IFM-GEOMAR REPORT

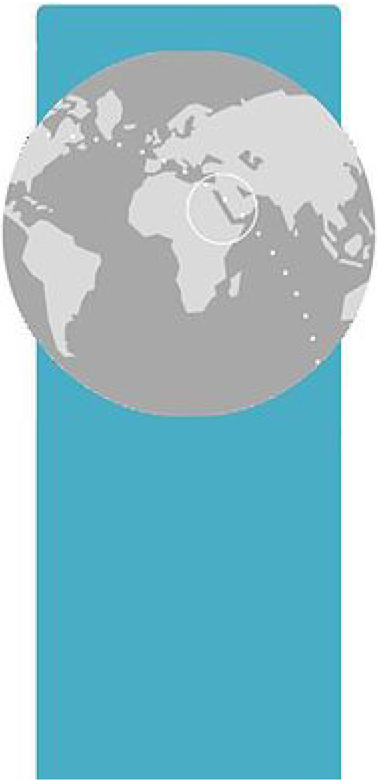
IFM-GEOMAR

Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

FS POSEIDON
Fahrtbericht / Cruise Report
P408

- The Jeddah Transect -

Jeddah - Jeddah, Saudi Arabia
13.01.–02.03.2011



Berichte aus dem Leibniz-Institut
für Meereswissenschaften an der
Christian-Albrechts-Universität zu Kiel

Nr. 46

August 2011

IFM-GEOMAR
Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

FS POSEIDON Fahrtbericht / Cruise Report P408

- The Jeddah Transect -

Jeddah - Jeddah, Saudi Arabia
13.01.–02.03.2011

Berichte aus dem Leibniz-Institut
für Meereswissenschaften an der
Christian-Albrechts-Universität zu Kiel

Nr. 46
August 2011

ISSN Nr.: 1614-6298

IFM-GEOMAR
Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

Das Leibniz-Institut für Meereswissenschaften
ist ein Institut der Wissenschaftsgemeinschaft
Gottfried Wilhelm Leibniz (WGL)

The Leibniz-Institute of Marine Sciences is a member of the Leibniz Association (Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz).

Herausgeber / Editor:
M. Schmidt, C. Devey, A. Eisenhauer and cruise participants

IFM-GEOMAR Report
ISSN Nr.: 1614-6298

Leibniz-Institut für Meereswissenschaften / Leibniz Institute of Marine Sciences
IFM-GEOMAR
Dienstgebäude Westufer / West Shore Building
Düsternbrooker Weg 20
D-24105 Kiel
Germany

Leibniz-Institut für Meereswissenschaften / Leibniz Institute of Marine Sciences
IFM-GEOMAR
Dienstgebäude Ostufer / East Shore Building
Wischhofstr. 1-3
D-24148 Kiel
Germany

Tel.: ++49 431 600-0
Fax: ++49 431 600-2805
www.ifm-geomar.de

Part A: Cruise Report of R/V POSEIDON cruise P408/1

Table of Contents

RV Poseidon Cruise No.: 408-1
Dates, Ports: 13 January 2011 (Jeddah) – 31 January 2011 (Jeddah)
Research subject: Red Sea Deeps, mapping, volcanology, sediment and brine formation
Chief Scientist: Prof. Dr. Colin W. Devey, IFM-GEOMAR, Kiel
Number of Scientists: 9 + 1 Saudi Military Observer
Project: Jeddah Transect

Scientific Crew

Name	Affiliation
Al Yousef, Saad	Ministry of Petroleum and Mineral Resources, Riyadh
Augustin, Nico	IFM-GEOMAR, Kiel
Bantan, Rashad	Marine Geology Dept. FMS, KAU, Jeddah
Devey, Colin	IFM-GEOMAR, Kiel
Haredy, Rabea	Marine Geology Dept. FMS, KAU, Jeddah
Kotob, Abdulnasser	Saudi Geol. Survey, Jeddah
Kwasnitschka, Tom	IFM-GEOMAR, Kiel
Laurila, Tea	Univ. Ottawa, Canada
van der Zwan, Froukje	IFM-GEOMAR, Kiel

Left to right: Bantan, Devey, Yousef, Kotob, Kwasnitschka, Hazemi, Augustin, Haredy; (Seated) van der Zwan, Laurila

1. Introduction

Colin Devey

While the cruise was initially aimed at studying the flow paths of hydrothermal circulation in the crust of the Red Sea (and especially the Atlantis II Deep), problems in obtaining the work permission from the Sudanese authorities led to a re-alignment of the cruise aims and we decided to look at the tectonic and magmatic development of Red Sea deeps. Two deeps in particular were targeted in accessible areas - the Hatiba and Port Sudan Deeps. With a program of high-resolution mapping and extensive geological sampling we were able to achieve a good overview of the geological development of a Red Sea Deep. Sedimentation and consolidation of the sediments would seem to occur very quickly, with even very clear volcanic seafloor forms quickly becoming sealed to sampling of basalts by dredging and returning carbonate crusts instead. In total over 4000 km^2 of seafloor were mapped with 30 m resolution, and over 60 sampling stations were occupied.

2. The Geological Setting of Red Sea Deeps

Tea Laurila

The Red Sea is a 2000-km-long and 250-450-km-wide basin created by continental rifting. Rifting of the Red Sea was preceded by massive and rapid (1.5 M.y.) eruption of flood basalts in Ethiopia and Yemen at around 30Ma [*Cochran*, 2005]. An episode of rift-parallel diking occurred along the whole Red Sea between 21-24 Ma. Volcanic activity occurs to the present day on land both in the Afar region (Ethiopia) and in the Harrats - small volcanic centres on the Arabian side of the Red Sea. In the middle of the Red Sea there is a shallow and wide main trough and deep (up to 2.5 km) narrow segmented axial trough. Within the narrow axial trough, deeps of more than 2000 meter occur, some of which are filled with (high temperature) brines. Stratigraphically the margins are underlain by continental basement of the Arabian or African plate. This basement is overlain by a thick sequence of Miocene evaporites which themselves are covered by younger pelagic sediments. In the centre of the Red Sea in areas where true seafloor spreading has begun the seafloor is composed of basalts with no evaporite cover.

The Red Sea rift zone reaches from approximately 17° N to 28° N; corresponding rifting rates vary from ~1.5 to 0.5 cm/year. The Red Sea rift formerly continued into the Gulf of Suez but ceased there when the Dead Sea transform became active [*Cochran*, 2005]. The recent seafloor spreading started near 17°N, ~5 Ma ago [*Cochran*, 1983]. From this position to about 19.5°N, a clear mature spreading centre is de veloped. Between 19.5°N and 23°N the spreading centres are separated from one another by areas of seafloor where no active oceanic crust formation is evident - a situation termed "discrete spreading cells". by Cochran [*Cochran*, 2005] It is within these cells that many of the deeps for which the Red Sea is renowned are found. The apparently northernmost occurrence of true oceanic crust formation is in the Nereus Deep at 23° N (opening s ince ~2 m.y. ago). North of ~25° N only diffuse extension takes place [*Cochran*, 1983] although some magmatism does occur [*Cochran*, 2005] such as at the Jean Charcot Deep (25°15´N) where Pautot et al. [*Pautot et al.*, 1984] found a large volcanic edifice surrounded by cool (23°C) brines. The lavas showed evidence of alkali-basalt affinities and relict amphibole phenocrysts, suggesting an intracontinental origin. Alltogether 25 deeps have been found in the Red Sea rift valley, but the setting of these varies greatly [e.g., *Anschutz and Blanc*, 1996; *Anschutz et al.*, 1999; *Anschutz et al.*, 2000; *Antonini et al.*, 1998; *Dekov et al.*, 2007; *Ghebreab*, 1998; *Hartmann et al.*, 1998; *Izzeldi*, 1987; *Pautot et al.*, 1984; *Pierret et al.*, 2010; *Schmidt et al.*, 2003; *Scholten et al.*, 1991]. Some deeps are floored by basalts, some by evaporites; some have brine at the bottom, others do not; some have metalliferous sediments and even chimneys, others have no significant ore mineralization (Gurvich, 2006). Thus, it appears that the deeps have developed independently of each other and in unique ways. Surprisingly, no relationship can be seen between the position of the deep along the axis and its character or evolutionary maturity [*Pierret et al.*, 2001].

During the POS403-1 cruise we studied two deeps (Hatiba and Port Sudan) which, between 20-22°N, are in the northern portion of the area showing true seafloor formation. We were able to collect some fresh basalt samples from the Hatiba Deep, observe clear volcanic seafloor structures and detect the presence of brine in the more southerly Port Sudan Deep.

3. Cruise Narrative

Colin Devey

The original aim of the cruise was to map and sample around the Atlantis II Deep and along the spreading axis to north and south of this deep, an area for which working permission was required by the vessel from Sudan. At the time when the ship sailed from Jeddah on 14 January 2011 permission to work had not yet been granted by the Sudanese authorities, so initial work was concentrated on working within the Hatiba and Port Sudan Deeps. The work began with multibeam mapping (see section 4 unterhalb). We mapped the eastern parts of both deeps and then began a program of sampling which consisted of sediment coring (either sedimentary grab or gravity corer) and volcanic sampling (by e.g. dredging and volcanic corer). After seeing the initial results of this sampling we proceeded to map out the full extent of the accessible parts of both deeps. In the case of Hatiba Deep this also lead to us discovering one area of recent submarine volcanism. The rhythm of sampling during the day and mapping at night continued the whole cruise. The ship returned punctually on 31 January 11 to Jeddah port.

4. Multibeam mapping

Nico Augustin, Tom Kwasnitschka

4.1. Methods

Extensive multibeam mapping was carried out during RV Poseidon cruise P408-1, by a Seabeam 3050 echosounder system provided by ELAC Nautik GmbH. The SeaBeam 3050 multibeam echosounder collects bathymetric, corrected backscatter, side scan and water column imaging (WCI) data at medium depths. The configuration installed on RV Poseidon operates in the 50-kHz frequency band at water depths ranging from 3 m below the transducers to approximately 3,000 m. It has an across-ship swath width of up to 140 degrees with up to 630 beams for each multi-ping. The complete system consists of 2 transmitter/ receiver units, a motion sensor, and a salinometer installed on RV Poseidon. Data acquisition was performed with the Hydrostar 3.5.8 software coupled with the Hypack 10.0.0.4 survey and processing software package, running under Microsoft Windows XP™ (Figure 1). The Hysweep survey module of Hypack bundle collected all data from the Seabeam echo sounder in its own HSX data format which was used for further processing. The native ELAC XSE-data format is only stored for archiving and was not used for postprocessing during the cruise.

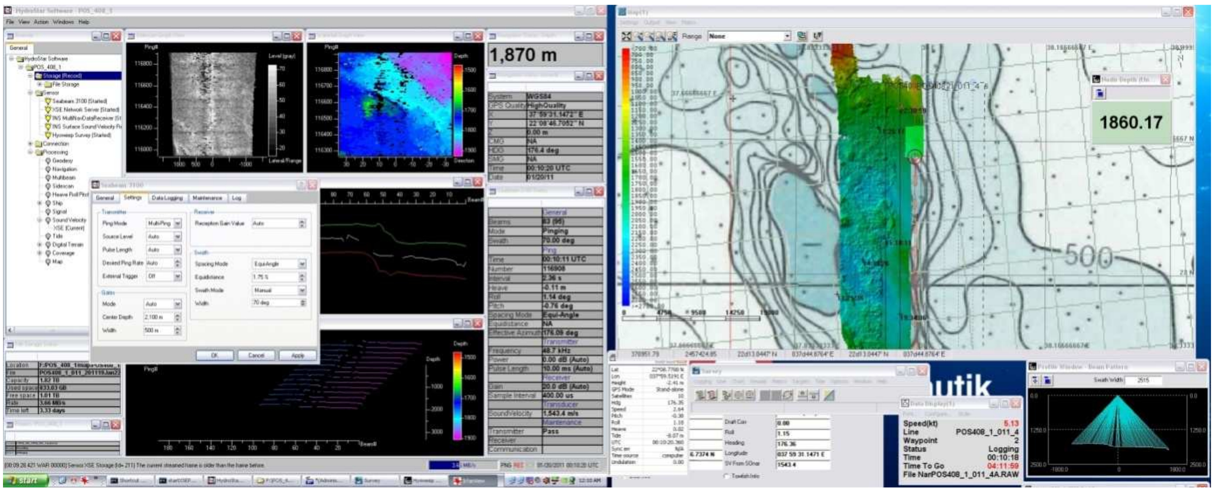


Figure 1: Hydrostar (left) and Hypack (right) graphical user interfaces during mapping survey of the Hatiba Deep.

During P408-1, about 215 hours of multi beam survey resulted in a bathymetric dataset of approximately 4,500 km^2 along the eastern part of the Red Sea Rift between 20°N and 22°30´N including large parts of the Hatiba Deep and the Port Sudan Deep. Additionally, multibeam data were collected during the transits from and to Jeddah (Saudi Arabia). The average ship speed during the bathymetric surveys of Hatiba Deep and Port Sudan Deep was 5 knots. During the transits good bathymetric data was collected at speeds of up to 10 knots, provided that weather conditions were acceptable.

The beam angle in Hydrostar mostly ran in automatic mode, but was manually corrected if necessary (e.g. if too small angles caused less overlap of the mapped track lines). The Ping mode was set to multiping. Source level, pulse length and desired ping rate were set to automatic. For bottom search the gates were set manually till the bottom signal was found and then switched to automatic mode.

A first, provisional data editing was made with the Hysweep Editor module (MBmax) including a spike filter and a filtering of overhanging and underlying pings. Other available filter options (e.g. quality filter) generated less effective or too strong results of beam filtering and were disabled. MBmax exported xyz-files including the intensity values of the beam signal. A Hypack HS2 file, including all beam information, has also been created for backup and later use. Final, area-based editing of large parts of the collected data sets has been carried out by using PFM files created by DMagic as well as the 3-D Editor modules included in the IVS 3-D Fledermaus™ software package (Figure 2). The Matlab-based HydroStar WCI Viewer (Figure 3) was used for online and offline visualization of collected WCI data. Unfortunately, this is only a viewer which makes it impossible at the moment to import the ELAC WCI files into 3rd party processing packages e.g. the IVS 3D FM Midwater module.

Final gridding and bathymetric map production was realized using the Fledermaus™ DMagic module. The data were gridded with a cell size of 35 m. Due to the good sea conditions during the survey of the Hatiba Deep the cell size was increased to 25 m for this area.

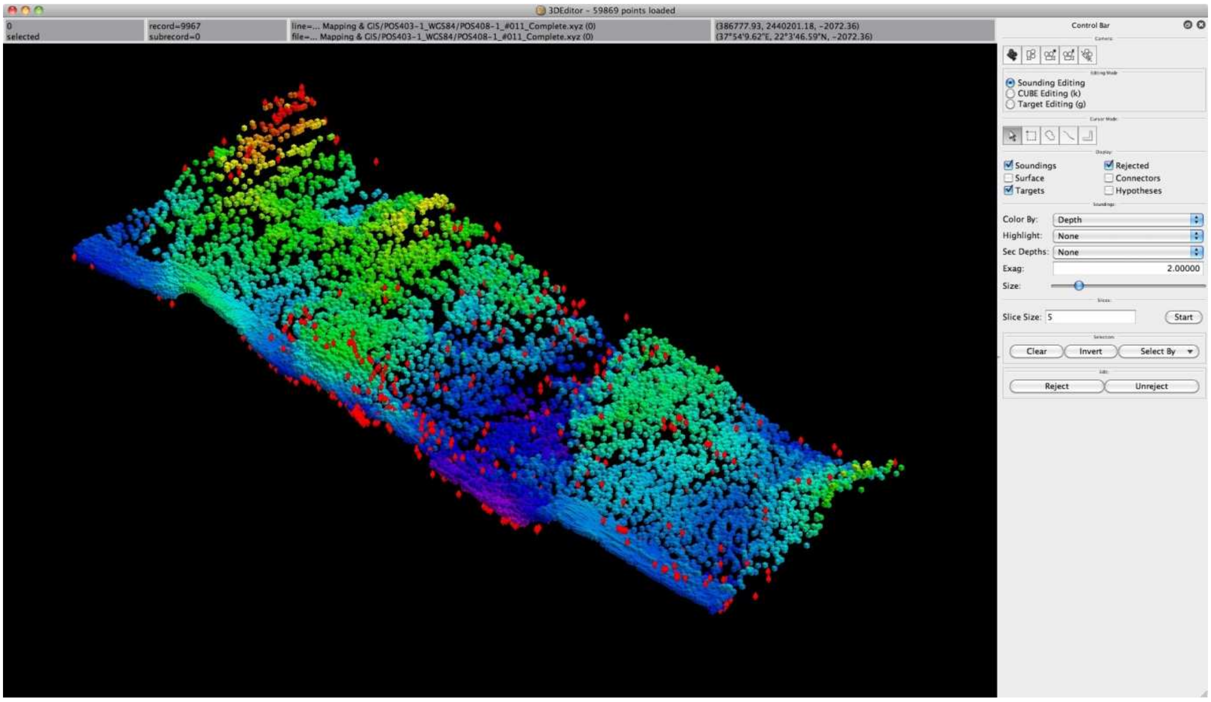


Figure 2: Area-based editing of a PFM file from a Hatiba Deep dataset with the 3-D Editor, which is included in the IVS 3-D Fledermaus™ package.

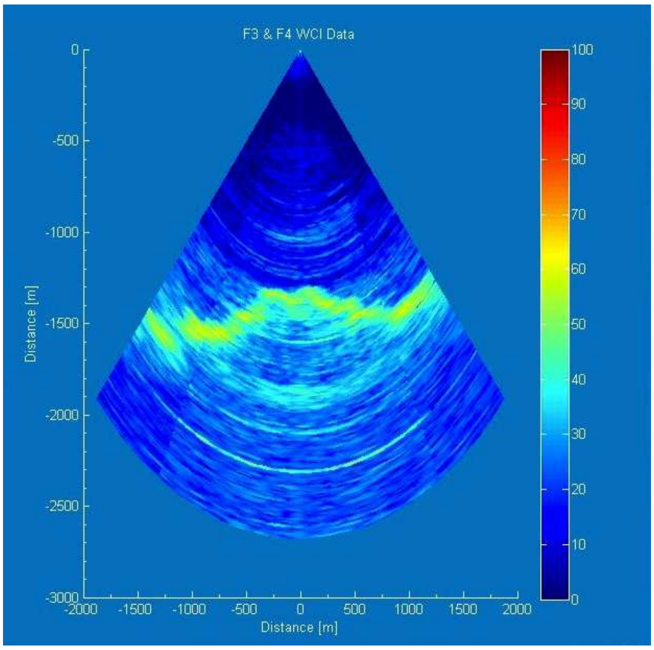


Figure 3: The Matlab-based WCI Viewer displays collected water column data. The bright yellow reflector marks the seafloor.

4.2. First Results

During P408-1 the first bathymetric maps of the eastern Hatiba Deep as well as the eastern Port Sudan Deep were created with a resolution of about 30 m. In addition, maps are being created of large parts of the Red Sea seafloor between and around the two deeps.

As known from older bathymetric charts (e.g., Laughton, 1970), the Hatiba Deep at 22°03´N consists of two NW-SE elongated basins, which are separated by a parallel striking ridge structure. During P408-1 we found that the NE Hatiba basin is not clearly separated from the SW Hatiba basin by merely a single ridge. Instead, the two basins that have water depths of more than 2240 m are separated by at least two parallel ridges and volcanic structures (Figure 4). Numerous structures that can be interpreted as having a volcanic origin, (e.g. small (<2 km) flat top volcanoes, volcano chains, as well as lower relief volcanic structures) can be found within the Hatiba Deep and the immediate rims of the deep. During cruise P408-1 basalts and basalt glass could only be recovered from the western part of the southern Hatiba basin, since other parts of the basin were covered in sediments. This indicates that the western part of the southern Hatiba basin is the most recent area of active seafloor spreading (Figure 5). The northern rim of the Hatiba basin is marked by a high, with small volcanic cones on its top, which is extensively cut by prominent NW-SE striking faults. Therefore the northern Hatiba Deep edge appears to be strongly affected by tectonics. The southeastern border of the deep seems to be covered by large masses of sediments (Figure 4).

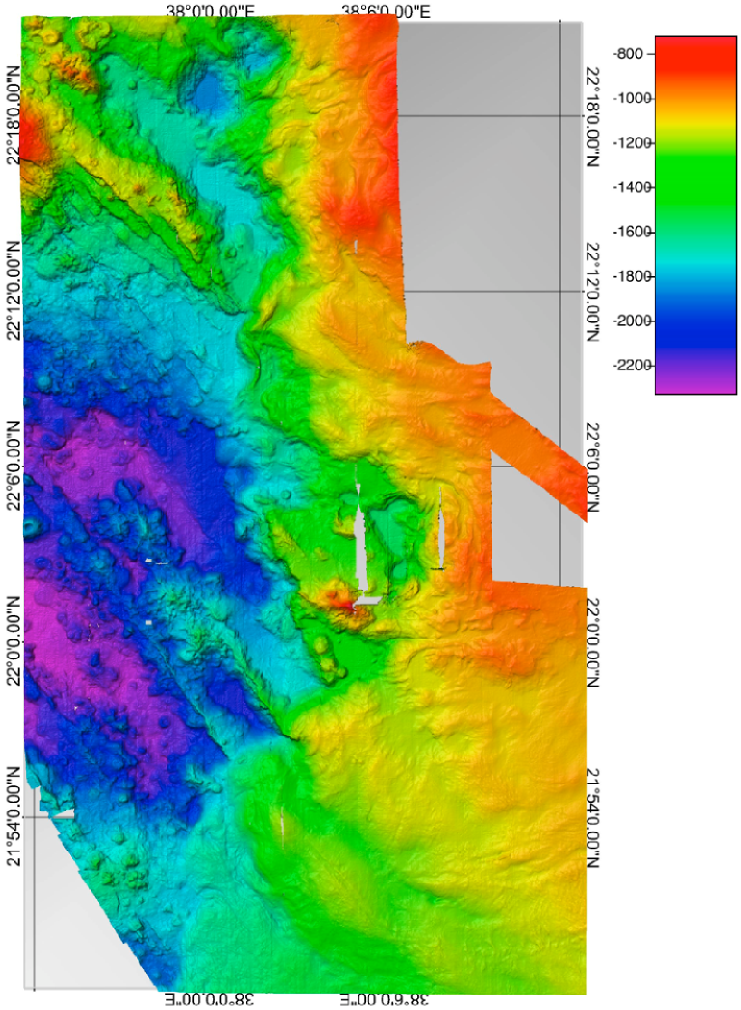


Figure 4: Multibeam map of the eastern part of the Hatiba Deep. The NW-SE striking features like scarps, ridges and volcanic features are clearly visible. The northern edge of the deep seems to be affected by tectonic processes, whereas the SE edge of the deep seems to be covered by large masses of sediment, which migrate north into the deep.

The second mapping target of P408-1 was the area of the brine-filled Port Sudan Deep, which is located 190 km south of the Hatiba Deep. During the mapping, the collected bathymetric data were not corrected for the high salinities that changed the sound velocities within the brine pool of the Port Sudan Deep because of missing calculations for sound velocities in such extreme conditions. However, the mapped parts of the Port Sudan Deep reveal an elongated NW-SE striking deep with rare volcanic structures. The NE flank of the Port Sudan Deep shows many landslides, which transported material into the deep and may cover main parts of the basaltic floor of the deep. Therefore it was not possible to recover any basaltic samples, instead sediments and carbonates were recovered from the deep. A prominent feature near the Port Sudan Deep (15 km north) is a crater structure with a diameter of about 1.8 km and a depth of >100 m. Because of the bulged rim of this crater, this structure could be interpreted as an explosion crater. A different possibility of the origin of such a depression could be dissolution of evaporates in the subseafloor and a resulting collapse of overlaying structures. However, this would not explain the bulged rims of the crater structure.

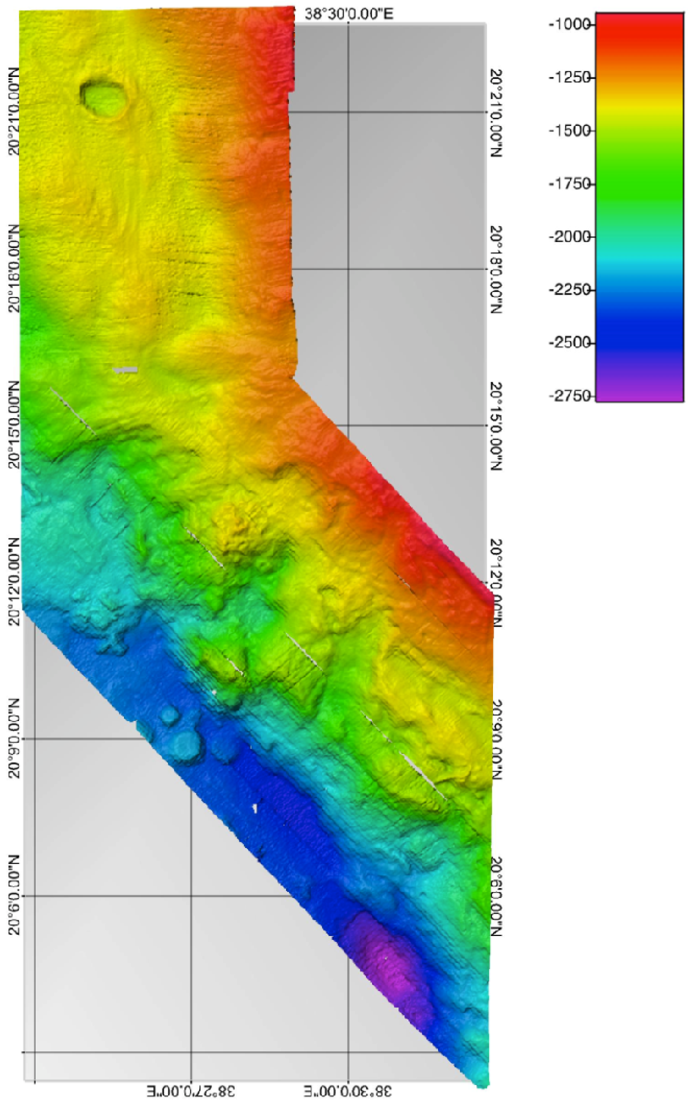


Figure 5: Bathymetric chart of the brine filled, NW-SE striking eastern Port Sudan Deep. Landslides from the NE wall of the deep may cause an increased transport of sediments into the deep, which cover large parts of the basin as well as volcanic structures. In addition a crater structure north of the deep, has been interpreted as an explosion crater of unknown origin.

