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HELMHOLTZ-ZENTRUM FÜR POLAR-
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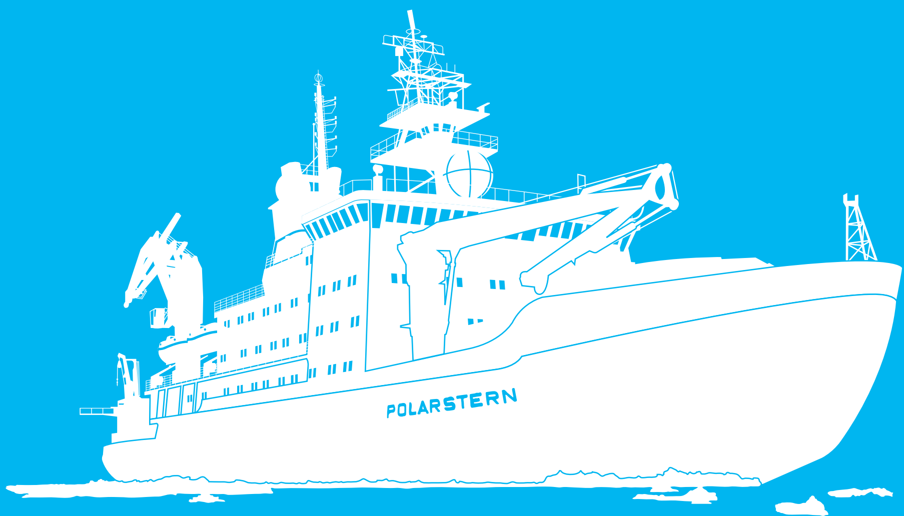
EXPEDITION PROGRAMME PS137

Polarstern

PS137
Tromsø - Tromsø
21 June 2023 - 31 July 2023

Coordinator: Ingo Schewe

Chief Scientist: Vera Schlindwein



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Bremerhaven, June 2023

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PS137 - ALOIS

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Tromsø – Tromsø

Chief scientist
Vera Schlindwein

Coordinator
Ingo Schewe

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1. ÜBERBLICK UND EXPEDITIONSVERLAUF

Vera Schlindwein DE.AWI

ALOIS (Arctic Lithosphere-Ocean Interaction Study) ist ein wegweisendes interdisziplinäres Experiment, das die Entstehung neuer Lithosphäre am arktischen Gakkel-Rücken und die damit verbundene hydrothermale Zirkulation erforscht. Vor 20 Jahren entdeckte die AMORE Expedition, dass sich die ultralangsame Ozeanbodenspreizung am Gakkel-Rücken nicht mit gängigen Modellen erklären lässt und mit ungewöhnlich starker hydrothermaler Aktivität einhergeht. Trotz dieser bahnbrechenden Erkenntnisse fanden wegen der schwierigen Eisbedingungen kaum weitere Experimente statt. Uns stehen nun speziell für Meereis konzipierte Tiefseetauchroboter und Ozeanbodenseismometer zur Verfügung, mit denen wir Aurora, eines der wenigen bislang entdeckten Hydrothermalfelder an ultralangsamen Rücken überhaupt und das einzige im Arktischen Ozean, besser erforschen wollen. Ein Jahr lang werden wir dessen Seismizität und hydrothermalen Plume beobachten. Wir werden das Vent-Feld kartieren und geophysikalisch, biogeochemisch und mikrobiologisch vermessen. So wollen wir klären, wie tief Fluide durch die Lithosphäre an ultralangsamen Rücken zirkulieren, was die Zirkulation antreibt, welche Energie- und chemische Flüsse in den Ozean freigesetzt werden und welche potentiell einzigartigen Tiefsee-Lebensformen sich darin entwickeln. Bei 3°E am Gakkel-Rücken trennt eine markante Grenze seit Entstehung des Eurasischen Beckens Bereiche unterschiedlicher Lithosphärenentwicklung. Mit seismischen und geologischen Profilen und Gesteinsproben wollen wir Lithosphärenstruktur und Herkunft der Schmelzen beidseits der Grenze klären und überprüfen, ob getrennte Konvektionszellen im Mantel die geologische Entwicklung des westlichen Eurasischen Beckens gesteuert haben. Wir werden nach weiteren Hydrothermalfeldern suchen und zu den bislang sehr wenigen Wärmestrommessungen im Nansen Becken beitragen um herauszufinden, ob ein erhöhter Wärmestrom potentiell zur Erwärmung des arktischen Bodenwassers beiträgt. ALOIS trägt zu AWIs Programmforschung bei und setzt die erfolgreiche Kooperation mit dem Exzellenzcluster MARUM und WHOI fort. ALOIS dient außerdem als zweiter Fahrtabschnitt der Expedition ATWAICE (PS131) in 2022. Die logistische Kombination beider Reisen ermöglichte, dass ozeanographische und seismologische Verankerungen ein Jahr registrieren konnten. Wir werden ozeanographische Verankerungen entlang des Yermak Plateaus bergen, die auf einem Profil durch die Eisrandzone das Einfließen warmen atlantischen Wassers unter das Meereis erfassen sollten. Zugleich bietet ALOIS die Möglichkeit, erneut Helikotper- und eisbasierte Messungen von Schmelztümpelverteilungen auf dem Meereis in Fortsetzung der ATWAICE Kampagne zu unternehmen. Damit integriert die Expedition zentrale Ziele des Helmholtz-Forschungsorgramms „Changing Earth – Sustaining our Future“ mit einer Verbindung zu den Themen “Ocean and Cryosphere in Climate.

Polarstern wird Tromsø am 21. Juni verlassen und nach einem kurzen logistischen Hafenanlauf in Longyearbyen mit der Aufnahme der Verankerungen am Yermak Plateau beginnen. Nach Abschluss der Verankerungsarbeiten werden wir versuchen, uns unseren Weg durch das Eis entlang der Spreizungsrichtung auf die westliche Vulkanzone des Gakkelrücken zu bahnen und dabei Wärmestrommessungen durchzuführen. Sobald wir am Aurora Vent Field angekommen sind, muss dort erst eine Verankerung geborgen werden. Dann werden wir kurze seismische Profile über die bereits seit einem Jahr registrierenden Ozeanbodenseismometer schießen, bevor wir diese Geräte bei günstigen Eisbedingungen bergen werden. Wir werden ca. 10 Tage am Aurora Vent Field verweilen und planen für die verbleibende Zeit Tauchgänge mit dem ROV NUI, Beprobungen von Vent Fluiden, Kameraaufnahmen des Meeresbodens, Gesteinsprobennahmen und hydrographische Messungen. Parallel dazu werden während der ganzen Reise und wann immer das Wetter es erlaubt, Helikopterflüge mit der Meereiskamera und zur Messung des Erdmagnetfelds stattfinden. Danach werden wir entlang der Westlichen Vulkanzone zu einer weiteren Hydrothermalanomalie bei ca. 1°45‘ W fahren und auf dem Weg, wie entlang der gesamten Reise, den noch wenig kartierten Meeresboden mit dem Fächerecholot vermessen. Bei 1°45’W werden wir 2 Tage verbringen, um nach Möglichkeit die Quelle der hydrothermalen Anomalie zu orten. Am 14. Juli wird uns die Kronprins Haakon mit der norwegischen GoNorth Kampagne treffen und für 10 Tage begleiten. Gemeinsam werden wir die 3°E Grenze erkunden und dort bei günstigen Eisbedingungen ein refraktionsseismisches Profil akquirieren, das den unterschiedlichen Krustenaufbau zu beiden Seiten der Grenze erfassen soll. Hierfür ist ein Zusammenarbeiten beider Schiffe von Vorteil, da sowohl seismische Messungen als auch die bathymetrische Kartierung dieser sehr unbekannten Region davon profitiert, wenn das messende Schiff in der Fahrspur des vorausfahrenden Schiffes fahren kann und die Messungen nicht durch Eisbrechen gestört werden. Außerdem werden wir die unterschiedlichen Möglichkeiten der ROVs auf beiden Schiffen ergänzend ausnutzen, um zu einer raschen und effizienten Erkundung und Beprobung hydrothermaler und geologischer Objekte zu kommen. Um den 24. Juli werden wir unser Messprogramm am Gakkelrücken beenden und wieder in Spreizungsrichtung mit begleitenden Wärmestrommessungen ins eisfreie Wasser fahren. Von dort treten wir den Rückweg nach Tromsø an, den wir kurz am 2022 neu entdeckten Jøtul Vent Field am Knipovich Rücken quer ab von Longyearbyen unterbrechen werden, um dort einige Ozeanbodenseismometer für eine weitere einjährige Registrierung von Erdbeben auszusetzen. Die Geräte werden 2024 wieder aufgenommen und bilden einen hervorragenden Vergleichsdatensatz zum Aurora Vent Field, wo wir ein anderes geologisches Umfeld für die hydrothermale Zirkulation erwarten. Am 31. Juli wird *Polarstern* in Tromsø einlaufen.

