

FS 'Alkor' Cruise 359 Cruise Report



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Table of Contents

1 Introduction and background	4
1.1 FS 'Alkor'	4
1.2 Background information	4
1.3 Participants	4
1.4 Regional setting	5
2 Scientific methods	6
2.1 Seismic surveying	6
2.1.1 Reflection seismics with airgun as source	6
2.1.2 Refraction seismics with airgun as source	6
2.1.3 Reflection seismics with sparker array as source	8
2.1.4 Acquisition system	8
2.1.5 Ship-board processing	9
2.2 Gravimetrics	9
2.2.1 Ship-mounted gravimeter	9
2.2.2 Portable gravimeter for reference measurements	9
2.2.3 Acquisition system	9
2.3 Single-beam parametric echo sounder and sub-bottom profiler	10
2.3.1 Acquisition system	10
2.3.2 Ship-board processing	11
2.4 Magnetics	12
2.4.1 Equipment	12
2.4.2 Acquisition system	12
3 Results	13
3.1 Data examples	13
3.1.1 Seismic profiles	14
4 Further data processing and interpretation	16
5 Acknowledgments	16

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1 Introduction and background

1.1 FS 'Alkor'

The research vessel FS 'Alkor' belongs to Leibniz Institute of Marine Sciences IFM-GEOMAR, which is based in Kiel, Germany. The vessel was chartered by the University of Hamburg for the purpose of this cruise. The construction of FS 'Alkor' was completed in 1990. The vessel has an overall length of 55.20 meters, a beam width of 12.50 meters and a draught of 4.16 meters. The top cruising speed of the vessel is 12.5 knots and it has a range of up to 7,500 sm (statute miles). FS 'Alkor' can carry up to 10 crew members and at most 12 scientists during a single cruise. The BRT – gross (bruto) registered tonnage – of the vessel is 999.08, or the equivalent of 2,827.40 m³.

1.2 Background information

The cruise was part of a course in marine geophysics and oceanography at the University of Hamburg, and students at the undergraduate level are required to participate in order to receive their degree. The data collected also serves the purpose of complimenting the existing data sets, especially the NeoBaltic seismic grid. Thus the cruise is not only exemplary in terms of teaching the students the different methods of data acquisition, but also provides grounds for expanding the knowledge of the geology in the area. However, from a students point of view, the cruise serves as a fundamental introduction to the geophysical methods used in oceanographic and marine geological research, and provides an opportunity to get hands-on experience with a wide variety of equipment.

During the cruise, various geophysical data acquisition methods were used. Ship mounted instruments running nearly the full duration of the cruise included a gravimeter, measuring the gravitational field beneath the vessel, and a narrow-beam parametric sub-bottom profiler, which provided high quality data depicting the bathymetry and the stratigraphy of the uppermost sediment layers below the sea floor. Magnetometers were towed at a fixed distance behind the vessel, gathering data throughout the majority of the cruise duration. Along planned profile lines, seismic data was collected. The majority of the lines are reflection seismic profiles, the rest refraction. An airgun, running at different capacities for the two methods, and a sparker-array were used as seismic sources. From a laboratory on board, all instruments were monitored with computers and a variety of software applications, while the participants kept a watch schedule overlooking the data acquisition day and night. As well as monitoring the incoming data, it was also transferred and stored safely, and various pre-processing steps were taken. On top of that students were introduced to some methods of processing bathymetric and seismic data, and were expected to complete the processing of the seismic and echo sounder profiles while on board.

The full duration of the cruise spanned from the 17th to the 27th of August 2010, but was divided into two as the total amount of students required to participate outnumbered the cabin capacity of the vessel. The first half of the cruise took place during the 17th-22nd of August, and the second half during the 22nd-27th of August. This report only covers the second part of the cruise, although the same methods and procedures were employed during the first half by another group of participants.

1.3 Participants

The participants of the second half of Cruise 359 on board FS 'Alkor' consisted of the ships crew (a detailed list of crew members is not included in this report), and the following scientists (mentioned in alphabetical order of last name):

Dr. G. Ali Dehghani, chief scientist, Institute of Geophysics, Centre for Marine and Atmospheric

Sciences (ZMAW), University of Hamburg

PD Dr. Christian Hübscher, PI/scientist, Institute for Geophysics, Center for Marine and Climate Research (ZMAW) , University of Hamburg

Sven Winter, seismic equipment technician, Institute for Geophysics, University of Hamburg

Rennva Arge (1st leg) and Jonas Zilmer Johansen (2nd leg), guest scientist, Institute for Geography and Geology, University of Copenhagen

The following students participated on leg1:

Matthias Schneider, Jorrit Schröder, Dela Spickermann, Alexander Zink, Mirco Czerwonka, Jan Walda, Jesko Treffler.

During leg2:

Janina Kammann, Doreen Kasper, Marius Kriegerowski, Moritz Nieschlag, Hannah Teuteberg, Daniela Wolf.

1.4 Regional setting

Data was collected in Danish and German marine territories, more specifically Kieler Bay, the Fehmarn Belt, Mecklenberger Bay and the Great Belt.