4.3. CTD Stations

During POS408-1, two CTD stations (02 and 34 CTD) have been performed to collect water column data, predominantly to create sound velocity profiles for the processing of echo sounder data. Based on the sound velocity profile of station 02 CTD the online correction of soundings has been done in HydroStar as well as in Hypack; exported xyz files are based on these corrections. 34 CTD was carried out to evaluate the effect of the brine layer in Port Sudan Deep.

The data of station 34 CTD, which include the brine pool of the Port Sudan Deep, are shown in Figure 6. The temperature is quite stable and relatively high (>20℃) until the CTD reached the top of the brine, where the temperature increased rapidly up to 36℃. The salinity also increases very strongly within the brine, up to values of 2000 psu. Software based calculations of the sound velocity in the brine of Port Sudan Deep seems to not worked properly for this extreme conditions. When the CTD entered the brine pool, two of three different models continuously calculated sound velocity values of 9999 m/s (Delgrosso, Wilson). The calculation after Chen-Millero reveals more realistic values between 2370 m/s and 1460 m/s, but with decreasing sound velocity versus increasing depth (at relatively stable temperature and salinity), which seems improbable.

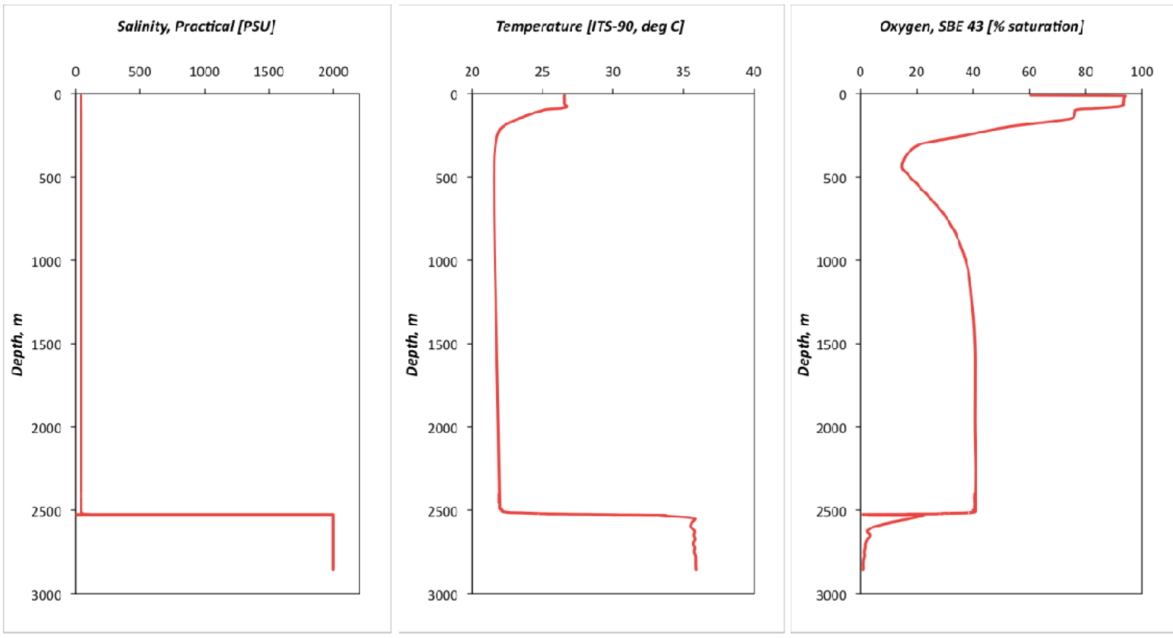


Figure 6: CTD profiles of water column salinity, temperature and oxygen from station 34 CTD clearly show the transition from the normal Red Sea water into the brine pool of Port Sudan Deep at a water depth of about 2520 m.

5. Sediment Samples

Rabea Haredy, Rashad Bantan, Saad Al Yousef, Abdulnasser Kotob

Sediments were sampled both with a gravity corer (maximum length 5m) and a grab sampler. Additionally, some sediments were collected in tubes fixed inside the mouth of the dredge. At one station a CTD was lowered into the Port Sudan brine layer - here water samples were collected, their positions are also listed. The following table shows the stations attempted, the samples collected and their descriptions.

Ship Station No	Sample No	Lat (N) Degree. Min. Decimal Min	Long (E) Degree. Min. Decimal Min	Sample Equip.	Sample Colour	Date	Time	Depth (m)	Remarks
523/1	523/1	20. 14. 603 N	38. 21. 984 E	Dredge/sediment traps	Not taken	17.01.11	5.53 UTC /8.53 AM SA	1972	Retrieved sample is hard muddy carbonated rocks with organic intrusions (Black colouring) / port Sudan Deep
005/1	JP1G	20. 8. 399 N	38. 26. 989 E	Grab Sampler	10YR 5.6	17.01.11	10.55 UTC/ 12.55 PM SA	2312	Muddy with fine sand/very fine sand size carbonate fragments/shell fragments/ port Sudan Deep
007/1	JP2D	22. 3. 593 N	37. 53. 822 E	Dredge	7.5YR 6.6	18.01.11	5.49 UTC/ 8.49 AM SA	1804	Hard carbonate based (some are coral) lied on top by hard muddy layer / Hatiba Deep
008/1	JP3G	22. 3. 501 N	37. 53. 751 E	Grab Sampler	7.5YR 4.4	18.01.11	8.41 UTC/ 11.41AM SA	2068	Muddy with fine sand/very fine sand size carbonate fragments/shell fragments/ Hatiba Deep
009/11	009/11	22. 8. 610 N	37. 54. 339 E	Dredge	Not taken	18.01.11	11.10 UTC/ 02.10 PM SA	1785	No sample were recovered/ south basin of Hatiba
010/11	JP4G	22. 6. 435 N	37. 54. 609 E	Gravity Corer	Not taken	18.01.11	13.35 UTC/ 04.35 PM SA	2134	No core sediments recovered, however, some hard carbonate rock (maybe coral) covered by thin muddy layer found in the core catcher/ Deep part of Hatiba Deep Basin
012/1	JP5G	22. 9. 272 N	37. 54. 278	Grab Sampler	10YR5.4	19.01.11	04.05 UTC/07.05 AM SA	1921	Muddy with fine sand/very fine sand size carbonate fragments/shell fragments/ Hatiba Deep
013/1	JP6G	22. 8. 630 N	37. 54. 034 E	Gravity Corer	Not taken	19.01.11	05.48 UTC/ 8.48 AM SA	2053	No core sediments recovered, however, some hard carbonate rock (maybe coral) covered by thin muddy layer found in the core catcher/ North part of Hatiba Deep Basin
014/1	JP7G	22. 07. 268 N	37. 53. 86 E	Gravity Corer	Not taken	19.01.11	08.47 UTC/11.47 AM SA	2102	No core sediments recovered, however, some hard carbonate rock (maybe coral) covered by thin muddy layer found in the core catcher/ North part of Hatiba Deep Basin
015/1	JP8G	22. 6.197 N	37. 54. 583 E	Grab Sampler	Not taken	19.08.11	10.15 UTC/01.15 PM SA	2199	No sample were recovered/ empty grab/ Location: north Hatiba Deep to the western side of the deepest part

Ship Station No	Sample No	Lat (N) Degree. Min. Decimal Min	Long (E) Degree. Min. Decimal Min	Sample Equip.	Sample Colour	Date	Time	Depth (m)	Remarks
016/11	JP9G	22. 2. 441 N	37. 54. 184 E	Grab Sampler	10YR 4.6	19.01.11	11.48 UTC/ 2.48 PM SA	2153	Mud with very fine/fine sand size carbonate/shell fragments/ north side of Hatiba Deep
017/1	JP10C	21. 59. 67 N	37. 54. 67 E	Gravity Corer	Not taken	19.01.11	13.30 UTC/ 04.30 PM SA	2219	No core sediments were recovered, however, some basaltic glass fragments were found in the core catcher/ deeper part of the basin in southern Hatiba Deep
018/1	JP11D	21. 59. 732 N	37. 54. 577 E	Dredge	Not taken	21.01.11	04.08 UTC/07.08 AM SA	2220	Lava flow (Basalt), rocks are coated with hard layer of mud and lava intruded into the muddy hard sediments/ Hatiba Deep
019/1	JP12D	22. 00. 603 N	37. 54. 23 E	Dredge	Not taken	21.01.11	06.43 UTC/ 09.43 AM SA	2222	Basaltic glass, hard muddy layer on top of basalt, rusty colour due to oxidisation / Hatiba Deep south basin
020/1	020/1	21. 58. 765 N	37. 57. 68 E	Dredge	Not taken	21.01.11	10.14 UTC/ 01.14 PM SA	2222	Dredge Empty; no samples were recovered/ Hatiba Deep - south East
021/1	021/1	21. 58. 784 N	37. 57. 192 E	Dredge	Not taken	21.01.11	12.23 UTC/03.23 PM SA	2216	Dredge Empty; no samples were recovered/ Hatiba Deep - south East/ mud found in the sediments traps
023/1	JP13G	22.11.895 N	37. 55. 294 E	Grab Sampler	7.5YR 5/6	22.01.11	3.49 UTC /06.49 AM SA	1733	Mud with very fine/fine sand size carbonate/shell fragments/ location Hatiba Deep
024/1	JP14G	22. 09.28 N	38. 01.304 E	Grab Sampler	7.5YR 5/6	22.01.11	5.52 UTC / 08.52 AM SA	1624	Mud with medium to coarse sand size carbonate fraction/ minor amount of gravel size carbonate fragments
025/1	JP15G	22.02. 401 N	38. 01. 207 E	Grab Sampler	10.YR 4/4	22.01.11	7.50 UTC / 10.50 AM SA	2014	Sandy mud with coarse to medium sand size fraction carbonate + Detrital Materials?/ Hatiba Deep
026/1	JP16C	22.02.423 N	38. 01. 335 E	Gravity Corer	Not taken	22.01.11	09.00 UTC / 12.00 PM SA	2008	Length 2.30 m, full, core catcher full of sample (JP16C - CC) CC is mud with basaltic glass
027/1	JP17G	21. 56. 646 N	37. 59.010 E	Grab Sampler	10YR 4/6	22.01.11	11.10 UTC / 02.10 PM SA	2070	Sandy mud with coarse to medium sand size fraction carbonate/ Hatiba Deep

Ship Station No	Sample No	Lat (N) Degree. Min. Decimal Min	Long (E) Degree. Min. Decimal Min	Sample Equip.	Sample Colour	Date	Time	Depth (m)	Remarks
028/1	JP18C	21.56. 647 N	37. 59. 010 E	Gravity Corer	Not taken	22.01.11	12.07 UTC /03.07 PM SA	2081	Recovering Length 1.65 m from total deployed 3.70 M, during cutting the core the top part fall out of the tube from 0-38 cm, this sediments in this interval was used as a surface sediments.
029/1	JP19C	21. 56. 242 N	38. 00. 094 E	Gravity Corer	Not taken	22.01.11	13.32 UTC / 4.32 PM SA	1962	Recovering Length 3.32 from total deployed 3.70 M,
034/1	034/1	20. 04. 623 N	38. 30. 720 E	CTD	Not Avalb	24.01.11	07.45 - 9.45 UTC	2700	Note: Depth to brine layer is 2700 m according to the ship eco-sounding. Water sample were taken as follow: (1) Bottom of the brine were sample at 2857 m depth according to the CTD altimeter (bottles no. 1+2); (2) above the bottom of the brine layer water sample at 2750 m depth (bottles no. 3+4); (3) middle of the brine layer water sample at 2650 m depth (bottles no. 5); (4) brine upper layer water sample at 2550 m Depth (bottles no. 6+7); (5) interaction layer between sea water and brine water sample at 2496 m Depth (Bottles no. 8)/ middle of the mapped basin of Port Sudan Deep
35/1	35/1	20. 04. 626 N	38. 30. 677 E	Dredge	Not Avalb	24.01.11	10.51 UTC/ 01.51 PM SA	2697	No samples were recovered/ Port Sudan
036/1	036/1	20. 06. 10 N	38. 29. 28 E	Dredge	Not Avalb	24. 01.11	13.25 UTC/ 04.25 PM SA	2370	No samples were recovered/ Port Sudan (north west of the basin)
038/1	JP20C	20. 09. 437 N	38. 28. 110 E	Gravity Corer	Not taken	25.01.11	03.55 UTC/ 06.55 AM SA	2122	Length 2.32 m, full, core catcher full of sample (JP20C - CC) CC is stiff (hard - dry) mud
039/1	JP21C	20. 06. 445 N	38. 31. 348 E	Gravity Corer	Not taken	25.01.11	5.55 UTC/ 08.55 AM SA	2179	Length 2.30 m, full, core catcher full of sample (JP21C - CC) CC is stiff (hard - dry) mud
040/1	040/1	20. 03. 47 N	38. 32. 87 E	Gravity Corer	Not Avalb	25.01.11	07.45 UTC/ 10.45 AM SA	1967	No core was recovered, length = 3.70 M, possibly the hard carbonated layer opened the core catcher and causes lose of sample(highly), other: core did not penetrate into the hard horizon

Ship Station No	Sample No	Lat (N) Degree. Min. Decimal Min	Long (E) Degree. Min. Decimal Min	Sample Equp.	Sample Colour	Date	Time	Depth (m)	Remarks
041/1	JP22C	20. 03. 504 N	38. 32. 846 E	Gravity Corer	Not taken	25.01.11	09.32 UTC/ 12.32 PM SA	2039	Length 2.32 m, full, core catcher sample (JP22C - CC) CC is sandy (hard) mud, the sediments thickness here is more than 2.32m as muddy sediments were filling the cavity inside the load which extend 1.30 m from the top of the core tube, so the top layer of the core may represent the sub-surface sediments at 1.29 m./ Port Sudan, sediments in the top of this core should be compared with the grab that were taken from the adjacent location (Sample no. JP26G)
042/1	JPC23C	20. 04. 641 N	38. 30. 723 E	Gravity Corer	Not taken	25.01.11	11.20 UTC/ 02.20 PM SA	2697	Note: Same as CTD Location, Length 2.32 m, full, core catcher sample (JP23C - CC) core catcher is dark grey clayey mud
043/1	043/1	20. 04. 25 N	38.31. 22 E	Grab Sampler	Not Avalb	25.01.11	13.08 UTC/04.08 PM SA	2507	No sample were recovered, grab did not hit the bottom, pulled up open, south east of port Sudan
044/1	JP24G	20.05. 028 N	38. 30. 326 E	Grab Sampler	Gley2 - 4/1 10B	26.01.11	04.06 UTC/07.06 AM SA	2628	North west of port Sudan deep, dark bluish grey watery fine metally deposits?
045/1	JP25G	20. 04. 66 N	38. 30. 72 E	Grab Sampler	2.5Y 4/4	26.01.11	06.19 UTC/09.19 AM SA	2701	Olive brown, Note: in the CTD location, centre of the basin in port Sudan from the mapped area
046/1	JP26G	20. 04. 22 N	38. 31. 218 E	Grab Sampler	Gley1 - 4/1 10Y	26.01.11	08.35 UTC/11.35 AM SA	2524	Dark greenish grey, clay stony materials?/ south east Port Sudan deep
047/1	047/1	20. 05. 696 N	38. 29. 955 E	Volcanic Corer	Not Avalb	26.01.11	11.27 UTC/ 02.27 PM SA	2417	No samples were recovered, surface covered by muddy deposits
048/1	048/1	20. 06. 639 N	38. 29. 441 E	Volcanic Corer	Not Avalb	26.01.11	13. 46 UTC/ 04.46 PM SA		No samples were recovered, north flank of port Sudan Deep in the mapped area
050/1	050/1	22. 01. 29 N	37. 53. 72 E	Dredge	Not taken	27.01.11	05.50 UTC/ 08.50 AM SA	2242	Lava, basaltic, covered by thin layer of mud, note: basaltic glass found as thin layer in comparison to previous glass recovered from the Hatiba Deep

Ship Station No	Sample No	Lat (N) Degree. Min. Decimal Min	Long (E) Degree. Min. Decimal Min	Sample Equp.	Sample Colour	Date	Time	Depth (m)	Remarks
051/1	051/1	22. 00. 00 N	37. 55. 46 E	Dredge	Not taken	27.01.11	08.50 UTC/ 11.50 AM SA	2188	hard muddy carbonated rocks?
052/1	052/1	22. 00. 00 N	37. 57. 05 E	Dredge	Not taken	27.01.11	11.27 UTC/ 02.27 PM SA	2037	No samples were recovered
054/1	054/1	22. 01. 99 N	37. 53. 88 E	Volcanic Corer	Not taken	28.01.11	03.56 UTC/ 06.56 AM SA	2251	No volcanic samples were recovered, but some mud (light brown with light grey in colour) stick to the bottom of the corer head / Hatiba Deep
055/1	055/1	22. 0.959 N	37. 54. 243 E1	Volcanic Corer	Not taken	28.01.11	05.42 UTC/ 08.42 AM SA	2246	No volcanic samples were recovered, but some light brown mud with shell (carbonate) medium sand size fraction found in the dead load/ Hatiba Deep, north part (main basin)
056/1	056/1	22. 0. 134 N	37. 53. 773 E	Volcanic Corer	Not taken	28.01.11	07.23 UTC/ 10.23 AM SA	2233	No recovery, some grey and light brown mud with medium coarse sand size fraction grains stick to small cores in the corer
057/1	057/1	22. 00. 96 N	37. 54. 24 E	Dredge	Not Avalb	28.01.11	09.34 UTC/ 12.34 PM SA	2235	No sample recover
058/1	058/1	21. 59.92 N	37.54. 74 E	Dredge	Not taken	28.01.11	11.54 UTC/ 02.54 PM SA	2212	Basaltic rocks with volcanic glass were sampled
060/1	060/1	22. 09. 36 N	38. 08. 79 E	Gravity Corer	Not Avalb	29.01.11	03.36 UTC 06.36 AM SA	890	No core recovered, length: 3.70 m, maybe slope area, or hard ground materials opened core catcher in the way up?
061/1	JP27C	22. 09. 36 N	38. 08. 78 E	Gravity Corer	Not taken	29.01.11	04.19 UTC/ 07.19 AM SA	892	Recovered core length: 76 CM from total deployment of 370 cm,
062/1	JP28G	22. 09. 40 N	38. 17. 25 E	Grab Sampler	10YR74	29.01.11	06.00 UTC/ 09.00 AM SA	638	very pale brown muddy sand, medium to coarse sand size fraction (carbonate)

Ship Station No	Sample No	Lat (N) Degree. Min. Decimal Min	Long (E) Degree. Min. Decimal Min	Sample Equp.	Sample Colour	Date	Time	Depth (m)	Remarks
063/1	JP29G	21. 56. 54 N	38. 17. 01	Gravity Corer	10YR74	29.01.11	08.29 UTC/11.30 AM SA	1013	Core deployed length 370 cm, however, no recovery (core did not penetrate into the ground) may be very hard ground, slope or not enough sediments in the sampled area, but 35cm sediments recovered from the core representing the surface samples
064/1	JP30C	21. 56. 05 N	38. 31. 72	Gravity Corer	Not taken	29.01.11	10.45 UTC/01.45 PM SA	847	Recovered core length: 338 CM from total deployment of 370 cm
065/1	JP31G	21.41.08 N	38. 31. 89 E	Gravity Corer	10YR 7/4	29.01.11	13.20 UTC/ 04.20 PM SA	860	Core deployed length 370 cm, however, no recovery (core did not penetrate into the ground) may be very hard ground, slope or not enough sediments in the sampled area, but 35cm sediments recovered from the core representing the surface samples - muddy sand medium to coarse sand size fraction (carbonate shells)
066/1	JP32C	21. 26. 21 N	38 . 16. 89 E	Gravity Corer	Not taken	30.01.11	04.06 UTC/ 07.06 AM SA	923	Recovered core length: 300 cm from total deployment of 370 cm
067/1	JP33C	21. 26. 58 N	38. 31. 93 E	Gravity Corer	Not taken	30.01.11	06.28 UTC/ 09.28 AM SA	860	Recovered core length: 308 cm from total deployment of 370 cm
068/1	JP34C	21. 26. 49 N	38. 45. 66 E	Gravity Corer	Not taken	30.01.11	8.42 UTC/ 11.42 AM SA	686	Recovered core length: 323 cm from total deployment of 370 cm

Note: All cores were divided into 100 cm in length and numbered from the top as follow 0-100 cm part 1/ and descend

6. Station List

Froukje van der Zwan

Station abbreviations: BG = Backengreifer/ Sedimentary grab; CTD = Conductivity Temperature Depth measurement; KDS = Kettensack Dredge/ Chainbag dredge; MB = Multibeam survey; SL = Schwerelot/ Sedimentary gravity core; TDS = Tonnendredge/ Barreldredge; VSR = Vulkanitstoßrohr/ Waxcorer

Station Area	Latitude (°N)/ Longitude (°E)	Date/ Time (UTC)	Depth (m)	Sample descriptions and samples taken (TS = thin section/microprobe slide; Gl = Glass; Mn = manganese; Qtz = quartz; Pl = Plagioclase)
1 MB	Mapping transit from Jeddah to Hatiba deep - 14.01.11 to 15.01.11			
2 CTD	22°29.9'/37°50.6'	15.01.11 ~14:00 - ~15:00	1270	CTD sound velocity used for correction of multibeam data.
3 MB	Mapping transit from N of Hatiba deep to S of Port Sudan deep over a central line - 15.01.11 to 17.01.11			
4 KDS Cone structure with flat top, steep slope, N of Port Sudan Deep	20°14.603'/38°21.984' to 20°15.110'/38°22.054'	17.01.11 5:18 - 7:52	1972 - 1744	17 pieces (labelled 523KDS, after original station name): 25x15x2 cm to 5x3x1 cm: hard sedimentary crust, yellowish-orange brownish calceaous mud-siltstone (no Qtz). Some layering of mudstone and bioturbated/distrubed coarser grained carbonates with shell fragments and coral structures + black dense Mn crust/bubbles Sediment from sedimenttrap: mud + black fragments
5 KDS Cone with flat top in the middle of Port Sudan Deep	20°8.399'/38°26.989' to 20°8.832'/38°26.840'	17.01.11 10:07 - 12:27	2312 - 2142	Empty (sediments in traps)
6 BG Same as endst. 5KDS	20°8.995'/38°26.974'	17.01.11 12:57 - 14:15	2165	Yellowish brown (10 YR 5/5) mud with very fine sand, fine (black) shell fragments
7 KDS S rim of cone structure with crater in between the 2 deeps of Hatiba Deep	22°3.593'/37°53.822' to 22°4.001'/37°53.974'	18.01.11 5:12 - 7:23	1804 - 1763	1: 3 x 17x15x2 cm to 10x7x1 cm: yelowish-light brown, calceous mud-siltstone, lots of mm-sized holes, coral structure (?). Similar as 523KDS 2: 20x15x3 cm: Mn crust, dull black, fine grained, covered with brown calceous coral-mudrock Sediment from sedimenttrap: mud + black fragments
8 BG S basin of Hatiba Deep	22°3.501'/37°53.751'	18.01.11 7:54 - 9:08	2011	(yellowish) lightbrown fine carbonate silt mud.
9 TDS Cone with flat top, N of Hatiba Deep	22°8.673'/37°54.356' to 22°8.965'/37°54.370'	18.01.11 10:31 - 12:10	1826 - 1784	Empty (sediments in traps)
10 SL 2.5m Deepest part of N-Hatiba basin	22°6.434'/37°54.609'	18.01.11 12:49 - 14:11	2134	Calceous sedimentary crust fragments, yellowish-light brown, less consolidated, many gastropods with high aspect ratio up to 1 cm long.
11MB	Mapping central Hatiba deep - 18.01.11 to 19.01.11			
12 BG Close to position 9TDS, N side of cone	22°9.272'/37°54.278'	19.01.11 3:23 - 4:38	1921	Yellowish brown (10YR 5/4) carbonate mud with very fine sand and very fine shell fragments.
13 SL 2.5m N-Hatiba basin, S from flank cone station 9TDS	22°08.51'/37°54.03'	19.01.11 5:02 - 6:29	2053	Sedimentary carbonated crust fragments, yellowish-light brown. Very fine shell fragments, some gastropods same as 10SL
14 SL 2.5m N-Hatiba basin, NW deep isolated part	22°07.268'/37°53.86'	19.01.11 7:06 - 8:29	2102	Less consolidated yellowish-brown fragments of carbonate crust including denser darker brown carbonate silt layers + some orange mud. Shell fragments + gastropods (as 10SL).
15 BG Northern Hatiba deep, W side, deepest part main basin	22°6.197'/37°54.583'	19.01.11 9:02 - 10:10	2199	Empty
16 BG N side of S Hatiba basin. On small round high in shallow part deep	22°2.441'/37°54.184'	19.01.11 11:02 - 12:11	2153	Yellowish brown calceous mud + very fine (<1 cm) gastropod (fragments). Similar as 6BG, 8BG, 12BG.
17 SL 2.5m Deepest part (on	21°59.67'/37°54.67'	19.01.11 12:57 -	2219	Ca. 30 basaltic glass chips, mm - <1 cm (Damaged core catcher)