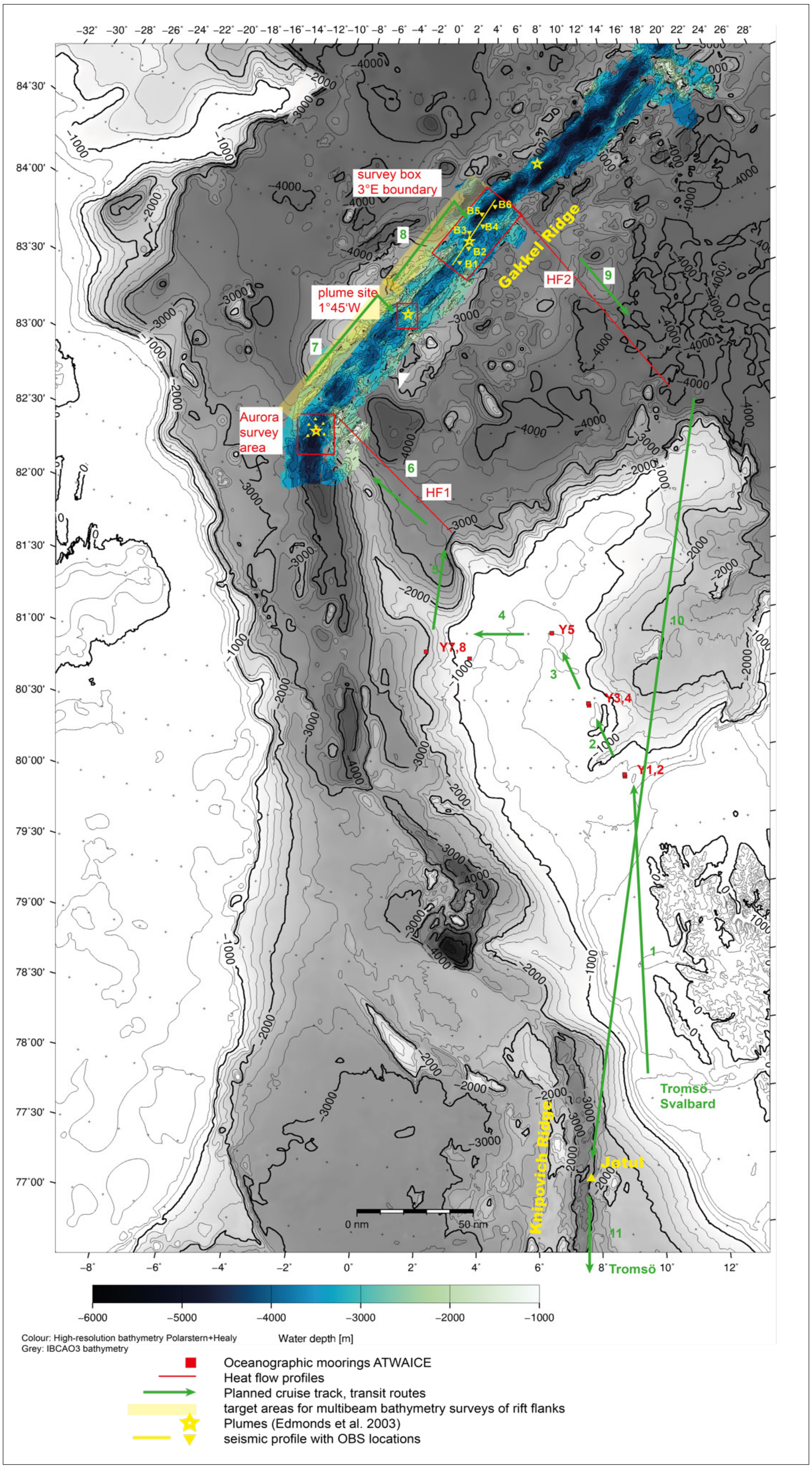

Abb. 1.1: Karte der geplanten Fahrtroute und des Hauptuntersuchungssgebiets
Fig. 1.1: Map of the planned cruise track and the main working areas

SUMMARY AND ITINERARY

ALOIS (Arctic Lithosphere-Ocean Interaction Study) is a pioneering interdisciplinary experiment investigating the formation of new lithosphere at the Arctic Gakkel Ridge and the associated hydrothermal circulation. Twenty years ago, the AMORE expedition discovered that the ultraslow seafloor spreading at the Gakkel Ridge cannot be explained by common models and is accompanied by unusually strong hydrothermal activity. Despite these groundbreaking findings, hardly any further experiments took place because of the difficult ice conditions. We now have deep-sea robots and ocean-bottom seismometers specially designed for sea ice, which we will use to better explore Aurora, one of the few known hydrothermal fields on ultraslow ridges and the only one in the Arctic Ocean basin. For one year we will observe its seismicity and hydrothermal plume. We will map the vent field and conduct geophysical, biogeochemical and microbiological surveys. In this way, we want to clarify how deep fluids circulate through the lithosphere at ultraslow ridges, what drives the hydrothermal circulation, what energy and chemical fluxes are released into the ocean, and what kind of potentially unique deep-sea life forms evolve in it. At 3°E on Gakkel Ridge, a prominent boundary has separated areas of different lithospheric evolution since the formation of the Eurasian Basin. With seismic and geological profiles and rock sampling we will explore the lithospheric structure and origin of melts on both sides of the boundary and understand whether separate convection cells in the mantle have controlled the geological development of the western Eurasian Basin. We will search for additional hydrothermal fields and add to the few heat flow measurements in the Nansen Basin to determine whether increased heat flow potentially contributes to the warming of Arctic bottom waters. ALOIS contributes to AWI's programme research and continues the successful cooperation with the Cluster of Excellence MARUM and WHOI. ALOIS also serves as the second cruise leg of the ATWAICE expedition (PS131) in 2022, and the logistical combination of both voyages allowed oceanographic and seismological moorings to register for a year. We will recover oceanographic moorings along the Yermak Plateau, which should record the inflow of warm Atlantic water under the sea ice on a profile through the ice margin zone. At the same time, ALOIS offers the opportunity to again undertake helicopter and ice-based measurements of melt pond distributions on the sea ice in continuation of the ATWAICE campaign. Thus, the expedition integrates central goals of the Helmholtz research program “Changing Earth – Sustaining our Future” with a link to the topics “Ocean and Cryosphere in Climate.

Polarstern will leave Tromsø on 21 June 2023 and, after a short logistical port call in Longyearbyen, will begin mooring recovery on the Yermak Plateau. Once the mooring work is complete, we will attempt to make our way through the ice in the spreading direction towards the Western Volcanic Zone of Gakkel Ridge, taking heat flux measurements as we go. Once we arrive at the Aurora Vent Field, we will first need to recover an oceanographic mooring. After that, we will acquire short seismic profiles over the ocean bottom seismometers that have already been recording for a year, before recovering these devices when ice conditions are favourable. We will stay at the Aurora Vent Field for about 10 days and plan to spend the remaining time diving with the ROV NUI, sampling vent fluids, taking seafloor camera imagery, sample rocks and conduct hydrographic measurements. In parallel, whenever weather permits throughout the cruise, helicopter flights with the sea-ice camera and magnetometer bird will take place. Afterwards, we will travel along the Western Volcanic Zone to another hydrothermal anomaly at about 1°45’ W and survey the still poorly mapped seafloor with the multibeam echo sounder on the way, as we did along the entire cruise. We will spend 2 days at 1°45’W trying to locate the source of the hydrothermal anomaly if possible. On 14 July 2023, *Kronprins Haakon* with the Norwegian GoNorth campaign on board will meet us and accompany us for 10 days. Together we will explore the 3°E boundary and, under favourable ice conditions, acquire a refraction seismic profile that will unravel the different crustal structure on both sides of the boundary. Both seismic measurements and bathymetric mapping of this very unknown region will benefit from the joint operations of both vessels and one vessel can follow in the lead of the other vessel such that the data quality will not be affected by ice breaking. For this, a cooperation of both ships is advantageous, as both seismic measurements and bathymetric mapping of this very unknown region benefit from the measuring ship being able to sail in the lane of the ship ahead and the measurements not being disturbed by ice breaking. In addition, we will complement the different capabilities of the ROVs on both vessels to achieve rapid and efficient exploration and sampling of hydrothermal and geological features. Around 24 July 2023, we will finish our measurement programme at Gakkel Ridge and return to the ice-free water in the direction of spreading with accompanying heat flow measurements. From there we will return to Tromsø, stopping briefly at the Jøtul Vent Field, which was newly discovered in 2022 on Knipovich Ridge just off Longyearbyen. We will deploy some ocean bottom seismometers for another year of earthquake recording. The instruments will be recovered in 2024 and will provide an excellent comparative data set to the Aurora Vent Field, given the different geological setting of hydrothermal circulation. *Polarstern* will arrive in Tromsø on 31 July 2023.

2. GEOPHYSICAL SURVEY PROGRAMME

Mechita Schmidt-Aursch[1], Henning Kirk[1], Norbert Lensch[1], Matthias Pilot[1], Chiara Tobisch[1], Annika Hellbrück[1], Viktoria Thamm[1], Vera Schlindwein[1,2]

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Grant-No. AWI_PS137_02

Objectives

The key objective of the geophysical programme is to understand active seafloor spreading processes at ultraslow spreading ridges better. Gakkel Ridge belongs to the slowest spreading mid-ocean ridges of the global system of diverging plate boundaries. Here, the production of melt filling the gap between the Eurasian and the American plate can hardly keep pace with the separation speed of the two continents. Instead of an elevated mid-ocean ridge with constant magma production resulting in an oceanic crust of about 8 km thickness, slow and especially ultraslow spreading ridges have irregular magma production in space and time such that a deep rift valley may form. In addition, the oceanic crust may be locally overthickened, thin or even absent exposing the Earth's mantle to the seafloor. The hydrothermal circulation of seawater through the newly formed ocean floor contributes to its cooling and an efficient exchange of energy and matter between the lithosphere and the ocean forming also the basis for deep-sea life around hydrothermal vent sites. Compared to the limited supply of melt, hydrothermalism at ultraslow spreading ridges appears to be abundant (Edmonds et al. 2003).

Microearthquakes accompany these spreading processes. They delineate active fault structures serving as pathways for hydrothermal fluids, show magma movement or cracking and tremor produced by hydrothermal circulation (e.g. Meier and Schlindwein 2018, 2021). In addition, earthquake waves passing through the subsurface can be used to image the crustal structure and reveal areas of melt (Meier et al. 2022). We will further measure anomalies in the Earth's magnetic field caused by local geology. Magmatic rocks become permanently magnetized as the rocks cool, freezing in the prevailing magnetic field. In areas, where magma production is missing, magnetic anomalies are strongly subdued such that even away from the present plate boundary when the seafloor gets older and is sediment-covered, we can get an idea of its origin and physical properties. With a combination of active and passive seismic and magnetic and gravity field measurements, we aim to explore the spatially strongly varying crustal structure of the ultraslow Gakkel ridge, targeting especially the 3°E boundary, where magmatic and amagmatic spreading occur in close vicinity, and to explore the style and geological functioning of hydrothermal circulation at Aurora vent field. On our way back to Tromsø, we will visit the newly discovered Jøtul vent field and deploy seismometers there. This vent field has a different geological setting compared to Aurora vent field such that we can broaden our understanding of hydrothermal circulation by a comprehensive study of vent fields with different geology.

Work at sea

Eight seismometers and an oceanographic mooring measuring temperatures and ocean currents were deployed close to Aurora vent field on western Gakkel Ridge during PS131 (Kanzow, 2023) in July 2022 (Fig. 2.1, Table 2.1). Before recovery of the ocean bottom seismometers, we will acquire two short seismic refraction profiles across the seismometer locations to measure seismic velocities in the crust and obtain a detailed image of the crustal structure. After that, all seismometers will be recovered. Their way to the sea surface can be tracked with the Posidonia positioning system, such that we know the exact position of the instruments even if they should get stuck beneath an ice floe. Recovery from underneath ice floes may involve complicated and time-consuming search and ship operations. After recovery, the clocks of the ocean bottom seismometers will be synchronised. Data will be read out and the seismometers will be prepared for a renewed short-term deployment at the 3°E boundary, where magmatic and amagmatic crustal production are juxtaposed. Here, we will complement a refraction seismic profile with additional seismic sensors on drifting ice floes (Table 2.2). The acquisition of this entire seismic profile is highly dependent on favourable ice conditions allowing for a safe recovery of the instrumentation shortly before the end of the survey.

In parallel to the scientific activities at Aurora vent field and the 3°E boundary we will acquire magnetic data using the Heli-bird adding to magnetic data that were acquired in 2001 during the AMORE expedition (Jokat & Schmidt-Aursch 2007) (Fig. 2.2, Table 2.3).

