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HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

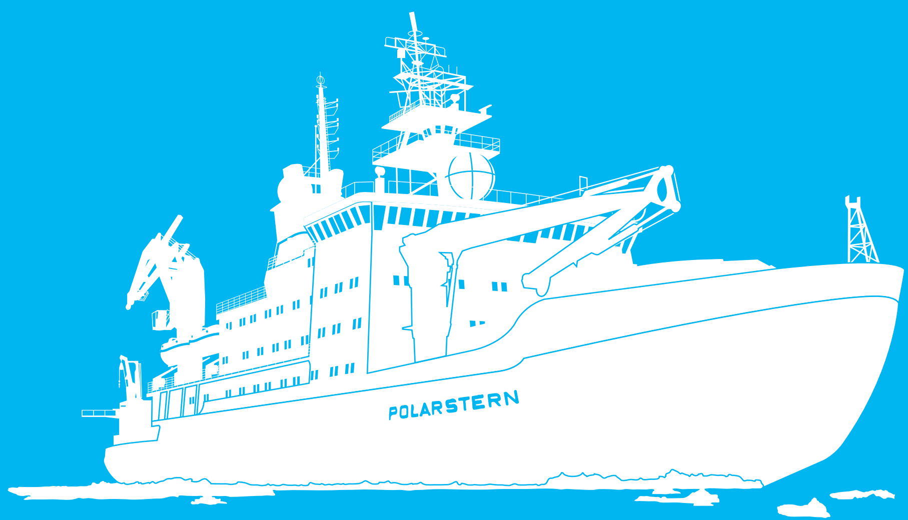
EXPEDITION PROGRAMME PS128

Polarstern

PS128
Cape Town – Cape Town
6 January 2022 – 28 February 2022

Coordinator: Ingo Schewe

Chief Scientist: Ralf Tiedemann



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The Expedition Programme *Polarstern* is issued by the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI) in Bremerhaven, Germany.

The Programme provides information about the planned goals and scientific work programmes of expeditions of the German research vessel *Polarstern*.
The papers contained in the Expedition Programme *Polarstern* do not necessarily reflect the opinion of the AWI.

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PS128

6 January – 28 February 2022
Cape Town – Cape Town

EASI-1
East Antarctic Ice Sheet Instabilities (1) –
Ice-Ocean-Climate Interactions

Chief scientist
Ralf Tiedemann

Coordinator
Ingo Schewe

Contents

Appendix

1. ÜBERBLICK UND FAHRTVERLAUF

Ralf Tiedemann[1], Juliane Müller[1]　　[1]DE.AWI

Die *Polarstern*-Expedition PS128 unter dem Titel „East Antarctic Ice Sheet Instability (EASI-1)“ ist die erste von drei geplanten Expeditionen, die sich mit der erdgeschichtlichen Instabilität des ostantarktischen Eisschildes (EAIS) und seinen Wechselwirkungen mit Zirkulationsänderungen im Südpolarmeer befasst. Die Reaktion des EAIS auf die anthropogene Erwärmung ist mit großen Unsicherheiten für die Vorhersage des zukünftigen Meeresspiegelanstiegs behaftet, weil die Eis-Ozean-Klima-Rückkopplungen kaum verstanden sind. Ihre Rekonstruktion, insbesondere für Zeiten in denen es wärmer war als heute, soll helfen, die Grundlagen für die Vorhersage zukünftiger Änderungen zu verbessern. Unsere Arbeiten konzentrieren sich auf den antarktischen Kontinentalabhang und die Küstenregion zwischen dem Weddellmeer und der Kooperationssee. Ziel ist die Gewinnung von marinen und terrestrischen Sedimentkernen und die Erfassung von ozeanographischen, marin-geophysikalischen und kontinental-geodätischen Daten. Damit wollen wir neue Erkenntnisse über die Änderungen in folgenden Bereichen gewinnen: Bildung von Antarktischem Bodenwasser vor Cape Darnley, ozeanischer Wärmetransport unter das Eisschelf der *Neumayer-Station III*, Verhalten der Eisaufsetzlinie, Meereisbedeckung, Schmelzwassereintrag und ozeanische Stratifizierung. Die Gewinnung langer Sedimentkerne und -oberflächen wird von bathymetrischen Kartierungen, sediment-echografischen und hydrografischen Untersuchungen (inkl. Wasser- und Planktonproben) begleitet. Die über Vibroseismik vermessenen Sedimentstrukturen unterhalb des Ekström-Schelfeises werden über den Kontinentalschelf mit marin-seismischen Profilen kartiert, um die präglazialen und glazialen Sedimentationsprozesse zu quantifizieren.

Die Expedition trägt zu den Zielen der Programmorientierten Förderung (PoF) der Helmholtz-Gemeinschaft, dem Forschungsprogramm "Erde im Wandel – Unsere Zukunft sichern" bei. Die Ziele unserer Expedition stehen im engem Zusammenhang mit diesem Programm, insbesondere mit dem Thema "Ozean und Kryosphäre im Klima". Dieses Thema wird die Ursachen, Mechanismen und Folgen von "Meeresspiegelveränderungen", "Erwärmung des Klimas" und "Klimavariabilität und -extreme" auf der Grundlage eines kombinierten Ansatzes von Beobachtungen, Rekonstruktionen (modern und paläo) und Erdsystemmodellierung untersuchen.

Der Fahrtabschnitt PS128 wird am 6. Januar 2022 in Kapstadt starten und am 28. Februar 2022 in Kapstadt enden. Bereits auf dem Transit Richtung Antarktis befindet sich das erste Untersuchungsgebiet (E) zwischen DelCano Rücken / Conrad Rücken und dem Antarktischen Kontinentalhang vor Enderbyland (Abb. 1). Am 13/14. Januar wird unsere Landgruppe für ihre 2-wöchigen Feldarbeiten in der Region der Molodeshny Oase an der belarussischen Station *Gora Vechernyaya* abgesetzt (Camp Glubokoje). Währenddessen werden die marinen Arbeiten am Kontinentalhang vor Cape Darnley in enger Abstimmung mit unseren australischen Kooperationspartnern durchgeführt (Untersuchungsgebiet D), die zur gleichen Zeit mit dem Forschungsschiff *Investigator* vor Ort sind. Ende Januar wird die Landgruppe wiederaufgenommen und die marinen Arbeiten im Untersuchungsgebiet C (Gunnerus Rücken, Riiser-Larsen-See, Lasarew-See) fortgesetzt. Je nach Wetterlage und Meereisbedingungen sind kurze Landexpeditionen möglich. Einen letzten Forschungsschwerpunkt der Expedition bilden geophysikalische und geologische Arbeiten auf dem Schelf und am Kontinentalabhang im Bereich der *Neumayer-Station III* (Arbeitsgebiet B). Nach Abschluss der Arbeiten wird Kapstadt auf dem kürzesten Weg angefahren.