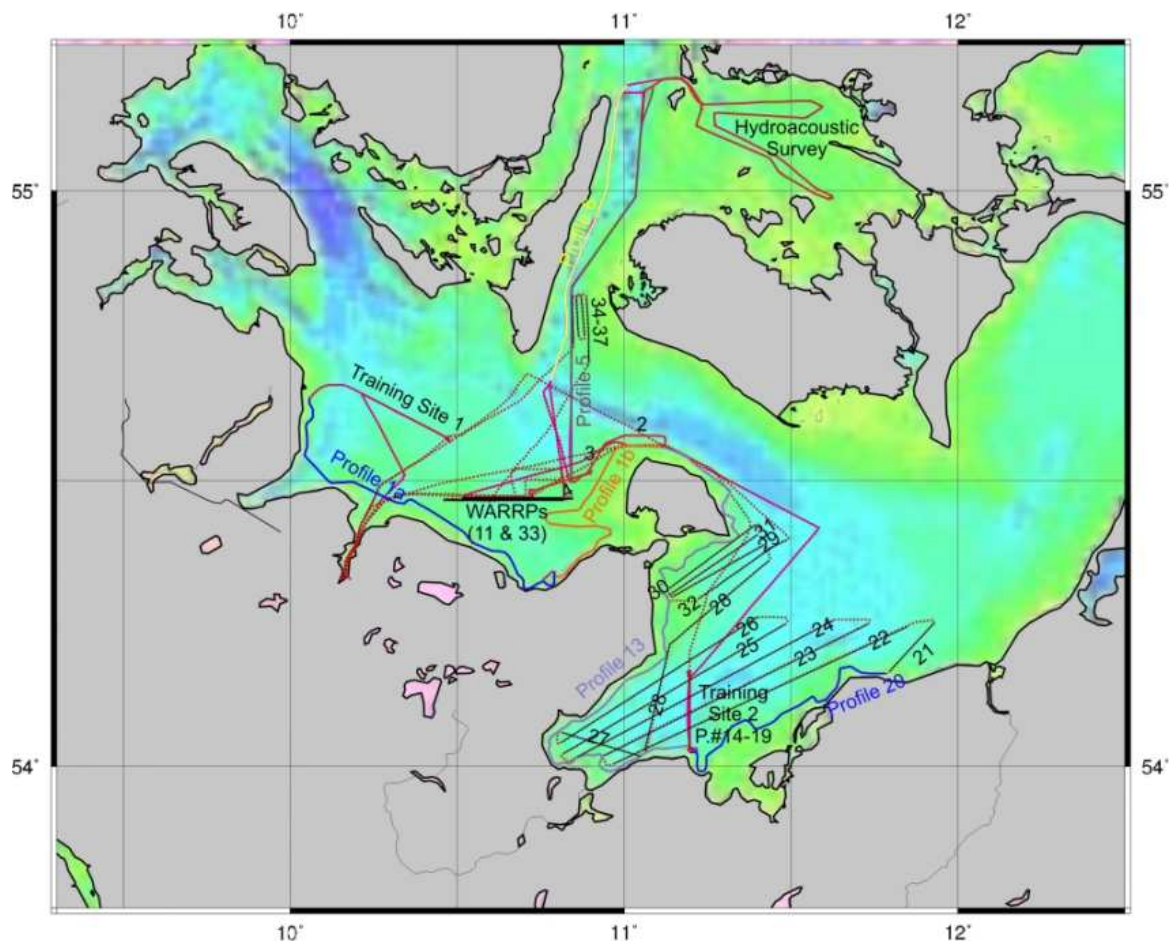


Figure 1: Overview map of the survey area.

2 Scientific methods

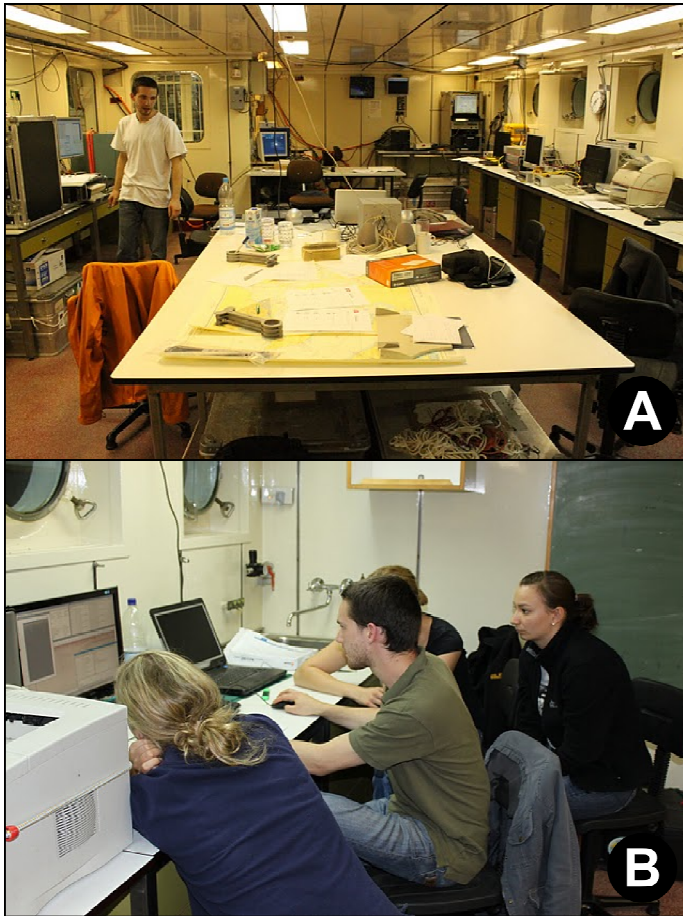


Figure 2: A) The lab. All monitoring of data acquisition and processing took place here. B) Students help one another with the processing of seismic data at the processing workstation.

seismics was used for the refraction surveys. However, the 45 in³ chamber was replaced with a 105 in³ chamber. Another important difference in the refraction survey was that both chambers were fired simultaneously. In other words, two chambers with a volume of 105 in³ and a pressure of 2000 psi/135 bar were fired at the same instant, with shot intervals ranging between 15 and 20 seconds.

Data was collected using two recoverable OBH (ocean bottom hydrophone) systems (see *Figure 3.C*). Each consisted of the following equipment:

2.1 Seismic surveying

2.1.1 Reflection seismics with airgun as source

Seismic energy was provided using a GI-Gun (see *Figure 4C*) running in "true GI-mode." The generator chamber had a capacity of 45 in³ and the injector chamber a capacity of 105 in³, both at a pressure of 2000 psi/135 bar. Shots were fired every 5 seconds. The idea of the injector is to prevent oscillation of the air bubble, thus clarifying the seismic source, and in turn giving better seismic return signals.

