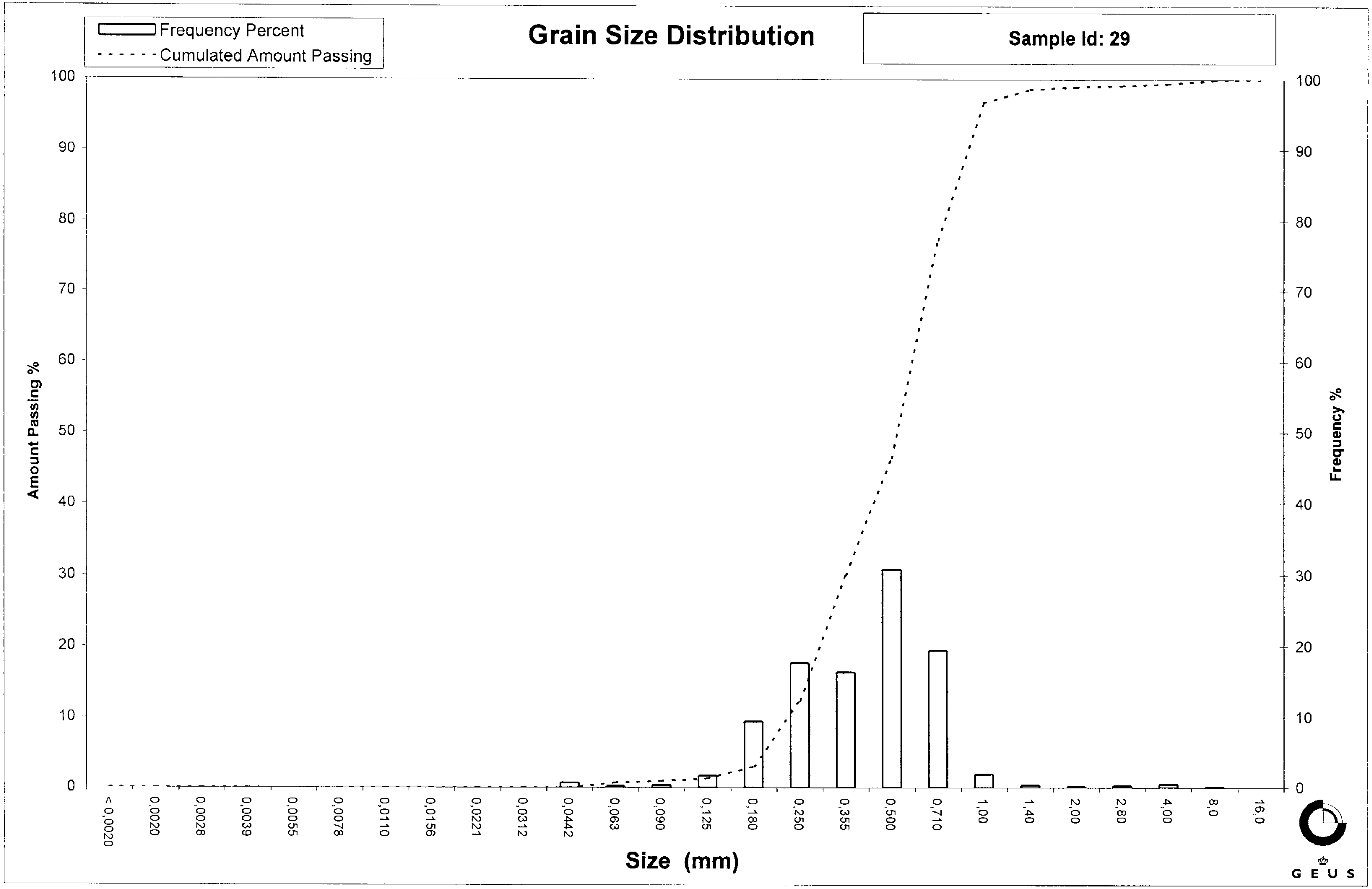

Grain Size Distribution
Sample Id: 29
Frequency Percent
Cumulated Amount Passing
Amount Passing %
Frequency %
100
90
80
70
60
50
40
30
20
10
0
< 0,0020
0,0020
0,0028
0,0039
0,0055
0,0078
0,0110
0,0156
0,0221
0,0312
0,0442
0,063
0,090
0,125
0,180
0,250
0,355
0,500
0,710
1,00
1,40
2,00
2,80
4,00
8,0
16,0
Size (mm)
GEUS

Grain Size Distribution

Geotechnical

Sample Id: 30
Lab. Id: 060386
Submitter: Bio/consult
Subject: Horns_Rev2 12/12/2005
Date: Februar 2006
Executed: I. Nørgaard
Remarks: Sample < 2 mm. Too small amount of material < 0,063mm for sedigrafanalysis. Sample Flocculate

GEUS

Total Weight 109,51 g

Size Fractions

		Size	Size	Weight	Weight	Cumulated amount passing
		mm	Φ	g	%	%
Sieve Analysis	Gravel	16,00	-4,00	0,00	0,00	100,00
Sieve Analysis	Gravel	8,00	-3,00	0,00	0,00	100,00
Sieve Analysis	Gravel	4,00	-2,00	0,52	0,47	99,53
Sieve Analysis	Gravel	2,80	-1,49	0,00	0,00	99,53
Sieve Analysis	Gravel	2,00	-1,00	0,08	0,07	99,45
Sieve Analysis	Sand	1,40	-0,49	0,30	0,27	99,18
Sieve Analysis	Sand	1,00	0,00	1,40	1,28	97,90
Sieve Analysis	Sand	0,710	0,49	15,76	14,39	83,51
Sieve Analysis	Sand	0,500	1,00	36,35	33,19	50,32
Sieve Analysis	Sand	0,355	1,49	38,83	35,46	14,86
Sieve Analysis	Sand	0,250	2,00	11,14	10,17	4,68
Sieve Analysis	Sand	0,180	2,47	3,01	2,75	1,94
Sieve Analysis	Sand	0,125	3,00	0,87	0,79	1,14
Sieve Analysis	Sand	0,090	3,47	0,51	0,47	0,68
Sieve Analysis	Sand	0,063	3,99	0,29	0,26	0,41
Sedigraph Analysis	Silt	0,0442	4,50	0,45	0,41	0,00
Sedigraph Analysis	Silt	0,0312	5,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0221	5,50	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0156	6,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0110	6,51	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0078	7,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0055	7,51	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0039	8,00	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0028	8,48	0,00	0,00	0,00
Sedigraph Analysis	Silt	0,0020	8,97	0,00	0,00	0,00
	Clay	<0,0020	>8,97	0,00	0,00	0,00

The analysis is executed according to DS/EN 933-1 extended by sieves to the ½ phi scale and test portion mass 0,1 kg

Size Classes (DGF-Bulletin 1 1988)

		Weight %
Clay	(< 0,002 mm):	0,00
Silt, fine	(0,002 mm - 0,006 mm):	0,00
Silt, medium	(0,006 mm - 0,020 mm):	0,00
Silt, coarse	(0,020 mm - 0,063 mm):	0,41
Sand, fine	(0,063 mm - 0,200 mm):	2,31
Sand, medium	(0,2 mm - 0,6 mm):	63,40
Sand, coarse	(0,6 mm - 2 mm):	33,33
Gravel	(> 2 mm):	0,55
Sum:		100,00

Moments Measures

Percentile Amount in sieve	Percentile Amount passing	d(mm)	Φ
5%	95%	0,94	0,09
16%	84%	0,72	0,47
25%	75%	0,66	0,61
40%	60%	0,56	0,83
50%	50%	0,50	1,00
75%	25%	0,40	1,33
84%	16%	0,36	1,48
90%	10%	0,30	1,71
95%	5%	0,25	1,98

Moments Statistics

Mean	0,98
Sorting	0,54
Skewness	-0,01
Kurtosis	1,07
Uniformity Coefficient	1,84

Size Classes and Percentiles are found by linear interpolation

Formulas

Mean (ϕ16%+ϕ84%+ϕ50%) / 3 (Folk and Ward 1957)

Sorting (ϕ84%-ϕ16%) / 4 + (ϕ95%-ϕ5%) / 6,6 (Folk and Ward 1957)

Kurtosis (ϕ95% - ϕ5%) / (2,44 * (ϕ75% - ϕ25%)) (Folk and Ward 1957)

Skewness (ϕ16%+ϕ84% - 2*ϕ50%) / (2*(ϕ84%-ϕ16%)) + (ϕ5%+ϕ95% - 2*ϕ50%) / (2*(ϕ95%-ϕ5%)) (Folk and Ward 1957)

Uniformity Coefficient (d60% / d10%) (dgf-Bulletin 1988)

Mean, sorting, skewness and kurtosis are based on "Amount in sieve". Uniformity coefficient is based on "Amount passing".

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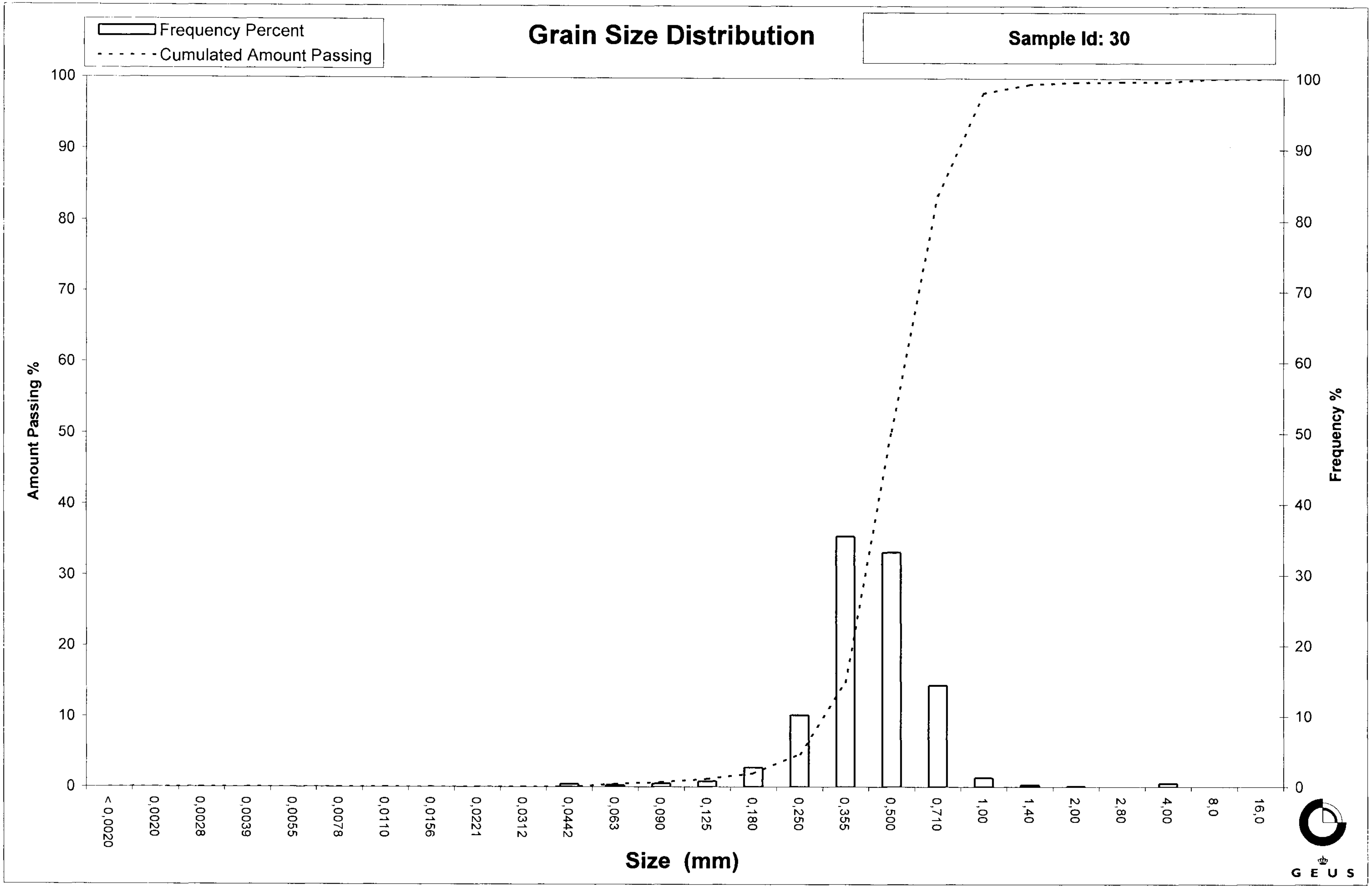


Frequency Percent
Cumulated Amount Passing
Grain Size Distribution
Sample Id: 30
Amount Passing %
Frequency %
100
90
80
70
60
50
40
30
20
10
0
< 0,0020
0,0020
0,0028
0,0039
0,0055
0,0078
0,0110
0,0156
0,0221
0,0312
0,0442
0,063
0,090
0,125
0,180
0,250
0,355
0,500
0,710
1,00
1,40
2,00
2,80
4,00
8,0
16,0
Size (mm)
GEUS

16. Appendix C: Dansurvey multibeam documentation

16.1 Appendix C1: Patch test

16.2 Appendix C2: Fixpoint

16.3 Appendix C3: Position check Esbjerg

16.4 Appendix C4: Hans M, online setup Horns Rev

16.5 Appendix C5: Hans M, bathymetric setup Horns Rev

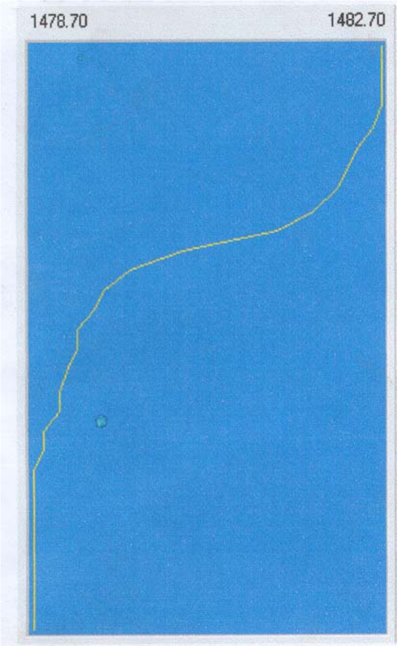
PATCH TEST

Calibration of EM 3002D system for

GEUS

02. May 2006

Sound Velocity Profile used: 02052006_1715
Pos 55 22 38.4 N 008 13 56.7 E
0.5 – 15.4 metres

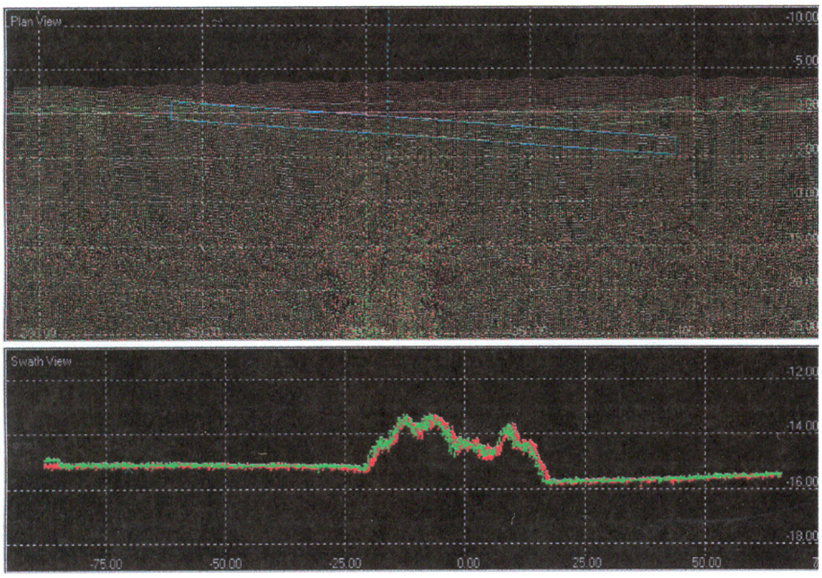


0.5 – 15.4 metres

Calibration of EM3002D Port Head

Latency Check:

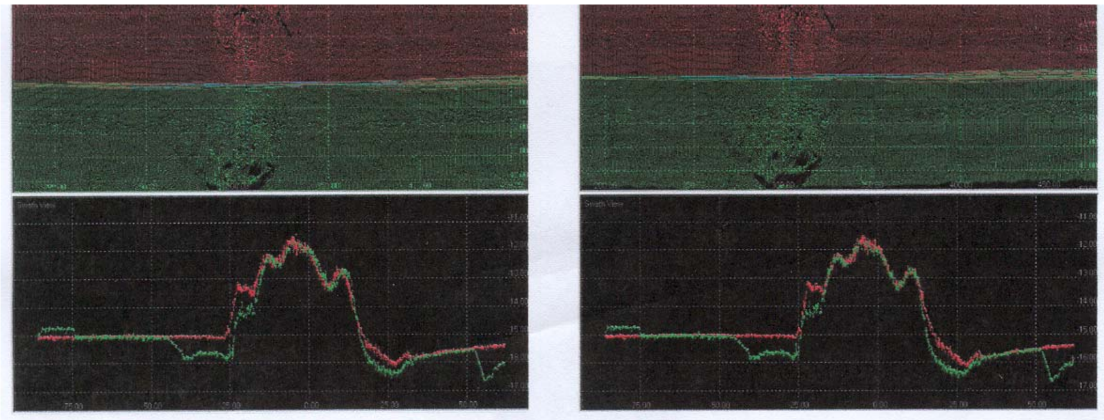
Latency Line **0004 – Centre Wreck (-40) PORT 4.3 knot**
0005 – Centre Wreck (-40) PORT 8 knot



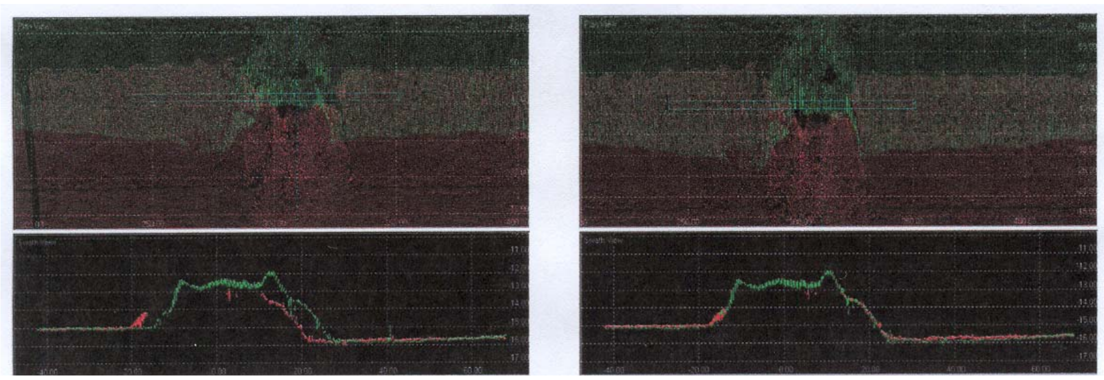
By measuring the variation between the "fast" and "slow" line the latency appeared to be negligible. The PPS time tagging of data strings are fully operational on data from PORT sonar head.