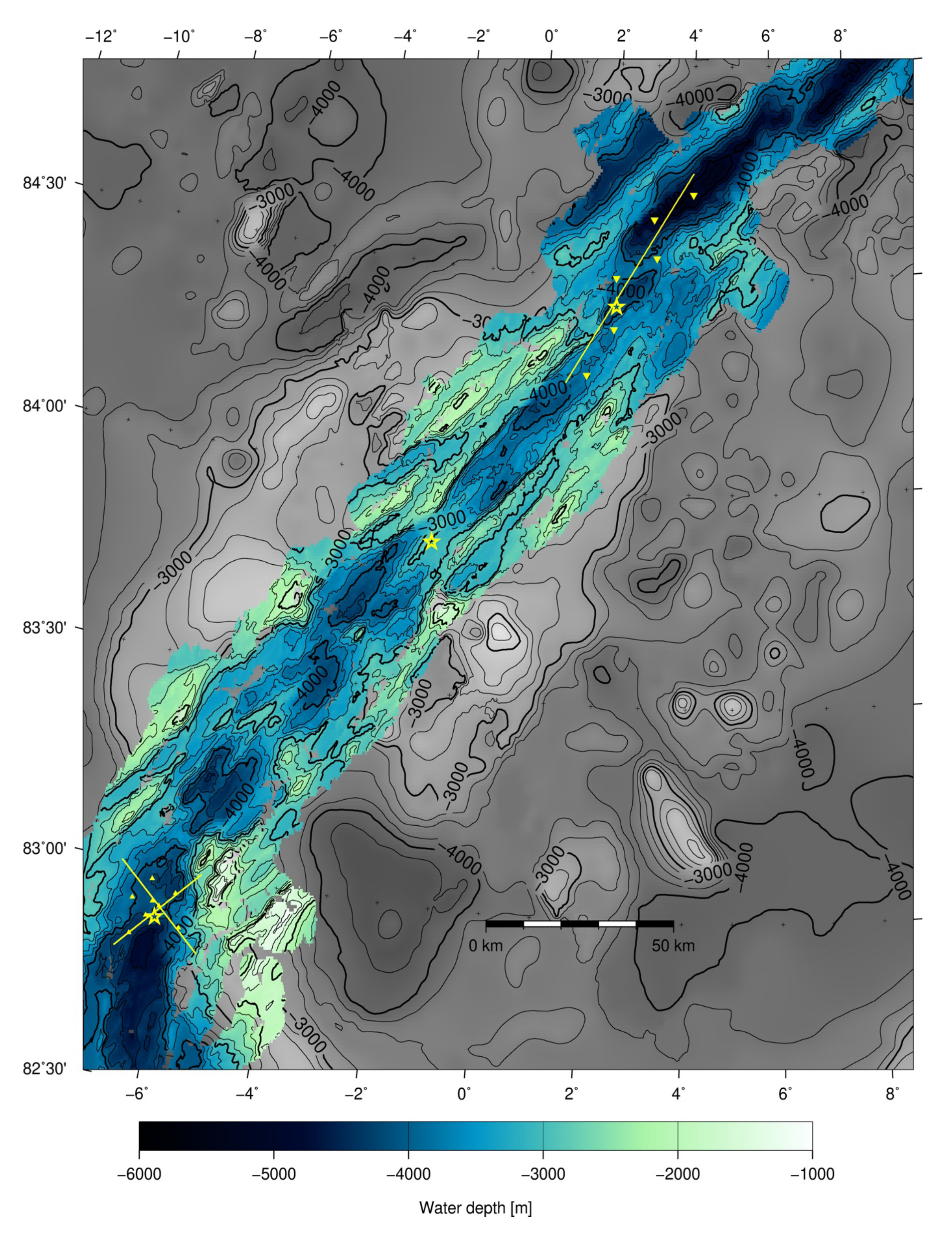

Fig. 2.1: Overview of seismic surveys during PS137. Triangles: OBS locations, lines: planned refraction seismic profiles, stars: Hydrothermal plumes (Edmonds et al. 2003).

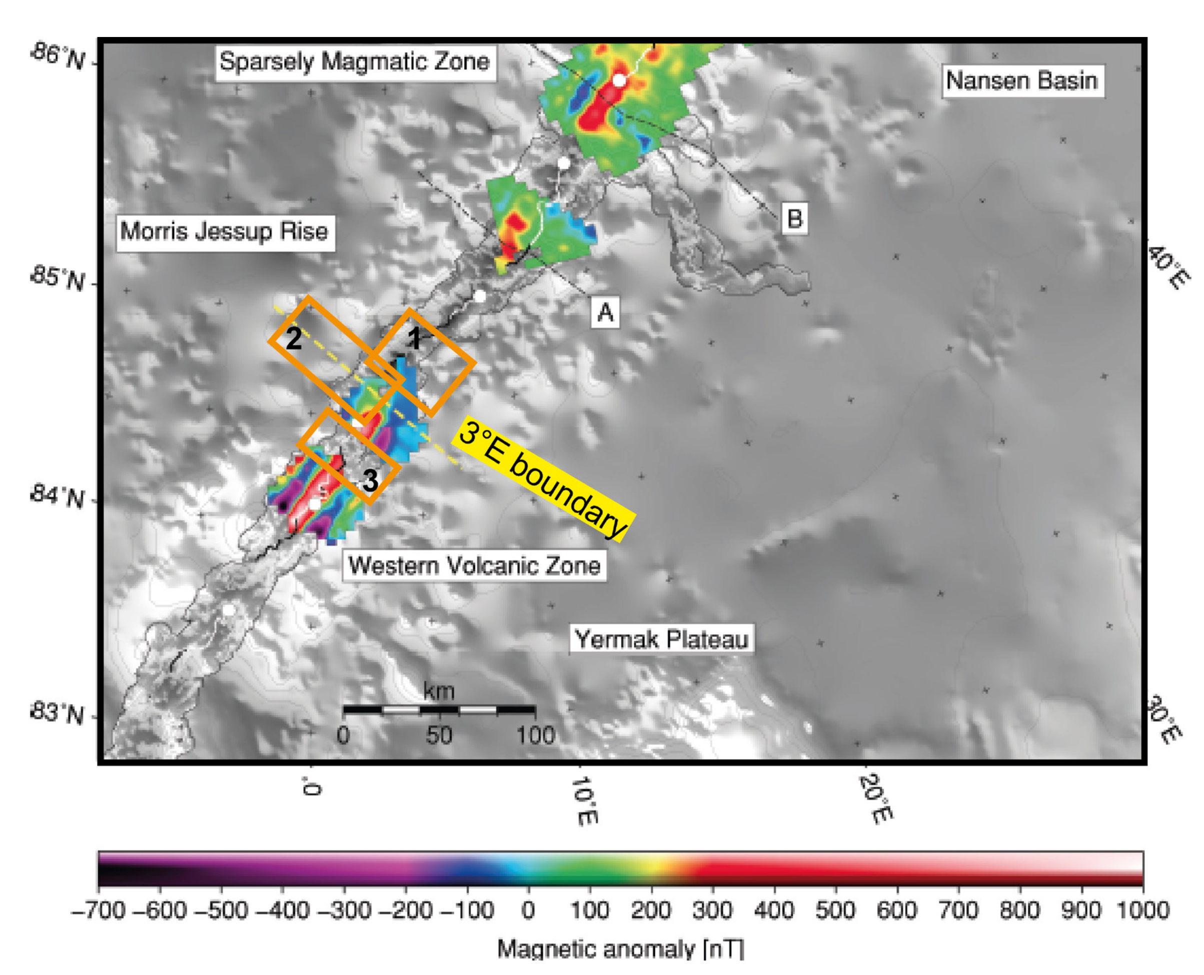

Fig. 2.2: Position of aeromagnetic survey boxes 1-3 in relation to previously acquired magnetic anomaly data (Jokat & Schmidt-Aursch 2007)

Tab. 2.1: Deployment positions of OBS Network and seismic profiles near Aurora vent site

	Deployment		**Deployment Position at surface**			**Deepest Posidonia position**		
Station	**Date**	**Time UTC**	**Latitude**	**Longitude**	**Depth (m)**	**Latitude**	**Longitude**	**Depth (m)**
AUR01	25.07.2022	09:53	82° 52.979‘ N	06° 25.383‘ W	4215	82° 53.059‘ N	06° 24.778‘ W	1565
AUR02	25.07.2022	00:05	82° 55.131‘ N	06° 20.667‘ W	4155	82° 55.248‘ N	06° 20.166‘ W	4183
AUR03	24.07.2022	23:25	82° 54.589‘ N	06° 12.218‘ W	3988	82° 54.569‘ N	06° 12.124‘ W	317*
AUR04	24.07.2022	16:48	82° 50.100‘ N	06° 40.500‘ W	4408	82° 49.911‘ N	06° 40.547‘ W	4511
AUR05	25.07.2022	17:19	82° 55.072‘ N	06° 44.413‘ W	3900	82° 55.021‘ N	06° 44.405‘ W	2052
AUR06	25.07.2022	19:50	82° 58.167‘ N	06° 26.032‘ W	4250	82° 58.124‘ N	06° 26.304‘ W	1567
AUR07	25.07.2022	22:14	82° 56.753‘ N	05° 55.852‘ W	4354	82° 56.772‘ N	05° 56.313‘ W	1527
AUR08	24.07.2022	19:44	82° 52.112‘ N	05° 45.272‘ W	3917	82° 52.268‘ N	05° 45.637‘ W	3943
		Start	**Latitude**	**Longitude**	**End**	**Latitude**	**Longitude**	
Profile 1			83° 00’ N	07° 05’ W		82° 49’ N	05° 20’ W	

	Deployment		Deployment Position at surface			Deepest Posidonia position		
Station	**Date**	**Time UTC**	**Latitude**	**Longitude**	**Depth (m)**	**Latitude**	**Longitude**	**Depth (m)**
Profile 2			83° 00’ N	05° 30’ W		82° 48’ N	06° 55’ W	
Profile 3			84° 15’ N	01° 00’ E		84° 45’ N	04° 00’ E	

Tab. 2.2: Refraction seismic profile with OBS positions and seismic profile. Seismic stations on ice floes will be placed at suitable locations between the OBS

	Approximate OBS Deployment Positions		
Station	**Latitude**	**Longitude**	**Approximate Depth [m]**
TDE01	84° 16.2‘ N	01° 30‘ E	3.800
TDE02	84° 22.8‘ N	02° 06‘ E	3.700
TDE03	84° 30‘ N	02° 06‘ E	3.900
TDE04	84° 33‘ N	03° 06‘ E	3.800
TDE05	84° 38.4‘ N	03° 00‘ E	5.000
TDE06	84° 42‘ N	04° 00‘ E	5.250
Seismic profile	**Latitude**	**Longitude**	
Start	84° 15’ N	01° 00’ E	
End	84° 45’ N	04° 00’ E	

Tab. 2.3: Planned areas for aeromagnetic profiling as seen in Figure 2.2. Aurora has no prior aeromagnetic profiles.