W side) of S-Hatiba basin		14:02		
18 KDS Deepest part SW Hatiba Deep, close to 17SL, in S part basin, dredging to East	21°59.732'/37°54.577' to 21°59.762'/37°54.931'	21.01.11 3:23 - 5:34	2220 - 2216	~16 basalt pieces of basaltic sheet flows with large gass bubbles (sed. interaction?). All quite similar. 1: 15x15x6 cm: Basalt tube with up to 1 cm thick glass crust around large voids (-10 cm), some filled with sediment. Also glass at contact voids/sediments. Massive basalt, no minerals visible, <1% vesicularity. Partially covered with palagonite-like, dark orange coating (rusty alteration). 2x Gl, TS 2: 20x20x5 cm: Basalt sheet flow, 4 mm glass crust on top, then 1-10 cm sed. layer, and 2nd 2-5 mm glass crust + 15 mm sed. on top. massive basalt, <1% vesicular + some 1/2 cm layers up to 10% vesicles. Fresh glass with rusty surface alteration. Gl, TS 3: 29x12x10 cm: end part of basaltic sheet flow (rounded edge) with up to 5 mm glass crust. 3 rock layers around large voids. Massive basalt, 2% vesicular, 2x5 mm layers of 10% vesicularity, following the upper surface. Fresh glass, rusty alteration. Gl, TS 4: 20x15x10 cm: Basaltic sheet flow, end part, twisted flow, around large (-7 cm) voids. Mainly glass, less basalt. Massive basalt <1% vesicular, but very fractured. Fresh glass, rusty alteration. Gl, 2x TS Extra rocks: 9 pieces of basalt sheetflow + <1cm glass crust (extra 1-9) 2 pieces of folded, irregular basaltic sheetflow, <1 cm thick glass crust on different sides (extra 10-11) 1 piece, glass crust (extra 12)
19 KDS Deepest part SW Hatiba Deep, N of 18 KDS, middle of basin	22°0.603'/37°54.23' to 22°0.832'/37°54.669'	21.01.11 6:01 - 8:15	2222 - 2230	~13 basalt fragments of sheet lava with thick glass crust 1: 50x25x20 cm: Tong of basalt sheet flow with well visible pahoehoe structures. ~1 cm thick glass crust on all sides. Massive basalt, no clear minerals/vesicularity. Fresh glass, slightly rusted. => rock to Jeddah, Gl to Kiel 2: 30x20x18 cm: Basalt sheet flow, with up to 2 cm thick glass on top and bottom. Top glass fragmented, bottom glass smouth. ~2cm thick basalt, 1 cm transition to glass at upper side. 5% vesicular. Fresh glass, rusted. Separate Top and Bottom Gl, TS 3: 20x12x7 cm: Basalt sheet flow with up to 3 cm glass crust on top and bottom and at one side. Sediment crust on top. 1/2 cm transition from basalt to glass (of small rounds). No crystals, vesicularity visible. Fresh glass, slightly rusted. Gl, TS 4: 20x12x10 cm: Glass rock (of sheet flow). Rounded structures at the bottom, more fragmented at the top. No basalt visible at outside, inside 1 cm thick layer. Fresh glass, rusted at surface, highly fractured. Sediment on sample. Gl, TS 5: 20x12x12 cm: End part of sheet lava. Rounded glass end of ~10 cm. with basalt layer of 2 cm thickness and 2 cm transition zone. Fresh glass, in circular fractures. Vesicular texture, slightly rusted. Gl, TS Extra rocks: 2 pieces of glass crust (extra 1-2)
20 KDS Hatiba SE-basin, bottom of Basin, irregular surface part in main basin	21°58.765'/37°57.168' to 21°58.79'/37°57.61'	21.01.11 ~9:30 - 11:28	2222 - 2179	Empty (sediments from traps)
21 KDS Same as 20 KDS, slight shallowing at end of dredge track	21°58.784'/37°57.192' to 21°58.826'/37°57.676	21.01.11 11:41 - ~14:00	2216 - 2159	Empty (sediments from traps)
22 MB	Mapping N part Hatiba deep - 21.01.11 to 22.01.11			
23 BG Shelf slope on NE flank of Hatiba	22°11.895'/37°55.294'	22.01.11 3:15 - 4:15	1733	Yellowish brown mud with very fine (shell-) fragments
24 BG Shelf slope N of Hatiba, W of sediment channel on slope	22°09.28'/38°01.304'	22.01.11 5:15 - ~6:10	1624	Yellowish brown mud, with medium- to coarse-sand sized carbonate. Minor amount of gravel sized fragments

25 BG Hatiba graben on transform(?) trace. Shallower E part of N basin	22°02.401'/38.01.207'	22.01.11 7:11 - 8:18	2014	Sandy mud, with coarse-medium size sand fraction. Carbonate + detrital particles (?)
26 SL 2.5m Same as 25 BG, (S)E rim of N Hatiba basin	22°02.423'/38°01.335'	22.01.11 8:23 - 9:31	2008	Core recovery: 2.30 m Sediment (yellowish brown) => to Jeddah Top loss: sediment came out top of weight Core catcher: 5x cm sized basaltic glass fragments, + smaller piece: hit basaltic floor Carbonate crust fragments recovered from weight: ~3 mm thick, with many gastropode shells, as in 10SL
27 BG S Hatiba basin, E shallower part, beneath ridge faults	21°56.646'/37°59.010'	22.01.11 10:27 - 11:29	2070	Sandy mud (medium-coarse fraction), carbonate + detrital material (?). Yellow-brown + some yellower mud.
28 SL 4m Same as 27 BG	21°56.647'/37°59.018'	22.01.11 11:32 - 12:29	2081	Core recovery: 1.65 m Sediment (yellowish brown) => to Jeddah Top loss: none Core catcher: some mm sized glass pieces: hit basaltic floor
29 SL 4m Sediment trap near NE graben boundary fault	21°56.242'/38°0.094'	22.01.11 13:32 - ~14:00	1962	Core recovery: 3.32 m. yellowish brown mud. Top loss: none Did not reach magmatic flour, core catcher intact. Core catcher: Gravel, with many shells and reddish and darker rocks (Mn-crumbs?)
30 MB	Mapping transit from Hatiba Deep to Port Sudan Deep, E of first mapping line - 22.01.11 to 23.01.11			
31 MB	Mapping Port Sudan Deep - 23.01.11 to 24.01.11			
32 CTD Deepest point Port Sudan deep	20°4.61'/38°30.73'	24.01.11 ~3:15 - ~4:00		CTD broke down after 315 meters; end cable cut off for repair.
33 KDS Port Sudan deep, S in brinepool. Flat bottom of deep	20°04.264'/38°30.96' to 20°04.87'/38°31.16'	24.01.11 4:33 - 7:30	2695 - 2478	Empty (dark yellowish-brown sediment in sediment traps, some black grains: glass?)
34 CTD Deepest point Port Sudan Deep, same as 32CTD	20°4.614'/38°30.739'	24.01.11 ~7:45 - ~9:45	2698	Brine at ~2550 m deep: H Temperature, H Salinity, L Oxygen Water samples: Bottles 1 + 2: 2857 m (Bottom) Bottles 3 + 4: 2750 m Bottle 5: 2650 m Bottles 6 + 7: 2550 m (top brine) Bottle 8: 2496 m
35 KDS N part of deepest basin Port Sudan deep, near 34CTD, brinepool	20°4.626'/38.30.677' To 20°4.832'/38°30.888'	24.01.11 10:02 - 12:12	2697 - 2668	Empty (dark yellowish-brown sediment in sediment traps, some black grains: glass?)
36 KDS Volcanic cone/structure, NW of/in Port Sudan Deep	20°06.10'/38°29.28' To 20°6.357'/38°29.212'	24.01.01 12:45 - ~14.55	2370 - 2336	Empty ((dark yellowish-brown sediment in sediment traps, some black grains: glass?)
37 MB	Mapping N of Port Sudan Deep - 24.01.11 to 25.01.11			
38 SL 2.5 m W flank Port Sudan Deep	20°09.44'/38°28.11'	25.01.11 3:19 -4:33	2122	Core recovery: 2.32 m: dense/stiff yellowish brown mud (in core catcher) Top loss: some sediment in weight, but not full.
39 SL 2.5 m East flank of Port Sudan Deep, downslope end of sediment channel	20°06.448'/38°31.348'	25.01.11 5:20 - 6:28	2179	Core recovery: 2.30 m: dense/stiff mud, some layering Top loss: unknown
40 SL 4 m East flank of Port Sudan Deep	20°03.47'/38°32.87'	25.01.11 7:08 - 8:20	1967	Empty, fragments of carbonate crust in core catcher and hard ground in ca 3.5 m: core catcher open: washed out.
41 SL 2.5 m SE flank Port Sudan deep, close to 40SL	20°03.504'/38°32.846'	25.01.11 8:57 - 10.00	2039	Core recovery: 2.32 m: sandy, stiff yelowish brown mud, some darker pieces (in core catcher). Top loss: out of top weight
42 SL 2.5 n Deep of Port Sudan basin, same as 34CTD	20°4.641'/38°30.723'	25.01.11 10:32 - 11:49	2697	Core recovery: 2.32 m: dark grey (organic?) mud (from core catcher).Top: carbonate crust fragments. Top loss: unknown
43 BG	20°04.25'/38°31.22'	25.01.11	2507	Empty: grap not closed (wrong estimate of depth because of

SE of Port Sudan Deep		12:13 - ~14.00		brine: no bottom contact)
44 BG NW of Port Sudan Deep	20°05.028'/38°30.326'	26.01.11 3:13 - 5:02	2628	Dark grey/black mud (4/1 10B), stiff.
45 BG Middle port Sudan Deep, same as 34CTD	20°4.66'/38°30.72'	26.01.11 5:17 - 7:25	2701 (+ brine)	Brown black mud
46 BG SE edge of Port Sudan Deep	20°04.22'/38°31.218'	26.01.11 7:41 - ~12.00	2524	Dark greenish grey mud (gley 1 4/1 10y)
47 VSR Flat deep, N of deepest part Port Sudan Deep, N of ridge (?) structure	20°5.696'/38°29.955'	26.01.11 10:41 - 11:56	2417	Small sediment fragments, not collected
48 VSR N flat of Port Sudan Deep	20°6.629'/38°29.441'	26.01.11 12:18 - 13:35	2386	Mud fragments, not collected
49 MB	Mapping transit Port Sudan Deep to Hatiba Deep; E of previous mappings - 26.01.11 to 27.01.11			
50 KDS Hatiba Deep, NW end of young volcanic graben	22°01.29´/37°53.72' To 22°01.57'/37°54.05'	27.01.11 5:11 - 7:35	2450 - 2173	~40 pieces of small (2-25 cm) glassy basalt & glass crusts. Thin layers (cm-sized) of sheet lava, some with rope/pahoehoe structures. And some carbonate- Mn-crusts 1: 12x12x5 cm: Basaltic sheet lava, irregular with smooth bottom. 1-3 cm glassy crust (fresh with rusty alteration). Sediment crust on top. Basalt: massive, no clear features. Fast transition to glass. Gl, TS 2: 15x12x5 cm: Glassy basaltic sheet flow. Basalt ~1% vesicular, some larger vesicles up to 2 mm. 1 Pl phenocryst present of 2 mm. ~1 cm glass crust on top (fragmented, rusty altered, fresh) and <2 mm on bottom. Some flow structures on top rock. One glass layer over ~1 mm sediment. Core is basaltic, transition to glass over ~1/2 cm, grainlike. Gl, TS. 3: 25x12x5 cm: Tube basaltic sheet flow. Large vesicles inside. Fresh (partly rusted and fragmented at surface) glass crust all around of min. 4 mm thick. Inner part: massive basalt, no clear features, or dense pure glass (?) Gl, TS 4: 10x8x2 cm: Basaltic sheet flow, mainly glass. ~1/2-1 cm basalt at one side, massive no features. Very small (mm scale) flow structures on surface. Min. 1 cm glass crust on top, mm's at bottom. Fresh with rusty alteration at surface. Very fine flow structures (following the outer surfaces) inside the rock, between glass and basalt (black and grey rock). Gl, TS 5: 15x15x2 cm: Bended (wavy) irregular ~1 cm thick sheet basalt with ropey/pahoehoe structures at top. Bottom: smooth but fractured. 2-10 mm glass crust, fresh, minor rust. Dense basalt, no features. Vague gradual transition basalt-glass with some flow-mix structures between both. Gl, TS 6: 8x4x2.5 cm: basaltic sheet flow. 2 mm thick glass crust on top and bottom, fresh, smooth. Basalt: 5% vesicular, some vesicles up to 3 mm and one cm's vesicle. Gl, TS 7: 9 pieces of sedimentary rock: loosely consolidated carbonate crust (6x), carbonate crust + orange mud on basalt, Mn- and carbonate-crust (orange surface; 2x) Extra samples: 8 pieces of sheeted lava with various flow structures: Ropey (Extra 1, 2, 3) Fine structured (Extra 4, 5), Smooth (Extra 6), Irregular (Extra 7), Glass crust (Extra 8)
51 KDS Hatiba Deep, hill directly E of young volcanic field. (e.g. 18 KDS, 19 KDS)	22°00.00'/37°55.46' To 22°00.30'/37°55.79'	27.01.11 8:13 - ~10:30	2362 - 2294	~30 pieces of sediment crust 1: 2 pieces, 20x15x5 cm and 18x15x10 cm: Carbonate sediment crust, Mn coated. Carbonate fragments on one side, black Mn crust on otherside, including black gastropod shells 2: 15x12x3 cm: Yellowish-brown carbonate crust, many gastropode shells
52 KDS 2nd E ridge, E of Hatiba Volcanic field	22°00.20'/37°57.05' To 22°0.36'/37°57.28'	27.01.11 10:49 - 13:00	2037 - 1942	Empty (yellowish brown sediment in sediment traps
53 MB	Mapping NE of Hatiba deep - 27.01.11 to 28.01.11			
54 VSR N part of basin Hatiba Deep	22°01.98'/37°53.88'	28.01.11 3:17 - ~4:30	2251	Mud, also on plate. Mixture of brownish and greyish stiff mud
55 VSR Hatiba Deep, in	22°00.959'/37°54.243'	28.01.11 4:58 - 6:17	2246	Mud, yellowish brown, coarse grained. (shell components?)

between volcanic centers of 18,19 KDS and 50 KDS				
56 VSR West part of Hatiba Deep	22°00.134'/37°53.773'	28.01.11 6:39 - 7:59	2233	Greyish mud
57 KDS Volcanic field NE corner, same as 55 VSR	22°00.96'/37°54.24' To 22°01.13'/37°54.45'	28.01.11 8:52 - ~10.50	2235 - 2234	Empty (sediments in traps)
58 KDS Hatiba volcanic field top (small pillow mound?)	21°59.92'/37°54.74' To 22°00.22'/37°54.90'	28.01.11 11:10 - ~13:30	2212 - 2219	~20 pieces of sheeted lava and tongs of basalt, very glassy + many pieces (>30) of carbonate/Mn crust 1: 40x25x20 cm: Basaltic lava tong, irregular smooth shape. Very glassy, min. 2 cm glass crust, only tine basalt fragments/grains in core. Fresh glass with rusty alteration at surface. Gl, TS 2: 25x15x15 cm: Basaltic lava tong. Lower surface part of a void filled with sediment. 1-2 cm glass crust all around, fresh, rusty altered at surface. Gradual transition basalt-glass over 1/2 cm. Massive basalt, no apparent features. Gl, 2x TS 3: 18x15x4 cm: Basaltic sheet lava, pure glass. Circular breaking structure. Fresh glass, rusty alteration at surface. Large void inside. Sediment crust on top. Flow lines in interior sample. Gl, TS. 4: 12x12x4 cm: Basaltic sheet lava, end part. Void inside, filled with sediment and some loose glass. Glass crust (fresh, minor rust) of 2-10 mm thick. Basalt is rusted at surface, massive, no clear features. Gl, TS 5: 10x6x6 cm: Basaltic rock, with 1 mm glass crust (fresh). Gradual basalt-glass transition over 1/2 cm. Massive basalt with 10% vesicularity. Gl, TS 6: 20x10x6 cm: Glassy lava tong, pure glass, fresh. Circular fracturing. Fine ropey surface, rusty (palagonite) altered all around the rock. Gl, TS 7: 10x8x3 cm: Pure glass crust. Bottom part attached to baked (?) hard light yellow sediment. Fresh glass, rusty alteration at surface. Gl, TS Sed. 1 + 2: Carbonate crust, Mn coated with yellowish orange mud. 5 pieces. Extra samples: 2 pieces of very glassy sheet lava (Extra 1,2)
59 MB	Mapping SE from Hatiba Deep - 28.01.11 to 29.01.11			
60 SL 4 m Shelf NE of Hatiba Deep	22°09.36'/38°08.79'	29.01.11 3:18 - ~3.50	890	Empty
61 SL 4 m Shelf NE of Hatiba Deep; same as 60 SL	22°09.36'/38°08.78'	29.01.11 4.04 - ~4:30	892	Core recovery: 76 cm
62 BG Shallow part of the shelf, NE of Hatiba Deep; at flow structure	22°09.41'/38°17.25'	29.01.11 5:41 - 6:12	638	Muddy sand, medium to coarse size fration, carbonate, very pale brown (10 yr 7/4)
63 SL 4 m Shelf, E of (Southern) Hatiba Deep	21°56.54'/38°17.01'	29.01.11 8:05 - 8:43	1013	Core recovery: mud in core catcher (10yr 7/4)
64 SL 4 m Shallower part of Shelf, E of 63SL	21°56.05'/38°31.72'	29.01.11 10:29 - 10:58	847	Core recovery: 3.38 m: greyish very dense sediment. Top loss: none
65 SL 4 m SE of Hatiba Deep on shelf; S of 64SL	21°41.08'/38°31.89'	29.01.11 13:05 - ~13: 40	860	Core recovery: mud in core catcher: light brown sandy mud
66 SL 4 m Shelf, NE of Atlantis II Deep	21°26.21'/38°16.89'	30.01.11 3:50 - 4:17	923	Core recovery: 3 m
67 SL 4 m Shelf E of 66SL	21°26.58'/38°31.93'	30.01.11 6:11 - ~6:45	860	Core recovery: 3.8 m
68 SL 4 m Shelf E of 67 SL, halfway between Jeddah and spreading axis	21°26.49'/38°45.66'	30.01.11 8:30 - ~9:00	686	Core recovery: 3.23 m

7. References

Anschutz, P., and G. Blanc (1996), Heat and salt fluxes in the Atlantis II Deep (Red Sea), in *Earth and Planetary Science Letters*, edited, pp. 147-159

Anschutz, P., et al. (1999), Hydrographic changes during 20 years in the brine-filled basins of the Red Sea, *Deep-Sea Res Pt I*, *46*(10), 1779-1792.

Anschutz, P., et al. (2000), Geochemical dynamics of the Atlantis II Deep (Red Sea): II. Composition of metalliferous sediment pore waters, *Geochimica et Cosmochimica Acta*, *64*(23), 3995-4006.

Antonini, P., et al. (1998), A segment of sea-floor spreading in the central Red Sea: basalts from the Nereus Deep (23 degrees 00 '-23 degrees 20 ' N), in *J Afr Earth Sci*, edited, pp. 107-114.

Cochran, J. R. (1983), A model for the development of the Red Sea, *A.A.P.G. Bull.*, *67*(1), 41-69.

Cochran, J. R. (2005), Northern Red Sea: Nucleation of an oceanic spreading center within a continental rift, *Geochem. Geophys. Geosyst.*, *6*, Q03006.

Dekov, V. M., et al. (2007), Fe-Mn-(hydr)oxide-carbonate crusts from the Kebrit Deep, Red Sea: Precipitation at the seawater/brine redoxcline, in *Marine Geology*, edited, pp. 95-119.

Ghebreab, W. (1998), Tectonics of the Red Sea region reassessed, *Earth-Sci. Rev.*, *45*, 1-44.

Hartmann, M., et al. (1998), Hydrographic structure of brine-filled deeps in the Red Sea - new results from the Shaban, Kebrit, Atlantis II, and Discovery Deep, *Marine Geology*, *144*(4), 311-330.

Izzeldi, A. Y. (1987), Seismic, gravity and magnetic surveys in the central part of the Red Sea - Their interpretation and implications for the structure and evolution of the Red Sea, *Tectonophysics*, *143*(4), 269-&.

Pautot, G., et al. (1984), Discovery of a large brine deep in the northern Red Sea, *Nature*, *310*(5973), 133-136.

Pierret, M., et al. (2001), Chemical and isotopic (Sr-87/Sr-86, delta O-18, delta D) constraints to the formation processes of Red-Sea brines, *Geochimica et Cosmochimica Acta*, *65*(8), 1259-1275.
Pierret, M. C., et al. (2010), Formation of Thetis Deep metal-rich sediments in the absence of brines, Red Sea, *J Geochem Explor*, *104*(1-2), 12-26.

Schmidt, M., et al. (2003), High-resolution methane profiles across anoxic brine-seawater boundaries in the Atlantis-II, Discovery, and Kebrit Deeps (Red Sea), in *Chemical Geology*, edited, pp. 359-375.

Scholten, et al. (1991), Evidence for episodic hydrothermal activity in the Red Sea from the composition and formation of hydrothermal sediments, Thetis Deep, *Tectonophysics*, *190*, 109 - 117.

8. Acknowledgements

Our thanks go to the Captain and crew of R.V. "Poseidon" for their excellent professional work throughout the cruise. The Royal Saudi Navy is thanked for support and protection whilst at sea. This sub-project was financed as part of the "Jeddah Transect" Project by the King Abdulaziz University (KAU), Ministry of Higher Education.

Part B: Cruise Report of R/V POSEIDON cruise P408/a/b

Table of Contents

RV Poseidon Cruise No.: 408-2
Dates, Ports: 6th February 2011 (Jeddah) – 12 February 2011 (Jeddah), Leg 2a
Dates, Ports: 12th February 2011 (Jeddah) – 20 February 2011 (Jeddah), Leg 2b
Research subject: Red Sea Deeps, fluid/gas characteristics, biogeochemistry
Chief Scientist: Dr. Mark Schmidt, IFM-GEOMAR, Kiel
Number of Scientists: 9 + 1 Saudi Military Observer
Project: Jeddah Transect

Nautical and Scientific Crews

a) Ship's crew Leg 2a,b

No.	Rank	Name	First Name	Home Country
1	Kapitän	Günther	Matthias	Germany
2	Chief. Off.	Windscheid	Bernhard	Germany
3	2nd Off.	Hänsel	Alexander	Germany
4	Chief Eng.	Stange	Hans-Otto	Germany
5	2nd Eng.	Hagedorn	Günter	Germany
6	Electrician	Klare	Dietmar	Germany
7	Motor man	Engel	Rüdiger	Germany
8	Bosun	Schrage	Frank	Germany
9	Mechanic	Peters	Ralf	Germany
10	Mechanic	Rauh	Bernd	Germany
11	Mechanic	Kohnke	Frank-Dieter	Germany
12	Mechanic	Hampel	Ulrich	Germany
13	Seaman	Kuhn	Ronald	Germany
14	Cook	Habecker	Horst	Germany
15	Steward	Mack	Ulrich	Germany

b) Scientific crew – Leg 2a

No.	Name & Given name	Function onboard	Home Country
1	Dr. Mark Schmidt	Chief scientist	Germany
2	Dr. Peter Linke	Co-chief scientist	Germany
4	Dr. Daniel F. McGinnis	Scientist	USA
5	Prof. Ali Basaham	Scientist	Saudi Arabia
3	Peggy Wefers	Technician	Germany
6	Peter Feldens	Scientist	Germany
7	Dr. Alaa Al-Barakati	Scientist	Saudi Arabia
8	Marine Captain Abdul Rahman Bin Saud Al Deghaither	Observer	Saudi Arabia
9	Moussa Al-Zobidi	Student/Technician	Saudi Arabia
10	Khalid S.I. Al-Dayel	Observer	Saudi Arabia
11	Ali Al-Shamrani	Student/Technician	Saudi Arabia

c) Scientific crew – Leg 2b

No.	Name & Given name	Function onboard	Home Country
1	Dr. Mark Schmidt	Chief scientist	Germany
2	Dr. Peter Linke	Co-chief scientist	Germany
4	Dr. Daniel F. McGinnis	Scientist	USA
5	Dr. Mamdouh Jamal	Scientist	Saudi Arabia
3	Peggy Wefers	Technician	Germany
6	Peter Feldens	Scientist	Germany
7	Dr. Alaa Al-Barakati	Scientist	Saudi Arabia
8	Marine Captain Abdul Rahman Bin Saud Al Deghaither	Observer	Saudi Arabia
9	Kazem Sultan	Student/Technician	Saudi Arabia
10	Dr. Elgasim Elgarafi	Observer	Sudan
11	Mustafa Gogandi	Student/Technician	Saudi Arabia

Left to right: Kazem Sultan, Mamdouh Jamal, Abdul Deghaithier, Elgasim Elgarafi, Mustafa Gogandi, Alaa Barakati, Peter Linke, Mark Schmidt, Peter Feldens, Peggy Wefers, Daniel McGinnis

Left to right: Khalid Al-Dayel, Ali Basaham, Ali Al-Shamrani, Moussa Al-Zobidi

1. Abstract

The research cruise P408-2 was conducted in order to investigate fluid/gas characteristics in sediment and water/brine, and to determine transport processes across sediment-seawater and brine-seawater interfaces in the Red Sea. Biogeochemical, oceanographic, and geophysical methods were used in a multidisciplinary approach. From this we expect new insights to sub-seafloor hydrocarbon formation related to variable heat flow, syn- and post-rifting fracturing, and the halokinetic structuring along the Jeddah Transect area in the Red Sea.