A towed hydro-acoustic streamer cable (see *Figure 3B*) was used to gather data with an initial offset of 37 meters. The active length of the streamer was 100 meters, with 16 separate channels. The channel distance in the streamer was 6.25 meters, and the shot interval obtained was around 12.5 meters, assuming a constant average velocity of 5 knots.

2.1.2 Refraction seismics with airgun as source

The same airgun used for the reflection seismics was used for the refraction surveys. However, the 45 in³ chamber was replaced with a 105 in³ chamber. Another important difference in the refraction survey was that both chambers were fired simultaneously. In other words, two chambers with a volume of 105 in³ and a pressure of 2000 psi/135 bar were fired at the same instant, with shot intervals ranging between 15 and 20 seconds.

A mounted cylinder containing the data logger, which was a Send GEOLON MLS marine longterm seismocorder, model MLS14. The data logger stored data on a PCMCIA Flashdisk/Harddisk(12 PCMCIA Slots Type 2 or 6 PCMCIA slots type 3 up to 24 Gigabyte), which was connected to a computer once the OBH was recovered, whereby data was transferred to the desired destination for viewing/processing, etc. It had inputs consisting of 3 seismometer channels and 1 hydrophone channel, all analogue and with configurable gain levels. The power supply for the data logger consisted of an external supply of 6.2 V to 16.5 V, and an internal supply of 3 AA alkaline battery cells for maintaining time synchronization without the external power supply. The time synchronization was maintained by DCF77, a long wave radio signal broadcast from Mainflingen, Germany. The data logger was connected to a preamplifier with model name Lown 21. The preamplifiers had the following specifications:

Input resistance:	33 MOhm
Amplification:	26 dB
Frequency response (-1 dB):	0 to 3.6 kHz
Min. Impedance:	2 kOhm 15 nF
Input signal range:	@ 0.3 - 50Hz 203 nV @ 3 - 3000Hz 553 nV

The power supply for the preamp and recorder was a 12 V battery pack. In the OBH frame, a hydrophone(High Tech, Inc. model HTI-04-PCA/ULF) sensor was mounted, with the following technical specifications:

Capacity:	60 nF
Sensitivity:	-195 dB
Resolution:	1 V/ μ Pa (18V/Bar)
Frequency range:	1/100 to 8 kHz
Max. depth:	6000 m
Temperature range:	-3 to 150°C

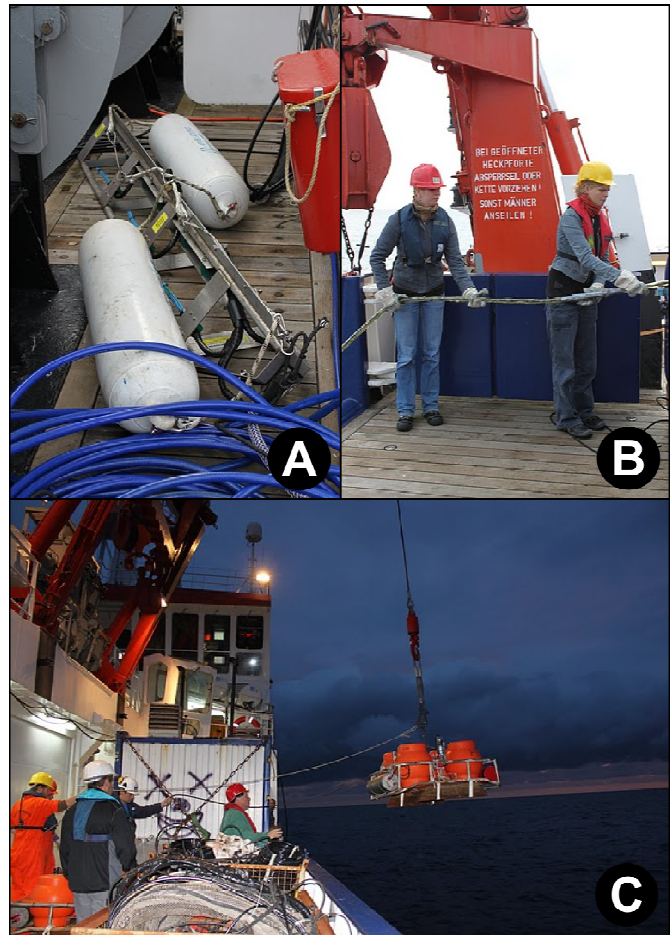


Figure 3: A) The Delta Sparker. B) Students guiding the streamer during deployment. C) The OBS being deployed.

Length: 171,5 mm
Diameter: 50 mm
Weight in air: 1100 g

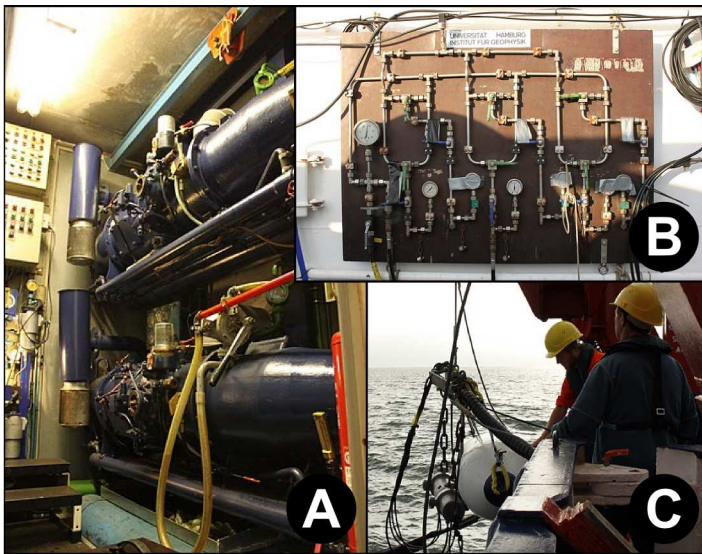


Figure 4: A) A view from inside the airgun compressor container. B) The compressor valve and gauge panel. C) The GI-Gun being deployed.

