RV Alkor/ Al 393

Cruisereport

1rst – 7th June 2012

Institute of Geosciences
Sedimentology, Coastal- and Continental Shelf Research
Christian-Albrechts-University, Kiel

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Kiel, August 2012

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Contents

1 List of participants

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All participants are working /studying at the Institute of Geosciences (IFG), Sedimentology, Coastal- and Continental Shelf Research of the Christian-Albrechts-University, Kiel.

All times and dates are given as UTC.

Used short forms:

SSS: Side Scan Sonar
SES: Sediment Echo Sounder
ADCP: Acoustic Doppler Current Profiler

2 Introduction

The cruise Al 393 from the 1st to the 7th March was organized as a cruise for Master students of the Marine Geosciences Master at the CAU Kiel. Different hydro acoustic devices, sampling methods (grab sampler and vibro corer) such as water column investigations were introduced and operated on the research vessel Alkor. The former goal to go to the North Sea had to be canceled due to bad weather conditions. Instead, after one tidal cycle in the Elbe, the Alkor headed back into the Baltic Sea and investigations were done in the area of the Wattenberg channel in front of Schleimünde. Hydro acoustic methods were used to map the region and specify sampling stations for the grab sampler, the vibro corer and video profiles (Fig.1).

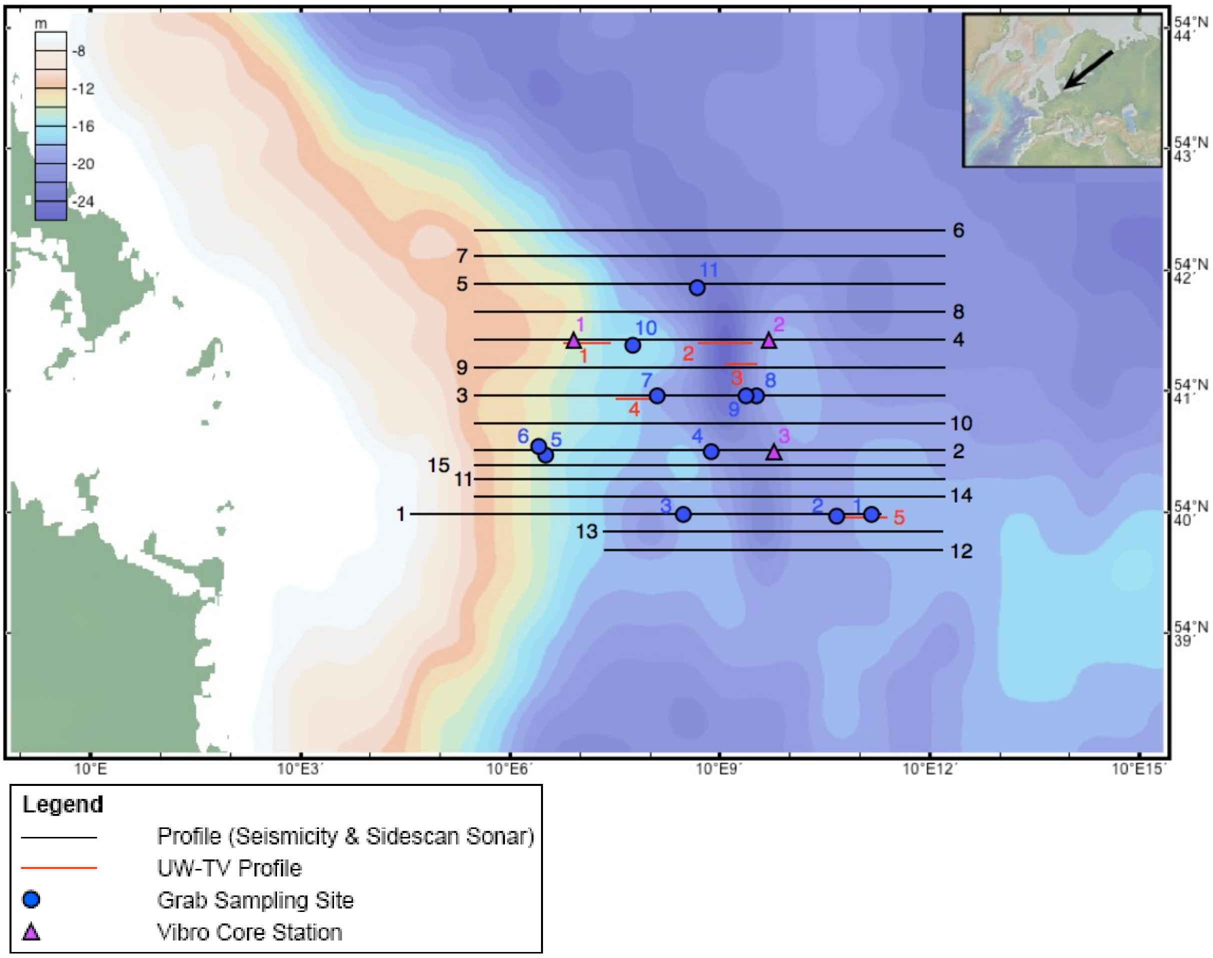

Fig.1: Survey Map of AL393 including all sites of data acquisition throughout the cruise (Bathymetrical Data: Global Multi-Resolution Topography (GMRT), as hosted by NSF & IEDA)

3 Geological setting

3.1 Elbe

The oldest traces of the fluvial topography of the river Elbe can be dated back to the Mesozoic but first reliable evidence originates from the tertiary. As a response to the climate change at the tertiary/quaternary boundary and its associated sea level regression, the river extended its valley to what is nowadays the Netherlands.

The most important stage of geomorphologic development for the Elbe however was the Quaternary especially the Elster-, Saale- and Weichsel-glacials and the associated warm periods “Holstein” and “Eem”. Glacial and fluvioglacial forces have repeatedly changed the river valley of the Elbe and its tributaries in the past.

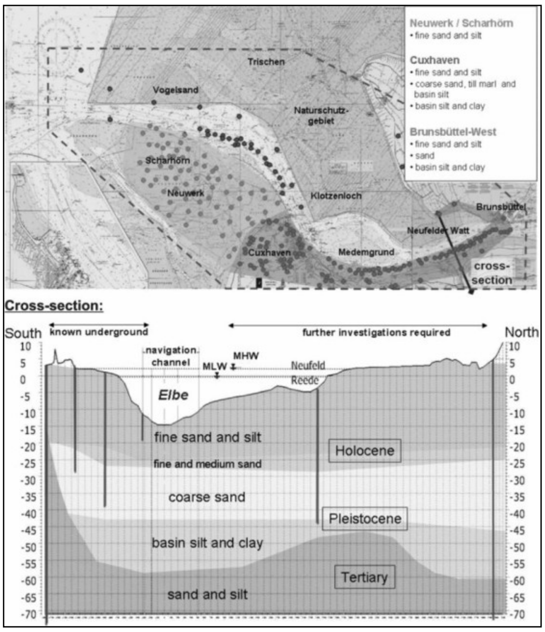

Fig.2: Cross-section of the Elbe (STROTMANN,2008)

During the Elster glacial the glacial advance was the strongest compared to the following ice ages. The ice shield almost covered the whole Tideelbe and Middle Elbe. In the end of the glacial two independent drainage channels were formed one called the “Saale-Mulde system” the other named “Elbe system”. The two independent drainage channels unified during the Saale glacial and in the end established more or less the actual river valley we can observe today.