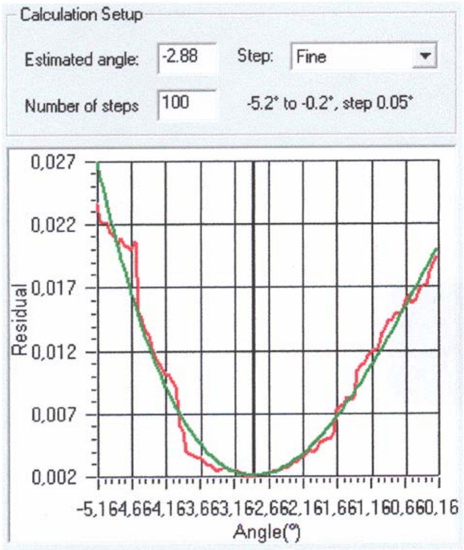
Roll Lines **0002 – Centre Wreck PORT**
0003 – Centre Wreck (40) PORT Roll = -0.12°

Pitch Lines **0009 – Centre Wreck (25) PORT**
0012 – Centre Wreck (25) PORT Pitch = -3.26°



Yaw Lines **0003 – Centre Wreck (40) PORT**
0006 – Centre Wreck (40) PORT Yaw = -2.88°

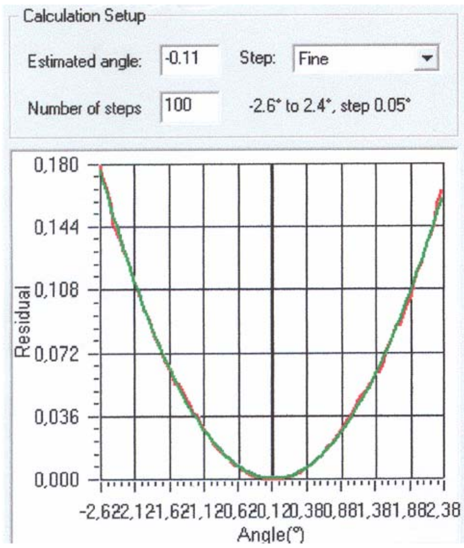




1. iteration (using values from 1. calculation):

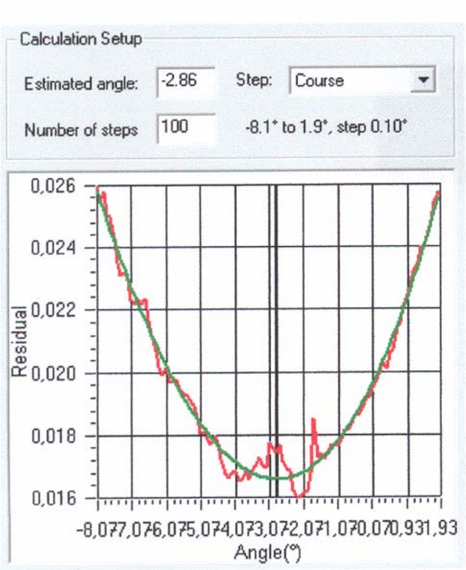
Roll Lines **0002 – Centre Wreck PORT**
0003 – Centre Wreck (40) PORT

Pitch = -3.26° Yaw = -2.88°
New Roll = -0.11



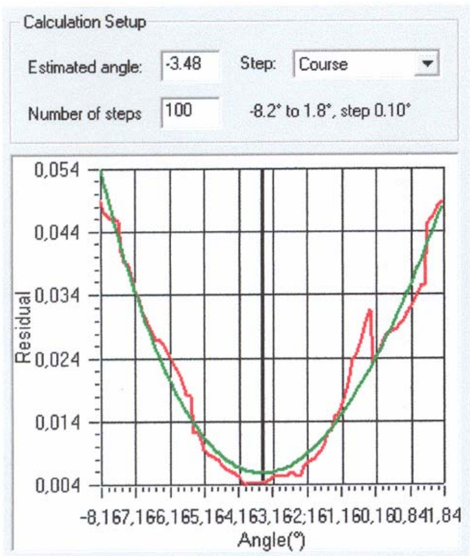
Pitch Lines 0009 – Centre Wreck (25) PORT
0012 – Centre Wreck (25) PORT

Roll - -0.11° Yaw = -2.88°
New Pitch = -2.86°



Yaw Lines 0003 – Centre Wreck (40) PORT
0006 – Centre Wreck (40) PORT Yaw = -2.88°

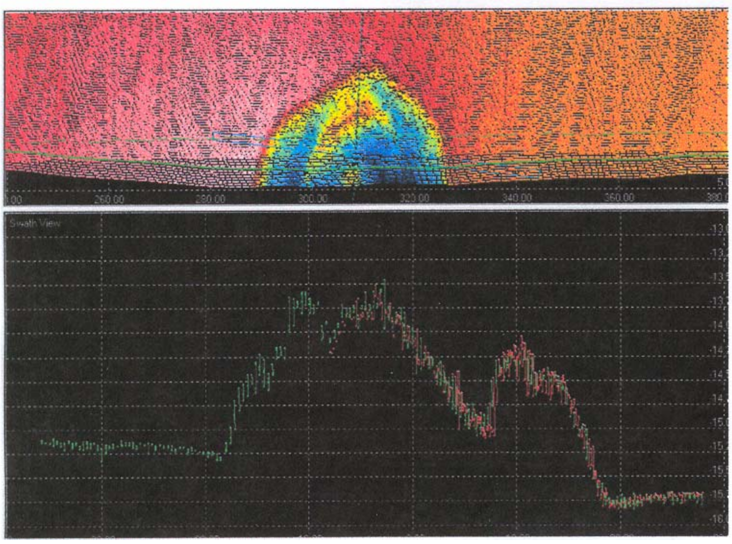
Roll = -0.11° Pitch = -2.86°
New Yaw = -3.42°



Final result PORT Head: Roll = -0.11° Pitch = -2.86° Yaw = -3.48°

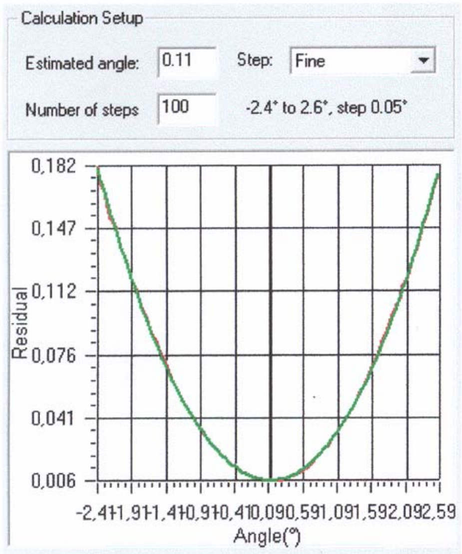
Latency Check:

Latency Line **0004 – Centre Wreck (-40) STBD 4.3 knot**
0005 – Centre Wreck (-40) STBD 8 knot

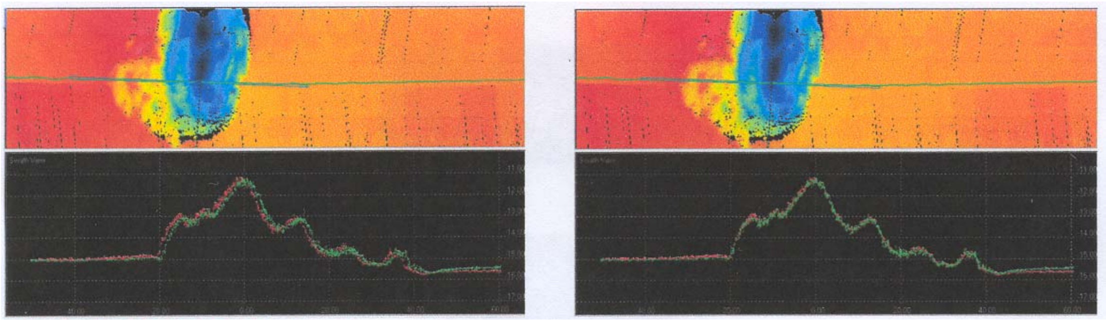


By measuring the variation between the "fast" and "slow" line the latency appeared to be negligible. The PPS time tagging of data strings are fully operational on data from STBD sonar head.

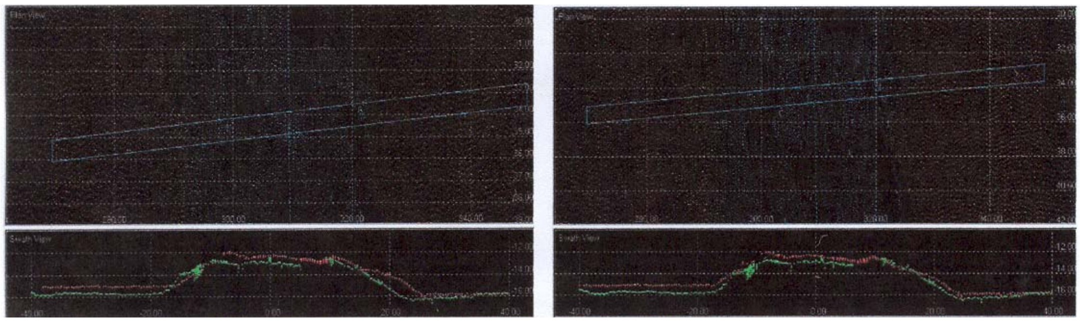
Roll Lines **0002 – Centre Wreck STBD**
0011 – Centre Wreck (-40) STBD Roll = 0.11°



Pitch Lines **0003 – Centre Wreck (40) STBD**
0008 – Centre Wreck (40) STBD Pitch = -2.88°

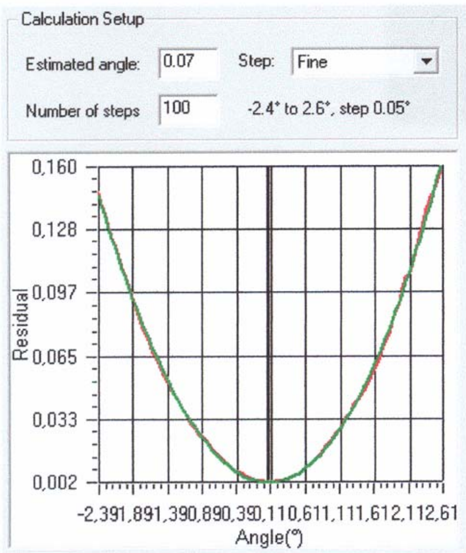


Yaw Lines **0011 – Centre Wreck (-40) STBD**
0012 – Centre Wreck (25) STBD Yaw = -3.00°



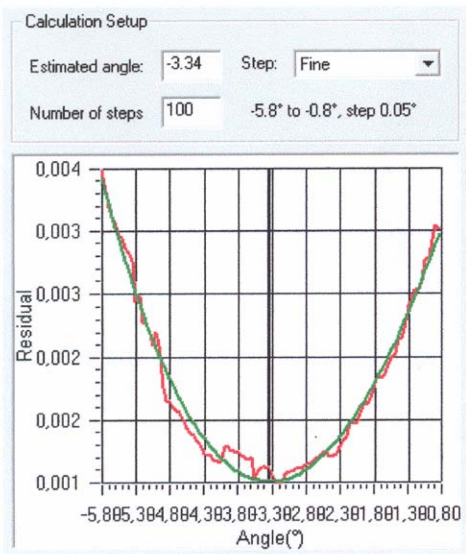
1. iteration (using values from 1. calculation):

Roll Lines **0002 – Centre Wreck STBD**
0011 – Centre Wreck (-40) STBD Roll = 0.11°



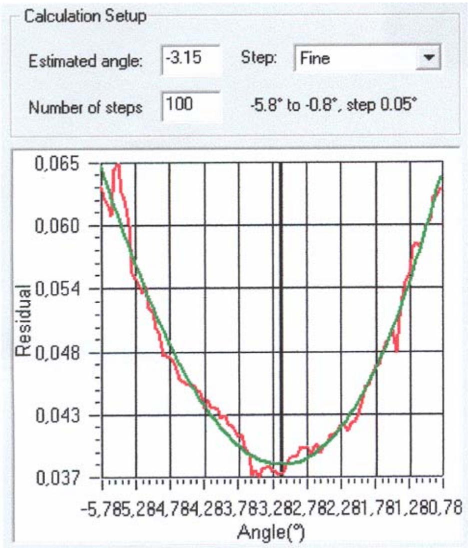
Pitch Lines **0003 – Centre Wreck (40) STBD**
0008 – Centre Wreck (40) STBD Pitch = -2.88°

Roll = 0.07° Yaw = -3.00°
New Pitch = -3.34°



Yaw Lines **0011 – Centre Wreck (-40) STBD**
0012 – Centre Wreck (25) STBD Yaw = -3.00°

Roll = 0.07° Pitch = -3.34°
New Yaw = -3.15°



Result of Patch test of GEUS EM3002D multibeam system on board Hans-M on Tuesday the 2nd of May 2006.

Final result STBD Head: **Roll = -0.07° Pitch = -3.34° Yaw = - 3.15°**
Final result PORT Head: **Roll = -0.11° Pitch = -2.86° Yaw = -3.48°**

Kort & Matrikelstyrelsen

Rentemestervej 8, København NV
Tlf. 35 87 50 50 - Fax 35 87 50 55

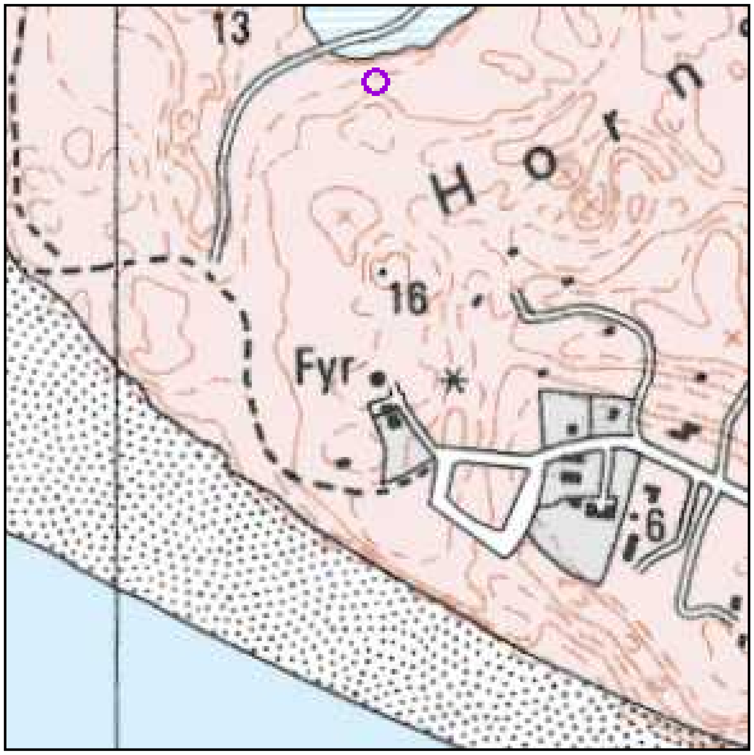
Fikspunktsbeskrivelse

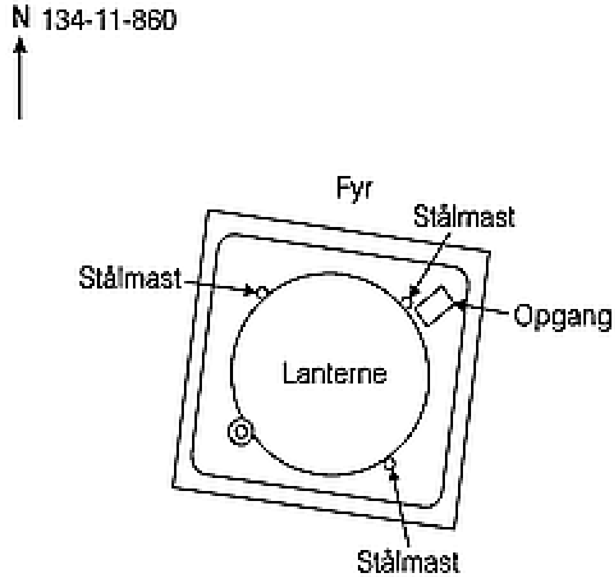
For	134-11-00860
Udskrevet	2006 04 24, 14.10

Permanent GPS station.
Punkt i top af Blåvandshuk Fyr.
Udfærdiget 2003

Koordinater

System	geoEeuref89
N	55 33 28.12874 sx
E	8 04 59.64456 sx
Ellipsoidehøjde	99.968 m
Beregnet	2002 03 20, 16.32


13
H o r n
16
Fyr
6


N 134-11-860
Fyr
Stålmast
Stålmast
Opgang
Lanterne
Stålmast

Position check carried out on the 2nd of May 2006

System description:
DC202 from AD Navigation
Technical specifications
Tracking:
20 Channel Dual Constellation (DC) GPS/GLONASS L1/L2
Cold start: < 60 seconds
Warm start: < 10 seconds
Reacquistion: < 1 second
Processing: Co-op Tracking and Advanced Multipath Reduction
DC200 Series RTK Positioning1 and Heading Accuracies2:
Horizontal: 1 cm + 0.15 ppm RMS (DC201/202)
Vertical: 1.5 cm + 0.15 ppm RMS (DC201/202)
Heading: 0.01 degrees RMS (DC202 only)
Update Rate:
Positioning: 5Hz (DC201/202) 20Hz Optional
Heading: 10Hz (DC202 Only) 20Hz Optional
RTK Initialisation1: Typically 10-30 seconds
Operating Range3: Up to 80 km
Built-in UHF Radio Modem:
Frequency Range: 380-470 MHz
25 Khz Channel Separation
19,200 bps on Air Transmission
Diversity Reception (Dual Antenna System)
Timing:
External PPS Output
PPS to TTL converted to RS232 Interrupt Signal
Output formats:
GPS based NMEA-0183 Messages
Proprietary ASCII and Binary Output Formats
CMR/RTCM, Differential Corrections
Input Formats:
CMR/RTCM, Differential Corrections

RTK base station setup position in official KMS point 134-11-00860 (use of KMS GPS receiver antenna) in Blaavandshuk lighthouse.

Referencestation setup position geoEuref89:

55 33 28.12874 sx 8 04 59.64456 sx 99.968 m

Scansurvey ApS - Baldershøj 26A - DK 2635 Ishøj Denmark
Phone + 45 43 77 43 01 Fax +45 43 77 43 02

Controlpoints 1000 and 1001 established by "Landinspektørerne Syd I/S" the 25th of April 2006 on Pier in fishery harbour in Esbjerg.

