EXPEDITIONSPROGRAMM NR. 84

FS POLARSTERN

ANT-XXVI/1

ANT-XXVI/2

ANT-XXVI/3

ANT-XXVI/4

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EXPEDITION PROGRAMME No. 84

RV POLARSTERN

ANT-XXVI/1
16 October 2009 - 25 November 2009
Bremerhaven - Punta Arenas

ANT-XXVI/2
27 November 2009 - 27 January 2010
Punta Arenas - Wellington

ANT-XXVI/3
30 January 2010 - 5 April 2010
Wellington - Punta Arenas

ANT-XXVI/4
7 April 2010 - 17 May 2010
Punta Arenas - Bremerhaven

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ANT-XXVI/1:	**Saad el Naggar/ Andreas Macke**
ANT-XXVI/2:	**Rainer Gersonde**
ANT-XXVI/3:	**Karsten Gohl**
ANT-XXVI/4:	**Arne Körtzinger**

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ANT-XXVI/1

16 October 2009 - 25 November 2009

Bremerhaven - Punta Arenas

Chief scientists

Bremerhaven - Las Palmas
Saad El Naggar

Las Palmas - Punta Arenas
Andreas Macke

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1. ÜBERBLICK UND FAHRTVERLAUF

Andreas Macke IfM-Geomar
Saad el Nagar Alfred-Wegener-Institut

Am 16. Oktober 2009 wird FS *Polarstern* den Atlantiktransfer von Bremerhaven nach Punta Arenas antreten. Die Fahrt wird zur kontinuierlichen Untersuchung atmosphärischer und ozeanischer Eigenschaften sowie der Energie und Stoffflüsse zwischen Ozean und Atmosphäre genutzt (Abb. 1.1). Folgende Projekte werden durchgeführt:

2 & 5: Autonome Messplattformen zur Bestimmung des Stoff- und Energieaustausches zwischen Ozean und Atmosphäre (OCEANET)
Um die experimentelle Erfassung von Stoff- und Energieaustausch zwischen Ozean und Atmosphäre auf eine solide Basis zu stellen, ist im Rahmen dieses Projektes mittels der Vernetzung der Expertisen des IFM-GEOMAR (CO_2-/O_2-Flüsse, photosynthetischer Status, Energiehaushalt, Fernerkundung), des IfT (Lidarmessungen), des GKSS Forschungszentrums („FerryBox“ und Fernerkundung der marinen Biologie mit ENVISAT/MERIS), und des AWI-Bremerhaven (CO_2-System, marine Infrastruktur von *Polarstern*) die Entwicklung autonomer Messsysteme geplant, die langfristig für den operationellen Betrieb an Bord verfügbarer Fracht- und Forschungsschiffe vorgesehen sind.

3: Tiefentemperaturfluktuationen im Vema-Kanal
Das Hauptziel ist eine Fortführung der hochpräzisen CTD-Beobachtungen in der Umgebung des Vema-Kanals zur Erfassung des kältesten AABW.

4: Test einer mobilen 2 x 20´ Container Friktionswinde mit einen JDR Lichtwellenleiter-(LWL-) Kabel
Während des Transfers nach Las Palmas soll an Bord von *Polarstern* eine zu den *Meteor*-Großgeräten gehörende mobile Hatlapa Friktionswinde mit einem LWL-Kabel von JDR getestet werden. Die Winde ist mit dem vorhandenen Kabel zur Zeit nicht einsatzfähig. Das Testprogramm dient dazu, die Einsatzfähigkeit von Winde und Kabel wieder herzustellen.

6: Erprobung auf See eines 18 mm Lichtwellenleiter und des telemetrischen Systems
Ein neues 18 mm Lichtwellenleiter sowie die zugehörige Telemetrie soll unter realistischen Bedingungen auf See getestet werden.

7: Erprobung auf See des erneuerten Unterwassernavigationssystems POSIDONIA
Nach einem ersten operationellen Test des neuen POSIDONIA während ARK-XXIII/1+2 soll auf dieser Fahrt eine abschließende Erprobung stattfinden.

8: Vorkommen, Verteilung und isotopische Zusammensetzung vom leichtflüchtigen organischen Halogenverbindungen entlang einer Nord-Süd-Achse des Atlantischen Ozeans
Obwohl bekannt ist, dass natürliche Quellen einen nicht zu unterschätzenden Beitrag zum Eintrag von leichtflüchtigen Halogenkohlenwasserstoffen in die Umwelt leisten, ist der Umfang dieses Eintrages noch weitestgehend unbekannt. Während der Überfahrt sollen kontinuierlich die Luft- und Oberflächenwasserkonzentrationen von leichtflüchtigen Halogenkohlenwasserstoffen sowie deren Isotopenverhältnisse bestimmt werden. Mit Hilfe der erhaltenen Daten sollen Erkenntnisse über die Nord-Süd-Verteilung leichtflüchtiger Halogenkohlenwasserstoffe gewonnen werden. Weiterhin soll die Frage beantwortet werden, ob die Substanzen anthropogenen oder biogenen Ursprungs sind und inwieweit das

Vorkommen von flüchtigen Halogenkohlenwasserstoffen in der Atmosphäre und im Oberflächenwasser durch küstennahe Quellen verursacht wird. Die Daten dienen dazu, noch fehlende Puzzelteile im Gesamtbild des natürlichen Halogenkohlenwasserstoffeintrages zu erhalten.

9: Aerosolfernerkundung durch FUBISS Himmels- und Sonnenradiometer
Die spektral hochauflösenden Sonnenphotometer FUBISS-ASA2 und FUBISS-ZENITH arbeiten im sichtbaren und nahinfraroten Wellenlängenbereich und werden vorrangig der Aerosolfernerkundung entlang der Fahrtroute des Schiffs dienen.

10: Diversität und Aktivität diazotropher Cyanobakterien
Die Zusammensetzung der Stickstofffixierenden Mikroorganismen-vergesellschaftung und deren Aktivität sollen anhand von molekularbiologischen Untersuchungen und Mikrokosmos-Experimenten bestimmt werden.

11: Parasound: Systemtest und Training unter Expeditionsbedingungen - Installation des "video grab" und MSCL.
Fahrtteilnehmer sollen in der selbsteffizienten Bedienung des neuen hüllenmontierten Parasound-Systems P-70 trainiert werden. Die studentische Ausbildung ist Teil der Graduiertenschule POLMAR. Der Multi-Sensor Core Logger (MSCL) soll für den Einsatz auf ANT-XXVI/2 installiert und kalibriert werden.

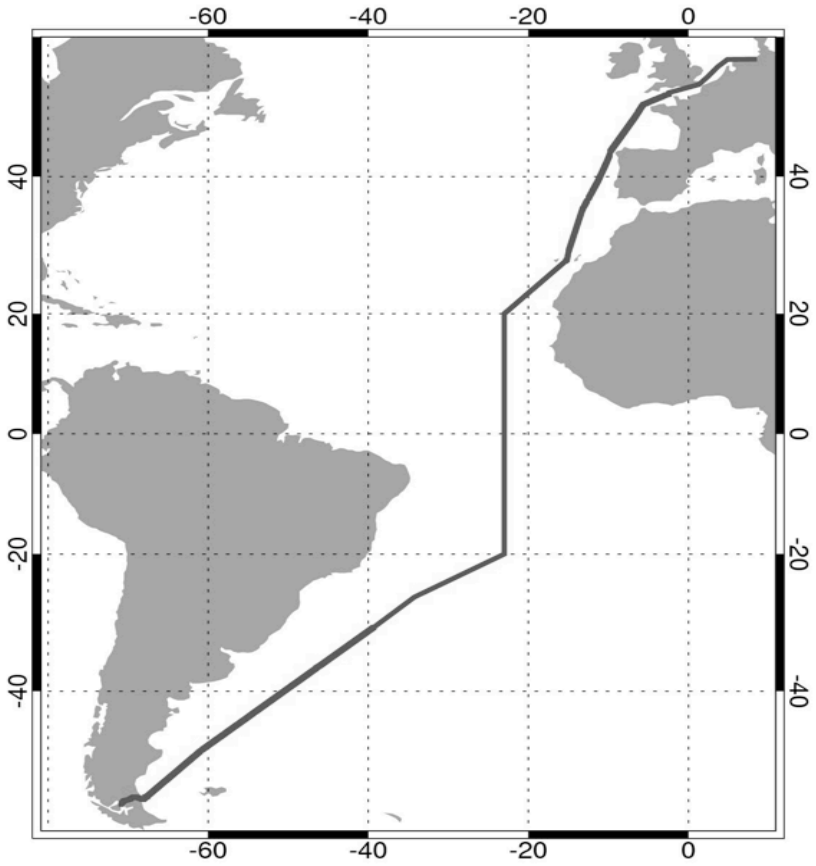

Abb. 1.1: Fahrtroute der Reise ANT-XXVI/1
Fig. 1.1: Cruise track of ANT-XXVI/1

ITINERARY AND SUMMARY

On 16 October 2009 *Polarstern* will start its Atlantic transfer from Bremerhaven to Punta Arenas (Fig. 1.1). The cruise will be utilized for continuous investigations of atmospheric and marine properties as well as for energy and material fluxes between ocean and atmosphere. The following projects will be carried out:

2 & 5: Autonomous measurement platforms for energy and material exchange between ocean and atmosphere (OCEANET - Atmosphere & Ocean)
In order to provide a solid basis for the observational monitoring of energy and material exchange between ocean and atmosphere it is planned to develop an autonomous observation system for operational use onboard available cargo- and research vessels. The project is based on a network of expertise from IFM-GEOMAR (CO_2-/O_2-fluxes, photosynthetic status, energy budget, remote sensing), IfT (lidar measurements), the GKSS research center (ferry box, remote sensing of marine biology with ENVISAT/MERIS) and AWI-Bremerhaven (CO_2-system, marine infrastructure of *Polarstern*).

3: Abyssal temperature fluctuations in the Vema Channel
The primary objective is to revisit the Vema Sill and Extension sites for additional high precision CTD observations of the coldest AABW in the Vema channel.

4: Test of a mobile 2 x 20´container Hatlapa friction winch with a JDR umbilical cable
During the transfer to Las Palmas we will conduct a test programme of mobile 2 x 20´container Hatlapa friction winch with a JDR umbilical cable. The mobile winch is not serviceable with the JDR umbilical cable in its present condition. The test programme aims to restore the operability of the winch with the JDR cable.

6: Sea trial and tests of the fibre optical 18 mm cable (LWL) and the telemetry system during ANT-XXVI/1
A new 18 mm fibre optical cable as well as the corresponding telemetric system shall be tested under realistic sea conditions.

7: Sea trial and tests of the upgraded under water navigation system "POSODONIA" during ANT-XXVI/1
Following a first operational sea trial during ARK XXIII/1 and 2 a final test shall be performed during this cruise.

8: Occurrence, distribution and isotopic composition of volatile organohalogens along a North-South transect of the Atlantic Ocean
Natural sources have been found to contribute to the input of volatile organohalogens to the environment. However, information on extension of the natural contribution is still scarce. During the *Polarstern* cruise the concentrations and isotopic distribution of volatile organohalogens in air and surface water along a North-South transect will be measured continiously.

The data will be used to obtain information on the North-South distribution, on a biogenic or anthropogenic origin and on possible coastal impacts on volatile organohalogen concentrations in seawater and air. Therefore, missing pieces in the picture of the environmental natural input of volatile organohalogens will be found.

9: Aerosol remote sensing with FUBISS sun and sky radiometer
The multispectral Vis/NIR sun- and sky-radiometers FUBISS-ASA2 and FUBISS-ZENITH will be used for the remote sensing of aerosols along the ship's path.

10: Diversity and activity of diazotrophic cyanobacteria
Phylogenetic diversity and metabolic activity of nitrogen-fixing microorganisms will be determined along the meridional transects by molecular biological methods as well as with microcosm experiments carried out on board.

11: Parasound: system testing and training under expedition conditions – installation of video grab and MSCL
Cruise participants will be trained in the self-efficient operation of the new hull-mount Parasound system P-70. Student training will be part of the POLMAR Graduate School. For the following cruise ANT-XXVI/2 a Multi-Sensor Core Logger (MSCL) will be installed and calibrated.

2. AUTONOMOUS MEASUREMENT PLATFORMS FOR ENERGY AND MATERIAL EXCHANGE BETWEEN OCEAN AND ATMOSPHERE (OCEANET): ATMOSPHERE

A. Macke, K. Bumke, J. Kalisch, M. Hieronymi, Y. Zoll, (IFM-GEOMAR), T. Kanitz (IfT), J. Bismarck, M. Starace (IfW-FU-Berlin), T. Heus (ZMAW), H. Kleta (DWD-MM)
D. Althausen,T. Ruhtz (not on board),

Objectives

a) Radiation & microwave remote sensing
The net radiation budget at the surface is the driving force for most physical processes in the climate system. It is mainly determined by the complex spatial distribution of humidity, temperature and condensates in the atmosphere. The project aims at observing both the radiation budget and the state of the cloudy atmosphere as accurate as possible to provide realistic atmosphere-radiation relationships for use in climate models and in remote sensing. While similar experiments have been performed from land stations, only few data from measurements over ocean areas exist. The present project is part of the “Meridional Ocean Radiation Experiment” MORE which uses Atlantic transfers of various research vessels for the combined measurements of the atmospheric state since 2004. The main project behind this cruise is the WGL-PAKT Initiative OCEANET.

A multichannel microwave radiometer will be applied to continously retrieve temperature and humidity profiles as well as cloud liquid water path over the ocean. Time series of these profiles will show small scale atmospheric structures as well as the effects of the mean state of the atmosphere and its variability on the co-located measurements of the downwelling shortwave and longwave radiation. The atmospheric profiles will also be used to validate the satellite based profiles from the IASI instrument onboard the new European polar orbiting satellite MetOp. Atmospheric aerosol optical thickness will be measured by means of hand held sun photometer and spectral solar radiometer. A spectral UV-radiometer will perform

high resolution UV radiance observations from 200 to 400 nm wavelengths. Most instruments will be integrated in the new container-based atmosphere observatory.

b) Fluctuation of subsurface radiation
Physical, biological and chemical processes in the surface near ocean react in a non-linear manner on the intensity of the available radiation.

A radiation measurement platform developed at IFM-GEOMAR will be deployed to obtain the temporal and spatial fluctuation of the spectral downwelling radiation at various depth. The device will be operated from a zodiac outside the light and and wave shadow of *Polarstern*.

c) Air-sea interaction and fluxes
Great emphasis has to be put on air-sea fluxes of momentum, sensible and latent heat to improve numerical models of weather forecast and climate simulations since oceans cover 71 % of the earth's surface. The fluxes of sensible and latent heat are also of importance for the energy budget of the ocean and the atmosphere. Due to the steady increase of many trace gases in the atmosphere like CO_2, *in-situ* gas flux measurements are required to establish parameterizations that provide flux estimates in climate models.

To estimate the turbulent fluxes of momentum, sensible heat, latent heat, and CO_2 a sonic-anemometer and an open path LiCor will be mounted. Measurements are taken at a sampling rate of 20 Hz (LiCor) respectively 30 Hz (sonic-anemometer) allowing to derive the fluxes by applying the inertial dissipation method. This method relies on measurements at high frequencies, less distorted by the motion and the superstructure of the ship than the covariance technique. Additional measurements of the sea surface temperature (SST) in combination with observations of the standard meteorological parameters and measurements of the CO_2 content in ocean and atmosphere at a lower data rate performed by marine chemist (see section 2) flux parameterizations can be derived.

To measure the SST a system of an upward and a downward looking radiometer is used. The measured brightness temperatures of the ocean and the atmosphere are also of interest for the estimates of the net radiation budget.

d) Autonomous observations of standard meteorological parameters
An autonomous meteorology observing system operated by the DWD will be tested in collaboration with the container based atmosphere observatory.

e) Lidar observations
The high temporal and spatial variability of atmospheric aerosol characteristics, i.e. in number concentration, size distribution, shape and chemical ingredients, complicates their exact specification and consideration in radiative transfer models.

The Raman lidar measurement technique is able to provide main information about the vertical profiles of aerosols. With this technique the particle backscatter and extinction coefficient can be determined, i.e. the aerosol optical properties can be described in a quantitative way. Furthermore the use of three backscatter coefficients and two extinction coefficients enable an inversion method to estimate the main microphysical properties at any measured height.

24-h measurements by the 3+2+1 Raman lidar system PollyXT aboard the *Polarstern* at its transit cruises imply the opportunity to characterize the optical and microphysical particle

properties above the Atlantic Ocean. These particles in the several layers of the atmosphere above the Atlantic are lifted up and are intercontinentally transported from certain source regions like anthropogenic emissions from North America, dust from Saharan region or smoke from biomass burning in South America or Africa.

Enhanced research is focused on the aerosol properties, due to their variable effects on down- and upwelling radiation, which are still uncertain. The determined optical and microphysical particle data will be used in the height resolved radiative model LibRadtran This model allows an estimation of the radiative influence of different aerosols, even if they occur in separated layers.

The height resolved results will be compared by simultaneous column integrated ship and space borne measurements, also in the case of vertically separated aerosol layers.

Work at sea

Upon departure from Bremerhaven the container-based atmosphere observatory will be installed at the observation deck of *Polarstern*. The following individual instruments are combined:

1. Multichannel microwave radiometer HATRPO. The instruments requires occasional calibrations with liquid nitrogen as well as tipp-calibrations under calm sea and homogeneous atmospheric conditions.
2. Multichannel Raman-Lidar Polly for aerosol measurements. PollyXT is designed as standalone portable Raman lidar system. After measurements at Manaus, Brazil and New Delhi, India it will be the first time, that this system will be operated onboard a ship. Therefore, the system requires calibration and technical service all the time. It will operate whenever weather is appreciable and placed in the OCEANET container at the Peildeck.
3. Whole sky imager for cloud structure measurements.
4. Handheld sun photometer (Microtops) for aerosol and cloud optical thickness.
5. Inclinometer for sea surface tilt measurements.
6. Sonic anemometer USA-1 to measure the wind components and temperature.
7. LiCor to measure water vapour and CO_2
8. M-100 absorption hygrometer to measure water vapour.
9. System of a KT-4 and a KT-19 radiometer to measure SST and the brightness temperature of the atmosphere
10. Subsurface spectral irradiance measurements and sea state registration.
11. Registration of irradiance variability in water due to waves - measured from zodiac.
12. Installation of the DWD autonomous meteorology observing system into the container-based atmosphere observatory.

Occasional extra-radiosoundings will have to be performed close to the overpass times of the MetOp satellite. Synoptical observations will be done every hour, aerosol optical thickness measurements every 30 minutes (under direct sun conditions). Most instruments require little maintenance.
Turbulence measurements should take place on a mast or similar device close to the bow to minimize the flow distortion by the ship's superstructure.

Expected results

1) 2d structure of the clear sky atmosphere and corresponding net radiation budget.
2) Horizontal structure of the cloud water path and its effect on the downwelling shortwave and longwave radiation.
3) Vertical structure of temperature and humidity as well as its variability for validation of satellite products.
4) Vertical profiles of tropospheric aerosols and their effect on radiation.
5) Sea surface roughness (tilt angle distribution).
6) Turbulent fluxes of momentum, sensible, and latent heat.
7) Flux of CO_2 between ocean and atmosphere.
8) Parameterizations for measured radiation fluxes (It is expected that this necessitates more data than those which will be gained during this planned cruise).
9) Parameterizations for subsurface irradiance fluctuations as function of depth and sea state.

3. ABYSSAL TEMPERATURE FLUCTUATIONS IN THE VEMA CHANNEL

H. Weber (IFM-GEOMAR)
W. Zenk, M. Visbeck (not on board)

Objectives

The equator bound flow of Antarctic Bottom Water (AABW) represents a significant limb of the global thermal-haline circulation. In the South Atlantic the deep western boundary along the continental rise carries AABW northward. The advected water masses originate from the Weddell Sea, where they are formed by deep winter-time convection. At the latitude 32° S the abyssal flow encounters two topographical constrains in form of the zonally aligned Santos Plateau and the Rio Grande Rise. These combined submarine mountain chains separate the Argentine Basin in the south from the Brazil Basin farther to the north. AABW finds its equatorward pathway through this natural impedance via a 790 km long canyon called Vema Channel (Fig. 3.1). The meridionally directed channel with water depths > 4500 meters provides a choke point for observations of water mass property and transport fluctuations of abyssal waters. Monitoring such fluctuations is vital for a state-of-the-art modeling of the global climate system.

A decade-scale record from the channel entrance (31° S, 39° W) indicates a clear increase of the lowest temperatures of the bottom water. Comparable observations from the exit region of the Vema Channel (26° S, 35° W) confirm the general abyssal temperature rise since 1991. The Vema Sill station at the entrance is internationally acknowledged as an ocean site observatory. *OceanSITES* is a worldwide system of long-term, deep water reference stations measuring regularly dozens of physical, geochemical, and biological variables (http://www.oceansites.org).

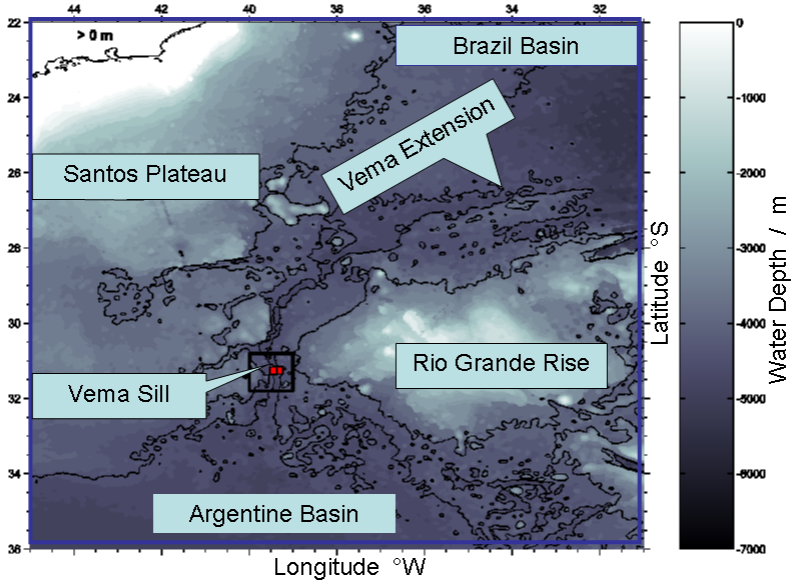

Fig. 3.1: Vema Channel in the South Atlantic. This canyon enables dense Antarctic Bottom Water to leave the Argentine Basin on its equator bound drift towards the Brazil Basin. Revisits to the Vema Sill and the Vema Extension are planned during legs ANT-XXVI/1 and 4, respectively.

Work at sea

Our prime objectives during ANT-XXVI/1 are revisits to the Vema Sill and Extension sites for additional high precision CTD observations of the coldest AABW in the Vema channel (see Fig. 3.1). It is desirable to repeat both stations on the return leg ANT-XXVI/4. Work time for each station of about 3.5 hours appears adequate. The Vema Channel is situated en-route to/from the Strait of Magellan.

Expected results

According to recent observations from *Polarstern* in the spring of 2009, the general drift towards higher near-bottom temperatures seems to fade away at the sill. So far, no such vanishing of significant temperature rise was observed at the extension. Both observations at identical locations were confirmed by almost synoptic Russian measurements. Under the assumption of a mean advection speed of Antarctic Bottom Water of ~ 5 cm/s our work hypothesis expects the arrival of less warmed-up water mass “front” at the extension later in 2009.

4. TEST OF A MOBILE 2 X 20´CONTAINER HATLAPA FRICTION WINCH WITH A JDR UMBILICAL CABLE

R. Werner (IFM-GEOMAR), T. Ohms (Control Station Meteor/Merian), M. Gehrung (GKSS).,B. Löffler (DFG Senatskommission für Ozeanographie), J. Rogenhagen, A. Pluder (Fielax / Laeisz), A. Rex, A. Schrapel (RF Forschungsschifffahrt), N.N. (Hatlapa)
not on board: K. Hoernle (IFM-GEOMAR)

Objectives

A mobile winch (manufacturer Hatlapa Marine Systems) consisting of a storage winch (20 kN) and a friction winch (150 kN) belongs to the „Meteor large equipment pool“. Both units have 20´container dimensions and weigh 20 t (incl. cable) and 18 t, respectively. The storage winch is equipped with a 3,500 m long 26 mm umbilical cable manufactured by JDR Cable Systems. The winch and the cable have been designed to deploy heavy instruments with high electrical power requirement such as, for example, the Rockdrill 2 by the British Geological Survey (BGS) in water depths up to 3,000 m. Rockdrill 2 is the latest generation of remotely operated sub-sea rockdrills. This new rockdrill can continuously core in 1.5 m sections up to a total of 15 m below seabed in water depths of 3,000 m or 10 individual cores, each up to 1.5 m, in a localized area. Because of its power requirements and weight, Rockdrill 2 cannot be operated with the cables usually installed on the winches of research vessels. The next deployment of the mobile Hatlapa winch with Rockdrill 2 is scheduled for summer 2010 onboard Sonne in the framework of the research project SO-208 PLUMEFLUX (14.08.2010 - 16.09.2010). SO-208 is a project of the working group of Prof. Hoernle (RD 4, IFM-GEOMAR) and aims at systematic sampling of the Galápagos Spreading Center (East Pacific) by drilling across ridge profiles in water depths of 2,000 – 3,000 m. During its last deployment in deep water conditions on *Meteor* in 2007, however, the outer armor of the JDR umbilical started to unwrap while deploying Rockdrill 2. Accordingly the mobile Hatlapa winch is not serviceable with the JDR umbilical cable in its present condition. We consider three possible reasons which may have caused this problem:

(1) The JDR umbilical cable already had problems on delivery.
(2) The JDR umbilical cable got twisted during deployment.
(3) The unfavorable arrangement of the friction winch and the storage winch on the deck of *Meteor* caused the problem. *Meteor's* working deck proved to be too small to arrange the storage winch and the friction winch properly in a row on the same level. Instead the storage winch was installed on the hatchway, i.e. higher than the friction winch. This arrangement made it necessary to fix the pulley which leads the cable from the storage winch to the friction winch. Otherwise the umbilical cable would have been in contact with the frame of the friction winch.

To restore the operability of the winch with the JDR cable, we intend to untwist the cable and thus hope to solve the problem. Therefore we plan to conduct a test programme in deep water conditions (at least 3,000 m) on *Polarstern*, whose deck also allows a proper arrangement of friction and storage winches (on the same level).

Work at sea

The test programme will be conducted on the *Polarstern*'s transit from Bremerhaven to Las Palmas in an area with > 3,000 m water depth. This will allow the complete extension of the umbilical cable in order to unwind it. Thereafter it is planned to lower and heave a weight being approximately equivalent to the weight of Rockdrill 2 to depths of 3,000 m. This test programme will require not more than 24 hours. We believe that after proper arrangement of friction and storage winches and unwinding the umbilical cable, the problems observed on *Meteor* in 2007 will not occur again. Finally, restoring the operability of the mobile winch with the JDR umbilical cable is a major prerequisite for its future use and the gained knowledge on how to solve such problems is invaluable if they should appear again.