Gas/fluid seeps at the seafloor and relations to subsurface reservoirs and migration channels are located by a combination of seismic and hydroacoustic methods (i.e. reflection seismic, multibeam bathymetry, ADCP; water column imaging with multibeam). The geophysical data is recorded along a transect between the hydrothermally active Atlantis II Deep (seafloor spreading) and the sediment-hosting shelf area near Jeddah (sediment basin type deposits).

Detailed oceanographic investigations were conducted in the Atlantis II Deep brine area to adequately define relevant transport processes by measuring currents in Red Sea deep water above the brine pool, and determining internal wave characteristics at the brine-seawater interface. Evidence for diffusive and/or turbulent transport will be derived from Microstructure profilers, ADCPs, and geochemical analyses.

Dissolved hydrocarbons in hot brine are determined and new data will be compared with data from 1995 and 1997. Stable isotope analyses and major/trace analyses are conducted to clarify subsurface biogeochemical processes (HCs inflow, degassing, thermal/bacterial/catalytic degradation). Moreover, spatial variations of gas concentrations and isotope signatures will give insights about local seeps and plume distribution in the Atlantis II Deep area. Geochemical characteristics of hydrothermal petroleum sampled from Atlantis II Deep sediment will help to quantify the importance of hydrothermal HC formation in this area. Moreover, searching for potential new microbial metabolic pathways related to hydrothermal activity and a reduced, hyper-saline environment is also a potential scientific target here.

2. Cruise Narrative

The research cruise P408-2a/b with RV Poseidon started on the 6th of February in Jeddah, Saudi Arabia. RV Poseidon met with a ship of the Royal Saudi Navy at the first scientific station approximately 10 nautical miles off the coast of Jeddah.

Most of the planned work was finished within the following days along the “Jeddah Transect” which connects Jeddah with the Atlantis II Deep by a virtual line. The Atlantis II Deep area was entered on the ninth of February after work permission for this area had also been approved by the Sudanese authorities and sent via the German Ministry for Foreign Affairs.

After spending 2 days at the Atlantis II Deep we headed east to exchange scientists and students on the 12th of February in Jeddah Islamic Port. Despite the reduction of working days at the beginning of the cruise, we had already fulfilled several of our scientific goals from Project 1 proposal at this time, and we had already got exiting new insights into brine-seawater exchange processes by our recent data sets. The observed fluid/gas release site discovered along the Jeddah Transect provided promising opportunities of sampling hydrocarbon-rich fluids and associated diagenetic products (authigenic carbonates?) from the seafloor during leg P408-2b .

The 13th to 15th of February was spent finishing most of our scientific work at Atlantis II Deep. In order to extend our geochemical data set of Red Sea brine between 19° and 26°N we then decided to visit the brine-filled Port Sudan Deep within Leg 2b.

For the following two days we sampled brine and sediment from Port Sudan Deep (19° N). After coming back to the Jeddah Transect area we investigated the so-called “Gas Site” which showed shallow gas in the seismic recordings. Two more days in the Atlantis II Deep finished the second part of research cruise P408-2 in the Red Sea.

Jeddah harbor was entered on the 20th of February early in the morning, and the research cruise P408-2 was finished in the afternoon of the 20th by introducing the Video CTD technique to the colleagues of P408-3 cruise.

3. Work performed and preliminary results

3.1 Station list

Station No	Gear	Gear No	Area	Date	Deploy time UTC (hhmm)	Latitude N (dd°mm')	Longitude E (dd°mm')	Water depth (m)	Recovery time UTC (hhmm)	Latitude N (dd°mm')	Longitude E (dd°mm')	Water depth (m)	Remarks
69	VCTD	1	Jeddah Transect	6/2/2011	1545	21 34.81	38 51.02	751	1714	21 35.12	38 50.52	726	No bottles fired HydroC-CH4, PAH
70/1 3	MSS	1	Jeddah Transect	6/2/2011	(1715) (1813) (1834)	(21 35.13) (21 35.09) (21 35.08)	(38 50.51) (38 49.49) (38 49.04)	750 750 760	1756 1822 1914				test1_0002.mrd test2_0003.mrd test3_0004.mrd
71	MB+SS	1 1	Jeddah Transect	6/2/2011	2000	21 34.2	38 43.2	780	0450	21 23.4	38 14.0	1130	
72	VCTD	2	Jeddah Transect	7/2/2011	645	21 23.375	38 13.690	1128	0811	21 23.36	38 13.70	1099	HydroC-CH4, PAH
73	GC	1	Jeddah Transect	7/2/2011	0923	21 23.933	38 15.824	1163	0947	21 23.94	38	1061	
74/1 3	MSS	2	Jeddah transect	7/2/2011	(1020) (1108) (1157)	(21 23.330) (21 22.97) (21 22.673)	(38 13.712) (38 13.90) (38 14.092)	1128 1128 1124	1223	21 22.454	38 14.209	1128 1128 1124	MSS04_0007.mrd MSS05_0008.mrd MSS06_0009.mrd
75	VCTD	3		7/2/2011	1421	21 26.21	38 23.77	918					Failure
76/1 3	MSS	3	Jeddah transect	7/2/2011	(1554) (1636) (1714)	(21 26.16) (21 21.025) (21 25.97)	(38 23.82) (38 23.915) (38 23.96)	918 919 903	(1554) (1636) (1714)	(21 26.16) (21 21.025) (21 25.97)	(38 23.82) (38 23.915) (38 23.96)	918 919 903	MSS07 MSS08 MSS09
77	MB+SS	2 2	Jeddah transect	7/2/2011	1910	21 26.333	38 13.950	988.0	0505	21 38.0	38 50.9	740.0	
78	VCTD	4	Jeddah transect	8/2/2011	0609	21 37.061	38 59.139	765.0	0720	21 37.045	38 59.0	765.0	200m recorded HydroC-CH4, PAH

Station No	Gear	Gear No	Area	Date	Deploy time UTC (hhmm)	Latitude N (dd°mm')	Longitude E (dd°mm')	Water depth (m)	Recovery time UTC (hhmm)	Latitude N (dd°mm')	Longitude E (dd°mm')	Water depth (m)	Remarks
79/1 6	MSS	4	Jeddah transect	8/2/2011	(0732) (0806) (0838) (0910) (0940) (1011)	(21 37.01) (21 36.767) (21 36.44) (21 36.25) (21 36.07) (21 35.86)	(38 59.08) (38 58.767) (38 58.47) (38 58.23) (38 58.08) (38 57.86)	764 763 763 765 769 773	1035	(21 37.01) (21 36.767) (21 36.44) (21 36.25) (21 36.07) (21 35.86)	(38 59.08) (38 58.767) (38 58.47) (38 58.23) (38 58.08) (38 57.86)	764 763 763 765 769 773	MSS10 >MSS15
80	GC	2	Jeddah transect	8/2/2011	1154	21 34.360	38 49.568	837.0	1218	21 34.349	38 49.588	771.6	Core recovery 328cm
81	MB	3	Jeddah transect	9/2/2011	1247	21 36.20	38 50.201	771	0500	21 18.3	38 3.0	1800.0	
82	VCTD	5	Atl. II	9/2/2011	0557	21 20.166	38 5.38	2131.0	0844	21 21.102	38 3.31	1970.0	HydroC-CH4, PAH ADCP
83	VCTD	6	Atl. II S.	9/2/2011	1042	21 20.517	38 4.913	2140.0	1235	21 20.52	38 4.869	2138.0	HydroC-CH4, PAH
84	VCTD	7	Atl. II N.	9/2/2011	1412	21 26.410	38 3.529	2058.0	1608	21 26.352	38 3.529	2117.0	HydroC-CO2, PAH
85	MB	4	Atl. II	9/2/2011	1804	21 18.13	38 53.19	1408.0	0507	21 28.57	38 3.56	1697.0	
86/1 2	MSS	5	Atl. II south	10/2/2011	(0627) (0800)	(21 20.514) (21 20.47)	(38 4.894) (38 4.92)	2139 2141		(21 20.514) (21 20.47)	(38 4.894) (38 4.92)	2139 2141	MSS16 >MSS17A
87	GC	3	Atl. II south	10/2/2011	0908	21 20.527	38 4.917	2103.7	1006	21 20.53	38 4.91	2319.0	370 cm core recovery
88	MSS	6	Atl. II North	10/2/2011	1111	21 26.394	38 3.544	2121		21 26.394	38 3.544	2121	MSS18 MSS18a
89/1	CTD	1-1	Atl. II North	10/2/2011	1220	21 26.354	38 3.541	2057.0	1230				SBE, pH, (label 8) tube was connected
89/2	CTD	1-2	Atl. II North	10/2/2011	1235	21 26.331	38 3.528	2058.0	1334	21 26.346	38 3.535	2058.0	SBE 1, pH tube was connected

Station No	Gear	Gear No	Area	Date	Deploy time UTC (hhmm)	Latitude N (dd°mm‘)	Longitude E (dd°mm‘)	Water depth (m)	Recovery time UTC (hhmm)	Latitude N (dd°mm‘)	Longitude E (dd°mm‘)	Water depth (m)	Remarks
89/3	CTD	2	A II North	10/2/2011	1415	21 26.343	38 3.544	2056.0	1555	21 26.312	38 3.531	2082.0	SBE 2, pH
90	MB+SS	5 3	Atl. II	10/2/2011	1700	21 26.46	38 6.93	1632	0544	21 23.16	38 12.96	1120.0	
91	VCTD	9	A II S. Central	11/2/2011	0842	21 23.14	38 3.407	2122.0	1035	21 23.143	38 3.315	2111.0	HydroC-CO2, PAH
92	VCTD	10	A II N. Central	11/2/2011	1141	21 21.899	38 3.889	2152.0	1334	21 21.849	38 3.870	2150.0	HydroC-CO2, PAH
93/1	MB	6	Atl. II	11/2/2011	1610	21 17.52	38 13.34	1430.0	2200	21 24.76	38 7.85	1679.0	
94	MB	8	Atl. II > Jeddah	12/2/2011	2201	21 24.76	38 8.39	1679.0	0313	21 39.61	38 50.0	697	
95	MB	9	Jeddah > Atl. II	12/2/2011	1625	21 33.685	38 53.52	754	0024	21 24.32	38 7.84	1612.0	
93/2	MB	7	Atl. II	13/2/2011	0025	21 24.32	38 7.84	1612.0	0426	21 25.90	37 47.14	1150.0	Proceeding 93 1
96/1	VCTD	11	Discover y	13/2/2011	0655	21 16.889	38 3.002	2261.0	0909	21 16.915	38 3.004	2200	HydroC-CO2, PAH
96/2,3	VCTD	12	Discover y	13/2/2011	1030	21 16.912	38 2.984	2200.0	1247	21 16.93	38 2.98	2200	HydroC-CH4, PAH RBR CTD
97	MSS	7	Discover y	13/2/2011	1320	21 16.97	38 2.94	2200	1438	21 16.97	38 2.94	2200	MSS19
98	MB+SS	10 1	Atl. II	13/2/2011	1700	21 26 28	38 05 37	1954	1935	21 28.89	38 13.76	877	Sparker died
99	MB	10 2	Atl. II	13/2/2011	2114	21 20.94	38 13.41	1121	0445	21 17.99	38 14.97	1250.0	
100	GC	4	Atl. II S. Central	14/2/2011	0642	21 21.893	38 3.875	2073.0	0747	21 21.95	38 3.86	2072	273 cm core recovery

Station No	Gear	Gear No	Area	Date	Deploy time UTC (hhmm)	Latitude N (dd°mm')	Longitude E (dd°mm')	Water depth (m)	Recovery time UTC (hhmm)	Latitude N (dd°mm')	Longitude E (dd°mm')	Water depth (m)	Remarks
101	VCTD	13	Discover y	14/2/2011	0900	21 16.906	38 3.018	2222.0	1142	21 16.944	38 3.010	2225.0	HydroC-CH4, PAH RBR CTD
102	MB	11	Atl. II	14/2/2011	1253	21 13.42	37 59.56	1651	1939	21 17.80	38 14.15	1299	
103	MB+SS	11 5	Atl. II	14/2/2011	1958	21 16.8	38 14.5	1360.0	0155	21 20.85	37 55.09	1192.0	
104/1	MSS	8	Discover y	15/2/2011	0520	21 16.523	38 2.998	2162		21 16.523	38 2.998	2162	MSS20 stopped 1500m MSS20a restart
105	MSS	9	Atl. II south	15/2/2011	0821	21 19.95	38 5.434	2163		21 19.95	38 5.434	2163	MSS21 stopped 1500m MSS21a restart
106	MSS	10	Atl. II south central	15/2/2011	1022	21 21.96	38 3.85	2148		21 21.96	38 3.85	2148	MSS22 stopped 1100m MSS22a 1330m MSS22b up cast (huge cable spooling)
107/1	MSS	11	Atl. II north central	15/2/2011	1237	21 24.61	38 3.94	2089		21 24.61	38 3.94	2089	MSS23 stopped 1100 MSS23a 1200m > (sensor cover)
107/2	MSS	12	Atl. II north central	15/2/2011	1431	21 24.58	38 3.905	2090		21 24.58	38 3.905	2090	COVERS OFF MSS24 stopped 1400m MSS24a 1489 >
108	MSS	13	Atl. II north	15/2/2011	1617	21 26.392	38 3.507	2084		21 26.392	38 3.507	2084	MSS25 stopped 1500m MSS25a 1548 >
109	MB	12	Atl. II > P.Sudan	15/2/2011	1946	21 16.01	38 13.65	1370.0	0555	20 3.688	38 30.218	2503.0	

Station No	Gear	Gear No	Area	Date	Deploy time UTC (hhmm)	Latitude N (dd°mm')	Longitude E (dd°mm')	Water depth (m)	Recovery time UTC (hhmm)	Latitude N (dd°mm')	Longitude E (dd°mm')	Water depth (m)	Remarks
110	GC	5	Port Sudan	16/2/2011	0610	20 4.611	38 30.733	2696.0	0735	20 4.62	38 30.710	2706.0	359 cm core recovery
111	VCTD	14	Port Sudan	16/2/2011	0900	20 4.579	38 30.734	2842.0	1003	20 4.614	38 30.722	2835.0	HydroC-CH4, PAH
112	MSS	14	Port Sudan	16/2/2011	1031	20 4.611	38 30.741	2860		20 4.611	38 30.741	2860	MSS26 to 1600m MSS26a 1600 to1800m MSS26b 1800 >
112/2	MSS	15	Port Sudan	16/2/2011	1334	20 4.640	38 30.723	2843	1521	20 4.640	38 30.723	2843	MSS27 stopped 2000m MSS27a 2234m (Added 2 thick rings=7thick rings. Replaced 2 shear sensors)
113	MB	13	Port Sudan	16/2/2011	0427	19 59.4	38 33.6	2040.0	0401	20 4.25	38 23.06	1888.0	
114	VCTD	15	Port Sudan	17/2/2011	0518	20.5.154	38 30.314	2718.0	0730	20 5.166	38 30.338	2793.0	HydroC-CH4, PAH new pressure head
115	VCTD	16	Port Sudan	17/2/2011	0908	20 5.477	38 31.613	2230.0	1250	20 4.644	38 31.151	2728.0	HydroC-CO2, PAH
116	MB	14	Port Sudan	17/2/2011	1400	20 9.28	38 26.12	2282.0	0458	21 16.37	38 12.42	2503.0	
117	VCTD	17	Gas site	18/2/2011	0709	21 27.94	38 15.76	708.0	0850	21 27.498	38 15.801	839.0	HydroC-CH4, PAH ADCP
118	VCTD	18	Gas site	18/2/2011	0917	21 27.539	38 5.985	794.0	1038	21 27.55	38 15.753	837.0	ADCP, started @ 600m
119	VCTD	19	Atl. II Deep	18/2/2011	1254	21 2.009	38 1.166	1692.0	1630	21 22.966	38 2.417	2092.0	CH4, PAH
120	MB	15	Atl. II	18/2/2011	1733	21 23.87	38 7.32	1750.0	0038	21 15.73	38 12.37	1358.0	

Station No	Gear	Gear No	Area	Date	Deploy time UTC (hhmm)	Latitude N (dd°mm')	Longitude E (dd°mm')	Water depth (m)	Recovery time UTC (hhmm)	Latitude N (dd°mm')	Longitude E (dd°mm')	Water depth (m)	Remarks
121	MSS	16	Atl. II South	19/2/2011	0315	21 19.930	38 5.490	2102.0					1st in transect, MSS28 to 1500 MSS28a >
122	MSS	17	Atl. II S.S. central	19/2/2011	0454	21 20.532	38 4.899	2109.0					MSS29 to 1500 MSS29a >
123	MSS	18	Atl. II South central	19/2/2011	0618	21 21.899	38 3.865	2131.0					MSS30 to 1500 MSS30a >
124	MSS	19	Atl. II N. Central	19/2/2011	0734	21 23.200	38 3.368	2124.0					MSS31 to 1500 MSS31a >
125	MSS	20	Atl. II N.N. central	19/2/2011	0905	21 24.583	38 3.978	2090.0					MSS32 to 1500 MSS32a >
126	MSS	21	Atl. II North	19/2/2011	1045	21 26.330	38 3.511	2082.0	1139	21 26.34	38 3.70	2031	Last in transect, MSS33 to 1500 MSS33a >

VCTD – Video CTD (Sea and Sun Technology)

CTD – Seabird CTD (RV Poseidon)

MSS – Microstructure Sensor

GC – Gravity corer

MB – Multibeam

SS – Sparker reflection seismic

3.2 Acoustic measurements

Peter Feldens

3.2.1 Multibeam echo sounder

Bathymetric data were collected during research cruise P408-2 by using a SeaBeam 3050 (L3-Communication/ELAC Nautik), hull-mounted on FS Poseidon. This state-of-the-art multibeam system works with a frequency of 50 kHz. It emits two acoustic fans simultaneously, and utilizes up to 386 reception beams for achieving a higher data-density compared to previous generations of multibeam echo sounders. Return signal intensities were recorded and bathymetry was visualized in real time on screen throughout the cruise (fig. 1). These data will provide us with high-resolution bathymetric maps and help to classify seafloor surface sediments. For selected areas, water column image data (WCI) was also recorded to identify gas bubbles in the water column.

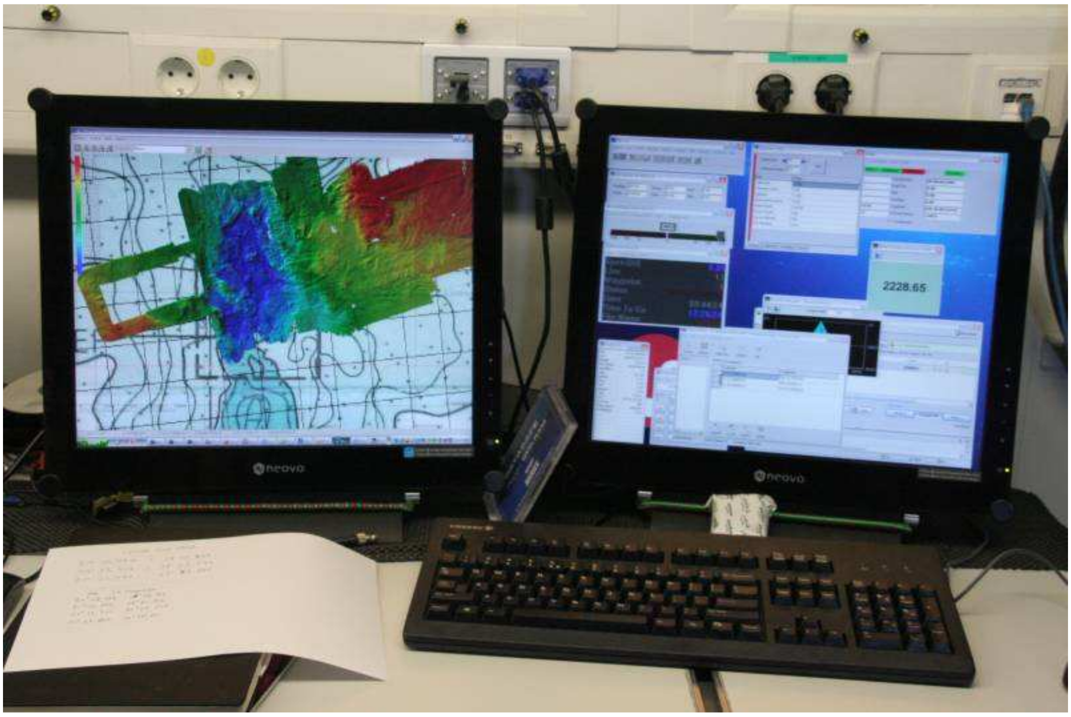


Figure. 1: Control panel of the Seabeam 3050 echosounder.

SW-NE directed profiles along the Jeddah transect were selected for the hydroacoustic surveys during P408-2a. The Jeddah transect is situated between the coastline and the main Red Sea graben axis. Therefore, the recorded data gives insight into structures over the whole continental shelf down to the adjacent Atlantis-II deep. Additionally, profiles along the central Red Sea rift axis and over the Port Sudan deep were recorded during the second cruise leg. The latter profiles are supplementary to data recorded during P408-1. In total, an area of approximately 3500 km^2 was mapped by multibeam echo sounder during cruise P408-2a and –2b (Fig.2).

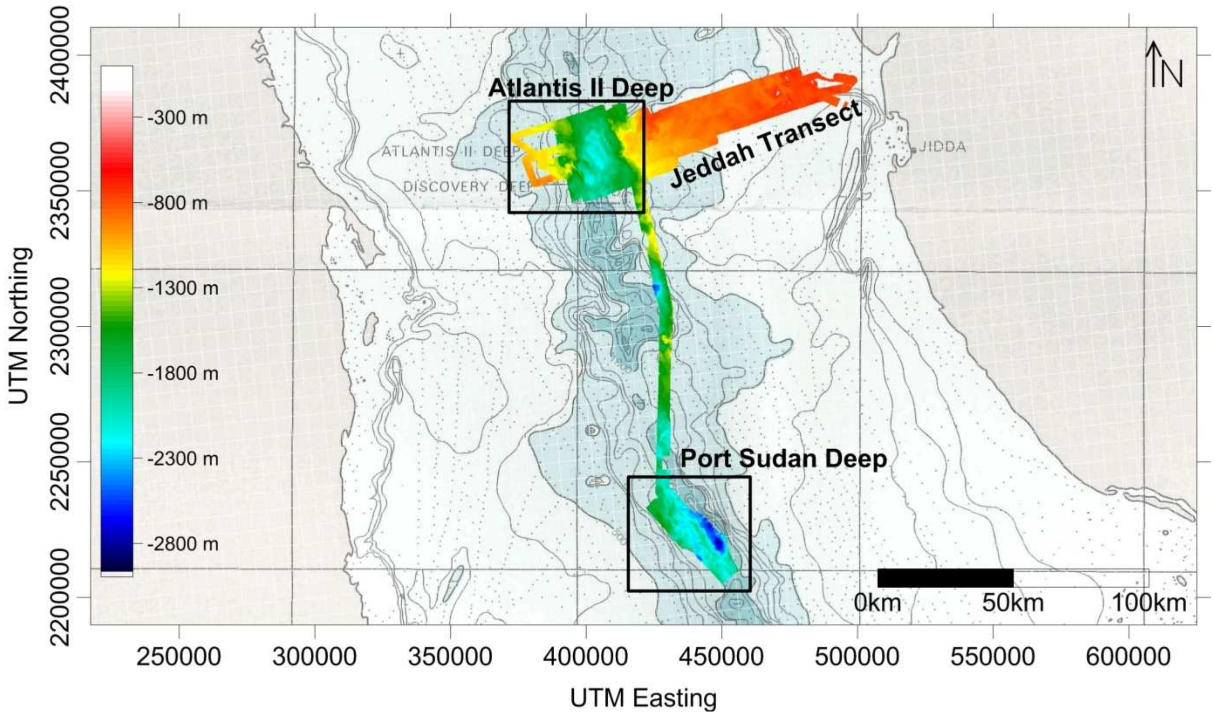


Figure 2: Overview of the collected bathymetric dataset. Rectangles mark position of subsequent figures.