KmsTrans Thursday, April 27, 2006 15:34

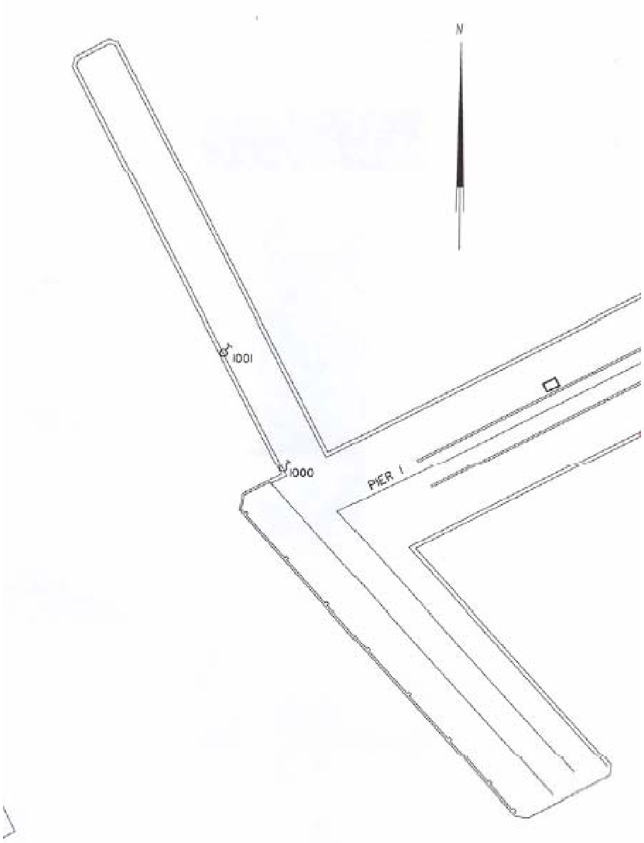
Transformation from s34j_h_dvr90 to utm32Eeuref89

1001

Input :	333441.94 m	117499.39 m	3.370 m
Output:	6 147 609.58 m	463 531.31 m	44.148 m

GPS Antenna height: 1.035 m

GPS Antenna ellipsoidal height (44.148 + 1.035) 45.183 m

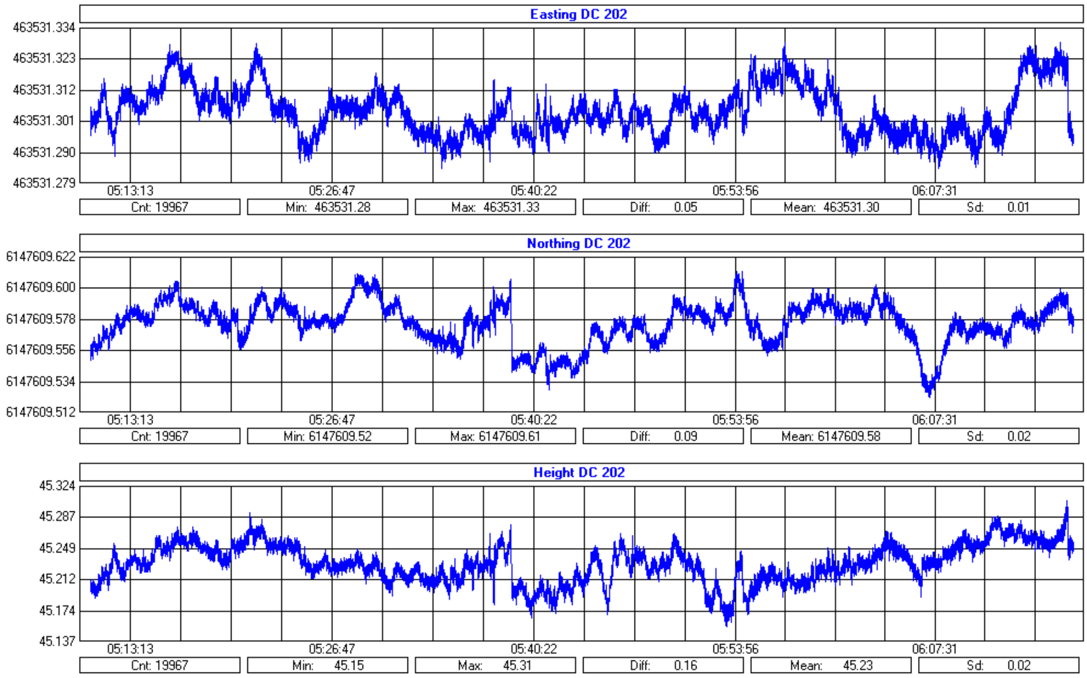


Scansurvey ApS - Baldershøj 26A - DK 2635 Ishøj Denmark
Phone + 45 43 77 43 01 Fax +45 43 77 43 02

Expected position 6 147 609.58 m   463 531.31 m

Expected height 44.148 m + 1.035 -   45.183 m

Measured position 6 147609.58 m 463 531.30 m (mean over 68 minuttes)
Measured height 45.23 m (mean over 68 minuttes)



SETTINGS SUMMARY

Database

C:\Data\Database\0015 - HR_001 - 0004.db

Objects

Number of objects	:	1
Object name	:	Hans M
Reference node	:	CoG
Reference node	:	CoG

Adjustments

Number of adjustments	:	1			
Adjustment name	:	DC 202	Adjustment type	:	No GPS | No DCS
Connected objects	:	1	System observations	:	4
Connected nodes	:	5	Offset observations	:	12

OBSERVATION FILTER SETTINGS

Count	System | Observation Observation Output	Status Obs. SD	Type Model SD	Obs.Age Spike Time	Skewing Parameter
1	DC 202	Input			
1	Latitude DC 202	Inactive	None	10.00	0.00
2	Longitude DC 202	Inactive	None	10.00	0.00
3	Height DC 202	Inactive	None	10.00	0.00
4	Height Node DC Main antenna	Inactive	None	10.00	0.00
2	MRU5	Input			
5	Pitch MRU5	Inactive	None	10.00	0.00
6	Roll MRU5	Inactive	None	10.00	0.00
7	Heave MRU5	Inactive	None	10.00	0.00
3	DC heading	Input			
8	DC heading	Inactive	None	10.00	0.00
4	SEAPATH 20 GYRO	Input			
9	SEAPATH 20 GYRO	Inactive	None	10.00	0.00
5	AML SV	Input			
10	Sound Velocity	Inactive	None	10.00	0.00

ECHOSOUNDER SETTINGS

Echosounder system	: EM3002D_PORT		
Adjustment name	: DC 202		
DTM storage	: Enabled	Layer *.pro file	: EM3002Port
DTM type	: Absolute depths	Delta height obs	: Heave MRU5
Heave blocking	: Disabled		
Depth blocking	: Disabled		
Range blocking	: Disabled		
Sector blocking	: Enabled	Minimum angle	: -75.000 m
		Maximum angle	: 75.000 m
Excluded beams	: 8-104,110-115		
Despike swath data	: Cross validation	Bottom type	: Normal
		Despike direction	: Both Directions
Reduce swath data	: Disabled		
Brightness test	: Disabled		
Colinearity test	: Disabled		
Refraction	: Use defined profile to correct for refraction		

ECHOSOUNDER SETTINGS

Echosounder system	: EM3002D_STBD		
Adjustment name	: DC 202		
DTM storage	: Enabled	Layer *.pro file	: EM3002STBD
DTM type	: Absolute depths	Delta height obs	: Heave MRU5
Heave blocking	: Disabled		
Depth blocking	: Disabled		
Range blocking	: Disabled		
Sector blocking	: Enabled	Minimum angle	: -75.000 m
		Maximum angle	: 75.000 m
Excluded beams			
Despike swath data	: Cross validation	Bottom type	: Normal
		Despike direction	: Both Directions
Reduce swath data	: Disabled		
Brightness test	: Disabled		
Colinearity test	: Disabled		
Refraction	: Use defined profile to correct for refraction		

SURVEY DEFINITIONS

General Definitions

Line sequence number	:	15
Line description	:	
UTC to GPS time correction	:	14.00 s
Survey Unit Name	:	Meters
Conversion factor to meters	:	1.00000000

Geodetic Definitions

Magnetic Variation Information

Undefined

Datum Definitions

Survey Datum	:	WGS84
Spheroid name	:	WGS 1984
Semi-major axis (a)	:	6378137.000 m
Semi-minor axis (b)	:	6356752.314 m
Conversion factor to meters	:	1.000000
Inverse flattening (1/f)	:	298.25722356
First eccentricity (e**2)	:	0.00669438
Second eccentricity (e'**2)	:	0.00673950

Datum Shift Definitions

Undefined

Height Datum Definition

Vertical datum	:	EGG97 (North Sea)
Height file	:	EGG-NSEA.BIN
Height level	:	No Level Correction
Height file	:	N/A
Height offset	:	0.000 m
MSL model	:	Manual Offset
MSL file	:	N/A
MSL level	:	No Level Correction
MSL file	:	N/A
MSL offset	:	37.950 m
MSL st.dev.	:	0.141 m
DTM mode	:	Absolute DTM's
DTM datum	:	EGG97 (North Sea)
DTM file	:	EGG-NSEA.BIN
DTM level	:	No Level Correction
DTM file	:	N/A
DTM offset	:	0.000 m

Projection Definition

Projection name	:	Universal Transverse Mercator (North Oriented)
Conversion factor to meters	:	1.000000
UTM zone number	:	32
Latitude of grid origin	:	0;00;00.000 N
Longitude of grid origin	:	9;00;00.000 E
Grid Easting at grid origin	:	500000.000 E
Grid Northing at grid origin	:	0.000 N
Scale factor at longitude of origin	:	0.999600

Offset Convention

Offset mode	:	Rectangular
Offset distances units	:	Meters
Offset angles units	:	Degrees

OBJECT DEFINITIONS

General Summary Information

Number of survey vessels or objects	:	1
Number of relay vessels or buoys	:	0
Number of external network nodes	:	0
Number of datums/spheroids defined	:	1

Vessel Definitions

Hans M

Streamers	:	0	Gun arrays	:	0
Buoys	:	0	Echosounders	:	0
Satellite receivers	:	0	USBL systems	:	0
Network nodes	:	5	Pitch/Roll/Heave sensors		

Correction to GMT	:	0.00 h
Correction to master vessel's time	:	0.000000 s
Height above draft reference	:	0.000 m

CoG

SHAPE	Point	X	Y	Z	Pen	Fill	Style
	1	-3.5	17.0	0.0	Up	On	Solid
	2	-5.7	14.5	0.0	Down	On	Solid
	3	-6.3	13.0	0.0	Down	On	Solid
	4	-7.0	11.0	0.0	Down	On	Solid
	5	-7.0	0.0	0.0	Down	On	Solid
	6	-6.3	-14.5	0.0	Down	On	Solid
	7	-0.6	-14.5	0.0	Down	On	Solid
	8	0.0	0.0	0.0	Down	On	Solid
	9	0.0	11.0	0.0	Down	On	Solid
	10	-0.7	13.0	0.0	Down	On	Solid
	11	-1.3	14.5	0.0	Down	On	Solid

Gun Array Definitions

NETWORK DEFINITIONS

Fixed Node Definitions

Variable Node Definitions

CoG

Object location	:	Hans M
X (Stbd = Positive):	:	0.000 m
Y (Bow = Positive):	:	0.000 m
Z (Up = Positive):	:	0.000 m

DC Main antenna

Object location	:	Hans M
X (Stbd = Positive):	:	0.000 m
Y (Bow = Positive):	:	0.210 m
Z (Up = Positive):	:	8.232 m

1000

Object location	:	Hans M
X (Stbd = Positive):	:	0.000 m
Y (Bow = Positive):	:	0.000 m
Z (Up = Positive):	:	-1.087 m

STBD EM3002 HEAD

Object location	:	Hans M
X (Stbd = Positive):	:	0.224 m
Y (Bow = Positive):	:	0.265 m
Z (Up = Positive):	:	-0.211 m

PORT EM3002 HEAD

Object location	:	Hans M
X (Stbd = Positive):	:	-0.190 m
Y (Bow = Positive):	:	0.251 m
Z (Up = Positive):	:	-0.232 m

Observation Definitions

DC heading	:	Bearing (True)
"At" node	:	CoG
"To" node 1	:	
Measurement unit code	:	Degrees
Positioning system description	:	DC heading
Propagation speed	:	0.0000000000 m/s
Lanewidth on baseline	:	0.0000000000 m/s
Scale factor	:	1.0000000000
Fixed system (C-O)	:	4.32000000 °
Variable (C-O)	:	0.000000 °
A priori SD	:	0.50 °
Quality indicator	:	No quality info recorded

SEAPATH 20 GYRO	:	Bearing (True)
"At" node	:	CoG
"To" node 1	:	
Measurement unit code	:	Degrees
Positioning system description	:	SEAPATH 20 GYRO
Propagation speed	:	0.0000000000 m/s
Lanewidth on baseline	:	0.0000000000 m/s
Scale factor	:	1.0000000000
Fixed system (C-O)	:	2.00000000 °
Variable (C-O)	:	0.000000 °
A priori SD	:	0.50 °
Quality indicator	:	No quality info recorded

Observation Definitions (continued)

Sound Velocity	:	Sound Velocity
"At" node	:	STBD EM3002 HEAD
Measurement unit code	:	Meters / Second
Positioning system description	:	AML SV
Propagation speed	:	0.0000000000 m/s
Lanewidth on baseline	:	0.0000000000 m/s
Scale factor	:	1.0000000000
Fixed system (C-O)	:	0.00000000 m/s
Variable (C-O)	:	0.000000 m/s
A priori SD	:	0.05 m/s
Quality indicator	:	No quality info recorded

Reference Station Definitions

SYSTEM DEFINITIONS

Position Navigation System

DC 202

Interfacing

Type	:	Position Navigation System			
Driver	:	ad Navigation DC-Series (Position)			
Port	:	7			
Baud rate	:	115200	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	0.000 s	Latency	:	0.000 s

Satellite System Definition

Position datum	:	WGS84
Satellite system name	:	WGS84

Satellite Receiver Definition

Receiver number	:	0
Receiver description	:	
Node identifier	:	DC Main antenna
Object location	:	Hans M
X (Stbd = Positive):	:	0.000 m
Y (Bow = Positive):	:	0.210 m
Z (Up = Positive):	:	8.232 m

Horizontal datum	:	WGS84
Vertical datum	:	WGS84
Height file	:	N/A
Height level	:	No Level Correction
Height file	:	N/A
Height offset	:	0.000 m

Connected Observations

Connected Nodes

Pitch, Roll and Heave Sensor

MRU5

Interfacing

Type	:	Pitch, Roll and Heave Sensor			
Driver	:	Simrad EM3000 R-P-H			
Port	:	6			
Baud rate	:	19200	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	0.000 s	Latency	:	0.000 s

System Parameters

MRU5

Object	:	Hans M
Location on object (Lever arm)	:	CoG
PRH sensor reference number	:	1
Rotation convention pitch	:	Positive bow up
Rotation convention roll	:	Positive heeling to starboard
Angular variable measured	:	HPR (roll first)
Angular measurement units	:	Degrees
Sign convention heave	:	Positive upwards
Measurement units heave	:	Meters
Quality indicator type pitch and roll	:	No quality info recorded
Quality indicator type heave	:	No quality info recorded
(C-O) pitch offset	:	0.000000
(C-O) roll offset	:	0.000000
(C-O) heave offset	:	0.000000

Description of pitch, roll and heave system
MRU5

Offset System

Offset System

Interfacing

Type	:	Offset System
Driver	:	
IP address	:	0. 0. 0. 0
Port	:	0
Update rate	:	0.000

Gyros and Compasses

DC heading

Interfacing

Type	:	Gyros and Compasses			
Driver	:	NMEA Compass ($--HDT)			
Port	:	5			
Baud rate	:	19200	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	0.000 s	Latency	:	0.000 s

Connected Observations

DC heading : Bearing (True)

Connected Nodes

CoG : Hans M

Gyros and Compasses

SEAPATH 20 GYRO

Interfacing

Type	:	Gyros and Compasses			
Driver	:	NMEA Compass ($--HDT)			
Port	:	11			
Baud rate	:	9600	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	0.000 s	Latency	:	0.000 s

Connected Observations

SEAPATH 20 GYRO : Bearing (True)

Connected Nodes

CoG : Hans M

Output System

AUTOPILOT

Interfacing

Type	:	Output System			
Driver	:	NMEA Autopilot $CCAPA (Steered Point)			
Port	:	13			
Baud rate	:	1200	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	1.000 s	Latency	:	0.000 s

PPS System

PPS Timetagging

Interfacing

Type	:	PPS System			
Driver	:	NMEA ZDA PPS (COM1)			
Port	:	18			
Baud rate	:	9600	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	0.000 s	Latency	:	0.000 s

Output System

ZDA to PU COM 3

Interfacing

Type	:	Output System			
Driver	:	NMEA GPZDA			
Port	:	15			
Baud rate	:	9600	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	1.000 s	Latency	:	0.000 s

Multibeam Echosounder

EM3002D_PORT

Interfacing

Type	:	Multibeam Echosounder
Driver	:	Simrad EM3002 XTF (R-Theta Format)
IP address	:	0. 0. 0. 0
Port	:	16101
Update rate	:	0.000

System Parameters

EM3002D_PORT

Object	:	Hans M
Number of transducers	:	Single
Transducer node 1	:	PORT EM3002 HEAD
Heading offset	:	-3.480 °
Roll offset	:	40.110 °
Pitch offset	:	-2.860 °
Maximum number of beams per ping	:	508
Unit is roll stabilized	:	No
Unit is pitch stabilized	:	No
Unit is heave compensated	:	No
Use sound velocity from unit	:	Yes

Underwater Sensor

AML SV

Interfacing

Type	:	Underwater Sensor			
Driver	:	Sound Velocity - Smart SV (AML, ASCII) (Active)			
Port	:	12			
Baud rate	:	9600	Data bits	:	8
Parity	:	None	Stop bits	:	1
Update rate	:	0.000 s	Latency	:	0.000 s

Connected Observations

Sound Velocity : Sound Velocity

Connected Nodes

STBD EM3002 HEAD : Hans M

Multibeam Echosounder

EM3002D_STBD

Interfacing

Type	:	Multibeam Echosounder
Driver	:	Simrad EM3002D Head II XTF (R-Theta Format)
IP address	:	0. 0. 0. 0
Port	:	16103
Update rate	:	0.000

System Parameters

EM3002D_STBD

Object	:	Hans M
Number of transducers	:	Single
Transducer node 1	:	STBD EM3002 HEAD
Heading offset	:	-3.150 °
Roll offset	:	-39.930 °
Pitch offset	:	-3.340 °
Maximum number of beams per ping	:	508
Unit is roll stabilized	:	No
Unit is pitch stabilized	:	No
Unit is heave compensated	:	No
Use sound velocity from unit	:	Yes