5. AUTONOMOUS MEASUREMENT PLATFORMS FOR SURFACE OCEAN BIOGEOCHEMISTRY (OCEANET): OCEAN

S. Aßmann (IFM-GEOMAR/GKSS), P. Fietzek (IFM-GEOMAR)
Not on board: A. Körtzinger, T. Steinhoff (IFM-GEOMAR), J. Bock, G. Friedrichs (CAU), M. Hoppema (AWI), H. Zemmelink (NIOZ)

Objectives

The aim of the WGL-PAKT-Initiative OCEANET is to develop new autonomous instruments for the investigation of energy and matter exchange at the air-sea interface. The multi-institutional participants from IFM-GEOMAR, GKSS, IfT and AWI intend to build up a sensor network that investigates atmospheric and surface ocean properties. In order to meet the growing demand for increased spatial and temporal data, autonomous sensor networks that can be deployed on merchant vessels are needed. Tests of new instruments and measuring techniques as well as the installation of instrumentation aboard *Polarstern* are essential components of the project.

The oceanic component of this study focuses on the marine carbon cycle in the surface ocean which is of high climate relevance but at the same time susceptible to climate change. The surface ocean's CO_2 source/sink function is maintained by a complex interaction of physical and biological processes. Therefore its understanding requires measurement of various different parameters as it is pursued within OCEANET.

During the upcoming fourth cruise the work carried out during the earlier transit expeditions (ANT-XXIV/4, ANT-XXV/1 and 4) will be continued. During the first OCEANET cruise the feasibility of autonomous underway measurements was assessed for a wide range of instruments for measurement of physical (temperature, salinity, turbidity), chemical (CO_2 partial pressure (pCO_2), pH, oxygen, total gas tension, nutrients), and biological parameters (chlorophyll a, photosynthetic parameters) and small intercomparison for measurements of pCO_2 took place. Within the second cruise the focus was on intercomparison measurements of CO_2 partial pressure with diverse autonomous underway flow-through as well as submersible systems. The work on the third transit dealt with the closer investigation of a commercial submersible pCO_2-sensor and included CTD cast with the instrument. Underway pCO_2-measurements were run as a reference. Nitrate and nutrient determinations were part of the work as well.

During ANT-XXVI/1 an optimized and improved submersible pCO_2-sensor will be investigated in detail. The instrument's data will be intercompared with data obtained by the underway system installed on *R/V Polarstern.* The different biogeochemical regions crossed during the cruise and its duration provide good conditions for comprehensive testing of instrumentation.

For the first time a cavity ring-down spectrometer (CRDS) will be used for the determination of the $\delta^{13}C$ isotopic ratio of surface water dissolved inorganic carbon (DIC) within an underway setup. In addition to the isotopic ratio the instrument will provide a pCO_2 dataset, which will be included in the intercomparison. Furthermore, experiments with a newly developed optical pH-sensor will be conducted. Carbonate system investigations would benefit from progress in this field.

Work at sea

Measurements will be made continuously on pumped surface seawater using the following approaches:

- Autonomous continuous measurements of pCO_2 in surface waters with different instruments; underway and submersible (AWI, NIOZ, IFM-GEOMAR).
- Autonomous continuous measurements of dissolved oxygen and total gas tension in surface waters (IFM-GEOMAR).
- Autonomous continuous measurements of pCO_2 and $\delta_{13}C$ isotopic ratio by means of cavity-ringdown spectroscopy (CAU, IFM-GEOMAR).
- Discrete water samples for dissolved inorganic carbon and alkalinity will be taken every 8-12 hours (IFM-GEOMAR).
- Discrete optical pH-measurements (IFM-GEOMAR, GKSS).

About 6 CTD casts (2,000 m) will be performed to calibrate and optimize an underwater pCO_2 sensor as well as to obtain pCO_2 profiles.

Expected results

We will generate high-quality data in a high temporal resolution along the meridional surface transect through the Atlantic Ocean. The combined data set of autonomously recorded and discrete samples will provide a detailed insight in the carbon chemistry of the surface waters.

The continuous flow through operation of the CRDS instrument will lead to first experimental results and information regarding the applicability of this promising technique as a new common tool for chemical oceanography.

The depth profiles with the improved pCO_2 sensor will provide useful input for its further optimization and the development of membrane based sensors in general.

6. SEA TRIAL AND TESTS OF THE FIBRE OPTICAL 18 MM CABLE (LWL) AND THE TELEMETRY SYSTEM DURING ANT-XXVI/1

S. El Naggar, B. Sablotny, S. Lehmenhecker (AWI), A. Pluder, J. Rogenhagen (Laeisz), H. Bohlmann (ISITEC)

A new 18 mm fibre optical coax cable (8,000 m) were purchased and installed on board *Polarstern* during the last ship yard stay of *Polarstern* in Bremerhaven between 25.09.09 and 16.10.09 to provide the scientists with state of the art of communications.

New designed telemetry system was also developed and installed to provide the multiuser by a common platform for power supply and under water data communications.

The sea trial and tests of the system under real operation conditions will be carried out during the cruise ANT-XXVI/1 on the way between Bremerhaven and Las Palmas (16.10.09 – 26.10.09).

The planned works are:

- Complete and tune the final hard ware installation
- Test of the communications and the attenuation through the optical and electrical slipping ring
- Sea trial, calibration and acceptance tests at location (about 24 hours) at 3,000 m water depth
- Recovering of Equipment
- Disembarking the test team in Las Palmas on 27.10.09.

7. SEA TRIAL AND TESTS OF THE UPGRADED UNDER WATER NAVIGATION SYSTEM "POSIDONIA" DURING ANT-XXVI/1

S. El Naggar, G. Rohardt (AWI), J. Rogenhagen (Laeisz), D. Roger (IXSEA)

The under water navigation system POSIDONIA was upgraded during the ship yard stay of *Polarstern* in Bremerhaven between 20.05.08 and 12.06.08.
Newly designed hard and software were installed and tested at harbour in Bremerhaven. New acoustic array and window were fix-installed nearby the moon pool in addition to the mobile acoustic array. A complete new electronic cabinet was installed, modified and tested. The first operational test under real conditions at sea was carried out during the cruise ARK-XXIII/1+2. A final sea trial and calibration were planned to be carried out during the cruise ANT-XXV/1 on the way to Las Palmas in the mean time between 03.11.08 and 10.11.08 at water depths of more than 3,000 m. The planned calibration and sea trials were not carried out during ANT-XXV/1 due to the technical problems occurred to the system. The system was faulty and not operational.

After repairing in Bremerhaven during the last ship-yard stay, 24.05.09 – 20.06.09, where the damaged acoustic array and window were replaced. The system was successfully used during ARK-XXIV cruise.

During ANT-XXVI/1 and on the way between Bremerhaven and Las Palmas (16.10.09 – 26.10.09) the system will be calibrated and tested.

The planned works are:

- Complete and tune the final installation according to the claims found out during the first sea trial tests on ARK-XXIV/1+2
- Mooring of calibration transponder
- Sea trial, calibration and acceptance tests at location (about 24 hours)
- Recovering of the Transponder
- Data analysis and validations
- Real operations between test location and Las Palmas
- Disembarking the test team in Las Palmas on 27.10.09.

8. OCCURRENCE, DISTRIBUTION AND ISOTOPIC COMPOSITION OF VOLATILE ORGANOHALOGENS ALONG A NORTH-SOUTH TRANSECT OF THE ATLANTIC OCEAN

F. Laturnus,T. Teschner (IfBM)
not on board: E. Bahlmann, R. Seifert (IfBM)

Objectives

The aim of this project is to measure the concentrations and isotopic distribution of volatile organohalogens in air and surface water along a North-South transect from Bremerhaven, Germany, to Punta Arenas, Chile.

Specific objectives are to

- specify the halogenated compounds and to determine the concentrations of volatile organohalogens in surface water and ambient air,
- calculate their fluxes and to identify places of sources and sinks of volatile organohalogens in the Atlantic Ocean,
- determine the carbon isotopic signatures of volatile halocarbons and their mixing ratios, both for marine and coastal terrestrial sources, and to identify the origin of the volatile organohalogens,
- record spatial patterns of the isotopic composition of volatile organohalogens in the atmosphere and in the upper water column along the North-South transect,
- improve our understanding of the land-to-ocean and land-to-atmosphere fluxes of organohalogens in the vicinity of West African and South America upwelling regimes.

Working schedule

For volatile organohalogens, ambient air and surface seawater samples, and for the determination of chlorophyll, surface water samples, will be continuously collected and analysed 6 times a day directly in the laboratory during the whole cruise. Additionally, once a day a large-volume air sample (150 l) will be collected on adsorbent tubes on the upper deck for isotope distribution analysis. The sample tubes and the chlorophyll samples need to be stored at -80^{o}C and -20^{o}C, respectively. Furthermore, small volumes of seawater used for the determination of adsorbable organic halogens (AOX) will be collected and stored at -20^{o}C for further analysis at the home laboratory.

Expected results

Measuring the concentrations of volatile organohalogens in air and seawater will lead to data on the North-South distribution covering different climate zones. Together with the determination of the carbon isotope signature of the single volatile organohalogens information on abiogenic or anthropogenic origin and on possible impacts by coastal or other sources on volatile organohalogen concentrations in seawater and air can be determined. Thus, data will be obtained on the global atmospheric distribution of volatile organohalogens and on the impact of natural and anthropogenic sources to the environmental budget of volatile organohalogens.

9. AEROSOL REMOTE SENSING WITH FUBISS SUN AND SKY RADIOMETER

J. von Bismarck, M. Starace, A. Hollstein (IfW-FU-Berlin)

Objectives

The main objective is to quantify the aerial distribution of aerosol particles along the ship's path using multispectral Sun- and sky-radiation measurements in the visible and near infrared region. The two radiometers FUBISS-ASA2 and FUBISS-ZENITH have so far been used for the ground based and airborne remote sensing of aerosols and are adapted to a continuous use on a moving platform.

In addition to the natural salt particles in the maritime boundary layer, airmasses over the Atlantic Ocean can contain transported dust and soot particles (e.g. from forest fires) as well as sulfate droplets from anthropogenic and natural sources. All of these have an influence on the surface net radiation budget either through direct scattering and absorption of solar radiation or by influencing cloud formation processes e.g. by providing cloud condensation nuclei.

Work at Sea

The aureole and sun photometer FUBISS-ASA2 and the FUBISS-ZENITH radiometer will be set up on the main deck to continuously obtain the solar, aureole and zenith radiation spectra when the light path is not obstructed by clouds. It is planned to start data processing aboard the ship.

Expected Results

The processed data will contain a set of column-based aerosol optical properties along the ship's path. Furthermore, using an inversion algorithm based on a radiative transfer model, conclusions about the aerosol type and some microphysical properties can be drawn.

10. DIVERSITY AND ACTIVITY OF DIAZOTROPHIC CYANOBACTERIA

J. LaRoche (not on board), H. Schunck, T. Baustian (IFM-GEOMAR)

Objectives

The main objective of this project is to asses the diversity and activity of diazotrophic microorganisms and to determine rates of carbon and dinitrogen fixation rates along the meridional transect. Discrete seawater samples will be taken and filtered at regular time intervals from the clean surface seawater supply, and frozen for later analysis with molecular biological methods (quantitative PCR, Sanger-Sequencing, etc.) and flow cytometry. Parallel seawater samples will be collected for on board incubation experiments for determination of carbon and N_2 fixation rates. For this purpose, the samples will be incubated in 4 litre polycarbonate bottles for 24 hours after an addition of stable nitrogen (^{15}N) and carbon (^{13}C) isotopes. The later analysis of the isotope-composition of the microorganisms will be carried out using mass spectrometry.

Work at Sea

- Filtration of surface seawater for DNA/RNA and flow cytometry analysis will be carried out at intervals of 6 hours throughout the transect.
- Carbon and N2-fixation rates will be measured in on-deck incubations every 12 hours throughout the transect.
- 6 - 7 more detailed depth profiles will be conducted during the cruise at regular intervals.

Expected results

As for a previous cruise ANT-XXIV/4, we will obtain quantitative abundance estimates for 7 phylotypes of diazotrophs using specific probes for the *nifH* gene which encodes a subunit of the nitrogenase enzyme. We will also determine where and when the *nifH* gene is actively transcribed during the transect. However, because the timing of ANT-XXVI/1 is in fall as opposed to the spring for ANT-XXIV/4, one of the goal is to observed whether or not the trends observe between the North and South Atlantic will persist still in the current cruise.

11. PARASOUND: SYSTEM TESTING AND TRAINING UNDER EXPEDITION CONDITIONS – INSTALLATION OF VIDEO GRAB AND MSCL

G. Kuhn, G. Freiwald, S. Ho, H. Kawohl, J. P. Klages, F. Lamy, A. Lindeque, C. Walther (AWI)

Objectives

The aim of the cruise participation is to train participants for self-efficient operation of the new hull-mount Parasound system P-70. This will ensure sufficient Parasound surveys for geological projects carried out on forthcoming expeditions of the *Polarstern* and other ships during the next years. The aim of the system test is to check the Parasound system after the last software update and bug fixes in order to make improvements possible if needed. Student training will be part of the POLMAR Graduate School.

Work at Sea

For the work at sea no extra ship time is required. Also, it is efficient to work along the line of the routinely planned transit track and ship velocity. The area at sea along the routine course track from the eastern British Channel to Las Palmas roadstead is particularly suitable for Parasound system training because the range of sea-floor topography, sediment penetration and water depth allows using all possible modes of operation. The work includes 24-hour operation during which participants are running the system under expedition conditions.

For the following cruise ANT-XXVI/2 a Multi-Sensor Core Logger (MSCL) will be installed and calibrated in Trockenlabor I. A deep-sea colour video system will be installed on a grab sampler in combination with the testing of the telemetry system. So testing the functionally will be included in the ship time for the telemetry system.

12. BETEILIGTE INSTITUTE / PARTICIPATING INSTITUTES

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RF	RF Forschungsschifffahrt GmbH Blumenthalstr. 15 28209 Bremen, Germany
ZMAW	Zentrum für Meeres- und Klimaforschung (ZMK) Bundesstrasse 53, 20146 Hamburg, Germany
ZMK	Universität Hamburg, Zentrum für Meeres- u. Klimaforschung Leitstelle METEOR / MERIAN Bundesstrasse 53 20146 Hamburg, Germany

13. FAHRTTEILNEHMER / PARTICIPANTS

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession
Aßmann	Steffen	IFM-GEOMAR, GKSS	Chemical Engineer
Baustian	Tina	IFM-GEOMAR	Student, biology
Bohlmann	Harald	ISITEC	Electronic Engineer
Bumke	Karl	IFM-GEOMAR	Meteorologist
El Naggar	Saad	AWI	Physicist
Fietzek	Peer	IFM-GEOMAR	Physicist, marine chemist
Freiwald	Grit	AWI	Mathematician
Gehrung	Martina	GKSS	Engineer
Hieronymi	Martin	IFM-GEOMAR	Offshore Engineer
Heus	Thijs	ZMAW	Meteorologist
Ho	Sze-Ling	AWI	Student, geology
Hollstein	Andre	IfW-FU-Berlin	Physicist
Kalisch	John	IFM-GEOMAR	Meteorologist
Kanitz	Thomas	IfT	Physicist
Kawohl	Helmut	AWI	
Klages	Johann Phillipp	AWI	
Kleta	Henry	DWD-MM	Engineer
Kuhn	Gerhard	AWI	Geologist
Lamy	Frank	AWI	Geoscientist
Laturnus	Frank	IfBM	Marine chemist
Lehmenhecker	Sascha	AWI	Engineer
Lindeque	Ansa	AWI	Geophysicist
Löffler	Sonja-B.	DFG-SKO	Geologist
Macke	Andreas	IFM-GEOMAR	Chief Scientist
Ohm	Thomas	ZMK	Engineer
Pluder	Andreas	Laeisz	Technical Superintendent
Rogenhagen	Johannes	Fielax/ Laeisz	Project Manager
Roger	Dominique	IXSEA	Engineer
Rohardt	Gerd	AWI	Oceanographer
Schunck	Harald	IFM-GEOMAR	Biological Oceanographer
Sablotny	Burkhard	AWI	Engineer
Starace	Marco	IfW-FU-Berlin	Physics Student
Teschner	Tanja	IfBM	Student
von Bismarck	Jonas	IfW-FU-Berlin	Physicist
Walther	Conny	AWI	Physicist
Weber	Hannah	IFM-GEOMAR	Student, biology
Werner	Reinhard	IFM-GEOMAR	Geologe
Zoll	Yann	IFM-GEOMAR	Meteorologist
Rex	Andreas	RF Forschungsschifffahrt	Chief Engineer FS Sonne
Schrapel	Andreas	RF Forschungsschifffahrt	Boatswain FS Sonne
N.N.		Hatlapa	Technician

14. SCHIFFSBESATZUNG / SHIP'S CREW

No.	Name	Rank
1.	Pahl, Uwe	Master
2.	Ettlin, Margrith	1. Offc.
3.	Krohn, Günter	Ch.Eng.
4.	Fallei, Holger	2. Offc.
5.	Janik, Michael	2. Offc.
6.	Pohl, Claus	Doctor
7.	Hecht, Andreas	R.Offc.
8.	Minzlaff,Hans-Ulrich	2. Eng.
9.	Sümnicht, Stefan	2. Eng.
10.	Kotnik, Herbert	3. Eng.
11.	Scholz, Manfred	ElecEng.
12.	Muhle, Helmut	ELO
13.	Himmel, Frank	ELO
14.	Voigt-Wentzel	ELO
15.	Winter, Andreas	ELO
16.	Loidl, Reiner	Boatsw.
17.	Reise, Lutz	Carpenter
18.	Bäcker, Andreas	A.B.
19.	NN	A.B.
20.	Guse, Hartmut	A.B.
21.	Hagemann, Manfred	A.B
22.	Scheel, Sebastian	A.B.
23.	Schmidt, Uwe	A.B
24.	Wende, Uwe	A.B.
25.	Winkler,Michael	A.B.
26.	Preußner, Jörg	Storek.
27.	Elsner, Klaus	Mot-man
28.	Pinske, Lutz	Mot-man
29.	Schütt, Norbert	Mot-man
30.	Teichert, Uwe	Mot-man
31.	Voy, Bernd	Mot-man
32.	Müller-Homburg, R.-	Cook
33.	Silinski, Frank	Cooksmate
34.	Martens, Michael	Cooksmate
35.	Jürgens, Monika	1.Stwdess
36.	Wöckener, Martina	Stwdss/Krankenschwester
37.	Czyborra, Bärbel	2.Stwdess
38.	Gaude, Hans-Jürgen	2.Steward
39.	Huang, Wu-Mei	2.Steward
40.	Silinski, Carmen	2.Stwdess
41.	Möller, Wolfgang	2.Steward
42.	Yu, Kwok Yuen	Laundrym.

ANT-XXVI/2

27 November 2009 - 27 January 2010

Punta Arenas - Wellington

Chief Scientist
Rainer Gersonde

CONTENTS

1. ÜBERBLICK UND FAHRTVERLAUF

Rainer Gersonde
Alfred-Wegener-Institut

Das Forschungsschiff *Polarstern* wird am 27. November 2009 den Hafen von Punta Arenas (Chile) an der Magellanstraße zur Expedition ANT-XXVI/2 verlassen. Diese Expedition wird *Polarstern* zum ersten Mal über den gesamten polaren Südpazifik nach Neuseeland bringen, wo ANT-XXVI/2 am 27. Januar 2010 nach 61 Tagen auf See zu Ende gehen wird. Schwerpunkt der Expedition ist ein marin-geowissenschaftliches Untersuchungsprogramm, bei dem an ca. 40 Positionen geologische Probennahmen und in sieben Untersuchungsgebieten seismische Voruntersuchungen durchgeführt werden sollen. Die geologische Probennahme soll hauptsächlich mit einem Multicorer zur Gewinnung von Oberflächensedimentproben und mit einem bis zu 30 m langen Kolbenlot zur Gewinnung von Sedimentkernen durchgeführt werden. An ca. 5 ausgewählten Positionen soll ergänzend ein bis zu 12 m langes Kastenlot (Kasten 30 x 30 cm, Kopfgewicht 3.8 t) eingesetzt werden um großvolumiges Probenmaterial zu gewinnen. Im Falle von ungünstigen Wetter- und Seegangsbedingungen soll ein bis zu 20 m langes Schwerelot zur Sedimentkerngewinnung eingesetzt werden. Die geplanten Probennahmelokationen reihen sich auf latitudinalen Schnitten über den Antarktischen Zirkumpolarstrom hinweg von saisonal meereisbedeckten Gebieten im Süden bis in die Subantarktische Zone (Abb. 1.1). Seismische Untersuchungen sollen in sieben Gebieten im östlichen und zentralen Sektor des polaren Südpazifiks als Voruntersuchungen zur endgültigen Erstellung des Tiefseebohrvorschlages 625-Full *Cenozoic Southern Ocean Pacific (CESOP) - a proposal for drilling Cenozoic history sites in the Pacific sector of the Southern Ocean* (Gersonde et al.) im Rahmen von Integrated Ocean Drilling Program (IODP) durchgeführt werden. Die marin-geologischen und geophysikalischen Untersuchungen werden ergänzt durch bathymetrische und sedimentechographische Vermessungen entlang der Fahrtroute. Diese Vermessungen sind Grundlage der Auswahl von geologischen Probennahmepositionen, Teil der geophysikalischen Voruntersuchungen an den vorgeschlagenen Bohrlokationen und sollen die Kenntnis der Topographie des Meeresbodens und der Sedimentverteilung im pazifischen Sektor des Südozeans erweitern. Ergänzend werden Probennahme von Staub aus der Atmosphäre sowie hydrographische Untersuchungen in der Wassersäule mit CTD und Kranzwasserschöpfer und darüber hinaus Planktonprobennahmen mit einem vertikalen Schließnetz (Multinetz mit 5 Netzen), einem Nansen-Netz und auf den Profilfahrten aus den wissenschaftlichen Pumpsystemen des Schiffes durchgeführt.

Nach Verlassen der Magellanstraße Richtung Pazifik wird *Polarstern* zunächst das Gebiet der Freden Seamounts im nördlichen Bellingshausenmeer ansteuern. In diesem Gebiet ist vor ca. 2.5 Millionen Jahren (oberes Pliozän) ein ca. 1 km großer Asteroid eingeschlagen, der nach bisherigen Untersuchungen eine ca. 40 Millionen Jahre alte Sedimentschicht zerstört hat. Der Eltanin-Einschlag ist bislang der weltweit einzige bekannte Einschlag eines großen Asteroiden in den tiefen Ozean. Vergangene Untersuchungen haben gezeigt, dass dabei in einem sehr großen Gebiet Meteoritenmaterial abgelagert worden ist, das damit als weltweit meteoritenreichstes Gebiet angesehen werden kann. Die geplanten marin-geologischen Untersuchungen werden hauptsächlich im Bereich des vermuteten Einschlagzentrums stattfinden. Seismische Untersuchungen sollen Grundlage für Tiefseebohrungen zur weiteren Erkundung des Einschlages ergeben.

Nach Durchführung der Untersuchungen im Eltanin-Einschlaggebiet sollen weitere marin-geologische Probennahmen und seismische Vermessungen an vorgeschlagenen

Bohrlokationen im Bereich des Ostpazifischen Rückensystems und des nördlichen Amundsen-Bellingshausenmeer-Beckens durchgeführt werden. Weitere latitudinale Schnitte sind im westlichen Amundsenmeer, im Rossmeer Sektor und über das Pazifisch-Antarktische Rückensystem hinweg Richtung Neuseeland geplant, wo das längste Untersuchungsprofil zwischen ca. 70°S und 40°S vermessen und beprobt werden soll. Der südliche Abschnitt dieses langen Profils ist möglicherweise durch Meereis bedeckt, dass sich erst im späten Südsommer aus diesem Gebiet zurückzieht. Die hydrographischen Untersuchungen und Beprobungen der Wassersäule sollen schwerpunktmäßig im Bereich der Schnitte im Osten und Westen des Fahrtgebietes durchgeführt werden. Zu Ende der Expedition soll in neuseeländischen Gewässern ein Tiefenprofil bestehend aus 4 - 6 Kolbenlotkernen aus Wassertiefen zwischen 5500 und 500 m auf dem Campbell Plateau gewonnen werden.

Die Vermessungen und Probennahmen während ANT-XXVI/2 sind Teil von nationalen und internationalen Programmen, u.a. dem AWI-Forschungsprogramm “Polar Regions and Coasts in the Changing Earth System” (PACES), dem Programm “The Ocean in the Earth System” am DFG-Forschungszentrum MARUM (Bremen), “Climate Change - Learning from the past climate” (Past4Future) im Siebten EU-Rahmenprogramm, dem internationalen und multidisziplinären Projekt “Bipolar Climate Machinery” (BIPOMAC), a study of the interplay of northern and southern polar processes in driving and amplifying global climate variability als Teil des PAGES (Past Global Changes) Focus 3 “Land/Ocean/Cryosphere/Biosphere Dynamics and Linkages” und weiterer kleinerer DFG and NSF geförderter Projekte. Konsens dieser Projekte ist, dass Prozesse im Südozean wie die biologische Pumpe, die Zirkulation und Stratifikation der Wassermassen, die Bildung von Ausdehnung von Meereis, der Austausch zwischen Atmosphäre und Ozean, sowie die Atmosphärenzirkulation und das Volumen und die Dynamik der Antarktischen Eisschilde wesentlich das quartäre Klimageschehen steuern und verstärken. Der Südozean ist überdies Bildungsgebiet von wichtigen Wassermassen und fungiert als „Misch- und Austauschstation“ zwischen den verschiedenen Ozeanbecken. Damit stellt der Südozean eine Schlüsselregion für die Weiterleitung von klimawirksamen Faktoren im globalen Klimageschehen dar. Bislang stützt sich unser Verständnis der Klima- und Ozeanentwicklung in südlichen hohen Breiten hauptsächlich auf paläozeanographische Ergebnisse aus dem atlantischen und indischen Sektor des Südozeans. Bislang liegen nur wenige Ergebnisse aus dem pazifischen Südozean vor, obwohl er flächenmäßig der größte Sektor des Südozeans und wichtiges Bildungsgebiet für Tiefen- und Zwischenwassermassen ist und darüber hinaus Schlüssel-gebiet für das Verständnis der Bildungsgeschichte und Dynamik Antarktischer Eisschilde darstellt, da ca. 70 % des Westantarktichen Eises in den polaren Südpazifik abfließen. Die paläozeanographischen Untersuchungen im Rahmen von ANT-XXVI/2 werden dazu beitragen, bestehende Wissenslücken zu schließen und damit unser Verständnis der Rolle des Südozeans im globalen Klimageschehen verbessern. Die geplanten Untersuchungen in der Wassersäule werden darüber hinaus zum weiteren Verständnis von klimawirksamen Prozessen in diesem bislang nur wenig untersuchten Gebiet des Weltozeans beitragen.