During the Weichselian there was only a moderate extension of the ice shield in southern direction. Though also the melt water amount was not that big and as a consequence accumulation of sediment took place. Boulders, gravel and sand got deposited in the river valley and to some extend filled it up. Later on during another period of high melt water amounts the river incised its bed again but did not erode it completely. The remnants of this erosion event are called “Niedeterrassensande” and still can be found in a 100 m to 10 km broad strip on both sides of the Elbe. During the latest glacial stage many tributaries developed and today’s sinuosity started to occur. In figure 2 a cross section of the Elbe is shown. Today we can subdivide the Elbe into the *Upper Elbe*, *Middle Elbe* and *Tideelbe*.

3.2 Baltic Sea

The Baltic Sea was mainly formed during and after the last glacial period the Weichselian (115 – 12 ka BP). Progressing and retreating ice fronts shaped the basin with high regionally varieties in the morphology. When the ice was retreating after the last glacial maximum 26.5 ka to 19 to 20 ka (Clark et al., 2009) around 14 the Baltic Ice Lake formed out of meltwater and river inflow (Niedermeyer et al., 2011). The Scandinavian landmass dealed as a barrier to the open ocean, whereas there was a small outflow through the Öresund (Björck, 2008). Due to the isostatic uplift of Scandinavia the water level was about the global sea level. The Ice Lake extended more to the west and in the Younger Dryas the water level dropped by 25 m (Niedermeyer et al., 2011) and an exchange with the salty world oceans was possible. The Yoldia Sea was formed. The connection to the world ocean via middle Sweden was closed by the proceeding uplift and the Ancylus Lake formed around 9.2 ka BP (Niedermeyer et al., 2011) (Fig 3). The Ancylus Lake was influenced by several transgressions and regressions resulting in the Littorina Sea and marine conditions established in the western part around 8 ka BP (Niedermeyer et al., 2011). The brackish water conditions in the Baltic Sea are a result of the reduced water exchange with the North Sea caused by the shallowing of the connections due to ongoing uplift.

Fig. 3: Freshwater Ancylus Lake at 9.2 ka BP (Björck, 2008)

4 Cruise Narrative

1rst June 2012

weather: Cloudy , wind 1.7-11m/s

06:00 Departure to the North Sea via Kiel Channel

16:00 Start water sampling in Elbe Estuary with CTD and Niskin Bottle in half hour steps

2nd June 2012

weather: Cloudy , wind 3-4 bft
00:00 continuing water sampling
17:00 End of water sampling

3rd June 2012

weather: NW wind, 4-5 bft, cloudy, wave height 0,3 m
04:00 Entering the channel towards the Baltic Sea
12:00 Reaching the survey area
12:45 Launching the devices into the water
13:50 Start of profile 1 (SSS, SES)
14:30 Start of profile 1 (Boomer)
19:30 End of profiling, SSS and Boomer on deck

4th June 2012

weather: NW wind, 3-4 bft, overcast, rain
06:00 Grab sampling stations (1-11)
12:00 continue profiling with SSS, Boomer, SES
19:30 end of profiling, SSS and Boomer on deck

5th June 2012

weather: W wind, 3 bft, overcast
06:00 vibro core stations 1-3
12:00 core description
14:30 profiling with SSS, SES and Boomer
19:30 end of profiling, SSS and Boomer on deck

6th June 2012

weather: W wind, 4,7 bft, cloudy
06:00 video profiles 1-3
10:00 profiling with SSS, SES and Boomer, sieving of grab samples
19:30 end of profiling, SSS and Boomer on deck, end discussion

7th June 2012

weather: W wind 4.7 bft, cloudy
06:00 clean-up of cabins and laboratories
08:00 docking in Kiel, control by customs, removal of university equipment off of the ship

5 Equipment

5.1 Sediment –Echo-Sounder

The Innomar SES-2000 is operated hull mounted on the vessel FS Alkor, using non-linear (parametric) acoustics. It is comparable with bathymetric systems, as a single-beam echo sounder.

Sound pulses are emitted straight to the bottom and reflections of the seafloor surface, sediment layers and obstacles inside the sediments are received.