3.2.2 Reflection seismic data acquisition

Reflection seismic data was acquired during P408-2 cruise using a Delta Sparker system (Applied Acoustics, Great Yarmouth, UK). The system comprises a power supply capable of discharging 12 kJ, a metallic frame towed behind the ship, and an 8-element single channel streamer. The acoustic signal is generated by rapidly discharging an electrical pulse between two electrodes, separated by seawater. By changing the electrodes ("tips") on the metal frame, the frequency of the system can be changed between app. 200 to 400 Hz and app. 4000 Hz. During the cruise, the lower frequencies were used, allowing for several hundred meters of penetration into the subsurface, while maintaining a relatively high maximal resolution of few meters. The use of higher frequencies would allow for a resolution in the range of decimeters, however, penetration depth would be substantially decreased in this case. The equipment including sparker frame, buoys, cables, power unit, and the sparker "in action" is shown in the following figure 3.

Figure 3: Sparker system and power supply unit used for reflection seismic data acquisition during P408-2, and the sparker firing with 10 kJ pulses.

In total, approximately 150 nautical miles of sparker profiles could be recorded during P408-2 before a failure of the power supply prohibited further measurements. Profiles were selected to cross seafloor features along the Jeddah transect, as well as the Atlantis II deep.

Additionally, two profiles cross coring stations of the Deep Sea Drilling Program, to allow for correlation of seismic interfaces with sedimentary layers. The recorded lines are displayed in Fig.4

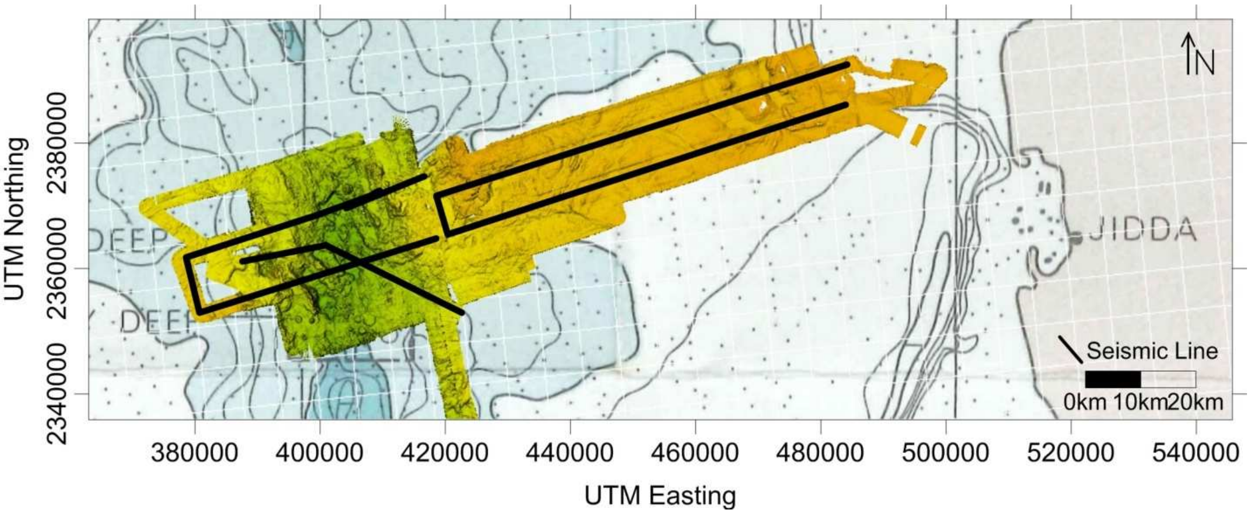


Figure 4: Overview of the recorded seismic lines.

3.2.3 Preliminary Results

The combination of high-resolution bathymetry and subsurface structure data forms a powerful framework for geomorphologic, geotectonic and stratigraphic studies. The unprocessed raw data already revealed some interesting features.

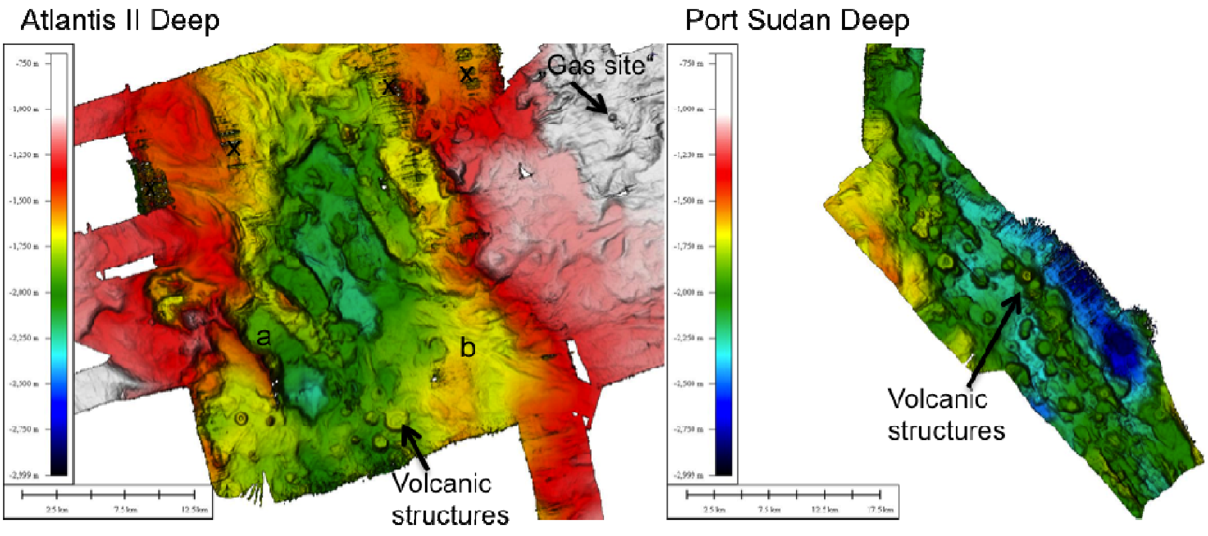


Figure 5: Detailed view of the Atlantis II and Port Sudan Deep. Positions are marked by rectangles in Fig 2. In both deep, volcanic structures are apparent, although more frequent in Port Sudan Deep. Steep fault and sliding structures form the boundary of the Atlantis II deep (a). Partly, sediment seems to flow into the deep (b). The displayed data is unprocessed, therefore numerous artifacts, mostly due to wave action, are visible in the data (marked by "x").

Of high interest is the bathymetric map of the Atlantis II deep (Fig.5), which has never before been recorded with comparable resolution (approximately 20 m). Fortunately, high-density brines filling parts of the Atlantis II deep had only little influence on depth measurements. Therefore, it will be possible to determine the exact volumes and surface areas of the different brine layers. Four of these layers can be differentiated in the seismic data due to their density stratification (Fig. 6B), supplementing information gathered by CTD measurements. Concentrated in the southern part of the Atlantis II deep, several volcanic structures could be observed, although much less frequent compared to the Port Sudan deep further south (Fig. 5). On the western slope of the deep, indications for normal faulting and slides are apparent, likely related to the continuing extension of the deep. In the south-east, sediment appears to be flowing into the Atlantis II deep. These flows might be connected to movements of the underlying evaporite strata, which was already described for the Red Sea area (Mitchell et al., 2010). The geochemistry of brine and metalliferous sediment related to subseafloor evaporite movement is of high scientific and economic interest in this area (e.g. Mitchell et al., 2011).

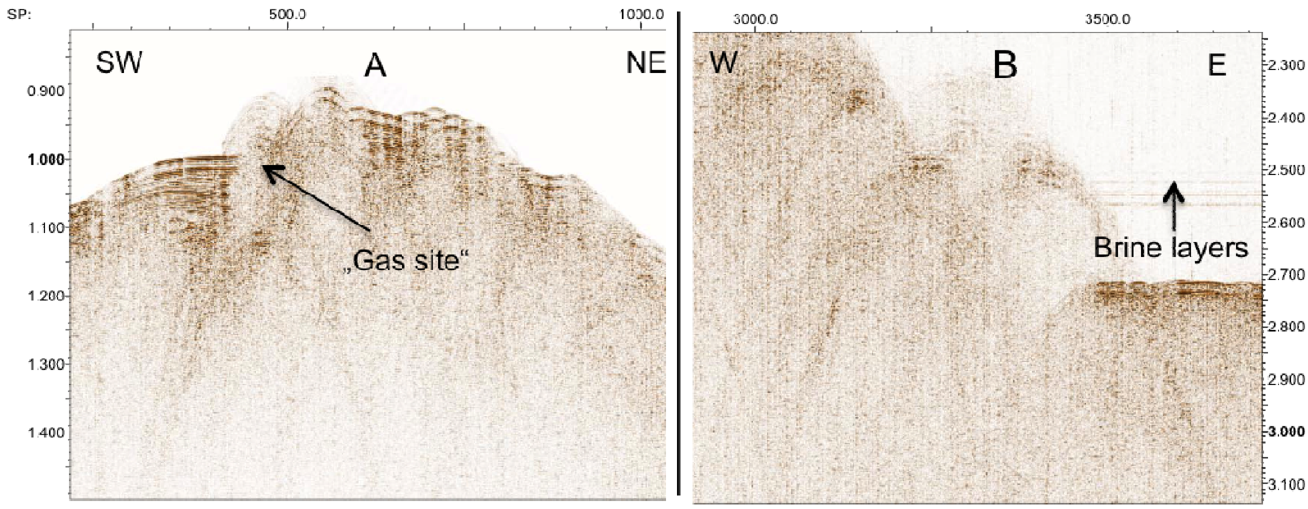


Figure 6: Details of two seismic lines (unprocessed data), crossing the "Gas Site" (A), and the Atlantis II Deep (B). X-Axis: Shotpoint number. Y-Axis: Two-Way travel time in seconds. A: At the "gas site" free gas within the sediment causes a blanking of seismic layers, as the gas absorbs the acoustic signal. B: Within the Atlantis II deep, four different brine layers can be distinguished.

At a water depth of approximately 750 m, gas is observed in the seismic data closely beneath the seafloor surface (Fig. 6A), indicating a potential gas seepage site. Bathymetric data show a series of rounded elevations (up to 120 m relative height, with a width of a few hundred meters) in close vicinity, preliminarily interpreted as young volcanic structures. No gas bubbles could be observed during two Video-CTD tracks; however, a fresh fracture system could be observed, potentially forming migration pathways for dissolved hydrocarbons.

Seismic profiles along the Jeddah transect revealed a continuous reflector at approximate depths of 1.3 to 1.5 s (Fig. 7). The reflector may represent the uppermost salt layer, deposited during the Miocene. This reflector was traced by Air Gun seismics in the Thetis Deep at a depth of approximately 1.5 s TWT (Mitchell et al., 2010). The much higher-resolution sparker seismics, in combination with information from DSDP cores 225 and 227, will allow us to create a detailed stratigraphy of the sediments above the salt layer. Eventually, it will be possible to relate the deformation pattern of the hemipelagic sediments, already described for the DSDP cores (Girdler & Whitmarsh 1974), to the movement of the evaporite. The S reflector cannot be traced beneath elevations reaching a relative height of up to 150 m and a width of up to 4.5 km m at water depths around 700 to 800 m (30 km offshore the coastline). Despite the depth and the highly active tectonic deformation in this area, the morphology of the elevation could resemble a drowned reef structure.

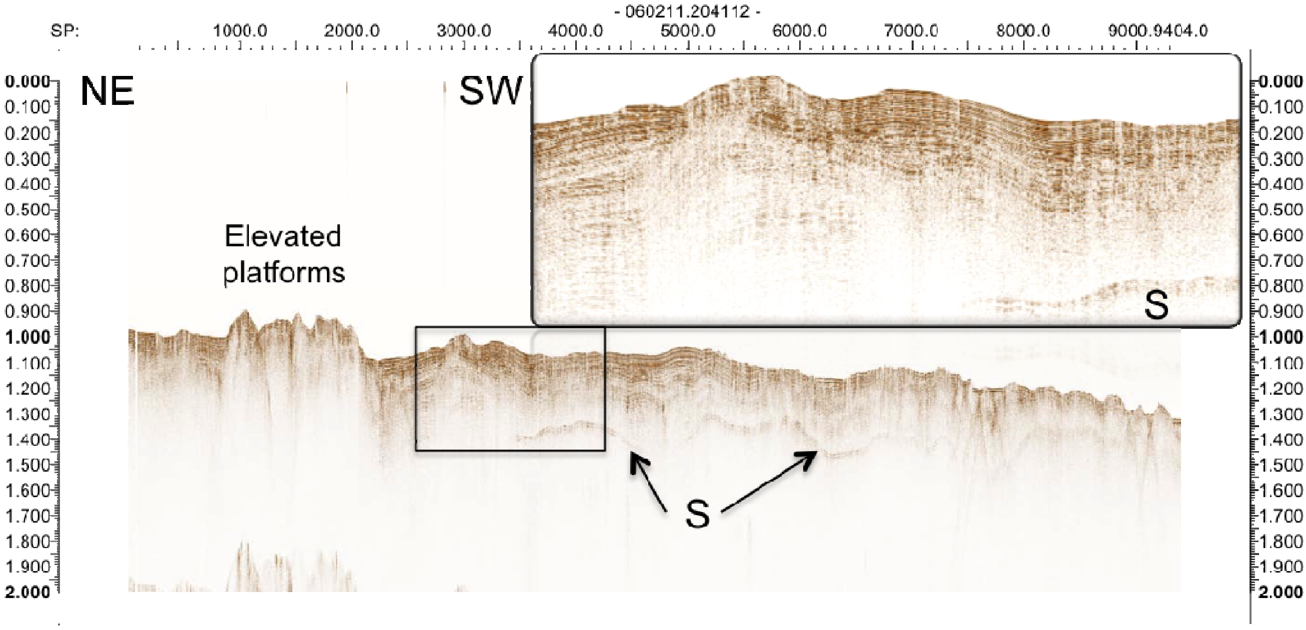


Figure 7: Seismic line 060211.204112 (unprocessed) along the Jeddah transect. X-Axis: Shotpoint number. Y-Axis: Two-Way travel time in seconds. Note that navigation has not yet been merged with the seismic data files. A reflector "S" is clearly visible along most of the profile, potentially representing the uppermost evaporite surface. Different stratigraphic units above the layer can be clearly recognized (Inset).

3.3 Water column sampling

Peter Linke, Mark Schmidt, Daniel McGinnis, Mustafa Gogandi, Moussa Al-Zobidi, Kazem Sultan, Ali Al-Shamrani, Peggy Wefers

3.3.1 Video CTD/ Water sampler rosette

A newly designed Video CTD (Sea & Sun Technology –SST-, Trappenkamp) was deployed during Poseidon cruise P408-2 (Fig. 8). This instrument combines a novel digital video and data telemetry (DST6000) with a modified CTD water sampler. The telemetry provides a bidirectional transmission of serial data (e.g. CTD or MSS data) and video data with a resolution of 720 x 576 pixels at 25 color images per second via a standard coaxial cable with a length of up to 8000 m. The main video camera consists of a full HD camcorder which can be controlled via the telemetry (zoom, start/stop internal recording with a resolution of 2.3 Mpixel). By using the integrated Ethernet interface several IP cameras can be controlled and their video data transmitted in parallel. During P408 an analog camera (Oktopus, Kiel) was used. Light is provided by 3 LED lights (Bowtech) which can be dimmed and adjusted to the required light conditions and turbidity. The telemetry provides power of up to 1.2 kW for external consumers. Two additional sensors are connected to the telemetry (Contros HydroC-CH_4 or CO_2 and PAH). All functions including triggering of the water samplers are controlled, data/videos displayed and recorded in the dry lab of RV Poseidon on a standard laptop with a second monitor by using the SST software (Fig. 9).

The VCTD water sampler rosette consists of a modified CTD (KMS86, Sea and Sun Technology) which was successfully adapted to the extreme saline and high-temperature conditions of the Red Sea brines (Tmax~68℃, S~270‰). The internal temperature of the underwater telemetry is displayed to monitor the impact of high-temperature conditions on the electronics. All instruments were integrated in the stainless steel frame which carries 12 x 10 l Niskin bottles. The distance of the instrument above the seafloor is controlled visually and by an acoustic bottom switch and is manually adjusted by the winch operator. For comparison, 3 CTD casts were conducted by using the shipboard Seabird CTD (Station 89-1 to 3). A pH sensor was mounted to the CTD in casts down to a water depth of 1200 m.

Figure 8: Deployment of the Video-CTD with various sensors integrated in the water sampler rosette.

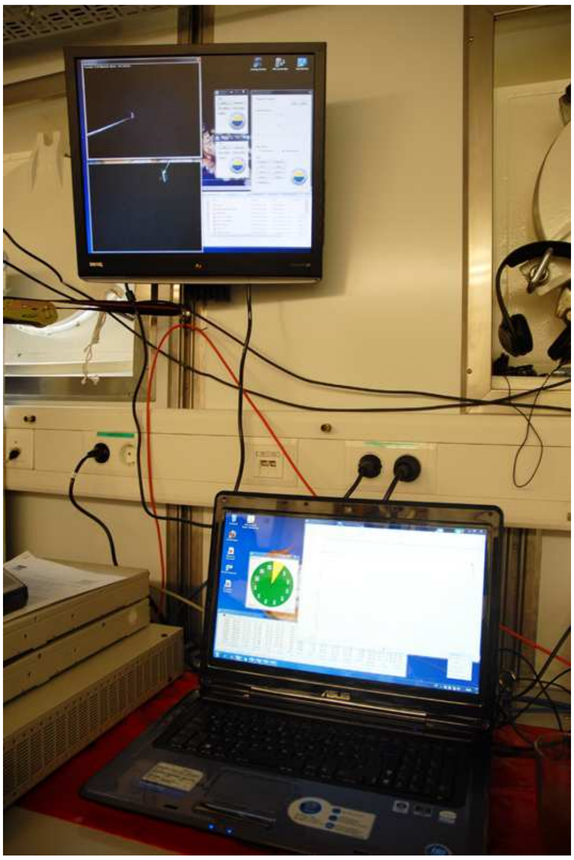


Figure. 9: Deck unit with on-line CTD data, water sampler control and video display of the two cameras.

3.3.2 Observations, data recording, and water sampling

Red Sea water column profiles

General oceanographic parameters were recorded along the Jeddah Transect and in brine-filled Atlantis II, Discovery, and Port Sudan Deeps during P408-2 by using the high-temperature Video CTD. Raw profile data for Atlantis II Deep North Basin are shown in Fig. 10. Seawater properties (i.e. density, salinity, etc.) are currently being calculated using the Thermodynamic Equations of Seawater – 2010 (TEOS-10; IOC et al. 2010; http://www.teos-10.org/pubs/TEOS-10_Manual.pdf).

The upper water column features a slight temperature and salinity gradient down to 500 meters. The water column has a peak in CO_2 concentrations and a corresponding O_2 minimum (not shown) at around 400 meters.

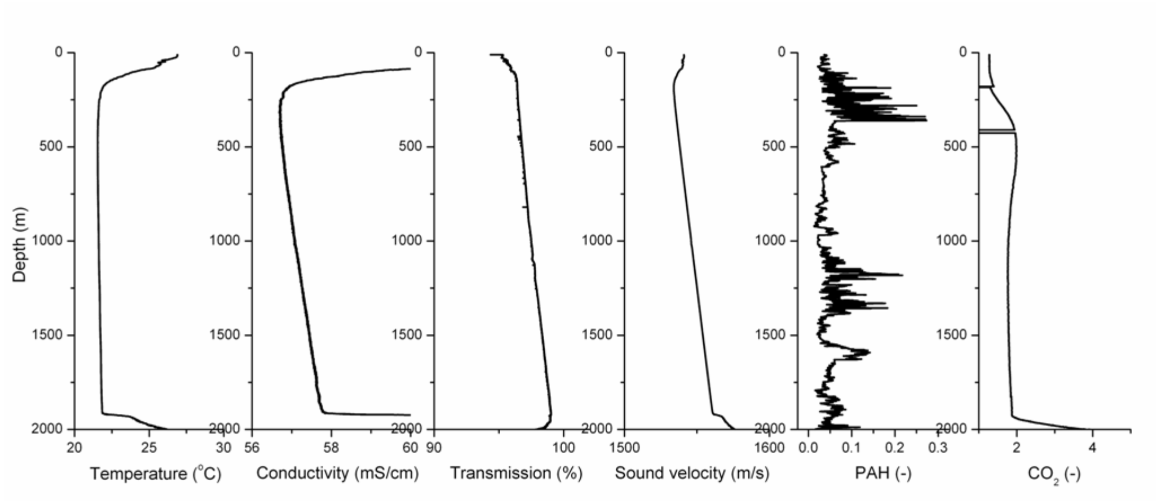


Figure 10: Water column profile at Atlantis II North Basin.

Preliminary analyses of the water column data reveal several interesting features. By using basic Thorpe scale analyses (reordering the potential density data) we are able to gain insight into the overturning length scales (mixing lengths) in the water column (Fig. 11). This analysis reveals very weak mixing in the top 250 meters (except for the surface mixed layer). The mixing increases at a steady rate as you go deeper to about 1400 meters. Stratification stability also decreases in this same range. Below 1400 meters, the water column appears to be well-mixed for last ~1100 meters. This needs more analyses, but if true would mean that this is the deepest well-mixed bottom boundary layer currently known.

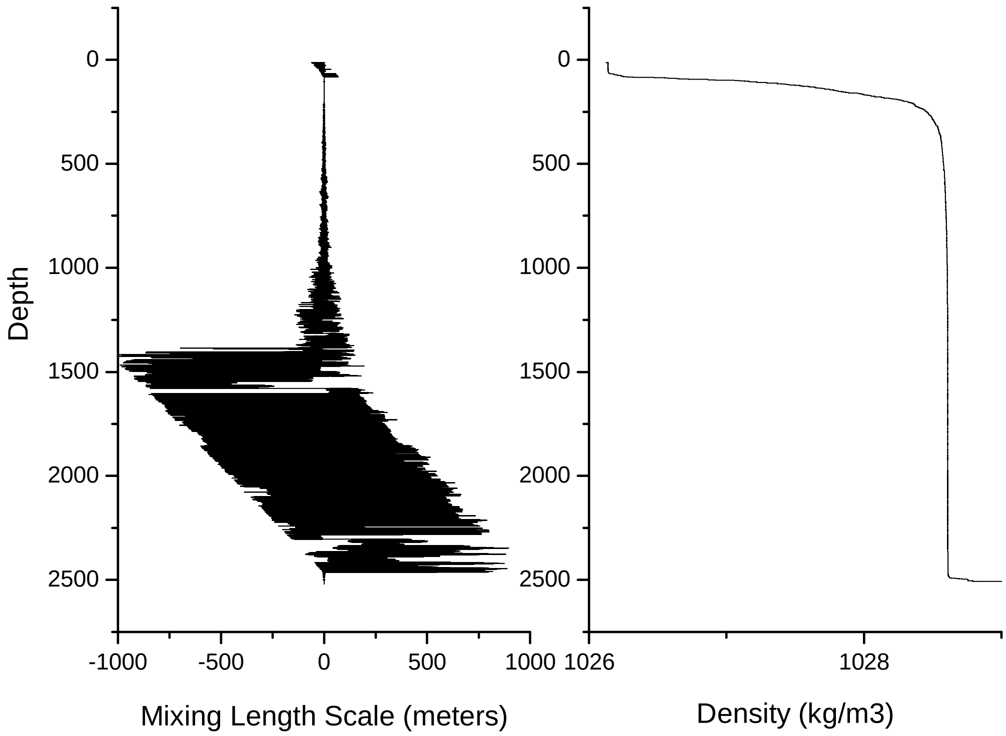


Figure 11: Preliminary processing of data as in indication of mixing. Left – overturning length scale obtained by rearranging density profile (right). Right – Density profile contains small-scale 'hidden' density inversions which are an indication of vertical eddies. Rearranging the profile into its corresponding smooth (and stable) profile leads to the Thorpe Displacements (mixing length scale) shown on right.

Red Sea brine profiles

The CTD data of the brine/seawater interfaces and brine are currently being processed. There are several challenges we face in processing these data. With the extreme temperatures (from 40 – 70℃) and very high salinit ies approaching 270 PSU, standard equations of state for seawater do not apply. We are currently waiting for salinity data from the water sampling data to process these profiles.

An intensive video CTD brine sampling program was conducted during P408-2 (VCTD, see station list). The redesigned sampler could be deployed for more than 1 hour in the hot brine of the Atlantis II Deep (SW and N-sub basins). The online video showed spectacular videos during penetration of the various brine-seawater interfaces (Upper Convective Layer 3 to Lower Convective Layer, Schmidt et al., 2003) in the brine-filled depression. It also gave us the opportunity to visually navigate the CTD/Niskin rosette 2 m above the seafloor to specific sampling sites. Concerning the expected flocculate bottom layer in Atlantis II Deep, the SW-basin shows more consolidated surface sediment than the N-basin. The maximum T-recording in the brine, measured with a calibrated high-temperature probe, was 68.2℃, which is slightly higher than the recording in 1997 (SO121 cruise). In general, the observed structure of the seawater/brine interface in Atlantis II Deep resembles the structure published by Schmidt et al., 2003. However, additional information was recorded during P408-2 by the attached Hydro-C/CH4 and /CO2 sensors (Contros, Kiel). A remarkably strong increase in gas concentrations (i.e. pCO2) in the transition zone above the brine was measured in great detail. This gives us highly resolved concentration profiles of gasses for density calculations and flux determinations.

We also conducted a really exciting and challenging near-seafloor Video CTD track in the Atlantis II Deep, starting at the western flank of the Atlantis II Deep (1850 mWD) down to the brine covered deep at 2050 mWD. Although the slope did look gentle in the bathymetry, we had to make our way through an area dominated by ~12-m -high cliffs, and several meters-wide and -deep fractures (Figs. 12, 13).