	Dimensions of survey box		
Survey Box	**Along axis [km]**	**Across axis [km]**	**Profile spacing [km]**
01 Sparsely Magmatic Zone	40	50	2
02 Three-Degree-East Boundary	25	80	2
03 Western Volcanic Zone	20	50	2
04 Aurora	20	50	1

Preliminary (expected) results

The processing of all geophysical data is very time consuming. We expect that apart from archiving of raw data and meta-data, only a first quality control and a conversion of recording data formats into processing data formats like the seismic formats MSEED or SEG-Y data conversion can be achieved during the cruise. Time-permitting we will inspect the seismic data for the occurrence of earthquakes and calculate power spectral density plots to assess the background noise of the seismic stations. Before further analysis can be done, a correction of all seismic data for a potentially non-linear clock drift is necessary. Subsequently, earthquakes can be identified, phases picked and earthquake located. This process will take at least 6 months such that results will not be available at the end of the cruise.

Data management

Magnetic and gravity 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). By default, the CC-BY license will be applied.

Raw seismological data will be archived and published in PANGAEA. Time-corrected miniseed archives of the seismological data will be submitted to GEOFON from where they are accessible with seismological data base query tools. Refraction seismic data will be archived in PANGAEA and can be queried through maps.awi.de.

This expedition was supported by the Helmholtz Research Programme "Changing Earth – Sustaining our Future" Topic 2, Subtopic 3.

In all publications based on this expedition, the **Grant No. AWI_PS137_02** will be quoted and the following publication 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.

For OBS data Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung et al.. (2017). DEPAS (Deutscher Geräte-Pool für amphibische Seismologie): German Instrument Pool for Amphibian Seismology. *Journal of largescale research facilities, 3*, A122. http://dx.doi.org/10.17815/jlsrf-3-165 will be cited.

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Jokat W, Schmidt-Aursch M (2007) Geophysical characteristics of the ultraslow spreading Gakkel Ridge, Arctic Ocean. Geophysical Journal International 168:983–998. https://doi.org/10.1111/j.1365-246X.2006.03278.x.

Kanzow T (2023) The Expedition PS131 of the Research Vessel Polarstern to the Fram Strait in 2022. Reports on Polar and Marine Research 770. https://doi.org/10.57738/BzPM_0770_2023.

Meier M, Schlindwein V (2018) First In Situ Seismic Record of Spreading Events at the Ultraslow Spreading Southwest Indian Ridge. Geophysical Research Letters, 45. https://doi.org/10.1029/2018GL079928.

Meier M, Schlindwein V, Scholz J-R, Geils J, Schmidt-Aursch Mc, Krüger F, Czuba W, Janik T (2021) Segment-scale seismicity of the ultraslow spreading Knipovich Ridge. Geochemistry Geophysics Geosystems 22, https://doi.org/10.1029/2020GC009375.

Meier M, Schlindwein V, Schmid F (2022) Magmatic activity and dynamics of melt supply of volcanic centers of ultraslow spreading ridges: hints from local earthquake tomography at the Knipovich Ridge. Geochemistry Geophysics Geosystems 23. https://doi.org/10.1029/2021GC010210.

3. NEREID UNDER ICE HYBRID AUV-ROV OPERATIONS

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Grant-No. AWI_PS137_04

Objectives

This chapter describes the research plan aboard PS137 for the research team using WHOI's *Nereid Under Ice* deep submergence vehicle to conduct hybrid AUV-ROV dives to the seafloor at selected target areas along the Gakkel Ridge as part of the ALOIS programme.

The main objectives of the NUI group on PS137 are linked to a complementary NASA-funded research project, with science and technology components, focussed on advancing the search for life on other ocean worlds (German et al., 2022a). *Scientifically*, our priority on PS137 is to collect samples of hydrogen-rich vent-fluids from the Aurora hydrothermal field, at a range of temperatures that cross the limits for life on Earth, to investigate the system's potential to host abiotic organic synthesis. We have demonstrated that such processes can arise on the similarly ultra-slow spreading Mid-Cayman Rise (McDermott et al., 2015) and there is preliminary evidence that similarly hydrogen-rich venting may also arise at the bottom of the ice-covered ocean of Saturn's moon Enceladus (Waite et al., 2017). On Earth, such seafloor fluid-flow environments provide energy for microbial metabolisms that underpin *chemo*synthetic ecosystems. Logically, similarly habitable environments could arise on other ocean worlds, expanding both the volume and diversity of habitable space within our own solar system (Hendrix et al., 2019) and among ocean world exo-planets (Quick et al., 2020). *Technologically*, our use of NUI during PS137 will build on our past work to autonomously explore for, and localize, submarine vent-sites within unexplored oceans (Branch et al., 2018, 2019). On PS137, our goal is to advance autonomous strategies to the next level: to enhance the near-seafloor search for characterization and selection of seafloor target sites *within* an identified hydrothermal field. We will take the opportunity of having autonomy experts at sea together with an experienced piloted-operations teams to collect training data-sets for future research into autonomous sampling site approach and landing.

In the wider context of ALOIS, our team contributions will also pursue two further whole-project objectives: in AUV mode, our NUI mapping surveys of individual vent-fields will provide new perspectives that help advance our understanding of the geological controls of venting along the Gakkel Ridge; in ROV mode, NUI will be able to conduct microbiological and macrobiological sampling at each vent-site, as a complement to our geochemical research, to investigate the biogeochemical underpinning of chemosynthetic microbial communities and to help place the vent-fauna of the Gakkel Ridge in a global biogeographic context.

Work at sea

- For each submersible dive we will exploit NUI's hybrid capabilities, using it in both autonomous underwater vehicle (AUV) mode and in remotely operated vehicle (ROV) mode. Upon launch, the vehicle will descend beneath the overlying ice cover in its streamlined AUV mode, transit to the selected work area guided by high-fidelity inertial navigation with acoustic aiding from the ship (Jakuba et al., 2008), and begin surveys close above the seafloor using mapping sonars, in-situ oceanographic sensors (CTD, optical clarity, redox) and down-looking photography.
- While operating in AUV mode, NUI will remain connected to our operations team aboard ship via its kms-long microtether. This means that we will be able to monitor the data from the vehicle in real time as it surveys across the seafloor and, wherever a suitable target for sampling is detected, we will be able to interrupt operations, open the vehicle's articulated bay doors and transform into ROV mode to conduct biogeochemical sampling operations. Upon completion of all sampling, we will be able to drive back up to survey height, re-close NUI's doors to minimize drag, and resume AUV surveys.
- We do not yet know the full extent of the Aurora vent-field (German et al., 2022b) but preliminary work has revealed the presence of at least three active vent-sites with a range of high and low temperature flow and associated microbial colonization and vent -endemic macro-fauna (Ramirez-Llodra et al., 2023). We plan a series of 5 dives at the Aurora site during the first phase of the field programme followed by two more dives to be conducted further East within the ALOIS study area (1°30 – 2°00'W, 2°00 – 2°15'E).
- At Aurora, plans will evolve according to discoveries and ice conditions at sea but each dive should have the capacity to complete one (100 m x 100 m) AUV survey and have the resources, within the course of the same dive, to conduct one detailed set of seafloor biogeochemical sampling operations. AUV surveys will involve the collection of data to examine the detailed microbathymetry at the vent-site using mapping sonars, distributions of sites of active fluid flow from in-situ oceanographic sensors (CTD, optical back-scatter, redox) and imaging of active and extinct vents using seafloor photography. At each sampling site, hydrothermal vent-fluid samples will be collected using isobaric gas-tight (IGT) samplers (Seewald et al., 2002) together with conjugate mineral deposit and/or rock samples. Biological samples will also be collected from each vent-site visited using a multi-chamber in-situ filtration "slurp" sampler which can be fitted with a range of filter meshes for microbial and/or macro-fauna sampling priorities.
- At the eastern ALOIS locations (2°W – 3°E), selection of NUI dives will be decided in response to results from CTD profiles at each location (re-occupied from Edmonds et al., 2003; Baker et al., 2004) but will have the same capabilities as at Aurora – to explore for exact sites of venting in AUV mode and, wherever such sites are found, to sample them in ROV mode.

Preliminary (expected) results

During the PS137 cruise we will expect to generate high resolution maps of the seafloor at Aurora revealing the locations and morphologies of both active and inactive components of the hydrothermal field. We will also expect to collect high-temperature vent-fluids from a suite of vent-sites within the Aurora field which will be measured on board ship for pH (25° C) and dissolved gas concentrations (H_2S, H_2, CH_4). Archived aliquots of fluids will be analyzed on shore for the aqueous concentrations of Na^+, K^+, Ca^{2+}, Mg^{2+}, trace metals, SO_4^{2-}, NH_3, Cl^-, C_1-C_5 hydrocarbons, and C_1-C_5 organic acids and the isotopic composition of Sr, B, Li, and H_2O. The carbon and hydrogen isotope ratios of CO_2 and C_1-C_5 hydrocarbons will be analyzed by gas chromatography-isotope ratio mass spectrometry (GC-IRMS). Analyzing the inorganic composition of the same vent fluids will allow us to constrain the effects of temperature and pressure on the vent fluids' inorganic compositions and the extent to which organic-inorganic interactions regulate the stability of organic species within a thermodynamic framework (Seewald 2001). Measurement of noble gases in the same samples (see Chapter 2) will provide an important basis for relating what we detect at the seafloor to dispersion of vent-sourced chemicals through the overlying plume. Any hydrothermal mineral precipitates or rock samples recovered from each vent-site using NUI will be analyzed ashore to determine mineral and chemical compositions using thin section microscopy, scanning electron microscopy, Raman spectroscopy and electron microprobe.

Data management

For this cruise NUI will be equipped with a Seabird FastCAT49 CTD, a Wetlabs ECO FLNTURTD dual-channel chlorophyll and turbidity fluorometer, a Franatech METS methane sensor, an APS Eh/Redox electrode, a forward-looking Blueview imaging sonar, a Kongsberg internal pan/tilt/zoom HD video camera, a SubC Rayfin digital camera with 4k video, custom JPL recording stereo pair cameras, upward and a downward looking 300 kHz RDI ADCP/DVLs, and a Norbit MBES multibeam bathymetric sonar Data from these systems along with vehicle engineering data will be provided to the Chief Scientist on external drives in native format for archival. Processed multibeam bathymetry and timeseries data (interpolated onto a 1 second timebase and including navigation) will be provided as netCDF and CSV files, respectively. In addition data will be archived at WHOI and available upon request.

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4. BATHYMETRY

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Grant-No. AWI_PS137_03

Outline

Seafloor morphology of seismic active sections of the ultra-slow spreading Gakkel Ridge (Arctic Ocean).

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 basic parameter for the understanding of the general geological setting of an area and tectonic landforms. Even information on tectonic processes and potential off-axis sources for earthquakes can be inferred from bathymetry.

While world bathymetry 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 modeled using satellite altimetry with a corresponding low resolution. Satellite-altimetry-derived bathymetry, therefore, lack the resolution necessary to resolve small- to mesoscale geomorphological features (e.g. sediment wave, glaciogenic features or 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.

Recent seismic activity near a narrow ridge on the northern flank of the rift valley of Gakkel Ridge could represent a newly forming axial volcanic ridge. Hence, it is of interest to expand the high-resolution bathymetry along the Gakkel Ridge (Arctic Ocean) towards the north (and south) to establish the position of the plate boundary, in order to fully cover the rift valley and adjacent rift flank. Furthermore, the resurveying of the seismically active ridge could reveal changes in the morphology or signs of recent volcanic edifices that help to understand the seismicity in context with the spreading processes in the area.