This parametric system bases on the transmission of two slightly different high frequencies with high energy levels, which results in a non-linear sound propagation. This is due to the fact, that the density of water, which is related to the sound velocity, behaves non-linear by high pressure changes. The two high main frequencies (around 200 kHz) interact with each other and rise new frequencies. Those are low enough to penetrate the seafloor. Both main primary frequencies are reflected back at the seafloor and provide bathymetric information.

5.2 Boomer

Boomer seismic is widely used for soft sediment, but although for sediment structures and obstacles.

It consists of two units: The source, which is placed on a catamaran (Fig.4) and the streamer.

To form the signal an aluminium plate separates suddenly from a copper coil embedded in an epoxy resin. The rapid discharge of a capacitor causes eddy currents, induced in the aluminium plate, which produce a rapid repulsion and a cavitation volume in the water. There are two pulses. The first one is due to the rapid outward acceleration of the aluminium plate. The second pressure pulse is formed by the implosion of the cavitation volume.

Fig. 4: Boomer Catamaran (Photo: Joost Thielsen)

A broad band of pulses is produced. Pulse lengths of 0.1-0.2 ms are capable for shallow water environments. Within this range they are able to resolve reflectors in a distance of less than 0.3 m. (Jones, 2004)

5.3 Side Scan Sonar

The Benthos C3D side scan sonar (Fig.5) was used for this cruise. Side Scan Sonars efficiently create images of large areas of the sea floor. The swath width can be changed from a few tens of meters up to 60 km, which enables it to cover areas of 10 km^2 to 20.000 km^2 per day.

Frequencies from 5kHz up to 1MHz might be used depending on the area and on the target

Fig.5: Benthos C3D (Photo: Joost Thielsen)

goal being mapped. The higher the frequency used, the higher the resolution. Side Scan Sonars can be applied in many different fields due to their differences in characteristics, like for example geology, archeology and in the military to detect sea mines. It provides an understanding of the differences in material and the texture of the seabed. It uses the backscatter of acoustic waves to make out those differences. The backscatter might change due to a variation in angle or material (f.e. grainsize). As it is dragged behind the ship it cannot be used as a bathymetrical device, because the height might have to be changed depending on the depth of the watercolumn and because of its own movements: heave, roll, pitch and yaw.

5.4 Acoustic Doppler Current Profiler

Fig. 5: ADCP (Photo: Elda Miramontes Garcia)

An Acoustic Doppler Current Profiler (ADCP) is a type of sonar that measures and records water current velocities over a range of depths.

An ADCP transmits sound pings (explosion) into the water column. Suspended particles “backscatters“ carried by water currents produce echoes which are “heard” by the ADCP. Echoes arriving later, from deeper in the water column, are assigned greater depths in the echo record. This allows the ADCP to form vertical profiles of current velocity. The ADCP senses in four orthogonal directions simultaneously. Particles within the current flow moving towards the instrument exhibit different frequencies from those moving away. This is the famous Doppler shift, which enables precise measurement of current speed and direction. When the ADCP is mounted in a moving vessel, the information obtained is used to measure water current speed, vessel speed and direction, and also distance above the sea bed. The ADCP also shows the distribution of suspended material.

When the ADCP is mounted on the seabed to look upwards it measures current velocity and direction and the direction of waves.

5.5 Niskin Bottle

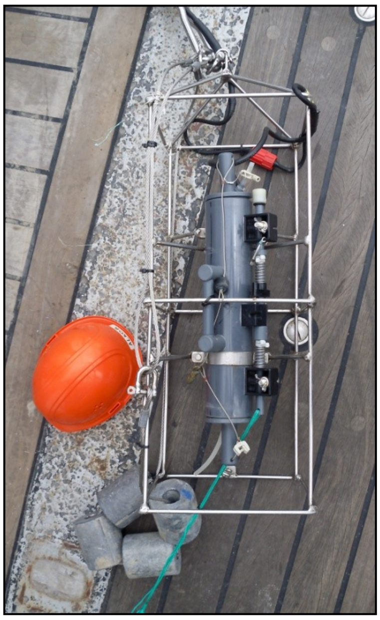

Fig. 6: Niskin Bottle (Photo: Joost Thielsen)