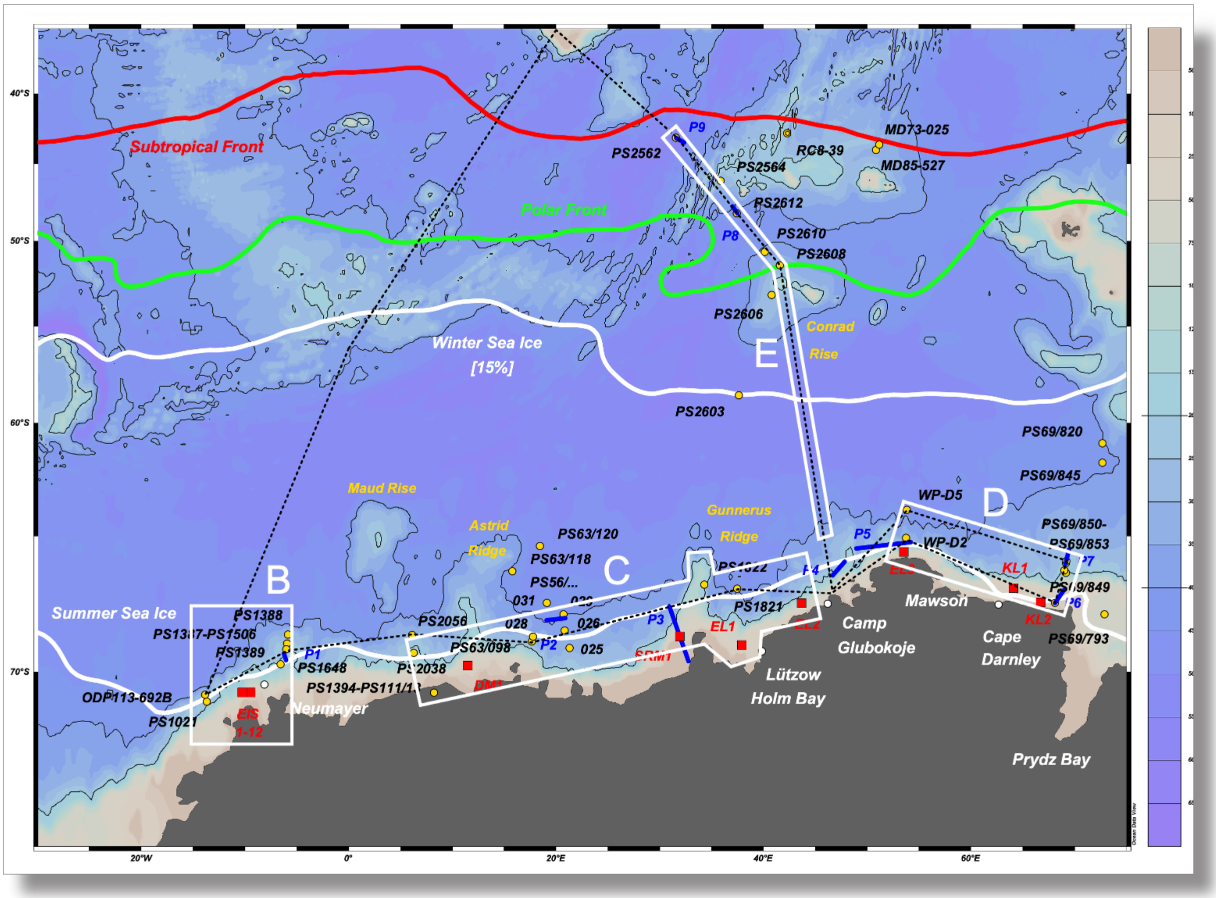

Abb. 1: Die Untersuchungsgebiete E-B der Polarstern-Expedition PS128:
Rote Kästchen kennzeichnen Zielgebiete auf dem Schelf. Gelbe Kreise markieren eine Auswahl von ehemaligen Kernlokationen. Die weiße Linie zeigt die gemittelte Position der 15 % Sommer-Meereisausdehnung. Die blauen Linien P1 bis P6 zeigen Beispiele für Parasound-Profile. Lützow Holm Bay, Camp Glubokoje und Mawson markieren Ziele für Landexpeditionen.

Fig. 1: Study areas E–B of Polarstern expedition PS128:
Red boxes indicate target areas on the shelf. Yellow circles mark selection of former sediment cores. The white line shows the averaged position of the 15 % summer sea ice extent. The blue Lines P1 to P6 show examples of parasound profiles.
Lützow Holm Bay, Camp Glubokoje and Mawson mark terrestrial activities.

SUMMARY AND ITINERARY

Ralf Tiedemann[1], Juliane Müller[1]   [1]DE.AWI

Expedition EASI-1 (East Antarctic Ice Sheet Instability) represents the first of three proposed expeditions that will examine the history of East Antarctic Ice Sheet Instability and its interaction with changes in Southern Ocean (SO) circulation. The behavior of the East Antarctic Ice Sheet (EAIS) under projected anthropogenic warming is a key uncertainty in predicting future sea level rise due to the influence of strong ice-ocean feedbacks, which are poorly understood. Reconstructing and disentangling these feedbacks during past warmer-than-present climate states is considered to provide an enhanced basis for improved prediction of future changes in the ice-ocean-climate system. Our goal is to acquire marine and terrestrial sediment records, in combination with oceanographic, marine-geophysical, and continental-geodetic data. Our work will focus on the Antarctic continental margin between the Weddell and Cooper Seas. The main focus of EASI-1 is to enhance our knowledge about changes in: Antarctic bottom water formation at Cape Darnley, ocean heat transport to the ice-shelf cavity below *Neumayer Station III*, grounding-line behaviour, sea ice cover, meltwater supply, and oceanic stratification. Recovery of long sediment records and surface sediments will be accompanied by bathymetric, sediment echosounding, and hydrographic surveys (including water and plankton sampling). In addition, we plan to conduct a seismic survey across the continental shelf to the sedimentary structures below Ekström Ice Shelf (EIS), known from vibroseis surveys, to quantify the pre-glacial and glacial sedimentation processes.

The expedition contributes to the goals of the Helmholtz Association's Programme-oriented Funding (PoF), the research programme "Changing Earth – Sustaining our Future". The goals of our expedition are closely related to this programme, in particular to the topic "Ocean and Cryosphere in Climate". Within this topic, the causes, mechanisms and consequences of "sea level rise", "climate warming" and "climate variability and extremes" will be investigated based on a combined approach of observations, reconstructions (modern and palaeo) and Earth system modelling.

Cruise leg PS128 will begin in Cape Town on 6 January 2022 and end in Cape Town on 28 February 2022. Already in transit to Antarctica the first study area (E) is to be found between DelCano Ridge / Conrad Ridge and the Antarctic continental slope off Enderbyland. On 13/14 January our land group will be dropped off at the Belarusian station *Gora Vechernyaya* (Camp Glubokoye) for their two-week field work in the Molodeshny Oasis region. Meanwhile, the marine work on the continental slope off Cape Darnley is being carried out in close coordination with our Australian cooperation partners (study area D), who are on site at the same time with their research vessel *Investigator*. At the end of January, the land party will be picked up and the marine work will be continued in study area C (Gunnerus Ridge, Riiser-Larsen Sea, Lasarev Sea). Depending on weather and sea ice conditions, short land expeditions are also possible. A final research focus of the expedition is geophysical and geological work on the shelf and continental slope in the area of *Neumayer Station III* (working area B). After completion of the work, Cape Town will be approached by the shortest route.

2. MARINE GEOLOGY AND PALEOCEANOGRAPH

Ralf Tiedemann[1], Juliane Müller[1], Johann Klages[1], Pascal Daub[1], Wee Wei Khoo[1], Norbert Lensch[1], Dirk Nürnberg[2], Lester Lembke-Jene[1], Taina Pinho[1], Vincent Rigalleau[1], Lisa Schönborn[1], Valea Schumacher[1], Thomas Arney[3], Henning Bauch[1], Bernhard Diekmann[1], Gesine Mollenhauer[1], Thorsten Bauersachs[4], Matthieu Civel-Mazens[5], Lea Fuchs[11], Alina Ivanova[11], Hinner Preckel[11], Ebbe Nürnberg[12], Patricia Sonnemann[13]

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[8]AU.UQ.EDU.SEES,
[9]AU.ANU.EDU,
[10]NZ.GNS.CRI,
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Grant No. AWI_PS128_01

Objectives and scientific programme

The overall goal is to enhance our understanding on the late Paleogene to Quaternary processes as well as the orbital to submillennial-scale evolution of ice-ocean-climate interactions during deglacial warming and climate intervals that were warmer than today. Therefore, we plan to probe marine sediment archives along the continental margin of Dronning Maud Land, Enderby Land and Mac. Robertson Land. Particular attention will be paid to processes that are related to basal ice shelf melting, including Warm Deep Water (WDW) intrusions into the ice shelf cavities and feedback mechanisms (e.g. freshening, sea ice cover) that control the formation and extent of Antarctic Bottom Water (AABW). Key hypotheses we will address in this context are:

- Marine ice-based portions of the Antarctic ice sheet collapsed during warmer than-present times at a temperature anomaly threshold of 2 – 3° C.
- The marine-based East Antarctic ice portions are similarly unstable as the West Antarctic Ice Sheet.
- The frequency, duration and extent of cross-continental shelf intrusions of warm Deep Water control the instability of ice sheets during past interglacials.
- Antarctic sea ice varied asynchronously with Arctic sea ice extent over centennial to millennial times scales and synchronously on orbital times scales.