SUMMARY AND ITINERARY

The research vessel *Polarstern* will leave the port of Punta Arenas (Chile) located at the Strait of Magellan on 27 November 2009 for leg 2 of its 26th Antarctic expedition. This cruise will bring *Polarstern* for the first time across the polar South Pacific to New Zealand where it will reach Wellington on 27 January 2010, after 61 days at sea. ANT-XXVI/2 is dedicated to

perform a comprehensive geoscientific programme including marine geological sampling at ca. 40 sites and seismic surveys in seven areas. The marine geological sampling will be accomplished primarily with the multicorer for surface sediment sampling and the piston corer (up to 30 m tube lengths) for the recovery of sediment cores. At selected locations (ca. 5) large volume cores will be gathered with the 30 x 30 cm kasten corer (length 12 m, head weight 3.8 t). In case weather and heave conditions prevent the deployment of the piston corer, an up to 20 m long gravity corer will be employed. The sampling sites are located on latitudinal transects across the zones of the Antarctic Circumpolar Current (ACC) between the seasonally sea ice covered zone to the South and the Subantarctic Zone in the North (Fig. 1.1). The seismic survey will be achieved at seven locations in the eastern and central sector of the Pacific Southern Ocean and represents together with the sediment sampling pre-site survey for the completion of the deep-sea drilling proposal 625-Full *Cenozoic Southern Ocean Pacific (CESOP) - a proposal for drilling Cenozoic history sites in the Pacific sector of the Southern Ocean* (Gersonde et al.) within the Integrated Ocean Drilling Program (IODP). The marine geological and geophysical programme is complemented by continuous echosounding and bathymetric survey for the definition of appropriate sediment sampling sites, as a part of the IODP pre-site survey and to further improve knowledge on the topography of the Southern Ocean and related sediment distribution. Additional ANT-XXVI/2 programmes include the sampling of atmospheric dust and the acquisition of hydrographic data and water samples with a CTD and rosette water sampler as well as the collection of phytoplankton and zooplankton with a vertical multinet (with 5 net devices), a Nansen plankton net and the *en route* sampling with ship´s pumping systems.

After leaving the western branch of the Strait of Magellan *Polarstern* will head towards the area of the Freden Seamounts in the northernmost Bellingshausen Sea (Fig. 1). This is the impact area of the Eltanin asteroid, the yet only known impact site of a large-sized (1 km in diameter) asteroid into the deep ocean. The impact took place in the Late Pliocene (ca. 2.5 Ma) and has disturbed the sediment column in the impact area back to Eocene deposits. Previous studies show that the Eltanin impact has generated a field of meteorite deposition, which represents the most meteorite-rich region known on the surface of the Earth. Marine-geological sampling will survey the potential ground-zero sites of the impact and seismic survey will provide the baseline for drilling the impact deposits as proposed within IODP proposal 625-Full.

After completion of the survey and sampling in the Eltanin impact area geoscientific sampling and seismic survey will be continued in the area of the East Pacific Rise and the northernmost Bellingshausen-Amundsen Sea basin. Further latitudinal transects are planned in the western Amundsen Sea, the Ross Sea sector and across the Pacific-Antarctic Ridge where the most extended transect is located between ca. 70°S and 40°S. The southern portion of this transect may be affected by sea ice, which retreats from this area only in late austral summer. Planned hydrographic survey and sampling of the water column will concentrate on the latitudinal transects in the eastern and western part of the survey area. At the end of the cruise when the *Polarstern* is on its route to Wellington it is planned to recover a suite of 4 - 6 piston cores (eventually also kasten cores) on a depth transect between the deep basin (5,500 m) and the top (500 m) of the Campbell Plateau located in the New Zealand EEZ

The collection of data and samples during ANT-XXVI/2 are part of national and international programmes, including the AWI research programme “Polar Regions and Coasts in the Changing Earth System” (PACES), the programme “The Ocean in the Earth System” conducted at the DFG Research Center MARUM (Bremen), the programme “Climate

Change - Learning from the past climate" (Past4Future) within the Seventh Framework EU-Programme, the international and multidisciplinary project "Bipolar Climate Machinery" (BIPOMAC), a study of the interplay of northern and southern polar processes in driving and amplifying global climate variability representing one of the three themes in PAGES (Past Global Changes) Focus 3 "Land/Ocean/Cryosphere/Biosphere Dynamics and Linkages" and other smaller DFG and NSF funded projects. Basic understanding of these programmes and projects is that in the Southern Ocean processes such as the biological pump, the circulation and stratification of water masses, the formation and distribution of sea ice, ocean-atmosphere exchange, atmospheric circulation, water vapor transport, and the volume and stability of continental ice on Antarctica play key roles in driving and amplifying Quaternary climate change. The Southern Ocean is also one of the ocean's primary sites of water mass formation, and a "junction box" where mixing occurs among major water masses from all large ocean basins. This makes the Southern Ocean to a key area for the transmission of climate change across the globe. So far, our picture of Southern Ocean climate development is primarily based on paleoceanographic studies from the Atlantic and Indian Ocean sectors of the Southern Ocean and very little information is presently available from the Pacific sector though it is representing the largest portion of the Southern Ocean. The Pacific sector represents for example a major site of deep and intermediate water formation and it represents the prime candidate to learn more on Antarctic ice sheet stability, as it collects about 70 % of the West Antarctic Ice Sheet drainage. The paleoceanographic work based on sediment cores to be recovered during ANT-XXVI/2 in the Pacific sector will help to close critical gaps in our understanding of the Southern Ocean´s role in the Quaternary climate cycles. The studies in the water column will significantly enhance our knowledge of climate-related processes in this yet poorly studied area of the global ocean.

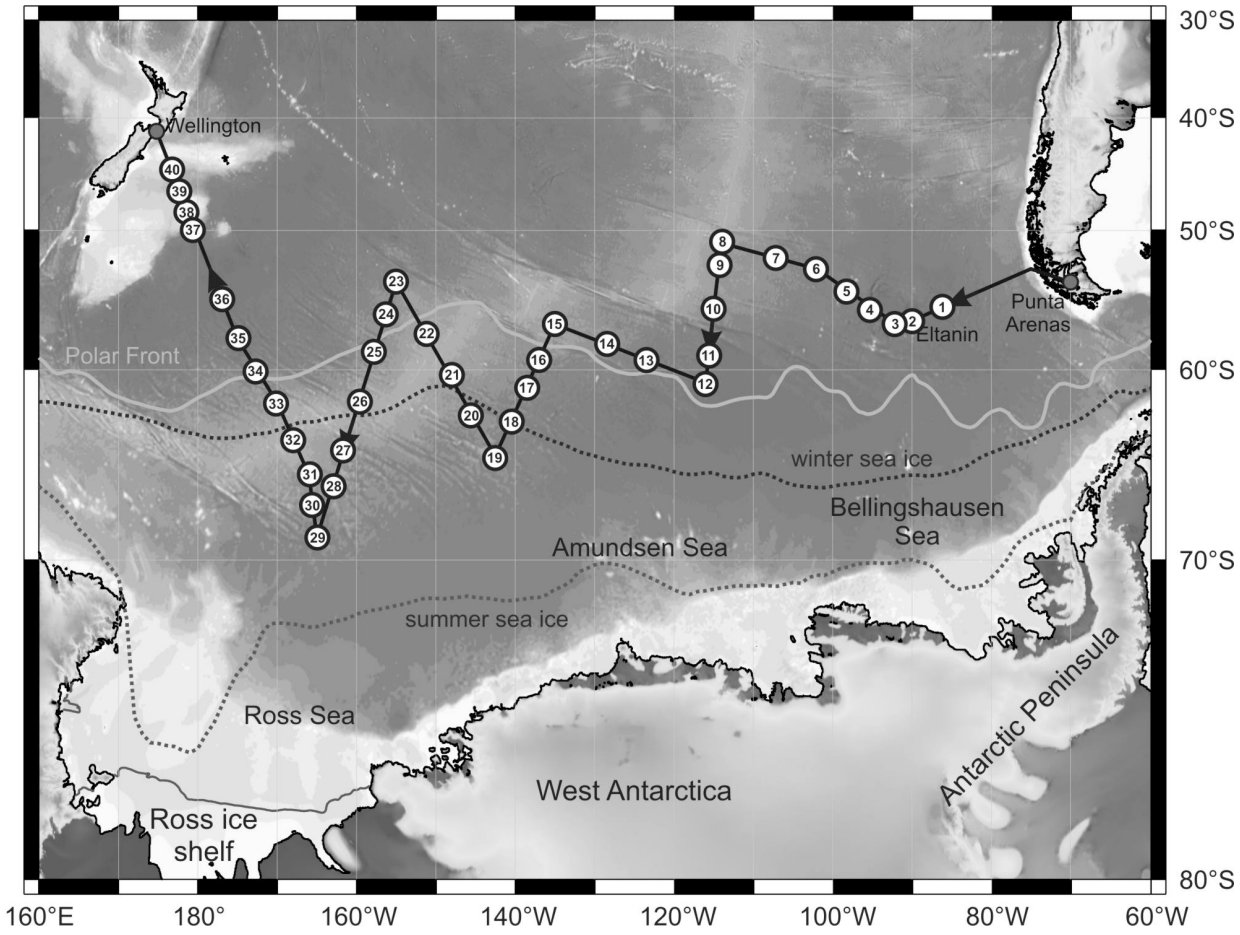

Abb. 1.1: Übersichtskarte des Untersuchungsgebiets mit der geplanten Fahrtroute und geplanter Beprobungsstationen während ANT-XXVI/2 mit Polarstern. ANT-XXVI/2 beginnt am 27.11.2009 in Punta Arenas/Chile und endet am 27.01.2010 in Wellington/Neuseeland.

Fig. 1.1: Overview map with the planned cruise track and sampling sites of Polarstern expedition ANT-XXVI/2. The cruise will begin on November 27, 2009 in Punta Arenas/Chile and will end on 27 January 2010 in Wellington/New Zealand.

2. MARINE GEOLOGICAL SAMPLING AND SURVEY

M. Arevalo, U. Bock, D. Damaske, T. Dufek, O. Esper, J. Frey, J. Gossler, R. Gersonde, T. Gölles, C. Heinzle, S.L. Ho, L. Hutzler, B. Kühl, F. Kersten, F. Lamy, N. Lensch, M. Meheust, D. Nowka, N.N., T. Schaper, I. Schulze, S. Steph, NN (AWI), M. Straub (ETH), A. Gogoi, L. Reichelt (GeoB), G. Cortese (GNS), M. Konfist (NIU), S. Fietz, A. Garcia-Martinez, G. Rueda, (UAB), K. Pahnke (UHAM), M. Saavedra (USAL)
Not on board: A. Abelmann, G. Kuhn, R. Stein, R. Tiedemann (AWI), G. Haug (ETH), T. von Dobeneck, T. Frederichs (GeoB), A. Rosell-Melé (UAB), J.-A. Flores (USAL)

Objectives

Marine geological sampling and survey will address scientific objectives related with the following research topics:

Timing and response of Pacific Southern Ocean paleoceanography to external forcing mechanisms, past climate tele-connections and inter-hemispheric links

The response of the southern high latitudes on millennial/centennial and orbital times-scales to both external climate drivers (insolation, solar variability), and internal amplifiers (e.g. thermohaline circulation, changes in the carbon cycle, sea ice albedo) is still not sufficiently established. While a number of high resolution records document the Pleistocene climate development of the Atlantic and Indian sector, the behaviour and role of the Pacific southern-high latitude sector, which links the low and high latitude Pacific with the Atlantic is still relatively unexplored. Consequently, a number of leading hypotheses postulating that changes in this sector could play an active role in triggering and propagating abrupt ocean-climate changes remain untested. For example, numerical model studies suggest that the discharge of melt-water from the WAIS and related reductions in surface water salinity could trigger a seesaw mechanism that has global scale consequences for ocean circulation and climate. Some available records from the mid-latitude South Pacific continental margins (i.e., off Chile and New Zealand) suggest that changes in Southern Ocean climate, southern westerly winds, and southern hemisphere water mass ventilation are all part and parcel of global millennial-scale climate events.

Even on orbital time-scales regional differences between the Southern Ocean sectors are evident. Although showing a similar pattern e.g. with Atlantic Southern Ocean records, the few available SST records from the Pacific Southern Ocean display lower glacial/interglacial amplitudes compared with the Atlantic sector. Reasons for this difference, which is also obvious from circum-Antarctic mapping of SST and sea ice for the Last Glacial Maximum (LGM) (see below), still need to be resolved.

Pleistocene changes in Pacific Southern Ocean physical environment (temperature, sea-ice) and ecosystem/export productivity regimes and their relation to atmospheric pCO_2 variability and the global nutrient regime

Southern Ocean physical and biological processes exert a strong impact on global ocean biogeochemical cycles and influence atmospheric CO_2 concentration. Crucial processes include ocean ventilation/stratification, sea ice extent/seasonality, and biological productivity/export. These processes may have acted as feedbacks that significantly contributed to the Cenozoic climate development. Especially sea ice, which represents a fast

changing variable with strong albedo feedback that profoundly affects the physical, chemical, and biological properties of Southern Ocean surface water, ocean ventilation and atmospheric circulation. High-resolution records of past sea-ice variability based on the diatom record in the Atlantic and Indian sectors of the SW reveal a close correlation between sea-ice variability and atmospheric CO_2 at Pleistocene terminations. Such pattern supports models calling for a role of sea ice in glacial-to-interglacial variations in atmospheric CO_2, but the magnitude of the sea-ice impact is yet under discussion as the models are still limited in accurate sea-ice reconstruction and only constricted circum-Antarctic sea-ice reconstructions based on the sediment record are yet available. Indeed, reconstruction of the LGM winter sea ice field and surface water temperatures point to a different behavior of these physical parameters in the Pacific sector during the LGM compared with the other sectors of the Southern Ocean. However, this observation relies on a small number of available samples from the Pacific sector calling for the urgent need to increase the set of sediment cores from this sector.

Biogeochemical models simulating modern global ocean nutrient (N, Si) distribution indicate that biological productivity at mid- and low-latitudes is controlled by physical and biological processes occurring at high latitudes, the Southern Ocean playing a primary role. Based on opal isotope measurements (δ^{30}Si, δ^{15}N), some studies postulate increased northward export of silicon during glacials and suggest that the Pacific may be an area of major silicon export, having strong implications on the productivity regimes in coastal upwelling areas and atmospheric CO_2 concentration. Such scenario needs to be tested on latitudinal sediment core transects from the Pacific sector.

Representing a High-Nutrient-Low-Chlorophyll (HNLC) area during warm climate modes the Southern Ocean has strong potential to represent a major CO_2 sink during glacial conditions, when increased input of the micronutrient iron enhances the biological pump. Sediment cores from the Pacific sector will provide insight to what extent glacial dust/iron import from the Australian continent and New Zealand has impacted Pacific Southern Ocean productivity, carbon export, and burial of biogenic particles. These records will be tied to Antarctic ice core records for a general understanding how changes in greenhouse gas concentration such as CO_2 are linked to the deposition of dust, dust-born iron, as well as to Southern Ocean temperature, stratification, biological productivity regimes and related carbon sequestration.

Pleistocene changes in the production and the mixing ratios of South Pacific deep and bottom water masses, and their role in affecting the global climate system

Very little is known about Pleistocene changes of deep water circulation in the Pacific sector of the Southern Ocean though it is among the primary sites of deep water mass water formation and represents the "junction box" of global ocean circulation where mixing occurs among water masses from other ocean basins. The formation and upwelling of deep water together with intermediate water and sea-ice formation are globally important as they link the thermal and gas composition of the ocean's interior with the atmosphere through air-sea exchange. Furthermore, changes in Southern Ocean deep water formation affect the global thermohaline circulation including changes in North Atlantic Deep Water (NADW) formation that are important for glacial-interglacial climate fluctuations and in particular for amplifying millennial climate variability during glacial periods.

In order to assess past changes in deep ocean circulation and ventilation, the generation of the first benthic carbon isotope records at different water depth in the Polar South Pacific and its comparison with records from other basins will be crucial to estimate changes in vertical and inter-basin δ^{13}C gradients.

A depth transect between the deep basin (5,500 m) and the top (500 m) of the Campbell Plateau will allow for the reconstruction of glacial/interglacial and millennial-scale changes in the vertical structure of the SW Pacific upper water column during the late Pleistocene, with focus on variations in the vertical position and/or properties of Subantarctic Mode Water (SAMW) and Antarctic Intermediate Water (AAIW). Today, these southern-sourced intermediate water masses play an important role for the redistribution of heat and freshwater within the upper ocean and are potentially one of the main sources for nutrient supply to the tropical thermocline. Furthermore, air-sea gas exchange in their formation regions north of the polar front acts as an important sink for atmospheric CO_2.

Radiogenic isotope tracing of past Antarctic Bottom Water flow in the South Pacific

The Sr and Nd isotopic signature of sediments allows to trace the present and past export of Antarctic Bottom Water (AABW) into the Southeast Pacific. This is based on the distinct Sr and Nd isotopic signatures ($^{87}Sr/^{86}Sr$, $1^{43}Nd/^{144}Nd$ expressed in $\sum$Nd units) of Antarctic rocks and sediments, in particular from the Ross Sea region, compared to those of the surrounding continents that allows tracing of the Antarctic signal in terrigenous sediments back to their source. That is, terrigenous sediments originating from Antarctica, such as AABW formed in the Ross Sea (RSBW) and its terrigenous load, should be uniquely recognizable by their isotopic signatures at selected stations along the cruise track, and the strength of the Antarctic signal should be indicative of the relative mixing ratio of Antarctic *versus* non-Antarctic sediments. Using these isotopic fingerprints in the fine fraction of terrigenous material from Antarctica that is transported by currents, we plan to study past changes in AABW export from the Ross Sea into the Southeast Pacific on glacial-interglacial to millennial time scales. Initially, we will focus on the last glacial-interglacial transition including the LGM, Antarctic Cold Reversal (ACR), and Holocene.

Improvement of Last Glacial Maximum (LGM) reconstruction of the Pacific Southern Ocean

The recently published synthesis of sea surface temperatures during the LGM from the Multiproxy Approach for the Reconstruction of the Glacial Ocean Surface (MARGO) project clearly reveals the lag of data in the South Pacific and in particular in the Pacific sector of the Southern Ocean. The few data available indicate reduced cooling in the Pacific sector and suggest a non-uniform cooling of the glacial Southern Ocean. Similar results have been obtained from sea-ice reconstructions. The scarce data from the Pacific sector point to smaller expansions of the LGM winter sea-ice in this sector. To substantiate the Pacific sector sea ice distribution, more data points are urgently needed. The apparent reduced LGM cooling of the Pacific Southern Ocean is in contrast to strong LGM cooling in the mid-latitude Pacific recorded in continental margin sediments off Chile and New Zealand.

Further evaluation of the Eltanin-asteroid impact in the Bellingshausen Sea

Earlier geological exploration have documented the presence of impact related sediment disturbances and deposition near the Freden Seamount (57.3°S, 90.5°W) in the northern Bellingshausen Sea. Deposits of the late Pliocene (2.5 Ma) Eltanin impact are unique in the known geological record. The only known example of a km-sized asteroid to impact a deep-ocean (5 km) basin, is the most meterorite-rich locality known. Available sediment core studies showed that sediments as old as Eocene were eroded by the impact disturbance and redeposited in three distinct units. The lowermost is a chaotic assemblage of sediment fragments up to 50 cm in size. Above this is a laminated sand-rich unit that deposited as a turbulent flow, and this is overlain by a more fine-grained deposit of silts and clays that settled from a cloud of sediment suspended in the water column. Meteoritic ejecta particles were concentrated near the base of the uppermost unit, where coarse ejecta caught up with

the disturbed sediment. More recent numerical modeling has allowed for the prediction of potential ground-zero sites of the impact. These sites are yet unstudied and will be surveyed in detail during ANT-XXVI/2 to validate the impact models, which indicate massive meteorite deposition in area of ground-zero. This study will substantially augment the determination of the impacted asteroid size, the impact angle and the impact effects on the sea floor in the area of maximum physical stress. It may also allow for the collection of larger volumes of unmelted asteroid fragments for further mineralogical studies.

Refinement of geomagnetic dating of Holocene-Pleistocene sediment records
The sediments of the deep Southern Ocean are mostly barren of biogenic carbonate, which limits the dating of Holocene-Pleistocene records by means of the oxygen isotope stratigraphy based on planktic and benthic foraminifers. New dating approaches include the generation of paleointensity records, which can be correlated over larger areas allowing for dating in combination with radiometric methods or oxygen isotope stratigraphy. The availability of such records from Southern Ocean sediments is still rather limited. The recovery of sediment records from carbonate bearing ridges and deep ocean basins during ANT-XXVI/2 will lead to further enhancement of this geomagnetic dating method.

Extension of surface sediment data sets for paleoceanographic proxy calibrations
A further important objective is the extension of surface sediment data sets for paleoceanographic proxy calibrations. Also in this respect, the Pacific sector of the Southern Ocean has not been covered sufficiently. This concerns relatively well established proxies such as siliceous and calcareous microfossil assemblages or alkenone SSTs but in particular also new organic biomarker SST proxies such as TEX86 that has a great potential for temperature reconstructions in high latitudes. Further proxies that will be studied in the cruise area are alkenones as a salinity proxy, the productivity proxies from alkenones and pigments, and the distribution of terrigenous biomarkers and their isotopic values to link it with the source of the terrigenous organic matter

Work at sea

To substantially augment our knowledge from the Pacific sector and to fill critical gaps in the understanding of Southern Oceans role in Pleistocene climate development we plan to recover long sediment cores and surface sediment samples at ca. 40 locations (Fig. 1). Coring is envisaged primarily with the piston corer (KOL) with expected core lengths of 25 - 30 m. If conditions do not allow for employment of the KOL, we will use a gravity corer (SL) for replacements that achieves up to ~20 m core length. At 4 - 5 selected stations, we plan to use a kasten corer (KAL, length 12 m) in order to obtain large amounts of sample material where necessary. Surface sediments will be collected with a multi-corer (MUC) at all core stations.

Coring will take place on transects extending from the seasonal sea-ice covered zone into the Subantarctic Zone of the Southern Ocean (Fig. 1), including latitudinal transects between ~180°W and ~100°W. The southern part of the latitudinal transect at 170°W is close to a transect intensively studied during the US Southern Ocean JGOFS Program (AESOPS) in 1997 - 1998. AESOPS collected and studied a large amount of biological and geochemical samples from the water column, including sediment traps, but did not recover long sediment cores. The ANT-XXVI/2 core locations were selected to provide depth transects between 5,000 and 2,500 m water depth (except for the Campbell Plateau where shallower water depth will be targeted) allowing a combination of proxies based on calcareous and siliceous microfossils, needed to establish a multi-proxy approach for paleoceanographic

reconstructions. The exact core location will be based on extensive bathymetric and sediment echo-sounding survey with Hydrosweep and PARASOUND.

A significant portion of the cores will be opened, documented, sampled and archived during the cruise. This will include preliminary biostratigraphic dating of the cores, based on the occurrence of diatoms, radiolarians, calcareous nannoplankton and foraminifers. Core-to-core correlation will be based on on-board logging of sediment physical properties, e.g. magnetic susceptibility, porosity, density and sediment color. The latter will be achieved by digital scanning of open cores using a "line scanner"-camera and image analysis.

Expected results

Based on preliminary information from the few other sediment cores available from the Pacific sector of the Southern Ocean (i.e., from US expeditions in the 1960´s and 1970´s), we estimate that cores recovered at the proposed locations will document up to 500 - 700 kyr, at various time resolutions. This time-frame is only slightly less than the past 8 climate cycles available from Antarctic ice-core and well suitable for addressing the above outline objectives and achieve a substantial improvement of our knowledge of the paleoceanographic and -climatic history of the Pacific Southern Ocean at orbital and millennial time-scales.

Our general strategy to obtain well established paleoceanographic reconstructions post-cruise is a multi-proxy approach, in which as many as possible geochemical, isotopical, paleobiological and sedimentological proxies are compared and combined with each other. The most important proxy data to be generated are:

- *Sea-surface temperatures* using geochemical (alkenones, Mg/Ca, TEX86) and paleobiological proxies (diatom and radiolarian transfer functions).
- *Sea-ice* reconstructions based on diatom transfer function technique or abundance pattern of sea ice indicator diatoms provide information on the maximum sea ice extent and (with some constraints) seasonality.
- *Salinity, meltwater and ice-rafted detritus (IRD)* based on diatom $\delta^{18}O$ paired with quantitative ice-rafted detritus (IRD) analyses provides information on the shedding of meltwater from the continental ice sheet and thus on ice sheet dynamics. Additionally, the use of alkenones as a paleosalinity proxy in the Pacific sector will be investigated.
- *Terrigenous sediment input changes* will be derived from high resolution core scanning (XRF and shipboard MSCL measurements) and biomarker studies.
- *Ocean circulation and ventilation/stratification* using $\delta^{18}O$ and $\delta^{13}C$ records from benthic foraminifera where available as well as bottom water temperatures based on Mg/Ca. Bottom water velocity will be derived from the mean and percentage of sortable silt. Sr and Nd isotopic signatures ($^{87}Sr/^{86}Sr$, $^{143}Nd/^{144}Nd$ expressed in εNd units) will allow tracing the past flow of Antarctic Bottom Water in the South Pacific.
- *Biological productivity* relying on a combination of geochemical and paleobiological proxies.

A crucial factor for the quality of our results will be the establishment of reliable age-models. We will base our age models on a combination of benthic/planktic isotope stratigraphies, diatom and radiolarian abundance stratigraphy, biostratigraphy and geomagnetic polarity/intensity stratigraphies. We further expect to tie our records to Antarctic ice-core records most likely via correlation of sea-surface temperatures from our marine records to atmospheric temperature records from Antarctica. In addition, the correlation of geomagnetic intensity records with ^{10}Be records from ice cores will be helpful. Radiocarbon dating in combination with ^{210}Pb and ^{226}Ra will be applied in younger sequences where suitable.

3. BATHYMETRIC SURVEY

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Not on board: H.-W. Schenke (AWI)

Objectives

With the 1-minute Global Bathymetric Grid, derived from the GEBCO Digital Atlas-Centenary Edition GDA-CE (http://www.ngdc.noaa.gov/mgg/gebco/gebco.html) and the 2-minute predicted bathymetric grid ETOPO2, small-scale models of the sea floor topography are available for continental modelling. However, the knowledge about large-scale bathymetry in the South Pacific is still insufficient for in-depth research work. This region is sparsely surveyed and charted. The predicted bathymetry supplied by ETOPO2 in this region is also lacking soundings, and the quality of the RA-signals are degraded by ice coverage. Thus, the GEBCO Guiding Committee has adjudged the South Pacific as high priority region for additional bathymetric surveys, preferably performed utilizing multibeam systems. In addition, the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission (IOC) has recently established a new ocean mapping programme for the creation of the International Bathymetric Chart of the South East Pacific (IBCSEP).

Work at sea

Multibeam bathymetric survey techniques provide a rapid means of determining the morphology and nature of the seafloor. The recent Hydrosweep DS-2 System onboard R/V Polarstern provides 59 individual soundings of the water depth and echo strength for each ping. Moreover sidescan information (2,048 echos per ping) is retrieved. The system can be operated with 90 or 120 degrees fan angle and is designed for deep-sea observations. Continuous bathymetric survey during expedition ANT-XXVI/2 will augment the knowledge of the large-scale bathymetry in the South Pacific. Bathymetric survey is also required as a part of the planned IOPD pre-site survey (see section 4. Pre-site Survey).