Other equipment on the frame was a Lexan mounting tube (length: 284,2mm, diameter: 83,5mm) and a Pig tail connector (length: 500mm, diameter: 9,1mm, plug length: 26,8mm, plug diameter: 36,4mm).

2.1.3 Reflection seismics with sparker array as source

For the reflection seismics with the sparker array as source, the sparker used was a Delta Sparker (see **Figure 3A**) made by Applied Acoustics Engineering Ltd. This sparker was a multi-tip sparker array which is an ideal choice for multi-channel seismic surveys using multi-channel streamers for shallow target 2D seismic exploration. It comes pre-manufactured with a 2.5 meter triangular tow frame, supplied with buoys.

The Delta Sparker has the following specifications:

<i>Physical specifications</i>		<i>Sound output</i>	
Dimensions (l x w x h):	2.55m x 0.35m x 0.25m	Source Level:	226 dB typical at 6000J
Weight:	~50 kg	Frequency range:	300 Hz to 5 kHz
Material:	Stainless Steel	Pulse Length:	0.3 - 5 mS. Dependent on tips and power input
Buoyancy:	2 x floats	Penetration:	800 mS achieved
Depth of tow:	Adjustable	Number of tips:	1 - 6 or 16 -96
<i>Electrical specifications</i>		<i>Compatibility</i>	
Recommended Power:	1500J - 12,000J	Energy source:	CSP-D to 2400J
Maximum Energy Input:	12,000J		CSP-S to 12,000J
Operating Voltage:	3000 - 4000 volts		
HV Cable type:	AAE HV 'Squid' Cables		

The same streamer configuration used for the reflection seismics with the GI-Gun as seismic energy source was also used for the sparker surveys. A shot interval of 10 seconds was used for the sparker surveying, as opposed to 5 seconds used in the airgun seismic reflection surveys.

2.1.4 Acquisition system

For gun control, an application called SureShot v.3.04 (see **Figure 8D**) was used. The application was set to fire the gun in cycle mode as opposed to external mode. The controller used was a Real Time Systems(RTS) controller module and the power supply was a FourShot system.

During the reflection seismics with the GI-Gun, the system was calibrated to ensure an injection delay of 32 ms and a sample interval of 2 ms.

Geometrics Marine Multiple Geode OS (see **Figure 8C**) was used for monitoring the data acquisition across all the streamer channels on a computer running Microsoft Windows.

2.1.5 Ship-board processing

While on board, students were introduced to the different steps involved in the processing of seismic data. The procedure for processing involved converting the files from *.sgy to a SeismicUNIX compatible format, and then utilizing pre-defined bash scripts for carrying out various processing steps. Processing included crooked line binning with a 12.5 m CMP distance, frequency filtering to eliminate noise(about 10,20 Hz – 200,400 Hz), NMO(normal moveout)-correction with a sound velocity of 1500 m/s, and stacking and time-wavenumber post stack time migration, and took place on a computer running Linux.

2.2 Gravimetrics

2.2.1 Ship-mounted gravimeter

During the entire duration of the cruise, gravimetric data was collected using a Bodensee gravimetric system, the Sea Gravity Sensor GSS 31 (see **Figure 5**). This system was comprised of a gravity sensor (see **Figure 5C**), a control unit(Control Electronics ZEK 31M), a sensor unit (Sensor Electronics GE31M) and a power supply(Power Supply PS31M) (see **Figure 5B**). This system provides extremely precise measurements of the gravitational field below the vessel, and is capable of instantaneously compensating for yaw, pitch and roll of the ship.

2.2.2 Portable gravimeter for reference measurements

The portable gravimeter used before and after the cruise was a LaCoste & Romberg Model G No. 260.



Figure 5: A) The ship-mounted gravimetric system. B) The gravimeter control unit. C) The gravimeter.

2.2.3 Acquisition system

For the ship mounted system, a Microsoft Windows application called KSS31 Data Access v.1.2.18 (see *Figure 8B*) was used to collect and monitor the gravimetric data, with a sampling interval of 5 seconds. All data was recorded in μgal .

The portable gravimeter was only used twice, once before the commencement of the cruise and once at the end of the cruise. Measurements were made at the pier in Kiel harbor, right in front of the mooring position of FS 'Alkor.' The resulting μgal values were recorded manually.

2.3 Single-beam parametric echo sounder and sub-bottom profiler

2.3.1 Acquisition system

Bathymetric data and sub-bottom profiles were collected using the SES-96 Standard (the same model is nowadays marketed under the name SES-2000 Standard, thus the remainder of the report will refer to the system by this name. See *Figure 8E*) from Innomar Technologie GmbH, Germany. The system consists of a Microsoft Windows PC unit running the software Simrad EK60, a transducer and an accompanying data cable. This system was a single narrow beam parametric sub bottom profiler system. Simrad is a sub-division of the Kongsberg Maritime AS company based in Norway. The following is a summary of the technical specifications of the system:

Transducer:	Nonlinear transmitter, linear receiver Beam width +/- 1,8° (0,22 x 0,22)m2
Transmitter:	Primary frequency: 100kHz Secondary frequencies: 4, 5, 6, 8, 10, 12, 15 kHz Electrical power: >18 kW Source level: >239 dB/ μPa re 1m Electronical beam Stabilization and beam steering
Pulse Width:	66 μSec to 800 μSec
Pulse Repetition Rate:	up to 50/sec depending on range
Water Depth Range:	1m to 500 m
Operating Ranges:	5m to 200 m
Sound Velocity Range:	1400 m/s to 1600 m/s
Penetration:	Up to 50 m depending on sediments and frequency
Resolution:	Sampling resolution: > 1 cm Multiple target resolution: > 5 cm Depending on frequency and operating range



Figure 6: The SES-2000 Standard transducer and accompanying data cable.