Sidescan Sonar

EM3002D SSS PORT

Interfacing

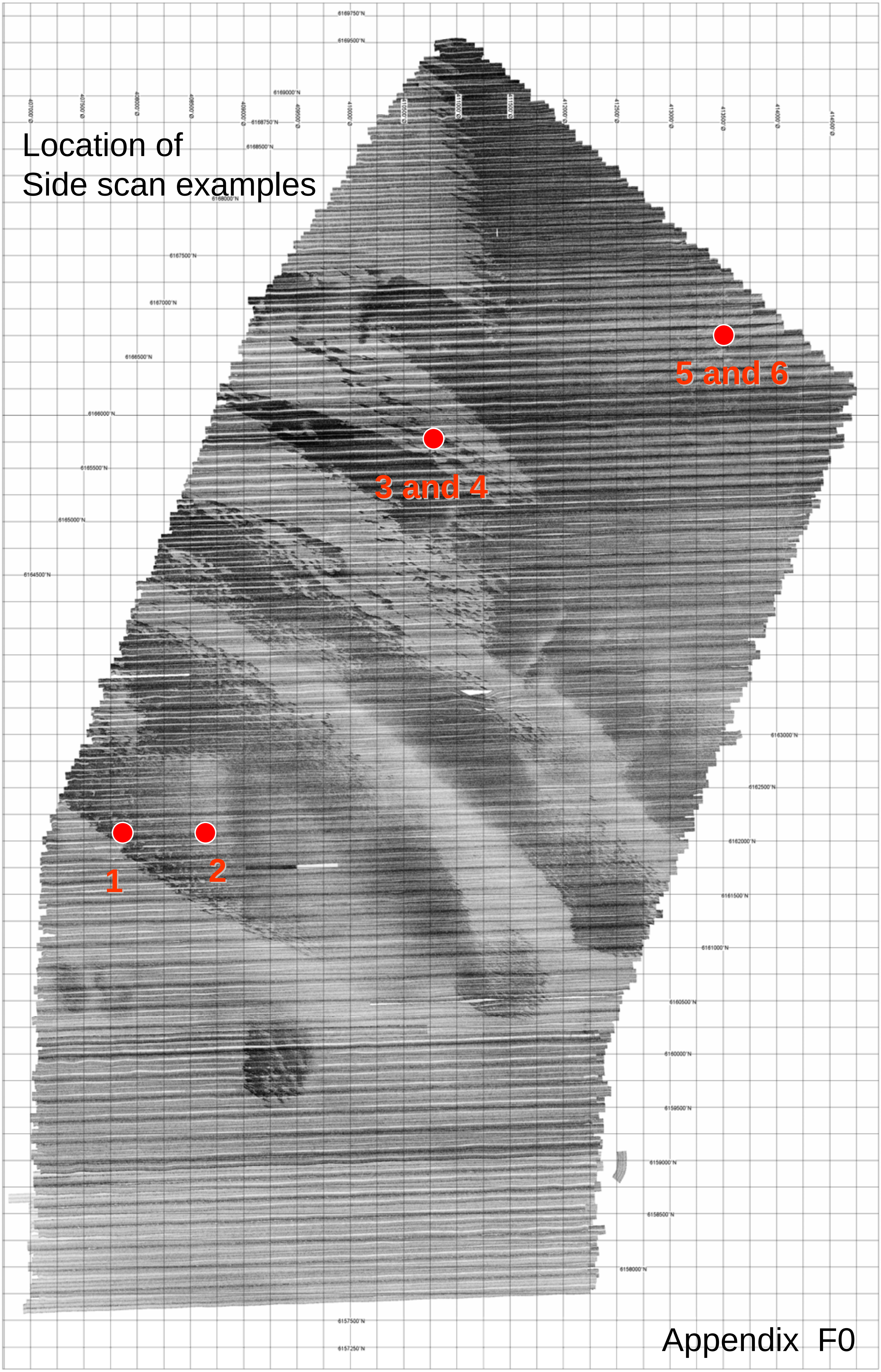
Type	:	Sidescan Sonar
Driver	:	Simrad EM3002D (Dual Head) Seabed Image
IP address	:	0. 0. 0. 0
Port	:	16102
Update rate	:	0.000

System Parameters

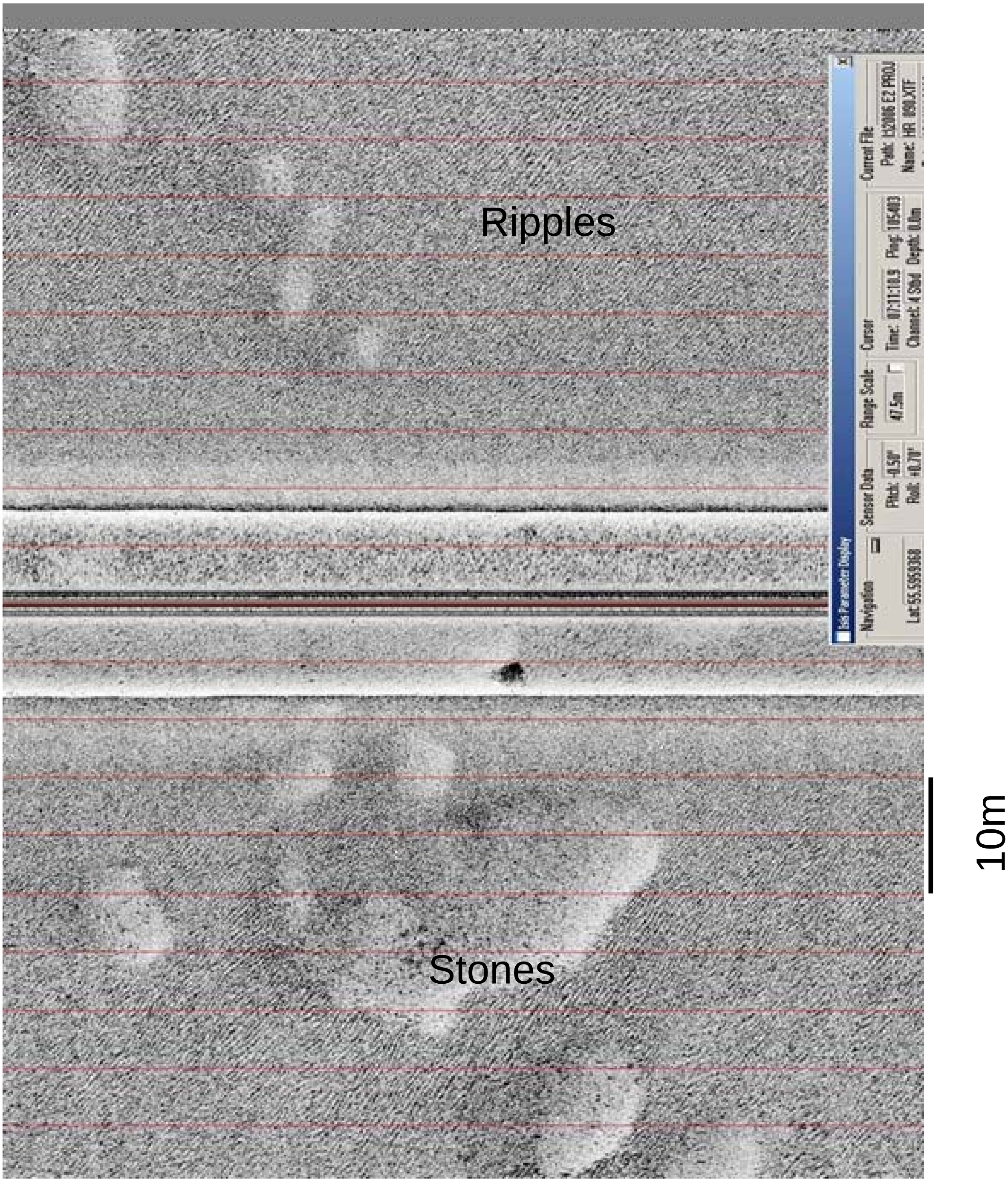
Manufacturer	:	Simrad
Model	:	Simrad EM3000
Number of beams	:	1
Number of channels	:	2
Associated multibeam system	:	EM3002D_PORT
Object location	:	Hans M

19. Appendix F: Side Scan examples

Location of
Side scan examples

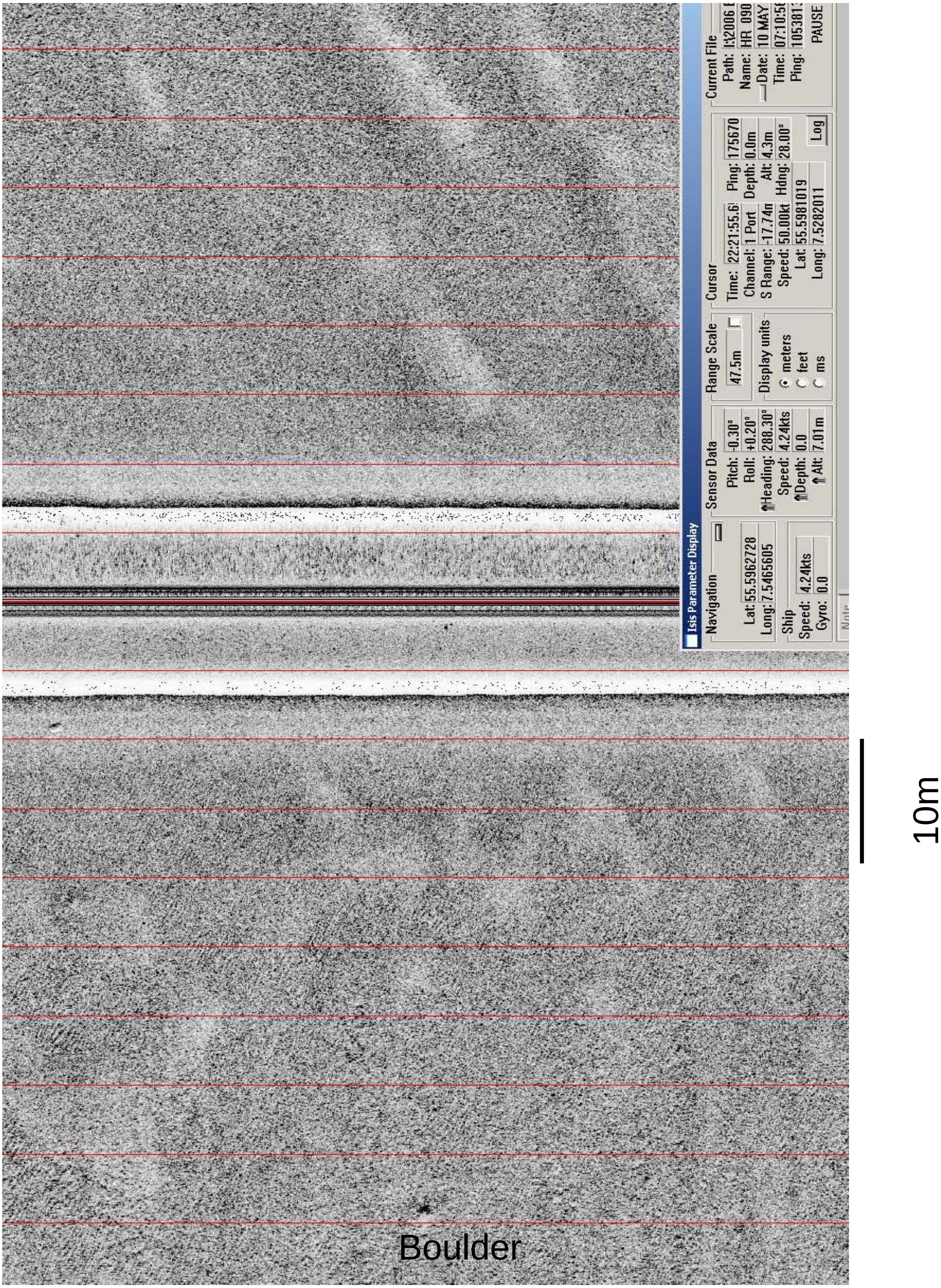


Appendix F0



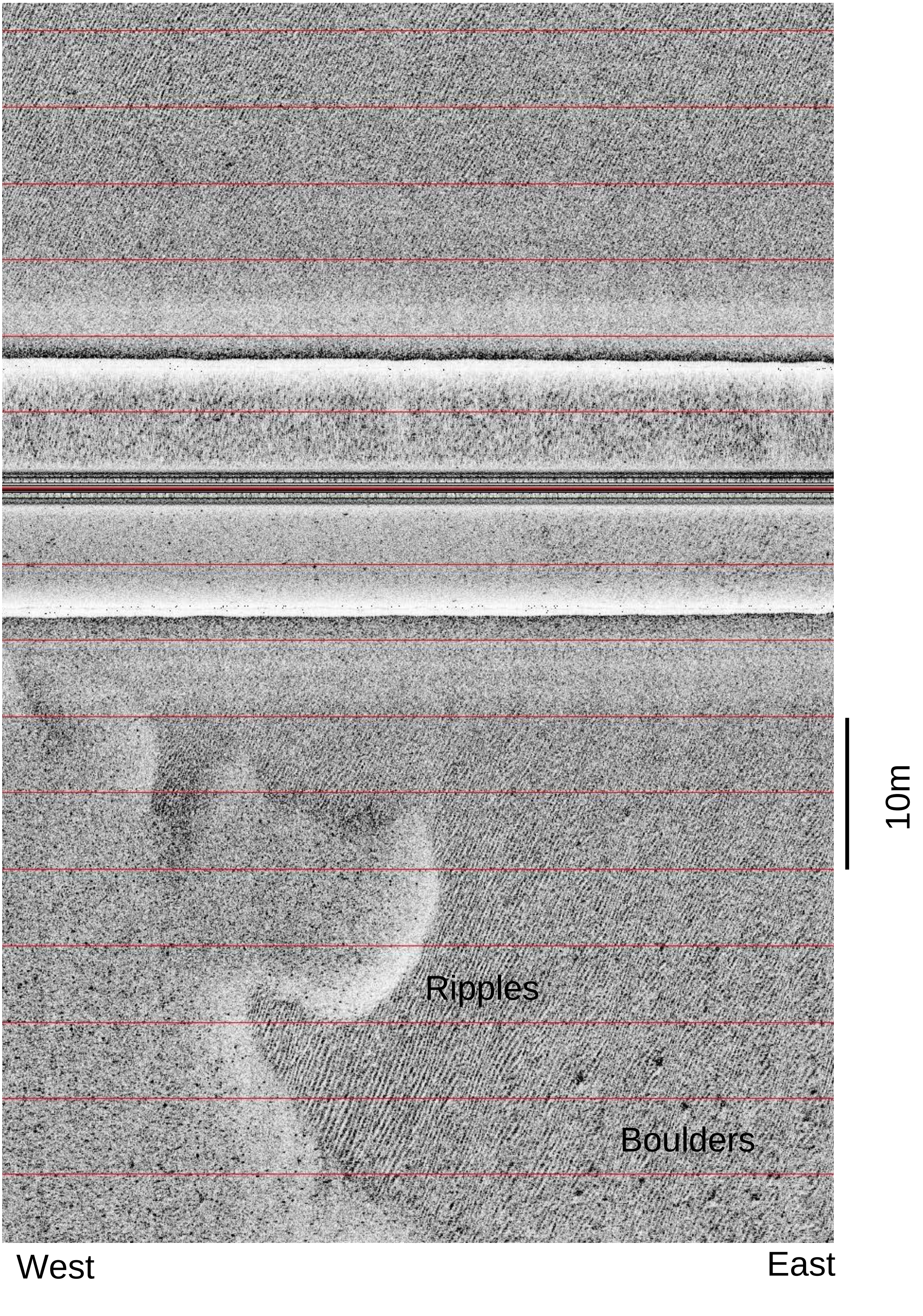
Partial thin sand ripple cover on residual till surface with Stones and Boulders on line number 90.

Appendix F1



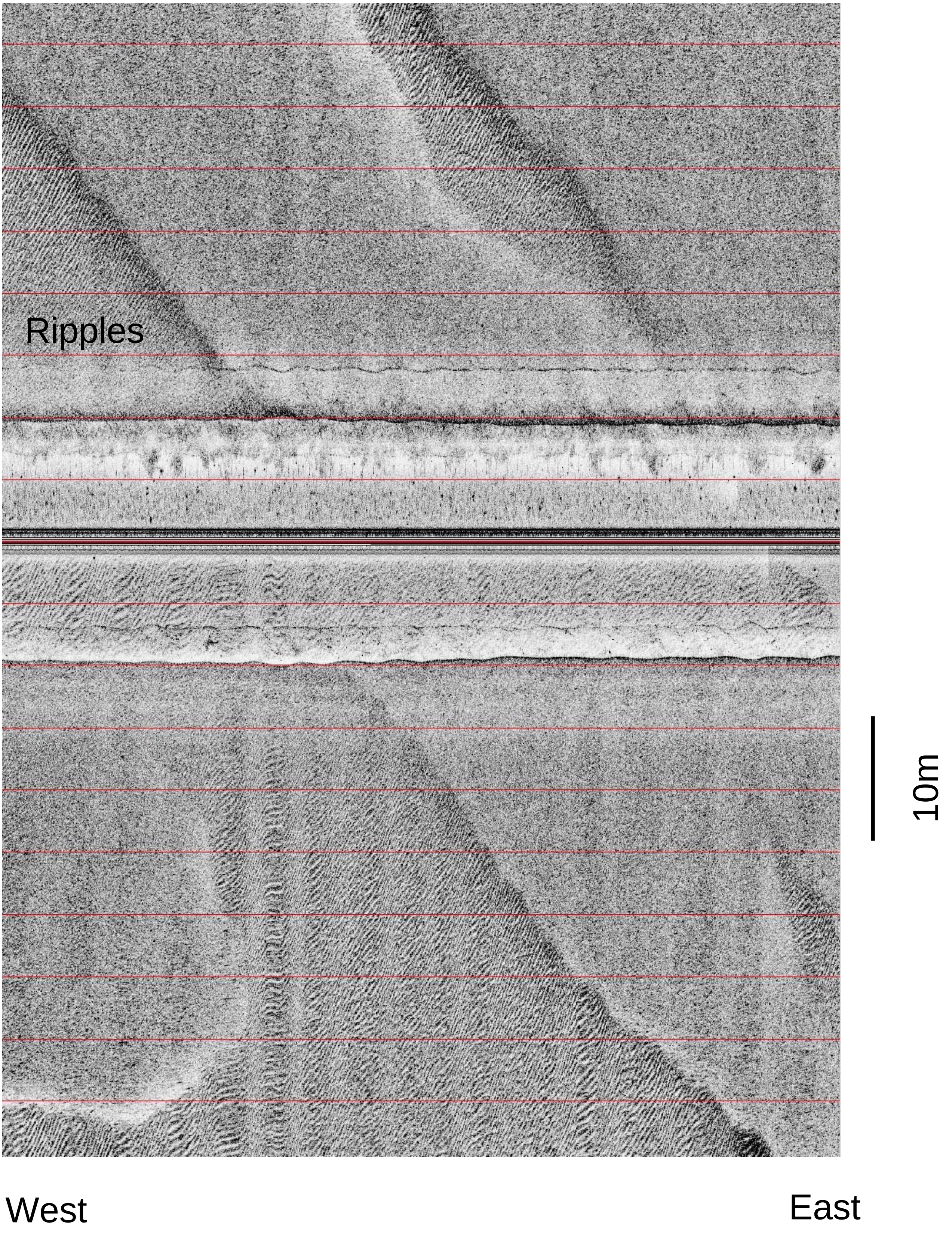
Partial thin sand ripple cover on residual till surface with Stones and Boulders
On line number 90.