4. PRE-SITE SURVEY FOR IODP DRILL PROPOSAL 625-FULL (CESOP)

M. Arevalo, U. Bock, D. Damaske, T. Dufek, O. Esper, J. Gossler, R. Gersonde, T. Gölles, C. Heinzl, S.L. Ho, L. Hutzler, B. Kühl, F. Kersten, F. Lamy, N. Lensch, M. Meheust, D. Nowka, N.N., T. Schaper, I. Schulze, S. Steph, NN (AWI)
Not on board: A. Abelmann, K. Gohl, G. Kuhn, R. Stein, R. Tiedemann, G. Uenzelmann-Neben (AWI), G. Haug (ETH), A. Rosell-Melé (UAB), J.-A. Flores (USAL)

Objectives

The South Pacific is one of the few areas of the global ocean lacking information on Cenozoic paleoclimatic development from deep-sea drilling records. The Integrated Ocean Drilling Program (IODP) proposal 625-Full *Cenozoic Southern Ocean Pacific (CESOP) - a proposal for drilling Cenozoic history sites in the Pacific sector of the Southern Ocean* (Gersonde et al.) has been positively reviewed by the IODP-iSSEP (Environment/Interior

Panel), and the generation of a revised full proposal has been recommended. The reviewers pointed out the requirement for such pre-site data before the proposal can further proceed.

The following primary objectives are targeted by IODP proposal 625-Full CESOP:

1) Response of the Pacific Southern Ocean to the opening and closure of gateways and South Pacific basin shape and its implication for Antarctic continental ice-sheet and ice-shelf development.
2) History of West Antarctic Ice Sheet (WAIS): its establishment, stability and impact on climate, ocean and environment.
3) Documentation of the early Pliocene polar South Pacific.
4) Timing and response of Pacific Southern Ocean paleoceanography to external forcing mechanisms, past climate teleconnections and interhemispheric links.
5) The Pacific sector's role in nutrient distributions and past shifts in atmospheric CO_2.
6) Improvement of Cenozoic southern high-latitude stratigraphy and microfossil biogeographic distribution patterns.
7) Deep-drilling examination of the late Pliocene impact of the >1 km sized Eltanin asteroid and its environmental consequences.

In combination with Parasound, Hydrosweep surveys and piston coring, seismic surveys will produce the appropriate pre-site survey database needed for drilling of Cenozoic sediments in the Southern Pacific Ocean. Comprehensive site survey will be accomplished during three cruises to the South Pacific in austral summers 2009/10 and 2010/11. During expedition ANT-XXVI/2 and the subsequent expedition ANT-XXVI/3, seismic surveys of the CESOP target areas South of 50°S between Chile and New Zealand will be performed (Fig. 4.1). The third cruise (SOPATRA) is scheduled for austral summer 2010/11 with *Sonne* and will focus on the eastern South Pacific between 55° and 30°S.

Work at sea

A multichannel seismic (MCS) reflection technique will be used to record the seismic record of sediments and basement in the area of the proposed drill sites FRE-1A, FRE-2A, EPR-3A, EPR-4A, EPR-5A, BEL-1B and UFZ-2A (Fig. 4.1). Each site will be surveyed with a cross profile with each axis of about 20 - 50 nm track length. Seismic recording is performed using a towed 600 m long hydrophone streamer and high-frequency GI-Guns as airgun source. Onboard quality control and data display will help determine the drill site characterisation. This is combined with bathymetric and sediment-echosounding survey as well as with the recovery of long piston cores to provide information on the sediment composition and sedimenation rates at the proposed drill sites, which will be achieved also at the proposed drill sites PAR-1A to PAR-4A. Additional multichannel seismic survey at the latter four sites will be conducted during ANT-XXVI/3.

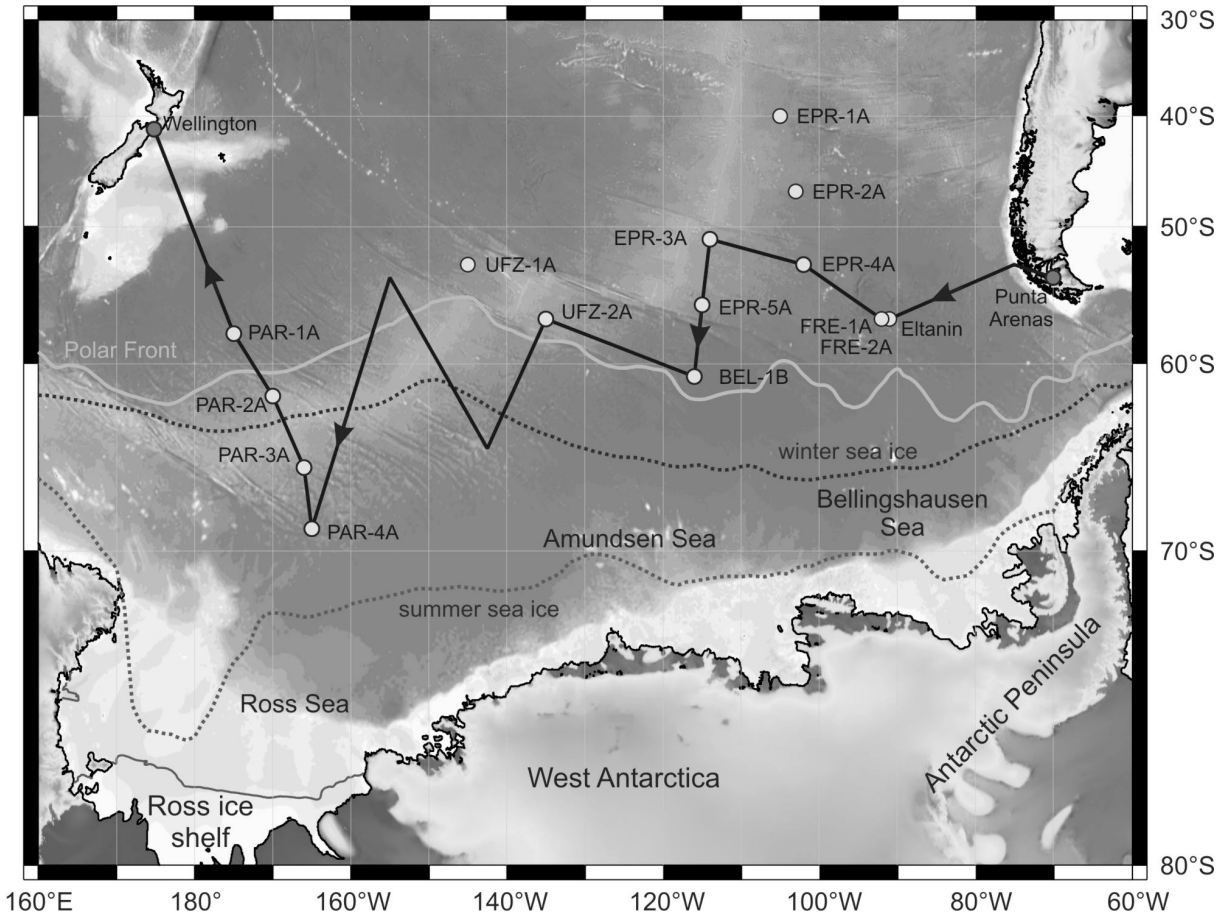

Fig. 4.1: Planned CESOP drill sites/target areas in the South Pacific. Pre-site survey including sediment-echosounding and bathymetric survey as well as sediment coring will take place during expedition ANT-XXVI/2 at all proposed sites except for EPR-1A, EPR-2A and UFZ-1A. Additional multi-channel seismics will be obtained during ANT-XXVI/2 at sites FRE-1A, FRE-2A, EPR-3A – 5A, BEL-1B and UFZ-2A.

5. WATER COLUMN STUDIES

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Not on board: A. Abelmann, (AWI), J.-A. Flores (USAL), Hyoung Chul Shin (KOPRI)

Objectives

Determination of plankton composition

Biological and physical processes in the Southern Ocean play a crucial role in initiating and shaping climatic changes. The Southern Ocean is the largest High-Nutrient-Low Chlorophyll (HNCL) area in the world and thus has the potential to become a major CO_2 sink when the efficiency of the biological pump increased as it has been postulated for glacial periods. Further, air-sea interactions in the Southern Ocean have a strong impact on the global ocean circulation loop and are supposed to be important in setting the rate of global overturning.

The hard parts of siliceous, calcareous and organic walled microorganisms (diatoms, radiolarians, planktic foraminifers, calcareous nannoplankton, dinoflagellates) are crucial tools to reconstruct past environmental conditions in the Southern Ocean by using paleobiological and geochemical methods. A new tool successfully used to reconstruct changes in environmental conditions such as ice-volume, surface salinity, nutrient concentration and primary production are stable isotopes (δ^{30}Si, δ^{18}O, δ^{15}N, δ^{13}C) of biogenic silica (BSi). For the interpretation of the paleobiological and geochemical data obtained from siliceous and organic-walled microfossils and the understanding of the complex mechanisms ecological information (latitudinal distribution and depth habitat) of living species in combination with hydrographic data, chorophyll and nutrient measurements are needed.

Radiogenic isotope tracing of modern Antarctic Bottom Water flow in the South Pacific

The distinct Antarctic ∑Nd signature known from Antarctic rocks and sediments should also be imprinted on seawater ∑Nd, in particular on AAWB formed in the Ross Sea and along Wilkes Land/Adelie Coast. In order to test this, we intend to measure ∑Nd in water column profiles along the cruise track with a focus on bottom water. The results will determine the Antarctic contribution to the Southern Ocean ∑Nd signal and hence provide crucial information on the Southern Ocean ∑Nd end-member required to reconstruct present and past ocean circulation.

Biomarker studies

The major objective is to obtain modern samples to constrain the calibration of the various biomarkers that we are applying downcore (alkenones, n-alkanes, pigments and GDGTs) given that not much has been done in the cruise area, and in fact in the Southern Ocean as a whole. We retrieve samples from the water column and surface sediments to measure their contents in the above biomarkers and measure the isotopic composition of alkenones (δD), n-alkanes (δ^{13}C) and pigments (δ^{15}N). This will allow us to calibrate and constrain in the Pacific Southern Ocean the UK37/UK37' and TEX86 for SST, alkenones as a salinity proxy, the productivity proxies from alkenones and pigments, and map out the distribution of terrigenous biomarkers and their isotopic values to link it with the source of the terrigenous organic matter and the position of the westerlies (see also section 6 Dust sampling).

Vertical profiles of dissolved organic matter (DIC), TA, pH, surface pCO_2, and selected non-CO_2 climate gases. Role of pelagic ecosystem processes

The Pacific sector of the Southern Ocean is a critical spot in the current global carbon cycle. Atmospheric CO_2 is absorbed in substantial amounts at the surface and sinks into the intermediate layer and is subsequently supplied to the Pacific interior in association with the formation of the Antarctic Intermediate Water (AAIW). South of the Polar Front, relatively CO_2-rich upwelling of deep water replenishes inorganic carbon to the upper layers. Although the hydrography is the primary determinant of the carbon cycle, poorly documented pelagic biota in this region will form a significant part of the control over the organic carbon pool by means of atmospheric CO_2 absorption via photosynthesis and sinking of biologically derived particulate carbon to depth. It is planned to measure vertical profiles of inorganic carbon and other non-CO_2 climate gases and have corresponding measurements of pelagic ecosystem processes. Main goals include:

- the study of dynamics of the inorganic carbon cycle in relation to hydrography and ecosystem processes in the Pacific sector of Southern Ocean;
- an assessment of anthropogenic CO_2 absorption by AAIW (Antarctic Intermediate Water) and CO_2 replenishment to the upper water column by CDW (Circumpolar Deep Water);

- the measurement of vertical profile of non-CO_2 climate gases (CH_4, N_2O, CO) in the Pacific sector of Southern Ocean;
- the study of the composition and size spectra of microalgal assemblages;
- the study of organic matter export by fecal pellets to deeper water.

Work at sea

The vertical and latitudinal distribution of siliceous and calcareous microorganisms will be documented on transects covering different hydrographic and productivity regimes from the Subantarctic Zone to the edge of the winter sea ice. For collecting diatoms that dwell in the euphotic zone, the upper sea surface will be sampled with the “Nansen” plankton net. Radiolarians and dinoflagellates that live in surface and deeper water layers will be sampled at selected depth intervals in the uppermost 1,000 m by using an opening/closing net (Type MPS 92 B, “Hydrobios” Kiel, Germany). Vertical CTD profiles and water samples for analyzing nutrient contents at selected depth levels will shed light on the relationship between hydrography, nutrient availability, species distribution and abundances of microorganisms. Additionally, water samples to be studies for their microorganism content will be sampled en-route with the ship´s pumping systems.

The seawater Nd isotopic studies require pre-concentration of rare earth elements from seawater. The minimum number of stations to be targeted is 5 stations (with a minimum of 3 depths per station: intermediate, deep, and bottom depth, ideally 6 - 8 depths per station). Additional stations along the cruise track may be sampled depending on water budget and time permitting. The sample volume required per analysis is 5 - 10 liters (5 l is minimum, 10 l is ideal). Seawater will be filtered through AcroPak filter cartridges directly from the Niskin bottles, requiring 5 - 10 mins per 10 liters. Sample processing at sea requires space for a peristaltic pump and ideally a nearby drain in an area of the lab that can be shielded from contamination by plastic sheets. The seawater samples will be acidified to pH = 3.5 with 6N hydrochloric acid (if necessary, pH adjustment will be done using ammonium hydroxide), and pumped through SepPak cartridges. This will reduce the sample volume from 10 l to 1cc.

For the biomarker studies, in regular intervals we will collect water samples from the CTD rosette from three depths, e.g. from chlorophyll maximum, subsurface and bottom waters. The chlorophyll maximum will be determined with a fluorescence probe attached to the CTD transmitting real-time data. Ideally, and according to other participants’ needs, 4 bottles are used per depth (total of 12 bottles). This will allow us to determine the biomarkers with separate filters and in duplicate. Collected water from the CTD rosette will be filtered by a fixed filter ramp with connected vacuum pump. Environmental data will be got from the CTD probes. Nearing the respective CTD stations, water samples shall be collected using the underway clean seawater pump (6 m). We will connect the water flow directly into four parallel filter systems. Salinity and temperature data will be monitored with the thermosalinograph at the same time. Hence, at each station we will get data from surface, chlorophyll maximum, subsurface and bottom water. All filters will be stored frozen in the -20ºC storage room and brought back home for analysis.

The DIC and gas analysis work will be based on Niskin water samples covering the full-depth range of the water column on transects across the Polar Frontal Zone. The required water budget is 8 liter (3 liter for the gases, 4 liter for HPLC pigments, 1 liter for FlowCAM). Iron addition grow-out experiments; conducted at 6 to 8 stations, require 10 liter water samples from surface and chlorophyll maximum layer. For investigating the role of pelagic ecosystem processes, access to plankton samples is needed (5 depth strata multi-net samples at

selected stations. In addition, a simple plankton tow (to 200 m water depth) is needed at roughly half of the water stations.

6. DUST SAMPLING

S. Fietz, A. Garcia-Martinez, G. Rueda, (UAB)
Not on board: ,A. Rosell-Melé (UAB)

Objectives

Little is known about modern eolian supply in the Pacific Southern Ocean that is strongly related to the strength and position of the southern westerly wind belt. In particular terrigenous organic biomarkers may be a useful proxy for the modern eolian supply. Information on the source of the terrigenous organic matter are needed to map out the distribution of terrigenous biomarkers and their isotopic values based on water and surface sediment samples. For the purpose of collecting dust, we take onboard a high volume air sampler and collect air particulates to measure long range transport of terrigenous organic matter and link its composition to air mass trajectories during the cruise. A side interest is to take advantage of the modern samples collected to look at organic pollutants, in the same samples collected for the biomarkers.

Work at sea

An active air sampler (TE-PNY1123, Tisch Environmental Inc.) will be installed on the 'monkey island' ('Peildeck') that simultaneously collect total suspended (airborne) particulates (TSP) as well as trap airborne organic vapors or gas-phase contaminants on polyurethane foam (PUF) whenever the ship is moving, especially nearing the CTD stations (i.e., where underway surface water samples are taken) to link air and water samples and, hence, study the incorporation from the atmosphere into the ocean. A total of 20 PUF and 60 TSP samples are planned.

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5.	Ritter, Michael	2. Offc.
6.	Dugge, Heike	2. Offc.
7.	Türke, Helmut	Doctor
8.	Hecht, Andreas	R.Offc.
9.	Minzlaff,Hans-Ulrich	2. Eng.
10.	Sümnicht, Stefan	2. Eng.
11.	Kotnik, Herbert	3. Eng.
12.	Scholz, Manfred	ElecEng.
13.	Muhle, Helmut	ELO
14.	Himmel, Frank	ELO
15.	Fröb, Martin	ELO
16.	Winter, Andreas	ELO
17.	Loidl, Reiner	Boatsw.
18.	Reise, Lutz	Carpenter
19.	Bäcker, Andreas	A.B.
20.	NN	A.B.
21.	NN	AB
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23.	Hagemann, Manfred	A.B
24.	Scheel, Sebastian	A.B.
25.	Schmidt, Uwe	A.B
26.	Wende, Uwe	A.B.
27.	Winkler,Michael	A.B.
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30.	Pinske, Lutz	Mot-man
31.	Schütt, Norbert	Mot-man
32.	Teichert, Uwe	Mot-man
33.	Voy, Bernd	Mot-man
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35.	Silinski, Frank	Cooksmate
36.	Martens, Michael	Cooksmate
37.	Jürgens, Monika	1.Stwdess
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40.	Gaude, Hans-Jürgen	2.Steward
41.	Huang, Wu-Mei	2.Steward
42.	Silinski, Carmen	2.Stwdess
43.	Möller, Wolfgang	2.Steward
44.	Yu, Kwok Yuen	Laundrym.

ANT-XXVI/3

30 January 2010 - 5 April 2010

Wellington - Punta Arenas

Chief Scientist
Karsten Gohl

CONTENTS

1. ÜBERBLICK UND FAHRTVERLAUF

Karsten Gohl
Alfred-Wegener-Institut

Seit dem letzten glazialen Maximum erfuhr der westantarktische Eisschild (WAIS) dramatische Volumenänderungen innerhalb kurzer Zeiträume. Der WAIS hat das Potenzial, den globalen Meeresspiegel um 3 - 5 m ansteigen zu lassen. Untersuchungen, die diese Variationen mit denen in der älteren und jüngeren geologischen Vergangenheit vergleichen und somit Parameter für Vorhersagemodelle ableiten lassen, sind daher dringend erforderlich. Mit dieser vordringlichen Fragestellung vor Augen beginnt der *Polarstern*-Fahrtabschnitt ANT-XXVI/3 am 30. Januar 2010 in Wellington (Neuseeland) und endet am 5. April 2010 in Punta Arenas (Chile) (Abb. 1.1). Diese Expedition hat primär geophysikalische und geologische Forschungsziele, die die vorglaziale und glaziale Entwicklung der Westantarktis entschlüsseln helfen sollen. Ein ozeanographisches und biogeochemisches Forschungsprogramm sind ebenso geplant wie ein Projekt zur automatischen Detektion mariner Säuger.

Das geowissenschaftliche Programm beginnt mit seismischen Voruntersuchungen an vorgeschlagenen Bohrlokationen des IODP-Bohrvorschlags 625 entlang der Transitstrecke von Wellington zum östlichen Rossmeer. Seismische Profile werden vom östlichen Rossmeer entlang des gesamten Kontinentalrandes von Marie-Byrd-Land aufgenommen, um das existierende seismische Profilnetz des Rossmeeres mit den Profilen im Amundsen- und Bellingshausenmeer für eine übergreifende Stratigraphie zu verbinden. Das Schließen dieser Datenlücke ist eine wichtige Voraussetzung zur Rekonstruktion einer zirkum-antarktischen Paläobathymetrie für paläoklimatische Simulationen. Die seismischen Daten werden in Verbindung mit helikopter-magnetischen Messflügen auch für Untersuchungen des kontinentalen Aufbruchs zwischen Neuseeland und Marie-Byrd-Land in der Spätkreide genutzt. Mit Erreichen des Hauptarbeitsgebietes im Amundsen Sea Embayment sollen die seismischen, sedimentechographischen, bathymetrischen und helikopter-magnetischen Messungen fortgesetzt werden. Kenntnisse über die Beschaffenheit und Eigenschaften der Sedimente und des Basements ergeben wichtige Parameter für die Rekonstruktion der tektonischen Entwicklung sowie der glazial-interglazialen Zyklizität von der frühesten Vereisung bis zum letzten glazialen Maximum. Das Gebiet der Pine-Island-Bucht ist bekannt für die dort seit kurzer Zeit beschleunigt stattfindenden Rückzüge der Pine-Island- und Thwaites-Gletschersysteme. Geothermische Wärmeflussmessungen sollen Einblick liefern in jüngere vulkanische Aktivitäten, die einen Einfluss auf das Fließverhalten des Eisschildes haben können. Im Amundsen Sea Embayment aber auch von anderen Lokationen des westantarktischen Kontinentalrandes werden Sedimentkerne zur Datierung und Rekonstruktion vergangener Schelfeisrückzüge gesammelt. Auch wird eine Beprobung der erst kürzlich an den Marie-Byrd-Seamounts entdeckten Tiefseekorallen stattfinden. Aufgeschlossene Gesteinsformationen entlang der Küste von Marie-Byrd-Land sollen aufgesucht werden, um Proben für die Analyse kosmogener Nuklide zu sammeln, die den Eisschildrückzug datieren helfen. Weitere Gesteinsproben werden für die Rekonstruktion der Denudations- und Hebungsgeschichte von Marie-Byrd-Land mit Hilfe von Spaltspuren-analysen genutzt. Wiederholungsmessungen an GPS-Messpunkten und die Einrichtung neuer Messpunkte auf Fels und auf den Schelfeisen entlang der Küste dienen der Bestimmung der horizontalen und vertikalen Bewegungen der Erdkruste sowie der Fließ- und Tidenbewegungen der Schelfeise.

Ozeanographische Prozesse sind mögliche Ursachen für beschleunigte Eisschild-bewegungen in der Westantarktis. Ein ozeanographisches Messprogramm mit CTD-

Messungen zielt auf die Verteilung and Einwirkung des zirkumpolaren Tiefenwassers auf dem Kontinentalschelf und im Bereich der Gletschermündungen des Amundsen Sea Embayment.

Die Methanproduktion während der Phytoplanktonblüte ist ein Prozess, der für den Südozean unzureichend verstanden ist. Wasserproben werden für Methangasanalysen gesammelt, wobei das gelöste Gas an Bord analysiert werden soll. Proben von antarktischem Phytoplankton werden genutzt, um die klimainduzierten Änderungen und die Biodiversität zu untersuchen.

Mit Hilfe eines thermographischen Systems findet ein Projekt zur Beobachtung von marinen Säugern statt. Dabei werden neu entwickelte Software-Algorithmen zur automatischen Detektion von Walen getestet.

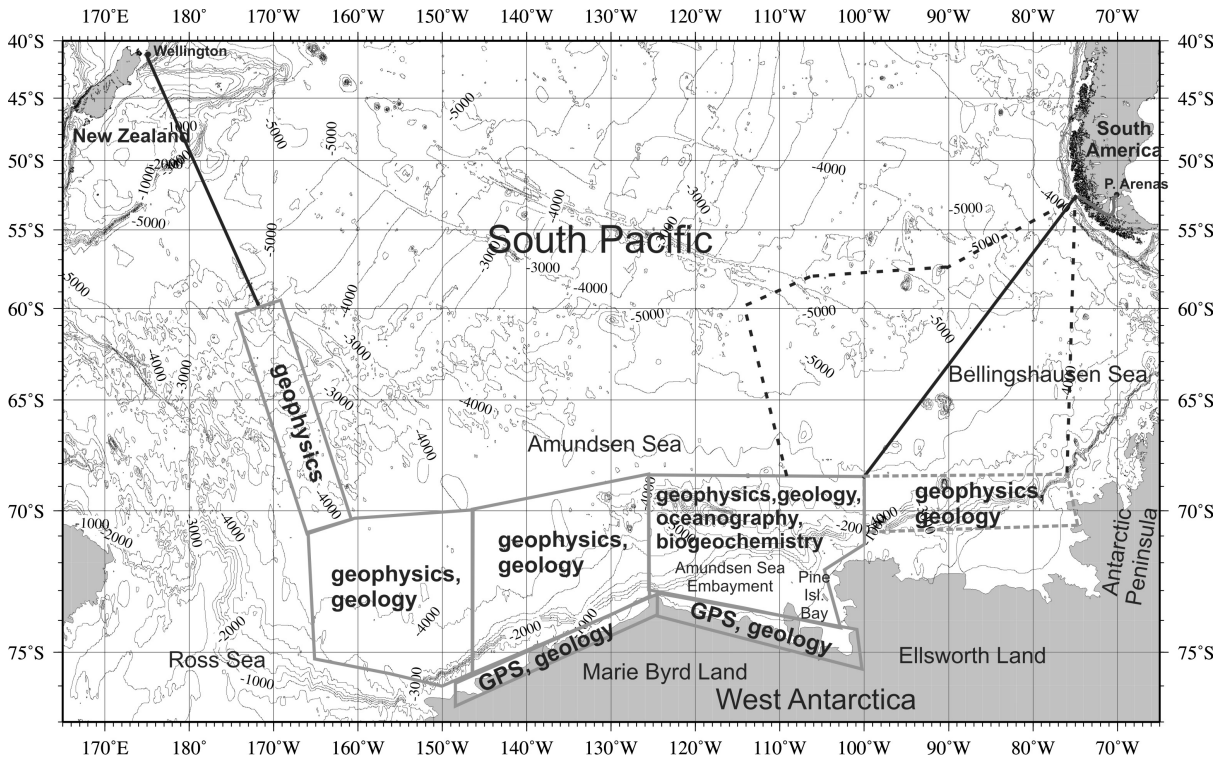

Abb. 1.1: Fahrtroute des FS Polarstern während der Expedition ANT-XXVI/3 von Wellington nach Punta Arenas. Die Hauptarbeitsgebiete im südlichen Amundsenmeer sind als grau umrandete Flächen angegeben. Hier muss die Fahrtroute abhängig von den Eisverhältnissen bestimmt werden. Gestrichelte Linien zeigen alternative Routen bzw. Arbeitsgebiete.
Fig.1. 1: Planned track of POLARSTERN during expedition ANT-XXVI/3 from Wellington to Punta Arenas. Grey-framed boxes indicate main working areas in the southern Amundsen Sea where ice conditions dictate the tracks. Hashed lines mark alternative tracks and work areas.