- Sea ice retreat favours the destabilization of ice shelves, accelerating continental ice mass loss.
- Changes in ice sheet melt and freshwater input affect Southern Ocean circulation and ecosystem processes, e.g. through fundamental changes in formation rates and physical and biogeochemical characteristics of abyssal AABW.

An important backbone to validate these hypotheses is the development of high resolution age models. Precise timeframes are required to allow for comparisons with other existing high-resolution climate proxy records derived from sediment and ice cores. We will apply a variety of stratigraphic methods, including marine oxygen isotope stratigraphy, ^{14}C-dating techniques, $^{230}Th_{ex}$, $^{231}Pa_{ex}/^{230}Th_{ex}$ methods, cross-correlation of proxy records with other well-dated records, paleomagnetics and tephrachronology. Other options (yet to be tested) include correlating proxy records from sediment and ice cores, that indicate changes in sea ice variability (e.g. Abram et al. 2013) by assuming synchronous variability. This could anchor the sediment stratigraphy to e.g. the ice core chronology of the EPICA DML ice core (EPICA Community Members, 2006).

The sediment archive at the continental margin off *Neumayer Station III* provides large quantities of well-preserved planktonic and benthic foraminifers (Grobe and Mackensen 1992) and thus, the opportunity to reconstruct glacial/interglacial temperature variations on centennial/ millennial to orbital timescales from the surface into the deep water. Temperatures will be reconstructed by means of Mg/Ca paleothermometry on planktic and benthic foraminifers (Nürnberg et al. 2000), the organic biomarker-based indices TEX^{L}_{86} and RI-OH' (Ho et al. 2014; Lamping et al., 2021; Park et al., 2019) and diatom/radiolarian transfer functions (Gersonde et al. 2005; Civil-Mazens et al. in prep.). Sea ice reconstructions will be based on analyses and intercomparisons of specific biomarker lipids (highly branched isoprenoids) and diatom assemblages. These studies will allow to assess the role of “Warm Deep Water” in ice-shelf melting and the response of the SO and sea ice to meltwater-induced freshening.

The sediment archives proximal and distal to the Cape Darnley Polynya offer an excellent opportunity to assess past changes in Cape Darnley Bottom Water/AABW formation, which is of global significance. A multi-proxy approach is required to reconstruct and understand the system (Borchers et al. 2016; Vorrath et al. 2019; Rickli et al. 2014). We will reconstruct changes in sea ice production, biogenic productivity, Nd isotopes and Rare Earth Elements indicative of the provenance of current-derived and ice-transported material as well as past regional changes in overturning circulation.

Our studies also aim to significantly improve our understanding of past EAIS extent, its flow and retreat patterns, and the related bed processes that controlled ice flow primarily since the last glacial to the Holocene (Klages et al. 2016; 2017). We will integrate and link bathymetric, seismic, marine geological, and modelling competence to map and document temporal changes in grounding line dynamics since the LGM.

Work at sea

Bathymetric and hydroacoustic surveys are used to identify (1.) core locations ideally containing undisturbed sediment sequences, (2.) sites with high sediment accumulation, (3.) sites that comprise the last 500 ka in the upper 20 m of the sediment archive and (4.) grounding lines, moraines and scour marks.
The standard coring programme includes the operation of the multicorer (MUC) and the piston/ gravity/box corer (PC/GC/BC). In area E (Fig. 1), we plan to retrieve new records and revisit former (key-) core locations to obtain fresh and additional material for measuring biomarkers

as well as established and new proxies. For example, at Conrad Rise we will re-visit coring locations (Fig. 1), where our sample material is depleted or not suitable for biomarker studies. Sediment records from the deep-sea basin (away from turbidites, area E) will be used to reconstruct changes in AABW dynamics. In area D, the work program is almost identical to that in area B, as we plan transects of sediment records from the Cape Darnley Polynya on the shelf and across the continental margin into the deep sea basin. In close proximity to the EIS, we will complement previous sub-ice shelf coring campaigns to define the extent and timing of grounded ice beneath and offshore the EIS. This work to constrain the past extent and retreat pattern of grounded ice and its timing since the LGM will continue in area C by combining information from multibeam and sediment echosounders with appropriate coring locations (KC and GC) on selected shelf sectors. In addition, we will collect sediment cores along a selected transect from the shelf towards more distal sites to obtain fresh/undegraded material (e.g. for biomarker studies) to reconstruct changes in ice cover and sea (sub)surface temperatures. In area B, we will perform an extensive sediment coring programme, targeting on sites distributed in water depth from 500 – 4,000 m to reconstruct the vertical water mass architecture and the different physical and chemical signatures of water masses. At foraminifer-bearing key stations, we will use the Kasten Corer (KC) and/or triple coring (PC/GC) to ensure that sufficient foraminifers are available for the application of certain paleoceanographic proxies and ^{14}C datings.

Gravity cores will be cut into 1 m sections and stored at 4° C. Prior to storage, all core sections will be analyzed for physical properties of the entire core using a Multi-Sensor-Core-Logger (MSCL-S, Geotek Ltd.). The MSCL device provides data at 1 cm depth intervals of wet-bulk density, porosity, p-wave velocity and magnetic susceptibility. Full processing of MSCL raw data will be carried out at sea, so that high resolution records of physical properties are available during the cruise. Selected sediment cores will be split onboard. Core images, descriptions of sediment properties and smear slide investigations of these cores allow an initial characterization of the sediments. However, some of the sediment cores remain unsplit until arrival at the home laboratories because the expected number of sediment cores is too high. Sampling of the Multi Corer sediment records (1 cm slices) into combusted glass vials (biomarker) and Whirlpack sampling bags will take place onboard. Samples designated for biomarker studies and ancient DNA analyses at home laboratories at AWI and Christian Albrechts University in Kiel will to be stored frozen (–20° C). Water samples will be filtered on board, acidified and subsequently co-precipitated.

Expected Results

In general, our expedition will provide new data and samples from key regions along the East Antarctic continental margin that will enhance our understanding of processes related to interactions in the ice-ocean-bedrock-climate system. This should improve our assessment of future ice sheet instability and associated changes in Southern Ocean circulation and ventilation.

On board, the combination of bathymetric and subsurface sediment features (parasound) in combination with core descriptions will already provide information on sedimentary structures and their morphological history in relation to former ice coverage, sub-ice hydrological conditions (sub-glacial lakes, meltwater channels), ice-flow dynamics and possible past natural collapses of ice shelves.

Sample and data management

The entire international community involved in the planned expedition will have immediate and preferential access to the cruise report, to shipboard data and samples retrieved. The availability of expedition data and samples may remain restricted to others not directly involved in the project. After a moratorium period that protects the interests of the project partners, the scientific community will have open access to data and samples.

In principle, AWI's research data policy follows the principles for the responsible handling of research data, which are based on the recommendations of the Helmholtz Association for guidelines on the management of research data, on the Guidelines of the European Commission on Data Management according to the FAIR principles and the guidelines of the Deutsche Forschungsgemeinschaft on handling research data.

AWI aims to publish at least the primary scientific data as soon as possible. The open-access cruise report will be published shortly after the cruise in the AWI series "Reports on Polar and Marine Research". It will contain detailed descriptions of the fieldwork conducted and initial results obtained along with lists of samples and data collected during the cruise. All data must be archived in a publicly accessible, citable long-term repository two years after collection. The archived data may be under moratorium for a maximum of two additional years. In addition, appropriate moratorium periods must be applied for and recorded in the data management plan. After the embargo periods have expired, the data must be made public immediately and actively using the FAIR principles. All data will be stored in international data bases (e.g., PANGAEA, DOD, SCAR SDLS), preferably in the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) operated as an open-access library by the AWI and the Center for Marine Environmental Sciences, University of Bremen (MARUM) within two years after the end of the cruise at the latest. By default, the CC-BY license will be applied.

Sediment samples and cores collected during *Polarstern* expeditions are usually archived in the AWI Core Repository, which is operated by the marine geology department since 1983. Cores are stored in sealed D-tubes at 4° C and an air humidity limited at 35 %. The repository is open to the scientific community for sampling subject to ongoing work at AWI including national and international collaborations.

