IFM-GEOMAR REPORT

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Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

RV Aegaeo
Fahrtbericht / Cruise Report
West Nile Delta Project Cruise - WND-V

15.06. – 25.06.2010
Heraklion- Heraklion (Greece)

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

Nr. 49

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1. ABSTRACT

Cruise WND-V was the fifth and final expedition of the West Nile Delta project carried out at IFM-GEOMAR with support from RWE-Dea. On this concluding cruise of the project, the two mud volcanoes North Alex and Giza were once again visited, this time using the Greek R/V AEGAEO. The primary purpose of the WND-V cruise was the recovery of instruments and observatories which had been deployed in or near the active centers of North Alex and Giza MVs over the past 30 months. In addition, complementary new data were acquired that were needed to better quantify the methane flux from the centers of both MVs. From 15 to 25 June 2010, the following activities were carried out:

- recovery of 12 long-term Ocean-Bottom-Seismometers (OBS) at North Alex MV, which had been deployed during POSEIDON cruise P388 in 2009.
- recovery of 4 instruments for measuring long-term pore pressure variations (piezometers) on the slope near North Alex MV, deployed during POSEIDON cruise P388 in 2009.
- recovery of 6 instruments for measuring long-term chemical flux (CATmeters) at Giza and North Alex MV.
- recovery of 1 instrument (OBMets) for measuring methane flux from the seafloor at North Alex MV.
- recovery of 2 tiltmeters for measuring seafloor deformation at North Alex MV.
- recovery of 2 long-term temperature observatories at Giza and North Alex MV.
- CTD casts in the central area of North Alex MV
- Imaging of bubble streams from the active center of North Alex using an SIMRAD EK60 sonar system.

Although hampered by poor weather during the final days of the cruise the recovery operations were finished two days earlier than expected. Bathymetric data acquisition however, which had been part of the original schedule had to be cancelled due to bad weather as well as technical problems with the deep water sonar systems.

2. INTRODUCTION

The working area of the West Nile Delta Project (WND) is the concession area operated by BP and RWE Dea offshore the Egyptian coast north of the city of Alexandria. Apparently rooted at depths of more than 5 kilometers, Giza mud volcano (Giza MV) and North Alex mud volcano (North Alex MV) are located in the immediate vicinity of designated gas production wells on the upper slope of the western Nile deep-sea fan (Fig. 2.1). The temporal development of the mud volcanoes as well as information about the slope stability of the shelf area are of major interest for the companies developing this reservoir. In the context of the West Nile Delta Project at IFM-GEOMAR, these two mud volcanoes were selected for detailed investigation to provide new insights into the dynamics of these unique sea floor features and their relation to gas reservoirs.

Temperature and heat flow measurements have shown that North Alex is the more active mud volcano, while Giza seems to be in a cooling phase. Therefore most of the investigation activities were concentrated on North Alex.

To detect and quantify the temporal variability of mud volcano dynamics in terms of gas, fluid, and sediment fluxes the WND had installed an array of different observation systems. These observatories closely monitored seismicity, fluid flow, deformation, temperature, and subsurface pressure variations. The primary goal of cruise WND-V was the recovery of these monitoring systems.

Although slope stability is not an issue directly linked to mud volcano processes, nevertheless it is an important boundary condition for future development efforts and was included in the WND research program. Four newly developed piezometers were provided by BP for this purpose, their recovery was another important aspect of the WND-V cruise.

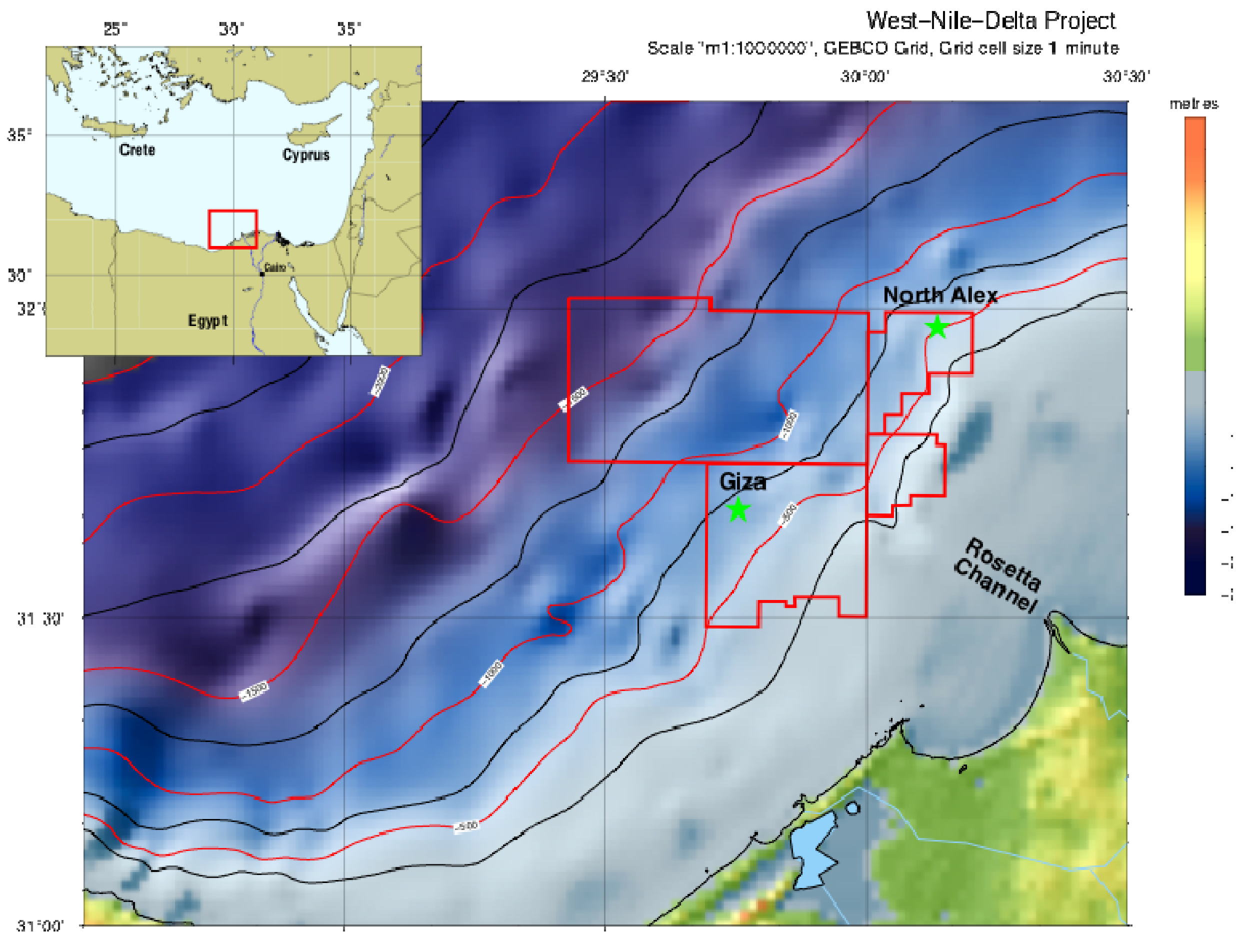

Figure 2.1: Location map of Giza and North Alex mud volcanoes. Red lines indicate borders of concession / research areas.

3. GEOLOGICAL SETTING

The West Nile Delta forms part of the source of the large turbiditic Nile Deep Sea Fan.

Crustal tectonics in the geodynamic framework around the Nile Fan are mainly influenced by the Suez-Rift area, the Arabian-African plate motion, and the subduction collision with the Anatolian Plate (Loncke et al., 2004). Since the late Miocene sediments have formed an up to 10-km-thick pile, which includes about 1 – 3 km of Messinian evaporates (Mascle et al., 2006). The sediment load of the overburden implies strong overpressures and salt-related tectonic deformation. Both are favourable for fluid migration towards the seafloor guided by the fractured margin.

Deep-cutting channel systems like the Rosetta channel characterize the continental slope. Bathymetric expressions of slides and numerous mud volcanoes in the area are expressions of active processes, which contribute to the ongoing modification of the slope.

The western deltaic system, Rosetta branch, has formed an 80-km-wide continental shelf. Here, at 500 m and 700 m water depth, the mud volcanoes Giza and North Alex have developed two major bathymetric features, which have proven to be active gas and mud-expelling structures.

4. OPERATIONS REPORT

Wednesday, 16 June 2010

19:30 **arrival in working area (center of NAMV)**

20:00 - 22:00 download of data from temperature observatory in the center of NAMV (only partially successful as modems did not communicate well due to outdated firmware on surface modem, however, bottom system is alive and collecting data)

22:00 - 24:00 CTD cast #1 at NAMV center, successful, no CH4 plume seen

Thursday, 17 June 2010

00:00 – 01:00 test of temperature microstructure analysis at center of NAMV (aborted after instrument was damaged by contact with ship's screw)

02:00 – 05:00 CTD cast #2 at NAMV center, successful, slow deployment, high CH_4 seen at 450 m in the center of NAMV

06:00 - 10:00 imaging of methane bubble plume at NAMV using SIMRAD system, successful – plume clearly identifiable in the central part of NAMV

10:00 - 14:00 recovery of 5 OBS stations (OBS), one failure (OBS SP 29)

14:00 - 17:30 ROV deployment, equipment test and inspection of temperature observatory at NAMV, found lost/ unresponsive OBS SP 29 and retrieved it by ROV (maneuver never been performed before)

17:30 - 20:00 download of data from temperature observatory (NAMV)

20:00 - 00:00 CTD casts at 1 station in the center of NAMV

Friday, 18 June 2010

00:00 - 04:00 imaging of methane plume at NAMV using SIMRAD EK 60

04:00 - 08:00 CTD casts at 1 station in the center of NAMV

08:00 - 16:00 recovery of temperature observatory (successfully retrieved data logger and surface chain of temperature sensors), recovery of CATmeters at NAMV:
CATmeter #1 (w/ flotation) not found, ROV retrieved,
relocation to CATmeter #6 - not found,
relocation to CATmeter #9 – found but recovery failed)

16:00 - 20:00 recovery of 2 tiltmeters,1 OBSMets and 2 OBS stations, one OBS could not be recovered (pick-up by ROV on Saturday, 19 June)

20:00 - 00:00 CTD casts at 1 station in the center of NAMV

Saturday,19 June 2010

00:00 - 04:00 imaging of methane plume at NAMV using SIMRAD EK 60

04:00 - 08:00 CTD casts at 1 station in the center of NAMV

08:00 - 16:00 ROV operations to recover 3 CATmeters near NAMV:
#8 found and retrieved, found
#6 found, apparently trawled away by fishing or knocked over by ROV umbilical
#9 found;
attempted recovery of lost OBS SP32 not successful, ballast found but without OBS, partially trawled

16:00 - 18:00 Recovery of piezometer 310/1: worked flawlessly
attempt to lift 310/2 from base failed, box stuck (complete station to be recovered on Sunday, 20 June)

18:00 - 20:00 ROV recovery of 2 last remaining OBS near NAMV (successful)

20:00 - 00:00 CTD casts at 1 station in the center of NAMV

Sunday, 20 June 2010

00:00 - 04:00 imaging of methane plume at NAMV using SIMRAD EK 60

04:00 - 08:00 CTD casts at NAMV center

08:00 - 15:00 ROV recovery of T-Obs at NAMV (successful)

15:00 -18:00 ROV recovery of 2 piezometer stations:
#2 found dredged away a few meters from station
#1 was not found, hydraulic stab discovered protruding from a deep crater, apparently also dredged by fishery

18:00 - 21:00 CTD casts at 1 station in the center of NAMV

21:00 - 23:00 imaging of methane plume at NAMV

23:00 - 04:00 additional CTD casts at NAMV

Monday, 21.06.2010

04:00 - 08:00 CTD casts

08:00 - 12:00 ROV recovery of piezometer #310/2

12:00 - 15:30 search for CAT#1

15:30 - 21:00 3 gravity cores in the center of N Alex MV

<u>Tuesday, 22.06.2010</u>

00:00 - 01:00 CTD casts at 1 station in the center of N Alex MV

01:00 - 08:00 transit to Giza MV (western part of WND working area)

08:00 - 21:00 standby, waiting on weather

21:00 – 23:00 deployment of ROV and recovery of CATmeter#1

23:00 – 00:00 download of partial data set from Giza T-Obs

<u>Wednesday, 23.06.2010</u>

01:00 – 03:00 T-Obs located, cables cut, modem and data logger successfully released; fell back to the seafloor, however, after getting tangled in the ship's screw due to operator error

04:00 – 08:00 CTD cast at one location off center Giza MV

09:00 – 12:00 search for and retrieval of data loggers from Giza T-obs

12:45 end of operations of cruise WND V

Table X: Summary of recovery operations

INSTRUMENT	# DEPLOYED	# RECOVERED
OBS	12	11 (1 lost)
OBT	2	2
OBSMets	1	1
CATmeter	3 (N ALEX)	3
CATmeter	1 (GIZA)	1
T-Obs	1 (N ALEX)	1
T-Obs	1 (GIZA)	1
Piezometer	3	3 (1 lost)
Total	27	27