Work at sea

The bathymetric data will be recorded with the hull-mounted multibeam echosounder Atlas Hydrosweep DS3. The main task of the bathymetry group is to plan and run bathymetric surveys in the survey areas and during transit. The raw bathymetric data will be corrected for sound velocity changes in the water column and will be 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 settings in the study areas. High-resolution seabed and sub-bottom data recorded during the survey will be made available for site selection and cruise planning. During the survey, the acoustic measurement will be carried out by three operators in a 24/7 shift mode (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 toward 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 Word 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 IBCAO (International Bathymetric Chart of the Arctic Ocean) and provided to the Nippon Foundation-GEBCO Seabed 2030 Project.

In all publications, based on this cruise, the **Grant-No. AWI_PS137_03** will be quoted and the following *Polarstern* article will be cited:

This expedition was supported by the Helmholtz Research Programme “Changing Earth – Sustaining our Future” Topic 2, Subtopic 3.

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.

5. HABITAT MAPPING

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Grant-No. AWI_PS137_03

Outline

Mapping of seafloor habitats and associated benthic fauna along the ultra-slow spreading Gakkel Ridge (Arctic Ocean).

Objectives

Benthic megafauna inhabit the sediment-water interface and are closely associated with their physical environment. Highly variable geo-morphologies found along the ultra-slow spreading Gakkel Ridge therefore provide diverse seafloor habitats which harbor different benthic communities. Previous research expeditions visited the location of the Aurora vent field (PS86, HK19 and HK21) and the Polaris vent site (PS101). During those expeditions, a rough topography featuring different benthic communities was reported for the Aurora vent field (Boetius, 2015). And on a nearby seamount a distinct sponge community with motile sponges was observed (Morganti et al., 2021).

In order to increase our knowledge on such unique ecosystems the OFOBS (Fig. 5.1) will be used as a platform to investigate different seafloor habitats and the associated benthic fauna. The OFOBS is a towed camera sled capable of being deployed in moderately ice-covered regions collecting acoustic as well as video and still image data from the seafloor (Purser et al., 2019).

The data collected during this expedition will serve three purposes: (1) habitat mapping of different locations across the Gakkel Ridge, (2) macroecological studies of megabenthic biodiversity patterns, and (3) contributing to the knowledge on the geo-morphology to aid the other biologist and geologist cruise participants in their work. OFOBS streams will be used to produce high-resolution 3D spatial models of the seafloor. These models will allow subsequent high-resolution analysis of terrain variables, such as slope, aspect and rugosity, and their relationship to the distribution of benthic fauna on a fine scale. For macroecological studies OFOBS images will be surveyed for the composition, diversity, and distribution of megabenthic assemblages. Additionally, the OFOBS can assist to recover equipment from the seafloor should it be required.

Work at sea

The set up and application of the OFOBS will be similar to investigations in other polar regions such as in the Weddell Sea, Antarctica (Hellmer, 2020). The OFOBS is a cabled/towed system deployed ~1.5 m above the seafloor at very low ship speeds of max. 0.5 knots (for more detailed information see (Purser et al., 2019)). While in operation, the exact location of the georeferenced system is determined and verified continuously by *Polarstern's* POSIDONIA system, and refined by the Inertial Navigation System (INS) and Dynamic Velocity Logger (DVL).

In addition to collecting image data, OFOBS will also collect in parallel high-resolution topographical information from the seafloor by using a sidescan sonar system and a forward-facing acoustic camera. The sidescan system allows a ~100 m swath of the seafloor to be investigated acoustically at the same time as the collection of still- and video-camera images.

Fig. 5.1: The Ocean Floor Observation and Bathymetry System (OFOBS); photo: L. Boehringer

Preliminary (expected) results

The overall aim of the OFOBS deployments is to collect images and acoustic topographical high-resolution data of the seafloor in order to improve our understanding of habitat distributions across the Gakkel Ridge. The image and acoustic data will be analyzed in a joint approach and 3D models may be generated.

Data management

Environmental data will be archived, published and disseminated according to international standards by the World Data Centre 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. All of the data will be made available to all other cruise participants at the end of the cruise.

This expedition was supported by the Helmholtz Research Programme “Changing Earth – Sustaining our Future” Topic 2, Subtopic 3 and Topic 6, Subtopic 1.

In all publications based on this expedition, the **Grant No. AWI_PS137_03** will be quoted and the following publication 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. HEATFLOW

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Grant-No. AWI_PS137_01

Outline

Little is known about the geothermal heat flow in the Arctic Basin. The heat flow across the Amundsen Basin was found to be abnormally high exceeding predictions of global lithospheric cooling models by a factor of two (Urlaub et al., 2009), deduced from just one research cruise, the AMORE expedition. Heat flow data from further transects of the Eurasian Basin are lacking. Newer heat flow values concentrate on ridge features like Aurora vent field and Karasik seamount.

In recent times, a relationship between seismicity and hydrothermal activity has been found. One of our aims is to reveal locations where fluid flow responds to seismic disturbances and thus constrain circulation patterns.

Objectives

At 3°E there is a boundary of unknown origin. We measure heat flow profiles to understand heat input into Arctic Ocean in its dependence to different styles of lithosphere formation. This is in combination with magnetic surveying to test the stability of the boundary in time and a seismic refraction survey. The question is: does the lithospheric structure and thermal regime of the lithosphere change across this boundary?

Already Nansen realized during his 1893-96 Fram expedition the oceanographic situation in the central Arctic Basin. He observed a temperature increase in the very deep part of the basin (> 4,000 m) and related this to the high pressure. We use high precision temperature measurements to distinguish between pressure related temperature increase and additional geothermal heat input into the deep and confined Arctic Basin.

Work at sea

Two heat flow transects will be acquired across the Nansen Basin to either side of the 3°E boundary to add to the sparse reconnaissance data (10 heat flow staions) to test the hypotheses of an increased geothermal heat flow into the Arctic Ocean. They will cover crustal ages of 0 to about 50 Ma in spreading direction. With these profiles we intend to validate the heat flow values in the Amundsen Basin measured during AMORE 2001 that grossly deviate from global models. We will compare heat flow and cooling history to either side of the 3°E boundary to reveal a potential influence of the spreading mode and melt availability. We will thus considerably add to the still very scarce heat flow data in the Eurasia Basin and help to constrain the heat budget of the Arctic Ocean.

Data management

Heat flow 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 expedition 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.

This expedition was supported by the Helmholtz Research Programme “Changing Earth – Sustaining our Future” Topic 2, Subtopic 3.

In all publications based on this expedition, the **Grant No. AWI_PS137_01** will be quoted and the following publication will be cited:

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7. GEOLOGY AND PETROLOGY

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Grant-No. AWI_PS137_07

Objectives

Objective 1: The Aurora vent field

In order to further our understanding of hydrothermal systems at ultraslow-spreading ridges, we will comprehensively study the geological setting of the Aurora vent field as well as of other vent sites, which we hope to locate during PS137. The style of the hydrothermalism is shaped by underlying geologic processes, i.e., by local geology at the respective sites that determine fluid pathways and seawater–rock reactions. At ultraslow-spreading ridges, particularly diverse types of hydrothermal systems result from the interplay between tectonic seafloor spreading and magmatic activity. Specific questions we aim to answer include: How deep do fluids circulate through the lithosphere at Aurora and which rock types do they interact with? What provides the heat source that drives hydrothermal circulation away from the spreading axis, within the deep rift-valley floor?

Objective 2: The 3°E boundary

We will investigate the lithospheric structure across the prominent 3°E boundary, where the seafloor spreading mode markedly changes from robust magmatic spreading to dominantly tectonic spreading. Rock sampling will help to test the hypothesis that ridge segmentation is controlled by mantle domains, and scientific questions that will be addressed are: Does the lithospheric structure and thermal regime of the lithosphere change across this boundary? Are there petrological and geochemical affinities between melt on either side? How is melt flow along axis either enabled or blocked by the boundary?

Work at sea

At the hydrothermal vent site(s), targeted rock and hydrothermal precipitate samples will be collected with the NUI vehicle. High-resolution seafloor mapping and imagery acquired by NUI and the OFOBS system will provide the geologic context of individual samples.

At the 3°E boundary, rock samples will be taken at sites of interest that we will carefully select based on high-resolution seafloor mapping. We will aim at dredging rocks from the floors and up the walls of the rift valley at both sides of the boundary. Additional targeted sampling will be conducted using the NUI vehicle.

Aboard *Polarstern*, samples will be cut, macroscopically described, and catalogued. They will then be dried and prepared for transport to the laboratories in Bremen, Münster, and Woods Hole.

Preliminary (expected) results

Hydrothermally altered rock and hydrothermal precipitates, i.e., chimney and crusts, collected at the Aurora vent site will be used to characterize phase assemblages at/close to the loci of fluid emission. The results will be combined with fluid geochemical and isotopic data to provide comprehensive insight into sub-seafloor processes. This will in particular shed light on the question in howfar ultramafic lithologies, being absent at the seafloor, contribute to the hydrothermal fluid composition. Further, the combined dataset of precipitates and fluid geochemistry will be used to estimate fluxes of metabolic energy that is provided when the discharging fluids enter the oxic overlying water column. This will allow us to estimate the bioenergetic potential of the hydrothermal system(s), providing an interface between geology and biology.

Rock samples from the 3°E boundary will be investigated petrologically and geochemically, to obtain insights into the provenance of melt on either side of the boundary and into chemical and isotopic heterogeneities in the mantle sources. Further, we will assess pressures of melting and crystallization by using melt inclusion and glass geochemical data, including volatile contents. The results will provide information on the thermal structure of the melting region, which will allow us to link geophysical characteristics of the rift sections with exposed rock types and properties.

Data management

All rock samples will be archived for long-term access in the repository of the MARUM, Bremen. Macroscopic rock descriptions will be published in the cruise report. Interested onshore scientists can request samples for related research. 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 expedition at the latest. By default, the CC-BY license will be applied.

In all publications based on this expedition, the **Grant No. AWI_PS137_07** will be quoted and the following publication 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.

8. PHYSICAL OCEANOGRAPHY AND BIOGEOCHMISTRY OF HYDROTHERMAL PLUMES

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Grant-No. AWI_PS137_06

Objectives

The main objective of the oceanography group is to conduct hydrothermal plume surveying and sampling of the Aurora vent site on the ultraslow spreading Gakkel Ridge in the Arctic Ocean. Plume surveys conducted by research vessels are, by necessity, snapshots of the actual hydrothermal activity. Therefore, to obtain a more solid estimate of the hydrothermal activity, a mooring was deployed in 2022 druing the cruise *Polarstern* cruise PS131 (ATWAICE), designed to monitor the hydrothermal plume (characterized by its distinguished temperature anomaly) and its dispersal (current directions) close to the vent.