The Niskin bottle is a cylinder made of plastic with stoppers at each end that are held open by plastic cords which are connected to a release mechanism. The stoppers themselves are connected by an elastic cord inside of the bottle. For the use with a hydrographic line two clamps are on the side of the cylinder. With this line it could be lowered to a certain depth and with a release mechanism the sampling could be activated. During the release the stoppers are being pulled into the ends of the cylinder and thereby trapping water from the sampling depth. Niskin bottles are also often used attached to a so called rosette (Carousel Water Sampler). The general function thereby is the same like in the cast with a hydrographic line. A release mechanism (AFM – Auto Fire Module), fixed on the rosette and connected to the bottles, closes the bottles in preliminarily programmed water depth. With the necessary programming knowledge the use of Niskin Bottles in connection with a rosette is a relatively easy way to get water samples of different water depth. During the cruise a so called CTD (Conductivity Temperature Depth) was also fixed on the Niskin bottle to measure standard values like depth or temperature and was complemented with a transmissiometer sensor for measuring turbidity. The release was thereby controlled through a weight hanging one meter below the device that started sampling in the moment of bottom contact.

5.6 Grain Size Analyzer

The grain size of the suspended matter was measured with the Particle grain size and shape analyser of L.O.T. Gmbh, Version 4.30, February 1993. We measured the grain size of natural suspended particles, the samples did not suffer any treatment after being taken from the water, and also of samples that were treated with ultrasound during six minutes. The aim of the ultraound is to break the flocks and obtain the individual particles.

The analyser contains a laser that goes through the sample and moves in a circular trajectory. The laser cannot go through the solid particles, so the laser does not reach the sensor and the particles form a shadow. The instrument measures the time that the shadow lasts. The grain size is calculated with this time and assuming that all the particles have a spherical shape.

5.7 Grab sampler

Throughout AL393 a bucket grab system was employed to retrieve samples from the sea floor at nine different locations (Map, Fig.1) in 14 overall attempts. The operating system is constructed according to HELCOM Guidelines for the retrieval and disposal of dredged material at Sea (adpt. 2007).

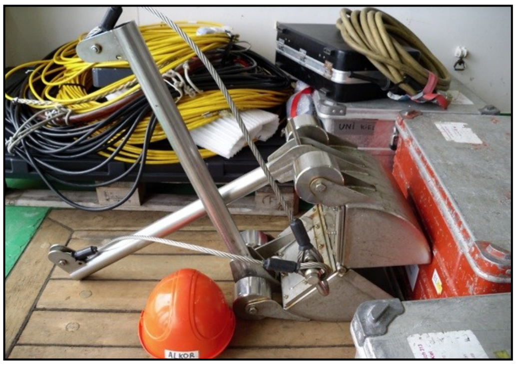

Fig. 7: The bucket grab sampler aboard R/V Alkor(Photo: Joost Thielsen)

5.8 Vibro Corer

In the course of AL393 a vibro corer was employed in order to retain three samples from sediment covered locations in the Baltic Sea (s. map, Fig.1, for locations). The equipment in use comprised a VK200 Vibro-Coring System that was heaved and launched starboard-sided from R/V Alkor.

Fig. 8: Lift Tower with VK200 Vibro Coring System aboard R/V Alkor (Photo: Joost Thielsen)

The embraced advantages of operating a vibro coring system are its subtle mode of penetration into shallow marine sediments and a high grade integrity of the cores taken. It works best on unconsolidated material of small to medium grain sizes, just as expected in the sampling area of AL393.