5. CREW

Ship's crew

Name	Position
Theodoros Kanakaris	Master
Dimitrios Mitraras	Chief Officer
Georgios Lambrianos	Second Officer
Angelis Tzoutzas	Chief Engineer
Panagiotis Ipsilantis	2nd Engineer
Pavlos Pavlidis	3rd Engineer
Gerasimos Argyris	3rd Engineer
Georgios Markis	Electrician
Anastasios Balasidis	Bosun
Konstadinos Padazis	AB
Christos Linardatos	AB
Alexandros Blachopoulos	AB
Konnos Tsachas	AB
Michail Kouliaroudis	AB
Frantzeskos Fratzis	Motor Man
Georgios Koutsoukos	Wiper
Anestis Karageorgis	Chief Steward
Nikolaos Roussos	Assistant Steward
Sokratis Argyris	Assistant Steward
Georgios Kioumortzidis	Chief Cook
Konstantinos Kougioumoutzoglou	Asscook
Leonidas Manousakis	ROV Engineer/ Operator
Emmanouil Kallergis	ROV Engineer/ Operator
Konstantinos Katsaros	ROV Operator
Theodoros Fotopoulos	ROV Technician/ Operator
Renieris Panagiotis	CTD Technician
Spiridon Maroulakis	Technician

Science crew

Name	Institute	Function
Warner Brückmann	IFM-GEOMAR	Chief Scientist; Piezometers
Thomas Brandt	IFM-GEOMAR	Technician, Piezometers
Tomas Feseker	IFM-GEOMAR	T-Observatory, Heat Flow
Helene Kraft	IFM-GEOMAR	OBS
Matthias Lunge	Contros	Technician, Methane sensors
Dorothée Makarow	IFM-GEOMAR	Documentation
Lorenzo Rovelli	IFM-GEOMAR	Oceanography
Mark Schmidt	IFM-GEOMAR	CTD Observations
Michael Donald Tryon	Scripps IO	CATmeters
Peggy Wefers	IFM-GEOMAR	Lab Technician, CTD
Martin Weinelt	kk+w	SIMRAD EK60 operator
Gero Wetzel	IFM-GEOMAR	Technician, T-Observatory, Heat Flow

Figure 5.1: The Science crew of WND-V

6. RESEARCH VESSEL AEGAEO AND ROV MAXROVER

R/V AEGAEO was built in 1985 and primarily operates in the Eastern Mediterranean. From June 1996 to February 1997, R/V AEGAEO was converted and enlarged by 10,5 m.

R/V AEGAEO is the mother ship of the ROV Max Rover that was extensively used during cruise WND V.

Figure 6.1: R/V AEGAEO

Figure 6.2: ROV Max Rover

R/V Aegaeo:

Gross Tons	778
Length	61.5 m
Breadth	9.60 m
Working Deck	80.0 m^2
Speed Cruise/ Speed Max.	12.0 / 12.5
Officers	9
Crew	13
Scientists	21
CTD Capabilities	CTD
Coring Capabilities	yes
Underwater Vehicles Supported	ROV, Manned Submersible
Dynamic Positioning	Manual
Global Positioning System Equipment	D-GPS
Winches	2
Cranes	Stern hydraulic A-frame SWL 10 t Side A-frame - SWL 1 t 1 main crane 3.5 t

7. INSTRUMENTS

7.1 OBS, OBSMETS, TILTMETERS

The Ocean Bottom Seismometer has been developed by IFM-GEOMAR since 1991. The latest “Lobster” design (Fig. 7.1.1) includes four cylinders made of syntactic foam, which provide buoyancy. They are fixed in a titanium frame to which pressure tubes with batteries and recording electronics are mounted. A 40-kg steel frame serves as anchor and is fixed to the instrument frame with an acoustic release system. A 4.5-Hz, three-component seismometer belongs to the system as well as a hydrophone. A radio beacon, a flash light and a flag serve as recovery aids once the unit has been released and floats awaiting recovery.

Figure 7.1.1: Ocean-Bottom-Seismometer – OBS - during deployment

In order to record active seismic signals, the system contains an MBS-type data logger. The logger is capable of recording events at a 10-kHz sampling frequency. For long-term observation of passive seismic events, a data logger with low power consumption (MLS) is used which samples at 100 Hz.

7.1.1 TILTMETERS

Long-term observation of seismic, thermal and fluid activity is complemented by tiltmeters (Fig. 7.1.2); which are used to observe possible changes in the slope of the seafloor within the central part of the mud volcano. Tiltmeters record variations of the slope angle within a nano radians resolution and hence should be capable of resolving possible seafloor reactions to fluid/ gas release events.

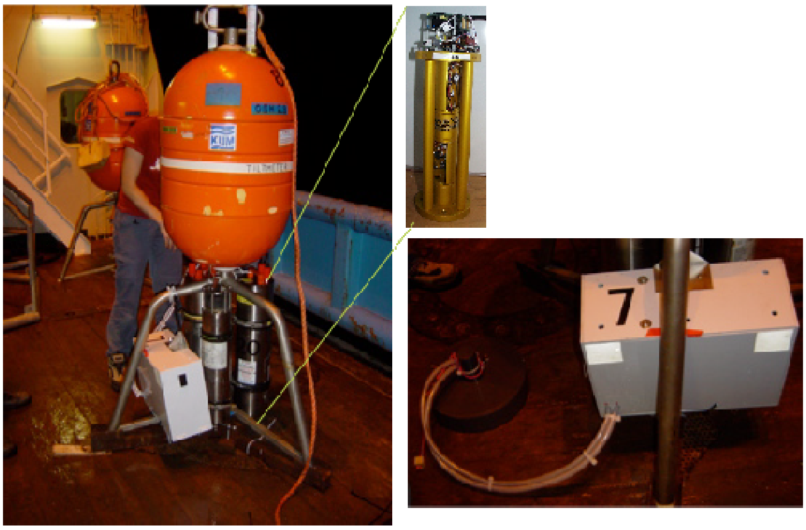

Figure 7.1.2: Ocean-Bottom-Tiltmeter (OBT)
Left: Tiltmeter frame with flotation and pressure tubes below.
Top right: The tiltmeter itself, two sensors with levelling system on top of each other.
Bottom right: CAT meter housing mounted to the tiltmeter frame

7.2 CATMETERS

During WND-3 cruise 64PE298, a total of seven CAT meters were installed on both mud volcanoes (North Alex: 6; Giza: 1) to monitor and determine fluid flow rates at specific locations such as bacterial mats. Two types of CAT meters were installed, their only difference being the mode of recovery: three instruments were deployed without a release system, three with an integrated release system, one was attached to a releasable tiltmeter OBMT.

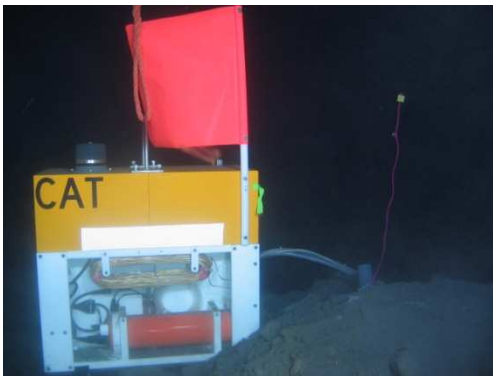

Fig. 7.2.1: CAT meter with acoustic release system

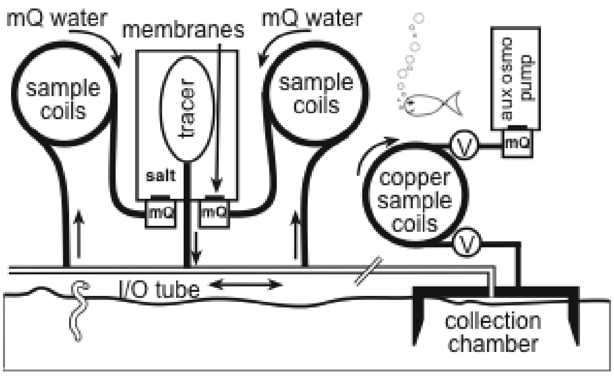

Fig. 7.2.2. CAT meter schematic

The Chemical and Aqueous Transport (CAT) meter (Fig. 7.2.1) [Tryon et al., 2001] is designed to quantify both inflow and outflow rates on the order of 0.01 cm/yr to 100 m/yr. At high outflow rates, a time series record of the outflow fluid chemistry may also be obtained. These instruments have been in use since 1998 and have been very successful in monitoring long-term fluid flow in both seep and non-seep environments. The CAT meter uses the dilution of a chemical tracer to measure flow through the outlet tubing exiting the top of a collection chamber (Fig. 7.2.2). The pump contains two osmotic membranes that separate the chambers containing pure water from the saline side that is held at saturation levels by an excess of NaCl. Due to the constant gradient, distilled water is drawn from the fresh water chamber through the osmotic membrane into the saline chamber at a rate that is constant for a given temperature. The saline output side of the pump system is rigged to inject the tracer while the distilled input side of the two pumps, respectively, is connected to separate sample coils into which they draw fluid from either side of the tracer injection point (Fig. 7.2.2). Each sample coil is initially filled with deionized water. Having two sample coils allows both inflow and outflow to be measured. A unique pattern of chemical tracer distribution is recorded in the sample coils allowing a serial record of the flow rates to be determined. Upon recovery of the instruments the sample coils are subsampled at appropriate intervals and analyzed using a Perkin-Elmer Optima 3000XL ICP-OES. Both tracer concentration and major ion concentration (Na, Ca, Mg, S, K, Sr, B, Li) are determined simultaneously. A subset of these instruments are equipped with an auxiliary osmotic pump connected to copper coils and high-pressure valves so that they can be returned to the surface at ambient pressure, maintaining the gas composition of the fluids for analysis.

As explained in Tryon et al., 2001, diffusion in the sample coils is negligible. Typical sample sizes are 25-75 cm of tubing, many times the characteristic diffusion length for typical seawater ions at ocean bottom temperatures. Our data has shown that we typically achieve resolutions of ~0.5% of the deployment time in the latest portions of the record and ~2% in the oldest portion for deployments of a year. At this time we have no quantitative data with regards to long-term He diffusion in the copper coils, however, since the diffusion coefficient (D) of He is ~$7x10^{-5}$, and of typical seawater ions is ~$1\text{-}3x10^{-5}$, the characteristic diffusion length ($\propto D^{1/2}$) for He should only be about twice that of the other species we analyze for (45 cm for a year at 25℃ and much less at ocean bottom temperatures). Our copper coils are a smaller diameter than the plastic coils and thus our samples are typically twice the length, offsetting any difference in diffusion length.

7.2.1 TYPES OF CAT METERS USED

Basic hand-held CAT

Dimensions: 50 x 46 x 55 cm (base x base x height)
Weight in air: 36 kg
Weight in water: 15 kg

The instrument housings and structure are made of PVC as well as the switching valves. All other hardware is 316 stainless steel; the top handle is a 316 stainless steel - standard Alvin T-handle. The dissolved gas system is made of copper refrigeration tubing with brass couplers and valves.

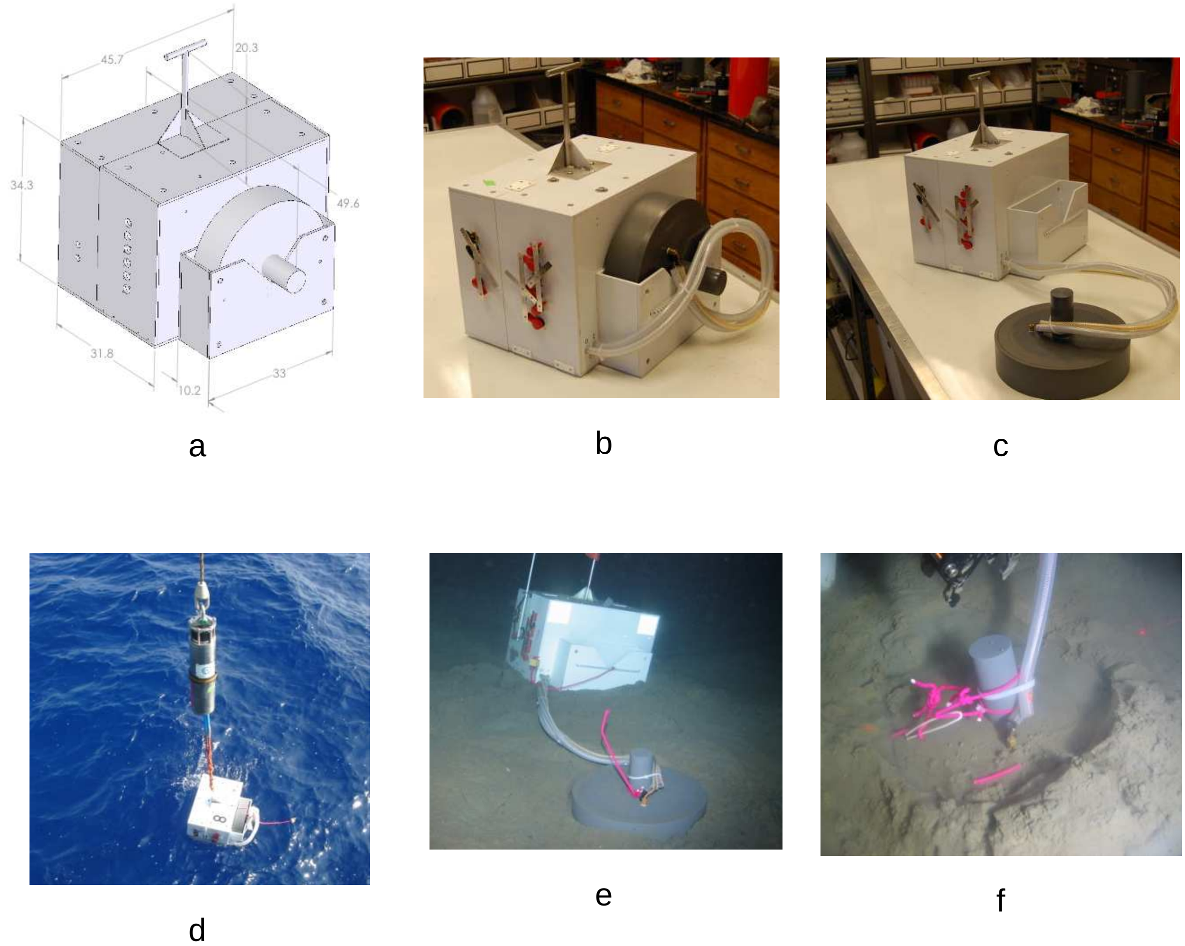

Fig. 7.2.2 a-f: Standard CA meter design, deployment and installation on the seafloor.