SUMMARY AND ITINERARY

Since the last glacial maximum, the West Antarctic Ice-Sheet (WAIS) has experienced dramatic volume changes within short periods of time. The WAIS has the potential to increase the global sea level by 3 - 5 m. Hence, studies are urgently required to show if these short-term variations can be compared to volume changes in the older and younger geological past which will provide parameters for prediction models. With this high-priority objective in mind, we will begin the cruise leg ANT-XXVI/III of *Polarstern* in Wellington (New Zealand) on 30 January 2010 and end in Punta Arenas (Chile) on 5 April 2010 (Fig. 1.1). The expedition has primarily geophysical and geological objectives with the goal to decipher the pre-glacial and glacial development of West Antarctica. An oceanographic and a biogeochemistry programme are also planned, and a marine mammal surveillance project will be conducted during the entire cruise.

The geoscientific programme will begin with a seismic pre-site survey on proposed drill sites for IODP proposal 625 on the transit from Wellington to the eastern Ross Sea. From the eastern Ross Sea and along the continental margin off Marie Byrd Land, seismic profiling will connect the existing seismic grid of the Ross Sea to the profiles in the Amundsen Sea Embayment and the Bellingshausen Sea in order to correlate the stratigraphy along the entire West Antarctic margin of the Pacific. Filling this data gap is an important prerequisite for the reconstruction of a circum-Antarctic paleobathymetry for paleoclimate simulations. The seismic data will also be used with the addition of helicopter-magnetic surveying for studies on the Late Cretaceous continental break-up between New Zealand and Marie Byrd Land. Arriving in the main working area, the Amundsen Sea Embayment, seismic and Parasound profiling, bathymetric surveying and helicopter-magnetic surveying will continue to reveal the characteristics of sediments and basement with the aim to reconstruct the tectonic history as well as the glacial-interglacial cyclicity from earliest glaciation to the last glacial maximum. The Pine Island Bay area is known for the recently accelerated retreat of the Pine Island and Thwaites Glaciers. Geothermal heat-flow measurements are expected to provide an insight into recent volcanic activities which may have an influence on ice-sheet dynamics. Cores of Quaternary sediments will be collected from the Amundsen Sea Embayment and other parts of the West Antarctic margin for analyses aimed to date past ice-shelf retreats. Recently discovered deep-sea corals will be sampled from the Marie Byrd Seamounts. Geological sampling projects at outcropping rock sites along the Marie Byrd Land coast are aimed to revealing the timing of the latest glacial retreat via cosmogenic nuclide analysis and to reconstruct the denudation and uplift history of Marie Byrd Land via fission-track analysis. Repeated and new GPS measurements on rock outcrops as well as on ice-shelves will be used to derive horizontal and vertical crustal motion and the motion and tidal behaviour of the ice-shelves.

Oceanographic processes have been debated as likely causes for accelerated ice-sheet variations in West Antarctica. An oceanographic programme with CTD casts in the Amundsen Sea Embayment is aimed to study the distribution and impact of Circumpolar Deep Water on the continental shelf and at the glacier mouths.

Methane production during the phytoplankton bloom is a process not well understood in the Southern Ocean. Water samples will be collected for methane gas analyses. The dissolved gases will be analysed on board. Samples of Antarctic phytoplankton will be used to study their climate induced changes and biodiversity.

Marine mammal surveillance will be performed using a thermal imaging device. Newly developed software algorithms will be tested for automatic detections of whales.

2. Tectonic, sedimentary and glacial processes of the Amundsen Sea Continental Margin, West Antarctica

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not participating: E. Weigelt (AWI)

Objectives

West Antarctica exhibits three geoscientific characteristics which are unique in their combination and highly significant for our understanding of the Earth system and for simulations of paleo-climate and climate/sea-level prediction scenarios: As opposed to East Antarctica, this part of the continent (1) has changed its bedrock relief through enormous tectonic change in the Cenozoic, possibly until the Quaternary, by the development of the West Antarctic Rift System (WARS) and the Marie Byrd Land dome, (2) has experienced intense magmatic and volcanic activity until recent times, and (3) has a predominantly submarine based ice sheet even after isostatic rebound adjustment of the lithosphere.

Little is known with regard to the interconnection between the topographic relief development, the West Antarctic Ice Sheet (WAIS) generation and dynamics as well as influences of volcanic/magmatic activity on ice flow behaviour. Since the last glacial maximum, the WAIS has experienced dramatic volume changes within short periods of time. Studies are urgently required to show if these short-term variations can be compared to volume changes in the older geological past.

Next to the ice drainage basins of the Weddell Sea and the Ross Embayment, Pine Island Bay within the Amundsen Sea Embayment forms the third-largest outflow area for the WAIS. The main ice streams from the WAIS into the Pine Island Bay flow through the Pine Island and Thwaites Glacier systems and have followed deeply eroded troughs on the inner to middle shelf. Most of the glacial-marine sediments have been transported onto the outer shelf of the Amundsen Sea Embayment and across the continental slope into the deep sea where they were redistributed by bottom currents. Geophysical surveys of the sedimentary sequences and the underlying basement of the shelf, slope and rise along the continental margin of Marie Byrd Land, the Amundsen Sea Embayment, Pine Island Bay will allow to decipher the tectonic, magmatic and sedimentary processes.

The aim is to reconstruct these processes in time-scales ranging from the rifting and break-up between New Zealand and West Antarctica in the Late Cretaceous to the beginning of major glaciation in the late Paleogene and Neogene and, further, to the youngest glacial cycles in the Quaternary. Accurate models of the geodynamic-magmatic and tectonic history as well as the sedimentary and glacial evolution provide important constraints for our understanding and reconstruction of the paleo-environment of West Antarctica and its impact on global sea-level variations. The following objectives will be addressed:

- Major boundaries between suspected crustal blocks and volcanic zones in Pine Island Bay have been proposed by various researchers without available data to prove their existence. The glacier troughs and Pine Island Bay itself are thought to have developed along such tectonic boundaries. Heli-magnetic, gravimetric and deep crustal seismic (reflection and refraction/wide-angle) surveys in the Pine Island Bay area will provide the necessary data base to map these boundaries and to derive models that link tectonic lineations to preferential sedimentary and ice stream transport paths.

- During and after separation from the Chatham Rise and Campbell Plateau (New Zealand), the continental margin of Marie Byrd Land developed as a rifted margin, probably accompanied by intensive volcanism in some parts. The question is whether this volcanism occurred mainly during the rifting process or during post-rift phases, or whether it developed in relation to the West Antarctic rift system. Helicopter-magnetic mapping and deep crustal seismic profiling of the continental margin of Marie Byrd Land will provide data to develop models of the magmatic evolution.
- Causes for the accelerated retreat of the Pine Island and Thwaites Glaciers are currently being debated. In addition to the influx of warm Antarctic Deep Water into the deep troughs of the Pine Island Bay shelf towards the grounding lines of the glaciers, increased heat flow can be considered to have an additional effect on the sensitivity of this part of the West Antarctic Ice Sheet. Recent volcanism has been identified in the area of the Hudson Mts. Heat flow measurements in sediments of the inner and middle shelf in the vicinity of the Hudson Mts. may provide a first estimate on the local geothermal heat flux.
- Sedimentary sequences across the shelf, slope and the continental rise contain archives for patterns of pre-glacial/glacial erosional and depositional processes as well as paleo-ocean current systems. Seismic reflection profiles, sub-bottom profiling (Parasound) and multibeam bathymetry (Hydrosweep) are datasets used to derive reconstructions of pre-glacial and glacial sedimentation processes and to derive constraints for glacial-interglacial cyclicity. The data will be used to prepare a shallow drilling (MeBo or SHALDRIL) proposal for the Amundsen Sea Embayment.
- Reconstructing paleoceanographic and palaeoclimate scenarios are restricted by the lack of realistic paleobathymetric models of the Southern Ocean. Within the international project *Circum-Antarctic Stratigraphy and Paleobathymetry* (CASP), the seismic data base is being evaluated for a unified circum-Antarctic stratigraphy. It is planned on this cruise to fill a major gap of continuous seismic coverage in the western Amundsen Sea in order to correlate the stratigraphy from the Ross Sea to the Amundsen and Bellingshausen Sea.
- Seismic pre-site surveys will be conducted in the southwestern Pacific on drill sites proposed in the paleoceanographic IODP proposal No. 625 by Gersonde et al. (see ANT-XXVI/2).

Work at sea

- Deep crustal seismic refraction/wide-angle reflection recordings will be performed along two profiles across the continent-ocean transition of the Marie Byrd Land margin and along one profile in the inner Pine Island Bay across a postulated crustal suture. Up to 15 ocean-bottom seismometers (OBS) will be deployed per profile. Exact profile locations will be selected during the cruise, depending on sea-ice distribution.
- Seismic reflection profiling will be conducted along the continental margin on the shelf and slope as well as in the deep sea from the eastern Ross Sea to the Amundsen Sea Embayment. Profiling will be densified and added in the Amundsen Sea Embayment to complement the first few multichannel profiles collected during ANT-XXIII/4 in 2006. Exact profile locations will be selected during the cruise, depending on sea-ice distribution. In addition, seismic pre-site surveys will be conducted on four proposed IODP drill sites on the transit from Wellington to the eastern Ross Sea.

- Swath-bathymetric surveying and sub-bottom profiling will accompany all seismic and other tracks. Additional data will be collected along glacial troughs on the shelf.
- Magnetic data will be collected using a three-component fluxgate magnetometer as well as the helicopter-towed caesium-vapour aeromagnetic sensor system. Heli-mag surveys will be performed at selected locations along the shiptrack on oceanic crust (mapping of seafloor spreading anomalies) and on the shelf of the Amundsen Sea Embayment to complement the first magnetic survey grid of ANT-XXIII/4 in 2006.
- Geothermal heat flow measurements will be conducted on the shelf of the Amundsen Sea Embayment, in particular in the inner Pine Island Bay close to the volcanic Hudson Mountains, using heat-flow sensors of the University of Bremen.
- Gravity data will be continuously collected using the ship's gravity meter.

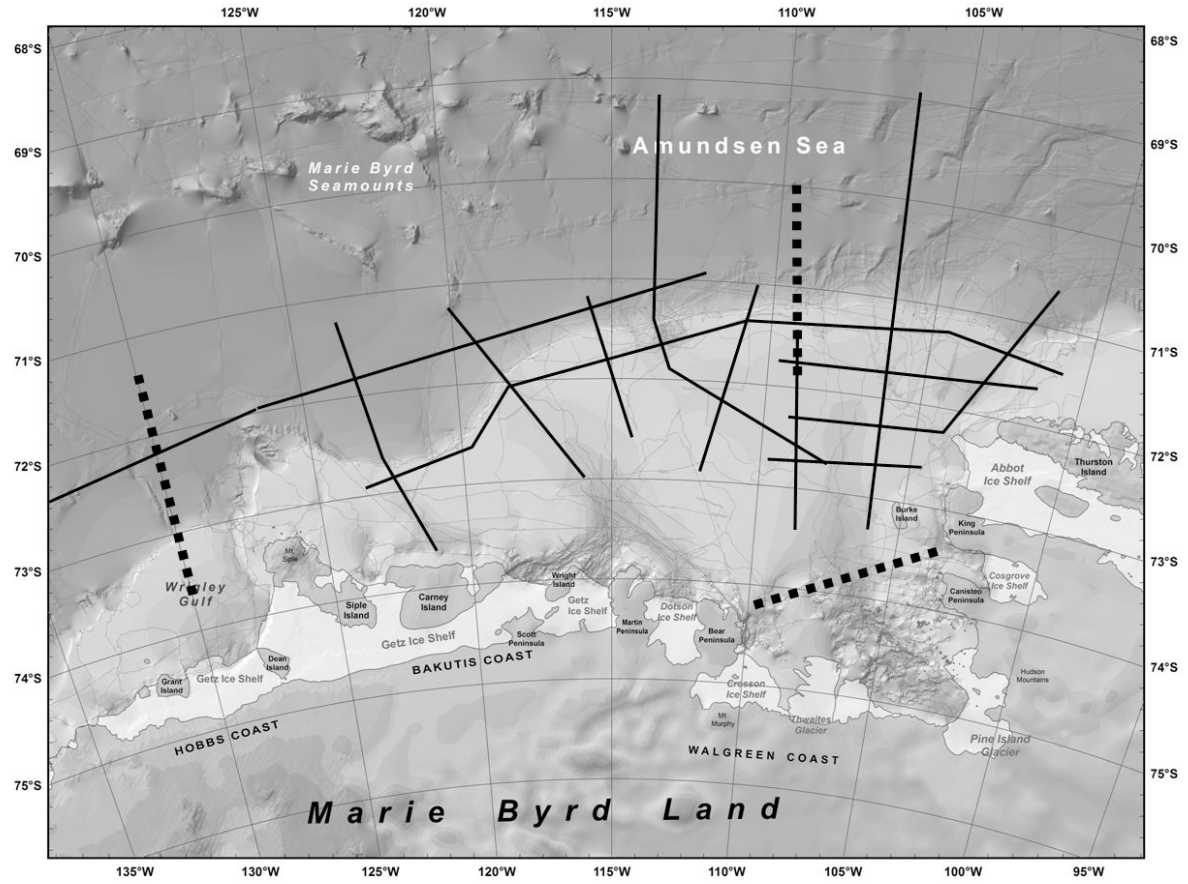

Fig. 2.1: Bathymetric map of the Amundsen Sea Embayment with planned multichannel seismic reflection profiles (solid lines) and deep crustal refraction profiles with OBS deployments (dotted lines). The exact profile locations depend on sea-ice distribution

3. WEST ANTARCTIC CONTINENTAL MARGIN SEDIMENTS AS RECORDERS OF VARIABILITY OF THE WEST ANTARCTIC ICE SHEET AND PALAEOCLIMATIC CHANGES DURING THE QUATERNARY

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not participating: R.D. Larter (BAS)

Objectives

The collapse of the West Antarctic Ice Sheet (WAIS) would result in a global sea-level rise between 3.3 and 5.0 m. At present it is not clear to what extent current retreat of WAIS grounding lines observed in the Amundsen Sea Embayment (ASE), in particular in Pine Island Bay, is part of ongoing recession that started before ca. 14.5 ka or if it reflects more recent climatic changes. During cruise ANT-XXIII/4 with *Polarstern* in 2006 and cruises JR141 and JR179 with RRS *James Clark Ross* in 2006 and 2008, respectively, AWI and BAS collected extensive marine geological and geophysical data sets from the ASE and the adjacent continental margin. Primary aims of this work were reconstruction of the poorly known deglaciation history in this sector of West Antarctica since the Last Glacial Maximum (LGM) and finding evidence of a possible WAIS collapse during the Quaternary. Thus far, geophysical results from these expeditions have revealed grounded ice advance to the shelf break in the ASE at the LGM and a complex pattern of glacial bedforms on the shelf, which results from variabilities in subglacial substrate, basal ice conditions and ice-flow rate. Results from marine sediment cores have shown that the inner shelf in the western ASE deglaciated before ca. 13 ka and that some of the meltwater channels there pre-date the last WAIS advance. Work on an older sediment core, which was collected by *Polarstern* from the continental rise offshore from Pine Island Bay in 2001, revealed a depositional anomaly from ca. 620 - 480 ka that might be related to a Mid-Quaternary collapse of the WAIS. Work on the data sets collected in 2006 and 2008 is ongoing, and the results constraining post-LGM grounding-line retreat in the ASE will be coupled with glaciological models to improve understanding of the stability and climate sensitivity of the WAIS. Nevertheless, some crucial gaps in the geographical coverage of the ASE shelf with geomorphological data and sediment cores that fully penetrated the post-LGM sediments have become obvious. Here, we propose to collect marine geological and geophysical data for closing these gaps in the ASE and to collect new data from the easternmost Ross Sea shelf and the Marie Byrd Land shelf to determine:

1) The LGM extent of the WAIS between the easternmost Ross Sea and Pine Island Bay,
2) the extent of fast ice flow in the former WAIS, and controls on the location and onset position of fast ice flow,
3) the post-LGM retreat history of the WAIS,
4) the timing and forcing of a possible WAIS collapse during the Quaternary.

During cruise ANT-XXIII/4, several dredges deployed on the Marie Byrd Seamounts unexpectedly recovered fossil deep-sea corals. Dating of some of the corals has shown that some lived during the last glacial period. Therefore, suitable geochemical analyses on these corals (e.g. U/Th-series and AMS ^{14}C dating) have the potential to reveal the ventilation age

of the deep Southern Ocean during the LGM. We propose to collect additional coral material from the Marie Byrd Seamounts to determine:

5) Whether the deep Southern Ocean south of the Antarctic Polar Front was a major global CO_2-sink during the LGM.

In case that *Polarstern* has to supply the base Jubany on King George Island at the end of cruise ANT-XXVI/3, we furthermore propose to collect geophysical data and sediment cores from Maxwell Bay and the shelf area of the former Wilkins Ice Shelf to investigate:

6) The Holocene climate history of King George Island and its relation to the warming of the Antarctic Peninsula over the past 50 years,

7) the history of the Wilkins Ice Shelf in order to determine, if its collapse in 2008 and 2009 is unprecedented during the Holocene.

Work at sea

Objectives 1-3

We propose to collect Hydrosweep and Parasound data from the West Antarctic continental shelf and slope between 155°W and 100°W. These data will show the extent of glacial morphological features, in particular the presence of cross-shelf troughs marking the palaeo-pathways of ice streams, and the distribution and thickness of till sheets left behind during the last deglaciation. We will combine the new data with existing data sets from the continental shelf offshore from Marie Byrd Land and in the ASE. According to Wellner et al. (2001), the only palaeo-ice stream troughs between the Ross Sea and the ASE are Sulzberger Bay Trough (SBT; ca. 155-152°W) and Wrigley Gulf Trough (WGT; ca. 130-128°W). Only sparse information comprising a few multi-beam tracks (which suggest WAIS advance to near the shelf edge), a short seismic profile (which shows the transition from crystalline basement to sedimentary substrate on the inner shelf) and a few radiocarbon dates obtained from two sediment cores (which suggest deglaciation of the inner shelf before ca 12.9 corrected ^{14}C ka) have been published for WGT. We propose the systematic swath-mapping of subglacial beforms along one of the troughs (probably WGT, as SBT may be located too far to the west) and the collection of gravity and box cores along a transect from the shelf break to the coast (at least 6 sites) for reconstructing the timing of WAIS-retreat since the LGM. Further targets for Hydrosweep and Parasound mapping are the middle-shelf in the ASE (ca. 118-106°W) for closing gaps in the corresponding data sets of the Dotson-Getz Trough (DGT) and for investigating the possible connection between an outer shelf trough at 113.5°W and the Pine Island Trough (PIT). Additionally, we propose to combine new multibeam data with existing swath data along the axis of PIT. As further targets for sediment cores we propose at least three sites identified on non-iceberg scoured parts of the middle to outer shelf of DGT, at least three sites in non-iceberg scoured areas on the outer shelf and middle shelf between 113.5°W and PIT, up to eight sites in front of and on the backslope of four grounding-zone wedges mapped in PIT, one site on the innermost shelf directly in front of Pine Island Glacier and one site on the inner shelf north of the Getz B Ice Shelf, where swath data show the onset of glacial lineations.

Objective 4

We propose to recover undisturbed Quaternary sedimentary sequences from the West Antarctic continental margin by piston coring and to collect undisturbed seafloor sediments using a multiple corer. We will target locations at water depths as shallow as 2,500 - 1,500 m, because these locations offer a better chance of carbonate preservation. The presence of calcareous foraminifera in the sediments will allow the application of oxygen

isotope stratigraphy for dating the sequences, which we will investigate for signs of a possible WAIS collapse in the past.

Objective 5

We propose to collect deep-sea corals from various locations on the Haxby Seamount and the Miller Seamount at water depths from 2,500 m to 2,000 m and from 2,000 m to 1,500 m. We will use a bottom-grab with video system (if available) or the AWI rock dredge for collecting the coral specimens.

Objective 6

We propose to collect gravity/piston cores in conjunction with box cores (at least 3 sites) from Maxwell Bay and other fjords in King George Island for recovering high-resolution marine sedimentary records of the Holocene climatic and oceanographic history of this region.

Objective 7

We propose to collect gravity cores in conjunction with box cores (at least three sites) from the shelf formerly covered by the Wilkins Ice Shelf (northwest of Alexander Island) for testing the hypothesis, whether the collapse of the Wilkins Ice Shelf in 2008 and 2009 was unprecedented during the Holocene. We will also use a multiple corer to obtain undisturbed sea-floor sediments, including material deposited during and since the ice shelf collapse.

Seafloor mapping will be carried out with the Atlas HYDROSWEEP DS-2 system and the Atlas PARASOUND DS-3 acoustic sub-bottom profiler. Sediment cores (up to 30 m long) will be recovered with piston and gravity corers and undisturbed samples from the seabed surface will be collected with giant box and multiple corers. The coral specimens will be collected with a Van-Veen grab (with video system) and/or a rock dredge.

Reference

Wellner, J.S., Lowe, A.L., Shipp, S.S. & Anderson, J.B. (2001). Distribution of glacial geomorphic features on the Antarctic continental shelf and correlation with substrate: Implications for ice behaviour. J. Glaciol. 47, 397-411.

4. GPS OBSERVATIONS IN WEST ANTARCTICA FOR THE DETERMINATION OF VERTICAL AND HORIZONTAL DEFORMATIONS OF THE EARTH'S CRUST AND FOR THE INVESTIGATION OF THE TIDAL DYNAMICS OF ICE SHELVES

M. Scheinert, R. Rosenau (TU Dresden)
not participating: R. Dietrich (TU Dresden)

Objectives

In order to deepen the knowledge on the glacial history and on the tectonic state of Antarctica it is important to investigate recent movements respectively deformations of the Earth's crust. It still makes sense to discuss East Antarctica and West Antarctica separately, e.g. with regard to a coherent pattern of plate tectonics. An interpretation on basis of the observations to be carried out will help to discriminate possible recent horizontal deformations. Vertical deformations can be caused by changing ice loads – yet connected with glacial history and with recent ice mass changes – or can be of tectonic origin, which still

has to be investigated. West Antarctica shows larger changes of its (marine based) ice sheet, which leads to an expectation of vertical deformations up to ten times larger than in East Antarctica. Especially the anticipated working area of the Pine Island Bay features the largest mass imbalance in entire Antarctica. The large outlet glaciers Pine Island Glacier and Thwaites Glacier show significant variations in their flow regime as well as in the ice mass changes. Nevertheless, they feature a negative mass imbalance, which causes significant vertical deformations. Altogether, the viscoelastic effect due to the glacial history and the elastic effect due to the recent ice mass changes may sum up to a vertical uplift in the level of 10 mm/year.

None or only a few GPS stations on bedrock exist in the extended working region of the ANT-XXVI/3 cruise (90°W to 150°W) respectively in entire West Antarctica. During the ANT-XXIII/4 cruise of *Polarstern*, the TUD Group set up four stations on bedrock in the Pine Island Bay region. These stations shall be re-occupied, and from the repeated observations statements on the horizontal and vertical movements can be inferred.

Furthermore, ice shelves and outlet glaciers, respectively, shall be investigated with regard to their motion and flow regime. The largest impact is excited by ocean tides, which the floating ice follows immediately by 100 % (depart of a small-scale region at the grounding zone). Realizing direct GPS observations of the floating ice the tidal dynamics can be investigated. Combining these observations with analyses of remote sensing data (ICESat laser data, Feature Tracking and/or SAR interferometry of optical and microwave data) the flow regime of the outlet glaciers and ice shelves will be determined. For this goal, we will also concentrate on the Pine Island Bay region and will also make use of observations already carried out in 2006.

The satellite based geodetic positioning by means of GPS allows for a precise determination of positions and – carrying out permanent or repeated observations – for a determination of motions. Stations on bedrock are realized in such a way that the marker is stable and that a high accuracy of the positioning (subcentimeter level) is possible. In the postprocessing precise coordinates and – comparing the different epochs – precise coordinate changes can be determined. For the stations on floating ice a precise kinematic positioning will be carried out, allowing to infer time series of horizontal and vertical coordinates.

Work on land

All locations will be reached by helicopter. The four stations on bedrock already observed in 2006 will be re-occupied. Additionally, new stations shall be set up. They will be chosen in such a way to find an optimum position due to exposure, geological conditions and free visibility over the horizon. The GPS equipment will be set up and remain at each location to observe permanently for 5 to 10 days at least. Stations on ice (ice shelf and outlet glaciers) will be re-occupied or set up for the first time. For up to eight locations already observed 2006 we aim to carry out observations of a longer duration to get more reliable time series. A close coordination with the activities of the other groups operating on land is anticipated in order to realize the works in an economic way.

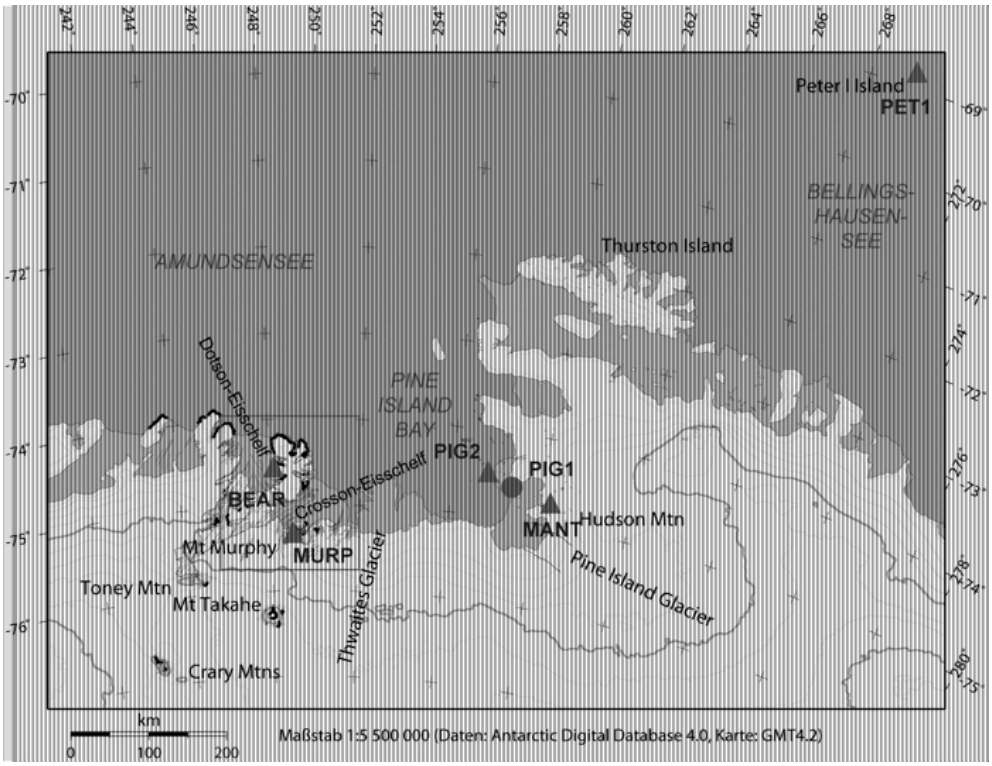

Fig. 4.1: Overview map of the area of interest focuses on the coastal parts of Pine Island Bay and Amundsen Sea. The GPS stations already observed 2006 are stations on bedrock (triangle) and on floating ice (circle). Further stations on floating ice are concentrated at Crosson and Dotson ice shelves (box, for details see Fig. 4.2). The station PET1 (Peter I Island), observed 1998 and 2006, will not be observed during the ANT-XXVI/3 cruise.