Any other data will be submitted to an appropriate long-term archive that provides unique and stable identifiers for the datasets and allows open online access to the data .In all publications, based on this cruise, the Grant No. AWI_PS128_01 will be quoted and the following *Polarstern* article will be cited: Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (2017) Polar Research and Supply Vessel POLARSTERN Operated by the Alfred-Wegener-Institute. Journal of large-scale research facilities, 3, A119. http://dx.doi.org/10.17815/jlsrf-3-163.

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3. BATHYMETRY OF THE EAST ANTARCTIC SEA

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Grant No. AWI_PS128_02

Objectives

Accurate knowledge of the seafloor topography, hence high-resolution bathymetry data, is a basic key information and necessary to understand many marine processes. It is of particular importance for the interpretation of scientific data in a spatial context. Bathymetry, hence geomorphology, is furthermore a fundamental parameter for understanding the general geological setting of an area and geological processes such as erosion, sediment transport and deposition. Even information about tectonic processes can be inferred from bathymetry.

While world bathymetric maps give the impression of a detailed knowledge of worldwide seafloor topography, most of the world's ocean floor remains unmapped by hydroacoustic systems. In these areas, bathymetry is modelled using satellite altimetry with a corresponding low resolution. Satellite-altimetry derived bathymetry therefore lack the resolution necessary to resolve small- to meso-scale geomorphological features (e.g. sediment waves, glaciogenic features and small seamounts). Ship-borne multibeam data provide bathymetric information at a resolution sufficient to resolve these features and enable site selection for the other scientific working groups on board.

Glacigenic landforms preserved at the seafloor can form the basis for the reconstruction of the dynamic history of the East Antarctic Ice Sheet. In particular, these landforms can shed light on its retreat since its maximum extent during the Last Glacial Maximum. Understanding the processes that led to this ice sheet retreat in the past can provide important information for predicting future responses of the East Antarctic Ice Sheet to changing climate conditions and oceanographic settings. Glacigenic landforms can only be determined in high-resolution bathymetric data sets. However, for the study areas of the EASI1 expedition in the Indian Ocean sector of the Southern Ocean, these data are sparse. It is therefore planned to acquire detailed bathymetric data of these areas with the ship's hydroacoustic instruments.

Furthermore, the collection of underway data during PS128 will contribute to the bathymetry data archive at the AWI and thus to bathymetric world datasets such as GEBCO (General Bathymetric Chart of the Ocean).

Work at sea

The bathymetric data will be recorded with the Atlas Hydrosweep DS3 hull-mounted multibeam echosounder. The main task of the bathymetry group is to plan and run bathymetric surveys in the study areas and during the transit. The raw bathymetric data will be corrected for sound velocity changes in the water column, further processed and cleaned for erroneous soundings and artefacts. Detailed seabed maps derived from the data will provide information on the general and local topographic setting in the study areas. The high-resolution seabed data recorded during the survey will be made available for site selection and cruise planning. During the survey, the acoustic measurements will be carried out by three operators working 24/7 hour shifts (except for periods of stationary work).

Preliminary (expected) results

Expected results will consist of high-resolution seabed maps along the cruise track and from the target research sites. The bathymetric data will be analysed to obtain geomorphological information of the research area. The expected results aim towards a better understanding of the geological processes in the research area.

Data management

Geophysical and oceanographic data collected during the expedition will be archived, published and disseminated according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) within two years after the end of the cruise at the latest. By default, the CC-BY license will be applied.

Furthermore, the data will be included in regional data compilations such as IBCSO (International Bathymetric Chart of the Southern Ocean) and provided to the Nippon Foundation – GEBCO Seabed 2030 Project.

In all publications, based on this cruise, the Grant No. AWI_PS128_02 will be quoted and the following *Polarstern* article will be cited:

Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (2017) Polar Research and Supply Vessel POLARSTERN Operated by the Alfred-Wegener-Institute. Journal of large-scale research facilities, 3, A119. http://dx.doi.org/10.17815/jlsrf-3-163.

4. MARINE GEOPHYSICS/PARASOUND

Karsten Gohl[1], Estella Weigelt[1], Christoph Gaedicke[2], Thorsten Eggers[1], Adalbert Pfeiffer[1], Jakob Hamann[1], Alejandro Cammareri[3], Juan Manuel Salazar[1]

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Grant No. AWI_PS128_04

4.1 The continental-marine seismic link of Dronning Maud Land: Reconstructing the long-term evolution of the Ekström ice streams

Objectives

The ice stream system feeding into the Ekström Ice Shelf represents one of the numerous small outlet glacier systems of East Antarctica. Considering that the behaviour of the EAIS with increasing global temperature is hardly known, a thorough assessment of the glacial dynamics of such a small outlet glacier system can provide important constraints on large proportions of the EAIS. A joint project between the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) and the AWI studies the potential of the sedimentary archive below the EIS for reconstructing Antarctic ice history and paleoclimate from warm Greenhouse climates to the latest Ice House era. A network of seismic profiles, including vibroseis lines (Fig. 2), has been acquired in the last 5 years and reveals a sequence of northward dipping, pre-glacial sediments overlain by glacial deposits showing near-seafloor and deeper buried features of glacial transport processes such as truncational discontinuities, grounding zone wedges and overdeepened sub-basins (Kristoffersen et al. 2014; Smith et al., 2019). As these glacial deposits are likely to continue offshore across the entire continental shelf, we aim to connect the seismic ice shelf network to the inner and outer continental shelf with additional seismic profiles in order to map the entire shelf sequences. Some seismic units and horizons can be dated via seismic correlation to the distal ODP Leg 113 drill sites near the Explora Escarpment of the eastern Weddell Sea and on Maud Rise. This will allow a complete seismo-stratigraphic analysis from early glacial periods to Quaternary glacial/deglacial cycles and a quantification of glacially induced variations in sediment transport during relevant warm times and colder periods within this Dronning Maud Land sector, which may be representative of many small glacier outlet regions of East Antarctica. Accordingly, the main goal is to decipher the sediment transport processes for deriving ice-sheet dynamics during major past warm periods from the Ekström Ice Shelf region.