<u>Acoustically releaseable CAT</u>

Dimensions: 80 x 38 x 91 cm (base x base x height)
Weight in air w/ ballast: 138 kg
Weight in air w/o ballast: 110 kg
Weight in water w/ ballast: 12 kg
Weight in water w/o ballast: -15 kg

The instrument consists of the basic CAT components as described previously, together with a frame, releaser and floatation. The frame is made of high-density polyethylene, the hardware is 316 stainless steel, the top handle is a 316 stainless steel hoop. The floatation is made of syntactic foam rated at 50 MPa (Syntech AM-37). The acoustic release electronics are in a 7075 Aluminum housing rated at 50 MPa and certified to 4500 meters for use with manned submersibles (safety factor of 1.5).

All other components are solid, oil- or water-filled: There are no other implodeable volumes.

a

b

c

Fig. 7.2.3 a-c: Releaser-equipped CAT meter, deployment (a) and installation (b) on the seafloor, standard CAT meter attached to OBT-1 (c)

7.3 PIEZOMETERS

As part of a cooperation with the BP West Nile Delta Geohazards Assessment Team (WND-GAT), a total of 4 piezometers had been deployed during a previous cruise, POSEIDON P388. These instruments are designed to measure the variability of differential pore pressure at a specific sediment depth. This is accomplished by penetrating the seafloor with a “stinger” assembled from several standard 1-m CPT stands with a special filter tip. From the filter tip a pressure-tight teflon tubing runs to the top-end of the “stinger” which terminates in a hydraulic stab above the seafloor. The hydraulic stab itself is connected to the data acqusition box by a pressure-tight coupling system. The data acquisition box houses two differential pressure sensors and loggers. These sensors compare pressure at the seafloor to the pressure at the filter tip. To measure verticality of penetration an independent tiltmeter is included in the acquisition box.

The piezometer consists of a small number of components enclosed in a block of POM plastics. The center of the block has an opening through which the hydraulic stab protrudes. The tip of the hydraulic stab mates with a pressure coupling that connects to two Keller DCX-22PDH pressure sensors (0-1bar, 0-2bar) with attached data loggers. The second sensor is an NGI-supplied tiltmeter in a bottle. The instrument design and parts are shown in Figs. 7.3.1, 7.3.2 and 7.3.3.

During cruise WND-V the piezometer data loggers were recovered either using the manipulator of the ROV or by retrieving the complete assembly including the stinger via wireline.

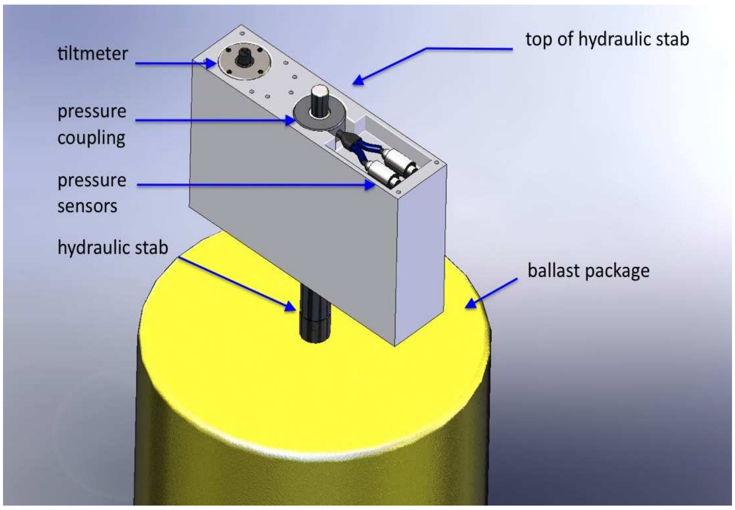

Fig. 7.3.1: Piezometer components positioned on top of the ballast package.

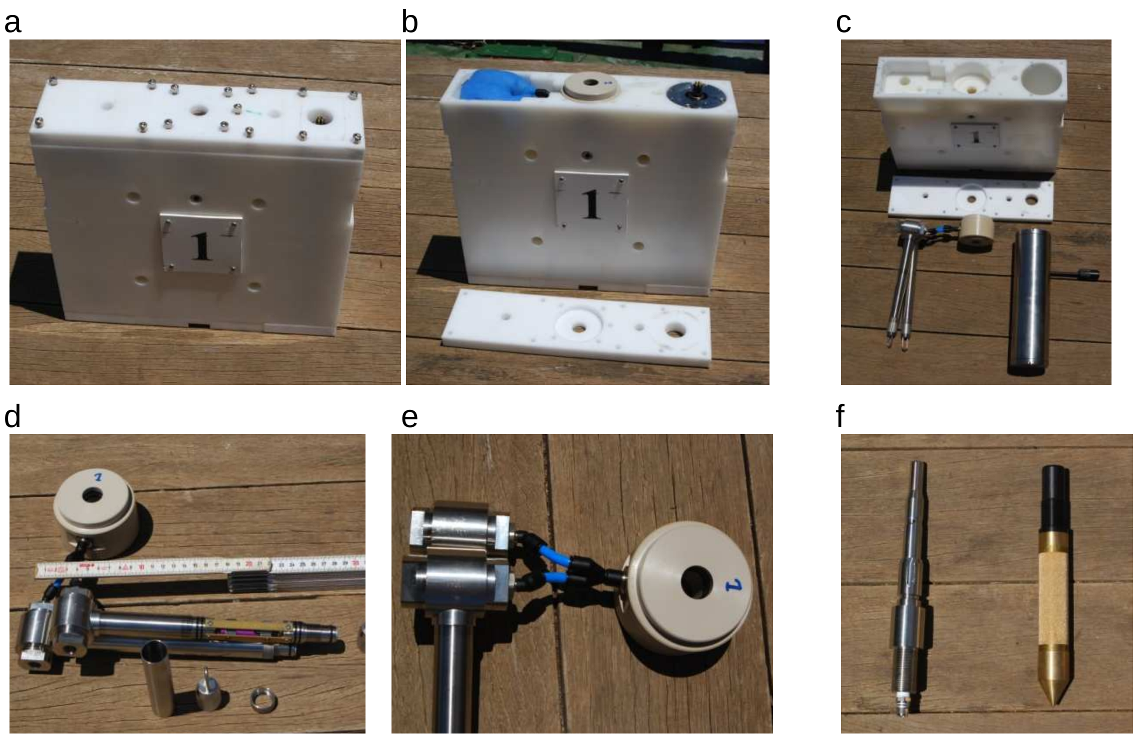

Fig. 7.3.2 a-f: Data acquisition box (a), with top cover opened (b), Keller differential pressure sensors and data loggers – pressure coupling – tiltmeter removed (c), sensors and data logger – pressure coupling (d, e), hydraulic stab and filter tip (f). Note that the handle for ROV operations is not shown here.

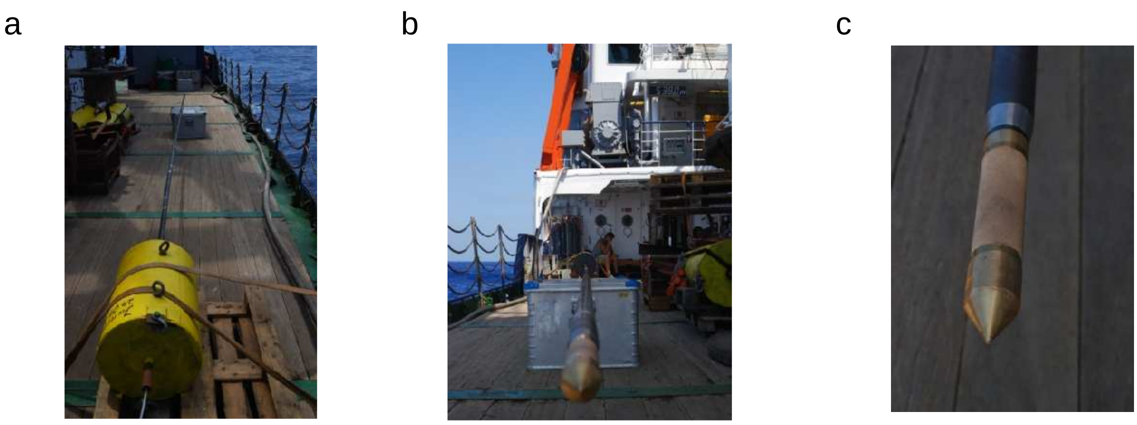

Fig. 7.3.3 a-c: Ballast package (a), assembled stinger with filter tip (b), filter tip detail (c).

7.4 TEMPERATURE OBSERVATORY

To investigate the temporal variability of mud volcano activity, temperature observatories were installed both at North Alex mud volcano and Giza mud volcano during the November 2008 R/V PELAGIA 64PE298 cruise. Each observatory consists of a 6-m-long solid steel lance with a concrete weight at the top, which is connected to a buoy. A thermistor chain with 7 temperature sensors is attached to the lance so that it enters the sediment when the lance penetrates the seafloor and records changes in the vertical sediment temperature profile. Bottom water temperature and the pressure at the position of the observatory are recorded by additional sensors mounted between the concrete weight and the buoy. Additionally, there is a second thermistor chain consisting of 24 temperature sensors, evenly distributed over an active length of 92 m. Following the winch-controlled deployment of the observatory, the second thermistor chain is laid out on the seafloor away from the lance to provide information about the spatial extent of seepage events.

The main components of the observatory are integrated into the buoy. Each thermistor chain is connected to a separate data logger which controls the measurements and stores the readings. The data loggers were synchronized and programmed to a sampling rate of 30 minutes. Each data logger mirrors the recorded data to an underwater serial port connected to an acoustic modem, which stores a copy and transmits the data to a surface vessel on demand.

7.5 CTD

Measurements of physical parameters in the water column define the hydrodynamic and constituent boundaries for benthic measurements as well as estimations of fluxes within the water column. These measurements include water currents, scalars (temperature, dissolved constituents measured with in situ sensors, etc.) and turbidity (particles, bubbles).

CTD (Conductivity-Temperature-Depth) measurements provide the background information on water column stratification with depth, and other scalar parameters (O2, pH, light transmission, etc.). Moreover, CTD data such as salinity, O2, Temperature and pH anomalies are used to help detect possible gas seepages.

On this cruise the ship's SBE9 Seabird CTD (Sea-Bird Electronics, Inc., Washington, USA) was used for oceanographic data aquisition. The SBE9 samples at 4 Hz and was equipped with the default sensors (temperature, conductivity, pressure), and standard additions (oxygen, light transmission). Furthermore, a 24-carosel rosette system was installed for discrete water sampling with 12 Niskin bottles attached (Fig. 7.5.1a).

Additionally, CO_2 and methane sensors (Contros HydroC sensors, Contros GmbH, Kiel) were mounted on the CTD frame and deployed at each CTD cast (Fig. 7.5.1b). The analogue output signal of the methane sensor was plotted online (SEABIRD data monitor) during CTD casts, the CO_2 and CH_4 sensor data was also stored in an internal data logger. Methane anomalies recorded by the sensors were compared with CTD data and acoustic indications bubble plume (SIMRAD, chapter 7.6).

Absolute concentrations of the sensors will be calculated after recalibration and comparison with Niskin bottle data.