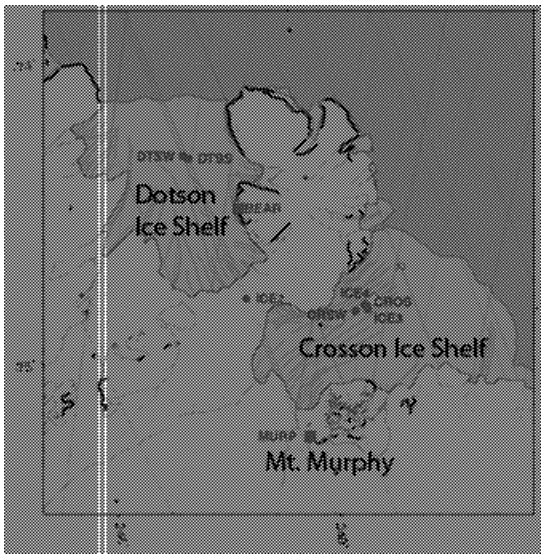

Fig. 4.2: Detailed map of Dotson and Crosson ice shelves. For explanations see Fig. 4.1

Tab. 4.1: Approximate coordinates of the bedrock stations (cf. Fig. 1)

Station	Latitude	Longitude	Height
PET1	-68°51'49"	-90°25'34"	32.4 m
MURP	-75°22'09"	-111°17'39"	656.8 m
BEAR	-74°24'44"	-111°53'16"	439.0 m
MANT	-74°46'45"	-99°22'05"	467.1 m
PIG2	-74°30'40"	-102°26'22"	15.4 m

5. COUPLING OF LITHOSPHERE GEODYNAMICS, SURFACE PROCESSES AND ICE SHEET EVOLUTION – CONSTRAINTS FROM MARIE BYRD LAND, WEST ANTARCTICA

C. Spiegel, J. Lindow (University Bremen), K. Gohl (AWI)
not participating: F. Lisker (University Bremen)

Objectives

The superimposed goal of this project is to gain a deeper understanding of the relation between ice sheet evolution and the geodynamic evolution of the underlying bedrock. Marie Byrd Land is an ideal place for such a study, because it is one of the geodynamically most active areas of Antarctica, situated within an active rift system with recent volcanism and comprising of an uprising dome structure. This geodynamically active crust forms the bedrock of one of the world largest ice sheets, which is currently in a state of rapid retreat.

Because information on both, long-term ice sheet evolution and geodynamic evolution are scarce for Marie Byrd Land, we are planning to generate two data sets for this project; one deciphering the geodynamic evolution based on a combination of low temperature thermochronology (fission track and (U-Th)/He analysis) with geophysical studies (deep crustal seismics, magnetics, gravity, geothermal heat flow, GPS); the other data set will be dealing with the millennium-scale evolution of the West Antarctic ice sheet based on cosmogenic nuclide analysis (^{10}Be, ^{26}Al). Thermochronology (zircon fission track, apatite fission track and apatite (U-Th)/He analysis) provides cooling paths through the upper ~10 km of the earth´s crust, thus recording movements, tectonic activity and erosion of the shallow crust and close to the surface, within the area of relief formation. Geophysical studies, on the other hand, provide data on the structure and thermal state and current crustal motion of the lithosphere. Finally, cosmogenic nuclide analysis yields exposure ages (assuming that erosion is negligible) and can thus be used for dating the age of bedrock exposure following glacial retreat.

The following aims / questions will be addressed by our project:

1. What is the surface expression of deeper lithospheric or mantle processes such as rifting, crustal extension, hot spot activity, and large-scale faulting? For this, we plan to combine geophysical and thermochronological data. The application of thermochronological dating methods will also provide a temporal framework for processes revealed by geophysical data.
2. Can we better define the temporal evolution of rifting in the West Antarctic Rift System? Based on apatite fission track ages and structural data, Storti et al. (2008) described the onset of oblique rifting in the West Antarctic Rift System at about 50 Ma. From thermal history modelling, they also suggest an earlier rifting period during the Early Cretaceous but emphasize that this interpretation is associated with high uncertainties. We will try to confirm and / or refine this rifting history by adding zircon fission track and apatite (U-Th)/He, thus providing constraints on the pre-Cenozoic as well as the late Cenozoic history of the West Antarctic Rift System.
3. Constraining the exhumation and erosion history of Marie Byrd Land and particularly of the Marie Byrd Land Dome. This topic is particularly relevant for our superimposed question of interrelations between ice sheet and lithosphere dynamics, because (i) exhumation and erosion usually changes topography, which in turn influences glacier movements by slope steepness, (ii) exhumation is often associated with surface uplift, and higher elevations generally favour formation of glaciers, as it has also been suggested for the uplift of the Transantarctic Mountains (Van der Wateren and Cloething, 1999), and (iii) exhumation and erosion do not only influence glaciation, but it is also the other way round: Because glaciation is a very effective mechanism for erosion, it can be expected that onset of glaciation and changes in the style of glaciation will directly change erosion rates, and, due to isostatic adjustment, also exhumation rates. In this respect, we also want to test the idea of Rocchi et al. (2006) who observed a change of erosion efficiency at ~15 Ma and ascribed that to a change from warm-based to cold-based glaciation in Marie Byrd Land. For addressing this topic, we plan to collect land samples using helicopter support and detrital samples from seafloor sediments retrieved by coring.
4. How did the geothermal gradient of Marie Byrd Land evolve through the geological past? This question is again of major importance for the relation of geodynamic and glacial processes, because the geothermal gradient affects the extent of basal melting and thus the availability of free subglacial water and the mobility of the glacier. Furthermore, it is relevant for understanding the history of crustal extension, rifting, and potential plume activity in Marie Byrd Land. Since we want to cover the time period of West Antarctic glaciation (i.e., ~Oligocene to the present), emphasize is again on apatite (U-Th)/He thermochronology, combined with apatite fission track thermochronology. These methods will be applied on samples collected from elevation profiles, i.e. from samples situated at different crustal levels prior to cooling. The paleo-geothermal gradient can be calculated by plotting the modelled temperatures at a given point in the geological past against the present-day sample elevations. The reconstructed paleo-geothermal gradient will be compared with the present geothermal gradient derived from heat-flow measurements in shelf sediments conducted during the ANT-XXVI/3 expedition in early 2010 as a test experiment. If these measurements are successful, they will provide us with trends for the present geothermal state of the Amundsen Sea Embayment and a strong boundary condition for modelling the basal ice-sheet conditions in this region.
5. When was the last glacial maximum, what was the maximum ice thickness, and how fast did individual glaciers retreat? These questions will be addressed by using cosmogenic nuclide analysis. Data exist so far from the Ford Ranges (close to the

Ross Sea), and from the Pine Island Bay area (Amundsen Sea sector). The relation between exposure age and present-day sample elevation gives a direct measure for the progressive exposure of bedrocks and thus for the rate of glacial retreat. Particularly by sampling higher elevated peaks we will be able to better constrain maximum ice thickness and the age of the last glacial maximum. Samples for cosmogenic nuclide analysis will be collected from the same sites as samples for thermochronological analysis (both methods use age-elevation relations), so that the two data sets can be directly related to each other. Joanne Johnson from the British Antarctic Survey, or a colleague of her, will also participate in the *Polarstern* cruise for collecting samples for exposure age dating. Thus, by a combined and coordinated sampling effort we will be able to much improve the data coverage for Marie Byrd Land in terms of the glaciation history.

Work on land

For the fieldwork, we will rely on helicopter support. Samples will be collected from exposed bedrock and erratic boulders along the coast of Marie Byrd Land. Exact sample location will depend on ice and weather conditions and helicopter availability. The fieldwork will be carried out in cooperation with the group of the British Antarctic Survey (Joanne Johnson or colleagues) and the geodetic group from the University of Dresden (Heiko Ewert and Ralf Rosenau). Sampling will focus on elevation profiles, as these are the basis for deducing glacial thinning rates as well as exhumation rates.

Expected results

- Key new data on the long-term (Ma) geodynamic evolution of Marie Byrd Land and the West Antarctic Rift System.
- Key new data on long-term (ka) glacial dynamics of the West Antarctic ice sheet, which will be compared with present-day glacial retreat rates deduced from satellite data.
- A deeper understanding of coupling and feedback mechanisms between lithosphere and ice sheet dynamics.
- Providing new benchmarks for future deglaciation models.

6. ASSESSING TIMING OF DEGLACIATION OF THE WEST ANTARCTIC ICE SHEET ALONG THE BAKUTIS COAST OF MARIE BYRD LAND

J. Smith, I. McNab (BAS)
not participating: J. Johnson (BAS)

Objectives

Some parts of the Antarctic ice sheet are currently showing considerable rates of change. For example, the Pine Island and Thwaites glaciers exhibit the most rapid elevation change/ice thinning and grounding-line retreat in Antarctica. It has been suggested that this area may be the most likely site for the initiation of collapse of the two million km^2 West Antarctic Ice Sheet (WAIS), which would result in a global sea-level rise of 5 to 6 m. We are beginning to understand the history of deglaciation in that sector of the WAIS, but as yet, we

know very little about past rates of change in other parts of the WAIS, e.g. the Bakutis Coast of Marie Byrd Land (MBL). The Bakutis Coast is of interest because recent radar altimetry and laser altimetry data demonstrate that modern rates of change are as rapid there as they are in the Pine Island and Thwaites Glacier catchments of the WAIS. We therefore need to study past rates of change there in order to put the recent changes into a longer-term context, and to compare the rates of change in different parts of the WAIS.

During ANT-XXIII/4 in 2006, Joanne Johnson collected samples for cosmogenic surface exposure dating from the Pine Island Bay region and the coast of eastern Marie Byrd Land. During ANT-XXVI/3, we aim to extend this dataset further west along the Bakutis coast of MBL, to assess past ice-sheet thinning rates there. We will collect rock samples for cosmogenic surface exposure dating from glacial erratics and bedrock surfaces. Nunataks will be sampled along altitudinal transects, to construct an age versus elevation record that will be used to constrain the vertical thinning of the WAIS through time. At coastal sites we will verify an intriguing result from ANT-XXIII/4, which suggests that rock at Hunt Bluff (Bear Peninsula) was ice-free during the last glacial period. This, and potentially other sites, may therefore have acted as biological refugia. We plan to combine our terrestrial data with marine geological data collected offshore from the Dotson and Getz Ice Shelves in 2006 during ANT-XXIII/4 and on the British Antarctic Survey RV *James C. Ross* cruise JR141.

Work plan

We plan to collect samples from rock exposures along the Bakutis Coast of Marie Byrd Land. We will concentrate our efforts on the region east of approximately 115°W, collaborating with Cornelia Spiegel's group (who will concentrate on the region west of this) in order to obtain as wide a spatial distribution as possible. The most suitable sites for our work are Mt Murphy, Bear Peninsula and the Kohler Range (e.g. Mt Meunier). Helicopter support will also be shared with that of the GPS programme of Reinhard Dietrich, who assisted our work on ANT XXIII/4 by sharing invaluable altitude measurements. In addition to the sampling for cosmogenic surface exposure dating, we will look for ancient deposits of snow petrel vomit ('mumiyo'), which can be dated with radiocarbon, and which could also indicate when nunataks became ice-free.

7. CIRCUMPOLAR DEEP WATER (CDW) VARIABILITY AND WEST ANTARCTIC ICE SHELF (WAIS) MELTING ON THE AMUNDSEN

M. Schröder, R. Timmermann, A. Wisotzki, L. Sellmann, S. Brunnabend (AWI)
not participating: H. Hellmer (AWI)

Objectives

This oceanographic project has three main objectives:

- Determination of CDW routes and properties from the continental slope to the ice shelf fronts fringing the Amundsen Sea.
- Measurement of shelf water characteristics to detect freshwater input due to ice shelf basal melting.
- Extension of collaborations with international colleagues who investigate the ocean's role in the mass loss of WAIS.

The WAIS community outlined a study plan in 2002, emphasizing the need for better information about the ocean circulation, ice thickness, sea floor morphology, and atmospheric forcing, along with improved numerical modelling of WAIS interactions with its surroundings. For the Amundsen Sea it is entirely plausible that ocean influence on the WAIS could increase from changes in ocean temperature, heat transport and vertical thermohaline structure, in response to altered atmospheric forcing, sea ice production on the continental shelf, and ice shelf morphology.

The first oceanographic stations occupied on the Amundsen continental shelf in 1994 have since been supplemented by late summer measurements in 2000, 2003, 2006, 2007, and 2008. This work has revealed that the 'warm,' salty CDW gains access to the continental shelf near the sea floor, particularly in the eastern sector, and ponds in glacially scoured troughs that extend deep beneath the ice shelves (Fig. 7.1). Where the ice shelves have deep grounding zones, they can be exposed to seawater more than 4°C above the *in-situ* melting point. This drives basal ice shelf melting orders of magnitude faster than beneath the large ice shelves of the Weddell and Ross Seas. Substantial thermohaline variability is apparent in some of the repeated late summer observations, but little is yet known about the seasonal cycle or interannual variability. Also lacking is information about the strength of the ocean circulation, heat transport to the ice shelf caverns, and how efficiently that heat is used for basal melting. Ocean warming documented at distant locations like the Antarctic Circumpolar Current (ACC) may be transmitted directly to the exposed glacial ice, or weakened in mixing across the Antarctic Slope Front. Heat transport from the continental shelf break to the ice shelf caverns may also be influenced by mixing over the rough bottom topography, tidal currents, winds, sea ice production, icebergs, and melt water impacts on the pycnocline.

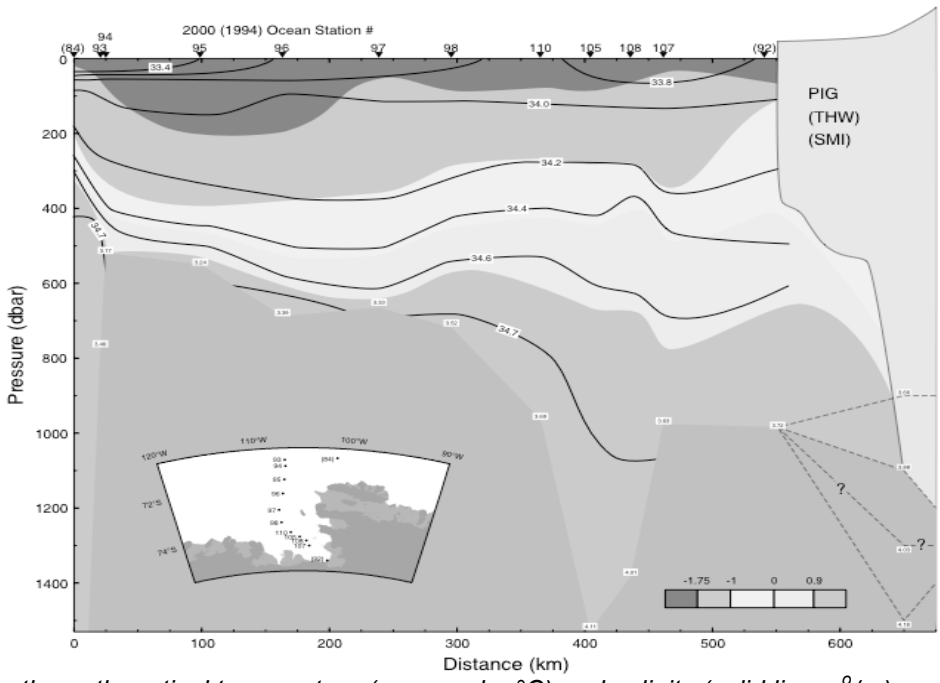

Fig. 7.1: North-south vertical temperature (grey-scale, °C) and salinity (solid lines, °/oo) section across the eastern Amundsen continental shelf, from ocean stations occupied in mid-March 1994 and 2000. Temperature ranges are arbitrarily extended into the Pine Island Glacier (PIG) cavity, an analogue here for cavities under the Thwaites (THW) and the Crosson Ice Shelf fed by Smith Glacier (SMI). The sea floor configuration under the Amundsen Ice Shelves is unknown but it will influence access of the deepest, warmest water to the grounding zones. Pressure (dbar) ~ depth (m).

Work at sea

The potential siting of CTD and helo-CTD casts in combination with water sampling during ANT-XXVI/3 will be based on the latest bathymetry chart of the Amundsen Sea and the station locations of previous cruises to the eastern Amundsen Sea. In particular, the sea ice cover and the mooring sites of RV *N.B. Palmer* cruise NBP09-01 will likely influence the final station distribution. However, our intention is to align stations across the continental shelf break and the two glacially scoured, north-south oriented troughs on the continental shelf (Fig. 7.2) to investigate the local and large-scale controls on CDW access to the continental shelf, and the sensible ocean heat reservoirs available to the ice shelf caverns. Due to unpredictable sea ice conditions, the area of interest is divided along ~110°W into sector A (Greater Pine Island Bay) and sector B (Dotson Trough). Since A is the prime target area, it contains the majority (54) of the total of 93 planned ship stations, plus additional helicopter-CTD stations concentrated along the ice shelf fronts where fast ice blocks access to narrow polynyas.

We plan to conduct several (depending on sea ice conditions) transects across the two main glacially scoured, north-south oriented troughs on the eastern Amundsen Sea continental shelf at ~105°W (Pine Island Bay) and ~115°W (Dotson), extending from the continental shelf break (72-74°S) to the fronts of Pine Island Glacier, and Crosson and Dotson Ice Shelves ~74°S. An unnamed bank at ~110°W between both troughs serves as border of sectors A and B. Sea ice conditions might permit a sampling only in sector B or a mixture of A and B. In addition, the transects may allow for a re-occupation of earlier CTD stations and the recovery/turn-around of moored instruments deployed during NBP09-01.

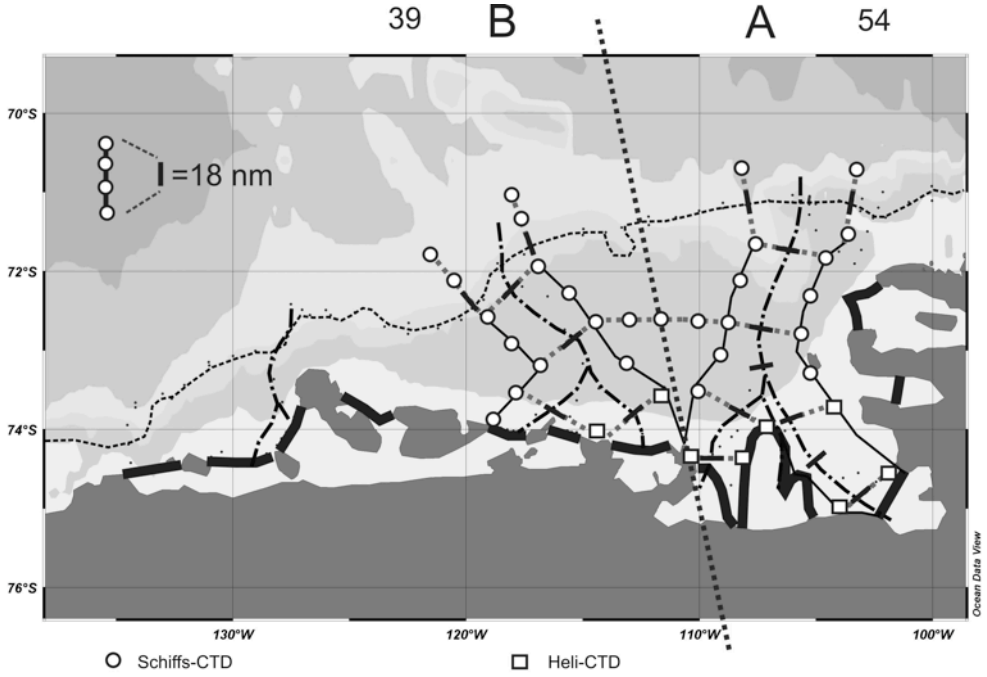

Fig. 7.2: Oceanographic working area on the eastern Amundsen Sea continental shelf divided in sector A and B. Shown are the coast , ice shelf fronts (thick solid lines), the shelf break (dashed thin lines), the orientation of the main troughs (dash dotted lines), station locations of cruise NBP07-02 (dots), and proposed section locations (solid lines) across the troughs. Each section represents a line of 18 nm with 4 CTD stations (as shown on the upper left) to guarantee a distance of 6 nm across the troughs. In addition, numerous helicopter CTD stations will be done in front of the southern ice shelves (squares). Numbers on top of the figure denote approx. station numbers for plan A (first priority) and plan B (alternative) depending on ice conditions.

Expected results

The experiment represents an important contribution to the long-term monitoring of CDW characteristics on the Amundsen Sea continental shelf and the freshwater input due to ice shelf basal melting, continuously conducted by colleagues in the US (LDEO) and UK (BAS), as part of the international ASEP (**A**mundsen **S**ea **E**mbayment **P**roject) and the WAIS initiative. It also provides additional hydrographic data for the validation of the coupled ice-ocean global finite element model FESOM focused on the Southern Ocean as part of AWI's research programme PACES (T1WP1.1 - Impact of Ice Sheets on the Earth System) and the EU (FP7- ENV.2008.1.1.1.1) project ICE2SEA - Estimating the Future Contribution of Continental Ice to Sea-Level Rise. The latter represents a cooperation with 22 European partners, representing various glaciological disciplines, all interested in the prediction of global sea level rise in a warmer climate.

8. INVESTIGATION OF METHANE IN-SITU PRODUCTION IN SURFACE WATER DURING THE PHYTOPLANKTON BLOOM IN THE SOUTHERN OCEAN

E. Damm, E. Lichte, C. Cychon (AWI)

Objectives

A methane surplus relative to the atmospheric equilibrium concentration is a persistent feature of most ocean surface water. Although it is evident that microbial *in-situ* methane production within the photic zone generates this super-saturation, the mechanism of methanogenesis remains poorly understood.

Methanogens may form methane via various pathways commonly classified with respect to the type of carbon precursor utilized, e.g. the methylothrophic pathway indicates the intact conversion of a methyl group to methane. Hence a principal pathway by which methane can be formed is methylotrophic methanogenesis. The contribution of methylated substrates is potentially large in the surface ocean, however, the direct evidence of the link between degradation of methylated substrates and production of the greenhouse gas methane is still lacking.

DMSP (dimethylsulfoniopropionate) is an abundant methylated substrate and large amounts are produced annually by marine phytoplankton. Its turnover plays a significant role in carbon and sulphur cycling in the surface ocean. DMSP degradation occurs via a demethylation pathway and a cleavage pathway. Cleavage of DMSP can be carried out by bacteria or by phytoplankton, and leads to formation of DMS (dimethylsulfide). DMS partly escapes to the atmosphere where it is oxidized to sulphuric acid and methanesulfonic acid. These sulphur-containing aerosols serve as cloud condensation nuclei altering the global radiation budget. Thus DMS may exert a cooling (negative) effect on earth's climate. However bacteria in the water column oxidize a large amount of the DMS before it can be released to the atmosphere. Anaerobic metabolism of DMS and further degradation products results in the production of methane. Hence, DMSP catabolism may also have a positive effect on the earth's climate due to the formation of the greenhouse gas, methane. During the cruise we measure DMSP particular and dissolved, its degradation product DMS and methane. While *in-situ* production is masked by a simultaneous and nearly equal *in-situ* methane oxidation

methane concentrations in the pycnocline are generally only slightly oversaturated. Hence the potential of the upper ocean methane cycle remains underestimated. Hence we take samples for measuring of the stable carbon isotopic ratio of methane which will be used to trace the *in-situ* production and the subsequent consumption processes because both processes alter the isotopic composition of the initial source material. Thus, a direct insight into the formation of a local methane cycle in surface water is likely to provide promising information. Due to estimate the stage of the phytoplankton bloom nutrients will be sampled and measured in the home lab.

Work at Sea

The investigations will be carried out the first time in the Amundsen Sea embayment. In the investigation area because of the relatively small and semi-enclosed area, water exchange is restricted and the pathways of these climate-relevant biogases can be studied in detail. Stations will be selected along the oceanography transects. Water samples will be collected in Niskin bottles mounted on a rosette sampler from the surface up to 200 m water depth at discrete depths depending of the fluorescence and the oxygen-sensor signal. The dissolved gases methane and DMS will be immediately extracted from the water and analysed on board ship, using a gas chromatograph equipped with a flame ionization detector (FID) and with a flame-photometer detector (PFPD), respectively. Further DMSP (dimethylsulfonio-propionate) particular and dissolved will be analysed on board. Gas samples for analyses of the $\delta^{13}C_{CH4}$ values and water samples for nutrient analyses will be stored and measured later in the home laboratory. In addition, experiments will be carried out to create methane production in seawater due to study the methane cycle in polar surface water and the pathway(s) of methanogenesis in aerobic environment.

Expected results

Recent climate change alters water mass formation and convection in the high latitudes. Our investigations are related to subsequent effects on natural biogeochemical cycles in the photic zone. The main focus is on potential feedbacks to pathways of climatically relevant biogases like methane and DMS during the shifting from a phytoplankton bloom to an oligotrophic system. Further, with this expedition we expect to expand our knowledge about the recent marine methane cycle. The aim of the investigations is to quantify the production and consumption during polar summer conditions and subsequently to estimate the potential sea to air flux of excess methane related to background concentrations.

9. CLIMATE INDUCED CHANGES AND BIODIVERSITY OF ANTARCTIC PHYTOPLANKTON

C. Wolf (AWI)
not participating: I. Peeken (AWI)

Objectives

Climate change is rapidly affecting physical and biological systems on the planet which cannot be explained by natural climate variation but attributed to increasing anthropogenic greenhouse gas concentrations. The polar oceans appear to be very sensitive to global warming due to the positive feedbacks associated with melting sea-ice and snow, thus losing

the albedo effect and in turn, having the absorbing ocean which preserves heat (IPCC Report 2007). The once dominant cold, dry continental Antarctic climate will be replaced by a trend towards later sea-ice advance, earlier retreat and consequently shorter sea-ice season which causes multi-level responses in the marine ecosystem. These changing environmental conditions will allow the intrusion of temperate key species into this polar habitat as has been demonstrated in the Arctic ocean. Compared to the Arctic, the currently still unfavourable growth conditions for *E*. *huxleyi* in the Antarctic might explain why so far no big coccilothophore blooms are present in this region. However, time series over the past two decades clearly demonstrate an increased southward abundance of this keystone species in the polar environment.

The Class Cryptophyceae (Division Cryptophyta) harbors ecologically relevant species, which are found widespread in aquatic environments. In the Antarctic, it has been observed, that Cryptophyta contribute significantly to the phytoplankton communities of the marginal ice zone in the Weddell-Scotia confluence area and in the Australian sector of the Southern Ocean. However, monitoring and identification of Cryptophycea is challenged due to contraints related to the size and the morphology of the cells. In ecological studies Cryptophyta are often pooled with other flagellated microalgae or, in some cases are assessed seperately but still pooled as a single group. Therefore, ecological information considering the abundance, seasonality or diversity of Cryptophyta in the marine environment is scarce.