Appendix F2

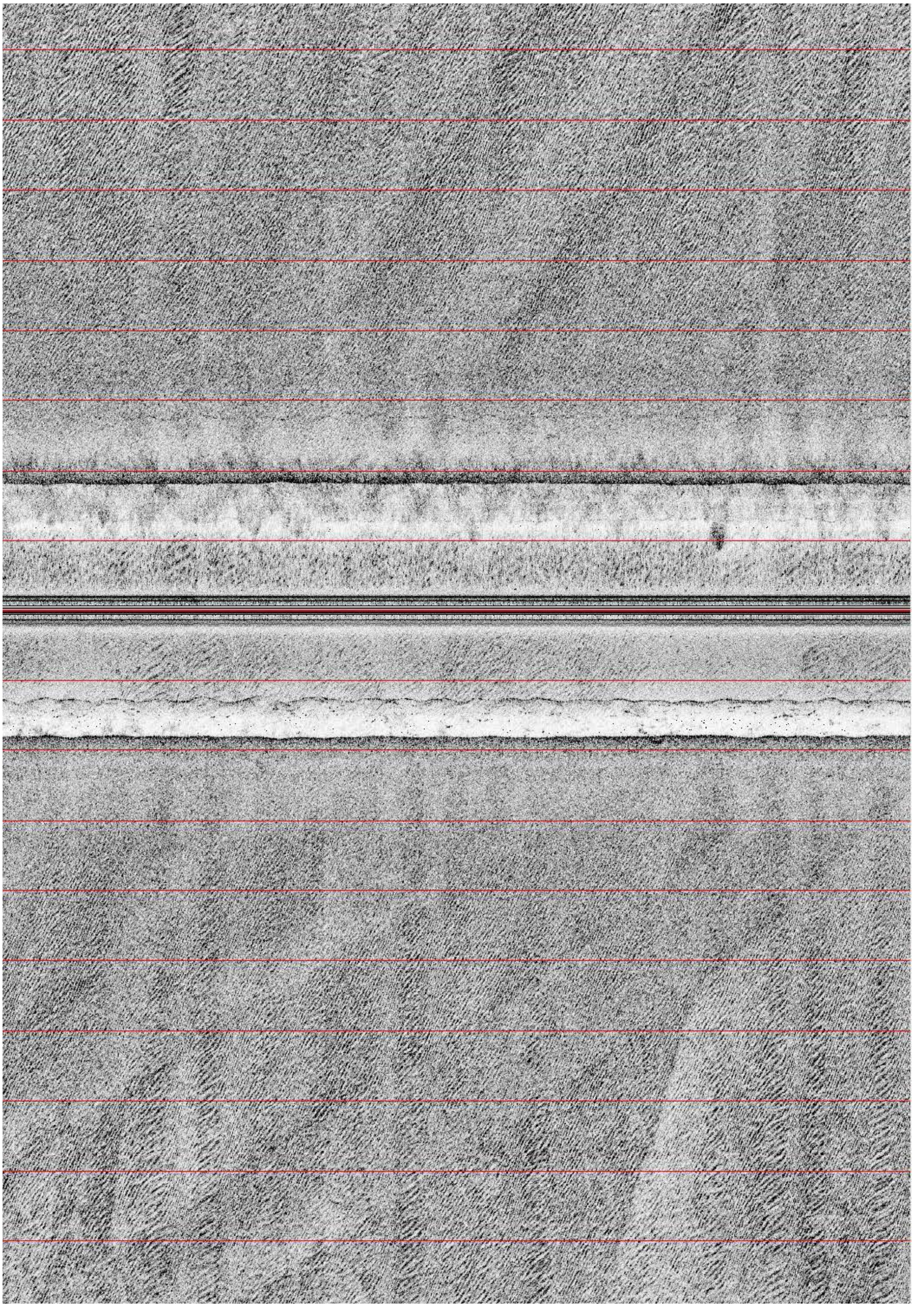


Partial thin sand ripple cover on residual till surface with Stones and Boulders on line number 160.

Appendix F3



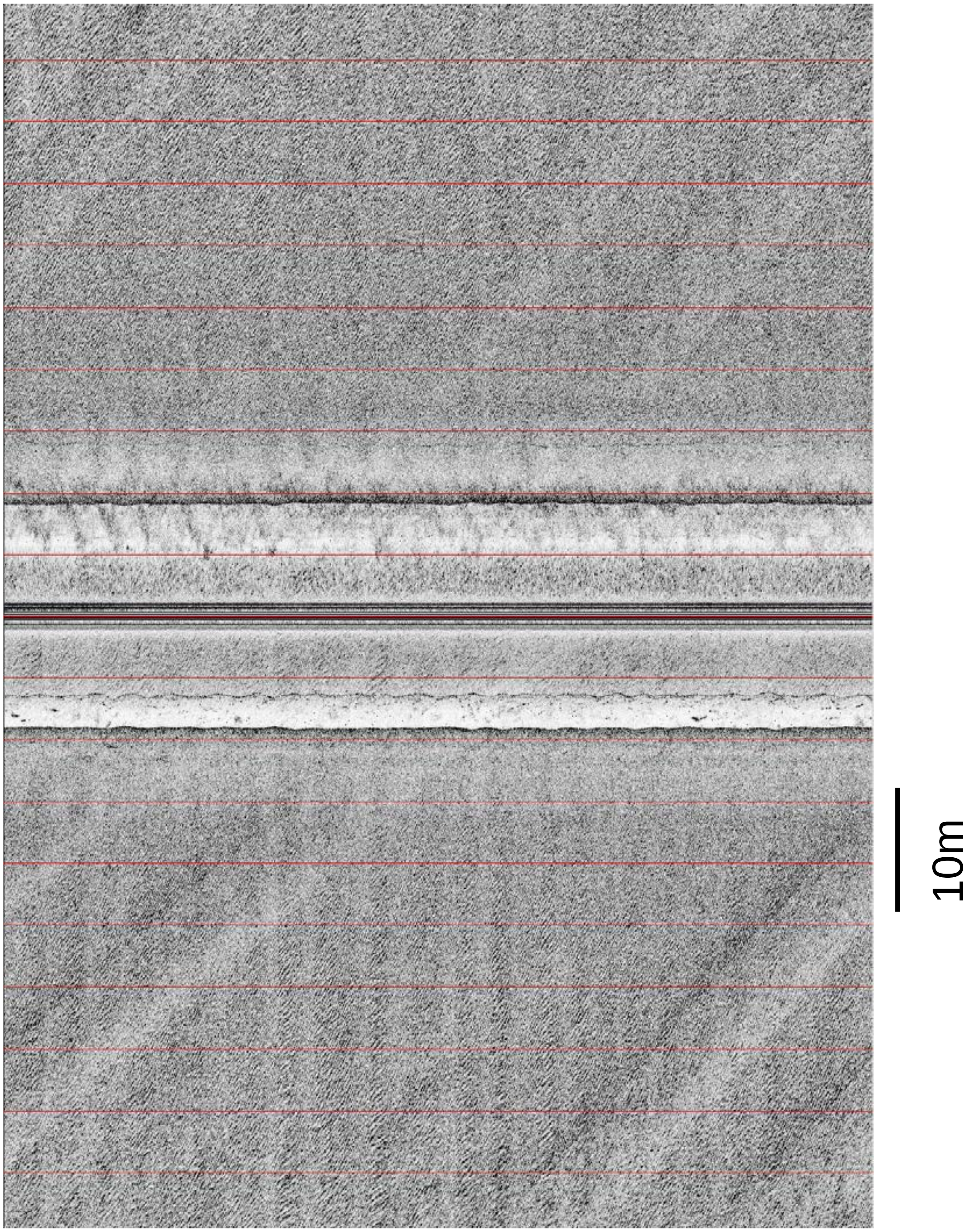
Partial thin sand ripple cover on residual till surface with Stones and Boulders on line number 160.



10m

West East

Traces of boom trawling on line 160.

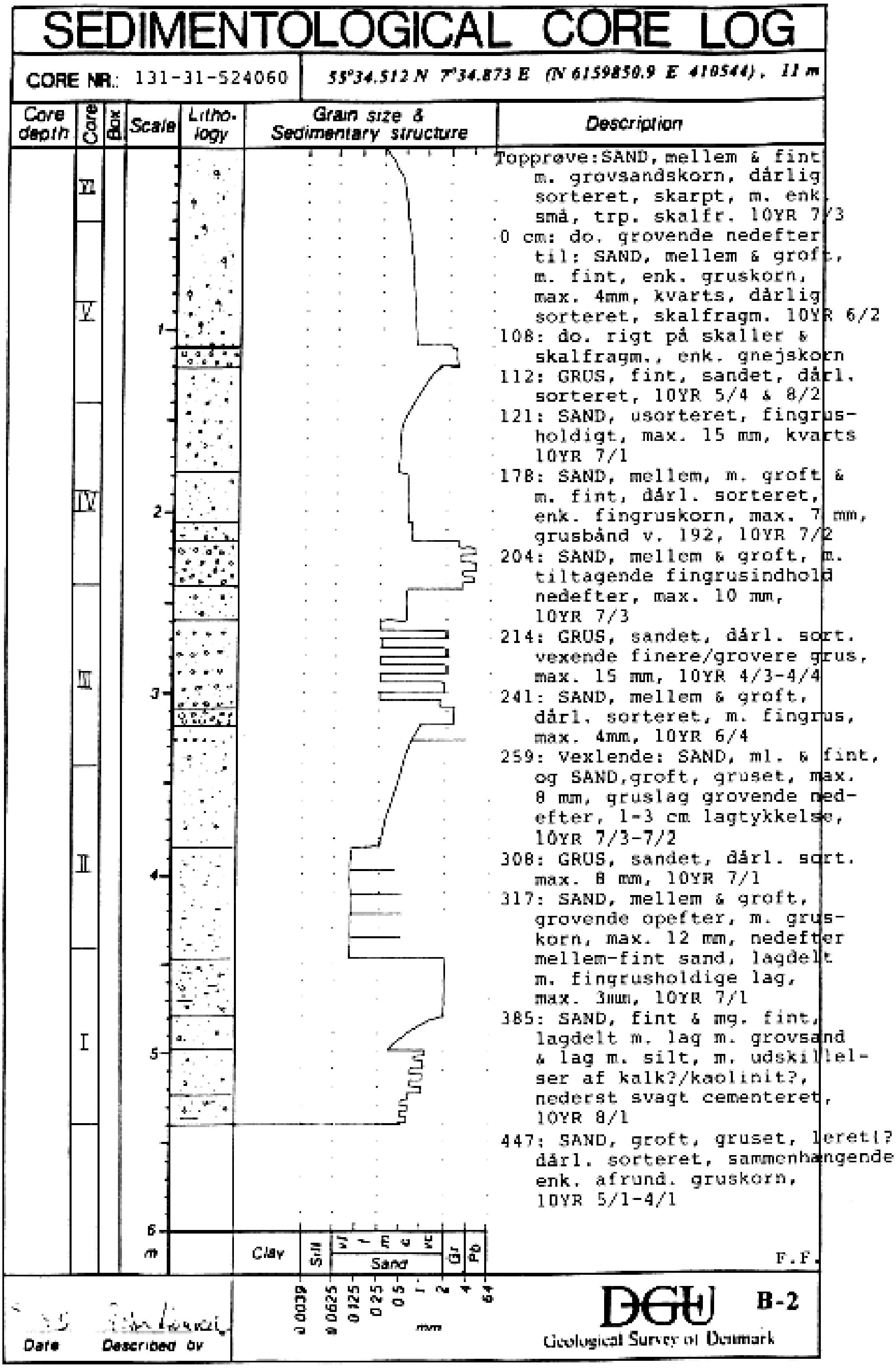


West East

Traces of boom trawling on line 160.

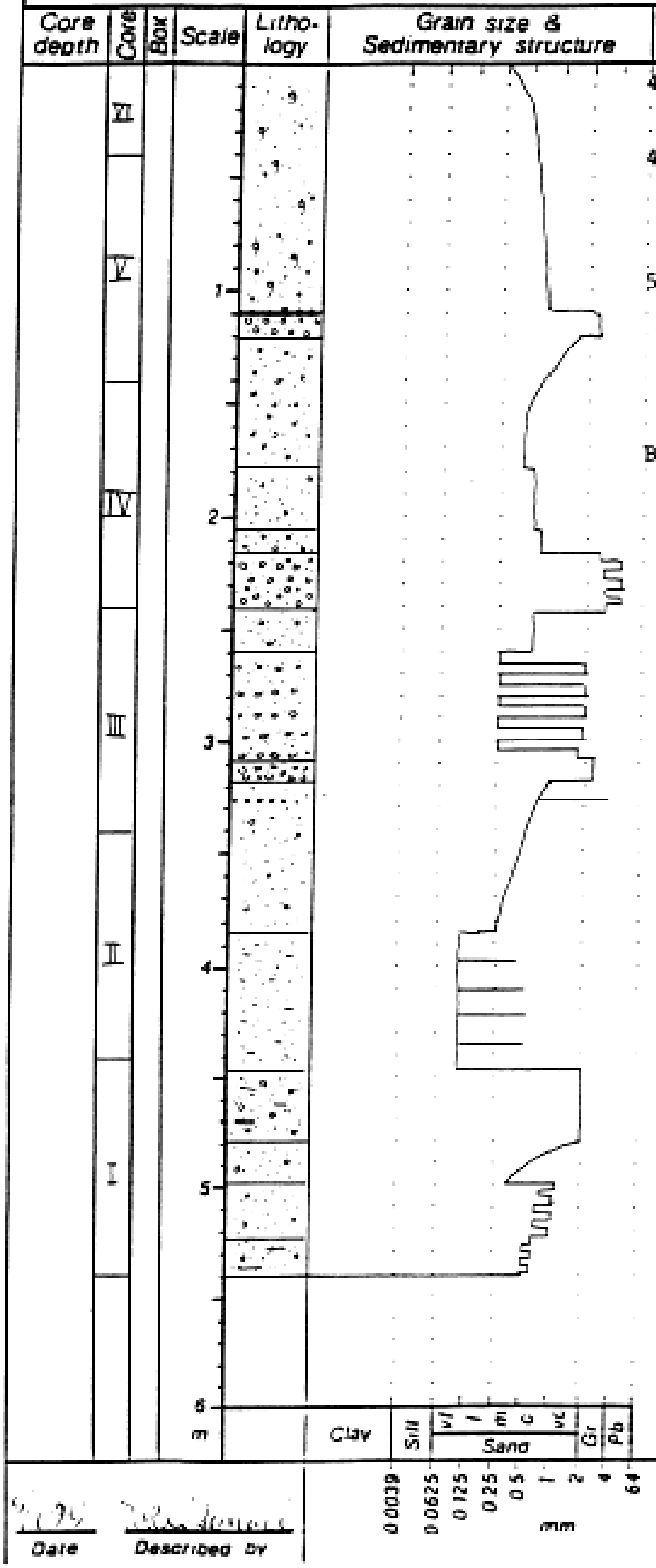
20. Appendix G: Existing vibrocores

Appendix G. Existing corings



SEDIMENTOLOGICAL CORE LOG

CORE NR.: 131-31-524060 fortsat



Description

479: SAND, mest groft - mellem, dårlig sorteret, svagt sammenhængende, 10YR 7/1

498: SAND, groft, lagvis mindre groft, dårlig sorteret, enk. afrundede gruskorn, max. 5 mm, svagt sammenhængende, 10YR 7/1

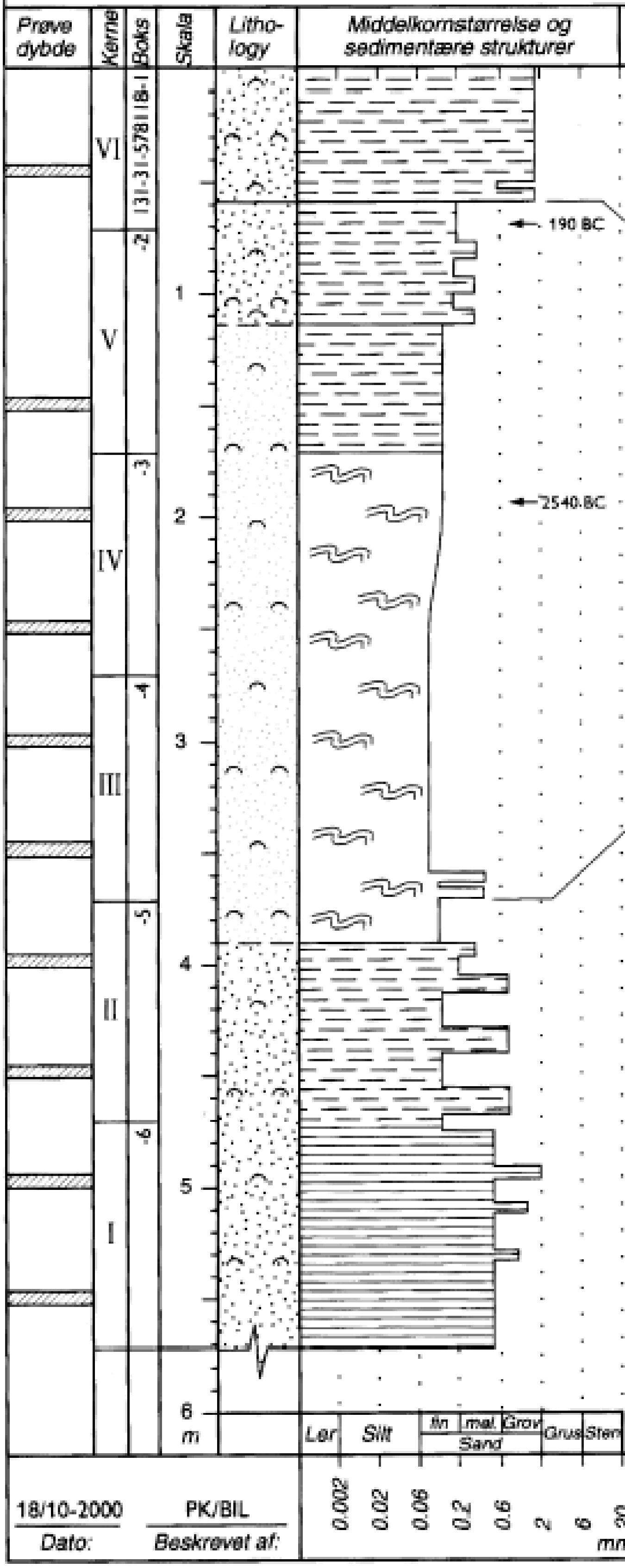
523: SAND, mest groft & mellem, leret, dårlig sorteret, enk. gruskorn, max. 5mm, afrundede til kantede, sammenhængende - stærkt sammenhængende, kalkudskill.(? 10YR 4/1

Bundprøve: do. tørt, smuldrende

DGU
Geological Survey of Denmark

SEDIMENTOLOGISK KERNE LOG

KERNE NR.: 578-118 | POSITION: 55°35,100 N 07°39,100 E | Vand dybde: 13,6 m



Beskrivelse

0-59: SAND, groft og mellem lamineret, i nedre del også mellem og fint, spredte skaller og skalfragmenter. Grå 5Y 5/1, iltes til lys rustbrun 10YR 5/4.