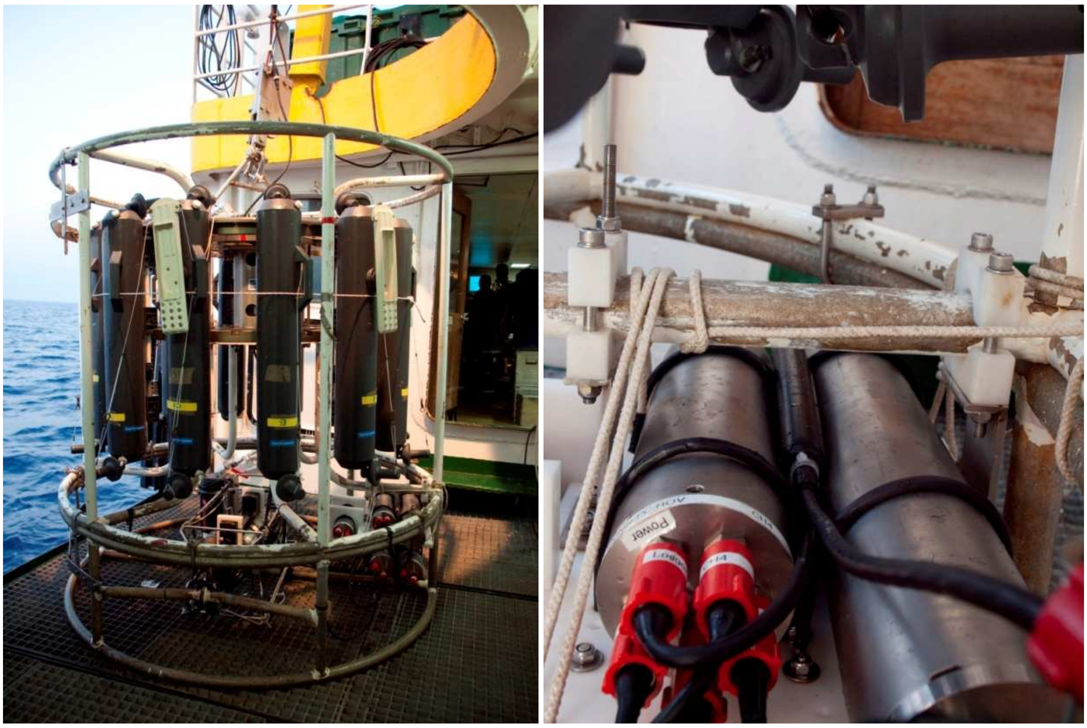

Fig. 7.5.1a/b: Niskin water sampling rosette with Seabird CTD (a), and Contros HydroC sensor package (b).

Geochemical data will be derived from seawater analyses of discrete Niskin bottle samples from selected water depths. Considering a general water depth of about 500 m at North Alex mud volcano, water depths of 10/ 30/ 50/ 100/ 150/ 200/ 250/ 300/ 350/ 400/ 450/ ~500m were selected for water sampling. Immediately after CTD recovery, about 1.8 l of seawater were transferred from each Niskin bottle into pre-evacuated glass bottles, according to Keir et al., 2008. A vacuum extraction line (Fig. 7.5.2) was then used to transfer the extracted gas into 20-ml headspace vials for gas-tight storage with 3 ml of saturated sodium chloride solution. Concentrations and stable isotope ratios of methane, higher hydrocarbons, and permanent atmospheric gases will be measured at IFM-GEOMAR.

For dissolved inorganic carbon (DIC) and alkalinity titration, seawater samples were transferred into 500-ml Schott glass bottles. The bottles were closed, after adding 100 µl of saturated HgCl-solution, with a greased glass stopper leaving a head space of about 3-5 ml. The DIC and alkalinity determinations will be conducted at the IFM-GEOMAR laboratories. Water sampling, DIC, alkalinity measurements, and pCO2 calculations will be performed according to Dickson et al., 2007. Calculated pCO2 values will be correlated with calibrated HydroC-CO_2 sensor data.

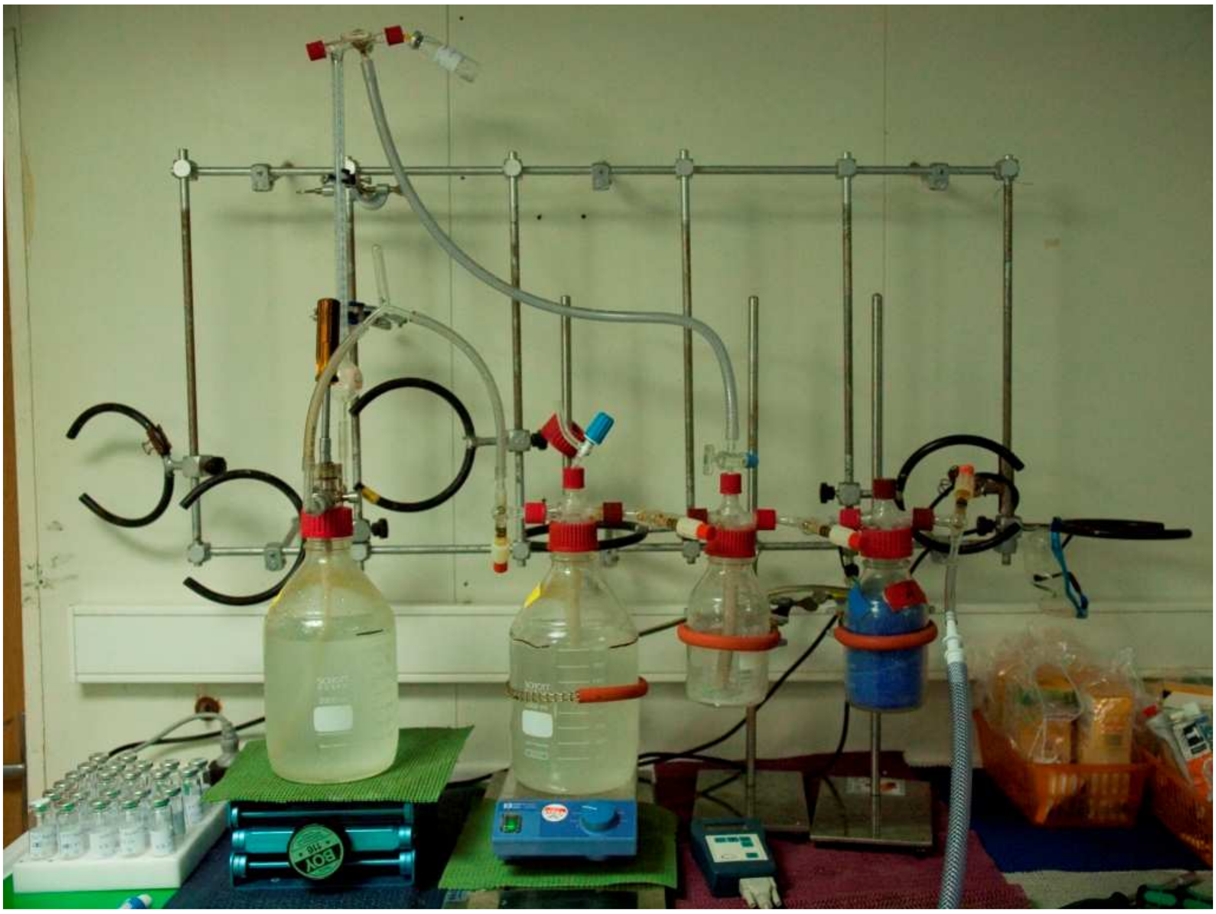

Fig. 7.5.2: Vaccum gas extraction line.

7.6 SIMRAD EK60

The SIMRAD EK60 is an echo sounder system with multiple frequency operation. The main imaging target is the water column itself (not, for instance, the seafloor or sub-bottom sediments). The system is mostly used by the fishing industry, who deploy the EK60 on trawling ships to identify schools of fish.

Basically, sounding signals emitted by the transducers are reflected by gas bubbles (i.e. air bladders of individual fish), thus providing a picture of the position and size of a potential target school.

On this cruise the SIMRAD EK60 echo sounder was aimed at a scientific target: gas bubbles in the water column known to originate from the central parts of North Alex Mud Volcano. The bubbles form a plume directly above the seafloor of North Alex. It was planned to repeatedly run surveys of crossing profiles at North Alex in order to get a picture of the location, extent and probably temporal variations of the bubble plume.

The general setup on R/V AEGAEO consists of

- two transducers mounted to the hull of the vessel at the deeper, forward part to minimize propeller noise and noise from turbulent water flow,
- two general-purpose transceivers (GPT),

- a processing unit (laptop computer) with the ER60 and BI60 software managing sounding operations, visualization and registration of the echograms,
- an Ethernet switch to connect the transceivers to the computer.

During the cruise and the bubble imaging surveys the transducers were operated at 38 kHz and 120 kHz respectively with maximum ping rate (about one ping per second). The echograms were directly visualized on the screen of the computer, received signals were recorded to hard disk. The raw data thus stored can be replayed by the ER60 software package.

8. WORK PERFORMED

8.1 NORTH ALEX – INSTRUMENT RECOVERY

8.1.1 TEMPERATURE OBSERVATORY

The temperature observatory installed at North Alex MV during the 64PE298 cruise of R/V Pelagia in November 2008 was inspected during ROV operations. The observatory was found to be in good condition. The vertical position of the main part appeared to be unchanged, but parts of the thermistor string laid out on the seabed had been covered by sediment, especially near the end of the string in the central part of the mud volcano. The observatory could be contacted via acoustic modem, but due to a known error in the modem software, only a small part of the observational data could be downloaded.

As a first step in the recovery procedure, the cable between the acoustic modem and the data logger connected to the seabed thermistor string was cut and both the logger and the thermistor string were brought up to the surface vessel by ROV. In a second step, the ROV connected a wire from the ship to the top of the observatory, which made it possible to recover the entire observatory including buoy with the modem and the second logger, the steel lance and the vertical thermistor string.

8.1.2 OBS, OBSMETS, TILTMETERS

15 stations (12 OBS, 2 OBT, 1 OBM) were planned to be recovered during the cruise. An acoustic signal was sent to each station to release it from the anchor. The releaser of OBS SP 29 failed, so the station had to be recovered by ROV. OBS SP 32 could not be found, it did not reply to the acoustic signal and was not located by ROV either.

After recovery, the recording units were stopped and the flashcards and batteries removed.

Table 8.1.1: OBS recoveries

Station	Latitude / [N]	Longitude / [E]	Recovered / date // time [UTC]	Remarks
OBS SP 25	31°57,9341'	30°08,3310'	17.06.2010 // 07:38	
OBS BB 26	31°58,1910'	30°08,1659'	17:06.2010 // 08:45	
OBS SP 27	31°58,4112'	30°08,0087'	17.06.2010 // 08:19	
OBS SP 28	31°58,0332'	30°07,8540'	17.06.2010 // 07:13	
OBS SP 29	31°58,3001'	30°08,4618'	17.06.2010 // 14:08	recovered by ROV
OBS SP 30	31°59,1047'	30°08,3082'	17.06.2010 // 09:44	
OBS SP 31	31°58,1027'	30°09,3240'	17:06.2010 // 09:11	
OBS SP 32	31°56,9441'	30°08,2781'		lost
OBS BB 33	31°58,0877'	30°07,1218'	18.06.2010 // 16:08	
OBS SP 34	31°59,4030'	30°10,2371'	19.06.2010 // 16:04	
OBS SP 35	31°59,3580'	30°05,8482'	19.06.2010 // 16:45	
OBS SP 36	31°55,7982'	30°08,3231'	18.06.2010 // 17:06	
OBT 4	31°57,9347'	30°08,4222'	18.06.2010 // 15:19	
OBT 6	31°57,9558'	30°08,2829'	18.06.2010 // 15:38	
OBM 2	31°58,1358'	30°08,1707'	18.06.2010 // 14:55	

8.1.3 PIEZOMETERS

On POSEIDON cruise P388, a total of 4 piezometers had been installed in two areas on the slope SE of North Alex MV, one highly prone to slope failure (SET 320) and the other in a stable environment (SET 310). The recovery was designed to be carried out by lifting the logging unit from the hydraulics on top of the stinger assembly.

Piezometer #310/1 was recovered using the ROV manipulator as planned.

Piezometer #310/2 could not be recovered at the first attempt as the logger unit was stuck (hydraulic stab covered with carbonate precipitate). Therefore, a wireline attached by ROV was used to lift the complete assembly from the seafloor (Fig. 8.1.1).

Piezometer #320/1 was not found at the deployment site, however, the top of the stinger assembly was located with the logging unit detached, which had apparently been dislodged by trawling activities.

Piezometer #320/2: the logging unit was found removed from the hydraulic stab 5m away from the deployment site.

Data downloads from the three successfully recovered logging units showed complete records for the whole period of installation.

Figure 8.1.1: Recovery of piezometer #310/2 by wireline (left), tip of stinger and hydraulic stab covered by carbonate (right).

8.1.4 CATMETERS

6 CAT meters had been deployed during WND-3 in November 2008. CAT 3 and CAT 7 were installed during POSEIDON P388 – WND-4 in July 2009. Three of the remaining four CATmeters – the three small ones numbered 6, 8, and 9 - were successfully recovered at North Alex during the WND-5 cruise. The acoustically releaseable CAT #1 that had not come up during the WND-4 cruise was not at the site any longer. As the anchor was not found either, we suspect that the instrument was moved by a trawl line, lost its anchor, and drifted away. There was ample

evidence of bottom trawling in the North Alex area. CAT 6 had been dragged offsite and the chamber was lying on its side.