The aim of the current project is to answer the following researchable questions:

1) Do we observe a further southward intrusion of *E*. *huxleyi* in the Antarctic?

E. *huxleyi* is a key species in biogeochemical cycles in the world ocean. Current investigations have shown a moving of *E*. *huxleyi* into Polar Regions and that its previous observed distribution is mainly considered to be a result of a temperature barrier. When this barrier has been overcome, this species tends to remain in the habitats despite cooling events are following and thus, more unfavourable growth conditions for this species occur. With ongoing warming resulting in occasionally intrusion of warmer water into the polar habitats it can be expected, that *E*. *huxleyi* will further extend its distribution into these regions. We therefore hypothesize that *E*. *huxleyi* due to climate change will get a common member of the Antarctic phytoplankton.

2) Will other key species in the Antarctic be affected by climate change?

Global warming will not only allow more temperate species to evolve in polar habitats, it also will affect typical polar species which are usually stenotherm and will loose their habitat. Thus not only the occurrence of invader species and the competition on available nutrients but also the unfavourable growth conditions will change the occurrence of polar species due to global warming. Therefore, we hypothesize that shifts in the Antarctic phytoplankton composition will occur due to the ongoing climate change.

3) How do Cryptophyceae contribute to the biodiversity of antarctic phytoplankton?

This study is dedicated to assess the abundance and diversity of Cryptophyceae in the Antarctic. This will involve surveillance of Cryptophyceae via high performance liquid chromatography (HPLC) and molecular approaches like sequencing of rDNA sequences, PHYLOCHIPS and fingerprinting methods. Furthermore, taxonomic classification of Antarctic Cryptophyceae shall be carried out taking advantage of approaches like culturing by serial dilution and scanning electron microscopy (SEM). This data set will contribute to further elucidate the ecological role of Cryptophyceae in the marine environment.

4) Can we monitor the changes of PFTs with satellite data in the Antarctic?

Field studies have the inherent problem of only covering limited space and time of a given ocean region. Although it will be always impossible to distinguish different phytoplankton species from space, a major new advantage would be to identify Phytoplankon Functional Types (PFTs), which can be tracked via satellite. Although this approach has been employed in tropic and temperate regions, fewer attempts have been carried out to investigate shifting phytoplankton distributions in Antarctic regions. This study shall deliver the ground-based data set for the development and validation of the PhytoDOAS method which shall be extended by the research group of Dr. Bracher for the detection of different coccolithophores.

Work at sea

During this cruise ground truthing data for phytoplankton samples will be monitored from surface water collected from the moon pool. Depth profiles will be taken from 30-45 stations with a resolution of 6 samples from CTD casts. For the identification of phytoplankton we will take filter samples for plankton pigments, DNA-chip technology (PHYLOCHIPS) and scanning electron microscopy (SEM). Water samples will be collected for light microscopy and for flow cytometry.

To provide reference spectra and for the validation of remotely sensed bio optical data it is essential to have highly precise phytoplankton absorption measurements and the pigment composition. Beside the above mentioned phytoplankton composition, particulate absorption in suspension and absorption of CDOM will be measured during the cruise using the point-source integrating-cavity absorption meter (PSICAM) at the same locations. For particulate absorption additional filters will be taken and measured with the more conventional spectrophotometer measurements for comparison purposes.

Expected results

This comprehensive data set derived from a wide variety of state of the art technologies allows establishing a profound knowledge of the phytoplankton in the investigation areas. The data can contribute to establish a baseline, which can be used to estimate the consequences of climate change for the antarctic phytoplankton. Applying the phytoplankton marker pigment technique and the PHYLOCHIPS allows distinguishing various phytoplankton groups and taxa very rapidly and additional it is possible to detect the pico- and nanoplakton, which can not be estimated by light microscopy. Pico- and nanoplankton will further be studied by flow cytometry to get a better quantification of these plankton groups. All data will be corroborated by light microscopy, analysis of rDNA sequences and molecular fingerprinting methods allowing to study the biodiversity of the polar plankton.

Since coccolithophores and cryptophyceae are the target group of this proposal, additional care will be taken to assess these groups by using the SEM technique. For the coccolithophores, this method will give detailed information about the state of the coccoliths, which can be classified into normal, malformed, incompletely grown and malformed incompletely grown coccoliths and thus can give information about the growth history of the found coccolithophores. For the cryptophyceae SEM is an indispensible tool for taxonomic identification. Thus it will provide us with reliable information on the species diversity within the Antarctic cryptophyceae.

All data together with the phytoplankton group composition will be used as reference spectra in satellite retrievals and for validation of satellite retrievals. With this we aim to achieve the quantitative distribution of PFTs on monthly bases. With this data set it will be possible to extend the limited temporal and spatial distribution sampled during this expedition.

10. MAPS: MARINE MAMMAL PERIMETER SURVEILLANCE

D. Zitterbart (AWI)
not participating: O. Boebel, L. Kindermann (AWI)

Objectives

The MAPS project focuses on the detection of marine mammals in the vicinity of *Polarstern*. Automated detection in particular is envisioned to aid mitigation procedures during future operations of some hydroacoustic instruments, to study the behavior of marine mammals in the vicinity of the ship and to support marine mammal observations aimed at determining their abundance and spatio-temporal distribution.

Whales may be detected on the basis of the thermal anomaly generated by the whale's blow, which stands in strong contrasts to the cold Antarctic environment. To achieve this, a 360°-scanning, high-resolution thermal imaging system, FIRST-Navy, will be used. This system, representing the state-of-the-art in infrared imaging, is mounted in the crow's nest of *Polarstern* and provides thermal images to monitors on the ship's bridge and in the operator's lab.

It is the primary purpose of this cruise, to test improved and newly developed software components which acquire, archive and analyze thermal images. Further, the reliability of auto-detection algorithms shall be validated in comparison with concurrent marine mammal observations by the ships nautical officers and additional observations.

Work at sea

The primary goal of our participation in this cruise is the operation of the thermal imaging device. We will test and validate the firm- and software improvements made since ARK-XXIV/1, as well as the newly developed automatic detection algorithms. If possible, the system shall be operated throughout the entire cruise and 10-min long video sequences of all occurrences of cetacean auto-detections as well as manually (by human observers) and regularly (time-based) triggered events shall be saved.

Expected results

This effort is expect to result in the collection of a comprehensive dataset for further system development and validation, behavioral analysis and a marine mammal sighting database. Sighting data will be merged with environmental proxies such as sea-ice conditions, water depth and sea surface temperature to be used in environmental suitability models. Behavioral analysis will provide the first high resolution tracks of marine mammals in the vicinity of the ship, including the distribution of concurrent ice-floes. System validation will lead to improved algorithms, with the aim to minimize the amount of false alerts.

11. BATHYMETRY

N. Ott, D. Graffe, S. Reinshagen (AWI)

Objectives

Polarstern is designed to work in areas with extensive sea ice. The vessel is equipped with a high-resolution multibeam echosounder and a sub-bottom profiling system and has

capabilities for bathymetric data acquisition during ice-breaking activities. Hydrosweep DS2 is a high performance multibeam echo sounder used to perform seafloor mapping in shallow and deep-water. Based on processed data the bathymetry group provides accurate digital data and printed maps as additional source of information for other fields of marine sciences and track planning.

Work at sea

The *Polarstern* expedition ANT-XXVI/3 covers regions of the Amundsen Sea and its embayment, where previous *Polarstern* expeditions took part, e.g. ANT-XI/3, ANT-XVIII/5a, and ANT-XXIII/4. Additionally, swath data and related ship tracks from British *James Clark Ross* and US icebreaker *Nathaniel B. Palmer* are prepared for track planning prior to the expedition. This is of great importance, because the Amundsen and the Bellingshausen Sea are the least mapped regions of the Southern Ocean.

The bathymetry group will acquire new data 24 hours per day during the complete expedition including transits from Wellington and to Punta Arenas. Measurements are conducted parallel to geophysical and geological surveys. Post-processing is performed nearly in real-time for the provision of the most recent data to the geophysicists, geologists and oceanographers. The transition zone from the continental shelf into the abyssal plains of the Southern Ocean is a key area for understanding the tectonic and sedimentary history of the Amundsen Sea and the Amundsen Sea embayment.

Expected results

The focus of this expedition is geophysical research aiming at subsurface structures and marine geological survey focusing on sedimentary history in the Southern Amundsen Sea. In addition to this, high-resolution swath data from shallow to medium water depth enables discrimination and localization of small surface structures and patterns within the embayment such as former ice streams beds. Swath data from medium depth to deep-water shows position, size, and distribution of geomorphologic features on the seafloor such as the Amundsen Ridges, seamounts and canyons of the continental slope.

12. BETEILIGTE INSTITUTE / PARTICIPATING INSTITUTES

	Adresse Address
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DWD	Deutscher Wetterdienst Geschäftsbereich Wettervorhersage Seeschifffahrtsberatung Bernhard Nocht Str. 76 20359 Hamburg/Germany
GNS	GNS Science 1 Fairway Drive, Avalon Lower Hutt, 5010/New Zealand
HeliService	HeliService International GmbH Am Luneort 15 27572 Bremerhaven/Germany
H&J Film	Hoferichter & Jacobs Film- und Fernsehproduktionsgesellschaft mbH Alte Schönhauser Str. 9 10119 Berlin/Germany
TU Dresden	Technische Universität Dresden Institut für Planetare Geodäsie 01062 Dresden/Germany
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13. FAHRTTEILNEHMER / PARTICIPANTS

Fahrtleiter: Karsten Gohl
Wellington - Punta Arenas

Name	Vorname/ First Name	Institut/ Institute	Beruf / Profession
Baque	Daniel	AWI	Geologist
Brenner	Frank	AWI	Geophysicist
Brunnabend	Sandra-Esther	AWI	Oceanographer
Chambord	Amandine	GNS	Geophysicist
Cychon	Christine	AWI	Biogeochemist
Damm	Ellen	AWI	Biogeochemist
Davy	Bryan	GNS	Geophysicist
Denk	Astrid	AWI	Geophysicist
Forwick	Matthias	University Tromsø	Geologist
Gohl	Karsten	AWI	Geophysicist
Gossler	Jürgen	AWI	Geophysicist
Graffe	Dorothea	AWI	Geodesist, Bathymetry
Gutjahr	Marcus	University Bristol	Geologist
Hammrich	Klaus	HeliService	Pilot, Helicopter
Heckmann	Hans-Hilmar	HeliService	Pilot, Helicopter
Heckmann	Markus	HeliService	Technician, Helicopter
Hillenbrand	Claus-Dieter	BAS	Geologist
Jernas	Patrycja	University Tromsø	Geologist
Kalberg	Thomas	AWI	Geophysicist
Kaul	Norbert	University Bremen	Geophysicist
Klages	Johann Philip	AWI	Geologist
Kopsch	Conrad	AWI	Technician, Geophysics
Kuhn	Gerhard	AWI	Geologist
Lensch	Norbert	AWI	Technician, Geophysics
Lichte	Ellen	AWI	Technician, Biogeochemistry
Lindeque	Ansa	AWI	Geophysicist
Lindow	Julia	University Bremen	Geologist
MacNab	Ian	BAS	Technician, Geology
Möllendorf	Carsten	HeliService	Technician, Helicopter
Müller	Eike	AWI	Geophysicist
Ott	Norbert	AWI	Geodesist, Bathymetry
Reinshagen	Sarah	AWI	Geodesist, Bathymetry
Romsdorf	Martin	AWI	Geophysicist
Rosenau	Ralf	TU Dresden	Geodesist
Scheinert	Mirko	TU Dresden	Geodesist
Schröder	Michael	AWI	Oceanographer
Sellmann	Lutz	AWI	Oceanographer
Smith	James	BAS	Geologist
Spiegel	Cornelia	University Bremen	Geologist
Timmermann	Ralph	AWI	Oceanographer
Uenzelmann-Neben	Gabriele	AWI	Geophysicist
Wiers	Steffen	AWI	Geologist

Name	Vorname/ First Name	Institut/ Institute	Beruf / Profession
Wisotzki	Andreas	AWI	Oceanographer
Wobbe	Florian	AWI	Geophysicist
Wolf	Christian	AWI	Biogeochemist
Zitterbart	Daniel	AWI	Geophysicist, Hydroacoustics
NN		DWD	Meteorologist
NN		DWD	Technician, Meteorology
NN		H&J Film	Film Media Representative
NN		H&J Film	Film Media Representative
NN		Brazilian Navy	Nautical Observer
NN		Brazilian Navy	Nautical Observer

14. SCHIFFSBESATZUNG / SHIP'S CREW

No.	Name	Rank
1.	Pahl, Uwe	Master
2.	Grundmann, Uwe	1. Offc.
3.	Ziemann, Olaf	Ch.Eng.
4.	Hering, Igor	2. Offc.
5.	Ritter, Michael	2. Offc.
6.	Janik, Michael	3. Offc.
7.	Meuschke, Felix	Doctor
8.	Koch, Georg	R.Offc.
9.	Kotnik, Herbert	2. Eng.
10.	Schnürch, Helmut	2. Eng.
11.	Westphal, Henning	2. Eng.
12.	Holtz, Hartmut	ElecEng.
13.	Dimmler, Werner	ELO
14.	Feiertag, Thomas	ELO
15.	??	ELO
16.	Nasis, Ilias	ELO
17.	Clasen, Burkhard	Boatsw.
18.	Brickmann, Peter	A.B.
19.	Burzan, Gerd-Ekke	A.B.
20.	Hartwig-Lab.,Andre	A.B.
21.	Kreis, Reinhard	A.B.
22.	Kretzschmar, Uwe	A.B.
23.	Moser, Siegfried	A.B.
24.	Schröder, Norbert	A.B.
25.	Schultz, Ottomar	A.B.
26.	Beth, Detlef	Storek.
27.	Dinse, Horst	Mot-man
28.	Fritz, Günter	Mot-man
29.	Kliem, Peter	Mot-man
30.	Krösche, Eckard	Mot-man
31.	Watzel, Bernhard	Mot-man
32.	Fischer, Matthias	Cook
33.	Tupy, Mario	Cooksmate
34.	Völske, Thomas	Cooksmate
35.	Dinse, Petra	1.Stwdess
36.	Hennig, Christina	Stw/Nurse
37.	Hischke, Peggy	2.Stwdess
38.	Hu, Guo Yong	2.Steward
39.	Streit, Christina	2.Stwdess
40.	Sun, Yong Sheng	2.Steward
41.	Wartenberg, Irina	2.Stwdess
42.	Ruan, Hui Guang	Laundrym.
43.	NN	Azubi
44.	NN	Azubi

ANT-XXVI/4

7 April 2010 - 17 May 2010

Punta Arenas - Bremerhaven

Chief scientist
Arne Körtzinger

CONTENTS

1. ÜBERBLICK UND FAHRTVERLAUF

Arne Körtzinger
IFM-GEOMAR

Das Forschungsschiff *Polarstern* wird am 7. April 2010 in Punta Arenas zur Heimreise nach Bremerhaven aufbrechen (Abb. 1.1). Schwerpunkt der Arbeiten sind kontinuierliche Messungen von Eigenschaften der Atmosphäre und des Oberflächenozeans sowie der Energie- und Materieflüsse über die Grenzfläche.

Autonome Messplattformen zur Bestimmung des Stoff- und Energieaustausches zwischen Ozean und Atmosphäre (OCEANET)
Um die experimentelle Erfassung von Stoff- und Energieaustausch zwischen Ozean und Atmosphäre auf eine solide Basis zu stellen, ist im Rahmen dieses Projektes mittels der Vernetzung der Expertisen des IFM-GEOMAR (CO_2-/O_2-Flüsse, photosynthetischer Status, Energiehaushalt, Fernerkundung), des IfT (aktive Fernerkundung), des GKSS Forschungszentrums („FerryBox“) und des AWI-Bremerhaven (Fernerkundung der marinen Biologie mit ENVISAT/MERIS) die Entwicklung autonomer Messsysteme geplant, die langfristig für den operationellen Betrieb an Bord verfügbarer Fracht- und Forschungsschiffe vorgesehen sind.

Chemische Messungen: Einsatz autonome Messgeräte und neue entwickelter Systeme für die Messung von Parametern des marinen CO_2-Systems (pCO_2, pH, δ^{13}C-DIC) sowie zusätzlicher Parameter.

Biologische Messungen: Die Zusammensetzung der stickstofffixierenden Mikroorganismenvergesellschaftung und deren Aktivität sollen anhand von molekularbiologischen Untersuchungen und Mikrokosmos-Experimenten bestimmt werden.

Atmosphärische Messungen: Der wissenschaftliche Fokus der atmosphärischen Messungen liegt auf Strahlungsmessungen und Fernerkundung (Kehrkanal-Mikrowellen-Radiometer), Atmosphäre-Ozean Flüssen (turbulente Flüsse von Impuls, sensibles und latenter Wärme und CO_2) sowie Lidar-Messungen (Mehrkanal-Raman-Lidar Polly für Aerosole).

Biooptische Messungen zur Verifikation von Satellitenmessungen und Ozeanmodellen
Nutzung von Fernerkungsdaten in Verbindung mit *in-situ* Messungen von Ozeanoptik, Phytoplanktonproduktivität und Zusammensetzung von partikulärem organischen Kohlenstoff mit dem Ziel, Abschätzungen der globalen marinen Primärproduktion sowie der Verteilung der wichtigsten funktionalen Gruppen des Phytoplanktons zu verbessern.

Chemische und Strahlungseffekte von atmosphärischem Staub auf Prozesse im Oberflächenozean – Biogeochemie des Atlantischen Ozeans (ADIOS-BAO)
Ziel des Vorhabens ist die Gewinnung eines umfangreichen Datensatzes zur Verteilung von Spurenmetallen (Al, Fe und Ti) lithogenen Ursprungs im Oberflächenozean unterschiedlicher Regionen. Zusätzlich sollen photochemisch beinflusste Größen (Wasserstoffperoxid, Nirite, CDOM) gemessen werden, um den Einfluss von Strahlung über Redoxprozesse auf die Auflösung von Staub zu untersuchen.

Analyse der chemischen Zusammensetzung mariner Aerosole entlang eines Meridionalschnitts im Atlantischen Ozean
Als innovative Methoden der Aerosoluntersuchung werden „high-mass resolution proton-transfer-reaction mass-spectrometer” (hi-res-PTR-MS) sowie die Massenspektrometrie

stabiler Isotope (IRMS) eingesetzt. Ziel ist die Charakterisierung der chemischen Zusammensetzung organischer Aerosole über verschiedenen Regionen des Atlantiks.

Messungen der Konzentration und Isotopie von Wasserstoff in Ozean und Atmosphäre
Ziel dieses Vorhabens ist die Messung der Konzentration und Isotopie von molekularem Wasserstoff in Ozean und Atmosphäre. Die Messungen sollen helfen, ozeanische Wasserstoff-Emissionen und ihre Rolle im globalen Wasserstoffkreislauf besser zu verstehen. Desweiteren soll meridionale Verteilung atmosphärischer Wasserstoffkonzentrationen der Verbesserung von Atmosphärenmodellen dienen.

Temperaturfluktuationen in der Tiefsee (Vema-Kanal)
CTD-Messungen im Vema-Kanal als Fortsetzung einer Zeitserie hochpräziser CTD-Untersuchungen im Antarktischen Bodenwasser (AABW).

Die Reise ANT-XXVI/4 wird vor allem aus kontinuierlichen Messungen in Oberflächenozean und Atmosphäre bestehen. Zusätzlich wird täglich eine Station mit CTD-Beprobung und ausführlichen Strahlungsmessungen durchgeführt.

Am 17. Mai 2010 wird die *Polarstern* in Bremerhaven einlaufen.

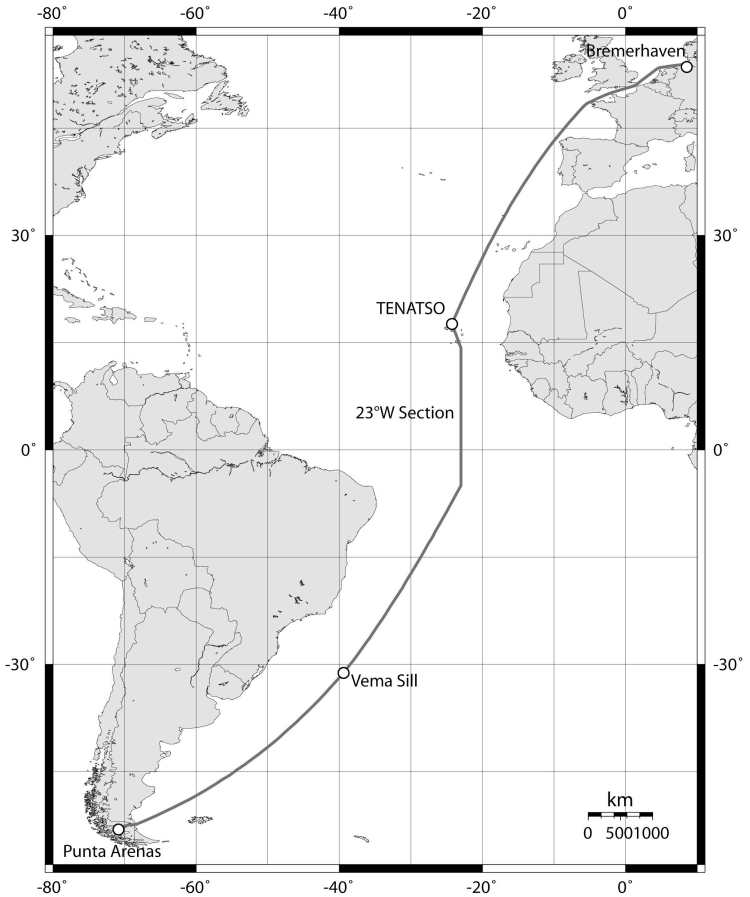

Abb. 1.1: Fahrtroute der Reise ANT-XXVI/4
Fig. 1.1: Cruise track of ANT-XXVI/4

ITINERARY AND SUMMARY

On 7 April 2010 *Polarstern* will depart form Punta Arenas for its Atlantic transfer to Bremerhaven (Fig. 1.1). The cruise will be utilized for continuous investigations of atmospheric and marine properties as well as for energy and material fluxes between ocean and atmosphere. The following projects will be carried out:

Autonomous measurement platforms for energy and material exchange between ocean and atmosphere (OCEANET - Atmosphere & Ocean)
In order to provide a solid basis for the observational monitoring of energy and material exchange between ocean and atmosphere it is planned to develop an autonomous observation system for operational use onboard of available cargo and research vessels. The project is based on a network of expertise from IFM-GEOMAR (CO_2-/O_2-fluxes, photosynthetic status, energy budget, remote sensing), the IfT (active remote sensing), the GKSS research center (ferry box, remote sensing of marine biology with ENVISAT/MERIS) and AWI-Bremerhaven (CO_2-system, marine infrastructure of *Polarstern*).

Chemical measurements: Operation of autonomous systems as well as new instruments for measurement of parameters of the marine CO_2 system (pCO_2, pH, δ^{13}C-DIC) as well as of ancillary parameters.

Biological measurements: Phylogenetic diversity and metabolic activity of nitrogen-fixing microorganisms will be determined along the meridional transects by molecular biological methods as well as with on board microcosm experiments.

Atmospheric measurements: The scientific focus of atmospheric measurements to be carried out during this cruise will be placed on radiation & microwave remote sensing (multi-channel microwave radiometer), air-sea interaction and fluxes (turbulent fluxes of momentum, sensible heat, latent heat, and CO_2 byy the inertial dissipation method), and Lidar observations (multi-channel Raman-Lidar Polly for aerosols).

Bio-optical measurements for satellite ground truthing and ocean optical modelling
Using remote sensing data in combination with *in-situ* measurements of ocean optics, phytoplankton productivity and composition of particulate organic carbon with the aim to improve estimates of global marine primary production and the distribution of major phytoplankton functional groups.

Atmospheric Dust and Irradiation effects on Ocean surface processes – Biogeochemistry in the Atlantic Ocean (ADIOS-BAO)
The aim of the project is to produce comprehensive data on crustally derived trace metals (Al, Fe and Ti) and phosphate in the surface ocean over contrasting regions of the Atlantic Ocean. In addition simultaneous measurements of photochemical influenced parameters (hydrogen peroxide, nitrite and CDOM) will allow the examination the influence of irradiation on dust dissolution via redox processes.

Analysis of the chemical composition of marine organic aerosol along a meridional transect of the Atlantic Ocean
Innovative methods for aerosol analysis employing high-mass resolution proton-transfer-reaction mass-spectrometer (hi-res-PTR-MS) and stable isotope ratio mass spectrometry (IRMS) will allow characterizing the chemical composition of organic aerosols over different regions of the Atlantic Ocean.

Measurement of concentration and isotopic signature of hydrogen in surface ocean and atmosphere
This project aims to measure the concentration and isotopic signature of hydrogen in the atmosphere and surface ocean. The ultimate goal is to quantify oceanic hydrogen emissions and their role in the global atmospheric hydrogen cycle. The latitudinal distribution of atmospheric hydrogen will be used to improve atmospheric models.

Abyssal temperature fluctuations in the Vema Channel
Revisit to the Vema Sill and Extension sites for continuation of a time series of high precision CTD observations of the coldest AABW in the Vema channel.

Cruise ANT-XXVI/4 will be based primarily on continuous measurements in surface ocean and atmosphere. In addition a daily hydrographic station including CTD-rosette sampling and radiation measurements will be performed.

Polarstern will arrive in Bremerhaven on May 17, 2010.

1. AUTONOMOUS MEASUREMENT PLATFORMS FOR ENERGY AND MATERIAL EXCHANGE BETWEEN OCEAN AND ATMOSPHERE (OCEANET): OCEAN

A. Körtzinger, S. Aßmann
Not on board: T. Steinhoff (IFM-GEOMAR), M. Hoppema (AWI), H. Zemmelink (NIOZ), F. Schroeder (GKSS)

a) Chemical measurements

Objectives

The aim of the WGL-PAKT initiative OCEANET is to develop new autonomous instruments for the investigation of energy and matter exchange at the air-sea interface. Through multi-institutional participation from IFM-GEOMAR, GKSS, IfT and AWI it is intended to build up a sensor network that investigates atmospheric and surface ocean properties. In order to meet the growing demand for increased spatial and temporal data, autonomous sensor networks that can be deployed on merchant vessels are needed. Tests of new instruments and measuring techniques as well as the installation of instrumentation aboard *Polarstern* are essential components of the project.

The oceanic component of this study focuses on the marine carbon cycle in the surface ocean which is of high climate relevance, but at the same time susceptible to climate change. The surface ocean's CO_2 source/sink function is maintained by a complex interaction of physical and biological processes all of which are potentially susceptible to global (climate) change. Therefore its understanding requires measurements of various different parameters as it is pursued within OCEANET.