These time series observations will be complemented with a thorough plume survey of the Aurora plume during PS137, observing the distribution of the plume parameters as temperature anomaly, turbidity, redox potential, or geochemical anomalies, and the environmental parameters as background flow and stratification. To map a hydrothermal plume, the water column will be surveyed with a see-sawing CTD/rosette system from the ship drifting with the ice (drift-yo CTD) equipped with additional sensors for redox potential and turbidity to allow for online plume detection and targeted sampling of the water column plume. In this way, we aim to estimate the long-term flux of the hydrothermal plume coming out of Aurora, to understand temporal changes in the activity of the hydrothermal system and to determine the interconnection between seismic events and potential perturbations of the water column plume.

The same observation set-up will be used to survey the Gakkel Ridge east of the Aurora site for further hydrothermal activity. A reconnaissance plume survey along the Gakkel Ridge showed a higher plume incidence than expected, based on the slow rate of spreading and hence low magma budget (Edwards et al., 2003; Baker et al., 2004). We plan to follow up on some of these plume observations with CTD/Niskin water sampler rosette tow-yo transects, to sample and analyze the plume water, specifically for hydrogen, methane, noble gases and dissolved metals. For the detection of previously unknown vent sites, the first step is to identify the hydrothermal plumes in the water column. This will help to locate the vent areas on the seafloor. From hydrogen, methane, metal, heat, and turbidity data collected in these surveys, inferences can be made about the nature of the vent which, prior work from PS86 and PS101 has revealed, can reveal important new insights into the style of venting at the seafloor, beyond what can be determined from *in situ* sensing, alone (Edmonds et al. 2003; Baker et al., 2004; German et al., 2022; Albers et al., *in prep*).

Helium and neon isotopes will be sampled within the plumes and the background throughout the water comlun, and measured in the home laboratories. Hydrothermal plumes are highly enriched in helium (isotopes: ^{3}He and ^{4}He), leading to elevated He/Ne ratios, as well a a higher δ^{3}He due to the higher proportion of the isotope 3He in the primordial helium from the hydrothermal vents. The helium isotopic composition is an important tracer for the distribution of vent fluids in the water column, since the inert gas helium is non-reactive and detectable over long distances away from the source. Hydrothermal plume samples collected by the CTD-rosette will be analyzed for H^2 and CH^4 onboard. The sampling and measurement routine includes collecting air-free aliquots in syringes from the Niskin bottles, equilibration at room temperature, and immediate analyzes via headspace extraction gas chromatography using flame ionization detection. Direct current measurements will be carried out at selected depths during the CTD casts to obtain concurrent information of the plume dispersal.

Work at sea

Main tools for the exploration surveys will be the CTD-Rosette equipped with biogeochemical sensors, geo-referenced by POSIDONIA transponders. CTD work will consist mainly of tow-yo stations where the instrument package is lowered and heaved repeatedly in a certain depth range, while the ship is drifting slowly with the ice. A number of standard stations at different locations will be added to sample background profiles and to obtain high resolution sampling of the water column at the Aurora site. The tow-yo stations are used for high-resolution mapping of the water column plume; the resulting transect of plume properties will allow to lay the groundwork for the NUI dives. Repeated profiles of density stratification allow determining mixing intensities and vertical property fluxes.

Miniature Autonomous Plume Recorders (MAPR, Baker and Milburn, 1997) that record (offline) temperature, pressure, turbidity, and oxygen reduction potential will be attached to the CTD cable in order to increase the spatial coverage and to capture possible plume signals. Turbidity on the CTD will be measured using a custom build Seapoint Turbidity Meters (5x normal gain), the same sensor that is used on the MAPR. Direct current measurements will be carried out at selected profiles using an acoustic current meter attached to the CTD instrument package.

Water samples for noble gases helium and neon will be taken in copper tubes to be analyzed after the cruise in the Bremen Mass Spectrometer Laboratory (Sültenfuß et al., 2009) for concentrations and isotopic ratios. In addition, water samples will be taken for the analysis of tritium, to separate the tritiugenic ^{3}He from the primordial signal. Water samples from the CTD-rosette will be taken for H_2 (cf. Section on Hydrothermal Plume Microbiology for details) and CH_4 analyses by GC-MS upon recovery of the rosette. Water samples from the CTD-rosette will be taken for post-cruise measurements of dissolved metals, specifically Fe and Mn, in the hydrothermal fluids. Aliquots of the fluid samples will be filtered (0.45 µm) and acidified with nitric acid to a pH of 1.7 and stored at 4° C for the remainder of the cruise. Dissolved and particulate metal concentrations will be measured post-cruise by ICP-MS at the Faculty of Geosciences at the University of Bremen.

Preliminary (expected) results

During the PS131 (2022), we deployed a mooring to conduct a year-long monitoring of the hydrothermal temperature anomalies in conjunction with the current speed and direction, as well as the seismic activity (OBS, V. Schlindwein). With the data from the recovered mooring, we aim to estimate the long-term flux of the hydrothermal plume coming out of Aurora, to understand temporal changes in the activity of the hydrothermal system, and to determine the interconnection between seismic events and potential perturbations of the water column plume. Further, helium and helium isotope ratios will be used to identify hydrothermal material in the water column, and to discriminate between conservative and non-conservative behavior of chemical species in the plume. Putting the exisiting and new data together, we hope to (1) determine the heat and chemical fluxes, as well as their temporal variability, of the Aurora site (2) link the variability of the plume observation to changes in the hydrothermal circulation in the crust, and (3) locate further vent sites to the east of the Aurora site.

Data management

Environmental and experimental 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 expedition at the latest. The CC-BY license will be applied.

Molecular data (DNA and RNA data) will be archived, published and disseminated within one of the repositories of the International Nucleotide Sequence Data Collaboration (INSDC, www.insdc.org) comprising of EMBL-EBI/ENA, GenBank and DDBJ).

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9. HYDROTHERMAL PLUME MICROBIOLOGY

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Grant-No. AWI_PS137_05

Objectives

Hydrothermal vents emit hot fluids that rise and dilute in the water column and finally reach neutral buoyancy. The fluids contain reduced compounds such as metals, methane, sulfide, and hydrogen, some of these compounds may provide the energy for chemoautotrophic microorganisms. The central objectives of the 'hydrothermal plume microbiology' team are to identify, quantify and culture the microorganisms that benefit from the geo-energy of the rising plumes, and to assess the role of the community in deep ocean biochemistry. Together with the oceanography team we will identify the plumes, and sample these water bodies and the surrounding waters (bottom water, below plume, above plume) with the CTD rosette and the *in-situ* pumps.

The water samples of CTD rosette will be used to determine concentrations of methane and hydrogen gas. We also plan to measure *in-situ* sulfide concentrations, but we still evaluate suitable methods. We will also follow the consumption of methane and hydrogen in plume water over time in bottle incubations. To reveal community compositions and cell abundances, DNA and RNA and filters will be retrieved.

We will quantify the chemosynthetic activity of microorganisms in the plume and reference sites in ^{14}C-bicarbonate incubations of CTD water. Heterotrophic activity and potential organic matter degration will be tracked in a ^{3}H-labeled leucine assay, and fluorogenic model substrates for extracellular hydrolytic enzimes assay. In addition, we will perform ^{13}C-bicarbonate incubations combined with lipid analysis to identify the lipids from key community members and their formation under specific plume conditions.Based on water samples from the non-buoyant plume we will aim to culture and isolate *Canididatus* Sulfurimonas pluma, which has been recently suggested to be the key hydrogen oxidizer in hydrothermal vents.

Some molecular and geochemical analyses require larger amounts of particulate material from the plume water, which we will retrieve by *in-situ* filtration.

Using the under-ice ROV NUI, we will aim to sample the fluids directly at the hydrothermal vent and collect sediments and rocks surrounding the vent for geochemical and microbiological analyses. We will use this opportunity to study the composition of the endmember fluids and benthic microbial communities. This effort will allow us to close the mass budgets in the hydrothermal vent system and validate the benthic-seeding hypothesis, which suggests that part of active plume communities derive from the seafloor and not only from background deep water column.

Work at sea

The main *in-situ* tools to retrieve samples for the Microbiology team are (*i*) the NUI H-ROV, which will identify and sample the hydrothermal systems at the seafloor, (*ii)* the CTD rosette, which will be used to sample the water column of the hydrothermal plumes of Aurora and new vent systems, (*iii*) the *in-situ* pumps, which allows to receive larger amounts of particulate matter from the water column.

Seafloor work

With the NUI H-ROV we will receive sediments cored with a push corer and rock material that we collect directly with the H-ROV arm or nets, and fluids samples retrieved with the WHOI titanium fluid sampler. From the fluid sampler, we analyze the concentrations of hydrogen. Therefore 1 mL fluid will be transferred into 256 ml bottles and gassed out. The concentrations of hydrogen are measured from the gas phase using gas chromatography equipped with a highly sensitive RCP detector (Peak Performer, Peak laboratories). Similar analyses will be done for methane by Jeff Seewald. For sulfate and sulfide concentrations, samples will be fixed with zinc acetate. In the home laboratory sulfide concentrations will be assessed in colorimetric measurements with the methylene blue methods. Sulfate, which will be measured by ion chromatography (Compact IC 930, Metrohm) will be used to assess the dilution by seawater.

To resolve which microorganisms benefit from the hydrothermal vents, rock d samples and sediment from the vent sites collected by NUI will be archived and stored at −80° C for molecular analyses in the home laboratory. In case we receive intact sediment cores we will sample porewater from the cores using Rhizon samplers or, in case of expected short cores, by sediment centrifugation. The retrieved water samples will be fixed in 0.5 mL zinc acetate solution. In addition, filtered porewater will be fixed for the quantification of dissolved inorganic carbon (DIC) and basic nutrients including ammonium. A similar analysis will be performed on vent fluids collected with the titanium fluid samples.

Water column work

After the OCEANOGRAPHY team confirmed the size and position of plumes by CTD campaigns in to-yo mode, the plumes can be sampled with the CTD rosette or *in-situ* pumps. The CTD rosette will provide highly defined samples from specific units in the plume, whereas the pumps allow *in-situ* filtration of large, but maybe less defined sample volumes (ca. 300 L).

Hydrogen concentrations and consumption: For plume hydrogen concentration measurement the CTD water will be collected with 50 mL syringes. A 10 ml headspace of ultrapure air is added on top. After that, the water is allowed to heat to room temp for 30 min, and agitation is used to transfer the hydrogen into the gas phase. Hydrogen is measured using the RCP-GC Peak Performer. To determine consumption rates replicate 256 ml bottles are filled headspace free with medium and are incubated for defined times (i.e. 0,1,2,3 and 5 days). At these time points a headspace is applied, hydrogen is transferred into the headspace by agitation and hydrogen is measured. If samples do not contain hydrogen, then hydrogen is added artificially. The same samples will be used for methane measurements by Jeff Seewald. Samples with strong hydrogen consumption can be used for the cultivation of Ca. Sulfurimonas.