Table 8.1.2: CAT meter recoveries at North Alex

CAT#	Longitude E	Latitude N	ROV-Dive #	Recovery date	Site description
1	31°58.1877	30°08.1528	?	Lost	North Alex MV, background flow site
8	31°58.0616	30°08.0829	?	19 June 2010	North Alex M, near small bacterial mat patch in very rough topography
6	31°57.9740	30°08.1950	?	19 June 2010	North Alex MV, near a black bacterial mat
9	31°57.9320	30°08.2430	?	19 June 2010	North Alex MV, near pogonophara field

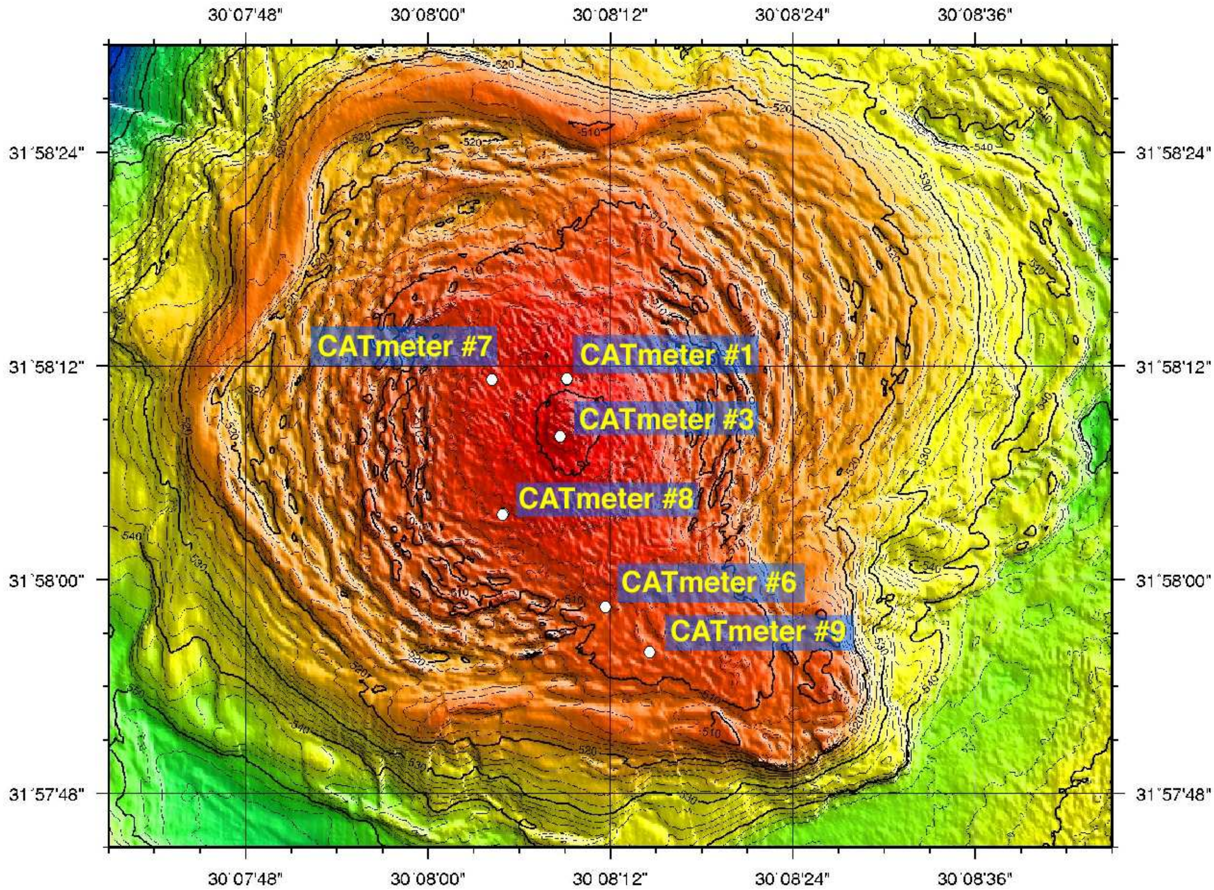

Figure 8.1.2: CATmeter deployment positions on North Alex

The instruments were in good condition and the sample coils were removed to be sent to Scripps for analysis.

8.2 GIZA – INSTRUMENT RECOVERY

8.2.1 CATMETERS

Only one deployment of a CATmeter with a release system was carried out at the center of Giza MV during WND-3. The background for this decision was the apparent lack of activity at Giza and the need to focus observation on one mud volcano, i.e. North Alex. The instrument failed to return to the surface when called via acoustic release on WND-4. On the fourth day of the WND-5 ROV operations we dove to Giza MV, immediately found the instrument and successfully recovered it. The copper gas coils were extremely corroded to the point of failure. Extreme corrosion was found everywhere on the instrument and pieces of the ballast were still stuck to the instrument frame, suggesting why the acoustic release had failed. Otherwise the instrument appeared to have worked properly and was in good condition.

Table 8.2.1: CAT meter recoveries at Giza MV

CAT#	Longitude E	Latitude N	ROV-Dive #	Recovery date	Site description
2	31°40.4920	29°45.3720	?	22 June 2010	Giza MV, near white bacterial mat next to end of surface temperature cable

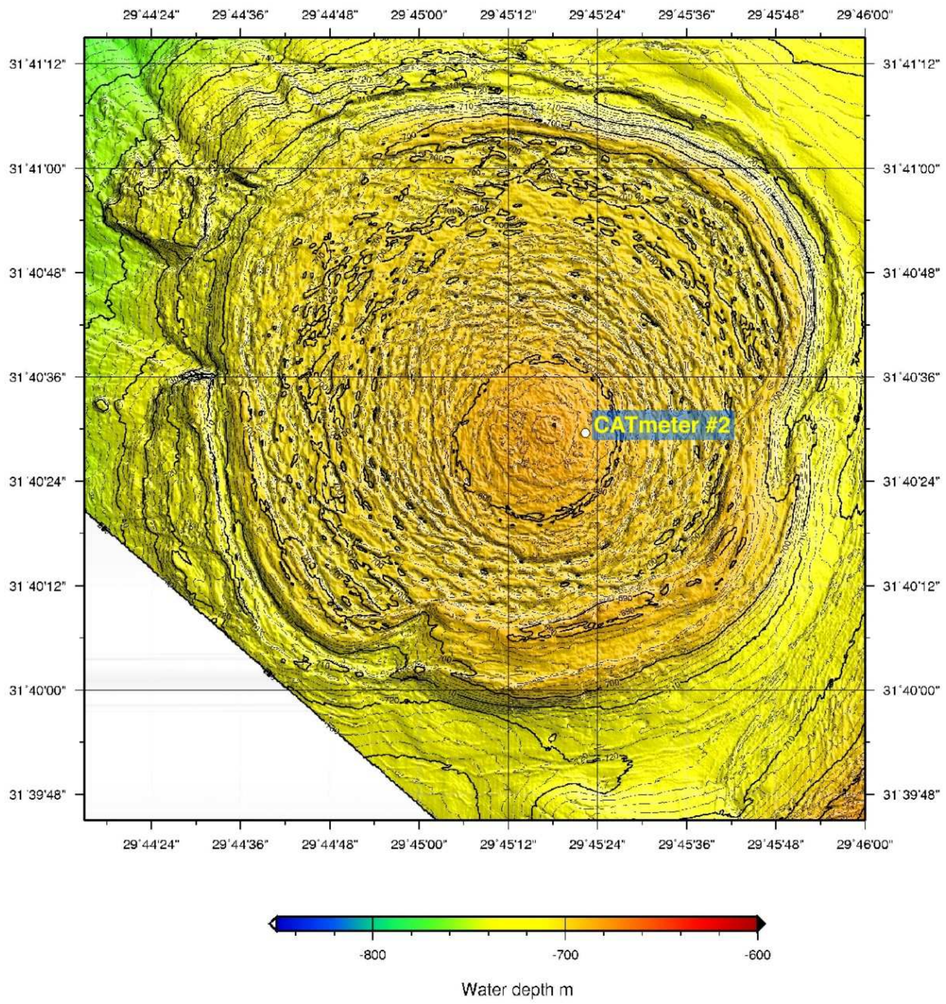

Figure 8.2.1: Position of CATmeter #2 on Giza mud volcano

8.2.2 TEMPERATURE OBSERVATORY

A second temperature observatory had been installed at Giza MV during the 64PE298 cruise of R/V Pelagia in November 2008. Unfortunately, weather conditions did not permit to recover the entire observatory using a wire deployed from the surface vessel. Therefore, it was decided to cut the cables between the data loggers and the thermistor strings along with supporting ropes in order to separate the buoyant upper part of the observatory, which holds the acoustic modem and the data loggers, from the lower part in the sediment. During ROV recovery, a small buoy with a flash was attached to the buoyant part of the observatory, and all connections to the lower part were cut using the ROV's manipulator arm. The buoyant part rose to the sea surface and was discovered close to the ship approximately 10 minutes after it had been separated. However, the observatory was pulled under the keel of the ship during an attempt to bring it on deck. The ship's propellers destroyed the assembly and both the acoustic modem and the data loggers were lost.

Fortunately, all parts could be located at the seafloor during the subsequent ROV dive. The ship's propellers had destroyed the data logger that had been connected to the seabed thermistor string, but the second data logger containing the temperature observations from the vertical thermistor string was found to be intact. Both data loggers could be recovered by the ROV.

8.3 CTD PROGRAM: FIRST RESULTS

During the cruise a total of 20 CTD casts were performed. In the North Alex mud volcano area 6 CTD casts were carried out without discrete Niskin bottle sampling, while an additional 2 stepwise upcast and 10 stepwise downcast CTD profiles were carried out with water sampling. The start and endpoint locations of the CTD casts in the North Alex mud volcano area are plotted in the bathymetric map (Fig. 8.3.1). In addition, a CTD downcast profile and a downcast water sampling profile were conducted 5 km downslope (northwest) of Giza mud volcano to provide a background reference. Station coordinates, water depths and start and end times of CTD casts are listed in the list of stations (Appendix). Temperature, salinity, density and the analogue signal of the methane sensor derived from the 20 CTD stations are plotted in figure 8.3.2 as a general overview.

<u>CTD casts with discrete sampling</u>

Figure 8.3.3. shows the results from the CTD cast that was taken within the seep area. At this location, the HydroC-CH_4 displayed the highest methane peak.

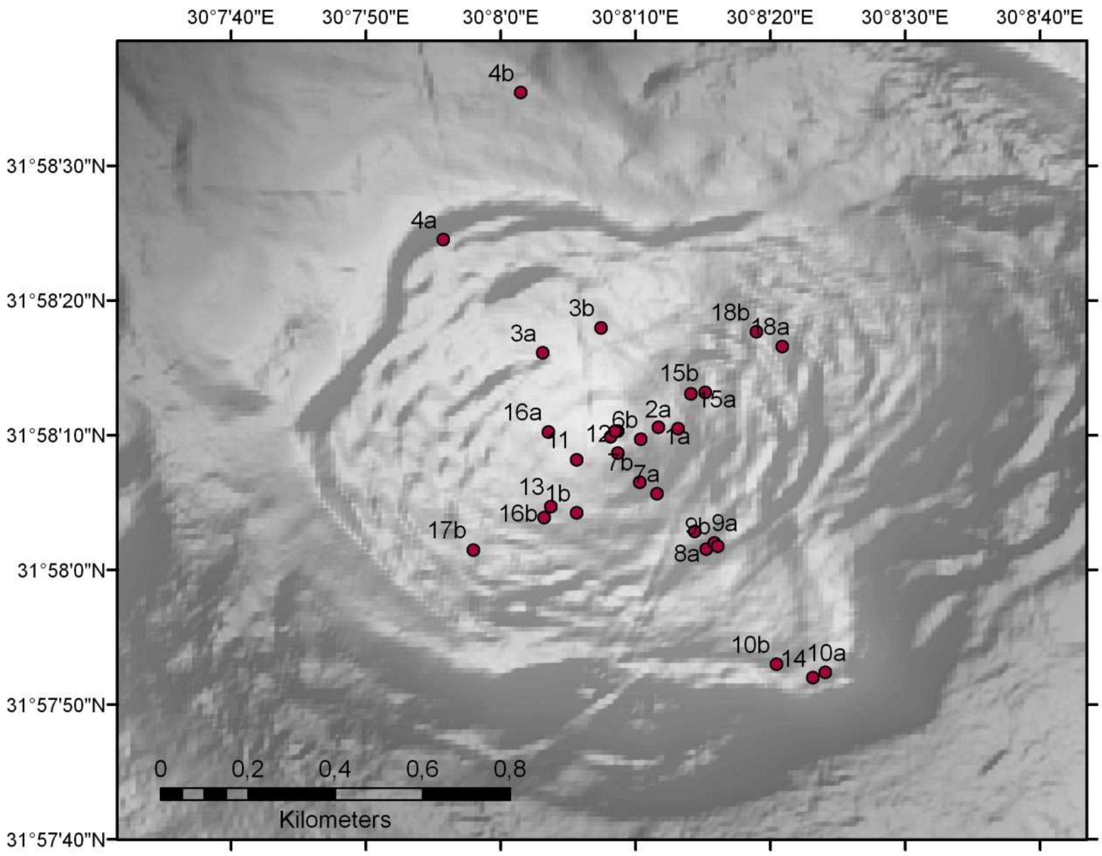

Fig. 8.3.1: Bathymetric map of North Alex mud volcano area with labeled locations of CTD stations (red dots; label "a" defines start, label "b" defines end location).