Accuracy:	100 kHz : 0,02 m + 0,02 % of water depth 10 kHz : 0,04 m + 0,02 % of water depth
Trigger:	Internal: depending on time control, output available External: input available, TTL compatible
Receiver Channels:	1 channel primary frequency 1 channel secondary frequency
Gain Controls:	AGC or manual 0 to 96 dB in 6 dB steps Time Variable Gain
Digitization:	16 bit (real dynamic 14 bit)
Signal Processing:	Noise reduction: stacking rate up to 64 DSP to increase signal to noise ratio, resolution and penetration, online view of processed echo data, replay of recorded data
Data Output:	Online storage of echo envelope in chosen range, online storage of raw signal in chosen range, system parameters and navigation data on hard disk backup: USB 2.0 interface for HD, MO-Disk or others Serial output for depth, time, position online Colour echo prints and thermal recorder prints
Data Input:	Serial input for navigation data (NMEA compatible) Serial input for motion sensor for heave compensation and roll/pitch compensation Remote control via TCP/IP network
System Components:	SES-2000 standard with integrated transmitter, receivers, DSP's, 10,4" TFT panel and integrated PC unit (0,53 x 0,42 x 0,49) m ³ weighing 49 kg Transducer with 30 m cable (0,25 x 0,35 x 0,08) m ³ weighing 31 kg (including cable)
Operating Conditions:	115-230 V AC +5%/-10%, 50 - 60 Hz, Power consumption < 1000 W Operating temperature: 0°C to 40 °C
Optional Features:	Water protected case in MIL standard Module Side Scan with separate transducer

2.3.2 Ship-board processing

On board, data was converted from the raw format to *.sgy format for later processing. Seperate profile sections were merged during this process. Other than that, the only steps taken were transfer of data to a safe location.

2.4 Magnetics

2.4.1 Equipment

The magnetometers (gradiometers) used were two SeaSPY (see **Figure 7**) which are manufactured in Canada by the company Marine Magnetics. The SeaSPY is an omni-directional magnetometer, capable of producing very good results regardless of the direction of the magnetic field. No alignment is necessary when surveying, regardless of course or location. As a rule of thumb, a magnetometer should be towed at sufficient distance from the ship, in order to avoid magnetic interference from the vessel. Thus one magnetometer was towed at a distance of about 250 meters, while the other was kept at a distance of 350 meters. By using two magnetometers, data can be calibrated according to the magnitude of interference present, and the results obtained will then have minimal errors. The SeaSPY, and the flotation cable used for towing and data streaming, have the following specifications:

<i>SeaSPY</i>		<i>Flotation cable</i>	
Absolute Accuracy:	0.1nT	Conductors:	Twisted pair
Sensor Sensitivity:	0.01nT	Strength Member:	Vectran
Counter Sensitivity:	0.001nT	Max Working Load:	2,500 kg
Resolution:	0.001nT	Outer Diameter:	1.9 cm
Dead Zone:	NONE	Bending Diameter:	25 cm
Heading Error:	NONE	Weight in Air:	125 g/m
Temperature Drift:	NONE	Weight in Water:	-20 g/m
Power Consumption:	1W standby, 3W maximum	Outer Jacket:	Orange Polyurethane
Timebase stability:	1ppm, -45°C to +60°C		Field Replaceable



Figure 7: A SeaSPY magnetometer being deployed.

Cable Termination:

Range:	18,000nT to 120,000nT
Gradient Tolerance:	Over 10,000nT/m
Sampling Range:	4Hz — 0.1Hz
External Trigger:	By RS-232
Communications:	RS-232, 9600bps
Power Supply:	15VDC-35VDC or 100-240VAC
Operating Temperature:	-45°C to +60°C
Temperature Sensor:	-45°C to +60°C, 0.1 step

2.4.2 Acquisition system

Data was acquired on a PC running Microsoft Windos, through the application SeaLINK (see **Figure 8A**), which provided an interactive text and real-time data plot interface displaying the data streaming in from the magnetometers. Data was recorded and viewed in nanotesla. It was possible to adjust the vertical and horizontal scales of the data plots, a feature that makes it easier to visualize the magnetic anomalies being measured and recorded.