The core tube is driven into the sediment by the force of gravity, enhanced by vibration energy (created by the vibrator motor at the top of the tube). The steel tubes are 3 meters long and 10x10 cm width. The sediment sample is hosted directly into the steel tube. The vibrocore has a prismatic structure that keeps the tube stable and straight.

4.9 Underwater video camera

For observing the sediment surface and to prove the assumptions made by the sidescan data, some video surveys were made with the underwater video system Mariscope. Just towed by hand at the side of the vessel while drifting, it is an uncomplicated system. A lamp allows to record with a good quality, even in low light environments. The data is directly transmitted to a computer, using the software 'Cinergy 200 USB EM'.

6 Scientific Summary

In the final discussion the results of all working groups are shortly summarized and an overall view is presented.

As the first part of the cruise was located in the Elbe estuary and dominated by completely different environmental conditions the results of the water column group are presented separately. The most important result thereby was the connection of sediment suspension with dynamics in the tidal cycle in the Elbe estuary. The SPM concentrations were slightly higher during the flood phase than the ebb phase which was in contrast to results of KAPPENBERG & FANGER 2007 where the ebb phase has shown highest SPM concentrations. Due to a different location, more asymmetric waves upstream and anthropogenic changes in the last 19 years this does not have to be a conflict. While the sediment concentration was in clear correlation to the tidal cycle grain sizes seemed to be related to stream velocity and period of a certain velocity. Finally measured temperature profiles have shown typical warm season conditions and in combination with salinity profiles the Elbe estuary could be identified as partially mixed estuary at the beginning of June.

The results of the sediment working group, especially the vibrocore data, gave an impressive overview of the geological development of the Baltic Sea in this area, although some assumptions due to a limited number of samples had to be made. So besides glacial till and recent marine sediments which were obviously influenced by storms former sediments of pelagic/limnic origin were found. These sediments represent different stages of the typical transgressional and stagnating conditions in the Baltic Sea history in the last 16ky. Sharp borders between limnic and marine facies might be accounted to the Littorina transgression around 8 ka BP.

The results of the grab sampler stations were in good agreement to the results of the sidescan sonar group results which were dominated by a clear change to finer sediments in the obvious channel structures (s. Fig.9). So recent sediment transport and distribution in the working area seemed to be primarily influenced by these channel structures and thus different pronounced current systems.

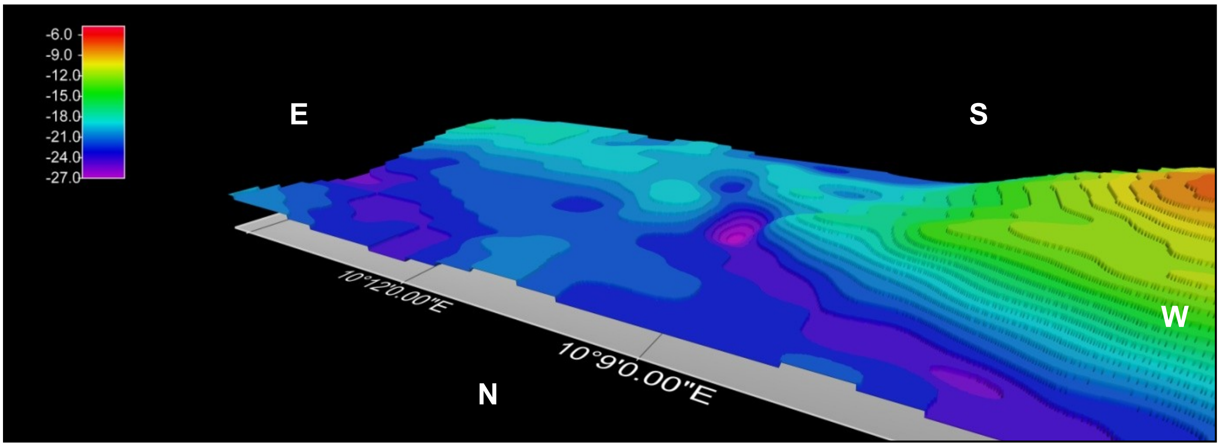

Fig. 9: Two distinct channel-like structures merging in the surveyed area of AL393 off the North-Eastern coast of Schleswig-Holstein (Vertical Exaggeration: 60, Bin Size: 100m | Bathymetrical Data: Global Multi-Resolution Topography (GMRT), as hosted by NSF & IEDA)