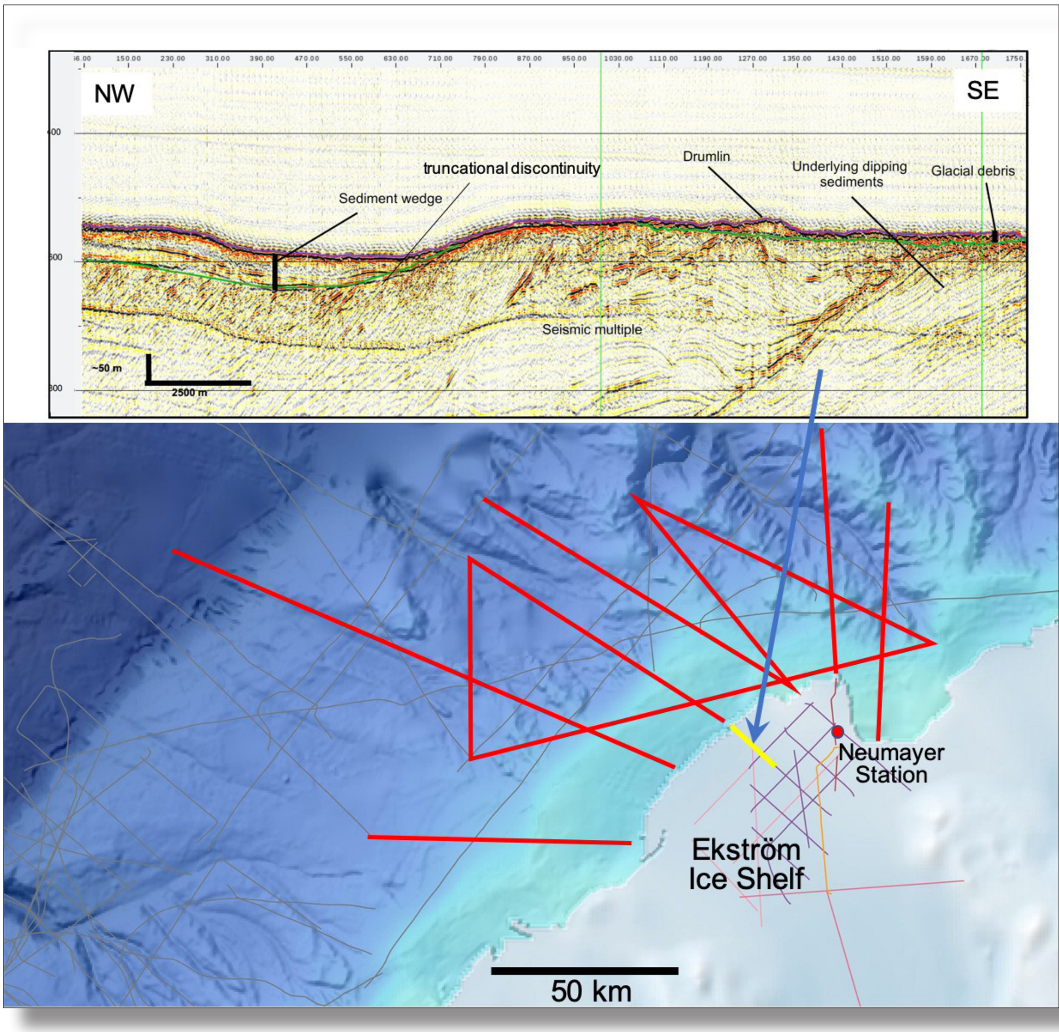

Fig. 4.1 Map showing existing (thin lines) as well as planned seismic profiles (thick red lines) on the continental shelf off the Ekström Ice Shelf (EIS) of Dronning Maud Land. The EIS was surveyed with vibroseis profiles (thin coloured lines) of which one example is shown above (marked as yellow line).

Work at sea

For the extension and connection of the seismic networks in area B, about 800 km (432 nm) of seismic profiling will be acquired on the continental shelf off the EIS (5 days including deployment/retrieval of seismic equipment and circumventing massive sea ice) by using a 600 m digital seismic streamer and seismic airgun sources. The exact profile locations will depend on sea ice conditions at the time of the expedition. If we identify a potential IODP drilling location, we will be prepared to perform the required seismic and bathymetric surveys.

Preliminary (expected) results

It can be expected that the offshore seismic profiles will provide images of glacially transported and deposited sediment sequences on the continental shelf off the EIS region. In connection to pre-existing seismic profiles on the continental rise and deep sea with links to ODP Leg 113 drill sites as well as to the pre-existing vibroseis lines on the EIS, we expect to decipher dominant phases of past EAIS advances and retreats in this DML sector.

Data management

Meta data and a short report will be submitted to DOD and PANGAEA. A full cruise report will be made available from PANGAEA within 6 months after the cruise. Seismic data will be submitted to the SCAR Antarctic Seismic Data Library System (SDLS) from which they will be made available to other users 4 years after data acquisition. Access for the science community will also be provided according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) within three years after the end of the cruise (moratorium period) at the latest. By default, the CC-BY license will be applied.

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4.2 Parasound: Sub-bottom profiling in the Indian Ocean sector of the Southern Ocean and along the Antarctic continental margin

Objectives

Accurate knowledge of the upper sedimentary strata via sub-bottom profiling data is necessary to study glacial-marine sedimentation processes of the younger past. The data provide basic information about the upper meters of subsoil for understanding geological processes such as erosion, sediment transport and deposition, or even tectonic processes. Glacially formed structures (e.g. moraines) preserved in the sub-bottom can help reconstruct the dynamic history of East Antarctic Ice Sheet, and can shed light on its retreat since its maximum extent during the Last Glacial Maximum. Understanding the processes that led to ice sheet retreat in the past can, in turn, provide important information for predicting future responses of the East Antarctic Ice Sheet to changing climate and oceanographic settings.

Imaging the upper few tens of meters, the sediment echography presents an important link between bathymetry (mapping the surface morphology) and reflection seismics (imaging the deep structures down to several km depth). Further, the integration of these three data sets is of particular importance for the interpretation of geological data in a spatial context.

The survey by sediment echography "Parasound" is essential to identify (1) core locations ideally containing undisturbed sediment sequences, (2) sites with high sediment supply.

Work at sea

Sediment echograph data will be recorded using the Atlas Teledyne Parasound P70 hull-mounted sub-bottom profiling system. The main task of the sediment echography group is to run surveys in the study areas and during transit, to provide information for station planning and sediment sampling sites. Profiling will be carried out in a 24-hour/7-day shift mode, and the data recorded will be promptly made available for site selection and cruise planning.

The detailed sub-bottom maps derived from the sediment-echography data will provide information on glacial-geomorphological features (e.g. grounding zone wedges), erosional structures, and depositional features (e.g. slumps, slides, fans). For the selection of coring locations, the data enable to identify areas of high and low sedimentation rates, outcrops, and to avoid areas of sediment redeposition and erosion.

Preliminary (expected) results

Expected results will consist of high-resolution seabed maps along the cruise track and from the target research sites. The sub-bottom data will be analyzed to provide geomorphological information about the uppermost sedimentary sequences of the research area. Expected results aim towards a better understanding of the geological processes in the research area.

Data management

Sub-bottom profiling data collected during the expedition will be archived published and disseminated according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) in accordance to the AWI research data guideline and directive (https://hdl.handle.net/10013/epic.be2ebee5-fb98-4144-9e74-aa1d38378c5e). The data will be made available upon request after a phase of restricted access of 4 years after data acquisition at the latest. By default, the CC-BY license will be applied.

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5. MARINE GEOCHEMISTRY: WATER COLUMN, BOTTOM WATER AND SEDIMENTARY POREWATER ANALYSES

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Objectives

The Atlantic and Indian Ocean sector of the Southern Ocean (SO) is a hydrologically highly dynamic basin. It is dominated by the eastward flowing and vertically well mixed Antarctic Circumpolar Current (ACC). Its deeper portions are occupied by Antarctic Bottom Water, dominantly but likely not exclusively sourced from the Weddell Sea. South of the ACC, the presence of the westward flowing Antarctic Slope Current (Williams et al. 2010) forms a thermal buffer zone around the East Antarctic Ice Sheet (EAIS) with near-freezing temperatures, preventing substantial submarine basal melting at present. The formation of new Antarctic Bottom Water (AABW) in front of the marine-based EAIS is a further important process in Antarctic waters. While the most important Antarctic Deep Water formation areas have long been known to lie in the southern Weddell and Ross Sea (e.g. Orsi et al. 1999; Purkey et al. 2018), other locations of AABW formations have been identified more recently such as the Cape Darnley region (Meijers et al. 2010; Williams et al. 2016; Williams et al. 2010). Generally speaking, AABW has warmed, declined in volume and freshened in recent decades, which likely will have consequences for the global sea level rise and heat budgets (Purkey et al. 2018). In this context, the water column work to be realized here will serve as an important assessment of the current state of regional AABW formation along the EAIS.

A major target for PS128 is the study of neodymium (Nd) isotope systematics within the water column. Neodymium belongs to the group of Rare Earth Elements (REE) and is systematically incorporated into continental and oceanic crust with unique isotopic signatures. Neodymium isotopes are also an increasingly employed tool to investigate the origin and flow path of water masses in the oceans today and in the past. This trace metal is supplied to the oceans through physico-chemical weathering on land and on the seafloor in shallow marine and continental rise settings. A recent modelling study reports that the relative contributions of Nd to seawater are ~60 % via boundary/benthic additions (i.e., from sediments to bottom water), ~32 % from riverine inputs, and ~9 % from partial dissolution of dust in the water column (Pöppelmeier et al., 2020). The Nd isotope signature thus reflects the isotopic signal of the material dissolving on land, in the water column (dust), or on the seafloor. As a consequence, water masses in contact with the ocean margin often change their isotopic composition successively along their flow path, whereas in the open ocean Nd isotopic compositions remains constant unless a parcel of water is mixed with another parcel of water with a different isotopic composition. Neodymium can therefore be categorized as behaving semi-conservative in seawater with a mean global residence time of about 690 years (Pöppelmeier et al. 2020). Earlier work by the PIs in the southern and northwestern Weddell Sea during PS111 (2018) and PS118 (2019) has already provided insights into the Nd isotopic and concentration behaviour in these areas, also highlighting localised hotspots of Nd addition to bottom waters on the shelf and Antarctic continental rise, most clearly resolvable along the northern Antarctic Peninsula. The Work to be realised during PS128 will extend this new database to East Antarctic areas that are hitherto largely unsampled for this emerging geochemical isotope water mass tracer.