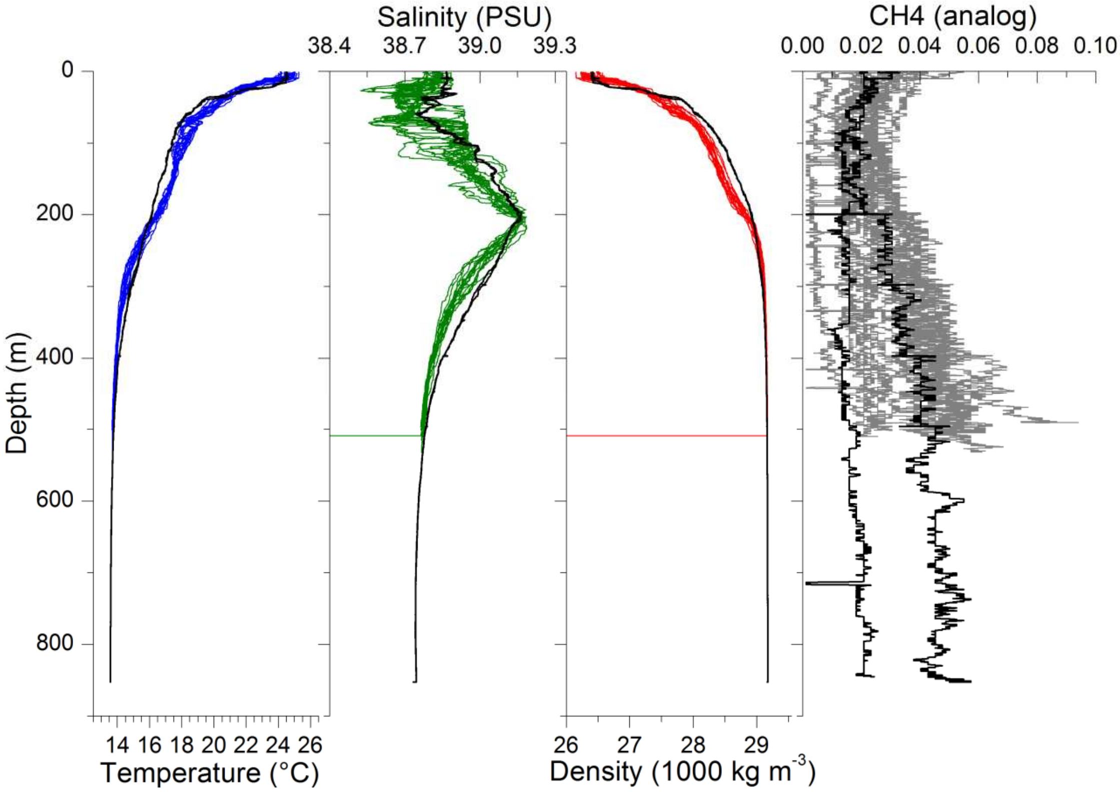

Figure 8.3.2: Overview of all CTD downcasts. Note that the black lines refer to the CTD casts taken outside the mud volcano area (background reference CTDs).

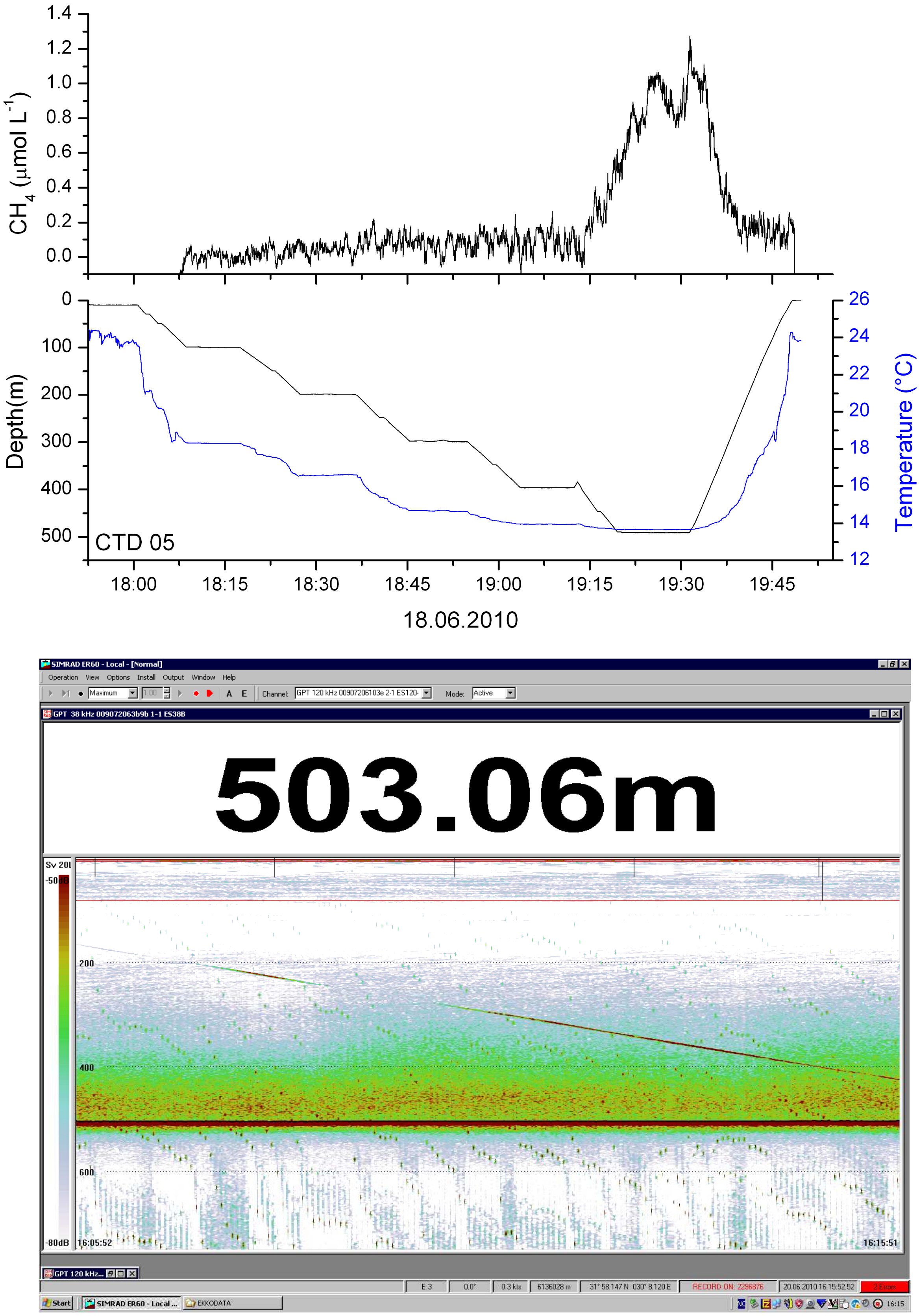

Figure 8.3.3: Result from a stepwise CTD profile (CTD5) showing depth, temperature and dissolved CH4-concentration measured by Contros HydroC sensor as a time series. SIMRAD echosounder recording (Lowermost screenshot) indicates that the CTD device (Red line) penetrates the near seafloor layer of gas bubble venting at about 400 m water depth.

Standard CTD casts

As vertical transport characterization and flux estimations are becoming more and more significant, i.e. with regard to mass balances or global perspectives, it is important to be able to provide estimations.

For transport and flux estimations, two characteristics of the water column have to be measured or estimated: the changes in concentration of a solute of interest, such as methane or oxygen, and vertical transport. Turbulent vertical transport can be described by means of the vertical eddy diffusion coefficient, K_z, as $K_Z = \gamma \cdot \varepsilon / N^2$ (Osborn 1980), were ε is the turbulence level, N^2 the water column stability and γ the mixing efficiency. The multiplication of K_z with a concentration gradient will then result in an estimation of turbulent flux, the direction of which, upward or downward, depends on the shape of the concentration profile.

Estimations of the turbulence level are generally carried out using microstructure profiles; however, a less accurate estimation can be obtained from standard CTD casts by means of the Thorpe Analysis (Thorpe, 1977).

The Thorpe Analysis enables estimation of length scales associated with turbulence-driven overturn events in stratified waters. Overturns cause water parcels to displace, thus creating inversions that are deviating from the ideal stable (non-turbulent) density profile in which the density is monotonic. The Thorpe displacement L' enables visualization of the extent of overturn events and is used to provide evidence for mixing events.

The Thorpe scale, which represents the vertical size of the overturning eddies, is defined as the root mean square of L', $L_T = rms(L')$. LT is expected and assumed to match with the Ozmidov scale LO, which represents the maximum vertical scale of eddies: $L_O = (\varepsilon / N^3)^{1/2}$ (Dillon, 1982). By determining LT from the Thorpe analysis, an estimation of the turbulence level can be calculated back from LO.

As the water column stability N^2 can easily be calculated from density profiles and a 0.2 value for γ can be assumed (Osborn, 980), the Thorpe analysis will lead to K_z estimations.

However, since CTDs usually lack the high sampling rate and the sensor resolution which would be necessary to observe small overturns and thus to lead to a reliable LT estimation especially in highly dynamic systems, an alternative method is also applied.

Lorke and Wüest (2002) have shown that the maximum displacement length Lmax can also be used for estimation of turbulence based on L' in temperature profiles. As Lmax can be easily detected by standard CTD system profiling at slow descent rates, turbulence and vertical diffusivity estimations can also be carried out following the relation $L_{max} = L_T \cdot 7.3 / \sqrt{2}$.

Preliminary results are displayed in Figure 8.3.4.

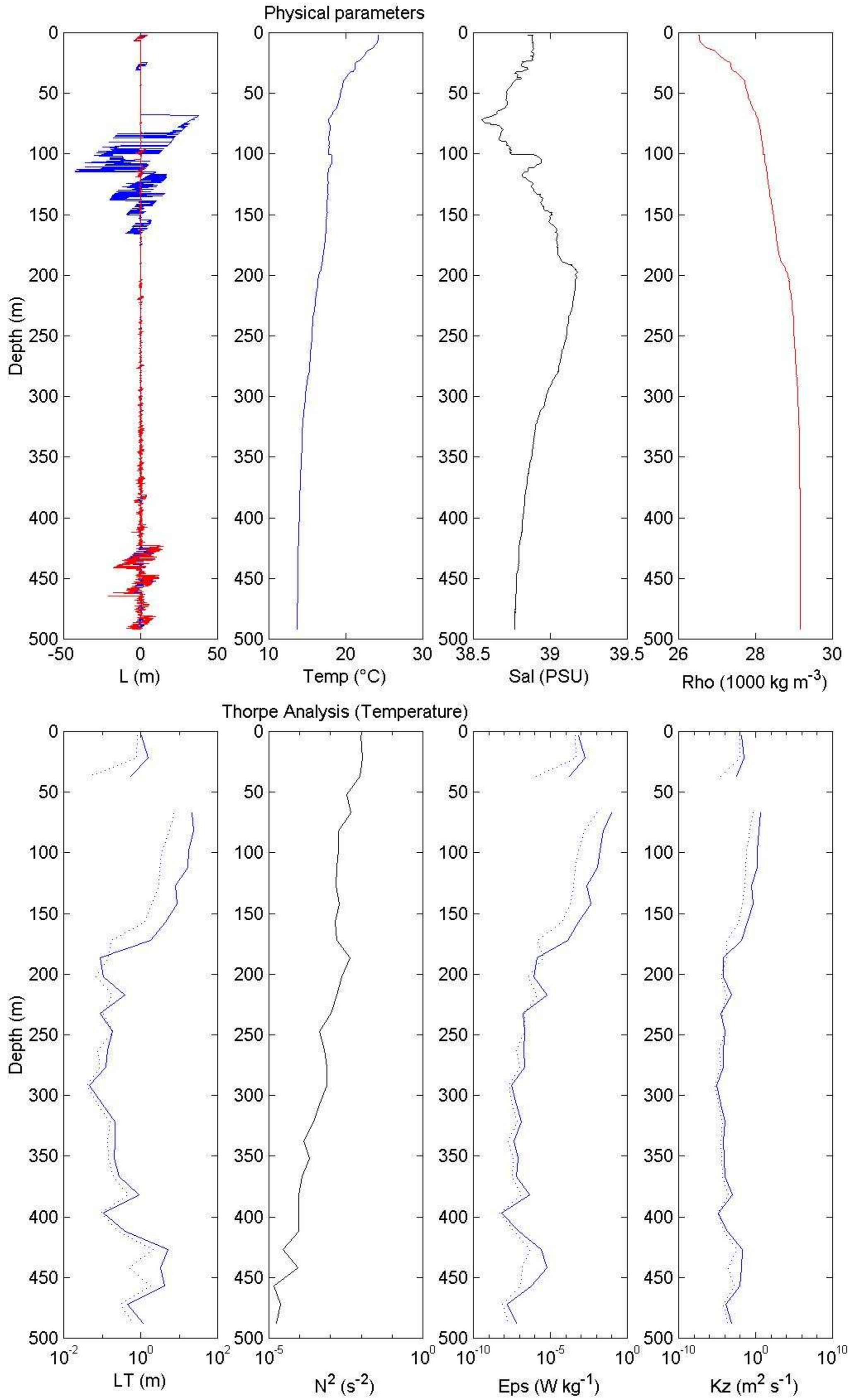

Figure 8.3.4: Preliminary results based on one standard CTD cast. Top: Thorpe displacement for both temperature (blue) and density (red) profiles. Bottom: Thorpe scale, turbulence level and Kz estimation based on LT (solid lines) and Lmax (dotted lines) as well as N^2 (black line). Note that the usable K_z values will come from an average of the whole standard CTD casts.