The seismic data was essential to choose the vibrocorer sites. All cores were taken in, or at the margin of filled channel like structures. It is possible to see different strata which can be found in the cores as well. Another phenomenon is the gas effect, which can be frequently seen in the SES and Boomer data. Usually gas originates by decay processes of organic material.

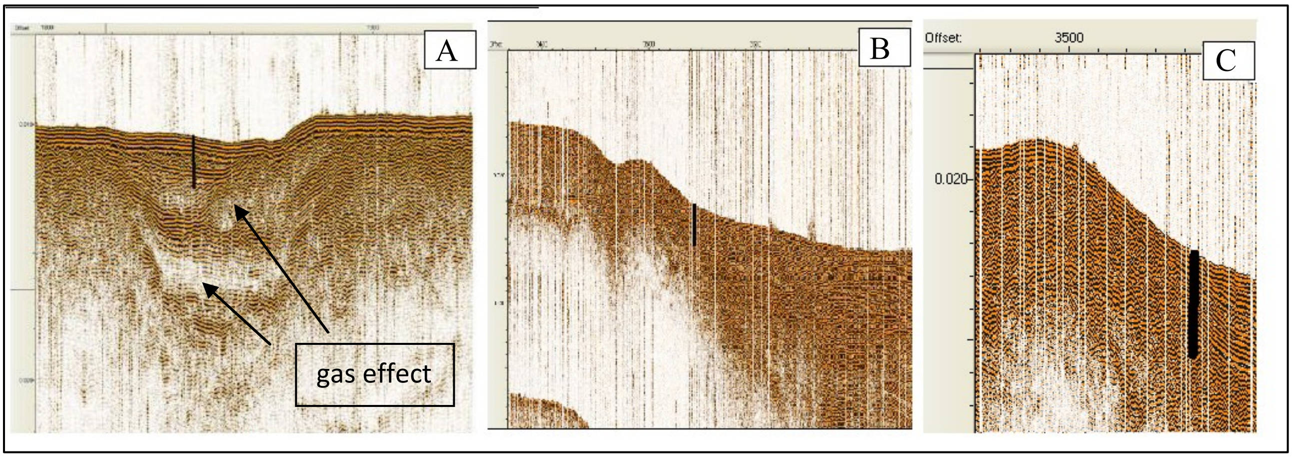

Fig. 10: All three vibrocore stations in the respective SES profile. A: 050612_1; B: 050612_2; C: 050612_3. The penetration depth of each core is around 2 and 3 m. Further down in the sediment, gas effect can be clearly seen. Especially in profile A.

In the sidescan data regions of alternating shade could be found, which were an indicator for heterogeneous surface grain size distribution and morphological textures at the seafloor. This heterogeneous surface grain size distribution also was obvious in the grab sampler data. In the working area different regions of higher interest were found where for example especially low backscatter values or throughout large distances very heterogeneous patterns of backscatter which position coincides with the westerly increasing slope of the sea floor towards the coastline of the Schleimünder Seegatt were visible. Throughout the sidescan data also several smaller scaled features identified as stones, cavities or spacious assemblages of mussels and other biota could be found which were also present in the samples of the grab sampler in these locations.

7 Acknowledgement

Special thanks go to the captain and the crew of the RV Alkor, such as to Helmut Beese who enabled the proper implementation of the cruise. We also wish to thank Dr. Klaus Schwarzer and Dr. Klaus Ricklefs for providing the opportunity to experience scientific working on a vessel with different kind of devices and methods.