Figure 12: About 12 m steep cliff (Atlantis II Deep)

Figure 13: Small fracture at Atlantis II Deep

The so-called “gas site” which was indicated by seismic reflection data as a potential seepage site, was monitored by the Video CTD. There was only time for 2 Video-CTD tracks in this area. Nevertheless, we found a big recent fracture parallel to the central axis of the Red Sea (captured photography in Fig. 14). This fracture is possibly the migration pathway for seeping gases. A bubbling site could not be found during the short tracks, however, this site is a potential target for future, more detailed research.

Figure 14: Recent fracture at the seafloor ("Gas site").

Water and brine sampling

Water and brine were sampled by the Video CTD at selected sites and depths. The attached Niskin bottles had been closed at selected depths and subsamples were taken onboard RV Poseidon from the Niskins. 820 subsamples have stored after chemical pretreatment, and at cold temperatures, respectively, for trace element, nutrient, and dissolved gas (including hydrocarbons) analyses to be performed in the land laboratories.

Onboard extraction of dissolved gasses was performed by vacuum degassing (Fig. 15). Some gas concentrations were analysed by onboard gas chromatography. The methane concentration ranges between the normal background CH_4 concentration of seawater (~ 3 nmol/L) and 4000 nmol/L in brine. This range is comparable to concentration data measured in 1997 (Schmidt et al., 2003).

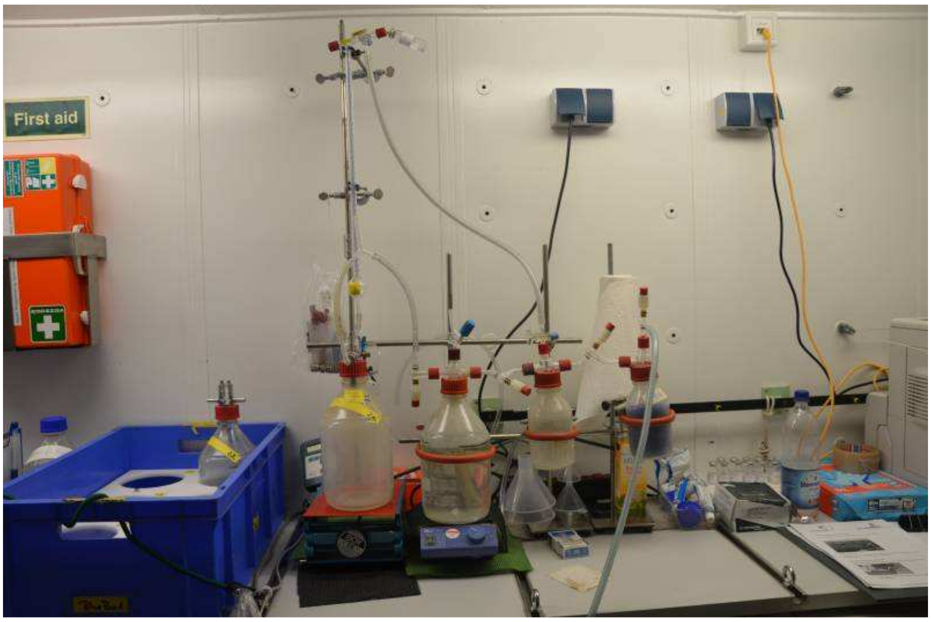


Figure 15: Onboard vacuum degassing device for extracting dissolved gasses. Extracted gasses are stored in head space vials for concentration and stable isotope analyses. Some methane concentrations were measured by onboard gas chromatography.

3.4 Microstructure Profiling

Daniel McGinnis, Alaa Barakati, Peter Linke

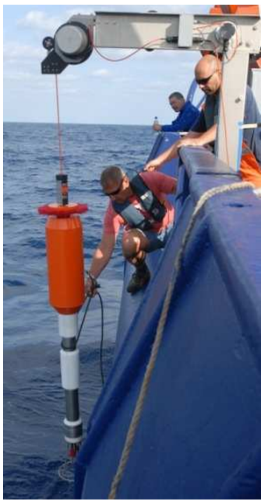


Figure 16: MSS90D2 deployment from stern of Poseidon.

Microstructure profilers are specialized oceanographic instruments capable of resolving water column constituents with a very high resolution (mm scale). The data collected include temperature, conductivity and shear. These measurements allow us to determine both the fine-structure of the water column and the vertical turbulent diffusivity. The turbulence is important to deduce the pathway and relative rate at which dissolved constituents are transported vertically throughout the water column. For POS408/2 we used a specially modified MSS90D2 probe capable of reaching >2000 meters depth, and withstanding temperatures of up to 70℃ (manufa ctured by Sea & Sun Technology, Trappenkamp, GER).

The MSS90D2 was deployed from the stern of RV Poseidon (Fig. 16) as a free-falling probe to decouple the probe from surface-wave motion or movement of the ship. The probe is attached to a neutrally buoyant cable that is used only for data transfer and probe recovery (Fig.17). The probe (Fig. 18) was equipped with 2x shear probes (to collect turbulence data), an accelerometer (to correct the readings according to the probe pitch/roll/yaw and vibration), two fast temperature sensors (FP07, ~7ms response time) and standard CTD sensors (Temperature, Pressure, Conductivity, membrane DO). The MSS90D2 transmits data at an extremely high rate, and samples at 1024 Hz (1024 data lines per second).

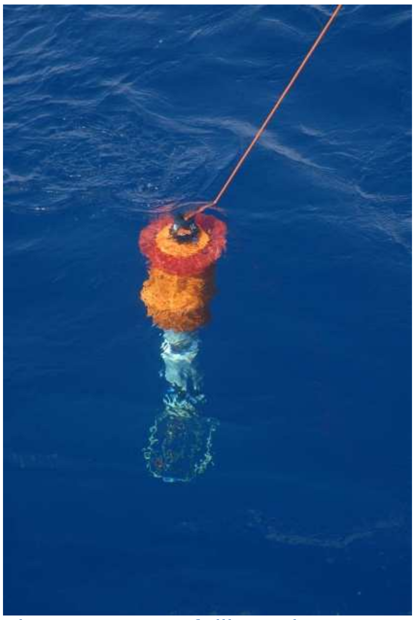


Figure 17: Free-falling microstructure profiler

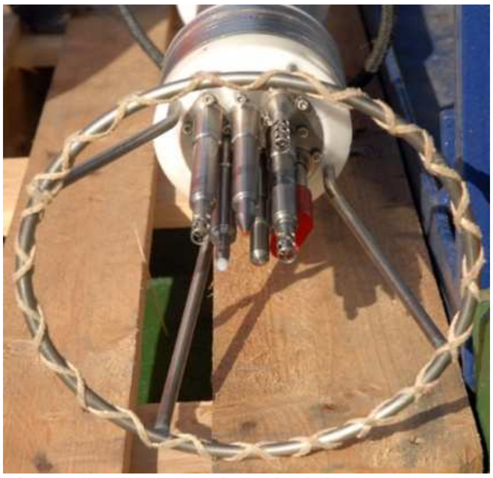


Figure 18: Sensor head of the MSS90D2

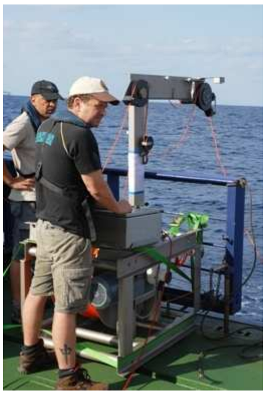


Figure 19: MSS90D2 winch.

Several modifications were necessary for the MSS90D2 to be deployed to the depths of Atlantis II (>2000 m). The housing was modified and the body of the probe was extended to withstand the pressure and high temperature. A specialized DSL telemetry unit and cable were adapted that the data could be transmitted from the probe to the laptop over the very long cable length. The cable length of ~3500 meters was necessary to reach depths in excess of 2000 meters while allowing for ship drift during the time the probe was deployed. To provide the proper buoyancy for a controlled profiling decent rate of ~60 cm/s, the probe was fitted with a hand-made floatation and drag-plate (orange parts of the probe shown on Fig. 16). To accommodate the necessary cable length, we leased the specialized winch from Sea and Sun Technology, Trappenkamp (Fig. 19). The winch was a prototype and was utilized for the first time on this cruise. To measure the wide-range of temperatures (from ~20 – 70℃), and additional fast-responding temperature s ensor was attached that could resolve up to 70℃. This was necessary as the standard fast-re sponse thermistors have a narrower, ‘standard’ range to maintain a high degree of precision.

The deployment goals were twofold – 1) to resolve the turbulence in the upper water column at the shelf to determine transport between the deep-water and coastal surface waters, a 2) to measure the fine-structure temperature within the deeps (mainly Atlantis II Deep). Despite delays due to rough sea conditions, we collected 33 microstructure profiles total, amounting to over ~66 km of data with a 1-mm resolution. The former profiles were performed with the free-falling probe descending at 60 cm/s to allow us to resolve the shear (a measure of the kinetic/mixing energy) to determine mixing coefficients and subsequently resolve the flux profiles of e.g. methane, CO_2 and oxygen. For the latter profiles, it was necessary to increase the probe decent rate to around 1 – 1.3 m/s so that the microstructure probe could penetrate the extremely dense brine layers.

The extreme pressure, temperatures (up to ~68℃) an d salinity compromised the buoyancy of the instrumentation when we profiled in Atlantis II for the first time. The compromised buoyancy only allowed profiling at a minimum speed of 1 m/s and therefore we were not able to perform upper-water column turbulence profiles any longer. Fortunately, we were able to obtain 15 casts along the Jeddah transect before this occurred, which will give us insight into the vertical mixing processes.

Fig. 20 shows the preliminary, pre-processed results from the MSS90D2 microstructure CTD. Shown are the profiles for shear, temperature and conductivity. The data are currently being processed – due to the specialized nature of the collected data, it is necessary to develop specific processing programs to determine the turbulence and filter noise from the data.
Seawater properties (i.e. density, salinity, etc.) are calculated using the Thermodynamic Equations of Seawater – 2010 (TEOS-10; IOC et al. 2010; http://www.teos-10.org/pubs/TEOS-10_Manual.pdf).

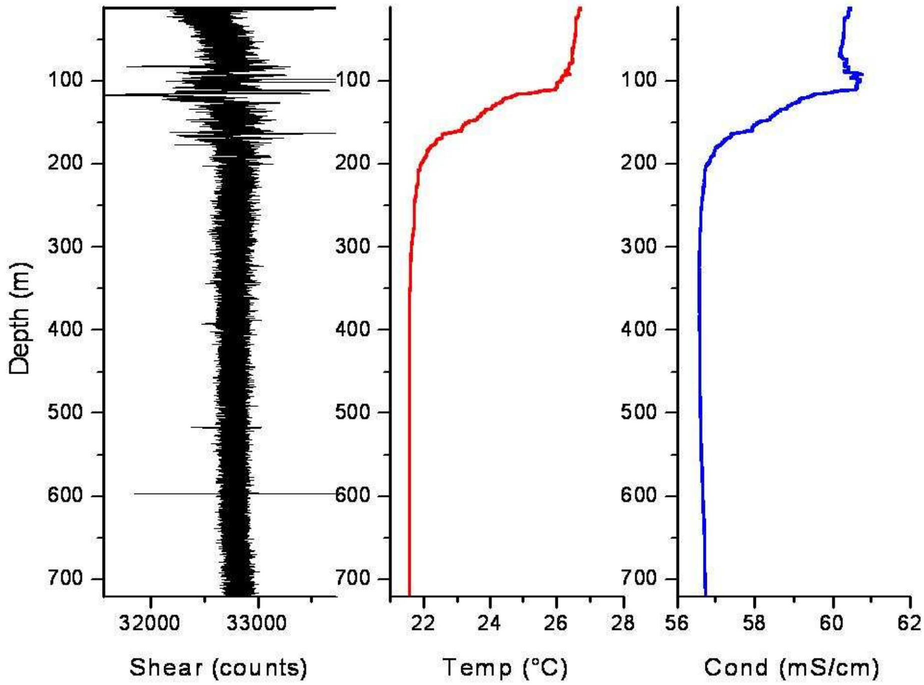


Fig. 20: Preliminary results of Red Sea oceanographic characteristics from free-falling MSS90D2 profiler

3.5 Sediment sampling

Ali Basaham, Mark Schmidt, Mustafa Gogandi, Moussa Al-Zobidi Kazem Sultan, Ali Al-Shamrani, Elgasim Elgarafi

Four gravity cores (Fig. 21) were successfully recovered from areas dominated by hydrothermal mineral deposits (Atlantis II Deep SW and N-basin), from Port Sudan Deep, and from more shallow areas near the coast of Saudi Arabia, respectively. Coring strategy was based on results of reflection seismic data. Sediment and porewater was sampled onboard from all cores after cutting and splitting (Figs 22 and 23). Porewater sampling was performed by using rhizones (Fig. 22). 129 porewater samples for further (isotope) geochemical analyses were stored (after chemical pretreatment) in respective containers and vials. 125 sediment samples were stored and shipped to Kiel for further analysis (48 samples at -18℃ for (organic) geochemical analyses).

Figure 21: Deployment of the 4-m-long gravity corer (top)
Figure 22: Split cores from the Atlantis II-S Deep (GC 3) (bottom)

Figure. 23: Cutting of the core liner

First results from porewater data (pH~5.5, S~270) of Atlantis II cores indicate homogenous porewater composition within the uppermost 4 m of hydrothermal sediment in the Atlantis II Deep. The Atlantis II-N Deep sediment showed the same metalliferous mud as it was recovered from the southern basin of Atlantis II (compare Figs 22 and 24), however, the sulfidic iron-phase was less abundant in the upper 4 m of the Atlantis II-N sediment core. The Port Sudan Deep showed a mixture of hemipelagic mud deposited in a brine environment with detrital sediment (probably slumps from the steep slope). The Port Sudan Deep core (Fig. 25) shows a mixture of hemipelagic mud deposited in a brine environment with detrital sediment contributions (probably slumps from the steep slope). Compared to the sediment from Shaban Deep (Red Sea), a paleostratigraphic story (2 sapropels, authigenic carbonates) could possibly be derived from the core (see e.g. Botz et al., 2007, 2011). Diagenetic carbonate crusts were also sampled from the core (GC2) taken nearest to the shoreline (~700 mWD).

In total, 129 sediment samples were stored.

Figure 24: Metalliferous mud (oxidic facies) recovered from Atlantis II North (GC 4)

Figure 25: Hemipalgic mud, detrital sediment, and authigenic carbonates in Port Sudan Deep sediment (GC 5)

Detailed sediment core descriptions are presented on the following pages. The core photography is provided on request.

Sediment core descriptions

P408-2 station 80 GC 2, 328cm

Segment (cm)	Depth (cm)	Color	Lithology	Remarks
0-128	0-2	Very pale orange		consolidated carbonate plate
	2-45	Light olive gray		biogenic carbonate concretions (pteropods)
	45-56	Light olive gray		biogenic carbonate concretions (pteropods)
	56-81		Silty clay sediment	intercalated with carbonate concretions (plates in millimeter size)
	81-104	Light olive gray		intercalated yellowish brown layers , black dotes probably “pyrite?” , mm size carbonate concretion, consolidated carbonate layer at 91cm, and carbonate crusts at 81cm
	104-128	Olive gray	Silty clay sediment	black dots “pyrite?” with 5mm carbonate concretions
128-228	128-145	Light olive gray	Sandy clay sediment	lenses of “pyrite?”
	145-167	Olive gray	Silty clay sediment	small black lenses “pyrite?”
	167-223	Light olive gray		black lenses “pyrite?”, soupy lenses carbonate concretions of cm size at 188
	223-228	Light olive gray mix with pale brown		light olive gray part is clay and pale brown is sandy clay with shell fragments
228-328	228-267	Light olive gray	Sandy clay sediment (Carbonaceous mud)	mixed with soupy lenses olive gray & yellowish brownish spots
	267-276	Olive gray		coarse layer, some shell fragments and, a lot of pterpods in the layer
	276-310	Light olive gray	Sandy clay sediment	abundant pteropods & shell fragments mixed with black lenses “pyrite?” with some yellowish lenses
	310-315	Light olive gray		soupy black lenses of cm size
	315-328	Olive gray	Clayey sediment	

P408-2 station 87 GC 3, 370 cm

Segment (cm)	Depth (cm)	Color	Lithology	Remarks
0-100	100	Black	Silty clay	- Black soupy silty clay sediment -Porewater salinity 250 ppt -pH 5.5
100-200	100-120	black	Silty clay	-Black soupy silty clay sediments -Porewater salinity 270 ppt -pH 5.5
	120-160	Reddish/grayish black		Reddish amorphous Fe-oxides (?) mixed with grayish black consolidated fragments
	160-200	Grayish black	Silty clay	Grayish black form silty clay sediments
200-300	200-300	Grayish black	Matrix Silty clay	- matrix of silty clay grayish black mixed with small lenses pale Red consolidated sediments, light bluish gray consolidated lenses (cm size), dusky purple consolidated lenses of (cm size) -Degassing bubbles *(see bubble in photo at about 230cm)* -Porewater salinity 270 ppt -pH 5.5
300-370	300-370 (300-365)	Grayish black	Matrix silty clay	- matrix of silty clay grayish black color mixed at 300-365 cm with (cm size) lenses of colored mineral precipitate(pale green, moderate Red, medium bluish gray) -Porewater salinity 270 ppt -pH 5.5

P408-2 station 100 GC 4

Segment(cm)	Depth (cm)	Color	Lithology	Remarks
	0-73	Olive brown to black	Clayey marl	Viscous Water content 50% Light carbonatic
	73-173	Olive brown bis black// ocker band	Clayey marl	2cm ocker(orange) band-limonitic Consistency and water content like above seems to be a continuity interrupted by the ocker band Light carbonatic
	173-220	Light olive gray to black with	Clayey marl with green lamellations	Like above ,same consistency and water content-viscous

		green very thin lamellations	in mm thickness	Light carbonatic
	220-250	Brown olive to black with white lamellations	Clayey marl	Like above same consistency and water content-viscous A 4 cm layer more green Light carbonatic
	250-273	Light brown red white green lammelations	Sandy, with small solidified allochtonous pieces	Mixture of allochtonous material

P408-2 station 110 GC 5

Segment (cm)	Depth, cm	Color	Lithology	Remarks
	0-14	Dark yellowish brown	Marl Sandy Water content 50%	Detrital facies
	14-21	Dark brown Ash like	Marl Sandy Water content 50%	Detrital facies
	21-72	Dark yellowish brown	marl	Detrital facies
	72-110	Dusky brown	Marl With sandy thin layers	Sandy thin layers are carbonatic apparently pieces of organic material most probably forminifer and pteropod etc
	110-113	Bright grey to white grey	Sandy marl	microcoquina layers with most probable pieces of foraminifera, pteropods etc detrital facies
	113-172	Dusky brown	Clayey marl with sandy intercalations	About 7 sandy lvery thin layers – carbonatic detrital facies
	172-190	Dusky brown	Clayey marl	Detrital facies-homogenous-water content 50%
	190-194	Light grey to white grey	Sandy with pieces of foraminifera,pteropods etc	Detrital facies –microcoquina layer
	194-206	Brown to light grey with very thin white grey intercalations	Sandy marl	Detrital facies,carbonatic

P408-2 station 110 GC 5 cont.

Segment (cm)	Depth (cm)	Color	Lithology	Remarks
	206-210	Olive brown to black	Clayey marl	Viscous Water content 50% Very thin layers light carbonatic grey to white grey intercalations
	210-231	Brown to grey	Clayey marl	Homogenous-water content 50%
	231-246	Light brown- with gray to white thin lamellations	Clayey marl	Poorly stratified Light carbonatic
	246-267	Grey brown	Clayey marl	On the base 1 3cm brown to whitish strong carbonatic layer
	267-269	Dark grey black	Clayey marl	
	269-273	Dark brown to black homogene	Clayey marl	
	273-290	Brown to dark brown	Clayey marl	
	290-291	Grey to white grey	Sandy marl	Microcoquina layer-dtrital facies
	291-333	Dark grey to black	Clayey marl	With very thin black lamelations
	333-358	Light grey	Clayey marl	homogenous
	358-359	Light grey	Sandy marl	Microcoquina layer –detrital facies

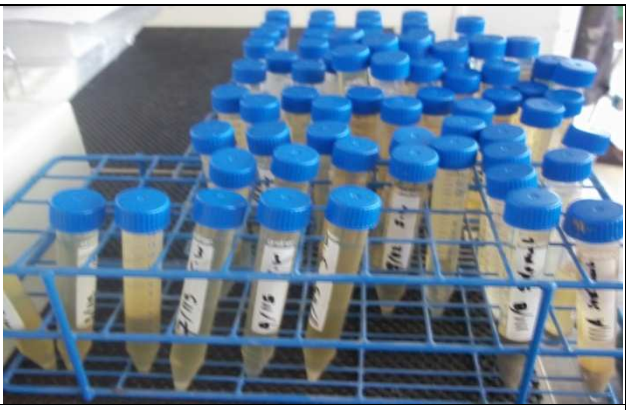
3.6 Microbiological investigations

Mamdouh Jamal, Mustafa Gogandi

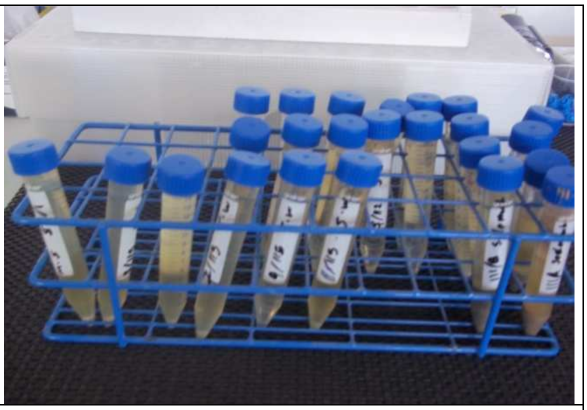
Many studies seeked to discover the natural microbiological life in the deep sea, it was expected in former times that there is no life at depths of ,more than ≥ 600 m. This picture changed when strains of bacteria could be isolated by using different cultivation methods, medium composition, different growing temperatures, cultivation pressure and many other techniques.

This study will focus on different goals like using new techniques and different medium compositions to classify culturable and unculturable bacteria sampled from Red Sea surface sediment and brine to use this information as a microbiological indicator for the occurrence of hydrocarbons. Moreover, bacterial strains are investigated concerning their relevance as antimicrobial producing sources against human, animal and plant diseases (e.g. Yan et al., 2003; Jamal et al., 2006; Jamal and Mudarris, 2010).

The following photo plate shows bacteria isolating/cultivation experiments conducted on the research cruise (and post-cruise laboratory techniques):

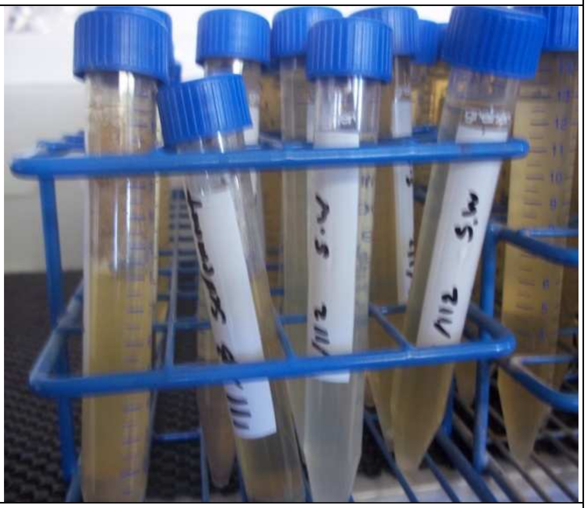


Different cultivation methods for culturing marine bacteria



Different cultivation methods for culturing marine bacteria

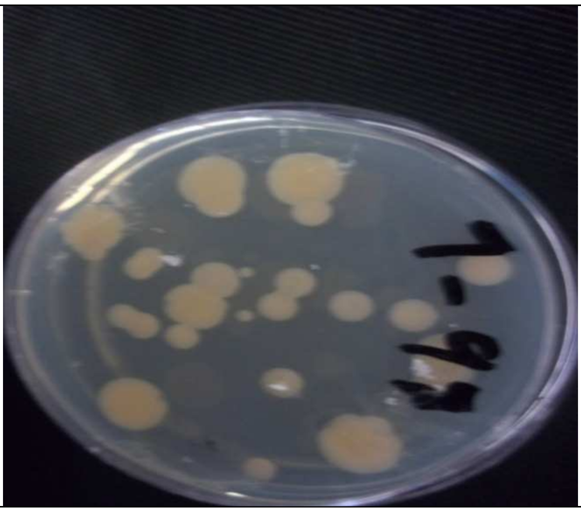
Different cultivation methods for culturing marine bacteria



Different cultivation methods for culturing marine bacteria

Different media used to isolate marine bacteria

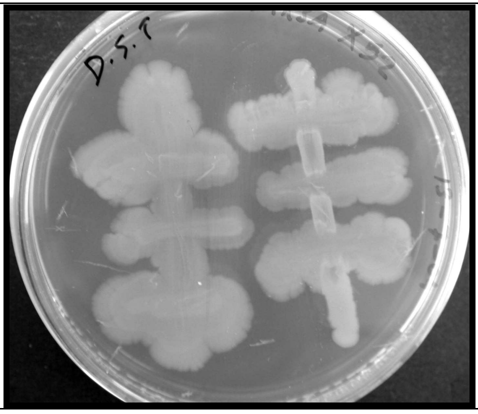
Different media used to isolate marine bacteria



Different media used to isolate marine bacteria

Different media used to isolate marine bacteria

Post cruise work
challenge between marine bacteria(pathogen) V MRSA, VRE, listeria (pathogenes)…etc



Post cruise work
Cross-streaking method for inhibition of MRSA(pathogen) by bioactive marine bacteria

4. References

Botz, R., Schmidt, M., Wehner, H., Hufnagel, H., and Stoffers, P. (2007) Organic-rich sediments in brine-filled Shaban- and Kebrit Deeps, Northern Red Sea. Chemical Geology 244, 520-553.