Global climate is critically sensitive to physical and biogeochemical dynamics in the subpolar Southern Ocean, since it is here that deep, carbon-rich layers of the world ocean outcrop and exchange carbon with the atmosphere (e.g., MacGilchrist et al. 2019). It is also here that much of anthropogenic carbon is taken up by the ocean (and enhanced glacial ocean carbon storage in the deep Southern Ocean is well established (e.g., Brovkin et al. 2012)). Changes in Southern Ocean carbon uptake and its export to depth are thus strongly impacting the global carbon cycle. The role of the Southern Ocean in anthropogenic carbon uptake has long been identified (Caldeira and Duffy, 2000), and it has been suspected that climate warming reduces the efficiency of this anthrogenic carbon uptake. More recently, the strength of this carbon sink has been described to have re-invigorated (Landschützer et al. 2015).

The distribution of deep ocean $\Delta^{14}C$ data of dissolved inorganic carbon (DIC) are often used to illustrate the rate of deep ocean circulation, as radiocarbon is an invaluable tool to trace exchange processes in the carbon cycle and to estimate time in closed reservoirs. For instance, $\Delta^{14}C$ of DIC can be used to map the uptake of atmospheric CO_2 into the ocean, or reflect input of aged carbon from the sea floor originating, e.g., from geologic sources. Despite their usefulness, high-resolution profiles of $\Delta^{14}C$ of DIC in the water column are scarce, in particular for the Southern Ocean. The current state of knowledge is based on a large international effort, the World Ocean Circulation Experiment conducted in the early 2000s.

The second largest carbon pool in the ocean consists of dissolved organic carbon (DOC), whose cycling is linked to the cycles of DIC and its particulate organic matter. DOC has been reported to be up to several thousand years old in deep waters, and the mechanisms of aging remain unresolved yet. It has been reported that DOC radiocarbon content decreases along with that of DIC, suggesting that transport of deep waters is the primary control of ^{14}C in DIC and DOC in the Southern Ocean (Druffel et al. 2021). As with DIC, high-resolution profiles of $DO^{14}C$ in the water column remain scarce.

As a first objective, the marine geochemistry team onboard PS128 will monitor the modern hydrological configuration, also including standard physical oceanographic parameters and oxygen concentrations. This is not only important for understanding the current state of SO's overturning dynamics, but will also serve as reference for any paleoceanographic reconstructions that will be realized using PS128 sediments (Chapter 2). Given the geochemical behaviour of Nd and DIC will be as outlined above, we will also specifically target the ocean floor by collecting multi core water (MUC water) that contains information about the Nd isotopic composition and $DI^{14}C$ at the ocean floor. In contrast to the standard CTD rosette seawater sampling that is usually targeting maximum depths at least five metres above the seafloor, we can hence directly target ocean water at the sediment – bottom water interface, a key locality for a variety of essential trace metals and micronutrients, including Nd.

The CTD and MUC water sampling work will further be complemented by the extraction of local marine porewaters that we will separate from multi cores at selected sites that will be obtained in close cooperation with the Marine Geology group (Chapter 2). Last but not least, the water column and benthic porewater work will be further extended by the sampling of continental ice containing Antarctic rock debris that PI M. Gutjahr is carrying out in cooperation with the land geology group onboard PS128 (Chapter 6).

Work at Sea

Water column samples for Nd isotopic and REE analyses will be collected by means of a CTD rosette. For selected water depths seawater oxygen concentrations obtained using the oxygen sensor attached to the CTD rosette will be calibrated against discrete water samples onboard using standard procedures (Winkler titration). The locations of the water sampling stations will be coordinated with Marine Geology stations to obtain a comprehensive picture from the sediments, across the sediment-bottom water interface into the open water column. Station time permitting, we will sample the open SO water column towards our transect to Antarctic coastal waters, carry out spatially finer resolved water sampling in the Cape Darnley area, but also target near-Antarctic waters in regular intervals on our transect west along the East Antarctic continental margin. We will pay particular attention to potential regional hotspots of AABW formation. Seawater samples will also be aliquoted for carbonate chemistry and radiocarbon ($D^{14}C$; to be realised by Gesine Mollenhauer). Additional samples will be taken for measurements of $DO^{14}C$.

We will further separate sedimentary porewaters obtained from MUC sampling via centrifugation processed following trace metal clean sampling protocols in an oxygen-free atmosphere (using argon in glove bags) allowing reliable determination of contamination-prone trace metals and their isotopic compositions as well as $DI^{14}C$. Sampling of the MUCs (2 cm slices) will also be realised to analyse key geochemical porewater properties (alkalinity, sulphate, nitrate, various trace metal concentrations).

The water samples will be filtered on board, acidified and, in the case of samples for trace metal analyses, subsequently co-precipitated using Fe chloride. The samples then will be transferred into appropriate storage vials (1L HDPE flasks, head-space vials, or 50 mL centrifuge vials during the cruise). All sedimentary porewater samples will also be sampled, centrifuged and filtered already onboard. Samples designated for nutrient and IC analyses at home laboratories at GEOMAR Kiel need to be stored frozen (–20° C), while porewater samples used for trace metal analyses will be further acidified to pH ~2 and taken home at ~4° C. Samples for DIC analyses will be poisoned with Hg_2Cl_2 and stored at 4° C. After collection, the basal ice samples will be stored in dedicated trace metal clean containers at –20° C and transported to GEOMAR Kiel for further processing in the clean lab facilities.

Expected results

Neodymium in seawater behaves semi-conservatively, hence as long as water masses are not in contact with the ocean margin they only change their Nd isotopic composition (ε_{Nd}) as a function of water mass mixing. For sites within the northern open water stations of PS128 we will therefore trace ε_{Nd} of ACC water masses and Weddell Sea Deep Water (e.g. Stichel et al. 2012). Given the expected continuous addition of Nd on the East Antarctic continental shelf and along its continental rise via the sediment-bottom water interface at the seafloor, these regional additions will be isotopically close to regional continental crust compositions. In the study area regional continental crust is largely of Precambrian age with African and Indian crustal affinities (Boger 2011). Roy et al. (2007) reported the presence of a crustal Nd isotopic gradient along the East Antarctic margin. Overall, we expect to observe isotopic gradients both along a latitudinal and longitudinal transects, with least radiogenic (lowest) ε_{Nd} being observed in Archean sections alongshore Dronning Maud Land. Whether the transfer of sediment-derived trace metals to bottom water in the study will also lead to substantially elevated bottom water Nd concentrations such as seen earlier along the West Antarctic shelf (Rickli et al., 2014) will depend on the intensity of local bottom water currents, which we will measure via ADCP. Physical oceanographic parameters (temperature, salinity, density) and oxygen concentrations will help quantifying the current ventilation state of this part of the East Antarctic continental margin. These parameters will also be invaluable for the interpretation of the radiocarbon data.

In contrast to Nd, radiocarbon decays with a half-life of 5,730 years, making ^{14}C of dissolved inorganic carbon (DIC) a suitable tracer for water mass overturning. However, exchange occurs between water and underlying sediments as well, potentially adding pre-aged carbon to the pool of DIC in bottom waters, while recently ventilated waters will carry a radiocarbon signature impacted by exchange with the atmosphere. We expect to quantify the impact of both processes as well as water mass mixing on the DIC ^{14}C signature and trace how they impact this parameter along water mass trajectories.

Dissolved organic carbon (DOC) in deep-sea waters, in contrast, is known to exhibit substantially lower ^{14}C values, but the processes responsible for the accumulation of this “old” carbon pool are poorly understood. With our sampling campaign, we plan to contribute novel data on DOC ^{14}C in a poorly sampled area and put them in context with the processes impacting DIC ^{14}C.

Data management

Environmental data will be archived, published and disseminated according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) within two years after the end of the cruise at the latest. By default, the CC-BY license will be applied.

Any other data will be submitted to an appropriate long-term archive that provides unique and stable identifiers for the datasets and allows open online access to the data.