59-113: SAND, fint til mellem, uklar lamination af mellem og fin sand, få skaller og skalfragmenter. Grå 5Y 6/1.

113-171: SAND, fint og mellem, uklar lamination, få skaller og skalfragmenter, skalsand ved basis. Grå 5Y 6/1.

171-370: SAND, fint, grovsiltet, nedaf finere og gradvis mere siltet, i nederste del enkelte lerede laminae og få fin- mellem sandlag, bioturberet, få skaller og skalfragmenter og mørke organiske partikler. Grå 5Y 5/1.

370-390: SAND, fint til meget fint, grovsiltet, bioturberet, med skalfragmenter. Grå 5Y 5/1.

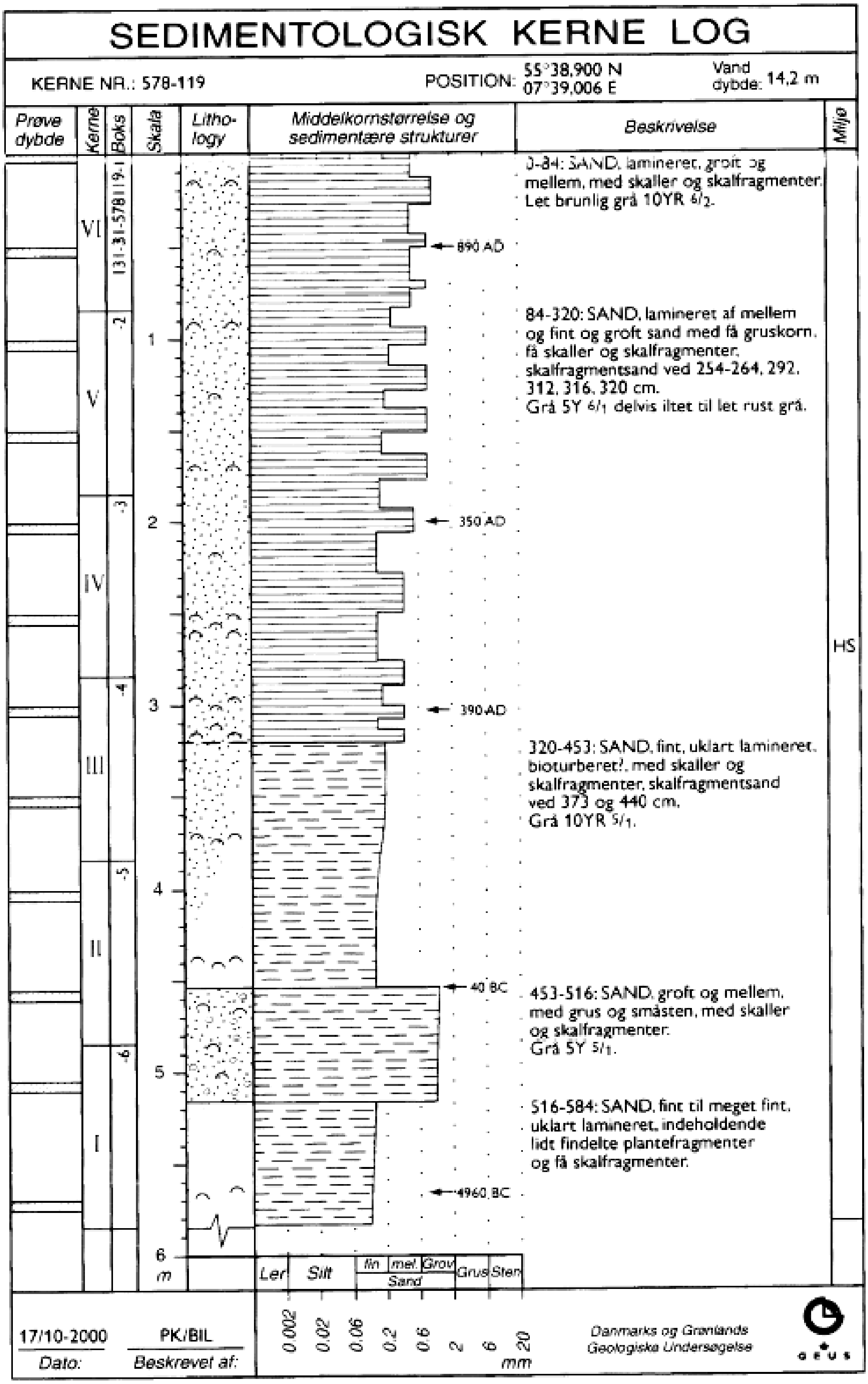
390-471: SAND, mellem, uklart lamineret med fine og få grove sandlaminae, få skaller og skalfragmenter. Grå 5Y 5/1-6/1.

471-571: SAND, mellem, lamineret enklete grovsandlag, få skaller og skalfragmenter. Grå 5Y 5/1-6/1.

Miljø: HS

18/10-2000 — Dato:
PK/BIL — Beskrevet af:

Danmarks og Grønlands Geologiske Undersøgelse — GEUS


SEDIMENTOLOGISK KERNE LOG
KERNE NR.: 578-119
POSITION: 55°38,900 N 07°39,006 E
Vand dybde: 14,2 m
Prøve dybde
Kerne
Boks
Skala
Litho-logy
Middelkornstørrelse og sedimentære strukturer
Beskrivelse
Miljø
131-31-578119-1
-2
-3
-4
-5
-6
VI
V
IV
III
II
I
1
2
3
4
5
6
m
890 AD
350 AD
390 AD
40 BC
4960 BC
0-84: SAND, lamineret, groft og mellem, med skaller og skalfragmenter. Let brunlig grå 10YR 6/2.
84-320: SAND, lamineret af mellem og fint og groft sand med få gruskorn, få skaller og skalfragmenter, skalfragmentsand ved 254-264, 292, 312, 316, 320 cm. Grå 5Y 6/1 delvis iltet til let rust grå.
320-453: SAND, fint, uklart lamineret, bioturberet?, med skaller og skalfragmenter, skalfragmentsand ved 373 og 440 cm. Grå 10YR 5/1.
453-516: SAND, groft og mellem, med grus og småsten, med skaller og skalfragmenter. Grå 5Y 5/1.
516-584: SAND, fint til meget fint, uklart lamineret, indeholdende lidt findelte plantefragmenter og få skalfragmenter.
HS
Ler
Silt
fin
mel.
Grov
Sand
Grus
Sten
0.002
0.02
0.06
0.2
0.6
2
6
20
mm
17/10-2000
Dato:
PK/BIL
Beskrevet af:
Danmarks og Grønlands Geologiske Undersøgelse
GEUS

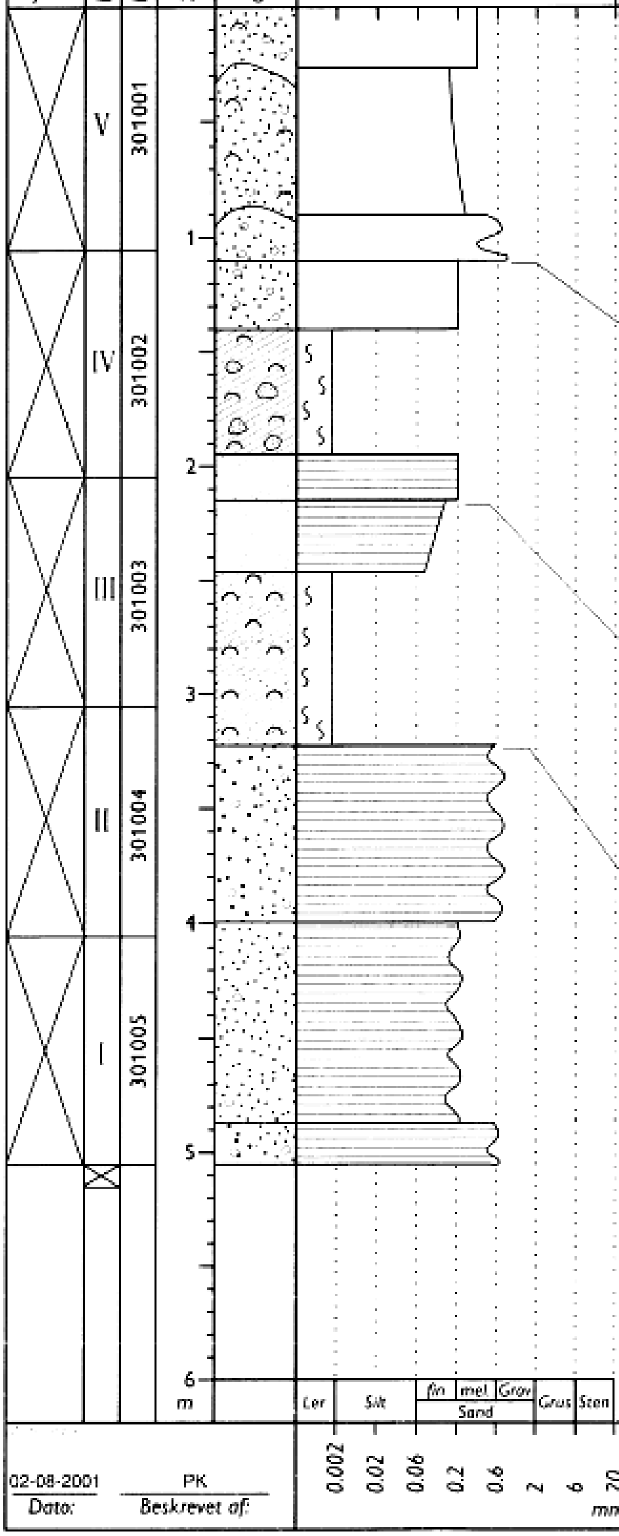
SEDIMENTOLOGISK KERNE LOG

KERNE NR.: Hav 578150, DGU 550715.7

POSITION: 55°34'733 N, 7°35'967 E

Vand dybde: 12,7m

Prøve dybde	Kerne	PKV.nr.	Skala	Lito-logi	Middelkornstørrelse og sedimentære strukturer	Beskrivelse	Miljø



0,00-0,30 SAND, mellem med få grovsandskorn, skalfragmenter, laggrænse forstyrret, lys gul brun 10YR 5/4.

0,30-0,90 SAND, fint til mellem, svagt siltet, få grovsandskorn og fingrus korn, skaller og skalfragmenter, laggrænse forstyrret, mørk grå 5Y 3/1.

0,90-1,10 SAND, mellem og groft, med fingrus, lys gulbrun 10YR 5/4.

1,10-1,40 SAND, fint til mellem, siltet, svagt leret, få gruskorn, en sten (11cm), skalfragmenter, mørk grå 5Y 3/1.

1,40-1,95 LER, siltet, fint lamineret, mange sandlommer (fint til mellem), bioturberet, skaller og skalfragmenter, (Ostrea, Clamys varius o.a.), mørk olivengrå 5Y 3/1, Eem.

1,95-2,15 SAND, fint til mellem, lagdelt, mørk grå 5Y 3/1, Eem.

2,15-2,47 SAND, fint, svagt siltet, grovende opad, lagdelt, gulbrun 10YR 5/4, Eem.

2,47-3,22 LER, siltet, svagt sandet til stærkt sandet, bioturberet mange skaller, (Ostrea), svagt lamineret i nedre del, oliven grå 5Y 4/1, Eem.

3,22-4,00 SAND, mellem og groft, lagdelt, lerede laminae, nogle fingrus korn, gulbrun 10YR 5/6 og gråbrun 10YR 5/2.

4,00-4,87 SAND, fint og mellem, lagdelt, med grovsandskorn og fingrus korn, lys gulbrun 10YR 6/4.

4,87-5,05 SAND, mellem og groft, med korn af fingrus, lagdelt, brungul 10YR 6/8.

Spids SAND, mellem og fint, med korn af fingrus, brungul 10YR 6/8.

Miljø: HS (0,00-1,40), QL, QS, QL, DS

Foto: Bilag 2.1 - 2.2

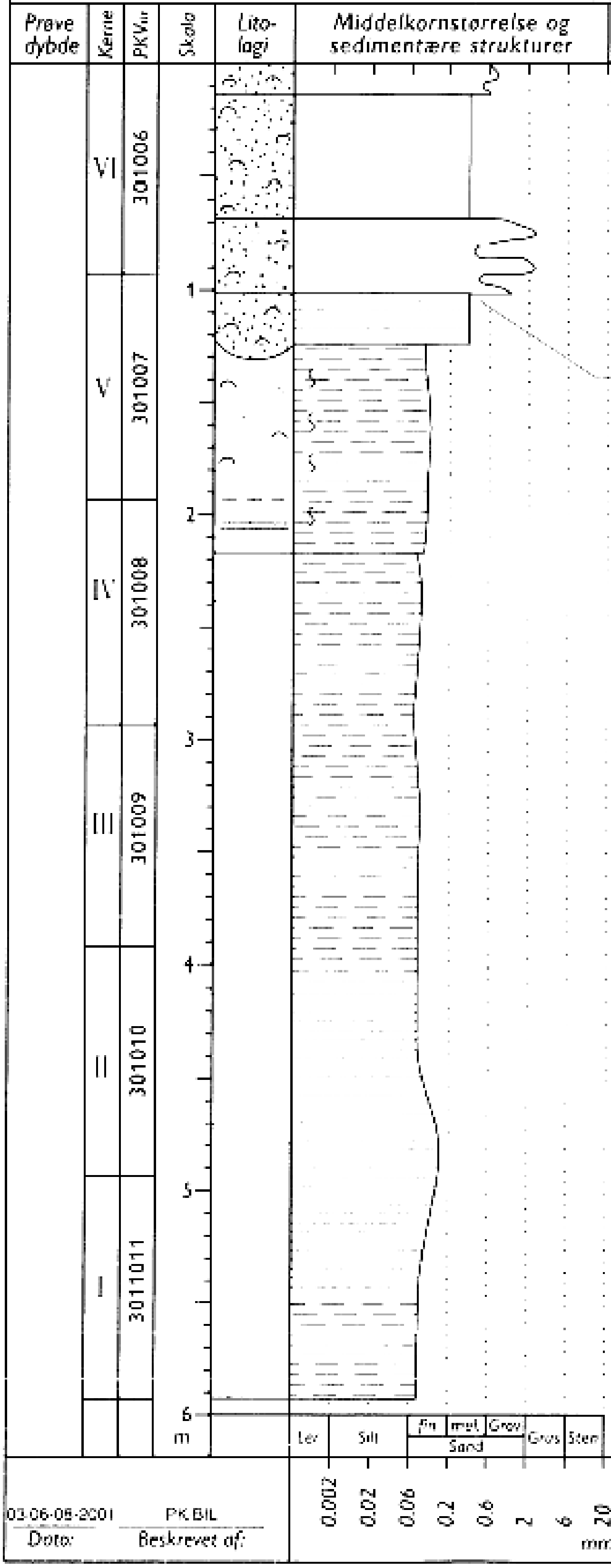
Dato:	Beskrevet af:
02-08-2001	PK

Danmarks og Grønlands Geologiske Undersøgelse — GEUS

Bilag 1.3

SEDIMENTOLOGISK KERNE LOG

KERNE NR.: Hav 578151 DGU 550715.8 **POSITION:** 55°36'875 N 7°35'923 E *Vand dybde:* **13,1 m**



Beskrivelse

0,00-0,14 SAND, mellem og groft, med kraftige skaller (Spisula, Solida) og skalfragmenter. gråbrun 10YR 6/3.

0,14-0,69 SAND, mellem, med fint og groft, få gruskorn, skaller og skalfragmenter. mørk grå 2.5Y 4/2

0,69-1,02 SAND, groft. med mellem og fint, med fint og groft grus, skaller (Spisula), mørk grå 10YR 4/1.

1.02-1.24 SAND, mellem, med fint, lamineret, få gruskorn, få skaller og skalfragmenter. mørk grå 5YR 4/1, nedre grænse forstyrret.

1.24-2.17 SAND, fint, let siltet, med lommer (gravegange?) af mellemsand, få gruskorn, få skaller (Spisula og Natica). svagt lamineret, nedre del: uden skaller og med få lerslirer, mørk grå 7.5YR 5/1-4/1.

2,17-5,93 SAND, fint, siltet, velsorteret, glimmerkorn, få små sorte plantefragmenter på utydelige laminae; ved 4.39-5.50: fint til mellem, velsorteret, lamineret i 1 à 5 mm lag, grovende opad i bunden, finende opad i toppen, grå 10YR 6/1. Twente Formation. Dette interval er forstyrret, antagelig ved boreprocessen.

Spids SAND, fint, velsorteret, grå 10YR 5/1.