8.4 SIMRAD BUBBLE IMAGING RESULTS

8.4.1 SURVEYS AT NORTH ALEX

The initial layout of the profiles to follow during surveys (Fig. 8.4.1) was drawn considering the planned locations of the CTD profiles. The two most central profiles (7, 108) run through or very close to these positions.

The other profiles run parallel to those two. Number, length and distribution of the lines where chosen to allow for covering the entire mud volcano during an assumed 4 hours per survey.

With the completion of survey 1 (light blue lines) it turned out that the transit time between profiles had been underestimated. Thus, the profiles for surveys 2-5 (red lines) were clipped. The changed plan also allowed for 4 additional profiles (6.5, 7.5, 107, 109) within the most central parts of the volcano. Survey 1 had shown that the bubble plume was detectable in the echograms on-screen for an area of about 400 m x 400 m.

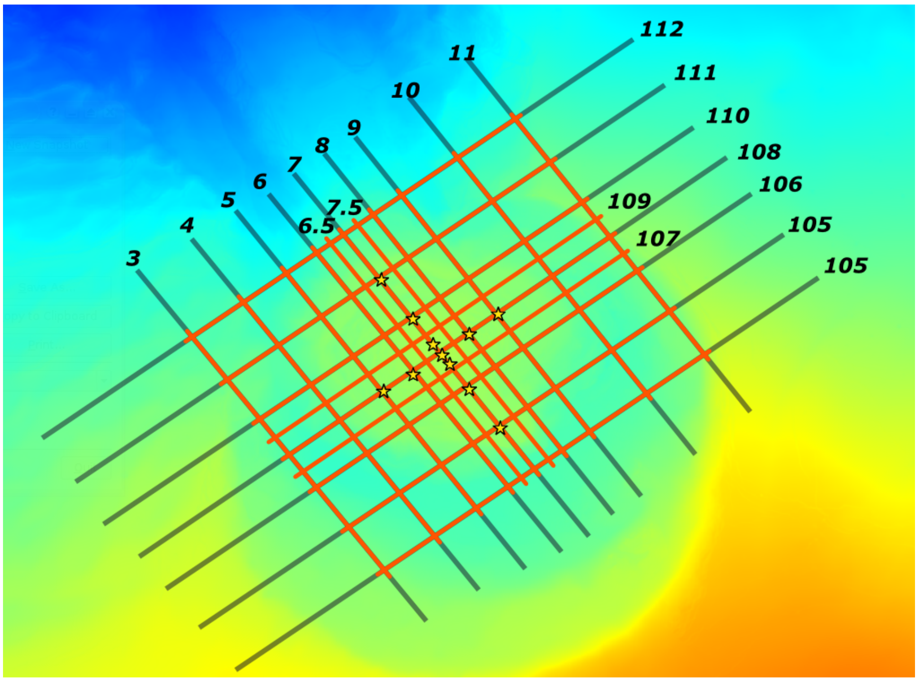

Figure 8.4.1: Survey Plan: Pseudo-color Image of North Alex Mud-Volcano Bathymetry.
Grey Lines: Profiles of Survey 1.
Red Lines: Profiles of Surveys 2 to 5.
Asterisks: Locations of CTD Profiles

Table 8.4.1: Start and End Positions of profiles for Surveys 2 to 5

Profile	start_x	start_y	end_x	end_y	Start Y		Start X		End Y		End X	
	dec.deg.	dec.deg.	dec.deg.	dec.deg.	Deg	Min	Deg	Min	Deg	Min	Deg	Min
3	30,133	31,956	30,121	31,970	**31**	**57,377**	**30**	**7,979**	**31**	**58,227**	**30**	**7,279**
4	30,136	31,958	30,124	31,972	**31**	**57,495**	**30**	**8,153**	**31**	**58,347**	**30**	**7,458**
5	30,138	31,960	30,127	31,974	**31**	**57,593**	**30**	**8,296**	**31**	**58,446**	**30**	**7,606**
6	30,140	31,961	30,129	31,975	**31**	**57,668**	**30**	**8,406**	**31**	**58,517**	**30**	**7,712**
6,5	30,141	31,962	30,129	31,976	**31**	**57,698**	**30**	**8,451**	**31**	**58,548**	**30**	**7,760**
7	30,142	31,962	30,130	31,976	**31**	**57,729**	**30**	**8,495**	**31**	**58,579**	**30**	**7,805**
7,5	30,142	31,963	30,131	31,977	**31**	**57,761**	**30**	**8,545**	**31**	**58,611**	**30**	**7,855**
8	30,143	31,963	30,132	31,977	**31**	**57,794**	**30**	**8,591**	**31**	**58,648**	**30**	**7,908**
9	30,145	31,964	30,133	31,979	**31**	**57,859**	**30**	**8,686**	**31**	**58,714**	**30**	**8,007**
10	30,148	31,967	30,137	31,981	**31**	**57,993**	**30**	**8,882**	**31**	**58,843**	**30**	**8,201**
11	30,151	31,969	30,140	31,983	**31**	**58,128**	**30**	**9,081**	**31**	**58,977**	**30**	**8,400**
104	30,132	31,956	30,151	31,969	**31**	**57,384**	**30**	**7,937**	**31**	**58,158**	**30**	**9,084**
105	30,130	31,959	30,149	31,972	**31**	**57,533**	**30**	**7,815**	**31**	**58,308**	**30**	**8,965**
106	30,128	31,961	30,148	31,974	**31**	**57,670**	**30**	**7,703**	**31**	**58,448**	**30**	**8,853**
107	30,128	31,962	30,147	31,975	**31**	**57,722**	**30**	**7,653**	**31**	**58,505**	**30**	**8,802**
108	30,127	31,963	30,146	31,976	**31**	**57,783**	**30**	**7,609**	**31**	**58,565**	**30**	**8,759**
109	30,126	31,964	30,145	31,977	**31**	**57,843**	**30**	**7,561**	**31**	**58,625**	**30**	**8,710**
110	30,125	31,965	30,144	31,978	**31**	**57,907**	**30**	**7,508**	**31**	**58,685**	**30**	**8,663**
111	30,123	31,967	30,143	31,980	**31**	**58,043**	**30**	**7,396**	**31**	**58,824**	**30**	**8,552**

Table 8.4.1: Duration of the Surveys

	Date/Time Ship	Date/Time UTC
Survey 1		
From	2010-06-17 06:02:36	2010-06-17 03:02:36
To	2010-06-17 09:52:15	2010-06-17 06:52:15
Survey 2		
From	2010-06-17 23:24:43	2010-06-17 20:24:43
To	2010-06-18 04:06:18	2010-06-18 01:06:18
Survey 3		
From	2010-06-19 00:28:28	2010-06-18 21:28:28
To	2010-06-19 03:40:04	2010-06-19 00:40:04
Survey 4		
From	2010-06-20 00:18:29	2010-06-19 21:18:29
To	2010-06-20 04:24:34	2010-06-20 01:24:34
Survey 5		
From	2010-06-20 21:49:50	2010-06-20 18:49:50
To	2010-06-21 02:44:45	2010-06-20 23:44:45

Surveys 2 to 5 comprised 20 profiles as listed in Table 8.4.1. The measurements where carried out between Thursday, 17 June, and Monday, 21 June.

Each survey started with the 5 most central profiles in NW/SE orientation (6, 6.5, 7, 7.5, 8), then switched to the central ones in NE/SW orientation (106, 107, 108, 109, 110). The remaining profiles where measured at the end. Survey 1 had to be interrupted after completion of profile 5 due to time constraints.

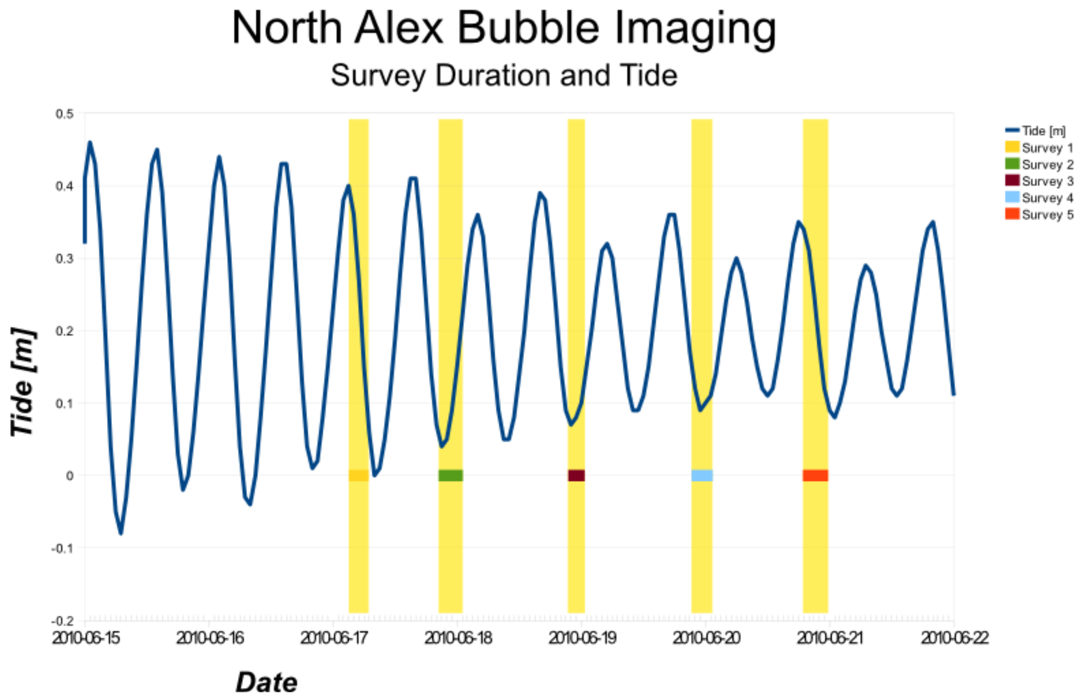

Figure 8.4.2: Survey Date and Duration Superimposed on the Tide as Predicted for Alexandria

Although it is yet unclear if a tidal range of roughly 0.4 – 0.5 meters has an influence on - or may act as a trigger to - the occurrence and amount of the gas bubbles emitted at North Alex mud volcano, we were able to obtain data covering most parts of the tidal cycle. The relevance of tidal effects has to be determined by post-cruise analysis.

First results of bubble imaging in the North Alex area show a persistent gas seep from the mud-volcano to the water column during surveys. However, the amount of bubbles (size of the plume in x, y and z direction) differs between surveys.

For instance, during survey 4 the lateral extent of the plume was ~ 250 m and the bubbles reached a water depth of around 200 m. Survey 3 shows a lateral extent of about 170 m and imaging shows bubbles to water depths of ~ 240 m. The tidal curve is on the decrease throughout survey 4, whereas it is increasing during survey 5.