Botz, R., Schmidt, M., Kus, J., Ostertag-Henning, C., Ehrhardt, A., Olgun, N., Garbe-Schönberg, D., Scholten, J. (2011) Carbonate recrystallisation and organic matter maturation in heat-affected sediments from the Shaban Deep, Red Sea. Chemical Geology 280, 126-143.

Girdler, R. W. & Whitmarsh, R. B. in Initial Reports of the Deep Sea Drilling Project, Vol. 23 (eds. Whitmarsh, R. B., Weser, O. E., Ross, D. A. & al., e.) 913-921 (U.S. Govt. Printing Office, Washington, D.C., 1974).

Jamal, M.T., Morris, P.C., Hansen, R., Jamieson, D.J., Burgess, G.J. and Austinm B. (2006) Recovery and Characterization of a 30.7-kDa Protein from Bacillus licheniformis Associated with Inhibitory Activity Against Methicillin-Resistant Staphylococcus aureus,Vancomycin-Resistant Enterococci, and Listeria monocytogenes. Marine Biotechnology, 8:587–592.

Jamal, M. T. and M.S. A. Mudarris. (2010) Separation of YbdN Bioactive Protein from Bacillus subtilis Isolated from the Red Sea algae Sargassum sp. with Bioactivity against Antibiotic Resistant Bacterial Pathogens. JKAU: Mar. Sci, 21-1, 53-64.

Mitchell, N.C., Ligi, M., Ferrante, V., Bonatti, E., and Rutter, E., 2010, Submarine salt flows in the central Red Sea: Geological Society of America Bulletin, v. 122, no. 5-6, p. 701-713.

Mitchell, N.C., Schmidt, M., Ligi, M. (2011) Comment on “Formation of Thetis Deep metal-rich sediments in the absence of brines, Red Sea” by Pierret et al. (2010), J. Geochem. Explor. 108 (1) 112-113.

Schmidt M, Botz R, Faber E, Schmitt M, Poggenburg J, Garbe-Schönberg D, Stoffers P (2003) High-resolution methane profiles across anoxic brine-seawater boundaries in the Atlantis-II, Discovery, and Kebrit deeps (Red Sea). Chemical Geology 200, 359-376.

Yan, L., Boyd, K.G., Adams, D.R. and Burgess, J.G. (2003) Biofilmcross − specific induction of antimicrobial compounds in bacilli. Appl. Environ. Microbiol., 69: 3719–3727

5. Acknowledgements

Looking back to both legs P408-2a and 2b, we are grateful for the chance to work in such a unique area as the central Red Sea graben and in particular the Atlantis II Deep area. Within the next few months, data evaluation and laboratory analyses will keep us busy and hopefully we will come out with some spectacular results soon. All scientists participating on the cruise acknowledge the professional and friendly support by the RV Poseidon crew. In particular, we also acknowledge the protection by the Royal Saudi Arabian Navy.

Appendix C: Cruise Report of R/V POSEIDON cruise P408/3

Table of Contents

RV Poseidon Cruise No.: 408-3
Dates, Ports: 23 January 2011 (Jeddah) – 02 March 2011 (Jeddah)
Research subject: Plankton diversity, nutrient gradients, trace metal & isotope chemistry
Chief Scientist: Prof. Dr. Anton Eisenhauer, IFM-GEOMAR, Kiel
Number of Scientists: 10 + 1 Saudi Military Observer
Project: Jeddah Transect

Nautical and Scientific Crews

a) Ship's crew Leg 3

No.	Rank	Name	First Name	Home Country
1	Kapitän	Günther	Matthias	Germany
2	Chief. Off.	Windscheid	Bernhard	Germany
3	2nd Off.	Hänsel	Alexander	Germany
4	Chief Eng.	Stange	Hans-Otto	Germany
5	2nd Eng.	Hagedorn	Günter	Germany
6	Electrician	Klare	Dietmar	Germany
7	Motor man	Engel	Rüdiger	Germany
8	Bosun	Schrage	Frank	Germany
9	Mechanic	Peters	Ralf	Germany
10	Mechanic	Rauh	Bernd	Germany
11	Mechanic	Kohnke	Frank-Dieter	Germany
12	Mechanic	Hampel	Ulrich	Germany
13	Seaman	Kuhn	Ronald	Germany
14	Cook	Habecker	Horst	Germany
15	Steward	Mack	Urich	Germany

b) Scientific crew – Leg 3

No.	Name & Given name	Function onboard	Home Country
1	Prof. Dr. Eisenhauer, A.	Chief scientist, Zooplankton	Germany
2	Prof. Dr. Aidaroos, Ali M.	Co-chief scientist	Saudi Arabia
4	Commander, Alahmari, Abdullah	Military observer	Saudi Arabia
5	Dr. Orif, I. Mohammed	Scientist, Chemist	Saudi Arabia
3	Dr. Augustin, Nico	Multibeam	Germany
6	Dr. Cand. Raddatz, Jacek	Scientist, CTD	Germany
7	Dr. Kürten, Benjamin	Scientist, Phyto - Zooplankton	Germany
8	Dr. Khomayis, Hisham-Sulaiman	Scientist, Phytoplankton	Saudi Arabia
9	Dr. Winder, Monika	Scientist, Phyto - Zooplankton	Germany
10	Adahodi, Kamal	Technician	Saudi Arabia
11	Alkambashi, Radi	Lab. Technician	Saudi Arabia
12	Audritz, Saskia	Lab. Technician	Germany

Cruise participants from the left to the right: A. Eisenhauer, M. Winder, J. Raddatz, H. Khomayis , A. Aidaroos, A. Kamal, A. Alahmari, R. Alkambashi, M. Orif, N. Augustin, S. Audritz, B. Kürten

1. Abstract

In the framework of the joint Saudi Arabian – German project “Jeddah Transect” in the Red Sea, cruise P408-3 focused on sampling and monitoring plankton diversity and the trophic structure of the pelagic food web along a north-south transect roughly between the location of the Atlantis II deep (21°23´N, 38°04´E) and the Farasan Islands (Southern End Station, 17°14´N, 40°28´E). This transect corresponds to a natural nutrient gradient of low-nutrient water in the North and higher-nutrient water in the South. The scientific program was accomplished by a water sampling program for Red Sea trace metal chemistry and isotope composition. Another focus of the cruise was to further continue high resolution mapping of the Red Sea bathymetry, in particular at and around the Atlantis II deep but also along the north-south transect. Preliminary results of the plankton community suggested spatial difference and high zooplankton diversity. First results of high-resolution mapping indicated “pockmark” structures as well as off-axis volcanism. In addition, on the shelf of the Farasan islands fossil reefs, most likely of Last Interglacial age were discovered but could not be mapped due to technical problems and lack of time.

2. Cruise Narrative

In the night of Tuesday, February 22nd, 2011, our seagoing equipment was unloaded from the container in Jeddah harbour and transported directly to RV Poseidon where it was stowed on board of RV Poseidon in the same night. German as well as Saudi Arabian expedition participants (see list below) arrived on board in the morning of Wednesday, February 23rd, 2011. At 4 pm the ship left Jeddah harbour towards the south heading to a position slightly north of the Farasan islands at 17°14´N, 40°28´E („Southern End Station“).
Due to safety regulations the transfer to the „Southern End Station“ was terminated midnight Thursday, February 24th 2011, and Poseidon steamed to a more northern station (19°4,44´N, 39°29,48´E) while waiting for protection by the Royal Saudi Arabian warship AlYarmook. At this station, taken as a reference station between the „Southern End Station“ and the „Atlantis II deep“, several CTDs were applied for water sampling. In addition, net catches were performed for plankton day and night samples. After arrival of the AlYarmook, Friday, February 25th 2011, 2:30 pm, and termination of the station work both ships Poseidon and AlYarmooth headed south towards the „Southern End Station“ which was reached on Saturday, February 26th, 2011, 7:30 pm. At this station Saudi- Arabian and German scientists performed an extensive CTD water sampling program. In addition, various nets were applied for day and night sampling of zooplankton and phytoplankton. For the marine geologist on board, multibeam mapping and echolot sounding became interesting because at a water depth of 120 to 150 m fossil reef structures appeared on the western flank of the Farasan islands bank. These structures may relate to the Last Glacial seawater lowstand about 20000 years ago. Station work at the „Southern End Station“ was terminated on Sunday, February 27th 2011, 2:00 pm, after which the ship left for the Atlantis II station. After reaching the Atlantis II deep (21°23´N, 38°04´E) on Tuesday, 01 st March, 2011, 01:30 am the station was continued by an extensive water sampling program for zoo- and phytoplankton using nets and Seabird CTDs. Starting at 4 am a CTD was lowered into the Atlantis II brine layer at a water depth of around 2000 m. Several layers of different temperature, about 50, 56 and 68°C, were found corresponding to different salinities, from 100 to 136 psu. Later on, station work at the Atlantis II deep was continued for sampling of zoo- and phytoplankton daytime material. The station ended with another CTD lowered to the Atlantis II deep for brine sampling. The station was terminated at Tuesday, 01st March, 2011, 8:00 pm. The ship headed to the pilot station off the harbour of Jeddah, where research cruise P408-3 ended on Wednesday March 2nd, 8:00 am.

3. Work performed and preliminary results

3.1 Stations

Station No	Date	Time (UTC)	Objective	Lat. (°N)	Lon. (°E)	Water Depth (m)	Comments	Area of investigation
127/1	23.02.2011	14:46	Multibeam	21°37	38°89	-	diverse Multibeam Tracks (unterbrochen für 128/1)	Transect to Red Sea Rift
128/1	24.02.2011	06:20	Flow meter	19,44°	39,72°	-	TEST (Calibration -/+ Net ,0-50 m)	Transect to Red Sea Rift
129/1-6	25.02.2011	07:20	CTD	19,09°	39,49°	1450	CTD-Downcasts-Water Samples for Zoo/phytoplankton(25 and 50 m)	Intermediate/reference
129/7-12	25.02.2011	11:20	Plankton net tows	19,09°	39,49°	1450	different sizes (55,150 and 20 m)	Intermediate/reference
129/13	25.02.2011	12:54	Bongo Net	19,09°	39,49°	1450	speed 1/2 knot, circles; 0,3/sec	Intermediate/reference
129/14-23	25.02.2011	14:09	CTD	19,09°	39,49°	1450	CTD-Downcasts für Plankton-water samples (50,75 and 100m) + 129/19 (1000 m-Water samples)	Intermediate/reference
129/24	25.02.2011	19:46	Plankton Net	19,09°	39,49°	1450	Night Zooplankton (1x 150 m-> 0-500 m, 1x surface ->150mm;	Intermediate/reference
							1/2 knot: 15min, 2x surface hand net – 5 min, 1x 0-50 hand net,	
130/1	25.02.2011	22:00	Multibeam	19,01°	39,49°	-	Transect mapping to southern End station	Transect

Station No	Date	Time (UTC)	Objective	Lat. (°N)	Lon. (°E)	Water Depth (m)	Comments	Area of investigation
131/1-5	26.02.2011	17:23	CTD	17,23°	40,50°	569	5 CTD-downcasts 25 and 50m	Southern End Station
132/1	26.02.2011	23:55	Multibeam	17,23°	40,08°	-	Shallow water mapping of fossil reef structure, problems with multibeam in shallow depth <200m	Shelf: Southern End
133/1	26.02.2011	20:30	Nets	17,23°	40,84°	569	Plankton net tows 2 x 0-500m, 150 m, 1 x surface tow 150 m; 15min hand tows ;15min	Southern End
134/1	26.02.2011	23:55	Multibeam	17,23°	40,83°	-	Shallow water mapping of fossil reef structure, problems with multibeam in shallow depth <200m	Shelf: Southern End
135/1	26.02.2011	02:00	CTD-VIDEO	17,38°	40,88°	79	fossil reef structure(?), problems with VIDEO CTD, Short video at 79m, heading 270°	Shelf: Southern End
136/1-10	27.02.2011	05:15	CTD	17,23°	40,84°	564	CTD-Downcasts-Water Samples for Zoo/phytoplankton(50,75 and 100m)	Southern End
136/11-16	27.02.2011	08:16	Nets	17,23°	40,84°	564	Plankton net tows 2 x 0-500m, 150 m, 1 x surface tow 150 m; 15min hand tows ;15min	Southern End
137/1	27.02.2011	10:30	Bongo Net	17,23°	40,84°	580	Bongo Net with 1 x 0- 500m obliqute tow	Southern End
138/1-6	28.02.2011	22:47	Plankton Tows	21,38°	38,07°	2037	Plankton towsıxı˜ m, a 500-0m, 200-0m surface 150min,	Atlantis II Deep

Station No	Date	Time (UTC)	Objective	Lat. (°N)	Lon. (°E)	Water Depth (m)	Comments	Area of investigation
138/7	01.03.2011	00:39	CTD-VIDEO	21,38°	38,07°	2100	Brine Sampling, Depths 15-2088m,T°C 26°- 68°C,Sal 39 -136,4	Atlantis II Deep
138/8-21	01.03.2011	07:00	CTD	21,38°	38,07°	1870	CTD ,3x25m,3x50m,3x75m,3x100m, 1x500m Bongo, Bongo 500-0m 35min	Atlantis II Deep
138/22-30	01.03.2011	10:00	Net tows	21,38°	38,07°	2025	several net tows from 55 -150 m, from 0-500m,	Atlantis II Deep
138/31	01.03.2011	14:15	CTD-VIDEO	21,36°	38,07°	2033	VIDEO-CTD for Brine Sampling, Depth from 2039-2128m, T°C 50-68, Sal 109,3-116,2	Atlantis II Deep

3.2 Nutrient gradients in the Red Sea: How do they correlate with plankton abundance and diversity?

The Red Sea ecosystem features nutrient gradients at temporal and spatial scales – none of them well explored and some more expected than demonstrated. During cruise P408-3, the Jeddah Transect project 3.1 aimed at exploring the effects of nutrients on plankton biodiversity and food web structures at different spatial scales in the Red Sea.

The Red Sea is suited for the project because of its natural longitudinal, eutrophic-oligotrophic gradient (S-N) and local nutrient gradients starting from coastal point-sources of eutrophication (E-W), and because of its high functional diversity of zooplankton, from small particles (<5 µm) feeding ("microphageous") Tunicata and Ostracoda to macrophageous Copepoda and predatory Amphipoda.

To reconstruct the structure of the lower pelagic food web, a complementary approach is adopted to study the composition of primary producers available as food sources to higher trophic levels of the pelagic food web and to determine macronutrient fluxes that are susceptible to change, due to changes in environmental conditions, or human impacts.

During cruise P408/3, an AlgaeOnlineAnalyser (AOA) was continuously supplied with surface seawater (3 m) and used to monitor changes in fluorescence at different wavelengths. The AOA mainly provided information of chlorophyll *a* and c-DOM concentrations. Attributable to the low biomass of phytoplankton, differentiation of algae groups was only partly achieved, due to the decreased sensitivity of the AOA at low ambient total chl *a* concentration <0.5 µg L^{-1}. However, during the cruise passages, several areas of increased chl *a* were observed.

The chemical and biological oceanographic sampling scheme included water and seston samples. Seawater was collected by CTD casts during day and night using a set of water samplers attached to the CTD rosette. Water was usually collected at all sites from several depths (3, 25, 50, 75, and 100 m, respectively). For the first two of three sampling sites, sampling depths were chosen after consultation of a manuscript by H. Weikert (unpublished manuscript), because of technical issues with the "Seabird CTD", which prohibited to define sampling depths according to changes in fluorescence as a proxy for algae biomass.

Water samples included samples for phytoplankton microscopy, nutrient analysis (NH_4^+, NO_3^-, NO_2^-, SiO_4^{3-}, PO_4^{3-}), total P and total N, flow cytometry (picophytoplankton), $DI^{13}C$, alkalinity, and trace metal analysis of Fe and Mn, respectively. Seston samples were collected including living and non-living components. Seston was collected for gravimetric quantification. Suspended particulate organic matter (POM; 0.7-60 µm particle size) was collected for bulk POM stable isotope analysis (SIA) of carbon and nitrogen ($\delta^{13}C$, $\delta^{15}N$, respectively). The abundances and concentrations of chl *a* and other accessory phytoplankton pigments, as well as phospholipid-derived fatty acids (PLFAs) of phytoplankton will be determined from the same POM size fraction later in the laboratory.

During the transit from the southernmost station towards the Atlantis II deep site, further samples were collected from the continuous seawater supply for phytoplankton biodiversity, bulk POM SIA, and pigment HPLC. Four additional sites were chosen, covering a range of nutrient conditions.

Water filtrations and processing of water samples were conducted in the dry laboratory, using glass filtration columns, Sartorius Polycarbonate columns using light vacuum and gravity filtration where applicable (e.g. nutrient samples). SIA samples were oven-dried at 60 °C on board. Microphytoplankton for flow cytometry, pigment and lipid samples were stored in $N_{2(liqu.)}$. Less sensitive samples were stored at room temperature.

3.3 Zooplankton and Phytoplankton Work on Board

The goal of the plankton sampling for this cruise was to investigate diversity and trophic dynamics of the plankton community along a South-North transect of the Red Sea. This latitudinal gradient consists of a natural nutrient gradient, whereby the Southern part is characterized by relatively 'high' nutrient availability due to water transfer from the Gulf of Aden and by low nutrient availability at the Northern region. It is expected that the food web in the high nutrient-availability region consists of a short food chain as a result of the dominance of large-sized diatoms that are directly grazed upon copepods. In contrast, small-sized phytoplankton and increased carbon cycling through the microzooplankton food web is expected to dominate in the low-nutrient northern region. Increased microzooplankton grazing would put the copepods at a higher trophic level compared to the direct algae-copepod food chain at the northern end.

3.3.1 Methods used for phytoplankton and zooplankton sampling

Vertical and horizontal phyto- and zooplankton tow nets were used to investigate plankton community composition and diversity at three stations in the upper 500 m of the water column. Zooplankton was collected using vertical tow nets from a depth of 500 m to the surface and horizontal net tows of 15 min during day- and nighttime using a 150-µm mesh size net and preserved with formaldehyde. For micro-zooplankton and taxonomic identification, vertical tow nets with a mesh size of 55 µm were used during daytime, and preserved with formaldehyde and ethanol, respectively. For collection of larger-sized zooplankton, oblique vertical tows using a duo Bongo net with a 300-µm and 500-µm mesh size were towed from a depth of 500 m to the surface for about 40 min. The water volume filtered was measured using a flow meter. In addition to quantitative zooplankton sampling, qualitative collections were conducted and either preserved with ethanol, frozen at -40℃ or kept alive for immediate sorting for stable isotope analysis.

At each station, phytoplankton was collected at depths of 2, 25, 50, 75, and 100 m; triplicate samples of 250 ml were collected. For larger-sized algae cells, vertical hand tows from 50 m to the surface and surface horizontal tows for 15 min using a 20-µm mesh size were conducted during day- and nighttime. All samples were fixed with acidic Lugol's solution.

Stable isotopes (SI) were used to identify the trophic structure of the food web. Therefore, zooplankton was identified into species (if possible), genus or higher order taxa, including filter feeders (Ostracoda, appendicularians, salps), Copepoda, Mysidae and species at higher trophic levels such as small fish, if available. Identified taxa were sorted into tin caps and dried overnight for later SI analysis.

3.3.2 Grazing experiments

In addition to sampling, micro-zooplankton experiments were done according to the dilution method by Landry et al. (1982) at two stations. Therefore, water was sampled from a depth of 20 m. Five dilution series of 20, 40, 60, 80 and 100% seawater in duplicate with nutrient addition (N, P, Si) and three dilution series without nutrient addition were prepared. Bottles were incubated for 24 h on deck in a tank with continuous seawater flow for temperature consistency and covered with a mesh screen to reduce sun radiation.

3.3.3 Preliminary results of zooplankton diversity

Zooplankton sorting for SI analysis gave a preliminary overview of the species diversity at each station. Overall, the zooplankton community was very diverse, consisting of many genera and species within a single genus. Copepods were particularly diverse. Some of the most abundant copepods were the Cyclopoida *Oncaea* spp., *Corycaeus* spp., *Oithona* spp., the Harpacticoida *Macrosetella* and *Microsetella*. The following Calanoida genera were very abundant: *Pleuromamma, Eucalanus, Euchaeta, Centropages, Sapphirinia, Rhincalanus, Labidocera*, and *Acartia*. In addition, Chaetognatha, appendicularians, salpidae, and

Euphausiidae were identified. On a first glance, zooplankton diversity was different across the S-N transect. At the ‘Intermediate Station’, salps were very abundant, whereas at the southernmost stations large-sized copepods dominated and at the Atlantis II station small-sized copepods. Detailed laboratory analysis will verify these visual observations.

3.4 CTD Measurements, water sampling and video observations

The CTD (Conductivity-Temperature-Depth) measurements are processed with a pumping system and integrated sensors that measure conductivity, temperature and water density. Additionally, we used a second CTD equipped with a video observation system. The “Seabird, SBE 11plus” is additionally equipped with a fluorescence detector for chlorophyll *a* measurements (according to Dr. Haardt) and sensors for dissolved oxygen as well as sound velocity detector which was attached to define different water masses. The regular CTD is a SBE 9plus model by Seabird connected to a rosette with 12 10-liter Niskin bottles to collect water samples from different depths. The CTDs deployments were conducted using a deck unit (from Seabird, SBE 11plus) connected to a PC for real-time acquisition of both downcast and upcast as well as for firing the bottles at the selected water depths.

The major objective of the CTDmeasurements during P408-3 was to gain information about water column stratification and to sample the water column in layers of high chlorophyll contents for phyto- and zooplankton measurements at water depths between 25 and 100m. Moreover, a second major aim of the Video CTD was to sample saline and hot brine waters.

The water for measurement of isotope systems such as Nd, U, Th as well as trace elements and divalent cations (Sr, Ca etc) was collected through the whole water column at the stations of the Atlantis II Deep. Brine water samples were collected from the greatest depth in the Atlantis Deep as well as from the surface.

3.5 Multibeam and Bathymetry Work on Board P408-3

During RV Poseidon cruise 408-3 multibeam mapping was carried out with a Seabeam 3050 echo sounder system provided by ELAC Nautik GmbH. The SeaBeam 3050 multibeam echo sounder collects bathymetric, corrected backscatter, side scan and water column imaging (WCI) data at medium depth over a wide swath in excess of 140 degrees. The configuration installed on RV Poseidon operates in the 50 kHz frequency band at water depths of up to approx. 3,000 m. It has an across-ship swath width of up to 140 degrees with up to 630 beams for each multi-ping. The whole system consists of 2 transmitter/receiver units, a motion sensor, and a salinometer installed on RV Poseidon. Data acquisition has been done with the software Hydrostar 3.5.8 coupled with the survey and processing software package Hypack 10.0.0.4 running under Microsoft Windows XP™ (Fig. 02). The Hysweep survey module of the bundle collected all data from the Seabeam echo sounder in its own HSX data format. The native ELAC XSE-data format has only been stored for archiving and was not used for post processing during POS408-1.

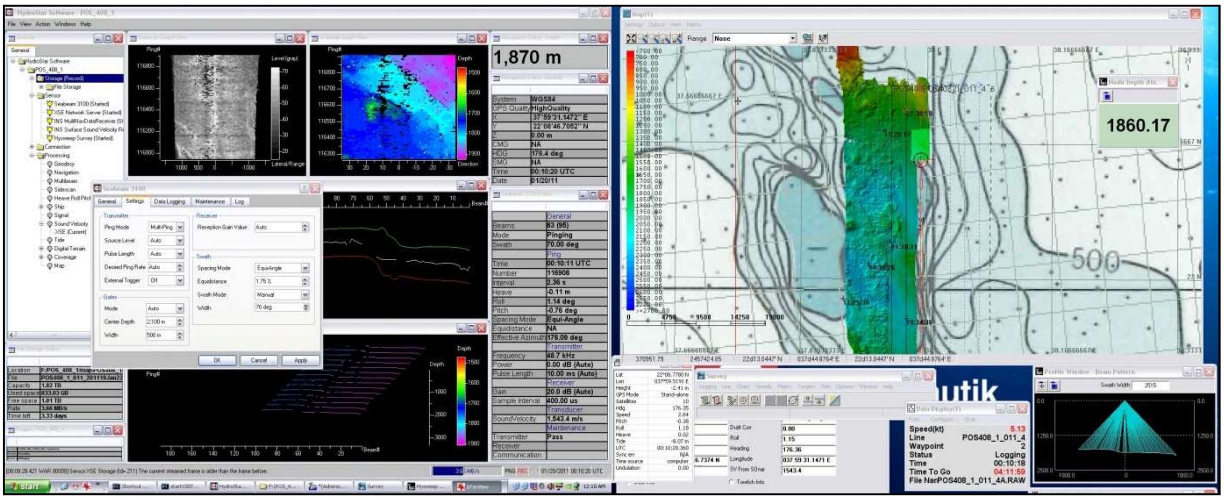


Figure 2: Hydrostar (left) and Hypack (right) graphical user interfaces

During P408-3, about 100 hours of multi beam survey collected bathymetric data during the transits of approximately 2,950 km^2 along the eastern Red Sea between 17°14N´ and 21°30´N. In addition to the transit survey one mult ibeam survey collected data of the northern slope of the Farasan Islands. The average ship speed during the bathymetric surveys of Hatiba Deep and Port Sudan Deep was 8-10 knots.