During the upcoming fifth OCEANET cruise, the work carried out during the earlier transits (ANT-XXIV/4, ANT-XXV/1 and 4, ANT-XXVI/1) will be continued. During the first OCEANET cruise the feasibility of autonomous underway measurements was assessed for a wide range

of instruments for measurement of physical (temperature, salinity, turbidity), chemical (CO_2 partial pressure (pCO_2), pH, oxygen, total gas tension, nutrients), and biological parameters (chlorophyll a, photosynthetic parameters) and a limited intercomparison for measurements of pCO_2 took place. During the second cruise a stronger focus was placed on intercomparison measurements of CO_2 partial pressure with different autonomous underway flow-through as well as submersible systems. The work on the third transit dealt with the closer investigation of a commercial submersible pCO_2-sensor and included CTD cast with the instrument. Underway pCO_2-measurements were run as a reference. Nitrate and nutrient determinations were part of the work as well. During ANT-XXVI/1 an optimized and improved submersible pCO_2-sensor was tested again in more rigorous fashion. During the fourth cruise a stronger focus is placed on underway pH measurements while the evaluation of commercially available pCO_2 instrumentation still plays a role. The different biogeochemical regions crossed during the cruise and its duration provide good conditions for a comprehensive testing of instrumentation.

Depending on the results of first trials during ANT-XXVI/1 a cavity ring-down spectrometer (CRDS) may be used again for the determination of the $\delta^{13}C$ isotopic ratio of surface water dissolved inorganic carbon (DIC) in an underway setup. In addition to the isotopic ratio the instrument also provide a pCO_2 dataset, which will be comparecd with the other pCO_2 data obtained. The various CO_2 system measurements will provide a detailed insight into the state of the surface ocean CO_2 system.

In addition to the measurements mentioned above an automatic FerryBox system that is permanently installed on *Polarstern* will be operated throughout the cruise.

Work at sea

Measurements will be made continuously on pumped surface seawater using the following approaches:

- Autonomous continuous measurements of pCO_2 in surface waters with different instruments; underway and submersible (AWI, NIOZ, IFM-GEOMAR)
- Autonomous continuous measurements of dissolved oxygen and total gas tension in surface waters (IFM-GEOMAR)
- Autonomous continuous measurements of pCO_2 and $\delta_{13}C$ isotopic ratio by means of cavity-ringdown spectroscopy (CAU, IFM-GEOMAR)
- Discrete water samples for dissolved inorganic carbon and alkalinity will be taken every 8 - 12 hours (IFM-GEOMAR)
- Discrete optical pH-measurements (IFM-GEOMAR, GKSS)

Expected results

We will generate high-quality data of CO_2 system parameters in a high temporal resolution along the meridional surface transect through the Atlantic Ocean. These will be combined with measurements of oxygen and total gas tension. The combined data set of autonomously recorded and discrete samples will provide a detailed insight in the carbon chemistry of the surface waters.

b) Biological measurements

Objectives

The main objective of this project is to asses the diversity and activity of diazotrophic microorganisms and to determine rates of carbon and dinitrogen fixation rates along the meridional transect. Discrete seawater samples will be taken and filtered at regular time

intervals from the clean surface seawater supply, and frozen for later analysis with molecular biological methods (quantitative PCR, Sanger-Sequencing, etc.) and flow cytometry. Parallel seawater samples will be collected for on board incubation experiments for determination of carbon and N_2 fixation rates. For this purpose, the samples will be incubated in 4-L polycarbonate bottles for 24 h after an addition of stable nitrogen (^{15}N) and carbon (^{13}C) isotopes. The later analysis of the isotope-composition of the microorganisms will be carried out using mass spectrometry.

Work at sea

- Filtration of surface seawater for DNA/RNA and flow cytometry analysis will be carried out at intervals of 6 h throughout the transect
- Carbon and N_2-fixation rates will be measured in on-deck incubations every 12 h throughout the transect
- 6 - 7 more detailed depth profiles will be conducted during the cruise at regular intervals.

Expected results

As during leg ANT-XXVI/1 we will obtain quantitative abundance estimates for seven phylotypes of diazotrophs using specific probes for the nifH gene which encodes a subunit of the nitrogenase enzyme. We will also determine where and when the nifH gene is actively transcribed during the transect. By comparison with the results of ANT-XXVI/1, one of the goals is to observe whether or not the trends observed between the North and South Atlantic will persist between the cruises.

2. AUTONOMOUS MEASUREMENT PLATFORMS FOR ENERGY AND MATERIAL EXCHANGE BETWEEN OCEAN AND ATMOSPHERE (OCEANET): ATMOSPHERE

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Not onboard: A. Macke, Y. Zoll (IFM-GEOMAR), D. Althausen, T. Kanitz (IfT)

Objectives

a) Radiation & microwave remote sensing

The net radiation budget at the surface is the driving force for most physical processes in the climate system. It is mainly determined by the complex spatial distribution of humidity, temperature and condensates in the atmosphere. The project aims at observing both the radiation budget and the state of the cloudy atmosphere as accurately as possible to provide realistic atmosphere-radiation relationships for use in climate models and in remote sensing. While similar experiments have been performed from land stations, only few data from measurements over ocean areas exist. The present project is part of the “Meridional Ocean Radiation Experiment” (MORE) which uses Atlantic transfers of various research vessels for the combined measurements of the atmospheric state since 2004. The main project behind this cruise is the WGL-PAKT initiative OCEANET.

A multichannel microwave radiometer will be operated to continuously retrieve temperature

and humidity profiles as well as cloud liquid water path over the ocean. Time series of these profiles will show small scale atmospheric structures as well as the effects of the mean state of the atmosphere and its variability on the co-located measurements of the downwelling shortwave and longwave radiation. The atmospheric profiles will also be used to validate the satellite based profiles from the IASI instrument onboard the new European polar orbiting satellite MetOp. Atmospheric aerosol optical thickness will be measured by means of handheld sun photometer and spectral solar radiometer. Most instruments will be integrated in the new container-based atmosphere observatory.

b) Air-sea interaction and fluxes

Great emphasis has to be put on air-sea fluxes of momentum, sensible and latent heat to improve numerical models of weather forecast and climate simulations since oceans cover 71 % of the Earth's surface. The fluxes of sensible and latent heat are also of importance for the energy budget of the ocean and the atmosphere. Due to the steady increase of many trace gases in the atmosphere like CO_2, *in-situ* gas flux measurements are required to establish parameterizations that provide flux estimates in climate models.

To estimate the turbulent fluxes of momentum, sensible heat, latent heat, and CO_2 a sonic-anemometer and an open path LiCor will be mounted. Measurements are taken at a sampling rate of 20 Hz (LiCor) respectively 30 Hz (sonic-anemometer) allowing to derive the fluxes by applying the inertial dissipation method. This method relies on measurements at high frequencies which are less distorted by the motion and the superstructure of the ship than the covariance technique. The CO_2 flux estimates will be compared directly with the CO_2 flux estimates derived from measurements of the CO_2 partial pressures in ocean and atmosphere performed by the ocean component of OCEANET (see section 1).

c) Lidar observations

The high temporal and spatial variability of atmospheric aerosol characteristics, i.e. in concentration, size distribution, shape and chemical nature, complicates their exact specification and consideration in radiative transfer models.

The Raman Lidar measurement technique is able to provide information about the vertical profiles of aerosols. With this technique the particle backscatter and extinction coefficient can be determined, i.e. the aerosol optical properties can be described in a quantitative way. Furthermore the use of three backscatter coefficients and two extinction coefficients enable an inversion method to estimate the main microphysical properties at any measured height. 24-hour measurements by the 3+2+1 Raman Lidar system PollyXT during *Polarstern's* transit imply the opportunity to characterize the optical and microphysical particle properties above the Atlantic Ocean. These particles in the several layers of the atmosphere above the Atlantic are lifted up and are intercontinentally transported from certain source regions like anthropogenic emissions from North America, dust from Saharan region or smoke from biomass burning in South America or Africa.

Enhanced research is focused on the aerosol properties, due to their variable effects on down- and upwelling radiation, which are still uncertain. The determined optical and microphysical particle data will be used in the height resolved radiative model LibRadtran. This model allows an estimation of the radiative influence of different aerosols, even if they occur in separated layers. The height resolved results will be compared by simultaneous column integrated ship and space borne measurements, also in the case of vertically separated aerosol layers.

Work at sea

During the entire cruise the new container-based atmosphere observatory will be installed on the observation deck of *Polarstern*. The following individual instruments will be operated during this leg:

1) Multichannel microwave radiometer HATRPO. The instrument requires occasional calibrations with liquid nitrogen as well as tip-calibrations under calm sea and homogeneous atmospheric conditions.
2) Multichannel Raman-Lidar Polly for aerosol measurements. PollyXT is designed as standalone portable Raman Lidar system. It will be placed in the OCEANET container on the observation deck and operated whenever weather conditions are adequate.
3) Whole sky imager for cloud structure measurements.
4) Handheld sun photometer (Microtops) for aerosol and cloud optical thickness.
5) Inclinometer for sea surface tilt measurements.
6) Sonic anemometer USA-1 to measure the wind components and temperature.
7) LiCor LI-7500 Open Path CO_2/H_2O Analyzer to measure water vapour and CO_2.
8) M-100 absorption hygrometer to measure water vapour.
9) KT-19 radiometer to measure SST and the brightness temperature of the atmosphere.

Expected results

1) 2D-structure of the clear sky atmosphere and corresponding net radiation budget.
2) Horizontal structure of the cloud water path and its effect on the downwelling shortwave and longwave radiation.
3) Vertical structure of temperature and humidity as well as its variability for validation of satellite products.
4) Vertical profiles of tropospheric aerosols and their effect on radiation.
5) Turbulent fluxes of momentum, sensible, and latent heat.
6) Flux of CO_2 between ocean and atmosphere.

3. BIO-OPTICAL MEASUREMENTS FOR SATELLITE GROUND TRUTHING AND OCEAN OPTICAL MODELLING

A. Theis (AWI), A. Sadeghi (IUP), R. Röttgers (GKSS), R. Reynolds, N.N. (SIO)
Not on board: A. Bracher (AWI/IUP), D. Stramski (SIO)

Objectives

It has been estimated that marine phytoplankton contributes 30 to 60 % to global primary production. The large uncertainty range is a result of the lack of global information on phytoplankton absorption and light penetration depth, which cannot be supplied by the current ocean colour satellite sensors. The spectral resolution of these sensors is not sufficient to extract the relevant information. The variation of phytoplankton absorption in ocean waters also affects the retrieval of chlorophyll a concentrations (a measure of phytoplankton biomass) derived from satellite data, which are important input data used in primary production models. Results by Vountas et al. (2007) and Bracher et al. (2009) show that specific phytoplankton absorption spectra, information on the light penetration depth and

the identification of two types of phytoplankton groups (diatoms, cyanobacteria) can be derived from the high spectrally resolved satellite data of the sensor SCIAMACHY. A future goal is to extend the exploitation of SCIAMACHY data in order to get information on the global distribution of other phytoplankton groups as well and to combine this new biooptical information from SCIAMACHY with common ocean colour data such as MERIS, SeaWIFS or MODIS, in order to get also a better spatial resolution of the distribution of different phytoplankton groups and also to improve biomass and primary production estimates. Besides the analysis of satellite data and applied model studies, field measurements in the open ocean of phytoplankton pigment composition, optical characteristics of phytoplankton and other water constituents, reflectance and underwater light measurements are highly precise input parameters for the validation of results from the analyses of satellite data and modelling.

In recent years, hyperspectral optical measurements have matured into one of the most powerful and fastest growing technologies in the field of remote sensing, and represent a promising approach towards discriminating and quantifying distinct phytoplankton groups in the world's oceans. A major research goal is to develop algorithms for assessing the biodiversity of phytoplankton communities from present and future *in-situ*, airborne, and satellite hyperspectral sensors. Our objective for this cruise will be the collection of a unique bio-optical data set which encompasses a wide variety of oceanic regions and ecosystems encountered during the expedition. We wish to determine how different phytoplankton communities, discriminated in terms of pigment-based dominant taxa and cell size, quantitatively affect the spectral shape of hyperspectral remote-sensing reflectance, $R_{rs}(\lambda)$. For this purpose, we will examine relationships between hyperspectral R_{rs}, inherent optical properties (IOPs) such as the spectral absorption and scattering coefficients, and phytoplankton taxa-specific pigment composition. We will also examine how other inorganic and organic seawater constituents, co-existing with phytoplankton communities, affect $R_{rs}(\lambda)$. Similar analysis will be conducted at the level of hyperspectral IOPs (e.g., the spectral backscattering coefficient, $b_b(\lambda)$, and absorption coefficient, $a(\lambda)$), which are primary determinants of $R_{rs}(\lambda)$.

Work at sea

1. Water samples

Discrete surface water samples will be taken daily from the ship's underway system (morning and evenings), and at multiple depths from the CTD-rosette at the noon stations. Various analyses performed onboard and post-cruise include:

- Filtration of water samples onto GF/F filters for HPLC pigment analysis, particulate absorption measurements including near IR absorbing particles;
- Particulate organic carbon and nitrogen concentrations, and mass concentrations of organic and inorganic suspended matter;
- Particle concentration, size distribution and individual particle imaging (for identification) will be measured onboard with a Coulter Multisizer III and Fluid Imaging FlowCam;
- Water samples will be preserved for flow cytometric measurements and microscopy for later analysis in the laboratory in Bremerhaven;
- Particulate absorption in suspension and absorption of gelbstoff will be measured during the cruise using the point-source integrating-cavity absorption meter (PSICAM) (Röttgers et al. 2005).

2. Online and *in-situ* optical measurements

- A FastTracka Fast Repetition Rate Fluorimeter (FRRF) will be used in a flow-through system with water continuously pumped from the moon pool to provide online data of chlorophyll fluorescence during the cruise.
- A second FastTracka FRRF will be attached to the CTD to take measurements in the water column during stations.
- Above-water remote sensing reflectance will be measured from onboard the ship with a set of three radiometers (TRIOS RAMSES). In-water values of downwelling spectral irradiance and upwelling spectral iradiance and radiance will be measured at the noon stations with a Satlantic hyperspectral radiometer system (surface time series), and complemented with vertical profiles (0 - 150 m) obtained from a second set of TRIOS RAMSES radiometers.
- Vertical profiles of inherent optical properties will be measured at the noon stations with a Multisensor Datalogger System. The core of this system consists of a Seabird SBE-25 CTD monitoring basic information on physical (temperature, conductivity) and biological (chlorophyll fluorescence) properties of the water column. Optical instrumentation includes sensors for multispectral backscattering (HobiLabs HS6 and a-βetas, WetLabs ECO-VSF) and beam attenuation (C-stars, WetLabs), and a LISST-100X (Sequoia) for measurements of near-forward scattering and derivation of the particle size distribution.

Expected results

The aim of this research project is to improve estimates of global marine primary production and the distribution of major phytoplankton functional groups by using remote sensing data in combination with *in-situ* measurements of ocean optics, phytoplankton productivity and composition and particulate organic carbon. In particular, data will be collected during this cruise to improve our understanding of the oceans variability in optical properties and to improve/develop remote sensing algorithms for the investigated research area. Through a better knowledge of the sinks and sources of CO_2 in the ocean a contribution will be made to a better understanding of changes in the world's climate as well as to the understanding of the marine food web.

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Röttgers R., Schönfeld W., Kipp P.-R., Doerffer R. (2005) Practical test of a point-source integrating cavity absorption meter: the performance of different collector assemblies. Applied Optics 44(26): 5549-5560.

4. ATMOSPHERIC DUST AND IRRADIATION EFFECTS ON OCEAN SURFACE PROCESSES – BIOGEOCHEMISTRY IN THE ATLANTIC OCEAN (ADIOS-BAO)

T. Wagener, A. Dammshäuser, M. Dunker, N.N. (IFM-GEOMAR), D. Gaiero (UNC)
Not on board: P. Croot (IFM-GEOMAR)

Objectives

This cruise is a continuation of our ongoing studies into the aerosol deposition of trace elements to the open ocean and its effect on ocean biogeochemical cycles. In cooperation with national and international partners we will assess the combined impacts of aerosol deposition and irradiation on the near surface biogeochemistry of P, N, Fe, Al and Ti. The cruise transect crosses regions potentially influenced by dust sources from Patagonia and the Sahara, providing the opportunity to compare the oceanic response to these different aerosol sources.

This work forms part of the German contribution to both SOLAS and GEOTRACES and is also a continuation of similar earlier work performed on the *Polarstern* (ANT-XVIII/1, ANT-XXIII/1) and the *Meteor* Cruise 55 in the central Atlantic looking at the effect of Saharan dust deposition on surface seawater iron concentrations.

Work at sea

Our work will focus on the simultaneous daily collection of atmospheric aerosols and surface seawater samples, along the cruise track, for analysis at sea and in the laboratory in Kiel. At each daily station, shipboard measurements will be made of coloured dissolved organic matter (CDOM), phosphate, Fe, Al, Ti and the transient redox species Fe(II) and H_2O_2 in near surface waters to examine the influence of dust supply and irradiation along the transect. Specific at sea experiments will focus on the instantaneous dissolution of the daily sampled aerosols with freshly collected seawater. Additional longer term experiments will utilize archived dust sources from the Sahara and Patagonia with clean seawater collected from different regions during the voyage to assess possible regional differences in the dissolution processes.

Expected results

During this expedition we expect to gain a comprehensive data on crustally derived trace metals (Al, Fe and Ti) and phosphate in the surface ocean over contrasting regions of the Atlantic Ocean. Simultaneous measurements of photochemical influenced parameters (hydrogen peroxide, nitrite and CDOM) will allow us to examine the influence of irradiation on dust dissolution via redox processes. Coupled with shipboard experiments on dust dissolution this will enable us to gain a better understanding of processes influencing the distribution of these elements in the Atlantic.

5. ANALYSIS OF THE CHEMICAL COMPOSITION OF MARINE ORGANIC AEROSOL ALONG A MERIDIONAL TRANSECT OF THE ATLANTIC OCEAN

Not on board: R. Holzinger (IMAU)

Objectives

This project involves fundamental research with innovative and new methods for aerosol analysis. The new techniques are a high-mass resolution proton-transfer-reaction mass-spectrometer (hi-res-PTR-MS) and stable isotope ratio mass spectrometry (IRMS). The hi-res-PTR-MS allows for resolving the fractional mass difference between O- and CH_4-components (i.e. 0.036 dalton) in molecules and thus allows measuring the degree of oxygenation of organic aerosols. We aim at characterizing the chemical composition of organic aerosols over different regions of the Atlantic Ocean.

Work at sea

During the cruise a high volume aerosol sampler will be operated to collect aerosol filter samples with a temporal resolution of 12 - 24 h. After collection the filter samples will be stored at -20°C and transported to our laboratory at Utrecht University for analysis.

Expected results

With our data we expect to gain new information on important questions in this field. We aim at constraining the source strength of marine organic aerosol. We will try to identify natural and anthropogenic precursor substances to aerosol formation, and we will gain insights on chemical processes that lead to aerosol ageing. All this information will help.

6. MEASUREMENT OF CONCENTRATION AND ISOTOPIC SIGNATURE OF HYDROGEN IN SURFACE OCEAN AND ATMOSPHERE

N.N. (IMAU)
Not on board: S. Walter (IMAU)

Objectives

Only few studies have tried to decipher the global budget of molecular hydrogen (H_2). Therefore its atmospheric cycle is poorly understood. In the little of future hydrogen base energy techniques we need to improve the situation – a task that we have taken on. This project is continuation of pilot studies that have been carried out previously (e.g., *Poseidon* cruise in 2007). Its aim is to measure the concentration and isotopic signature of hydrogen in the atmosphere and surface ocean. The ultimate goal is to quantify oceanic hydrogen emissions and their role in the global atmospheric hydrogen cycle. The latitudinal distribution of atmospheric hydrogen will be used to improve atmospheric models.

Work at sea

Throughout the cruise, air samples for analysis of hydrogen isotopes will be taken regularly

(at least every 6 h) from a sampling spot on the compass platform. In addition continuous underway measurements of hydrogen concentrations in surface seawater and atmosphere will be carried out with a Reducing Compound Photmeter (RCP). The continuous hydrogen measurement will be compared with the ones based on discrete air samples for verification purposes. Furthermore discrete surface water samples will be taken regularly for analysis of hydrogen isotopes. Also, for verification purposes additional discrete samples will be drawn from surface Niskin water samples at hydrographic stations. All isotope analyses will be carried out in the home laboratory.

Expected results

- Isotopic signatures of hydrogen in atmosphere and surface ocean
- Air-sea hydrogen fluxes
- Improved understanding and modelling capabilities of atmospheric hydrogen

7. ABYSSAL TEMPERATURE FLUCTUATIONS IN THE VEMA CHANNEL

Not on board: W. Zenk, M. Visbeck (IFM-GEOMAR)

Objectives

The equatorbound flow of Antarctic Bottom Water (AABW) represents a significant limb of the global thermohaline circulation. In the South Atlantic the deep western boundary along the continental rise carries AABW northward. The advected water masses originate from the Weddell Sea, where they are formed by deep wintertime convection. At the latitude 32°S the abyssal flow encounters two topographical constraints in form of the zonally aligned Santos Plateau and the Rio Grande Rise. These combined submarine mountain chains separate the Argentine Basin in the south from the Brazil Basin farther to the north. AABW finds its equatorward pathway through this natural impedance via a 790 km long canyon called Vema Channel (Fig. 7.1). The meridionally directed channel with water depths > 4500 m provides a choke point for observations of water mass property and transport fluctuations of abyssal waters. Monitoring such fluctuations is vital for a state-of-the-art modelling of the global climate system.

A decade-scale record from the channel entrance (31°S, 39°W) indicates a clear increase of the lowest temperatures of the bottom water. Comparable observations from the exit region of the Vema Channel (26°S, 35°W) confirm the general abyssal temperature rise since 1991. The Vema Sill station at the entrance is internationally acknowledged as an ocean site observatory. *OceanSITES* is a worldwide system of long-term, deep water reference stations measuring regularly dozens of physical, geochemical, and biological variables (http://www.oceansites.org).

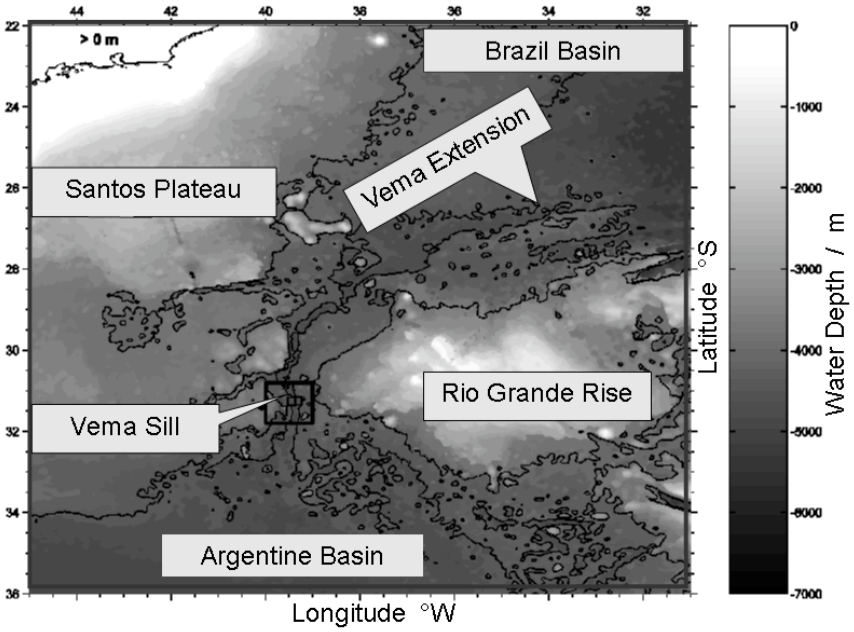

Fig 7.1: Vema Channel in the South Atlantic. This canyon enables dense Antarctic Bottom Water (AABW) to leave the Argentine Basin on its equatorbound transit towards the Brazil Basin. Revisits to the Vema Sill and the Vema Extension are planned during legs ANT-XXVI/1 and 4, respectively.

Work at sea

Our prime objectives during ANT-XXVI/4 are revisits to the Vema Sill and Extension sites for additional high precision CTD observations of the coldest AABW in the Vema channel (see Fig. 7.1). Work time for each station of about 3.5 h appears adequate. The Vema Channel is situated en-route from the Strait of Magellan.

Expected results

According to recent observations from *Polarstern* in the spring of 2009, the general drift towards higher near-bottom temperatures seems to fade away at the sill. So far, no such vanishing of significant temperature rise was observed at the extension. Both observations at identical locations were confirmed by almost synoptic Russian measurements. Under the assumption of a mean advection speed of Antarctic Bottom Water of ~5 cm/s our work hypothesis expects the arrival of less warmed-up water mass “front” at the extension later in 2009.

11. BETEILIGTE INSTITUTE / PARTICIPATING INSTITUTES

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Bumke	Karl	IFM-GEOMAR	Scientist, meteorologist
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Dunker	Mirja	IFM-GEOMAR	Student, chemistry
Gaiero	Diego	UNC	Scientist, chemist
Hieronymi	Martin	IFM-GEOMAR	Ph.D. student, meteorology
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Reynolds	Rick	SIO	Postgraduate researcher, biologist
Röttgers	Rüdiger	GKSS	Scientist, biologist
Sadeghi	AliReza	IUP	Ph.D. student, physics
Theis	Anja	AWI	Ph.D. student, biologist
Wagener	Thibaud	IFM-GEOMAR	Postdoc, chemist

13. SCHIFFSBESATZUNG / SHIP'S CREW

No.	Name	Rank
1.	Pahl, Uwe	Master
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3.	Ziemann, Olaf	Ch.Eng.
4.	Hering, Igor	2. Offc.
5.	Janik, Michael	3. Offc.
6.	Erich, Matthias	Doctor
7.	Koch, Georg	R.Offc.
8.	Kotnik, Herbert	2. Eng.
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10.	Westphal, Henning	2. Eng.
11.	Holtz, Hartmut	ElecEng.
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14.	NN	ELO
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18.	Burzan, Gerd-Ekkeh.	A.B.
19.	Hartwig-Lab.,Andreas	A.B.
20.	Kreis, Reinhard	A.B.
21.	Kretzschmar, Uwe	A.B.
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23.	Schröder, Norbert	A.B.
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27.	Fritz, Günter	Mot-man
28.	Kliem, Peter	Mot-man
29.	Krösche, Eckard	Mot-man
30.	Watzel, Bernhard	Mot-man
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32.	Tupy, Mario	Cooksmate
33.	Völske, Thomas	Cooksmate
34.	Dinse, Petra	1.Stwdess
35.	Hennig, Christina	Stw/Nurse
36.	Hischke, Peggy	2.Stwdess
37.	Hu, Guo Yong	2.Steward
38.	Streit, Christina	2.Stwdess
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41.	Ruan, Hui Guang	Laundrym.

FS POLARSTERN

ANT-XXVI/1	**16.10.2009 - 25.11.2009**	**Bremerhaven - Punta Arenas**
ANT-XXVI/2	**27.11.2009 - 27.01.2010**	**Punta Arenas - Wellington**
ANT-XXVI/3	**30.01.2010 - 05.04.2010**	**Wellington - Punta Arenas**
ANT-XXVI/4	**07.04.2010 - 17.05.2010**	**Punta Arenas - Bremerhaven**