Biomolecular analyses: For DNA or RNA extraction defined volumes (usually 10 L) of water are filtered Sterivax filtration operated with peristaltic pumps. Filters are immediately frozen in liquid nitrogen and stored at −80° C to preserve the RNA. For cells count (applying fluorescence *in-situ* filtration) defined volumes of water (1 L) will be fixed with prefiltered formalin solution (2 % final concentration). After that, the water will be filtered on 45 mm filters. Filters will be washed with 0.2-µm filtered seawater and ethanol 70 %, and stored at −20° C.

Carbon fixation: Water samples will be pulled into 60 mL glass syringes, which are sealed with stopcocks and kept at *in-situ* temperature. In the radioisotope lab, defined amounts of carrier-free 14C sodium bicarbonate (100 kBq per sample) are added via a syringe. In subsets, additional substrates (hydrogen, sulfur compounds, methane) are added and samples are incubated for defined times. The water is filtered and the filters are exposed to an HCl atmosphere. The remaining radioactivity in the particulate fraction is measured from the filters.

Leucine uptake: for each water assay, 40 mL of seawater will be amended with with 3H-leucine and leucine mix (1:4) at final concentration of 5 nM, and incubated in the dark at *in-situ* temperature. Incubation times will range between 1 to 12 hours. The incubations will be stopped with addition of formaldehyde (2 % final concentration). The samples will be filtered through 0.2-um polycarbonate filter (Millipore), rinsed three times with 5 mL of 5 % TCA (ice-cold). The remaining radioactivity in the particulate fraction is measured from the filters.

Extracellular enzymatic activity: The hydrolysis of the fluorogenic substrate analogous β-glucoside (MUF-β), N-acetyl-glucosamine (MUF-N-Ac), leucine (MCA), and fluorescein diacetate (FDA) will be measured to estimate potential activity rates of β-glucosidase, chitobiase, aminopeptidase, and esterase enzymes in the seawater samples. Seawater samples (3 mL) will be incubated in the dark at a final concentration of 10 µM for MUF-B and FDA, 100 µM for MUF-N-Ac, and 500 µM MCA. The incubations will be stopped at four different interval times (0, 12, 24, 48 h) and the fluorescence will be measured with fluorometer.

Lipid stable isotope probing: Large amounts of water (10-30 L) are transferred into two-component welding foil. Specific amounts of substrates (1 µM hydrogen or 1 µM sulfide, final concentration) and 13C-bicarbonate (10 % 13C, final concentration) are added. After defined incubation times (5 days) the experiments are stopped by filtration of the cells onto 0.2 µm filters. In the home laboratory assimilation of 13C of specific lipids will be measured by the isotope pattern matching approach (Lipp et al., in prep.). The aim of this approach is to identify marker lipids for specific hydrogenotrophic taxa.

Retrieval of large amounts of plume biomass with *in-situ* pumps: he *in situ* pumps will be charged with batteries and the filtration units are loaded with 10 µm pore size support filters and 0.2 µm pore size polycarbonate filters and pre-programmed. The *in-situ* pumps will be attached to the CTD rosette or inclose distances to the rosette. The old *in-situ* pumps will be programmed to start and stop at a defined time at which the CTD is expected to reach the target position (in plume, above plume or reference sites). Two recently purchased pumps can be connected to a CTD releaser. Like this these pumps can be turned on and off remotely, allowing more defined samplings. When the pumping has terminated the pumps will be hived. The filtered will be rapidly removed, photographed, transferred to 15 ml centrifugation tubes, and shock-frosted in liquid nitrogen and stored at −80° C. In the home laboratory samples will be used for metagenomic sequencing, transcription analysis, or mineral phases are analyzed by the petrology group.

Cultivation of Ca. S. pluma: Onboard, plume water bottles withstrong hydrogen consumption will receive additional hydrogen. Bottles with increasing hydrogen consumption are subsampled and transferred to synthetic growth medium. The culture will be taken home, and further enrichment/ isolation steps will be performed in the home laboratories.

Preliminary (expected) results

During PS86 and PS101 we visited two hydrothermal vents at the Gakkel Ridge and got first results on the community compositions of Arctic hydrothermal vents. During this mission, we identified potential key microorganisms for hydrogen and sulfide oxidation (Sulfurimonas and SUP05, Molari et al., 2023). During this expedition we aim to deepen our mechanistic understanding in particular of bacterial hydrogen oxidation in plumes, we want to understand the role and functioning of Ca. Sulfurimonas pluma and we will quantify the turnover of substrates in the environment. We expect the following results

- Quantification of fluid emissions from specific hydrothermal vents of the Gakkel Ridge and assessment of the reduced compounds.
- Knowledge on the microbial consumption of the hydrothermal plumes of the Gakkel Ridge
- Quantification of biomass production by chemoautotrophic community members
- Identification and quantification of lipids from autotrophic members of the plume communities
- Cultivation of a pelagic hydrogen-oxidizing strain of Ca. Sulfurimonas

Data management

Environmental and experimental 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 expedition at the latest. The CC-BY license will be applied.

Molecular data (DNA and RNA data) will be archived, published and disseminated within one of the repositories of the International Nucleotide Sequence Data Collaboration (INSDC, www.insdc.org) comprising of EMBL-EBI/ENA, GenBank and DDBJ).

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10. PHYSICAL OCEANOGRAPHY AND OCEAN-SEA ICE COUPLING IN THE MARGINAL ICE ZONE

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This physical oceanography group will carry out work related to ocean-sea ice coupling in the Marginal Ice Zone (MIZ).

Objectives

The expedition PS131 **AT**lantic **WA**ter pathways to the **ICE** in the Nansen Basin and Fram Strait (**ATWAICE**) addressed, amongst other objectives, ocean controls on sea-ice melt and the couplings to biogeochemistry, biology and the atmosphere in the MIZ north of Svalbard (Kanzow 2023). Our respective objective represents the major focus of ATWAICE related to key mechanisms of rapid Arctic sea ice decline and Arctic Amplification. These include processes affecting heat fluxes in the air-ice-ocean system, ocean mixed layer-halocline coupling, ice melt and ice-edge dynamics in the MIZ. We posit that oceanic eddies, fronts and tidal mixing shape the sea-ice distribution in the MIZ which leads to locally enhanced ice melting as well as to the generation of stratified areas with suppressed melting. These processes result in sea-ice characteristics that can be distinguished by different gradients of sea-ice floe size, concentration, roughness and thickness. Our study also aims to understand the complex physical-chemical-biological interactions that control biogeochemical cycling and ecosystem functioning. Our guiding questions in the MIZ are:

Q1: What are the pathways and processes in the inflow regions of warm AW to the Arctic Ocean that transport heat and nutrients to the sea ice and into the euphotic layer in the MIZ?

Q2: How does the dynamic structure (stratification, mixing rates, (sub-)mesoscale activity) of the upper ocean change spatially from open ocean across the MIZ to the pack ice? How does it change seasonally with strongly varying atmospheric forcing?

Q3: What is the fate of sea ice in the summer melting season? And how does it change over time as oceanic mixing and atmospheric fluxes change over time?

Q4: How do the physical (sub-)mesoscale structures (fronts, ice-edge, eddies, etc.) and sea-ice properties (e.g., melt ponds, light transmission) impact biological production?

During the cruise PS131, high-resolution towed sections (velocity, stratification) by means of the Triaxus topAWI platform (von Appen et al. 2020) have been performed across the MIZ, revealing frontal characteristics and submesoscale dynamics, and several moorings were deployed, which are expected to provide year-round Eulerian observations of stratification and ocean currents (yielding daily to seasonal under-ice stratification and heat fluxes). The main objective for the present cruise is the recovery of said moorings.

Work at sea

As listed in Table 10.1, we will recover eight oceanographic moorings, one of which, Aurora-1, is related to the work outlined in Chapter 8. These moorings generally contain observations for water temperature and salinity as well as current velocity. Additionally, some also target sea-ice properties and biogeochemical/biological parameters. Furthermore, a mooring was equipped with a 30 m plastic tube at its top that can get hit by sea ice without being destroyed; this allows the sensors to be placed closer to the ocean surface than would otherwise be possible (for more information, see Kanzow (2023)). At all mooring locations we will perform CTD stations.

Tab. 10.1: List of moorings to be recovered. All moorings were deployed during PS131 in 2022.

Name	Deployment Station	Longitude	Latitude	Depth [m]	Top [m]
Y1-1	PS131_58-2	10° 3.66' E	80° 24.08' N	691	23
Y2-1	PS131_59-1	10° 3.65' E	80° 25.00' N	693	128
Y3-1	PS131_62-2	8° 43.30' E	80° 56.95' N	768	6
Y4-1	PS131_63-1	8° 43.18 E	80° 57.95' N	790	16
Y5-1	PS131_66-1	7° 9.13' E	81° 30.08' N	485	17
Y7-1	PS131_83-1	1° 4.34 E	81° 20.97' N	1548	22
Y8-1	PS131_85-1	3° 10.27 E	81° 18.82' N	800	16
Aurora-1	PS131_77-1	6° 15.04 W	82° 53.87' N	3906	96

Preliminary (expected) results

The data from the recovered moorings will allow an analysis of the seasonal variability of key oceanographic variables related to ice-ocean coupling, for instance stratification, heat fluxes, and ocean currents (mainly related to Q2 above). These observations will complement the towed observations and intense ice station work during PS131. The corresponding CTD station close to the respective moorings will aid the quality assessment and correction of the moored instrument data.

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 expedition at the latest. By default, the CC-BY license will be applied.

This expedition was supported by the Helmholtz Research Programme "Changing Earth – Sustaining our Future" Topic 2, Subtopic 2.1.

In all publications based on this expedition, the **Grant No. AWI_PS137_09** will be quoted and the following publication 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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Kanzow T (2023) The Expedition PS131 of the Research Vessel Polarstern to the Fram Strait in 2022/ H. Bornemann (editor), Berichte zur Polar- und Meeresforschung = Reports on polar and marine research, Bremerhaven, Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, 770. https://doi.org/10.57738/BzPM_0770_2023.

11. SEA ICE

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Grant-No. AWI_PS137_11

Objectives

The main objective of the sea-ice group during the PS137 expedition is to study melt processes at the sea-ice surface, in particular properties of melt ponds. Melt ponds lead to a decrease in reflectivity of sea ice, which has consequences for the energy and mass balance of the ice and the primary productivity in the upper ocean. Additionally, the extent of melt ponds is a sign of the extent of surface melting and freshwater release to the ocean, both of which contribute to upper ocean stratification.

There have been studies on deriving the bathymetry of melt ponds using airborne hyperspectral or RGB imagery (König et al 2020a, Fuchs 2023) but so far the methods have mostly been used for individual ponds. One main focus of our intended sea-ice research activities is therefore to carry out helicopter and drone survey flights collecting data on 3-dimensional melt pond geometry and the distribution of melt ponds for entire floes. In particular floes featuring a composite of sea ice of different age and structure will be considered in order to further study the relationship between these parameters and melt ponds properties (Landy et al. 2015).