At shallow water depths <200 m the multibeam created unusual halfpipe-like patterns of the bottom signal (Fig. 03). Therefore, different tracklines did not match and data from water depths <200 can not be used for interpretation of bottom features. Checks of the multibeam settings as well as the sound velocity profiles did not result in any solution. The error occurred in the HydroStar software and was likely not induced by the Hypack module.

Additionally, an error occurred from time to time during the post processing of the HSX data files. Whereas the Hysweep window displayed the collected data without problems during the active surveys, the MBMax-processed data showed several gaps in the data. However, this error was not reproducible and the processed and exported data show a bunch of non-georeferenced beams at the end or in the middle of the produced gaps.

The beam angle was mostly set in Hydrostar to automatic mode, but manually corrected if necessary (e.g., because of less overlap of the mapped track lines). The Ping mode was set to Multiping. Source Level, Pulse Length and Desired Ping Rate were set to automatic. For bottom search first the gates were set manually and switched to automatic mode after the bottom signal was found. A first data editing has been made with the Hysweep Editor module (MBmax) including a spike filter and a filtering of overhanging and underlying pings. Final gridding and bathymetric map production was realized using the Fledermaus™ DMagic module. The data were gridded with a cell size of 25-35m.

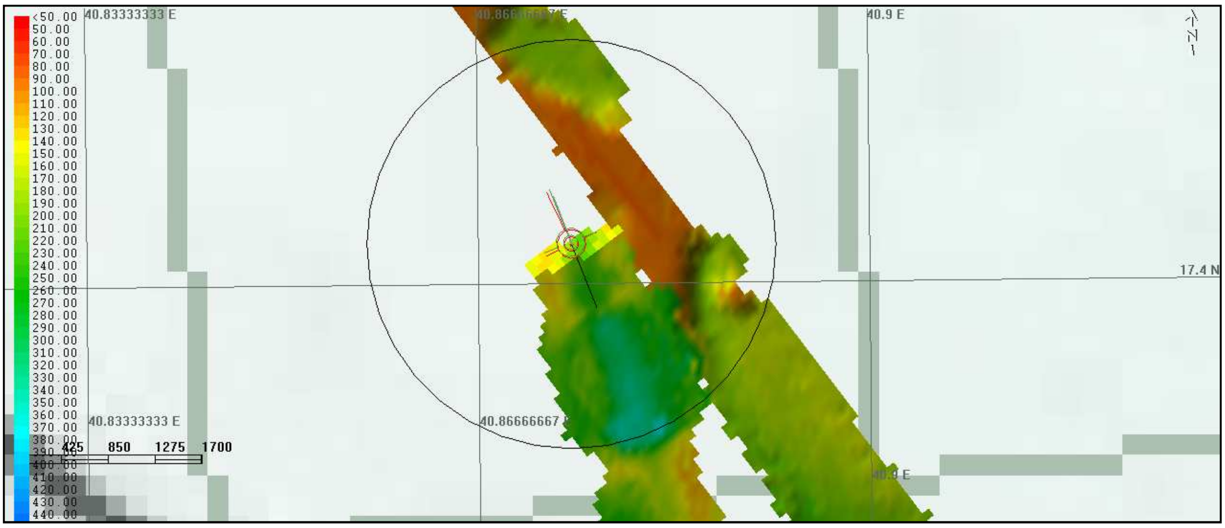


Figure 3:: The Hysweep screen shot shows the mismatch of two multibeam tracks in shallow water depths NW of Farasan Ilands, Southern Red Sea. While the multi beam depth below the ships position (center of black circle) is showing 180m, the single beam deep sea echo sounder of RV Poseidon was showing 80m. This offset of 100m was confirmed by a video-guided CTD which revealed a water depth of 80m at the bottom.

3.5.1 First Results

Pockmark structures

Multibeam mapping during cruise P408-3 revealed large areas of so called “pockmark structures” at water depths <700 m (Fig. 04). The diameters and depths of the pockmarks vary from 70-450 m and 2-20 m, respectively. Due to the circumstances that the in-transit multibeam mapping only recorded track lines of about 2-3 km in width, it is not clear which general topographic features these pockmarks are related to. Often the pockmarks seem to be related to depressions and elongated, fault-like features. In general, the formation of pockmarks seems to be related to ascending gas, fluid and/or to biogenic/thermogenetic processes (e.g., Jané, 2010). Some pockmarks fade to elongated, parabolic scour marks, which most likely could be interpreted as transported sedimentary material by localized flow eddies of the lee side of the pockmarks and therefore can be used as current indicators. Additionally collected water column data may provide some more information about the origin of the pockmarks and reveal whether the pockmarks are still active or not. This has to be evaluated after the cruise.

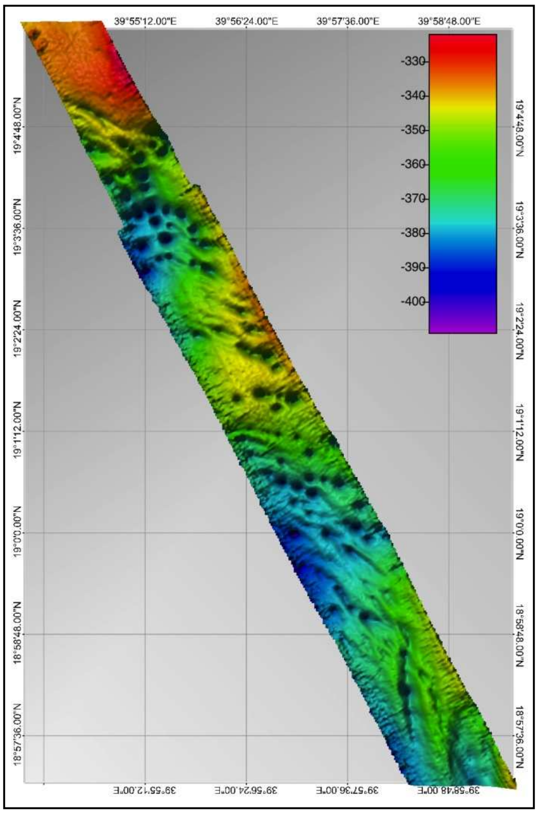


Figure 4: Pockmark field along the transit of RV Poseidon cruise P408-3

Volcanic features

During the transit of P408-3 Poseidon sporadically crossed some volcanic structures whose bathymetric characteristics were collected by the multi beam system. These volcanoes were found at water depths of about 1440 m and are related to outer rims of the Red Sea Rift. The volcanic structures show diameters of up to 2 km and an elevation of up to 250 m compared to the surrounding seafloor. At least two volcanoes were found with a central caldera and some features resembling lava flow (Fig. 05).

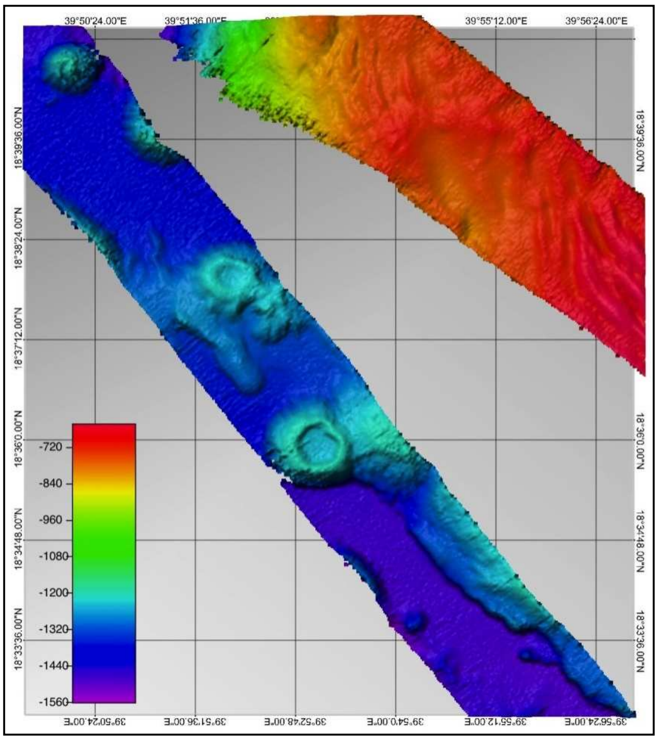


Figure 5: The map shows two caldera volcanoes which Poseidon passed during transit to the "Southern End Station" .

Fossil reef structures

During the transit to the so called “southern end station” at 17°14´N, 41°E the Poseidon crossed steep structures approximately 70km north of the Farasan Islands (Fig. 06). These structures were visible in the multi beam pattern as well as in the screens of single beam echo sounder, which are installed at the wheelhouse. The structures are supposed to be ancient, most likely Last Interglacial reef structures about ~20,000 years old. The shallowest parts are at water depths <80m and show elevation differences to the surrounding seafloor of about 80m. Unfortunately, after the structures had been crossed the ship’s heading was changed to SW, however, the multi beam system started to create half-pipe like features whenever the water depth was shallower than 200 m. Therefore, a following detailed multibeam survey of these structures did not provide accurate data of these features.

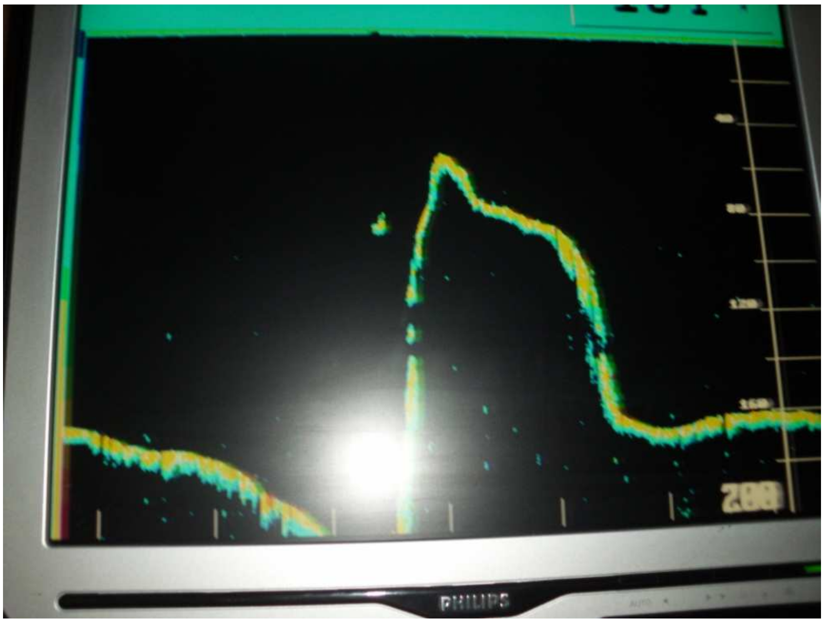


Figure 6: This picture was taken by a digital camera directly from the echolot sounder on the bridge of the POSEIDON. Most likely it shows a drowned reef about north of the Farasan Islands at a water depth of about 130 m.

4. References

G. Jané, A. Maestro, G. Ercilla, J. López-Martínez, J.R. De Andrés, D. Casas, D. González-Aller, M. Catalán-Morollón (2010): Occurrence of pockmarks on the Ortegal Spur continental margin, Northwestern Iberian Peninsula. *Marine and Petroleum Geology*, **27:** 1551-1564

M. R. Landry, and R. P. Hassett (1982). Estimating the grazing impact of marine micro-zooplankton. *Marine Biology,* **67**: 283-288.

5. Acknowledgements

The scientists on board highly acknowledge the professional, friendly and sustainable support of the RV Poseidon crew during P408-3. In particular, we also acknowledge the protection by the two Royal Saudi Arabian warships AIYARMOOK and AMR, respectively.

IFM-GEOMAR
Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

IFM-GEOMAR Reports

No.	Title
1	RV Sonne Fahrtbericht / Cruise Report SO 176 & 179 MERAMEX I & II (Merapi Amphibious Experiment) 18.05.-01.06.04 & 16.09.-07.10.04. Ed. by Heidrun Kopp & Ernst R. Flueh, 2004, 206 pp. In English
2	RV Sonne Fahrtbericht / Cruise Report SO 181 TIPTEQ (from The Incoming Plate to mega Thrust EarthQuakes) 06.12.2004.-26.02.2005. Ed. by Ernst R. Flueh & Ingo Grevemeyer, 2005, 533 pp. In English
3	RV Poseidon Fahrtbericht / Cruise Report POS 316 Carbonate Mounds and Aphotic Corals in the NE-Atlantic 03.08.–17.08.2004. Ed. by Olaf Pfannkuche & Christine Utecht, 2005, 64 pp. In English
4	RV Sonne Fahrtbericht / Cruise Report SO 177 - (Sino-German Cooperative Project, South China Sea: Distribution, Formation and Effect of Methane & Gas Hydrate on the Environment) 02.06.-20.07.2004. Ed. by Erwin Suess, Yongyang Huang, Nengyou Wu, Xiqiu Han & Xin Su, 2005, 154 pp. In English and Chinese
5	RV Sonne Fahrtbericht / Cruise Report SO 186 – GITEWS (German Indonesian Tsunami Early Warning System 28.10.-13.1.2005 & 15.11.-28.11.2005 & 07.01.-20.01.2006. Ed. by Ernst R. Flueh, Tilo Schoene & Wilhelm Weinrebe, 2006, 169 pp. In English
6	RV Sonne Fahrtbericht / Cruise Report SO 186 -3 – SeaCause II, 26.02.-16.03.2006. Ed. by Heidrun Kopp & Ernst R. Flueh, 2006, 174 pp. In English
7	RV Meteor, Fahrtbericht / Cruise Report M67/1 CHILE-MARGIN-SURVEY 20.02.-13.03.2006. Ed. by Wilhelm Weinrebe und Silke Schenk, 2006, 112 pp. In English
8	RV Sonne Fahrtbericht / Cruise Report SO 190 - SINDBAD (Seismic and Geoacoustic Investigations Along The Sunda-Banda Arc Transition) 10.11.2006 - 24.12.2006. Ed. by Heidrun Kopp & Ernst R. Flueh, 2006, 193 pp. In English
9	RV Sonne Fahrtbericht / Cruise Report SO 191 - New Vents "Puaretanga Hou" 11.01. - 23.03.2007. Ed. by Jörg Bialas, Jens Greinert, Peter Linke, Olaf Pfannkuche, 2007, 190 pp. In English
10	FS ALKOR Fahrtbericht / Cruise Report AL 275 - Geobiological investigations and sampling of aphotic coral reef ecosystems in the NE-Skagerrak, 24.03. - 30.03.2006, Eds.: Andres Rüggeberg & Armin Form, 39 pp. In English

No.	Title
11	FS Sonne / Fahrtbericht / Cruise Report SO 192-1: MANGO: Marine Geoscientific Investigations on the Input and Output of the Kermadec Subduction Zone, 24.03. - 22.04.2007, Ernst Flüh & Heidrun Kopp, 127 pp. In English
12	FS Maria S. Merian / Fahrtbericht / Cruise Report MSM 04-2: Seismic Wide-Angle Profiles, Fort-de-France – Fort-de-France, 03.01. - 19.01.2007, Ed.: Ernst Flüh, 45 pp. In English
13	FS Sonne / Fahrtbericht / Cruise Report SO 193: MANIHIKI Temporal, Spatial, and Tectonic Evolution of Oceanic Plateaus, Suva/Fiji – Apia/Samoa 19.05. - 30.06.2007, Eds.: Reinhard Werner and Folkmar Hauff, 201 pp. In English
14	FS Sonne / Fahrtbericht / Cruise Report SO195: TOTAL TOnga Thrust earthquake Asperity at Louisville Ridge, Suva/Fiji – Suva/Fiji 07.01. - 16.02.2008, Eds.: Ingo Grevemeyer & Ernst R. Flüh, 106 pp. In English
15	RV Poseidon Fahrtbericht / Cruise Report P362-2: West Nile Delta Mud Volcanoes, Piräus – Heraklion 09.02. - 25.02.2008, Ed.: Thomas Feseker, 63 pp. In English
16	RV Poseidon Fahrtbericht / Cruise Report P347: Mauritanian Upwelling and Mixing Process Study (MUMP), Las-Palmas - Las Palmas, 18.01. - 05.02.2007, Ed.: Marcus Dengler et al., 34 pp. In English
17	FS Maria S. Merian Fahrtbericht / Cruise Report MSM 04-1: Meridional Overturning Variability Experiment (MOVE 2006), Fort de France – Fort de France, 02.12. – 21.12.2006, Ed.: Thomas J. Müller, 41 pp. In English
18	FS Poseidon Fahrtbericht /Cruise Report P348: SOPRAN: Mauritanian Upwelling Study 2007, Las Palmas - Las Palmas, 08.02. - 26.02.2007, Ed.: Hermann W. Bange, 42 pp. In English
19	R/V L'ATALANTE Fahrtbericht / Cruise Report IFM-GEOMAR-4: Circulation and Oxygen Distribution in the Tropical Atlantic, Mindelo/Cape Verde - Mindelo/Cape Verde, 23.02. - 15. 03.2008, Ed.: Peter Brandt, 65 pp. In English
20	RRS JAMES COOK Fahrtbericht / Cruise Report JC23-A & B: CHILE-MARGIN-SURVEY, OFEG Barter Cruise with SFB 574, 03.03.-25.03. 2008 Valparaiso – Valparaiso, 26.03.-18.04.2008 Valparaiso - Valparaiso, Eds.: Ernst Flüh & Jörg Bialas, 242 pp. In English
21	FS Poseidon Fahrtbericht / Cruise Report P340 – TYMAS "Tyrrhenische Massivsulfide", Messina – Messina, 06.07.-17.07.2006, Eds.: Sven Petersen and Thomas Monecke, 77 pp. In English

No.	Title
22	RV Atalante Fahrtbericht / Cruise Report HYDROMAR V (replacement of cruise MSM06/2), Toulon, France - Recife, Brazil, 04.12.2007 - 02.01.2008, Ed.: Sven Petersen, 103 pp. In English
23	RV Atalante Fahrtbericht / Cruise Report MARSUED IV (replacement of MSM06/3), Recife, Brazil - Dakar, Senegal, 07.01. - 31.01.2008, Ed.: Colin Devey, 126 pp. In English
24	RV Poseidon Fahrtbericht / Cruise Report P376 ABYSS Test, Las Palmas - Las Palmas, 10.11. - 03.12.2008, Eds.: Colin Devey and Sven Petersen, 36 pp, In English
25	RV SONNE Fahrtbericht / Cruise Report SO 199 CHRISP Christmas Island Seamount Province and the Investigator Ridge: Age and Causes of Intraplate Volcanism and Geodynamic Evolution of the south-eastern Indian Ocean, Merak/Indonesia – Singapore, 02.08.2008 - 22.09.2008, Eds.: Reinhard Werner, Folkmar Hauff and Kaj Hoernle, 210 pp. In English
26	RV POSEIDON Fahrtbericht / Cruise Report P350: Internal wave and mixing processes studied by contemporaneous hydrographic, current, and seismic measurements, Funchal – Lissabon, 26.04.-10.05.2007 Ed.: Gerd Krahmann, 32 pp. In English
27	RV PELAGIA Fahrtbericht / Cruise Report Cruise 64PE298: West Nile Delta Project Cruise - WND-3, Heraklion - Port Said, 07.11.-25.11.2008, Eds.: Jörg Bialas & Warner Brueckmann, 64 pp. In English
28	FS POSEIDON Fahrtbericht / Cruise Report P379/1: Vulkanismus im Karibik-Kanaren-Korridor (ViKKi), Las Palmas – Mindelo, 25.01.-12.02.2009, Ed.: Svend Duggen, 74 pp. In English
29	FS POSEIDON Fahrtbericht / Cruise Report P379/2: Mid-Atlantic-Researcher Ridge Volcanism (MARRVi), Mindelo- Fort-de-France, 15.02.-08.03.2009, Ed.: Svend Duggen, 80 pp. In English
30	FS METEOR Fahrtbericht / Cruise Report M73/2: Shallow drilling of hydrothermal sites in the Tyrrhenian Sea (PALINDRILL), Genoa – Heraklion, 14.08.2007 – 30.08.2007, Eds.: Sven Petersen & Thomas Monecke, 235 pp. In English
31	FS POSEIDON Fahrtbericht / Cruise Report P388: West Nile Delta Project - WND-4, Valetta – Valetta, 13.07. - 04.08.2009, Eds.: Jörg Bialas & Warner Brückmann, 65 pp. In English
32	FS SONNE Fahrtbericht / Cruise Report SO201-1b: KALMAR (Kurile-Kamchatka and ALeutian MARginal Sea-Island Arc Systems): Geodynamic and Climate Interaction in Space and Time, Yokohama, Japan - Tomakomai, Japan, 10.06. - 06.07.2009, Eds.: Reinhard Werner & Folkmar Hauff, 105 pp. In English
33	FS SONNE Fahrtbericht / Cruise Report SO203: WOODLARK Magma genesis, tectonics and hydrothermalism in the Woodlark Basin, Townsville, Australia - Auckland, New Zealand 27.10. - 06.12.2009, Ed.: Colin Devey, 177 pp. In English

No.	Title
34	FS MARIA S. MERIAN Fahrtbericht / Cruise Report MSM 03-2: HYDROMAR IV: The 3rd dimension of the Logatchev hydrothermal field, Fort-de-France - Fort-de-France, 08.11. - 30.11.2006, Ed.: Sven Petersen, 98 pp. In English
35	FS SONNE Fahrtbericht / Cruise Report SO201-2 **KALMAR: K**urile-Kamchatka and **AL**eutian **MAR**ginal Sea-Island Arc Systems: Geodynamic and Climate Interaction in Space and Time Busan/Korea – Tomakomai/Japan, 30.08. - 08.10.2009, Eds.: Wolf-Christian Dullo, Boris Baranov, and Christel van den Bogaard, 233 pp. In English
36	RV CELTIC EXPLORER Fahrtbericht / Cruise Report CE0913: Fluid and gas seepage in the North Sea, Bremerhaven – Bremerhaven, 26.07. - 14.08.2009, Eds.: Peter Linke, Mark Schmidt, CE0913 cruise participants, 90 pp. In English
37	FS SONNE Fahrtbericht / Cruise Report: TransBrom SONNE, Tomakomai, Japan - Townsville, Australia, 09.10. - 24.10.2009, Eds.: Birgit Quack & Kirstin Krüger, 84 pp. In English
38	FS POSEIDON Fahrtbericht / Cruise Report POS403, Ponta Delgada (Azores) - Ponta Delgada (Azores), 14.08. - 30.08.2010, Eds.: Torsten Kanzow, Andreas Thurnherr, Klas Lackschewitz, Marcel Rothenbeck, Uwe Koy, Christopher Zappa, Jan Sticklus, Nico Augustin, 66 pp. In English
39	FS SONNE Fahrtbericht/Cruise Report SO208 Leg 1 & 2 Propagation of Galápagos Plume Material in the Equatorial East Pacific (PLUMEFLUX), Caldera/Costa Rica – Guayaquil/Ecuador 15.07. - 29.08.2010, Eds.: Reinhard Werner, Folkmar Hauff and Kaj Hoernle, 230 pp, In English
40	Expedition Report "Glider fleet", Mindelo (São Vincente), Republic of Cape Verde, 05. – 19.03.2010, Ed.: Torsten Kanzow, 26 pp, In English
41	FS SONNE Fahrtbericht / Cruise Report SO206, Caldera, Costa Rica – Caldera, Costa Rica, 30.05. – 19.06.2010, Ed.: Christian Hensen, 95 pp, In English
42	FS SONNE Fahrtbericht / Cruise Report SO212, Talcahuano, Chile – Valparaiso, Chile, 22.12. – 26.12.2010, Ed.: Ernst Flüh, 47 pp, in English
43	RV Chakratong Tongyai Fahrtbericht / Cruise Report MASS-III, Morphodynamics and Slope Stability of the Andaman Sea Shelf Break (Thailand), Phuket - Phuket (Thailand), 11.01. - 24.01.2011, Ed.: Sebastian Krastel, 42 pp, in English.
44	FS SONNE Fahrtbericht / Cruise Report SO-210, Identification and investigation of fluid flux, mass wasting and sediments in the forearc of the central Chilean subduction zone (ChiFlux), Valparaiso – Valparaiso, 23.09. – 01.11.2010, Ed.: Peter Linke, 112 pp, in English.

IFM-GEOMAR
Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

Das Leibniz-Institut für Meereswissenschaften ist ein Institut der Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz (WGL)

The Leibniz-Institute of Marine Sciences is a member of the Leibniz Association (Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz).

Leibniz-Institut für Meereswissenschaften / Leibniz-Institute of Marine Sciences
IFM-GEOMAR
Dienstgebäude Westufer / West Shore Building
Düsternbrooker Weg 20
D-24105 Kiel
Germany

Leibniz-Institut für Meereswissenschaften / Leibniz-Institute of Marine Sciences
IFM-GEOMAR
Dienstgebäude Ostufer / East Shore Building
Wischhofstr. 1-3
D-24148 Kiel
Germany

Tel.: ++49 431 600-0
Fax: ++49 431 600-2805
www.ifm-geomar.de