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9 Appendix

Table 1: Grab sample stations

Sample	Lat./Long.	Depth [m]	Description
040612_01	54°39,981'/ 10°11,099'	23,60	Mud, 2 horizons, very few shells
040612_02.a	54°39,907'/ 10°10,906'	21,90	boulder covered with sandy mud, grab sampler not closed
040612_02.b	54°39,917'/ 10°10,925'	21,88	Till, grab sampler not fully closed
040612_02.c	54°39,892'/ 10°10,927'	21,78	Till
040612_03.a	54°39,950'/ 10°08,461'	19,70	peat, coarse material, grab sampler not fully closed
040612_03.b	54°39,968'/ 10°08,471'	18,80	2 horizons, sand, gravel, living mussels
040612_04.a	54°40,481'/ 10°08, 777'	19,24	boulder, fine sand, red algae, garb sampler not closed
040612_04.b	54°40,470'/ 10°08,766'	19,22	2 horizons,shell fragments, boturbation, fine sand
040612_05	54°40,426'/ 10°06,433'	16,00	ripples, shell fragments, medium sand gradually progressing to coarser material
040612_06	54°40,480'/ 10°06,408'	14,90	mussles, gravel, red algea medium to coarse sand, flint
040612_07.a	54°40,950'/ 10°07,979'	18,44	flint stone, grab sampler not closed
040612_07.b	54°40,963'/ 10°08,021'	18,50	flintstones, gravel, grab sampler not closed
040612_07.c	54°40,987'/ 10°08,024'	18,42	shell fragments, medium sand, fine gravel, grab sampler not fully closed
040612_08	54°40,964'/ 10°09,566'	31,63	shell fragments, anoxic, silt, small amount of clay
040612_09	54°40,957'/ 10°09,369'	22,48	sandy silt, pebbles, clay
040612_10.a	54°41,429'/ 10°07,712'	16,86	grab sampler not closed
040612_10.b	54°41,396'/ 10°07,712'	16,10	algea, fine to coarse sand, grab sampler not closed
040612_10.c	54°41,409'/ 10°07,714'	16,64	big boulder, red algae, grab sampler not closed, no sample taken
040612_11.a	54°41,904'/ 10°08,725'	17,40	closed, but not filled
040612_11.b	54°41,909'/ 10°08,698'	17,34	Sea urchant, boulder, red algae, medium sand, grab sampler not fully closed

040612_11.c	54°41,914'/ 10°08,721'	17,40	medium sand, fine sand, clay, shell fragments, stones with red algae

Table 2: Video Profiles

	Start			End		
Profile	**Lat./Long.**	**Time [h]**	**Depth [m]**	**Lat./Long.**	**Time [h]**	**Depth [m]**
060612_01	54°41,475'/ 10°06,861'	7:04	16,09	54°41,465'/ 10°07,757'	7:34	15,58
060612_02	54°41,483'/ 10°08,788'	7:54	20,40	54°41,490'/ 10°09,565'	8:58	21,36
060612_03	54°41,221'/ 10°08,996'	9:16	22,24	54°41,208'/ 10°09,161'	9:33	25,87
060612_04	54°40,923'/ 10°07,750'	10:11	17,41	54°40,910'/ 10°08,190'	10:28	18,69
060612_05	54°39,839'/ 10°11,131'	10:56	22,42	54°39,843'/ 10°11,489'	11:06	23,63

Table 3: Vibro Core stations

Sample	Lat./Long.	Waterdepth [m]	Penetration Depth [m]	Gain [m]
050612_01	54°41,449'/ 10°06,905	15,82	1,60	1,37
050612_02	54°40,445'/ 10°09,662'	24,35	2,35	2,30
050612_03.a	54°41,442'/ 10°09,959'	24,38	3,00	0,00
050612_03.b	54°41,448'/ 10°09,515'	27,48	2,70	2,34