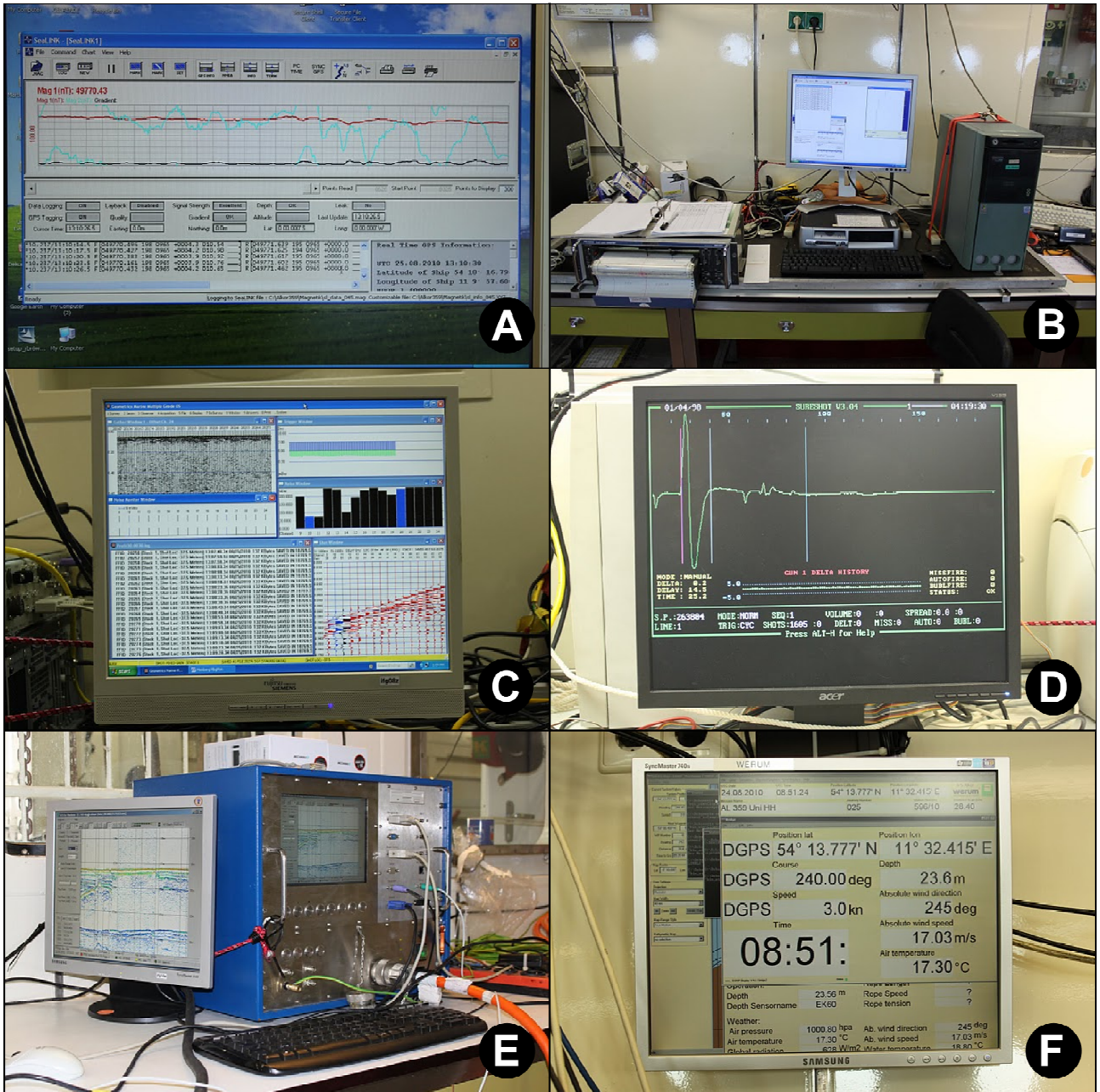


Figure 8: A) SeaLINK magnetic data console. B) KSS31 Data Access v.1.2.18 gravimetric data console. C) Geometrics Marine Multiple Geode OS console. D) SureShot v.3.04 gun control console. E) SES-96 Standard console. F) The ship's internal navigational data screen.

3 Results

3.1 Data examples

At the time of submission of this report, only preliminarily processed reflection seismic profiles with the GI-Gun as seismic energy source were available, so a few examples of those are included. Unfortunately, magnetic and gravimetric data examples, as well as the bathymetric/sub-bottom profiles will be omitted.

3.1.1 Reflection seismic profiles

See the overview map in *Figure 1* for the location of the profiles displayed in this section.

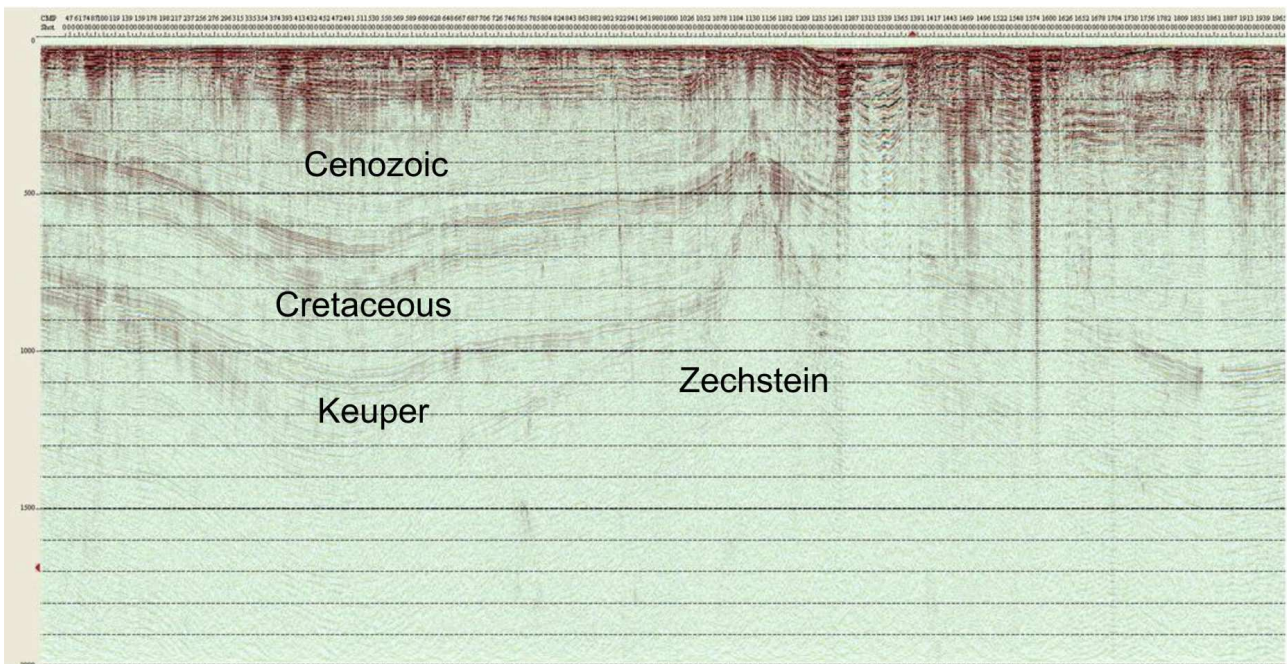


Figure 9: Alkor-HH10_1a.migtk. Reflection seismic profile shot with GI-Gun along profile 1a.