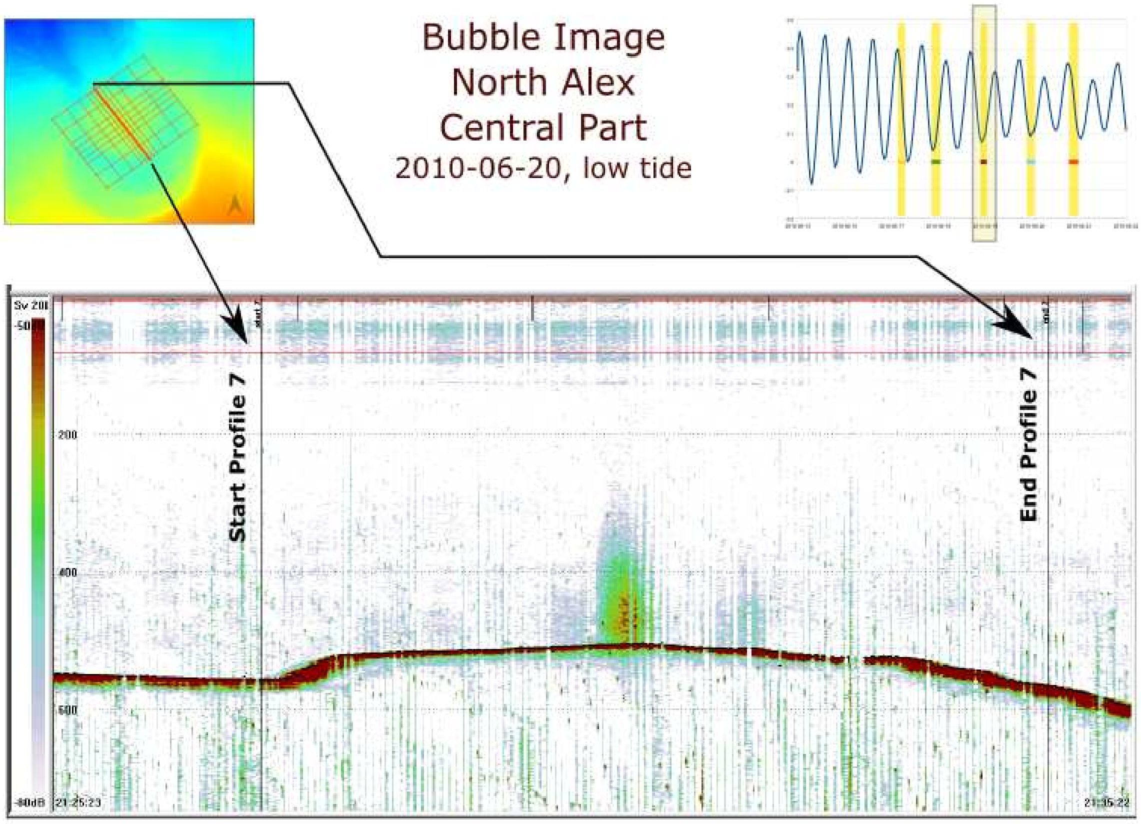

Figure 8.4.3: Central Profile 7 on 20 June. Profile started when the tide was rising. Bubbles detectable at water depths of up to ~ 240 meters

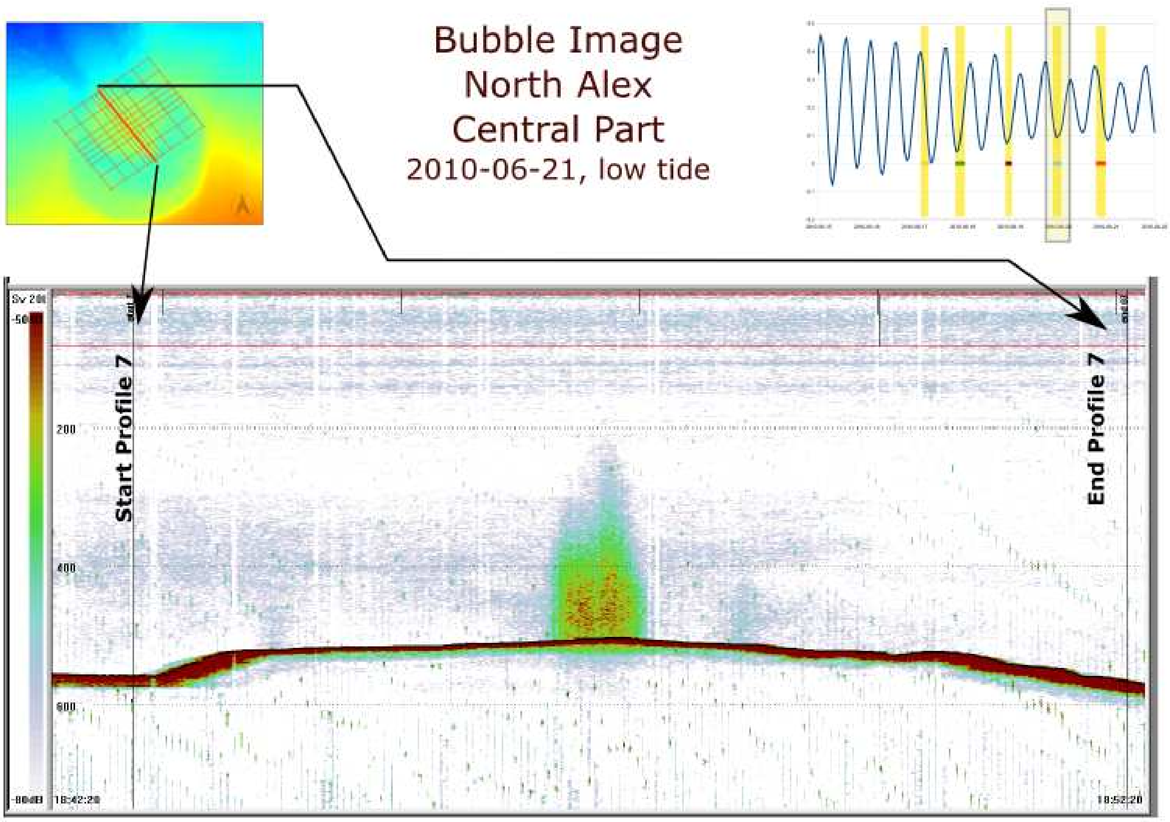

Figure 8.4.4: Central Profile 7 on 21June. Profile started when the tide was still falling. Bubbles detectable at water depths of up to ~200 meters.

8.4.2 SURVEYS AT GIZA

Originally, no bubble imaging surveys had been planned for the Giza Mud-Volcano area. However, while the ship had to weather heavy wind conditions temporarily preventing the continuation of the equipment recovery campaign, the SIMRAD system was running and registering. As expected, the echograms did not show any bubble plume comparable to North Alex.

The data have been logged and saved, though. The location of the profiles will be inferred from these data and the ship's navigational records.

9. ACKNOWLEDGEMENTS

We would like to acknowledge substantial and tireless efforts by the captain and crew of R/V Aegaeo. The outstanding support of the crew was a major contribution to the successful operation. We gratefully acknowledge RWE Dea Hamburg for funding the WND project and RWE Cairo for their support during the permitting process. BP provided the principal hardware components for the Piezometer development.

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11. APPENDIX

1. List of stations

station_no	gear	gear_no	area	date	deploy time (UTC)	latitude	longitude	water depth	recovery time (UTC)	latitude	longitude	depth	remarks
1	MODEM	1	N Alex	16.06.10	16:45	31°58,118 N	30°08,148 E	475,0	19:09	31° 58,188 N	30°08,139 E	n.a.	comm. problems
2	CTD	1	N Alex	16.06.10	19:35	31°58,144 N	30°08,155 E	505,0	20:35	31° 58,176 N	30°08,195 E	505,0	ok
3	Microstruct	1	N Alex	16.06.10	21:00	31°58,259 N	30°08,046 E	510,0	23:00	31° 58,259 N	30°08,259 E	n.a.	instrument broken
4	CTD	2	N Alex	17.06.10	0:19	31°58,174 N	30°08,219 E	505,0	2:22	31°57 ,897 N	30°08,897 E	n.a.	ok
5	SIMRAD	1	N Alex	17.06.10	3:00	?	?	?	?	?	?	?	ok
6	OBS	SP 28	N Alex	17.06.10	n.a.	n.a.	n.a.	506,0	7:13	31°58,012 N	30°07,880 E	n.a.	ok
7	OBS	SP 25(01)	N Alex	17.06.10	n.a.	n.a.	n.a.	499,0	7:38	57°57,935	30°08,384 E	n.a.	ok
8	OBS	SP 29	N Alex	17.06.10	n.a.	n.a.	n.a.	574,0	n.a.	n.a.	n.a.	n.a.	failure, no comms.
9	OBS	SP 27(03)	N Alex	17.06.10	n.a.	n.a.	n.a.	506,0	8:19	31°58,434 N	30°08,035 E	n.a.	ok
10	OBS	BB 26	N Alex	17.06.10	n.a.	n.a.	n.a.	490,0	8:45	31°58,217 N	30°08,191 E	n.a.	ok
11	OBS	SP 31	N Alex	17.06.10	n.a.	n.a.	n.a.	471,0	9:11	31°58,084 N	30°09,395 E	n.a.	ok
12	ROV-TOBS	1	N Alex	17.06.10									inspection dive
13	ROV-OBS	SP 29	N Alex	17.06.10				508,0	14:08	31°58,221 N	30°08,653 E	n-a.	retrieval by ROV
14	MODEM	2	N Alex	17.06.10									
15	CTD	3	N Alex	17.06.10	16:47	31°58,268'N	30°08,052'E	510,0	19:04	31°58, 299'N	30°08,124'E	512,0	
16	SIMRAD	2											
17	CTD	4	N Alex	18.06.10	1:20	31°58,408'N	30°07,929'E	523,0	3:37	31°58,59 0'N	30°08,025'E	523,0	
18	Tom												
19	Warner												
20	Catmeter 6/9												
21	OMB	OBM 02	N Alex	18.06.10				488,0	14:55	31°58,168' N	30°08,291' E	n.a.	ok
22	OBT	OBT 04	N Alex	18.06.10				500,0	15:19	31°57,922' N	30°08,531' E	n.a.	ok
23	OBT	OBT 06	N Alex	18.06.10				496,0	15:38	31°57,858' N	30°08,314' E	n.a.	ok
24	OBS	OBS BB 33	N Alex	18.06.10				528,0	16:08	31°57,940' N	30°07,085' E	n.a.	ok
25	OBS	OBS SP 32	N Alex	18.06.10				430,0	16:12				failure, no comms.
26	OBS	OBS SP 36	N Alex	18.06.10				377,0	17:06	31°55,679' N	30°08,430' E	n.a.	ok
27	CTD	5	N Alex	18.06.10	17:45	31°58,171 N	30°08,145 E	494,0	19:50	31°58, 164 N	30°08,136 E	494,0	
28	CTD	6	N Alex	18.06.10	20:30	31°58,171 N	30°08,142 E	494,0	21:06	31°58, 161 N	30°08,173 E	494,0	
29	SIMRAD		N Alex	18.06.10									
30	CTD	7	N Alex	19.06.10	1:55	31°58,094 N	30°08,193 E	507,0	3: 40	31°58,108 N	30°08,172 E	507,0	
31													
32													
33													
34													
35													

station_no	gear	gear_no	area	date	deploy time (UTC)	latitude	longitude	water depth	recovery time (UTC)	latitude	longitude	depth	remarks
36	OBS	OBS SP 34	N Alex					561,0	16:04	31°59,405' N	30°10,286' E	n.a.	ok
37	OBS	OBS SP 35	N Alex					684,0	16:45	31°59,330' N	30°05,892' E	n.a.	ok
38	CTD	8	N Alex	19.06.10	18:23	31°58,025 N	30°08,254 E	510,0	19:15	31°58, 047 N	30°08,240 E	510,0	
39	CTD	9	N Alex	19.06.10	20:35	31°58,033 N	30°08,264 E	510,0		31°58,029 N	30°08,268 E	510,0	
40	SIMRAD		N Alex										
41	CTD	10	N Alex	20.06.10	2:40	31°57,873 N	30°08,401 E	518,0	4:36	31°58,88 3 N	30°08,341 E	518,0	
42													
43													
44	CTD	11	N Alex	20.06.10	15:52	31°58,136 N	30°08,097 E	490,0	16:12	31°58, 154 N	30°08,138 E	490,0	
45	CTD	12	N Alex	20.06.10	16:29	31°58,144 N	30°08,145 E	480,0	17:03	31°58, 148 N	30°08,162 E	480,0	
46	CTD	13	N Alex	20.06.10	17:07	31°58,078 N	30°08,062 E	510,0	17:40	31°58, 081 N	30°08,076 E	510,0	
47	CTD	14	N Alex	20.06.10	17:52	31°57,866 N	30°08,386 E	519,0	18:23	31°58, 882 N	30°08,402 E	519,0	
48													
49	CTD	15	N Alex	21.06.10	1:15	31°58,217 N	30°08,253 E	509,0	2:50	31°58,21 9 N	30°08,253 E	509,0	
50	CTD	16	N Alex	21.06.10	3:35	31°58,077 N	30°08,059 E	518,0	5:15	31°58,06 4 N	30°08,054 E	518,0	
51													
52													
53													
54													
55	GC												
56	CTD	17	N Alex	21.06.10	18:00	31°58,021 N	30°07,944 E	520,0	19:30	31°58, 024 N	30°07,966 E	520,0	bottom contact
57	CTD	18	N Alex	21.06.10	20:06	31°58,276 N	30°08,348 E	520,0	21:27	31°58, 294 N	30°08,316 E	520,0	
60	CTD	19	Giza	22.06.10	1:44	31°43,002 N	29°44,00 E	861,0	3:20	31°43,030 N	29°43,961 E	861,0	
61	CTD	20	Giza	22.06.10	4:00	31°42,998 N	29°43,986 E	861,0	4:40	31°43,02 0 N	29°43,986 E	861,0	

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