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6. CONTINENTAL GEOLOGY AND GEODESY

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6.1. Late Quaternary deglaciation and climate history of Thala Hills, Enderby Land

Objectives

The East Antarctic Ice Sheet (EAIS) has long been recognized as stable, due to its characteristic of being mostly grounded on bedrock lying above sea level (as opposed to the mostly marine-based West Antarctic Ice Sheet). However, in the past decade modelling approaches and field evidence have revealed that processes related to basal ice shelf melting, including intrusions of relatively warm Circumpolar Deep Water (CDW) into the ice shelf cavities, may also have a destabilizing effect on some portions of the EAIS (e.g., Deconto & Pollard 2016; Rintoul 2018). As opposed to afflicted regions such as Wilkes Land, minimal changes or even mass-gain have been observed in Enderby Land (Rignot et al. 2019). In this respect, paleoglaciological reconstructions from this part of the EAIS may provide information on ice and bed characteristics that foster ice sheet stability. The maximum ice sheet extent during the Last Glacial Maximum (LGM, 19 to 23 ka) as well as the subsequent retreat history are still largely unconstrained for Enderby Land (Bentley et al. 2014). Exposure ages of glacial erratics indicate ice sheet retreat starting in the early to mid-Holocene (ca. 9 to 5 ka) at the flanks of two outlet glaciers in Enderby Land and eastern Dronning Maud Land (White & Fink 2014; Kawamata et al. 2020), see eastern part of area C in Figure 6.1. This timing of postglacial ice retreat differs from coastal areas in Mac.Robertson Land, see eastern part of area D in Figure 6.1, where post-LGM ice-sheet thinning occurred significantly earlier and was likely initiated by rising eustatic sea level around 14 ka (Mackintosh et al. 2011). The different timing of ice retreat points to different regional drivers of deglaciation, which may be coupled with regionally specific oceanographic and topographic properties.

In order to better understand the drivers of ice sheet stability/instability in relation to region-specific characteristics, such as bed topography, shelf geometry and oceanographic parameters, detailed studies are needed on understudied regions like Enderby Land. Within the scope of expedition PS128 (EASI-1) we want to obtain new field data and sediment samples from unglaciated coastal areas in the study region to

1. constrain the timing of ice sheet retreat and subsequent fluctuations in presently un-glaciated areas
2. reconstruct climatic conditions following local deglaciation

Our project is closely linked to other participating groups of neighbouring disciplines, such as Geodesy (see below), Marine Geology (Chapter 2), Bathymetry (Chapter 3) and Marine Geochemistry (Chapter 5).

A further objective of the shore-based research targets the collection of basal continental ice containing enclosed crustal debris. This objective serves to better constrain isotope geochemical signatures of crustal sequences along the East Antarctic continental margin. First, it is important to obtain regional isotope geochemical information on the crust for comparison with sedimentary isotope geochemical signatures collected offshore on the Antarctic shelf or continental rise. Second, we are interested in regional-scale glacial weathering dynamics in East Antarctica. Under non-glacial climatic conditions exposed crustal rocks undergo chemical and physical weathering during which primary mineral phases are partially dissolved and transported towards the oceans within streams and rivers. In Antarctica, this situation is very different: crustal rock sequences are mainly eroded only physically prior to the transfer into shelf and deep water sedimentary depocenters. Even more, continental rocks experience extreme glacial grinding, with substantial consequences for the solubility of finer grained rock debris in Southern Ocean seawater. During this process, previous studies have found that certain accessory mineral phases are weathered very efficiently, whilst others are more inert against glacial weathering (Gutjahr et al. 2014; Dausmann et al. 2019; Süfke et al. 2019). As a result, we need to assess whether trace metal isotope signatures released from such glacial debris (and quantitatively captured within the enclosing ice) indeed match bulk rock isotopic signatures. Isotope geochemists refer to this process as incongruent weathering. The elemental and isotopic data retrieved from this work will also help to better understand particulate, adsorbed and dissolved Nd and Pb isotopic signatures of the porewater from the sediments also collected during PS128.

Work on Land

During the expedition PS128 we want to visit Thala Hills, an unglaciated coastal area in EL. Thala Hills host ca. 40 lakes and ponds at different altitudes, some of which likely contain post-glacial sediment sequences. During the planned 14 days of field work, we intend to recover sediment successions from selected lakes and ponds to 1.) obtain information on environmental changes spanning the time since initial ice retreat from Thala Hills and to 2.) gain information on temporal changes in RSL.

Primary targets for lake coring will be the ca. 30 m deep Glubokoje Lake (67.67° S, 45.88° E) and other smaller water bodies that have sufficient water depth to not freeze to the ground in winter (Starmach 1995). If possible, we will also obtain sediment cores from adjacent marine inlets, which may provide important information on past sea-level low stands and environmental conditions in the coastal ocean (e.g., Berg et al. 2010, 2013, 2020). The lake and marine sediment sampling will be complemented by geomorphological investigations and sampling of glacial erratics for exposure dating and sampling of snow petrel stomach oil deposits (Antarctic mumiyo deposits).

We will also collect samples of biological soil crusts for biodiversity studies in collaboration with U. Karsten (University of Rostock). The samples will provide the first inventory of microbial diversity in the study area, which is crucial to study for assessing ecological impacts of future environmental changes on the microbiome of Antarctica.

Field work will be conducted as a joint team with the Geodesy group of TU Dresden (see below). Furthermore, the work will be logistically supported by the Belarussian Antarctic Expedition (BAE), who operates a summer station in the study area. We intend to cooperate scientifically as well.

Along the cruise track of PS128, other unglaciated coastal sites in Enderby Land will be visited for sampling of lake sediments, snow petrel stomach oil deposits and glacial erratics, if accessible. Wherever possible and at a maximum of ten locations, we will sample continental ice with enclosed debris for the isotopic geochemical investigations of Nd and Pb. To this end, individual blocks of maximum 20 kg will be cut out from basal ice sequence using a small drilling tool, an ice saw and a hammer. Samples will be wrapped in cling film and taken back to the clean laboratories at GEOMAR Kiel for further processing.

Expected results

Our work will provide new records of spatio-temporal changes of ice sheet geometry and climatic conditions since local deglaciation, which are key data to better understand ice-ocean-climate interactions in this presumptively stable portion of the EAIS. The Nd and Pb isotopic data will provide crucial boundary parameters for the marine geology as well as marine geochemical investigations.

Data management

Environmental data will be archived, published and disseminated according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) within two years after the end of the cruise at the latest. By default, the CC-BY license will be applied.

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6.2. Interaction between mass changes of the Antarctic ice sheet and solid Earth in East Antarctica

Objectives

The past and current evolution of the Antarctic Ice Sheet is one of the most important topics regarding Climate Change and the global rise of the sea level. In this respect, the Ice Sheet Mass Balance Intercomparison Exercise (IMBIE) (Shepherd et al. 2018) still reveals remarkable differences between the three main satellite-based methods to infer the Antarctic ice-mass balance. Among the regional estimates those for the East Antarctic Ice Sheet (EAIS) are least certain which is reflected by the largest average per-epoch standard deviation of individual solutions of ±37 Gt/a and the uncertainty of ±46 Gt/a for the average 25-year mass trend yielding a gain of 5 Gt/a (Shepherd et al. 2018). Regarding the gravimetric method, it has still to be emphasized that glacial-isostatic adjustment (GIA) “remains poorly constrained” (ibid.), although the GIA mass effect makes up about 50 % of the Antarctic-wide ice-mass balance. In contrast, the GIA effect plays a negligible role in the geometric and input/output method.

Past developments and aspects of future research w.r.t. GIA were discussed by Whitehouse (2018) while Whitehouse et al. (2019) reviewed recent GIA models for Antarctica. There is still a high variance of modelled GIA-induced vertical displacement rates regarding both, their spatial pattern and magnitude. This variance can be partially explained by the different methodology underlain the GIA modelling which can be categorised as either forward models (using either 1D or 3D–rheology), coupled GIA-ice sheet models, or models based on data inversion (Whitehouse et al. 2019). Caron et al. (2018) developed a global GIA model based on a stochastic approach in a Bayesian framework adopting a varying 1D-rheology and an ice-load history. The model runs are constrained by relative sea-level (RSL) data and vertical deformation rates derived from GNSS sites in Europe, North America and Antarctica. Caron et al. (2018) yields agreement to GNSS-inferred results also in regions where GNSS data were not included in their modelling, e.g. in north-east Greenland (Kappelsberger et al. 2021). Thus, developments in the theoretical basis of GIA modelling refer to different aspects of rheology and time scales involved in the deformation of the solid Earth. However, it has to be emphasized that geodetic GNSS measurements at specially marked bedrock points provide most valuable observational evidence to constrain the GIA modelling since they are capable to infer coordinate changes with an accuracy at the level of mm/a.