In *Figure 9*, various structural elements are present, as well as some examples of velocity pull-up/down which may occur due to a variety of factors, one being biogenic activity in the sediments causing gas to be present. Multiples of reflections are also seen. The data can be used to develop an understanding of the glaciotectionic evolution of the area, amongst other interesting research topics possible with high resolution shallow seismic profiles of this sort.

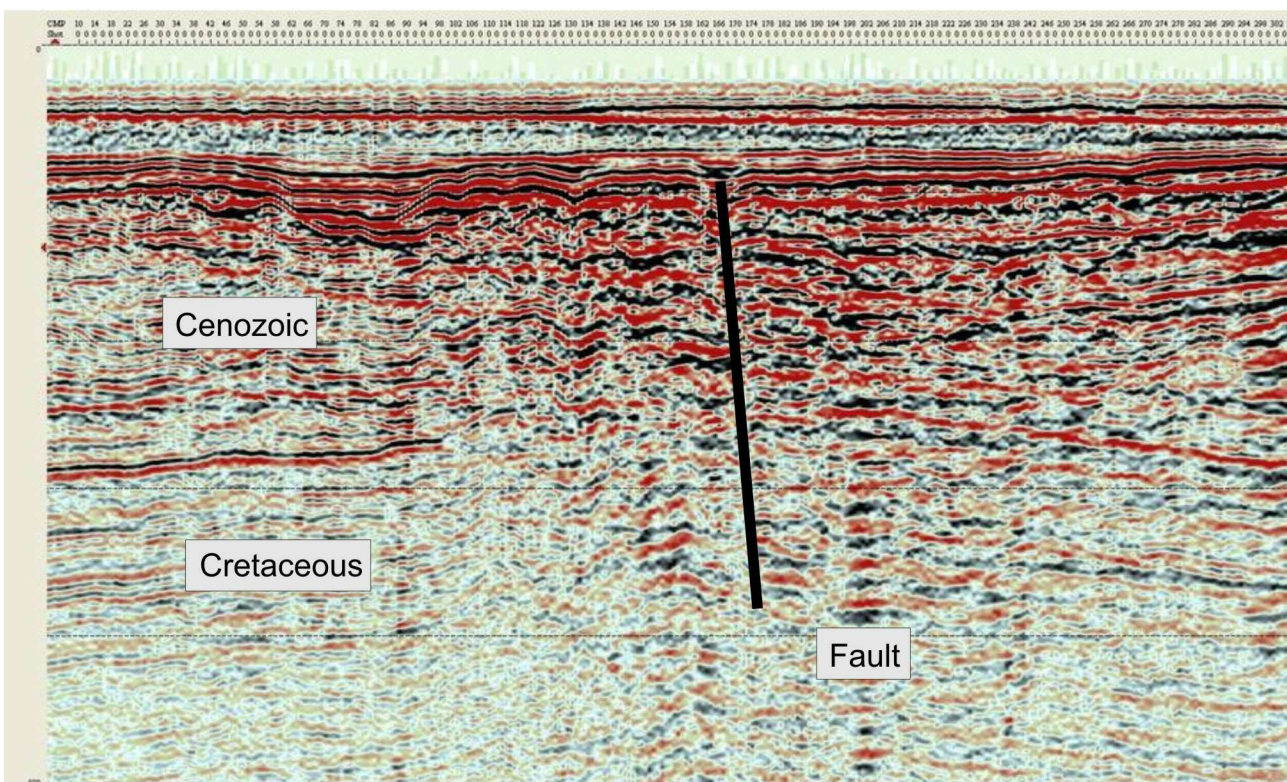


Figure 10 exemplifies the high resolution of the reflection seismic data within the uppermost sediment layers. With existing data from the NeoBaltic seismic grid, and with the newly collected data from the shallow near-coastal areas which were not surveyed previously, the marine territories are well covered, which makes it possible to make a comprehensive analysis of the geological history of the area.