The combination of the RGB images from the DSLR cameras mounted on the helicopter and the multispectral sensor on the drone allow for a method comparison in deriving pond geometry, which constitutes a second main research focus of the sea-ice team aboard *Polarstern*.

Satellite remote sensing serves as a valuable supplement to *in-situ* measurements and allows for synoptic and multi-temporal data collection. Therefore, we will use remote sensing data (Sentinel-2) to enhance and verify algorithms for retrievals such as floe size, melt pond coverage, melt pond depth (König et al. 2019) and ice drift (König et al. 2020b, Wang et al. 2021). The satellite remote sensing retrieval of these parameters, including the spectral behaviour of sea ice and melt ponds, is dependent on spectral information, which requires a retrieval of their optical properties (e.g., König et al. 2019, Malinka et al. 2018).

During the cruise, especially drone survey will be conducted to bridge from field to satellite scale. The drone is equipped with a sensor with the same spectral setting as Sentinel-2 which allows for a direct comparison in the spectral domain.

The surveyed region will potentially be revisited during the IceBird Summer campaign in August 2023 when the melt ponds are expected to start refreezing. Therefore, the current expedition plays a role in strengthening the existing set of campaign data for statistical analysis of open ponds in summer. It will thereby expand the data set of optical imagery in the area surveyed during previous IceBird Summer and *Polarstern* campaigns.

Work at sea

Helicopter surveys

We will carry out extensive melt pond, surface roughness and surface temperature surveys with *Polarstern*'s helicopter *D-HARK* over individual selected floes as well as distances of up to 80 nautical miles. Alongside melt pond coverage, pond size and depth will be measured with standard downward-looking DSLR cameras. An airborne laser scanner (ALS) will be used to survey ice surface roughness and to obtain additional melt pond information. A thermal infrared imaging system will provide surface temperatures and derived floe size and melt pond information.

We plan to carry out as many surveys as possible to get data from a reasonable amount of different floes. The main focus will be on grid flights with a large image overlap of 60-80 % (Fuchs 2023) over individual floes in order to derive 3-dimensional pond geometry from the high resolution RGB imagery. Additionally, we will also perform transect flights to document the melt pond fraction and 2-dimensional pond properties over a larger area. Helicopter flights for our purpose are possible both during steaming and during stations.

Drone surveys

We plan to conduct drone surveys over the Arctic sea ice as well as of melt ponds. Since the hyperspectral AISAeagle sensor operated from the helicopter in previous expeditions is not available, we will use a DJI Matrice 210 RTK V2 equipped with the multispectral MicaSense RedEdge-MX Dual Camera. The RedEdge-MX Dual Camera enables high spatial resolution imaging of snow and ice as well as water surfaces, even when no fixed ice stations are planned during ALOIS. The camera offers ten spectral bands (from coastal blue at 444 nm to near infrared at 842 nm) in the respective wavelength ranges of the bands of Sentinel-2. Using this sensor setting, we aim at validating satellite-based applications that enable monitoring of sea ice, melt ponds and their evolution during the Arctic summer.

In-situ observations

In case of ice stations, we are planning measurements with a measuring unit equipped with three OceanOptics STS-VIS spectro-radiometers on a person-mounted and gimbal-stabilized monopod. Two of the spectro-radiometers measure down- and upwelling irradiance simultaneously. An additional spectro-radiometer for measuring upwelling radiance is also attached. The *Stickle* will be used over snow and ice surfaces as well as melt ponds to obtain valuable spectroradiometer measurements also in combination with the drone survey data from the Matrice.

Satellite remote sensing

We will use optics-based satellites (Sentinel-2 and Planet) to achieve large-scale mapping of floe sizes, melt pond depths and coverages. Sentinel-2 data will be received directly on board of *Polarstern* and will support our scientific planning and work during the ALOIS cruise.

Preliminary (expected) results

We expect to obtain a comprehensive characterization of melt pond properties from the helicopter-borne remote sensing surveys, including a unique data set of high resolution 3-dimensional pond geometries for entire sea-ice floes. From the combination of helicopter and drone surveys we expect to collect two independent data sets of pond bathymetry from RGB and multispectral imagery, allowing for a novel comparison between the two acquisition methods.

We expect that the *in-situ* and drone data from ALOIS will build on the data obtained during PS131 (ATWAICE) and enrich it with important spectral elements. This is especially true for the validation of a satellite-based application based on Sentinel-2 that allows monitoring of melt ponds and their evolution on the summer Arctic sea ice. We expect to obtain high spatial resolution images of snow and ice surfaces as well as melt ponds along the *Polarstern* track with a particular focus on the Western Gakkel Ridge region.

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 expedition at the latest. By default, the CC-BY license will be applied.

This expedition was supported by the Helmholtz Research Programme "Changing Earth – Sustaining our Future" Topic 2, Subtopic 2.1.

In all publications based on this expedition, the **Grant No. AWI_PS137_11** will be quoted and the following publication 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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APPENDIX

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTES

A.2 FAHRTTEILNEHMER:INNEN / CRUISE PARTICIPANTS

A.3 SCHIFFSBESATZUNG / SHIP‘S CREW

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTES

Affiliation	Address
DE.AWI	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Postfach 120161 27515 Bremerhaven Germany
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DE.IUP	Institut für Umweltphysik Universität Bremen Otto-Hahn Allee 1 28359 Bremen Germany
DE.MARUM	MARUM – Center for Marine Environmental Sciences University of Bremen Leobener Str. 8 D-28359 Bremen Germany
DE.MPIMM	Max Planck Institute for Marine Microbiology Celsiusstraße 1 28359 Bremen Germany

Affiliation	Address
DE.NHC	Northern HeliCopter GmbH Gorch-Fock-Straße 103 26721 Emden Germany
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US.JPL	NASA Jet Propulsion Laboratory 4800 Oak Grove Drive Pasadena CA 91109 USA
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US.WHOI	Woods Hole Oceanographic Institution Woods Hole Road Woods Hole MA 02543 USA

Not on board	
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A.2 FAHRTTEILNEHMER:INNEN / CRUISE PARTICIPANTS

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession	Fachrichtung/ Discipline
Albers	Elmar	US.WHOI	Scientist	Geology
Böhringer	Lilian	DE.AWI	PhD candidate	Biology
Branch	Andrew	US.JPL	Engineer	Engineering Sciences
Bünger	Hans Jakob	DE.DRIFT NOISE	Scientist	Sea Ice Physics
Curran	Molly	US.WHOI	Engineer	Oceanography
Dalpe	Allisa	US.WHOI	Engineer	Oceanography
Dettling	Nicolas	DE.AWI	PhD candidate	Oceanography
Engicht	Carina	DE.AWI	Technician	Oceanography
Genske	Felix	DE.UNI-Münster	Scientist	Geology
German	Christopher	US.WHOI	Scientist	Geoscience
Gischler	Michael	DE.NHC	Pilot	Helikopter Service
Hecken	Timo	DE.DRF	Technician	Helikopter Service
Hellbrück	Annika	DE.AWI	Student	Geophysics
Höppner	Laura	DE.AWI	Student	Geophysics
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Jakuba	Michael	US.WHOI	Engineer	Engineering Sciences
Kaufmann	Marie	DE.UNI-Bremen	Student	Biology
Kaul	Norbert	DE.UNI-Bremen	Scientist	Geophysics
Kirk	Henning	DE.AWI	Technician	Geophysics
Klaembt	Christopher	DE.MPIMM	Student	Geoscience
Klesh	Andrew	US.JPL	Scientist	Glaciology
Lensch	Norbert	DE.AWI	Technician	Geophysics
Lindzey	Laura	US.UW	Engineer	Engineering Sciences
Lion	Victor	DE.CAU	Student	Geoscience
Loer	Rosemary	US.WHOI	Student	Engineering Sciences
Mette	Jonathan	DE.UNI-Bremen	Student	Oceanography
Molari	Massimiliano	DE.MPIMM	Scientist	Biology
Naklicki	Victor	US.WHOI	Scientist	Engineering Sciences
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Plötz	Hannah	DE.AWI	Student	Geophysics
Reifenberg	Simon	DE.AWI	PhD candidate	Oceanography

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession	Fachrichtung/ Discipline
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Rohleder	Christian	DE.DWD	Technician	Meteorology
Schaubensteiner	Stefan	DE.NHC	Pilot	Helikopter Service
Schlindwein	Vera	DE.AWI	Scientist	Geophysics
Schmidt-Aursch	Mechita	DE.AWI	Scientist	Geophysics
Seewald	Jeffrey	US.WHOI	Scientist	Oceanography
Seifert	Michael	DE.DRF	Technician	Helikopter Service
Silvia	Matthew	US.WHOI	Engineer	Engineering Sciences
Suter	Patrick	DE.DWD	Scientist	Meteorology
Thamm	Viktoria	DE.AWI	Student	Geophysics
Tobisch	Chiara	DE.AWI	Student	Geophysics
Unland	Ellen	DE.AWI	Student	Geophysics
Walter	Maren	DE.UNI-Bremen	Scientist	Oceanography
Warnke	Fynn	DE.AWI	Scientist	Geophysics
Wegener	Gunter	DE.UNI-Bremen	Scientist	Biology
Zhu	Qing Zeng	DE.UNI-Bremen	Scientist	Geoscience

A.3 SCHIFFSBESATZUNG / SHIP‘S CREW

Name	Vorname	Position
Langhinrichs	Moritz	Master
Langhinrichs	Jacob	Chiefmate
Eckenfels	Hannes	Chiefmate Cargo
Rusch	Torben	Chief
Weiß	Daniel	2nd Mate
Peine	Lutz	2nd Mate
Dr. Guba	Klaus	Ships Doc
Pliet	Johannes Oliver	ELO
Ehrke	Tom	2nd. Eng
Westphal	Henning	2nd. Eng
Farysch	Tim	2nd. Eng
Pommerencke	Bernd	SET
Frank	Gerhard	ELO
Schwedka	Thorsten	ELO
Winter	Andreas	ELO
Krüger	Lars	ELO
Brück	Sebastian	Bosun
Keller	Euge Jürgen	Carpen.
Möller	Falko	MP Rat.
Buchholz	Joscha	MP Rat.
Schade	Tom	MP Rat.
Decker	Jens	MP Rat.
Niebuhr	Tim	MP Rat.
Lutz	Johannes	MP Rat.
Luckhardt	Arne	MP Rat.
Jassmann	Marvin	MP Rat.
Probst	Lorenz	MP Rat.
Clasen	Nils	MP Rat.
Deutschbein	Felix Maximilian	MP Rat.

Name	Vorname	Position
Schröder	Paul	MP Rat.
Fink	Anna-Maria	MP Rat.
Preußner	Jörg	Storek.
Schnieder	Sven	Cook
Bogner	Christoph Friedemann	Cooksm.
Lang	Gerd Martin	Cooksm.
Witusch	Petra	Chief Stew.
Ilk	Romy	2nd Stew
Fehrenbach	Martina	2nd Stew
Golla	Gerald	2nd Stew
Winkler	Maria	2nd Stew
Shi	Wubo	2nd Stew
Chen	Quanlun	Laundym