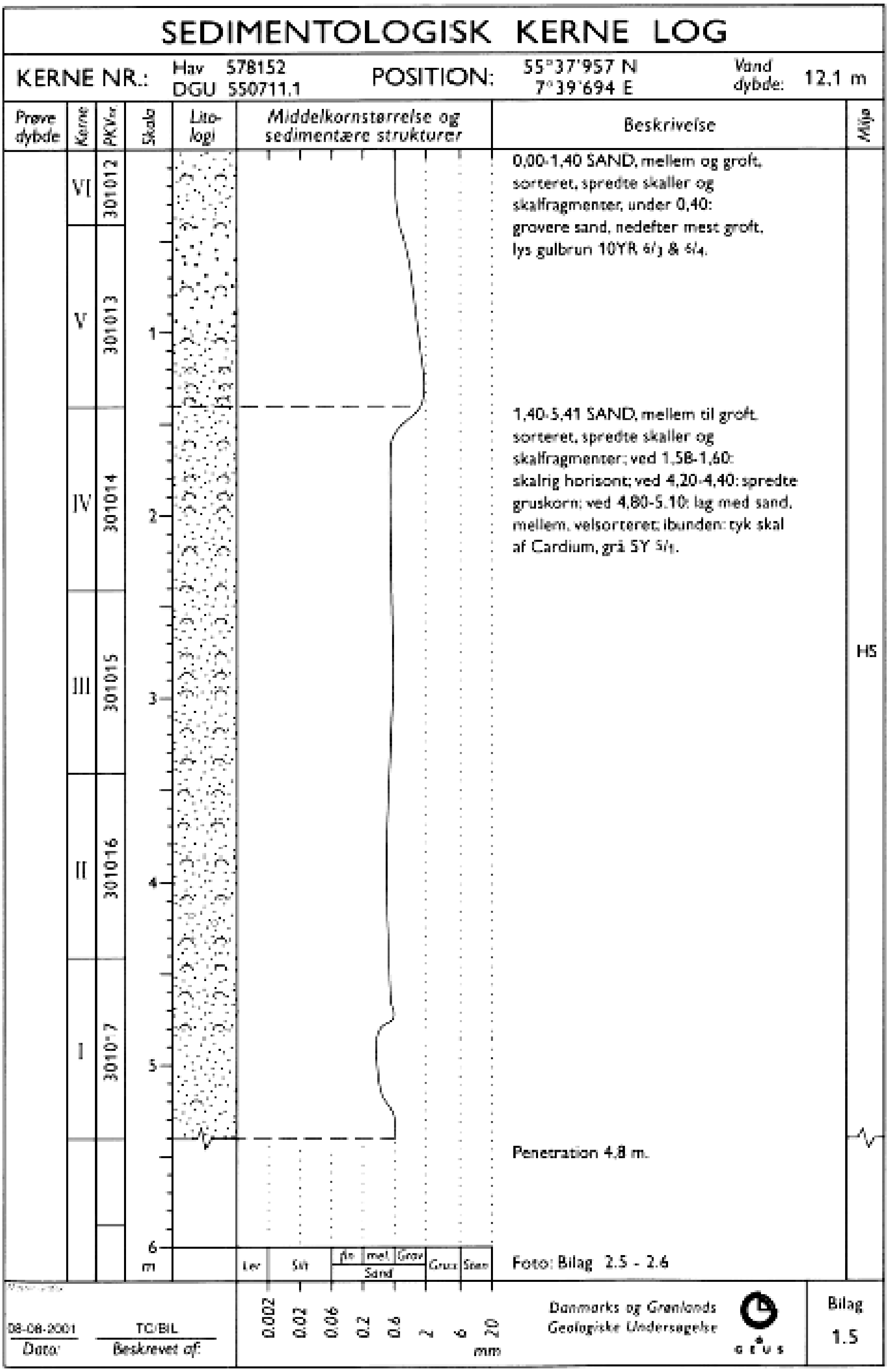
Foto: Bilag 2.3 - 2.4

Miljø: HS, TS

03-06-08-2001 PK BIL
Dato: *Beskrevet af:*

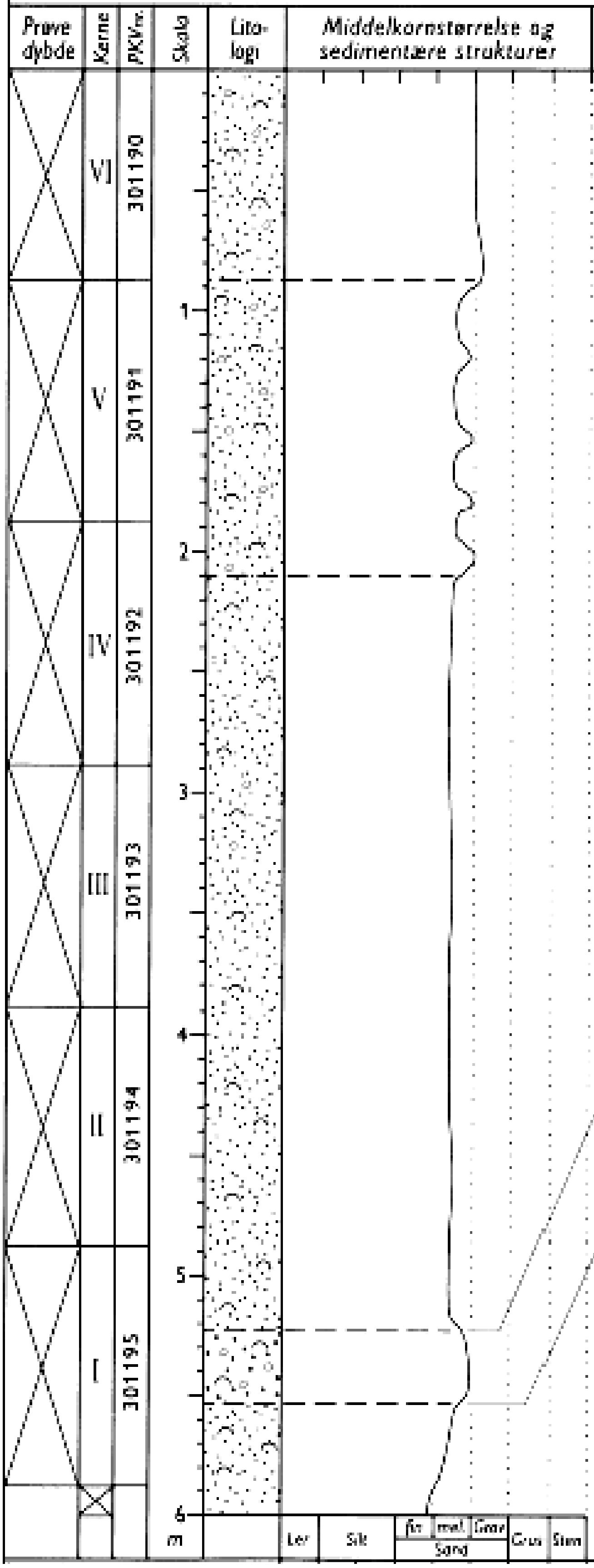
Danmarks og Grønlands Geologiske Undersøgelse GEUS

Bilag 1.4


SEDIMENTOLOGISK KERNE LOG
KERNE NR.: Hav 578152 DGU 550711.1
POSITION: 55°37'957 N 7°39'694 E
Vand dybde: 12,1 m
Prøve dybde
Kerne
PK Vnr.
Skala
Lito-logi
Middelkornstørrelse og sedimentære strukturer
Beskrivelse
Miljø
VI 301012
V 301013
IV 301014
III 301015
II 301016
I 3010'7
1
2
3
4
5
6
m
0,00-1,40 SAND, mellem og groft, sorteret, spredte skaller og skalfragmenter, under 0,40: grovere sand, nedefter mest groft, lys gulbrun 10YR 6/3 & 6/4.
1,40-5,41 SAND, mellem til groft, sorteret, spredte skaller og skalfragmenter; ved 1,58-1,60: skalrig horisont; ved 4,20-4,40: spredte gruskorn; ved 4,80-5,10: lag med sand, mellem, velsorteret; ibunden: tyk skal af Cardium, grå 5Y 5/1.
HS
Penetration 4,8 m.
Foto: Bilag 2.5 - 2.6
Ler
Silt
fin
mel.
Grov
Sand
Grus
Sten
0.002
0.02
0.06
0.2
0.6
2
6
20
mm
08-08-2001
Dato:
TC/BIL
Beskrevet af:
Danmarks og Grønlands Geologiske Undersøgelse
GEUS
Bilag
1.5

SEDIMENTOLOGISK KERNE LOG

KERNE NR.: Hav 578153 / DGU 550711.2 POSITION: 55°37'981 N / 7°41'968 E *Vand dybde:* 12.3 m



Beskrivelse

0.00-0.88 SAND, mellem til groft, sorteret, nedefter gradvist grovere, få gruskorn, spredte muslinger og skalfragmenter, få spredte fingrus korn af flint, lys gulbrun 2,5Y 6/3.

0,88-2,10 SAND, mellem, sorteret, uregelmæssige, ikke lagdelte striber af mellem til groft sand, svagt fingruset i grove fraktion, spredte skaller og skalfragmenter, store muslinger (Solen), ved 1,78: lille søpindsvin, lys gulbrun 2,5Y 6/3.

2,10-5,23 SAND, mellem, velsorteret, enkelte gruskorn, spredte skaller og skalfragmenter, mørke mineraler, grå 2,5Y 5/1; ved: 3,88-4,88, grå 5Y 6/1; øvre grænse kort og jævn.

5,23-5,53 SAND, mellem til groft, sorteret, få grovgrus korn, sten (flint), spredte skaller og skalfragmenter, enkelte store muslinger, lys brungrå 2,5Y 6/2.

5,53-5,88 SAND, mellem, nedefter fin til mellem med jævn overgang, spredte mørke mineraler, spredte skalfragmenter, enkelte skaller (Cardium), grå 5Y 5/1.

Spids SAND, fint til mellem, spredte skaller (Spisula) og skalfragmenter, grå 5Y 5/1.

Penetration 6 m.

Foto: Bilag 2.7 - 2.8

21. Appendix H: Proposal for vibrocore sampling

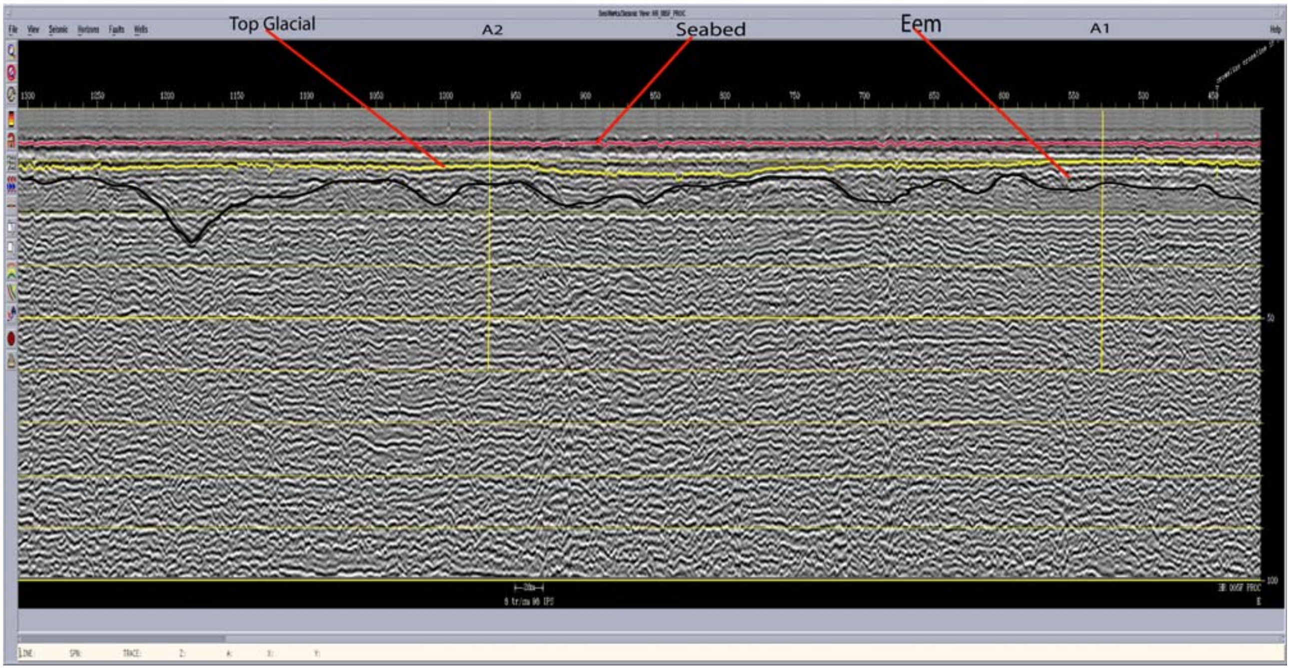
To: Energi e2
From: Steen Lomholt
Copy: Peter Gravesen
Confidential: ja
Date: 05-07-2006
GEUS-NOTAT No.:
J.No. GEUS:

Subject: Udpegning af 7 boringspositioner på Horns Rev

Nærværende notat er GEUS's kommentarer til de 7 udpegede boringspositioner på Horns Rev.

Boring A1

Boringen er placeret i det sydøstlige hjørne af HR2 Vindmølleparken i et område, hvor der i GEUS's oversigtlige kortlægning er mulighed for at påtræffe Eem aflejringer.
Området er illustreret på et udsnit af seismik linie nr HR_005 (Se figur 1)



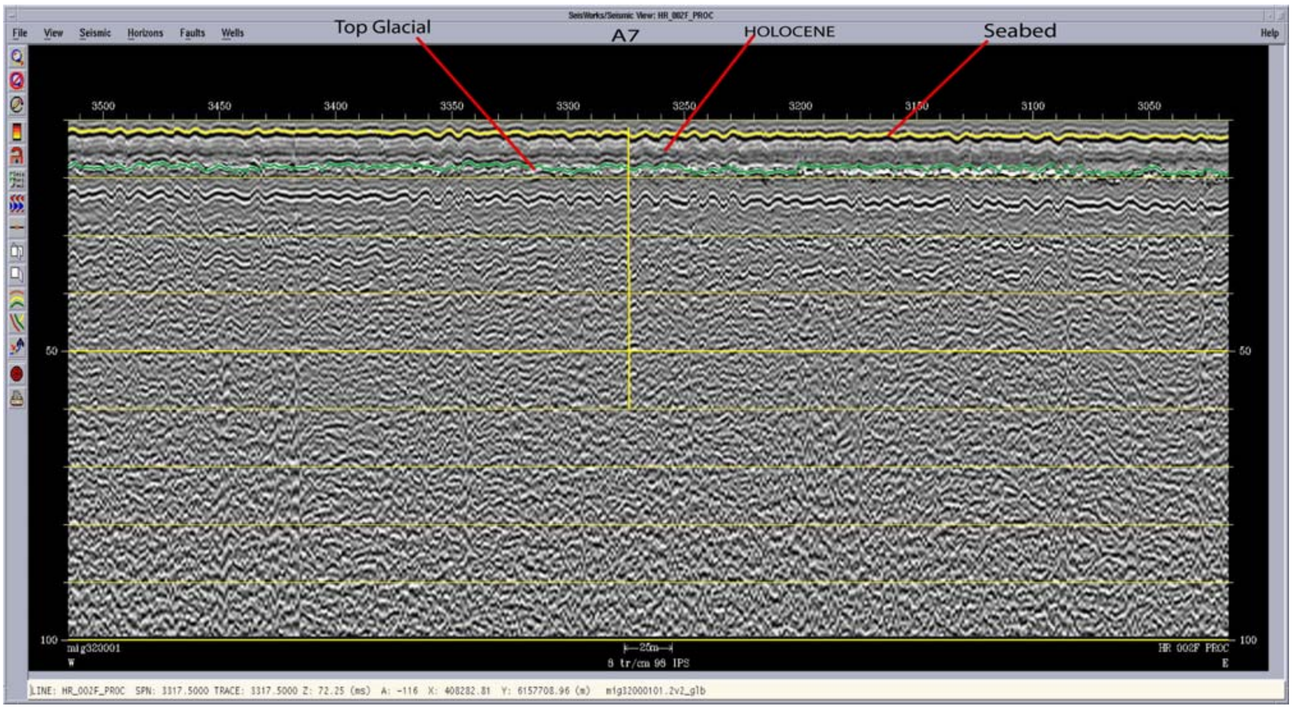
Figur 1 Seismisk sektion HR_005 Position A1 (Vertikal skala er i ms. (50 ms svarer ca til 40 m's dybde)).

Geological Survey of
Denmark and Greenland (GEUS)
Ministry of the Environment
Øster Voldgade 10
DK-1350 Copenhagen K
Denmark
Telephone +45 38 14 20 00
Telefax +45 38 14 20 50
E-mail geus@geus.dk

På det seismiske profil er der vist møllepositionerne A1 og A2 og længden af det gule boringspor er lige omkring 50 m. Som det ses af figuren, er der imellem havbundens og glacialoverfladens reflektionerne et Holocænt sandlegeme, med så nogenlunde ensartet tykkelse igennem profilet. Det forventes at der på positionen er et mindre Eem lag, på 3 m i tykkelsen. Dette er tilsvarende i position A2. Det ser ud, til baseret på ovenstående tolkning af geologien på boringsstedet, at boringen vil kunne opfylde det mål, at vurderer Eem aflejringernes sammensætning i område på den valgte position.

Boring A7

Boringen er placeret i det sydvestlige hjørne af HR2 Vindmølleparken i et område, hvor der i GEUS's oversigtlige kortlægning er mulighed for at påtræffe glaciale aflejringer umiddelbart under et ensartet marint Holocænt sandlag..
Området er illustreret på et udsnit af seismik linie nr HR_002 (Se figur 2)

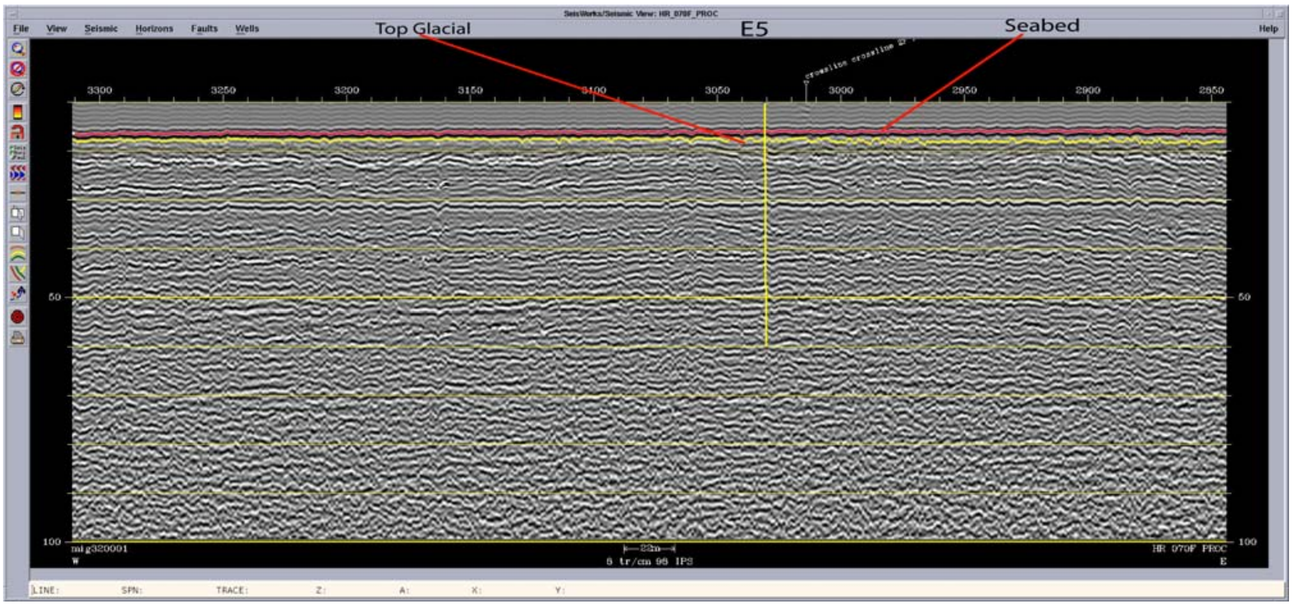


Figur 2 Seismisk sektion HR_002 Position A7(Vertikal skala er i ms . (50 ms svarer ca til 40 m's dybde)).