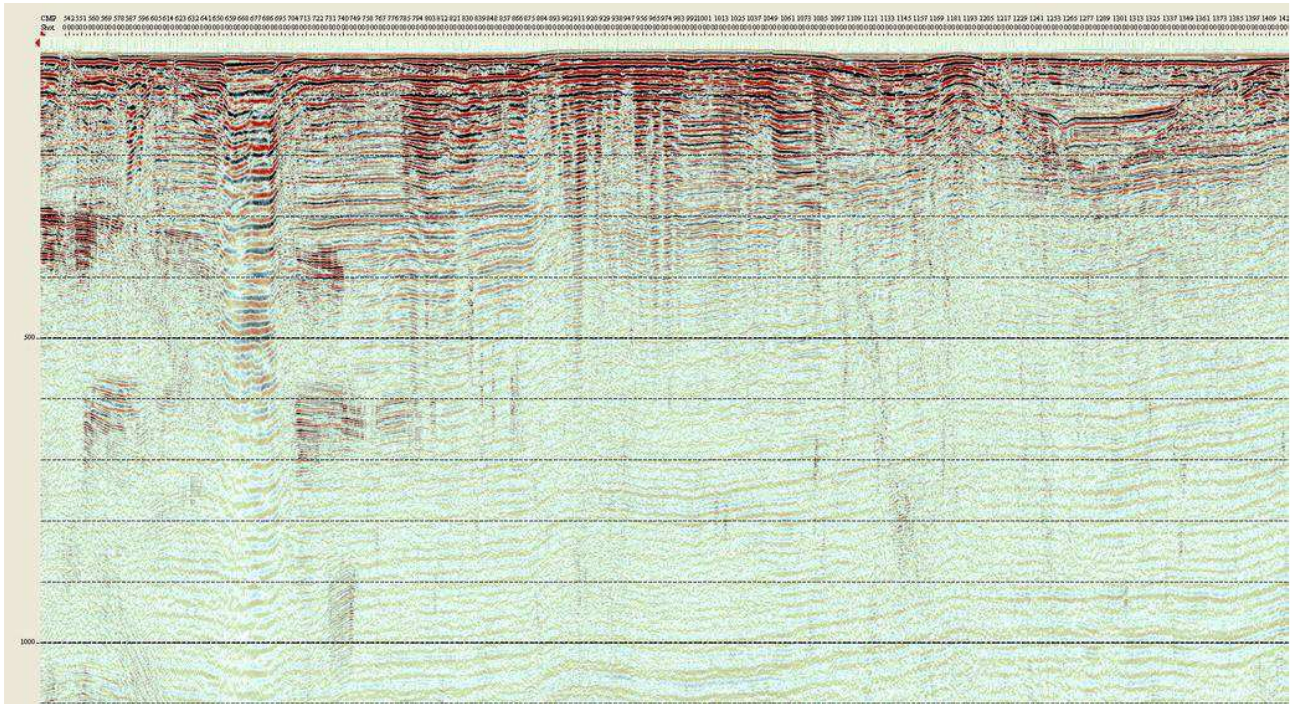


Figure 11: Alkor-HH10_27.migtk. Reflection seismic profile shot with GI-Gun along profile 27.

In **Figure 11** various elements are present, such as a large channel and multiple velocity pull-downs. This once again exemplifies the potential for the data to be used as grounds for a detailed sequence stratigraphic analysis of the uppermost sediment layers and as an indicator for the presence of gas and fluids.

Common for the seismic profiles is that the data rarely covers areas deeper than 500-750 ms TWT in very much detail, and as such they are mostly viable for studying the geological evolution within the Quaternary period. A greater depth may be obtained by firing the gun/sparker at longer intervals. Nonetheless, getting greater depth coverage was not the purpose of this cruise, but it is, however, possible together with the refraction seismic data collected, to study deeper lying deposits such as the Zechstein salt, and eventually draw conclusions as to the effect of the underlying salt dynamics on the uppermost sediment layers.

An instance from the wide-angle reflection / refraction experiment is shown in Figure 12. The identified diving wave from the Zechstein salt has an apparent velocity of ca. 5 km/s.

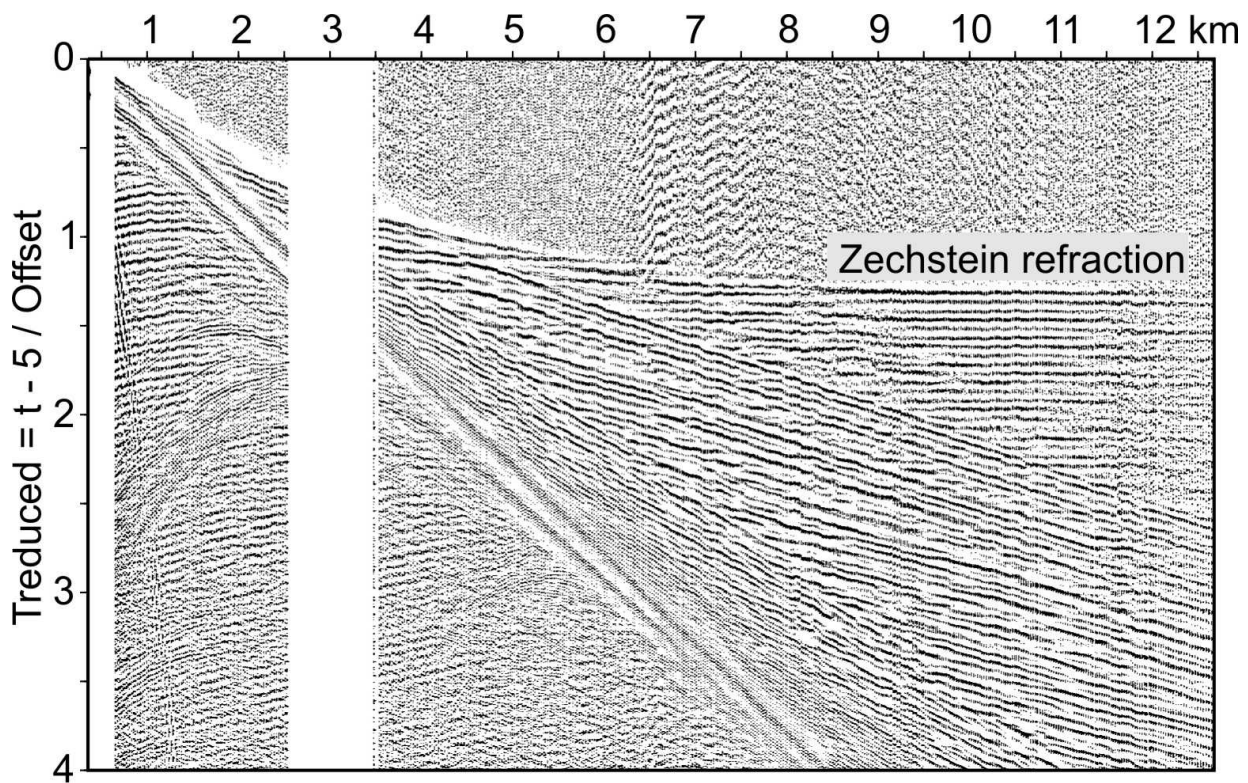


Figure 12: Wide-angle reflection / refraction recording showing refracted phase from Zechstein salt.

4 Further data processing and analysis

The seismic and hydroacoustic data will be processed and interpreted in the following courses: “Seismic interpretation” (BSc) and “Seismic data processing” (MSc).

Gravity and magnetic data will be processed and interpreted in the course “Processing of marine gravity and magnetic data (BSc. and MSc.)

5 Acknowledgments

We would like to thank captain and crew of FS 'Alkor' for the outstanding support throughout the cruise. We would also like to thank Lars Ole Boldreel at the Institute for Geography and Geology, University of Copenhagen, for his support and Jonas Zilmer Johansen for this report.