Dronning Maud Land (DML) and Enderby Land, where *Polarstern* is going to during its cruise PS128, are areas where vertical deformation rates caused by GIA are expected to be relatively small. The only method to directly measure GIA is given by performing geodetic GNSS measurements on bedrock. For this, the group of TU Dresden initiated campaign-style geodetic GNSS measurements in DML in 1995, and in Enderby Land in 2006. These GNSS sites are situated in the mountain ranges that run parallel to the coast about 100 to 200 km inland as well as in coastal areas like Oasis Molodeshny (Thala Hills). Carrying out repeated GNSS measurements we are able to cover time spans of about 15 years. We expect to determine the vertical deformation rate with an accuracy of down to a few mm/a. Thus, the GNSS-inferred vertical deformation rates will serve as constraints for an improved GIA determination.

Work on land

It is planned to realize a land-based field campaign in the area of Oasis Molodeshny (Thala Hills) for about two weeks. This will be done together and in close cooperation with the group of the University of Cologne. In that area, repeated GNSS measurements will be carried out at three existing sites (see Table 6.1 and Fig. 6.1). Furthermore, we will support the work of the group of the University of Cologne (see also Fig. 6.1). The field work will be logistically supported by the Belorussian Antarctic Expedition who operates the station *Gora Vechernyaya*.

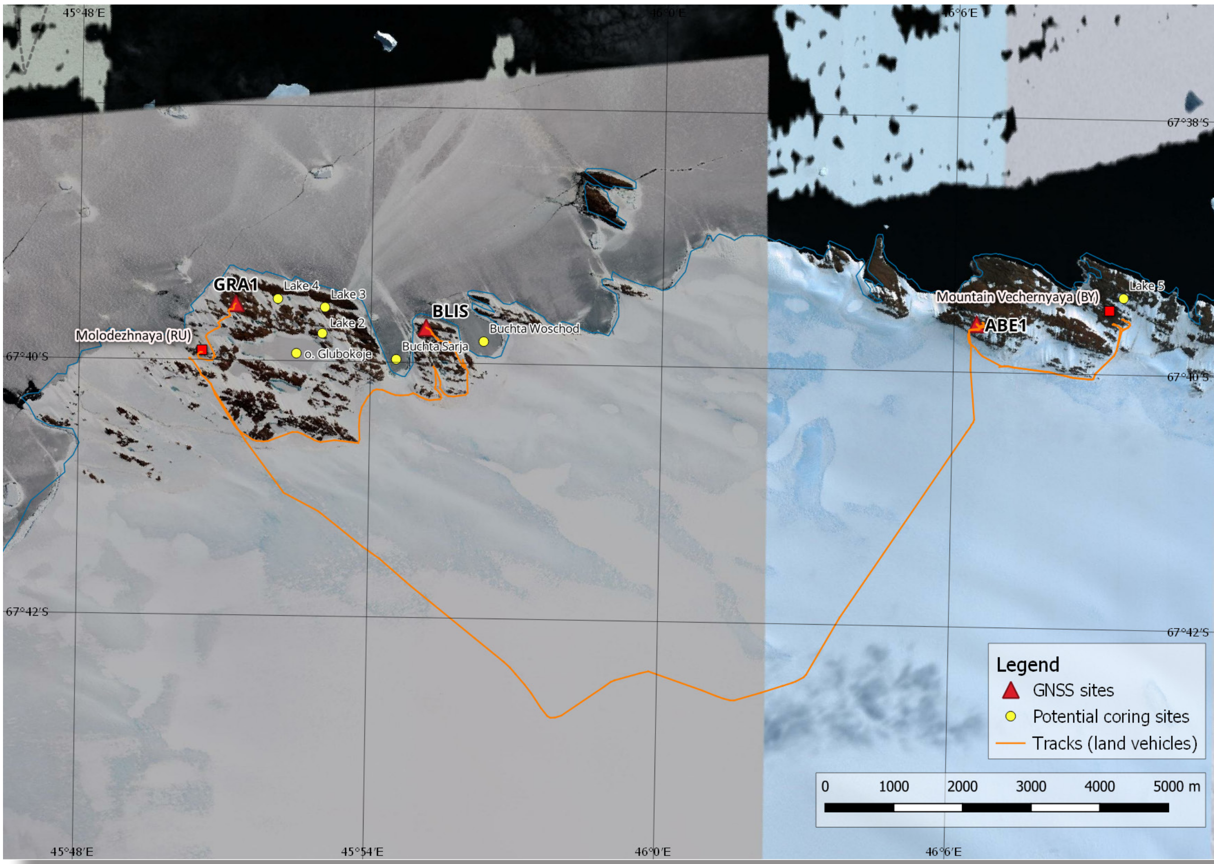

Fig. 6.1: Overview map of the area of investigation for the planned land-based field campaign. The three geodetic GNSS sites to be re-observed are marked by red triangles. Furthermore, potential sampling sites to be realized by the group of University of Cologne are marked by yellow circles. In that area, the two Antarctic stations Molodeshnaya (Russia) and Gora Vechernyaya (Belarussia) are situated in a distance of about 20 km.

Tab. 6.1: Geodetic GNSS sites planned for re-observation

ID	Location	Latitude (South) [°]	Longitude (East) [°]
ABE1	Abendberg	67.6604	46.1078
BLIS	Blisnetzow	67.6621	45.9189
GRA1	Granat	67.6593	45.8535

Expected preliminary results

The GNSS observations will be processed at the home institution (so-called post-processing using the Bernese GNSS Software). In the analyses latest standards have to be incorporated used in geodesy (e.g. consistent and precise realization of the reference frame). In the end, we will infer vertical deformation rates for the three observation sites. The long time span of 15 years will additionally support to reach a high level of accuracy of the inferred deformation rates.

Data management

The geodetic GPS data will be stored within the frame of the SCAR GPS Database which is maintained at TU Dresden. The long-term preservation of the data will be maintained also through the close cooperation within the SCAR Scientific Programme INSTANT (Instabilities and Thresholds of Antarctica). A common structure of the data holdings is ensured through the application of the same scientific software package utilized to analyze geodetic GNSS measurements at TU Dresden (i.e., the Bernese GPS Software). Further products and resulting models will be archived archived, published and disseminated according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) within two years after the end of the cruise at the latest. By default, the CC-BY license will be applied.

In all publications, based on this cruise, the Grant No. AWI_PS128_06 will be quoted and the following *Polarstern* article will be cited:

Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (2017) Polar Research and Supply Vessel POLARSTERN Operated by the Alfred-Wegener-Institute. Journal of large-scale research facilities, 3, A119. http://dx.doi.org/10.17815/jlsrf-3-163.

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6	Hering	Igor	2nd Mate
7	Müller	Andreas	ELO
8	Dr. Römer	Mario	Ships Doc
9	Ehrke	Tom	2nd. Eng
10	Krinfeld	Oleksandr	2nd. Eng
11	Rusch	Torben	2nd. Eng
12	Pommerencke	Bernd	ELO
13	Müller	Andreas	ELO
14	Schwedka	Torsten	ELO
15	DLV	DLV	ELO
16	Krueger	Lars	ELO
17	Brück	Sebastian	Bosun
18	Lello	Ants	Carpen.
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23	Decker	Jens	MP Rat.
24	Weiss	Daniel	AB
25	TBN	TBN	AB
26	TBN	TBN	AB
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28	Thiele	Linus	MP Rat.
29	Waterstradt	Felix	MP Rat.
30	Clasen	Nils	MP Rat.
31	Hansen	Jan Nils	MP Rat.
32	TBN	TBN	MP Rat.

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34	Matter	Sebastian	Cooksm.
35	TBN	TBN	Cooksm.
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37	TBN	TBN	Nurse
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41	Chen	Quanlun	2nd Stew.
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