Som det ses af figuren, er der imellem havbundens og glacialoverfladens reflektionerne et Holocænt sandlegeme, med ensartet tykkelse igennem hele profilet. På profilet er der vist mølleposition A7. Længden af det gule boringspor er lige omkring 50 m. Som det fremgår af figuren er der på positionen et Holocænt sandlag på omkring 4 m's tykkelse. Det ser ud til baseret på ovenstående tolkning af geologien på boringsstedet, at boringen vil bore 4-5 m Holocænt sand, og herefter bore det glaciale, som underlejrer sandet. Det kan ikke vurderes ud fra de seismiske data hvor tyk moræenen er i området eller om der er flere moræner af forskellig sammensætning.

Boring E5

Boringen er placeret centralt i Vindmølleparken i et område, hvor der, ifølge GEUS's kortlægning kan forventes et tyndt holocænt sandlag over de glaciale lag.
Området er illustreret på et udsnit af seismik linie nr. HR_070 (Se figur 3)

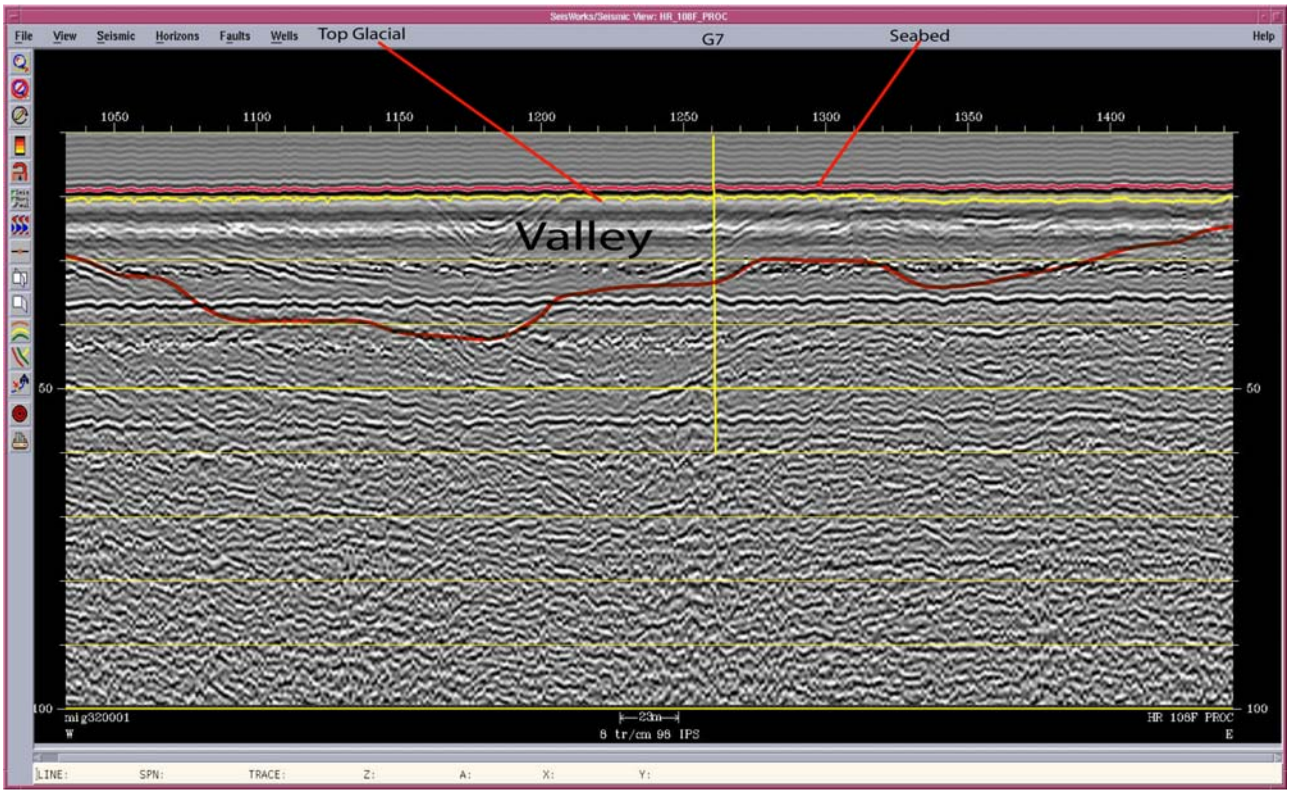


Figur 3 Seismisk sektion HR_070 Position E7 (Vertikal skala er i ms. (50 ms svarer ca til 40 m's dybde)).

På profilet er der vist møllepositionen E5 og længden af det gule boringspor er lige omkring 50 m. Som det ses af figuren, er der imellem havbundens og glacialoverfladens reflektionerne et meget tyndt Holocænt sandlegeme, med en svag stigende tykkelse mod øst. På boringspositionen forventes et tyndt Holocænt sandlag på ca. 1 m's tykkelse.
Det ser ud, til baseret på ovenstående tolkning af geologien på boringsstedet, at boringen vil kunne opnå et mål om at vurderer de glaciale aflejringer sammensætning på den valgte position. Der er flere interne seismiske reflektioner på borestedet i de tolkede glaciale lag, som kunne indikere, at dette lag ikke er homogent i området men består af flere enheder.

Boring G7

Boringen er placeret centralt i Vindmølleparken i et område, hvor der, ifølge GEUS's kortlægning kan forventes at være en vestlig gren af et dalsystem som er kortlagt flere steder i området. (Se figur D 8, et tyndt holocænt sandlag over de glaciale lag.
Området er illustreret på et udsnit af seismik linie nr. HR_108(Se figur 4)

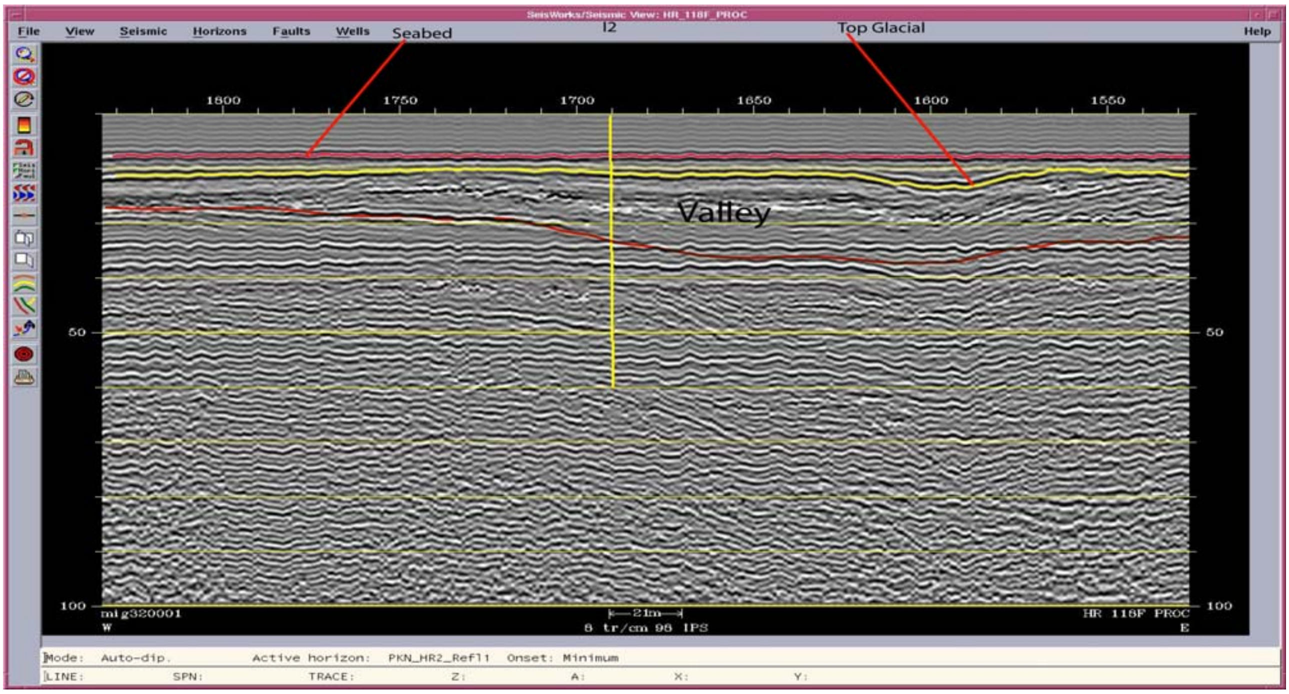


Figur 4 Seismisk sektion HR_108 Position G5 (Vertikal skala er i ms. (50 ms svarer ca til 40 m's dybde)).

På profilet er der vist møllepositionen G5 og længden af det gule boringspor er lige omkring 50 m. Som det ses af figuren, er der imellem havbundens og glacialoverfladens reflektionerne et meget tyndt Holocænt sandlegeme, med en svag stigende tykkelse mod øst. På boringspositionen er der et tyndt Holocænt sandlag på ca. 1 m's tykkelse som dækker dalsystemet. Med den valgte boringsplacering, vil der kunne bores omkring 10 m af dalsystemets aflejringer. Tolkning af dalbunden er meget usikker på grund af at de seismiske data bliver generet af multipler. Det ser ud, til baseret på ovenstående tolkning af geologien på boringsstedet, at boringen vil kunne opfylde et mål om at vurderer dalsystemets aflejringer og sammensætning på den valgte position.

Boring I2

Boringen er placeret centralt i Vindmølleparken i et område, hvor der, ifølge GEUS's kortlægning kan forventes at være en østlig gren af et dalsystem som er kortlagt flere steder i området (Se figur D 8, dækket af et holocænt sandlag over de glaciale lag.
Området er illustreret på et udsnit af seismik linie nr. HR_118 (Se figur 5)

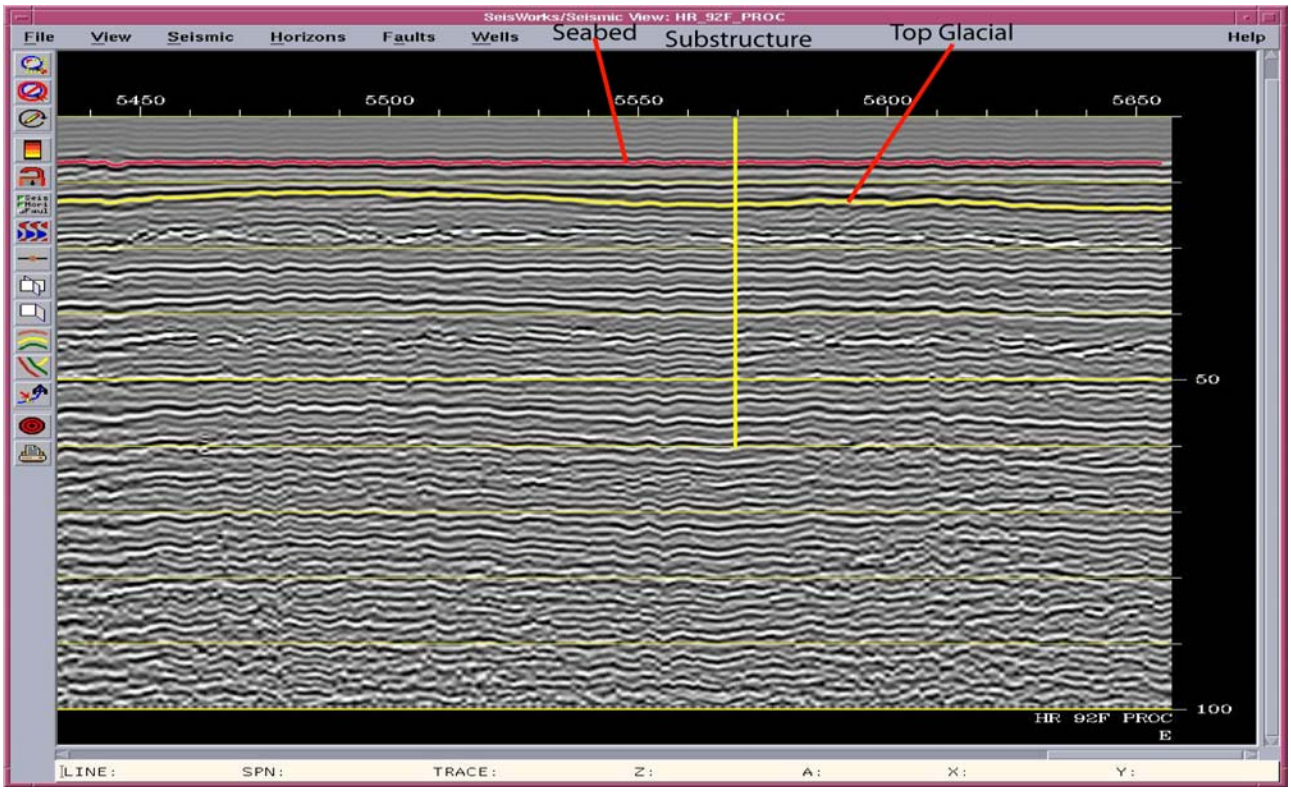


Figur 5 Seismisk sektion HR_118 Position I2 (Vertikal skala er i ms. (50 ms svarer ca til 40 m's dybde)).

På profilet er der vist mølleposition en I2 og længden af det gule boringspor er lige omkring 50 m. Som det ses af figuren, er der imellem havbundens og glacialoverfladens reflektionerne et Holocænt sandlegeme, med varierende tykkelse på 2-4 m's tykkelse som dækker dalsystemet. På boringsstedet er tykkelsen af det Holocæne sand ca. 2 m. Med den valgte boringsplacering, vil der kunne bores omkring 9-10 m af dalsystemets aflejringer. Tolkning af dalbunden er noget usikker på grund af at de seismiske data bliver generet af multipler. Det ser ud, til baseret på ovenstående tolkning af geologien på boringsstedet, at boringen vil kunne opfylde et mål om at vurderer dalsystemets aflejringer i den østlige forgrening og sammensætning på den valgte position.

Boring Substructure 1

Boringen er placeret langs den østlige afgrænsning af vindmølleparken centralt i Vindmøllepark området i et område, hvor der, ifølge GEUS's kortlægning kan forventes at være et holocænt sandlag over de glaciale lag.
Området er illustreret på et udsnit af seismik linie nr. HR_092 (Se figur 6)

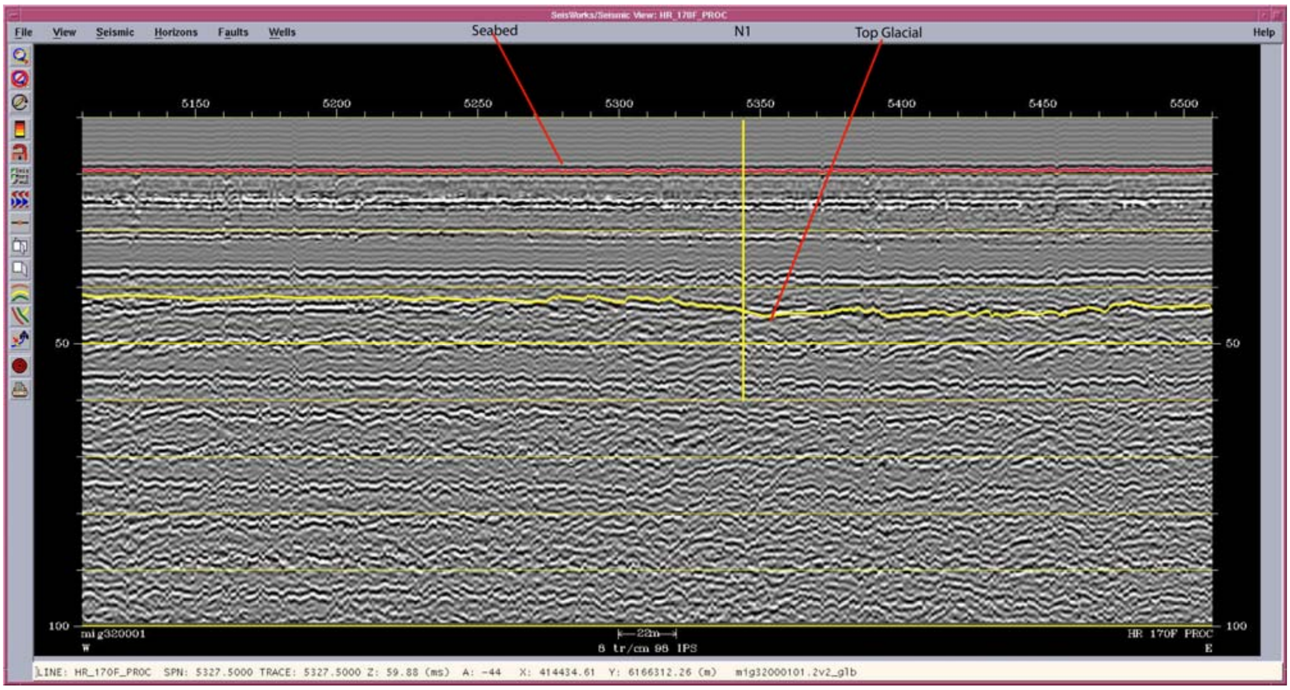


Figur 6 Seismisk sektion HR_092 Position Substructure 1 (Vertikal skala er i ms. (50 ms svarer ca til 40 m's dybde)).

På profilet er der vist møllepositionen Substucture 1 og længden af det gule boringspor er lige omkring 50 m.Som det ses af figuren, er der imellem havbundens og glacialoverfladens reflektionerne et Holocænt sandlegeme, med varierende tykkelse på 2-4 m's tykkelse som dækker det glaciale. På boringsstedet er tykkelsen af det Holocæne sand ca. 3 m. Med den valgte boringsplacering, vil der, efter at det Holocæne sand er gennemboret forventes glaciale aflejringer af varierende sammensætning i de dybere dele.

Boring N1

Boringen er placeret det nordøstlige del af Vindmølleparken i et område, hvor der, ifølge GEUS's kortlægning kan forventes en større tykkelse af det holocæne sandlag over de glaciale lag (Se figur D6 og 7).
Området er illustreret på et udsnit af seismik linie nr. HR_170 (Se figur 7)



Figur 7 Seismisk sektion HR_170 Position N1 (Vertikal skala er i ms. (50 ms svarer ca til 40 m's dybde)).

På profilet er der vist møllepositionen N1 og længden af det gule boringspor er lige omkring 50 m. Som det ses af figuren, er der imellem havbundens og glacialoverfladens reflektioner et meget tykt Holocænt sandlegeme i området. På boringspositionen er det Holocænt sandlag på 18-20 m's tykkelse. Dette udfyldere et større dalsystem som strækker sig imod nordvest-sydøst, øst for selve vindmølleparken. Med den valgte boringsplacering, vil der således kunne bores 18 til 20m af holocæne aflejringer, efterfulgt af glaciale sediementer. Tolkning af dalbunden er meget usikker på grund af at de seismiske data bliver generet af multipler. Det ser ud, til baseret på ovenstående tolkning af geologien på boringsstedet, at boringen vil kunne opfylde et mål om at vurdere de tykke holocæne aflejringer i området.